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Golder Associates

REPORT ON

GROUNDWATER UNDER THE DIRECT INFLUENCE OF SURFACE WATER STUDIES

TOWNSHIP OF NORTH DUNDAS

WINCHESTER WATER SUPPLY WELLS

Submitted to:

The Township of North Dundas
547 St. Lawrence Street
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EXECUTIVE SUMMARY

The following executive summary highlights key points only; for complete information and findings, as well as the limitations provided in Section 8.0, it is necessary for the reader to examine the complete report.

Golder Associates was retained by the Township of North Dundas to conduct *Groundwater Under the Direct Influence of Surface Water* (GUDI) studies for seven municipal wells from which the water supply for the Village of Winchester is derived. Included in this study were bedrock wells 1, 4, 5, and 6 and overburden deposit wells 7a, 7b, and 7c (well field 7).

The purpose of the study was to determine if the wells are under the direct influence, or are potentially under the direct influence of surface water based on the criteria defined in the *Terms of Reference for Hydrogeological Study to Examine Groundwater Sources Potentially Under Direct Influence of Surface Water* outlined by the MOE in October, 2001.

In accordance to the MOE terms of reference wells 1, 4, 7b, and, 7c were deemed to be not under the direct influence of surface water. Wells 5, 6, and 7a were deemed to be potentially under the direct influence of surface water. No immediate bacteriological issues were identified.

It is recommended that a subsequent study be undertaken to determine if the aquifer materials in which wells 5, 6, and 7a are completed are providing effective *in situ* filtration of groundwater. This study would involve determining particle counts for particles in the size range of 10 microns and greater in groundwater derived from these wells. The study should also confirm that particle counts are not likely to change during storm, seasonal, or other environmental changes.

TABLE OF CONTENTS

In Order
Following
Page 26

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was retained by the Township of North Dundas to conduct *Groundwater Under the Direct Influence of Surface Water* (GUDI) studies in accordance with the terms of reference outlined by the Ontario Ministry of the Environment (MOE) for seven municipal wells from which the water supply for the Village of Winchester is derived. Completion of these GUDI studies is in fulfillment of recommendations made in the Engineer's Report for the Winchester STSE completed by Stantec Consulting Ltd. in March, 2001 (Stantec, 2001).

1.1 Background

The Village of Winchester is located approximately 50 km south of the City of Ottawa, within the Township of North Dundas (see Key Plan, Figure 1).

The village derives its water supply from four pumping wells completed in bedrock (wells 1, 4, 5, and 6), and a well field comprised of three pumping wells completed in overburden sediments (wells 7a, 7b, and 7c). The locations of the wells are illustrated on the Site Plan (Figure 2). Wells 4 and 7c are standby wells that are pumped only in cases of emergency or as backup during maintenance of other wells. Each of the bedrock wells and the well field is equipped with its own disinfection system and pumping facility located in a pump house which either contains the well head (wells 1, 4, and 5) or is located near the well heads (well 6 and well field 7). The disinfecting system injects sodium hypochlorite solution into the water. The pumping facilities use either a submersible or turbine pump to deliver water to the Village distribution system.

The Ontario Clean Water Agency (OCWA) is the current operating authority of the Winchester municipal water supply system. Pumping is controlled through a control center at the OCWA office located at 475 Ottawa Street in Winchester.

1.2 Study Objectives

The purpose of the current study was to determine if water supply wells 1, 4, 5, 6, 7a, 7b, and 7c are under the direct influence or are potentially under the direct influence of surface water based on the criteria defined in the *Terms of Reference for Hydrogeological Study to Examine Groundwater Sources Potentially Under Direct Influence of Surface Water* outlined by the MOE in October, 2001 (MOE, 2001b). These criteria are summarized in a flow chart illustrated in Figure 3.

2.0 INVESTIGATION PROCEDURES

For the purpose of characterizing the geological and hydrogeological conditions in the area of Winchester, a review of overburden geology, bedrock geology, drift thickness, and topographic maps, as well as various publications and reports pertaining to the geology and hydrogeology of this area was completed.

For the purpose of characterizing the local geology and hydrogeology in the immediate area of each of the wells, a review of water well records and reports on projects completed in the area of each of the wells by Golder and various other firms was completed. Historical pumping test data were obtained for each of the bedrock wells and the well field. Transmissivities and storage coefficients for the bedrock and overburden aquifers in the area of each of the wells were extracted from this historical data. From this data the hydraulic conductivity of the aquifers was calculated according to equation 1, and the linear velocity of groundwater was calculated according to equation 2.

(1) $T = Kb$

(2) $v = (Ki)/n$

where: T = transmissivity, K = hydraulic conductivity, b = saturated thickness of the aquifer, v= linear velocity, i=hydraulic gradient, n=porosity

Distance-drawdown data obtained from historical pumping tests were used to determine horizontal hydraulic gradients around the wells. These gradients were used to calculate the linear velocity of groundwater under current pumping conditions around each of the wells.

Capture zones for each of the bedrock wells under current pumping conditions were calculated according to equation 3 which describes the edge of a capture zone for a confined aquifer when steady state conditions have been reached (Fetter, 1994).

(3) $x = -y/\tan(2\pi Kbiy/Q)$

where: y = the half width of the capture zone perpendicular to groundwater flow, x = distance to the downgradient edge of the capture zone from the well, Q = pumping rate

Pumping rates, water levels under static and pumping conditions, and ground surface elevations at the locations of the wells were obtained from the Winchester branch of OCWA.

Surface water features around each of the wells were delineated from examination of topographic maps, and on-site inspection of the areas surrounding each of the wells.

Untreated water at each of the wells was sampled and analyzed for campylobacter and aerobic spores, as well as for a suite of parameters typically used to characterize municipal water supplies. A composite sample of untreated water from wells 7a and 7b was analyzed for cryptosporidium and giardia, as these wells obtain their supply from a watertable aquifer.

Daily measurements of turbidity, pH, electrical conductivity, and temperature were taken by OCWA on untreated water samples collected at each of the wells over a two week period from April 15 2002, to April 26, 2002. Daily precipitation data for Russell Ontario, located approximately 20 km north of Winchester collected over the two week sampling period were obtained from the South Nation River Conservation Authority. Daily precipitation data collected from this location from January 2001 to February 2002 was also obtained. Measurements of each of the parameters were plotted for the purpose of visually interpreting if the measured parameters correlate to precipitation events. Such correlations are an indication of surface water influence.

Measurements of turbidity for groundwater samples collected from each of the wells in January and February 2002, as well as concentrations of e.coli, total coliforms, and heterotrophic plate counts measured in raw water collected at each of the wells in 2001 was obtained from OCWA. Turbidity measurements were taken at regular intervals with a turbidity meter connected to a data logger, located at each of the well heads. These data were also plotted together with precipitation data over time for the purpose of interpreting if the measured parameters correlate with precipitation events.

3.0 CONCEPTUAL MODEL OF STUDY AREA

3.1 Geology

3.1.1 Overburden Geology

The surficial geology in the area in which the water supply wells are located consists mainly of glacial deposits and relatively younger Champlain sea sediments that were deposited in the Cenozoic. Isolated areas are overlain with post-Champlain Sea deposits consisting of organic muck and peat (Geological Survey of Canada, 1982). Overburden geology of the study area is illustrated in Figure 2. The three main physiographic regions in the area are: 1) till plains; 2) clay plains; and 3) glaciofluvial outwash deposits. The till and clay plains dominate the study area. The till plains are composed of sandy, and silty compact diamicton consisting dominantly of lodgement till. In areas that lie below approximately 160 m above sea level, the till plains are in places overlain by a discontinuous deposit consisting of gravel, sand, and boulders. A basal gravel till is present at the interface between glacial till and the bedrock surface (Geo-analysis Inc. and J.L. Richards & Associates Ltd., 1992). The clay plains are composed of offshore marine deposits that consist of massive blue-grey clay, silty clay, and silt. They are calcareous and fossiliferous and locally overlain by thin sands. The thickness of the till and clay plains ranges from non existent in small isolated areas to approximately 20 m. These deposits overlie the area in which the bedrock wells are located, as is illustrated in plan view in Figure 4 and in cross section in Figure 5. Glaciofluvial outwash deposits cover isolated locations of the study area. These deposits are comprised of an assortment of sand, gravel, clay, ice-contact stratified drift, and till. The most prominent galcialfluvial outwash feature in the study area is the north-south trending Morewood Esker located between the villages of Morewood and Winchester. It is approximately 7.5 km in length and between 0.1 and 1 km wide. The core of the esker consists of coarse sand and gravel. These coarse grained deposits are exposed laterally along the central portion of the esker. However, the core is flanked by various compositions of finer sands, silts, and clays, and is underlain by glacial till. The thickness of the overburden sediments in the area of the esker ranges from approximately 5 to 20 m. The overburden wells are located within the Morewood Esker as is illustrated in plan view in Figure 6 and in cross section in Figure 7.

3.1.2 Bedrock Geology

The bedrock geology in the area in which the water supply wells are located consists of Lower to Middle Ordovician sedimentary rocks that dip gently eastward along a major synclinal structure (Ministry of Natural Resources, 1985). The oldest unit to outcrop in the area is the Oxford Formation composed of light to dark grey sublithographic to fine crystalline dolostone and commonly contain stromatolites and calcite filled vugs. Overlying the Oxford Formation is the Rockcliffe Formation which consists of interbedded light greenish grey quartz sandstone, and green shale; a basal conglomerate occurs locally within the unit. Interbeds of calcarenite and silty dolostone occur in the upper part of this formation. Overlying the Rockcliffe formation is the Gull River Formation which consists of interbedded silty dolostone, lithographic to fine crystalline limestone, oolitic limestone, shale, and fine grained calcareous quartz sandstone. The area is transected by a series of steeply dipping normal faults and fault zones striking northwest to northeast. Bedding which is close to horizontal often dips steeply adjacent to faults and within fault zones.

3.2 Hydrogeology

3.2.1 Surface Water and Drainage

The topography of the study area is generally flat with elevations ranging from approximately 70 to 80 m above sea level (asl). The study area is located approximately 10 km to the north-west of a long, wide, flat till ridge that extends northeast in the direction of the St. Lawrence River. This ridge is the local topographic high that acts as a divide between surface water flowing towards the north to the Ottawa River, and surface water flowing towards the south to the St. Lawrence River (Charron, 1978). All of the supply wells for Winchester are located within the watershed of the South Nation River which empties into the Ottawa River approximately 50 km to the north. Most of the wells also lie within the basin of the Castor River which flows to the north-east and eventually empties into the South Nation River (Energy, Mines and Resources, 1982). The abundance of low permeability clays and silts in the overburden contributes to ponding of water in areas of topographic lows. Several perenial ponds and wetlands and many ephemeral ponds exist within the study area. Studies in several drainage basins in the area have demonstrated that the surface drainage basin is semi-independent from the underlying bedrock aquifer groundwater drainage basin. The bedrock groundwater drainage basins appear to underlie several surface water divides (Geo-analysis Inc. and J.L. Richards & Associates Ltd., 1992).

3.2.2 Overburden Aquifer

An aquifer is defined as a saturated permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients (Freeze and Cherry, 1979). The overburden sediments of the till and clay plains that overlie most of the study area consist mainly of fine grained sediments that have low values of hydraulic conductivity and therefore can not transmit significant quantities of water. However, the coarse grained glaciofluvial outwash deposits within the Morewood Esker form a locally excellent aquifer. Wells constructed within these deposits have relatively high yields of potable quality.

Coarse grained deposits of the esker are exposed laterally along the center if the esker and are thus considered to be unconfined. The proximity of these sediments to the ground surface makes them potentially susceptible to contamination. The flanks of the esker which are overlain by finer grained silts and clays may be classified as semi-confined. These finer sediments provide a much slower access for surface water infiltration, thus limiting the potential for downward migration of contaminants into the aquifer.

Based on the groundwater elevation data, the general direction of natural groundwater flow within the Morewood Esker is to the north, following the long axis of the esker. However, a component of groundwater flow is in a southerly direction in the south portion of the esker, forming a groundwater divide approximately 500m north of County Road 3. It has been considered that this condition is likely a result of the topographic high that is present in this area. The horizontal hydraulic gradient within the esker has been measured to be 1×10^{-4} (Golder Associates, 1995).

The overburden aquifer of the Morewood Esker will be recharged by infiltrating precipitation on an ongoing basis. The majority of recharge will occur where the coarse granular central core and sandy flanks of the esker are exposed at the surface (Golder Associates, 1995). The permeable material that comprises the core of the esker is underlain by impermeable till and clay. Water infiltrating these permeable deposits comes out as springs at the base of these deposits (Charron, 1978). Wells 7a, 7b, and 7c that comprise well field 7 are completed in the overburden deposits of the Morewood Esker.

3.2.3 Bedrock Aquifers

Groundwater flow in fractured bedrock such as dolostone, limestone, and shales is controlled by and occurs along and through fractures, bedding planes, and contacts between bedrock and surficial deposits. Often the upper sections of bedrock are more weathered and fractured and thus have a higher hydraulic conductivity than the lower, more massive sections.

The two main hydrostratigraphic bedrock units in the area of the site are: 1) the Oxford Formation Aquifer that consists mainly of dolostone; and 2) the Rockcliffe and Gull River Formation Aquifer that consists mainly of limestones and shales (Geo-analysis Inc. and J.L. Richards & Associates Ltd., 1992). Wells constructed in these hydrostratigraphic units have variable yields ranging from poor to fair. In most cases wells can yield sufficient water for individual domestic use. However, dry wells have been reported and high yielding wells are rare (Geo-analysis Inc. and J.L. Richards & Associates Ltd., 1992). The quality of water obtained from these aquifers is generally potable. However, elevated levels of hardness, iron content, mineral content, and sulphide odour have been recorded in water at various locations within these aquifers. Wells constructed in shale bearing bedrock often yield water of poor quality resulting from elevated concentrations of sulphate. In areas where groundwater quality is poor, water quality often deteriorates with depth due to the increased age and elongated flow path of the groundwater, which give rise to increased mineralization of the water. Villages which solely depend on the bedrock aquifers for individual and commercial use are experiencing a progressive increase in mineralization of the water over time, even in high yielding wells (Geo-analysis Inc. and J.L. Richards & Associates Ltd., 1992).

The arial extent of the bedrock aquifers in the study area are largely overlain by several meters of low permeability clays and silts that act as an aquitard by storing water and transmitting it slowly into the aquifer. Thus the bedrock aquifers in the study area are classified as confined/semi-confined. The presence of an aquitard helps to preserve the quality of groundwater in the underlying aquifer by preventing rapid transport of contaminants from the surface into the bedrock.

The potentiometric head in the bedrock aquifers in the study area generally decreases from south-west to north-east, thus groundwater flow is expected to be towards the north-east (Geo-analysis Inc. and J.L. Richards & Associates Ltd., 1992).

Recharge of the bedrock aquifers is expected to occur in locations where the bedrock outcrops, where the overburden is thin, or in areas where relatively permeable sediments are in contact with the bedrock. Some recharge occurs from storage in the overlying aquitard, especially in areas of local topographic lows where depression focused recharge may occur. Recharge zones are expected to be in areas of topographic highs. The till ridge located to the south-east of the study area is considered to be the main recharge zone, and the low lying flat clay plains on which the study area is located are considered to be discharge zones. The presence of bogs and flowing artesian wells in the study area are indicators that the study area is indeed located in a discharge zone.

Municipal wells 1, 4, 5, and 6 are completed in bedrock.

4.0 GUDI STUDIES FOR INDIVIDUAL BEDROCK WELLS

4.1 Well 1

4.1.1 Characterization of Well and Its Hydrogeological Setting

Well 1, constructed in 1958, is located at the south end of St. Lawrence Street (UTM Zone 18, 473009 E, 4992176 N). The elevation of the ground surface at this location is 76.8 m. A major steeply dipping fault is located approximately 300 m east of the well.

The well was originally drilled to a depth of 94.5 m but because water of poor quality (high concentrations of chloride and low concentrations of calcium and magnesium) was encountered below depths of 71.6 m, a packer was set at 58 m (Pitts, 1971). Two water bearing zones, one at 24.3 m and the other at 47.5 m, were reported in the water well record. The water well record indicates that overburden deposits at the well are 8.5 m thick. Included in these overburden deposits is a layer, approximately 1.2 m in thickness, of low permeability fine grained sediments that likely acts as a confining layer, or aquitard to the underlying limestone bedrock aquifer. The water well record for well 1 is included in Appendix A. According to water well records for wells drilled within a 1 km radius of well 1, the thickness of overburden deposits ranges from 0.6 to 15 m with most areas covered in at least 6 m of sediments. The thickness of the confining layer ranges from non existent to approximately 9.1 m. It is at least 3.0 m thick in most areas. Thus the bedrock aquifer in which well 1 is completed is classified as semi-confined.

Well 1 is equipped with a vertical turbine pump located 45.7 m below ground surface. It is currently pumped at a rate of approximately 0.409 m^3/min. According to data collected at the well head from 1999 to 2002, static water levels in the well range from 16 to 25 m below ground surface, and pumping levels in the well range from 31 to 39 m below ground surface.

Transmissivity of the bedrock aquifer in the area of well 1 was reported to be approximately 100 m^2/day. The storage coefficient was estimated to be 6×10^{-6} (Pitts, 1971). Assuming a saturated thickness of 49 m at the time of the pumping test, hydraulic conductivity of the bedrock aquifer was calculated to be 2 m/day. Using these values, and assuming horizontal hydraulic gradients are similar to the topographic gradients in the area, and a porosity of 0.10 for the limestone aquifer, the linear velocity of groundwater within the bedrock aquifer under non-pumping conditions was calculated to be between 0.02 and 0.002 m/day. Thus in 50 days groundwater could travel between 0.1 and 1 m under non-pumping conditions. Horizontal gradients (distance-drawdown data) around the well under pumping conditions could not be found, thus groundwater velocities and 50 day travel distances could not be determined for this well under pumping conditions. Table 2 includes values used to calculate travel times. Under current pumping conditions, the estimated location of the downgradient edge of the capture zone is 1.3 km from the well. The estimated width of the capture zone, perpendicular to groundwater flow is 8 km. Table 1 includes values used to calculate the capture zone.

4.1.2 Description of Local Surface Water Features

Well 1 appears to be located on a surface water divide between water that flows toward the north to the East Castor River and water that flows toward the south to the South Nation River. The most significant surface water body within 500 m of the well is the Cross Summers Drain, a small watercourse located approximately 200 m to the east that empties into the South Nation River. Small and discontinuous ephemeral watercourses, less than 0.30 m deep, located along St. Lawrence Street, and small ephemeral ponds, less than 0.30 m deep, located in various areas around the well were observed during the 2002 spring thaw. It is considered that these water courses are not directly hydraulically connected the bedrock aquifer.

4.1.3 Evaluation of Groundwater Quality and Correlation with Precipitation Events

Campylobacter was not detected in water collected from well 1. The concentration of aerobic spores in water collected from well 1 was measured at 1 CFU per 1000 ml; this is considered to be within the range of typical concentrations for groundwater not affected by a surface water source. Certificates of Analysis are included in Appendix B.

Chemical analysis of untreated groundwater collected from well 1 for a suite of parameters typically used to characterize municipal water supplies show no exceedances of the Maximum Acceptable Concentration (MAC), Interim Maximum Acceptable Concentration (IMAC), or Aesthetic Objectives outlined in the Ontario Drinking Water Standards (ODWS). Concentrations of hardness exceed the ODWS Operational Guidelines. The results of these analysis along with the appropriate ODWS standards/objectives are included in Appendix D. Certificates of analysis are included in Appendix B.

Although precipitation events were infrequent over the two week sampling period, daily measurements of turbidity, pH, electrical conductivity, and temperature had no obvious correlation to these events. Values for daily measurements of these parameters are included in Appendix D.

Cyclic, short-lived increases in turbidity, as high as 4.5 NTU, were observed in well 1 throughout January and February of 2002. These increases are interpreted to be associated with the daily starting up of the pump. With the exception of these cyclic increases, turbidity values are less than 1 NTU. Increases in turbidity do not show correlation with precipitation events. Graphs of turbidity and precipitation versus time are illustrated in Appendix E. Data points for precipitation have been joined for ease in interpretation on these graphs.

E. coli and total coliforms were not detected in any of the groundwater samples collected on a weekly basis in 2001 from well 1. Heterotrophic Plate Counts (HPC) in these groundwater samples range from 0 to 430 counts/ml. Increases in HPC do not show correlation with precipitation events. Graphs of HPC and precipitation versus time are illustrated in Figure 8.

4.1.4 Evaluation: Is Well 1 Under the Direct Influence of Surface Water?

Refer to Figure 3 for a summary of the MOE criteria used to classify wells as: 1) under the direct influence; 2) potentially under the direct influence; or 3) not under the direct influence of surface water. The discussion herein will follow the order of the flow chart of Figure 3.

Physical evidence of surface water contamination was not observed in well 1. Measurements of turbidity were consistently low in water collected from this well. The surface water organism, campylobacter, was not detected in water collected from this well; aerobic spores were present in concentrations that are within the typical range for groundwater not affected by a surface water source. Therefore, according to the MOE terms of reference, well 1 is not classified as being under the direct influence of surface water.

Neither total coliforms nor *E. coli* have been detected in water collected from well 1. The well is located within 500 m of surface water. The bedrock aquifer from which the well is drawing is considered to be semi-confined. Static water levels in well 1 were reported to be below 15 m from ground surface. The well is not part of an enhanced recharge/infiltration project. Observation of changes in surface water levels or hydraulic gradients beside surface water bodies was not performed as part of the current study. However, it should be noted that surface water bodies near well 1 are likely underlain by fine grained sediments that act as a confining layer to the underlying bedrock aquifer. This confining layer is expected to prevent a hydraulic connection between surface water and the bedrock aquifer. Water quality parameters including turbidity, electrical conductivity, pH, and temperature do not appear to fluctuate significantly and rapidly in response to climatological conditions. In conclusion to these statements, in accordance with the MOE terms of reference well 1 is classified as being not under the direct influence of surface water.

4.2 Well 4

4.2.1 Characterization of Well and Its Hydrogeological Setting

Well 4, constructed in 1972, is located approximately 350 m west of the Village of Winchester limit on Main Street (UTM Zone 18, 471261 E, 4992678 N). The elevation of the floor of the well house within which the well head is located is 74.8 m.

The well was drilled to a depth of 28.0 m. A water bearing zone located at a depth of between 21.3 to 23.2 m was reported in the water well record. The water well record indicates that overburden deposits at the well are 6.70 metres thick. These deposits consist of till that likely acts as a confining layer, or aquitard to the underlying limestone bedrock aquifer. The water well record is included in Appendix A. According to water well records for wells drilled within a 1 km radius of well 4, the thickness of overburden deposits ranges from non existent to 17 m with most areas covered in at least 5 m of sediments. The nearest bedrock outcrop is located approximately 600 m east of the well. The thickness of the confining layer ranges from non existent to approximately 12 m. It is at least 3 m thick in most areas. Thus the bedrock aquifer in which well 4 is completed is classified as semi-confined.

Well 4 is equipped with a submersible pump. It is a standby well that is pumped only in cases of emergency. When used, it is pumped at a rate of approximately 0.09 m^3/min. The static water level was approximately 7.68 m below the ground surface on April 24, 2002.

Based on a 72 hour pump test performed by Norman H. Ursel Associates Ltd. in 1972, transmissivity of the bedrock aquifer in the area of Well 4 was estimated to be 76 m^2/day. The storage coefficient was not calculated. Assuming a saturated thickness of 22 m at the time of the pumping test, and a porosity of 0.10 for the limestone aquifer, hydraulic conductivity was calculated to be 3.45 m/day. Using these values, and assuming horizontal hydraulic gradients are similar to the topographic gradients in the area, the linear velocity of groundwater within the bedrock aquifer under non-pumping conditions was calculated to be approximately 3.4×10^{-3} m/day. Thus in 50 days groundwater can travel approximately 0.2 m under non-pumping conditions. Using distance-drawdown data from the pumping test, horizontal gradients around the well under pumping conditions were calculated to be about 0.02. Thus the linear velocity of groundwater within the bedrock aquifer under pumping conditions was calculated to be 0.7 m/day. Hence in 50 days groundwater can travel an estimated 35 m under pumping conditions. Actual pumping rates of the well are less than the pumping rate of 0.36 m^3/min that was employed during the pumping test so this estimate for 50 day travel time is considered to be conservative. Table 2 includes values used to calculate travel times. Under current pumping conditions, the estimated location of the downgradient edge of the capture zone is 300 m from the well. The estimated width of the capture zone, perpendicular to groundwater flow is 2 km. Table 1 contains values used to calculate the capture zone. Well 4 has a noticeable hydraulic connection to well 5 located 747 m from it; lowering of water levels in well 4 correspond to the pumping of well 5.

