Endodrift-Up Reservoir Hypothesis: a Case for Clyde

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[Abstract]

Introduction

The author only heard that Clyde, Ohio was classified a "Cancer Cluster" after Christmas of 2010, brought to his attention by his wife, after reading an article on it from the Internet. The point of this case that concerned him, as with most cancer cluster cases, is that the cause of the dramatic and sudden rise in cancer cases in Clyde was still unknown, leaving the community still unsettled. The small town of just over six-thousand people is less than an hour's drive from the author's home, so on New Years Day, he performed a cursory survey of the area. While the author is by no means a noted expert on cancer, nor a noted expert in environmental science, having only taken one university course in Environmental Science and one in Biology, his career has had notable moments of discovering general scientific causes and/or effects that have eluded others. However, having never been to Clyde, Ohio, he did not make any agreement or disagreement with the assumptions added to the news article almost seemingly ad hoc. Some of these articled suspicions were 1) local factories, 2) an environmental waste dump a half-mile underground and 3) the water supply itself. In general, the rise in cases did not appear to be of natural, long term environmental causes, as there has been a growing population in Clyde for decades, and the rise in numbers of these cases began to surface around 2000, peaking in 2005 and 2006.

The water supply assumption above held some interest for various reasons. The EPA had come to Clyde and tested the water supply in January a year or two earlier and found higher than normal levels of Strontium. Strontium is a hard, silver-white alkaline-earth metal (element 38 on the periodic table) commonly found in bedrock, the very bedrock floor or Clyde's Raccoon Creek, the town's water source used to fill Raccoon Creek Reservoir. Strontium 90 is radioactive and produced in the fallout of nuclear explosions. This isotope is particularly dangerous, as it accumulates in human bone for years. However, the EPA never did claim that this was the source of concern, as Clyde is not a region of prior nuclear fallout, quickly diminishing the possibility that its radioactive isotope was even present. The most common isotopes of Strontium have similar chemical properties and reactions to Calcium and Magnesium, both essential human minerals, and probably should not cause any concern or alarm. Additionally, the types of cancer occurring in Clyde were widely varied, not limited to bone cancer (assuming that the accumulation of Strontium 90 in bone would cause *bone cancer* before other forms), or any other for that matter.

The water supply assumption however, did still hold some weight with the author for other reasons, even as nothing else about the water supply was noted by the EPA (to his knowledge). This assumption is largely based on the point made in the last sentence of the above paragraph: *the types of cancer are varied*. Typically when one inhales or ingests a carcinogen, if it is to develop into cancer, it tends to do so in the cells it first comes into contact with, as these are the cells most saturated with the substance. It is for this reason that when smokers inhale carcinogens, the likelihood of getting lung cancer is higher than bone cancer or other types—for chewing tobacco, mouth cancer. However, when a substance is suspended in a fluid and then ingested, the fluid can carry the substance throughout the body for quite some time—to the digestive system, the circulatory system, the lymph system or any of the organs. Thus, it is a reasonable argument to investigate the water supply of a cancer cluster community whose cancer types are varied. But finding a carcinogen in a large body of moving water is like finding a needle in a haystack—actually harder than finding a needle in a haystack, as at least in the hay stack one knows he or she is looking for a needle. In this case, a separate statistical investigated is required, as it first would need to be determined what the carcinogen is, or at least the likelihood of what it could be. Only at that point would it be possible to test specifically for a particular toxin. The author's cursory survey of Clyde, as well as this paper on a whole, is that—a probabilistic investigation into a single cause of cancer in that town that makes the town's problem effectively unique.

Possible Common Culprits

There are often a number of environmental suspects that need to be accounted for in any cancer cluster case. One probably should look at the most common causes first, and rule any out if possible. Many of these can be ruled out from a distance, but most require on-location survey. Some of these common culprits (or suspected culprits) are 1) radon, a radioactive gas sometimes emitted from uranium deposits in granite, 2) high voltage AC power lines in the proximity of parks or schools, 3) natural toxic deposits and 4) pollution.

Occasionally, the concentration of uranium in granite can be exceedingly high. Natural minerals in composite stones (such as granite) is sporadic, one rock having a large deposit of uranium and another none at all. Granite is a common stone rising naturally over time to farm surfaces near and around Clyde, collected by the farmers and transported elsewhere, often for decorative yard pieces and businesses. The first bank one sees upon driving into town boasts a large granite wall at their entrance. Larger granite stones are typically quarried and cut for tabletops and cemetery tombstones, and typically have no environmental impact whatsoever. Though occasionally they do. In fact the largest uranium mines in the world are found in Australia—in mountain ranges that the Aborigines have for centuries considered either "cursed" or "sacred," due to the then-mysterious illnesses caused by long term exposure to the region. However, in the opinion of the author, after seriously considering a high concentration of uranium in granite as a possible culprit for Clyde, he considers it a low concern at this point, as the rise (2001) and fall (2006+) in the number of cases of cancer in Clyde suggest that if uranium were present in the area years ago, it still would be today, considering the isotope's long half-life. Instead, just as the history of the Aborigines suggest, such environmental culprits are centuries in the making, not years. Additionally, the quantities of granite used for decorative purposes through Clyde did not seem any more abundant than any other given community.

Ionizing gamma waves given off in the proximity of high voltage AC power lines have been known for decades to disrupt DNA molecules, which can lead to cancer. Upon driving to Clyde from Toledo, the author took note of low hanging power lines in some of the small towns, some power lines even looking damaged, perhaps from heavy summer winds. However, once arriving in Clyde, the situation appeared much different. In fact, having three generations of electricians before him, the author considered the electrical construction of Clyde to be if anything admirable, as there were nothing at all to take note of near the schools, churches, buildings, nor near the various community parks. Therefore, after serious consideration, the author considers a high voltage factor to be of little or no concern in this case.

Figure 1: A Clyde Park Illustrating no Neighboring High Voltage Hazards

Photo taken by Author on 1-1-11

The possibility of natural toxic deposits or emissions existing in Clyde are slim. As mentioned earlier, the EPA tested the water, but they also tested the air. The air was found to very clean, which is rather common for rural communities far from high-traffic cities. Some farming communities with high concentrations of cattle or other livestock can have a low air quality, but Clyde is not a candidate for this. But gas emissions in Clyde is certainly possible. The town of Green Springs just four miles away clearly has a distinct sulphuric odor upon passing the springs, noticeable even from within the car. One may reasonably consider the possibility of emission of other natural gases.

Figure 2: Health Spa in Green Springs

Photo taken by Author on 1-1-11

Such dangerous gas emissions however would be difficult to either rule in or rule out, as an emission of this sort could be short-lived, possibly never to return, and it might be difficult to detect unless the air just happens to be measured at the moment of emission. Compare to a geyser, which may only last a few seconds or minutes and then drop back down. This is fairly similar to how gas emissions can occur. In fact, due to the sudden increase in number of cancer patients in Clyde from 2001, its peak in 2005-2006 and some decline from that point, one is tempted to consider this (a one-time emission) a valid possibility. The only real problem with this that the author sees is that with such assumptions, one may then also be tempted to ignore further research into other causes, perhaps the actual cause, thereby accepting (wishing) the problem has subsided. In truth, if this is as of yet an unknown, then another spike in the number of cases could legitimately be in store in the next year or two. It very well may not, but it seems prudent to also consider something else that *is* testable, and not simply leave the lives of Clyde to mere circumstance.

