OSM TECHNOLOGY TRANSFER
APPLIED SCIENCE
FINAL REPORT FACT SHEET

USDOI Office of Surface Mining Reclamation and Enforcement

*"OSM publishes Applied Science Final Report Fact Sheets as part of its technology transfer function to inform interested parties about results from completed Applied Science Projects funded by OSM. The completed reports can be found at our website: www.techtransfer.osmre.gov/"*

# ENHANCING MINE SUBSIDENCE PREDICTION AND CONTROL METHODOLOGIES FOR LONG-TERM LANDSCAPE STABILITY.

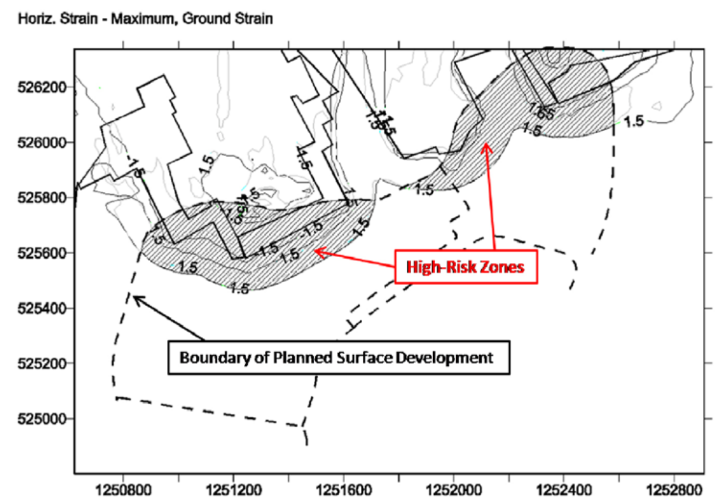
**Dr. Michael Karmis and Dr. Zacharias Agioutantis**
*Virginia Polytechnic Institute and State University, Blacksburg, Virginia*
*Department of Mining and Minerals Engineering*

## Project Description and Objectives:

The Surface Deformation Prediction System (SDPS) software package, a tool for predicting ground movements above undermined areas, was initially released in 1989 and has been improved in the intervening years. During this period, the researchers identified further areas in mine subsidence prediction and control that should be improved to provide better ground deformation prediction for long-term stability. Enhanced subsidence prediction capability is essential because of extensive post mining land use, increasing urbanization of undermined surface properties, and the proximity of current resources to urban areas. The specific project objectives included developing and improving subsidence engineering parameters; improving existing prediction methodologies; applying subsidence methodologies to landscape stability and control; developing tools to evaluate landscape stability based on long-term mine level stability; and, incorporating results into SDPS.

## Applicability to Mining and Reclamation:

The project was developed under OSM special interest topic "Landscape Stability" and is of particular relevance to the sub-topic "subsidence and long-term stability issues associated with underground mines." There is very little published research regarding updating prediction methodologies with respect to the influence of local geological parameters. Also, as the need to use reclaimed land for urban activities becomes more acute every day, updated procedures to verify and enforce appropriate mine planning with respect to surface effects mitigation will be of great benefit. The issues of secondary landscape stability due to underground mining as well as




ABOVE IMAGE: Risk Assessment Map - Overlap of threshold strain with planned surface development.

the normalization of damage criteria as applied to surface structures will allow more detailed calculations in critical borderline cases which are more common today.

## Methodology:

In order to accomplish the objectives of the project, case studies were collected and analyzed for static and dynamic conditions, the model for the dynamic analysis was updated, new models were developed for landscape stability and control and for long-term stability, and a number of new tools and functions were developed and incorporated into the SDPS. Finally the results of this research effort were integrated into the revised SDPS User's Manual which includes examples for all new functions and tools.

CONTINUED ON BACK...

