Natural Stone Council

The United Voice of the Natural Stone Industry

Best Practices of the Natural Stone Industry

Quarry Site Maintenance and Closure

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The Natural Stone Council (NSC) is a collaboration of businesses and trade associations that have come together to promote the use of Genuine Stone® in commercial and residential applications. By pooling resources, their goal is to increase the understanding of, preference for, and consumption of these natural products. Trade associations affiliated with the NSC include Allied Stone Industries, Building Stone Institute, Elberton Granite Association, Indiana Limestone Institute, Marble Institute of America, National Building Granite Quarries Association, and the National Slate Association.

The Natural Stone Council is committed to supporting sustainable initiatives and innovations at all levels of the production of Genuine Stone® products. As such, the NSC has established a Sustainability Committee made up of key industry members to elevate the issue of sustainability within the industry and provide a body responsible for planning and implementing relevant initiatives. In 2007, the NSC Sustainability Committee engaged in a partnership with the Center for Clean Products (CCP) at the University of Tennessee to assess current industry operations relating to dimensional stone production. The best practices identified and presented in this document are a direct result of the NSC and CCP's efforts to identify and improve the environmental profile of the natural stone industry.

Importance of Site Maintenance & Quarry Closure

In order to address the significant stresses posed on the environment by the extraction of stone from the earth, the Natural Stone Council is providing operational standards to encourage environmentally responsible quarry practices. The following pages propose guidelines to reduce environmental stresses over the life of the quarry by employing best site maintenance practices. This document also presents best practices for a return of safety and natural stability to a closed quarry site. Meeting requirements for site closure will be easier if best practices are followed throughout quarry operations. Proper site maintenance can reduce costs and increase a manufacturer's good standing in public perception. This report includes:

- Issues that create need for good site maintenance
- Benefits of site maintenance and quarry closure best practices
- Guidelines for best site maintenance practices
- Guidelines for safe and environmentally conscious quarry closure
- Resources available for further information

The Impact of Quarry Operations

Extracting stone from the earth is an arduous endeavor that affects the local ecosystem and community on a number of levels. In particular, quarry operations greatly modify landscape and topography, can displace wildlife populations, and require significant quantities of water and energy. Additionally, potential occupational health and safety risks exist for quarry employees, and local residents may experience noise and vibrations. Responsible site maintenance, however, can make a remarkable difference in the magnitude of these impacts as well as the financial burdens that may be attached to them.

The Public

Although the location of quarries is primarily determined by the location of geologic deposits, being situated nearby a major highway is preferable to minimize transportation costs. This often results in quarry sites that are established close to human habitation. Blasting, cutting, and truck traffic contribute to noise, vibration, and dust problems for local residents. Further, the public may protest the unfavorable aesthetics and the safety hazards posed by stone piles and quarry holes. By following best practices, these effects on quarry neighbors and the negative perceptions held by the general public can be mitigated.

The Employees

A quarry can provide jobs for the local population, but the work can be physically demanding and hazardous. Airborne particulates, the use of heavy machinery and haul trucks, and the size and weight of the cut stone blocks are all dangers to health and safety. The Mine Safety and Health Administration (MSHA) provides policies and regulations to maintain quarry workers' safety and well-being, but additional site guidelines may be set forth by each quarry operator. The practices advocated in this document provide some suggestions.

The Natural Environment

Stone quarrying, if executed without regard to surrounding ecosystems and geologic conditions, can easily disrupt the balance of wildlife, plant life, and water bodies in the area. For instance, removal of native vegetation coupled with alteration of topography can generate erosion problems, and site runoff can impact local waterways. The former may impede daily operations, while the latter may lead to regulatory fines. It is essential, therefore, that quarry plans be developed with an emphasis on limiting habitat loss, waterway damage, erosion, pollution, noise, and vibrations. Additionally, sites should be returned to original topographic and vegetative conditions once the quarry is closed.

