East Darling Harbour Geotechnical and Environmental Investigation

Summary of Findings

Sydney Harbour Foreshore Authority

September 2006

004432RP03 Final

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ERM

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Environmental Resources Management Australia Pty Ltd Quality System

FINAL REPORT

Sydney Harbour Foreshore Authority

East Darling Harbour Geotechnical and Environmental Investigation

Summary of Findings

September 2006

Reference: 004432RP03 Final

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1 INTRODUCTION

1.1 BACKGROUND

Environmental Resources Management Australia Pty Ltd (ERM) was commissioned by Sydney Harbour Foreshore Authority (the Foreshore Authority) to conduct a Combined Environmental and Geotechnical Site Assessment of the East Darling Harbour site located on Hickson Rd, Millers Point, NSW (*Figure 1* of *Annex A*). This project was undertaken in accordance with the scope of work outlined in ERM's tender package dated March 2006 (Reference: 0010562 Rev3).

ERM understands that the State Government of NSW established an international urban design competition for the renewal of the East Darling Harbour Foreshore site. The Foreshore Authority, as one of the major stakeholders, are involved with undertaking various studies to inform the design and future development process.

1.2 OBJECTIVES

The identified objectives of this project were to:

- identify and document the existing environmental and geotechnical site conditions in preparation for development planning;
- conduct work that was compliant with all statutory regulations and guidelines in relation to the Environmental Planning and Assessment (EP & A Act) Act, State Environmental Planning Policy 55 (SEPP 55) and the Contaminated Land Management Act 1997 (CLM Act 1997); and
- Prepare the collected information and liaise with relevant stakeholders involved in the site renewal process so that an acceptable outcome could be achieved.

1.3 SCOPE OF WORKS

In order to satisfy the project objectives the following scope of works was undertaken by ERM:

- review of the available environmental and geotechnical information, studies, and plans in relation to the site to gain a background level of understanding;

- completion of a 'Stage One – Preliminary Investigation' in accordance with SEPP 55 and the CLM Act 1997, including a desk-top study of existing and previous land uses;

- completion of a 'Stage Two – Detailed Investigation' in accordance with SEPP 55 and the CLM Act 1997 based on the findings of the 'Stage 1 – Preliminary investigation', including drilling, sampling and analysis at a total of 150 locations across the site; and

- completion of geotechnical investigations and analysis including borelogs, foundation analysis and recommendations report combined with the environmental drilling and testing.

2 SUMMARY OF FINDINGS

The following Section presents a brief summary of the key elements of the Stage One Environmental, Stage Two Environmental and Geotechnical Investigations.

2.1 STAGE ONE – PRELIMINARY INVESTIGATION

2.1.1 Environmental Setting

Site Location

The site refers to Lots 1 through 6 of Deposited Plan (DP) 876514, predominantly located adjacent to Hickson Rd, Millers Point, NSW. A site location plan is presented as *Figure 1* of *Annex A* and a site layout plan identifying the individual lots is presented as *Figure 2* of *Annex A*.

The Section 149(2) and (5) planning certificates obtained from the City of Sydney Council, indicate that the site is currently zoned Maritime and Transport in Central Sydney under the Sydney Local Environment Plan (LEP) 2005.

Key information relevant to this assessment provided in the s149 certificates is summarised as follows:

- A number of the lots contain listings for heritage items under the Sydney Local Environment Plan, 2005 and are subject to various other heritage controls.
- The Minister is the consent authority for Lots 2, 3, 5 and 6.
- The entire site is affected by the City of Sydney Contaminated Land Development Control Plan 2004.

Surrounding Land Use

At the time of site inspection, the following land uses were noted in the area surrounding the site:

- North: To the north is Sydney Harbour;
- South: South of the overseas passenger terminal portion of the site is the commercial King Street Wharf area, comprising retail shops, restaurants and residential apartments;

- East: Immediately to the east is Hickson Road, which borders the southern half of the site to the east. Beyond Hickson Road is the Sydney CBD comprising commercial high rise buildings; and

- West: To the west is Sydney Harbour.

Site Layout and Topography

The site covers a total area of approximately 22 hectares. Four large receiving warehouse style buildings (transit sheds) are present on the site. The south-western portion of the site is an operational passenger terminal (Berths 7 & 8) operated by Sydney Ports Corporation, with an operational stevedoring terminal operated by Patrick General Stevedoring located to the north (Berths 3, 4, 5 and 6). The far north eastern portion of the site, known as Moores Wharf, contains a sandstone building and this section of the site is currently utilised as a base for marine operations by Sydney Ports Marine Services.

