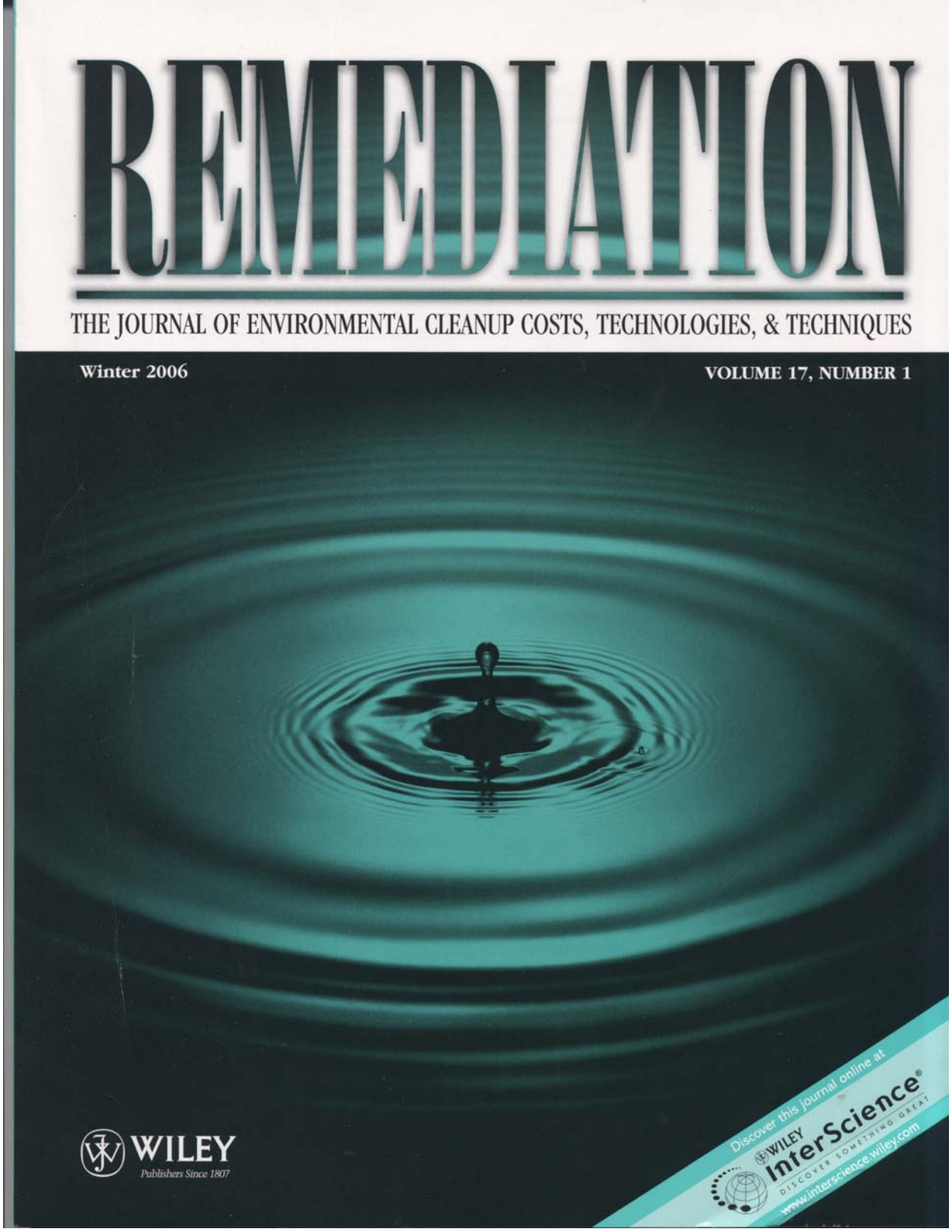

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http://www.members.aol.com/annejlee/STP-Remediation-pap.pdf

Progress Toward Remediation of the Sydney Tar Ponds: A Major Canadian PCB/PAH "Superfund" Site

