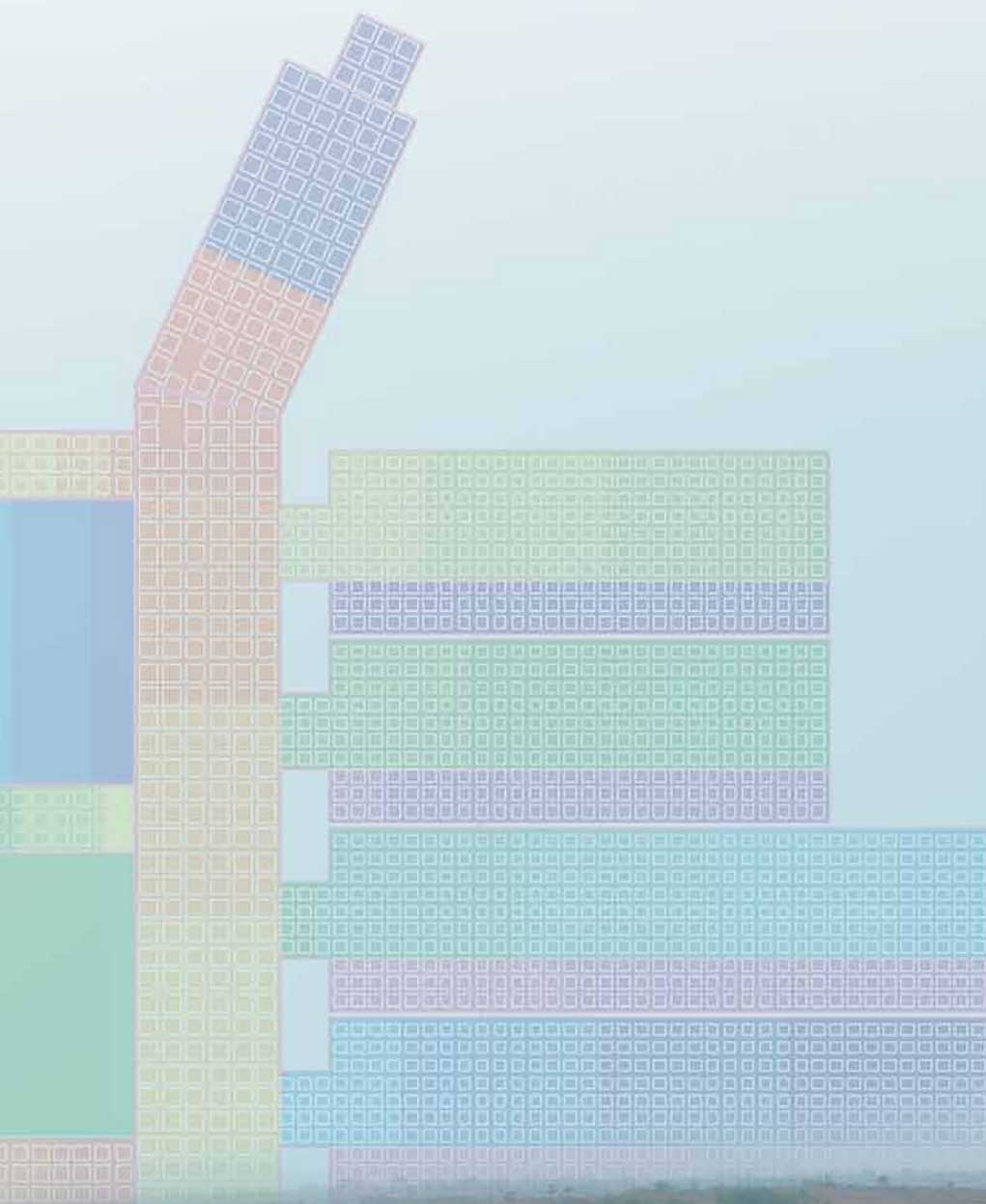
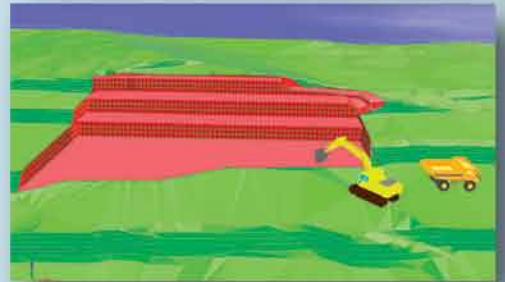


CARLSON MINING

— *Comprehensive Mining Software Solutions*

- Underground Mining
- Surface Mining
- Geologic Modeling
- Drilling/Blasting
- Permitting
- Reserve Studies
- Machine Control
- Reclamation



Carlson[®]
...The Mining Solution



Top attributes of Carlson Mining software solutions include:

- Easy to learn
- Affordable
- Fast-paced client-driven development
- Runs inside AutoCAD®; comes with IntelliCAD® built-in
- Reads existing geologic data
- Drawings can be linked to databases
- Real-time survey guidance
- Real-time remote data exchange
- On-site & remote support
- Access to a production & support team with combined 100+ years of mining software experience

Planning, Engineering or Automating a Mine – Look to Carlson

In use throughout the world, Carlson mining solutions, including machine control, have expanded beyond coal into the phosphate, trona, limestone, aggregates, granite, clay, and even the hard rock markets. Whether the application is underground mining, surface mining, permitting, geologic mapping, reserves studies, or reclamation, Carlson provides uniquely powerful automation combined with our trademark ease-of-use.

Carlson Software listens to its customers and builds its software to meet users’ needs. We consider there’s a direct correlation between being the dominant software in this

market – 90 percent of the U.S. coal industry utilizes Carlson Mining software – and our commitment to both advanced technology and customer service.

Enhancements to the software continue on an ongoing basis. In recent years, improvements have included expanding 3D abilities within bench pit design, augmentation of the haul truck cycle analysis routines, new spoil placement timing, adding options for color settings for enhanced visual feedback in the underground timing sequencing, the ability to produce customized, more professional reports and much more as we move into the future.

TABLE OF CONTENTS

Intro to Carlson Mining 2 - 3

Carlson Geology 4 - 7

Underground Mining 8 - 9

Carlson Surface Mining 10 - 11

Basic Mining / SDPS 12

Survey / Civil / Hydrology / GIS 13

Natural Regrade 14 - 15

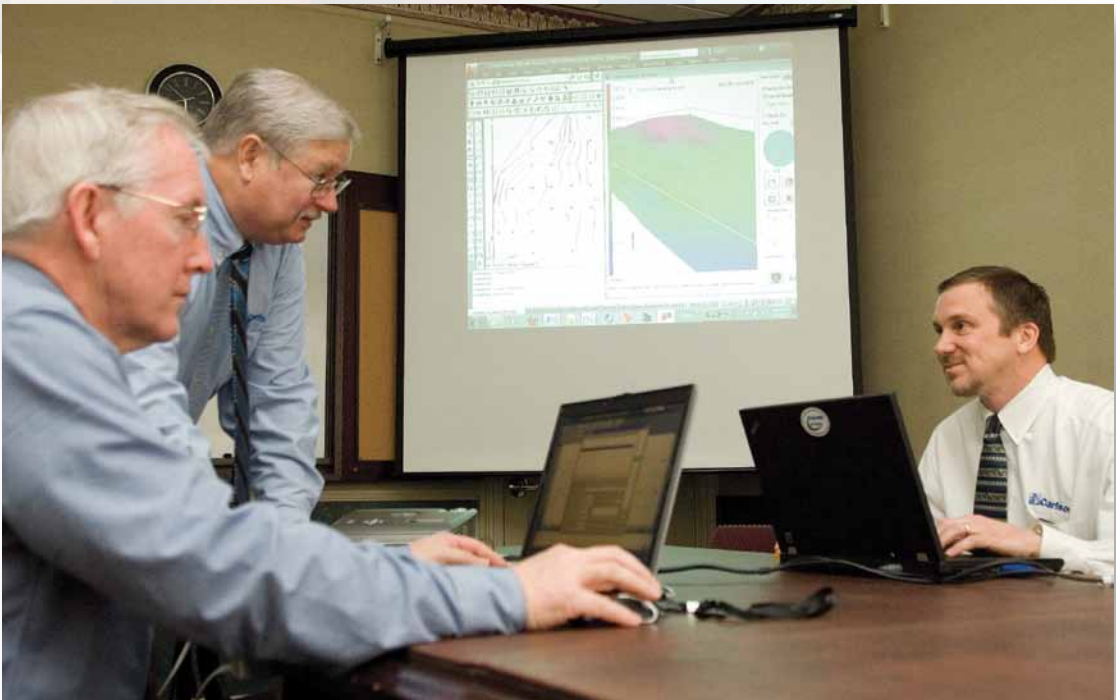
Carlson Complementary Solutions/Contact Info Back Page

“From the very beginning of the company, Carlson Software has focused on mining applications. Our location within a five-hour drive of virtually all mines in the U.S. Appalachian and Illinois coal basin dictated that and helped us realize the real need for automation of processes. Our goal is to ensure greater mining productivity utilizing best practices as they apply throughout the world. Together with our software engineers, our experienced sales staff, and our valued customers, we look forward to meeting your needs.”

