

Revised Work Plan for the Evaluation of Groundwater Recirculation System

Proposed Mountsberg Quarry



Prepared for
St. Marys Cement

Submitted by
Gartner Lee Limited

September 2006

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of Groundwater Recirculation System**
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Reference: **GLL 60492**

Distribution:
1 St. Marys Cement (Electronic)
1 Gartner Lee Limited

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1. Introduction

CBM St. Marys Cement is intending to establish a quarry (herein referred to as the Quarry) in the Amabel Formation dolostone to supply aggregate. The proposed quarry site is located on Part of Lot 1, and Lots 2 and 3, Concession 11, geographic Township of Flamborough, now The City of Hamilton. The site is located between Regional Road 508 (Centre Road) and Milborough Line, and is about 4 km north of the community of Carlisle. The proposed development area covers an area of about 154 ha (380 acres). An additional 4 ha, fronting on the west side of Milborough Line, will be used for an entrance road.

The subject property has been the focus of a series of investigations dating back to 2003. The product of the hydrogeologic investigations is the draft Hydrogeological Level 2 Report (Gartner Lee Limited, 2005) that presented a summary of the geologic and hydrogeologic information collected on the property and surroundings to the release date of the report, and a preliminary assessment of the potential effect of the proposed quarry on the water resources in the vicinity of the property. This report was issued to the City of Hamilton and applicable regulatory agencies to provide them with the opportunity to offer constructive comment on the work that had been undertaken.

Peer review comments were subsequently received from the City of Hamilton's consultants, the Ministry of Municipal Affairs and Housing, the Ministry of the Environment, and the Ministry of Natural Resources on the draft report and an earlier report titled "Preliminary Hydrogeological Assessment, proposed Dolostone Quarry, Township of Flamborough" (Gartner Lee Limited, August 2004). The reviewers focused on the need for additional detail on the geologic and hydrogeologic setting, groundwater and surface water relationships and viability of the proposed mitigation approach, which will involve the recirculation of the extracted groundwater and is referred to as a Groundwater Recirculation System (GRS).

A draft Work Plan that outlines the work that was proposed for the next stage of field investigation was prepared and circulated to the City of Hamilton for review and comment. Copies were also be distributed by the City to its peer reviewers and to the identified agencies, CH, MNR, and MOE. Comments were subsequently received from the City's peer review consultants (Jagger Hims Limited). Recommendations provided in the City's response have been incorporated into this document (Revised Work Plan for Evaluation of the GRS).

This document describes one component of a larger work program, namely the field-testing to be conducted to demonstrate the viability/feasibility of the proposed GRS. The work will involve the performance of a series of short- duration pumping tests.

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The work program described in Section 2 will consist of two related tasks. The initial task (described in Section 2.1) will involve the completion of downhole geophysics and televiewer logging at three existing test wells that have been installed on the property. Dynamic flow profiling and depth specific sampling will follow this downhole logging.

This work is currently being undertaken, as the information collected will be useful in finalizing the scope of work for the second task in the program.

The second task (described in Section 2.2) will involve a pilot-scale investigation of the GRS. This will involve the installation of additional wells, pumping of the wells to simulate the drawdown induced by the development of a quarry on the property and the release of the extracted water to a test length of the GRS, consisting of a recharge trench and open boreholes. The objectives of the work as outlined herein are to:

- collect additional geologic and hydrogeologic data that will aid in the overall characterization of the Amabel Formation with respect to the distribution of the fractures and productive water-bearing zones within this unit and the groundwater/surface water relationship;
- evaluate the validity of the GRS as a measure to mitigate the dewatering-induced drawdown associated with the development of a quarry on the subject property; and,
- assess the impact of simulated quarry drawdown, with and without migration, on a sample of ecological features (seep, ponds and wetlands) that may be affected by changes in shallow groundwater and calibrate wider modeling exercises to assess impacts on ecological features too remote from the test to be directly assessed, such as streamflow and more remote wetlands.

It is intended that this document be submitted to the MOE in support of an application to obtain the necessary Permit to Take Water (PTTW) for the testing program. An implementation schedule for undertaking this work is presented in Section 3.

2. Work Plan

2.1 Characterization of the Amabel Formation

A field program will be undertaken to collect additional information on the Amabel Formation. This Formation is to be quarried and there is an identified need to better characterize the physical and water-bearing properties of the unit. As indicated, the information will be used to finalize the scope of work proposed for evaluating the GRS.

Three bedrock test wells (TW10, TW12 and TW13) were installed in 2004 and tested (Permit to Take Water 0714-65YNCS) to evaluate aquifer properties and the potential effect on adjacent wetlands.

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The test results are presented in a letter report dated March 4, 2005 addressed to Mr. Paul Odom, Director, Section 34, copies of which were provided to the Ministry of the Environment in accordance with Condition 4.7 of the PTTW.

Information on the physical properties of these three test wells is currently limited to driller-generated water well records (WWR). These wells remain accessible and it is proposed that downhole geophysical and televiewer logging be completed for TW10, TW12 and TW13. This work would in turn be followed by a short-term, stepped pumping test during which a dynamic flow profile (spinner log) and a video profile would be produced. The work program will provide useful information on the bedrock lithology, location and attitude of the primary water bearing fractures, and groundwater quality.