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The Muggah Creek estuary in Sydney, Nova Scotia, received liquid and solid wastes from a steel mill and its associated coke ovens for approximately 100 years. This resulted in pollution of soils and sediments with polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), heavy metals, and other pollutants, including those in untreated domestic wastewaters. The Canadian federal and Nova Scotia provincial governments organized the Sydney Tar Ponds Agency (STPA) to develop a remediation approach for the Coke Ovens site soils and Sydney Tar Ponds sediments. The STPA developed a remediation approach for the Sydney Tar Ponds sediments, involving solidification/stabilization (S/S) through mixing cement and other materials into the sediments, and then capping them as a waste pile. High-density polyethylene (HDPE) plastic sheeting vertical barriers are proposed to be used to divert groundwater and surface water from entering into the S/S-treated sediments and to collect any water and associated pollutants released from the S/S-treated sediments. The Coke Ovens site soils are proposed to be landfarmed to reduce some of the PAHs and other pollu-tants and then capped with a layer of soil. This remediation program is estimated to cost on the order of $400 million (CAN). This article presents a review of the significant potential problems with the STPA proposed remediation strategy of the Sydney Tar Ponds sediments and Coke Ovens site soils. © 2006 Wiley Periodicals, Inc.

INTRODUCTION

For approximately 100 years, a steelmaking facility and its associated coke ovens located on the shores of Muggah Creek estuary in Sydney, Nova Scotia, discharged wastewaters and deposited solid wastes that have contaminated both the estuarine sediments and the nearby shoreline. In an effort to clean up the contaminated Coke Ovens site and Tar Ponds sediments, the Sydney Tar Ponds Agency (STPA) was organized. According to the STPA's Web site (http://tarpondscleanup.ca):

> 100 years of steel and coke production left more than a million tonnes of contaminated soil and sediment in Sydney.
>
> * * *
>
> The Tar Ponds and Coke Ovens lie in the heart of Sydney, an historic community on the eastern coast of Cape Breton Island, Nova Scotia, Canada.

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The STPA has the responsibility of developing a plan for remediation of the contaminated sites. The STPA Web site, under "Our Solution," states:

> **A $400 Million Plan**
> The cleanup plan put forward by the federal and provincial government relies on technologies that have proven successful on similar sites, of which there are many across North America.
>
> We will dig up and destroy the worst contaminants, then treat the remaining materials in place before containing them within an engineered containment system.

The STPA and its consultants prepared the Environmental Impact Statement (EIS) for the proposed remediation of the sites. It is available online at http://www.tarpondscleanup.ca/default.asp?T=7&M=106, with a "plain language" summary available at http: //tarpondscleanup.ca/EIS/PlainLanguage_EIS.pdf.

The Sierra Club of Canada, Cape Breton Group, became concerned about the adequacy, reliability, and technical feasibility of the STPA's proposed approach of excavation and incineration of the most contaminated sediments and soils.

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The Sierra Club of Canada, Cape Breton Group, became concerned about the adequacy, reliability, and technical feasibility of the STPA's proposed approach of excavation and incineration of the most contaminated sediments and soils. Further, there was concern as to whether the proposed *in situ* mixing of cement with the Tar Ponds sediments (in a process known as solidification/stabilization [S/S]), followed by capping and surface-water and groundwater flow diversion/collection, would prevent further releases of polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), heavy metals, and other pollutants in the Tar Ponds sediments that adversely affect public health and the environment. Information on the Sierra Club's position on the proposed remediation of the Coke Ovens site soils and Tar Ponds sediments is available at http://www.sierraclub.ca/national/sydney-tar-ponds/.

JOINT REVIEW PANEL

As a result of the controversy regarding the adequacy, reliability, and technical feasibility of the STPA's proposed remediation approach for the Coke Ovens site soils and Tar Ponds sediments, in July 2005 the Minister of the Environment for Canada and the Minister of Environment and Labour for Nova Scotia established a Joint Review Panel, consisting of Lesley Griffiths, MCIP (Chair); William H. R. Charles, QC; and Louis LaPierre, PhD, to conduct an environmental assessment of the proposed Sydney Tar Ponds and Coke Ovens Site Remediation Project. Further information on the expertise and experience of the Joint Review Panel members is available from http://www.stpco-review.ca/site/article.php3?id_article=2&lang=en. This panel established a Web site, http://www.stpco-review.ca/site/sommaire.en.php3. According to this Web site:

> The Panel has the responsibility to identify, evaluate and report on the potential environmental effects to the federal Minister of the Environment and the Nova Scotia Minister of Environment and Labour. In conducting the environmental assessment, the Joint Review Panel will take into consideration a number of factors, as outlined in the Joint Panel Agreement.

