coffey geotechnics
SPECIALISTS MANAGING THE EARTH

INTERPRETATIVE REPORT ON PRELIMINARY GEOTECHNICAL, ACID SULFATE SOIL, AND ENVIRONMENTAL (CONTAMINATION STATUS) ASSESSMENT

The Lakes Estate
North Boambee Road, Coffs Harbour NSW
Doug Gow & Associates Pty Ltd

GEOTCOFH02233AA-AE
27 February 2008

Coffey Geotechnics Pty Ltd ABN 93 056 929 483
1,18 Hurley Drive Coffs Harbour NSW 2450 Australia
PO Box 704 Coffs Harbour NSW 2450 Australia

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

27 February 2008

Doug Gow & Associates Pty Ltd
445 Townsend Street
Albury NSW 2640

Attention: Ben Fryer

Dear Ben

Interpretative Report on Preliminary Geotechnical, Acid Sulfate Soil, and Environmental (Contamination Status) Assessment at The Lakes Estate, North Boambee Road, Coffs Harbour NSW

Please find enclosed our interpretative report for The Lakes Development (Stage 2) near to North Boambee Road in Coffs Harbour. This report provides a preliminary assessment of ground conditions based on findings and analyses undertaken to date with specific reference to the preliminary development plan that has been advised to Coffey.

Attention is also drawn to the appended sheets entitled “Important Information about Your Coffey Environmental Site Assessment” and “Important Information about Your Coffey Report” which should be read in conjunction with this report.

If you have any questions please contact Matt Rowbotham, Emma Coleman or the undersigned at our Coffs Harbour office.

For and on behalf of Coffey Geotechnics Pty Ltd

M Rowbotham

per

Iain Turner

Associate Geotechnical Engineer

Distribution:	Original held by:	Coffey Geotechnics Pty Ltd (Coffey)
	1 Copies	Coffey (Coffs Harbour library)
	3 Copies	Doug Gow & Associates Pty Ltd

Coffey Geotechnics Pty Ltd ABN 93 056 929 483
1,18 Hurley Drive Coffs Harbour NSW 2450 Australia
PO Box 704 Coffs Harbour NSW 2450 Australia
T (+61) (2) 6651 3213 F (+61) (2) 6651 5194 www.coffey.com

CONTENTS

CONTENTS

CONTENTS

Figures

Tables

Appendices

1 INTRODUCTION

Coffey Geotechnics Pty Ltd (Coffey) was requested by Ben Fryer of Doug Gow & Associates Pty Ltd to carry out preliminary geotechnical and environmental assessment studies for the proposed next stage of The Lakes residential subdivision, located at North Boambee Road, Coffs Harbour, NSW. The work was commissioned by correspondence dated 25 October 2007.

A combined contamination status and geotechnical investigation has been undertaken. The work has additionally included assessment of the acid sulfate soil status of soils within the potentially affected lower lying land.

Environmental Investigations have concentrated on the following.

- Contamination status assessment, with particular emphasis on understanding the historic land use of parts of the site for banana cultivation and the specific contaminants that can be associated with banana plantations.
- An assessment of acid sulfate soil status in lower lying valley bottom areas and advice on the possible need for a management plan.

Key geotechnical aims of the assessment were as follows.

- To provide an assessment of potential slope instability issues with particular focus on areas with slopes in excess of 10°.
- To offer recommendations for appropriate erosion prevention and sediment control measures with reference to the preliminary layout proposals. Where need be advice might be given on changes to the layout or for remediation measures to be implemented to reduce potential for damage from ground instability.
- Preliminary advice on foundation conditions across different sectors of the site is given.

2 SITE LOCATION AND SURROUNDING LANDUSE

The site covers an area of some 53.15ha that is accessed from North Boambee Road, Coffs Harbour in NSW.

Extending beyond the initial partially completed phase of development at The Lakes the study area specifically comprises Lot 95 DP 1111430 (Lot 95), Lot 2 DP 607602 (Lot 2), a portion of Lot 101 DP 619946 (Lot 101), Lot 1 DP 1089778 (Lot 1), and Lot 10 DP 1071628 (Lot 10). It is within the City of Coffs Harbour Local Government Area, Parish of Bonville and County of Raleigh.

The overall locality is shown on Figure 1 and the site layout is shown on Figure 2.

The site incorporates some low lying, valley bottom areas but is distinctively characterised by steep sided hills and narrow steeply plunging valleys that are typical of the Coffs Harbour hinterland. At the time of the investigation the entire area of the planned new stage of development was in agricultural use with lower lying areas being used for grazing; within the site at its north eastern boundary there was a single timber framed and fibreboard clad house. This house together with associated sheds is the only building within the current site area.

The general vicinity of the development area is described as semi rural; there are a number of relatively widely spaced houses within this hilly area on the periphery of Coffs Harbour.

3 SUMMARY OF PREVIOUS WORK UNDERTAKEN AT THE LAKES

The current investigation area is a proposed new stage in the overall subdivision at The Lakes. Earlier stages of the subdivision are located east and south of the current investigation site. Work that has been undertaken by Coffey during the previous stages of development is summarised below.

Coffey has provided geotechnical advice, an acid sulfate soil status assessment and environmental (contamination status) assessments on an ongoing basis for the earlier stages between mid 2003 and 2007. To date, the scope of Coffey's involvement has included:

- Contamination status assessments, including identifying areas formerly used for banana plantations, carrying out sampling and analysis in these areas, and providing recommendations on remediation options where contamination has been identified. On completion of remediation works validation sampling and laboratory analysis was carried out.
- Geotechnical assessments including:
    - advice on construction of minor structures including boulder walls (rock stack walls) and culverts, as well as on site preparation and fill construction procedures.
    - advice on erosion prevention measures.
    - assessment of suitability of on site materials for reuse as fill, site classification for design of spread footings and ground bearing slabs (Australian Standard 2870-1996) and the provision of parameters used in the design of pavement.
- Acid sulfate soil assessment and provision of management recommendations for handling of acidic soils.
- Advice and monitoring during earthworks, including 'Level 1 Construction Monitoring' (Australian Standard 3798-1996), observation of concrete pours, and observations of footing excavations.

4 SCOPE OF INVESTIGATION

Three key aspects of work have been undertaken as part of the recent investigations, and each are discussed in turn within subsequent sections of this report.

4.1 Environmental (Contamination Status Assessment)

Environmental (contamination status assessment) investigation is optimally undertaken in a phased approach.

Phase 1

The initial phase of works comprised a desk-top study site history assessment based on a review of aerial photographs held by the State Government as well as a search of historical ‘titles’, i.e. previous land ownership that can provide evidence of former land use.

Additionally, as part of this Phase 1 work, reference was made to published New South Wales Environmental Protection Agency notices (that might relate to recorded pollution incidents or potentially contaminating land uses or waste disposal sites). Similarly a review has been undertaken of the dangerous goods records that are held by NSW ‘WorkCover’ and of any records (e.g. development applications) that are held by Coffs Harbour City Council and are readily available and pertain to the site.

For general assessment, an investigation of published geology (Geological Survey of NSW) and reference to licensed groundwater wells has been made, as this can affect migration of pollutants and also identify potential targets at risk.

The desktop study was supplemented by a walkover survey as well as with interviews with people who are familiar with the site.

Phase 2

The Phase 2 works that have been completed as part of this investigation were based on the findings from Phase 1 that had identified specific areas of environmental concern.

Work comprised the collection of surface samples using hand tools on three areas of the site that represented (parts of) former banana plantations (designated as part of this study as Area 1, Area 2 and Area 3 as shown on Figure 2) as well as sampling in the area of the house and garden shed. Representative soil samples were scheduled for chemical (contamination) testing for specifically identified ‘contaminants of concern’ as summarised below.

- Laboratory analysis of soil samples from the former banana plantations for arsenic, lead and organochlorine pesticides (OCPs).

  In the first instance sampling in areas where banana plantations are assessed to have encroached onto the site has been undertaken in a regular 25m x 25m grid in accordance with stipulations within the NSW EPA (1997) ‘Guidelines for Assessing Banana Plantation Sites’. Some additional testing has been recommended based on specific findings during the Phase 1 work.

- Analysis of representative samples from the house and shed area for potentially contaminating substances such as lead based paints, pesticides and the potential presence of asbestos fibres within the soils.

4.2 Preliminary Geotechnical Assessment

The geotechnical assessment has also been undertaken in a phased approach, aiming to optimise findings from the overall investigation.

The assessment builds on previous work completed in the area by Coffey, with particular emphasis on issues associated with construction on relatively steeply sloping land that falls within the currently proposed stage of development.

Initial work included a review of published geological data and a detailed review of aerial photographs taken between 1964 and 2001. The photographs were reviewed as stereographic pairs, that is a powerful tool in the exaggeration of landforms and, using series' of photographs taken over a period of time, the technique can be helpful in the identification of past instability (i.e. landslides).

The desktop study review was followed up by a detailed walkover survey to enable observation of geomorphological (landform and land processes).

Based on the findings from the desk top study and walkover survey a preliminary subsurface investigation was undertaken, concentrating on key areas of concern within steeply sloping ground, the axes of valleys and in lower lying potentially soft soil areas. The latter coincides with investigation for potential or actual acid sulfate soils.

The investigation comprised the excavation of 25 test pits on sloping ground and 11 in low lying areas using a mechanical backhoe, allowing logging, *in situ* testing and collection of samples for laboratory testing by an engineering geologist from Coffey.

4.3 Acid Sulfate Soil Status Assessment

The series of 11 test pits that were excavated within low lying ground were specifically positioned within the area identified by published acid sulfate soil survey data as potentially, though with a low risk, of being acid sulfate affected.

The published data represent a collation of mapped recent coastal alluvial soil types with reference to topography (ground elevation) that can be used in a preliminary assessment of potentially acid sulfate affected soil.

Figures 2 and 6 show the area where acid sulfate soils might be anticipated and also the layout of test pits that have been completed.

Soil samples are initially assessed by monitoring their reaction with a strong oxidant; then further analysis is undertaken on selected samples based on an interpretation of the vigour of the initial oxidation reaction.

5 ENVIRONMENTAL (CONTAMINATION STATUS) ASSESSMENT – PHASE 1 STUDY

5.1 Review of Published Geology and Hydrogeology Data

The 1:250,000 scale Geological Survey of New South Wales map of Coffs Harbour / Dorrigo indicates that the site locality is underlain by the Brooklana Formation comprising of quartz impregnated mudstone and muddy sandstone (termed siliceous argillite and greywacke) and possible slate. Low lying areas may contain Quaternary age alluvium, comprising of clay and silt grading to sand and gravel with depth.

The Acid Sulfate Soil risk map for Coffs Harbour shows that the south-eastern corner, an area of approximately 45,000m^2 (4.5ha) on the southeast corner of the site has a “low” probability of acid sulfate soils existing between 1m and 3m below ground surface as shown on Figure 2. Other areas of the site are shown as having no known occurrence of acid sulfate soil.

