EMS Benefits to Structured Decision Making: A Case Study of an Alternative Accounts Assessment for Mine Water Disposal

AMEC at a glance

- FTSE 100 company
- Market cap* **c.£3.2 billion**
- **#6** in ENR's Top 500 Design Firms

- Over **29,000** employees in:
  - Europe 11,000
  - Americas 14,500
  - Growth Regions 3,500
- Revenue some **£4.2 billion,** or:
  - Aus $6.4 billion
  - Cdn $6.6 billion
  - US $6.6 billion

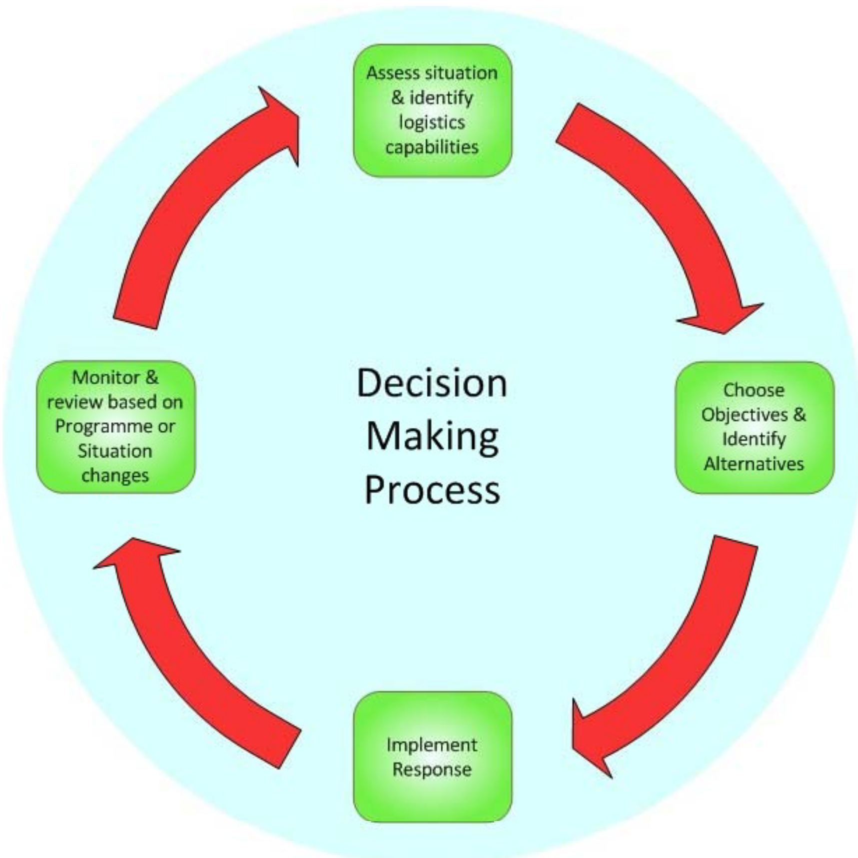
- Operating in over **40 countries** worldwide

- Serving **oil & gas, mining, clean energy and environment & infrastructure** markets across the world

Focused supplier of consultancy, engineering and project management services

* As at 9 August 2013

Structured Decision Making



- The Alternatives Accounts Assessment is a decision-making tool for mine water disposal that incorporates a multitude of information and stakeholder concerns.
- It provides due diligence through the documentation of the information obtained to justify the outcome.
- An EMS (i.e. evaluating impacts, defining objectives) would benefit from a rigorous decision making protocol.
- Assessing impacts and selecting continuous improvement objectives in a structured manner increases due diligence and minimizes liability.

Case Study

- The mine is situated in a forest in Canada consisting of 23 contiguous mineral dispositions totalling 9,280 hectares.
- An airborne geophysical survey and other subsequent exploration programs identified in excess of 200 million diluted tonnes of diamonds.
- The extraction phase of the project will be carried out over a 20 year period and will produce over 30 million carats.
- The project has robust economics and has been advanced past a Feasibility Study with design and construction plans being developed.

Environmental Management – SHE MS

- A Draft EIS (DEIS) was submitted for the extraction, construction and operation of the mill and diamond mine.
- The DEIS proposed a conventional open pit mine with 15m high benches and the following major components:
  - two (2) open pits;
  - overburden and rock storage pile;
  - coarse processed kimberlite pile;
  - fine processed kimberlite containment facility;
  - water management reservoir;
  - diamond processing plant;
  - and other related infrastructure.

- The DEIS also included pit dewatering and a safety, health and environmental, management system (SHE MS) to support construction and operations.
- Regulators determined that the DEIS did not provide enough detail of the evaluation of the mine water disposal options.

The Issue

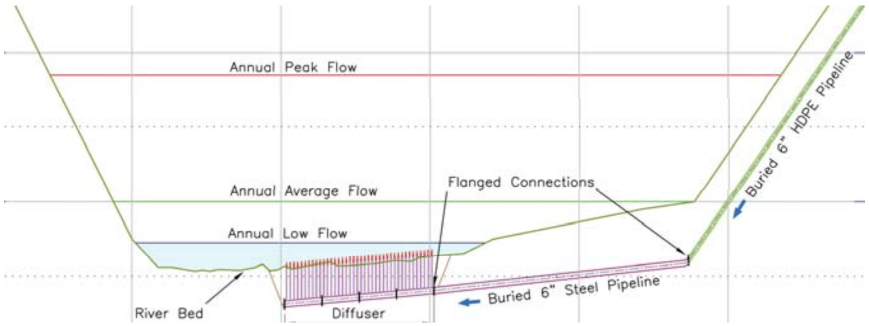
- Mine operations require pit dewatering included in volumes up to 154,000 m^3/day.
- The existing HSE Management System developed to support construction and operations included an environmental impact assessment process but lacked the appropriate detail to identify the option to dispose of the waste mine water with the least environmental and economical impact.
- It was determined that the DEIS required a more rigorous assessment process in identifying a suitable method to dispose of the waste mine water.

