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Ethics Case Study on Flint Water Crisis

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Course Outline:

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Timeline of Events
Lead in the Tap Water
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Examination

Professional Ethics

Ethics is concerned with moral principles and behaviors. Like doing the right thing and considering others before oneself.

Professional ethics are standards of behavior for working professionals. For example, the Hippocratic Oath has been taken by physicians since the fourth century BCE. The oath established several principles of medical ethics still in use around the world, including medical confidentiality and non-maleficence.

Today, professional behavior standards are set and enforced by:

- Employers, such as corporations,
- Professional organizations, and
- Federal, state, or local regulations.

Professional standards directly benefit those receiving professional services. The standards also indirectly benefit professionals who gain the trust of the public and gain protection from other professionals. Behavioral standards keep professionals working on an equal playing field.

Disciplinary consequences (punishments) help ensure practitioners follow the behavior standards. Many behavioral standards are covered by an employer, professional organization, and in regulations. Thus, breaking a standard can result in consequences from multiple entities.

Engineering Ethics

Engineering is one of the main professional fields. As such, there are several behavioral standards specific to engineers. In the United States, a popular document is the “Code of Ethics for Engineers” by the National Society of Professional Engineers (NSPE).

Each state has rules for professional conduct specific to engineers. These rules are usually located in the state administrative code in the chapter/section for engineering. These state rules are enforceable and with disciplinary consequences.

NSPE Code of Ethics for Engineers

This is the most widely accepted document for engineering ethics in the United States is the “Code of Ethics for Engineers” by the National Society of Professional Engineers (NSPE).

The main statements are copied here:

I. Fundamental Canons

Engineers, in the fulfillment of their professional duties, shall:

1. Hold paramount the safety, health, and welfare of the public.
2. Perform services only in areas of their competence.
3. Issue public statements only in an objective and truthful manner.
4. Act for each employer or client as faithful agents or trustees.
5. Avoid deceptive acts.
6. Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

II. Rules of Practice

1. Engineers shall hold paramount the safety, health, and welfare of the public.
2. Engineers shall perform services only in the areas of their competence.
3. Engineers shall issue public statements only in an objective and truthful manner.
4. Engineers shall act for each employer or client as faithful agents or trustees.
5. Engineers shall avoid deceptive acts.

III. Professional Obligations

1. Engineers shall be guided in all their relations by the highest standards of honesty and integrity.
2. Engineers shall at all times strive to serve the public interest.
3. Engineers shall avoid all conduct or practice that deceives the public.
4. Engineers shall not disclose, without consent, confidential information concerning the business affairs or technical processes of any present or former client or employer, or public body on which they serve.
5. Engineers shall not be influenced in their professional duties by conflicting interests.
6. Engineers shall not attempt to obtain employment or advancement or professional engagements by untruthfully criticizing other engineers, or by other improper or questionable methods.
7. Engineers shall not attempt to injure, maliciously or falsely, directly or indirectly, the professional reputation, prospects, practice, or employment of other engineers. Engineers who believe others are guilty of unethical or illegal practice shall present such information to the proper authority for action.
8. Engineers shall accept personal responsibility for their professional activities, provided, however, that engineers may seek indemnification for services arising out of their practice for other than gross negligence, where the engineer's interests cannot otherwise be protected.
9. Engineers shall give credit for engineering work to those to whom credit is due, and will recognize the proprietary interests of others.