4.2.2 Description of Local Surface Water Features

Well 4 appears to be located on a surface water divide between water that flows toward the north to the East Castor River and water that flows toward the south to the South Nation River. There are no significant surface water bodies located within 500 m of the well. An ephemeral pond, approximately 25 m in diameter and less than 0.30 m deep was located approximately 100 m to the south of the well during the 2002 spring thaw. Other smaller ephemeral ponds, as well as an ephemeral and discontinuous watercourse located along Main Street were also observed during the 2002 spring thaw.

4.2.3 Evaluation of Groundwater Quality and Correlation with Precipitation Events

Campylobacter was not detected in water collected from well 4. The concentration of aerobic spores in water collected from well 1 was measured at 4 CFU per 1000 ml; this is considered to be within the range of typical concentrations for groundwater not affected by a surface water source. Certificates of Analysis are included in Appendix B.

Chemical analysis of untreated groundwater collected from well 4 for a suite of parameters typically used to characterize municipal water supplies show no exceedances of the MAC, IMAC, or Aesthetic Objectives outlined in the ODWS. Concentrations of hardness exceed the ODWS Operational Guidelines. The results of these analysis along with the appropriate ODWS standards/objectives are included in Appendix C. Certificates of Analysis are included in Appendix B.

Although precipitation events were infrequent over the two week sampling period, daily measurements of turbidity, pH, electrical conductivity, and temperature had no obvious correlation to these events. Daily measurements of these parameters are included in Appendix D.

Turbidity was not measured in well 4 during the months of January and February in 2002.

In 2001 analysis of *E. coli* , total coliforms, and HPC were not performed on groundwater derived from well 4.

4.2.4 Evaluation: Is Well 4 Under the Direct Influence of Surface Water?

Refer to Figure 2 for a summary of the MOE criteria used to classify wells as: 1) under the direct influence; 2) potentially under the direct influence; or 3) not under the direct influence of surface water. The discussion herein will follow the order of the flow chart of Figure 3.

Physical evidence of surface water contamination was not observed in well 4. Measurements of turbidity were consistently low in water collected from this well. The surface water organism, campylobacter, was not detected in water collected from well 4; aerobic spores were present in concentrations that are within the typical range for groundwater not affected by a surface water source. Therefore, according to the MOE terms of reference, well 4 is not classified as being under the direct influence of surface water.

Analysis of water collected from well 4 for total coliforms and *E. coli* has not been regularly performed. Well 4 is located within 500 m of surface water. The bedrock aquifer from which the well is drawing is considered to be semi-confined. Static water levels in well 4 were reported to be less than 15 m below ground surface, however the water bearing zone is at a depth of 22 metres, which is greater than 15 metres below ground surface. The well is not part of an enhanced recharge/infiltration project. Observation of changes in surface water levels or hydraulic gradients beside surface water bodies was not performed as part of the current study. However, it should be noted that surface water bodies near well 4 are likely underlain by fine grained sediments that act as a confining layer to the underlying bedrock aquifer. This confining layer is expected to prevent hydraulic connection between surface water and the bedrock aquifer. Water quality parameters including turbidity, electrical conductivity, pH, and temperature do not appear to fluctuate significantly and rapidly in response to climatological conditions. In conclusion to these statements, in accordance with the MOE terms of reference well 4 is classified as not under the direct influence of surface water.

4.3 Well 5

4.3.1 Characterization of Well and Its Hydrogeological Setting

Well 5, constructed in 1972, is located west of the Village of Winchester, along Highway 31 (UTM Zone 18, 470455 E, 4993002 N). The elevation of the floor of the well house within which the well head is located is 74.83 m.

The well was drilled to a depth of 28 m. Three water bearing zones located at depths of between 14 to 16, 19.5 to 22.9, and 24.3 to 28 m were reported in the water well record. The water well record indicates that overburden deposits at the well are 4.3 m thick. These deposits include a layer of fine grained sediments, approximately 1.8 m in thickness, that likely acts as a confining layer, or aquitard to the underlying limestone and dolomite bedrock aquifer. The water well record for well 5 is included in Appendix A. According to water well records for wells drilled within a 1 km radius of well 5, the thickness of the overburden deposits ranges from non existent to 12 m with most areas covered in at least 3 m of sediments. The nearest bedrock outcrop is located approximately 500 m south of the well. The thickness of the confining layer ranges from non existent to approximately 12 m. It is at least 3 m thick in most areas. The bedrock aquifer in which wells 5 is completed is therefore classified as semi-confined.

Well 5 is equipped with a submersible pump located at a depth of 20 m below ground surface. It is currently pumped at a rate of 0.295 m^3/min. According to data collected at the well head from 1999 to 2002, the static water levels range from 0 to 7.3 ft below ground surface and pumping levels range from 11 to 17 m below ground surface.

Based on a 52 hour pump test performed by Norman H. Ursel Associates Ltd. in 1972, transmissivity of the bedrock aquifer in the area of Well 5 was estimated to be approximately 114 m^2/day. The storage coefficient was not calculated. Assuming a saturated thickness of 24 m at the time of the pumping test, hydraulic conductivity was calculated to be 4.75 m/day. Using these values, and assuming horizontal hydraulic gradients are similar to topographic gradients in the area, and a porosity of 0.1 for the limestone aquifer, the linear velocity of groundwater within the bedrock aquifer under non-pumping conditions was calculated to be approximately 4.75×10^{-3} m/day. Thus in 50 days groundwater could travel approximately 0.24 m under non-pumping conditions. Using distance-drawdown data for the pumping test, horizontal gradients around the well under pumping conditions were calculated to be about 0.01. Thus the linear velocity of groundwater within the bedrock aquifer under pumping conditions was calculated to be 0.4 m/day. Hence in 50 days groundwater can travel an estimated 21 m under pumping conditions. Actual pumping rates of the well are less than the pumping rate of 0.45 m^3/min that was employed during the pumping test, so this estimate for 50 day travel time is considered to be conservative. Table 2 includes values used to calculate travel times. Under current pumping conditions, the estimated location of the downgradient edge of the capture zone is 650 m from the well. The estimated width of the capture zone, perpendicular to groundwater flow is 4 km. Table 1 contains the values used to calculate the capture zone.

4.3.2 Description of Local Surface Water Features

Well 5 is located in the watershed of the Annable Drain, a tributary of the East Castor River. The most significant bodies of water located within 500 m of the well are: 1) the Annable Drain, a small watercourse located approximately 300 m north of the well; and 2) a wetland approximately 300 m in diameter, located about 500 m north-west of the well. Small ephemeral ponds as well as an ephemeral and discontinuous watercourse located along Highway 31 were observed within 500 m of the well during the 2002 spring thaw.

4.3.3 Evaluation of Groundwater Quality and Correlation with Precipitation Events

Campylobacter was not detected in water collected from well 5. The concentration of aerobic spores in water collected from well 5 was measured at 15 CFU per 1000 ml; this is considered to be within the range of concentrations for groundwater not affected by surface water. Certificates of Analysis are included in Appendix B.

Chemical analysis of untreated groundwater collected from well 5 for a suite of parameters typically used to characterize municipal water supplies show no exceedances of the MAC, IMAC, or Aesthetic Objectives outlined in the ODWS. Concentrations of hardness exceed the ODWS Operational Guidelines. The results of these analysis along with the appropriate ODWS standards/objectives are included in Appendix C. Certificates of analysis are included in Appendix B.

Although precipitation events were infrequent over the two week sampling period, daily measurements of turbidity, pH, electrical conductivity, and temperature had no obvious correlation to these events. Daily measurements of these parameters are included in Appendix D.

Cyclic, short-lived increases in turbidity, as high as 4.8 NTU, were observed in well 5 throughout January and February of 2002. However, these increases are interpreted to be associated with the daily starting up of the pump. With the exception of these cyclic increases, turbidity values are less than 1. Increases in turbidity do not appear to be correlated to precipitation events. Graphs of turbidity and precipitation versus time are illustrated in Appendix E.

E. coli and total coliforms were not detected in any of the groundwater samples collected sporadically throughout 2002 from well 5. Heterotrophic Plate Counts (HPC) in these groundwater samples range from 0 to 120 counts/ml. Increases in HPC do not appear to be correlated to precipitation events. Graphs of HPC and precipitation versus time are illustrated in Figure 8.

4.3.4 Evaluation: Is Well 5 Under the Direct Influence of Surface Water?

Refer to Figure 2 for a summary of the MOE criteria used to classify wells as: 1) under the direct influence; 2) potentially under the direct influence; or 3) not under the direct influence of surface water. The discussion herein will follow the order of the flow chart of Figure 3.

Physical evidence of surface water contamination was not observed in well 5. Measurements of turbidity were consistently low in water collected from this well. The surface water organism, campylobacter, was not detected in water collected from well 5; aerobic spores were present in concentrations that are within the typical range for groundwater. Therefore, according to the MOE terms of reference, well 5 is not classified as being under the direct influence of surface water.

Neither total coliforms nor *E. coli* have been detected in water collected from well 5. Well 5 is located within 500 m of surface water. The bedrock aquifer from which the well is drawing is considered to be semi-confined. One of the water bearing zones in well 5 was reported to be less than 15 m below ground surface. The well is not part of an enhanced recharge/infiltration project. Observation of changes in surface water levels or hydraulic gradients beside surface water bodies was not performed as part of the current study. However, it should be noted that surface water bodies near well 5 are likely underlain by fine grained sediments that act as a confining layer to the underlying bedrock aquifer. This confining layer is expected to prevent hydraulic connection between surface water and the bedrock aquifer. Water quality parameters including turbidity, electrical conductivity, pH, and temperature do not appear to fluctuate significantly and rapidly in response to climatological conditions. In conclusion to these statements, in accordance with the MOE terms of reference well 5 is classified as being potentially under the direct influence of surface water due to the fact that it is located within 500 metres of surface water and is drawing water from formations that are less than 15 metres below ground surface.

4.4 Well 6

4.4.1 Characterization of Well and Its Hydrogeological Setting

Well 6, constructed in 1982, is located west of the Village of Winchester, (UTM Zone 18, 467341 E, 4992352 N). The elevation of the ground in the location of the well is 79 m.

The well was drilled to a depth of 15.8 m. One water-bearing zone located at a depth of between 12 and 15.2 m was reported in the water well record. The water well record indicates that overburden deposits at the well are 6.7 m thick. These deposits include a layer of fine grained sediments, approximately 4.8 m in thickness, that likely acts as a confining layer, or aquitard to the underlying limestone bedrock aquifer. The water well record is included in Appendix A. According to water well records for wells drilled within a 1 km radius of well 6, the thickness of overburden deposits ranges from 2 to 15 m with most areas covered in at least 6 m of sediments. The thickness of the confining layer ranges from non existent to approximately 9 m. It is at least 3 m thick in most areas. The bedrock aquifer in which wells 6 is completed can therefore be classified as semi-confined.

Well 6 is equipped with a submersible pump. It is currently pumped at a rate of 0.3 m^3/min. According to data collected at the well head from 1999 to 2002, the static water levels range from 3 to 5 m below ground surface, and pumping levels range from 5 to 10 m below ground surface.

Based on a 72 hour pump test performed by Morrison Beatty Ltd. in 1986, transmissivity of the bedrock aquifer in the area of well 6 was estimated to be 208 m^2/day. The storage coefficient was estimated to be 1.9×10^{-4}. Assuming a saturated thickness of 9 m at the time of the pumping test, hydraulic conductivity was calculated to be 23 m/day. Using these values, and assuming horizontal hydraulic gradients are similar to the topographic gradients in the area, and a porosity of 0.10 for the limestone aquifer, the linear velocity of groundwater within the bedrock aquifer under non-pumping conditions was calculated to be approximately 0.023 m/day. Thus in 50 days groundwater could travel approximately 1.15 m under non-pumping conditions. Using distance-drawdown data for the pumping test, horizontal gradients around the well under pumping conditions were calculated to be about 4.2×10^{-3}. Thus the linear velocity of groundwater within the bedrock aquifer under pumping conditions was calculated to be 0.97 m/day. Hence in 50 days groundwater can travel an estimated 48 m under pumping conditions. Actual pumping rates of the well are less than the pumping rate of 0.6 m^3/min that was employed during the pumping test so this estimate for 50 day travel time is considered to be conservative. Table 2 includes values used to calculate travel times. Under current pumping conditions, the estimated location of the downgradient edge of the capture zone is 500 m from the well. The estimated width of the capture zone, perpendicular to groundwater flow is 3 km. Table 1 includes values used to calculate the capture zone.

4.4.2 Description of Local Surface Water Features

Well 6 is located in the watershed of the East Castor River. The most significant bodies of water located within 500 m of the well are: 1) a small watercourse located approximately 200 m east of the well; and 2) man-made irrigation ponds located approximately 450 m west of the well.

4.4.3 Evaluation of Groundwater Quality and Correlation with Precipitation Events

Campylobacter was not detected in water collected from well 6. The concentration of aerobic spores in water collected from well 6 was measured at 7 CFU per 1000 ml; this is considered to be within the range of concentrations for groundwater not affected by surface water. Certificates of Analysis are included in Appendix B.

Chemical analysis of untreated groundwater collected from well 6 for a suite of parameters typically used to characterize municipal water supplies show no exceedances of the MAC, IMAC, or Aesthetic Objectives outlined in the ODWS. Concentrations of hardness exceed the ODWS Operational Guidelines. The results of these analysis along with the appropriate ODWS standards/objectives are included in Appendix C. Certificates of analysis are included in Appendix B.

Although precipitation events were infrequent over the two week sampling period, daily measurements of turbidity, pH, electrical conductivity, and temperature had no obvious correlation to these events. Daily measurements of these parameters are included in Appendix D.

Cyclic, short-lived increases in turbidity, as high as 4.8 NTU, were observed in well 6 throughout January and February of 2002. However, these increases are interpreted to be associated with the daily starting up of the pump. With the exception of these cyclic increases, turbidity values are less than 1. Increases in turbidity do not appear to be correlated to precipitation events. Graphs of turbidity and precipitation over time are illustrated in Appendix E.

E. coli and total coliforms were not detected in any of the groundwater samples collected from well 6 on a weekly basis throughout 2002. Heterotrophic Plate Counts (HPC) in these groundwater samples range from 0 to 624 counts/ml. Increases in HPC do not appear to be correlated to precipitation events. Graphs of HPC and precipitation over time are illustrated in Figure 8.

4.4.4 Evaluation: Is Well 6 Under the Direct Influence of Surface Water?

Refer to Figure 2 for a summary of the MOE criteria used to classify wells as: 1) under the direct influence; 2) potentially under the direct influence; or 3) not under the direct influence of surface water.

Physical evidence of surface water contamination was not observed in well 6. Measurements of turbidity were consistently low in water collected from this well. The surface water organism, campylobacter, was not detected in water collected from well 6; aerobic spores were present in concentrations that are within the range for groundwater not affected by surface water. Therefore, according to the MOE terms of reference, well 6 is not classified as being under the direct influence of surface water.

Neither total coliforms nor *E. coli* have been detected in water collected from well 6. The well is located within 500 m of surface water. The bedrock aquifer from which the well is drawing is considered to be semi-confined. Water Bearing Zones in well 6 were reported to be less than 15 m below ground surface. The well is not part of an enhanced recharge/infiltration project. Observation of changes in surface water levels or hydraulic gradients beside surface water bodies was not performed as part of the current study. However, it should be noted that surface water bodies near well 6 are likely underlain by fine grained sediments that act as a confining layer to the underlying bedrock aquifer. This confining layer is expected to prevent hydraulic connection between surface water and the bedrock aquifer. Water quality parameters including turbidity, electrical conductivity, pH, and temperature do not appear to fluctuate significantly and rapidly in response to climatological conditions. In conclusion to these statements, in accordance with the MOE terms of reference well 6 is classified as being potentially under the direct influence of surface water, due to the fact that it is located within 500 metres of surface water and is drawing water from formations that are less than 15 metres below the ground surface.

5.0 GUDI STUDIES FOR OVERBURDEN WELLS

5.1 Characterization of Well Field and Its Hydrogeological Setting

Wells 7a, 7b, and 7c are located within a 25 m radius and comprise well field 7. The well field is located north-east of the Village of Winchester within the Morewood Esker (UTM Zone 18, 476879 E, 5000464 N). The elevation of the ground surface is 75.5 m at well 7a and 79.9 m at wells 7b and 7c.

Wells 7a, 7b, and 7c were completed in the permeable sediments of the esker with screens of approximately 4 m in length. They extend to the underlying till encountered at depths of 10, 14.5, and 15 m respectively. Water well records for the wells are included in Appendix A. No fine grained/low permeability sediments overly the esker in the location of the wells, thus the overburden aquifer is classified as unconfined.

Each of the wells is completed with a submersible pump. Wells 7a and 7b are currently being pumped at a combined rate of 1.3 m^3/min. Well 7c is a standby well that is only pumped in cases of emergency. According to data collected at the well heads from 1998 to 2001, static water levels range from 3.7 to 4.6 m below ground surface in 7a, and 3.5 to 5.8 m below ground surface in 7b. Water levels during pumping range from 3.8 to 5.8 below ground surface in 7a and 4.1 to 6.2 m below ground surface in 7b.

Based on a 30 day pump test performed by Golder in 1995 at well 7a, transmissivity of the overburden aquifer was estimated to be 1100 m^2/day. The storage coefficient was estimated to be between 0.02 to 0.32. A saturated thickness of 9 m was reported at the time of the pump test. Using these values, the hydraulic conductivity was calculated to be 122 m/day. Using the value of $1x10^{-4}$ for horizontal hydraulic gradient reported by Golder (001-2798), and assuming a porosity of 0.25 for the overburden aquifer, the linear velocity of groundwater within the overburden aquifer under non-pumping conditions was calculated to be 0.048 m/day. Thus in 50 days groundwater can travel approximately 2.4 m under non-pumping conditions. Using distance drawdown data from the pumping test, horizontal hydraulic gradients in the well under pumping conditions were calculated to be $8x10^{-4}$. Thus linear velocity of groundwater within the aquifer under pumping conditions was calculated to be 0.390 m/day. Hence in 50 days groundwater can travel an estimated 19.5 m under pumping conditions. Actual pumping rates at the well field are less than the pumping rate of 1.5 m^3/min that was employed during the pumping test so this estimate for travel time is considered to be conservative. During the pumping test drawdowns in excess of 1 m were limited to a zone of about 130 m of the test well. The point of zero drawdown was estimated to be located at a distance of 3500 m from the test well. Table 2 includes values used to calculate travel times.

5.2 Description of Local Surface Water Features

Well field 7 is located in the watershed of the East Castor River. The most significant bodies of water located within 100 m of the well field are small, manmade ponds derived from the excavation activities that have taken/are taking place on the esker. The nearest of these ponds is located approximately 100 m to the south of well 7a and approximately 180 m to the south of wells 7b and 7c.

5.3 Evaluation of Groundwater Quality and Correlation with Precipitation Events

Campylobacter, cryptosporidium, and giardia were not detected in the composite water sample collected from wells 7a and 7b. The concentrations of aerobic spores in water collected from the overburden wells were measured at 17, 11, and 34 CFU per 1000 ml for wells 7a, 7b, and 7c respectively. These are considered to be within the range of concentrations for groundwater not affected by surface water. Certificates of Analysis are included in Appendix B.

Chemical analysis of untreated groundwater collected from wells 7a, 7b and 7C was carried out for a suite of parameters typically used to characterize municipal water supplies. Results for wells 7a and 7b show no exceedances of the MAC, IMAC, or Aesthetic Objectives outlined in the ODWS. Concentrations of hardness exceed the ODWS Operational Guidelines for results 7a and 7b. Analysis of untreated water collected from 7c exceeded the ODWS Aesthetic Objective for manganese and the MAC for turbidity as outlined in the ODWS. These exceedances may be the result of inadequate development of the well, which is normally off-line, prior to sampling. The results of these analysis along with the appropriate ODWS standards/objectives are included in Appendix C. Certificates of analysis are included in Appendix B.

Although precipitation events were infrequent over the two week sampling period, daily measurements of turbidity, pH, electrical conductivity, and temperature had no obvious correlation to these events. Daily measurements of these parameters are included in Appendix D.

Cyclic, short-lived increases in turbidity, as high as 5.8 NTU, were observed in composite samples of water collected from wells 7a and 7b throughout January and February of 2002. These increases are interpreted to be associated with the daily starting up of the pump. Graphs of turbidity and precipitation over time that illustrate these trends are included in Appendix E. Turbidity was not measured in well 7c during January and February of 2002.

E. coli and total coliforms were not detected in any of the groundwater samples collected on a weekly bases in 2002 from wells 7a and 7b, or in the one sample collected from well 7c. Heterotrophic Plate Counts (HPC) in these groundwater samples range from 0 to 404 counts/ml for samples collected from well 7a and 0 to 1000 counts/ml for samples collected in 7b. No HPCs were detected in the sample collected from 7c. Increases in HPC do not appear to be correlated to precipitation events. Graphs of HPC and precipitation versus time are illustrated in Figure 8.

5.4 Evaluation: Is Well Field 7 Under the Direct Influence of Surface Water?

Refer to Figure 3 for a summary of the MOE criteria used to classify wells as: 1) under the direct influence; 2) potentially under the direct influence; or 3) not under the direct influence of surface water. The flow chart of Figure 3 is followed in the evaluation provided in subsequent paragraphs.

Physical evidence of surface water contamination was not observed in well 6. Measurements of turbidity were consistency low in water collected from this well. The surface water organisms campylobacter, cryptosporidium, and giardia were not detected in water collected from the overburden wells; aerobic spores were present in concentrations that are within the typical range for groundwater not affected by surface water. In conclusion to these statements, according to the MOE terms of reference, the overburden wells are classified as not being under the direct influence of surface water.

Neither total coliforms nor *E. coli* have been detected in water collected from the overburden wells. The well 7a is located within 100 m of surface water. Well 7b and 7c are located beyond 100 metres of surface water. They are drawing from an unconfined aquifer. Static water levels in the wells were reported to be less than 15 m below ground surface. The wells are not part of an enhanced recharge/infiltration project. Observation of changes in surface water levels or hydraulic gradients beside surface water bodies was not performed as part of the current study. Water quality parameters including turbidity, electrical conductivity, pH, and temperature do not appear to fluctuate significantly and rapidly in response to climatological conditions. In conclusion to these statements, in accordance with the MOE terms of reference the overburden well 7a is classified as being potentially under the direct influence of surface water. Overburden wells 7b and 7c are classified as not being under direct influence of surface water.

6.0 ASSESSMENT OF THE PHYSICAL CONDITION OF ON-SITE WELLS

Refer to the Engineer's Report completed by Stantec in March, 2001.

7.0 CONCLUSIONS AND RECOMMENDATIONS

In accordance to the MOE terms of reference bedrock wells 1 and 4 and overburden wells 7b and 7c are classified as being not under the direct influence of surface water. Bedrock wells 5 and 6 and overburden well 7a are classified as being potentially under the direct influence of surface water. However, with respect to the latter bedrock wells, the presence of thick overburden deposits, including a confining layer consisting of fine grained sediments in the areas surrounding these wells likely prevents the direct infiltration of surface water into the underlying bedrock aquifer in which these wells are completed. No bacteriological issues were apparent during this review. It therefore seems unlikely that these wells are under the direct influence of surface water.

It is recommended that a subsequent study be undertaken at wells 5, 6 and 7a to determine if the aquifers are providing effective *in situ* filtration of groundwater. This study would involve determining particle counts for particles in the size range of 10 microns and greater in groundwater derived from these wells. Water that consistently contains significantly less than 100 particles per millilitre is considered to be effectively filtered. The study should also confirm that particle counts are not likely to change during storm, seasonal, or other environmental changes. The time frame of the current study as well as the limited resources that were available in terms of particle counters during the current study did not allow for the counting of particles to be performed within the scope of this work. No bacteriological issues were apparent during this review, however no recent bacteriological results were available for well no. 4. Even though this well is not an active part of the distribution system, regular testing for bacteriological parameters would be recommended.

8.0 LIMITATIONS AND USE OF REPORT

This report was prepared for the exclusive use of The Township of North Dundas. The report, which specifically includes all tables, figures and appendices, is based on data and information collected by Golder Associates and is based solely on the conditions of the properties at the time of the work, supplemented by historical information and data obtained by Golder Associates as described in this report. Each of these reports must be read and understood collectively, and can only be relied upon in their totality.

Golder Associates has relied in good faith on all information provided and does not accept responsibility for any deficiency, misstatements, or inaccuracies contained in the reports as a result of omissions, misinterpretation, or fraudulent acts of the persons contacted or errors or omissions in the reviewed documentation.