A search of the NSW Department of Water and Energy groundwater bore data was carried out. Of the order of 41 groundwater bores were found within a 1km radius of the site. No bores were located on the site. A summary of these bores is provided in Table A1 together with copies of information sheets presented in Appendix A. Generally the information shows groundwater standing levels (3m to 18m) and water bearing zones (8m - 9m to 60m - 70m) varying significantly as a reflection of the topography. The area has low lying alluvial floodplains and steep sided hills.

5.2 Review of Site History Data

Site history information was obtained from a review of aerial photographs, a search of historical titles, a check of NSW EPA notices, a search of dangerous goods licenses held by WorkCover, a review of Coffs Harbour City Council records for the site, and interviews with people familiar with the site. Copies of original documents and/or information are presented in Appendix A.

5.2.1 Review of Series’ of Historic Aerial Photographs

A selection of aerial photographs dating from 1954 to 2001 has been viewed. A brief description with inferred details of the site in each photograph is summarised in Table 1 below.

Table 1: Summary of Site in Aerial Photographs

Date	Description
1954	The majority of the site has been cleared, with bushland apparent in gullies and some steep areas. Area 1 appears to be a banana plantation. Area 2 has been cleared, but no banana plantation is present. Area 3 is not cleared, though this may be a banana plantation under cultivation. Other cleared areas of the site appear to be used for cattle grazing. There are a few scattered residences in the surrounding area, but it is generally rural land.
1964	Similar to 1954, the bushland appears to have grown back in the middle area of the site. The three banana plantations areas have bananas under cultivation. There appears to be a shed on the south side of Area 1.

Table 1: Summary of Site in Aerial Photographs

Date	Description
1977	The majority of the site is cleared, with notably more areas cleared than in 1954. The three banana areas have bananas under cultivation, except for the northern portion of Area 2. The shed on banana Area 1 is visible. Three houses or large sheds and one small shed are located in the south-east corner, it is not clear if they are on the site area or not.
1984	Similar to 1977, except for banana Area 2 that has been cleared, and the houses/sheds on the south-east corner appear to have been removed, except for one house and small shed.
1994	The whole site is largely cleared, except for a ring of trees around banana Area 2 and the northern portion of the site. All three banana areas have been cleared. The house and shed are still located on the south-east corner, and the shed on banana Area 1 appears to be in the same location. A creek/gully appears to run down the eastern side of the site. There is more development in the nearby area, but the site appears to remain as rural land. Bishop Druitt school is present on the southern side of North Boambee Road, although it appears to be under construction.
2001	Similar to 1994. Bishop Druitt school appears to have been completed.

5.2.2 Titles Search

A titles search was carried out by Advance Legal Search Pty Limited for each lot.

Lot 95 has been owned by Noubia Pty Ltd (who are one of the principals for the current investigation) since 2003. Prior to this, it was owned by W H Bailey and Sons (Boambee) Pty Ltd since 1971. Numerous individual banana growers owned the lot from 1913 to 1971.

Lot 2 has been owned by Dragen and Mandolion (who are two of the principals for the current investigation) since 2003. From 1967 to 2003 it was owned by Rosalind and David McGregor, who were milk vendors, and also banana growers. Prior to this, the titles search indicates that Lot 2 had been owned by dairy farmers since 1908.

A portion of Lot 101 was very recently purchased by Noubia Pty Ltd (October 2007). The titles search indicates that it was owned by Michael and Jill Walker. People with the surname Walker had owned the lot since 1961, and the titles indicate that they were banana growers. Prior to being owned by the Walkers, the lot was owned by numerous individual farmers. Based on available information from surrounding areas the owners were likely dairy farmers or banana growers.

Lot 1 is Crown Road owned by The State of New South Wales. No information is given on when the lot was granted.

Lot 10 has been owned by Mandolion and Dragen since 2003.The lot has been amalgamated from numerous previous lots. Portions of the lot from 1967 to 2003 were owned by David and Rosalind McGregor and then by numerous farmers and dairy farmers since 1908. Other portions of the lot from 1968 to 2004 were owned by Albert Max Golding, a banana grower, and then by farmers since 1908.

5.2.3 NSW EPA Notices

A check of the NSW EPA website on 23 November 2007 revealed that no notices have been issued on the site or adjacent properties under the Environmentally Hazardous Chemicals Act (1985) or the Contaminated Land Management Act (1997).

5.2.4 Dangerous Goods License Records

WorkCover dangerous goods licensing records were reviewed and no records pertaining to the site were located.

5.2.5 Coffs Harbour City Council Records

A review of the records held by Coffs Harbour City Council (Council) was carried out on 17 December 2007. The records for Lot 101 DP 619946 and Lot 1 DP1089778 were not reviewed as Council had these listed as being owned by others and therefore Coffey Geotechnics did not have access to these records.

A portion of Lot 101 was recently purchased, which from the other historical searches appears to have been used for cattle grazing. Lot 1 is a Crown Road, and from the historical searches appears to have been used as a banana plantation.

The Council records contained large amounts of information on previous stages of The Lakes residential subdivision. The records included information on archaeology, bush fire areas, flood zones, sediment and erosion, tree planting, flora and fauna assessments, and acid sulfate and environmental assessments (carried out by Coffey). There was information concerning stormwater drainage, pollution prevention, and a stormwater detention basin.

A Statement of Environmental Effects (SEE) was present; the sections that covered contamination were all based on previous reports prepared by Coffey.

A Development Application (DA) was submitted in 1991 for subdivision of land previously owned by the McGregor's. The DA indicates that there is no environmental impact from the subdivision. It appears that the subdivision may have occurred, as the land previously owned by the McGregor's previously extended across North Boambee Road where Bishop Druitt College now stands.

A golf course was proposed in the late 1990's (Lot 3 DP711234 now part of Lot 10 DP1071628) on property previously owned by the Golding's (now the eastern part of the site). It does not appear that the golf course was ever set out.

A letter dated 18 October 1993 from Council to David McGregor indicates that Council believe there are chemical residues on the property (Lot 7 DP813195 now part of Lot 10 DP1071628). This was in response to the McGregor's application for erection of a dwelling.

Five Building Applications (BAs) were recovered from the microfiche archives. These were for construction of a dwelling on Halls Road in 1967, additions to the dwelling in 1974, a garage for the dwelling in 1976, and installation of a fibreglass pool for the dwelling in 1981. The fifth BA was cancelled; it was unclear what the BA had been for. It appears that this dwelling and associated structures were not constructed or are located beyond the current site.

5.2.6 Interviews

An interview with Mr Murray Bailey was carried out on 28 November 2007. Mr Bailey has lived in the area for a several decades, and was a previous owner of part of the site.

Mr Bailey indicated that there were three areas on the site previously used as banana plantations, and he also indicated that many surrounding areas beyond the site boundary were also used for banana growing. The other areas of the site were generally used for cattle grazing, and some areas were left as undisturbed bushland.

Mr Bailey indicated that a former shed on one of the banana plantation areas that was identified from the historic records search (see Area 1 on Figure 2) was likely to have been a packing shed. Mr Bailey could not recall any other packing sheds or processing areas elsewhere on the site.

5.3 Potential Areas of Environmental Concern (AEC) and Chemicals of Concern (COC)

Based on the site history information and site observations, three main potential Areas of Environmental Concern (AEC) have been identified.

- **AEC 1**: Banana plantation areas;
- **AEC 2**: Packing shed associated with banana plantations. Lead based paints and pesticides may have been used on and around the building, and the building may have been constructed with asbestos containing materials, and;
- **AEC 3**: Existing and former buildings. Lead based paints and pesticides may have been used on and around the buildings, and the buildings may have been constructed with asbestos containing materials.

The likely chemicals of concern associated with the past and current activities, as identified by the site observations and the site history study include:

- Banana Plantations and Packing Sheds (AEC 1 (three locations) and AEC 2 (specific location within banana Area 1))
  - metals (specifically arsenic and lead) used in pesticides.
  - organochlorine pesticides (OCPs).
- Existing and former buildings (AEC 3)
  - metals (arsenic, cadmium, chromium, copper, lead, nickel, zinc, mercury).
  - OCPs & organophosphorous pesticides (OPPs).
  - Asbestos containing construction materials.

Samples were collected in the former plantation areas 'AEC 1' and from 'AEC 3'. These have been scheduled for analysis to help detect the presence of any of the contaminants of concern.

Whilst AEC 2 falls within AEC 1, guidelines recommend a greater density of sampling in any former banana plantation processing areas and this further sampling is currently under consideration.

6 ENVIRONMENTAL (CONTAMINATION STATUS) ASSESSMENT – PHASE 2 STUDY (FIELD INVESTIGATION)

Based on the NSW EPA (1997) Guidelines for Assessing Banana Plantation Sites (referred to as the NSW EPA 1997 Guidelines), the following sampling regime was carried out in three banana areas at sampling depths of 0-75mm and 0-150mm:

- Area 1: 58 sample locations in a 25m spaced grid.
- Area 2: 27 sample locations in an 11m spaced grid.
- Area 3: 58 sample locations in a 25m spaced grid.

Refer to Figure 2 for location of the former plantation areas and Figures 3 to 5 for the layout of individual sampling points.

Samples were also collected around the house and garden shed, with one sample collected at each corner of the house and two samples collected at either end of the garden shed.

Fieldwork was carried out on 19 and 26 to 29 November and 5 December 2007 by a Coffey environmental scientist. The fieldwork carried out on 19 November consisted of designating sample locations in Area 1 and marking them with a stake. The client's contractor subsequently excavated recently placed fill in sample locations exposing the original topsoil layer. In areas where the excavations were deep, the contractor excavated the locations while Coffey field staff were on site, and samples were collected from the excavator bucket.

At each of the sample locations in the banana plantation areas, one sample was collected as a representative of soil from the ground level to 75mm depth and one sample was collected at ground level to 150mm below the existing (or previous) surface. The samples at the house and garden shed were collected as representative for soils at ground level to 150mm depth.

The samples were collected directly into laboratory supplied glass jars. The samples were then placed in chilled insulated containers during fieldwork and transport to the laboratory. Sampling equipment was decontaminated between each sampling location. Fifteen field duplicate samples were collected, and three wash blank samples were collected.

7 ENVIRONMENTAL (CONTAMINATION STATUS ASSESSMENT) – INTERPRETATION OF FINDINGS

7.1 Sampling & Analysis Schedule

Samples were forwarded under chain of custody conditions to a NATA accredited laboratory for the analyses described below.

The ground level to 150mm representative samples collected from the banana plantation areas (AEC1) were tested for their arsenic and lead content. The ground level to 75mm representative samples from the banana plantations were composited, with generally three to four samples being blended to make up each composite sample. The composite samples were then tested for their potential OCP content.