The author thus tends more in this analysis to the fourth culprit listed above: pollution, particularly in regards to the water supply.

Christopher Creek and Raccoon Creek

Such discussions on water pollution are highly sensitive, especially to small communities. Investigation into these matters is nothing the author takes lightly, as the financial impact of pollution can cost millions of dollars and can affect hundreds or thousands of lives and jobs in various ways. Consider Los Angeles California's polluted water supply, where eventually millions (perhaps billions) of dollars were required to construct canals hundreds of miles to the Colorado River in order to replace the city's local water supply. Such cases are expensive for large cities, but can be devastating to small rural towns. While the EPA found nothing to speak of in regards to the water supply, there are good reasons to consider their test inconclusive and perhaps even inappropriate for the reasons that will be pointed out in this paper.

This is a topic that the author has a lifetime of personal experience with, having grown up in a suburban home backed up to the ever-polluted Christopher Creek (the term "creek" is actually inaccurate, as it is more correctly a *drainage ditch*). The author recalls the ditch being polluted from early childhood, warned not to go into the water for any reason by neighbors and parents. But at least in the those years, the ditch was clean enough to freeze over in the winter for children to ice skate on. But it has not frozen over for decades, even though it is slow-moving and the neighboring fast-moving Maumee River freezes over every year. The corporation responsible for polluting this ditch is well-known in town, and not of concern for this paper. However, their clean-up requirements may be of interest. Christopher Creek is not a source of water for anyone in the community, and thus there are certain low limits of pollution allowable by the city, county and/or state.

From time to time there are occurrences where those pollution limits are exceeded, and the corporate-polluter is required to pay the clean-up expense, which has often occurred some four houses down from the author's home. At such levels it is known that the toxins can become airborne by evaporation (ecodrift), and then it *does* become a potential hazard even though the water is not used for drinking. The main issue in this is that pollution from moving water is not a measurable constant; rather, the concentration of pollutants case rise to hazardous levels and then can even drop down to drinkable levels after a period of time. If the EPA measured drinking water in Clyde in January, then one has yet to consider the rest of the year as a remaining culprit.

Arriving in Clyde and visiting their community park based on Raccoon Creek, one does not immediately get the impression that the community is a victim of pollution. One may instead first notice the flourishing mallard duck population at the park.

Figure 3: Mallard Ducks on Raccoon Creek

Photo taken by Author on 1-1-11

But what may not be evident to the lay person is that water fowl is not a good example of the coal-mine canary for water pollution. While bird and human lungs share similarities, their digestive systems are more highly adaptable to toxins than ours, as many of the seeds and grasses they consume regularly are highly toxic naturally. In return, birds consume clay and/or small stones that neutralize these toxins, allowing the toxic seeds to benefit their diet. Logically speaking, if mallards were representative of human digestion, scientists would be using lab ducks instead of lab rats for their experimentation. Instead, one would be better off referring to any decline in frog, turtle, snake or small mammal populations over the years.

Consider again Christopher Creek, the duck populations thrive throughout the year, largely because the ditch never freezes over.

Figure 4: Mallard Ducks on Christopher Creek

Photo taken by Author on 1-3-11

But by looking to the ground on the hill to the left, one may find the victims whose digestive systems are more similar to ours.

Figure 5: Dead Squirrel next to Christopher Creek

Photo taken by Author on 1-3-11

Figure 6: Photo Illustrating Proximity of Dead Squirrel to Christopher Creek

Photo taken by Author on 1-3-11

While the author did not happen upon any visible signs of pollution affecting the wildlife in Clyde, neither did he note any wildlife *at all* in the vicinity—except for the mallards, and that they were all located in the creek and not the reservoir. The author is not impressed or convinced of the notion of *quality* water with the EPA's January test, nor the mere presence of the mallards in Raccoon Creek for the very reasons illustrated above. Instead, a further serious statistical analysis is required, which is what leads to the hypothesis, the basis of this paper.

The Endodrift-Up Reservoir Hypothesis

If there is pollution to be found in Clyde's Raccoon Creek, one should probably first consider where the water treatment plant is located on the creek in relation with potential polluters. In the Internet article the author read in regards to this, it noted only corporations and facilities, namely the Whirlpool Corporation and the environment waste injected a half mile below Clyde. But there are some other corporations and facilities in Clyde too the author has noted. However, the town seemed to the author to be very well planned in this regard, as each one of these facilities or factories are located down-stream from the water treatment plant, and could not at all be leaking water back up-stream *toward* the treatment plant.

Per the underground environmental waste dump assumption, the author is not interested in this for Clyde, especially as most of this waste would serve as soil fertilizer rather than a carcinogen source. Even at that, such waste would more likely seep up to Green Springs four miles away, while Raccoon Creek is shallow, insignificantly non-cavernous and begins from a trajectory away from the direction of that town anyway. While a case or two of environmental waste causing varied ailments have been known through lake drift, it is difficult to find cases in the literature of bio waste causing cancer, much less to the extent of causing a cancer cluster. While it may be difficult to shake such assumptions with a looming waste dump below a cancer cluster community, it needs to be remembered that such designs are present in perfectly healthy towns around the country. And it is largely important to consider the magnitude of a depth of ½ a mile, especially in regards to a town with a maximum elevation not much more than 700 feet.

Instead, in terms of water pollution, one really needs to look up-stream. Raccoon Creek begins miles south of the town, winds through town and then ends up draining into Lake Erie miles to the north where it then disperses. If there were to be source of the pollution, one must trace the origins of the creek south of Clyde. However, there are few, if any, facilities, factory or corporation in the miles south of town; thus, not much to look for in this regard. The article in question noted that a town 50-60 miles south of Clyde was classified as a cancer cluster by the state years ago, but by tracing the path of the creek on a map, one will find that it no where reaches a distance of 50-60 miles—not even by a stretch. In fact, the creek begins and ends with virtually two common denominators: rolling hills and farm fields.

Figure 7: Hills and Farm Fields South of Clyde

Photo taken by Author on 1-1-11

This begins to bring into suspect a source of pollution that is in many ways the most difficult to consider, as it directly affects farmers, those who are most in need of support, the feeders of society—but also those without the resources to prevent pollution. Pesticides are a requirement for any farm, absolutely essential, and have virtually baked their way into our rural life-line. So long as human beings farm, insects, fungus and other pests also will try to feed on our plants. Yet, from a strictly unbiased scientific standpoint, pesticides rise to the top of the list of potential pollutants of Clyde in the opinion of the author. The reasons why will be explained in depth.

