Huntington River Study
Summer 2006

Summary

The Huntington River Study measuring Escherichia coli (*E. coli*) took place once again this past summer. Evaluation of the Huntington River by the Huntington River Conservation Commission began in 2002, sampling the river within the Town of Huntington. This year (2006) the study was extended to cover the Richmond segment of the river. Additional samples were taken in the Richmond section of the Winooski River. Forty five volunteers, 20 from Huntington and 25 from Richmond, covered 16 regular sites along the Huntington River, plus additional sites for spot checks and for duplicate samples to check accuracy, totaling 216 samples. Very few samples were missed, testimony to the commitment of all the samplers and their backups. Clearly, many in our Towns are committed to the water quality of the river. *E. coli* bacteria serve as a marker of fecal contamination. This bacterium is considered the best sentinel for human pathogens, but does not necessarily itself cause human disease. Over time and also distance along the river, levels of *E. coli* varied widely along the river with occasional extremely high values recorded. Adjusting for an abnormal distribution of results, evidence was found for a significant increase in *E. coli* counts between the first sample site (Sheldrake) and the last (Cochran Bridge). These bacteria do not survive well outside the intestine, and so there is likely to be significant loss of viability as they travel down the river. More *E. coli* organisms, therefore, are likely to have been added as one moves down the river than was observed from the actual counts. Values at the same site on different sampling days and between adjacent sites on the same day were highly variable arguing against a chronic, regular source of contamination. The level of contamination in 2006 was significantly correlated with water level on the sampling day, though no cause and effect relationship has been established. Certain sites (Brace Bridge, Dugway West) appear to be particular hot spots, warranting additional scrutiny in future studies. The data also suggest the importance of further monitoring of certain feeder streams such as Owls Head Brook. The level of contamination exceeded Federal Standards in 8.8% of the samples. State standards, the most stringent nationally, were exceeded in 26.4%, although the State standard also has been exceeded in mountain streams considered to be pristine. Volatility in the numbers from week to week at the same site and between adjacent sites indicates that the level of contamination may change rapidly, limiting the usefulness of weekly postings. However, seasonal postings would appear warranted at sites where contamination routinely is high during periods of high water.

A detailed summary has been posted on:

http://www.gmavt.net/~aaronw/ecoli.htm

Introduction

The Huntington River Study measuring Escherichia coli (*E. coli*) took place once again this past summer. Evaluation of the Huntington River by the Huntington River Conservation Commission began in 2002, sampling the river within the Town of Huntington. This year (2006) the study was extended to cover the Richmond segment of the river. Additional samples were taken periodically in the Winooski River.

This study was underwritten by a grant from the Vermont Department of Environmental Conservation (VTDEC) to cover the actual costs of the laboratory testing itself.

Sixteen sites along the river were sampled on a regular weekly schedule (**Figure 1**). Criteria for site selection included accessibility and landowner permission, the location of swimming holes, the locations of feeder streams and even distribution along the river. Several other sites also were spot-checked based on previous studies as well as ongoing results during the sample season. Samples were taken each week, from July 20 through September 19. Generally collected on Tuesday mornings between 6:45 and 7:15 AM, samples immediately were delivered to the Waterbury testing lab at the VTDEC for analysis.

Throughout the survey, certain rigorous steps were taken to assure the quality of samples taken. For example, sample collection location and time of day collected were consistent. Sample bottles were handled with stringent care to avoid (human) contamination. Samples were taken up-stream of the sampler, whenever possible at mid-depth. Ten percent of the samples were field duplicates to assess the accuracy of the sampling process (see below). All samples were transported on ice to the testing lab in Waterbury well within required time.

Table 1 and **Figure 2** present the raw data. Also shown in the table are data regarding river level taken at 1500 East Street as well as summary data regarding general characteristics of the results (GEOMEAN and MEDIAN: more about these below). A total of 216 samples were part of the regular sampling series, plus an additional 20 from the Winooski River. As part of a regular quality check, 27 additional duplicate samples were taken (same person, same time, same exact location) as a field check of laboratory accuracy. These data also are invaluable in trying to determine how samples from separate locations are different from one another. Finally, 37 additional samples were taken at sites scheduled periodically over the sampling period.

Very few scheduled samples were missed. This is testimony to the commitment of all the volunteers (20 from Huntington, 25 from Richmond) and their backups who took part in the study (see appendix for a list). Many citizens in our Towns clearly are committed to the water quality of the river.

It also is apparent that the results are not normally distributed (think statistics and a bell-shaped curve). In several cases, there were extremely high values (highest was for Dugway West the week of September 5). It is very unlikely, for a number of reasons, that these high numbers represent measurement error. Much more likely is that these high results are telling us about potentially serious sources of bacterial contamination that need to be followed more closely as these studies continue. This could include such sources as overflowing beaver dams, sporadically ineffective septic systems or agricultural runoff. In any case, the skewed nature of the data requires special kinds of analysis from a data description point of view. The standard method in the water quality field is to calculate the Geometric Mean (GEOMEAN: see appendix for details). An alternative workhorse is to calculate median values (half of the measurements are above and half are below the median).

Measuring *E. coli*

The method used to measure *E. coli* is specific to it. *E. coli* is an indicator (sentinel) for dangerous contamination. Its presence indicates human and / or animal fecal contamination and the possible presence of unidentified human pathogens. However, the *E. coli* species measured is NOT specific for pathogenic *E. coli* but rather the species in general. Other species of *E. coli* do not make humans sick, just the pathogenic forms.

The method used by the VTDEC Laboratory is based on using a color reaction to measure the activity of a key enzyme found in all *E. coli* species, β-D-galactosidase. It assumes that all *E. coli* measured have the same amount of this enzyme. A multi-well procedure is used in which 100 ml of sample is distributed into individual wells. Color indicating enzyme activity is measured after the samples have been incubated at 35 degree centigrade (a bit below body temperature) using a color reference comparator. The data are then converted to MPN units (Most Probable Number). Data are reported as the number of organisms per 100 milliliters (ml) of water.

For quality assurance purposes, the State Laboratory requires that certain accuracy standards be met in the field check samples. When fewer than 25 colonies of *E. coli* are measured in a specific single sample, the relative percent difference (RPD) cannot exceed 125%. The threshold when more than 25 colonies are measured is 50%. RPD is the difference between the two samples divided by the average of the two, expressed as a percentage. This level of variability needs to be considered when evaluating results from individual sites.

Additional field checks involve taking duplicate samples (same person, time, location) which also have to meet stringent criteria. Results from analyses of duplicate field samples from the 2006 study are presented in **Table 2**.

With that in mind, there are both Federal (Environmental Protection Agency) and State (Division of Water Quality) Standards for water quality in terms of bacterial contamination. The unit of measure is the Most Probable Number (MPN) of organisms per 100 milliliters of water. The Federal Standard is 235 as an absolute value or a GEOMETRIC MEAN (GEOMEAN) of 126. The State figure is 77 for a single sample. According to State documents, a level of 77 indicates that one can be 75% certain that 3.4 persons in 1000 will get sick. Vermont's standard is the most stringent in the country and is based on a mix of scientific and political considerations. While the State would consider sites above 77 to be unsafe for swimming, it also is known that undisturbed and unaltered mountain streams can carry an *E. coli* burden that exceeds 77. VTDEC scientists required a GEOMEAN of over 77 over at least five samples in a season before considering water quality violations. It is for this reason that the State Water Quality Division currently is re-assessing the cut-off level of 77. The more stringent State standard supersedes the federal one.

The literature strongly suggests that it is extremely difficult for *E. coli* to live outside the intestines for any length of time. Even factors like sunlight affect viability (which is a reason why all samples were taken in the morning). This is very important to bear in mind as one compares data from different points in the river. Bacteria from an upstream site may die before reaching the next downstream site. Therefore, *E. coli* levels are unlikely to be cumulative as one proceeds downstream. This is demonstrated when downstream sites have lower levels of *E. coli* than sites upstream.

Analysis

Table 3 shows the dates and sites that were measured to be above the Federal (Pink / dashed) or State (Pink plus yellow / speckled) Standard for contamination. These are raw data, so the federal standard of 235 and the State Standard 77 applies as a single sample, not the mean. The federal Standard was exceeded in 8.1% and the State Standard in 24.2% of the samples. These principally were clustered on three sample days (6/20, 6/27, 8/1). Inspection of the data suggests these high values are associated with high water levels.

Indeed, perhaps the most striking observation was the very strong correlation in 2006 ($p < 0.002$, 2-tailed test) between water level and contamination (**Figure 3**). A correlation, of course, does not establish a cause-and-effect relationship. Much in the sense that the *E. coli* measurement itself is a surrogate for potential presence of pathogens, water level (at least for 2006) would appear a good indicator of increased contamination. At least for 2006, there was more contamination when water levels were high. There could be many causes for this, including increased land runoff, overflowing beaver dams or overflowing septic systems. Thus, the safety conscious should be more wary when water levels are high.

The relationship between water level and contamination in 2006, held pretty well for the individual regular sample sites (**Figure 4**). The relationship in several cases was much less clear when *E. coli* values were very high (e.g. Sheldrake, East Street). The relationship especially was strange at Dugway West. More is said about this site below.

This relationship between water level and contamination was not consistent. For example, water level was quite high on July 5, yet contamination was uniformly low. River height remained high after some 1.7 inches of rain June 30 to July 2 (**Figure 5**). The lack of any rain July 2-4 may have allowed contamination to taper while the river was still subsiding.

Historically, the relationship between contamination and water level has been less clear. The data from the 2003 Huntington segment study suggested an inverse relationship. This was less clear for 2004, while the generally higher water levels in 2005 supported the 2006 finding.

Figure 6 shows an upward trend in the GEOMEAN data for the season as one progresses down the river. Such a trend is less apparent when median data are plotted (**Figure 7**).

A Sign Test was performed to determine if the most downstream value (Cochran Bridge) was higher than the most upstream (Sheldrake) over the sampling period **Table 4**). The result (p = 0.01) supports the claim that the distribution of *E. coli* counts was higher at Cochran Bridge. However, some caution is required, since on three dates, the difference in values was very small (less than 10 MPN).

This finding indicates that *E. coli* contamination was being added as one proceeded downstream. The actual measurements as one moved downstream almost certainly are an underestimate of added contamination, since as mentioned before, there is a very high likelihood that a significant number of *E. coli* added to the river did not survive for long during their down stream journey.

All of the GEOMEAN values for the entire data sets for each site were considerably below the Federal Standard. However, five of the GEOMEAN values were above the State Standard of 77, the highest being 101.9 for Dugway West. The figure comes in under the Standard if the highest value (1730) is dropped. Whether several of the higher values are statistically higher than the State Standard is unclear: the aforementioned RPD for the group of samples had an average error of 22%. Similarly, values just below the State Standard may actually be above it.

According to Federal and State practice, GEOMEANS are to be applied to sets of 5 samples taken within a period of 30 days. This constraint fits the 2006 sampling well GEOMEANS over five consecutive sampling dates on a rolling basis through the sampling period. **Table 5** shows application of this 5-sample method over the first five weeks of the 2006 study, the 5-week period over which levels were highest. In this case, none of the GEOMEAN values exceeded Federal, while all of them exceeded State levels.

These same GEOMEAN data may contain important clues with regard to sources of contamination. For example, it looks as if there were two spikes in the measurements as one moved downstream. One was at Brace Bridge, the second at Dugway West.

The Dugway West data are interesting. For 11 of 14 weeks, the Dugway West number was higher than the preceding one. The aforementioned statistical Sign Test indicated that values at Dugway West were significantly higher than at the upstream site immediately above (Moultroup Bridge; p = 0.016). Again, caution is required in interpreting this finding since in this case 7 of the paired values were different by less than 10 organisms per 100 ml.

