Epidemiologic Study of Health Effects Associated With Low Pressure Events in Drinking Water Distribution Systems

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Request for OMB Approval of a Reinstatement with Changes Information Collection

Supporting Statement A

Date 9/28/2018

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- **Goal of the study:**

The purpose of this data collection is to conduct an epidemiologic study in the U.S. to assess whether individuals exposed to low pressure events in the water distribution system are at an increased risk for acute gastrointestinal or respiratory illness.

- **Intended use of the resulting data:**

Study findings will inform the Environmental Protection Agency (EPA), CDC, and other drinking water stakeholders of the potential health risks associated with low pressure events in drinking water distribution systems and whether additional measures (e.g., new standards, additional research, or policy development) are needed to reduce the risk for health effects associated with low pressure events in the drinking water distribution system.

- **Methods to be used to collect:**

We will conduct a cohort study among households that receive water from seven water utilities across the U.S. The water systems will be geographically diverse and will include both chlorinated and chloraminated systems. These water utilities will provide information about low pressure events that occur during the study period using a standardized form (approximately 13 events per utility). Utilities will provide address listings of households in areas exposed to the low pressure event and comparable households in an unexposed area to CDC staff, who will randomly select participants and send them an introductory letter and questionnaire. Consenting household respondents will be asked about symptoms and duration of any recent gastrointestinal or respiratory illness, tap water consumption, and other exposures including international travel, daycare attendance or employment, animal contacts, and recreational water exposures.

- **The subpopulation to be studied:**

An estimated 7,900 individuals 18 years of age or older will be contacted from among households that receive water from seven water utilities across the U.S.

- **How data will be analyzed:**

The data will be analyzed using statistical regression models with SAS statistical software.

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A. Justification

1. Circumstances Making the Collection of Information Necessary

This is a request from CDC for a 36 month reinstatement with changes of an existing data collection. The purpose of this data collection is to continue to conduct an epidemiologic study in the U.S. (similar to a study conducted in Norway (Nygard, Wahl et al. 2007)) to assess whether individuals exposed to low pressure events in the water distribution system are at an increased risk for acute gastrointestinal or respiratory illnesses (Table

A.1.1). Pursuant to the terms of clearance, a non-substantive change request was required after completion of a pilot study and was approved on 11/12/2014. Pilot study data collection, analysis, and evaluation took longer than expected, and there were delays in implementing data infrastructure and IT updates needed to scale-up the procedures for a multi-site study. To address this, we are asking for a 36 month reinstatement for data collection. The approved OMB expiration date is 08/31/2018, but this did not allow enough time to complete the data collection. Utility capacity and reporting of events for the study occurred at a lower and more variable rate than initially expected. A reinstatement will allow the study to reach the needed number of events and provide adequate time to recruit new utilities.

There are no proposed changes to the methodology or information collection forms in this reinstatement request. As a part of this reinstatement, the project team is seeking approval to enroll a sixth and seventh water utility sites instead of five to increase the diversity of participants and water systems in the study, and strengthen statistical power of stratified analysis results. The site from the pilot volunteered to participate in the multi-site study, and four additional utilities have been enrolled. Two are finished with data collection and three are planning to continue reporting events. The five utilities are diverse in their geographic locations, size of population served, and secondary disinfectant types (i.e., two use monochloramine and three use chlorine), which could improve the diversity of study participants and facilitate stratified analyses by disinfectant type, which is one of the team's analysis goals. To improve diversity of respondents, the two new utilities will also be unique from the other utilities in geographic location, and size of population served. The project team seeks to enroll at least one utility that uses a monochloramine secondary disinfectant to match the number of events collected from utilities using chlorine to provide a stronger comparison when stratifying analyses by disinfectant type.

There would be an anticipated decrease to the annualized burden to survey respondents. Annualized costs to respondents were updated with May 2017 U.S. Department of Labor's national occupational employment and wage estimates data to reflect changes to the mean hourly wages. Annualized costs to the government were updated to reflect the 36 month reinstatement request.

For the full multi-site study, the study team aims to conduct a prospective cohort study among households that receive water from seven water utilities across the United States. These geographically diverse water utilities provide information about low pressure events that occur during the study period. Following approximately 79 low pressure events (LPE), an estimated 7,900 households (2,633 from areas exposed to the LPE and 5,267 from comparable but unexposed areas) will be invited to participate. We estimate that 3,160 surveys will be completed and returned, providing data on 6,320 individuals. A total of 80 estimated annualized hours of respondent burden are expected for the full multi-site epidemiologic study.

As of July 11, 2018, there have been 53 study events reported. There have been 1,850 household surveys received, with data on 4,515 individuals. Overall response rate for the

multi-site study has been consistently around 40%. We have increased our target events goal from 65 to 79, based on the already collected data having a larger proportion of smaller events than expected.

After consenting to participate, the selected households will be asked to respond to questions about symptoms and duration of AGI and acute respiratory illness (ARI) that occurred during the 2-week period following the low pressure event. Respondents will also be asked about relevant exposures during the 2-week period. Participation in this study will be voluntary. No financial compensation will be provided to study participants. A refrigerator magnet showing a 1-year calendar will be provided as a small token of appreciation to those invited to participate.

No existing U.S. data sources can be used to answer this research question. This study would be, to our knowledge, the first U.S. study to systematically examine the association between low pressure events and acute gastrointestinal and respiratory illnesses. Study findings will help the EPA, CDC, and other drinking water stakeholders prioritize and direct future research and policy efforts that address public health risks associated with drinking water distribution systems. This data collection supports CDC's research agenda goal of "Decreasing health risks from environmental exposures," as waterborne illnesses are environmental exposure health risks. Data collection authority is found in Section 301 of the Public Health Service Act (42 U.S.C. 241) (Attachment A).