There are two ways pesticides commonly get into drinking supplies, that which is referred to as 1) ecodrift and 2) endodrift. Ecodrift is the most commonly known, but not a likely concern for Clyde. It involves the pesticide drifting through the air, usually from aerial crop dusting. On his survey of the farms south of Clyde, the author only saw tractor dusters at a quick glance, those that disperse the pesticides only a few inches to a foot from the ground. These tractors are largely automatic, programmed so that the farmer his or her self need not be near the field when spraying, as it is well known in the literature that most pesticides are harmful to humans if taken in sufficient quantities. Thus, if sizable quantities of pesticides were making their way to Clyde's water supply, then it would most likely be due to endodrift. Endodrift is the seepage of the pesticides into the ground, then to the streams after it rains, which is then picked up by the water treatment plants.

In consideration of the topography of the area, the arguments for the pesticide assumption develop into a valid hypothesis. Within Clyde itself and to the north, toward Lake Erie and Toledo, the terrain is notably flat. However, just a mile or so south (and west) of Clyde, along the winding path of the Raccoon Creek into the farmland, the terrain almost instantly rises to an elevation of 600-700 feet, creating a funnel-like drain leading right back down toward the town.

Figure 8: Looking across a Hill Southwest of Clyde

Photo taken by Author on 1-1-11, Clyde is behind the camera to the right

Figure 9: Looking up a Hill South of Clyde

Photo taken by Author on 1-1-11, Clyde is directly behind the camera

Due to inefficiencies of pesticide spraying on hilly farmland in consideration of rapid runoff, farmers commonly tend to increase pesticide quantities for any useable effect. In other words, it is much more efficient to spray on flat terrain, as the pesticide stays on the surface area for a longer period of time, thereby having a more potent effect. An endodrift scenario arises for Clyde, it being at the bottom of the hill and consuming the runoff collecting at the bottom of the hill. Even if the farmers south of Clyde are not increasing the quantities of pesticides, as is commonly done when spraying on hilly land, the topography alone gives a high probability that these pesticides are arriving in the drinking water in large enough quantities to be harmful for human consumption. The author will provide those probabilities and the math involved in the next section. The scenario is this: 1) the farmers need to spray, 2) they farm on hilly land and need to spray in larger quantities to be effective, 3) it rains, 4) the run-off seeps into the drainage ditches surrounding the farm,

Figure 10: Ditch between Hilly Field and Road South of Clyde

Photo taken by Author on 1-1-11

5) The pesticides are channeled to neighboring creeks,

Figure 11: Small Flowing Creek Bed South of Clyde

Photo taken by Author on 1-1-11

6) The smaller creeks converge on Raccoon Creek, 7) arrive at a pump near the reservoir and treatment facility,

Figure 12: Raccoon Creek Winding up to the Reservoir

Photo taken by Author on 1-1-11

8) Is picked up by the pump when the waters levels are high (and only when the water levels are high) and brought into what is called an "up reservoir" (literally raised above the ground, as opposed to being dug out),

Figure 13: Clyde's Up Reservoir

Photo taken by Author on 1-1-11

9) Brought into the treatment plant, filtered and treated as best can be done, 10) stored in a water tower for later access as drinking water or the water park just meters away,

Figure 13: Clyde's Water Tower (left) and Water Park (right)

Photo taken by Author on 1-1-11

11) What is not picked up by the pump is then channeled through town for aesthetic parks,

Figure 14: Mother and Son near Raccoon Creek

Photo taken by Author on 1-1-11

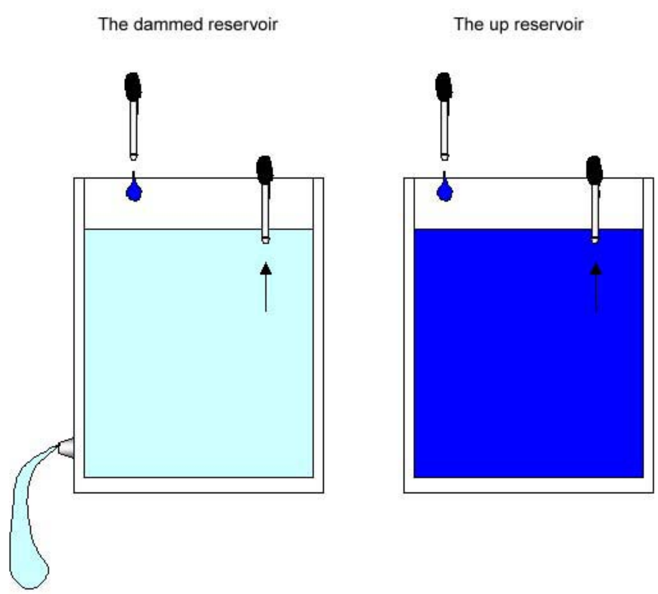
And then lastly, 12) drained into Lake Erie and dispersed.

However, there is one tangent to this scenario, one that raises the second part of the hypothesis, that which includes not only pesticides, but also the Clyde *up reservoir* itself: the pumping aspect from a moving body of water, as opposed to a dammed reservoir. If the terrain and farmland itself were the sole problem for Clyde, then a question could be raised, how is it that other communities throughout the United States can coexist with similar scenarios, and why yet another cancer cluster just an hour south of Clyde? The answer just might lie in the rise in construction projects in recent decades of up reservoirs themselves in middle to southern Ohio (and Indiana), while other hilly farmland westward (North Dakota, Arizona, etc.) consist largely of dammed reservoirs or natural lakes. In order to determine on a small scale whether or not there could be any difference between the two in terms of pesticide pollution, the author constructed a small scale experiment.

The experiment consisted of 1) two eye droppers (the pumps), 2) two containers of equal volume, one with a drainage plug (the dammed reservoir) and the other without a plug (the up reservoir), 3) water and 4) food coloring. The idea was that by continuously draining a reservoir that is dammed, but is otherwise completely restricting the flow of the intake stream or river containing pesticides, would the damming of the flow better disperse the pesticide into smaller quantities per volume or not.

The food coloring represented the pesticide flow for easy visual measure. Both containers were filled with water, but the container with the plug (the dammed reservoir) was allowed to drain continuously and slowly. The other container (the up reservoir) was only drained with the eye dropper when the water was taken, as if being a drinking water supply. By adding food coloring to both containers in equal amounts with one eye dropper and withdrawing the water with the other eyedropper over an equal amount of time, the results immediately showed that far more food coloring (pesticides) became concentrated in the container without the plug (the up reservoir), and transferring them to other containers (the water tower analogy) did little to change the result.

