

APPENDIX D

Groundwater Assessment

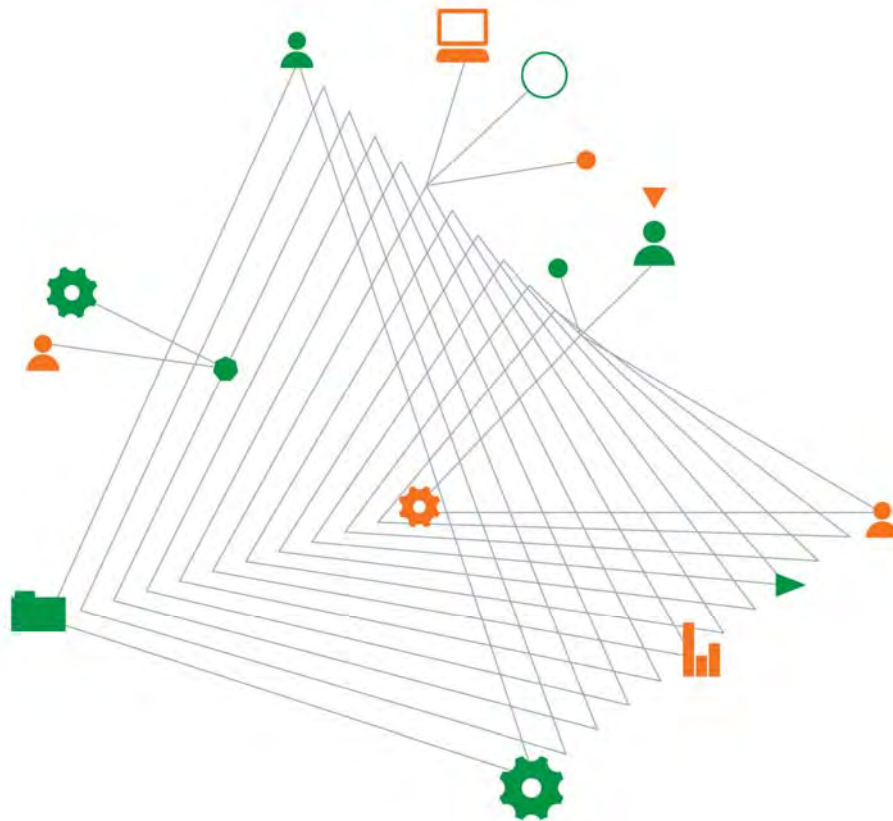


Health Infrastructure NSW

St George Hospital - Stage 2 Redevelopment

Groundwater Assessment

2 December 2014



Experience
comes to life
when it is
powered by
expertise

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St George Hospital - Stage 2 Redevelopment

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For and on behalf of Coffey



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Quality information

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Revision 1	Including Aurora comments	6 Nov 2014	BR	RJB	BR
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Executive Summary

This report provides assessment of groundwater impacts in relation to a proposed lift core for the St George Hospital Stage 2 Redevelopment, Gray Street, Kogarah, NSW.

Coffey Geotechnics Pty Ltd (Coffey) understands that Stage 1 works for the development involved construction of a new Emergency Department on Gray Street which was recently completed. Stage 2 works will involve construction of a new Acute Services Tower above the Emergency Department building, with construction of a new tower lift core.

This assessment responds specifically to the Stage 2 works and impacts on groundwater in relation to the proposed lift core, and addresses the Director General Requirements (DGRs) relating to groundwater.

The DGRs, response to the DGRs based on this assessment, and the section of the report in which the relevant assessments can be found are provided in the table below.

Director General Requirement Relating to Groundwater	Assessment Response	Report Section
<p>13. Groundwater</p> <p><i>Address whether the proposal is likely to (a) intercept, (b) use or (c) affect groundwater.</i></p>	<p>(a) There are no groundwater level records in the immediate vicinity of the proposed lift core. Based on available data, we assess that excavation for the lift core may intercept groundwater.</p>	5 and 6
	<p>(b) Groundwater inflow to the proposed excavation for the lift core will constitute a groundwater loss ("use"), assuming collected inflow water is discharged to stormwater and not returned to the aquifer. The groundwater lost to the excavation is assessed to be up to 0.01 L/s.</p>	6.1
	<p>(c) The proposed excavation for the lift core is expected to preferentially draw groundwater towards it. The groundwater flow regime at the site will therefore be modified, with increased groundwater flowing towards the lift core. However, this effect is assessed to be limited to within 50 m of the lift core, and thus limited to the St George Hospital site.</p> <p>If groundwater levels at the lift core are higher than the excavation/lift core floor level, groundwater will enter the excavation/lift core through the soldier pile wall. The excavation/lift core will act as a groundwater sink. Groundwater collected by the lift core will require collection and discharge. Provided collected groundwater is discharged to an appropriate receptor (e.g., stormwater or sewer), groundwater quality is not expected to be impacted by the lift core.</p>	6.1 and 6.3