2. Purpose and Use of Information Collection

The pilot study demonstrated that the study procedures will yield high-quality data needed to answer the research questions. Continued data collection is needed to evaluate whether LPEs are associated with illness.

Contamination of water in distribution systems is a risk factor for disease, accounting for approximately 15% of drinking water outbreaks in community water systems reported during 1971–2006 (Craun, Brunkard et al. 2010). Each year, approximately 240,000 water main breaks occur in the U.S. (U.S. Environmental Protection Agency 2009) -- occasionally boil water advisories are issued, but we do not have good data to assess whether people are getting sick when water pipes break and pressure is lost. Few published studies have identified the human health risk associated with low pressure events in drinking water distribution systems (Payment, Siemiatycki et al. 1997; Hunter, Chalmers et al. 2005; Nygard, Wahl et al. 2007; Etheridge 2011; Save-Soderbergh et al. 2017). Three of these were prospective studies conducted outside the United States (Payment, Siemiatycki et al. 1997; Nygard, Wahl et al. 2007; Save-Soderbergh et al. 2017), and two were retrospective studies that relied on self-report of low pressure as well as self-report of symptoms (Hunter, Chalmers et al. 2005; Etheridge 2011). One retrospective study conducted in the United States, following a water emergency in Alabama, identified significant dose-response associations between number of days of low water pressure or loss of water service and increased prevalence of self-reported AGI (Etheridge 2011).

The study will have over 85% statistical power to detect an association of the magnitude identified in the similar study from Norway — the Nygard study (RR~1.6).

Table A.1.1 -- Summary of Study Design

Study design	Prospective cohort study
Setting	Households receiving water from one of six water utilities across the U.S. Water utilities will be geographically diverse and will include systems that use both chlorine and chloramines as their secondary disinfectants
Primary outcome	Self-reported AGI
Secondary outcome	Self-reported ARI
Sample Size	6,320 individuals (2,107 exposed; 4,213 unexposed)
Analytic methods	Calculate incidence rates for both exposed and unexposed groups, odds ratios, risk difference, and attributable risk percent; conduct conditional logistic regression, matched on low-pressure event.
Duration	90 months

In the United States, drinking water distribution systems are designed to deliver safe, pressurized drinking water to our homes, hospitals, schools and businesses. However, the water distribution infrastructure in the U.S. is aging, with many of our pipes 50-100 years old and in need of replacement. The U.S. Environmental Protection Agency (EPA) estimates that over 250 billion dollars (U.S. Environmental Protection Agency 2009) will be needed over the next 20 years to upgrade, maintain, and replace the several million miles of pipelines and components that comprise our water infrastructure. Failures in the distribution system such as water main breaks, cross-connections, back-flow, and pressure fluctuations can result in potential intrusion of microbes and other contaminants into the distribution system that can cause acute gastrointestinal and respiratory illness (Swerdlow, Woodruff et al. 1992; LeChevallier, Gullick et al. 2003; Borchardt, Haas et al. 2004; Lambertini, Spencer et al. 2011) .

Approximately 180 million cases of acute gastrointestinal illness (AGI) occur in the U.S. each year (Scallan et al. 2011) but we do not have reliable data to assess how many of these cases are associated with drinking water. From 1971–2006, over 800 waterborne disease outbreaks associated with drinking water were reported to the Centers for Disease Control and Prevention (CDC) by state, local, and territorial health departments, resulting in close to 600,000 cases of AGI (Craun, Brunkard et al. 2010). Exposure to waterborne pathogens through drinking water distribution systems accounted for approximately 15% of outbreaks in community water systems and 10% of outbreaks in public water systems (Craun, Brunkard et al. 2010). Still, outbreak surveillance systems only capture a small fraction of waterborne illness; the true burden of drinking water-related AGI and acute respiratory illness (ARI) in the U.S. is unknown. More specifically, limited data are available on human health risks associated with exposure to drinking water during and after the occurrence of low pressure events in drinking water distribution systems.

Past epidemiological studies have found conflicting results regarding the association between drinking water and AGI (Table A.1.2). In intervention trials, the amount of

gastrointestinal illness attributed to drinking municipal tap water has ranged from less than 11% (Colford, Wade et al. 2005) in the U.S. to 34% (Payment, Richardson et al. 1991) in Canada. This variation may be due in part to differences in the quality of the underlying source water (Hellard, Sinclair et al. 2001), treatment processes, participant blinding issues (Payment, Richardson et al. 1991; Payment, Siemiatycki et al. 1997), or other factors (Colford, Roy et al. 2006). The only studies thus far that systematically examined low pressure events and gastrointestinal illness using a prospective cohort study design were conducted in Norway from 2003-2004 (Nygard, Wahl et al. 2007) and Sweden from 2014-2015 (Säve-Söderbergh, Melle, et al. 2017). These studies found that individuals exposed to low pressure events in the distribution system (e.g., water main breaks or repairs) were at a higher risk for gastrointestinal illness during the weeks following a main break or repair as compared to individuals in unexposed areas.

Table A.1.2 − Studies of association between tap water consumption and acute gastrointestinal illness.

Country	**Principal Investigator**	**Year**	**Incidence Rate Ratio**	**Risk Attributable to Tap Water (%)**
Canada	Payment	1988–89	1.52	34%
Canada	Payment	1993–94	1.14	14%
Australia	Hellard	1997–99	0.99	—
U.S.	Colford	2000–02	0.98	—
Norway	Nygard	2005–06	1.58	37%
Sweden	Save-Soderbergh	2014-15	1.9	38%

Overview of the Data Collection System
Information for this data collection will be obtained from the public in two ways: paper surveys filled out by study respondents and returned via postal mail to CDC study staff; and web-based surveys filled out by respondents who respond via a password-protected website housed at CDC. Data from the paper surveys will be entered into a Microsoft Access (2007) database and data from the web-based survey will be provided from the computer developers in a SAS® 9.3 file.

