Three-Dimensional Computational Pneumatic Modeling: Why It Is a Must When Designing Remedial Systems

Matthew Ambrusch (mambrusch@langan.com) (Langan Engineering, Parsippany, NJ, USA)
Omer Uppal (Langan Engineering, Parsippany, NJ, USA)
Stewart Abrams (Langan Engineering, Lawrenceville, NJ, USA)
Murray Fredlund (SoilVision Systems, Ltd, Saskatoon, SK, Canada)

Background/Objectives. As the industry of site remediation continues to mature, the industry is continually searching for new ways to enhance the predictability of a proposed remedial strategy, ultimately resulting in a more cost effective and schedule conscience remedial approach. In this spirit, much attention has recently been given to better predicting the performance of various pneumatic remedial technologies under varying and site-specific conditions. As is the mother of all inventions, this necessity has resulted in the development of various pneumatic models which are aimed at providing a reasonable and verifiable solution to complex subsurface pneumatic problems. One such model is SVAIR™ (SoilVision Systems, Ltd.), a three-dimensional (3-D) computational model which utilizes finite element analysis to model subsurface air flow, whether induced actively or passively, taking into consideration a number of boundary, steady-state, and temporal (transient) conditions. This model has recently been used by Langan to simulate the effectiveness of a proposed landfill gas (LFG) collection system on a 200 acre landfill, as part of the site redevelopment strategy for the subject case study. Requiring the approval of numerous local, regional and state regulatory agencies, the model was crucial for the regulatory acceptance of the conceptual LFG collection system design.

Approach/Activities. When implementing such a model, the ability to calibrate the model outputs is paramount. After developing a 3-D site conceptual model, incorporating site-specific characteristics such as topographic elevations and various surface and subsurface features, initial model scenarios are simulated with the intention of vetting the results against the observed pneumatic relationships during a field pilot test (i.e., extraction air flow rate and applied vacuum relationship). Through manipulation of estimated pneumatic characteristics, such as intrinsic permeability, the model can be precisely calibrated, at which time design model simulations are initiated. The ability to mimic the observed pneumatic relationships provides a higher level of confidence in the final design model outputs. For the subject case study, Langan was able to simulate the LFG flow rate in the refuse and determine the correlation between applied vacuum and LFG extraction flow rate at an extraction well and the resultant influence at varying distances, through the use of SVAIR™. The model allowed the prediction of the system performance at any spatial point in the landfill at any given time to evaluate whether the system would be protective of human health and the environment for the life of the proposed development.

Results/Lessons Learned. In addition to being able to demonstrate the expected performance of the proposed LFG collection system, the model also confirmed the significance of several important pneumatic phenomena. The model allowed for the assessment of how multiple wells extracting in close proximity to one another, as compared to one well alone, affects the subsurface pneumatics. The effect barometric pressure fluctuations have on the subsurface vacuum propagation, as well as the relationship between the achievable subsurface pore air/gas velocity and pore air/gas volume exchanges within the radius of influence (ROI) of an extraction well and its ability to combat barometric pressure effects within the ROI were also

evaluated. This presentation will demonstrate the use of 3D pneumatic modeling for designing an effective LFG collection system for the subject 200 acre landfill redevelopment case study.