**Appendix A. Water Workforce Methodology**

*Note: To classify water jobs, this report relies on many of the same methods used in previous Brookings research to identify infrastructure jobs. For more information on these methods, see “Beyond Shovel-Ready: The Extent and Impact of U.S. Infrastructure Jobs” available at:*

[*http://www.brookings.edu/~/media/research/files/reports/2014/05/09-infrastructure-jobs/beyond-shovelready.pdf*](http://www.brookings.edu/~/media/research/files/reports/2014/05/09-infrastructure-jobs/beyond-shovelready.pdf)

*1. Employment data*

This report primarily uses 2016 employment data publicly available from the U.S. Bureau of Labor Statistics (BLS) Occupational Employment Statistics (OES) program, which releases estimates annually. The OES program bases these estimates on a semi-annual mail survey in May and November in partnership with State Workforce Agencies. The survey measures employment for workers in non-farm establishments. Estimates for 2016 were drawn from 1.2 million establishments across six panels of data collected over three years (May 2016, November 2015, May 2015, November 2014, May 2014, and November 2013). The sample is developed from state unemployment insurance files.[[1]](#endnote-1)

OES employment and wage data are defined in terms of specific occupations and industries, as established under the 2010 Standard Occupational Classification (SOC) system and 2012 North American Industry Classification System (NAICS). This report focuses on detailed SOC occupations and 4-digit NAICS industries. OES cross-industry occupational employment and wage estimates are available across national, state, metropolitan statistical area, metropolitan division, and nonmetropolitan geographies, while industry-specific estimates are available for the nation only.

Supplemental information has also been gathered from the BLS Employment Projections (EP) program, Quarterly Census of Employment and Wages (QCEW) program, Current Employment Statistics (CES) program, and the Occupational Information Network (O\*NET), an online resource center and database sponsored by the Department of Labor’s Employment and Training Administration. Additional demographic and economic data come from the U.S. Census Bureau’s American Community Survey (ACS) and the Current Population Survey (CPS), a joint effort between BLS and the U.S. Census Bureau. Finally, to analyze the location of specific water utilities, we use information compiled by the U.S. Environmental Protection Agency (EPA) in its Facility Registry Service (FRS), an online database that tracks environmental compliance in individual facilities across the country.

*2. Defining water jobs*

This analysis aims to classify the most relevant jobs linked to water infrastructure construction, operation, design, and governance nationally. While many previous studies have conducted surveys of individual water utilities – to focus on utility-specific operations in a given region – this analysis aims to build off this work and define a broader suite of “water jobs” across the country.

Developing a clear and concise definition of the types of activities involved in water jobs is key when investigating specific industries and occupations. In particular, we define water jobs as:

*“Jobs directly involved in the construction, operation, design, and governance of water infrastructure systems nationally, including drinking water, wastewater, stormwater, and green infrastructure. These positions span the public and private sector and involve oversight, maintenance, and financial and administrative support, including involvement in managing several closely-related physical assets, such as pipes and septic systems.”*

In turn, water jobs are not simply limited to the internal operations of utilities, but also cover a wide assortment of industries and establishments across the country.

*3. Defining water industries*

Next, we identified a list of industries closely linked to this definition. Relevant information from the U.S. Census Bureau Industry Statistics Portal has aided in the identification of these industries. In addition, we considered relevant industry clusters identified in previous research, including the AWWA Career Clusters study, the WRF Workforce Sustainability Initiative, and BLS utility analyses.[[2]](#endnote-2) It is important to note that there can be difficulties defining a precise range of water-related industries due to aggregations in existing public data sources.[[3]](#endnote-3)

A list of eight water industries have been identified[[4]](#endnote-4), with relevant sub-industries highlighted below:

* **Water, Sewage and Other Systems (NAICS 2213)**
  + Includes water supply and irrigation systems, sewage treatment facilities, and steam/AC supply
* **Utility System Construction (NAICS 2371)**
  + Includes water, sewer line, and related structures construction
  + Most relevant sub-industry: Water and sewer system construction (NAICS 23711)
* **Other Heavy and Civil Engineering Construction (NAICS 2379)**
  + Includes channel, land drainage, dredging, pipeline, and flood control project construction
* **Plumbing, Heating, and Air-Conditioning Contractors (NAICS 23822)**
  + Includes contractors primarily engaged in installing and servicing plumbing equipment, who may provide both parts and labor when performing work.
* **Other Specialty Trade Contractors (NAICS 2389)**
  + Includes site preparation contractors involved in trenching, excavating, and draining, including weeping tile and septic tank installation
  + Most relevant sub-industry: Site preparation contractors (NAICS 23891)
* **Management, Scientific, and Technical Consulting Services (NAICS 5416)**
  + Includes environmental consulting services, such as water quality inspection
  + Most relevant sub-industry: Environmental consulting services (NAICS 54162)
* **Remediation and Other Waste Management Services (NAICS 5629)**
  + Includes septic tank cleaning and servicing, sewer and storm basin maintenance, and the remediation of contaminated sites, including soil remediation and revegetation
  + Most relevant sub-industries: Remediation services (NAICS 56291) and All other waste management services (NAICS 56299)
* **Local Government, excluding schools and hospitals (OES designation) (NAICS 9993)**
  + Includes many local publicly-owned water utilities; note that federal and state government employment is excluded here, which in general covers a broader range of unrelated workers and activities

Other miscellaneous industries, such as Architectural, Engineering, and Related Services (NAICS 5413), are excluded due to the lack of reliable information to pinpoint water-specific activities or employment.

Note that BLS QCEW and CES data provide additional clarity for 5- and 6-digit NAICS industries missing from the OES estimates. By calculating a relevant share of employment found in these industries, it is easier to see how much employment is directly related to water infrastructure operation, maintenance, and so on. This will be explored in more detail below.

*4. Defining water occupations*

Based on the water jobs definition and list of industries described above, the analysis next attempts to determine the most relevant occupations.

It does so by following three steps: (a) considering the largest occupations in NAICS 2213 (water, sewage, and other systems), the cleanest industrial categorization related to water utility activities; (b) considering occupational definitions and activities, as defined by BLS, alongside other mission-critical occupations identified in previous studies[[5]](#endnote-5); and (c) considering employment concentrations of these occupations across the core set of eight industries identified above.

For step (a), 95 different occupations were found in NACIS 2213 with employment totaling 47,500 workers; however, only 84 had data available (i.e. non-suppressed). The top 25 occupations accounted for 86 percent of all employment in this industry, as highlighted below.

**Table A1: 25 Largest Occupations in Water, Sewage and Other Systems (NAICS 2213), 2016**



*Source: BLS Occupational Employment Statistics*

For step (b), 35 occupations were identified, based on BLS definitions and other studies as being essential to water utility operations.[[6]](#endnote-6) Many of these occupations paralleled those identified in NAICS 2213 (water, sewage, and other systems).[[7]](#endnote-7) However, some went beyond this industry, including many engineering and administrative positions found in other closely related establishments across the country; for instance, engineering technicians, architectural and civil drafters, and bill and account collectors were among the occupations identified.

For step (c), we identified a total of 212 occupations as being particularly essential and concentrated across the eight water industries.[[8]](#endnote-8) Many of the biggest occupations, such as plumbers, water treatment operators, and pipelayers, had more than 50 percent of their national employment concentrated in these eight industries, as shown in Table A2. While no statistical benchmark was established to include or exclude certain occupations, most occupations had 2 percent or more of their national employment concentrated in the eight water industries.[[9]](#endnote-9) All of the largest occupations in NAICS 2213 identified in step (a) were found here, and the 35 occupations identified in step (b) were also found.[[10]](#endnote-10)

**Table A2: Selected Occupations with High Shares of Employment in the Eight Water Industries, 2016**



*Source: Brookings analysis of BLS Occupational Employment Statistics.*

*5. Calculating water employment*

Finally, based on these water industries and occupations, we aimed to identify the total number of workers employed in water jobs nationally and across different regions.

Imprecise data classifications make it challenging to count the number of workers employed in water jobs – and to group together a definite list of occupations. For instance, by their occupational definitions alone, workers in only 3 occupations are exclusively (and explicitly) employed in water jobs. They total nearly 150,000 workers nationally:

**Table A3: Relevant Water Occupations, Regardless of Industry**



*Source: BLS Occupational Employment Statistics.*

To calculate the number of workers employed in water jobs, this report uses a two-step process: (a) first, it includes all workers employed in the 3 occupations above nationally (regardless of industry), before (b) adding this total to a share of workers employed in the remaining 209 water occupations identified in the previous section (section 4). By doing so, we developed employment estimates for the 212 water occupations.

