



Unification for Underground Resilience Measures
National Science Foundation Award # 2133356

Engaging Stakeholders for Strengthening Underground Infrastructure: Focus Group Findings

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Town +Gown: NYC

It's 10 P.M., January 1, 2075

**Do We Know Where Our Subsurface Infrastructure Is, Actually? Can We Get to It Easily to Minimize Disruptions? Do We Still
Have Subsurface Spaghetti?**

Session: Future Utilidor Considerations

New York, NY: Under the Ground.3, 4 WTC, 43rd Floor, HRA Dumpson Center
June 5, 2025

Goal

- Collaborate with key stakeholders and use exploratory research methods, including focus groups, to identify critical themes and knowledge gaps for underground infrastructure resilience
- Assess stakeholder understanding, experience, and needs to address underground vulnerabilities
- Identify extent of existing collaboration and foster future engagement

The geographic coverage is two neighborhoods in New York City: Midtown Manhattan and Sunset Park Brooklyn that differ in social and economic characteristics.

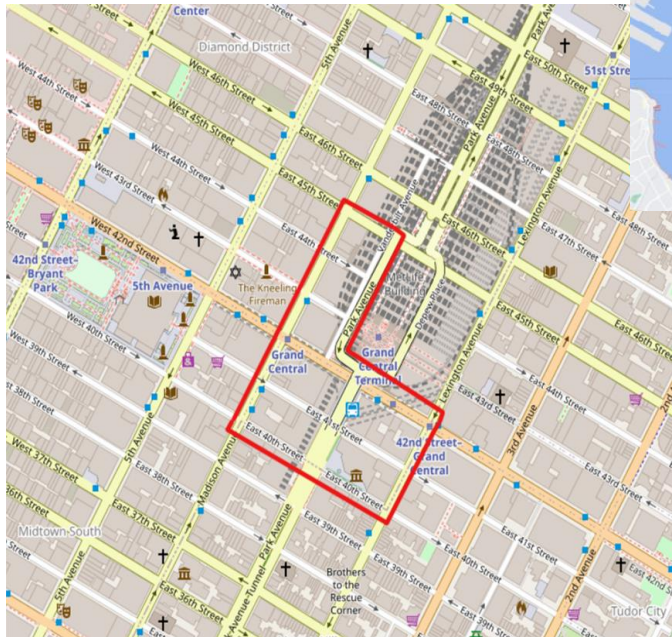
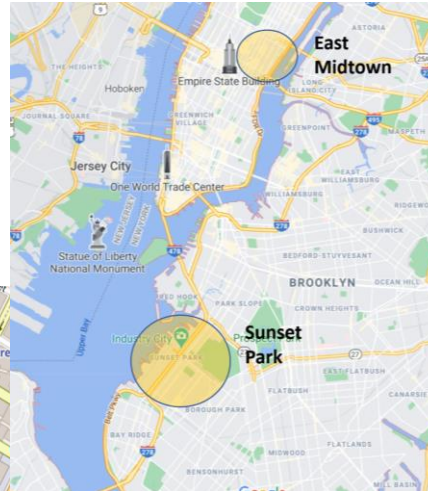
This presentation is drawn from C.E. Restrepo, R. Zimmerman, D. F. Laefer, A. Leidner, W. Dorf, P. Gmelch, and K. Hertz (2025) "Stakeholder engagement to strengthen underground infrastructure resilience." *Environ Syst Decis* 45, 10, 15 pp. <https://doi.org/10.1007/s10669-025-10003-8>.

The focus group project is part of UNUM Unification for Underground Resilience Measures under National Science Foundation Award # 2133356. It is a multi-disciplinary project to identify and engage various stakeholders to address problems of and solutions for underground infrastructure.

