

# Preliminary investigation of the impact of recent development on the quantity and quality of Susquehanna River Water along the Route 28 Corridor, Hartwick, New York

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## ABSTRACT

The recent development of a baseball-oriented tourist industry along the Route 28 corridor through Hartwick, New York, has raised the concerns of local residents about the impact of industry-related water use on the quantity and quality of future groundwater resources. Because groundwater and surface waters are directly connected to one another, this study used observations from the Susquehanna River parallel to the Route 28 corridor to identify changes in groundwater quality and quantity. Observations were made and water samples were collected at four points along the Susquehanna River on 15 August 06, while the Cooperstown Dreams Park was in session: two sites were upstream of the Dreams Park facility and two were at or below it. The number of fecal coliform colonies rose sharply between the upstream and downstream sites which may have an impact on water quality. The source of this increase may be the septic system on the Dreams Park property or runoff from adjacent agricultural lands that contain livestock waste. River discharge also decreased slightly between the upstream and downstream sites suggesting that the Susquehanna is losing water to the groundwater system in the vicinity of the Dreams Park property. The most likely causes of this change in discharge are groundwater pumping wells near the Dreams Park property which are either owned by Dreams Park or an adjacent land owner. Two buildings were observed on the banks of the river on the Dreams park property which may be pump houses. More data are needed to explore these possibilities. This study recommends that weekly sampling for the same parameters be conducted during the summer of 2007, that a groundwater modeling study be developed to best quantify the impacts of new pumping wells on the volume of groundwater locally available, and that the modeling study be used to create drought management strategy for the Route 28 corridor in partnership with local and county regulators.

## INTRODUCTION

The burgeoning development of the tourism industry along State Highway Route 28 through the Town of Hartwick, New York, herein called the “Route 28 corridor,” has raised the concerns of area residents that the activities of the tourist industry may be excessively depleting the quantity of local groundwater resources and/or degrading the quality of these resources (Figure 1). Of particular concern is a baseball summer camp facility called “Cooperstown Dreams Park” which pumps water from the local groundwater aquifer to irrigate baseball fields and to supply drinking water and sanitation facilities for an estimated 14,000 players and coaches living on site over an 11 week period between June and August (Harris, personal interview, 2006). Irrigation water returning to the groundwater below the site potentially contains plant

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fertilizer including nitrates (NO<sub>3</sub>) and phosphates (PO<sub>4</sub>) as well as industrial herbicides and pesticides, whereas leachate from the facility's septic system may contain microorganisms called fecal coliforms, plus nitrate. Surrounding agricultural and domestic land use may also contribute fertilizers, fecal coliforms, pesticides and herbicides to groundwater and surface water, and most likely farms and homes along the Route 28 corridor affected local water quality to some degree prior to tourism development.

This study uses observations of the water quality and discharge measurements in the Susquehanna River parallel to the Route 28 corridor and inclusive of the Dreams Park facility to interpret changes in the local groundwater system. During rain events, a portion of the rainwater landing upon the ground surface seeps into pore spaces in the soil and eventually increases the volume of groundwater held below the land surface. This groundwater slowly moves downhill through interconnected pore spaces in the sediments that fill the valley and eventually flows into to the Susquehanna River. Because of this connection between groundwater and river water, contaminants added to the groundwater along the Route 28 corridor may cause contaminant concentrations in the Susquehanna River to rise. Moreover, groundwater pumping for agricultural, tourist, and domestic water supplies decreases the volume of groundwater reaching the Susquehanna River which could affect the volume of water flowing down the Susquehanna over time, called "river discharge." If large volumes of groundwater are pumped from the groundwater system or if pumping wells are situated close to the river banks, water will flow from the river into groundwater system, causing a decrease in river discharge over a section of river. For further explanation, see discussions on sustainable yield by Fetter (2001).

In July 2006, the Otsego County Conservation Association, acting on behalf of residents along the Route 28 corridor, requested that Dr. Devin Castendyk, Assistant Professor in the Earth Sciences Department and Water Resources Program Coordinator at the State University of New York, College at Oneonta, investigate the validity of residents' concerns. This report presents the preliminary findings of this investigation and provides recommendation for future study. The specific objectives of this study are as follows:

- (1) Record changes in the discharge of the Susquehanna River upstream and downstream of the Dreams Park site during peak tourist season;
- (2) Record changes in water quality in the Susquehanna River upstream and downstream of the Dreams Park site during peak tourist season;
- (3) Interpret the impact, if any, of the tourist industry on the quantity and quality of local water groundwater resources; and
- (4) Identify current data gaps and propose recommendations for future study.

