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2009 ANNUAL REPORT ON THE PORT LUDLOW AREA GROUNDWATER MONITORING PROGRAM FOR PORT LUDLOW ASSOCIATES, LLC

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by

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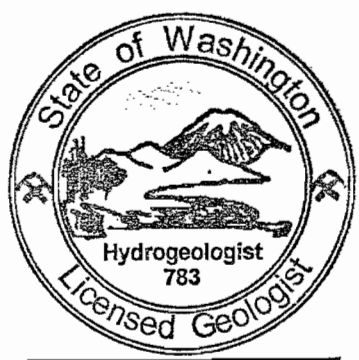

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Introduction

As a condition of plat approval, Jefferson County required that Port Ludlow Associates, LLC, with their subsidiary company Olympic Water & Sewer, Inc. (OWSI, formerly Ludlow Water Company), conduct a groundwater-resource monitoring program. To that end, Robinson Noble, Inc. was retained to develop, conduct, and supervise this program. The program was initiated in April 1994 with the contacting of possible participants. The monitoring program concentrates on the North and South Aquifers (described below) and encompasses the area presumed to overlie these aquifers as well as a substantial area surrounding each aquifer. The current groundwater monitoring network is comprised of 18 wells owned and maintained by seven separate participants, including OWSI.

The goal of the monitoring program is to detect potential impacts to the area aquifers through the development of a long-term hydrologic record. To accomplish this, five basic parameters are monitored throughout each monitoring year: 1) static water levels, 2) pumping water levels, 3) production, 4) water quality, and 5) precipitation. Static and pumping water levels are measured at various intervals at each of the sites. Water levels in wells operated by OWSI are typically measured bi-monthly during the summer months and once a month during the rest of the year. Water levels in the other wells in the monitoring network are typically measured on a quarterly basis. Production from OWSI wells is dutifully tracked and recorded throughout the year. Production volumes from each of the other wells in the network are recorded where available. Water quality measurements are made on an annual basis. The primary focus of water quality monitoring is to decipher potential sea-water intrusion trends, and analyses are, therefore, limited to chloride and conductivity. Precipitation is measured both at the OWSI office in the northern part of the basin and at Well 13 in the south (see Figure 1). Precipitation is also tracked for the National Oceanographic and Atmospheric Administration (NOAA) gage at Chimacum located just outside the study area to the northwest.

Significant Monitoring Network Modifications

The Devine Well, one of several domestic supply wells in the monitoring network, was reconfigured in 2003 such that it could no longer be monitored. This well was not replaced with an alternate monitoring point.

In 2005, OWSI completed construction of two new production wells in the South Aquifer, which are designated as Wells 15 and 16. OWSI does not have immediate plans to use Well 15 for production but incorporated the well into the monitoring network and has been collecting

data from it since 2005. Because Well 15 is not a production source, it provides a good non-pumping observation point for the South Aquifer away from other pumping centers.

Following the construction of Well 16 in 2005, OWSI began the process of bringing the well on line (i.e., installing pumps and constructing other infrastructure). This process was completed and Well 16 was put into service midway through the 2008 monitoring year. During the three-year period between initial construction (August 2005) and when the well was put on line (July 2008), no data was generated for Well 16. However, over this period, monitoring continued through Well 13, which is adjacent to Well 16 and serves as a redundant monitoring point for this area (see Figure 1). Presently, because both Wells 13 and 16 are used for production, monitoring continues to be conducted for both sites.

Port Ludlow Area Aquifers

Robinson Noble has conducted several studies in the Port Ludlow area evaluating groundwater resources. In these previous studies, four principal aquifers were identified. These are the North, South, South Valley, and Well 1 Aquifers (Robinson & Noble, 1987). The four aquifers were defined using differing methods dependent on the type and amount of information available. A detailed explanation of the methods used can be found in Appendix E of the Port Ludlow Development Program EIS. The boundaries of the four area aquifers, and the locations of the wells that currently comprise the monitoring network, are shown on Figure 1.

Identification of Monitoring Wells

When the monitoring network was initially established, Robinson Noble developed a preliminary list of acceptable wells to be included. These wells were selected to provide a comprehensive coverage of the area encompassing the aquifers. The preliminary list of wells included most of the OWSI wells, along with wells operated by other water purveyors within the boundaries of the North and South Aquifers. Also included were privately-owned domestic wells located in specific areas of concern. Where well owners on the preliminary list, including some major water purveyors, declined to participate, additional wells (mostly private) were added to the monitoring network in those areas to improve coverage.

Currently, OWSI only withdraws water from the North and South Aquifers. The water company's wells in the North Aquifer are completed from 139 feet above mean sea level (MSL) to 37 feet below MSL. OWSI's wells in the South Aquifer are completed from 12 to 137 feet below MSL. In selecting wells to monitor in the North and South Aquifer areas, the completion elevation of the well, and not simply the location, was a primary consideration.

In addition to monitoring the North and South Aquifers, the monitoring network includes three wells owned by OWSI located in and near the South Valley Aquifer. These wells allow long-term monitoring of the South Valley Aquifer, which currently has no active production wells.

Jefferson County Public Utility District (JCPUD) has an existing monitoring program for wells in the Shine area. Data from that monitoring program have been obtained and included in the Port Ludlow monitoring network. Table 1 lists all of the wells included in the current monitoring network.

Discussion of Data Collected

Information gathered for each well is discussed below. For comparison purposes, the water level data for the monitoring network was compiled and plotted on similar scales. Water level data is referenced to individual measuring points, typically top of casing. The most recent water quality results are provided in Table 2. The historical trends and ranges for chloride and conductivity are discussed for each well. Note that the State drinking water standards for chloride and conductivity are 250 mg/l and 700 micromhos/cm, respectively. Rainfall data are also discussed in a separate section following the individual well discussions.

Table 1. List of wells in the Port Ludlow area monitoring program

Owner	Well name	Location	Aquifer
Olympic Water & Sewer, Inc.	Well 2	T28N/R1E-8K	North
	Well 3	-8H	"
	Well 4N	-8P	"
	Well 4A	-21F	South Valley
	Well 9	-21F	"
	Well 12	-29A	"
	Well 13	-21R	South
	Well 14	-21R	"
	Well 15	-21R	"
	Well 16	-21R	"
Neault	Private	-15R	South
Woodruff (Hayden-Elaser)	Private	-8L	North
Jefferson County WD#1	Paradise Bay	-27G	South
Jefferson County PUD	Bywater #1	-34M	South
	Bywater #2	-35D	"
	Shine Plat #2	-33N	"
Hendrickson	Private	-34L	South
Hill	Private	-33Q	South

Olympic Water & Sewer, Inc. Monitoring Wells

Well 2 (North Aquifer)

Well 2 is one of three OWSI production wells located in the North Aquifer (along with Wells 3 and 4N which are discussed in the two subsequent sections). The static and pumping water levels and annual production for Well 2 are presented in Figure 2. The water level data show seasonal trends (short-term annual pattern) as generally declining in the summer and increasing (recharging) in the winter. Static water levels in Well 2 during 2009 ranged between 94.4 and 99.9 feet below the measuring point (bmp).

Fluctuations in the long-term water-level pattern for Well 2 appear to be influenced by both changes in precipitation and well production. It is difficult to quantify precisely the influence each has on water levels, but it appears that production is the dominant factor. As illustrated by the data presented in Figure 2, a progressive increase in production for the period between 2001 and 2007 corresponds with a progressive water level decline over the same period of time. As presented in Figure 21, precipitation over this time period was generally average and relatively stable. The dominant influence of production on Well 2 is further illustrated by the fact that when production was significantly decreased during 2008 and 2009, the corresponding water level trend leveled out and then increased. The average production from Well 2 during 2008 was 29.6 gallons per minute (gpm), which is down approximately 41% from the previous year's production of 50.0 gpm. The average production from Well 2 during 2009 was 16.0 gpm, which is down an additional 46 % from 2008.

Starting in about 1994, the static and pumping water level trends in Well 2 show a progressive divergence which is often indicative of decreasing well efficiency. A loss of efficiency was verified with pumping tests conducted in 2004 and again in January 2008. In 2004, attempts were made to rehabilitate Well 2, but because of several obstructions present in the well, rehabilitation was not possible. Following these testing and rehabilitation efforts, Well 2 was equipped with a new pump, which was set with the intake at a lower level to compensate for the increasing efficiency losses. The new pump has a higher instantaneous production rate than the previous pump, which probably exacerbated the problem with declining efficiency. A comparison of the overall drawdown in 2008 with the amount of drawdown recorded for 2003 (when the average production rates were similar) shows that approximately 30 more feet of drawdown is induced now. The lowest pumping level recorded for 2008 is 196.3 feet, which is less than 11 feet of water above the pump intake at 207 feet. With further reductions in production during 2009, the lowest pumping level recorded was 191.5 feet (on July 28 during the peak summer months). Although up from the previous year, this still equates to less than 16 feet of water over the pumping inlet during the peak production period. OWSI is currently making plans to construct a replacement well at or near the Well 2 site.

Water quality results from Well 2 show that chloride and conductivity have been variable throughout the history of the well, with an overall slightly increasing conductivity trend and relatively stable chloride trend. Although conductivity concentrations appear to be increasing

slightly, they are still well below the drinking water limit and, in the absence of an increasing chloride trend, it is not indicative of seawater intrusion. Records for the period between 1968 and 2006 show the chloride concentration in this well has ranged from 3.7 to 11.0 mg/l and conductivity has ranged from 108 to 206 μhoms/cm. No new water quality data were recorded for 2009.

Well 3 (North Aquifer)

The static and pumping water levels and annual production for OWSI's Well 3 are presented in Figure 3. Like Well 2, the water level data show the short-term seasonal trends as generally declining in the summer and recharging in the winter. Static water levels in Well 3 during 2009 ranged between 181.8 and 189.4 feet bmp. As with Well 2, the long-range water level pattern for Well 3, particularly after 1980, indicates that there is a dominant response between water levels and production and a less pronounced response to precipitation changes. Figure 3 shows that between 1980 and present, static and pumping water levels generally parallel each other and decline and rise proportionately with corresponding increases and decreases in the annual production.

Similar to Well 2, water levels in Well 3 show a significant decline that corresponds with a progressive increase in production between 2001 and 2004. Unlike Well 2, water levels in Well 3 continued to decline for a period of approximately two years (2004 to 2006) even though production remained stable. In 2007, production in Well 3 was reduced from 26.5 gpm the previous year to 20.8 gpm (a 22% reduction), with a corresponding leveling of the water level trend. Production in 2008 was reduced to 5.1 gpm (a 75% reduction from the previous year), which did have a corresponding rise in water levels. Production during 2009 again increased slightly to 10.0 gpm (which equates to an average reduction of approximately 64% since 2007), with no major corresponding changes in water level trend. The apparent sluggishness or lag in response time between changes in production and water levels may be attributable, at least in part, to a slow recharge rate in the aquifer. However, it is likely that this apparent lag is largely attributable to the fact that production in OWSI's other two production wells in the North Aquifer (Well 2 discussed previously and Well 4N discussed in the following section) continued to increase over the period between 2004 and 2007. Pumping levels in Well 3 have been near the level of the pump intake (which is just above the well screen) for the past several years, and in fact, OWSI has had some issues with air entrainment. As such, OWSI has been actively reducing production at Well 3 to try to allow water levels to recover at this site. The lowest pumping level at Well 3 during 2008 and 2009 was 228.8 feet for both years, which equates to just under 12 feet of water over the intake at 240.5 feet.

Water quality results from Well 3 show that the chloride and conductivity have been fairly stable throughout the history of the well, with records dating back to 1986. Chloride concentrations have ranged from 2.0 to 9.9 mg/l, and conductivity has ranged from 155 to 227 μhoms/cm between 1986 and 2006. No new water quality data were recorded for 2009.

