

Table 4.2: Evaluation of Pilot Trial Work Plan

Work Plan Element and Where Addressed	Details	Auditor Comments
		Management of Liquid and Non Liquid Waste'. The Work Plan does not address the disposal of spent carbon filters from the SVE system.
Hours of operation and Schedule s3.13, s7	Hours of operation are specified in the Work Plan. The overall trial schedule including initial approvals and post-trial reporting is estimated at 36 weeks, with a 16 week period of on-site activities (installation, operation and post-trial monitoring).	The level of detail provided is considered adequate. Hours of operation are subject to approval by others.
Contacts/ Community Relations s4.2	The Work Plan refers to the CMP which reportedly contains a list of key persons and relevant stakeholders affiliated with the site activities and includes a communication plan. The Work Plan states that community consultation will be managed by Lend Lease and will be part of a broad, comprehensive community consultation strategy.	The Auditor has not reviewed the CMP or the community consultation strategy. Consideration of these elements is not relevant to the current review.
Reporting s4.2 s6	A single Pilot Trial Summary Report is proposed to be prepared following completion of the pilot trial activities. A summary of the communication plan is provided in the Work Plan, with full details in the CMP. The summary indicates the following: - Daily reporting within the project team, eg, to site manager and project manager. - Reporting of results and data collected to relevant stakeholders and regulators, as appropriate - Weekly meetings between stakeholders, minuted in a weekly report that will be distributed electronically to project managers of VeruTEK, AECOM, Lend Lease and any other relevant stakeholders (as appropriate). - Representatives from AECOM, VeruTEK, Lend Lease, and any other relevant stakeholders are to be notified within 24 hours of any incidents.	The proposed content of the Pilot Trial Summary Report is considered appropriate. Specific stakeholders are not identified in the Work Plan and the Auditor has not reviewed the CMP or the detail of the communication plan. The degree of communication to external stakeholders and regulators appears reasonable, however, this is subject to approval by others.

The Work Plan is considered by the Auditor to be an adequate documentation of the proposed pilot trial for the purposes of this review. Some items were not addressed, in particular, relevant licenses, approvals and waste management aspects. In addition, I have not reviewed documents referred to such as the CMP and HSP. Consideration of these elements is not relevant to my consideration of the suitability and appropriateness of the proposed pilot trial with respect to site contamination.

4.4 Monitoring Program

Establishment of an appropriate monitoring program is essential to the success of the pilot trial, since reliable results are required for the appropriate design of the full-scale remediation system. The Auditor undertook a detailed review of multiple drafts of the monitoring program as part of this review.

The Work Plan describes the monitoring network and the monitoring program to be implemented during three phases of the pilot trial, as follows:

1. pre-injection
2. concurrent with injection/ extraction
3. post-injection.

Monitoring is proposed according to the following components:

- process monitoring – to inform adjustments to the system operational parameters
- performance monitoring – to track the movement of injected chemicals and nature of reactions
- groundwater sampling – to assess the effectiveness of the treatment
- soil sampling – to assess the effectiveness of the treatment
- soil vapour sampling – to assess potential impacts from the generation of vapours as a result of S-ISCO and SEPR oxidation reactions.

A detailed monitoring schedule is presented in the Work Plan for each trial area in Tables 7A and 7B, which are attached to this letter. Key features of the monitoring program are as follows:

- A combination of new and existing monitoring fixtures are to be used as outlined in Table 4.1 of this letter.
- Measurements are to be taken *ex situ* using field instruments, *in situ* using continuous logging equipment, and analysis of samples will be undertaken at an on-site laboratory as well as specialist off-site laboratories.
- Process monitoring will commence at an initial high frequency (hourly) during start-up and immediately after any major process changes, which will decrease to less frequent (daily) during day-to-day operation at steady-state injection conditions.

