USING ARCPAD® TO IDENTIFY SOIL PROBE LOCATIONS FOR VERIFYING SOIL RESPREAD THICKNESS ON RECLAIMED LAND[1]

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Abstract: North Dakota Public Service Commission (NDPSC) policies require that soil respread thickness be verified by soil probing reclaimed land prior to bond release approval. The topsoil and subsoil thicknesses observed from soil probing were compared to those presented on the bond release application soil respread thickness map. Soil respread thicknesses usually vary within the bond release area as grade approvals were submitted during contemporaneous reclamation. The objective of this paper was to identify soil probe locations within soil respread thickness boundaries using tablet computer software. The use of ArcPad software with GPS positioning on a tablet computer allowed accurate probe placement within soil respread thickness boundaries when displayed on geo-referenced raster images or as shapefile polygons. The topsoil and subsoil thickness observations and supporting data were recorded in an ArcPad QuickForm® created for the soil probe location shapefile. The QuickForm was activated by capturing a GPS point at each probe location. Additional data fields of the soil probe shapefile attribute table were populated after adding the shapefile to an ArcMap® map document. The shapefile attribute table was exported to analyze the data in spreadsheet form. Soil probe locations collected as spatial data in ArcPad allow subsequent analysis and display in an ArcMap map document.

Additional Key Words: suitable plant growth material, grade approval, bond release, point location

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Introduction

The redistribution of adequate topsoil and subsoil, collectively termed suitable plant growth material (SPGM), is critical for the successful reclamation of North Dakota's surface coal mined land. All topsoil must be removed from mine disturbance areas for redistribution, while sufficient subsoil must be removed from mine disturbance areas to satisfy redistribution requirements. Subsoil redistribution requirements typically vary based on the graded spoil quality. The SPGM respread thicknesses presented in a bond release application must be verified by soil probing prior to granting bond release approval to ensure that the proper depths of SPGM were respread.

Prior to redistributing SPGM over a disturbance area, the mine must submit a grade approval package that includes a post-mining topography map and a map identifying the thickness of SPGM to be respread over the graded area. Although there are exceptions, the subsoil redistribution thickness proposed in a typical grade approval package is based on the graded spoil properties, particularly Sodium Adsorption Ratio (SAR) and texture. (North Dakota Admin. Code, 2007). The option of using graded spoil properties to determine subsoil redistribution thickness requires that composite spoil samples be collected for chemical and physical analysis. The grade approval package must depict the composite sample locations on the topsoil and subsoil respread thickness map, and provide the graded spoil laboratory analyses (North Dakota Public Service Commission, 1995). The required total thickness of SPGM in the grade approval area, or within subareas of the grade approval area, is based on the graded spoil properties, as shown in Table 1.

Table 1. Topsoil and Subsoil Redistribution Thickness Based on Graded Spoil Properties (North Dakota Admin. Code 2007)

---------- Spoil Properties -------------		Total Redistribution Thickness
Texture	SAR	Topsoil plus Subsoil
Loam or Finer	< 12	61 cm (24 in)
Sandy Loam or Coarser	< 12	91 cm (36 in)
Not Applicable	12 - 20	91 cm (36 in)
Not Applicable	> 20	122 cm (48 in)

Figure 1 is an example of a post-mining topography, topsoil and subsoil respread thickness map submitted for a grade approval request. Differing SPGM respread thicknesses are proposed for the grade approval area based on the analysis of samples collected at the spoil sample locations, and using the criteria in Table 1 to determine the total SPGM respread thickness.