— R. Bruce Carlson
President & Founder,
Carlson Software

Carlson Mining: Designed to Work for You

The Carlson Mining Division receives direct attention from Carlson Software Founder and President Bruce Carlson (foreground) and is led by Steve Richards (center) and Grant Wenker (right).



Create geologic models with surfaces or block models and display in cross-section and 3D for analysis and reserve estimation

The Carlson Geology Module uses drillhole and sample data to create accurate and easy-to-use subsurface geologic models. It uses industry standard modeling algorithms to create both stratigraphic surface models and hardrock ore block models. Highlights include:

- Import any drillhole format and store data in CAD or external database such as SQLite
- Utilize fast macros to reproduce the model with new drilling, samples and surveys
- Fault automatically at any dip-angle and displacement to offset the geology
- Create geologic cross-sections and fence diagrams instantly from polylines, picking points or saved alignments
- Generate mine reserves and reserve classification for Measured, Indicated and Inferred analysis with flexible reporting directly into Excel

Stratigraphic Modeling

Drillholes

- Import from any format using custom settings, storing in CAD or linked to SQLite database
- Draw geologic columns in section or in 3D for correlation and checking
- Validate holes with queries and reports to highlight data errors
- Use tools such as Fern and Horizon Codes combined with Drillhole equations for high level model building

Cross-Sections & Fence Diagrams

- Instantly view sections from polylines or realtime with dynamic section line movement
- Hatch sections by attributes and grade with drillholes posted for model correlation
- Stack up sections in 2D, or place in 3D for visualization with mine designs and topo
- Create the initial sections for dragline range diagrams using the real geology and surfaces

Faults

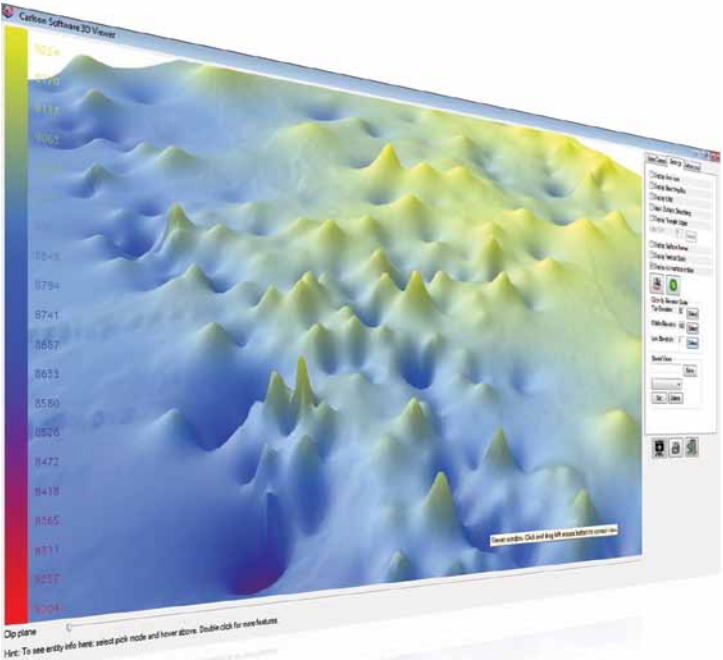
- Place fault lines at the topography with variable dip-angles and displacements to create normal or strike-slip faults
- Draw the fault plane for viewing in 3D
- Have the program find the displacement shift by analyzing the surrounding drillholes
- Apply faults to existing model with new data

Mine Reserves

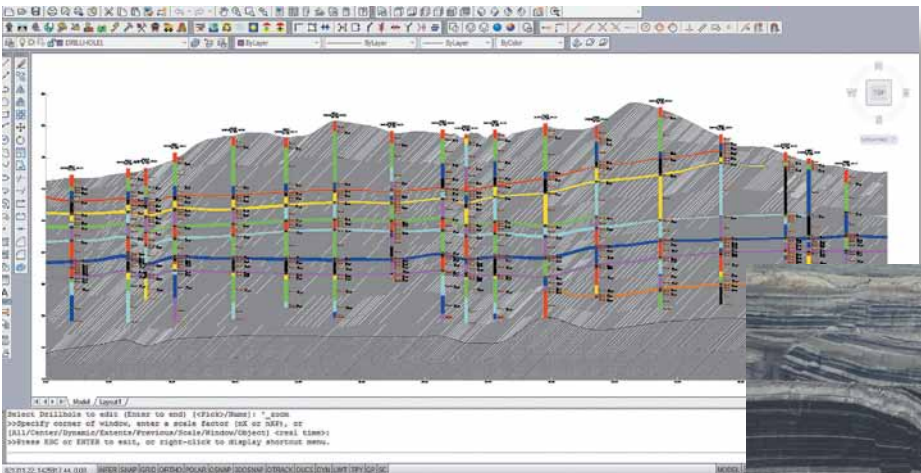
- Use the Pre-calculated model for reserves with weight-averaged quality attributes
- Create strip ratio grids to determine mineable reserves regions
- Format the reports with equations and attribute options while exporting directly into Excel
- Analyze deposits with Reserve Classification to report and hatch the measured, indicated, inferred and hypothetical results
- Fine tune the reserves with automatic options such as minimum thickness of ore and waste, dilution above and below, recovery, density and weathered depth
- Breakout the reserves by vertical quantities, overall highwall slopes, or detailed bench-by-bench designs and surface history files

Modeling

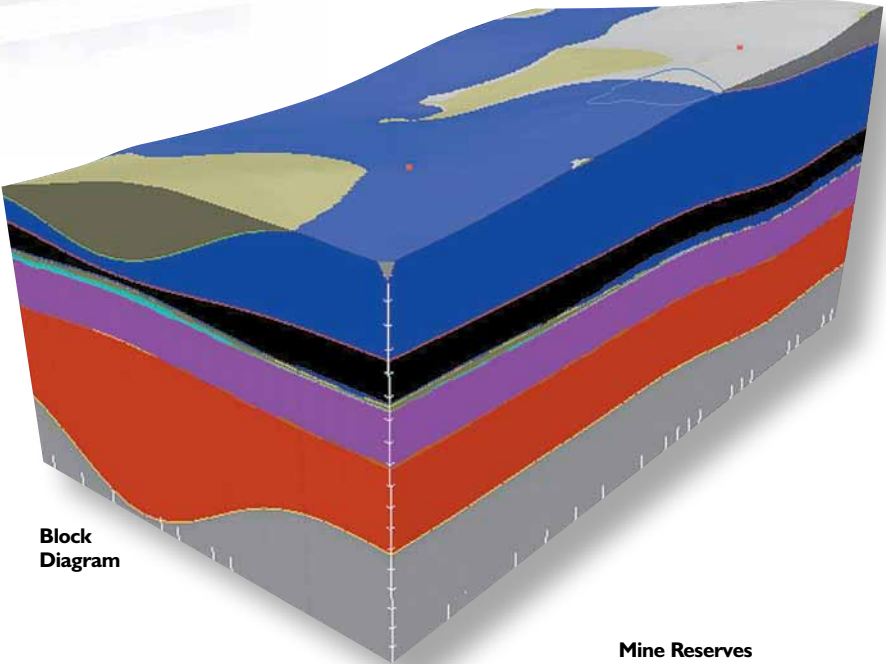
- Use industry-standard geological modeling algorithms and calculate residuals to see which method is recommended
- Create macros and utilities to reproduce the model with new data
- Check the models with inspector tools and color-hatched isopachs
- Enhance the model with limit lines, strata polylines, pit and channel samples combined with the drilling
- Add grids or TINs to the Pre-calculated model for reserves and sections