Noteworthy, for the two very high results at Dugway West, results were markedly reduced by the next site downstream. Importantly, a major feeder stream, Owls Head Brook, comes into the Huntington River immediately upstream from the Dugway West site.

One possible explanation of the rapid drop in values is that, at certain times, Owls Head delivers contaminated water to the Huntington as measured at the Dugway West site, and the contamination is diluted out shortly thereafter. Though *E. coli* viability also may be a contributor, it seems unlikely that viability could explain such a large drop.

One attempt was made on the last sampling date (Sept 19) to assess possible contamination from Owls Head Brook. Samples were taken in the Brook, just upstream from where it enters and as usual at Dugway West. These numbers were all very low and unremarkable, but that may well be because water level was low: the values for the whole river were well under State Standard. Owl's head Brook certainly will bear careful monitoring in the coming year.

Based on the extent of use, perhaps the Gorge becomes an important sampling site (**Figures 3 and 4**). Samples were taken some 100 yards down from the main pool at the base of the falls. The highest value was for the week of June 27 when water level was at its highest over the study period. That was the only time when contamination was above Federal Standard, while the State level was exceeded on a total of seven occasions (and tied once). There was a fairly clear relationship between water level and contamination.

Figure 8 shows that there also is an inverse correlation between GEOMEAN E. coli values and water conductivity taken at the Horseshoe Bend swimming hole in Huntington. That is, as GEOMEAN values increase, conductivity decreases. This means, in addition, that there is an inverse correlation between water conductivity and water level (**Figure 9**). It is not clear intuitively why this should be, but the relationship deserves further analysis. Again, correlations do not prove a cause and effect relationship.

Surveying the data, it is clear that contamination levels can change markedly over a week's time. This could be due to a number of factors. For example, as described above, it is difficult for *E. coli* to live outside the intestines for any length of time. Just as for a swimming pool, the level of contamination (water) is determined by how much is coming in and how much is leaving. Two key variables regarding what is leaving are water flow and the rate of organism dying. In any case, a reasonable interpretation of the pattern of contamination suggests that ongoing contamination at an unsafe level is not occurring.

The variability between weeks makes the possibility of point contamination from such sources as failed (or no) septic systems less likely, as that contamination should be more steady. As well, one might predict such contamination would lead to higher values when water levels are low (less dilution), the opposite of what was seen in 2006.

At the same time, there are other explanations. For example, "point sources" may exist that are triggered by high water, even natural ones such as beaver dams.

Also quite variable in several cases was the difference in values at adjacent sites along the river. This is best exemplified by the striking fall at two sampling dates between a very high value at Dugway West and the next value at Yaggy a relatively short distance further on. Factors that might explain this are described above. They suggest that an upstream measurement is not always a good indicator of what will be found further down stream.

Overall, results from the 2006 season were some of the best we've seen in 4 years of rigorous sampling. Reasons for the improved water quality this year are still being evaluated and discussed, and answers are likely to only come with further sampling.

Floating Sites.

Table 6 shows results from sites that were sampled once a month or spot checked through the survey period (floating sites). The purposes here included sampling feeder streams and locations identified as possible hot spots. In past years, Floating Sites have been used to further investigate areas found to have high bacteria levels during a previous sample round. Typically, floating samples are used to "bracket" upstream and downstream of high locations in an effort to refine source locations. Floating sites were not heavily used in 2006, primarily due to the overall low bacteria levels. Monthly sampling was continued on major tributaries to the Huntington River. These tributaries have been regularly monitored once a month in past sample seasons. In addition, a few upstream sites (such as 7 Falls) that were dropped from weekly monitoring in 2006 were added to the monthly sample schedule.

The Winooski River

As the summer survey progressed, interest grew in sampling the Winooski River. Two sites were selected: The Jonesville Bridge (just upstream from where the Huntington River enters, tree rope side); and the Bridge Street Bridge (at Volunteers Green). Many predicted that Winooski values would be quite high, given the river's history as the valley's sewer. As shown in **Table 1**, Winooski River values generally were slightly higher than those for Cochran Bridge, just upstream from where the Huntington enters the Winooski) though this was not universally the case. The Federal Standard was exceeded twice and State Standard four times at these two Winooski River sites.

The values for August 22 were abnormally high. It is unlikely the numbers are in error, given what is known about the accuracy of the sampling and assay. Rather, it would appear likely that the contamination came from upstream. Noteworthy in this regard is that there was heavy rain (2.5 inches in Jonesville) two days before.

Unfortunately, it appears that there has been no ongoing sampling of the Winooski in our area during the Huntington River surveys or in the recent past.

Human Health

A key question for many is what are safe levels of bacterial contamination. *E. coli* has been used as a sentinel for potentially dangerous bacterial contamination. In this study, there are no records indicating that dangerous (pathogenic) *E. coli* is present due to the fact that the appropriate measurements have not been made to assess the presence of pathogenic strains. These are much more difficult, time-consuming and expensive tests than those done in the studies to date.

A key issue regards when it is appropriate to post warnings at sites that are contaminated above Standard. All sites on certain dates provided values below the State Standard (**Table 3**). However, all sites at one point or another also had higher values than the standard. The difficulty of posting results once known is that they are out of date, with a good likelihood that, by posting date, they are below the Standard (see **Table 3**). It would appear more appropriate to provide a general posting indicating contamination levels may be above standard when water levels are high (see Figure 2) especially for those sites where this especially has been found so far to be true. The issue here is whether a "threshold" water level can be established for warning purposes.

Finally, one always must remember that *E. coli* is serving as an indicator (sentinel). There is no assurance that when *E. coli* levels change dramatically that true pathogens change in parallel fashion.

Human health, of course, is a relative term. For example, the risk of death from bacterial contamination is less than getting a serious case of the flu. It also depends on the individual actions of swimmer. Ingesting river or pond water anywhere significantly increases the risk of illness.

The Future

Continued surveys of the Huntington River are essential to understanding safety issues related to bacterial contamination. These are necessary to establish the level of hazard as well as the causes of contamination. Results to date indicate that it will be difficult to support a conclusion regarding hot spots from a statistical point of view, absent a much larger data set. The relationships between rainfall, water level and contamination require confirmation. The identification of possible "spot" sources and their contributions during high and low water represent work in progress. Potential new trouble spots in the Richmond segment need to be confirmed and the survey of feeder streams added. Measurements to determine whether contamination is of animal or human origin or whether pathogenic *E. coli* are present, must be contemplated. A more complete survey of the Winooski River also is desirable. Mechanisms need to be put in place to warn the public about high water levels at least at certain sites, and a publicly accessible source of up-to-date water level data be made available.

Best practices for clean, safe river waters require everyone's continuing attention, behavior and support.

HUNTINGTON RIVER STUDY 2006

DATA

TABLE 1

Huntington River Study 2006 Main Sites

	20-Jun-06	27-Jun-06	5-Jul-06	11-Jul-06	18-Jul-06	25-Jul-06	1-Aug-06	8-Aug-06	14-Aug-06	22-Aug-06	29-Aug-06	5-Sep-06	12-Sep-06	19-Sep-06	GEOMEAN
Sheldrake	114	116	56	178	48	50	130	32	10	39	22	14	24	19	42.9
Shaker Mountain	152	179	56	79	60	58	64	19	18	71	22			12	48.6
Brace Bridge	86	249	43	79	40	102	156	687	66	156	36	60	21	20	77.8
Spence Bridge	125	186	28	88	125	66	248	61		137		36	32	6	66.0
East Street		172	38	61	179		110	55	22	79	31	37	22	43	55.3
Bridge Street	130	228	57	69	201	57	131	61	18	78	26	26	14	28	57.2
Cemetary	144	214	55	52	172	59	114	83	22	72	28	20	15	22	55.3
Audubon Horseshoe	179	387	49	36	118	82	214	45		81	58	22	18	18	65.2
Audubon Hemlock	112	387	50	56	145	111	140	59	23	96	20	37	17	13	58.7
Moultroup Bridge	186	308	48	28	91	55	172	51	22	167	25	20	13	12	51.7
Dugway West	192	461	55	161	93	63	1410	52	36	107	22	1730	6	44	101.9
Yaggy	173	461	60	140	105	86	172	49	21	102	51	133	12	49	79.9
Gorge	193	326	98	138	88	74	150	51	18	88	31	77	15	34	70.9
Triple Buckets	291	387	86	210	56	72	145	41	11	121	16	61	13	28	64.8
Chalet Trail	365	313	91	108	69	62	96	42	17	102	19	38	11	22	58.8
Cochran Bridge	411	461	72	130	55		219	36	20	96	20	66	24	43	74.0
Winooski Jonesville					105	172	124	63	30	1550	101	63	142	14	98.2
Winooski Bridge St					67	121	114	68	18	980	98	72	105	12	79.3
GEOMEAN wo Winooski	172.7	280.2	56.1	87.2	91.8	69.3	165.0	55.3	20.7	94.3	26.6	49.4	15.9	22.4	
GEOMEAN	172.7	280.2	56.1	87.2	90.9	75.9	159.1	56.4	21.0	125.4	31.1	51.3	20.3	21.1	

Conductivity	93	44.9	90	120.2	115	103.8	79.5	111.9	129.3	87.5	117.4	124.5	127	131.5
Water Temp (deg C)	15.8	16.8	16.8	18.8	19.8	17.6	19.6	18.6	13.8	13.8	17	15.7	9.7	17.5
Water Level ft (stake)	1.5	3.3	1.7	0.75	0.8	0.88	1.4	0.8	0.6	1.4	0.75	0.7	0.6	0.45
Water Level (vertical)	1.11	2.45	1.26	0.56	0.59	0.65	1.04	0.59	0.45	1.04	0.56	0.52	0.45	0.33

Table 2

Location	Date	Results	% RPD	Absolute Diff.
Moultrop Bridge Duplicate	20-Jun-06	114	48	72
Moultroup Bridge	20-Jun-06	186		
Cemetary	27-Jun-06	214	3.8	8
Cemetary Duplicate	27-Jun-06	206		
Lower Gorge	27-Jun-06	387	6	24
Lower Gorge Duplicate	27-Jun-06	411		
Spence Bridge	27-Jun-06	186	20.3	42
Spence Bridge Duplicate	27-Jun-06	228		
Gorge	5-Jul-06	98	36.1	30
Gorge Duplicate	5-Jul-06	68		
Shaker Mtn.	5-Jul-06	56	28.6	14
Shaker Mtn. Duplicate	5-Jul-06	42		
Chochran Br Duplicate	11-Jul-06	152	15.6	22
Cochran Bridge	11-Jul-06	130		
Moultroup Bridge	18-Jul-06	91	5.3	5
Moultroup Bridge Duplicate	18-Jul-06	96		
Brace Bridge	25-Jul-06	102	37.2	32
Brace Bridge Duplicate	25-Jul-06	70		
Cemetary	25-Jul-06	59	25.2	17
Cemetary Duplicate	25-Jul-06	76		
Yaggy	25-Jul-06	86	29.3	22
Yaggy Duplicate	25-Jul-06	64		
Dugway West	1-Aug-06	1410	20.4	320
Dugway West Duplicate	1-Aug-06	1730		
Shaker Mtn.	1-Aug-06	64	65.3	62
Shaker Mtn. Duplicate	1-Aug-06	126		
Cemetary	8-Aug-06	83	20.5	19
Cemetary Duplicate	8-Aug-06	102		
Chalet Trail	8-Aug-06	42	15.4	7
Chalet Trail Duplicate	8-Aug-06	49		
Triple Buckets	8-Aug-06	41	4.8	2
Triple Buckets Duplicate	8-Aug-06	43		
Audubon Horseshoe	14-Aug-06	19	31.1	7
Duplicate	14-Aug-06	26		
Chalet Trail	22-Aug-06	102	0	0
Chalet Trail Duplicate	22-Aug-06	102		
Spence Bridge	22-Aug-06	137	19.7	30
Spence Bridge Duplicate	22-Aug-06	167		
East St. Duplicate	29-Aug-06	24	25.5	7
East Street	29-Aug-06	31		
Cemetery	5-Sep-06	20	26.1	6
Cemetery Duplicate	5-Sep-06	26		
East St. Duplicate	5-Sep-06	43	15	6
East Street	5-Sep-06	37		
Brace Bridge	12-Sep-06	21	100	14
Brace Bridge Duplicate	12-Sep-06	7		
East Street	12-Sep-06	22	9.5	2
East Street Duplicate	12-Sep-06	20		
Moultroup Bridge	12-Sep-06	13	7.4	1
Moultroup Bridge Duplicate	12-Sep-06	14		
Spence Bridge	19-Sep-06	6	58.8	5
Spence Bridge Duplicate	19-Sep-06	11		
Triple Buckets	19-Sep-06	28	7.4	2
Triple Buckets Duplicate	19-Sep-06	26		

