Engineering Submission

to

Mining Subsidence Board

RE:

PROPOSED HMRI BUILDINGS

Rankin Park, John Hunter Hospital

Submitted 10th July 2009

Compiled by Arup
Job No. 206014-00

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1.1 Introduction

The HMRI site is located within the Newcastle Mine Subsidence District and this building engineering report is part of ongoing consultations with the Mining Subsidence Board (MSB). This report outlines how the proposed HMRI buildings cope with potential future trough-subsidence whilst maintaining their functionality as laboratory & admin spaces.

1.2 HMRI Proposed Buildings

The Hunter Research Medical Institute (HMRI) proposes a new facility at the Rankin Park Campus of the John Hunter Hospital at New Lambton Heights, Newcastle.

The proposed HMRI facility comprises of three linked buildings – the West Wing & Atria, East Wing and Pod buildings. Figure 1 also shows a potential future extension beyond the East Wing.

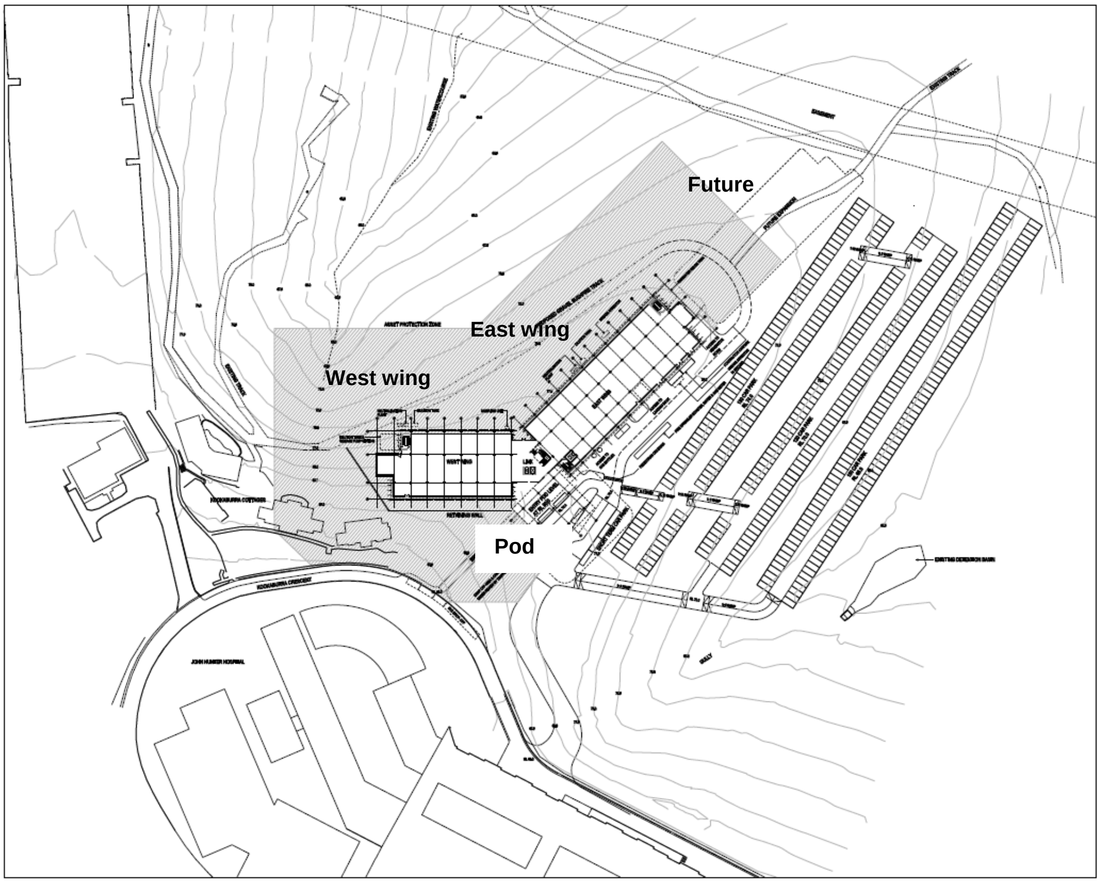


Figure 1 – Site Layout Plan of proposed HMRI buildings at Rankin Park Campus

1.3 Executive Summary – MSB Engineering Submission

This engineering submission to the MSB aims to demonstrate how the HMRI buildings will cope with potential future differential settlement due to possible subsidence from the underlying coal mine workings in the Borehole Seam.

This report responds to the design criteria established by Coffey.

We propose to establish a regular monitoring programme for the HMRI buildings to assess the accumulative land subsidence. If subsidence exceeds the set limits (2mm in 1000mm), then the building/s will be re-levelled. To achieve this, the provision for future jacking & access to all vertical load- bearing elements has been incorporated into the substructure design. This approach allows the superstructure, and all architectural, façade and internal services to be designed for normal building movements and tolerances of 1 in 500.

Coffey's have reported the estimated maximum surface settlement to be 110mm. So potentially, any or all of the HMRI buildings could be jacked up to 110mm over their lifetime. To accommodate this, all incoming and outgoing services will have flexible articulated joints to allow for an accumulative differential settlement of up to 110mm between the buildings and surrounding subsiding ground.

2.0 Coffey – Mine Subsidence Assessment

Coffey's have produced a Mine Subsidence Assessment for the proposed HMRI buildings, refer report GETOWARA20576AB-AB dated 26th May 2009.

The report (pp4) states that

> In order to satisfy the MSB and gain approval for the development, it is necessary to demonstrate that:
>
> - The risk of failure of the pillars is acceptably low for the proposed development; and / or
> - Should failure occur, the resulting damage to the proposed development will be acceptable and safe, serviceable and repairable; and / or
> - The risk of subsidence can be reduced or removed by structural measures or remediation of the workings, usually by injecting a cement/fly ash grout into the mine workings through boreholes drilled from the surface.

For a comprehensive overview of the prevailing subsurface conditions, refer to Coffey's report. Based on the knowledge gained from the deep borehole undertaken as part of the HMRI Geo-investigation and four other deep boreholes for which Coffey have data, Coffey generated a the design surface subsidence profile.

From a building engineering viewpoint, this subsidence design criteria is the crucial information, as contained in the extracts below (pp 14-16) :

9.2 Mine Subsidence

Due to the amount of cover above the mine workings, only trough subsidence is considered feasible. In BH 22, 0.29m of crush was determined. Comparing this to the 0.5m of crush in boring 6, it appears that 0.2m of additional crush is possible at mine level. Therefore, based on the maximum subsidence factor of 0.55, the possible future vertical surface subsidence is 0.11m or 110mm. Estimated subsidence parameters as indicated in Table 6 were developed based on procedures in Holla, 1987 assuming relatively level ground conditions.

TABLE 6 – ESTIMATED TROUGH SUBSIDENCE PARAMETERS

PARAMETER	VALUE
Maximum Subsidence, Smax	110 mm
Maximum Tensile Strain, +Emax	0.76 mm/m
Maximum Compressive Strain, -Emax	1.24 mm/m
Maximum Tilt, Gmax	3.7mm/m
Tensile Curvature radius (convex)	12.6 km
Compressive Curvature radius (Concave)	7.6 km

An angle of draw of 26.5° (2V:1H) within rock overburden is typically adopted for the northern coal fields of the Hunter Valley. This is based on longwall subsidence data presented in Holla (1987). The angle of draw through soil is believed to be similar to that through rock.

Extract from Coffey's Mine Subsidence Assessment, GETOWARA20576AB-AB, 26 May 2009

9.3 Designing for Subsidence

When proposed building gets above three stories the current position of the MSB is that all plausible movements need to be designed for, or the building be designed in such a way that cost of repair is sufficiently small (exact value will need to be discussed with the MSB) or grouting to stabilise the mine workings performed. Sometimes the risk to developments by Mine Subsidence is not always a catastrophic event and as such it may be possible to design developments for 'maximum conceivable' subsidence. This is case at our site where workings have already crushed to some extent.

10 CONCLUSIONS

Coal in the Borehole Seam has been mined under the site by Lambton Colliery which operated between 1862 and 1941, with the site area under mined somewhere between 1885 and 1895 using bord and pillar methods with working height estimated to be 2m. Retreat mining was performed in haulageways in about 1915 to 1918. The current location of the mine plan can be seen in Drawing 1.

Borings used in the subsidence assessment included BH22 drilled during the current investigation and four borings drilled in a previous investigation.

It appears that approximately 0.3 to 0.5m of crushing has occurred in pillars with lower factors of safety at the site. It appears that about 110mm of additional trough subsidence could occur at the site.

As previously mentioned, the Mine Subsidence Board must assess the level of risk which is acceptable to them based on the likelihood and consequences of further crushing.

