Department of Science, Information Technology and Innovation

Caley Valley Wetlands

Preliminary assessment of impacts to Caley Valley Wetlands from Abbot Point Coal Terminal post Tropical Cyclone Debbie.

July 2017

Queensland Government

Prepared by

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Science Delivery Division
Department of Science, Information Technology and Innovation
AND

Conservation and Sustainable Services
Department of Environment and Heritage Protection

July 2017

Executive summary

The Department of Science, Information Technology and Innovation (DSITI) was commissioned to conduct a Preliminary Site Assessment of Caley Valley Wetlands adjacent to the Abbot Point Bulk Coal Terminal (Abbot Point Terminal). The site had been subject to an authorised release of water from the secondary settlement pond (which is part of the stormwater system) from Abbot Point Terminal.

Satellite imagery collected after Tropical Cyclone Debbie appeared to show dark waters downstream of a release point extending into the wetland. Consistent with a temporary emissions licence (TEL), the coal terminal operator, Abbot Point Bulkcoal Pty Ltd, sampled the stormwater release as soon as practicable and safe. The results of testing indicated that the release into the wetland was below the thresholds set in the licence condition.

In April 2017, staff from DSITI and the Department of Environment and Heritage Protection (EHP) wetland group undertook a preliminary assessment of the site. The objective for the preliminary site assessment was to assess the presence or otherwise of coal fines associated with the release, and if present, to undertake an initial assessment as to whether this has caused impacts to the wetlands. This report provides a summary of results from the April sampling program.

The Caley Valley is a nationally important wetland and is listed in the Directory of Important Wetlands in Australia. The site contains coastal grass sedge wetland, mangroves, saltmarsh, creeks and channels and a lacustrine wetland (a lake). The Caley Valley Wetlands complex is a large relatively intact wetland system covering an area of about 5154 hectares. Although the wetland has been modified, it supports a wide range of wetland values including migratory and threatened birds.

Key findings of this preliminary assessment were:

- Although there were indications of recent flooding, there was little visual evidence of coal fines across the whole of the wetland. This is consistent with trace levels (<1%) of coal measured at most sites.
- Coal fines were only visually observed at a site immediately downstream of the licensed discharge point to the south of the spillway of settlement pond 2. This is consistent with the results from the sediment analysis at this site, which found that coal composed approximately 10% of the sample. There appeared to be partial coverage of the wetland substrate and the lower stems of marine couch (*Sporobolus virginicus*) with coal fines. Even so, there did not appear to be any impediment to growth of wetland plants in this area as new growth, in response to the recent flooding, was evident.
- Minor concentrations (approximately 2%) of coal fines were measured downstream of the spillway at a site in the wetlands opposite the licensed discharge point site.

Coal fines do not appear to have caused widespread impacts in the wetland. It is likely that any impacts from the stormwater discharge were mitigated by the large amount of water flowing naturally through the wetland. Nonetheless, further assessment is warranted to more accurately delineate the area potentially impacted downstream of the licensed discharge point, and to monitor the response of the wetland to the authorised discharge.

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1 Introduction

Satellite imagery collected after Tropical Cyclone Debbie appeared to show dark water in the Caley Valley Wetland downstream of the Abbot Point Bulk Coal Terminal (Abbot Point Terminal). The Caley Valley wetland is adjacent to the Abbot Point Terminal and was subject to an authorised temporary release of stormwater runoff from the coal terminal during Tropical Cyclone Debbie. DSITI was commissioned to conduct a preliminary assessment of potential impacts in the wetlands from an authorised release of contaminated water from the adjoining coal loading terminal.

As required under the temporary emissions licence, the Coal Terminal operator, Abbot Point Bulk Coal Pty Ltd, sampled at their licensed discharge point into the wetland as soon as practicable and safe. The authorisation set limits for contaminant levels of 100 mg/L for suspended solids, including coal fines, with a pH no greater than pH 9. The authorised release period was from 27 March to 30 March 2017. The water sample results were within the thresholds set under the licence conditions. The temporary emissions licence (TEL) is presented as Attachment A.

Caley Valley Wetlands are large, nationally important wetlands that provide habitat for several threatened waterbirds, such as the Australian painted snipe. Media reports in early April 2017 showed images indicating that the whole of the wetlands had been impacted by coal fines released during Cyclone Debbie. Subsequently, concerns were raised that environmental harm had occurred across the wetland.

The objective for the preliminary site assessment was to assess the presence or otherwise of coal fines associated with the release, and if present, to undertake an initial assessment as to whether this has caused impacts to the wetlands. Between 27 and 28 April 2017, DSITI and EHP staff undertook a sediment investigation to identify whether coal had smothered the wetland sediment.

2 Site Description

Caley Valley Wetlands are nationally important wetlands covering an area of about 5154 ha and the wetland is listed in the Directory of Important Wetlands in Australia. The site is a complex system of wetland types and has a diversity of habitats, including coastal grass sedge wetland, mangroves, saltmarsh, creeks and channels and a lake. The wetlands are located in the dry tropics and are subject to seasonal changes in the extent of fresh water inundation. The consequential wetting and drying cycle of these wetlands is critical to the environmental values they support.

Over the past 60 years the site has been subject to several modifications, including the construction of bund walls that have changed the hydrology of the site – limiting the influence of the tidal waters on the site. Although the wetland has been modified, it supports a wide range of wetland values, including habitat for migratory and threatened birds.

2.1 Key Nature Conservation Values

Caley Valley Wetlands are a Matter of State Environmental Significance, providing habitat for large numbers of waterbirds, including threatened and migratory birds, with up to 48,000 waterbirds observed on site during high use times (BAAM 2012). The coastal grass-sedge wetlands is particularly important habitat for the endangered Australian painted snipe (*Rostratula australis*) with sightings at several locations (Figure 1). Such habitats occurs to the south and the west of the settlement pond spillway, and therefore, the presence of this species within the wetland was a concern following the release of waters containing coal fines.

The adjoining saltmarsh within the estuarine wetland also provides habitat for threatened migratory shorebirds that seasonally access the area. For example, Figure 1 shows observations of critically endangered eastern curlew (*Numenius madagascariensis*) within the Caley Valley Wetlands.

The site assessment took into consideration the known habitat for threatened waterbirds so as to assess potential impacts on the wildlife habitat.

3 Surrounding Land Use

The landscape surrounding the wetland contains a mix of cleared grazing land and native forests. The wetland is located in a valley surrounded by Mount Roundback, Mount Luce and Mount Little, which are largely covered by remnant vegetation. There is a quarry located near Abbot Point supplying aggregate for construction, road sealing and rail purposes.

Cleared areas within the Salisbury Plain and Don River catchment are used for cattle grazing. Although grazing can be a compatible land use, erosion associated with some grazing practices contributes to downstream sedimentation.

4 Limitations

4.1 Access

Access to this large wetland system was limited and as a result sampling was confined to the edge of the wetland. The selection of sample sites was guided by potential locations of contamination, known locations of threatened wildlife and gaps in baseline information.

4.2 Information Gaps

Key information gaps that limit the interpretation of survey results are:

- *Baseline sediment quality conditions*. The lack of baseline sediment quality data has limited the scope of the analysis of impacts.
- *Seasonal variations in vegetation, especially during flood events.* Wetting and drying cycles, and associated changes in vegetation structure are not well documented. This is an important information gap that has reduced the ability to assess impacts of coal residue accumulation in the wetland.
- *Waterbird Habitat Usage*. There is a lack of information on waterbird use of the wetland over time.

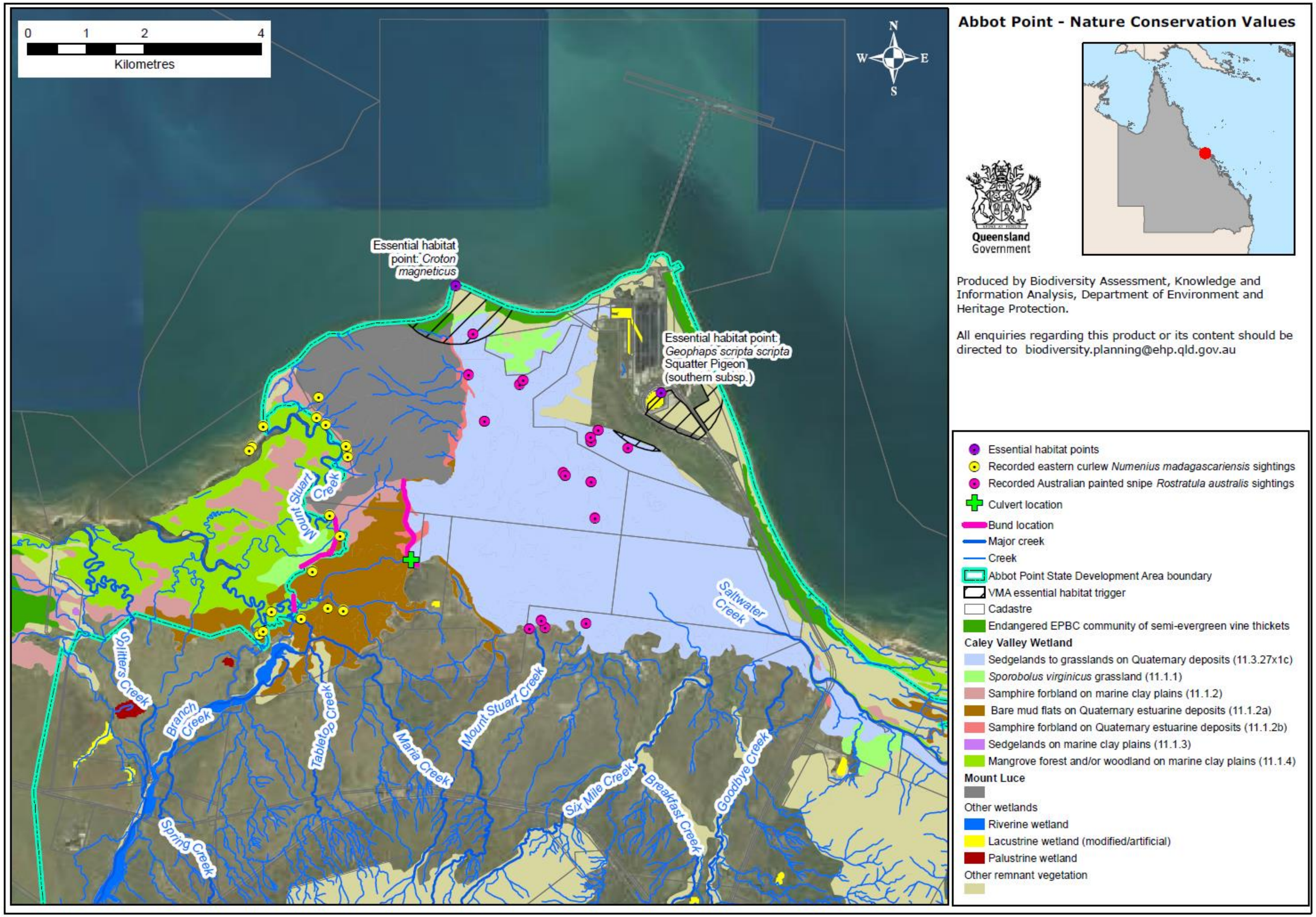

Figure 1: Abbot Point nature conservation values

5 Potential Sources of Contamination

Material, whether it is coal fines, sediment or other contaminants from the stockpile of coal, has the potential to mobilise directly into the wetland stormwater runoff. Coal residues from the Terminal's stockpile are channelled into stormwater treatment ponds – and may move into the wetland environment during high flow periods. Smothering of organisms including benthic communities is the main risk from coal particles released to water (GHD 2012; Berry et al. 2016; Berry et al. 2017). The leaching of contaminants from coal is a potential risk to aquatic ecosystems; however, recent studies have shown the risk associated with metals and/or polycyclic aromatic hydrocarbons (PAH) leaching from coal into seawater is low (Cabon et al. 2007; Jaffrennour et al. 2007; Lucas and Planner 2012; Berry et al. 2016; Berry et al. 2017). As such, the preliminary assessment focused on risk associated with the smothering of benthic communities.

Freshwater enters the wetlands via runoff from the Salisbury Plain and the slopes to the south and south east from Mount Roundback and Mount Little. Surface water from the Coal Terminal's stormwater treatment ponds most likely contributes a relatively small amount of water to the wetland. Previous studies (BMT WBM 2012) demonstrated that during high rainfall events, the wetland receives floodwater from the Don Catchment – a potential source of significant sediment loads.

6 Methods

6.1 Visual Assessment

Prior to the site inspection, satellite and aerial images and other spatial data were examined to guide the selection of sampling sites. This included mapping of threatened waterbirds known to occur in the wetland.

Sites were visited and photographs were taken at each site. Each site was visually assessed for coal fines and impacts on the local wetland environment. Images are presented in Attachment 2.

The field inspection incorporated the use of remotely piloted aircraft systems (or drones) equipped with cameras as platforms to assist in the collection of information on-site regarding the extent of the impact. The drones fill the gap between the satellites images and on ground monitoring and enabled the surveying to be more targeted. The drone provided real-time monitoring and was able to fly at lower altitudes providing detailed images of the wetland substrate. While on site, a drone was used to make observations of inaccessible locations including known waterbird habitat. The drone operator took extreme care not to disturb birds during the operation.

6.2 Sampling Sites

Between 27 and 28 April 2017, eight sites were sampled for water and sediments. Sampling locations were identified with the aid of satellite images. Areas that appeared to be dark were targeted for sampling (Figure 2). Threatened waterbird habitat was also a consideration in the identification of sample sites.

Seven sites were within the wetland (Figure 2 and Figure 3), and a water and sediment sample was collected from the secondary settlement pond at Abbot Point Terminal (Figure 3).

Figure 2: Copernicus Sentinel-2 satellite image (11 April 2017) of Caley Valley wetland and sediment sampling locations. The image is displayed as a true colour composite with bands 4, 3 and 2 assigned respectively to the red, green and blue colours. The satellite image was used to help identify sampling locations.

The sites sampled are shown in Figure 2 and Figure 3 and are listed below.

- CV-S2-0417. Secondary settlement pond on the Abbot Point terminal site, immediately upstream of spillway and authorised release point W1. Sample collected from edge of the settlement pond.
- CV-DS1-0417. Site immediately downstream of authorised release point W1.
- CV-ODS-0417. Site on the opposite end of the spill way to CV-DS1-0417.
- CV-BG-0417. Site on western arm of the freshwater wetland, not immediately downstream of the spillway runoff.
- CV-EB-0417. Site on northern end of eastern bund.
- CV-BO-0417. Site at outflow pipe on southern end of the eastern bund.
- CV-PS2-0417. Southern site near known painted snipe sightings.
- CV-SC-0417. Site in Saltwater Creek.

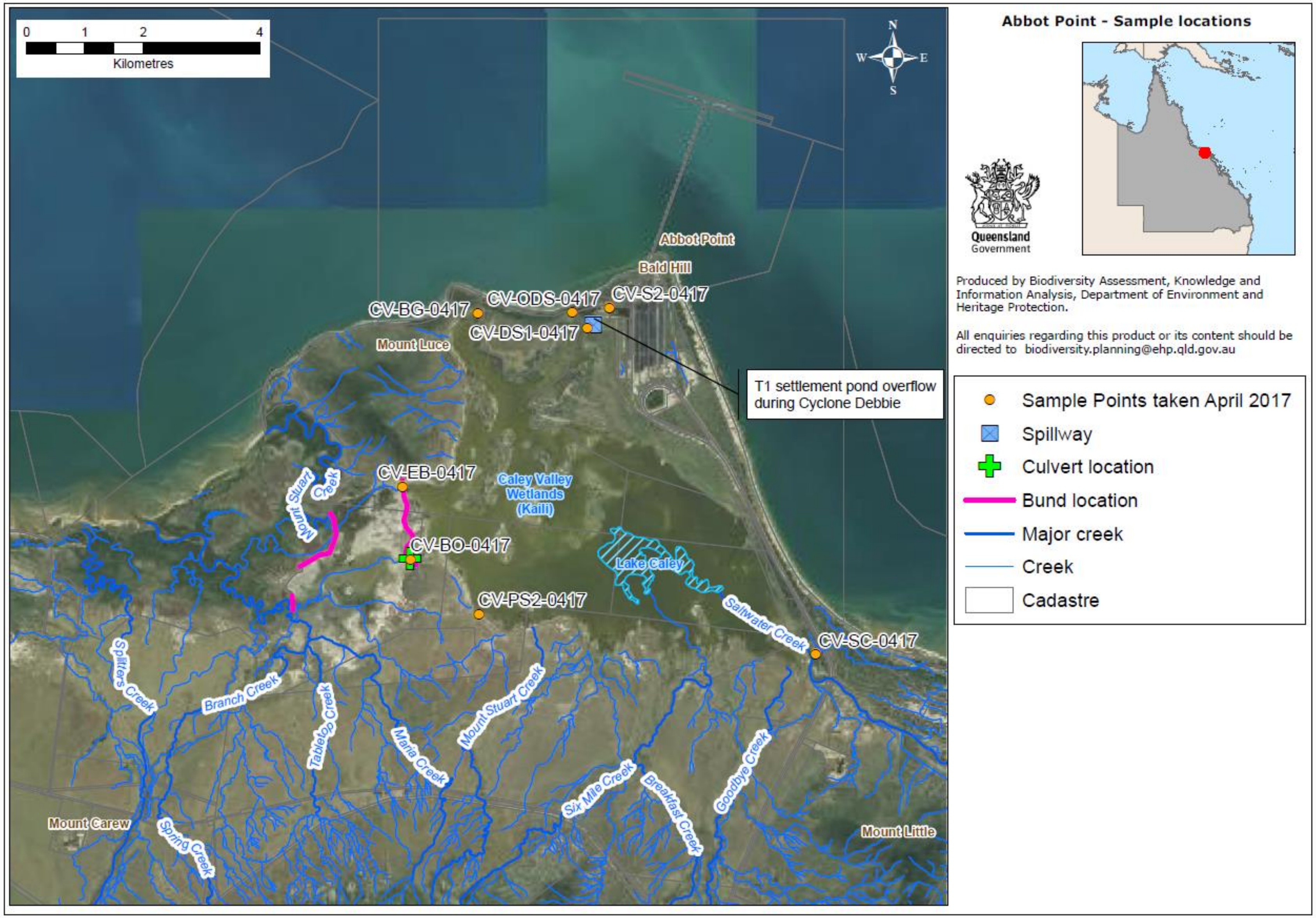

Figure 3: Sites sampled on 27 and 28 April 2017 in the Caley Valley Wetlands by DSITI and EHP staff.

