ACT Geotechnical Engineers

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11 August 2023
Our ref: HR/C14017.2

Zauner Construction
via email: Adrien.clements@zauner.com.au

Attention: Mr Adrien Clements

Dear Sir,

PROPOSED SHARED USER PATH BRIDGE
LAKE CONJOLA ENTRANCE ROAD, LAKE CONJOLA, NSW
ACID SULFATE SOIL MANAGEMENT PLAN

We are pleased to present our acid sulfate soil management plan (ASSMP) for the proposed Shared User Path Bridge, located on Lake Conjola Entrance Road, in Lake Conjola, NSW.

The report outlines the methods and results of exploration, describes site subsurface conditions, and provides recommendations for pre-excavation measures, methodology for on-site treatment and management of acid sulfate soils, and water and leachate monitoring.

Should you require any further information regarding this report, please do not hesitate to contact our office.

Yours faithfully
ACT Geotechnical Engineers Pty Ltd

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ZAUNER CONSTRUCTION

PROPOSED SHARED USER PATH BRIDGE
LAKE CONJOLA ENTRANCE ROAD, LAKE CONJOLA, NSW

ACID SULFATE SOIL MANAGEMENT PLAN

AUGUST 2023

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ACID SULFATE SOIL MANAGEMENT PLAN

1 INTRODUCTION

At the request of the Zauner Construction, ACT Geotechnical Engineers Pty Ltd are pleased to provide an Acid Sulfate Soil Management Plan (ASSMP) for the proposed Shared User Path Bridge, in Lake Conjola, NSW.

The project involves the construction of a Shared User Path (SUP) bridge on Lake Conjola Entrance Road, adjacent to the existing bridge. The site is located on the flood-plain of Lake Conjola, and the present groundsurface level is low-lying. ACT Geotechnical Engineers conducted an investigation for the development, including acid sulfate soil testing, in March 2023 (Report JF/C14017).

The development will require a large volume of cut-to-fill earthworks. As there are acid sulfate soils present, an acid sulfate soil management plan (ASSMP) is required for the development.

The aim of the acid sulfate soil management plan is as follows:

- pre-excavation measures
- methodology for on-site treatment and management of acid sulfate soils
- water and leachate monitoring

The ASSMP has been developed in accordance with the guidelines of the NSW Acid Sulfate Soil Management Advisory Committee (ASSMAC) Acid Sulfate Soil Manual 1998 (Reference 1), together with the Guidelines for Fresh and Marine Water Quality (Reference 2), the Queensland Acid Sulfate Soil Technical Manual (Reference 3) and the National Acid Sulfate Soils Guidance, National acid sulfate soils sampling and identification methods manual 2018 (Reference 4).

ACT Geotech conducted a geotechnical investigation and ASS testing for the development in March 2023 (Report JF/C14017), comprising four (4) auger boreholes to ~5.5/6.0 m depth, with Standard Penetration Tests (SPT)s taken in each at about 1.5 m depth intervals from 1.0 m depth. Also, three (3) Dynamic Cone Penetrometer (DCP) tests were taken to 0.9/2.4 m depth. The investigation found the subsurface profile to comprise very loose to very dense alluvial and residual Sand soils to 2.0m/9.0m depth, underlain by extremely weathered bedrock to >7.0m/>10.5m depth.

2 SITE DESCRIPTION & GEOLOGY

The site for the proposed shared user path bridge is adjacent to the northern side of the existing road bridge on Lake Conjola Entrance Road in Lake Conjola, NSW. The proposed shared user bridge will cross an inlet of Conjola Lake. Figure 1 shows the site locality while Figure 2 is a recent aerial photograph showing the present site layout.

The 1: 250,000 Ulladullla Geology Map (Reference 5) documents the area to be underlain by Permian age Shoalhaven Group Conjola Formation, comprising congolomerate, sandstone and silty sandstone.

