ABSTRACT

Computer visual simulations are used to portray proposed landscape changes with true color and photo-realistic quality. This technical paper presents three case studies of surface mining operations where computer visual simulations were used in the design and planning of mining and reclamation.

The Florida Canyon Gold Mine in central Nevada is in the process of planning for closure within the next five years. As part of the revegetation, recontouring, and visual impact analysis of the closure plan, the consulting landscape architects developed a series of 16 computer visual simulations, from four Key Observation Points (KOP's), for two alternative mining and reclamation options.

The Black Pine Mine in southern Idaho is a gold mining operation adjacent to an interstate highway. Computer visual simulations were developed which accurately and realistically depict the mining operations and reclamation for a five to ten year time frame. These images were successfully used in the EIS and permitting process. They were developed by the consulting landscape architects and the landscape architect from the Sawtooth National Forest.

The Barrick Mercur gold mine is located in west central Utah. The mine has been in operation since the turn of the century. The consultants were asked to develop computer visual simulations showing the proposed re-contouring and revegetation of the major heap leach dump and for the administrative and ore processing facilities for a five to ten year time frame. The grading design and computer visual simulation images were developed by the consulting landscape architects and were used in the closure permitting process.

This illustrated paper describes the development criteria, process, and use of computer visual simulations on these three projects. The issues of computer visual simulation accuracy, bias, credibility, ethics, and realism are discussed. The use of computer visual simulations as a tool in the planning and design of surface mining operations is presented, along with discussion of their use in project permitting and public involvement. The importance of visual simulations in reclamation, revegetation, and erosion control is discussed.
INTRODUCTION

Surface mining reclamation addresses a wide range of environmental issues, including soil conservation, revegetation, surface and sub-surface hydrology, landform design, erosion control, animals, and visual quality. A variety of technologies are employed which are often clearly understood only by the professional utilizing them. For example, the soil scientist may use sophisticated sampling and analysis tools that are foreign to a hydrologist. This presents a significant challenge to teams of professionals striving to work together to improve environmental quality.

Landscape architects are often involved in the reclamation process. Their individual expertise may cover a diversity of environmental challenges, particularly vegetation, landform design and erosion control. Visual quality, or landscape aesthetics, is generally considered the landscape architect's area of unique expertise. There are numerous analytical techniques for assessing and managing landscape visual quality, including the Visual Resource Management system used by the USDI Bureau of Land Management, and the Scenery Management System (formerly Visual Management System) employed by the US Forest Service. In addition, photo-realistic visual simulations, using advanced computer graphics technology, can now accurately portray proposed landscape conditions with true color and high resolution. These computer visual simulations communicate not only the visual quality of the proposed landscape, but also provide a realistic picture of revegetation, erosion control, and other reclamation activities which can be shared and understood by a diversity of professionals, land managers, private operators, and the public. These visual simulations can become the common ground for effective dialogue about surface mine reclamation.

This paper describes the history of visual simulation use and technology, the major issues, and the use by landscape architects in the design and planning of surface mine reclamation. Environmental quality considerations addressed with this technology are landscape visual quality, landform design, revegetation, and erosion control. Three case study sites, currently operating surface gold mines using the cyanide heap leach process in Nevada, Idaho, and Utah, are discussed.

HISTORY OF VISUAL SIMULATION USE AND TECHNOLOGY

Landscape architects have used visual simulations as a way of portraying the planned future condition of landscapes for many years (Zube, et al, 1987). Sir Humphrey Repton, a famous 19th century English landscape gardener, used "before" and "after" overlay sketches to communicate his design intentions to his aristocratic clients. For many years, hand drawn sketches, photographic montage, and elaborate artist's renderings have been used by landscape architects and other environmental designers to illustrate the look of proposed landscapes.

In the last decade, advances in computer imaging and graphic technologies have made possible the affordable production of highly realistic, accurate, and credible visual simulations. With fast desk-top computer hardware and sophisticated imaging and graphics software, the skilled landscape architect/environmental designer can now provide
clients, agency land managers, and the public easily understood photograph quality predictions of future landscapes. The majority of the technology is available off the shelf and is affordable to most professional consulting offices. High quality graphic output devices support a variety of image presentation media, including color prints, photographs, slides, and videotape.