For and on behalf of Coffey Geotechnics Pty Ltd

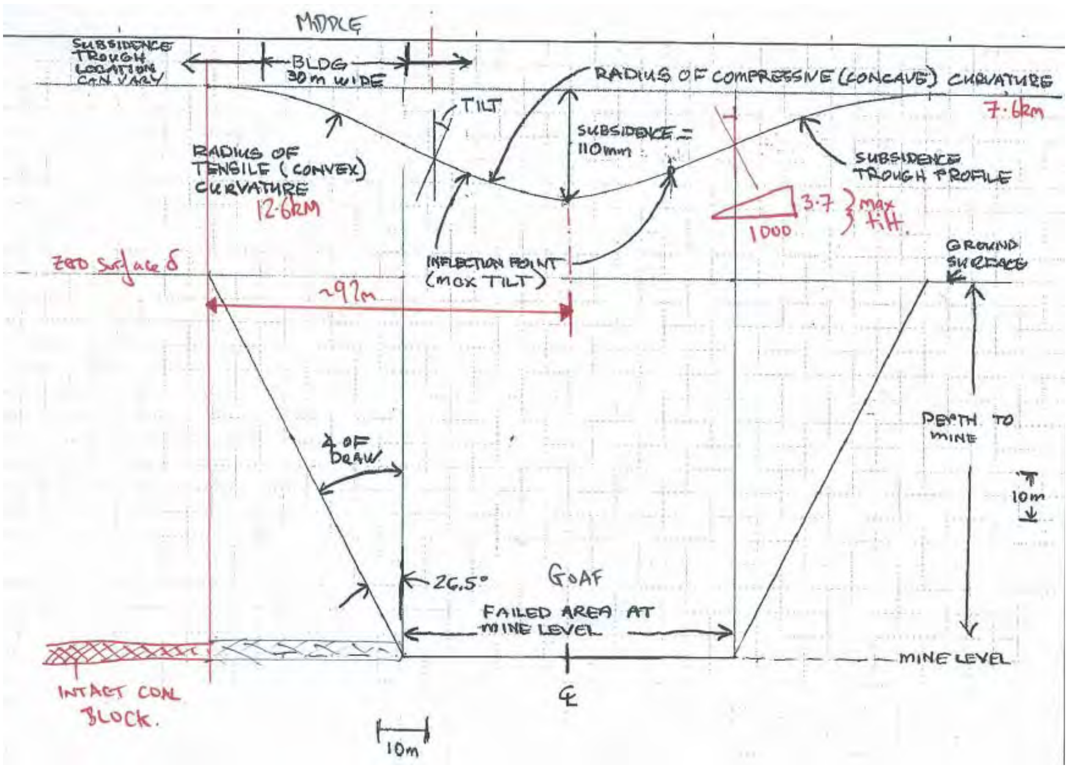
Arthur Love

Arthur Love

Principal Geotechnical Engineer

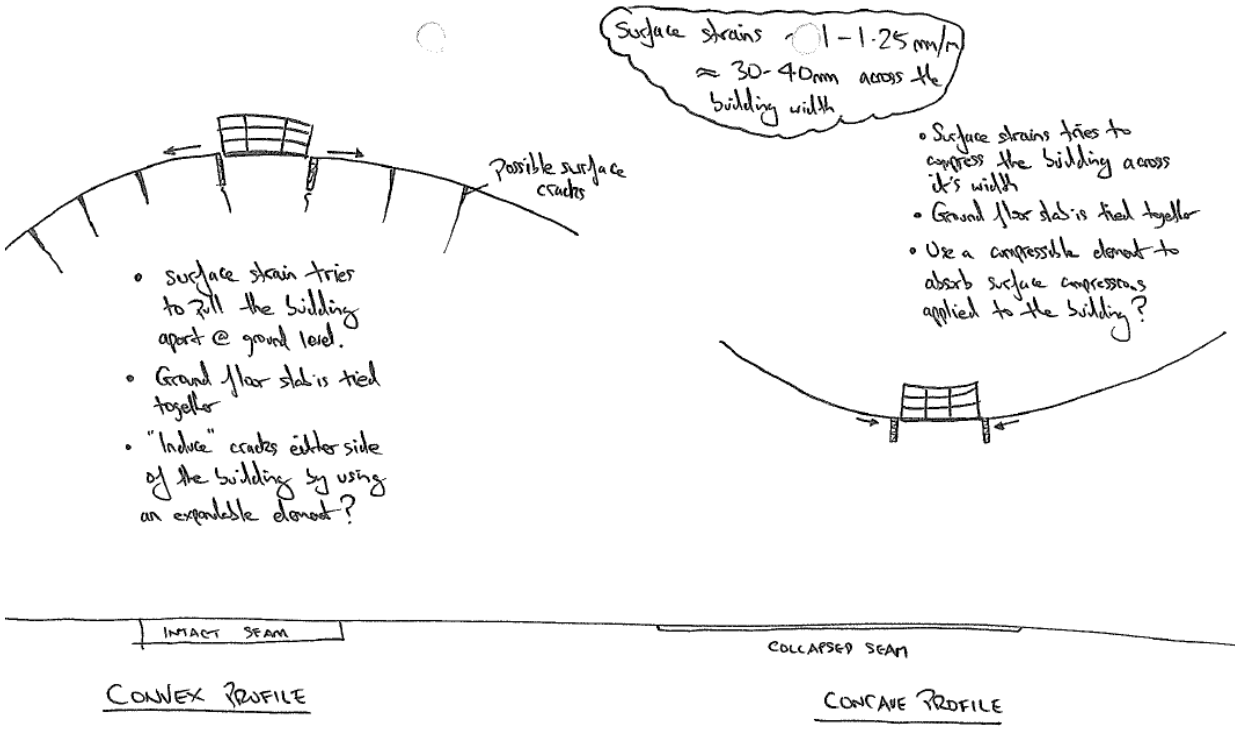
Extract from Coffey's Mine Subsidence Assessment, GETOWARA20576AB-AB, 26 May 2009

2.1 Estimated Trough subsidence profile



Conceptual Subsidence Profile – Coffeys original sketch in black (overlain by Arup notes in red)

Coffey's have clarified that the future (northern-most) wing of the building is most likely to see the most severe tilt. The relative displacements of the West and East wings are likely to be less in reality though the same principles/solutions will apply. It is likely that there will be some longitudinal subsidence effects. The building wings are expected to physically lie on the convex portion of the subsidence curve and in the region of maximum tilt. This suggests that surface strains could be expected to be mainly tensile (i.e. a tendency for the ground surface to open up rather than compress). Further to discussions with the MSB and Coffey on 1st July 2009, the development must assume that the concave compression surface strains could also occur. These profiles are shown on the simplified sketches below.



Arup sketches of convex and concave profiles

Coffey consider that the subsidence would be a gradual process-taking place over a timeframe of months/years rather than an abrupt event. This is very important as it provides the opportunity to monitor and correct for settlements before they become excessive and therefore a problem. The rationale for this is based on the following, which renders a rapid collapse scenario unlikely:

> Subsidence from pillar crushing has already occurred to some extent based on the boring data.

> The mine is flooded so oxidation of the coal pillars is greatly reduced

> The absence of claystone in the floor and above the pillars eliminates the risk of material softening leading to an abrupt pillar punching event

> The coal is underlain by high strength sandstone which is unlikely to allow pillar failure by punching into the floor.

In broad terms, the maximum estimated crushing at mine level is in the order of 200mm, which relates to a maximum predicted surface settlement of 110mm

The absolute subsidence is much less significant than the relative subsidence as far as buildings are concerned - i.e. rate-of-change of settlement; curvature; tilt etc

Coffey expect that the subsidence will be primarily across the width of the building - primarily due to a large pillar to the North West that has probably not failed, and is not expected fail in the future. Crushing of the remaining workings is the driver for generating the subsidence profile.

It should be noted that the risk of subsidence within the design life of the development is considered by Coffey to be low.

3.0 HMRI Buildings - Structural Overview

The proposed HMRI building consists of two main wings and a Pod centred around an atria which acts as the main movement space.

The East and West wings each have four levels of floor space (L1, L2, L3 & L4). Plant rooms exist at both far ends, as well as along a central strip of Roof (L5=LR), to be covered over by lightweight steel. The East and West wings have columns at 6.6m centres on a 9.2 – 11.0 – 6.5m grid, with stability provided by designated shear walls about plant areas, stairwells & lifts.

The Pod stands on double-storey columns, with its two floor levels at L3 and L4, which cantilevering 2.5-3.6m beyond the vertical columns (arranged 3x3). The Pod has a lightweight steel roof over (L4=LR).

To facilitate lateral movements & any future subsidence, each of the East & West wings and Pod building act as distinct buildings with movement joints separating them from each other.

The laboratory floor-plates within the East and West wings (Grids B-C-D) are designed to be as insensitive as practical to footfall-induced vibration. This has lead to a stiff RC floor (250thk slabs & 2400x600dp bandbeams). The pod's cantilevers also require very stiff L3 RC beams 1200dp x 700w to minimise vertical deflections.

The development comprises 3 separate structures separated by movement joints (East Wing, West Wing and Pod). Each structure has a separate stability system.

A full set of preliminary structural plans and sections is contained within Appendix B.

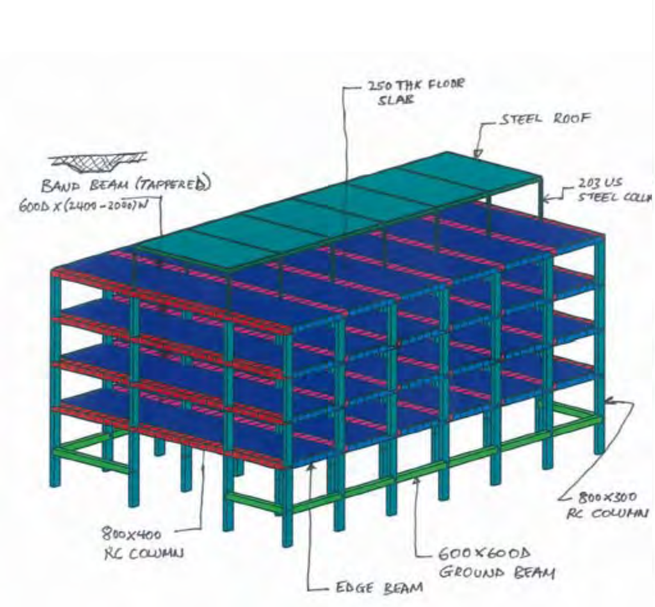
3.1 Structural Framing

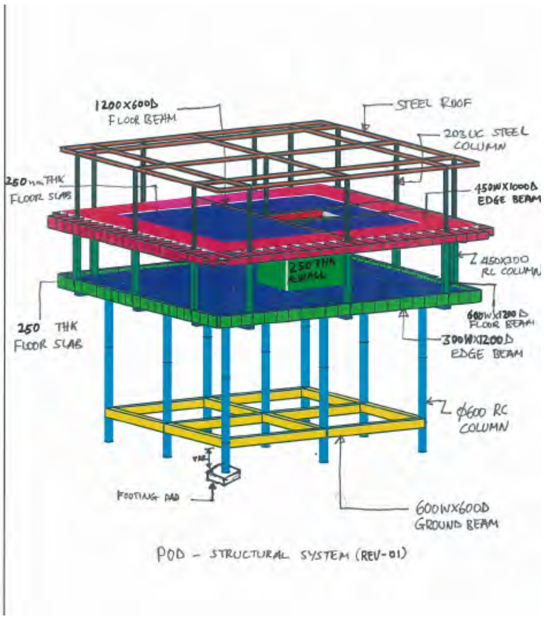
> Both West and East Wing's have a columns located at 6.6m ctrs on a 9.2, 11, 6.5m grid. A 250thk slab spans to 2400w x 600dp band-beams

> The entire structure will be founded within very hard sandstone. The sandstone outcrops above the West Wing (requiring bulk excavation), but falls away to be 3m under the far end of the East Wing (Grid 25). So the opportunity exists from Grids 18-25 to create an under croft.

> The Pod has two upper floor levels (L3 and L4) which sit on 9No. 600sq double height columns. The exposed soffit of L3 has 1200dp x 700w beams running over the column and cantilevering out to pick up a 1200dp x 400w perimeter beam, with 250thk infill slab. The 9No. columns pad footings will be founded into the sandstone, and tied together with ground beams under the road level.

> Stability walls are 250thk around stairwells, lift cores and shear walls





Arup Isometrics **Main wings** **Pod building**

4.0 Mine Subsidence - design approach

Clear design principles and techniques shall allow the structure to accommodate ground movement resulting from mine subsidence. If surface strains in the ground are transferred into the structure, the tensile and compressive strains may cause building elements to crack, shear, buckle or tilt.

The major impacts of mine subsidence on buildings are:

> vertical subsidence (Settlement)

> horizontal displacement

> horizontal strains

> curvature

> tilt

The conceptual methodologies to mitigate each the above risks of subsidence-related damage are outlined below.

4.1 Design for vertical subsidence (Settlement)

The HMRI RC frames have been designed to mitigate deflection and hence footfall induced vibration as much as is practically possible, resulting in very stiff RC frames. These stiff elements are unable to sufficiently flex to accommodate the 3.7mm in 1000mm maximum differential settlements defined by Coffey's as an upper limit of future mine subsidence that may be imposed on the HMRI buildings.

As Coffey's are confident that any future subsidence with be gradual, Arup propose a monitoring regime be instigated, and that the buildings re-levelled before the differential settlement exceeds tolerable limits (2mm in 1000mm).

Thus the provision is being made for accessible jacking points under all columns, cores and shear walls to allow for future re-levelling, in case of future mine-related subsidence. This allows the superstructure and associated façade & services to be designed in accordance with standard building tolerances.

Settlement beyond these values may overstress the ground beams and floor slabs. Large settlements could also damage non-structural elements such as partition walls, facades and other brittle finishes. To design the structural elements to accommodate the subsidence movement may have a greater impact on the cost of the building than incorporating in the future provision to re-level.

