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SUSTAINABLE MANAGEMENT

OF

CONTAMINATED SITES

-- CHANGING TO A HOLISTIC APPROACH --

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Executive Summary

For many years Canada's federal government and the province of British Columbia (BC) struggle with land remediation strategies, policies and regulations. Regulatory uncertainty and an elaborate and unpredictable regulatory process are considered key barriers for contaminated site redevelopment.

This document envisions a change of British Columbia's current contaminated sites regulations into a more holistic and sustainable approach and is based on the writer's experience in both the Netherlands and British Columbia. This unique experience made it clear that British Columbia's contaminated sites approach is technocratic and prescriptive in comparison to other Western jurisdictions leaving hardly any room for innovation and flexibility. British Columbia could benefit from a major change to a more sustainable approach which can be achieved by taking the following steps:

1. Think differently, act differently: from a technocratic to a holistic approach.
2. Change to pragmatic and holistic environmental policies and regulations.
3. Risk management instead of risk elimination.

As the contaminated land sector matures along with the technologies that make remediation possible and the debate about climate change and related sustainability issues continue during these tough economic times, the moment is here to start the journey towards a truly sustainable remediation industry. The real challenge is not green end-of-pipe solutions but making sustainability a key part of the decision-making process, creating a broader focus on risks posed by contamination and utilizing a wider variety of remediation technique selection, installation and operation.

The following steps are suggested for moving forward to a more sustainable contaminated sites regulation:

1. Learn from previous site assessments and risk assessments.
2. Have the dialogue with communities.
3. Broader focus on contamination – the sustainability debate.
4. Incorporate sustainability in the selection of site remediation strategy.
5. Focus on site remediation.
6. Allow redevelopment early in the remediation process.

This document may become a starting point for a lively debate on how to incorporate a holistic approach in contaminated sites management. It is the author's believe the change to a holistic approach will result in a significant increase in site remediation, redevelopment and economic growth for British Columbia.

List of Acronyms and Definitions

BC	The province of British Columbia, Canada.
Brownfield	Means real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant.
CSAP	Society of Contaminated Sites Approved Professionals of British Columbia.
CSR	British Columbia Contaminated Sites Regulation.
DSI	Detailed Site Investigation.
EMA	British Columbia Environmental Management Act.
EPH	Extractable Petroleum Hydrocarbons.
Greenfield	Means undeveloped land in a city or rural area either used for agriculture, landscape design, or left to evolve naturally. These areas of land are usually agricultural or amenity properties being considered for urban development.
MOE	British Columbia Ministry of Environment.
Pareto Principle	Means a theory that states for many phenomena 80% of the effects stem from 20% of the causes; also called 80-20 rule, Pareto's law.
PSI	Preliminary Site Investigation.
Triple Bottom Line	Means a method of evaluating corporate performance by measuring profits as well as environmental sustainability and social responsibility.
UST	Underground Storage Tank.
Wbb	Dutch Soil Protection Act (Wet Bodembescherming).

Biography

Richard Römer is a senior project manager and remediation specialist with over 18 years of experience in contaminated sites management. He has been involved in a wide variety of environmental projects. These projects have included complex in-situ remediation utilizing a wide range of techniques, feasibility studies, remediation plans, contaminated sites investigations, including numerous monitoring programs on industrial sites and landfills concerning natural attenuation.

He has worked with industries, cities and governmental organizations on challenging and complex problems in order to achieve a balanced approach to the management of contaminated sites. In feasibility studies he compared remedial options to social, economic and environmental aspects; a relative unique approach in BC but a widely accepted approach in The Netherlands. Richard Römer is a passionate advocate for a holistic approach to contaminated sites management, and presented his vision of incorporating social and economic aspects in the decision-making process at the First Annual Conference of the Science Advisory Board for Contaminated Sites in BC in September, 2011.

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SUSTAINABLE MANAGEMENT OF CONTAMINATED SITES

--- CHANGING TO A HOLISTIC APPROACH ---

1 Introduction

For many years I witnessed the struggle of both the federal government and the Province of British Columbia (BC) with land remediation strategies, policies and regulations. As many other jurisdictions, BC developed environmental policies for contamination to protect their citizens and the environment which in itself is a very admirable goal. These policies have led to greater awareness of the general public, businesses and industries in BC and numerous contaminated sites have been remediated and are no longer a threat to human health and the environment.

On the flipside many contaminated sites (brownfields) are still not remediated and are not redeveloped or are underutilized. Despite BC government incentives for the redevelopment of brownfield sites only a few brownfields have been remediated and these sites were mainly located in the bigger cities and/or at attractive locations (waterfront). Smaller communities in BC are confronted with fenced off contaminated sites which are not contributing to the local economy and reflecting poorly on their surroundings.

In general the remediation of these contaminated sites is not feasible due to an imbalance in financial, environmental and social factors (the triple-bottom-line), which leads to an unsustainable situation. Main contributors to this unsustainable situation are emotional motives, the technocratic focus and complexity of the BC environmental regulations, a missing long-term and encompassing vision (broader than the environment) in combination with an abundance of available pristine sites (greenfield sites) in BC.

Stakeholders have identified **three key barriers** to brownfield redevelopment[1]:

- **Financing** – remediation costs can exceed the expected finished value of a redeveloped site. Traditional lenders are reluctant to finance the remediation phase. Greenfield development is easier and cheaper.
- **Liability** – risk and perceived risk of environmental orders (regulatory certainty) and third party lawsuits (civil liability risks).
- **Regulatory Process** – margin of profit on a brownfield project is strongly impacted by delays (stakeholders find existing system too cumbersome).

In addition, in smaller communities **a lack of market drivers** for new development, including brownfield redevelopment, is considered a significant barrier.

[1] Presentation 'Remediate, Redevelop, Revitalize…' Canadian Delegation on Soil & Groundwater to the Netherlands by Marcia Wallace, Brownfields Coordinator, Ministry of Municipal Affairs and Housing, Government of Ontario, May 26, 2008.

In this time of limited economic growth today may be the right moment for offering the people of BC a more sustainable solution to contaminated sites remediation so that the environment, the economy and the public will benefit in the near future and BC stays ‘the best place on earth’.

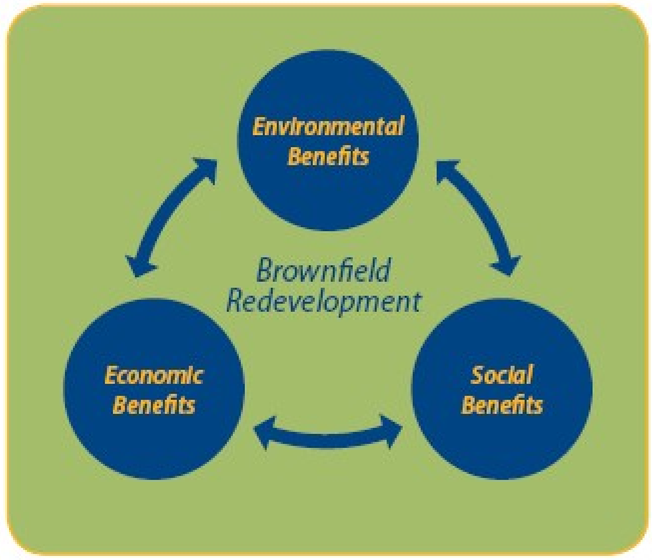

Figure 1: Brownfield Redevelopment Benefits[2]

This document envisions a change of current contaminated sites regulations into a more holistic and sustainable approach and is based on the writer’s experience in both the Netherlands (14 years) and British Columbia (8 years). This unique experience made it clear that BC’s contaminated sites approach is technocratic and prescriptive in comparison to other Western jurisdictions leaving hardly any room for innovation and flexibility. Surprisingly and despite the obvious slow pace of site remediation including the limited variety of utilized remediation techniques, major chances in the contaminated sites regulations have not been made; lessons learned from other jurisdictions seem to be overlooked. It is the writer’s opinion that BC could benefit from a major change to a more sustainable approach which can be achieved by taking the following steps:

4. Think differently, act differently: from a technocratic to a holistic approach.
5. Change to pragmatic and holistic environmental policies and regulations.
6. Risk management instead of risk elimination.

These steps are further described in the next sections.

[2] B.C. Brownfield Renewal Website – The Basics – What are the benefits?

