APPENDIX C-1

Technical Memorandum, Review of 'Hydrogeologic Conditions At and Near the Proposed Madera Quarry,' Luhdorff & Scalmanini, Consulting Engineers, dated October 28, 2009

Review of "Hydrogeologic Conditions At and Near The Proposed Madera Quarry"

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Luhdorff and Scalmanini, Consulting Engineers (LSCE) have undertaken a review of the report entitled "Hydrogeologic Conditions At and Near the Proposed Madera Quarry" prepared for Madera Quarry, Inc. by Kenneth D. Schmidt and Associates (KDSA), Groundwater Quality Consultants, October 2009. The scope of review was three-fold:

- review and comment on the results of well and aquifer testing, with focus on the applicability of the test results for use in estimating effects of the proposed mining and processing on nearby wells, specifically private wells;
- review and comment on the results of the dewatering analysis, with focus on the resultant estimate of the rate of groundwater inflow into the proposed excavation from fractured bedrock, and the fate of that inflow during both the mining and the post-mining (reclamation) phases, and the impacts of inflow on nearby wells, specifically private wells; and
- review the results of pumping impacts analysis, i.e. planned pumping of two water supply wells for plant process, with focus on estimated impacts on nearby wells, specifically private wells.

The results of our review are summarized in the following four sections, with the first three entitled to correspond to the three scoped topics listed above, and a fourth to separately address the fate of all inflow to the excavation under reclaimed conditions.

Well and Aquifer Testing

As part of earlier work associated with the exploration and development of groundwater at the proposed quarry site, Madera Quarry Wells 1, 4 and 5 were tested by others in 2001 for durations of 1 day (Wells 1 & 5) and 3 days (Well 4). For the more extensive analysis in its subject report, KDSA conducted pumped well/aquifer tests at three Quarry wells to determine long-term yields of the wells and to estimate the hydraulic properties of the fractured bedrock aquifer system in which the wells are completed. Well 1 was tested for 18 days in October, 2005; Well 5 was tested for 15 days in October-November, 2005; and Well 10 was tested for 34 days in October-December, 2008. We understand that some question has previously been raised with regard to the duration of the initial pumped well tests. To place that issue in context, it is useful to recognize that the State Health and Safety Code (Titles 17 and 22 of the California Code of Regulations) includes alternative provisions for determination of the capacity of wells completed in bedrock. Since those provisions are for domestic water supply, they can be considered conservative if applied to testing of the Quarry supply wells. The alternatives in the Health and Safety Code for well testing include 72-hour (3 day) and 10-day tests, followed by interpretation generally comparable to that conducted by KDSA as discussed below. Such as there is any question about the adequacy of the KDSA test durations, all three tests substantially exceed the standards in the Health and Safety Code, and can thus be concluded to have been of sufficient duration to determine the long-term capacities of the tested wells, and to interpret aquifer response (drawdown) for calculation of representative aquifer characteristics for subsequent impact analyses.

Each of the three tests conducted by KDSA was termed a constant head test (variable pumping capacity to maintain a near-constant pumping water level in the tested well), in contrast to the widely practiced well/aquifer testing that involves maintaining a constant pumping capacity. KDSA reports the constant head method to have been conducted for decades in the foothills and mountains of the Sierra Nevada to determine reliable long-term well yields. It also reports that the test data can be interpreted to determine aquifer characteristics (transmissivity and storage coefficient) by applying the well-known Jacob approximation of the Theis Non-Equilibrium Formula based on an assumption that the fractured rock is equivalent to porous media (unconsolidated aquifer materials) for which the Theis Formula was developed. Ultimately, KDSA's interpretation of the three pumped well/aquifer tests results in three sets of aquifer characteristic values which are judged to be the "best" values for the fractures in which the respective tested wells are completed. The resultant aquifer characteristic values are then subsequently used by KDSA to estimate dewatering rates for the proposed excavation, and to estimate impacts of water supply pumping and excavation dewatering for the proposed project on nearby private wells. Finally, KDSA reports a number of "apparent" aquifer characteristic values which are numerical artifacts of using the Jacob approximation method for aquifer test interpretation in settings like the Madera Quarry location where some of the monitored wells are poorly connected (through fractures) to the pumped well(s). The latter "apparent" values are noted to be of limited use, specifically only for calculating the drawdown impact of the tested well on the monitored well where the drawdown data was collected.

