TECHNICAL MEMORANDUM

Date:	October 10, 2013	**Project No.:**	083-93183.002
To:	Margo Gillaspy	**Company:**	Skagit County Public Works
From:	Carl Einberger, LHg; Derek Holom , LHg, Paul LaPointe, Ph.D.		
cc:	Jacque Klug, Washington State Dept. of Ecology	**Email:**	
RE:	**SKAGIT COUNTY EXEMPT WELL METERING PROGRAM**		

1.0 INTRODUCTION

This Technical Memorandum presents the results of voluntary exempt well metering conducted in the Skagit Basin. The data collection and analysis discussed in this memorandum was conducted by Golder Associates, Inc. (Golder) under contract to the Skagit County Public Works Department (County). The study was jointly funded by the County, the Washington State Department of Ecology (Ecology), and the City of Anacortes. The County also conducted several activities in support of this study, as detailed in this memorandum. In addition, the Skagit County Public Utility District (Skagit PUD) also provided support with equipment on a portion of the monitoring.

The primary objectives of the metering study are to:

- Identify a network of volunteer exempt well users for installation of meters and collect monitoring data on water use over the period of at least one year.
- Create a database for managing information collected from the metering program.
- Statistically analyze attributes of metered properties in comparison to other parcels in the Fisher-Carpenter and Upper Nookachamps (also referred to as the Main Stem Nookachamps sub-basins.
- Estimate indoor versus outdoor use, where feasible based on the metering records.

1.1 Background

In 2001, Ecology established an instream flow rule (WAC 173-503) for the Skagit River to maintain minimum instream flows to protect salmon and other natural resources. The in-stream flow rule was amended in 2006 to establish reservations of groundwater by sub-basins for specific out-of-stream uses not subject to instream flows, including agricultural irrigation; domestic, municipal, commercial, and industrial use; and stock watering.

The Carpenter-Fisher sub-basin of the lower Skagit River basin was closed to further withdrawals in June 2011, because residential growth and associated new exempt wells exceeded the limits of the reservation amount. The Upper Nookachamps sub-basin is also close to reaching the limitations on new exempt

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wells associated with the reservation. This study targeted these two sub-basins for the metering program given their reservation status.

1.2 Volunteer Metering Network

In Fall 2010, the County conducted a survey in the Carpenter-Fisher and Upper Nookachamps sub-basins to select volunteer candidates for a well metering study. This work was conducted with support from Golder in developing the survey and Ecology in implementing the survey. As part of the solicitation for metering volunteers, the County agreed to maintain the confidentiality of volunteers. Eighteen volunteers participated in this study.

In 2011, Badger Recordall M-25 meters were installed by a private contractor (Wolfe Mechanical) on 18 exempt wells interspersed within the sub-basins. The meters were set to measure hourly use data throughout the study. The volunteer residences range from mobile homes to large multi-family households, with lot sizes ranging from 0.25 acre to more than 5.5 acres. Of the total 77 acres monitored, 39.5 acres are described as “cleared” and the remaining 37.5 are described as “wooded/brush”. In keeping with the County’s confidentiality agreement with volunteers, no specific mention of parcel numbers for the volunteers is used in this memorandum, and the individual homes are referred to as Properties 1 through 18.

Metering data for all of 2012 are presented in this memorandum. The data collected by the meters were downloaded through onsite visits conducted on a periodic basis by Golder. The Skagit PUD provided data retrieval instrumentation (Radix handheld computer) for Golder’s use during the study. The PUD also conducted bi-monthly remote measurements of the meters during the study.

2.0 METERING DATA MANAGEMENT

An Access database was prepared by Golder to allow compiled data to be queried and analyzed. In addition to hourly data on water use obtained from the meters, data on metered and non-metered parcel characteristics within the Carpenter-Fisher and Upper Nookachamps sub-basins were incorporated into the database from the County’s Geographic Information System (GIS) parcel database.

County personnel prepared a filtered subset of the County’s parcel database limiting the data to parcels with the following attributes for incorporation into the metering study database:

- Parcels within the Carpenter-Fisher and Upper Nookachamps sub-basins; and
- Parcels outside of the City of Mount Vernon and Skagit County Sewer District No. 2. These parcels are assumed to be on septic systems.

The metering study database allows sorting based on various attributes of the parcels available from the County’s GIS database, including several key parameters that may influence water use:

- Land Use

- Building Value
- Land Area
- Improved Land Value
- Unimproved Land Value
- Living Area
- Number of Full Baths
- Number of Master Baths
- Number of Half Baths
- Number of Bedrooms
- Basin (Carpenter-Fisher or Upper Nookachamps)
- Undeveloped Area

Metering results and analysis supported by use of the metering study database are presented in the following sections of this memorandum.

3.0 METERING RESULTS

Metering results from the 18 monitored properties have been evaluated for the following:

- Average annual daily use
- Average annual indoor daily use (estimated)
- Average annual outdoor daily use (estimated)
- Weekly average of daily use
- Weekly average of daily use during the peak period of outdoor use

The results of this evaluation are discussed in this section.

Table 1 presents a summary of metering data for the 18 monitored properties. A graphical summary of the mean monthly average of daily groundwater use for all properties combined is presented in Figure 1. Additional summaries of the mean weekly average of daily groundwater use for all properties combined (Figure 2) and mean daily groundwater use for all metered properties combined (Figure 3) have also been developed from the metering data. Figures A-1 through A-18 (Attachment A) present the monthly average of daily groundwater use for all metered properties. Figures B-1 through B-18 (Attachment B) show the weekly average of daily groundwater use for all metered properties. Figures C-1 through C-18 (Attachment C) present the daily groundwater use for the properties.

Average annual daily use was calculated directly from the metering data, and ranged from 56 to 463 gal/day, with an average for all of the properties of 176 gal/day (Table 1).

Average indoor use was determined by averaging water use for the year excluding observed peaks in water use during the period from May through October, assumed to be the typical range of significant outdoor water use. Some exceptions outside of this period have been noted, particularly around holiday

periods, but these were considered indoor use peaks. Average annual outdoor use was then determined by subtracted the average annual indoor use from the average annual total use. Specific periods assumed to represent a combination of indoor and significant outdoor use for each property are discussed in the individual property summaries that follow. For seven of the properties, it did not appear that there was significant outdoor use, and it was not possible to determine indoor vs. outdoor use.

The estimated average annual indoor daily use ranged from 84 to 270 gal/day, with an average of 131 gal/day (Table 1) for the 12 properties where it was estimated. Average annual outdoor daily use ranged from four to 122 gal/day with an average of 33 gal/day for the 12 properties.

The minimum monthly average of total daily use ranged from zero to 172 gal/day, with an average of 107 gal/day (Table 1). The maximum monthly average of total daily use ranged from 133 to 2293 gal/day, with an average of 410 gal/day.

The peak weekly averages of total use are presented for the weeks ending August 11 through September 15. This period corresponds with observed peaks in total use for the properties, as illustrated Figures 1 and 2. The maximum weekly average of total daily use is 3015 gal/day for an individual property (Property No. 4).

Figures 1 and 2 both clearly illustrated the increase in water use during the outdoor watering season. The maximum mean weekly average of daily groundwater use for all properties combined is 467 gal/day on August 18 (Figure 2), and the maximum mean daily average for all properties is 630 gal/day, also on August 18 (Figure 3).

A summary of key responses to the volunteer survey conducted prior to metering, metering observations, and outdoor use assumptions for each property follows. The period assumed for significant outdoor use was excluded from the calculation of average annual indoor daily use:

Property No. 1

- Survey Responses:
  - Permanent residence, 1 occupant
  - Conservation fixtures in place
  - No lawn watering
- Metering observations:
  - Annual average daily use = 56 gal/day
  - Indoor vs. outdoor use was not delineated.
  - Maximum monthly average of daily use = 142 gal/day (January)
  - Maximum weekly average of daily use = 375 gal/day (January 21)
  - Maximum daily use = 638 gal/day (January 19)

Property No. 2

- Survey responses:
  - Permanent residence, 2 occupants
- Metering observations:
  - Annual average daily use = 328 gal/day
  - Average annual indoor daily use (estimated) = 206 gal/day
  - Average annual outdoor daily use (estimated) = 122 gal/day
  - Period assumed for significant outdoor use = August 4 – September 29
  - Maximum monthly average of daily use = 1074 gal/day (August)
  - Maximum weekly average of daily use = 1163 gal/day (August 25)
  - Maximum daily use = 1335 gal/day (August 8)

Property No. 3

- Survey Responses:
  - Permanent residence, 2 occupants
  - Lawn/garden watering
  - Stock watering
  - Rain Barrels (200 gallon tank)
- Metering observations:
  - Annual average daily use = 95 gal/day
  - Average annual indoor daily use (estimated) = 85 gal/day
  - Average annual outdoor daily use (estimated) = 10 gal/day
  - Period assumed for significant outdoor use = August 4 – September 29
  - Maximum monthly average of daily use = 169 gal/day (August)
  - Maximum weekly average of daily use = 465 gal/day (March 31)
  - Maximum daily use = 1086 gal/day (March 28)

Property No. 4

- Survey Responses:
  - Permanent residence, 3 occupants
  - Lawn/garden watering
  - Also use a spring with associated water right for lawn and garden watering
- Metering observations:
  - Annual average daily use = 463 gal/day
  - Indoor vs. outdoor use was not delineated.
  - Maximum monthly average of daily use = 2293 gal/day (August)

- Maximum weekly average of daily use = 3015 gal/day (September 8)
- Maximum daily use = 5737 gal/day (September 17)

Property No. 5

- Survey Responses:
  - Permanent residence, 3 occupants
  - Conservation fixtures in place
  - Lawn/garden watering (garden irrigation system)
  - Rain Barrels
- Metering observations:
  - Annual average daily use = 163 gal/day
  - Average annual indoor daily use (estimated) = 119 gal/day
  - Average annual outdoor daily use (estimated) = 44 gal/day
  - Period assumed for significant outdoor use = July 7 – September 27
  - Maximum monthly average of daily use = 388 gal/day (August)
  - Maximum weekly average of daily use = 614 gal/day (September 18)
  - Maximum daily use = 2116 gal/day (August 15)

Property No. 6

- Survey Responses:
  - No survey information available
- Metering observations:
  - Annual average daily use = 105 gal/day
  - Average annual indoor daily use (estimated) = 89 gal/day
  - Average annual outdoor daily use (estimated) = 16 gal/day
  - Period assumed for significant outdoor use = August 4 – September 29
  - Maximum monthly average of daily use = 218 gal/day (September)
  - Maximum weekly average of daily use = 549 gal/day (September 29)
  - Maximum daily use = 1955 gal/day (September 24)

Property No. 7

- Survey Responses:
  - Permanent residence, 4 occupants
  - Conservation fixtures in place
  - Lawn watering
- Metering observations:
  - Annual average daily use = 181 gal/day

- Indoor vs. outdoor use was not delineated.
- Maximum monthly average of daily use = 242 gal/day (January)
- Maximum weekly average of daily use = 322 gal/day (March 17)
- Maximum daily use = 930 gal/day (August 25)

Property No. 8

- Survey Responses:
  - Permanent residence, 2 occupants
  - Conservation fixtures in place
  - Lawn watering
  - Rain Barrels
- Metering observations:
  - Annual average daily use = 148 gal/day
  - Indoor vs. outdoor use was not delineated.
  - Maximum monthly average of daily use = 226 gal/day (January)
  - Maximum weekly average of daily use = 244 gal/day (January 28)
  - Maximum daily use = 337 gal/day (January 22)

Property No. 9

- Survey Responses:
  - Permanent residence, 3 occupants
  - Conservation fixtures in place
  - Lawn watering
- Metering observations:
  - Annual average daily use = 145 gal/day
  - Indoor vs. outdoor use was not delineated.
  - Maximum monthly average of daily use = 176 gal/day (June)
  - Maximum weekly average of daily use = 257 gal/day (June 16)
  - Maximum daily use = 356 gal/day (June 10)

Property No. 10

- Survey Responses:
  - Permanent residence, 2 occupants
  - Conservation fixtures in place
  - Lawn watering
  - Stock watering
- Metering observations:

- Annual average daily use = 183 gal/day
- Indoor vs. outdoor use was not delineated.
- Maximum monthly average of daily use = 226 gal/day (March)
- Maximum weekly average of daily use = 277 gal/day (August 11)
- Maximum daily use = 622 gal/day (May 16)

Property No. 11

- Survey Responses:
  - Permanent residence, 2 occupants
  - Conservation fixtures in place
  - Lawn watering (irrigation system)
  - Stock watering
- Metering observations:
  - Annual average daily use = 197 gal/day
  - Average annual indoor daily use (estimated) = 180 gal/day
  - Average annual outdoor daily use (estimated) = 16 gal/day
  - Period assumed for significant outdoor use = July 21 – December 31
  - Maximum monthly average of daily use = 498 gal/day (October)
  - Maximum weekly average of daily use = 652 gal/day (September 8)
  - Maximum daily use = 1069 gal/day (September 5)

Property No. 12

- Survey Responses:
  - Permanent residence, 2 occupants
  - Lawn watering
- Metering observations:
  - Annual average daily use = 188 gal/day
  - Indoor vs. outdoor use was not delineated.
  - Maximum monthly average of daily use = 222 gal/day (July)
  - Maximum weekly average of daily use = 292 gal/day (July 14)
  - Maximum daily use = 562 gal/day (October 19)

Property No. 13

- Survey Responses:
  - No survey information available
- Metering observations:
  - Annual average daily use = 106 gal/day

- Average annual indoor daily use (estimated) = 75gal/day
- Average annual outdoor daily use (estimated) = 31 gal/day
- Period assumed for significant outdoor use = May 12 - May 19, July 7 – August 25
- Maximum monthly average of daily use = 260 gal/day (August)
- Maximum weekly average of daily use = 438 gal/day (August 18)
- Maximum daily use = 872 gal/day (August 12)

Property No. 14

- Survey Responses:
  - Season residence (8 months), 2 occupants
  - Conservation fixtures in place
  - Lawn watering
  - Rain Barrels
- Metering observations:
  - Annual average daily use = 154 gal/day
  - Average annual indoor daily use (estimated) = 93 gal/day
  - Average annual outdoor daily use (estimated) = 61 gal/day
  - Period assumed for significant outdoor use = August 4 – September 29
  - Maximum monthly average of daily use = 463 gal/day (August)
  - Maximum weekly average of daily use = 571 gal/day (September 8)
  - Maximum daily use = 1120 gal/day (August 5)

Property No. 15

- Survey Responses:
  - Permanent residence, 1 occupant
  - Conservation fixtures in place
  - No lawn watering
  - Limited garden watering (flower baskets)
- Metering observations:
  - Annual average daily use = 88 gal/day
  - Average annual indoor daily use (estimated) = 84 gal/day
  - Average annual outdoor daily use (estimated) = 4 gal/day
  - Period assumed for significant outdoor use = August 4 – August 25
  - Maximum monthly average of daily use = 133 gal/day (August)
  - Maximum weekly average of daily use = 217 gal/day (August 18)
  - Maximum daily use = 566 gal/day (August 17)

Property No. 16

- Survey Responses:
  - Permanent residence, 2 occupants
  - Lawn watering
- Metering observations:
  - Annual average daily use = 165 gal/day
  - Average annual indoor daily use (estimated) = 146 gal/day
  - Average annual outdoor daily use (estimated) = 19 gal/day
  - Period assumed for significant outdoor use = August 4 – September 29
  - Maximum monthly average of daily use = 286 gal/day (August)
  - Maximum weekly average of daily use = 413 gal/day (July 28)
  - Maximum daily use = 1046 gal/day (July 26)

Property No. 17

- Survey Responses:
  - Permanent residence, 2 occupants
  - Conservation fixtures in place
  - Lawn watering
  - Rain barrels
- Metering observations:
  - Annual average daily use = 104 gal/day
  - Average annual indoor daily use (estimated) = 96 gal/day
  - Average annual outdoor daily use (estimated) = 8 gal/day
  - Period assumed for significant outdoor use = August 4 – August 25
  - Maximum monthly average of daily use = 176 gal/day (August)
  - Maximum weekly average of daily use = 268 gal/day (August 11)
  - Maximum daily use = 646 gal/day (August 17)

Property No. 18

- Survey Responses:
  - Permanent residence, 2 occupants
  - Lawn watering
- Metering observations:
  - Annual average daily use = 297 gal/day
  - Average annual indoor daily use (estimated) = 270 gal/day
  - Average annual outdoor daily use (estimated) = 26 gal/day
  - Period assumed for significant outdoor use = August 4 – September 29

- Maximum monthly average of daily use = 516 gal/day (November)
- Maximum weekly average of daily use = 1111 gal/day (November 17)
- Maximum daily use = 1512 gal/day (November 14)

4.0 PRECIPITATION DATA

Figure 4 is a plot of the cumulative precipitation for May through October (the expected range of significant outdoor water use) from 1994 through 2012 (1996 data was unavailable) in the Skagit River basin. The precipitation data were obtained from the Washington State University (WSU) Agriculture Weather Network program (AgWeatherNet). The weather station is located in Skagit County near Mt. Vernon.

As shown on Figure 4, the WSU Mt Vernon station received average precipitation relative to the period of record until late June, when a short period of higher than average rainfall occurred until early July. At that time a very dry period occurred, with little rainfall from early July through mid-October (one of the longest dry spells in the last 16 years). From July 24 through October 11, only 0.15 inches of rainfall were recorded. This suggests that for properties where significant outdoor water use occurred, this period should represent a relatively high level of total use compared to a typical year.

5.0 STATISTICAL ANALYSIS OF REPRESENTATIVENESS OF RESULTS

A statistical analysis was completed to evaluate the representativeness of the 18 metered properties relative to other parcels in the Carpenter-Fisher and Upper Nookachamps sub-basins.

There are many statistical techniques to estimate the properties of a larger population from a smaller sample drawn from that population. This implicitly requires that the smaller sample be statistically representative of the larger population. Since this study relied upon volunteers, it was necessary to determine if the volunteered parcels were representative of the water usage expected for the parcels in Carpenter-Fisher and Upper Nookachamps sub-basins that were part of the monitoring network.

There are many factors that potentially relate to water usage: the number of bathrooms, the improved and unimproved land value, the type of structure (mobile home, rural single family dwelling, etc.), the age of the dwelling, the building value, the total acreage, living area, and the number of bedrooms, among others. These variables were available for both the metered and unmetered parcels. To the extent that these factors in the metered properties are similar to the unmetered parcels, they are potentially representative of the unmetered parcel water usage.

Representativeness was quantified by measuring the similarity in several aspects of the parcels that potentially impact water usage. Parcel parameters considered included:

- Neighborhood

- Land Use
- Year Built
- Building Value
- Land Area
- Improved Land Value
- Unimproved Land Value
- Living Area
- Number of Full Baths
- Number of Master Baths
- Number of Half Baths
- Number of Bedrooms
- Basin (Carpenter-Fisher or Upper Nookachamps)
- Assigned Land Use Class
- Undeveloped Area

A K-Nearest Neighbor (KNN) cluster analysis was used to assess whether the monitored properties were representative of the residential parcels that were not part of the monitoring network. The KNN method can incorporate continuous, ordinal, and categorical data types, and thus all of the measured data could be assessed to determine the similarity between the unmonitored and monitored parcels. There were 18 monitored parcels and 1,155 unmonitored parcels within the Carpenter-Fisher and Upper Nookachamps sub-basins. The KNN procedure was carried out using SPSS, a commercial statistics software system (www.spss.com). The similarity was quantified by using a distance metric based on the Z-scores (i.e. the number of standard deviations an observation is above or below the mean) of the continuous data, and a normalization of the categorical data, such that the differences for each variable carried approximately the same weight. The locations in variable space were calculated for each metered and unmetered parcel based on these normalized variables.

Figure 5 shows the locations of the monitored and unmonitored residential parcels in terms of what was determined through the analysis to be the most important variables: building value, land use and construction year. Monitored parcels were designated as “Focal Data” in order to make it easier to visually assess the representativeness of the monitored properties.

It is clear from visual examination of this chart that the red points (monitored parcels) are well dispersed throughout the blue points (unmonitored parcels), and red points are present in all major clusters. Figure 6 shows some additional views of the data in terms of other variables:

- Land Use
- Building Value
- Improved Land Value

- Year Built
- Land Area
- Unimproved Land Value

The red symbols either bracket or are well-dispersed throughout the blue symbols, which indicates that the characteristics of the monitored parcels are similar to or bracket the unmonitored parcels. Overall, the KNN analyses indicate that the monitored properties are representative of the unmonitored parcels, with perhaps only a few (approximately 10 to 20) exceptions within the unmonitored parcels.

As part of the KNN cluster analysis, the percentages of unmonitored parcels that were most similar to a specific monitored property were determined:

Property No.	% Similar
1	2.35%
2	3.79%
3	2.89%
4	8.76%
5	0.45%
6	6.14%
7	1.08%
8	6.41%
9	4.88%
10	11.56%
11	5.69%
12	2.80%
13	1.08%
14	4.97%
15	3.97%
16	1.36%
17	20.23%
18	11.56%

For example, 20.23% of the unmonitored parcels were most similar to Property No. 17. The evenness in the percent similarity in all but three parcels shows that the monitored sample is broadly representative of the unmonitored data, although Property Nos. 10, 17, and 18 are the most similar to the unmonitored parcels. It is of note that none of these properties appear to have significant outdoor water use associated with them.

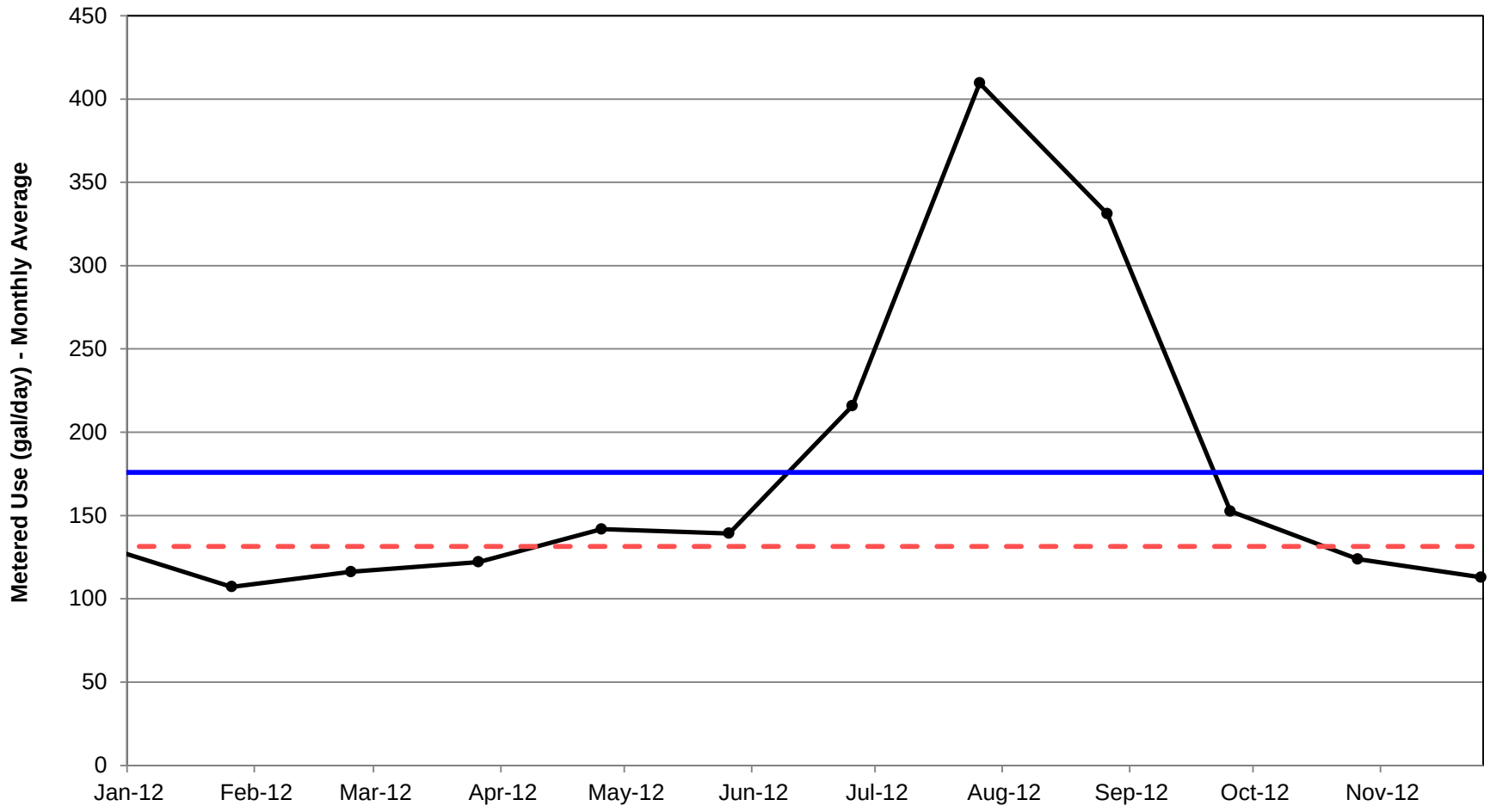
6.0 SUMMARY AND CONCLUSIONS

Eighteen properties with exempt wells in the Carpenter-Fisher and Upper Nookachamps sub-basins of the Skagit River watershed were monitored for groundwater use during 2012. The properties were identified through solicitation of volunteers and equipped with flow meters. A database for managing information collected from the metering program was developed and used the data analysis presented in this memorandum. Estimates of indoor versus outdoor use were developed, where feasible based on the metering records. A statistical analysis of the data using KNN cluster analysis methods was conducted to determine the representative of the monitored properties relative to unmonitored parcels. Key conclusions from the study include:

- Average annual daily use ranged from 56 to 463 gal/day, with an average for all of the properties of 176 gal/day.
- Twelve of the properties showed seasonal increases in water use that are likely associated with outdoor water use.
- The estimated average annual indoor daily use ranged from 84 to 270 gal/day, with an average of 131 gal/day for the 12 properties where it was estimated. Average annual outdoor daily use ranged from four to 122 gal/day with an average of 33 gal/day for the 12 properties.
- The minimum monthly average of total daily use ranged from zero to 172 gal/day, with an average of 107 gal/day. The maximum monthly average of total daily use ranged from 133 to 2293 gal/day, with an average of 410 gal/day.
- The maximum weekly average of total daily use for any of the monitored properties is 3,015 gal/day.
- Precipitation during the expected outdoor watering season of May through October was evaluated and compared to other years. In comparison to the available record from 1994 through 2011, precipitation at the WSU Mt Vernon station was average relative to the period of record until later June, when a short period of higher than average rainfall occurred until early July. From that point on, a significant dry spell occurred from early July through mid-October, suggesting that for properties where significant outdoor water use occurred, this period should represent a relatively high level of total use compared to a typical year.
- The KNN cluster analysis indicated that the monitored parcels are representative of the parcels within the Carpenter-Fisher and Upper Nookachamps sub-basins that were not part of the monitoring program.
- The percentages of unmonitored parcels that were most similar to a specific monitored property were also evaluated. The evenness in the percent similarity in all but three parcels shows that the monitored sample is broadly representative of the unmonitored data, although Property Nos. 10, 17, and 18 are the most similar to the unmonitored parcels.

Table 1: Summary of Exempt Well Metering Data

						Weekly Average of Total Daily Use During Peak Period of Outdoor Use (gal/day)					
Property No.	**Annual Average Daily Use (gal/day)**	**Average Annual Indoor Daily Use (estimated) (gal/day)**	**Average Annual Outdoor Daily Use (estimated) (gal/day)**	**Minimum Monthly Average of Total Daily Use (gal/day)**	**Maximum Monthly Average of Total Daily Use (gal/day)**	**8/11/2012**	**8/18/2012**	**8/25/2012**	**9/1/2012**	**9/8/2012**	**9/15/2012**
1	56	Not Estimated	Not Estimated	36	142	52	44	39	55	50	34
2	328	206	122	152	1074	1084	1100	1163	1117	1042	1009
3	95	85	10	58	169	183	189	135	120	160	77
4	463	Not Estimated	Not Estimated	0	2293	2371	2941	1924	2332	3015	1138
5	163	119	44	84	388	291	614	329	482	250	226
6	105	89	16	75	218	281	110	136	133	149	100
7	181	Not Estimated	Not Estimated	81	242	28	217	245	108	120	180
8	148	Not Estimated	Not Estimated	72	226	88	82	83	90	60	86
9	145	Not Estimated	Not Estimated	126	176	126	109	140	152	118	136
10	183	Not Estimated	Not Estimated	142	226	277	189	173	165	174	201
11	197	180	16	0	498	359	483	483	515	652	481
12	188	Not Estimated	Not Estimated	172	222	179	207	209	159	213	132
13	106	75	31	15	260	227	438	199	134	186	46
14	154	93	61	0	463	548	466	463	473	571	452
15	88	84	4	61	133	133	217	63	104	126	132
16	165	146	19	120	286	291	296	236	275	274	220
17	104	96	8	64	176	268	247	117	16	91	132
18	297	270	26	156	516	397	467	283	568	534	352
All Properties	176	131	33	107	410	399	468	357	389	432	285



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LEGEND

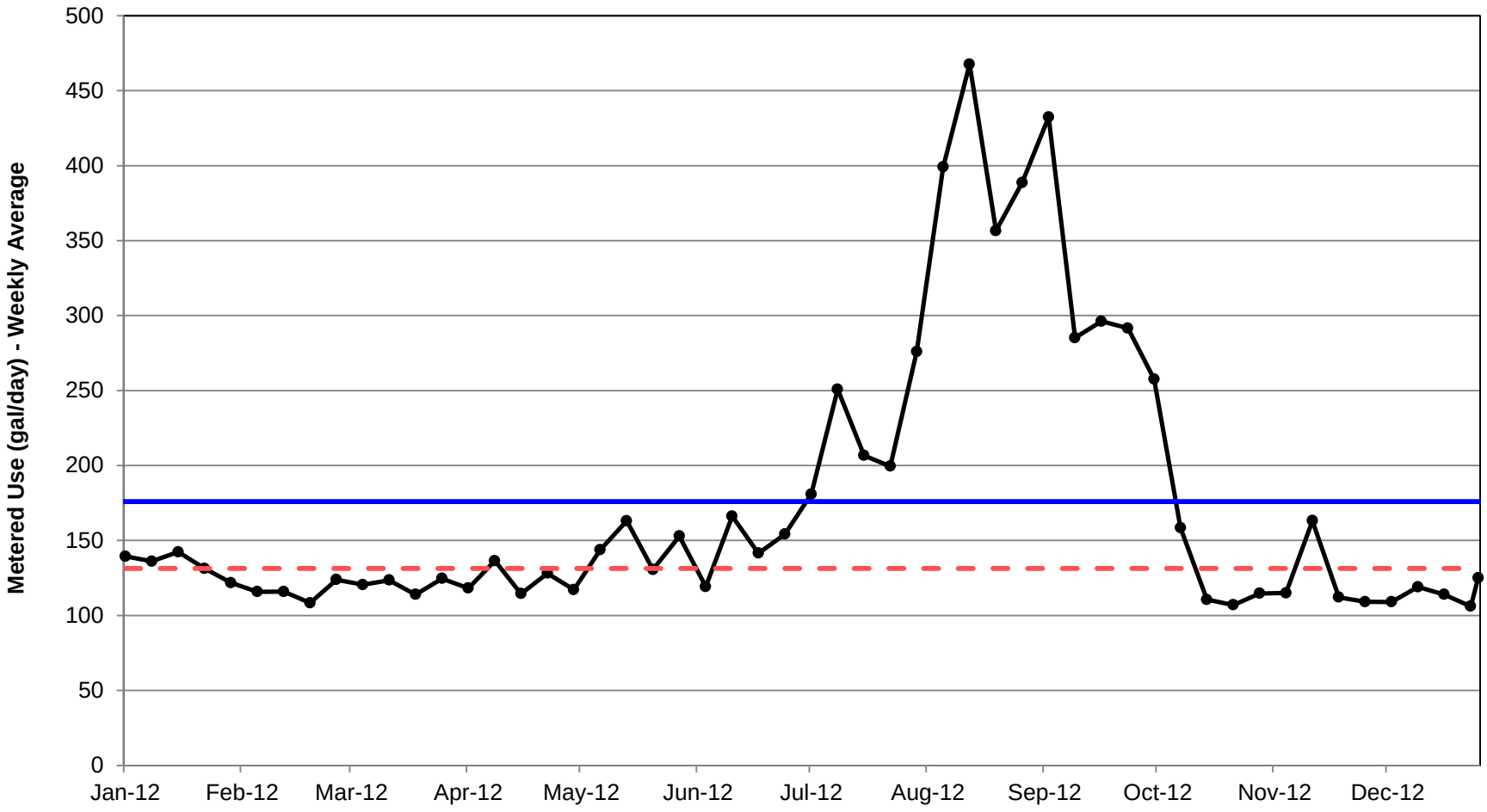
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **1**