Benefits of Site Maintenance and Closure

The best practices outlined in this document bring a multitude of advantages to a stone quarry. These include:

- *Reduction in cleanup costs*: Proactive site maintenance over the life of the quarry reduces the time and money spent on site cleanup when the quarry closes; reclaiming a well-maintained site is less laborious than restoring one with a poor preservation plan.

- *Reduction in fuel costs:* Reducing machine idling durations, maintaining infrastructure, and optimizing haul distances reduce fuel consumption and thus expenses.

- *Avoidance of regulatory penalties:* Site organization and proactive hazard management mitigates potential for occupational exposure and regulatory fees. MSHA penalties range from $60 to $220,000 per violation (MSHA 2009), while OSHA fines can be in the range of $0 to $70,000 per violation (OSHA 2007).

- *Increase in employee safety & morale*: Employees that feel safe at work are more likely to make a greater personal investment in the company.

- *Generation of revenue*: Site maintenance, interim restoration, and final rehabilitation can increase land value for future leasing and/or sale. Additionally, overburden and sludge may be sold for use in road construction and agricultural applications (see best practice document on Water Consumption, Treatment, and Reuse).

- *Increased efficiency*: A clean and well-organized quarry site can increase production efficiency by ensuring open paths and roadways, reducing debris, and increasing the safety of employees.

- *Enhancement of company reputation*: Adequate maintenance and rehabilitation practices can result in greater community acceptance of the quarry and respect for the company. A company with a reputation for being socially responsible is likely to retain current customers and attract new ones.

Best Practices

As described above, effective site maintenance and quarry closure benefit quarry operations by reducing costs and promoting a healthier and safer work area. MSHA, OSHA, and other state regulating bodies have enacted laws to manage occupational risks, and the practices recommended here are intended to not only build upon those stipulations but also to provide direction for quarries operating in states that have not promulgated more stringent legislation. As such, the NSC recommends that every quarry establish a site maintenance and closure plan that addresses at least the topics identified in this report, as well as applicable government regulations.

Minimizing Dust, Noise and Vibrations

Although dust, vibrations, and noise from the site are typically considered a nuisance, they can also create a hazard to the local community and wildlife. For instance, airborne particulates pose a potential health risk to quarry employees in the forms of respiratory, dermal, and ocular irritation or damage. Of particular concern in some stone quarries is inhalation of dust containing silica, which can lead to silicosis, a lung disease resulting in inflammation of the lungs and breathing

difficulties. Ensuring that these best practices are followed will help prevent such health problems.

Reducing Noise and Vibrations

Quarry equipment and detonation practices can cause public disturbance through noise pollution and geologic vibration. To maintain positive relations with the neighboring public, it is recommended that a plan to minimize these events be developed. Examples of objectives to include within such a plan consist of the following:

- Replace blasting with the use of wire saws, belt saws, and expanding mortar where possible.
- When blasting is necessary, use the minimum amount of explosive material coupled with micro-sequential detonation to reduce vibrations (Rustan 1998).
- Detonate explosives only during times of the day designated by the local Department of Commerce or other regulatory body, and sufficiently notify nearby occupants of any routine blasting schedule. Consider consulting the occupants about the time of the day that blasting would be least bothersome.
- Avoid blasting on days with high humidity and cloud cover; these weather conditions can cause noise levels to seem more intense (Walker Industries 2008).
- Turn off saws and machines when not in use, and consider one-way on-site traffic to lessen the use of backup sirens.
- Strategically place rows of trees and other tall vegetation around operations to act as sound barriers. Be sure to avoid creating enclosures where dust plumes could become trapped.

A number of states have limitations on over pressure air standards (i.e., noise) and ground vibrations at the site property line. Contact your state's regulatory agency for more information.

