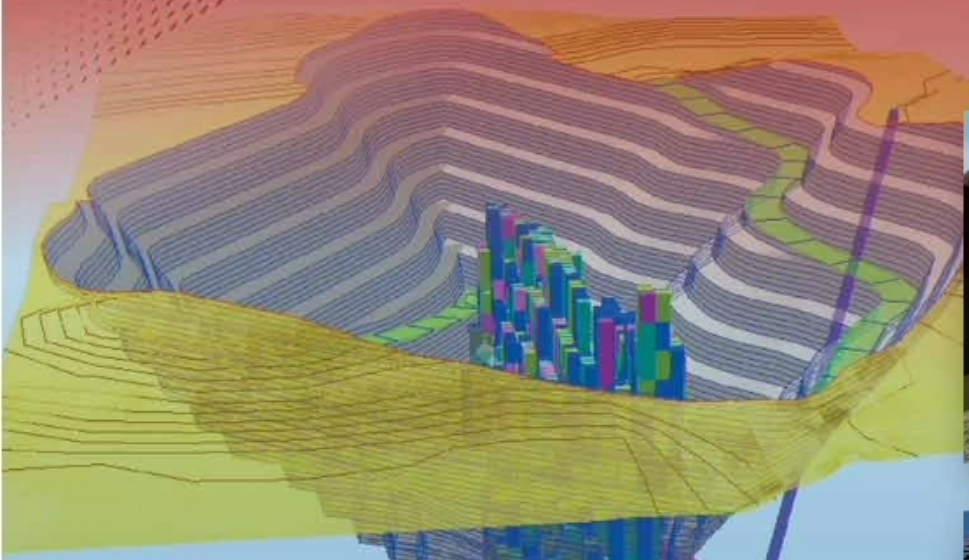
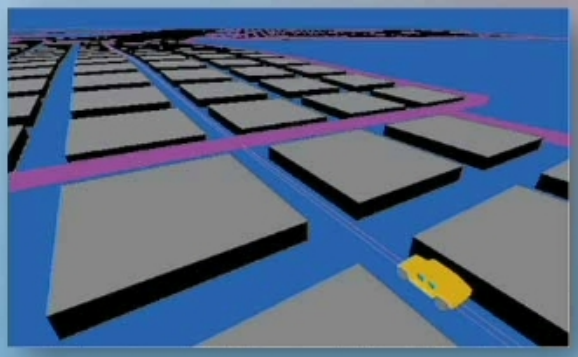
Carlson Mining

— Comprehensive Mining Software Solutions





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

Carlson®
...The Mining Solution

MINING SOFTWARE SOLUTIONS

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 and remote support
- Access to a production & support team with combined 100+ years of mining software experience

Whatever your need, 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 believe there's a direct correlation between our status as the dominant software in this market (approximately 90 percent of the U.S. coal industry utilizes Carlson Mining software) and our commitment to both advanced technology and customer service. Enhancing the software is a never ending process, which is seen through some of our recent improvements such as expanded 3D abilities within bench pit design, added support for underground solids, a significant redesign of the haul truck cycle analysis routines, added cut methods for dragline range diagrams, and much more.

Carlson ...The Mining Solution

TABLE OF CONTENTS

"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 Software's Mining and Machine Control Teams

Analyze, model and fine-tune your geology

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 databases such as SQLite
- Utilize fast macros to reproduce models with new drilling, samples or surveys
- Design faults at any distance and dip angle to offset geology
- Create geologic cross-sections and fence diagrams instantly from polylines, saved alignments, or by picking points
- Calculate mine reserves and output to a variety of report formats

Stratigraphic Modeling

Drillholes

- Import from any format using custom settings
- Store drill data in CAD or link to external databases
- Draw geologic columns in section-view or in 3D to correlate and validate strata
- Validate holes with queries and reports
- Use tools such as Strata Polylines and Horizon Codes combined with drillhole equations to build complex models
- Import E-Log LAS files and core images for hole validation

Cross-Sections & Fence Diagrams

- Plot geologic cross-sections or view in realtime with dynamic section line adjustment
- Color cross-sections by strata or grade and plot drillholes for reference
- Stack up sections in 2D, or place in 3D for visualization with existing topography and mine designs
- Create initial sections for accurate dragline range diagrams

Faults

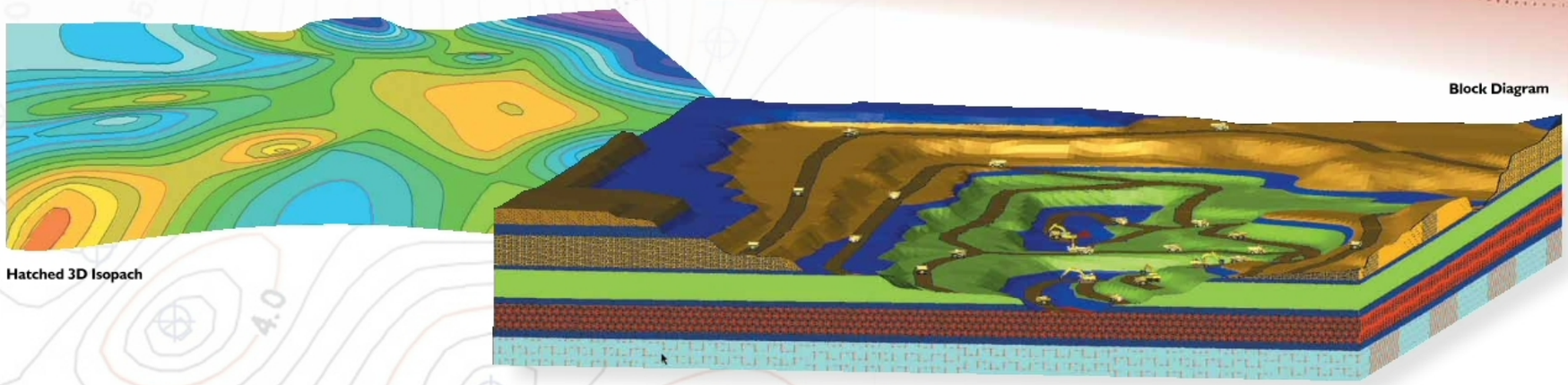
- Add fault lines with variable dip-angles and displacements to create normal, reverse or strike-slip faults
- Draw fault planes for viewing in 3D
- Calculate fault shift automatically by analyzing surrounding drillholes

