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DEAR REV-1: A Computer System to Assist in Reclamation Planning of Postmine Topography

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Abstract. DEAR REV-1 is a computer system designed to assist in planning and evaluating reclamation of post-mine topography on surface mine lands. The system was developed by integrating portions of SEAMPLAN[1] and STAMPEDE[2] software with new system routines on a Harris 550 minicomputer. All DEAR REV-1 functions entail the central ability to represent a surface as a network of square grid cells. Grid surfaces are compared using an array of standard mathematical functions (+, -, x, ÷). Area, volume, and slope factors can be computed for any given surface and analyses can be partitioned respective to defined geographical entities (i.e., land use type, etc.).

A case example is provided which illustrates key functions of DEAR REV-1. Other applications of DEAR REV-1 not germane to this particular example also are discussed.

Introduction

The DEAR REV-1 (Data Entry and Review - Revision 1) system was developed by the Reclamation Division of the State of North Dakota as part of a regulatory program to enforce environmental performance standards, particularly standards for reclamation of post-mine topography. Requirements outlined under the Surface Mine Control and Reclamation Act of 1977 (SMCRA) and respective state laws specify reclamation of mined lands to approximate original contour (AOC). The AOC standard has been the subject of extensive discussions between regulatory officials and mine operators regarding what constitutes AOC and how best to achieve this standard. The DEAR REV-1 system was designed to assist in planning and evaluation of post-mine topography for AOC and has application in other areas of surface mine reclamation.

System Functions

DEAR REV-1 was developed by integrating portions of the SEAMPLAN[1] and original STAMPEDE[2] software with resident graphics and plotting routines on a Harris 550 large-scale minicomputer and adding new program functions to increase system flexibility. The system was constructed as 24 functionally distinct, reentrant programs all defined by a supervisory menu selector. All programs can be operated in an interactive time-sharing mode or in combination batch-interactive for delayed processing through a job queue. Hardware interface and software support components were utilized through the Harris mainframe in a straightforward manner to maximize system flexibility and adaptability. A four-pen ZETA drum plotter, remote line printer, Summagraphics digitizer, Tektronics graphics display, high-speed (9600 baud) communication lines, and Harris computer constitute the hardware support for DEAR REV-1.

Surface Approximation

Central to the DEAR REV-1 system is the ability to approximate a surface whereby three-dimensional data points (XYZ), which are distributed about a x-y plane as random Z values or as isopleth lines, are converted to represent a surface of square grid cells. Conversion from isopleth line to grid cell has been used by other authors in applying computer processes to surface mine operations.[3,4] A unique feature of DEAR REV-1 is the accuracy and speed by which surfaces are approximated. Up to one million grid cells can be used to represent a surface. Surface approximations of one hundred thousand grid cells (cell size not exceeding 50-feet square) were commonly made by the Reclamation Division with response times typically less than five minutes.

Data is entered into the DEAR REV-1 system by continuous digitization of map contours or point values and, for selected options, by keyed input of XYZ coordinates. The user has the ability to "filter" the data whereby only those points which are important to define a surface are retained. Data filtering speeds computer processing and, thus, reduces costs without loss of accuracy in surface

approximation. Once a data set has been selected, surface fitting is accomplished by numerical approximation[2] whereby an array of square grid cells is superimposed on the x-y plane, and missing cell values (cells not defined by a data value) are determined relative to adjacent data points. The accuracy of the surface approximation can be reviewed by physically plotting the digitized contours over contours generated through surface fitting and determining how closely the lines match. If necessary, grids can be interactively adjusted until an acceptable surface approximation is developed.

Standard Grid Operations

DEAR REV-1 provides the user with an array of standard mathematical functions (-, +, ÷, x) which can be applied as operations within or between grids. Scalar values (integer or decimal) can be used to increase or decrease surface elevations uniformly across a grid. Operations between grids can be used to compare surfaces or to create new surfaces. Examples include premine and postmine comparisons of topography (via subtraction) to evaluate overburden displacement, comparisons of temporal changes in groundwater potentiometric levels and comparison of postmine stream profiles. Surfaces can be created which represent thickness as in the case where surfaces defining the top and bottom of coal are subtracted to yield a coal isopach map.

Cut and Fill Assessment

Cut and fill assessment is a logical extension of grid operations which allows the calculation of areas and volumes above or below a given surface elevation. Values are calculated by summing area or volume by grid cell across the grid array. Examples where cut and fill may be used would be in design of post-mine topography, haulroads, and sedimentation ponds where soil volumes are balanced in a manner which minimizes grading costs. Another example would be the quantitative estimate of coal reserves from an isopach map.

