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STAFF REPORT
Planning Commission

November 20, 2014

Item #9

File No. 2250-10PAM

Lehigh Permanente Quarry

Public Hearing to Consider (a) Reclamation Plan Annual Status Report; (b) Compliance with Stormwater Discharge Requirements for the East Materials Storage Area (EMSA); and (c) Feasibility of Facility (or Alternative) to Treat Selenium at Lehigh Permanente Quarry during Reclamation

Staff Recommendation:

1. Accept the Reclamation Plan Annual Report for Reporting Period July 1, 2013 to June 30, 2014; and

2. Determine Lehigh is currently complying with stormwater discharge requirements for the EMSA; and

3. Determine that it is feasible to construct, install and operate a facility to treat selenium for water discharged from the West Materials Storage Area (WMSA) and Quarry Pit during Reclamation; and,

4. Continue the hearing to January 22, 2015 to determine the feasibility of a facility (or alternative) to treat selenium from water discharged from the EMSA to allow Lehigh-Permanente Quarry additional time to evaluate the feasibility of alternative options.

Applicant and Owner:	Lehigh Southwest Cement Company ("Lehigh")
Address:	24001 Stevens Creek Boulevard, Cupertino
Project Location:	Westerly terminus of Stevens Creek Boulevard, Cupertino, Permanent Quarry (Mine ID #91-43-0004)
General Plan Designation:	Hillsides
Current Zoning:	HS-d1
Property Size:	3,500 acres, of which 1,238 acres comprise the Reclamation Plan boundary
Present Land Use:	Surface Mining
Supervisorial District:	5
Prepared by:	Pat Angell, Contract Planner
Reviewed by:	Rob Eastwood, Principal Planner
	Marina Rush, Planner III
Approved by:	Nash Gonzalez, Director, Department of Planning and Development

PROJECT DESCRIPTION

The matter before the Planning Commission includes the following three items:

1. **Annual Report**

The Planning Commission will consider the Annual Report, for reporting period July 1, 2013 to June 30, 2014, regarding Lehigh-Permanente Quarry and compliance with the existing Reclamation Plan and Mitigation Monitoring and Reporting Program.

On June 26, 2012, the County of Santa Clara Board of Supervisors approved a new Reclamation Plan for Lehigh-Permanente Quarry. Approval of the Reclamation Plan included certification of an Environmental Impact Report (EIR) prepared for the Plan and adoption of a Mitigation, Monitoring, and Reporting Program (MMRP), implementing the mitigation measures identified in the EIR. Condition of Approval #8 of the Reclamation Plan requires the preparation of an Annual Report regarding the status of the Reclamation Plan as follows:

An Annual Report shall be prepared by the County each year that summarizes compliance with the RPA and conditions of approval, Mitigation Monitoring and Reporting Program, and annual SMARA inspections and review of financial assurance cost estimates.

a. Annual Report shall be presented to the Planning Commission at a public meeting by December of each year, starting in 2013.

b. Mine Operator shall provide a reasonable amount of funding to the Department of Planning and Development for all aspects of report preparation, including but not limited to reimbursement for staff time, consultant fees, attorney's fees, and direct costs associated with report production and distribution.

c. Mine Operator shall provide by October 1 of each year, the information requested by the Planning Manager that is needed for the preparation of the Annual Report.

d. The County will include information provided by the Regional Water Quality Control Board related to the Water Board's determination regarding the Mine Operator's compliance with water quality standards, including waste load allocation and other permitting requirements, and the effectiveness of best management practices (BMPs) on the site.

2. Compliance with Stormwater Discharge Requirements

Reclamation Plan Condition of Approval #80 requires the County to schedule a public hearing before the Planning Commission if for two consecutive years, the water sampling test results show that stormwater discharging from the EMSA into Permanente Creek exceeds water quality standards for selenium. The water quality standard for selenium is 5 μg/l (micrograms per liter) pursuant to the Basin Plan Water Quality Objective as determined by the San Francisco Bay Regional Water Quality Control Board (RWQCB).

3. **Feasibility of Selenium Treatment Facility (or Alternative) for the EMSA and/or WMSA and Quarry Pit**

Reclamation Plan Condition of Approval #82 requires the Planning Commission to hold a public hearing no later than 30 months after the Reclamation Plan approval (by December 2014) to determine the feasibility of installing and operating a treatment facility (or alternative) to treat selenium for water discharged from the EMSA, WMSA, and Pit. The facility (or alternative) would be designed to achieve the Basin Plan Water Quality Objective for selenium (total recoverable selenium of 5 μg/l) for discharge from the EMSA and/or to achieve the "base level" standard for the WMSA and Quarry Pit[1] during reclamation of Permanente Quarry.

REPORT STRUCTURE

This staff report first provides background and history regarding Lehigh to provide context for the three actions before the Planning Commission. Following this background and history, each of the three decision items before the Planning

[1] "Base levels" is defined as water testing results for an average for two years immediately prior to the start of Phase II reclamation for discharge into Permanente Creek from the WMSA and Quarry Pit. Condition of Approval #81(b).

Commission are explained in sequential order, with staff analysis and recommendation presented for each decision. The outline will be as follows:

1. Background
   a) Lehigh Permanente Quarry History
   b) 2012 Reclamation Plan
   c) Analysis of Selenium within the 2012 Reclamation Plan and EIR
   d) Lehigh Cement Plant

2. Reclamation Plan Annual Report

3. Stormwater Discharge from the EMSA Area

4. Selenium Treatment Feasibility
   a. Feasibility of Treatment for the WMSA and Quarry Pit
   b. Feasibility of Treatment for the EMSA

5. Public Concerns Not Related to the Three Actions Before the Planning Commission

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1. BACKGROUND

a) Lehigh Permanente Quarry History

The Lehigh Permanente Quarry is a limestone and aggregate surface mining operation, located in unincorporated Santa Clara County within the eastern foothills of the Santa Cruz mountain range, west of the City of Cupertino. Quarrying activities at the site associated with the harvesting of limestone began in the early 1900s. In 1939, Permanente Corporation acquired approximately 1,500 acres of the Quarry site and then continued to acquire surrounding lands over the next several years until the total ownership reached its current size of 3,510 acres. The quarry is currently operated by the Lehigh Southwest Cement Company (herein referred to collectively, Lehigh).

On February 2, 2011, the County Board of Supervisors determined that mining operations at Lehigh are a legal nonconforming use (i.e., a vested right) within specific parcels including the current Reclamation Plan area, and as such, continued surface mining within the vested parcels does not require a use permit. However, the State Surface Mining and Reclamation Act (SMARA) requires all surface mines to have an approved reclamation plan. A reclamation plan establishes the processes and timelines for reclaiming (or restoring) a quarry site after surface mining is completed so that quarries are returned to a stable state and do not present a hazard to the public.

Pursuant to SMARA, a reclamation plan was approved by Santa Clara County for the Quarry in 1985 and amended in June 2012 to include additional mined areas onsite.

b) 2012 Reclamation Plan

The 2012 Reclamation Plan requires reclamation of approximately 1,238 acres that have been disturbed by surface mining at the quarry. The reclamation is to occur over a 20-year period in accordance with the reclamation requirements of SMARA. The main areas encompassed within the Reclamation Plan include *the Quarry Pit*, where limestone and aggregate material is harvested, and two areas where overburden (surface materials that are not harvested) is stockpiled – *the West Materials Storage Area (WMSA)* and *East Materials Storage Area (EMSA)*. Other areas requiring reclamation include the *Rock Plant*, and *Rock Crusher* (used to process aggregate), *Permanente Creek Restoration Area (PCRA)* and geotechnical *Exploration Area* located south of Permanente Creek. These areas are shown on the attached map [Attachment 2].

Reclamation of the site will occur in three phases:

- **Phase I** will occur over approximately nine years (2012 – 2021) and involves reclamation activities in the EMSA and South Exploration areas, and continued mining activities in the WMSA and Quarry Pit. Reclamation activities in the EMSA include placement of overburden within a permanent stockpile, contouring to final shape, covering with non-limestone bearing material and soil, and revegetation, the South Exploration area includes completing revegetation. Reclamation activities in the PCRA also begin.
- **Phase II** will occur over approximately five years (2021 – 2026) and includes reclamation activities within the WMSA, Quarry Pit, and PCRA. During Phase II, the overburden within the WMSA stockpile will be moved via a conveyor system to use as backfill of the Quarry Pit. The EMSA will be reclaimed during Phase II or sooner.
- **Phase III** will occur over approximately five years (2027 – 2032) and involves completion of conveying the overburden from the WMSA into the Quarry Pit, reclamation of the remaining areas, and removal of equipment, buildings, and several roads.

c) Analysis of Selenium in the 2012 Reclamation Plan and EIR

Two actions before the Planning Commission concern the amount of selenium within the surface water that discharges from the Reclamation Plan areas into Permanente Creek, and if water treatment is feasible. This section provides background information regarding selenium at Lehigh and the requirements of the 2012 Reclamation Plan and EIR requirements for reducing selenium within onsite surface water.

Selenium is one of the 118 elements on the Periodic Table (identified as Se) and a member of the sulfur group of non-metallic elements. Selenium is nutritionally essential for human health, however in higher concentrations, its exposure can have detrimental impacts to fish and wildlife, and at significantly higher concentrations, impacts to humans. Recognizing the potential to affect fish and wildlife populations, the RWQCB has established a water quality Basin Standard of 5 μg/L (micrograms per liter) for selenium.

Selenium is naturally found within the limestone minerals that are harvested at the Lehigh Permanente Quarry. When the limestone is exposed to water and air (oxidized), the selenium becomes mobile within the water. As such, quarrying limestone increases the potential for higher selenium concentrations in stormwater runoff.

Prior water quality test results show the concentration of selenium is elevated above the adopted 5 micrograms per liter (μg/L) RWQCB Basin standards in samples taken from various locations in the quarry and in Permanente Creek downstream of Lehigh. The San Francisco Bay RWQCB has listed Permanente Creek as impaired due to higher selenium concentrations.

SMARA requires that reclamation plans address water quality and comply with State Water Quality Standards. The 2012 Reclamation Plan includes design methods to reduce selenium concentrations in stormwater runoff following the reclamation. The final reclamation design method is the placement of a permanent non-limestone material cap, comprised of rock, over the existing overburden materials at the EMSA and over areas within the WMSA where limestone may be exposed. The cap will include at least one-foot of non-limestone material and an overlying vegetative cover, which will prevent the exposure of any limestone that may exist in these areas from contact with stormwater to prevent the mobilization of selenium.

For final reclamation, the Quarry Pit will be backfilled with overburden material from the WMSA and placement of approximately 63,000 tons of organic matter into the upper 25 to 50 feet of backfill. This approach, which has been used in other pit mines that have similar water quality issues, will create an anaerobic (not exposed to air) environment within the Quarry Pit, thus reducing the concentration of selenium in the surface and/or groundwater passing through this area and into Permanente Creek to below the Regional Water Quality Control Board Basin Standards.

In accordance with the California Environmental Quality Act (CEQA), the County prepared an Environmental Impact Report (EIR) to identify potentially significant impacts that would result from implementation of the 2012 Reclamation Plan and identify feasible mitigation measures that would reduce the extent of the impacts to a less than significant level.

The EIR concluded that selenium concentrations in stormwater runoff will be reduced to below adopted Basin Standards following final reclamation of Lehigh-Permanente Quarry. It also disclosed that selenium concentrations in stormwater runoff *may temporarily increase* during reclamation activities because the reclamation activities (for example, contouring of overburden piles, conveying overburden from the WMSA to the pit) could expose limestone contained in the overburden and lead to the contribution of additional selenium in stormwater runoff. In order to address this potentially significant environmental impact, the EIR identified best management practices (BMPs) to be used during reclamation to minimize contact between limestone and stormwater (Condition of Approval #79). However, it was uncertain at the time of 2012 Reclamation Plan adoption if these methods would be completely effective in preventing selenium from entering into stormwater and discharging into Permanente Creek during reclamation. In CEQA terms – the EIR could not conclude that the BMP's (as mitigation measures) would reduce the significant selenium impacts to a less than significant level.

In order to evaluate other potential mitigation measures that could reduce selenium impacts during reclamation, the County contracted with CH2MHill to evaluate the feasibility and costs to install a selenium treatment plant at Lehigh. CH2MHill determined that, from an engineering perspective, a treatment plant could be installed onsite to treat discharge from the Quarry Pit and WMSA areas, contingent upon the completion of subsequent studies evaluating water management and other factors needed to specifically design a treatment plan. The estimated costs, at that time, to construct a treatment plant for the WMSA/Quarry Pit was between $31.8 and $127 million, with operating costs of $6.5 million per year.

CH2MHill did not provide specific costs or design parameters for a system to treat stormwater flows from the EMSA during the first ten-year period of reclamation and stated that treatment of EMSA stormwater would be challenging due to inconsistent water flows from the area (stormwater only occurs during winter storm events).

Due to the need to conduct additional studies to ultimately determine the feasibility of installing and operating a treatment plant, the County could not conclude in 2012 that the installation of a treatment facility was a feasible mitigation measure. The Final EIR prepared for the 2012 Reclamation Plan determined that selenium impacts during reclamation were significant and unavoidable and the Board adopted a statement of overriding considerations when certifying the EIR. However, acknowledging that further studies and testing could demonstrate that the installation of a treatment plant may be feasible, the EIR identified a mitigation measure, incorporated as Condition #82 of the Conditions of Approval, that requires further evaluation of the feasibility of selenium treatment be conducted by Lehigh following adoption of the 2012 Reclamation Plan, including the pilot testing of treatment options at the quarry. The results of this further evaluation would be presented to the Planning Commission no later than 30 months after Reclamation Plan adoption in June 2012 for consideration and a determination by the Planning Commission, based on the additional studies and testing, if treatment is feasible.

Under Condition of Approval #82 the Planning Commission must determine whether it is "feasible" to build and operate a water treatment system that is capable of controlling selenium to levels consistent with current discharge standards during interim reclamation activities. Condition of Approval #82 requires Lehigh to pursue technologies to control selenium discharges from two main reclamation areas at the quarry site: (a) the EMSA and (b) the Quarry pit and WMSA. The Quarry pit and WMSA are treated as one area because all stormwater from the WMSA drains into the Quarry Pit, from where together all water is pumped via a network of ponds and pipes into Permanente Creek. The EMSA is treated as a separate area.

Defining "Feasible"

As Condition #82 originates from mitigation measures within the Final EIR prepared for the 2012 Reclamation Plan, the term "feasible" must be evaluated based on its definition in CEQA. The term "feasible" under CEQA has a specific meaning—"capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, social, and technological factors." (Pub. Res. Code § 21061.1.) CEQA's Guidelines add that a determination of feasibility may take into account "legal" factors. (Cal. Code of Regulations, tit. 14, § 15364.)

d) Lehigh Cement Plant

The Lehigh cement plant uses the mined limestone in the manufacturing of cement, and is located near the entrance to the site of the property, east of the Quarry Pit. The Lehigh Cement Plant operation is an authorized use operating under a Use Permit (County File No. 173.023) originally issued on May 8, 1939. The Leigh cement plant roof mounted "short" stacks were recently replaced with a freestanding single stack ("kiln stack") of 295 feet in height and 15 feet in diameter and a single cooler vent stack ("cooler stack") of 116 feet in height and 7 feet in diameter. These new stacks will improve emissions dispersion and further improve overall emissions from the cement plant in order to comply with air quality standards of the Bay Area Air Quality Management District (BAAQMD).

The Department of Conservation's Office of Mine Reclamation (OMR) confirmed that the cement plant is not part of the Permanente Quarry surface mining operation and as such, is outside the Reclamation Plan area (OMR correspondence, August 23, 2007).

