Feasibility Review: Waste Disposal Options - Hunters Hill Property

30 March 2011

State Property Authority

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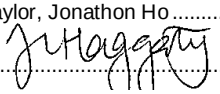
Signed:  .....

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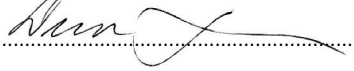
Signed:  .....

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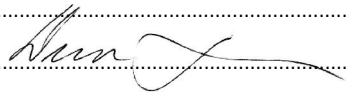
Signed:  .....

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30 March 2011

Mr. Jeff Goodchild
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Dear Jeff

Feasibility review: Waste disposal options - Hunters Hill Property

Please find enclosed PB's final draft report for the Nelson Parade, Hunters Hill Site. Should you have any questions or comments regarding this report, please contact either myself or Jo Haggerty.

Yours sincerely

Derek Low
Section Executive – Environmental Management, Ecology and Climate Change
Parsons Brinckerhoff Australia Pty Limited

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Introduction

This report outlines the results of Parsons Brinckerhoff's (PB) high-level feasibility review of options for managing the restricted solid waste, which will be generated in the remediation of the former Radium Hill Company site in Nelson Parade, Hunters Hill (the Site).

Background

In the early 1900s, the Radium Hill Company processed uranium ore at the Site, which resulted in tailings and waste products being deposited over the surface of the Site. The Site has been the subject of numerous studies and investigations to determine the level of radiological and chemical contamination present, and identify appropriate remediation methods. In 2008, a Parliamentary Inquiry was conducted into remediation of the Site.

The radiologically impacted soils, which are the focus of this report, have been classified by the NSW Department of Environment, Climate Change and Water (DECCW) as 'restricted solid waste'.

The NSW State Property Authority (SPA) is managing the remediation of the Site.

In 2010, the SPA selected an appropriate remediation strategy for the Site, and started to prepare the application for planning approval for the remediation work. The remediation strategy involved the excavation and disposal of the restricted solid waste to a licensed landfill in Sydney; the SITA landfill in Elizabeth Drive, Kemps Creek. The SITA landfill is the only landfill licensed to accept restricted solid waste in NSW.

In October 2010 the NSW Government announced that waste from the Site would be not be disposed at the SITA landfill facility, and directed the SPA to investigate alternative management and/or disposal options. The SPA subsequently commissioned this report.

Scope and methodology

PB has conducted a preliminary evaluation of ten options for the management and/or disposal of the restricted solid waste. These include:

- Options for the off-Site disposal of the restricted solid waste, at:
  - A dedicated cell within an existing NSW landfill (requiring an amendment of the landfill operator's licence) (Option 1).
  - A new purpose-built facility / landfill in NSW, potentially on Crown land or within a disused mine (Option 2).
  - An existing interstate or Commonwealth landfill / facility for restricted solid waste (Option 3).
  - The SITA landfill at Elizabeth Drive, Kemps Creek (Option 4).
  - An overseas disposal location (Option 5).
- Option 6: Temporary storage of the restricted solid waste at a storage facility. The waste would be stored until it could be disposed of at a proposed centralised national repository for waste with low levels of radioactivity.

- Option 7: Treatment of the restricted solid waste, at an off-Site temporary treatment plant.
- Option 8: On-Site encapsulation of the restricted solid waste.
- Option 9: Managing the waste in place.
- Option 10: The 'Do nothing' option.

The feasibility of these options has been assessed using evaluation criteria which included: technical/engineering feasibility; regulatory and approvals considerations; consistency with government policy and directives; environmental impacts, risks and management requirements; health impacts, risks and management requirements; community issues; impacts on the future use of the Site; impacts on the future use of the disposal site; time; and cost.

Findings

All of the identified options for the management and/or disposal of the restricted solid waste involve aspects and potential impacts which would need to be carefully assessed and managed. However, a few of the options are considered to be more viable than the others and these are worth investigating further.

While options in NSW such as disposal in a monocell at an existing landfill (Option 1), or disposal at a disused mine or vacant Crown land site (Option 2) are likely to be technically feasible, there will be considerable investigation and cost implications associated with site selection, environmental and engineering studies, designing an appropriate repository/monocell, community consultation, obtaining planning approvals (for Option 2), obtaining or amending licences, construction, and ongoing monitoring, management and reporting.

For both Options 1 and 2, there is uncertainty around how long it will take, and whether it will in fact be possible, to identify a suitable disposal site. It is estimated that site selection, planning approvals and disposal of the restricted waste could take three to five years. As the waste includes radionuclides with long half-lives, long term management and monitoring (and associated funding) arrangements would need to be implemented at the disposal site for at least 300 years. Both options would likely encounter some community opposition, as has been the case with the SITA landfill option.

For Option 3, there is currently no national repository for waste of this type. The SPA has contacted all State and Territory jurisdictions in an attempt to find a suitable disposal facility. South Australia is the only state which has not yet responded. While an appropriate facility exists in Western Australia, it is not permitted to accept waste from interstate. No suitable facilities were identified in the other states. The SPA is continuing its inquiries into this option.

The most straightforward, timely and cost effective option is disposal of the waste at the SITA landfill (Option 4). However, this option is not consistent with the NSW Government's October 2010 announcement, and the Mulgoa community in the vicinity of the landfill is opposed to this option.

Disposal overseas (Option 5) is being investigated by the SPA. A complex and time consuming permit and approvals process is anticipated with this option, with significant risk that, even if an appropriate overseas disposal location is found and the receiving country's government approves disposal, media attention and community opposition could prompt that government to delay or reverse its decision. Resolving a disposal location, obtaining approvals and disposing the waste could take two to four years, and would be very costly.

Temporary storage of the waste (Option 6), though not technically complex, relies on the future establishment of a national waste repository which will accept the restricted solid waste. There is no certainty regarding the location and timing of any new national repository. The temporary storage facility would require site selection, planning approvals, licensing, design, construction and ongoing management. Some community opposition would likely be encountered. In considering this option, the high cost of transporting and disposing the waste at a future national repository would also need to be factored in.

Waste treatment (Option 7) is technically complex. Even if the waste was suitable for treatment with current technology, the treatment process would concentrate the waste, so although there would be a smaller quantity requiring disposal, the waste would either still be classified as restricted solid waste, or could be classified as hazardous waste. So, treatment would not provide a solution to the waste disposal issue.

On-Site encapsulation (Option 8), while also expensive and technically complex, may be a feasible solution. However, the main issue with this option is the strong opposition of Nelson Parade residents. It is understood that the residents' concern is primarily the stigma associated with the waste, rather than any real health risks. Significant time and effort would need to be expended in engineering and environmental feasibility studies for this option, as the containment cell would need to have a 300 year design life. Ongoing monitoring and management would also be required over this period. However, if the containment cell was constructed aboveground in the foreshore, it may still be feasible to develop the main upper portion of the Site for residential use.

Options 9 ('Manage in place') and 10 ('Do nothing') represent poor environmental and community outcomes. The foreshore (lower) part of the Site is regulated under the *Contaminated Land Management Act* which obliges the owner to remediate the site. A 'Do-nothing' option would not comply with this regulation or the recommendations of the 2008 Parliamentary Inquiry. The Site would also not be suitable for residential use if the 'Do nothing' option was adopted.

In conclusion:

- Although it does not comply with the NSW Government's October 2010 announcement, the SITA Elizabeth Drive Landfill represents the best disposal option for the restricted waste.
- The following options are feasible , but more detailed assessments need to be carried out to determine the extent to which measures can be put in place to overcome associated environmental, engineering, socio-economic and other issues:
  - Disposal to an interstate landfill.
  - Encapsulation on-Site.
  - Disposal to a monocell within an existing NSW landfill.
- The following options are very complex, with significant time and cost implications and low chances of success. However, these options could be considered in more detail if further assessment of the above options show that they would not be suitable:
  - Overseas disposal.
  - Disposal to a purpose-built facility in NSW.

- The following options do not warrant further consideration at this time:
  - Temporary off-Site storage.
  - Treatment.
  - Manage in place.
  - Do nothing.

Recommendations

PB recommends that the following further actions and investigations be undertaken:

SITA Elizabeth Drive Landfill option:

- Explore whether the NSW Government could reconsider its announcement ruling out this option.

Interstate landfill option:

- Obtain a response from the South Australian government, and explore the possibility of returning the waste to Radium Hill.
- If a likely disposal site is identified:
  - Understand the state's specific approvals process, and any permitting requirements.
  - Determine scope and cost of supporting studies, approvals, transportation, disposal and monitoring.
  - Investigate the extent to which measures can be put in place to adequately manage the associated environmental, engineering, socio-economic and other issues.

Encapsulation on Site option:

- Determine scope and cost of supporting studies, approvals, design, construction, disposal and monitoring.
- Investigate the extent to which measures can be put in place to adequately manage the associated environmental, engineering, socio-economic and other issues.

NSW landfill monocell option:

- Identify several potentially suitable locations, through direct contact with landfill operators.
- Develop site selection criteria for the landfills / monocells.
- Determine scope and cost of supporting studies, approvals, design, construction, transportation, disposal and monitoring.
- Investigate the extent to which measures can be put in place to adequately manage the associated environmental, engineering, socio-economic and other issues.

1. Introduction

This report outlines the results of Parsons Brinckerhoff's (PB) high-level feasibility review of options for the management of the restricted solid waste which will be generated in the remediation of the former Radium Hill Company site in Hunters Hill, New South Wales.

The Site comprises 7, 9 and 11 Nelson Parade, Hunters Hill, and foreshore areas adjacent to 5, 7, 9, 11 and 13 Nelson Parade, Hunters Hill.

The Radium Hill Company operated at the Site between 1911 and 1915, processing uranium ore which had been shipped to the Site from South Australia. The processing of uranium ore resulted in tailings and waste products being deposited over the surface of the Site. The Site has been subject of numerous studies and investigations to determine the level of radiological and chemical contamination present, and identify appropriate remediation methods. The radiologically impacted soils have been classified by the NSW Department of Environment, Climate Change and Water (DECCW) as "restricted solid waste".

The NSW State Property Authority (SPA) is managing the remediation of the Site.

In mid 2010 SPA signed an agreement with SITA for the disposal of approximately 5,000 tonnes of restricted solid waste from the Site at the SITA landfill in Elizabeth Drive, Kemps Creek (herein referred to as the "SITA landfill"). The SITA landfill is licensed to accept restricted solid waste. .

In October 2010 the NSW Government announced that waste from the Site would be not be disposed at the SITA landfill facility, and directed the SPA to investigate alternate disposal options.

Consequently, the SPA engaged PB to undertake this feasibility review of restricted waste disposal options.

The Options Review comprises two stages. The objectives of Stage 1 were to:

- Identify available options.
- Provide a relatively high-level feasibility assessment of available options, focussing on regulatory, technical, environmental, health, practical, cost, schedule and risk management issues.
- Identify any potential showstoppers associated with the options, and any areas which may require further information or study before feasibility can be assessed.

This draft report comprises the key deliverable for Stage 1. The agreed scope, assumptions, and limitations for this report are included in Appendix A.

It is understood that this draft report will be used by the SPA to inform decisions made by the Project Steering Committee for the Site with respect to its preferred restricted waste management options.

Stage 2 of the Options Review will comprise a more detailed feasibility assessment of the preferred options.