Director General Requirement Relating to Groundwater	Assessment Response	Report Section
<p>13. Groundwater</p> <p><i>Demonstrate that the proposal is consistent with the NSW State groundwater policies, and does not detrimentally impact on groundwater quality or the health of groundwater dependent ecosystems.</i></p>	<p>NSW State groundwater policies relevant to the development include:</p> <ul style="list-style-type: none"> • NSW Office of Water <i>Aquifer Interference Policy</i> (September 2012) • <i>Water Management Act 2000</i> • <i>Water Act 1912.</i> <p>The potential impact of the proposed lift core on groundwater quality and groundwater dependent ecosystems (GDE) was assessed in accordance with the <i>NSW Aquifer Interference Policy</i>.</p> <p>The proposed lift core is assessed to induce “minimal” impact upon groundwater quality and GDE in accordance with the <i>NSW Aquifer Interference Policy</i>.</p>	<p>6.3, 6.4 and 7</p>

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1. Introduction

This report provides assessment of groundwater impacts in relation to a proposed lift core for the St George Hospital Stage 2 Redevelopment, Gray Street, Kogarah, NSW.

Coffey Geotechnics Pty Ltd (Coffey) understands that Stage 1 works for the development involved construction of a new Emergency Department on Gray Street which was recently completed. Stage 2 works will involve construction of a new Acute Services Tower above the Emergency Department building, with construction of a new tower lift core.

Our assessment responds specifically to the Stage 2 works and impacts on groundwater.

Assessment of the impacts of development works on groundwater has been completed for inclusion in an Environmental Impact Statement (EIS). The EIS must address the following:

- Whether the proposed development is likely to intercept, use or affect groundwater
- Demonstrate that the proposed development is consistent with the NSW State groundwater policies, and does not detrimentally impact on groundwater quality or the health of groundwater dependent ecosystems.

This report responds to these requirements in relation to the proposed lift core.

2. Background data

As discussed in our Element 2 Site Investigation / Risk Assessment Report (dated 23 July 2014), numerous geotechnical investigations have been conducted in the vicinity of the development. In addition the groundwater level data collected for our previous report, borehole logs prepared by Coffey and Jeffery and Katauskas Pty Ltd (J&K) documented in the following reports were reviewed for groundwater data as part of this assessment:

1. J&K report reference: 25264Z, dated 2 November 2011
2. J&K report reference: 25264Z Let 2, dated 12 January 2012
3. Coffey report reference: S9043/1-AB, date June 1989
4. Coffey report reference: S9043/2-AB, dated August 1990
5. Coffey and Hollingsworth report reference: 2557, dated 25 November 1968
6. J&K Borehole logs dated 1993 (9 boreholes)
7. J&K Borehole logs dated 1995 for Hydrotherapy Building (2 boreholes)
8. J&K Borehole logs dated 1996 for Education Centre (3 boreholes)
9. J&K Borehole logs dated 1999 for Psychiatric Unit (7 boreholes).

The locations of the boreholes are shown in Figure 1.

3. Subsurface conditions

The 1:100,000 scale Geological Map of Sydney indicates that the site is underlain by Triassic age Hawkesbury Sandstone. Hawkesbury Sandstone generally consists of medium to coarse grained quartzose sandstone with interbedded mudrocks including siltstone and shale. The sandstone typically weathers to form a relatively thin residual soil comprising clayey sand and sandy clay, whereas siltstone and shale typically weather to form clay and gravelly clay.

Previous geotechnical investigations indicate that subsurface conditions at the site comprise fill overlying residual soils (sand and clay) overlying sandstone, consistent with the conditions indicated by the geology map.

4. Proposed lift core and ground conditions

We understand from Enstruct Group Pty Ltd (Enstruct) that the lift core will comprise three core blocks as shown in the Enstruct sketch in Appendix A. Excavation for the lift core will extend 4 m below the existing building ground floor level of 28.7 m AHD. The excavation will be retained by a soldier pile wall with shotcrete infill.

