



Wastewater System Resilience: Learning from Connecticut Wastewater Systems

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Foreword

Wastewater managers face many challenges from not only extreme storms but also from changes in the economy, aging infrastructure, an uncertain regulatory environment, and a changing climate. Given these challenges, wastewater managers in Connecticut are building resilience. For the purposes of this publication, we define resilience as activities to help prepare for, cope with, recover and learn from events that disrupt wastewater service provision whether during normal or emergency operations. The purpose of this document is to share lessons learned from Connecticut wastewater managers that are building resilience and through that sharing to help managers learn from each other and strengthen and support resilience building efforts.

Introduction

Approximately 130 municipal and private wastewater systems operate in the State of Connecticut with permitted treatment capacities ranging from less than one million gallons per day to 60 million gallons of wastewater per day. Extreme weather events, equipment failures or malfunctions, and other non-routine occurrences can result in sewage backups, overflows, and/or bypassing of untreated or partially treated into waterways. Storms can be particularly disruptive. A survey of Connecticut wastewater systems conducted from November 2015 to April 2016 revealed that 72 percent of systems experienced disruptive impacts from past storms such as power loss, flooding, bypassing, and loss of access from past storms (see Figure 1).

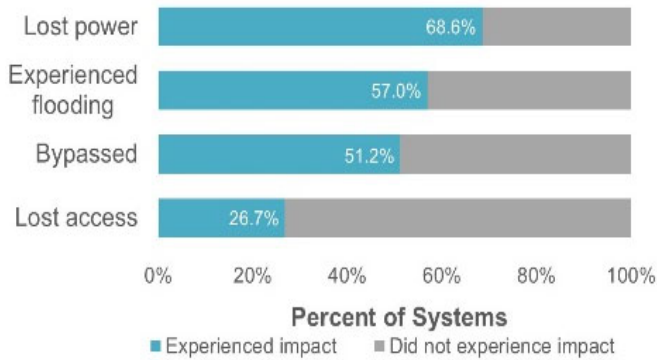


Figure 1 Percent of Connecticut wastewater systems who experienced power loss, flooding, bypassing, or access loss from past storm events (n=86). For more information on the survey and for additional survey results see Kirchhoff and Watson (2019).

Aging infrastructure, demographic shifts, economic crises, billions of unfunded capital needs (ASCE 2011), and cyber security could further increase vulnerability and undermine long-term sustainability and resilience of wastewater systems in Connecticut and across the USA. For the purposes of this publication, we define resilience as activities that help wastewater managers prepare for, cope with, recover, and learn from events that disrupt wastewater service provision whether during normal or emergency operations.

In the Northeastern USA, wastewater managers have resources available to help inform resilience building efforts. The New England Interstate Water Pollution Control Commission (NEWIPCC) provides a wastewater treatment plant design manual, *Guides for the Design of Wastewater Treatment Works* (also known as Technical Report 16 or TR-16), and a supplementary document, *Preparing for Extreme Weather at Wastewater Utilities: Strategies and Tips*. TR-16 focuses on wastewater treatment plant design including in the most recent addition, key concepts and design criteria related to flooding, storm surge, extreme weather, and climate change (NEIWPC 2016a,b). While TR-16 is primarily for engineers and regulators, the audience for the supplementary *Strategies and Tips* document is wastewater system managers and operators. The *Strategies and Tips* document synthesizes the experiences of Northeast wastewater utilities affected by recent major storm events (e.g., Hurricane Sandy, Hurricane Irene, and winter storm Alfred) and provides a set of strategies and tips for planning, preparing, coping with and recovering from major storm events.

This publication—*Wastewater System Resilience: Learning from Connecticut Wastewater Systems*—compliments these NEIWPC resources. Unlike the NEIWPC publications that emphasize storm and climate resilience, this publication has broader but complimentary aims. Herein we provide ideas and concepts to help wastewater systems build resilience 1) in day-to-day operations, 2) to non-climatic stressors, 3) to extreme events, and 4) to a changing climate. This report also shares strategies and tips used by Connecticut wastewater systems not previously discussed in the NEIWPC *Strategies and Tips* document. The intended audience for this document are the hard working wastewater superintendents, managers, operators and local government pollution control authorities working together to increase the resilience of wastewater systems in Connecticut and beyond.