The downhole logging to be completed at each of the three wells will consist of:

- Natural gamma;
- Short-long resistivity;
- Single point resistance;
- Hole caliper;
- Fluid conductivity and temperature; and,
- Acoustic televiewer logging.

The logging will be referenced to the top of casing elevations.

The pumping test conducted on each well will involve the use of a submersible pump capable of producing 30 L/s with a total dynamic head of 60 m on 125 mm column pipe. A brief, step test at successively higher rates up to 30 minutes in duration, will be performed at which time dynamic profiling (spinner log) will be conducted. A video profile under pumping conditions will also be generated. A PTTW is not expected to be required on the basis that the volume of water to be taken will be less than 50,000 L/day.

On completion of the above logging, depth specific sampling will be conducted which would involve pumping of the wells and sampling during pumping, using small sampling pumps set at various depths in the well. The samples will be analyzed for general chemistry including, major ions and common trace metals. The chemistry data will be used in predicting the potential effect of the pumping discharge on stream water quality during the proposed GRS testing (Section 2.2).

This information will be processed and a summary log profile will be prepared for each well. The log will present the geology as reported in the WWR, will highlight the locations of major fractures and bedding features and will present the geophysical traces. Captured video images of the major openings will be inserted in the log where applicable for presentation purposes. The information collected would be compiled in figures and tables.

2.2 Assess Viability of the Proposed GRS

2.2.1 Background

Unmitigated dewatering associated with the development of the quarry is predicted to drawdown groundwater levels in the vicinity of the quarry. This will in turn reduce the groundwater flux (baseflow) to the wetlands of the Lower Mountsberg Creek Wetland Complex and could potentially affect local residential wells by reducing the available water column. The water generated during dewatering would need to be discharged to Mountsberg Creek, which could alter the flow and quality of the surface water. In recognition of the potential impacts, it will be necessary to implement measures to maintain the groundwater levels in the vicinity of the quarry and to reduce the volume of water that would be released to Mountsberg Creek.

Our recommendation for mitigating the effects of quarry dewatering would be to release the groundwater and surface water collected within the quarry to a recharge structure installed between the footprint of the quarry area and adjacent wetland features and residential wells. By re-circulating the extracted water, the groundwater level along the perimeter of the quarry (at the point of release) would be maintained. This in turn, would maintain the water level in the adjacent wetland.

This mitigation measure is referred to as a ‘Groundwater Recirculation System’ or GRS. The GRS as initially envisioned would consist of a shallow trench excavated through the overburden to the upper surface of the dolostone. Water collected within the quarry from dewatering would be discharged to the trench where it would infiltrate to sustain the groundwater level between the quarry and the adjacent wetland features and nearby residential water supplies. This mitigation approach employs methods that are commonly applied to induce infiltration for purposes of recharge, maintenance of water levels and for establishing hydraulic barriers to alter groundwater flow patterns [(Huxley *et al.*, 2004)¹ and (Corcoran *et al.*, 2005)²].

The application of this approach for the purposes stated herein, at the Flamborough site, has to date only been evaluated through the application of a computer model. The model predicted that recharge of the water produced from dewatering of the quarry to a trench, in combination with open boreholes extending between the trench and the base of the Amabel Formation, should introduce sufficient water to maintain a suitable hydraulic head in the bedrock thereby sustaining groundwater levels along the perimeter of the quarry excavation. However, in recognition of the limitations of the model application, it was felt that it would be important to test this concept in the field.

¹ *Optimizing the Efficiency of Recharge Factors as a Mechanism for Mitigating the Impacts of Quarry Dewatering.* Huxley *et al.*, March 2004

² *Evaluation of recharge Trench System, North boundary Contaminant Treatment System, Rocky Mountain Arsenal Commerce City Colorado,* Corcoran *et al.*, 2005.

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We propose to evaluate the effectiveness of the GRS by conducting pumping tests to simulate dewatering in proximity to the quarry face, and to construct a segment of the proposed GRS through which the extracted water is introduced. It is intended that the pumping tests be of sufficient duration to provide test results that approach steady-state conditions and are not compromised by precipitation events that may occur during the testing interval.

2.2.2 Testing Approach

As currently envisioned, a series of pumping test will be completed employing three new test wells, which are to be installed [referred to as TW14, TW15 and TW16 in Figure 2 (attached)]. Existing well TW10, located in the general area will be converted into a multi-level monitoring well.

To simulate the drawdown induced along an open quarry face all the three wells will be pumped at a rate that is able to draw the water level at the wells down to the approximate depth of the quarry. The initial pumping test would be conducted with the pumped water being released to Mountsberg Creek. This testing would simulate the effects of the quarry without mitigation and will provide a baseline against which the proposed performance of the GRS will be assessed.

The water level response will be monitored through an extensive network of wells, mini-piezometers and staff gauges. Water samples will be collected from Mountsberg Creek during the testing to evaluate water quality changes due to the release of groundwater to the Creek and water temperature will be monitored.