J&K (2011) borehole BH5 lies in the immediate vicinity of the proposed lift core and indicates that, for an excavation floor level of 24.7 m AHD, the excavation will fully penetrate the fill and residual soils, and penetrate the sandstone by some 0.5 m.

We assume that the lift core will be constructed such that surface water and groundwater present in the fill will be prevented from entering the excavation/lift core.

5. Groundwater

St George Hospital lies on a topographical mound, with the hospital complex approximately centred over the mound. The Emergency Department on Gray Street lies downgradient to the immediate west.

Groundwater elevations are expected to follow topography, with high groundwater levels at approximately the centre of the site/mound, falling with distance away from the centre.

Borehole logs in items 1, 6 and 7 listed in Section 2 above included groundwater level information. In addition, Coffey measured groundwater levels at the site on 20 June 2014 in those piezometers (BH401, BH205 and BH408) installed by Coffey.

Table 1 provides recorded groundwater levels at the site. Groundwater levels are also shown on Figure 2.

Based on recorded groundwater levels, the groundwater table consistently lies in the relatively shallow weathered sandstone.

There are no groundwater level records in the immediate vicinity of the proposed lift core. However, measured groundwater levels are consistently between 1.5 m and 4.0 m below ground surface. This suggests that the groundwater level in the vicinity of the lift core may be between 27.0 m AHD and 24.5 m AHD.

Variation in groundwater levels due to rainfall is not captured by the measurements recorded (and listed in Table 1).

Coffey experience indicates that groundwater levels in Hawkesbury Sandstone located in urban environments in Sydney typically vary by up to 0.5 m in response to rainfall recharge.

Thus, the groundwater level in the vicinity of the lift core may rise as high as 27.5 m AHD.

Table 1: Groundwater Levels

Borehole Completed By	Borehole	Groundwater Level Below Ground Surface (m)	Groundwater Level (m AHD)	Date Groundwater Level Measured	Time of Measurement Since Drilling Completed
Coffey, 2014	BH401	4.0	27.9	20 Jun 2014	Two months
Coffey, 2014	BH405	3.9	24.2	20 Jun 2014	Two months
Coffey, 2014	BH408	2.1	21.4	20 Jun 2014	Two months
J&K, 2011	BH3	2.5	27.9	14 Oct 2011	On completion of coring
J&K, 1995	BH101	1.5	26.0	25 Jul 1995	On completion of (auger) drilling
J&K, 1995	BH102	2.7	~26.2	25 Jul 1995	On completion of (auger) drilling
J&K, 1993	BH4	4.0	26.6^	24 Nov 1993	Five days
J&K, 1993	BH5	2.6	28.6^	24 Nov 1993	Five days
J&K, 1993	BH6	3.0	28.1^	24 Nov 1993	Two days
J&K, 1993	BH7	2.2	29.1^	24 Nov 1993	Two days

^Assumes borehole log datum is -68.1 m AHD.

6. Impact assessment

Based on available groundwater level records and the potential for groundwater levels to rise in response to rainfall recharge, the groundwater level in the vicinity of the lift core may rise as high as 27.5 m AHD, some 3 m above the proposed lift core excavation floor level of 24.7 m AHD.

We therefore assess that excavation for the lift core may intercept groundwater.

We have assessed the potential impact of the lift core excavation on groundwater levels and flow, groundwater quality, existing groundwater users (registered with NSW Office of Water) and groundwater dependent ecosystems (GDE).

6.1. Groundwater levels and flow regime

The lateral extent of groundwater drawdown was assessed by analytical methods based on theory presented by Edelman (1972) for radial drawdown from an extensive aquifer. This assessment provides a conservative estimate of drawdown under steady state flow conditions.

The assessment assumes:

- The total excavation footprint is some 110 m² with a floor level of 24.7 m AHD
- The groundwater level in the aquifer is 27.5 m AHD

- A hydraulic conductivity of 0.01 m/day for the clay and sandstone. This hydraulic conductivity value is typical of field test results for Hawkesbury Sandstone and residual clay in Sydney geological settings similar to those at the development site
- Groundwater flow enters the excavation/lift core through the clay and sandstone (there is no contribution from surface water or from the fill, which are cut-off from entering the excavation/lift core)
- The aquifer contributing to inflow is approximately 17 m thick
- Absence of water bearing features (such as fault zones) within the rock
- Infiltration of 2% (typical of urban settings) of mean annual rainfall of 1,085 mm (the 114-year mean for Bureau of Meteorology Station at Sans Souci Public School).