The site is primarily covered with bitumen and areas of concrete and is used predominantly for storage. Vehicular access to the site is from Hickson Road on the eastern boundary of the site. A site layout plan is provided as *Figure 2* of *Annex A*.

The topography of the site is relatively flat, having been historically cut and filled. The site abuts a cliff face on the eastern boundary in the northern portion of the site.

Site Geology, Hydrogeology and Hydrology

According to the 1:100 000 Geological Survey of NSW (Sydney) Sheet 9130 (Ed 1) 1983, the site is generally underlain by man-made fill and Hawkesbury Sandstone of the Wianamatta Group.

Information obtained from the Department of Natural Resources (DNR) indicated that there are 32 registered groundwater bores situated within a four kilometre radius of the site. Review of the groundwater abstract bore information indicated that these bores are used for irrigation and monitoring. None of the listed bores were registered for drinking water purposes. No registered groundwater bores were identified on the site.

The closest surface water bodies to the site are Darling Harbour and Port Jackson located immediately adjacent to the west and north of the site respectively.

2.1.2 Site History

A review of various aerial photographs of the site dating back to 1951 and title deeds dating back to 1860 along with a number of relevant reports from previous investigations was conducted.

The reviewed title deeds indicate that portions of the site were historically owned by merchants, compositers, manufacturers and various shipping companies prior to 1900. Following this, ownership of the site appears to have been largely transferred to the Sydney Harbour Trust (SHT) Commissioners and the site appears to have remained in the ownership of various government bodies including the Maritime Services Board of NSW, Sydney Ports Corporation and the Marine Ministerial Holding Corporation. Parts of the site have been subject to various commercial leases between 1900 and the present.

The aerial photographs of the site indicate that the majority of the site appears to have been used as a ship berthing / dock facility between 1951 and the present. The aerial photography also indicates that much of the site has been reclaimed from the harbour to create the present site layout. Significant reclamation earthworks are indeed visible in one of the reviewed aerial photographs dated 1972

Further information regarding the history of the site was obtained from a previous review of the site prepared by URS entitled Contamination Review for Darling Harbour Berths 3 – 8, 2001. A summary of this information is detailed as follows:

A gasworks owned by the Australian Gas Light Company (AGL) was previously located on part of the site (parts of berths 5, 6 and 7). The construction of the gasworks began in 1840 and the actual production of gas began in 1841. In 1916 the gasworks property was acquired by the Sydney Harbour Trust (SHT); however AGL continued to occupy the gasworks under a lease agreement until 1921. SHT occupied the former gasworks from 1921 until the current time. Between 1922 and 1925 AGL demolished the gas holders and purifiers and backfilled the gas holding tanks at the former gasworks site. The Maritime Services Board used the former gasworks for workshops and stores, and added many warehouse buildings to the former gasworks area.

The exact history of the remainder of the site is unclear. Originally the remainder of the site consisted of finger wharves. These wharves were changed over time and then removed, and the site was filled in.

2.1.3 Potential Areas And Chemicals Of Concern

The site has been subject to potentially contaminating activities in the past, including the use of part of the site as a gas works, use of uncharacterised fill on site, and vehicle maintenance activities. In addition, current activities at the site also represent a potential contamination risk, including above- and below-ground diesel storage/distribution, chemical and waste storage, above-ground petroleum storage, and vehicle/ equipment washing and maintenance. Potential areas of concern (PAOC) have been identified from previous investigations conducted at the site and site visits by ERM.

The PAOC can be described as follows:

- **Area of Former Finger Wharves on the Western Part of Berths 3 – 8:** Due to the use of uncharacterised fill and dumping of wastes from the former gas works in this area there is the potential for soil contamination to be present.

- **Former Gasworks Area** - Gas production and distribution activities conducted on parts of the site represent a potential source of significant contamination. The area is located in the south-east of the site and was estimated by URS to cover an approximate area of 5,420 square metres. Indicative locations of former gasworks structures (interpreted from the abovementioned URS report) are shown of *Figure 2* of *Annex A*.

- **Current Industrial Activities in the Former Gasworks Area** – May also represent a contamination risk. Particular items of interest included: a large equipment wash bay, two diesel above-ground storage tanks (ASTs) a liquid propane gas (LPG) AST, a dangerous goods (DG)/hazardous waste storage area and a vehicle/equipment maintenance workshop.

- **Wash Bay No. 2** - A second equipment wash bay is located along the eastern property fence line, immediately south of the site entrance.