2 Think Differently, Act Differently: From a Technocratic to a Holistic Approach

2.1 Mind Shift

Since the Contaminated Sites Regulation came into effect on April 1, 1997 we strive to remediate soil, groundwater, sediment and soil vapour to their applicable environmental standards. Although an abundance of knowledge is available throughout the world including the development of advanced remediation techniques, the main remediation technique used in BC is the complete removal of contamination by using excavation and haul ('dig and dump'). In many jurisdictions dig and dump is considered one of the most unsustainable solutions to a contaminated site, basically moving the pollution problem from one site to another, in the meantime using energy and taking up valuable landfill space. If complete removal is not a feasible option the solution is found in a total opposite direction: 'doing nothing' by using a risk assessment approach.

Unfortunately BC's technocratic and prescriptive regulations leave hardly any room for remediation options different from complete removal and doing nothing. This can be changed by developing policies and regulations using a more pragmatic and holistic approach clearing the path to more sustainable site remediation options. Furthermore, the idea of 'removing all contamination' has proven to be technically unachievable for many sites and on top of that so expensive that a polluter is not able or not willing to pay. The province of BC will likely go bankrupt if present contaminated sites are cleaned up according to current regulations within the lifespan of one generation; unfortunately this statement cannot be verified because there still is no information on the amount of contaminated sites in BC including associated remediation costs. A change in regulations will create technically achievable options and offer more affordable options.

In support of this regulatory change we also have to change our emotions concerning contamination. The primary goal of remediation should be to clean the subsurface in order to make a site suitable for its intended use. Partly because of our emotions ('the subsurface needs to be clean' and 'contamination makes you ill'), partly because of fear for claims ('the government will likely force us to completely remove contamination in the future') we strive to remediate a site to extensive measures creating the following vicious circle (a catch 22-situation):

- Emotional motives lead to unnecessary strict environmental remediation goals.
- These remediation goals generate costly remediation approaches.
- High remediation costs create significant financial risk for redevelopment.
- Due to high financial and psychological risks redevelopment is only justified using extensive remediation methods.

This circle cannot be broken by using technical knowledge and regulations alone. A mind shift of the general public, regulators and consultants is required to allow for more sustainable solutions to site remediation. For instance, for contaminated sites exposure a cancer risk level of 1-in-100,000 ($1*10^{-5}$) is generally recommended to assess and manage sites contaminated with carcinogenic substances[3]. It is

[3] Federal Contaminated Sites Risk Assessment in Canada. Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment – Appendix B.

recognized that this is a conservative (safety) margin which will have negligible impact on human health. To put this in perspective, for a citizen of BC the risk of a transport accident leading to death is $8*10^{-5}$ and the risk of an accidental injury leading to death is $22*10^{-5}$. In other words, the chance that somebody in BC dies of a transport or other accidental injury is 30 times higher than the chance of developing cancer by being exposed to contamination[4]. This becomes more relevant when a dig and dump site remediation requires a significant increase in truck movements.

The BC Ministry of Environment (MOE) undertook little to put this side of contamination risk into perspective. The MOE seems inwardly focused, dealing with formatting existing standards and administrative processes including the addition of several new regulations only increasing the general perception that contamination is 'bad' and should be removed at all costs. Examples of new and restrictive regulations are the regulation on soil vapour investigation and remediation and the implementation of drinking water use as generic use on contaminated sites including a new land use tier for high-residential areas.

A more lenient attitude of the MOE towards her own regulations will generate opportunities for the clean-up of many more sites in BC and a mind shift within the Ministry is likely of greater importance than a mind shift of the general public. The way of thinking should shift from a 'complete removal' approach to a risk management (holistic or sustainable) approach. This is not the risk-based approach the MOE is promoting at the moment; the suggested risk based approach involves a broad perspective which includes social and economic risks and benefits (triple bottom line) and which is not the current approach based on merely technical considerations and unilateral environmental aspects.

2.2 'The User Determines' instead of 'The Polluter Pays'

The principle of 'The Polluter Pays' contributes to our sense of justice but in reality this principle is difficult to achieve especially when 'older' contamination is present. Polluters are hard to trace or are not able to contribute to remediation costs. In practice 'The Polluter Pays' leads to stagnation in clean-up and subsequently the redevelopment of a site. In many cases, local authorities and/or a new site owner could benefit from swift redevelopment due to increased property taxes and more efficient site use leading to more profits.

In the Netherlands, a small country with a high population density[5] and consequently a high pressure on land use, this was addressed by separating 'historic' contamination from 'recent' contamination. The year the Soil Protection Act[6] (1987) came into effect was used as dividing line between historic and recent contamination. The remediation efforts of historic contamination depended on land use, contaminant volume and contaminant depth which significantly simplified and streamlined the process. The triple bottom line principle (three pillars of sustainability) was used to provide financially efficient and socially accepted remediation options that also benefited the environment and protected human health.

[4] Statistics Canada, Table CANSIM 102-0563 and 384-5000. Average of years 2007-2011.

[5] The land mass of the Netherlands is 33,700 km^2 (slightly larger than Vancouver Island) with an estimated population of 16.9 million (2015) which is half the population of Canada.

[6] Wet Bodembescherming (Wbb) – Dutch Soil Protection Act, 3 July 1986.

In this approach the site-user determines the land-use of a site, like for instance: residences with the possibility for vegetable gardens (more remediation effort) or high-rise building with underground parking lot (less remediation effort). These land use options are more comprehensive than BC's land use options. With this method a site user is more in control of the amount of remediation effort necessary in combination with the possible land use options and subsequently has better grip on the financial aspects of a redevelopment. The change to a more holistic approach has resulted in a significant increase in site remediation, redevelopment and economic growth now reaching the stage of complete remediation or contaminant management of all Dutch contaminated sites in 2020.

BC could use April 1, 1997, the year the Contaminated Sites Regulation[7] came into effect, as the dividing date between historic and recent contamination. A polluter could reasonable have known that causing pollution after this date was in violation with the regulations and demanding a complete removal of contamination seems appropriate. However, contamination caused before 1997 still has to be dealt with but can be managed in a more pragmatic and more sustainable approach. This approach will be further explained in the next section.

[7] Environmental Management Act – Contaminated Sites Regulation, B.C. Reg. 375/96, deposited December 16, 1996, effective April 1, 1997.

3 Pragmatic Approach to Contaminated Sites

3.1 Current Legislation

The current legislation to address contaminated sites can be compared with a qwerty (see text box). Once the regulations were an excellent solution to the then prevailing problems. Meanwhile, the approach does not comply with BC's current problems and needs. The current over-protocolled policies and regulations can be viewed in a similar light. The policy that was formulated in response to a few severe incidents (Love Canal in the USA, Sidney Tar Ponds in Nova Scotia, False Creek and Britannia Mine in BC) is still in place but is considered outdated and not catching up with current market developments and wishes.

QWERTY
In the time of old typewriters the order of the keyboard was deliberately chosen. It was aimed to build in an automatic slowness for the fast fingered typists so that type bars would not slam together and get damaged. This issue is resolved since the introduction of the PC but the slow qwerty-system remains.

The environmental policy is suffering from the cauliflower effect; the basis of the Environmental Management Act and the Contaminated Sites Regulation are solid: protection of human health and the environment (the stem of the cauliflower). Protocols, guidelines, technical and administrative procedures (the florets of the cauliflower) are created to support the implementation of the Regulation. Unfortunately, the florets prevent a plain sight of the stem i.e., over-protocolled regulation lead to losing sight of the encompassing goals.

Once it is decided to clean-up a site, the regulatory process is considered sluggish and unpredictable which is not contributing to public perception and trust and exposing site owners to financial risks and liabilities. Current legislation treats every contaminated site the same way leading to 'red tape' and contributing to the perception of 'using a shotgun to kill a fly'. Every project needs to be shoved through the same regulatory funnel and because of the different 'shapes' of the projects the funnel is getting clogged. To help shoving the projects through the funnel, the MOE created an additional funnel known as the Roster of Approved Professionals (CSAP) resulting in an even more standardized process. Instead, the MOE should have focused on creating a regulatory sieve to speed up the contaminated sites process.