Based on these assumptions, the assessed groundwater inflow to the excavation/lift core is assessed to be up to 0.01 L/s (0.5 ML/year). Groundwater drawdown (greater than that experienced due to seasonal variation) is expected to be limited to distances of up to 50 m of the lift core.

Groundwater is expected to be preferentially drawn to the proposed lift core. Groundwater flows within the aquifer may be modified, with increased groundwater flowing towards the lift core. However, this effect would be limited to within 50 m of the lift core and thus be limited to the St George Hospital site.

6.2. Existing groundwater users

To assess the potential impact of the lift core on existing groundwater users, a search of NSW Natural Resources Atlas registered groundwater bores was conducted on 21 October 2014.

The nearest groundwater bore on record (GW024615) lies over 400 m to the south east, well beyond the assessed extent of groundwater drawdown influence.

Groundwater impacts on (registered) groundwater users are therefore not expected.

6.3. Groundwater quality

If groundwater levels at the lift core are higher than the excavation/life core floor level, groundwater will enter the excavation/lift core through the soldier pile wall. The excavation/lift core will act as a groundwater sink. Groundwater collected by the lift core will require collection and discharge. Provided collected groundwater is discharged to an appropriate receptor (e.g., stormwater or sewer), groundwater quality is not expected to be impacted by the lift core.

6.4. Groundwater dependent ecosystems

The nearest groundwater dependent ecosystems (GDE) identified by the Australian Government Bureau of Meteorology Atlas are located in As Tanner Reserve and Scarborough Park approximately 1 km to the east of the site. As groundwater drawdown is assessed to be limited to within approximately 50 m of the lift core, the lift core is not expected impact on GDE.

7. Policy, legislation and potential impacts

The *NSW Aquifer Interference Policy* (September 2012) considers assessment of impacts of aquifer interference activities on water resources and the concept of ensuring “no more than minimal harm” (referred to in the *Water Management Act 2000*).

The minimal impact considerations are dependent upon the impacted aquifer type (alluvial, coastal, fractured rock or other special cases) and whether the aquifer is classified as “highly productive” or “less productive groundwater” (based on total dissolved solids concentration).

The proposed basement will draw groundwater from the sandstone (fractured rock) aquifer.

Total dissolved solids (TDS) measurements are not available for groundwater at the site. For the purposes of this assessment, we make the conservative assumption that the fractured rock (sandstone) aquifer would classify as a “highly productive” aquifer.

The minimal impact considerations for aquifer interference activities in these aquifers are listed in Table 2 along with our assessment of the potential impact.

In accordance with the Department of Primary Industries NSW Office of Water *Aquifer Interference Policy*, the development is assessed to induce “minimal” impact upon groundwater resources.

Table 2: Aquifer Interference Policy Minimal Impact Consideration

Impact On	Impact Consideration	Assessed Impact
Water Table	<p>1. Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic “post-water sharing plan” variations, 40 m from any:</p> <p>(a) high priority groundwater dependent ecosystem; or</p> <p>(b) high priority culturally significant site;</p> <p>listed in the schedule of the relevant water sharing plan.</p> <p>A maximum of a 2 m decline cumulatively at any water supply work.</p> <p>2. If more than 10% cumulative variation in the water table, allowing for typical climatic “post-water sharing plan” variations, 40 m from any:</p> <p>(a) high priority groundwater dependent ecosystem; or</p> <p>(b) high priority culturally significant site;</p> <p>listed in the schedule of the relevant water sharing plan then appropriate studies(6) will need to demonstrate to the Minister’s satisfaction that the variation will not prevent the long-term viability of the dependent ecosystem or significant site.</p> <p>If more than 2 m decline cumulatively at any water supply work then make good provisions should apply.</p>	<p>The nearest groundwater dependent ecosystems (GDE) and water supply work (NSW Office of Water registered bore) to the proposed lift core are located beyond the assessed extent of groundwater drawdown influence imposed by the lift core.</p> <p>Therefore, the lift core is not expected to impact on the water table within 40 m of GDE or water supply works.</p>
Water	1. A cumulative pressure head decline of not more than a 2 m	The nearest water supply work