As the current Reclamation Plan does not apply to the cement plant, it is not subject to the three actions before the Planning Commission evaluated within this staff report and thus is not discussed further.

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2. 2012 RECLAMATION PLAN ANNUAL REPORT

The Reclamation Plan, adopted on June 26, 2012, is subject to 89 Conditions of Approval (COA), which include the mitigation measures set forth in the Mitigation Monitoring and Reporting Program (MMRP) from the certified Environmental Impact Report (EIR) prepared for the 2012 Reclamation Plan (the mitigation measures begin at COA 42).

COA #8 of the Reclamation Plan requires the preparation of an Annual Report regarding the status of the Reclamation Plan, specifically evaluating (a) compliance with the Conditions of Approval and MMRP, and (b) the annual SMARA inspections and financial assurance that funds reclamation of the site.

The first Annual Report was accepted by the Planning Commission in December 2013. This second Annual Report covers the reporting period between July 1, 2013 and June 30, 2014.

On October 1, 2014, Lehigh submitted a compliance report to the County documenting its compliance with the Conditions of Approval (COA) and MMRP. County staff prepared a separate Annual Report, which is included as Attachment 1 to this staff report.[2]

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[2] Both the Lehigh prepared compliance report and County staff's annual report are available from the Planning Department Lehigh webpage, and were posted prior to the completion and distribution of this staff. Documents may be viewed at: http://www.sccgov.org/sites/planning/PlansPrograms/SMARA/PermanenteQuarry/Pages/PermanenteMain.aspx

The findings of the Annual Report are summarized below, including: (a) Reclamation Plan activities; (b) compliance with conditions of approval and the MMRP; and (c) SMARA inspections and financial assurance. Comprehensive information describing these areas is found within the Annual Report itself, including a table that describes compliance with each COA (Appendix A to the Annual Report No. 2).

a) Reclamation Plan Activities (July 1, 2013 – June 30, 2014)

Between July 1, 2013 and June 30, 2014, the operations in Reclamation Plan Area included continued mining and processing operations within the Quarry Pit, EMSA, WMSA, Rock Crusher/Support Area. No new reclamation activities occurred at the Rock Plant and South Exploration areas during this reporting period. A summary of reclamation activities that have occurred within each of the areas is included below.

Activities within the Main (Quarry) Pit included the following:

- Mining continued within the quarry.
- Partial reclamation activities began with the placement of all overburden materials within the pit along the western wall.

Activities within the WMSA included the following:

- A new topsoil stockpile area was created. Large woody debris were placed on these new topsoil stockpiles that will be used in the future as part of reclamation of Permanente Creek.
- Straw wattles and hay bales were added to drainage outfalls along the southern WMSA slope.

Activities within the EMSA included the following:

- Stockpiling of non-limestone capping materials.
- The northeastern portion of the EMSA was being re-graded to create a benched slope to better control stormwater runoff and improve the water quality of Pond 30 discharges.
- Clean out of fill from drainage ditch along the western edge of the EMSA as well as the creation of additional catch basins to catch sediment that was entering the drainage ditch.

- Installation of new rock armoring for the outfall of Pond 30 as well as the installation of sensor at the outfall to alter the operator when discharge begins to facilitate stormwater sampling.

Activities within the Crusher/Support Area included the following:

- Construction of a new primary and secondary crusher.
- Dismantling of old primary crusher.

b) Compliance with Conditions of Approval and MMRP

- **General Requirements.** An updated storm water pollution prevention plan (SWPPP) was submitted. Training for mining staff, vendors, contractors and consultants who work onsite was completed this reporting period.

- **Reclamation Requirements.** Lehigh completed mapping that identifies existing and future stockpiles of limestone, overburden, topsoil, and aggregate materials. The wooden stakes installed in 2012 demarcating the north and eastern boundaries of the WMSA and EMSA were replaced with metal t-posts. In addition limestone boulders in the Permanente Creek Restoration Area that were identified during AR 1 were analyzed further by geotechnical consultant for feasibility of removal. This analysis identified that removal would require equipment that has a potential to destabilize the creek channel and increase erosion and sedimentation in Permanente Creek. The limestone boulders were also tested and it was confirmed that the boulders are not a significant selenium source. The geotechnical consultant concluded the potential creek damage from further removal efforts far outweighed any adverse effect of leaving boulders in place. Finally, test plots were installed five years ago to test methods for revegetation to achieve the Reclamation Plan success criteria. The data results showed the revegetation could be achieved with the guidelines specified in the report (Appendix N to Appendix D of the Annual Report).

- **EIR Mitigation Measures.** The mine operator provided documentation of compliance with multiple conditions and mitigation measures as identified in the EIR, including submittal of documentation of a greenhouse gas emission reduction plan (Condition #72) and the protection of biological resources (Conditions #48 – 61) associated with Reclamation Plan activities.

- **Water Quality Testing.** Water quality sampling and testing occurred for rain events in February and April 2014, to test for the concentration of selenium and other constituents in water discharged from the EMSA into Permanente Creek. Both tests showed selenium concentrations in excess of the applicable water quality standards, as discussed further under Section 3 (Stormwater Discharge from the EMSA Area) below.

c) SMARA Inspections and Financial Assurance review

In compliance with the Surface Mining and Reclamation Act, County staff and consultants to the County conducted inspections of Lehigh to ensure mining and reclamation activities were in conformance with the 2012 Reclamation Plan. Inspections during the reporting period included an Annual Inspection on September 23 and 24, 2013, BMP inspections for October 2013 through April 2014, June and July 2014. Monthly site visits to observe quarry operations for compliance with the RPA and conditions of approval were initiated in February 2014. The inspections found that the quarry was in compliance with SMARA. There were no violations of compliance with the 2012 Reclamation Plan.

The County certified that the 2013 Financial Assurance Cost Estimate (FACE) is adequate for reclamation and complied with the Financial Cost Estimate Guidelines published by the State Mining and Geology Board. The 2013 FACE in the amount of $54,723,295.00, was an increase over the prior year's amount of $51,391,835.00. The revised Financial Assurance and associated increased rider for the bond was submitted to the State Office of Mine Reclamation and approved by the County.

Staff recommends that the Planning Commission accept the Annual Report.

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3. STORMWATER DISCHARGE FROM THE EMSA AREA

Condition of Approval (COA) #80 from the 2012 Reclamation Plan requires Lehigh to test stormwater discharges from the EMSA into Permanente Creek to determine if it meets water quality standards for selenium. As Lehigh is required to use best management practices during reclamation of the EMSA area to minimize selenium in stormwater runoff (COA #78), this stormwater testing also verifies the effectiveness of these measures.

In accordance with COA #80, if test results for two consecutive years show that stormwater discharging from the EMSA into Permanente Creek exceeds total recoverable selenium of Basin Plan Water Quality Objective of 5 µg/L (micrograms per liter) or other applicable discharge requirement as determined by the RWQCB, then the County must schedule a public hearing before the Planning Commission to determine whether the Mine Operator is complying with stormwater discharge requirements of 5 µg/L. COA # 80 states:

Monitoring and Determination of BMP Effectiveness for the EMSA:

a. *Within 30 days of RPA approval, sampling and testing shall occur within 24 hours after a qualifying rain event. If no qualifying rain event occurs within 30 days of RPA approval, then testing shall begin at the first qualifying rain event. Testing shall be conducted in accordance with the Interim Stormwater Monitoring Plan developed and approved in accordance with Condition #79.*

b. *If test results for two consecutive years show that stormwater discharging from the EMSA into Permanente Creek exceeds total recoverable selenium of Basin Plan Water Quality Objective, currently 5 µg/L (micrograms per liter), or other applicable discharge requirement as determined by the RWQCB, then the County shall schedule a public hearing before the Planning Commission to determine whether the Mine Operator is complying with stormwater discharge requirements. For purposes of triggering Planning Commission review, the sampling shall occur at locations where water discharges to Permanente Creek.*

c. *If the Planning Commission determines that the Mine Operator is not complying with discharge requirements, then the operator shall install a treatment system (or alternative) as described in Condition #82. (Implements Mitigation Measures 4.4-5 and 4.10-2c)*[i]

Stormwater tests of water discharging from the EMSA into Permanente Creek were conducted by Lehigh during the 2012-2013 and 2013-2014 winter (rainy) seasons. Stormwater was only collected and tested when water was discharging from Pond 30 in the EMSA (which collects all stormwater runoff for the EMSA area) into Permanente Creek. Attachment 3 is a map showing the locations of the various Lehigh ponds and discharge points for water discharging into Permanente Creek. In total, two tests were taken during the 2012-2013 season and two tests were taken during the 2013-2014 season. The selenium concentrations measured in these test results are shown in the table below:

Pond 30 Sampling Results 2012-2014	
Date	Result (in ug/l)
12/5/12	5.9
12/26/12	Non-Detect
2/27/14	14.6
4/2/14	29.2

**Non-detect = below detectable limits.*

As shown, the EMSA has had two consecutive years in which the stormwater discharge has exceeded the total recoverable selenium of Basin Plan Water Quality Objective of 5 µg/L and triggers the requirement for a public hearing by the

Planning Commission to determine whether Lehigh is complying with stormwater discharge requirements.

a) Staff Analysis of Discharge Compliance

Staff has evaluated the water quality testing data for the EMSA stormwater discharges. The Planning Commission has two options available for interpreting the water quality data and determining if Lehigh is in compliance with the discharge standards, per Condition #80.

Option #1

The concentration of selenium within the test results for the first storm water test of the 2012-2013 season exceeds the water quality standard (5.9 µg/L) and the selenium concentrations for the test results from the 2013-2014 season exceed the standards (14.6 and 29.2 µg/l). The County has referred these test results to the RWQCB for review and comment, but as of the date of the completion of this staff report, has not received any reply. As the measured levels exceed the 5 µg/l water quality standard for two consecutive seasons and the County has not received any additional feedback or information from the RWQCB regarding any modification to the 5 µg/l standard or additional recommendations, Option #1 is for the Planning Commission to determine that Lehigh is not complying with storm water discharge requirements because test results from two consecutive years show that stormwater discharging from the EMSA into Permanente Creek exceeds total recoverable selenium of 5 µg/l.

Option #2

The storm water tests conducted for the 2012-2013 season show one test that is "non-detect" (not measurable, below the standard), and one test result that is 5.9 µg/L, for selenium concentration. The 5.9 µg/L test result is only 0.9 µg/L over the 5.0 µg/L water quality standard. Staff has discussed with both Lehigh and the County's hydrogeologist / water quality consultant (Peter Hudson, PG, CEG, and Director Environmental Science Associates) regarding the significance of a stormwater exceedance that is less than 1 µg/L over the standard. Mr. Hudson's provided the following comments regarding variability in water chemistry in the samples from Pond 30 [Attachment 5]:

> *ESA has reviewed the November 13, 2014 letter provided by Lehigh Southwest Cement Company Permanente Quarry (Lehigh) that addressed the variability of selenium concentrations in two samples obtained from Pond 30 in December 2012. As reported by Lehigh, the December 2012 samples were just at [(5.9 micrograms per Liter (µg/L)] or below the water quality objective (and laboratory reporting limit) of 5.0 µg/L. The 5.9 µg/L selenium result was a valid laboratory result and based on these laboratory results, there can be little dispute that selenium was present in the December 5 water sample. However, the*

selenium concentration detected was only a trace amount (less than 1 µg/L), just slightly over what the laboratory can confidently report as selenium.

Considering that Pond 30 is located at the base of a limestone quarry that can potentially produce elevated selenium concentrations in the stormwater, it is ESA's opinion that the slight 0.9 µg/L exceedance of selenium typifies a localized variation in background water quality for Pond 30 and does not indicate the lack or failure of stormwater best management practices (BMPs). If stormwater BMPs were not in place or had failed at some point during December 2012, it is ESA's opinion that the selenium concentrations in Pond 30 stormwater would likely have been much higher and would have been detected in the stormwater discharge sampling.

Under this Option #2, the Planning Commission could conclude that the level of selenium concentration detected was only a trace amount and Lehigh did not exceed the discharge requirements for two consecutive years. Thus, Lehigh is in compliance with storm water discharge requirements. However, if the 2014-2015 rainy season test results show that storm water discharges at the EMSA exceed the 5 µg/l standard, then this matter will return to the Planning Commission in 2015 for the Planning Commission to determine whether Lehigh is complying with the storm water discharge requirements.

Staff recommends, in considering both options listed above and per the guidance received by the County's water quality consultant, that the Planning Commission pursue Option #2 and determine that Lehigh has not exceeded the water quality standards for two consecutive years and is complying with the stormwater discharge requirements.

4. SELENIUM TREATMENT FACILITY FEASIBILITIY

In adopting the 2012 Reclamation Plan, the County determined that further evaluation was required to determine the feasibility of installing and operating a treatment facility (or alternative) at the EMSA, WMSA, and Quarry Pit to treat selenium in water to meet adopted water quality standards.

This requirement was incorporated as COA #82, which required Lehigh to begin designing and testing a selenium treatment facility at the quarry and present its findings regarding the feasibility of installing and operating a treatment facility (or alternative) to treat all water affected by reclamation activities and selenium within a two year period (24 months). This information must be presented within 30 months to the Planning Commission. The Planning Commission must determine whether it is feasible (as that term is defined under CEQA) to install and operate a water treatment system that is capable of controlling selenium to levels consistent with current discharge standard during interim reclamation activities. COA #82 states:

Design, Pilot Testing, and Implementation of Selenium Treatment Facility or Alternative for the EMSA and/or WMSA and Quarry Pit.

a. *Within 30 days of RPA approval, the Mine Operator shall begin designing a treatment facility (or alternative) and pilot system for discharge into Permanente Creek. The treatment shall be designed to achieve the Basin Plan Water Quality Objective for selenium (total recoverable selenium of 5 µg/L) for discharge from the EMSA as defined in Condition #80, and/or to achieve the "base level" standard for the WMSA and Quarry Pit as defined in Condition #81 (reference to Mitigation Measures 4.10-2d).*

b. *The Mine Operator shall complete design, pilot testing, and feasibility analysis for a treatment facility within 24 months of RPA approval or by such other time as may be prescribed by the RWQCB.*

c. *The Planning Commission shall hold a public hearing no later than 30 months after RPA approval to determine feasibility of the treatment facility (or alternative). The Planning Commission may defer the public hearing if the RWQCB determines that additional time is necessary to complete the design, pilot testing, and feasibility analysis. If the Planning Commission determines that a treatment facility is feasible, the Planning Commission shall also establish a timeline for implementing the treatment facility.*

d. *Construction, installation, and operation of a treatment facility (or alternative) shall be required if discharge requirements are not met as described under Conditions # 80 and # 81 based on a determination of the Planning Commission, and if it has been determined feasible by the Planning Commission following a public hearing. (Implements Mitigation Measures 4.4-5 and 4.10-2e.)*

Per the analysis within the Reclamation Plan EIR, the scope of focus for determining the feasibility of Selenium treatment is limited to water discharges that are affected by ***interim*** reclamation activities. Other types of activities, for example, ongoing quarrying operations to harvest limestone and aggregate, and whether it is feasible to install and operate a water treatment facility to address selenium associated with these other types of activities, is not within the scope of the Planning Commission's determination.

The Final EIR determined that selenium concentrations in stormwater will meet water quality standards upon final reclamation of Lehigh.

a) Sierra Club Consent Decree (*Sierra Club v. Lehigh Southwest Cement Company and Hanson Permanente Cement, Inc.*)

In 2013 Lehigh entered into a Consent Decree with the Sierra Club resolving a lawsuit regarding violations of the Clean Water Act. The lawsuit alleged that Lehigh was discharging pollutants from the quarry pit into Permanente Creek without an authorizing national pollutant discharge elimination system ("NPDES") permit and in violation of Lehigh's storm water discharge permit.