Table 3

Huntington River Study 2006 Measurements Above Federal and Stae Standards

	20-Jun-06	27-Jun-06	5-Jul-06	11-Jul-06	18-Jul-06	25-Jul-06	1-Aug-06	8-Aug-06	14-Aug-06	22-Aug-06	29-Aug-06	5-Sep-06	12-Sep-06	19-Sep-06	
GEOMEAN	172.7	280.2	56.1	87.2	90.9	75.9	159.1	56.4	21.0	125.4	31.1	51.3	20.3	21.1	
Water Level ft (stake)	1.5	3.3	1.7	0.75	0.8	0.88	1.4	0.8	0.6	1.4	0.75	0.7	0.6	0.45	
Water Level (vertical)	1.11	2.45	1.26	0.56	0.59	0.65	1.04	0.59	0.45	1.04	0.56	0.52	0.45	0.33	
Huntington ONLY															
Above Federal	3	10	0	0	0	0	2	1	0	2	0	1	0	0	19
%	20.0	62.5	0.0	0.0	0.0	0.0	12.5	6.3	0.0	0.0	0.0	6.7	0.0	0.0	
Above State	11	15	0	6	3	1	12	1	0	5	0	2	1	0	57
%	73.3	93.8	0.0	37.5	18.8	0.0	75.0	6.3	0.0	18.8	0.0	13.3	0.0	0.0	

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Shaker Mountain	152	179	56	79	60	58	64	19	18	71	22			12	48.6	59
Brace Bridge	86	249	43	79	40	102	156	687	66	156	36	60	21	20	77.8	72.5
Spence Bridge	125	186	28	88	125	66	248	61		137		36	32	6	66.0	77
East Street		172	38	61	179		110	55	22	79	31	37	22	43	55.3	49
Bridge Street	130	228	57	69	201	57	131	61	18	78	26	26	14	28	57.2	59
Cemetary	144	214	55	52	172	59	114	83	22	72	28	20	15	22	55.3	57
Audubon Horseshoe	179	387	49	36	118	82	214	45		81	58	22	18	18	65.2	58
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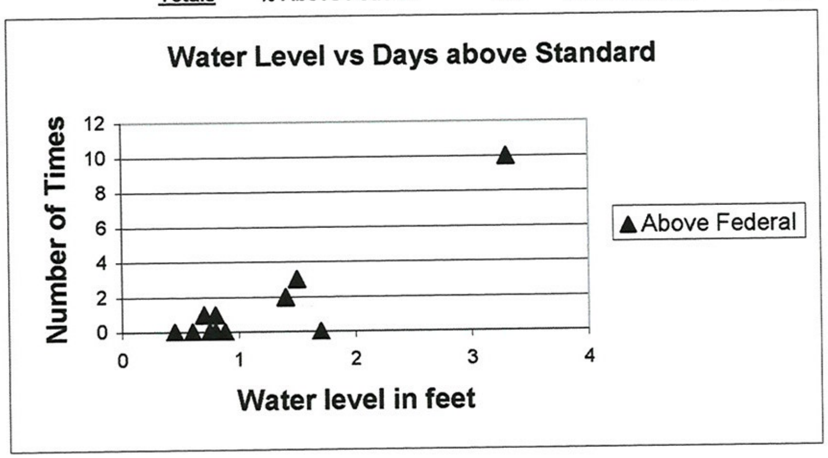
Dugway West	192	461	55	161	93	63	1410	52	36	107	22	1730	6	44	101.9	78
Yaggy	173	461	60	140	105	86	172	49	21	102	51	133	12	49	79.9	94
Gorge	193	326	98	138	88	74	150	51	18	88	31	77	15	34	70.9	82.5
Triple Buckets	291	387	86	210	56	72	145	41	11	121	16	61	13	28	64.8	66.5
Chalet Trail	365	313	91	108	69	62	96	42	17	102	19	38	11	22	58.8	65.5
Cochran Bridge	411	461	72	130	55		219	36	20	96	20	66	24	43	74.0	66
Winooski Jonesville					105	172	124	63	30	1550	101	63	142	14	98.2	103
Winooski Bridge St					67	121	114	68	18	980	98	72	105	12	79.3	85
	15	16	16	16	16	14	16	16	14	16	15	15	15	16		

Totals % Above Federal 8.8 % Above State 26.4



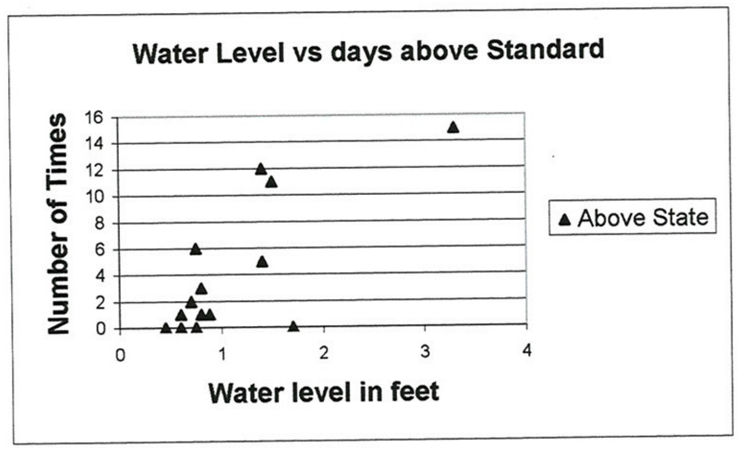


TABLE 4

Huntington River Study 2006: Sign Text

Date	Sheldrake	Cochran	Moultroup	Dugway W.	C - S	D - M
20-Jun	114	411	186	192	297	6
27-Jun	116	461	308	461	345	153
6-Jul	56	72	48	55	16	7
11-Jul	178	130	28	161	-48	133
18-Jul	48	55	91	93	7	2
25-Jul	50		55	63		8
1-Aug	130	219	172	1410	89	1238
8-Aug	32	36	51	52	4	1
14-Aug	10	20	22	36	10	14
22-Aug	39	96	167	107	57	-60
29-Aug	22	20	25	22	-2	-3
5-Sep	14	66	20	1730	52	1710
12-Sep	24	24	13	6	No Diff	-7
19-Sep	19	43	12	44	24	32

For Sheldrake vs Cochran:

x = 10/12 0.833 number of pairs (n) = 12

Ho p = 0.5 (Distributions are the same)

HI p > 0.5 (Distribution at C is higher)

P= 0.5

Z = X-P/SQRT (P9/n) X-P = 0.333

Z = 2.31 Sq. root (P9/n) = 0.1443

Therefore p = 0.01

For Moultroup vs Dugway Wset:

x = 11/14 0.786 number of pairs (n) = 14

Ho p = 0.5 (Distributions are the same)

HI p > 0.5 (Distribution at C is higher)

Z = X-P/SQRT (P9/n) X-P = 0.286

Z = 2.14 Sq. root (P9/n) = 0.1443

Therefore p = 0.016

TABLE 5

Huntington River E. coli Study 2006

	20-Jun-06	27-Jun-06	5-Jul-06	11-Jul-06	18-Jul-06	25-Jul-06	1-Aug-06	8-Aug-06	14-Aug-06	22-Aug-06	29-Aug-06	5-Sep-06	12-Sep-06	19-Sep-06	GEOMEAN
Sheldrake	114	116	56	178	48	50	130	32	10	39	22	14	24	19	91.3
Shaker Mo	152	179	56	79	60	58	64	19	18	71	22			12	93.7
Brace Brid	86	249	43	79	40	102	156	687	66	156	36	60	21	20	78.1
Spence Br	125	186	28	88	125	66	248	61		137		36	32	6	93.5
East Street		172	38	61	179		110	55	22	79	31	37	22	43	91.9
Bridge Stre	130	228	57	69	201	57	131	61	18	78	26	26	14	28	118.6
Cemetary	144	214	55	52	172	59	114	83	22	72	28	20	15	22	108.7
Audubon H	179	387	49	36	118	82	214	45		81	58	22	18	18	107.6
Audubon H	112	387	50	56	145	111	140	59	23	96	20	37	17	13	112.0
Moultroup	186	308	48	28	91	55	172	51	22	167	25	20	13	12	93.1
Dugway W	192	461	55	161	93	63	1410	52	36	107	22	1730	6	44	148.8
Yaggy	173	461	60	140	105	86	172	49	21	102	51	133	12	49	147.7
Gorge	193	326	98	138	88	74	150	51	18	88	31	77	15	34	149.6
Triple Buck	291	387	86	210	56	72	145	41	11	121	16	61	13	28	162.7
Chalet Trai	365	313	91	108	69	62	96	42	17	102	19	38	11	22	150.6
Cochran B	411	461	72	130	55		219	36	20	96	20	66	24	43	157.7
Winooski Jonesville					105	172	124	63	30	1550	101	63	142	14	98.2
Winooski Bridge St					67	121	114	68	18	980	98	72	105	12	79.3
GEOMEAN	172.7	280.2	56.1	87.2	91.8	69.3	165.0	55.3	20.7	94.3	26.6	49.4	15.9	22.4	
GEOMEAN	172.7	280.2	56.1	87.2	90.9	75.9	159.1	56.4	21.0	125.4	31.1	51.3	20.3	21.1	

Conductivity	93	44.9	90	120.2	115	103.8	79.5	111.9	129.3	87.5	117.4	124.5	127	131.5
Temp (deg C)	15.8	16.8	16.8	18.8	19.8	17.6	19.6	18.6	13.8	13.8	17	15.7	9.7	17.5
.evel ft (stake)	1.5	3.3	1.7	0.75	0.8	0.88	1.4	0.8	0.6	1.4	0.75	0.7	0.6	0.45
.evel (vertical)	1.11	2.45	1.26	0.56	0.59	0.65	1.04	0.59	0.45	1.04	0.56	0.52	0.45	0.33