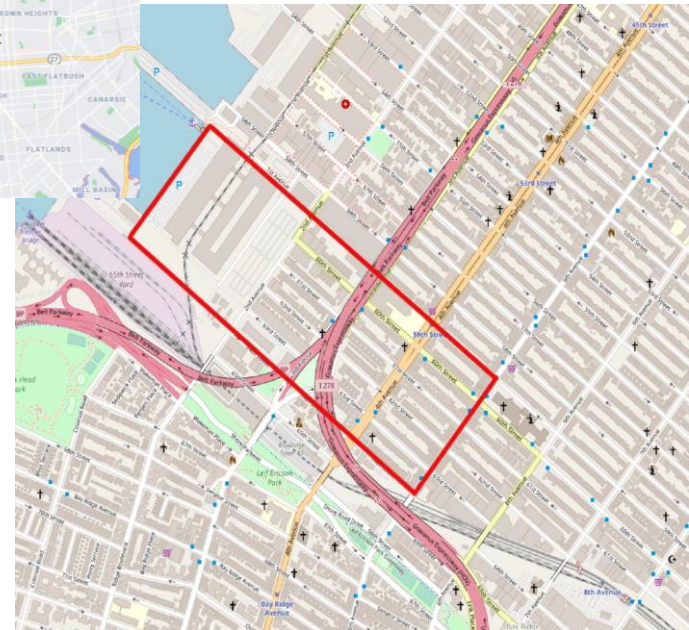
NSF Award Abstract: https://www.nsf.gov/awardsearch/showAward?AWD_ID=2133356&HistoricalAwards=false

UNUM Project Pilot Areas

The two areas differ in social and economic characteristics and underground infrastructure issues



East Midtown, Manhattan



Sunset Park, Brooklyn

Source: Restrepo, Zimmerman, Laefer, Leidner, Dorf, Gmelch, and Hertz (2025) "Stakeholder engagement to strengthen underground infrastructure resilience." Environ Syst Decis 45, 10, 15 pp.

<https://doi.org/10.1007/s10669-025-10003-8>, p. 2. and UNUM web site <https://wp.nyu.edu/unum/>

Underground Infrastructure: What it is and selected characteristics and threats

Example

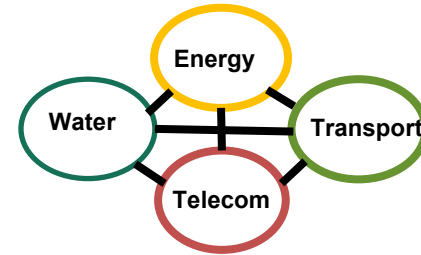


Electrical & wastewater infrastructure

Photo by R. Zimmerman 2022, Upper West Side, NYC

Underground infrastructure is usually considered safer given its protection from above ground threats, however, it faces threats of its own.

Interconnections and Interdependencies



Selected Underground Threats

Environmental Conditions

- Chemical corrosion (acidity, alkalinity)
- Moisture
- Earth movement
- Material constraints (concrete, steel)

