A SYSTEMATIC WEB-BASED APPROACH FOR THE ACQUISITION, COLLATION AND COMMUNICATION OF SOIL-REGOLITH DATA

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INTRODUCTION

Soil-landscape systems are inherently complex and the product of a unique integrative history of ancient and modern hydro-pedological processes. This makes it difficult for scientists and resource managers to assess the sustainability of environmental systems, i.e., to make balanced and integrated judgements on natural resource and environmental conditions in specific regions. Assessing soil-landscapes involves selecting key attributes and methods to describe, quantify and integrate pedological, hydrological, geological, biogeochemical and mineralogical information. This is in order to seek answers to important environmental questions across a variety of temporal and spatial scales (i.e., varying from molecular scale up to the macroscopic environmental systems scale in paddocks, catchments or regions). To incorporate these factors, Fitzpatrick *et al.* (2003) developed a systematic approach (a sequence of steps) to construct easy-to-follow pictorial manuals for identifying critical soil indicators, land use options and best management practices. These manuals contained sketches of typical landscape cross-sections (i.e., idealised descriptive, explanatory or 4D predictive mechanistic toposequence models) with colour photographs of soils to enable farmers to readily compare these features with their own soil-landscapes. This approach has been successfully applied and adopted in three regions (Mt Lofty Ranges in SA, Victoria and Iraq marshlands). However, apart from these areas the approach has not been adapted to other regions around the world, probably because: (i) there is no easy-to-follow systematic framework for helping construct the toposequence models; and, (ii) colour manual printing and changes are expensive.

Hence, the objective of this study was to describe a systematic web-based data site approach for improved acquisition, collation and communication of diverse soil-regolith data by incorporating examples from existing projects. A significant problem with large multi-organisational and multi-disciplinary research efforts is uniformity in data acquisition, collation and communication (ACC). This can be overcome, independent of project size, by implementing a series of minimum, basic requirements that must be adhered to during ACC. This systematic approach incorporates any or all of the highly effective techniques for soil-regolith field description protocols, such as the USDA Field book for describing and sampling soils (Schoeneberger *et al.* 2002), Australian Soil and Land Survey Field Handbook (McDonald *et al.* 1990) and using Munsell Soil colour notation (Munsell Soil Color Charts 1994) as well as the commonly used project management tools (e.g., GANTT charts, etc.) to create a flexible and dynamic template for ACC. The steps outlined in this paper will assist in:

- Planning environmental and mineral exploration soil-regolith projects of any size;
- Maintaining uniformity of field protocols and hence quality of data acquisition;
- Rapid and effective communication between a multidisciplinary project team;
- Dynamic progress reporting to client and other interested parties;
- Production of a final report;
- Providing a cost effective alternative to colour filled pamphlets and booklets; and,
- Reporting findings to the general public via the internet.

This new approach was originally inspired by: (i) the difficult task of collating large quantities of geological, soil, hydrological, geochemical and mineralogical data to construct mechanistic toposequence models; and, (ii) effectively communicating this information as part of a PhD thesis. To solve this problem, a high level of data organisation was achieved through a web-based data site, thus allowing large quantities of information to be rapidly discussed and reviewed in a logical manner. Subsequently, it was deemed advantageous to adopt and expand on this approach to develop a framework to cope with vast quantities of data generated by a large multidisciplinary acid drainage project in the wheat belt of Western Australia (Rogers & George 2005).

Scientific researchers are often faced with the task of summarizing, condensing and effectively communicating large amounts of complex data. It is difficult to collate and link large quantities of diverse data in multidisciplinary projects (Benda *et al.* 2002). Poor planning and a lack effective communication can

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produce vast quantities of eclectic and confusing information that is difficult to digest. Universities and research organisations produce countless remarkable discoveries, insights and advances. However, their ability to share this knowledge with the community, government and industry rarely matches their research capability (Cribb & Hartomo 2002). Consequently, a structured approach is needed to ensure suitable soil-regolith indicators are selected and used efficiently.