The Consent Decree established interim and final treatment and discharge compliance deadlines. The terms of the Consent Decree require Lehigh to install an interim treatment system by October 1, 2014 to treat water discharged from the WMSA and Quarry Pit and a final treatment system by September 30, 2017 for all water discharges from the cement plant and quarry to Permanente Creek to achieve continuous compliance with NPDES limits and all other water quality standards applicable

The interim treatment system to be installed by October 1, 2014 addresses water that is collected from the quarry pit and WMSA within Pond 4A (before discharging into Permanente Creek), and is specifically defined as

> A water pollution abatement system and associated flow modulation facilities designed, constructed and operated to treat up to 24,000 gallons per hour of the quarry pit water currently associated with Pond 4A (quarry pit and primary crusher washdown) for the primary purpose of substantially reducing Selenium in the quarry pit water prior to discharge. Operation of this interim treatment system is also intended to inform the final design and successful operation of the final treatment system. (Pg. 4.)

The final treatment system described by Consent Decree is to be installed by Lehigh no later than September 30, 2017 and is defined as:

> A water pollution abatement system and associated flow modulation facilities designed, constructed and operated to achieve continuous compliance with all NPDES permit limits, and all water quality standards applicable to Permanente Creek, for all discharges to Permanente Creek from the Facility, including quarry pit water and process water currently associated with Pond 4A (quarry pit and primary crusher washdown), Ponds 9 & 11 (cement plant process waters in Pond 11 that flow through Pond 9), and Pond 20 (cement plant truck wash), and only excluding authorized storm water discharges from Pond 9 (after Pond 11 no longer flows to Pond 9),

Pond 13, Pond 20 (after truck wash water no longer flows to Pond 20), and Pond 30. (Pg. 3-4.)

The Consent Decree requires the interim treatment system to treat water from the Quarry Pit and WMSA. The final treatment system is intended to address all water discharges, excluding authorized storm water discharges from the EMSA and Cement Plant area, to meet water quality standards for selenium (5 µg/l). Therefore, the Consent Decree will require that surface water discharging from the EMSA, excluding authorized stormwater discharges, that is in excess of the water quality standards be treated and the method for accomplishing this be operational by September 30, 2017.

b) Comparison between the Consent Decree and COA #82

Unlike the County's COA #82 requiring a finding of feasibility prior to installation of the water treatment facility (or alternative) at the EMSA, WMSA, and/or Quarry pit, the requirements of the Consent Decree for treating water is not dependent on a finding of feasibility, as that term is defined under CEQA. The County's conditions of approval, however, are distinct from the Consent Decree because the County's conditions stem from a CEQA mitigation measure—under CEQA a mitigation measure must be feasible. The existence of the Consent Decree does not eliminate compliance with the Reclamation Plan and COA #82 relating to the feasibility of a treatment facility to address selenium discharged into Permanente Creek from ***interim*** reclamation activities.

Staff believes the Planning Commission must still determine whether installation and operation of a water treatment facility at the EMSA, WMSA, and/or Quarry pit is feasible. However, in determining feasibility, the Planning Commission may consider the Consent Decree along with any other relevant factors.

c) Frontier Technology Treatment System

In Fall 2013, Lehigh installed a pilot treatment system using Frontier Water Systems technology ("Frontier"). The Frontier system utilizes non-hazardous bacteria to establish anaerobic "reducing" conditions, which change the selenium from a dissolved state to a solid state that can be precipitated out in a solid form and collected for disposal. The pilot system operated at the 750-level pond within the Quarry pit from October 16, 2013 to November 15, 2013. The pilot system reduced selenium levels in treated water to below 5 µg/L.

The data generated by the pilot system indicated that the Frontier system can be scaled to a larger treatment system with consistent results and that it is technologically possible to operate a water system capable of treating water from the Quarry pit and the WMSA to below the 5 μg/L criterion. Lehigh began installing the Interim Treatment System (ITS) adjacent to Pond 4a in early 2014 with construction completed in October 2014.

The ITS is now operational for the 2014-2015 wet season. Data generated over the next two years' wet seasons (2014-2015 and 2015-2016) will enable Lehigh to confirm (in April 2016 or later) if it is technologically possible to expand the system's inflow capacity to handle all water discharged from the Quarry pit and WMSA.

d) Feasibility of Treatment for WMSA and the Quarry Pit

Lehigh provided its analysis of the feasibility of treatment as part of its Annual Report submittal (see Appendix B of the Annual Report, [also Appendix P to Appendix D of Lehigh's Annual Report compliance submittal]).

Lehigh has determined based on preliminary results from the Frontier system that it is feasible to install and operate a treatment system that is capable of treating water for selenium below the 5 μg/L for the WMSA and Quarry Pit discharge points into Permanente Creek. Water quality data from two winter seasons (2014-2015 and 2015-2016) will finalize this determination. Lehigh's analysis also submits "that it is appropriate to amend the Conditions of Approval to acknowledge that the ITS will operate, and to thereafter reassesses (in April 2016 or later) the feasibility of this technology to treat all pit and WMSA water." (*Feasibility of Water Treatment for Discharges From The Permanente Quarry Containing Selenium*, p. 10.)

County staff concurs with this feasibility determination by Lehigh At this time not all of the process steps needed to design and construct a treatment system (with resulting water quality data) have yet been completed demonstrating that all water from the WMSA / Quarry pit can be treated to meet the 5 μg/l. Nevertheless, the Consent Decree requires Lehigh to install a treatment facility by September 2017 to treat all water discharged into Permanente Creek to meet the 5 μg/l standard. This requirement mandates installation of a treatment system by 2017 and presumes that treatment is feasible. Under COA #82, selenium treatment is only required, if feasible, for the WMSA / Quarry Pit during ***interim*** reclamation. The WMSA / Quarry pit is not scheduled to begin interim reclamation (per the 2012 Reclamation Plan) until 2021. Given the timelines established under the Consent Decree, all water from the WMSA / Quarry pit will be treated by the treatment facility several years ahead of this time period. As the ITS is currently operational and Lehigh is legally required to install a final treatment facility by September 2017, staff believes that the installation of a treatment facility meeting the 5 μg/l standard "can be accomplished in a successful manner within a reasonable period of time," meeting the feasibility requirements under CEQA.

County staff has provided the RWQCB staff with the reports received by Lehigh and prepared by the County and requested feedback regarding the determination regarding selenium treatment feasibility as it relates to the Consent Decree. At the time of completion of this staff report, staff has not yet received any feedback from RWQCB staff.

In lieu of feedback from RWQCB, staff recommends that the Planning Commission determine that the installation of a treatment facility for the WMSA / Quarry pit is feasible, in compliance with Condition #82. Per Condition #82, if the Planning Commission determines that it is feasible to install a selenium treatment facility it must also establish a timeline for the installation of the facility. Per the Consent Decree, Lehigh is required to install a final treatment facility by September 30, 2017. Thus, staff recommends that the installation of the treatment plant follow this mandated timeline.

With respect to Lehigh's request that the Conditions of Approval be amended to acknowledge the current operation of the ITS and allow for further feasibility analysis based on more test results, staff believes that the test results from the ITS can continue to be evaluated as part of the Planning Commission's Annual Report, and if there is new information within these reports that changes the assumptions regarding treatment feasibility or the timeline for installation, that a potential change to the conditions of approval be revisited at that time.

e) Feasibility of Treatment for EMSA

COA #82 requires the Planning Commission to determine if the installation and operation of a treatment facility is feasible to treat selenium during interim reclamation for the Quarry Pit, WMSA, and EMSA (prior to final reclamation of these areas). As the EMSA area is to be reclaimed ahead of the Quarry Pit / WMSA areas and has a different drainage system (it does not drain into the Quarry Pit), the feasibility of selenium treatment is evaluated separately.

Under the 2012 Reclamation Plan, the EMSA area will be reclaimed within the first nine years, with reclamation completed by 2021. Lehigh has recently accelerated reclamation of the EMSA area and final grades will be achieved in 2015. Placement of the non-limestone cap and vegetation activities will follow in subsequent years. As the requirement for selenium treatment under COA #82 focuses on the ***interim*** reclamation period (before final reclamation), this time period is both immediate and short.

Lehigh's feasibility analysis considers if a treatment system or alternative would be feasible at the EMSA for the interim reclamation period. The following is a summary of the analysis (see Appendix E of the Annual Report [Appendix P of Lehigh's Annual Report submittal]). The report concludes that (1) operation of a treatment system at the EMSA is not feasible and several other alternatives, such as trucking or piping the water to the Frontier system or Quarry pit, are also not feasible. One alternative that could reduce selenium concentrations in EMSA is the enlargement of Pond 30 which collects all EMSA storm water. However, Lehigh states that additional time is needed to complete geotechnical studies demonstrating the pond can be enlarged. Each of these treatment options or alternatives are described below.

1) Treatment System Feasibility

Unlike the WMSA/Pit, where there is a constant source of water in the Quarry Pit (collected from surface water and groundwater seeps and detained in the Pit), the water flows at the EMSA containing selenium are intermittent. Water flows only occur during the wet season when stormwater discharges from the EMSA into the downstream detention basins and Permanente Creek. The treatment of selenium, specifically using the Frontier system, requires a constant water source that is stable in temperature and composition. Thus the intermittent and occasional water flows from the EMSA cannot support installation of a water treatment system similar to what is proposed for the WMSA/Pit. This technological challenge was initially identified by CH2MHill during their work for the County on the 2012 Reclamation Plan and EIR in identifying selenium treatment technologies that could be used onsite.

Due to this technological challenge, it is infeasible to construct and operate an independent selenium treatment facility at the EMSA area using the Frontier (or like) system. In addition to the technological infeasibility, the cost to construct and operate a separate system in the EMSA would be substantial and is significantly disproportionate to the short duration in which it would operate–the system would only operate until final EMSA reclamation is complete, which is estimated by Lehigh to be achieved between 2015 and 2021.

Other selenium treatment technologies have been previously studied for their potential application at the Quarry (wetlands, reverse osmosis), but these technologies were deemed infeasible due to their cost and size constraints. In summary, based on the evidence presented by Lehigh since 2012, the construction of an independent selenium treatment system at the EMSA is not feasible.

2) Alternative (approach) Feasibility

COA #82 requires Lehigh to consider a treatment system or *alternative* to address Selenium impacts. Three potential alternatives that would reduce selenium within the EMSA stormwater discharges were evaluated by both Lehigh and County staff. These include (1) piping or trucking water from the EMSA to the Frontier system, (2) piping or trucking water from the EMSA to Quarry pit, and (3) enlarging EMSA pond 30 to detain more stormwater runoff and minimize discharges into Permanente Creek. Each of these alternatives is discussed below.

Piping / Trucking Stormwater to the Frontier System

Under this alternative, stormwater would collect from Pond 30 in the EMSA and be transported to the Frontier system for treatment. The EMSA stormwater would be treated along with the Quarry Pit / WMSA water prior to being discharged into Permanente Creek. Transport would occur through either pumping the water through a series of pipes, or collecting the water in water trucks to be delivered to the Frontier system.

Lehigh has identified several factors that make this approach infeasible. First, the Frontier system treatment process requires a steady flow of intake water with a stable temperature and chemistry composition, which is currently provided from the Quarry pit water. The introduction of stormwater from the EMSA with a different temperature and chemical composition would not be compatible with this requirement. Second, according to Lehigh, its permits from the RWQCB do not allow for the redirection of stormwater within the quarry site. Third, the construction of a piping system is estimated to cost $4 million and it is questionable whether it is economically feasible given the short amount of time left when interim reclamation activities are occurring.

Piping / Trucking to the Quarry Pit

An alternative to trucking or piping the water directly to the Frontier Technology system would be transporting the EMSA stormwater to the Quarry Pit. Depending on the route, the travel or pipeline distance from the EMSA to the Quarry Pit is shorter than the distance from the EMSA to the Frontier system site. In addition, this approach would appear to address the technological challenge of introducing the EMSA stormwater directly into the Frontier system. Under this approach, the stormwater would be deposited into the Quarry pit where it would intermix with existing pit water before being collected and pumped to the Frontier system for treatment. This intermixing could allow the EMSA water to equalize with the Pit water, in terms of temperature and composition, allowing it to be treated by the Frontier system.

While this approach could be technologically feasible, Lehigh has cited the same legal and cost constraints explained under the first alternative – that the RWQCB permit prohibits the transport of water onsite and that the cost for pumping or trucking is prohibitive compared to the short duration of use.

Enlargement of Pond 30

A third alternative to addressing selenium in EMSA stormwater is the enlargement of Pond 30, the collection pond for all stormwater from the EMSA. Pond 30 is located next to Permanente Creek and detains EMSA stormwater before it is discharged into the creek. Pond 30 could be substantially enlarged in order to collect a greater volume of stormwater from larger storm events. By increasing its size and detention capacity, less stormwater would be discharged into Permanente Creek. In addition, by capturing and detaining more stormwater, the amount of selenium could be diluted further.

Enlarging Pond 30 may be a feasible alternative; however, Lehigh has reported that it needs to complete soils / geotechnical analysis to ensure that enlarging Pond 30 will not undermine soil stability in the area and to determine how large Lehigh can physically make the pond with the space available and geotechnical conditions. Lehigh has also indicated that pond enlargement will require review by the RWQCB and possibly other agencies.

Staff Analysis of Alternatives

Staff concurs with Lehigh's conclusion that it is infeasible to pipe or truck EMSA stormwater discharge to the Frontier system or pit. The County's third party hydrogeologist (Pete Hudson), has further confirmed that introduction of the EMSA stormwater directly into the Frontier system for treatment is infeasible due to incompatibility of temperature and composition.

With respect to the alternative of piping or trucking the EMSA stormwater to the Quarry pit, the County has not received any information from the RWQCB that refutes Lehigh's position that this intermixing of water is prohibited. Lehigh's feasibility analysis was referred to RWQCB staff for review and response but as of the date of the completion of this staff report, no response has yet been received.

Nevertheless, the cost to either install a pump / piping system or operate a water trucking operation to transport the EMSA stormwater to the Quarry pit would be substantial, especially when compared to the short remaining ***interim*** reclamation time anticipated to occur at the EMSA.

With respect to the alternative of enlarging Pond 30 to provide additional capacity to capture EMSA stormwater, staff believes this is a potentially feasible alternative because it can likely be accomplished in a successful manner within a reasonable period of time. While this alternative does not treat the EMSA stormwater for selenium and thus it is unlikely that it could absolutely prevent EMSA stormwater discharges (with higher selenium) into Permanente creek, it still is a feasible alternative that will act to substantially reduce potential selenium impacts during ***interim*** reclamation. This alternative appears to be "feasible", taking into account economic, environmental, social, and technological factors. However, the cited geotechnical studies are first required to confirm that the pond can be engineered and constructed correctly to avoid instability.

Staff recommends that Lehigh be allowed to continue to evaluate whether enlarging Pond 30 is feasible and the Planning Commission continue this portion of the hearing until January 22, 2015 to make the feasibility determination.