2. Waste Management Options

The restricted waste disposal options which are discussed in this review and were agreed with the SPA, are as follows:

- Off-site disposal:
  - Option 1: Disposal at an existing NSW landfill.
  - Option 2: Disposal at a purpose-built facility in NSW (for example at a disused mine or crown land site).
  - Option 3: Disposal at an interstate or Commonwealth landfill/facility.
  - Option 4: Disposal at the SITA landfill at Elizabeth Drive, Kemps Creek.
  - Option 5: Disposal at an overseas facility.
- Temporary off-site storage:
  - Option 6: Storage at a purpose built facility, with eventual disposal to a future centralized national waste repository.
- Treatment:
  - Option 7: Treatment at an existing or purpose built temporary facility in Australia.
- Encapsulation:
  - Option 8: Onsite encapsulation of the restricted waste.
- Other options:
  - Option 9: ‘Manage-in-place’.
  - Option 10: ‘Do nothing’ option

These options are described and evaluated in the following sections.

3. Evaluation Criteria

The evaluation criteria which have been used to assess the feasibility of the various waste management options were agreed in a workshop with the SPA and DECCW representatives on November 25, 2010. The evaluation criteria are summarised below and described in more detail in Appendix A.

- Technical and engineering feasibility.
- Regulatory / approval considerations.
- Consistency with government policy, guidance and directives.
- Environmental impacts, risks and management considerations.
- Health risks.
- Community issues.
- Impacts on the use of the Site.
- Impacts on the future use of the disposal location.
- Time (indicative time for the completion of the remediation project).
- Costs (qualitative, relative to the costs associated with disposal at the SITA landfill).

4. Waste Description and Classification

The waste of interest for this evaluation was generated as a result of the onsite operation of the Radium Hill Company NL processing plant which extracted radium from uranium ore between 1911 and 1915. Approximately 500 tonnes of ore is believed to have been processed in the plant and as a result of these operations, tailings with radiological properties were deposited into several dumps on the Site. Extensive soil relocation occurred during subsequent developments at the Site and the tailings were distributed more widely over the Site.

The radiologically impacted soil comprises approximately 5,000 tonnes of material which is classified as “restricted solid waste” under the DECC (2008) Waste Classification Guidelines, Part 3: Waste Containing Radioactive Material.

This restricted waste is not considered a “radioactive substance” as it does not meet the definition of radioactive substance provided in clause 5 of the NSW *Radiation Control Regulation 2003*, having a specific activity of less than 100 Bq/g.

The half-lives of the radionuclides present in the impacted soils at the Hunters Hill Site are long, and radioactivity may not attenuate for hundreds of years. As a consequence, any waste management solution will need to be effective in the very long term.

The following sections of this report examine the ten waste management options outlined above. More detailed information on the radionuclides present, levels of radioactivity, characterisation of the waste as Naturally Occurring Radiological Material (NORM), and potential exposure pathways, is provided in Appendix B.

5. Evaluation of Off-Site Disposal Options

The offsite disposal options which have been evaluated are illustrated in Figure 5-1 and discussed below.

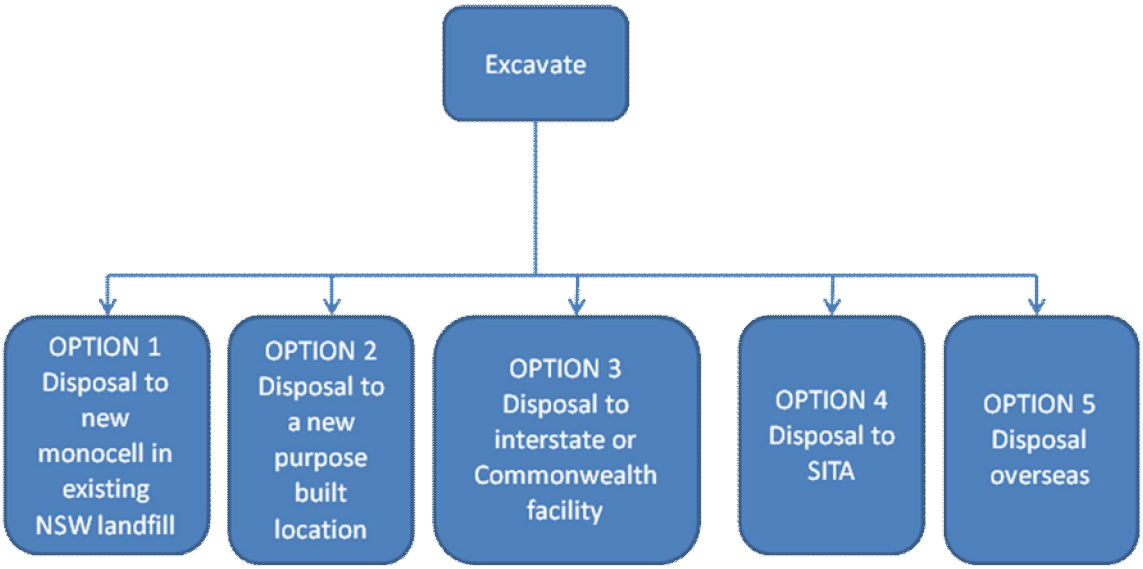

Figure 5.1 Offsite Disposal Options

5.1 Option 1: Disposal at an existing NSW landfill

5.1.1 Description

This option comprises the construction of a purpose-built monocell within an existing NSW landfill, for the disposal of the restricted solid waste. Unless already permitted, the landfill operator's licence would have to be amended to permit acceptance of the restricted solid waste.

Consultation with WSN Environmental Solutions (formerly Waste Services NSW) revealed that there are limited potential NSW government –operated landfills in Sydney which could accommodate a monocell, with the landfill at Eastern Creek being identified as the only possible location.

5.1.2 Technical/Engineering feasibility

This option is considered to be more technically complex than disposal of the waste at the SITA landfill (discussed as Option 4), as an appropriate location would have to be identified and investigated, which would likely involve the completion of comprehensive environmental and engineering studies. A new monocell would have to be designed and constructed at the landfill. The monocell would need to be equipped with liners and controls, in accordance with the general performance requirements and design considerations set out in the NSW EPA (now DECCW) Draft Environmental Guidelines for Industrial Waste Landfilling (NSWEPA 1998).

Although complex, there are no known significant conceptual technical or engineering barriers associated with this option. Any actual technical or engineering constraints would be dependent on the specific location selected for the monocell.

Dedicated waste monocells have been constructed within other landfills in the past. For example, a waste-specific monocell has been constructed and used for the disposal of NORM wastes by Gippsland Water at the waste disposal facility at Dutson Downs in Victoria. The NORM wastes in this case comprise sludges from offshore drilling operations, which are stabilised and buried in engineered landfill cells with multiple bentonite clay and HDPE liners and leachate monitoring (Gippsland Water 2010).

5.1.3 Regulations and approvals

Any NSW landfill accepting restricted waste must be licensed by DECCW. For this option to be permissible, the landfill operator's existing licence would have to be amended to allow the acceptance of restricted waste. The likelihood of obtaining a restricted waste licence is not known as site specific factors would be taken into consideration.

Planning approval for the remediation project could continue on its current path (with application and determination under Part 3A of the NSW *Environmental Planning and Assessment Act 1979)*, however implementation of remediation would probably be delayed, as the disposal location would have to be licensed before project approval could be granted.

5.1.4 Government policies and directives

From a remediation policy perspective, DECCW endorses the policy of the Australian and New Zealand Environment and Conservation Council (ANZECC) and National Health and Medical Research Council (NHMRC) – as published in the Australia and New Zealand Guidelines for the Assessment and Management of Contaminated Sites (ANZECC 1992). Under this policy, the preferred options for remediation and management of this Site would be (in descending order):

- on-site treatment of contamination – so that the contaminant(s) are either destroyed or the associated hazard is reduced to an acceptable level; then
- off-site treatment of contamination - so that the contaminant(s) are either destroyed or the associated hazard is reduced to an acceptable level, after which the formerly contaminated material is returned to the site.

If these options cannot be implemented, then the other options that should be considered include:

- removal of contaminated material to an approved site or facility (such as a landfill), followed, where necessary by the reinstatement of excavations using clean fill; then
- consolidation and isolation of the contaminated material on-site by containing the contaminated material within a properly designed barrier.

So, from a policy perspective, disposal at a licensed landfill, while not a 'referred' solution, would be considered acceptable.

This option is consistent with ARPANSA best practice guidance (ARPANSA 2008a), which is summarised in Appendix C.

5.1.5 Environmental impacts

The main environmental impacts would comprise short term impacts on traffic in the vicinity of Nelson Parade, associated with transporting the material to the landfill. Additional short-term environmental impacts would also be associated with construction of the new landfill monocell, but these should be relatively straightforward to mitigate, as with any typical construction project. As the disposal location will already be developed as a landfill, it is unlikely that ecological or heritage impacts would be significant issues, however, these will obviously be location-dependent.

It is assumed that the monocell would be fit-for-purpose, with controls in place to mitigate environmental impacts associated with disposal of the material, and the landfill would be operated in accordance with DECCW licence conditions, such that residual environmental impacts are likely to be minimal and acceptable.

Long term management of the waste would be required and would be conducted by the landfill operator as part of management of the wider landfill facility, with monitoring and management equipment and resources in place, along with security arrangements. Risks of uncontrolled releases or exposures at the landfill are considered to be low.

During transport of the restricted solid wastes, there would be a low risk of accidental release of dust or loss of containment. These risks would be minimised by standard controls and precautions, and would be particularly low if the landfill was located nearby, within the Sydney area.

5.1.6 Health impacts

The Site will be cleaned up to achieve radiation levels at or near background, benefitting local residents and future Site users.

Workers at the landfill would need to employ occupational health and safety measures (which may entail additional training and equipment) to ensure exposure to radiation in soils is minimised to acceptable levels.

5.1.7 Community issues

The SPA has indicated that the Hunters Hill community would respond favourably to a solution which removed all of the waste from the Site.

Attitudes of the community in the vicinity of any future monocell within a landfill are not known at this stage. However, it is reasonable to assume that some community objection, as has been experienced within the Kemps Creek community near the SITA landfill, would be encountered.

5.1.8 Impacts on Site use

The Site would be clean and suitable for future residential use.

5.1.9 Impacts on future use of the disposal location

As the disposal site would already be an operating landfill, this solution is not anticipated to pose any additional real constraints on land use at or surrounding the landfill during its operational phase.

Additional ongoing management and monitoring activities would be required for the waste monocell.

Post-closure use of the landfill property may be affected by the presence of a monocell containing soils with radiological properties. Any proposals for post-closure use would need to consider the long half-lives and exposure pathways of the radionuclides present.

5.1.10 Time

It is estimated that this solution could be completed within approximately two to three years, with uncertainty around the time it would take to find an appropriate landfill and obtain DECCW licences.

5.1.11 Cost

Costs will be associated with environmental and engineering feasibility studies, approvals, construction, and ongoing monitoring. Costs are anticipated to be moderate to high compared to the SITA Elizabeth Drive Landfill option.

5.1.12 Summary

The key findings associated with this option can be summarised as follows:

Advantages

- The Site would be clean and suitable for residential use.
- There would be minimal associated environmental and health impacts.
- The disposal method is consistent with government policy and guidance.
- Some of the long term management arrangements would already be in place (as within an existing landfill).

Constraints/Disadvantages

- It is likely to be challenging to find a suitable landfill location.
- The landfill operator will require a DECCW licence to accept restricted waste.
- Attitudes of the community around the landfill location have not been tested, but some objection can be anticipated.
- Long term ongoing management will be required.

- The costs associated with the implementation of this option are likely to be moderate to high.