4 SUBSURFACE CONDITIONS & GROUNDWATER

The site was investigated by ACT Geotechnical Engineers on 1 March 2023 (Report JF/C14017), which found the subsurface profile to comprise the following in Table 1:

TABLE 1
Subsurface Soil Profile Summary

Geological Profile	Typical Depth Interval	Description
ASPHALT	0.0m to 0.01m/0.03m	Only encountered in BH2 and BH3.
TOPSOIL	0.0m to 0.8m	Silty SAND; brown, black, fine to coarse sand, low plasticity silt, some organic material, dry to moist, loose. Only encountered in BH1.
UNCONTROLLED FILL	0.0m/0.03m to 0.8m/1.5m	Sandy GRAVEL; brown, fine to coarse gravel, fine to coarse sand, with low plasticity clay, with cobbles up to 100mm, dry to moist, dense. Not encountered in BH1.
ALLUVIAL SOIL	0.8m/1.5m to >5.5m/6.0m	Silty SAND and SAND; black, grey, fine to coarse sand, low plasticity silt, with organic matter, very loose to medium dense, moist to wet.

The uncontrolled fill was encountered within the road embankment adjacent to the proposed new bridge. The profile at the proposed bridge location is expected to comprise natural alluvial soils from a shallow depth.

Groundwater was encountered while augering BH1, BH2 and BH4 at 2.0m/2.5m depth. Permanent groundwater is expected to correspond to the water level in the adjacent lake inlet, but this should be confirmed during construction. Temporary, perched seepages could also occur at shallower depth within the more pervious soils following rainfall.

5 IMPLICATIONS OF PRESENCE OF ACID SULFATE SOILS

Coastal, low-lying alluvial soils, lying below about RL12, may contain framboidal pyrite or other sulphides. These are rounded, microbially generated microscopic mineral grains, which are stable in soils below the water table, or in dense clay-rich soils that are periodically re-wetted. In such situations, where the sulphides are kept out of contact with air, they are relatively stable, and generally in "equilibrium" with the local environment. Soils, which have appreciable pyrite or other sulphides which have not yet reacted significantly with air, are referred to as Potential Acid Sulfate Soils, or PASS.

If sulphide-bearing or pyritic soils are disturbed by excavation, thereby allowing ready access of the sulphides to oxygen in the air, a spontaneous or irreversible natural oxidation reaction takes place. This results in the generation of sulphuric acid or acid sulfates. Pyritic soils, which have begun to generate acid, are referred to as Actual Acid Sulfate Soils (AASS). The acid is transported by water, and if allowed to build up in sufficient concentration, poses a direct environmental threat to organisms that come in contact with such waters.

Additionally, increasingly acidic waters can dissolve many metal ions which would otherwise remain insoluble and hence not available for uptake by organisms. These ions include aluminium and iron, plus a suite of heavy metals such as zinc, lead and cadmium, which at elevated levels can be toxic to plants, animals and humans.

The measure of acidity in waters is pH; pure neutral water has a pH of 7; pH values below 7 are acidic, pH values above 7 are basic or alkaline. The pH scale is logarithmic so a decrease of 1 pH unit represents a 10-fold increase in the concentration of hydrogen ions, which is the measure acidity. Further, the actual pH level is important because each metal has its own critical solubility, so a decrease in pH from 6 to 5 may be more undesirable than a pH decrease from 5 to 4 if, say, 5.5 is the critical pH for solubilisation.

Most organisms can cope with pH in the range 5.5 to 8.5 - pH values in natural waters below 5 are undesirable; below 4, they are generally unacceptable.

6 LABORATORY TESTING OF SITE SOILS FOR ACID SULFATE SOILS

A total of four (4) Spocas tests were carried out on representative samples of the site soils (Report JF/C14017). Testing was conducted on the alluvial soils and the results are summarised in Table 2.