- An alternative accounts assessment was developed in accordance with Environment Canada's *Guidelines for the Assessment of Alternatives for Mine Waste Disposal*. (the 'Guidelines') to assess options for mine water disposal.

The Guidelines – Step One

Identification of Candidate Alternatives

- Step One entails listing all possible options for mine water disposal.
- Each option is conceptual but must be satisfactorily considered from a construction, operational and closure perspective in sufficient detail.



Diffuse Release to Riverbed

Spray Evaporation

- Several exclusions exist within the Guideline:
  - Distance
  - Presence based on protected areas;
  - Legal boundaries; and
  - Corporate policy
- Anecdotal characterization

Identification of Candidate Alternatives

WATER MANAGEMENT ALTERNATIVES

Option	A	B	C	D	E	F	G	H
Name	Spray Evaporation	Diffuser System	Mixing SKR and Mannville Formation ground water at diamond process plant before discharge back into SKR	Mixing SKR and Mannville Formation ground water immediately before discharge back into SKR	Mannville Water injected into infiltration gallery	Mannville Formation ground water into exfiltration/evaporation pond	Irrigate Fort a la Corne Forest with Mannville Formation ground water	Deep well injection of Mannville Formation ground water
Construction Approach	Construction of one or more spray evaporators connected with hoses and/or piping. Also include the contruction of holding pond.	Construction of a diffuser system directly in the Saskatchewan River (SKR) along with pipeline and holding tank/pond to stage effluent prior to release.	Construction of a River Water Intake (RWI) and discharge in the SKR along with pumping station, pipelines and mixing tank prior to release.	Construction of a RWI and discharge in the SKR along with pipelines and mixing tank prior to release.	Construction of an infiltration gallery and a holding tank/pond prior to release.	Contruction of a pond that will allow the exfiltration of the water to the ground and evaporation to the atmosphere.	Construction of spray irrigation equipment connected with hoses and/or piping and a holding pond.	Construction of well and holding tank/pond and piping.
Operational Approach	Mannville Formation groundwater will be pumped to a the holding pond where the spray evaporators will be stationed.	Mannville Formation groundwater will be pumped to a holding tank/pond where it will be released through the diffuser.	Mannville Formation groundwater and SKR water will be pumped to a mixing tank at the diamond process plant where it is mixed and used as make up water for the plant. Surplus will be released back to the SKR.	Mannville Formation groundwater and SKR water will be directed to a mixing tank at the side of the SKR, mixed and then released back to the SKR.	Mannville Formation groundwater will be directed to a holding tank/pond and release to shallow ground water through an infiltration gallery.	Mannville Formation groundwater will be directed to a pond specifically designed to allow exfiltration and evaporation.	Mannville Formation groundwater will be directed to a pond and pumped to spray irrigation equipment located in Fort a la Corne forest.	Mannville Formation groundwater will be directed to a holding tank/pond and pumped into the constructed deep well.
Closure Approach	Removal of on-land infrastructure; Reclamation of pond may be likely due to elevated concentration of various parameters.	Removal of on-land infrastructure; Removal of diffuser pipe and diffuser from the SKR.	Removal of on-land and in-river infrastructure.	Removal of on-land and in-river infrastructure.	Reclaim the infiltration gallery and above-ground facilities.	Removal of on-land infrastructure; Reclamation of pond may be likely due to elevated concentration of various parameters.	Removal of on-land infrastructure; Reclamation of pond	Removal of above ground infrastructure; seal the well. Reclamation of pond

Identification of Candidate Alternatives

WATER MANAGEMENT ALTERNATIVES

Option	A	B	C
Name	Spray Evaporation	Diffuser System	Mixing SKR and Mannville Formation ground water at diamond process plant before discharge back into SKR
Construction Approach	Construction of one or more spray evaporators connected with hoses and/or piping. Also include the construction of holding pond.	Construction of a diffuser system directly in the Saskatchewan River (SKR) along with pipeline and holding tank/pond to stage effluent prior to release.	Construction of a River Water Intake (RWI) and discharge in the SKR along with pumping station, pipelines and mixing tank prior to release.
Operational Approach	Mannville Formation groundwater will be pumped to a the holding pond where the spray evaporators will be stationed.	Mannville Formation groundwater will be pumped to a holding tank/pond where it will be released through the diffuser.	Mannville Formation groundwater and SKR water will be pumped to a mixing tank at the diamond process plant where it is mixed and used as make up water for the plant. Surplus will be released back to the SKR.
Closure Approach	Removal of on-land infrastructure; Reclamation of pond may be likely due to elevated concentration of various parameters.	Removal of on-land infrastructure; Removal of diffuser pipe and diffuser from the SKR.	Removal of on-land and in-river infrastructure.

The Guidelines – Step Two

Prescreening Assessment

- The purpose of Step 2 is to "optimize the decision making process" so that "noncompliant" alternatives (the 'fatal flaw analysis') that have obvious deficiencies are eliminated from further consideration.

Mixing and Immediate Discharge

Infiltration Gallery

- This makes the process manageable and focused on realistic possibilities.
- The criteria is unique for each project and must clearly demonstrate why an option is eliminated from further consideration.
- Criteria needs to follow a simple Yes or No format.