Impact On	Impact Consideration	Assessed Impact
Pressure	<p>decline, at any water supply work.</p> <p>2. If the predicted pressure head decline is greater than requirement 1(a) above, then appropriate studies are required to demonstrate to the Minister's satisfaction that the decline will not prevent the long-term viability of the affected water supply works unless make good provisions apply.</p>	<p>(NSW Office of Water registered bore) to the proposed lift core is located beyond the assessed extent of groundwater drawdown influence imposed by the lift core.</p> <p>Therefore, the lift core is not expected to impact on the pressure head at any water supply work.</p>
Water Quality	<p>1. Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40m from the activity.</p> <p>2. If condition 1 is not met then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply works.</p>	<p>The excavation/lift core is expected to act as a groundwater sink (provided groundwater collected by the excavation/lift core is discharged to an appropriate receptor).</p> <p>The lift core is therefore not expected to modify groundwater quality.</p>

8. Conclusions

Based on available groundwater level records, and considering the potential for groundwater levels to rise in response to rainfall recharge, we assess that excavation for the lift core may intercept groundwater.

Groundwater is expected to be preferentially drawn to the proposed lift core. However, this effect would be limited to within 50 m of the lift core, and thus be limited to the St George Hospital site.

Groundwater extracted from the aquifer by the proposed excavation/lift core is assessed to be minor (0.01 L/s or 0.5 ML/year).

Groundwater quality, existing groundwater users (registered with NSW Office of Water) and groundwater dependent ecosystems (GDE) are not expected to be impacted by the assessed groundwater drawdown.

In accordance with the Department of Primary Industries NSW Office of Water *Aquifer Interference Policy*, the development is assessed to induce “minimal” impact upon groundwater resources.

9. Limitations

Our assessment assumes specific conditions in relation to construction of the lift core. Should conditions differ from those assumed in this report, the assessment conclusions made here may not be relevant.

This report is further based on data collected at a limited number of piezometers and boreholes at discrete locations. Subsurface conditions can change over relatively short distances.

Groundwater monitoring should be conducted during construction to verify the consistency of groundwater (levels, flow and quality) and ground conditions with those assumed/adopted in this assessment.

The attached document entitled *Important Information about Your Coffey Report* provides additional information on the uses and limitations of this report.

10. References

Edelman, J.H. (1972), *Groundwater Hydraulics of Extensive Aquifers*, International Institute for Land Reclamation and Improvement, Wageningen, Netherlands.

Important information about your **Coffey Report**

As a client of Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project.

Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by

earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

Important information about your **Coffey** Report

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

Data should not be separated from the report*

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way.

Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment.

Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

Rely on Coffey for additional assistance

Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical information in Construction Contracts" published by the Institution of Engineers Australia, National headquarters, Canberra, 1987.