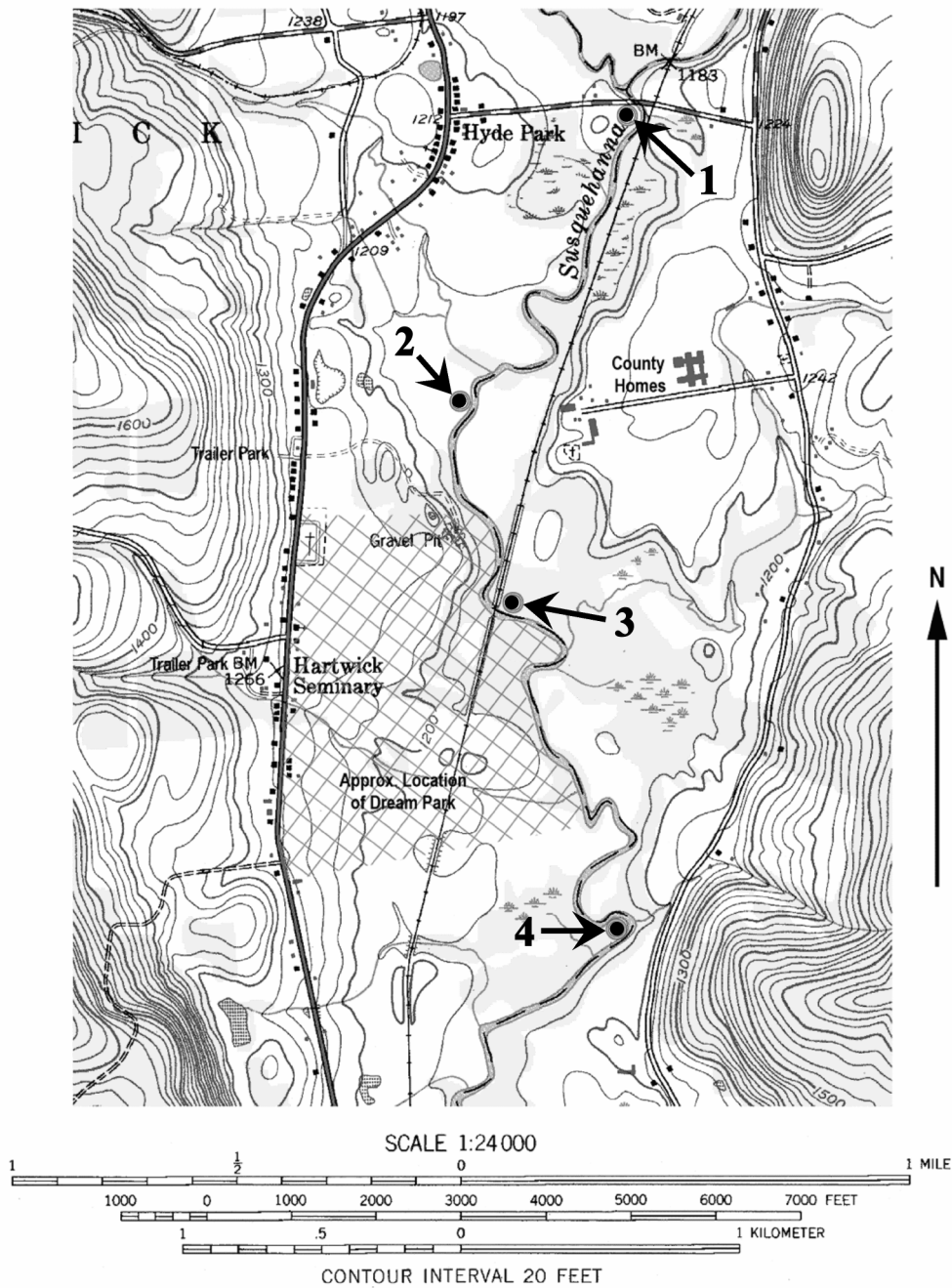


Figure 1. Map of the Route 28 corridor and the Susquehanna River through Hartwick, New York, showing the location of the Dreams Park facility (gray cross-hatching) in relation to study Sites 1 to 4 (numbered purple circles). Modified from U.S. Geological Survey (1974).