6.3 Sediment Sampling

At each sampling location composite sediment samples were taken. This involved the collection of five replicate samples of approximately 10x10 cm in area and approximately 1 cm depth at each site and combining them together before taking a subsample for analysis. This is a standard field sample practice as sediments can be highly heterogeneous and compositing a number of samples into a single sample is a way of adjusting for variation found in sediment samples.

Samples were collected using a stainless steel trowel and were mixed in a stainless steel bowl. All equipment was thoroughly cleaned between sites. Disposable gloves were used when collecting samples, with a fresh pair used at each site. From each composite sample, duplicate samples were obtained by splitting the contents of the bowl into two jars. Samples were kept chilled on ice after collection.

Samples were sent to the University of Queensland Materials Performance (UQMP) laboratory for analysis of the percentage of coal in each sample. Analysis was undertaken using both Stereo microscopy and Scanning Electron Microscopy (SEM), combined with Energy Dispersive Spectroscopy (EDS) that was used to identify the elemental composition of particles. Laboratory reports are presented in Attachment 3, and a more detailed explanation of the methodology is also provided in Attachment 3.

It should be noted that this is a semi-quantitative method. As there is no recognised standard method to analyse coal in sediment, duplicate samples were sent to two different laboratories in order to assess the variation between different methods. This assessment is discussed in Attachments 4 and 5.

6.4 Water Sampling

As this survey was primarily a sediment quality survey, only total suspended solids (TSS) samples were analysed and *in situ* water quality data collected using a YSI 556 MPS multi-parameter meter. Elevated TSS results can be related to sediment inputs. Disposable gloves were used when collecting samples, with a fresh pair being used at each site to prevent contamination of samples. Samples were kept chilled on ice after collection. Samples were taken to Brisbane by DSITI staff and stored in a locked fridge.

Water samples taken for TSS analysis were sent to Australian Laboratory Services (ALS), a National Association of Testing Authorities (NATA) Australia accredited laboratory.

7 Results

7.1 Visual Assessment

Observations were recorded at each site using a camera and a video recorder (images of each site are presented in Attachment 2). Although there were indications of recent flooding, there was little evidence of coal fines across the whole of the wetland. This is consistent with the trace levels of coal measured at most sites sampled within the wetland.

Coal residues were only observed at a site downstream of the licensed discharge point (CV-DS1-0417). It is not unexpected that an accumulation of the coal fines would be present at this site. This may be associated with the authorised release of settlement pond water into the wetland, which was reported to have up to 80 mg/L of suspended solids, and below the TEL limit of 100 mg/L.

The impacts at this site included what appeared to be partial coverage of the wetland substrate with coal fines and coal residue, and partially discolouring of the lower stems of the marine couch (*Sporobolus virginicus*). This is consistent with the sediment analysis at this site.

Although there was evidence of discolouration and what appeared to be coal residues, there did not appear to be any impediment to growth of wetland plants such as mangrove clubrush (*Schoenoplectus litoralis*), which is responding (i.e. emerging as new growth) to the recent flooding (Figure 4).

Figure 4: Mangrove clubrush (*Schoenoplectus litoralis*) is the bright green emerging reed in this photo at site CV-DS1-0417.

7.2 Coal in Sediment Results

The estimates of coal in the sediment showed that the highest percentage of coal (approximately 10%) was found immediately downstream of the licensed discharge point (Table 1). Approximately 2% coal (Table 1) was found in the sediment of the secondary settlement pond (CV-S2-0417) and downstream of the spillway (CV-ODS-0417) at the opposite side of the wetland to CV-DS1-0417 (Figure 3). Trace amounts (<1%) of coal were detected at all other sites (Table 1). These results were consistent with observations made in the wetland, and indicate that widespread smothering of the wetland by coal fines did not occur.

Table 1: Estimate of percentage of coal in sediment (projected area % basis). Green shaded cell indicates secondary on-site settlement pond, orange shaded cells indicate sites immediately downstream of spill way, blue shaded cells indicate general wetland sites

Site	Estimate of percentage of coal in sediment
CV-S2-0417	2%
CV-DS1-0417	10%
CV-ODS-0417	2%
CV-BG-0417	trace
CV-EB-0417	trace
CV-BO-0417	trace
CV-PS2-0417	trace
CV-SC-0417	trace

7.3 Water Quality Results

In situ water quality data and TSS results were compared to the Queensland Water Quality Guidelines (QWQG) (EHP 2009) for upper estuarine waters in the Central Coast Region **(**Table 2) where applicable.

pH exceeded the QWQG at four of the seven sites (Table 2). Elevated pH levels have been reported in the wetlands previously, with pH exceeding the upper guideline value of pH 8.4 throughout the wetlands depending on the time of the year and site (GHD 2013, BMT WBM 2015), with a maximum of pH 9.5 measured historically in the wetland to the east of the eastern bund (BMT WBM 2015).

The dissolved oxygen (DO) concentration (measured as % saturation) exceeded the guidelines at all sites (Table 2). Historically, dissolved oxygen concentrations have been highly variable in the wetland (GHD 2013 and BMT WBM 2015), with concentrations of up to 325% saturation being measured in the wetland to the east of the eastern bund (BMT WBM 2015). Large mats of benthic algae and algae covering vegetation was noted at many sites, which would contribute to the high concentrations of oxygen in the waters.

TSS exceeded the QWQG at only two sites, CV-DS1-0417 on 27 April 2017 and CV-PS2-0417 on 28 April 2017 (Table 2). A second sample collected at CV-DS1-0417 on the 28 April 2017 was below the QWQG, illustrating the variability in water quality over time (Table 2). Historically, TSS measurements that exceeded the QWQG have been found throughout the wetland, but in general were less than 60 mg/L (GHD 2013).

Although pH, DO and TSS measurements exceeded the QWQGs at a number of sites, overall, the water quality measurements obtained between 27 and 28 April 2017 were within historical limits, and did not indicate anything unusual occurring in terms of physico-chemical parameters at the time of sampling.

Table 2: Total suspended solid and *in situ* results from sampling compared to Queensland Water Quality Guidelines (EHP 2009)

Site	Date and time	Temperature (°C)	pH range	Dissolved oxygen (% saturation range)	Electrical conductivity (mS/cm)	Total Suspended Solids (mg/L)
QWQG Upper Estuarine Central Coast Region			7.0-8.4	70-100	N/A	25
CV-DS1-0417	27/04/2017 9:10	29.60	7.52	101.7	6.821	44
	28/04/2017 12:15					14
CV-BG-0417	27/04/2017 11:40	29.09	8.77	112.0	4.987	<5
CV-ODS-0417	27/04/2017 12:50	28.90	7.92	103.7	5.75	12
CV-SC-0417	27/04/2017 15:00	29.71	8.28	101.8	0.962	25
CV-BO-0417	28/04/2017 8:15	23.80	8.92	113.2	4.621	6
CV-EB-0417	28/04/2017 9:30	23.87	9.55	136.3	5.024	7
CV-PS2-0417	28/04/2017 10:15	24.22	8.44	135.2	4.311	36

8 Conclusion

Based on the available results, coal fines do not appear to have caused widespread impacts in the wetland. There was evidence of coal fines on the surface of the muddy substrate and base of the vegetation in a relatively small area in the vicinity of the licensed discharge point. It is likely that the impacts from the stormwater discharge were mitigated by the large amount of water flowing through the wetland. Nonetheless, further assessment is warranted to more accurately delineate the area potentially impacted downstream of the licensed discharge point, and to monitor the response of the wetland to the authorised discharge.

9 References

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Lucas, SA and Planner, J 2012, 'Grounded or submerged bulk carrier: the potential for leaching of coal trace elements to seawater', *Marine Pollution Bulletin,* vol 64, 1012–1017.

Attachment 1 – Temporary Emissions Licence

Notice

Environmental Protection Act 1994

Notice of decision - Temporary emissions licence

This statutory notice is issued by the administering authority pursuant to section 357J of the Environmental Protection Act 1994*, to advise you of a decision or action*

Abbot Point Bulkcoal Pty Ltd
Level 25, 10 Eagle Street,
Brisbane QLD 4000

Attention: Lorna Lockhart
Email: Lorna.Lockhart@APT1.com.au

Your reference: EPPR00577113
Our reference: 223431 / ENEL07198317

Amendment by agreement of a temporary emissions licence for the Abbot Point Bulk Coal Terminal (T1)

The administering authority has amended the temporary emissions licence (TEL) with your agreement.

This TEL commences on 27 March 2017 and ends on 30 March 2017 inclusive.

This TEL overrides the following conditions of environmental authority EPPR00577113:

- **Condition F1:** *A discharge to water/s may only occur from discharge location W1 and W2 if it meets the quality criteria in* ***Table 2 – Contaminant release limits to water****.*
- **Condition F2:** *Contaminants other than settled/treated stormwater runoff waters must not be released from the site to surface waters or the bed or bank of surface waters unless otherwise authorised by this approval.*

All conditions of environmental authority EPPR00577113 (EA) continue to apply for the duration of this TEL, with the exception of conditions F1 and F2 and associated Table 2, which are temporarily replaced by:

- **Condition TEL1:** A discharge to water/s may occur from discharge locations W1 and W2 if it meets the water quality criteria in **Table TEL1 - Contaminant release limits to water**.

Table TEL1 – Contaminant release limits to water

Monitoring location	Quality characteristic	Min	Max	Monitoring frequency
W1 (E611876.19, N7800108.34), W2 (E612781.48, N7801060.72)	Suspended solids	-	100mg/L	As soon as practicable and safe during the release
	pH	6	9	
	Electrical conductivity	-	7000µS/cm	

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- **Condition TEL2:** Contaminants are permitted to be released from W1 and W2 to surface waters or the bed or bank of surface waters between 8:00pm 27 March 2017 to midnight 30 March 2017.

Abbot Point Bulk Coal Licence Discharge Locations

W1	Discharge Point from the Secondary Settlement Pond
W2	Sample Plant Water Drain
W3	Land adjacent to the Surge Bin sediment sump
W4	Land adjacent to the Main Sub Station sediment sump
W6	Outflow from the oil/water separator from motor vehicle workshop
W7	Outflow from the final holding tank of the sewage treatment plant

Figure 1: Contaminant Release Point – W1 and W2 for this TEL.

Definitions

The following definitions apply to conditions of this TEL:

- **EA** means environmental authority EPPR00577113.
- **TEL holder** means the holder of environmental authority EPPR00577113.

Grounds for the Decision

The administering authority has made this decision in accordance with section 357J of the *Environmental Protection Act 1994*.

Should you have any queries in relation to this notice, please contact Sophie Connors on telephone (07) 4987 9344.

K Bennink	28/3/17
Signature	Date

Kate Bennink
Department of Environment and Heritage Protection
Delegate of the administering authority
Environmental Protection Act 1994

Enquiries:
Business Centre (Coal)
Department of Environment and Heritage Protection
PO Box 3028
EMERALD QLD 4720
Phone: (07) 4987 9320
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Attachment 2 – Images of Caley Valley Wetlands, 27-28 April, 2017

CV-DS1-0417

CV-ODS-0417

CV-BG-0417

CV-EB-0417

CV-BO-0417

CV-PS2-0417

CV-SC-0417

Attachment 3 - Laboratory Report – Examination of Sludge deposits by Stereomicroscopy and Scanning Electron Microscopy (UQMP)

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LABORATORY REPORT

Subject:	**EXAMINATION OF SLUDGE DEPOSITS BY BY STEREOMICROSCOPY AND SCANNING ELECTRON MICROSCOPY**
UQMP Project No.	C03136.04
Prepared for:	DSITI
Prepared By:	Fiona Jones
Date:	18th May 2017

Sample Description:

	Client Sample Identification#	**UQMP #**
1	CV-DSI-0417	UQMP # 14907
2	CV-BG-0417	UQMP # 14908
3	CV-ODS-0417	UQMP # 14909
4	CV-S2-0417	UQMP # 14910
5	CV-SC-0417	UQMP # 14911
6	CV-BO-0417	UQMP # 14912
7	CV-EB-0417	UQMP # 14913
8	CV-PS2-0417	UQMP # 14914

#Method Ref: Internal UQMP method.

1. SAMPLES AND METHODS

1.1 Samples Preparation

The samples were supplied as sediments in glass jars, consisting of solids and slurries in a range of volumes from approximately 120 mL to 200 mL in each jar. The contents of the jars were emptied into a large beaker, large stringy plant debris was removed before mixing, demineralised water was added to allow the solids to de-clump and mix to a smooth homogenous slurry.

Three sub samples were created from each slurry for further examination, this was essential due to fine clay particles present: A plastic pasture pipette was used to draw in the slurry on occasion extraneous vegetation would prevent the slurry from flowing into the pipette this was removed and returned to the sample.

Sub sample 1. A few drops of the slurry were placed directly onto a cellulose filter. The final sub-sample defined as Sludge Overall or Sludge OA.

Sub sample 2. Consists of a few drops of the slurry filtered through a 500-micron filter onto a cellulose membrane under vacuum, the suspended fines pipetted off and retained. This sub-sample is defined as Intermediate.

Sub sample 3. This sample contains a few drops of the fines removed from Sub sample 2 and placed onto a cellulose membrane.

All aliquots of the samples were collected whilst mixing to ensure homogeneity was maintained. The sub-sample created in this process was defined as fines.

The particles retained on the 500-micron filter were not examined, however are retained for future reference if required.

1.2 Stereo Microscope Examination

The samples were initially examined by stereomicroscopy, using a Nikon SMZ25 stereo microscope at magnifications up to 100×.

2. SCANNING ELECTRON MICROSCOPY

A portion of each sample filter was excised and placed onto a conductive carbon tape for SEM examination. The samples were examined and analysed using a JEOL 6460LA scanning electron microscope (SEM). The SEM was operated at 20 kV in back-scattered electron composition contrast (BSE) imaging modes. In BSE images the contrast is influenced by the chemical composition (specifically the average atomic number, Z) of the material being imaged. Dark regions represent low average atomic number (light elements) and bright regions represent high average Z (heavy elements).

Regions of interest were chemically analysed by energy dispersive X-ray spectroscopy (EDS). EDS can be used to identify the chemical elements present and in some cases to provide approximate stoichiometric ratios. However, EDS is only semi-quantitative, especially when analysing small particles, for the following reasons:

- The significant size of the analysis volume (typically around 3 μm) and hence the difficulty of eliminating interference from surroundings;
- Contamination by carbon on the specimen surface and within the SEM vacuum chamber;
- The inherent sensitivity limits of the instrumentation.

3. RESULTS

Deposit presented as coarse grains to very fine grains and mixtures of both, typically rounded weathered particles. Most particles were very small clay particles < 2 µm. Coal was detected in all samples examined with most of the samples displaying trace levels. Trace level is defined as < 1 % or less than 1 particle in 100. One sample presented with 10% coal, CV-DSI-0417, UQMP # 14907 whilst two samples CV-ODS-0417, UQMP # 14909 and CV-S2-0417, UQMP # 14910 contained 2 % coal. The major particle type in all deposit was aluminosilicate based mineral dust. Marine biological debris was noted in traces amounts within the samples mostly as algae, occassionaly diatoms, as the primary focus was to determine the presence or absence of coal particles, little attention was payed to identification and analysis.

All sub samples were examined including the Sludge Overall, Intermediate and Fines. Some of the data for CV-DSI-0417, UQMP #14907 is included in the Appendix C and demonstrates the typical particle types observed in the deposits examined The data for the remaining samples is available on request, a summary table of the combined microscopy is presented in this document.

Appendix A attached presents the table of results of the combined microscopy observations.

Appendix B presents colour picture micrographs of the stereomicroscopy images.

Appendix C displays the Illustrative SEM photomicrographs and spectra taken of an overall area of the deposit. The SEM photomicrographs were taken with Back Scattered Electron (BSE) imaging, in which average atomic number is roughly proportional to brightness. For example, coal particles appear darker than siliceous mineral dust and biological particles somewhat darker again.

Spectral data generated was placed in tables, with weight % converted to Major, Minor and Trace.
Reported as follows:

- Major >5 Weight %
- Minor 5 to 1 Weight %
- Trace < 1 %

A colour range was used as a visual guide in the three sectors Major, Minor and Trace, with colours appearing more intense as the weight percentage increases.
SEM/EDS weight % are not reported directly due to the semi-quantitative nature of the technique.

