State of New Jersey
Department of Environmental Protection

2024 NEW JERSEY STATEWIDE WATER SUPPLY PLAN

APPENDIX F

ESTIMATING NEW JERSEY RESIDENTIAL, INDUSTRIAL AND COMMERCIAL DEMANDS BY PUBLIC COMMUNITY WATER SYSTEM

Appendix F:

Estimating New Jersey Residential, Industrial and Commercial Demands By Public Community Water System

TABLE OF CONTENTS

ESTIMATING NEW JERSEY RESIDENTIAL, INDUSTRIAL AND COMMERCIAL DEMANDS BY PUBLIC COMMUNITY WATER SYSTEM

An analysis of the relationship between residential, industrial and commercial water demands and the percentage of residential, industrial and commercial land uses within the developed portion of public community water systems (PCWS) service areas in New Jersey. Using voluntary data from PCWS, there is a very strong positive relationship between the percentages of residential land use and water sales. Industrial demands do not show a correlation, perhaps in part because the water demands per unit area of industrial land uses range from low (e.g., warehouses) to high (e.g., beverage manufacturing). Finally, there is a strong moderate positive relationship between the percentages of commercial land use and water sales. Using DEP data from Water Quality Accountability Act reporting on percent residential water sales only, the relationship between percentages of residential land use and water sales is weaker overall but better for PCWS with high percentages of residential land use. These results were used to develop modeling assumptions in the 2050 demands model (see Appendix D) for PCWS that lack full data on residential, industrial and commercial water demands.

Primary Author: Daniel J. Van Abs, PhD, FAICP/PP, Rutgers University
Statistical Analysis: Jillian Drabik, PhD

OVERVIEW

The 2024 New Jersey Statewide Water Supply Plan includes multiple forecast scenarios for total, summer and non-summer demands by public community water system (PCWS) to the year 2050. These forecasts use two different starting points. One is the 2016-2020 annual average demand, and the other is the peak annual average demand from the 2016-2020 years.

PCWS demands have multiple components. For simplicity, metered demands can be split into residential, industrial and commercial (RIC) demands, and then a component for water losses (actual and real). Each component will have a different demand trend. Water losses are addressed in a separate white paper. This white paper discusses the methodology for assessing existing RIC demands based on available PCWS data and extrapolating the demands to PCWS for which utility-specific data are not available.

Existing residential demand data have been provided by nearly 200 PCWS in response to the Water Quality Accountability Act (WQAA), expressed as a percentage of total metered water sales. Separately, eight PCWS owners provided data voluntarily on the split between residential, industrial and commercial metered water sales (i.e., excluding water losses) for 34 PCWS. In both cases, residential information provided is dependent on how a PCWS classifies customers; specifically, one possible source of inconsistency is whether major apartment buildings or complexes are considered residential (based on the ultimate users) or commercial (based on the billed customer as a commercial entity). Also, some PCWS may have residential end users who live in mixed-use buildings that are charged as commercial customers. For the purposes of this study, the assumption is that all residential end users are represented in the PCWS residential sales percentages.

The purpose of this analysis is to determine whether there is a sufficient correlation between the percentage of residential, industrial and commercial demands and the percentage of residential, industrial and commercial land uses within the PCWS service areas. Where a good correlation is identified, it can be used to estimate the RIC demand splits for PCWS lacking such data.

EVALUATION OF RIC WATER SALES (VOLUNTARY DATA)

Data on industrial and commercial demands are very limited, as few PCWS have submitted data on these sectors to DEP. For this project, DEP requested voluntary provision of RIC demand splits (as percentage of water sales) from PCWS that had significant industrial and commercial land uses (greater than 2% or 6%, respectively, of their service areas). Of the PCWS targeted, data were received from the systems listed below.