The concept or practice of considering fractured bedrock to be "equivalent" to porous media has been successfully applied in other settings like the proposed Madera Quarry. Although the fundamental assumptions related to the theory (e.g. Theis Non-Equilibrium Theory) to describe unconsolidated aquifer response to pumping are not satisfied in a fractured rock environment, water level responses in fractured rock aquifers have been observed in many places to be similar to those in porous media (logarithmic water level decline vs. time) at constant pumping rates. In the specific case of the Madera Quarry pumped well/aquifer tests, KDSA used the "constant drawdown" part of the tests to estimate long-term individual well yields, but actually interpreted water level response to near constant pumping rates (noted to be slightly declining in the latter stages of the testing) to estimate aquifer characteristics. The latter is consistent with the application of the Jacob approximation to the Theis Non-Equilibrium Formula on an "equivalent" porous media basis.

While some of the aquifer test interpretation by KDSA is not the same as what we might independently employ, most notably in the application of the Jacob approximation for interpretation of recovery data (water level recovery after the cessation of test pumping), the numerical results reported by KDSA can be concluded to be representative of the hydraulic properties of the fractured rock environment at the proposed quarry site, particularly when recognizing the anisotropy (differences in hydraulic properties in various directions around the tested wells) and lack of homogeneity that is apparent in varying responses to pumping at the network of wells that were monitored during testing.

It is well recognized that, in the great majority of fractured rock settings, transmissivity values are small, i.e. fractures are not significantly permeable. Thus, the small "best" values of transmissivity concluded by KDSA from its interpretation of the pumped well/aquifer tests, in the range of about 150 to 260 gallons per day per foot of aquifer width (gpd/ft), are reasonable values for use in estimating quantities like groundwater inflow rates to an excavation and the effects of groundwater pumping and/or excavation dewatering on surrounding groundwater levels and wells completed in the same general fractured aquifer system. Certainly, if one were so inclined, debate could be raised regarding things like the failure of fractured rock to satisfy the assumptions embedded in the fundamental work of Theis and the subsequent approximation by Jacob. However, the net result of that debate would most likely be that the "best" values estimated by KDSA would still be the most applicable, or that slightly different values might be applicable for some reason. However, if the latter were the case, the difference would almost assuredly be small, rendering the subsequent analyses of excavation dewatering and pumping impacts to differ very little from that derived from the values of aquifer characteristics reported by KDSA.

Excavation Dewatering

KDSA estimated the rate of groundwater inflow to the proposed Madera Quarry excavation by applying Darcy's Law to calculate flow rates across each of the four sides of the approximately rectangular excavation. In applying Darcy's Law, KDSA utilized some of the aquifer characteristics determined from the well/aquifer tests described above, in combination with estimated hydraulic gradients (slopes of the groundwater surface) in the respective directions around the excavation. In its calculations, KDSA took into account the anisotropy in the local fractured aquifer system (different values of transmissivity in various directions relative to the excavation: higher in the direction of mapped lineaments in the area, and lower in the direction normal to the lineaments). It also took into account the planned grouting of fractures encountered in the excavation to impede groundwater inflow (and thus reduce the rate of dewatering that would be required during mining, as well as eliminate the formation of a groundwater lake in the excavation after the cessation of mining and dewatering). KDSA's calculated rate of groundwater inflow across all four sides of the excavation is 20,000 gallons per day (gpd), or about 14 gallons per minute (gpm), when it is fully dewatered. That rate (or smaller rates during earlier stages of excavation) could be used to meet part of the estimated average water requirement of 35 gpm for processing at the proposed project. The estimated groundwater inflow rate to the excavation would be expected to continue after mining and dewatering are completed. KDSA concludes that, with the intended reclamation to native vegetation on the bottom and benches of the excavation, evapotranspiration by that vegetation would consume all the groundwater inflow, as well as all the inflow from precipitation, thus precluding the accumulation of inflow to form a permanent lake in the excavation. KDSA notes that there would be short periods of high precipitation in the winter when some temporary ponding of water in the bottom of the excavation would be expected to occur. The fate of the combined inflows from precipitation and groundwater are further discussed below.