The panel conducted 17 days of public hearings in Sydney, Nova Scotia, in April and May 2006, in which the STPA and all others interested in the remediation of the Coke Ovens site soils and Tar Ponds sediments were provided an opportunity to present reports and testimony to the Joint Review Panel regarding their views on the STPA's proposed approach for remediation of these sites. Drs. G. Fred Lee and Anne Jones-Lee were asked by the Sierra Club of Canada to conduct a review of the STPA's Environmental Impact

Statement for the proposed remediation project, focusing on the proposed remediation of Coke Ovens site soils and Tar Ponds sediments. Their report (Lee, 2006a) provides a detailed review of the STPA's EIS, as well as comments on the STPA's presentation at the Joint Review Panel hearing. Dr. Lee presented testimony at the hearing on May 15, 2006. PowerPoint slides from his presentation (Lee, 2006b) are available online at http://www.members.aol.corn/annejlee/SydneyTarPondsPowerPt.pdf.

The results of this review have applicability not only to the Sydney Tar Ponds sediment remediation, but also to other sites where remediation approaches involve S/S treatment of high-organic wastes, soils, and sediments.

EFFECTIVENESS OF SOLIDIFICATION/STABILIZATION

In accordance with the Sierra Club of Canada's request, the focus of Dr. Lee's report and testimony was on the STPA's proposed solidification/stabilization and capping of Tar Ponds sediments and landfarming and capping of Coke Ovens site soils as a reliable means of preventing further contamination of the estuary by PCBs, PAHs, heavy metals, and other pollutants in the sediments/soils of these two sites. The STPA, in their EIS and in their testimony at the Joint Review Panel hearing, claimed that their proposed remediation approaches for these two sites were based on well-established technologies that had been demonstrated to be highly effective for similar kinds of contamination at other sites in North America. They also claimed that the Tar Ponds sediments remediation approach, involving mixing of the sediments with cement and other materials and then capping them, would result in a "walk-away" remediation of these sediments that would require little or no further intervention after 25 years.

On the other hand, Drs. Lee and Jones-Lee concluded, based on their experience and the literature, that the STPA's proposed solidification/stabilization, capping, and flow diversion approach was not a reliable approach for immobilization/containment of the pollutants in the Tar Ponds sediments. They also concluded that, rather than developing a "walk-away" approach as claimed by the STPA, considerable intervention would be needed to adequately monitor and maintain the S/S-treated sediments and the flow diversion structures that the STPA proposed be used to keep surface water and groundwater from entering the S/S-treated sediments and from leaving the treated sediments to cause further pollution of the estuary. They further concluded that, at some time in the future, the Nova Scotia provincial government, which would inherit the responsibility for post-25-year remediation of the Tar Ponds sediments, could conclude that the S/S treatment of these sediments, and the associated capping and flow diversions, was not a reliable approach, and that it would be necessary to excavate and treat the polluted sediments offsite.

The STPA claimed that their proposed remediation approaches for these two sites were based on well-established technologies that had been demonstrated to be highly effective for similar kinds of contamination at other sites in North America.

The Joint Review Panel report issued on July 12, 2006, is available online at http://www.gov.ns.ca/enla/ea/tarponds/TarPonds_EnvironmentalAssessmentReport.pdf. The executive summary of the Joint Review Panel report summarized the STPA-proposed remediation approach as follows:

> At the Coke Ovens site, containment structures around the perimeter would prevent ground-water from entering the site. Material from the Tar Cell and sediments from Coke Ovens Brook would be excavated and sent by rail to a temporary incinerator. Approximately 40% of the site, where contaminants in the soils exceed certain levels, would be capped to limit the infiltration of surface water and to prevent people or wildlife from coming into contact with

the contaminants. In some areas, STPA would carry out a form of bioremediation called land-farming before capping, in order to treat some of the hydrocarbons in the soil. Nonhazardous waste debris generated during the remediation at both sites may be landfilled in an uncapped portion of the site. Remediation of the Coke Ovens site would be complete by 2011.

At the Tar Ponds, two areas of sediments with PCBs in higher concentrations (over 50 parts per million) would be excavated, conditioned and transported by rail for incineration. The remaining sediments in the Tar Ponds would be solidified in-place using cement and other materials, and capped. STPA would construct an internal drainage system in order to manage the influx of both groundwater and seawater. Remediation of the Tar Ponds would be complete by 2014.