Signed for and on behalf of UQ Materials Performance

Fiona Jones

Fiona Jones

4. APPENDIX A

4.1 TABLE OF COMBINED MICROSCOPY RESULTS

PARTICLE IDENTITY		PERCENTAGE (Projected area basis)		
	SAMPLE #	UQMP # 14907	UQMP # 14908	UQMP # 14919
	PARTICLE TYPE / SAMPLE ID	*CV-DSI-0417*	*CV-BG-0417*	*CV-ODS-0417*
BLACK	COAL	10	tr	2
	SOOT			
	BLACK RUBBER DUST			
INORGANICS & MINERALS	MINERAL DUST (Soil or Rock Dust.)	**90**	**100**	**98**
	MINERAL DUST (type = Fly Ash)			
	MINERAL DUST (type = Cement Dust)			
	MINERAL DUST (type =glassy)			
	GLASS FRAGMENTS			
	COPPER SLUDGE			
	P/S SLIME & FUNGI			
	INSECT DEBRIS			
	PLANT DEBRIS			
	PLANT DEBRIS (type = plant char)			
	PLANT DEBRIS (type =)			
GENERAL ORGANIC TYPES	WOOD DUST			
	FIBRES (type = Miscellaneous)			
	STARCH			
	PAINT			
	PLASTIC FRAGMENTS			
	RED RUBBER DUST			
COMMENTS		§ The focus of the analysis was to determine the presence or absence of coal; marine biological material was not examined or classified. Large particles of plant debris were removed, as they generally obstruct the view of numerous particles. Coal was observed in all samples and when reported as trace particles were observed at < 1%.		

4.2 TABLE OF COMBINED MICROSCOPY RESULTS

PARTICLE IDENTITY		PERCENTAGE (Projected area basis)		
	SAMPLE #	UQMP # 14910	UQMP # 14911	UQMP # 14912
	SAMPLE ID **PARTICLE TYPE**	*CV-S2-0417*	*CV-SC-0417*	*CV-BO-0417*
BLACK	COAL	2	tr	tr
	SOOT			
	BLACK RUBBER DUST			
INORGANICS & MINERALS	MINERAL DUST (Soil or Rock Dust.)	**98**	**100**	**100**
	MINERAL DUST (type = Fly Ash)			
	MINERAL DUST (type = Cement Dust)			
	MINERAL DUST (type =glassy)			
	GLASS FRAGMENTS			
	COPPER SLUDGE			
	P/S SLIME & FUNGI			
	INSECT DEBRIS			
	PLANT DEBRIS (General)			
	PLANT DEBRIS (type = plant char)			
	PLANT DEBRIS (type =)			
GENERAL ORGANIC TYPES	WOOD DUST			
	FIBRES (type = Miscellaneous)			
	STARCH			
	PAINT			
	PLASTIC FRAGMENTS			
	RED RUBBER DUST			
COMMENTS		§ The focus of the analysis was to determine the presence or absence of coal; marine biological material was not examined or classified. Large particles of plant debris were removed, as they generally obstruct the view of numerous particles. Coal was observed in all samples and when reported as trace particles were observed at < 1%.		

4.3 TABLE OF COMBINED MICROSCOPY RESULTS

PARTICLE IDENTITY		PERCENTAGE (Projected area basis)		
	SAMPLE #	UQMP # 14913	UQMP # 14814	
	SAMPLE ID	*CV-EB-0417*	*CV-PS2-0417*	
	PARTICLE TYPE			
BLACK	COAL	tr	tr	tr
	SOOT			
	BLACK RUBBER DUST			
INORGANICS & MINERALS	MINERAL DUST (Soil or Rock Dust.)	**100**	**100**	**100**
	MINERAL DUST (type = Fly Ash)			
	MINERAL DUST (type = Cement Dust)			
	MINERAL DUST (type =glassy)			
	GLASS FRAGMENTS			
	COPPER SLUDGE			
	P/S SLIME & FUNGI			
	INSECT DEBRIS			
	PLANT DEBRIS (General)			
	PLANT DEBRIS (type = plant char)			
	PLANT DEBRIS (type =)			
GENERAL ORGANIC TYPES	WOOD DUST			
	FIBRES (type = Miscellaneous)			
	STARCH			
	PAINT			
	PLASTIC FRAGMENTS			
	RED RUBBER DUST			
COMMENTS		§ The focus of the analysis was to determine the presence or absence of coal; marine biological material was not examined or classified. Large particles of plant debris were removed, as they generally obstruct the view of numerous particles. Coal was observed in all samples and when reported as trace particles were observed at < 1%.		

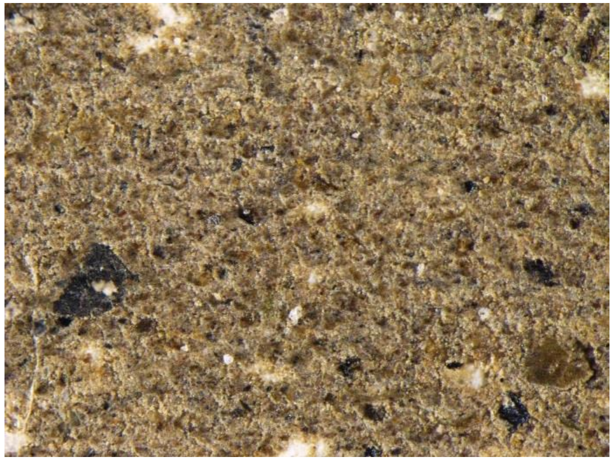
4.4 PARTICLE IDENTITY LEGEND

Insect parts/debris	Includes arachnids. Present as crushed body fragments, trichomes, wing scales, etc.
P/s slime	Polysaccharide slime. This extra-cellular bio-polymeric material may have different sources which might include microbiological growth, vertebrate excreta, decomposing biological matter, etc. Sometimes seen in these samples as a stringy gel binding other particles together. Sometimes fungal hyphae associated with the gel.
Copper sludge	Some well developed turquoise crystal growths can be found, but usually as subhedral to euhedral grains. Sometimes as blue highlights on a greenish cakey material. This is probably copper salts precipitated from the copper sulfate algaecide solution as the hydroxide, with or without sulfate and or phosphorous inclusion.
Mineral matter	Usually equant siliceous appearance and typically colourless to brown, transparent to translucent, euhedral, rounded grains. The clays very fine particles. Other constituents of siliceous appearance, sand etc.
Plant Debris/ char	Usually as trichomes, fragmented tissue, reproductive products and structures. Sometimes charred particles from incinerator, grass or bush fires.
Fly ash particles	Appears as spheroidal particles - colourless, milky or black
Coal dust	Black, equant, sharp angled grains. Some glossy; some edges dark brown translucent.
Soot	Black glossy spherical to botryoidal aggregates, typically hollow or lacey. Usual source is incompletely burnt organic liquids, eg. fuel oils.

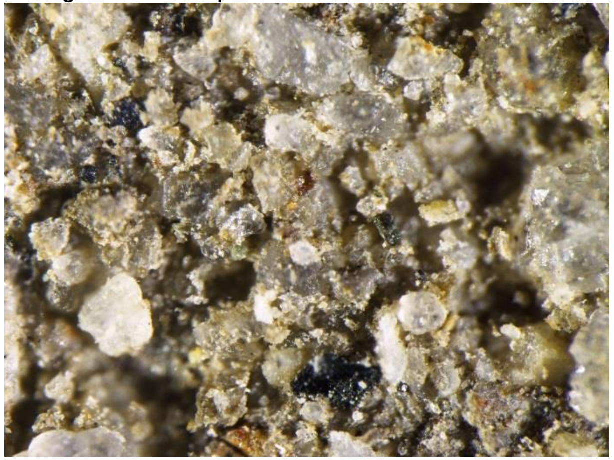
5. APPENDIX B

5.1 STEREOMICROSCOPY PICTURE MICROGRAPHS

StMPM1. ,CV-DSI-0417, UQMP # 14907. Very small dark brown to gold coloured particles with a number of black angular particlates, typical of coal noted and dispersed through out the deposit.



StMPM2. CV-BG-0417, UQMP # 14908. Predominantly a brown deposit with a small number of dark particle present.



StMPM3. CV-ODS-0417, UQMP # 14909. Coarse grained particles with a range of colours from white to brown with a few black angular particles in the field of view.

StMPM4. CV-S2-0417, UQMP # 14910. A few coarse particles with very fine particles dispersed throughout the deposit predominantly light brown with some gold coloured and translucent particles.

5.2 STEREOMICROSCOPY PICTURE MICROGRAPHS

StMPM5. CV-SC-0417, UQMP # 14911. Very fine grained particles predominantly light brown to gold in colour.

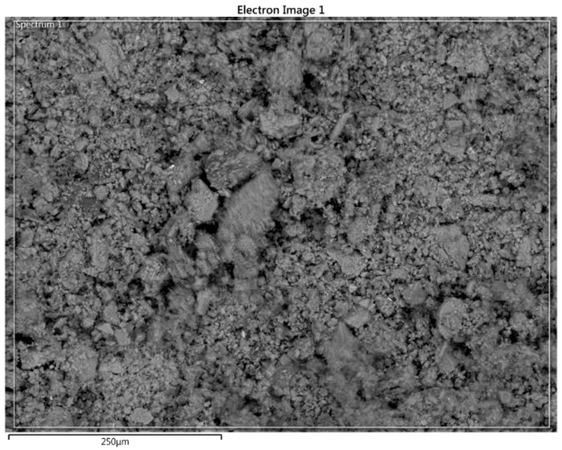
StMPM6. CV-BO-0417, UQMP # 14912. Medium grained particles predominantly ligt brown to gold in colour.

StMPM7. CV-EB-0417, UQMP # 14913. Coarse grained particles with particles mostly light brown to gold with a few translucent particles scattered throughout.

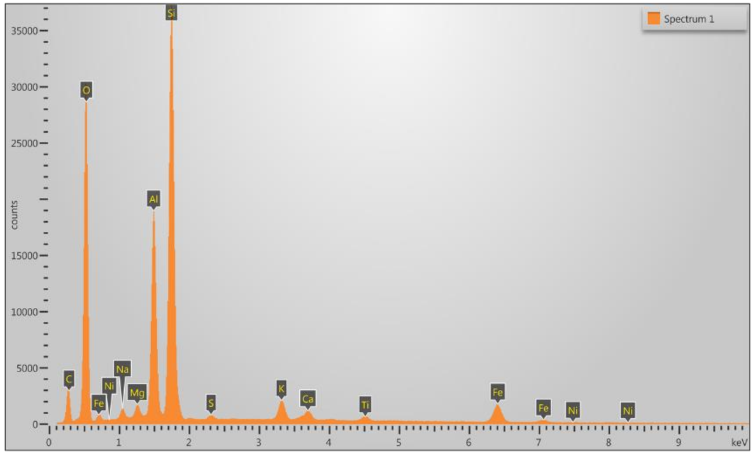
StMPM8. CV-PS2-0417, UQMP # 14914. Coarse grained particles mostly light brown to gold with a few translucent particles throughout the deposit.

APPENDIX C. SEM/BSE IMAGE AND SEM/EDS ANALYSIS AND ELEMENTAL SUMMARY OF SLUDGE OVERALL CV-DSI-0417

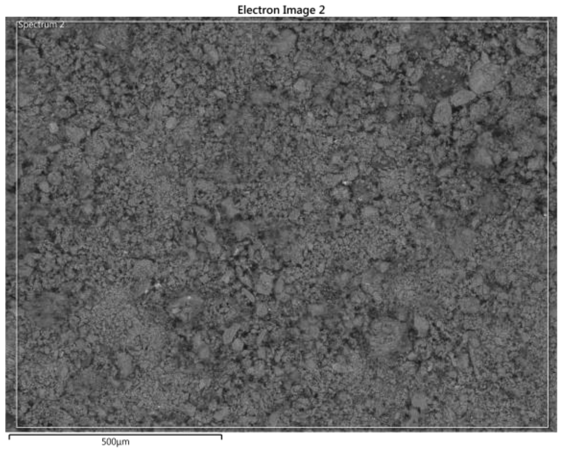
5.3 AN SEM/BSE IMAGE AND SEM/EDS SPECTRUM OF AN OVERALL AREA OF THE DEPOSIT



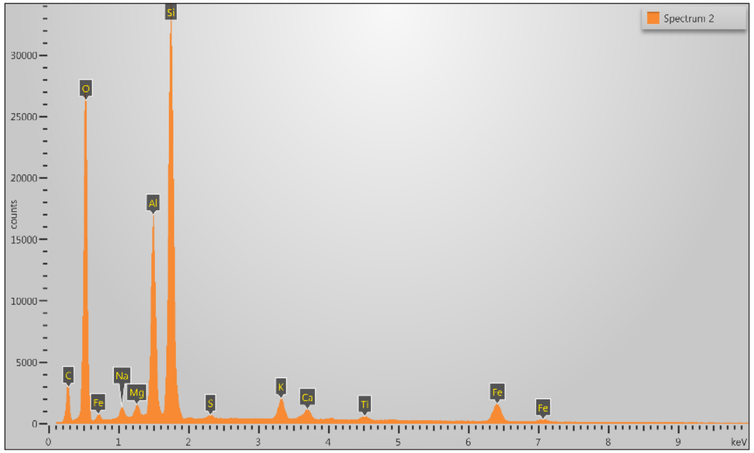
PM1. CV-DSI-0417, UQMP # 14907. An SEM/BSE image of a characteristic overall area selected for SEM/EDS analysis. (200 x Magnification)



EDS1. CV-DSI-0417, UQMP # 14907. The SEM/EDS spectrum of the overall area displays major peaks of carbon, oxygen, aluminium and silicon with minor amounts of potassium and iron and trace amounts of the balance of the elements. This elemental profile is consistent with observations a deposit consisting predominantly of mineral dust.



PM2. CV-DSI-0417, UQMP # 14907. An SEM/BSE image of a characteristic overall area selected for SEM/EDS analysis. (100 x Magnification)



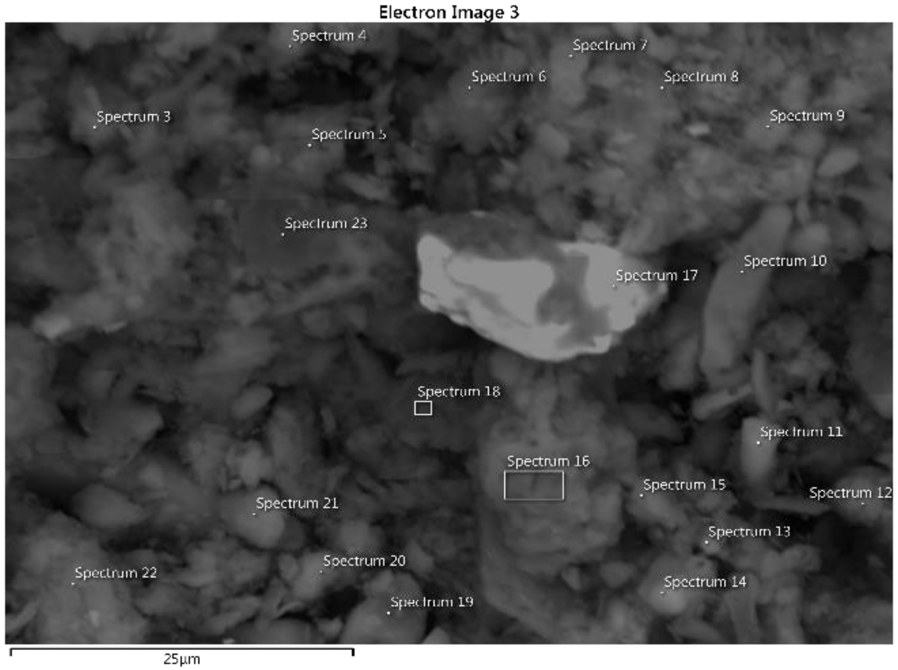
EDS1. CV-DSI-0417, UQMP # 14907. The SEM/EDS spectrum of the overall area displays major peaks of carbon, oxygen, aluminium and silicon with minor amounts of potassium and iron and trace amounts of the balance of the elements. This elemental profile is consistent with observations a deposit consisting predominantly of mineral dust.

Table 1. CV-DSI-0417, UQMP # 14907. An Elemental Summary of Overall Areas (Sludge Overall) analysed by SEM/EDS.

Spectrum Label	C	N	O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	V	Mn	Fe	Ni	Cu	Ag	La	Ce	Pr	Nd	Sm	Description/Nominated Particle
1	Major		Major	Trace	Trace	Major	Major		Trace		Minor	Trace	Trace			Minor	Trace								Overall area of the deposit at 100 x magnification
2	Major		Major	Trace	Trace	Major	Major		Trace		Minor	Trace	Trace			Minor									Overall area of the deposit at 200 x magnification

The elemental summary table of CV-DS-0417 displays elements detected for an overall area captured at 100 X and 200 X magnification. Major elements detected were carbon, oxygen, aluminium and silicon with minor amounts of potassium and iron and trace amounts of the balance of the elements. The SEM/EDS elemental profile of this deposit is typical of all the deposits examined with a predominance of aluminosilicate based mineral dust, typically from soil and rock.