Figure 15: The 2-Plugged Container Experiment



What at first may seem obvious in the above experiment is that draining an up reservoir periodically may help this problem a bit. But what is less obvious is that even from the first couple drops into the container, it was visible that the blue coloring tended to disperse in the direction of the outlet plug of the dammed reservoir, by means of suction. While in the up reservoir, the dispersing of the food coloring (the pesticides) tended slightly toward to eye dropper itself (the pump). This was considered a significant result. Once the coloring was completely dispersed in the up reservoir, this became less evident; instead, what became clear was the significant discrepancy between the shades of the two containers, and thus the concentration of the solution. While this may be less of a factor for Clyde when the creek is high and the water moving faster, it is unclear to this author by what means the facility uses to determine the creek flow and when or if the reservoir is drained. It was at this point the author felt the hypothesis was completely valid for further investigation, but further probabilities needed to be considered, specifically in regards to the town of Clyde, Ohio. It was at least evident to the author that Raccoon Creek is a rather slow moving body of water for an effective and safe up reservoir in consideration of the above experiment.

Figure 16: The Slow-Moving Raccoon Creek

Photo taken by Author on 1-1-11

Probabilities of the Endodrift-Up Reservoir Hypothesis at Clyde

The next sections of this paper are largely mathematical, as the previous written description of the hypothesis may not be as easy to get a fuller picture for the mathematical reader. In the same, the more verbal reader may get a clearer picture of the hypothesis from the previous pages. For purposes of completeness, two parts and two approaches to this hypothesis are presented. There is a systematic way to determine the validity of a particular hypothesis by means of statistical measurement, even for a problem that is difficult to define and difficult to measure. However, by following at least some specific protocol, better testing methods can be applied to the problems in Clyde, and hopefully the work presented will explain why the author expressed earlier how the EPA's January water test was termed "inappropriate."

To begin, a simple Farmer Spray Algorithm has be extracted by the author from some of the more common pesticide spraying techniques, those likely used in the region south of Clyde, Ohio, which does tend to illustrate some measurable pattern, that which might be used to better equip the community with the right tools. The factor to consider in this is the method to determine the chance a particular spray will occur on any given day left to random factors, the personal choice of the farmer his or her self.

The Random Spray Factor

The following factor yields a constant value for the probability of the occurrence of a pesticide spray in the area having *x* number of farms for any given day of the month within the farming season.

To begin, using computer randomization,
Let ρ be a random number between zero and one,
Let *Q* be the resulting value of the conditional,
Let *d* be the average number of days in a month (30),

$$Q\ (\rho, d) = \text{if } \rho < (1 / d), \text{ then } Q = 1, \text{ else } Q = 0 \qquad (1)$$

Apply (1) for 30 days for one farmer.

Let *f* of *Q,* of *x* be the sum of all the values of *Q* of rho, of *d* for all the farmers for every day of the month.

$$f\ (Q, x) = \sum_{x=1}^{\infty} Q_x \qquad (2)$$

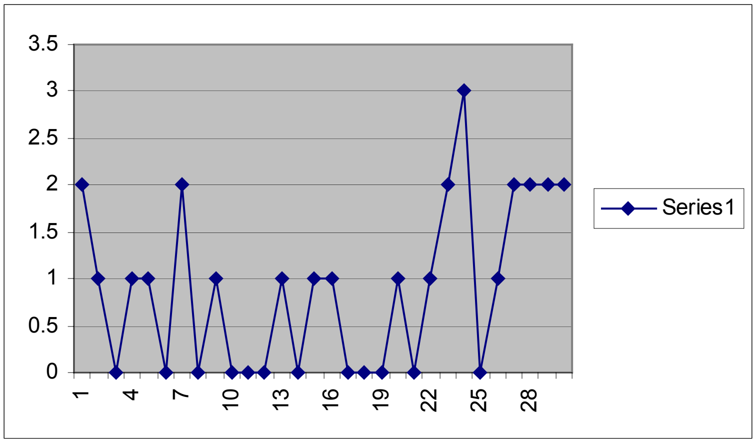
One can construct a random matrix that might look like the following, where the ones and zeros from *Q* of rho, of *d* become the arguments of *f* of *Q*, of *x*:

Matrix 1: f of Q, of x values and arguments

Days >>>	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
f (Q, x) >>>	2	1	0	1	1	1	1	0	0	1	0	2	1	1	2	2	2	0	0	1	0	0	1	1	1	0	1	1	0	1
# Farmers: x																														
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
25	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
30	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0

The results of the above run of random values ρ in [Matrix 1] can be graphed as such, the result of a different iteration:

Graph 1: f of Q, of x



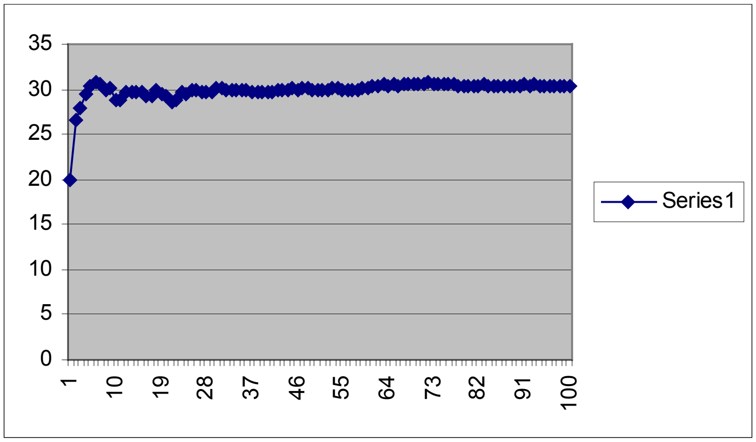
Where one can see above that leaving such actions to mere chance results in days where sprays can and do occur in clusters, and then on other days no sprays at all may occur. And this paper has not even yet taken into account weather, as a farmer on hilly terrain will not likely spray his or her crop on rainy days, as the rain would run off too quickly and lighten the pesticide's potency. A concrete probability in this can be determined based on the number of farmers.

Let *g* of *f*, of *Q*, of *x, of y* be the average of f or *Q,* of *x* over some number of months *y*.

$$g\ (f, Q, x, y) = \frac{f\ (Q, x)}{y} \tag{3}$$

Such a graph may look something like the following, taking *y* to one hundred months:

Graph 2: g of f, of Q, of x



Where one gets convergence on the same number of farmers, which is thirty. Applying this function to forty five farmers and *g* of *f*, of *Q*, of *x, of y* converges on 45. Applying this function to one hundred and fifty two farmers and *g* of *f*, of *Q*, of *x, of y* converges on 152. Hence,

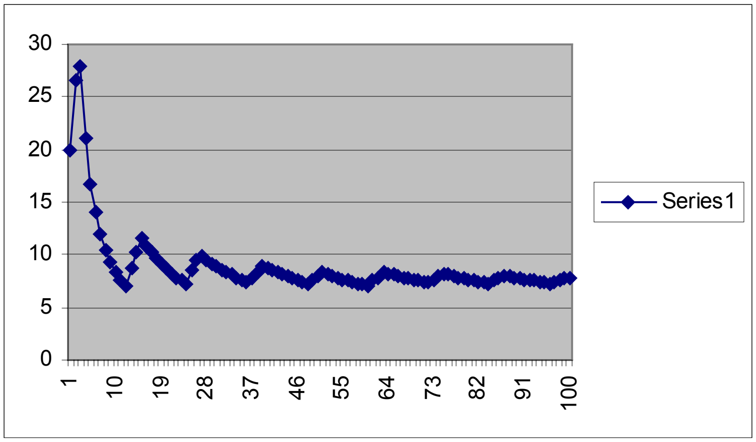
$$g\ (f,\ Q,\ x,\ y) = x \qquad (4)$$

The above allows the individual farmer to spray once or twice (or sometimes three times), without altering the algorithm. While it is completely uncertain to the author how many times a farmer sprays in Clyde, the algorithm is flexible enough to be adjust according to actual practices, so long as the number of farmers in the area are known. The variable *x* (again, the number of farmers in the region, those whose farms drain into the water supply) can be modified to match actual practices.

