Flora Glen: A Second (and third, and fourth) Look

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Over the course of this semester, the class has learned many sampling techniques, testing procedures, and observational skills, and performed them for several different locations. The purpose of this investigation was to utilize as many of the skills learned during this course as possible on one site. Through pH and ANC analysis, measuring the levels of conductivity, fluoride, chloride, sulfate, calcium, magnesium, sodium, potassium, lead, fecal coliform bacteria, and total coliform bacteria, water and sediment depth and area calculations, and observation of the surroundings of Flora Glen Pond, a more in-depth profile of this one site has been formed.

The area dividing Birch Hill and Bee Hill, Flora Glen, has an interesting history. This plot of land, which is located off of Bee Hill road, has been purported to be the site of the writing of William Cullen Bryant's "Thanatopsis," (though biographers say this is not true), and has had an influential part in the history of water needs in Williamstown. According to Williamstown: The First Two Hundred Years, in the early 1900s, the area was a site where "urchins and elders"(page 29) gathered chestnuts. A decade later, it became a spot for romantic visitors and summer people seeking exercise. In the twenties, "country lads and college students chose it for amorous dalliance." Today, the pond and surrounding area are simply a beautiful place to visit, and a wonderful site for ENVI experiments.

The pond was created in 1895, when the Williamstown Water Company, which had been authorized to supply water to the town since 1885, decided to build a dam there. This new reservoir was then connected to the Cold Spring pipeline in the valley below, in the hopes that it would satisfy the rising water needs of the town.

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However, as a result of this action, Cold Spring had to be cut from the system to prevent the reservoir from draining into it, so the net gain in water supply was scant (pages 239-240). In 1912, Flora Glen was cut from the system due to water contamination from the privy of the adjacent house, which had existed since 1800, and was currently owned by J. W. Bullock, the principal owner of the water company. Cold Spring was reinstated, and the previous water system was restored. It was rumored at this time that the pond was taken off of the water system because a young negro boy had drowned there in 1912. In addition to this use, the pond had another contribution to the town. Until the 1950s, the pond was used to provide ice to Willamstown (although no documentation of this could be found, the house of local history found a former worker at the pond who confirmed its use as an ice pond).

Since the 1880s, the land around the pond has been owned by various people. During the 1880s, it was the property of a squatter named Malady, after whom the area is sometimes referred to as Malady Gulley. Although the name Flora Glen continued to be the popular appellation, it became permanently misspelled on many maps as Flora's Glen, where it remains to this day. Later, as previously mentioned, the area was owned by J. W. Bullock, who farmed there. More recently (from 1947-1953), the area was owned by R.R.R. Brooks, the author of the aforementioned history of Williamstown.

The appearance of the pond and surrounding area is typical of many in New England. The pond itself, which is located at an altitude of about two hundred and fourty-five feet, is fed by Glen Brook,

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which enters from the southwest. Water exits via a waterfall through the dam on the eastern end of the pond. On the eastern, western, and southern sides, the pond is bordered almost entirely by deciduous trees, including many which are paper birches. On the southwestern side, a small marsh-like area has formed, scattered with tufts of grass, and littered with branches, logs, and other natural debris. At the inflow of the pond, the few coniferous trees in the area are found. These few hemlocks are located adjacent to the point of rocks and pebbles next to the inlet to the pond. In addition to this bit of land protruding into the pond, there is a second peninsula to the north, completely covered with grass, shrubs, and small trees. The area behind this is a dense forest of deciduous trees, fallen tree trunks, and shrubs. Some of the species present in the area are barberry, sumac, wild grapes, sensitive fern, evening primrose, various mosses, lichens, fungi, and soft rush. There has been evidence of human refuse in the area, including a mesh screen found at the first visitation of the site at the beginning of the semester. On the northwestern side of the pond the hillside at first is a mass of bushes, before giving way to a covering of grass that is a continuation of the lawn of the house on the northeastern side. North of these bushes is an area that looks as if it was once a field, where the species of grass is different than that on the lawn. At the northeastern corner, there is a metal pole stuck in the ground (more evidence of human presence), followed by a small, dense stand of trees and bushes. This adjoins the dam itself, a stone structure that extends about sixty-five feet across the pond, with an eight foot break that is a sheer drop off, creating a waterfall that falls onto rocks below, before eventually flowing into Hemlock Brook. On the southeastern edge one can find a portion of the RRR Brooks trail, which winds through the forest (see vegatation map for visual representation).

In addition to the vegetative life, there is abundant animal life in and around the pond. Next to the northern peninsula, there is a nesting area for hundreds of bullfrog tadpoles, in addition to the congregation of several small fish. Smaller species of frogs, salamanders, and garter snakes can also be found in or near the pond. Evidence of deer, rabbits, and raccoons has also been found. Obviously, there is human habitation in the area, as the pond is located directly off of Bee Hill Road (which has existed since 1800), and down hill from an occupied house. This occupation and use has had an impact on the pond, which will be shown later.

The actual contents of the pond, both water and sediment, show many interesting patterns. Water depth never extends below four or five feet. The water is deepest at what is roughly the center of the pond, and gradually becomes shallower as one moves towards the edges of the pond. The eastern end, that feeding directly into the waterfall, is the shallowest, having a depth of less than one foot for a distance of fifty feet before the outflow (see water depth map for detailed representation of the various water depths). The water flow is a fairly direct one, from inlet to outlet, so much of the surface water does not appear to be moving at times. In the two fingers of water formed by the protrusion of the peninsulas, the water is completely stagnant, and filled with algae. This algae extends somewhat to the periphery, as its evidence in sample three shows.