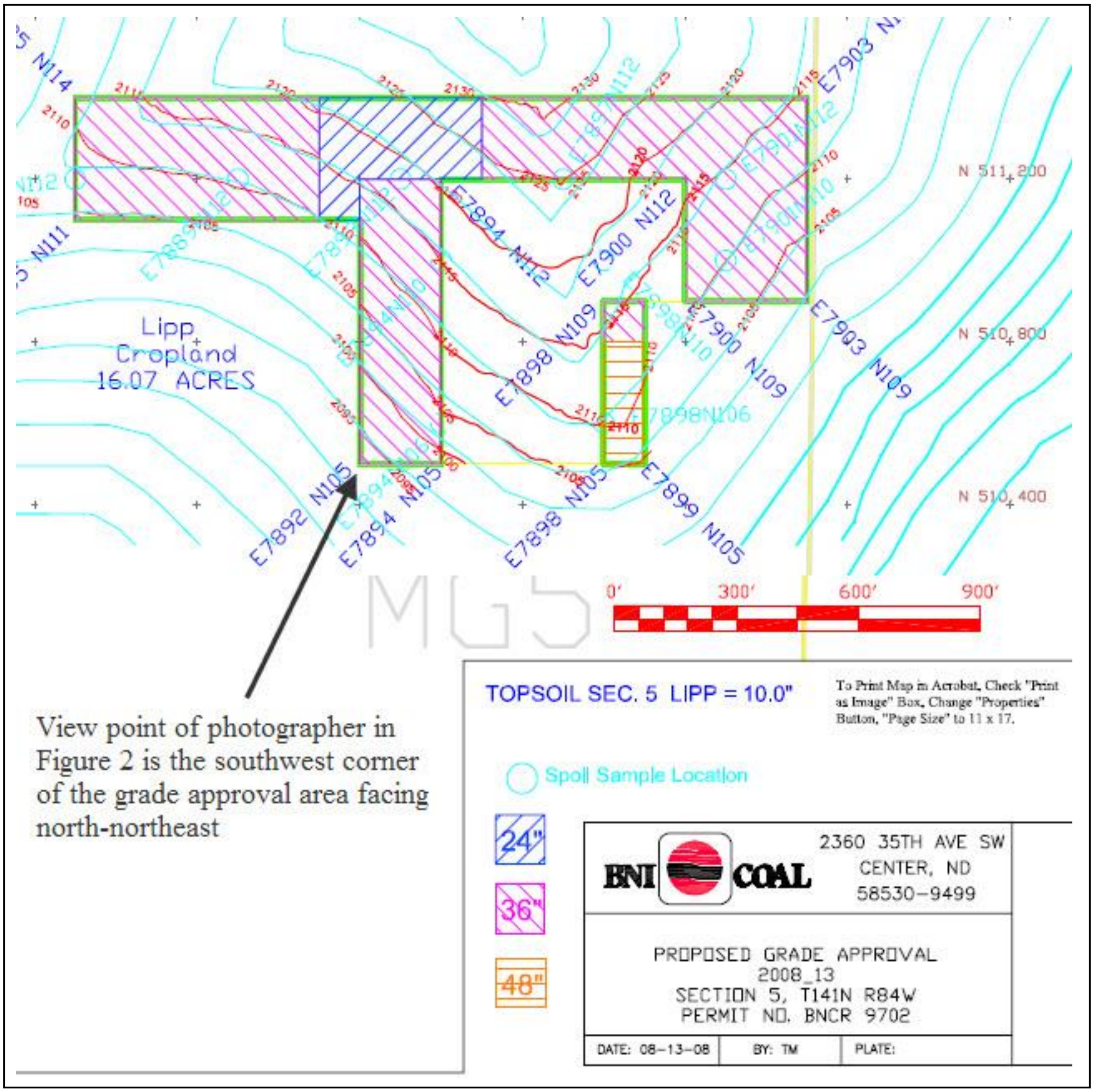

Figure 1. Grade approval package post-mining topography, topsoil and subsoil respread thickness map, and location of graded spoil sample locations.

Figure. 2 depicts the redistribution of subsoil and topsoil on the grade approval area shown in Fig. 1, with the photographer's location shown by the arrow in Fig. 1.

Figure 2. Photograph of subsoil and topsoil redistribution on a grade approval area, looking north-northeast, where subsoil and topsoil has been redistributed progressing from east to west (right to left). Shown on the left on the western edge of the grade approval area is graded spoil; the western edge of the subsoil respread is shown in the center; and shown on the right is the western edge of the topsoil respread.

Methods and Materials

After an ArcPad map file was created from ArcMap with the desired vector and raster data, the first step in using ArcPad for verifying SPGM respread thickness was the acquisition of SPGM respread thickness maps. The maps contained topsoil and subsoil respread thickness labels within each SPGM respread boundary, and the SPGM respread boundary lines were of adequate weight to view on a tablet computer. Depending on the mining company, the map was provided in a variety of formats, ranging from paper to an AutoCAD® drawing. Regardless of the map format and the image manipulation that was necessary, the objective was to export the map from ArcMap as a tagged image file with an associated world file that was added to the ArcPad map file.

An Xplore Technologies® tablet computer with ArcPad 7.1 was used in collecting the attributes of soil probe locations to verify SPGM respread thicknesses. The computer possessed an internal GPS unit, but an external unit was also used, as shown in Fig. 3.