Pre-Screening Assessment

Pre-Screening Assessment

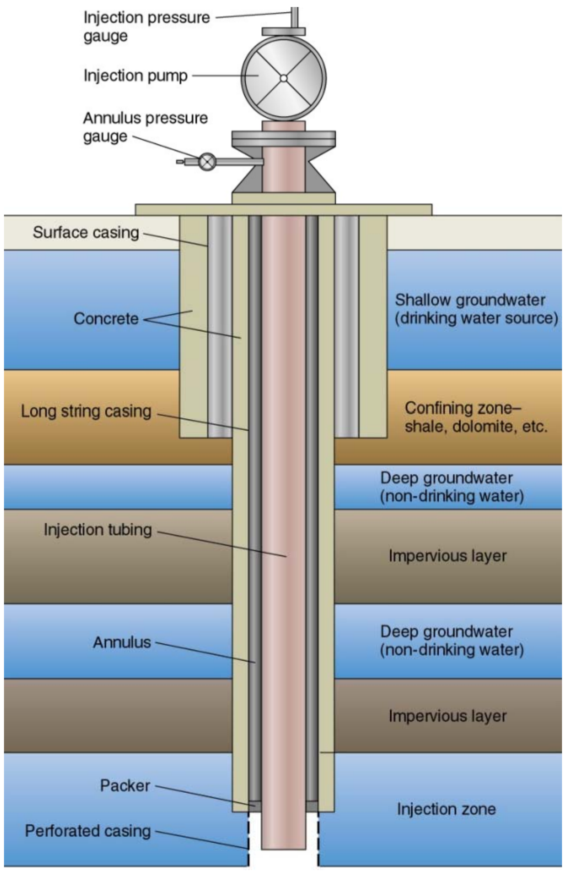
Criteria	Rationale	A - Spray Evaporation	B - Diffuser System	C - Mixing SKR and Mannville Formation ground water at diamond process plant before discharge back into SKR	D - Mixing SKR and Mannville Formation ground water immediately before discharge back into SKR	E - Mannville Water injected into infiltration gallery	F - Mannville Formation ground water into exfiltration/evaporation pond[4]	G - Irrigate Fort a la Corne Forest with Mannville Formation ground water	H - Deep well injection of Mannville Formation ground water
Does this technology have sufficient capacity to manage expected volume of water?	The alternative must have the ability to process the total daily volume of water generated without additional technologies required.	Yes	Yes	Yes	Yes	Yes	No	No	Yes
Can water quality of discharge effluent be managed appropriately?	The effluent from this alternative must not have a water quality parameters that cannot be managed.	No	Yes	Yes	Yes	No	No	No	Yes
Is this alternative option economically feasible?	This alternative must be econmonically viable.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Potential candidate for Water Management		No	Yes	Yes	Yes	No	No	No	No
Summary of reasons for exclusion		Evaporation is reduced during winter months and will lead to additional snow accumulation and excess spring runoff. High TDS and sodium concentrations may reduce evaporation and any infiltration water could negatively effect plant growth and soil structure.	Not excluded	Not excluded	Not excluded	The water is unlikely to meet recieiving environment guideline when it reaches surface water bodies.	Little evaporation will occur during winter months and the pond will freeze over leading to a glacier formation which will melt in spring and could overflow the holding pond.	Water will not percolate into the soil when it is frozen in winter and ice will form on the surface, build during the winter and thaw in the spring leading to super saturated soil. High TDS and sodium concentrations would make any infiltration water could negatively effect plant growth and soil structure.	This alternative would make the mining project uneconomic due to the high cost of development and operation of multiple wells necessitated by -the volume of water from pit-dewatering and makes this unfeasible.

Pre-Screening Assessment

PRE-SCREENING ASSESSMENT

Account	Pre-Screening Criteria	Rationale	A - Spray Evaporation	B - Diffuser System	C - Mixing SKR and Mannville Formation ground water at diamond process plant before discharge back into SKR
Environmental Issues	Water Quality - Does the option introduce a discharge that will have water quality parameters that cannot achieve regulatory requirements?	Options that propose uncontrolled discharges to the environment will not likely receive regulatory approval.	Yes - water will be discharged to atmosphere.	No	No
Technical Issues	Water Storage / Retention Requirements - Does the option require significant additional storage to process the total daily volume of water generated?	Additional storage increases the footprint of the option and increases the potential for malfunction.	No	No	No
Project Economic Issues	Capital Expenditure Requirements - Does the option adversely effect or significantly increase capital expenditure requirements?	Options that significantly alter project economics are not financially viable.	No	No	No
Socio-economic Issues	Public Approval - Does the option present an alternate that stakeholders and the general public will oppose?	Options with which stakeholders and/or the general public have apprehension will increase oppostion to the proposed solution.	Yes - general public will likely have apprehension to airborne nature of discharge.	No	No
Potential candidate for Water Management			No	Yes	Yes
Summary of reasons for exclusion			Evaporation is reduced during winter months and will lead to additional snow accumulation and excess spring runoff. High TDS and sodium concentrations may reduce evaporation and any infiltration water could negatively affect plant growth and soil structure.	Not excluded	Not excluded

The Guidelines – Step Three



Deep Well Injection

Alternative Characterization

- In Step 3 site specific characterization criteria is compiled.
- There are four categories for characterization criteria:
  - Environmental characterization;
  - Technical characterization;
  - Project economic characterization; and
  - Socio-economic characterization.
- Characterization must be based on factual information and does not entail evaluating impacts.
- This step provides the basic details of each of the identified options to be used in the following steps.