TABLE 2

SPOCAS Laboratory Test Results

Test Hole Number	**BH1.2**	**BH2.2**	**BH3.2**	**BH4.2**
Depth (m)	2.0 – 4.0	2.5 – 3.0	2.5 – 3.0	1.0 – 1.5
Material Type	**ALLUVIAL SOIL**; sand	**ALLUVIAL SOIL**; sand	**ALLUVIAL SOIL**; sand	**ALLUVIAL SOIL**; sand
pH_{kcl} (before oxidation)	9.4	9.2	9.3	7.8
pH_{ox} (after oxidation)	8.0	7.9	8.0	6.0
Total Actual Acidity (mol H^+/tonne)	<2	<2	<2	<2
Total Potential Acidity (mol H^+/tonne)	<2	<2	<2	<2
Total Sulphidic Acidity (mol H^+/tonne)	<2	<2	<2	<2
a-Net Acidity without ANC (mol H^+/tonne)	<10	33	57	<10
Liming Rate without ANC (kg $CaCO_3$/tonne)	<1	2	4	<1

7 ACTION CRITERIA

The National acid sulfate soils sampling and identification methods manual (Reference 4) provides soil and water indicators for the presence or absence of ASS materials in its Table 5.3, which is modified from Ahern et al. (1998b), and is reproduced in Table 3.

TABLE 3

National acid sulfate soils sampling and identification methods manual Table 5.3 Soil and water indicators for the presence or absence of ASS materials

Field pH of water	**Water analysis SO_4^{2-}:Cl^- (by mass)**	**Field soil or water indicators**	**Typical soil reaction to 30% H_2O_2**	**Preliminary assessment**
6-8	Approx. 0.14 but may be in the range 0.1-0.2	Nil	Nil reaction and no drop in pH	No PASS material present. Must be verified by laboratory chemical analysis
		PASS indicators present	Mild to strong effervescence and drop in pH	PASS present but has probably not been oxidized at any time. Must be verified by

Field pH of water	Water analysis SO_4^{2-}:Cl^- (by mass)	Field soil or water indicators	Typical soil reaction to 30% H_2O_2	Preliminary assessment
				laboratory chemical analysis
<5	Approx. 0.14 but may be in the range 0.1-0.2	Nil	Nil reaction and no drop in pH	No PASS present and low pH can be attributed to causes other than RIS oxidation. Must be verified by laboratory chemical analysis
		PASS indicators present	Mild effervescence and drop in pH	PASS present but has probably not been oxidized at any time. Existing low pH can be attributed to other causes. Must be verified by laboratory chemical analysis
6-8	0.2-0.5	Unclear indicators	Mild effervescence and drop in pH	Presence of PASS is uncertain. Must be verified by laboratory chemical analysis
	>0.5	Indicators of AASS or PASS present	Mild to strong effervescence and drop in pH	Presence of PASS plus the presence of substantial Acid Neutralising Capacity. Must be verified by laboratory chemical analysis
<5	0.2-0.5	Unclear indicators	Mild effervescence and drop in pH	Presence of PASS is uncertain. Must be verified by laboratory chemical analysis
	>0.5	Indicators of AASS or PASS present	Mild to strong effervescence and drop in pH	Presence of PASS with little or no Acid Neutralising Capacity. Must be verified by laboratory chemical analysis

The National acid sulfate soils sampling and identification methods manual (Reference 4) also provides action criteria for different soil types. The action criteria Table 5.4 from the manual is adapted from Dear et al. (2014) and reproduced below in Table 4 (National acid sulfate soils sampling and identification methods manual, 2018, Table 5.4).

TABLE 4

National acid sulfate soils sampling and identification methods manual Table 5.4 Action criteria based on the texture and volume of material disturbed

Type of material		Net Acidity			
		1-1000 t materials disturbed		>1000 t materials disturbed	
Texture range (NCST)	Approximate clay content (%)	% S-equiv. (oven-dried basis)	Mol H^+/t (oven-dried basis)	% S-equiv. (oven-dried basis)	Mol H^+/t (oven-dried basis)
Fine light medium to heavy clays	>40	≥0.10	≥62	≥0.03	≥18
Medium clayey sand to light clays	5-40	≥0.06	≥36	≥0.03	≥18
Coarse and Peats sands to loamy sands	<5	≥0.03	≥18	≥0.03	≥18

8 DISCUSSION OF RESULTS

The laboratory test results show the site soils to be in the range of a pH greater than 6, exhibit a drop in pH and have substantial Acid Neutralising Capacity. Therefore, according to Table 3, the preliminary assessment description of the soil is: presence of PASS plus the presence of substantial Acid Neutralising Capacity.