Dust Control

Dust is generated both at point sources (e.g., drilling, sawing) and as fugitive emissions from blasting and excavation operations as well as haul roads. Mitigation of airborne particulates is paramount in sustaining the health of quarry employees. In addition to upholding MSHA and OSHA regulations regarding exposure prevention (e.g., providing workers with dust masks), a management plan may include additional efforts to avoid poor air quality, such as the following:

- Ensure that all saws and drilling machines have adequate dust catchment or air filtration systems, particularly when the machines are situated in a confined or enclosed area where air flow is limited. Water mists may be used conservatively to remove airborne particulates.
- Cover with a tarp any stock piles of and carrier trucks hauling loose material.
- Lay gravel on quarry access roads, and install grates to knock dirt off of vehicle tires. The use of asphalt or concrete paving will also minimize dust but may not be economically feasible for every site.

- Conservatively mist any dirt or gravel paths with water once or twice a day. Chemical suppressants are also available, but only biodegradable, nontoxic options are recommended in order to prevent local water system contamination.

- Avoid drilling and sawing when the cloud ceiling is low or the wind is high so that dust plumes are not whipped dangerously around the vicinity.[1] Similarly, avoid drilling and sawing when little to no wind exists so that dust is not trapped at the site of generation.

- Retain or replace as much native vegetation as possible throughout the quarry's operation. Root structures help maintain soil stability, while tall vegetation—particularly trees—can act as a filter for dust plumes flowing through.

- To learn more about working in an environment with silica dust, visit: http://www.msha.gov/S&HINFO/SILICO/SILICO.HTM

Petroleum Product Management

Petroleum product use is a concern from both an economic and an environmental standpoint. With regard to the former, petroleum products are not inexpensive, and improper management can lead to inefficient consumption and even spills, both resulting in additional expenses to replenish quarry supplies. Moreover, petroleum products can have deleterious effects on terrestrial and aquatic organisms via a number of pathways; ingestion can be poisonous, while sheens of oil on surface water can reduce gas transmission and suffocate oxygen-dependent aquatic organisms (Leighton 2000). MSHA and the EPA provide regulations for spill prevention and response plans, as well as useful information for heavy equipment management. Website resources are listed below.

Fuel and Emissions

- Minimize idling time for machines to reduce fuel waste and emissions. Systems like an auxiliary power unit (APU) or direct-fired heater (DFH) preserve cab temperature and power electrical accessories while the engine is turned off (Storey et al. 2003). Contact your heavy equipment vendor to learn about technologies offered.

    - Calculate your cost savings when you reduce your idling time: http://www.transportation.anl.gov/engines/idling.html
    - Learn more about idling from the EPA and Argonne National Laboratory: http://www.epa.gov/ne/eco/diesel/idling.html http://www.transportation.anl.gov/engines/idling.html

- Minimize transport distances by designing the quarry with haul distance economy in mind.

- Consider using an engine-retrofitting system to reduce fuel use and decrease carbon emissions. When purchasing equipment, prioritize the selection of more energy efficient models. Contact your heavy equipment vendor to learn about technologies offered.

[1] Limits for cloud ceiling and wind speed are a function of site characteristics. If your state regulatory agencies does not specify this value, it is recommended that a quarry operator determine an adequate value for the site. Look to other states' policies for guidance.

Lubricants

- Establish and implement an equipment maintenance plan to avoid petroleum leaks and spills.

- Recycle motor oil and other lubricants used to maintain machinery. Visit your community's web page or http://earth911.org/ to find a nearby location for motor oil recycling drop-off. Additional disposal and recycling information can be found on the EPA's website at http://www.epa.gov/epaoswer/hazwaste/usedoil/index.htm.

- Build drainage channels to catch runoff from equipment that use petroleum products, and ensure that proper measures are taken to clean the water before returning it to a waterway or storm sewer (see NSC best practice document on Water Consumption, Treatment, and Reuse).