On completion of the initial test and the evaluation of the results, a trench (about 150 m in length) will be excavated to an average depth of about 1 m into the bedrock at a location about 35 m north of the three test wells that are to be installed. The precise location of the trench will be reviewed and field-checked by a terrestrial ecologist to ensure no detrimental effects from trenching on the adjacent woodlands. This trench would be used as a point of discharge for the extracted groundwater during the second pumping test to be conducted on the three wells. The intent is to simulate the use of a perimeter trench to maintain groundwater levels beyond the quarry face. Figure 2 shows the approximate locations of the wells and the trench along with proposed dimensions between the respective features.

Additional bedrock monitoring wells will be installed, and existing piezometers, staff gauges and flow meters, installed at various locations and varying depths, would be used to monitor the dewatering effects and the ability of the constructed trench to mitigate these effects. Additional tests will be undertaken to examine various mitigation strategies including the addition of open boreholes that extend between the base of the trench and the proposed base of the quarry at about 36 m and the possible induced fracturing of the bedrock.

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2.2.3 General Considerations

The following series of activities will be undertaken:

1. Finalize the selection of a suitable location on the property for conducting the testing. The intent is to locate the pumping wells within the proposed quarry footprint and the mitigation system (recharge trench/open boreholes) along the periphery of the quarry footprint. To minimize the efforts to construct the trench, consideration should be given to locating the trench in an area where the bedrock is relatively close to surface. As it will be desirable to establish the impact on the shallow groundwater flow system and surface water, the test location should be reasonably close to one of the instrumented wetland areas. [Note: Based on a review of available data, it is proposed that the pumping test be positioned north of TW10 with the GRS constructed between this location and the Lower Mountsberg Creek Wetland Complex wetland located to the north. This area is intensively instrumented (Figure 1, attached). It is also noted that, access to the north for the installation of additional observation/monitoring wells is good.]
2. Installation of three additional test wells (TW14, TW15 and TW16) spaced about 60 m apart. Well construction would involve advancing individual boreholes through the overburden about 2 m into the underlying bedrock and setting casing to the top of rock. The borehole would then be advanced with continuous coring to a target depth of about 50 m and subsequently reamed to a diameter of about 300 mm. The core will be placed in core boxes and logged by a geologist.
3. Installation of additional wells for observation/monitoring purposes. These would include five deep boreholes (diameter of 150 mm), labeled MW1 to MW5, to be positioned strategically in relation to the pumping wells and GRS alignment (see Figures 2 and 3). Following Task 4, the open boreholes would be completed as multi-level monitoring wells. The deep boreholes would be advanced in a manner similar to that proposed for the deep test wells (with continuous coring and logging by a geologist). Shallow bedrock wells to depths of about 5 m to 10 m will also be installed at each location.
4. On completion of the test wells (TW 14, TW15 and TW16) and deep boreholes (MW1 through MW5), downhole geophysics and complete flow profiling of selected wells will be undertaken to identify the dominant water-bearing fractures. The geophysics will be completed in the three test wells and boreholes MW3, MW4 and MW5. (Option: Possible collection of groundwater samples for geochemical characterization will be taken at various depths in the wells to establish a profile of groundwater quality.)
5. Following a review of the data collected during Task 4, the 5 deep boreholes will be reconfigured as multi-level monitoring wells. It is currently proposed that piezometers with 2 m to 3 m long screens set be installed in the open boreholes. For purposes of scoping this work, it is assumed

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that monitoring wells would be set at depths of 35 m and 20 m. Bentonite seals will be placed between the screened intervals.

6. The pumping tests are expected to produce a substantial volume of water that will need to be managed. The primary option during the initial pumping test is to release the water to Tributary A of Mountsberg Creek. This would allow for monitoring of water quality and quantity response in the Creek and surrounding wetlands to a range of pumping scenarios from the full discharge of approximately 112 L/s to reduced discharge rates during the GRS testing. The information will be of value in assessing the impacts of any discharge that may be necessary during quarry operations. Figure 1 illustrates the location for the proposed overflow pipe alignment and discharge point to Tributary A of Mountsberg Creek. Discharge from the overflow pipe will be metered to confirm the water recharge/loss by the trench. The discharge point along the Creek will be engineered to minimize erosion. This would involve the placement of plywood sheets and concrete blocks at the point of discharge to disperse the flow over a large vegetated area along the Creek bank.
7. During the GRS testing, water levels in adjacent seeps and pools will be monitored using existing stations equipped pressure transducers/data loggers as well as by visual observations. An understanding of the response or lack thereof, to pumping in these features will be helpful in characterizing the hydrology of the seeps, wetlands and streamflows and in interpreting the results of modeling exercises. Additional monitoring points will be added, if needed. The existing rainfall and atmospheric pressure gauges will be utilized during the testing.
8. The final configuration of the proposed mitigation structure (GRS) will consist of a 150 m long perimeter trench excavated into bedrock with open boreholes advanced from the base of the trench to the proposed base of the quarry. The trench will be excavated at a location north of TW10 (see Figures 1 and 2, attached). The bedrock excavation depth may vary depending on the bedrock topography, however the goal is to excavate a trench with an average depth of 1 m into the bedrock. Figure 4 illustrates the GRS mitigation concept.
9. As currently proposed, the GRS will be constructed in three steps. An open trench will initially be excavated using an excavator and/or dozer to the top of bedrock. The side slopes should be maintained at a safe slope consistent with overburden thickness encountered along the trench alignment. The base of the trench would need to be about 4 m to 5 m wide to accommodate equipment to be used during the next steps Step 10 (to deepen the trench) and Step 11 (to drill open boreholes). To minimize erosion and deposition of the sediment on the bedrock surface, the walls/slope of the trench are to be covered with a geotextile fabric.
10. On completion of the open trench in the overburden, the trench will be extended about 1 m into bedrock. This will likely involve the use of an excavator equipped with a hydraulic hammer to break up the rock, which would subsequently be removed. The intent of this extension of the