However, the reality that farmers spray in the winter time is nonsense. Thus, the probability of having a spray occur on any given day, and thus the probability that the drinking water will be contaminated in January (again, the month at which the EPA tested the drinking water) might be quite slim. Using the same means above, but restricting the spray season to occur only for 3 months, the summer months, one must include only ¼ the iterations of *g* of *f*, of *Q*, of *x, of y* to determine what value it converges on, but divide by the same number of months in a year.

With sprays occurring only within 3 months of the year, one gets

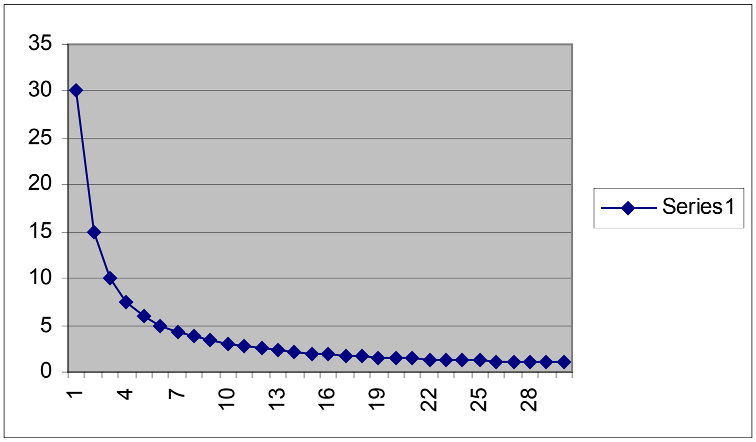
Graph 3: g of f, of Q, of x for 3 months out of the year



It converges somewhere between seven and eight. Thus, for 30 farmers in the area, that gives just a 25 % probability (7.5 / 30 = 0.25) that a spray will occur on any given day, exactly ¼ of the 100 % chance considering 30 farmers. The important point in this is that the above example uses thirty farmers in thirty days, and thus one gets an even 100% and 25% value. However, increasing the number of farmers to just forty five, the probability of a spray occurring on any given day (while still limiting sprays to within 3 months) rises to 40%, and then toward 100% for even more farmers. While it may be obvious that the probability is not representative of reality outside the spray months, as the farmers would never spray in January or February, such examples better explain the probabilities of detecting a pesticide when testing the water within those months, just as the EPA did. The author herein is only discussing the probabilities of the chance of a spray, and not the possibility of the pesticide arriving in the water supply. For that he will need to present the full extent of these factors, as the above is largely for illustration purposes only—*largely* illustration, as there is another point in this.

Suppose a limit was placed on the farmers to spray only one day a month, a calm, sunny day, or perhaps two or three days, anything controlled, not left to random possibilities. Allow the author to demonstrate the above functions when the spray dates are controlled to one day a month.

Graph 4: g of f, of Q, of x for 1 month, one spray / month



For 30 days, when the chance of a spray is limited, the probability drops to 3.33%, compared to 25 % when left to random sprays. By stretching that out to an entire year, considering only allowing 3 months out of the year for spraying, the probability of a spray occurring in Clyde on any given day drops to 0.8333%, and even farther over the course of a decade. Keep in mind, this is only the first of these probabilities, as it has not yet been discussed any probability that Clyde's water is being polluted by pesticides at all. The author adds this now, as cancer is a probabilistic disease, the more one is exposed to a carcinogen, the greater the chance of it developing into cancer. Indeed, there are a number of inexpensive solutions to the problem of pesticide pollution, so long as the information is made known. In short, if the dates of the sprays are controlled to the beginning of the month (for example), then the pumps to the reservoir could easily be shut off on rainy days within the first week or so afterward, or whatever solution best fits a town's needs.

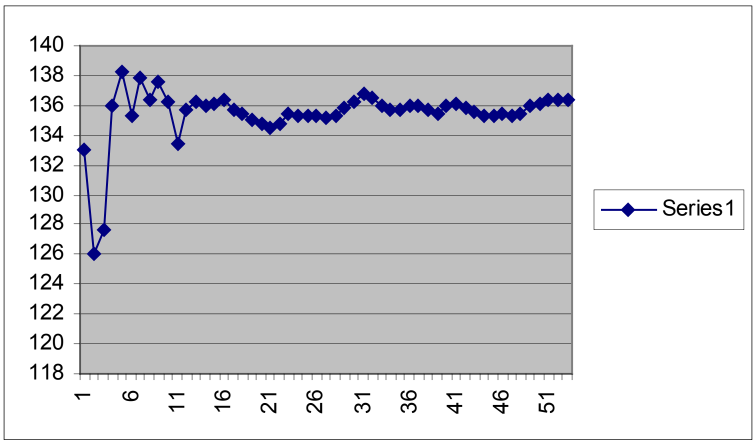
The above functions and methodology will be used a handful more times throughout this paper in order to illustrate other, more important factors, those that put a hard number on the odds that Clyde is being polluted by pesticides at all. These are the mathematical tools used in this analysis, those at the base of this hypothesis.

Farmer Drift Control Factor

The concept of endodrift was discussed in the sections earlier. While the days that farmers spray their fields can be reasonably prevented from randomness, endodrift may be a bit more difficult. Endodrift is due to weather and topographic factors. However, there are still some methods for cutting down on the probability that pesticides will make their way to the water supply, as will be discussed. And even if one particular farm is hillier than another, by considering the average of the whole, one can make better decisions near the pump that brings the run off into the reservoir. There are highly advanced mathematical tools involving Schrodinger non-linear functions and Riemann manifolds that have been available for decades (if not centuries), that could and should be applied to the topographic problems of pesticide run off on hilly farms, but for mere simplicity, the author will present a simplified version in order to put forth the concept on how to apply such factors.