__Summary of Staff Recommendations__

Staff recommends the Planning Commission take the following actions:

1. **Annual Report:** The Planning Commission accept the Annual Report.
2. **Compliance with Stormwater Discharge Requirements for the EMSA:** The Planning Commission adopt Option #2 and determine that Lehigh has not exceeded the water quality standards for two consecutive years and is complying with the stormwater discharge requirements per Condition #80.
3. **Feasibility of Treatment Facility for WMSA/Quarry Pit:** The Planning Commission determine that the installation of a treatment facility for the WMSA / Quarry pit is feasible, in compliance with Condition #82, and that the installation of the final treatment facility shall follow the mandated timeline per the Consent Decree, September 30, 2017.
4. **Feasibility of Treatment Facility for EMSA:** The Planning Commission continue the hearing until January 22, 2015 for making a determination of feasibility for selenium treatment at the EMSA for Lehigh to complete the evaluation of whether enlarging Pond 30 is feasible.

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5. PUBLIC CONCERNS NOT RELATED TO THE THREE ACTIONS BEFORE THE PLANNING COMMISSION

As evidenced by public testimony during the October 23, 2014 workshop, the Lehigh site generates substantial interest from members of the public. Many issues of concern raised by the public that are outside of the scope of the Reclamation Plan and the three actions before the Planning Commission. A summary of these issues is provided for background

a) New Quarry Pit

The 2012 Reclamation Plan does not allow for a new quarry pit. While an application was previously submitted for a new quarry pit, the mine operator withdrew this request on June 3, 2011 and no new application for a new quarry pit has been submitted. Any future proposed quarry pit would require a new Reclamation Plan and would be subject to obtaining a Use Permit.

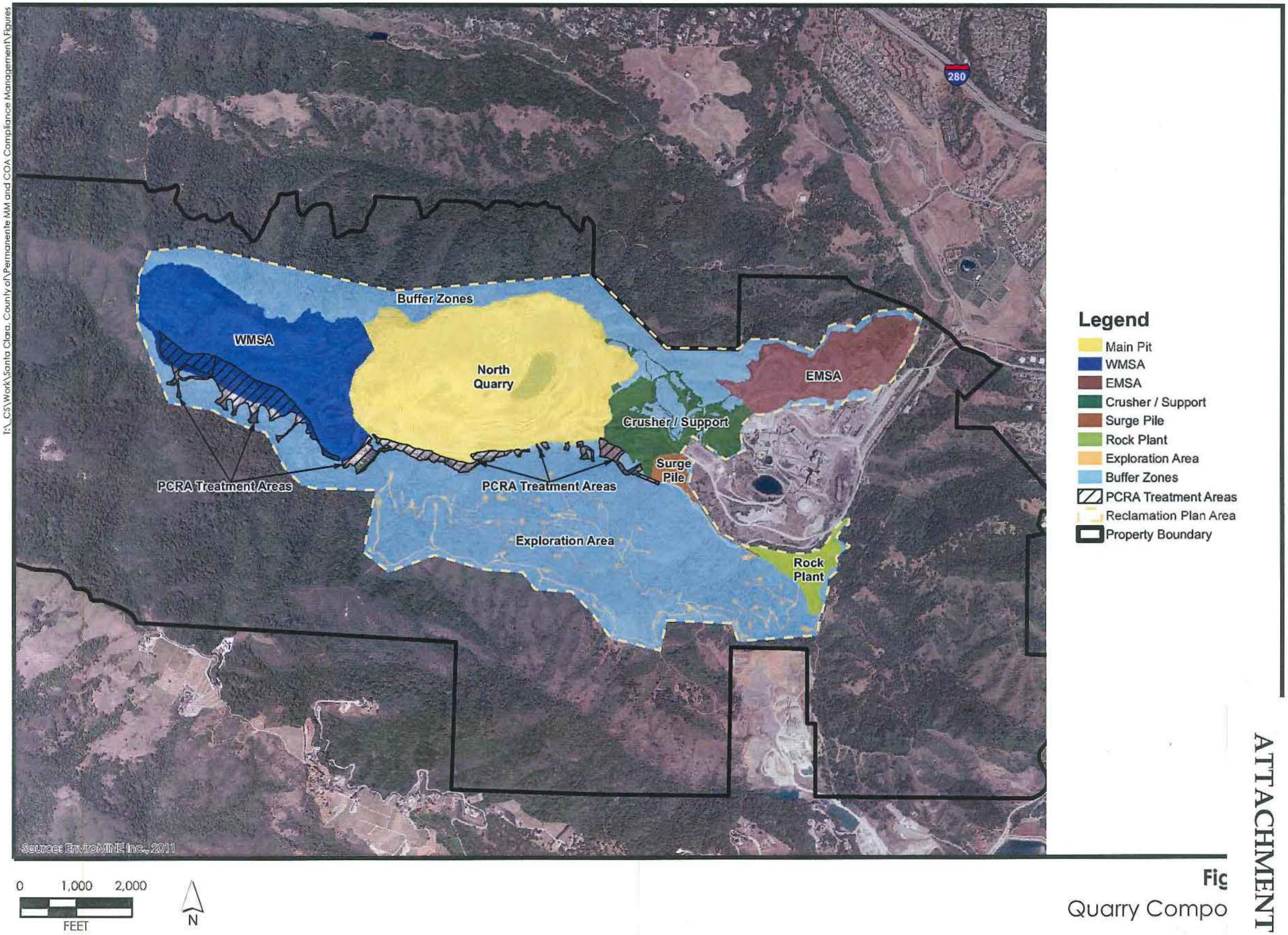
b) Contamination Issues Associated with Quarry

There have been concerns about historic operations and contamination of the site. The RWQCB has issued investigative orders and have required Lehigh to submit work plans to determine if contamination exists at the WMSA and EMSA (soil and groundwater contamination). These activities are on-going between Lehigh and the RWQCB, but are not related to operation of the quarry and its reclamation.

ATTACHMENTS

Attachment 1 – Annual Report (provided under separate cover and electronically)
Attachment 2 – Map of Permanente Quarry and Reclamation Areas
Attachment 3 – Map showing ponds and drainage system at the Quarry
Attachment 4 – November 13, 2014, Lehigh correspondence regarding EMSA stormwater discharge.
Attachment 5 – November 14, 2014, Mr. Peter Hudson, Comments on Water Quality Variability in Samples from Pond 30 – December 2012.

Attachment 1 – Annual Report (provided under separate cover and electronically)



Fig

Quarry Compo

ATTACHMENT NO. 2

ATTACHMENT NO. 3

ATTACHMENT NO. 4

Lehigh
HEIDELBERGCEMENT Group

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November 13, 2014

Marina Rush, Planner III
Department of Planning and Development
Santa Clara County
70 W. Hedding Street, 7th Floor, East Wing
San Jose, CA 95110

Lehigh Permanente Quarry
RE: Comments on Water Chemistry Variability in Samples From Pond 30 – December 2012

Dear Ms. Rush:

Lehigh Southwest Cement Company Permanente Quarry (Lehigh) has been reporting stormwater sampling results to Santa Clara County (County) of discharges from Pond 30 which receives stormwater runoff from the East Material Storage Area (EMSA) since the 2012 wet season. During that season, two samples were collected and analyzed in December 2012 with results reported for selenium of 0.0059 milligrams per liter (mg/L) and Non Detect (<0.005 mg/L) . These two samples were collected 21 days apart on December 5 and 26 respectively. The first sample was 0.0009 mg/L above the Practical Quantitation Limit (PQL) established by the reporting laboratory for selenium, or just 18% above the PQL of 0.005 mg/L.

The Santa Clara County Planning Department has asked for Lehigh's view of the practical ramifications of a sampling result so close to the PQL and regulatory criterion, particularly considering the second, "non-detect" result shortly afterwards. The Planning Department raises a valid question. While commercial environmental laboratory analytical results use statistical methods to limit the effects of analytical method variability in their reports, the reality of sampling variation in water chemistry due to temporal variability must be considered when one value so close to the PQL, in this case the December 5 value, is considered.

The issue of temporal variability of trace metal concentrations between samples taken at the same location but at different times is well documented and two cited papers illustrate this.

The first, *United States Geological Survey Fact Sheet 086-03* from December 2003 (Nimick, D.A. 2003, attached), documents measured metal concentration variability as a function of time between samples taken at the same locations at different times of the day and different days. This fact sheet describes trace metal diurnal (daytime to nighttime) variations of 54% to 500% in slightly alkaline waters. One of the key suspected contributors in this variation is the sorption (adhering to) of trace metals to particles in the water. Both of these conditions are also representative of Pond 30 discharges.

The second cited paper, *Water Quality Variability In Tributaries Of The Cheat River, A Mined Appalachian Watershed* (Petty, J.T. and Barker, J., 2004, attached) also describes temporal variation of samples collected from mining impacted streams over numerous days and months. Some of these variations were dramatic, for example, over 600% for Aluminum (ranging 0.05 mg/L to 0.38 mg/L). The paper was published by the American Society of Mining and Reclamation. In their discussion, the similar factors contributing to variability were stated including sorption and hydrologic (flow) variations.

These papers illustrate the challenges of analyzing a very small set of sampling data where there is inherent variability in concentrations, and an extremely small variation above a very low PQL for selenium. Lehigh has concerns regarding the implications of one sample event under these circumstances. It is preferable from the standpoint of water-quality management to review the trend and range of concentrations over time. The December 2012 results, on balance, indicate that Lehigh complied with the stormwater best management practices requirements in the 2012-13 rainy season, and that these BMPs were effective in reducing selenium concentrations in EMSA storm runoff to levels below the selenium criterion.

References Cited

Petty, J.T. and Barker, J. 2004. *Water Quality Variability In Tributaries Of The Cheat River, A Mined Appalachian Watershed.* American Society of Mining and Reclamation. Proceedings National Meeting of the American Society of Mining and Reclamation and the 25th West Virginia Surface Mine Drainage Task Force.

Nimick, D.A. 2003. Diurnal Variation in Trace-Metal Concentrations in Streams. United States Geological Survey Fact Sheet. FS-086-03.

Gregory A Knapp

Gregory Knapp
Director Environmental Affairs
Lehigh Hanson Region West

USGS
science for a changing world

Diurnal Variation in Trace-Metal Concentrations in Streams

Assessing concentrations of trace metals in streams is found to be significantly more complex than previously thought. New research indicates that concentrations of metals dissolved in stream water vary by time of day.

Trace metals in streams can be toxic to fish and aquatic insects. Therefore, sampling streams for metals is an important aspect of water-quality monitoring. In the past, scientists assumed that a stream water sample collected at any time of the day would provide an accurate assessment of metal concentrations on that day assuming streamflow was relatively constant. Recent studies, however, have shown that dissolved concentrations of some trace metals exhibit substantial and consistent variation throughout the day (fig. 1). The magnitude and widespread occurrence of these diurnal (24-hour) concentration patterns, or cycles, was unexpected. This discovery of the consistent occurrence of diurnal metal cycles has significant implications for how we study and monitor the environment.

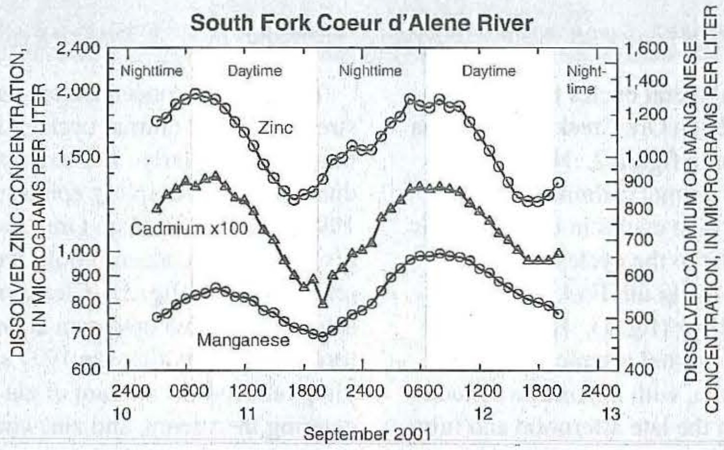

Figure 1. Diurnal variation in dissolved metal concentrations in South Fork Coeur d'Alene River, Idaho (site 2 on fig. 4).

Scientists and government agencies will need to consider diurnal metal cycles to ensure accurate assessment of metal concentrations in streams.

DIURNAL METAL CYCLES

Daily variations in dissolved metal concentrations are shown in figure 1 for the South Fork Coeur d'Alene River in Idaho. These variations are examples of diurnal metal cycles. Two important characteristics of diurnal metal cycles are the time of day when the minimum and maximum concentrations occur and the magnitude of the change in metal concentration. In the South Fork, the timing of the diurnal cycles for cadmium, manganese, and zinc was similar. Concentrations of these metals increased during the night, reaching the highest values shortly after sunrise. Concentrations then decreased during the late morning and early afternoon, reaching the lowest values during mid to late afternoon.

South Fork Coeur d'Alene River, Idaho (site 2 on fig. 4)

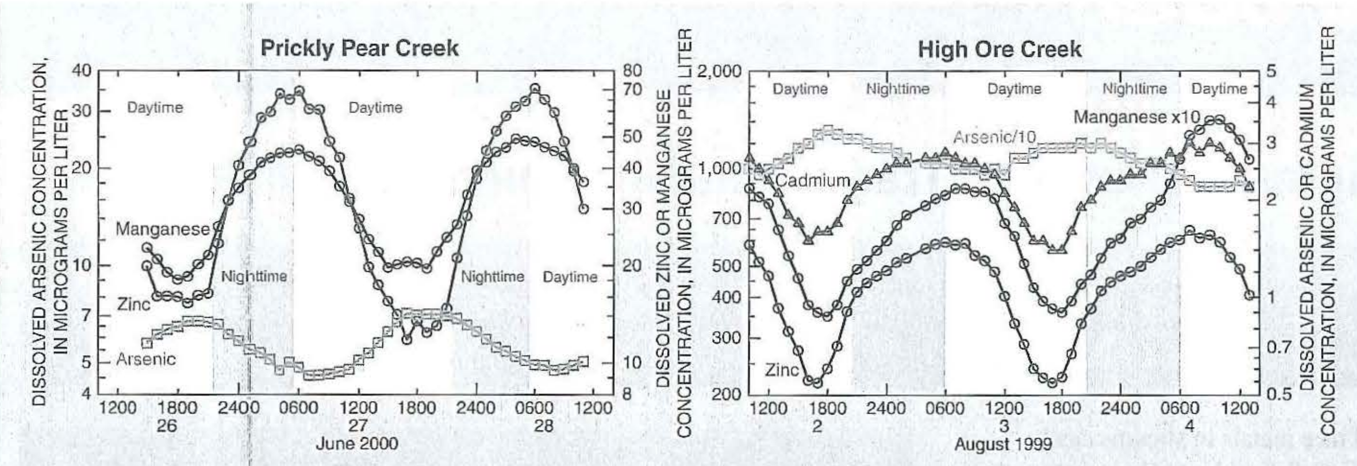

Figure 2. Diurnal variation in dissolved metal concentrations in Prickly Pear Creek (site 7) and High Ore Creek (site 13), Montana.

Diurnal metal cycles for Prickly Pear and High Ore Creeks in Montana are shown in figure 2. Note that the timing of diurnal cadmium, manganese, and zinc cycles in these streams was similar to the cycles for these metals in the South Fork Coeur d'Alene River (fig. 1). However, the timing of diurnal arsenic cycles was the opposite, with maximum concentrations in the late afternoon and minimum concentrations in the early morning.

The potential magnitude of diurnal metal cycles is shown by the data for Prickly Pear and High Ore Creeks (fig. 2). Diurnal cycles for zinc were the largest, with concentrations changing as much as 500 percent in Prickly Pear Creek. Cadmium and manganese cycles were intermediate, with changes as much as 120 and 290 percent, respectively, in High Ore Creek. Diurnal variations in arsenic concentrations (as much as 54 percent in Prickly Pear Creek) were proportionally much less than the variations for cadmium, manganese, and zinc.