- New Jersey American Water (multiple)
- East Brunswick Water Utility
- Evesham Municipal Utility Authority (MUA)
- Passaic Valley Water Commission
- Ridgewood Water
- Sayreville Water Department
- South Brunswick Township Water Division
- Washington Township (Gloucester) MUA

In addition, RIC data for Newark Water & Sewer Department were used from the 2040 PCWS water demands study (Van Abs et al., 2018). Data were provided on the percentage of water sales (i.e., metered flows at the customer) for residential, industrial and commercial customer categories for a total of 35 PCWS. New Jersey American Water provided data both on PCWS with significant industrial and commercial customers (e.g., Raritan, Mount Holly, Atlantic County, Western/Delaware, Coastal North, Passaic) and most of their other PCWS, many of which are primarily residential in nature and one of which (International Trade Center) is primarily an office/industrial complex.

Many of these PCWS also reported the percentage of sales for residential customers under the WQAA reporting requirements. A comparison of the two residential values (WQAA submittals and voluntary data) showed little difference for some systems, while other showed larger differences. For those with major differences, some showed higher percentages of residential demands under the voluntary data than for the WQAA data. However, this difference is primarily due to New Jersey American having submitted a single percentage of residential demand for all PCWS (58.4%, a statewide weighted average) through the WQAA, whereas the values provided by New Jersey American for the RIC evaluation were for each PCWS separately. In other cases, the WQAA values are higher than the voluntary data; most notably Sayreville Water Department. Because the voluntary data were specifically requested and generated for this study, the assumption is that they are more reliable than the WQAA data, which provide no other data points for comparison.

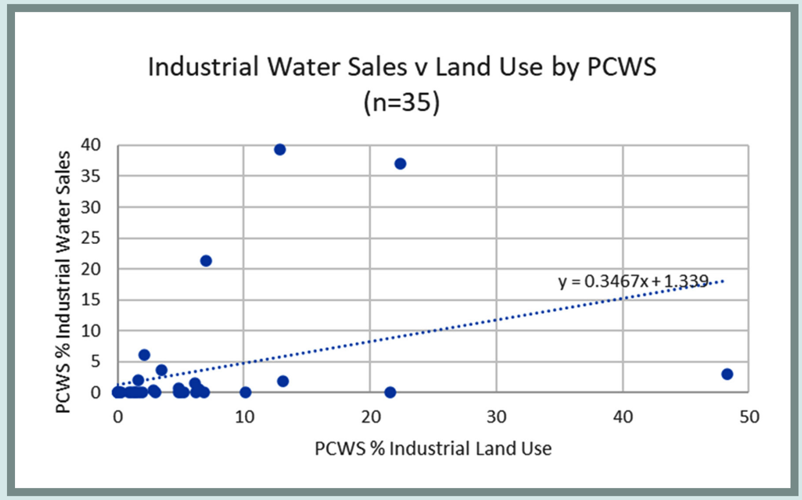
The second step of the analysis is to compile residential, industrial and commercial land use information for each PCWS. This analysis is based on the 2015 LULC and was performed as part of the 2040 PCWS demands study (Van Abs et al., 2018). For this analysis, only the residential, industrial and commercial land use percentages are used, totaling 100%; in other words, land uses that are not served (e.g., wetlands, forests, barren land) are not included even though they are located within the overall service area. This information was added to the spreadsheet.

Using this information, the percentage of demands were compared to the percentage of sales for each PCWS.

RESIDENTIAL

The following scattergram shows the relationship between residential water sales and land use by PCWS. Visually, the chart shows a strong relationship between the two factors. Only one outlier exists, New Jersey American-International Trade Center in the lower left corner, which is a primarily commercial/industrial PCWS with minimal residential land use or demands.

The Pearson correlation coefficient method was used to measure the relationship between PCWS percent water sales and percent land use across residential, industrial, and commercial sectors both with and without outliers. The coefficient measures the relationship between two variables with a number between -1 and 1, in which -1 indicates a very strong negative relationship (an increase in variable A is associated with a decrease in variable B), 0 indicates no relationship, and 1 indicates a very strong positive relationship (an increase in variable A is associated with an increase in variable B). Outliers were defined as all PCWS with % water sales or % land use greater than two standard deviations above or below the mean.

