Engineering and the Flint Water Crisis: Ethical and Technical Shortcomings

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Abstract: Lead poisoning is a devastating health problem that can cause great damage to a community, with the responsibility of protecting communities from lead poisoning often falling to the engineers responsible for designing their water treatment system. In Flint, Michigan, the engineers involved with the design of the system failed to meet the technical demands of designing a water distribution system when they neglected to include corrosion control. In addition to the failure of engineers to properly design the system, the engineers involved behaved in an unethical way that worsened the crisis. The engineers failed to protect the citizens of Flint by failing to meet the technical needs of the water treatment process and failing to live up to the ethical standards expected of them, which all engineers should look at in order to avoid making similar mistakes in the future. I will take a closer look at the relevant research regarding the failures in the engineering design process of Flint, and compare the behavior of the engineering firms involved to what is described in the National Society of Professional Engineer's code of ethics to illustrate the role that engineers played in the Flint water crisis and the importance of stopping similar mistakes from happening in the future.

Lead poisoning, which can cause developmental delay, hearing loss, and seizures in children, may seem like something that would be avoidable in the United States. But in the town of Flint, Michigan, up to 30,000 children may have been exposed to it and could suffer from its devastating effects (Mayo Clinic, 2016; Higgins 2018). These children in Flint were affected by lead poisoning because the government authorities and engineers failed in their responsibility to provide the community of Flint with safe drinking water. The water flowing to many of the homes in Flint was made unsafe by a failure in the engineering design process to account for the corrosion of the lead pipes that supplied many of Flint's homes (Masten, Davies, and McElmurry, pg. 32, 2016). The lead pipes going into the community of Flint began to corrode when the decision was made to switch water sources to the Flint River, which was not properly prepared for during the engineering design process, and led directly to an increase in lead levels in the water. This lead pollution could have been avoided if the engineers involved had made sure that corrosion control was included in Flint's water system, a process for which they were ethically responsible. The failure of engineers to account for corrosion and other risk factors involved with switching Flint's water supply to the Flint River was both a technical and ethical failure that greatly damaged the people of Flint. It should be examined closely by engineers in order to prevent mistakes like these from happening again.

The Flint water crisis was an avoidable catastrophe that was caused by a failure between engineers and government authorities to design an effective and safe system. While the engineering firms involved, such as Lockwood, Andrews, and Newnam Inc. (LAN), were not directly contracted to address corrosion by the city of Flint, they were concerned about the possibility of corrosion, but chose to follow the city's decision to follow the insufficient

guidelines of the Michigan Department of Environmental Quality (MDEQ) despite their concerns (LAN, pg. 5, 2016). By choosing to let the issue of corrosion control go, the engineers contributed to the Flint water crisis and failed to live up to the standards for engineers set up in the National Society of Professional Engineer's (NSPE) Code of Ethics. By failing to meet the ethical standards set for engineers, the engineers contributed to the damage done to the community of Flint.

Ethical failings by the engineers were augmented by technical failings involved in the engineering design process, worsening the extent of the crisis. According to Susan J. Masten, a professor in the Department of Civil and Environmental Engineering at Michigan State University with 35 years of water treatment experience, there were at least five warning signs that should have raised concern about the possibility of corrosion in Flint: "Process changes that result in pH or alkalinity changes, process changes that affect the CSMR, change in coagulant, introduction of a new acid to the process, and introduction of a new base" (Masten et al, pg. 31, 2016). All of these warning signs were present, but they were not considered in the engineering design notes (Masten et al., pg. 31, 2016). The technical failings in the design of Flint's water system were not limited to the design of the water treatment process. The inclusion of lead pipes in the homes of many Flint residents was a major oversight that could have been corrected years before the crisis occurred if Flint had followed the example of towns such as Madison, Wisconsin. In Madison, the city government realized the risk involved with the lead pipes and implemented a successful program to remove the lead pipes in their city (Bodin, pg. 16, 2016). The Flint Water crisis could have been avoided if the engineers involved in Flint had recognized the problems associated with the lead pipes and then proceeded to implement a pipe replacement plan.

