Appendix C: Comments on May and November 2005 P.E. LaMoreaux and Associates Documents

Review of May 18, 2005 *Karst Investigation Report, Delineation of Capture Zone of Liddell Spring, Santa Cruz, California,* prepared by P.E. LaMoreaux & Associates (PELA) for RMC Pacific Materials, Inc. (RMCPMI), Davenport, California.

This is a technical review of the subject document as it pertains to hydrogeologic issues relevant to preparing an Environmental Impact Report (EIR) for the proposed expansion of the Bonny Doon Quarry in Davenport, California by RMC Pacific Materials, Inc. (RMCPMI). This review also addresses additional information provided during a June 21, 2005 oral presentation by the report's author, P.E. LaMoreaux & Associates (PELA), at the Santa Cruz County Environmental Planning Department.

Data, information, and analysis supporting our comments are provided in the relevant sections, tables, and figures of our report.

General Comments

The PELA report presents an important body of well documented work that includes the first successful tracer study linking Liddell Spring to several point sources of recharge. It thus contributes significantly to an understanding of the local hydrogeology. However, a number of the conclusions seem simplistic and/or overreaching in relation to the available information and remaining uncertainties.

The report states that its "delineation of the catchment basin for Liddell Spring provides the information necessary to assist with the mitigation of the episodic turbidity problem at the spring" (p. 37). However, delineation of the spring's overall recharge area does not necessarily relate to the quarry's potential to directly impact the spring.

The structure of the report does not build on a comprehensive and critical review of existing data or past studies. Rather, interpretations made in past studies up to nearly 50 years ago, often based on relatively little information, are selectively cited in support of the report's own conclusions.

Climatic Conditions

An accurate characterization of the climatic conditions under which the 2003-05 PELA study was conducted is critical to interpreting its results and their relevance to the full range of climatic conditions under which the quarry expansion may occur. Based on NOAA and other precipitation stations in the region (e.g., Santa Cruz, Ben Lomond 4, San Gregorio 2 SE, Lockheed), precipitation during the 2003 water year (WY; i.e., October 2003 through September 2004) was about 90 to 100 percent of average and WY 2004 was about 80 to 90 percent of average. Although WY 2005 was relatively wet at about 120 to 140 percent of average, no karst tracers were introduced during WY 2005 and a relatively small portion of the overall monitoring program extended into WY 2005, prior to the apparent termination of all field monitoring in February 2005.

The report describes 2004 as a "year of more than average rainfall" (pp. 60) based on a comparison of data collected by PELA and the quarry's historical precipitation record. Data from NOAA precipitation stations in the surrounding region, however, indicate that precipitation during WY 2004 was only about 80 to 90 percent of average. Because precipitation occurs primarily from the passage of regional frontal storms, it is unlikely that the relative magnitude of seasonal precipitation would differ significantly in the quarry area. This suggests that a statistical comparison between the PELA data and the referenced historical record is invalid.

The report states that the study's monitoring period included "a significant rainstorm [event] on April 15, 2003 with a one-day rainfall of 6.7 inches" (p. 3). A comparison with other daily records suggests that PELA's precipitation total for this date included precipitation from prior days of the month, mostly April 12-13.

The PELA study was preceded by two years that were dry to slightly below average. Precipitation during WY 2001 was about 75 to 85 percent of average while WY 2002 was about 90 to 100 percent of average. The study's results reflect below average moisture conditions given these antecedent conditions and below average to average precipitation during most of the study. As stated by PELA "like in any other well-developed karst aquifer, the transport of sediments is episodic and is very sensitive to the flow regime" (p. 61). The timing of the study did not coincide with the type of wet conditions and flow regime most likely to be associated with potential turbidity impacts from existing and future quarry operations. Furthermore, the study did not provide any analysis (e.g., of the historical data record) that could be used to quantitatively or conceptually extrapolate its results to conditions during average to wet periods.

Groundwater Level Monitoring

The report does not contain any plots or maps of groundwater level data collected by PELA, nor does it present or discuss any groundwater level data collected prior to the PELA study. Thus, the report's description of the groundwater system contributing to Liddell Spring is unrepresentative of average or wet conditions, and there is no assessment of the maximum range of water-level fluctuations. It appears that little or no groundwater level monitoring occurred during 2000-02.

Spring Monitoring

The report presents PELA's monitoring results for Plant Spring located about 1,400 feet east of Liddell Spring. PELA monitored Plant Spring for two years beginning in November 2002. The City of Santa Cruz has been overseeing the current Liddell Spring monitoring program since October 2000. Other monitoring of Liddell Spring has occurred over several decades.

PELA's monitoring record for Plant Spring contributes to the overall understanding of the local hydrogeology. However, past studies have recognized distinct differences between Liddell and Plant springs' flow, water quality, and responses to short- and long-term climatic conditions. The PELA report does not present a summary or analysis of the Liddell Spring monitoring record. The significance of the Plant Spring data is diminished by not being presented in the context of the Liddell Spring record.