Data will be collected by CDC staff and CDC contractors affiliated with the study. No other data collection partners will be involved. Data will be maintained for the lengths of time outlined in the sections below. Contact information (which is the only Information in Identifiable Form (IIF) that will be collected during this study) will be kept in a password-protected database separate from the survey information and will be deleted and blacked out from paper records within two years of study completion.

Items of Information to be Collected
The only IIF that will be collected will be contact information for the study participants (i.e., name, mailing address, phone number, e-mail if available). No dates of birth, social

security numbers or other types of IIF will be collected. Within one week following an LPE, the water utilities will provide contact information of residential customers (service connections) affected by the LPE and residential customers (service connections) in an area unaffected by the LPE (e.g., persons in a different pressure zone) to CDC study staff, using a secure, encrypted file transfer protocol (FTP) site. From this address list, a random sample of exposed and unexposed households will be generated by CDC study staff. Households will only be surveyed once (either as a household exposed to an LPE or as an unexposed household).

Information will be collected from the public on water service and use and self-reported illnesses (see Attachments D-N for survey instruments and related documents). Information obtained through this data collection will include:

- Symptoms and duration of AGI and ARI
- Impact of illnesses, including hospitalization and loss of school/work
- Presence of chronic health condition with gastrointestinal or respiratory symptoms
- Household water service, use and consumption (type of drinking water, number of glasses of tap water consumed per person/per day, change in taste, color, or odor of tap water)
- Recent international travel
- Children or adult household member attending or employed at daycare
- Pets in the household and other animal contact
- Recreational water exposure
- Basic demographics: age, race/ethnicity and sex

Our primary outcome measure will be self-reported AGI. AGI will be defined as an episode of vomiting or diarrhea (≥3 loose stools in a 24-hour period) during the two weeks after the low pressure event ("two week period"). Our secondary outcome will be self-reported ARI. ARI will be defined as at least two of the following: fever, sore throat, runny nose, or cough during the two week period of interest.

Participants' initials will be asked for on the questionnaire in order to facilitate individual-specific responses. Initials will only be maintained in the study database until data cleaning is complete, after which they will be destroyed. Where paper records exist (i.e., paper surveys), initials will be blacked out within two years of data cleaning completion. Utility customer names will be used to facilitate communication, because personalized correspondence has been shown to improve survey response rates (Dillman 2007). Address information is necessary in order to identify households that are within the potentially exposed and unexposed areas and will also be used to address correspondence and estimate water distribution system-specific variables. Once these variables have been created, addresses will be deleted and blacked out from paper records within two years of data cleaning completion. Address information will be kept in a password-protected database. Records of any address not selected to participate in the study will be deleted within two years of study completion.

Identification of Website(s) and Website Content Directed at Children Under 13 Years of Age

Should they choose to participate, survey respondents will have the opportunity to respond to the survey via the internet. No children (<18 years of age) will be asked to respond to the web-based (or postal version) of the survey. Regardless of which manner a person chooses to participate in the study, for households where children <18 years of age are present, we will ask a parent or guardian to answer questions and provide information on behalf of the child. The consent brochure specifies that only an adult (≥18 years of age) is eligible to complete the questionnaire (see Attachment G), and this information is reiterated in the survey booklet (see Attachments H and I).

The U.S. EPA estimates that we will need to invest approximately $300 billion over the next 20 years to upgrade and replace our aging drinking water infrastructure (U.S. Environmental Protection Agency 2009). In development of the Revised Total Coliform Rule (TCR) under which water quality in the distribution system is measured and regulated (as part of the Safe Drinking Water Act), EPA established a Research and Information Collection Partnership (RICP) to identify the highest priority research needs regarding drinking water distribution systems and to help determine whether regulatory action is needed to address distribution system risks (U.S. Environmental Protection Agency 2008). This study was selected as one of ten high priority areas for the drinking water sector (U.S. Environmental Protection Agency and Water Research Foundation 2010). CDC, EPA and the Water Research Foundation (WRF) have provided financial support for the study, recognizing the importance of understanding the risk that low pressure events in the nation's water distribution system infrastructure present for public health. While no single study can provide all information needed to inform EPA regulations, and the proposed study cannot claim to fully represent all utilities in the U.S. or conclusively determine whether small increases in risk (i.e., 50% or less increase) occur, the proposed study will supply the first systematically collected epidemiologic data on health effects from low pressure events in the U.S.

This study will also supply data that can contribute to a larger effort to estimate the burden of waterborne disease in the U.S., an activity which has been proposed in multiple agency budgets and is funded in part with full time equivalent (FTE) and other programmatic support by the Waterborne Disease Prevention Branch within the Division of Foodborne, Waterborne and Environmental Diseases at CDC. These gaps include the association between low pressure events and illness (largely unknown in the U.S.), how often people use filters, and the amount of tap water consumed per day.

CDC, EPA, and other drinking water stakeholders will use the data generated from this study to inform regulation and rule development, and to direct future research efforts that address public health risks associated with drinking water distribution systems. The results from this epidemiologic study will also address EPA's research goals by providing a characterization of the baseline risks of adverse health effects associated with low or negative pressure events in the distribution system and the potential for reduction in those risks associated with different water treatment types or repair strategies. The negative impact of not conducting this study is that policy-makers, government agencies and the water sector will not have the data and information they need on the potential health

impact associated with low pressure events and other breakdowns in our nation's drinking water infrastructure, which is critical to assess the safety and reliability of our public drinking water supply.