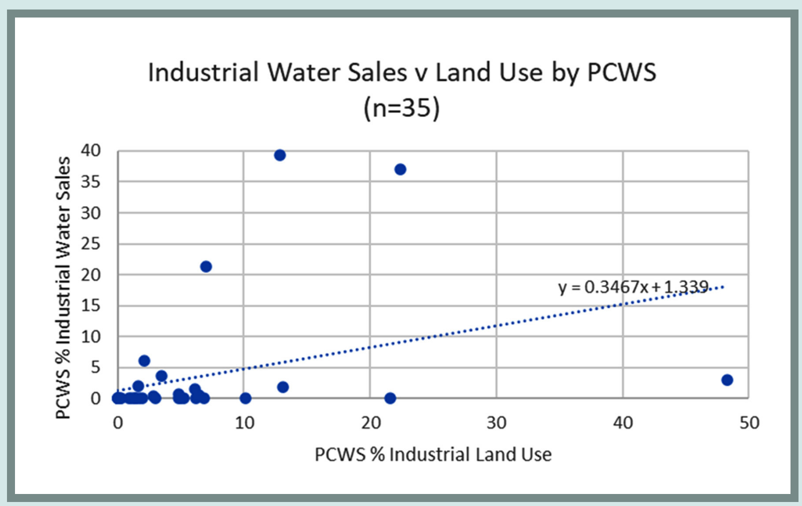


The Pearson correlation coefficient in the scattergram above is 0.831 (0.783 with outliers removed), which indicates a very strong positive relationship between PCWS percent of residential water sales and percent of service area with residential land use. A t-test was conducted to test if there is a statistically significant relationship between PCWS percent of residential water sales and percent of service area with residential land use. The p-value of this relationship both with and without outliers was less than 0.0001, indicating that PCWS percent of residential water sales has a statistically significant relationship with the percent of PCWS service area dedicated to residential land use. The best fit line for this scattergram (outliers included) is y = 0.962x – 6.4027. (With the outliers removed, the best fit line for this scattergram is y = 1.1845x - 24.151.)

INDUSTRIAL

The following scattergrams show the relationship between industrial water sales and land use by PCWS using two different groups. The first chart is for all 35 PCWS in the worksheet, while the second chart is for the 19 PCWS with greater than 2% industrial land in the service area. In both cases, a clear correlation between demands and land use is not visually obvious. Some major outliers exist. The highest industrial demands are in Sayreville (39.3%) and Newark (37.1%); in both cases, industrial land coverage is in the middle of the scale at 12.8% and 22.4%, respectively, which indicates a concentration of industry with significant water demands. New Jersey American-Raritan System has a high industrial demand (21.3%) with a lower industrial land use (7.0%), indicating an even stronger concentration of water-intensive industry.

Conversely, South Brunswick has an industrial demand of essentially zero, despite industrial land use at 21.6%; the township is a major warehousing hub along the New Jersey Turnpike. Likewise, New Jersey American-Logan System has a small industrial demand (2.7%) compared to a very high industrial land base (48.3%).



Several major difficulties exist with analyzing industrial demands. First, industrial land uses are usually a small percentage of total service areas, except for PCWS that were built to serve an industrial zone. Second, industrial land uses can range from high-demand manufacturing facilities to low-demand warehousing. Third, industrial demands have shifted significantly since the 1980s, with a great increase in warehousing and a decrease in high-demand manufacturing. Fourth, some industries are self-supplied for part or all of their water needs, and yet may be located within PCWS service areas. For these reasons, assessing industrial demands is the most complex and difficult component of RIC analysis.