The site soils fall under the type of material of Coarse and Peats according to Table 4. Therefore, the trigger for an ASS management plan are a-Net Acidity values of greater than 18 mol H^+/t. Two of the samples ie. from boreholes BH2.2 and BH3.2 exceed this value, triggering the need for a detailed ASS Management Plan.

9 ACID SULFATE SOIL RISKS

Given that the laboratory testing indicates that the soils contain PASS, and that the development will require the disturbance/excavation of greater than 1000 tonnes of soil, the threshold criteria for the requirement of a detailed ASS Management Plan has been met.

Given that the laboratory testing indicated positive results for the potential presence of acid sulfates within the site alluvial soils, all on-site soil should be considered to be affected by acid sulfates, and need to be tested/monitored.

It is considered that an appropriate ASS Management Plan should include:

- Additional testing of the acid sulfate soil potential to supplement the results of the investigations to date. This testing should be done prior to the start of earthworks.

- Establishment of cut-off drains and bunds leading to sediment ponds, to ensure that all run-off that is generated on-site does not enter natural water bodies. All areas where earthworks and soil disturbance is occurring should be totally bunded to retain the water. Crushed limestone can also be placed in drainage lines.

- All soil taken off-site should be neutralised using lime prior to removal from site.

- To neutralise the soil being used in on-site earthworks, and to reduce the risk of future damage to concrete and steel structures, these excavated soils can be treated with lime during earthworks. The "Acid Sulfate Soil Manual", provides guidelines on required lime dosages. Based on our testing, between 2kg and 4kg of good quality agricultural $CaCo_3$ per tonne of soil disturbed would be required, which is approximately 4kg to 8kg per m^3.

- Surface, groundwater and sediment pond water quality monitoring prior to, during and subsequent to the earthworks process.

It is considered that the implementation of the controls and procedures of the ASS Management Plan will ensure that ASS related issues will be handled in an appropriate manner and in accordance with the relevant legislation.

10 RESPONSIBILITIES

The Project Manager (PM) for the earthworks contractor is responsible for the correct implementation of the ASS protocols presented in the ASS Management Plan. With respect to ASS management, the PM is responsible for on-site monitoring. To this end, an independent, suitably qualified consultant should inspect the site, on both regular and random basis, and carry out sampling and/or in-situ measurements as are necessary to check compliance with the ASS Management Plan.

As a guide, the following inspection/monitoring regime is suggested:

Stockpiles of excavated soil	Daily for pH of leachate (if any) from soil stockpile and weekly for pH of soil.
Sediment pond water quality and level	Weekly and prior to any discharge
Groundwater monitoring bores and streams	Monthly

It is the independent consultant's responsibility to inform the PM immediately on discovery of noncompliance or exceedance and to detail appropriate remedial measures. The requirements of ASS management are in addition to, but do not over-ride any standard procedure such as safety considerations. Where conflict results, or may result from, the implementation of the ASS management against other performance criteria including occupational health and safety, it is the contractor's responsibility to obtain directives from the PM. However, in all cases, legislative requirements must be paramount.

11 MANAGEMENT STRATEGY

11.1 Earthworks Process

It is assumed that there will be cut-to-fill works with fill material that will be sourced on site. The total amount of cut-to-fill material that is expected to be about 500 m^3.

Topsoil should be stripped off the earthworks area at the start of works, and should be stockpiled on-site, and used for landscaping at the conclusion of the earthworks.

11.2 Areas of Disturbance

The banks of the inlet of Conjola Lake where the bridge is proposed will be disturbed during the development.

11.3 Neutralising Materials

All soils that are worked during excavation should be treated with a neutralising material. These soils include all soils that are being used as fill, stockpiled soils (including topsoil), and all soils that are taken off-site. The water in the sediment ponds will also have to be neutralised.