METHODOLOGY

The methodology discussed in this paper looks at ways of structuring large data sets to provide a tool for rigorously planning data acquisition, coupled with rapid and effective communication. Web display and delivery was chosen due to its almost universal availability. While Microsoft FrontPage 2003 was used to construct the web based data set, any web authoring software is appropriate. The data web site manager requires a basic-to-advanced knowledge of the web authoring program (depending on the desired sophistication of the data site) and a good scientific grasp of the data being displayed. The steps below (Box 1) outline the procedures necessary for developing a generic soil-regolith, web-based data set.

BOX 1: Steps for constructing a web-based data set.

Stage 1. ***Prior to field work***

a. Define the project objectives;
b. Identify the spatial coverage of the area to be studied;
c. Break the area down into sites where observations and samples will be taken (new sites can be added at any time during field work);
d. Identify methodologies and laboratory techniques required, available and budgeted to achieve project objectives; and,
e. Ensure field equipment required for sample collection is appropriately matched to chosen methodologies and laboratory techniques.

Stage 2. ***In the field (at each site)***

a. Reconfirm site location with GPS;
b. Photograph site from a number of perspectives including any defining features (e.g., large trees) in fields of view;
c. Sample and describe soil, rocks, vegetation according to established conventions (e.g., McDonald *et al.* 1990, Schoeneberger *et al.* 2002) and appropriate to the techniques that will be applied in the laboratory;
d. Collect representative sub-samples to be stored in chip trays;
e. Photograph each sample, with scale, from a minimum of two perspectives and zoom settings; and,
f. Draw a brief schematic highlighting important landscape features, photograph locations and sample locations.

Stage 3. ***Data collation and communication***

a. Construct a site locality map using appropriate software (e.g., Arc GIS) to begin to highlight any spatial relationships between sites (Figure 1a);
b. Import map into web authoring program;
c. Use site photos and information from schematic and field notes to construct a summary web page of each site, providing some general information and links to more detailed data (Figure 1b);
d. Use HyperText Markup Language (HTML) to hotlink each site locality on the map (Figure 1a) to the corresponding site summary web page (Figure 1b);
e. Use sample photos and field notes to construct a summary page for each sample, group of samples or profile as appropriate (Figure 1c) and use HTML to link back to site summary web pages (Figure 1b);
f. Create data summary pages for each sample, group of samples or profile that contains or has links to all detailed field observations and laboratory results (Figure 1d);
g. As more data is returned from the Laboratory it can easily be added to the data site via the data summary pages (Figure 1d);
h. Once all the data has been uploaded to the web site, HTML links can be incorporated to highlight relationships between samples from different locations that share physical and chemical characteristics;
i. Further data interpretation facilitates the addition of graphs, statistical analysis, diagrams and conceptual models to the web site. This provides a convenient storage location that keeps the interpretation within the bounds of the project; and,
j. Each product of interpretation (e.g., graphs, conceptual models, etc.) is HTML-linked to the sample, sample site and data that produced it (Figure 1e).

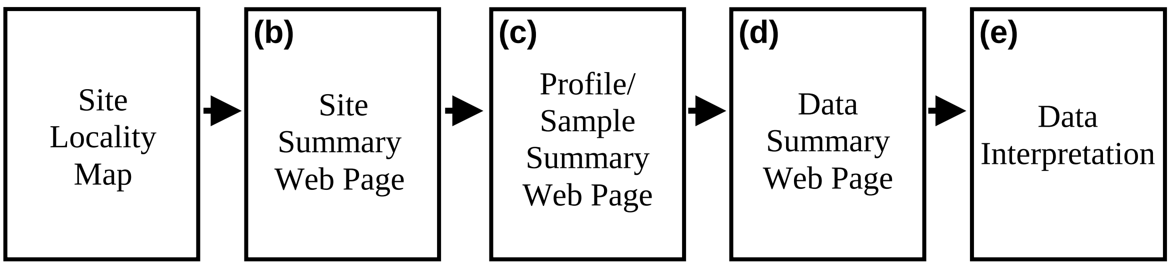

Figure 1: Flow diagram outlining the main components of a web based data set.