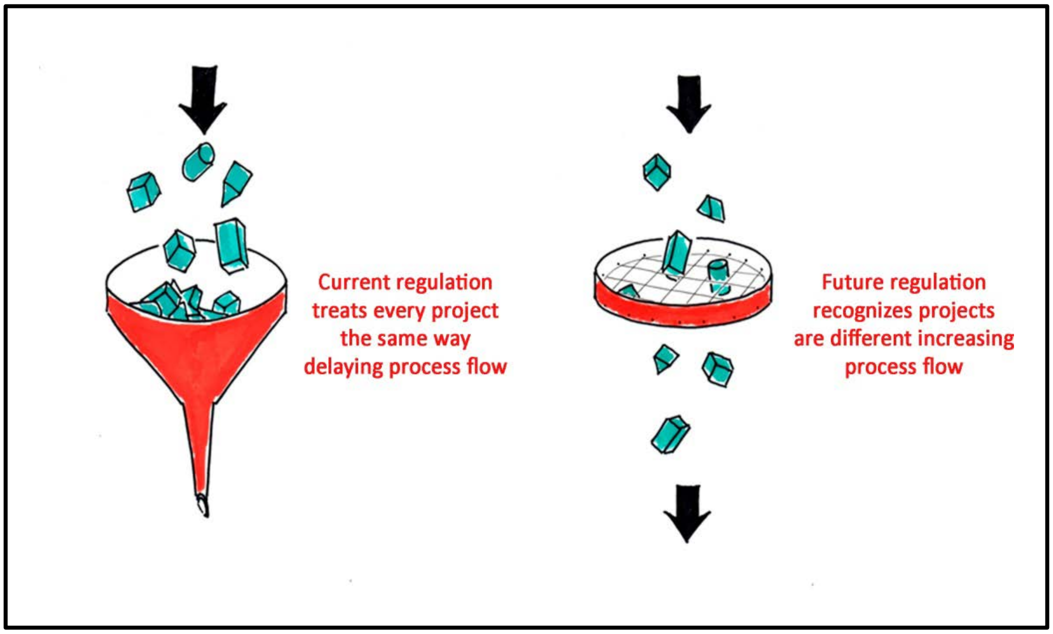

Figure 1: Current Environmental Regulation and Desirable Future Regulation

Current standards consist of many 'florets'. Soil standards are dependent on land use (Generic Numerical Soil Standards: e.g., residential use) and if part of the Matrix Numerical Soil Standards on other aspects like human health protection aspects (e.g., intake of contaminated soil), environmental protection aspects (e.g., toxicity to soil invertebrates and plants) and water use (e.g., aquatic life) to name a few. Livestock ingestion and groundwater flow to surface water used by freshwater or marine aquatic life is also included. For some contaminants the standard is dependent on the pH of the soil. In contrast, water standards are dependent on aquatic life use, irrigation use, livestock use and drinking water use. For some contaminants the standard is also dependent on pH, water hardness, salinity and type of crop. Altogether, the determination of specific soil and groundwater standards for a particular site is an onerous process not taking into account future redevelopment and remediation activities which may change the chosen assumptions for standard determination (e.g., change in pH, reduced groundwater flow) creating another layer of complexity.

Current regulations dictate contaminants need to be remediated independent of the depth of contamination. Furthermore, the (im)mobility and biodegradation of contaminants are not taken into account during the remediation process. Last but not least, it is not possible to redevelop a site with residual contamination without conducting a risk assessment. It is expected that for most contaminated sites (e.g., urban industrial and commercial areas) the risk assessment would be standardized by now but reality shows that assumptions and calculations have to be determined for every single site. Even more, as soon as circumstances change (additional development, change in land use) the risk assessment needs to be revised further increasing the redevelopers' sense of technical and financial uncertainty. Financial unpredictability is considered one of the main reasons 'dig and dump' is the preferred remediation option at this moment.

3.2 Site Assessment and Remediation Fundamentals

In order to change the current legislation into a pragmatic and therefore more sustainable legislation we have to understand a few contamination and remediation fundamentals:

- Immobile and mobile contaminants.
- Contamination depth.
- Source zone and plume.
- Cost of remediation.

This is not new; a risk assessment is based on the same fundamentals namely contaminant behaviour and contaminant transport in soil, groundwater and soil vapour.

Immobile contaminants have a tendency to significantly bind to soil particles (adsorption, precipitation) and therefore have a low solubility and volatility. Examples are: metals, polycyclic aromatic hydrocarbons (PAHs), the heavier compounds of mineral oil and pesticides. These contaminants are mainly present in the first metres of soil when contaminated fill material was used at a site or by commercial/industrial activities. Also, the associated risks for immobile contaminants are more prevalent in the first metres of soil. In general, a pronounced and distinct source area with high concentrations of immobile contaminants is most likely not present and contamination is distributed diffusely over a wider area.

Mobile contaminants are more soluble and/or volatile and are therefore moving more freely through the soil matrix. Examples are: aromatics, oil products and chlorinated hydrocarbons (e.g., tetrachloroethene also known as 'Perc'). In general, vertical transport is prevalent in the unsaturated zone (downward as product flow; upward as vapour) while horizontal transport is more prevalent in the saturated zone and following the groundwater flow direction. Mostly, mobile contaminants consist of a source area with high concentrations and/or free product (point source) and a plume with lower concentrations of contaminants dissolved in groundwater or soil vapour. The source area and especially the plume can penetrate in deeper soil layers and transport of contaminants through groundwater is the main pathway. Figure 2 shows a conceptual model of immobile and mobile contaminants.

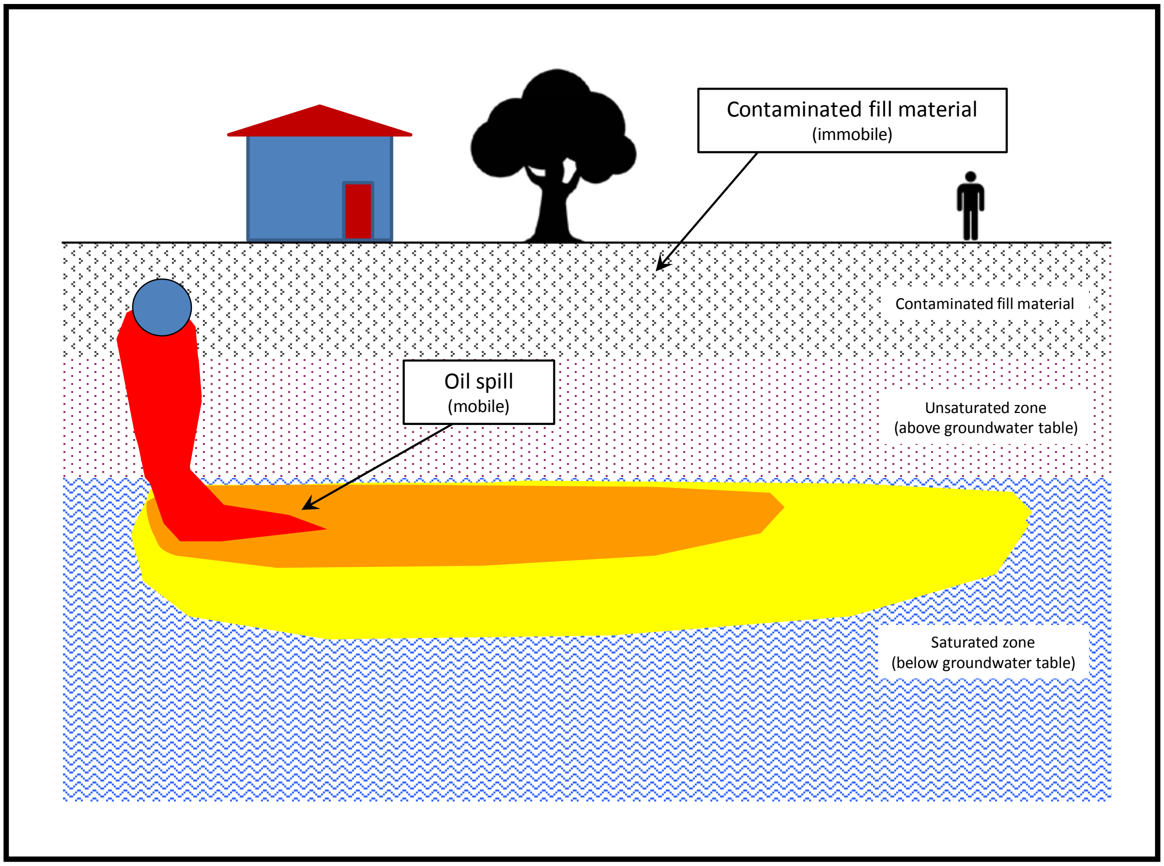

Figure 2 Conceptual Model of Immobile and Mobile Contaminants

The contamination depth is important for both human health and environmental risks. Humans can be exposed to contamination by direct contact but also indirectly through for instance the inhalation of contaminated vapours. This pathway is especially important when dealing with enclosed areas and areas underneath buildings (for instance, impacted air present in crawl spaces). In general, humans, plants, trees and soil invertebrates use the first 2 to 3 m of the subsurface for activities, like: building, underground utilities, rooting and feeding.