Well 4N (North Aquifer)

Well 4N is the third of the three active OSWI wells located in the North Aquifer. Water level and production information for Well 4N are presented in Figure 4. The short-term water level pattern for Well 4N exhibits considerably higher seasonal variation than in either Well 2 or Well 3. During 2009 the static water level in Well 4N ranged from 191.3 to 209.9 feet bmp (nearly 20 feet as compared to just under 5.6 feet in Well 2 and 7.6 feet at Well 3). The exact cause of this higher seasonal fluctuation is not completely understood, but it is obvious that Well 4N is more sensitive in the short-term to changes in precipitation. Despite this higher seasonal fluctuation, the long-range water level pattern for Well 4N, like Wells 2 and 3, indicates that there is still a dominant response between water levels and production. Figure 4 shows (particularly after 1992) that static and pumping water levels have generally paralleled each other, declining and rising proportionately with corresponding increases and decreases in the annual production. During 2009 however, there appears to be a slight divergence between pumping and static water levels that coincides with a slight reduction in production for the year. Whether this pattern is indicative of declining well efficiency can not be definitively assessed with out several more years of additional water level and production data.

Similar to Wells 2 and 3, water levels in Well 4N show a significant decline that corresponds with a progressive increase in production that started in 2002 and continued through 2008. Production in Well 4N was increased approximately 20% from 47.9 gpm in 2007 to 59.6 gpm in 2008. This is more than four times the increase that occurred in the previous year (6% increase from 45.2 gpm in 2006). During 2009, production decreased slightly to 57.0 gpm, which still equates to an average increase of approximately 16% since 2007). The recent increase in production at Well 4N is the result of OWSI's efforts to reduce pumping at Wells 2 and 3 (because of the problems discussed above) while still trying to meet demand from the North Aquifer. However, in reducing stress on Wells 2 and 3, the stress on Well 4N is being increased. The lowest pumping level at Well 4N during 2008 was 290.9 feet, which left less than ten feet of water over the pump inlet at 300 feet. In 2009, even with a reduction in the average production rate, the lowest pumping level was down to 293.2 feet (on June 28), which leaves less than seven feet over the pump inlet during the peak summer pumping period. Continued pumping at the current production rates, especially during the summer months when aquifer water levels are at their lowest, will likely result in water levels being drawn down further. Lower pumping levels in-turn, will certainly lead to issues with air entrainment and could result in damage to the pump or the well. Production at this site should be reduced over the next year to allow water levels in the well to recover and provide sufficient drawdown reserve (to accommodate seasonal variation) and sufficient water over the pump inlet (to allow for proper pump operation).

Water quality results from Well 4N show that the chloride and conductivity have been stable throughout the history of the well, with records dating back to 1980. The chloride concentration has consistently been less than 5 mg/l, and the conductivity has ranged from 149 to 204 µhoms/cm. No new water quality data were recorded for 2009.

Well 4A (South Valley Aquifer)

Well 4A is an inactive well located in the South Valley Aquifer. A hydrograph for the well is presented on Figure 5. In 2009, water levels measured in Well 4A were at or above the top of casing. This is consistent with the highest historical levels observed.

Water quality results for this well show the chloride concentration has ranged from 5.0 to 6.5 mg/l, and the conductivity has ranged from 165 to 310 µhoms/cm. No new water quality data were recorded for 2009.

Well 9 (South Valley Aquifer)

Well 9 is another inactive well located in the South Valley Aquifer. Its hydrograph is presented on Figure 6. In 2009, water levels in Well 9 ranged from 5.8 to 7.5 feet. This is comparable to the range in previous years, which show a stable trend since monitoring of the well began in 1994.

Water quality results show the chloride concentration has ranged from 4.8 to 9.0 mg/l, and the conductivity has ranged from 150 to 245 micromhos/cm. No new water quality data were recorded for 2009.

Well 12 (South Valley Aquifer)

Well 12 is also an inactive well located in the South Valley Aquifer. A hydrograph for Well 12 is presented on Figure 7. In 2009 the static water levels ranged from 6.8 to 7.4 feet. These levels are consistent with historical levels for this well.

Water quality results show that the chloride concentration has ranged from 3.0 to 5.0 mg/l, and the conductivity has ranged from 77 to 120 µhoms/cm. No new water quality data were recorded for 2009.

Well 13 (South Aquifer)

Well 13 is one of several OWSI wells located in the South Aquifer (along with Wells 14, 15 and 16 which are discussed in the three subsequent sections). Up until several years ago, Wells 13 and 14 were the only two wells operated by OWSI in this aquifer. However, between 2000 and 2003, Well 13 began showing signs of declining efficiency and increasing problems with sand production. Shortly there after, OWSI began a well construction program to augment lost production from Well 13. In early 2005, OWSI completed construction of Well 15 located approximately 1,000 feet north of Wells 13 and 14 (Figure 1). However, water quality testing at Well 15 indicated elevated arsenic levels and, instead of expending capital towards a treatment facility, OWSI decided to construct a second well closer to Well 13 where arsenic levels were known to be within current standards. In the summer of 2005, OWSI completed the construction of Well 16 approximately 100 feet southeast of Well 13. In 2008, construction of the infrastructure associated with Well 16 was completed and the well was put into service. OWSI currently uses Wells 13, 14, and 16 for production in the South Aquifer and Well 15 as an observation well in the same system.

Figure 8 presents the water level and production data for Well 13. Water levels presented in Figure 8 prior to 1994 were obtained using airline equipment and are somewhat suspect (water levels were measured manually after 1994). Similar to the wells in the North Aquifer, the water level data for Well 13 show the short-term seasonal trends as generally declining in the summer and recharging in the winter. The magnitude of the seasonal fluctuation, however, is markedly less in the South Aquifer wells than it is in the North Aquifer wells, which is not unexpected since the South Aquifer occurs at a much greater depth. Static water levels in Well 13 during 2009 (in the absence of one anomalous measurement recorded for early June) ranged between 367.2 and 369.5 feet bmp. The long-range water level pattern for Well 13 (starting in 1994) shows that static water levels remained relative stable through 2002 regardless of increasing production, and then decline slightly between 2003 through at least 2008 despite an overall reduction in the production at Well 13 over this same five year period. In 2009, Well 13 was not used for production and it appears that the static water level trend may have flattened over the past year.

The slow responsiveness of the aquifer water levels at Well 13, in response to changes in production (precipitation has been fairly stable since 2001) is likely attributable, at least in part, to the greater depth of the South Aquifer (as compared to the response observed for the shallower North Aquifer). The continued decline in water levels in Well 13 may also be to some degree a response to corresponding increases in production at other South Aquifer wells, namely Well 14 (discussed in the subsequent section). Well 16, is in closer proximity to Well 13 than Well 14, but has only been used for production for the past year and a half. Regardless, recent production at Well 16 has been relatively high and is likely contributing to this effect as well. Given the availability of Well 16 for production, and the past problems with declining efficiency and sand production at Well 13, it is not advisable to rely on Well 13 for significant production volumes. However, as Well 16 is utilized increasingly more, it is advisable to continue regular monitoring at Well 13.

Water quality results from Well 13 show that throughout the history of the well, the chloride concentration has been fairly steady and conductivity has been slightly increasing. Despite this the apparent increasing trend for conductivity, levels are still well below the drinking water limit, and in the absence of an increasing chloride trend, are not indicative of seawater intrusion. Records dating back to 1983 show the chloride concentration has ranged from 3.9 to 5.9 mg/l, and conductivity has ranged from 138 to 206 μhoms/cm. No new water quality data were recorded for 2009.

Well 14 (South Aquifer)

Figure 9 presents the water level and production data for OWSI's Well 14. Figure 9 shows that, similar to Well 13, the short-term seasonal trends at Well 14 are generally declining in the summer and recharging in the winter. As with Well 13, it shows too that there is also less seasonal fluctuation in Well 14 as compared with the OWSI wells completed in the North Aquifer. In 2009 the static water level in Well 14 ranged from 375.3 to 378.6 feet bmp.

For the long-term trend, Figure 9 shows that the static water level in Well 14 has declined fairly steadily a total of approximately six feet from 1993 through at least 2008. This declining water level trend correspond with a steady increase in production that has generally occurred over this same time period. Up until recently, Well 14 (augmented by Well 13) has been a primary production source in the South Aquifer. Production at Well 14 reached a maximum average production of 84.3 gpm in 2006. Production then declined approximately 19% from the previous year during 2007 to 68.6 gpm, and an additional 25% in 2008 to 51.3 gpm. In 2009, the average annual production rate at Well 14 was 23.6 gpm, which is 54% lower than 2008. In total, production at Well 14 has been reduced approximately 72% during the past three years. These reductions in production are attributable partly to lower demand, but also to the fact that additional production is being generated through Well 16 (during 2008 and 2009). As shown on Figure 9, static water levels appear to have leveled off during 2008 and 2009, which appears to be related to the reductions in the production rate at this site initiated in 2007 (again the precipitation trend has been relatively stable since 2001). Between 1994 and 2007, the pumping water levels in Well 14 generally parallel the static water levels, declining as production increased. Pumping water levels flattened off during 2007 and 2008, and then rose significantly in 2009 in apparent response to the reduced production rate. There are currently no indications of significant declines in efficiency at Well 14 and no changes to the current operation are recommended.

Water quality results from Well 14, which date back to 1993, show that both the chloride concentration and conductivity have remained relatively stable. Chloride values have ranged between 0.3 and 7.9 mg/l. Conductivity has ranged from 141 to 200 µhoms/cm. Water quality analyses conduced during 2009 reported a chloride concentration of less than 20 mg/l and a conductivity level of 183 µhoms/cm. Although chloride was reported with a higher detection limit (previous reports typically indicate chloride levels of less than 5 mg/l), when considered with the conductivity measurements, there does not appear to be a change in trend for either parameter.

Well 15 (South Aquifer)

Well 15 was constructed approximately 1,000 feet north of Wells 13 and 14 in early 2005 in an attempt to replace declining production at Well 13. However, because of water quality issues related to arsenic and hydrogen sulfide, the well has never been utilized for production. However, OWSI may eventually put this well into service as demand dictates. Because Well 15 is not currently a production source, it provides a good non-pumping observation point for the South Aquifer, away from other pumping centers.

Figure 10 presents the hydrograph of Well 15. At time of construction in February 2005, the static water level in Well 15 was 405.6 feet bmp. Subsequent measurements in August 2005 indicate a seasonal fluctuation of approximately two feet, which is comparable to the fluctuation observed in Wells 13 and 14. Static water levels measured at Well 15 during 2009 (disregarding one anomalously high level recorded in June) ranged between 406.8 and 407.4

feet. The long-term water level pattern recorded to date for this well indicates that static water levels are relatively stable in this portion of the South Aquifer.

Water quality results obtained during the initial testing of Well 15 in 2005 indicated a chloride concentration of 4 mg/l and a conductivity of 184 µhoms/cm. No new water quality data were recorded for 2009.

Well 16 (South Aquifer)

Well 16 is located approximately 100 feet southeast of Well 13. Along with Well 15, Well 16 was completed in 2005 to replace the declining production capacity at Well 13. OWSI completed construction of the infrastructure associated with Well 16 in 2008 and the well is currently in service.

Figure 11 presents the hydrograph of Well 16. At time of construction in July 2005, the static water level in Well 16 was 376.0 feet bmp. Subsequent water level measurements were not made during 2006, 2007, and the first part of 2008 (as construction of infrastructure was completed). During 2009, static water levels in Well 16 ranged between 376.5 and 380.7 feet. These measurements indicate a similar range and seasonal fluctuation pattern as the other wells in the South Aquifer (generally declining in the summer and recharging in the winter). In 2009, which represents the first full year of production, Well 16 produced at an average annual rate of 105.5 gpm. The lowest pumping water level recorded during 2009 was 456.8 feet bmp, which is consistent with the pumping water levels predicted during the initial testing of the well. Currently there are insufficient water level data to assess meaningful water level trends for this well and additional monitoring is required to assess the effects of long-term pumping. Presently, no changes to pumping are recommended for Well 16.

Water quality results obtained during the initial testing of Well 16 in 2005 show that the chloride concentration was 4 mg/l and the conductivity was 169 µhoms/cm. No new water quality data were recorded for 2009.