In comparison to the residential scattergram, the positive relationship between all PCWS percent industrial water sales and percent of service area with industrial land use was much weaker, with a Pearson correlation coefficient of 0.339. However, PCWS percent industrial water sales were found to have a statistically significant relationship with PCWS industrial land use, with a p-value of 0.046. With the removal of outliers, the Pearson correlation coefficient decreased to 0.138, indicating a very weak relationship between industrial water sales and land use. Statistical testing with the removal of outliers resulted in a non-significant relationship (p=0.453) between industrial water sales and industrial land use, leading to the conclusion that there is not enough evidence to suggest that industrial water sales and land use are associated with each other. The best fit line for this scattergram (outliers included) is y = 0.3467x + 1.339. With the removal of outliers, the best fit line for this scattergram is y = 0.1165x + 0.7585.

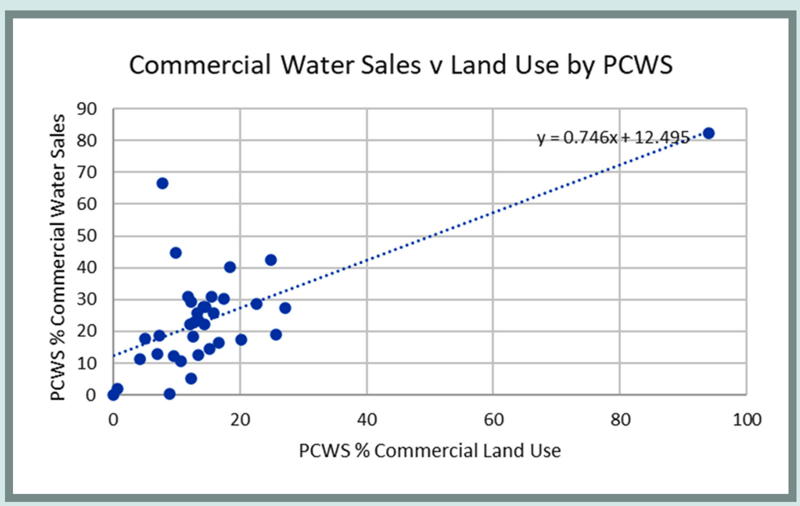
The scattergram with only PCWS with greater than two percent industrial land use in their service area indicates an even weaker relationship between PCWS percent industrial water sales and industrial land use compared to the scattergram with all PCWS included. The Pearson correlation coefficient is 0.231, indicating a relatively weak positive relationship between percent industrial water sales and industrial land use. This relationship was also found to be not significant (p=0.328). With the removal of outliers, the Pearson correlation coefficient became negative and indicated almost no relationship between industrial water demand and industrial land use (-0.049), which was also found to be nonsignificant (p=0.851). The best fit line for this scattergram (outliers included) is y = 0.2585x + 3.271. With the removal of the outliers, the best fit line for this scattergram is y = -0.0531x + 2.4829.

Based on these statistical tests, the correlation between industrial demands and land uses is not strong, making it difficult to extrapolate these results to PCWS for which no industrial demands are available.

COMMERCIAL

The following scattergram shows the relationship between commercial water sales and land use by PCWS. Visually, the chart shows a solid relationship between the two factors. As with the chart for residential demands, only one outlier exists, New Jersey American-International Trade Center, which is a primarily commercial PCWS with minimal residential land use or demands. However, while that PCWS is an extreme example, it is roughly in line with the other data points.

PCWS percent commercial water sales and percent commercial land use was found to have a **strong moderate positive relationship**, with a Pearson correlation coefficient of 0.671 (0.557 with outliers removed). The t-test findings also indicated that the relationship between PCWS commercial water sales and commercial land use is statistically significant with a p-value of less than 0.0001. With the outliers removed, t-test results still provided enough evidence to find a statistically significant relationship between commercial water sales and commercial land use (p=0.001). The best fit line for this scattergram (outliers included) is y = 0.746x + 12.495. With the removal of outliers, the best fit line for this scattergram is y = 0.9711x + 8.0473.



The statistical tests for commercial demands, when combined with the even stronger relationship for residential demands, provide a solid foundation for estimating these demands for PCWS that lack RIC data, where the industrial land uses in the PCWS service area are minimal.