DISCUSSION

The steps listed in stages 1a-e (Box 1) seem obvious but are vitally important for the efficient and cost-effective implementation of a field-based soil-regolith project. Careful planning can shorten time spent in the field and reduce the likelihood of unnecessary follow-up data collection. Identifying all possible methodologies and laboratory techniques that may be used during the project will mean that any specialised equipment required for data collection will be on hand.

Stage 2a-2f (Box 1) outlines the steps that should be taken to maintain the value of data collected in the field. Irrespective of the money spent on laboratory techniques and sample analysis, data becomes useless if we don’t know where the sample comes from or its context in the regolith environment. A mud map recording sample and photo locations aids in accurately documenting data collection. Chip trays provide a simple yet vital method of communicating regolith characteristics to: (i) members of a project team; (ii) the client; and, (iii) the scientist conducting subsequent laboratory investigations. Chip trays are photographed and digitally incorporated into the web-based data site to facilitate rapid communication. Digital photos are an effective method of documenting site and sample characteristics. They aid memories and provide relative locations at sample sites. Photographs are an excellent method of communication and hence a vital component of a web-based data set for collating and communicating soil-regolith information.

The points raised in stage 2 (Box 1) do not replace good quality, thorough field observations. These steps simply ensure that field work maintains its value whilst providing the means to construct a tool for highly effective and rapid communication.

Stage 3a-j (Box 1) concerns the collation and subsequent communication of soil-regolith data collected in the field. The aim of the web-based data set is to provide HTML links in every location a user requires further information. This can only be achieved if the data set manager has a firm grasp of the science being displayed and the requirements of the end user. The first stage is to group data according to where it was collected. This is most easily achieved by constructing a map of the study area delineating site locations (Figure 2(i)). The locality map, when linked to the site summary pages, allows rapid and simple navigation between sites and provides links to more detailed information. The location of each sample or group of samples taken at each site is displayed on photos in the site summary pages (Figure 2(ii)). This provides an accurate record of a sample's locality relative to others and their spatial distribution in the regolith environment. For this reason it is vital to obtain quality site photographs in the field (stage 2(ii)). Each sample, group of samples or profile can then be investigated in more detail via an HTML link to a sample summary page (Figure 2(v)). These pages give more detailed information on each sample and their location within a profile or group of samples. Quality photographs, with a scale, of each sample can be invaluable in later data interpretation. Data summary pages (Figure 2(vi)) contain or have direct HTML links to all the observations and data recorded in the field (pH, Eh, etc.), subsequent laboratory observations (colour, texture, etc.) and results from laboratory techniques (XRD, XRF, ICP-MS, etc.). Once the basic structure of the data site (described above) has been constructed any additional data can be added quickly and easily. Data, such as SEM photos, can be made available as soon as they have been acquired (Figure 2(vii)). Chip tray photos can be added to save the need for retrieving samples from storage (Figure 2(viii)). Often multi-organisational and multi-disciplinary research efforts involve team members spread over vast distances making it impractical for all to have accesses to samples. Spreadsheets containing geochemical data (e.g., XRD (Figure 2(ix)) and XRF (Figure 2(x)) can be made available for download, via the data site, without risking the original data. There is no practical limit to the amount and type of data that can be stored and displayed in this fashion (Figure 2(iii)).

Interpretation can commence coincident with, or following, data upload to the web-based data site. Data can be grouped via HTML links according to shared physical and chemical characteristics. Interpretive models (Figure 2(iv)), graphs, statistical analysis and other forms of interpretation can be included in the site. The advantage of this is that interpretation does not exist independent of the data that created it but is instead instantly accessible via HTML link.