- The results of all monitoring will be reported immediately to the site manager and project manager to enable optimisation of the system or implementation of any contingency actions.
- Daily gauging for NAPL in five wells near the tar tank will be performed during the SEPR phase and daily gauging of the groundwater level in all wells in the Hickson Road trial area will be performed during the SEPR and S-ISCO phases (when injection is occurring).
- Collection of SUMMA canister soil vapour samples and analysis by an off-site laboratory will occur once in the pre-injection phase and weekly during the injection/ extraction and post-extraction phases.
- Daily monitoring by a PID and multi-gas meter (or equivalent) will be undertaken within utility pits, service access points and monitoring well heads, as well as in the breathing zone (ambient air) above these locations. The frequency of monitoring may be reduced based on the results of the monitoring program and pilot trial activities to a frequency not less than weekly.
- In the event that PID readings 5.0 ppm above background concentrations are detected in the breathing zone for a period of more than 5 minutes, Draeger Tube samples will be collected to confirm whether the PID reading is representative of benzene.
- Quantitative odour monitoring will be conducted daily using a nasal ranger in at least six locations, in the early morning when dispersion conditions are expected to be at their worst. Odour measurements will be compared with baseline monitoring data collected prior to work commencing at the site.
- The overall effectiveness of the treatment (validation) will be determined by comparison of pre-trial and post-trial sampling results. Post-trial samples will be collected approximately one month after completion of the injection process by AECOM as an independent evaluation of the VeruTEK trial. A complete monitoring round will be undertaken for groundwater, while soil will be assessed by five grid-based boreholes pre- and post-trial in each trial area. Pre- and post-trial samples will be collected in approximately the same areas (location shifted slightly) and at the same depth intervals.
- Proposed QA/QC procedures and samples are discussed for the soil, groundwater and soil vapour sampling programs. The proposed QA/QC is considered adequate. Soil vapour QA/QC includes leak testing and 10% duplicates. Further QA/QC samples are not considered necessary given the primary purpose of soil vapour sampling is performance monitoring (see below).

There were some minor inconsistencies in the Work Plan, or some items that were clarified to the Auditor by VeruTEK but which were not documented in the final Work Plan. These are as follows:

- Daily PID monitoring is to be undertaken as it enters and exits the carbon canister (written in s5.6 but not clear in Tables 7a and 7b of the Work Plan). It is presumed this information will be used in assessing the need for carbon replacement.
- The breathing zone action level of 5 ppm was reportedly set based on the Short Term Exposure Limit [STEL] concentration for benzene (s5.5.2), however, the Auditor notes

that there is no STEL for benzene, and the Time Weighted Average [TWA] is 1 ppm. Revision of this action level may be warranted.

- The screened interval for the tar tank (Hickson road) injection wells is reported as 3-5mBGL (approx.). The Auditor queried this installation and asked if the wells were proposed to be installed to the base of the tar tank which may vary slightly from 5mBGL. VeruTEK responded that the 5m installation depth was approximate. The Auditor notes that screening of the tar tank injection wells to the base of the tar tank is desirable.
- The Auditor queried the integrity of soil vapour monitoring points being used for SVE and the validity of the soil vapour samples collected. VeruTEK responded that the flow of the SVE system is designed to create a slightly negative pressure toward the system which will not compromise the integrity of the well construction. The purpose of the monitoring is not to quantify the amount of soil gas or measure representative soil vapour concentrations, but rather to monitor changes in soil vapour as an indicator of whether soil vapour concentrations are changing (increasing), and to thereby verify that the pilot trial implementation is not creating a soil vapour issue. This response is considered acceptable.
- The Auditor queried the Block 5 injection well construction with respect to screening of fill versus natural materials and the potential for preferential flowpaths. VeruTEK responded that due to the heterogeneous, isotropic distribution of contamination and geologic properties, during injection well installation the soil cores will be examined before the final well screen interval is selected. This Site-specific analysis may indicate that it is necessary to install multiple injection well completions at a given location, screened at different depths, to enable complete and comprehensive treatment of contamination in heterogeneous media. This response is considered acceptable.
- Between 5 and 10 soil samples are proposed to be collected from each bore during the post-trial validation. The Work Plan does not specify how many samples will be analysed. In the Auditor's opinion, analysis of at least three samples from each bore would be required to adequately represent the treated depth (around 5m).

Overall, the monitoring program documented in the Work Plan is considered by the Auditor to be a sufficiently rigorous program to allow for timely identification of potential impacts to receptors and adequate assessment of the trial performance. Detailed consideration has not been given to the operational monitoring aspects, however, the general approach of initial high frequency (hourly) monitoring is considered appropriate.