The assessment of environmental conditions at this site has been made using the results of physical measurements and chemical analyses of liquids from a number of locations. The site conditions between sampling locations have been inferred based on conditions observed at borehole locations. Subsurface conditions may vary from these sampled locations.

The services performed, as described in this report, were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

Any use which a third party makes of this report, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. Golder Associates accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

The findings and conclusions of this report are valid only as of the date of this report. If new information is discovered in future work, including excavations, borings, or other studies, Golder Associates should be requested to re-evaluate the conclusions of this report, and to provide amendments as required.

GOLDER ASSOCIATES LTD.

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TABLE 1

CAPTURE ZONE ANALYSES
BEDROCK WELLS

Well	Pumping Rate, Q (m^3/s)	Hydraulic Conductivity, K (m/s)	Saturated Aquifer Thickness, b* (m)	Hydraulic Gradient, i	x_o (m)	y_{max} (m)
1	6.82×10^{-3}	2.31×10^{-5}	37	1×10^{-3}	1270	3990
4	1.52×10^{-3}	3.99×10^{-5}	20	1×10^{-3}	302	949
5	4.92×10^{-3}	5.50×10^{-5}	22	1×10^{-3}	647	2033
6	7.58×10^{-3}	2.66×10^{-4}	9	1×10^{-3}	504	1583

Notes:

* based on reported static groundwater levels in April 2002

x_o = distance to the downgradient edge of the capture zone from the well

y_{max} = maximum half-width of the capture zone, perpendicular to groundwater flow

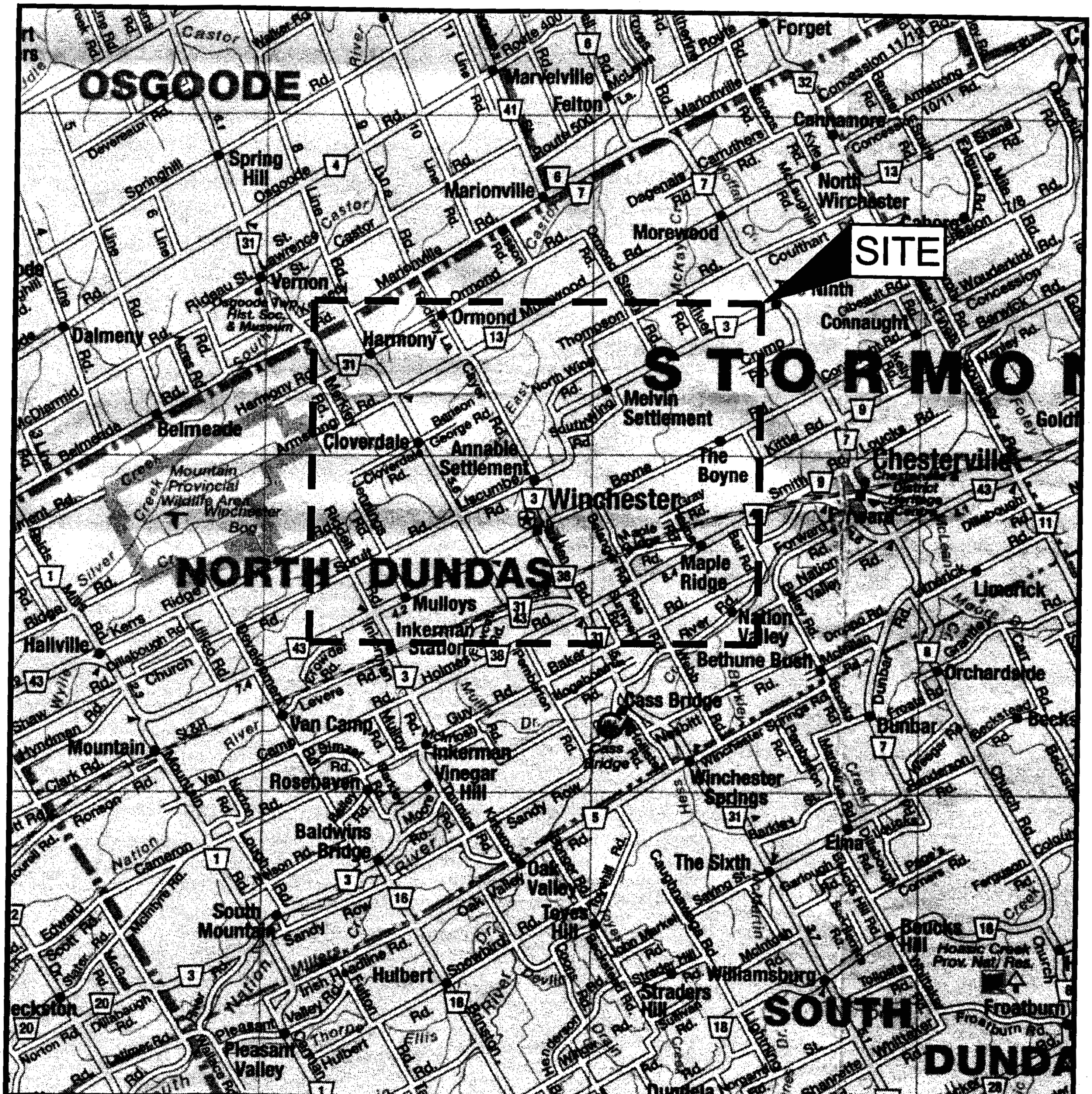
TABLE 2

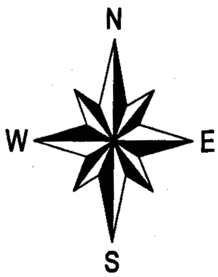
GROUNDWATER FLOW ANALYSES
BEDROCK WELLS

Well	Transmissivity, T (m^2/day)	Saturated Aquifer Thickness, b* (m)	Hydraulic Conductivity, K (m/day)	Assumed Hydraulic Gradient (non-pumping conditions), i	Linear Velocity (non-pumping conditions) (m/day), v	Hydraulic Gradient (pumping conditions), i	Linear Velocity (pumping conditions) (m/day), v
1	100	49	2	$1x10^{-4}$ to 1×10^{-3}	0.02 to 0.002	--	--
4	76	22	3.4	1×10^{-4}	$3.4x10^{-3}$	0.02	0.7
5	114	24	4.8	1×10^{-4}	$4.8x10^{-3}$	0.01	0.48
6	208	9	23	1×10^{-4}	0.023	$4.2x10^{-3}$	0.97
7a	1100	9	122	1×10^{-4}	0.05	$8x10^{-4}$	0.39

NOTES

*based on reported static groundwater levels in April 2002
* as reported at time of pumping test
porosity (n) was assumed to be 0.1 for bedrock wells (well 1, 4, 5, 6)
porosity (n) was assumed to be 0.25 for overburden wells (well 7a)



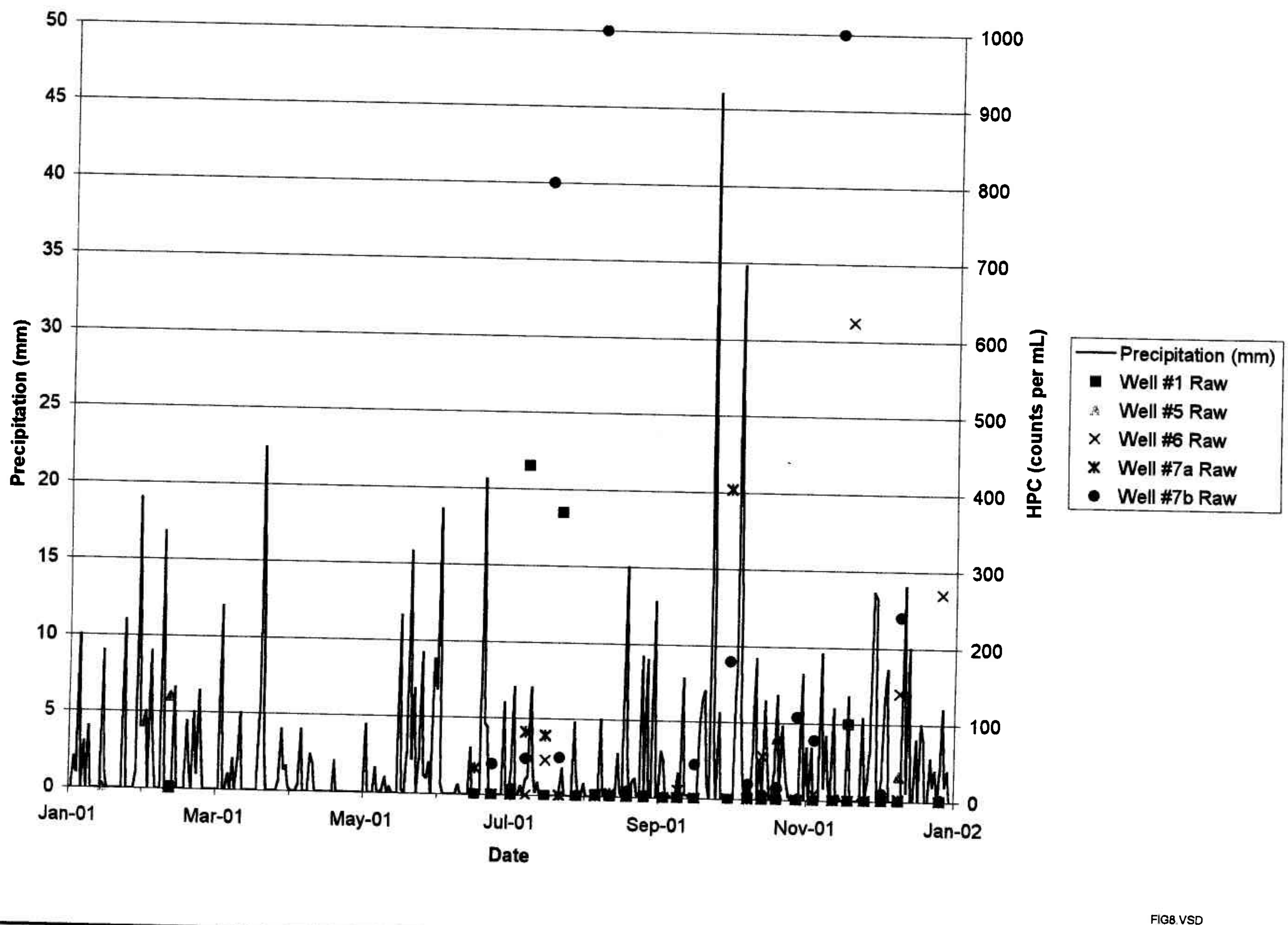


SPECIAL NOTE
THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT

Golder Associates
Ottawa, Ontario

SCALE	1: 200,000	TITLE	KEY PLAN
DATE	APRIL 2002		
DESIGN			
CADD	S.L.		
FILE No. 0212748-1000-01.dwg	CHECK	A.B.	
PROJECT No. 021-2748 REV.	REVIEW		FIGURE 1

Drawing file: 0212748-1000-01.dwg Apr 22, 2002 - 4:58pm



Golder Associates	Date: April 2002	Drawn: A.B.	Trends in Precipitation and Heterotrophic Plate Count Winchester Wells	FIGURE 8
	Project: 021-2748	Chkd: B.J.V.		

APPENDIX A

WATER WELL RECORDS

Well 1

DUNDAS COUNTY 18

MUNICIPALITY CONCESSION ETC	LOT	WELL NO	UTM EASTING NORTHING	ELEV FEET	DATE	DRILLER	CSG DIA INS	KIND OF WATER	WATER FOUND FEET	STAT LVL FEET	PUMP LVL FEET	TEST RATE GPM	TEST TIME HR/MN	WATER USE	OWNER/LOG/SCREEN DEPTHS IN FEET TO WHICH FORMATIONS EXTEND
WINCHESTER VILLAGE (CONTINUED....)															
		18- 880	472390 4992502	240	08/56	1526	4	FR	42	13	18	3	2/00	DO	DURVAL M MSND 0006 HPAN BLDR 0021 LMSN 0055
		18- 868	472433 4993044	240	08/53	2308	4	FR	33	12	20	5	2/00	DO	STUART E HPAN 0025 LMSN 0035
		18- 981	472487 4991710	251	09/55	2308	4	FR	25	6	8	6	1/00	ST	COONS B HPAN 0006 LMSN 0028
		18- 878	472489 4993263	240	12/55	2308	4	FR	50	6	12	2	1/30	DO	MARQUETTE J HPAN 0016 GREY LMSN 0054
		18- 889	472494 4991745	250	09/62	4704	4	FR	73	20	25	15	2/00	ST DO	COONS B CLAY 0010 LMSN 0073
		18- 2499	472499 4992699	250	01/79	1505	6	FR	73	15	35	5	1/00	CO	AQUA-FUN POOLS BRWN FILL LOOS PCKD 0005 BRWN HPAN HARD PCKD 0025 GREY LMSN STNS HARD 0083
		18- 983	472504 4992271	255	01/65	1802	6	FR	48	15	55	40	1/00	CO	LAPORTE W L HPAN 0011 SHLE 0055
		18- 855	472530 4992696	255	10/51	4704	5	FR	122	60	90	8	1/00	DO	SUMMERS P PRDG 0018 HPAN 0049 LMSN 0123
		18- 1490	472539 4992661	245	11/72	1505	6	FR	177	12	80	1J	1/00	DO	REYNOLDS G H BRWN TPSL SAND 0002 BRWN GRVL SAND CLAY 0048 GREY LMSN 0185
		18- 886	472645 4993094	235	05/58	1505	8	FR FR FR	65 160 204	13	42	35	4/30	PS	VILLAGE WATER SUPPLY TPSL 0001 CLAY 0008 LMSN 0018 GREY LMSN 0231
		18- 890	472657 4993238	235	06/65	2308	4	FR	75	30	60	6	2/00	ST DO	HOLMES C HPAN 0048 LMSN 0078
		18- 980	472678 4991621	250	06/54	1505	6	FR FR FR FR	150 175 225 272	7	250	50	36/00	IN	ONT CHEESE MARKETING TPSL 0002 HPAN 0012 GRVL CLAY 0020 GRVL MSND 0030 LMSN 0300
		18- 843	472752 4991989	245	06/50	4704	5	FR	82	12	12	3	24/00	DO	ANGUS D A HPAN BLDR 0031 LMSN 0084
		18- 887	472815 4991891	250	06/58	1505	8	FR FR FR FR	80 156 202 306	10	25	35	4/00	DO	WINCHESTER VILLAGE TPSL 0002 CLAY 0006 MSND HPAN GRVL 0028 GREY LMSN 0080 GREY LMSN 0156 GREY LMSN 0202 GREY LMSN 0206 GREY LMSN 0310
		18- 982	472914 4991582	250	09/62	4704	5	FR	143	35	75	15	2/00	ST DO	LINK H PRDG 0018 HPAN BLDR 0038 LMSN 0143
		18- 830	999999 9999999		05/47	4704	5	FR	50	2	5	30	/30	ST DO	WALKER L CLAY 0014 LMSN 0050
		18- 831	999999 9999999		05/46	3504	5	FR		12	52	15	/30	CO	WINCHESTER HOTEL CLAY GRVL MSND 0050 LMSN 0156
		18- 832	999999 9999999		09/48	1505	5	FR FR	175 250	17	37		4/00	DO	SUMMERS A TPSL 0008 CLAY STNS MSND 0034 LMSN 0298
		18- 842	999999 9999999		06/50	3504	5	FR	64	62	102	8	1/00	DO	ROYAL BANK GRVL 0020 CLAY HPAN 0048 LMSN 0127
		18- 856	999999 9999999		01/52	1547	4	FR		9	15	5	1/00	DO	ROSE M M HPAN 0030 LMSN 0039

2. Test Well 2 Well #4

Driller's log of formations:

0 to 22 feet	stony till
22 to 92 feet	grey dolomite and limestone

Diameter of hole: 8 inches

Casing diameter and position: 10 inch - 0 to 22 feet

Water-bearing zones: 70 and 76 feet

Static level: 0 feet

Depth: 92 feet

Grouting: cement 0 to 8 feet

History:

Mar. 29/72	- moved drill onto site and commenced drilling
Apr. 11/72	- well completed to 61 feet
	- pumped for 1.5 hours at 30 gpm
Apr. 14, 15 & 17/72	- carried out specific capacity tests on well
Apr. 17/72	- well completed to 92 feet
Apr. 18, 19 & 20/72	- developed well
Apr. 21/72	- 2-hour step test at 50, 80, 110 & 140 gpm followed by 2.5 hour test at 80 gpm
Apr. 24/72	- 72-hour test
May 1/72	- moved drill to site 3

.3 Test Well 3 Well #5

Driller's log of formations:

0 to 8 feet	sand and gravel
8 to 14 feet	hardpan
14 to 92 feet	grey dolomite and limestone

Diameter of hole: 8 inches

Casing diameter and position: 8 inches, 0 to 15 feet

Water-bearing zones: 46 to 52 feet
64 to 75 feet
80 to 92 feet

Static level: 0 feet

Depth: 92 feet

Grouting: cement 0 to 10 feet

History:

May 1/72 - drilling commenced
May 15/72 - well at a depth of 86 feet

May 24/72 - 2-hour step test at 30, 70, 110 and 142 gpm
May 24, 25
& 26/72 - 54-hour test at 100 gpm

morrison beatty limited
consulting engineers and hydrogeologists

TW2/82 Well #6
INSTANT WATER WELLS Ltd
Village of Winchester
PROJECT NO. 325-821

A2

Ministry of the Environment
Ontario

The Ontario Water Resources Act

WATER WELL RECOR

County or District	Township	Con.	Lot
Dundas	Mountain	7.	20

Village of Winchester, Test Drilling Contract W 2. — 23 Oct.

WELL # 2.

LOG OF OVERBURDEN AND BEDROCK MATERIALS

General Colour	Most Common Material	Other Materials	General Description	Depth From
Brown	Topsoil		Loose	0
Grey	Clay	Cobbles	Packed	2
Brown	Sand	Gravel	Cemented	18½
Grey	Limestone	Rock	Hard	22½
			total depth	52 ft

WATER RECORD

Water found at feet: 40-50 — Fresh

CASING & OPEN HOLE RECORD

Inside Diam.	Material	Wall Thickness	From	To
254 mm	Steel	6.35 mm	0	24½

SCREEN

PLUGGING & SEALING RECORD

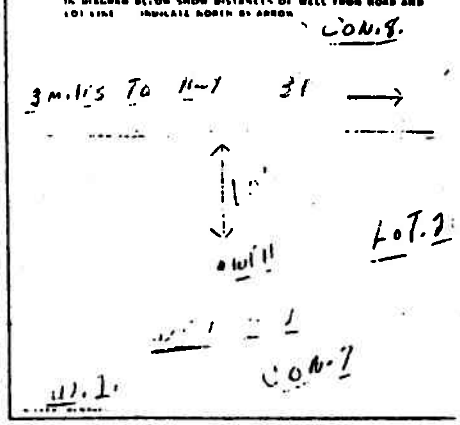
PUMPING TEST

Pump; Pumping rate: 200; Duration of pumping: 48

Static level: 7'6"; Water level end of pumping: 25

LOCATION OF WELL

In diagram below show distances of well from road and lot line. Indicate north by arrow.



FINAL STATUS OF WELL: X Water supply

WATER USE: X Municipal

METHOD OF DRILLING: X

CONTRACTOR

Name of well contractor: Ramon H. Casselman — Licence number: 1505

Address: Williamsburg, Ontario

Name of driller: Currie McIntosh

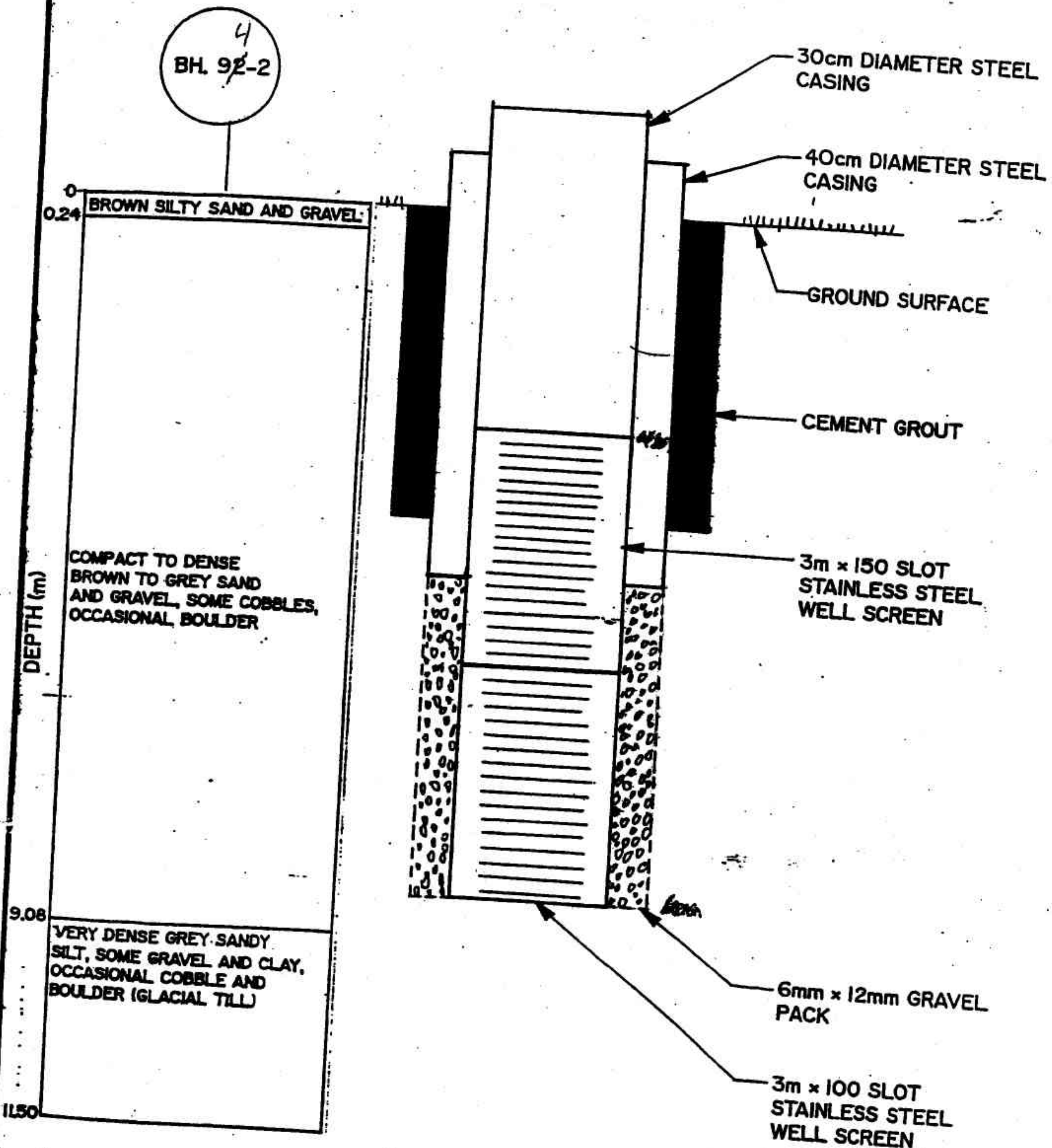
Signature of contractor: [signature] — Submission date: 23 Oct. 82

OFFICE USE ONLY

OWNER'S COPY

TEST WELL SCHEMATIC DRAWING

FIGURE 4 7a



SCALE : 1 : 75 VERT.