## METHODOLOGY

This study was conducted on 15 August 06, which was assumed to correspond to a period of peak of tourist activity, maximum water consumption, and minimum groundwater recharge due to low rainfall. Cheers from spectators at the Dreams Park facility could be heard from the river during sampling, verifying that the facility was in use. Precipitation conditions were slightly less than ideal prior to sampling. Under optimal conditions, river discharge would be measured during a drought period consisting of several weeks without rainfall where groundwater pumping for irrigation would be at a maximum and where groundwater would be the only source of water contributing to the volume of the Susquehanna River, a condition known as “base flow discharge.” Within the 24-hour period prior to sampling, rain gauges at the State University of New York, College at Oneonta recorded 0.43 inches of rainfall; a non-trivial amount of rainfall (Blechman, personal communication 2006). However, little rainfall had occurred over the days prior to sampling such that the discharge measurements should closely approximate base flow conditions.

River observations and water samples were collected at four sample locations on the banks of the Susquehanna River, spaced at approximately 4500 foot intervals, spanning a section of the river above and below the Dreams Park facility (Figure 1). Site 1 situated on the west bank below the confluence of Oaks Creek and the Susquehanna River in Hyde Park, directly below the Route 11C bridge, represented background conditions prior to any impacts by development along the Route 28 corridor and also provided convenient public access to the river. Site 2 was located on the west bank approximately 4500 feet downstream from Site 1, above the Dreams Park facility and roughly parallel to the County Home. One small stream entered the river along the west bank between Sites 1 and 2 but the major gains and losses to river discharge between these points should reflect groundwater input/output. Site 3 was located on the east bank parallel to Dreams Park, approximately 7000 feet from Site 1, immediately downstream of a bridge for the Charlotte Valley Railroad. Patrons at Dreams Park were clearly audible at this location. We observed a small building producing a mechanical noise on the west bank of the river immediately upstream of the railroad bridge which may house a pumping well for Dreams Park. No significant stream inputs entered the river between Sites 2 and 3. A second small building that also produced a mechanical noise was observed shortly after Site 3, and may be a second pumping well for Dreams Park. Site 4, located on the west bank of prominent eastward-bending meander, approximately 11,500 feet downstream of Site 1, represented downstream conditions below the Dreams Park facility. A small stream with notable discharge entered the river immediately above the sample point on the east bank of the river.

Physiochemical observations of river water were recorded at each site, including temperature, electrical conductivity, dissolved oxygen and pH using a YSI multi-parameter probe. Water samples collected at each site were analyzed for fecal coliforms, total dissolved phosphorous (TP), total dissolved nitrogen (TN), combined nitrite and nitrate ( $\text{NO}_2 + \text{NO}_3$ ), and ammonium ( $\text{NH}_4$ ) at laboratory facilities at the SUNY Oneonta Biological Field Station in Cooperstown. One water sample was collected at each site for fecal coliform analysis. The number of fecal coliforms was measured 4 times in each sample and reported as the number of colonies per 100 mL (APHA 1989). One water sample for nutrient analysis was collected at Sites 1 and 2, and duplicate samples were collected at Sites 3 and 4. Nutrients were analyzed

using a Lachat QuickChem FIA+® water autoanalyzer following methods by Ebina et al. (1983), Liao (2001), Liao and Marten (2001) and Pritzlaff (2003).

River discharge was measured at each site using methods described by Dunn and Leopold (1978). The river was divided into 10 foot segments along a transect perpendicular to the direction of river flow and the river velocity was measured at the side of each segment using an electromagnetic flow meter by Marsh-McBirney. Velocities were recorded at a depth equal to approximately 60% of the total river depth. Using the width (ft), the average depth (ft), and the average velocity (ft/sec), the discharge (ft<sup>3</sup>/sec) flowing through each segment was calculated. The total river discharge at each site was equal to the sum of the discharge through each segment.

## RESULTS

The average number of fecal coliform colonies per 100 mL of water increased by 200 colonies between background samples collected above Dreams Park at Sites 1 and 2 and samples collected at Dreams Park and downstream of Dreams Park at Sites 3 and 4, as shown in Figure 2. Two common sources of fecal coliforms include leachate from septic systems and feces from livestock such as cows, sheep, and pigs. Fecal coliforms are a family of water-borne, intestinal bacteria and at least one type of fecal coliform, *E. coli*, is harmful to human health. For example, *E. coli* found on spinach leafs was responsible for recent health epidemics in the United States (Lambert 2006). As such, the number of fecal coliforms colonies in a 100 mL water sample indicates the potential for the water to contain *E. coli* and other harmful bacteria.

