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Assess Approaches to Training and Developing Hydrology and Hydraulics (H&H) Staff in Transportation Agencies

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16. Abstract There is presently significant understaffing and turnover of staff specializing in Hydrology and Hydraulics (H&H) within agencies overseeing transportation infrastructure. To gain an understanding of the present state of knowledge and training among H&H staff across the transportation industry, surveys were carried out to evaluate the effectiveness and perceptions of training, resources, mentoring, and approaches for knowledge transfer for H&H staff in DOTs across the United States (including TxDOT), as well as in other government agencies and private sector firms. Over one hundred survey responses underwent evaluation to determine current effective training practices and identify innovative approaches to improve H&H training, in order to provide recommendations on best practices moving forward.					
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Transportation Agency Approaches to Training and
Developing Hydrology and Hydraulics (H&H) Staff**

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Chapter 1. Introduction

Water on roadways can be deadly. For example, hydroplaning can occur with only a few millimeters of standing water on a roadway, which can cause a significant reduction in the tire grip on the roadway surface. This allows a vehicle to spin out of control (Hermange et al., 2022; Vilsan et al., 2025), causing injuries and fatalities, along with damage to vehicles, property, and highway infrastructure, and at times resulting in costly lawsuits (Mounce & Bartoskewitz, 1993). For example, a recent hydroplaning incident on I-35 just north of Waco, Texas, contributed to vehicle-pedestrian impact due to flawed highway design (Barrett, 2022). Similarly, drivers on flooded highways can face issues, such as engine or vehicle damage, being stranded or possibly drowning, or crashing into medians or highway structures, thus sustaining devastating health or property issues. Proper roadway design, bridge design (both for runoff from the bridge deck and management of scour and bridge pier stability), drainage, and other aspects of transportation infrastructure are significantly affected by the presence of standing and moving water. Thus, it is imperative for there to be coordination between structural and/or roadway engineers, and experts in Hydrology and Hydraulics.

1.1. Background

Hydrology and Hydraulics are two topics covered in typical undergraduate curricula for students pursuing Bachelor's degrees in Civil Engineering and Environmental Engineering programs. Broadly speaking, both of these topics are about water, given the *hydro* root within each, but they have distinct focuses and unique features. They both provide means to evaluate water dynamics in natural and manmade scenarios, combining science, mathematical, and engineering approaches to quantify and predict phenomena, such as flooding, humidity, and soil moisture content, for example.

According to the United States Geological Survey (USGS), “Hydrology is the science that encompasses the occurrence, distribution, movement and properties of the waters of the earth and their relationship with the environment within each phase of the hydrologic cycle” (USGS, 2019). In other words, Hydrology primarily deals with the water cycle, or the “endless circulation of water between the earth and its atmosphere” (Chow et al., 1988). The water cycle includes processes including precipitation, infiltration, groundwater flow, runoff, evaporation, and many others that describe the passage and storage of water in

various natural and anthropogenic environments (Brutsaert, 2023). The processes of the water cycle can be observed in our daily lives, yet quantification of hydrologic processes draws upon knowledge of heat transfer, geotechnical engineering, conservation of mass, momentum, and energy, along with a host of complementary engineering and geosciences topics.

By contrast, Hydraulics, or *Hydraulic Engineering*, applies principles of fluid mechanics to understand the collection, storage, control, and transport of water (Prasuhn, 1987). Hydraulic engineers often deal with topics such as pipe flow and open channel flow, which involves an understanding of flow control devices such as pumps, valves, weirs, sluice gates, and other devices (Sturm, 2010). Applications within Hydraulics can vary from water supply and distribution to stormwater management and drainage, and to sediment transport and scour (Akan & Houghtalen, 2003; Chien & Wan, 1999).

Because they are a subset of Civil Engineering, careers specializing in Hydraulic Engineering and Hydrology tend to be lumped into a single role within agencies, shortened to “H&H” for Hydrology and Hydraulics. Both Hydrology and Hydraulics appear in the Fundamentals of Engineering exam for Civil Engineers, and it is generally expected that any practicing civil or environmental engineer should have a fundamental mastery of these topics from undergraduate coursework.

Whereas many individuals pursuing careers in Transportation Engineering tend to specialize in topics, such as structural engineering, systems operations, traffic, controls, pavement and materials, geotechnical engineering, and others, H&H also plays a critical role in the design and maintenance of transportation infrastructure. Rainfall can pose significant risk in both the safety and longevity of transportation systems, due to threats to the infrastructure itself (i.e. roadway surface, geotechnical foundations, structural stability), as well as the safety of drivers navigating wet or flooded roadways. It has been reported that Texas incurs more than twice the number of flash flood-related fatalities than any other state in the United States, in large part linked to Texas having such significant roadway coverage across the state (Frech, 1999).

For roadway bridges crossing water either for rivers or depressions that experience sporadic flash flooding, scour is an important topic for maintaining the integrity and stability of the piers and bridge structure. Scour is the process in which sediment (e.g. sand, gravel) is removed or eroded surrounding or in the wake of submerged objects, such as bridge piers (Melville & Coleman, 2000). Interactions between fluid flow (i.e. due to river currents or flooding) with the structure and with sediment particles can cause mobilization of sediment,

ultimately producing a scour hole (Briaud et al., 2009). Should the scour holes become deep enough, continued exposure of the bridge pier can threaten its integrity, ultimately compromising the stability of the bridge (Briaud et al., 2012). Flash flooding is rather common in Texas, particularly in Central Texas, which is often called “Flash Flood Alley” (Segal, 2024). Here, it is critical to understand the existing substrate in rivers or crossings prone to flooding, as well as the climate and likelihood of severe precipitation or flooding, in order to properly design the bridge piers or install mitigation efforts to reduce scour induced by strong fluid flows.

Alternatively, rainfall and/or flooding on roadways can create major interruptions to transport, thus necessitating understanding of stormwater management. Managing water from rainfall and runoff can take many forms, including culvert design (Brunner, 2020), removal of water from roadways via curb inlets (Hodges et al., 2018a, 2018b) or land use mechanisms (Barrett et al., 1998). Strategies for mitigation can include implementation of permeable pavement or innovative roadway materials that provide drainage across the roadway surface (Charbeneau et al., 2011; Klenzendorf et al., 2012; Drake et al., 2013; Imran et al., 2013), and design of bridge rails or median barriers that accommodate water passage (Klenzendorf et al., 2010; Bin-Shafique et al., 2011; Bligh et al., 2024), among others.

Texas highways have suffered significant flooding due to highway median barriers. Median barriers can act as dams, causing sustained flooding and backwater effects (Dobrovolsky et al., 2021), thus requiring interventions to remove barriers to release waters. Alternatively, barriers can become mobilized, due to buoyancy effects, necessitating subsequent cleanup for vehicular traffic to resume (Bligh et al., 2024). Recent design and implementation of median barriers suitable for flood-prone areas has been undertaken in Texas, based largely on prior efforts focused on evaluating the hydraulic performance of bridge rails and other barriers intended both to sustain vehicular crashes and support roadway drainage (Charbeneau et al., 2009; Williams & Menges, 2010, 2012).

While it is expected that all Civil and Environmental Engineering Bachelor’s degree holders should have a fundamental mastery of H&H topics, additional training is generally necessary for H&H staff to learn how to apply this background knowledge to job- or site-specific needs. Further, it is possible that many practicing engineers have not taken H&H courses, due to pursuing other degrees or department-specific limitations. Hence, there is a need for agencies to provide or facilitate trainings for newly hired employees, as well as for continuing education to support longer term staff or individuals who are changing their focus

within transportation infrastructure agencies, to keep up with modern technology and design principles.

The National Highway Institute (NHI) has developed training courses in Hydrology and Hydraulics, as part of the U.S. Department of Transportation's Federal Highway Administration. A search of the NHI directory for "*Hydraulics*" yields 33 courses, spanning topics such as reviews of basic principles, culvert design, sea level rise for coastal highways, stream stability, bridge scour, and many others. The price per course, per participant, ranges from \$0 to over \$1,000, for a mix of web-based and instructor-led experiences.

In addition, the American Society of Civil Engineers offers specific courses in particular topic areas relevant to H&H roles. For example, a series of presentations from the 2024 World Environmental & Water Resources Congress was assembled into three hours of courses specific to *Hydraulics Modeling for Transportation Infrastructure*, which can be counted toward Continuing Education Units or Professional Development Hours.

Given highly different climates, topographical features, watershed features, and geological structures, coupled with other natural and anthropogenic conditions in various locations, the resources available at the national level may or may not be relevant to support H&H roles in all transportation agencies. Some state-level transportation agencies support enrollment in NHI's courses, for example Massachusetts (see UMass Amherst's referral to the NHI Hydraulic Toolbox, linked in References). However, not all federally offered resources are relevant for all states, nor are all needs of the US necessarily covered by these offerings.

The Texas Department of Transportation (TxDOT) H&H Section supports enrollment in NHI courses, while also offering their own H&H training to their staff as well as to non-TxDOT consultants, contractors, and government employees. They offer a range of courses beginning with Basic Hydrology & Hydraulics. Staff can follow different training "flow paths" such as for software modeling or drainage design, allowing them to specialize further. Available training topics include culvert design, river modeling, bridge scour analysis, and urban drainage, among others. The trainings at TxDOT are offered in a range of formats, some in person and some web-based (both live and on-demand). Beyond more traditional forms of training, TxDOT H&H also engages in a training method known as Applied Design Training (ADT). ADT is a collaborative method that focuses on a specific type of design (for example: off-system bridge replacement). The process involves formal training on the design process combined with hands-on workshops, peer mentoring, trouble-shooting workshops, and collaborative quality control reviews. It is meant to target knowledge gaps

and be an immersive process that teaches H&H staff a specific design skill over a set amount of time.

The development of training programs is an ongoing process requiring direct feedback from staff on the existing strengths, gaps, and challenges of the available programs. This project seeks to better inform training program development by collecting data on the current state of staff training for H&H programs across different transportation agencies in the U.S.

1.2. Problem Statement

This research uses survey data collected from public and private transportation agencies to answer the following questions:

1. What is the current state of H&H training and knowledge within the Texas Department of Transportation (TxDOT), other state Departments of Transportation (DOTs), and private firms?
2. What is the present state of H&H training and innovation nationwide?
3. What guidance can be provided to identify inconsistencies and gaps in training, and what recommendations can be made for TxDOT to target improved training resources?

The survey was developed in accordance with the technical objectives in the TxDOT Research Project Statement 26-020-01. Those objectives are listed below:

1. Determine what training resources are being utilized.
2. Determine which H&H training topics transportation agencies prioritize.
3. Determine how specific needs of the DOT are assessed to support the development of training curricula.
4. Determine how training is being delivered.
5. Determine which technological innovations have been leveraged to improve training outcomes.
6. Determine which topics are being taught.

7. Determine whether states create their own training content or rely primarily on national resources.
8. Determine whether transportation agencies are grappling with any specific gaps in H&H training resources.
9. Determine how training is evaluated and implemented to improve efficacy, including the frequency of revisions.
10. Determine what approaches are utilized to transfer knowledge from seasoned staff to newer staff.

1.3. Literature Review

As part of survey development, the UT Austin survey team conducted a preliminary review of the existing literature surrounding staff training and an evaluation of common practices and innovations. The literature review served as background for understanding current training practices, existing gaps or prevalent issues, and potential training evaluation strategies.

The most salient points found through the literature review are described in the following paragraphs:

Types of trainings and evaluation criteria. In their review paper, Martin et al. (2013) provide a thorough background of available job training methods, analyzing them according to several criteria such as modality, interaction level, and trainer presence. The review focused on the following types of training, referred to as “core methods”: case study, games-based training, internship, job rotation, job shadowing, lecture, mentoring and apprenticeship, programmed instruction, role-modeling, role play, simulation, stimulus-based training, and team-training. These core methods served as a base for the UT Austin survey team in developing questions around different training practices and their efficacy.

Staff perceptions. In a study of floodplain administrators in the Flood Emergency Management Agency (FEMA) Region 6, a survey was deployed to examine training deficiencies among staff. The survey explored the perceived strengths and challenges of floodplain administrators in their ability to perform their roles considering location, experience, and previous training (Seibendeck et al., 2022). The survey identified individual experiences, and the results offered insights into training needs and potential strategies that could benefit floodplain administrators in their roles. To address training gaps and enhance training opportunities,

Seibendeck et al. (2022) recommended that surveys target members' perception of current training and development. Questionnaires should collect qualitative and quantitative data to identify perceived training gaps and outline future needs. Survey questions should target the perceptions from entry-level staff to senior management to identify training priorities and develop the structure for Continuing Professional Development (CPD). Assessing perceived technical skills, soft skills, and skill gaps enables comprehensive curriculum development to advance organizational objectives (Olawande, 2001). In developing the H&H survey, the UT Austin survey team used this study as a starting point for developing questions in which the survey taker could share their own perceptions of their abilities and the effectiveness of current training practices at their organization.

Curriculum evaluation. Curriculum evaluation and program assessment are critical to ensure training is aligned with organizational priorities and student needs. Trainees arrive to organizations with a wide range of educational backgrounds and experiences. The goal of training programs is to fill in knowledge gaps. To know if the training programs are succeeding, curriculum evaluation is employed (Martin et al., 2013). A study by Stafford et al. (2019) presents an advanced and innovative approach to curriculum evaluation. The study evaluates the Air Force Foundational Competencies Model, which proposes training should involve four steps: developing self, developing others, developing ideas, and developing organizations. This allows trainees to develop mastery in their role and prepares them to train others. Ongoing and iterative feedback on the assessment and evaluation of curriculum planning, development, implementation, and effects enables organizations to implement recommendations and improve training outcomes (Stafford et al., 2019). In order to know whether innovative strategies such as those presented in Stafford et al. (2019) are applicable to H&H training programs in the transportation industry, the current state of curriculum evaluation throughout the industry needs to be identified. Understanding curriculum evaluation strategies is outlined in the Research Project Statement technical objectives and was incorporated into the H&H survey.

The main ideas identified in this literature review were used to support the survey development process described in the following section.

Chapter 2. Survey Development and Distribution

2.1. Survey Development

A survey was created and refined to address the three research questions and ten technical objectives in the Research Project Statement. This section outlines the survey development process.

During the initial survey development stage in September 2025, a kickoff meeting was held with the TxDOT H&H team to clarify and fine-tune what information the survey should collect. TxDOT's current H&H training program and the specifics around how trainings are administered were shared.

Initially, the survey was split into six sections:

1. *Where do you work and what is your role?* This section collects information on the organization that the survey taker works for, their position within that organization, and their years of experience working in H&H. It provides context for the survey data and will help to track trends that might arise among different types of organizations (federal, state-level, academic, private, etc.).
2. *Experience with H&H Trainings.* This section collects information on what trainings the survey taker has completed and for which topic areas (i.e., hydrology, culverts, bridges, etc.). It also asks the survey taker about how knowledge is transferred at their organization, whether it be formal mentoring, shadowing programs, etc. The goal of this section is to understand what kinds of trainings staff are engaging with, which entities provide those trainings, and what are the most common avenues through which knowledge is transferred among staff at different organizations.
3. *Evaluating H&H Training Priorities and Efficacy.* This section centers around the survey taker's perceptions of the trainings that they have engaged with and their opinions of the training program at their organization specifically. The survey asks the respondent to rank H&H topic areas based on how important they are to their organization and then to indicate how confident they feel in each topic area. The survey taker is also asked to indicate whether receiving training in a specific topic area has impacted their ability to do their job effectively. Furthermore, the

survey taker is asked to rank organizations that offer H&H trainings and to identify challenges and gaps of the training program at their organization. This section also asks about the survey taker's perception of informal job training. The goal of this section is to better understand how staff feel about and interact with H&H trainings. The data collected here can be used to identify the most salient deficiencies of H&H training programs.

4. *Technology and Innovation.* This section focuses on training modality, i.e., *how* trainings are administered. It asks the survey taker to provide a breakdown of the different ways trainings are administered at their organization, such as virtual, web-based or on-demand, in-person, informal, or other. The survey taker is then asked to rank these methods in order of personal preference. This section of the survey also explores technological innovations and their potential to increase training efficacy. Finally, this section includes space for the survey taker to provide any additional thoughts they might have which have not yet been captured by the other survey questions.
5. *Contact Information.* This section collects the survey taker's contact information and asks them whether the survey team may follow up with them if necessary.
6. *Demographics.* This section includes questions to collect demographic information about the survey taker. Information from this section will only be reported in aggregate to protect the anonymity of all survey takers.

After the initial survey was created, it was shared with the TxDOT team for review. An in-person meeting was held with TxDOT in December 2025 to discuss the survey and any potential modifications. The survey was modified based on feedback from the meeting. The main changes are listed below:

1. *Where do you work and what is your role?* A new question was added to this section, asking the survey taker whether they have ever held a supervisor role on H&H projects.
2. *Experience with H&H Trainings.* No notable changes were made to this section at this time.
3. *Evaluating H&H Training Priorities and Efficacy.* Two new questions were added to this section. The first question was for non-supervisors only and asked the survey taker to identify the greatest challenges they have

faced in their own training. The second question asked all survey takers to identify the greatest strength of the training program at their organization.

- 3.B. New section added - *Supervisor Perspectives*. A new section was added to capture the perspectives of staff who have worked in supervisory roles in H&H in the transportation industry. The section includes two questions and will only be presented to survey takers who answer "yes" to the supervisor question in Section 1. The first question asks the survey taker to identify which topic areas people on their team(s) have struggled with the most. The goal of this question is to identify respondent-reported knowledge gaps in H&H training. The second question asks the survey taker to identify what challenges they have faced with regard to the training and transfer of knowledge for H&H staff.
4. *Technology and Innovation*. No notable changes were made to this section at this time.
5. *Contact Information*. Minor wording adjustments were made to this section for clarity.
6. *Demographics*. A new question was added to this section, asking the survey taker to specify their degree title (if applicable).

In January 2026, additional feedback from the TxDOT H&H team was shared on the initial survey. The survey was again modified, and the main changes are listed below:

1. *Where do you work and what is your role?* A new question was added asking the survey taker to identify whether they were currently a TxDOT employee. This question was added for easier analysis of responses and for some display logic that was needed later in the survey regarding Applied Design Training. Some minor wording was also changed in this section for better clarity.
2. *Experience with H&H Trainings*. To ensure all objectives of the study were addressed, a new question was added to this section regarding Applied Design Training (ADT), asking the survey taker whether their organization employs ADT or some similar program. This question will only be displayed if the survey taker indicated they do not work for TxDOT. If the survey taker indicated that the survey team may follow up with them, more information about ADT may be collected during an interview, if needed. Some additional topic areas were added to the

questions in this section, including “basic hydraulics”, “hydraulics modeling”, “basic hydrology”, “hydrologic modeling”, “detention”, and “drainage”; “bridges” was changed to “bridge hydraulics”.

3. *Evaluating H&H Training Priorities and Efficacy*. Two questions from this section were relocated to a later section. This was done for better survey flow and clarity.
- 3.B. *Supervisor Perspectives*. No notable changes were made to this section at this time.
4. *Technology and Innovation*. For additional clarity, definitions and examples were added to the technological innovations question in this section.
5. New section added – *Final Thoughts*. A new section was added to collect the final thoughts of the survey taker. This section includes some relocated questions from other sections as well as one additional question which asks the survey taker to identify how frequently trainings at their organization are evaluated to assess their effectiveness.
6. *Contact Information*. No notable changes were made to this section at this time.
7. *Demographics*. No notable changes were made to this section at this time.

Once the survey was deemed complete and ready for distribution, the final version was shared with TxDOT H&H staff.

A complete copy of the finalized survey is presented in Appendix A.

2.2. Survey Distribution

The target population for this survey was H&H professionals working in transportation at public and private organizations throughout the U.S. This could include state departments of transportation (DOTs), public agencies at varying levels of government, academic institutions, private engineering firms, non-profit organizations, and more. The goal was to receive a wide range of survey responses that represented varied perspectives across different organizations.

Survey distribution was handled jointly between the UT Austin researchers and TxDOT. The survey was distributed to the following groups on the following dates via email:

1. TxDOT mailing list for state DOTs—March 6th, 2026
2. TxDOT internal mailing list for H&H staff—March 6th, 2026
3. Environmental & Water Resources Institute (EWRI) Austin Chapter mailing list—April 22nd, 2026
4. EWRI Urban Water Resources Research Council mailing list—April 29th, 2026
5. List of attendees who recently completed TxDOT H&H trainings—May 7th, 2026
6. American Society of Civil Engineers (ASCE) Texas Section members newsletter—June 9th, 2026
7. TxDOT internal mailing list for H&H staff and mailing list for state DOTs (reminder; survey reopened)—June 30th, 2026

Chapter 3. Data Processing

The survey was created in Qualtrics and distributed through a Qualtrics survey link. All data were collected and stored online on the Qualtrics website. To analyze the responses, the data were exported as an Excel file from Qualtrics, manually pre-processed and anonymized, and uploaded into a Jupyter notebook for analysis using Python. The following libraries were used to analyze and visualize the data:

- adjustText (1.4.0)
- GeoPandas (0.14.4)
- Matplotlib (3.9.2)
- NumPy (1.26.4)
- pandas (2.2.2)
- plot_likert (0.5.0)
- Plotly (5.24.1)
- SciPy (1.13.1)
- seaborn (0.13.2)

3.1. Blank and Duplicate Responses

As part of data pre-processing, blank and duplicate responses were identified and deleted. The process for identifying blank and duplicate responses was conducted in Excel.

For blank responses:

- =COUNTA() was used to count the number of cells containing responses for each row (excluding introductory and demographics questions).
- Any row with less than 25 cells containing responses was excluded from the final set of responses for data analysis. 25 was selected as the cutoff from a practical (rather than statistical) perspective. The goal was to eliminate responses that were blank or almost completely blank while not eliminating responses where survey takers had provided useful information that could be reasonably included in the analysis.

For duplicate responses:

- =COUNTIF(Name Column, Name)>1 was used to identify cells where more than one response included the exact same name for the survey

taker. For duplicates, the row with the lower number of responses (according to =COUNTA()) was deleted. Any long-form write-in responses were migrated to the survey response that was kept.

- To identify duplicate responses when the survey taker did not indicate a name, a list of standardized organization names was utilized. Using filtering in Excel, each organization name was manually checked, and if multiple responses were submitted for the same organization, the “title and dept.” and “years_exp” columns were examined to determine whether these were truly different survey takers or potential duplicates. Once potential duplicates were identified, the same =COUNTA() method was used to identify and delete the “less complete” response. Any long-form write-in responses were migrated to the survey response that was kept.

3.2. Free-Response Questions

The survey included some essay-type questions (free-response). The answers to the free-response questions were analyzed via thematic analysis, using the methods described by Coates et al. (2021) and Naeem et al. (2023) as a guide. This process is commonly referred to as qualitative coding. The specific procedure used for this report is summarized below:

1. All responses were downloaded into a spreadsheet, separated by question. The following steps were carried out separately for each question.
2. Two rounds of inductive coding were conducted. During each round, each response was read individually and tagged with key words or phrases corresponding to the quote. During the second round of inductive coding, the focus was on using shorter phrases (one to two words) and maintaining consistency of interpretation across quotes.
3. Once the inductive coding was complete, all key words were refined into a definitive set of final words/phrases, referred to as “codes.”
4. During the third round of coding, each response was read again and tagged with one to four codes from the final list, as applicable.
5. Once all responses were tagged with their corresponding codes, similar codes were grouped into categories. Categories were then used to develop the themes discussed in this report.