Private Wells

Woodruff Well (North Aquifer)

The Woodruff well, now owned by Michael and Nancy Hayden-Elaser (but continued to be referred to herein as the Woodruff well), is the only private well in the monitoring network completed in the North Aquifer. A hydrograph of this well is presented as Figure 12. The Woodruff well was reported to have been deepened at some point after initial construction to 219 feet. No water level information is available for the time of original construction. The water level measured at the initiation of monitoring (May 17, 1993) was 151.2 feet bmp. Subsequent water level measurements generally show, on an annual basis, a decline in summer months and rise in winter months. The variation may be in part a response to seasonal variation, as well as a response to seasonal pumping of wells in the immediate vicinity. In 2009, water levels ranged between 154.9 and 157.9 feet.

The long-term water level pattern shows relatively stable water levels between 1994 and 1998, a general rise between 1999 and 2000 of approximately 10 feet, and then stable water levels again until 2002. Starting in 2003 and continuing through 2007, water levels in this well show a consistent decline, similar to the declining trend observed in the other North Aquifer wells during this same period. In 2008 and 2009, water levels appear to have stabilized and may have recovered some, which is likely a response to the reductions in production at OWSI's North Aquifer wells.

Water quality analyses show that chloride concentrations have ranged from 2.5 to 5.9 mg/l. Conductivity has ranged from 152 to 221 μhoms/cm. In 2009, chloride and conductivity were measured respectively at less than 5.0 mg/l and 201 μhoms/cm.

Devine Well

The Devine well is located on the northern fringe of the South Aquifer, near the shoreline of Port Ludlow Bay, in the Ludlow Beach Tracts. In 2003 the wellhead for this well was reconfigured such that there is no longer access to measure water levels. The static water level measurements for this well through 2003 are shown on Figure 13. The original static water level at construction (May 14, 1980) was reported to be 39 feet. The initial water level measurement for the monitoring network (May 17, 1994) was 38.5 feet. With the exception of two water level measurements made in August 1994 (likely post-pumping recovery levels), the data show a slight rising trend (less than two feet) through 1999. The data collected after 1999 show a slight water level decline through 2000 and a leveling off through 2003. Water levels recorded through 2003 are consistent with the original static level and do not indicate an overall declining trend. Based solely on its proximity to the shoreline, this well is likely affected by tidal fluctuations to some degree. Seasonal fluctuation appears to be fairly minimal. In 2003, water levels in the well ranged between 37.5 and 38.9 feet.

Water quality analyses show that the chloride concentration has ranged from 3.0 to 7.5 mg/l, and the conductivity ranged from 223 to 320 μhoms/cm. No new water quality data were recorded for 2009.

Neault Well

The Neault well is located on the fringe of the South Aquifer, near the shoreline of Puget Sound, at Tala Shores. The water levels measured in this well are presented in Figure 14. According to the State Water Well Report for this well, the original static water level at construction (January 25, 1978) was 15 feet below the top of casing. The initial monitoring network water level (June 1, 1993) was 31.5 feet. Subsequent water level measurements have been highly variable. This variability is likely caused by a complicated combination of factors including tidal influences, seasonal variation, and pumping activity. A number of off-trend (extremely low) water level measurements taken initially in 1994 and 1995, and then again in 2002 and 2003, are almost certainly post-pumping recovering water levels and don't represent

true static levels. Similar recent off-trend measurements, which also likely represent post-pumping recovering water levels, include the 39.0 foot measurement recorded for January 15, 2007, the 53.5 foot measurement recorded for July 11, 2007, the 38.6 foot measurement recorded on July 28, 2008, and the 39.4 foot measurement recorded January 17, 2009. The general long-term water level pattern for this well (estimating between the variations and excluding obvious off-trend measurements) appears to be increasing from 1994 to 2000, steady between 2001 and 2005, and possibly increasing up through the present.

Water quality analyses show that the chloride concentration has ranged from 3.9 to 10 mg/l. In 2009, chloride was measured at 6.0 mg/l. Conductivity has ranged from 185 to 254 μhoms/cm, with the highest measurement made in 2009. Although conductivity concentrations appear to be increasing slightly since 1999, levels are still well below the drinking water limit, and in the absence of an increasing chloride trend, it is not indicative of seawater intrusion.

Hendrickson Well (South Aquifer)

The Hendrickson well, which replaced the Hodges well in the monitoring network in 1995, is a private domestic well located in the southern portion of the South Aquifer northeast of the Shine area. The water levels measured for this well are presented on Figure 15. The original static water level at construction (September 25, 1980) was reported to be 161 feet. In conjunction with the testing of JCPUD's Bywater Well 1, the Hendrickson well was monitored continuously from March 2 through 7, 1992. During that time period, the water levels varied between 159.8 to 160.2 feet, much of which appeared to be in response to barometric changes. The initial network water level (August 2, 1995) was 158.5 feet. Only being measured quarterly, it is difficult to assess the seasonal water level pattern for this well. However, the magnitude of the variation appears to be on the order of other wells completed in the South Aquifer. In 2009, water levels ranged between 163.9 and 164.2 feet. Historically, long-term water level patterns in this well have been stable through 2001, declining from 2002 to 2007, and stable again in 2008 and 2009. The long-term water level pattern in this well is generally comparable to the pattern observed in OWSI's Wells 13 and 14.

Water quality analyses show that the chloride concentration has ranged from less than 5.0 to 11.8 mg/l, and the conductivity has ranged from 139 to 206 μhoms/cm. No new water quality data were recorded for 2009.

Jefferson County Water District #1's Paradise Bay Well (South Aquifer)

The Paradise Bay Well is located in the central portion of the South Aquifer. Static water levels, and limited pumping water levels have been provided from 1994 through 2004 (Figure 16). Water level data (static or pumping levels) have not been provided since 2004. Production data has been provided from 1994 through 2005 but no new data was provided since 2005. The Water District reported that the static water levels in 2004 ranged between 321 and 322 feet, which was down slightly from the previous two years but within historical trends. Production records show a slight, but progressive, increase in production between 1997 and 2004. In 2005

the average continuous production rate was reported as 14.1 gpm, down slightly from 15.7 gpm during the previous year.

Water quality analyses for this well show the chloride concentration has ranged from 1.9 to 5.9 mg/l, and the conductivity has been between 116 and 178 µhoms/cm. Water quality analyses conduced during 2009 indicated a chloride concentration of less than 20 mg/l and a conductivity level of 153 µhoms/cm. Although chloride was reported with a higher detection limit (previous reports typically indicate chloride levels of less than 5 mg/l), when considered with the conductivity measurements, there does not appear to be a change in trend for either parameter.

Jefferson County PUD's Monitoring Network Wells

Bywater Bay Well 1 (South Aquifer)

Bywater Bay Well 1 is located in the South Aquifer area approximately 1¾ miles south of OWSI's Wells 13 and 14. This well is included in JCPUD's monitoring network and, for a time, was also monitored by Pope Resources. In 1997, Pope Resources deferred monitoring to JCPUD. The water level and production data collected for this well are shown on Figure 17. The initial network water level (May 22, 1992) was 163.6 feet bmp. The long-term trend for this well shows that static water levels remained relatively between 1995 and 1999, declined through 2002, and then have been relatively stable to slightly declining through 2008. However, some water levels appear to represent pumping or post-pumping recovering water levels and may not accurately reflect water level trends. Most notable are the anomalously low water levels measured on July 1, 2002 (206.7 feet), during the second half of 2006 (210.0 and 203.6 feet), and during the second half of 2008 (208.8 and 204.2 feet). These specific off-trend measurements almost certainly represents a pumping water level and have been plotted as such. The water level measured on July 9, 2007 (191.9 feet), also appear to represent a level intermediate between static and pumping levels. Minimal production data has been provided for this well and no new water level data was provided in 2009.

Water quality analyses show that the chloride concentration in this well have ranged from 2.9 to 7.7 mg/l, and the conductivity has ranged from 162 to 250 µhoms/cm. Water quality analyses conduced during 2009 reported a chloride concentration of less than 5 mg/l and a conductivity level of 218 µhoms/cm.

Bywater Bay Well 2 (South Aquifer)

Bywater Bay Well 2 is located in the southeast portion of the South Aquifer approximately 1¼ miles southeast of OWSI's Wells 13 and 14. Like Bywater Bay Well 1, Bywater Bay Well 2 is currently monitored by JCPUD. Water level and production data collected for the monitoring network are presented in Figure 18. This well was reportedly deepened from 254 feet to 323 feet in 1994. The static water level, at the time the well was deepened, was 252.2 feet. The initial monitoring water level (May 23, 1994) was 258.0 feet bmp. No new water level or production data was provided for 2008 or 2009. In 2007, water levels in this well ranged between 259.15

and 291.8 feet. The static water level data for this well reported between 1996 and 2007 indicates an overall declining trend. Limited production data provided for this well indicate production has remained relatively stable up through 2007.

Water quality analyses for Bywater Bay Well 2 show that the chloride concentration have ranged from 5.0 to 19 mg/l, and the conductivity has ranged from 110 to 326 μhoms/cm. Water quality analyses conduced during 2009 reported a chloride concentration of 10 mg/l and a conductivity level of 325 μhoms/cm. The overall water quality pattern shows a slightly increasing trend for both chloride and conductivity since 1994. The trend is somewhat irregular though and does not definitively indicate saltwater intrusion. Both the chloride concentrations and the conductivity are currently well below regulatory limits.

Shine Plat Well 2

The Shine Plat Well 2 is a community well located in the Shine area, outside the identified boundary of the South Aquifer. Measured water levels collected for the network are presented in Figure 19. The original static water level at construction in 1991 was reported to be at a depth of 2 feet. The initial monitoring water level (September 1993) was 14.8 feet. Subsequent water level measurements have been highly variable. In 2009, measured water levels ranged from 2.3 to 23.5 feet. This variability is likely caused by pumping activity in both this well and the nearby Shine Plat Well 1. Overall, however, a generally stable trend is represented by the highest recorded water levels since 1995.

Water quality analyses show that the chloride concentration have ranged from 4.2 to 10 mg/l, and the conductivity has ranged from 183 to 255 μhoms/cm. Water quality analyses conduced during 2009 reported a chloride concentration of 5.67 mg/l and a conductivity level of 244 μhoms/cm.

Hill Well

The Hill well is a private domestic well located on the southern fringe of the South Aquifer along the shoreline of Puget Sound in the Shine area. A hydrograph representing water levels collected for the network is presented as Figure 20. The original static water level at construction in 1983 was reported to be 30 feet. A water level of 36.5 feet was measured by Roats Engineering in September 1993. Subsequent measurements show considerable variation. This variability is likely a result of a combination of factors including pumping activity at the Hill well itself, seasonal variation, and possibly tides. In 2009, water levels ranged from 29.1 to 44.1 feet. Generally, the long-term water level pattern appears to indicate a declining trend between 1995 and 2001, and then a rising trend through present.

Water quality analyses show that the chloride concentration in this well have ranged from 24 to 35 mg/l, and the conductivity has ranged from 339 to 475 μhoms/cm. Water quality analyses conduced during 2009 reported a chloride concentration of 25.9 mg/l and a conductivity level of 395 μhoms/cm. Both the chloride and conductivity levels in this well are relatively high compared to other wells in the network, suggesting minor saltwater influence, but not

necessarily saltwater intrusion. The Hill well is located approximately 500 feet from the shoreline, and at times, pumping water levels are a few feet below sea level. The well location, pumping water levels, and the completion elevation of 20 to 25 feet below sea level make the Hill well susceptible to saltwater intrusion. To date, however, water quality data collected for the monitoring network show stable to slightly declining chloride and conductivity levels, and no clear indication of an increased risk of saltwater intrusion.

Water Quality

The results from the most recent water quality analyses for the monitoring network are presented in Table 2. For historical values, refer to previous year-end summary reports. Historical water quality data show stable chloride concentrations and conductivity values for all the wells in the monitoring network. Additionally, the most recent water quality data show chloride concentrations and conductivity values are all within the applicable Washington State drinking water standards.