Figure 3. Xplore Technologies tablet computer used in collecting the attributes of soil probe locations

The second step in using ArcPad for verifying SPGM respread thickness was creating a soil probe location point shapefile and an associated QuickForm. Instructions for creating a shapefile and associated QuickForm are in Chapter 6 (ESRI, 2007). The QuickForm is an input form that allows the entry of attribute data as the soil probe location spatial data is captured. A consistent attribute field naming convention and field type was used for shapefiles. Setting a precision value (number of decimal places) for the number fields of required topsoil and subsoil thickness is necessary if the SPGM respread map has thickness labeled in unit tenths, or if observed thickness will be reported in unit tenths. Figure 4 depicts the sequence as a new soil probe location shapefile and associated QuickForm was created. The QuickForm was created in conjunction with the new shapefile, but could have been created at a later time. As shown in Fig. 4 (middle and lower), the QuickForm "Fields" tab was used to select which shapefile attribute fields were included in the QuickForm, and the "Controls" tab was used to select which shapefile attribute fields were defined as required entries as attribute data was being collected.

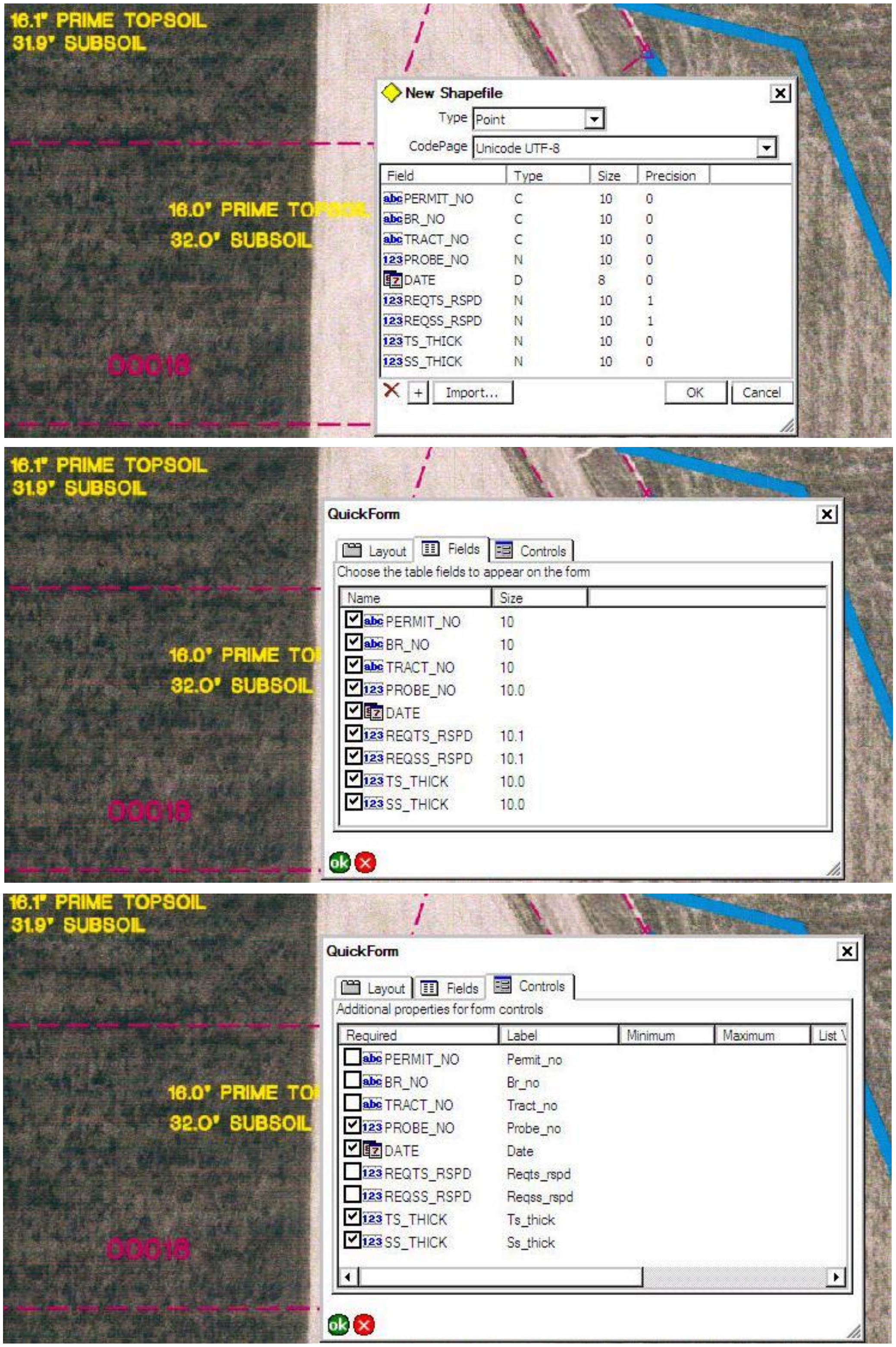

Figure 4. Sequence of creating a new shapefile and QuickForm as displayed in ArcPad, from upper to lower: new soil probe location shapefile; shapefile fields included in the QuickForm; and required shapefile