3.3. Interviews

While the research team had the ability to conduct follow-up interviews for further information if needed, no interviews were carried out. The survey responses provided extremely valuable feedback regarding H&H training (as presented in the analysis below), and interviews were not deemed necessary at this time.

Chapter 4. Survey Population

After pre-processing, a total of 136 survey responses were used for the analysis in this report. The survey population included staff at TxDOT, other state DOTs, city and county departments in Texas, and private sector organizations. The breakdown of respondents by organization type can be seen in **Fig. 1**.

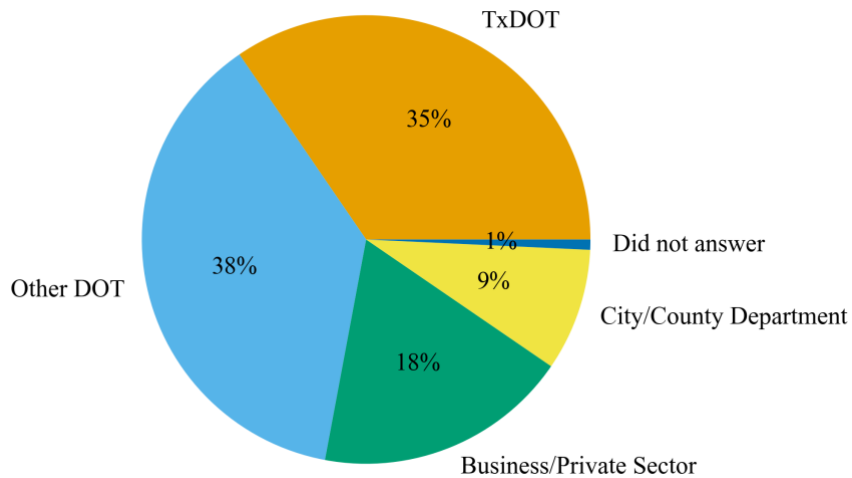


Fig. 1. Survey respondents split by organization type.

Among the 47 respondents who work at TxDOT, 29 of them specified the district they work in. The map in **Fig. 2** illustrates the districts that are known to have participated in the survey.

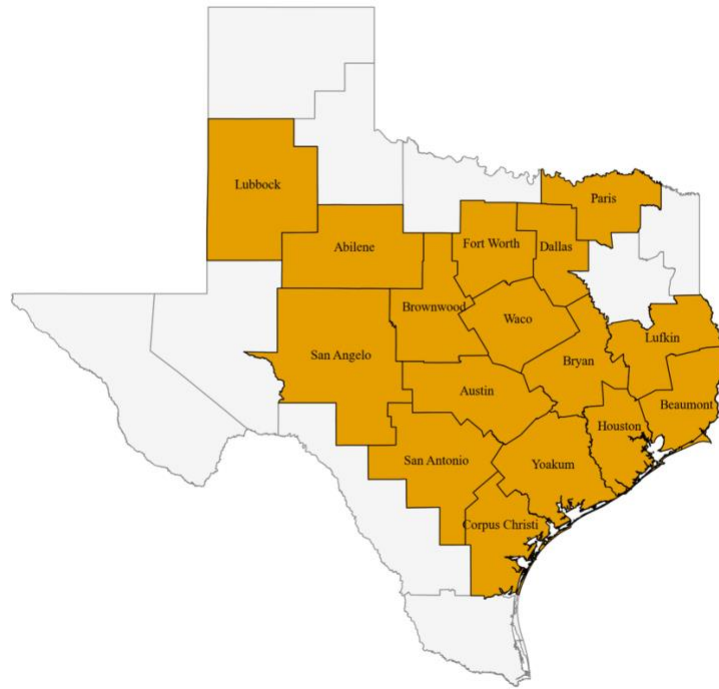


Fig. 2. Map of TxDOT districts. Districts colored in orange are confirmed to be represented in the survey.

In addition to TxDOT, 27 other state DOTs participated in the survey. The map in **Fig. 3** illustrates which other DOTs are represented in the survey data. Participation ranged from one to eight responses per DOT that is represented.

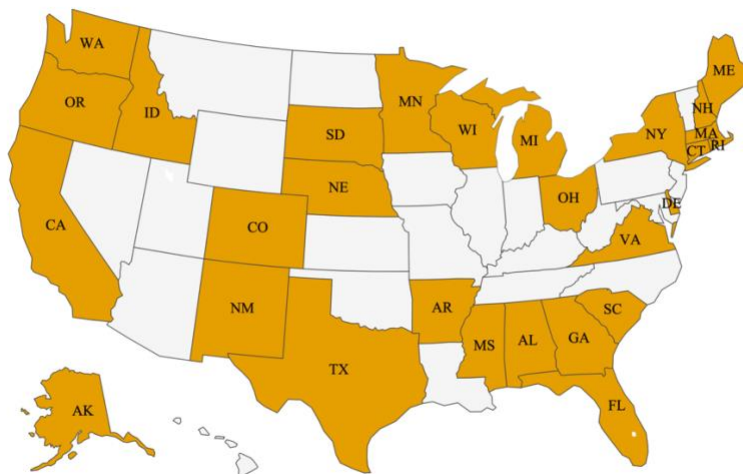


Fig. 3. Map of U.S. states. States colored orange are confirmed to have participated in the survey.

The full survey population breakdown is included in **Table 1** and **Table 2**. The demographics show that the survey data includes respondents of diverse ages, experience levels, and organization types. About 80% of respondents indicated they have either a bachelor's or master's degree, most in either civil or environmental engineering. The gender breakdown of respondents is comparable to national trends in civil engineering (U.S. Bureau of Labor Statistics, 2025). The racial breakdown shows some deviation from national trends while still including respondents from a range of racial backgrounds (U.S. Bureau of Labor Statistics, 2025).

Please note that throughout the report the number of respondents per question may vary depending on how many survey takers answered each question.

Table 1. Survey demographics.

Highest Degree	n (%)
Less than high school degree	0
High school diploma or GED	0
Some college, but no degree	1 (0.7)
Associate degree (2-year)	1 (0.7)
Bachelor's degree (4-year)	68 (50.0)
Master's degree	42 (30.9)
Doctoral degree	8 (5.9)
Professional degree (JD, MD)	1 (0.7)
Did not answer	15 (11.0)
Gender	n (%)
Man	81 (59.6)
Woman	31 (22.8)
Other	0
Prefer not to say	6 (4.4)
Did not answer	18 (13.2)
Age	n (%)
18-24	0
25-34	29 (21.3)
35-44	34 (25.0)
45-54	26 (19.1)
55-64	24 (17.6)
65 or older	7 (5.1)
Did not answer	16 (11.8)

Table 2. Survey demographics (continued).

Race and Ethnicity	n (%)
American Indian / Native American or Alaska Native	1 (0.7)
Arabic or Middle Eastern	2 (1.5)
Black, African American or African	1 (0.7)
Chinese, Japanese, Korean, Vietnamese, or from India	11 (8.1)
Mexican or Mexican-American, Central American, South American, Other Latino/a or Hispanic	19 (14.0)
Pacific Islander	0 (0.0)
White, Caucasian, or European (including people from Spain)	78 (57.4)
A race/ethnicity not listed here	1 (0.7)
Prefer not to answer	8 (5.9)
Did not answer	20 (14.7)
Organization Type	n (%)
TxDOT	47 (34.6)
Other DOT	51 (37.5)
Business/Private Sector	25 (18.4)
City/County Department	12 (8.8)
Did not answer	1 (0.7)
Has Respondent Worked as a Supervisor	n (%)
Yes	104 (76.5)
No	31 (22.8)
Did not answer	1 (0.7)
Years of Experience in H&H in Transportation	n (%)
0 to 3 years	10 (7.4)
3 to 6 years	18 (13.2)
6 to 10 years	22 (16.2)
10 to 15 years	21 (15.4)
15 to 20 years	17 (12.5)
Over 20 years	47 (34.6)
Did not answer	1 (0.7)
Total Respondents	n (%)
Total	136 (100.0)

Chapter 5. Data Analysis

5.1. Conceptual Framework

Using the problem statement and technical objectives as a guide, the framework in **Fig. 4** was developed for analyzing the survey data:

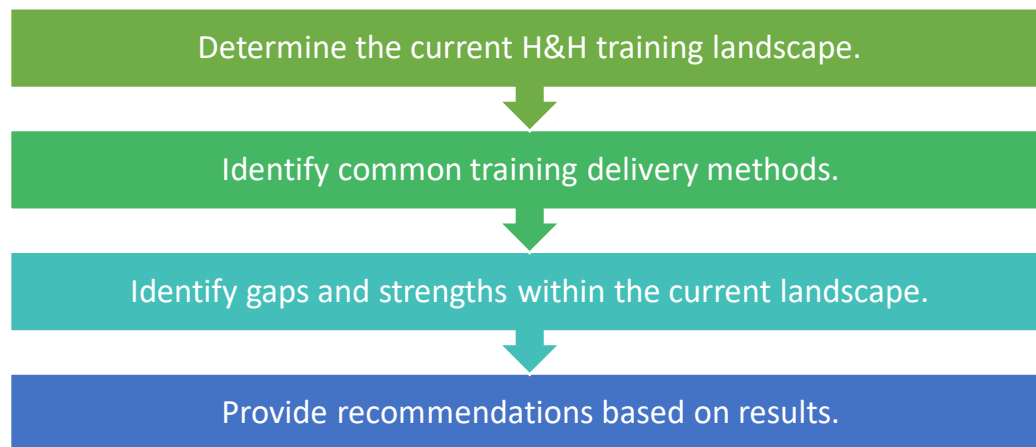


Fig. 4. Conceptual framework for data analysis.

5.2. Current H&H Training Landscape

Available resources. To better understand the current training landscape for H&H staff, the survey asked respondents to identify which organizations they have received formal job training from. Respondents were asked to select all that apply from a list of the following training organizations:

- Federal Highway Administration
- National Highway Institute
- American Society for Civil Engineers
- Army Corp of Engineers
- Their state DOT
- Academic institution
- Private sector organization
- Other

Fig. 5 shows the results, split by respondent organization type. Each bar represents a different group of respondents, and the colors in the bars represent the different organizations that provide trainings. The color spread of each individual bar illustrates how respondents from different organizations have relied on different sources for their H&H trainings. For example, respondents at TxDOT indicated they have mostly encountered state-provided trainings, while respondents at other DOTs indicated they have encountered more national trainings than internal state trainings. Respondents from the private sector and local government agencies indicated a more even spread across training organizations.

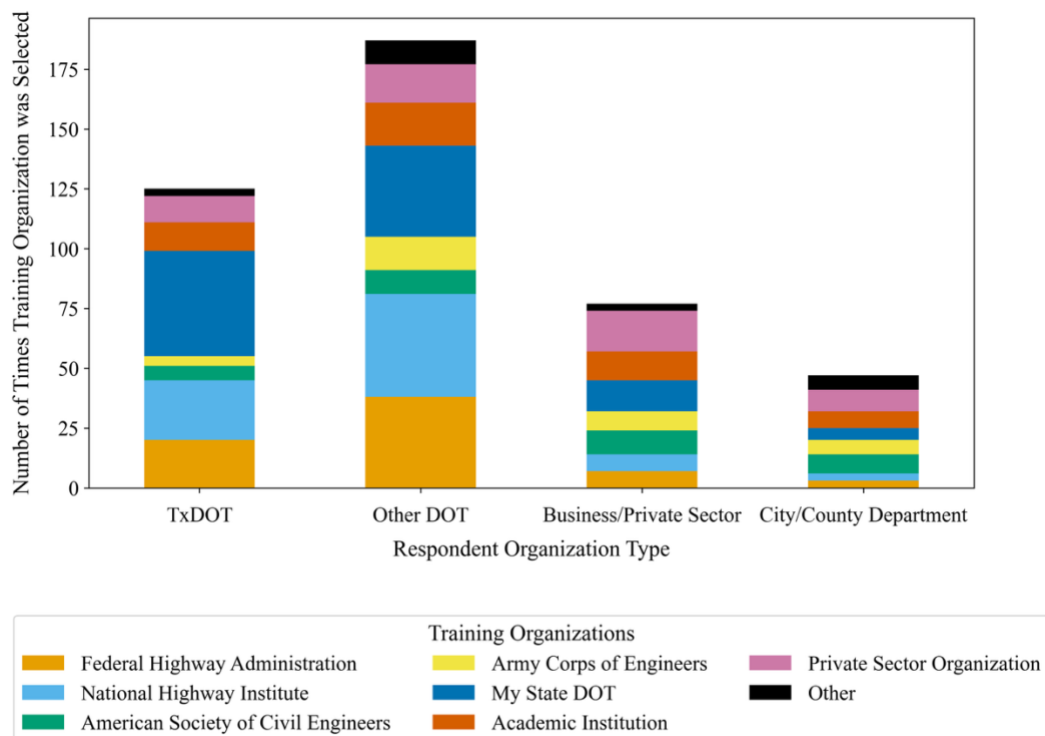


Fig. 5. Organizations providing training, split by respondent organization type.

It should be noted that respondents were asked to answer the question with regards to trainings they have received at any point in their career, so there may not be a direct one-to-one correlation between the respondent selection and training prevalence at certain organization types.

To understand which topic areas are covered by current trainings, the survey provided a list of topic areas and asked respondents to indicate in which areas they had received formal H&H training and who had provided that specific training. Respondents were asked to select all training organizations that apply for each topic area.

It should be noted that respondents may have had a hard time distinguishing between state and national trainings (which are sometimes hosted by the state). The survey asked respondents to answer to the best of their ability. In the case of respondents who worked for TxDOT, a link to a list of known trainings was provided. To prevent the survey taker from guessing, there was an option to select “I received training in this topic, but I am not sure from who.”

Fig. 6 shows the training organizations respondents indicated they were receiving trainings from. Note these results are similar to those in **Fig. 5**, but they may not match up exactly because they are from a separate survey question. Results are displayed as a percentage of the total selections. For example, the results indicate that of all the trainings respondents reported (across all topics and all training organizations), 25% of those reported trainings were provided by a state DOT.

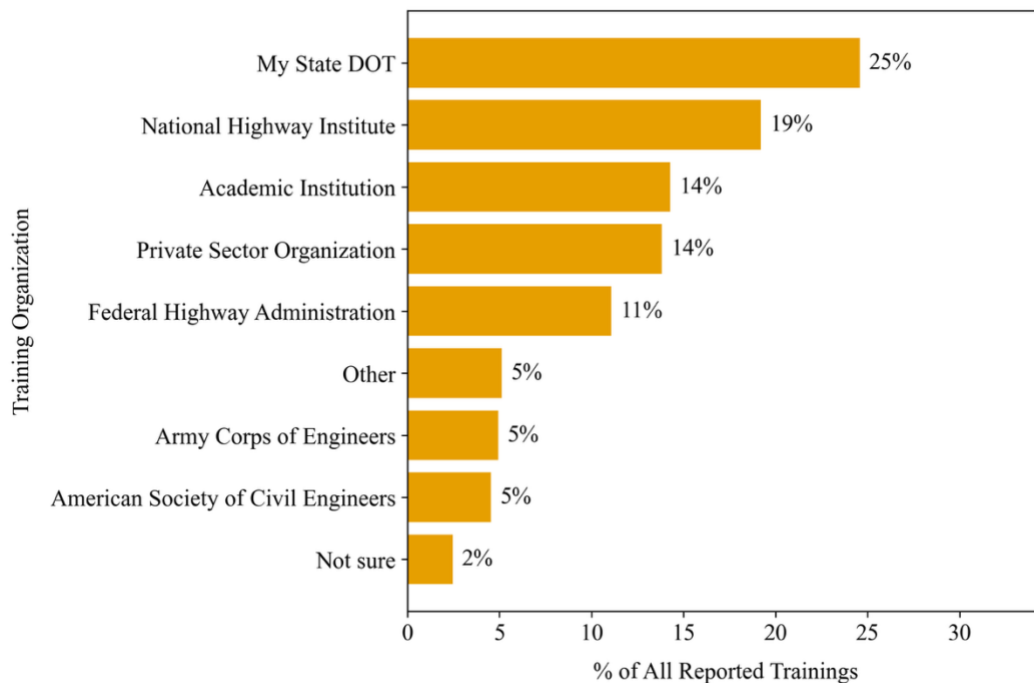


Fig. 6. Training organization coverage as a percent of all reported trainings.

Fig. 7 illustrates which topics respondents reported having received formal training in, regardless of the training organization. The topic areas are in descending order, with Basic Hydraulics being the topic area that the most respondents indicated having received formal training in. **Fig. 8** breaks down the results from **Fig. 7** by respondent organization type. Note that the percentages for **Fig. 7** and **Fig. 8** are calculated as a percentage of the total survey respondents.

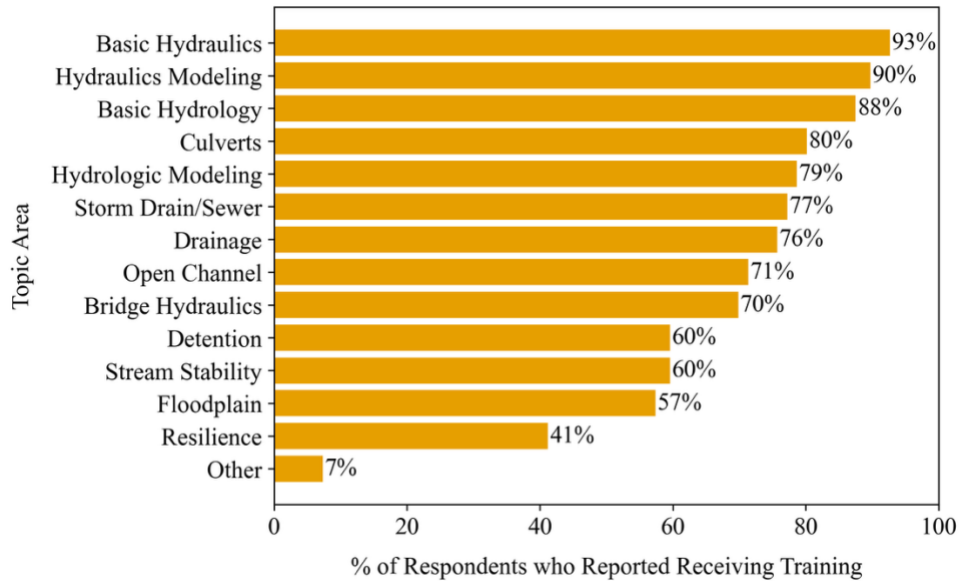


Fig. 7. Topic areas that respondents have received training in.

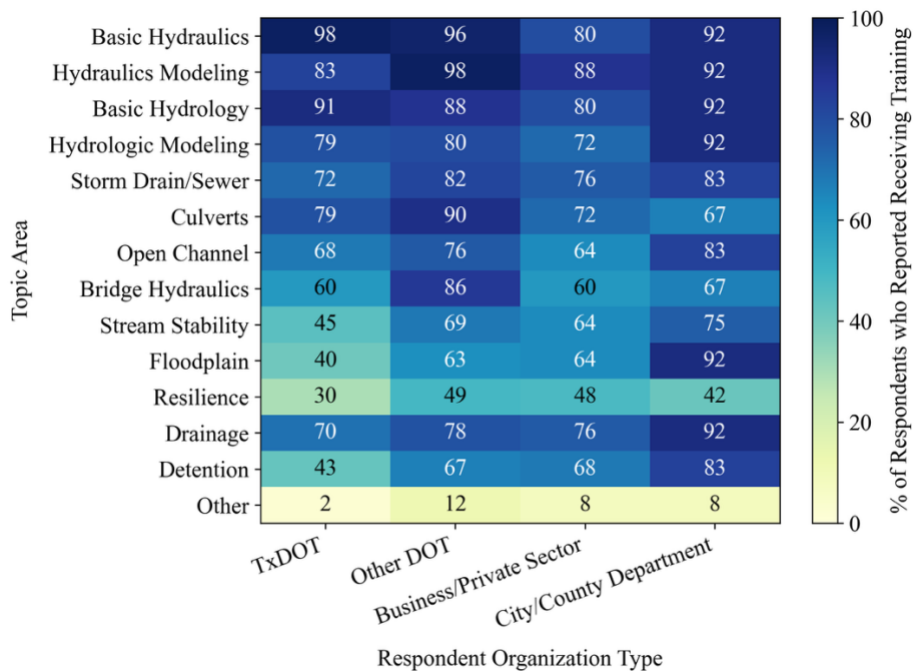


Fig. 8. Topic areas that respondents have received training in, split by respondent organization type.

Fig. 9 breaks down the same results, but as training organization-topic area pairs, indicating which topics survey takers have received training in and from which organization. The number in each square reflects how many times that training organization-topic area pair was selected.

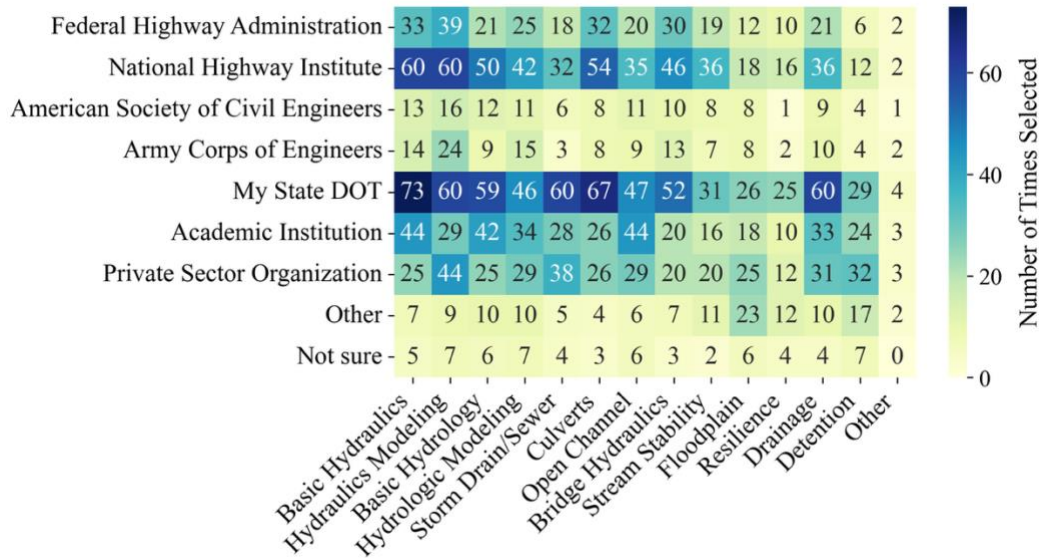


Fig. 9. Training organizations vs. training topic areas.