Two composite samples showed elevated concentrations of OCP (Dieldrin). The eight samples which made up the two composites were analysed for OCPs individually.

The samples collected at the house and garden shed (AEC3) were tested for a range of commonly occurring metals/ metalloids (arsenic, cadmium, chromium, lead, nickel, zinc, and mercury), organochlorine (OCPs) and organophosphorous pesticides (OPPs) and also examined for the presence of asbestos fibres.

7.2 Soil Investigation Levels (SILs)

In order to assess the impact of contamination in soils on the site, the results of soil analyses are compared with guidelines in the following references:

- NSW EPA (1997) Guidelines for Assessing Banana Plantation Sites, and;
- NSW DEC (2006) Guidelines for the NSW Site Auditor Scheme (2nd edition).

The NSW DEC (2006) Guidelines for the NSW Site Auditor Scheme summarises the National Environmental Health Forum (NEHF) investigation levels[1] for protection of human health for different land uses and also provide guidelines for provisional phytotoxicity (potential to damage growth of plants) investigation levels for a range of contaminants in soils.

The NSW EPA (1997) Guidelines for Assessing Banana Plantation Sites provides guidance on human health investigation thresholds for contaminants associated with banana plantation sites. These are similar to the thresholds for residential use provided in the NSW (2006) Guidelines.

There are currently no national or NSW guidelines for asbestos in soil. The NSW DEC has advised that asbestos is a human health issue and not an environmental issue. On the advice of the NSW Department of Health, the NSW DEC have advised NSW Site Auditors (Site Auditors Meeting 1 March 2000) that “no asbestos in the soil at the surface is permitted”. Enhealth (2005) provides some guidance on assessing and managing asbestos in soil although does not provide a threshold concentration or investigation level for asbestos.

Where appropriate the results for each contaminant tested for have been compared to NEHF A criteria (Column 1) for residential with gardens and accessible soil (home-grown produce contributing <10% fruit and vegetable intake; no poultry), including children’s day-care centres, preschools, primary schools, townhouses, villas, and provisional phytotoxicity criteria (Column 5) provided in the NSW DEC (2006) Guidelines.

7.3 Quality Assurance/Quality Control

Samples were transported under chain of custody conditions and in chilled insulated containers to MGT Environmental Consulting Pty Ltd (MGT) Melbourne laboratory which is NATA accredited for the analyses. A copy of the chain of custody documentation is included with the laboratory test results in Appendix C.

---

[1] In Imray and Langley (1996). Health Based Soil Investigation Levels. (In The Health Risk Assessment and Management of Contaminated Sites – Proceedings of the Third National Workshop on the Health Risk Assessment and Management of Contaminated Sites. Contaminated Sites Monograph Series No.5, 1996. South Australian Department of Health and Family Services

The laboratory conducted internal quality control using laboratory duplicates, spikes and method blanks. The results are shown with laboratory report sheets in Appendix C and a Data Validation Report is presented with each laboratory report. Analytical methods used for the laboratory testing are also indicated on the laboratory report sheets. The results of laboratory quality control testing are considered to be within acceptable limits.

For QA/QC purposes 15 duplicate samples required analysis. The duplicate soil samples collected during fieldwork from the banana plantations were tested for arsenic and lead, and the duplicate sample collected from near the house was analysed for metals (arsenic, cadmium, chromium, copper, lead, nickel, zinc, mercury), and OCPs & OPPs. The relative percentage differences (RPD) between the primary and duplicate samples are summarised in Table A presented at the back of the report. Three wash blank samples were also tested.

The comparison of the test results for the primary and field duplicate samples indicates that duplicate pairs I7 and DUP 3 had an RPD of 53% for arsenic, M7 and DUP 9 had an RPD of 59% for arsenic, and S5 and DUP 10 had an RPD of 59% for lead, which exceed the control limit of 50%. The other duplicate pairs had RPDs within the control limit. The wash blank samples WB 1 and WB 3 showed concentrations of analytes below the laboratory limit of reporting (LOR). The wash blank sample WB 2 showed trace concentrations of lead, however given the low concentrations of lead in the soil samples it is considered that this does not affect the validity of the results.

Based on the above assessment it is considered that the field and laboratory methods are appropriate and that the data obtained is valid and considered to reasonably represent the concentrations at the sampling points at the time of sampling.

7.4 Comparison of Results with Soil Investigation Levels

The laboratory test results for soil are summarised and compared to the SILs discussed in Section 7.2. within Tables B to G that are included within the series of tables reproduced at the end of this report.

7.4.1 AEC1 – Banana Plantations

Area 1

- Arsenic concentrations in soil samples analysed were found to be above the residential end use criteria in 16 of the 58 samples analysed. Concentrations of arsenic were over provisional phytotoxicity criteria were recorded in 50 of the 58 samples analysed.
- Lead concentrations were below the residential end use criteria and provisional phytotoxicity criteria in each sample analysed.
- OCP concentrations were detected in 6 of the 15 composite samples analysed and all detected concentrations were below the residential end use criteria in each composite sample analysed.

Area 2

- Arsenic concentrations in soil samples tested were found to be above the residential end use criteria in 14 of the 27 samples analysed. Concentrations of arsenic over provisional phytotoxicity were recorded criteria in 26 of the 27 samples analysed.
- Lead concentrations were below the residential end use criteria and provisional phytotoxicity criteria in each sample analysed.

- OCP compounds were not detected in the composite samples analysed, and therefore concentrations were below the residential use criteria in each composite sample analysed.

Area 3

- Arsenic concentrations in soil samples were found to be above the residential end use criteria in 8 of the 58 samples analysed. Concentrations of arsenic were over provisional phytotoxicity criteria in 41 of the 58 samples analysed.
- Lead concentrations were below the residential use and provisional phytotoxicity criteria in each sample analysed.
- Dieldrin (an OCP) concentrations exceeded the *pro rata* modified criterion adopted for composite samples in two of the composite samples. The eight samples which made up these two composites were tested individually for Dieldrin (see next bullet point for results). Concentrations of OCPs were detected in two of the other composite samples and were found to be below the residential end use criteria. Each other sample analysed had OCP concentrations below the laboratory limit of reporting (LOR).
- Dieldrin concentrations exceeded the residential criteria in two of the individually tested samples. The other individual samples showed concentrations of OCPs below the residential criteria.

7.4.2 AEC 3 – House and Shed Area

- Concentrations of commonly occurring metals (arsenic, cadmium, chromium, copper, lead, nickel, zinc, and mercury) were below the residential end use criteria. Concentrations of zinc exceeded the provisional phytotoxicity (hindrance to growth of some plants) criteria in each sample tested. Concentrations of the other metals were below the provisional phytotoxicity criteria;
- OCP compounds were detected in the samples analysed, but the concentrations were below the residential end use criteria;
- Concentrations of OPPs were below the LOR and the residential end use criteria;
- No asbestos was detected in the samples tested.

7.5 Interpretation of Results

Each of the three banana areas (AEC 1) showed a concentration of arsenic within the soil samples that is over both the residential end use and the provisional phytotoxicity criteria.

Area 3 showed concentrations of Dieldrin over the *pro rata* modified criterion for composite samples. Analysis of the individual samples which made up the composite samples indicated one sample from each composite which exceeded the residential end use criteria. The other individual samples had concentrations of Dieldrin below the residential end use criteria.

The results for the samples collected around the house and garden shed showed concentrations of contaminants below the residential end use criteria. However, concentrations of zinc exceeded the provisional phytotoxicity criteria in each sample tested and this could impact plant health in this area.

7.6 Discussion and Recommendations

The investigation has identified three former banana growing areas within the site boundary. It is not uncommon for soils within banana growing areas to be affected with contaminants associated with pesticide use.

Laboratory test results suggest that soils affected by arsenic prevail in each of the three identified former banana plantations. Additionally the persistent pesticide Dieldrin has been identified in two individual samples from Area 3. Marginally elevated zinc concentrations have been recorded in samples taken from the house area.

Some additional analyses are recommended to assist in finalising the interpretation and provision of recommendations for environmental remediation.

Based on the results of the assessment, it is recommended that the following be carried out:

- Sampling and analysis in the area of the possible former packing shed to a greater density is advised in accordance with the NSW EPA (1997) Guidelines relating to banana cultivation. This can be undertaken in a phased manner, to help assess whether a potential spill 'plume' could extend downhill from the shed site. Further research into the previous use of the shed could uncover the need for a variation in 'chemicals of concern' to be tested for, and on their spatial distribution;

- An assessment of the vertical extent of arsenic and Dieldrin contamination in the banana plantation areas as this can affect the extent and methodology of remediation works that can be adopted.

7.6.1 Likely Remedial Options

Some remediation work is likely to be required in parts of the three former banana plantation areas. The method of remediation will depend on the vertical extent (depth) of the contamination, and also on the proposed end use (and management) of the affected areas. The remediation measures must satisfy a strategy to break a 'source, pathway to receptor (target)' model that can reasonably be conceptualised.

At this stage the remediation options identified are:

- *Removal of Source* (excavating contaminated soil and disposing to landfill). With this technique the excavation walls and floors are subsequently validated by sampling and analysis to help assess whether the contamination affected soils have successfully been removed. The soil to be disposed of to landfill would also require waste classification testing.
- *Vertical Mixing* (blending of soil): This technique is acceptable in banana cultivation areas where it is assessed that contaminants in shallow soils can be blended with those below (practical to a maximum depth of 500mm) to sufficiently reduce the overall concentrations. The areas are subsequently validated, by sampling and analysis to assess the effectiveness of the vertical mixing.
- *Encapsulation* (capping or burying of contaminated soil such as beneath areas of pavement, hardstanding, buildings or maintained public open space). This can economically be used in situations where the potential for contaminant migration to a target at risk is acceptably ameliorated. In general terms such techniques must consider movement within groundwater, as ground gas, as odour or for the potential for the contaminant to impact construction materials. The method requires clear recording so the hazard is easily identified during the production of risk assessments for future construction or maintenance works.

8 GEOTECHNICAL ASSESSMENT – DESK STUDY AND WALKOVER SURVEY

8.1 Stereoscope Mapping - Slope Instability Assessment

Stereoscopic viewing of pairs of aerial photographs that were obtained from the New South Wales Department of Lands has been undertaken. The technique allows a three dimensional view of the photographed landscape. Overlapping photograph pairs taken in 1964 and in 2001 has enabled changes in the landscape over this period to be highlighted. Such areas were then targeted by a site walkover assessment and test pitting investigation.

The results of the mapping indicated that no obvious, significant changes in slope shape had occurred over the 37 years.

Land use in 1964 was similar to that of 2001, being predominantly banana plantation or cattle grazing. This allowed relatively good exposure mapping in cleared areas or those with less tree cover over many of the slopes. The more heavily vegetated areas are less suited to this mapping technique.