5.2 Option 2: Disposal at a purpose-built location

5.2.1 Description

This option involves disposal of restricted solid waste at a purpose-built facility, which could include at a derelict mine site or on vacant Crown land.

5.2.2 Technical/Engineering feasibility

The key consideration for this option would be identifying an appropriate site for near surface burial. NHMRC guidance (detailed in Appendix C) provides suggested site selection criteria. In accordance with the NHMRC guidance (NHMRC 1993), the most appropriate site would be in an industrial area or remote area of low population and arid climate. Less ideal but still potentially appropriate local sites could be considered but for the purposes of this high-level evaluation report, consideration of this option (provided below), assumes that a relatively remote location would be selected. Environmental and engineering studies would be required to confirm the suitability of a site for disposal of the waste.

Once an appropriate site is selected, a near surface repository would need to be constructed. It is estimated that the 3,000 cubic metres (m^3) of waste could be accommodated within an area 30 metres long, 30 metres wide, and 10 metres deep (including allowance for cover). The repository would need to satisfy the general performance requirements and design considerations set out in the NSW EPA (now DECCW) Draft Environmental Guidelines for Industrial Waste Landfilling (NSWEPA 1998), and take the NHMRC guidance into consideration.

Design requirements would likely include provision of:

- Suitable engineered barriers to guarantee the integrity of the waste, minimise the possibility of water infiltration, and prevent radionuclide migration, with a design life of more than 300 years.
- Suitably engineered cover, to stabilise the structure, prevent ingress of water, discourage entry of animals or people and inhibit erosion. The minimum cover requirement is five metres between the top of the waste and the top surface of cover.
- A surface water management system.
- A buffer zone.

5.2.3 Regulations and approvals

Planning approval would need to be obtained for the near surface repository. Depending on the specifics of the repository, and Department of Planning's specific requirements in this case, planning approval would either be required under Part 3A or Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). Under Part 3A, an Environmental Assessment would be required, and the Minister for Planning would be the determining authority. Under Part 4, depending on Local Environmental Plan provisions, an Environmental Impact Statement would be required and the local council would be the determining authority.

Under the *Protection of the Environment Operations Act 1997* (POEO Act), an environmental protection licence would likely be required from DECCW for the operation of the facility.

It is anticipated that the approvals process for this option could significantly delay the commencement of remediation at the Site, as planning approval for Site remediation would not be granted until a viable and approved destination for the waste had been identified.

The likelihood of success in obtaining planning approvals and licences is not known, and will be strongly dependent on: finding an appropriate location for the repository; good community and stakeholder involvement and consultation; and working in co-operation with DECCW.

5.2.4 Government policies and directives

From a remediation policy perspective, disposal at an approved facility, while not a 'preferred' solution, would be considered acceptable.

This option is consistent with ARPANSA best practice guidance (ARPANSA 2008).

5.2.5 Environmental impacts

Assuming the site has been selected and designed in accordance with NHMRC guidance and DECCW requirements, environmental impacts associated with constructing and operating the facility are likely to be manageable, with few residual impacts. This option is more energy-intensive, considering that an entirely new facility will be constructed, probably at considerable distance from the Hunters Hill Site.

As part of the development of the repository, monitoring equipment will have to be installed and operated, and regular reporting of monitoring results will likely be required. If the facility is built at a location which does not have a permanent on-site workforce, it will require more effort to ensure that appropriate inspection, monitoring and maintenance is occurring to ensure minimal environmental risks.

If the repository is remote from the Hunters Hill Site, the distance over which the waste will have to be transported increases the likelihood of an accidental release. However with good management arrangements, environmental risks should be adequately mitigated. Ensuring adequate long-term funding for the design life of the repository (300 years) will be of key importance in making sure long-term inspection and maintenance is occurring.

5.2.6 Health impacts

The Site will be cleaned up to achieve radiation levels at or near background, benefitting local residents and future Site users.

Health impacts to the local community around the repository site are likely to be minimal, assuming appropriate siting, design and construction.

If the facility is built at a location which does not have a permanent on-site workforce, it will require more effort to ensure that appropriate inspection, monitoring and maintenance is occurring to ensure minimal health risks.

Workers at the repository will require appropriate training and equipment to employ occupational health and safety measures and ensure exposure to radiation associated with the waste is minimised to acceptable levels.

5.2.7 Community issues

SPA has indicated that the Hunters Hill community would respond favourably to a solution which removed all of the waste from the Site.

Attitudes of the community in the vicinity of any future repository are not known, however it is likely that some community opposition would be encountered.

5.2.8 Impacts on Site use

The Site would be clean and suitable for future residential use.

5.2.9 Impacts on future use of the disposal location

Long term management, monitoring and security arrangements would need to be established at the repository site, with appropriate long-term funding. Future uses of the repository site would likely be limited.

5.2.10 Time

It is estimated that remediation and disposal could be completed within approximately three to five years, assuming an appropriate site can be located. There is, however, considerable risk that community opposition and the approvals process could extend this time-frame.

5.2.11 Cost

Costs associated with environmental and engineering studies for site selection, planning approvals, construction of the repository, transportation, and ongoing management, monitoring and security are anticipated to be high.

5.2.12 Summary

The key findings associated with this option can be summarised as follows:

Advantages

- The Site would be clean and suitable for residential use.

Disadvantages

- It is likely to be challenging to find a suitable location for the repository.
- There would be significant consulting fees associated with selecting a site, design and construction.
- Planning and DECCW approval would be needed for the facility.
- The site would probably be remote, involving higher transport costs.
- The site will require long term monitoring and management.
- Some local community objection is likely.

5.3 Option 3: Disposal at an existing interstate or Commonwealth landfill

5.3.1 Description

The investigation of opportunities to dispose of the waste at an interstate or Commonwealth landfill or facility is being led by the SPA. At the time of writing, the SPA's work is underway but not completed. Information provided by the SPA to date has been documented below.

5.3.2 Technical/Engineering feasibility

The SPA has contacted the Federal government and State and Territory jurisdictions, seeking possible locations for disposal of the restricted solid waste.

South Australia is yet to respond to the SPA. The responses from other states are summarised as follows:

- Victoria: The Environment Protection Authority representative advised that they are still considering the technical information we have provided, but that options are limited.
- Queensland: The Department of Environment and Resource Management advised that there are no facilities in Queensland licensed to accept the waste.
- Northern Territory (NT): Department of Natural Resources, Environment, The Arts and Sport advised that NT legislation expressly prohibits the importing of nuclear waste, and the construction or operation of nuclear waste storage facilities. (The restricted solid waste at the Site is not however, nuclear waste).

- Western Australia (WA): Two waste facilities exist which are licensed to accept waste with low levels of radiation. These are:
  - Red Hill in eastern Perth operated by Eastern Metropolitan Regional Council. At this stage, it appears that overall threshold levels for radioactivity in the licence conditions are lower than the radioactivity of the waste from Hunters Hill. However the ultimate authority on acceptance is the WA Radiological Council, and the SPA has provided the necessary technical information for their review.
  - Mount Walton East, which is 480km northeast of Perth, and managed by a division of the WA Department of Treasury and Finance. The facility is licensed to accept low-level radioactive materials, but the acceptance criteria, which are described in a ministerial statement, state that: "only waste generated in Western Australia shall be accepted for disposal at the facility".

The SPA is pursuing a number of these options with other states but, at this stage, none appears likely to be successful.

There is currently no national repository for the disposal of wastes of the type present at the Hunters Hill Site. While the federal government has undertaken several rounds of investigations into feasible sites for the disposal of low level radiological material, no preferred site appears to have been identified. There are indications that attempts to establish a national facility have recently regained momentum, with the tabling of the *National Radioactive Waste Management Bill 2010*, however there is no publicly available timetable for the establishment of such a facility.

The source of the restricted solid waste is Radium Hill, in South Australia (SA). The Radium Hill mine site has closed and is under rehabilitation and management by the Department of Primary Industry and Resources SA (PIRSA). The Radium Hill site has been used for the disposal of low level radioactive materials in the past, as recently as 1998 (PIRSA 2010), including wastes from the remediation of the Dry Creek, SA radium refinery. It is not known whether the SA government would permit the return of the waste from Hunters Hill to a cell within the Radium Hill site.

Under the assumption that a suitable interstate disposal site could be found, this option would most likely be technically feasible, with the key consideration being loading and securing the waste for the long haul to an interstate destination.

5.3.3 Regulations and approvals

The planning approval process currently underway for the remediation project (Part 3A Environmental Assessment), would be suitable for the remediation activities at the Site. The Environmental Assessment would need to document the applicable licence/permit requirements for transporting the waste interstate and confirm all regulatory requirements were being adhered to (see below).

Additional planning approvals required in the State receiving the restricted solid waste would be subject to the relevant State, territory and Federal legislation requirements.
The complexity of this process could be high and timeframes to complete necessary steps could be long. It is likely that other federal and state-specific licensing and permit arrangements would also have to be put in place for the transportation of the waste across state boundaries and for its final disposal.

5.3.4 Government policies and directives

Disposal of waste in an appropriately approved interstate facility or landfill would be generally consistent with DECCW remediation policy and ARPANSA guidance.

5.3.5 Environmental impacts

Environmental impacts associated with the disposal of the waste are anticipated to be readily manageable and acceptable, given the waste would be disposed at an existing facility and managed in accordance with local regulations. Transportation of the waste long distances would be relatively energy-intensive, and presents opportunities for incidents such as accidental loss of containment.

Long term management of the waste would be conducted by the landfill /facility operator as part of management of the wider landfill facility, with monitoring and management equipment and resources in place, along with security arrangements. Risks of uncontrolled releases or exposures at the facility are considered to be low.

5.3.6 Health impacts

The Site will be cleaned up to achieve radiation levels at or near background, benefitting local residents and future Site users.

Health impacts to workers at the disposal site and the local community around the disposal site are likely to be minimal, given that the waste would be disposed at an existing facility and managed in accordance with local regulations.

5.3.7 Community issues

SPA has indicated that the Hunters Hill community would respond favourably to a solution which removed all of the waste from the Site. Attitudes of the community in the vicinity of any interstate disposal location are not known. As the disposal site would be an existing facility approved for the acceptance of waste like that present at the Hunters Hill Site, significant community objections are considered unlikely, however, some objections may be encountered.

5.3.8 Impacts on Site use

The Site would be clean and suitable for future residential uses.

5.3.9 Impacts on future use of the disposal location

As the disposal site would likely be an already established facility, this solution is not anticipated to pose any additional real constraints on surrounding land use.

5.3.10 Time

It is estimated that, with this option, remediation could be completed within one to three years, assuming an appropriate site can be located.

5.3.11 Costs

Costs would be associated with transportation and disposal fees, with no ongoing management or monitoring fees. Costs are anticipated to be high.

5.3.12 Summary

The key findings associated with this option can be summarised as follows:

Advantages

- The Site would be clean and suitable for residential use.
- There would be minimal associated environmental and health impacts.
- The disposal method is consistent with government policy and guidance.
- Long term management arrangements would already be in place.

Disadvantages

- It is likely to be challenging to find a suitable landfill / facility.
- Planning and interstate approvals are needed for disposal interstate.

5.4 Option 4: Disposal at the SITA landfill

5.4.1 Description

This option comprises disposal of the restricted solid waste at the licensed SITA landfill located at Elizabeth Drive, Kemps Creek, approximately 41 km west of the Sydney CBD.