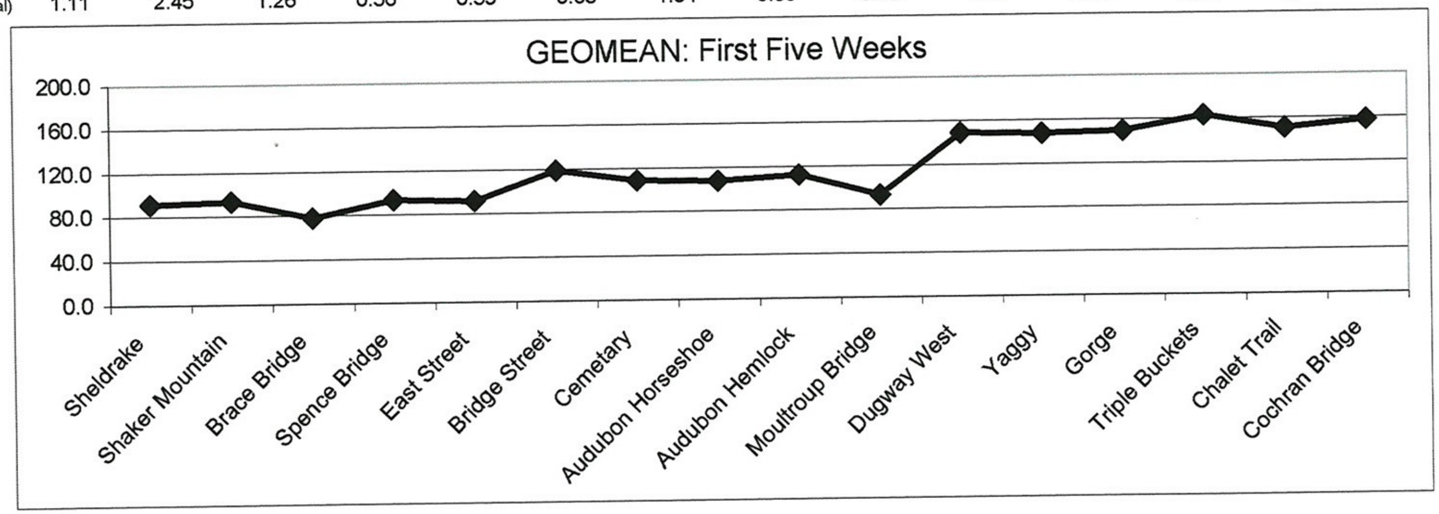


Table 6

Huntington River Study 2006 Brooks and Floating Sites

CATEGOR	Location	20-Jun-06	27-Jun-06	5-Jul-06	11-Jul-06	18-Jul-06	25-Jul-06	1-Aug-06	8-Aug-06	14-Aug-06	22-Aug-06	29-Aug-06	5-Sep-06	12-Sep-06	19-Sep-06
BRK	Brushy Brook		96				185					37			6
BRK	Carpenter Brook		102				17								16
BRK	Cobb Brook		78				34					6			1
BRK	Fargo Brook		156				84					7			
BRK	Hollow Brook		461				34					30			36
BRK	Owls Head Brook						93								
BRK	Owls Head Dugway														4
FLOAT	7 Falls		49				11					9			
FLOAT	Above Owls Head														43
FLOAT	Brushy Trib Culvert						51								
FLOAT	Rec Field		387				51					20			16
FLOAT	Brent Field		160				93					13			16
FLOAT	Carse Bridge		135				24					20			
FLOAT	Owls Head Huntington														25

FIGURE 1

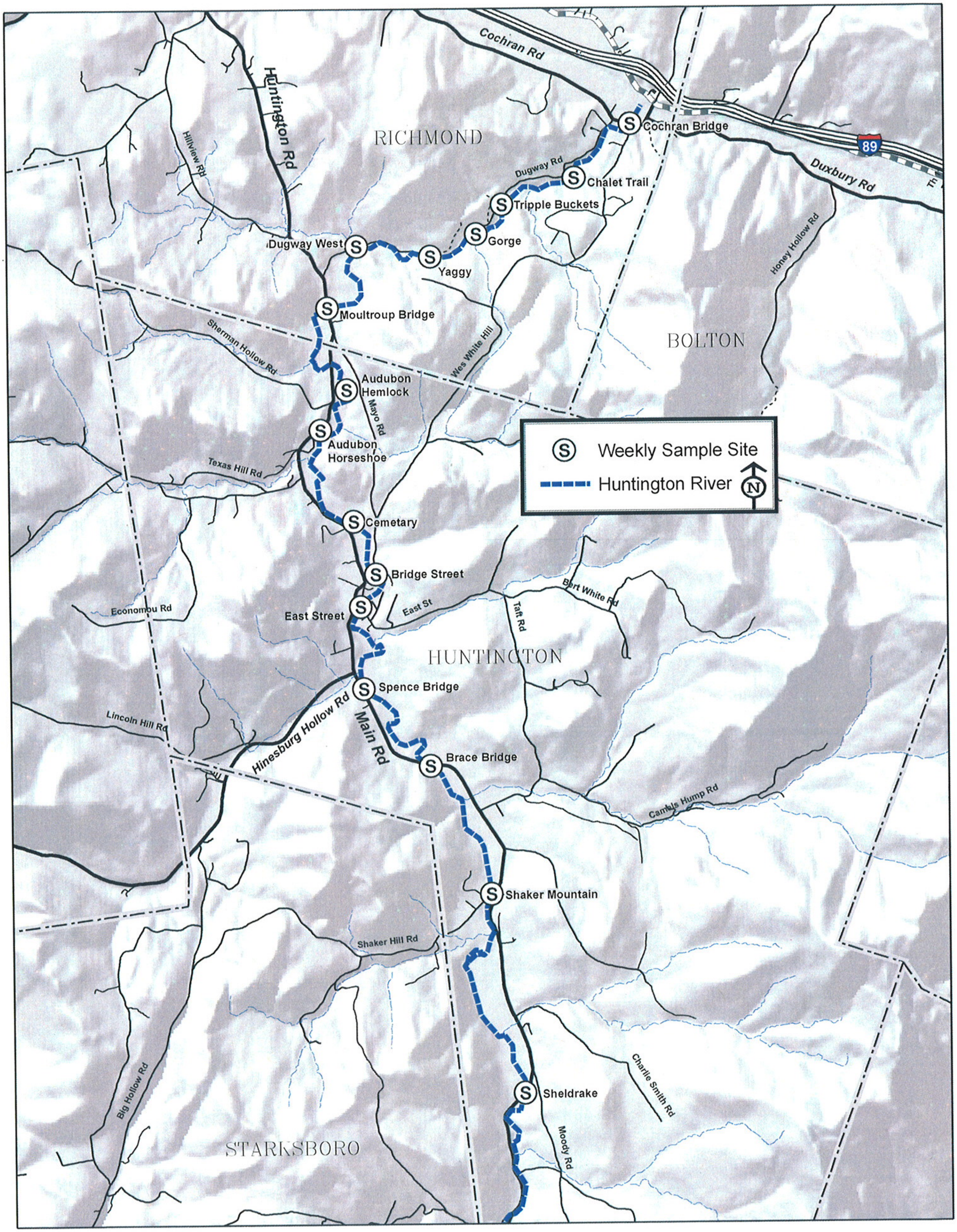

Cochran Rd
Huntington Rd
Hillview Rd
RICHMOND
Cochran Bridge
89
Duxbury Rd
Dugway Rd
Chalet Trail
Tripple Buckets
Gorge
Yaggy
Dugway West
Honey Hollow Rd
Moultroup Bridge
Sherman Hollow Rd
Wes White Hill
BOLTON
Audubon Hemlock
Mayo Rd
Audubon Horseshoe
Texas Hill Rd
Weekly Sample Site
Huntington River
N
Cemetary
Bridge Street
East Street
East St
Bert White Rd
Taft Rd
Economou Rd
HUNTINGTON
Spence Bridge
Lincoln Hill Rd
Hinesburg Hollow Rd
Main Rd
Brace Bridge
Camels Hump Rd
Shaker Mountain
Shaker Hill Rd
Charlie Smith Rd
Sheldrake
Big Hollow Rd
Moody Rd
STARKSBORO

FIGURE 2
Part 1 of 3

HUNTINGTON RIVER STUDY 2006 BOX PLOTS

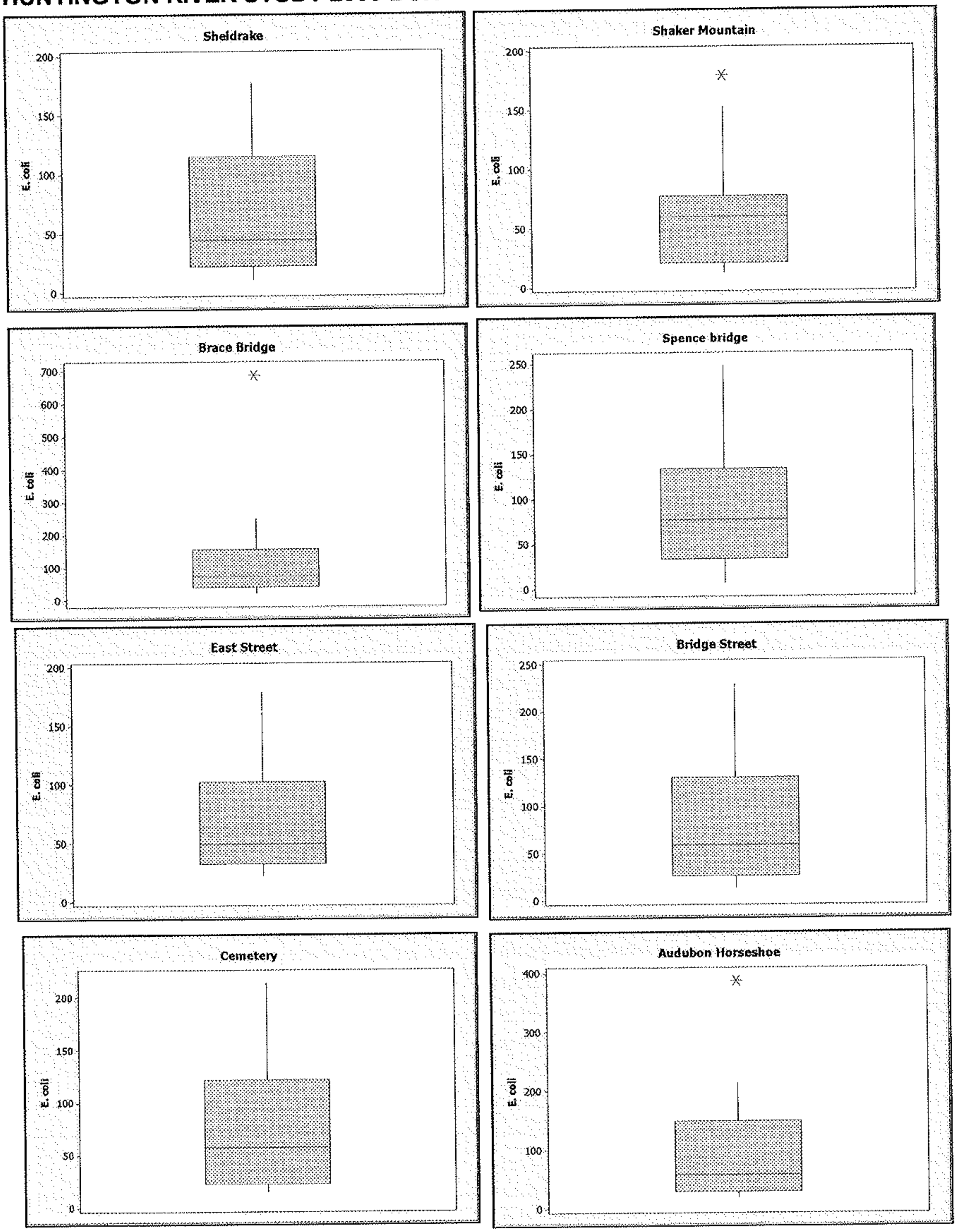
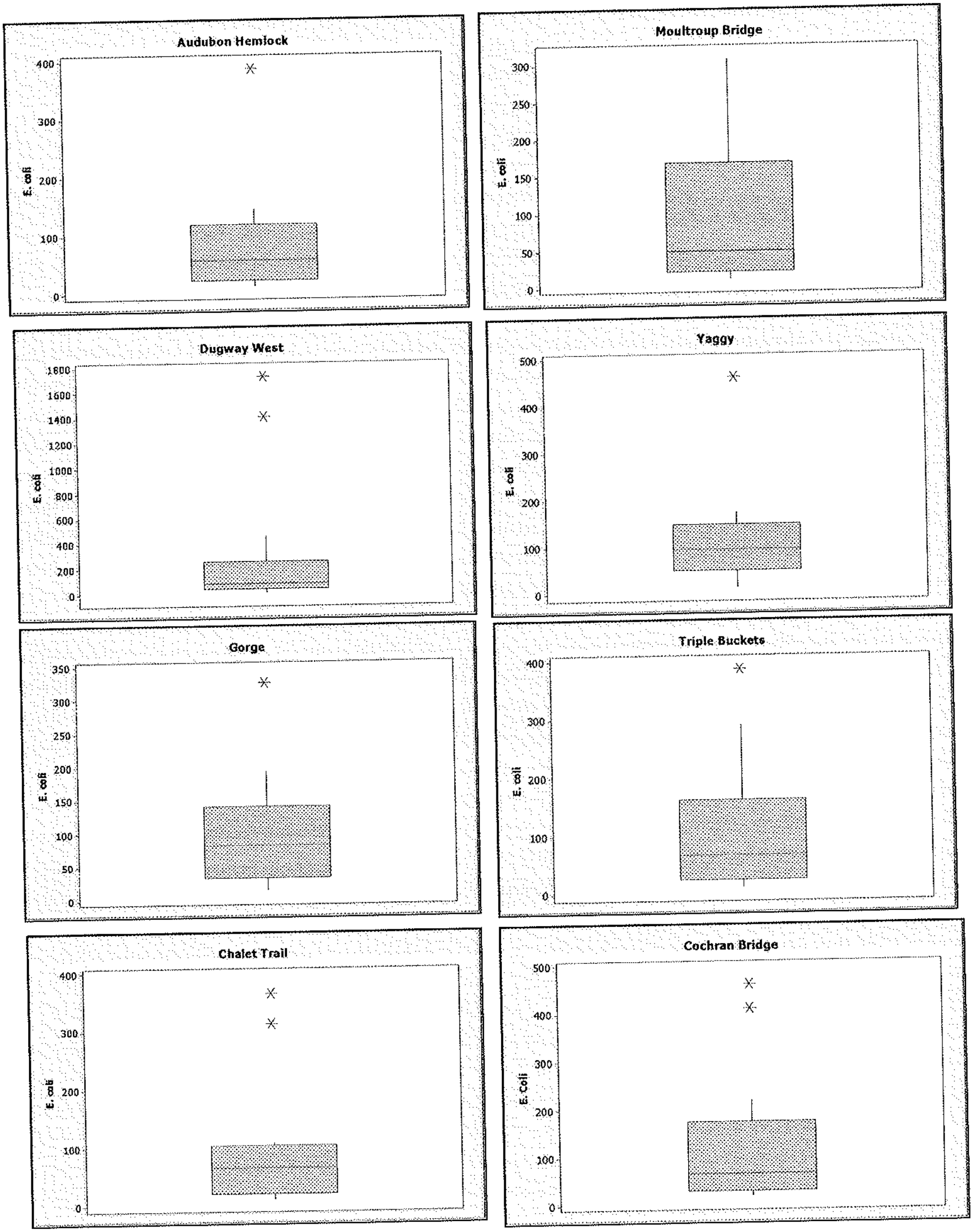