**VISUAL SIMULATION ISSUES**

There are several technical, legal, and ethical issues associated with the development and use of computer visual simulations. This paper will discuss the major ones within each category.

Technical issues include hardware, software, input, and output. A basic computer visual simulation station would include a scanner for digitizing slides and photographs, a fast computer with sophisticated monitor and graphics tablet, software including imaging, painting, and desktop publishing, and output to a number of different devices for prints, photographs, slides, and videotape. The major consideration is compatibility and operator skill. A computer visual simulation station is a very specialized array of equipment that must be carefully matched in terms of speed, color capability, software communication, and operator understanding. Generally, it is not wise to attempt to make an existing computer system that is used for typical office procedures (word processing, spreadsheets, etc.) do double duty as a visual simulation station. The complexities of the visual simulation hardware and software require careful configuration and operating system management, which sometimes conflicts with the demands of other types of software. It is therefore preferable that the visual simulation system be configured as a stand-alone system, and the operators receive specialized training in its use.

Visual simulation legal issues include copyright, ownership, and use as legal documents (Chenoweth, 1989). Copyright law is complex. The use of sophisticated imaging and photo-manipulation computer systems has introduced new issues never before imagined and which have not yet been fully resolved. As a general rule, any image or substantial portion of an image that is copyrighted cannot be used in the development of computer visual simulations without permission. For this reason, many professionals producing computer visual simulations will only use images taken by themselves or by their clients with written authorization for use. Ownership of visual simulations is generally a matter of negotiation among client, consultant, and agency officials, with joint ownership and rights to reproduction of ten held in common. The final issue, use as legal documents, is not yet clearly defined by case law. For example, if a mine operator contracts for a visual simulation, submits the visual simulation as part of a permitting document, but then does not perform the reclamation to the standards as portrayed in the simulation, is the operator in violation of the permit? How is such non-conformance measured? How are penalties assessed? There are many unanswered questions.

Ethical issues include credibility, accuracy, representativeness, bias, and realism (Sheppard, 1989). Realism can now be effectively achieved with today's highly sophisticated hardware and software. Accuracy is often cited as the most important aspect of visual simulations, however recent research indicates that accuracy tolerances may be within fairly liberal ranges (up to +/-15%), before the human eye can detect error (Watzek and Ellsworth, 1994).
The true test of realism and accuracy, as with the other ethical issues, lies in the technical skill and professional ethics of the person producing the simulation. Great care must be devoted to making decisions based on fact and best professional judgement and not on conjecture or graphic/artistic license. This can be particularly challenging for people with little training in graphic arts who may not understand the basics of perspective, foreshortening, distance, value, color, etc.

THE FLORIDA CANYON GOLD MINE PROJECT

The Florida Canyon Gold Mine (parent company Pegasus Gold) is located in west central Nevada, near the town of Imlay. This is a cyanide heap leach process mine, with a projected life of less than five years. It is located on USDI BLM land and is subject to the applicable laws and regulations of the State of Nevada and the federal government.

In 1995, the mine operators contracted with EALA (subcontractor to SWCA, Inc. of Salt Lake City) to produce a series of 16 computer visual simulations of the proposed mine expansion, reclamation, erosion control, and revegetation activities for use in their closure permit application. In addition, the relocation of two existing high voltage power lines were visually simulated. EALA’s landscape architects worked closely with the Florida Canyon Mine reclamation specialists and engineers, Mr. Steve Drummond, Mr. Doug Stewart, and Mr. Dan Moore in developing the visual simulations.

EALA’s visual simulations represented proposed mine expansion activities and reclamation over a 3 to 10+ years time frame. There were two mine expansion and reclamation options under consideration. The first option was an additional, detached heap leach area. The second option involved expansion of the existing pad area. In both options, the total disturbed area would increase in size by more than double. The landscape architects were asked to simulate the new landforms for the two options from several key observation points (KOP’s). These KOP’s were determined in consultation with land managers from the BLM. Three KOP’s were located on the adjacent Interstate Highway within two miles of the disturbance areas.

EALA’s landscape architects first undertook the task of occupying the four KOP’s for photography. The majority of the photographs were taken in late summer, however, the photos for the powerlines re-alignment, an issue which was at first not considered visually significant, were taken in early Winter. There were serious logistical implications of this later photography for visual simulation purposes. An additional site visit was required to take these photographs, but more importantly the weather and lighting conditions of early winter were much different from late summer. The advantages of using a computer based visual simulation system were evident, as the necessary adjustments were within the tolerances of the graphics system.