MEAN DAILY GROUNDWATER USE (MONTHLY AVERAGE) FOR ALL METERED PROPERTIES

SC/Well Pilot Metering Program/WA

083-93183



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LEGEND

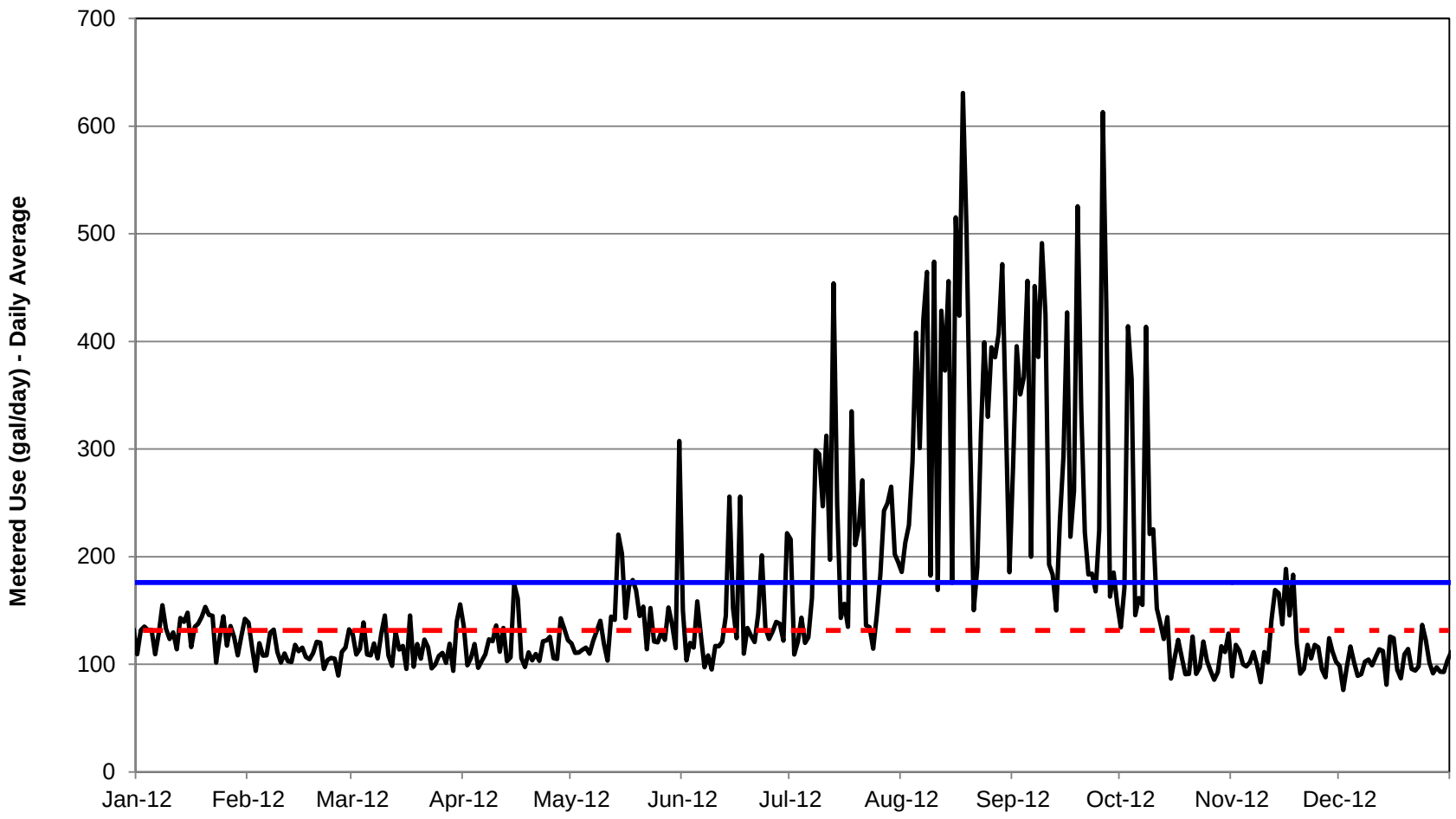
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **2**

MEAN DAILY GROUNDWATER USE (WEEKLY AVERAGE) FOR ALL METERED PROPERTIES

SC/Well Pilot Metering Program/WA

083-93183



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LEGEND

Total Water Use (Metered)

Average Indoor Use (Estimated)

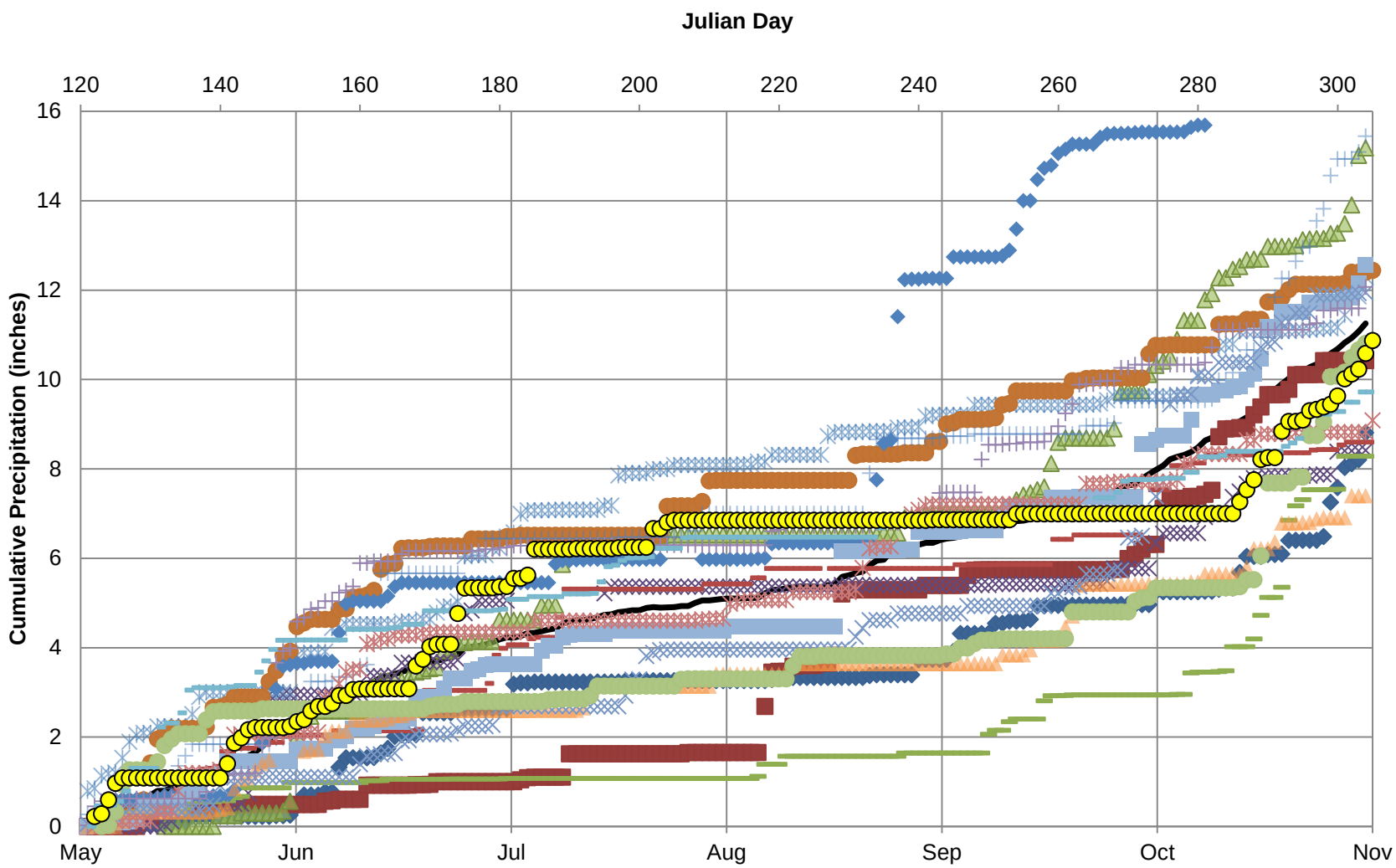
Average Annual Use

FIGURE **3**

MEAN AVERAGE DAILY GROUNDWATER USE FOR ALL METERED PROPERTIES

SC/Well Pilot Metering Program/WA

083-93183



Data provided courtesy of Washington State University AgWeatherNet. Data are copyright of Washington State University.

Golder Associates

LEGEND

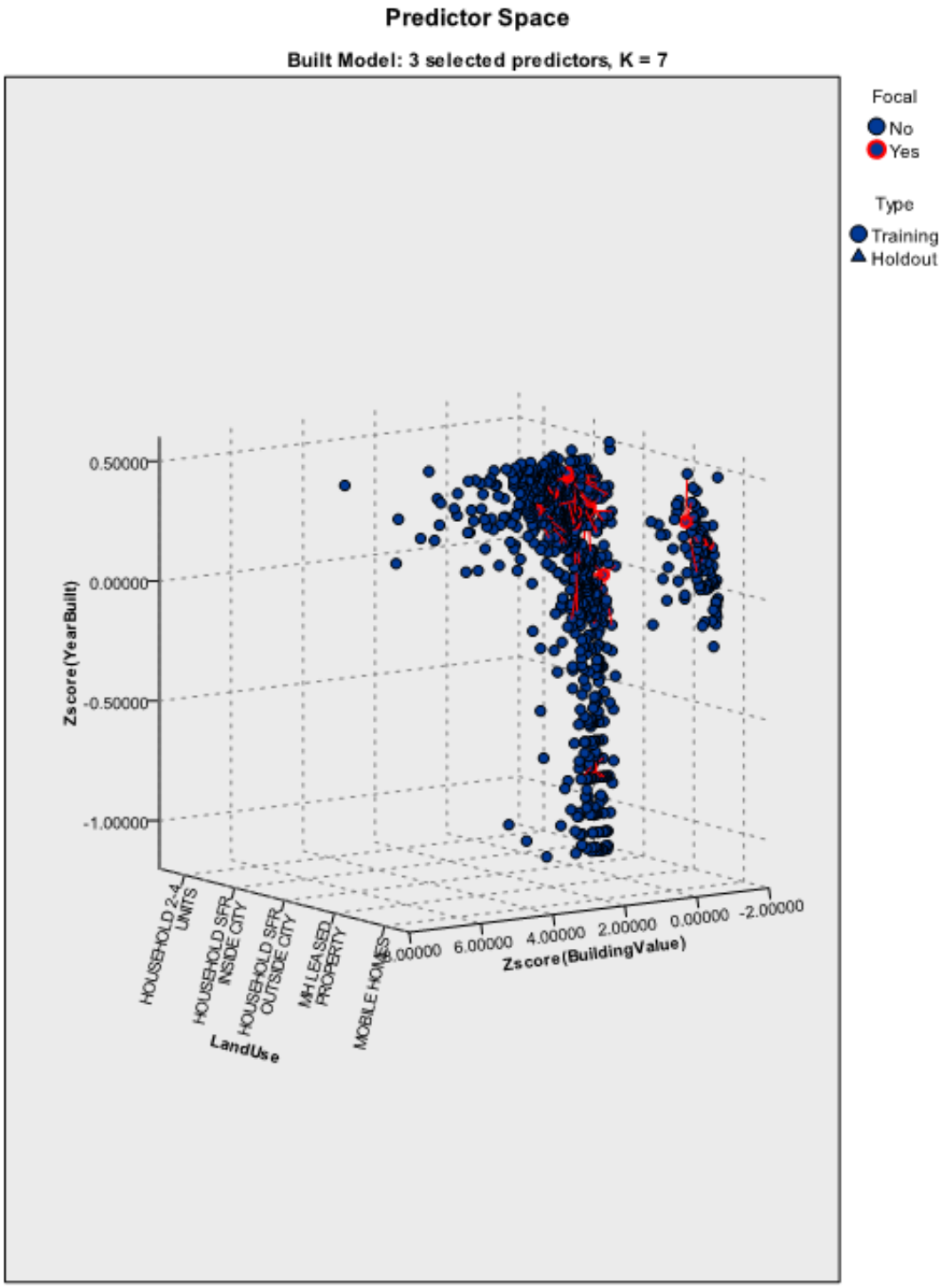
1994	1995	1997	1998
1999	2000	2001	2002
2003	2004	2005	2006
2007	2008	2009	2010
2011	2012	Average	

FIGURE **4**

PRECIPITATION AT WSU WEATHER STATION MT VERNON, WA

SC/Well Pilot Metering Program/WA

083-93183



NOTES

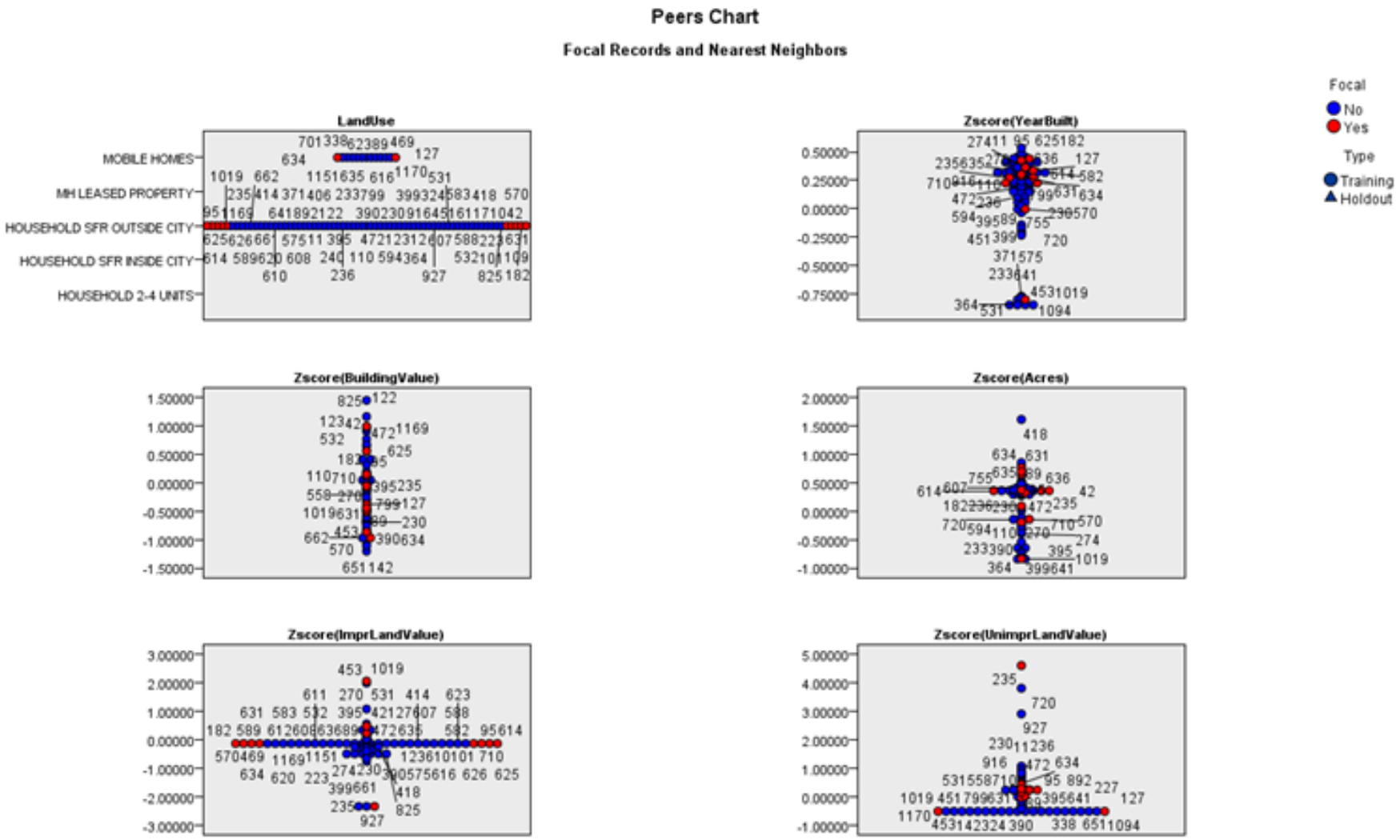
This Chart is a lower-dimensional projection of the predictor space, which contains a total of ten predictors.

Red Symbols are the monitored parcels that constitute the focal data, while the blue symbols represent unmonitored parcels.

FIGURE **5**

K-NEAREST NEIGHBOR (KNN) RESULTS

SC/WELL PILOT METERING PROGRAM/WA



NOTES

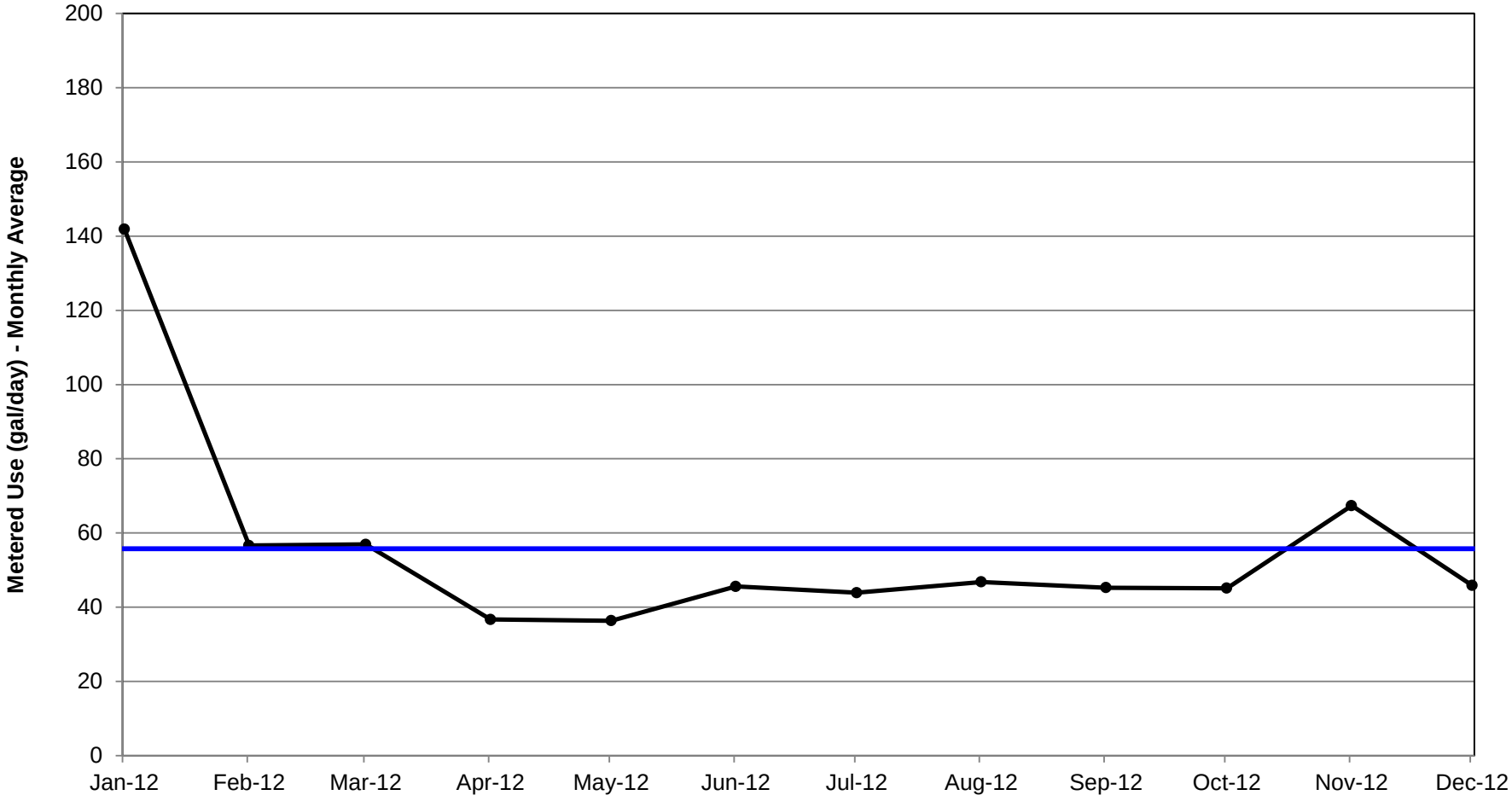
Charts depict the similarity between the monitored and unmonitored parcels in terms of other variables used in the analysis. Numbers represent internal parcel IDs.

FIGURE **6**

K-NEAREST NEIGHBOR (KNN) PEERS CHARTS

SC/WELL PILOT METERING PROGRAM/WA

Attachment A



Note: Indoor vs. outdoor use not determined.

Golder Associates

LEGEND

Total Water Use (Metered)

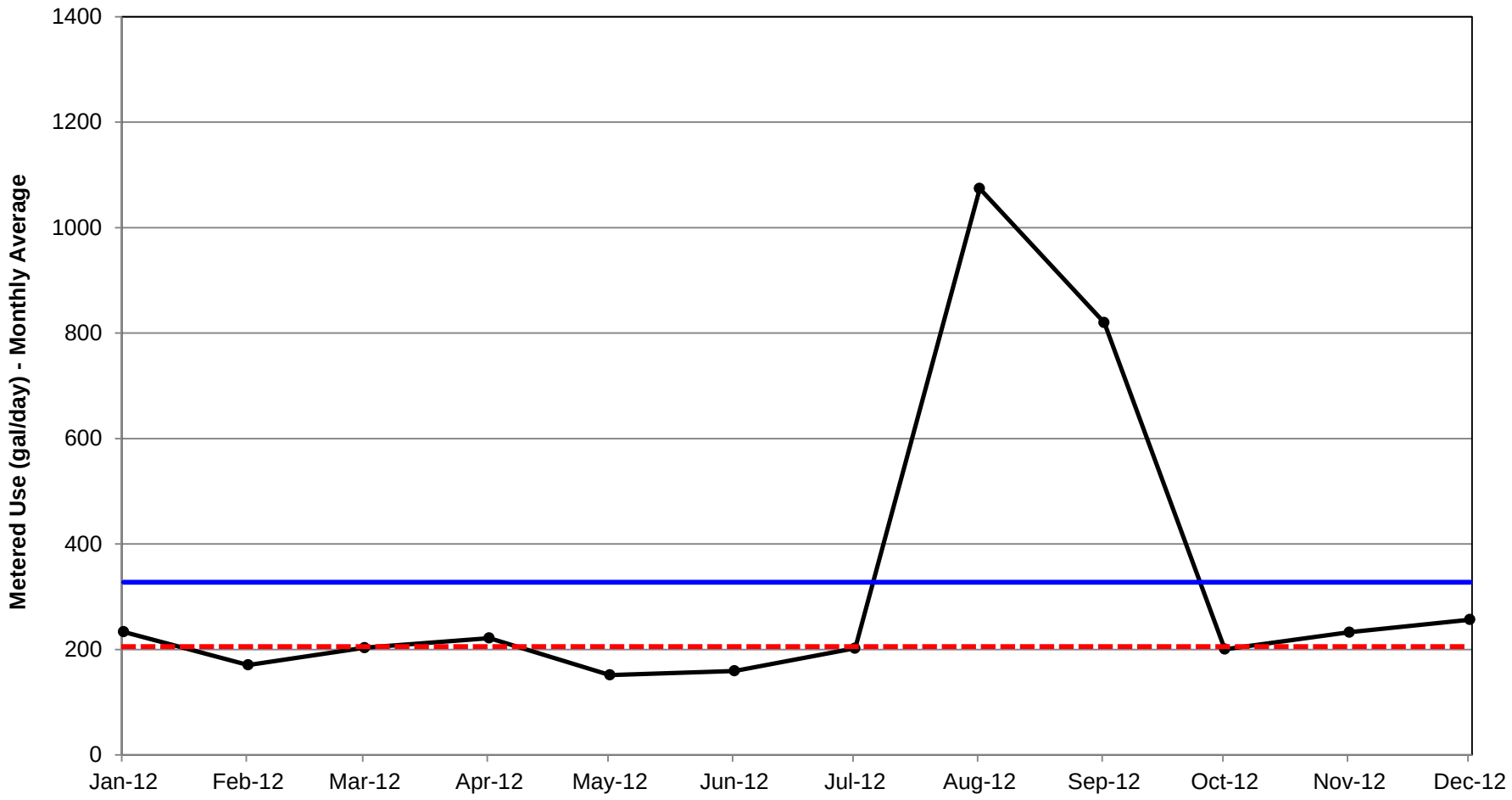
Average Annual Use

FIGURE **A-1**

DAILY GROUNDWATER USE (MONTHLY AVERAGE)
PROPERTY NO. 1

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

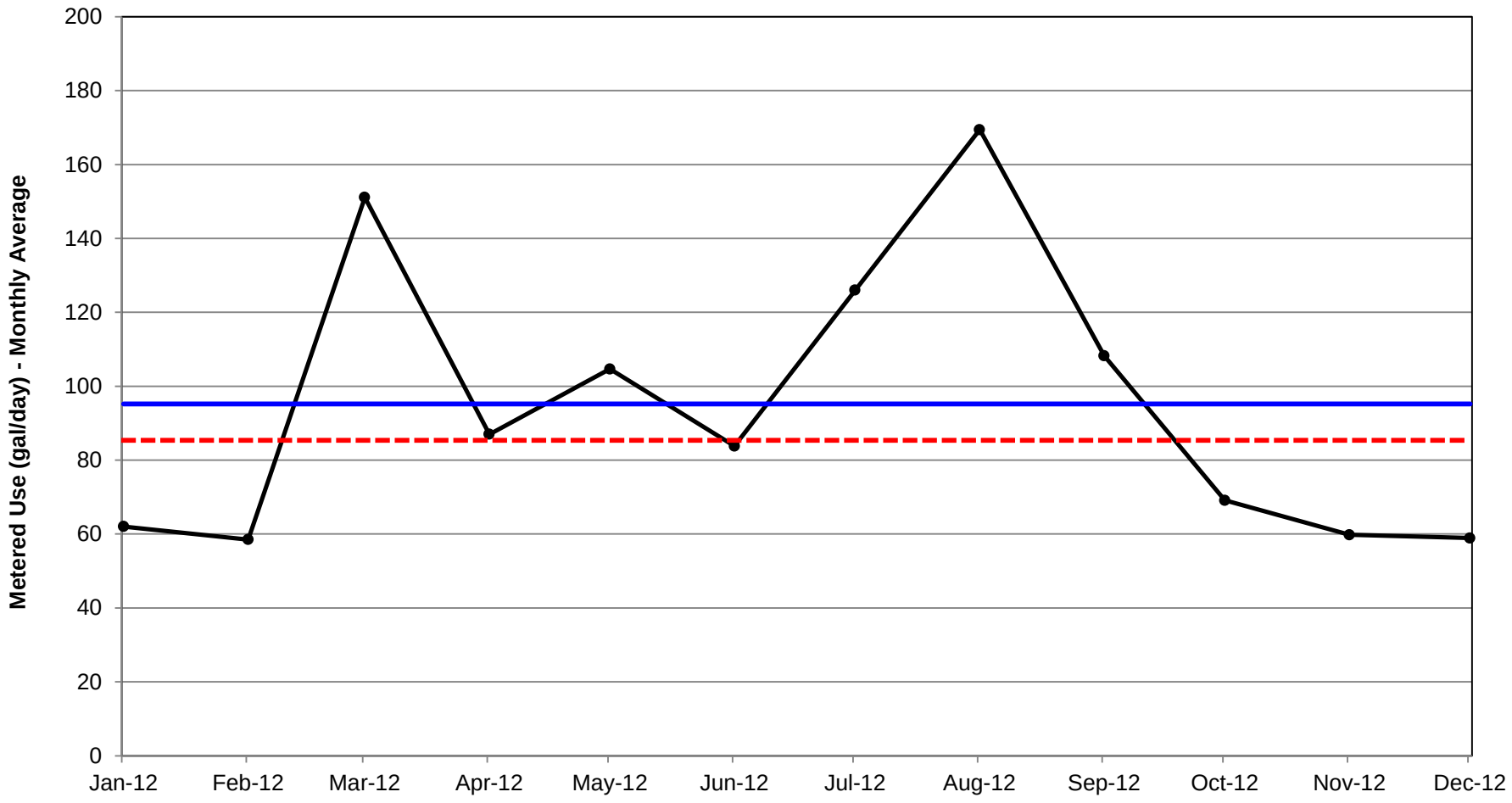
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **A-2**

DAILY GROUNDWATER USE (MONTHLY AVERAGE)
PROPERTY NO. 2

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

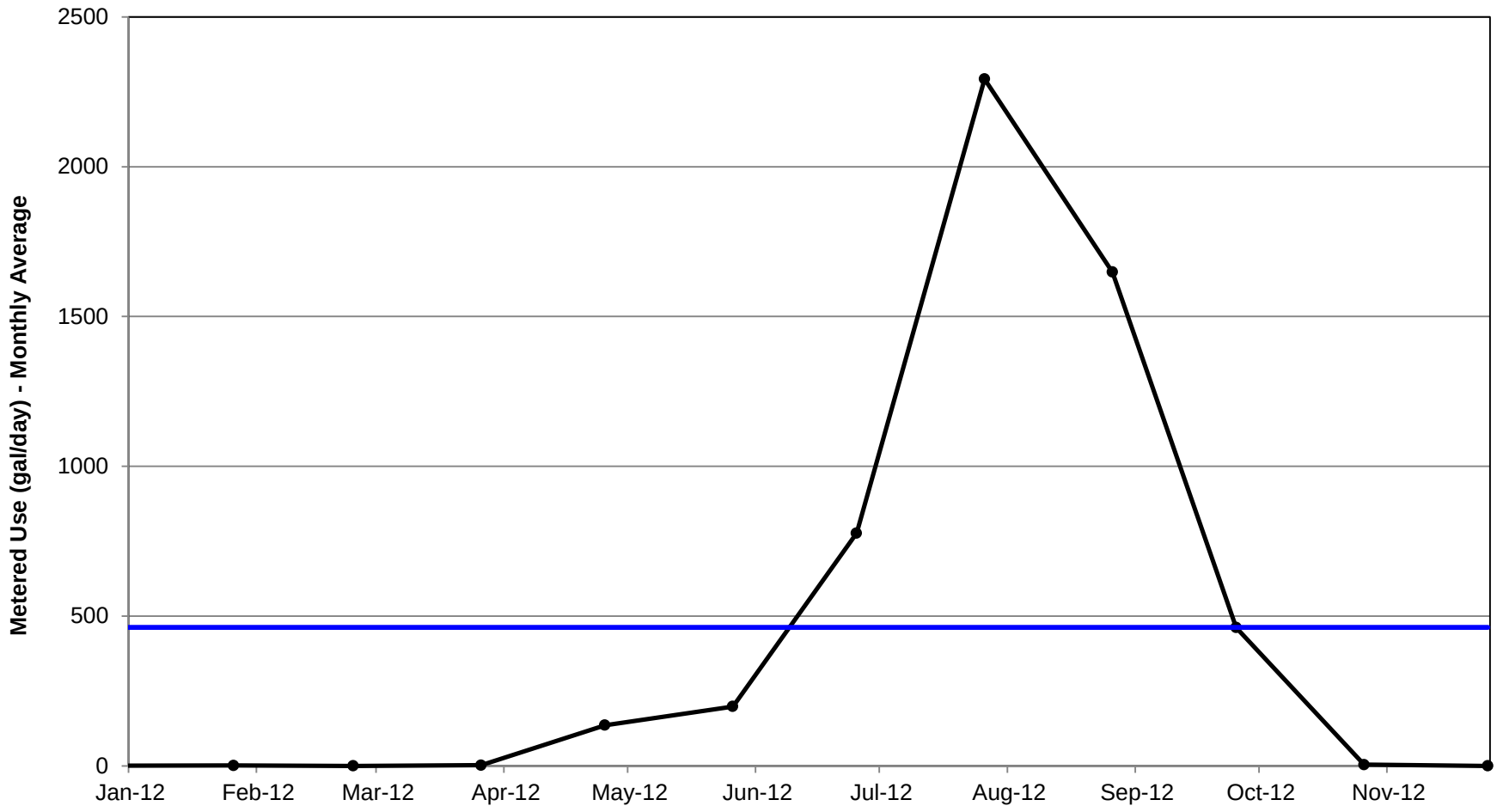
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **A-3**

DAILY GROUNDWATER USE (MONTHLY AVERAGE)
PROPERTY NO. 3

SC/Well Pilot Metering Program/WA

083-93183



Note: Indoor vs. outdoor use not determined.
.