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trench is to allow for greater storage capacity and to enhanced contact between discharge water and the bedrock surface to achieve greater recharge to the bedrock groundwater system.

11. The discharge lines from the wells will be directed into the bedrock trench. This will reduce potential problems associated with water losses at the overburden and bedrock contact, erosion of overburden soils along the sidewalls of the excavation and potential clogging of the bedrock from the eroded sidewall.
12. Test 2 will be undertaken once the trench as been completed. The water extracted from the pumping wells is to be discharged directly into the trench. Each discharge line will be branched with one leg conveying water to the trench and the second leg to convey surplus water to the Creek. Each leg would be equipped with a flow meter.
13. Following the second test, open boreholes will be drilled at a 10 m spacing along the axis of the trench to the base of the Amabel Formation at about 36 m below ground surface. The intent of the boreholes is to convey the water to deeper bedrock zones. [Note: If the performance of the system does not meet design objectives, methods to enhance fracturing of the bedrock along the trench will be evaluated. This may include hydraulically induced fracturing of the boreholes or blasting.]
14. Each discharge line from the pumping wells will be metered. Because the extraction rate may exceed the recharge rate, one or more of the discharge lines between the wells and the trench will be branched to allow for release of water to the Creek. The overflow from the GRS trench outlet will also be metered to determine the volume difference between water entering the trench and water exiting the trench through the outflow pipe. The difference between discharge to the trench and the overflow to the Creek will demonstrate the recharge potential of the GRS. The information collected will establish the relationship between pumping volumes, trench length and the recharge/recirculation potential.
15. Temperature gauges will be installed on the discharge lines or within the trench to observe any change in temperature during testing. The Creek will also be instrumented with temperature loggers to monitor thermal effects of the discharge. The pumping and observation wells with transducers/data loggers.
16. Private wells within 1,000 metres of the test site will be identified and the owners will be provided with written notification of the pending testing at least 72 hrs before the testing is undertaken. The notification will: describe the program; provide a schedule; and a 24-hr contact telephone number to report any interference to existing supplies. In addition, a procedure for reporting complaints and protocol for the provision of a temporary water supply to any impacted well users will be established and copies provided to the MOE and the Hamilton Health Unit.

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17. A Category 3 PTTW will be obtained for the tests (see general program outlined below).

2.3 Proposed Pumping Tests

We anticipate that testing would involve the following series of pumping tests.

2.3.1 Pumping Test 1

Stepped Pumping Test: An initial step test will be conducted on each of the three test wells on installation, to establish their capacity to produce water. Each step will be of 30 minutes to 1 hour in duration and will involve pumping each well at an increasingly higher rate with monitoring of adjacent observation wells. Water will be discharged to Tributary A of Mountsberg Creek. The step test data would be reviewed to select pumping equipment prior to proceeding with the next stage of testing. Samples will be collected at appropriate intervals to characterize water quality.

Constant Head Pumping Test: The initial pumping test will be undertaken to assess the un-mitigated impact of the water taking and the effectiveness of the monitoring system in establishing drawdown response. This will provide a baseline against which the GRS testing results will be compared and provide an opportunity to install additional monitoring points if warranted. Because the drawdown induced during this testing is un-mitigated, the response will be indicative of a ‘worst case’ impact and provide useful information on the potential magnitude of the dewatering associated with the quarry development. Any complaints of interference with private well supplies would most likely occur during this initial test.

Based on computer simulation that it will be necessary to pump the three test wells at a combined rate of about 1,500 IGPM (114 L/s) to achieve a head drop at the pumping wells of about 30 m.

As envisioned, pumping of each of three test wells would be initiated in sequence at a constant rate of about 1/3 of the estimated total rate of the taking. In other words, pumping would start at one well initially for a period of 4 hrs followed by a second well for an additional 4 hrs and lastly, the third well for the remainder of the test. All three wells will continue to pump until a steady state condition in the deep bedrock monitoring wells is approached.

The water produced during the test would be discharged to Tributary A of Mountsberg Creek. The groundwater and surface water response to this taking would be monitored. The data would be reviewed to assess potential performance of the pumping system as designed and any interference effects prior to proceeding with the next test stage. Measures to mitigate interference, if necessary, would be implemented.

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2.3.2 Pumping Test 2

Pumping Test 2 would involve the discharge of the extracted water or a portion thereof to the open trench. Basically, the initial test (Test 1) would be repeated with the same volumes generated from the same wells, only with the discharge from the wells released to the trench to simulate the perimeter recharge system. Because recharge will occur under gravity drainage the recharge rate may be lower than the rate at which water is extracted. It may therefore be necessary to direct any overflow to the above-mentioned tributary to balance recharge with the pumping rate.