Mine Reserves

- Use Geologic Models for reserve estimation with weight-averaged quality attributes
- Create strip ratio grids to determine economically feasible mine areas
- Detail reports with custom equations
- Export reports directly to text, Excel, Access, XML, and other database formats
- Analyze deposits with Reserve Classification to report and hatch measured, indicated, inferred and hypothetical results
- Fine tune reserve estimation with waste dilution, strata specific recovery percentages, variable densities and thickness filtering
- Categorize reserves by vertical quantities, overall highwall slopes, or detailed bench-by-bench designs and divide volumes over time with surface history files

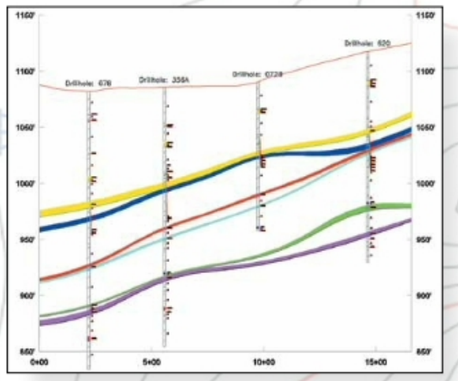
Modeling

- Use industry-standard modeling algorithms and supporting commands to ensure accurate representation of the geology
- Create macros to update models with new data
- Check models with inspection tools and colored, hatched isopachs
- Enhance models with Limit Lines and Strata Polylines for detailed strata behavior
- Automatically model strata pinchout and seam splits
- Analyze Geologic Models and user-modified Mining Models to compare available and recoverable reserves

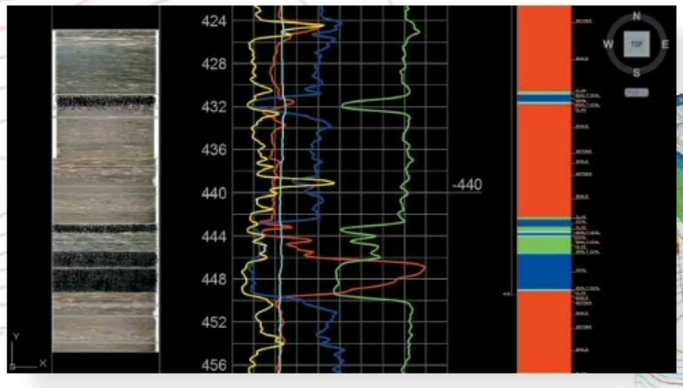


Hatched 3D Isopach

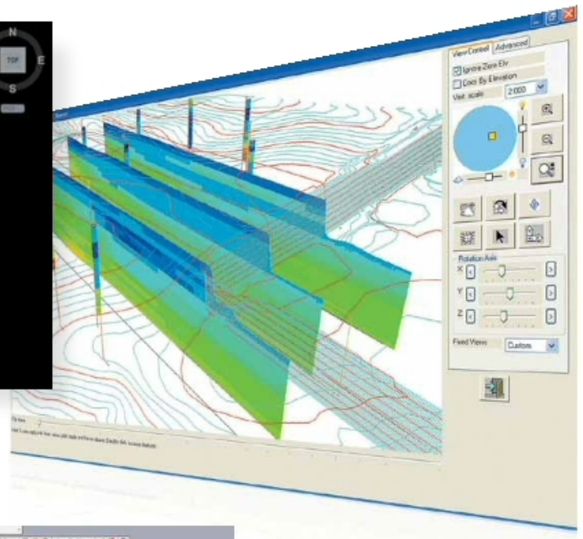
Block Diagram



Seam Splitting

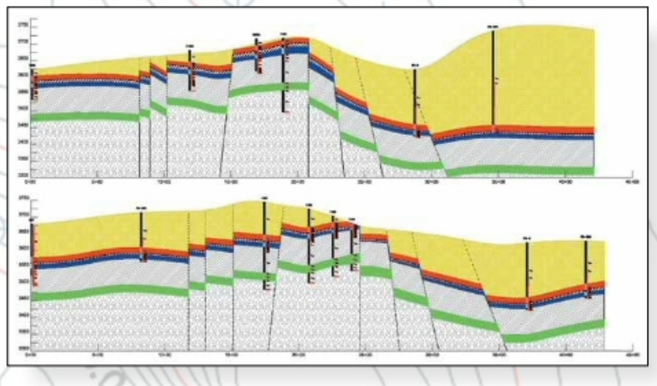


eLog and Core Image

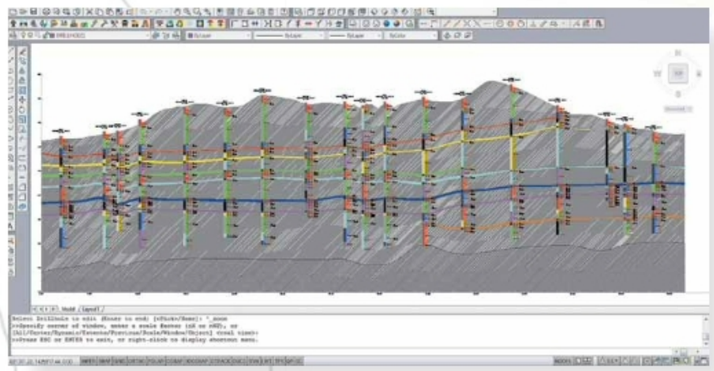


3D Fence Diagram

Faulted Seam Modeling



Geologic Columns & Fence Diagram



Block Modeling

Kriging & Variograms

- Make block models by Discrete, Inverse Distance or Kriging methods
- Use the Variogram Generator to analyze trends and 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 define just one grade
- Add cost per grade for Lerchs-Grossman optimized pit design
- Set colors and intervals for smooth hatching and legend viewing

Block Viewing

- View partial or full block models with inclusion/ exclusion perimeters
- Toggle visibility of block grades to inspect models
- Inspect models by depth or elevation with instant feedback on grades
- Add drillholes, surface topography and mine designs on top of blocks for full design visualization

Fence Diagrams & Hatching

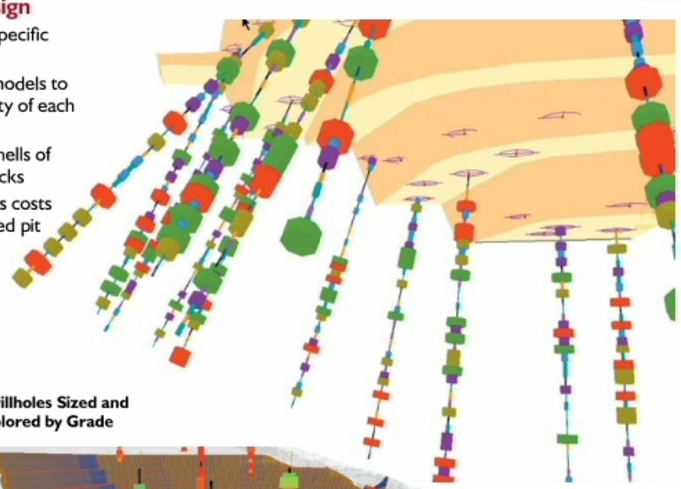
- Hatch and color by grade parameters for easy 2D and 3D viewing
- Size drillholes by grade parameter for intuitive 3D inspection
- Color elevation or bench grids by block model and grade parameters