This pipe replacement plan did not happen; instead, the water crisis resulted in a badly damaged community. Engineers play a key role in the water treatment process, making it important that these mistakes are not made again. Engineers should examine the Flint water crisis closely in order to learn how to behave in a more ethical and effective manner in the future in order to prevent a similar crisis from happening again.

Engineering Technical/Design Failures in the Flint Water Crisis

The Flint water crisis was not a tragedy that happened overnight. It was caused by a series of poor decisions made during the engineering design process for the water distribution system in Flint. The first failure in the engineering design process came when the city of Flint decided to switch its water supply from the Detroit Water and Sewage Department back to the Flint River, which had previously been the source of Flint's water (Masten et al., pg. 23, 2016). This switch of water sources was not a problem on its own. However, the time frame in which the switch was made created a situation that made it difficult for the Flint water treatment plant to be fully prepared for distributing water by the time that it was opened to the public (Masten, et al, pg.23, 2016). The water system could have been fully prepared if there had been enough time, but the rushed time frame caused several warning signs for corrosion associated with switching water sources that should have been considered during the engineering design process to be missed.

The warning signs for corrosion that were missed during the engineering design process contributed to the crisis and the damage done to the community of Flint. Any time that a treatment change occurs in a water distribution system, there are warning signs that must be considered relating to the corrosion of lead pipes such as: pH and alkalinity changes, chloride-to-sulfate mass ratio changes, change in coagulant, introduction of a new acid, and introduction of a

new base (Masten et al., pg. 31, 2016). All of these changes to the water treatment process occurred in Flint's water treatment plant and should have caused corrosion to be considered in the design process. Despite the presence of these warning signs, the treatment plant lacked any sort of corrosion treatment for its water (Masten et al., pg. 32, 2016). This lack of corrosion treatment was caused by a failure to properly watch for the warning signs present in the water treatment process as well as by the failure of those in charge of designing the system to listen to the workers at the Flint water treatment plant.

The failure of those involved with the engineering design process to listen to the many people concerned about corrosion contributed to the damage done to Flint, and is an example of actions that should not be taken when designing a water treatment plant. More than once during the engineering design process, the Flint water treatment plant workers stated that they did not believe that the plant would be ready in the time specified. They were either not heard or were ignored altogether. One email was sent by an employee named Michael Glasgow, who stated that the treatment plant was not going to be prepared (Davis Reynolds Rothstein Sikkema, pg. 17, 2016). In addition to the warnings sent by the water treatment plant workers, Miguel del Toral with the EPA raised concern about how Flint could be prepared for distributing water if it had no corrosion control in its process (Davis et al., pg. 17, 2016). Despite the warnings by the plant workers and others, no corrosion estimates were included in the engineering design notes for reasons that are unknown (Masten et al. pg. 32, 2016). This unexplainable failure in the engineering design process places a significant amount of blame for the Flint water crisis on the shoulders of the engineers involved with the Flint water treatment plant. The many technical failings by engineers in the Flint Water Crisis leaves this question: what steps could have been taken to ensure that lead corrosion had not even been an issue in Flint in the first place?

The Flint water crisis could have been prevented by engineers if they cooperated with the citizens of Flint to remove the lead distribution pipes that were feeding water into many of Flint's homes, similar to what was done in Madison, Wisconsin or Lansing, Michigan. In Madison, Wisconsin, the city government realized that there were higher levels of lead than what they believed to be acceptable in their water supply, so they decided that they were going to take action in order to fix this problem (Bodin, pg. 16, 2016). Their solution to their lead pipe problem was to replace all of their lead service lines, which would require the help of engineers. There was a problem with this plan though. The city only owns the pipes up until they reach private property, making it difficult to replace pipes past the road. The city's solution to this problem was to pass an ordinance requiring everyone to replace their lead service pipes, and they worked with property owners by reimbursing them half of the cost of replacing the pipes on their property (Bodin, pg. 16, 2016). This process cost Madison fifteen and a half million dollars over 11 years, a relatively small price when compared to the twenty-six and a half million dollars spent by the state of Michigan on legal bills related to the Flint water crisis as of September, 2018 (Bodin, pg. 16, 2016) (Livengood, pg. 1, 2018). This price difference is shocking, especially considering that this money could have been spent protecting the people of Flint by following a similar process to what was done in Lansing.