As part of our review, LSCE approached the estimate of groundwater inflow to the excavation in a different manner than employed by KDSA. Recognizing that the planned grouting of fractures on the excavation face represents a local, thin, high impedance (severe reduction of fracture permeability at the excavation face) to groundwater inflow, we chose to prepare a simple two-layer numerical groundwater flow model of the fractured aquifer system at and around the proposed excavation, with aquifer parameters unaffected by the excavation or grouting except right at the excavation face. The first layer of the model extends to the depth of the planned excavation, and the second layer extends several hundred feet deeper to account for any potential upward flow through fractures into the bottom of the excavation. Surrounding groundwater levels were taken from the measurements in wells in the area and contours of equal groundwater elevation reported by KDSA. Similarly, anisotropic aquifer parameters were taken from the KDSA aquifer test interpretations (155 gpd/ft in the direction of mapped lineaments and about 1/3 of that value, 50 gpd/ft, in the perpendicular direction). The grouting of fractures at the excavation face was simulated by imposing a layer of low permeability (0.00003 ft/day, or 10^{-8} cm/sec), considered to be conservative, or slightly higher than the permeability of a cement grout likely to be used for grouting of fractures. Using the preceding parameters, and considering the fractures to have lower permeability in the vertical direction than in the horizontal direction, the simulated rate of groundwater inflow to the proposed excavation is 21gpm. For the conditions at the proposed project site, we would consider that rate to be practically comparable to the KDSA estimate in that the estimated groundwater inflow to the excavation will be very small, and much less than either the estimated water requirement for processing during active mining or the evapotranspirative consumption by native vegetation in a reclaimed configuration.

After utilizing the model as described above, we conducted a number of other model runs to examine the sensitivity of results to various input parameters. Those variations included increases and decreases (one or two orders of magnitude) in horizontal (both and separate anisotropic directions) and vertical hydraulic conductivity, increases and decreases (one order of magnitude) in aquifer storage coefficient, and a decrease (one order of magnitude) in the hydraulic conductivity of grout. For all cases except for significantly higher horizontal hydraulic conductivity (equivalent to transmissivity at least ten times higher than interpreted from the well/aquifer tests), the overall simulated range of groundwater inflow rates is about 10 to 35 gpm. As above, inflow rates throughout that entire range are small, and would still be consumed by plant processing or by evapotranspiration by native vegetation as further discussed below.

As a final comment on the modeled simulation of groundwater inflow rates to the proposed excavation, we would consider that approach to be more robust in that it more directly reflects the physical conditions which are intended to occur, i.e. a thin impedance to groundwater inflow located at the excavation face, whereby the native aquifer materials (fractures) away from the excavation face are physically unaffected by the grouting. The net effect on groundwater conditions (surrounding groundwater levels) is then a very steep decline across the grouted excavation face, and minimal drawdown in the balance of the surrounding fractured aquifer system. In other words, the effects of inflow to the excavation are limited to the immediate vicinity of the excavation itself, and are either extremely small or do not extend to the locations of nearby private wells.