Area-Slope

Slope characteristics of a surface provide useful information on changes in postmine topographic features. The area-slope function of DEAR REV-1 calculates slope across a surface for each grid cell by computing the maximum slope between corner mesh points. A tabular printout is provided which shows the proportion of a surface (acres) within each user-defined slope class (i.e., 0-3%, 3-6%, etc.). An area-slope map can be plotted which displays different slope categories by shading individual grid cells with varying densities and color of lines and which orientates the lines in the direction of maximum slope.

Window

Often it is desirable to limit analyses of area-slope or cut and fill to a specific geographical entity such as a land use type, drainage channel or soils complex which is encompassed within the x-y plane of a grid surface. DEAR REV-1 performs a function entitled "window" whereby a subarea of a surface can be delineated similar to logical intersection. The subarea or "window" is input to DEAR REV-1 either by digitizing the outline (digitizer tablet or terminal crosshairs can be used) or by input of ordinal coordinates. Grid operations are performed which eliminate data points outside the window boundary. The resulting subarea then can be analyzed independent of the original surface.

Assessment of Post-Mine Topography - North Dakota Example

To illustrate the utility of DEAR REV-1, an actual case example was taken from North Dakota in which the excavation of a pit for disposal of waste ash from a coal-fired electric generation plant was proposed at a strip mine. The post-mine topography of the backfilled pit was projected as an area of high relief compared to the surrounding terrain. An analysis was performed to evaluate the ash pit site and adjoining areas for AOC and to assess the quantity and location of displaced overburden.

Maps were digitized and surface approximations made for the pre-mine topography (Figure 1) and postmine topography (Figure 2) of the ash disposal site and adjoining areas. The location of the ash pit was delineated by inputting x-y coordinates through the "window" function of DEAR REV-1.

To compare the change in topographic relief, area-slope maps were developed of the pre-mine topography (Figure 3) and post-mine topography (Figure 4). These maps depicted an increase in the post-mine slope of the ash pit site. However, slopes did not increase uniformly across the entire map area. In some cases, post-mine slopes were less. A quantitative comparison of slope categories