5.4.2 Technical/Engineering feasibility

This option is considered to be a technically straightforward and feasible solution, with no engineering or technical constraints identified.

According to SITA representatives, the waste would be placed in a cell designed to receive restricted solid waste, co-disposed with restricted waste from other sources. The cells have a triple liner system, comprising clay, a geosynthetic clay liner and high density polyethylene (HDPE), with leachate detection and control systems. Radon gas generated from the waste would be dispersed through natural diffusion.

5.4.3 Regulations and approvals

The SITA landfill is the only landfill currently licensed to accept restricted solid waste in NSW.

As such, disposal of waste at this location is allowable under the existing regulatory regime. Under this scenario, the process for obtaining planning approval for the remediation project would proceed on its current trajectory, with completion and submittal of the environmental assessment, and determination by the NSW Department of Planning under Part 3A of the NSW *Environmental Planning and Assessment Act 1979.*

No additional planning approvals or licence amendments would be required.

5.4.4 Government policies and directives

This option was ruled out by the NSW Premier in a public announcement on October 24, 2010, and as such is not consistent with a current state government directive.

From a remediation policy perspective however, disposal at the SITA landfill, while not currently a “preferred” solution, would be considered acceptable.

This option is consistent with ARPANSA best practice guidance (ARPANSA 2008a).

5.4.5 Environmental impacts

The main environmental impacts would comprise short term impacts on traffic. Environmental impacts at the SITA landfill (including dust, emission of radon, potential for leachate generation and migration) should be easily mitigated within the already controlled landfill area, in accordance with licence conditions, and any residual impacts are likely to be minimal and acceptable

Risks of uncontrolled releases or exposures at the landfill are considered to be low. During transportation, there is a low risk of accidental release of dust or loss of containment. These risks would be minimised by standard controls and precautions, and considering the relatively short distance of travel, would most likely be minimal and acceptable.

5.4.6 Health impacts

The Site will be cleaned up to achieve radiation levels at or near background, benefitting local residents and future Site users.

Workers at the SITA landfill would employ occupational health and safety measures to ensure exposure to radiation in soils is minimised to acceptable levels. SITA has completed a risk assessment to establish health and safety protocols which would be implemented for handling and management of the waste.

5.4.7 Community issues

SPA has indicated that the Hunters Hill community would respond favourably to a solution which removed all of the waste from the Site.

Some residents and community groups in the Mulgoa area have publicly indicated their objections to disposal of the waste at the SITA landfill.

5.4.8 Impacts on Site use

The Site would be clean and suitable for future residential uses.

5.4.9 Impacts on future use of the disposal location

Long term management of the waste would be conducted by SITA as part of management of the wider landfill facility, with monitoring and management equipment and resources in place, along with security arrangements.

As the disposal site is already an operating restricted waste landfill, this solution is not anticipated to pose any additional constraints on future land use at or surrounding the SITA landfill.

5.4.10 Time

It is estimated that the Site could be remediated and the waste could be disposed of within approximately one year.

5.4.11 Cost

Costs would be associated with transportation and disposal fees, with no ongoing management or monitoring fees. This option is estimated to have the lowest cost, when compared to other options presented in this report.

5.4.12 Summary

The key findings associated with this option can be summarised as follows:

Advantages

- The Site would be clean and suitable for residential use.
- There would be minimal associated environmental and health impacts.
- Long term management arrangements are already in place.
- It would be a relatively fast and cost-effective solution.

Constraints / disadvantages

- It is not consistent with a current NSW government directive.
- There have been objections from the Mulgoa community.

5.5 Option 5: Disposal overseas

5.5.1 Description

This option involves the export of waste overseas for disposal.

The SPA has engaged the existing remediation contractors Enviropacific Services to investigate possible overseas disposal options. At the time of writing, Enviropacific's investigations are underway but not completed. Information provided by the SPA to date has been documented below.

5.5.2 Technical/Engineering feasibility

This option would be relatively straightforward, involving the placement of waste into containers appropriate for shipping and disposal, local transportation to Port Botany, shipping to the destination country, and local transportation to the disposal facility.

An initial disposal option identified in South Korea has been ruled out by the South Korean government. Other options, particularly in the United States of America, are under investigation.

PB could not find any precedent for the overseas disposal of wastes similar to the type present at the Hunters Hill Site.

5.5.3 Regulations and approvals

International conventions, Australian regulations, and the likely regulations of any receiving nation will make for a complex and time consuming approval process.

The Basel Convention (to which Australia is a signatory) states:

"that hazardous wastes and other wastes should, as far as is compatible with environmentally sound and efficient management, be disposed of in the State where they were generated."

Options are available for the management of the waste within Australia, which may decrease the chances of obtaining approval for overseas disposal.

Notwithstanding the Basel Convention, the Commonwealth Department of Sustainability, Environment, Water, Population and Communities advised SPA that the export of the restricted solid waste from the Hunters Hill Site would not be covered by regulations relating to either hazardous waste or radioactive waste (as the activity level is below threshold levels). This may mean that if a willing overseas disposal option were identified, export licences may not be necessary.

Even if the necessary approvals are obtained, there is a real risk that media attention, and community and political pressure in the destination country could result in approvals being later revoked or postponed (as was recently the case with the Danish government's decision to postpone acceptance of hexachlorobenzene waste from Orica's Botany site, despite an earlier approval (SMH, 2010)).

It is anticipated that the approvals process for this option could significantly delay the commencement of remediation at the Site, as planning approval for Site remediation would not be granted until a viable and approved destination for the waste had been identified.

5.5.4 Government policies and directives

Export is not a solution advocated by ARPANSA.

From a remediation policy perspective, disposal at an approved facility, while not a 'preferred' solution, would be considered acceptable.

5.5.5 Environmental impacts

The main environmental impacts would comprise short term impacts on traffic in the vicinity of the Site and disposal location.

Transportation of the waste long distances would be relatively energy-intensive.

Environmental impacts at the disposal site should be easily mitigated within an already controlled disposal area and existing monitoring and management regime. Any residual impacts are likely to be minimal and acceptable.

Risks of uncontrolled releases or exposures at the disposal location are considered to be low. During transportation, there is a risk of accidental release of dust or loss of containment, due to the number of times the waste will need to be handled, and the distance of travel. However, these risks would be minimised by standard controls and precautions, and would most likely be minimal and acceptable.

5.5.6 Health impacts

The Site will be cleaned up to achieve radiation levels at or near background, benefitting local residents and future Site users.

Health impacts to workers at the disposal site and the local community around the disposal site are likely to be minimal, given that the waste would be disposed at an existing facility and managed in accordance with local regulations.

5.5.7 Community issues

The SPA has indicated that the Hunters Hill community would respond favourably to a solution which removed all of the waste from the Site.

Community attitudes to this option are not known. It is likely that some form of community objection to this option would be encountered.

The approvals process and (if successful) export will attract media attention, as has been the case with the intended export of waste from the Orica Botany site.

5.5.8 Impacts on Site use

The Site would be clean and suitable for future residential use.

5.5.9 Impacts on future use of the disposal location

Long term management of the waste would be conducted by the disposal facility, with monitoring and management equipment and resources in place, along with security arrangements.

As the disposal facility is already accepting waste of the type present at the Hunters Hill Site, this solution is not anticipated to pose any additional constraints on future land use at or surrounding the disposal facility.

5.5.10 Time

It is estimated that this solution could be completed within approximately two to four years, with uncertainty around the time it would take to find an appropriate disposal facility, and complete all approvals.

5.5.11 Cost

Costs associated with obtaining approvals, transportation, and disposal fees are anticipated to be high.

5.5.12 Summary

The key findings of this option can be summarised as follows:

Advantages

- The Site would be clean and suitable for residential use.
- Long term management arrangements are already in place.

Constraints / disadvantages

- It is likely to be challenging to find an overseas government willing to accept the waste.
- The approvals process will be time consuming and complex, with success uncertain.
- Uncertainties associated with obtaining permission to export and dispose the waste overseas will impact the planning approval process for the remediation of the Site.
- Media attention and community objections are likely.

6. Evaluation of the Temporary Storage Option

The temporary offsite storage option is illustrated in Figure 6-1 and discussed below.

Figure 6.1 Flowchart for temporary offsite storage

6.1 Option 6: Temporary storage

6.1.1 Description

This option involves the excavation of the restricted solid waste, placement in containers suitable for temporary storage, and transportation to a facility in NSW which is appropriate for temporary storage. The waste would be stored until a national waste repository has been constructed, at which time it will be transported to the national facility.

The main risk associated with this option is that a national repository may not be established for many years, and even if established, is not guaranteed to accept the waste. The most recent consideration of potential sites for a national repository focussed on possibilities in the Northern Territory (NT) (for example at Muckaty Station). It is likely that any future national repository would be located in the NT. For this reason, a temporary storage facility would be best located near good road or rail access between Sydney and the NT.

6.1.2 Technical/Engineering feasibility

Establishment of a temporary storage facility would require some specialist design and input, and would likely need to include features outlined in ARPANSA guidance (2008b, discussed in Appendix C). There are no obvious engineering or technical constraints to the design or construction of such a facility.

The temporary facility could be a purpose-built or retrofit existing warehouse. Storage containers appropriate for transportation, storage and disposal may have to specially designed or modified, and practicalities around loading the containers would need to be factored into the remediation work schedule.

6.1.3 Regulations and approvals

The planning approval process currently underway for the remediation project (Part 3A Environmental Assessment) would be suitable for the remediation activities at the Site.

The Environmental Assessment would need to document the applicable licence/permit requirements for transporting the waste to the storage site and storing the waste at the site. Completion of the Environmental Assessment would be dependent on all regulatory requirements being completed.

Depending on the existing development consent for the storage location, a separate planning approval process may be required for the facility to allow for it to receive and store the waste.

Under the POEO Act an environmental protection licence is required for scheduled activities listed in Schedule 1 of the Act. The disposal or interim storage of the waste would likely constitute a Schedule 1 activity requiring licensing. Depending on the existing use of the facility and its current licensing framework, changes to the existing licences or a new licence may need to be applied for.

6.1.4 Government policies and directives

The temporary storage of waste would be consistent with ARPANSA guidance.
Long term/indefinite storage of waste would not be consistent with ARPANSA guidance or ecologically sustainable development principles (namely inter-generational equity) which are taken into consideration by the Department of Planning when determining project applications.

6.1.5 Environmental impacts

Environmental impacts associated with the construction of the temporary storage facility would likely be minimal and easy to mitigate. A temporary storage facility would be appropriately sited, have controls in place, and operate in accordance with planning approvals and licence conditions, to prevent unacceptable environmental impacts.

Transportation to a storage facility and (eventually) remote disposal location would be energy-intensive. The possibility that, if a national waste repository is not developed, the waste will be stored indefinitely, would not promote intergenerational equity.

Robust funding and governance arrangements for ongoing management and future transportation and disposal to a national repository would help ensure that environmental risks are minimised.

6.1.6 Health impacts

The Site will be cleaned up to achieve radiation levels at or near background, benefitting local residents and future Site users.

Health impacts to workers at the temporary storage facility and the local community around the temporary storage facility are likely to be minimal, given that the temporary storage facility would be appropriately sited, have controls in place, and operate in accordance with planning approvals and licence conditions.

6.1.7 Community issues

The SPA has indicated that the Hunters Hill community would respond favourably to a solution which removed all of the waste from the Site.

Attitudes of the community in the vicinity of any temporary storage location are not known, however some form of community objection is likely.

6.1.8 Impacts on Site use

The Site would be clean and suitable for future residential uses.