Flint Water Crisis Overview

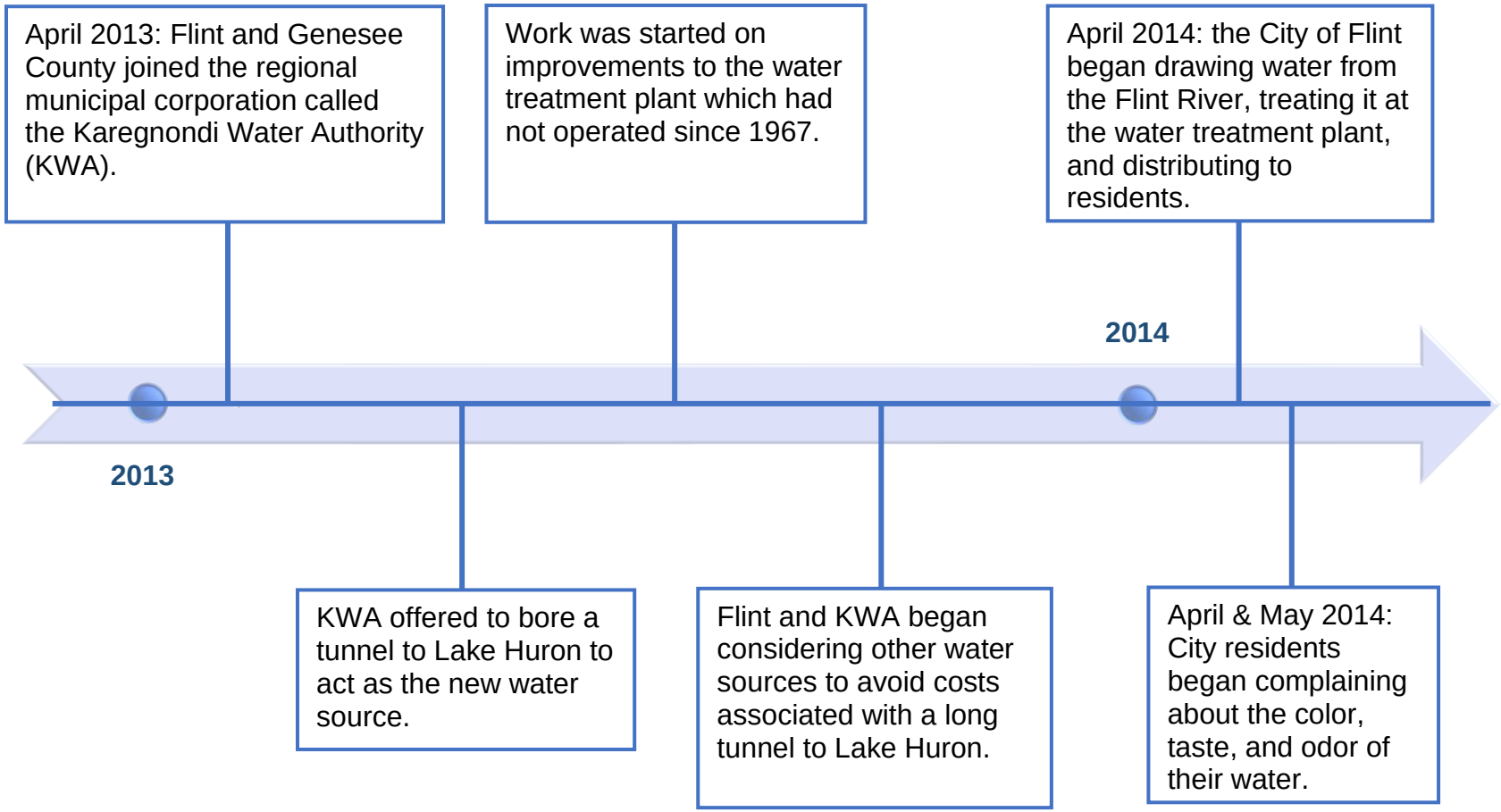
The Flint Water Crisis is one of the most well-known public health disasters in recent American history. It all started in April 2014, when the City of Flint, Michigan, switched its water supply from treated water from Lake Huron to water from the Flint River. This decision was taken to save money but had devastating consequences due to a series of critical failures in both public administration and engineering judgement. The result was thousands of residents being exposed to lead poisoning and an outbreak of Legionnaires' disease.