Golder Associates

LEGEND

Total Water Use (Metered)

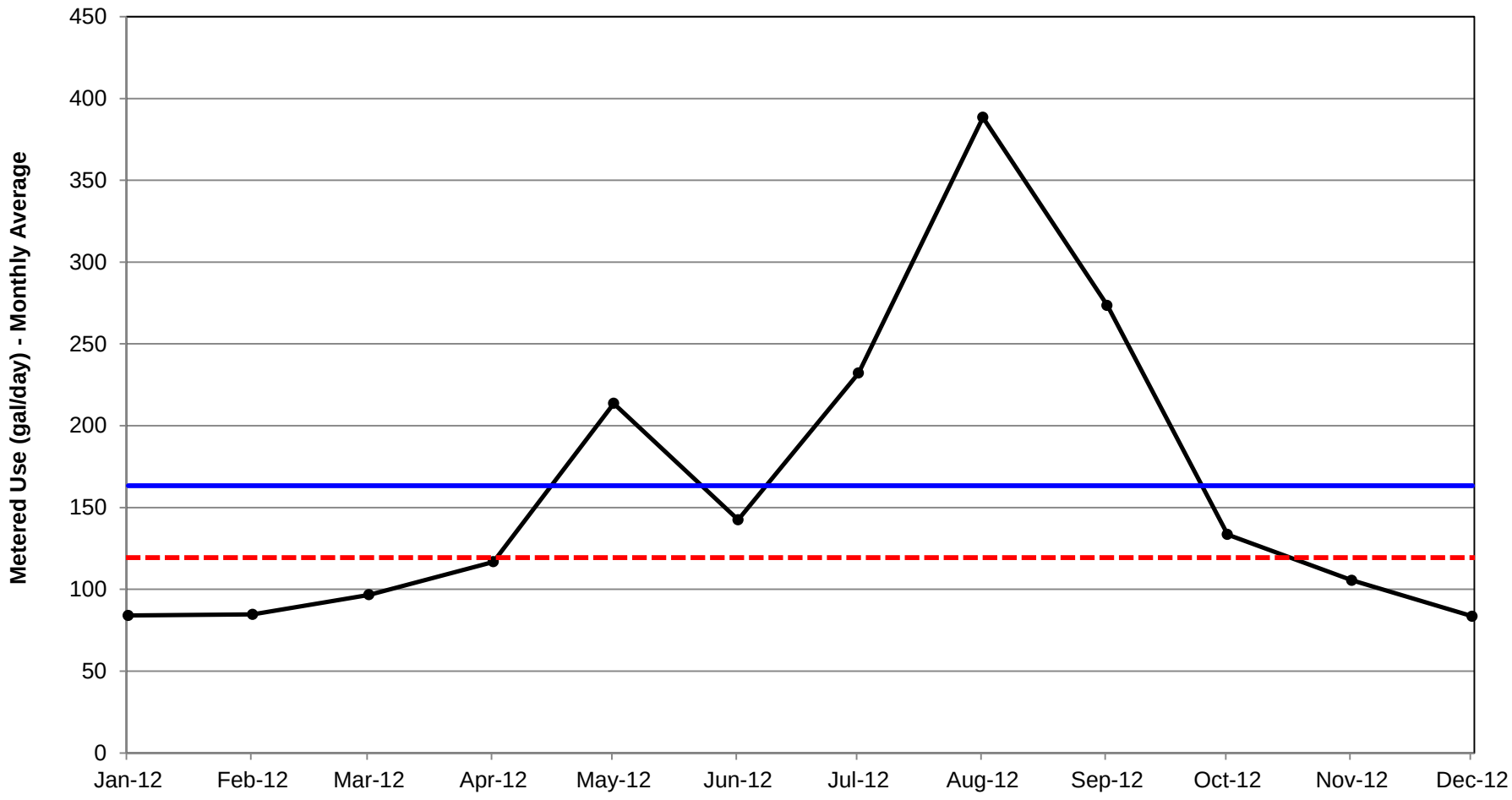
Average Annual Use

FIGURE **A-4**

DAILY GROUNDWATER USE (MONTHLY AVERAGE)
PROPERTY NO. 4

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

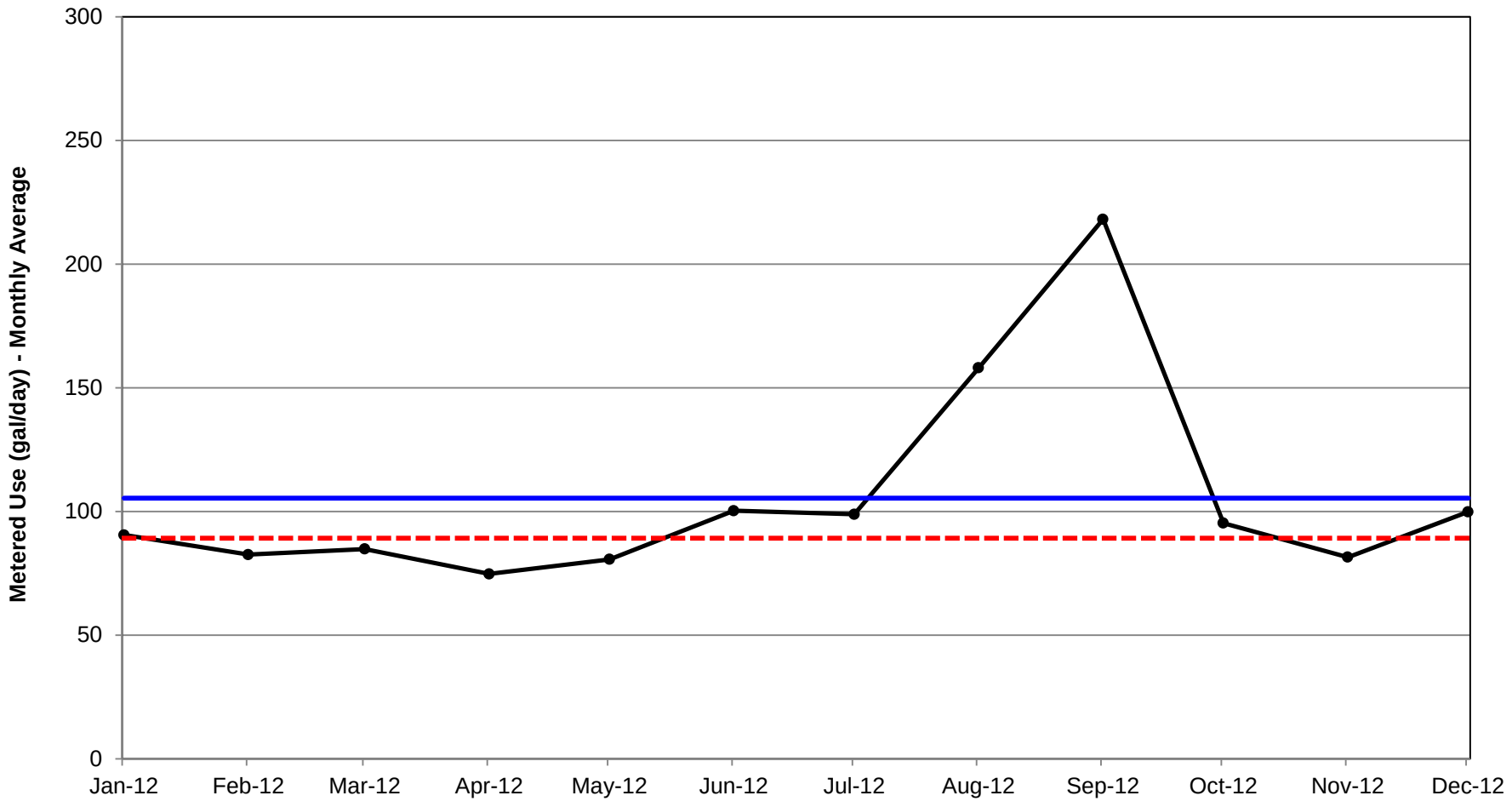
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **A-5**

DAILY GROUNDWATER USE (MONTHLY AVERAGE)
PROPERTY NO. 5

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

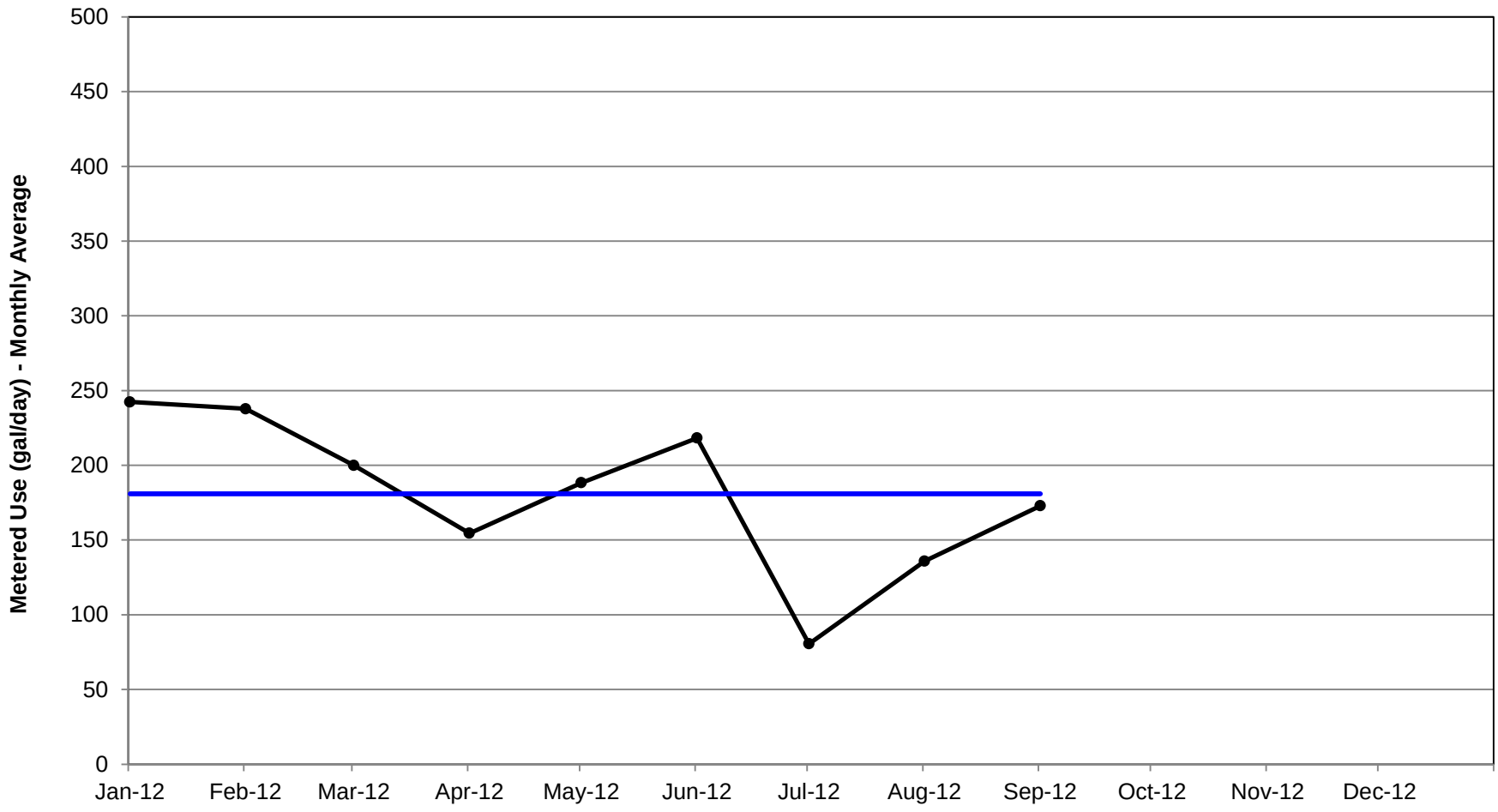
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **A-6**

DAILY GROUNDWATER USE (MONTHLY AVERAGE)
PROPERTY NO. 6

SC/Well Pilot Metering Program/WA

083-93183



Note: Indoor vs. outdoor use not determined. No data available after September 22, 2012

Golder Associates

LEGEND

Total Water Use (Metered)

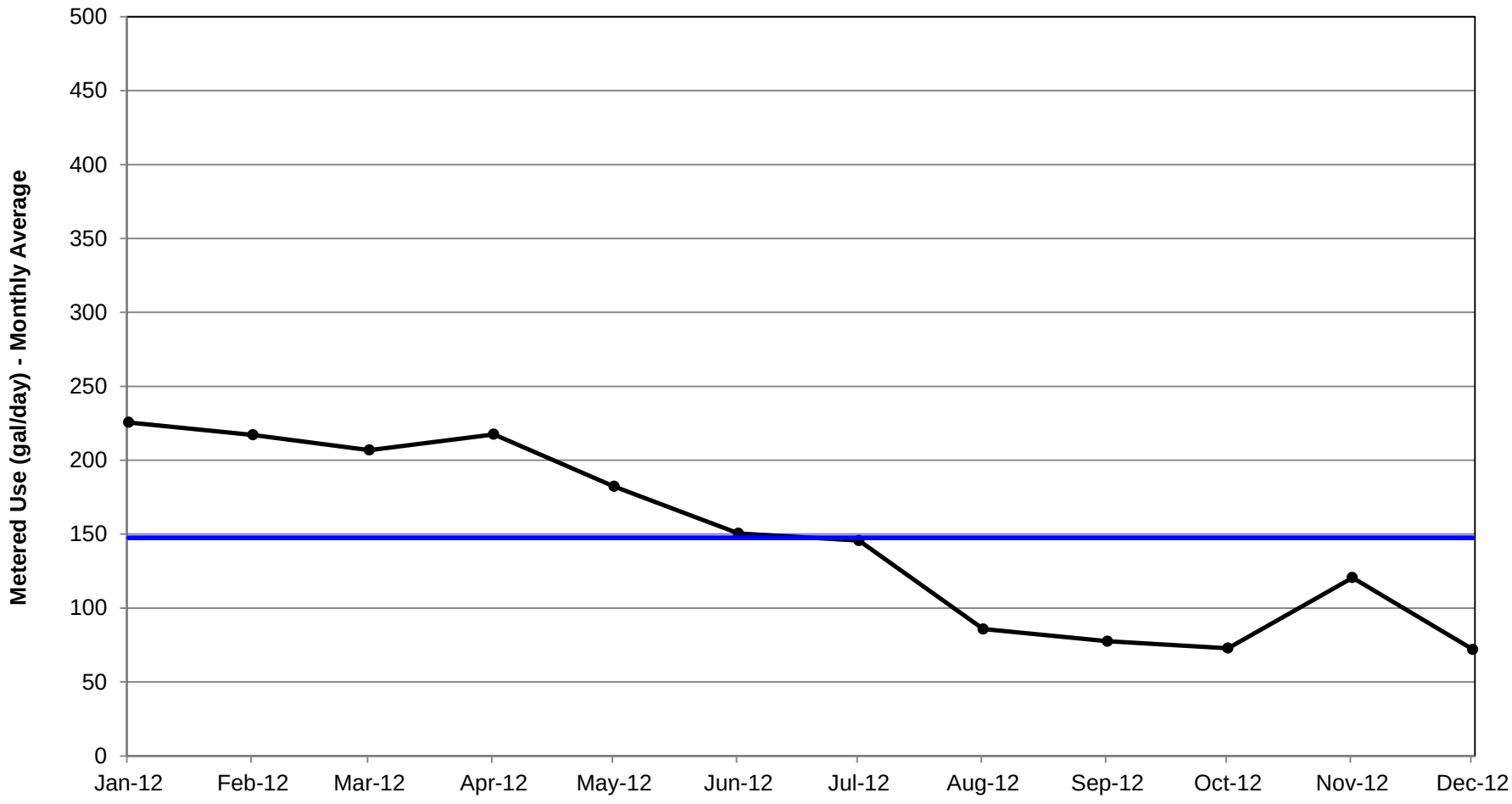
Average Annual Use

FIGURE **A-7**

DAILY GROUNDWATER USE (MONTHLY AVERAGE)
PROPERTY NO. 7

SC/Well Pilot Metering Program/WA

083-93183



Note: Indoor vs. outdoor use not determined.

Golder Associates

LEGEND

Total Water Use (Metered)

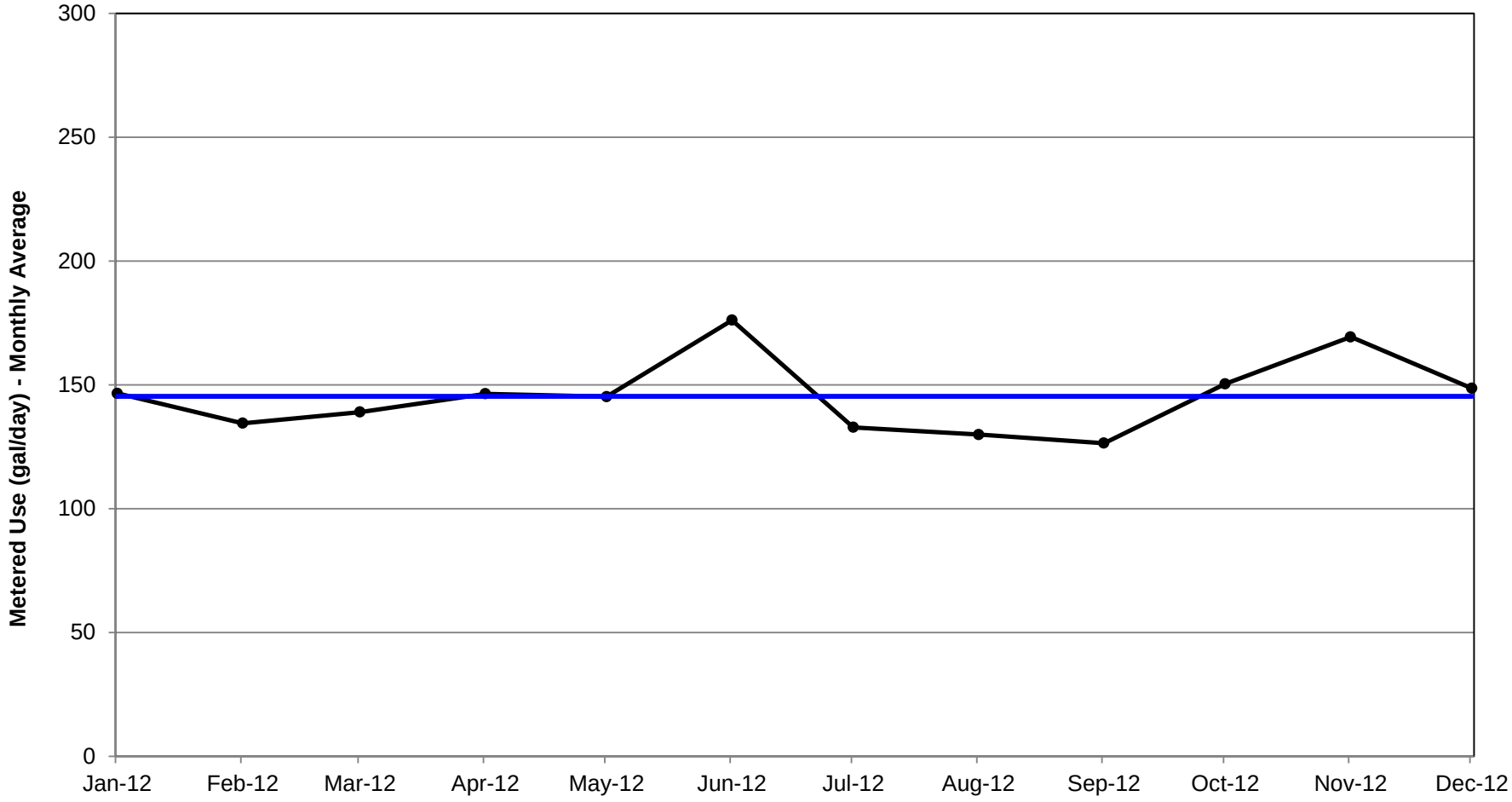
Average Annual Use

FIGURE **A-8**

DAILY GROUNDWATER USE (MONTHLY AVERAGE)
PROPERTY NO. 8

SC/Well Pilot Metering Program/WA

083-93183



Note: Indoor vs. outdoor use not determined.

Golder Associates

LEGEND

Total Water Use (Metered)

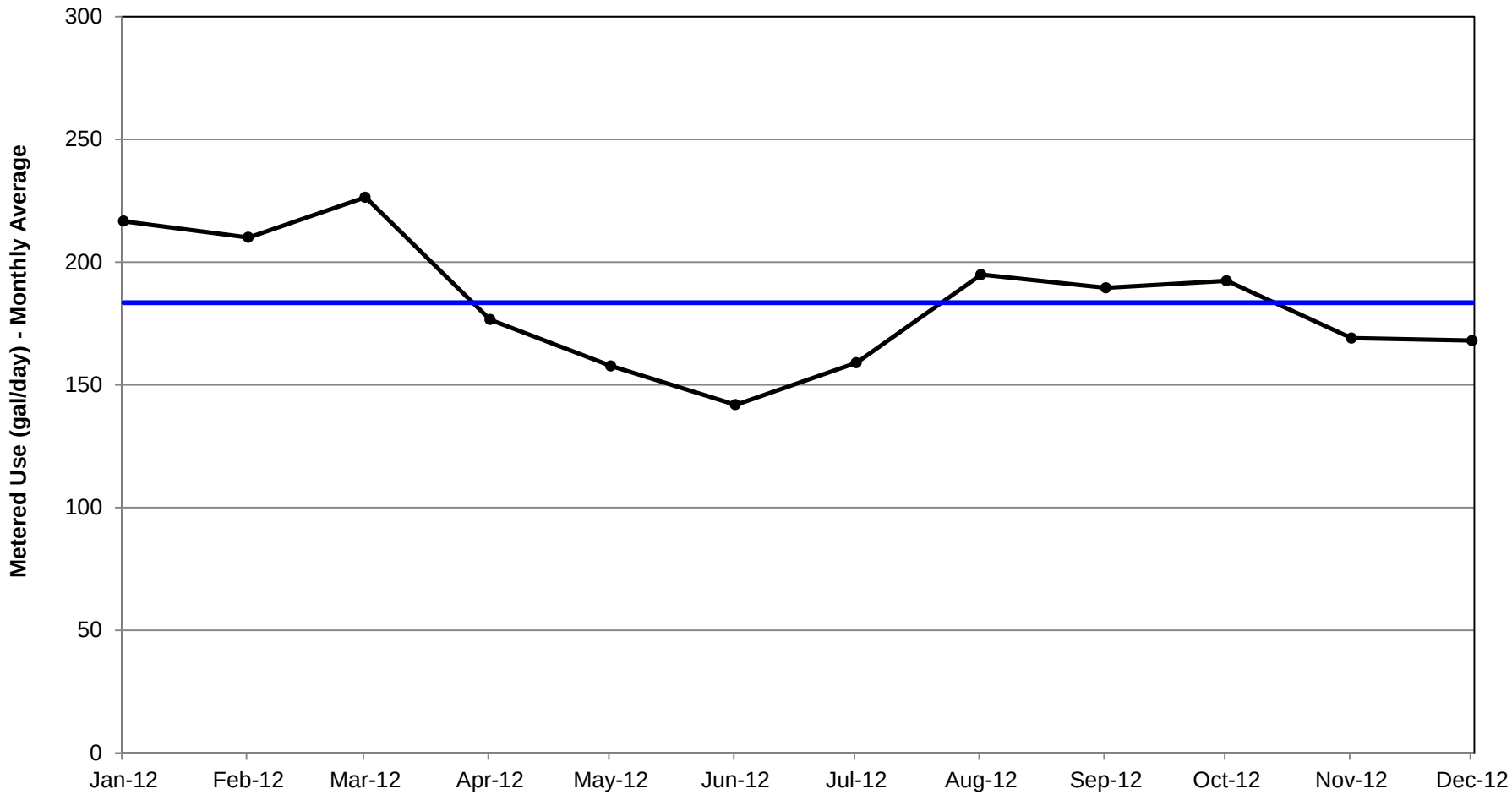
Average Annual Use

FIGURE **A-9**

DAILY GROUNDWATER USE (MONTHLY AVERAGE)
PROPERTY NO. 9

SC/Well Pilot Metering Program/WA

083-93183



Note: Indoor vs. outdoor use not determined.

Golder Associates

LEGEND

Total Water Use (Metered)

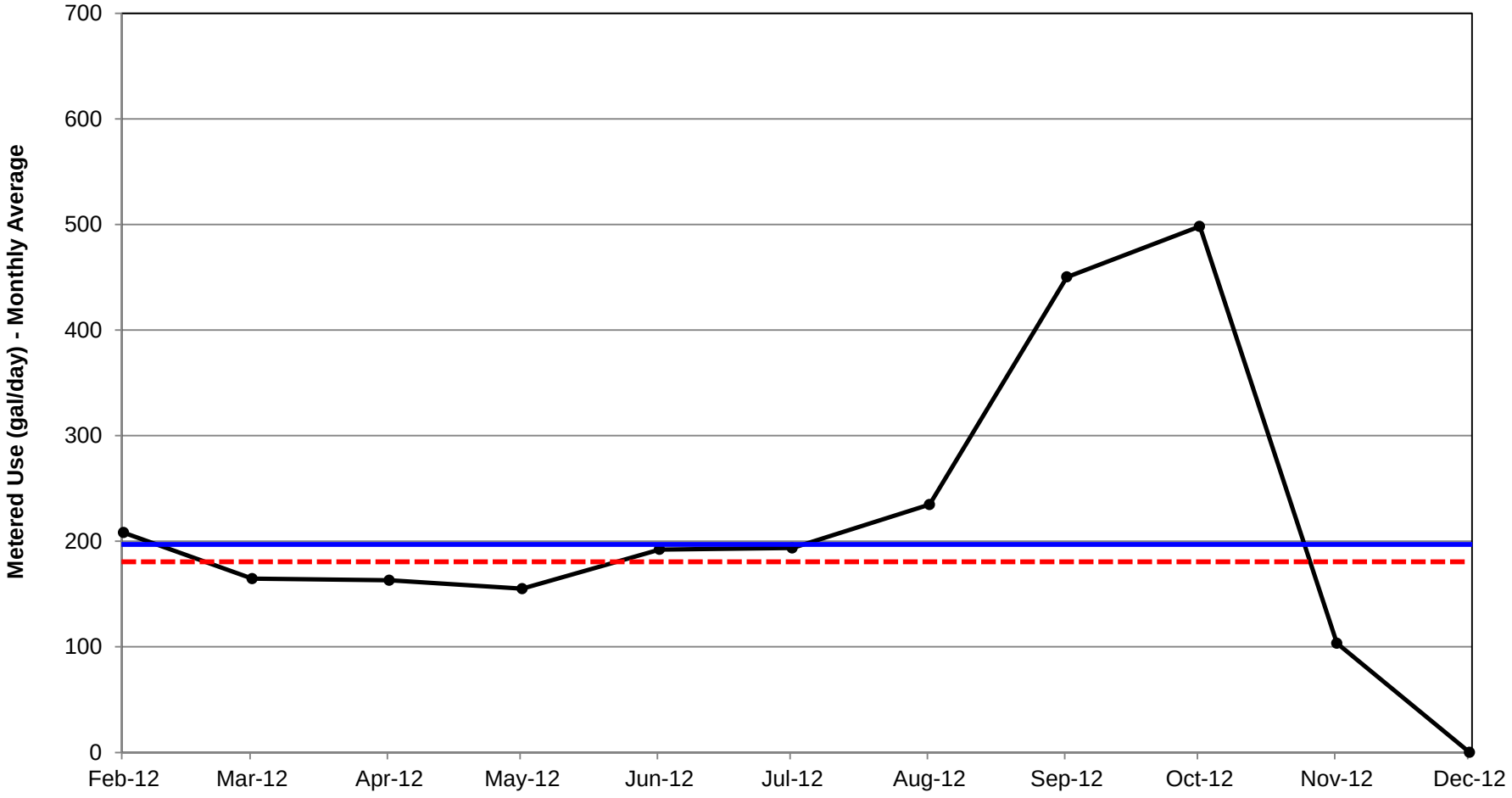
Average Annual Use

FIGURE **A-10**

DAILY GROUNDWATER USE (MONTHLY AVERAGE)
PROPERTY NO. 10

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

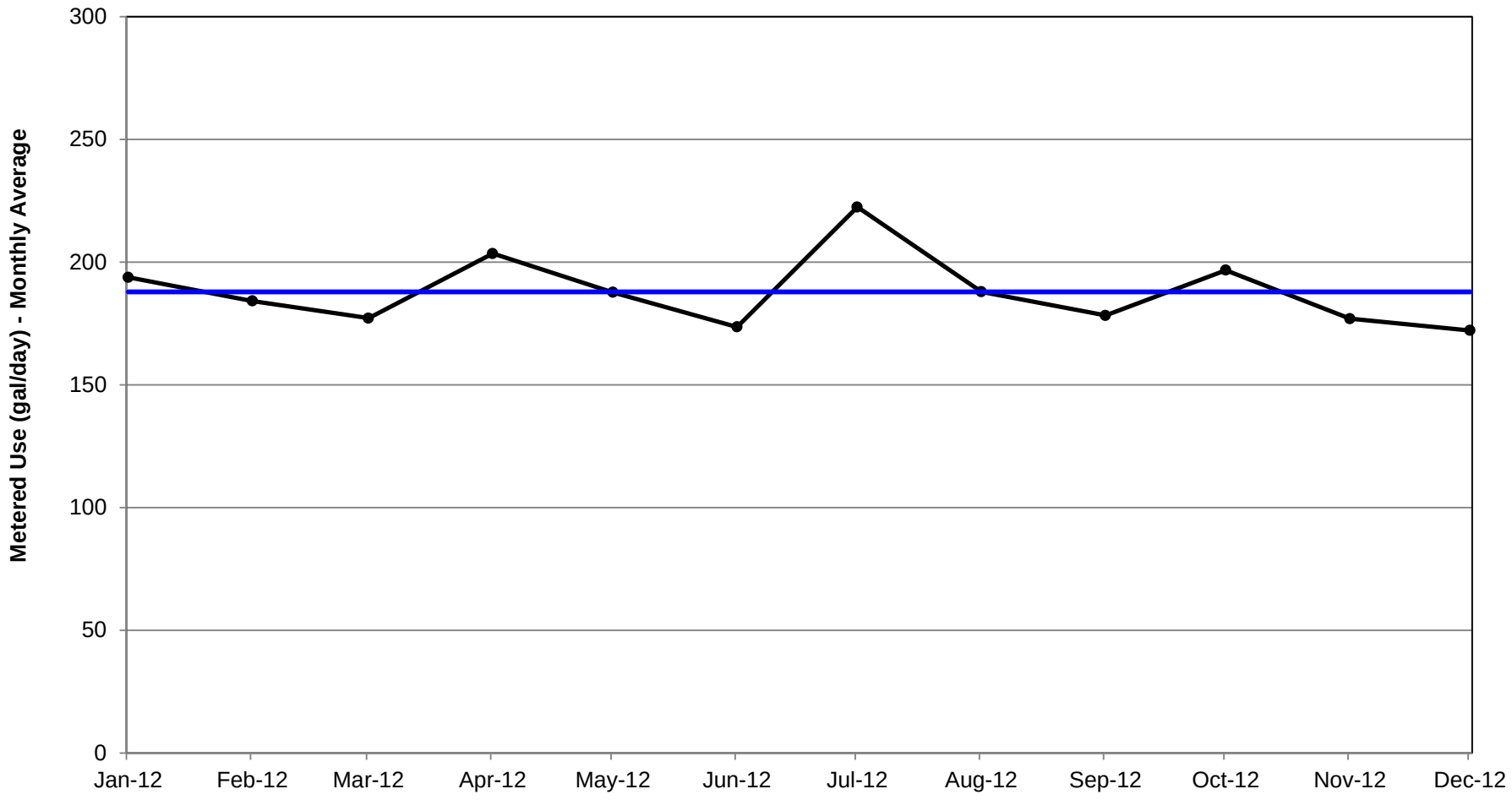
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **A-11**

DAILY GROUNDWATER USE (MONTHLY AVERAGE)
PROPERTY NO. 11

SC/Well Pilot Metering Program/WA

083-93183



Note: Indoor vs. outdoor use not determined.