The web based data set provides a dynamic framework to manage large, complex projects (Figure 3). A project team often includes numerous scientists from many different fields (Figure 3a). A huge range of eclectic information is gathered during the life of a multidisciplinary project (e.g., geochemical data, soil data, water chemistry and spatial information). These data are passed on to the data web site manager (Figure 3b) who collates it (described above) to produce a web-based data set (Figure 3c). The data set can then be used by the different members of the project team to communicate internally. Information is easier to interpret (Figure 3e) because it can be viewed within the context of the whole project rather than discipline defined subsections. Throughout the project the client has access to the collated data and the subsequent interpretation via the web-based data set (Figure 3d). This improves communication between the client and project team thus increasing the likelihood of a satisfactory outcome for all parties.

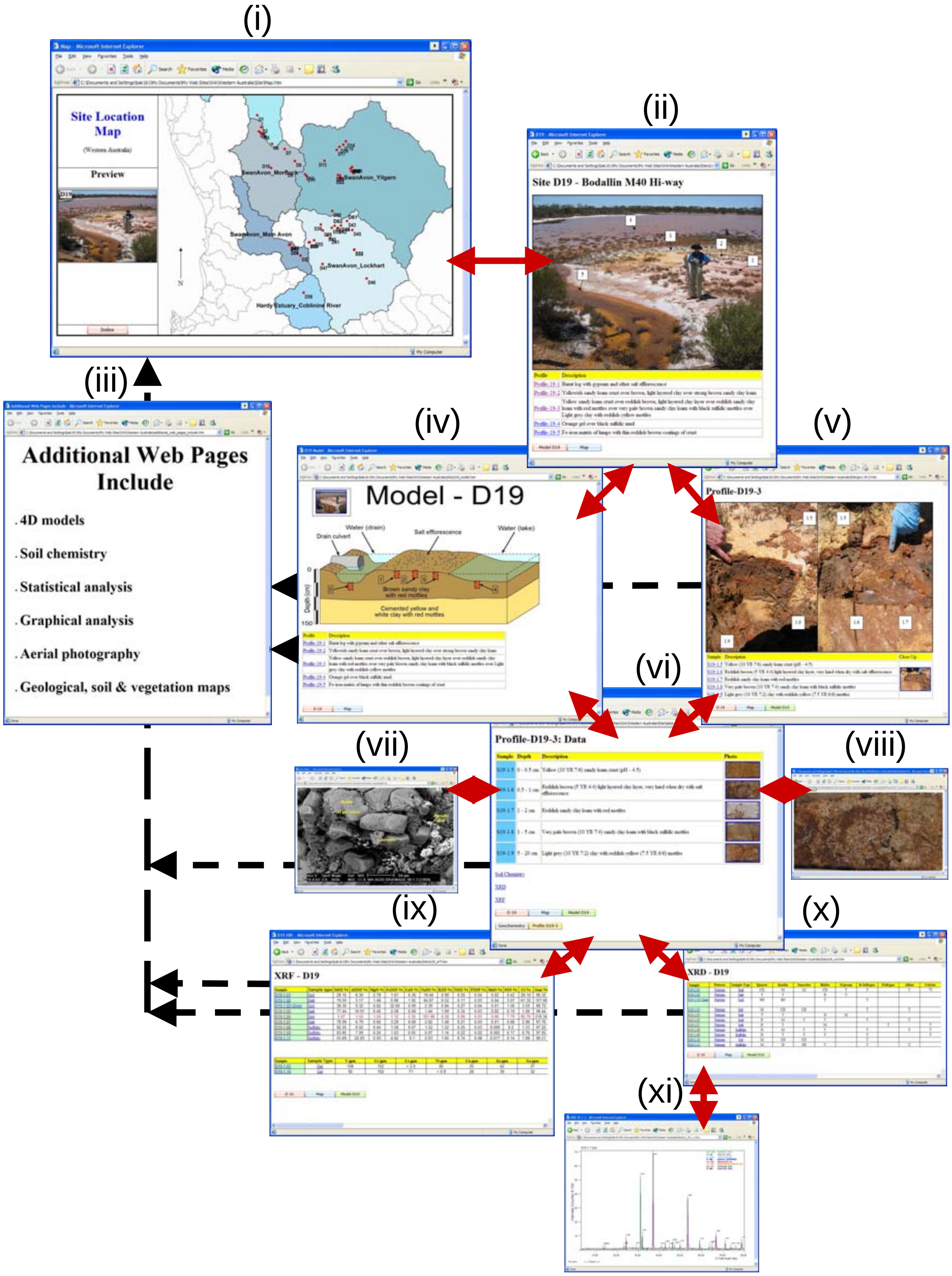

Figure 2: Flow diagram constructed of web views from a Western Australian acid sulfate soil web-based data set. Views represent: (i) Site locality map; (ii) site summary web page; (iii) additional web pages that were included in the data set; (iv) 3-dimensional, interpretive model; (v) profile/sample summary page; (vi) data summary page; (vii) SEM photograph; (viii) chip tray photograph; (ix) XRF data; (x) XRD data; and, (xi) XRD spectra.

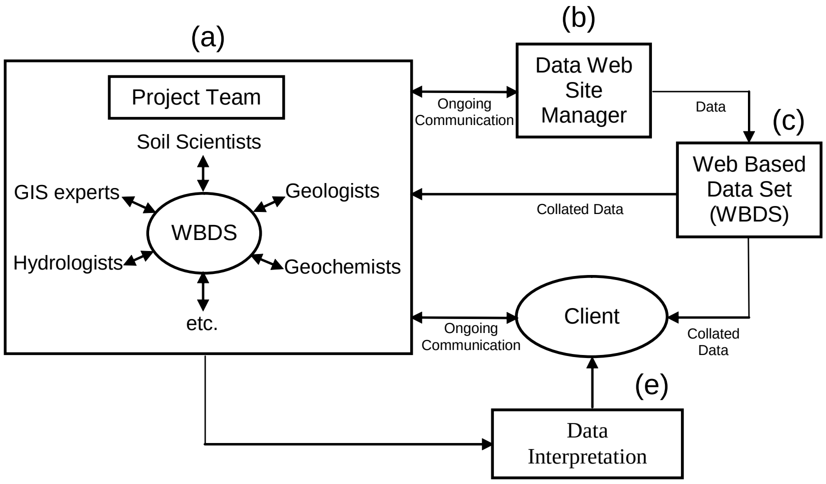

Figure 3: How a web-based data set should be used as part of a dynamic framework to manage large, complex projects.

An extension of the web-based data site is to use a SharePoint web site. This allows any member of a project team to add and alter information on the site. Any additions or updates to a SharePoint web site occur immediately. The site is always live and reflects changes as they are made. This can, however, create confusion as team members use the SharePoint site as a dumping ground for data. The site will rapidly lose cohesion unless everyone with access has excellent communication skills and a firm grasp of the authoring program and the data being entered. It is hence recommended that SharePoint sites be avoided for the authoring of this type of data site.

An alternative is for team members to create data site sections that can be screened and uploaded by the data site manager. In this circumstance a SharePoint web site is very useful for exchanging data between team members and conveying data and/or data site sections to the data site manager.

FUTURE WORK

The web-based data site described above has been adopted for the following two national projects:

- National Atlas for Coastal Acid Sulfate Soils (managed by CSIRO Land and Water, coordinated by The National Committee for Acid Sulfate Soils); and,
- National Atlas for Inland Acid Sulfate Soils (managed by CRC for Landscapes Environments and Mineral Exploration, coordinated by The National Committee for Acid Sulfate Soils)

These data sites will be integrated with web-based acid sulfate soil maps located on The Australian Soil Resource Information System (ASRIS).

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