Mine Reserves

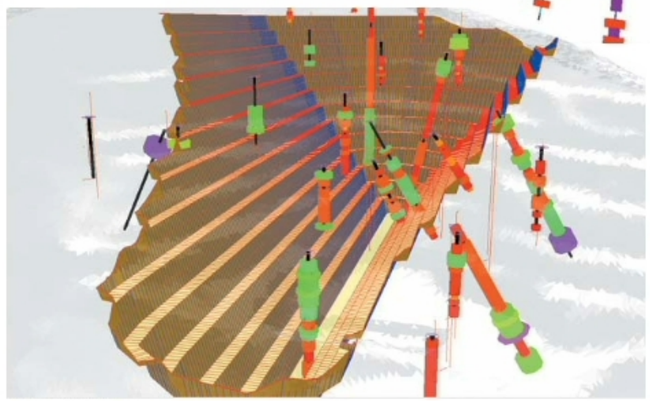
- Breakout tonnage and volume reports by grade
- Calculate overburden for surface mines to get to specific ore blocks

Optimized Pit Design

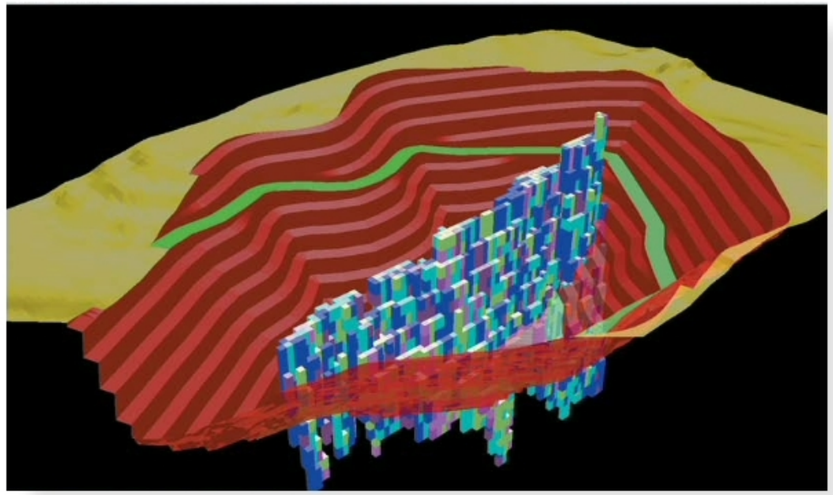
- Define grades with specific cost amounts
- Create value block models to determine profitability of each block
- Output optimal pit shells of profitable mining blocks
- Re-run calculations as costs change to view revised pit limits