The first of the three highway KOP's was at "Milepost 136", approximately two miles south of the main interchange accessing the mine site (figure 1). This is the first significant view of the mine site as travelers approach from the South. This KOP lies at the crest of a long, subtle increase in grade on the highway. The visual
simulations show how the proposed mining waste and leach areas will be designed so as to visually obscure the highwalls. These simulations also illustrate how the successful revegetation of the previous year was used as a guide for the anticipated revegetation success of ten years hence.

The next highway KOP was from the "Humboldt Interchange" (figure 2). The visual simulation of the view from this road was deemed to be the most important view of the site, due to its close proximity. The mine activities dominate the view from here. This view is panoramic to the long axis of the mining activities, both existing and proposed. Existing mine administrative and processing facilities are highly visible from this KOP. The visual simulations from this view show how the land form of the mining and leach areas will be contoured and shaped so as to become visually similar to the alluvial fans and foothills of the surrounding landscape. Revegetation is simulated as might reasonably be expected after 10 years.

The third highway KOP is at “Milepost 139.5” (figure 3), one and a half miles north of the Humboldt interchange. It is the last view of the mine area for the northbound traveler, but the first view for the southbounders. It was considered by the BLM land managers to be the more critical of the two approach views. Relatively little of the mine excavation area can be seen from here, and much of the lower levels of the waste and leach pad areas are obscured by a low, subtle intervening ridge. The proposed powerlines are quite distant from this KOP, becoming essentially invisible to the naked eye near the excavation areas. The landform of a low ridge will be visually compatible with the immediate surroundings, as can be seen in the visual simulations.

The computer visual simulations will be submitted by the mining company as part of their closure and reclamation plan in the Spring of 1996. The BLM has expressed confidence that the visual simulations, which will be displayed as large posters at public meetings, will be of great assistance in communicating the mining company's intent for the expansion and reclamation of the Florida Canyon Mine.
**Milepost 136 View -- Mining Option Two -- Existing Condition**

**Milepost 136 View -- Mining Option Two -- End of Mining**

**Milepost 136 View -- Mining Option Two -- 10 Years After Reclamation**

Figure 1. Milepost 136 Computer Visual Simulations of Existing Condition, End of Mining, and Ten Years After Reclamation, at the Florida Canyon Gold Mine. (Note: Originals in Full Color).
Figure 2. Humboldt Interchange Computer Visual Simulations of Existing Condition, End of Mining, and Ten Years After Reclamation, at the Florida Canyon Gold Mine. (Note: Originals in Full Color)
Figure 3. Milepost 139.5 Computer Visual Simulations of Existing Condition, End of Mining, and Ten Years After Reclamation, at the Florida Canyon Gold Mine. (Note: Originals in Full Color).
THE BLACK PINE GOLD MINE PROJECT

The Black Pine Gold Mine is located in southeastern Idaho, near the town of Burley. The heap leach mining operation is planned to continue for approximately five more years. It is located on US Forest Service land and is subject to the applicable laws and regulations of the State of Idaho and federal government. In 1993, the mine operators contracted with Ellsworth and Associates, landscape architects, inc. (consultant), to produce a series of computer visual simulations of the proposed reclamation, erosion control, and revegetation activities for use in their closure permit application. The landscape architects worked closely with the reclamation engineer Mr. Crellin Scott, and with Mr. Terry Fletcher, Sawtooth National Forest landscape architect, in developing the visual simulations.

The visual simulations would represent proposed mine expansion activities and reclamation over a 5 to 10 year time frame. From previous reclamation experience on site, the mine reclamation specialists surmised that a revegetation success rate of 50-70% would be reasonable, with regarded slopes not to exceed 1.5:1. The landscape architects were asked to visually simulate new landforms as visually similar to the natural landforms of the area, when technically feasible.

Visual simulations were produced to show the recontouring and revegetation activities proposed for the site. These visual simulations not only illustrate restoration of visual quality, but also give a clear picture of recontouring, erosion control, and revegetation. Three sets of visual simulations were developed. One was a foreground view of a typical mine exploration road. Another was a foreground/middleground view of a typical mine haul road. The final visual simulation was a middleground/background view of the waste dump. Each simulation was done in late summer, during mid-day, from photographs taken by consultant's staff on-site.