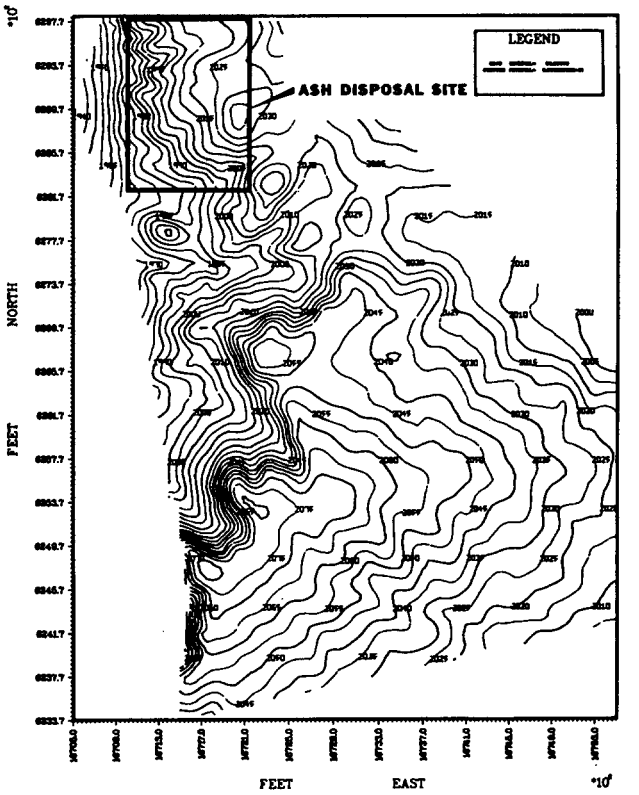

FIGURE 1 PRE-MINE TOPOGRAPHY OF THE ASH DISPOSAL SITE AND ADJOINING AREAS

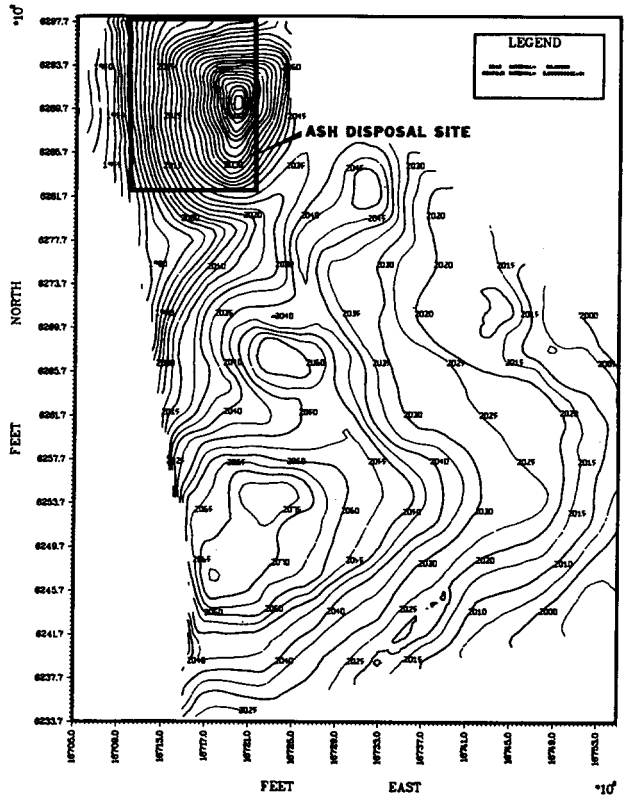

FIGURE 2 POST-MINE TOPOGRAPHY OF THE ASH DISPOSAL SITE AND ADJOINING AREAS

for the ash pit (Table 1) and the ash pit plus adjoining areas (Table 2) supported findings that post-mine slopes were substantially steeper on the ash disposal site but differed less from pre-mine slopes when comparisons were made across the entire mine area.

Quantity and displacement of overburden were determined by subtracting the pre-mine topography (Figure 1) from the post-mine topography (Figure 2). The result, given in Figure 5, shows a net increase in post-mine elevations across the entire ash disposal pit. Analysis via the "cut and fill" function of DEAR REV-1 revealed that elevations increased because of a post-mine overburden balance of 50,098 cubic yards per acre. Over the entire mine area, changes in elevations were both positive and negative, and the net overburden balance was 7,324 cubic yards per acre. These findings supported conclusions based on area-slope analysis that the map area as a unit approached AOC closer than the ash disposal site.

As shown in the above example, assessment of AOC is dependent upon user definition of the geographical area to be examined and the level of analysis to be performed. Caution must be taken to interpret results in accordance with the intended objective of evaluating compliance with AOC standards. A valuable asset of DEAR REV-1 is the discretion given the user to pattern AOC analysis to the unique nature of a given problem.

Conclusion

DEAR REV-1 incorporates analytical tools useful in evaluating AOC for post-mine topography. In the ash pit example, DEAR REV-1 provided an assessment of changes in the distribution and numerical level