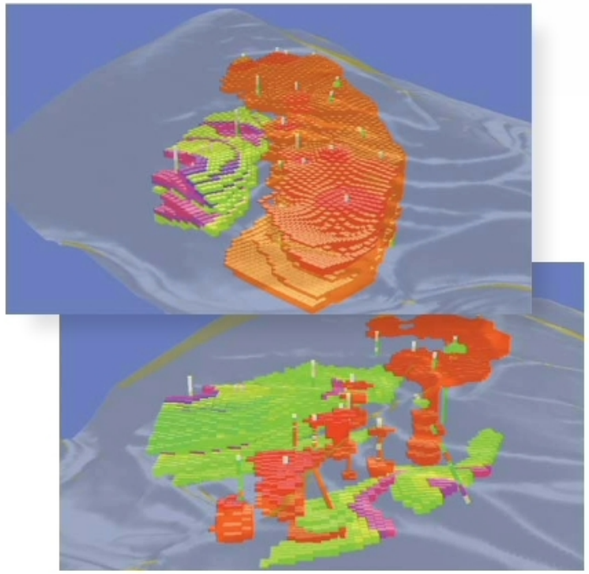


Drillholes Sized and Colored by Grade

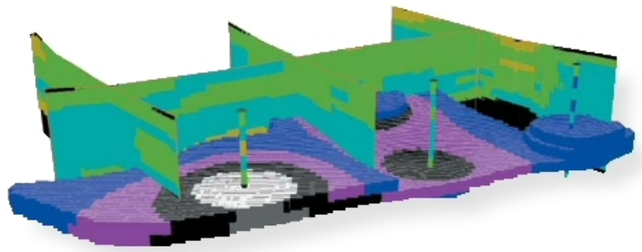


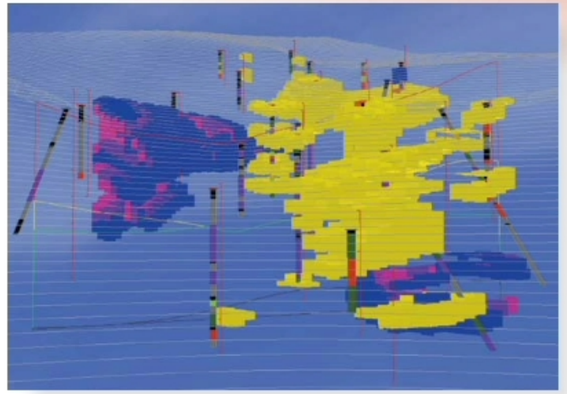
Block Model with Optimum Pit

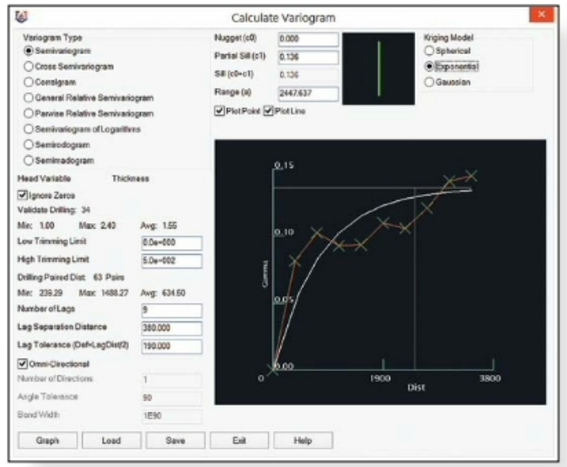




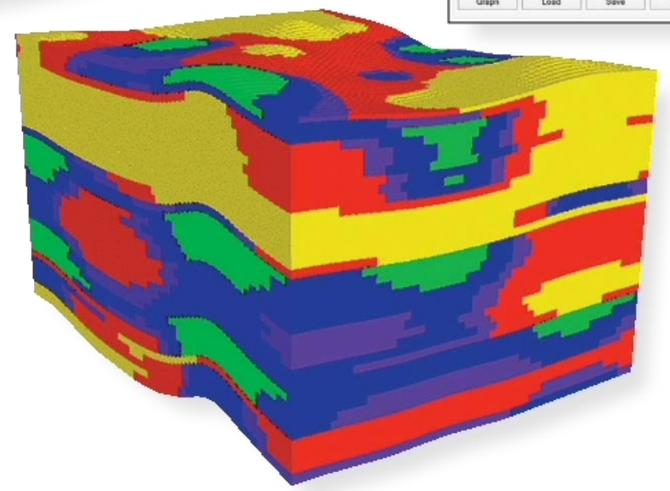
Block Models







Kriging and Variograms



Plan, draft and update your underground mine plan

Quickly calculate volumes, generate tonnage reports, define any pattern of pillar cut, 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 cost savings.

Underground Mine Mapping

- Process survey data and seamlessly generate mine maps
- Calculate end-of-month tonnage for each working section
- Use standard mapping symbols from the Mine Symbol Library, or build your own
- Layout your room and pillar mine automatically using Advanced Panel Layout
- View mine plan in 3D

Underground Mine Reserves

Calculate reserves, complete with quality attributes, thickness and grades calculated and displayed with user-defined parameters, such as:

- Tonnage
- Overburden
- Area mined
- Quality
- Time period
- Equipment

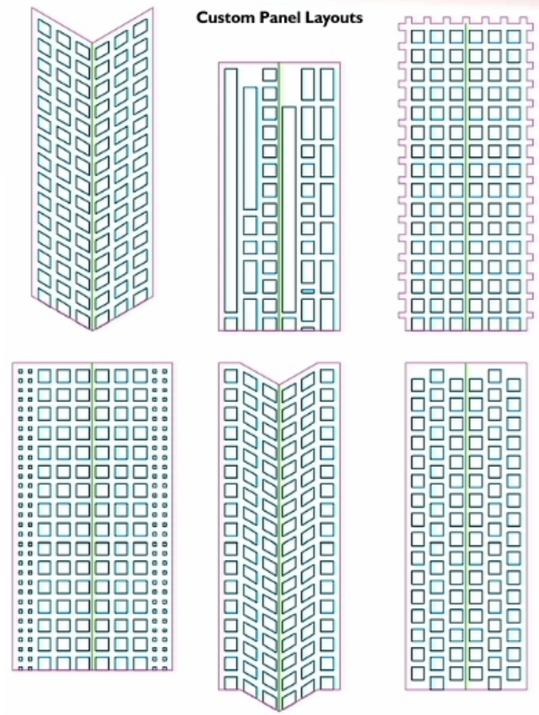
Underground Scheduling

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 delays or illogical precedence rules. Added options for color settings enhance visual feedback in the underground timing sequencing. Retreat mining can also be included in the scheduling to split the panels by advance and retreat.

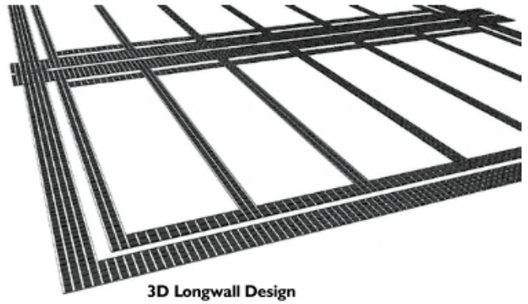
- Schedule timing and quality forecast based on Geologic Models
- Individually schedule mining sections based on both productivity and operating schedules
- Forecast difficult mining areas using Difficulty Factors as a function of time, location, or thickness
- Add location-based events to account for specific tasks such as belt moves, belt heads, stopping points, longwall moves, etc.
- Update mine plans with new information and quickly reforecast timing
- Export reports directly to text, XML, Excel, Access, or other database formats
- Automatically calculate extraction ratios for custom pillar layouts
- Generate panel data from simple text on mine maps
- Break down timing results by property owners

Solids

- Create underground solids from cavity scans, section surveys or design templates
- Slice solids by predefined strata for volume classification
- Apply cross-sectional designs to alignments
- Create entries, drifts, raises, ventilation and stopes as solid models
- Import cavity scan clouds and report volumes