The Guidelines – Step Four

Multiple Accounts Ledger

- Step 4 identifies elements that will differentiate the options and provides a basis for scoring and weighting (Step 5).
- Four "sub-accounts" (Aspects) are developed under the categories. Sub-Accounts must:
  - Be impact driven;
  - Differentiate the options;
  - Be unambiguous;
  - Not be redundant; and
  - Rate each option independently.
- Indicators should be developed to allow for measurability

ALTERNATIVE CHARACTERIZATION

Account	Sub-account	Sensitivity Weighting	Rationale	B - Diffuser System			C - Mixing SKR and Mannville Formation ground water at diamond process plant before discharge back into SKR			D - Mixing SKR and Mannville Formation ground water immediately before discharge back into SKR		
				Commentary	Risk	Relative Risk	Commentary	Risk	Relative Risk	Commentary	Risk	Relative Risk
Environmental Issues	Water Quality - Near Field Effects	5	Alternatives that pose the greatest control of effluent quality provide a lower degree of risk of regulatory non-compliance.	**Low risk;** Release rate is designed for maximum concentration at low flow periods; A diffuser enlarges the dilution zone and mix the effluent more rapidly with the receiving water body.	1	0.2	**Low Risk**; Decreased low flow periods reduces intake and risks ability to meet discharge criteria; The existence of bed load or suspended load sediment affects the design concept and the suitability of the site for locating an intake.	1	0.2	**Low Risk**; Decreased low flow periods reduces intake and risks ability to meet discharge criteria; The existence of bed load or suspended load sediment affects the design concept and the suitability of the site for locating an intake.	1	0.2
	Water Quality - Far Field Effects	5	Alternatives that pose the greatest control of effluent quality provides a lower degree of risk of regulatory non-compliance.	**Low risk;** Release rate is designed for maximum concentration at low flow periods.	1	0.2	**Low Risk**; Decreased low flow periods reduces intake and risks ability to meet discharge criteria.	1	0.2	**Low Risk**; Decreased low flow periods reduces intake and risks ability to meet discharge criteria.	1	0.2
	Water Discharge Quantity	1	Alternatives that have the least volume of discharge and the greatest control of the discharge provide a lower impact to the environment.	**Low risk;** This option produces the least possible quantity of discharge and is designed to have minimal to no impact due to erosion.	1	1	**Low to medium risk**; The intake structures require minimal maintenance but increase the discharge quantity by a factor of eight (8).	2	2	**Low to medium risk**; The intake structures require minimal maintenance but increase the discharge quantity by a factor of eight (8).	2	2
	Aquatic Biota	4	Alternatives that effect aquatic biota more significantly poses a greater risk of regulatory non-compliance.	**Low risk**; This option is predicted to have no significant effect on the aquatic biota	1	0.3	**Low risk**; This option is predicted to have no significant effect on the aquatic biota	1	0.3	**Low risk**; This option is predicted to have no significant effect on the aquatic biota	1	0.3
	Noise	3	Alternatives that generate higher levels of noise poses a greater risk of regulatory non-compliance and stakeholder impact.	**Low risk**; This option will not generate noise during operation. Construction will generate short term noise effects.	1	0.3	**Low to medium risk**; The noise generated from the pumping infrastructure will be easily managed through the housing of the noise generating parts. Construction will generate short term noise effects.	2	0.7	**Low to medium risk**; The noise generated from the pumping infrastructure will be easily managed through the housing of the noise generating parts. Construction will generate short term noise effects.	2	0.7
Technical Issues	Water Storage / Retention Requirements	3	Alternatives that have high storage / retention requirements pose a greater degree of risk of operational malfunction.	**Low risk**; A diffuser requires only minimal water sequestration in order to maintain a positive pressure across the diffuser columns in relation to the hydrodynamic force of the river.	1	0.3	**Low to medium risk**; Moderate water storage / retention is required to attain constancy in effluent parameter concentration. Low flow periods reduced intake increasing retention quantity.	2	0.7	**Low to medium risk**; Moderate water storage / retention is required to attain constancy in effluent parameter concentration. Low flow periods reduced intake increasing retention quantity. A	2	0.7
	Dilution Requirements	5	Alternatives that require dilution introduce additional infrastructure and increase the risk of operational malfunction and impact on the environment.	**Low risk**; A diffuser does not require dilution. Diffuser installation discharges are hydraulically optimized to allow for highly turbulent discharges resulting in strong initial mixing and effluent distribution.	1	0.2	**Medium risk**; Mannville Formation groundwater will be diluted with the process plant water prior to discharge. However, this will be insufficient to attain desired parameter concentrations and a River Water Intake (RWI) will be required.	3	0.6	**Medium risk**; Mannville Formation groundwater will be diluted with water from the SKR prior to discharge requiring the installation of a River Water Intake (RWI).	3	0.6
	Installation Requirements	3	Alternatives that have many components have an increased risk of operational malfunction and have a greater risk of permanent impact on the environment.	**Low to medium risk**; Construction will require the temporary installation of a coffer dam or similar water retaining structure to install piping and associated infrastructure. However, contruction plans will include the necessary rehabilitation of the river bed as will closure plans. Once installed minimal environmental impacts expected.	2	0.7	**Medium Risk**; Construction of the river water intake (RWI) will also require the temporary installation of a coffer dam or similar water retaining structure. Installation of the pipeline between the RWI and the process plant and back to the SKR will be below grade and will involve land disturbance. Ongoing impact from the RWI will require ongoing maintenance to minimize environmental impact.	3	1	**Medium Risk**; Construction of the river water intake (RWI) will also require the temporary installation of a coffer dam or similar water retaining structure. Installation of the pipeline between the RWI and the process plant and back to the SKR will be below grade and will involve land disturbance. Ongoing impact from the RWI will require ongoing maintenance to minimize environmental impact.	3	1
	Detailed Design	1	Alternatives that have many components require additional design and have an increased risk of operational malfunction and have a greater risk of impact on the environment.	**Low risk**; Periods of low flow, hydraulic transients (Surges), riverbed movement and physical damage contribute to minimized effectiveness of the diffuser. However, current diffuser port design minimizes backflow of sand, silt and debris which reduces the hydraulic capacity of the outfall and compromises the initial dilution.	1	1	**Low to medium risk**; A river water intake (RWI) located in below freezing air temperature requires protection for screens against the formation of anchor and/or frazil ice. Anchor ice in rivers can significantly reduce flow into RWIs.	2	2	**Low to medium risk**; A river water intake (RWI) located in below freezing air temperature requires protection for screens against the formation of anchor and/or frazil ice. Anchor ice in rivers can significantly reduce flow into RWIs.	2	2
	Regulatory	5	Alternatives which require regulatory interaction pose a greater risk of not receiving approval.	**Medium risk**; Diffuser ports are installed in or at the river bed and involve the disruption of aquatic habitat. However, effluent concentration of some parameters will likely require DFO approval.	3	0.6	**Low to medium risk**; The discharge may not require additional permit approvals from the DFO; However, the RWI will require initial design review and ongoing maintenance to ensure fish are adequately protected.	2	0.4	**Low to medium risk**; The discharge may not require additional permit approvals from the DFO; However, the RWI will require initial design review and ongoing maintenance to ensure fish are adequately protected.	2	0.4
	Navigability	4	Alternatives that interfere with navigability pose a greater risk of damage from surface travel or vandalization and introduce visible items into the river which risk raising objection from stakeholders.	**Low risk**; Diffuser have minimal interference with surface navigability.	1	0.25	**Low to medium risk**; A river water intake (RWI) located in below freezing air temperature requires protection for screens against the formation of anchor and/or frazil ice. Anchor ice in rivers can significantly reduce flow into RWIs.	2	0.5	**Low to medium risk**; A river water intake (RWI) located in below freezing air temperature requires protection for screens against the formation of anchor and/or frazil ice. Anchor ice in rivers can significantly reduce flow into RWIs.	2	0.5
	Operation and Maintenance	2	Alternatives that have significant operational or maintenance requirements pose a greater risk of malfunction.	**Low risk;** Diffuser have minimal operational and / or maintenance requirements.	1	0.5	**Low to medium risk**; A river water intake (RWI) has operation and maintenance requirements to avoid fish entrainment in pumping devices and other associated infrastructure.	2	1	**Low to medium risk**; A river water intake (RWI) has operation and maintenance requirements to avoid fish entrainment in pumping devices and other associated infrastructure.	2	1

