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Subject: **Posting DNR bond**

This report, revised following our discussion, addresses the cleanup costs of a spill that originates from barging operations associated with the Tulsequah Chief Mine and that affects US waters. The work was conducted as input to determining the amount of a bond to be posted with DNR relating to abandoning equipment in place along the water route.

Generally, the literature focuses on the cost of cleaning up **oil** spills. Costs vary considerably and are not linearly related to the size of the release due to response methods, oil type, season, location, receiving body, etc. Damage claims have been excluded from these calculations versus the costs of direct response activities since impacts depend on many different factors. The US Natural Resource Damage Assessment (NRDA) Process, for example, also referred to as the Damage Assessment, Remediation, and Restoration Program (DARRP) can take years for the National Atmospheric and Oceanic Administration (NOAA) to implement in following its three steps of (1) preliminary assessment, (2) injury assessment/restoration planning and (3) restoration implementation.

Salvage costs were not included in these determinations, as discussed. Legal questions also require consideration by trained people with experience in such matters, e.g., regulatory rules, compensatory versus punitive damages, etc. The US Oil Pollution Act of 1990 (OPA-90) more exactly defines limits of liability and refers to $600 per gross ton of a vessel or $500,000, whichever is greater, as the maximum amount re: the total liability of a responsible party for the size of vessel in question. Nevertheless, I have summarized the main factors and noted relevant data that should shed light on the request for spill cost information.

Sincerely,

Laurence B. Solsberg, P.Eng.

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Introduction

There is a risk of spills of various substances that will be shipped to the Tulsequah Chief Mine by air cushion barge (ACB) from Juneau to the barge landing site at the confluence of the Taku and Tulsequah rivers. The water route covers approximately 95 kilometres (59 miles) of which approximately 85 km (53 miles) is in US waters.

Diesel is transported in the greatest quantity and the cost to clean up a diesel spill was seen as a worst-case scenario. Spills of reagents were also briefly investigated but these are for the most part water-soluble and actual cleanup costs such as booming, skimming, recovery and disposal are likely to be limited and therefore much lower. This report summarizes possible cleanup costs for a "worst-case" spill scenario of 50,000 litres of diesel. It also points to the importance of preventative steps that will be taken such as contingency planning, training, and program management.

All reagents packaged in bags and "supersacs" will be transported in containers on the ACB. Lined drums, tanker trucks and other containers will be used in the transportation on the barge of other materials (see Background Information). This reduces the likelihood of a release along with any significant consequences including diesel, which will be carried in tank trucks. Segregation of the reagents will reduce the likelihood of chemical interactions, particularly with acids. The IMDG Code, which addresses these concerns, will be strictly followed. The principles of the International Cyanide Management Code will also be complied with in any operations involving sodium cyanide including transportation, handling and storage.

Diesel spills might in theory be cleaned up if only because diesel is an insoluble petroleum product that might leave some residue and, with due care and attention, a safe response can be mounted. Often, however, it quickly dissipates and its cleanup is also often limited in coastal and river environments. See also Spill Response below.

Spill Response

The factors that affect response and dissipate spills include (1) in river reaches, the water velocity, sediment load, water depth (1 to 4 1/4 m or 3 to 14 ft), and discharge (500 to 1000 m^3/s or 17,700 to 35,300 cfs) and, (2) in the marine corridor, water depth and flushing action of tides plus wind and wave energy. Salt water also has a buffering effect on many chemicals.

Effective containment and control of most of the reagents will often not be practical should a spill occur in open water conditions. Sediment load will mask the spill location in the river and dilution of the reagents, most of which are soluble, will occur as they are carried downstream.

Should an accident occur during winter, then it is very likely that concerns for environmental impacts reduce significantly. Should diesel be spilled, then in situ burning could be an option where an ice and snow cover exists and conditions, along with quick regulatory approval, allow this option to be implemented.

Spill prevention is the highest priority. During transfers, the ACB will be on shore, and it is unlikely that a mishap will occur that will result in a significant release to water. Historically, it is in the delivery (and especially during fuel transfer by pumping) that the majority of spill incidents occur involving vessels. Pre-booming at source may be difficult in river currents and can only likely address a release of diesel and not reagents. Response along the marine corridor will be similarly limited – which is where the DNR concern applies.