Pumping Impacts on Private Wells

For purposes of estimating the potential impacts of pumping for project water supply, KDSA distributed the planned project pumping between Quarry Wells 1 and 10 to meet the total estimated water requirement of 55 acre-feet per year, which equates to an equivalent full-time pumping capacity of about 35 gpm. To minimize the projected impacts of operating those two wells on nearby private wells, KDSA took into account actual observations during the pumped well/aquifer tests and assigned more capacity to Well 1 (25 gpm, or about 20% of the long-term yield determined from analysis of the pumped testing of Well 1 described above), and the balance to Well 10 (10 gpm, also about 20% of its long-term yield determined from analysis of the pumped testing described above). KDSA then used the Theis Non-Equilibrium Formula to calculate an approximate effect of that pumping on groundwater levels at selected private wells around the proposed project, and also to develop a contour map of projected drawdown attributable to the project along mapped lineaments (where the results of the pumped well/aquifer tests indicated that the effects are expected to be larger and more distant from the project) and on both sides of the mapped lineaments (where results of the pumped well/aquifer tests indicated that the effects are expected to be smaller and less distant from the project). In applying the Theis Non-Equilibrium Formula, KDSA utilized values of aquifer characteristics derived from interpretation of the pumped well/aquifer tests described above, using those considered to be most representative of conditions along the lineaments for those calculations, and using the "apparent" values for calculations normal to the lineaments. KDSA's reported results include tabulation of projected impacts at several selected nearby private wells (ranging from about one foot to a maximum of 20 feet), individual discussion of the largest projected impact (about 20 feet at a single private well located along a lineament east of the proposed project), and the contour map noted above to show the distribution of projected water level impacts around all mapped private wells within about 1-1/2 miles of the proposed project. The reported estimates of project impact on groundwater levels are not limited to just the effects of pumping for water supply, but also include the effects of excavation dewatering to capture groundwater inflow to the proposed excavation as discussed above.

As part of our review, we were able to replicate the projected impacts calculated by KDSA for wells located other than along the mapped lineaments. In particular because they reflect variations of actual observations of pumping impacts during the pumped well/aquifer testing described above, all of which were small in those directions, those calculated estimates of projected impacts appear to be good indicators of what can be expected. In the direction of the lineaments, we were able to approximate, but not exactly replicate, the projected impacts calculated by KDSA for wells generally aligned with the lineaments mapped where Quarry Wells 1 and 10 are located. For the most part, the differences between our estimates and those calculated by KDSA appear to all be attributable to our different approaches to estimate groundwater inflow (and surrounding impact) to the proposed excavation. Interestingly, where KDSA used a reduced value of aquifer transmissivity to incorporate the effects of grouting at the excavation face for purposes of estimating groundwater inflow to the excavation, it used the full value of transmissivity for purposes of estimating the effects of dewatering on nearby private wells. The net effect of that approach is to present a conservative estimate of combined effects (larger than is likely to occur). As discussed above, the results of our modeled analysis of groundwater inflow, where the effects of grouting are reflected in a localized low-permeability layer at the excavation face, show steep drawdown right at the excavation, and little to no propagation of drawdown into the fractured aquifer beyond the immediate location of the excavation. Thus, our independent assessment would be that the combined effects of proposed project pumping and excavation dewatering, as presented by KDSA in its Figure 31, and also as itemized (about 20 feet) for a single well (Graham East) along the lineament associated with Quarry Well 1, are notably conservative.

The range of potential pumping and dewatering impacts presented by KDSA, less than 10 feet in almost all cases and up to a maximum of about 20 feet in one well, are not sufficient to cause a notable change in pumping capacity for the types of deepwell submersible pumps that are typically used in private wells like those near the proposed project site. Thus, the nearby private well owners could anticipate their respective individual water supply wells to discharge at essentially the same capacities prior to, during, and after the proposed project is operational. In the same regard, the range of potential pumping impacts will contribute to slightly increased energy requirements for pumping from the private wells. Using the largest projected impact reported by KDSA to place that in context, a project-related increase in pumping depth of 20 feet (for the Graham East well) would translate, depending on the individual efficiency of the particular pump, into an additional energy requirement of about 35 kilowatt-hours (kwh) per acre-foot of water pumped. The KDSA report includes records of metering of several private wells near the proposed project and concludes that, for those wells that were metered, the average water use per private lot was about 1,250 gallons per day. The latter figure equates to annual water use of about 1.4 acre-feet per lot. The additional energy requirement to pump that amount of water from a well with the largest project-related pumping impact would then be about 50 kwh per year. At current energy prices, and depending on how much power is otherwise used by nearby private well owners, that additional energy requirement would likely cost about $10 to $15 per year. Of course, all the smaller project-related pumping impacts would translate to proportionally smaller increases in energy consumption and related costs.