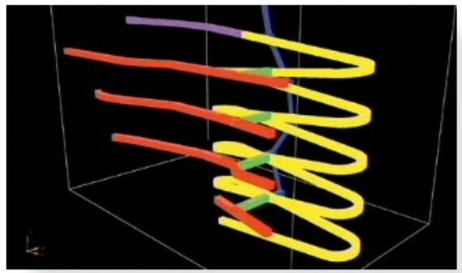


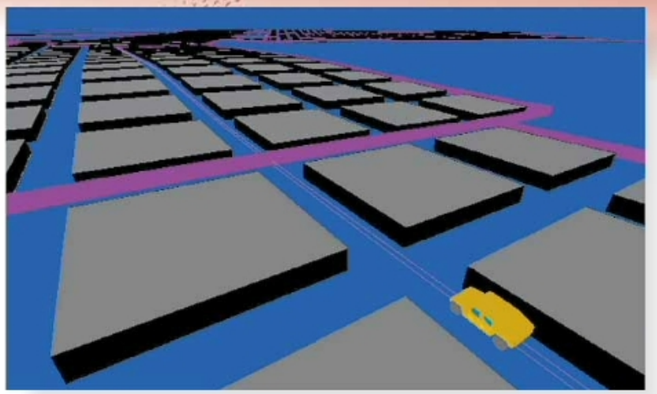
Custom Panel Layouts



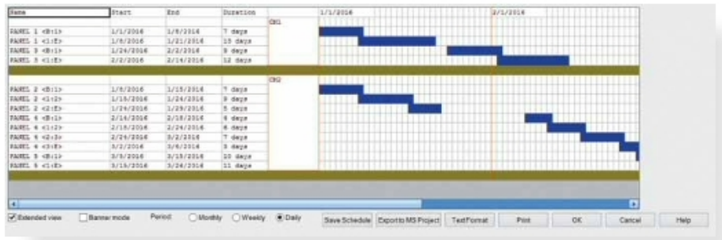
3D Longwall Design

Solids from Templates



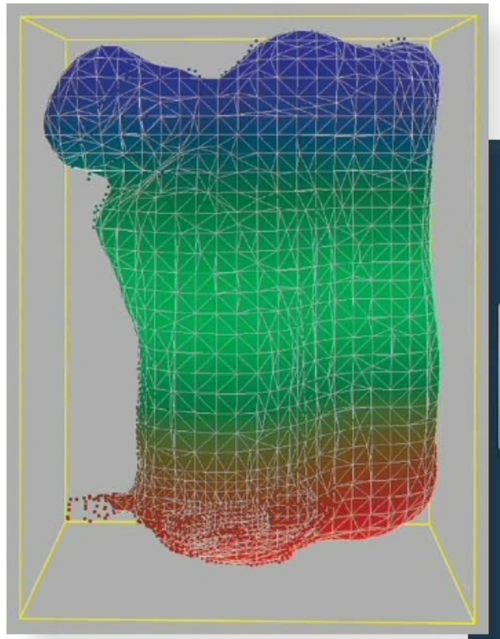


3D Underground Room and Pillar Simulator



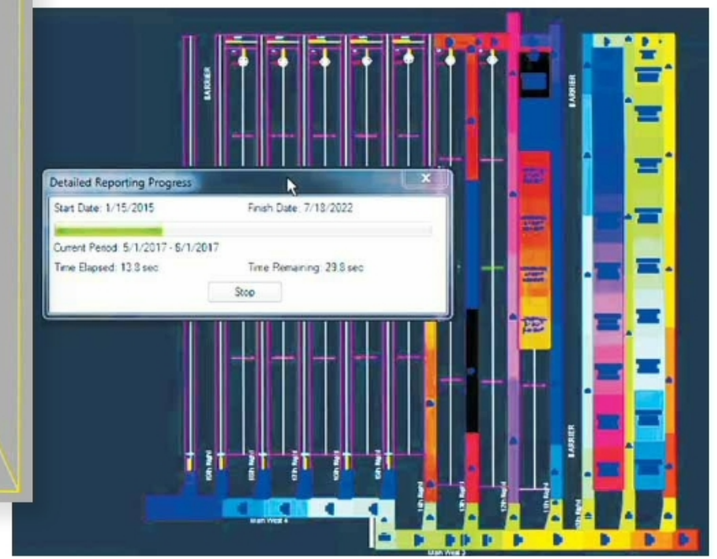
Gantt Chart Reporting

Mine Symbol Library



Cavity Scans

Underground Timing



Design, modify, and simulate your surface mine

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

- 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 timing routines allow you to evaluate multiple 'what-if' scenarios while providing detailed production reports. As timing may be based on calendar periods, tonnages, or volumes of overburden, the user is able to analyze the project intuitively. With upgraded features to analyze haul cycle routes, sequence dragline cuts, and easily define the mine progression, you can count on Carlson to get the job done!

3D Pits & Spoil Design

- Design pits with varying highwall angles and bench parameters
- Construct spoil piles in a variety of shapes and styles
- Incorporate ramps in the pit or spoil pile with berms and ditches
- Designate benches by strata, elevation, or quality for both pits and spoil

Pit, Property & Spoil Layouts

- Utilize multiple pit layout algorithms to represent full mine pits or simply subdivide reserves into smaller production blocks for short-term scheduling
- Create simple or complex pit shapes using commands such as Pit Matrix Layout and Layout by Advance
- Subdivide and identify pits with property lines to automatically calculate royalties

Surface Mine Reserves

- Calculate reserves from drillholes on-the-fly, block models, or stratified geologic models
- Choose between vertical quantities, overall highwall slopes, or detailed bench layback designs
- Store quantities and qualities into the pits for scheduling
- Create full reports including volume, tonnage, quality, area and strip ratios
- Analyze deposits with Reserve Classification for measured, indicated, inferred, and hypothetical categorization

Haul Cycle Analysis

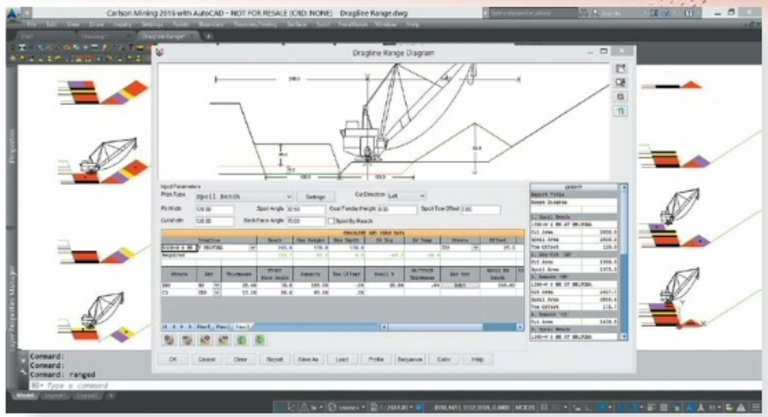
- Define truck fleet productivity
- Create haul road networks for possible routes based on color-coded 3D centerlines
- Calculate cycle time, overall productivity and required truck fleet size

Dragline Range Diagrams

- Test interactive range diagram options for detailed dragline sequences and associated volumes
- Analyze dragline height, reach, and digging depth limits based on design geometry
- Combine dozer push analysis with cast blasting, shovel, and dragline analysis to obtain optimal combination of equipment type and sequencing
- Process section designs to create pits and spoiled surfaces in 3D