Diurnal metal cycles occur over a wide range of concentration levels. For instance, diurnal zinc cycles were found at concentrations greater than 1,000 μg/L in the South Fork Coeur d'Alene River (fig. 1) and at concentrations less than 80 μg/L in Prickly Pear Creek (fig. 2). Units of micrograms per liter (μg/L) are equivalent to parts per billion.

Trace-metal concentrations in streams exhibit diurnal cycles routinely and regularly. For example, during diurnal sampling episodes in 1995 and 1997 on High Ore Creek, dissolved zinc concentrations were relatively high (fig. 3). Cleanup efforts conducted upstream at an historical mine site after the 1997 sampling reduced the amount of zinc entering the stream, and zinc concentrations were lower during samplings in 1999-2001. These data show that the diurnal zinc cycle persisted and that the timing remained the same, even though the general concentration level changed substantially during the 6-year period.

Data on diurnal metal cycles for 13 streams in Montana and northern Idaho (fig. 4) are presented by Nimick and others (2003). The data document and confirm the widespread occurrence of diurnal metal cycles. The streams had gravel beds and were typical of mountain headwater streams in the northern Rocky Mountains. The streams varied in size, with the smallest having streamflow of about 0.5 cubic feet per second (ft^3/s) and the largest having streamflow of 270 ft^3/s at the time of sampling. One aspect common to diurnal metal cycles is that they occur in streams that have neutral to slightly alkaline pH, which is typical of most streams in the Nation. These types of diurnal metal cycles have not been observed in acidic streams more directly affected by mine drainage.

Diurnal metal cycles have previously been reported in a few instances. Diurnal cycles in dissolved arsenic concentrations were measured in Whitewood Creek, South Dakota (Fuller and Davis, 1989), and in the Madison and Missouri Rivers, Montana (Nimick and others, 1998).

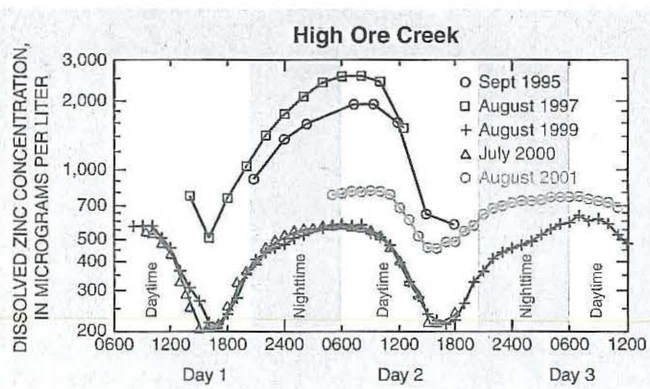

Figure 3. Diurnal variation in dissolved zinc concentrations in High Ore Creek (site 13), Montana, 1995-2001.

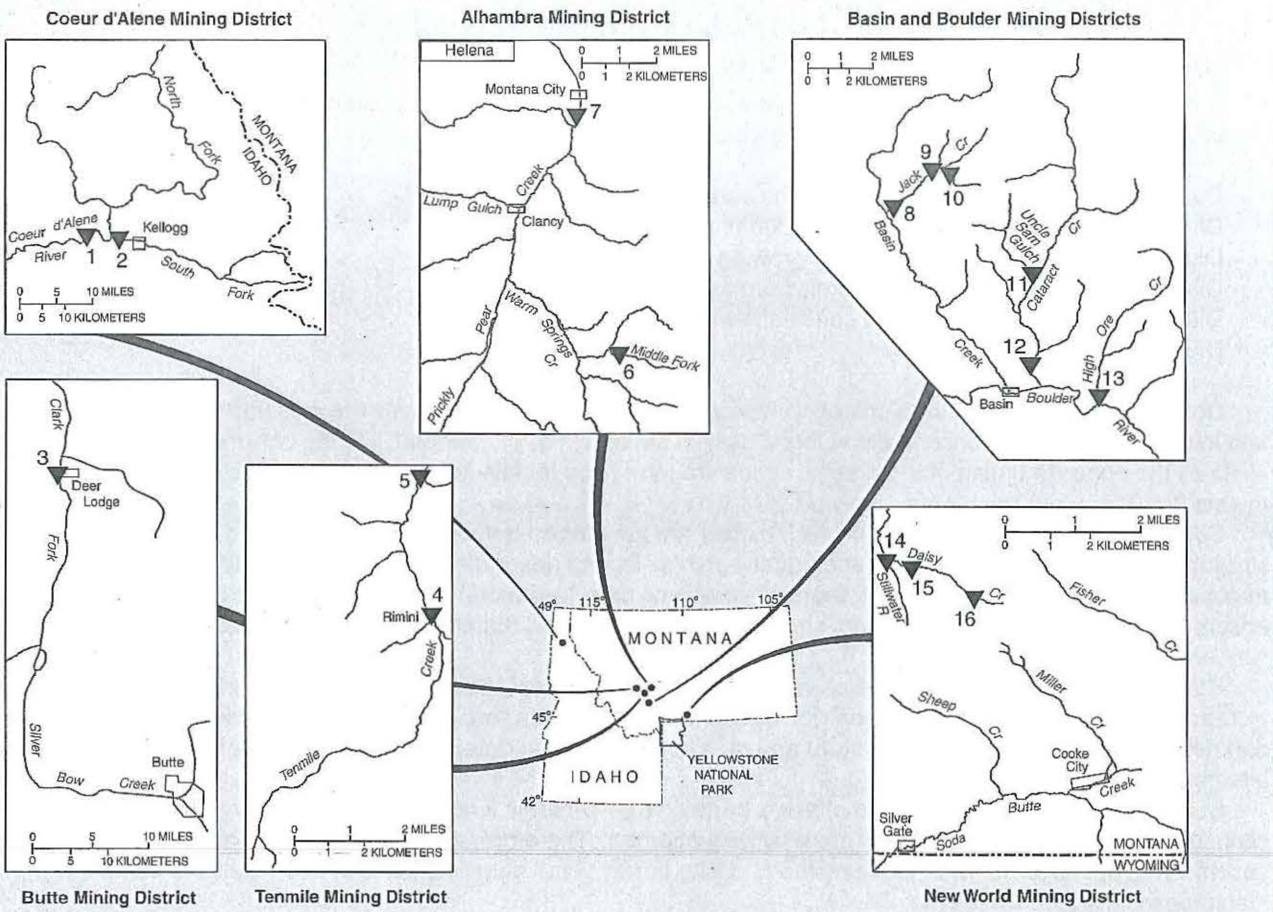

Figure 4. Data describing diurnal metal cycles were collected during low flow at 16 sites on 13 streams draining historical mining areas in Montana and Idaho. At each site, water samples were collected hourly for 1- to 2-day periods. The pH was acidic at sites 10 and 16, and diurnal metal cycles did not occur.

Bourg and Bertin (1996) and Brick and Moore (1996) were the first to document diurnal zinc cycles.

IMPLICATIONS

Water-quality data commonly are collected to characterize metal concentrations in streams. These data are used to establish baseline environmental conditions, indicate the locations of important metal sources, plan and evaluate cleanup of contaminated sites, detect long-term trends in metal concentrations, and evaluate potential risks to fish and other aquatic organisms. However, if diurnal variability of metal concentrations is substantial and persistent, such evaluations likely are, at least, much less certain than previously thought and, at worst, potentially misleading or wrong. In the future, the implications of diurnal metal cycles will be an important consideration when designing plans for water-quality sampling and evaluating historical data on metal concentrations.

Collecting water-quality samples in Prickly Pear Creek, Montana (near site 7 on fig. 4)

What Causes Diurnal Metal Cycles?

A number of physical, chemical, and biological mechanisms potentially can explain diurnal cycles in dissolved metal concentrations. These mechanisms include:

- Diurnal cycles of sorption of metals to the surfaces of streambed material
- Diurnal cycles of formation and dissolution of minerals containing metals
- Diurnal cycles of uptake of metals by growing aquatic plants
- Diurnal variation of the input of metals from an upstream source
- Diurnal changes of geochemical conditions within the streambed
- Diurnal variation of streamflow

Sorption best explains diurnal metal cycles for two reasons. First, it explains the concurrent timing of the high and low dissolved metal concentrations found daily in streams (fig. 1). Second, it is the only mechanism that explains the opposite timing of the arsenic concentration cycles relative to the concentration cycles of the other metals (fig. 2).

Sorption is a chemical reaction in which metals are transferred between stream water and the surfaces of streambed materials, such as rocks and aquatic plants. During desorption, metals are detached from streambed materials and added to stream water, thereby increasing dissolved metal concentrations in stream water. During adsorption, metals are transferred from stream water to streambed materials, thereby decreasing dissolved metal concentrations.

Sorption is affected by the temperature and pH of stream water. Water temperature and pH commonly increase in streams during the day and decrease during the night in response to the daily cycles of daylight and darkness. These changes in temperature and pH are key factors in determining the amount of each metal that is adsorbed or desorbed.

Sorption of a specific metal ion is affected by its charge. Arsenic ions are negatively charged whereas cadmium, manganese, and zinc ions are positively charged. Therefore, arsenic desorbs when the other metals adsorb. This opposite behavior explains the opposite timing of the diurnal arsenic cycles relative to cadmium, manganese, and zinc cycles (fig. 2).

This Fact Sheet was prepared by David A. Nimick and is based on the journal article:

Nimick, D.A., Gammons, C.H., Cleasby, T.E., Madison, J.P., Skaar, Don, and Brick, C.M., 2003, Diel cycles in dissolved metal concentrations in streams--Occurrence and possible causes: Water Resources Research, v. 39, no. 9, 1247, doi:10.1029/2002WR001571.

Suggestions for additional information:

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WATER QUALITY VARIABILITY IN TRIBUTARIES OF THE CHEAT RIVER, A MINED APPALACHIAN WATERSHED[1]

J. Todd Petty and Jennifer Barker[2]

Abstract. An understanding of the dynamics of metals and other solutes from mine drainage is essential to successful planning and stream remediation in mined Appalachian watersheds. Consequently, we conducted a study designed to quantify the spatial and temporal dynamics of trace metals and other water chemistry variables across a range of mining impairment. Water chemistry was monitored every three weeks in 34 stream segments of the lower Cheat River basin in northeastern West Virginia. Water sampling was conducted regardless of flow levels over a period from May 2002 – October 2003 and produced data on spatial and temporal variation in water temperature, dissolved oxygen, pH, conductivity, alkalinity, acidity, hardness, total dissolved solids, and dissolved concentrations of sulfates, iron, aluminum, manganese, cadmium, chromium, and nickel. Our study produced the following results. 1) Water chemistry was temporally variable in all streams examined; however, variability was generally highest in the moderately impaired streams. 2) Severely impaired waterbodies experienced poorest water quality during periods of extended low flows, whereas moderately impaired streams experienced poorest water quality under a variety of moderate and high flow conditions. 3) Elevated trace metal concentrations (chronic and acute) were common in moderately impaired streams and may provide an explanation for biological degradation in these streams. Our results suggest that water samples must be taken during late winter and late summer seasons in order to properly quantify chemical conditions in moderately impaired streams. Furthermore, full restoration of mining impacted watersheds may not be possible unless remediation approaches target reductions in trace metals and control temporal variability in water quality.

Additional Key Words: acid mine drainage, aquatic chemistry, coal mining, streams, trace metals

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Introduction

There is a critical need for restoration action and more effective watershed management approaches in the Mid-Atlantic Highlands (MAH) region of the eastern U.S. (Jones et al. 1997). The MAH consists of the mountainous portions of Pennsylvania, Maryland, Virginia, and Kentucky, and the entire state of West Virginia. A recent assessment by the USEPA of stream ecological condition in the MAH found that more than 70% of streams are severely or moderately impaired by human related stressors (USEPA 2000a). Impairment to aquatic communities in this region extends from a range of human related activities, including agriculture, forestry, and urban development, but mining related impacts are unquestionably the most severe. For example acid mine drainage (AMD) from abandoned mines has degraded hundreds of miles of streams in West Virginia alone.

Several recent scientific advances and policy directives have improved the likelihood of effectively managing mining impacted watersheds in this region. First, the West Virginia Division of Environmental Protection (WVDEP) has worked in cooperation with the USEPA to conduct watershed assessments and develop Total Maximum Daily Load (TMDL) programs for AMD impacted watersheds throughout the state (WVDEP 1999, USEPA 2000b). The successful implementation of these programs would dramatically improve surface water chemistry and ecological integrity of aquatic ecosystems in the state. Second, the WV state legislature recently passed a stream Anti-Degradation policy, which theoretically will protect remaining high quality aquatic resources in the region. Third, West Virginia, with support from the USEPA, industry representatives, and local watershed organizations is exploring the feasibility of developing watershed specific and statewide water quality trading programs. If successful, the trading program could facilitate implementation of TMDL plans, produce significant improvements in water quality, and reduce the economic burden of meeting clean water goals in the region.

Despite these advances, our understanding of the fundamental physical, chemical, and biological processes in mined Appalachian watersheds remains incomplete. Most importantly, we lack a clear understanding of water quality variability in AMD impacted watersheds and how this variability may ultimately influence stream ecological condition. An understanding of the dynamics of metals and other solutes from mine drainage is essential to the successful management and remediation efforts in mined Appalachian watersheds. Consequently, the specific objectives of our study were to: 1) quantify temporal variability in dissolved metals and other solutes within the lower Cheat River watershed, 2) identify the timing of worst water quality conditions in moderately and severely impacted streams, and 3) quantify spatio-temporal variability in trace metal concentrations and assess the likelihood that trace metals may be causing significant biological degradation in this watershed.

Methods

Study Area and Sampling Design

The Cheat River is part of the upper Ohio River basin and is formed by the confluence of the Shavers Fork and Black Fork in Parsons, WV. From this confluence, the Cheat River flows 135 km north to Point Marion, PA, where it enters the Monongahela River. The Cheat River drains a watershed of approximately 3,700 km^2, and is located almost entirely within north-central West Virginia. The economy in the northern portion of the watershed has been dominated by coal mining over the last century, and as a result, many streams in the lower Cheat River watershed have been degraded by acid mine drainage discharged from abandoned mines (Williams et al. 1999).

Sampling sites in this study were chosen based on their expected level of impairment from acid mine drainage. Thirty-four sites were chosen on 14 tributaries of the lower Cheat River: five sites were chosen as unimpaired reference sites (i.e., stream segments that drain watersheds without any mining activity), four sites were chosen as severely impaired sites (i.e., sites with extremely high acidity levels), and the remaining 25 sites were selected across a range from low to moderately high acidity levels. For brevity we refer to each group of sites as unimpaired, severely impaired, and moderately impaired, respectively.

Field Sampling

We sampled all study sites every three weeks, beginning May 2002 and ending May 2003. Water samples were taken regardless of flow level. Each sampling event generally spanned 2-3 consecutive days. We used area-velocity techniques to calculate stream flow (m^3/s) at each site at the time water sampling occurred. Daily variation in stream flow was also monitored at a single location (Big Sandy Creek) for the entire study period in order to document general flow conditions in the lower Cheat River watershed. Temperature (C), pH, specific conductivity, dissolved oxygen (mg/L), and total dissolved solids (mg/L) were measured on site using a YSI 650 unit with a 600XL sonde. At each site, two water samples were collected. A 500 mL water sample was filtered using a Nalgene polysulfone filter holder and receiver, using mixed cellulose ester membrane disc filters with a 0.45 μm pore size. Filtered samples were immediately treated with 5 mL 1:1 nitric acid to bring the pH below 2. This acidification prevented dissolved metals from dropping out of solution prior to analysis. These filtered water samples were used for analysis of aluminum, iron, manganese, nickel, cadmium, chromium, and hardness (mg/L). An unfiltered 1-liter grab sample was also collected for analysis of alkalinity, acidity, and sulfates. Unfiltered samples were kept on ice after collection, and stored in the laboratory at 4^{o} until analysis could be completed.