6.1.9 Impacts on future use of the storage location

There will be ongoing maintenance and management requirements at the temporary storage facility.

Assuming the temporary storage facility is located in an industrial area with adequate controls, this solution is not anticipated to pose any additional real constraints on future use of the storage site.

6.1.10 Time

It is estimated that, with this option, remediation could be completed within approximately two to three years, assuming an appropriate site can be located.

6.1.11 Cost

Costs for the approvals, design and construction of the storage facility, and transportation to the facility are anticipated to be moderate.

Costs for transportation and ultimate disposal at any future national repository are not known and cannot be estimated at this stage.

6.1.12 Summary

The key findings associated with this option can be summarised as follows:

Advantages

- The Site would be clean and suitable for residential use.
- There would be minimal potential risks to workers, the community and the environment.
- An existing government property (such as a warehouse) could be retro-fitted for this purpose.

Disadvantages / Constraints

- A suitable site would need to be found.

- DECCW approval would be needed for the storage facility.
- It defers a final solution so does not comply with the principle of intergenerational equity.
- There is a risk that a national repository may not proceed or accept the waste. There is also no clear timeframe for a national depository.
- Long term inspection and maintenance would be required.

7. Evaluation of Treatment Options

The flowchart provided as Figure 7-1 indicates a typical treatment scenario.

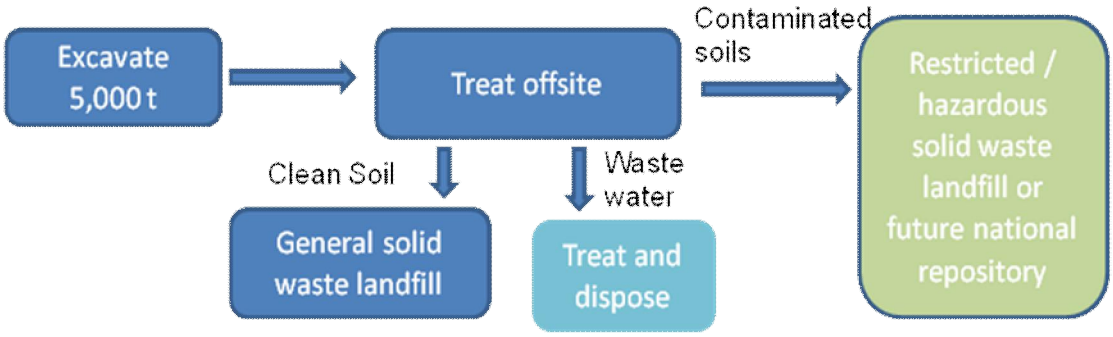

Figure 7.1 Flowchart indicating a typical treatment process

7.1 Option 7: Treatment of waste

7.1.1 Description

Options for the treatment of the restricted solid waste are relatively limited. In general, wastes with radiological properties are managed through the following approaches:

- Dilute and disperse; or
- Concentrate and retain (ARPANSA 2010).

These options are discussed and evaluated below.

7.1.2 Technical/engineering feasibility

In the case of the restricted solid waste from the Hunters Hill Site, the “dilute and disperse” option would require the addition of a substantial quantity of clean soil or cement to reduce the activity to levels which would be appropriate for disposal as general solid waste. Dilution as a remediation solution at Hunters Hill has been publicly ruled out by DECCW, in their representation to the Legislative Council General Purpose Standing Committee No. 5 (2008) that dilution of the material was not an acceptable way of complying with the standards. This option is not feasible, and has not been evaluated here.

Conceptually, the “concentrate and retain” (or treatment) option for the restricted solid waste comprises treating the soil to reduce the quantity of contaminated soil requiring specialized disposal and enable disposal of the clean soil as general solid waste in a municipal landfill.

Feasible treatment technologies for soils with radiological properties similar to the restricted solid waste at the Site comprise segregation and sorting, followed by soil washing.
These processes are described in more detail in Appendix D. Other emerging technologies have also been discussed and evaluated in Appendix D.

Before full-scale soil washing could be undertaken on the restricted solid waste from the Site, treatability tests would be necessary to determine whether treatment would be effective, and which washing agents, if any, should be used.

In the event that the waste was amenable to soil washing, PB has not been able to identify any commercial soil washing plants currently operating in Australia, so to undertake soil washing, a temporary mobile plant would have to be imported from overseas. The treatment facility would likely be established at on offsite location, as the dust and noise and wastewater generated, and the space limitations at the Site would make on-Site treatment difficult. Once established offsite, soil would be processed, and segregated into clean soil (suitable for disposal as general solid waste) and contaminated soil requiring disposal. Wastewater would also be generated, and would have to be treated and disposed of appropriately.

Assuming that the volume of contaminated soil is successfully reduced by 90%, 4,500 tonnes of clean soil could be disposed as general solid waste and approximately 500 tonnes of contaminated soil would still need to be disposed. Notably, the activity level of the contaminated soil would be increased, such that the waste would either still need to be disposed as restricted solid waste, or may need to be disposed as hazardous waste (and meet the definition of a “radioactive substance”) due to its increased radioactivity.

Treatment of the waste, as a stand-alone solution will therefore not achieve the project objectives, and is not considered technically feasible.

7.1.3 Regulations and approvals

Planning approval for the remediation project would proceed on its current path, but would not be approved until a license was in place permitting the temporary treatment plant.

Depending on the specifics of the treatment facility, planning approval for it would either be required under Part 3A or Part 4 of the EP&A Act. Under Part 3A an Environmental Assessment would be required to be prepared for the facility to satisfy the Director General’s Requirements issued for the project. Under Part 4 of the EP&A Act an Environmental Impact Statement (EIS) would be required to be prepared for the facility.

The treatment of the waste at an interim treatment location would likely constitute a Schedule 1 activity requiring licensing by DECCW under the *Protection of the Environment Operations Act 1997*.

7.1.4 Government policies and directives

From a remediation policy perspective, although treatment is considered a preferred option, complete treatment of the restricted solid waste from the Site is not feasible.

This option is not consistent with ARPANSA best practice guidance (ARPANSA 2008).

7.1.5 Environmental impacts

Environmental issues associated with the operation of the treatment plant include noise, wastewater management, dust and traffic. The treatment process will consume large quantities of energy and water. When properly designed, constructed, and operated, soil washing is a safe remediation technology that has been used extensively around the world. Environmental monitoring conducted during remediation would provide a safeguard against any uncontrolled released of air-borne emissions. Nonetheless, environmental monitoring would require a higher level of control for this option when compared to other options.

Environmental risks associated with the concentrated waste, would be greater, as the waste would contain higher levels of radioactivity. Environmental impacts would be dependent on where and how the concentrated waste is ultimately disposed.

7.1.6 Health impacts

For workers at the treatment facility, occupational health and safety controls and monitoring would prevent unacceptable risks to worker health.

Potential health risks associated with the concentrated waste, would be greater, as the waste would contain higher levels of radioactivity. Health risks would be dependent on where and how the concentrated waste is ultimately disposed.

7.1.7 Community issues

Treatment does not offer a complete solution, as the concentrated waste would still need to be disposed. Attitudes of the community to increasing the level of radioactivity present in the waste are not known, but some objection is likely, depending on how and where the waste is ultimately disposed.

7.1.8 Impacts on Site uses

The Site would be clean and suitable for future residential uses.

7.1.9 Impacts on future use of the treatment location

Assuming the temporary treatment facility is located in an industrial area with adequate controls, this solution is not anticipated to pose any additional real constraints on surrounding land use.

7.1.10 Time

It is estimated that, with this option, treatment could be completed within two to three years. Additional time may be required to resolve the issue of where and how to dispose of the concentrated waste.

7.1.11 Cost

Costs will include costs for treatability studies, treatment, disposal of treated soil as municipal solid waste, and disposal of the concentrated restricted or hazardous waste soil, and are anticipated to be high.

7.1.12 Summary

The key findings associated with this option can be summarised as follows:

Advantages

- The Site would be clean and suitable for residential use.

Disadvantages / Constraints

- The problem is not solved, as treated waste would still need a disposal location.
- The concentrated waste would likely be classified as a hazardous and a radioactive substance.
- There is no current treatment facility, so a bespoke facility would be imported, requiring approvals and delays.
- There would be more potential impacts on the environment and community (higher radioactivity, wastewater).
- The costs of implementing this option would be high.

8. Evaluation of the on-site encapsulation option

The onsite encapsulation option is illustrated in Figure 8-1 and discussed below.

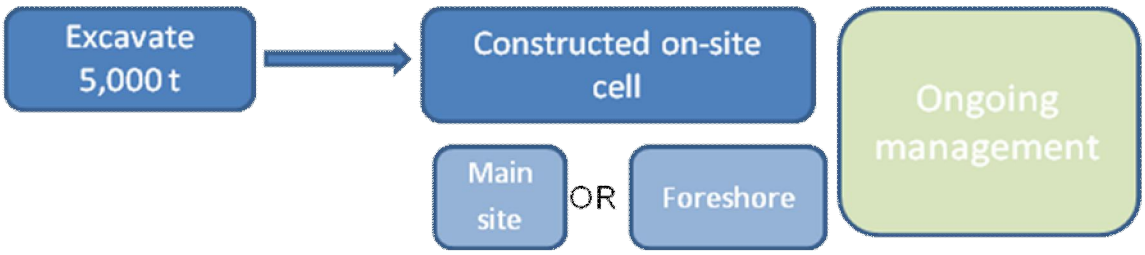

Figure 8.1 Flowchart illustrating the encapsulation option

8.1 Option 8: Onsite encapsulation

8.1.1 Description

On-site encapsulation essentially isolates the restricted solid waste such that exposure pathways to potential receptors are eliminated. At the Site, the encapsulation option would comprise permanent storage of the soils in an underground or above ground concrete vault, either on the main portion of the Site, or on the foreshore area.

8.1.2 Technical/Engineering feasibility

Some Australian and international examples exist of low level radioactive materials being collected and sealed in containers, buried in engineered trenches or concrete vaults, and covered with a closure cap to prevent infiltration into the underground disposal area. While the radioactive waste, in many instances, is packed in drums, casks, special boxes or other sealed containers prior to burial, very low activity wastes (materials slightly above natural background levels posing lower risks) are often disposed directly into an engineered cell without a container. The engineered cell would still be capped with a low permeability material such as concrete to minimise infiltration of liquids, promote drainage, minimise erosion, and accommodate settling/subsidence. A liner system with specifications to consider materials, minimum thicknesses, conductivity, physical strength, and chemical resistance should be constructed below the containment cell. A leachate collection and management system should also be considered.

The containment structure must demonstrate the ability to limit radiation exposure to potential receptors, and provide mitigation measures for surface infiltration as well as leachate generation. Any potential radon gas generated from storage/encapsulation of the waste would need to also be collected and vented to an appropriate outlet point on the property.

An alternative encapsulation method, although not typically encountered overseas, is above-ground containment in concrete vaults. The advantages of the above-ground containment approach include ready access for maintenance and inspection, the ability to store large volumes of waste.

In a search for comparable case studies, no examples of permanent encapsulation of radioactive soils in a residential setting have been identified by PB.

At the Site, assuming a total mass of 5,000 tonnes of low level radioactive waste requiring on-site encapsulation, and an average bulk soil density factor of 1.6-1.7 grams per cubic centimetre (g/cm^3), a volume of approximately 3,000 m^3 of contaminated soil would need to be available within the encapsulation facility. The size of the foreshore parcels (approximately 500 m^2) will be insufficient to accommodate this volume of encapsulated waste underground, without constructing the containment cell below the water table (as there is less than 5 metres freeboard from the surface of foreshore to the inferred groundwater table, less when considering future sea level rise).