Unfortunately, carrying out step (b) is easier said than done since OES data tend to only be available for a broader group of NAICS industries (at the 2-, 3-, or 4-digit level). To determine the most relevant occupational employment totals, the analysis uses QCEW and CES data when possible to create a finer cut of employment, based on the most relevant 5- and 6-digit NAICS industries. Table A3 shows the relevant employment “weights” used for each of the eight water industries.

**Table A4: Employment Weights for the Eight Water Industries, 2016**



*Source: Brookings analysis of BLS QCEW and CES data.*

*\*\*\*\*Note: Employment totals shown for local government shown here do not equate directly to NAICS 9993 (OES designation) due to CES definitions.*

For example, since NAICS 2213 (Water, sewage, and other systems) is entirely related to the water definition spelled out in the first section, 100 percent of its occupational employment is included. However, NAICS 2371 (Utility system construction) includes a broad swath of unrelated energy construction, so only a portion of its employment is counted; in particular, NAICS 23711 (Water and sewer line construction) is the most relevant sub-sector in this industry and is responsible for employing 177,390 workers nationally (or 36.8 percent of all workers in NAICS 2371). Likewise, according to CES data, local government utilities account for 4.3 percent of local government employment, excluding schools and hospitals; in turn, 4.3 percent of local government employment associated with the 212 occupations is included.

A similar process is followed for NAICS 2389, NAICS 5416, and NAICS 5629. For NAICS 23822 (plumbing and hvac contractors), additional weights were applied to control for unrelated employment associated with heating and air conditioning repair.[[11]](#endnote-11)

At the same time, we adjusted employment totals for specific occupations found to be mission-critical in previous utility studies. In particular, rather than weighting these occupations like all other occupations, 100 percent of their employment is counted across the eight water industries instead. For instance, industrial machinery mechanics are often found to be mission-critical, and there are 13,100 of them employed across the eight water industries. In turn, all 13,100 of these workers are included. A total of 10 occupations are treated this way: electricians, meter readers, industrial machinery mechanics, helpers—electricians, architects, machinists, landscape architects, plumbers, helpers--plumbers, and pipelayers.[[12]](#endnote-12)

Beyond looking at the water sector as a whole, we also calculated utility-specific employment totals. In particular, by looking at NAICS 2213 and NAICS 9993 together, it becomes easier to see how many workers may be employed in water utilities nationally. In total, nearly 298,000 workers are estimated to be employed in water utilities using this method. Not surprisingly, the largest occupation are water treatment plant operators (102,500 workers), which account for about 34 percent of this total.

Since occupational data by industry are not available at a sub-national level, we used national occupational shares to determine regional water employment totals.

For example, when calculating the water employment for each metropolitan area, cross-industry occupation totals are weighed by national water shares. These “water weights” are based on the share of employment for a given occupation in the eight water industries. For example, as shown earlier in Table A2, 52.2 percent of all meter readers are employed across the eight water industries, so this share (.522) is used to weigh their cross-industry employment at the metropolitan scale. Similarly, because water treatment operators are identified as always being water-related, their share (1.00) is used to include all of their employment in every metropolitan area. The same process is repeated to calculate utility-specific employment totals at a metropolitan level.

Notably, cross-industry occupational employment for individual metropolitan areas in this report is based on detailed occupation totals. In short, this means only employment in occupations that were not suppressed at the detailed level is included. Likewise, wages are only counted for those occupations without suppressions. Typically, OES cross-industry totals for metropolitan areas, in particular, are higher than totals seen here because OES totals include suppressed and nonsuppressed data.

*6. Comparing wages at the national and metropolitan levels*

Throughout the report, OES wages are based on straight-time, gross pay, which includes forms of compensation such as cost-of-living allowances and over-the-road pay, but excludes overtime pay and holiday bonuses. Mean hourly and annual wages are highlighted in this report, in addition to percentile wages (10th, 25th, 50th, 75th, and 90th). By definition, workers at the 10th and 25th percentiles earn wages at the lower end of each occupation and industry, while workers at the 75th and 90th percentiles earn wages at the higher end.

Nationally, we look exclusively at cross-industry wages for the 212 water occupations. Although wages for individual occupations can vary by industry, this cross-industry perspective follows the same approach used to count national water employment, consistently viewing these occupations in a larger national context.