As such, the substructure and ground-floor design incorporates:

> Fully suspended ground floor slab

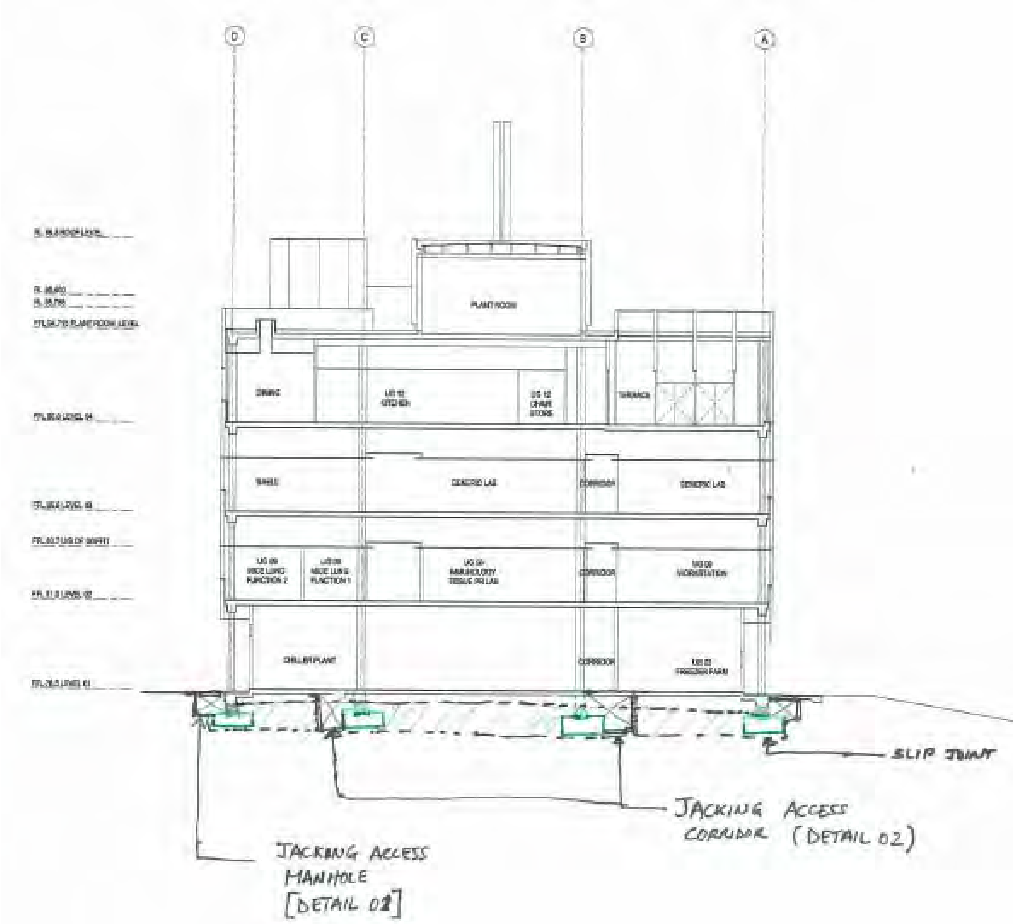
> Provision of orthogonal ground beams to support suspended slabs

> Provision to access & jack every column, shear wall & core.

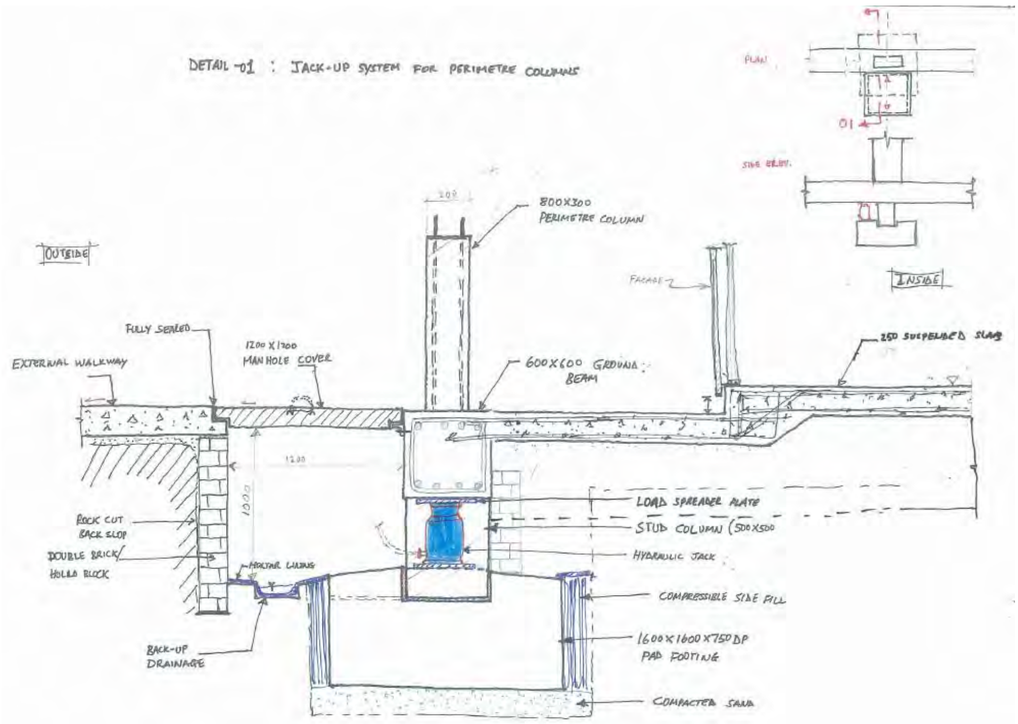
> Sub-floor access is provided via manholes to external columns (Grids A&D) and & corridors to internal columns (Grids B&C). Core walls will be accessed internally.

Conceptual sketches of the proposed jacking scheme are included overleaf:

Conceptual sketches of access & temporary jacking

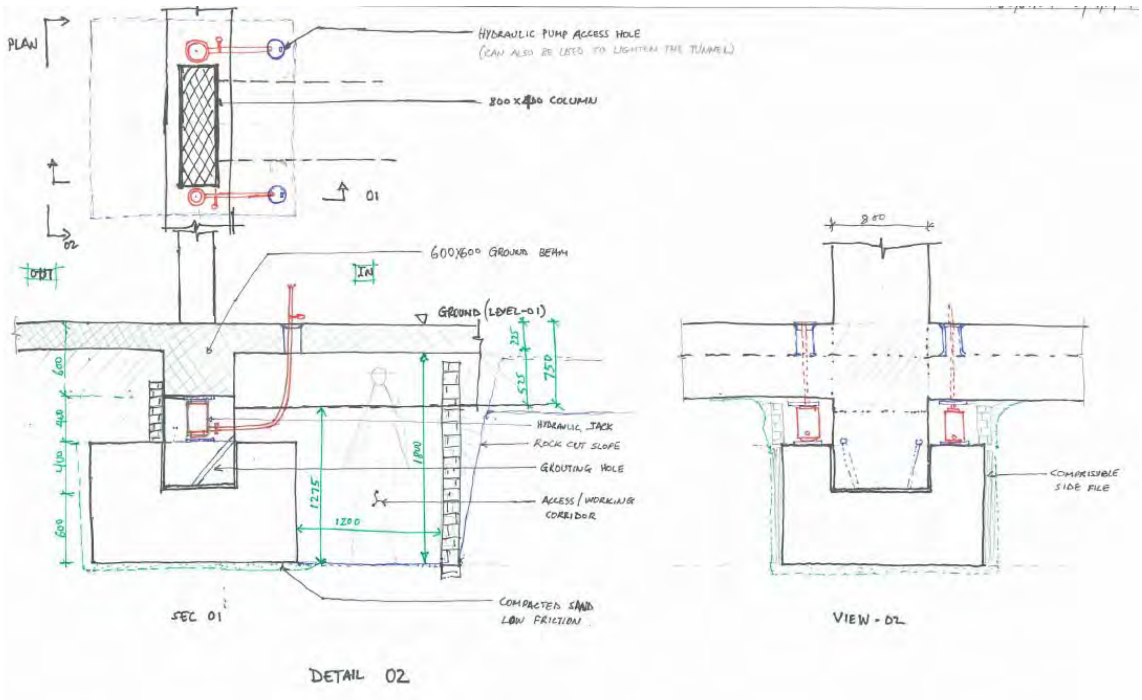


Jacking Access – via manholes to external columns & corridors internally

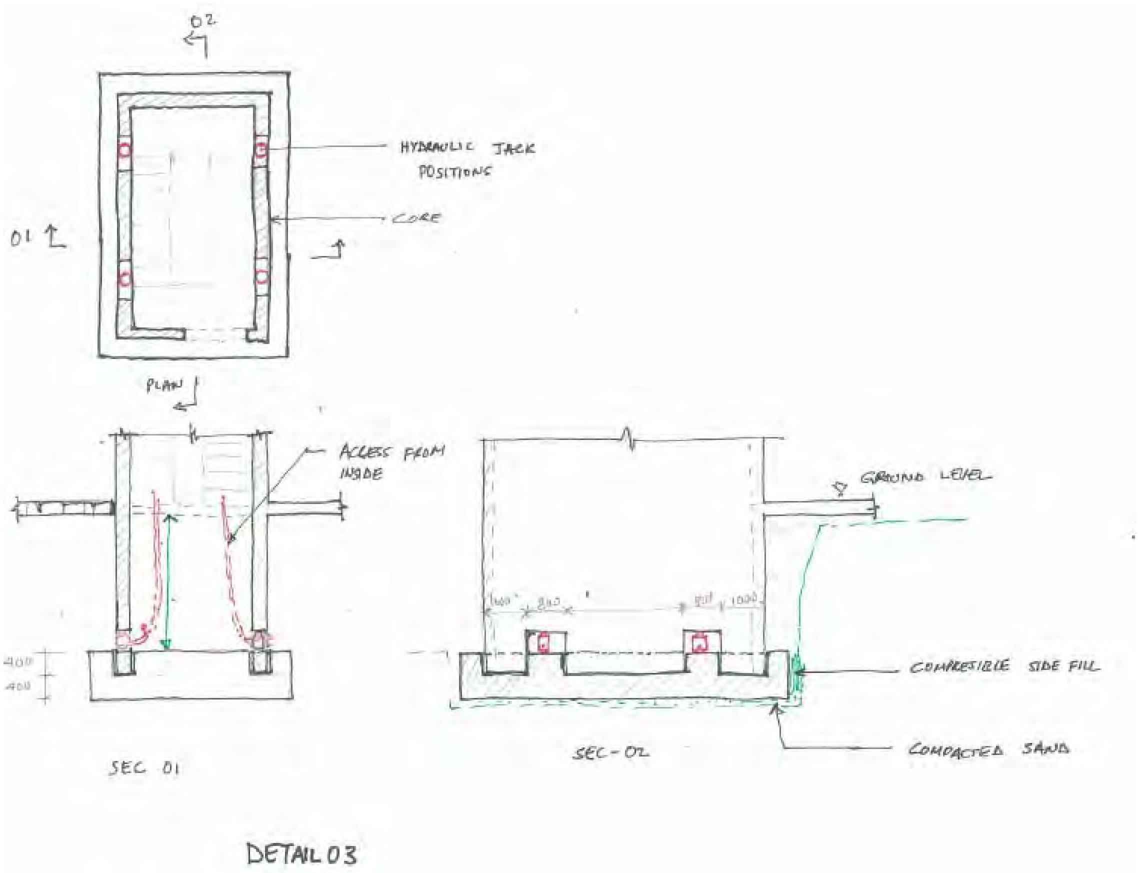


Proposed Manhole access detail – to all external columns along Grids A & D.