The encapsulation would therefore have to be undertaken either aboveground at the foreshore; below ground on the main portion of the Site; or aboveground on the main portion of the Site.

On the main portion of the Site, only minimal soil cover overlies the natural sandstone bedrock, so an underground containment cell would have to be excavated into the sandstone up to a depth of 3-4 metres. PB understands that available and accessible siting locations may be constrained by an existing sewer line as well as the need to maintain a geotechnically safe working distance from existing cliff lines to prevent undermining stability of the cliff line.

Above-ground encapsulation on the main Site and the foreshore would also pose some constructability constraints, and involve stockpiling of soils at the Site.

Engineering and environmental studies will be required to assess the suitability of the Site. Potential impacts of events such storms, earthquakes, sea level rise, and other climate change factors will need to be considered.

All of the options, though very complex, are considered technically feasible to construct.

The challenging aspect of the encapsulation option is the need to maintain the integrity of the structure for hundreds of years, due to the long half-lives of the main radionuclides.

The 1987 SKP Review of Environmental Factors (SKP 1987) suggested that above-ground containment represented the optimal method when considering environmentally and socially preferred solutions. SKP provided conceptual design plans for four concrete cylinders (silos) at the base of the foreshore properties, extending 7 metres in height up to the top of the cliff line. An alternative design could consider consolidation of the silos into a single containment unit (vault) rising to the top of and mirroring the shape of the cliff line. As indicated above, the siting of such a structure would need to consider climate change induced sea level rise (predicted to be 0.9 m higher than 1990 levels by 2100).

8.1.3 Regulations and approvals

The current planning approval for project (Part 3A Environmental Assessment) would need to be expanded to gain approval for encapsulation activities. Additional specialist studies/expansions of current specialist scopes would need to occur.

DECCW has indicated that a licence would not be required for the encapsulation cell, however this advice will need to be confirmed.

8.1.4 Government policies and directives

Based on DECCW's hierarchy of preferred options for site remediation and management, on-site containment of the soil appears to be the least desirable remediation approach.

Although this solution could be considered a form of "near surface disposal", an approach which is suggested by ARPANSA (2008a), one of the suggested key criteria for siting such a facility is the recommendation that it be located in an area of low population density (NHMRC 1993), which the Site is not.

8.1.5 Environmental impacts

Increased localised temporary environmental impacts are likely during the construction phase, as soil will be stockpiled onsite, there will be more potential for dust, additional machinery and materials will be required (involving additional trucks and noise), and the management of stormwater runoff will be more complicated. In the case of installing a subsurface structure on the main portion of the Site, substantial noisy rock breaking and rock removal will be required.

The aboveground options will have aesthetic impacts, when viewed from Parramatta River, however, these could be somewhat mitigated through good design and landscaping.

Post-closure monitoring would need to be designed and implemented, and should continue for as long as the restricted solid waste remains radioactive above background levels. Monitoring would comprise inspection of the integrity and stability of the containment cell as well as monitoring of leachate and ambient air monitoring (on and off-site) for radon emission levels. Ensuring adequate long-term funding for the design life of the containment cell (300 years) will be of key importance in making sure long-term inspection and maintenance is occurring.

8.1.6 Health impacts

The encapsulation / containment cell should include a system to collect and disperse radon gas aboveground, to prevent gas migration to, and accumulation in, surrounding structures.

Workers involved in placing the restricted solid waste in the containment cell will implement occupational health and safety measures to prevent unacceptable impacts to their health.

Assuming the containment cell performed as designed, surrounding residents would not experience health impacts.

Again, ensuring adequate long-term funding for the design life of the containment cell (300 years) will be of key importance in making sure long-term inspection and maintenance is occurring.

8.1.7 Community issues

Based on feedback at community meetings, SPA has advised that the Nelson Parade community would be opposed to on-site encapsulation as a solution. In the opinion of the SPA, the objections arise not out of concern relating to health impacts, but because of the stigma and misperceptions which may impact property values. While attitudes of the wider community to this option are not known, some opposition is likely.

8.1.8 Impacts on Site uses

For encapsulation on the main part of the Site, it will be possible to demonstrate that the encapsulation would not pose health risks to future residents at the Site. However it will be difficult to:

- overcome perceptions and stigma associated with the restricted solid waste remaining on the Site;
- obtain regulatory approvals for residential use at the Site; and
- design a residence which provides for ongoing access to the containment cell.

As such, it is unlikely that the Site could be developed for residential use. Alternative uses could include open space / public parkland.

In the scenario where the encapsulation is placed in the foreshore area, it may be possible to develop the main portion of the Site for residential use, and the remaining portions of the foreshore could potentially be converted to publicly accessible open space.

In both scenarios, a funded inspection and maintenance program will be required to facilitate long-term risk management, and security arrangements would need to be put in place to prevent vandalism and access inside the containment cell.

8.1.9 Impacts on future use of the disposal location

As the restricted solid waste will be placed on-Site, this evaluation criteria has been covered in Section 8.1.8.

8.1.10 Time

It is estimated that, with this option, remediation could be completed within approximately two the three years.

8.1.11 Cost

Costs for this option will include fees for specialist environmental and engineering studies, design services, securing approvals, construction, and ongoing monitoring and maintenance. Costs are anticipated to be high.

8.1.12 Summary

The key findings associated with this option can be summarised as follows:

Advantages

- There would be no off-site transport of the wastes.
- The works could be completed reasonably quickly when compared to most other options (but implementation would be heavily dependent on the timing involved in obtaining approvals).

Constraints / Disadvantages

- It is a technically complex solution.
- There are likely to be community objections.
- Approvals may be more difficult to secure.
- Land use will be restricted, and depending on design, residential use could be precluded.
- This option will affect the resale value of the site.
- Long term management will be needed.

9. Evaluation of the 'Manage-in-place' option

9.1 Option 9: Manage in place

9.1.1 Description

The option involves the removal and appropriate offsite disposal of some of the chemically contaminated restricted solid waste from the foreshore area, with no removal of the radiologically impacted restricted solid waste. Any restricted solid waste that is both chemically and radiologically impacted would remain on-Site.

9.1.2 Technical/Engineering feasibility

This solution would be straightforward to implement, as a basic remediation project involving excavation and landfill disposal.

This option will not achieve the basic project objective, which is remediating the Site to manage human health risks such that the Site will be suitable for residential use.

9.1.3 Regulations and approvals

The current planning process would need to be changed to be applicable only to the removal of the chemically contaminated soil. It is unlikely that this option would obtain planning approval.

No additional approvals or licensing of the Site would likely be required. However land use restrictions, prohibiting residential uses, other structures, and other uses on the site, would have to be put in place. Access restrictions to the site would also need to be put in place.

9.1.4 Government policies and directives

This option would not be consistent with the recommendations of the Legislative Council, General Purpose Standing Committee No 5 Report (2008), which, although not binding, indicates a state government preference for the comprehensive remediation of the Site.

9.1.5 Environmental impacts

During excavation works, the main environmental impacts would comprise short term impacts on traffic. Other potential impacts such as dust and stormwater runoff will be readily mitigated as part of the remediation works.

No significant environmental impacts would be associated with the failure to remove the radiologically impacted soils. Environmental impacts may be associated with leaving chemically contaminated restricted solid waste soils at the Site. Consideration of issues associated with the chemically impacted soils at the Site is outside the scope of this report.

This option would not be consistent with the ecologically sustainable development principle of inter-generational equity as it potentially puts the onus on future generations to find and implement a solution.

9.1.6 Health impacts

Health risks to remediation workers would be mitigated through occupational health and safety practices to prevent and monitor exposure to chemical and radiological contaminants.

The radiologically impacted restricted solid waste will remain on-Site. As no exposure pathways will be addressed by this option, the Site will continue to present existing levels of risk to neighbours.

Periodic monitoring of the Site and surrounds would be conducted to: confirm that soils remaining at the Site continue to pose no unacceptable health risks to neighbours; and identify any incidences of unacceptable risk if and when they arose.

9.1.7 Community issues

As the Nelson Parade community is already frustrated at the lack of progress in remediation work (documented in the Legislative Council, General Purpose Standing Committee No 5 Report (2008)), a solution which fails to address all of the restricted solid waste would likely face objections from the local community.

9.1.8 Impacts on Site uses

The Site would not be suitable for residential use. Ongoing monitoring would be required at, and around the Site. Funding arrangements will need to be established to ensure monitoring will be continue long-term.

9.1.9 Impacts on future use of the disposal location

As the restricted solid waste with radiological properties will remain on-Site, this evaluation criteria has been covered in Section 9.1.8.

9.1.10 Time

If approved, the removal of the chemically contaminated soil could be completed within one year. However, the approval process could substantially delay the remediation, and it is unlikely that planning approval would be granted.

9.1.11 Cost

Costs would comprise fees for excavation and disposal of a portion of the restricted solid waste (likely to be low), and ongoing monitoring costs (likely to be high).

9.1.12 Summary

The key findings associated with this option can be summarised as follows:

Advantages

- There are no advantages.

Constraints / Disadvantages

- The contamination problem is not resolved. Health and environmental issues would be largely unchanged.
- Approvals will be very difficult to secure.
- Significant community objection is anticipated.
- Future Site use would be restricted, and residential use would be precluded.
- Long term management and monitoring will be needed.

10. Evaluation of the 'Do nothing' option

10.1 Option 10: Do nothing

10.1.1 Description

This option entails no action at the Site, which would not achieve the basic project objective, which is remediating the Site to manage human health risks such that the Site will be suitable for residential use.

10.1.2 Technical/Engineering feasibility

There are no technical or engineering constraints associated with this option.

10.1.3 Regulations and approvals

The current planning process would not continue.

An Environment Protection Authority (EPA) declaration of remediation site (Declaration Number 21083; Area Number: 3249) has been issued for the foreshore portion (Lot 1 of 544937 and Lot 1 of DP 641068) of the site under the *Contaminated Land Management Act 1997*. As a result, remediation action is required to address the chemical contamination present at the foreshore and the 'do-nothing' option would not meet regulatory requirements.

10.1.4 Government policies and directives

This option would not be consistent with the recommendations of the Legislative Council, General Purpose Standing Committee No 5 Report (2008), which, although not binding, indicates a state government preference for the comprehensive remediation of the Site.

10.1.5 Environmental impacts

There would be no remediation activity, so no associated environmental impacts.

There would be no changes to the environmental risks associated with the Site.

This option would not be consistent with the ecologically sustainable development principle of inter-generational equity as it puts the onus on future generations to find and implement a solution.

10.1.6 Health impacts

There would be no remediation activity, so no associated health impacts.

There would be no changes to the health risks associated with the Site.

10.1.7 Community issues

As the Nelson Parade community is already frustrated at the lack of progress in remediation work (documented in the Legislative Council, General Purpose Standing Committee No 5 Report (2008)), a solution which fails to address the restricted solid waste would likely face objections from the local community.

10.1.8 Impacts on Site uses

The Site would not be suitable for residential use. Suitability for other uses would have to be evaluated by conducting a health risk assessment. It is likely that the Site would have no appropriate use in its current condition.

10.1.9 Impacts on future use of the disposal location

As the restricted solid waste will remain on-Site, this evaluation criteria has been covered in Section 10.1.8.

10.1.10 Time

No action is proposed.