FIGURE 2

Part 2 of 3



Huntington River Study 2006 Explanation of Boxplots

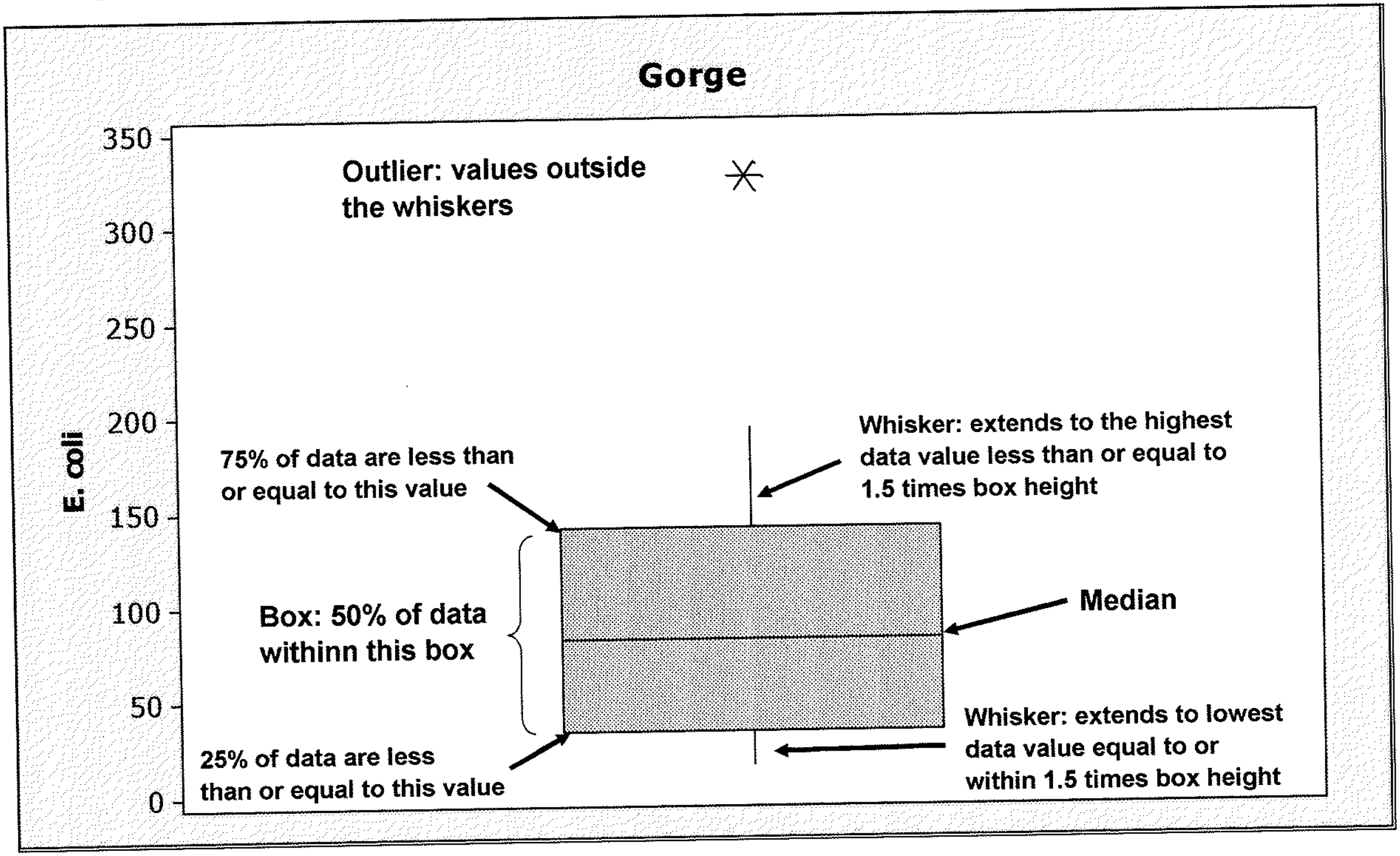


FIGURE 3

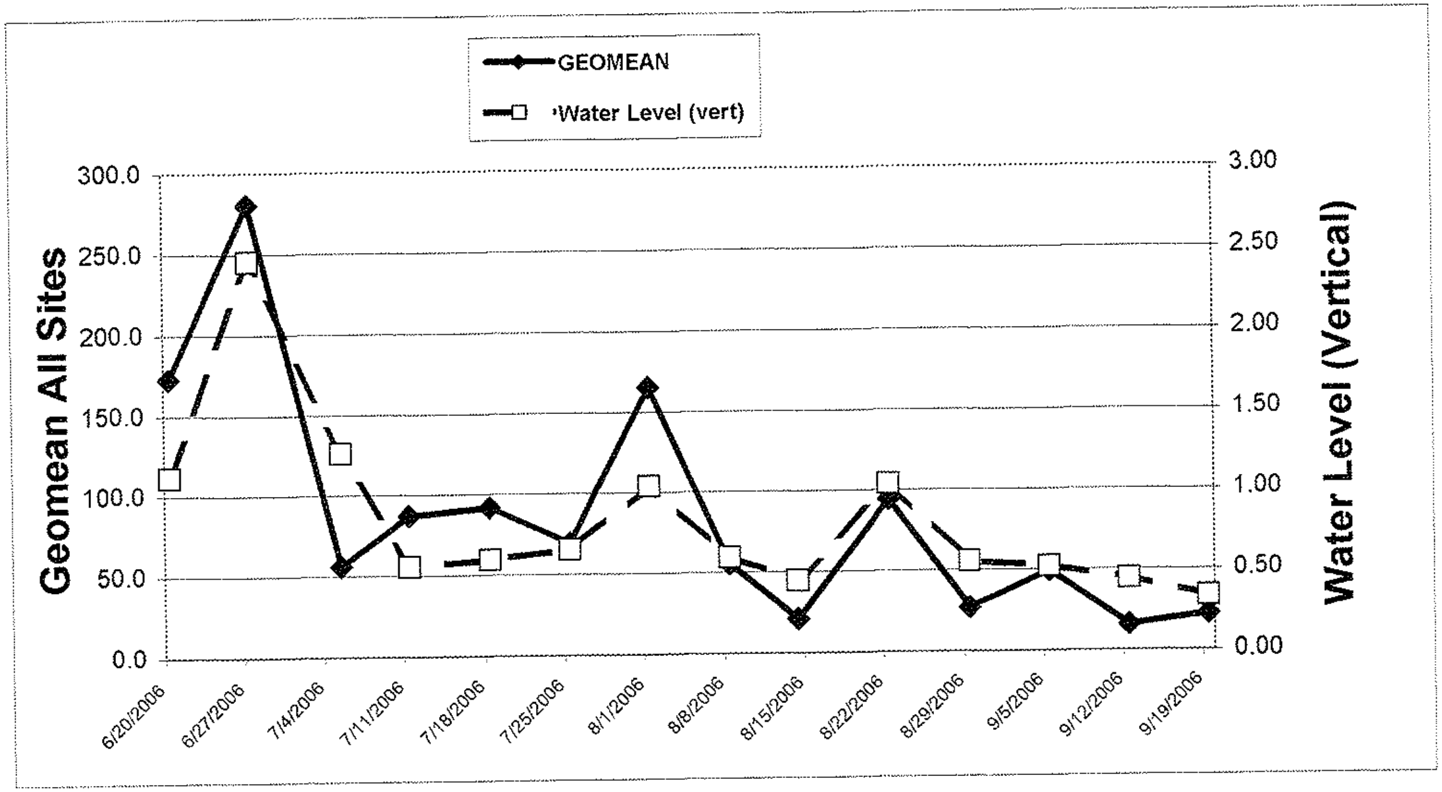

GEOMEAN
'Water Level (vert)
Geomean All Sites
Water Level (Vertical)
300.0
250.0
200.0
150.0
100.0
50.0
0.0
3.00
2.50
2.00
1.50
1.00
0.50
0.00
6/20/2006
6/27/2006
7/4/2006
7/11/2006
7/18/2006
7/25/2006
8/1/2006
8/8/2006
8/15/2006
8/22/2006
8/29/2006
9/5/2006
9/12/2006
9/19/2006