Geophysical Investigations

PELA's geophysical investigations using ground penetrating radar and electrical resistivity tomography were unsuccessful in siting monitoring wells that encountered groundwater conduits within the subsurface karst. Nolan, Zinn Associates, however, used an analysis of fracture patterns apparent at the ground surface and in air photos to successfully locate a karst groundwater conduit in connection with Liddell Spring (the "NZA" monitoring well). This demonstration of a correlation between fractures and groundwater conduits suggests that fractures provide a potential vertical conduit for the transport of water and sediment from near the ground surface down to groundwater, especially as fractures become more exposed during quarry operations.

Isotope Analysis

PELA analyzed February 2003 groundwater and spring samples for two stable isotope ratios, deuterium to hydrogen and oxygen-18 to oxygen-16, expressed as delta values δD and $\delta^{18}O$, respectively. Our independent analysis of these data (see report Section 4.3.4) differs from PELA's contention that the perched and saturated groundwater zones are significantly distinct and separate.

Tracer Tests

PELA's tracer test results should be qualified as follows:

- The definition of a positive detection as two consecutive samples having 5 to 10 times the background concentration (or quantification limit in the case of a non-detect background concentration) may omit some detections of physical significance.
- Although the study cannot be faulted for uncooperative weather, it should be acknowledged that the tracer test results reflect karst groundwater flow toward the end of a four-year period of below average precipitation. Past studies have observed that the groundwater system behaves differently during and following wet periods. For example, the report states that "dye tracing at sinkhole SH-11 [adjacent to the expansion area] does not indicate that this area is actively connected to Liddell Spring" (Table IX-1). This statement should be completed as follows: "*during conditions similar to that of the study period, which were relatively dry*."
- Two different tracers were inserted into the Reggiardo Creek swallow hole (SS-1), one with a "very low" absorption tendency and one with a "moderate" adsorption tendency (Tables VIII-1 and VIII-3). At Liddell Spring, the former was detected within 13 days whereas the latter was never detected in three months. Given this discrepancy, there is some uncertainty regarding the results for tracers with "moderate" adsorption tendencies. Two different tracers, both with moderate adsorption tendencies, were inserted into SH-11 near the expansion area and neither was detected at any of the sampling points using PELA's assumed detection criteria. These tracers had to travel a large vertical distance under relatively dry conditions to reach the saturated zone. Under these circumstances, it is reasonable to suspect that their moderate adsorption tendencies contributed to their lack of detection.

Tracers should have been introduced into monitoring wells M1B and M1A given (a) the need to evaluate potential flow paths between the proposed expansion area and Liddell Spring and (b) the unfavorable hydrologic conditions for inserting tracers into SH-11. In its November 4, 2003 letter to Nolan, Zinn & Associates, PELA stated "We evaluated the well logs of M1A and M1B and do not think either of them can serve as a dye injection point." No further explanation was provided

Liddell Spring Estimated Catchment Area

The report states that the "delineation of the catchment basin for Liddell Spring provides the information necessary to assist with the mitigation of the episodic turbidity problem at the spring" (p. 37). Although delineation of the catchment basin is useful to understanding the overall hydrology, it does not in and of itself address the potential for the proposed quarry expansion to introduce sediment into the underlying karst groundwater flow, regardless of its source of recharge. Relatively minor sources of recharge may help transport large sediment loads that result in significant turbidity impacts.

Degree of Hydraulic Connection between the "Unsaturated" and Saturated Zones

Although PELA acknowledges that "the study area has very complex geology and hydrogeology" (pp. 74), it presents a simplistic conceptual model in which "the karst terrane consists of two distinct zones—the deeper saturated zone and the unsaturated zone above it" (pp. 74). Furthermore, PELA repeatedly asserts a simplistic interpretation regarding the hydraulic relation between these two zones. For example: "The unsaturated zone has a poor hydraulic connection downward with the saturated zone" (pp. 75); "There is very poor hydraulic connection between the unsaturated zone and the saturated zone" (p. xvii); "The unsaturated zone has poor hydraulic connection with the saturated zone. Therefore, the sediment contribution from the quarry area…is very limited" (p. xix); "The data collected in this study do not indicate a strong hydraulic connection between the unsaturated zone and the saturated zone" (p. 58). It is difficult to reconcile the acknowledged complexity of the karst groundwater system with the notion that it consists of two distinct and essentially isolated zones.

According to PELA, the fact that some wells encounter perched conditions establishes that there is an overall poor hydraulic connection between a deep, fully saturated zone and the various perched zones. However, the existence of other wells that do not encounter perched conditions is evidence that there is vertical connection to allow groundwater percolation to deeper zones. Indeed, the perched zones must percolate to deeper zones or else they would completely fill and discharge as local springs at relatively high elevation.