Rainfall

Precipitation in the Port Ludlow area has been collected at the OWSI office since 1979. Plots of annual totals at Port Ludlow and at NOAA's Chimacum 4S weather station are given on Figure 21. The 31-year average for Port Ludlow is 32.55 inches per year (in/yr). This compares to the 30-year average at the Chimacum Station (2009 records not yet available for Chimacum) of 28.56 in/yr. The difference of 3.99 in/yr between the two locations is consistent with the isohyetal map in Water Supply Bulletin 54. However, the averages are greater at Port Ludlow and Chimacum than that suggested by the isohyetal map (which is based on 1931-1960 data).

Since 1991, rainfall has also been collected at a "South Bay" station located at Well 13. Rainfall in 2009 totaled 30.97 inches at the Port Ludlow office and 32.95 inches at the South Bay station. The 19-year average for the South Bay station is 33.92 in/yr, which is slightly above the Port Ludlow office station average of 33.06 in/yr for the same period of record.

Summary

Sixteen years of monitoring have provided for an analysis of the condition of aquifers in the Port Ludlow area. The monitoring network, initiated in April 1994, currently includes 18 wells from seven participants, including four wells in the Shine area that are part of a Jefferson County PUD monitoring network.

In general, all wells in the network show seasonal variations. Water levels decline in the spring/summer months and rise in the fall/winter months. These variations are likely contributable to a combination of several factors. Most of the natural recharge to the aquifers occurs in the fall and winter, causing a rise in water levels. Then, increases in withdrawals from area aquifers during the spring through fall accentuate the normal decline in water levels occurring as a result of the natural discharge of the aquifers during the time of lower recharge. Other non-seasonal factors, such as barometric effects (some wells have been shown to be

nearly 100% efficient in the area), tidal effects, and measurements of post-pumping recovering water levels, add to the "noise" of the trend analyses. With the seasonal variations in mind, none of the aquifers within the monitoring network (with the exceptions noted below for the North Aquifer) showed a significant overall decline from historical levels in 2009. OWSI's combined annual average production for 2009 was 212.1 gpm (342.0 acre-feet) from all aquifers. This is up slightly from the combined production recorded for 2008 of 200.7 gpm (323.7 acre-feet), but still down from the 2007 total of 222.6 gpm (359.1 acre-feet). This overall decrease in production for the past two years, particularly as it applies to the North Aquifer, appears to be helping to reverse the declining trends observed for this area prior to 2008.

Table 2. Recent water quality analyses for the Port Ludlow area monitoring network

Well Name	Chloride (mg/l)	Conductivity (μhoms/cm)	Date Sampled
Well 2	5.6	203	1/10/06
Well 3	5.5	197	1/10/06
Well 4N	<5.0	186	1/10/06
Well 4A	5.0	310	9/7/95
Well 9	4.9	245	2/20/96
Well 12	5.0	120	8/29/88 & 11/30/72
Well 13	<5.0	196	1/10/06
Well 14	<20.0	183	10/28/09
Well 15	5.0	184	2/5/05
Well 16	4.0	169	8/4/05
Devine Well	<5.0	223	10/8/03
Woodruff Well	<5.0	201	10/08/09
Neault Well	6.0	254	10/07/09
Hendrickson Well	<5.0	167	10/09/08
JCWD#1 Paradise Bay Well	<5.0	153	10/07/09
JCPUD Bywater Well 1	<5.0	218	10/6/09
JCPUD Bywater Well 2	10.0	325	10/7/09
Shine Plat Well 2	5.7	244	10/06/09
Hill Well	25.9	395	10/06/09

Starting in 2001, water levels in each of OWSI's three primary production wells in the North Aquifer (Wells 2, 3, and 4N) show a declining trend that has persisted up until a few years ago. Water levels in the nearby Woodruff Well, also completed in the North Aquifer, have shown a similar declining trend over this same period. These declining water levels were likely the result of production increases that have occurred incrementally over this same period. In the seven-year period between 2001 and 2007, total withdrawal from the North Aquifer by OWSI increased incrementally from 71.7 gpm (116 acre-feet) to 118.7 gpm (191.5 acre-feet). A reduction in the production rate during 2008 and 2009 appears to be reversing this trend. The total production by OWSI from the North Aquifer in 2009 was 83.0 gpm (133.8 acre-feet), which is down 11.3 gpm (18.2 acre-feet) from 2008 and 35.7 gpm (57.7 acre-feet) from 2007.

In the central portion of the South Aquifer, production at OWSI's Wells 13 and 14 has steadily increased up through 2006. Starting in 2007, and particularly during 2008 and 2009, production from Wells 13 and 14 has steadily decreased as OWSI transitions production to their new Well 16. Overall production from the South Aquifer over this period has only increased slightly. OWSI's total production from the South Aquifer respectively during 2006, 2007, 2008, and 2009 was 125.6 gpm (202.6 acre-feet), 103.9 gpm (167.6 acre-feet), 106.5 gpm (171.8 acre-feet), and 129.1 gpm (208. 2 acre-feet). Limited production data for both the Jefferson County Water District #1 Paradise Bay Well and the Jefferson County PUD Bywater Bay Well 2 indicate that production at these wells has remained relatively steady since the mid 1990's (production data for Jefferson County PUD Bywater Bay Well 1 is insufficient for assessing any trends). Recent declining trends for static water levels are indicated for OWSI Wells 13 and 14, Jefferson County PUD Bywater Bay Wells 1 and 2, and for the private Hendrickson Well. Presently these various declining trends are not considered significant or detrimental to the South Aquifer as a resource and, in actuality, likely represent localized water level declines related to pumping. Although the water level record at OWSI's Well 15 currently only incorporates five years of monitoring, indications are that water levels in the central portion of the South Aquifer, away from the influence of pumping, have remained stable over the past several years.

In the South Valley Aquifer, water levels in Wells 4A, 9, and 12 continue to show stable long-term water level trends with seasonal variations of up to four feet. These variations are most likely the result of variations in seasonal recharge.

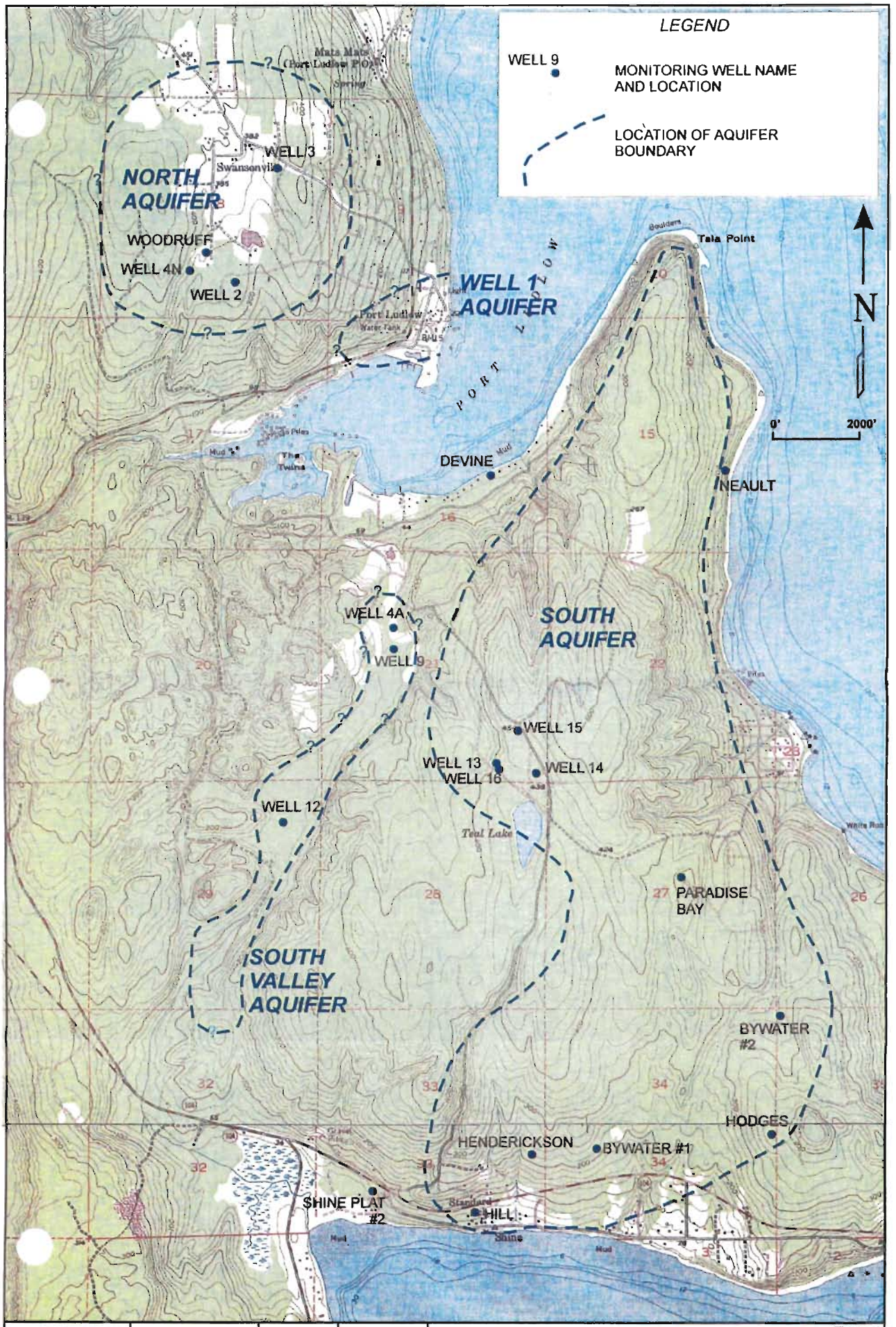
With the exception of the Devine Well, the private wells in the network located within 500 feet of the shoreline show highly variable water levels, the largest being up to 50 feet in Shine Plat Well 2. The variation in water levels is most likely the result of the combination of tides, barometric effects, seasonal recharge, and variations in pumping activity in the monitored wells and/or wells in their immediate vicinity.

Water quality results from the monitoring network wells show that chemistry has remained relatively stable in all aquifers. There are currently no indications of saltwater intrusion for any of the wells in the monitoring network.

Recommendations

The Port Ludlow groundwater monitoring program continues to function as designed. The current program provides adequate coverage and information on the aquifers in the Port Ludlow area. The continuation of monitoring water levels and water quality sampling in all network wells will allow long-term trend analysis of the aquifers in the Port Ludlow area. Based on the information gathered in 2009, the frequency of water level measurements can be maintained at the current intervals. Water quality sampling should remain on an annual basis. It is also recommended that the monitoring of rainfall continue at the Olympic Water & Sewer's office and at the South Bay gage.

The monitoring program has collected a strong baseline of data and has provided an initial, long-term trend analysis. With the exception of the North Aquifer, there are currently no definitive indications of significantly declining water levels related to groundwater production. Additionally, there are no definitive indications of rising chloride and conductivity levels. The hydrographs for wells completed in the North Aquifer indicate that the aquifer water levels were recently declining in response to pumping. OWSI has recently implemented plans to address this issue, which includes construction of additional wells, exploration for an alternate – deeper source in the North Bay area, and possibly shifting production to other aquifer systems (namely the South and South Valley Aquifers). A reduction in the production from OWSI's North Aquifer Wells appears to be affecting a recovery of water levels in the aquifer. Continued caution and additional vigilance is warranted for the next several years with regards to this system in particular. The continuation of the monitoring program can insure that proper management of the groundwater resource is maintained.



ROBINSON NOBLE SAIC	Note: Basemap taken from USGS Lofall / Port Ludlow Quadrangles	PM: MTW February 2010 1685-005B	Jefferson County T 28 N/R 1 E Scale 1" = 2000'	Figure 1 Port Ludlow Area Goundwater Monitoring Network Olympic Water and Sewer, Inc.