- **South-West Corner of Transit Shed No. 5** - Heavy staining was observed outside of the south-west corner of Transit Shed No 5. It is suspected that an Aboveground Storage Tank was previously located in this area

- **Berth 2 Moores Wharf** - A 15,000 litre diesel UST, a 10,000 litre petrol UST and a portable, self bunded chemical storage unit is situated in the north-western portion of the area.

The following chemicals of potential concern for soil and groundwater were identified in a previous review conducted by URS (2001) and confirmed during ERM's site visit.

- Metals including cadmium, chromium, copper, nickel, lead, zinc, mercury and arsenic. These metals may be connected with gas works wastes and/or fill materials.

- Cyanide and sulphates related to gas works wastes.
- Petroleum Hydrocarbons (TPH) and BTEX (benzene, toluene, ethyl benzene and xylene) compounds. These compounds are associated with oils and greases from vehicle maintenance activities and wastes that may have been dumped or used as part of gas works operations.
- Polycyclic Aromatic Hydrocarbons (PAHs) associated with gas works wastes and fill materials.
- Phenols and PCBs, these may be associated with fill or gas works wastes.

2.2 STAGE TWO - DETAILED INVESTIGATION

2.2.1 *Investigation Methodology*

A total of 153 geotechnical and environmental soil bores were drilled across the site between 1 May 2006 and 15 July 2006. 103 of these boreholes were drilled on systematic triangular grid pattern and the remaining 50 locations were targeted at potential areas of concern identified using information gathered both during the stage one investigation and the initial results of intrusive works. It should be noted that two proposed boreholes located between the north-western corner of Warehouse 5 and the seawall were unable to be completed due to ongoing site activities in this area

All soil bores were drilled using truck mounted drilling rigs under the supervision of an ERM Environmental Scientist and two geotechnical engineers from Jeffery and Katauskas Group (J&K). The environmental soil bores were drilled using a solid flight augering techniques and the deeper geotechnical component of the soil bores utilised a combination of solid flight augering, wash boring and diamond coring techniques.

Groundwater monitoring wells were installed in 24 selected boreholes located adjacent to the western and northern boundary of the site and within the former gasworks area.

The location of all boreholes and monitoring wells is presented on *Figure 2* of *Annex A*.

Soil Sampling Regime

The subsurface profile encountered at each location was continuously logged in the field and details of colour, particle size, plasticity, consistency, moisture content, structure, inclusions, staining and odour were recorded. Samples were obtained at regular intervals for field screening purposes. These samples were screened using a photoionisation detector (PID) with a 10.6 eV lamp.

One or more soil samples were collected at each sampling location for laboratory analysis using a "split-spoon" sampler to collect undisturbed samples where possible. Samples were collected at regular intervals of 0.3-0.5, 1.5-1.95 and 3.0-3.45 m below ground level (bgl) in the upper portion of the bore. Where possible, samples were collected at depth within selected environmental boreholes and where possible in geotechnical boreholes.

Groundwater Sampling Regime

All of the 24 newly installed monitoring wells were developed and then purged until sufficient water was removed to obtain stabilised readings of field parameters including pH, Eh, DO, EC and temperature measured using a water quality meter, which was calibrated prior to use. Low-flow sampling techniques were then used to obtain representative groundwater samples for laboratory analysis from all of the monitoring wells installed. Water samples were collected using equipment dedicated to each borehole to eliminate the potential for cross-contamination between sample locations.

Laboratory Analysis

Samples were submitted to NATA accredited analytical laboratory (ALS Environmental Pty Ltd and the secondary laboratory LabMark registration number: 13542 (Sydney)),

The analytical suite for each testing location was developed based on a review of the site history and comprised a selection of the following compounds.

- Inorganics (As, Cd, Cr, Cu, Hg, Ni, Pb and Zn);
- Toxicity Characteristic Leaching Potential (TCLP) inorganics;
- Polycyclic Aromatic Hydrocarbons (PAHs);
- Total Petroleum Hydrocarbons (TPH);
- Benzene, Toluene, Ethylbenzene and Xylene (BTEX);
- Polychlorinated Biphenols (PCBs);
- Sulphate;

- Total Cyanide;
- Phenols;
- Organochlorinated pesticides (OCP); and
- Organophosphate pesticides (OPP).