EVALUATION OF WQAA REPORTED RESIDENTIAL WATER SALES

As part of annual WQAA reporting, DEP requires PCWS to submit information on the percentage of water sales for residential customers. As with the voluntary data, the definition of residential customers resides with the PCWS. As noted previously, for the purposes of this study, the assumption is that all residential end users are represented in the PCWS residential sales percentages.

Data for 211 PCWS were submitted to DEP and provided for this analysis; after elimination of data from the PCWS for which voluntary data were provided, 179 PCWS were used for this part of the analysis. Of these, two were then modified as apparent data entry errors (Harrison Water Department, from 0.6% residential to 60%, and West Cape May from 6.3% to 63%). A few others are questionable because of the large disparity between the residential sales and residential land uses (e.g., Berlin Water, Ocean Gate Water, and Veolia New Jersey for both Olde Milford Estates and Bald Eagle Commons). For example, Ocean Gate Water reported 20% residential demand, but the service area is 95% residential. However, the causes were not readily apparent and therefore the values were left as reported.

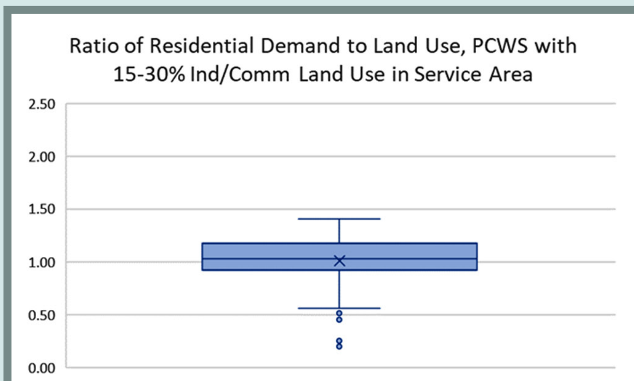
For this dataset, no information was provided on industrial and commercial demands. Therefore, the assumption is that aggregate industrial and commercial demands are the inverse of residential demands (i.e., Industrial/Commercial % = 100 – Residential %).

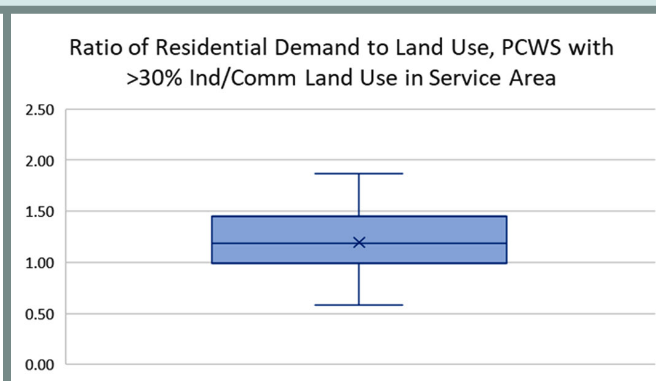
As with the prior analysis, service area land use percentages for residential, industrial and commercial land uses were drawn from the 2015 LULC coverage. Because the industrial and commercial demands are being addressed in aggregate, the land uses were likewise aggregated.