SPECIAL NOTE
THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT

Date DEC 21 1994
Project 941-2747

Golder Associates

Drawn K.M.
Chkd. KAM

WELL 7B

Ministry of the Environment
Ontario

The Ontario Water Resources Act
WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

COUNTY OR DISTRICT	TOWNSHIP BOROUGH CITY TOWN VILLAGE	CON BLOCK TRACT SURVEY ETC	LOT
UNDAS	WINCHESTER	Conc. IX Ref: Plan 8R-624	15 PNE 1/2

The Corporation of the Village of Winchester
ADDRESS 54 St-Lawrence street Box 489, Winchester Ontario, KOC 2KO
DATE COMPLETED DAY 16 MO 05 YR 96

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	TO
	Silt, Sand & Gravel	WELL NO. B	Top Soil, Silt Sand, gravel	0	4 m
rown	Gravel		Silty gravel	4	6 m
wn	Gravel		Large sixe gravel well rounded	6	12.5m
y			Mixture gravel & grey fine sand	12.5	14.5m
rey			Gumbo till, grey till	14.5	

WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS

CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	TO
	☑ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC	30"	0	4.8m
	☐ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC	24"	0	12.6m
	☐ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC	12"	0	9.1m

SCREEN

SIZE(S) OF OPENING (SLOT NO.)	DIAMETER	LENGTH
250	12" INCHES	15 FEET

MATERIAL AND TYPE — DEPTH TO TOP OF SCREEN — FEET

PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)
0	1.8m	Cimentious grout

PUMPING TEST METHOD ☒ PUMP ☐ BAILER
PUMPING RATE 300 USgpm GPM
DURATION OF PUMPING 72 HOURS
STATIC LEVEL — WATER LEVEL END OF PUMPING — Drawdown 50 cm
☐ PUMPING ☐ RECOVERY
15 MINUTES / 30 MINUTES / 45 MINUTES / 60 MINUTES — FEET
IF FLOWING, GIVE RATE — GPM
PUMP INTAKE SET AT — FEET
WATER AT END OF TEST ☐ CLEAR ☐ CLOUDY
RECOMMENDED PUMP TYPE ☐ SHALLOW ☐ DEEP
RECOMMENDED PUMP SETTING — FEET
RECOMMENDED PUMPING RATE — GPM

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.

WELL A

WELL B

WELL C

DRILLERS REMARKS

147696

FINAL STATUS OF WELL
☑ WATER SUPPLY
☐ OBSERVATION WELL
☐ TEST HOLE
☐ RECHARGE WELL
☐ ABANDONED, INSUFFICIENT SUPPLY
☐ ABANDONED POOR QUALITY
☐ UNFINISHED
☐ DEWATERING

WATER USE
☐ DOMESTIC
☐ STOCK
☐ IRRIGATION
☐ INDUSTRIAL
☐ OTHER
☐ COMMERCIAL
☑ MUNICIPAL
☐ PUBLIC SUPPLY
☐ COOLING OR AIR CONDITIONING
☐ NOT USED

METHOD OF CONSTRUCTION
☑ CABLE TOOL
☐ ROTARY (CONVENTIONAL)
☐ ROTARY (REVERSE)
☐ ROTARY (AIR)
☐ AIR PERCUSSION
☐ BORING
☐ DIAMOND
☐ JETTING
☐ DRIVING
☐ DIGGING ☐ OTHER

NAME OF WELL CONTRACTOR: LA COOPERATIVE ENVIROTECHEAU
WELL CONTRACTOR'S LICENCE NUMBER: 14963
ADDRESS: 2251 chemin St-François, Dorval, Qc., H9P 1K3
NAME OF WELL TECHNICIAN: BENOIT BOUCHARD
WELL TECHNICIAN'S LICENCE NUMBER:
SIGNATURE OF TECHNICIAN/CONTRACTOR:
SUBMISSION DATE: 15 10 96

OFFICE USE ONLY

WELL -7C

Ministry of the Environment

The Ontario Water Resources Act

WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK [X] CORRECT BOX WHERE APPLICABLE

County or District	Township, Borough, City, Town, Village	Con, Block, Tract, Survey etc.	Lot
DUNDAS	WINCHESTER	Con IX Ref: Plan 8R-624	15 PNE 1/2

Owner	Address	Date Completed
The Corporation of the Village of Winchester	54 St-Lawrence street Box 489, Winchester, On	Day 13 Mo 08 Yr 96

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

General Colour	Most Common Material	Other Materials	General Description	Depth From	Depth To
Dark Yellow	Silt, Sand & Gravel	Clay (muddy)	Muddy Silty Sandy Gravel	0	4 m
	Gravel		Gravel	4 m	13.90
…ay	Sand Silt Clay		Compact Till	13.90	15 m
	Shale		Bedrock	15 m	
		WELL NO. C			

WATER RECORD

Water Found at - Feet	Kind of Water
	[X] Fresh

CASING & OPEN HOLE RECORD

Inside Diam Inches	Material	Wall Thickness Inches	Depth From	Depth To
	Steel	30"	0	4.8 m
		24"	0	14 m
		12"	0	10.5m

SCREEN

Slot No.	Diameter	Length
250	12" inches	15 feet

Material and Type: Stainless Steel — Depth to top of screen: 31.64 feet

PLUGGING & SEALING RECORD

Depth Set At From	To	Material and Type
0	1.8 m	Cimentious grout

Pumping Test Method: [X] Pump [ ] Bailer — Pumping Rate: 300 US GPM — Duration of Pumping: 72 hours

Drawdown 30cm

LOCATION OF WELL

In diagram below show distances of well from road and lot line. Indicate north by arrow.

WELL A

WELL B

WELL C

147697

FINAL STATUS OF WELL: [X] Water supply

WATER USE: [X] Municipal

METHOD OF CONSTRUCTION: [X] Cable tool

Name of Well Contractor: LA COOPERATIVE ENVIROTECHEAU — Well Contractor's Licence Number: 14963

Address: 2251 chemin St-François, Dorval, Qc., H9P 1K3

Name of Well Technician: BENOIT BOUCHARD

OFFICE USE ONLY

APPENDIX C

RESULTS OF CHEMICAL ANALYSIS OF GROUNDWATER

NORTH DUNDAS GUDI STUDIES - REPORT OF MONITORING RESULTS

Project: 021-2748

Sample Source: **Winchester Well #1**

Sheet: 1

Parameter	ODWS/O	15-Apr-2002
Date Sampled:		15-Apr-2002
Alkalinity (CaCO3)	30-500	307
Aluminum	0.1	<0.050
Ammonia (as N)		0.76
Barium	1	0.030
Beryllium		<0.002
Boron	5	1.000
Cadmium	0.005	<0.00010
Calcium		67.0
Chloride	250	166.0
Chromium	0.05	<0.001
Cobalt		<0.0002
Colour (TCU)	5	<2
Conductivity (uS/cm)		1220
Copper	1	0.0030
Fluoride	1.5	0.34
Hardness (CaCO3)	80-100	328
Iron	0.3	0.04
Lead	0.01	<0.0010
Magnesium		39.00
Manganese	0.05	0.010
Molybdenum		<0.010
Nickel		<0.010
Nitrate (as N)	10	<0.10
Nitrite (as N)	1	<0.10
pH (pH units)	6.5-8.5	8.1
Phosphorus (total)		<0.01
Potassium		17.0
Silicon		3.84
Silver		<0.0001
Sodium	200	114.0
Strontium		4.730
Sulphate	500	110.0
Tannin & Lignin		<0.1000
Thallium		<0.00100
Titanium		<0.010
TKN		0.81
Turbidity (NTU)	1	0.2
Vanadium		<0.0010
Zinc	5	<0.010

All values reported in mg/L unless otherwise noted.

Golder Associates

NORTH DUNDAS GUDI STUDIES - REPORT OF MONITORING RESULTS **Project: 021-2748**

Sample Source: **Winchester Well #4**

Sheet: 1

Date Sampled: 15-Apr-2002

Parameter	ODWS/O	
Alkalinity (CaCO3)	30-500	286
Aluminum	0.1	<0.050
Ammonia (as N)		0.03
Barium	1	0.040
Beryllium		<0.002
Boron	5	0.170
Cadmium	0.005	<0.00010
Calcium		81.0
Chloride	250	43.0
Chromium	0.05	<0.001
Cobalt		0.0002
Colour (TCU)	5	<2
Conductivity (uS/cm)		827
Copper	1	0.0030
Fluoride	1.5	0.21
Hardness (CaCO3)	80-100	383
Iron	0.3	0.04
Lead	0.01	<0.0010
Magnesium		44.00
Manganese	0.05	0.010
Molybdenum		<0.010
Nickel		<0.010
Nitrate (as N)	10	0.62
Nitrite (as N)	1	<0.10
pH (pH units)	6.5-8.5	8.0
Phosphorus (total)		<0.01
Potassium		6.0
Silicon		3.57
Silver		<0.0001
Sodium	200	20.0
Strontium		1.620
Sulphate	500	99.0
Tannin & Lignin		<0.1000
Thallium		<0.00100
Titanium		<0.010
TKN		<0.05
Turbidity (NTU)	1	0.5
Vanadium		<0.0010
Zinc	5	0.050

All values reported in mg/L unless otherwise noted.

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NORTH DUNDAS GUDI STUDIES - REPORT OF MONITORING RESULTS

Project: 021-2748

Sample Source: **Winchester Well #5**

Sheet: 1

Date Sampled:		15-Apr-2002
Parameter	ODWS/O	
Alkalinity (CaCO3)	30-500	340
Aluminum	0.1	<0.050
Ammonia (as N)		0.63
Barium	1	0.110
Beryllium		<0.002
Boron	5	0.760
Cadmium	0.005	0.00010
Calcium		94.0
Chloride	250	223.0
Chromium	0.05	<0.001
Cobalt		0.0002
Colour (TCU)	5	<2
Conductivity (uS/cm)		1500
Copper	1	0.0010
Fluoride	1.5	0.26
Hardness (CaCO3)	80-100	474
Iron	0.3	0.03
Lead	0.01	<0.0010
Magnesium		58.00
Manganese	0.05	0.030
Molybdenum		<0.010
Nickel		<0.010
Nitrate (as N)	10	<0.10
Nitrite (as N)	1	<0.10
pH (pH units)	6.5-8.5	8.0
Phosphorus (total)		0.01
Potassium		18.0
Silicon		4.56
Silver		<0.0001
Sodium	200	116.0
Strontium		5.350
Sulphate	500	78.0
Tannin & Lignin		<0.1000
Thallium		<0.00100
Titanium		<0.010
TKN		0.77
Turbidity (NTU)	1	0.3
Vanadium		<0.0010
Zinc	5	<0.010

All values reported in mg/L unless otherwise noted.

Golder Associates

NORTH DUNDAS GUDI STUDIES - REPORT OF MONITORING RESULTS **Project: 021-2748**

Sample Source: **Winchester Well #6**

Sheet: 1

Date Sampled: 15-Apr-2002

Parameter	ODWS/O	15-Apr-2002
Alkalinity (CaCO3)	30-500	315
Aluminum	0.1	<0.050
Ammonia (as N)		0.06
Barium	1	0.070
Beryllium		<0.002
Boron	5	0.080
Cadmium	0.005	0.00010
Calcium		115.0
Chloride	250	64.0
Chromium	0.05	<0.001
Cobalt		0.0005
Colour (TCU)	5	<2
Conductivity (uS/cm)		1050
Copper	1	0.0560
Fluoride	1.5	0.34
Hardness (CaCO3)	80-100	534
Iron	0.3	0.01
Lead	0.01	<0.0010
Magnesium		60.00
Manganese	0.05	0.010
Molybdenum		<0.010
Nickel		<0.010
Nitrate (as N)	10	1.01
Nitrite (as N)	1	<0.10
pH (pH units)	6.5-8.5	8.0
Phosphorus (total)		0.06
Potassium		6.0
Silicon		4.44
Silver		<0.0001
Sodium	200	16.0
Strontium		4.750
Sulphate	500	197.0
Tannin & Lignin		<0.1000
Thallium		<0.20000
Titanium		<0.010
TKN		0.21
Turbidity (NTU)	1	0.4
Vanadium		<0.0010
Zinc	5	<0.010

All values reported in mg/L unless otherwise noted.

Golder Associates

NORTH DUNDAS GUDI STUDIES - REPORT OF MONITORING RESULTS Project: 021-2748

Sample Source: **Winchester Well #7A**

Sheet: 1

Date Sampled: 15-Apr-2002

Parameter	ODWS/O	
Alkalinity (CaCO3)	30-500	203
Aluminum	0.1	<0.050
Ammonia (as N)		<0.02
Barium	1	0.170
Beryllium		<0.002
Boron	5	<0.050
Cadmium	0.005	<0.00010
Calcium		82.0
Chloride	250	12.0
Chromium	0.05	<0.001
Cobalt		<0.0002
Colour (TCU)	5	<2
Conductivity (uS/cm)		539
Copper	1	0.0030
Fluoride	1.5	0.25
Hardness (CaCO3)	80-100	267
Iron	0.3	<0.01
Lead	0.01	<0.0010
Magnesium		15.00
Manganese	0.05	<0.010
Molybdenum		<0.010
Nickel		<0.010
Nitrate (as N)	10	0.21
Nitrite (as N)	1	<0.10
pH (pH units)	6.5-8.5	8.0
Phosphorus (total)		<0.01
Potassium		2.0
Silicon		3.32
Silver		<0.0001
Sodium	200	7.0
Strontium		0.294
Sulphate	500	83.0
Tannin & Lignin		<0.1000
Thallium		<0.00100
Titanium		<0.010
TKN		0.10
Turbidity (NTU)	1	0.2
Vanadium		<0.0010
Zinc	5	<0.010

All values reported in mg/L unless otherwise noted.

Golder Associates

NORTH DUNDAS GUDI STUDIES - REPORT OF MONITORING RESULTS **Project: 021-2748**

Sample Source: **Winchester Well #7B**

Sheet: 1

Date Sampled: 15-Apr-2002

Parameter	ODWS/O	
Alkalinity (CaCO3)	30-500	225
Aluminum	0.1	<0.050
Ammonia (as N)		<0.02
Barium	1	0.170
Beryllium		<0.002
Boron	5	<0.050
Cadmium	0.005	<0.00010
Calcium		133.0
Chloride	250	19.0
Chromium	0.05	<0.001
Cobalt		<0.0002
Colour (TCU)	5	<2
Conductivity (uS/cm)		750
Copper	1	0.0030
Fluoride	1.5	0.21
Hardness (CaCO3)	80-100	406
Iron	0.3	<0.01
Lead	0.01	<0.0010
Magnesium		18.00
Manganese	0.05	0.050
Molybdenum		<0.010
Nickel		<0.010
Nitrate (as N)	10	2.21
Nitrite (as N)	1	<0.10
pH (pH units)	6.5-8.5	7.9
Phosphorus (total)		<0.01
Potassium		2.0
Silicon		3.54
Silver		<0.0001
Sodium	200	7.0
Strontium		0.358
Sulphate	500	164.0
Tannin & Lignin		<0.1000
Thallium		<0.00100
Titanium		<0.010
TKN		0.10
Turbidity (NTU)	1	0.1
Vanadium		<0.0010
Zinc	5	<0.010

All values reported in mg/L unless otherwise noted.

Golder Associates

NORTH DUNDAS GUDI STUDIES - REPORT OF MONITORING RESULTS **Project: 021-2748**

Sample Source: **Winchester Well #7C**

Sheet: 1

Parameter	ODWS/O	
Date Sampled:		15-Apr-2002
Alkalinity (CaCO3)	30-500	230
Aluminum	0.1	<0.050
Ammonia (as N)		0.02
Barium	1	0.040
Beryllium		<0.002
Boron	5	<0.050
Cadmium	0.005	0.00010
Calcium		210.0
Chloride	250	16.0
Chromium	0.05	<0.001
Cobalt		0.0007
Colour (TCU)	5	<2
Conductivity (uS/cm)		1030
Copper	1	0.0010
Fluoride	1.5	0.18
Hardness (CaCO3)	80-100	615
Iron	0.3	0.18
Lead	0.01	<0.0010
Magnesium		22.00
Manganese	0.05	0.240
Molybdenum		<0.010
Nickel		<0.010
Nitrate (as N)	10	0.13
Nitrite (as N)	1	<0.10
pH (pH units)	6.5-8.5	7.9
Phosphorus (total)		<0.01
Potassium		2.0
Silicon		4.07
Silver		<0.0001
Sodium	200	9.0
Strontium		0.419
Sulphate	500	333.0
Tannin & Lignin		<0.1000
Thallium		<0.00100
Titanium		<0.010
TKN		0.10
Turbidity (NTU)	1	2.0
Vanadium		<0.0010
Zinc	5	0.010

All values reported in mg/L unless otherwise noted.

Golder Associates

NORTH DUNDAS GUDI STUDIES - REPORT OF MONITORING RESULTS   **Project: 021-2748**

Sample Source: **Chesterville Well #5P**   Sheet: 1

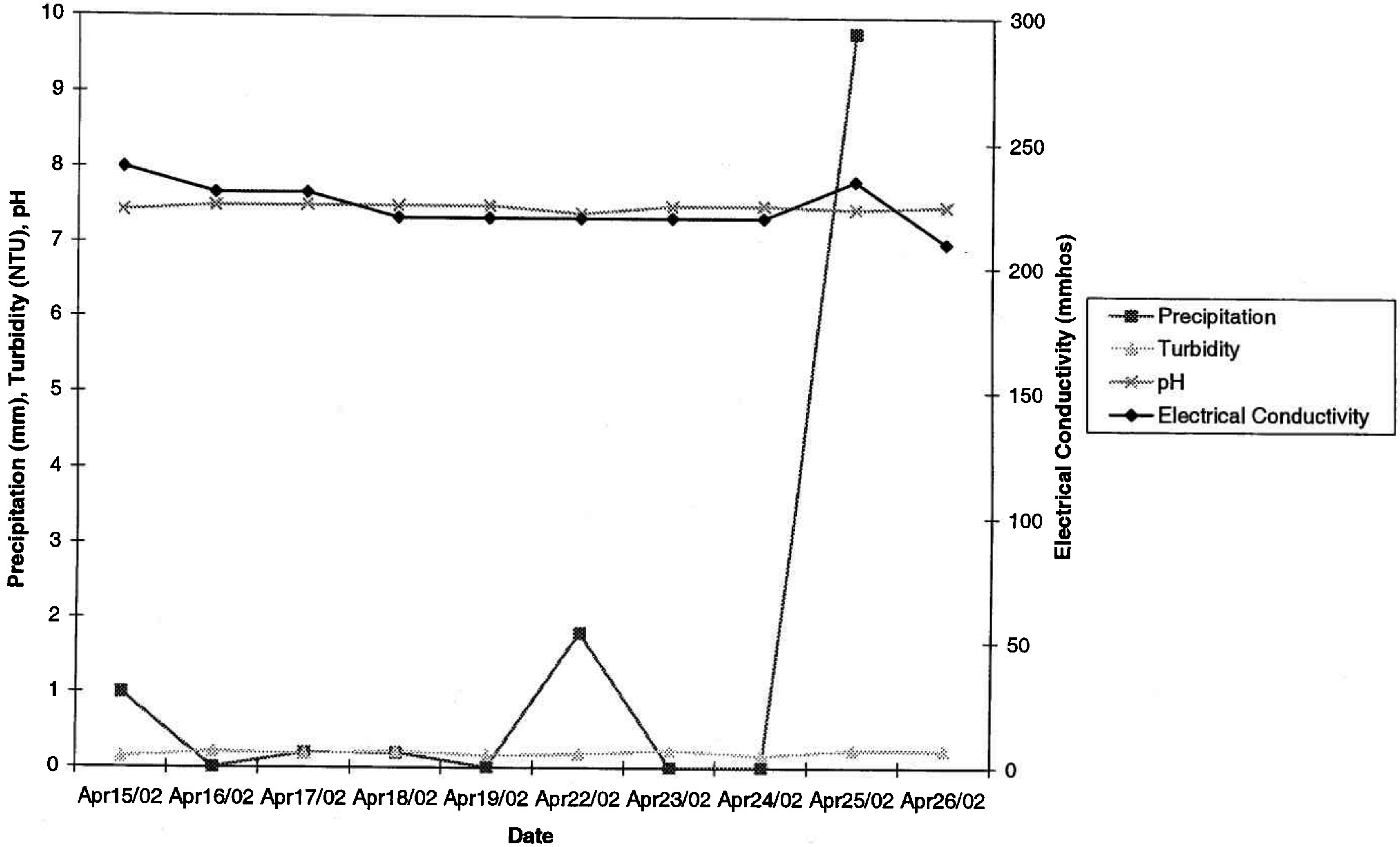
Parameter	ODWS/O	15-Apr-2002
Date Sampled:		15-Apr-2002
Alkalinity (CaCO3)	30-500	198
Aluminum	0.1	<0.050
Ammonia (as N)		<0.02
Barium	1	0.130
Beryllium		<0.002
Boron	5	<0.050
Cadmium	0.005	<0.00010
Calcium		68.0
Chloride	250	41.0
Chromium	0.05	<0.001
Cobalt		<0.0002
Colour (TCU)	5	<2
Conductivity (uS/cm)		612
Copper	1	<0.0010
Fluoride	1.5	0.22
Hardness (CaCO3)	80-100	260
Iron	0.3	0.11
Lead	0.01	0.0010
Magnesium		22.00
Manganese	0.05	0.010
Molybdenum		<0.010
Nickel		<0.010
Nitrate (as N)	10	<0.10
Nitrite (as N)	1	<0.10
pH (pH units)	6.5-8.5	8.0
Phosphorus (total)		<0.01
Potassium		2.0
Silicon		3.15
Silver		<0.0001
Sodium	200	25.0
Strontium		0.173
Sulphate	500	81.0
Tannin & Lignin		<0.1000
Thallium		<0.00100
Titanium		<0.010
TKN		0.06
Turbidity (NTU)	1	0.5
Vanadium		<0.0010
Zinc	5	<0.010

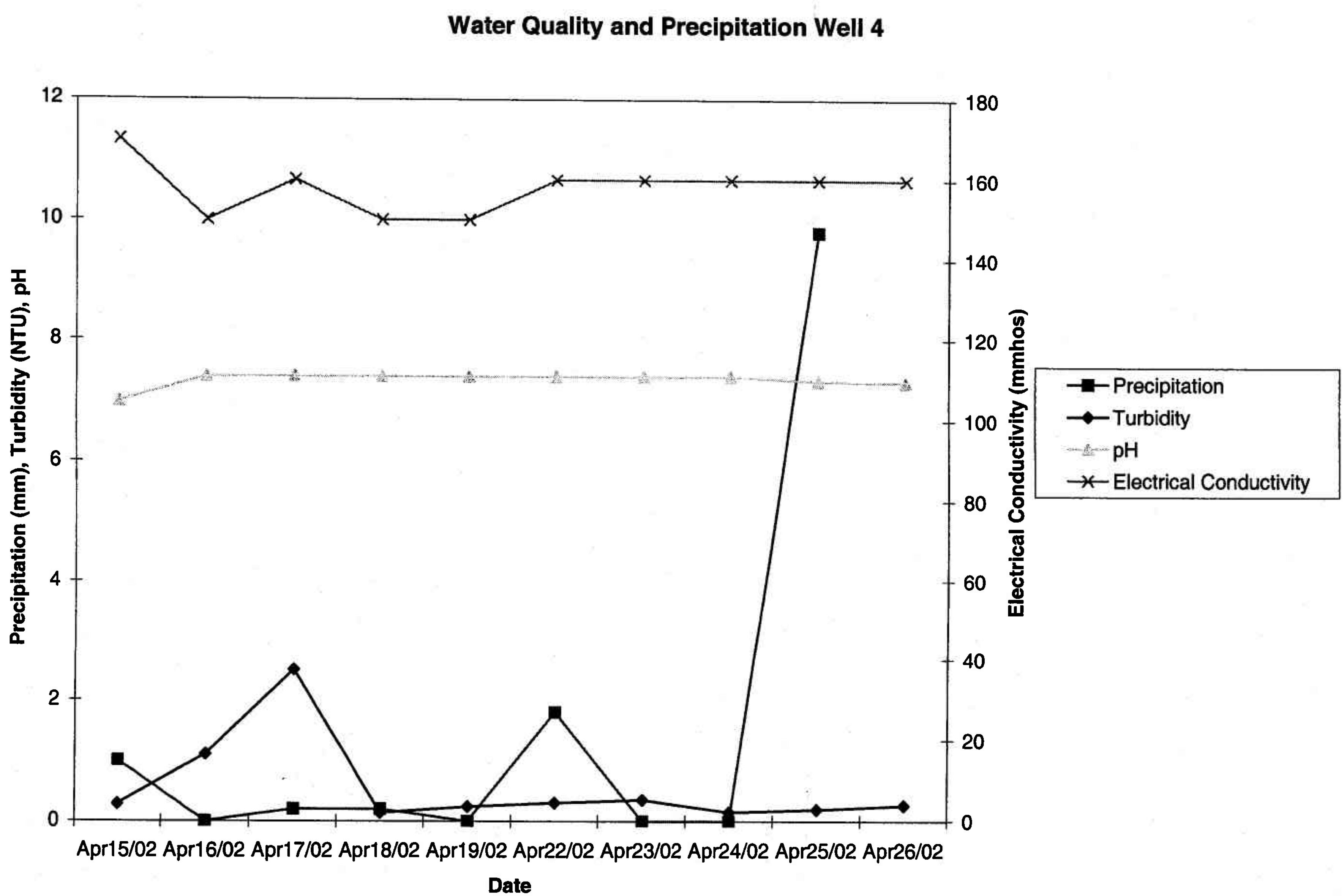
All values reported in mg/L unless otherwise noted.