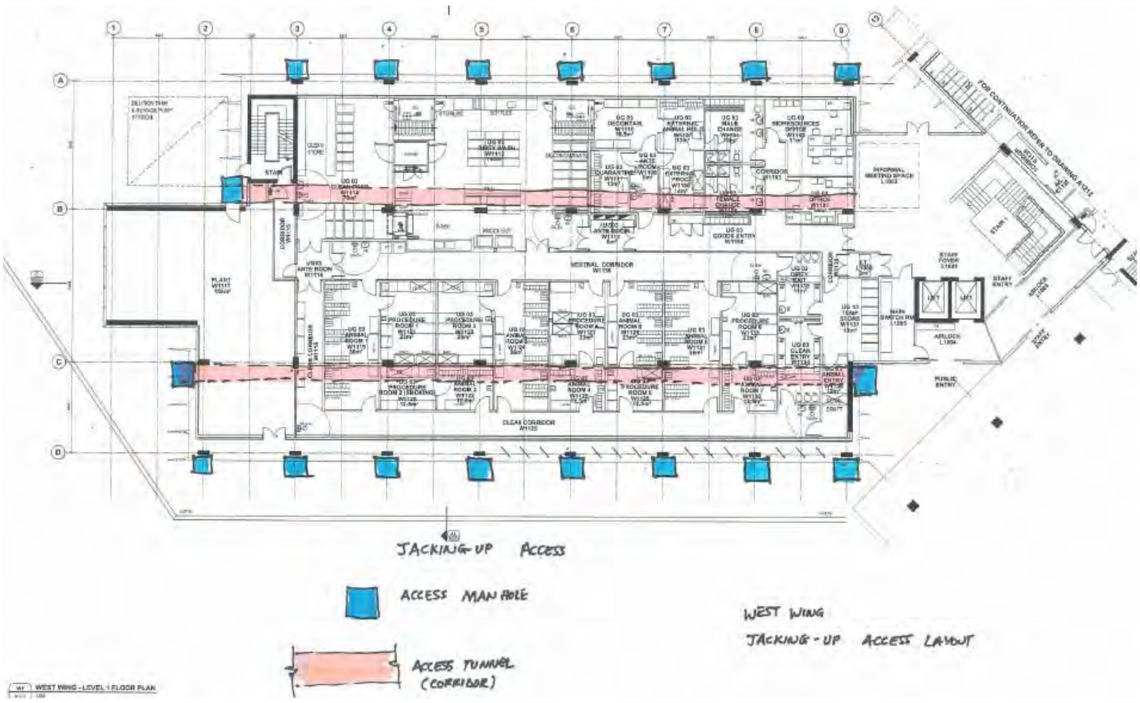
… Conceptual sketches of access & temporary jacking



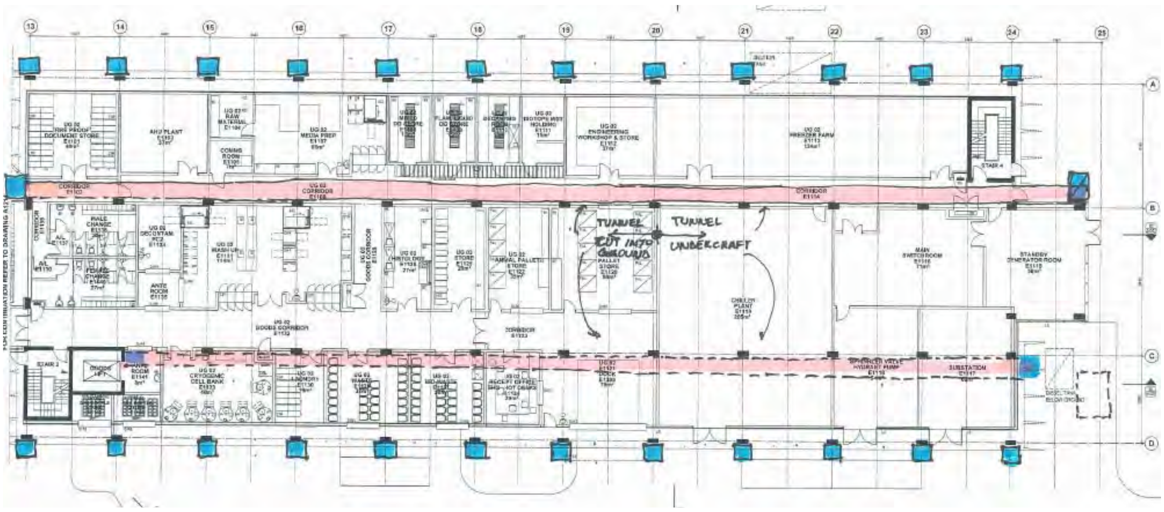
Column jacking via access trench - to internal columns along Grids B & C



Core - jacking points provided in each corner.



West Wing – jacking access. Blue = manhole, Pink = sub-floor access corridor



East Wing – jacking access. Blue = manhole, Pink = sub-floor access corridor

Pod – manholes to be provided to each column

4.2 Design to accommodate horizontal displacement

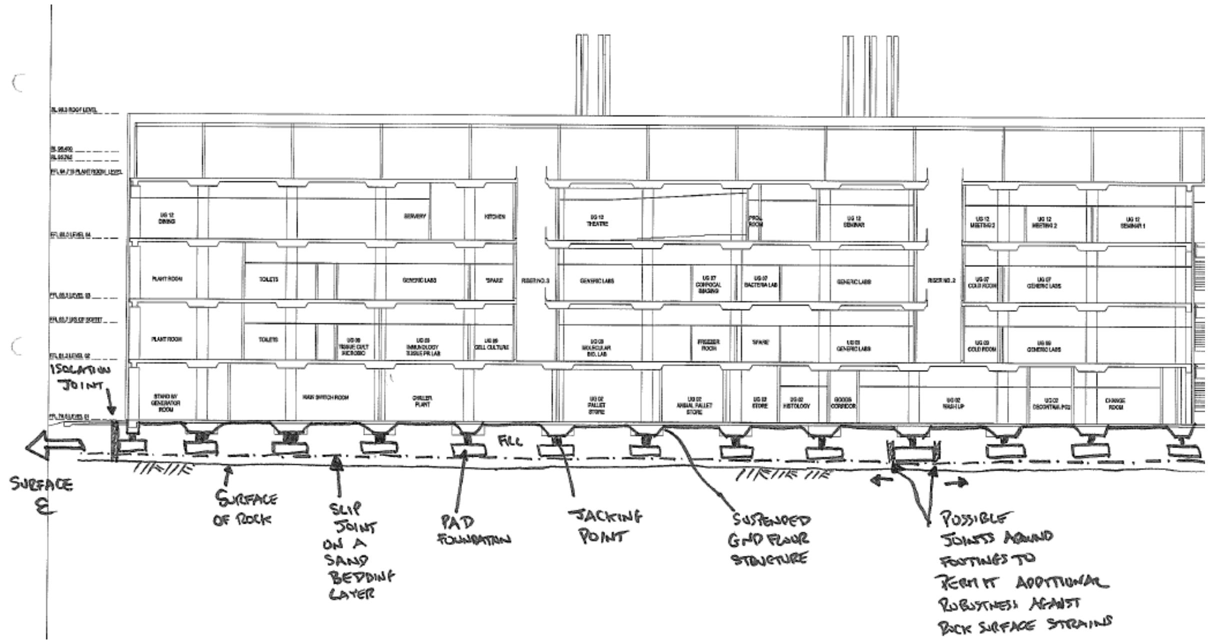
Horizontal displacements will be limited as vertical ones are via re-levelling works.

4.3 Design to accommodate surface ground strains

Surface strains resulting from a convex or concave profile are transferred to the building through its footing systems. The ground surface tensile strains are several times higher than is required to crack or crush reinforced concrete. Therefore these are best avoided/controlled by isolating the building from surface strain events

Thus a slip layer will be formed on the plane under the pad footings. This slip layer is intended to reduce friction between the building and the ground, and thus allow the ground to slip under the building. This slip layer will comprise a sand base, and possibly also a bituminous or plastic membrane between the pads and sand base.

Furthermore, compressible material will isolate each pad footing from the surrounding soil and any compressive or tensile strains that are present. A compressible material like void former will be used for this purpose. An alternative and/or supplementary solution to be investigated is cutting a trench all around the buildings to a depth just below the pad footings, which could take out the surface strains before they even affect the pad footings. A cost analysis will determine the final detail.



Sketch showing isolated pad footings & slip layer under

4.4 Design to accommodate curvature

Curvature will be controlled by re-levelling of the buildings. As well as vertical settlement being monitored, so will the buildings rotation. This will be achieved by having survey points permanently placed above every jacking point (ie every column, each end of a shear wall, and each corner of a core) as well as at the L5 roof slab level (to measure tilt). All survey monitoring of the new HMRI buildings will be compared back to the as-built survey to assess the post-construction settlement and rotation.

4.5 Design to accommodate tilt

The magnitude of overall tilt is much more than a building in a non-subsidence area would normally be expected to accommodate - 110mm across the building width. This is particularly important for a laboratory facility with containment requirements and use of sensitive equipment As such, tilt will also be controlled by re-levelling of the buildings so that the differential settlement and rotation limits of the buildings are not exceeded.

5.0 Monitoring of ground subsidence

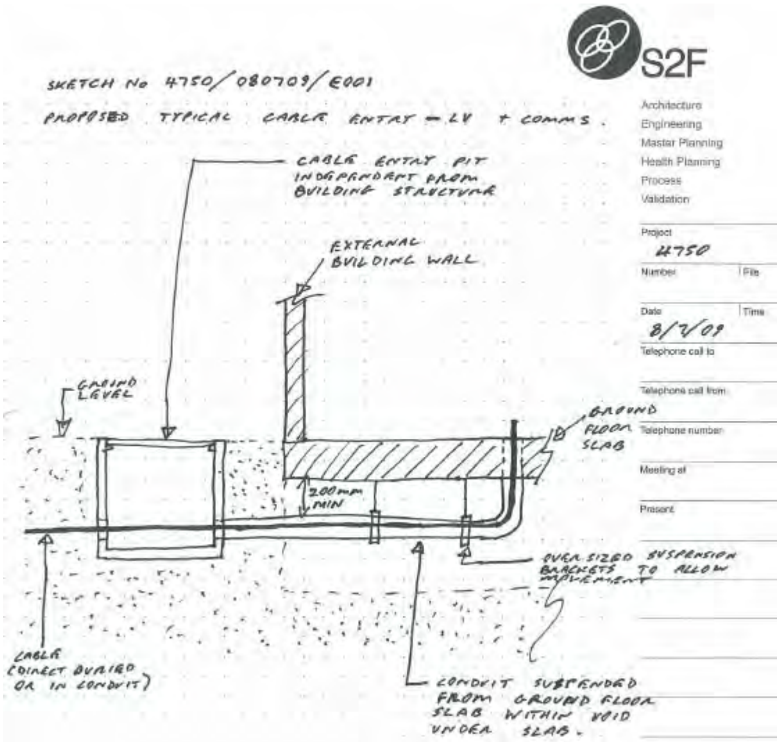
Datum markers will be provided above every jacking point, ie at each column, both ends of a shear wall, and all four corners of a core. The as-built HMRI building will be surveyed so that any future subsidence can be correlated back to the as-built geometry to assess how much subsidence has occurred and the appropriate re-levelling performed. A guideline document will be produced to state how regularly monitoring is to be done, and what the trigger points are for re-levelling. Please note that the jacks will be temporarily installed only as needed.