During the construction phase wastewater generated by activities at both sites will be treated before discharge to one or more water treatment facilities. STPA would continue to pump and treat groundwater after construction has been completed for as long as monitoring results showed it to be necessary.

A temporary incinerator would be constructed at either the Victoria Junction or Phalen sites in order to incinerate approximately 150,000 tonnes of contaminated sediments and soils. The incinerator would operate for three years; construction and then decommissioning would take another two years. STPA has also proposed an alternative means of carrying out the Project that would eliminate the use of incineration, and would solidify/stabilize all of the Tar Ponds sediments in-place. The Tar Cell material and Coke Ovens Brook sediments would be similarly treated together at the Tar Cell.

... there are significant questions about the ability of S/S treatment of high-organic wastes to effectively immobilize organic pollutants so that they do not cause environmental pollution.

Lee (2006a) discussed many of the significant deficiencies in the STPA's proposed approach for remediation of the Sydney Tar Ponds sediments and Coke Ovens site soils with respect to providing immobilization/containment of pollutants present at these sites for as long as the pollutants would be a threat to cause further environmental pollution. Of particular concern is the STPA's assessment that S/S treatment of sediments with high organic content (over 50 percent total organic carbon) has been demonstrated to be a highly effective method of immobilizing pollutants. Lee (2006a) provides a review of the literature on the effectiveness of S/S treatment of wastes and contaminated soils and sediments, focusing on the information provided in two American Society of Testing and Materials (ASTM) conferences (Gilliam & Wiles, 1992, 1996). These two conference proceedings provide a comprehendsive review of S/S treatment issues. As discussed in papers presented at these conferences, there are significant questions about the ability of S/S treatment of high-organic wastes to effectively immobilize organic pollutants so that they do not cause environmental pollution.

The Memorandum of Agreement (MOA) between the Government of Canada and the Government of Nova Scotia regarding remediation of the Sydney Tar Ponds and Coke Ovens sites (http://tarpondscleanup.ca/reports/MOA.pdf) requires that the remediation approach used be a "proven technology" that has been "successfully employed for projects of similar size and nature." The STPA erroneously assumes that prior use of S/S treatment at other sites is equivalent to a demonstration that it is a proven technology. As discussed by Lee (2006a), the S/S treatment approach has not been adequately and reliably evaluated with respect to prevention of release of pollutants over the time that the pollutants in the S/S-treated soils will be a threat. It has been Lee's experience in reviewing Superfund site-allowed approaches for remediation that the approaches adopted often do not adequately and reliably consider the long-term effectiveness in preventing future environmental pollution.

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With respect to the potential effectiveness of S/S treatment of contaminated soils and sediments, Lee (2006a) has provided a number of quotes from the literature, including the following from Conner (1990):

> To date, there has been little or no verification of these tests [leach test results] to ensure that they accurately predict behavior of the treated material in the field setting.
>
> * * *
>
> Even though S/S has been used for over 30 years there is no direct evidence of long-term material durability in the field. The durability of a S/S waste is dependent on how well it endures long term exposure to environmental stresses. A number of physical and chemical tests have been applied to S/S wastes to determine the durability of the material. Generally, these tests are short term tests and do not give a full correlation to field performance.

Further, Means et al. (1996) stated:

> The long-term performance of treated waste is not clearly understood, and no definitive test procedures exist to measure or assess this property. The Toxicity Characteristic Leaching Procedure (TCLP) is not an adequate measure of long-term leaching. Monitoring data from field disposal sites are needed to detect the premature deterioration of solidification or stabilization of previously processed wastes. Because of the uncertainties surrounding long-term performance, wastes previously treated using S/S and disposed of may have to be retrieved and retreated in the future.

In addition, Wiles and Barth (1992) of the U.S. Environmental Protection Agency stated:

> However, results of several studies, as well as data from remediation of several Superfund sites, have raised concerns about whether S/S is a valid technology for treating organic-bearing wastes.
>
> Furthermore, studies also provide evidence that tests other than the regulatory extraction tests [for example, toxicity characteristic leaching procedure (TCLP)] will be required to evaluate the effectiveness of S/S, especially when applied to organic wastes.
>
> These results suggested that any successful durability test or predictive model will have to account for significant chemical and structural changes over time that influence leaching rate.
>
> The durability of S/S wastes remains unclear, in part [due] to the relative time that the technology has been used, and to the lack of information on the sites using it.
>
> Evaluation of S/S process design, performance, and treatment efficiency should be based on a matrix of several testing protocols. No single test, such as TCLP, can provide all the information required to evaluate contaminant release potential, contaminant release rate, and physical durability. An appropriate test matrix to evaluate S/S processes should include tests that will address these factors.