As such, mean and percentile wages for individual occupations like water treatment operators and pipelayers are a main focus of this report. When viewed together, though, we average wages for all 212 water occupations based on employment. Without the full OES survey sample, this approach is intended to approximate a distribution of earnings across all water occupations, reflecting the large number of workers earning competitive wages at lower percentiles compared to the small number of workers earning competitive wages at higher percentiles.

At the metropolitan level, we also consider cross-industry wages for these 212 water occupations. Because most areas do not employ workers across all of these occupations—and some records may be suppressed—we examine wages only for occupations with reported employment. We calculate overall water wages for each metropolitan area on the basis of the relative weight for each water occupation. All hourly and annual wages—mean and percentile—are averaged for each area using levels of occupational employment.

*7. Measuring skills in terms of education and training*

This report examines skills in terms of education and training typically needed for the 212 water occupations.

BLS tracks levels of education required for different occupations. Typical levels of education attained—and needed for entry—are based on the following education levels for workers ages 25 years and older: doctoral or professional degree; master’s degree; bachelor’s degree; associate’s degree; postsecondary non-degree award; some college, no degree; high school diploma or equivalent; and less than high school.

To get a more precise sense of the knowledge, tools/technologies, and levels of training needed to fill water occupations, we also looked more deeply into the 22.2 version of the O\*NET database, updated in February 2018.[[13]](#endnote-13) Since O\*NET uses a slightly different occupational classification system compared to the 2010 SOC system, we used a crosswalk to consistently relate the two systems. In total, O\*NET codes more than 900 occupations, which have been related to 772 detailed SOC occupations. 200 of the 212 water occupations had complete information in O\*NET.[[14]](#endnote-14)

Through a series of worker questionnaires, O\*NET ranks the extent to which occupations require certain types of knowledge, tools/technologies, and levels of training. In these surveys, incumbent workers select one of several possible categories to describe the training and experience typically needed for their occupation. In turn, each category reveals a specific share of these responses; for example, 34.6 percent of water treatment operators indicated that they needed 2 to 4 years of on-the-job training. To determine the most relevant categories of training and experience frequently required for water occupations, we have focused our attention on those categories that received the greatest share of responses from incumbent workers (the mode).

For on-the-job training, O\*NET includes 9 different categories based on duration: none or short demonstration; up to 1 month; 1 to 3 months; 3 to 6 months; 6 months to 1 year; 1 to 2 years; 2 to 4 years; 4 to 10 years; and over 10 years.

For related work experience, O\*NET includes 11 different categories, also based on duration: none; up to 1 month; 1 to 3 months; 3 to 6 months; 6 months to 1 year; 1 to 2 years; 2 to 4 years; 4 to 6 years; 6 to 8 years; 8 to 10 years; and over 10 years.

O\*NET also compiles extensive information on the tools and software technologies used in individual occupations. While O\*NET provides specific examples – such as Adobe Systems software or Microsoft Word – used by each occupation, the focus of this analysis is on more generalized commodities – like personal computers, forklifts, and two-way radios – as defined in 6 the United Nations Standard Products and Services Code (UNSPSC). In total, 4,300 individual commodities are classified, including 4,174 tools and 126 software technologies.

In this report, we analyzed the number and type of commodities associated with each detailed SOC occupation nationally. An aggregation of these commodities revealed distinct concentrations of tools and technologies in water occupations. Plumbers and electricians, for instance, use more than 100 different tools and technologies to perform their jobs. Associated levels of employment were also compared alongside these commodity totals.

*8. Investigating demographic characteristics*

Finally, we explored certain demographic characteristics for the 212 water occupations, primarily at a national level. Through a combination of data provided by the BLS Employment Projections (EP) program, the Current Population Survey (CPS), and the American Community Survey (ACS), we looked at age, gender, and race by detailed occupation. It is important to note that data quality issues exist for many smaller occupations, in particular; where gaps existed, we looked at broad occupational totals instead.[[15]](#endnote-15)

In addition to examining the median age of detailed occupations, we also examined relevant age ranges, which include: 16 to 19, 20 to 24, 25 to 34, 35 to 44, 45 to 54, 55 to 64, and 65 and over. To calculate age ranges for the water workforce as a whole, we used a weighted average based on employment levels across the 212 water occupations.

Similar methods were used to calculate gender ratios (male vs. female) and racial information (white, black, Asian, and Hispanic). While weighted totals are reported for the water workforce as a whole, looking at individual occupations tends to offer the greatest clarity for analyzing gender and racial breakdowns within the water sector.