8.2 Walkover Survey

Prior to excavating the test pits, a walkover survey was undertaken focussing on geomorphological and geological features of the landscape and any existing exposures in the nearby area, together with groundwater and surface water features that are identifiable. The walkover also allowed inspection of low lying areas for evidence of potential acid sulfate soil conditions.

8.2.1 Topography

The site is typified by steeply sloping hills and narrow valleys that open out towards lower lying areas towards the coastal plain.

The proposed further development at The Lakes will extend to the west and east or north east (referred to as areas 1.2 and 2.2 & 4.2 respectively), with two specific further limbs of development stretching to the north (area 6.2) and north west (areas 7.2, 8.2 and 9.2) (refer to Figure 2).

A ridge is orientated in an approximate north to south direction into the central northern portion of the development area where slopes drain to the east and west into relatively broad valleys.

The landscape becomes considerably steeper into the more distant limbs that rise into the hills. Notably development in area 6.2 is proposed within two deeply incised converging valleys and in areas 7.2, 8.2 and 9.2 the development will extend from the valley onto a steep sided hill.

To the east of the existing development the land rises above low lying land that is indentified as potentially underlain with Quaternary alluvium (area 1.2). It is here that potentially low strength and compressible as well as possible acid sulfate soils were investigated.

Two small livestock watering dams (estimated as being less than 250m^2 in area) were also noted during the site investigation in the axes of valleys/ watercourses. Water was present within distinct channels in the valley axes at areas 7.2 and 8.2 as well as in an incised channel in area 6.2. Surface water flows from this area towards the artificial lake (Lake 5) that is in area 1.2. Springs are likely to be common in the lower lying valley sides. Whilst not specifically identified, reedy grasses in areas 3.2 and 7.2 especially are possibly associated with springs.

Stockpiles of fill have been placed in the southwest portion of the site (within Banana Plantation Area 1). The fill was placed during previous phases of the subdivision works near Lake 2. The fill covers an area of about 2.5ha and ranges between about 0.2m to 4m in thickness.

At the time of the investigation the site was undeveloped. There were some tracks cut into the sides of some of the slopes where banana plantations had been located and to access grazing fields.

Bedrock was exposed on the upper slopes and crest of the ridge in the far western area of the site to be developed (area 9.2). This was the only rock exposure noted.

8.2.2 Slope Instability

Much of the development is proposed on sloping, and in some locations very steeply sloping ground. Critical to the investigation is the assessment of slope instability and this was the focus of the walkover survey and subsequent subsurface investigation.

Notably the majority of steep slopes were observed to have a cover of colluvium. Colluvium is a term applied to soils that have been subject to downslope movement in their development.

No evidence of deep seated instability was specifically recorded either by the review of aerial photographs or by the walkover survey. Such evidence could include inclined or rotated trees or fence posts that could also result from soil creep, or sharp breaks in slope that could represent landslide backscarps from slumped soils. Similarly hummocky ground or wet ground within hillslopes could represent the toe of landslides, and no such features were identified during the survey.

Despite the above potential for ongoing soil creep in colluvium that mantles the steeper slopes cannot be overlooked.

A boulder of high strength meta-siltstone rock about 1m in diameter was noted within the axis of the gully in area 6.2. From a walkover of the areas upslope, no further boulders or rocky outcrops were noted, and its provenance is unclear. A reservoir (tank) is located above this slope and the boulder could have originated from cutting undertaken to prepare its foundation.

The survey did not identify any areas of boulders or rock outcrops above the planned development areas that could represent a source of risk to end users from toppling or rolling.

9 GEOTECHNICAL ASSESSMENT – INTRUSIVE INVESTIGATION

The 34 test pits were excavated using a 13 tonne excavator equipped with a 600mm width bucket. Eleven of these test pits were excavated within the low lying area identified as possible acid sulfate (or potential acid sulfate) soils. These test pits are designated ASTP1 to ASTP11 inclusive. The remainder were excavated into sloping ground as part of the investigation into potential slope instability. These are designated SSTP1 to SSTP23.

Fieldwork was carried out in the full time presence of an engineering geologist from Coffey who nominated the test pit locations, logged the subsurface conditions and collected samples. Engineering logs of the test pits are presented in Appendix B.

The subsurface conditions have been separated into the low lying area associated with the acid sulfate soil assessment and hillslope areas associated with the slope instability assessment.

The following soil profile has been interpreted in the low lying area subject to acid sulfate soil assessment:

- **Fill (ASTP8 and ASTP11 only):** Clay, generally moist; overlying,
- **Topsoil:** Silt, low plasticity, moist, dark brown, root affected to 0.3m depth; overlying,
- **Alluvial Soil 1:** Interbedded (or lenses) of clay and silt, low to medium plasticity clay, moist, pale grey with orange/brown and red/brown mottling, soft to firm between 0.5m and 1m depth; overlying,
- **Alluvial Soil 2:** Interbedded (or lenses) of clay and silt, low to medium plasticity clay, moist, pale grey with orange/brown and red/brown mottling, stiff to very stiff clay and weakly cemented silt materials extending beyond the depth of investigation.

The following geological profile has been interpreted in the hillslope area subject to the slope instability assessment:

- **Topsoil:** Silt, low plasticity, moist, dark brown, root affected to between 0.15m and 0.3m depth; overlying,
- **Colluvial Soil 1:** Silt/ clay, low plasticity, moist, pale grey and pale brown, firm to stiff between 0.3m and 5m depth; overlying,
- **Colluvial Soil 2:** Clay, low to medium plasticity, moist, red/brown to orange/brown, firm to stiff within the axis of some water courses and stiff to very stiff along ridgelines and hillslopes away from gully axes. Some gravel and boulders of meta-siltstone and quartz were noted within the colluvium (Stage 6.2 only); overlying,
- **Residual Soil:** Clay low to medium plasticity, moist, red/brown to orange/brown, very stiff to hard and friable, occasional ironstone nodules within soil matrix, grading to,
- **Extremely Weathered to Highly Weathered Meta-Siltstone:** Relic rock structure with extremely closely spaced defects (spacing < 80mm), estimated very low strength, pale grey, brown/red and yellow brown, extensively iron oxide stained rock mass grading to,
- **Highly Weathered Meta-Siltstone:** Extremely closely spaced defects (spacing < 80mm), estimated very low to low strength, pale grey with brown/red and yellow/brown iron oxide staining to part of the rock mass and along some joint defects.

Test pit SSTP21 was the only location where moderately to slightly weathered rock was encountered at this location excavator bucket refusal was encountered at 1.5m depth. The meta-siltstone bedrock was estimated as medium to high strength with extremely closely to medium spaced defects (between 80mm to less than 800mm).

Groundwater seepage was observed in some of the test pits undertaken in the low lying area of area 1.2. Surface water was also noted to be ponding on the surface with the flat low lying area of area 1.2 and in the axis of the broad gully between areas 7.2 and 8.2. A drainage trench from the north-western corner of Stage 1.2 towards Lake 5 had a steady flow of surface water.

10 GEOTECHNICAL ASSESSMENT - CONSIDERATION FOR DESIGN AND CONSTRUCTION

10.1 Construction on Sloping Ground

The investigation has recorded a significant cover of colluvial soil over sloping ground, which is indicative that the site is likely to be subject to soil creep. Whilst no evidence of past deep seated instability has been noted during the investigation it will be important for each house site to be further inspected for evidence of possible deep seated instability during preparation for construction. Also note that construction of the access will change the landform such that instability may be more likely. For preliminary guidance, engineered fill or permenant cut batter slopes should not be constructed at gradients any steeper than 2H to 1V (26°) up to 3m in height. Excavations in natural soil materials may also be retained by engineer designed retaining walls, soil nail walls or the like. Excavations in rock will be required to be battered back or supported, (rock support may facilitate the use of rockbolts, dowels, mesh and shotcrete). Appropriate batter angles or support for excavations in rock will require site specific assessment as construction proceeds.

It is the nature of colluvium that it has been subject to downslope movement in its formation. As such there is potential for preexisting shear planes within the soil. The potential reduced shear strength of the soils on these planes must be considered in the design of slopes (cuttings) and retaining structures for example. It is advised that post peak/ residual shear strength parameters be adopted in the design of all retaining structures that support colluvium. Retaining walls must found within residual soil or bedrock below the colluvium.

Sloping ground is susceptible to erosion, and this will be enhanced during site clearance and construction periods. The presence of vegetation has the dual benefit of binding surface soils and reducing soil moisture, increasing its shear strength. Clearance of vegetation should be kept to the minimum that is practical.

Erosion of soils can be exacerbated where springs exist and improved drainage in such areas will be needed. From initial observation particular attention must be paid to lower slopes, notably in areas 3.2 and 7.2.

10.1.1 Areas of Steep Surface Slopes (greater than 10º)

Construction on steeply sloping ground (in particular areas with slopes greater than 10º) must take into account the potential for near surface ‘soil creep’ within the colluvium.

All construction should be in accordance with good hillside practice as illustrated on the attached Figure in Appendix E. This implies that houses should be of “pole type” construction supported on piles that are extended into bedrock beneath the colluvium. Design of piles must take into account potential for lateral loading from soil creep, requiring them to extend into the underlying bedrock. The bedrock will provide capacity in end bearing and side adhesion (skin friction) for piles. The construction of cut/fill platforms in this area is not considered appropriate.

Soil creep can impact shallow footings, walls, footways, services and gardens. If minor cutting is required, retaining structures can be designed for the support of sloping and potentially creep affected soils. The key to the design of retaining structures and also for maintenance of slope stability is the provision of drainage away from critical areas behind walls and at the crests of slopes. The stability of cuts in rock would need to be assessed progressively as construction proceeds. Rock support such as rockbolts, dowels, mesh and shotcrete may be required.

A site specific stability assessment taking into account the landform and nature of the specific residence will be required for each site on steeply sloping ground.

10.1.2 Areas of Gentle Surface Slopes (less than 10º) and Deep Soil Profiles

Construction in shallow sloping ground (say less that 10º) might be less critical in terms of slope instability. Specific investigation should be undertaken at each house site to assess the subsoil profile for its foundation characteristics in terms of support of spread footings and ground bearing slabs or piles.

Drainage of any sloping ground will be imperative for the control of soil creep. Cut/fill platforms may not be economically practical on some sites depending on the configuration of the structure and specific allotment. Although stability issues are likely to be a bit less critical than in steeply sloping areas, good hillside practice as shown in Appendix E should be followed unless specific engineering advice to the contrary is obtained.

10.1.3 Shallow Bedrock

Higher slopes at the ridge in the far north-western end of the site have a shallow cover of soil overlying high strength meta-siltstone and in some areas bedrock is exposed at the surface.

The bedrock will provide an appropriate foundation for the support of footings. There can be increased construction costs associated with excavating for footings and services into bedrock. The potential for uplift can become critical for buildings constructed in this location. The bedrock will provide axial capacity for piles and anchors if required.

10.2 Construction in Low lying Areas

Three specific areas of low lying ground are shown on Figure 2.