Resource effectiveness. To understand where potential strengths or gaps in the training landscape may lie, the survey asked respondents to rank the organizations they have taken trainings from. As can be seen in **Fig. 10**, results show that respondents from TxDOT favor their own state DOT trainings, respondents from other state DOTs favor National Highway Institute trainings, respondents from the private sector favor their own private sector trainings, and respondents from local government agencies favor private sector trainings and “other” trainings. These rankings could be influenced by the higher volume of certain trainings, such as state and national trainings. However, as seen in **Fig. 11**, the same trends generally persist when normalizing the ranking results using the following equation:

$$\left(\frac{\# \text{ of times training org. was ranked 1st by respondents from this org. type}}{\# \text{ of times training org. was ranked at all by respondents from this org. type}} \right) \times 100$$

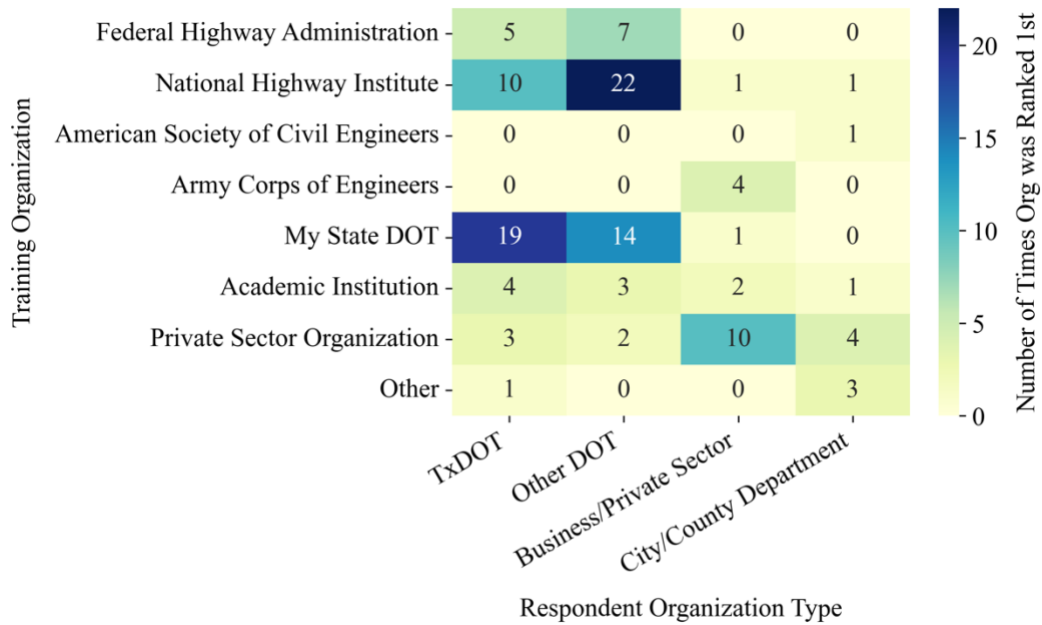


Fig. 10. Training organization rankings, split by respondent organization type.

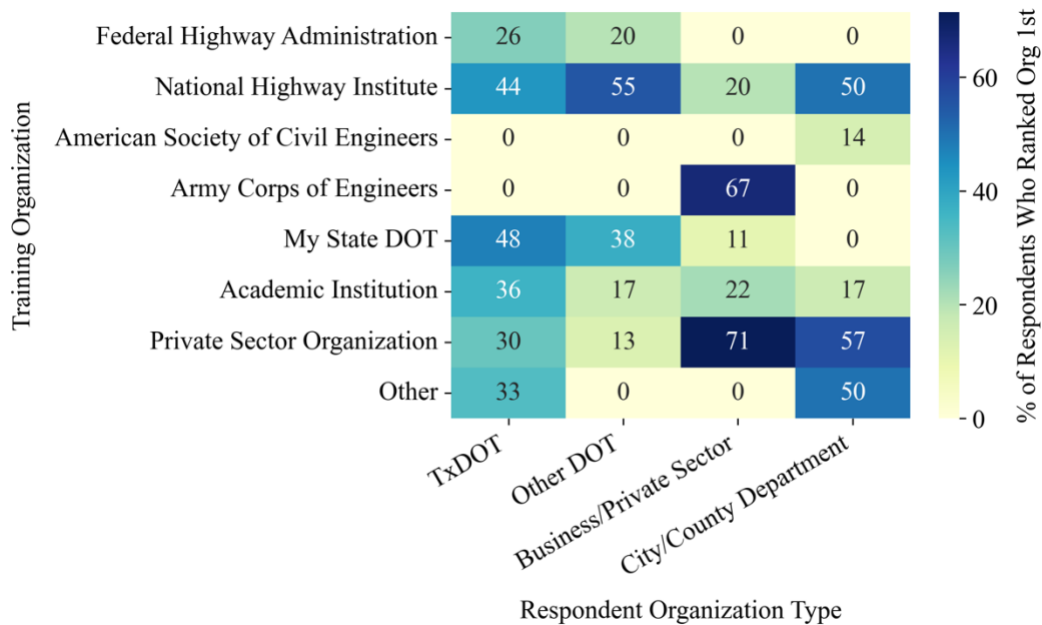


Fig. 11. Training organization rankings as a % of total respondents from a specific organization type who ranked that option.

The survey also aimed to assess the efficacy of trainings in specific topic areas. Respondents were asked to indicate how impactful they have found the trainings they have taken to be. Respondents could select from the following list of options for each topic area:

- No impact: The trainings I received in this topic area had *no effect* on my ability to do my job effectively.
- Minimal impact: The trainings I received in this topic area have *slightly improved* my ability to do my job effectively.
- Moderate impact: The trainings I received in this topic area have *moderately improved* my ability to do my job effectively.
- Considerable impact: The trainings I received in this topic area have *greatly improved* my ability to do my job effectively.

Note that respondents were only shown topic areas for which they had previously indicated they had received training. **Fig. 12** shows the overall results, with topics sorted in descending order of what percentage of respondents indicated the trainings were either moderately or considerably impactful.

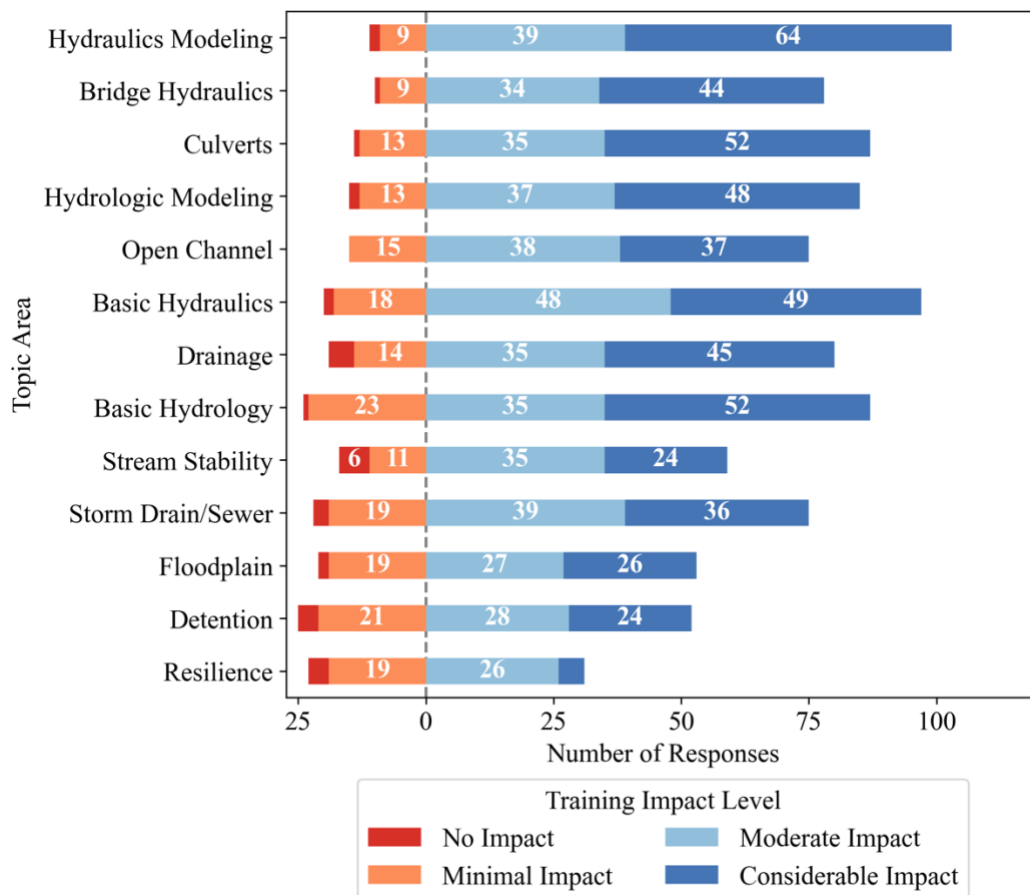


Fig. 12. Overall impact of trainings per topic area.

Topic area importance. Training needs may vary depending on which H&H topics matter most to an organization. This variation could be due to organization

type, geographic conditions, or something else. Regardless of the reason, it is important to understand which H&H topics are prioritized by agencies to target training improvements effectively. To address this, the survey asked respondents to rank a list of 13 H&H topics according to how important each topic is to their current organization. Respondents were also able to rank an “Other” category, if applicable. However, only six respondents ranked “Other,” so it was excluded from this analysis.

Fig. 13 shows the results across all respondents, indicating the number of times each topic was ranked first and the number of times it was ranked in the top three. Topics are shown in descending order of number of times ranked 1st. **Fig. 14**, **Fig. 15**, **Fig. 16**, and **Fig. 17** show the results broken down by respondent organization type. As can be seen in the figures, there is variation in topic prioritization depending on respondent organization type. These results will be utilized in later analyses throughout this report.

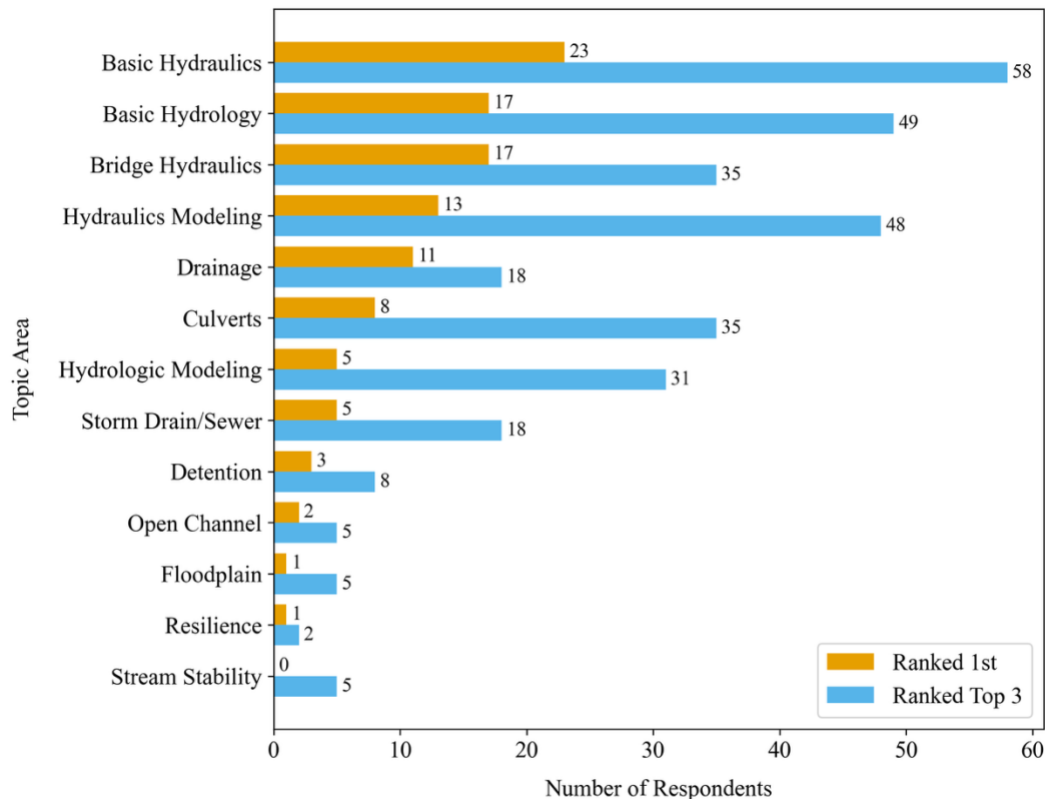


Fig. 13. Topic area prioritization across all respondents.

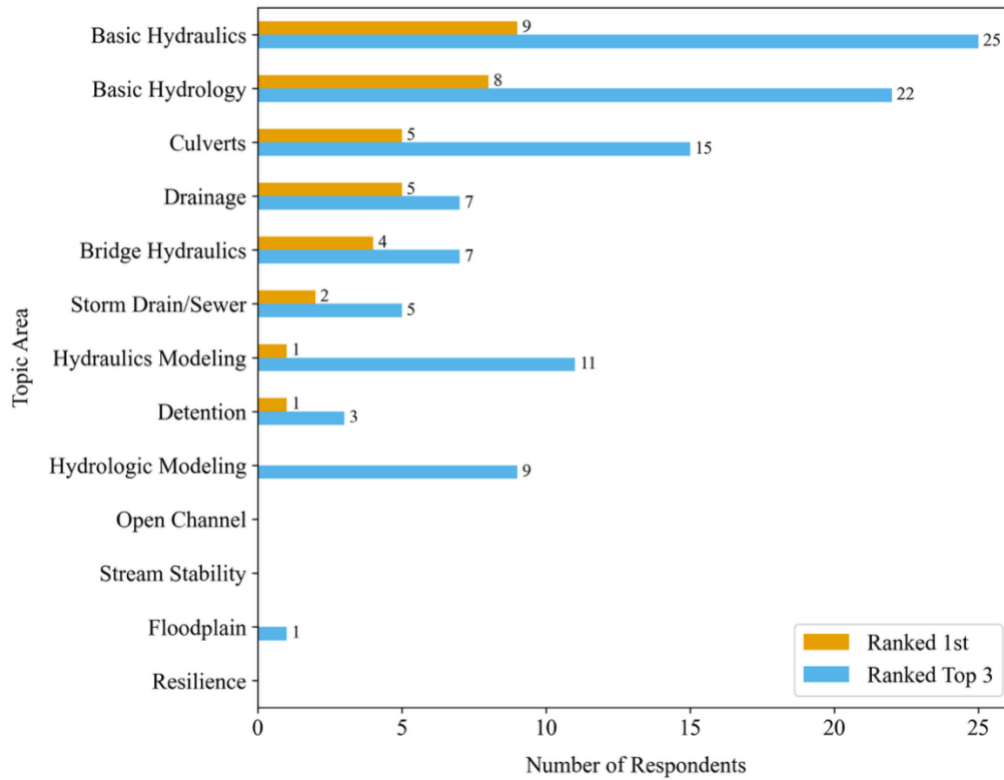


Fig. 14. Topic area prioritization by respondents from TxDOT.

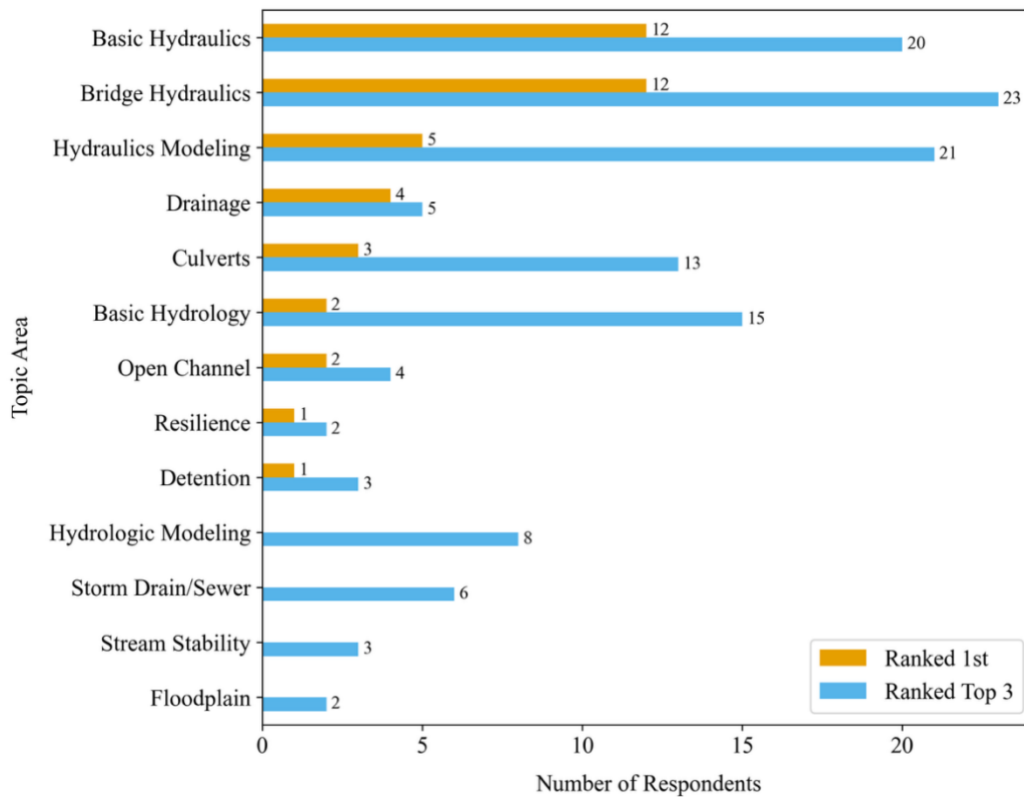


Fig. 15. Topic area prioritization by respondents from other DOTs.

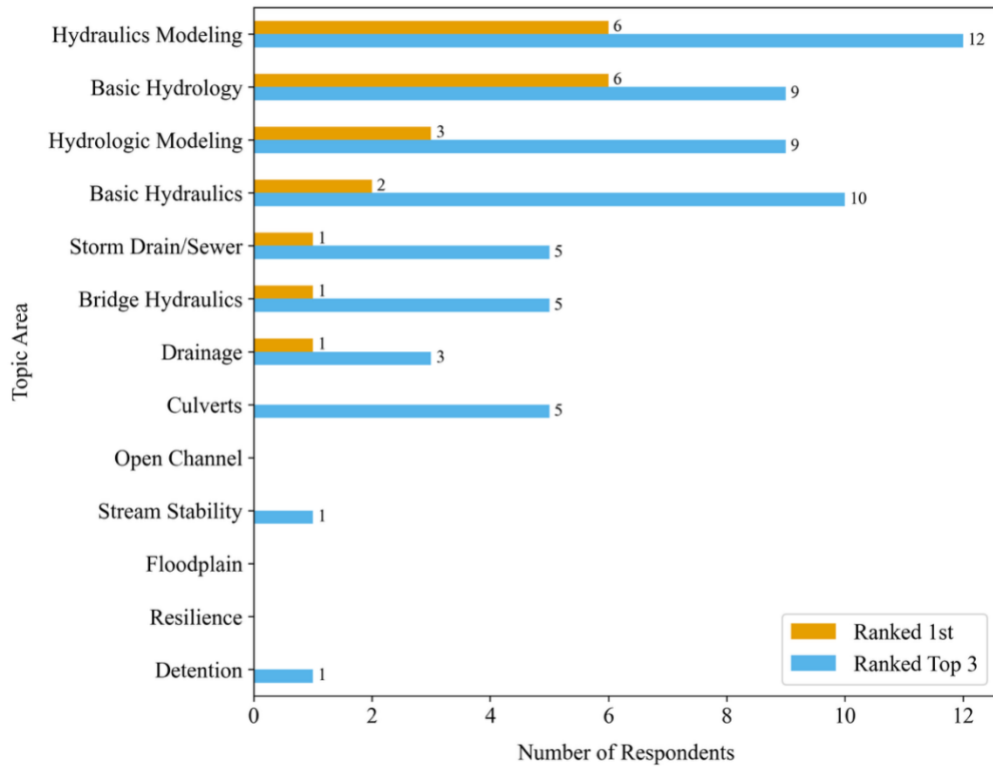


Fig. 16. Topic area prioritization by respondents from private sector organizations.

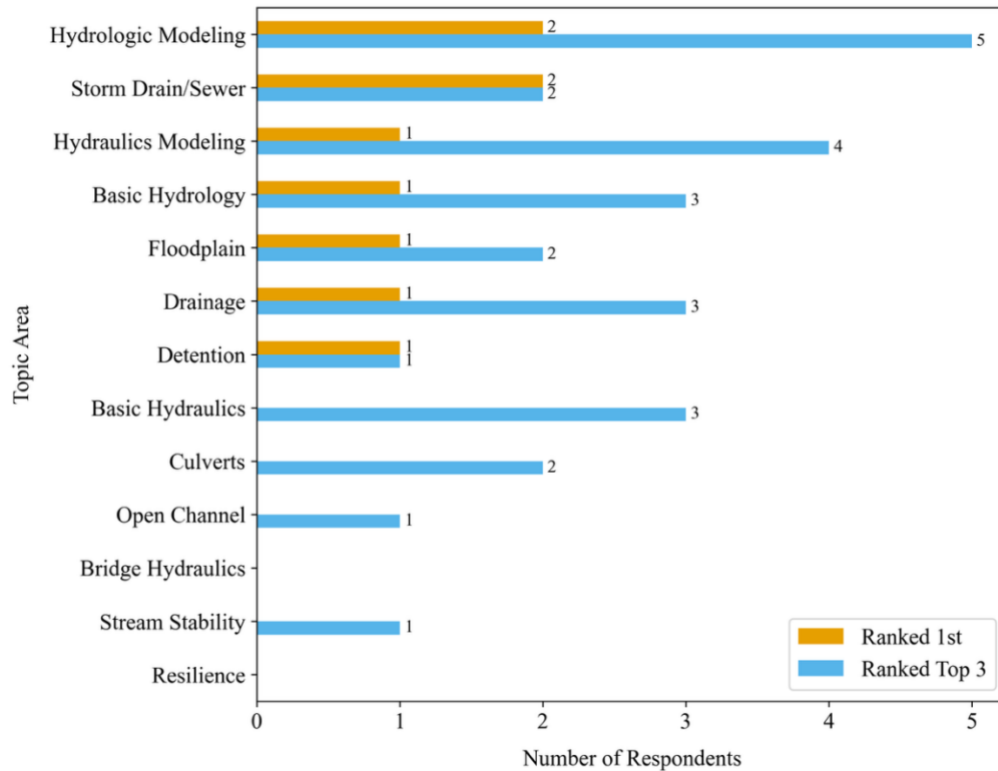


Fig. 17. Topic area prioritization by respondents from city and county departments.

Topic area importance and knowledge alignment. The next step in understanding the current landscape is to examine if topic prioritization aligns with current staff knowledge. In other words, are staff performing well in the topics that are most important to organizations? To better understand this, the survey asked respondents to indicate how confident they felt in each of the topic areas. Respondents could select from a list of options:

- Not at all confident
- Somewhat confident
- Moderately confident
- Very confident

For analysis, these options were assigned a value of 1 to 4, respectively. It is expected that a staff member's level of experience in H&H will affect their confidence level in each topic. **Fig. 18** confirms this, as mean confidence in respondents with more years of experience is generally higher across all topics. **Fig. 19** shows mean confidence for each topic split by organization type. In both figures, topics are displayed in descending order of mean confidence across all respondents, with resilience having the lowest overall mean confidence and basic hydraulics having the highest overall mean confidence.