A truck mounted Giddings Machine Company soil probe was used to verify SPGM respread thickness, as shown in Fig. 5. A 1.22 m (48 in) length tube of 2.54 cm (1 in) diameter was used to retrieve a soil core to the desired depth.

Figure 5. Truck mounted Giddings Machine Company soil probe used to collect soil cores for thickness observations.

Soil probe locations where chosen while traversing the bond release area with the probe truck's location shown by the GPS position displayed on the SPGM respread thickness map. The soil core retrieved at a probe location was placed in a plastic tray to accurately measure the topsoil and subsoil thickness, as shown in Fig. 6. After recording the soil core observations in

Figure 6. Soil core retrieved from a probe location for observation. Topsoil was present from 0 to 25.4 cm (10 in), subsoil was present from 25.4 cm (10 in) to 76.2 cm (30 in), and spoil was present below the subsoil.

writing, and with the soil probe shapefile in editing mode, a point was captured from the editing tool bar. The shapefile's QuickForm was activated as the point was captured, at which time the required entries were made in the QuickForm, as shown in Fig. 7. As previously noted, some shapefile attribute fields were defined as required entries as attribute data was collected in the QuickForm. Figure 8 depicts the attention message that was displayed when a required field had not been populated.

Results and Discussion

Using ArcPad to identify soil probe locations for verifying SPGM respread thickness on reclaimed land was a significant improvement compared to using printed maps. The basic ArcPad functions of a GPS position display and tracklog alone provided the investigator with the knowledge to avoid respread boundaries where SPGM thickness may have considerable variation, and to provide more even distribution of probe locations. Of course the greater value of using ArcPad arises from the ability to capture spatial data and enter essential shapefile attributes in the field. After the spatial data and essential attributes were collected, the shapefile was added to an ArcMap map document where the remaining attribute fields were populated, and the attribute table was exported to a spreadsheet program for summary statistical analysis.