Human Dimensions of Wastewater Resilience

In our conversations with Connecticut wastewater system managers, we found that the most resilient wastewater systems have excellent staff, good asset management, and effective leadership. Excellent staff are reliable, knowledgeable, well trained, resourceful and effective communicators. These staff are involved in the decision-making process and work well together to make sense of complex situations and build support for change. Good leaders support staff development and a ‘learning culture’. In addition, good leaders create an environment that encourages staff to think about and work towards building resilience. They also cultivate strong relationships with their customers and town and state authorities to support making changes to increase resilience.

In addition to excellent staff, good asset management, and effective leadership, wastewater systems that employed a mix of resilience building approaches—both hard and soft, big and small, or temporary and permanent—are on average more resilient. For example, a typical resilient wastewater system had managers who made small, temporary or intermittent changes to reduce their systems’ vulnerability first before shifting to larger, more expensive permanent changes such as adding plant capacity or undertaking large-scale flood proofing efforts. Building resilience through smaller scale adaptations is possible when managers know their system’s vulnerabilities and whether or not and for how long these smaller temporary interventions will work.

Finally, while staff, asset management, leadership, and employing a diversity of resilience building approaches is necessary, alone they are not sufficient; resilient wastewater systems employ an adaptive management (AM) approach. By AM, we mean managers promote ongoing learning including learning from experimentation and trial and error as well as from other wastewater systems’ experiences to enhance resilience. Ongoing learning helps wastewater systems assess risks and make adaptive, informed decisions. Implementing AM often involves transformation, which may include taking advantage of new technologies or reimagining or reconfiguring the wastewater system (see Figure 2). While many resilience resources stress the importance of flood-proofing and other physical measures for building resilience and while this is indeed important, lessons from Connecticut wastewater systems suggests wastewater resilience also depends on the capacity of the human systems to implement AM and build resilience.

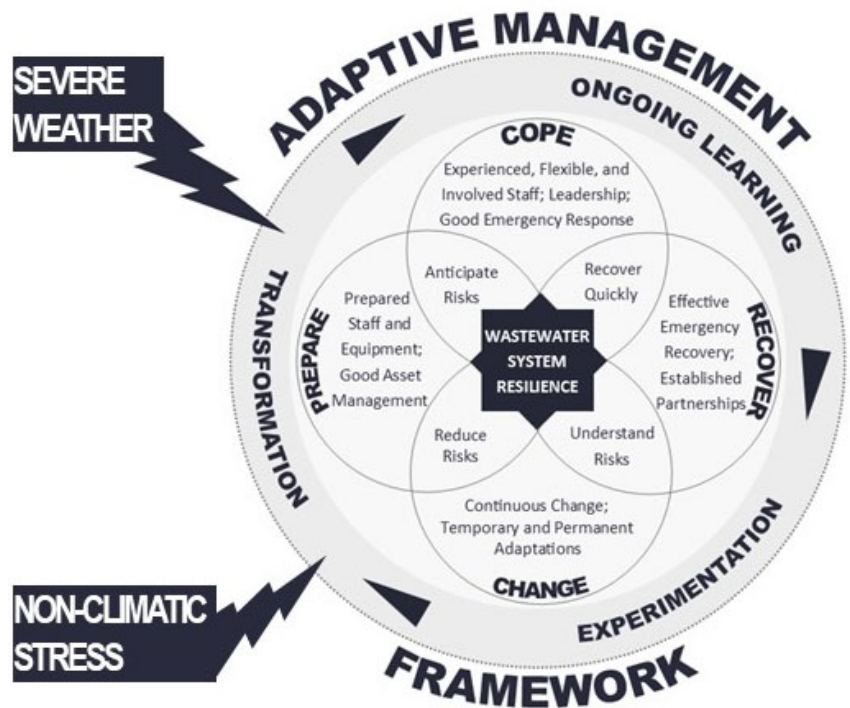


Figure 2 An adaptive management framework to build resilience to climatic (extreme storms) and non-climatic stress. Adapted from Mullin and Kirchoff (2018). To learn more about AM see (Mullin and Kirchoff 2018).

