EXPLANATORY NOTES FOR THE 1:30,000 REGOLITH-LANDFORM MAP OF WHITE DAM, OLARY DOMAIN, SOUTH AUSTRALIA

I. Lau, G.S. Heinson & S.M. Hill

CRC LEME, School of Earth & Environmental Science, University of Adelaide, SA, 5005

INTRODUCTION

The regolith and landforms of the White Dam area were mapped at 1:30,000 scale (included at rear of this paper). This was undertaken to gain an understanding of the geomorphology of the landscape, and the regolith materials in the region. A second reason for mapping the regolith-landforms in the region was to link surface materials with remotely sensed data, in particular hyperspectral imagery. Until recently hyperspectral imagery has predominantly been used to map minerals and surficial materials (e.g., Dehaan & Taylor 2004), with few published accounts of the utilisation of this technology for characterisation of regolith-landform units (RLUs). Geological mapping had previously been performed in the region at 1:250,000 (Forbes 1991) as well as 1:25,000 scale mapping to the west and south (Crooks 2002).

LANDSCAPE AND CLIMATE

The landscape of the region is part of the bedrock-dominated Olary Ranges and the flanking regolith-dominated lowlands associated with the Lake Eyre Basin and Murray Basin. The study area contains the major regional drainage divide between the Murray Basin (Murray-Darling catchment) to the south, and the Lake Eyre Basin (Lake Frome catchment) to the north. The northerly-draining system includes Bulloo Creek and other tributaries of the Mingary Creek system, which eventually terminate in the lowlands of the Strzelecki Desert. Only in exceptional circumstances may water reach Lake Frome. The far southwest of the area includes the headwaters of the southerly-flowing Olary Creek, which eventually flows onto the lowlands of the northwestern Murray Basin.

The topographic relief of the entire area is a little over 150 m, with the highest point in the southwest of the area near MacDonald Hill (which rises to 373 m ASL immediately west of the study area) and the lowest areas at about 180 m ASL in the far northeast of the study area. The climate of the area is semi-arid with ca. 200 mm of rainfall, mostly falling irregularly throughout the year (Bureau of Meteorology 2004).

VEGETATION

The vegetation of the area consists of chenopod shrubland dominated by *Atriplex vesicaria* (bladder saltbush), *Sclerolaena spp.* (copper-burrs) and *Maireana sp.* (e.g., *M. pyramidata* and *M. sedifolia* - bluebushes). Minor open woodland with a chenopod understorey includes tree species *Casuarina pauper* (belah), *Alectryon oleifolius* (rosewood), and *Acacia aneura* (mulga). Tree cover has markedly declined in the post-settlement period (since the late 1800s) for a combination of reasons, including the use of timber in construction, firewood and clearance for grazing (Jenson 2001).

LAND USE

The region has predominantly been managed for pastoral grazing since the 1860s. This has altered the vegetation cover and composition as well as changed some of the landforms. These features are obvious at paddock boundaries where different management practices have been operational. The area is presently managed with the stations of 'Tikalina', 'Bulloo Creek' and 'Bindarah'.

METHODS AND DATASETS

The digital data consisted of multispectral, hyperspectral, geophysical and topographical imagery and were examined for their usefulness when applied to regolith-landform mapping. Relatively low-cost Landsat and ASTER space-borne satellite data were compared to ortho-rectified photography and hyperspectral imagery for pattern recognition. Each dataset were used to add a different component of information to the final product. For example, geophysical datasets, such as radiometrics, were utilised for their ability to reveal information on surface materials when differentiation was inconclusive with the other imagery. Digital elevation models were found to be useful for adding landform and geomorphic information to the mapped regolith units, enabling areas of low topographic relief and rises to be differentiated.

Mapping for this exercise was performed on transparent film over 1:30,000 scale printed images. Completred polygons on film were drum scanned, digitised and imported into a GIS at Geoscience Australia (Brian

In: Roach I.C. ed. 2004. *Regolith 2004.* CRC LEME, pp. 188-193.

Pashley *pers. comm.* 2004). Onscreen mapping of the digital datasets using a GIS package (ArcView version 3.3) was used for polygon classification and final map creation. Once the information had been digitised, a small number of units were further sub-divided into different regolith-landforms on the basis of field notes and information from the integrated datasets.