Golder Associates

LEGEND

Total Water Use (Metered)

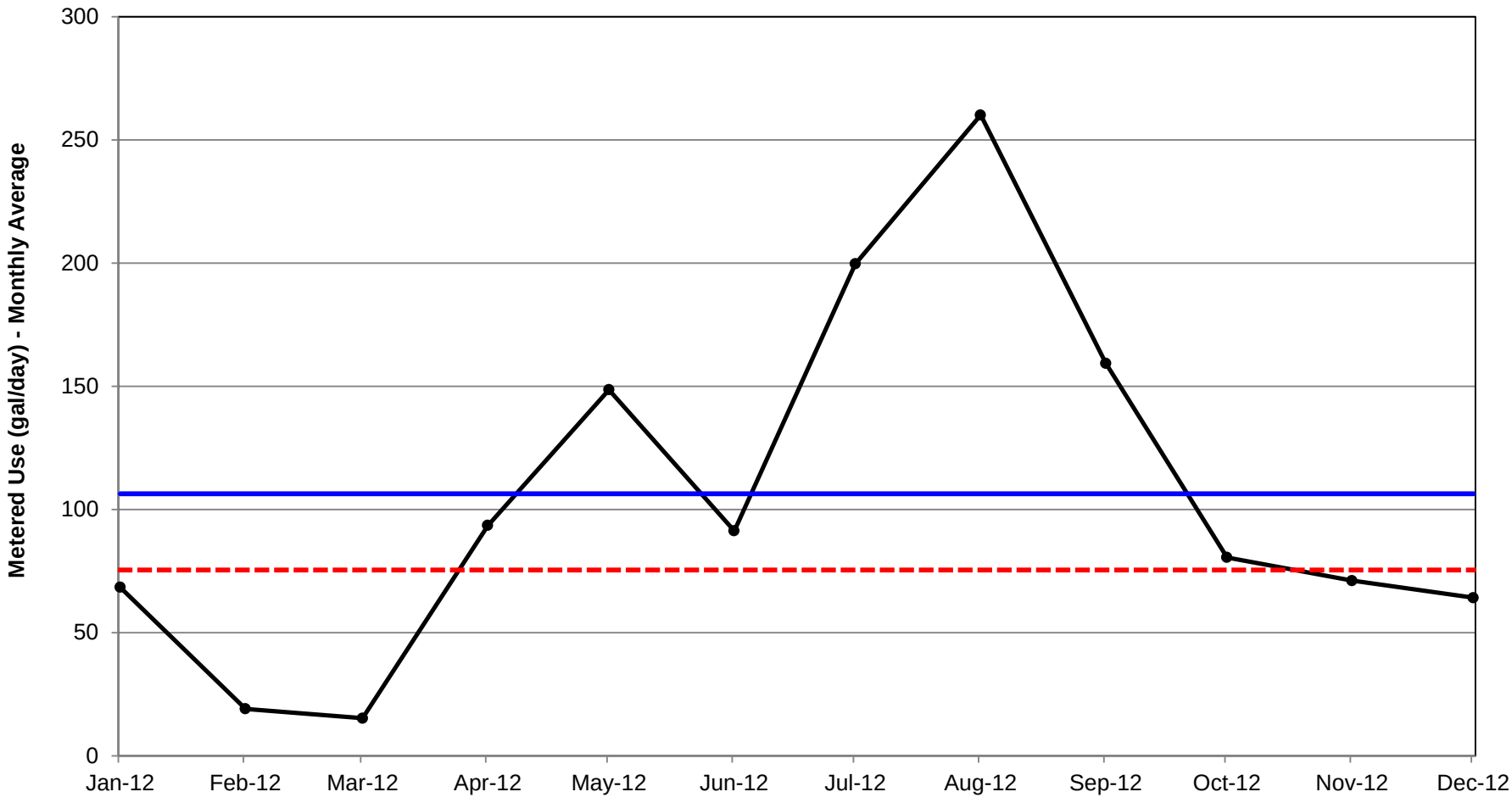
Average Annual Use

FIGURE **A-12**

DAILY GROUNDWATER USE (MONTHLY AVERAGE)
PROPERTY NO. 12

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

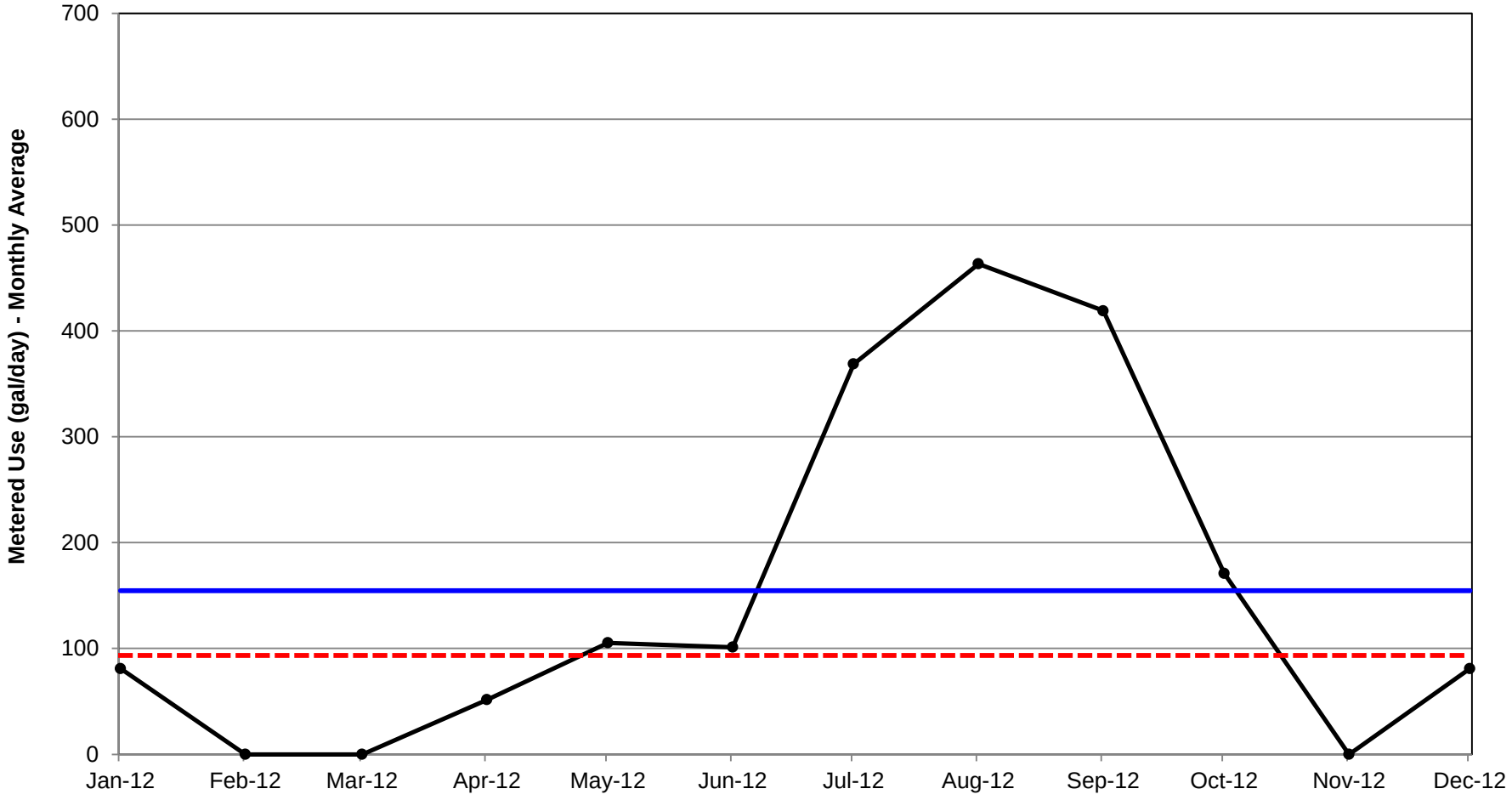
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **A-13**

DAILY GROUNDWATER USE (MONTHLY AVERAGE)
PROPERTY NO. 13

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

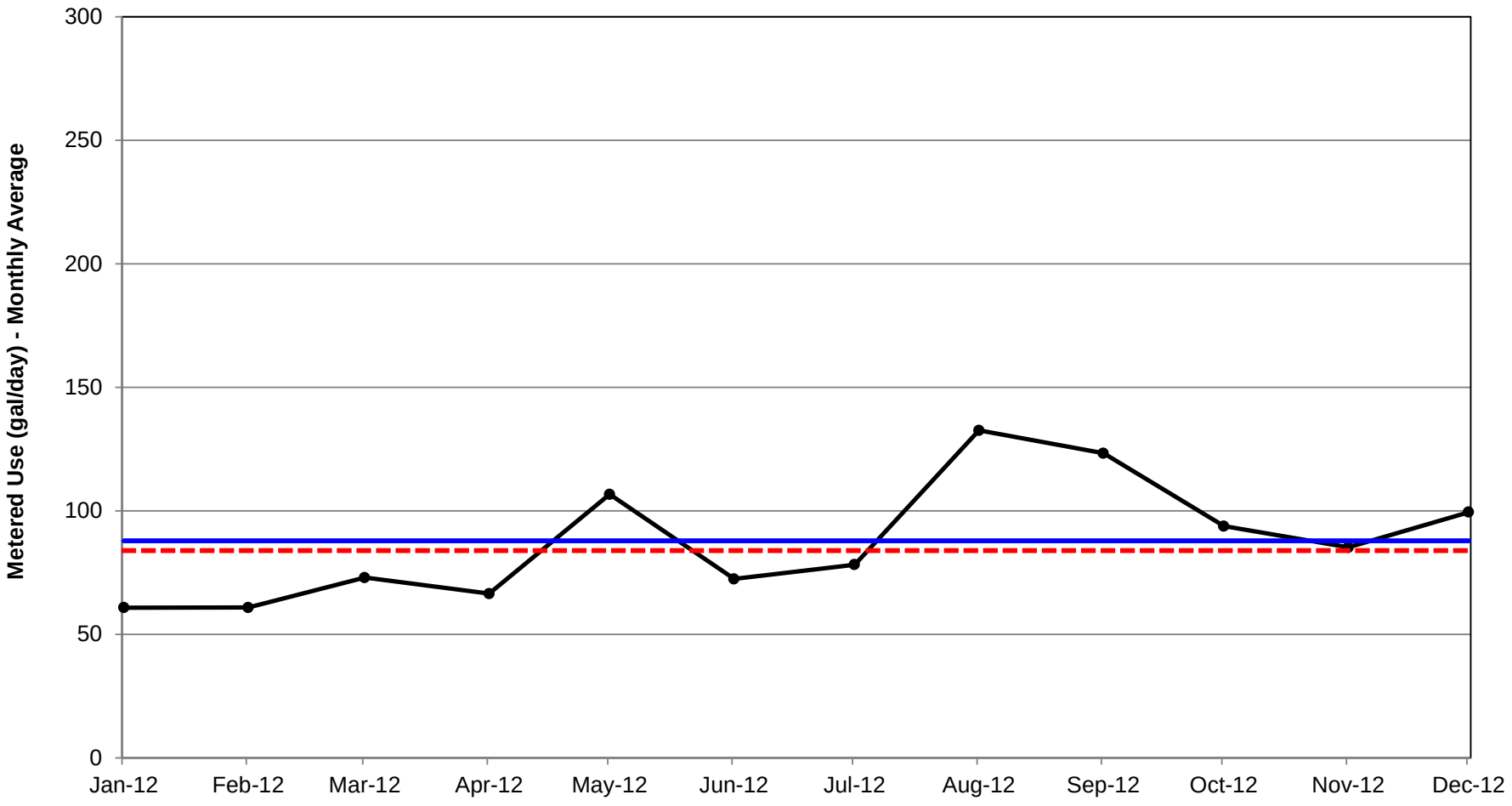
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **A-14**

DAILY GROUNDWATER USE (MONTHLY AVERAGE)
PROPERTY NO. 14

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

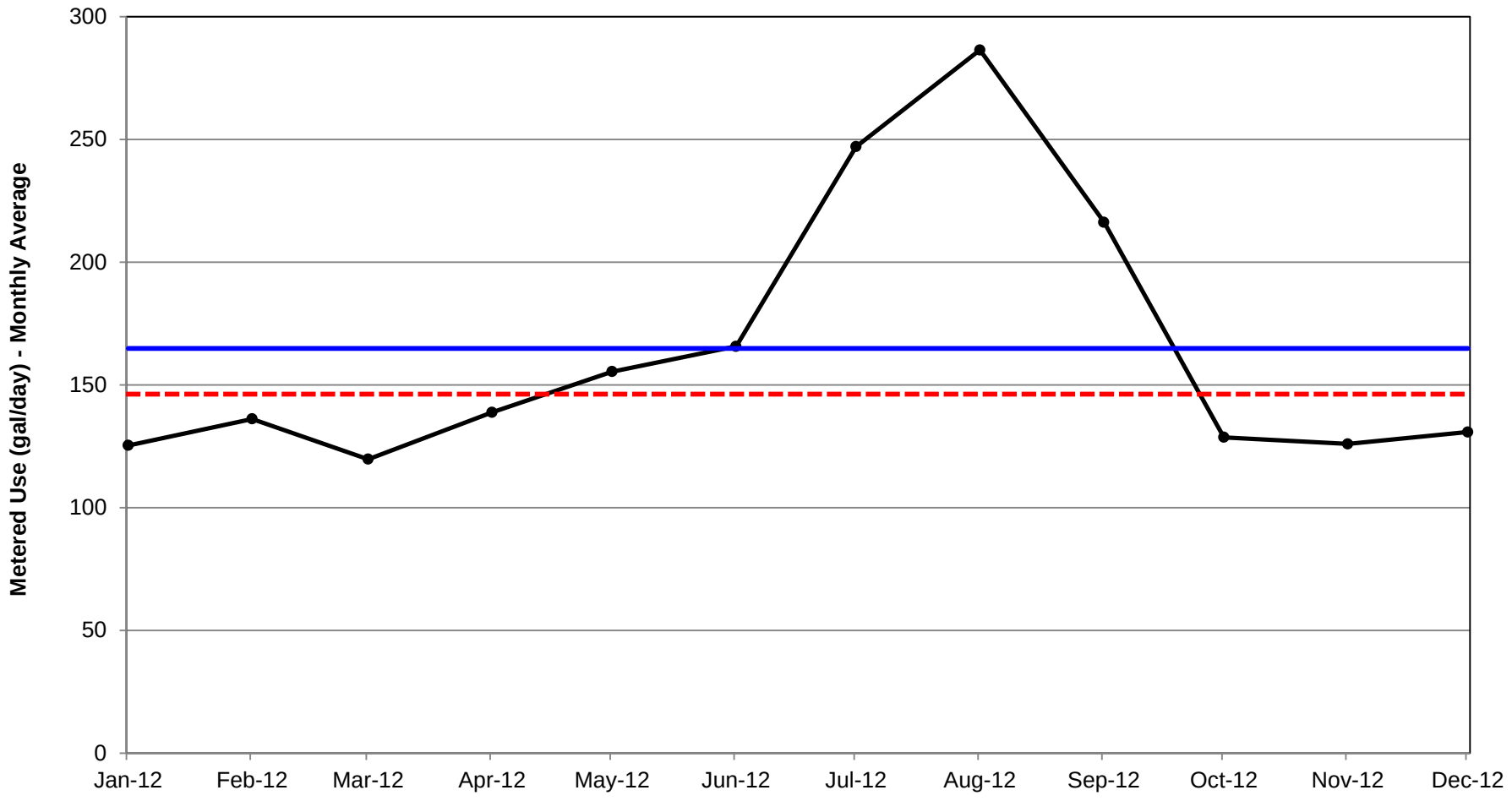
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **A-15**

DAILY GROUNDWATER USE (MONTHLY AVERAGE)
PROPERTY NO. 15

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

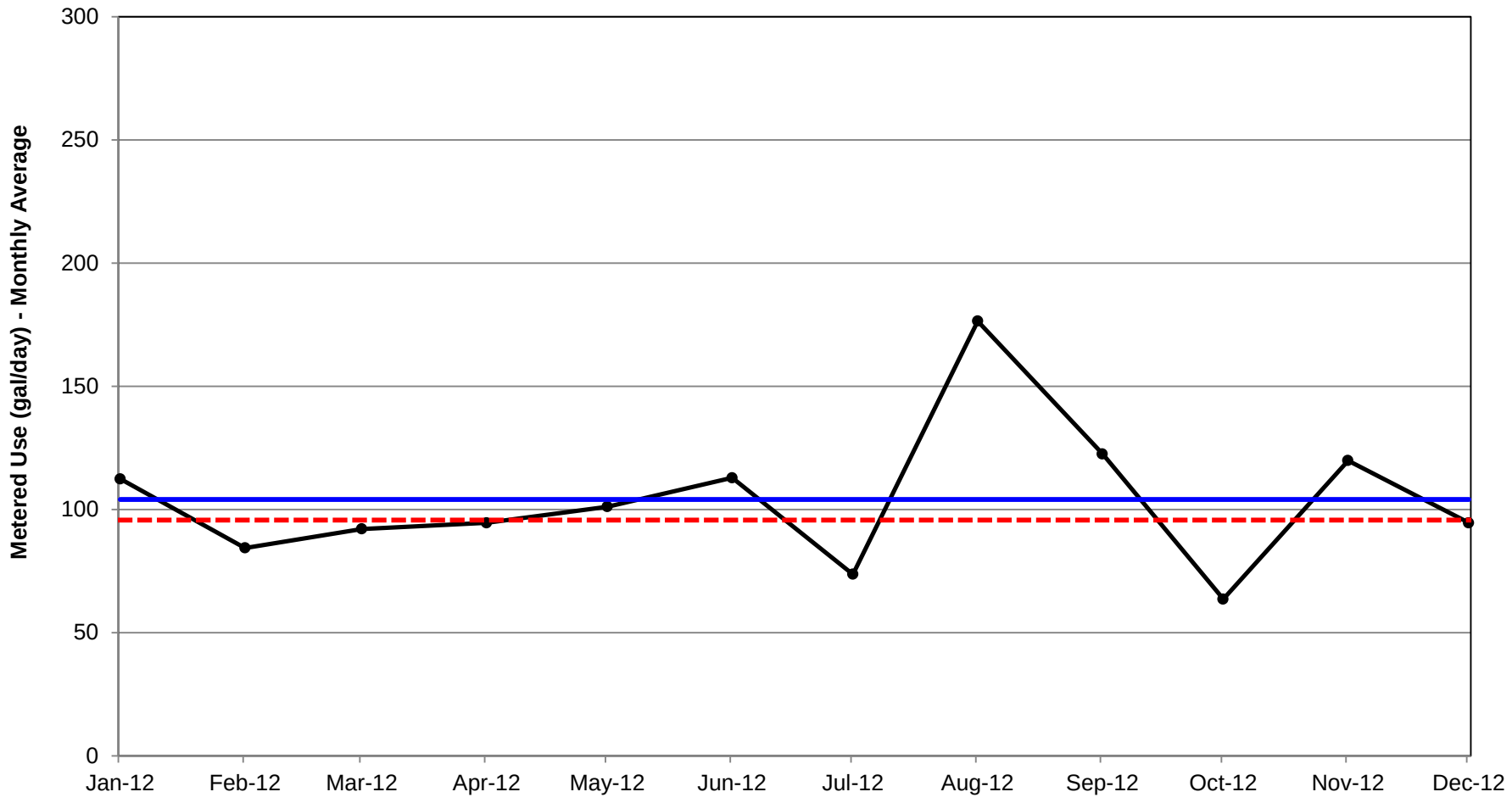
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **A-16**

DAILY GROUNDWATER USE (MONTHLY AVERAGE)
PROPERTY NO. 16

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

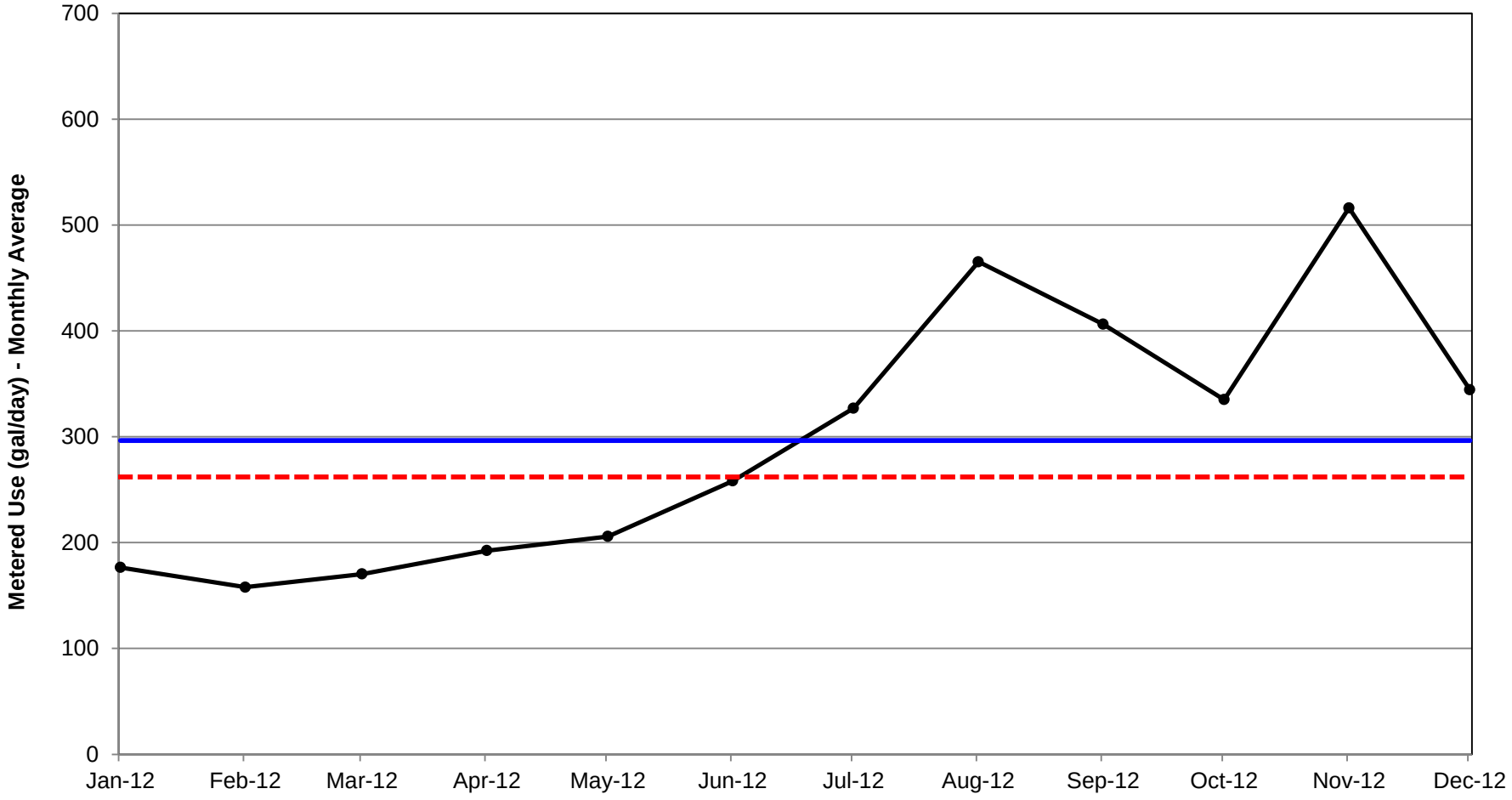
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **A-17**

DAILY GROUNDWATER USE (MONTHLY AVERAGE)
PROPERTY NO. 17

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

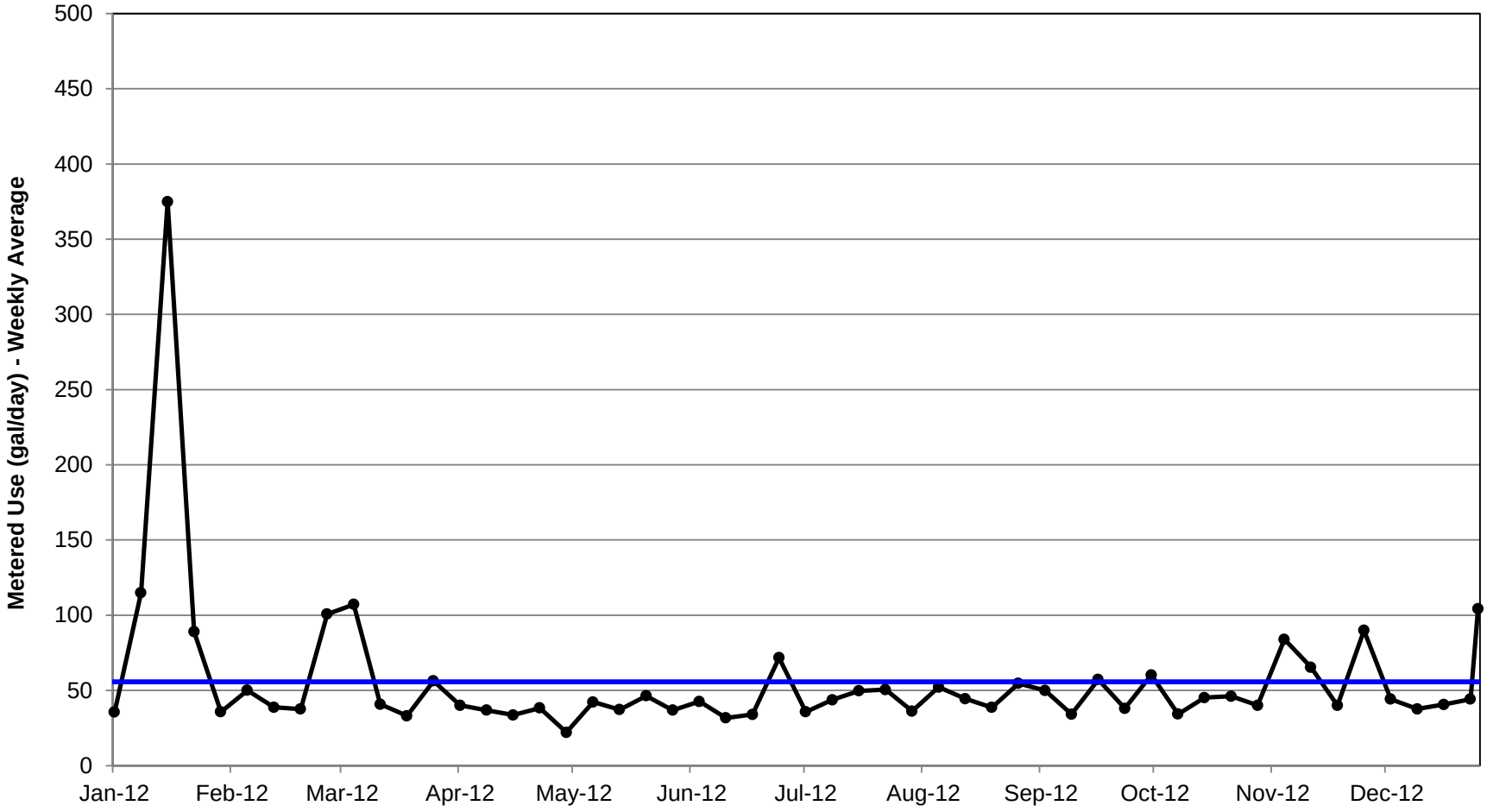
FIGURE **A-18**

DAILY GROUNDWATER USE (MONTHLY AVERAGE)
PROPERTY NO. 18

SC/Well Pilot Metering Program/WA

083-93183

Attachment B



Note: Indoor vs. outdoor use not determined.

Golder Associates

LEGEND

Total Water Use (Metered)

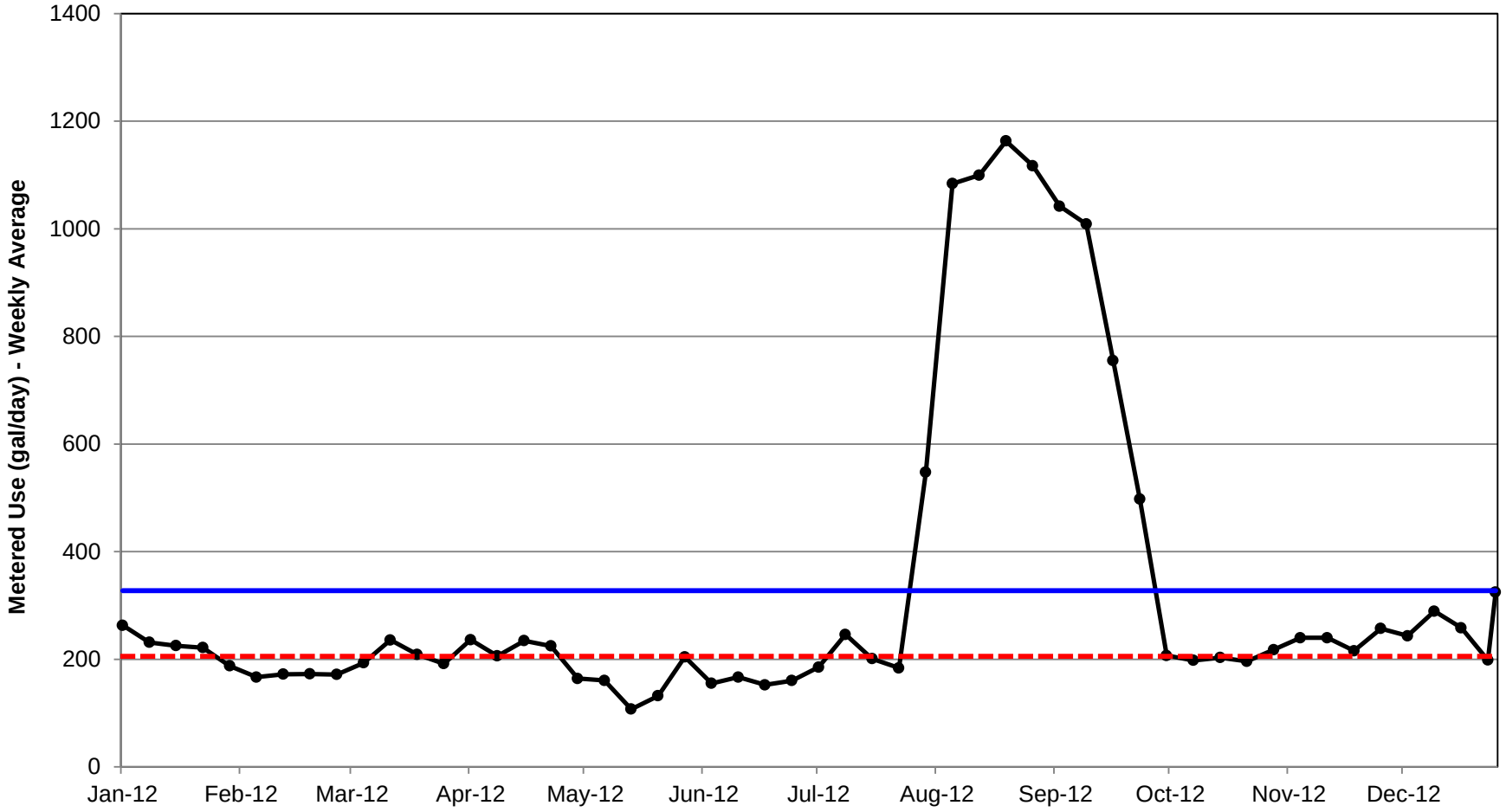
Average Annual Use

FIGURE **B-1**

DAILY GROUNDWATER USE (WEEKLY AVERAGE)
PROPERTY NO. 1

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

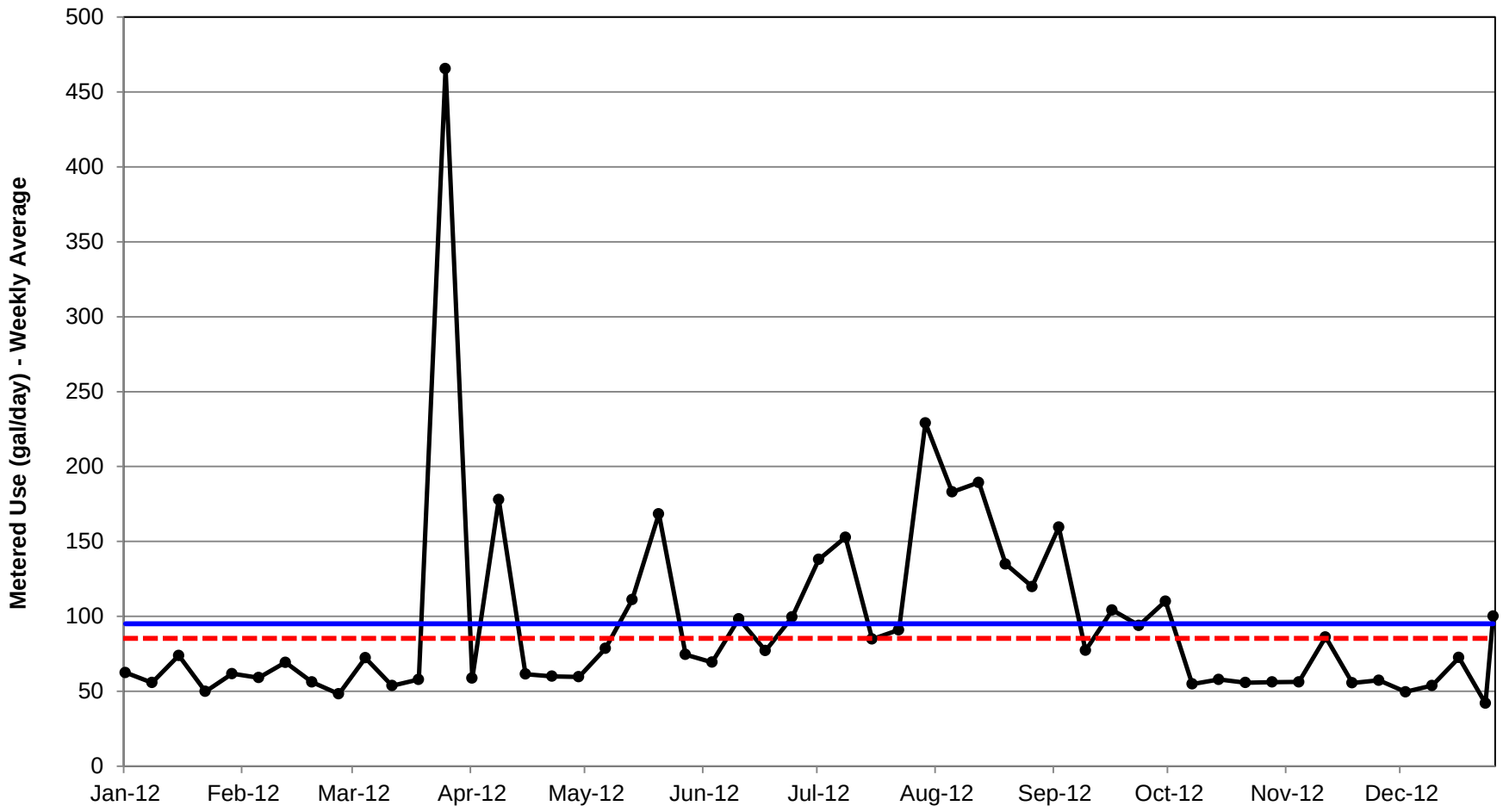
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **B-2**