If engineers in Flint would have worked with the city officials to replace the lead pipes in the city following the example of Lansing, they could have prevented the Flint water crisis from ever happening in the first place. In Lansing, the city government realized that they needed to replace their old lead service pipes, so they came up with a new and creative solution to solve their problem. Lansing's solution to the problem was to couple their lead pipe replacement project with their already planned sewer overflow replacement project. Not only did they

combine two projects together to save costs; they also designed a new process where the new pipes they were installing would push out the outdated lead pipes, eliminating the need to dig trenches in order to install the new pipes (Boding, pg. 16, 2016). Engineering helped to solve Lansing's lead problem. Engineering in Flint, on the other hand, augmented the crisis.

Ethical Shortcomings of Flint's Engineers

Part of the blame for the harm done to the community of Flint falls on the engineers because the engineering firms involved with the project failed to meet the ethical standards expected of them. During the Flint water crisis, two engineering firms failed to meet the ethical standards set forth for them by the National Society of Professional Engineers (NSPE). One of these engineering firms was Veolia North America. Veolia North America was contracted to assess the water quality in Flint, and in their report, they suggest that Flint should flush its fire hydrants in order to help with discoloration complaints due to the corrosion of the water (Veolia, pg. 6, 2015). Their recommendation was simply to minimize the problem by using a temporary solution. Flushing out the hydrants was not a new or creative idea that would have protected the people of Flint from lead poisoning. Instead, it was a solution that avoided the real problem and was aimed solely at pleasing the public in the short term. This is one of the most alarming ideas suggested by engineers during the Flint water crisis because instead of proposing a real solution to the problem, like in Lansing or Madison, the engineers proposed a useless solution to minimize complaints about the water made by the people of Flint.

Veolia's decision to assess the corrosion issue as a means to mitigate complaints by the community of Flint shows a complete disregard for the health of the people living there (Veolia, pg. 6, 2015). Not once in their report do they seem concerned with the fact that the corrosion of the pipes may have a much more damaging effect on the community of Flint than just the color

of the water. This is a major oversight by the engineers involved, considering that lead service lines "can represent as much as 75 percent of the observed lead concentration in tap water" (LaFrance, pg. 62, 2017). The key role of lead pipe corrosion in increasing lead concentration should have caused the engineers at Veolia to spend more time on the corrosion issue. They did not bring it up as a major point of concern when they finished their report. In their report, Veolia states that because the previous reports on the water say the water meets state and federal standards, the water is safe to drink (Veolia, pg. 2, 2015). The failure of Veolia's engineers to properly address the community's corrosion and discoloration concerns during its assessment of Flint's water treatment process is an ethical failure.

Veolia failed ethically when they made their report on their water quality assessment by not living up to the standards set by the NSPE's code of ethics. One of the main concerns voiced by the people of Flint was the discoloration of their water according to Veolia's report, but they drew very little attention to the problem of discoloration and corrosion. Instead, they chose to focus mainly on controlling the levels of total trihalomethane issues associated with the Flint Water Treatment Plant (Veolia, pg. 3, 2015). Throughout their report, they seem to show a disregard for the citizens concern using language such as, "Flushing the fire hydrants can be useful in cleaning out lines to minimize discolored water complaints" (Veolia, pg. 6, 2015). Veolia chose to focus on one aspect of the system that was not corrosion and ignored the concerns of the public, meaning Veolia failed to meet the National Society of Professional Engineers' (NSPE) code of ethics, which states that engineers are professionally obligated to serve the public interest at all times (NSPE, pg. 1, 2018). Veolia did not seek out the best interests of the public because they heard the concerns of the public and ignored them by limiting the focus of their assessment strictly to what was in their contract.