The area of the pond and volume of water were calculated in this manner. A spot was chosen from which to measure distance, and one end of a measuring tape was held at this spot (thanks to Ian Penner '93, who was an excellent post for this portion of the work). A second person then boarded an inflatable boat with the other end of the tape, and paddled to various points on the bank of the pond, so that lengths and widths could be determined. The bank person recorded the lengths and the degree on the compass at which they were found, so that a map (see original map for location and length of rays) could be constructed from this data (these points have been marked on the map which shows sampling locations, it was also necessary to use a second point of reference). The actual surface area was found by tracing this map on the digitizer (in the Clark geology building), as were the areas of the drainage basin and the individual divisions of water and sediment depths.

To find water and sediment depths, both people went out on the pond in the boat, and one held the boat still with a probe, while the other used another probe and the measuring tape to find the actual depths. These depths were plotted on a map of the pond (see water and sediment depth maps), and bathymetry lines were drawn for the various depths. The areas of the individual sections were multiplied by an average of the possible depths (increments of one foot, starting at 0.5 feet were used, except for the 0-1ft portion of the sediment, as multiple points could be used to weight the average in this case) to obtain the volume of the pond's water and sediment. The volume of water was thus found to be approximately 3.48×10^4 cubic feet, and that of sediment to be 2.01×10^4 cubic feet (see

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calculations sheet for details of work here). This water volume is over thirteen times less than that of the drainage basin, which is 4.61 x 10^{8} ft^3. In contrast, the area is slightly over nine hundred times less, the drainage basin area being 1.92 x 10^{7} ft^2. Finally, it can be calculated that approximately 4.60 x 10^{8} cubic feet of water pass through and out of the pond every year.

The pattern for sediment depth varied from that of water. The sediment was deepest more towards the inlet, which seems logical, since much sediment enters in this manner (perhaps some also enters the pond through erosion). With the exception of the southeastern side of the pond, the sediment at the edge of the pond was less than a foot deep for a distance of roughly twenty-five to sixty feet around the periphery of the pond. Here there is an interesting point to notice. Between points C and D, there is a noticeable increase in sediment depth, from 2.3 to 6.1 feet, in a distance of only one foot. This can be explained by a flooding of the pond due to the storm on May 2, 1992. Site C is not usually submerged, and therefore the water has not penetrated to such depths as it has at site D, which is always under water. Also, the sediment in the southern finger is colored orange, indicating a possible leakage of copper from the ground in this area, which may be of natural or human origin.

Tests were performed at several sites to detect the presence of fecal and total coliform bacteria, which can often be indicators of contamination. These sites, numbers 1, 2, 4, 7, and 9, were chosen due to their locations (see sampling site map). Samples were taken an arm's length away from the bank at the indicated locations.

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Sample 1 was taken from the inlet to the pond, while 7 was taken at the foot of the falls which serve as the outlet. Sample 2 was obtained in one of the stagnant fingers of the pond. Samples 4 and 9 were chosen to represent the northern and southern sides of the pond, respectively, as the eastern and western ends had been sampled. In retrospect, it might have been useful to test all of the samples for bacteria, however, at the onset of this project this was not seen as necessary, so only these five samples were taken in sterile bottles. The samples were filtered and tested for bacteria in accordance with the directions given in Laboratory Exercise two, and further instructions can be found in the lab in Bronfman Science Center, room 165.

Fecal bacteria were only found in two samples, #2 and#7 (see data tables for any figures referred to from this point on). One colony was found in sample 2, indicating perhaps that stagnant pools foster bacterial growth. This theory is supported by the high number (200) of total coliform bacteria at this site. Four fecal colonies were found at site seven, leading one to suspect human contamination. This seems possible, as this site is the outflow site, and lays just past the Bee Hill bridge. Any substances falling off of the bridge would fall directly into the water, or might leak into it from the surrounding soil. The low number of total colonies (30) at this point strongly indicates that the high fecal figure is due to human interference.

The total bacteria figures showed large numbers in different areas. In addition to sample 2, samples #1 and #4 also showed elevated bacteria presence, at 250 and 150 colonies respectively.

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The elevated level at site 1 may indicate contamination upstream, as this is the pond's only inlet. In addition, the level of bacteria lowers as one moves away from the inlet, indicating a dilution of the numbers by distance, which supports this theory. As to sample 4, perhaps some sort of human contamination is washing down the hill from the house, a theory which could be proved or disproved by further testing in this area. The bacteria level at site 9 was 80, which, while higher than that of sample 7, is not quite on the scale of #1-2 and 4.

The chemical data from the pond are interesting in that they have few correlations between data sets, but very logical ones within sets by location. These samples were tested for pH on a pH meter in room 165, then titrated with 1.6 N sulfuric acid to obtain ANC readings. The conductivity readings were also done in this lab. The samples were run on the Ion Chromatograph for fluoride, chloride, and sulfate values, and on the Atomic Absorption Spectrometer for calcium, magnesium, sodium, potassium and lead (through heavy metal analysis). Procedures for these tests can be found in Laboratory Exercises one and two, and in lab with the machines themselves. The two correlations found between data both had correlations of .71. The levels of calcium and chloride rose together, showing evidence of the marble bedrock in the Williamstown area, which contains calcium carbonate. Also, the conductivity rose as the sulfate values dropped, for unknown reasons (this may well be a coincidental correlation).