Cost of Spill Cleanup

Various sources were reviewed that address oil spill cleanup costs (see References). Costs to clean up chemical spills are not similarly reported. The work of Dagmar Schmidt Etkin of Environmental Research Consulting was used to estimate costs. Her research is used by the US Environmental Protection Agency in its Basic Oil Spill Cost Estimation Model (BOSCEM). The main factors are summarized below that are usually considered in estimating cleanup costs with additional comments added where appropriate.

Because many technical factors determine the actual costs of a spill incident, simple comparisons between different events based on a single parameter such as spill volume can be highly misleading. Note that an understanding of the relative importance of the various factors can also help focus the development of more practical spill contingency plans and, if ever needed, a cost-effective response. A short-coming of the costing methods is that they do not use estimates specific to the fate and behaviour of a spill but rather apply various modifiers to pre-determined base costs and therefore can err on the conservative side.

Method 1 (Etkin 2000)

Etkin integrated various cost factors into a single algorithm. This approach generates a conservative estimate for cleanup: manual methods were applied to a smaller (i.e., more expensive to clean up) release of diesel, based on highest (US) world-wide unit costs, affecting extensive, continuously sensitive shoreline in an area with high regional concerns.

$Cu_i = Cl_i\, t_i\, o_i\, m_i\, s_i$ *and* $Cl_i = r_i\, l_i\, Cn$ *and* $Ce_i = Cu_i\, A_i$ *where:*

Cu_i	=	response cost per unit for scenario, *i*
Cl_i	=	cost per unit spilled for scenario, *i*
Cn	=	general cost per unit spilled in US, *n*
Ce_i	=	estimated total response cost for scenario, *i*
t_i	=	oil type modifier factor for scenario, *i*
o_i	=	shoreline oiling modifier factor for scenario, *i*
m_i	=	cleanup methodology modifier factor for scenario, *i*
s_i	=	spill size modifier factor for scenario, *i*
r_i	=	regional location modifier factor for scenario, *i*
l_i	=	local location modifier for scenario, *i*
A_i	=	specified spill amount for scenario, *I*

Applying the Etkin formulae from her paper and values in 1999 US dollars:

Cn	=	$17.81/L (North America) $23.02 (US)
t_i	=	0.18 (diesel)
o_i	=	0.61 (20-90 km)
m_i	=	1.89 (manual)
s_i	=	0.65 (34-340 tonnes)
r_i	=	1.25 (regional concern)
l_i	=	1.48 (local concern)
A_i	=	50,000
Ce_i	=	estimated total response cost for scenario, *i*
Cu_i	=	response cost per unit for scenario, *i*

The total cleanup cost is estimated to be $287,227
(Corrected to 2008 $US by adding 25% @ an annual inflation rate of approximately 3%.)
Spill Response Cost ($2008) = $359,033

Method 2 (Etkin 2004)
EPA's Basic Oil Spill Cost Estimation Model (BOSCEM) developed by Etkin was also applied to estimate the cleanup costs of a diesel spill. A mechanical recovery efficiency of 50% was assumed to partially account for dissipation of the diesel. These costs include shoreline oil removal, mobilization, source control, mechanical removal, and protective booming and therefore actual costs of a spill might reduce significantly.

To calculate spill response cost, the base per-gallon response cost based on oil type/volume/response method and effectiveness (Table 1 in paper), was multiplied by the medium modifier (0.7 – moderate impact - in Table 4) and by the spill amount:

per-gallon response cost X *medium modifier* X *spill amount = total response cost*

The total cleanup cost for light fuels @ $41/gal x 0.7 x 13,209 = $379,098

NOTE: If in situ burning is used with 50% efficiency then this cost reduces to $166,433. Again, each of the above figures could be increased by 10% to account for inflation:

Spill Response Cost ($2008) = $417,008 $183,076 (burning option)

The response cost is somewhat higher than the calculations based on Etkin's 1999 data. It assumes more costly, intensive manual methods that are required in addition to mechanical operations and so a higher base number results. Still, the numbers are comparable.