The second test would initially involve diversion of pumped water from one pumping well to the trench. Based on the response of the aquifer to trench recharge, the second pumping well would be diverted, followed in turn by the third. Every effort will be taken to maintain a constant head during pumping at the approximate base of the Amabel Formation. As such, the pumping rate will likely need to be increased to accommodate the re-circulated water.

Samples would be collected during the testing to monitor changes to water quality over the testing interval. Real time monitoring of temperature would be conducted either in the trench or in the discharge line from the central most test well.

The test duration is planned to be 90-hours but may be extended to 120-hours depending on system response to pumping. Once the testing has been completed, the pumping will stop and recovery will be monitored.

The objective of this pumping test is to demonstrate the GRS capacity to control groundwater levels.

2.3.3 Pumping Test 3

Install Open Boreholes: In preparation for the third pumping test, open boreholes (150 mm diameter) will be installed along the axis of the trench. A separation distance of 10 metres between open boreholes will be deployed at the beginning of this of the test, but may be decreased to 5 m. The boreholes will be advanced with an air track rig or similar equipment to a depth below surface of about 35 m without coring or logging of the boreholes.

Pumping Test: The pumping test will proceed similar to that proposed for the second test with the goal of drawing the water level at the pumping wells to the base of the Amabel Formation. The objective of this test is to determine the influence of open boreholes on groundwater recharge through the trench. Again, the final pumping rate will depend on the volume of re-circulated water that may need to be accommodated. Water levels, inflow, outflow and temperature will be carefully monitored to assess

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potential changes in outflow volume. The second and third test wells will be brought on line in 4-hour sequencing, pending the results of the outflow and resulting infiltration assessment of the trench system.

All three wells will be pumped in unison for a period of 90-hours except under the condition where: a) the recharge at the trench is not able to accommodate the discharge flow necessitating that overflow be direct to the Creek; and, b) the water level response in the adjacent monitoring wells indicated poor recovery. Should the above condition develop, the testing will be terminated early and additional open boreholes will be advanced along the axis of the trench to enhance recharge to the bedrock groundwater system.

2.3.4 Optional Pumping Tests 4 and 5

Once the new open boreholes have been installed, the pumping sequence will be repeated. Should the recharge and water level recovery in the monitoring wells be insufficient, consideration will be given to undertaking hydraulic fracturing or blasting to enhance fractures along the trench alignment. The goal of the blasting is to enhance fracture density that is expected to increase recharge to the bedrock groundwater system.

The pumping sequence will then be repeated.

Reporting: On completion of the testing, a summary report will be prepared that presents and interprets the test results. This report will be included as an appendix to the Level 2 Hydrogeological Report).

3. Project Schedule

An implementation schedule for the work outlined in this Work Plan will be developed following consultation with the City of Hamilton and other interested parties. It is proposed that the work described in Sections 2.1 be initiated as soon as practical.

We propose that the work outlined herein be undertaken as soon as practical. However, it is recognized that no testing can be undertaken until the Ministry of the Environment has issued the appropriate PTTW.

Table 1 is a preliminary schedule designed to accommodate the three proposed pumping tests outlined in Section 2.2. The schedule represents actual days of “active testing” of the GRS and it is anticipated that there will be down time between stages to allow for the review and interpretation of the test data, the recovery of water levels and to set up the equipment for the next test.

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Reporting over this period will include Monthly Progress reports that document the work completed in the previous month. As currently proposed, a draft report will be prepared for delivery within 6 weeks of the completion of the testing program.

4. References

The following documents are provided on the CD that accompanies this Work Plan:

Corcoran, *et al.*, January 2005: Evaluation of Recharge Trench System, North Boundary Contaminant Treatment System, Rocky Mountain Arsenal Commerce City Colorado. ERDC/GSL TR-05-5

Gartner Lee Limited, August 2004: Preliminary Hydrogeological Assessment, proposed Dolostone Quarry, Township of Flamborough.

Huxley, *et al.*, March 2004: Optimizing the Efficiency of Recharge Factors as a Mechanism for Mitigating the Impacts of Quarry Dewatering.

Stantec Consulting Ltd., 2006: PTTW Discharge Water Quality Analysis. Memorandum from Jim Perrone dated September 5, 2006

Stantec Consulting Ltd., 2006: Excerpt from EIS and Level 2 Natural Environment Report; Proposed Mountsberg Quarry. Dated February 24, 2006

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Table 1. Time Schedule for GRS Pilot-Scale Testing

Trench Construction and Well Drilling	
3 to 5 weeks to install the test and monitoring wells and construct the trench	

Pumping Test 1 with Discharge of Flow to Mountsberg Creek	
Step Test	
Day 1	1 hour step-tests for each newly installed test well
Constant Head Pumping Test	
Day 2	8:00 AM Initiate pumping of TW14
	12:00 Initiate pumping of TW15, continued pumping of TW14
	16:00 Initiate pumping of TW16, continued pumping of TW14 & TW15
Day 3 & 4	Continue pumping of all 3 wells discharging flow
Day 5	10:00 AM Shut down all Pumping Wells
	Monitor Recovery