FIGURE 4
Part 1 of 3

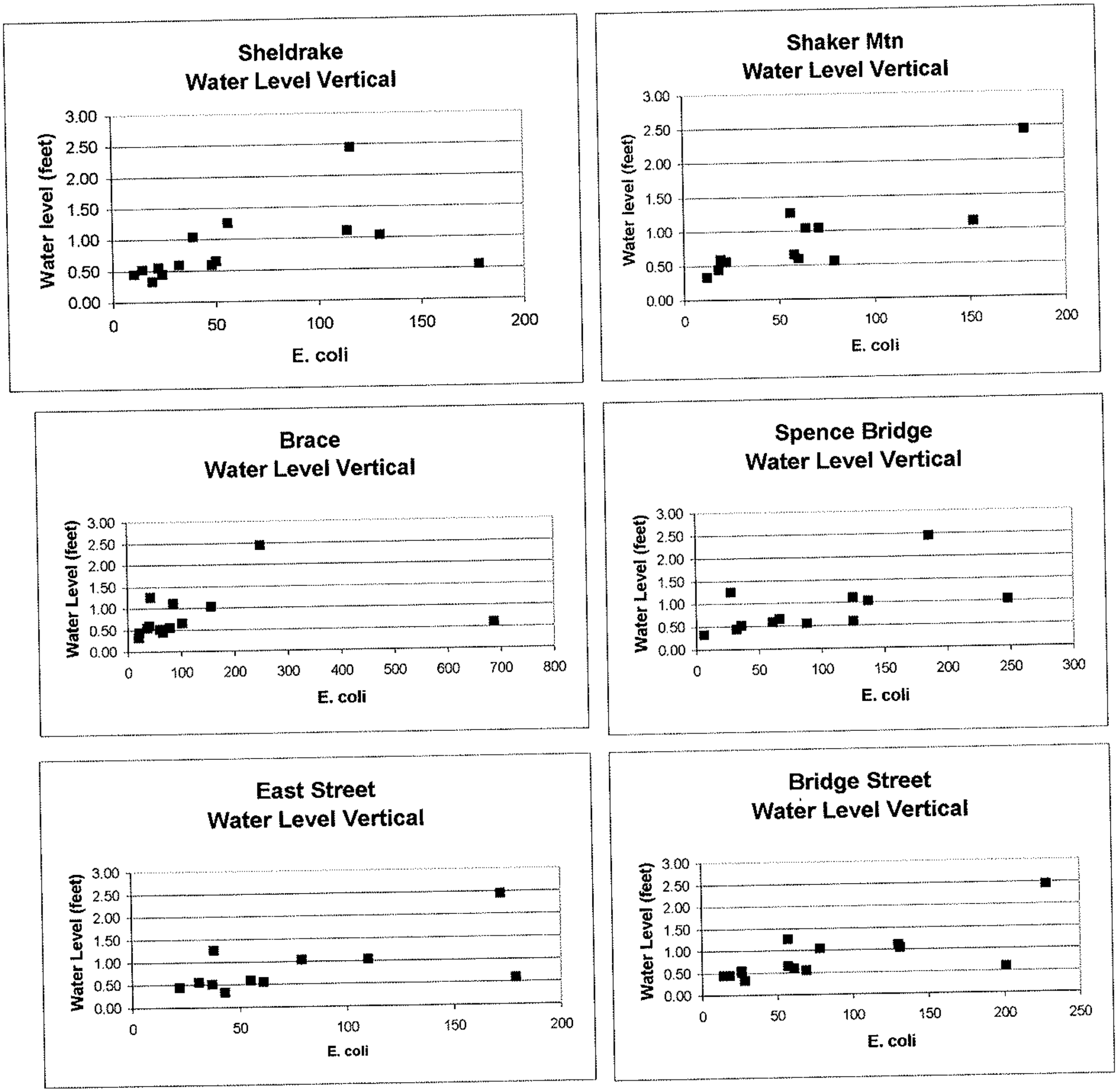
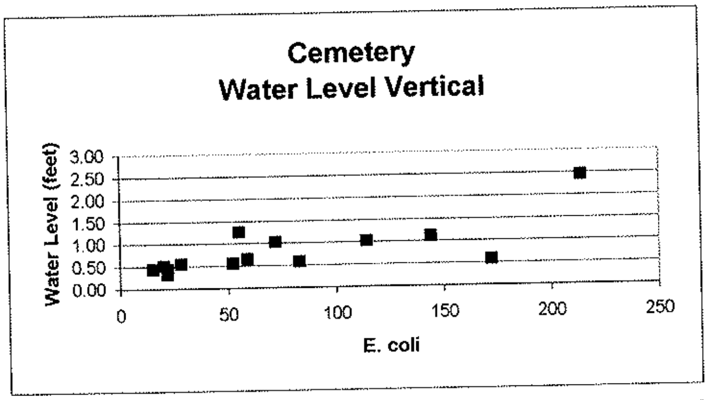
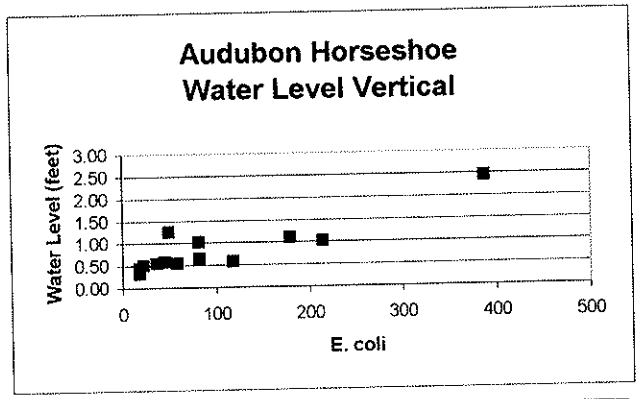
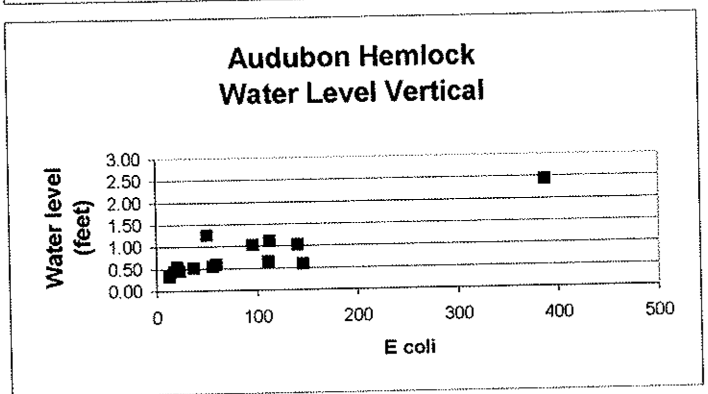
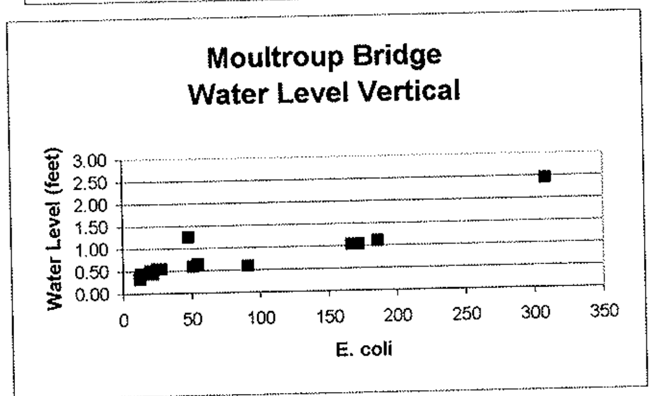


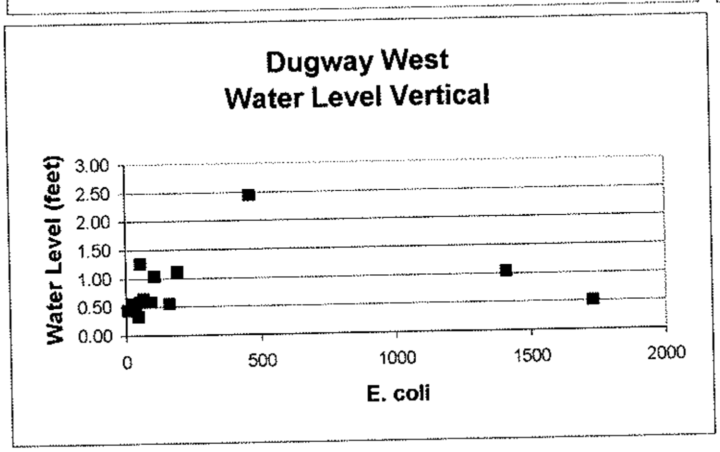
FIGURE 4
Part 2 of 3











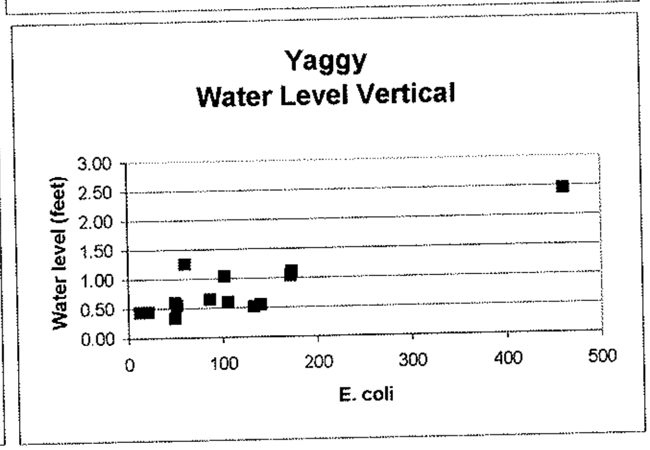
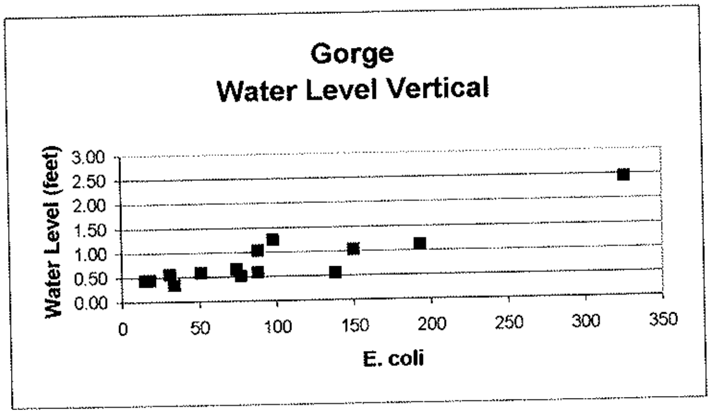
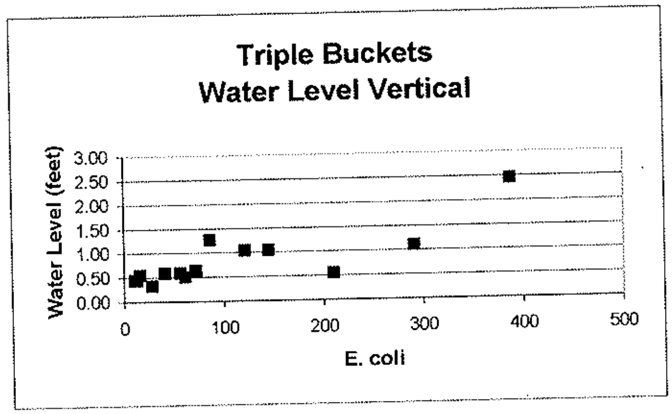
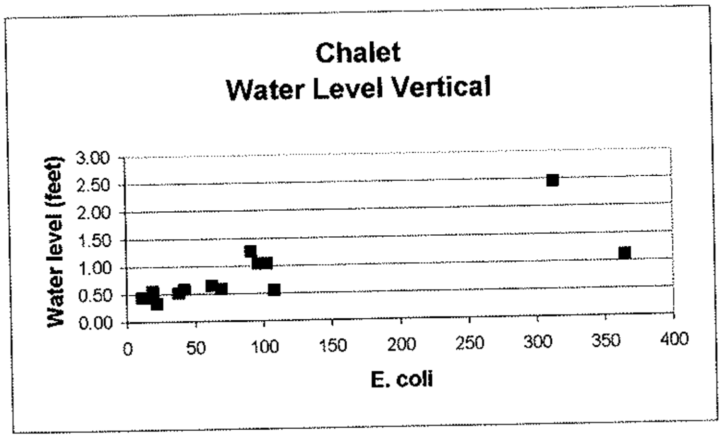