APPENDIX D

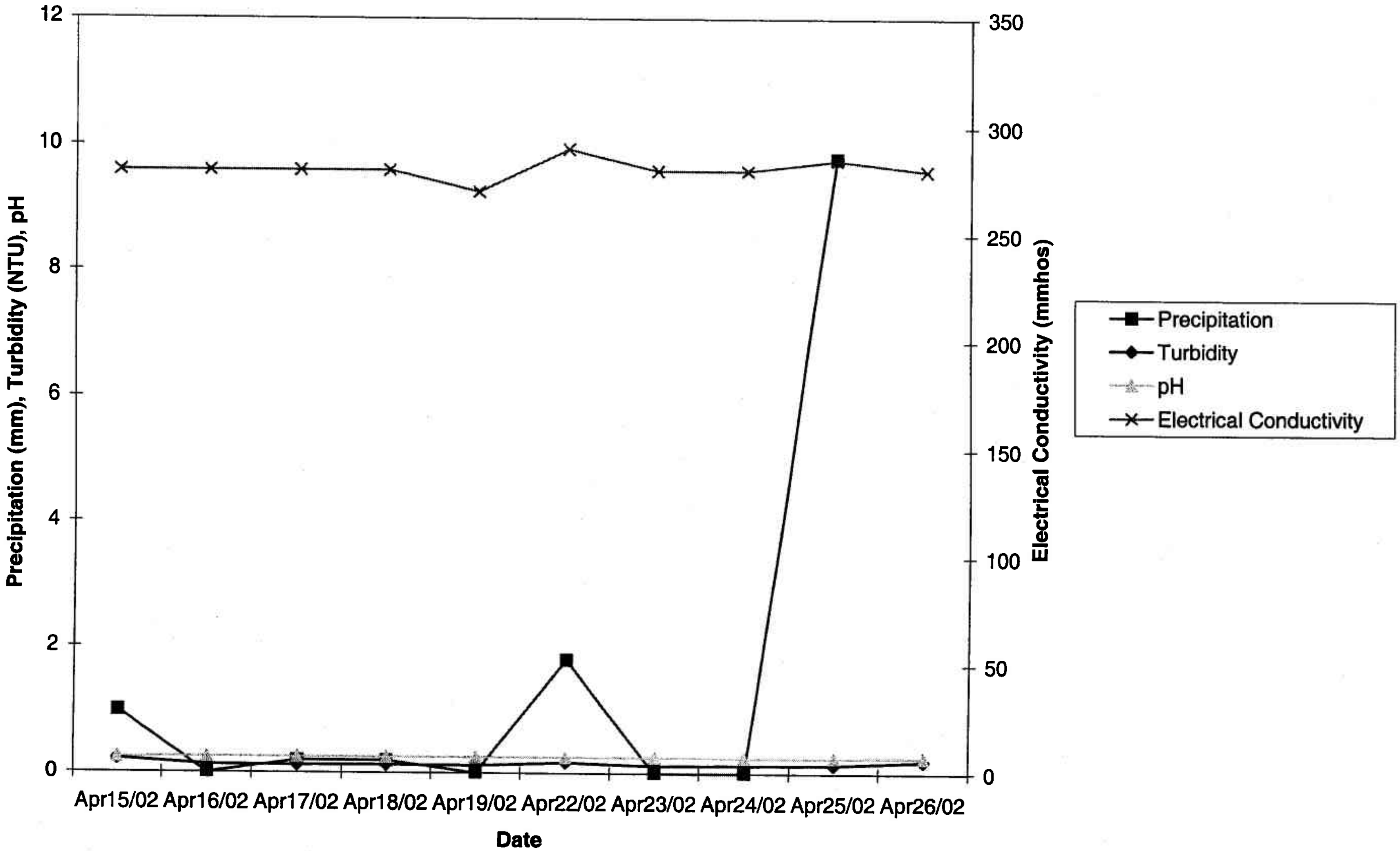
DAILY MEASUREMENTS OF FIELD PARAMETERS

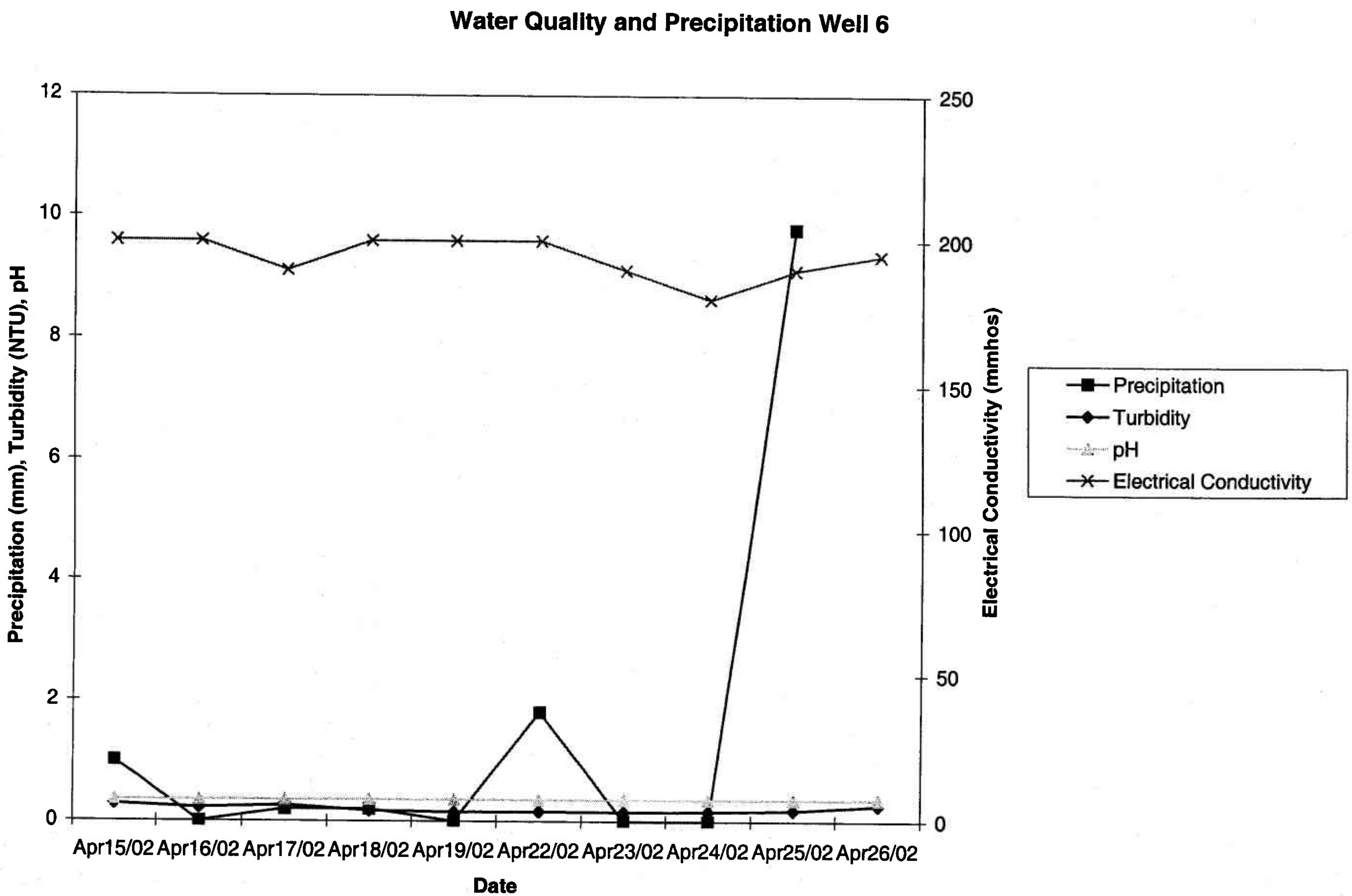
Water Quality and Precipitation Well 1

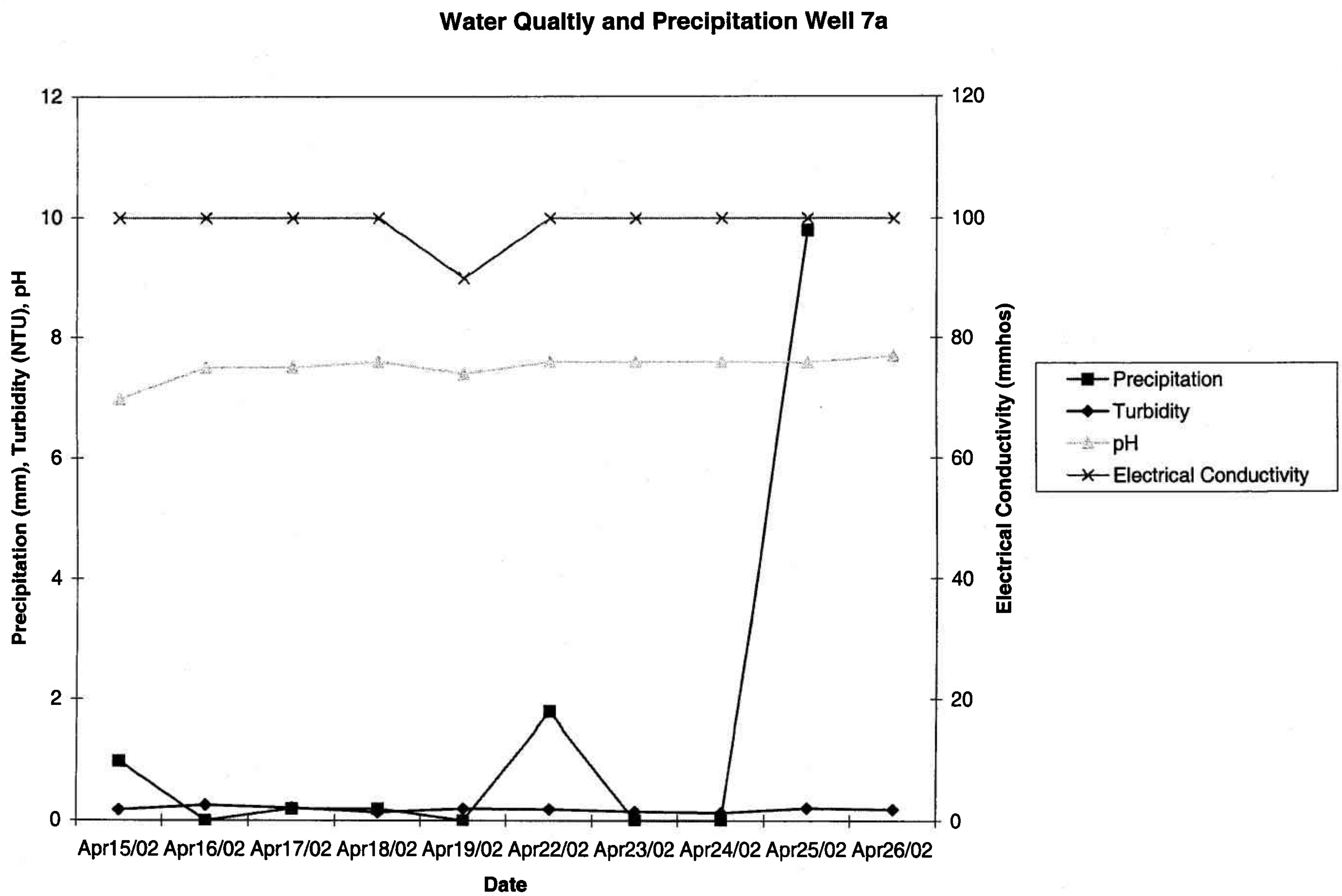



Water Quality and Precipitation Well 4
Precipitation (mm), Turbidity (NTU), pH
12
10
8
6
4
2
0
Electrical Conductivity (mmhos)
180
160
140
120
100
80
60
40
20
0
Apr15/02 Apr16/02 Apr17/02 Apr18/02 Apr19/02 Apr22/02 Apr23/02 Apr24/02 Apr25/02 Apr26/02
Date
Precipitation
Turbidity
pH
Electrical Conductivity

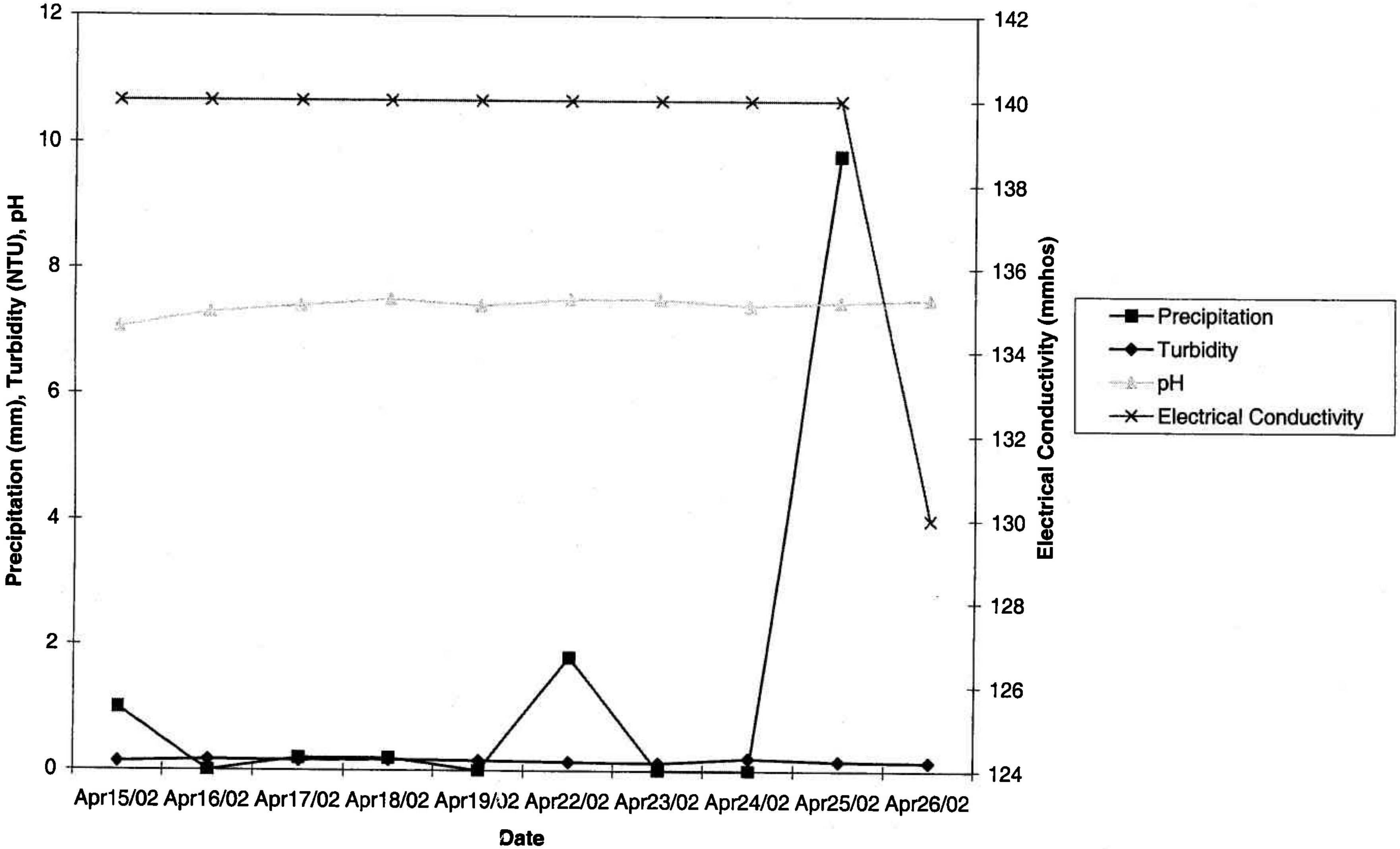
Water Quality and Precipitation Well 5



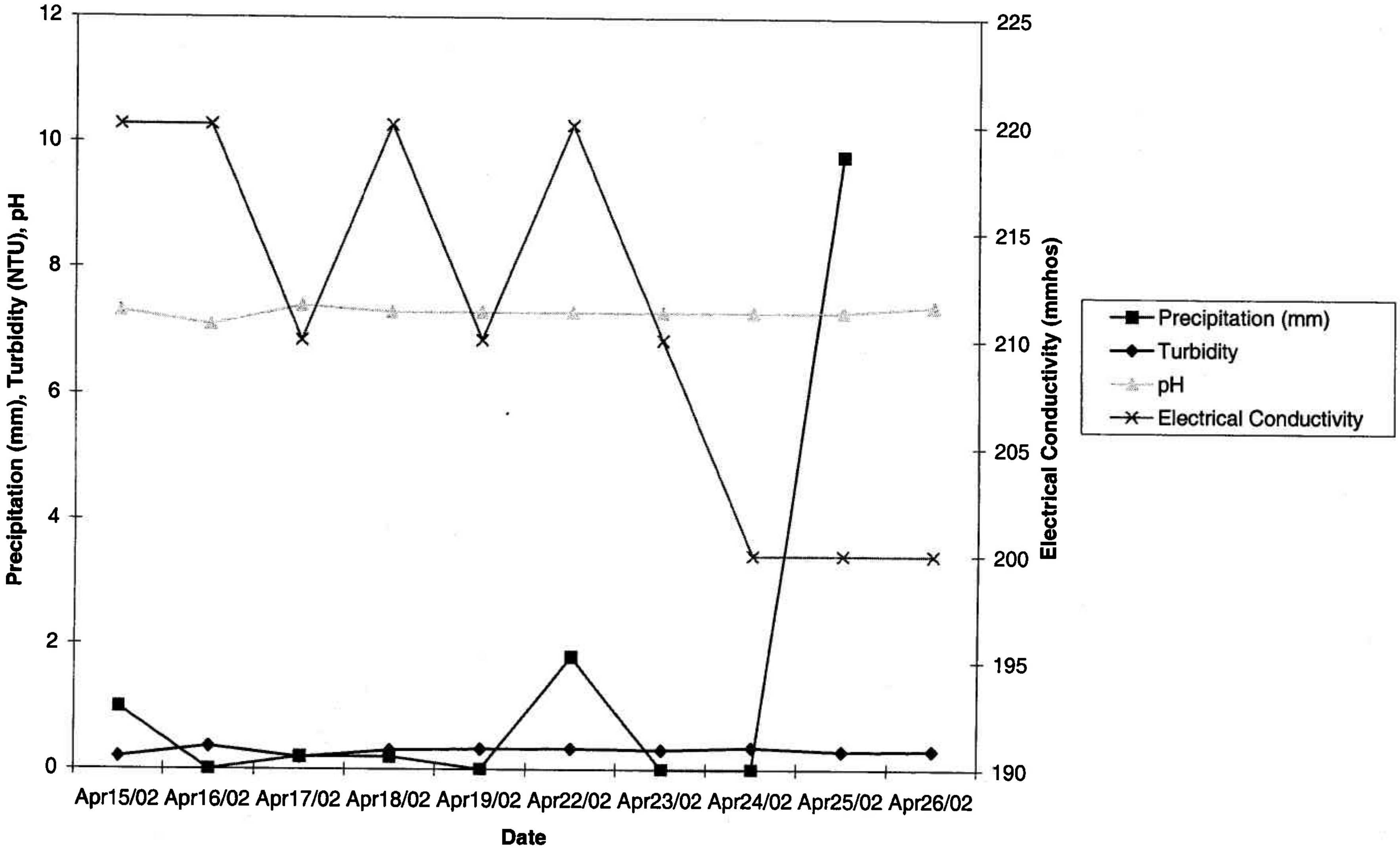

Water Quality and Precipitation Well 6
12
10
8
6
4
2
0
Precipitation (mm), Turbidity (NTU), pH
250
200
150
100
50
0
Electrical Conductivity (mmhos)
Apr15/02 Apr16/02 Apr17/02 Apr18/02 Apr19/02 Apr22/02 Apr23/02 Apr24/02 Apr25/02 Apr26/02
Date
Precipitation
Turbidity
pH
Electrical Conductivity


Water Qualtly and Precipitation Well 7a
12
10
8
6
4
2
0
120
100
80
60
40
20
0
Precipitation (mm), Turbidity (NTU), pH
Electrical Conductivity (mmhos)
Apr15/02
Apr16/02
Apr17/02
Apr18/02
Apr19/02
Apr22/02
Apr23/02
Apr24/02
Apr25/02
Apr26/02
Date
Precipitation
Turbidity
pH
Electrical Conductivity