5 Evaluation of Risks

The Work Plan identifies potential receptors, risks and mitigation/ contingency measures discussed throughout the document and specifically in s1.3.4 and 3.11. Potential receptors were identified as follows:

- Darling Harbour;
- The trees planted along Hickson Road;
- Site workers and visitors;

- The Sydney Water Company (SWC) SPS adjacent to the Block 5 Pilot Trial area;
- Underground services within Hickson Road;
- Workers and residents of properties surrounding and adjacent to the Hickson Road Pilot Trial area, including the child care centre located at 30 Hickson Road and the basements at 30 and 38 Hickson Road;
- Archaeological resources and relics in the subsurface of Block 5; and
- The basement water treatment system at 38 Hickson Road.

The receptors identified are the potential risk to these considered in the Work Plan are considered appropriate.

The key risk issues and proposed mitigation and contingency measures discussed in the Work Plan have been summarised by the Auditor in Table 5.1, below. The need for implementation of certain measures will be determined based on the results of the monitoring program, discussed above in Section 4.4.

Table 5.1: Summary of Risk Mitigation and Contingency Measures		
Risk Issue	Proposed Measures	Comments
Migration of injected chemicals or enhanced migration of groundwater contamination from Block 5 trial towards Darling Harbour or the SPS	Close monitoring of reaction rates and the treatment front. Implementation of pumping from groundwater monitoring wells if required. The system includes the connections required to implement this contingency.	Monitoring and contingency measures considered adequate. Quantitative action levels for implementation of contingency action are not identified.
Migration of injected chemicals or enhanced migration of groundwater contamination from Hickson Road trial towards Darling Harbour, amenities building or buildings on Hickson Road, including 30 and 38	Limited connectivity with surrounding bedrock is expected, however, water injection pump tests are proposed in the tar tank prior to trial commencement to establish the connectivity with the surrounding groundwater and soil vapour Continuous extraction from within the tar tank Close monitoring of reaction rates and the treatment front. Implementation of pumping from groundwater monitoring wells if required. The system includes the connections required to implement this contingency.	Monitoring and contingency measures considered adequate. Quantitative action levels for implementation of contingency action are not identified.
Potential byproducts from additives	VeruTEK report that the chemicals used in S-ISCO and SEPR, as well as the products of their chemical reactions, are harmless to the environment in the context of the pilot trial	The arguments presented appear reasonable, however, the Auditor has not undertaken a detailed review to verify this aspect.

Table 5.1: Summary of Risk Mitigation and Contingency Measures

Risk Issue	Proposed Measures	Comments
		Injection of the chemicals is subject to approval by DECCW.
Damage to underground services within Hickson Road	Only the non-corrosive oxidant peroxide will be used in Hickson Road to prevent adverse effects to services encased in metal or concrete Informed intrusive works will avoid services during installation of the system	Risk mitigation measures considered adequate.
Damage to underground infrastructure associated with the SPS	Informed intrusive works will avoid services during installation of the system	Risk mitigation measures considered adequate.
Generation of vapours and odours. The reaction of hydrogen peroxide generates oxygen that may displace contaminated vapours. There is potential for impact by potentially odorous, toxic and/ or flammable vapours on below ground services, building basements and ambient air from transport of vapours through the soil or through preferential flow paths (such as service trenches).	A low pressure SVE system will operate continuously throughout the duration of the S-ISCO and SEPR injections and extractions to prevent migration of vapours outside the trial areas through the subsurface or releasing to ambient air The system includes an extra SVE line in Hickson Road which can be mobilised in an emergency to increase capacity and coverage of the SVE system The extraction points will be closely monitored Additional SVE points may be installed in key locations (eg, Hickson Road footpath and 30 Hickson Road) if elevated/ unsafe vapour concentrations are detected Daily PID monitoring of: - utility pits, service access points and monitoring well heads (accumulation monitoring) - ambient air above these locations Draeger Tube testing will be performed to determine if PID readings exceeding 5ppm above background comprise benzene. If confirmed, the project manager and relevant stakeholders will be notified and corrective action will be implemented. Daily odour monitoring will be undertaken. The project manager and relevant stakeholders will be notified and corrective action will be implemented in the event that elevated odour dilution concentrations (compared to baseline data) are noted for more than two consecutive daily monitoring events.	Monitoring and contingency measures considered adequate. Quantitative action levels are provided for ambient air PID and odour measurements. Action levels for accumulation monitoring and soil vapour sampling are not specified, however elevated/ unsafe levels are referenced. Site specific risk assessment may be required to assess if levels are "unsafe".