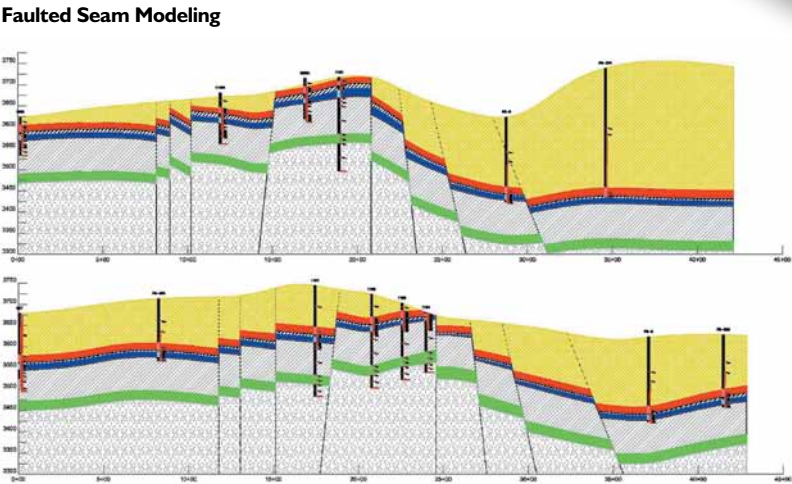
Hatched 3D Isopachs



Drillholes

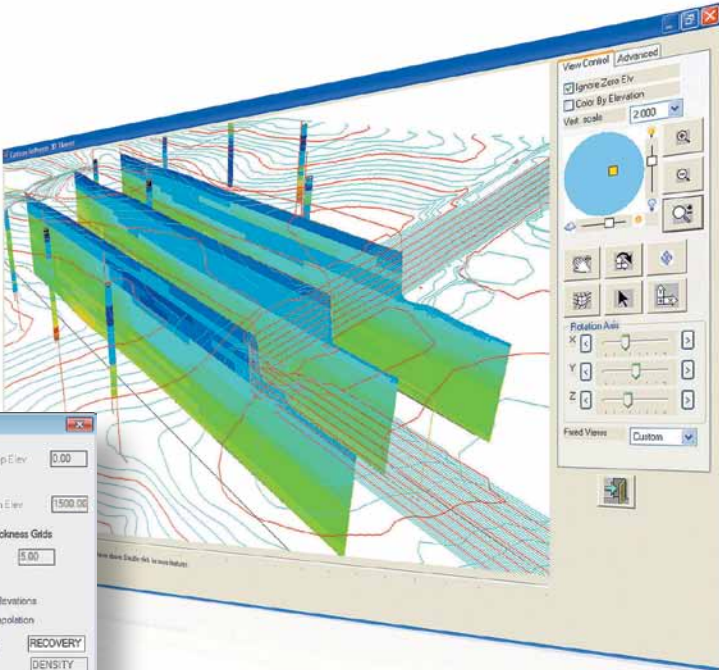
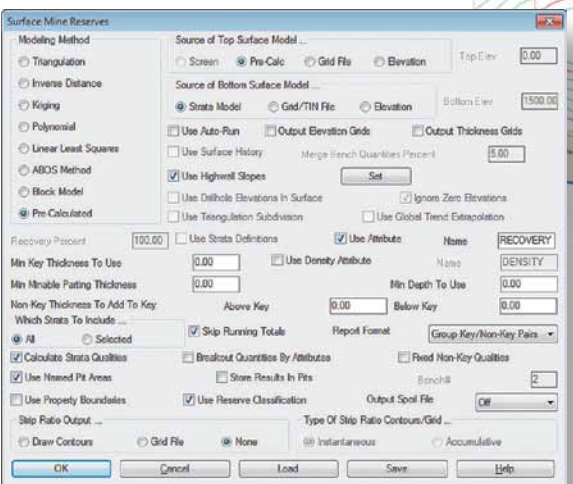


Block Diagram



Faulted Seam Modeling

Mine Reserves



3D Fence Diagram

Block Modeling

Kriging & Variograms

- Make block models by 3D Inverse Distance or Kriging
- Use the Variogram Generator to determine the nugget, sill and range
- Choose from Variogram types such as Semivariogram, Covariance and Correlogram

Grade Parameters

- Enter grade ranges to determine different classes of material for volumes and reporting
- Combine up to 50 attributes to determine just one grade
- Add cost per grade for value block model and Lerch-Grossman optimized pit design
- Set colors and intervals for smooth hatching and legend viewing

Block Viewing

- View partial or entire block model with inclusion/exclusion perimeters
- Turn blocks of similar grades on or off like layers to peel away and see inside the model
- Inspect the block model by depth or elevation with instant feedback on grades
- Add drillholes, surface topography and mine designs on top of blocks for full visualization

Fence Diagrams & Hatching

- Hatch and color by grade parameters for easy grade viewing in section or 3D
- Display drillholes in section or 3D and color by grade parameters
- Color elevation or bench grids by the block model and grade parameters
- Color hatch pits by block model

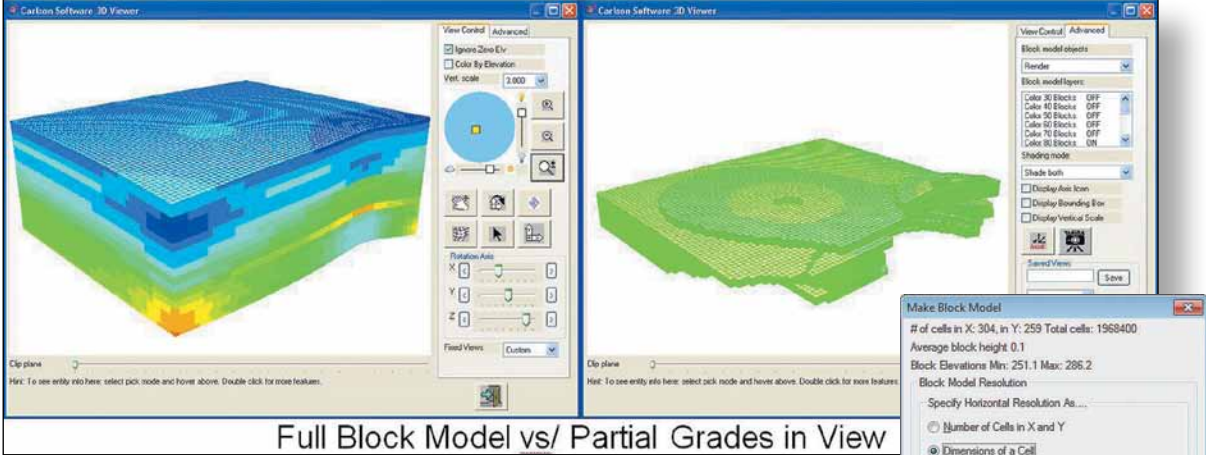
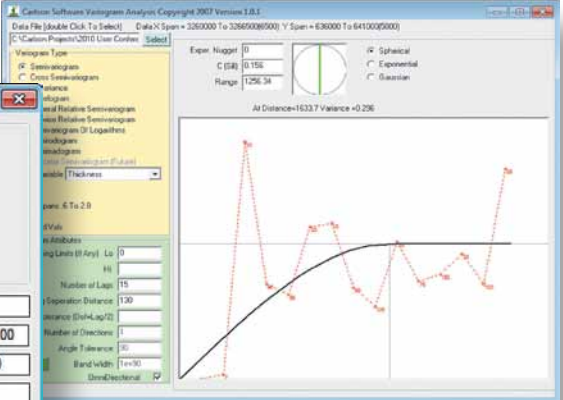
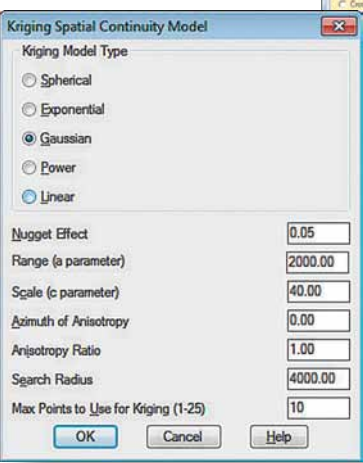
Mine Reserves

- Breakout quantities by grade attributes to report tons and volume in the various grade breakdowns
- Calculate overburden for surface mines to get to specific ore blocks

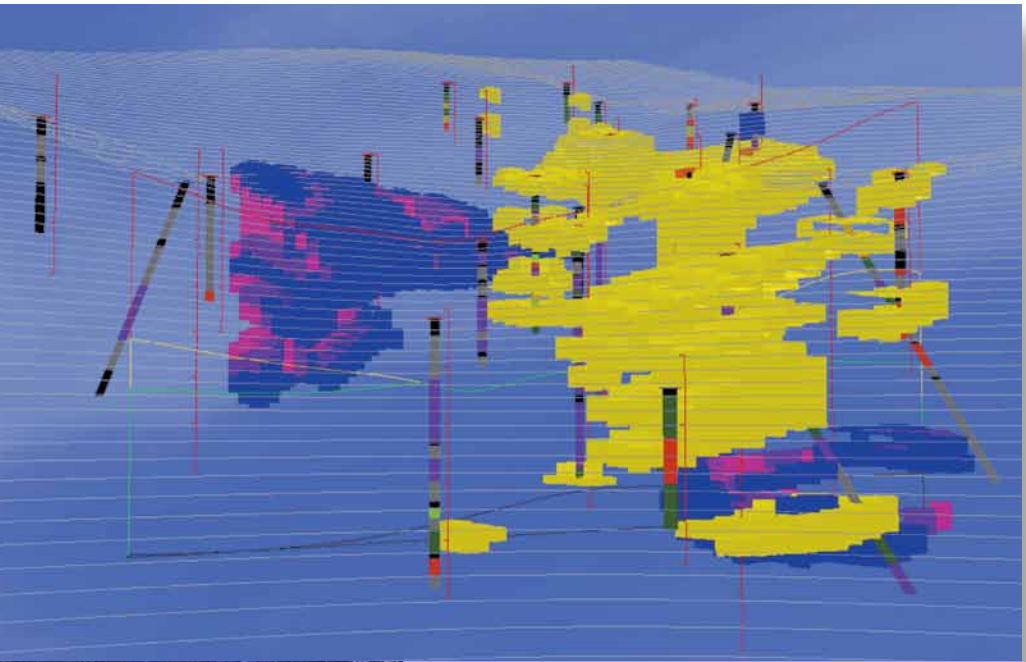
Pit with Benches & Ramps

- Define grades with a specific cost amount
- Create a value block model where each block is a profit or loss calculation
- Create output grid of the optimal pit shell of profitable mining blocks
- If costs change, re-run with few changes to view the revised pit shell