3. Use of Improved Information Technology and Burden Reduction

This data collection will involve two response options for survey participants: mail and internet. During the pilot, the majority of respondents chose to return the survey by postal mail (70%), using the provided return envelope. The data quality of the web surveys was higher than the paper surveys because data verification rules and question skip patterns were built into the survey interface. Since the web survey instructions and access information were printed on the survey materials, rather than sent electronically to customers, it might have been inconvenient for respondents to access a computer, type the link to the website, and log-in to take the survey. Additionally, the study team will add an outbound telephone call as a reminder and additional opportunity for survey participation before the final appeal letter is sent in an attempt to further increase the response rate (Attachment M). However, this call is currently only feasible in a single utility due to several factors, including: state laws restricting the sharing of phone numbers and data systems at utilities may not be able to provide customer phone numbers the file needed,.

All respondents will have the opportunity to respond via the internet. A web-based version of the survey is being offered because it will:

- Reduce the time burden on respondents as compared to other methods of survey completion because of the built in skip patterns and internal logic controls for efficiently routing the respondent to the relevant questions;
- Employ a variety of prompts to encourage survey completion;
- Have data entry validation to limit data entry errors and reduce data cleaning efforts; and
- Data entry into the database is automatic thereby eliminating the need for manual data entry, which also limits data entry errors.

We expect both versions of the survey to take approximately 12 minutes to complete.

Participation in this data collection is voluntary, individuals will be able to discontinue participation at any time point, and all efforts will be made to reduce the time burden on participants.

4. Efforts to Identify Duplication and Use of Similar Information

There are no similar data available, and this study would not be a duplication of any studies currently being conducted in the U.S. No existing U.S. data sources can be used to answer this research question. During the past two decades, only a handful of epidemiologic studies looking at the risk for gastrointestinal illness associated with drinking water have been conducted globally (see Table A.1.2). Two of these studies looked at distribution system risks using a prospective study design, and neither of these studies were conducted in the U.S. Through consultation with other government agencies and national and international water experts, we feel confident that this type of study has

not been conducted in the U.S. and would not be a duplication of efforts. Additionally, we have searched databases of scientific literature in the disciplines of public health, environmental engineering, and water microbiology (e.g., PubMed, Web of Science, Google Scholar), and attended national meetings (American Public Health Association, American Water Works Association, and American Backflow Prevention Association meetings as well as EPA symposia) to attempt to identify similar epidemiological studies that may have been conducted in the U.S. and elsewhere. This study would be, to our knowledge, the first U.S. study to prospectively examine the association between low pressure events in the water distribution system and illness (AGI or ARI).

5. Impact on Small Businesses or Other Small Entities
No small businesses will be involved in this data collection.

6. Consequences of Collecting the Information Less Frequently
Respondents will be asked to respond to this data collection only one time. Our utility partner's staff will be filling out LPE forms, collecting water samples and sending us costumer information for each of the 13 events they collect. There are no legal obstacles to reduce the burden.

7. Special Circumstances Relating to the Guidelines of 5 CFR 1320.5
This request fully complies with the regulation 5 CFR 1320.5.

8. Comments in Response to the Federal Register Notice and Efforts to Consult Outside the Agency

A. A 60-day Federal Register Notice was published in the *Federal Register* on August 29, 2018, vol. 83, No. 168, pp. 44053 (Attachment B). CDC received four non-substantive public comments (Attachments B1, B2, B3, and B4). CDC received one substantive public comment (B5). A response was sent thanking the commenter for his support of the study (B6).

B. Consultation outside the CDC began in 2008 with the following persons and is ongoing:

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9. Explanations of Any Payment or Gift to Respondents

Study participants will receive a refrigerator magnet calendar that includes information on emergency preparedness from the CDC with the initial survey mailing. This magnet will highlight the two week period of interest for the study, thus serving as a visual aid to improve recall for participants. The magnet can also be regarded as a token gift. Including a token gift has been shown to improve response rates in mailed surveys (Dillman 2007).

10. Protection of the Privacy and Confidentiality of Information Provided by Respondents

The National Center for Emerging and Zoonotic Infectious Diseases reviewed this submission and determined that the Privacy Act applies.

Privacy Impact Assessment Information (Attachment R)

A. The Privacy Act applies to this data collection because personally identifying information (e.g., contact information) will be requested and could potentially be linked to survey responses, although its intended use is (a) to randomly select study participants, (b) to identify exposed and unexposed households and (c) to calculate water distribution system-specific measures (e.g., water residence time, distance from location of low pressure event, etc.) of consented participating households. The applicable System of Records Notice is 09-20-0136.

B. To protect respondent privacy, the study team has put the following technical, physical, administrative and procedural safeguards in place:

- Personal identification information (e.g., mailing address and other contact information) for each household is collected by water utility collaborators as part of their routine business operations (e.g., for billing and service purposes). Once an LPE has been identified, the water utility will provide the CDC study team

with a list of addresses in the area potentially exposed to the LPE and a comparable or larger number of addresses in an area not exposed to the LPE, through a secure, encrypted file transfer protocol (FTP) site. At CDC, mailing addresses will be uploaded into the study participant management database.

- Address information will be deleted no later than two years after study completion. All addresses of households that were not selected to receive a survey will be deleted within two years of study completion. Permanent data will be anonymous. Respondents will not and cannot be contacted for further follow-up.
- We plan to report only anonymous, aggregate data.
- We have no plans to share participant personal identification information (e.g., address) and will keep individuals' answers private and secure to the extent allowed by law. The measures to safeguard privacy are described to respondents in the informed consent process (Attachment G).
- Access to the web-based questionnaire will be obtained through the use of a personal pass code that is sent to each household in the survey packet that includes the paper version of the questionnaire. The personal pass code allows only that specific household to access the website. No personal identification information will be collected in the web-based version of the questionnaire.
- Personal identification information (e.g., mailing address) and questionnaire answers (including from the web-based and paper-based versions of the survey) will be stored on a CDC password-protected computer server. Completed paper surveys will be stored in a locked office. Access to the electronic data and to the paper documents will only be granted to authorized personnel at CDC who are working on the study.