Figure 2: Well 2 water levels and production rate (28N/1E-8K)
Depth of well = 245 feet, surface elevation = 300 feet MSL.
Completion elevation = 86 to 55 feet above MSL
Aquifer: North

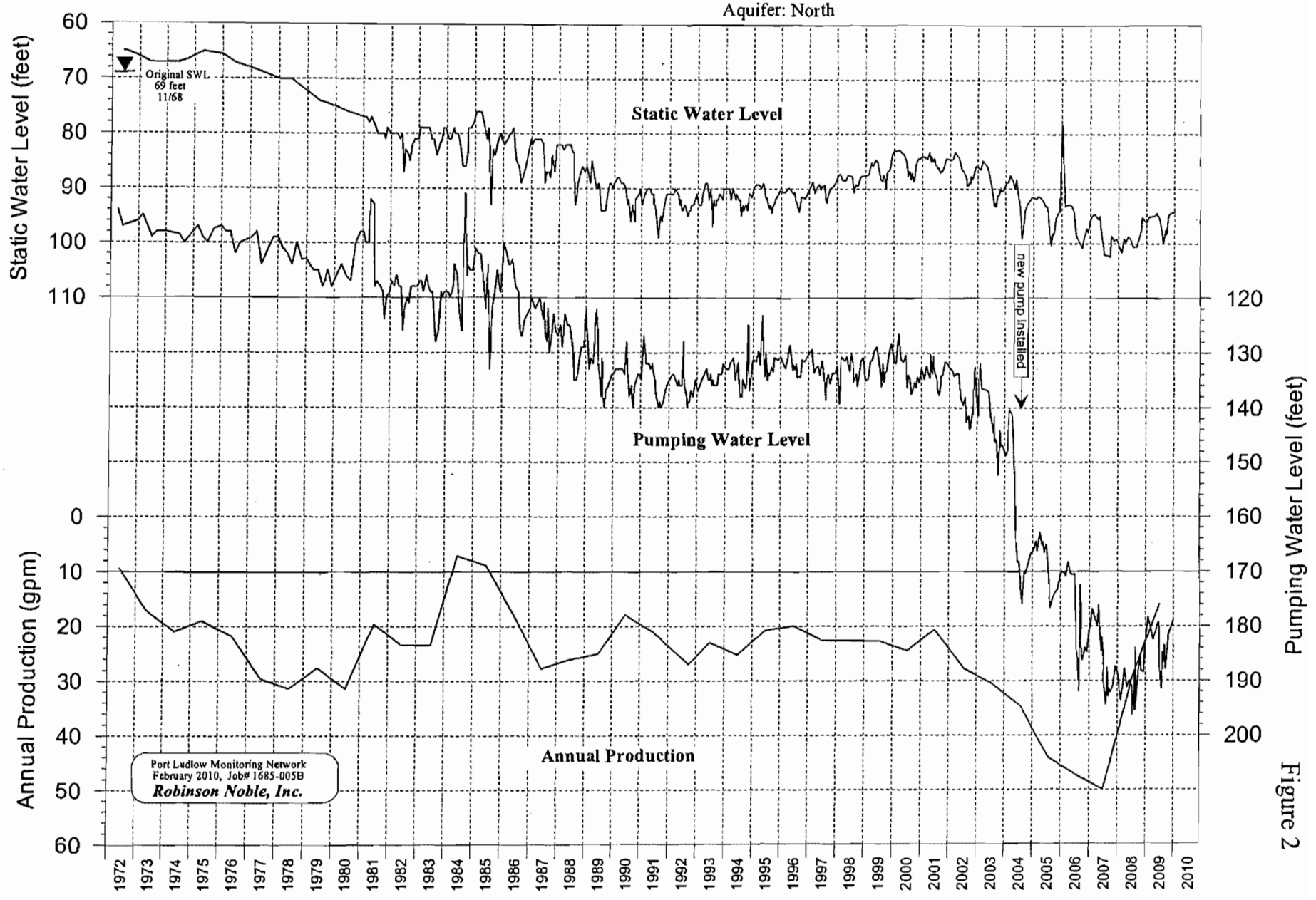


Figure 2

Figure 3: Well 3, water levels and production rate (28N/1E-8H)
Depth of well = 257 feet, surface elevation = 378 feet MSL.
Completed elevation = 139 to 123 feet above MSL
Aquifer: North

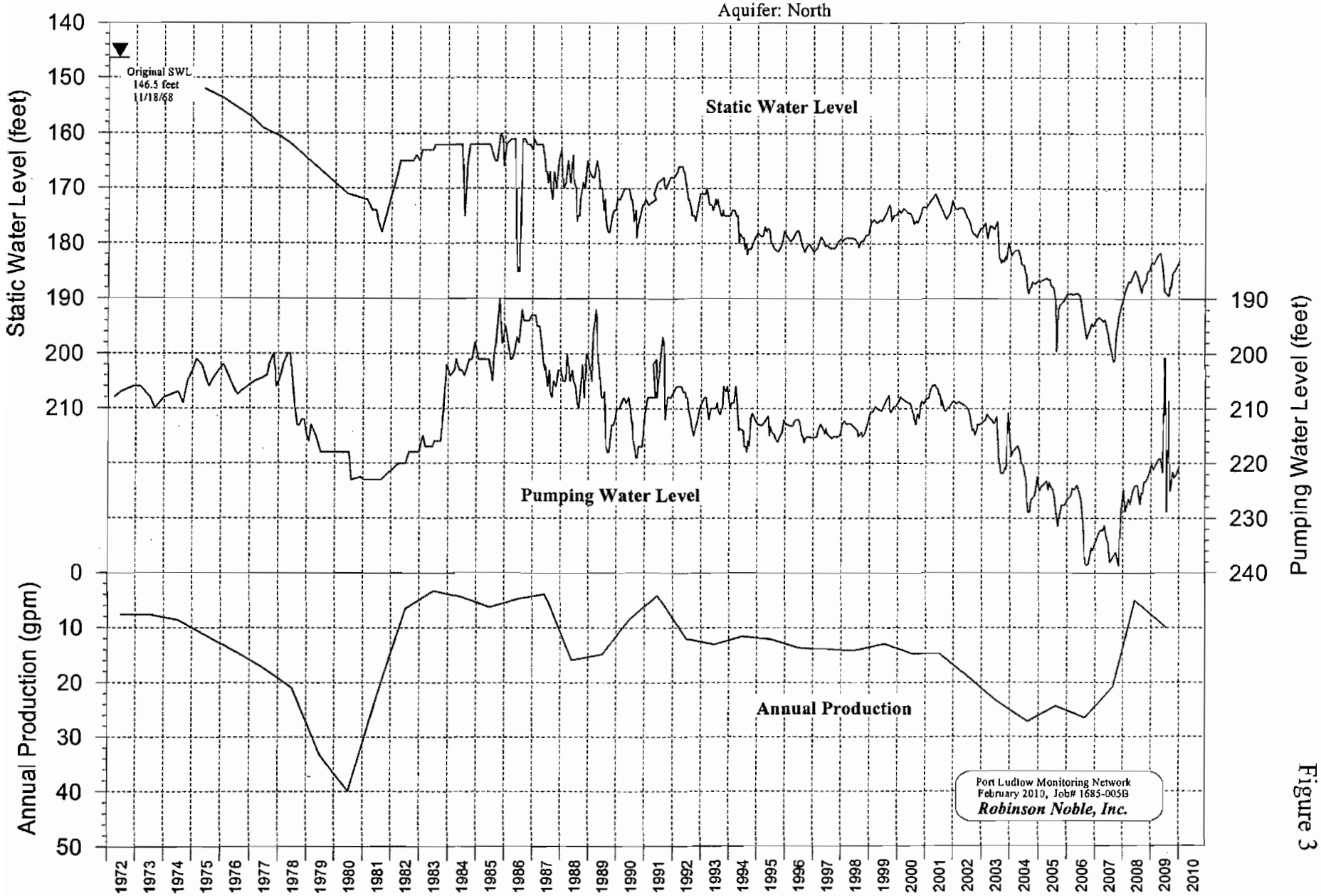


Figure 3

Figure 4: Well 4N water levels and production rate (28N/1E-8P)
Depth of well = 387 feet, surface elevation = 340 feet MSL.
Completion elevation = 24 feet above to 37 feet below MSL
Aquifer: North

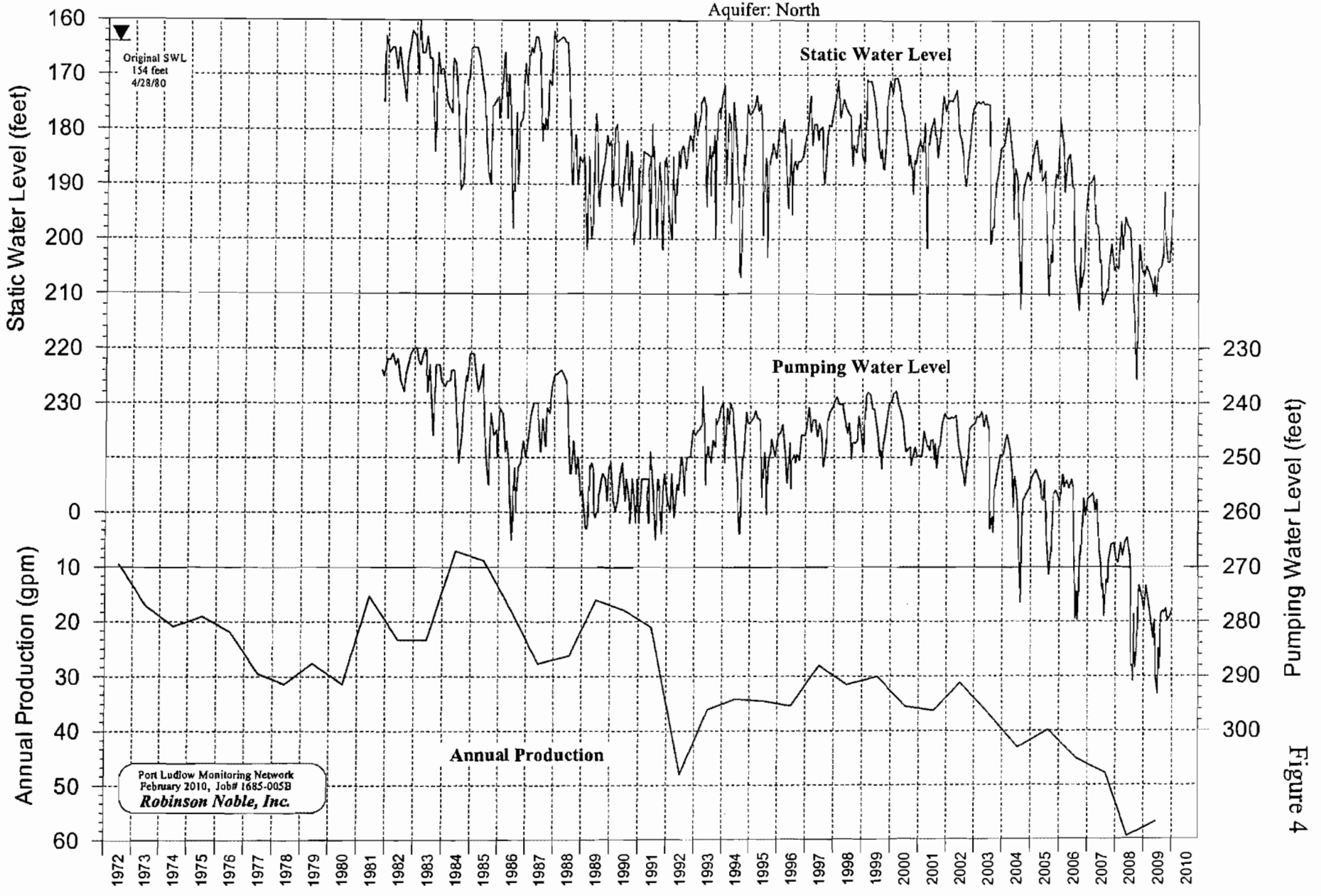


Figure 4

Figure 5: Well 4A water level (28N/01E-21F)
Depth of Well = 43 ft, surface elevation = 155 ft,
Completion elevation = 117 to 114 ft above MSL
Aquifer: South Valley