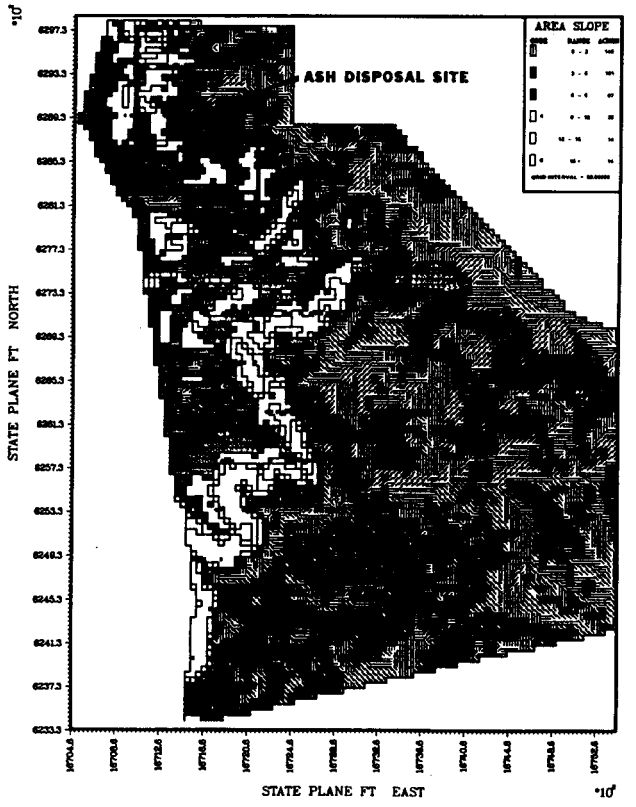

FIGURE 3 PRE-MINE AREA SLOPE OF THE ASH DISPOSAL SITE AND ADJOINING AREAS

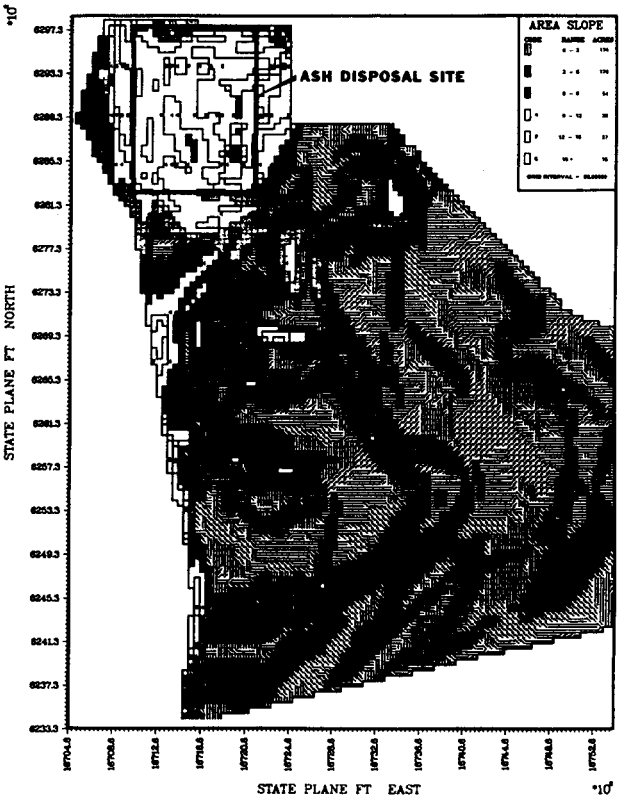

FIGURE 4 POST-MINE AREA SLOPE OF THE ASH DISPOSAL SITE AND ADJOINING AREAS

Table 1. Slope categories by acreage for pre-mine and post-mine topography of the ash disposal pit.

	SLOPE CATEGORIES					
	0-3%	3-6%	6-9%	9-12%	12-15%	15%
Pre-mine Topography	5.0[A]	11.0	15.0	8.0	2.0	--
Post-mine Topography	--	1.0	2.0	9.0	19.0	10.0

[A] Units given in acres.

Table 2. Slope categories by acreage for pre-mine and post-mine topography of the ash disposal pit plus adjoining areas.

	SLOPE CATEGORIES					
	0-3%	3-6%	6-9%	9-12%	12-15%	15%
Pre-mine Topography	149[A]	191	67	33	14	14
Post-mine Topography	174	170	54	28	27	15

[A] Units given in acres.

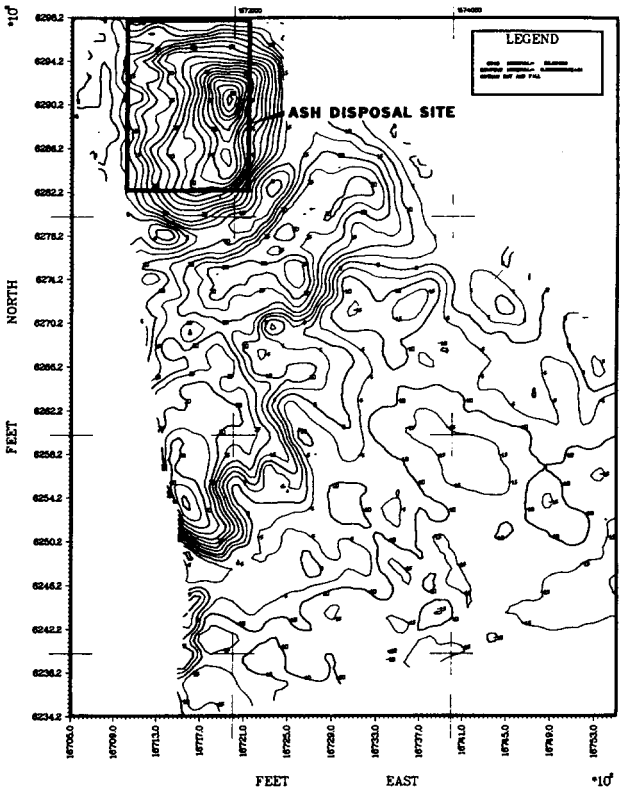

FIGURE 5 NET CHANGE IN POST-MINE ELEVATIONS OF THE ASH DISPOSAL SITE AND ADJOINING AREAS

of slope and in the quantity and geographical displacement of overburden. DEAR REV-1 can be used to apply AOC standards in other situations such as changes in post-mine land use (i.e., rangeland to cropland) and reestablishment of stream gradients.

In addition to being a powerful means for evaluating AOC, the DEAR REV-1 system can be used in a variety of applications where comparisons between or within surfaces are performed. Examples already cited include comparisons between ground water potentiometric surface and calculation of reserves from coal isopach maps. Another application might be in approximations of post-mine topography based on coal and overburden thickness, pre-mine surface elevations, and overburden swell factors.

The general flexibility of DEAR REV-1 makes the system a useful tool for both the mine operator and the regulatory authority. DEAR REV-1 can assist in developing realistic reclamation plans and in evaluating those plans from an objective standpoint.

References

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