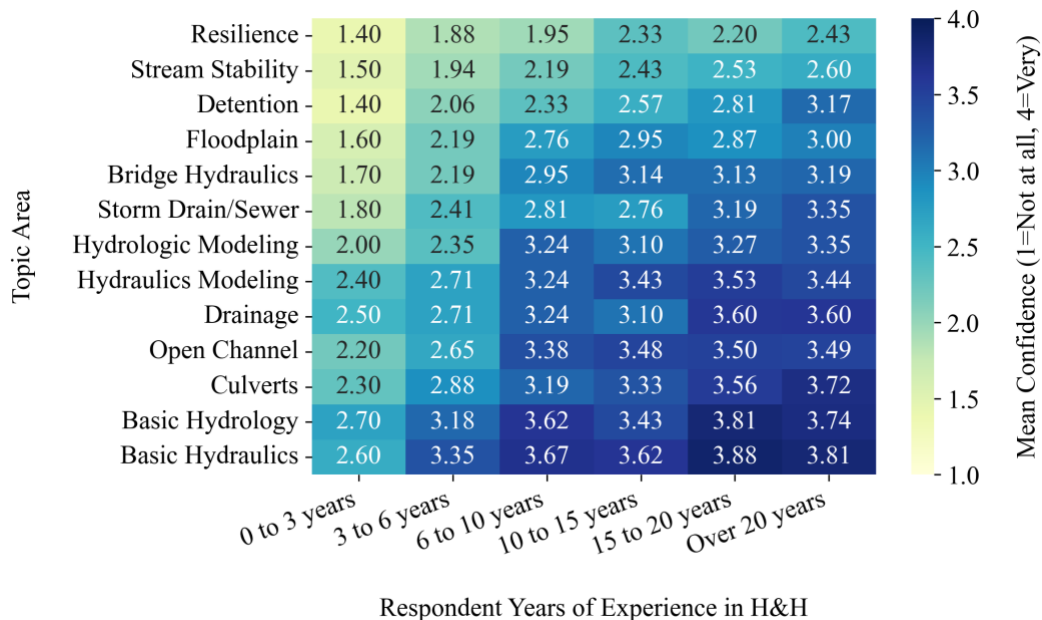


Fig. 18. Mean respondent confidence in each topic area, split by respondent years of experience.

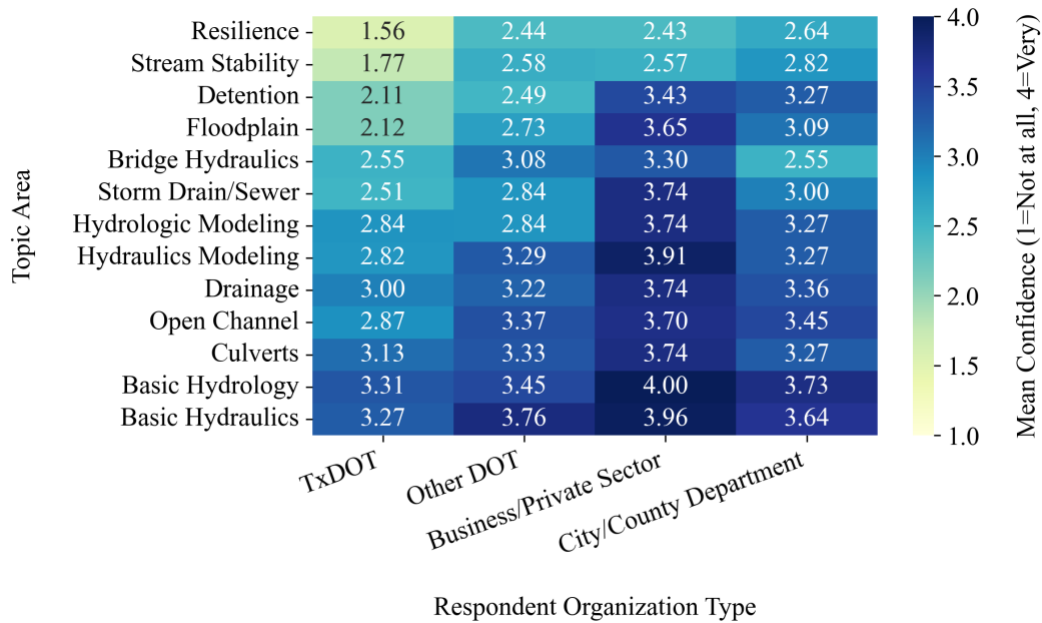


Fig. 19. Mean respondent confidence in each topic area, split by respondent organization type.

Potential issues may exist where staff knowledge in a topic area (measured here as confidence in a topic) does not align well with how important that topic is to an organization. For each topic, mean importance (ranking) and mean confidence were calculated (first across all respondents, then split by organization type). All mean values were normalized—and ranking values were inverted—to be on a scale from 0 to 1, where 0 indicates the least respondent confidence and the least topic importance, and 1 indicates the highest respondent confidence and the highest topic importance. **Fig. 20**, **Fig. 21**, and **Fig. 22** plot the normalized mean values in a scatter plot with respondent confidence on the y-axis and topic importance on the x-axis. The dashed lines on each figure represent the median of each data set. All three figures show a strong correlation between respondent confidence and topic importance.

The lower-right quadrant of each graph contains topics that, on average, are of above-median importance but in which respondents have below-median confidence. This quadrant represents potential knowledge gaps and misalignment between how confident staff feel in a topic and how important that topic is to their organization. Across all organizations (**Fig. 20**), there are three topics that fall into, or on the border of, the bottom right quadrant:

- Storm Drain/Sewer
- Hydrologic Modeling
- Bridge Hydraulics

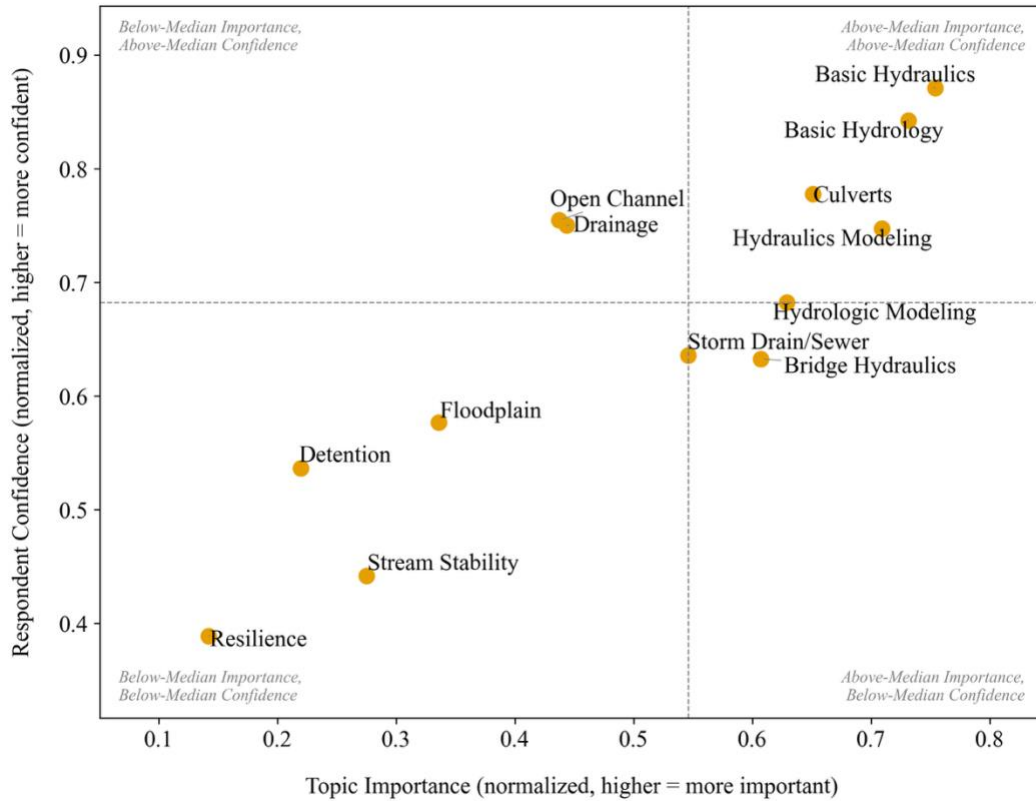


Fig. 20. Respondent confidence vs. topic importance across all respondents.

When breaking down the results by respondent organization type (**Fig. 21** and **Fig. 22**), the results shift slightly but remain similar for state agencies (TxDOT and other DOTs). The three graphs indicate potential gaps across TxDOT and other DOTs in:

- Storm Drain/Sewer
- Hydrologic & Hydraulics Modeling
- Bridge Hydraulics

These potential gaps will be further explored in Section 5.4 of this report.

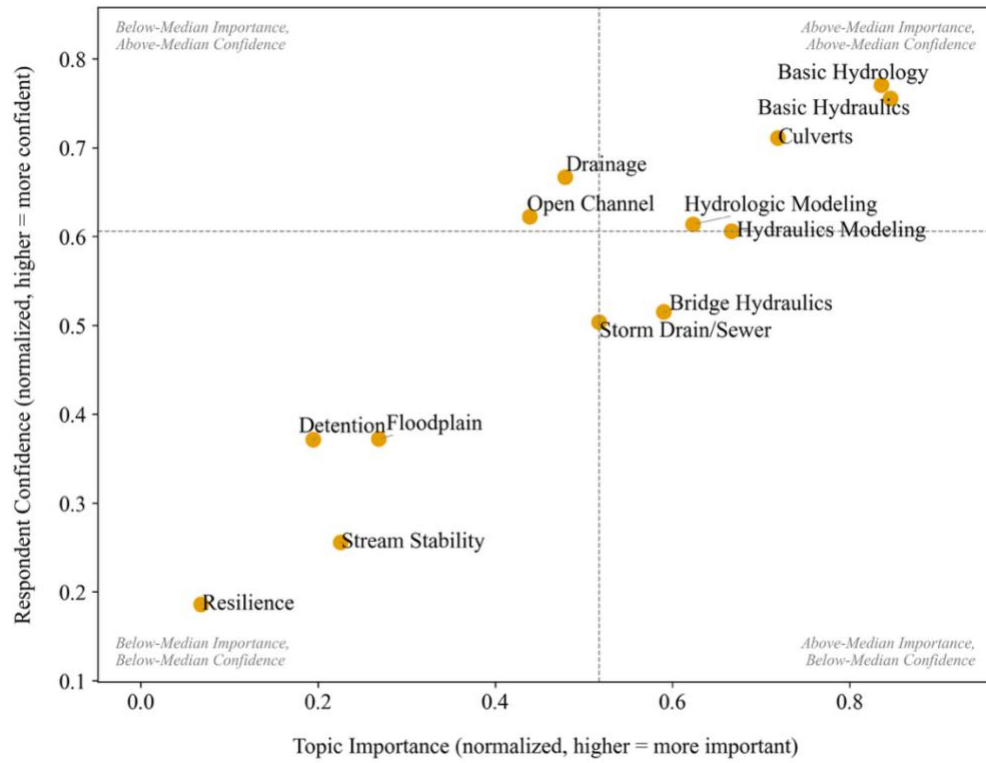


Fig. 21. Respondent confidence vs. topic importance for respondents from TxDOT only.

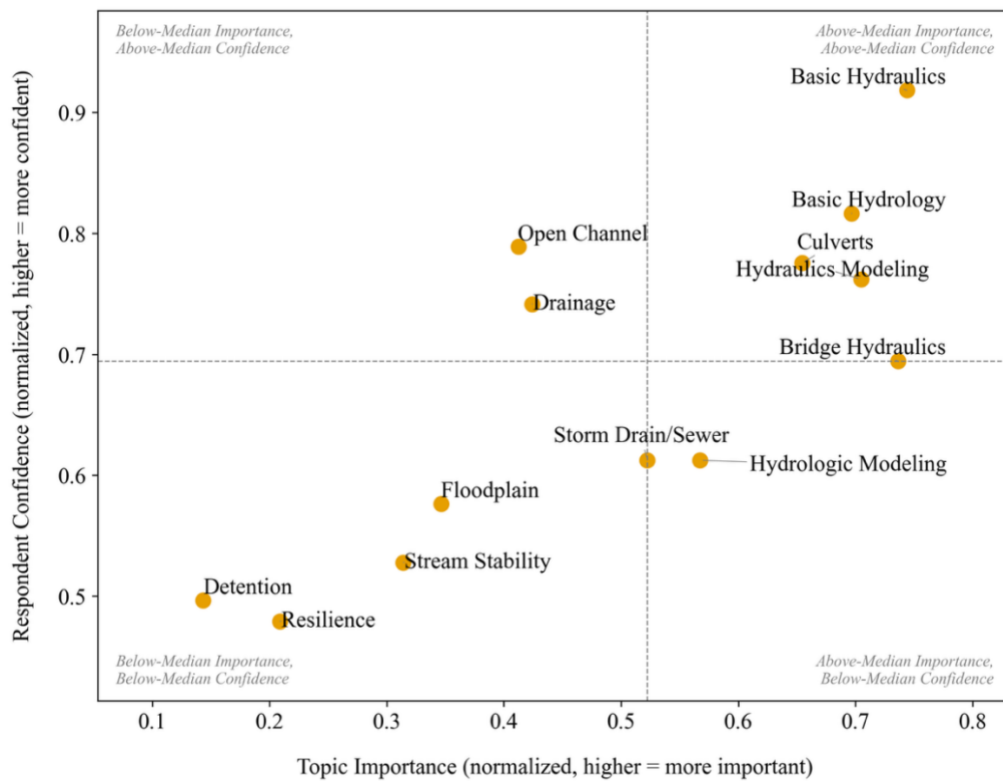


Fig. 22. Respondent confidence vs. topic importance for respondents from other DOTs only.

5.3. Training Delivery, Innovation, and Evaluation Methods

Training method prevalence vs. preference. The success of a training program relies not only on the quality of the trainings, but on how trainings are delivered. To examine training delivery, the survey asked respondents to consider the following delivery methods:

- Virtual (live)
- Web-based (on-demand)
- In-person
- Informal/mentoring/on-the-job
- Other

Survey takers were asked to indicate what percent of trainings at their organization were delivered through each method. **Fig. 23** shows the results which indicate that all four training delivery methods (excluding “other”) are utilized at least 15% of the time at all four organization types. According to the results, the most prevalent delivery method varies by organization type:

- TxDOT: Virtual (live)
- Other DOTs: Informal/mentoring/on-the-job
- Business/Private Sector: Informal/mentoring/on-the-job
- City/County Department: In-person

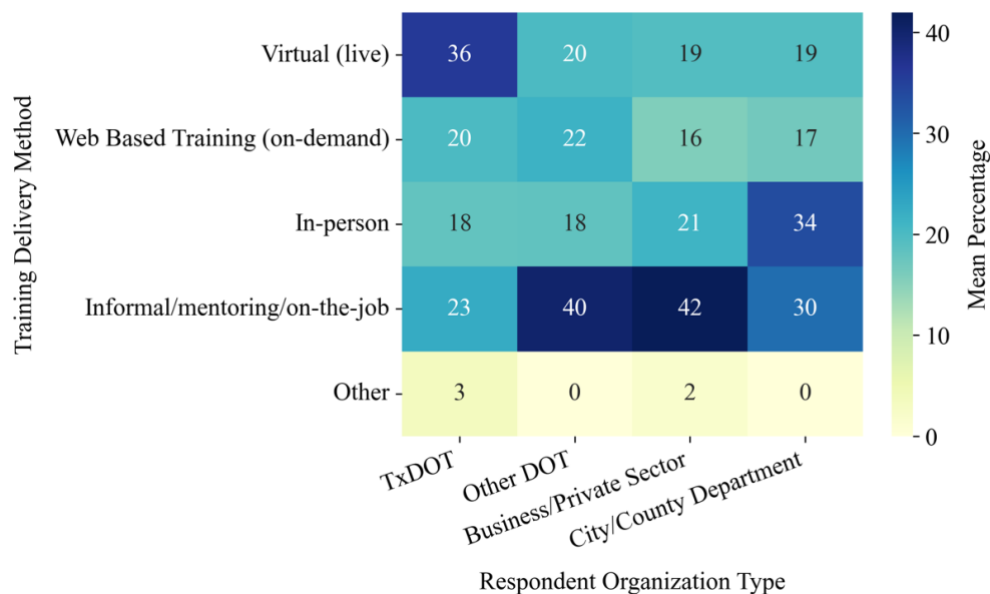


Fig. 23. Prevalence of different training delivery methods, split by respondent organization type.

Beyond indicating the prevalence of certain training delivery methods, the survey also asked respondents to rank delivery methods from most to least preferred. **Fig. 24** shows the results, broken down by respondent organization type. For each organization type, the most preferred method (the method ranked 1st the most times) of respondents corresponded to the most prevalent method at that same organization type (**Fig. 23**). This means that the most common training delivery method at each organization type is also the most well-liked by respondents. Overall, the results indicate that respondents prefer trainings that are live, whether those trainings are online or virtual, formal or informal. By contrast, on-demand trainings are generally the least preferred among respondents.

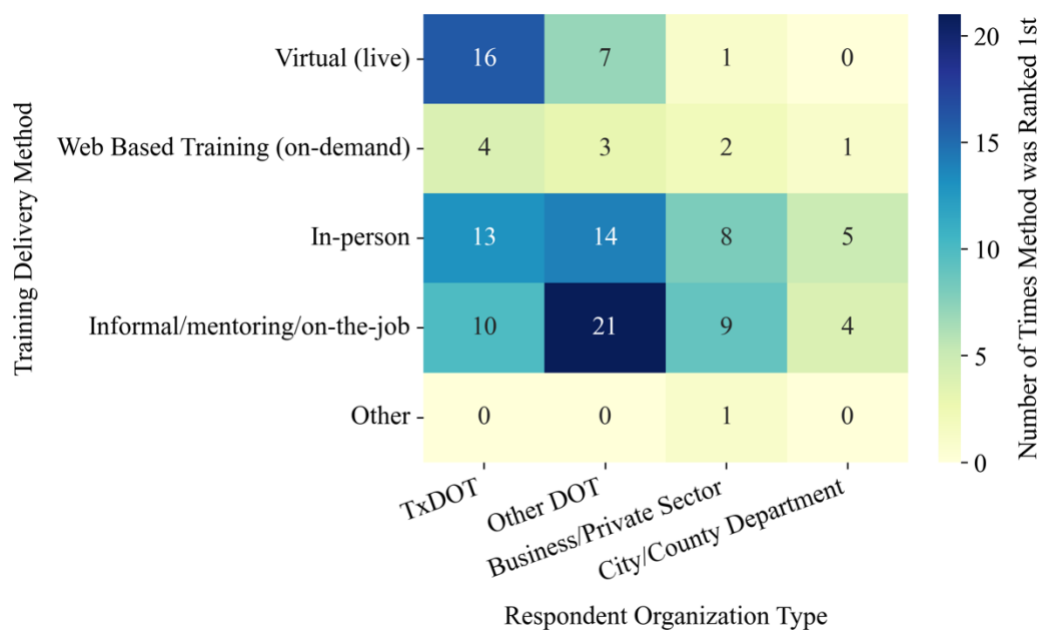


Fig. 24. Respondent preference for different training delivery methods, split by respondent organization type.

A comparison of how common a delivery method (prevalence) is vs. how much respondents like it (preference) may help illuminate potential gaps in training delivery practices. **Fig. 25** and **Fig. 26** compare the mean prevalence vs. mean preference for each delivery method for TxDOT and other DOTs, respectively. The means were normalized—and ranking values were inverted—on a scale from 0 to 1, 0 being the least prevalent or least preferred, and 1 being the most prevalent or most preferred. The lower-right quadrants of these graphs indicate training delivery methods that are above the median preference but below the mean prevalence. This means these are delivery methods that respondents like, but that may be less common at their organizations. For both TxDOT and other DOTs, in-person training falls in this quadrant, indicating a potential leverage point for future trainings.

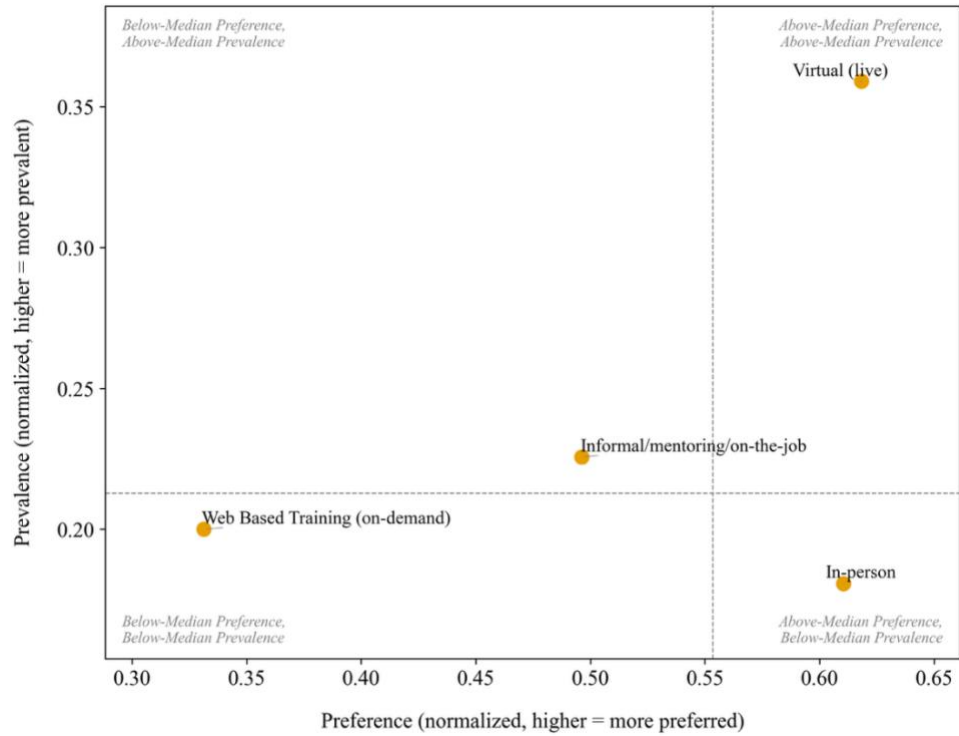


Fig. 25. Training delivery method prevalence vs. preference for respondents from TxDOT only.

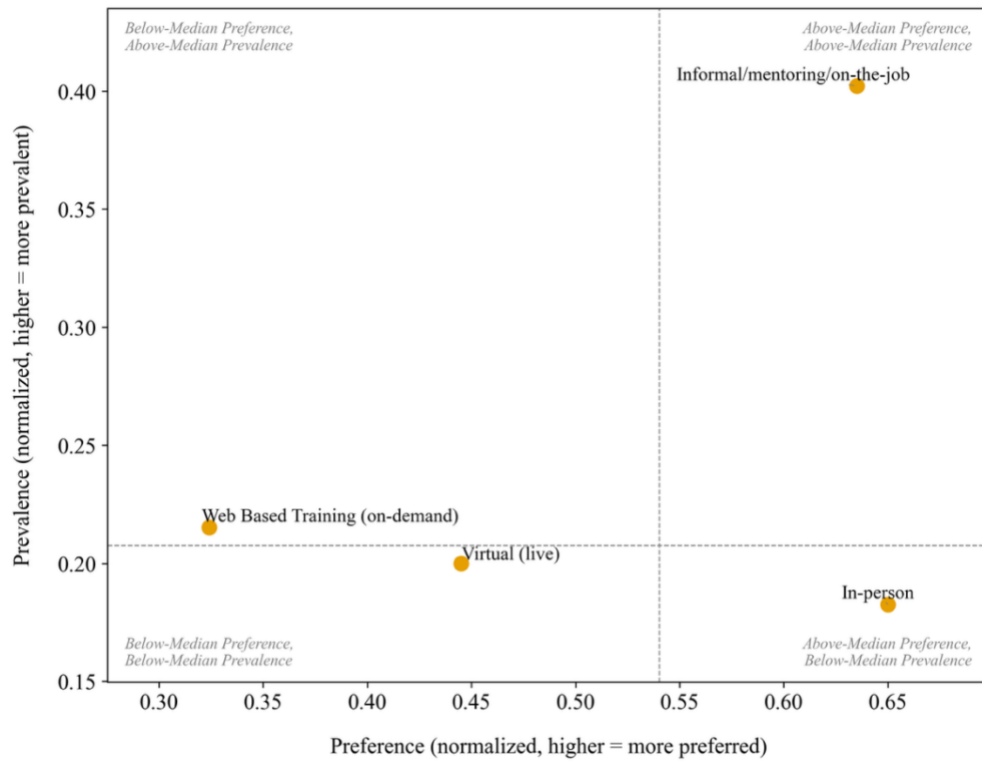


Fig. 26. Training delivery method prevalence vs. preference for respondents from other DOTs only.