Within data sets, there were several noticeable anomalies. Firstly, all of the pH values are in the 7.09 to 7.66 range except one.

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The pH for sample 6 is only 4.46. The exact cause of this is not known. While another sample was taken and tested from this site, and the pH of the new sample fit with the other pHs, the second sample has been discounted for two reasons: this sample was taken while the pond was flooded, and the ANCs of the two samples adjacent to #6 are both low (#5=16, #7=18), a fact which is logical given the original low pH. A possible cause of this low pH may be the stand of trees and bushes directly adjacent to the water in this area. Here the vegetation directly borders the pond, while in other areas it is somewhat removed from the edge. Perhaps these plants are the cause of the acidic pH.

The chloride and sodium figures also have an interesting feature. Both sets show high values for site 7, at which the chloride level is 64.8, and the sodium level is 32.7. These figures fit in with the earlier theory of pollution from Bee Hill road. Although a gravel road is unlikely to be salted, any chemicals placed on the road surface could easily fall into the brook when it rains, and some appear to have done so. The chloride levels themselves are also very high, ranging from 15.6- 64.8, with most falling in the high twenties to low thirties. These findings correlate with Heather Stoll's (class of '94) work on road salt, as she found high chloride levels in this region as well.

The conductivity readings show a pattern as well. Except at sites 2-5, these levels are all above 200. At these sites the levels drop. This indicates a lowering of ions in the water at these points, which may somehow be connected to the house and its occupants, but which is more likely due to the fact that these sites are farther away from the direct current flow than others, and therefore do not contain many of the ions that enter the pond. The lead data show a similar pattern. At sites 3-4, the levels are lower than at all the other sites (with the exception of site 1, at which the level is higher), where the lead figures are between 4.0-4.8. At these sites, the levels drop to between 2.8-3.2. The cause in this drop is unknown, perhaps further research can discern its origin. Another noticeable piece of data in this area is the high level of potassium (11.2) at site 3. This may be due to the algae in the area (previously mentioned). Perhaps this direct influence of organic material has caused this rise in potassium.

Perhaps the most interesting and puzzling piece of data is one which does not appear in the data table. At this pond, a site with a high organic presence, virtually no nitrate was found. These samples were taken in late April, which adds to the puzzle, because in this portion of New England, the plants do not visibly appeared to grow for a few more weeks, so nitrate should have been found in the water. The only possible solution here is that the plants were growing internally, and were thus using up the pond's nitrates. In passing, the fluoride levels in the pond were also almost negligible, and have not been commented on because they show no important trends.

In conclusion, this experiment has given rise to many new ideas. While many trends have been shown and explained, there are still many for which a cause has not been determined. Perhaps further testing would explain these (especially the absence of nitrates!). While there is room for human error in the various

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processes of the project, most of the data seem logical, and therefore are probably fairly accurate. Through this work, a more complete, though by no means total, picture of Flora Glen pond and its surroundings has been obtained. One now sees an ecosystem that is flourishing in many ways, but which has been noticeably changed by human contamination.

Many thanks are due to people who were instrumental in the completion of this project. MUCH gratitude to Sandy Brown for all her help in the lab, and to Ian Penner '93, and Profs. Art, Dethier, and Evans for their assistance. The staffs of the Williamsiana collection in Stetson and the House of Local History on Route 2 were very helpful in finding background material, and Heather Stoll '94 gave useful ideas on some of the material presented here.

Thanks also to Rebecca Beavers '93 and Haroon Cheema '94 for letting me use their wordprocessor and printer!

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Bibliography

Brooks, Robert R.R. Williamstown: The First Two Hundred Years. Williamstown: The McClelland Press, 1953.

All materials provided as text for ENVI 102, including class labs.

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Appendix of Maps and Tables

1. Key for maps
2. Vegetation Map
3. Water Depth Map
4. Sediment Depth Map
5. Original Map
6, 7. Calculations
8. Sampling Sites and Width Measurement Sites (Map)
9, 10. Data Tables
11. Graphs
12. Map Showing Drainage Basin

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Key for Vegetation Map

= deciduous trees

= coniferous trees

, = fallen trees, logs

, = various shrubs and bushes

, = various grasses

= house

= metal pole

= RRR Brooks Trail

= water entrance/flow

= gravel/stone point

, = sediment visible

Key for Water Depth Map

= 0-1 ft.

= 1-2 ft.

= 2-3 ft.

= 3-4 ft.

= >4 ft.

letter = measurement site

Key for Sediment Depth Map

= 0-1 ft.

= 1-2 ft.

= 2-3 ft.

= 3-4 ft.

= 4-5 ft.

= 5-6 ft.

= 6-7 ft.