As a closing comment on the topic of pumping impacts on private wells, it is noteworthy that all the pumping impacts estimated by KDSA are numerically small, leading to the expectation that private pump capacities will be practically unaffected, and pumping costs will be minimally increased as discussed above. Those results are consistent with the actual observations of groundwater levels in private wells discussed by KDSA relative to pumping at the Quarry property and at private wells, and as illustrated in KDSA's Figure 7. The regular measurement of groundwater levels in multiple private wells over most of the last two years has coincided with pumping of the two planned Quarry supply wells (Wells 1 and 10), which were used for irrigation supply of about 60 af over the last year (or about the same amount of water as projected for proposed Quarry operations). The record of measured water levels in private wells shows no discernable effects of that pumping; thus, the empirical observations of actual pumping impacts, caused by pumping of the same wells as proposed for Quarry water supply, and caused by pumping an annual amount comparable to the estimated demand of the Quarry operation, show that the calculated projections of pumping impacts for the proposed project are consistent with what has been observed.

Fate of Inflow to the Excavation

As noted above, KDSA concludes that grouting of fractures in the proposed excavation will impede groundwater inflow to a rate of about 20,000 gpd (14 gpm), which could be used to meet some of the estimated plant process water requirements during mining. Our understanding is that the quarry could make use of some or all of that water for part of its plant process water requirements; alternatively, it may simply discharge the groundwater inflow, as well as any inflow from precipitation, to the existing stock pond and then use it for irrigation on its lands adjacent to the mining operation. In either case, there would not be a permanent accumulation of ponded water in the bottom of the excavation during mining.

KDSA also concluded that a permanent lake will not form in the excavation after completion of mining because native plant evapotranspiration would consume the combination of precipitation and groundwater inflow, except for short periods of high precipitation in the winter when there would be some temporary ponding in the bottom of the excavation. It is not clear how the KDSA analysis accounted for other than groundwater inflow, notably precipitation, under reclaimed conditions. Consequently, to further examine the potential for a lake to form in the reclaimed excavation, our review extended to account for the fate of both groundwater inflow and precipitation, notably because the latter represents a larger component of inflow that cannot "run off" from the excavation and, since surrounding groundwater is at a higher elevation, cannot infiltrate from the excavation into groundwater.

Our understanding of planned reclamation in the excavated mine is that a series of terraces and the floor of the excavation, covering a total of about 78 acres, will be reclaimed by placing 12 inches of unconsolidated overburden and 4 inches of topsoil on the entire area. The topsoil and overburden will have been stockpiled from the original surface of the excavation for that purpose. The reclaimed surfaces will then be planted to native vegetation like that naturally occurring in the area, and the reclaimed native vegetation will be left to thrive when water is naturally available, and to be dormant when water is seasonally no longer available.

In the reclaimed excavation, the two sources of available water supply will be groundwater inflow and incident precipitation. KDSA reports that the latter has been independently estimated by others to be an average of about 16 inches per year. On the excavation footprint, that average precipitation rate represents a total volume of about 105 acre-feet per year. Within the excavation, most of that water (after interception of a small fraction by the vegetation itself) will combine with groundwater inflow and tend to fill the pore space of the reclaimed overburden and topsoil, up to the limits of their water holding capacity, with any surplus then accumulating as ponded water on the ground surface. A combination of evapotranspiration by the native vegetation and evaporation from any ponded water surface will then tend to remove the inflow from groundwater and precipitation. Two water budgets were prepared to examine the balance, or imbalance, between inflows and outflows, one at the scale of average annual conditions and a second on a monthly time steps to account for seasonal variations in both precipitation and evapotranspiration, which in turn can be expected to result in seasonal variations in soil moisture, ponded water, and plant growth.