It is recommended that the neutralising material comprise a good quality aglime or quicklime. Stores of aglime or quicklime should always be on site, with the lime mixed into soil as it is placed and compacted. Lime should also be added to the water in the sediment ponds in case of unexpected overflow into natural waterways, or before discharging.

Aglime is noncorrosive and requires no special handling techniques. Quicklime is dangerous to use, being very reactive and corrosive (caustic), and special handling and safety procedures are required. When mixed with water, the reaction generates substantial heat, so the lime should be slowly added to a large amount of water.

11.4 Pre-Excavation Measures

Pre-excavation measures designed to reduce the risk of acid release to natural and forming part of the ASS Management Plan for the site include:

- Conduct testing of the surface water (Lake Conjola inlet) for background levels and subsequent comparison during the excavation and earthworks phases. Testing should include pH, dissolved oxygen (DO), total dissolved solids (TDS), total suspended solids (TSS), and Fe (total) and Al (total).

- On-going testing of the acid sulfate soil potential within the proposed excavation depths to supplement the results of the previous investigations and to confirm the proposed liming rates.

- The preparation at least one, gently sloping, bunded and lined sediment pond of sufficient size to accept any potential rainfall run-off. The area should incorporate a limed guard layer, surface water diversions and should be either bunded off using non-ASS material, or a circumferential drain dug to collect and localise any leachate and direct it back to the sediment pond.

11.5 Excavation & Placement Procedures

11.5.1 Topsoil

The proposed works area is covered by a thin layer of topsoil. This topsoil must be stripped at the start of earthworks, as it is unsuitable as a foundation under roads and buildings, and is not suitable for use as controlled fill. The stripped topsoil should be stockpiled on-site, and can then be re-used at the conclusion of earthworks for landscaping.

Aglime or quicklime should be blended into the topsoil as it is placed into the stockpile. Based on our testing, between 2kg and 4kg of good quality agricultural $CaCo_3$ per tonne of soil disturbed would be required, which is approximately 4kg to 8kg per m^3.

Surface drainage measures should ensure that any leachate from the stockpile drains into a sediment pond, and cannot drain off-site.

11.5.2 Soil Used for On-Site Fill

The on-site excavated soil should be spread over the fill area in thin layers (~200mm maximum thickness). Aglime or quicklime should be blended into the placed soil prior to or during compaction. Based on our testing, between 2kg and 4kg of good quality agricultural $CaCo_3$ per tonne of soil disturbed would be required, which is approximately 4kg to 8kg per m^3.

11.5.3 Stockpiled Soils

Excess soils that will be used on-site or taken off-site at a later date should be stockpiled. Aglime or quicklime should be blended into the soil as it is placed into the stockpile. Based on our testing, between 2kg and 4kg of good quality agricultural $CaCo_3$ per tonne of soil disturbed would be required, which is approximately 4kg to 8kg per m^3.

Surface drainage measures should ensure that any leachate from the stockpile drains into a sediment pond, and cannot drain off-site.

11.5.4 Soils to be Taken Off-Site

Soils that will be taken off-site should be treated on-site prior to removal. Soils can either be treated as it is stockpiled (see Section 9.5.3), or treated using lime prior to or during loading into trucks. Based on our testing, between 2kg and 4kg of good quality agricultural $CaCo_3$ per tonne of soil disturbed would be required, which is approximately 4kg to 8kg per m^3.

11.6 Water & Leachate Monitoring, Treatment & Discharge

If left unmanaged, the acidity and heavy metals released by oxidation of ASS materials may be transported by water. Such water can contaminate both groundwater and surface water, eventually entering waterways and the ocean.

The aim of the ASS Management Plan is to minimise the impact on the environment and to ensure that ASS leachate, which enter and mix with natural waters, meet acceptable guidelines. Continued monitoring of the water in the sediment ponds will be required to demonstrate that target criteria are met.