FIELDWORK AND GROUND SURVEY

Three periods of fieldwork, each lasting a week, were conducted to validate and ground-truth the interpretations from the imagery. The initial period of fieldwork, following the preliminary image interpretations, consisted of transects of all the accessible station tracks to gain an overview of the area. The second field trip involved the recording of site descriptions and the collection of samples of different regolith materials for laboratory spectral analysis to compare with the HyMap™ hyperspectral responses. The final stage of fieldwork consisted of a detailed collection of samples from costeans at the White Dam Prospect and transects from the Wilkins, Green & Gold and Luxemburg regions.

REGOLITH MAPPING SCHEME

The mapping scheme used here has been adapted from the AGSO/GA Regolith-Landform Unit program, commonly referred to as the RTMAP scheme (Pain *et al.* in press). The mapped units represent surficial areas of similar landform and regolith characteristics that can be identified at the scale the mapping was performed. The units described in regolith-landform mapping are typical associations of materials and areas of similar attributes and do not necessarily represent 'pure' or 'uniform' regolith materials and landforms. The 'purity' of RLUs are scale-dependant and vary with map size (Wilford *et al.* 2001).

RLUs are first described in the field and from remote sensing imagery, including attributes such as: lithology; landform; surface materials; minor attributes; and vegetation. Polygon colours and codes on the map are used in the presentation of the RLUs. The RLU codes include three main components: the regolith materials, represented by capital letters; landforms, represented in lowercase letter codes; and, a modifier number, which is used to designate smaller variations between the major RLUs. Mapping codes are general classifications of the units and should be used to identify the mapped polygons and as a guide to the detailed descriptions only.

REGOLITH-LANDFORM UNIT DESCRIPTIONS

The following provides a description of some of the attributes of the RLUs interpreted for the mapping area, with a particular emphasis on its remote-sensing characteristics

Fill

Fm_1 (Fill, man made materials).

Fill consisted of areas of human activity where there had been direct disturbances to the regolith-landforms causing changes in the landscape or the regolith features. The construction of the Barrier Highway and trans-Australian railway had a significant impact on the paths of the drainage features that intersected both. The excavation of canals underneath the rail tracks had resulted in the creation of swamps with abundant vegetation in these regions. The area flanking the road and track were heavily vegetated due to increased water runoff.

The construction of dams and channels for the collection of water had created considerable changes in the depositional environment surrounding these features. Changes included the increase of gullying and erosion in channels or the deposition of alluvial materials as overbank deposits. In the low-lying regions, where significant disturbances have occurred, there was an increase in the ponding of water at the surface and a subsequent increase in the number of swamps. These regions were highlighted in the imagery by an increased abundance of vegetation. Where increased erosion had occurred due to a change in the environment by human interaction, the area was typically found to be bare of vegetation, which displayed a higher soil response in the multispectral imagery and a red-brown colour in the ortho-photography.

TRANSPORTED REGOLITH

Alluvial sediments

Aaw_1 and Aaw_1 (Alluvial swamp)

Swampy regions generally on topographically low-lying areas where water ponded on alluvial plains, after rainfall events (Aaw_1). Vegetation was typically dense with a mixed community of chenopod shrubs and trees. These RLUs were highlighted in the ortho-photographs by dark green to black elongate shapes adjacent to channels and dams.

Swampy depressions occur on erosional or depositional plains and were subdivided into the units occurring within channels (Aaw_1) and those that occur as depressions in alluvial regions (Aaw_2). These depressions were characterised by rounded clay playas, which displayed a high contrast to the surrounding red-brown quartzose materials in the ortho-imagery. The vegetation communities were significantly different from the chenopod shrubland, with *Eriochloa australiensis* dominating.

Aed₁ (Alluvial material in erosional depressions) and Aed₂ (Alluvial material in erosional depressions associated with moderate topographic relief and saprolite exposures)

Vegetation within minor channels and drainage features (Aed_1) was observed throughout the region adjacent to regions of sheetflow sediments. These features occurred in areas that were topographically low and thereby acted as conduits for runoff during and immediately following rainfall events. The flanking regions are sheetflow-dominated on low plains and exposures of saprolite occur in areas of moderate relief. The formation of depressions in regions of higher relief predominantly occurred adjacent to exposures of slightly weathered bedrock, which were associated with incising channels and the immediately flanking gully slopes (Aed_2). These regions were less likely to contain significant amounts of vegetation due to the higher flow rates and lower rates of water penetration into the harder substrate.

Afa_1 (Alluvial material in an alluvial fan)

Floodout fans of alluvial material (Afa_1) were typically found on a variety of landforms where changes in the energy regime and channel confinement had occurred. Typically the outwash fans occurred where an incised channel encountered a larger, less confined channel or alluvial plain. Fans were also associated with abrupt changes in the slope gradient, relating to the watercourse passing through different landforms. The fans represented a change from narrow, deeply incising channels to broad plains containing meandering channels. The fans were typically densely vegetated by shrubs (e.g., *Xanthium sp.*) or were sparsely vegetated and contained abundant amounts of lithic gravels.