Weather

- Temperature (freeze/thaw; heat)
- Heavy precipitation

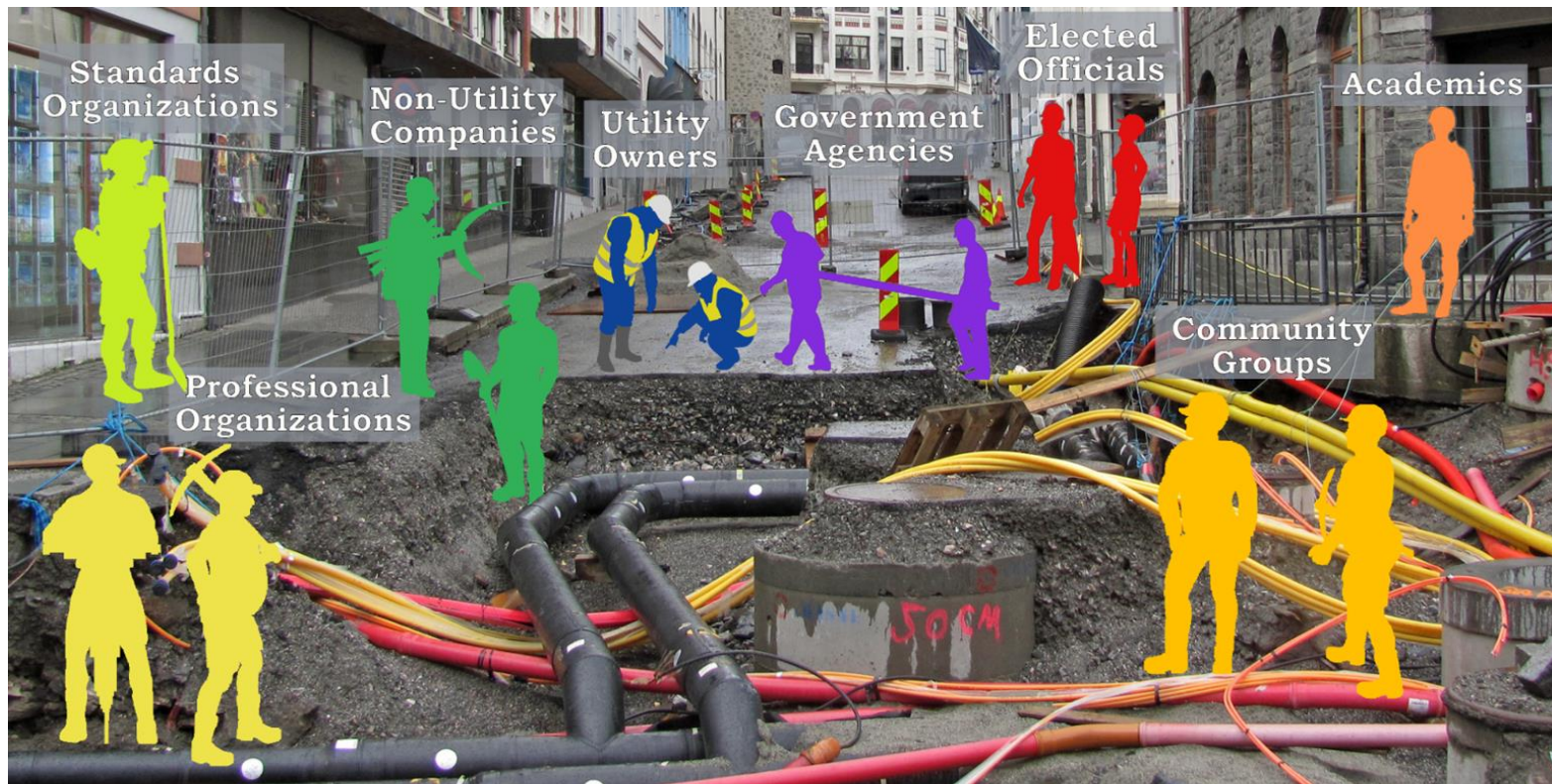
Human Intervention

- Excavation accidents
- Flooding (drainage problems)
- Underground fires

Functional Relationships

- Transportation/electric power
- Co-location of telecom/electric

Underground Infrastructure: Types of Stakeholders



Source: Peter Gmelch, UNUM project

The stakeholders reflect a variety of types of organizations and responsibilities.

Examples of threats to underground infrastructure involving interdependencies

- Energy (gas) to water: Gas from leaking pipes can travel through sewer lines potentially contributing to explosions
- Water to energy (gas): Water leaks in sandy soil undermine gas pipe support contributing to gas escape
- Transportation to energy (electric): Winter use of salt leading into manholes can contribute to electric fires
- Transportation to multiple infrastructures: Heavy truck traffic and transit vibration can undermine and weaken utility distribution
- Energy (steam) to telecommunications: Steam pipe heat can melt nearby telecommunications cables



Street systems and underground drainage problems. Photo by R. Zimmerman

Photo by R. Zimmerman 2022, Upper West Side, NYC

Source: UNUM, Unification for Underground resilience Measures” funded by the National Science Foundation (2133356).

Focus Group Methodology

- Focus groups are a common method for obtaining rapid information and promoting discussion (Krueger and Casey 2008). They often precede and provide input to more detailed methods such as surveys. Limitations are that the constituents are not randomly selected which can introduce bias.
- Typical characteristics of focus groups:
 - Size is usually about 10 or fewer people
 - Duration is about an hour or two
- The research emphasizes qualitative techniques:
 - Identification and recruitment of subjects: “snowball sampling” technique (qualitative) where an initial set of people are identified who then recommend others
 - Focus group script and implementation guides data acquisition

Sources:

Krueger, R.A. and Casey, M.A. 2008. Focus groups: A practical guide for applied research. 4th edition. New York, NY: Sage.