Neutralisation of the sediment pond water should be carried out with a calcium hydroxide solution made from CaO or quicklime slurry; there is a natural limit to the pH in solution of around 12.2, and the neutralisation product is gypsum. The use of MgO is not recommended as the magnesium sulfate product is highly soluble, and can generate water with unacceptably high total dissolved solids (TDS).

Applicable target water criteria (after ANZECC 2000 or NSW Clean Waters Regulations 1972 where no ANZECC Guidelines are available) are for surface discharge (unlikely on the basis that the site should be fully bunded, with all run-off captured in sediment ponds) or for potential subsurface migration of water from the proposed sediment pond to the groundwater or the stormwater system or the Lake Conjola inlet, are as follows:

i) pH between 6.5 and 9.0

ii) Dissolved oxygen (DO) > 6 mg/L (> 80 – 90% saturation)

iii) Total dissolved solids (TDS) < 1500 mg/L

iv) Total suspended solids (TSS) < 50 mg/L

v) Fe (total) < 0.5 mg/L and Al (total) < 0.055 mg/L for pH > 6.5.

Discharges (if required) should meet quality requirements, be controlled and preferably be conducted during substantial flows in the natural water systems. All water quality indicators should be checked before proposed discharge, to allow for any additional remediation if required to meet the criteria defined above. Just prior to discharge, pH and DO should also be checked.

12 CONTINGENCY PLANNING

The Acid Sulfate Soil Management Advisory Committee (ASSMAC) Guidelines (Reference 1) indicate a range of contingency elements for inclusion in management plans. These include field operation elements such as provision of immediate response to non-conformances, the holding of adequate materials on site and testing to confirm the adequacy of remedial measures, together with up-to date reporting.

Contingency measures are included within the site excavation, monitoring, treatment and reporting protocols which are designed to provide an early detection of a non-conformance and a consequent corrective action. Any modification of the protocols required to meet unexpected conditions shall be agreed to by the PM. Monitoring shall be used to confirm the effectiveness of any changes.

The principal contingency during earthworks is by control of water/treated leachate within the sediment ponds. The discharge of water/leachate will be halted where a non-conformance is identified, the source investigated and corrective actions implemented. Where remedial action fails or monitoring results indicate on-going failure of the management strategy to meet performance criteria, the excavation should cease during resolution of the required change in methodology.