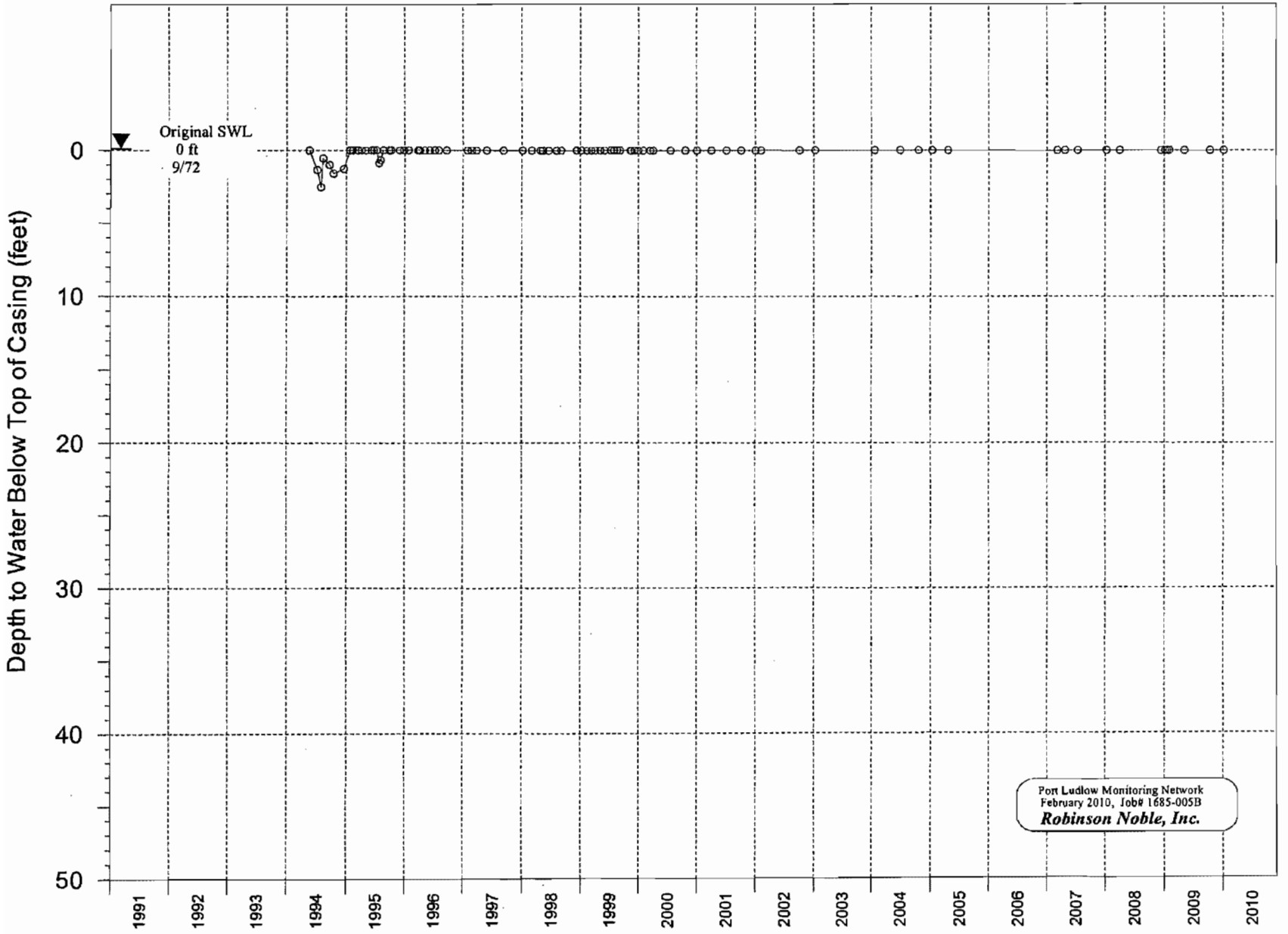


Figure 5

Figure 6: Well 9 water level (28N/01E-21F)
Depth of Well = 79 ft, surface elevation = 160 ft,
Completion elevation = 114 to 109 ft above MSL
Aquifer: South Valley

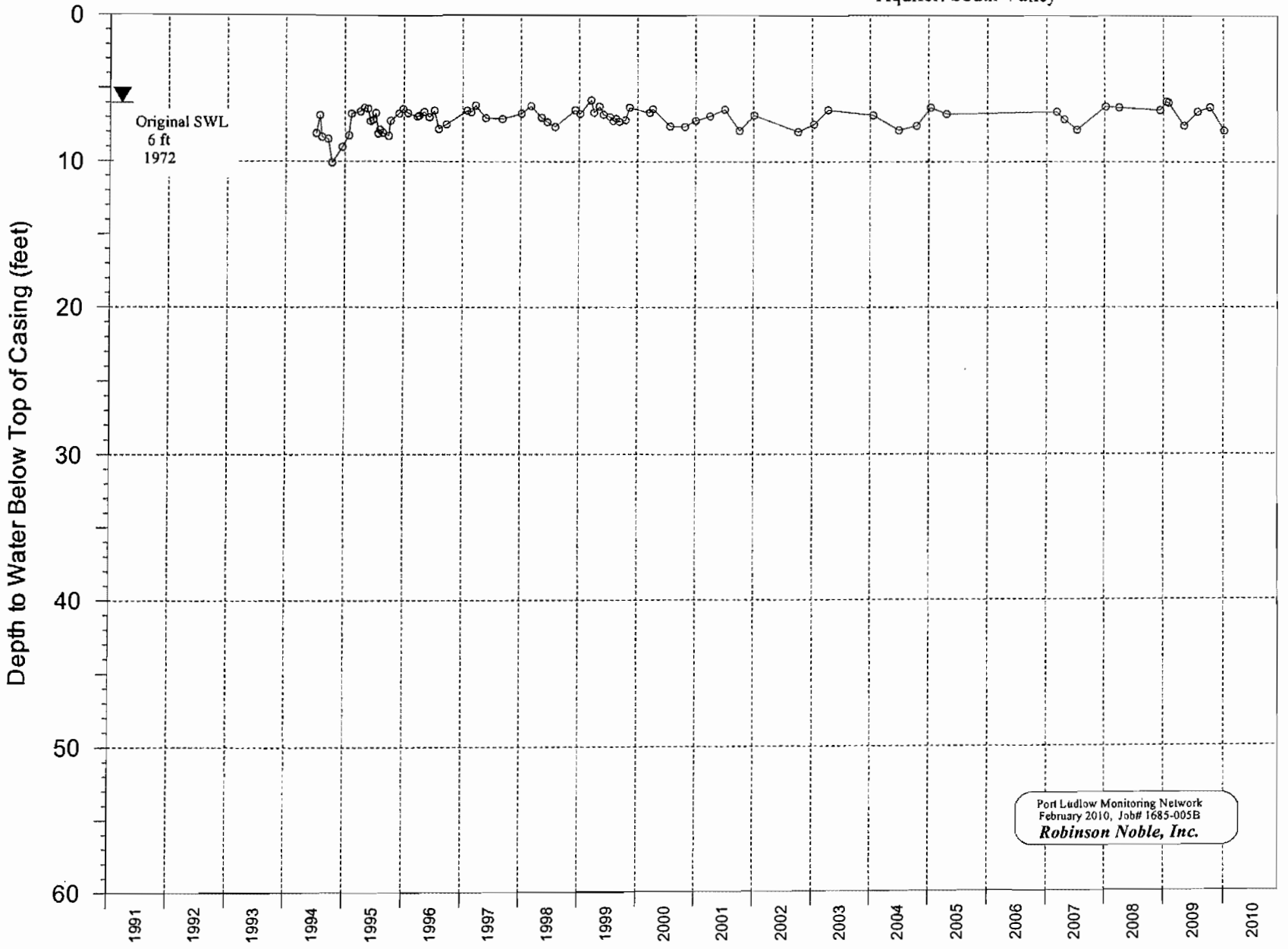


Figure 6

Figure 7: Well 12 water level (28N/01E-29A)
Depth of Well = 43 ft, surface elevation = 135 ft,
Completion elevation = 107 to 102 ft above MSL
Aquifer: South Valley

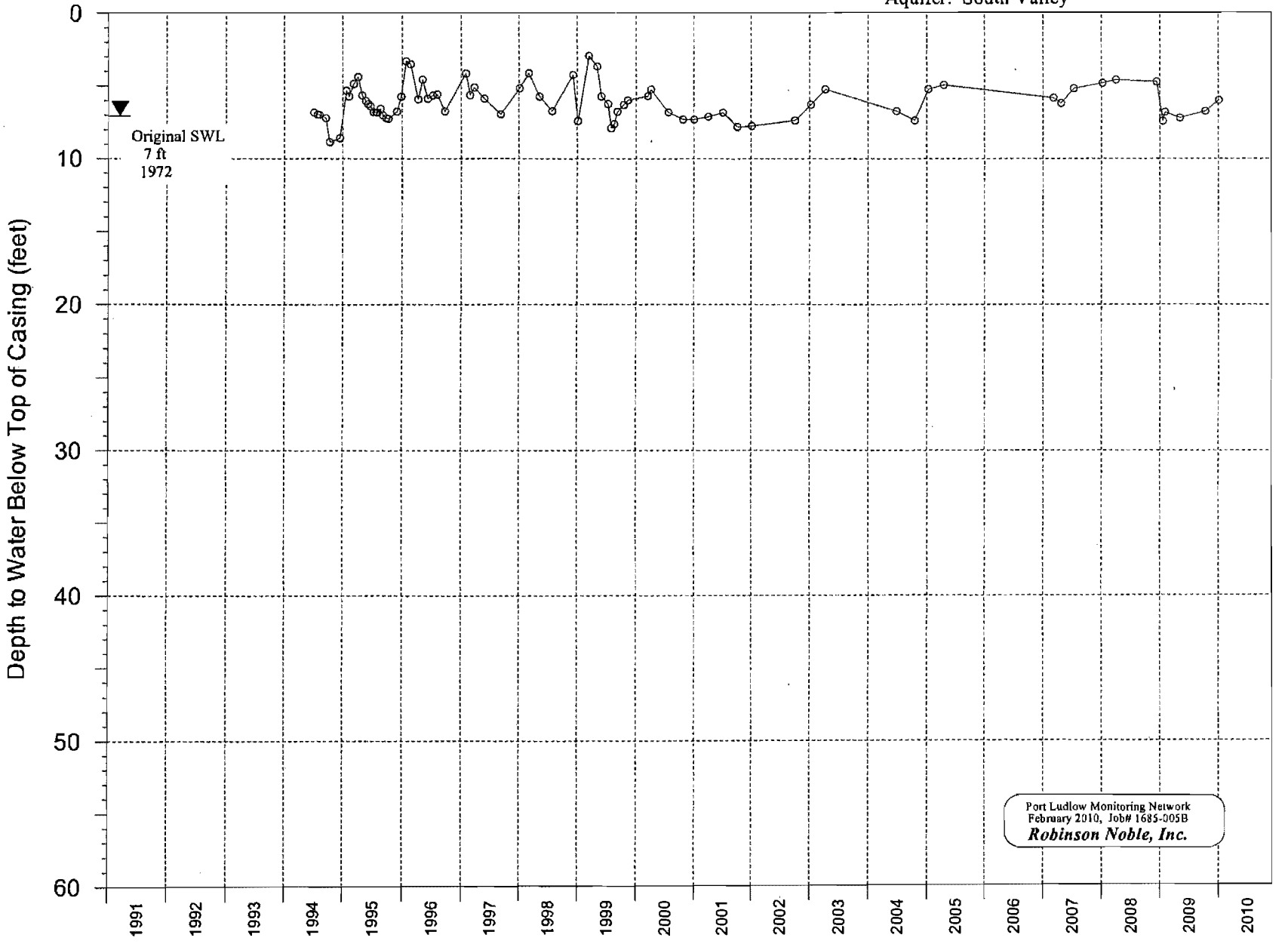


Figure 7

Figure 8: Well 13 water levels and production rate (28N/1E-21R)
Depth of well = 464 feet, surface elevation = 420 MSL.
Completion elevation = 12 to 44 feet below MSL
Aquifer: South