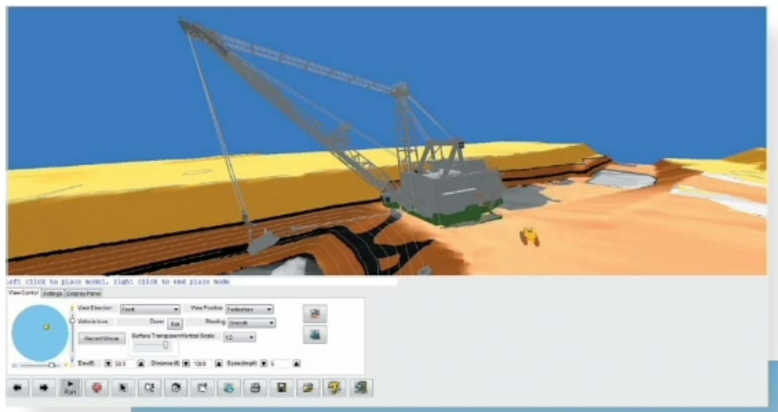
Scheduling & Timing

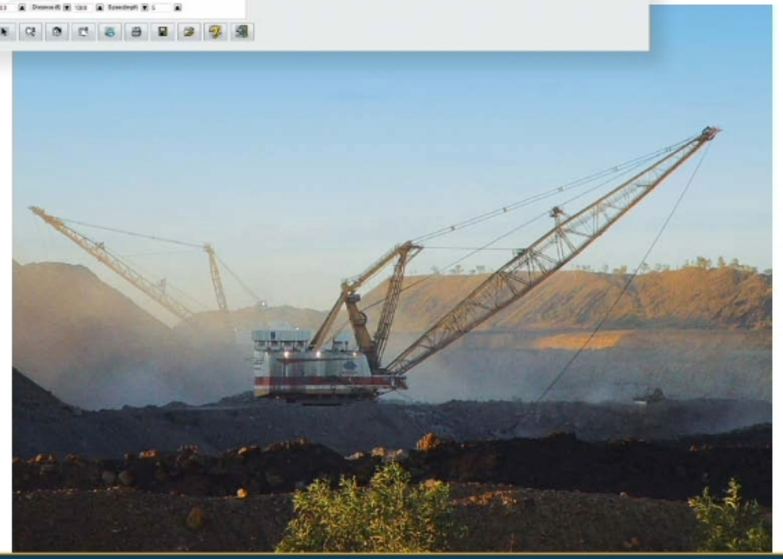
- Base surface mining rates on overburden removal or ore tonnage
- Apply equipment calendars for individual units or collective fleets
- Create multiple calendars to explore "what if?" scenarios
- Produce color-coded timing maps
- Base timing on calendar periods, tonnage or on volume of overburden
- Set production requirements per user-defined time periods
- Integrate precedence rules to account for timing constraints
- Schedule pits with 3D Pick for short range sequencing
- Create 3D surfaces of each period scheduled to simulate the mine progression



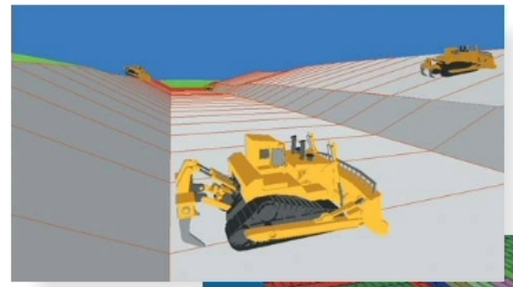
Range Diagram

3D Dragline



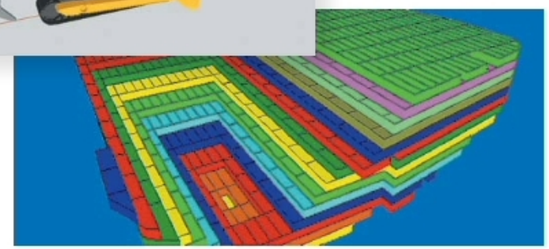


3D Benched Pits



Dozer Push Pit Design

3D Pit Timing

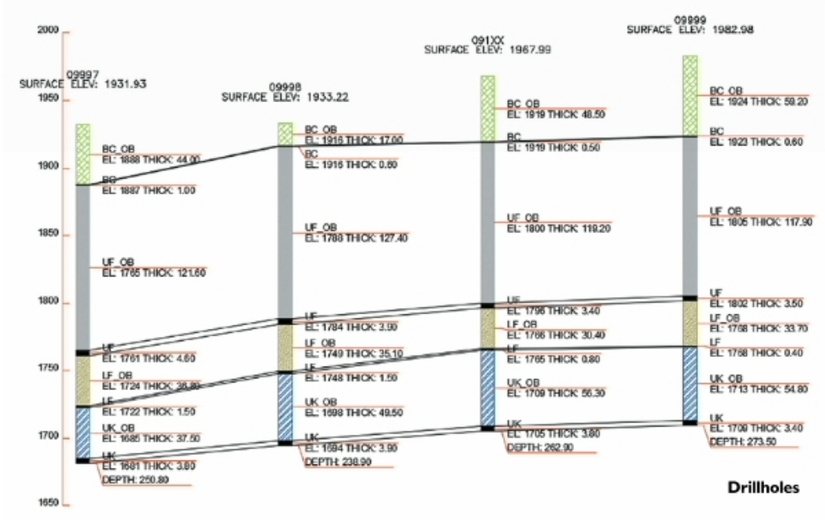


Carlson Basic Mining Module

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 addon 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.

- Basic drillhole entry
- Reserve estimation and fence diagrams (on-the-fly only)
- Underground mine mapping
- Panel layout
- End of the month volume reports
- Stockpile volume calculation

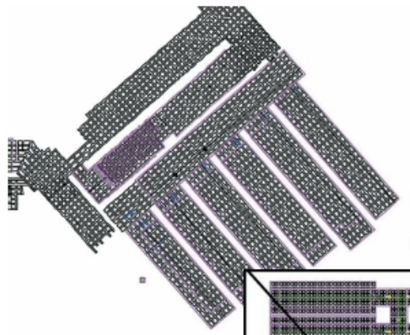


Drillholes

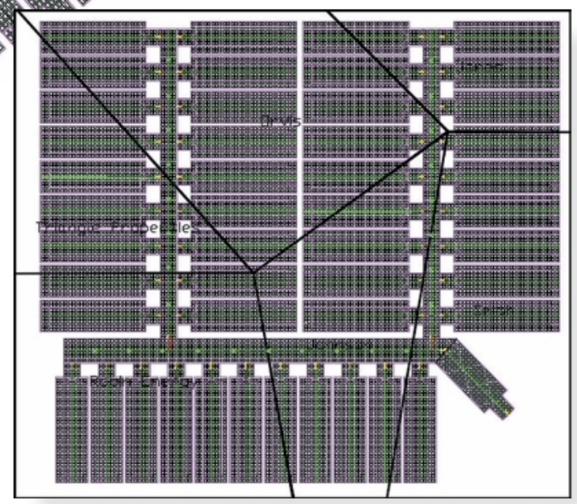
SDPS

Surface Deformation Prediction System

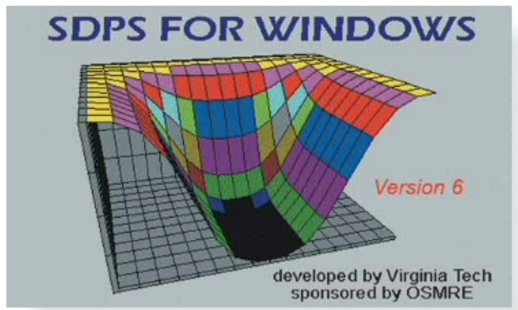
Generate isopachs and subsidence based on depth of mining, geological characteristics, and mine design parameters. This high-end program predicts and represents the settlement of the surface topography due to underground mining. SDPS is a niche program developed through Virginia Tech and Carlson Software is the world's only distributor.