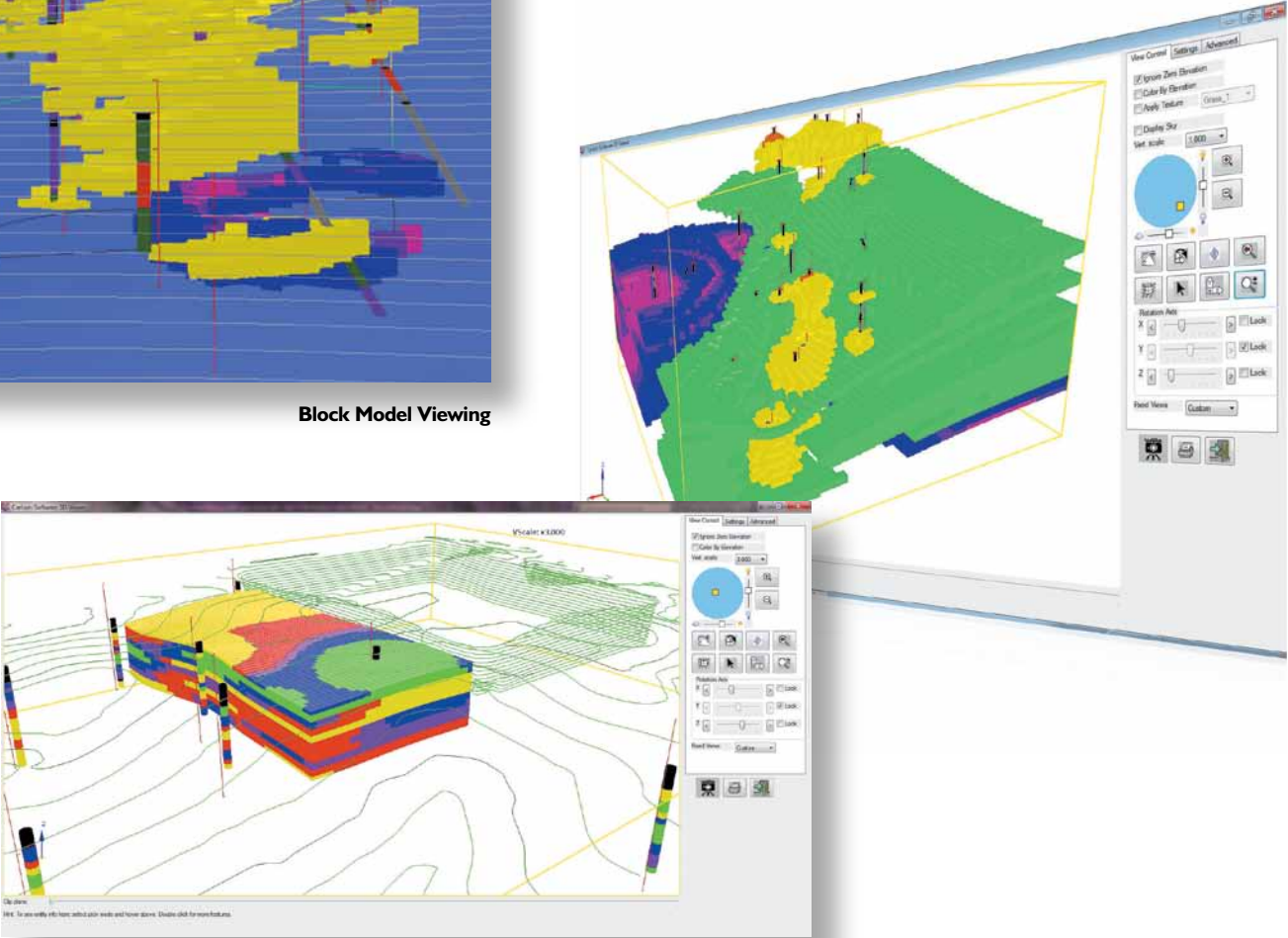
Kriging and Variograms



Block Viewing



Block Model Viewing



Get the power to draft the mine and draw it automatically

Quickly generate volumes, generate tonnage reports, define any pattern of pillar cut, determine attributes, thickness and grades, and produce accurate individualized reports.

All of this is accomplished with Carlson Software's renowned ease-of-use, enabling most applications to be completed in minutes vs. hours, thereby increasing efficiency and savings.

Underground Mine Mapping

- Process survey data and generate the mine map seamlessly with the mine mapping features in Carlson's Basic Mining or Underground Mine Modules
- Calculate end-of-month tonnage on each section in one of three ways with Quantities either by: Average, Grid, or Centerline
- Use the full array of mining symbols from the Mine Symbol Library, or build your own library of mining symbols, pillaring plans, point symbols, or map symbols
- Automatically connect the survey data using Auto-Connect Pillars
- Layout your room and pillar mine automatically using Advanced Panel Layout features
- Draw and then view the underground in 3D

Underground Mine Reserves

Determine these complete with quality attributes, thickness and grades calculated and displayed using user-defined parameters, such as:

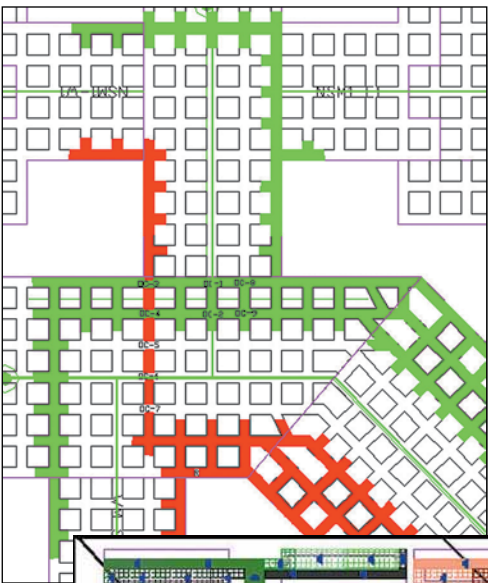
- tonnage
- overburden
- area mined
- qualities
- periods
- equipment
- cost

Underground Scheduling

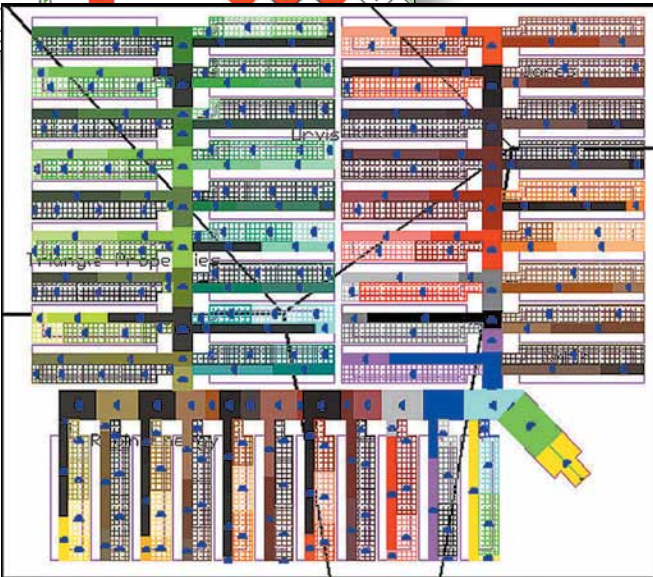
Knowing precedence is critical in underground mining, Carlson's timing routines provide valuable information to assign equipment to reduce idle time and increase production rates by avoiding delaying or illogical layout elements and precedence.

Added options for color settings enhance visual feedback in the underground timing sequencing. Retreat mining can also be included in the scheduling, splitting the panels by advance and retreat.