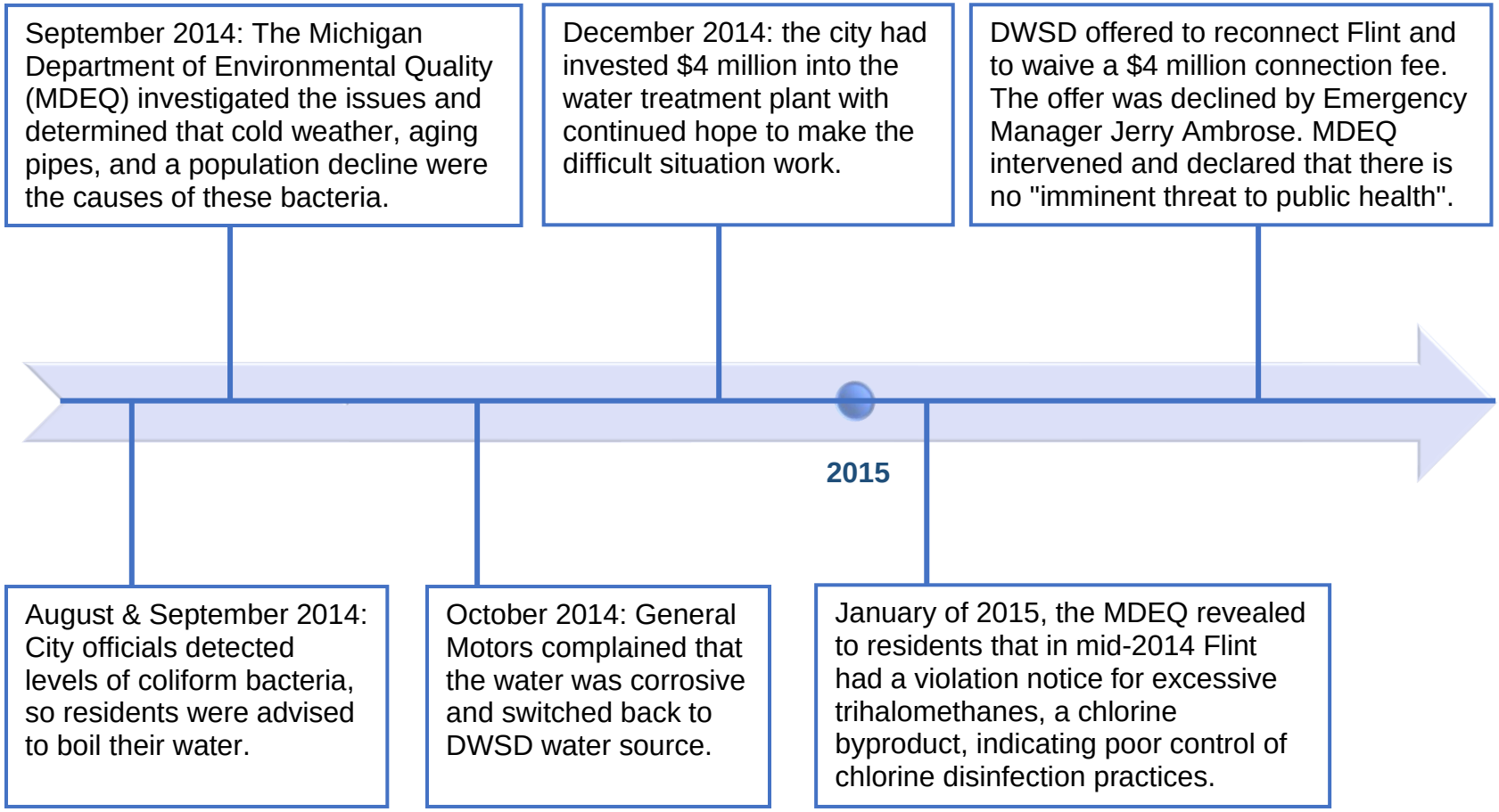
Figure 1: Flint River in Flint, Michigan.
Source: commons.wikimedia.org/wiki/File:Flint_River_in_Flint_MIchigan.jpg, p.d.