This narrow focus in Veolia's water quality report caused them to brush off the corrosion issue. This is an ethical failing because one of the most important factors to consider during the engineering design process is the health of the public. The first fundamental canon of the NSPE's code of ethics is, "Engineers, in the fulfillment of their professional duties, shall hold paramount the safety, health, and welfare of the public" (NSPE, pg. 1, 2018). Veolia failed to meet this ethical standard by choosing to address water discoloration as an attempt to limit public complaints rather than looking at the health implications of the corrosion issue. Failing to meet this ethical standard created serious issues considering the number of people who were placed in harms way by Veolia's failure to properly address the issue of lead corrosion. While Veolia's failure to properly address the public's concern about corrosion caused considerable damage to the community of Flint, it was not the most damaging ethical failure that they committed during their time working on the Flint water treatment system.

Veolia stated that the water in Flint was safe to drink in their report. This could be considered a deceptive act that contributed even more to the damage done to the people of Flint. The reason Veolia's statement could be considered a deceptive act is several procedures were not properly followed in the water treatment plant before its opening, but Veolia stated that the water was safe to drink anyway (Veolia, pg. 2, 2015). This statement would have been difficult to make, though, because prior to and during the operation of the Flint Water Treatment Plant, measurements for bromate were not properly taken for much of the plant's operation and the required testing for E. Coli and Cryptosporidium was not completed (Masten et al., pg. 27-28, 2016). By stating that the water was safe for drinking, Veolia failed to meet the NSPE's code of ethics by committing a deceptive act (NSPE, pg. 1, 2018). Veolia's statement was deceptive because they told the community that the water was safe for drinking. Yet many of the tests

necessary had not been performed, so they could not have known with certainty that the water was safe for the people of Flint to drink. Despite their misleading behavior and many other ethical failings, Veolia claims that they have no responsibility for the Flint Water Crisis.

Veolia argues that they hold no responsibility in the Flint Water Crisis because they stuck with exactly what they were contracted to do by the city of Flint (Veolia, 2016). While this argument does hold some merit, it does not mean their actions did not contribute to the damage done to the community. Veolia makes a valid argument when they say that it is the government that is to blame, and not them. The Flint Water Advisory Task Force's (FWATF) Final Report clearly places the blame on the emergency manager of Flint, the state government, and the Michigan Department of Environmental Quality (MDEQ) (FWATF, pg. 1, 2016). Veolia not having any of the blame directly placed on them by the FWATF does not mean they are not morally or ethically responsible for the damage that was done to the community. The FWATF does not place the blame on Veolia, but it also does not remove the blame from them simply because they are not mentioned in the report. The FWATF, in addition to reporting on the failures of the government in its report, sent a series of questions to another one of the engineering firms involved, Lockwood, Andrews, and Newnam, Inc. (LAN). The FWATF clearly believed that the actions of the engineers involved with the Flint water crisis was an important factor to consider.

LAN's responses to the FWATF's questions show many important details about how the unethical actions of engineers damaged the community of Flint. In the FWATF's questions to LAN, the FWATF asked, "What was the nature of the discussions regarding Lead and Copper Rule compliance requirements?" (Lockwood, Andrews, and Newnam Inc., pg. 5, 2016). LAN responded that they were aware of the Lead and Copper Rule, and that they had recommended to

the city of Flint that they address the issue of Corrosion (LAN, pg. 5, 2016). LAN claims that they were then told by Flint officials that the MDEQ guidelines did not require water softening for corrosion control so they would not be including it in the final design of the water treatment process (LAN, pg. 5, 2016). After being told by Flint officials that corrosion control would not be included in the water treatment process, LAN decided to drop the issue because they were not contracted to address the issue of corrosion (LAN, pg. 5, 2016). While LAN did what they were contracted to do, possibly clearing them of legal responsibility, they failed to uphold the ethical standards set forth for them in this situation.