Figures

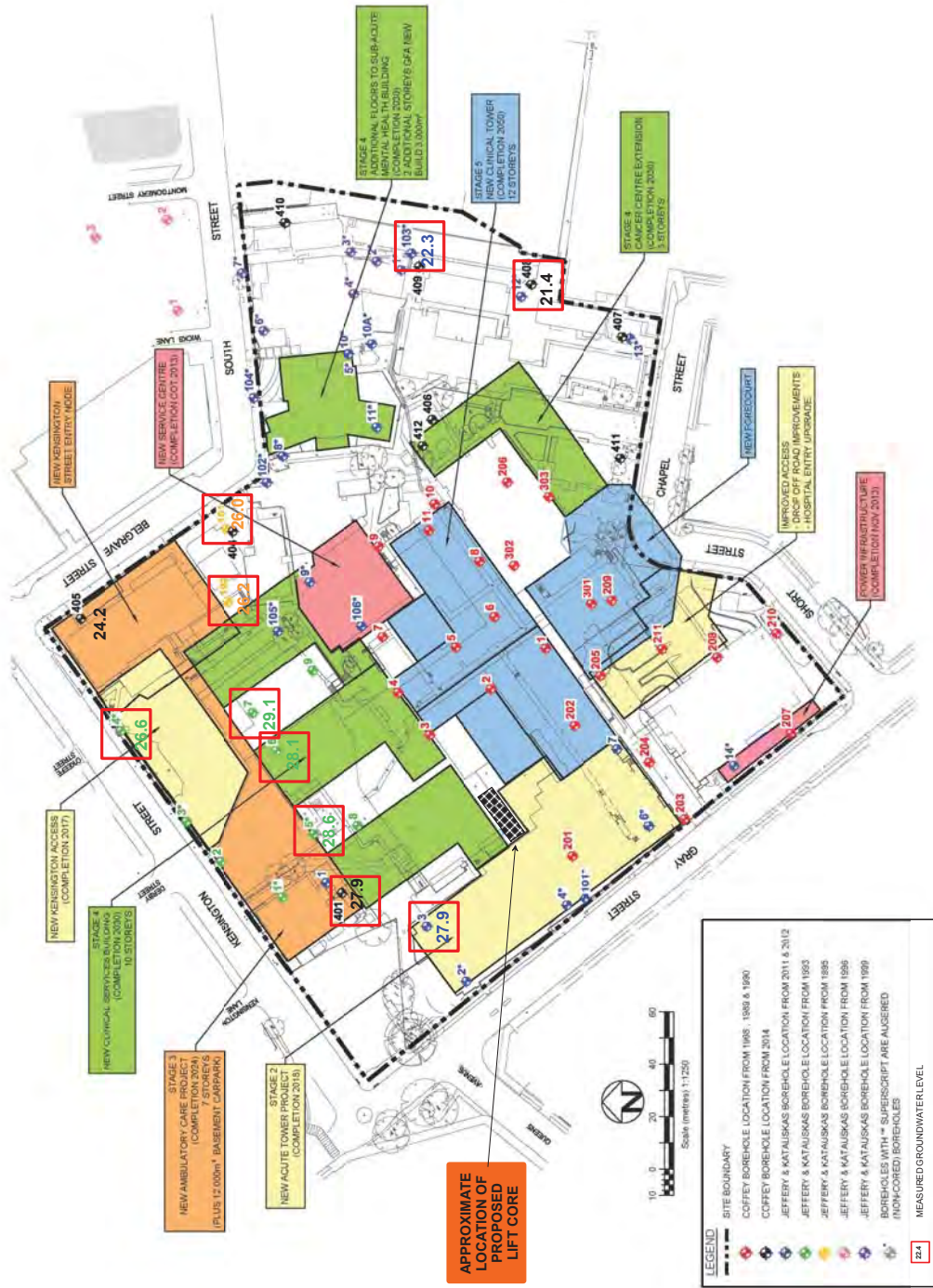
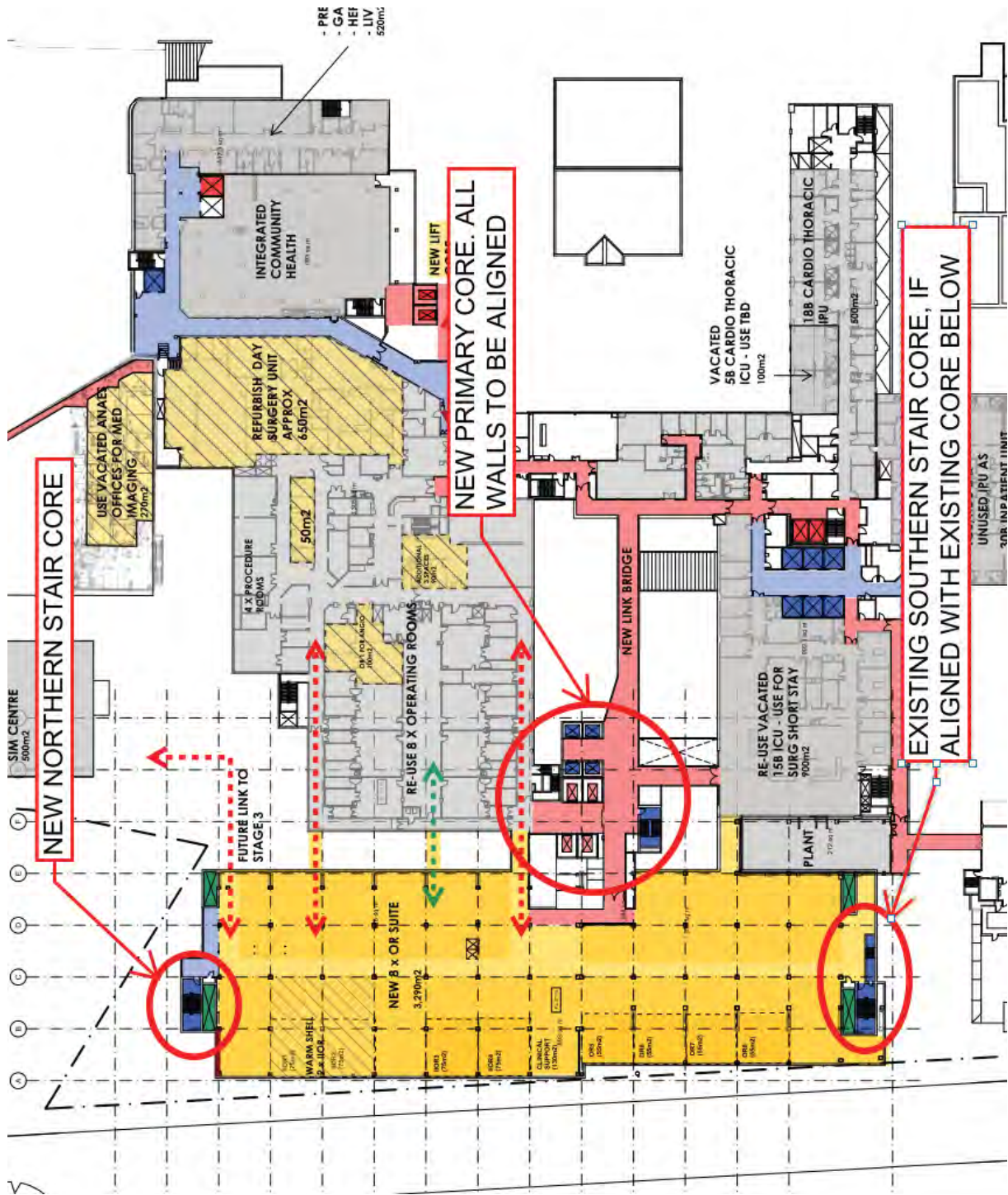