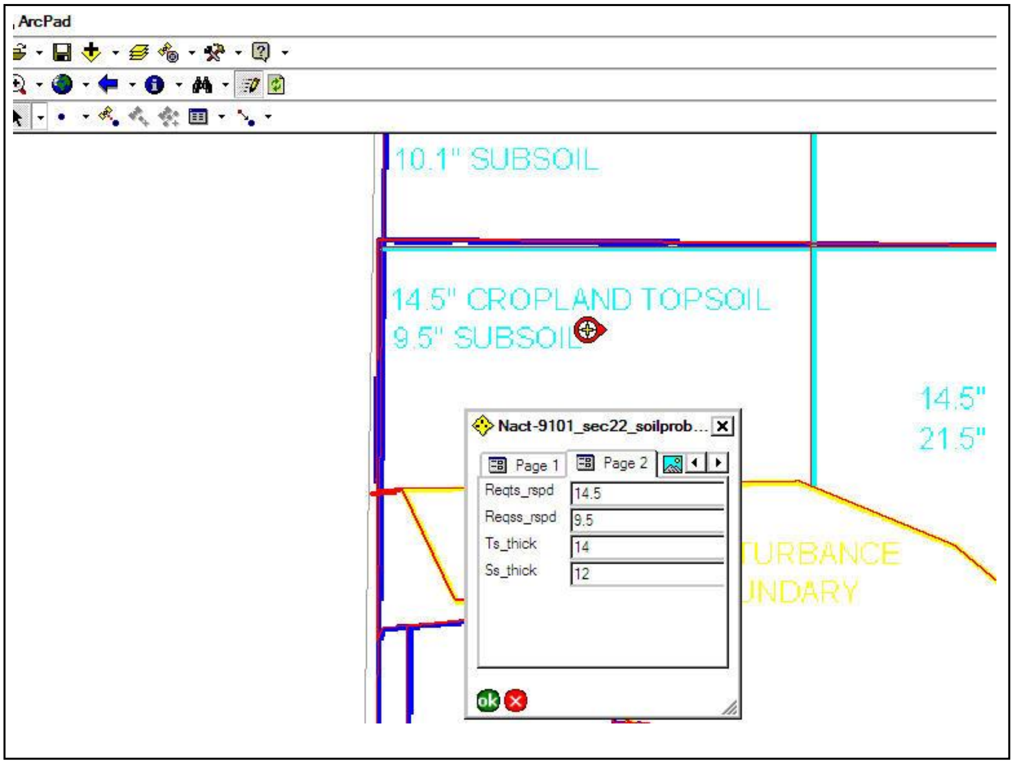

Figure 7. Entering soil probe location shapefile attributes in the QuickForm. The soil probe location is shown by the GPS position display. Reqts_rspd and Reqss_rspd fields refer to thicknesses shown on the

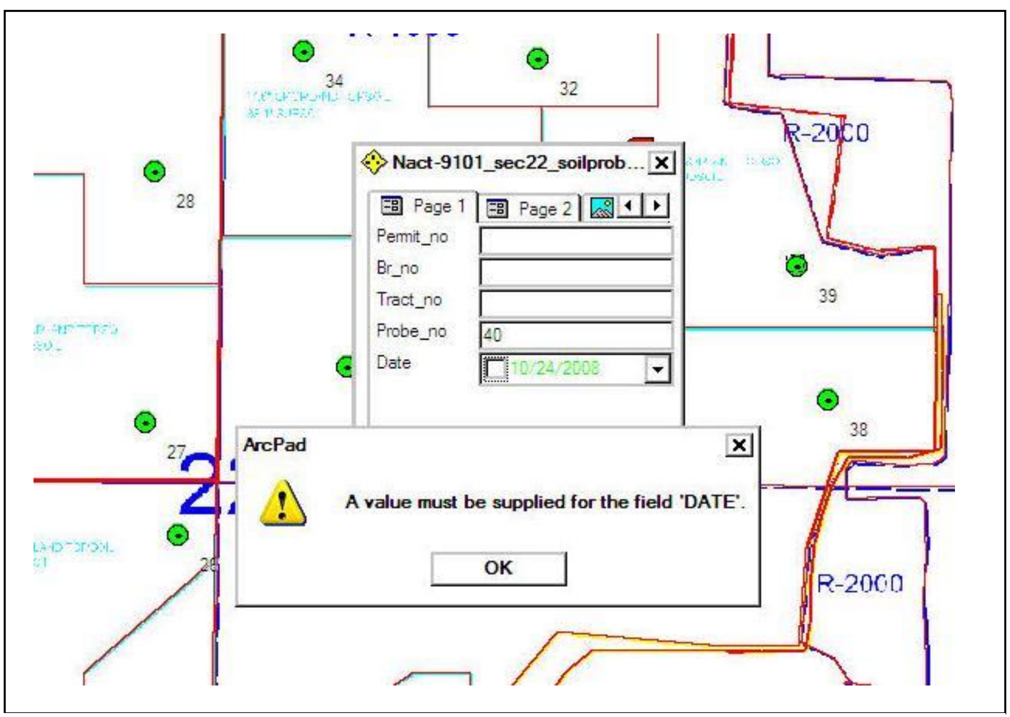

Figure 8. Fields defined as required QuickForm entries must be populated.

Using a label expression in ArcMap, the soil probe locations were labeled with topsoil and subsoil thickness at each probe location, and displayed on the SPGM respread thickness map.

ArcPad was useful not only for displaying soil probe locations on the SPGM respread thickness map, but on other raster data as well. An AutoCAD drawing of the SPGM respread thickness map allowed the option of exporting the SPGM respread boundaries as a polygon shapefile for use in the ArcPad map file. The polygon shapefile could only be used as an overlay to raster data because it was not attributed for SPGM respread thickness. It was useful, however, for locating former associated disturbance features such sedimentation ponds and stockpiles on active mine aerial photography, and for interpreting post-mine features such as settling or repair areas visible on recent aerial photography. Figure 9 is a comparison of a SPGM respread boundary polygon shapefile overlain on active mine and post-mine aerial photography.

Conclusions

Creating and using a soil probe location shapefile and QuickForm in ArcPad proved to be an effective method and a significant improvement for collecting soil probe data to verify SPGM respread thickness. Perhaps the greatest advantages of using ArcPad for this investigation lie in its simplicity and flexibility. With little practice, an investigator can quickly create shapefiles and associated QuickForms in a field setting. Care is required, however, in creating shapefile attribute fields. Inconsistent attribute field type selections, inconsistent field naming conventions, or incorrect precision settings can be problematic for data collection and its subsequent use. Once the spatial data and essential attributes are collected, the attribute table can be expanded and analyzed in ArcMap, and the point locations can be presented in various ways to provide a permanent record for the bond release decision.