Restrepo, Zimmerman, Laefer, Leidner, Dorf, Gmelch, and Hertz (2025) “Stakeholder engagement to strengthen underground infrastructure resilience.” *Environ Syst Decis* 45, 10, 15 pp. <https://doi.org/10.1007/s10669-025-10003-8>, p. 3, 4..

Method Details

- Focus groups were conducted separately for two groups utilities and community totaling 15 participants altogether.
- Two 90-minute virtual focus groups were held in February 2022.
- Coverage was transmission and distribution systems not production.
- Stakeholders were invited via email to participate in a Zoom discussion, given timing during the COVID-19 epidemic.
- Participants were drawn from utilities, government agencies, professional organizations, elected officials, community groups and the private sector.
- Participants were initially stakeholders identified during the planning grant and additional stakeholders were identified during the full grant.
- Participation in the focus groups was voluntary, anonymous, and they were able to withdraw from the Zoom meeting at any time.
- NYU Institutional Review Board (IRB) procedures were followed, adhering to anonymity of participants, consent forms were used

Focus Group Script Topics

The focus groups script included four general areas (with flexibility to allow for additional topics suggested by participants)

- Knowledge of underground infrastructure: Data limitations in underground infrastructure and additional information stakeholders face in meeting their planning and response needs when these systems fail
- Vulnerabilities: Underground infrastructure vulnerabilities, including factors such as age of infrastructure, that concern the various stakeholders
- Engagement and collaboration for information adequacy: Existing mechanisms for collaborating around underground infrastructure resilience and their current limitations; information sources
- Bipartisan Infrastructure Law (Public Law#117-58 2021): Potential ways in which the Infrastructure Law and emerging long-term resilience policies for underground infrastructure

I. Results Indicated By Focus Group

Participants: Underground Infrastructure Knowledge

Participants were knowledgeable about the underground infrastructure through failure cases failures and their impacts, including cascading impacts, mentioning:

- Steam pipe explosion disrupting various activities for months in Midtown Manhattan
- Flooding impacts from sewer and drainage system malfunctions in severe storms
- Water main breaks in Manhattan dense developed areas
- Drainage issues flooding subway lines



Catch basins, leading to the underground, NYC

Photo by R. Zimmerman 2022



Watermain break, street collapse, gas pipeline cut, and fire occurred.

Source: NYCEP

Source: Restrepo, Leidner, Dorf, Gmelch, and Hertz (2025) "Stakeholder engagement to strengthen underground infrastructure resilience." 4Zimmerman, Laefer, 5, 10, 15 pp. <https://doi.org/10.1007/s10669-025-10003-8>, p. 5.

I. (continued) Results Indicated By Focus Group

Participants: Knowledge and Information

Knowledge and information participants identified included:

- Where underground infrastructure is located, i.e., an inventory
- Databases and maps including data overlays from utilities to direct stakeholders to where and how to undertake digging
- How cascades occur
- Age of infrastructure as a factor to estimate potential failure points
- Contact points for information in the event of a failure, e.g., other utilities, use of 811call line

Knowledge of impacts of underground infrastructure

- Stakeholders from utilities and asset owners identified being most commonly affected by water and communications
- Telecommunication failures could disrupt the internet
- During excavations, inaccurate knowledge of adjacent underground infrastructure, particularly transit-related, can create failures, which a central database could provide

II. Results Indicated By Focus Group

Participants: Addressing Vulnerabilities

Participants identified vulnerabilities analogous to knowledge and information issues:

- Knowledge of what is underground and where it is located is needed
- Mechanisms for how damage occurs
- Databases and maps provided by information and data overlays as a basis for excavation
- Age of infrastructure as a factor to estimate potential failures
- Proactive planning to anticipate failure points
- Distinguishing differences between long-term and short-term vulnerabilities since these may involve different mitigation measures

III. Results Indicated By Focus Group

Participants: Engagement and Collaboration and Information Sources

Information sources

- Ad hoc often reactive collaboration
- Information available when development occurs