= >7 ft.

letter = measurement site

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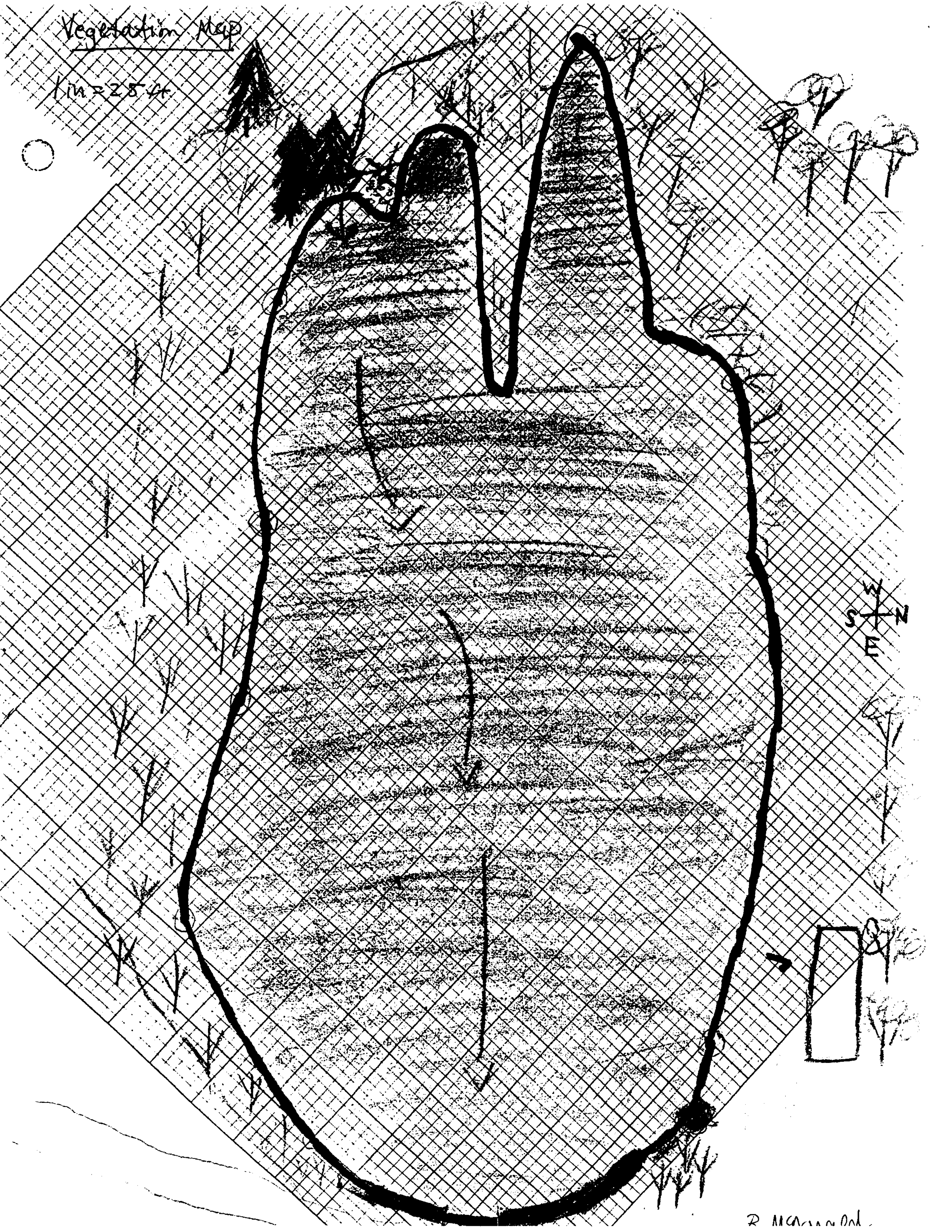
Vegetation Map
1in = 25 ft
W
S
N
E

Water Depth Map

1 in = 25 ft.