Mitigating Factors
The two methods for estimating spill cleanup costs err on the conservative side. There are specific factors that might significantly reduce any costs that should be considered when determining a reasonable level at which the bond should be posted:

The costing models assume that diesel will strand on shoreline and require manual cleanup.

A spill of diesel or reagents that enters the Taku River or Inlet is likely to dissipate relatively quickly and there will be limited opportunities to apply manual or mechanical methods.

Cleanup costs for diesel will be far less than if the substance released were persistent, viscous and adhesive such as weathered crude oil or bunker. Residue that remains after oil strands may require a combination of natural and manual cleaning that might primarily involve removal especially by the former route, i.e., wave, current and tidal energy.

Should a spill occur during winter, containment and control of a spill might be more feasible. There is a possibility that diesel could be burned in situ.

A knowledgeable spill response management team that is quickly assembled to make decisions on appropriate actions to take could reduce costs significantly. A shoreline treatment specialist who can offer practical, expedient advice will further reduce costs.

Training in the proper storing, handling, and transfer of all substances and quick response to spills are key. These will be a part of contingency planning and the ongoing management of facilities and operations and will reduce the likelihood of a large release and cleanup.

These mitigating factors should reduce cleanup costs significantly. They are in no way meant to diminish the possible significance with which spills in the Taku River and area are viewed and the response that might be demanded by agencies and local communities.

Conclusions

Spill cleanup costs were computed in 2008 $US as input to estimating the amount of a bond to be posted for a release into US waters. If it is assumed 50,000 litres of diesel somehow escape from tanker trucks on a barge, then the direct cleanup costs were estimated to vary between **$359,033** and **$417,008**. Many factors point to the lower actual cost of a response including:

- Packaging and containerization result in a much smaller release than 50,000 litres
- Dissipation of a non-persistent oil such as diesel in the river or coastal waters
- Minimal on-water response operations
- Combination of natural cleaning action and reduced manual methods
- Overall reduced shoreline cleanup
- Possibility of release onto snow/ice and reduced impacts
- Possibility of using in-situ burning methods during winter

Further reductions to cleanup costs should also result from and point to the importance of:

- Comprehensive and practical contingency plans
- Proper packaging, securing and segregation of reagents on the ACB
- Practical training on accident prevention and spill response
- Ongoing management of facilities, operations and procedures
- Well trained spill management team familiar with Incident Command System
- Availability of knowledgeable shoreline advisor

This costing exercise points to an amount for the bond that should be considerably lower than that provided by the calculations for what is likely to transpire in the way of a spill and required cleanup. If 10,000 litres, for example, of diesel were released then costs would reduce by 1/5. A figure of $250,000 would therefore not be unreasonable to consider to address concerns for both cleanup and salvage costs.

Background Information

A discussion of the factors that affect spill cleanup costs follows that provides background information to the cost estimates. A brief review of reagents is also included.

Oil Type

Oil type is one of the most important factors governing cleanup costs. Generally, the more viscous and persistent the oil, the more difficult and costly the cleanup is. Spills of light refined products such as diesel often do not require extensive cleanup. In the Taku River and along the marine route, a diesel spill will likely largely dissipate. "Rapid evaporation" of "light end components" does NOT always occur along with total dispersion of diesel. Some very light residual oil could remain on shorelines and attempts to remove it, albeit limited, might have to be made as occurred during the sinking of BC Ferry's Queen of the North in March 2006. Still, this type of response is far less costly than one involving crude oil or Bunker C.

Amount Spilled, Spill Location, Rate of Spillage/Season

The amount of oil spilled is an important factor in determining overall response costs. A 1,000 tonne spill is likely to result in far wider contamination than a 1 tonne spill. However, spills that occur offshore and that do not contaminate coastline result in minimal cleanup. The cost of such responses would be limited to aerial monitoring of slick movement and dispersion. A spill in the Taku River would be closely monitored due to ecological and other sensitivities. This emphasizes the need to compare cleanup costs based on more than spill volume.

The rate of spillage can also be an important factor. For example, the cleanup operation required in response to a single large release of oil may be considerable but may be completed in a matter of weeks. However, the same quantity of oil lost over several months from a damaged vessel or container(s) close to the coast may require a prolonged cleanup.