Aap_1 and Aap_2 (Alluvial material on an alluvial plain)

Alluvial plains are related to areas of alluvial material forming low-lying landforms associated with channels and depressions (Aap_1). The material adjacent to the channels was dominantly alluvial in origin, with some sheetwash input and reworking. The banks of the channels were mostly vegetated by chenopod shrubland and low forbs. A distinction was made between the landforms where the banks and areas adjacent to the channels did not contain vegetation and the red-brown colouration of the alluvial materials could be seen in the imagery (Aap_2). Typically the floors of the channels and depressions were vegetated, predominantly by grasses and chenopods, with minor *Acacia aneura.*

Channel deposits

ACa_1 (Alluvial channel in an alluvial landform)

Alluvial channels consisted of drainage features containing lithic material, predominantly quartzose, feldspathic and micaceous fragments as well as red-brown quartzose sands. The channels were mostly bare of vegetation. The banks of the ephemeral watercourses and flanking areas were typically lined by chenopods and trees. Minor exposures of highly weathered saprolite occurred in areas proximal to topographically elevated regions where the channel was incising into shallow valley-fill material.

Overbank deposits

$Aoap_1$ and, $AOap_2$ (Alluvial overbank deposits on alluvial plains)

Areas of low relief, flanking channel systems associated with valleys that contained lithic fragments, quartz sands and abundant clays were mapped as overbank deposits. These regions have a dark, brown-red colouration with lighter orange-brown rounded mottles representing the alluvial deposition of material from overflow of the adjacent channels during ephemeral flooding events. The overbank regions displayed distinct dark, brown-red and yellow -brown circular features, observed as a mottled appearance in the ortho-imagery.

Aeolian sediments - Aeolian sand

$ISps_1$ (Aeolian material on aeolian sand plains)

This RLU was tentatively interpreted on the basis of the presence of tree stands occurring in circular to oval-shaped gatherings on red-brown materials. The unit typically occurred on depositional plains, surrounded by sheetwash and alluvial materials.

Colluvial sediments-sheetflow deposits

These landforms occurred flanking most of the prominent bedrock and indurated regolith exposures. The dominant mechanism of sediment transport was by way of shallow overland flow, with slope creep and rock fall providing a minor input.

$CHfs_1$ (Sheet-flow material on a sheet-flood fan with abundant quart lag) and $CHfs_2$ (Sheet-flow material on a sheet-flood fan with abundant)

Regions characteristic of shallow overland water flow were dominated by sheetflow processes, which displayed prominent vegetation contour banding. These were flanking areas of low to moderate topographic relief. Surface materials alternated from abundant quartzose lag ($CHfs_1$) to bare soil and soil crusts with minor lag ($CHfs_2$). The units were typically flanked by minor channels, containing linear stands of vegetation perpendicular to the contour banding. The units blended into regions of discrete vegetation banding as the slope angle decreased.

$CHpd_1$, $CHpd_2$ and $CHpd_3$ (Sheet-flow material on a depositional plain)

Areas where the surficial transport was dominated by overland sheetflow of colluvial materials, in low-lying topographic regions was mapped as CHpd. Surface lags and gravels were widespread throughout the areas mapped within this RLU. Vegetation consisted of poorly linear banded to isolated groupings of chenopods, representing the weak influence of the surface transport mechanism in their formation and orientation, in contrast to the vegetation of CHfs RLUs. Sheet wash materials derived from adjacent regions of higher relief are deposited in this RLU.

$CHep_1$ and $CHep_4$ (Sheet-flow material on an erosional plain)

Areas of bare soil with minor vegetation growth occur throughout the lower-lying topographic regions, typically adjacent to alluvial channels that have energies transitions from moderate to low energy. These RLUs were characterised by surface incision by shallow rills, perpendicular to topographic contours. Vegetation was sparse and limited to low forbs with a well-developed cryptogam cover. $CHep_4$ occurred in regions adjacent to saprolite exposures and areas of subcrop with a low abundance of vegetation cover. The materials at the surface were dominated by ferruginous saprolite and indurated materials. This unit displayed a distinctive dark red-brown colour in the ortho-imagery and a smooth surface texture.