On an average annual basis, the combined inflows from groundwater (22 afy) and total precipitation (105 afy) represent a total water supply of 127 afy for the native vegetation to be planted on the 78 acres of reclaimed surfaces of the excavation. On a unitized basis, the total inflow represents about 1.6 acre-feet of water per acre of reclaimed surface (about 19 inches per year of available water per acre of reclaimed surface). That amount of water is slightly more than estimates of evapotranspiration by native vegetation in the area, but well within the capacity of native vegetation to consume water if it is available. In summary, at the scale of total available water over a year, native vegetation can be expected to consumptively use all the inflow, with the net result that no surplus will remain to accumulate as a lake at the bottom of the excavation.

The preceding average annual analysis inherently assumes that, as inflow occurs, it is "absorbed", or stored, for uptake by vegetation as needed. In the case of the planned reclamation, however, there is a finite limit to subsurface storage capacity, which is limited to the moisture holding capacity of the reclaimed overburden and topsoil. If the inflow rate exceeds the combination of available soil moisture holding capacity and evapotranspiration rate by vegetation over a short-term period, the excess inflow will accumulate as ponded water on the soil surface. Whether that can be expected to occur in the proposed quarry, and if so, whether it would persist on a perennial basis, was examined by preparing a water budget to track inflows and outflows on a monthly basis throughout the course of a year. Groundwater inflow was assumed to be uniform at the rate estimated by KDSA (20,000 gpd), and precipitation was considered to vary in direct proportion to the average monthly gaged rates at the Madera CIMIS (California Irrigation Management Information Service) station. Based on that distribution, average precipitation at the site ranges from trace amounts in June through September, to peak amounts between 2 and 3 inches per month between December and March. For the planned reclamation, the moisture holding capacity of the overburden/topsoil profile was assumed to be 1.5 inches per foot of thickness. Potential evapotranspiration by native vegetation was computed from reference evapotranspiration at the Madera CIMIS station and published "crop" coefficients for native vegetation (specifically grasses and sagebrush). Over the course of a year, the resultant potential evapotranspiration by native vegetation ranges from less than an inch per month from November through February, to more than 7 inches per month in June through August. Of course, under natural conditions in the project area, there is insufficient available water to supply the potential evapotranspiration in the peak months, so the native vegetation is dormant at that time; in the case of the reclaimed excavation, there will be an accumulation of water through the rainfall season, combined with groundwater inflow, that could supply that potential evapotranspiration. The monthly water budget was prepared to examine whether evapotranspiration would cumulatively utilize all available water, as suggested by the average annual budget above, and also to examine whether there would be seasonal periods when surplus water would be expected to pond in the excavation, and seasonal periods when available water would be exhausted and native vegetation would become dormant as is the prevailing natural state around the planned quarry.

The monthly water budget shows that, beginning in the fall (October) and continuing through mid-December, the combination of precipitation and groundwater inflow are sufficient to meet the potential evapotranspiration of native vegetation, and to fill soil moisture in the reclaimed overburden/topsoil profile. In the succeeding wet months, the combined inflows would exceed the combination of evapotranspiration by native vegetation and the moisture holding capacity of the reclaimed overburden and topsoil, resulting in a ponding of up to about 5 inches of water in March and April. In subsequent months, the combined inflows would be less than consumption by the native vegetation, resulting in gradual depletion of the ponded water over the period through about mid-June, after which total inflows would be less than the potential evapotranspiration. In those subsequent months, available soil moisture would be depleted by plant uptake, resulting in dry surface condition on the reclaimed vegetated land. In summary, there would be some seasonal accumulation of surface water in the reclaimed excavation, beginning in January and extending through May, but it would be progressively consumed by vegetation such that it would be exhausted by June and there would not be a perennial accumulation that would appear as a year-round "lake".

Such as the seasonal accumulation of water, i.e. ponding, in the excavation is undesirable, one logical means to avoid it would be to place a thicker profile of overburden/topsoil on the reclaimed surfaces, thereby increasing the total moisture holding capacity of the soil complex such that, in the months when inflows exceed consumption by the vegetation, the surplus is stored in the soil profile, and does not accumulate as surface water on the reclaimed surfaces.