Within these areas groundwater was recorded to be very shallow, and parts were flooded. In each area the underlying soils include low strength clay and, most critically, silt. These soil types are especially susceptible to deterioration under trafficking; they are subject to rapid losses in strength (bearing ratio) with slight increases in their moisture.

It is likely that provision of a working platform will be needed to allow subsequent construction to proceed, including the provision of subgrade for pavement and the placement of engineered fill for support of buildings and structures. Such a platform would comprise free draining and adequately robust granular fill that is placed and compacted in layers to provide a relatively rigid mattress. Depending on the subsurface conditions encountered, construction of working platforms may require the use of geofabric and geogrid materials. During site preparation observation should be undertaken by a geotechnical engineer who can advise on the possible need for initial excavation of superficial unsuitable soils (e.g. high compressibility or organic soils) prior to placement of the platform, subgrade improvement or structural fill. There might also be a need to consider acid sulfate soil conditions in this regard. Based on the observation, advice could be given for the placement of geofabric or grid basal reinforcement that could be beneficial over an especially low strength subgrade.

10.3 Road Construction on Sidelong Slopes and in Valley Axes

Preliminary layout plans provided to date indicate that some of the access roads might be located along the sides of watercourses and gullies where relatively steep slopes will cross perpendicular to the road alignment.

Roads located in these areas will require relatively significant earthworks to allow them to be terraced into the hillslopes. Specific attention must be paid to the design of earthworks on sloping ground, whereby engineered fill must be placed onto level benches that are cut into the slopes. Depending on the design slope angles and the space provided for the roads the final design may need to incorporate retaining walls. Provision and maintenance of drainage on sloping ground and at retaining structures will be imperative. For preliminary guidance, engineered fill or permenant cut batter slopes should not be constructed at gradients any steeper than 2H to 1V (26°) up to 3m in height. Excavations in rock will be required to be battered back or supported, (rock support may facilitate the use of rockbolts, dowels, mesh and shotcrete). Appropriate batter angles or support for excavations in rock will require site specific assessment as construction proceeds.

A detailed specification for earthworks will be required prior to construction.

Sloping ground within the valley axes will be susceptible to erosion, and this will be enhanced during site clearance and construction periods. The presence of vegetation has the dual benefit of binding surface soils and reducing soil moisture, increasing its shear strength. Clearance of vegetation should be kept to the minimum that is practical.

The plans show some roads aligned within the axes of valleys, notably in area 9.2. Throughout the site the steep valleys are subject to flash flow associated with storm events. In places deeply incised gullies have cut into the valley bottom alluvium. The provision and long term maintenance of adequate drainage beneath roads to accommodate flash flows might be impractical and it is envisaged that the layout might need to be amended, possibly to create a ring road that passes either side of the watercourses.

Measures to help control erosion in the valley axes gullies can be adopted. These can include provision of proprietary geofabric liners that can be incorporated within open grassed and rock fill lined gullies.

The roads must be designed with sufficient drainage for control of runoff from the valley sides into the central gully as cutting and embankment slopes will be susceptible to erosion.

11 ACID SULFATE SOIL ASSESSMENT

Acid sulfate soils (ASS) typically contain significant concentrations of iron sulphide (pyrite) which when exposed to air will oxidise and can generate of sulphuric acid. Unoxidised pyritic soils are referred to as potential ASS (PASS) and once oxidation occurs and acidic conditions are generated the soils are referred to as actual ASS (AASS).

Pyritic soils typically form in anaerobic environments, commonly being associated with tidal flats, salt marshes and mangrove swamps. They are most commonly located below elevations of some 5m above AHD. They can also form as bottom sediments in coastal rivers and creeks. Pyritic soils of concern on low lying NSW coastal lands have mostly formed in the Holocene period

Disturbance or poorly managed development in acid sulfate areas can adversely impact ecological systems and also can produce aggressive conditions for construction materials including concrete.

The NSW Department of Land and Water Conservation 1:25,000 scale Acid Sulfate Soil Risk Map of Coffs Harbour shows that about 4.5ha of the site is located in an area of low probability of acid sulfate soils occurring between 1m and 3m depth below the ground surface.

11.1 Proposed Excavation

At this stage the maximum depth of excavation, the volume of soil to be disturbed and the proposed work schedule is not known.

11.2 Soil Sampling and Laboratory Testing

Fieldwork for the acid sulfate soil and geotechnical investigation comprised a site walkover, mapping of site features and excavation of 11 test pits designated ASTP1 to ASTP11 within area 1.2 (refer to figures 2 and 6). Engineering logs are presented in Appendix B.

Samples were sealed in plastic and chilled prior to their transport to the analytical laboratory.

Samples were screened for the possible presence of potential ASS using laboratory methods 21Af and 21Bf (Ref. Ahern CR, Blunden B and Stone Y (eds) (1998), Acid Sulfate Soil Laboratory Methods Guidelines, ASSMAC). Each was analysed for its pH prior to mixing with a strong oxidising agent to assess whether this created a variation in its pH.

The results from the acid sulfate soil screening tests are shown on the laboratory result sheets presented in Appendix D.

The alluvial soil has been observed to have a low organic content, as is immediately apparent from its pale colour and whilst this could represent a low pyrite content the soils were observed to have some staining and to include ironstone concretions.

Results from the initial 'screening' test indicated the following.

- Each soil sample was recorded to have an initial acidic composition.
- Oxidation with hydrogen peroxide produced a pH reduction of greater than 1.5 units in 12 of the 30 samples tested, creating a pH of 3 or less in 6 of the samples (ASTP1 0.5-0.8m, ASTP3 0.5-0.7m, ASTP6 0.0-0.2m, ASTP7 0.6 t0 0.8m, ASTP8 1.0-1.3m and ASTP11 1.0-1.3m. The negative pH 'shift' and soil samples within a peroxide solution recording a pH below 3 can

indicate the presence of potential acid sulfate soil.

Based on the results of the screening tests, 22 samples were selected for Suspension Peroxide Oxidation – Combined Acidity and Sulfate (SPOCAS) analysis which included Total Actual Acidity (TAA), Reducible Oxidisable Sulfur (S_{POS}), Reduced Inorganic Sulfur and Pre-oxidisation Sulfate (S_{KCl}). The results of this testing are presented in Appendix D and are summarised in Table 2.

Table 2: Summary of Acid Sulfate Soil SPOCAS Testing

Location & Depth (m)	TAA (Mole H+/Tonne)	Action Criteria For TAA Mole H^+/Tonne	$\%S_{POS}$	Action Criteria For $\%S_{POS}$	$\%S_{Cr}$	Action Criteria For $\%S_{Cr}$	$\%S_{KCl}$
TP1: 0.5 – 0.8	**44**	18	0.02	0.03	<0.01	0.03	<0.01
TP2: 0.2 – 0.4	**49**	18	0.01	0.03	<0.01	0.03	0.01
TP3: 0.5 – 0.7	**51**	18	0.01	0.03	<0.01	0.03	<0.01
TP3: 1.5 – 1.7	**52**	18	0.02	0.03	<0.01	0.03	0.02
TP4: 1.1 – 1.3	18	18	<0.01	0.03	<0.01	0.03	<0.01
TP4: 2.0 – 2.2	14	18	0.01	0.03	<0.01	0.03	<0.01
TP5: 0.5 – 0.7	**50**	18	**0.04**	0.03	<0.01	0.03	<0.01
TP6: 0.0 – 0.2	**30**	18	<0.01	0.03	<0.01	0.03	<0.01
TP6: 1.0 – 1.2	6	18	<0.01	0.03	<0.01	0.03	<0.01
TP6: 2.9 – 3.1	11	18	**0.03**	0.03	<0.01	0.03	<0.01
TP7: 0.6 – 0.8	**30**	18	<0.01	0.03	<0.01	0.03	<0.01
TP7:1.5 – 1.7	7	18	<0.01	0.03	<0.01	0.03	<0.01
TP8: 0.6 – 0.8	6	18	<0.01	0.03	<0.01	0.03	<0.01
TP8: 1.0 – 1.3	**68**	18	<0.01	0.03	<0.01	0.03	0.02

Table 2: Summary of Acid Sulfate Soil SPOCAS Testing (Cont'd)

Location & Depth (m)	TAA (Mole H+/Tonne)	Action Criteria For TAA Mole H^+/Tonne	$\%S_{POS}$	Action Criteria For $\%S_{POS}$	$\%S_{Cr}$	Action Criteria For $\%S_{Cr}$	$\%S_{KCl}$
TP8: 2.2 – 2.5	**54**	18	<0.01	0.03	<0.01	0.03	0.02
TP9: 0.4 – 0.6	**43**	18	<0.01	0.03	<0.01	0.03	<0.01
TP9: 2.0 – 2.2	**48**	18	<0.01	0.03	<0.01	0.03	0.01
TP10: 1.1 – 1.3	**39**	18	<0.01	0.03	<0.01	0.03	<0.01
TP10: 1.8 – 2.0	**33**	18	<0.01	0.03	<0.01	0.03	0.01
TP10: 2.8 – 3.0	4	18	<0.01	0.03	<0.01	0.03	<0.01
TP11: 1.0 – 1.3	**66**	18	<0.01	0.03	<0.01	0.03	0.02
TP11: 3.3 – 3.6	**63**	18	<0.01	0.03	<0.01	0.03	0.02

Note: Values in **shaded and bold** exceed adopted action criteria;

11.3 Conclusions and Recommendations For Acid Sulfate Soils

The results of the testing indicate that the soils at the site are unlikely to have pyritic sulfur, but may contain organic sulfur. This is supported by the low S_{POS}, S_{CR} and S_{KCl} results and the relatively high TAA results in the 15 of the 22 samples tested. These results suggest that the soils are unlikely to be ASS.

Notwithstanding this, low pH values were obtained for the subsurface soils within an area of “low probability of acid sulfate soils between 1m and 3m of the ground surface”.

On this basis it is recommended that the soils are not ASS, but are acidic soils (pH <5). Therefore, it is recommended that the regulatory authority (i.e. local Council) is consulted to determine if a management plan for acidic soils is required. Acidic soils are unlikely to cause significant harm to the environment, as the production of acid is slow and is unlikely to leach from the soils in significant quantities in their natural state. Should the soils be disturbed and be washed into waterways then acidification of the water can occur. Acidic soils can have a negative effect on vegetation growth, especially vegetation that is not native to Australia, and concrete footings can also be corroded by acidic soils.

Generally, two options for dealing with acidic soils may be considered. These include implementation of a sediment control plan which would prevent acidic soils from entering waterways, or treatment of the acidic soils with lime. The decision as to which option to adopt would depend on the need to implement a sediment control plan for the development, and/or the volumes of materials that may be excavated and treated with lime.