It is intuitive to think that modality preferences might vary with respondent age (e.g., a certain age group may prefer in-person training over online training). During data analysis, the sensitivity of modality preferences to age was explored. However, no age-specific trends were identified. For all age groups, in-person training was either the most preferred or second-most preferred training method and web-based training was the least preferred.

Transferring institutional knowledge. Training programs can facilitate knowledge transfer beyond technical concepts. They can serve as vehicles for transferring institutional knowledge from more experienced staff to newer staff. This transfer of knowledge is critical for passing on information that is often specific to an organization, like workflow and standard operating procedures (SOPs). It allows for newer staff to learn the intricacies of how their organizations function. Sometimes, something as seemingly simple as knowing who to go to with a question is information that can only be gleaned from peer-to-peer interactions, shadowing, mentoring, and other forms of knowledge transfer.

The survey asked respondents to indicate how knowledge is transferred from seasoned staff to newer staff at their organization. Survey takers were given five options to choose from:

- Formal mentoring program
- Shadowing
- Quality control/peer review process
- Informal (peer to peer or mentor to peer)
- Other

Respondents were able to select as many options as applicable. **Fig. 27** shows the results as percentages of the total selections, split by organization type. As an example, **Fig. 27** indicates that informal knowledge transfer makes up 40% of the total selections made by respondents who work at TxDOT. The results are generally consistent across organization types. Informal training makes up the greatest percentage of total selections, followed by quality control/peer review (except for local government agencies, where shadowing is the second most selected method).

Respondents who selected “other” were asked to specify the method of knowledge transfer. 24 survey takers wrote in a method for “other,” with the most common answer being some form of written/recorded documentation such as how-to guides, SOPs, recorded videos, or manuals.

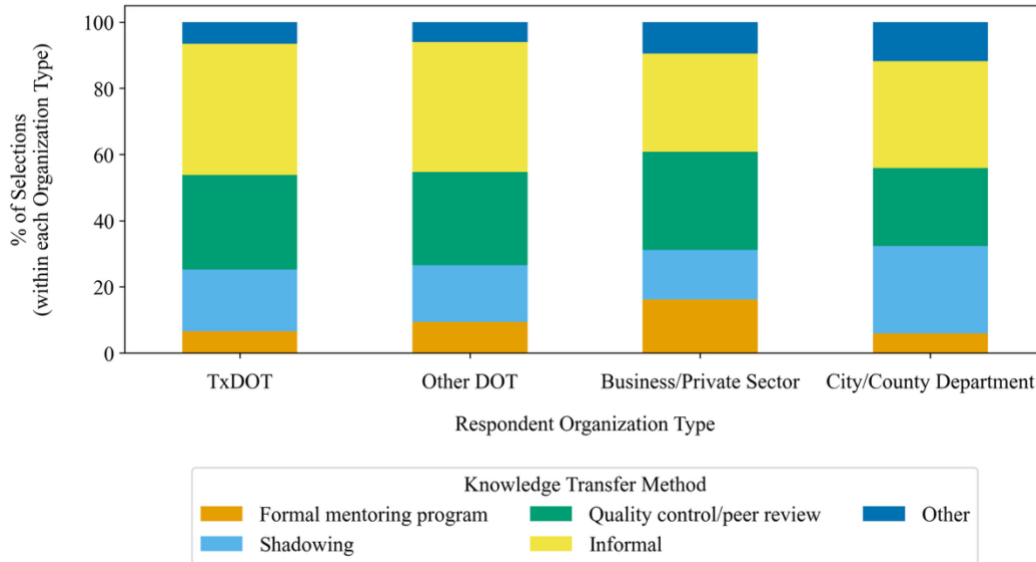


Fig. 27. Knowledge transfer methods as a percent of total selections, split by respondent organization type.

Fig. 28 shows the same results, broken down by respondent age instead of organization type to illustrate whether the knowledge transfer methods staff are encountering might vary by age group. However, the results are consistent with those in **Fig. 27**, and no significant changes were observed. It should be noted that 16 respondents did not answer the age question on the survey and their responses are therefore excluded from **Fig. 28**. All age groups present in **Fig. 28** had between 24 to 34 respondents, except for “65 or older” which had only 7 respondents.

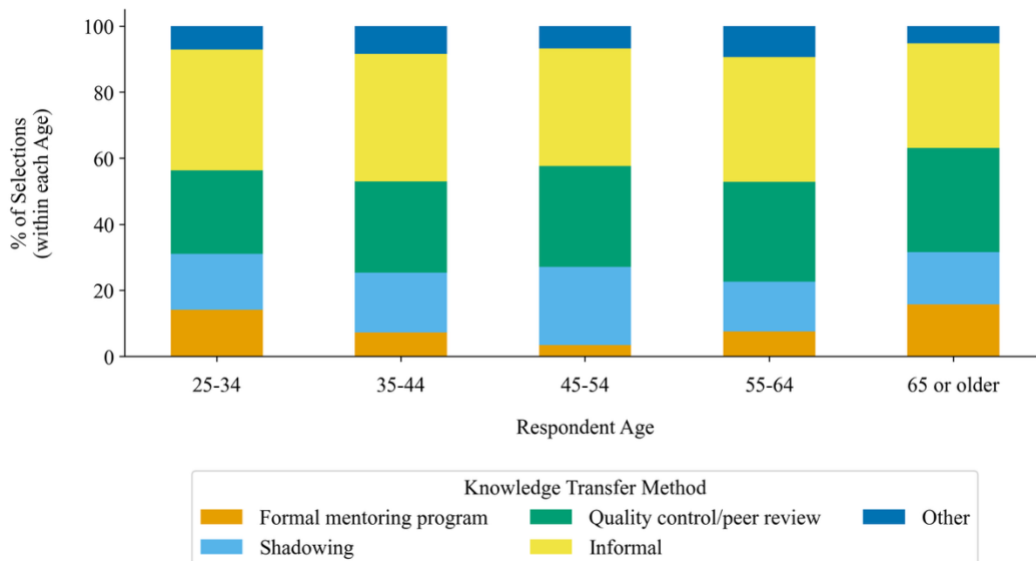


Fig. 28. Knowledge transfer methods as a percent of total selections, split by respondent age.

Informal training. For the purposes of this survey, “informal training” mainly refers to informal mentoring, learning-by-doing, and learning from working with more experienced peers. The survey asked respondents to describe their perceptions of the informal training they have received and to indicate what methods they have found effective or ineffective. This was a free-response question for which a thematic analysis was carried out (please see Section 3.2). There were 88 responses to this question—a breakdown by respondent organization type can be found in **Table 3**. Below are the takeaways from the responses.

All percentages refer to the percent of responses out of the number of respondents who answered the question. Percentages by organization type are provided for TxDOT and other DOTs, but only if they represent at least three excerpts.

Table 3. Response breakdown for informal training question.

Organization Type	Number of Respondents
TxDOT	29
Other DOT	34
Business/Private Sector	16
City/County Department	9

- *Value of informal training.* 28% of respondents (28% of respondents from TxDOT and 32% of respondents from other DOTs) noted the importance of informal training, with many respondents indicating it is the most effective form of training. Respondents expressed that the typical hands-on nature of informal training is a crucial part of the training process. A few excerpts are included below:

“Informal training is invaluable because you are usually dealing with nuanced situations, where very specific topics or issues arise. This is where you can catch the things not covered in the book.”

“Informal training (peer mentoring and "on the job" training) has been the primary method for learning my job. Having experienced designers at hand has been the most effective/utilized tool for my development as a hydraulic engineer.”

“Informal training is the bedrock of getting up to speed at any new job.”

- *Applied training.* 49% of respondents (55% of respondents from TxDOT and 35% of respondents from other DOTs) mentioned applied training in their response. Applied training refers to learning-by-doing, such as working on a project, going out into the field, practicing with case studies, etc. Multiple respondents underscored the importance of gaining hands-on experience, suggesting that applied training is practical and helps fill in the gaps of formal trainings. Respondents also mentioned the need for repeated practice for trainings to have a lasting effect. A few excerpts are included below:

“Training as your working on a real world project is more useful than generic training. It is specific to what someone is working on.”

“This ‘on the job’ training allows inexperienced engineers to grow while contributing to the project design which resonates beyond formal trainings. To have an accomplishment that translates to the real world and doesn't end in a certificate provides lasting experiences that stick with engineers throughout their careers and ultimately bolsters their technical "experience" in a lasting manner.”

“Learning by doing is key. Advance your project efforts while you are learning, get guidance often from experts and keep things moving.”

- *Learning from experienced peers.* 36% of respondents (31% of respondents from TxDOT and 44% of respondents from other DOTs) mentioned peer interaction in their response. Multiple respondents noted the value of working alongside experienced staff who they could go to with questions. Respondents also expressed that collaborating with peers is helpful for exchanging ideas and working through challenges. A few excerpts are included below:

“Conferring with coworkers (engineers and EITs) concerning hydraulics challenges has been an effective learning tool in my career.”

“Shadowing, and informal peer to peer mentorship through project work is by far the most effective tool that I have seen to grow the engineering technical capabilities of younger staff.”

“Guidance from coworkers is an excellent way to learn because their methods are usually directly applicable to the work I am trying to perform.”

- *Standardization and supplemental resources.* 26% of respondents (17% of respondents from TxDOT and 35% of respondents from other DOTs) noted that the quality of informal training can vary, so it requires standardization and supplemental resources. Respondents expressed that a downside of informal training is the potential for inconsistency depending on the ability and capacity of the person(s) giving the training. Multiple respondents noted that informal training, while critical, needs to be supplemented with written documentation or formal trainings. A few excerpts are included below:

“This is effective if you have a very skilled staff, otherwise the learning by doing is a challenge and important things in review can be missed.”

“[Informal training] should be supplemented with structured trainings to ensure that incorrect practices or misunderstandings are not intentionally passed on.”

“However, the biggest issue with informal training is the quality of everyone's training can be fairly different.”

- *Barriers to informal training.* 19% of respondents (14% of respondents from TxDOT and 29% of respondents from other DOTs) identified specific barriers to informal training in their response. These barriers mainly included high staff turnover, time constraints, inconsistency in quality of training, and isolation. Multiple respondents expressed that while informal training is critical for knowledge transfer, carrying it out effectively requires sufficient time, adequate staff, and intentional collaboration. A few excerpts are included below:

“The primary downside is when turnover gets too high knowledge tends to concentrate into 1 or 2 people and it is often hard to then have the time spread the knowledge again.”

“Informal training is very situational. It relies on having staff with experience and availability to step away from their work to help you.”

“When I started there were adequate mid-level staff to do this. Now, there is a gap in the mid-level staff so senior level staff are handling everything from management to production to mentoring and there is much less time for transferring knowledge.”

Applied design training. TxDOT’s H&H section utilizes a training methodology known as applied design training (ADT). ADT is a collaborative training method that focuses on a specific type of design that is common for H&H staff (for example: off-system bridge replacement). The process involves formal training on the design process combined with hands-on workshops, peer mentoring, troubleshooting workshops, and collaborative quality control reviews. It is meant to target knowledge gaps and be an immersive process that teaches H&H staff a specific design skill over a set time. The survey asked respondents from outside of TxDOT to indicate whether their organization employs ADT or something similar. The goal of this question was to determine if ADT is a widespread practice across other DOTs, private sector organizations, and local government agencies.

Fig. 29 shows the results, displayed as percentages of the total respondents for each organization type. For example, the results show that 61% of respondents from other DOTs indicated that there is no similar ADT process at their organization. Overall, the results show that the majority of other DOTs and local government agencies surveyed do not have an existing ADT method in place (or if they do, staff are not aware of it).

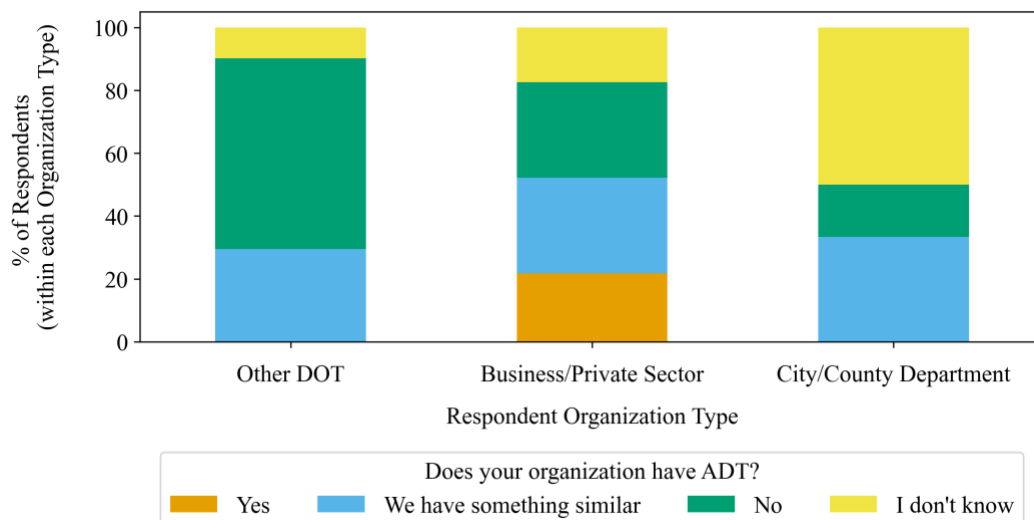


Fig. 29. ADT prevalence at non-TxDOT organizations. Shown as the percentage of respondents indicating whether their organization has ADT, split by respondent organization type.

These results present a potential opportunity to fill a train method gap. As discussed in the previous section of this report, trainings that focus on real projects and allow a hands-on approach to learning were described by multiple respondents as being the most effective types of trainings. The results in **Fig. 29** suggest the possibility for collaboration between TxDOT and private sector

organizations to expand these methods and make them more accessible to other organizations.

Technology and innovation. As part of analyzing training delivery methods, the survey asked respondents to identify effective training innovations or technologies they have encountered. Survey takers were given the following list of innovations:

- Learning Management Systems (LMS)—A software application for administering, documenting, tracking, reporting, automating, and delivering educational courses and training programs.
- Adaptive Learning Systems—An educational method that leverages computer algorithms and artificial intelligence to allow course material to be customized to the learner. Students are provided extra practice when they struggle with a topic and given more challenging material when they perform well. Examples: SC Training, Udemy, Adaptemy, LinkedIn Learning, Coursera.
- Gamification—Application of game playing and mechanics – like points, badges, and leaderboards - in educational contexts to encourage participation and engagement with course material. Examples: Learning Pool, Elucidat, Central
- Video-Based Learning—Educational approach that utilizes video, images, audio, graphics, and text to deliver knowledge and training. Example: YouTube tutorials.
- Virtual Reality—Educational approach that utilizes virtual reality technology to immerse students in virtual environments that simulate real-world scenarios and allow them to interact with digital objects and characters. Examples: Google Arts & Culture Expeditions (virtual field trips), Labster (virtual labs), Lifeliqe (workforce training)
- Other (please specify)

From the list, respondents were asked to select the methods they have encountered and found useful. **Fig. 30** illustrates the results, which indicate that video-based learning is most popular across respondents at all organization types. It should be noted that low votes on a method may be a result of that method being less *common* (i.e., survey takers may not have encountered it), not necessarily less *effective*. The “Other” category was excluded from analysis due to a low response rate.

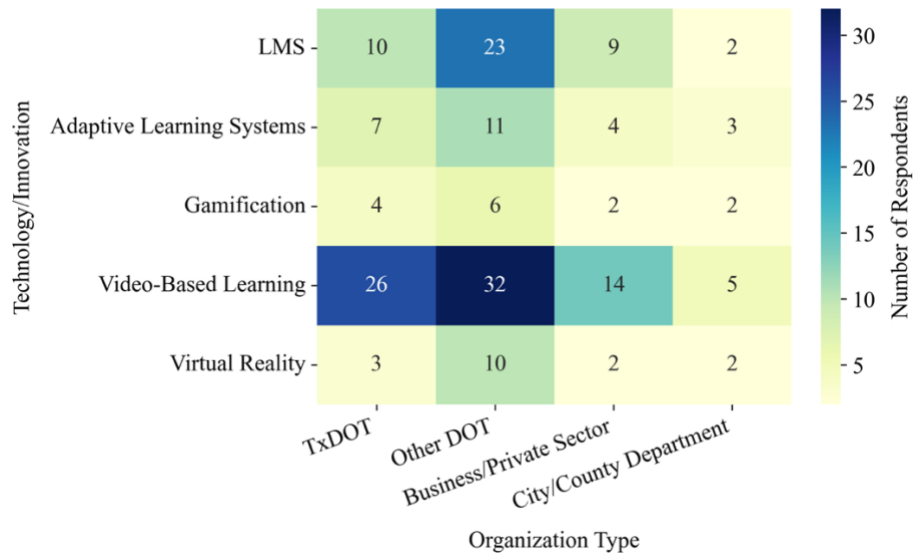


Fig. 30. Training innovations, split by respondent organization type.

Training evaluations. With evolving regulations, technical standards, and technology, trainings need to be evaluated and updated accordingly. The survey asked respondents how frequently trainings at their organization were evaluated to assess their effectiveness. There were 120 respondents to this question: 42 from TxDOT, 45 from other DOTs, 22 from the private sector, and 11 from local government agencies. **Fig. 31** shows the responses, with TxDOT having the highest evaluation rate: 76.2% of TxDOT staff who answered this question indicated that evaluations take place after every training. The results suggest that evaluations may not be as common at other DOTs, private sector organizations, and local government agencies.

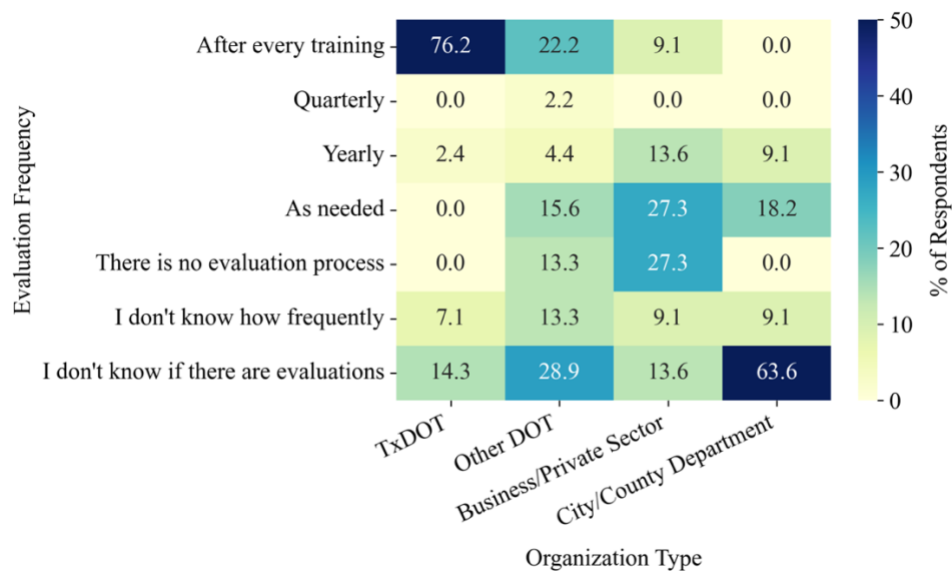


Fig. 31. Training evaluation frequencies (as a percent), split by organization type.

5.4. Potential Gaps and Barriers to Training

Respondent-reported gaps. Early in the survey, respondents were asked whether they had ever served in a role where they supervised others in H&H. Survey takers who answered “Yes” were asked directly: “In your experience, which of the following topics have people on your team(s) struggled with the most?” Respondents were asked to select up to three topic areas for this question. There were 81 total respondents; 24 for TxDOT, 31 for other DOTs, 19 for the private sector, and 7 for local government agencies. **Fig. 32** shows the results, indicating the following top knowledge gaps (as identified by respondents) for each organization type:

- TxDOT: Hydraulics Modeling, Hydrologic Modeling, and Bridge Hydraulics
- Other DOTs: Hydrologic Modeling, Hydraulics Modeling, and Stream Stability
- Business/Private Sector: Hydraulics Modeling, Basic Hydrology, Basic Hydraulics, Bridge Hydraulics, and Stream Stability
- City/County Department: Stream Stability, Hydraulics Modeling, and Resilience.

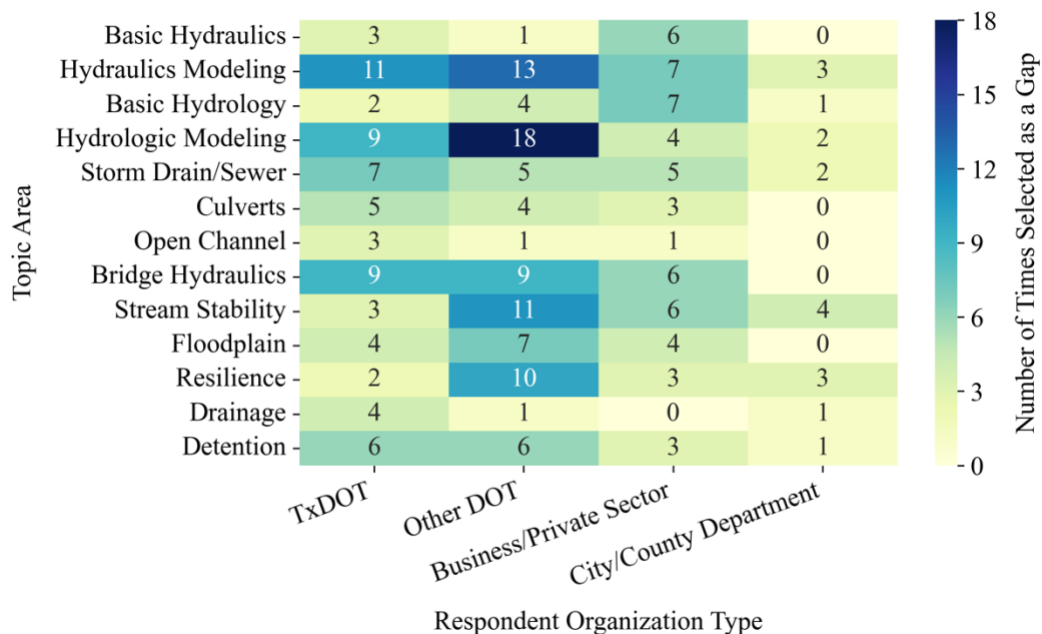


Fig. 32. Respondent-reported gaps, split by organization type.