Strategies and Tips Used by Connecticut Wastewater Systems to Build Resilience

In addition to the survey, from October 2016 to March 2017, we interviewed 29 wastewater managers from across Connecticut to understand the nature and severity of past storm impacts, the types of adaptive changes made, what motivated those changes, and what helped or hindered making changes. We also asked managers about adaptation to future climate change. For a complete description of the interviews, analysis, and findings see Mullin and Kirchhoff (2018) and Kirchhoff and Watson (2019).

Connecticut wastewater managers employ a wide range of strategies to build resilience. Many of the strategies used for building resilience to extreme events align with the strategies and tips presented in the *Preparing for Extreme Weather at Wastewater Utilities: Strategies and Tips* (NEIWPC 2016b). In addition to the strategies already included in the NEIWPC *Strategies and Tips* document (NEIWPC 2016b), on the next several pages we present six additional resilience building strategies and tips: 1) Promote Ongoing Learning and Experimentation; 2) Maintain and Improve Equipment and Infrastructure; 3) Transform where Possible; 4) Invest in Many Diverse Resilience Building Actions; 5) Take Advantage of New Technology but Beware the Technology Trap; and, 6) Monitor and Take Advantage of Regulatory Change. These are strategies used by Connecticut wastewater systems that are not included in other guides and that speak to a broader range of resilience building efforts including for: 1) day-to-day operations, 2) non-climatic stressors, 3) extreme events, and 4) a changing climate. Along with each strategy and tip, we present select quotes from Connecticut wastewater managers that illustrate each strategy referring to interviewees by code for anonymity.

1) Promote Ongoing Learning and Experimentation

Fostering ongoing organizational learning and change especially through a willingness to experiment and learn from new techniques that help wastewater systems reduce vulnerabilities and increase resilience.

- “...we finally have the resources at our fingertips that allow us to really keep a pulse on how efficient our collection system and pump stations are operating.” (S35)
- “...if you don’t have a good measurement process in place, [you can’t adjust or] know how to portion it.” (DE18)
- “Don’t wait until it’s going wrong and then try to figure it out. You’re going to fail ... the best time to make changes is when things are going pretty good. Not wholesale

changes, but tinker around a little. I always tell people here if they want to try something, go ahead and monkey around with it and see what you can come up with. If it works, great. If not, we ditch it.” (O20)

- “I mention to them all the time to make a list of all the things you’ve learned in the last six months that you didn’t know.” (O20)
- “They come down to the plant frequently and have conversations with [us] on the ideas that they have or ideas that we may have for improvement.” (S11)
- “...we definitely look at what others have done to get to where we are here.” (S08)
- “Periodically you’ll be at a conference or something. I’m always curious on how people are – especially after the last series of big storms over the last few years; people had a lot of problems with their emergency generators.” (S21)

2) Maintain and Improve Equipment and Infrastructure

Perform continuous and preventative maintenance and repair of equipment and infrastructure to ensure the best equipment performance. Perform regular inspections and cleanings (e.g., routine cleaning of collection systems and wet wells) to reduce future problems.

- *“We really did a really good job maintaining those generators through the years so that in the time of an emergency they all performed like they were supposed to. We didn’t have any quit on us. The equipment held up.” (O20)*
- *“Pump station maintenance gets done every week.” (S12)*
- *“The money that's set aside for maintenance is spent on maintenance. What we don't spend this year will get carried over to next year, so there's nothing in it for us to not maintain the equipment.”(S29)*

Implement continuous / incremental infrastructure improvements and split large capital improvement projects into a sequence of smaller chunks to the extent possible.