The acidic soils could be treated with lime to increase the pH. A bulk density of 1.6t/m^3 has been assumed for the residual soils. Using the Total Actual Acidity (TAA) results, the liming ratio requirements were assessed to be 1kg/m^3 to 35kg/m^3 of soil for acidic soils excavated.

Good quality fine agricultural lime should be used to treat the excavated soils. In calculating the liming ratios, a factor of safety of 1.5 has been allowed (as recommended in the ASSMAC guidelines) above the theoretical requirement to take into account the rate of lime reactivity and the possibility of inhomogeneous mixing.

In addition, it is recommended that the alluvial soils be considered as having a severe exposure classification in respect to aggressivity to buried structural elements. The recommendations indicated in AS2159-1995, with respect to concrete piles (Table 6.1 of that document) should be adopted for foundations at the site.

For and on behalf of Coffey Geotechnics Pty Ltd

per

Iain Turner

Associate Geotechnical Engineer

Important information about your **Coffey** Environmental Site Assessment

Uncertainties as to what lies below the ground on potentially contaminated sites can lead to remediation costs blow outs, reduction in the value of the land and to delays in the redevelopment of land. These uncertainties are an inherent part of dealing with land contamination. The following notes have been prepared by Coffey to help you interpret and understand the limitations of your environmental site assessment report.

Your report has been written for a specific purpose

Your report has been developed on the basis of a specific purpose as understood by Coffey and applies only to the site or area investigated. For example, the purpose of your report may be:

- To assess the environmental effects of an on-going operation.
- To provide due diligence on behalf of a property vendor.
- To provide due diligence on behalf of a property purchaser.
- To provide information related to redevelopment of the site due to a proposed change in use, for example, industrial use to a residential use.
- To assess the existing baseline environmental, and sometimes geological and hydrological conditions or constraints of a site prior to an activity which may alter the sites environmental, geological or hydrological condition.

For each purpose, a specific approach to the assessment of potential soil and groundwater contamination is required. In most cases, a key objective is to identify, and if possible, quantify risks that both recognised and unrecognised contamination pose to the proposed activity. Such risks may be both financial (for example, clean up costs or limitations to the site use) and physical (for example, potential health risks to users of the site or the general public).

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man and may change with time. For example, groundwater 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 the 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 and/or on the property.

Interpretation of factual data

Environmental site assessments identify actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from indirect field measurements and sometimes other reports on the site are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact with respect to the report purpose and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how well 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, parties involved with land acquisition, management and/or redevelopment should retain the services of Coffey through the development and use of the site to identify variances, conduct additional tests if required, and recommend solutions to unexpected conditions or other 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 with redevelopment or on-going use of the site. 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.

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

Important information about your **Coffey** Environmental Site Assessment

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. In particular, a due diligence report for a property vendor may not be suitable for satisfying the needs of a purchaser. Your report should not be applied for any purpose other than that originally specified at the time the report was issued.

Interpretation by other professionals

Costly problems can occur when other professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other professionals who are affected by the report. Have Coffey explain the report implications to professionals affected by them and then review plans and specifications produced to see how they have incorporated 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, laboratory data, 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), field testing and laboratory evaluation of field samples. This information should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Contact Coffey for additional assistance

Coffey is familiar with a variety of techniques and approaches that can be used to helo reduce risks for all parties to land development and land use. It is common that not all approaches will be necessarily dealt with in your environmental site assessment report due to concepts proposed at that time. As a project progresses through planning and design toward construction and/or maintenance, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Environmental 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 other 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.

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

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.

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

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

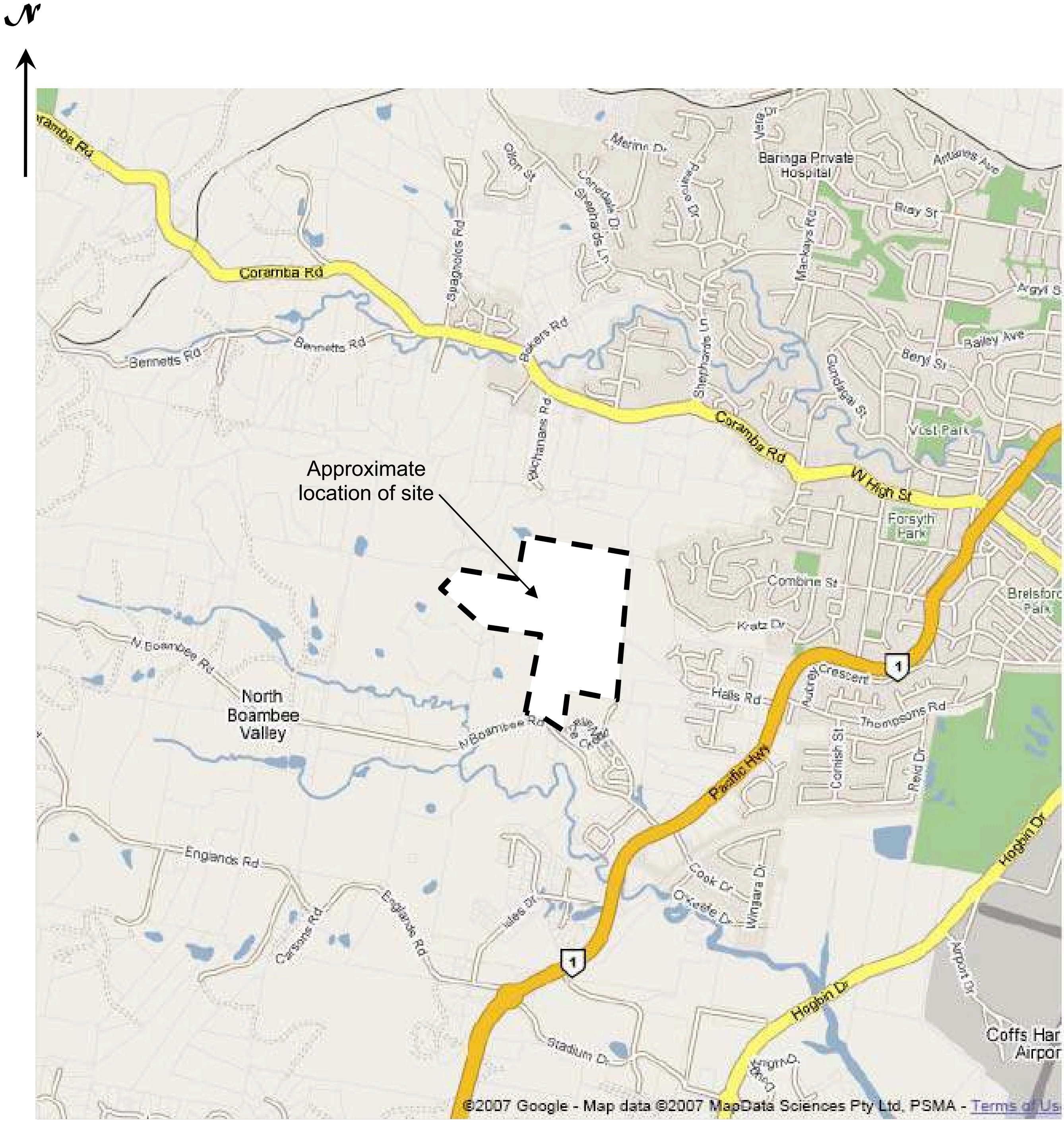
Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As 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

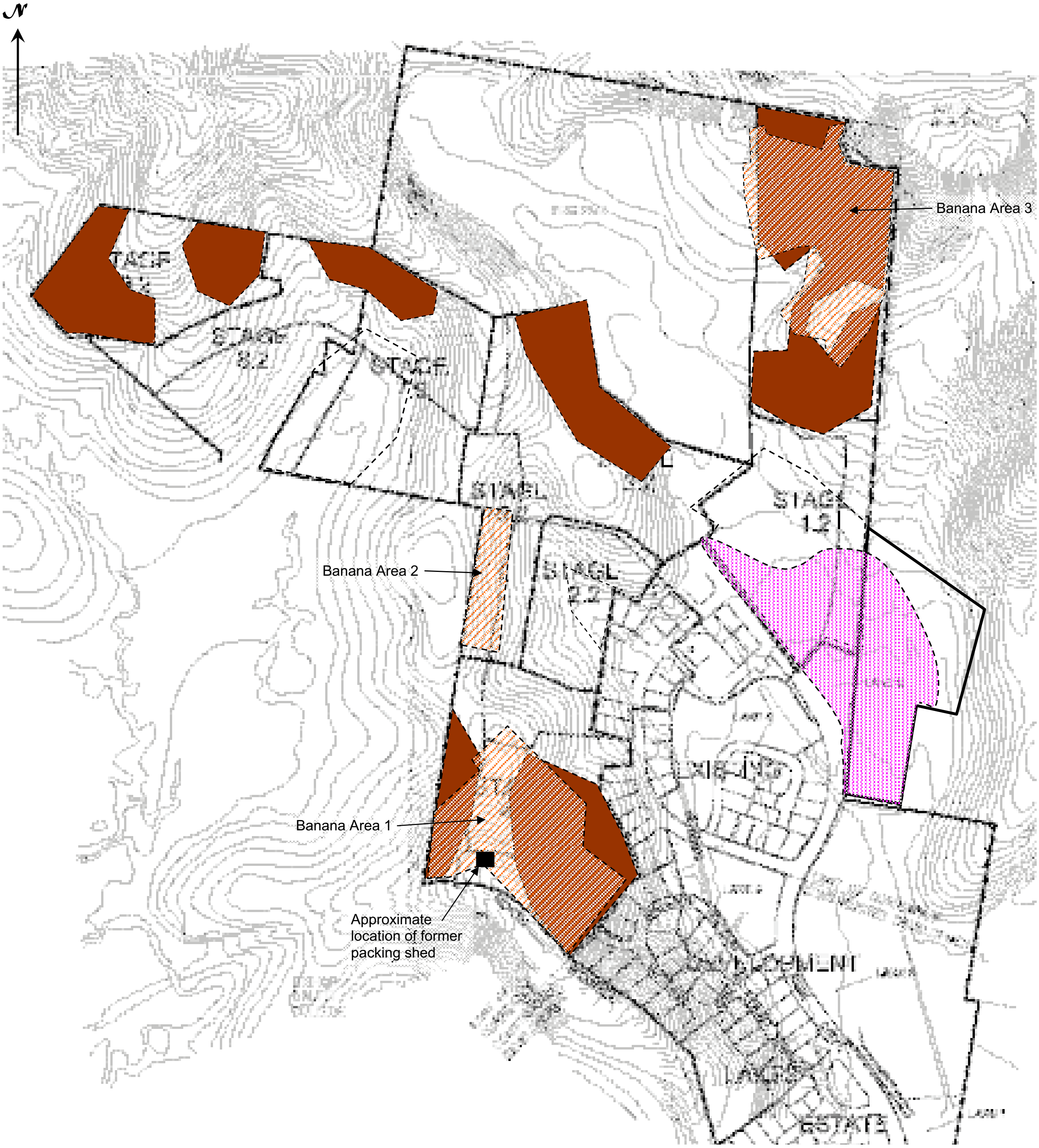
Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, 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



drawn	ELC	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	Doug Gow & Associates Pty Ltd
approved			project:	The Lakes Estate North Boambee Drive Coffs Harbour NSW 2450
date	17-12-2007			
scale	NTS		title:	Site Layout Plan
original size	A4		project no: GEOTCOFH02233AA-AE	figure no: FIGURE 1