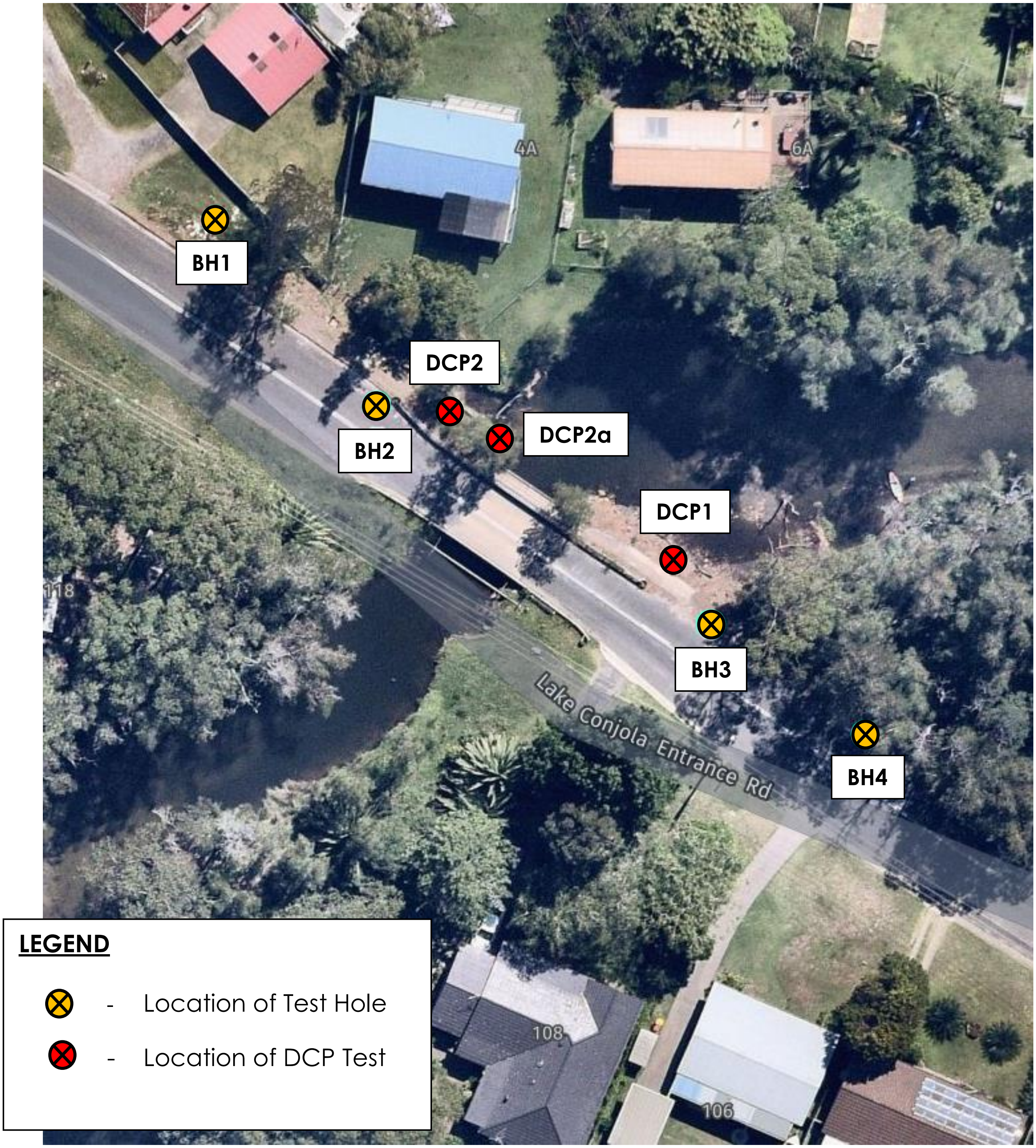
ACT Geotechnical Engineers Pty Ltd

REFERENCES

Reference 1	Stone, Y, Ahern C R, and Blunden B 1998, "Acid Sulfate Soils Manual 1998", Acid Sulfate Soil Management Advisory Committee, Wollongbar, NSW, Australia.
Reference 2	Australian Government 2017, "Water Quality Management Framework", accessed via < https://www.waterquality.gov.au/anz-guidelines/framework>.
Reference 3	Dear, S-E., Ahern, C. R., O'Brien, L. E., Dobos, S. K., McElnea, A. E., Moore, N. G. & Watling, K. M. 2002 "Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines", Brisbane: Department of Science, Information Technology, Innovation and the Arts, Queensland Government.
Reference 4	Sullivan, L, Ward, N, Toppler, N and Lancaster, G 2018, National Acid Sulfate Soils guidance: National acid sulfate soils sampling and identification methods manual, Department of Agriculture and Water Resources, Canberra ACT. CC BY 4.0.
Reference 5	Andrews, E.C. et al. 1996, "Ulladulla Sheet S1 36-13 1:250,000 Series", Geological Survey of New South Wales, Sydney.
Reference 6	Ahern C R, Stone, Y, and Blunden B 1998, "Acid Sulfate Soils Assessment Guidelines", Acid Sulfate Soil Management Advisory Committee, Wollongbar, NSW, Australia.

WESTLAKE PUNNETT & ASSOCIATES
PROPOSED SHARED USER PATH BRIDGE
SITE LOCALITY

ACT Geotechnical Engineers Pty Ltd	**C14017**	**FIGURE 1**



WESTLAKE PUNNETT & ASSOCIATES
PROPOSED SHARED USER PATH BRIDGE
AERIAL PHOTOGRAPH & LOCATIONS OF TEST HOLES

ACT Geotechnical Engineers Pty Ltd	**C14017**	**FIGURE 2**