2.2.2 *Soil And Groundwater Conditions*

Observed Geology

The geology observed in boreholes drilled by ERM and J&K was consistent with lithological descriptions from previous investigations. The geology at the site can generally be summarised as follows:

Table 2.1 Observed Geology

Lithological Unit	Description	Depth Below Ground Level (m)	Average Thickness (m)
Fill	Grey/Brown, gravelly / silty sand, poorly sorted, fine to coarse grained, with brick and gravel inclusions. This material was encountered at most boreholes / monitoring well locations.	0.0 – 21.0	8.4
Natural Marine Sediment	Brown, grey, sandy clay, moist. This unit was observed in deeper geotechnical boreholes at most locations across the site.	0.34 – 17.4	3.24
Hawkesbury Sandstone Bedrock	Brown/grey, fine-medium grained	0.5-31.04	Unknown

A layer of fill was observed in all boreholes. Boreholes drilled in the northern and eastern portion of the site were generally devoid of a layer of natural sediment, the profile indicated that the fill was underlain by sandstone bedrock. In the middle and southern portion of the site, the fill layer was underlain by natural marine sediments. This material was underlain by brown/grey fine to medium grained sandstone bedrock.

Observed Hydrogeology

Groundwater was detected in all monitoring wells on-site. The depth to water recorded in the monitoring wells during the July 2006 well gauging event ranged between 1.7 m bgl in well MW10 to 2.495 m bgl in MW08. The relative elevation of groundwater in the monitoring well network ranged from a high of 0.648 m AHD in well MW10 to a low of 0.07 m AHD in well MW08. Some significant short term variations in groundwater levels were observed during drilling and sampling operations, particularly in those wells located close to the seawall. This, along with the generally saline nature of the groundwater, indicates that the groundwater regime on the site is likely to be strongly influenced by tidal fluctuation.

Anecdotal evidence provided by site employees and representatives of the Foreshore Authority indicated that groundwater flow in the vicinity of the former Gasworks may also be influenced to some extent by dewatering activities in basements of buildings on the eastern side of Hickson Rd.

Soil Conditions

ERM understands that the intended future land use of the site is likely to be a combination of mixed use (commercial/residential) and open space (park lands). The relevant applicable criteria that has been adopted for the purposes of this report is as follows:

- NEPM (1999) HIL 'A' Residential with garden/accessible soil;
- NEPM (1999) HIL 'E' Parks, recreational open space and playing fields; and
- NSW EPA 1994 Guidelines for assessing service station sites (petroleum hydrocarbon and volatile organic compounds).

As the proposed boundary between the dominant future land uses (ie open space and built form) has not yet been finally resolved, ERM has taken a conservative approach and applied the more stringent NEPM (1999) HIL 'A' guidelines to the entire site. In addition, for comparative purposes, reported concentrations of analytes exceeding NEPM (1999) HIL 'E' have also been included. Adoption of the less stringent NEPM (1999) HIL 'E' criteria in relevant parts of the site may reduce the total volume of soil requiring remediation, however it will not likely preclude the need for remedial activities in certain areas of the site.

Generally, there are two areas on site that have concentrations of the constituents of concern above the NEPM (1999) HIL 'A' and NSW EPA 1994 criteria. These areas are located in the vicinity of the former gasworks and in the north western portion of the site adjacent to Warehouse 3 (*Figure 3, Annex A*). The primary constituents of concern exceeding the adopted site criteria identified at these areas were:

- lead;
- copper;
- Polycyclic Aromatic Hydrocarbons (PAHs) including Benzo[a]pyrene;
- Total Petroleum Hydrocarbons (TPH); and
- Benzene, Toluene, Ethylbenzene and Xylenes.

A plan showing the location of all soil samples containing concentrations of one or more chemicals of concern above the relevant criteria is presented in *Figure 3* of *Annex A*.

In addition to these two general impacted areas, some localised 'hotspots' have been observed on the western portion of Wharf 8, on the eastern boundary north of transit shed 5 and on the western edge of warehouse 4. These localised 'hotspots' are impacted by Benzo[a]pyrene, total PAHs and lead located within the fill layer to a maximum depth of 3.45 m bgl. Further, sulphate in eight samples at concentrations above the applicable NEPM (1999) Interim Urban criteria for protection of built structures (2000 mg/kg) were identified (*Figure 3, Annex A*).

Groundwater Conditions

Results of the laboratory analysis of samples collected during the sampling event indicate that the majority of impact to groundwater observed appears to be related to the observed soil impact in the area of the former gasworks. There is however, impact observed in wells that may be related to other sources (such as the underground storage tank in the north eastern corner). The constituents of concern identified in these areas were:

- Polycyclic Aromatic Hydrocarbons (PAHs);
- Total Petroleum Hydrocarbons (TPH);
- Benzene, Toluene, Ethylbenzene and Xylenes;
- Metals; and
- Cyanide.