LEGEND:

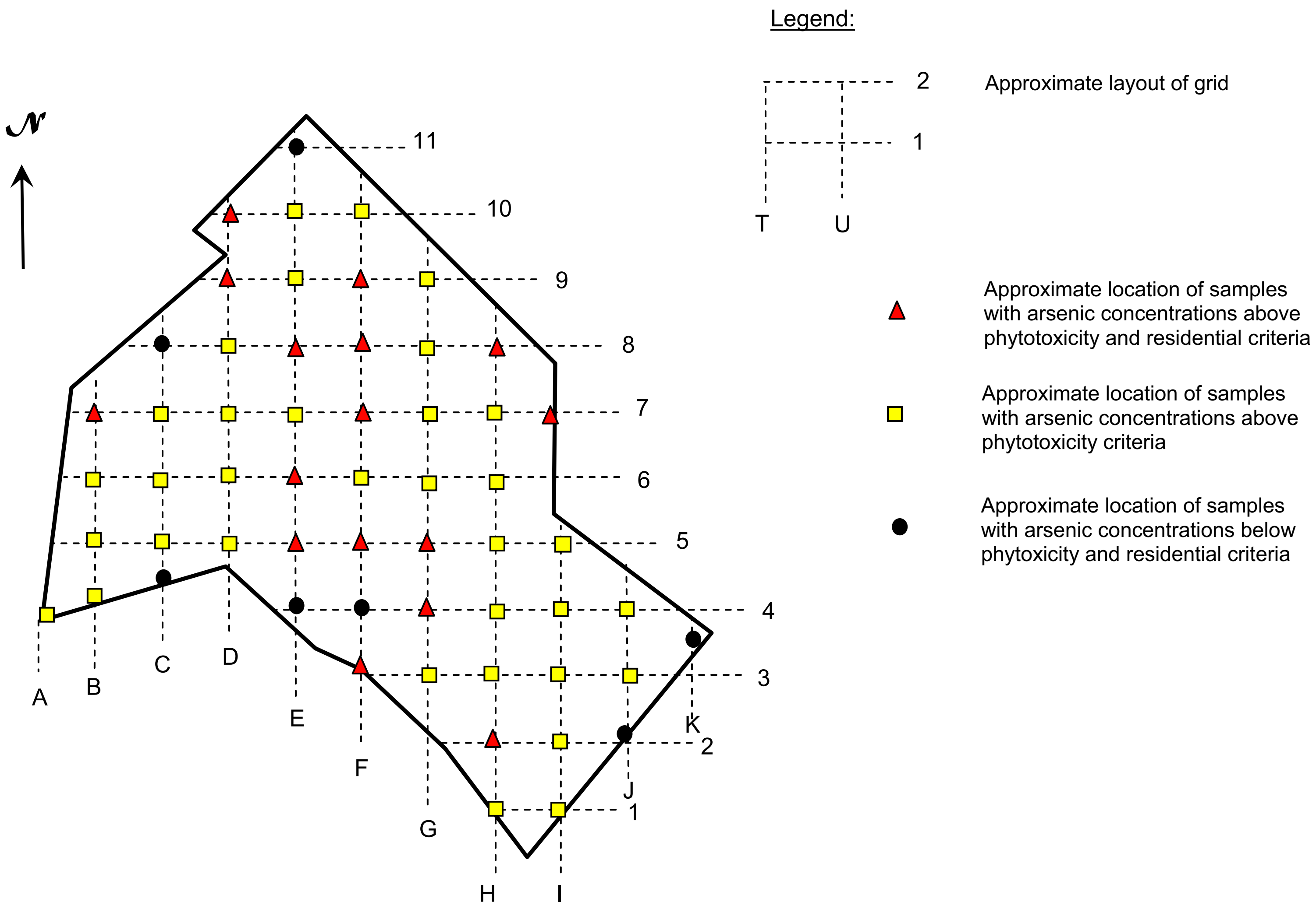
Approximate location of former banana plantations

Approximate location of low lying areas

Approximate location low probability of acid sulfate soils between 1m and 3m bgs

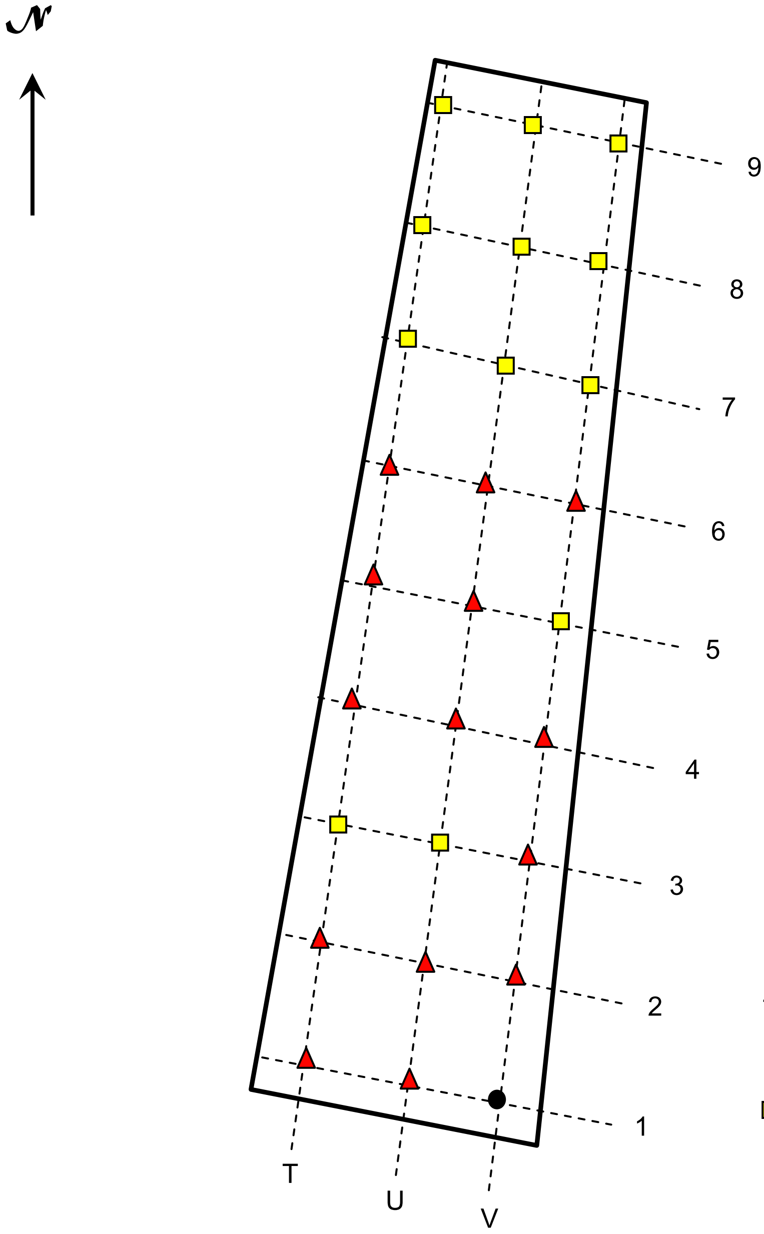
Approximate location of steep sloping areas

drawn	ELC	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	Doug Gow & Associates Pty Ltd	
approved			project:	The Lakes Estate North Boambee Drive Coffs Harbour NSW 2450	
date	17-12-2007				
scale	~1:5000		title:	Site Layout Plan	
original size	A3		project no: GEOTCOFH02233AA-AE		figure no: FIGURE 2



drawn	ELC	client: Doug Gow & Associates Pty Ltd
approved		project: The Lakes Estate Coffs Harbour Noth Boambee Drive Coffs Harbour NSW 2450
date	17-12-07	
scale	~1:2500	title: Sample Locations in Banana Area 1
original size	A4	project no: GEOTCOFH02233AA-AE — figure no: FIGURE 3

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

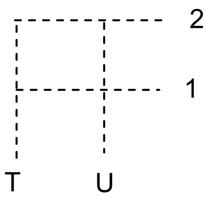


Legend:

▲ Approximate location of samples with arsenic concentrations above phytotoxicity and residential criteria

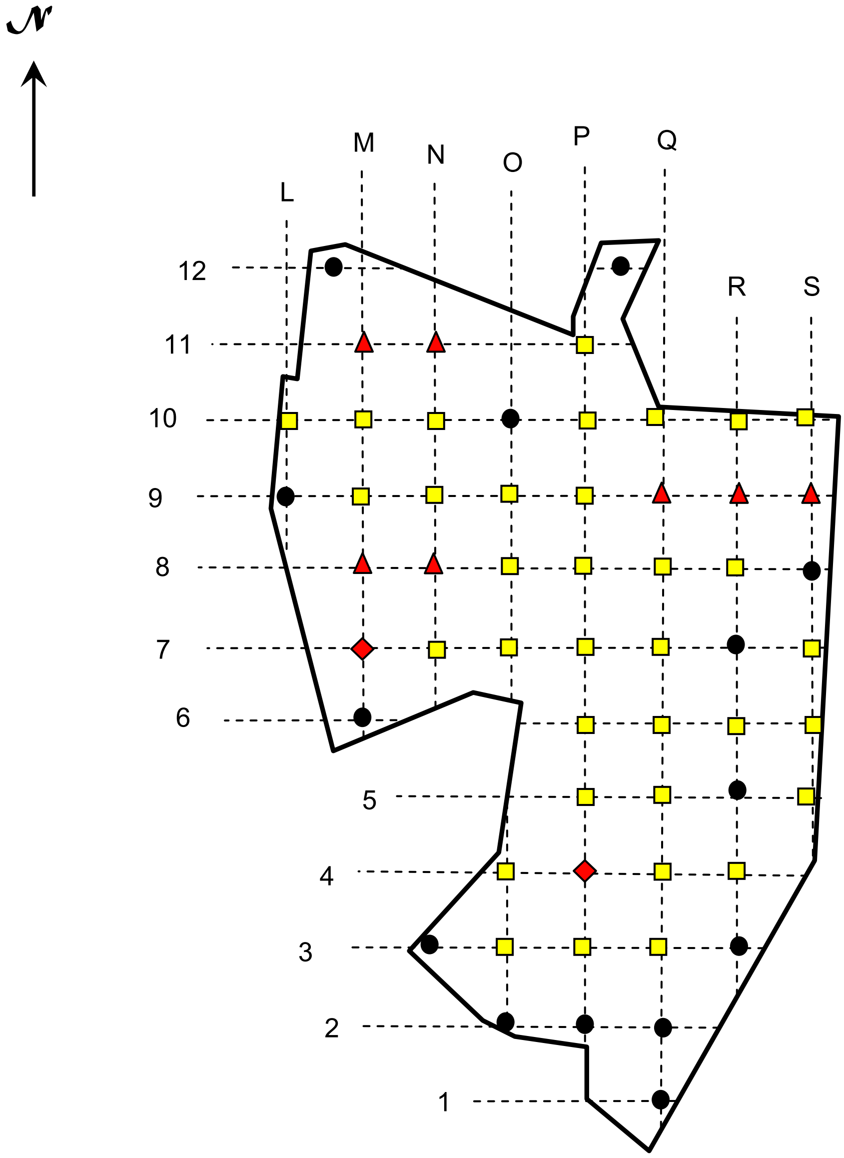
■ Approximate location of samples with arsenic concentrations above phytotoxicity criteria