Fig. 33 shows the same results but as percentages—each number indicates what percent of the respondents from each organization type indicated that topic area as a knowledge gap. Note that the percentages will not add up to 100 because respondents were able to select up to three gaps.

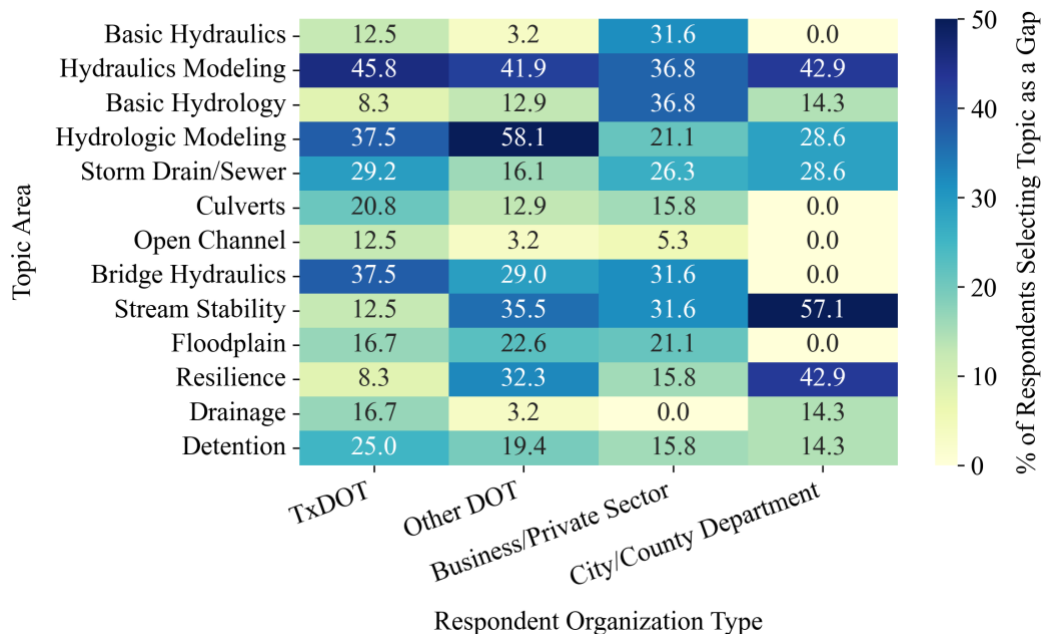


Fig. 33. Respondent-reported gaps as a percentage of respondents who selected each gap, split by respondent organization type.

Combining gap indicators. As discussed throughout this report, the survey aimed to identify potential topic area gaps among H&H staff by asking respondents to indicate the following:

- How important a topic area is to their organization
- How confident they feel in each topic area
- What topic area gaps they have identified among people on their teams
- How impactful they have found trainings they have taken in each topic area to be

Topic areas that are higher in importance but lacking in one of the other three categories represent potential for future improvements. To classify performance in each of the above categories the following metrics were calculated:

- Importance score: average topic area importance ranking, inverted and normalized from 0 to 1 (higher score means higher importance)

- Confidence score: average confidence in a topic area, normalized from 0 to 1 (higher score means higher confidence)
- Respondent-reported gap score: percent of respondents who identified a topic as a knowledge gap among staff (higher score means a higher percentage of respondents identified a gap)
- Impact score: average impact level of trainings in a topic area, normalized from 0 to 1 (higher score means higher impact)

These metrics will collectively be referred to in this report as “gap indicators.”

Table 4 shows the calculated scores for each gap indicator and topic area aggregated across all respondent organization types. “Minimum n” refers to the minimum number of respondents for that topic area across the four indicators.

Table 5 includes descriptive statistics for each gap indicator.

Table 4. Gap indicator scores for each topic area. Results are aggregated across all respondent organization types and sorted in descending order according to Importance Score.

Topic Area	Importance Score	Confidence Score	Respondent-Reported Gap Score	Impact Score	Minimum n
Basic Hydraulics	0.75	0.87	12.3	0.74	81
Basic Hydrology	0.73	0.84	17.3	0.75	81
Hydraulics Modeling	0.71	0.75	42.0	0.82	81
Culverts	0.65	0.78	14.8	0.79	81
Hydrologic Modeling	0.63	0.68	40.7	0.77	81
Bridge Hydraulics	0.61	0.63	29.6	0.79	81
Storm Drain/Sewer	0.55	0.64	23.5	0.70	81
Drainage	0.44	0.75	7.4	0.74	81
Open Channel	0.44	0.75	6.2	0.75	81
Floodplain	0.34	0.58	18.5	0.68	74
Stream Stability	0.27	0.44	29.6	0.67	76
Detention	0.22	0.54	19.8	0.65	77
Resilience	0.14	0.39	22.2	0.53	54

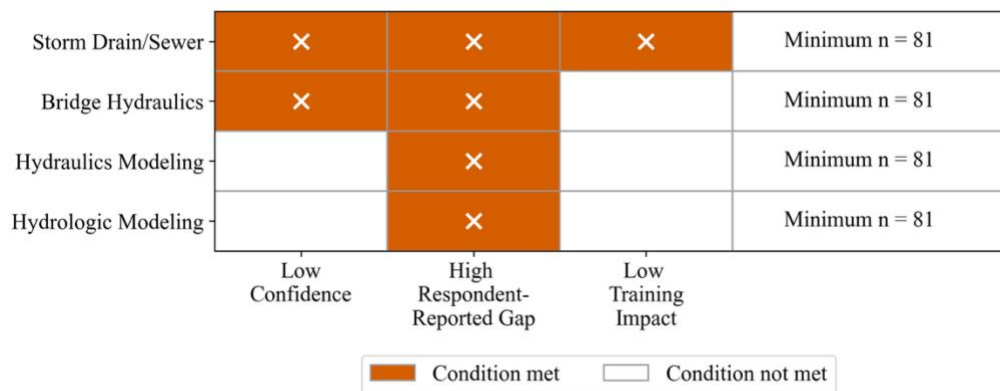
Table 5. Descriptive statistics for **Table 4**.

	Median	Min.	Max.	Std.
Importance Score	0.55	0.14	0.75	0.21
Confidence Score	0.68	0.39	0.87	0.15
Respondent-Reported Gap Score	19.8	6.2	42.0	11.2
Impact Score	0.74	0.53	0.82	0.08

Each score was compared to the median score for that indicator. If a score was equal to or above the median, it was considered “high;” if it was below the median, it was considered “low.” Topic areas were deemed to have a gap if they had a high importance score and at least one of the following:

- Low confidence
- High respondent-reported gap
- Low training impact

Fig. 34 shows topic areas that were identified as meeting the above criteria. The results suggest that Storm Drain/Sewer, Bridge Hydraulics, Hydraulics Modeling, and Hydrologic Modeling are the topic areas where gaps may exist in the current training landscape.



*"Minimum n" reflects the minimum number of respondents across the Importance, Confidence, Respondent-Reported Gap, and Impact questions.
For all questions, the distinction between "Low" and "High" is relative to the median for that group. "High" is inclusive of the median.*

Fig. 34. Classification of topics according to their gap indicators across all organization types.

Fig. 35, Fig. 36, Fig. 37, and Fig. 38 break down the results by respondent organization type. Note that for each figure, the median used to classify topics was the median for that organization type. Storm Drain/Sewer, Hydraulics Modeling, and Hydrologic Modeling are the three topics that consistently appear as potential gaps regardless of respondent organization type.

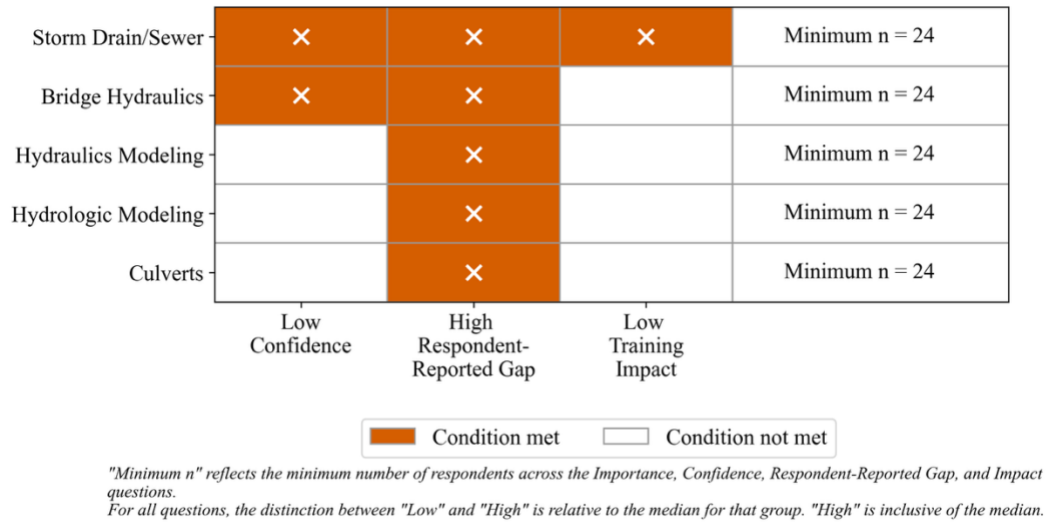


Fig. 35. Classification of topics according to their gap indicators for respondents from TxDOT only.

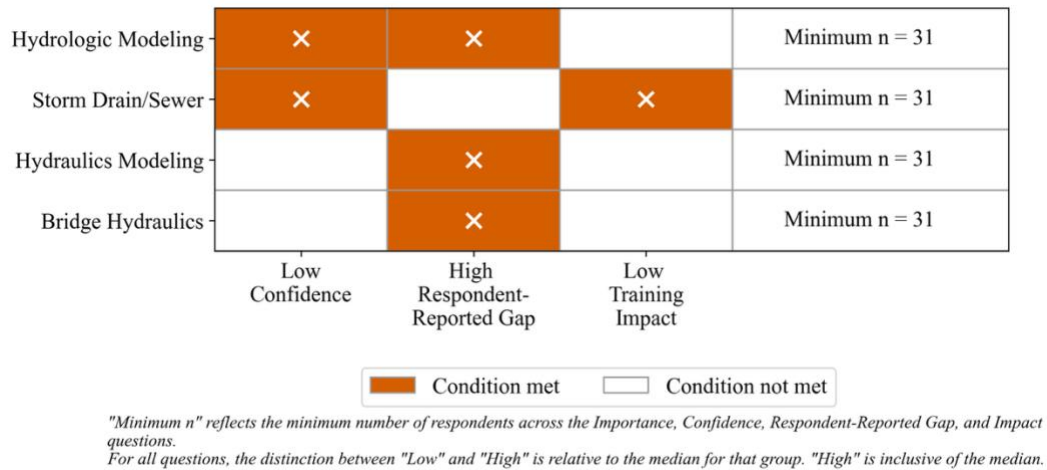


Fig. 36. Classification of topics according to their gap indicators for respondents from other DOTs only.

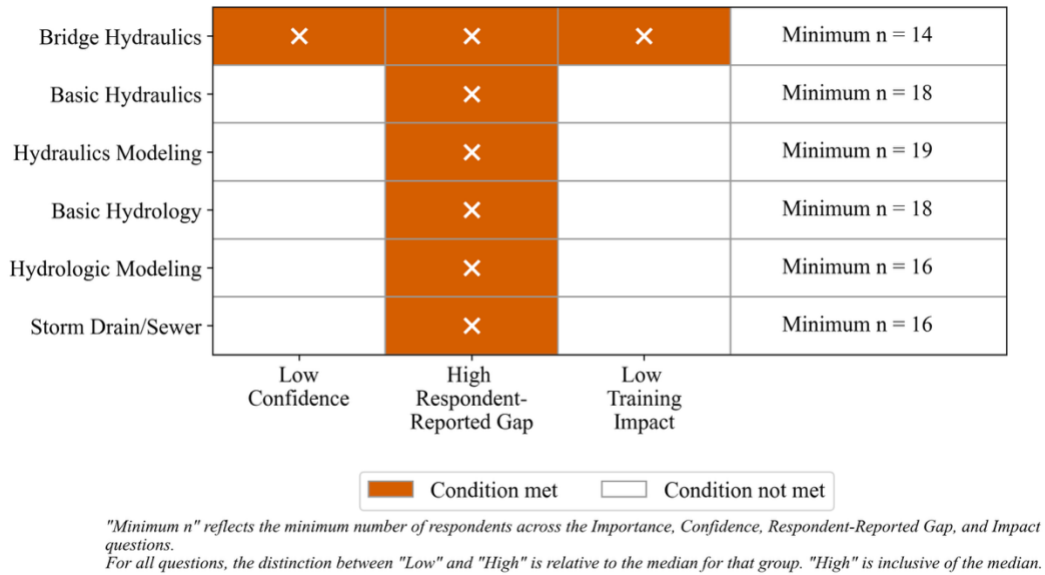


Fig. 37. Classification of topics according to their gap indicators for respondents from private sector only.

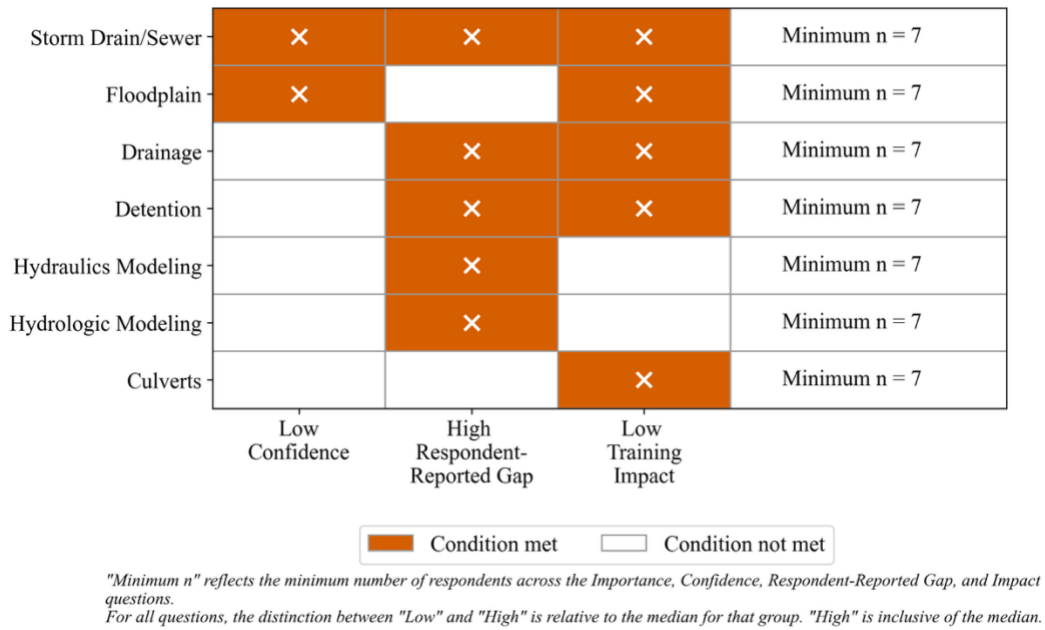


Fig. 38. Classification of topics according to their gap indicators for respondents from city/county departments only.

Barriers to trainings. The survey asked respondents to rank challenges they may have faced with regard to their own training and transfer of knowledge. Survey takers were presented with the following list of options and asked to rank them in order of how big of a challenge they have posed throughout the respondent's career in H&H:

- Lack of time: Insufficient time to dedicate to training staff
- Lack of resources: Limited classes, supplementary materials, online modules, etc.
- Interpersonal barriers: Lack of trust, negative relationships, lack of open dialogue, etc.
- Technological barriers: Lack of access to certain software and tools
- Lack of accessibility: Issues with language barriers, technical jargon, etc.
- Information overload: Staff receive too much information without clear prioritization
- Other

Ranking an option 1 would mean the respondent believes that option has been the biggest barrier to training and the transfer of knowledge for them and the teams they have been a part of. **Fig. 39** shows the results of how many times each barrier was ranked 1st, split by organization type. Lack of time was the barrier ranked 1st the most times across all organization types, suggesting it poses the greatest challenge when training staff.

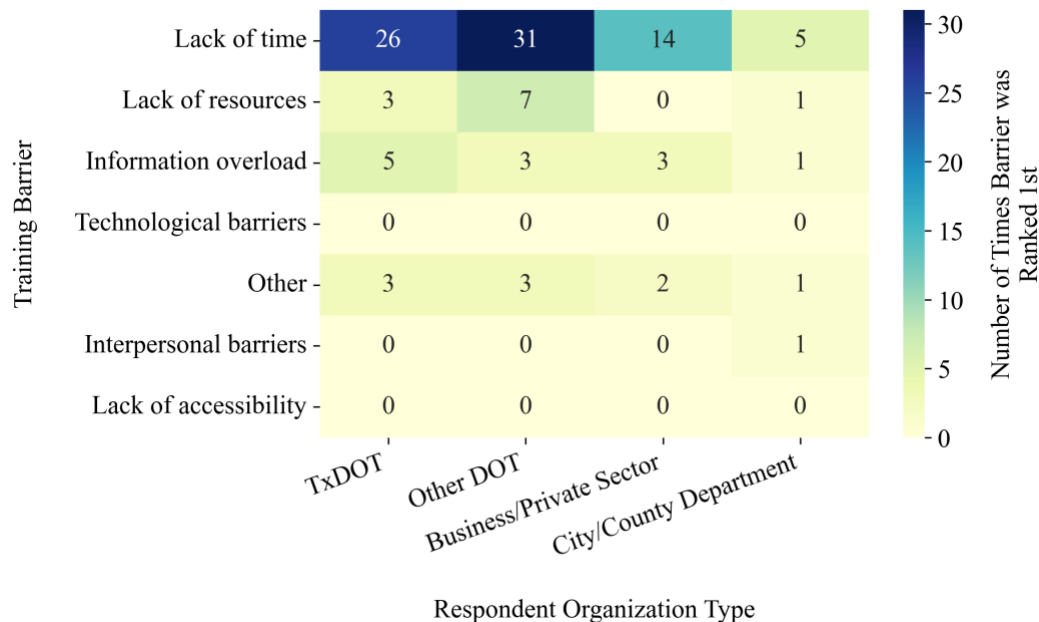


Fig. 39. Barriers to training (number of times ranked 1st), split by respondent organization type.

The mean ranking was calculated for each barrier, then results were normalized and inverted on a scale from 0 to 1 so that the least significant barrier to training would receive a ranking of 0 and the most significant barrier to training would receive a ranking of 1 (i.e., the closer to 1, the more significant of a barrier an option is). To normalize results, rankings were compared to the total number of options each respondent ranked. **Fig. 40** shows the results, split by respondent organization type. Barriers are sorted in descending order by normalized mean rank (calculated across all organization types). The mean ranking results confirm that lack of time is deemed the greatest barrier to training by respondents, followed by lack of resources and information overload, with some slight variation among respondents from different organization types.

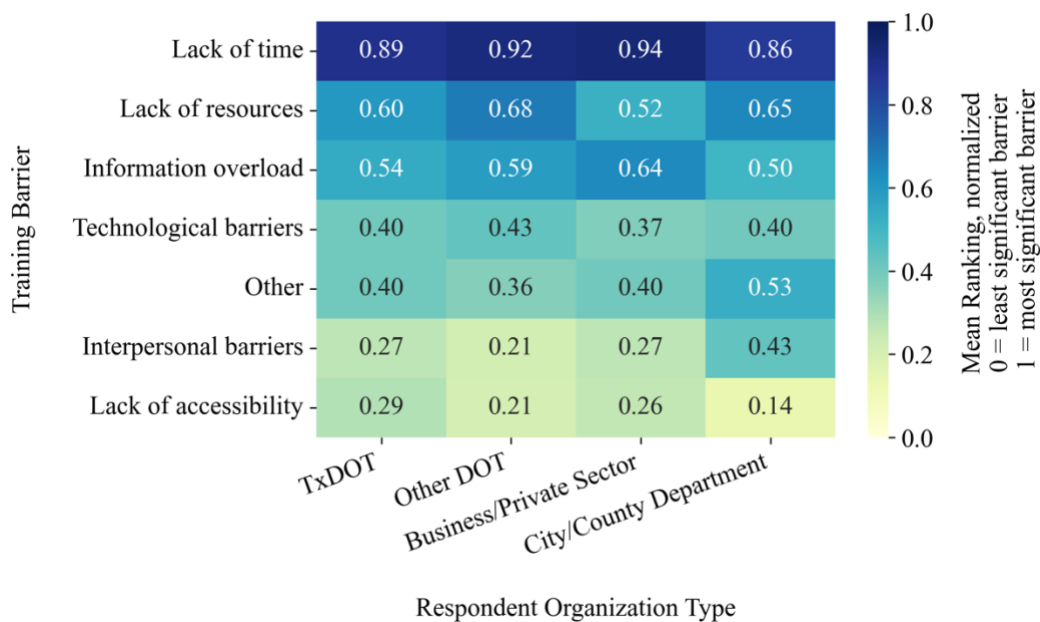


Fig. 40. Barriers to training (mean, normalized ranking), split by respondent organization type.

For this question, respondents had the opportunity to select “Other” and write in a barrier that was not included in the list of options. Among the write-in responses, the following barriers were listed most frequently (an example excerpt is included for each barrier):

- Lack of opportunity to practice and apply knowledge from trainings

“We are pretty decent at training staff when needed but the problem is we can often go more than a year before needing the knowledge again which allows large gaps to rapidly emerge.”

- High staff turnover/staff rotation out of department

“Short tenures (job-hopping) by new staff (on average) disincentives putting resources into training. Training is often put on individual team leaders to do on their own time.”

- Insufficient funding

“Limited budget to support training”

- Lack of motivation or interest from staff

“Overconfidence - many people think ‘I know this stuff’ and they don’t understand it as well as they think they do.”

5.5. What Makes Training Effective

The survey asked respondents to identify the greatest strength of the training program or practices at their organization. This was a free-response question for which a thematic analysis was carried out (please see Section 3.2). There were 72 responses to this question; a breakdown by respondent organization type can be found in **Table 6**. Below are the main strengths identified based on the responses.

All percentages refer to the percent of responses out of the number of respondents who answered the question. Percentages by organization type are provided for TxDOT and other DOTs, but only if they represent at least three excerpts.

Table 6. Response breakdown for strengths question.

Organization Type	Number of Respondents
TxDOT	25
Other DOT	29
Business/Private Sector	14
City/County Department	4

Training availability, accessibility, and variety. 29% of respondents (48% of respondents from TxDOT and 17% of respondents from other DOTs) noted access to trainings as a strength of their organization’s training program. Specifically, they mentioned that trainings are readily available to them, easy to locate, and are offered across a range of topics. A few excerpts are included below:

“The greatest strength of the trainings...are the wide range and variety of trainings offered and their accessibility, with most being offered virtually.”

“[A strength is] The variety and willingness to send people to training.”

“We are able to budget appropriately for training and can pull from a wide variety of sources.”

Learning on the job. 26% of respondents (20% of respondents from TxDOT and 28% of respondents from other DOTs) mentioned on-the-job training as a strength of their organization’s training program. This included mention of peer-to-peer engagement, mentorship from more experienced staff, and real-time feedback on projects. Multiple respondents expressed the importance of being able to connect with other staff and lean on each other for support. Respondents also expressed that working on a real project with proper guidance is a powerful learning tool. A few excerpts are included below:

“When specific information is needed quickly, a subject matter expert is usually available to assist with instruction.”