In contrast with most of the immobile contaminants the mobile contaminants have a distinctive source zone with high concentrations (red zone in Figure 2) and a plume with lower concentrations (orange and yellow zone in Figure 2). Directly after a spill the source zone will spread vertically through the unsaturated zone until it reaches groundwater. Contaminants will then dissolve and spread in the prevailing groundwater flow direction. Due to dilution, biodegradation and precipitation/adsorption (so called 'Natural Attenuation') concentrations in groundwater decrease at greater distance from the source zone. The plume will spread in the groundwater until a steady state is reached, i.e., an equilibrium between dissolved contaminants from the source zone and natural attenuation. This steady state can even be reached when a continuous spill is present (for instance, a leak in an underground storage tank). Suffice to say that when the source zone is removed, the plume will reach a steady state sooner and will likely become a retracting plume over time. As a result the contamination will still be present but will not spread through groundwater.

The distinction between source zone and plume has a significant effect on remediation costs. In many jurisdictions around the world it was found that remediation costs follow the Pareto principle, also known as the 80-20 rule. Approximately 20% of total remediation costs were used to remediate 80% of the contamination and hence 80% of the costs were used to remove the last 20% of contamination. In other words, the removal of the source zone can be achieved for approximately 20% of the costs but the removal of the plume requires an additional 80% of the total remediation costs. The Pareto principle is valid for both a remediation of a mobile contamination by excavation as well as by in-situ remediation. The graph in Figure 3 is an example of an in-situ remediation technique lasting 3 years.

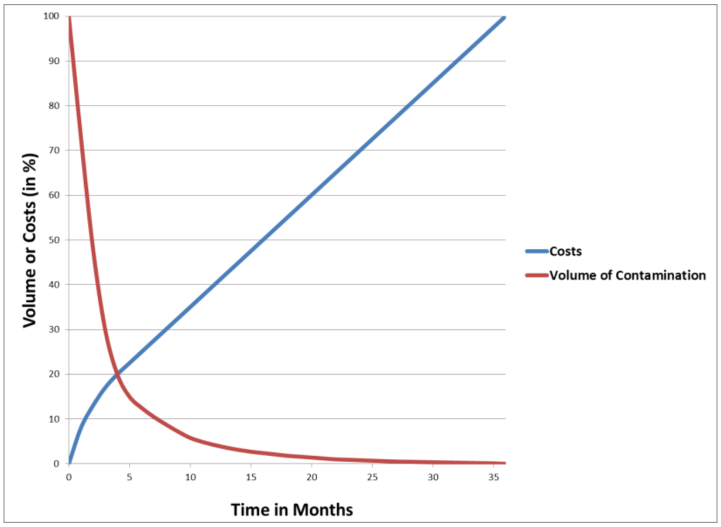

Figure 3: Costs versus Removal of Mobile Contaminants in Time

The 'biggest bang for your buck' is found by removing the volumes with the higher concentrations of contaminants; removal of soil and groundwater with lower concentrations will automatically lead to a decrease in cost-efficiency.

The removal of only the source zone and leaving the contaminant plume in place takes full advantage of the microbiological breakdown and natural attenuation potential of the subsurface. Natural processes are doing most of the work in reducing current concentrations to acceptable levels. Furthermore, the removal of only the source zone will stimulate the use of in-situ remediation techniques when CSR standards do not have to be met immediately. The use of biodegradation and in-situ remediation techniques will further improve the overall sustainability of the site remediation process.

3.3 Change in Approach

The challenge is finding a sustainable approach to contaminated sites, meaning the equilibrium between environmental, social and economic aspects (triple bottom line). The current regulation is focused on reducing concentrations of contaminants as fast as possible in order to allow the development or sale of the site because building permits for development, redevelopment and site upgrades are not issued before a satisfactory site remediation. Risk assessment is an alternative to active site remediation but is in most cases not successful without active remediation and is a costly, time consuming and uncertain process (especially when site conditions change in the future) which contributes to an increase in (perceived) environmental and financial liability. Furthermore, leaving contamination in place requires additional investigative work, to name a few: soil vapour investigations, hydrogeological studies and continuous soil and groundwater monitoring further reducing the economic feasibility of this approach.

Summarized, current legislation seems to focus on 'feeding the regulatory process' instead of 'cleaning up' a site, as long as the florets of the cauliflower are followed the site remediation can continue totally neglecting the social and economic impacts. One could even argue only part of the environmental aspects are considered without looking at the general environmental benefit. An example is the removal of an oil spill consisting of a couple of liters of hydrocarbons by methods of digging, transporting and dumping the contaminated soil at a landfill located kilometres away from the site burning thousands of litres of hydrocarbons in the process and moving the initial problem from one site to the other; in general not considered a sustainable approach but currently common practice and widely accepted in the work field. Figure 4 depicts the position of the current legislation in the sustainability triangle.

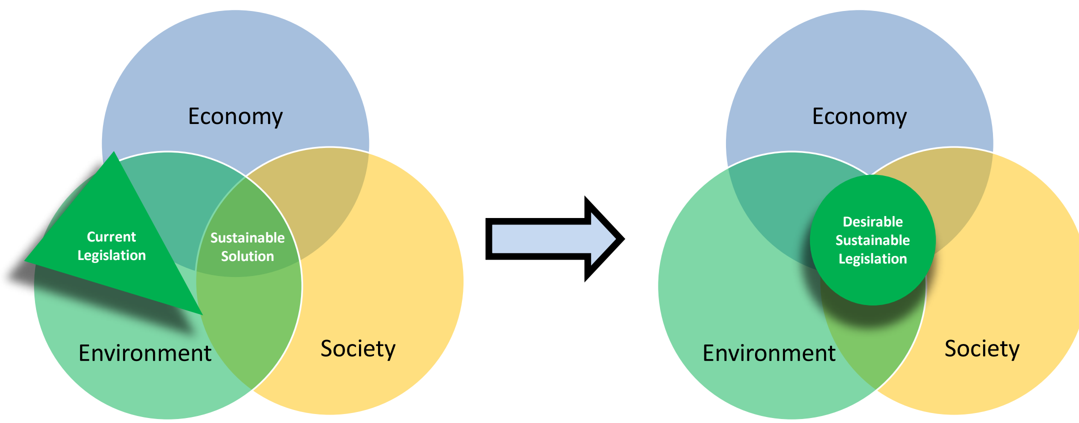

Figure 4: Position of Current and Desirable Legislation in Sustainability Triangle

The challenge is to move the current legislation to a more sustainable position within the triangle. This is further described in the next Section.

4 Risk Management instead of Risk Elimination

4.1 Introduction

Current legislation is focused on reducing contamination to concentrations below the applicable standards whatever the costs and consequences and within a limited amount of time, i.e. risk elimination. In many cases, a risk assessment as alternative solution is not working due to the presence of mobile and/or volatile contaminants which pose a potential threat of contaminant migration e.g., over the property boundary, into a sensitive ecosystem or showing up in buildings. As a consequence, several lines of evidence are necessary and in many cases repeated sampling and monitoring rounds to ensure the risk assessment assumptions are still valid further extending the starting point of site remediation and development. Furthermore, current risk assessment methods will not dictate site remediation goals in order to make a risk assessment approach successful. When land use changes a new risk assessment is required to confirm no risks exist for the intended land use. All in all, an onerous and expensive process with unpredictable outcome which further increases financial liabilities without a clear environmental and social gain.

Looking at the limited amount of successfully remediated sites and the characteristics of completed remediated sites (i.e., highly desirable locations in urban areas) it should be concluded that the regulatory quest for risk elimination has failed the sustainability test. One may even argue this approach was bound to fail from the start due to the limited amount of data gathered during site assessments and pertaining soil and contaminant heterogeneity and consequent heterogeneity in sampling collection, transport and analyses making several lines of evidence and/or multiple sampling rounds necessary further increasing costs. Heterogeneity is another nail in the coffin for risk elimination by using technocratic solutions and further decreases the success rate of this approach.

Evidently, we have to look for a more sustainable approach which accepts a level of uncertainty and acknowledges a broader environmental spectrum including the importance of economic and social aspects throughout the site remediation decision-making process. It is my belief that this can be achieved by incorporating lessons learned from both site investigations and risk assessments and changing the regulatory focus on the clean-up of a site instead of 'feeding the regulatory processes'. In other words, to work towards a solution instead of over-defining the problem. The key to a more sustainable approach is incorporating the following factors into the regulations:

- Type of contamination
- Depth of contamination
- Mass of contamination
- Time

These factors will give the maximum flexibility in remediation approaches and may include the use of a wide variety of in-situ remediation techniques including the utilization of the natural capability and resilience (natural attenuation) of the subsurface. This concept is further explained in the following Sections.