Laboratory Analysis

All samples were analyzed at Black Rocks Test Lab in Morgantown, WV, using procedures from the 18^{th} edition of Standard Methods for the Examination of Water and Wastewater (Clesceri et al. 1992). Acidity and alkalinity as $CaCo_3$ were determined using the titration method (methods 2310 and 2320B, respectively). Sulfate was determined using the turbidimetric method (method 426C). Iron, manganese, nickel, cadmium and chromium were analyzed with an AAS (atomic absorption spectrophotometer) using method 3111B. Aluminum was analyzed using an AAS, using method 3111D. Hardness as $CaCo_3$ (SM18-2340B) was measured using an AAS, using calculations from method 3111B.

Our statistical analyses were directed towards describing the degree of water quality variability, the timing of worst chemical conditions, the quantity and types and dynamics of dissolved trace metals and differences in water chemistry dynamics between severely impaired and moderately impaired streams. We used coefficients of variability (CV) of each water quality parameter as a measure of temporal variability in water chemistry in reference and impaired streams.

Results

Streams in the lower Cheat basin experienced significant day-to-day and seasonal variation in stream flow (Fig. 1). Discharge patterns could be separated into three distinct phases. Phase 1 was a relatively wet Spring in April and May 2002. Phase 2 consisted of a prolonged dry period from June – October 2002. This dry period was then followed by an unusually wet Fall 2002 and Winter 2003 (Phase 3) (Fig. 1). These alternating wet and dry periods provided a good opportunity to quantify changes in stream chemistry across a variety of hydrologic conditions.

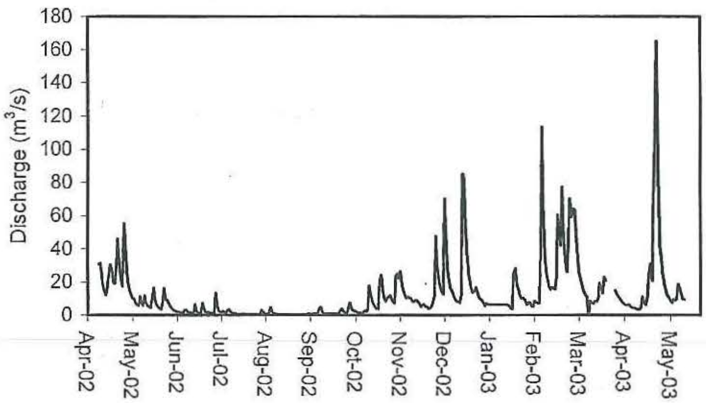


Figure 1. Daily mean discharge during the course of the study. Discharge was gaged continuously on Big Sandy Creek at Rockville, WV (USGS 03070500).

Each stream segment was sampled 17 times over the course of the one year study resulting in a total of 578 samples. Although water chemistry was highly variable, we observed consistent differences in chemical conditions among unimpaired, moderately impaired, and severely impaired stream segments (Table 1). Specifically, unimpaired streams tended to possess the following characteristics relative to moderately and severely impaired segments: higher pH, lower conductivity, higher alkalinity, lower acidity and sulfate concentration, and lower concentrations of dissolved metals (Table 1). Interestingly, differences in dissolved iron and aluminum concentrations between unimpaired and moderately impaired streams were minor (e.g. mean iron concentrations were 0.18 mg/L in unimpaired streams vs. 0.22 mg/L in moderately impaired streams). However, trace metal concentrations (i.e., Mn, Ni, Cd, and Cr) differed between the two stream types by an order of magnitude (Table 1).

Table 1. Summary statistics for water chemistry variables from unimpaired, moderately impaired, and severely impaired stream segments. Mean values were calculated across all sample dates. Avg. CV refers to the average variability of stream segments within each category. The higher the value the more highly variable water chemistry was from sample date to sample date.

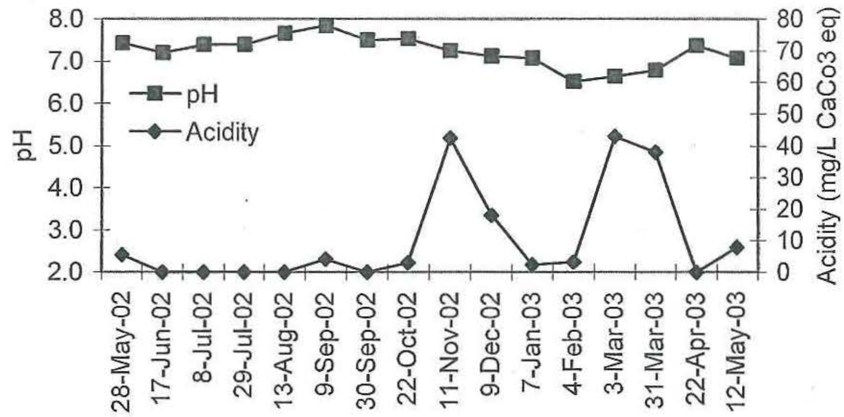
	Unimpaired			Moderately Impaired			Severely Impaired		
	Mean	Range	Avg. CV	Mean	Range	Avg. CV	Mean	Range	Avg. CV
pH	7.2	7.0 - 7.4	7	6.3	4.1 – 7.0	8	3.3	2.7 - 3.9	10
Temperature (^{0}C)	11.5	10.6 - 12.5	7	11.0	10.2 - 14.4	8	9.7	8.1 - 10.4	11
Sp. Conductivity (µS/cm)	103	71 - 154	32	198	35 - 527	53	1222	747 - 1757	38
Total Hardness (mg/L)	29.7	19.1 - 43.9	31	47.8	10.7 - 122.7	50	158.1	100.8 - 261.1	45
Alkalinity (mg/L $CaCO_3$ eq.)	24.7	15.7 - 36.4	40	11.1	0.0 - 25.6	75	0.0	0.0 - 0.0	.
Acidity (mg/L $CaCO_3$ eq.)	6.7	3.5 - 10.5	203	20.5	8.3 - 44.7	105	272.1	130.2 - 460.0	64
Sulfate (mg/L)	16.2	9.1 - 41.5	88	65.9	11.5 - 225.8	68	608.6	363.1 - 908.8	43
Iron (mg/L)	0.18	0.11 - 0.27	104	0.22	0.09 - 0.44	117	24.19	5.27 - 58.47	73
Aluminum (mg/L)	0.15	0.12 - 0.17	66	0.55	0.12 - 2.80	82	17.34	8.51 - 31.77	73
Cadmium (mg/L)	0.0014	0.0012 - 0.0016	74	0.0020	0.0010 - 0.0052	108	0.0029	0.0024 - 0.0038	67
Chromium (mg/L)	0.0009	0.0006 - 0.0012	100	0.0017	0.0006 - 0.0064	117	0.0073	0.0036 - 0.0146	75
Manganese (mg/L)	0.027	0.015 - 0.035	97	0.335	0.045 - 1.645	77	3.752	1.564 - 8.232	58
Nickel (mg/L)	0.009	0.008 - 0.010	87	0.022	0.009 - 0.083	73	0.240	0.147 - 0.390	60

Water Quality Variability

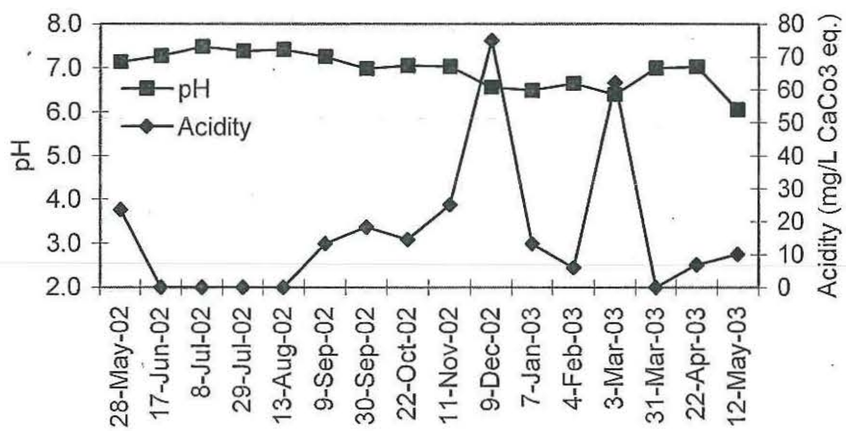
The primary objective of our study was to quantify the degree of temporal variability in water quality in streams of the lower Cheat River watershed. Our analyses indicated that chemical conditions were highly variable in all streams studied, regardless of relative impairment level. Figures 2 – 4 illustrate the typical range of chemical variability in the three stream types examined: unimpaired, moderately impaired and severely impaired. Two important findings emerge from these graphs. First, unimpaired and moderately impaired streams possessed good water quality for most of the year and variability was marked by pulses of poor chemical condition (Fig. 2-4). This was especially true for acidity and dissolved aluminum and iron during periods of increased stream flow (Fig. 2 and 3). In contrast, water chemistry in severely impaired streams tended to remain poor for most of the year and variability was marked by pulses of improved chemical condition, probably as a result of dilution from precipitation events (Fig. 2-4). Second, unimpaired and moderately impaired streams exhibited similar water chemistry dynamics for pH, acidity, aluminum and iron (Fig. 2 and 3). However, unimpaired and moderately impaired streams consistently displayed measurable differences in the dynamics of manganese and trace metals such as nickel (Fig. 4). Specifically, dissolved manganese and trace metal concentrations in unimpaired streams remained low throughout the year. However, chronic levels of manganese persisted throughout the year, and episodic doses of trace metals were common in moderately impaired streams (Fig. 4).

The degree of temporal variability in water chemistry varied as a function of stream type (i.e., unimpaired, moderately impaired, and severely impaired) and depended on the chemical parameter of interest. Generally, we found that temporal variability in condition was highest in the moderately impaired streams and lowest in unimpaired and severely impaired streams (Fig. 5 and 6). This pattern was especially true for trace metals such as cadmium and chromium (Fig. 6). The only exception to this rule was for acidity for which unimpaired streams exhibited the greatest amount of temporal variability (Fig. 5). The low temporal variability in water chemistry observed in unimpaired streams indicates that these streams possess good water quality under most flow conditions. Likewise, low variability in severely impaired streams indicates that these streams typically possess very poor water quality. In contrast, the moderately impaired streams alternate between good and poor water quality, resulting in a high lever of temporal variability in chemical conditions.

A. Roaring Creek 1



B. Muddy Creek 4



C. Martin Creek

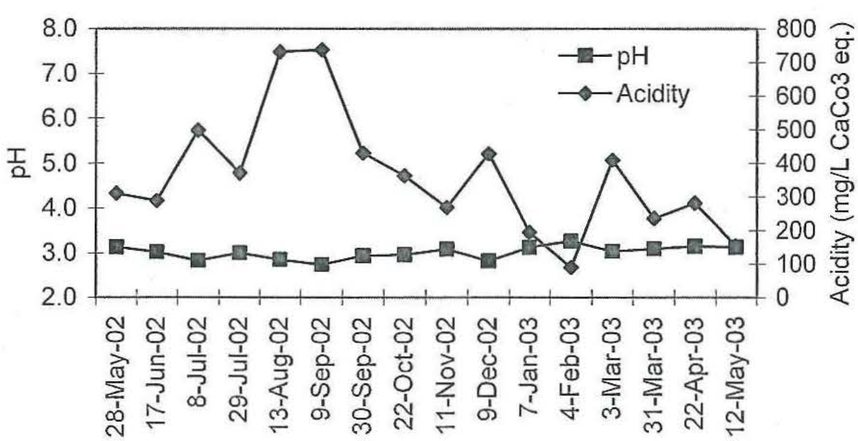
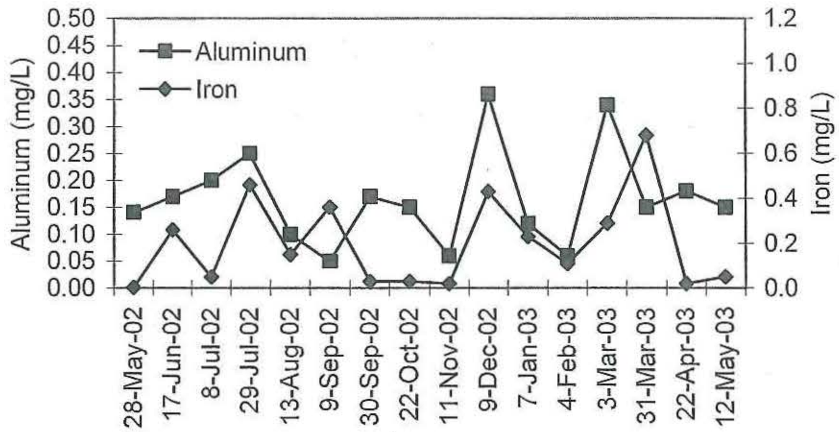


Figure 2. Variability in pH and Acidity within an unimpaired (A), a moderately impaired (B), and a severely impaired (C) stream segment of the lower Cheat River watershed.

A. Roaring Creek 1



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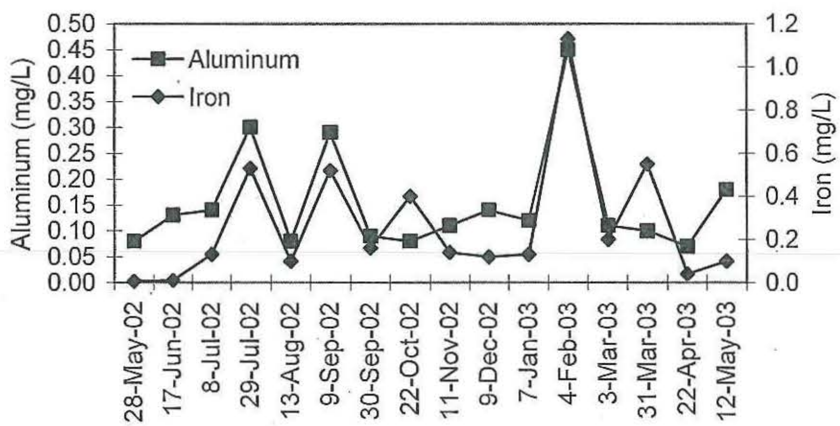