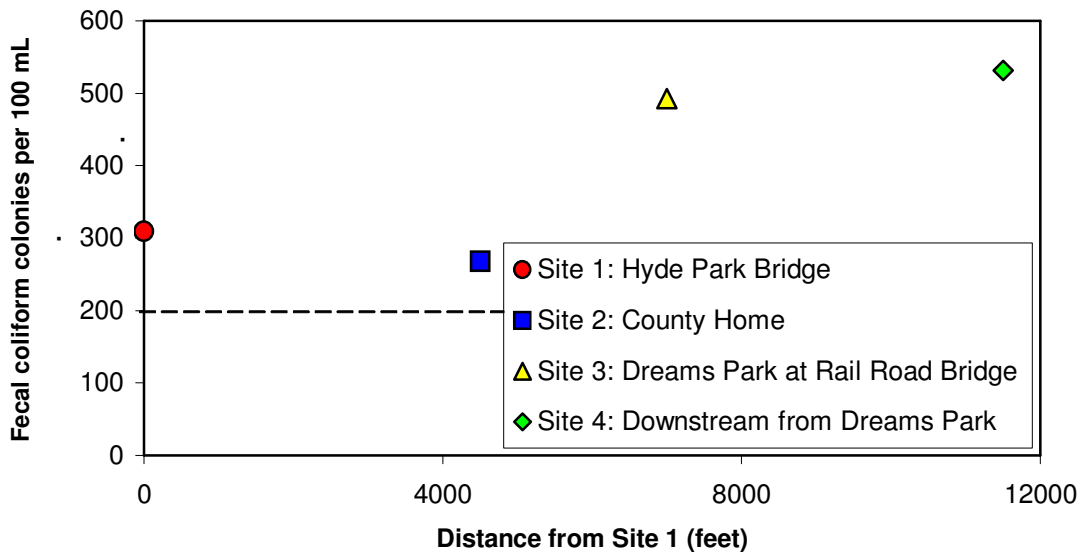


Figure 2. Average number of fecal coliform colonies per 100 mL measured in the Susquehanna River on 15 August 06. Dashed line indicates the New York State water quality standard for the mean of 5 or more samples collected within one month (NYSDEC 1999).

For water classified as “fresh surface water,” the New York State Department of Environmental Conservation (NYSDEC) requires that “The monthly geometric mean [of the number of fecal coliform colonies per 100 mL], from a minimum of five examinations, shall not exceed 200” (NYSDEC, 1999). Though more samples are required to determine compliance with this water quality standard, each of the samples collected on 15 August exceeded 200 colonies per 100 mL and a notable increase in the number of colonies occurred beside the Dreams Park site (Figure 2).

Low nutrient concentrations were observed at each site. Total phosphorous concentrations were relatively constant and ranged from 23.3 to 33.7  $\mu\text{g/L}$  (Figure 3). Total nitrogen concentrations (not shown) were also relatively constant and ranged from 0.027 to 0.037 mg/L. The combined concentration of nitrite ( $\text{NO}_2$ ) and nitrate ( $\text{NO}_3$ ) increased downstream but was well below the New York State water quality standard for fresh surface water of 10 mg/L (NYSDEP 1999). Ammonium ( $\text{NH}_4$ ) concentrations (not shown) were below the instrument detection limit of 0.04 mg/L at each site, and well below the New York State water quality standard for fresh surface water of 2 mg/L (NYSDEP 1999). Sources of nutrients include fertilizer and livestock waste resulting from agricultural land use, and leachate from septic systems.

River discharge increased by 15  $\text{ft}^3/\text{sec}$  over the 4500 feet between Sites 1 and 2, and by 13  $\text{ft}^3/\text{sec}$  over the 4500 feet between Sites 3 and 4 (Figure 5). With the exception of two small streams, no obvious surface water inputs or outputs were observed along the river, suggesting that the observed increases in flow between these points was due to groundwater input. Opposite conditions were observed between Sites 2 and 3, where discharge decreased by 19  $\text{ft}^3/\text{sec}$ , indicating that water is flowing from the river to the groundwater aquifer near the Dreams Park.