Water Quality Data and Precipitation Well 7b

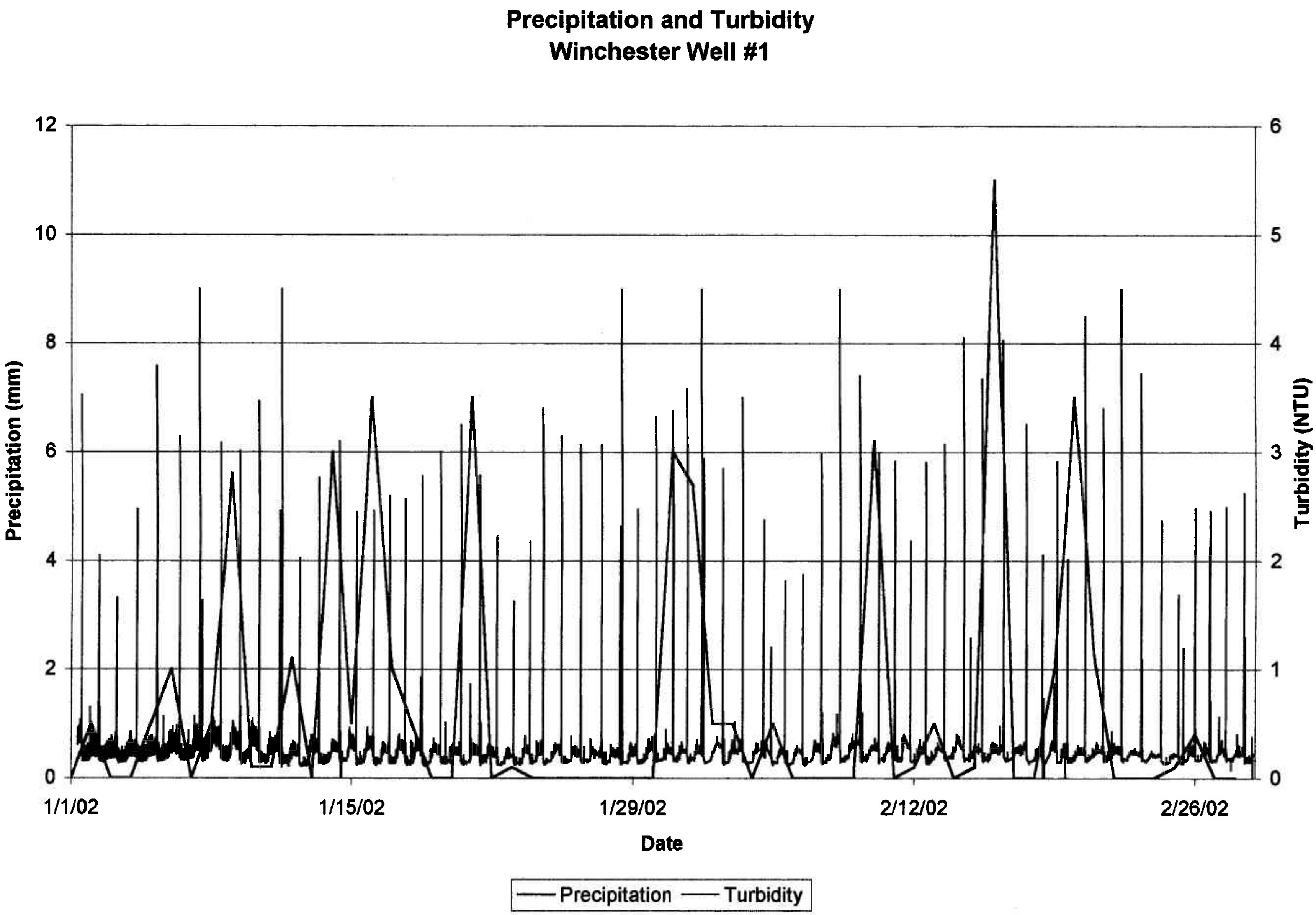


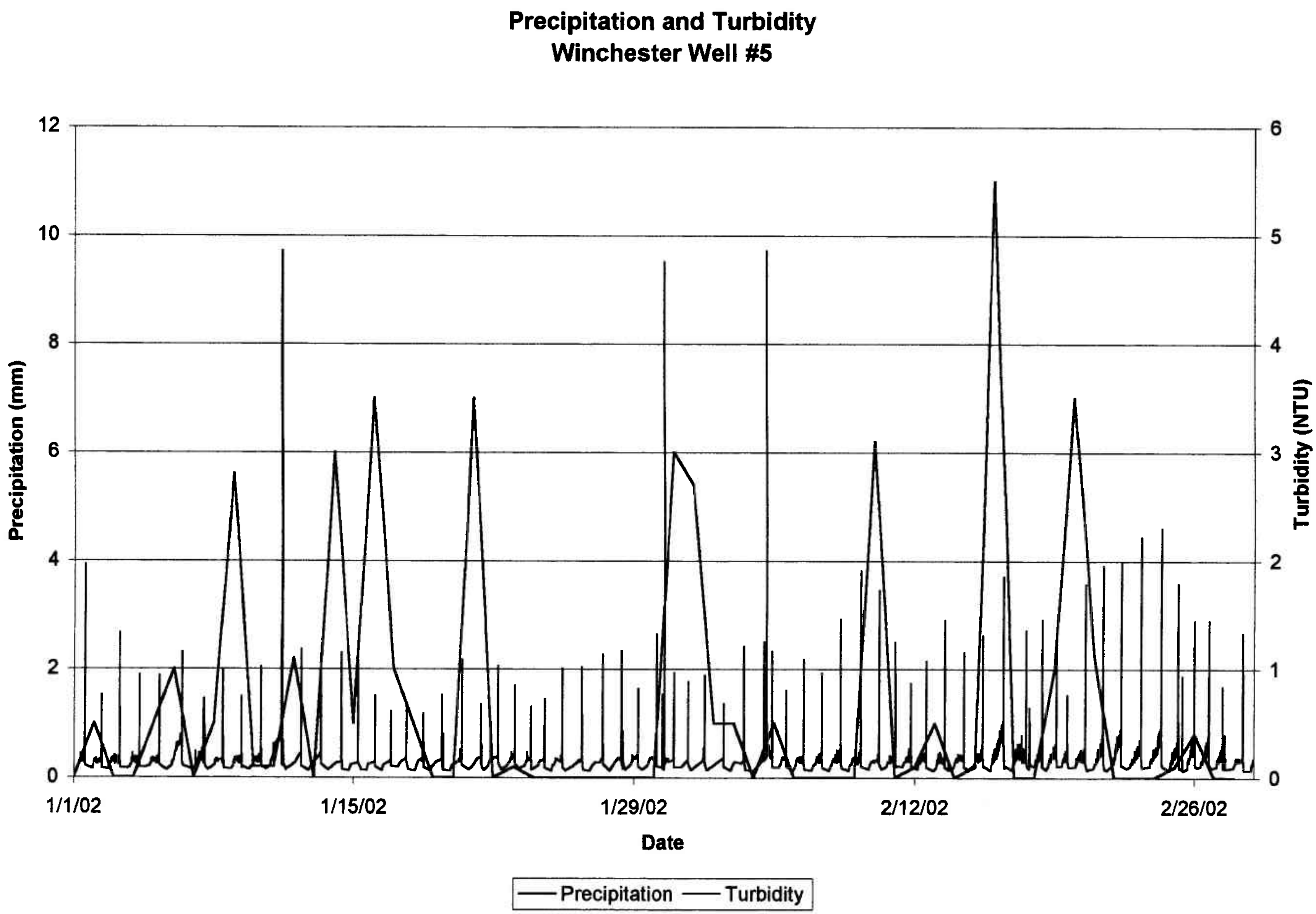
Water Quality and Precipitation Well 7c



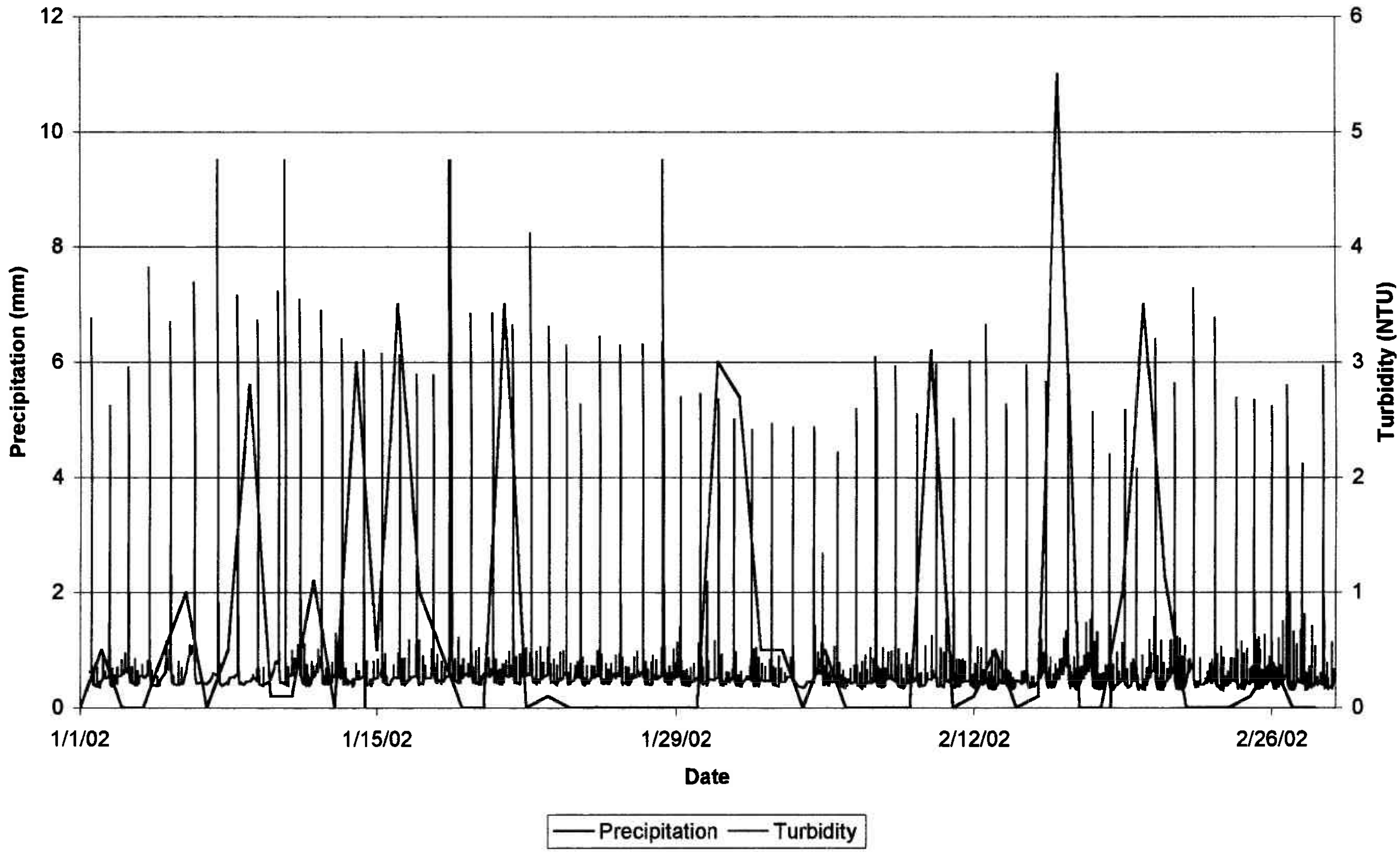
APPENDIX E

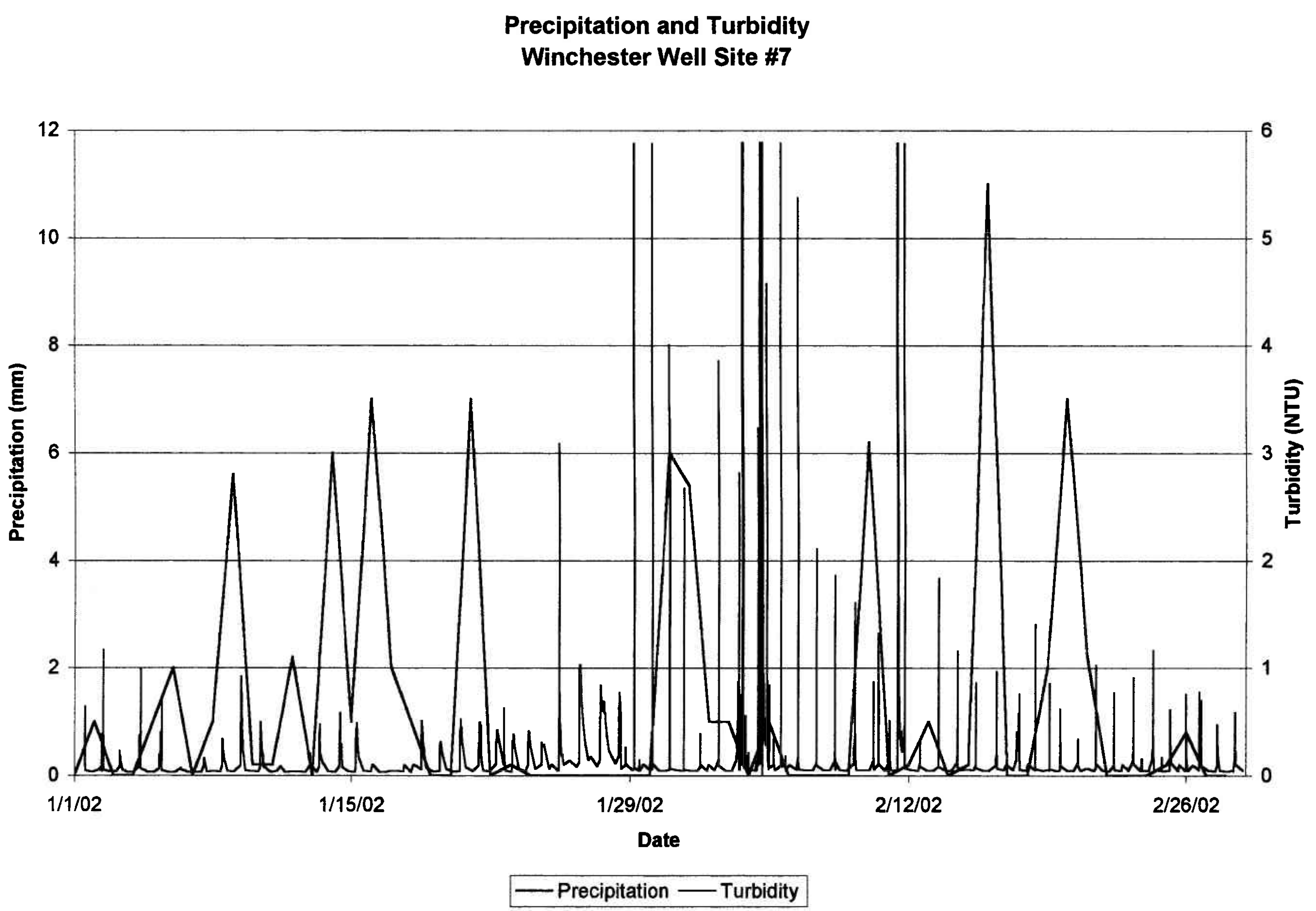
GRAPHS OF TURBIDITY VERSUS TIME


Precipitation and Turbidity
Winchester Well #1
Precipitation (mm)
Turbidity (NTU)
0
2
4
6
8
10
12
0
1
2
3
4
5
6
1/1/02
1/15/02
1/29/02
2/12/02
2/26/02
Date
Precipitation
Turbidity


Precipitation and Turbidity
Winchester Well #5
12
10
8
6
4
2
0
Precipitation (mm)
6
5
4
3
2
1
0
Turbidity (NTU)
1/1/02
1/15/02
1/29/02
2/12/02
2/26/02
Date
Precipitation
Turbidity

Precipitation and Turbidity
Winchester Well #6




Precipitation and Turbidity
Winchester Well Site #7
Precipitation (mm)
12
10
8
6
4
2
0
Turbidity (NTU)
6
5
4
3
2
1
0
1/1/02
1/15/02
1/29/02
2/12/02
2/26/02
Date
Precipitation
Turbidity

Golder Associates Ltd.

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Golder Associates

September 10, 2002

021-2748/6000

Township of North Dundas
636 St. Lawrence Street
P.O. Box 489
Winchester, Ontario
K0C 2K0

Attention: Mr. Howard Smith

**RE: RESULTS OF PARTICLE COUNT STUDY
WINCHESTER WATER SUPPLY WELLS
TOWNSHIP OF NORTH DUNDAS, ONTARIO
MOEE REF. NO. 1069-5ASJ6M**

Dear Sir:

This letter is an addendum to the Golder Associates Ltd. report "Groundwater Under the Direct Influence of Surface Water Studies, Township of North Dundas, Winchester Water Supply Wells", dated April 2002 (hereafter referred to as "the April 2002 GUDI report") and should be read in conjunction with this report.

The April 2002 GUDI report presented the results of studies conducted for seven municipal wells from which the water supply for the Village of Winchester, Ontario is derived. The studies and evaluation methodology of the wells followed the criteria defined in the Ministry of the Environment (MOE) document "Terms of Reference for Hydrogeological Study to Examine Groundwater Sources Potentially Under Direct Influence of Surface Water" (hereafter referred to as "the MOE terms of reference", Ministry of the Environment, October 2001).

It was concluded in Section 7.0 of the April 2002 GUDI report that four of the seven wells were not under the direct influence of surface water, in accordance with the MOE terms of reference. The remaining three wells (Wells 5, 6 and 7a) were interpreted to be potentially under the direct influence of surface water and it was recommended that subsequent particle count studies be undertaken at these wells to determine if the aquifers are providing effective *in situ* filtration of groundwater. These studies were initiated following issuance of the April 2002 GUDI report.

The purpose of this letter is to provide a description of the particle count study objectives and the methodology used in the particle count studies and to present and discuss the data that was collected during these studies. A clear conclusion is provided indicating whether there is effective *in situ* filtration.

PARTICLE COUNT STUDY OBJECTIVES

The objective of the particle count studies was to evaluate the need for filtration in accordance with the conditions in Section 3.5 of the MOE terms of reference. Section 3.5(ii) of the terms of reference states that the all of the following conditions must be met in order to conclude that the aquifer is providing effective *in situ* filtration:

a) particle count data must show that the water consistently contains significantly less than 100 particles per millilitre that are 10 microns or greater in size;

b) it must be confirmed that the particle count is not likely to change during storm, season or other regular environmental changes; and,

c) the raw water must be characterized by good microbiological quality.

Condition (c), above, was discussed in the April 2002 GUDI report and it was determined that the raw water quality from each of the wells flagged as "potentially under the direct influence of surface water" was characterized by good microbiological quality, based on e.coli, total coliforms and heterotrophic plate count concentrations.

The specific objectives of the particle count studies were, therefore, to evaluate the raw water quality from each of the three wells (i.e., Winchester Wells 5, 6 and 7a) in terms of the above conditions (a) and (b).

PARTICLE COUNT STUDY METHODOLOGY

Particle counters were installed in-line at each of the wells before or immediately after the point of sodium hypochlorite injection (i.e., with negligible contact time).

Winchester Well 7a is part of a well field (Winchester Well Site No. 7) which contains Wells 7a, 7b and 7c. Presently (and at the time of the particle count study at Well Site No. 7) only Wells 7a and 7b are operating. Both wells 7a and 7b cycle on simultaneously. Well 7a cycles off approximately 5 minutes before Well 7b. All three wells at Well Site No. 7 are joined by a common header. The particle counter was installed in the common header at Well Site No. 7.

Therefore the particle count data collected represents a composite water sample from Wells 7a and 7b, with the exception of the last approximate 5 minutes of a pump cycle in which only Well 7b is running.

The particle counting equipment used in the particle count studies for Winchester Wells 5 and 6 was a *Water Quality Analyzer* Model WQA 2000, while a *Water Particle Counter* Model WPC-22 was used at Winchester Well Site No. 7. Both instruments were manufactured by ARTI (Accurate, Reliable, Traceable Instruments) Inc.

All particle counting equipment was rented by the Township of North Dundas. The Ontario Clean Water Agency (OCWA), Chesterville Hub, set up and operated the equipment. All equipment was supplied by Pine Environmental Services Inc. of Mississauga, Ontario, who instructed OCWA on the set-up, use and maintenance of the equipment and the related software. Calibration certificates for the particle counting equipment were provided to OCWA by Pine Environmental Services Inc.

The particle counters were configured to monitor the number of particles per millilitre that were 10 microns or greater in size. The intent was to record particle count measurements a minimum of approximately 4 times per hour for the duration of the study. The particle counter equipment used at Wells 5 and 6 had internal data storage capacity, while a personal computer was set up for use with the particle counter installed at Well Site No. 7 to store collected particle count data. The particle counter used at Wells 5 and 6 was set up to record particle counts every 18 minutes, due to storage buffer limitations, while the particle counter used at Well Site No. 7 recorded particle counts every minute.

Representative total daily precipitation data was obtained from Environment Canada, Ontario Region, based on measurements at the Ottawa Airport (YOW) throughout the duration the particle count studies.

The strategy used to collect and evaluate the particle count data was to run the particle counters at each well for a minimum duration of two weeks and to compare any fluctuations in the particle count data to the corresponding total daily precipitation data. It was considered that if no correlation between changes in the particle count data and significant precipitation events could be made than this would be evidence that the particle count is not likely to change during storm, season or other regular environmental changes. At the same time, the particle count values could be compared to the criteria stipulated in the MOE terms of reference (i.e., compared to 100 particles per millilitre in the size range 10 microns and greater). A time frame of two weeks was selected on the basis that two weeks may be sufficient time to span a significant precipitation event as well as demonstrate consistency in results during dry periods. A review of particle count and precipitation data following two weeks of monitoring would determine the need to extend the length of the monitoring period.

Particle count study dates and duration are summarized in the following table:

Well/Well Site	Start Date	End Date
5	May 10, 2002	May 31, 2002
6	June 10, 2002	June 24, 2002
7	June 3, 2002	June 17, 2002

Note: Some interruptions in particle count data collection at Well 5 were experienced due to required particle counter maintenance/cleaning.

RESULTS AND DISCUSSION

The results of the particle count studies are represented graphically in the attached figures.

Figures 1A, 2A and 3A illustrate the particle counts (i.e., number of particles per millilitre equal to or greater than 10 microns in size) and the total daily precipitation (as reported for the Ottawa Airport by Environment Canada) for the entire duration of each particle count study at Winchester Wells 5, 6 and Well Site No. 7, respectively.

Figures 1B, 2B and 3B illustrate the particle counts and total daily precipitation during and immediately following a significant precipitation event for the studies at Wells 5, 6 and Well Site No. 7, respectively. Figures 1C, 2C and 3C present the particle counts and total daily precipitation during a dry period during which negligible precipitation occurred.

Winchester Well 5

The number of particles equal to or greater than 10 microns in size measured at Winchester Well 5 were generally less than 100 particles per millilitre with typical counts less than 3 particles per millilitre. Occasional spikes in the particle count data were observed at concentrations up to about 35 particles per millilitre. These spikes were noted both during periods of precipitation and during dry periods. It is considered that such spikes are related to disturbance of sediments in the well or piping when the pump cycles on. Some interruptions in the collection of particle count data were experienced at Well 5 on May 14 to 16, 2002, May 22 to 24, 2002 and May 30 to 31, 2002 due to required maintenance or cleaning of the particle counting equipment.

Anomalous particle count levels were observed on May 13, 2002, during a precipitation event. Between 11:53 am and 2:17 pm on May 13, 2002, particle count concentrations were reported at levels between about 190 and 215 particles per millilitre. These anomalous particle counts are illustrated in Figure 1B-2. In order to investigate any probable causes for these anomalous data, Golder Associates requested pump cycle (i.e., flow) and turbidity data for the same time period from OCWA. A plot of these data is provided in Attachment A. OCWA reported that interruptions to electricity during the time frame in question caused the pump at Winchester Well 5 to cycle on and off continuously over a short period of time. This cycling is evident in the flow plot (bottom series) in Attachment A. A corresponding response in turbidity levels is also evident in the turbidity plot (top series) in Attachment A. Spikes in turbidity levels at the start of each pump cycle can also be observed in Attachment A. This support the hypothesis provided above that regular spikes in particle count levels are related to disturbance of sediments in the well or piping when the pump cycles on.

Precipitation continued following the period of anomalous particle counts observed on May 13, 2002. It is noteworthy that the total precipitation data point plotted for May 14, 2002 is shown on Figures 1A, 1B, 1B-2 and 1C at the *start* of May 14, 2002 when, in fact, this point represents the total precipitation received between 12:00 am and 11:59 pm on May 14, 2002. The corresponding particle counts following the anomalous period on May 13, 2002 and over the course of May 14, 2002, returned to typical levels which are indistinguishable from particle counts at this well during dry periods (i.e., as illustrated in Figure 1C).

As discussed in the April 2002 GUDI report, the presence of thick overburden deposits, including a confining layer consisting of fine grained sediments in the area surrounding Winchester Well 5 likely prevents the direct infiltration of surface water into the underlying bedrock aquifer in which this well is completed. In consideration of the information related to Winchester Well 5 in the April 2002 GUDI report and based on the results of the particle count study at Well 5, it is concluded that the aquifer is providing effective *in situ* filtration.

Winchester Well 6

Consistent particle count data was observed during the particle count study conducted at Winchester Well 6. The number of particles equal to or greater than 10 microns in size measured at Winchester Well 6 were less than 100 particles per millilitre with typical counts less than 1 particle per millilitre. Occasional spikes in the particle count data were observed at concentrations less than 10 particles per millilitre. These spikes were noted both during periods of precipitation and during dry periods. It is considered that such spikes are related to disturbance of sediments in the well or piping when the pump cycles on.

As discussed in the April 2002 GUDI report, the presence of thick overburden deposits, including a confining layer consisting of fine grained sediments in the area surrounding Winchester Well 6 likely prevents the direct infiltration of surface water into the underlying bedrock aquifer in which this well is completed. In consideration of the information related to Winchester Well 6 in the April 2002 GUDI report and based on the results of the particle count study at Well 6, it is concluded that the aquifer is providing effective *in situ* filtration.

Winchester Well Site No. 7

The number of particles equal to or greater than 10 microns in size measured at Winchester Well Site No. 7 were generally less than 100 particles per millilitre with typical counts less than 1 particle per millilitre. Regular spikes in the particle count data were observed at concentrations generally less than 100 particles per millilitre (but occasionally up to about 200 particles per millilitre). One anomalous particle count spike was observed on June 4, 2002 at concentrations up to about 1700 particles per millilitre. The particle count spikes were noted both during periods of precipitation and during dry periods and were short in duration (generally less than 5 minutes). It is considered that such spikes are related to disturbance of sediments in the well or piping when the pump cycles on.

Possible modifications to the pumping cycle and/or equipment may help to eliminate or decrease the magnitude of the particle count spikes observed at Well Site No. 7 related to the pumping cycle. The concern with high particle counts is primarily related to the potential inefficiency of chlorine to disinfect bacteria that form or are part of organic particles. A cost-effective way to potentially discount this concern may be to examine a sample of the particles with a Scanning Electron Microscope (SEM). This type of analysis can distinguish organic particles from inorganic particles. Demonstration that the particles contained in the spikes are primarily inorganic would discount the significance of the particle count spikes observed at Well Site No. 7. Based on the nature of the geological setting of Well Site No. 7, with wells screened in a sand and gravel aquifer, it is considered probable that the particles contained in the particle count spikes are, in fact, inorganic.

In consideration of the information related to Winchester Well Site No. 7 in the April 2002 GUDI report and based on the results of the particle count study at Well Site No. 7, it is concluded that the aquifer is providing effective *in situ* filtration.

We trust this addendum letter, in conjunction with the April 2002 GUDI report, presents an adequate evaluation on the potential for each of the seven municipal wells from which the water supply for the Village of Winchester, Ontario is derived to be under the direct influence of surface water, as defined by the MOE terms of reference. If you have any questions or concerns, please do not hesitate to contact the undersigned.

Yours truly,

GOLDER ASSOCIATES LTD.