Figure 2: Groundwater Levels

Appendix A - Enstruct Sketches



4900mm TO EXISTING BLDG (EAST)

EXISTING CAPPED TRADEWASTE DRAINAGE AND CHAMBER VENT PROVIDED IN STAGE 1 PANSION G PIT TO BE LEVEL EXACT WITH EXTERNAL

INDICATES 450mm DIAMETER RETENTION SOLDIER PILES WITH SHOTCRETE INFILL. 600mm (MIN) STRUCTURAL ZONE REQUIRED FOR RETENTION.

EXISTING Ø150 SEWER APPROX. ALLOW TO DIVERT AROUND NEW GROUND FLOOR BUILDING WORKS - STAGE 2

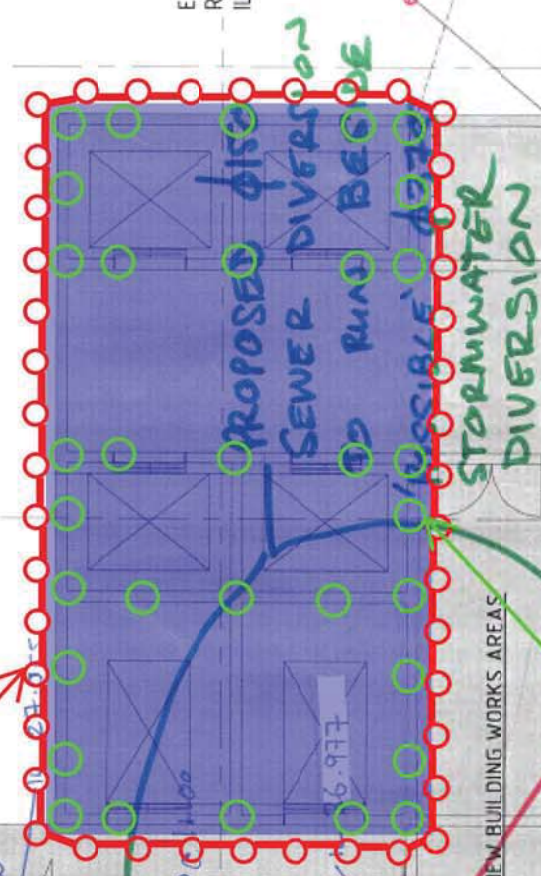
LOCATE AND CONNECT TO EXISTING Ø100

EX.SMH RL28.130 IL27.130

IL26.84.7 CONNECT TO EX.SMH AND MAKE GOOD

EX.SMH RL28.200

EX IL26.728 (ASSUMED)



INDICATES CORE FOUNDATION AT RAFT SLAB AND CONSTRUCT DIVERSION TO PROPOSED PILING SYSTEM

INDICATES POTENTIAL CORE FOUNDATION PILES (LOCATIONS INDICATIVE ONLY AS DETAILED LATERAL ANALYSIS AND PILE DESIGN REQUIRED TO CONFIRM SIZE AND SPACING. IF CLASS III ROCK OR BETTER ENCOUNTERED AT BASE OF RAFT SLAB NO FOUNDATION PILING REQUIRED.