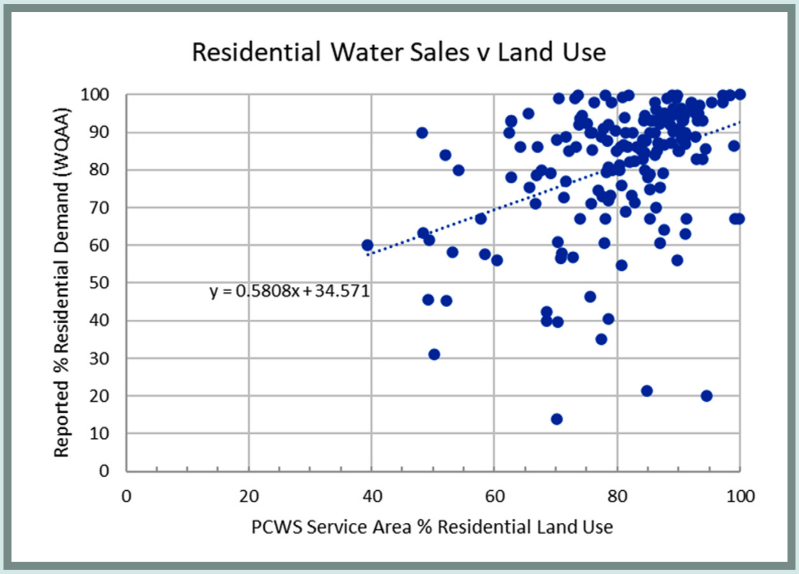
RESIDENTIAL

The first analysis focuses on the relationship of residential demands to residential land use, for PCWS with either 15% to 30% or greater than 30% industrial and commercial land use. The box and whisker plot for the 15% to 30% group indicates a tight relationship, with a median of 1.03 and a range from 0.92 to 1.17. The conclusion is that service areas with limited industrial and commercial land uses have a close relationship between residential demands and land uses. The second chart shows a greater range (0.99 to 1.45) and higher median (1.18), indicating that service areas with higher percentages of industrial and commercial demands have a less predictable relationship between residential demands and land uses; these areas are likely to be more urbanized and with high density residential areas, which have lower per capita residential water demands than is true for suburban areas (Van Abs et al., 2018).

The scattergram to the right shows the relationship between residential water sales and land uses for all PCWS in the data set. The pattern is far less linear than the results for the voluntary data discussed in the prior section, but still show a visual pattern correlating the two factors, with some significant outliers. For example, it is difficult to reconcile a service area of 100% residential land with a residential water demand of less than 80%, or a service area of 95% residential land with a residential water demand of 20%, which raises questions of whether the reported values represent a percentage of total sales (i.e., metered water at the customer level) or a percentage of total water delivered into the distribution system, which would include water losses and unmetered demands. Reporting errors are also possible, as this is the first year that these values were required under the WQAA reporting.





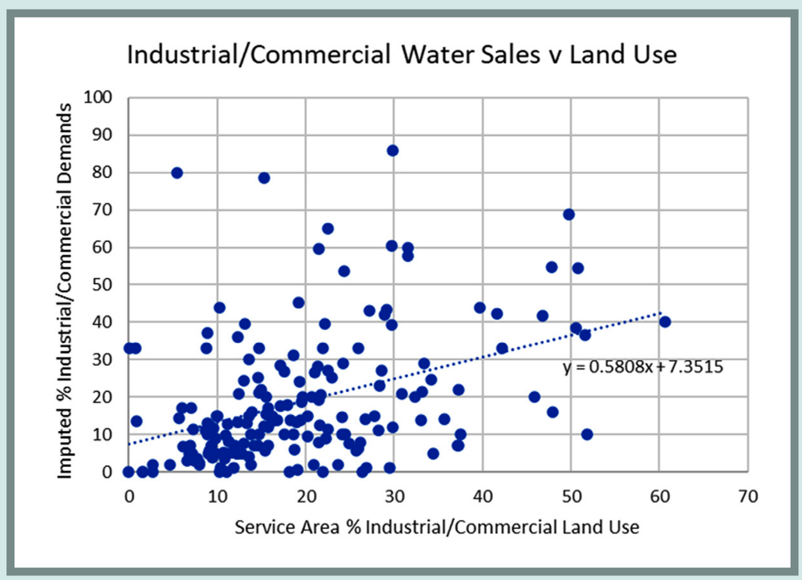


In comparison to the residential data based on PCWS volunteer data, the positive relationship between reported percent PCWS residential water sales and percent residential land use was much weaker, with a Pearson correlation coefficient of 0.398 (compared to the residential volunteer data's coefficient of 0.831). With the outliers removed, the Pearson correlation coefficient was slightly lower (0.327). However, this relationship both with and without outliers was found to be statistically significant with a p-value of less than 0.0001. The best fit line for this scattergram (outliers included) is y = 0.5808x + 34.571. With the outliers removed, the best fit line for this scattergram is y = 0.4104x + 51.333. The following equation is used to calculate residential (RES) demands from total demands :