DAILY GROUNDWATER USE (WEEKLY AVERAGE)
PROPERTY NO. 2

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

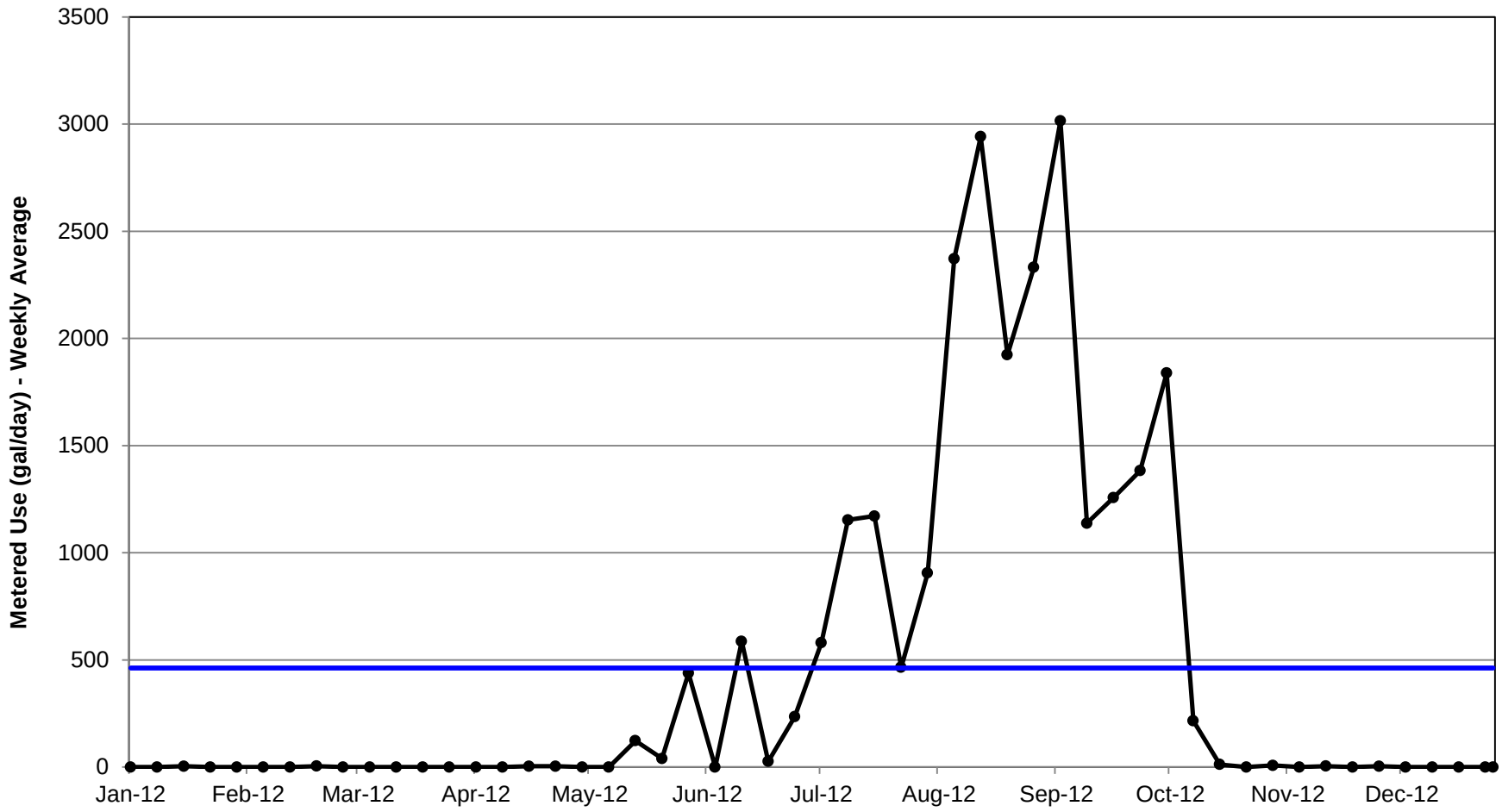
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **B-3**

DAILY GROUNDWATER USE (WEEKLY AVERAGE)
PROPERTY NO. 3

SC/Well Pilot Metering Program/WA

083-93183



Note: Indoor vs. outdoor use not determined.
.

Golder Associates

LEGEND

Total Water Use (Metered)

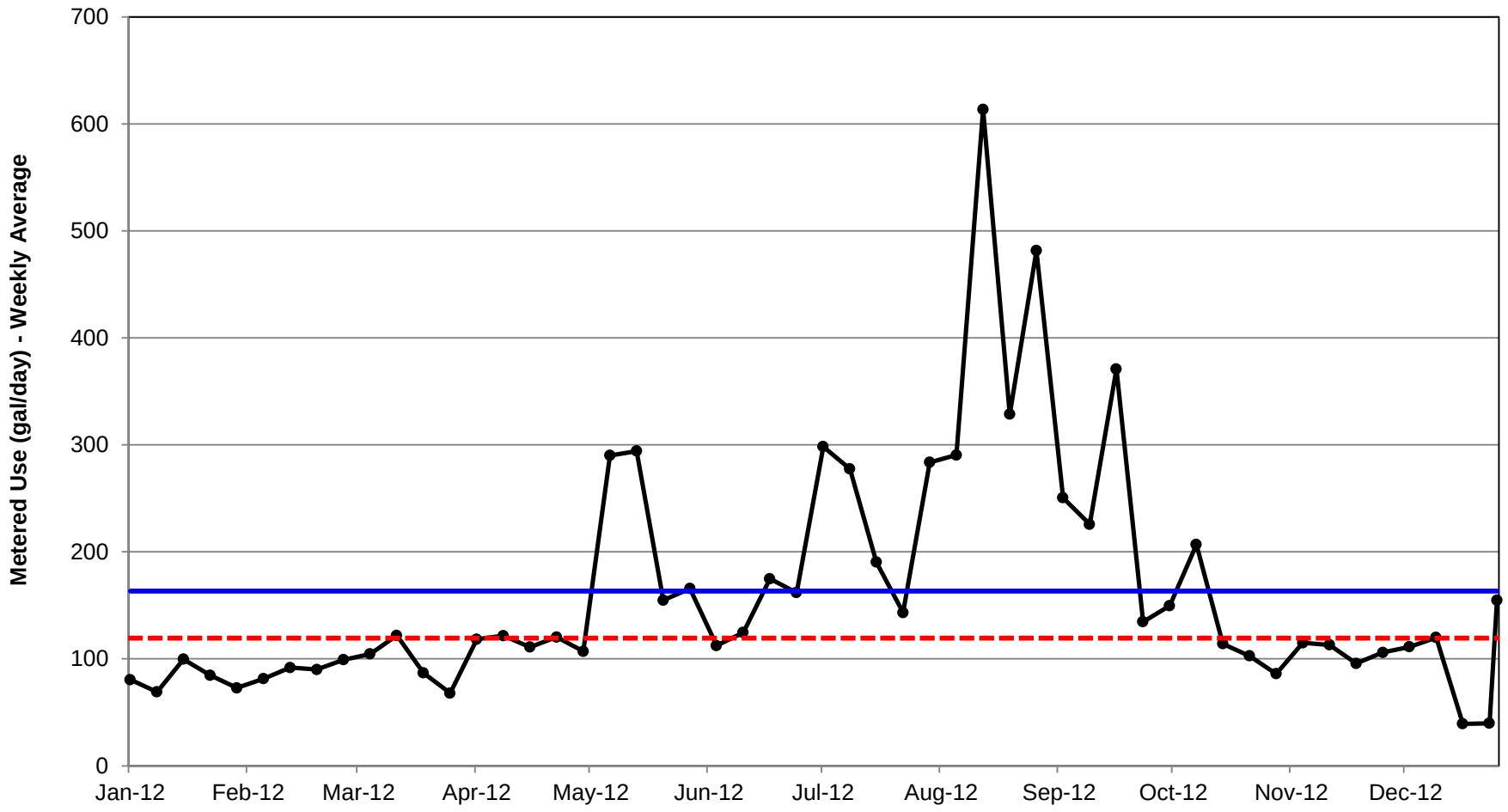
Average Annual Use

FIGURE **B-4**

DAILY GROUNDWATER USE (WEEKLY AVERAGE)
PROPERTY NO. 4

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

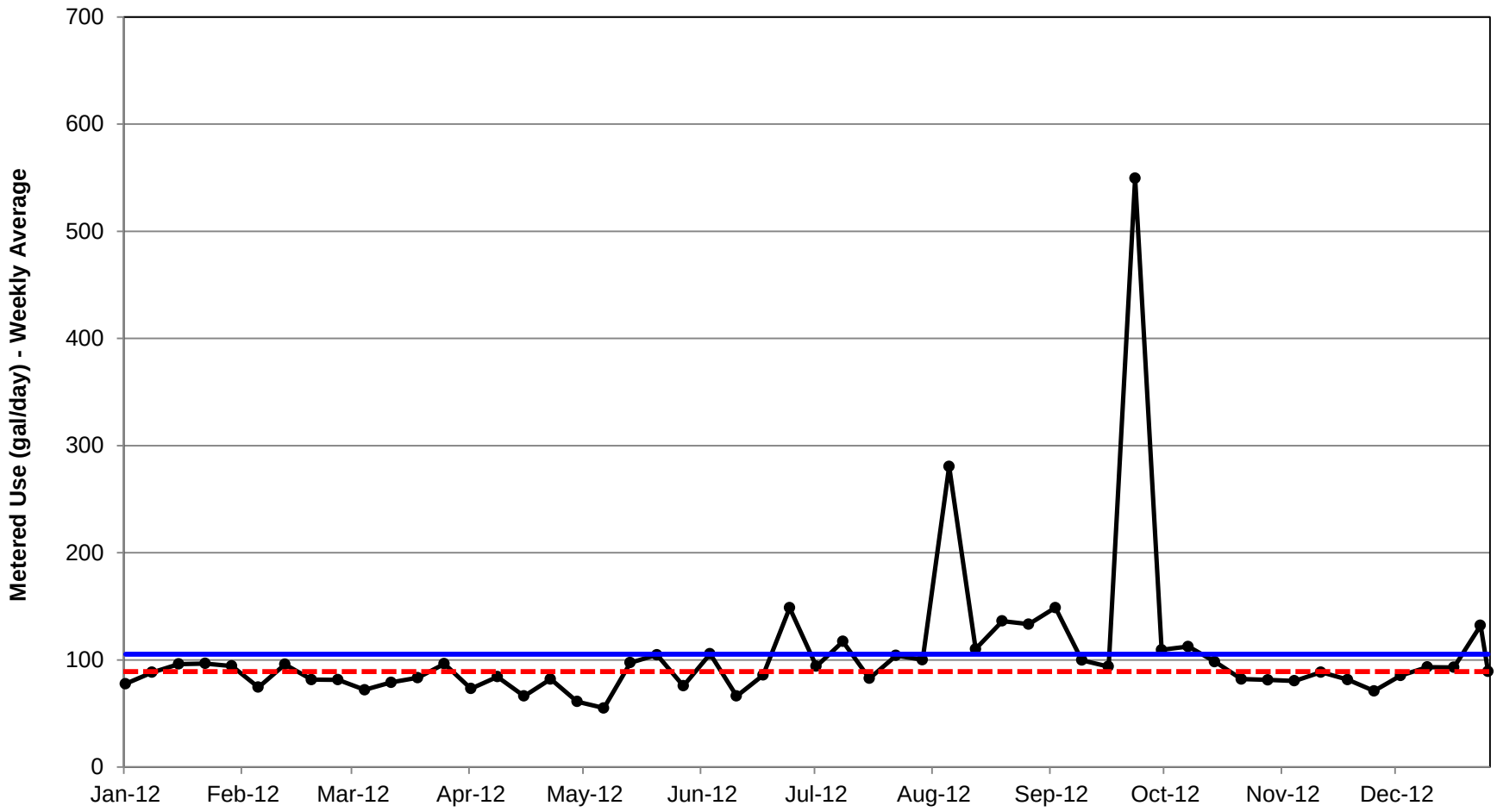
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **B-5**

DAILY GROUNDWATER USE (WEEKLY AVERAGE)
PROPERTY NO. 5

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

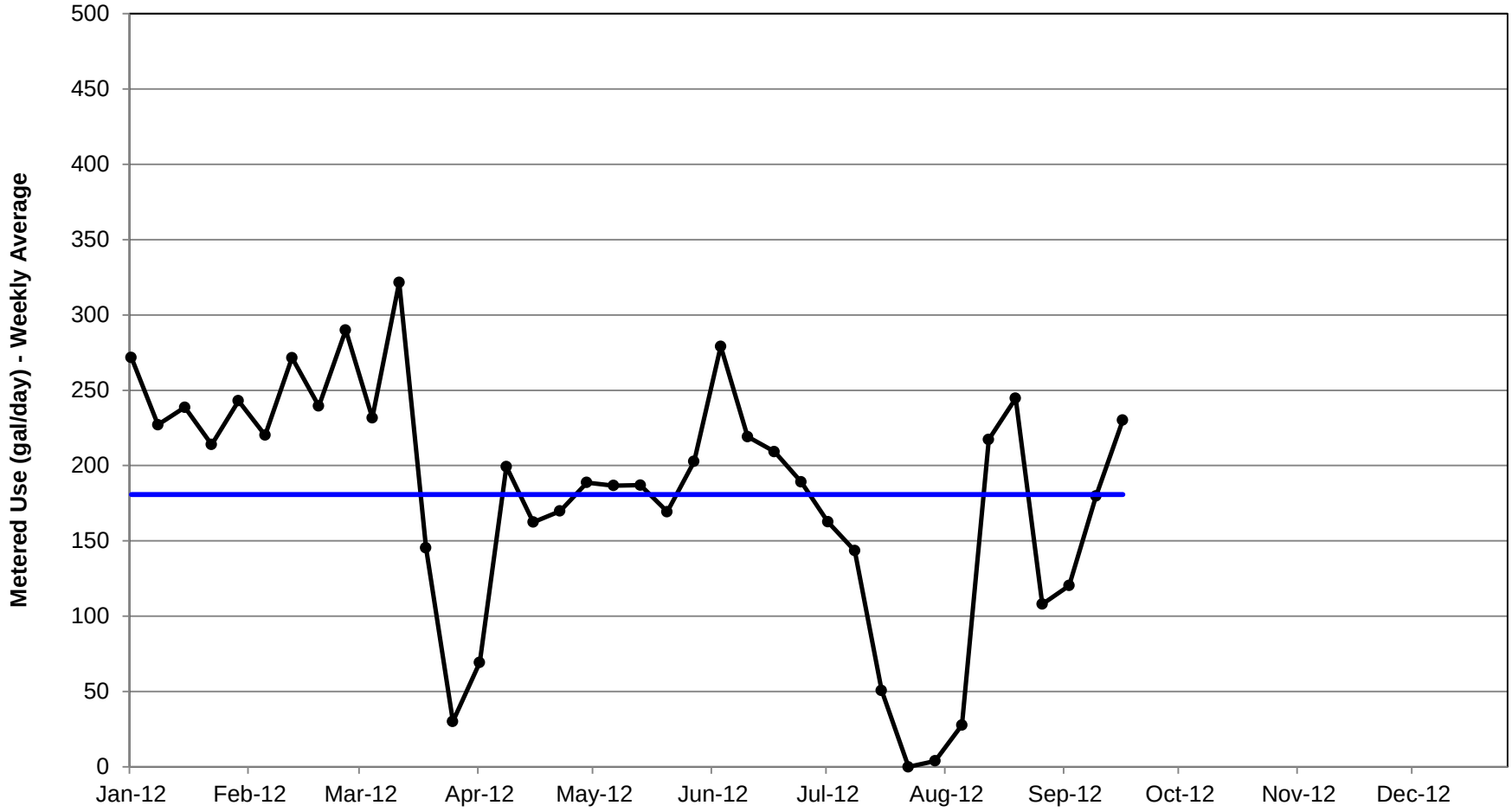
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **B-6**

DAILY GROUNDWATER USE (WEEKLY AVERAGE)
PROPERTY NO. 6

SC/Well Pilot Metering Program/WA

083-93183



Note: Indoor vs. outdoor use not determined. No data available after September 22, 2012

Golder Associates

LEGEND

Total Water Use (Metered)

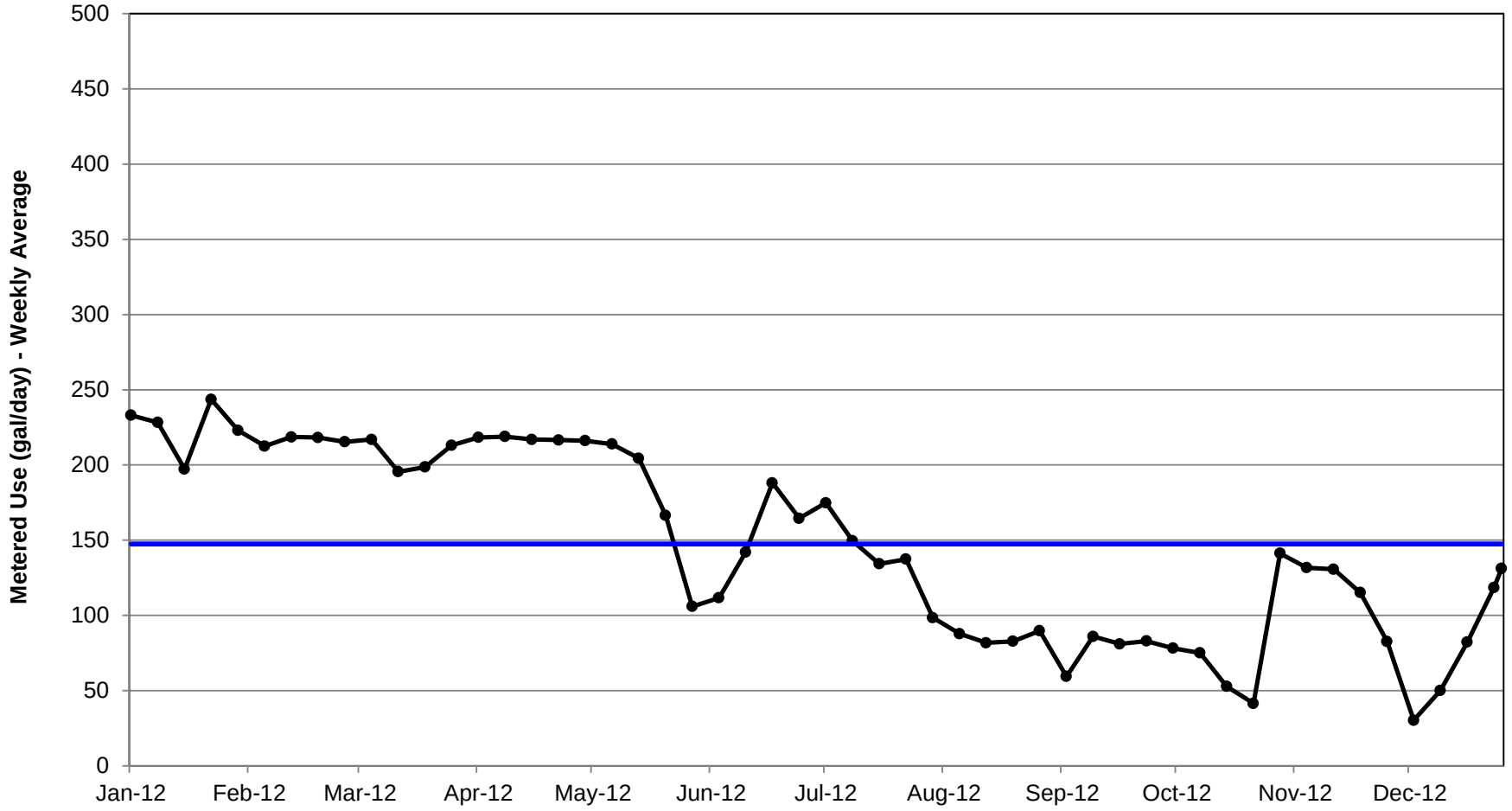
Average Annual Use

FIGURE **B-7**

DAILY GROUNDWATER USE (WEEKLY AVERAGE)
PROPERTY NO. 7

SC/Well Pilot Metering Program/WA

083-93183



Note: Indoor vs. outdoor use not determined.

Golder Associates

LEGEND

Total Water Use (Metered)

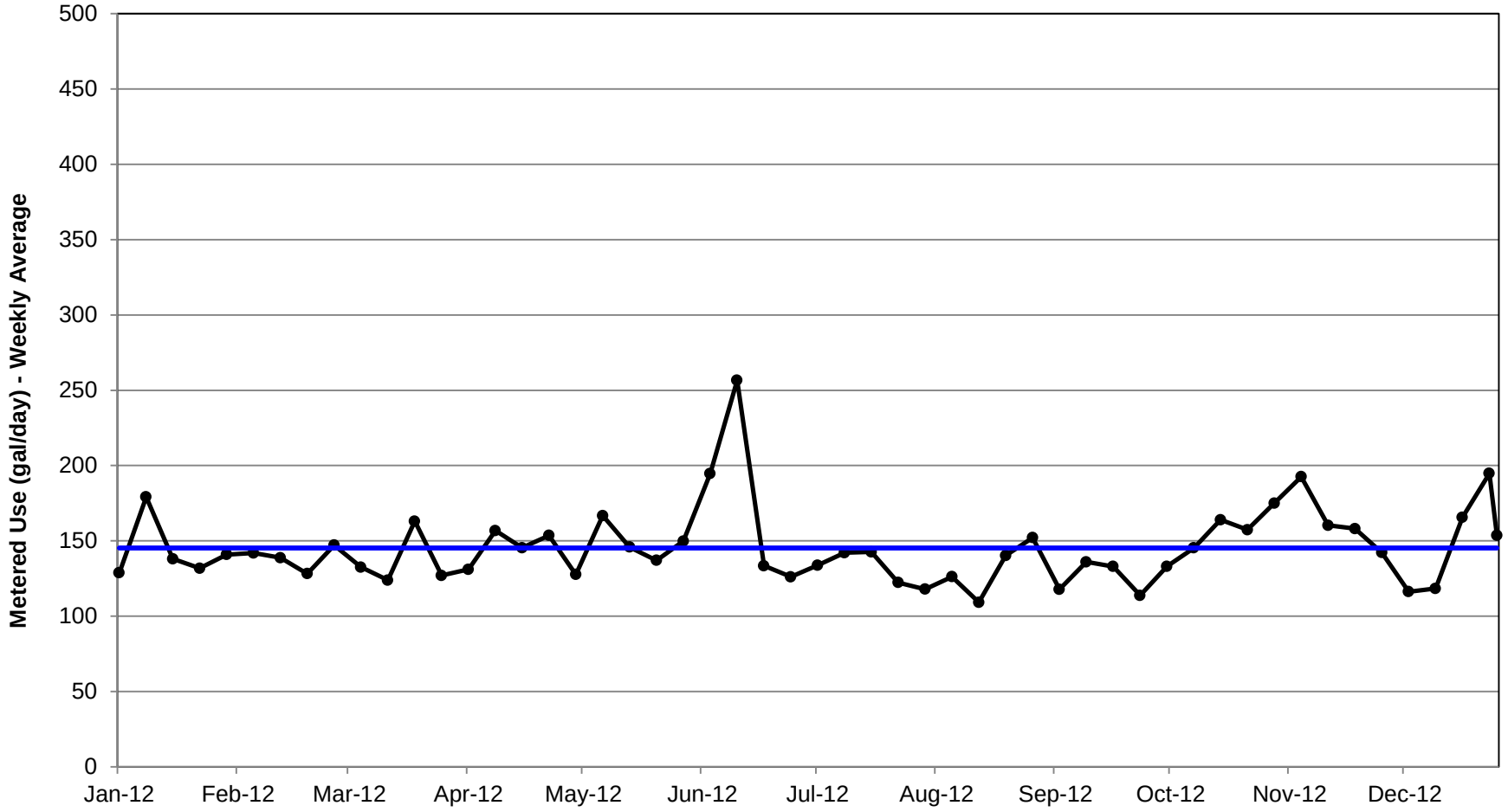
Average Annual Use

FIGURE **B-8**

DAILY GROUNDWATER USE (WEEKLY AVERAGE)
PROPERTY NO. 8

SC/Well Pilot Metering Program/WA

083-93183



Note: Indoor vs. outdoor use not determined.

Golder Associates

LEGEND

Total Water Use (Metered)

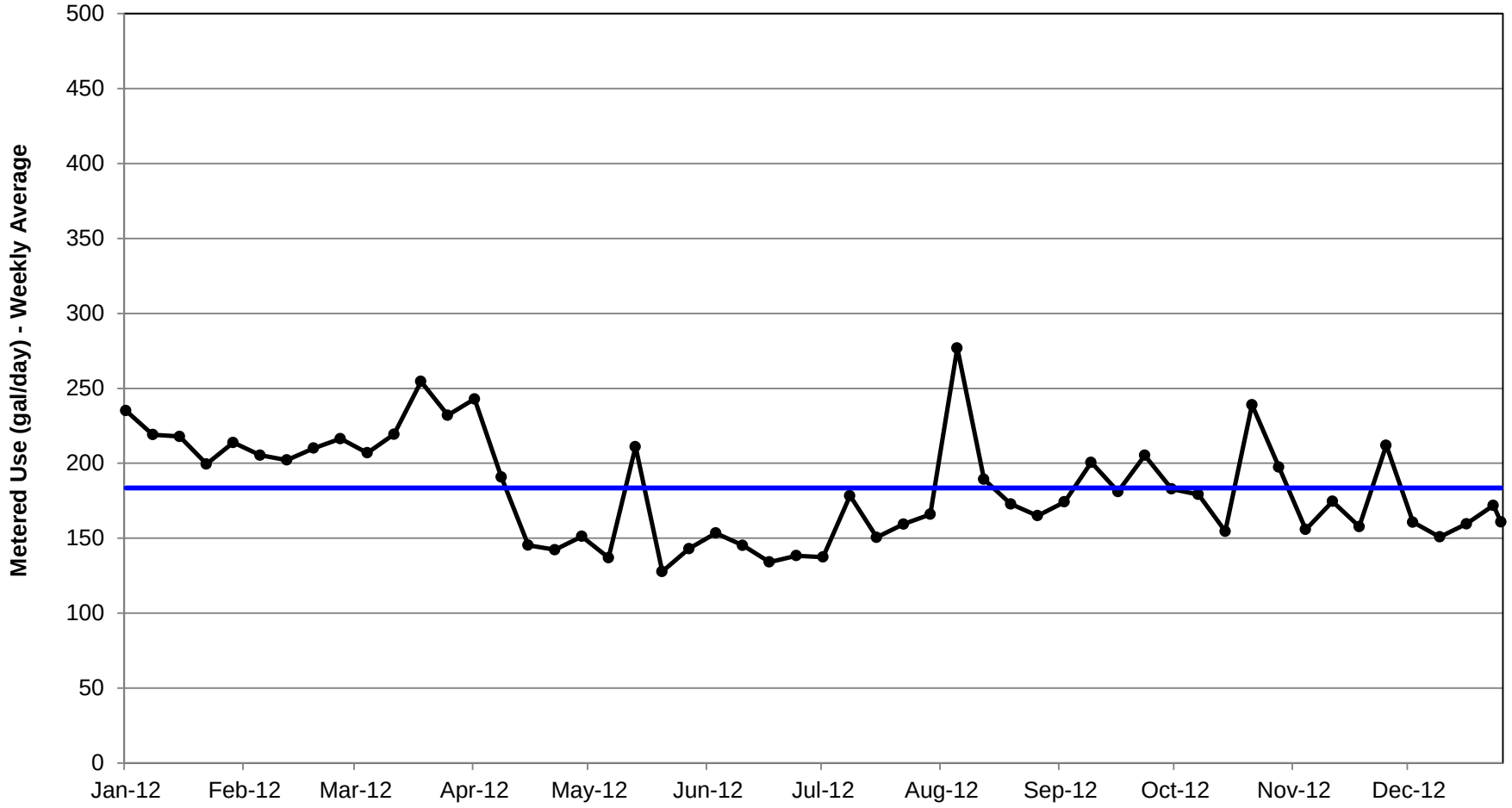
Average Annual Use

FIGURE **B-9**

DAILY GROUNDWATER USE (WEEKLY AVERAGE)
PROPERTY NO. 9

SC/Well Pilot Metering Program/WA

083-93183



Note: Indoor vs. outdoor use not determined.