2.3 *GEOTECHNICAL INVESTIGATION*

All geotechnical investigation, analysis and interpretation works were subcontracted to a specialist geotechnical engineering firm - Jeffery and Katauskas Pty Ltd (J & K). Following is a summary of the geotechnical report produced by J & K.

Jeffery and Katauskas Pty Ltd (J&K) have completed a geotechnical investigation at Wharves 3 to 8 at Darling Harbour. The investigation comprised the drilling of 153 boreholes, of which 50 were drilled primarily for environmental purposes, and 78 where a core of the sandstone bedrock was obtained.

The site is currently a flat port facility and container terminal occupying the northern half of the eastern shore of Darling Harbour; this area has been reclaimed by the staged construction of seawalls and placement of fill. Sandstone cliffs or cut rock faces occur on the eastern side of the site, ranging up to about 15m in height.

The upper levels of the fill were predominantly sandy, becoming more clayey with depth. The fill was generally relatively shallow at the eastern side of the site, increasing to 15m to 17m at a line about 30m east of the seawall. In the majority of the boreholes, the augers and diamond core drill strings were pushed significantly off line, sometimes causing loss of equipment or abandonment of the borehole. Refusal to further penetration also occurred at several locations. Possible causes of refusals include large concrete, timber and steel obstructions within the fill material

The alluvial/marine sediments comprised predominantly sandy clays and extended to the sandstone bedrock. Sandstone bedrock was generally shallow near the northern end of the site and along Hickson Road, becoming deeper to the west and also at the northern extremity of the site. The sandstone bedrock formed a 'bay' type feature over the southern two-thirds of the site, with the deepest rock level being encountered at about RL-28m AHD (which is approximately 30m depth).

Geotechnical issues associated with the proposed development include:

- *There are many obstructions within the fill which are likely to cause difficulties during piling operations. We expect that the type of piling most suited to these conditions would be driven piles which have a greater ability to punch some of the rubble aside, though even then some premature refusal could occur which may then require the adoption of additional piles and pile caps, or pre-drilling to try to remove some of the obstructions. Using driven pre-cast or steel piles also avoids issues with loss of grout or concrete into large voids in the fill, and also limits the necessity for offsite disposal of drilling spoil which may contain chemical contaminants (Refer to the ERM report for further details of contamination).*

- *There are some elevations of sulphates within the soil and this provides a relatively aggressive environment for concrete.*

- *The presence of large pieces of rubble within the fill will hinder excavation for service trenches.*

- *The poorly compacted nature of fill means that any substantial structures will need to be piled to the bedrock.*

- *Given the close proximity of the site to the harbour, groundwater levels within the site are expectedly relatively high, and basement excavations will require relatively impermeable shoring and dewatering systems.*

3 CONCLUSIONS AND RECOMMENDATIONS

Based on a preliminary review of the results of the combined geotechnical and environmental investigation, ERM make the following conclusions and recommendations:

Environmental

- A review of relevant previous investigations, title records and aerial photographs identified historical and current landuses and practices which may have resulted in impacts to soil and groundwater on the site.
- A number of Potential Areas of Concern were identified during the Stage One Investigation, in particular the area of the Former Gasworks and the Area of Former Finger Wharves on the Western Part of wharves 3 through 8 where significant filling activities have reportedly taken place.
- The Stage Two Investigation utilised a combination of systematic and judgemental sampling to evaluate the extent and degree of potential impacts to soil and groundwater.
- The results of the Stage Two Investigation confirmed that impacts to soil and groundwater were present at levels exceeding the adopted published assessment criteria.
- The observed impacts to soil were predominantly concentrated in two areas of the site, namely the area of the Former Gasworks and the north-western portion of the site. The primary compounds of concern identified were lead, PAHs and TPH BTEX compounds.
- Observed impacts to groundwater were predominantly concentrated in the vicinity of the former gasworks, however concentrations of selected metals exceeding the adopted assessment criteria were identified in all of the installed monitoring wells.
- Although concentrations of a number of compounds exceeding the adopted published site assessment criteria were identified in both soil and groundwater, the true extent of potential risks to human health and the environment should be assessed through a site specific risk assessment, which can be undertaken separately or as the initial part of a Remedial Action Plan (RAP).
- Based on the observed extent and degree of impacts to soil and groundwater, ERM considers that remediation will likely involve source removal and exposure control in certain portions of the site.
- Additional investigations may be required to fully delineate the identified hotspots prior to completion of a Remedial Action Plan (RAP).
- ERM consider that the Site could be made suitable for the proposed future landuse if appropriate remedial and validation works are undertaken.