FIGURE 4
Part 3 of 3







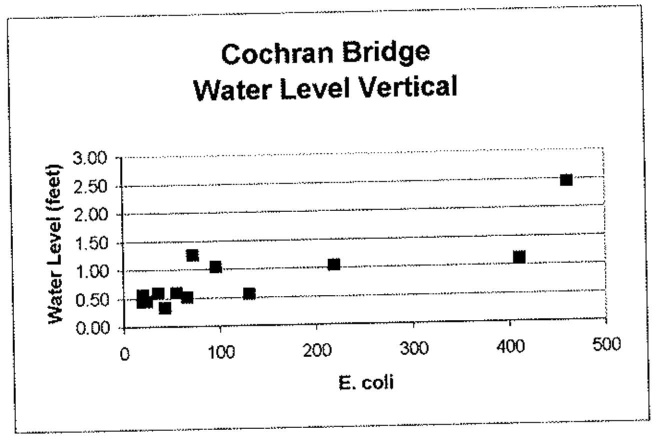
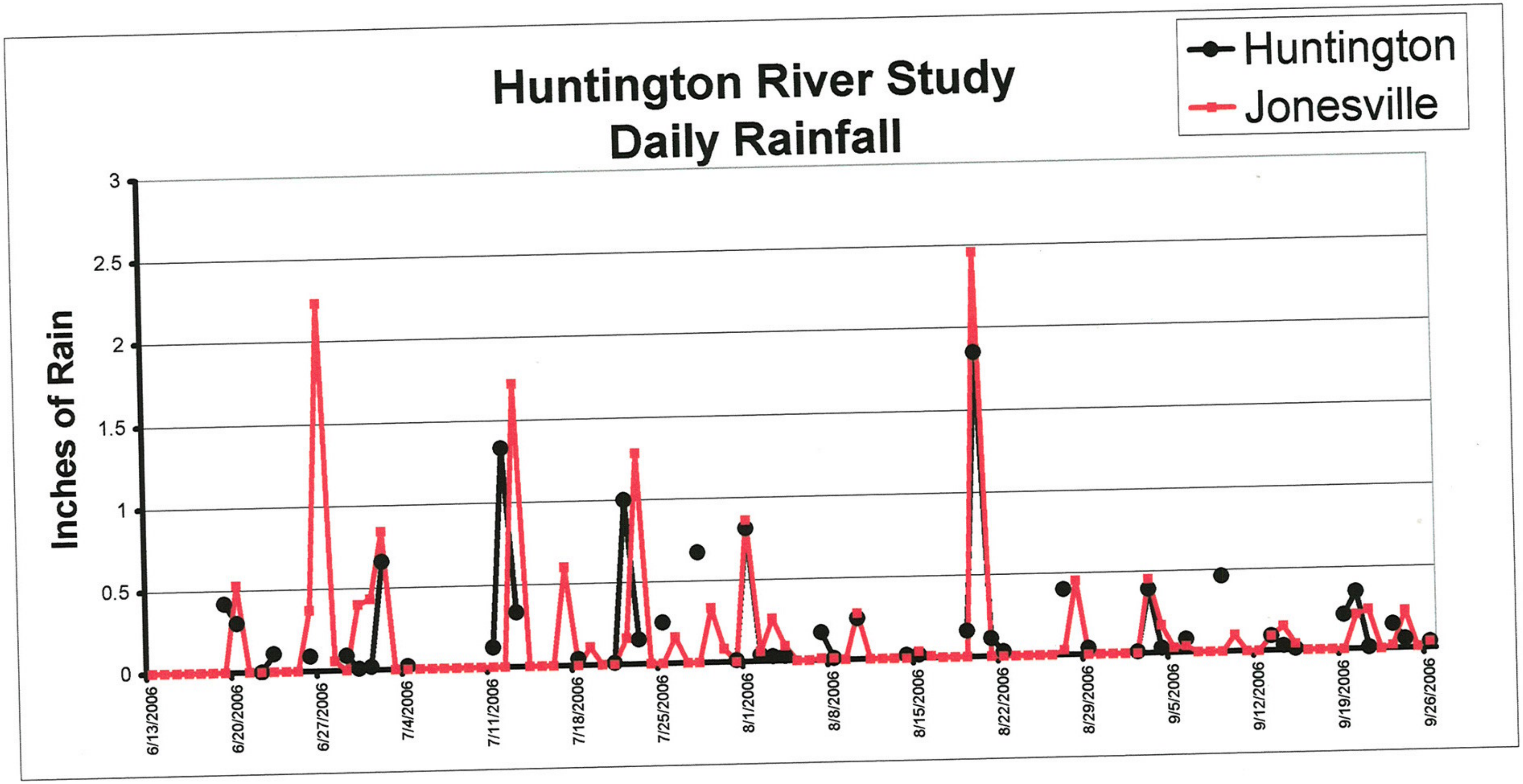


FIGURE 5



Huntington River Study
Daily Rainfall
Huntington
Jonesville
Inches of Rain
0
0.5
1
1.5
2
2.5
3
6/13/2006
6/20/2006
6/27/2006
7/4/2006
7/11/2006
7/18/2006
7/25/2006
8/1/2006
8/8/2006
8/15/2006
8/22/2006
8/29/2006
9/5/2006
9/12/2006
9/19/2006
9/26/2006

FIGURE 6

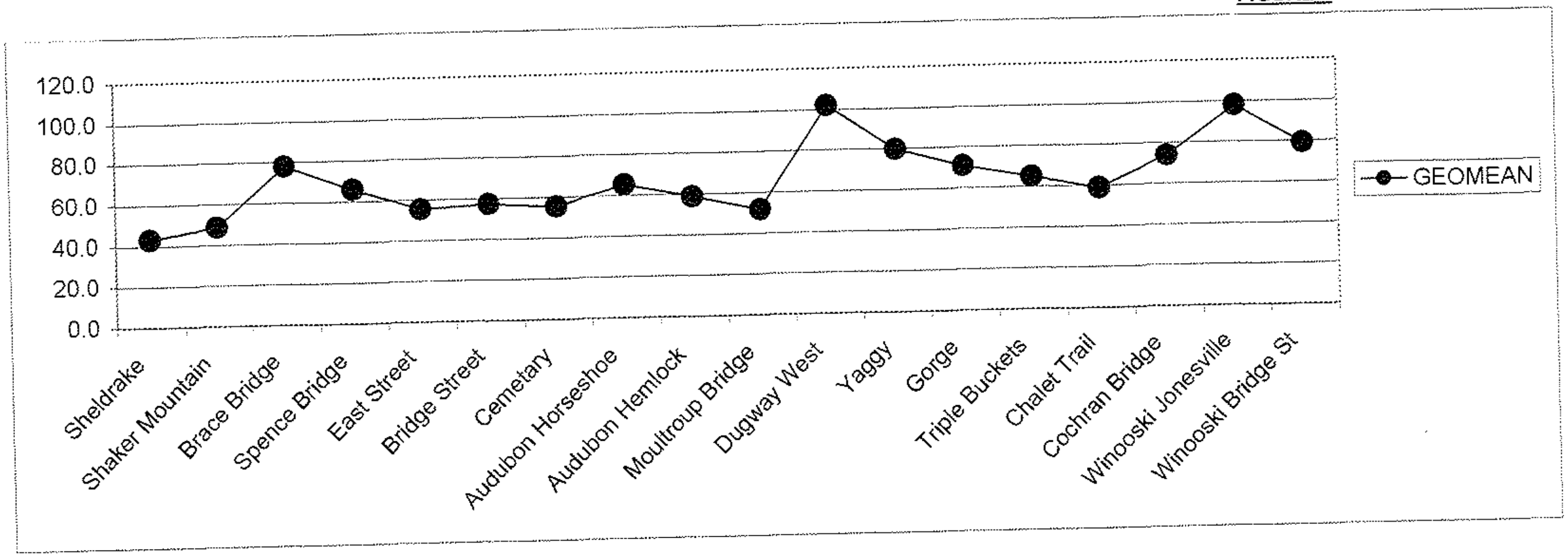

120.0
100.0
80.0
60.0
40.0
20.0
0.0
Sheldrake
Shaker Mountain
Brace Bridge
Spence Bridge
East Street
Bridge Street
Cemetary
Audubon Horseshoe
Audubon Hemlock
Moultroup Bridge
Dugway West
Yaggy
Gorge
Triple Buckets
Chalet Trail
Cochran Bridge
Winooski Jonesville
Winooski Bridge St
GEOMEAN