Summary Conclusions

Based on extensive review of the report entitled "Hydrogeologic Conditions At and Near the Proposed Madera Quarry" by Kenneth D. Schmidt and Associates, October 2009, complemented by independent technical work as part of the review, the findings and conclusions of that review effort can be summarized as follows.

- As a basis for the extensive analysis in its report, KDSA conducted lengthy pumped well/aquifer tests at three of the Quarry wells, including the two wells planned to be used for water supply for the proposed project. Those tests extended for 18 days, 15 days, and 34 days in Quarry Wells 1, 5 and 10 respectively. While there are no "standards" for test duration to determine the sustainability of groundwater supply for an industrial quarry operation, the California Health and Safety Code includes requirements for minimum testing of domestic water supply wells. The durations of the KDSA tests substantially exceed those requirements and are thus concluded to be of sufficient duration to determine the respective well capacities, and to be interpreted for purposes of estimating impacts of the proposed project.

- The hydraulic aquifer characteristics interpreted from the pumped well/aquifer tests can be concluded to be representative of the fractured bedrock aquifer system, and to reflect the lack of homogeneity and the anisotropy that are obviously present in the area. While theoretical debate could be raised regarding the applicability of available theory for aquifer test interpretation in that fractured bedrock setting, there is no available alternative theory; and any arbitrary but reasonable adjustments to the KDSA interpretations, to resolve such a debate, would most likely have minimal impact on the subsequent impact analyses.

- The KDSA estimate of groundwater inflow (seepage) to the proposed excavation, after grouting of fractures to impede inflow, was independently checked by development and application of a localized numerical groundwater flow model. Both analyses concluded comparable, small inflow rates when the proposed excavation reaches full depth. Those inflow rates, which range from 14 to 21 gallons per minute, will be utilized for some combination of process water supply, irrigation on adjacent Quarry lands, and water supply for native vegetation to be planted on reclaimed surfaces in the proposed excavation.

- Based on tested aquifer response, the combination of pumping from two Quarry wells for project water supply and the dewatering of groundwater inflow to the proposed excavation is estimated to have a generally small impact on groundwater levels at nearby individual domestic wells. At all but a couple of nearby wells, the estimated impacts are less than 10 feet; at the other two wells, estimated impacts are 13 and 20 feet. None of those is likely to cause a measurable change in pumping capacity from those wells. The largest projected impact, 20 feet, can be expected to require an increase in energy consumption of about 50 kwh per year for typical water use in the area; the incremental cost of that energy would be about $12 to $15 per year. The energy and cost impacts at all other nearby wells would be proportionally smaller.

- The small estimated impacts calculated by KDSA from its interpretation of pumped well/aquifer tests can be considered to be empirically supported by monitoring that detected no observable impacts over the last year, when the planned Quarry supply wells were used for irrigation supply of about 60 acre-feet, which is slightly more than the projected annual Quarry water requirement of about 55 acre-feet per year.

- During active mining, the combination of groundwater inflow and incident precipitation on the proposed excavation can be completely utilized by a combination of plant operations and irrigation of Quarry lands adjacent to the excavation. After active mining, planned reclamation of the excavation by placement of overburden and topsoil, and planting of native vegetation, will consume the combination of groundwater inflow and incident precipitation. During the wetter months of December through March, precipitation can be expected to exceed consumption by the reclaimed vegetation, resulting in standing water up to about 5 inches deep by March and into April. Typical subsequent increases in consumption by vegetation, and corresponding decreases in seasonal precipitation, can be expected to deplete that standing water over the course of May and June. Overall, the reclaimed excavation can thus be expected to have seasonal accumulations of shallow water, up to about 5 inches deep, through the rainy months and into spring; but it would not contain a perennial lake as reclaimed vegetation would consume the seasonal accumulations of water, along with water stored in the reclaimed soils.