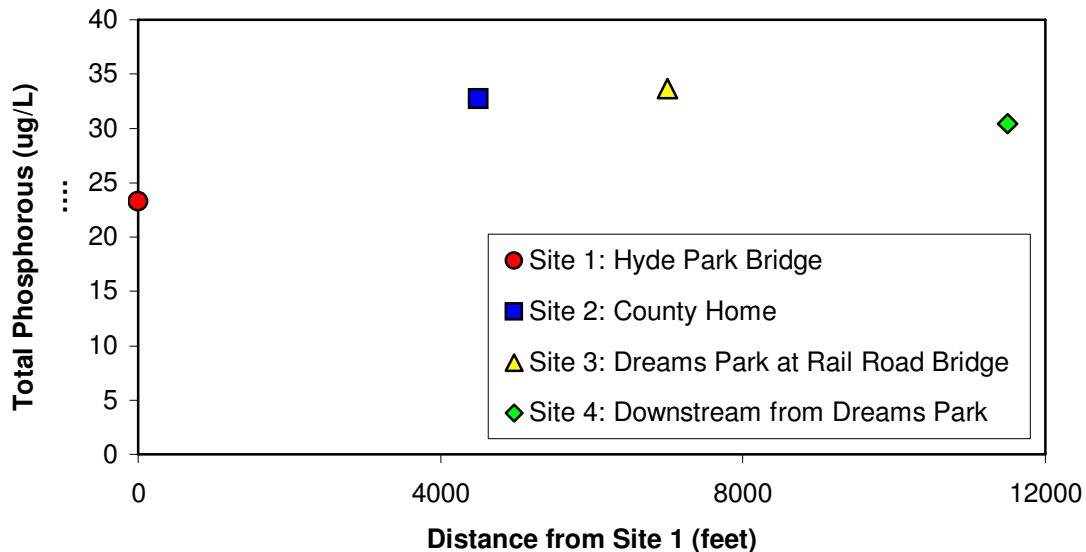


Figure 3. Concentrations of total phosphorous ( $\mu\text{g/L}$ ) measured in the Susquehanna River on 15 August 06.

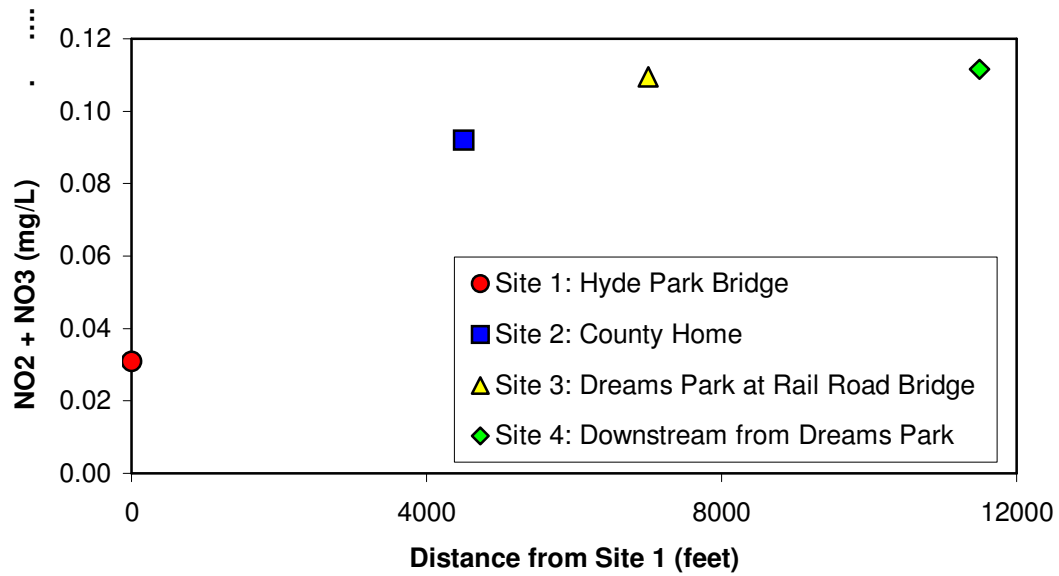


Figure 4. Combined concentrations of nitrite (NO<sub>2</sub>) and nitrate (NO<sub>3</sub>) measured in the Susquehanna River on 15 August 06. Values are well below the New York State water quality standard for fresh surface water of 10 mg/L (NYSDEP 1999).