CDC study staff who are contractors are subject to a non-disclosure agreement.

C. Return of a completed survey constitutes consent, as stated in the instructions on the cover of the survey booklet. (Attachments H and I).

Participants are told that the information they provide will be treated in a secure manner and that no identifying information will be shared or appear on any reports. Specifically, the consent brochure states:

> "When the study is complete, your contact information will be removed from our files. No personal information about you will appear on any report. Survey responses will be treated in a secure manner and will not be disclosed, unless otherwise compelled by law."

D. Study participants are informed that participation is voluntary and that they are not required to answer any specific questions. Specifically, the consent form states:

> "There is no penalty if you decide not to participate. However, we hope that you will choose to participate in this important study."

A Privacy Impact Assessment is included in this submission (Attachment R).

11. Institutional Review Board (IRB) and Justification for Sensitive Questions

IRB Approval
This study has been approved by CDC's IRB (see Attachment O).

Sensitive Questions
There are no sensitive questions being asked in this data collection.

12. Estimates of Annualized Burden Hours and Costs

A. Estimated Annualized Burden Hours

We anticipate a continued response rate of 40%. We have implemented several study design modifications following the Dillman Tailored Design Method to encourage participation and improve response rates compared to previous studies (see section B.3 for a discussion of how this was derived) (Dillman 2007). We plan to include as many as 79 low pressure events in this study (13 at each of 6 to 7 utilities). Based on the current mean event size of 100, we expect to obtain data on approximately 3,160 households from 79 events. We estimate that survey responses will include data on 2 individuals per household, on average, resulting in health outcome data on approximately 5,520 individuals. The recruitment schedule will provide over 85% power to detect an odds ratio of 1.6, the effect size identified in the Nygard study, in an overall analysis (see section B.1 for a description of how this was calculated).

Considering the pilot data and the new e-mail contact, we anticipate that of the estimated 3,160 households that return the survey, 40% of respondents (1,264 households) will respond via the web-based survey, and 60% of respondents (1,896 households) will respond via paper. Each household respondent will complete only one survey and the average burden per response for both versions of the survey is expected to be 12 minutes.

Approximately 1,200 surveys remain to be collected for the study during the 36 month reinstatement (from 3 still active utilities, and two possible new utilities). The estimated annual burden hours to respond to web-based questionnaire is 32 hours (1/3 x (480) x 12/60) and the paper-based questionnaire is 48 hours (1/3 x (720) x 12/60), for a total of 80 (32+48) annual burden hours for households filling out the household survey.

The burden to the utility personnel participating in the study was also evaluated following the pilot. Because the CDC Environmental Microbiology Laboratory must sometimes respond to public health emergencies that temporarily limit the lab's capacity for research projects, it will not be feasible to collect ultrafiltration samples (UF) for each of the 79 events in the study. Instead, the utility laboratory will collect grab samples from each event and UF samples will be collected from about 2/3 of all events to allow for efficient progress on the epidemiologic study at times when the CDC lab is unable to receive samples. Utilities will work with CDC to verify event eligibility before proceeding with a study response; at that time, CDC will let them know whether to collect the UF samples. The low pressure event (LPE) Form burden per event for events that include UF samples

is 145 minutes (15 minutes to write in the information and 130 minutes to collect and ship the samples). The LPE Form burden per event for events that only include grab samples is 45 minutes (15 minutes to write in the information and 30 minutes to collect and ship the samples).

The estimated time of 3 hours needed to provide contact information on affected and unaffected households was also evaluated following the pilot. During the pilot study, it was preferable for utility personnel to use knowledge of the water system and hydraulic principles to select the affected and unaffected areas, instead of using pressure models to identify the areas; the burden and annualized cost of work remained the same. The estimated time to provide contact information on affected and unaffected households is 3 hours (2 hours for utility personnel to use knowledge of the water system and hydraulic principles to select the affected and unaffected areas and 1 hour of clerical time for a total of 3 hours).

The estimated annualized burden for the LPE form is 6 hours (15 minutes x 5 active utilities x 5 events), the estimated annualized burden for the water samples is 38 hours [5 utilities*((130 minutes x 3 events with UF samples) + (30 minutes x 2 events without UF samples))], and the estimated annualized burden for the customer contact information is 42 hours (3 hours x 5 utilities x 5 events / 3 years). 3 years refers to the current 36 month reinstatement.

Thus, the total annualized response burden for this data collection is estimated at 199 hours (Table A.12.1). The total burden for the 36 month period is estimated to be 597 hours.

Table A.12.1- Estimated Annualized Burden Hours (for 3 still active Utilities, and two possible new Utilities)

Type of Respondent	**Form Name**	**Number of Respondents**	**Number of Responses per Respondent***	**Average Burden per Response (hours)**	**Total Burden (hours)**
Water Utility customer	Paper-based questionnaire	240	1	(12/60)	48
	Web-based questionnaire	160	1	(12/60)	32
Water utility maintenance worker	LPE form, ultrafilter and grab samples	5	3	(145/60)	36
	LPE form, grab samples	5	2	(45/60)	8
Water Utility Environmental Engineer	Line listings	5	5	2	50
Water Utility Billing clerk	Line listings	5	5	1	25
	Total				199

*Number of responses per respondent has been annualized to give an accurate annual estimate

B. Estimated Annualized Burden Costs

The annualized cost to water utility customer survey respondents for the multi-site study was estimated using the total annual burden (48 + 32= 80 hours) and the mean hourly wage in the U.S. for all occupations ($24.34, obtained from the U.S. Department of Labor's May 2017 national occupational employment and wage estimates data, available at: https://www.bls.gov/oes/current/oes_nat.htm#00-0000). Given these numbers, the maximum total annualized cost of this data collection to utility customer respondents is estimated to be $1,168.32 for the paper-based questionnaire (48 x $24.34=$1,168.32) and $778.88 for the web-based questionnaire (32 x $24.34 =$778.88)(See Table A.12.2).