Multiple Accounts Ledger

ALTERNATIVE CHARACTERIZATION			
Account	**Sub-account**	**Sensitivity Weighting**	**Rationale**
Environmental Issues	Water Quality - Near Field Effects	5	Alternatives that pose the greatest control of effluent quality provide a lower degree of risk of regulatory non-compliance.
	Water Quality - Far Field Effects	5	Alternatives that pose the greatest control of effluent quality provides a lower degree of risk of regulatory non-compliance.
	Water Discharge Quantity	1	Alternatives that have the least volume of discharge and the greatest control of the discharge provide a lower impact to the environment.
	Aquatic Biota	4	Alternatives that effect aquatic biota more significantly poses a greater risk of regulatory non-compliance.
	Noise	3	Alternatives that generate higher levels of noise poses a greater risk of regulatory non-compliance and stakeholder impact.

The Guidelines – Step Five

ALTERNATIVE CHARACTERIZATION

Account	Sub-account	Sensitivity Weighting	Rationale	B - Diffuser System			C - Mixing SKR and Mannville Formation ground water at diamond process plant before discharge back into SKR			D - Mixing SKR and Mannville Formation ground water immediately before discharge back into SKR		
				Commentary	Risk	Relative Risk	Commentary	Risk	Relative Risk	Commentary	Risk	Relative Risk
Environmental Issues	Water Quality - Near Field Effects	5	Alternatives that pose the greatest control of effluent quality provide a lower degree of risk of regulatory non-compliance.	**Low risk;** Release rate is designed for maximum concentration at low flow periods; A diffuser enlarges the dilution zone and mix the effluent more rapidly with the receiving water body.	1	0.2	**Low Risk**; Decreased low flow periods reduces intake and risks ability to meet discharge criteria; The existence of bed load or suspended load sediment affects the design concept and the suitability of the site for locating an intake.	1	0.2	**Low Risk**; Decreased low flow periods reduces intake and risks ability to meet discharge criteria; The existence of bed load or suspended load sediment affects the design concept and the suitability of the site for locating an intake.	1	0.2
	Water Quality - Far Field Effects	5	Alternatives that pose the greatest control of effluent quality provides a lower degree of risk of regulatory non-compliance.	**Low risk;** Release rate is designed for maximum concentration at low flow periods.	1	0.2	**Low Risk**; Decreased low flow periods reduces intake and risks ability to meet discharge criteria.	1	0.2	**Low Risk**; Decreased low flow periods reduces intake and risks ability to meet discharge criteria.	1	0.2
	Water Discharge Quantity	1	Alternatives that have the least volume of discharge and the greatest control of the discharge provide a lower impact to the environment.	**Low risk;** This option produces the least possible quantify of discharge and is designed to have minimal to no impact due to erosion.	1	1	**Low to medium risk**; The intake structures require minimal maintenance but increase the discharge quantity by a factor of eight (8).	2	2	**Low to medium risk**; The intake structures require minimal maintenance but increase the discharge quantity by a factor of eight (8).	2	2
	Aquatic Biota	4	Alternatives that effect aquatic biota more significantly poses a greater risk of regulatory non-compliance.	**Low risk**; This option is predicted to have no significant effect on the aquatic biota	1	0.3	**Low risk**; This option is predicted to have no significant effect on the aquatic biota	1	0.3	**Low risk**; This option is predicted to have no significant effect on the aquatic biota	1	0.3
	Noise	3	Alternatives that generate higher levels of noise poses a greater risk of regulatory non-compliance and stakeholder impact.	**Low risk**; This option will not generate noise during operation. Construction will generate short term noise effects.	1	0.3	**Low to medium risk**; The noise generated from the pumping infrastructure will be easily managed through the housing of the noise generating parts. Construction will [illegible]	2	0.7	**Low to medium risk**; The noise generated from the pumping infrastructure will be easily managed through the housing of the noise generating parts. Construction will [illegible] short term noise effects.	2	0.7
Technical Issues	Water Storage / Retention Requirements	3	Alternatives that have high storage / retention requirements pose a greater degree of risk of operational malfunction.	**Low risk**; A diffuser requires only requires minimal water sequestration in order to maintain positive pressure across the diffuser columns in relation to the hydrodynamic force of the river.	1	0.3	**Low to medium risk;** Moderate water storage / retention is required to attain constancy in effluent parameter concentration. Low flow periods reduced intake increasing retention quantity.	2	0.7	**Low to medium risk;** Moderate water storage / retention is required to attain constancy in effluent parameter concentration. Low flow periods reduced intake increasing retention quantity. A	2	0.7