5.1 AN SEM/BSE IMAGE OF PARTICLES SELECTED FOR SEM/EDS ANALYSIS



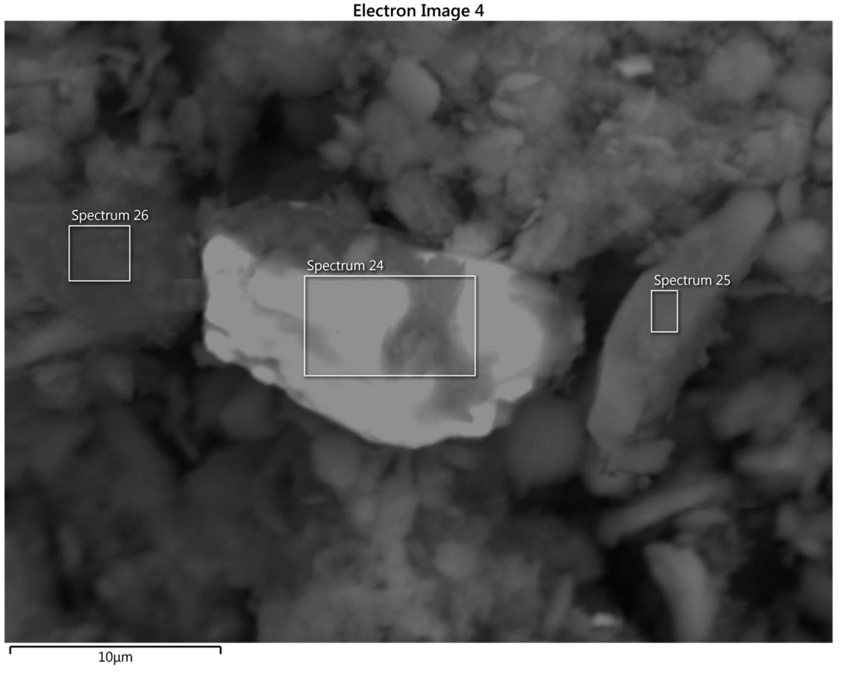
PM3. CV-DSI-0417, UQMP # 14907. An SEM/BSE image of a particles selected for SEM/EDS analysis.

Table 2. AN SEM/EDS ELEMENTAL SUMMARY PARTICULATES SELECTED ABOVE FOR ANALYSIS.

Spectrum Label	C	N	O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	V	Mn	Fe	Ni	Cu	Ag	La	Ce	Pr	Nd	Sm	Description/Nominated Particle
3	Major		Major	Trace	Trace	Major	Major	Trace	Trace		Trace	Trace	Trace			Minor									Mineral dust, Aluminosilicate - clay
4	Major		Major	Minor	Trace	Major	Major				Minor	Trace	Trace			Minor									Mineral dust, Aluminosilicate - clay
5	Major		Major	Trace	Trace	Major	Major	Trace	Trace		Minor	Trace	Trace			Minor									Mineral dust, Aluminosilicate - clay
6	Major		Major	Trace	Trace	Major	Major				Trace	Trace	Trace			Minor									Mineral dust, Aluminosilicate - clay
7	Major		Major	Minor	Trace	Major	Major	Trace	Trace		Trace	Trace	Trace			Minor									Mineral dust, Aluminosilicate - clay
8	Major		Major	Minor	Trace	Major	Major				Minor	Trace	Trace			Minor									Mineral dust, Aluminosilicate - clay
9	Major		Major	Minor	Trace	Major	Major				Trace	Trace	Trace			Minor									Mineral dust, Aluminosilicate - clay
10	Major		Major	Minor	Trace	Major	Major				Trace	Minor	Trace			Minor									Mineral dust, Aluminosilicate - clay
11	Major		Major	Trace	Trace	Major	Major				Major					Minor									Mineral Dust, Potassium Aluminosilicate - clay
12	Major		Major	Trace	Trace	Major	Major				Minor	Trace	Trace			Major									Mineral dust, Aluminosilicate - clay
13	Major		Major	Trace	Trace	Major	Major				Minor	Trace	Trace			Minor									Mineral dust, Aluminosilicate - clay
14	Major		Major	Trace	Major	Major	Major				Trace	Minor				Minor									Mineral Dust - Calcium, Magnesium, Aluminosilicate - clay
15	Major		Major	Trace	Minor	Major	Major		Trace		Trace	Trace	Trace			Minor									Mineral dust, Aluminosilicate - clay
16	Major		Major	Minor	Trace	Major	Major				Trace	Trace	Trace			Minor									Mineral dust, Aluminosilicate - clay
17	Major		Major	Minor	Trace	Major	Major	Trace			Trace	Trace				Minor			Trace	Major	Major	Minor	Major	Minor	Mineral Dust, Lanthanide - Aluminosiilcate
18	Major		Major	Trace	Trace	Major	Major		Trace		Minor	Trace	Trace			Major									Mineral dust, Aluminosilicate - clay
19	Major		Major	Trace		Minor	Major			Trace	Trace	Trace	Trace			Minor									Mineral dust, Silicon rich - quartz
20	Major		Major	Trace	Trace	Major	Major		Trace	Trace	Minor	Trace	Trace			Major									Mineral dust, Aluminosilicate - clay
21	Major		Major	Trace	Trace	Major	Major				Trace	Trace	Trace			Major									Mineral dust, Aluminosilicate
22	Major		Major	Trace	Trace	Major	Major		Trace		Minor	Trace	Trace			Minor									Mineral dust, Aluminosilicate - clay
23	Major		Major	Trace	Trace	Minor	Major	Trace	Trace		Trace	Trace	Trace			Minor									Coal - High ash

CV-DSI-0417 (Sludge Overall), UQMP # 14907. A summary table of particles selected above for SEM/EDS analysis. A high ash coal particle was detected with most of the particles consisting of a grain size of < 2 µm. Clay minerals typically are aluminium silicates containing cations, alkalies and alkaline earth metals as essential components. Magnesium and iron often substitute in the matrix for aluminium. There small size creates a large surface area to volume ration and reactive surface area with high cation exchange capacities. Some clays can increase their volume by 50 % with water absorption, which can create instability in soils.

5.2 AN SEM/BSE IMAGE OF PARTICLES SELECTED FOR SEM/EDS ANALYSIS



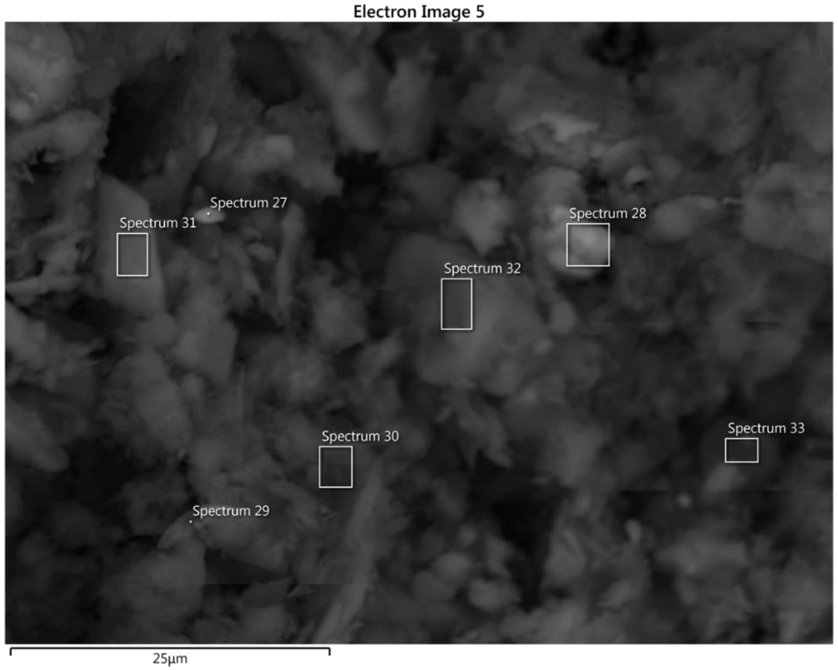
PM4. CV-DSI-0417 (Sludge Overall), UQMP # 14907. An SEM/BSE image of a particles selected for SEM/EDS analysis.

Table 3. AN SEM/EDS ELEMENTAL SUMMARY OF PARTICULATES SELECTED ABOVE FOR ANALYSIS.

Spectrum Label	C	N	O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	V	Mn	Fe	Ni	Cu	Ag	La	Ce	Pr	Nd	Sm	Description/Nominated Particle
24	Major		Major	Trace	Trace	Major	Major	Minor			Trace	Trace				Minor			Minor	Minor	Major		Minor		Mineral Dust, Phosphorous, Lanthanide - Aluminosiilcate
25	Major		Major	Minor	Trace	Major	Major				Trace	Minor				Trace									Mineral dust, Aluminosilicate - clay
26	Major		Major	Trace	Trace	Minor	Major	Trace	Trace		Trace	Trace	Trace			Minor									Coal - High ash

CV-DSI-0417 (Sludge Overall), UQMP # 14907. The elemental summary suggests a particle typical of the elemental profile displayed in each spectrum.

5.3 SEM/BSE IMAGE OF PARTICLES SELECTED FOR SEM/EDS ANALYSIS



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PM5. CV-DSI-0417 (Sludge Overall), UQMP # 14907. An SEM/BSE image of a particles selected for SEM/EDS analysis.

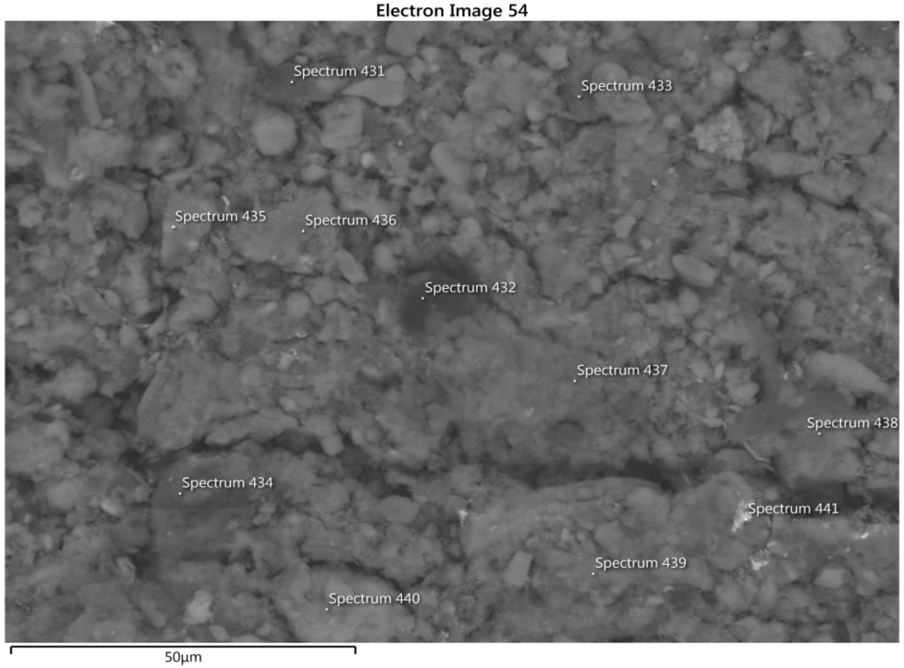
Table 4. AN SEM/EDS ELEMENTAL SUMMARY OF PARTICULATES SELECTED ABOVE FOR ANALYSIS.

Spectrum Label	C	N	O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	V	Mn	Fe	Ni	Cu	Ag	La	Ce	Pr	Nd	Sm	Description/Nominated Particle
27	Major	Major	Major	Trace	Trace	Major	Major		Trace		Trace	Trace	Major	Trace	Trace	Major		Trace							Mineral Dust -Iron-Titanium aluminosilicate
28	Major	Minor	Major	Trace	Trace	Major	Major		Trace		Minor	Trace	Major	Trace		Major									Mineral Dust -Iron-Titanium aluminosilicate
29	Major	Minor	Major	Trace	Trace	Major	Major		Trace		Minor	Minor	Trace			Major									Mineral Dust -Iron-aluminosilicate - clay
30	Major		Major	Trace	Trace	Major	Major				Minor	Minor	Minor			Major									Mineral Dust -Iron-aluminosilicate - clay
31	Major		Major	Trace	Trace	Major	Major		Trace		Minor	Major	Trace			Major									Mineral Dust - Calcium aluminosilicate
32	Major		Major	Trace	Trace	Major	Major		Trace		Minor	Trace	Trace			Major									Mineral Dust -Iron-aluminosilicate - clay
33	Major		Major	Trace	Trace	Major	Major		Trace		Minor	Trace	Trace			Major		Trace							Mineral Dust -Iron-aluminosilicate - clay

CV-DSI-0417 (Sludge Overall), UQMP # 14907. The elemental summary suggests a particle typical of the elemental profile displayed in each spectrum.

6. SEM/BSE IMAGE AND SEM/EDS ELEMENTAL SUMMARY OF INTERMEDIATE CV-DSI-0417 PARTICLES

6.1 SEM/BSE IMAGE OF PARTICLES SELECTED FOR SEM/EDS ANALYSIS



PM6. CV-DSI-0417, UQMP # 14907. An SEM/BSE image of a particles selected for SEM/EDS analysis.

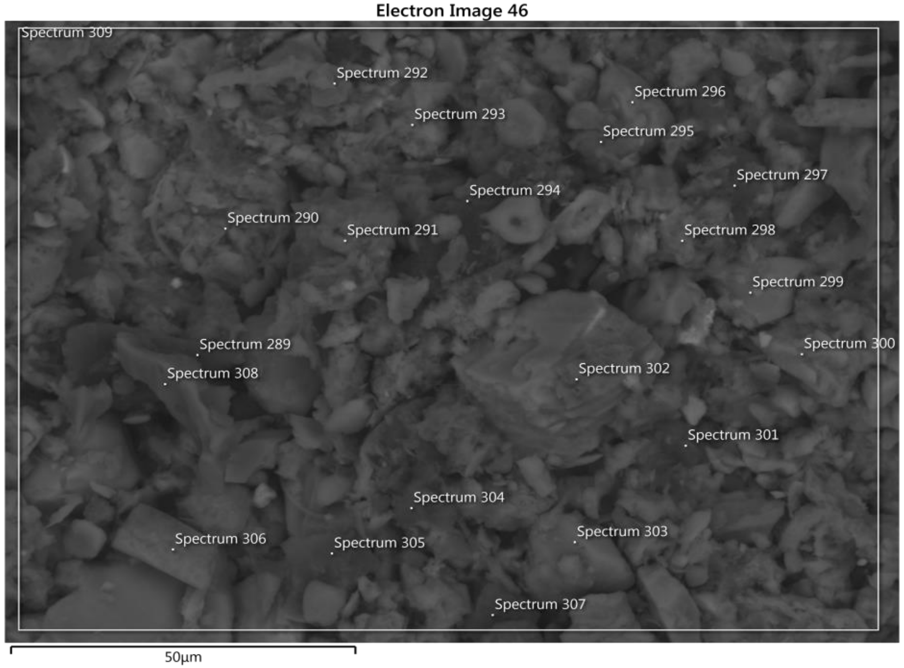
6.2 Table 5. CV-DSI-0417, UQMP # 14907. An Elemental SUMMARY OF INTERMEDIATE CV-DSI-0417 PARTICLES

.

Spectrum Label	C	N	O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Mn	Fe	Ni	Description/Nominated Particle
Spectrum 431	Major	Minor	Major	Trace	Trace	Minor	Major		Trace		Trace	Trace	Trace	Trace	Minor		Suggestive of Coal
Spectrum 432	Major		Major	Trace	Trace	Minor	Major	Trace	Trace		Trace	Trace	Trace		Minor		Coal
Spectrum 433	Major		Major	Trace	Trace	Minor	Major	Trace	Trace		Trace	Minor	Trace	Trace	Major		Suggestive of Coal
Spectrum 434	Major		Major	Trace	Trace	Minor	Major	Trace	Trace	Trace	Trace	Trace	Trace		Minor		Coal
Spectrum 435	Major		Major	Trace	Major	Minor	Major				Trace	Major	Trace		Major		Mineral Dust - Calcium-Magnesium Aluminosilicate
Spectrum 436	Major		Major	Trace	Minor	Major	Major	Trace	Trace		Trace	Trace	Trace		Major		Mineral Dust - Iron-Aluminosilicate
Spectrum 437	Major		Major	Trace	Minor	Major	Major				Minor	Trace	Trace		Major		Mineral Dust - Iron-Aluminosilicate
Spectrum 438	Major		Major		Trace	Major	Major		Trace		Trace	Trace	Trace		Minor		Mineral Dust - Quartz
Spectrum 439	Major		Major		Minor	Major	Major	Trace	Trace		Minor	Trace	Trace		Major		Mineral Dust - Iron-Aluminosilicate
Spectrum 440	Major		Major	Minor	Minor	Major	Major	Trace			Trace	Trace	Trace		Major		Mineral Dust - Iron-Aluminosilicate
Spectrum 441	Major		Major		Trace	Major	Major	Minor			Trace	Trace	Trace		Minor	Major	Mineral Dust - Nickel Phosphorous aluminosilicate

CV-DSI-0417 (Intermediate), UQMP # 14907. The elemental summary suggests a particle typical of the elemental profile displayed in each spectrum.

7. SEM/BSE IMAGE AND SEM/EDS ELEMENTAL SUMMARY OF FINE CV-DSI-0417 PARTICLES



PM6. CV-DSI-0417, UQMP # 14907. An SEM/BSE image of a particles selected for SEM/EDS analysis.