P.A.S. Benson, P.Eng.
Environmental Engineer

B.J. Velderman, M.Sc., P.Geol.
Senior Hydrogeologist/Associate

PASB:BJV:cr:dc
n:\active\2700\021-2748 north dundas gudi studies\ltr-008 02aug27 winchester addendum.doc

Attachments

c.c.: Ministry of the Environment - Toronto (2 copies)
Blair Henderson, Ontario Clean Water Agency, Chesterville, Ontario
Fern Dicaire, Stantec Consulting Ltd., Ottawa, Ontario

FIGURE 1A
Particle Count Results
Winchester Well No. 5

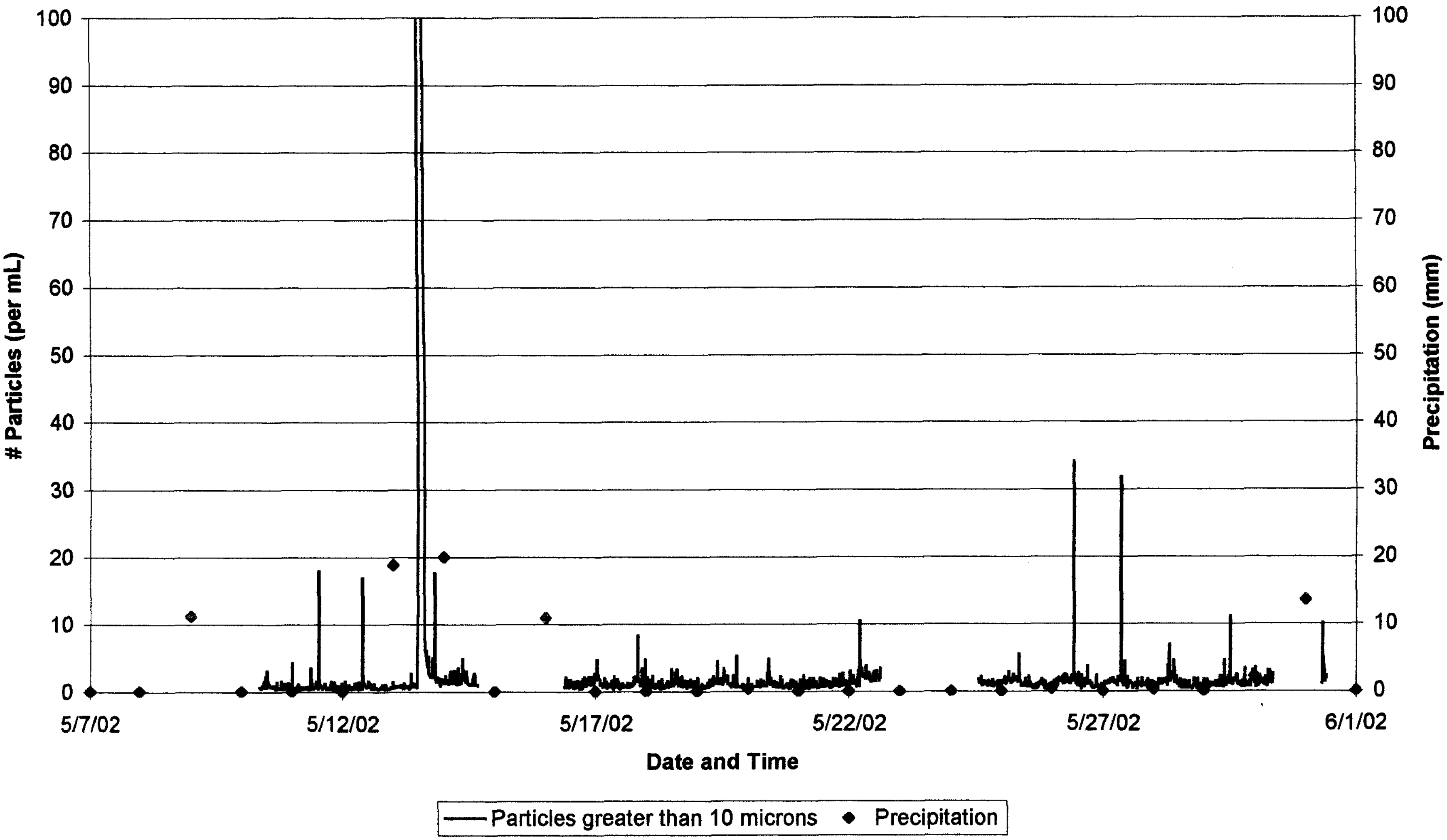


FIGURE 1B
Particle Counts During Precipitation Period
Winchester Well No. 5

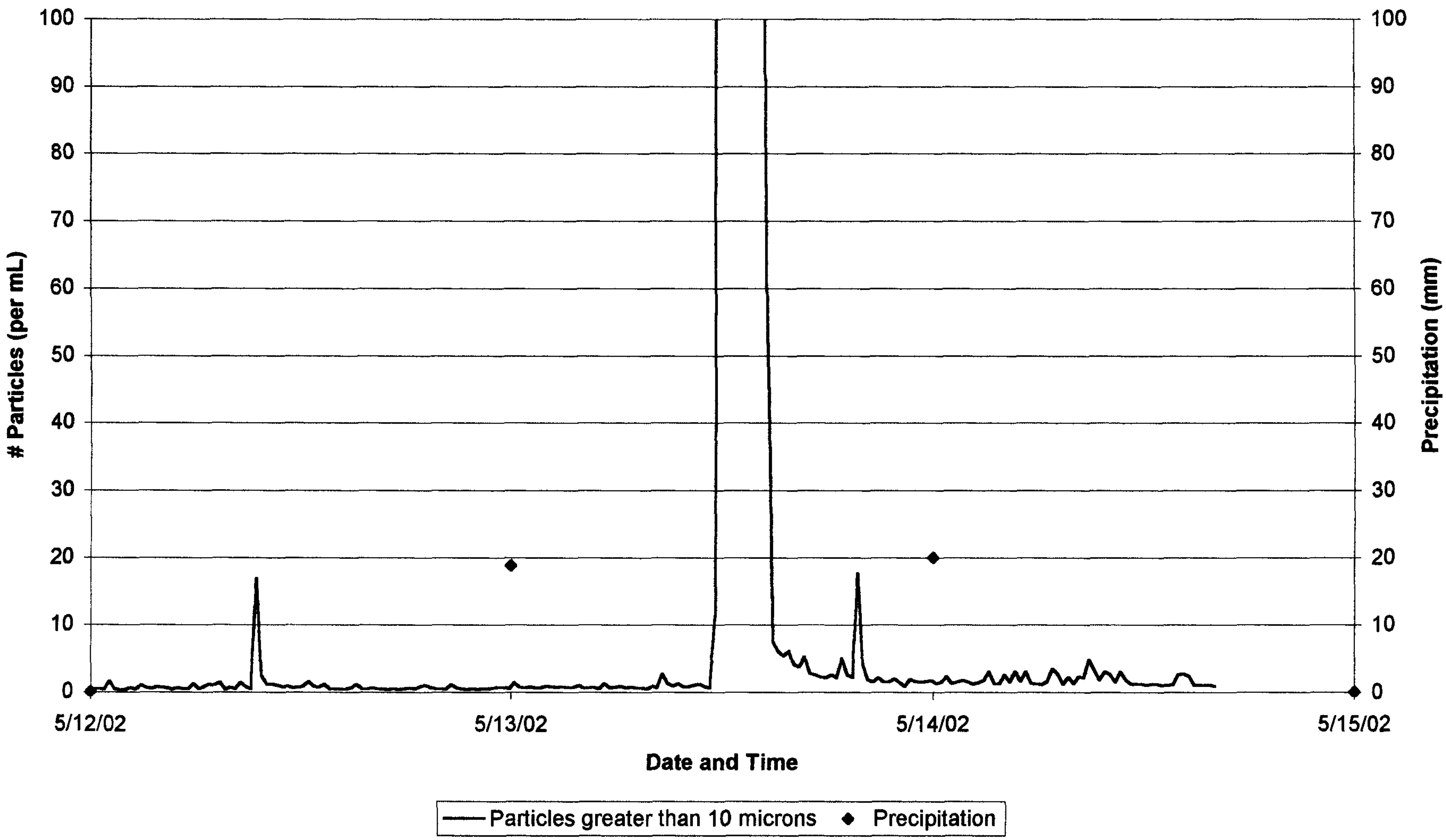


FIGURE 1B-2
Particle Counts During Precipitation Period
Winchester Well No. 5

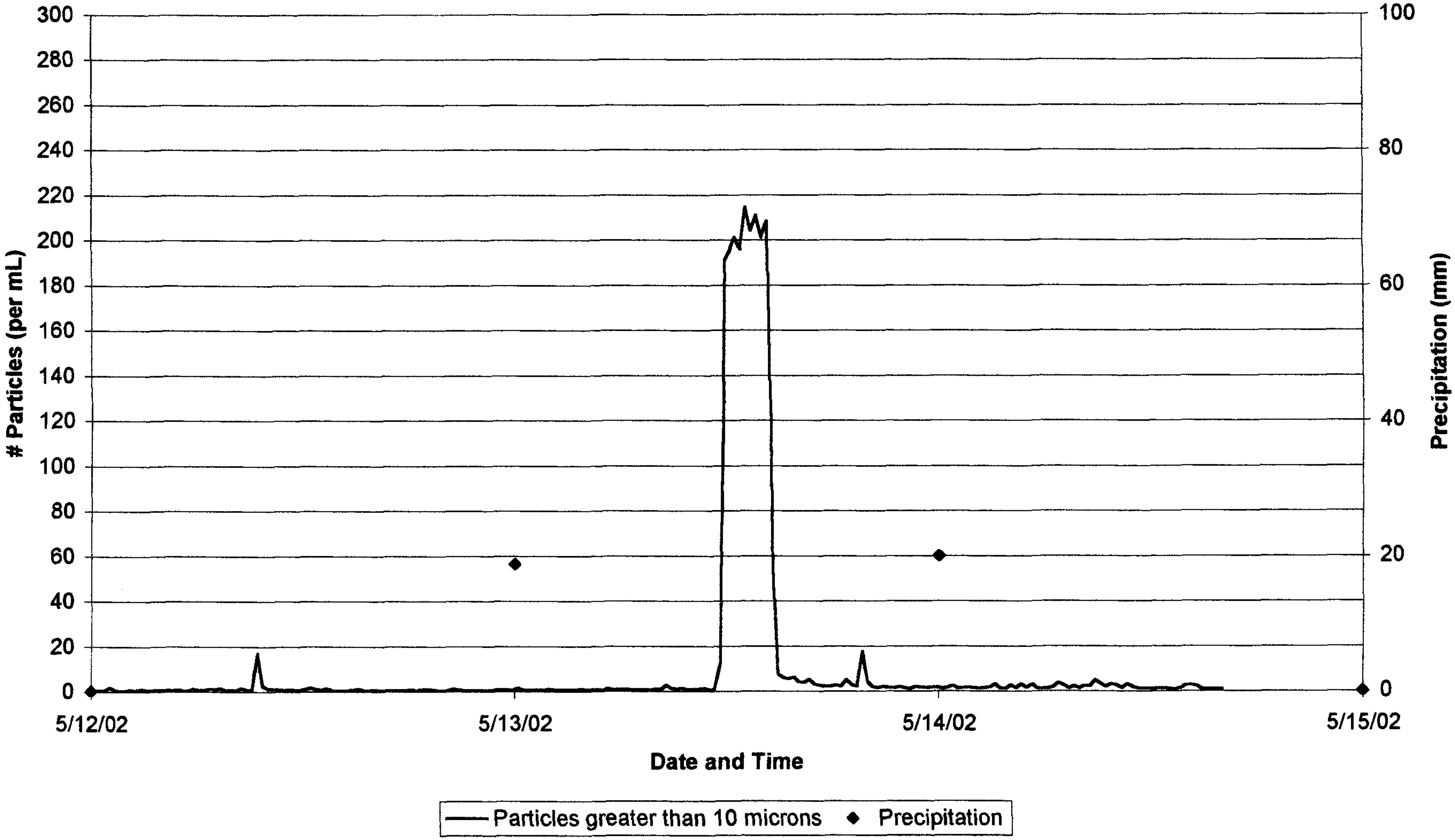


FIGURE 1C
Particle Counts During Dry Period
Winchester Well No. 5

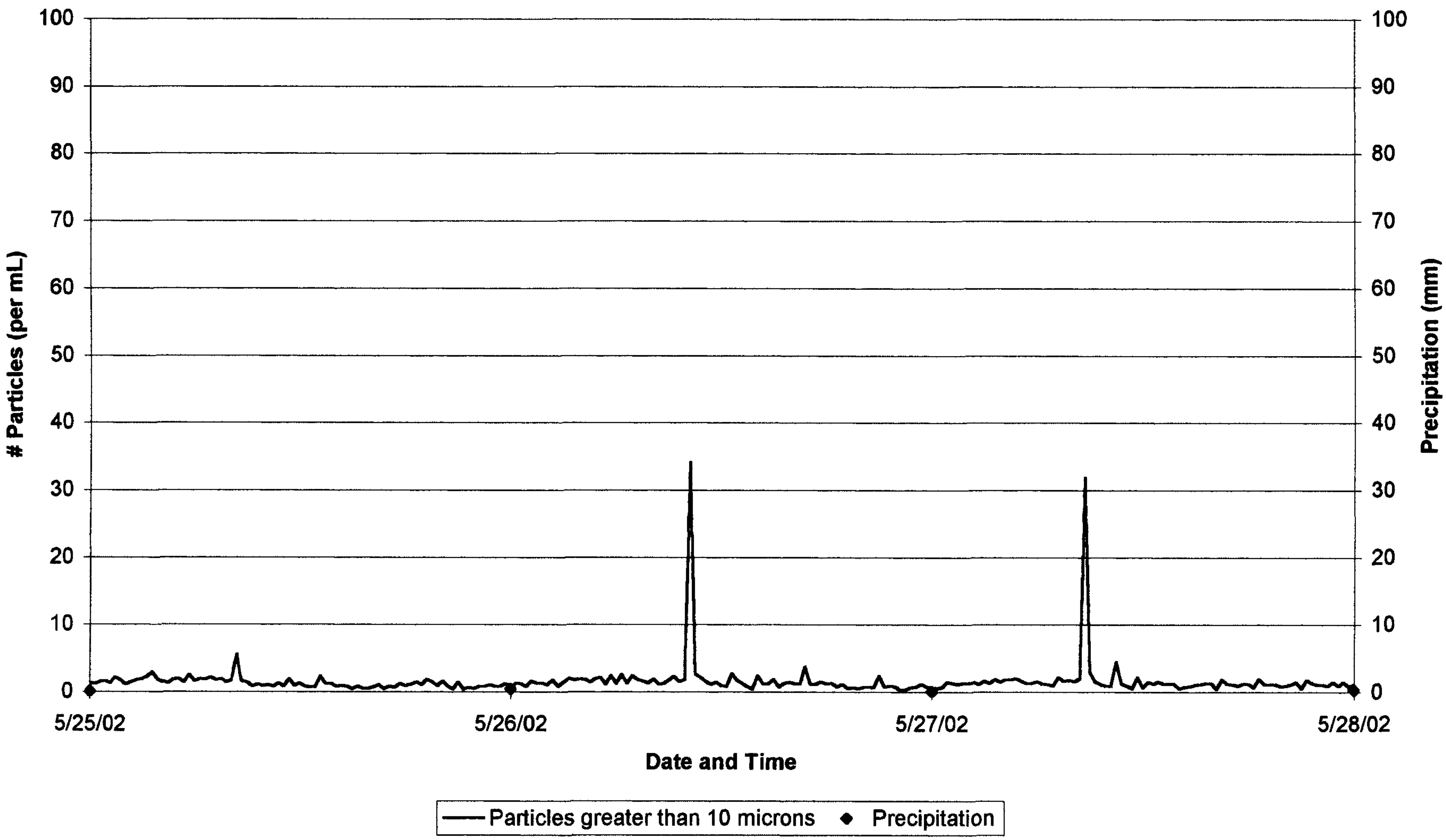


FIGURE 2A
Particle Count Results
Winchester Well No. 6

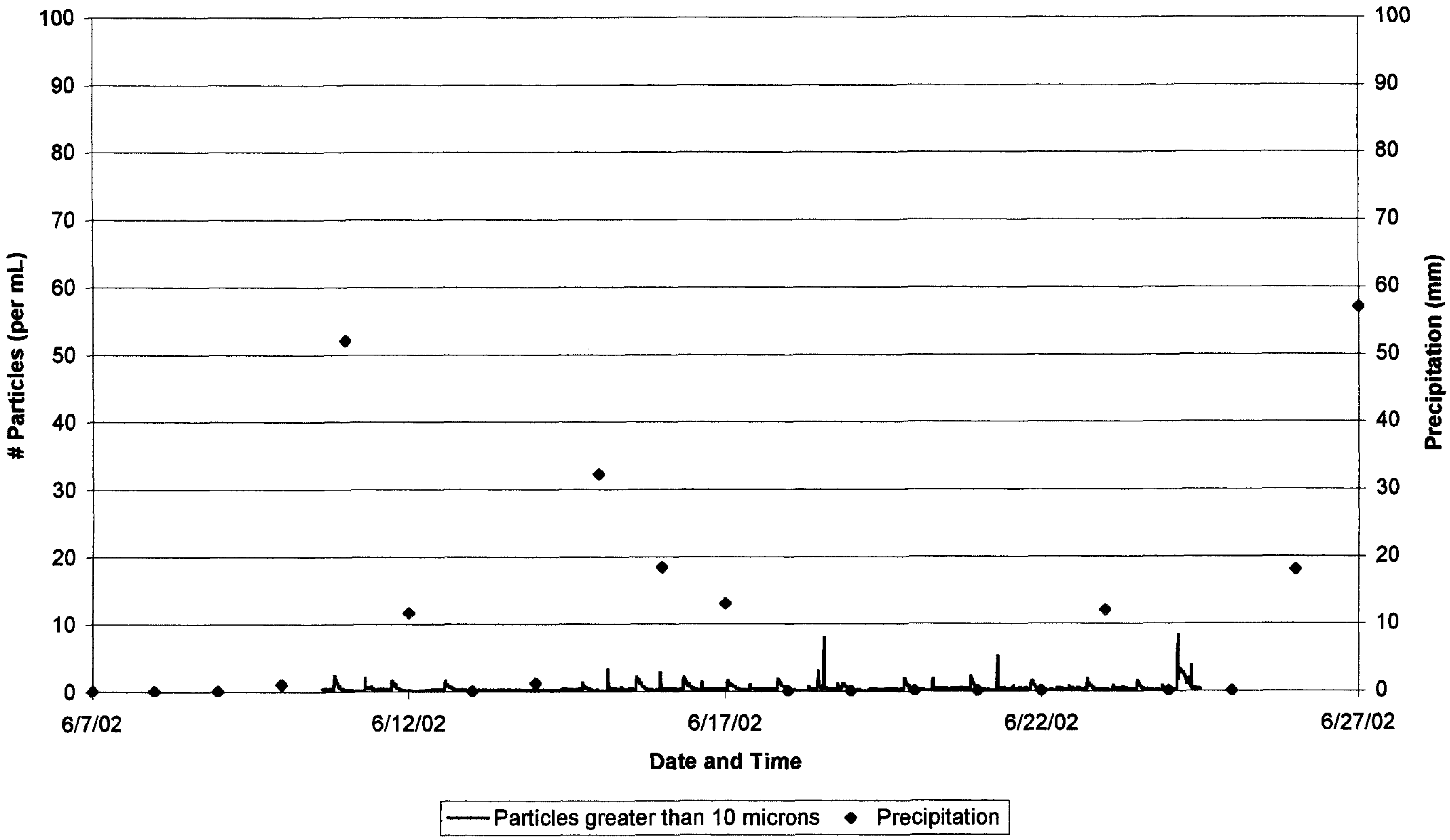


FIGURE 2B
Particle Counts During Precipitation Period
Winchester Well No. 6

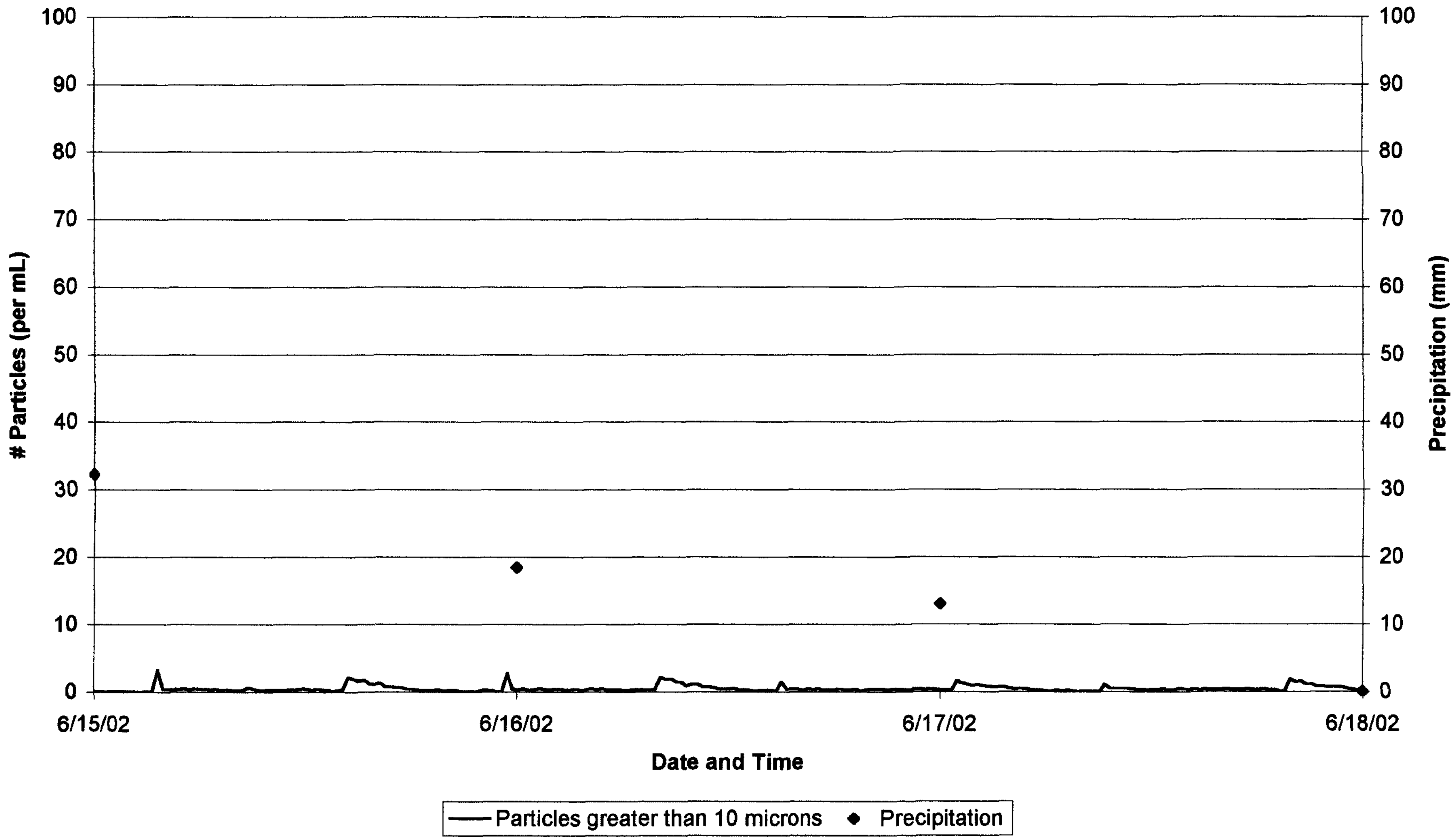


FIGURE 2C
Particle Counts During Dry Period
Winchester Well No. 6

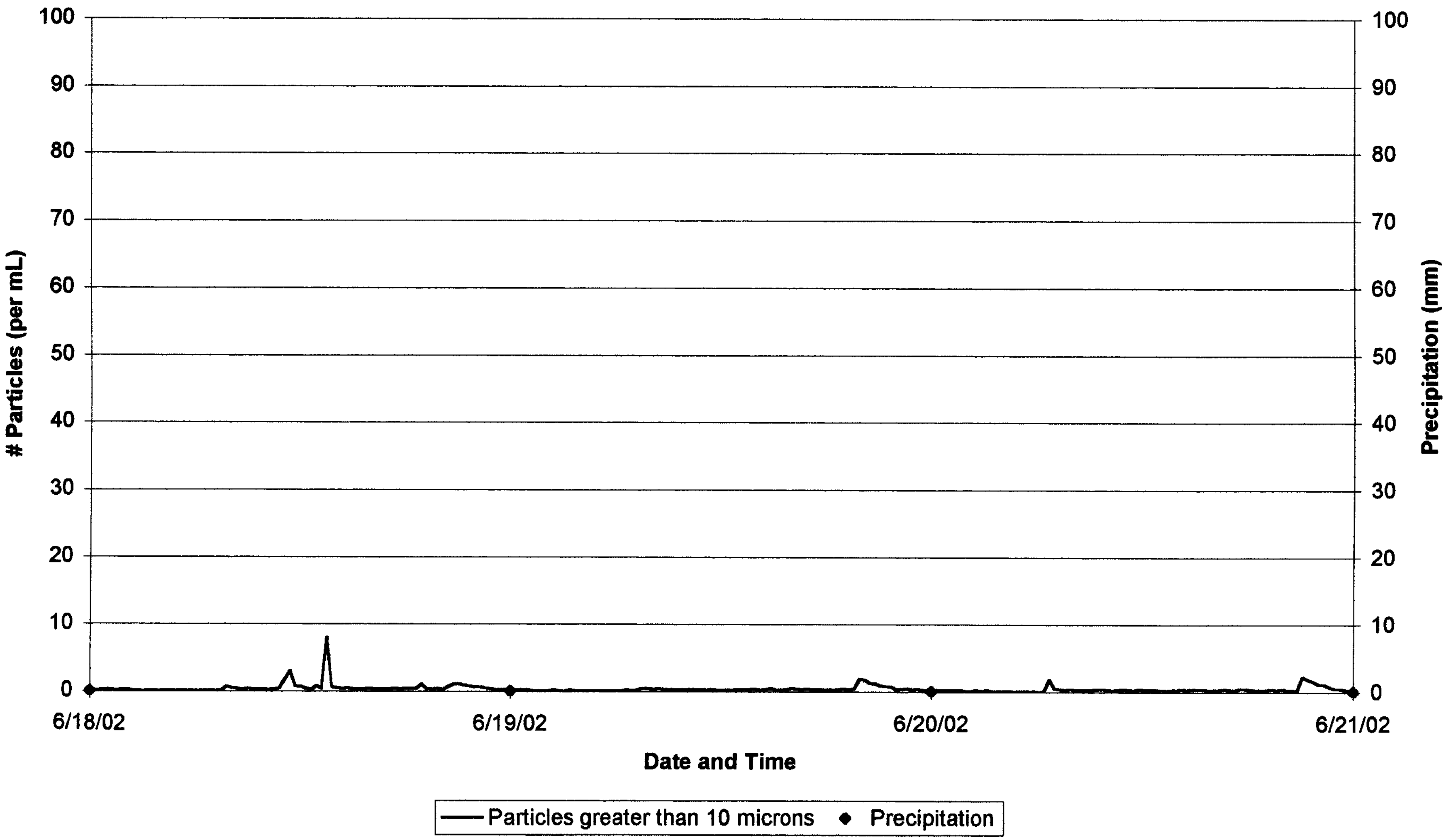


FIGURE 3A
Particle Count Results
Winchester Well Site No. 7

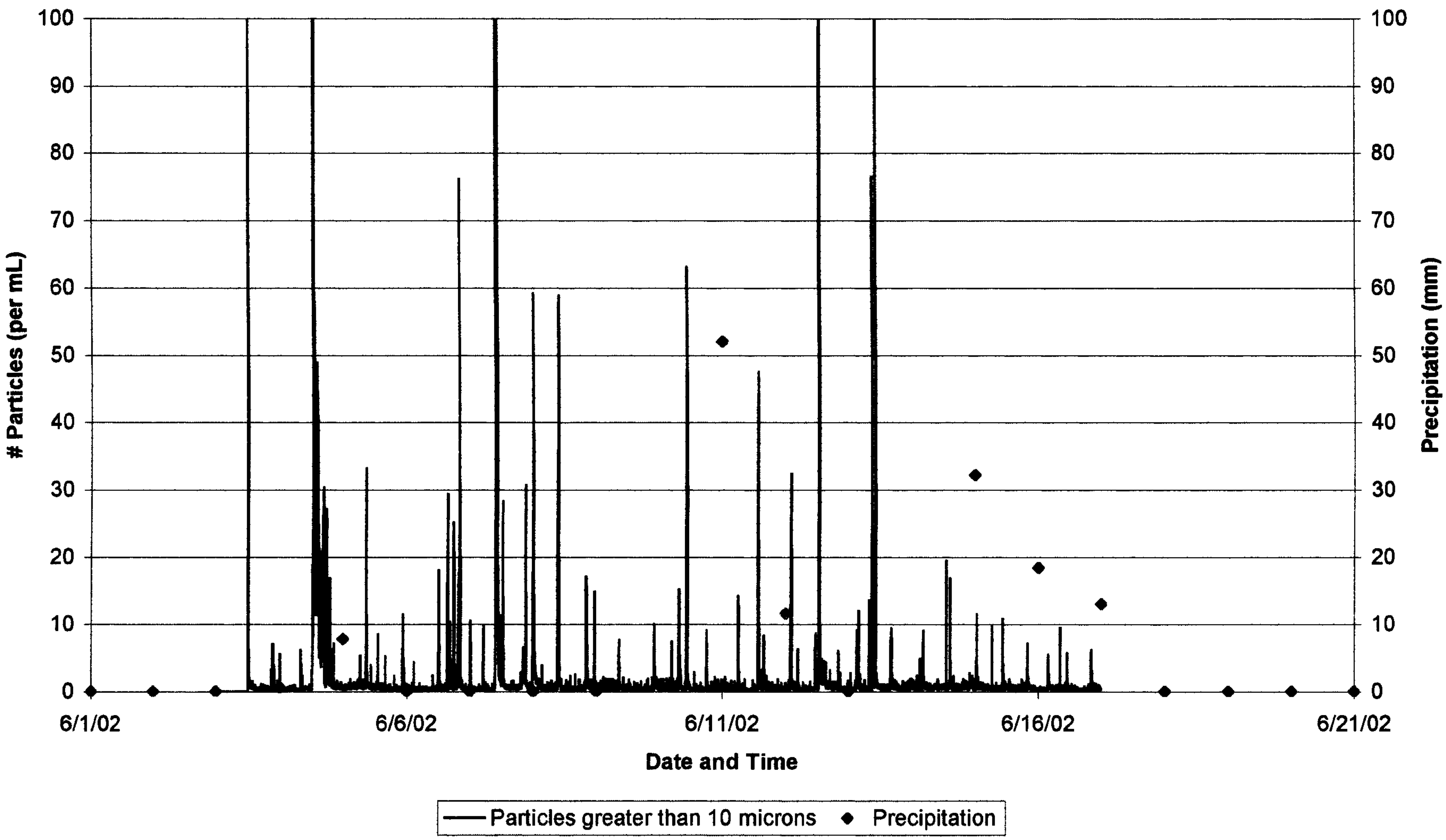


FIGURE 3B
Particle Counts During Precipitation Period
Winchester Well Site No. 7

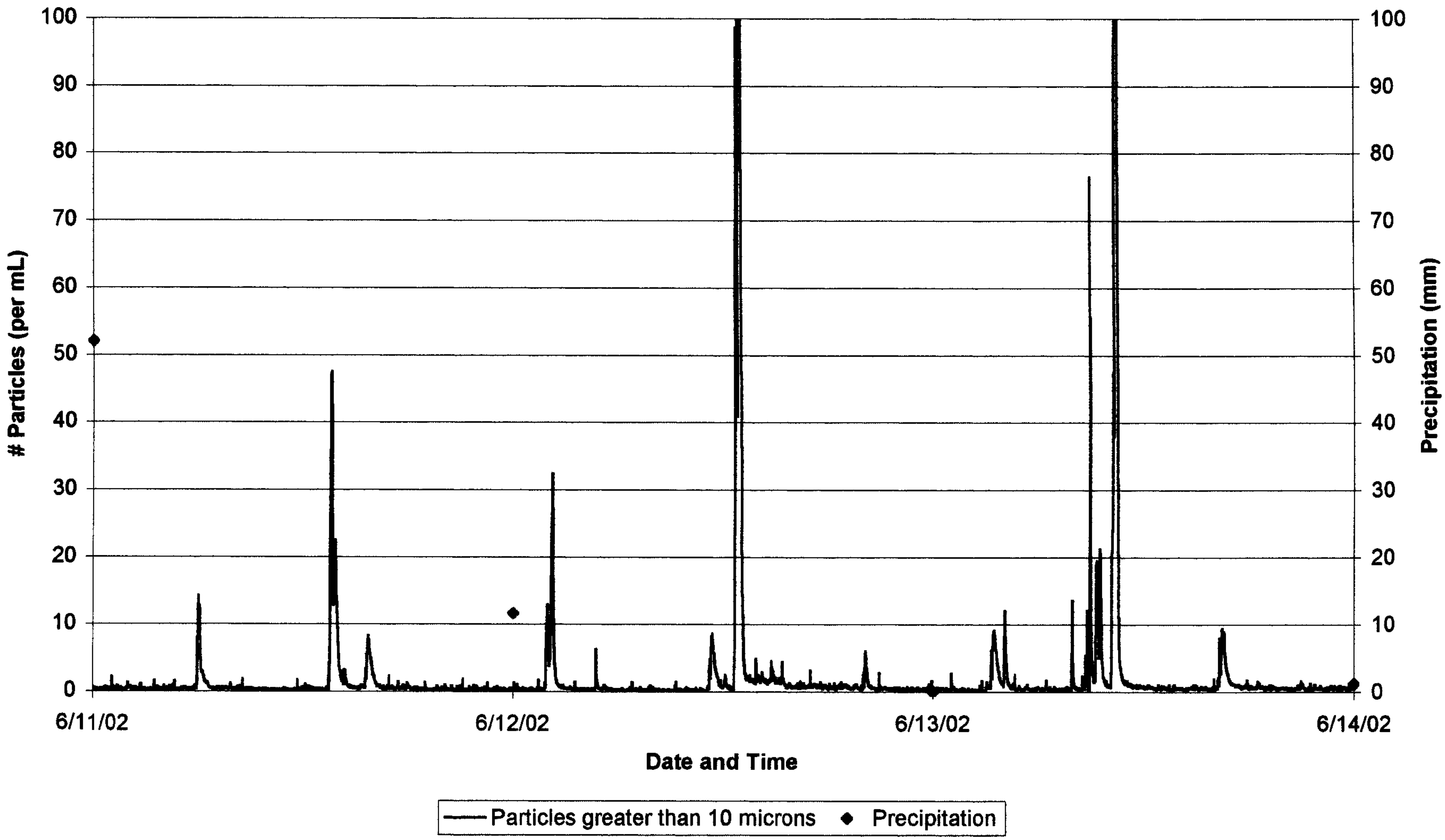
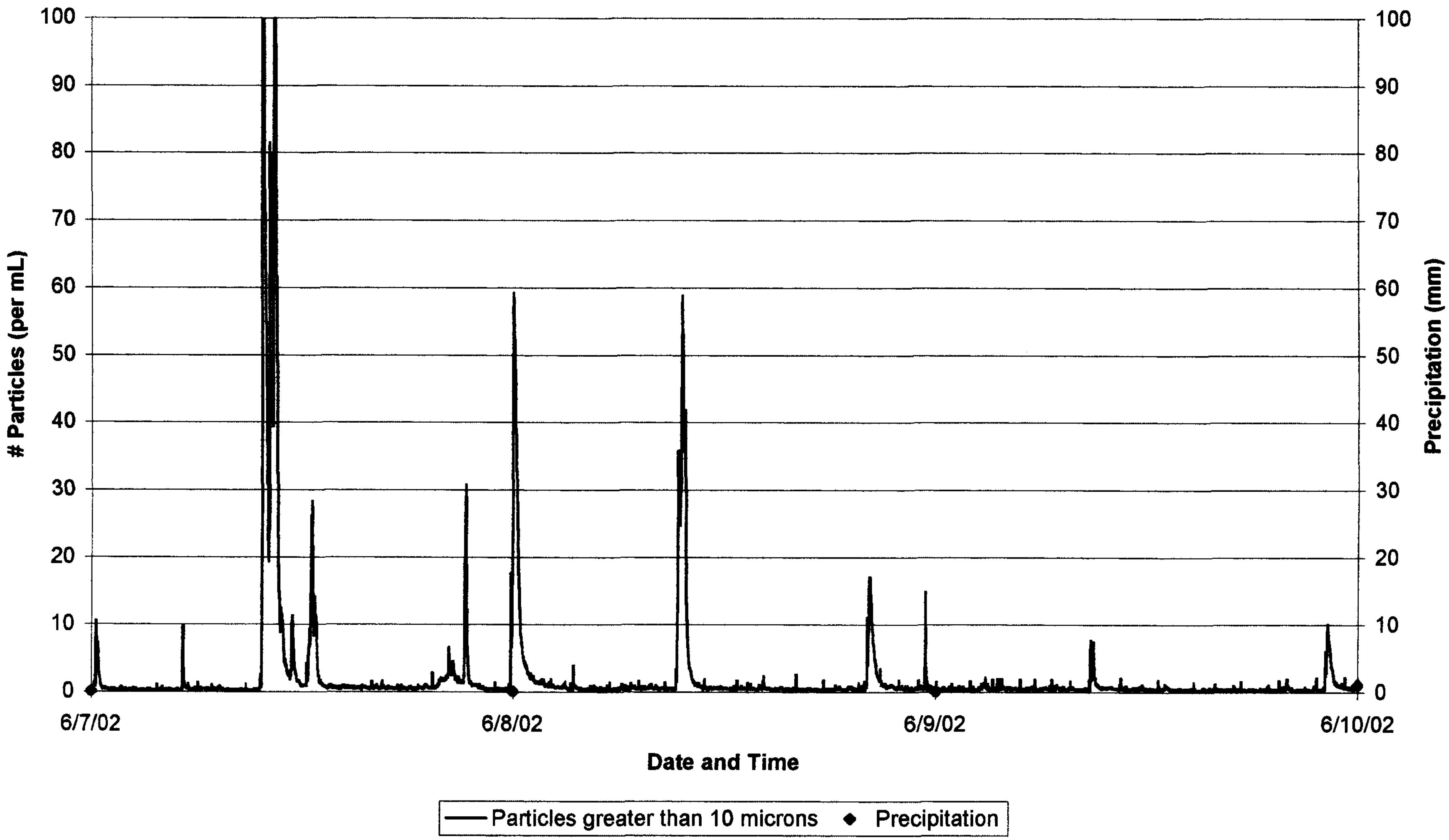


FIGURE 3C
Particle Counts During Dry Period
Winchester Well Site No. 7

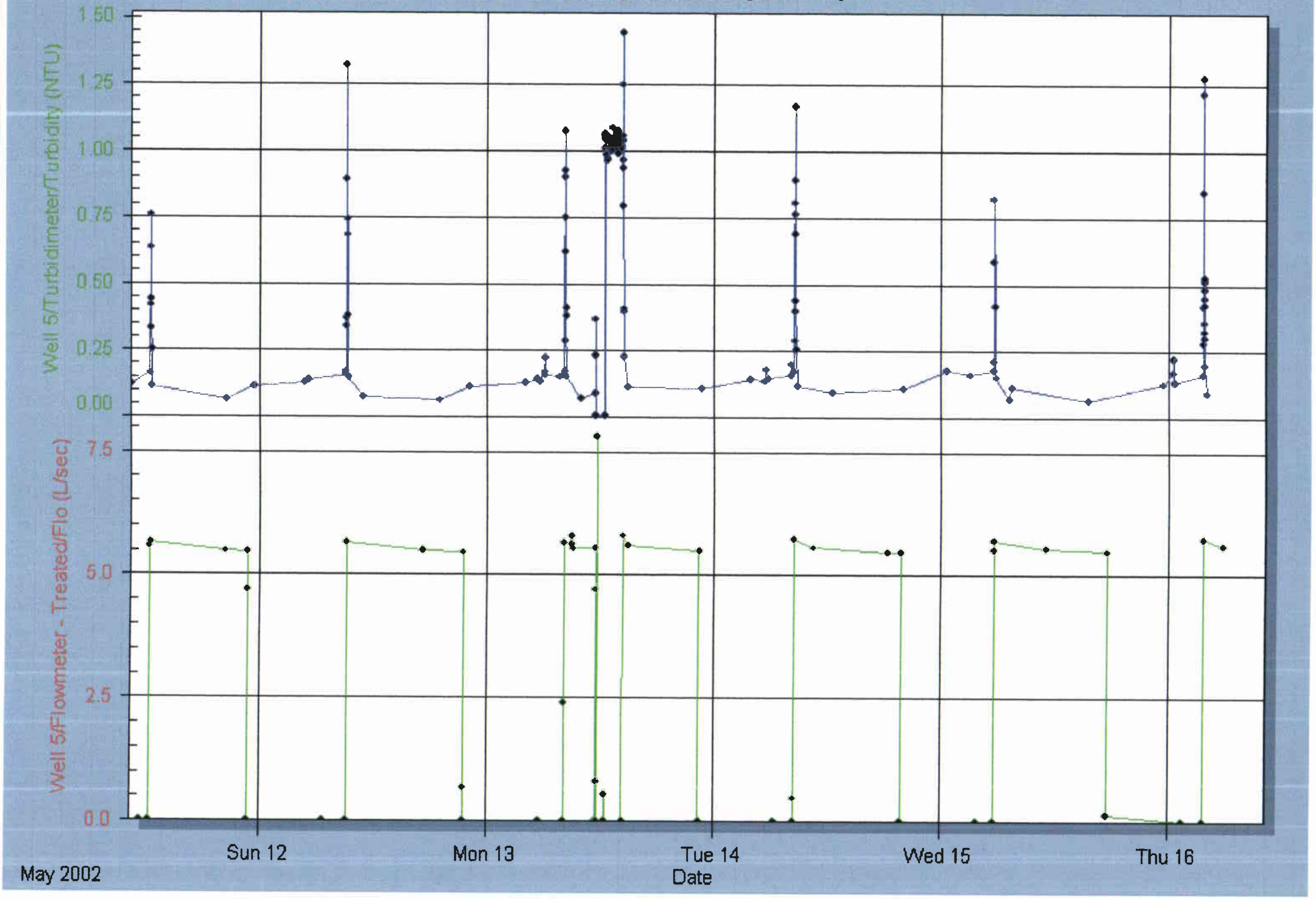


ATTACHMENT A

TURBIDITY AND FLOW DATA
MAY 12 TO MAY 16, 2002
WINCHESTER WELL 5

Outpost 5 Trending

Wednesday, August 28, 2002 [10:20:42]



Golder Associates Ltd.

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Ottawa, Ontario, Canada K2C 2B5
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Fax (613) 224-9928

Golder Associates

October 4, 2002

021-2748

Township of North Dundas
636 St. Lawrence Street
P.O. Box 489
Winchester, Ontario
K0C 2K0

Attention: Mr. Howard Smith

RE: INTERPRETATION OF MOE GUDI TERMS OF REFERENCE WITH RESPECT TO WINCHESTER AND CHESTERVILLE WATER SUPPLY WELLS, TOWNSHIP OF NORTH DUNDAS, ONTARIO

Dear Sir:

Following the Groundwater Under Direct Influence of Surface Water (GUDI) studies completed by Golder Associates for the Winchester and Chesterville water supply wells, it was concluded that Winchester Wells 5, 6 and 7a and Chesterville Wells 5-production and 5-standby were potentially under the direct influence of surface water, based on the Ministry of the Environment (MOE) document "Terms of Reference for Hydrogeological Study to Examine Groundwater Sources Potentially Under Direct Influence of Surface Water" (hereafter referred to as "the MOE terms of reference", Ministry of the Environment, October 2001).

Background

Section 2.0 of the MOE terms of reference states:

Potential GUDI wells will be considered to be under the direct influence of surface water unless this hydrogeological study proves otherwise to the satisfaction of the Director. In accordance with the Ontario Drinking Water Standards, water from GUDI wells must receive chemically assisted filtration and disinfection (or equivalent treatment process) unless this hydrogeological study shows, to the satisfaction of the Director, that the aquifer is providing effective in situ filtration.

As such, particle count studies were initiated at the above wells in accordance with Section 3.5 of the MOE terms of reference. Subsequent to completion of the particle count studies, addendum letters were issued by Golder Associates on August 30, 2002 summarizing the results of the particle count studies and concluding that the aquifers servicing each of the wells flagged as potentially under the direct influence of surface water were providing effective in situ filtration.

Golder Associates inferred from the statement in Section 2.0 of the MOE terms of reference (stated above) that determination of effective in situ filtration provided supporting evidence that the wells were not under the direct influence of surface water. As such, concluding statements for each of the wells in question were provided by Golder Associates in the August 30, 2002 letters indicating that the wells were interpreted to not be under the direct influence of surface water.

Ministry of the Environment

Following discussions with Mr. Jim Gehrells of MOE on September 5, 2002, Golder Associates deleted the statements concluding that the wells were not under the direct influence of surface water and re-issued the text from the August 30, 2002 on September 10, 2002. The re-issued letters essentially concluded only that the aquifers servicing each of the wells flagged as potentially under the direct influence of surface water were providing effective in situ filtration.

A follow-up call was made by Golder Associates to Mr. Gehrells on September 18, 2002 to gain a better appreciation for the MOE's position on water supply wells that have been determined to be potentially under the direct influence of surface water in accordance with the MOE terms of reference. The following summarizes our understanding of the MOE's position, based on our discussions with Mr. Gehrells.