“The strength of our training is that it is tied to real work. I have learned a lot from working on actual projects, asking questions, and learning from experienced supervisors and coworkers.”

“[A strength is] Our mentorship and availability to help all staff members through challenging issues.”

Needs-based and personalized trainings. 15% of respondents (12% of respondents from TxDOT and 17% of respondents from other DOTs) expressed that a strength of the trainings at their organizations is that they are tailored to staff needs. Respondents expressed a preference for trainings that are specific to their job and adaptive. Some respondents indicated this was accomplished through training-needs surveys, while others noted the ability of trainers to adapt trainings in real time depending on the audience. A few excerpts are included below:

“[A strength is] Understanding the audience having different learning speeds and identifying curriculum that best helps the "new" along with "experienced" user.”

“We evaluate staff competency and needs to select/prioritize training courses.”

“The formal trainings we do for our group are done by experts in our group and tailored to the work we do.”

Up-to-date trainings. 13% of respondents (21% of respondents from other DOTs) mentioned that keeping trainings updated was a strength of their organization. Respondents noted the importance of having trainings that follow the latest software, policies, and science. A few excerpts are included below:

“Appreciate how the trainings follow the latest versions of the software.”

“We are constantly updating trainings every 2-3 years with best available science.”

“We are constantly updating the training based on updates in software e.g. HEC-RAS versions and features.”

Chapter 6. Recommendations

6.1. Recommendations Directly from Respondents

The survey asked respondents whether they had any recommendations for H&H trainings at their organization. This was a free-response question for which a thematic analysis was carried out (please see Section 3.2). There were 49 responses to this question—a breakdown by respondent organization type can be found in **Table 7**. Below are the main recommendations identified based on those responses.

All percentages refer to the percent of responses out of the number of respondents who answered the question. Percentages by organization type are provided for TxDOT and other DOTs, but only if they represent at least three excerpts.

Table 7. Response breakdown for recommendations question.

Organization Type	Number of Respondents
TxDOT	16
Other DOT	20
Business/Private Sector	8
City/County Department	5

Applied trainings. 20% of respondents (31% of respondents from TxDOT) recommended that trainings should be centered around real-world examples. Respondents indicated a preference for trainings that allow them to work through practical problems step by step. A few excerpts are included below:

“We could definitely benefit from more real-world examples and trainings. All of the trainings are for ideal, simple conditions, that aren't always beneficial when you are trying to perform modeling and analysis on complicated locations.”

“I also think more training based on real project examples, modeling, permitting, and lessons learned would be useful. Workshops led by seasoned professional within the agency add a lot of value because they bring practical experience, real world perspective, and lessons that are not always captured in formal training.”

“Field trips to view actual installations and operation of drainage facilities would be valuable.”

In-person and organization-specific. 18% of respondents (15% of respondents from other DOTs) expressed that trainings work best when they are adaptable and tailored to a department’s needs. Specifically, multiple respondents recommended in-person or in-house training (conducted by staff from within the department) to increase engagement and allow the instructor to modify trainings as needed. A few excerpts are included below:

“[I recommend] Department specific training by supervisors.”

“Training that covers technical concepts is best done in-person where the instructor can gauge participant comprehension, and modify or augment as needed.”

“It is best to have the training focused on how our organization's criteria are met by the training.”

Staff and resources. 18% of respondents (30% of respondents from other DOTs) expressed a desire for additional resources, whether that be funding, more H&H staff, dedicated training staff, or increased access to trainings. A few excerpts are included below:

“We need additional staff or consultant augmentation to deliver our historical training offerings.”

“We need more funding for Training.”

“I would love for H&H educator role that could focus on staff development for the State.”

6.2. Recommendations Based on Data Analysis

The following list of recommendations was developed based on the overall results of the survey. Recommendations are split into three sections: training delivery, topic area prioritization, and underlying barriers.

6.2.1. Training Delivery

Prioritize applied trainings and provide in-house trainings where possible.

Nearly half of all respondents to the informal training free-response question mentioned applied training in their response. Applied training refers to trainings that center around real-world examples, allowing a trainee to problem-solve and receive guidance or feedback on the results. Respondents indicated they value trainings that are practical and meant to address the specific challenges they face on the job. As mentioned in Section 6.1 of this report, trainings may benefit from leveraging in-house resources such as department supervisors or subject matter experts to increase access to applied trainings. Having someone from within a specific department or from a specific office allows the trainings to be more targeted and tailored to the needs of staff. Support should be given to departments to develop their own in-house resources, with focus on trainings that involve practical application, problem solving, and realistic examples. As seen in **Fig. 29** there is also an opportunity to expand the Applied Design Training (ADT) methods currently utilized by TxDOT and some private sector organizations to fill potential applied training gaps at other organizations.

Increase live training options with a focus on flexibility. The results in **Fig. 24** indicate that respondents prefer live trainings, whether those trainings be in-person or virtual, formal or informal. **Fig. 25** and **Fig. 26** show that in-person training poses a potential opportunity because it falls in the above-median preference but below-median prevalence category among respondents at both TxDOT and other DOTs. In the responses to the free-response questions, survey takers indicated that live trainings are beneficial because they can be adapted in the moment according to the needs of the audience and because staff questions can be answered in real time. Overall, this indicates that live training options are preferable. However, live trainings require special attention to flexibility to ensure that staff can access them. Some respondents indicated that travel money, travel time, and scheduling conflicts may hinder their ability to take advantage of in-person training options. Ways to increase the accessibility of live trainings can include offering multiple trainings session options, recording live virtual sessions, and providing travel stipends as needed.

Leverage existing trainings. **Fig. 5** shows which entities respondents from different organization types have relied on for trainings. The results indicate that respondents from TxDOT have relied mostly on state trainings, respondents from other DOTs have relied mostly on National Highway Institute (NHI) trainings, and respondents from the private sector and local government agencies have relied mostly on private sector trainings (but with a more even spread across other

trainings entities as well). **Fig. 10** and **Fig. 11** show how respondents ranked the organizations they have taken trainings with. The results show that the state trainings and NHI trainings were consistently ranked highly by respondents from TxDOT and other DOTs. Moreover, in the free response questions, a few respondents praised NHI trainings directly, saying they are effective. This indicates a potential opportunity to leverage NHI trainings to address any existing trainings gaps.

6.2.2. Topic Area Prioritization

Prioritize topic areas with identified gaps. **Fig. 34** indicates four topic areas where potential gaps were identified. **Fig. 35** and **Fig. 36** show similar results, but broken down for TxDOT and other DOTs, respectively. These figures indicate topic areas that were ranked as having high importance but that also have at least one knowledge gap (either low confidence, high respondent-reported gap, or low training impact). Using these results, TxDOT and other DOTs could target topics that would benefit most from training improvements. The results indicate that TxDOT should focus training improvements in Storm Drain/Sewer, Bridge Hydraulics, Hydraulics Modeling, Hydrologic Modeling, and Culverts. It should be noted that all four organization types have overlap in identified gaps for Storm Drain/Sewer, Hydraulics Modeling, and Hydrologic Modeling. This may present an opportunity for collaboration to address these gaps.

6.2.3. Underlying Barriers

Ensure adequate staff and resources. To maximize training effectiveness, organizations should ensure their departments have adequate staff and resources to carry out necessary trainings. As seen in **Fig. 40**, respondents identified lack of time as the greatest challenge they faced with their own training, followed by lack of resources and information overload. In the free-response answers, respondents echoed this sentiment, recommending either additional funding or additional staff as improvements to their organization's training program. Some respondents cited turnover as an issue that prevents the transfer of knowledge from more experienced staff to newer staff at their organization. To maximize any training program improvements, these underlying barriers must also be addressed.

Maximize consistency of informal training. The survey results indicate that informal training is a vital part of knowledge transfer in an organization. **Fig. 27** shows informal training as the most prevalent method of knowledge transfer across all respondent organization types. In the responses to the free-response questions, survey takers mentioned the importance of informal training,

emphasizing the value of working directly with peers or mentors on real-world projects. However, as respondents also noted, informal training tends to be inconsistent and highly dependent on who is delivering the training. Because of the casual and unofficial nature of informal training, this is a challenging issue to address. Potential solutions could involve structured discussions with staff around training philosophy or efforts toward more formal mentoring and shadowing programs. As noted by respondents, informal training should be supplemented with written documentation (SOPs, manuals, etc.) to ensure all staff receive adequate and standardized information throughout their training.

Chapter 7. Value of Research

7.1. Introduction

In accordance with the scope of TxDOT Project 0-7271, *Synthesis: Assess Transportation Agency Approaches to Training and Developing Hydrology and Hydraulics (H&H) Staff*, the Research Team at CTR has prepared an estimate for the Value of Research (VoR) associated with the research products delivered for this project.

The benefit areas deemed relevant and identified by the Receiving Agency in conjunction with the Performing Agency for the purpose of establishing the VoR encompass both qualitative and economic areas. The benefit areas identified for this project are summarized in **Table 8** on the following page.

7.2. Qualitative Benefit Areas

7.2.1. Level of Knowledge

The results of this study have provided significant perspective on the priority areas of interest of H&H staff across DOTs nationwide (including TxDOT), as well as across city/county departments and business/private sector organizations in Texas. The survey responses (which admittedly carry subjectivity) made possible the evaluation of relative confidence levels of staff across different topic areas, as well as the evaluation of the effectiveness of training programs targeting those topic areas and the training methods used to deliver them. With participation in the survey from 28 DOTs (TxDOT included), and at least 16 (of 25) different districts statewide within TxDOT, significant perspective was gained on the current state of knowledge and knowledge transfer that occurs within the H&H sector of the transportation industry, which was largely unknown prior to this study. The survey respondents provided a wealth of information, and analysis of their responses yielded an understanding of presently-used effective strategies and suggested recommendations to improve training capabilities and address identified gaps in knowledge transfer approaches. For example, the data indicated a training gap in the storm drain/sewer topic area, despite it being ranked as high priority by respondents. With this information, TxDOT has an opportunity to develop specialized trainings in storm drain/sewer, and/or incorporate it into their own programming, to get ahead of the curve and proactively lead this effort for future growth and efficiency.

Table 8. Selected Benefit Areas for Project 0-7271

Selected	Benefit Area	Qual	Econ	Both	TxDOT	State	Both
X	Level of Knowledge	X			X		
	Management and Policy	X			X		
	Quality of Life	X			X		
	Customer Satisfaction	X			X		
	Environmental Sustainability	X				X	
	System Reliability		X		X		
	Increased Service Life		X		X		
X	Improved Productivity and Work Efficiency		X		X		
X	Expedited Project Delivery		X		X		
	Reduced Administrative Costs		X		X		
	Traffic and Congestion Reduction		X			X	
	Reduced User Cost		X			X	
	Reduced Construction, Operations, and Maintenance Cost		X			X	
	Materials and Pavements		X			X	
	Infrastructure Condition		X				X
	Freight movement and Economic Vitality		X				X
	Intelligent Transportation Systems		X				X
X	Engineering Design Improvement			X			X
	Safety			X			X

7.2.2. Engineering Design Improvement

Without a deep background in a particular topic area, coupled with experience in design and confidence in decision-making processes, it can be difficult for an engineer to translate classroom knowledge into effective design practices. Exposure to real problems through hands-on or applied training and mentoring is essential to prepare engineers to tackle increasingly complex or novel issues. The aim of this study is to identify potential training program improvements that address this and lead to more comprehensive, effective, and proactive solutions for H&H issues in the transportation sector. These improvements in engineering design can have significant impacts, such as reduced flood risk, and can help reduce unintended negative consequences that may arise in designs carried out with limited expertise.

7.3. Economic Benefits

Economic analysis pertaining to three functional areas relevant to the performance of this project and identified in the project agreement was requested.

- (a) Expedited Project Delivery
- (b) Improved Productivity and Work Efficiency
- (c) Engineering Design Improvement

Analyzing these functional areas, the research team generated **Fig. 41**, which can be found in the following section (7.4). The considerations that went into the computation of the VoR (explained in greater detail below) can be summarized as follows.

To estimate the value of *expedited project delivery*, consider an idealized hypothetical project involving the H&H engineers of TxDOT. Assume a typical project duration of 18 months, where the H&H component may cost an average of \$175,000, according to estimates provided by the Receiving Agency. For a new project, engineers may spend anywhere between 5-30% of their time learning skills and knowledge required to tackle the project at hand, on an as-needed basis. This range is fairly broad, given an array of expertise and experience, which can be highly variable across a team of staff engineers.

The synthesis project completed herein has an ultimate goal of improving the training of H&H staff within TxDOT (as well as across the transportation industry in the US). Thus, if improvements to training and learning on a regular basis can reduce the amount of ad hoc training needed on a project-by-project basis, a

notable reduction in the amount of time the H&H engineers need to spend *learning* the information required to approach the new project can be expected. Project time can instead be used to address the problems at hand in a solution-oriented manner more expeditiously.

If, for the sake of estimation, improved training of H&H staff results in project completion time reduction of 10% (through proactive training that eliminates the 5-30% spent on learning for each new project), then \$17,500 per 18-month project, or roughly \$11,700 annually, would be saved. Over the last year, over 800 projects were carried out across all of TxDOT that involved an H&H component. With an estimated savings of \$11,700 per year per project, a total of \$9.36M per year is calculated, across the entire state of Texas.

Considering *improved productivity and work efficiency*, a roughly 10% improvement in efficiency can again be estimated if improvements to training lead to an increase in staff knowledge, retention, and confidence in approaching new situations. One of the barriers to training noted in the survey was time available to participate in trainings and to participate in mentoring or informal training experiences, which are highly valuable in staff development. By improving productivity and work efficiency, time becomes available for dedicated professional development and knowledge training experiences for H&H staff. This can lead to improved employee satisfaction in their roles and increased retention, thus reducing the burden of subsequent searches for replacement staff incurred from high turnover rates. Ultimately, this can result in a reduction of the costs associated with routine hiring (i.e. recruiting and onboarding) of early career employees. The H&H workforce across TxDOT hovers around 100 staff members, with salaries of roughly \$110,000 annually (with variation according to experience level and role). Estimates of onboarding, insurance, and other logistics associated with hiring of engineers in state roles are roughly 30% of annual salary. Assuming 15% H&H staff turnover annually, (thus, the search and hire for roughly 15 engineers each year), the direct cost incurred is equal to \$450,000. If this turnover can be reduced to 5% through improvements in training and mentoring, and therefore improved morale that supports retention, the resultant savings are estimated to be \$300,000 annually. In addition, there are programs within TxDOT in which employees rotate through different specialty areas (such as H&H) and so there would likely be additional benefits to TxDOT beyond the 100 H&H-focused employees accounted for within this calculation.

Further, improved efficiency and growth in the knowledge base within TxDOT's H&H staff means there is the potential to reduce TxDOT's reliance on hiring

consultants from private firms to fill gaps, for example, in areas such as hydraulics modeling. By improving training and mentorship in targeted areas, TxDOT could handle more of their work in-house, thus leading to future cost savings that are not included in the present calculation.

With regard to engineering design improvement, consider the following approach: improvements in training and knowledge of H&H staff in the transportation industry will result in fewer unintended negative consequences, and subsequently will reduce the likelihood for designs to result in lawsuits or other difficult outcomes for TxDOT and for local communities. There have been a few recent tragic events with which TxDOT was (or is) involved, where unfortunate H&H-related outcomes have been said by media outlets to be linked with TxDOT activity.

For example, it has been surmised that modifications to IH-10 are responsible for flooding of the Devillier ranch, following Hurricanes Harvey (2017) and Imelda (2019), due to highway median barriers acting as dams and restricting the drainage of floodwaters. Another example in 2016 includes lawsuits against TxDOT regarding potential threats to three endangered species found within environmentally sensitive areas that intersect with an Austin highway expansion where sediment management was of concern.

It is estimated that TxDOT spends on the order of \$10M annually on legal services provided by the Texas Office of the Attorney General. For the sake of estimation, assume the legal expenses associated with H&H-related issues such as those mentioned above are roughly \$1M per case, and perhaps there is an H&H-related case of notable magnitude every 5 years. This results in approximately \$200,000 savings in legal expenses annually, provided that improvements in H&H staff training result in fewer negative outcomes that are potentially deemed the result of TxDOT activity. This is a conservative estimate, as it does not include any potential payouts to plaintiffs, in the event that TxDOT activity is found responsible for unfortunate H&H consequences.

Accumulating annual cost savings from the three economic benefit areas discussed in this section yields a savings in year 1 of \$1.085M. Assuming these are repeated annual savings at a 3% inflation rate, a 5-year period with consistent economic savings given the improvements to training results in a total of \$5.76M, upon which the subsequent VoR is based.

7.4. Computed Value of Research (VoR)

The values discussed above have been compiled into computation of the VoR, summarized in **Fig. 41**, including the calculation of the net present value of the research over a 20 year period.



Fig. 41. Summary of VoR Calculations for Project 0-7271

7.5. Discussion

Overall, the results of this study suggest that H&H staff are aware of the importance of workforce training and the effect it has on their ability to perform well in their jobs. Trainings can have compounding effects, not only improving performance of the staff member who receives the training, but also of the other staff members who interact with that employee. This is evident when analyzing responses from survey takers on the free response questions of the survey. Survey takers noted the importance of relying on experienced peers and supervisors to aid in knowledge transfer and to supplement formal trainings they receive. This indicates that knowledge disseminates across employees, and that training improvements have a wide reach, well beyond the staff who directly receive each training. Therefore, an effective training program provides the foundation for effective knowledge transfer from experienced staff to newer staff at an organization.

Many survey takers also noted that a majority of the trainings they receive are informal. While highly important, informal trainings have the potential to be inconsistent and dependent on the abilities and time constraints of the individual mentor/peer/supervisor delivering the training. This further highlights the importance of robust training programs that provide a strong knowledge base for staff to build off. The more standardization and resources that can be provided, the more productive and consistent informal training can be. Through a strong training program, knowledge transfer becomes more fruitful, and agencies like TxDOT perform more effectively as an organization.

This VoR estimate was developed by the research team based on an understanding of the functional areas and an assessment of the relative importance of various factors. This estimate includes several assumptions that broadly characterize the landscape of engineers at state agencies and bulk statistics, with specific metrics about TxDOT H&H staff provided by the Receiving Agency as requested. The values highlighted are conservative estimates only, but they can provide a means to evaluate the potential economic savings associated with improvements in knowledge delivery and mentoring relationships. Although it is difficult to quantify the monetary value of knowledge, the impacts can be long-lasting and significant.

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Appendix A: Survey

Survey Questions

Start of Block: Block 1 - Introduction

Introduction

Thank you for participating in this study titled: *Assessing approaches to training and developing hydrology and hydraulics (H&H) staff at TxDOT and other organizations*. The study seeks to analyze the current state of H&H training programs at the Texas Department of Transportation (TxDOT) and other agencies/DOTs throughout the U.S. to find potential opportunities for improving them.

The survey will ask you about your organization's H&H training practices. It includes questions about your organization (where you work, what kind of projects your organization focuses on, etc.); your professional experience (your specialization, what training materials you have used, etc.); and on your perspectives (opportunities and challenges) on the current state of H&H training at your organization.

Your participation is voluntary and it is totally up to you to decide whether you want to participate. Even if you decide to be a part of the study now, you may change your mind and stop at any time. You may also skip questions, if desired.

Your privacy is important to us. The raw survey data is only visible to the UT Austin survey team. All survey data we collect will be de-identified, meaning we will separate your answers from any information that could identify you personally. Any contact information you provide will only be used to follow up with you (if needed) and will not be shared with anyone outside of the survey team.

At the end of the survey, we will ask for your permission to follow-up if we have any clarifying questions. We expect that this survey will take about 20 minutes to complete.

Contact Information:

If you have any questions, concerns, or complaints about this research now or in the future, you may contact our team at:

Blair Johnson Associate Professor, University of Texas at Austin
Phone: 512-232-1863 Email: blairjohnson@utexas.edu

Isabel Gonzalez-Garcia Graduate Research Assistant, University of Texas at Austin

Email: isg375@my.utexas.edu

If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researchers, please contact the following:

The University of Texas at Austin Institutional Review Board

Phone: 512-232-1543 Email: irb@austin.utexas.edu

Press the arrow to advance to the next page and start the survey.

Section 1 of 7: Where do you work and what is your role?

The questions in this survey will refer to your "organization" or "department". By "organization" or "department", we are referring to the organization, institution, business, department, or agency you currently work for.

How do you best classify your organization or department?

- ☐ Federal Agency (1)
- ☐ State Agency (2)
- ☐ County Department (3)
- ☐ City Department (4)
- ☐ Academia (5)
- ☐ Business/Private Sector (6)
- ☐ Nonprofit or community-based group (7)
- ☐ Other (please specify) (8) _____

Do you currently work at the Texas Department of Transportation (TxDOT)?

☐ Yes (1)

☐ No, I do not work for TxDOT (2)

What is the name of your organization? Please be as specific as possible.

What is your current position at your organization? Please list title and department, including division or district if applicable (e.g., Transportation Engineer, Transportation Planning and Programming Division).

How many years of experience do you have working in hydrology & hydraulics (H&H) for the transportation industry? This question refers to overall years of experience after college, including advanced degrees (Masters or PhD) and/or any organizations or departments you may have worked for before your current position.

- ☐ 0 to 3 years (1)
- ☐ 3 to 6 years (2)
- ☐ 6 to 10 years (3)
- ☐ 10 to 15 years (4)
- ☐ 15 to 20 years (5)
- ☐ Over 20 years (6)

Are you (or have you been) in a role where you supervise others on H&H projects?

- ☐ Yes (1)
- ☐ No (2)

End of Block: Block 1 - Introduction

Start of Block: Block 2: Training Experience

Section 2 of 7: Experience with H&H Trainings

Please indicate which entities you have received formal job training from (select all that apply).

This question refers to training you have received at any point in your professional career.

- ☐ Federal Highway Administration (1)
- ☐ National Highway Institute (2)
- ☐ American Society of Civil Engineers (please specify institute: EWRI, G-I, T&D, etc) (3)
- ☐ Army Corps of Engineers (4)
- ☐ My State DOT (please specify which state) (5) _____
- ☐ Academic Institution (Please specify which institution) (6) _____
- ☐ Private Sector Organization (please specify which organization) (7)
- ☐ Other (Please specify) (8) _____



Below is a list of common H&H discipline/topic areas. Indicate in which areas you have received formal training and who the training was from, to the best of your recollection (select all that apply).

Some trainings at your organization may actually be national or state trainings that your organization has adopted/renamed. Please keep this in mind and answer the questions to the best of your ability.

If you work at TxDOT, you can see a flow chart of H&H trainings at this link.

If you are not sure who you received a training from, you can select the option in the last column. If you did not receive training in a topic area, you should leave the row blank.