6.0 Conclusion - Structure response

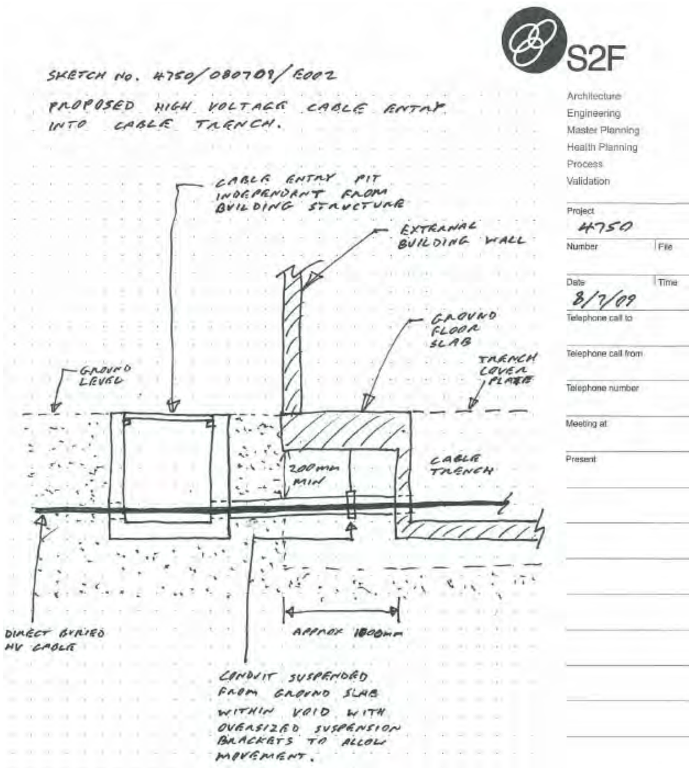
The proposed HMRI buildings house specialist laboratories and their associated workspaces. The floors have been designed to minimise footfall-induced vibrations which dictates a stiff RC structure. Such a building type cannot accommodate differential settlements in the order of 110mm, due to mine –related land subsidence. As this subsidence is expected to occur the long-term, it can be monitored. When monitoring shows that the actual subsidence is approaching the normal building limits of 2mm in 1000mm, then it is proposed that the affected buildings will be re-levelled. As such, provision for jacking has been incorporated below the L1 ground slab at every vertical support. It is envisaged that jacking would be required if differential settlement limits of L/500 or H/500 were exceeded, which for instance, equates to 12mm between columns at 6.6m ctrs.

7.0 Electrical Engineering

High voltage, low voltage and communication electrical conduits will service the proposed HMRI facility. In each case, the incoming electrical conduit will go from being embedded in the ground, to entering the building. To accommodate any future differential movements due to settlement and subsequent jacking of the building, the conduits will be fixed to the L1 ground slab with oversize suspension brackets, as is illustrated in the sketches below.



Section – LV and communication conduit coming into HMRI buildings



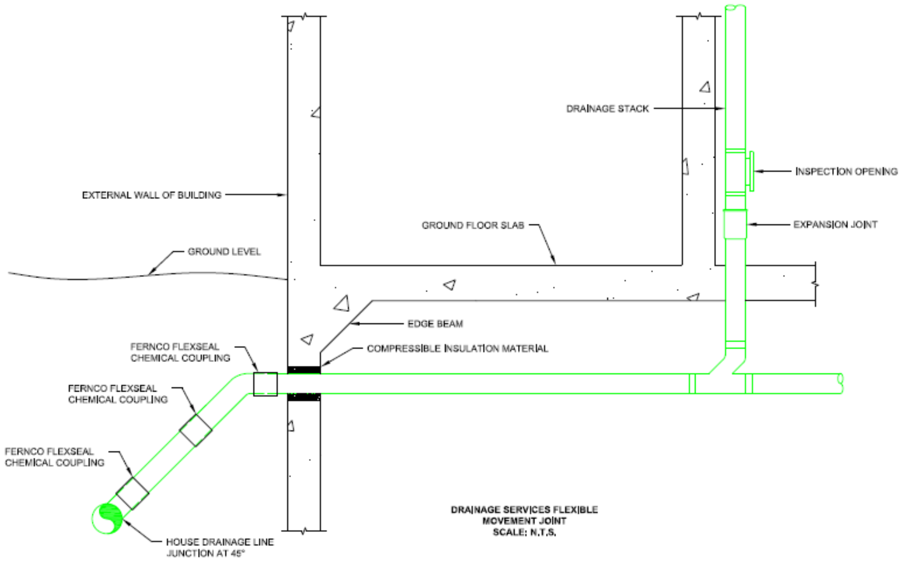
Section - HV conduit coming into HMRI buildings

8.0 Mechanical Engineering

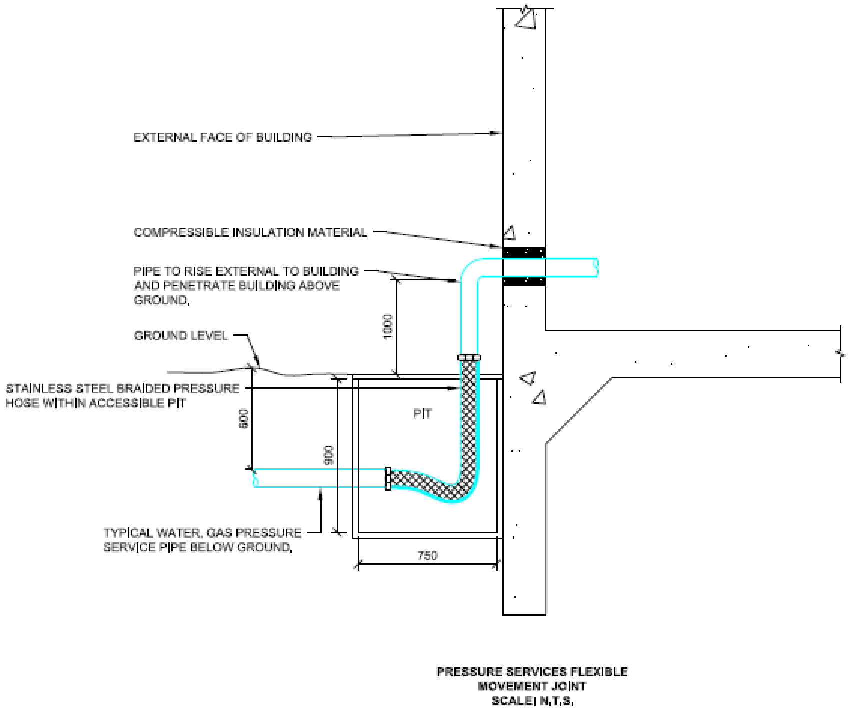
No mechanical infrastructure services cross the building envelope, nor penetrate the L1 ground slab. As such, all mechanical services will generally move with the building, and will be able to accommodate normal building movements and tolerances of 2mm in 1000mm. Although extra flexible articulation of mechanical ducts etc is not therefore required, we may consider providing flexible joints on longer runs of pipe work or ductwork to accommodate additional movement if required.

9.0 Hydraulic Engineering

The sketch below illustrates the preliminary detail of how the drainage pipes will accommodate differential movements between the re-levelled building and subsiding ground of up to 110mm.



Drainage Pipes - Flexible Movement Detail



Pressure Services - Flexible Movement Detail

10.0 Conclusion

This report outlines the estimated maximum plausible mining subsidence profiles that may be expected at the HMRI buildings at Rankin Park, and how the structure and relevant building systems will be designed to mitigate the risk of damage.

The risk of future subsidence is considered to be low but must be safeguarded against. Furthermore, the anticipated rate of subsidence movements are considered to be sufficiently low such that regular monitoring and re-levelling can be carried out should relative settlement values exceed trigger values.

Re-levelling the building, or parts thereof, by means of jacks under the vertical structural elements is considered to be both a practical and cost-effective means to respond to imposed curvature and tilt. Isolation of the building footings from the surrounding rock mass by means of slip membranes and compressible joints will accommodate imposed ground surface strains.

The structural provision for re-levelling has been conceptually outlined, as have the conceptual articulation details for incoming and outgoing building services at the building perimeter. The above therefore significantly mitigates the risk of mining subsidence-related damage to the building fabric and functionality.

Compiled by Arup
Job No. 206014-00

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Project title	HRMI	Job number	206014
Meeting name & number	Meeting with MSB	File reference	
Location	MSB Offices, Newcastle, NSW	Time & date	10:00 1 July 2009
Purpose of meeting	Review MSB Requirements and Approval Process		

Present	Greg Cole-Clark, MSB Arthur Love, Coffey Stuart Diver, APP	Phil Alexander, MSB David Knott, Coffey Sean McGinn, Arup David Sparks, Aurecon
Apologies		
Circulation	Those present David Rann, APP Julian Scnalan, S2F	 Wojceich Pluta, DCM Ashley Willis, Arup

Action

References

- Coffey MSB Report extract
- Coffey subsidence profile
- Arup sketches **(attached):**

1. Site Location & Geology

Coffey presented the site location and summarised the geology with reference to the site investigation undertaken and borehole cores which were brought to the meeting. The cores showed good core recovery with the crushed coal seam clearly evident. Competent material exists both above and below the coal seam (forming the ceiling and floor to the workings respectively). Other evidence of subsidence since the mine workings existed, taking the form of inclined cracks in the overlying rock with no signs of water-formed deposition material.

2. Determination of surface subsidence profile

Coffey presented their analyses and interpretation of the available data. Large pillars exist to the west of the northern-most proposed new building with a factor of safety of at least 1.0 (and in some cases rather more). These were unlikely to collapse. Coffey noted that every borehole and many trial pits in the immediate area exhibited evidence that subsidence had taken place.

Prepared by	Sean McGinn
Date of circulation	7 July 2009
Date of next meeting	

Project title	Job number	Date of Meeting
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There is good evidence that the subsidence that was likely to have taken place already has done so. The risk of subsequent subsidence is therefore low but needs to be accounted for in the new building design.

The nature of the geology and condition of the floor/ceiling of the workings is such that any subsequent subsidence is expected to be a gradual process taking place over months and years rather than hours and days.

The magnitude of the values of tilt and surface strain reported in Coffey's analyses was not inconsistent with those expected by the MSB. The subsidence profile provided by Coffey was developed for the most onerous region of the development – towards the northern end of the north block. It is understood that the magnitude of the subsidence is likely to be less for the southern block but there are insufficient data available to justify specific reduced values. MSB would certainly not accept figures of approximately half those in the proposed profile – the order of reduction necessary to enable the building and associated systems to accommodate the settlements without special consideration. It was therefore concluded that the proposed profile should be applied for all lateral cross-sections of the building.

MSB previous approvals for the hospital building related to subsidence values of the order of 100mm and a tilt of 2.5mm/m. It is unlikely that the latter figure would be acceptable to the MSB for any new development in this area.

On the basis of the above, further geotechnical site investigations in relation to subsidence issues are not considered necessary.

Due to the inherent inaccuracies in both the location of the proposed building relative to the existing coal features and the assumptions in the analyses, the recommendation of the meeting was to initially assume that the building cross-section could exist at any part of the proposed profile – i.e. both the concave and convex portions of the profile.

The most significant aspects of the subsidence profile are:
Tilt – a maximum of 3.7mm/m
Surface tensile strain of 0.76 mm/m
Surface compressive strain of 1.24 mm/m

Coffey are to advise on the potential longitudinal subsidence profile. — Coffey

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3. Conceptual Structural Design

The new development comprises a 4-storey reinforced concrete framed building with partial roof-top plant room. The building is divided into three separate structures with regards to stability – each isolated from one another by a movement joint. Refer to the attached sketch.

The laboratory building has specific design criteria including:

- Tight controls on floor vibration
- Containment requirements
- A high degree of servicing

The former criterion necessitates a rigid floor structure and therefore less compliant than a regular building to accommodate imposed settlements. The latter criteria suggest as continuous a building as possible with minimal joints for movement/articulation.

The magnitude of tilt imposed on such a rigid structure results in very high internal structural forces, and building services/facades/lifts etc with a high degree of compliance and flexibility.

As the subsidence is expected to a gradual and long-term phenomenon, this provides the opportunity to monitor and respond to subsidence events. The structural proposal to respond to the issue of tilt is to make provision for the subsequent re-levelling of the building should the settlement reach target values. The current proposal is to provide a jacking point under each column and core due to the unpredictable nature of an actual displacement profile. Note that jacks do not need to be installed – just the provision for them should subsidence actually occur in the future. Access to the jacking points is to be integrated into the architectural layouts. Mitigating the risk of damage due to tilt by re-levelling also provides the opportunity to use building services and façade systems with no special provision for subsidence as long as the trigger subsidence/re-levelling values are set accordingly.