- Establish spill prevention and control measures in accordance with federal and state EPA and MSHA regulations so that proper action may be taken to avoid and manage spill situations. Additional information can be found on the following websites:

    - EPA regulations: http://www.epa.gov/OEM/content/spcc/index.htm
    - MSHA regulations: http://www.msha.gov/regs/complian/ppm/PMVOL4A.HTM

Land Maintenance and Ecosystem Conservation

For safety, monetary, and environmental reasons, extreme care must be taken to minimize the operational footprint at the quarry site. Proper management can curtail occupational hazards and environmental degradation, ultimately creating financial savings. The following maintenance practices will make site closure less labor intensive (and thus less fiscally demanding) and will allow a faster recovery rate for the local ecosystem. It is advised that each quarry establish a maintenance and conservation plan to sustain site integrity. The strategy may include the goals described below, among others, as appropriate for the quarry of interest.

Site Cleanliness and Organization

Maintaining organization and general tidiness at the quarry allows for efficiency in daily task performance, creates a less hazardous work environment, and portrays a sense of corporate responsibility to site visitors, potential customers, and neighbors. Recycling and reusing materials may reduce garbage haul fees or generate income through the sale of scrap metal and old equipment. The NSC best practice document on Waste Management expands on the recommendations provided in this section.

- Designate areas for scrap stone storage, and plan for its sale, removal, or later use as fill material (see Operations Waste section below).

- Designate secure areas for trash disposal and recycling bins; ensure that all waste is properly removed from the site.

- Attempt to recycle or reuse any waste including worn machine parts, packaging materials, water, motor oil, and even slurry or sludge; the NSC best practice document on Water Consumption, Treatment, and Reuse further explains potential uses of wastewater sludge.

Minimizing Erosion and Runoff

Although erosion and runoff are natural processes, they are not necessarily favorable. Sediment, debris, and chemicals—such as petroleum products—can be washed into waterways, potentially damaging water supplies and aquatic life (Relf 2001). Fertile soil can be stripped from the land surface, intensifying the cost and difficulty of revegetation during site closure. In light of these potential challenges, it is suggested that a site maintenance plan include prevention and management of erosion and runoff. Objectives of the plan may include but should not be limited to the following:

- Maintain topsoil in any areas not in use.
- Maintain maximum existing vegetation coverage, and replant any areas not in use, especially to either side of haul roads.
- Slow stormwater runoff with contoured, low-gradient drains and channels, as well as retention ponds. A series of ponds may also be used to remove sediment and other contaminants from water before reuse or reintroduction into natural waterways; the NSC best practice document on Water Consumption, Treatment, and Reuse provides further explanation.
- Additional information and assistance can be obtained through the below resources:
    - USDA National Soil Erosion Research Lab: http://www.ars.usda.gov/main/docs.htm?docid=2973
    - Government of Ontario - Ministry of Agriculture, Food & Rural Affairs: http://www.omafra.gov.on.ca/english/engineer/facts/87-040.htm#Effects

Respecting and Conserving Ecosystems

Maintaining the area adjacent to the quarry will not only enhance the operation's image as one that is environmentally-considerate but may, in turn, prove operationally and fiscally advantageous. Benefits that may be seen are explained below along with suggestions about how to conserve ecosystems.

- Keep disturbed area as small as possible, and ensure vehicles keep to the designated paths. This minimizes the future labor and finances required during quarry reclamation.
- Research local wildlife populations to understand any issues with threatened or endangered species in the region. Regulations regarding endangered species and their habitats are located on the US Fish & Wildlife Service's Endangered Species Program webpage: http://www.fws.gov/endangered/.
- If surface water diversion is necessary, take care to ensure that downstream ecosystems, residential areas, and water supplies are not impaired.
- Minimize removal of native vegetation. As explained previously, plant life aids in soil stability and overall ecosystem health.

Quarry Closure Practices

Responsible closure and rehabilitation of a quarry site is just as important as high-quality site maintenance to public health and safety and the recovery of the natural environment. Removing

waste, restoring topography, replacing soil, and replanting native vegetation are the key practices for quarry closure and restoration. In fact, some states require a reclamation plan that includes these aspects. A 2008 industry survey showed that 68% (41/60) of the operators who responded to the question already have a quarry closure plan in place at their facility.[2]

Planning for closure and restoration from the beginning of an operation makes the process easier; waste can be removed as it is created, excavation can be planned so that topography restoration is less complicated, new soil can be composted, and existing plant species can be documented for more successful replanting. Site rehabilitation can make the land more valuable and attractive for resale. Additionally, establishing a closure strategy (and communicating that activity to the public) can help enhance the company's reputation as a socially-responsible operation.