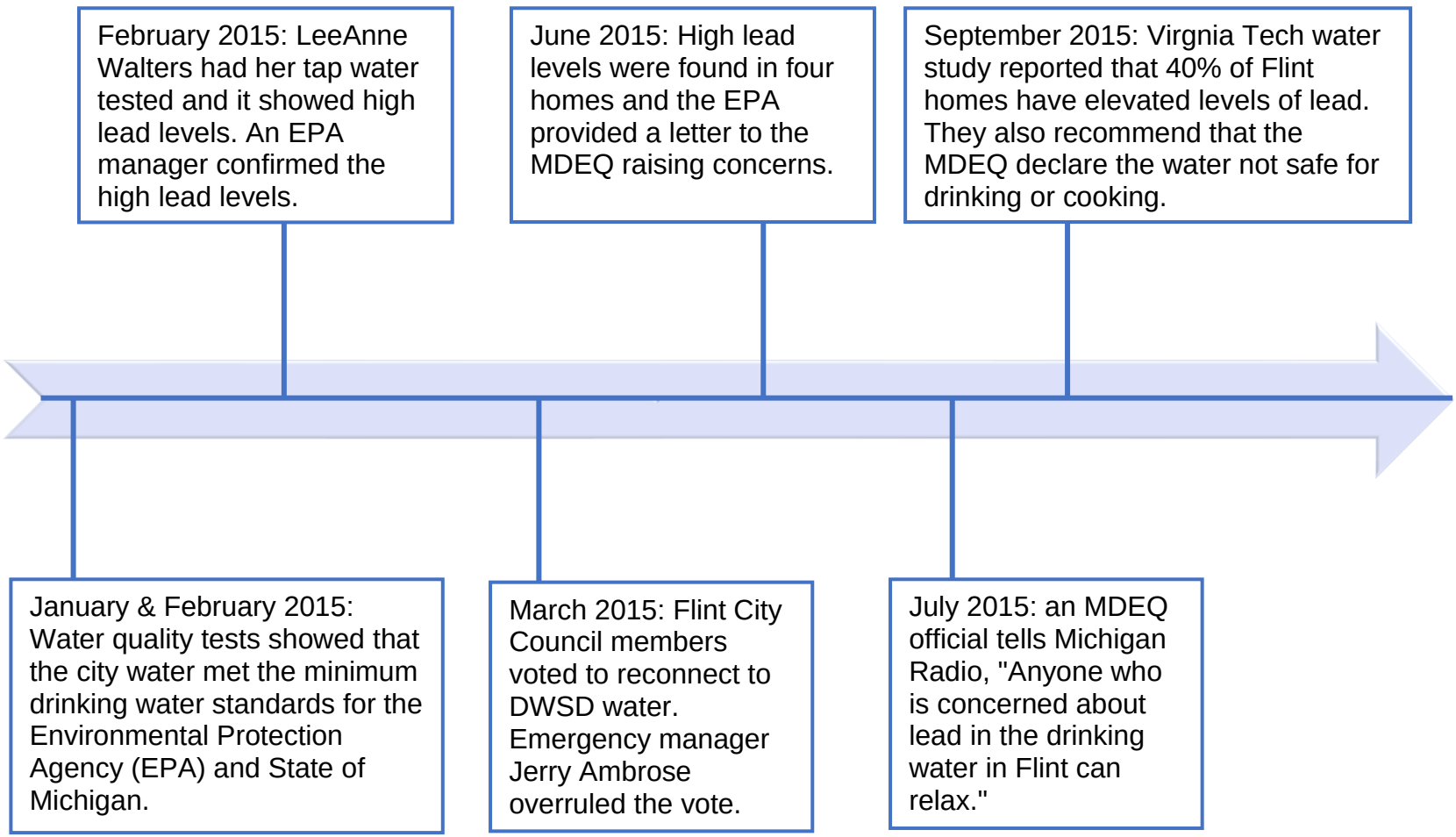
Background

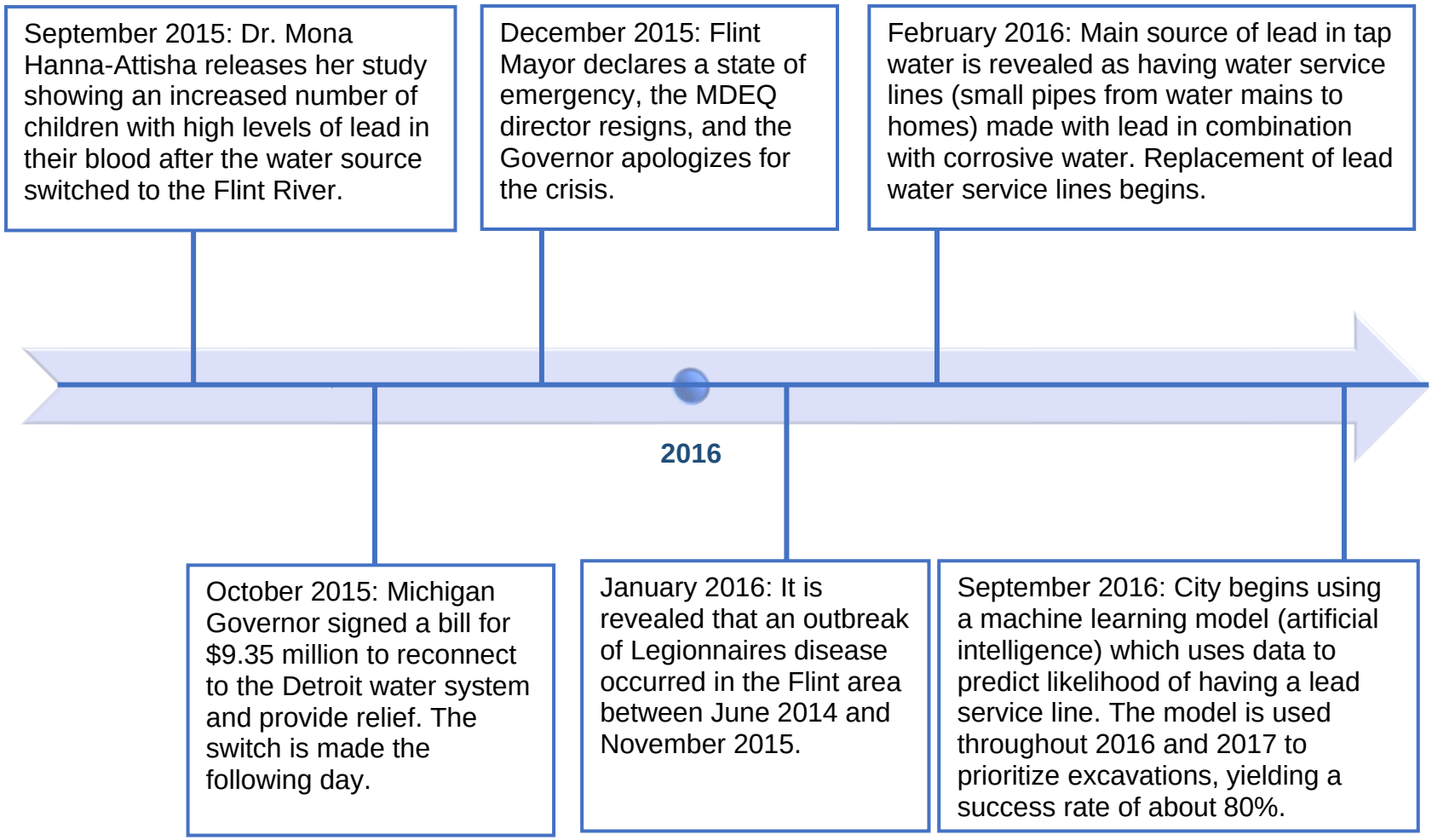
Flint is a city with approximately 80,000 people. Prior to the crisis, the city had faced significant financial difficulties. The city administrators put pressure on nearly all departments to cut costs, including water utilities. The city was paying millions of dollars each year to purchase treated water from the Detroit Water and Sewerage Department (DWSD). It was realized that the city could save around $2M each year by drawing and treating their own water.