Each contour = 1 foot

1 in = 25 ft

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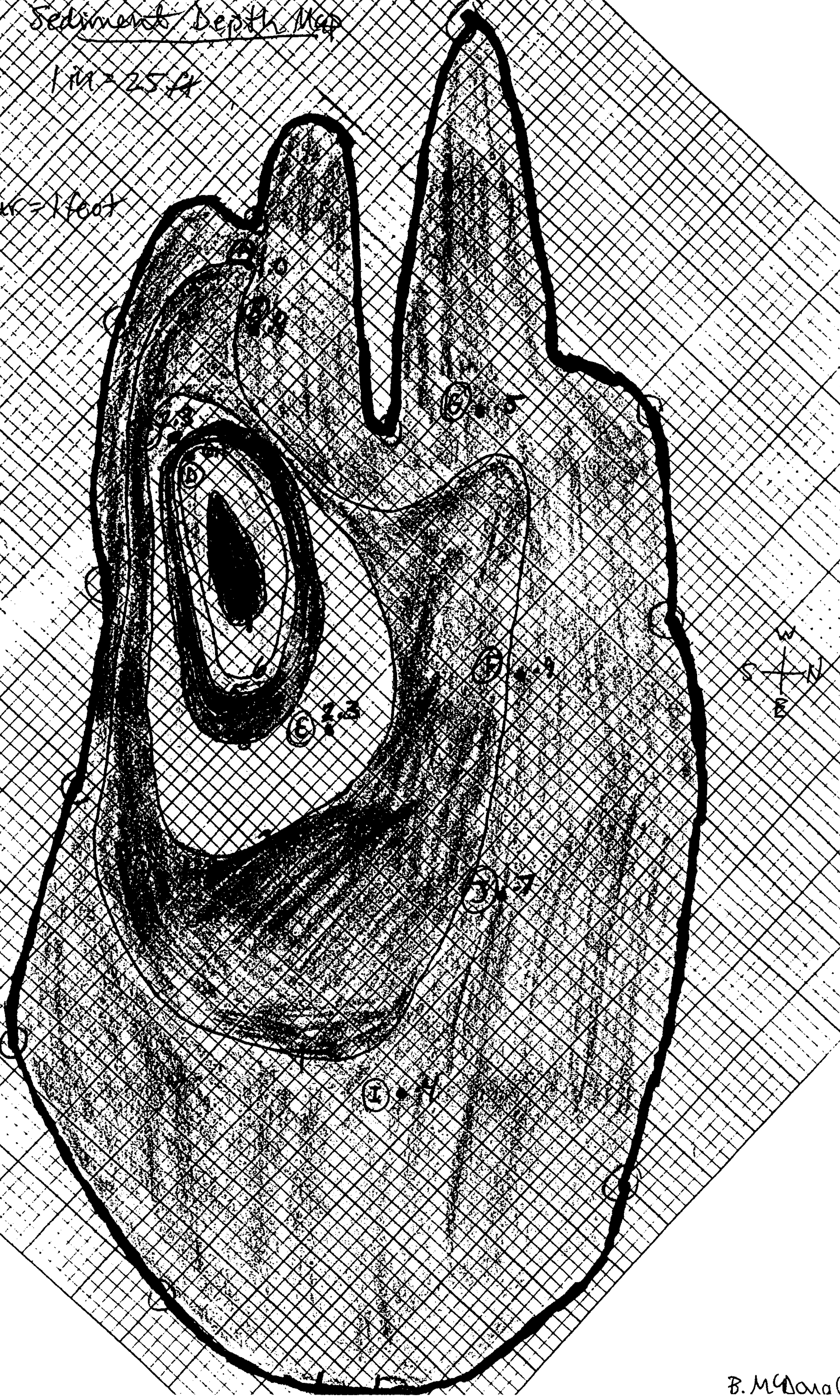
Sediment Depth Map

1 in = 25 ft

Each contour = 1 foot



1 in = 25 ft

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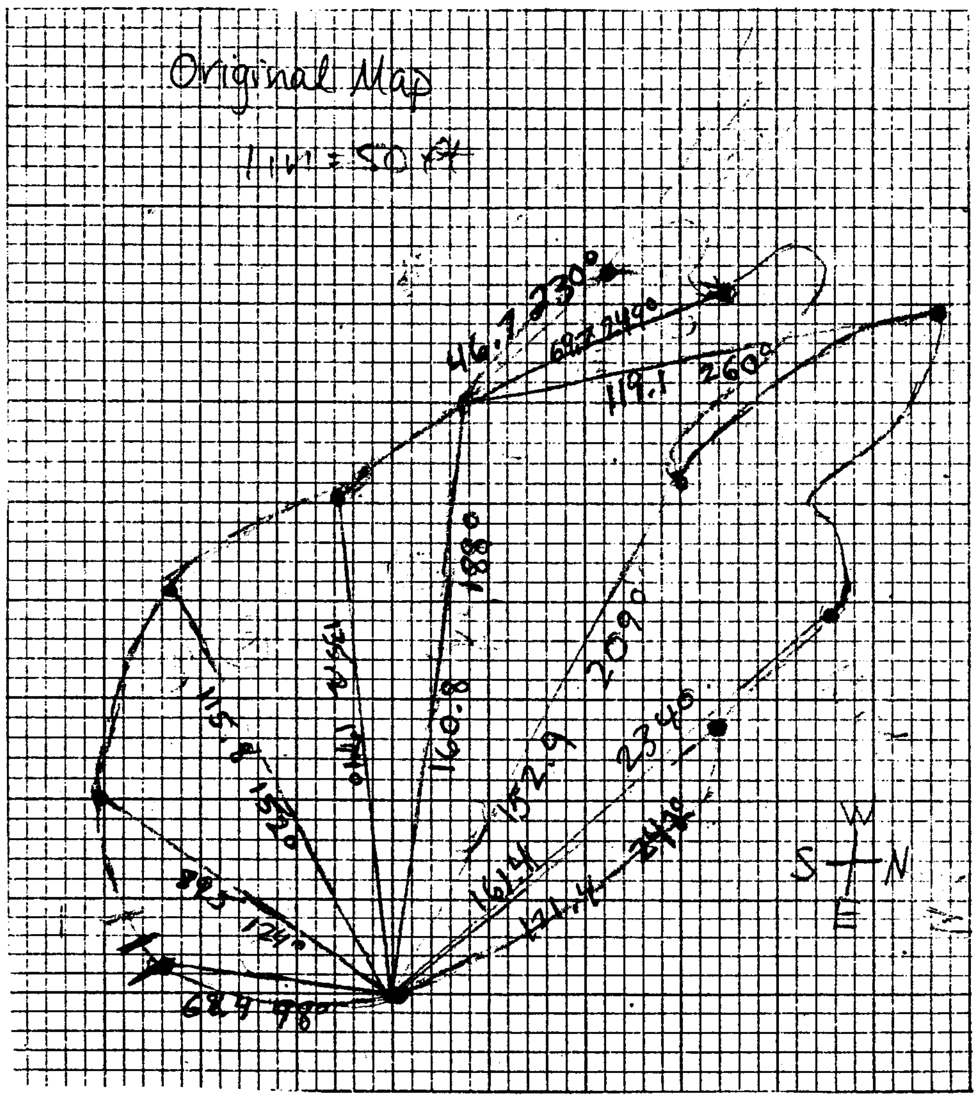
Original Map
1 in = 50 ft
46.7 230°
68.3 249°
119.1 260°
188°
160.8
115.8
152°
89.5
124°
68.4 98°
209°
152.9
161.4
234°
121.4
244°
W
S
N
E