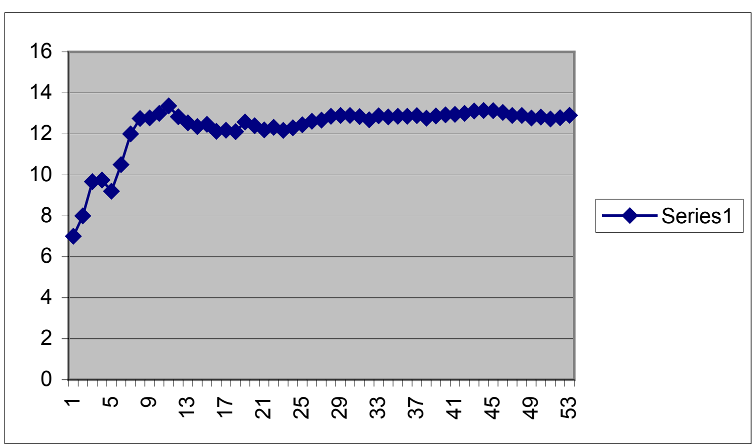
Referring back to (1), let $d = 10$, being there a 1 in 10 chance from all area farms that pesticides will run off, though the value d could be 100 or 100,000, depending on the results given from non-linear functions and/or Riemann manifolds or the like (the hilliness of a particular farm). Thus, let us suppose there is a 1 in 10 chance this will occur in the area. Let the number of farmers $x = 45$. By applying d to (1) and x to (2-4), we get convergence in (4), beginning as early as the 13^{th} month or so, its value ~ 136.

Graph 5: g of f, of Q, of x for 54 months, pesticide run off for d = 10



This gives a 100% probability (136 / 54 > 1) that pesticides will arrive in the creek. By decreasing the average probability of run off from the farms by 10 times d = 100, $x = 45$, one gets

Graph 6: g of f, of Q, of x for 54 months, pesticide run off for d = 100



g of *f*, of *Q*, of *x* drops to ~ 12.9, reducing the probability of pesticide in the creek to 23.89%, which is an improvement. Keep in mind as well, that by raising the number of farmers x above 45, there is also an increase in the probability. To get the probability below 1% for approximately 45 farmers, *d* needs to be closer to 1000, a 1 in 1000 chance that the pesticides will run off at all, which will get the chance of pesticides existing in the creek down to around 0.3% in 54 months or less. In reality, this may be difficult to accomplish, but there are various methods available, as will be discussed later. Most importantly, even if the farmers were able to reduce the probability on their own farm by even 10 more times than this, a 1 in 10,000 chance, the over all possibility of pesticides arriving in the creek only changes from 0.3% to 0.1% in 54 months, which is not terribly significant compared with the reduction of 1/10 to 1/100 or 1/100 to 1/1000, representing an unnecessary burden for the farmer to go any further. This suggests that improvements to reduce the likelihood of pesticides being in the drinking supply itself would need to pick up the brunt of the burden after the farmers can best limit their own run off. It is the above probabilistic factor that the author refers to as the Farmer Drift Control Factor (FDCF).

Yet, the above says nothing about how a farmer can make such improvements, nor does it say how to determine such a factor based on any given farm. To do so, a second form of the factor needs to be calculated. The best method to improve the FDCF in all cases (except perhaps by not using pesticides at all of course, which reduces the factor to zero), involves *distance*. Because of the natural filtering of materials through the ground, increasing the distance these chemicals need to travel through the earth greatly decreases the chances of pesticides ever getting into the water supply.

Let the following distances and factors be considered:

H = Maximum altitude (height) of a farm
L = Altitude of the creek (lowest point)
RS = Rise = *H* – *L*
RN = The Run, the average distance of the farm (accounting for the distance to the edge of every square foot or meter) to the creek's edge
S = Slope Factor or Rise / Run
FCD = The distance from the farm to the nearest creek's edge (in Clyde it was noted to be only a few feet or so):
CFD = The distance from that point in the creek to the reservoir's pump, often less than a mile.
EDF = Endodrift factor = *FCD* / *CFD*
DF = Drift Factor = *S* / *EDF*

The Drift Factor *DF* is equivalent to *FDCF*, hence the second form mentioned above, except that it specifically refers to an individual farm rather than to the average from the area. The *FDCF* is the average of all the individual farmer's *DF*. Below is an example calculation of one particular farmer whose unfortunate *DF* would add to an overall poor *FDCF*.

H = 700'
L = 600'
RS = 100'
RN = 3000

$S = .0333333$
$FCD = 5'$
$CFD = 6000'$
$EDF = FCD / CFD = 0.00008$
DF = Drift Factor = $S / EDF = 416.667$, which is > 100, and in other words, based on farmer drift control factor, this example does not include a 1 in 1000 chance his pesticides will endodrift; rather, it’s closer to a 1 in 5 chance.

For a farmer to get within a 1 in 1000 chance, he or she does have some options, though some are simply not practical. But some are. A farm lying on a theoretically flat land has an advantage, as just such a situation reduces this factor to zero, having absolutely no chance of pesticides arriving in the creek, as for a perfectly flat farm, the water simply will sink directly downward. However, in nature, this is an unobtainable goal, one perhaps to strive toward, but impossible to obtain. But let us just be generous in this example and suppose a farmer lucked out and the slope is minimal only to a few feet distance up or down, but then also suppose his farm is as close to the creek as was the previous example, and also that they are the same sized farms.

$H = 600'$
$L = 598'$
$RS = 2$
$RN = 3000$
$S = .000066667$
$FCD = 5'$
$CFD = 6000'$
$EDF = FCD / CFD = 0.00008$
DF = Drift Factor = $S / EDF = 0.833333$, which is $< 1\%$, and in other words, based on the farmer drift control factor equivalence, this example does indeed include only a 1 in 1000 chance his pesticides will endodrift, which, if he were the only farmer in the area, the goal would already be met due to the terrain alone.

It should be mentioned that by working out a number of examples of the above, it actually adds to a higher probability that pesticides will be present in the water the farther up stream a particular farm is. This has everything to with the fact that creeks are narrower the farther upstream, leading to a higher concentration per area and includes the fact that the creek is virtually a moving line (as opposed to a lake), the pesticide concentration becomes additive the longer the creek is, the farther the farm is up-stream. However, by adding distance between the farm’s edge and the creek itself (or runoff ditch), this disadvantage can be compensated. In fact, in all cases, the most effective fix for reducing a high DF for a particular farm is, perhaps unfortunately, *unused* land (that which is not sprayed at all). And then leaving that land between the farm and the drainage ditch. The filtering by means of natural earth itself is the most effective means; the thicker the filter, the cleaner the water.

In short, using the guidelines above, the smaller the farm, the less pesticides would be required. The less slope, the less pesticides the farmer needs, as studies show many of the pesticides are lost on such terrain due to run off, but also that the run off of highly sloped farms adds to overall unfortunate odds. Additionally, the fewer farms up-stream reduces this probability, but by moving those farms farther from the creek itself, it can be compensated. While none of this considers the fact that by pushing a farm back reduces the year-end yield for the particular farmer, it does show how the risks of pesticides arriving in the creek can be reduced substantially. The financial matters are completely outside the scope of this study, more a matter between the farmer, his community and his or her county, state or federal governments. The purpose of this paper is only to present the math and the hypothesis that such pesticide factors are at play in the number of cancer cases within Clyde, Ohio, and how they come into play in the drinking water.