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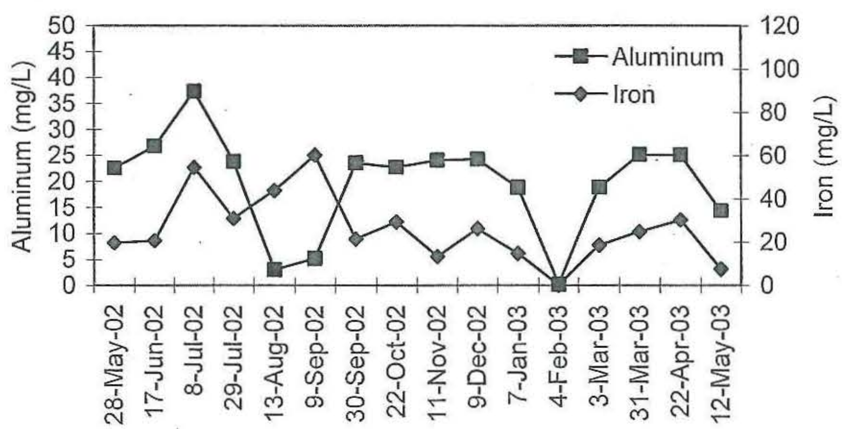
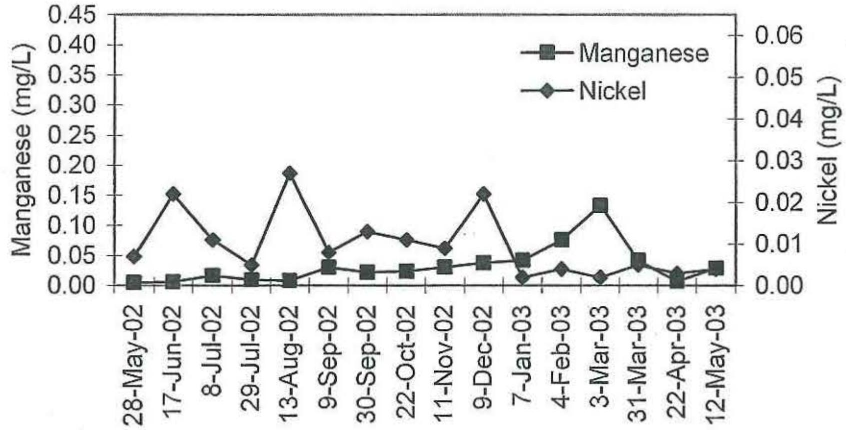
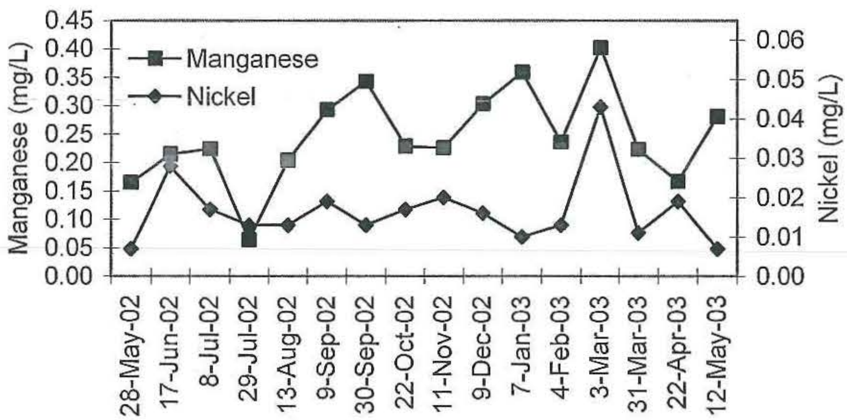


Figure 3. Variability in dissolved Aluminum and Iron concentrations within an unimpaired (A), a moderately impaired (B), and a severely impaired (C) stream segment of the lower Cheat River watershed.

A. Roaring Creek 1



B. Muddy Creek 4



C. Martin Creek

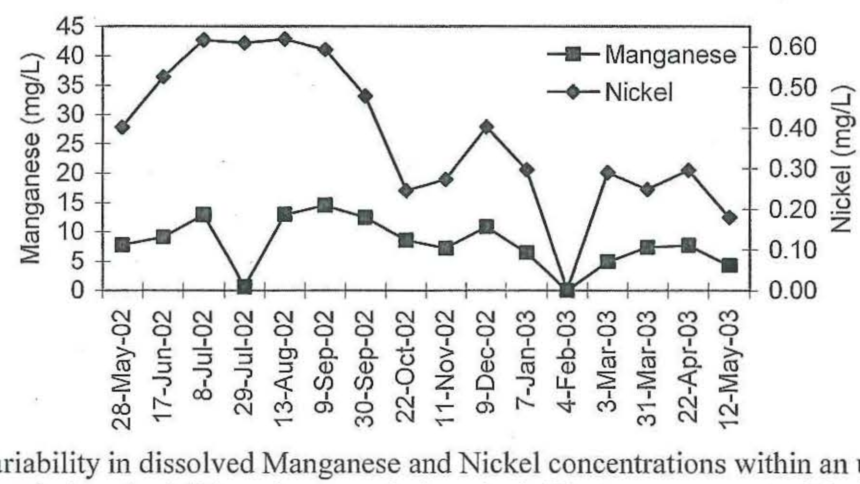


Figure 4. Variability in dissolved Manganese and Nickel concentrations within an unimpaired (A), a moderately impaired (B), and a severely impaired (C) stream segment of the lower Cheat River watershed.

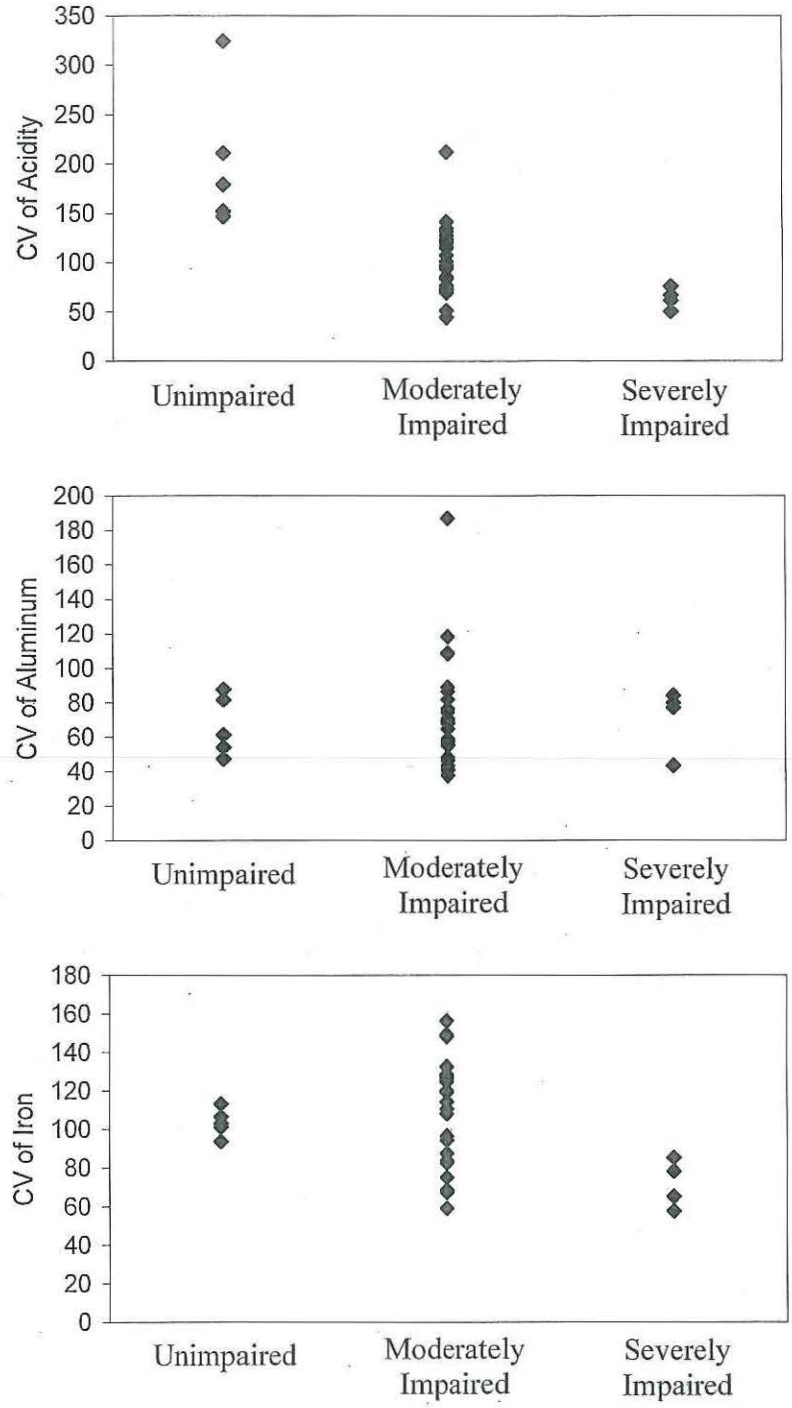


Figure 5. Temporal variability in acidity and dissolved aluminum and iron concentrations within unimpaired, moderately impaired, and severely impaired stream segments of the lower Cheat River watershed. Each symbol represents a relative measure of day-to-day variability in water chemistry at a specific study site.

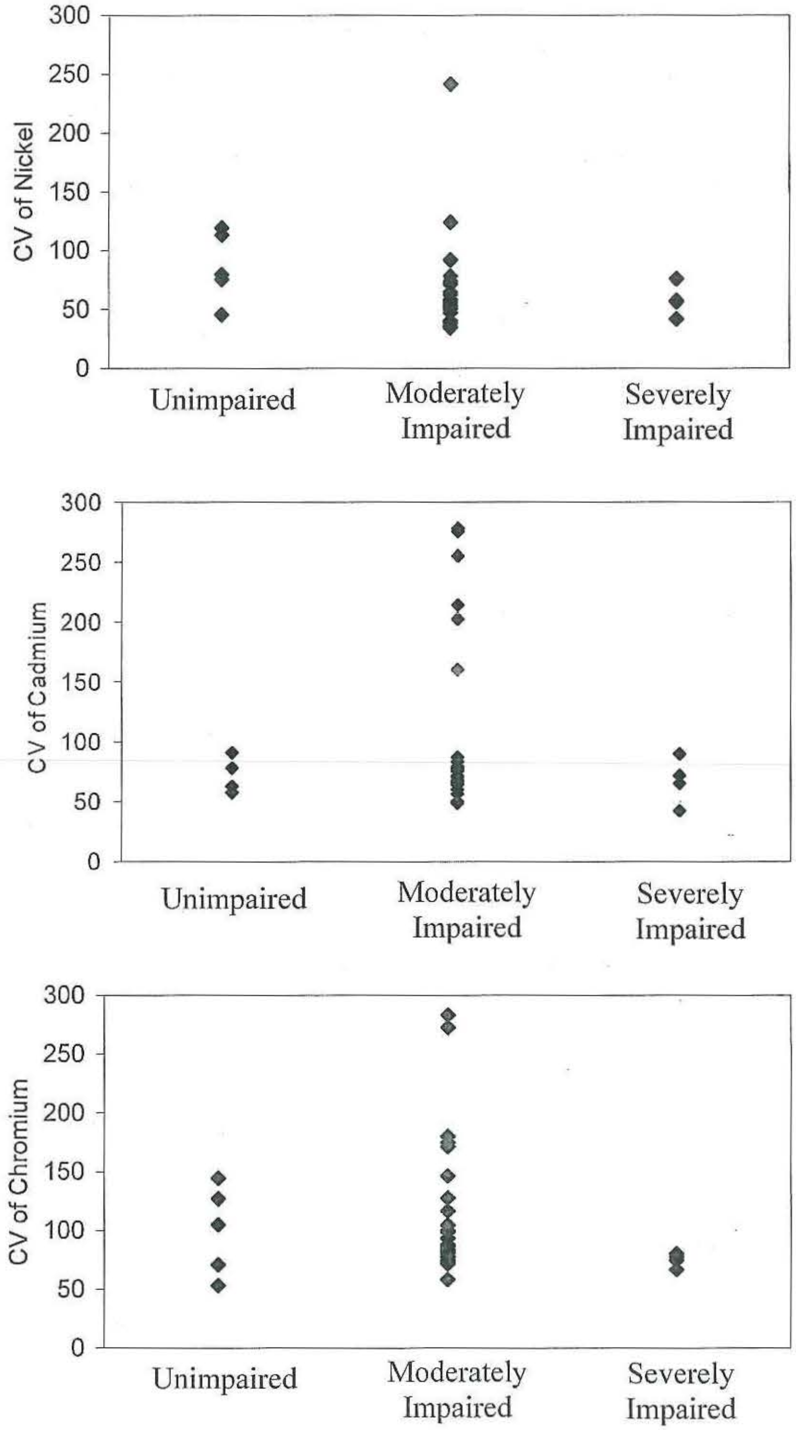


Figure 6. Temporal variability in dissolved trace metal concentrations within unimpaired, moderately impaired, and severely impaired stream segments of the lower Cheat River watershed. Each symbol represents a relative measure of day-to-day variability in water chemistry at a specific study site.

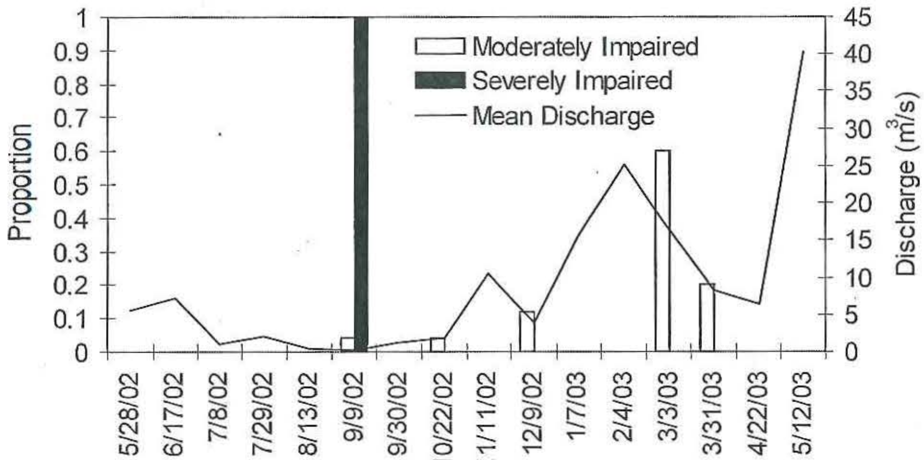
Timing of Worst Water Quality Conditions

Our second objective was to identify times during the year in which water quality was at its worst in moderately and severely impaired streams of the Cheat River watershed. To do this, we identified the sampling date for which a given parameter for a given stream was at its worst condition (e.g., date of minimum pH recorded or date of maximum acidity recorded). We then calculated the proportion of streams for which the parameter was at its worst for each sampling date and constructed frequency histograms for each water quality parameter separately and for all parameters combined. These analyses determined that severely impaired streams were consistently at their worst during prolonged periods of low flow in summer months (Fig. 7 and 8). This pattern was true for all parameters examined. In contrast, we found that conditions in moderately impaired streams typically were at their worst during high flow periods in winter and early spring. This was especially true for parameters such as acidity and iron concentration (Fig. 7). However, there was considerable variation in the timing of worst conditions in moderately impaired streams depending on the parameter examined. For example, maximum nickel concentrations were recorded during dry periods in some streams and during wet periods in others (Fig. 8a). When all parameters were combined, we found that the timing of worst conditions in moderately impaired streams was bimodal: some streams exhibited their worst conditions during dry periods in summer, whereas other streams exhibited poorest conditions during wet periods in winter and early spring (Fig. 8b).

Trace Metal Concentrations

Our third objective was to quantify the spatial and temporal dynamics of trace metal concentrations in streams of the lower Cheat River watershed. We observed significant levels of spatial and temporal variability in dissolved trace metal concentrations. Concentrations of dissolved trace metals were always low in unimpaired streams (Fig. 9). However, trace metal concentrations in moderately and severely impaired streams were extremely variable, with some streams possessing very low concentrations and other streams experiencing significant pulses of dissolved trace metal loads (Fig. 9). Two important results emerged from our analyses of trace metal concentrations. First, many of the highest concentrations of dissolved cadmium and chromium were observed in moderately impaired streams rather than severely impaired streams (Fig. 9). Second, most streams did not possess high concentrations of all trace metals. Instead, some streams possessed high concentrations of cadmium, whereas others possessed high concentrations of chromium (Fig. 9).