The existing mine exploration road was previously regarded and prepared for topsoil and vegetation. The visual simulation shows a variety of grasses, forbs, and shrubs that could reasonably be expected (figure 4). The mine operator had successfully established vegetation three years earlier on a similar exploration road, at the same altitude, aspect, and slope, using the same seed mix. Photographs of the previously revegetated area were used for the existing exploration road, therefore yielding a highly accurate, realistic, and credible visual simulation.

The visual simulation of the future condition of the haul road emphasized landform regrading on steep slopes, with revegetation success in the 50-70% range (figure 5). It was determined that the steep slopes of the existing landform would cause difficulties in stabilizing the slopes, and therefore it would be most realistic to portray some slumping and dispersion within the 5-10 year time frame of the visual simulations. As can be seen, the top edges of the existing haul road are still visible in the simulation, as is the slumping evident in the existing condition image. The existing drainageway was considered important, and is shown intact in the visual simulation. A range of anticipated revegetation success can also be seen in the simulation, with less success on the steeper, rockier slopes.
Figure 4. Computer Visual Simulation of Proposed Mine Exploration Road Revegetation at the Black Pine Gold Mine. (Note: Originals in Full Color).

Figure 5. Computer Visual Simulation of Proposed Haul Road Regrading and Revegetation at the Black Pine Gold Mine. (Note: Originals in Full Color).

The third on-site visual simulation is of the mine waste; dump (figure 6). The existing dump extends downslope with the toe near the administrative offices. The visual simulation shows the dump regarded to a 3:1 slope, with subtle landform ridges on the near side. Additional landform diversity, although preferable from a visual quality standpoint, might diminish revegetation and erosion control success, therefore the proposed landform is basically uniform. The landscape architects' analysis of the existing ridges and drainages in the area indicated that such a landform would be visually acceptable, since the majority of viewers will be further distant than the visual simulation viewpoint.
These computer visual simulations were submitted as part of the Black Pine Mine proposed expansion and reclamation/closure plan. The plan was recently approved. Reclamation activities are currently underway and closure is expected by the end of the decade.

THE BARRICK MERCUR GOLD MINE PROJECT

The Barrick Mercur Gold Mine is located in west central Utah, near the town of Tooele. This is also a cyanide heap leach process mine, with a projected life of approximately five years. It is located near US Forest Service and BLM land and is subject to the applicable laws and regulations of the State of Utah and the federal government.

In 1995, the mine operators contracted with the consulting landscape architects to produce a series of computer visual simulations of the proposed reclamation, erosion control, and revegetation activities for use in their closure permit application. The consulting landscape architects worked closely with the reclamation specialists and engineers, Mr. Shawn Davis, Mr. Mike Richardson, and Mr. Craig Olsen in developing the visual simulations.

As with the Black Pine Mine, visual simulations would represent proposed mine expansion activities and reclamation over a 5 to 10 year time frame. There were two reclamation projects of concern to the mine operators. One was a heap leach area. The landscape architects were asked to first design, and then simulate a new landform for the leach area which would be visually similar to the natural landforms of the area and maintain stable slopes. Acceptable slopes would be no steeper than 2:1 and preferably 3:1 or gentler. The second project site was the existing administrative and ore processing facilities. The landform and revegetation design for this area were to be conceptual only, pending final design decisions. The landscape architects were asked to show the area as basically level, with some diversity of landform for visual interest and enhanced revegetation potential. The existing access road would be maintained.
The landscape architects first undertook the design of the new landform, with enhanced visual quality and stable slopes for effective re-vegetation and erosion control the major considerations. A careful analysis of the characteristic landscape of the area, in terms of slopes, drainages, and general landform was conducted. Observations were recorded in notes, photographs, and sketches. From this analysis, a grading plan which reflected the characteristic landscape of the immediate area was developed and approved by the mining engineers. Visual simulations were then developed based on this grading design. Four key viewpoints were selected for the heap leach area visual simulations, two of which will be discussed here. The photographs for these views were taken in very early Spring, with snow-capped peaks and little new vegetative growth.