● Approximate location of samples with arsenic concentrations below phytoxicity and residential criteria

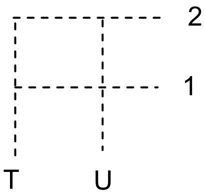


Approximate layout of grid

drawn	ELC	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	Doug Gow & Associates Pty Ltd
approved			project:	The Lakes Estate North Boambee Drive Coffs Harbour NSW 2450
date	17-12-07			
scale	~1:1250		title:	Sample Locations Banana Area 2
original size	A4		project no: GEOTCOFH02233AA-AE	figure no: FIGURE 4



Legend:



Approximate layout of grid

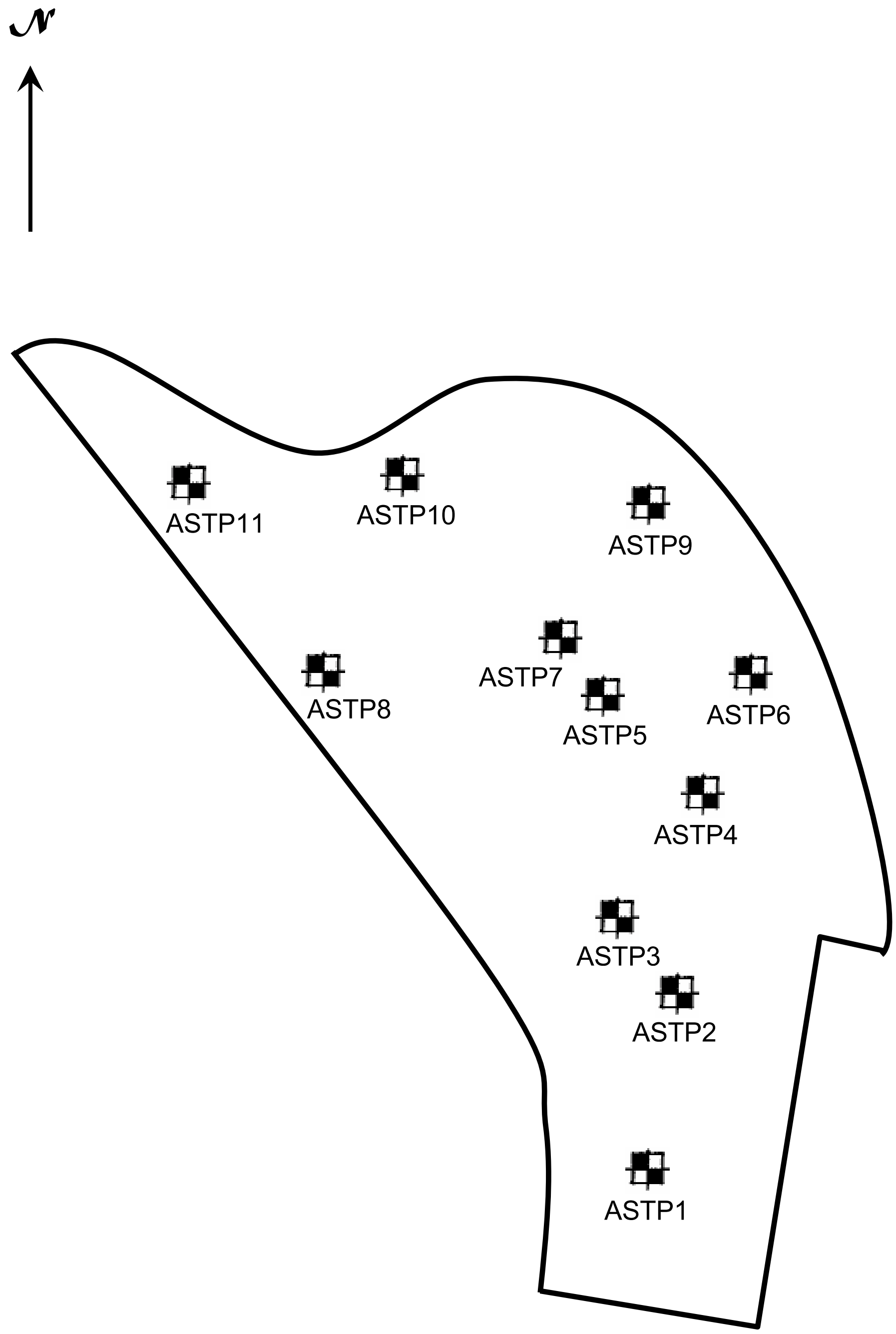
Approximate location of samples with arsenic concentrations above phytotoxicity and residential criteria

Approximate location of samples with arsenic concentrations above phytotoxicity criteria

Approximate location of samples with OCP concentrations above residential criteria and arsenic concentrations above phytotoxicity criteria

Approximate location of samples with arsenic concentrations below phytoxicity and residential criteria

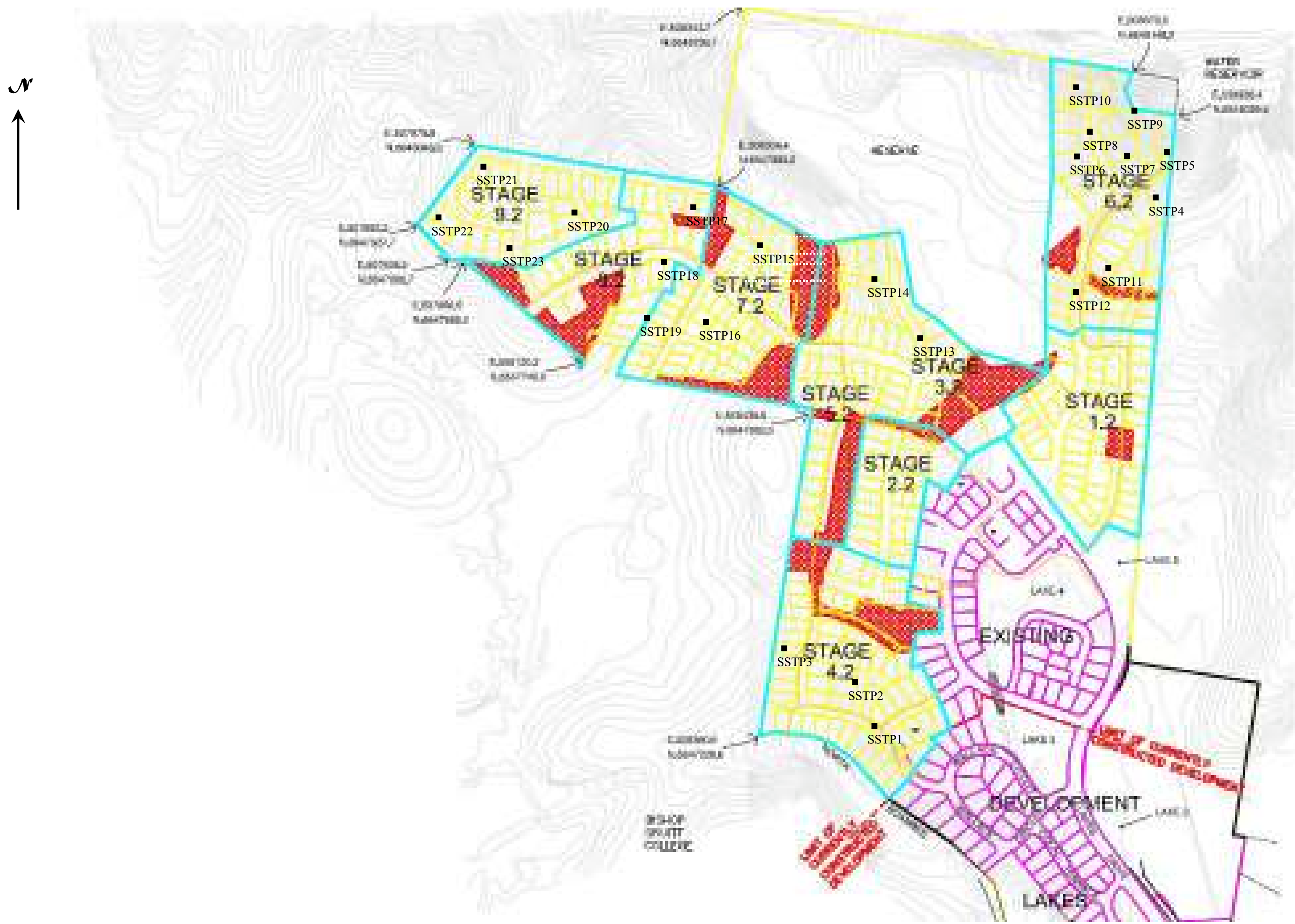
drawn	**ELC**	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	**Doug Gow & Associates Pty Ltd**
approved			project:	**The Lakes Estate North Boambee Drive Coffs Harbour NSW 2450**
date	**17-12-07**			
scale	**~1:2500**		title:	**Sample Locations Banana Area 3**
original size	**A4**		project no: **GEOTCOFH02233AA-AE**	figure no: **FIGURE 5**



LEGEND:

ASTP1 — Approximate location on test pits in potential acid sulfate soil area

drawn	ELC	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	Doug Gow & Associates Pty Ltd
approved			project:	The Lakes Estate North Boambee Drive Coffs Harbour NSW
date	18-12-2007			
scale	~1:2500		title:	Location of Test Pits in Potential Acid Sulfate Soil Area
original size	A4		project no: GEOTCOFH02233AA-AE	figure no: FIGURE 6



revision	description	drawn	approved	date		drawn	MR	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client: Doug Gow And Associates Pty Ltd	
						approved			project: The Lakes Estate Stages 1.2 To 9.2	
						date	12/12/07			
						scale	NTS		title: Site Plan Showing Approximate Test Pit Locations in Steep Slope Areas	
						original size	A3		project no: GEOTCOFH02233AA-AE	figure no: FIGURE 7