Rain Factor

Suffice to say, none of the above would ever come into play if it were not for rain. The obvious downsize is that the crops need rain to grow. Thus, from a scientific standpoint, the rain needs to be factored into the equation.

> *RPA* = The amount of rain that falls over a given surface area of land in either Gallons / ft^2 or liters / m^2 for the metric system
> *FFPA* = The amount of potentially contaminated water flowing in the creek from the rain across a certain area at the edge of the farmer's property in gallons / (creek width in feet x creek depth in feet) (or literes / m^2 for metric), which may be limited to the farm itself if there are no other farms up stream.
> *RF* = The Rain Factor *RPA* / *FFPA*.

Hence, if the rain does not arrive to the creek, RPA = 0, and too does RF = 0, as the creek would not even be flowing to the pump enough and the pump only picks up water when it reaches a certain threshold. The greater the rainfall, the greater the endodrift effect. This allows for the next definition.

The area of the creek where the intake pump is located, and how many gallons flow passed that frame of reference, needs to be accounted for. If the intake allowed all the water to flow into the reservoir, then the calculation would be easier. However, because the pesticides are dispersed more in a wider creek, the area near the pump intake needs to be accounted for, and ideally the water would be pumped in from the widest section of the creek. Additionally, a small intake area for the pump would lower the risks by mere probabilities, as it would be limiting its intake of water from a larger surrounding area in which the pesticides flow. This is not true in terms of standing water (such as a lake), but it does become a factor in a moving creek or river, as the pesticide concentrations are in constant flux.

Such factors can be accounted for using the following:

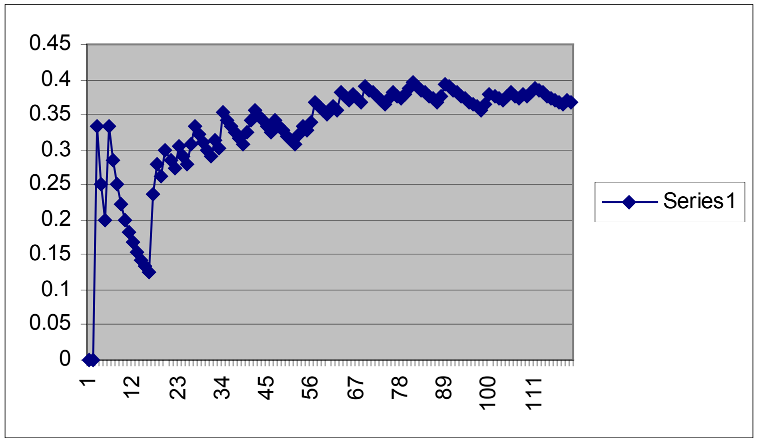
PCW = Pump Creek Width
PCD = Pump Creek Depth
PCA = Pump Creek Area
IA = Pump intake area
PG = Gallons the pump draws

CG = Gallons of water that flow by the frame of reference in the creek
PFPA (the same concept of the farmers FFPA, except that it will likely end up being larger at the pump than at the farm) = CG / PCA
IFA = Intake flow area
DW = PG / IFA, the amount of water drawn
IF = DW / PFPA, the intake factor
CWP = RF x IF, the Clean Water Potential
CDC = CWP / (CWP – FDCF), the Clean Draw Coefficient, the percent chance that the draw includes only clean water (referring to the absence of pesticides, not dirt or the like)
PF = 1 – Q, the reservoir Pesticide Factor, the percent chance that the draw includes pesticides

Thus, taking that large list of variables above into account, if 10,000 gallons of water (for example) fall over 1,000,000 square feet of a single farm area whose *FDCF* is rather poor, suppose *FDCF* = 500, and only one-tenth of the water that falls makes it to the creek, passing a creek area of twenty square feet, and an intake pump having an area of one square foot that draws just one-hundredth of the water that passes its area of thirty-six feet, the resulting $PF = 1.388\ldots x\ 10^{-5}$. This is a rather small value. Now take into account a larger area of one billion square feet and more rainfall equal to one billion gallons, a gallon per every square foot, which can easily happen in less than a day in Ohio, and the fact that having more farms increases the need for more drainage ditches between them, which allows for more of the water that falls on the farm to reach the creek, and suppose 90% of it ends up in the creek, one gets *PF* = .00138 or approximately 0.14%. This is a Pesticide Factor value that is exceedingly high.

To compare, imagine there was a 0.14% chance you and nine others would ingest an indefensible cancer causing agent in one day from something you ate in that day. By applying $1 / d = 0.00138$ to (1) and $x = 10$ (ten total people) to equations (2-4), for the first two months, likely no one would have ingested it. However, in just under three years, *all* of the ten would have. In fact, by carrying that test forward, assuming the cancer was slow acting and the same amount of consumption continued, the percent chance rises to 36%, which suggests that over time, consuming the same small portion ends up increasing the chance of *inevitable* ingestion.

Graph 7: g of f, of Q, of x over time for 1 / d = 0.00138



That is indeed a terribly high probability for such a dangerous substance. Yet, by alone getting the farmers to reduce their *FDCF* = 1, using the exact same values above, one would get a *PF* = 2.7777…x 10^{-6}. The result then for ten people every month, in a ten year period, is that it would not be likely at all than *anyone* out of the ten would ingest the carcinogen. Even by applying the same value to fifty people over ten years, it would still not be likely that any of them would ingest it. The random matrix applied (like that from Matrix 1) would simply consist of zeroes.

Reservoir and Cancer Probabilities

Once the previous factors are considered, it is possible to calculate the probability of anyone in Clyde getting cancer from the drinking water. However, since the number of cancer cases peaked in 2005-2006, some of the variables may have changed since then; perhaps the farmers switched to a less toxic pesticide. What is wholly possible is to calculate are the probabilities of what *has* occurred in relation with the pesticide potentials. Even if the problem has already been solved already in Clyde, and improvements have been made to all of the above (or the next factors that will be presented), the following may serve to make clear the probabilities of such circumstances over the past years—perhaps applicable to future improvements.

The next consideration in these calculations would be the filtering system itself. Typically filters cannot filter out toxins, as many are smaller than the filter pore, and neither the chlorine, nor cyanuric acid additives will neutralize them. They can only reduce the probability, as the toxins may attach to larger objects (moss, grasses etc.), which *would* get trapped in the filter. Thus, we get another probability, the probability of a free toxin passing the filter.

FTP = Free Toxin Probability

Then, another probability has to do with the human body itself, as humans ingest toxins all the time, carcinogens and the like. Typically, with proper anti-oxidant diets, the liver can handle most of these, in a similar way the mallard ducks in Christopher

Creek can still flourish. However, it just takes one molecule for the body to not process properly to result in malignant cancer. This probability can be referred to as such:

EFCP = the Effective Free Carcinogen Probability; that is, the probability that cancer will be activated after consuming the carcinogen.