There is still a lack of reliable information on the long-term effectiveness of S/S treatment of wastes that are high in organic content.

Barth (personal communication, 2006) indicated that the situation today is no different than it was in 1992 when he and Wiles developed their paper on this issue. There is still a lack of reliable information on the long-term effectiveness of S/S treatment of wastes that are high in organic content.

Thornburg et al. (2006), in a recent study titled "Effectiveness of *In Situ* Cement Stabilization for Remediation of Sediment Containing Coal Tar Derived Hydrocarbons," found that S/S treatment of these organic sediments was not effective in preventing release of pollutants from them.

The STPA literature review on the effectiveness of S/S treatment for contaminated soils and sediments failed to reference the work of others, such as cited above and in Lee

(2006a), on the potential problems with S/S treatment being an effective method of long-term prevention of release of pollutants from the treated sediments/soils. The Agency also failed to mention readily available references in the literature to the inappropriateness of using the TCLP for evaluating the effectiveness of S/S treatment.

Lee (2006a) has discussed the inadequate approach used by the STPA in evaluating cement-based S/S treatment of the Sydney Tar Ponds sediments, where the agency used the TCLP to evaluate the effectiveness of treatment. As discussed earlier and by Lee (2006a), the TCLP, while widely used, is recognized by those who understand its origin and appropriate use to be an unreliable approach for evaluating the adequacy of S/S treatment of wastes and sediments. The TCLP is not designed to evaluate the leaching of materials from solids. Its purpose is to determine whether a particular type of solid waste should be placed in a municipal solid waste landfill or a hazardous waste landfill.

The STPA erroneously assumed that because they could not measure a release in the TCLP test, there was no release, and, therefore, S/S treatment of these sediments was effective.

Further, and most important, in the agency's studies of S/S treatment of Sydney Tar Ponds sediments, the Agency used an analytical method detection limit for measurement of PCBs released from the treated sediments that was well above the concentrations that are known to bioaccumulate to excessive levels in edible organisms. The STPA erroneously assumed that because they could not measure a release in the TCLP test, there was no release, and, therefore, S/S treatment of these sediments was effective.

Overall, although S/S treatment of solid wastes has been widely applied, largely because it is initially cheaper than removal and adequate treatment of the wastes, it is not a proven technology that has been successfully demonstrated on similar wastes to the Sydney Tar Ponds sediments.

The Joint Review Panel for the STPA proposed remediation approach reached the following key findings with respect to STPA's proposed approach for S/S treatment of the Sydney Tar Ponds sediments:

> STPA described the Project as permanent remediation that would at some undefined time in the future require no further monitoring or maintenance—in other words, a "walk away" solution. The Panel believes this may be true for the Coke Ovens, but not for the Tar Ponds. Therefore, STPA, the regulators and the public must be prepared for the possibility that the Tar Ponds site will have to be managed in perpetuity;
>
> Both the community and STPA have placed great importance on the use of proven technologies. The Panel is not convinced that the solidification/stabilization technology is proven for use in the Tar Ponds context—that is, to be applied to organic contaminants in organically enriched sediments in an estuary with potential groundwater and seawater influx. The Panel understands that the primary remediation technology to be applied to the Tar Ponds is containment, with use of solidification/stabilization as a secondary approach. Nevertheless, the Panel believes that further pilot studies must be carried out and specific targets reached before this technology is approved for use in the Project.

The Joint Review Panel provided several recommendations that are pertinent to the remediation of the Coke Ovens and Tar Ponds site soils/sediments, as follows:

> The Panel reviewed extensive information regarding the advantages and disadvantages of using solidification/stabilization technology, which has been used quite extensively in other areas to address contaminated sites. Much of the discussion centered on whether the technology could be considered proven for the Tar Ponds context (largely organic contaminants in organically enriched sediments, in an estuarine location), how the proposed internal drainage system would work, what

performance criteria were appropriate and how they should be tested. Concerns were also raised about the reported results of STPA bench scale tests of the technology on both Tar Ponds and Tar Cell materials. The Panel recognized that containment rather than solidification/stabilization is the primary remediation approach, but concluded that if the technology is to be used it needs to be further evaluated through a pilot study based on specific performance criteria ensuring that solidification/stabilization would not significantly increase contaminant mobility.