Timeline of Events









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Lead in the Tap Water

Although there were several water quality problems after Flint switched to drawing water from the Flint River, the main problem was the corrosivity of the water which resulted in lead leaching from water service lines. Lead water pipes were commonly installed in the 20th century and national plumbing codes allowed them into the 1970s. Lead solder was also used to joined copper pipes. In 1986, Congress amended the Safe Drinking Water Act to prohibit the use of lead pipes and lead solder in public water systems that supply drinking water. However, lead continued to leach into drinking water especially under corrosive conditions.

In 1991, the EPA Lead and Copper Rule was passed, which set a limit for lead of zero. According to the rule, when corrosion control alone is not sufficient to control lead levels, the water provider must educate the public about the risks of lead in drinking water and to replace lead service lines. Most service lines are on private property and are owned by the homeowner, adding challenges to pipe replacement programs.

A high percentage of homes in Flint were built before the 1980's and had lead water service lines. With the DWSD supplied water, the lead generally did not leach into the water, so the lead water pipes were not seen as problematic. However, when the switch was made to treating water from the Flint River, the water corroded the iron and lead pipes, leaching metals into the water system. At the beginning of the crisis, no effort was made to educate the public or replace the lead pipes.

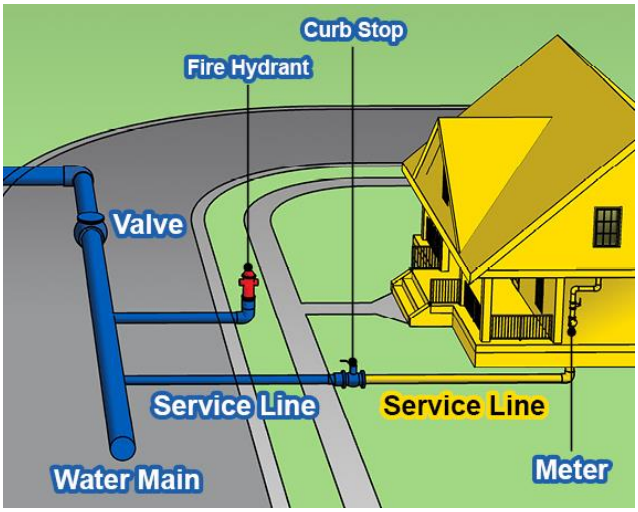

Figure 2: Example water service line with curb stop at property line.
Source: Great Lakes Water Authority, cropped

Corrosive Water

Corrosive water can be due to one or more of the following, with bold items associated with the Flint Water Crisis:

- **Low pH (below 6.5 is acidic)**
- High pH (above 8.5 is basic)
- **Low alkalinity (which results in pH swings)**
- Softness (lack of dissolved calcium and magnesium)
- Conductivity (high concentrations of ions)
- **High chloride ions (from overdosing disinfection or drawing from surface water with road salt runoff)**
- **Low phosphates (often added in water treatment)**
- High dissolved solids
- High dissolved oxygen
- **High hydrogen sulfide (from groundwater or sulfate-reducing bacteria)**
- High temperature (over 140 deg F)

The Flint Water Treatment Plant included softening, turbidity removal, and disinfection. These processes reduced the alkalinity (the ability to resist a pH change), decreased the pH by up to one log unit, and doubled the chloride concentration of the treated water. The water quality parameters revealed a condition in which corrosion of iron and lead pipes is well known.