NTS
RS

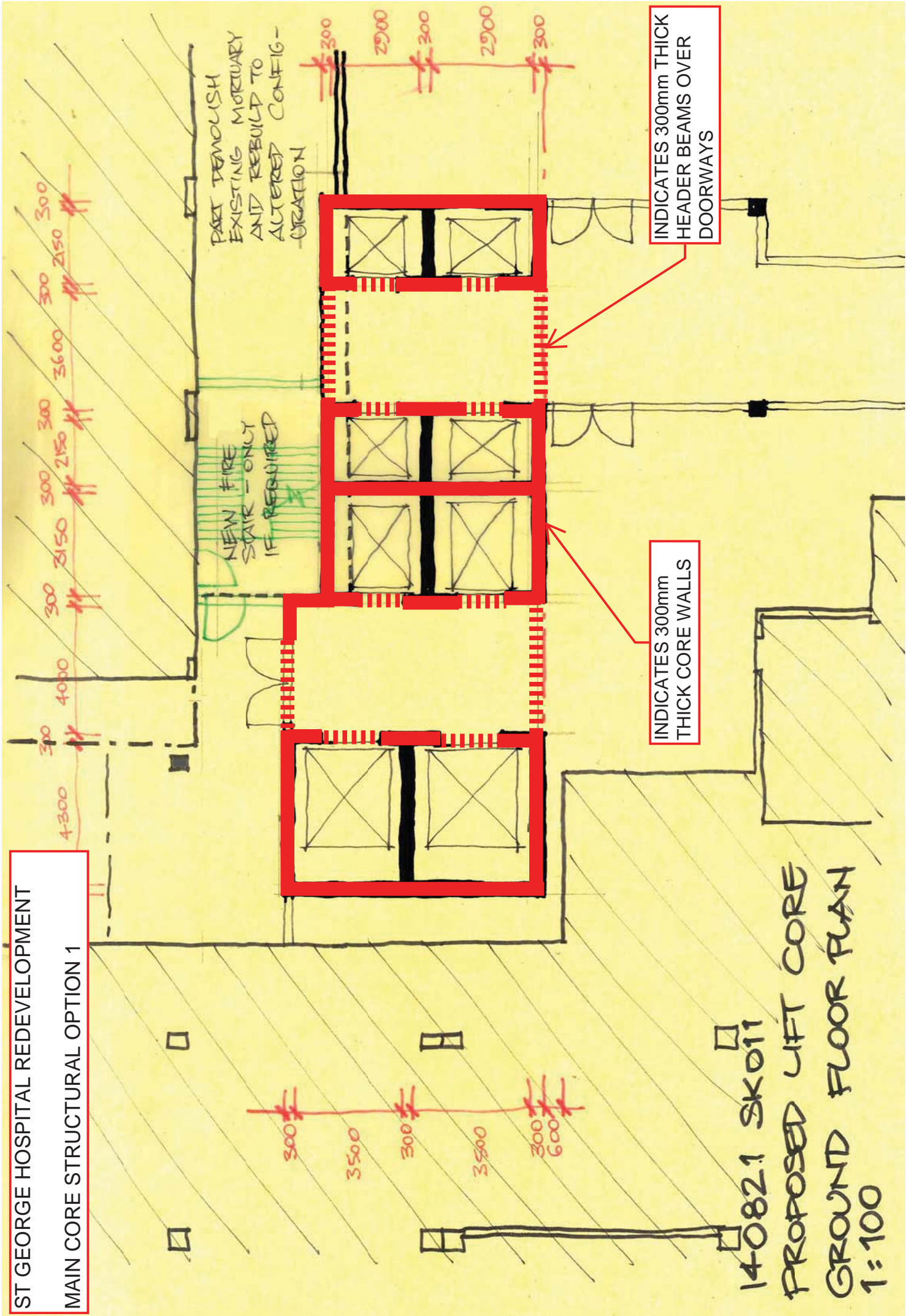
FROM UP PLANT ROOM

E AND RISKS FOR IN DBE (TO SKY)

EXP 50

ST GEORGE HOSPITAL REDEVELOPMENT

MAIN CORE STRUCTURAL OPTION 1



14082.1 SK011

PROPOSED LIFT CORE
GROUND FLOOR PLAN
1:100