7.1 Table 6. CV-DSI-0417, UQMP # 14907. An Elemental SUMMARY OF FINE CV-DSI-0417 PARTICLES

Spectrum Label	C	O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Fe	Cu	Description/Nominated Particle
Spectrum 289	Major	Major	Trace	Trace	Minor	Major		Trace	Trace	Trace	Trace		Trace		Coal
Spectrum 290	Major	Major	Trace	Trace	Major	Major		Trace		Trace	Trace	Trace	Minor		Mineral Dust - Aluminosiilcate - clay
Spectrum 291	Major	Major	Trace	Trace	Major	Major		Trace		Trace	Trace	Trace	Minor		Mineral Dust - Aluminosiilcate - clay
Spectrum 292	Major	Major	Trace	Trace	Minor	Major				Trace	Trace	Trace	Minor		Mineral Dust - Silicon rich - quartz
Spectrum 293	Major	Major	Trace	Minor	Major	Major				Minor	Trace	Trace	Major		Mineral Dust - iron - Aluminosiilcate - clay
Spectrum 294	Major	Major	Trace	Trace	Major	Major		Trace		Trace	Trace	Trace	Minor		Mineral Dust - Aluminosiilcate - clay
Spectrum 295	Major	Major	Trace	Trace	Major	Major				Minor	Minor	Trace	Minor	Trace	Mineral Dust - Calcium Aluminosilicate - clay
Spectrum 296	Major	Major	Minor	Trace	Major	Major				Trace	Minor		Minor		Mineral Dust - Calcium Aluminosilicate - clay
Spectrum 297	Major	Major	Trace	Trace	Major	Major		Trace		Trace	Trace	Trace	Minor		Suggestive of High Ash Coal
Spectrum 298	Major	Major	Trace	Trace	Major	Major		Trace		Trace	Trace	Trace	Minor		Mineral Dust - Aluminosiilcate - clay
Spectrum 299	Major	Major	Minor	Trace	Major	Major				Trace	Minor	Trace	Minor		Mineral Dust - Calcium Aluminosilicate - clay
Spectrum 300	Major	Major	Trace	Minor	Minor	Major		Trace		Trace	Minor	Trace	Minor		Mineral Dust - Calcium Magnesium Aluminosilicate - clay
Spectrum 301	Major	Major	Trace	Trace	Major	Major		Trace		Minor	Minor	Minor	Major	Trace	Mineral Dust - Aluminosilicate - clay
Spectrum 302	Major	Major	Minor	Trace	Major	Major				Minor	Trace	Trace	Minor		Mineral Dust - Sodium Aluminosilicate - clay
Spectrum 303	Major	Major	Major	Trace	Major	Major				Trace	Minor		Trace		Mineral Dust - Sodium Aluminosilicate - clay
Spectrum 304	Major	Major	Trace	Trace	Minor	Major	Trace	Trace		Trace	Trace	Trace	Minor		Coal
Spectrum 305	Major	Major	Trace	Trace	Major	Major		Minor	Trace	Trace	Trace	Trace	Minor		Suggestive of High Ash Coal
Spectrum 306	Major	Major	Trace	Trace	Minor	Major			Trace	Trace	Trace		Trace		Mineral Dust - Aluminosiilcate - clay
Spectrum 307	Major	Major	Trace	Trace	Minor	Minor		Minor	Trace	Trace	Trace	Trace	Trace		Coal
Spectrum 308	Major	Major	Trace	Trace	Minor	Major		Minor	Trace	Trace	Trace	Trace	Minor		Coal
Spectrum 309	Major	Major	Trace	Trace	Major	Major		Trace		Minor	Minor	Trace	Minor	Trace	Overall Area of the fines

CV-DSI-0417 (Fines), UQMP # 14907. The elemental summary suggests a particle typical of the elemental profile displayed in each spectrum.

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The author acknowledges the facilities, and the scientific and technical assistance, of the Australian Microscopy & Microanalysis Research Facility at the Centre for Microscopy and Microanalysis, The University of Queensland

Attachment 4 – Overview of Inter-laboratory Comparison

Currently there is no recognised standard method for the quantification of mass or volumes of coal in sediment, and different laboratories use different methods that will potentially vary with respect to reportable masses or volumes. To assess the potential variation between results obtained from different methods, duplicate samples were sent to UQMP and to ALS Coal Technology (ALS). The duplicate samples were collected at two locations on 28 April 2017; from in the vicinity of the authorised released point and at the site designated as DS1. These sample locations were identified as CV Shore, and CV Wetlands. Samples were collected in the same manner as outlined in the main document.

Both laboratories used microscopic methods; however, ALS reported results on a per cent volume basis and UQMP reported results on a projected per cent area basis. The estimates of coal in the sediments from ALS were – CV Wetlands (15% volume), CV Shore (27% volume) compared to UQMP –projected area CV Wetlands (10% estimated projected area basis) and CV Shore (10% projected area basis).

Further analysis was undertaken by ALS using the density separation method (float and sink testing - reported on a per cent mass basis), as the other methods do not consider the varying densities of coal, mineral and organic matters. This analysis estimated coal in sediment - CV Wetlands (3%), and CV Shore (6%).

To provide an independent review of the unexpected variation in results obtained from the different methodologies used by the laboratories, advice was sought from specialists within CSIRO Energy. This review is provided in Attachment 5.

In order to compare the three methods, the results from the two microscopic methods were converted to per cent abundance by mass by Graham O'Brien, CSIRO Energy (Table A4.1). Overall, the results obtained in the UQMP microscopic method, were in agreement with those obtained by ALS using the density separation method, with the caveat that the float and sink results provided a result for coal plus organic matter. Graham O'Brien's review has suggested that by using oil immersion optics, the ALS microscopic method may have biased the results, and suggested that air lens optics would have made the visual distinction between organic coal and mineral particles less ambiguous.

Table A4.1: Analysis of samples reported on a mass % basis

Laboratory	Method	Sample	Coal %
ALS	Microscopy	CV Shore	18.0
		CV Wetlands	10.0
ALS	Float Sink	CV Shore	6*
		CV Wetlands	3*
UQMP	Microscopy	CV Shore	5.6
		CV Wetlands	5.7

Note: * indicates a result comprised of coal and organic matter.

Attachment 5 – Review of Sediment Sample Results (CSIRO)

ENERGY
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Review of Sediment Sample Results

Qld Dept. of Environment and Heritage

Graham O'Brien
Report number: EP175925 July 2017

Report to:

Department of Environment and Heritage Protection

Department of Science, Information Technology and Innovation

Citation

O'Brien G (2017) Review of sediment samples results – Qld Dept. of Environment and Heritage. CSIRO, Australia.

Background

Graham O'Brien, Principal Coal Technologist, CSIRO Energy, was requested to undertake a review of two reports produced by ALS Coal Richlands Laboratory and University of Queensland's Materials Performance (UQMP) laboratory for the analysis of two sediment samples identified as CV Shore and CV Wetlands. This review was to include comments on the methods used and the results obtained by both laboratories. This review also compared the results obtained by these laboratories with the results obtained when a density separation method (Float and Sink Analysis) was used to separate the heavier density minerals in the sediments from the lighter density coal and organic particulates. The DISTI and EHP (2017) report provided background material for the purpose of conducting these analyses.

The Department of Science, Information Technology and Innovation (DSITI) was commissioned to conduct a Preliminary Site Assessment of Caley Valley Wetlands adjacent to the Abbot Point Bulk Coal Terminal (Abbot Point Terminal). The site had been subject to an authorised release of water from the secondary settlement pond (which is part of the stormwater system) from Abbot Point Terminal.

Satellite imagery collected after Tropical Cyclone Debbie appeared to show dark waters downstream of a release point extending into the wetland. Consistent with a temporary emissions licence (TEL), the coal terminal operator, Abbot Point Bulkcoal Pty Ltd, sampled the stormwater release as soon as practicable and safe. The results of testing indicated that the release into the wetland was below the thresholds set in the licence condition.

In April 2017, staff from DSITI and the Department of Environment and Heritage Protection (EHP) wetland group undertook a preliminary assessment of the site. The objective for the preliminary site assessment was to assess the presence or otherwise of coal fines associated with the release, and if present, to undertake an initial assessment as to whether this has caused impacts to the wetlands.

The DISTI and EHP (2017) report describes the sampling method used for the collection of the samples. At each sampling location composite sediment samples were taken. This involved the collection of five replicate samples of approximately 10x10 cm in area and approximately 1 cm depth at each site and combining them together before taking a subsample for analysis. This is a standard field sample practice as sediments can be highly heterogeneous and compositing a number of samples into a single sample is a way of adjusting for variation found in sediment samples.

The five replicated samples collected at each site were mixed in a stainless steel bowl using a stainless steel trowel to produce a composite sample for that site. From each composite sample, duplicate samples were obtained by splitting the contents of the bowl into two jars. Samples were kept chilled on ice after collection. For the CV shore and CV Wetlands samples, one jar was supplied to ALS Coal Richlands laboratory and the second jar was sent to University of Queensland's Materials Performance laboratory (UQMP).

Analysis Methods

ALS Method.

The ALS report describes the following methodology used to analyse the two samples.

> After receipt, the samples were dried overnight in an oven to remove excess water. The samples were prepared by crushing any oversize material down to a 1mm top size using a mortar and pestle to limit over-crushing. Samples were then prepared as per normal petrographic samples by mounting the crushed samples in an acrylic resin, which is polished via a multistage polishing procedure on a Struers Tegra polishing system to produce a suitable surface for reflected light microscopy. A manual point count of each sample was conducted with the material under the crosshairs of the microscope being classified as coal, mineral matter or organic matter. 500 points were counted on the sample at 500x magnification. Some example images were included in the LAS Coal report (Appendix 1).

It is my assessment that the samples were prepared and the analyses conducted in accordance with Australian Standards (AS2856 parts 1 and 2) and results were reported on a volume % basis. The photomicrographs in the report showed that these analyses had been undertaken using an oil immersion lens. This is the standard method used when undertaking an assessment of coal samples.

UQMP Method

The analyses were conducted using an Internal UQMP method. Full details of the method are contained in the UQMP report (Appendix 2). Details of this method are summarized below.

> The samples (supplied in jars) consisted of solids and semi solid sludge. The contents of each jar was emptied into a large beaker, large stringy plant debris was removed before mixing, demineralised water was added to allow the solids to de-clump and mix to a smooth homogenous slurry. Three sub samples were created from each slurry for further examination. This was essential due to fine clay particles being present. A plastic pasture pipette was used to remove an aliquot of the slurry. On occasion extraneous vegetation would prevent the slurry from flowing into the pipette and this was removed and returned to the sample. All sub samples were collected whilst mixing to ensure homogeneity was maintained.
>
> - Sub sample 1. A few drops of the slurry were washed onto a cellulose filter with demineralised water. The final sub-sample defined as “Sludge as Received”.
> - Sub sample 2. Consists of a few drops of the slurry filtered through a 500-micron filter onto a cellulose membrane under vacuum, the suspended fines pipetted off and retained. This subsample was defined as “Intermediate”.
> - Sub sample 3. This sample contains a few drops of the fines removed from Sub sample 2 and placed onto a cellulose membrane. This subsample is defined as “Fines”
>
> The samples were initially examined by stereomicroscopy, using a Nikon SMZ25 stereo microscope at magnifications up to 100X. For each sample a portion of each sample filter was excised and placed onto a conductive carbon tape for Scanning Electron Microscopy (SEM) examination combined with Energy Dispersive Spectroscopy (EDS). The SEM was operated at 20 kV in back-scattered electron composition contrast (BSE) imaging modes. In BSE images the contrast is influenced by the chemical composition of the material being imaged. Dark regions represent low average atomic number (light elements) and bright regions represent high average atomic number (heavy elements). Regions of interest were chemically analysed by energy dispersive X-ray spectroscopy (EDS). The UQMP report stated that the

EDS method is only semi-quantitative, especially when analysing small particles, for the following reasons:

- The significant size of the analysis volume (typically around 3 μm) and hence the difficulty of eliminating interference from surroundings;
- Contamination by carbon on the specimen surface and within the SEM vacuum chamber,
- The inherent sensitivity limits of the instrumentation.

The UQMP report, which is reproduced in full in Appendix 2, contains a table of combined microscopy results for the two samples. The abundances of coal, mineral dust and organic matter (plant debris and filamentous algae) in these samples were reported on a projected area basis. The report does not provide detail for the number of individual measurements that were done by optical microscopy and SEM and how these results were combined.

Results

ALS Coal and UQMP results for CV Shore and CV Wetlands samples results reported on a volume%/projected area basis.

ALS Coal laboratory used a manual point counting method and the reported volume abundances were proportional to the number of individual coal, mineral and organic particulates counted. UQMP reported results on a projected area abundance basis. The results obtained by ALS and UQ for the CV Shore and CV Wetlands samples are shown below (Table 1). For both sediment samples ALS reported more coal than did UQMP.

Table 1: Analysis results from the reports provided by ALS Coal and UQMP. Results are reported on a volume %/ projected area basis.

	Sample	Coal %	Mineral %	Organic %
ALS-DSITI samples	CV Shore	26.8	64.2	9.0
(Volume% basis)	CV Wetlands	15.4	73.0	11.6
UQMP- DSITI samples	CV Shore	10	90	trace
(projected area basis)	CV Wetlands	10	88	2

CSIRO assessed these results to verify that these differences seen between the two methods were statistically significant using the criteria outlined in Australian Standard AS2856.2. The standard deviation and hence repeatability and reproducibility of repeat measurements is determined by the number of points counted during each analysis. The expected repeatability, based on 500 particles being counted are shown in Table 2. The expected reproducibility when analyses are conducted on different samples, by different operators is approximately twice the repeatability values shown in Table 2.

Table 2: Repeatability of point counting methods, based on 500 particles being counted for duplicate analyses conducted by the same operator on the same sample (AS2856.2).

Volume percentage of component	Standard deviation of the volume percentage (s)	Repeatability $(2\sqrt{2})s$
5	1.0	2.8
20	1.8	5.1
50	2.2	6.3
80	1.8	5.1
95	1.0	2.8

The agreement between the results obtained by ALS Coal and UQMP for these two samples are outside of the reproducibility limits defined in AS2856.2 thereby indicating that the ALS Coal and UQMP results were significantly different.

Float and Sink Testing results conducted on CV Shore and CV Wetland samples.

DISITI organised for further testing, using a different analytical method, to be undertaken to investigate why these results reported by ALS and UQMP were significantly different. This testing employed a density separation method (float and sink analysis) to determine the proportion of mineral and the combined proportions of coal and organic material in these two samples. A float and sink test simply involves putting a sample into a liquid of known density and particles of lesser density float and particles of greater density sink. This process is detailed in ISO standard 7936:1992 Hard coal - Determination and presentation of float and sink characteristics - General directions for apparatus and procedures.

This was done using the reserve material for the samples which were supplied to ALS Coal by DSITI. These samples had been crushed to a topsize of 1mm, prior to ALS Coal undertaking their microscopic analyses, so these reserve samples were suited for undertaking this testing. The tests were done using an organic liquid with a density of 1.80g/cc. Thus when the sample was placed in this liquid the individual mineral particles sank and the individual coal and organic particles floated. The initial sample mass used to undertake these tests and the mass and mass % which reported to the F1.80 and S 1.80 density factions are shown in Table 3.

Table 3: ALS float and sink results for CV Shore and CV Wetland samples.

	Mass (g)	Mass%
CV Shore – 58.3g initial mass		
F1.80 – (coal + organic material)	3.5	6.0
S1.80 – (minerals)	54.5	94.0
Total	58.0	100.0
CV Wetland – initial mass 66.8g		
F1.80 – (coal + organic material)	1.8	2.7
S1.80 – (minerals)	64.6	97.3
Total	66.4	100.0

These tests reported that CV Shore contained 94.0% minerals and 6.0% coal and organic material and that the CV Wetland sample contained 97.3% minerals and 2.7% coal and organic material.

ALS Coal and UQMP results for CV Shore and CV Wetlands samples reported on a mass % basis.

To enable the results that were reported by ALS Coal and UQMP to be compared with the float and sink test results CSIRO used the densities of the constituents to calculate their mass abundances. Reporting results on a volume% / projected area basis does not consider that the coal, mineral and organic constituents have different densities. The relative density values for coal, biomass mass (organic matter) and minerals determined in the literature are shown below.

- Relative density coal 1400kg/m^{-3} for coal (Preston & Sanders 1993)
- Relative density biomass 385kg/m^{-3} (Wiemann and Williamson, 2012)
- Relative density of minerals 2600kg/m^{-3} (AS2856.2, 1998)

These relative density values were used to calculate the mass abundance of the coal, mineral and organic matter in each sample (mass = volume X density) to report the results shown in Table 1 on a mass% basis (Table 4).

Table 4: Analysis results reported on a calculated mass % basis

	Sample	Coal %	Mineral %	Organic %
ALS-DSITI samples	CV Shore	18.0	80.3	1.7
	CV Wetlands	10.0	87.9	2.1
UQMP- DSITI samples	CV Shore	5.6	94.4	0.0
	CV Wetlands	5.7	94.0	0.3

The calculated UQMP results showed that the CV Shore sample contained 5.6% coal and the CV Wetlands sample contained about 5.7% coal (by mass) which were significantly less than the coal reported by ALS Coal for these samples. The float and sink tests showed that the CV Shore sample contained 6.0% (by mass) coal plus organic material and the CV Wetland sample contained 2.7% coal plus organic material (by mass).