	Dilution Requirements	5	Alternatives that require dilution introduce additional infrastructure and increase the risk of operational malfunction and impact on the environment.	**Low risk**; A diffuser does not require dilution. Diffuser installation discharges are hydraulically optimized to allow for highly turbulent discharges resulting in strong initial mixing and effluent distribution.	1	0.2	**Medium risk**; Mannville Formation groundwater will be diluted with the process plant water prior to discharge. However, this will be insufficient to attain desired parameter concentrations and a River Water Intake (RWI) will be required.	3	0.6	**Medium risk**; Mannville Formation groundwater will be diluted with water from the SKR prior to discharge requiring the installation of a River Water Intake (RWI).	3	0.6
	Installation Requirements	3	Alternatives that have many components have an increased risk of operational malfunction and have a greater risk of permanent impact on the environment.	**Low to medium risk**; Construction will require the temporary installation of a coffer dam or similar water retaining structure to install piping and associated infrastructure. However, contruction plans will include the necessary rehabilitation of the river bed as will closure plans. Once installed minimal environmental impacts expected.	2	0.7	**Medium Risk**; Construction of the river water intake (RWI) will also require the temporary installation of a coffer dam or similar water retaining structure. Installation of the pipeline between the RWI and the process plant and back to the SKR will be below grade and will involve land disturbance. Ongoing impact from the RWI will require ongoing maintenance to minimize environmental impact.	3	1	**Medium Risk**; Construction of the river water intake (RWI) will also require the temporary installation of a coffer dam or similar water retaining structure. Installation of the pipeline between the RWI and the process plant and back to the SKR will be below grade and will involve land disturbance. Ongoing impact from the RWI will require ongoing maintenance to minimize environmental impact.	3	1
	Detailed Design	1	Alternatives that have many components require additional design and have an increased risk of operational malfunction and have a greater risk of impact on the environment.	**Low risk**; Periods of low flow, hydraulic transients (Surges), riverbed movement and physical damage contribute to minimized effectiveness of the diffuser. However, current diffuser port design minimizes backflow of sand, silt and debris which reduces the hydraulic capacity of the outfall and compromises the initial dilution.	1	1	**Low to medium risk**; A river water intake (RWI) located in below freezing air temperature requires protection for screens against the formation of anchor and/or frazil ice. Anchor ice in rivers can significantly reduce flow into RWIs.	2	2	**Low to medium risk**; A river water intake (RWI) located in below freezing air temperature requires protection for screens against the formation of anchor and/or frazil ice. Anchor ice in rivers can significantly reduce flow into RWIs.	2	2
	Regulatory	5	Alternatives which require regulatory interaction pose a greater risk of not receiving approval.	**Medium risk**; Diffuser ports are installed in or at the river bed and involve the disruption of aquatic habitat. However, effluent concentration of some parameters will likely require DFO approval.	3	0.6	**Low to medium risk**; The discharge may not require additional permit approvals from the DFO; However, the RWI will require initial design review and ongoing maintenance to ensure fish are adequately protected.	2	0.4	**Low to medium risk**; The discharge may not require additional permit approvals from the DFO; However, the RWI will require initial design review and ongoing maintenance to ensure fish are adequately protected.	2	0.4
	Navigability	4	Alternatives that interfere with navigability pose a greater risk of damage from surface travel or vandalization and introduce visible items into the river which risk raising objection from stakeholders.	**Low risk**; Diffuser have minimal interference with surface navigability.	1	0.25	**Low to medium risk**; A river water intake (RWI) located in below freezing air temperature requires protection for screens against the formation of anchor and/or frazil ice. Anchor ice in rivers can significantly reduce flow into RWIs.	2	0.5	**Low to medium risk**; A river water intake (RWI) located in below freezing air temperature requires protection for screens against the formation of anchor and/or frazil ice. Anchor ice in rivers can significantly reduce flow into RWIs.	2	0.5
	Operation and Maintenance	2	Alternatives that have significant operational or maintenance requirements pose a greater risk of malfunction.	**Low risk;** Diffuser have minimal operational and / or maintenance requirements.	1	0.5	**Low to medium risk;** A river water intake (RWI) has operation and maintenance requirements to avoid fish entrainment in pumping devices and other associated infrastructure.	2	1	**Low to medium risk**; A river water intake (RWI) has operation and maintenance requirements to avoid fish entrainment in pumping devices and other associated infrastructure.	2	1