There is precedent for re-levelling buildings by jacking. MSB note that they will normally only meet the cost of re-levelling buildings once subsidence exceeds 7mm/m. The project therefore should make provision for the associated cost.

The structural concept for mitigating the risk of damage due to surface strains involves isolation of the structure from the supporting rock in the horizontal direction by incorporating a slip membrane – possibly on a sand bed. The supporting rock is competent and therefore pad foundations are proposed. To further mitigate the effects of strain, a vertical movement joint to the depth of the footings is proposed around the perimeter of the building. See attached sketches. Note that the sketches relate to a surface tensile strain only. With reference to the above, surface compressive strains will also need to be accommodated.

4. Next Steps

The next MSB Board Meeting is schedules for 22nd July and the agenda

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of which must be finalised ten days in advance. Arup are to produce an engineering report to the MSB prior to July 10th for inclusion in this meeting.	Arup

The Engineering report is to include:

- A description of the site conditions and proposed building
- Conceptual methodologies to mitigate the risk of subsidence-related damage
- The structural response to the subsidence profile produced
- The response of the building infrastructure to the subsidence profile (i.e. incoming services with flexible joints, facades etc)

The MSB will normally respond within a week following the Board Meeting	MSB

In reply please send to: Head office

Our reference:

Your reference:

Contact: Greg Cole Clark 4908 4395

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Level 17, 1 Nicholson Street
Melbourne VIC 3000

7 August 2009

Dear Sir,

TBA08-09394N1 Lot 132 DP 1053492 Sec No Lookout Road, Rankin Park

In December 2008 the Members of the MSB approved the above development subject to conditions that included geotechnical assessment and design. Coffey Geosciences report 'Proposed HMRI Buildings Rankin Park Campus – Mine Subsidence Assessment (GEOTWARA 20576AB-AB dated 20 June 2009) was provided in response to the conditions. Following analysis of the mine workings the Coffey Report provides the following estimated trough subsidence parameters.

Maximum Subsidence	110mm
Maximum Tensile Strain	0.76mm/m
Maximum Compressive Strain	1.24mm/m
Maximum Tilt	3.7mm/m
Tensile curvature	12.6km
Compressive curvature	7.6km

These parameters have been utilised in the Engineering submission compiled by Arup and dated 10 July 2009 for the proposed HMRI buildings.

Based on the advice from Coffey Geosciences submitted by the applicant, the Mine Subsidence Board accepts that the geotechnical requirements of the approval have been achieved.

Arup has submitted design principles to address the parameters in the Coffey Geosciences report. The Board accepts this structural engineering advice.

As discussed, the Mine Subsidence Board has a policy that it does not relevel structures where tilts are less than 7mm/m. As the specialist use of the building requires tilts of less than 2mm/m tilt, the Board recognises the building will be designed so the owner can relevel the structure should this be required.

As required by Condition 3 of the approval, final drawings are to be submitted prior to commencement of construction, and are to contain a certification by a qualified Structural Engineer to the effect that the improvements will be

MINE SUBSIDENCE BOARD

NEWCASTLE
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117 Bull Street
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constructed in accordance with any design parameters provided by a Geotechnical Engineer, who has analysed the mine workings, and any damage, would be slight, localized and readily repairable.

As agreed, permanent survey marks shall be established on each of the buildings following their construction. A baseline survey shall be undertaken upon installation of the survey marks and a further set of readings taken after 12 months. The location of all permanent survey points and the survey results shall be provided to the Mine Subsidence Board.

Please do not hesitate to contact the District Manager, Mr Phil Alexander, or myself if we can be of further assistance.

Yours faithfully

G.J Cole-Clark
Chief Executive Officer

Cc Phil Alexander
Paul Gray

PROPOSED HMRI BUILDINGS, RANKIN PARK CAMPUS - MINE SUBSIDENCE ASSESSMENT

APP Corporation

GEOTWARA20576AB-AB
22 June 2009

Coffey Geotechnics Pty Ltd ABN 93 056 929 483
19 Warabrook Boulevard Warabrook NSW 2304 Australia

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

22 June 2009

APP Corporation
PO Box 1285
NEWCASTLE NSW 2300

Attention: Stuart Diver

Dear Stuart

RE: PROPOSED HMRI BUILDINGS, RANKIN PARK CAMPUS

OHN HUNTER HOSPITAL, NEW LAMBTON HEIGHTS

MINE SUBSIDENCE ASSESSMENT

Please find enclosed our report for the mine subsidence assessment carried out on the above site. The report should be read in conjunction with the attached sheet entitled, *Important Information about your Coffey Report.*

If you have any questions regarding this matter please contact the undersigned.

For and on behalf of Coffey Geotechnics Pty Ltd

Arthur Love

Arthur Love

Principal Geotechnical Engineer

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CONTENTS

1 INTRODUCTION

This report presents an overview of the findings of a mine subsidence assessment undertaken by Coffey Geotechnics Pty Ltd (Coffey) as instructed by APP Corporation Pty Ltd on behalf of HMRI, for two to three proposed HMRI Buildings, to be located at the John Hunter Hospital, New Lambton Heights, as shown on Drawing 1. This mine subsidence assessment was commissioned by APP. The objectives of this assessment were to undertake necessary investigative drilling, testing and analysis to enable interpretation and reporting of potential mine subsidence impacts to the proposed buildings.

The Borehole Coal Seam was mined beneath site between 1885 and 1920, by the Lambton Colliery. The workings are at a depth ranging from 80m at the northern end to 120m under the main hospital. This change is mainly due to the change in surface RL across the site. Mining was performed using the bord and pillar method where pillars were left between bords to support the mine roof (see reference on Drawing 1). The mined height has been recorded to range from 1.84m (6'0 1/2 ") to 2.95m (9'8").

The site is within a designated mine subsidence district and the Mine Subsidence Board (MSB) is an integrated referral authority for any improvement. In order to satisfy the MSB and gain approval for proposed developments, it is necessary to:

- Demonstrate that the risk of subsidence at some time in the future is sufficiently low for proposed developments; and / or should subsidence occur, the resulting damage to the proposed development is acceptable and safe, serviceable and repairable; or
- Reduce the risk of subsidence by stabilization, usually in the form of grouting or partial grouting of the workings.

What constitutes acceptable risk is determined by the MSB and is dependent on the quantity and reliability of the available information as well as the size, function, structural design and potential repair costs of the proposed development.

2 SCOPE OF WORK UNDERTAKEN

This assessment included an investigation phase that involved drilling of one borehole to below the Borehole Coal Seam and the utilization of existing boreholes from previous work on and in the site area as shown on Drawing 1. Existing data was obtained from a review of the following information sources:

- Records of previous deep boreholes and reports by Coffey in the area, N1857/2;
- Mine Subsidence Board (MSB) mine working records in the form of plans;
- Record Tracing (RT) of mine workings supplied by Department of Primary Industries – Mineral Resources, RT255, Borehole Seam workings by the Lambton Colliery;
- Previous reports within the area by other consulting firms;
- 1:25,000 Scale Land and Property Information Sheet, Newcastle;
- 1:100,000 Scale Newcastle Coalfield Regional Geology Sheet.

3 PROPOSED DEVELOPMENT

As shown on Drawing 1, the site is located on the northern side of the existing hospital and south of a power line easement. It is understood the development will consist of two, with reference made to possible future third, four storey concrete framed buildings with a steel framed plant room on top. It is also understood that the steel framed area may also include a limited amount of additional open office space. The current designs indicate the buildings will be 53.9m x 30.7m, 67.0m x 30.7m and 59.9m x 30.7m for buildings one to three respectively, the third being the possible future building.

Car parking is currently proposed as shown on Figure 1. However, as there some steep terrain in the area, some cut and filling will be required. This area is also susceptible to mine subsidence.

4 EXISTING SURFACE CONDITIONS

A survey plan of the building area topography has been supplied by C R Hutchison & Co Drawing No 14344/22 and has been utilised in Drawing 1.

The site is generally on the upper slopes of a north easterly spur which comes off the main north westerly trending ridge. The surface RL for the building area ranges from 85m at the southern end to 70.5m at the northern end. Due to the small size of this spur, the car parking will be in the gully zone to the east of the building envelopes.

Drainage gullies exist to the North West and south east of the spur. Site slopes range from 3° along the main part of the spur up to 20° towards the gullies. At the southern end of the site under building One the site has steeper slopes on the order of 15°. The width of the flatter zone of the crest is on the order of 50m to 70m.

In the area of the proposed buildings the site is mainly covered with scattered eucalypts with other native smaller plants. In the area between proposed buildings One and Two a medical officers amenities building, tennis courts and associated car parking are present. On the eastern side, where car parking is planned, the area is bushland with some gravel tracks. Between the two zones a small bicycle track also runs through the site. At the northern end of the site is an electricity line easement which is cleared and has an access track.

5 GEOLOGIC CONDITIONS

5.1 General Subsurface Conditions

Based on the 1:100,000 Newcastle Geological Series Sheet 9231 (1995) ‘Newcastle Coalfield Regional Geology’, and available borehole information, the areas of fill at the site are judged to be underlain by the following geological units:

- The base of the Permian aged Adamstown Subgroup of the Newcastle Coal Measures consisting of the Kotara Formation with the Merewether Member and underlying units. This subgroup is underlain by;
- The Permian aged Lambton Subgroup of the Newcastle Coal Measures consisting of sandstone, siltstone, claystone, coal, and tuff. This subgroup contains the Victoria Tunnel, Nobbys, Dudley, Yard and Borehole Coal seams with the Borehole Seam forming the base of this subgroup. This seam is underlain by;
- Waratah Sandstone.

The strata directly above the Borehole Seam belong to the Tighes Hill formation which is typically comprised of interbedded siltstones and sandstones. The strata below the Waratah Sandstone does not influence the mining at the site and no mining has been performed below the Borehole Seam.

5.2 Geologic Structure

The site is located within an estuarine deposition system. Typically in the Newcastle Area the geological layers dip in a southwest direction at 1 in 30 to 1 in 40 which matches the 1 in 30 dip to the southwest drawn on RT255. A slight difference is given in Kingswell, (1890) which indicates that the dip is 1 in 40 to the south.

Geologic mapping indicates the area of interest is free from faults and dykes. The nearest dyke to the site is drawn to be about 500m to the northeast of the site, (it should be noted that this has not been labelled and is only estimated to be a dyke), with others being about 800m to the northwest. The nearest faults are drawn to be 700m to the north west or 800m to the south as shown on RT255. The southern faults have throws of 1’ (0.30m) to 2’4” (0.71m) while the north eastern faults have throws up to 12’ 8” (3.86m). In both cases, these faults trend southeast to northwest.

6 MINING AND MINE SUBSIDENCE

6.1 General

Mine subsidence refers to the downward movement of the ground surface due to the failure of support at mine level. Subsidence can take the form of sinkholes or troughs as shown on Figure 1. Sinkholes (Potholes) are usually circular collapse depressions with sides that can be steep and abrupt or gently sloping towards the center. Sinkhole formation is controlled by the thickness of the rock overburden, jointing of the rock, mining conditions, and bulking of the roof fall material. Sinkholes are not expected at the site due to the conglomerate above the mine workings and overburden depth.