Operations Waste

Upon closure, the quarry site should be cleared of any materials that would not naturally be found in the area. This should not be difficult if best practices are maintained throughout the life of the quarry. Ensure that all trash and recycling is removed as well as any machine parts and packaging material. Stored overburden and other stone waste should not be left in piles, and—ideally—none should be sent to a landfill. Scrap stone can be sold, used as refill or landscaping, crushed for other applications (such as concrete production), or otherwise dealt with responsibly. Additional information can be found in the NSC best practice on waste management.

Topography Restoration

Effective geomorphology is a science. Such considerations as stone type, climate, native plantlife, and surrounding geology can impact the success of the rehabilitated site (Duque et al. 1998). For instance, if a slope is steeper than 30º, vegetation alone will likely be unsuccessful; erosion prevention and structural methods will also be needed (Jim 2001). Furthermore, the size and consistency of stone pieces used as refill can impact the speed of erosion and the ability for soil and vegetation to survive. As such, even when undertaking simple filling operations, consulting a geological engineer is recommended.

Scrap stone and overburden, materials native to the quarry hole, should be used to refill the quarry and restore topography. The amount of scrap, however, may be insufficient to completely satisfy the needs of the hole. As such, other options exist to reclaim the site.

- Overburden, rock, or gravel from other sites can be used to fill the quarry hole.
- Water may be used to create a recreational fishing or swimming location. However, safety-related signage is recommended in order to ensure the welfare of patrons. Adequate understanding of local groundwater system and exposed geology is also required to maintain water quality and level.

Filling the quarry hole with municipal solid waste and/or hazardous material is prohibited by the Resource Conservation and Recovery Act (RCRA). Such improper disposal can contaminate groundwater, eradicate surrounding ecosystems, and make the site unsuitable for future use (Van Loon 2002). Hazardous wastes in particular must be sent to an appropriate facility for disposal. Monetary penalties exist for noncompliance with dumping laws. For more details on RCRA and applicable regulations, visit the EPA's website at http://www.epa.gov/osw/laws-regs/index.htm.

[2] This (unpublished) data was collected during the benchmarking initiative of the natural stone industry conducted by the University of Tennessee Center for Clean Products in the spring of 2008.

Soil Replacement

The success of replanted vegetation relies largely on soil quality. Soil must have adequate depth and porosity to allow root growth, sufficient tackiness to discourage rapid erosion, adequate moisture content, and the appropriate chemical composition with regard to nutrient content (Jim 2001). To best achieve these objectives, a comprehensive approach should be adopted, developed from the following options:

- Stockpile soil that is removed with overburden for future use during reclamation.
- Purchase topsoil from a local distributor.
- Off-set the amount of purchased soil with compost. This material is nutrient-rich and would reduce the cost associated with purchased soil as a compost heap could be maintained during quarry operations.

Replanting and Reforesting

In order to effectively repopulate a quarry site with flora, several items must be considered. Of paramount importance is the type of species to be planted. If replanting is conducted with only one or two species or nonnative species, the vegetation may not survive. A second consideration that is particularly germane to quarry sites is topography. Species planted on slopes must grow quickly enough to prevent soil erosion. To ensure effective replanting and reforesting, a quarry closure plan should thoroughly discuss a revegetation approach. Such an approach may include, but is not limited to, the following tasks:

- Note the types and locations of plant and tree species growing on the site prior to overburden excavation.
- Conduct research to determine suitable species to plant on sloped areas.
- Consult with a local forester to design an appropriate revegetation plan.

Without a proper replanting and reforestation strategy, the local ecosystem could tip further off balance instead of returning to stasis.