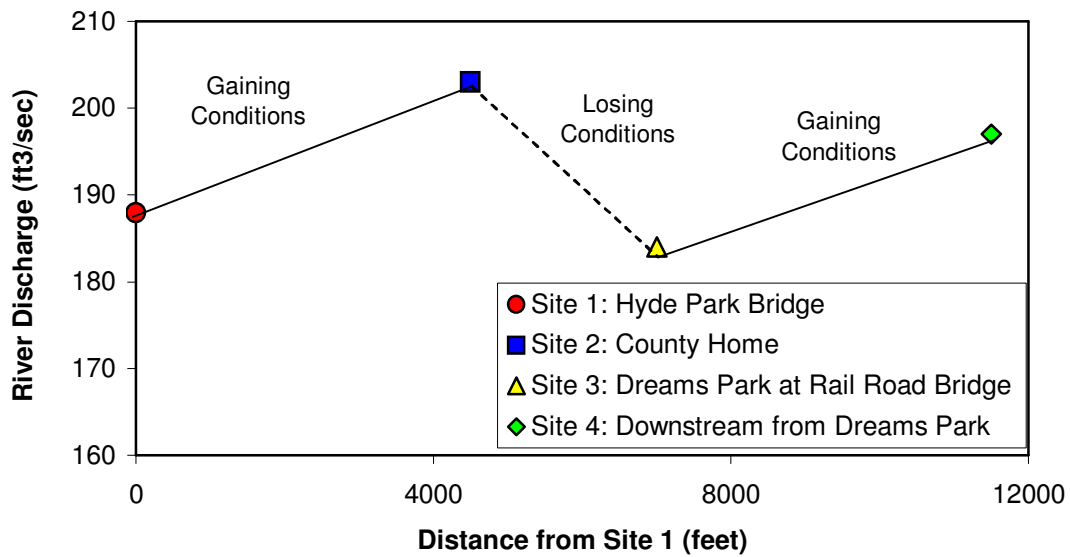


Figure 5. Discharge (ft<sup>3</sup>/sec) of the Susquehanna River measured on 15 August 06. Lines illustrate the change in discharge between each site.

## DISCUSSION AND RECOMMENDATIONS

The most significant findings of this preliminary investigation are the increase in the number fecal coliform colonies (Figure 2) and a decrease in discharge (Figure 5) in the Susquehanna River adjacent to the Dreams Park facility. The source of fecal coliforms may have been either septic systems or agricultural fields containing livestock waste. It is possible that leachate from the Dreams Park septic field increased fecal coliform numbers in the groundwater which drained into the Susquehanna and caused the number of fecal coliforms in the river to increase. Alternatively, agricultural fields adjacent to the Dreams Park facility may have contained livestock waste that washed directly into the Susquehanna during the rain event on 14 August, the day before sampling. Rain water landing on animal waste could also have infiltrated into the groundwater below the agricultural fields which then flowed into the Susquehanna.

To investigate these possibilities, the groundwater on both banks of the Susquehanna River parallel to Dreams Park should be sampled and measured for fecal coliforms between July and August. Wells on the Dreams Park property that are situated close to the river could provide useful groundwater samples (see below). Simple and inexpensive piezometers made of PVC piping could be installed into the river banks and used to obtain groundwater samples where wells do not currently exist. The Susquehanna River along with small streams entering the Susquehanna between Sites 1 and 4 should be sampled at the same time as groundwater wells. New York State Department of Conservation requires a minimum of five samples collected within a one-month period to determine whether fecal coliforms levels exceed the state water quality guideline of 200 colonies per 100 mL (NYSDEC 1999), therefore at least five rounds of sampling should be planned. It should be recognized that the one-day fecal coliform numbers recorded at all four sites already exceeded 200 colonies per 100 mL, and that reporting a water quality infringement to the state may have impacts beyond the local tourist industry, namely the farmers and home owners in the area.

In regard to discharge, several factors can cause a river to change from “gaining” conditions observed between Sites 1 and 2, and 3 and 4, to “losing” conditions observed between Sites 2 and 3, such as climate, geology, and groundwater pumping (Fetter 2001). During prolonged periods of low rainfall, the regional water table adjacent to the river can lower below the river surface elevation, in which case water will flow from the river to the groundwater aquifer. Climate conditions would impact a longer section of the river than explored in this study, and since gaining conditions were observed between Sites 1 and 2, and 3 and 4, climate is unlikely to be responsible. An abrupt, large change in permeability of the sediments underlying the river could also lead to water leaving the river provided the hydrologic gradient sloped away from the river banks. Given the profile of the Susquehanna River Valley through Hartwick, there is no evidence to suggest that the hydrologic gradient naturally slopes away from the river, nor is an abrupt, large change in the permeability of stream sediments likely here. The most likely cause is groundwater pumping.

Pumping water from an aquifer at a greater rate than it can be replaced by groundwater flow creates a “cone of depression,” or dewatered zone, around a well. If the well is located close to a river, the cone of depression can extend to the river causing water to drain from the

river into the aquifer. Whereas no obvious surface water diversions were observed between Sites 2 and 3, two small buildings were observed within 50 feet of the river on the Dreams Park property above and below Site 3 (Figure 5). Judging from the size of these structures and the constant mechanical noise emanating from both, it is possible that these are pump houses. If so, the cone of depression produced by these wells could be responsible for the reduction in the discharge of the Susquehanna River.