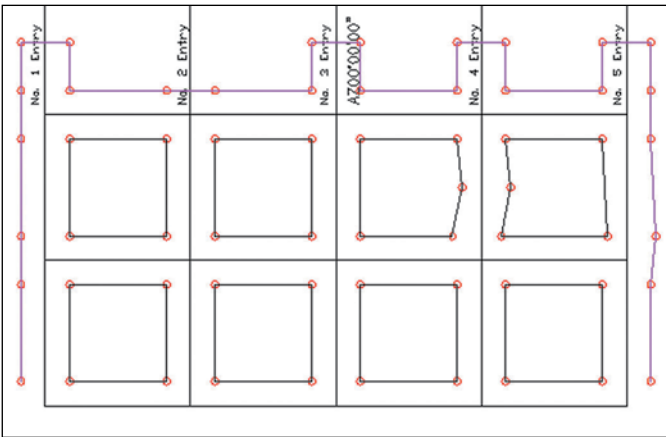
- Schedule timing and quality forecast, tying into the geologic model
- Individually schedule mining sections based on both productivity and operating schedules
- Forecast difficult mining areas using Difficulty Factors in several different ways, for example as a function of time, location, or thickness
- Place drawing events in the mine to accumulate specific tasks such as belt moves, belt heads, stopping points, longwall moves, etc.
- Update your mine and re-forecast quickly using one of two methods
- All reports export directly to XML Reports, ASCII text files, and more
- Automatically calculate extraction ratios when pillars are drawn, or input the ratio using simple closed polylines on the PERIM layer representing the panel
- Much of the panel data can be input by just keying in text on specifically named layers such as Difficulty, Extract, Ret_Extract, and more
- Accumulate timing results by property owners



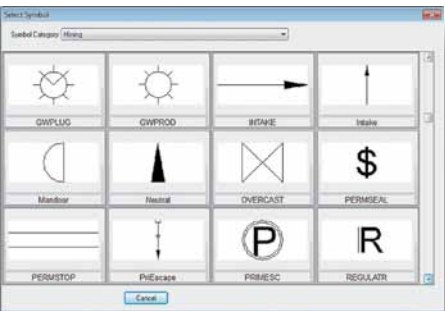
Any pattern of Pillars can be defined



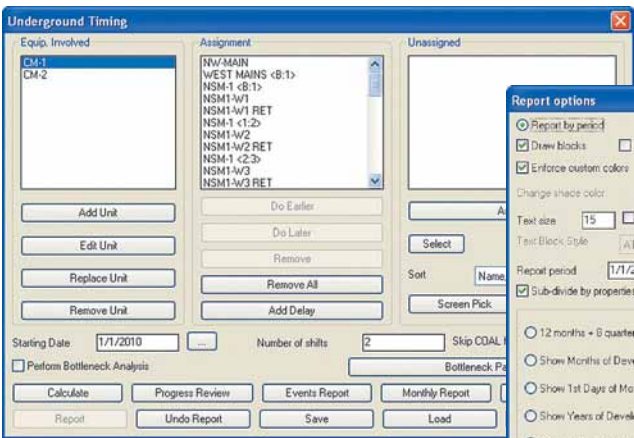
Longwall Mining



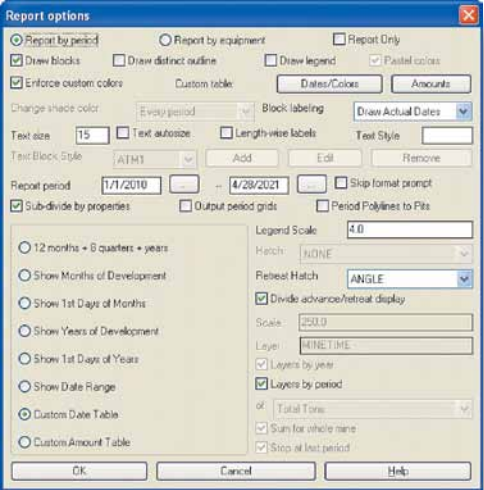
Auto-detection of Pillar Corners



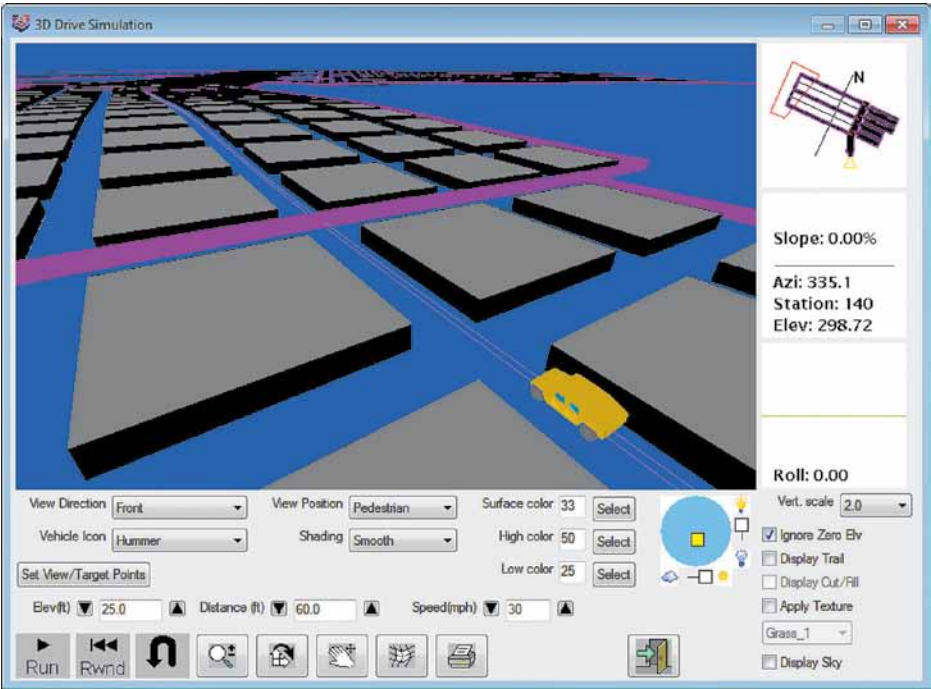
Mine Symbol Library example



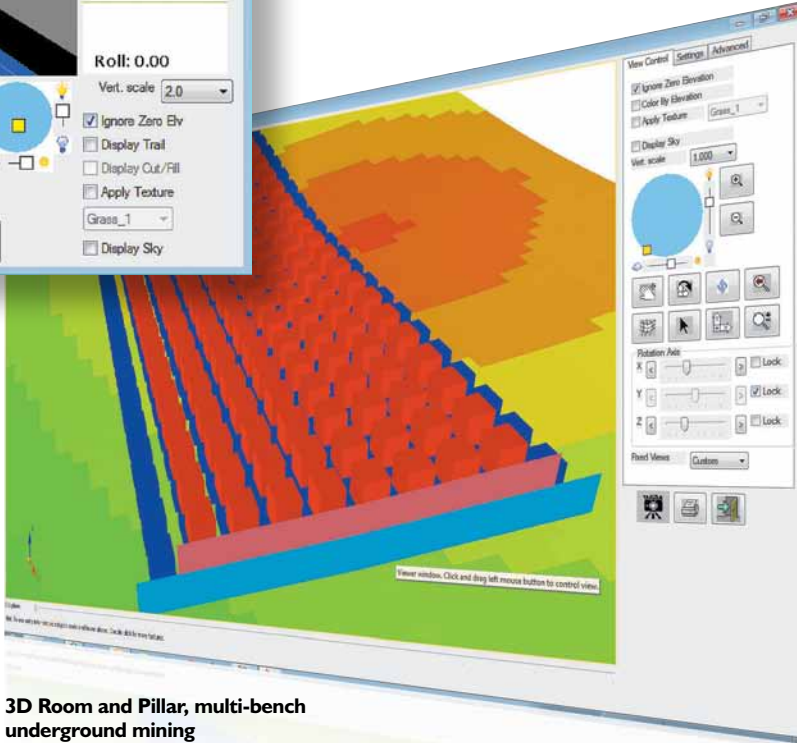
Underground Timing



Choose your report format



3D Underground Room and Pillar Simulator



3D Room and Pillar, multi-bench underground mining

For complex surface mining design and techniques with precise scheduling and timing

The Carlson Surface Mining module enables users to find the most efficient mine design by testing layouts in plan, section and 3D view. Use Carlson to:

- Integrate geologic and surface modeling with plan view, 3D view, and section view mine layout routines
- Get accurate calculations of overburden, ore quantities, strip ratios, rehandle, and ultimately, cost
- Easily convert any road or ditch centerline, dam, building pad, pit or other defined object into a final terrain

Carlson's color-coding highlights production timing and statistics and its calendars explore "what if?" scenarios and monitor equipment usage. Also get the ability to base timing on calendar periods, tonnages, or on volumes of overburden.

Multiple slope groups are now easy to define for all pit blocks globally with symbols for different slope and bench templates on different sides. You can now cut through the benches whether working from the top down or the bottom up with automatic ramp building.