Troughs are broad, shallow depressions that result from the failure of one or more pillars. Pillars can fail by crushing or punching into the roof or the floor. The trough size and deformations depend on the mined width, mined height, thickness and hardness of overburden rocks, and pillar stability. Deformations from trough subsidence can extent beyond the limits of mining. The zone beyond the limit of mining that is impacted by trough subsidence is determined by the angle of draw. (Angle β in Figure 1). Within the Newcastle Coal Measures an angle of draw of 26.5° to the vertical is generally adopted. This angle translates to one horizontal for every two vertical. That is, should workings at a depth of 66m, collapse beyond 33m from the site, significant surface subsidence at the site would not be expected.

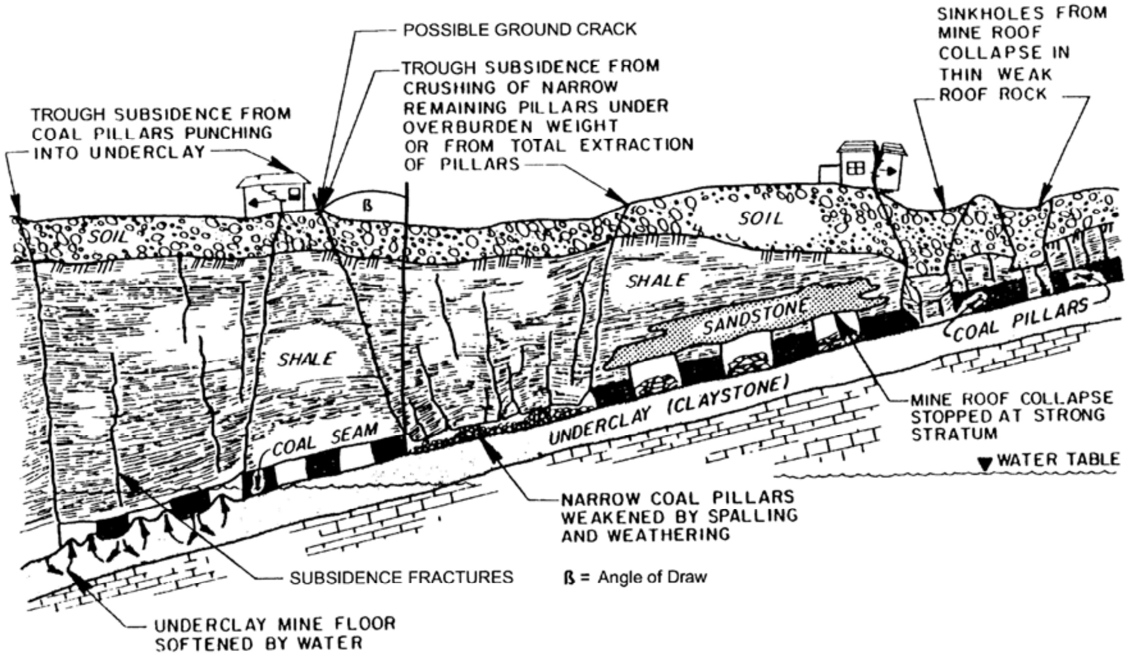


Figure 1 - Types of subsidence (Knott, 2006, modified from Bruhn, et al., 1978).

6.2 Mine Subsidence Boards Perspective

The site is located within a designated Mine Subsidence District and as such the MSB is an integrated referral authority for proposed development. If subsidence damage occurs, the Mine Subsidence Compensation Act 1961 requires the MSB to compensate the land owner, usually by way of repairing the damage.

In order to satisfy the MSB and gain approval for the development, it is necessary to demonstrate that:

- The risk of failure of the pillars is acceptably low for the proposed development; and / or
- Should failure occur, the resulting damage to the proposed development will be acceptable and safe, serviceable and repairable; and / or
- The risk of subsidence can be reduced or removed by structural measures or remediation of the workings, usually by injecting a cement/fly ash grout into the mine workings through boreholes drilled from the surface.

In broad terms, the risk of subsidence is the product of the likelihood of a subsidence event occurring and the consequences of that event. The likelihood and magnitude of subsidence is a function of the depth of mining, thickness of coal extracted, geological conditions and method of mining. From the MSB's perspective, the relevant consequence is measured by the expected cost of repair. The taller the building or greater the development density, the greater the risk of subsidence remediation costs, regardless of the likelihood of its occurrence.

The risk of subsidence for a three to four storey building on the subject site would normally be acceptable to the MSB and current Mine Subsidence Development Guidelines for the area reflect this philosophy. In comparison, the higher cost of repair for buildings over four stories means that the risk of subsidence at the site would not be acceptable to the MSB, unless investigation in to the resultant movements were carried out and found to be within tolerable levels, for which the building can be designed to accommodate.

6.3 History and Extent of Mining

The site and surrounding area is undermined by abandoned coal mine workings in the Borehole Seam. This seam was found in 1848 by the Australian Agricultural Company (AA Co). The Borehole Seam was heavily mined in the greater Newcastle City area between 1850 and 1950. Within the Newcastle District, the Borehole Seam is generally about 6m thick. This thickness decreases to the south and west and is shown in a measured section on the RT to be 2.95m thick.

6.3.1 Scottish-Australian Mining Company

The Lambton Colliery that operated under the site was owned by the Scottish-Australian Mining Company. The company was formed in 1860 in London for the purpose of acquiring mineral property in the Australian Colonies. In 1862 the mine manager arrived from England and commenced work in the upper north eastern part of the estate. In the late 1860's this mine had one of the largest outputs of any of the collieries in Australia. In the early 1880's the mining operation moved to the 280 acres of the 'commonage' before returning to the main mining area.

Main headings at mine level were then installed across the estate with large 18m to 27m (20 yard to 30 yard) wide pillars being left to protect the headings. Pillars shown on the RT range from 2.5m to 10m wide (headings not included) and about 30m to 40m long. The general pillar size is at the lower end of the scale at approximately 4m with pillars with rooms widths about 6 to 8.5m wide. The extraction ratio is in the order of 65%.

Current available dates indicate the first workings were done between 1885 and 1895. Later the coal from the large barriers left along the headings was extracted. Dates of these are shown with the pillars under the site being extracted between June 1915 and Oct 1918.

The thickness of the Borehole Seam beneath the site has been reported to be 6' 0½" (1.84m) (Pittman 1912, 8' 7½" (2.63m) (Andrews 1925) and 9' 8" (2.95m) (RT255 Lambton Colliery). Kingswell, (1890) indicates that the seam averages nearly 10' (3.05m) with between 6' (1.8m) and 8' (2.4m) mined.

The mine was officially closed in 1941.

6.4 Discussion on Borehole Seam Workings

6.4.1 Position of Workings

The current interpreted location of the mine workings, on RT255 is shown on Drawing 1. This location is based on surface features drawn on the RT and a GPS surface survey of several shafts shown on the RT and a survey drawing in RT255. It was indicated on this survey drawing that 'an accurate correlation between the information on RT255 and the surface exists'. This location was then adjusted by less than 5m to the south west to account for drilling data from boreholes BH6, BH7, BH8 and BH9 from the previous work.

It should be noted that this location may not be totally accurate since BH 22 encountered a pillar. However, any difference should have minimal effect on the proposed development as the workings are generally similar within the zone of difference of the actual location of the mine with respect to the surface. It should be noted however that this alignment varies from the position of current MSB records by about 16m to south east.

6.4.2 Surface Subsidence

A number of incidences of subsidence above the mine have been reported by the Sydney Morning Herald and by Thomas Croudace, the mine manager; however, the location of these events is not clear.

6.4.3 Seam Thickness and Pillar Height

A reproduction of the seam section from the RT is provided on Drawing 3.

The full seam height for the seam averages approximately 10’ (3.05m) Kingswell, 1890) with between 6’ (1.8m) and 8’ (2.4m) mined. It was also described as splendid coal with only 2 small bands. Looking at the section it appears that this refers to the middle three sections of coal 14” (0.36m) of coal left in the roof and 1’6” (0.46m) of coal below the Penny Band left in the bottom.

Under the site the working thickness has been reported to be values of 6’ 0½“ (1.84m) (Pittman 1912 and 8’ 7½“ (2.63m) (Andrews 1925) with a typical seam section being 9’ 8” (2.95m) (RT255 Lambton Colliery).

6.5 Mining in Other Seams

In a few sections of the original estate, limited workings have been carried out in the Victoria Tunnel Seam. The nearest workings to the site are about 1km to the southwest or 1.5km to the north. Therefore mining in this seam is not a consideration at the site.

No records or reports of mining in the seams between the Victoria Tunnel and the Borehole Seam have been found. Therefore, mining in these seams is not an issue.

7 SUBSURFACE INVESTIGATION

7.1 Previous Investigations

As part of an investigation by Coffey in 1983, four boreholes were drilled within the Hospital grounds down to the mine workings as shown on Drawing 1. These boreholes were carried out in pairs, one within a bord and one through a pillar, so that crushed height and remnant void space could be determined. The conditions encountered in the borings are summarised on Table 4 and logs are provided in Appendix A.

7.2 Current Investigation

Boring 22 was drilled to below the Borehole Seam at the site between 4 April 2009 and 17 April 2009 at the location shown on Drawing 1. The log is provided in Appendix A. The geologic formations are briefly summarized in Table 1.

Coffey provided full time monitoring of the drilling with an engineering geologist. Borehole 22 was located by a Coffey field representative, based on a target pillar. The ‘As-Drilled’ location was surveyed by C. R. Hutchinson Surveyors.

The borehole was drilled by Total Drilling using a truck mounted drilling rig. The borehole was advanced through the soil zone and weathered rock using a casing advancer, with SPTs being taken at 1.5m intervals until the driller thought that rock capable of being cored had been reached. The soil cuttings and SPTs were visually assessed to provide an indication of soil types and penetration rate was used to assess soil density/consistency. Rock was cored using HQ3 drilling equipment. The HQ3 equipment provides a 61.1mm core sample of the rock. The standard run length was approximately 3m (the length of each rod) with shorter runs carried out due to stoppages or other problems during drilling. The recovery of each run was compared with the length of the run and zones of loss were determined by the Coffey representative. Where possible, the core was logged in the splits to differentiate between fractures due to drilling and those caused by subsidence or natural processes. After drilling was completed, downhole geophysical logging was performed as indicated in the following section. After geophysical logging, the hole was backfilled with soil.

The borings were logged in accordance with the Australian Standard for Geotechnical Site Investigations (AS1726-1993). In addition, the RQD of each stratum (SRQD) and the Relative Dip (RD) of each stratum were determined and recorded on the log.

TABLE 1 – SUMMARY OF STRATA FROM BOREHOLE DATA

SUBGROUP	FORMATION	APPROX. THICKNESS (m)	DESCRIPTION
Adamstown	Residual Soil	1.6	Residual soil derived from the Kotara and Lambton formations.
	Kotara	<12	Interbedded conglomerate sandstone, siltstone and tuff
Lambton	Victoria Tunnel Seam	2 to 3	Coal seam, not mined
	Shepherds Hill	10	Interbedded Siltstones and Sandstones of fine to medium grain size, typically medium to high strength.
	Nobbys Coal	1	Coal seam, not mined
	Bar Beach	30	Conglomerate and Interbedded Siltstones and Sandstones of fine to medium grain size, typically medium to high strength.
	Dudley	1.5 to 2	Coal seam, not mined
	Bogey Hole Formation	20	Interbedded Siltstones and Sandstones of fine to medium grain size, typically medium to high strength.
	Yard Coal	0.8	Coal seam, not mined
	Tighes Hill	19	Interbedded Siltstones and Sandstones of fine to medium grain size, typically medium to high strength.
	Borehole Seam	3	Coal, mined under the site by the Lambton Colliery.
	Waratah Sandstone	>5	Sandstone

Since the elevation of the base of the mine workings is below sea level, the Borehole Seam mine workings appears to be flooded to some extent.