PELA states that "the active conduits often lie very close to the local drainage level as observed in many active karst systems" (p. 58). However, because the region is under going tectonic uplift, it is reasonable to infer that conduits formed at ancestral drainage levels that are now distributed throughout the uplifted marble body.

Turbidity

Similar to its acknowledgment that "the study area has very complex geology and hydrogeology" (p. xiv), the PELA report acknowledges the "complicated processes of sediment transport in the karst aquifer" (p. xviii). However, in addressing the potential for water quality impacts from quarrying, PELA reasserts its simplistic interpretation of the hydrogeology: "Because of the poor hydraulic connection between the unsaturated zone and the saturated zone, the sediment contribution from the [quarry area] is very limited" (p. 63).

PELA's citation of several anecdotal accounts of heavy sedimentation and turbidity following the initial clearing and start of quarry operations (pp. 64-65) does not support its contention that there is poor vertical connection between the ground surface and the various groundwater zones. PELA does not explain why similar sediment and turbidity impacts should not be expected as a result of clearing and quarrying in the proposed expansion area. Indeed, PELA states that "the turbidity at Liddell Spring can be affected by…logging, construction, and clearing" (p. 73).

Report's Conclusions, Recommendations, and Proposed Mitigation Measures

PELA concludes that "the data collected from this investigation and the data analysis indicate that the operation of the Bonny Doon Limestone Quarry should have a negligible effect on the flow of

Liddell Spring" (p. 57). This conclusion lacks support given past history, incomplete knowledge of the expansion area, and reasonable alternative interpretations of the site hydrogeology.

PELA states that "the impact of quarrying operations on Liddell Spring is minor because the major sources for the spring water and sediments are allogenic [i.e., derived from beyond the immediate quarry area]. The quarrying operation is conducted in the unsaturated zone of the karst land and the unsaturated zone has poor hydraulic connection with the saturated zone" (p. 75). While groundwater recharge in the quarry area accounts for a minor percentage of Liddell Springflow, it appears sufficient to transport significant additional sediment associated with quarry operations into the groundwater system, such as occurred during the early 1970s. Data collected during the PELA study did not represent wet conditions when sediment transport is greatest. The assertion that there is now and will continue to be poor hydraulic connection between the various groundwater zones is not well supported.

In the "unlikely event that quarrying impacts the flow to Liddell Spring," PELA suggests four mitigation measures (p. 77):

1. Supplement the City's water supply with a diversion from Plant Spring.

   Plant Spring discharges at an approximate average rate of 180 gpm, of which the quarry diverts about 20 gpm. The remaining flow equals about one-fifth of the City's average annual diversion from Liddell Spring, and as such could only partially mitigate lost production as a result of quarrying. Furthermore, the partial transfer of Plant Spring water rights to the City would need to be addressed, along with potential impacts to downstream habitat as a result of diminished flows. The quarry's development of an alternative water supply to replace any reduced use of Plant Spring could have additional, separate impacts on Liddell Spring.

2. Construct a detention basin within the quarry to temporarily contain any groundwater intercepted by quarrying, and divert this water to the City's intake at Liddell Spring.

   This essentially would substitute a "new" surface water source for a springflow source, and thus involve issues related to sustainability, exposure to surface contamination, and changes in water rights.

3. Construct production wells that intercept karst conduits feeding Liddell Spring in the area between the quarry and the spring's recharge areas, and convey the pumped groundwater to the City's existing spring intake.

   Wells that successfully intercept significant karst conduits may be very difficult to locate and construct. The sediment load in these conduits might cause excessive wear on the wells' pumps. In light of California's water laws, there may be some inequity in exchanging a right to divert springflow for a right to pump groundwater from a well.

4. Prevent Reggiardo and Laguna creek streamflows from recharging the karst, and instead pipe this water to the City's Liddell Spring intake.

   Again, this would be a substitution of surface water for springflow. It would also result in reduced water-supply storage. Springflow yields are more sustainable during the dry season and droughts, and are generally of better quality. If this measure were implemented, it would seem more reasonable to convey these flows to the City's downstream diversions rather than its Liddell Spring intake.

During its June 21, 2005 presentation, PELA proposed a fifth mitigation measure:

5. Provide the City with a water treatment facility capable of mitigating increased Liddell Spring turbidity as a result of quarrying.

   This could effectively address water quality impacts, but would not address any water quantity impacts.

The quantity and quality of established municipal water supplies are managed very conservatively in California. Potentially significant impacts to water production from Liddell Spring may be unavoidable given the interconnectivity and complexity of the karst groundwater system, the unavoidable generation of sediment by quarry operations, and the potentially unavoidable capture of significant precipitation and runoff within mined areas. A suitable package of relatively indirect mitigation measures (e.g., treatment, water supply replacement) will require negotiation between RMC and the City.