FIGURE 7

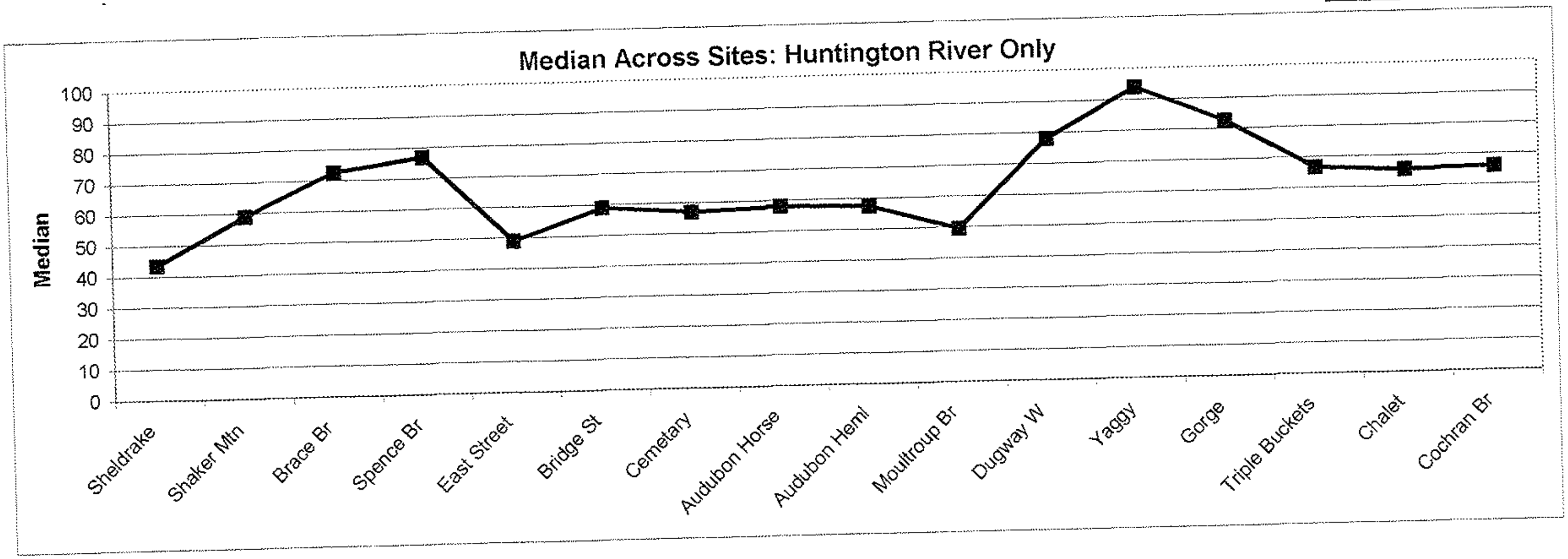
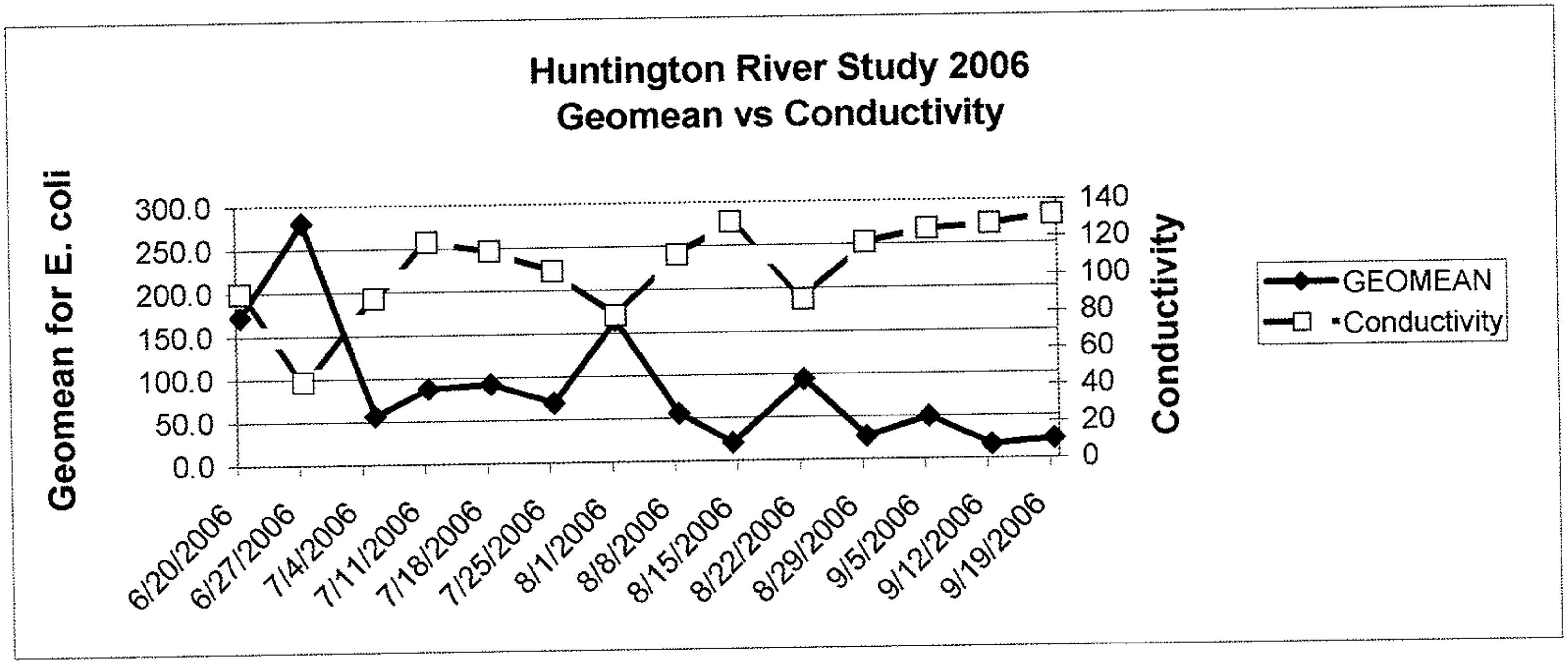

Median Across Sites: Huntington River Only
Median
100
90
80
70
60
50
40
30
20
10
0
Sheldrake
Shaker Mtn
Brace Br
Spence Br
East Street
Bridge St
Cemetary
Audubon Horse
Audubon Heml
Moultroup Br
Dugway W
Yaggy
Gorge
Triple Buckets
Chalet
Cochran Br

FIGURE 8



Huntington River Study 2006
Geomean vs Conductivity
Geomean for E. coli
300.0
250.0
200.0
150.0
100.0
50.0
0.0
140
120
100
80
60
40
20
0
Conductivity
6/20/2006
6/27/2006
7/4/2006
7/11/2006
7/18/2006
7/25/2006
8/1/2006
8/8/2006
8/15/2006
8/22/2006
8/29/2006
9/5/2006
9/12/2006
9/19/2006
GEOMEAN
Conductivity

FIGURE 8a

SUMMARY OUTPUT Geomean vs Conductivity

Regression Statistics	
Multiple R	0.889184914
R Square	0.790649811
Adjusted R Square	-1.166666667
Standard Error	35.38223876
Observations	1

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	14	56736.51794	4052.608424	45.32022538	#NUM!
Residual	12	15022.83384	1251.90282		
Total	26	71759.35178			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept							-1.6914E-306	2.3812E-306
X Variable 1							-2.0189E-306	2.4416E-306
X Variable 2							-4.8483E-307	4.8483E-307
X Variable 3							-3.61035819	-3.61035819
X Variable 4							3.89561E+76	3.89561E+76
X Variable 5							0	0
X Variable 6		1.78827E-06	-2.7112E-301	1	-3.8963E-06	3.8963E-06	-4.56957E-05	4.56957E-05
X Variable 7							1.627E-297	1.627E-297
X Variable 8							0	0
X Variable 9							373.6768253	373.6768253
X Variable 10							1.6269E-297	1.6269E-297
X Variable 11							-4.61308E-62	4.61308E-62
X Variable 12							1.0386E+103	-1.0386E+103
X Variable 13	373.6768253	43.73598159	8.543922229	1.90546E-06	278.3843092	468.9693415	278.3843092	468.9693415
X Variable 14	-2.727580325	0.405164624	-6.732029811	2.09727E-05	-3.61035819	-1.84480246	-3.61035819	-1.84480246

FIGURE 9

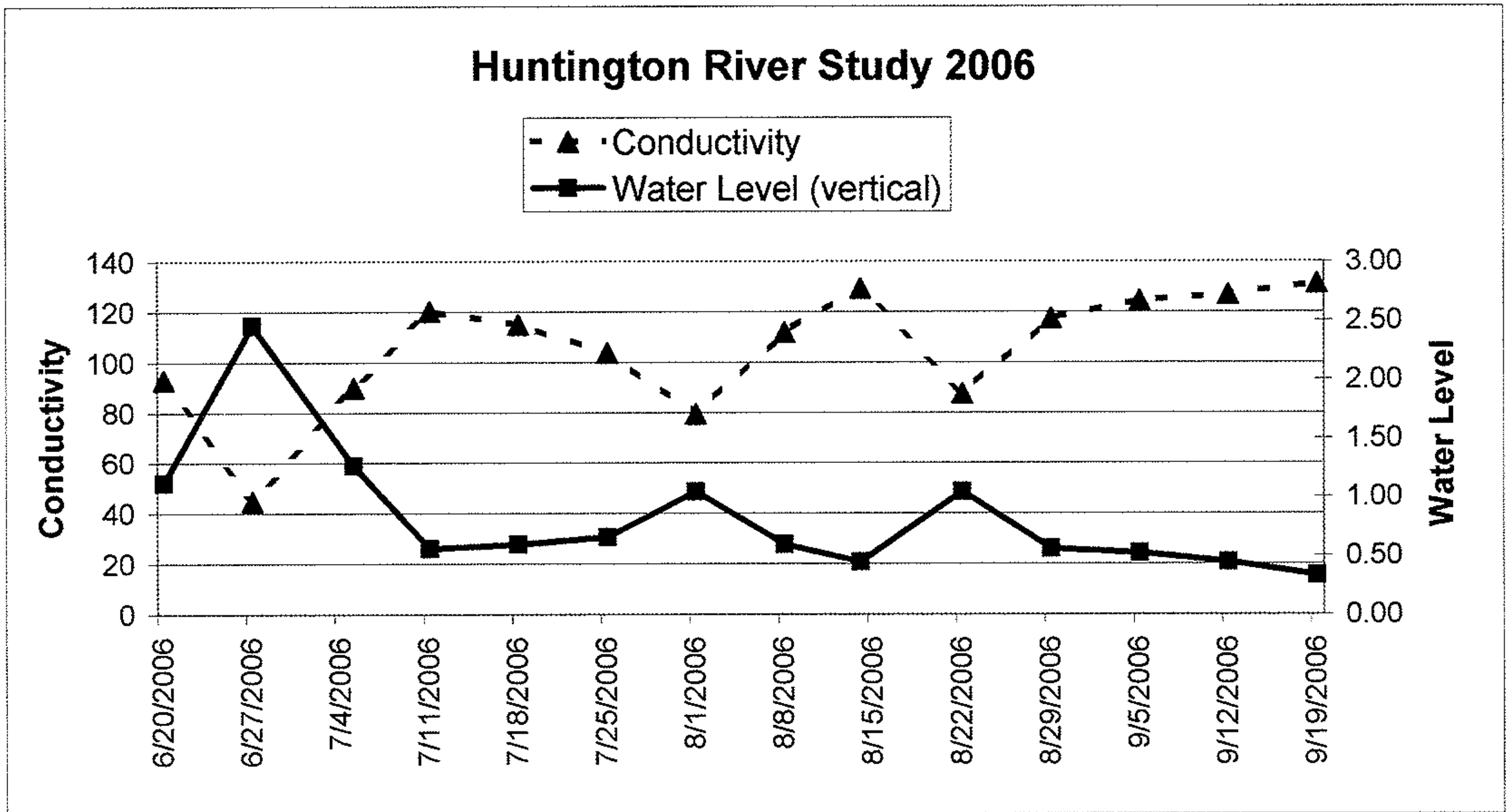

Huntington River Study 2006
Conductivity
Water Level (vertical)
Conductivity
Water Level
140
120
100
80
60
40
20
0
3.00
2.50
2.00
1.50
1.00
0.50
0.00
6/20/2006
6/27/2006
7/4/2006
7/11/2006
7/18/2006
7/25/2006
8/1/2006
8/8/2006
8/15/2006
8/22/2006
8/29/2006
9/5/2006
9/12/2006
9/19/2006

FIGURE 9a

SUMMARY OUTPUT Conductivity vs Water Level

Regression Statistics	
Multiple R	0.953078172
R Square	0.908358002
Adjusted R Square	-1.166666667
Standard Error	7.63150938
Observations	1

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	14	6927.310061	494.8078615	118.9443294	#NUM!
Residual	12	698.8792251	58.23993542		
Total	26	7626.189286			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept							73.32483279	-73.32483279
X Variable 1							-2.289E-131	2.289E-131
X Variable 2							0	0
X Variable 3							3.916724991	3.916724991
X Variable 4							-2.1261E-148	-2.1261E-148
X Variable 5							-3.6183E-308	3.6538E-308
X Variable 6							3.444800447	19.7859068
X Variable 7							-4.4317E-190	4.4317E-190
X Variable 8							0	0
X Variable 9							-293.6543206	317.6543206
X Variable 10							-3.4447E+175	-3.4447E+175
X Variable 11							-3.082E+179	3.082E+179
X Variable 12							2.78336E+62	-2.78336E+62
X Variable 13	140.2848017	3.794131983	36.97414913	9.8282E-14	132.0180984	148.551505	132.0180984	148.551505
X Variable 14	-42.05530372	3.85610546	-10.90616016	1.39209E-07	-50.45703563	-33.65357182	-50.45703563	-33.65357182