1. For more information on the OES survey’s methods, see: <https://www.bls.gov/oes/2016/may/oes_tec.htm> [Accessed April 2018]. [↑](#endnote-ref-1)
2. For more information, see: <https://www.careeronestop.org/competencymodel/competency-models/water-sector.aspx>, <http://www.waterrf.org/publicreportlibrary/4206.pdf>, <https://www.bls.gov/careeroutlook/2017/article/pdf/water-utility-jobs.pdf> [Accessed April 2018]. [↑](#endnote-ref-2)
3. For instance, many utility-specific activities are bundled under local government, which also includes several unrelated activities, including healthcare and education. Additional background on this issue is described in BAYWORK, 2017. [↑](#endnote-ref-3)
4. Note that six of these eight industries – NAICS 2213, NAICS 2371, NAICS 2379, NAICS 23822, NAICS 2389, and NAICS 5629 – were found to be particularly important in designating related water occupations. A more detailed approach was needed to weight employment in NAICS 9993 (local government), in particular. [↑](#endnote-ref-4)
5. For instance, see: Quinn, 2014. [↑](#endnote-ref-5)
6. Previous Brookings research on infrastructure jobs was especially helpful in designating other related occupations in this respect. In other words, since water industries tend to share many similarities with the infrastructure sector as a whole, we would expect some of the same types of occupations to be engaged in water construction, operation, design, and governance. [↑](#endnote-ref-6)
7. Note that some of the previous water occupations identified in NAICS 2213 are also included on this list of 35 occupations. [↑](#endnote-ref-7)
8. Note that an additional 67 occupations were removed, due to being (1) suppressed or (2) out-of-scope per BLS and Census definitions. Some examples of these include: firefighters (SOC 33-2011), roustabouts, oil and gas (47-5071), and rail-track laying and maintenance equipment operators (SOC 47-4061). [↑](#endnote-ref-8)
9. It is important to note that many water occupations – 199 of the 212 – were found in local government, including maintenance and repair workers, civil engineers, and meter readers for utilities. However, calculating a precise number of workers to include for each of these occupations in local government required a more nuanced approach, as explored below. [↑](#endnote-ref-9)
10. The only occupation not previously identified – or found among the eight water industries – were hydrologists (SOC 19-2043), which by definition, are water-related. [↑](#endnote-ref-10)
11. In particular, employment totals for four water-related occupations – plumbers (SOC 47-2152), helpers—plumbers (SOC 47-3015), septic tank servicers (SOC 47-4071), and pipelayers (SOC 47-2151) – were used to calculate the relevant share of water employment in NAICS 23822. Since QCEW and CES do not offer a finer look into plumbing-specific contractors, the employment totals for these four occupations were divided over the industry total, leading to a share of 34 percent. [↑](#endnote-ref-11)
12. While small, employment was also reduced for two additional occupations primarily concentrated in local government activities – bus and truck mechanics (SOC 49-3031) and automotive service technicians (SOC 49-3023) – given their out-of-scope activities. [↑](#endnote-ref-12)
13. Additional information on the O\*NET 22.2 database is available at: <https://www.onetcenter.org/db_releases.html> [Accessed April 2018]. [↑](#endnote-ref-13)
14. Due to a lack of O\*NET data, the following 12 water occupations are excluded in the skills and training analysis: Drafters, All Other (SOC 17-3019), Designers, All Other (SOC 27-1029), First-Line Supervisors of Protective Service Workers, All Other (SOC 33-1099), Building Cleaning Workers, All Other (SOC 37-2019), Sales and Related Workers, All Other (SOC 41-9099), Information and Record Clerks, All Other (SOC 43-4199), Office and Administrative Support Workers, All Other (SOC 43-9199), Agricultural Workers, All Other (SOC 45-2099), Helpers, Construction Trades, All Other (SOC 47-3019), Motor Vehicle Operators, All Other (SOC 53-3099), Transportation Workers, All Other (SOC 53-6099), and Material Moving Workers, All Other (SOC 53-7199). [↑](#endnote-ref-14)
15. For instance, occupations like dredge operators (SOC 53-7031) only amount to about 1,760 workers across the country and may have data quality issues. Thus, demographic information for Transportation and Material Moving Occupations (SOC 53-0000) as a whole are imputed for suppressed data at a detailed level. [↑](#endnote-ref-15)