10.1.11 Cost

No action is proposed, so no remediation cost will be involved. Costs may be associated with the failure to comply with regulatory requirements (for example, fines, legal costs).

10.1.12 Summary

The key findings associated with this option can be summarised as follows:

Advantages

- There are no advantages.

Constraints / Disadvantages

- The problem would not be resolved. Health and environmental issues would be unchanged.
- It does not comply with regulatory requirements.
- Significant community objection is anticipated.

The Site would effectively be sterilised and likely unfit for any use..

11. Summary of findings and conclusions

The findings of PB's initial options review are summarised graphically in Table 11-1.

As indicated in Table 11-1, there appear to be no simple solution to the management and/or disposal of restricted solid waste at the Site. However, several of the options have sufficient merit to warrant further consideration.

In conclusion:

- Although it does not comply with the NSW Government's October 2010 announcement, the SITA Elizabeth Drive Landfill represents the best disposal option for the restricted waste.
- The following options are feasible , but more detailed assessments need to be carried out to determine the extent to which measures can be put in place to overcome associated environmental, engineering, socio-economic and other issues:
  - Disposal to an interstate landfill.
  - Encapsulation on-Site.
  - Disposal to a monocell within an existing NSW landfill.
- The following options are very complex, with significant time and cost implications and low chances of success. However, these options could be considered in more detail if further assessment of the above options show that they would not be suitable:
  - Overseas disposal.
  - Disposal to a purpose-built facility in NSW.
- The following options do not warrant further consideration at this time:
  - Temporary off-Site storage.
  - Treatment.
  - Manage in place.
  - Do nothing.

Table 11.1 Summary of Options Evaluation

Option	Technical and engineering feasibility	Regulations and approvals	Consistency with government policy and directives	Environmental Impacts	Health Impacts	Community issues	Impacts on Site use	Impacts on future use of the disposal site	Time (years)	Estimated cost range (2)		Further consideration of option recommended
										Construction, transport, disposal costs	Ongoing management costs	
1. Disposal to a NSW landfill	Complex solution. Requires environmental and engineering studies, design and construction of dedicated monocell	Landfill licence amendment required. Delays to planning approval for the remediation	Consistent with government policies and directives	Few environmental impacts, easily managed and mitigated. Long term monitoring required at landfill	Minimal health risks, easily mitigated. Long term monitoring required at landfill	Unknown, but some community objection likely	Site can be developed for residential use	Long term monitoring required. May impact post-closure use of landfill site	2 – 3 May be longer if problems finding a landfill	Moderate to high	Moderate	Yes
2. Disposal at a purpose-built facility (eg. derelict mine, Crown land)	Complex solution. Site selection will be onerous. Requires environmental and engineering studies, design and construction of a dedicated facility	The disposal facility will require planning approval and a licence from DECCW. Delays to planning approval for the remediation	Consistent with government policies and directives	Assuming good site selection and controls, few environmental impacts, easily managed and mitigated. Long term monitoring required.	Assuming good site selection and controls, few health impacts, easily managed and mitigated. Long term monitoring required.	Unknown, but some community objection likely	Site can be developed for residential use	Long term monitoring required. May impact future use of the disposal site	3 - 5 May be longer if problems with site selection and approvals	High	High	No
3. Disposal at a Commonwealth or interstate landfill	No current Cwth landfill. No interstate landfill found yet. SPA investigations ongoing. If a disposal location is found, technically straightforward	Interstate approvals will be needed for disposal. A permit / licence may be needed for movement of waste across State borders. Delays to the planning approval for the remediation	Consistent with government policies and directives	Few environmental impacts, easily managed and mitigated. Transportation will be energy-intensive Long term monitoring required at landfill	Minimal health risks, easily mitigated. Long term monitoring required at landfill	Unknown, but some community objection likely	Site can be developed for residential use	Long term monitoring required. No impact on the post-closure use of the disposal site	1 – 3 Assuming a disposal and willing State government can be found	High	None	Yes
4. Disposal to SITA landfill	Easy solution to implement	Straightforward approvals process. No additional licensing required. No delay to the planning approval for the remediation	Not consistent with Premier's decision	Few environmental impacts, easily managed and mitigated. Long term monitoring required at landfill	Minimal health risks, easily mitigated. Long term monitoring required at landfill	Objection within the Mulgoa local community	Site can be developed for residential use	Long term monitoring required. Minimal impact on the post-closure use of the disposal site	1 year	Low	None	No

Option	Technical and engineering feasibility	Regulations and approvals	Consistency with government policy and directives	Environmental Impacts	Health Impacts	Community issues	Impacts on Site use	Impacts on future use of the disposal site	Time (years)	Estimated cost range (2)		Further consideration of option recommended
										Construction, transport, disposal costs	Ongoing management costs	
5. Disposal overseas	If an overseas disposal site can be found, this is technically straightforward	Complex approvals process. Approvals needed from the Federal government and the receiving country's government. Low chance of success in obtaining approvals. The receiving government may change its mind (as with Orica). Significant delays to the planning approval for the remediation	Generally consistent	Few environmental impacts, easily managed and mitigated. Transport is energy-intensive Long term monitoring required at disposal site	Minimal health risks, easily mitigated. Long term monitoring required at disposal site.	Unknown, but some community objection likely. Media attention likely	Site can be developed for residential use	Long term monitoring required. No impact on the post-closure use of the disposal site	2 – 4 Assuming a disposal site is found and approvals are obtained	High	None	Yes
6. Temporary off-Site storage Pending disposal to a future national centralised waste repository	Technically straightforward. Significant uncertainty with if or when a national repository will be built, for long-term disposal of the waste	Planning approval may be needed for the temporary storage location. A DECCW licence may be needed. Delays to the planning approval for the remediation	Consistent with government policies and directives, assuming the national repository is built	Few environmental impacts, easily managed and mitigated. Monitoring required at storage site.	Few health impacts, easily managed and mitigated. Monitoring required at storage site.	Unknown, but some community objection likely.	Site can be developed for residential use	Monitoring required. No impact on the post-closure use of the temporary storage facility	2 – 3 Assuming an appropriate storage site can be found	Moderate	High (including transport to, and disposal at, a national respository) Funding arrangement needed to secure final disposal	No
7. Treatment	Technically complex, with significant treatability studies needed. Treatment will reduce the quantity of waste, but increase the radioactivity. Does not solve the problem	Planning approval and DECCW licence required for the treatment facility. Delays to the planning approval for the remediation.	Not consistent with policies or guidance	At the treatment facility, there may be some environmental impacts requiring a moderate level of effort for management / mitigation. Higher environmental risk associated with need to manage / disposal of waste with higher radioactivity.	Minimal health risks, easily mitigated. Higher health risks associated with need to manage / disposal of waste with higher radioactivity.	Unknown, but some community objection likely, particularly around treatment facility and ultimate disposal location	Site can be developed for residential use	No impact on the post-closure use of the temporary treatment facility	2 – 3 May be longer, depending on how and where waste is disposed	High	Likely high, but dependent on how and where waste is disposed	No

Option	Technical and engineering feasibility	Regulations and approvals	Consistency with government policy and directives	Environmental Impacts	Health Impacts	Community issues	Impacts on Site use	Impacts on future use of the disposal site	Time (years)	Estimated cost range (2)		Further consideration of option recommended
										Construction, transport, disposal costs	Ongoing management costs	
8. On-Site encapsulation	Technically complex, but possible	Additional studies needed for planning approval for the remediation	Not a preferred approach, but not precluded	During construction, there will be some environmental impacts requiring a moderate level of effort for management / mitigation. Long term monitoring will be required	Minimal health risks, easily mitigated. Long term monitoring will be required	The local (Nelson Parade) community is opposed to this option, based on impacts on property values	Residential use may be possible if waste is encapsulated aboveground in the foreshore area Long term monitoring, security and access will be required	Not applicable	2 - 3	High	High. Funding arrangement needed for ongoing monitoring	Yes
9. Manage in place	Straightforward, but will not achieve project objective	Small amendment to planning approval application. Unlikely to be approved.	Not consistent with recommendations of the Parliamentary Inquiry	Some environmental impacts requiring a moderate level of effort for management / mitigation. Long term monitoring will be required	No significant change to health risks Long term monitoring will be required	Likely that the local (Nelson Parade) community would be opposed to this option	Residential use not possible. Long term monitoring will be required	Not applicable	1	Low	High Funding arrangement needed for ongoing monitoring	No
10. Do nothing	No action. Will not achieve project objective	Current planning approval process would be stopped Remediation of the foreshore is a regulatory requirement. This option would not comply.	Not consistent with recommendations of the Parliamentary Inquiry	No change to environmental risks associated with the Site	No change to health risks associated with the Site	Likely that the local (Nelson Parade) community would be opposed to this option	Residential use not possible.	Not applicable	None	Failure to comply with regulatory requirements may have cost implications	None	No

12. Recommendations

PB recommends that the following further actions and investigations be implemented:

SITA Elizabeth Drive Landfill option:

- Explore whether the NSW Government could reconsider its announcement ruling out this option.

Interstate landfill option:

- Obtain a response from the South Australian government, and explore the possibility of returning the waste to Radium Hill.
- If a likely disposal site is identified:
  - Understand the state's specific approvals process, and any permitting requirements.
  - Determine scope and cost of supporting studies, approvals, transportation, disposal and monitoring.
  - Investigate the extent to which measures can be put in place to adequately manage associated environmental, engineering, socio-economic and other issues.

Encapsulation on Site option:

- Determine scope and cost of supporting studies, approvals, design, construction, disposal and monitoring.
- Investigate the extent to which measures can be put in place to adequately manage associated environmental, engineering, socio-economic and other issues.

NSW landfill monocell option:

- Identify several potentially suitable locations, through direct contact with landfill operators.
- Develop site selection criteria for the landfills/monocells.
- Determine scope and cost of supporting studies, approvals, design, construction, transportation, disposal and monitoring.

Investigate the extent to which measures can be put in place to adequately manage associated environmental, engineering, socio-economic and other issues

13. References

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Appendix A

Scope, assumptions and limitations

Appendix A

Scope, Assumptions and Limitations

Scope

This Options Review has been conducted by PB for the State Property Authority (SPA), in accordance with the scope and methodology outlined in our proposal dated November 9, 2010, which the SPA authorised on November 10, 2010.

Assumptions

- Spoil which will be generated in the remediation of the Site will comprise approximately 5,000 tonnes of soil which has been classified in-situ as restricted solid waste.
- This initial Options Review will focus on material classified as restricted solid waste due to radiological properties, on the assumption that there is a manageable solution for any material with chemical contamination present at the Site.
- Additional radiological and chemical characterization data will be available in a matter of months, as a result of the work which is currently being completed by consultants CH2MHill and ANSTO.
- This initial Options Review recognizes that community and political responses to options are important considerations, and will be addressed in detail at later stages. This Options Review will only document known or likely community and other stakeholder opinions.
- Consideration of transport options is not included at this stage.

Evaluation Criteria

The evaluation criteria used in this review are as follows:

- **Technical and engineering feasibility** – including: whether the option will achieve the project objectives; whether there is sufficient space onsite to accommodate the option; whether there is a track record of success with the option in Australia or overseas; whether suitable equipment / facilities are current availability in Australia; and other technical / constructability constraints as advised by Enviropacific.
- **Regulatory / approval considerations** – including: whether the option is allowable under the current regulatory and approval framework; what additional approvals (if any) would be required; and the likelihood of success in securing any additional approvals, with a focus on planning approvals and the need for licensing by DECCW.
- **Consistency with government policy, guidance and directives** - principally the NSW Premier's directive that the waste cannot be disposed of at the SITA landfill, DECCW's preference hierarchy for the remediation of contaminated land, and ARPANSA guidance.