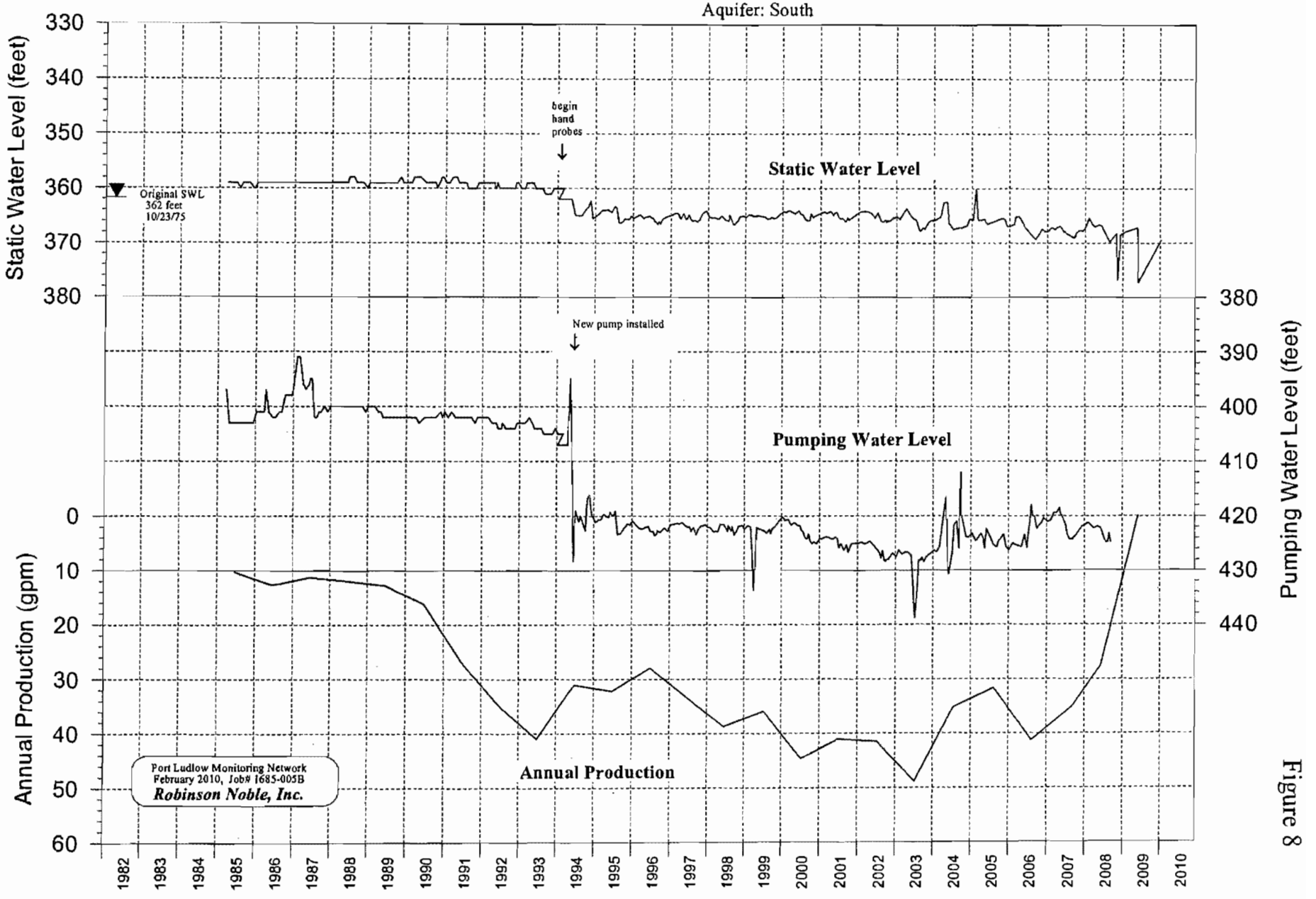


Figure 8

Figure 9: Well 14 water levels and production rate (28N/1E21R)
Depth of well = 526 feet, surface elevation = 440 MSL.
Completion elevation = 65 to 84 feet below MSL
Aquifer: South

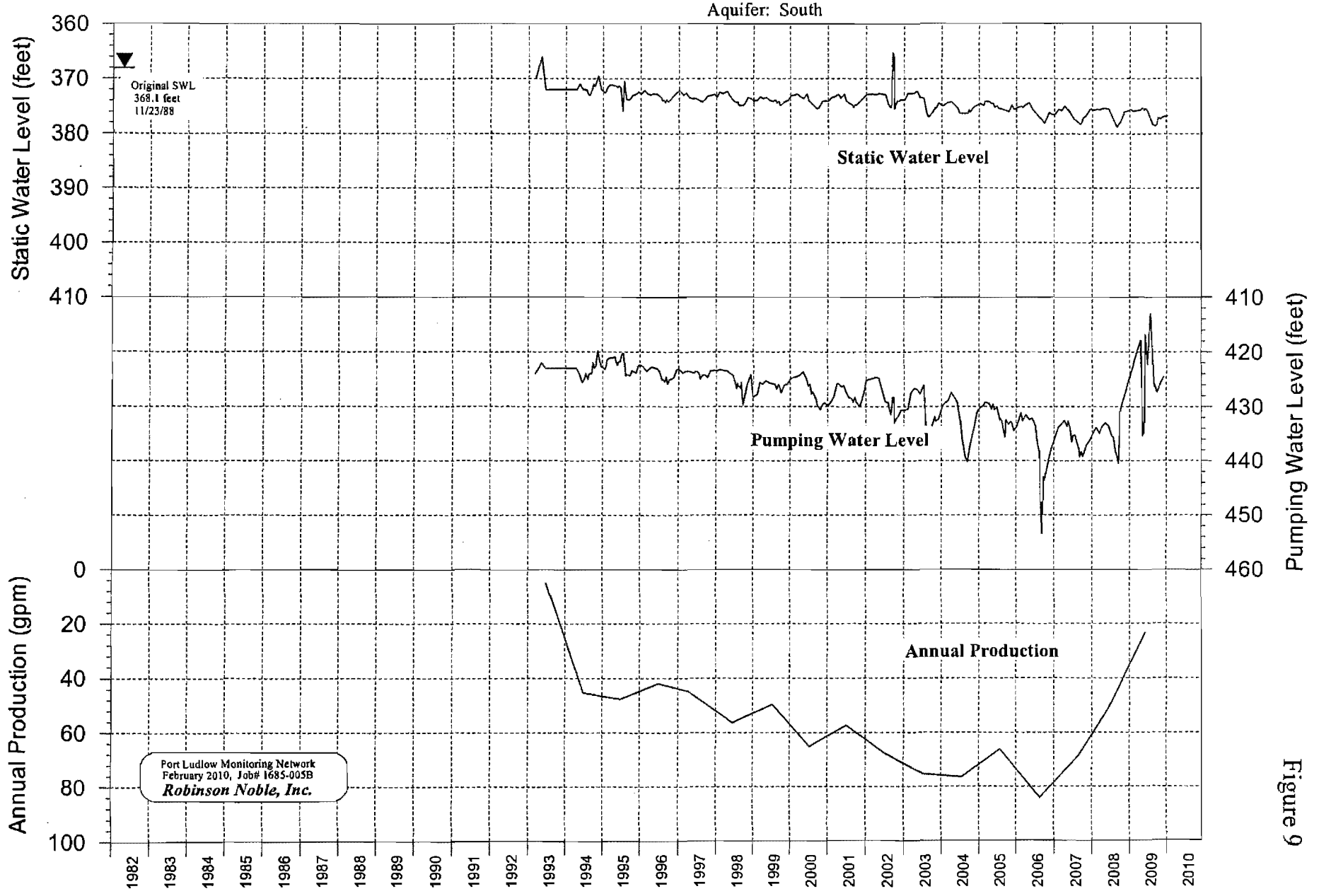


Figure 9

Figure 10: Well 15 water levels and production rate (28N/1E21R)
Depth of well = 613 feet, surface elevation = 455 MSL.
Completion elevation = 80 to 137 feet below MSL
Aquifer: South

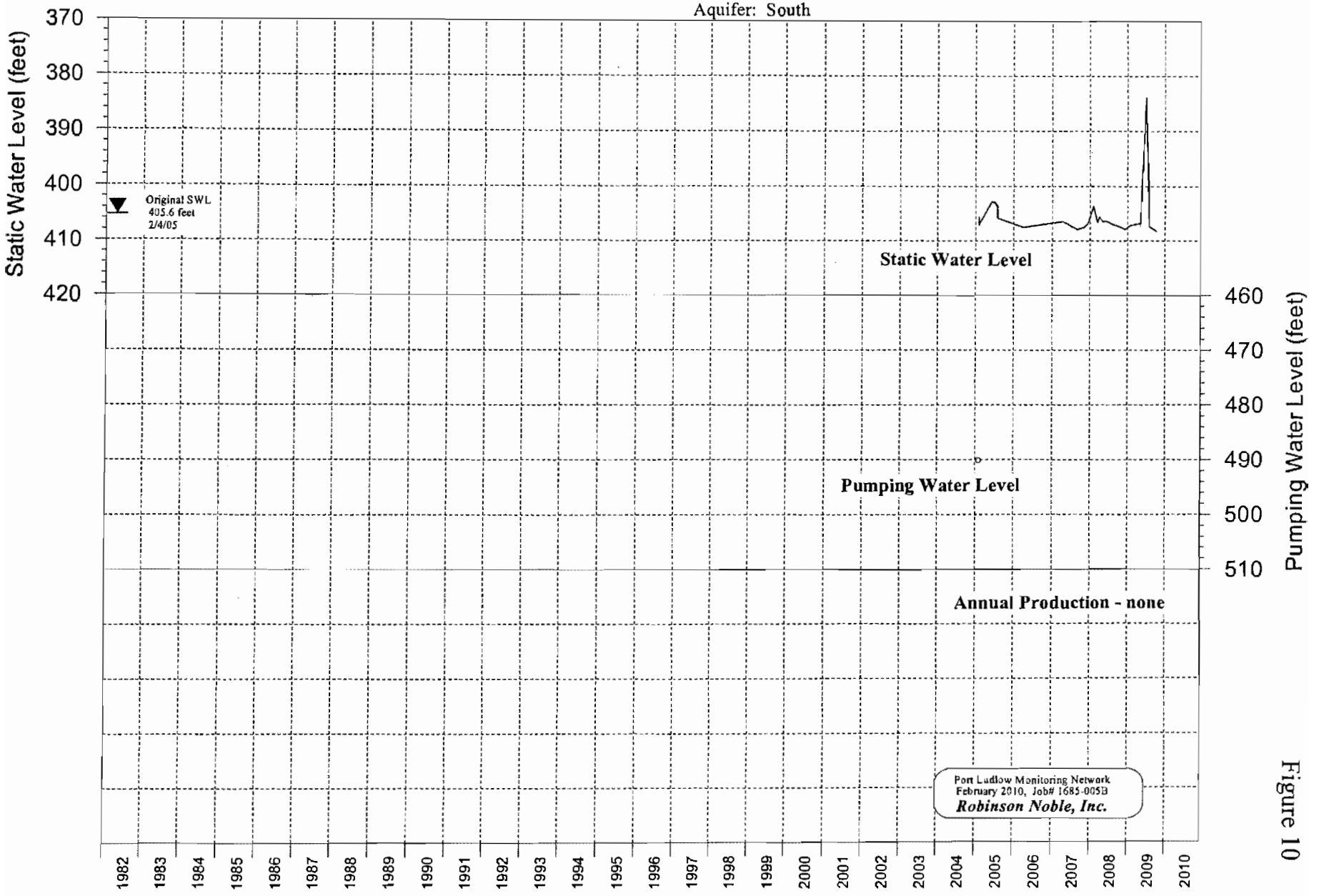


Figure 10

Figure 11: Well 16 water levels and production rate (28N/1E21R)
Depth of well = 543 feet, surface elevation = 430 MSL.
Completion elevation = 69 to 105 feet below MSL
Aquifer: South