Value-Based Decision Process

- Step 5 assigns scores and weighting factors (sensitivity) to each of the options for each sub-account through the use of qualitative scales.
- Weighting assigns the importance of each sub-account to the assessment process and can be completed in consultation with a variety of project stakeholders.
- Weighting factors allow the analyst to assign relative importance of one indicator as compared to another
  - this weighting factor reflects the analyst's bias.

Multiple Accounts Ledger

ALTERNATIVE CHARACTERIZATION								
Sub-account	Sensitivity Weighting	Rationale	B - Diffuser System			C - Mixing SKR and Mannville Formation ground water immediately before discharge back into SKR		
			Commentary	Risk	Relative Risk	Commentary	Risk	Relative Risk
Water Storage / Retention Requirements	3	Alternatives that have high storage / retention requirements pose a greater degree of risk of operational malfunction.	**Low risk**; A diffuser requires only requires minimal water sequestration in order to maintain positive pressure across the diffuser columns in relation to the hydrodynamic force of the river.	1	3	**Low to medium risk;** Moderate water storage / retention is required to attain constancy in effluent parameter concentration. Low flow periods reduce intake increasing retention quantity.	2	6
Installation Requirements	3	Alternatives that have many components have an increased risk of operational malfunction and have a greater risk of permanent impact on the environment.	**Low to medium risk**; Construction will require the temporary installation of a coffer dam or similar water retaining structure to install piping and associated infrastructure. However, contruction plans will include the necessary rehabilitation of the river bed as will closure plans. Once installed minimal environmental impacts expected.	2	6	**Medium risk**; Construction of the river water intake (RWI) will also require the temporary installation of a coffer dam or similar water retaining structure. Installation of the pipeline between the RWI and the mixing installation will be below grade and will involve land disturbance. Ongoing impact from the RWI will require ongoing maintenance to minimize environmental impact.	3	9
Regulatory	5	Alternatives which require regulatory interaction pose a greater risk of not receiving approval.	**Medium risk**; Diffuser ports are installed in or at the river bed and involve the disruption of aquatic habitat. However, effluent concentration of some parameters will likely require DFO approval.	3	15	**Low to medium risk**; The discharge may not require additional permit approvals from the DFO; However, the RWI will require initial design review and ongoing maintenance to ensure fish are adequately protected.	2	10
Navigability	2	Alternatives that interfere with navigability pose a greater risk of damage from surface travel or vandalization and introduce visible items into the river which risk raising objection from stakeholders.	**Low risk**; Diffuser has minimal interference with surface navigability.	1	2	**Low to medium risk**; A river water intake (RWI) located in below freezing air temperature requires protection for screens against the formation of anchor and/or frazil ice. Anchor ice in rivers can significantly reduce flow into RWIs.	2	4
Operation and Maintenance	2	Alternatives that have significant operational or maintenance requirements pose a greater risk of malfunction.	**Low risk;** Diffuser has minimal operational and / or maintenance requirements.	1	2	**Low to medium risk**; A river water intake (RWI) has operation and maintenance requirements to avoid fish entrainment in pumping devices and other associated infrastructure.	2	4

The Guidelines – Step Six

Step Six – Sensitivity Analysis

- Step 6 identifies where bias and subjectivity has entered the assessment
  - Assigning different weighting sensitivities to each of the sub-accounts typically results in different conclusions
- Weighting sensitivities that have been developed without input from stakeholders exposes the assessment process to risk.
- Weighting factors scale the importance of stakeholders and client value system.
  - If the assignment of weighting has been done collaboratively with the appropriate stakeholders, then it is reasonable to assume that those weightings suggest consensus.

Unique feature

- ISO 14001 EMS's do not assess the system for bias.
- This step identifies and addresses bias and subjectivity.
- This step accounts for stakeholder and regulator input.
- This step helps organizations identify "blind spots" in due diligence and liability.

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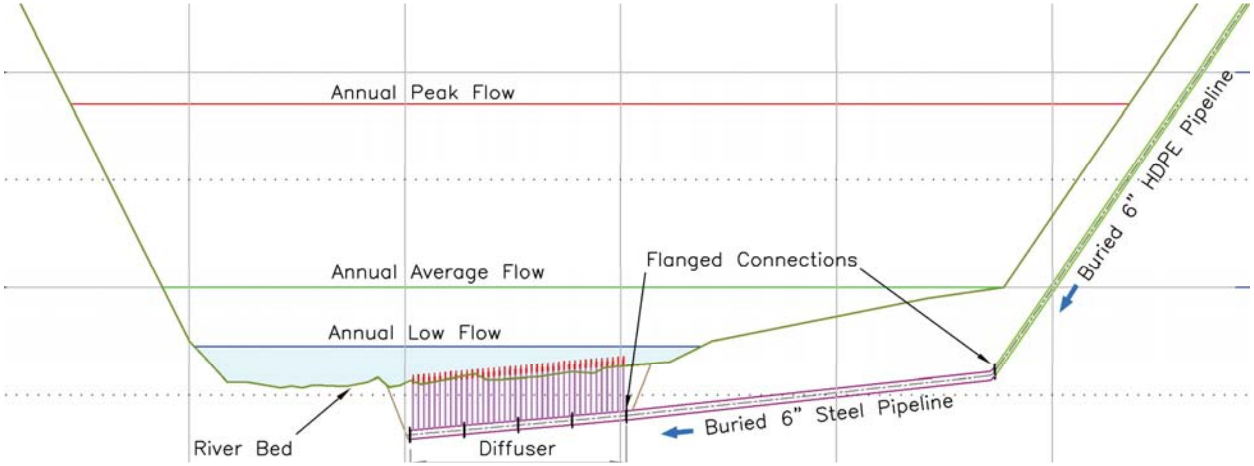
The Guidelines – Step Seven