RES Demand = (Total Demand – Water Loss) X (0.4104 (% RES Land Use) + 51.333) (Equation 1)

INDUSTRIAL AND COMMERCIAL

The following scattergram shows the relationship between aggregated water sales and land use by PCWS for these two sectors, which is essentially the inverse of the residential scattergram above. In this case, aggregating industrial and commercial demands and land uses provides a stronger correlation than the analysis of industrial demands alone using the voluntary data. For commercial demands, this chart is similar to the chart from the voluntary data, but with far more data points.



A moderate positive relationship was found between PCWS reported percent industrial and commercial water sales and percent industrial and commercial land use, with a Pearson correlation coefficient of 0.398 (0.327 with outliers removed). The relationship between industrial and commercial water sales and land use both with and without outliers was found to be statistically significant with a p-value of less than 0.0001. Based on this data's Pearson coefficient with outliers removed, the relationship between industrial and commercial water sales and land use is considered much weaker than the voluntary commercial water sales and land use data (0.557), but stronger than the total voluntary industrial water sales and land use data (0.138). The best fit line for this scattergram (outliers included) is y = 0.5808x + 7.3515. However, with outliers removed, the best fit line for this scattergram is y = 0.4104x + 7.6249.

SELECTION OF RELATIONSHIPS BETWEEN DEMANDS AND LAND USES

Where a PCWS has provided RIC data voluntarily for this study, or residential percentages under WQAA where voluntary RIC data were not provided, the reported values will be used. The question is how to fill data gaps for PCWS without complete information.

The residential evaluation using the voluntary PCWS data provides a robust correlation between both residential and commercial demands and land uses, and it has sufficient data points (35) to support a linear relationship that can be used for PCWS lacking RIC or WQAA residential data, where industrial land uses are minimal (true of most small systems). For example, of those reporting residential data under the WQAA data, 78 of the 179 have less than 2% industrial land in their service areas.

However, the voluntary data have far fewer data points for industrial demands and the relationship between demands and land use is much weaker; many of the 35 PCWS have no or minimal industrial or commercial land uses, or both. That requires a reliance on the second analysis, even though the industrial/commercial aggregate demands are based on inverse of the residential percentages reported in the WQAA dataset and cannot be disaggregated. For this reason, analysis of existing and future demands for PCWS that lack RIC or residential data will be the portion of total demand that is not allocated to water losses or residential demands.

WATER DEMAND PROJECTIONS BY CUSTOMER SECTOR

Residential demand projections are affected by population, housing density and water conservation trends. Industrial demands are heavily dependent on industry type (e.g., warehousing versus food processing) and trends. Commercial demands (including retail and wholesale marketing, office buildings, and public buildings such as schools and governments) are affected by population trends and economic forces (e.g., shifts in purchasing practices from local stores or malls to big box stores to online shopping).

The 2050 PCWS water demands model addresses future demands differently for each sector.

- **Residential Demands:** Demand changes are based on population changes. For reductions, per capita demands will be those associated with the existing service area residential land use densities. For population increases, the per capita demands are assumed to be those associated with high density residential land uses (i.e., 5 units per acre or more), reflecting recent land development practices.
- **Commercial Demands:** Where current information exists on commercial demands, the projection assumes that these demands will change in proportion to population changes.
- **Industrial Demands:** Where current information exists on industrial demands, the projection assumes that these demands will remain static.
- **Industrial/Commercial Demands:** Where current information exists on aggregate industrial and commercial demands, the projection assumes that these demands will change in proportion to population changes except for PCWS with high industrial land use percentages. In most cases, commercial demands will be the driving factor for PCWS service areas.