Key issues and needs

- Identifying and maintaining contacts specific to a particular underground activity in light of staff turnover before and after an incident to support communication
- Keeping data current and accessible
- A key organization for management of information and access to it



Photo by R. Zimmerman 2022

**Identifying and
Communicating
Underground Infrastructure
Location: Street Markings**

Collaboration: Illustrative Types

	Collaboration Type*	Objective: Degree of Control	
Activity		Low or Moderate	High or Extreme
Active	Protest; activism, adversarial action	Occupy movement; demonstrations; sit-ins	Infrastructure removal, blockage: e.g. roads, dams
	Empowerment, capacity building	“Resilience Hub” development; sponsor resource commitments	Hub Ownership; ombudsmen
	Co-Production	Citizen science monitoring inputs to scientific databases	Stakeholder definition of knowledge components and analytical protocols
	Agreements, regulatory / non-regulatory	MOUs, contracts, compensation	Binding agreements; sanctions or punitive measures
	Community-based participatory research (CBPR)	Various applications, initially from health fields	Information ownership
	Communication including risk communication	One-way communication dissemination	Two-way and multiple path interactive communication
	Information provision; education; training; attention getting	Traditional public participation and hearing attendance; formal learning	Project stakeholders (proponents, opponents) provide information, select curricula content
Passive	Sponsor/manager information requests	Public opinion polls; input of opinions, facts	Inputs into survey data from focus groups

*Drawn from general stakeholder literature references in R. Zimmerman, “The Centrality of Collaboration in Social Services for Sustainability and Communities,” *Proceedings of the International Conference on Sustainable Development (ICSD)*, Posted November 10, 2022. https://ic-sd.org/wp-content/uploads/2022/11/submission_455.pdf, pages 2-4, Table 1.

IV. Results: Bipartisan Infrastructure Law (Infrastructure Investment and Jobs Act)

- P.L. 117-58 was signed into law November 15, 2021. It broadly covers many types of infrastructure and mechanisms for fund provision
- Participants generally had heard of the law
- Mechanisms to provide community resources to access the Law's benefits were considered a need
- Knowledge and communication of the applicability of sections of the law to particular needs was identified

Sources:

Restrepo, Zimmerman, Laefer, Leidner, Dorf, Gmelch, and Hertz (2025) "Stakeholder engagement to strengthen underground infrastructure resilience." *Environ Syst Decis* 45, 10, 15 pp. <https://doi.org/10.1007/s10669-025-10003-8>, p. 9, 10.

U.S. Congress (November 15, 2021) PUBLIC LAW 117-58—NOV. 15, 2021 135 STAT. 429 Short title: Infrastructure Investment and Jobs Act

<https://www.congress.gov/117/plaws/publ58/PLAW-117publ58.pdf>

Summary of Focus Group Results:

Key Themes for Underground Infrastructure Resilience Identified in Focus Groups

- Infrastructure failures cascading across systems can occur underground and affect utilities and communities in different ways and are caused by different factors.
- Infrastructure systems that stakeholders are most concerned about when failures or accidents occur were water and communication related with telecommunication being an important concern for cascading effects.
- Databases for underground infrastructure should be mapped and digitized for easy access.
- Better ongoing, proactive mechanisms are important for collaboration beyond just project and event specific and should be available for both non-emergency times (regular maintenance and operation) as well as emergencies and should including regular calls and meetings.
- Government agencies and utilities need to retain institutional knowledge in part due to staff changes.

Source: Restrepo, Zimmerman, Laefer, Leidner, Dorf, Gmelch, and Hertz (2025) "Stakeholder engagement to strengthen underground infrastructure resilience." *Environ Syst Decis* 45, 10, 15 pp. <https://doi.org/10.1007/s10669-025-10003-8>, p. 10, 11, 12, 13.

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- NSF Award Abstract:
https://www.nsf.gov/awardsearch/showAward?AWD_ID=2133356&HistoricalAwards=false
- NYU News release:
<https://engineering.nyu.edu/news/nyu-tandon-and-wagner-project-look-below-surface-make-nyc-more-resilient>
- Project web site:
<https://wp.nyu.edu/unum/>

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