Discussion

Three different methods, the two microscopic methods and the density separation method were used to determine the proportion of minerals, coal and organic matter in the two sediment samples. The density separation method provided mass abundance for the mineral and mass abundance for the coal plus organic matter whilst the two microscopic methods provided volume/projected area abundances for the mineral, coal and organic matter for these samples. To enable these results to be assessed required them to be reported on the same basis. Therefore, the microscopic results were converted to mass % abundances using referenced values of relative density. Main comments about the results provided by these different methods are:

- The float and sink results did not provide discrimination between coal and organic matter and hence the F1.80 material provides detail on the **maximum amount of coal that could be present** in these samples. If required a further float and sink separation could be undertaken (using a liquid with a specific gravity of between 0.8 and 1.2g/cc) to separate the coal from the organic matter. Alternatively, a microscopic assessment could be conducted on the F1.80 density fraction to provide detail on the amount of coal and other constituents in this fraction. As the microscopic assessment would determine the volume abundance of these constituents these results would need to be converted to a mass % basis for reporting. If there is a need to quantify the abundance of the different mineral particulates in the sediments, SEM analyses could be conducted on the S1.80 fraction.

- When reported on a mass% basis the UQMP results agreed quite well with the float sink results reported, with the caveat that the float and sink results reported a combined amount of coal plus organic matter. The method used by the UQMP (Jones, 2017) stated that "*The contents of the jars were emptied into a large beaker, **large stringy plant debris was removed** before mixing, demineralised water was added to allow the solids to de-clump and mix to a smooth homogenous slurry.* The removal of the plant debris may have had implications for the amount of coal reported as the analyses were conducted on an almost organic matter free basis. If this method is used for future analyses I would recommend that the plant debris and the remaining sediment sample be weighed and the results combined for reporting. The results would then need to be reported on a mass % basis.

- For these two samples, the ALS Coal microscopic method reported significantly more coal than did the other two methods. One reason may be that ALS Coal performed these analyses using the method described in AS2856.2, where immersion oil is placed on the polished surface of the block and the analyses are undertaken using an oil immersion objective. The immersion oil is used as it provides significantly more contrast between the different coal constituents. However, as some of the minerals have a similar refractive index to that of the immersion oil, it is often difficult to identify the liberated mineral particles in the sample. This is demonstrated below in Figure 2.

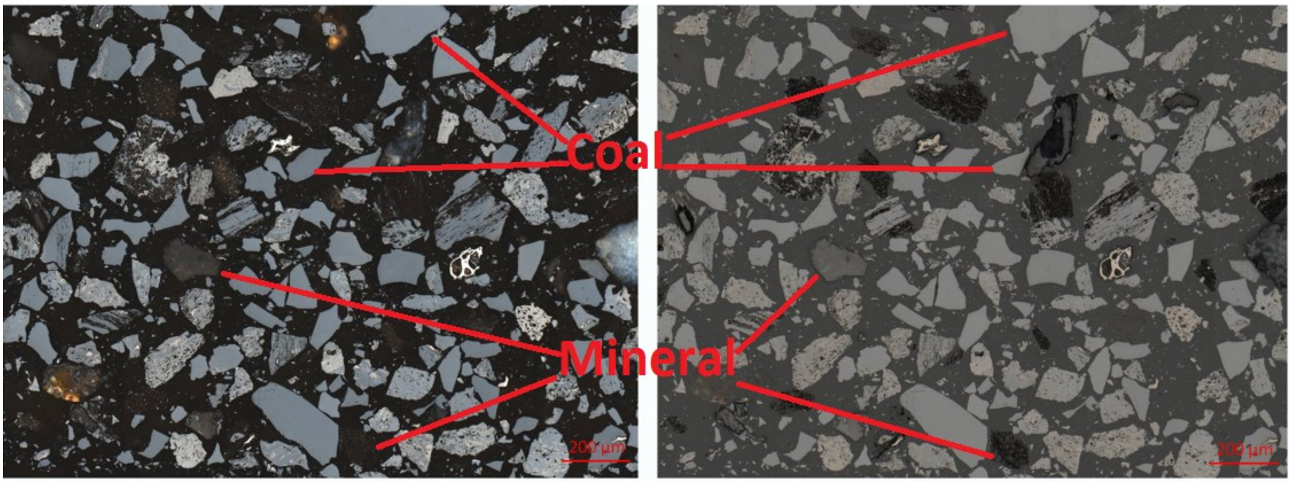

Figure 2a: Optical photomicrograph collected in reflected light using an oil immersion objective of a sample containing coal and mineral particles

Figure 2b: Optical photomicrograph collected in reflected light using an air objective of a sample containing coal and mineral particles

Hence I would recommend that:

- Future analyses of sediment samples should be performed using an air objective
- Results be reported on a mass% basis.

References

AS 2856.1-2000 (R2013) Coal petrography Preparation of coal samples for incident light microscopy

AS 2856.2-1998 (R2013) Coal petrography Maceral analysis

Cash W. (June 7, 2017), DSITI Sediment Samples. ALS Global.

DSITI and EHP, 2017, Protection Caley Valley Wetlands- Preliminary assessment of impacts to Caley Valley Wetlands from Abbot Point Coal Terminal post Tropical Cyclone Debbie. Report prepared by Environmental Monitoring and Assessment Sciences Science Delivery Division Department of Science, Information Technology and Innovation and Conservation and Sustainable Services Department of Environment and Heritage.

ISO 7936:1992 Hard coal - Determination and presentation of float and sink characteristics - General directions for apparatus and procedures

Jones F. (June, 2017), Laboratory report - Examination of sludge deposits by stereomicroscopy and scanning electron microscopy. UQMP

Preston KB and Sanders RH, 1993, Estimating the in situ relative density of coal, Australian Coal Geology vol.9, pp.22–26.

Wiemann Michael C., Williamson G. Bruce, 2012, Density and Specific Gravity Metrics in Biomass Research, United States Department of Agriculture, Forest Service, General Technical Report FPL–GTR–208

Appendix 1

Cash, W. (June 7, 2017). *DSITI Sediment Samples.* ALS Global.

Microscopic Analysis

WILLIAM CASH/DSITI SEDIMENT SAMPLES

June 7, 2017

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Contents

1. Introduction

ALS Energy – Coal Technology were contacted by Suzanne Vardy from the Department of Science, Information Technology and Innovation to conduct analysis of environmental samples to determine if there is any coal present. Microscopic analysis was conducted on the samples at the ALS Coal Petrography and Imaging Centre at Richlands. The samples received for analysis were the following:

CV Shore

CV Wetlands

2. Procedure

After receipt, samples were dried overnight in an oven to remove excess water. The samples were prepared by crushing any oversize material down to a 1mm top size using a mortar and pestle to limit over-crushing.

Samples were then prepared as per normal petrographic samples by mounting the crushed samples in an acrylic resin, which is polished via a multistage polishing procedure on a Struers Tegra polishing system to produce a suitable surface for reflected light microscopy.

A point count of each sample was conducted with the material under the crosshairs of the microscope being classified as coal, mineral matter or organic matter. 500 points were counted on the sample at 500x magnification. Some example images are included below.

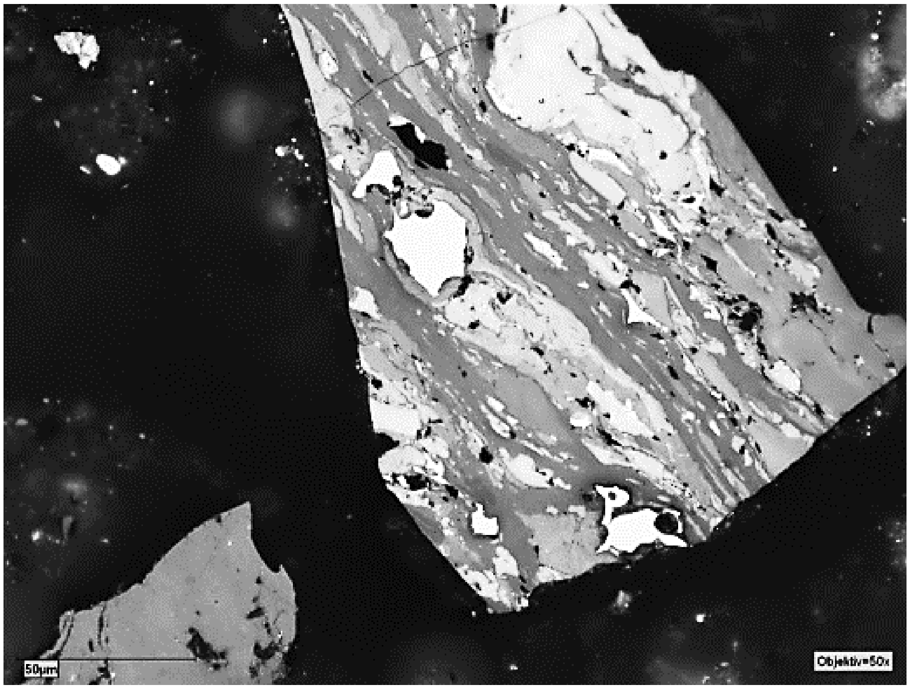

Figure 1: A coal dust particle, with the darker grey Vitrinite and lighter grey/white of Inertinite; 50x objective, oil immersion, reflected white light.

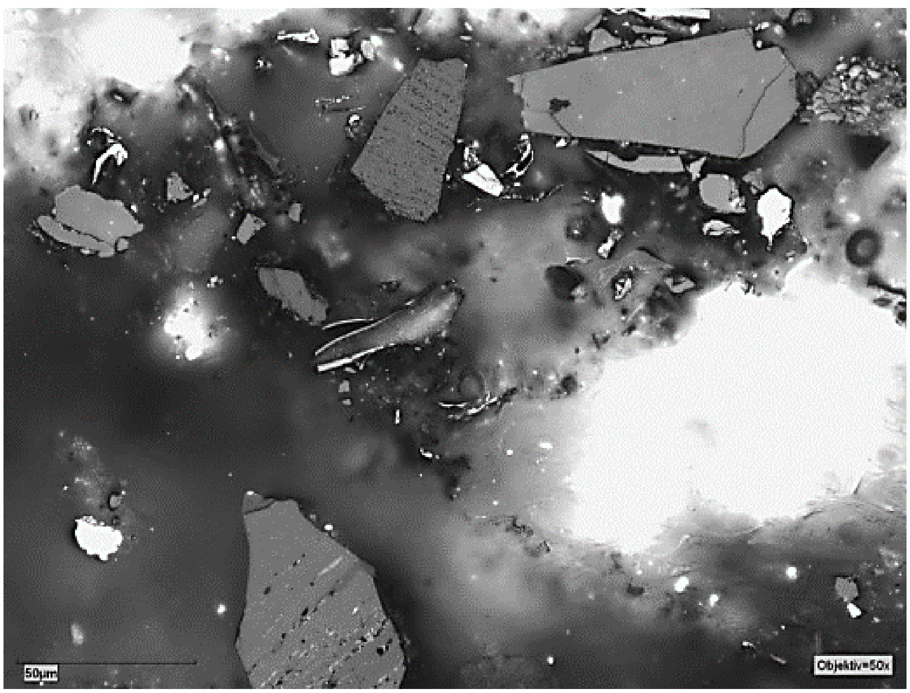

Figure 2: A cluster of Vitrinite grains and some interspersed minerals; 50x objective, oil immersion, reflected white light.

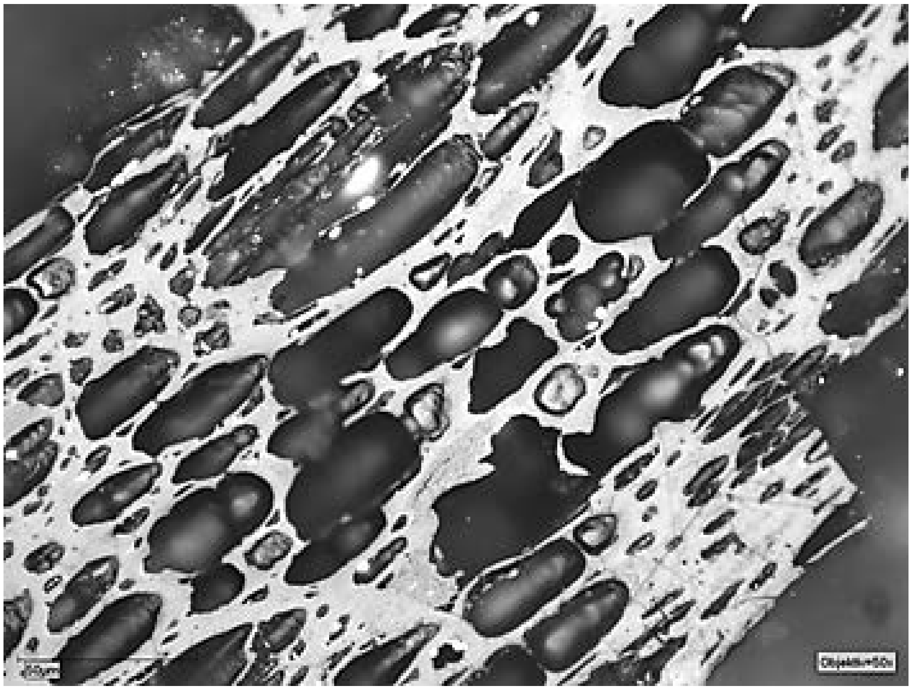

Figure 3: Organic matter; 50x objective, oil immersion, reflected white light.

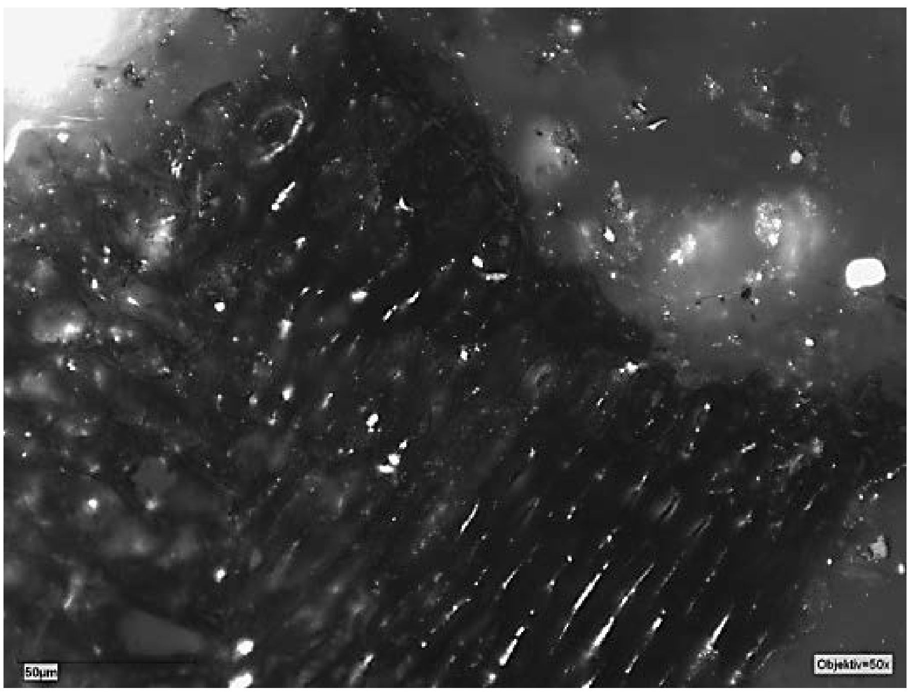

Figure 4: Organic Matter; 50x objective, oil immersion, reflected white light.

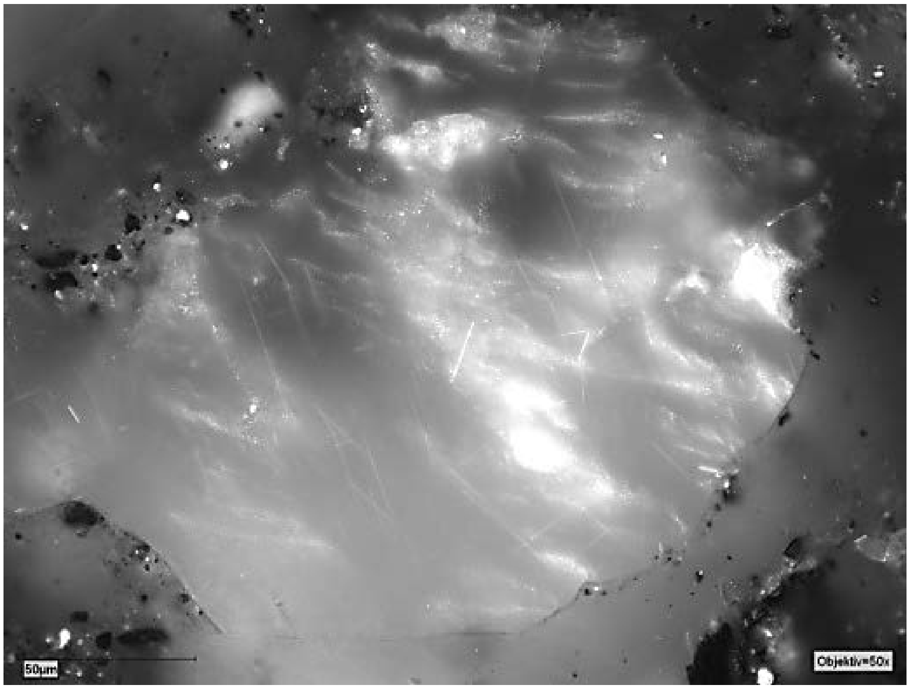

Figure 5: Mineral Matter; 50x objective; oil immersion, reflected white light.