3D Pits & Spoil Design

- Try varied bench parameters on different sides of the pits by tagging Slope groups
- Alter the slope, width, and height of the benches in pit through different material or depth
- Place ramps strategically by testing in design, just select slope and starting location to have ramps automatically carved into the pit even with switchbacks
- Base benches on strata, elevation, or quality for both pits and spoil

Pit, Property & Spoil Layouts

- Use several pit layout algorithms to represent actual mine pits or simply to subdivide reserves into smaller production blocks for reserves or scheduling
- Choose any shape for your layout from simple to extremely complex using commands such as Pit Matrix Layout and Layout by Advance
- Further subdivide and identify pits by ownership automatically for instant lease and royalty-calculations-by-owner using the property lines
- Create spoil location polygons for spoil timing
- Name property boundaries for use in reserves and scheduling

Surface Mine Reserves

- Calculate reserves from drillholes on the fly, or from pre-calculated grid or block models
- Choose between vertical quantities, overall highwall slopes, or detailed bench layback designs
- Store quantities or grids into the pits for scheduling
- Create full reports of volume, tons, quality, area and strip ratios
- Analyze deposits with Reserve Classification for measured, indicated and inferred results

Haul Cycle Analysis

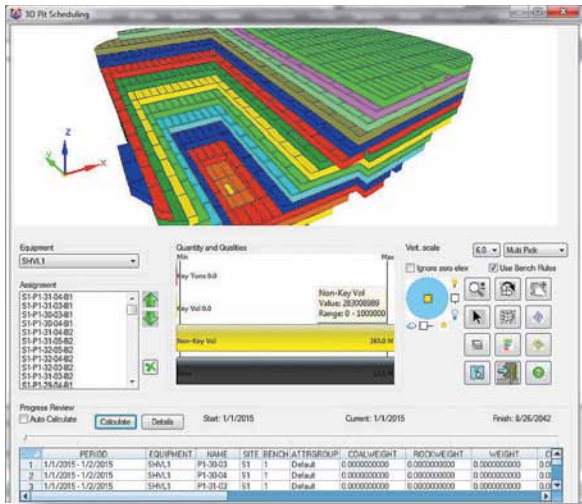
- Define truck fleet productivity (pick from 24 pre-defined trucks plus add own)
- Create haul road networks for possible routes based on color-coded 3D polylines with length and slope
- Calculate and report cycle time, overall productivity or truck fleet size required

Dragline Range Diagrams

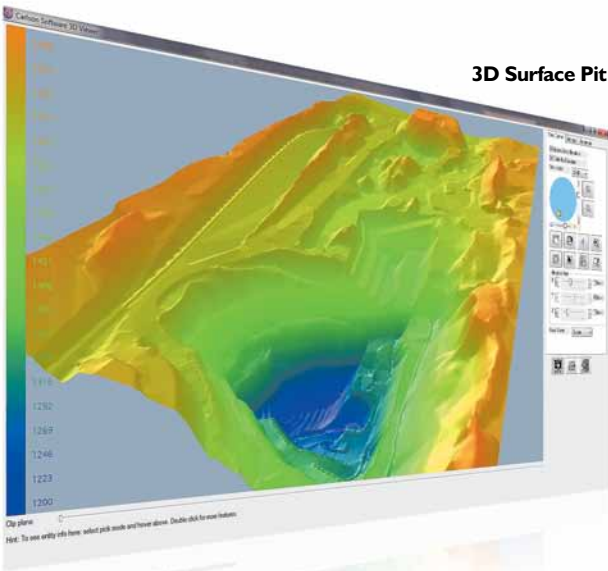
- Test interactive range diagram options for detailing dragline sequences and associated volumes
- Analyze dragline height, reach, and digging depth limits based on design
- Combine dozer push analysis with cast blasting, shovel, and dragline analysis to obtain the optimal combination of equipment and mining sequencing
- Process the section design to 3D creating pits and the spoiled surface

Scheduling & Timing

- Base surface mining rates on overburden removal or ore tonnage
- Apply equipment calendars/usage to individual or collective fleets
- Create multiple calendars to explore "what if?" scenarios
- Get color-coded view to highlight the production timing and statistics
- Base timing on calendar periods or tonnages or on volumes of overburden
- Set production requirements per user-defined time periods
- Attach precedence requirements to any timing blocks
- 3D Pick for short range sequencing with multiple select and colored benches
- Automatically create 3D surfaces of each period scheduled to simulate the mine progression and play it back for review
- Combine dozer push analyses with cast blasting, shovel and dragline analysis to obtain the optimal combination of equipment and mining sequencing
- Sequence placement of spoil given cuts and haul fleets and combine that with the mining advance to play back the entire mine progression



3D Pit Timing

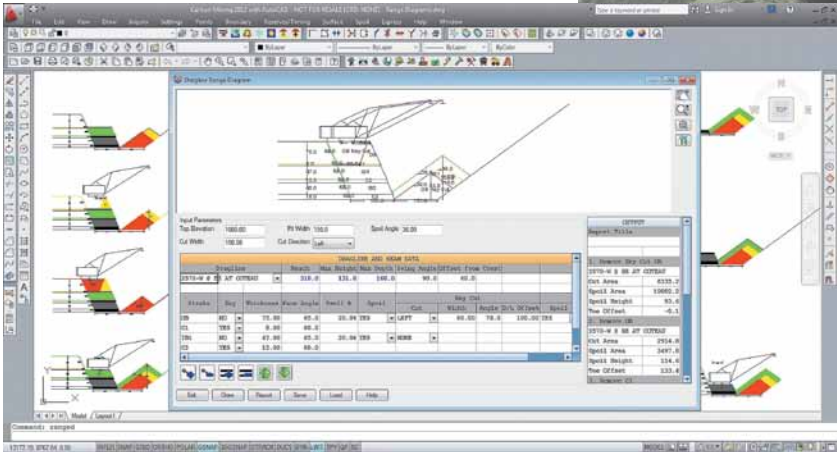


3D Surface Pit

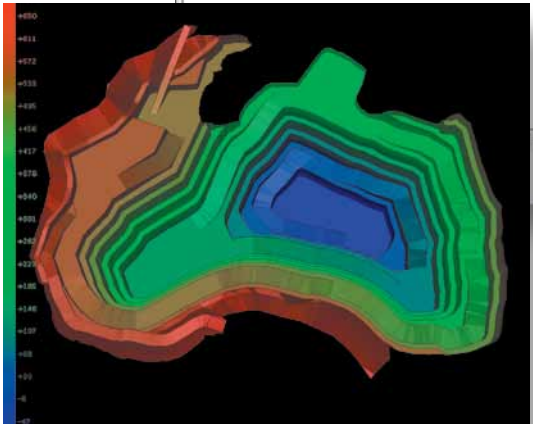
3D Benches



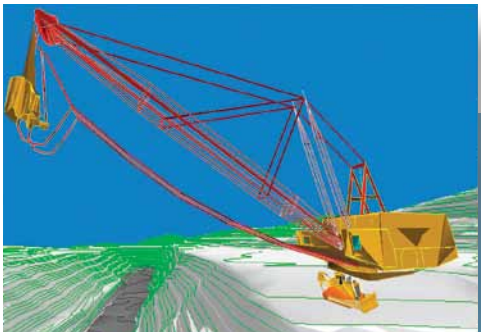
Range Diagram



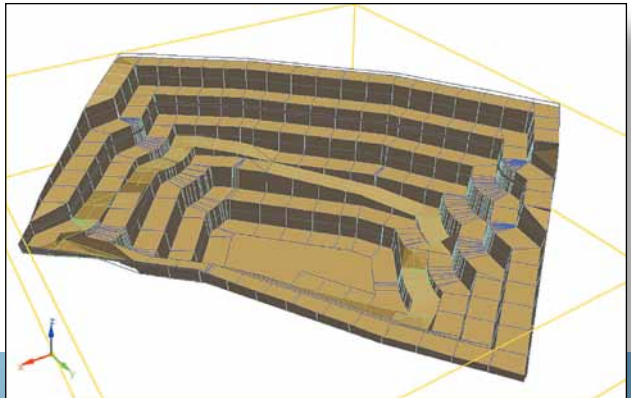
Mine Reserves



3D Dragline



Pit with Benches & Ramps



Carlson Basic Mining Module

Affordable and Upgradable

Here's the software you need to get started or for mining basics at a low cost. It's the perfect AutoCAD/IntelliCAD mining add-on to Carlson Civil and is geared to those who need a low cost tool for simple mining practices. It can be upgraded to any of the other Carlson Mining modules at any time.