Golder Associates

LEGEND

Total Water Use (Metered)

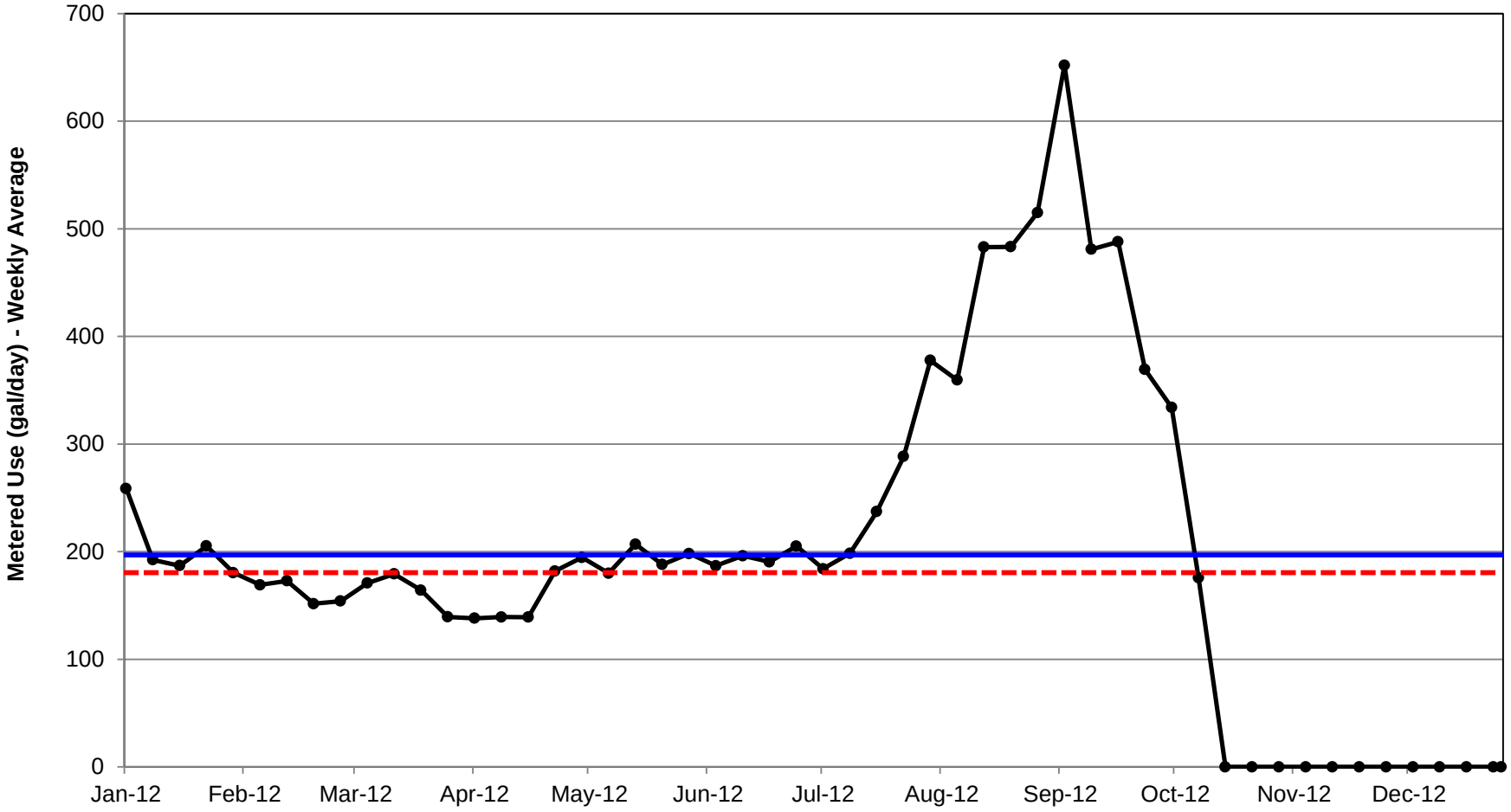
Average Annual Use

FIGURE **B-10**

DAILY GROUNDWATER USE (WEEKLY AVERAGE)
PROPERTY NO. 10

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

Total Water Use (Metered)

Average Indoor Use (Estimated)

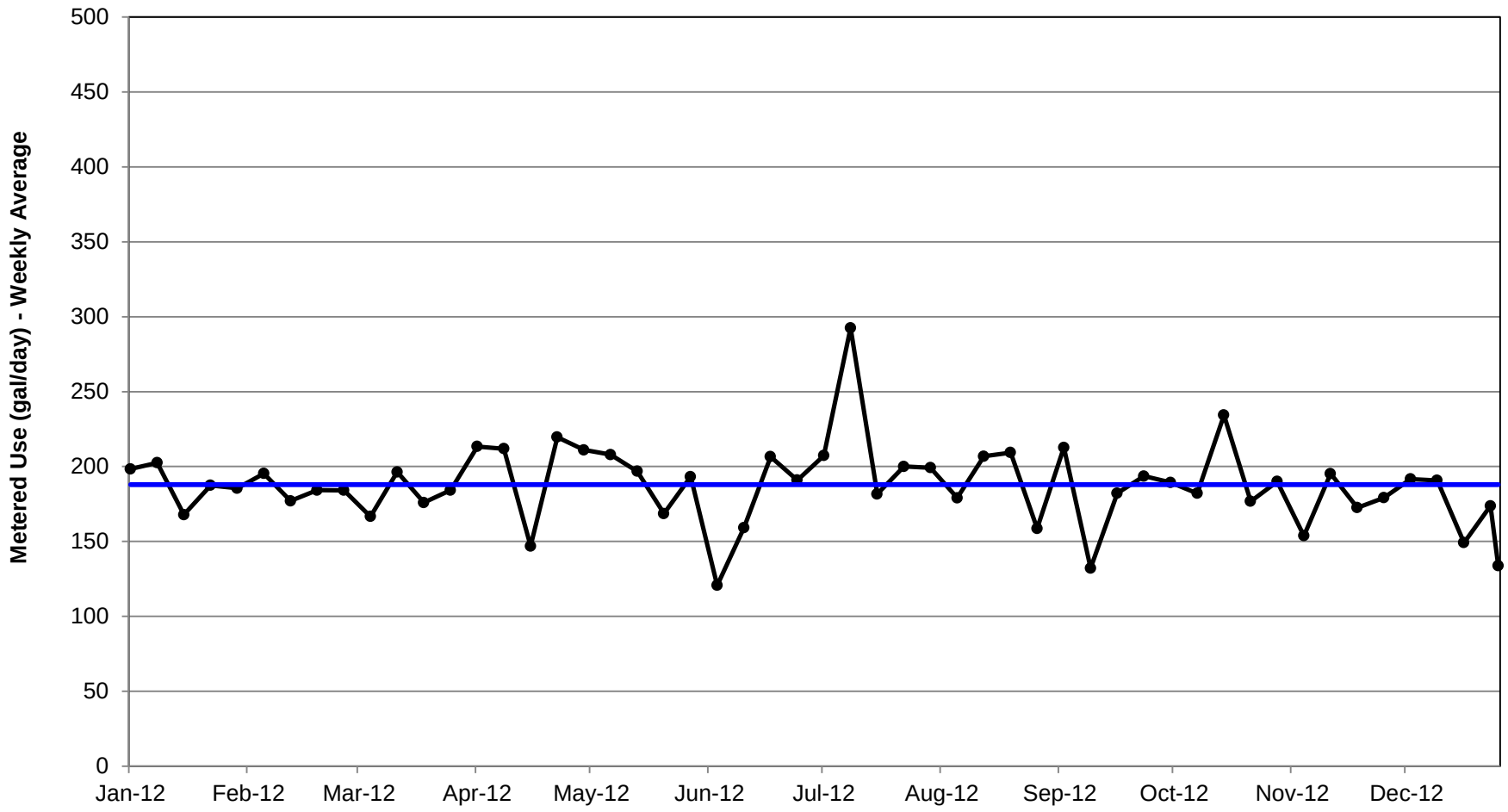
Average Annual Use

FIGURE **B-11**

DAILY GROUNDWATER USE (WEEKLY AVERAGE)
PROPERTY NO. 11

SC/Well Pilot Metering Program/WA

083-93183



Note: Indoor vs. outdoor use not determined.

Golder Associates

LEGEND

Total Water Use (Metered)

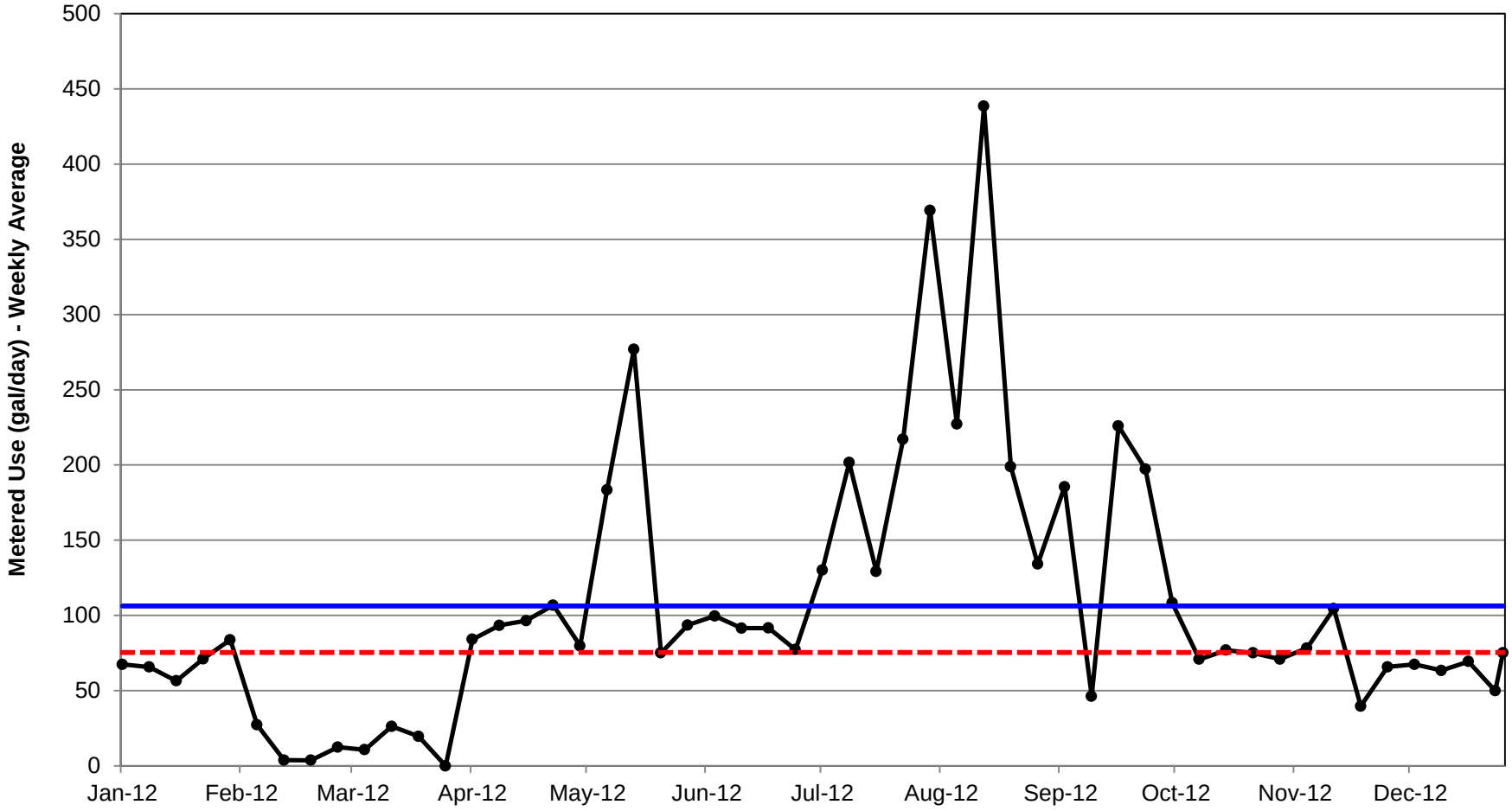
Average Annual Use

FIGURE **B-12**

DAILY GROUNDWATER USE (WEEKLY AVERAGE)
PROPERTY NO. 12

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

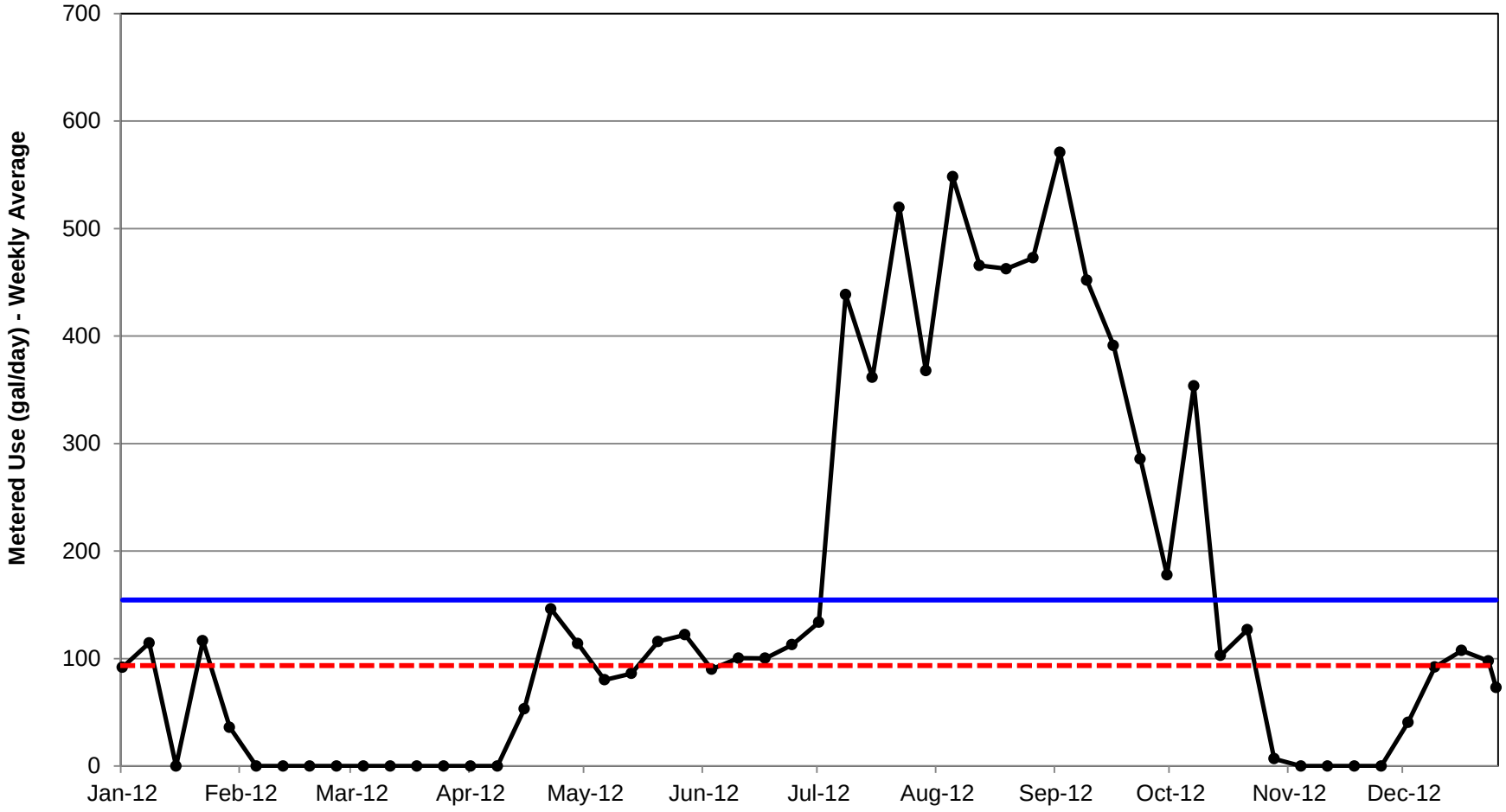
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **B-13**

DAILY GROUNDWATER USE (WEEKLY AVERAGE)
PROPERTY NO. 13

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

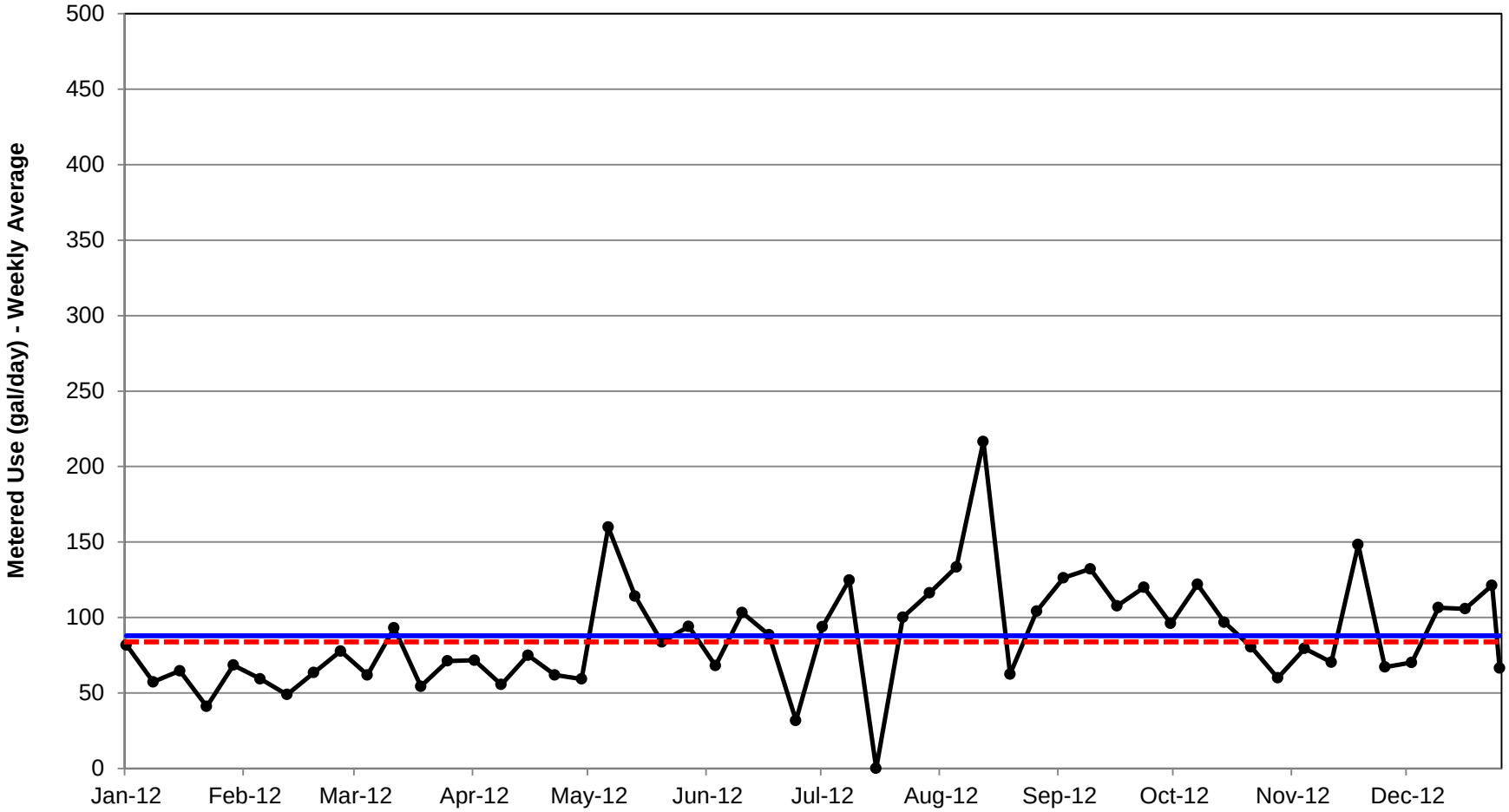
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **B-14**

DAILY GROUNDWATER USE (WEEKLY AVERAGE)
PROPERTY NO. 14

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

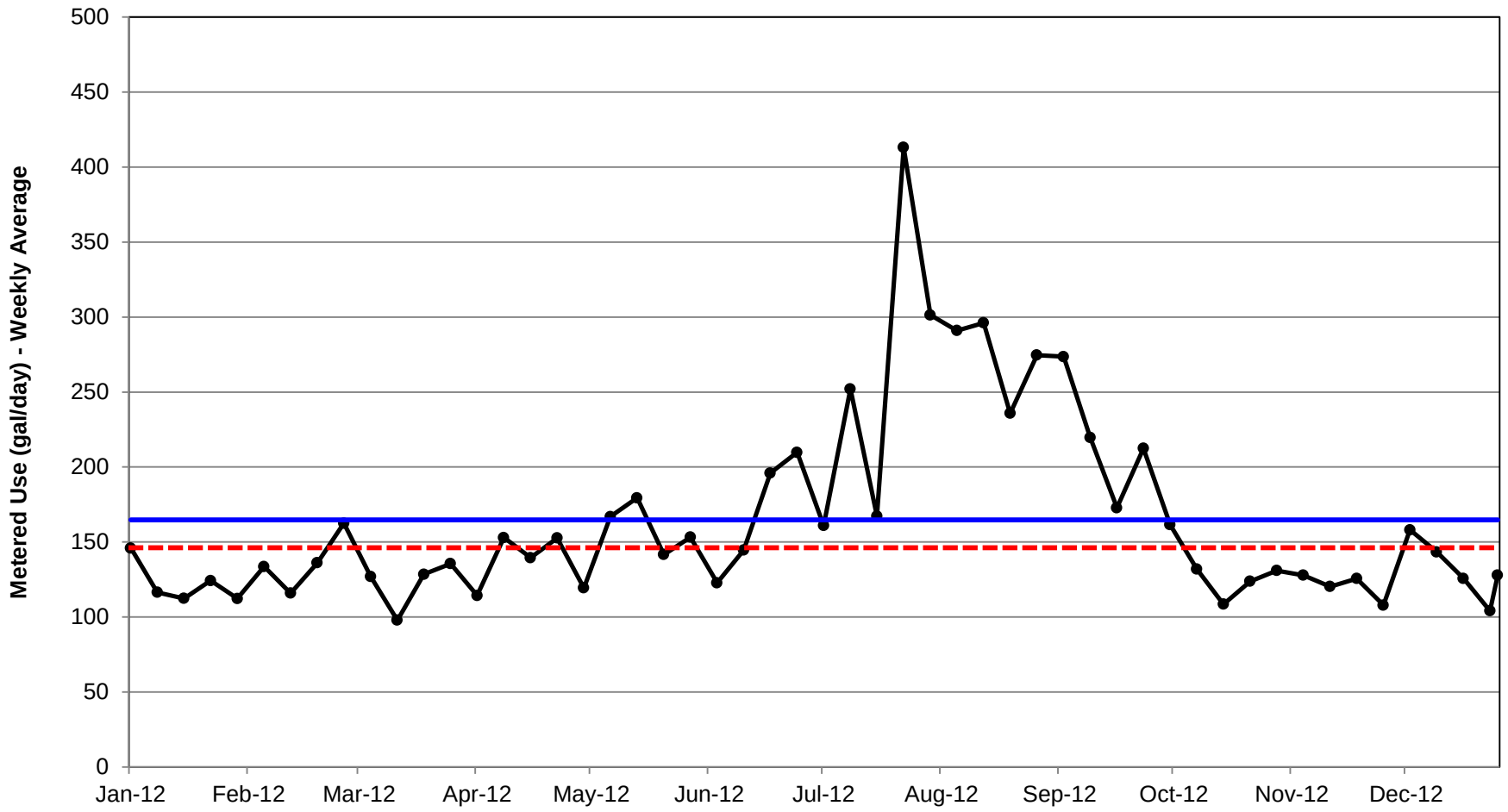
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **B-15**

DAILY GROUNDWATER USE (WEEKLY AVERAGE)
PROPERTY NO. 15

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

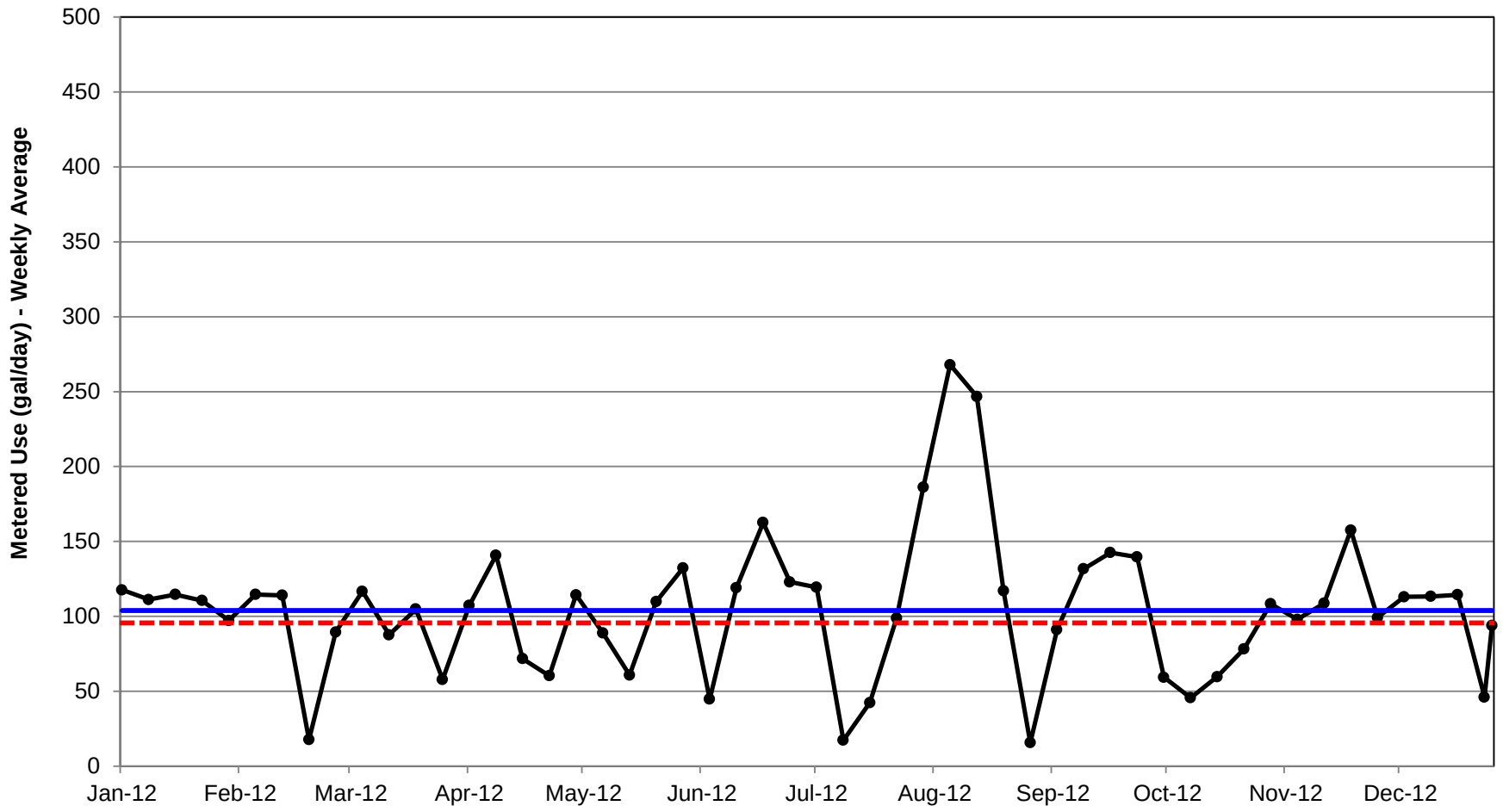
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **B-16**

DAILY GROUNDWATER USE (WEEKLY AVERAGE)
PROPERTY NO. 16

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

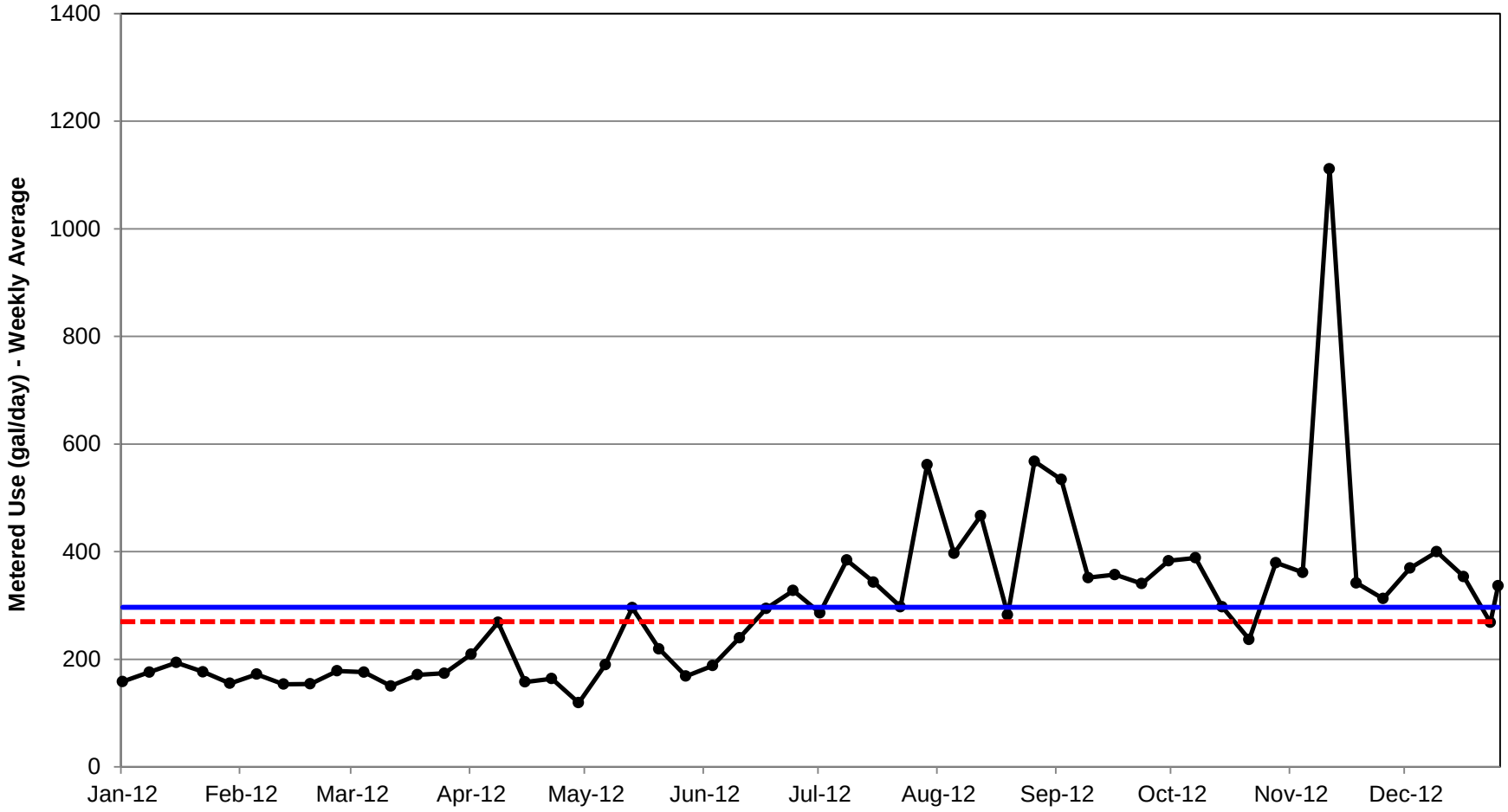
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **B-17**

DAILY GROUNDWATER USE (WEEKLY AVERAGE)
PROPERTY NO. 17

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

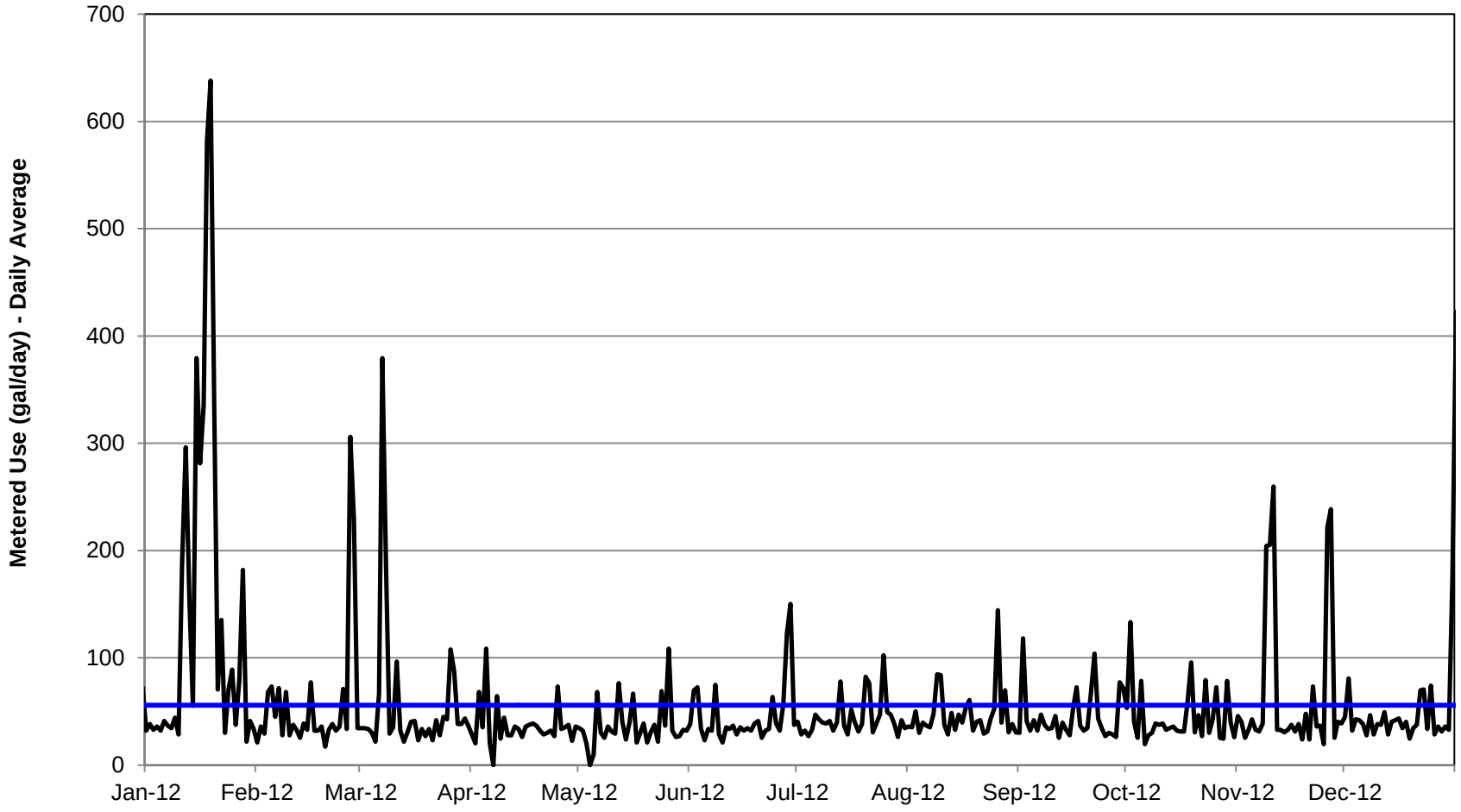
FIGURE **B-18**

DAILY GROUNDWATER USE (WEEKLY AVERAGE)
PROPERTY NO. 18

SC/Well Pilot Metering Program/WA

083-93183

Attachment C



Note: Indoor vs. outdoor use not determined.