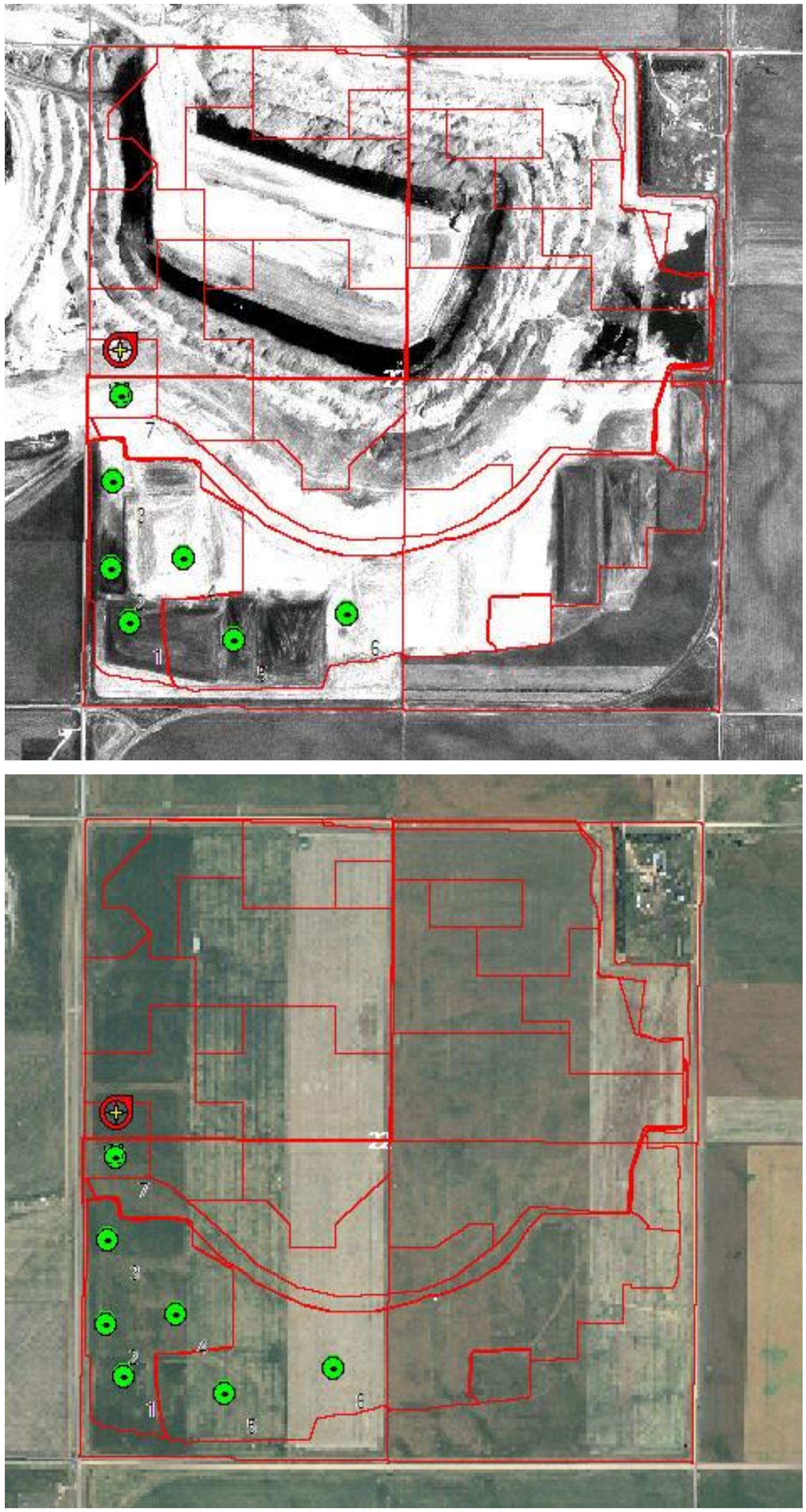

Figure 9. Comparison of a soil respread boundary polygon shapefile overlain on mid-1990's active mine photography (upper), and 2008 post-mine photography (lower). Green circles were completed probes, and the current location was shown by the GPS position display.

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