Calculations

total precip in drainage basin 42 in/yr
amount of evapotranspiration − 18 in/yr

24 in/yr runoff

Total Area of drainage basin
4.43 in² (on digitizer)

Total Area of Pond
33.85 in² (on digitizer)
33.85 × 625 = $\boxed{21156.25\ ft^2}$

map scale 1:25,000

25000 ÷ 12 = 2083.33   1" = 2083.33'   (1)² = (2083.33)²   1 in² = 4340263.89 ft²

4340263.89
× 4.43

= Total Area of Drainage Basin ≈ $\boxed{1.92 \times 10^7\ ft^2}$

19227369.03 ft²
× 24 in

= 461456856.7 ft³ ≈ $\boxed{4.61 \times 10^8\ ft^3}$ Total Vol of H_2O in drainage basin

H_2O areas (by digitizer)   1 in = 25 ft   1 in² = 625 ft²

0 ft − 1 ft (33.85 in²) − (19.23 in²) = 14.62 in² × 625 ft² = 9137.5 ft²
1 ft − 2 ft (19.23 in²) − (12.8 in²) = (6.43 in²) × 625 ft² = 4018.75 ft²
2 ft − 3 ft (12.8 in²) − (5.4 in²) = (7.4 in²) × 625 ft² = 4625 ft²
3 ft − 4 ft (5.4 in²) − (1.31 in²) = (4.09 in²) × 625 ft² = 2556.25 ft²
>4 ft (1.31 in²) = (1.31 in²) × 625 ft² = 818.75 ft²

H_2O volumes

0 ft − 1 ft 9137.5 ft² × .5 ft (average of depths) = 4568.75 ft³
1 ft − 2 ft 4018.75 ft² × 1.5 ft = 6028.125 ft³
2 ft − 3 ft 4625 ft² × 2.5 ft = 11562.5 ft³
3 ft − 4 ft 2556.25 ft² × 3.5 ft = 8946.875 ft³
>4 ft 818.75 ft² × 4.5 ft = 3684.375 ft³

total H_2O vol 34790.625 ft³ ≈ $\boxed{3.48 \times 10^4\ ft^3}$

Sediment areas

0 ft − 1 ft (33.85 in²) − (11.03 in²) = (22.82 in²) × 625 ft² = 14262.5 ft²
1 ft − 2 ft (11.03 in²) − (3.67 in²) = (7.36 in²) × 625 ft² = 4600 ft²
2 ft − 3 ft (3.67 in²) − (1.66 in²) = (2.01 in²) × 625 ft² = 1256.25 ft²
3 ft − 4 ft (1.66 in²) − (1.3 in²) = .36 in² × 625 ft² = 225 ft²
4 ft − 5 ft (1.3 in²) − (1.05 in²) = (.25 in²) × 625 ft² = 156.25 ft²
5 ft − 6 ft (1.05 in²) − (.81 in²) = (.24 in²) × 625 ft² = 150 ft²
6 ft − 7 ft (.81 in²) − (.28 in²) = (.53 in²) × 625 ft² = 331.25 ft²
>7 ft (.28 in²) = (.28 in²) × 625 ft² = 175 ft²

Sediment Volumes

0 ft – 1 ft $14262.5\,ft^2 \times .3\,ft$ (weighted average) $= 4278.75\,ft^3$

1 ft – 2 ft $4600\,ft^2 \times 1.5\,ft$ (average of depths) $= 6900\,ft^3$

2 ft – 3 ft $1256.25\,ft^2 \times 2.5\,ft = 3140.625\,ft^3$

3 ft – 4 ft $225\,ft^2 \times 3.5\,ft = 787.5\,ft^3$

4 ft – 5 ft $156.25\,ft^2 \times 4.5\,ft = 703.125\,ft^3$

5 ft – 6 ft $150\,ft^2 \times 5.5\,ft = 825\,ft^3$

6 ft – 7 ft 33[illegible].25 $ft^2 \times 6.5\,ft =$ 21[illegible].[illegible]25 ft^3