$CHep_2$ and $CHep_3$ (Sheet-flow material on an erosional plain)

$CHep_2$ and $CHep_3$ were colonised by dense vegetation clumps with varying abundances of quartzose gravels. These units had a dark green and white mottled appearance representing the alternating quartz and vegetation surface cover.

$CHed_1$ (Sheet-flow material in an erosional depression)

This RLU consisted of cobbles of lithic materials and quartzose gravels in elongate drainage depressions. The depressions typically occurred adjacent to saprolite exposures in areas of moderate topographic relief. The gravels also occurred lower in the landscape, adjacent to larger alluvial channels, where gravel lags had been deposited in linear hollows parallel to slope.

$CHel_1$ (Sheet-flow material on a low hill)

Colluvial and sheetflow material, dominantly lithic materials from adjacent saprolite exposures or subcrop on topographically elevated regions, was mapped as $CHel_1$. A thin layer of red-brown quartzose sands typically mantles the underlying saprolite and colluvial materials.

$CHer_1$ and $CHer_2$ (Sheet-flow material on a low erosional rise)

These units formed extensive regions in the northern and central portions of the mapping area. The sheetflow materials were associated with the low rises and gently undulating topography. The surficial regolith materials consisted of sub-angular lithic and quartzose gravels with minor red-brown quartzose sands forming a 'patchy' contour banding pattern. These regions typically contain RCAs within the regolith. The RLU is typically colonised by a sparse chenopod shrubland dominated by *Atriplex vesicaria, Maireana spp*. shrubs and *Casuarina pauper* trees.

Cep_1 (Colluvial material on an erosional plain)

The colluvial material flanking saprolite exposures or basement subcrop typically has a pale grey-blue to white mottled appearance in the ortho-photography, representing the lithic and quartzose cobbles and gravel lag materials dispersing downslope. A thin layer of red-brown quartzose sand mantles this unit and is mixed with the surface lags. This RLU typically grades into sheetflow-dominated units that are colonised by dense chenopod shrublands, making the location of the boundary difficult to spot on the ortho-imagery.

***Cer_1* (Colluvial material on an erosional rise)**
Regions of colluvial material mantling the slopes of low to moderate topographic rises, which display a smooth texture and a grey-blue colour in the ortho-photographs were mapped as Cer_1. The material typically consists of lithic and quartzose cobbles and gravel lags. Vegetation is typically sparse although the surface lags may be coated by cryptograms, causing the colouration seen in imagery.

***IN SITU* REGOLITH**
Saprolith - Moderately weathered bedrock
SMer (Moderately weathered saprolite on low erosional rises)
The moderately weathered bedrock materials are mostly confined to areas of relatively recent erosion, such as gullies or sheet-eroded areas. The moderately weathered material was highly friable, and easily fell apart when kicked. Most of the moderately weathered bedrock types were schists. Where the slatey cleavage has opened up, kaolinite had replaced many of the primary alumino-silicate minerals and displayed a weak ferruginous staining. Typically the saprolite has a well-developed cryptogram cover. Powdery and minor hardpan regolith carbonate accumulations occur more extensively on calcareous and dolomitic bedrock types. These lithologies typically have well developed rillen-karren and surface dissolution features (Ashley *et al.* 1998). The landscape expression for this unit was typically subdued and mostly formed erosional rises with 9-20 m topographic relief within slightly elevated rounded exposures within depressions of alluvial units. In the ortho-photography, this unit contains pale red to light blue mottles within red-brown areas on alluvial plains and erosional rises.

Saprock Slightly weathered bedrock
***$SSel_1$* (Slightly weathered saprolite on low hills)**
Exposures of bedrock in areas of moderate topographic relief (20-70 m) displayed a grey-blue appearance in the ortho-imagery. Mantles of red-brown fine quartzose sand were typically thin. Isolated and stands of *Acacia aneura* and *Casuarina pauper* occurred across some of the exposures.

***$SSer_1$* (Slightly weathered saprolite on erosional rises)**
The regions classified by this RLU typically contain a shallow layer of red-brown quartzose sands partially concealing the basement exposures. The unit appeared pale-red-brown with isolated blue-grey patches in the ortho-imagery, representing exposures of saprock. These regions typically flanked exposures of saprock on the crests of rises and low hills.

SUMMARY OF THE REGOLITH-LANDFORMS OF THE WHITE DAM AREA
The White Dam area consists of both bedrock- and regolith-dominated areas. The central and eastern parts of the mapping area consists of low and subdued landforms, whereas the MacDonald Ranges and the area to the north of the White Dam Prospect display moderate topographic relief. Saprolite is exposed in topographically elevated areas and on erosional low relief landforms. The saprolitic material in the lower regions was more highly weathered than the exposures of the MacDonald Ranges. The exposures are typically flanked by regions dominated by sheetflow processes, containing transported materials. These regions were dissected by depressions and channels which carry the eroded material to topographically lower-lying landforms. Deposition of the transported sediments occurred in the regions of low-lying topography, characterised by broad alluvial plains and swampy depressions.