Pumping Test 2 – Discharge to Open Trench	
Day 1	8:00 AM Initiate pumping of TW14 and discharge flow to trench
	12:00 Initiate pumping of TW15, continued pumping of TW14, discharging the combined flow to the trench and any overflow to Mountsberg Creek.
	16:00 Initiate pumping of TW16, continued pumping of TW14 & TW15, discharging the combined flow to the trench and any overflow to Mountsberg Creek.
Days 2, 3 and 4	Continue Pumping of all three wells
Day 5	10:00 AM Shut down Pumping system, Monitor Recovery and Assess performance
	Monitor Recovery

Pumping Test 3 – Conduct Pilot-Scale Testing of Fully Constructed GRS	
Install open boreholes along trench axis.	
1 weeks to install the open boreholes along the axis of trench	
Pumping Test*	
Day 1	8:00 AM Initiate pumping of TW14 and discharge flow to trench
	12:00 Initiate pumping of TW15, continued pumping of TW14, discharging the combined flow to the trench and any overflow to Mountsberg Creek.
	16:00 Initiate pumping of TW16, continued pumping of TW14 & TW15, discharging the combined flow to the trench and any overflow to Mountsberg Creek.
Days 2, 3 and 4*	Continue Pumping of all three wells
Day 5	10:00 AM Shut down Pumping system, Monitor Recovery and Assess performance
	Monitor Recovery

(* NOTE:.) Pumping Test 3 may be terminated early if the recharge is poor and it is determined that additional open boreholes are required.

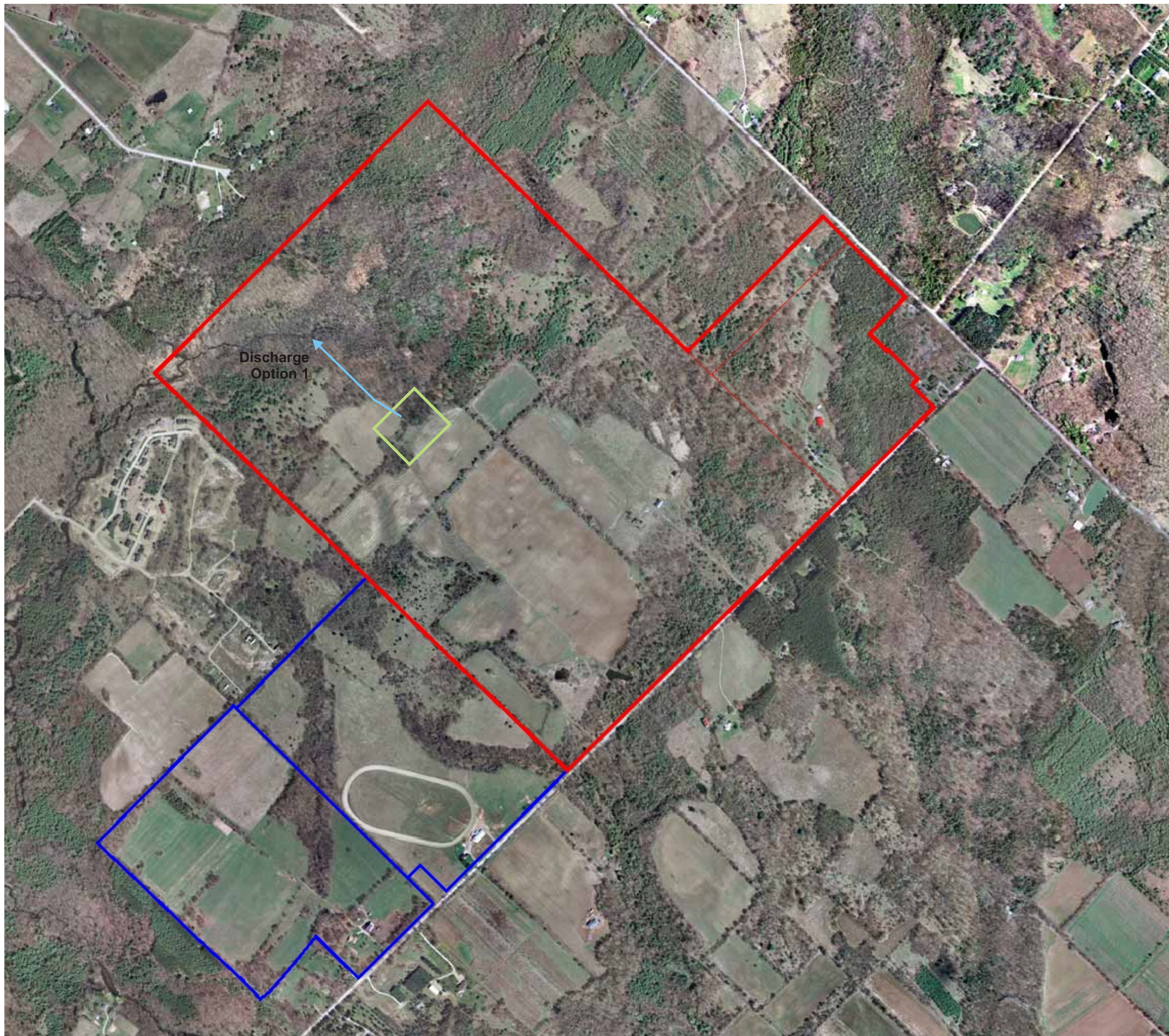
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Table 1 continued. Time Schedule for GRS Pilot-Scale Testing