The decrease in discharge between Site 2 and 3 could also suggest that the net volume of groundwater withdrawals from the entire Hartwick aquifer system exceeds the net volume of groundwater recharging the upland regions of the aquifer, causing water to flow from the river to the aquifer to match demand. This scenario is less likely because the region receives a considerable amount of rainfall such that a very large amount of water would need to be removed for this to occur. Exploring this question requires more data coupled with detailed groundwater modeling (see below).

Although changes in fecal coliform numbers and river discharge coincide with the location of the Dreams Park property, it would be premature to attribute these changes to Dreams Park without more data. It is possible that these trends are temporally anomalous and do not represent average conditions along this stretch of the Susquehanna over time, that fecal coliforms are generated from a source other than Dreams Park, or that other pumping wells along the river could be producing the observed discharge changes. More observations are needed over time to verify these trends, to determine the cause of these variations, and to determine whether the observed changes constitute a significant impact to the Susquehanna.

The objectives of future research should be as follows: to determine whether changes in fecal coliforms and river discharge only occur between June and August, when Dreams Park is in full operation; to determine whether these changes consistently occur throughout these months; and to determine whether these trends represent significant impacts on the water quality and water quantity of the Susquehanna River. One cost-effective strategy would be to provide funds for the SUNY Oneonta Biological Field Station to employ 2 interns to sample and measure the discharge of the Susquehanna River at the same sites used in this study once a week during the summer of 2007, beginning in late May and concluding in early September. It is important to collect data for at least two weeks on either side of Dreams Park's operational season to establish background conditions in the Susquehanna. While it is essential that fecal coliform analyses be conducted, nutrient analyses should also be performed as future data may prove important. Turbidity may also be explored as these data are useful for water management studies. From a logistical perspective, permission to access the river should be requested from the property owners at the end of Clintonville Road from State Route 33 on the east bank of the river, as this is a convenient river access point.

The best method to investigate the broader concerns of residents (i.e. the impact of recent development on the quantity and quality of groundwater available along the Route 28 corridor), is to develop a groundwater model of the region. Developing an accurate model that provides useful information about available water supplies will require substantial field data and modeling time, both of which can contribute to significant costs. On the other hand, a simple, inexpensive model could be produced that requires minimal real-world data, but the results would have little

value to planners. Some basic model inputs include the location of wells in the study area, the well logs for these wells, the average pumping rates for these wells, and the frequency of well operation. Some of this data may already be in possession of Mary Beth Vargha at the Otsego County Planning Office in Cooperstown, New York. Additional data can be requested by going door to door and requesting data from homeowners. Again, student interns through SUNY Oneonta may be a cost-effective means to obtain this information. A geophysical study using seismic, resistivity and gravity methods could be performed by students in the Earth Sciences Department at SUNY Oneonta to explore the nature and depth of sediments and bedrock below the site. Although a geophysical study could be performed free of charge, this would require site access and a flexible time frame. The results of the geophysical study could be very valuable when compared to available well data. An aquifer pump test would be essential to determine the properties of the aquifer (i.e. transmissivity, hydraulic conductivity, and storativity) and accurately determine model inputs. Finally, data on the average river discharge of the Susquehanna River, precipitation rates, and water levels in observation wells would need to be monitored over time in order to accurately calibrate the model. It may be acceptable to monitor river discharge from the Hyde Park bridge (Site 1) and to use meteorological data from SUNY Oneonta or Cooperstown for model input. As with any modeling exercise, the need for unforeseen data by the modeler should be recognized at the onset if a useful model is to be generated. Ultimately, the model output should be validated using field observation and calibrated if necessary.

The most useful products that can be expected from this modeling study are the identification of domestic wells that have the potential to “go dry” by the development of future wells, and an estimated volume of groundwater reaching the Susquehanna River as a result of groundwater pumping. Those funding this future research should recognize that there is a possibility that the model will show there is enough precipitation landing in the watershed in an average year to supply all the water demands along the Route 28 corridor despite development. This was the conclusion of a group of students from SUNY Oneonta who conducted preliminary water balance calculations for the Route 28 corridor during a class titled GEOL 382 Introduction to Hydrogeology in the fall of 2005. However, these calculations did not consider extremely dry conditions which may occur during a drought.