Table 5.1: Summary of Risk Mitigation and Contingency Measures

Risk Issue	Proposed Measures	Comments
	SVE may be implemented at the accumulation points if unsafe vapour concentrations or odours attributable to the pilot trial are detected. Other potential corrective actions identified are: • suspension and/or modification of injections; • amendment of the SVE system; • increase of laboratory and field monitoring frequency; and • conduct of ambient VOC monitoring from the location in question to determine whether the increased soil vapour concentrations have impacted on ambient air quality (relative to background VOC concentrations)	
Movement of treatment front exclusively through preferential, more porous pathways in Block 5 trial area	If the influence of the treatment chemistry is not detected adequately in monitoring wells throughout the treatment zone and at varied depth intervals, additional injection wells will be installed to ensure that all areas of contamination are contacted and treated.	Monitoring and contingency measures considered adequate.

The risk issues identified and mitigation/ contingency measures proposed are considered generally adequate, however, the following is noted:

- The requirement for carbon filter replacement for the SVE system is not discussed in the Work Plan, and licensing/ approvals and discharge limits are not defined (refer Table 4.2). These issues need to be resolved to ensure inappropriate discharge of contaminant vapours does not occur.
- Although the degree of monitoring and proposed contingency measures are considered appropriate, quantitative action levels are not specified for when contingency action would be implemented in relation to migration of groundwater impacts or treatment chemicals, or in relation to vapour accumulation and soil vapour sampling. This highlights the need for careful consideration of monitoring results and the possible requirement for site specific risk assessment to be undertaken during the trial. Sufficient resources should be allocated to allow for the assessment of monitoring results within an appropriate timeframe and all 'elevated' results should be reported to the stakeholders.

6 Conclusions and Recommendations

Based on the investigation reports, bench scale treatability study and Pilot Trial Work Plan reviewed by the Auditor, the proposed pilot trial and monitoring approach is considered generally appropriate, and the level of detail presented in the Work Plan is considered adequate for the purposes of my review. In my opinion, if implemented successfully, the pilot trial should produce reliable results that could be applied to the full-scale design of the Barangaroo remediation.

The risk issues identified and mitigation/ contingency measures proposed are considered adequate, however, quantitative action levels for the implementation of contingency actions are not specified for all monitoring aspects. Careful and timely consideration of all monitoring results will be required and all 'elevated' results should be reported to the stakeholders to ensure appropriate action levels are adopted.

This review has not addressed the licences or approvals required for the works, technical aspects of the treatment technology or remediation system design, or considerations such as dangerous goods management, health and safety, operational environmental management, waste management and traffic management.

I recommend that the pilot trial be implemented considering the comments made throughout this letter.

* * *

Consistent with Department of Environment, Climate Change and Water (DECCW and formerly NSW EPA) requirement for staged "signoff" of sites that are the subject of progressive assessment, remediation and validation, I advise that:

- This advice letter does not constitute a Site Audit Report or Site Audit Statement.
- At the completion of the remediation and validation I will provide a Site Audit Statement and supporting documentation.
- This interim advice will be documented in the Site Audit Report.

Yours faithfully



ENVIRON Australia Pty Ltd
Graeme Nyland
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Attachment 1: Site Location
Attachment 2: Site Layout and Investigation Locations
Attachment 3: Lot Layout and Previous Gasworks Layout
Attachment 4: Pilot Trial Locations
Attachment 5: Block 5 Pilot Trial Layout
Attachment 6: Hickson Road Pilot Trial Layout
Table 7A: Block 5 Monitoring Schedule
Table 7B: Hickson Road Monitoring Schedule

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Site Location

Lend Lease (Millers Point) Pty Ltd
 Sampling Analysis and Quality Plan
 Barangaroo Data Gap Investigation
 Hickson Road, Millers Point NSW

Figure
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