MANAGING WATER FLOW

One of the areas of particular concern, as noted in Dr. Lee's report (Lee, 2006a), is the STPA-proposed approach for attempting to prevent/limit the amount of surface water and groundwater that will enter or leave the S/S-treated sediments. The STPA proposes to use high-density polyethylene (HDPE) sheeting vertical walls to prevent groundwater from entering the S/S-treated sediments, and to use water collection/diversion ditches lined with HDPE to collect and transport out of the S/S-treated sediments any water that contacts the sediments. The STPA also proposes to prevent surface water from infiltrating into the S/S-treated sediments through the use of a geosynthetic clay liner (GCL) in the soil cap. The STPA failed to adequately and reliably report on the literature, which demonstrates that HDPE sheeting is subject to deterioration that can cause it to be an ineffective barrier for transport of water/pollutants. Also, the STPA failed to report on the problems with geosynthetic liners in caps being a long-term, effective means of preventing water from infiltrating into landfills, which can leach pollutants from the wastes. These issues are discussed in the Lee (2006a) report, which makes reference to the report prepared by Lee and Jones-Lee (2006), in which an extensive discussion of these issues is presented. As they point out, there are documented cases in the literature where HDPE liners have failed within a few years after installation. Further, there are significant problems with geosynthetic liners failing to perform as designed, within a few years after their installation.

The STPA failed to adequately and reliably report on the literature, which demonstrates that HDPE sheeting is subject to deterioration that can cause it to be an ineffective barrier for transport of water/pollutants.

The Joint Review Panel recommended the following:

> The Project involves extensive interception of groundwater to reduce future contact between both ground and surface water with remaining contaminated soils and sediments. The Panel agrees that this component of the Project will have a beneficial effect on environmental quality, and has recommended the use of more extensive hydrographic modeling to refine Project design and avoid any adverse impacts from redirection of groundwater flows, and a comprehensive groundwater monitoring program.
>
> Both the Tar Ponds site and extensive areas of the Coke Ovens site will be capped. The Panel heard questions and criticisms about the design, function, durability and monitoring of the caps, and has made recommendations to address these issues.

In summary, as discussed in Lee (2006a) and summarized in the PowerPoint slides for Dr. Lee's testimony, the panel's conclusions regarding potential problems with the STPA's proposed approach of S/S treatment, capping, and flow diversion were in accord with Drs. Lee and Jones-Lee's conclusions, in that the STPA has not adequately and reliably discussed the potential problems with the proposed remediation of the Coke Ovens and Tar Ponds sites in providing long-term control/containment of the residual pollutants that are proposed to be left in these site soils/sediments after site remediation. Lee and Jones-Lee's (2006) report provides detailed discussions of the technical basis for their conclusions on these issues.

NEED FOR INDEPENDENT OVERSIGHT OF JOINT PANEL'S PROPOSED STUDIES

Overall, it is concluded that the Joint Review Panel has appropriately assessed many of the potential problems with the STPA's proposed approaches for remediation of the Coke Ovens site soils and wastes and the Tar Ponds sediments. An area that was not specifically discussed by the panel that Dr. Lee discussed in his report and in his presentation at the hearing is the problem with the long-term integrity of the STPA-proposed water diversion/control structures based on sheets of HDPE. As Dr. Lee discussed, the literature contains references to a number of studies that have shown that such plastic sheeting can deteriorate fairly rapidly and lose its effectiveness in preventing water/pollutants from passing through it.

Lee (2006c) has provided additional discussion of the Joint Review Panel's evaluation of the STPA-proposed approach for Sydney Tar Ponds sediments and Coke Ovens site soil remediation. In his comments, he states that it will be important that an independent technical panel of experts in areas pertinent to S/S be appointed to oversee the panel's recommended additional studies to be conducted by the STPA on the potential effectiveness of treatment of the Tar Ponds sediments. Appointment of an independent expert panel consisting of individuals who have not been and will not be dependent on Canadian federal or Nova Scotia provincial support will be essential to potentially developing reliable information pertinent to evaluating the potential effectiveness of the proposed Coke Ovens site and Tar Ponds sediment remediation.

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