The physical characteristics of the spill site (e.g., prevailing winds and weather, tidal range, currents, water depth, coastal topography) also have a bearing on response costs. The sensitivity of different shoreline types, the extent to which they self-clean, and the availability and cost of local labour and resources will influence the overall costs. A diesel spill in Taku Inlet is likely to dissipate> There will likely be limitations on containment and removal systems on open water due to winds, waves and currents..

The Taku River will be of high national/international importance for fishing, indigenous peoples, tourism, and conservation. Seasonal differences will also occur in the sensitivity of these resources to a spill. This in turn will determine the requirement for, and extent of, spill cleanup and its cost. The costs during winter and high wind/wave conditions could be lower.

Shoreline Cleanup

In many oil spills, the most expensive component of the response is the shoreline cleanup. This is generally the most labour-intensive and time-consuming part of the operation.

Shoreline response strategies are moving towards "natural cleansing" options in shoreline locations that are exposed to wave action. There is a greater awareness of the impacts of aggressive shoreline cleaning tactics such as hot-water washing and use of heavy machinery.

Shoreline cleanup operations that rely primarily on manual techniques are relatively expensive compared to the much lower costs of natural cleaning methods, which often require only careful monitoring. Often, local interests press for aggressive cleanup responses on oiled shorelines despite evidence that such operations can cause greater long-term damages.

Usually, a Shoreline Cleanup Assessment Technique is applied whereby shoreline is segmented, assessed for cleanup needs, and then treated. This is a possibility for reaches of the Taku River but it is unlikely that a lengthy cleanup will be involved for reagents or diesel.

Management of Response Operations

Inadequate planning often results in the mistakes of previous spills being repeated. The result is damage to the environment that could have been avoided and thus, excessive costs. The tendency to react to political, media and public perceptions and pressures, rather than basing decisions on technical realities, is a problem that can also escalate the cost of any incident beyond what would be considered "reasonable" under the international compensation conventions. Redcorp/Redfern requires a management team for spill response that is familiar with the Incident Command System and includes members who have sound local environmental, socio-economic and spill countermeasures knowledge to avoid this pitfall.

SeaPro

SEAPRO, an oil spill response co-operative in Juneau, responds to oil spills and not chemical releases (Dave Owings, 2008). Personnel costs exclusive of expenses would be approximately $10,000 per day with a management team and ten responders. It is difficult to estimate cleanup costs on this basis since it is very incident-specific.

Risk of Spills

The following substances will typically be shipped on the barge to the mine site:

Supplies	
Material	**Approximate Weight (tonnes)**
Diesel	47
Cement	34
Process Consumables	21
Misc. Equipment and Supplies	6
Food and Camp Supplies	5
Propane	2
Explosives	2
Process Plant Maintenance Supplies	1.5
Rock Bolts	0.5
Misc. Underground Supplies	0.2

Process Consumables	
Material	**Delivery Container**
Flocculant	25 kg bags
Copper Sulphate ($CuSO_4$)	1,000 kg supersacs
Zinc Sulphate ($ZnSO_4$)	1,000 kg supersacs
Sodium Sulphite ($Na2SO_3$)	1,000 kg supersacs
Methyl Isobutyl Carbinol	Tanker truck or 200 L drums
DF250 (frother)	Tanker truck
Potassium Amyl Xanthate	Pellets in 1,000 kg drum or 1-tonne tote bags
Sodium Cyanide (NaCN)	Briquettes in 100 kg drums or 1-tonne tote bags
Sodium Metabisulphite ($Na_2S_2O_5$)	Powder form in 1,000 kg fabric bags
Sodium Ethyl Xanthate	Pellet form in 1,000 kg drums
3418A	Liquid in drums
Sulphuric Acid (H_2SO_4)	Tanker truck
Dextrin	100 kg fabric bags or 25-kg bags
Ferric Sulphate ($Fe_2(SO_4)_3$)	Tanker truck
Lime	Unslaked powder form in 40-tonne trucks

Diesel
Clear, yellowish flammable liquid transported by tanker truck that floats on water, is insoluble, and has toxic effects on fish and vegetation. Booming, skimming, manual removal using sorbents and/or burning are sometimes possible but unlikely as on-water operations in the Taku River and nearby coastal environment. Shoreline, river bank cleanup may be needed.