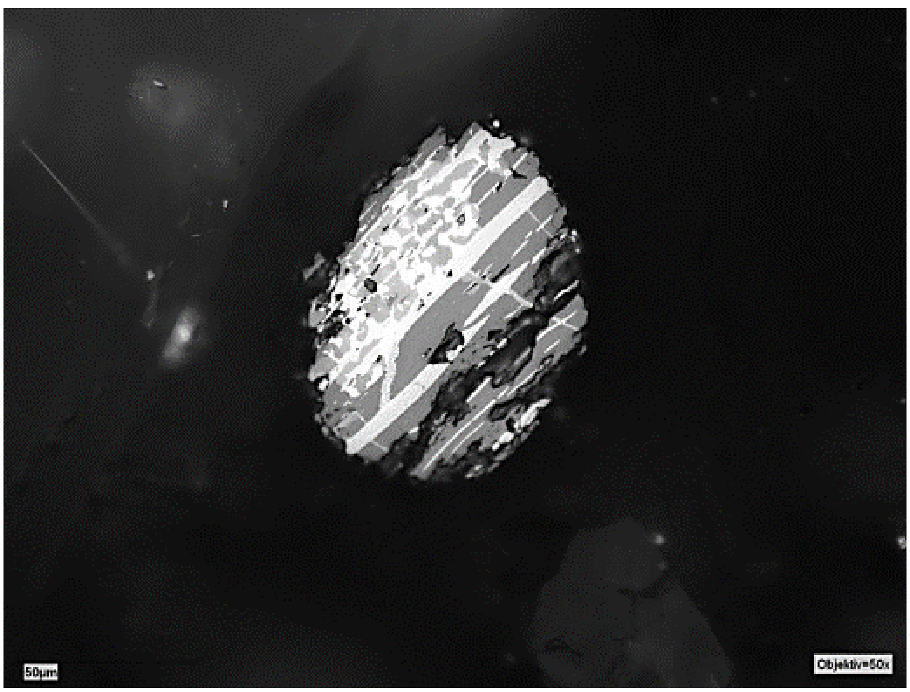

Figure 6: Mineral Matter; 50x objective, oil immersion, reflected white light.

3. Results

The results of the point count are outlined in the following table:

Sample	Coal (%)	Mineral (%)	Organic (%)
CV Shore	26.8	64.2	9.0
CV Wetlands	15.4	73.0	11.6

Quite a significant volume of coal was observed in both of the samples with 26.8% in the CV Shore sample and 15.4% in the CV Wetlands sample. The remainder of the sample was predominantly made up of mineral matter with a small volume of organic material also observed.

Appendix 2

Jones, F. (June 23, 2017). *Laboratory report - Examination of sludge deposits by stereomicroscopy and scanning electron microscopy.* UQMP.

UQMP
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LABORATORY REPORT

Subject:	**EXAMINATION OF SLUDGE DEPOSITS BY STEREOMICROSCOPY AND SCANNING ELECTRON MICROSCOPY**
UQMP Project No.	C03136.05
Prepared for:	DSITI
Prepared By:	Fiona Jones
Date:	23rd June 2017

Sample Description:		**Client Sample Identification #**	**Sample Collection Date**	**UQMP #**
	1	EHP S.V CV WETLANDS	28/04/17 12:15	UQMP # 14961
	2	CV SHORE	28/04/17 12:20	UQMP # 14962

#Method Ref: Internal UQMP method.

1. SAMPLES AND METHODS

1.1 Samples Preparation

The samples were supplied as sediments in glass jars, consisting of solids and semi solid sludge. The contents of the jars were emptied into a large beaker, large stringy plant debris was removed before mixing, demineralised water was added to allow the solids to de-clump and mix to a smooth homogenous slurry.

Three sub samples were created from each slurry for further examination, this was essential due to fine clay particles present: A plastic pasture pipette was used to remove an aliquot of the slurry on occasion extraneous vegetation would prevent the slurry from flowing into the pipette this was removed and returned to the sample.

Sub sample 1. A few drops of the slurry were washed onto a cellulose filter with demineralised water. The final sub-sample defined as “Sludge as Received”.

Sub sample 2. Consists of a few drops of the slurry filtered through a 500-micron filter onto a cellulose membrane under vacuum, the suspended fines pipetted off and retained. This sub-sample was defined as “Intermediate”.

Sub sample 3. This sample contains a few drops of the fines removed from Sub sample 2 and placed onto a cellulose membrane. This subsample is defined as “Fines”

All sub samples were collected whilst mixing to ensure homogeneity was maintained.

The particles retained on the 500-micron filter were not examined, however are retained for future reference if required.

1.2 Stereo Microscope Examination

The samples were initially examined by stereomicroscopy, using a Nikon SMZ25 stereo microscope at magnifications up to 100×.

2. SCANNING ELECTRON MICROSCOPY

A portion of each sample filter was excised and placed onto a conductive carbon tape for SEM examination. The samples were examined and analysed using a JEOL 6460LA scanning electron microscope (SEM). The SEM was operated at 20 kV in back-scattered electron composition contrast (BSE) imaging modes. In BSE images the contrast is influenced by the chemical composition (specifically the average atomic number, Z) of the material being imaged. Dark regions represent low average atomic number (light elements) and bright regions represent high average Z (heavy elements).

Regions of interest were chemically analysed by energy dispersive X-ray spectroscopy (EDS). EDS can be used to identify the chemical elements present and in some cases to provide approximate stoichiometric ratios. However, EDS is only semi-quantitative, especially when analysing small particles, for the following reasons:

- The significant size of the analysis volume (typically around 3 μm) and hence the difficulty of eliminating interference from surroundings;
- Contamination by carbon on the specimen surface and within the SEM vacuum chamber,
- The inherent sensitivity limits of the instrumentation.

3. RESULTS

This analysis was performed to determine the presence of coal and approximate percentages present. The deposits consisted predominantly of coarse to very fine grain aluminosilicate based mineral dust, typically rounded weathered particles. Black glossy angular particles examined by stereomicroscopy were identified as coal by SEM. Coal was detected in both samples at 10 %, with minor to trace amounts of plant debris and trace amounts of algae noted.

All sample fractions were examined including Sludge as Received, Intermediate and Fines. Appendix C displays the overall areas of all the fractions examined.

Appendix A attached presents the table of results of the combined microscopy observations.

Appendix B presents colour picture micrographs of the stereomicroscopy images.

Appendix C displays the Illustrative SEM photomicrographs and spectra taken of an overall area of the deposit. The SEM photomicrographs were taken with Back Scattered Electron (BSE) imaging, in which average atomic number is roughly proportional to brightness. For example, coal particles appear darker than siliceous mineral dust and biological particles somewhat darker again.

Appendix D displays an SEM BSE photomicrograph and an SEM/EDS spectrum of a coal particle.

Signed for and on behalf of UQ Materials Performance

Fiona Jones

Fiona Jones

4. APPENDIX A

4.1 TABLE OF COMBINED MICROSCOPY RESULTS

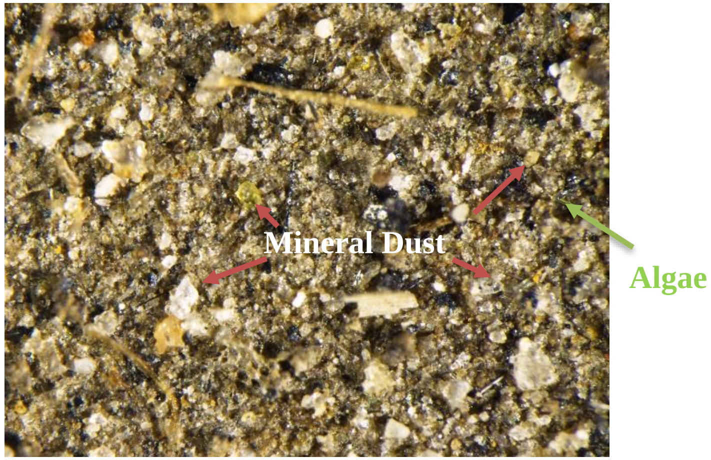
PARTICLE IDENTITY		PERCENTAGE (Projected area basis)	
	SAMPLE #	UQMP # 14961	UQMP # 14962
	SAMPLE ID / **PARTICLE TYPE**	EHP S.V CV WETLANDS	CV SHORE
BLACK	COAL	10	10
	SOOT		
	BLACK RUBBER DUST		
INORGANICS & MINERALS	MINERAL DUST (Soil or Rock Dust.)	**88**	**90**
	MINERAL DUST (type = Fly Ash)		
	MINERAL DUST (type = Cement Dust)		
	MINERAL DUST (type =glassy)		
	GLASS FRAGMENTS		
	COPPER SLUDGE		
	P/S SLIME & FUNGI		
	INSECT DEBRIS		
	PLANT DEBRIS	2	tr
	FILAMENTOUS ALGAE	tr	tr
	PLANT DEBRIS (type =)		
GENERAL ORGANIC TYPES	WOOD DUST		
	FIBRES (type = Miscellaneous)		
	STARCH		
	PAINT		
	PLASTIC FRAGMENTS		
	RED RUBBER DUST		
COMMENTS		§ The focus of the analysis was to determine the presence or absence of coal; marine biological material was not examined or classified. Large plant debris fragments were removed, as they obstruct the view of numerous particles.	

4.2 PARTICLE IDENTITY LEGEND

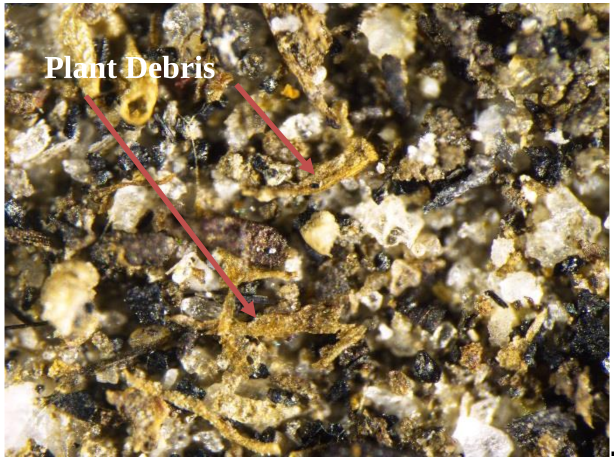
Insect parts/debris	Includes arachnids. Present as crushed body fragments, trichomes, wing scales, etc.
P/s slime	Polysaccharide slime. This extra-cellular bio-polymeric material may have different sources which might include microbiological growth, vertebrate excreta, decomposing biological matter, etc. Sometimes seen in these samples as a stringy gel binding other particles together. Sometimes fungal hyphae associated with the gel.
Copper sludge	Some well-developed turquoise crystal growths can be found, but usually as subhedral to euhedral grains. Sometimes as blue highlights on a greenish cakey material. This is probably copper salts precipitated from the copper sulfate algaecide solution as the hydroxide, with or without sulfate and or phosphorous inclusion.
Mineral matter	Usually equant siliceous appearance and typically colourless to brown, transparent to translucent, euhedral, rounded grains. The clays very fine particles. Other constituents of siliceous appearance, sand etc.
Plant Debris/ char	Usually as trichomes, fragmented tissue, reproductive products and structures. Sometimes charred particles from incinerator, grass or bush fires.
Fly ash particles	Appears as spheroidal particles - colourless, milky or black
Coal dust	Black, equant, sharp angled grains. Some glossy; some edges dark brown translucent.
Soot	Black glossy spherical to botryoidal aggregates, typically hollow or lacey. Usual source is incompletely burnt organic liquids, eg. fuel oils.

5. APPENDIX B

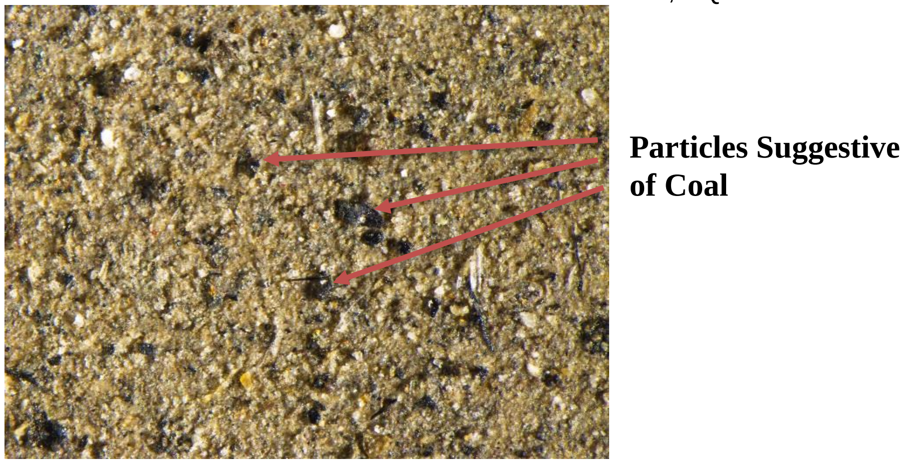
5.1 STEREOMICROSCOPY IMAGES OF THE SEPERATED DEPOSIT FRACTIONS OF THE EHP S.V CV WETLANDS SAMPLE.



A. EHP S.V CV WETLANDS, UQMP # 14961. As Received Fraction.



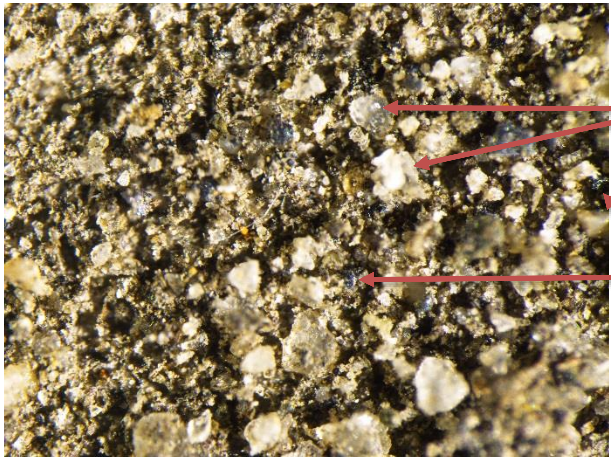
B. EHP S.V CV WETLANDS, UQMP # 14961. Intermediate Fraction.



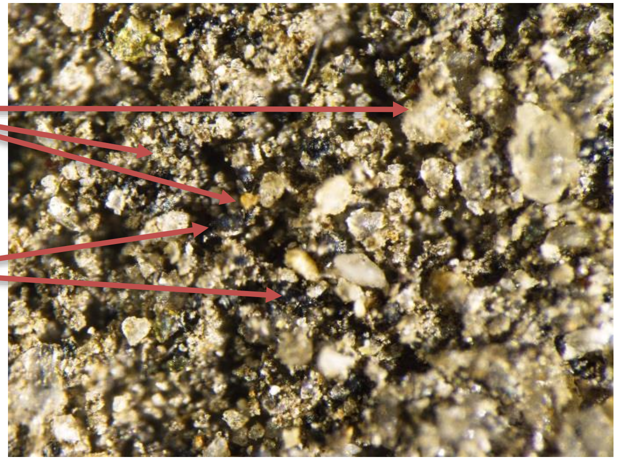
C. EHP S.V CV WETLANDS, UQMP # 14961. Fine Fraction.

All deposit fractions A, B and C display black sharp angular particulates consistent with the appearance of coal. A and B show coarse grained mineral dust particles with a range of colours from translucent, white, yellow to brown whilst C displays the same colour range with finer mineral dust particulates. The brownish yellow coloured, fibrous appearing particulates are suggestive of plant debris and small green filamentous algae is noted.

5.2 STEREOMICROSCOPY IMAGES OF THE SEPERATED DEPOSIT FRACTIONS OF THE CV SHORE



D. CV SHORE, UQMP # 14962. As Received Fraction.



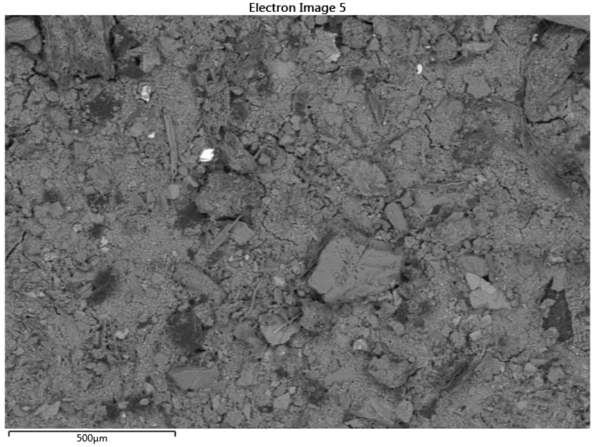
E. CV SHORE, UQMP # 14962. Intermediate Fraction.

F. CV SHORE, UQMP # 14962. Fine Fraction.

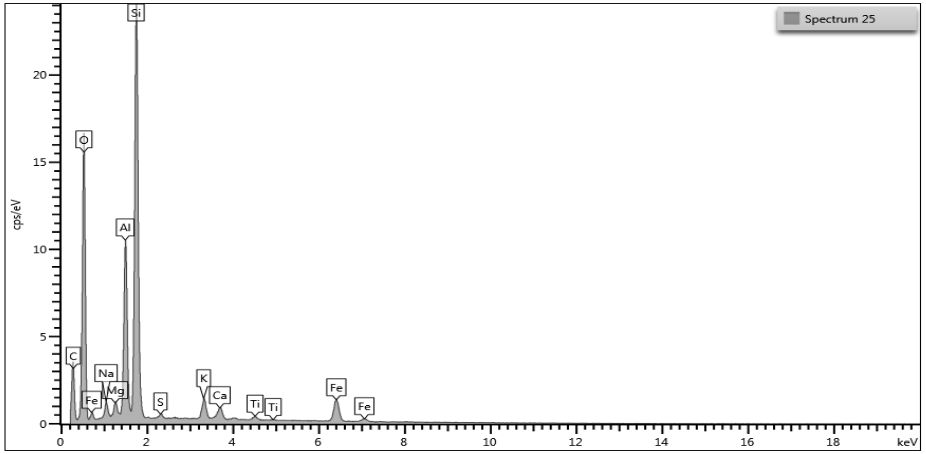
Images D, E and F display coarse and fine grained mineral dust particles from translucent, white, yellow to brown. Black glossy angular particles suggestive of coal are scattered throughout all fractions of the deposit. Plant debris is noted in the fine fraction (F) and several filamentous algae particles are also present.