The first viewpoint is from the existing access road which will be maintained with slight alignment adjustment during reclamation. The visual simulation of the view from this road was deemed to be the most important view of the site. This view is perpendicular to the long axis of the proposed landform. It illustrates the full extent of the new landform in panorama, and shows the potential for re-vegetation and control of erosion on the various slopes (figure 7). Existing equipment storage areas, seen in the lower right corner of the existing condition, will be removed. The flat-topped, unnatural landform of the leach area will be contoured and shaped to resemble the surrounding landscape, as specified in the grading plan. The visual simulation shows a ridge in the foreground, which defines the proposed drainage between this ridge and the leach area. Re-vegetation as shown is as can be expected over a 10 year period, and is based on the success rate of similar areas planted a few years previously. In this high altitude environment (over 7,000 feet), primarily grasses and small shrubs will establish in that period.

The second viewpoint is further down the access road, parallel to the long axis of the landform. This vantage point would allow a view of the north side of the landform and show clearly the proposed drainageways and the adjusted alignment of the road (figure 8). The steeper slopes are on the back side, as are the major proposed drainages. Pockets of snow were simulated to clearly show the shape and form of the drainages and to indicate direction of runoff flow. Considerations for re-vegetation are similar in this view as in the previous one.

The final visual simulation was of the conceptual reclamation of the facilities area (figure 9). This visual simulation was used to communicate the intent of the mine operator to leave the site with an acceptable landform, re-vegetated, and without erosion problems. Although no final grading plan was developed, as stated previously the general landform would likely be level with some undulations. The existing access road was conceptually designed, meeting grade at the upper and lower ends. This view also shows the reclaimed leach area described above (just left of center in the image), and other mining excavations in the background. This visual simulation was developed in mid-summer, hence there is less snow and more green vegetation than in the previous two.

The computer visual simulations were submitted by the mining company as part of their interim closure plan in the summer of 1995. The plan has been approved.
Valley Fill Leach #2 South Side View Existing

Figure 7. Computer Visual Simulation of Valley Fill Leach #2 South Side View at Barrick Mercur Gold Mine. (Note: Originals in Full Color).
Figure 8. Computer Visual Simulation of Valley Fill Leach #2 East End View at Barrick Mercur Gold Mine. (Note: Originals in Full Color).

Figure 9. Computer Visual Simulation of Conceptual Reclamation of Ore Processing and Administrative Facilities Area at Barrick Mercur Gold Mine. (Note: Originals in Full Color).
THE IMPORTANCE OF VISUAL SIMULATIONS IN RECLAMATION, REVEGETATION, AND EROSION CONTROL

These examples illustrate the various advantages of visual simulations in the design and planning of surface mining reclamation. The careful planning and management for visual quality in primarily natural environments is important. Visual simulations provide the mine operator, regulatory agencies, and the public with a common base of understanding about the scenic consequences of reclamation activities. In many cases, the public and even trained professionals have difficulty expressing their ideas and concerns about environmental design and, in this case, reclamation. For all of these people, a realistic and credible visual simulation is "worth a thousand words".

As discussed earlier, a variety of professionals are involved in the design and planning of mining reclamation. With visual simulations, the hydrologist can clearly understand the implications of the engineer's and landscape architect's grading designs. The revegetation specialist can see, with photographic clarity, the proposed landform that must support new growth. The soil scientist can make more informed decisions about replacing and reclaiming soils when the "lay of the land" is represented in more than a two dimensional grading plan with contour lines and spot elevations. The wildlife biologist, concerned with issues such as access, cover, vegetative diversity, and refuge can benefit tremendously from "seeing" the proposed landscape clearly and realistically. All aspects of erosion control, perhaps the most interdisciplinary of all reclamation activities, benefit from the communication "common denominator" of visual simulations.

REFERENCES CITED


John C. Ellsworth, licensed landscape architect, is the President of Ellsworth and Associates, landscape architects, inc. He has a Bachelor's degree in Natural Science from the University of Arkansas, and a Master's degree in Landscape Architecture from Utah State University. John has over 15 years experience in landscape architecture, with professional expertise in visual resource analysis and management and computer visual simulation. John is the author of over 50 professional papers and presentations. He has taught landscape architecture at the University of Idaho, and is currently on the faculty at Utah State University. In his leisure time John enjoys fishing, cross-country skiing, wildlife and landscape photography, and motorcycling.