A corrosion control plan was required by the federal Lead and Copper Rule, however there is no record of a corrosion assessment being done until late in the crisis. Water was not treated to maintain water quality parameters within commonly acceptable ranges. A corrosion inhibitor was not added, which would have prevented the leaching of lead into the drinking water.

Lead Poisoning

Lead can cause serious health problems if too much enters your body from regularly drinking water with lead. Lead in the body can cause damage to the brain and kidneys, and can interfere with the production of red blood cells that carry oxygen to all parts of your body.

Lead exposure can cause serious harm to children's health, including:

- Damage to the brain and nervous system
- Delayed growth and development
- Behavior problems
- Learning problems and underperformance in school
- Decreased ability to pay attention
- Lower IQ
- Hearing loss
- Weight loss

Heros

Citizen LeeAnne Walters is recognized as the first to reveal the Flint water crisis. She found poor water quality in her house and then led a citizens' movement that tested tap water around the City. The results showed that one in six homes had lead levels that exceeded the EPA's safety threshold.

Another hero is pediatrician in Flint, Dr. Mona Hanna-Attisha, played a vital role in exposing the public health emergency. She had a friend that was a water expert. Over a glass of wine, her friend explained that the drinking water wasn't being treated properly and likely had high levels of lead in many homes. Dr. Mona became concerned for her patients. She began testing lead levels in the blood of children living in Flint. Her research showed a significant increase in lead levels in children drinking tap water in Flint. She shared her findings with anyone that would listen. Her findings were initially dismissed by state officials but were later acknowledged.

Figure 1: Left: LeeAnne Walters who first exposed high lead levels in drinking water. Right: Dr. Mona Hanna-Attisha who found increased lead levels in children's blood.
Source: commons.wikimedia.org/wiki/File:Dr._Hanna_Attisha_smiling_in_lab_coat.jpg, HappyPenguinista, CC-BY-SA-4.0

Recovery

It took much too long for city and state officials to realize the water crisis and stop covering up the reality of the health impact to residents. Eventually it was accepted that corrosive water was causing the leaching of lead and that major changes were needed. Immediate efforts were made to adjust water quality parameters and add a corrosion inhibitor to the treatment process. Then, the water source was switched back to DWSD with improvements recognized withing days. However, with so many homes having lead water service lines, the risk of the lead returning to drinking water remained unacceptable high. It became extremely important to know which houses had lead service lines so they could be replaced.

Technology and Innovation

At the University of Michigan (U-M), a collaboration of professors and students of different fields developed a form of artificial intelligence called a machine learning model. A machine learning model is a program that can find patterns or make decisions from a previously unseen dataset. In other words, it can learn and grow in intelligence.