## Highlights:

The development of subsidence (or any deformation) at a point as a function of time is generally termed "subsidence development." Previously, the maximum deformations calculated for the transient case were a percentage of the final deformations forecast for the mined area. In order to enhance the capabilities of ground deformation prediction, alternate formulations were analyzed and incorporated into the software influence function so that it is more flexible in calculating subsidence development profiles. In many cases both vertical movements and horizontal movements are available to the field engineer for estimating the parameters used in the prediction model (e.g., tangent of influence angle, subsidence factor, and edge effect adjustment). A methodology was developed to calibrate those parameters using either or both of measured vertical subsidence and measured ground strain.

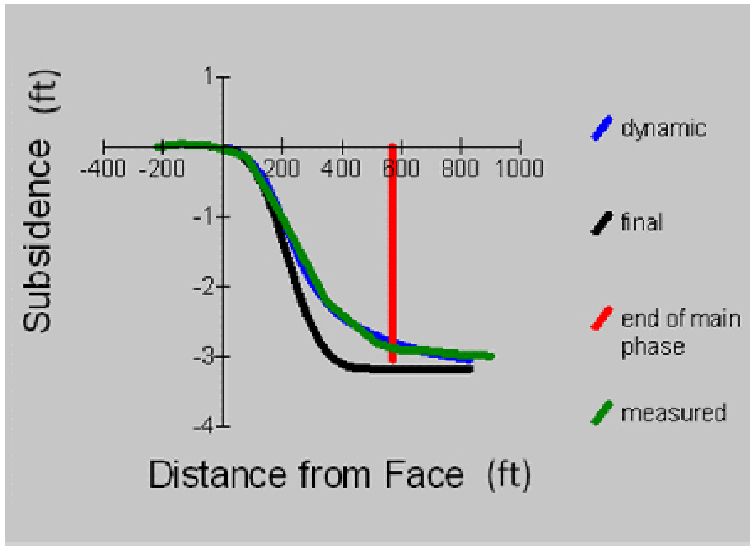
Damage criteria for structures have been developed and are available in existing literature. Equivalent ground deformation indices compatible with the output of the surface deformation prediction software (e.g., horizontal or ground strain) were developed. By this means, a risk assessment approach can be applied to delineate areas with potential landscape control problems; these areas can easily be shown on topographic maps of the area.

The issue of how long-term stability of underground pillars affects landscape stability and hence surface structure stability is very complex. Nevertheless there are numerous examples in the literature showing that reclaimed land can be used for urban activities (landfills, mall construction, etc), provided a thorough investigation is undertaken. To fulfill this objective, an evaluation of long-term stability of underground workings was developed based on a probabilistic approach for underground mine stability.

## Results/Findings:

In summary, the following software enhancements were implemented as a result of this project:

- Mine plan definition was modified to allow for long-term stability information;
- The dynamic function was re-written to implement the theory for dynamic subsidence as well as calculation of dynamic slope, dynamic horizontal displacement, dynamic curvature, and dynamic horizontal strain;
- The calibration procedure was enhanced to allow for:
  1) Locking of calibration parameters obtained from a subsidence profile and optional utilization of such parameters in calibration using strain profiles;
  2) Option to calibrate for maximum values of horizontal or ground strain as well as for minimizing the total error during strain calibration;
  3) Calculation of ground strain for prediction points on a grid and for scattered prediction points;
- A new function was added in the calculation menu for calculating long-term stability;
- New contouring routines were developed utilizing the Surfer package (Golden Software);
- The User's Guide was enhanced both by adding more examples pertaining to the use of the new / advanced features of the influence function and by adding / enhancing the theoretical sections related to the Influence Function Method.




Above Image: Dynamic subsidence prediction curve.

**Website Information:**

The final project report can be found at **http://www.techtransfer.osmre.gov/NTTMainSite/appliedscience/2007appscience/CompletedProjects/2007VATechSubsidenceSDPS.pdf**


**Principal Investigator:**

**Dr. Michael Karmis**
*Virginia Polytechnic Institute and State University*
(540) 231-5273
mkarmis@vt.edu

**OSM Project Technical Representative:**

**Thomas Mastaller**
(412) 937-2108
tmastaller@osmre.gov

**For Further Information About OSM's Applied Science Programs:**

**Kimery Vories** - kvories@osmre.gov - (618) 463-6463, Ext. 5103