A. Acidity



B. Iron Concentration

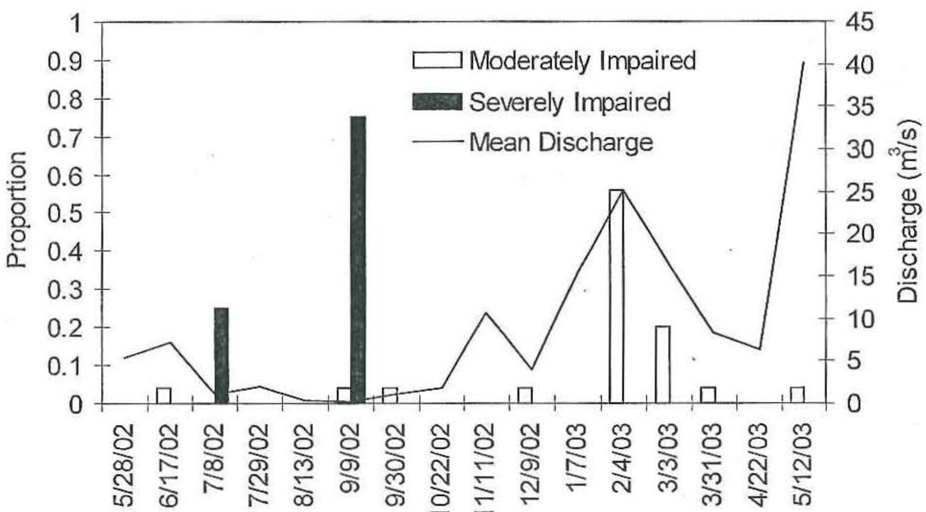
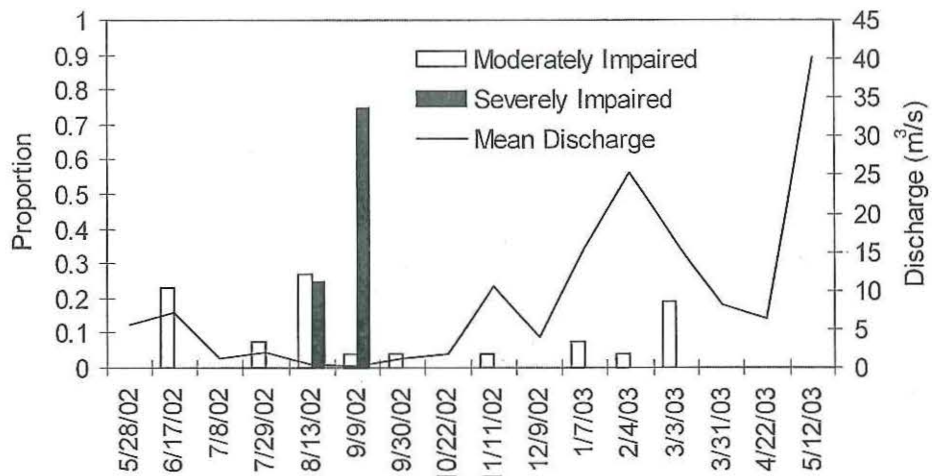


Figure 7. Proportion of streams for which the maximum acidity (A) and iron concentration (B) was recorded on a given date. Data are presented separately for severely impaired and moderately impaired streams. Daily mean discharge recorded on Big Sandy Creek also is presented.

A. Nickel Concentration



B. All Parameters Combined

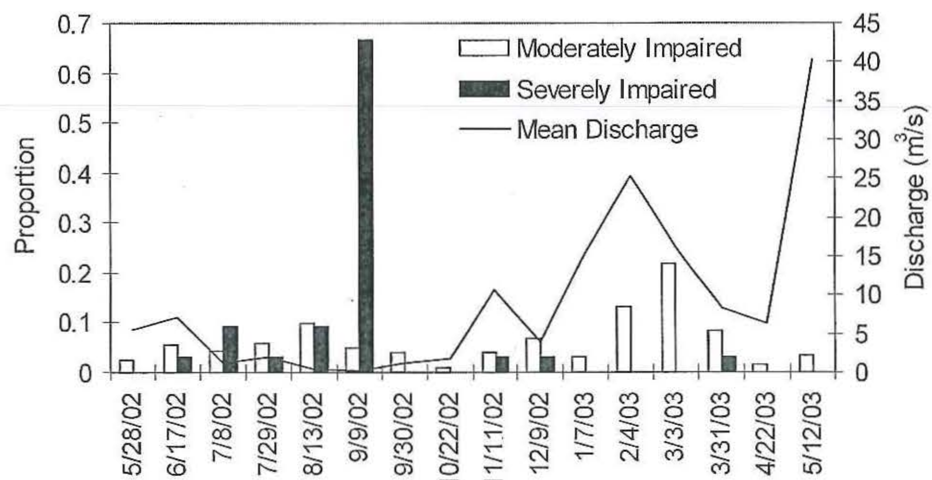


Figure 8. Proportion of streams for which the maximum nickel concentration (A) and minimum or maximum value of all parameters combined (B) was recorded on a given date. Data are presented separately for severely impaired and moderately impaired streams. Daily mean discharge recorded on Big Sandy Creek also is presented.

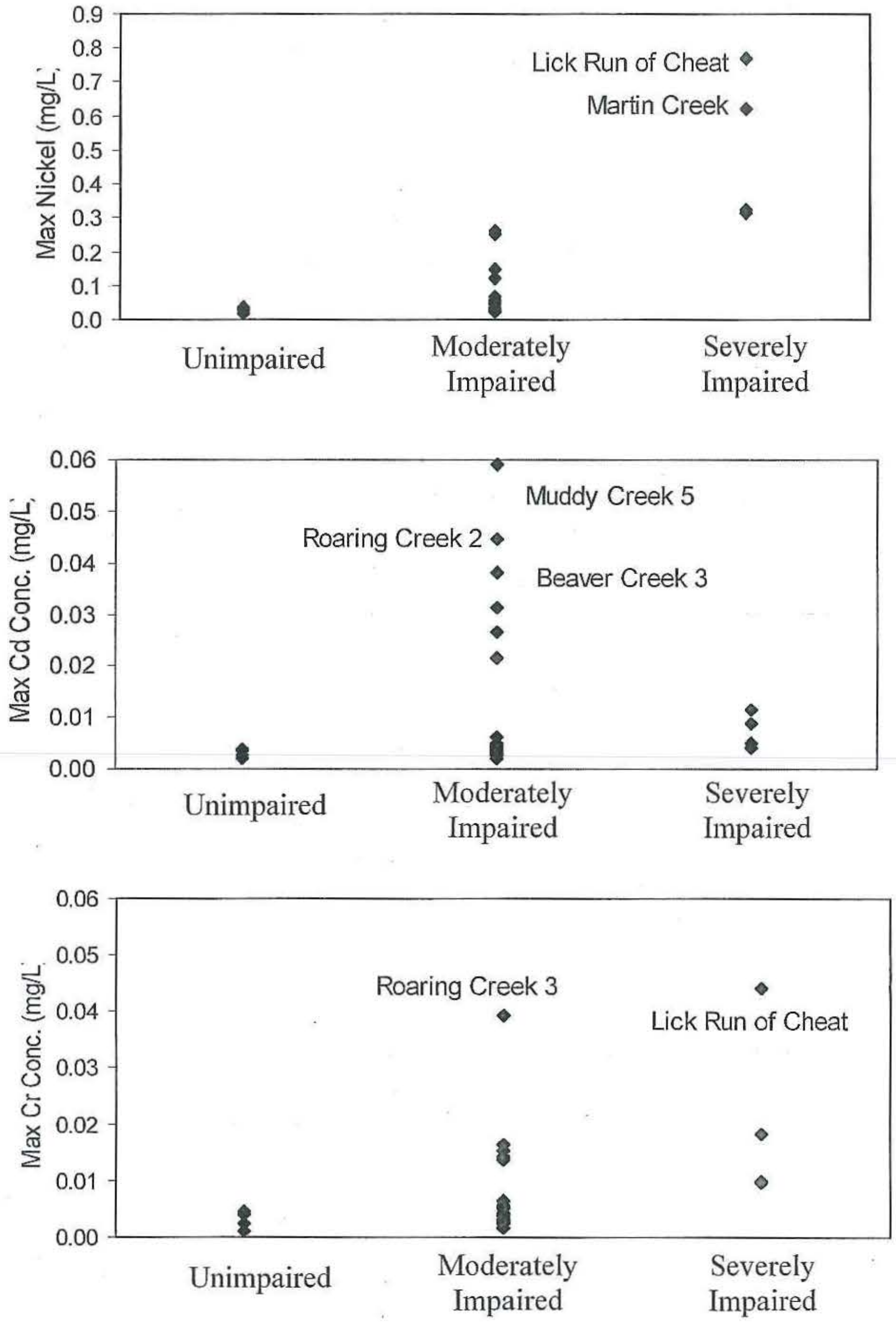


Figure 9. Maximum recorded dissolved concentrations of trace metals from unimpaired, moderately impaired, and severely impaired streams of the lower Cheat River watershed. Names of stream segments with relatively high trace metal concentrations are shown. Note that many of the highest cadmium and chromium concentrations were observed in moderately impaired streams.

Discussion

Water chemistry was extremely variable in streams of the lower Cheat River watershed. Although this was true for all stream types examined, temporal variability in chemical condition was highest in the moderately impaired streams. Several factors influence spatial and temporal variability in water chemistry in streams that receive AMD. This variation results from both hydrologic inputs and instream processes (McKnight and Bencala 1990, Sullivan and Drever 2001). Hydrologic inputs can originate from precipitation, direct overland flow, subsurface flow through shallow soils, drainage from shallow and deep aquifers, as well as direct inputs from flooded deep mines. Instream processes include dilution, acid neutralization, metal release and adsorption from sediments, as well as precipitation and coprecipitation (Nordstrom and Ball 1986, McKnight and Bencala 1990, Jurjovec et al. 2002).

Water quality variability was lowest in the unimpaired streams. The variability that was observed resulted from elevated acidity from precipitation events. However, because these streams were moderately alkaline, pH remained high (i.e., >6.5), and dissolved metals remained at very low concentrations. Consequently, brief doses of elevated acidity are unlikely to have a significant effect on the overall condition of unimpaired streams. Water quality variability also was relatively low in severely impaired streams, but for different reasons. Most of the water in severely impaired streams originates from flooded deep mines. The effluent from these mines has extremely low pH (2-3) and high concentrations of dissolved metals. Because these inputs are relatively constant, instream conditions are almost always poor. Occasionally, however, large precipitation events or snow melt will dilute AMD and severely impaired streams will experience brief periods of relatively good water quality. Moderately impaired streams in the lower Cheat River watershed possessed much more variable water chemistry than either the severely impaired or unimpaired streams. There are several possible reasons for this variability. First, these streams possess a much lower alkalinity than unimpaired streams. Therefore, they are more likely to be impacted by acid precipitation events. Second, pH in these streams was depressed and more likely to move between 4.5 and 6.5. At this level, many metals move between conservative and non-conservative behavior resulting in dramatic variability in dissolved metal concentrations.

The high variability in trace metal concentrations that we observed in moderately impaired streams was particularly interesting. It is also interesting that some of the highest concentrations of dissolved cadmium and chromium were observed in moderately impaired rather than severely impaired streams. A possible explanation for these findings is that moderately impaired streams are receiving large inputs of trace metals from disturbed acidic soils in the surrounding watershed. During wet periods when vegetation is dormant, acidic soil water and water in shallow aquifers may mobilize trace metals and deliver them to the moderately impaired streams. A poorly understood component of trace metal dynamics in the Cheat River watershed is the interaction between trace metals, sediments, and aluminum and iron precipitates. Trace metals are often removed from the water column during mixing by either adsorption to sediment particles such as clay or coprecipitation with aluminum and iron precipitates (Routh and Ikramuddin 1996, Jurjovec et al. 2002). These trace element complexes remain immobilized in the sediment and are only released when the pH decreases. Dissolved trace metal concentrations may be higher in moderately impaired streams than severely impaired streams because there is less iron and aluminum precipitate. Consequently, coprecipitation of trace metals may occur at a lower rate resulting in higher dissolved trace metal concentrations in the moderately impaired streams. Regardless of the mechanisms controlling trace metal dynamics, a more complete understanding of trace metal / sediment / precipitate interactions in the Cheat River watershed is needed.

Our results support numerous studies that have found that severely impaired streams in mined watersheds experience worst conditions during low flow periods (Filipek et al. 1987, Brake et al. 2001, Sulliven and Drever 2001). During these periods, severely impaired streams are dominated by mine water because surrounding soils and shallow aquifers are dry. To our knowledge, our study is one of the first to examine temporal variability in water chemistry across a wide range of moderately impaired streams. In contrast to the severely impaired streams, many of the moderately impaired streams experience their best conditions at low flows and their worst conditions during high flows. This pattern suggests that the dominant sources of impairment to moderately impaired streams come from surface mines and/or disturbed shallow aquifers. During dry periods, soils and shallow aquifers are dry and deeper, alkaline aquifers are the dominant water source to these streams. During wet periods, however, the shallow water sources become saturated and supply water to streams, especially in winter and early spring. It may be at this time that moderately impaired streams are receiving the highest loads of acidity and dissolved metals from the surrounding watershed. It also may be a time when trace metals are being released from the sediments because of lowered pH.

Management Implications

Our results produced two important management implications for mined watersheds. First, our results indicate that water samples taken during dry periods will accurately characterize chemical conditions in severely impaired streams, but not in moderately impaired streams. This is important, because most streams segments in the Cheat Watershed are moderately impaired, rather than severely impaired (WVDEP 1999). Consequently, effective monitoring of these watersheds will require a sampling regime that is most likely to effectively characterize both moderately and severely impaired waterbodies. Our results indicate that water quality monitoring programs must quantify surface water chemistry during both dry and wet periods. Moderately impaired streams exhibit their poorest conditions during moderately wet periods in winter and early spring when terrestrial vegetation is dormant and soils and shallow aquifers are saturated. Second, we believe that effective restoration of mined watersheds will need to consider how to manage water quality variability and trace metal concentrations. Our results suggest that water quality variability and trace metals are probably the most important factors limiting the overall condition of moderately impaired streams. Without proper management of variability and trace metals we may never fully restore AMD impacted ecosystems.

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ATTACHMENT NO. 5

Memorandum

date November 14, 2014

to **Marina Rush**
Department of Planning and Development
County of Santa Clara

Rob Eastwood
Department of Planning and Development
County of Santa Clara

from Peter Hudson PG, CEG
Environmental Science Associates

Subject Comments on Water Chemistry Variability in Samples From Pond 30 – December 2012

ESA has reviewed the November 13, 2014 letter provided by Lehigh Southwest Cement Company Permanente Quarry (Lehigh) that addressed the variability of selenium concentrations in two samples obtained from Pond 30 in December 2012. As reported by Lehigh, the December 2012 samples were just at [(5.9 micrograms per Liter (µg/L)] or below the water quality objective (and laboratory reporting limit) of 5.0 µg/L. The 5.9 µg/L selenium result was a valid laboratory result and based on these laboratory results, there can be little dispute that selenium was present in the December 5 water sample. However, the selenium concentration detected was only a trace amount (less that 1 µg/L), just slightly over what the laboratory can confidently report as selenium.

Considering that Pond 30 is located at the base of a limestone quarry that can potentially produce elevated selenium concentrations in the stormwater, it is ESA's opinion that the slight 0.9 µg/L exceedance of selenium typifies a localized variation in background water quality for Pond 30 and does not indicate the lack or failure of stormwater best management practices (BMPs). If stormwater BMPs were not in place or had failed at some point during December 2012, it is ESA's opinion that the selenium concentrations in Pond 30 stormwater would likely have been much higher and would have been detected in the stormwater discharge sampling.