The annualized cost to the water utility company personnel who complete the LPE forms and collect the environmental samples for the multi-site study was estimated to be 44(36 + 8) hours and the mean hourly wage in the U.S. for industrial machinery mechanics $25.54 (obtained from the U.S. Department of Labor's May 2017 national occupational employment and wage estimates data, available at: https://www.bls.gov/oes/current/oes_nat.htm#00-0000). Given these numbers, the maximum total annualized cost of this data collection to utility company mechanic respondents is estimated to be $1,123.76(44 x $25.54=$1,123.76) (See Table A.12.2).

To provide line listings of customer contact information, the utilities will first use knowledge of the water system and hydraulic principles to select the affected and unaffected areas (to be performed by an engineer, taking approximately 2 hours), and then use utility billing records identify household contact information (performed by clerical staff, taking approximately 1 hour) for CDC staff to randomly select participants from (Attachment Q). The annualized cost to the water utility company personnel who select the affected and unaffected areas for the multi-site study was estimated using the annual burden 50 hours and the mean hourly wage in the U.S. environmental engineers ($43.83, obtained from the U.S. Department of Labor's May 2017 national occupational employment and wage estimates data, available at: https://www.bls.gov/oes/current/oes_nat.htm#00-0000). Given these numbers, the maximum total annualized cost of this data collection to utility company engineer respondents is estimated to be $2,191.50 (50 x $43.83=$2,191.50) (See Table A.12.2).

The annualized cost to water utility clerical staff who provide CDC with the line listings of addresses of affected and unaffected residents for the multi-site study was estimated using the annual burden 25 hours and the mean hourly wage in the U.S. for billing and posting clerks ($18.49, obtained from the U.S. Department of Labor's May 2017 national occupational employment and wage estimates data, available at: https://www.bls.gov/oes/current/oes_nat.htm#00-0000). Given these numbers, the maximum total annualized cost of this data collection to billing clerks is estimated to be $462.25 (25 x $18.49=$462.25) (See Table A.12.2).

Summing across the four respondent categories, we anticipate that the maximum total annualized cost for the multi-site study would be $5,724.71.

Table A.12.2- Estimated Annualized Burden Costs

Type of Respondent	Form Name	Annualized Burden Hours	Hourly Wage Rate	Annualized Respondent Cost
Water Utility customer	Paper-based questionnaire	48	24.34	1,168.32
	Web-based questionnaire	32	24.34	778.88
Water utility maintenance worker	LPE form, ultrafilter and grab samples	36	25.54	919.44
	LPE form, grab samples	8	25.54	196.32
Water utility environmental engineer	Line Listings	50	43.83	2,191.50
Water utility billing clerk	Line listings	25	18.49	462.25
Total				5,724.71

13. Estimates of Other Total Annual Cost Burden to Respondents or Record Keepers

There are no other costs to respondents or record keepers.

14. Annualized Cost to the Government

The costs incurred by the government for this one-time data collection include the costs for personnel time, printing and mailing paper-based surveys, laboratory supplies, travel, and publication charges (see Table A.14.1).

The estimated annualized cost to the federal government is $515,651 (Table A.14.1). The total cost, over a 36 month reinstatement would be $1,680,074 [($515,651 per year for personnel * 3 yrs.) + $133,121 for supplies, travel, and publishing)].

Table A.14.1 – Annualized Budget, Multi-site and Pilot Study	Hours or Units per Year	Hourly or Unit Cost	Total Cost per Year
Epidemiologist (Co-PI)	520	51.38	26,718
Sr. Environmental Engineer (Research, Co-PI)	416	71.76	29,853
Environmental microbiologist	2,080	37.25	77,480
Project coordinator	2,080	33.65	69,992
Epidemiologist (IT)	1,040	62.50	65,000
Epidemiologist (Analysis)	1,040	62.50	65,000
Statistician	1,040	42.78	44,491

Student Assistant	333	12.00	3,996
Laboratory supplies	426	125.00	53,250
Printing and mailing	6,854[a]	10.5[b]	71,971
Water utility site visits (2 CDC staff/visit)	3	2,300	6,900
Page charges and reprints for publishing study paper	1	1,000	1,000
Total:			515,651

[a]The annual units of mailings were determined from the statistical power calculations and an expected 40% participant response rate.

[b]The unit cost for mailings include the cost for printing, envelopes, labels, and the calendar magnet. Since there are multiple mailing items that have different unit costs, the unit cost of 10.5 represents the total unit costs for all mailing items.

15. Explanation for Program Changes or Adjustments

The burden for survey participants and water utility participants has decreased from the burden shown in the current inventory.

Previously we indicated that we needed 12-18 months for new data collection. To address potential scheduling challenges discovered during the pilot, the study team will plan for scheduling conflicts and conduct a staggered scale-up to multiple utility sites, which will require a reinstatement of 36 months of data collection.

16. Plans for Tabulation and Publication and Project Time Schedule

Table A.16.1 provides the data collection activity schedule. Previously we indicated data collection would be completed 12-18 months after obtaining OMB approval. During the pilot, there were scheduling challenges during the winter season or during other busy periods at CDC or the utility. To address this, the study team has planned for scheduling conflicts and implemented a staggered scale-up to multiple utility sites; for these reasons a 30 month extension had been requested. An additional 36 month reinstatement has been requested to allow time for the study team to recruit a sixth and seventh utility, and collect study events from them.