Geotechnical

- There are many obstructions within the fill which are likely to cause difficulties during piling operations, driven piles are most suited to these conditions.

- There are some elevated concentrations of sulphates within the soil, providing a relatively aggressive environment for concrete.

- The presence of large pieces of rubble within the fill will hinder excavation for service trenches.

- Groundwater levels within the site are expectedly relatively high and basement excavations will require relatively impermeable shoring and dewatering systems.

Annex A

Figures

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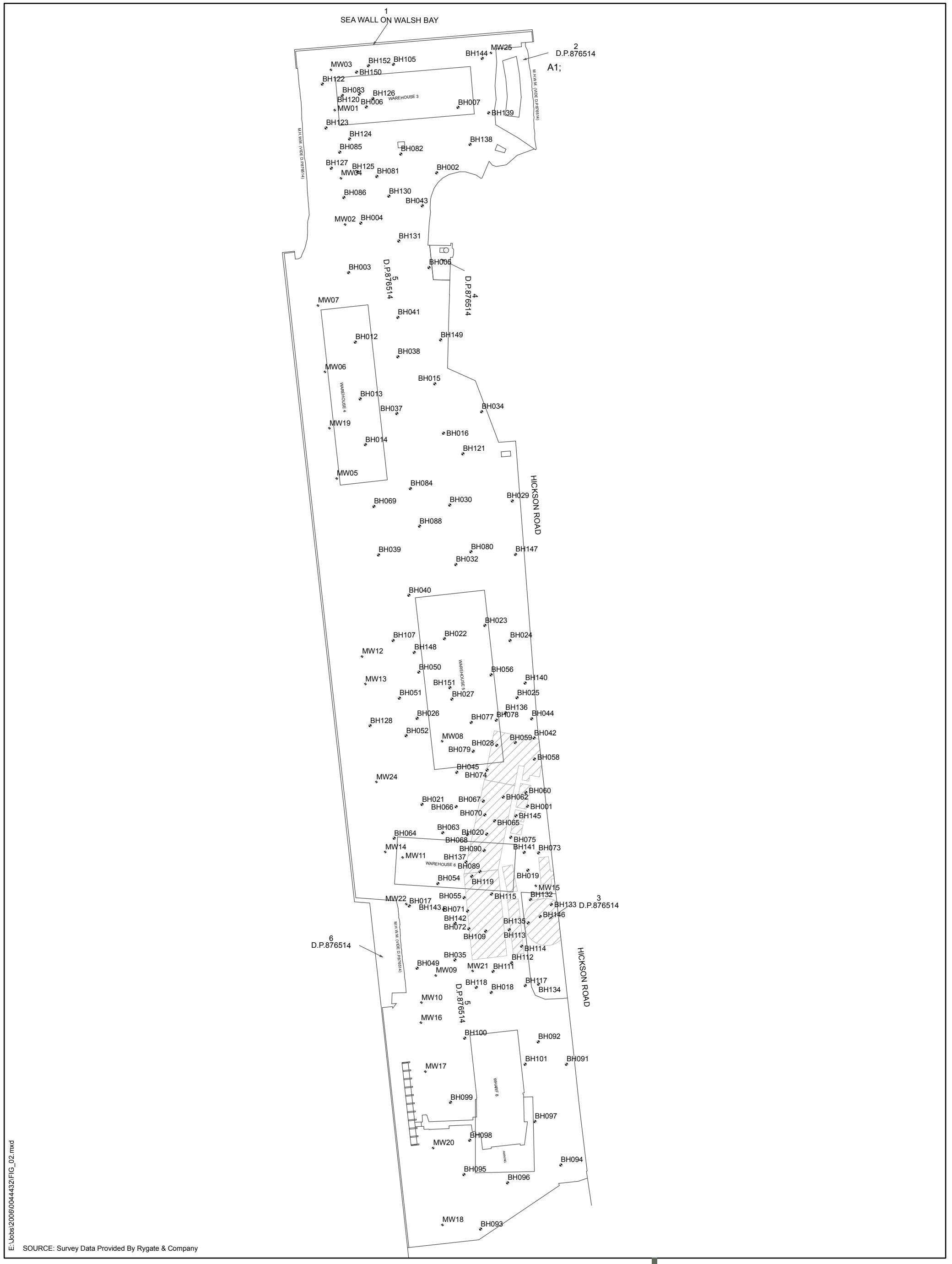
Not to Scale