Features include:

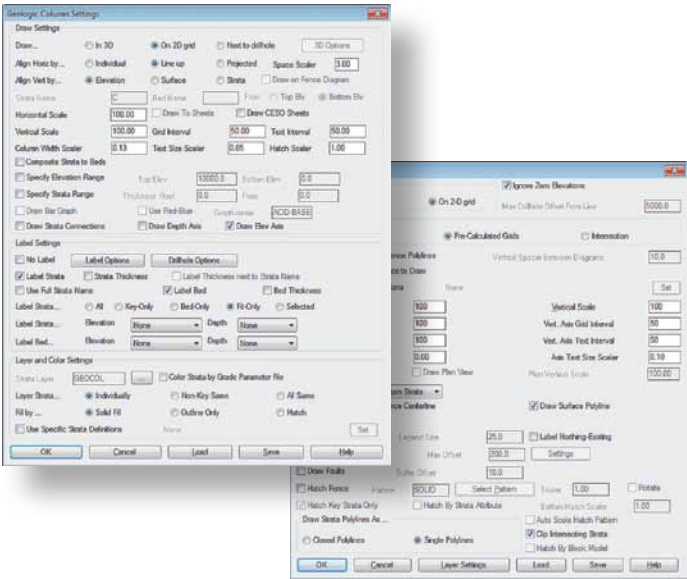
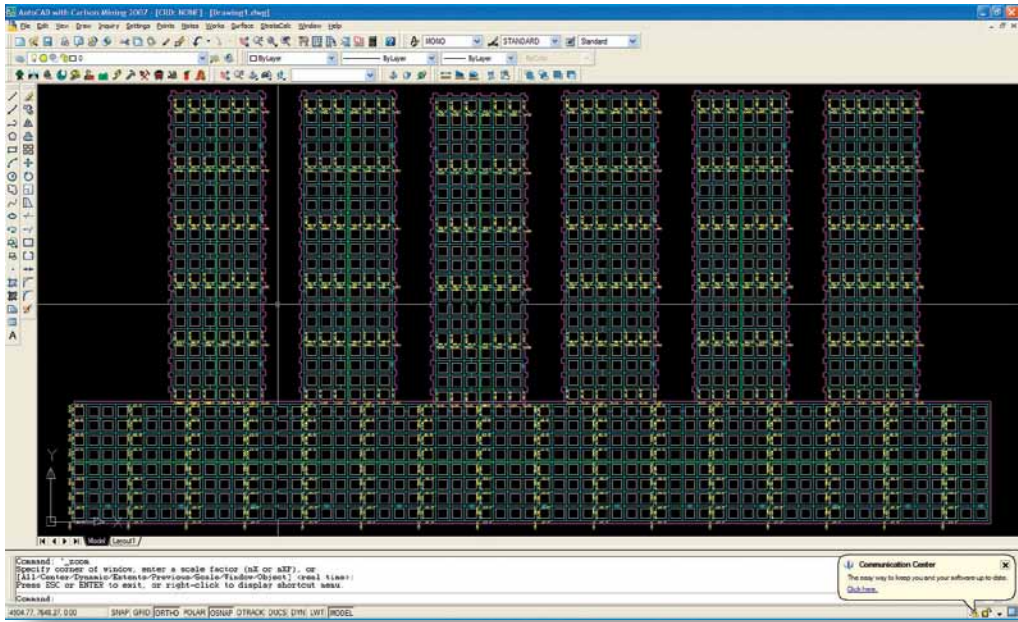
- Basic drillhole entry
- Reserves and fence diagrams (on-the-fly only)
- Underground mine mapping
- Layout
- Quantities

SDPS

Subsidence Deformation Prediction System

Generate isopachs and subsidence based on depth of mining, geological characteristics, and mine design parameters.

This high-end program predicts and represents the settlement of the surface topography due to underground mining. SDPS is a niche program developed through the Virginia Poly-Technical University and Carlson Software is the world's only distributor.



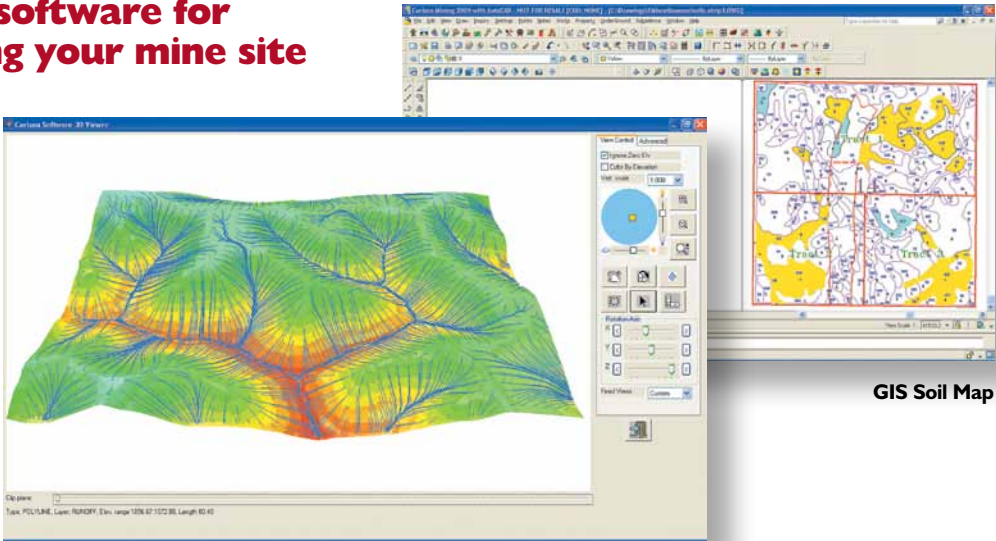
Carlson office design software for designing or upgrading your mine site

Carlson Survey. A completely intuitive survey solution provides versatile and intuitive raw data editing and processing, Network Least Squares, the easiest and most powerful Field-to-Finish, legal description and deed writing and reading, and a full complement of COGO tools for every survey application.

Carlson Civil. For all your terrain detail — roads, ramps, pits, ditches, reclamation — use your creativity to the fullest with Carlson Civil. The fully dynamic (but only when you want it to be) environment allows defining your project folder to suit your organization and your own annotation style, exploring of “what if?” scenarios with a simple drag and drop, and editing or changing the design and all surfaces and volumes automatically in real time.

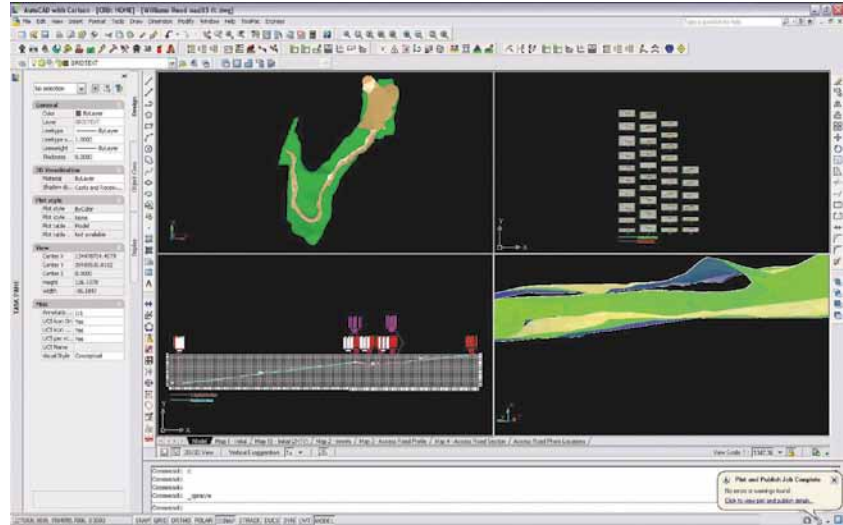
Carlson Hydrology. Get complete automation with full 3D design to compute runoff coefficients from layers, run rainfall events through your fully designed system, analyze the watershed for any storm event and then build the structures to detain and reroute the runoff, build ponds and spillways with channels, weirs, pipes and culverts, and also connect with HydroCAD® to determine stormwater chamber specifications and run rainfall events.

Carlson GIS. New linkage with Esri® allows you to immediately perform preliminary engineering and hydrological studies and planning analysis. Also get the ability to link objects in the drawing to the external database for queries in addition to linking ownership boundaries, leases, mine plans, and properties to the database in order to easily query and retrieve quantities, tonnage, and ore quality.



Runoff Tracking

GIS Soil Map



Haul Road Design



Coordinating
MINE DESIGN with MINE OPERATIONS
and MINE CLOSURE = EFFICIENCY

Do it right the first time with Natural Regrade for mine reclamation — working *with* nature brings real savings

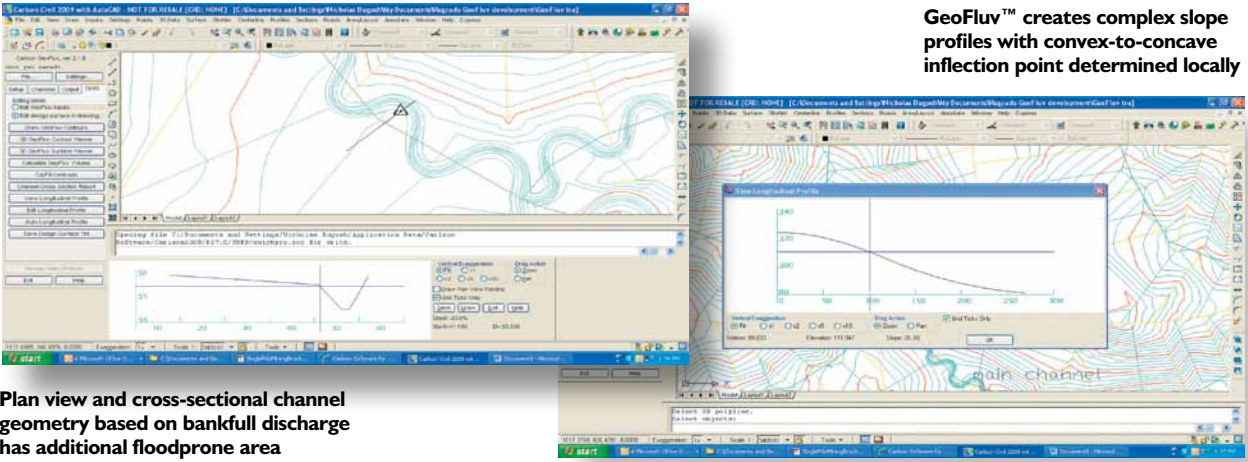
The Natural Regrade reclamation design will:

- Help meet *and* exceed environmental standards
- Provide maintenance-free stability against erosion and true sustainability
- Provide reclaimed land run-off water quality comparable to surrounding undisturbed lands.
- Encourage wildlife and plant diversity in the reclaimed land
- Enhance the local view shed by returning the natural beauty of the land



Uniform slopes & artificial water conveyances of traditional methods of land reclamation are no match for the forces of nature

“*Before even breaking ground*, savvy operators consider material placement that is needed for a reclamation plan that meets *all* requirements. Mining and reclamation plans that are designed to work together will minimize material handling and can make big savings.”
— Nicholas Bugosh, GeoFluv Developer

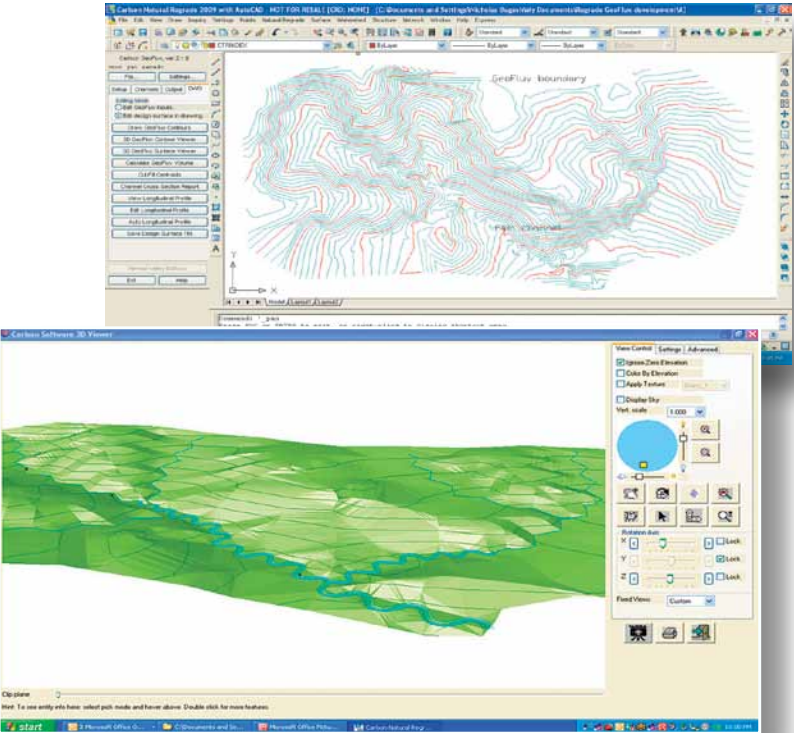


Plan view and cross-sectional channel geometry based on bankfull discharge has additional floodprone area

GeoFluv™ creates complex slope profiles with convex-to-concave inflection point determined locally

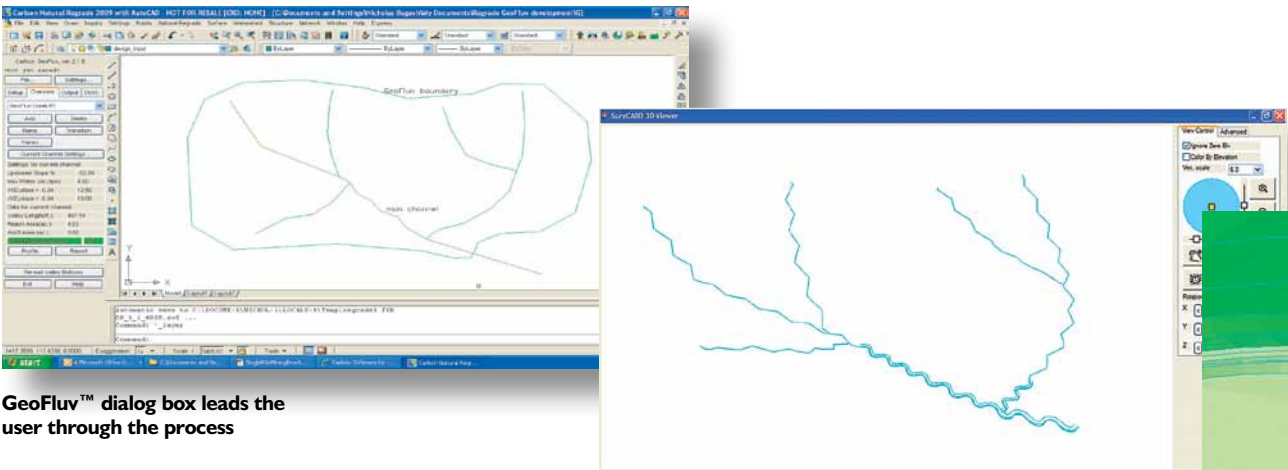


Natural Regrade makes a design for a stable landform that satisfies local empirically determined user inputs



Powerful 3D viewer aids final design editing of the draft landform

Natural Regrade is ideal for integrating with Global Positioning System and machine control, for example Carlson Grade, to simplify and speed construction and reduce costs. The need to survey and stake the designs in the field is eliminated using these technologies



GeoFluv™ dialog box leads the user through the process

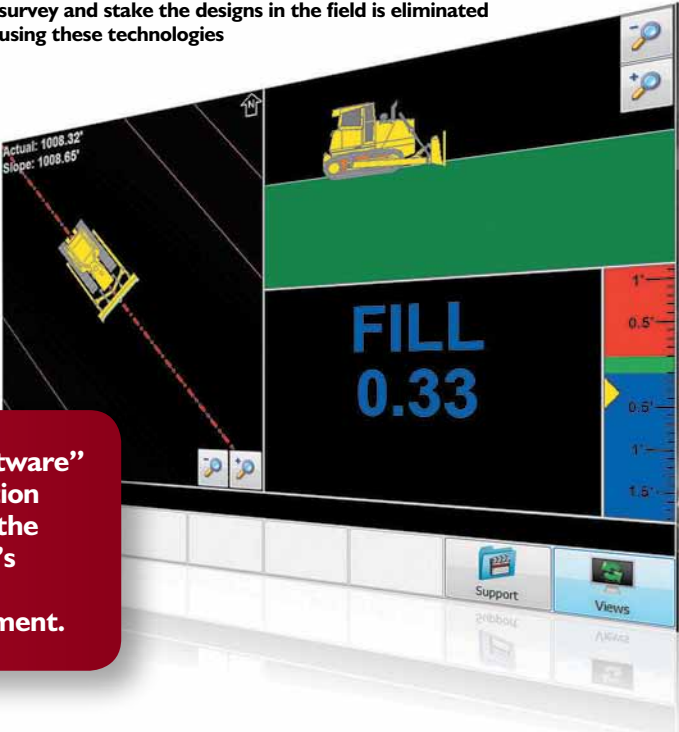
GeoFluv™ integrated 3D channel network using local empirically-determined drainage density

Rather than fight the natural forces that shape the land, Natural Regrade with GeoFluv creates a landscape that harmonizes with those forces and does not require expensive long-term maintenance and repair

Natural Regrade automatically sets channel confluences to grade — change one and the others adjust



Named a “TIPS Core Software” in 2007 for mine reclamation design and review use by the U.S. Dept. of the Interior’s Office of Surface Mining, Reclamation and Enforcement.



CARLSON COMPLEMENTARY SOLUTIONS



Data Collection: Look to Carlson for comprehensive data collection software featuring powerful features to enable doing more, better, and in less time. These include Carlson SurvCE, Carlson SurvPC, and Carlson Field (the latter two made to work in the field on rugged PCs). Supporting hardware manufactured to Carlson's specifications include handheld data collectors, GNSS receivers, and total stations.



Machine Control: Carlson Machine Control Mining Systems offer powerful software with complementary hardware to maximize productivity while increasing efficiency and safety. Heavy equipment operators will know their grade and location without the need for stakes in all conditions and supervisors will know what's going on with real-time position and height inspection capabilities.



For more information call or visit: 800-989-5028 • 606-564-5028; www.carlsonsw.com • mining@carlsonsw.com



© Copyright 2015 Carlson Software, Inc. All rights reserved.
Carlson Software is a registered trademark of Carlson Software, Inc. Trademarks provided under license from Esri. All other product names or trademarks belong to their respective holders.