Golder Associates

LEGEND

Total Water Use (Metered)

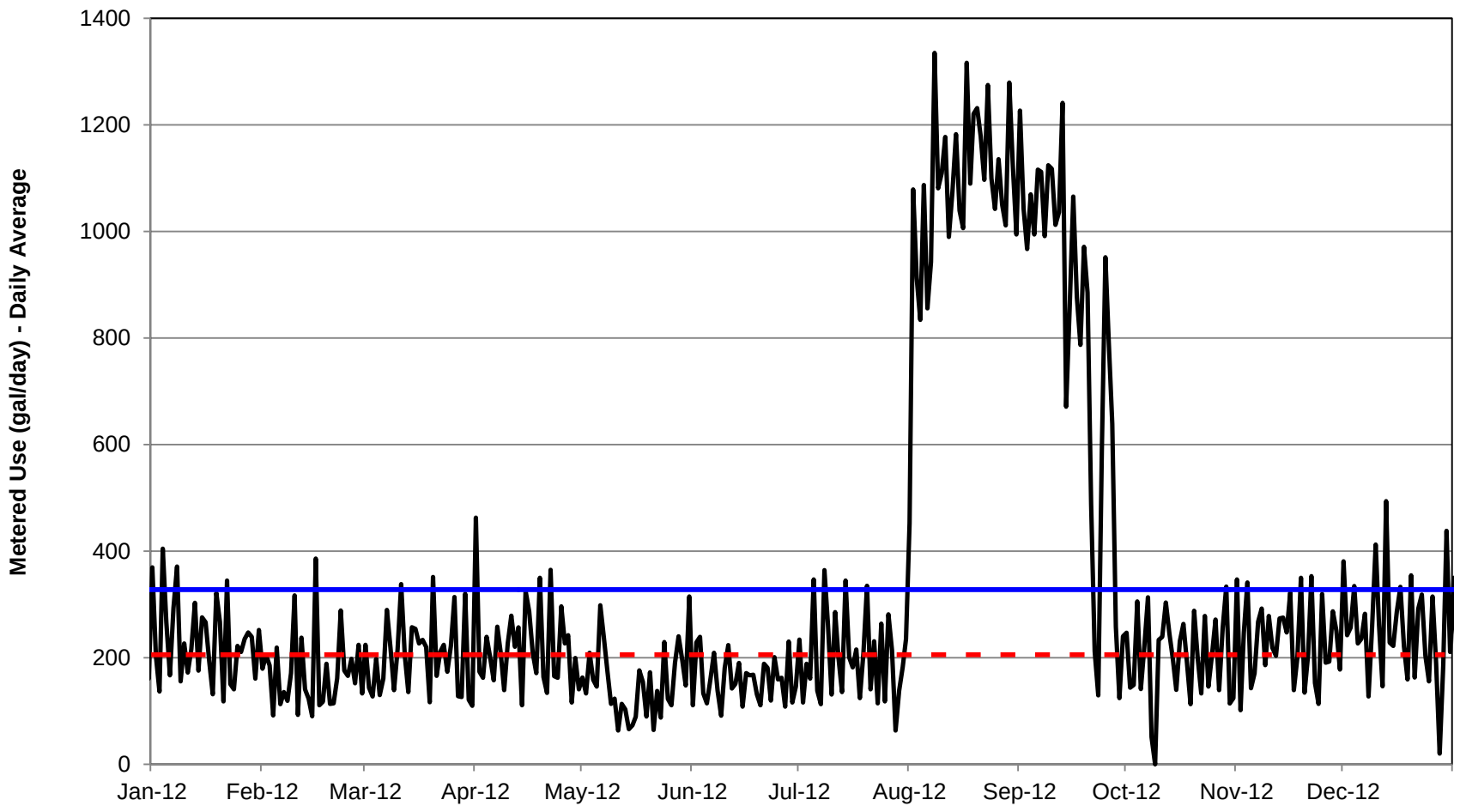
Average Annual Use

FIGURE **C-1**

DAILY GROUNDWATER USE
PROPERTY NO. 1

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

Total Water Use (Metered)

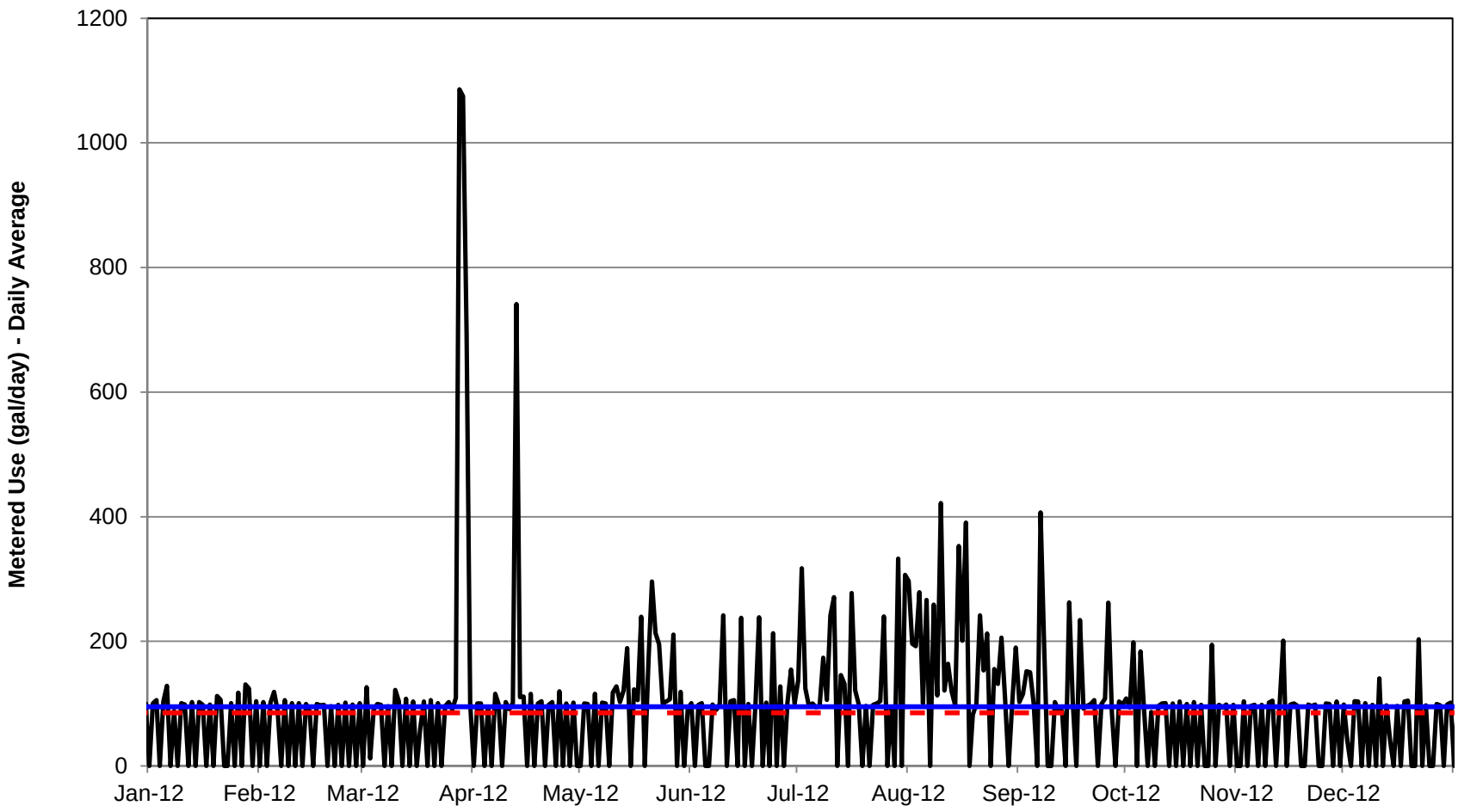
Average Annual Use

FIGURE **C-2**

DAILY GROUNDWATER USE
PROPERTY NO. 2

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

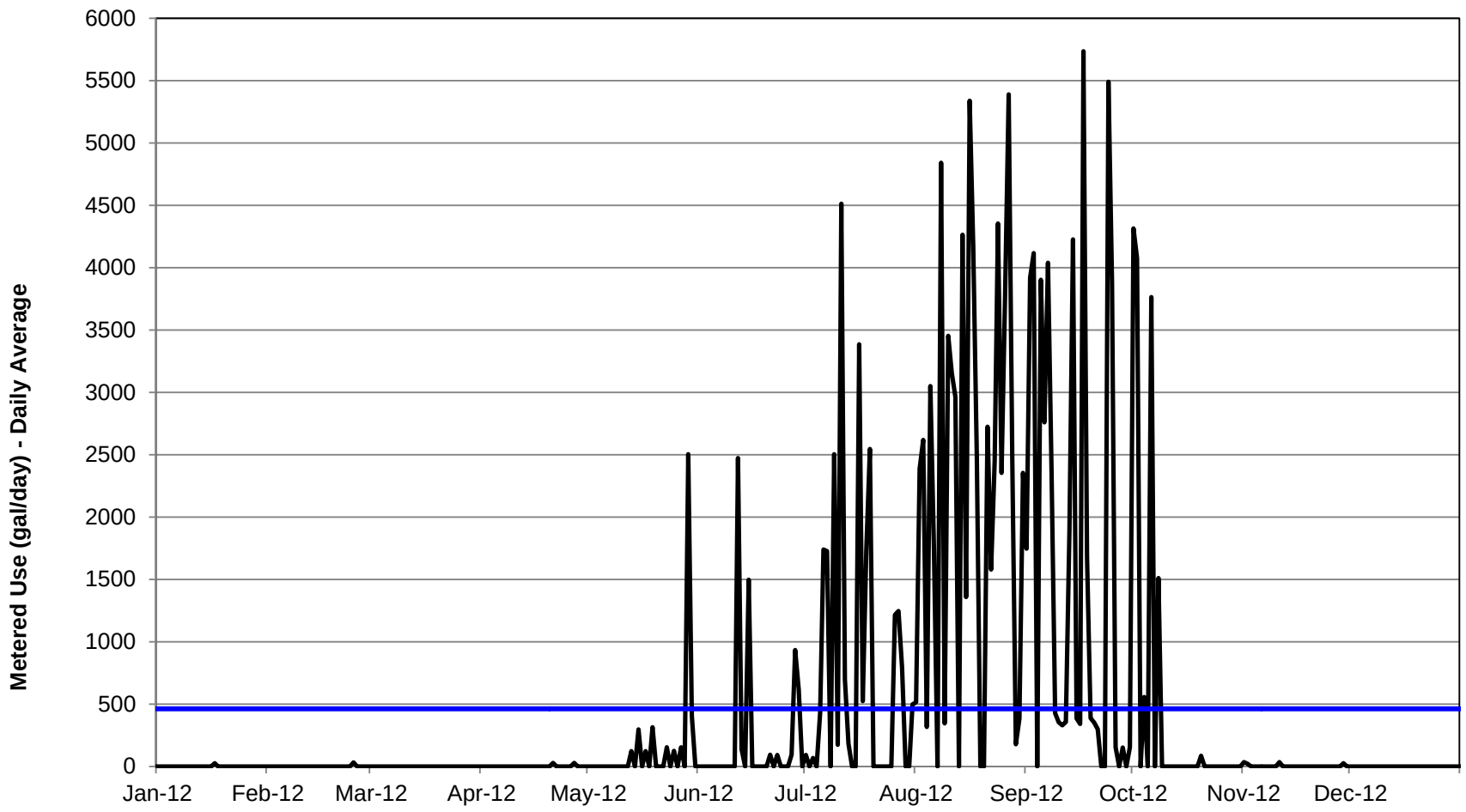
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **C-3**

DAILY GROUNDWATER USE
PROPERTY NO. 3

SC/Well Pilot Metering Program/WA

083-93183



Note: Indoor vs. outdoor use not determined.

Golder Associates

LEGEND

Total Water Use (Metered)

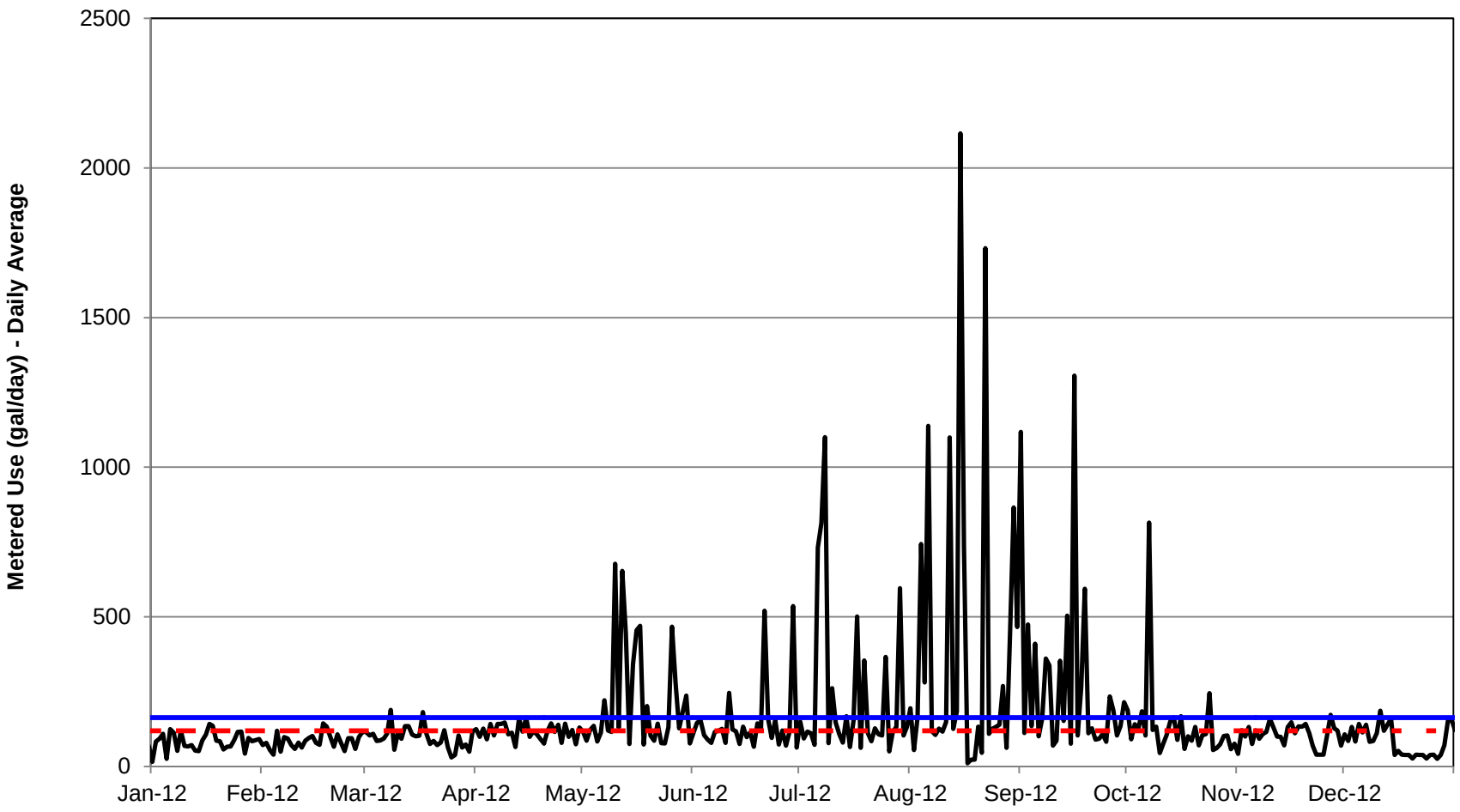
Average Annual Use

FIGURE **C-4**

DAILY GROUNDWATER USE
PROPERTY NO. 4

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

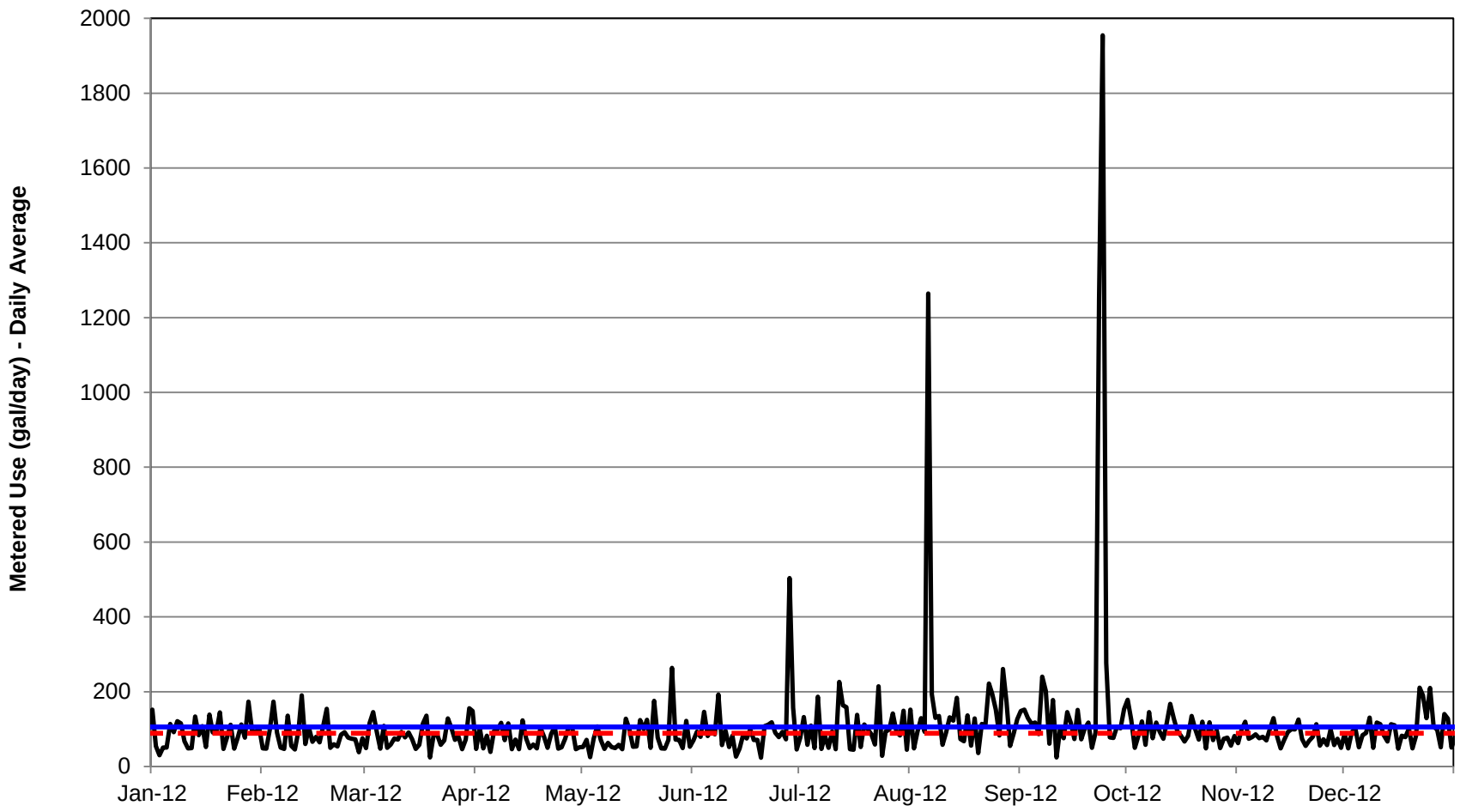
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **C-5**

DAILY GROUNDWATER USE
PROPERTY NO. 5

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

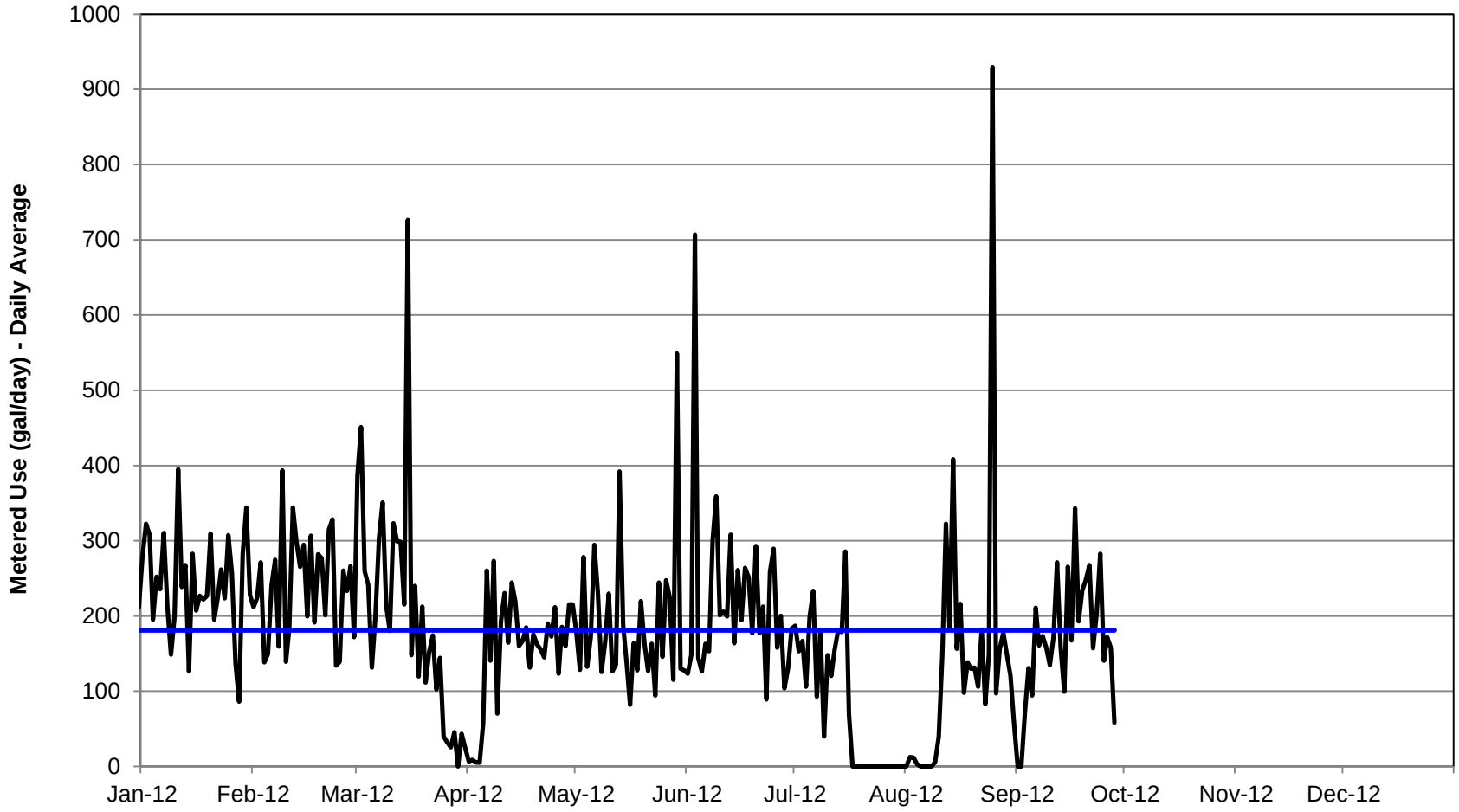
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **C-6**

DAILY GROUNDWATER USE
PROPERTY NO. 6

SC/Well Pilot Metering Program/WA

083-93183



Note: Indoor vs. outdoor use not determined. No data available after September 22, 2012

Golder Associates

LEGEND

Total Water Use (Metered)

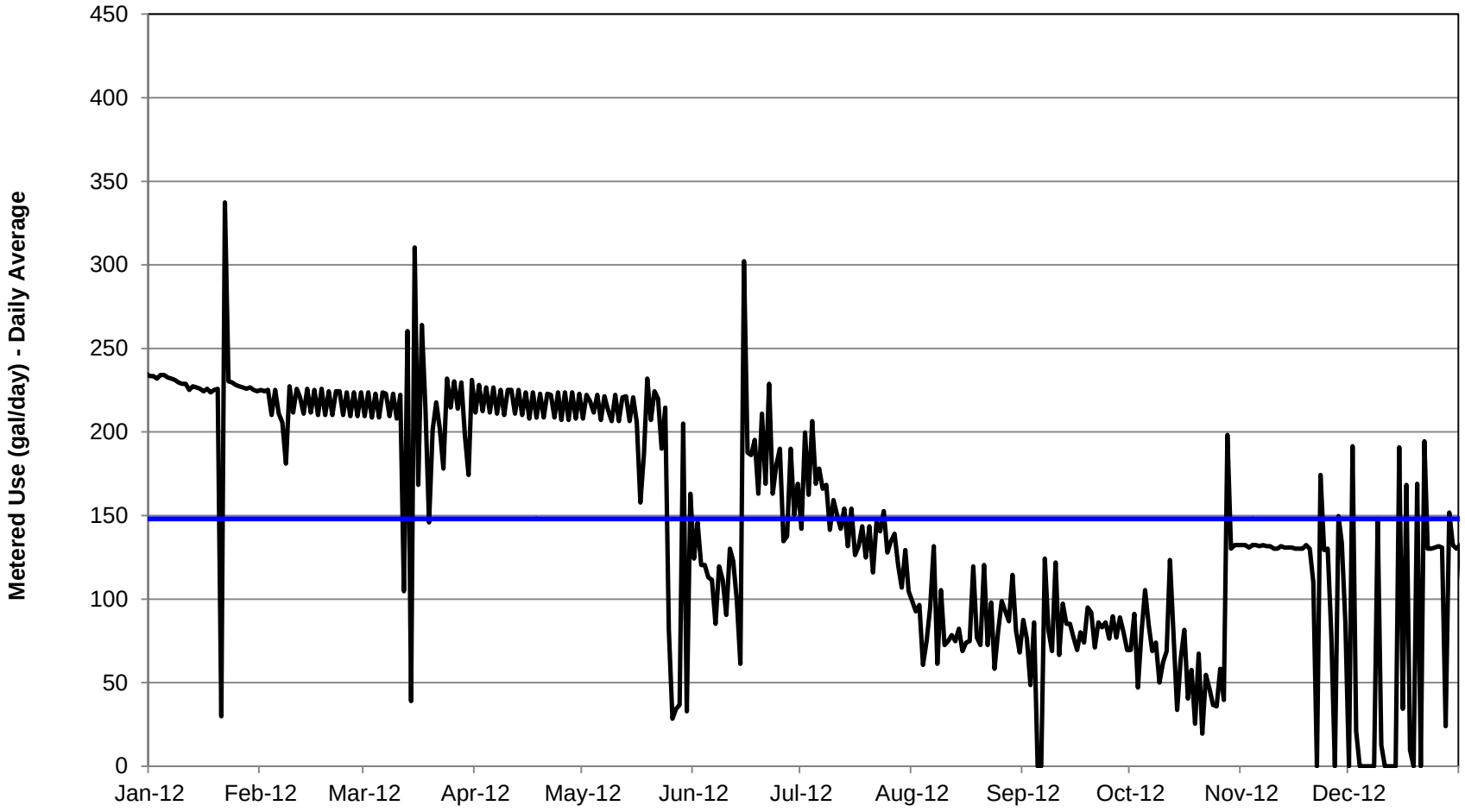
Average Annual Use

FIGURE **C-7**

DAILY GROUNDWATER USE
PROPERTY NO. 7

SC/Well Pilot Metering Program/WA

083-93183



Note: Indoor vs. outdoor use not determined.

Golder Associates

LEGEND

Total Water Use (Metered)

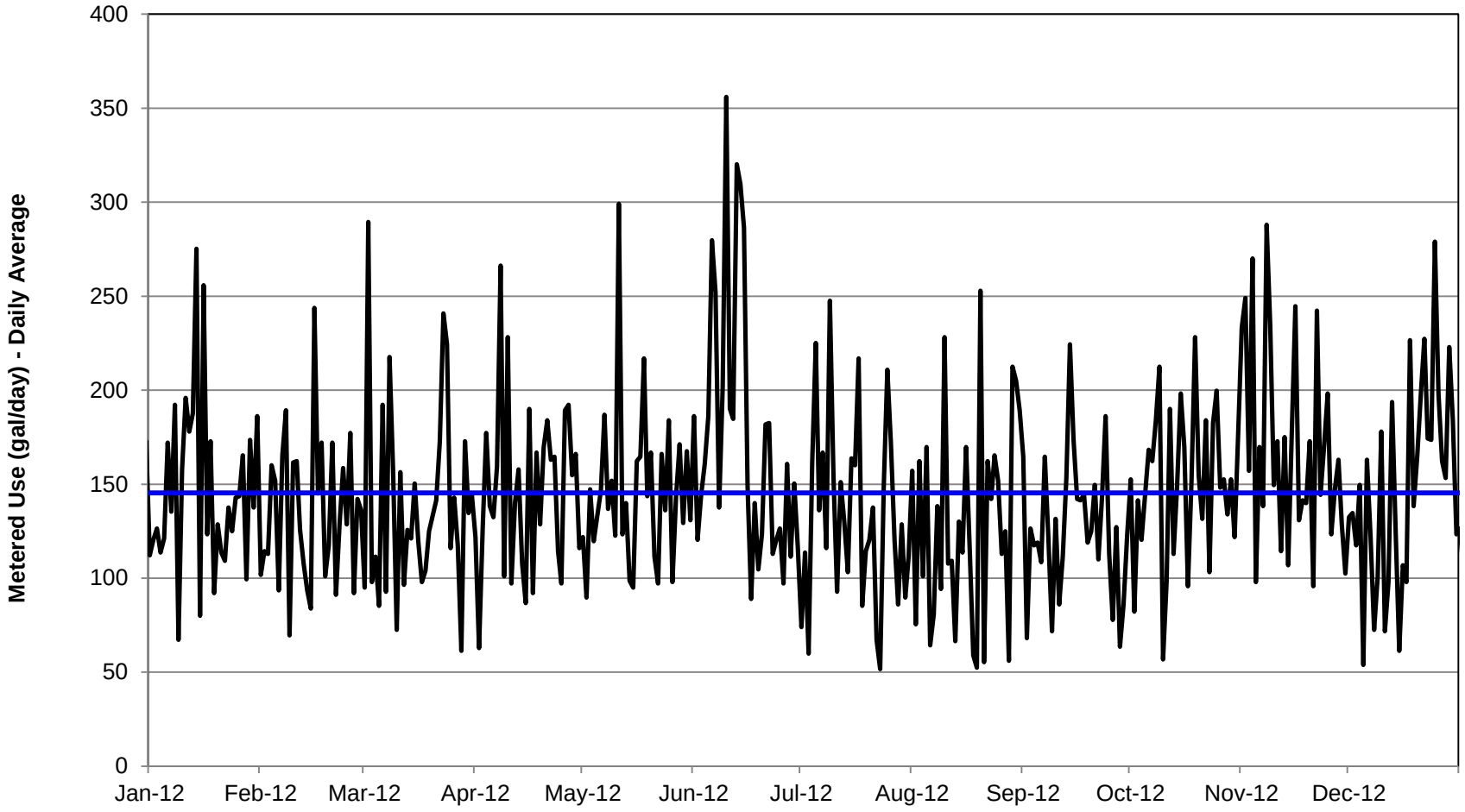
Average Annual Use

FIGURE **C-8**

DAILY GROUNDWATER USE
PROPERTY NO. 8

SC/Well Pilot Metering Program/WA

083-93183



Note: Indoor vs. outdoor use not determined.

Golder Associates

LEGEND

Total Water Use (Metered)

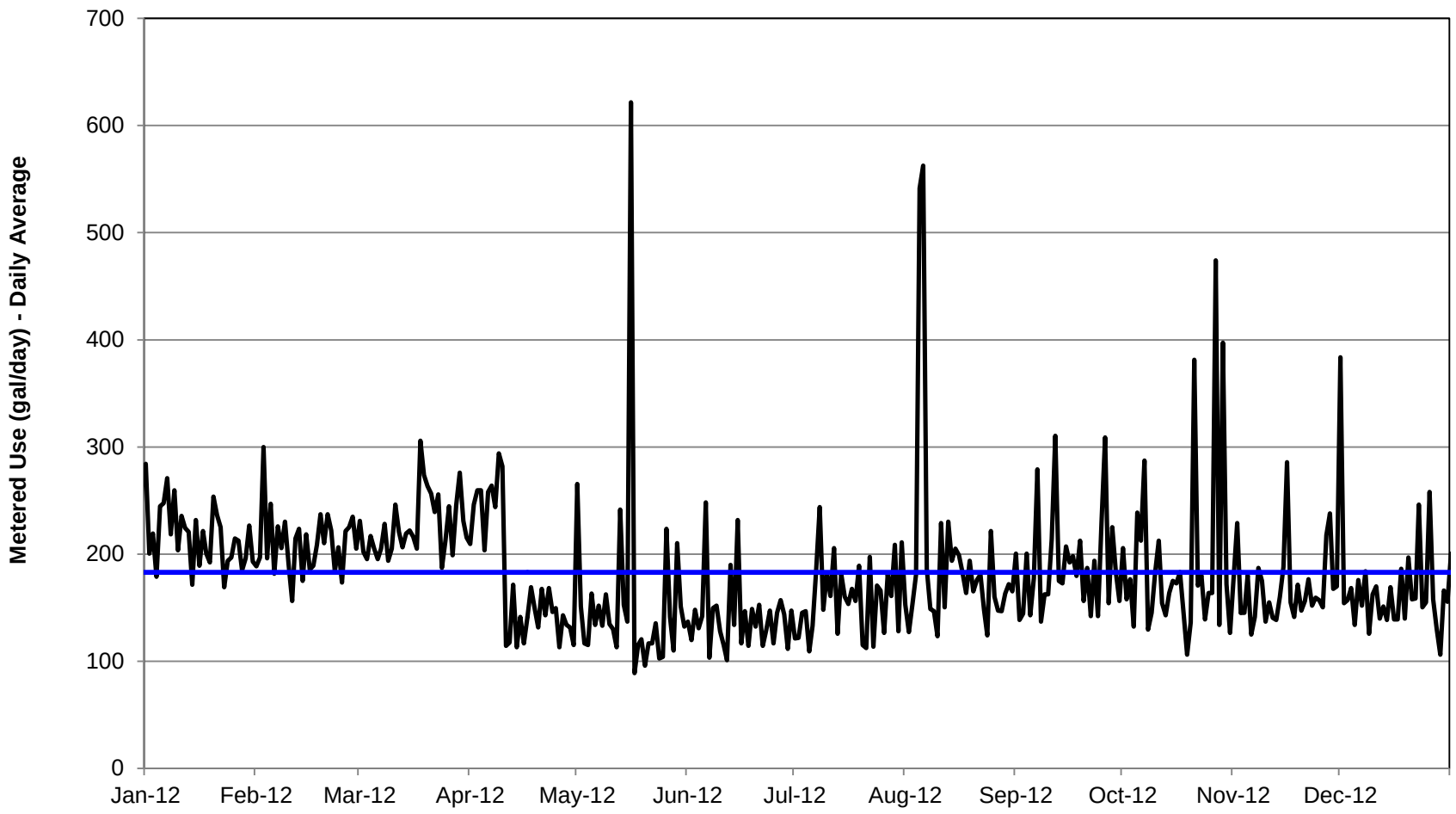
Average Annual Use

FIGURE **C-9**

DAILY GROUNDWATER USE
PROPERTY NO. 9

SC/Well Pilot Metering Program/WA

083-93183



Note: Indoor vs. outdoor use not determined.