Figure 1 **Site Location Plan**

SHFA - East Darling Harbour



E:\Jobs\2006\0044432\FIG_02.mxd

SOURCE: Survey Data Provided By Rygate & Company

N

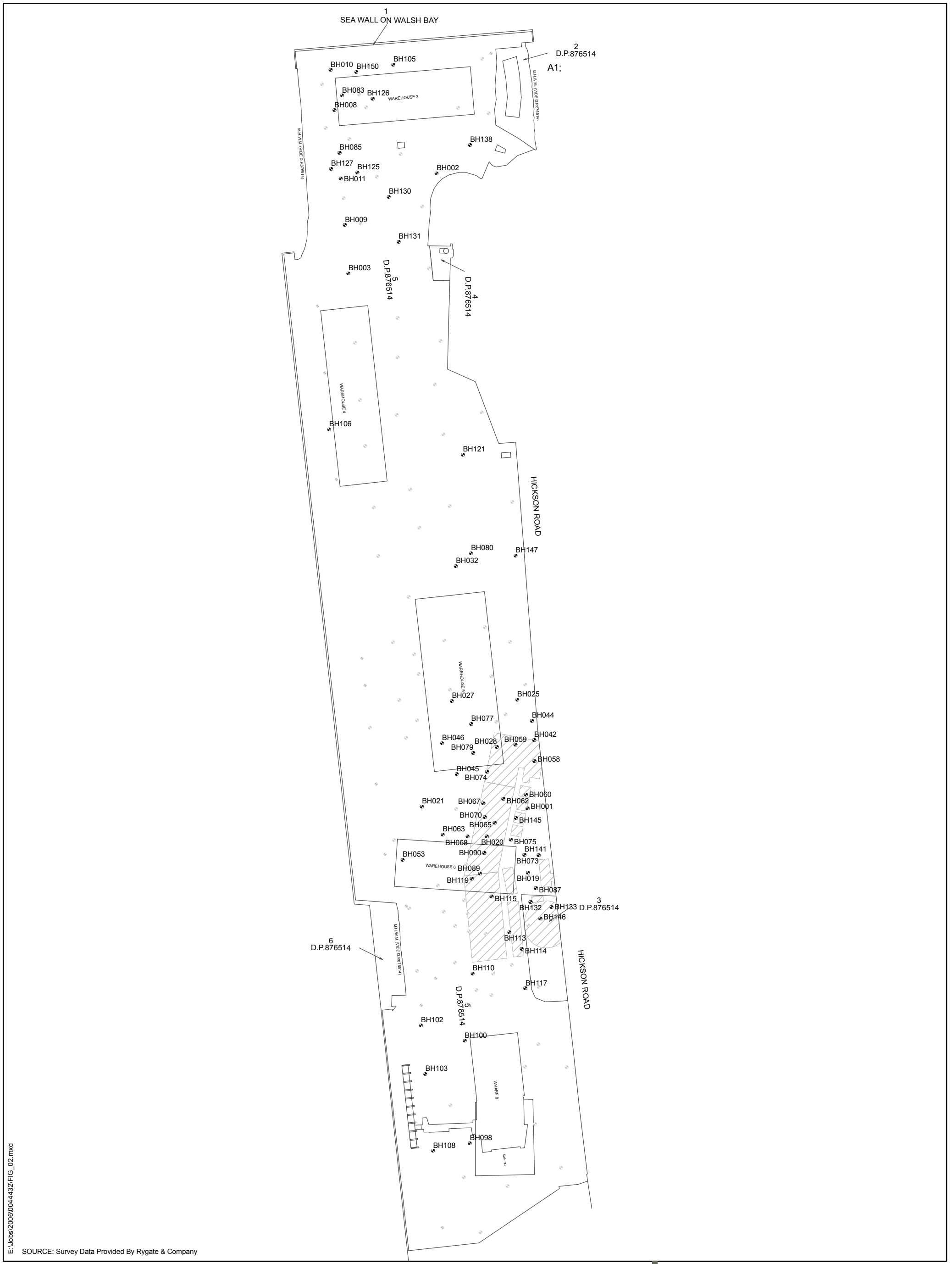
0 35 70 140 Metres

Legend

- Site Features
- Boreholes
- Monitoring Wells
- Indicative Locations of Former Gasworks Structures