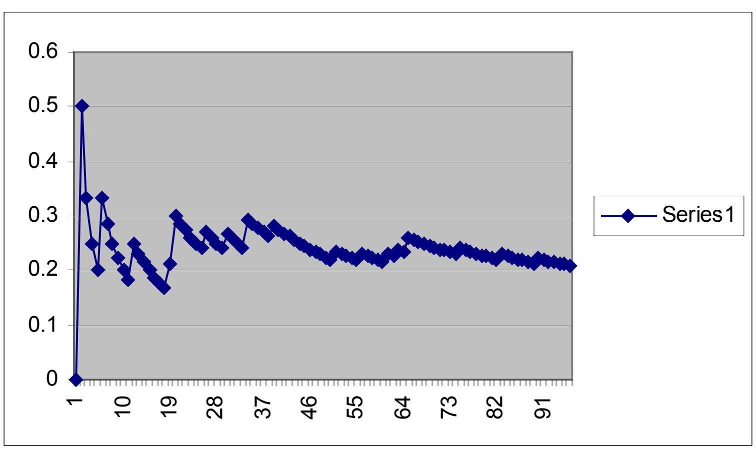
The EFCP, however, is perhaps a probability better calculated after the next to be presented, as in Clyde, if the rise in the number of cases of cancer are due to pesticides, then we already know the result of the next.

CP = the chance of getting malignant cancer in a certain community from pesticides, the Cancer Probability

$$CP = (EFCP + FTP + PF) / 3 \quad (5)$$

If one already knows the number of pesticide cancer victims in an area, the population and the like, one can calculate the exact value of *CP* without knowing the *EFCP*, the *FTP* or the *PF*. The author will herein calculate the approximate value of *CP* for just the children of Clyde, those under eighteen years of age. From 2001 to 2009, twenty children were diagnosed with cancer and according to the U.S. Census Bureau, the average population of Children in Sandusky county under eighteen is 24.3%. The population of Clyde is roughly 6064, so this gives on average a population of 1473 children. By applying various values to d in (1) and $x = 1473$ to (2-4), we see that the only value for d to result in the number of cancer patients in Clyde would have to be in the vicinity of $d = 200{,}000$. That's a *CP* just under 10 years = 0.000005 or leaving an open chance of 1 in 200,000 per month (per *month*, not the ten-year period) that a child will get cancer, and the average number of children diagnosed per month results in approximately 0.208333.

Graph 8: g of f, of Q, of x probability graph of child diagnosed per month



There are two unknowns to this author that certainly are known to someone in the community of Clyde (or can easily be checked by them), either to the farmers or the water treatment facility, and those are 1) the toxicity of the pesticides being used in the area (the EFCP), the percent chance that it would cause cancer upon ingestion and 2) the quality of the filter (the FTP), the percent chance the pesticide molecule could fit through the pores of the filter. With those two values one could easily calculate the reservoir Pesticide Factor (PF). The author will demonstrate how to do so by applying some reasonable ad hoc values to the EFCP and FTP.

Let

EFCP = 0.0000001, a 1 in a 1,000,000 chance the toxin would cause cancer upon ingestion
FTP = 0.001, a 1 in a 1,000 chance the toxin could pass through the pores of the filter

By rearranging (5) to solve for the absolute value of the Pesticide Factor,

$$PF = | 3CP – EFCP – FTP | \quad (6)$$

One gets

$$PF = | 3 \times 0.000005 – 0.0000001 – 0.001 | = 0.1\% \quad (7)$$

Recall from the previous section that 0.14% was considered unreasonably high for any probability. Thus, even if the toxicity of the pesticide being used only has a one in a million chance of causing cancer upon ingestion and the filter being used leaves just a one in a thousandth chance of letting the pesticide through the pores (which is, in the author's opinion, exceedingly generous), taking into account the number of cases of cancer in the area, there remains a 0.1% chance that there were pesticides in the reservoir between 2001 and the time the EPA tested the water. That is an enormously high probability, a 1 out of 10 chance.

For a more closer relationship than the one used for the 0.14% earlier, consider the comparison of having 1 month out of 12 in a year, where there may be a 0.1% chance there are pesticides in the reservoir over a period of time. Even if the farmers only sprayed their crop in a single month, say in April, there would still be at least 36 days out of the year where the water would be guaranteed to be perfectly clean, pesticides undetectable. Additionally, as demonstrated earlier regarding the Random Spray Matrix, such random values tend to cluster, which means there would almost always be even more than 36 days available of clean water with such probabilities (though it only takes a single bad glass of water to ingest carcinogens). And those clean water days would most likely tend to be those in the months prior to the month the sprays occur, those such as January, February and March. It was for this reason the author referred to the EPA's January test as "inappropriate," as the only days one could effectively test for pesticides in drinking water in such a rural community would be on the days or weeks after the first rains, just after the sprays occurred. The fact that Raccoon creek extends through miles of hilly farmland (guaranteed to be subjected to pesticides) is obvious and does not need math to back it up. Thus, pesticides should have been tested for and should have been tested for in the days and weeks after the sprays occurred—not one time, months later.

Conclusion

While the author certainly could not know the reasons for the EPA testing the water supply of rural community of Clyde, Ohio in the month of January, as such reasoning could be any number of things, he certainly does feel that pesticides have gotten into the water supply over the course of the past decade and that these pesticides were indeed the cause of the rise in number of cancer victims in the area. The author does not know what those pesticides were, nor what quantities they were in, but by probabilistic determination, it seems highly unlikely that it should be anything else. In fact, it seems from a cursory survey of the area, unless major changes have been made (a change to a less toxic pesticide perhaps, significantly better filtration, etc.), there still should exist a serious problem in this regard today. The hilly farmland and drainage ditches in the area all still lead to the up reservoir; that much is clear. And by strict probabilistic determination with what is known to the author (population, number of cases, topographic details), it would be highly unlikely that the Clyde Cancer Cluster case could be due to any other reason than pesticides in the drinking water.

Having been in the field of Quality Assurance (at all levels from QA Engineer, Lead and Manager), consisting of collaborations with a number of fortune 500 companies, this author's opinion is that a study into the unknowns of this case be made more clear, such as what the pesticides used in the area were in the past decade and to the filtration system itself. And lastly, and most importantly, it seems justified that this coming year all such testing of the drinking water should include testing of the reservoir and the creek also, and that such testing should be heavily monitored in the days after heavy rains and/or sprays. Perhaps then this problem could be eliminated completely for Clyde. While it may not be practical for the small town of Clyde to simply do away with their reservoir and replace it was a dammed system, nor may it be practical to pump water into the community from elsewhere, it certainly should be a requirement that the system in placed be properly monitored and tested regularly. In comparison, while nuclear power plants may also be useful and efficient, it only takes one major break to make the entire project a disaster. In the same, there really can be no room for mistake with an up reservoir, as compared with dammed reservoirs, as they really are the experimental new breed—there are many more factors to consider with them and many more unknowns than with something both humans and animals have been building for centuries.