Optional Pumping Tests		
Install additional open boreholes along trench axis		
1 week to install additional boreholes.		
Pumping Test 4*		
Day 1	8:00 AM	Initiate pumping of TW14 and discharge flow to trench
	12:00	Initiate pumping of TW15, continued pumping of TW14, discharging the combined flow to the trench and any overflow to Mountsberg Creek.
	16:00	Initiate pumping of TW16, continued pumping of TW14 & TW15, discharging the combined flow to the trench and any overflow to Mountsberg Creek.
Days 2, 3 and 4*		Continue Pumping of all three wells
Day 5	10:00 AM	Shut down Pumping system, Monitor Recovery and Assess performance
		Monitor Recovery

(* NOTE:) The pumping test may be terminated early if the recharge is poor even with the additional boreholes and it is necessary to apply blasting to enhance fracturing.

Apply hydraulic fracturing or blasting to enhance fractures and hydraulic connection to bedrock aquifer		
2 to 3 week to undertake hydraulic fracturing or blasting of boreholes.		
Pumping Test 5*		
Day 1	8:00 AM	Initiate pumping of TW14 and discharge flow to trench
	12:00	Initiate pumping of TW15, continued pumping of TW14, discharging the combined flow to the trench and any overflow to Mountsberg Creek.
	16:00	Initiate pumping of TW16, continued pumping of TW14 & TW15, discharging the combined flow to the trench and any overflow to Mountsberg Creek.
Days 2, 3 and 4*		Continue Pumping of all three wells, divert TW14 to Trench
Day 5	10:00 AM	Shut down Pumping system, Monitor Recovery and Assess performance
		Monitor Recovery