7.2.1 Downhole Geophysical Survey

A downhole geophysical survey was performed by Groundsearch Australia to confirm the position of the top and bottom of the Borehole Seam and other strata in BH22. The results are summarized in Table 2 and the portion of the geophysical log where the coal was encountered is provided in Appendix B. In areas of core loss, the locations of the coal top and bottom were reviewed using geophysical data. The geophysical work was performed through the steel drill casing due to instability of the borehole side walls. A plot of the deviation of the hole from vertical is also included in Appendix B. It indicates deviation of 1.4m to the north west..

TABLE 2 – SUMMARY OF GEOPHYSICAL DATA FOR BOREHOLE SEAM

BOREHOLE	DEPTH TO TOP OF SEAM (m)	DEPTH TO BOTTOM OF SEAM (m)	SEAM THICKNESS (m)	REMARKS
BH22	84.90	87.56	2.66	

7.2.2 Laboratory Testing

Laboratory testing on rock samples was performed after the drilling was completed. The testing consisted of point load testing and unconfined strength testing. Axial and diametric Point Load tests were performed for each borehole at intervals of 3m or less in accordance with AS4133.4-1-1993. The results are provided on the logs in the form of Is(50) values in units of MPa and the laboratory sheets for the uniaxial compressive strength testing are provided in Appendix C.

TABLE 3 – SUMMARY OF UNIAXIAL COMPRESSIVE STRENGTH TESTING

UNIT	MATERIAL	DEPTH (m)	UNIAXIAL COMPRESSIVE STRENGTH (MPa)
Signal Hill Conglomerate	Conglomerate	31.375 – 31.55	14.4
Signal Hill Conglomerate	Conglomerate	35.01 – 35.18	16.7
Bogey Hole Formation	Silty Shale	47.645 – 47.82	24.1
Tighes Hill Formation	Interlaminated Siltstone and Sandstone	77.365 – 77.52	28.8
Tighes Hill Formation	Silty Shale	82.145 – 82.32	12.5

8 SUBSURFACE CONDITIONS FROM BORINGS

8.1 General Conditions

A geologic section has been developed across the site as shown on Drawing 2 using borings from the current and previous investigations. These sections indicate the approximate thickness of the soil zone, primary rock types, and the depth to the Borehole Seam.

8.1.1 Soil Zone

The soil zone across the site is variable and ranges from 0.5 to 2m thickness, with the greatest thicknesses present on the flanks of gullies or in areas where Victoria Tunnel or Nobbys coal seams or the Nobbys Tuff are outcropping. The soil is typically fill consisting of sandy gravel or topsoil underlain by residual clayey soils.

8.1.2 Rock Overlying the Borehole Seam

Surface topography and the slight dip of the rock strata result in a varying cover thickness above the Borehole seam with outcropping of some units within the site area. As shown on Section A-A, the rock thickness above the Borehole Seam is greatest at the South western end of the site, where it is approximately 106m thick, and decreases to the northeast, where it is estimated to be 75 m thick. Rock units above the Borehole seam are outlined in Table 1, and generally consist of conglomerate, sandstone, siltstone, shale, and coals. There are four coal seams present above the Borehole Seam which are, in order of depth, Victoria Tunnel Seam, Nobbys Seam, Dudley Seam and Yard Seam. The two upper seams were encountered at shallow depth at the north eastern end of the site and are moderately to extremely weathered with the Victoria tunnel Seam being hard to distinguish from soil during drilling of BH 22.

8.1.3 Rock Strength

The strength of the rock overlying the Borehole seam coal generally varies with rock type and degree of weathering. Point Load testing was undertaken on the recovered core with an additional five core samples sent to Coffey's Glendenning laboratory for uniaxial compressive strength (UCS) testing, results attached in Appendix C, with point load data shown on the engineering log. Rock strengths range from very low to very high. The general strengths of the different rock types based on Point Load testing are outlined below:

- Sandstone - medium to very high;
- Conglomerate - low to high;
- Silty Shale – very low to low;
- Coal – very low to low.

8.1.4 Borehole Seam

The Borehole Seam was encountered in borings 6 and 9 from the 1983 investigation and in boring 22 from the current investigation. Borings 7 and 8 from the 1983 investigation encountered mine workings and were not drilled to the floor of the mine. The Morgan and Jerry Bands are not indicated as being present as on the typical coal section from the mine shown on Drawing 3.

The conditions in the Borehole Seam encountered in these borings are summarized in Table 4. Poor coal recovery was typically experienced in areas where crushing was experienced. The amount of crushing was determined by comparing the thickness of the coal in the boring with the thickness of coal of 2.95m indicated on the RT. As indicated in Table 4, the crushing varied from 0.29m to 0.5m.

TABLE 4 – SUMMARY OF BOREHOLE SEAM CONDITIONS ENCOUNTERED IN BORINGS

BORING	TARGET MINE CONDITION	DEPTH TO TOP		SEAM THICKNESS IN BORING (m)	AMOUNT OF CRUSHING (m)	REMARKS
		TOP (m)	BOTTOM (m)			
6	Pillar	116.8	119.25	2.45	0.5	1.39m of coal not recovered in middle of seam
7	Bord	116.05, top of 25mm, void	*Terminated	-	-	-
8	Bord	104.75, top of 0.5m void	*Terminated	-	-	-
9	Pillar	106.85	108.8	1.95	Drilling method not suitable to determine accurately	No Void (percussion drilling)
22	Pillar	84.9	87.56	2.66	0.29	Seam thickness based on geophysical survey
Terminated above bottom of seam.						

8.1.5 Rock below the Borehole Seam

The Waratah Sandstone was encountered in the borings encountering coal. In BH 22, it was generally fine to coarse grained and had high strength.

8.2 Subsidence Features

Voids were not encountered above the mine workings. Subsidence fractures typical of those encountered in areas of trough subsidence were encountered in the borings from the current and previous investigations. These fractures result from the breaking of the strata due to loss of support at mine level due to pillar crushing. BH 22 was the only boring cored for the total rock length encountered and these fractures appear to have started below 46m to directly above the Borehole Seam. The relative dip of these fractures varied from about 40 to 90°. Also, generally several parallel to sub parallel fractures formed at a spacing of less than 1m.

Changes in relative dip of the strata due to subsidence were not detected due to the relatively low dip of the rock and zones of cross-bedding with variable dips. This condition may indicate that significant rotation of the rock did not occur due to the crush event.

8.3 Pillars

The RT indicates that the coal seam was about 10' or 3m thick. It is believed that the mine workings beneath the site have crushed to some extent as indicated by trough subsidence fractures encountered in the borings above mine level and the crushed zones in the coal recovered in BH22. Crushing is confirmed by the thickness of coal found in BH6 and BH9 where the coal thickness was approximately 2.5 and 1.8m respectively. It should be noted that the thickness of coal in BH 9 was determined by percussion drilling and is not accurate enough for estimating the amount of pillar crushing at that location. The likelihood of crushing is also increased by the extraction of the barrier coal around the headings.

9 SUBSIDENCE ANALYSES

9.1 Pillar Stability Calculations

Based on the available information on the depth of the Borehole Seam and the layout of the workings, several preliminary pillar stability calculations have been conducted. The stability of selected pillars was assessed using rectangular pillar theories incorporated in the Modified UNSW Power Law as presented in Galvin (1998) and Galvin (1996). Of the several input factors used in the analysis, the critical variables are working height, pillar dimensions and overburden stress. A working height of 2m was used in the pillar calculations based on historical data and quality of the coal recovered in BH 22. The pillar dimensions were measured on a print of the RT. Overburden stresses were estimated using the interval between the average surface elevation and the top of the coal. Transfer of load from retreat mined haulageways to adjacent pillars was assessed using the procedures in the Australian Coal Association Research program (ACARP) Final Report – Chain Pillar Design (Calibration of ALPS) C6036 Oct 1998. In this approach, the load transferred from the retreat mined area is distributed over a zone of adjacent pillars based on empirical equations developed from longwall mining.

Based on this preliminary assessment and boring data, some pillars appear to have factors of safety that indicate a high potential for crushing while other larger pillars appear to remain uncrushed as indicated in Table 5. For example a pillar with a factor of safety of 1.0 would have a probability of failure of 5 in 10 while a pillar with a factor of safety of 2.11 has a probability of failure of 1 in 1,000,000.

TABLE 5 – PRELIMINARY PILLAR STABILITY CALCULATION RESULTS

PILLAR	OVERBURDEN THICKNESS (m)	PILLAR WIDTH (m)	PILLAR LENGTH (m)	HEIGHT (m)	TRIBUTARY WIDTH (m)	TRIBUTARY LENGTH (m)	FACTOR OF SAFETY	
							Tributary Load	Tributary and Abutment Load
12	78	2.5	35	2	9	37	1.0	1.0*
13	80	8.5	37	2	16	40	4	3.9
14	81	6	37	2	14.5	39.3	2.3	1.9
15	82	4.5	38	2	12.5	40.3	1.8	1.0

**Too far from abutment to have load increase*

It appears that the workings may be flooded to some extent since the base of the coal is below sea level. Measurements made in the 1983 borings encountering the mine workings had water levels of about RL 0. The analyses have assumed dry conditions.

9.2 Mine Subsidence

Due to the amount of cover above the mine workings, only trough subsidence is considered feasible. In BH 22, 0.29m of crush was determined. Comparing this to the 0.5m of crush in boring 6, it appears that 0.2m of additional crush is possible at mine level. Therefore, based on the maximum subsidence factor of 0.55, the possible future vertical surface subsidence is 0.11m or 110mm. Estimated subsidence parameters as indicated in Table 6 were developed based on procedures in Holla, 1987 assuming relatively level ground conditions.

TABLE 6 – ESTIMATED TROUGH SUBSIDENCE PARAMETERS

PARAMETER	VALUE
Maximum Subsidence, Smax	110 mm
Maximum Tensile Strain, +Emax	0.76 mm/m
Maximum Compressive Strain, -Emax	1.24 mm/m
Maximum Tilt, Gmax	3.7mm/m
Tensile Curvature radius (convex)	12.6 km
Compressive Curvature radius (Concave)	7.6 km

An angle of draw of 26.5° (2V:1H) within rock overburden is typically adopted for the northern coal fields of the Hunter Valley. This is based on longwall subsidence data presented in Holla (1987). The angle of draw through soil is believed to be similar to that through rock.

9.3 Designing for Subsidence

When proposed building gets above three stories the current position of the MSB is that all plausible movements need to be designed for, or the building be designed in such a way that cost of repair is sufficiently small (exact value will need to be discussed with the MSB) or grouting to stabilise the mine workings performed. Sometimes the risk to developments by Mine Subsidence is not always a catastrophic event and as such it may be possible to design developments for ‘maximum conceivable’ subsidence. This is case at our site where workings have already crushed to some extent.

10 CONCLUSIONS

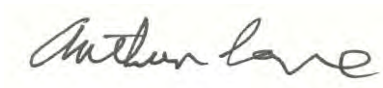
Coal in the Borehole Seam has been mined under the site by Lambton Colliery which operated between 1862 and 1941, with the site area under mined somewhere between 1885 and 1895 using bord and pillar methods with working height estimated to be 2m. Retreat mining was performed in haulageways in about 1915 to 1918. The current location of the mine plan can be seen in Drawing 1.

Borings used in the subsidence assessment included BH22 drilled during the current investigation and four borings drilled in a previous investigation.

It appears that approximately 0.3 to 0.5m of crushing has occurred in pillars with lower factors of safety at the site. It appears that about 110mm of additional trough subsidence could occur at the site.

As previously mentioned, the Mine Subsidence Board must assess the level of risk which is acceptable to them based on the likelihood and consequences of further crushing.

For and on behalf of Coffey Geotechnics Pty Ltd



Arthur Love

Principal Geotechnical Engineer

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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.

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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.

Drawings