- *“...we’re looking at chipping away at some of the infrastructure improvements on an ongoing basis.” (DE18)*
- *“I guess it looks like small increments, but something as small or as minimal as getting these pump stations to the point that we can see them back here, it’s been a process of probably eight or nine years.” (O20)*

- *“...continuously invest in our infrastructure here so it's an ongoing improvement process. We typically invest between \$50,000 and \$100,000 annually in our collecting system and we've gone through \$25 million in upgrades since 2008.” (S14)*
- *“...looking at the capital projects projected over twenty years is the start, and then it all depends on what’s breaking down or not breaking down, what needs repair, etcetera.” (S06)*
- *“... we’ve been slowly replacing things but some of the generators are affordable. They’re in the \$20,000 to \$40,000 range. So we can put that into our budget and save for it and the next year do it.” (O20)*

3) Transform where Possible

Look for opportunities to make radical, cost effective changes that transform the system or operations where possible.

- *“Our impetus has been also to remove pumping stations. We’re in the midst of reducing one, Savage Hill Road, so that it becomes a gravity. So we can get rid of that whole system frankly.” (DE18)*
- *“We have a facility that's basically between solar, and their digester complex, and they have something else going on there where they're net zero energy use.” (S29)*

4) Invest in Many Diverse Resilience Building Actions

Invest in small and large scale, temporary and permanent physical infrastructure resilience building actions as well as human dimensions actions (training, staffing, planning, etc.) to build resilience.

Stock extra pumps. Invest in submersible pumps and/or have auxiliary pumps available in case of an emergency.

- “We have a few extra pumps, brand new, sitting on standby in case one burns, we can just plug in the next.” (S13)
- “...the ones we have now are submersible grinders and they're just all over better for wastewater and that's probably the biggest gains that we've made...” (E17)

Add hydraulic capacity. Hydraulic capacity can be added at the plant or in the collection system.

- “...our plant was redone ... and it is oversized, over-engineered ...we're able to handle [excess flows] with no problem...” (S13)
- “We have capacity, so the added hydraulic loading doesn't really affect us that much.” (S14)
- “...we put larger pipes underground ... so we could handle larger flows...” (S19)
- “we have a tunnel system underground, putting in the ability to have tunnel flooding protection.” (S24)

Implement temporary and/or permanent flood protection or damage control measures.

- “...the station does have a berm around it but the driveway is not as high as the berm... So after the first one [flood] several years ago we staged sandbags for the driveway area...” (S12)
- “...put in permanent flood prevention barriers...” (S12)
- “...dykes and levees and floodgates, and we have two huge effluent pumps that have no problem pushing against the water that could be out there...” (S13)
- “I have a procedure in place to meet with electricians to actually pull a couple of pumps out, bring them to higher ground and hold them until things subside.” (S06)

Prioritize team building and collaborative decision making. Collaborative decision making takes advantage of team experience and expertise.

- “I've got my staff heavily involved ... because you get everyone's opinions and ideas and as a group collectively you come up with a lot more ideas or problems that you didn't know existed out there that you can try to correct in the facility with the upgrade.” (S19)
- “... exchanging information...ongoing day-to-day, keep people involved and let them hear the decision making.” (S09)

Invest in training, cross-training, and building capacity to solve problems internally. Being able to do more with in-house staff expertise often improves resilience.

- *“We train constantly, exchanging information, and so I would say definitely training” (S09)*
- *“...we train them, you know, as they get more accustomed to the plant how to reset the facility when the power comes back on.” (S19)*
- *“We actually had had the manufacturers come in and train us how to rebuild stuff and that's been able to save a lot of money in big downtime.” (S28)*
- *“...so that if somebody's out sick, there's enough cross-training that takes place so that anybody can step into any role and that facility will continue to run...” (S10)*
- *“The problem becomes when everybody, all the other municipalities are relying on those same outside contractors, when there is an emergency we're all chasing after those same contractors.” (W05)*

Bring new employees on early to aid in transfer of knowledge and experience from more experienced team members to newer team members.