Demonstration that an aquifer is providing effective in situ filtration does not change the assessment that a well is potentially under the direct influence of surface water if a well is flagged as such, based on the criteria outlined in the MOE terms of reference. Demonstration of effective in situ filtration only addresses the question of whether or not chemically assisted filtration is required. Mr. Gehrells indicated that disinfection will need to be provided for wells that are considered to be potentially under the direct influence of surface water, regardless of whether or not the aquifer provides effective in situ filtration. It was further indicated that the MOE will be issuing amending conditions to the Consolidated Certificates of Approval outlining the disinfection requirements, as appropriate. The disinfection contemplated by MOE may include treatment by ultraviolet light or increased chlorine contact time.

Golder Associates does not consider that the MOE's position on disinfection was clear in the MOE terms of reference, and that their position contradicts the statement in Section 2.0, indicated above, that "water from GUDI wells must receive chemically assisted filtration ***and disinfection***" unless effective in situ filtration can be demonstrated.

Golder Associates' Opinion with Regard to Winchester Wells 5 and 6

Winchester Wells 5 and 6 were concluded to be potentially under the direct influence of surface water, according to the MOE terms of reference, due to the fact that they are bedrock wells located within 500 metres of surface water and are drawing water from formations that are less than 15 metres below the ground surface.

The surface water bodies identified within 500 metres of Winchester Well 5 included a small municipal drain, located approximately 300 metres north of the well and a small wetland (approximately 300 metres in diameter), located about 500 metres north-west of the well. The first of three water bearing zones at Winchester Well 5 was reported at the time of drilling to be between depths of 14 and 16 metres (i.e., very close to the 15-metre criteria in the MOE terms of reference).

The surface water bodies identified within 500 metres of Winchester Well 6 included a small watercourse located approximately 200 metres east of the well and man-made irrigation ponds located approximately 450 metres wells of the well. The only water bearing zone identified at Winchester Well 6 at the time of drilling was at a depth of between 12 and 15.2 metres.

A thick overburden deposit is present in the vicinity of Winchester Wells 5 and 6 (up to about 15 metres over most of the areas within a one kilometre radius of Wells 5 and 6,), including a confining layer of fine grained sediments (with a thickness of at least 3 metres in most areas). The thick overburden and confining layer is expected to prevent the direct infiltration of surface water into the underlying bedrock aquifer in which these wells are completed.

The studies by Golder have shown that these wells have dependable subsurface filtration of surface water and infiltration. Based on the existing hydrogeological setting of Winchester Wells 5 and 6 and on the results of the particle count studies conducted at these wells, it is our opinion that these wells should not be considered to be under the direct influence of surface water. (The definition of Groundwater Under the Direct Influence of Surface Water (GUDI) means groundwater having incomplete/undependable surface filtration of surface water and infiltration).

Golder's Opinion with Regard to Winchester Well 7a and Chesterville Well 5

Winchester Well 7a and the wells at Chesterville Well Site No. 5 were concluded to be potentially under the direct influence of surface water, according to the MOE terms of reference, due to the fact that they are overburden wells located within 100 metres of surface water with static water levels less than 15 metres below ground surface.

The nearest surface water bodies to Chesterville Well Site No. 5 and Wichester Well Site No. 7 are small man-made ponds derived as a result of excavation below the groundwater table. The distance from the closest of these ponds to Chesterville Well 5-production and Winchester Well 7a is about 80 metres and 100 metres, respectively (i.e., close to the 100 metre criteria for overburden wells in the MOE terms of reference).

The studies by Golder have shown that these wells have dependable subsurface filtration of surface water and infiltration. Based on the results of the particle count studies conducted at Winchester Well Site No. 7 and Chesterville Well Site No. 5, it is our opinion that under the existing conditions, these wells should not be considered to be under the direct influence of surface water.

We appreciate the intent of the MOE terms of reference but offer, however, that the generalizations made (e.g., proximity to surface water bodies) are not entirely appropriate for the specific wells discussed in this letter.

Yours truly,

GOLDER ASSOCIATES LTD.

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