Vegetation and surficial materials were useful as mapping surrogates. The presence of colonies of *Maireana sedifolia* were correlated with the presence of RCAs at shallow depths. These regions are typically associated with erosional rises, with a thin friable regolith substrate.

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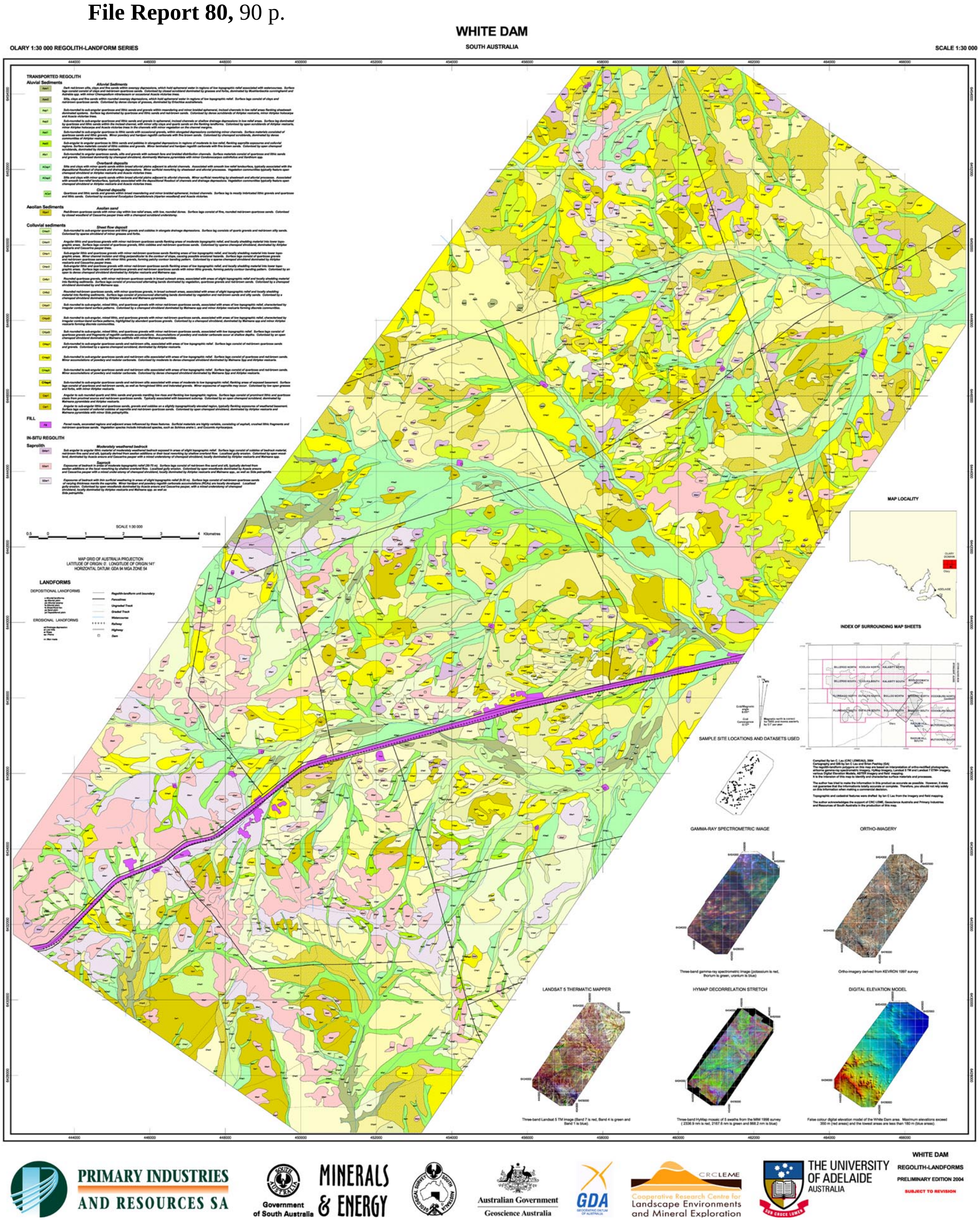

The White Dam 1:20,000 regolith-landform map (not to scale).