>7 ft $175\,ft^2 \times 7.5\,ft = 1312.5\,ft^3$

total sediment vol $= 20100.625\,ft^3 \approx \boxed{2.01 \times 10^4\,ft^3}$

Area Drainage Basin / Area of Pond $= 907.53/1$

Volume Drainage Basin / Volume Pond (H_2O) $= 13247.13/1$

Total Vol Through Pond [illegible] $\times 10^8\,ft^3$

$-\,3.48 \times 10^4\,ft^3$

$460{,}905{,}200.00 \approx \boxed{4.60 \times 10^8\,ft^3}$

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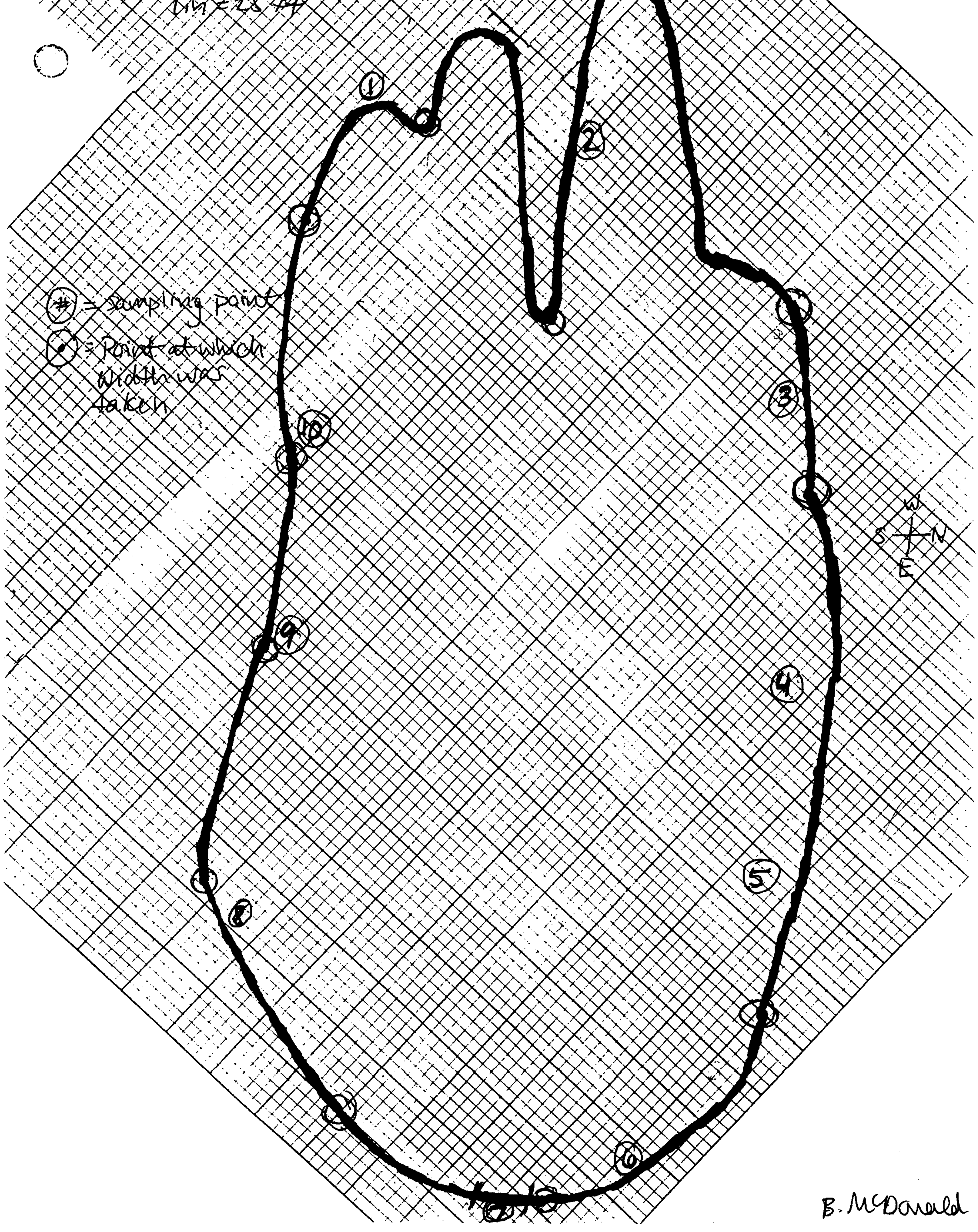
Sampling Sites and Reference Points

1 in = 25 ft



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	pH	ANC	Conductivity	F	Cl	SO_4	Ca^{+2}	Mg^{+2}	Na^{+}
1	7.5100	28.000	221.00	0.020000	31.200	5.8600	10.800	1.8000	20.100
2	7.2100	26.000	191.00	0.0000	46.000	5.4200	11.200	2.0000	22.700
3	7.0900	26.000	177.00	0.0100000	15.600	7.3000	9.1000	1.8000	20.400
4	7.1900	30.000	154.00	0.020000	32.200	13.080	11.400	2.0000	20.400
5	7.5900	16.000	199.00	0.0100000	31.800	5.8800	11.000	1.6000	21.300
6	4.4600		210.00	0.0000	26.200	5.6400	11.000	1.6000	21.400
7	7.6600	18.000	200.00	0.0100000	64.800	5.2800	13.100	2.2000	32.700
8	7.5000	24.000	209.00	0.0100000	27.400	5.1600	10.500	1.5000	22.800
9	7.5300	26.000	211.00	0.0100000	29.800	6.1000	11.500	1.7000	26.800
10	7.3500	18.000	208.00	0.0100000	23.000	5.1200	11.200	1.7000	17.800
			(micromohs/cm)	(ppm)	(ppm)	(ppm)	(mg/l)	(mg/l)	(mg/l)