LAN's choice to let the issue of corrosion control go damaged the community of Flint. This is a failure of their ethical responsibility to protect the health of the public. The first fundamental canon of the NSPE code of ethics is that engineers are to hold the health of the public above all else (NSPE, pg. 1, 2018). The code of ethics goes even further to explain what holding the health of the public as the top priority looks like when it states, "If engineers' judgment is overruled under circumstances that endanger life or property, they shall notify their employer or client and such other authority as may be appropriate" (NSPE, pg. 1, 2018). LAN was overruled in a situation directly pertaining to the health of the public in this situation. They chose not to notify any authorities who may have been able to assist with the situation and prevent the Flint water crisis.

Conclusions

Engineers contributed to the damage done to the community of Flint when they failed to behave ethically and to design a safe and effective water distribution system. According to Lori Higgins from the *Detroit Free Press*, up to 30,000 kids in Flint will need to have screenings to ensure that they receive the help they need based on the effects that the lead had on them

(Higgins, 2018). Once the screening of these children is done, the real work begins. State and local health officials will have to begin working with the children and their families to ensure that the affected children receive all of the help that they need to address the many health issues that are associated with elevated blood lead levels (Higgins, 2018). Due to elevated blood lead levels, these children could now be facing a lifetime of dealing with health issues ranging from learning difficulties to seizures, all because the engineers involved with Flint did not rise to the challenge and protect the citizens of Flint (Mayo Clinic, 2016). The damage is already done in Flint, but much can be learned by engineers who look at the ethical and technical failings of engineers in the Flint water crisis.

Learning from the mistakes made at Flint is especially important for engineers because water crises are not unique to the city of Flint. They have occurred in many different forms in various locations across the United States and the world. Locations such as Las Vegas, India, and Australia are examples of places that have recently encountered a water crisis of some kind (Fishman, 2011). One particular crisis that provides a great learning example for engineers occurred in Perth, Australia. The behavior of engineers in Perth provides an example effective water distribution and what engineers should do when they are tasked with providing safe water to a community. Perth was facing a shortage of water. Their solution was a desalination plant that would purify ocean water and make it drinkable (Fishman, pg. 206, 2011). The public in Perth was concerned about damaging the environment by increasing the salt concentrations in the ocean near the desalination plant and increasing greenhouse gas emissions by burning fuel to run the plant, but unlike in Flint, the engineers involved with Perth decided that they would listen to the public and addressed both of these issues with unique and creative solutions by using solar panels to address pollution concerns and a dispersion system to address the salt concentration

issue (Fishman, pg. 206, 2011). If the engineers in Flint had followed this example, rather than limiting themselves to the narrow scope of their contract, they may have been able to prevent the Flint water crisis.

Engineers can learn a great deal about the best ways to address the technical issues related to water crises if they look at what went wrong in Flint in comparison to what went right in places like Madison, Lansing, or Perth. Across the U.S., it is estimated that there are over six million lead service pipes that will cost 31 billion dollars to replace (Lafrance, pg. 64, 2017). The scope of the lead pipe problem in the U.S. makes it all the more important that engineers learn from the mistakes made in Flint, due to the role that engineers play in the design process for any water distribution system.

Engineers, while not solely responsible for the damage done in Flint, contributed a great deal to the Flint water crisis and should learn from the mistakes made by engineers during the crisis. At several points along the way, the engineers involved should have realized that lead corrosion would have been a serious issue endangering the health of the people of Flint. Instead, the engineers failed to meet the technical demands of designing an effective and safe water distribution system and fulfill their professional and ethical obligations to the people of Flint. All of these actions damaged the community of Flint. Instead, the engineers focused on contract details and saving money for the city of Flint. All engineers should look at the actions taken by the engineers involved with the Flint water crisis in order to better understand of how failing ethically has direct repercussions on the lives of the people they serve.

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