Basic Mining Layouts



Subsidence Deformation Prediction System



Carlson office design software for designing or upgrading your mine site

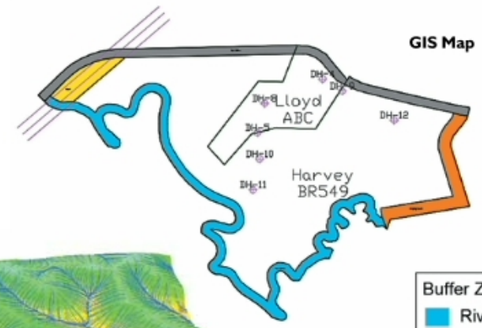
Carlson Survey. A completely intuitive survey solution provides versatile and intuitive raw data editing and processing, Network Least Squares, the easiest and most powerful Field-to-Finish, legal description and deed writing and reading, and a full compliment of COGO tools for every survey application.

Carlson Civil. For all your terrain detail — roads, ramps, pits, ditches, reclamation — use your creativity to the fullest with Carlson Civil. The fully dynamic environment allows you to define your project folder to suit your organization annotation style, explore "what if?" scenarios with a simple drag and drop, and edit to automatically update all surfaces, profiles, cross section plots, and volumes.

Carlson Hydrology. Get complete automation with full 3D design to compute runoff coefficients, route 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 analyze rainfall events.

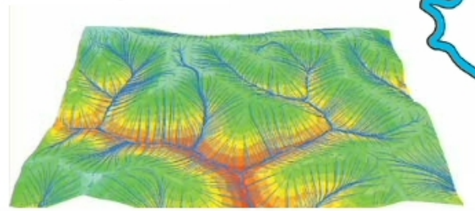
Carlson GIS. Linkage with Esri® allows you to immediately perform preliminary engineering and hydrological studies and planning analysis. Link drawing objects to external databases to query volumes, tonnage, and ore quality based on property boundaries, mine plans, and buffer zones for highly detailed reports.

GIS Data



GIS Map

Runoff Tracking



Haul Road Design

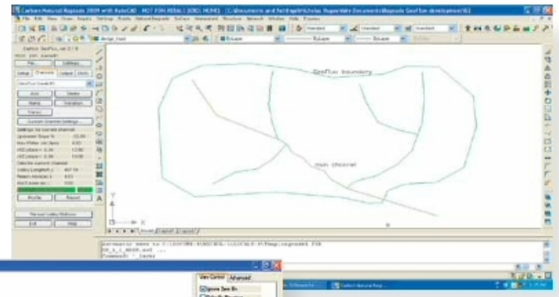
Carlson ...The Mining Solution

Reclaim, revegetate, and restore your mine site

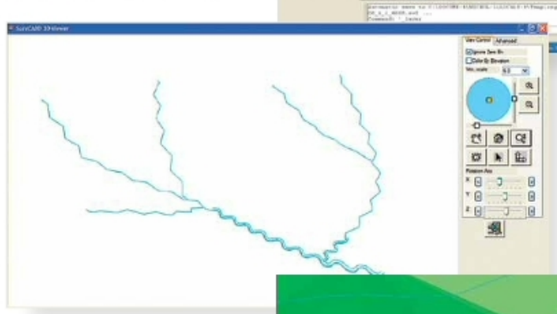
Do it right the first time with Natural Regrade for mine reclamation — working with nature brings real savings

- Meet and exceed environmental standards
- Provide maintenance-free stability against erosion and true sustainability
- Attain water quality comparable to undisturbed surrounding lands
- Encourage wildlife and plant diversity
- Enhance view sheds by restoring areas to their natural beauty

Named a "TIPS Core Software" for mine reclamation design and review use by the U.S. Dept. of the Interior's Office of Surface Mining, Reclamation and Enforcement.

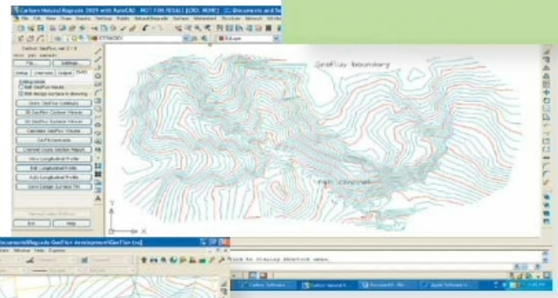


GeoFluv™ dialog box leads the user through the process



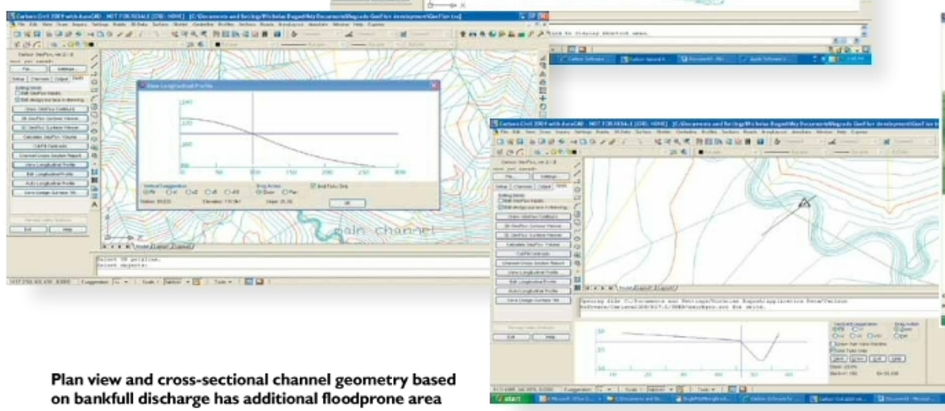
GeoFluv™ integrated 3D channel network using local empirically-determined drainage density