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	K	Pb	Fecal Bacteria	Total Bacteria
1	1.4000	5.0230	0.0000	250.00
2	4.6000	4.0290	1.0000	200.00
3	11.200	3.2530		
4	5.6000	2.8710	0.0000	150.00
5	3.9000	4.4230		
6	1.8000	4.0290		
7	7.5000	4.1270	4.0000	30.000
8	6.7000	4.8220		
9	4.0000	4.3240	0.0000	80.000
10	1.5000	4.2250		
	(mg/l)	(μg/l)		

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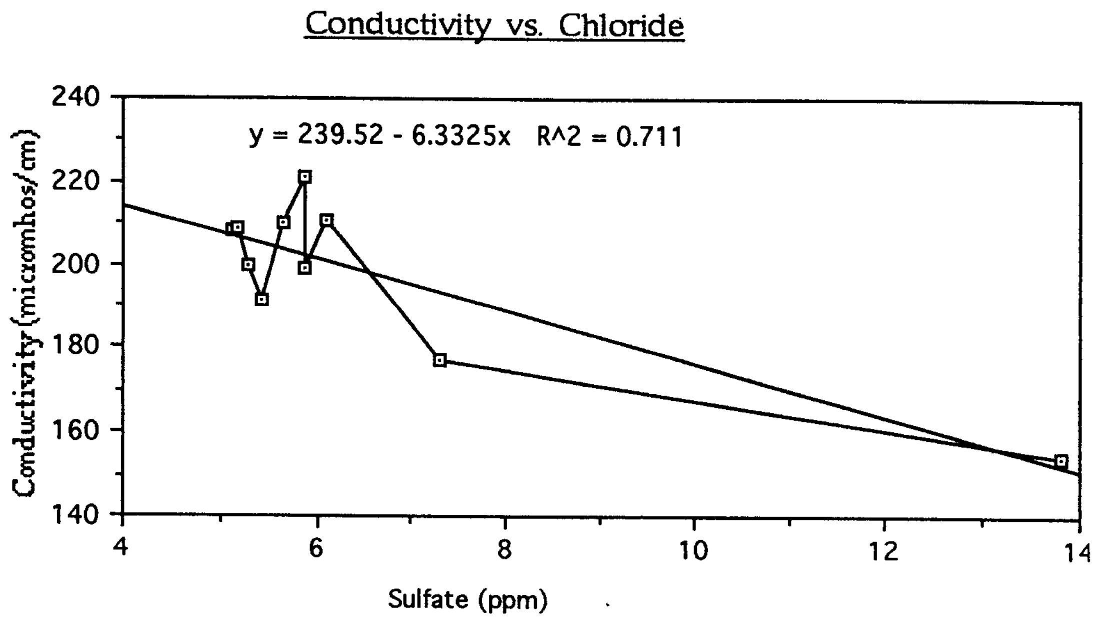
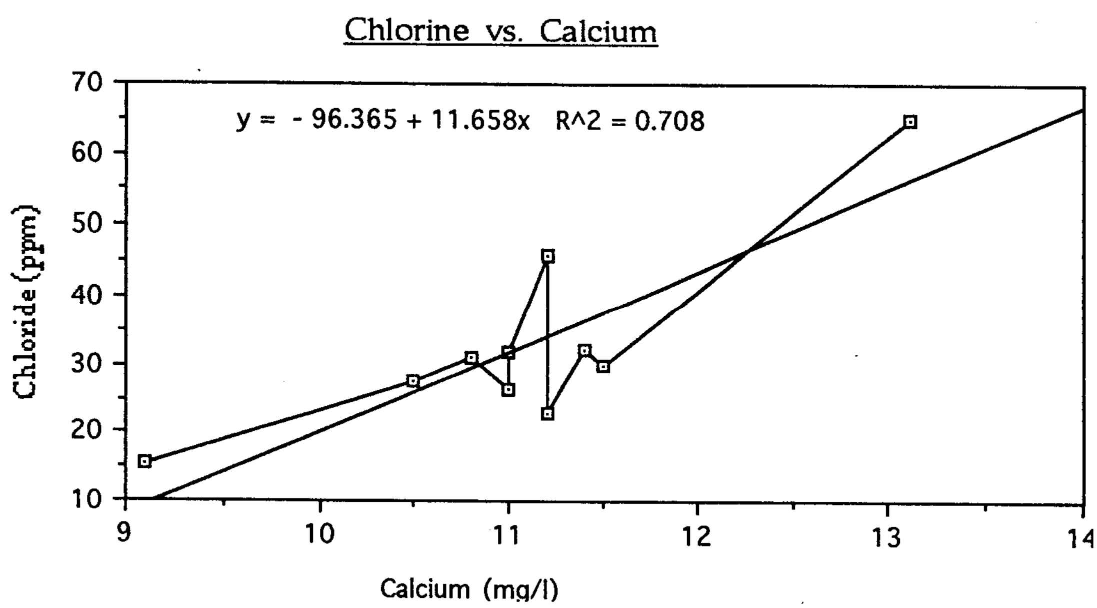


Conductivity vs. Chloride
y = 239.52 - 6.3325x R^2 = 0.711
Conductivity (micromhos/cm)
240
220
200
180
160
140
4
6
8
10
12
14
Sulfate (ppm)



Chlorine vs. Calcium
y = - 96.365 + 11.658x R^2 = 0.708
Chloride (ppm)
70
60
50
40
30
20
10
9
10
11
12
13
14
Calcium (mg/l)

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