To increase the value of the model study and help finance the expense, one option is to frame the study in the context of a drought management plan. Determining the potential effects of drought conditions on the water supply along the Route 28 corridor would be timely as the Route 28 corridor is now a major income-generating resource for the county which a drought could threaten, and the potential for a drought may be greater now than in past years given the recent climate variations and the occurrence of extreme weather events such as the Flood of 2006. In fact, precipitation during June and July 06 was 2.5 times the historical mean for this period (Blechman 2007). Such a study could become a valuable management tool if efforts are coordinated with local municipalities and watershed managers, such as the Town of Hartwick, the Otsego County Soil and Water Conservation District and Susquehanna River Basin Commission, to produce a Drought Management Strategy for the Route 28 corridor. Furthermore, framing the groundwater modeling study in the context of drought management has the potential to somewhat reduce animosity between opposing groups by addressing a greater

common concern. Finally, there may be additional funds available from State and Federal sources if a drought management strategy is specified as a goal of the modeling effort.

## CONCLUSIONS

This preliminary investigation has shown that fecal coliform levels increase and river discharge decreases along a section of the Susquehanna River parallel to the Dreams Park facility, even during a summer experiencing precipitation rates 2.5 times of those normal (Blechman 2007). Since the data presented herein only reflect one day of sampling, more data need to be collected over time to see if the same trends occur in the same locations before, during, and after the facilities operational season. The source of fecal coliforms must be objectively identified along with the cause of the water loss. There is also a need to determine whether these changes in water quality and water quantity represent significant changes to the Susquehanna River from a regulatory standpoint. For these reasons, this study recommends weekly sampling at the same sites for the same parameters during the summer of 2007.

The best method to address the residents' concerns over water availability is to create a computer groundwater model of the Route 28 corridor. This will require significant data to minimize the model's assumptions and increase its accuracy, yet some of this data could be obtained from residents or collected by students at minimal cost. One possible option that might increase external funding options and improve relationships between residents, businesses, and municipalities would be to propose a Drought Management Study for the Route 28 corridor to determine water availability, growth potential, and drought indicators, and to prepare an action plan to minimize financial losses during the next major drought.

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## APPENDICES

Appendix 1. Physiochemical and river discharge data measured at Sites 1 through 4 on the Susquehanna River, August 15<sup>th</sup> 2006.

<b>Parameter</b>	<b>Site 1</b>	<b>Site 2</b>	<b>Site 3</b>	<b>Site 4</b>
Temperature (°C)	22.2	22.7	22.8	22.7
Conductivity (µS/cm)	0.32	0.31	0.31	0.31
Dissolved Oxygen (mg/L)	8.7	8.3	8.6	8.4
pH	8.4	8.4	8.4	8.4
River Discharge (ft <sup>3</sup> /sec)	188	203	184	197

Appendix 2. Fecal coliform data collected from Sites 1 through 4 on the Susquehanna River, on August 15<sup>th</sup>, 2006.

<b>Sample Number</b>	<b>Sample volume (mL)</b>	<b># Colonies per sample volume</b>	<b># Colonies per 100 mL</b>	<b>Average # colonies per 100 mL</b>
<b>Site 1</b>	5	18	360	310
	10	33	330	
	50	128	256	
	100	294	294	
<b>Site 2</b>	5	19	380	269
	10	28	280	
	50	99	198	
	100	216	216	
<b>Site 3</b>	5	21	420	493
	10	67	670	
	50	225	450	
	100	430	430	
<b>Site 4</b>	5	29	580	532
	10	73	730	
	50	179	358	
	100	458	458	

Appendix 3. Nutrient data collected from Sites 1 through 4 on the Susquehanna River, on August 15<sup>th</sup>, 2006.

<b>Sample Number</b>	<b>Total Phosphorous</b>	<b>Total Nitrogen</b>	<b>Nitrite (NO<sub>2</sub>)+ Nitrate (NO<sub>3</sub>)</b>	<b>NH<sub>4</sub></b>
	<b>µg/L</b>	<b>mg/L</b>	<b>mg/L</b>	<b>mg/L</b>
<b>Site 1</b>	23.3	0.272	0.031	BD
<b>Site 2</b>	32.7	0.340	0.092	BD
<b>Site 3a.</b>	32.0	0.343	0.110	BD
<b>Site 3b.</b>	35.3	0.305	0.109	BD
<b>Site 3</b>	33.7	0.324	0.110	BD
<b>Average</b>				
<b>Site 4a.</b>	29.9	0.402	0.112	BD
<b>Site 4b.</b>	31.0	0.342	0.111	BD
<b>Site 4</b>	30.5	0.372	0.112	BD
<b>Average</b>				

BD= below detection, < 0.04 mg/l