Basic Hydraulics (1)	☐ Federal Highway Administration (1)	☐ National Highway Institute (2)	☐ American Society of Civil Engineers (3)	☐ Army Corps of Engineers (4)	☐ My State DOT (5)	☐ Academic Institution (6)	☐ Private Sector Organization (7)	☐ Other (8)	☐ I received training in this topic, but I am not sure from who (9)
Hydraulics Modeling (2)	☐ Federal Highway Administration (1)	☐ National Highway Institute (2)	☐ American Society of Civil Engineers (3)	☐ Army Corps of Engineers (4)	☐ My State DOT (5)	☐ Academic Institution (6)	☐ Private Sector Organization (7)	☐ Other (8)	☐ I received training in this topic, but I am not sure from who (9)
Basic Hydrology (3)	☐ Federal Highway Administration (1)	☐ National Highway Institute (2)	☐ American Society of Civil Engineers (3)	☐ Army Corps of Engineers (4)	☐ My State DOT (5)	☐ Academic Institution (6)	☐ Private Sector Organization (7)	☐ Other (8)	☐ I received training in this topic, but I am not sure from who (9)

Hydrologic Modeling (4)	☐ Federal Highway Administration (1)	☐ National Highway Institute (2)	☐ American Society of Civil Engineers (3)	☐ Army Corps of Engineers (4)	☐ My State DOT (5)	☐ Academic Institution (6)	☐ Private Sector Organization (7)	☐ Other (8)	☐ I received training in this topic, but I am not sure from who (9)
Storm Drain/Sewer (5)	☐ Federal Highway Administration (1)	☐ National Highway Institute (2)	☐ American Society of Civil Engineers (3)	☐ Army Corps of Engineers (4)	☐ My State DOT (5)	☐ Academic Institution (6)	☐ Private Sector Organization (7)	☐ Other (8)	☐ I received training in this topic, but I am not sure from who (9)
Culverts (6)	☐ Federal Highway Administration (1)	☐ National Highway Institute (2)	☐ American Society of Civil Engineers (3)	☐ Army Corps of Engineers (4)	☐ My State DOT (5)	☐ Academic Institution (6)	☐ Private Sector Organization (7)	☐ Other (8)	☐ I received training in this topic, but I am not sure from who (9)
Open Channel (7)	☐ Federal Highway Administration (1)	☐ National Highway Institute (2)	☐ American Society of Civil Engineers (3)	☐ Army Corps of Engineers (4)	☐ My State DOT (5)	☐ Academic Institution (6)	☐ Private Sector Organization (7)	☐ Other (8)	☐ I received training in this topic, but I am not sure from who (9)
Bridge Hydraulics (8)	☐ Federal Highway Administration (1)	☐ National Highway Institute (2)	☐ American Society of Civil Engineers (3)	☐ Army Corps of Engineers (4)	☐ My State DOT (5)	☐ Academic Institution (6)	☐ Private Sector Organization (7)	☐ Other (8)	☐ I received training in this topic, but I am not sure from who (9)
Stream Stability (9)	☐ Federal	☐ National	☐ American	☐ Army	☐ My	☐ Academic	☐ Private	☐ Other	☐ I

	Highway Administration (1)	Highway Institute (2)	Society of Civil Engineers (3)	Corps of Engineers (4)	State DOT (5)	Institution (6)	Sector Organization (7)	(8)	received training in this topic, but I am not sure from who (9)
Floodplain (10)	☐ Federal Highway Administration (1)	☐ National Highway Institute (2)	☐ American Society of Civil Engineers (3)	☐ Army Corps of Engineers (4)	☐ My State DOT (5)	☐ Academic Institution (6)	☐ Private Sector Organization (7)	☐ Other (8)	☐ I received training in this topic, but I am not sure from who (9)
Resilience (11)	☐ Federal Highway Administration (1)	☐ National Highway Institute (2)	☐ American Society of Civil Engineers (3)	☐ Army Corps of Engineers (4)	☐ My State DOT (5)	☐ Academic Institution (6)	☐ Private Sector Organization (7)	☐ Other (8)	☐ I received training in this topic, but I am not sure from who (9)
Drainage (12)	☐ Federal Highway Administration (1)	☐ National Highway Institute (2)	☐ American Society of Civil Engineers (3)	☐ Army Corps of Engineers (4)	☐ My State DOT (5)	☐ Academic Institution (6)	☐ Private Sector Organization (7)	☐ Other (8)	☐ I received training in this topic, but I am not sure from who (9)
Detention (13)	☐ Federal Highway Administration (1)	☐ National Highway Institute (2)	☐ American Society of Civil Engineers (3)	☐ Army Corps of Engineers (4)	☐ My State DOT (5)	☐ Academic Institution (6)	☐ Private Sector Organization (7)	☐ Other (8)	☐ I received training in this topic, but I am not sure from who (9)
Other (Please specify) (14)	☐ Federal Highway Administration	☐ National Highway Institute (2)	☐ American Society of Civil	☐ Army Corps of Engineers	☐ My State DOT	☐ Academic Institution (6)	☐ Private Sector Organization	☐ Other (8)	☐ I received training in

(1)

Engineers (3)

(4)

(5)

(7)

this topic, but
I am not sure
from who (9)

Of the following H&H topic areas, which have you applied in your work? "Your work" refers to any work experience you have had, at your current organization or otherwise, specifically in the transportation industry. Select all that apply.

- ☐ Basic Hydraulics (1)
- ☐ Hydraulics Modeling (2)
- ☐ Basic Hydrology (3)
- ☐ Hydrologic Modeling (4)
- ☐ Storm Drain/Sewer (5)
- ☐ Culverts (6)
- ☐ Open Channel (7)
- ☐ Bridge Hydraulics (8)
- ☐ Stream Stability (9)
- ☐ Floodplain (10)
- ☐ Resilience (11)
- ☐ Drainage (12)
- ☐ Detention (13)
- ☐ \${training_areas/ChoiceTextEntryValue/14} (14)

The preservation of institutional knowledge is an important characteristic of a successful organization. We are interested in how knowledge is transferred from seasoned staff to newer staff at your organization. Please select any methods that you have utilized at your **current** organization.

You may select all that apply.

- ☐ Formal mentoring program (1)
- ☐ Shadowing (2)
- ☐ Quality control/peer review process (3)
- ☐ Informal (peer to peer or mentor to peer) (4)
- ☐ Other (please specify) (5) _____

The Texas Department of Transportation employs a methodology called Applied Design Training (ADT). We are curious to know if other organizations across the U.S. offer a similar type of training for their staff.

Please read the definition below and tell us whether your organization has a similar program.

Applied Design Training: ADT is a collaborative training method that focuses on a specific type of design that is common for H&H staff (for example: off-system bridge replacement). The process involves formal training on the design process combined with hands-on workshops, peer mentoring, trouble-shooting workshops, and collaborative quality control reviews. It is meant to target knowledge gaps and be an immersive process that teaches H&H staff a specific design skill over a set amount of time.

- ☐ Yes, my organization has an ADT program or a training program that follows a very similar methodology to ADT. (1)
- ☐ My organization does not have an ADT program, but we do employ a different innovative and immersive training methodology to address gaps in design knowledge for our staff. (2)
- ☐ No, my organization does not have any program similar to this or any program specifically for addressing gaps in design knowledge for staff. (3)
- ☐ I don't know if there is a program similar to this at my organization. (4)

End of Block: Block 2: Training Experience

Start of Block: Block 3: Training Perceptions



Section 3 of 7: Evaluating H&H Training Priorities and Efficacy

Please rank the following topics based on how important they are to your **current** organization.

To rank each option, type a number from 1 to 14 into the box next to it. Please only assign each ranking once. Ranking a topic "1" would mean it is the **most important** to your organization.

If you work for an organization that spans multiple disciplines or geographic areas, please answer this for your specific office (i.e., the specific city and department you work in).

- Basic Hydraulics (1)
- Hydraulics Modeling (2)
- Basic Hydrology (3)
- Hydrologic Modeling (4)
- Storm Drain/Sewer (5)
- Culverts (6)
- Open Channel (7)
- Bridge Hydraulics (8)
- Stream Stability (9)
- Floodplain (10)
- Resilience (11)
- Drainage (12)
- Detention (13)
- [\\${training_areas/ChoiceTextEntryValue/14}](#) (14)

Indicate how **confident** you feel in each of the following disciplines:

Basic Hydraulics (2)	☐ Not at all confident (1)	☐ Somewhat confident (2)	☐ Moderately confident (3)	☐ Very confident (4)
Hydraulics Modeling (3)	☐ Not at all confident (1)	☐ Somewhat confident (2)	☐ Moderately confident (3)	☐ Very confident (4)
Basic Hydrology (4)	☐ Not at all confident (1)	☐ Somewhat confident (2)	☐ Moderately confident (3)	☐ Very confident (4)
Hydrologic Modeling (5)	☐ Not at all confident (1)	☐ Somewhat confident (2)	☐ Moderately confident (3)	☐ Very confident (4)
Storm Drain/Sewer (6)	☐ Not at all confident (1)	☐ Somewhat confident (2)	☐ Moderately confident (3)	☐ Very confident (4)
Culverts (7)	☐ Not at all confident (1)	☐ Somewhat confident (2)	☐ Moderately confident (3)	☐ Very confident (4)
Open Channel (8)	☐ Not at all confident (1)	☐ Somewhat confident (2)	☐ Moderately confident (3)	☐ Very confident (4)
Bridge Hydraulics (9)	☐ Not at all confident (1)	☐ Somewhat confident (2)	☐ Moderately confident (3)	☐ Very confident (4)

Stream Stability (10)	☐ Not at all confident (1)	☐ Somewhat confident (2)	☐ Moderately confident (3)	☐ Very confident (4)
Floodplain (11)	☐ Not at all confident (1)	☐ Somewhat confident (2)	☐ Moderately confident (3)	☐ Very confident (4)
Resilience (12)	☐ Not at all confident (1)	☐ Somewhat confident (2)	☐ Moderately confident (3)	☐ Very confident (4)
Drainage (13)	☐ Not at all confident (1)	☐ Somewhat confident (2)	☐ Moderately confident (3)	☐ Very confident (4)
Detention (14)	☐ Not at all confident (1)	☐ Somewhat confident (2)	☐ Moderately confident (3)	☐ Very confident (4)
<code>#{training_areas/ChoiceTextEntryValue/14}</code> (15)	☐ Not at all confident (1)	☐ Somewhat confident (2)	☐ Moderately confident (3)	☐ Very confident (4)

Earlier, you specified in which areas you have received formal training. Please indicate to what extent you believe the training you received in each topic area has improved your ability to do your job effectively.

The following definitions apply:

No Impact: The trainings I received in this topic area had no effect on my ability to do my job effectively.

Minimal Impact: The trainings I received in this topic area have slightly improved my ability to do my job effectively.

Moderate impact: The trainings I received in this topic area have moderately improved my ability to do my job effectively.

Considerable impact: The trainings I received in this topic area have greatly improved my ability to do my job effectively.

$\text{\$}\{\text{training_areas}/\text{ChoiceDescription}/1\}$ (2)	☐ No Impact (1)	☐ Minimal Impact (2)	☐ Moderate Impact (3)	☐ Considerable Impact (4)
$\text{\$}\{\text{training_areas}/\text{ChoiceDescription}/2\}$ (3)	☐ No Impact (1)	☐ Minimal Impact (2)	☐ Moderate Impact (3)	☐ Considerable Impact (4)
$\text{\$}\{\text{training_areas}/\text{ChoiceDescription}/3\}$ (4)	☐ No Impact (1)	☐ Minimal Impact (2)	☐ Moderate Impact (3)	☐ Considerable Impact (4)
$\text{\$}\{\text{training_areas}/\text{ChoiceDescription}/4\}$ (5)	☐ No Impact (1)	☐ Minimal Impact (2)	☐ Moderate Impact (3)	☐ Considerable Impact (4)
$\text{\$}\{\text{training_areas}/\text{ChoiceDescription}/5\}$ (6)	☐ No Impact (1)	☐ Minimal Impact (2)	☐ Moderate Impact (3)	☐ Considerable Impact (4)
$\text{\$}\{\text{training_areas}/\text{ChoiceDescription}/6\}$ (7)	☐ No Impact (1)	☐ Minimal Impact (2)	☐ Moderate Impact (3)	☐ Considerable Impact (4)

$\{\text{training_areas}/\text{ChoiceDescription}/7\}$ (8)	☐ No Impact (1)	☐ Minimal Impact (2)	☐ Moderate Impact (3)	☐ Considerable Impact (4)
$\{\text{training_areas}/\text{ChoiceDescription}/8\}$ (9)	☐ No Impact (1)	☐ Minimal Impact (2)	☐ Moderate Impact (3)	☐ Considerable Impact (4)
$\{\text{training_areas}/\text{ChoiceDescription}/9\}$ (10)	☐ No Impact (1)	☐ Minimal Impact (2)	☐ Moderate Impact (3)	☐ Considerable Impact (4)
$\{\text{training_areas}/\text{ChoiceDescription}/10\}$ (11)	☐ No Impact (1)	☐ Minimal Impact (2)	☐ Moderate Impact (3)	☐ Considerable Impact (4)
$\{\text{training_areas}/\text{ChoiceDescription}/11\}$ (12)	☐ No Impact (1)	☐ Minimal Impact (2)	☐ Moderate Impact (3)	☐ Considerable Impact (4)
$\{\text{training_areas}/\text{ChoiceDescription}/12\}$ (13)	☐ No Impact (1)	☐ Minimal Impact (2)	☐ Moderate Impact (3)	☐ Considerable Impact (4)
$\{\text{training_areas}/\text{ChoiceDescription}/13\}$ (14)	☐ No Impact (1)	☐ Minimal Impact (2)	☐ Moderate Impact (3)	☐ Considerable Impact (4)
$\{\text{training_areas}/\text{ChoiceTextEntryValue}/14\}$ (15)	☐ No Impact (1)	☐ Minimal Impact (2)	☐ Moderate Impact (3)	☐ Considerable Impact (4)



Please rank the following organizations based on how effective you believe the trainings you've taken with them were.

To rank each option, type a number into the box next to it. Please only assign each ranking once. Ranking an organization "1" would mean their trainings were the **most effective**.

- _____ Federal Highway Administration (1)
- _____ National Highway Institute (2)
- _____ American Society of Civil Engineers (please specify institute: EWRI, G-I, T&D, etc) (3)
- _____ Army Corps of Engineers (4)
- _____ My State DOT (please specify which state) (5)
- _____ Academic Institution (Please specify which institution) (6)
- _____ Private Sector Organization (please specify which organization) (7)
- _____ Other (Please specify) (8)

We are interested in what challenges you have faced with regard to your own training and transfer of knowledge.

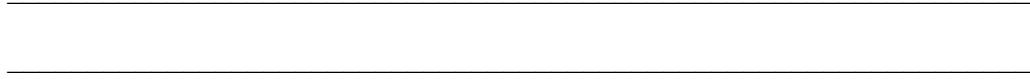
Please rank the following options in order of how big of a challenge they have posed to you throughout your career working in H&H.

To rank each option, type a number from 1 to 7 into the box next to it. Please only assign each ranking once. Ranking an option "1" would mean you believe that option has been the **biggest barrier** to training and the transfer of knowledge for you and the teams you have been a part of.

- _____ Lack of time: Insufficient time to dedicate to training staff (1)
- _____ Lack of resources: Limited classes, supplementary materials, online modules, etc. (2)
- _____ Interpersonal barriers: Lack of trust, negative relationships, lack of open dialogue, etc. (3)
- _____ Technological barriers: Lack of access to certain softwares and tools (4)
- _____ Lack of accessibility: Issues with language barriers, technical jargon, etc. (5)
- _____ Information overload: Staff receive too much information without clear prioritization (6)
- _____ Other (please specify) (7)

Informal job training is an important piece of developing expertise in any field. This may include informal mentoring, learning-by-doing, learning from working with more experienced peers, etc.

Can you share what your perception is of the **informal** trainings you have received? What has been effective? What has been ineffective?



End of Block: Block 3: Training Perceptions

Start of Block: Section 3.b Supervisor Perspectives



Section 3.b of 7: Supervisor Perspectives

Earlier in the survey you indicated that you have worked as a supervisor on H&H projects. We are interested in your perspective on existing gaps in H&H training practices. In your experience, which of the following topics have people on your team(s) struggled with the most?

In other words, where are there knowledge gaps that could be addressed through better training practices?

Please select **up to three** topic areas.

- ☐ Basic Hydraulics (1)
- ☐ Hydraulics Modeling (2)
- ☐ Basic Hydrology (3)
- ☐ Hydrologic Modeling (4)
- ☐ Storm Drain/Sewer (5)
- ☐ Culverts (6)
- ☐ Open Channel (7)
- ☐ Bridge Hydraulics (8)
- ☐ Stream Stability (9)
- ☐ Floodplain (10)
- ☐ Resilience (11)

- ☐ Drainage (12)
- ☐ Detention (13)
- ☐ Other (Please specify) (14)

As a supervisor, we are interested in what challenges you have faced with regard to the training and transfer of knowledge for H&H staff.

Please rank the following options in order of how big of a challenge they have posed to you and your team(s).

To rank each option, type a number from 1 to 7 into the box next to it. Please only assign each ranking once. Ranking an option "1" would mean you believe that option has been the **biggest barrier** to training and the transfer of knowledge for your team(s).

- _____ Lack of time: Insufficient time to dedicate to training staff (1)
- _____ Lack of resources: Limited classes, supplementary materials, online modules, etc. (2)
- _____ Interpersonal barriers: Lack of trust, negative relationships, lack of open dialogue, etc. (3)
- _____ Technological barriers: Lack of access to certain softwares and tools (4)
- _____ Lack of accessibility: Issues with language barriers, technical jargon, etc. (5)
- _____ Information overload: Staff receive too much information without clear prioritization (6)
- _____ Other (please specify) (7)

End of Block: Section 3.b Supervisor Perspectives

Start of Block: Block 4: Tech and Training Modality

Section 4 of 7: Technology and Innovation

We are interested in knowing how trainings are delivered at your organization. Please indicate approximately what percent of all trainings offered at your organization are offered through each method.

Please make sure your values add up to 100.

For example:

Virtual (live): 30

Web Based Training (on-demand): 30

In-person: 20

Informal/mentoring/on-the-job: 20

Other (): 0

_____ Virtual (live) (1)

_____ Web Based Training (on-demand) (2)

_____ In-person (3)

_____ Informal/mentoring/on-the-job (4)

_____ Other (please specify) (5)

Page Break

Section 4 of 7: (continued)

Please rank the following training methods based on your preference for each.

To rank each option, type a number from 1 to 5 into the box next to it. Please only assign each ranking once. Ranking a method "1" would mean that is your **most preferred** method for receiving training.

- _____ Virtual (live) (1)
 - _____ Web Based Training (on-demand) (2)
 - _____ In-person (3)
 - _____ Informal/mentoring/on-the-job (4)
 - _____ `#{modality/ChoiceTextEntryValue/5}` (6)
-

We are interested in what technological innovations, if any, could be used to make H&H trainings more effective. Please select any innovations you have encountered and think are useful for maximizing training effectiveness.

If you have experience with one of the below choices, but did not find it effective, please do NOT select it.

Please select all that apply.

- ☐ **Learning Management Systems (LMS)**—A software application for administering, documenting, tracking, reporting, automating, and delivering educational courses and training programs. Examples: Canvas, Blackboard Learn, 360Learning, Adobe Learning Manager, Litmos, Schoology, WorkRamp, talentlms (1)
- ☐ **Adaptive Learning Systems**—An educational method that leverages computer algorithms and artificial intelligence to allow course material to be customized to the learner. Students are provided extra practice when they struggle with a topic and given more challenging material when they perform well. Examples: SC Training, Udemy, Adaptemy, LinkedIn Learning, Coursera (2)
- ☐ **Gamification**—Application of game playing and mechanics – like points, badges, and leaderboards - in educational contexts to encourage participation and engagement with course material. Examples: Learning Pool, Elucidat, Central (3)
- ☐ **Video-Based Learning**—Educational approach that utilizes video, images, audio, graphics, and text to deliver knowledge and training. Example: Youtube tutorials (4)
- ☐ **Virtual Reality**—Educational approach that utilizes virtual reality technology to immerse students in virtual environments that simulate real-world scenarios and allow them to interact with digital objects and characters. Examples: Google Arts & Culture Expeditions (virtual field trips), Labster (virtual labs), Lifeliqe (workforce training) (5)
- ☐ Other (please specify) (6) _____
- ☐ Other (please specify) (7) _____
- ☐ Other (please specify) (8) _____

End of Block: Block 4: Tech and Training Modality

Start of Block: Block 5: Final Thoughts

Section 5 of 7: Final Thoughts

How frequently are the trainings at your organization evaluated to assess their effectiveness?

- ☐ Every training is followed by an evaluation. (1)
- ☐ Trainings are evaluated at least quarterly. (2)
- ☐ Trainings are evaluated at least yearly. (3)
- ☐ Trainings are evaluated as needed but with no pre-determined timeline. (4)
- ☐ There is no evaluation process for trainings at my organization. (5)
- ☐ My organization has a training evaluation process but I don't know how frequently the evaluations are administered. (6)
- ☐ I don't know if there is a training evaluation process at my organization. (7)

What would you say is the greatest strength of the training program/practices at your organization? Please be as specific as possible.

Please use this space to indicate any recommendations you have for H&H trainings at your organization. This could be improvements to the process or suggestions of new trainings that could be offered. Any insight is welcome.

Is there anything else you would like to share with us?

End of Block: Block 5: Final Thoughts

Start of Block: Block 6 - Contact Information

Section 6 of 7: Contact Information

If we have additional questions, is it okay if we follow-up with you?

☐ Yes (1)

☐ No (2)

If yes, please provide your name:

If yes, please provide your email address:

End of Block: Block 6 - Contact Information

Start of Block: Block 7 - Respondent Demographics

Section 7 of 7: Demographics

Before ending the survey, we are going to ask you a few demographic questions, which help ensure we're hearing diverse viewpoints. As a reminder, your responses are confidential.

This information will only be reported in aggregate (e.g., 25% of the participants were under the age of 45). We will not link demographic data to specific organizations or departments or share information that could identify individual participants.

If you do not wish to answer a question, you may leave it blank.

This is the final section of the survey.

What is the highest level of school you have completed or the highest degree you have received?

- ☐ Less than high school degree (1)
- ☐ High school diploma or GED (2)
- ☐ Some college, but no degree (3)
- ☐ Associate degree (2-year) (4)
- ☐ Bachelor's degree (4-year) (5)
- ☐ Master's degree (6)
- ☐ Doctoral degree (7)
- ☐ Professional degree (JD, MD) (8)

If you have received an Associate degree or higher, please specify the degree title (e.g., Civil Engineering, B.S.).

Please indicate the race/ethnicity you identify with:

Please select all that apply.

- ☐ American Indian / Native American or Alaska Native (1)
- ☐ Arabic or Middle Eastern (2)
- ☐ Black, African American or African (3)
- ☐ Chinese, Japanese, Korean, Vietnamese, or from India (4)
- ☐ Mexican or Mexican-American, Central American, South American, Other Latino/a or Hispanic (5)
- ☐ Pacific Islander (6)
- ☐ White, Caucasian, or European (including people from Spain) (7)
- ☐ A race/ethnicity not listed here (please specify) (8) _____
- ☐ Prefer not to answer (9)

Which of the following best describes your gender?

- ☐ Man (1)
- ☐ Woman (2)
- ☐ Other (3)
- ☐ Prefer not to say (4)

What is your age?

- ☐ 18-24 (1)
- ☐ 25-34 (2)
- ☐ 35-44 (3)
- ☐ 45-54 (4)
- ☐ 55-64 (5)
- ☐ 65 or older (6)

Thank you for your time! This is the end of the survey.

Once you hit the arrow below, the survey will be submitted. Before hitting the arrow, feel free to go back through the survey and review/edit your answers.

End of Block: Block 7 - Respondent Demographics