Flocculant
Off-white, non-flammable powder that is soluble and forms a viscous solution in water. Packaged in bags. Toxic to fish and plants. Limited response.

Copper Sulphate ($CuSO_4$)
Bluish powder that is non-flammable and sinks and mixes incompletely in water. In supersacs. Toxic to fish and plants. Limited response.

Zinc Sulphate ($ZnSO_4$)
White crystalline pellets that sink and mix with water. Supersacs. Results in aquatic toxicity. Limited response.

Sodium Sulphite ($Na2SO_3$)
White, non-flammable powder that sinks in and partially mixes with water. Supersacs. Ecological effects not indicated but some impacts can be expected. Limited response.

Methyl Isobutyl Carbinol
Clear, colourless, flammable liquid with low water solubility (1.82 g/100 g at 20°C) that floats and has relatively low aquatic toxicity. Stored in tanker trucks and drums. Limited response since residue will be difficult to locate.

Dowfroth DF250 (frother)
Yellow-to-dark brown liquid (98% ether) that is flammable, floats and is partially soluble in water. Transported in tanker truck. It can cause impacts to aquatic and marine life. Limited response. Some shoreline removal using manual methods may be possible.

Potassium Amyl Xanthate
Combustible yellow pellets, somewhat soluble in water (16.9 g/100 g at 0°C), high pH, toxic to fish. Stored in drums or bags. Neutralization with sodium bicarbonate can be tried.

Sodium Cyanide (NaCN)
White crystalline briquettes that are non-flammable and sink and are soluble in water. Stored in drums or bags. Highly toxic to aquatic and marine life. Response hazardous, limited.

Sodium Metabisulphite ($Na_2S_2O_5$)
White to yellow-white crystalline granules that are non-flammable and are very soluble in water, forming an acidic solution and producing toxic sulphur dioxide gas. Stored in bags. Environmental toxicity is not reported but should be anticipated. Limited response.

Sodium Ethyl Xanthate
Pale yellow flammable pellets that sink in, mix and react with water to result in a low pH (acidic) mixture of various compounds that would have toxic impacts. Stored n drums. Limited response.

Aerophine 3418A
Yellowish, non-flammable liquid stored in drums that is slightly alkaline and sinks and mixes completely in water. It is not classified as dangerous to the environment. Limited response.

Sulphuric Acid (H_2SO_4)
Colourless-to-brown corrosive, non-flammable liquid that sinks, mixes, reacts with water. Highly toxic. Transported by tanker truck. Neutralization with sodium bicarbonate can be tried.
Dextrin

Non-flammable, stable white to off-white solid (starch or vegetable gum) stored in bags that sinks in water (is “soluble in hot water”) and presents minimal risk to the environment. Manual removal can be tried where this is feasible to consider.

Ferric Sulphate ($Fe_2(SO_4)_3$)
Greyish-white powder that sinks and is soluble in water and therefore likely has impacts to aquatic and marine life (no environmental toxicity data indicated). Transported by tanker truck. Limited response.

Lime
White-to-grey, non-flammable powder/granular corrosive solid transported by truck. Sinks and is soluble in water to form calcium hydroxide. High pH could result in significant impacts to aquatic, marine organisms. Neutralization with sodium bicarbonate can be tried.

A brief review of the substances that might be released serves to indicate relative concerns. Most of the reagents are water soluble, toxic, and will therefore present concerns and difficulties in cleanup if their packaging is compromised. However, any amount released is very likely to be minimal because of their packaging and placement in containers on the ACB. Sulphuric acid, DF250 frother and sodium cyanide warrant separate albeit brief review. Both the acid and frother are shipped in tanker truck and could cause impacts if a tank is somehow breached. Spill response might be limited unless there is a smaller, more continuous release and, in the case of the acid, a neutralizer can be added. Sodium cyanide is a high toxicity chemical that poses cleanup difficulties and high hazards to responders and the environment.

References

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Dave Owings 2008 General Manager SEAPRO, personal communication