- **Environmental impacts, risks and management** – including: a high-level assessment of the likely severity of impacts on air quality, water quality, noise, traffic, amenity, and energy and water intensity; the ease with which impacts can be mitigated; and the likely severity of any residual impacts. Impacts associated with transportation, treatment, storage and / or disposal are the focus here, rather than impacts associated with the excavation of soils and reinstatement of the Site. Environmental risks, including consideration of: the risk of uncontrolled releases / accidents; vulnerability to external factors such as geological events and climate change (sea level rise); the level of risk management and mitigation measures required (short and long term), including security arrangements; and whether the solution provide adequate access for long term management.

- **Health risks** – including: a high-level assessment of risks to future occupants, local residents, local communities, remediation workers; the ease with which risks can be mitigated; and the likely severity of any residual risks. Risks associated with transportation, treatment, storage and / or disposal are the focus here, rather than risks associated with the excavation of soils and reinstatement of the Site.

- **Community issues** – including known or likely community attitudes to the option. It is acknowledged that for many of the options, community attitudes have not yet been canvassed or tested.

- **Impacts on the future use of the Site**

- **Impacts on the future use of the disposal location**

- **Costs for management of wastes** – comprising a qualitative indication of costs, relative to the SITA landfill disposal solution, including establishment and ongoing management costs.

- **Likely time-frame to implement the option** – indicative ranges (inclusive of all activities required to complete the remediation, for example securing approvals, selecting sites, conducting trials).

Limitations

Scope of services and reliance of data

This report has been prepared in accordance with the scope of work/services set out in the contract, or as otherwise agreed, between PB and the client. In preparing this report, PB has relied upon data, surveys, analyses, designs, plans and other information provided by the client and other individuals and organisations, most of which are referred to in the report (the data). Except as otherwise stated in the report, PB has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in this report (conclusions) are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. PB will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to PB.

Study for benefit of client

This report has been prepared for the exclusive benefit of the client and no other party. PB assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with in this report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in this report (including without limitation matters arising from any negligent act or omission of PB or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in this report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own inquiries and obtain independent advice in relation to such matters.

Other limitations

To the best of PB's knowledge, the facts and matters described in this report reasonably represent the conditions at the time of printing of the report. However, the passage of time, the manifestation of latent conditions or the impact of future events (including a change in applicable law) may have resulted in a variation to the conditions.

PB will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

Appendix B

Detailed waste description

Appendix B

Detailed Waste Description

Radiological analytical results currently available for soil samples from the Site are summarised in Table A1.

Table B.1 Activity of Radionuclides in Soil

Radionuclide	Mean (Becquerel per gram (Bq/g))	Range (Bq/g)	95% Upper confidence limit Mean Specific Activity (Bq/g)
U-238	3.17	0.25 - 9.0	4.35
Th-230	3.9	0.085 – 14.5	6.71
Ra-226	7.05	0.42 – 30.75	10.12
Pb-210	4.8	0.35 – 15.9	6.59
Ra-228	0.13	0.035 – 2.3	0.38
Th-228	0.11	0.025 – 1.6	0.34

Totals			
Mean		**95% UCL**	
Total specific activity	66.78 Bq/g	Total specific activity	94.52 Bq/g
Total activity ratio	26.98 Bq/kg	Total activity ratio	37.87 Bq/kg
Specific activity ratio	26.96 Bq/g	Specific activity ratio	37.87 Bq/g

Source: Egis 2000a, Egis 2000b

The waste is classified as restricted solid waste under the DECC (2008) Waste Classification Guidelines, Part 3: Waste Containing Radioactive Material, as it has a specific activity ratio greater than 1, and a total activity ratio greater than 1.

The waste is not considered a “radioactive substance” as it does not meet the definition of radioactive substance provided in clause 5 of the NSW *Radiation Control Regulation 2003*, having a specific activity of less than 100 Bq/g, and therefore is not a radioactive waste or a hazardous waste.

Exposure pathways which should be considered in the evaluation of options for the management and disposal of wastes of the type present at the Site are (ARPANSA 2008):

- Inhalation of radioactive dust
- Inhalation of radon gas
- Ingestion of impacted soil or water
- Ingestion of radionuclides which have entered the food chain (for example, groundwater or surface water affected by radionuclides, used for irrigation or watering stock)
- Direct exposure to associated gamma radiation.

The waste contains Naturally Occurring Radioactive Material (NORM). As such, guidance provided by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) on the management of NORM is relevant to the disposal of the restricted solid waste from the Site.

Appendix C

Summary of NORM guidance documents

Appendix C

Summary of NORM guidance documents

Disposal

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) has developed best-practice guidance for the management of NORM, as the Safety Guide, Management of Naturally Occurring Radioactive Material (NORM), Radiation Protection Series Publication No. 15 (ARPANSA 2008). Suggested management / disposal options outlined in this document, which are relevant to the type of waste at the Site, include:

- Near surface burial.
- Disposal to landfill.
- Disposal into underground mine with cemented backfill.
- Disposal into mine waste rock dumps, smelter slag dumps, mine tailings dams or power plant ash ponds (it is noted that this option may be an interim measure in some cases).

The Safety Guide notes that, except in unusual circumstances, storage of NORM wastes should not be considered as a long term management option, because of the very long half-lives of the radionuclides typically of interest.

Near Surface Burial

ARPANSA guidance for NORM (ARPANSA 2008a) indicates that near surface burial can be an appropriate approach to management and disposal of NORM residues, and that the Code of Practice for Near Surface Disposal of Radioactive Wastes in Australia (the Near Surface Disposal Code) (NHMRC 1993) is applicable to bulk NORM residue disposal. The Near Surface Disposal Code indicates that waste of the type present at the Site would fall into "Category C" waste, and sets out good-practice site selection, design and management requirements for an appropriate near surface repository.

Key suggested site selection criteria include (NHMRC 1993):

- An area of low rainfall, free from flooding with good drainage, and stable geomorphology.
- Water table more than 5 metres below the base of the waste, and unlikely to fluctuate significantly.
- Location away from known or anticipated seismic, tectonic or volcanic activity.
- An area of low population density and low future population growth.
- Groundwater not fit for human consumption, pastoral or agricultural use.
- Suitable geotechnical and geochemical properties to inhibit migration of radionuclides.

In designing a repository for Category C waste, NHMRC (1993) provide the following design requirements (among others):

- Suitable engineered barriers to guarantee the integrity of the waste, minimise the possibility of water infiltration, and prevent radionuclide migration, with a design life of more than 300 years.
- Suitably engineered cover, to stabilise the structure, prevent ingres of water, discourage entry of animals or people and inhibit erosion. The minimum cover requirement is five metres between the top of the waste and the top surface of cover.
- Surface water management system to be provided.
- A buffer zone to be provided.

Temporary Storage

ARPANSA provides guidance on the design and management of storage of waste with radioactive properties in their Safety Guide, Predisposal Management of Radioactive Waste, Radiation Protection Series No. 16 (2008b). Key considerations in establishing a waste storage facility include:

- Implementation of inspection procedures.
- Storage conditions which preserve the integrity of the storage container and enable easy retrieval of the waste for disposal.
- Provision for the venting of gases which may accumulate (eg. radon).
- Regular radiation monitoring and measurement of radon gas levels.
- Fire protection.
- Security and surveillance.

Appendix D

Technical Feasibility - Treatment

Appendix D

Technical Feasibility - Treatment

Feasible treatment technologies for soils with radiological properties, like the restricted solid waste at the Site comprise segregation and sorting, followed by soil washing.

Segregation and sorting

Segregation of the waste material would comprise some level of manual or mechanical sorting process to minimise the volume of contaminated material requiring further management of disposal. The objective of the sorting process would be to screen and segregate the waste based on particle size. It is believed that segregation followed by sorting and screening of the waste would allow consolidation of relatively higher contaminated fine particles from remaining low level concentration materials. It is possible that some portion of the segregated materials would be suitable for reuse without further treatment or management.

The volume reduction strategy relies on separation of the portions of soil which are most polluted, thereby reducing the amount of soil requiring further remediation, and relies on the assumption that the radioactive elements may have the tendency to absorb to more fine-grained soils such as silt and clay than to larger-grained soils such as sand and gravel.

Soil washing

The main, viable treatment process (beyond segregation/screening) that may be applicable to the Hunters Hill site is soil washing. Based on discussions with industry specialists in Australia and a review of international case studies, soil washing represents the only suitable technology that has been implemented (either on a trial basis or full-scale) on similar wastes. This technology also represents a volume reduction strategy that operates under a similar principal as segregation and screening.

Soil washing is a water-based physical separation process which is designed to remove a broad range of contaminants from soil. It has been successfully trialled for radioactive contaminants in a number of demonstration projects located in the USA and Canada with a summary of project details provided in Table D-1 below

Table D.1: Examples of successful soil washing projects

Project	Location	Year	Contaminants Treated	Results
Maywood FUSRAP Site	Maywood, NJ, USA	Late 1990s	Radioactive soil contaminated with radionuclides (uranium, thorium, radium)	1,000 tonnes treated Volume reduction of 80% achieved
USDOE Hanford	Hanford, WA, USA	1990s	Radioactive soil contaminated with radionuclides (uranium, thorium, cesium) and metals	380 tonnes treated Volume reduction > 90% achieved
USDOE RMI Site	Ashtabula, OH, USA	Mid 2000s	Uranium	20,000 tonnes treated

The soil washing process comprises a scrubbing unit to which water, detergents (optional) and contaminated soil are added. The mixture is then passed through sieves, mixing blades, and water sprays to separate the soil by particle size. The sand and gravel settle to the bottom of the scrubber while the silt and clay may be suspended in the wash water which is then filtered. The wash water is then removed and treated, if required. Clean soils are validated, and disposed as general solid waste. The reduced quantity of radioactive materials are disposed to an appropriate facility. As indicated in Table D-1, the volume of contaminated soil can be reduced by between 80 and more than 90 percent (%).

Other technologies

Other segregation and treatment processes that have been trialled overseas include:

- Thermal treatment of waste to reduce volume.
- Vitrification.
- Application of chemically bonded phosphate ceramics (CBPCs) used for stabilisation of radioactive wastes.

A summary of these technologies with examples are provided in Table D.2 below

Table D.2: Status of emerging technologies

Technology	Applications	Pilot or Full Scale	Examples
Thermal treatment	Various including radionuclides	Pilot	Various facilities in USA, Western Europe Removal efficiency dependent on organic content of soil
Vitrification	Radioactive wastes	Pilot	AVM (Atelier de Vitrification de Marcoule) plant in Marcoule, France from 1970s Defense Waste Processing Facility (DWPF) at the Savannah River Site, SC, USA in mid 1990s Full-scale plant construction currently in process – USDOE Hanford Site Typically used to vitrify radioactive liquid wastes
CBPC stabilisation	Radioactive waste	Pilot	Argonne National Laboratory-West (ANL-W) nuclear-waste-processing demonstration plant Process is still considered experimental.

It should be noted that these technologies either may not be applicable to the site if organic content in soils is minimal (thermal treatment), or are emerging technologies (plasma-arc vitrification, application of CBPCs) which are currently being developed or have not been used in any full scale application.

These limitations render the above technologies impractical for the purposes of this feasibility review.