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

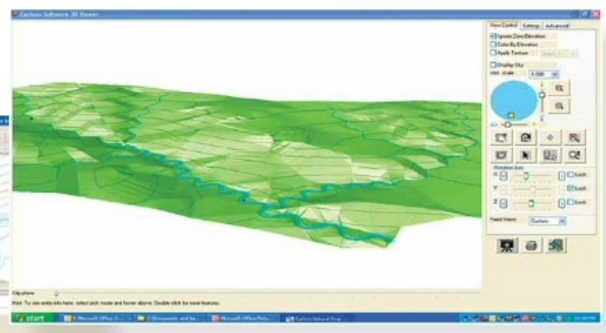


Natural Regrade automatically sets channel confluences to grade — change one and the others adjust

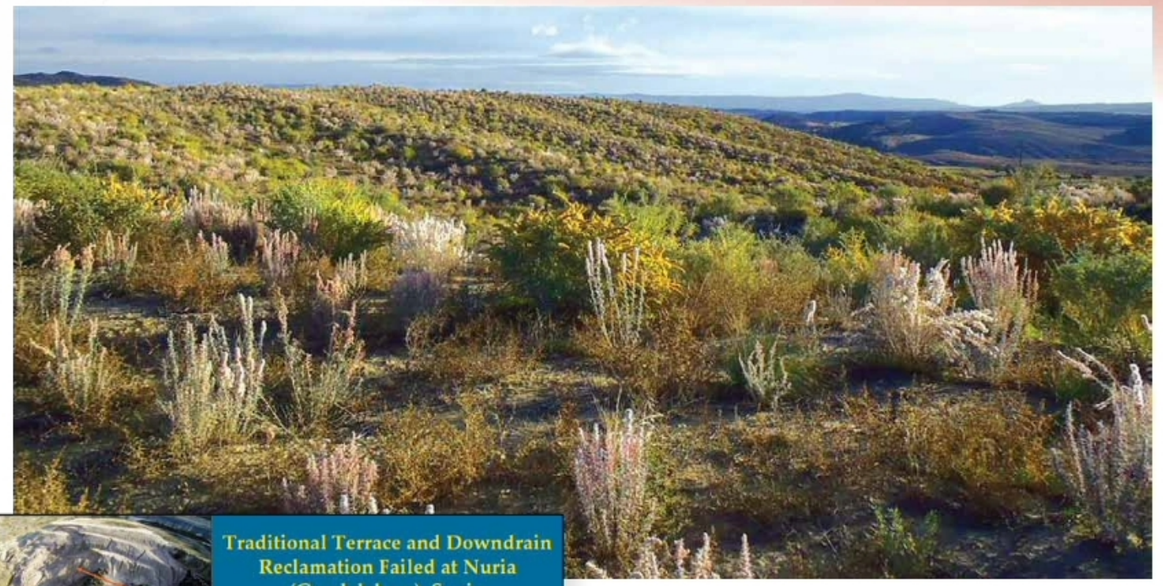
GeoFluv™ creates complex slope profiles with convex-to-concave inflection point determined locally



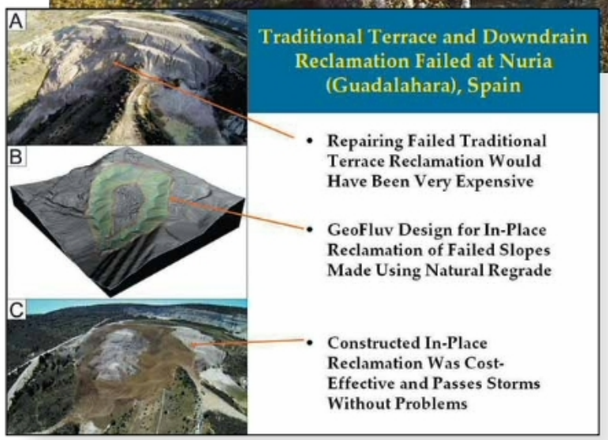
Plan view and cross-sectional channel geometry based on bankfull discharge has additional floodprone area



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



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



"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

GeoFluv Awards listed:

2015, II National (Spanish) **Award on Sustainable Mining and Metallurgy** by Restauración Geomorfológica for design made using Natural Regrade

2011 Earth Science Achievement Award, March 2011, Santa Fe, NM

2009, Intermat Silver Innovation Award in Services Category, January 2009, Paris, Franc

2008 USDI, OSM, "**The Mid Continent Regional Award**", Indiana Department of Natural Resources, Division of Reclamation, Log Creek Church AML Sites 900 & 2040

2008 Finalist in the Innovation Category at the 2008 Cement Industry Energy & Environmental Awards jointly by *Portland Cement Association and Cement Americas magazine*.

2008 State of Wyoming Department of Environmental Quality, Abandoned Mine Land Division (AML) **2008 AML Reclamation Award Nominee**

2004 Dept. of the Interior, OSM "National" and "**Best of the Best**" **Reclamation Awards**

2001 Excellence in Reclamation for Innovative Reclamation Practices by New Mexico Energy, Minerals and Natural Resource Department, Mining and Minerals Division

2001 Interstate Mining Compact Commission April 2004 Annual Reclamation Award - Honorable Mention

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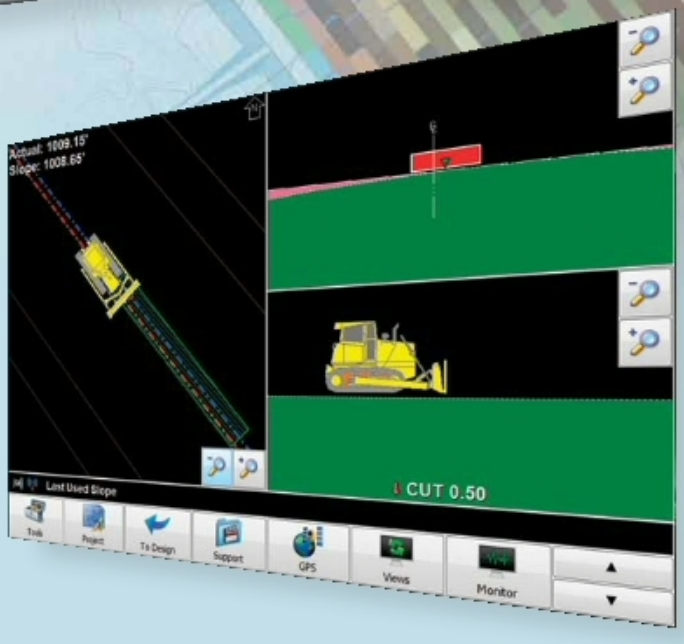
Machine Control: Carlson Machine Control Mining Systems offer powerful software with complementary hardware to maximize productivity while increasing efficiency and safety. Heavy equipment operators will know their grade and location without the need for stakes in all conditions and supervisors will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



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