Table A.1.6- Data collection activity schedule

Activity	**Time Frame**
Data collection	0-36 months after obtaining OMB reinstatement approval
Data analysis	24-40 months after obtaining OMB reinstatement approval
Manuscript development	40-46 months after obtaining OMB reinstatement approval

This is a prospective cohort study. The goal of the analysis is to assess whether households in areas exposed to LPEs have an increased risk for AGI and ARI. The primary unit of analysis will be the individual. Secondary analyses may be conducted using the household as the unit of analysis. We will measure the incidence of AGI and ARI among exposed and unexposed individuals and calculate odds ratios (OR), risk

difference, and attributable risk percent for AGI and ARI associated with LPEs in drinking water distribution systems. Since the exposed and unexposed households selected for each LPE will be matched on housing type, pipe material and size, and drinking water source, conditional logistic regression will be implemented to account for this matched sampling design. By conditioning on the LPE, we will be able to appropriately control for these matching variables and evaluate the effect of LPE exposure within each LPE. We will also control for individual-level covariates, such as age and chronic medical conditions. In addition to analyzing data from participants across all utilities combined, we plan to stratify our analyses by type of water treatment used (i.e., chlorine versus monochloramine as a secondary disinfectant). Descriptive and inferential statistical analyses will be conducted using statistical software SAS v.9.3 (SAS Institute, Cary, NC).

We anticipated previously that the participation rate in this study would be approximately 60%, we are planning for assessing non-response bias. We will conduct a non-response bias analysis by comparing responders to non-responders with respect to available exposure data (e.g. exposure to LPE) overall and stratified by water system, characteristics of LPE, and water utility characteristics. We will also conduct a sensitivity analysis to determine the potential impact on study results given different assumptions about illness rates in exposed and unexposed non-responders. If our response rate is lower than anticipated, we will still have over 85% power to detect an odds ratio of 1.6 in the overall analysis as long as at least 40% of invited households participate; however, our power to conduct a stratified analysis would be limited (see Part B section 3 for details of power calculations with 40% response rate).

17. Reason(s) Display of OMB Expiration Date is Inappropriate
The display of the OMB expiration date is not inappropriate.

18. Exceptions for Certification for Paperwork Reduction Act Submissions
There are no exceptions to the certification.

19. Response to Terms of Clearance
The study team completed a non-response bias analysis to investigate potential differences between study respondents and the general population. We compared the demographic information available in our survey (sex, age, race, and ethnicity) to demographic information in the census tracts where the low pressure events occurred, stratified by utility site. We have attached a table with our findings, below is an overall summary of our results.

Overall, individuals represented in our survey were not significantly different than the general population based on sex. However, individuals represented in our survey were significantly more likely to be white at 4 of 5 utility sites, and significantly less likely to be black/African American at 4 of 5 sites. Individuals represented in the survey were significantly less likely to be Hispanic at 2 of the 5 sites. Individuals represented in the survey were also more likely to be over 64 years of age at 4 out of 5 sites. (Table below).

This analysis of non-response bias will be conducted again at the conclusion of the study to investigate the final differences in characteristics between study respondents and the general population. Currently, participants differ from the overall population in the study sites, which limits the generalizability of the study. Further, the study only includes a limited number of utility sites which are not representative of other utilities across the country.

Table A.19.1 – Nonresponse Bias Analysis: demographic comparison of survey respondents with census tract population estimates for age, race, and sex

	Age								
	17 and under			18-64			65 and older		
Site	survey %	census %	p-val	survey %	census %	p-val	survey %	census %	p-val
A	17.7	17.0	0.466 2	59.7	58.4	0.322 7	22.6	24.7	0.068 1
B	22.3	23.4	0.347 3	53.2	59.7	0.000 1	24.6	17.0	0.000 1
C	16.6	22.2	0.000 1	63.3	63.9	0.739 1	20.1	13.9	0.000 1
D	25.5	23.3	0.048 9	60.2	64.5	0.000 5	14.3	12.2	0.017 7
E	19.5	23.2	0.304 3	58.5	63.3	0.287 1	22.0	13.5	0.025 2

	Race/Ethnicity								
	White			Black			AI/AN		
	survey %	census %	p-val	survey %	census %	p-val	survey %	census %	p-val
A	88.7	87.4	0.130	2.2	3.8	0.000	1.6	0.4	0.001
B	71.5	62.0	0.000	16.6	31.1	0.000	1.0	0.2	0.008
C	72.5	66.3	0.000	17.5	27.0	0.000	1.5	0.1	0.002
D	89.6	85.6	0.000	1.9	3.7	0.000	1.1	0.8	0.304
E	86.2	75.7	0.001	4.1	5.9	0.391	4.1	1.8	0.202
	Asian			Hawaiian/Pacific Islander			Hispanic		
	survey %	census %	p-val	survey %	census %	p-val	survey %	census %	p-val
A	3.5	3.5	0.935	0.3	0.1	0.118	6.1	9.9	0.000
B	4.6	3.8	0.177	0.6	0.0	0.011	2.9	3.1	0.544
C	2.8	2.8	0.960	1.0	0.1	0.009	4.7	4.2	0.495
D	2.1	6.6	0.000	0.4	0.0	0.028	4.3	8.9	0.000
E	3.3	6.4	0.050	0.0	1.4	0.000	10.6	6.6	0.156

	Sex		
	Male		
	survey %	census %	p-val
A	48.0	48.8	0.573

B	48.3	47.1	0.383
C	44.4	47.6	0.071
D	49.8	49.0	0.520
E	52.5	51.1	0.766

*Census estimates are based on census tract level population estimates for each utility site location