4.2 Site Assessments

Regardless of the regulatory process the current phases of site assessments will be required; a Stage 1 Preliminary Site Investigation (PSI), a Stage 2 PSI followed by a Detailed Site Investigation (DSI) to delineate the present contaminants in horizontal and vertical direction. The delineation of contaminants as depicted in the conceptual model (Figure 2, Section 2.2) using Stage 2 PSI and DSI strategies may look like the drilling program as shown in Figure 5 which include boreholes and groundwater monitoring wells. Note that soil vapour wells are not included in the site assessment; this will be explained in Paragraph 4.3.4.

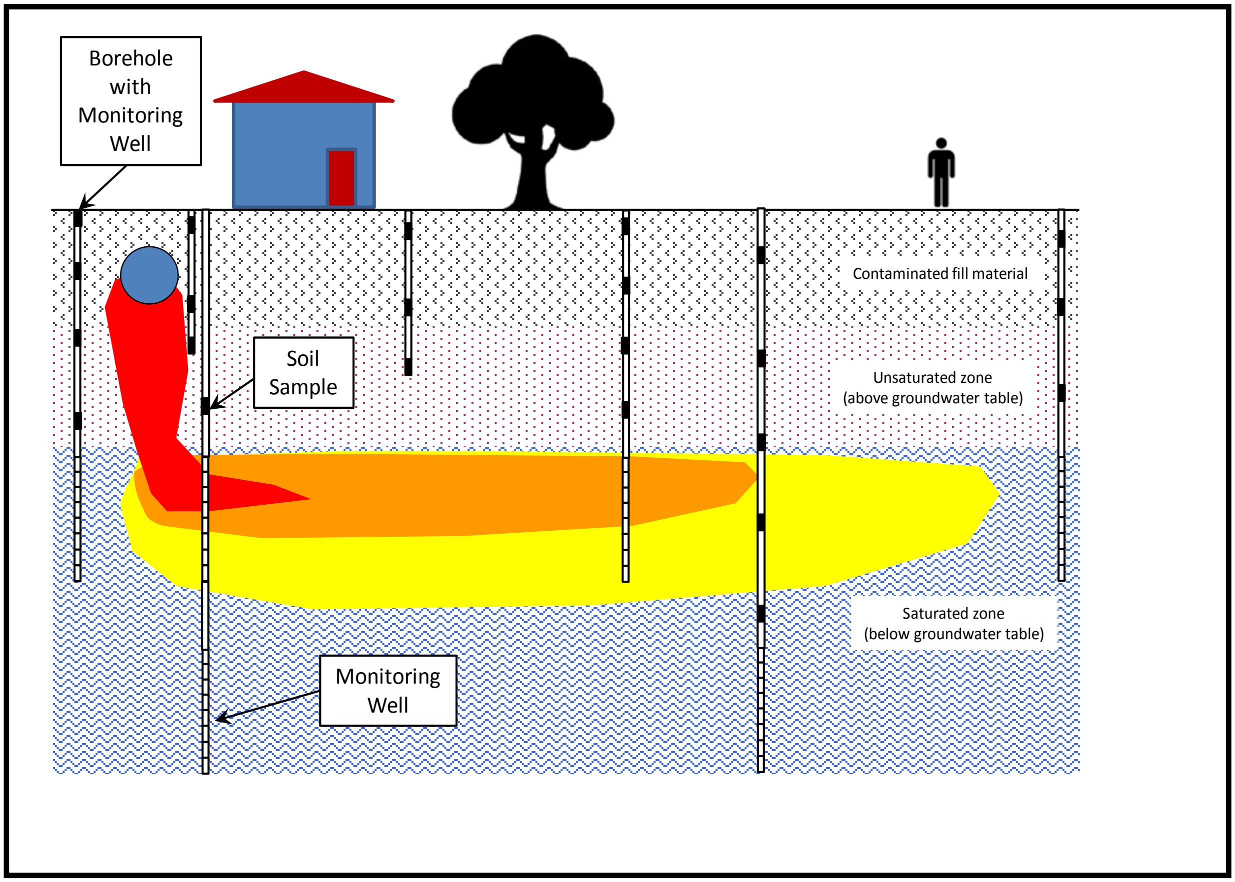

Figure 5: Conceptual Model of Immobile and Mobile Contaminants: Site Investigation Stage and Delineation of Contaminants in Soil and Groundwater

The site assessment indicated a contamination with immobile contaminants in the first metres of soil and a mobile contamination in soil and groundwater caused by a leak in an underground storage tank (UST). The soil contamination was limited to the direct surroundings of the tank; unfortunately part of the oil reached the groundwater table which created a contaminant plume (orange and yellow area). The deeper groundwater layers were not impacted with EPH. The groundwater plume is moving with the prevalent groundwater flow (from left to right) due to the continuous leaching from the concurrent soil contamination. Volatile compounds were detected in the EPH contamination.

4.3 Holistic Approach Think Tank

The holistic approach combines a removal option with a risk assessment option by taking the Pareto-principle (80 – 20 rule) and broader environmental, social and economic aspects into account including the type, depth and volume of the contamination and introducing the factor time to site remediation. This option focuses on site remediation instead of site assessment. The holistic approach is only achievable when changes have been made to the current regulations. Now let's assume a Holistic Approach Think Tank was assigned by the MOE which gathered the in BC available site investigations, site remediation reports and risk assessments, discussed the sustainability of the approaches and developed recommendations for a more holistic approach. The following sections describe the likely outcomes of this imaginative Think Tank in an attempt to convert the regulatory funnel into a sieve. These outcomes are already incorporated in legislation around the world and are derived from the writer's experience.

4.3.1 Holistic Approach Immobile Contaminants

Site investigations showed that in many cases immobile contaminants consist of elevated concentrations in soil but not in groundwater. In these cases, the first couple of metres of soil are most important for human health, invertebrates and plants as indicated by many conducted risk assessments. Therefore, a site remediation will be most effective in the top layer, the elevated soil concentrations in deeper layers are inconsequential because groundwater is not affected and therefore soil in deeper soil layers can be left in place. Site remediation is further standardized by the introduction of guidelines for redevelopment; dependent on site use soil needs to be removed to prescribed depths. The example for residential areas is presented in Figure 6.

