Extreme Events and Asset Management: The “Whys” and “Hows” in 30 Minutes or Less

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Who we are

VEMAX Management Canada Inc.
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What we do

Asset Management for towns, villages, hamlets and rural municipalities.
  ◦ PS3150
  ◦ NAMS

Strategic decision support for public and private sector clients.
  ◦ Support rational economic decisions in the context of risk.
    ◦ Cost-benefit analysis, life cycle costing and corresponding risk assessment within a Decision Analysis or optimization framework.
    ◦ E.g., LIRA (Ag. Ca.), Optimal D&R contributions in the context of risk (Potash industry), Permit pricing for overweight vehicles (SMHI), etc.
Infrastructure and Environmental Infrastructure Impacts and Beneficial Management Practices Adaptation Options

A MUNICIPAL PRIMARY WEIGHT COST RECOVERY FEE STRUCTURE STUDY

Land & Infrastructure Resiliency Assessment (LIRA) in the Redberry Lake Biosphere Reserve Planning Region – Cost Benefit Assessment

St. Louis Bridge Replacement/Rehabilitation Feasibility Study

Cost-Benefit Analysis of Decommission, Reclamation and Tailings Management Scenarios for Potash Mine Sites in Saskatchewan: A Decision Analysis Modeling Approach

Green Decision Making Framework for Pavement Surface Rehabilitations

Policy and funding for mine decommission and reclamation within Saskatchewan’s potash industry

SMHI transport strategy Phase 1: Oil & gas development in Saskatchewan and its implications for transportation demand in the Province
Asset Management

Project level
- Determine treatment actions necessary to minimize life cycle costs of sustaining acceptable service levels for individual infrastructure components (e.g., individual road segments).

Network level
- Determine budget monies required to sustain acceptable service levels over entire network, OR
- Determine optimal service levels achievable given limited budget.
- (So network level must “communicate” with project level to determine allocation of treatments across segments of the network).
E.g., Road infrastructure

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<th>Network level</th>
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<td>(Road network)</td>
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<th>Project level</th>
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<td>(Road segment)</td>
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Asset Management and Extreme Events

Extreme events introduce a “systematic bias” to treatment requirements and, therefore, budget forecasts for infrastructure.

Depending on our response to this “systematic bias”, we may incur higher operating and/or capital costs to optimally sustain our infrastructure.

◦ (So we better plan for it.)
Why worry?
E.g., Road infrastructure and periodic flooding

- Damage to road segments and intersections
- Disruption to travel and access to services
How do we respond to this threat?

Option A: Plan for it (be prepared).
- “Map” the threat and identify vulnerabilities (e.g., map floodwaters and identify road segments at risk)
- Communicate potential threat to users so they can prepare as well (e.g., plan alternate routes)
- If damaged by flooding, repair road segments when floodwaters recede

Option B: Modify infrastructure (eliminate vulnerability).
- “Map” the threat and identify vulnerabilities
- Improve drainage infrastructure (e.g., clear and maintain existing natural channels, site and install culverts) and raise road grades where needed

Each of these options has corresponding action and budget implications.
Option A: Cash Flow Profile

IF extreme event occurs (e.g., rapid snowmelt and/or heavy rains), then a cost of $100,000 is incurred.

(This includes the cost of road repair plus cost of temporary disruption to travel and access.)
Option B: Cash Flow Profile

Capital cost of $250,000 incurred at Year 0 to eliminate infrastructure vulnerabilities.

IF extreme event occurs (e.g., rapid snowmelt and/or heavy rains), then a cost of $0 is incurred.
What are we comparing?

We are comparing:
- The risk of incurring a cost of $100,000 at some Year $t$ (Option A) against,
- The certainty of incurring a cost of $250,000 at Year 0 (Option B).

How do we rationally compare the risk of one thing versus the certainty of another?
How do we compare?

Let’s use a *Present Worth* method of comparison (i.e., distill all our numbers to a Present Worth equivalent measure).

- Assume:
  - Infinite service life of infrastructure (once it’s down, it’s there for life).
  - Real discount rate of 5% (a common rate for long-lived infrastructure).
  - The extreme event (i.e., extreme “run-off” event) occurs, on average, once every 25 years.
    - Then, in any given year, the probability of an extreme event is 1-in-25 (or 4%).
Option A: *Expected* Present Worth

In any given year, the probability of an extreme event is 1-in-25 (4%).
- 4% probability × $100,000 cost = *Expected (average)* value of $4,000 per year.

Given a compound annual real discount rate of 5%, we can translate our annual estimate of $4,000 to a Present Worth equivalent total as follows:
- $4,000 per year / 5% real rate of discount = *Expected* Present Worth of $80,000.

So the *Expected* Present Worth of Option A is $80,000.
Option B: Present Worth

For Option B, we estimate a cost of $250,000 at Year 0.

So the Present Worth of Option B is $250,000.
Option A or Option B?

Since the Expected Present Worth of Option A (at $80,000) is less than the Present Worth of Option B (at $250,000), rational economics suggests that Option A is the best option.
What are the implications of Option A?

From an Asset Management standpoint, Option A suggests that the affected community will experience a shortfall in their operating budget if they fail to plan for extreme events.

- In other words, they are systematically “short-changing” the contingency funds they require to prepare for an extreme event that will come some day.

- This suggests that it is important to establish an appropriate contingency fund for the risks they face if they wish to continue to optimally manage their infrastructure assets.
So how do we incorporate the risk of extreme events into our asset management planning and practices?

◦ **“Map” the threat:** Whether flooding, drought, high winds, hail, ice storms, *et cetera*, determine the spatial arrangements of the threat (where relevant).

◦ **Quantify the risk:** Characterize, in probabilistic terms, the risk of such events occurring in your region.

◦ **Identify infrastructure vulnerabilities:** Estimate what will happen to your infrastructure assets *if* an extreme event of some type occurs.

◦ **Estimate impact on stakeholders:** Estimate how infrastructure vulnerabilities can impact infrastructure providers as well as infrastructure users.

◦ **Cost–out the impacts:** Estimate the costs associated with differing impacts on differing stakeholders (e.g., repair costs, temporary service disruption costs, etc.).

◦ **Develop options:** From “do nothing” to emergency planning to infrastructure modification – give due consideration to the options available.
10 Steps to Success

So how do we incorporate the risk of extreme events into our asset management planning and practices (continued)?

- **Compare options:** Using a Present Worth or Annual Worth approach, compare each option on the basis of direct costs and impact costs.

- **Select preferred option:** Given the results of the analysis, select a preferred option.

- **Determine action and budget implications.** What do you need to do to implement the preferred option (today and on-going)? What are the corresponding capital, operating and contingency budget implications?

- **Plan accordingly.**
Discussion