List of Attachments *

A. Authorizing Legislation
B. 60 day Federal Register Notice
B1. Public comment
B2. Public comment
B3. Public comment
B4. Public comment
B5. Public comment
B6. Response to public comment
C. Pilot Evaluation Logical Framework
D. Advance Letter
E. Cover Letter – Paper
G. Consent Brochure
H. Household Survey – Paper
I. Household Survey – Web – Screen Shots
J. Thank you/Reminder Letter
K. Replacement Survey Cover Letter – Paper
M. Reminder Phone Script
N. Final Appeal Letter
O. IRB Approval Continuation
P. Low Pressure Event Form
Q. Utility Customer Information

* Attachments F and L are no longer used

References

Borchardt, M. A., N. L. Haas, et al. (2004). "Vulnerability of drinking-water wells in La Crosse, Wisconsin, to enteric-virus contamination from surface water contributions." Applied and Environmental Microbiology **70**(10): 5937-5946.

Colford, J. M., Jr., S. Roy, et al. (2006). "A review of household drinking water intervention trials and an approach to the estimation of endemic waterborne gastroenteritis in the United States." J Water Health **4 Suppl 2**: 71-88.

Colford, J. M., T. J. Wade, et al. (2005). "A randomized, controlled trial of in-home drinking water intervention to reduce gastrointestinal illness." American Journal of Epidemiology **161**(5): 472-482.

Craun, G. F., J. M. Brunkard, et al. (2010). "Causes of outbreaks associated with drinking water in the United States from 1971 to 2006." Clin Microbiol Rev **23**(3): 507-528.

Dillman, D. A. (2007). Mail and Internet Surveys: The Tailored Design Method. New Jersey, John Wiley & Sons, Inc.

Etheridge, B. P., T; Holiday, J; Underwood, R; Woernle, C; Zajac, L; Morrison, M; Brunkard, J; Miller, M; Otto, C; Hightower, A; Wolkon, A; Gargano, J; Freeland, A; EIS Officers (2011). Community Health Impact of Extended Loss of Water Service - Alabama, January 2010. Morbidity and Mortality Weekly Report, Centers for Disease Control and Prevention. **60:** 161 - 166.

Gargano J, Hill V, Adam E, Schneeberger C. Pilot CDC epidemiologic study of low pressure events in drinking water distribution systems and request for utility participants. Water Research Foundation. Public Project Papers. September 2014. http://www.waterrf.org/resources/pages/PublicProjectPapers-detail.aspx?ItemID=19.

Hellard, M. E., M. I. Sinclair, et al. (2001). "A randomized, blinded, controlled trial investigating the gastrointestinal health effects of drinking water quality." Environ Health Perspect **109**(8): 773-778.

Hill V, Gargano J, Adam E, Schneeberger C. (2014). Epidemiologic study of health effects associated with low pressure events in a drinking water distribution system. American Water Works Association (AWWA) 2014 Water Quality Technology Conference. New Orleans, LA.

Hunter, P. R., R. M. Chalmers, et al. (2005). "Self-reported diarrhea in a control group: a strong association with reporting of low-pressure events in tap water." Clin Infect Dis **40**(4): e32-34.

Lambertini, E., S. K. Spencer, et al. (2011). "Virus contamination from operation and maintenance events in small drinking water distribution systems." Journal of Water and Health **9**(4): 799-812.

LeChevallier, M. W., R. W. Gullick, et al. (2003). "The potential for health risks from intrusion of contaminants into the distribution system from pressure transients." J Water Health **1**(1): 3-14.

Nygard, K., E. Wahl, et al. (2007). "Breaks and maintenance work in the water distribution systems and gastrointestinal illness: a cohort study." International Journal of Epidemiology **36**(4): 873-880.

Payment, P., L. Richardson, et al. (1991). "A randomized trial to evaluate the risk of gastrointestinal disease due to consumption of drinking water meeting current microbiological standards." Am J Public Health **81**(6): 703-708.

Payment, P., J. Siemiatycki, et al. (1997). "A prospective epidemiological study of gastrointestinal health effects due to the consumption of drinking water." International Journal of Environmental Health Research **7**(1): 5-31.

Scallan E, Griffin PM, Angulo FJ, Tauxe RV, Hoekstra RM. Foodborne illness acquired in the United States--unspecified agents. Emerging infectious diseases. 2011;17(1):16-22. doi:10.3201/eid1701.091101p2.

Save-Soderbergh, M., et al. (2017). "Gastrointestinal illness linked to incidents in drinking water distribution networks in Sweden." Water Res 122: 503-511.

Swerdlow, D. L., B. A. Woodruff, et al. (1992). "A waterborne outbreak in Missouri of Escherichia coli O157:H7 associated with bloody diarrhea and death." Ann Intern Med **117**(10): 812-819.

U.S. Environmental Protection Agency. (2008). "Total Coliform Rule/Distribution System (TCRDS) Federal Advisory Committee Agreement in Principle." Retrieved December 6, 2010, from http://www.epa.gov/safewater/disinfection/tcr/pdfs/tcrdsac/agreementinprinciple_tcrdsac_2008-09-18.pdf.

U.S. Environmental Protection Agency. (2009). "Aging Water Infrastructure (AWI) Research: Water Distribution Systems." Retrieved August 24th, 2009, from http://www.epa.gov/awi/distributionsys.html.

U.S. Environmental Protection Agency and Water Research Foundation. (2010). "Final Priorities of the Distribution System Research and Information Collection Partnership." Retrieved September 3, 2010, from http://www.epa.gov/safewater/disinfection/tcr/pdfs/tcrdsac/finpridsricp051010.pdf