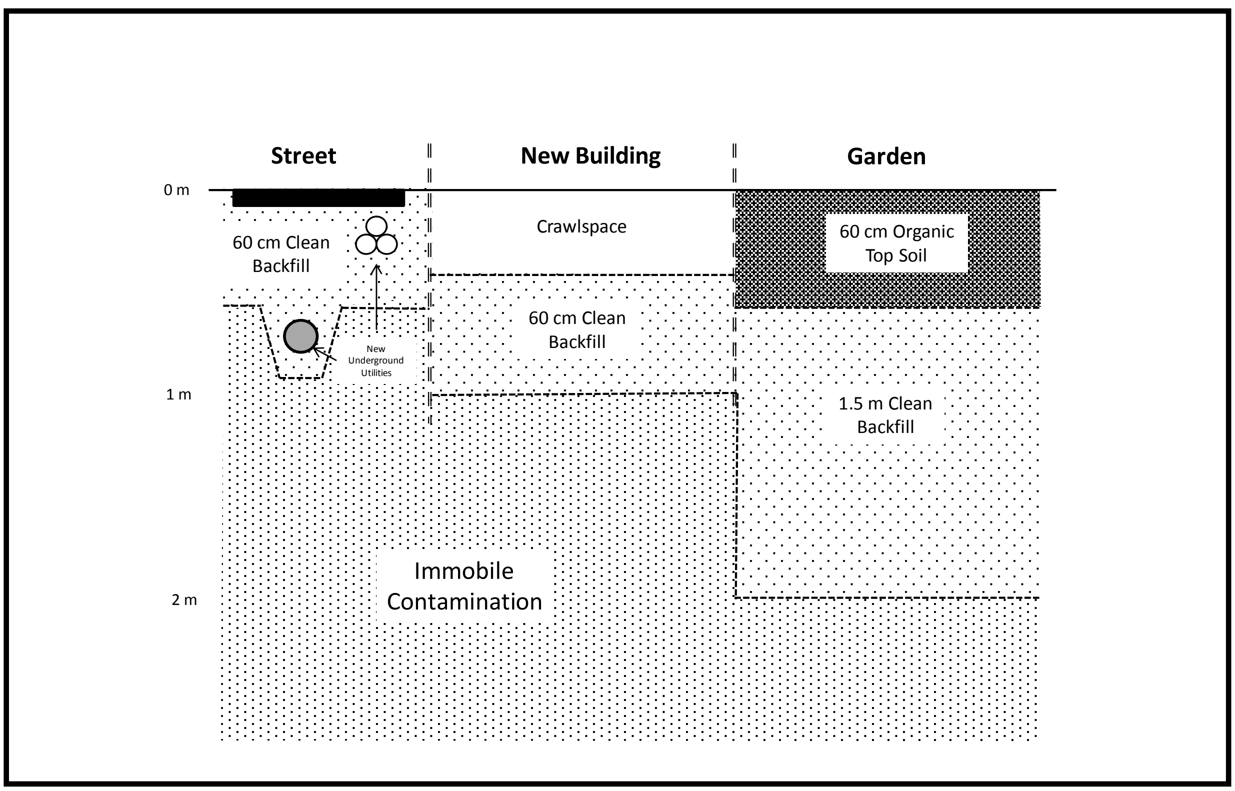

Figure 6: Example of Standardized Site Remediation for Immobile Contamination and Residential Land Use

This standardized approach clearly demonstrates to the redeveloper what effort of soil removal is required for a specific land use also increasing flexibility in the chosen redevelopment options. No additional risk assessment will be necessary for the residual immobile contamination further reducing assessment costs.

4.3.2 Holistic Approach Mobile Contaminants

It was found the removal of a mobile contaminant source zone led to a stabilized plume and in time a diminishing plume. A groundwater monitoring program was deemed sufficient to keep track of the plume and stability could likely be demonstrated in 5 to 10 years of monitoring. In the meantime a fallback scenario was planned in case the plume would expand over earlier defined boundaries. This remediation effort was sufficient to allow for a building permit. Further site investigations of impermeability of deeper soil layers were deemed unwarranted because groundwater monitoring indicated a stable or diminishing plume.

4.3.3 Holistic Approach Residual Contamination

The presence of immobile residual contamination in deeper layers was deemed inconsequential if the subsurface was removed to land use guidelines (see example in Figure 6) and no contamination was found in groundwater. The presence of mobile residual contamination was deemed inconsequential if the source zone was removed and groundwater monitoring indicated the residual plume was stable or diminishing. In both cases redevelopment was allowed without the need for a risk assessment and consequently a building permit could be issued.

4.3.4 Holistic Approach Soil Vapour

Due to the extensive amount of data gathered in soil vapour investigations around BC the Think Tank determined such investigations are only required after determination of high concentrations of volatile contaminants in soil and groundwater instead of detectable concentrations. Applying the described holistic approach source zones of mobile contamination were removed including the volatile (mobile) compounds making soil vapour investigation redundant.

4.4 Example of Holistic Approach

A site remediation is described using the conceptual model depicted in Figure 5 as an example. The goal of the site remediation is to manage risks and liabilities by a partial removal of both immobile and mobile contamination and taking advantage of natural processes for remediation of residual contamination. The immobile contamination is removed dependent on future land use; in this case residential use (Figure 7A). The source zone of the mobile contamination is treated with an in-situ remediation technique (for instance, biostimulation including air sparging) to levels higher than the applicable standards but strongly reduced the contamination mass (Figure 7B). The plume is monitored (Figure 7C) and a stable plume or retracting plume is expected within 5 years after remediation of the source zone. Natural attenuation is expected to reduce groundwater concentrations below the applicable standards in 5 – 10 years (Figure 7D). Redevelopment permits are granted after remediation of the top layer and source zone. A continuous monitoring program is in place for a 10 year period. After redevelopment the installation of underground utilities is only permitted under guidance of an environmental consultant as described in an Operations and Maintenance Plan.

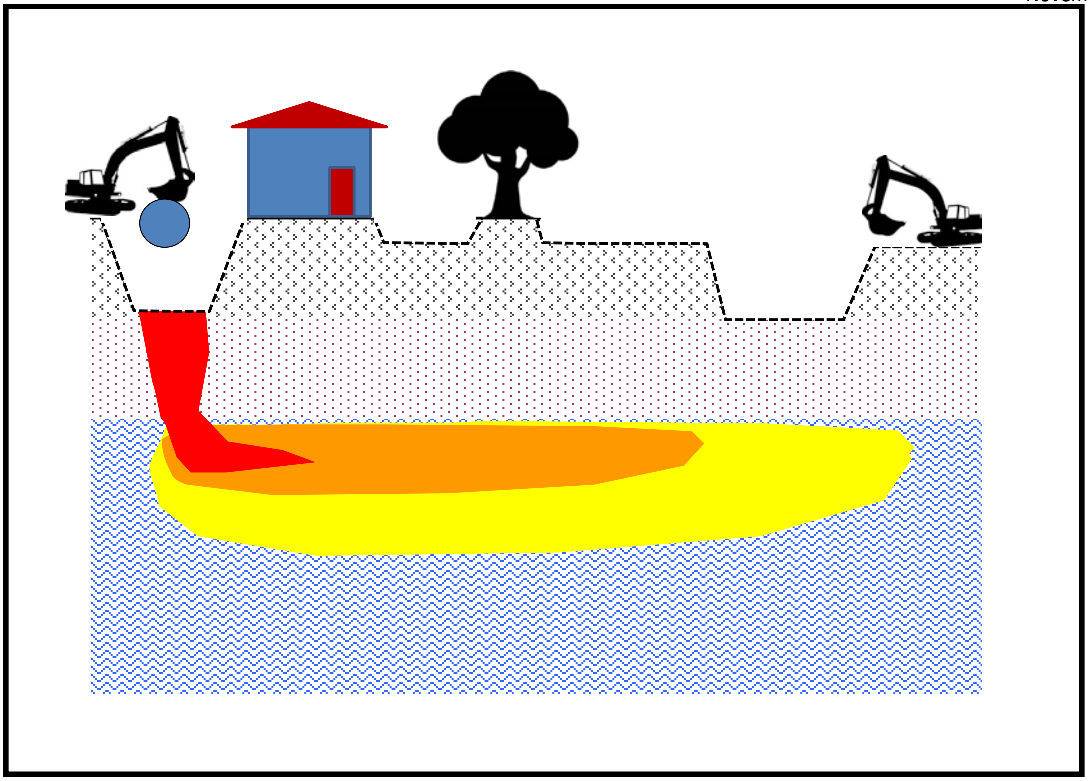

Figure 7A: Holistic Approach: Removal of Underground Utilities and Soil Dependent on Land Use

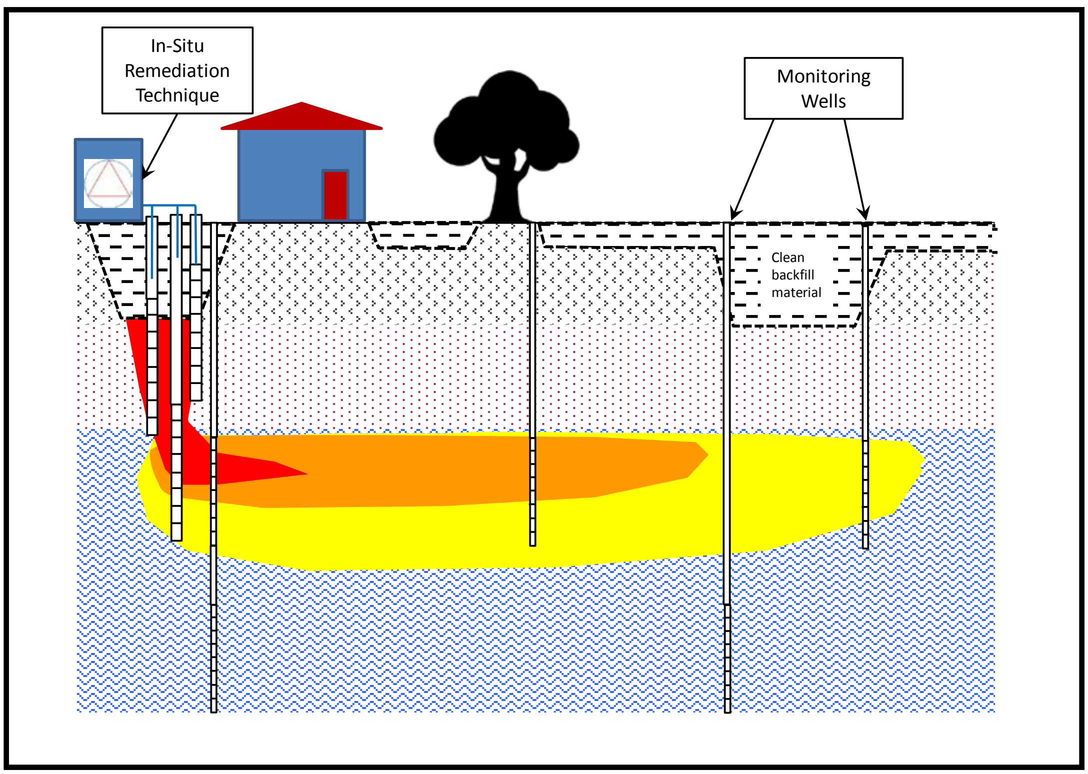

Figure 8B: Holistic Approach: In-Situ Remediation Technique for Removal Source Zone and Groundwater Monitoring Program