Figure 2 **Site Layout Plan Showing Investigation Locations**

SHFA - East Darling Harbour



E:\Jobs\2006\0044432\FIG_02.mxd

SOURCE: Survey Data Provided By Rygate & Company

N

0 35 70 140 Metres

Legend

- Site Features
- Locations With Soil Impacts Identified Above Criteria
- Boreholes
- Monitoring Wells
- Indicative Locations of Former Gasworks Structures

Figure 3 **Locations of Soil Impacts Above Site Assessment Criteria**

SHFA - East Darling Harbour

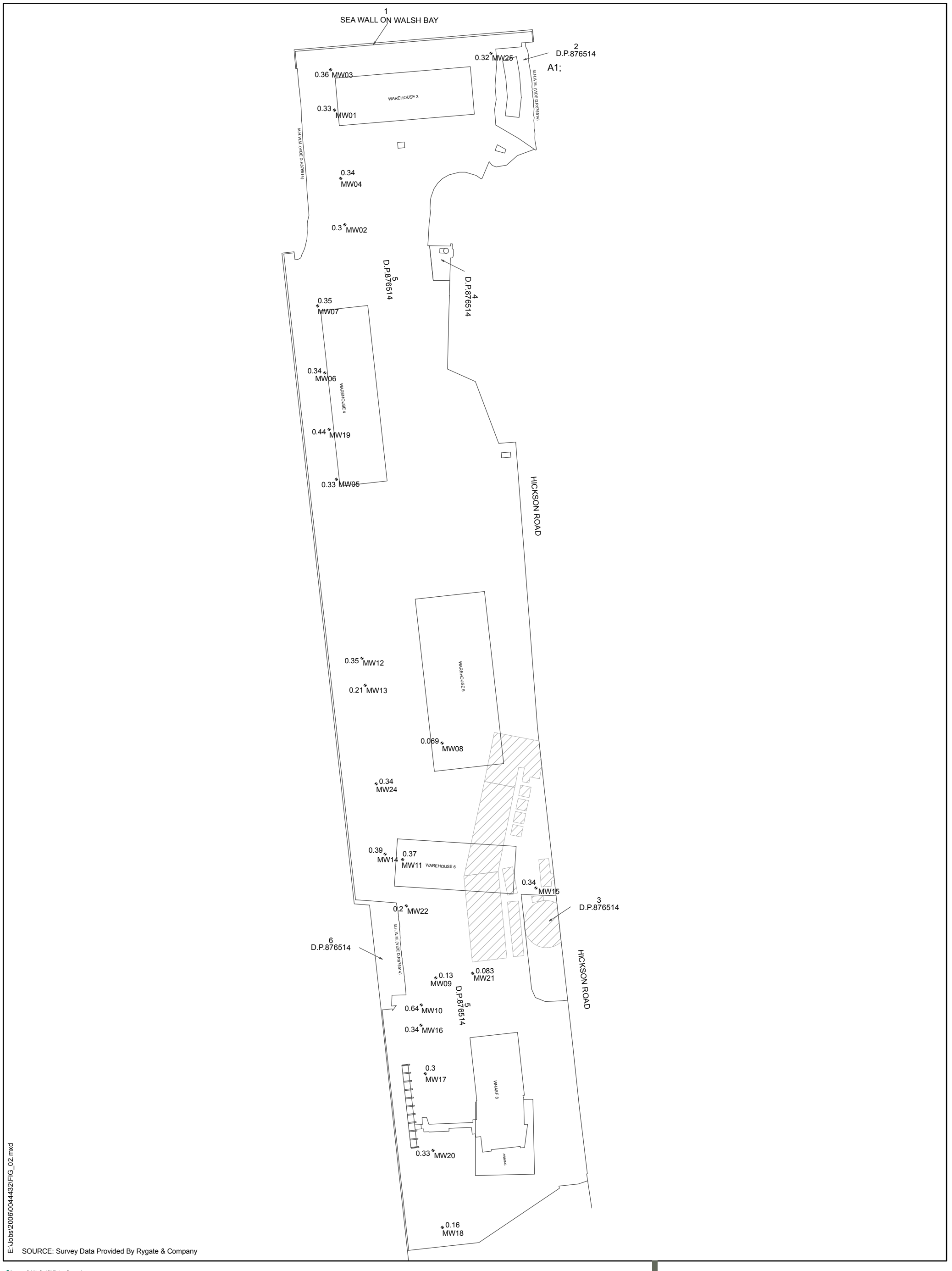


Figure 4 **Site Layout Plan Showing Monitoring Wells and Observed Groundwater Elevations**

SHFA - East Darling Harbour