Golder Associates

LEGEND

Total Water Use (Metered)

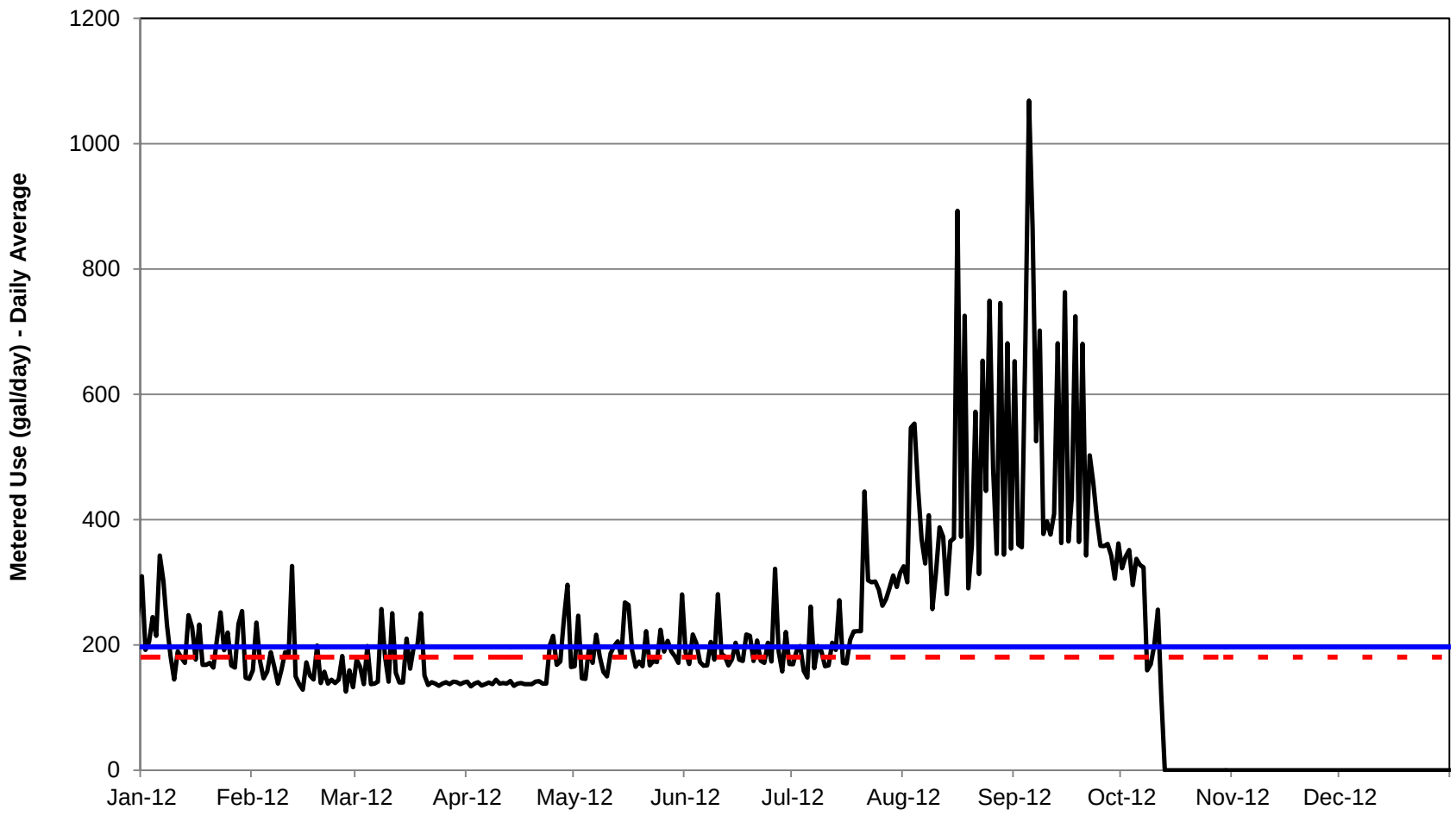
Average Annual Use

FIGURE **C-10**

DAILY GROUNDWATER USE
PROPERTY NO. 10

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

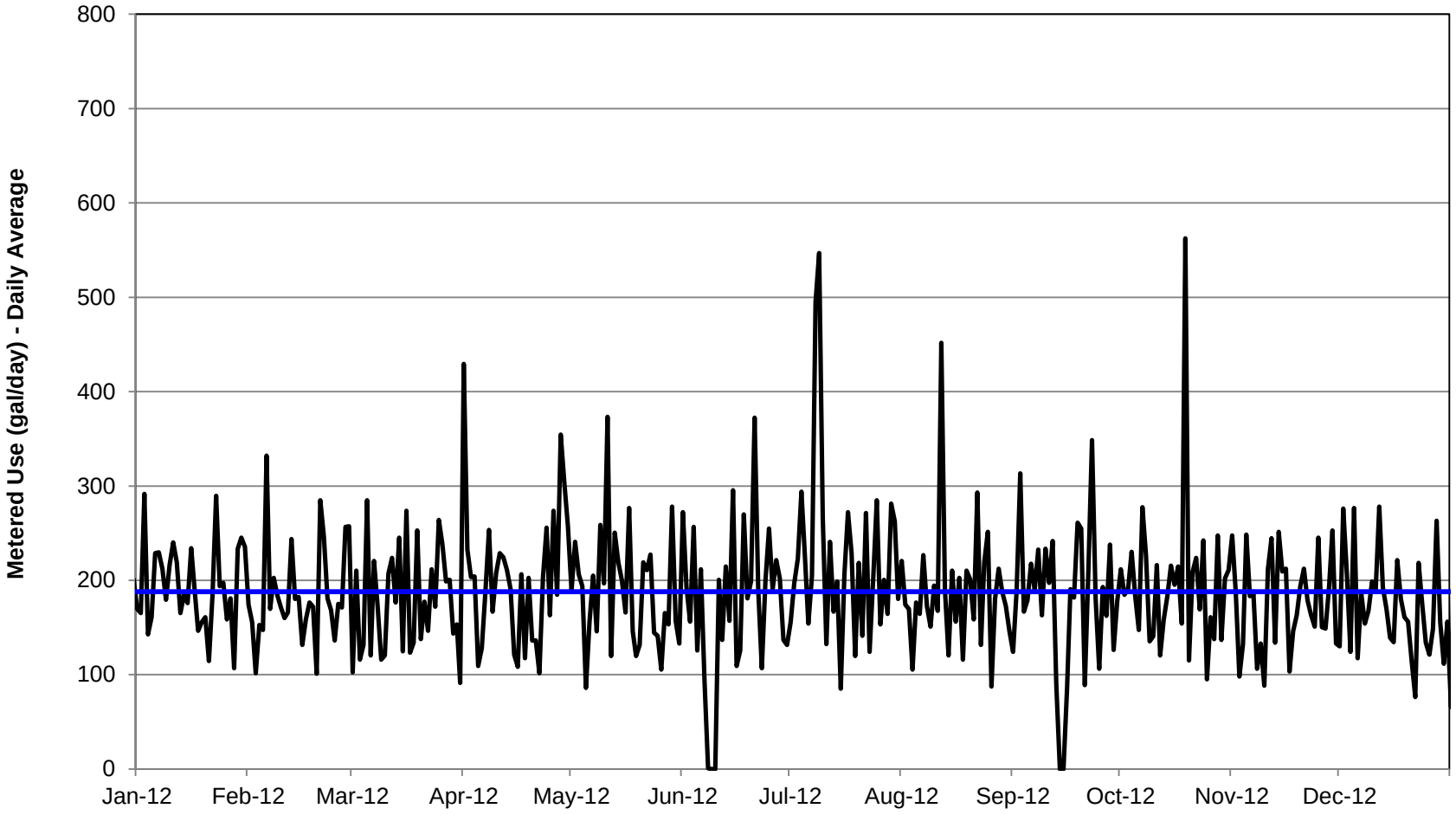
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **C-11**

DAILY GROUNDWATER USE
PROPERTY NO. 11

SC/Well Pilot Metering Program/WA

083-93183



Note: Indoor vs. outdoor use not determined.

Golder Associates

LEGEND

Total Water Use (Metered)

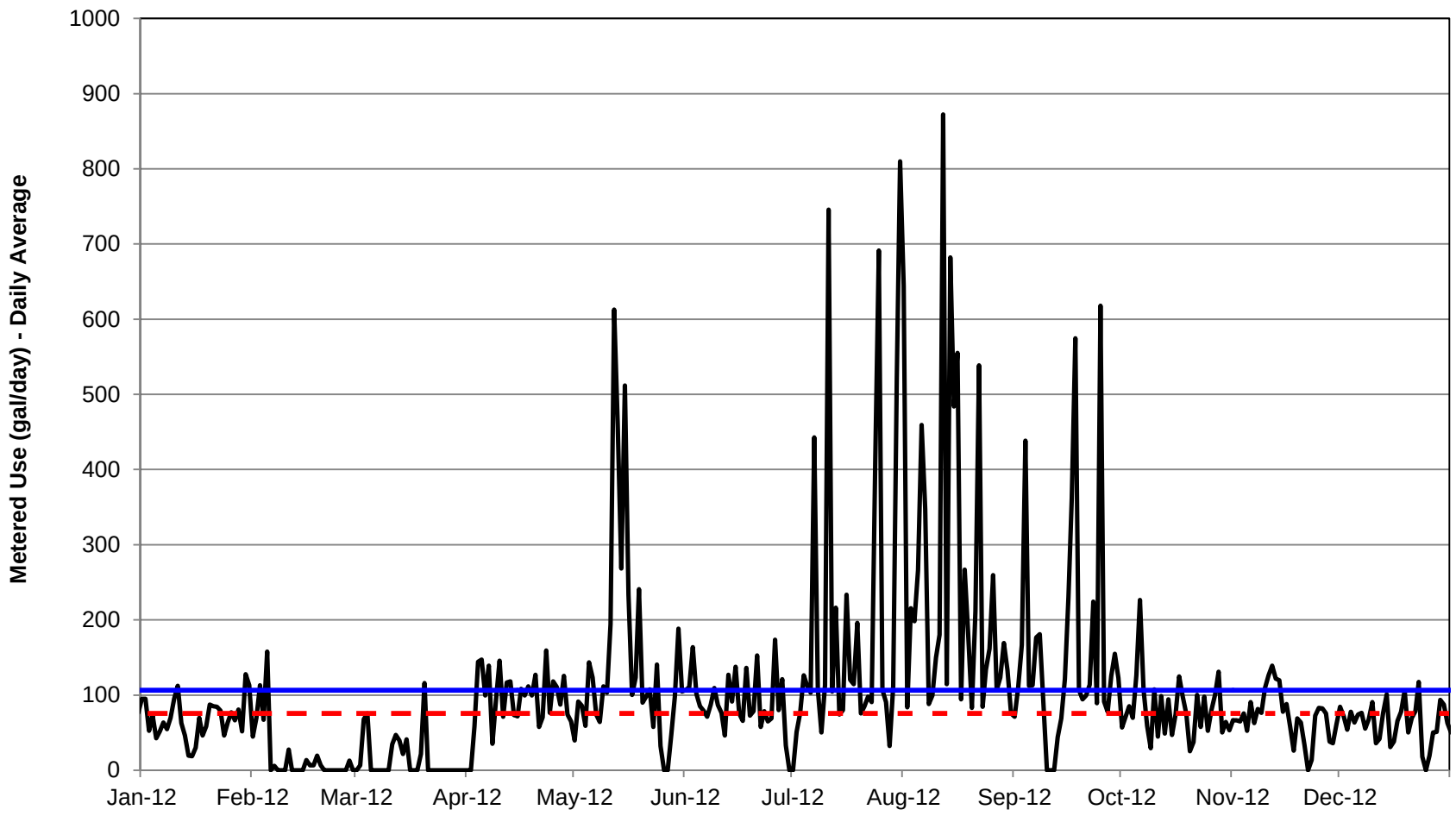
Average Annual Use

FIGURE **C-12**

DAILY GROUNDWATER USE
PROPERTY NO. 12

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

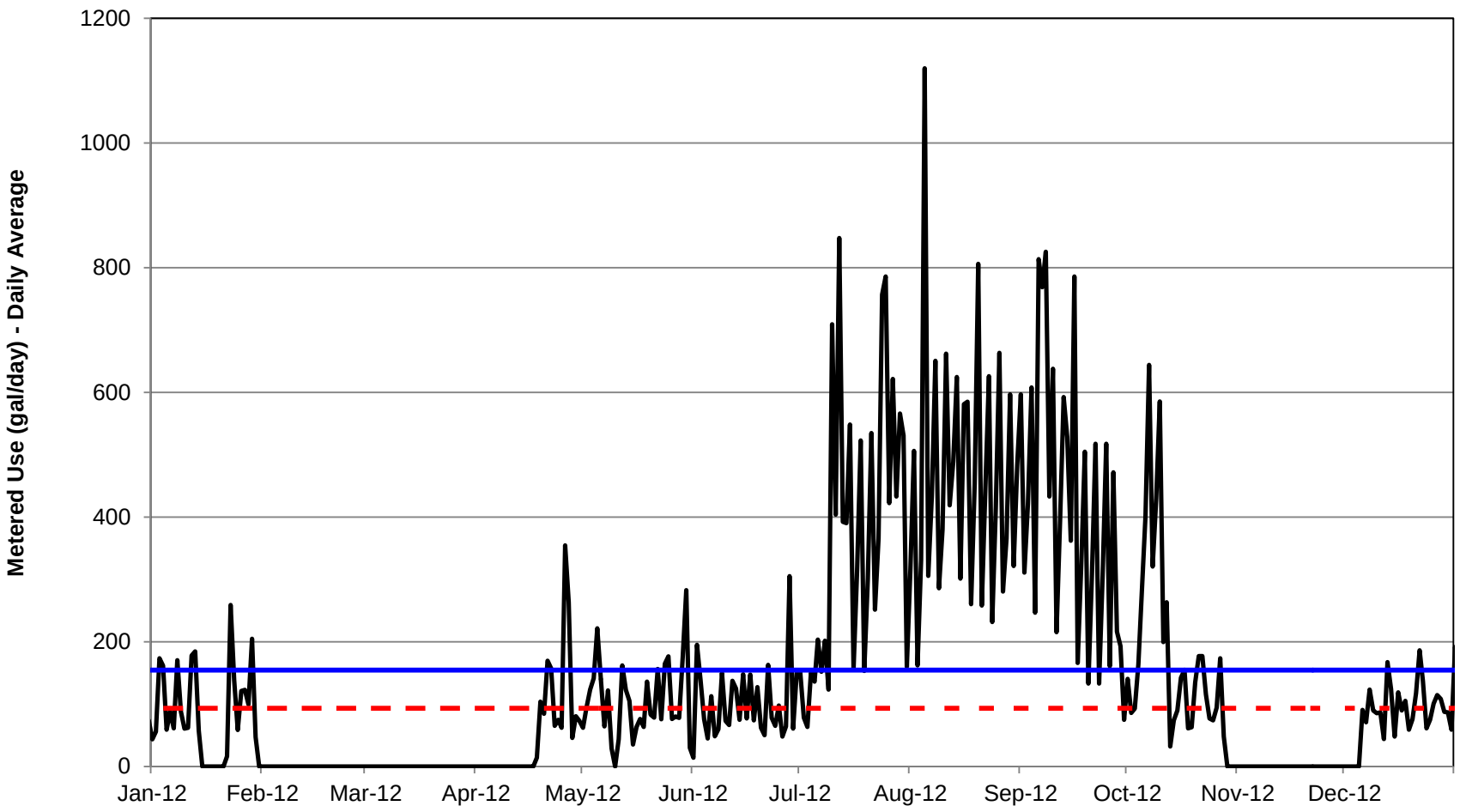
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **C-13**

DAILY GROUNDWATER USE
PROPERTY NO. 13

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

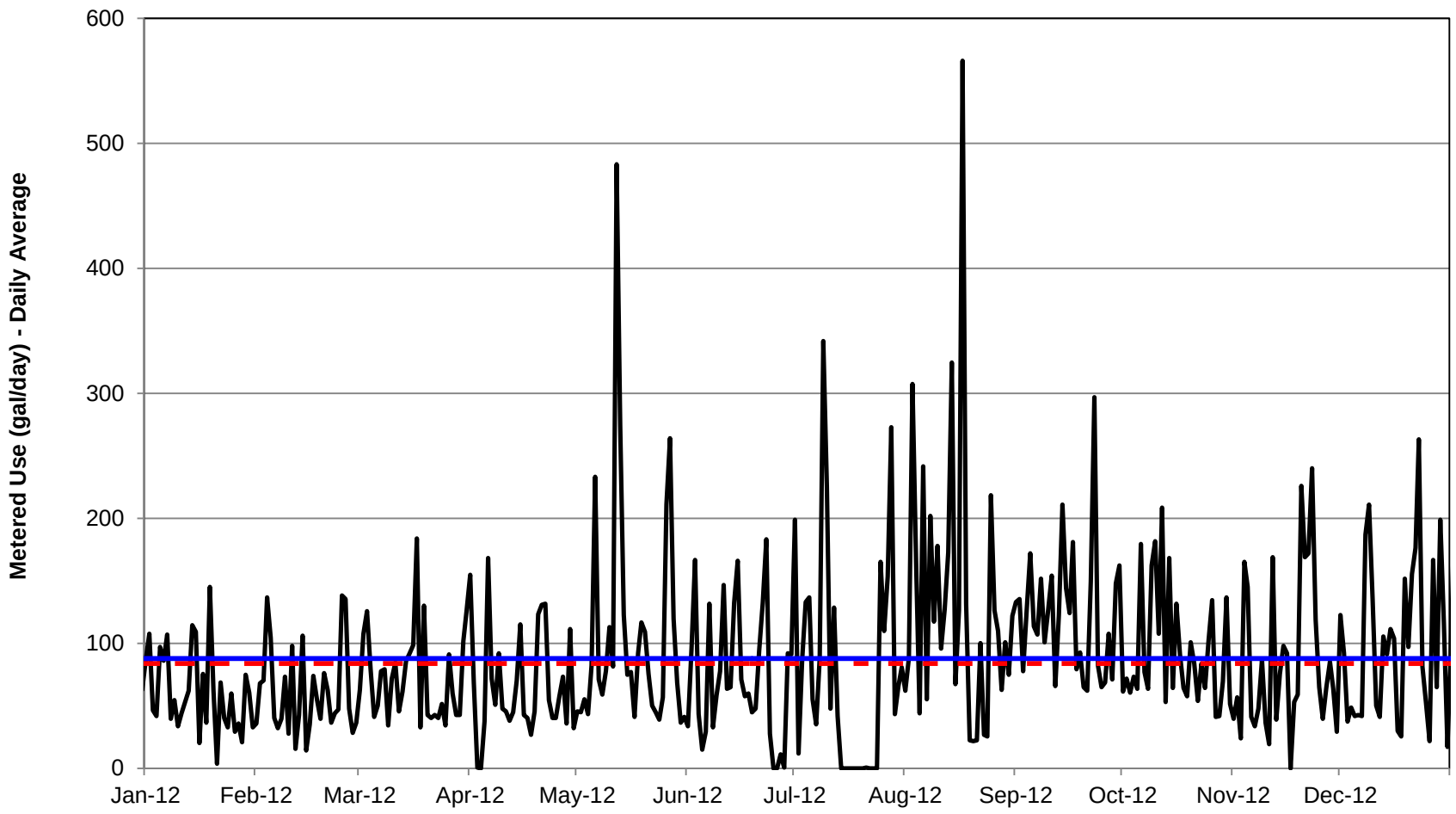
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **C-14**

DAILY GROUNDWATER USE
PROPERTY NO. 14

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

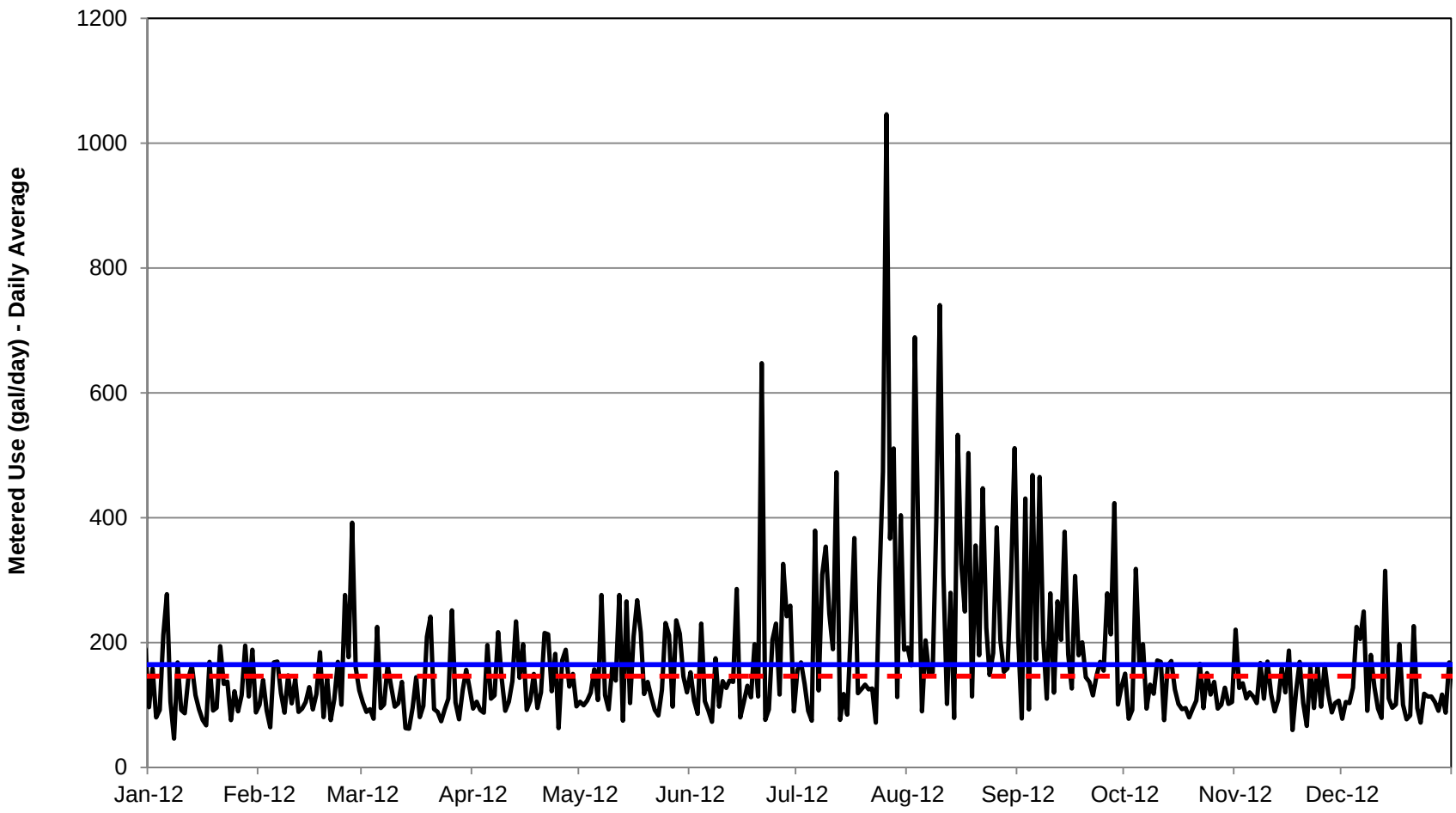
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **C-15**

DAILY GROUNDWATER USE
PROPERTY NO. 15

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

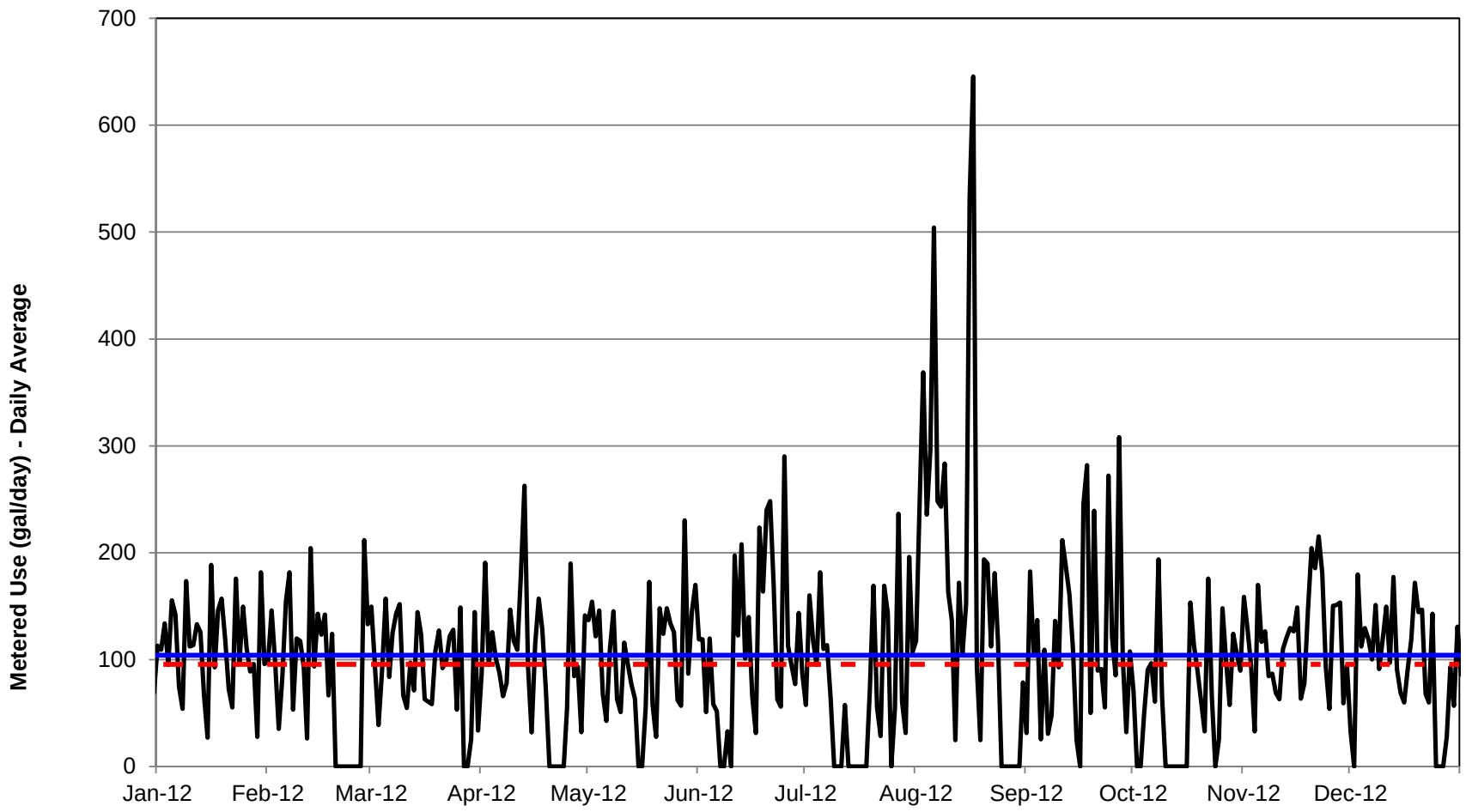
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **C-16**

DAILY GROUNDWATER USE
PROPERTY NO. 16

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

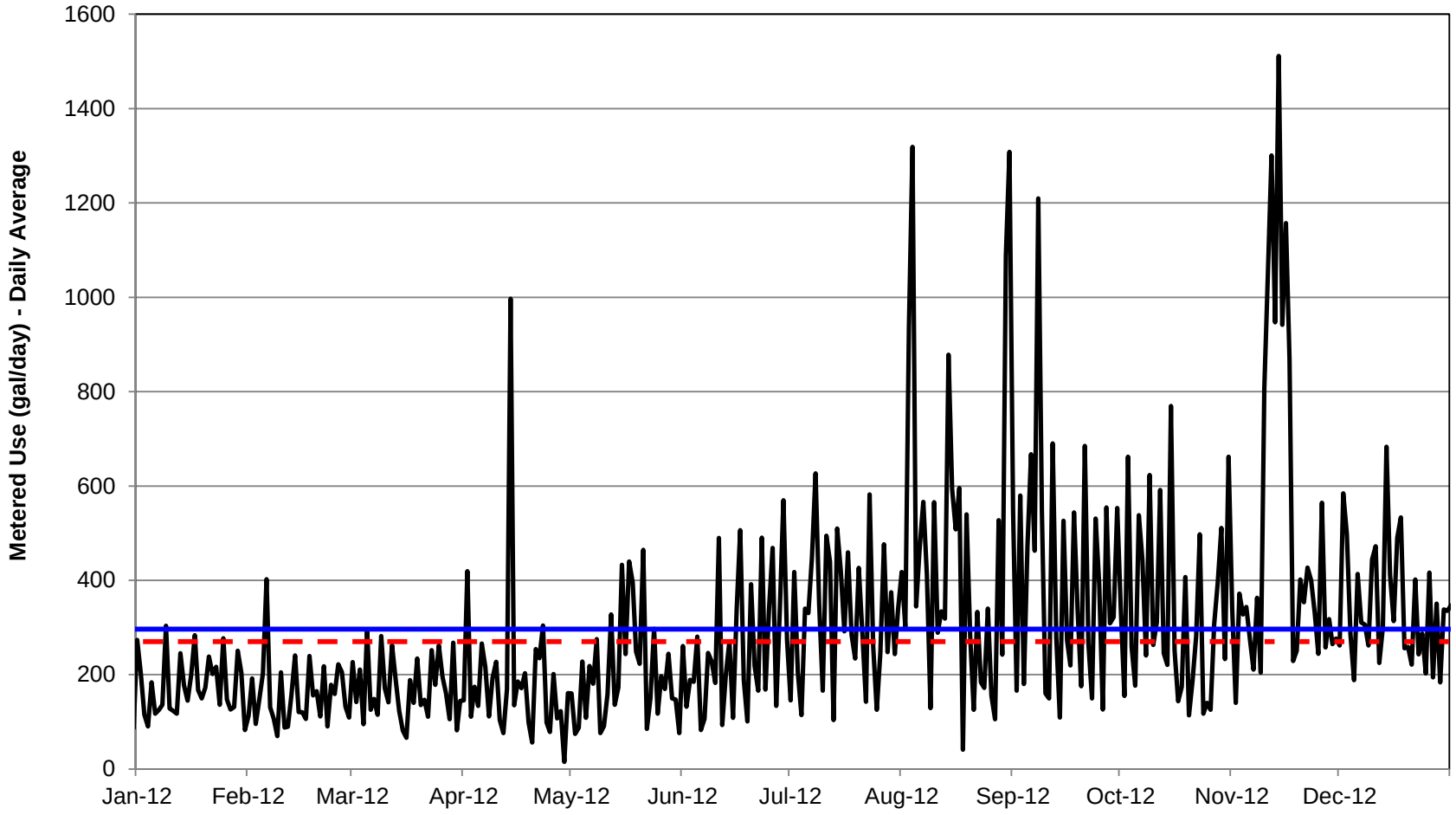
- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **C-17**

DAILY GROUNDWATER USE
PROPERTY NO. 17

SC/Well Pilot Metering Program/WA

083-93183



Golder Associates

LEGEND

- Total Water Use (Metered)
- Average Indoor Use (Estimated)
- Average Annual Use

FIGURE **C-18**

DAILY GROUNDWATER USE
PROPERTY NO. 18

SC/Well Pilot Metering Program/WA

083-93183