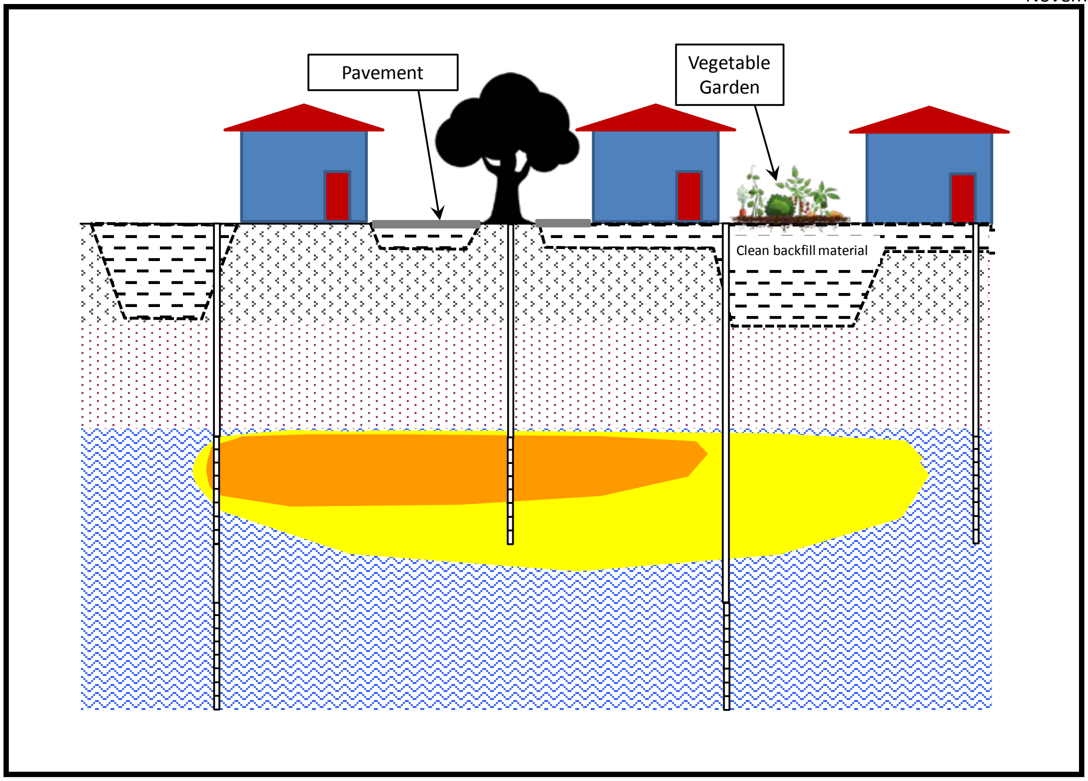

Figure 8C: Holistic Approach: Redevelopment and Monitored Natural Attenuation of Residual Contamination

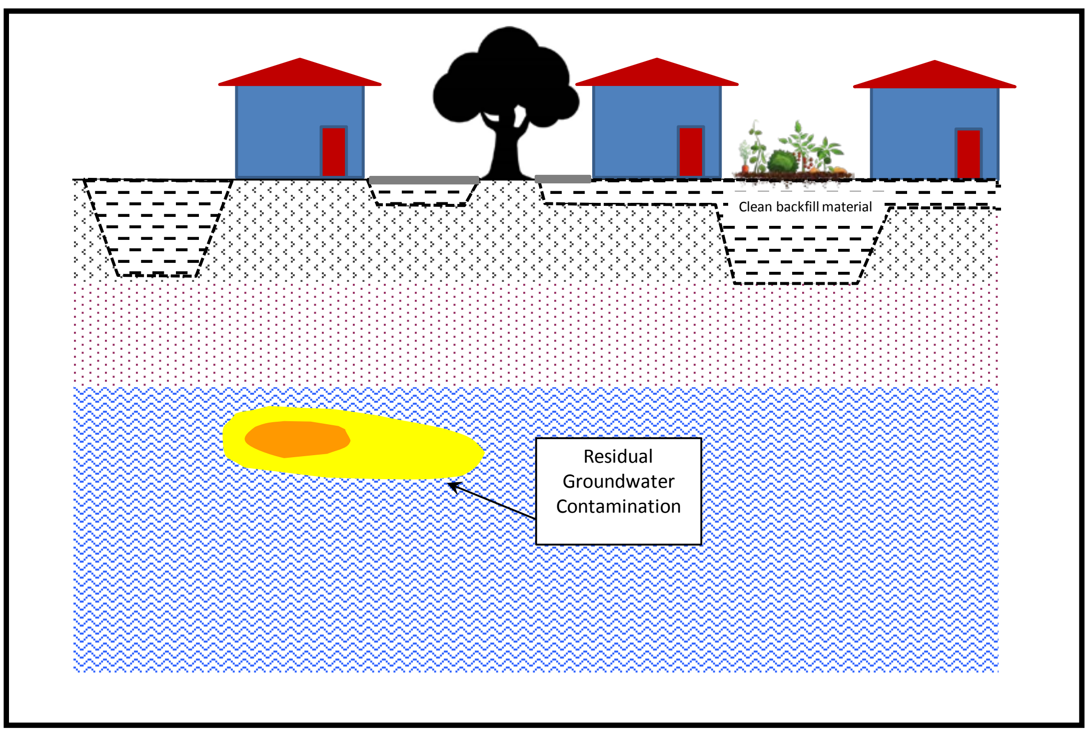

Figure 8D: Holistic Approach: End Stage Site Remediation after 5 – 10 Years

4.5 Triple Bottom Line Holistic Approach Example

Environmental

In comparison to a complete removal approach the environmental advantages of the holistic approach are the partial removal of soil and groundwater. Partial removal further reduces the environmental impacts on soil and air, reducing waste streams, reducing the pressure on landfill space and decreasing the use of energy (carbon footprint). Furthermore, it will allow for the use of a wider variety in-situ remediation techniques and will take full advantage of biological processes which are already naturally occurring in the subsurface.

Disadvantage is the presence of groundwater contamination for a longer period of time although groundwater concentrations are already strongly reduced after the first stage of site remediation.

Social Aspects

Social advantages of the holistic approach are the reduced amount of material transported therefore reducing the effect on human health and safety; less excavator and truck movements decreases the potential for accidents and transport emissions. The building including significant vegetation could stay in place.

Disadvantages are part of the contamination will stay in place creating a level of uncertainty and liability for the public. Compliance with regulatory objectives will take a longer period of time. Neighbours may be uncomfortable with the presence of residual contamination. These disadvantages are the same for a risk assessment approach.

Economic Aspects

Economic advantages of the holistic approach are the lower cost for site remediation due to reduced excavation volumes, focus on source zone removal and streamlined and lenient regulations making a redevelopment financially feasible. Development can take place immediately after soil removal creating financial flexibility for the redeveloper. Upfront costs like additional site investigations and risk assessments are redundant due to the streamlined regulatory process recommended by the Think Tank and focus on site remediation further reducing costs and time.

Economic disadvantages are the long-term costs for monitoring including long-term financial project risks although these risks will likely be much lower than in the case of a risk assessment.