Step Seven – Document Results

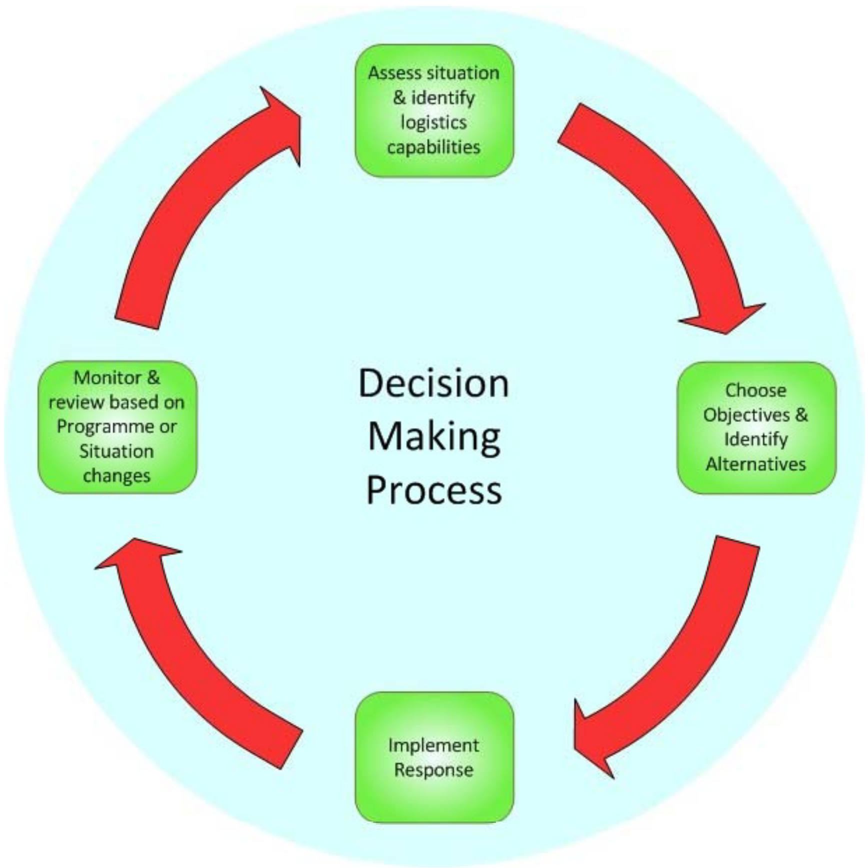
- Step 7 is the final step in the assessment and documents the results
- The selected option in this case was multi-port diffuser (Option B).
- The diffuser had the lowest overall relative risk score and had the least environmental and technical issues.



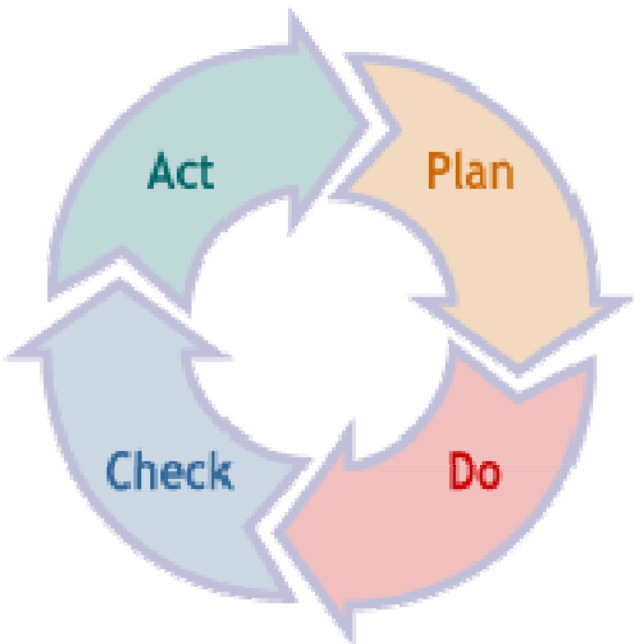
Diffuse Release to Riverbed

Conclusions

- The Alternatives Accounts Assessment is designed to identify the option that most favors project economics and socio-economics and least impacts the environment.
- It is a decision making tool that incorporates a quantitative characterization of a multitude of information (qualitative and quantitative)
- It contextualizes viable options while recognizing the views of stakeholders.
- It attempts to minimize subjectivity from the environmental decision making process or account for its inclusion.



Commentary



- The Alternatives Accounts Assessment is a decision-making tool that incorporates a multitude of information and stakeholder concerns
- It provides due diligence and minimizes liability through the documentation of the information obtained to justify the outcome.
- EMS development would benefit from this type of a rigorous decision making protocol.
- Incorporating sensitivity weighting and a sensitivity analysis into impact analysis would help focus the selection of continuous improvement objectives.

Thank you!

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