- *“Probably half the staff has been here long enough. If you walked around and went to any piece of equipment here, they can tell you who made it, who is the rep, what type of lubricant is in it, what's the greasing schedule, how old it is. There are hundreds of pieces of equipment and everyone has this in their head.” (O20)*
- *“Having an experienced staff. Of course you don't want to have everybody at 65 years old, either. Sprinkle in some young people, too, so it can get passed on, that tribal knowledge. I think that gets missed sometimes, too.” (O20)*

- *“I don't see that workforce coming up behind us... replacing these 20 to 25-year employees. I have an employee that's gonna retire in ten years. I want to hire his replacement now. We don't make the investment in people coming up to be able to do this work.” (S10)*
- *“Our assistant plant manager is very hands on, really close to the training staff, and if he wasn't so hands on, if he wasn't so knowledgeable and then shared his knowledge with our staff, then it probably could have been terrible, yeah.” (E17)*

Establish and nurture mutual aid relationships.

Having established lines of communication and relationships with others (e.g., wastewater systems, utilities, etc.) help systems improve resilience especially during emergency events.

- *“they call and say hey our flusher truck is down for a couple of days can you give me the number of a guy who's on call so that if we have an issue can we borrow your flusher truck so we can operate it and we go okay fine, no problem.” (S16)*
- *“...it comes down to emergency preparedness and relying in case we need something that could be shared with other facilities or that other facilities may have something that could be shared with us, that type of planning.” (S08)*
- *“But sometimes they'll need a line jettied. So they'll call us up and we'll send a guy out there. Work with them to get that line opened up.” (S32)*

5) Take Advantage of New Technology but Beware the Technology Trap

New technologies can enable better day-to-day maintenance and monitoring and help identify problems. Technology can also help in emergency response by enabling remote monitoring and control.

- *“I did just invest in a new robotic camera.”* (S24)
- *“...we’re getting a GPS system, because we’ve got to have a GPS system for mapping...”* (S26)
- *“The biggest thing... we learned ... is to incorporate remote sensing and basically be able to see the pump station from the comfort of the control room so we do not have to drive out there unless there truly is a problem.”* (O20)
- *“Something as simple as thinking about our cellular modems are 3G so we know we’re going to have to go up to 4G modems at some point so we started buying now because each modem is somewhere between \$300 and \$400 and we’re going to need 11 or 12 of them.”* (O20)

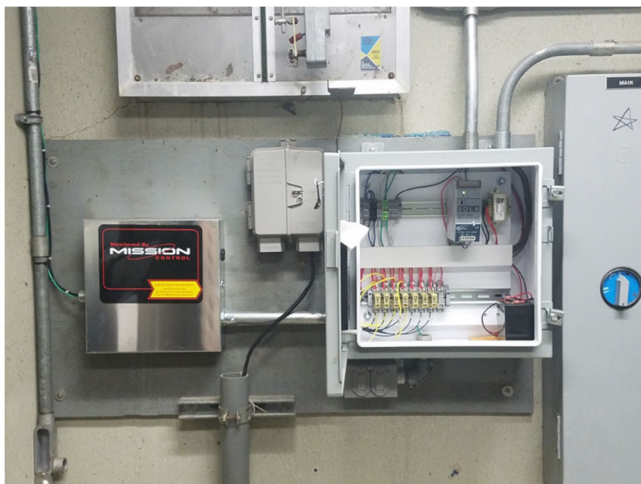


Figure 3 Mission Control dialer. Photo courtesy of Kevin Cini, City of Groton WPCA.

- *“Computerized Maintenance Management Systems. If you're gonna have the best equipment, you've gotta put the best maintenance in.”* (S30)

While technology has clear benefits, some systems noted that technology can also sometimes limit flexibility in response options.

- *Now we have installed all these new generators ... they’re brand new 2013 or 2014 models ... but the flip side is they’re all computer controlled, so if one of them doesn’t start, there’s not a damn thing we can do about it anymore until we can get the vendor in here to make a repair.”* (S19)

6) Monitor and Take Advantage of Regulatory Change

Anticipate regulatory changes and make proactive adjustments. Early compliance may enhance wastewater system resiliency and speed recovery.

- *“...we did switch from diesel to propane in anticipation of more stringent air quality acts coming out.”* (S09)
- *“Any new things CTDEEP are going to require in the future... anticipate those...”* (S34)

References and Other Resources

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