6. APPENDIX C. SEM/BSE IMAGE AND SEM/EDS ANALYSIS OF THE AS RECEIVED, INTERMEDIATE AND FINE FRACTIONS OF THE SLUDGE SAMPLES.

6.1 AN SEM/BSE IMAGE AND SEM/EDS SPECTRUM OF AN OVERALL AREA AS RECEIVED OF THE OF EHP S.V CV WETLANDS DEPOSIT.

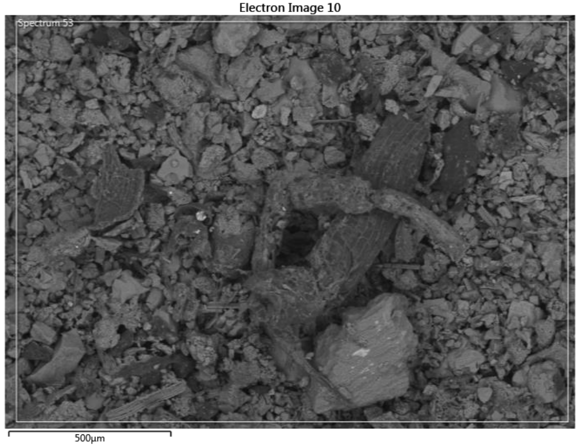


PM1. EHP S.V CV WETLANDS, UQMP # 14961, Sludge as Received Fraction. An SEM/BSE image of an overall area of the As Received Fraction, selected for SEM/EDS analysis.

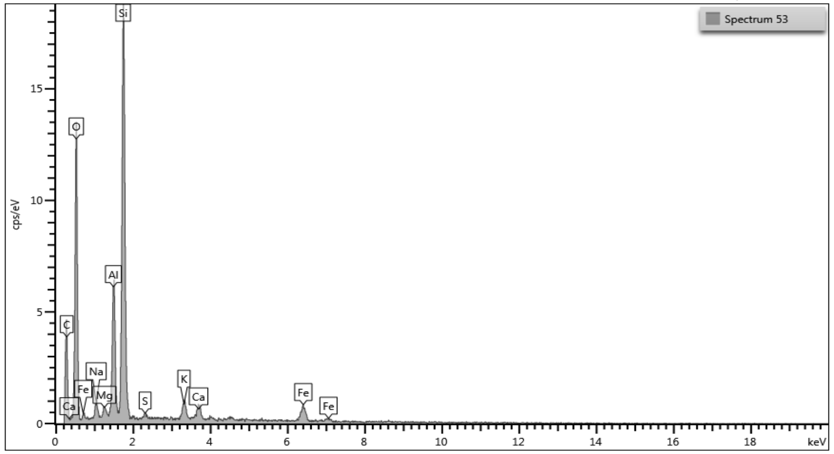


EDS1. EHP S.V CV WETLANDS, UQMP # 14961. The SEM/EDS spectrum of the overall area displays major peaks of oxygen, aluminium and silicon with minor amounts of carbon, sodium, potassium and iron and trace amounts of the balance of the elements. The SEM/EDS elemental profile is consistent with stereomicroscopy observations of the deposit consisting predominantly of mineral dust with a minor amount of organic material.

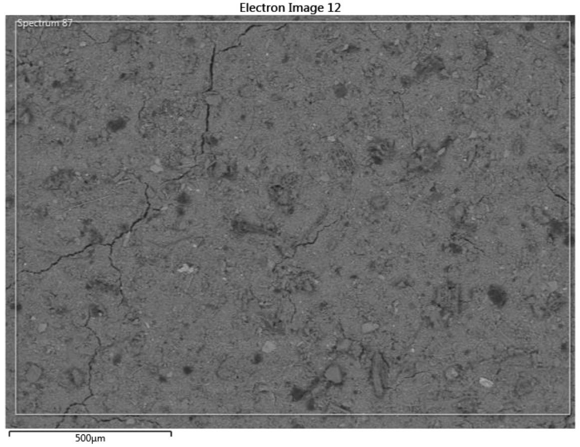
6.2 AN SEM/BSE IMAGE AND SEM/EDS SPECTRUM OF AN OVERALL AREA OF THE INTERMEDIATE AND FINE FRACTION OF EHP S.V CV WETLANDS DEPOSIT.



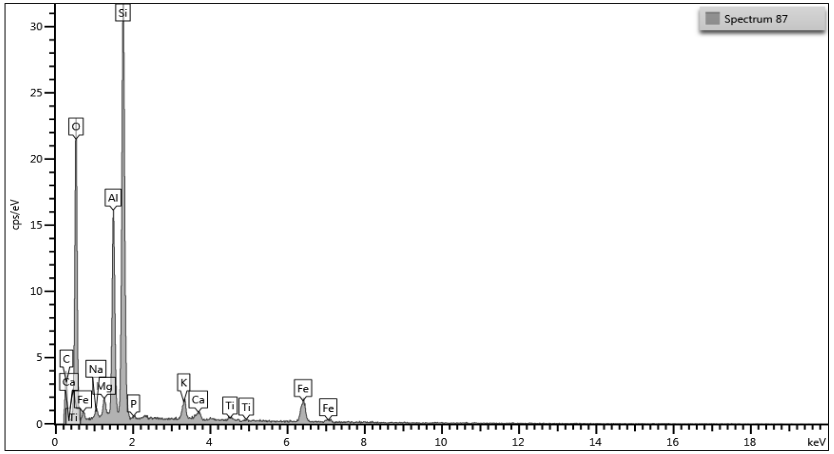
PM2. EHP S.V CV WETLANDS, UQMP # 14961. An SEM/BSE image of an overall area of the Intermediate Fraction, selected for SEM/EDS analysis.



EDS2. EHP S.V CV WETLANDS, UQMP # 14961. The SEM/EDS spectrum of the overall area displays major peaks of oxygen, aluminium and silicon with minor amounts of carbon, sodium, potassium and iron and trace amounts of the balance of the elements. The SEM/EDS elemental profile is consistent with the sludge as received fraction.

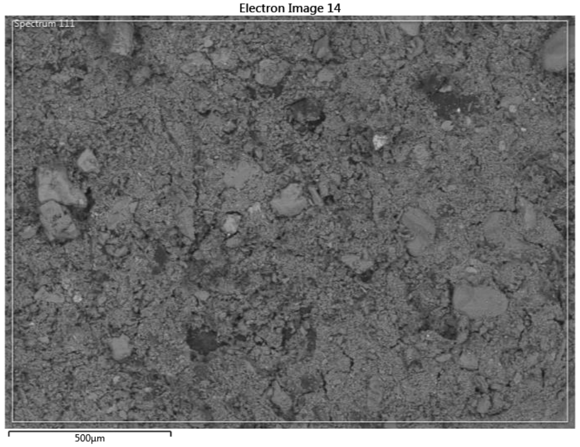


PM3. EHP S.V CV WETLANDS, UQMP # 14961. An SEM/BSE image of a characteristic overall area of the Fine Fraction, selected for SEM/EDS analysis.

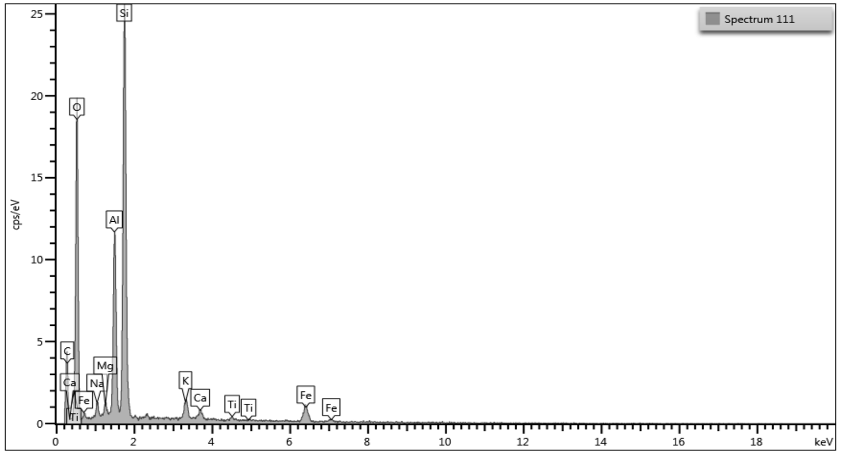


EDS3. EHP S.V CV WETLANDS, UQMP # 14961. The SEM/EDS spectrum of the overall area displays major peaks of oxygen, aluminium and silicon with minor amounts of carbon, sodium, potassium and iron and trace amounts of the balance of the elements. The SEM/EDS elemental profile is consistent with the sludge as received fraction and intermediate fraction.

6.3 AN SEM/BSE IMAGE AND SEM/EDS SPECTRUM OF AN OVERALL AREA OF THE SLUDGE AS RECEIVED CV SHORE DEPOSIT.

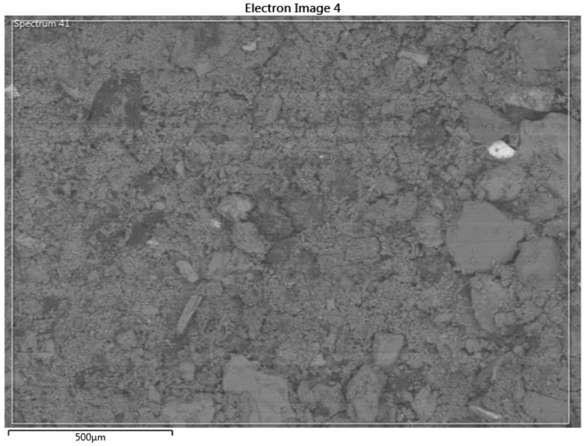


PM4. CV SHORE, UQMP # 14962. Sludge as Received Fraction. An SEM/BSE image of an overall area of the As Received Fraction, selected for SEM/EDS analysis.

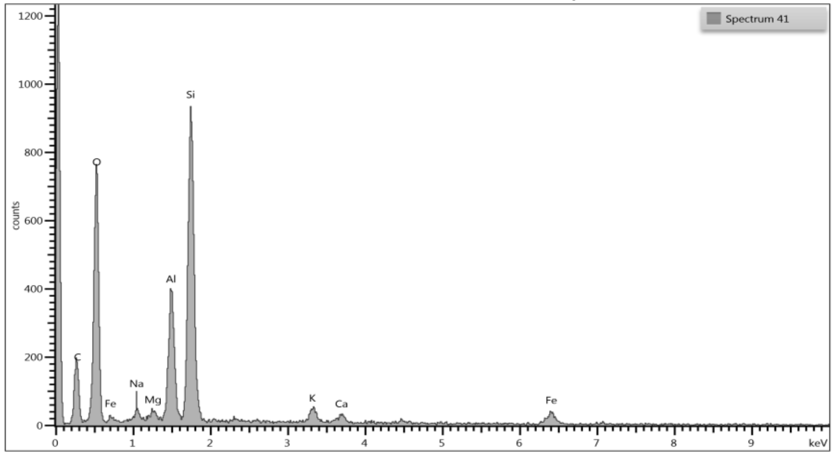


EDS4. CV SHORE, UQMP # 14962. As Received Fraction. The SEM/EDS spectrum of the overall area displays major peaks of oxygen, aluminium and silicon with minor amounts of carbon, sodium, magnesium, potassium and iron and trace amounts of the balance of the elements. This SEM/EDS elemental profile is consistent with the stereomicroscopy observations of a deposit consisting mostly of aluminosilicate based mineral dust with a minor organic component.

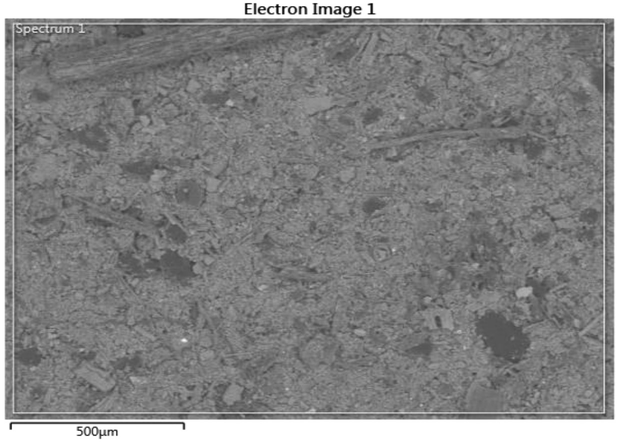
6.4 AN SEM/BSE IMAGE AND SEM/EDS SPECTRUM OF AN OVERALL AREA OF THE CV SHORE INTERMEDIATE AND FINE FRACTION OF THE DEPOSIT.



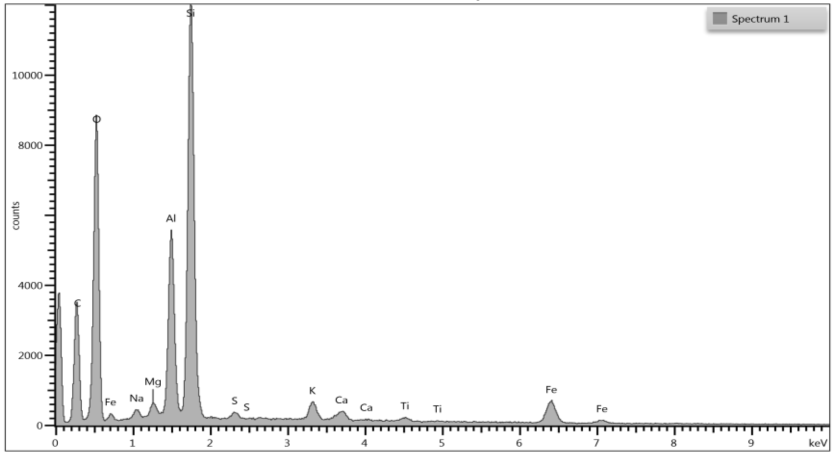
PM5. CV SHORE, UQMP # 14962. An SEM/BSE image of an overall area of the Intermediate Fraction, selected for SEM/EDS analysis.



EDS1. CV SHORE, UQMP # 14962. The SEM/EDS spectrum of the overall area displays major peaks of oxygen, aluminium and silicon with minor amounts of carbon, sodium, magnesium, potassium and iron and trace amounts of the balance of the elements.

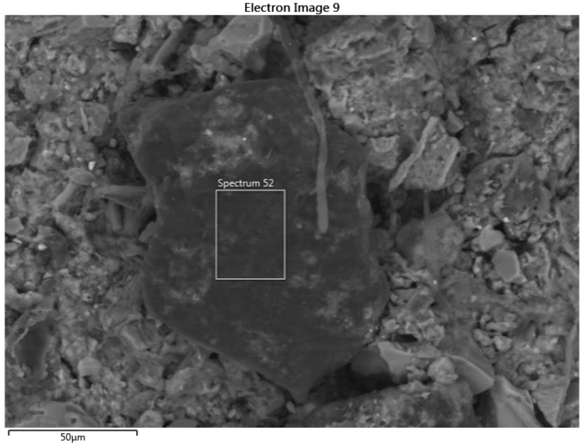


PM6. CV SHORE, UQMP # 14962. An SEM/BSE image of an overall area of the Fine Fraction, selected for SEM/EDS analysis.

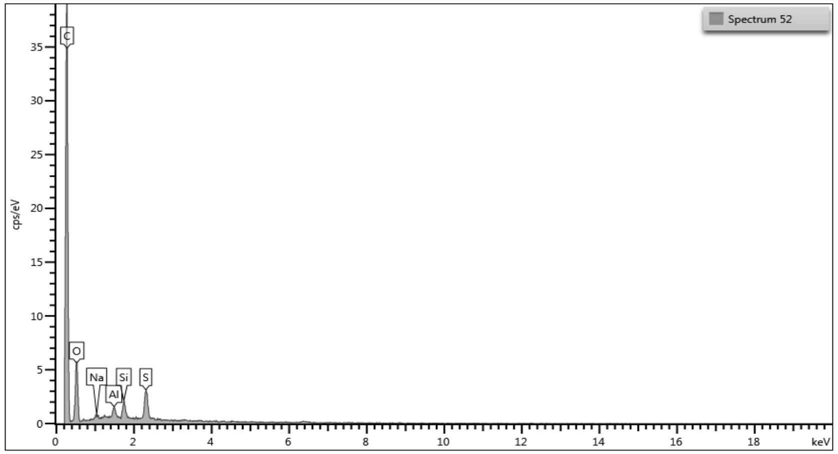


EDS2. CV SHORE, UQMP # 14962. The SEM/EDS spectrum of the overall area displays major peaks of oxygen, aluminium and silicon with minor amounts of carbon, sodium, magnesium, potassium and iron and trace amounts of the balance of the elements.

7. APPENDIX D. SEM/BSE AND SEM/EDS SPECTRA OF A COAL PARTICLE



PM7. EHP S.V CV WETLANDS, UQMP # 14961. An SEM/BSE image of a coal particle annotated with Spectrum 52 selected for SEM/EDS analysis.



EDS7. EHP S.V CV WETLANDS, UQMP # 14961. Carbon is the major element of the SEM/EDS spectrum, with minor amounts of oxygen and sulfur and trace amounts of the balance of the elements, the elemental profile is characteristic of a low ash coal particle.

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