4.6 Remediation Options Comparison

In many jurisdictions a remediation options comparison is completed to demonstrate the validity of a holistic approach. As a minimum the complete removal option is compared to a holistic approach but other options can be included, like a risk assessment approach. The options are then compared to several environmental, social and economic aspects. Examples of aspects are:

Environmental Aspects:

- Removed contaminant mass (volume * concentration)
- Human health and Environmental risk reduction
- Environmental impacts on surrounding: emissions to air and water, amount of solid waste.
- Use of energy and resources (carbon footprint)

Social Aspects:

- Decrease in responsibilities: reducing the chance for third party claims after remediation
- Community satisfaction: impact on the site and direct surroundings
- Impact of site remediation on human health and public safety
- Risk of failure

Economic Aspects:

- Remediation costs
- Duration including continuous monitoring
- Increased land use opportunities

The remediation options can be compared in a qualitative, quantitative or semi-quantitative way. For instance, aspects are scored using a plus, zero or minus in the qualitative comparison. The overall score is the sum of the individual scores per aspect. Besides the abovementioned aspects and dependent on the site, specific aspects can be added for comparison like for instance: the reduction of cultural, historic, archeologic or geologic values, damage during remediation, nuisance (e.g. dust, noise), increased reputation (social license) or increased land value. Furthermore, more weight can be allocated to specific aspects, for instance site remediation costs or risk reduction. A next step could be to quantify certain aspects (semi-quantitative comparison) or all aspects (quantitative comparison).

A remediation options comparison can be helpful in choosing the optimal remediation approach and some capacity is given in the BC EMA. Section 56 of the policy states that '*a person conducting or otherwise providing for remediation of a site must give preference to remediation alternatives that provide permanent solutions to the maximum extent practicable, taking into account the following factors:*

a) *any potential for adverse effects on human health or for pollution of the environment;*
b) *the technical feasibility and risks associated with alternative remediation options;*
c) *remediation costs associated with alternative remediation options and the potential economic benefits, costs and effects of the remediation options;*
d) *other prescribed factors*.'[8]

Hence, the BC EMA already allows room for incorporation both cost-effective and sustainability factors into the selection of remediation options. Unfortunately, regulatory support and guidelines are not provided by the MOE and this method has hardly ever been used.

[8] BC Environmental Management Act [SBC 2003] CHAPTER 53, assented to October 23, 2003 – Section 56 – Current to February 24, 2016

5 Moving Forward

As the contaminated land sector matures along with the technologies that make remediation possible and the debate about climate change and related sustainability issues continue during these tough economic times, the moment is here to start the journey towards a truly sustainable remediation industry. The real challenge is not green end-of-pipe solutions but making sustainability a key part of the decision-making process, creating a broader focus on risks posed by contamination and utilizing a wider variety of remediation technique selection, installation and operation.

The following steps are suggested for moving forward to a more sustainable contaminated sites regulation.

1. **Learn from previous site assessments and risk assessments**

Unfortunately the amount of contaminated sites in BC is unknown and consequently the overall site remediation costs are unknown. It is the writer's strong belief that BC will easily go bankrupt if the province decides to clean-up all contaminated sites within the timespan of one generation further underlining that the technocratic (cauliflower) regulations are unsustainable from an economic perspective alone. Much could be learned from a BC wide assessment of contaminated sites including location, type (mobile or immobile) and extent (mass, volume and depth) of contaminants. Although it will help the MOE tremendously in determining a long-term strategy for site remediation this BC wide assessment has never been completed further cloaking the need for a more pragmatic and holistic approach.

The writer predicts that 80% of the sites in BC will consist of immobile and mobile contamination more or less in conformity with the site conceptual model as shown in Figure 2 and likely located within city boundaries. A standardized risk assessment specifically developed for these sites could accelerate and streamline the remediation process. The MOE introduced a Screening Level Risk Assessment (SLRA) in the past but failed to address general contaminated site characteristics and therefore SLRA's are currently hardly used.

Rethinking the parameters of risk assessment may not lead to a pivotal change as some might think. A significant impacted site will still need considerable remediation efforts. The difference will be seen when developments are being considered and the scale of remediation being required is proved to be disproportionate. Then a scenario can be created where we can get a better bang for our remediation dollar and have more chance of bringing sites back into beneficial reuse, while still dealing with those risks that absolutely need to be dealt with.

This document provides handles for rethinking risk assessment with a focus on contaminant type, depth and volume and incorporating the factor time to site remediation. In other jurisdictions risk assessments are streamlined and can be accomplished by importing parameters in an easy to use computer program; only for complex sites (e.g., the last 10 – 20 %) a detailed risk assessment is required to determine risks associated with contamination.

2. Have the dialogue with communities

Smaller communities in BC struggle with the redevelopment of contaminated sites. Many contaminated sites are undeveloped which create a public eyesore and a reduction in tax revenues. Having the conversation with smaller communities (read: smaller then Vancouver or Victoria) will help in understanding the financial and social burdens these communities face on a daily basis. The financial impact of abandoned or underutilized contaminated sites on communities' tax revenue over many years could make an early site remediation financially feasible when using a holistic approach.

3. Broader focus on contamination – the sustainability debate

BC's contaminated sites regime is a flawed beast, as anyone in the industry would admit, including those who administer it. However, it does do what it says on the tin, addressing contamination of sites and requiring that they are cleaned up to safe levels. As explained in this document the current regulations require a disproportionate, in some ways even singular, focus on the risks posed by the contamination in the subsurface rather than the more holistic risks created by some of the other issues like dig and dump. Human health risk assessment is inherently conservative with a focus on risks from contamination ignoring other human health risks.

Disagreement of how we conduct risk assessment have been plentiful and arguments have always been about what level we set as an unacceptable risk to human health and the environment and not whether the level of contamination present should be the factor of most importance in the first place. Many industrial and commercial companies including municipalities do not want to stick their head above the parapet and ask whether we should have that debate but in terms of both sustainability and the current context of tough economic times this may be the time.

BC policy-makers will have to face up to making some hard choices and perhaps accepting slightly lower levels of perceived protection to the public. However, they can then make a judgement on whether for instance using an in-situ technique instead of dig and dump will reduce the overall level of exposure. By starting the sustainability discussion BC may create a platform for meaningful debate. This debate should not collapse into hysteria, being: 'we could not possibly relax the quantitative risk assessment criteria because that is putting our children at risk', instead it should be about the whole range of risks associated with a contaminated site that we should look at and then make sure we make a balanced assessment.

As suggested in this document the implementation of a Contaminated Sites Holistic Approach Think Tank comprised of a wide variety of experts will be a great first step in starting this discussion.

4. Incorporate sustainability in selection of site remediation strategy

The introduction of remedial options comparison is a helpful and in some cases an essential tool in guiding the abovementioned sustainability debate and is underutilized in BC. Many jurisdictions recognized the usefulness of remediation options comparisons for the selection of the most sustainable remediation approach. Some jurisdictions made these evaluations mandatory for site remediation completed by province or municipality to ensure the most balanced approach was implemented for the general public. It is the writer's opinion that BC could benefit from the introduction of remediation options comparisons in current legislation and in many cases the holistic approach will appear to be the most favourable, sustainable and cost-effective option.

5. Focus on site remediation

The current focus of BC's regulation is on assessing a site instead of cleaning up a site, i.e. describing the problem instead of solving the problem. Examples are the emphasis in the investigative stage on soil vapour investigations, risk assessments, aquifer transmissivity and protection of aquifers for potential drinking water use. Most of these potential risks will likely be resolved after completion of a site remediation making a large part of the investigative effort redundant and a financial burden. A critical look at the necessity of gathering exhaustive information prior to site remediation is therefore valid.

Time and finances are wasted by implementing 'The Polluter Pays' principle on sites with 'older contamination'. More flexible approaches to historic contamination (contamination before a set date, e.g., April 1, 1997) will stimulate the use of more sustainable remediation strategies, like in-situ remediation techniques and natural attenuation and will reduce the redevelopment time.

6. Allow redevelopment early in the remediation process

Redevelopment of a contaminated site can be achieved using a streamlined approach for the top layer of soil and a focus on source removal and plume stability in the deeper layers of soil and groundwater. The issuance of a building permit in the early stage of the remediation process will require further monitoring and effort from the redeveloper but will also allow for early recuperation of costs making the redevelopment more cost-effective. Checks and balances need to be in place including the financial flexibility for implementing an alternative remediation strategy when long-term remediation goals are not met. The development risks will be higher but go hand in hand with increased project and financial flexibility.

I hope this document will become a starting point for a lively debate on how to incorporate a holistic approach in contaminated sites management. It is my sincere belief the change to a holistic approach will result in a significant increase in site remediation, redevelopment and economic growth for BC.

Forward BC Ministry of Environment!

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