LEGEND

 Approximate Location of Groundwater Recharge Trench

 Approximate Location of Discharge System

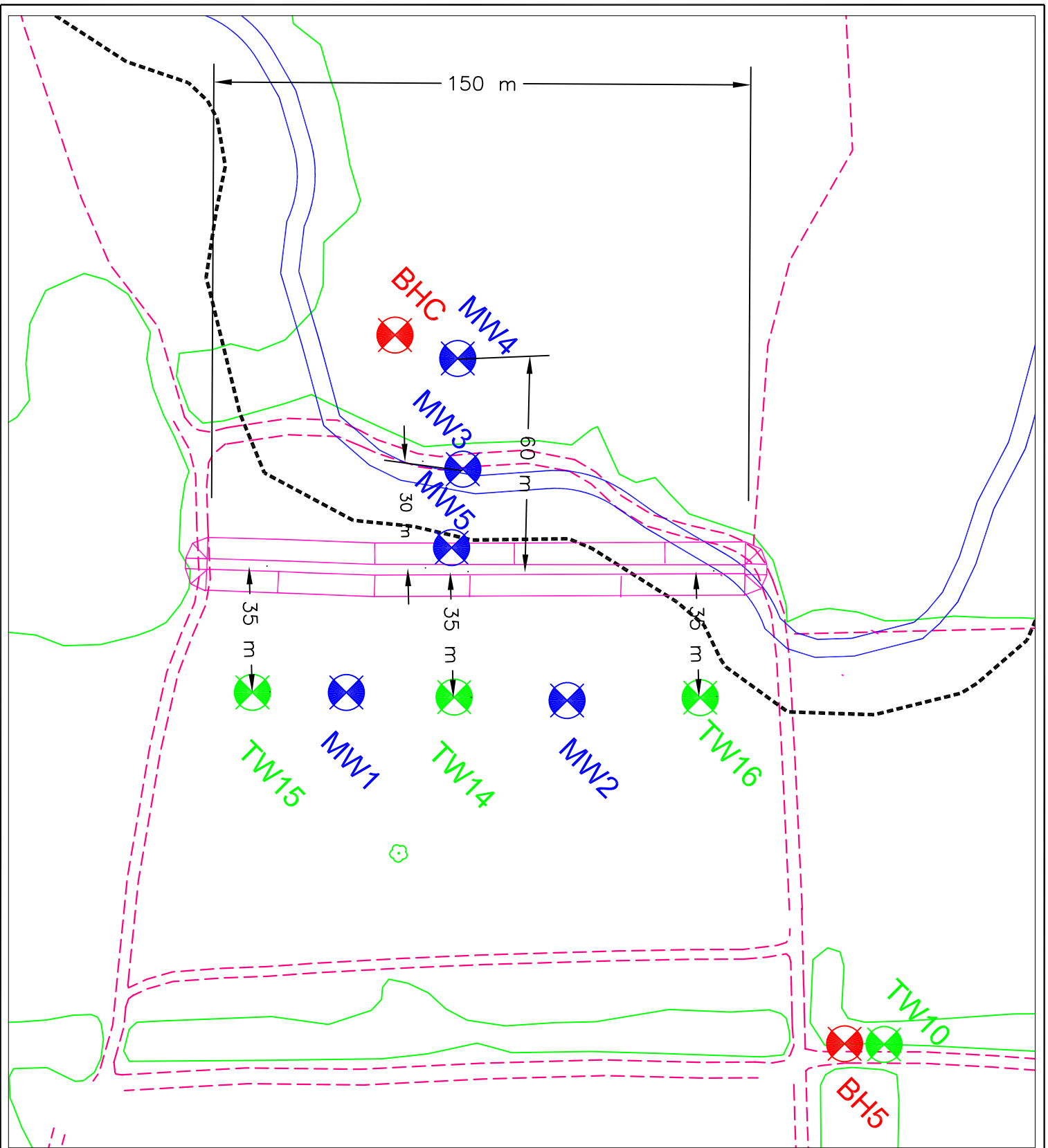
Groundwater Recharge Trench

FIGURE
1

PROPOSED MOUNTSBERG QUARRY

Project 60492 (60492\2006\GRSLocMap.cdr)





Legend

- Proposed Trench Alignment (Long Environmental)
- Wooded Area
- - - Recharge Trench Configuration
- - - Pathways
- - - - - Extraction Limit (Long Environmental)
- ⊗ Existing Well
- ⊗ Test Monitors
- ⊗ Pumping Wells

PROPOSED MOUNTSBERG QUARRY

Figure 2

Recharge Trench Schematic

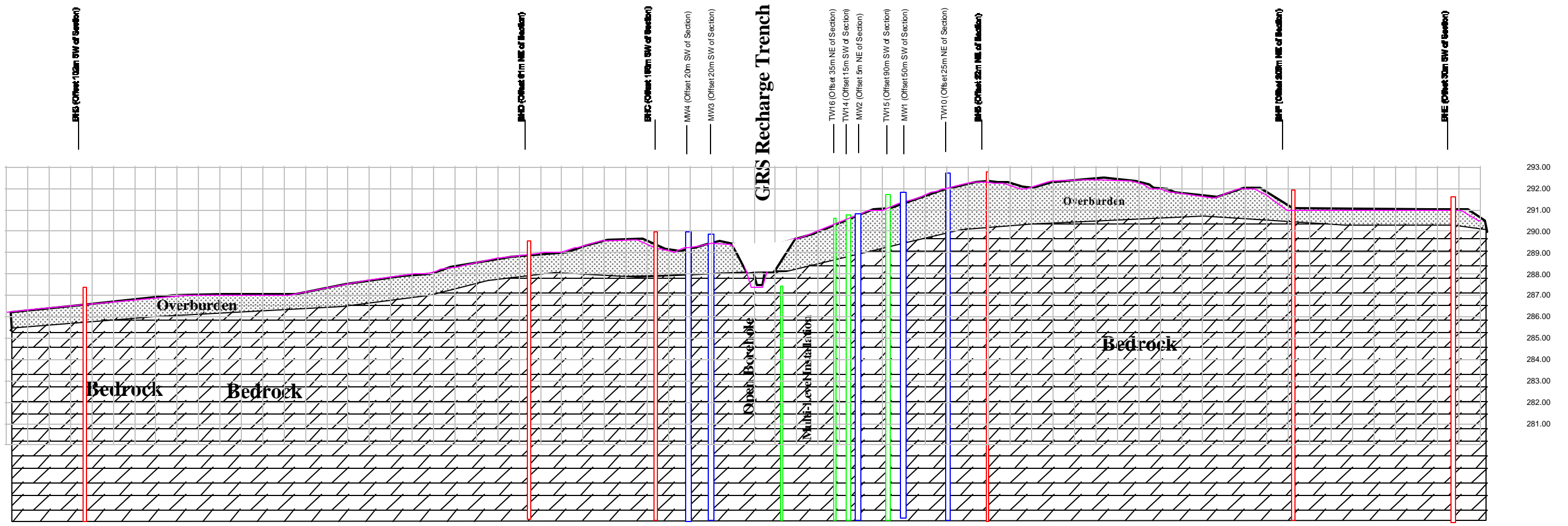
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Gartner Lee

NORTH

SOUTH



MW16 (Offset 100m SW of Section)

MW10 (Offset 25m NE of Section)

MW15 (Offset 20m SW of Section)

MW4 (Offset 20m SW of Section)

MW3 (Offset 20m SW of Section)

MW16 (Offset 100m SW of Section)

MW16 (Offset 35m NE of Section)

MW14 (Offset 15m SW of Section)

MW2 (Offset 5m NE of Section)

MW15 (Offset 90m SW of Section)

MW1 (Offset 50m SW of Section)


MW10 (Offset 25m NE of Section)

MW16 (Offset 20m NE of Section)

MW16 (Offset 20m NE of Section)

MW16 (Offset 20m SW of Section)

293.00
 292.00
 291.00
 290.00
 289.00
 288.00
 287.00
 286.00
 285.00
 284.00
 283.00
 282.00
 281.00

PROPOSED DOLOSTONE QUARRY	Figure 3
Cross-Section Schematic of Proposed Groundwater Recharge Trench	
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 Gartner Lee Limited	
	Scale nts