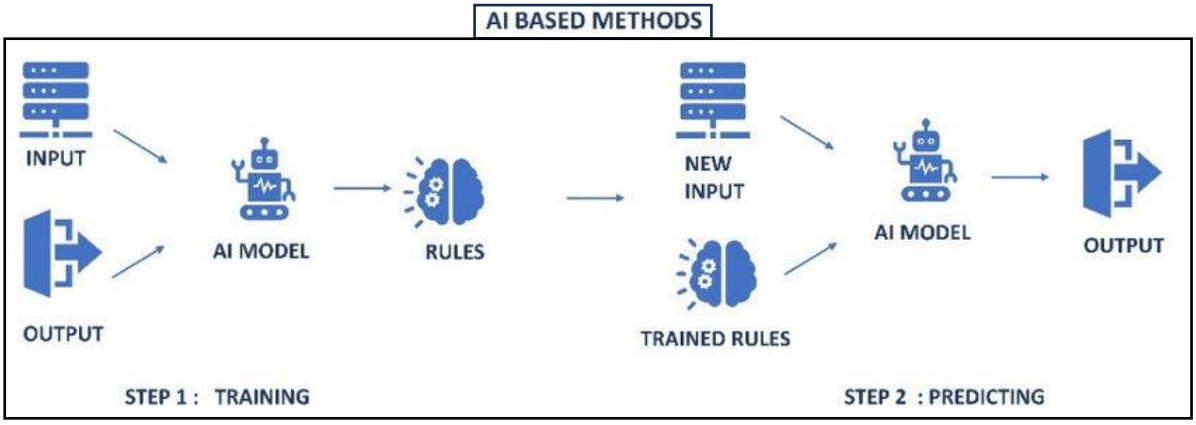

Figure 4: Machine learned models use AI-based algorithms to analyze initial datasets to find patterns and create rules (step 1). These trained rules are applied to new inputs to provide solutions to complex problems (step 2).
Source: https://ui.adsabs.harvard.edu/abs/2022RemS...14.3377K/abstract, CC-4.0

The model was applied to housing data in the City of Flint and findings to date on which houses have lead pipes. The model was asked to predict the likelihood of each house having a lead service line. The model was used throughout 2016 and 2017 to prioritize service line replacement and had a success rate of about 80%. This far exceeded previous efforts and likely saved many households from lead exposure.

Although there were many administrative and engineering failures in the Flint Water Crisis, the willingness to try innovative technology for the sake of public health is admirable.

Similar machine learning modeling techniques have been developed and applied to other water systems nationwide, including Pittsburgh, Pennsylvania and Denver, Colorado.

Lessons Learned

The following are lessons learned from the Flint Water Crisis as applied to each of the fundamental cannons.

Canon 1: Hold paramount the safety, health, and welfare of the public.

The engineers that designed the Flint wastewater treatment plant upgrades and oversaw its commissioning neglected to consider the corrosivity of the water which is critical for public health when homes have lead pipes. It seems that a fast schedule and low budget were higher priorities than the health of the public.

An example of holding the public health above profit is when the DWSD offered to reconnect Flint and to waive a $4 million connection fee. It seems this gesture was out of genuine concern for the health of Flint residents and not for profit.

Canon 2: Perform services only in areas of their competence.

In the months prior to and during the crisis, there was a general lack of evaluations and recommendations from engineers experienced in drinking water treatment systems. During the crisis, most of those making decisions and giving public statements had little to no engineering background and did not cite insights and recommendations from engineering experts.

Canon 3: Issue public statements only in an objective and truthful manner.

Through the crisis, many public statements were made that downplayed the health risk. This includes statements by engineers from the MDEQ, the city, and consultants paid for by the city or KWA. Although it is important to be a faithful agent to a client (per Canon 4), statements should be factual and not conceal matters of public health and safety. The misleading statements only delayed the necessary interventions that brought an end to the crisis.

Canon 4: Act for each employer or client as faithful agents or trustees.

Engineering staff from the MDEQ chose to hide critical information such as poor water quality test results and the health risk of lead in drinking water. The staff work for the public and serve to protect the public.

Canon 5: Avoid deceptive acts.

In the midst of the crisis, an MDEQ official not only hide important information but declared on the radio “Anyone who is concerned about lead in the drinking water in Flint can relax.” This was deceptive and only prolonged finding and implementing solutions that saved lives. Transparency and integrity should be upheld to avoid deception.

Canon 6: Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

By the end of the crisis, the public did not trust engineering consultants that worked for the city or KLA. There was a pattern of poor conduct, such as those described under Canons 1 through 5 above.

However, there were also engineers, scientists and others that helped the public understand the situation and helped find solutions that saved many people from lead exposure. For example, the group of professors and students from the University of Michigan that developed the machine learning model which successfully found lead pipes so replacement could be done efficiently. This innovate approach helped restore the reputation of professionals and showed that technology can be applied for the good of the people.

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