Company Showcase

Nestled in the scenic foothills of the Oley Valley located in Berks County, Pennsylvania is one company that knows first-hand the meaning of environmentally-considerate quarry operations: Rolling Rock Building Stone, Inc. Rolling Rock is a family owned business steeped in a long history of mining and producing building stone that extends back over 50 years. Currently operated by second generation members of the Weller family who were born and raised locally, strong ties and a deep appreciation for the natural beauty and environment in which their business has flourished and evolved through the years has made environmental considerations an inherent element of company policy.

As good stewards of the environment, Rolling Rock has built a corporate culture that takes great pride in operating their facility in a manner that is both environmentally responsible as well as sustainable for future generations. Gary Weller, President of Rolling Rock emphasizes the preservation of environmentally sensitive areas located in the lower elevations of their mine property. These areas consist primarily of pastures, wetlands, and streams in addition to potential habitats preferable to an endangered species known as the bog turtle. Due to the delicate nature of this ecosystem, extensive environmental and ecological impact studies over the years have been required to protect the integrity of these sensitive areas.

Quarry roads are laid with gravel to minimize dust, and scrap stone is used to create drainage ditches as well as provide support to the adjacent hillslope.

With these challenges in mind, it has been critical to implement strict maintenance and reclamation programs to minimize and prevent erosion and runoff. Maintenance and reclamation programs are continuous and concurrent with mining, consisting of both temporary and permanent features as the quarry site develops. Rolling Rock's maintenance program includes, but is not limited to, the following items:

- Paved and well graveled haul roads to mitigate dust and runoff.
- Regular street sweeping to collect dust and debris.
- Containment ponds, stone lined traps, and silt fencing for water settling and filtration.
- Terraced slopes and benches to control and direct runoff laterally rather than directly down slope.
- Temporary vegetation to control sediment runoff until the site is completely quarried and ready for final reclamation.
- Final reclamation where the topography is returned as close as possible to the original pre-mining contour.
- Permanent vegetation consisting of special grasses for wildlife management and a re-forestation program which includes a diversified selection of trees.

Company Showcase (cont.)

Gary states, "Although concurrent maintenance initiatives can save on overall costs associated to long term reclamation goals, this in itself has never been the driving force behind our maintenance program. A love of the outdoors and a strong commitment to nature are the true motivators."

Quarry reclamation includes restoring natural topography and replanting native vegetation.

Rolling Rock has also found that there are countless indirect benefits of a strong environmental commitment which are many times overlooked but create real value for any company. In Gary's words, "Just because you can't attach a dollar sign, doesn't mean there's no value in the big picture." For instance, corporate social responsibility can accomplish the following:

- Strengthen ties and support better relationships with the local community;
- Generate a corporate culture that promotes and instills a good environmental policy among employees; and
- Transcend into a safety-conscious workplace.

When customers and clients visit a clean, orderly, and environmentally-considerate workplace, it says something about you and your products, and this, in turn, will result in more business. People tend to spend money where they feel most comfortable.

As Gary asserts, "Above all, it is our responsibility as an industry to promote both a healthy environment and sustainable operations for the mutual benefit, enjoyment and growth of future generations."

Quarry site during reclamation processes.

Final Remarks

Responsible quarry management includes implementation of economic, safe, and environmentally-considerate operations. Preserving and repairing site integrity over the course of the quarry's life generates a smaller need for human resources and land restoration—ultimately implying a lower financial burden—at the time of closure. Refilling the exposed area reduces occupational hazards as well as risk imposed on anyone who may be visiting the location after deactivation. By employing the best practices explored in this document, stone quarry operators will not only realize these benefits but also improve the overall public perception of quarrying practices.

For questions regarding the content of this brochure or to learn more about the Natural Stone Council's sustainability efforts, please visit the GenuineStone® website at www.genuinestone.com or contact the NSC Sustainability Committee chairman, John Mattke, at 320-685-3621.

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