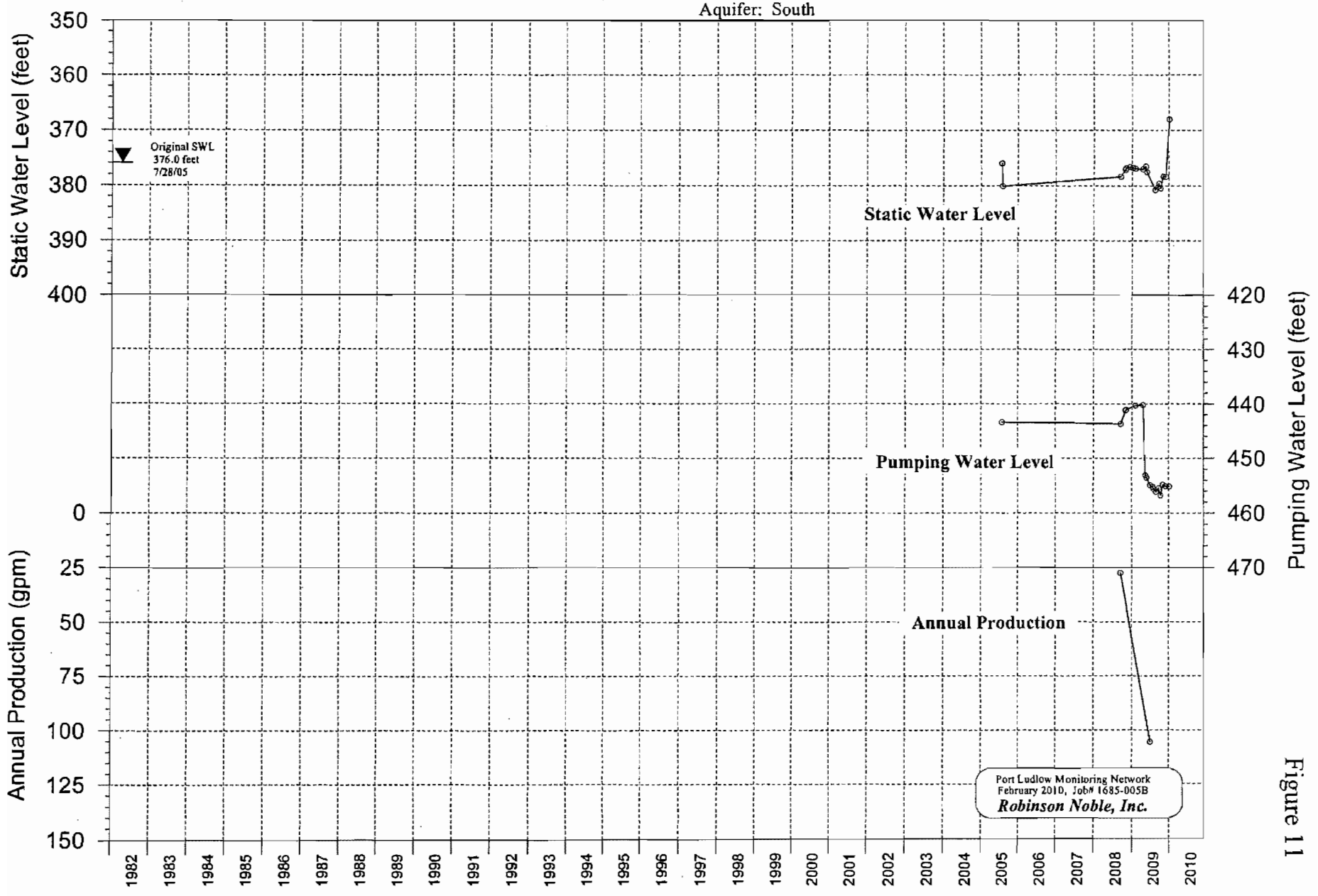


Figure 11

Figure 12: Woodruff (Hayden-Elaser) private well water level (28N/01E-08L)
Well = (deepened to 219 ft), surface elevation = 350 ft,
Completion elevation = 131 ft MSL. Note: Construction SWL not available
Aquifer: North

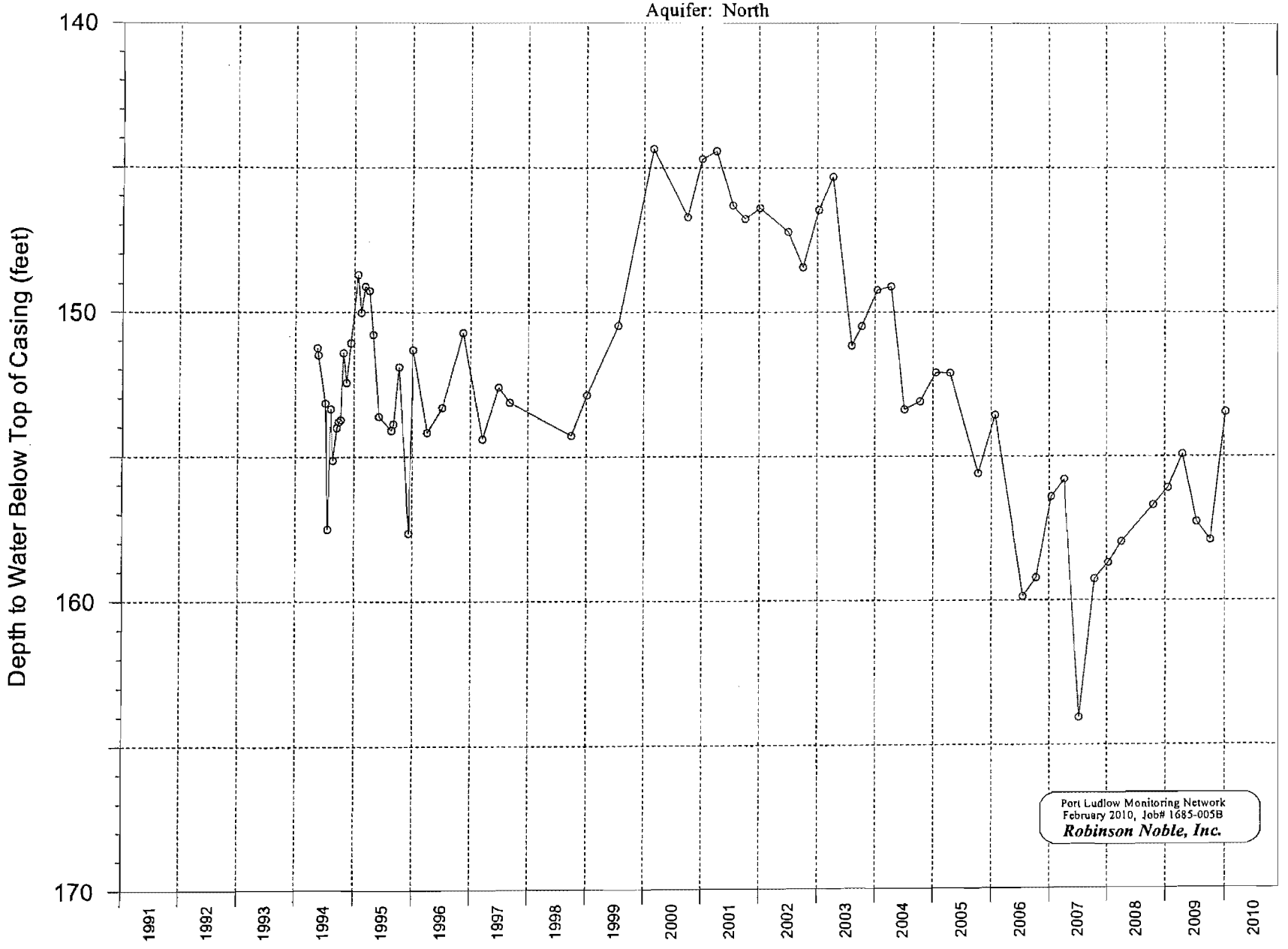


Figure 12

Figure 13: Devine private well water level (28N/01E-16Q)
Depth of Well = 78 ft, surface elevation = 50 ft,
Completion elevation = 23 to 28 ft below MSL
Aquifer: South

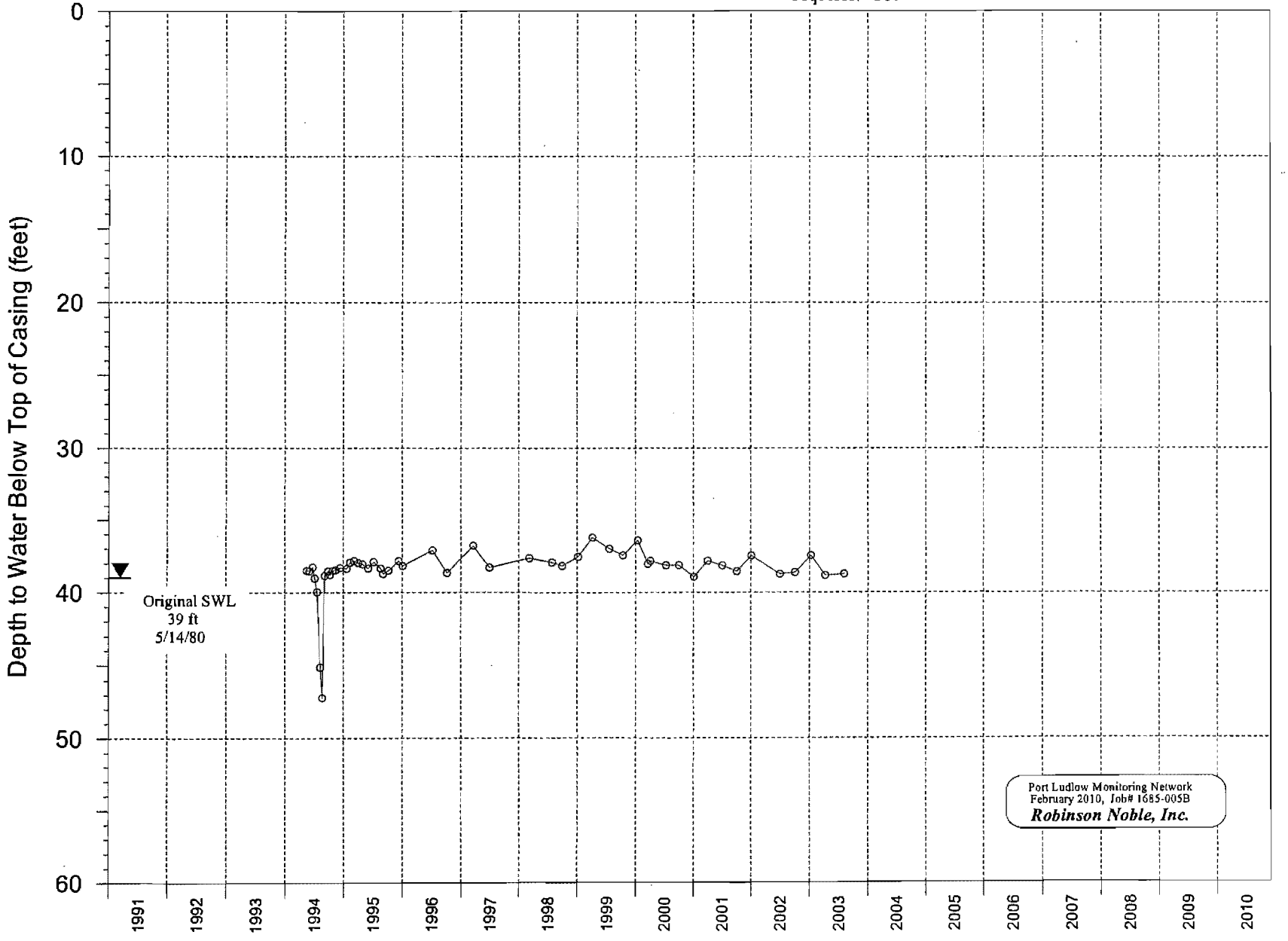


Figure 13

Figure 14: Neault private well water level (28N/01E-15R)
Depth of Well = 101 ft, surface elevation = 60 ft,
Completion elevation = 36 to 41 ft below MSL
Aquifer: South

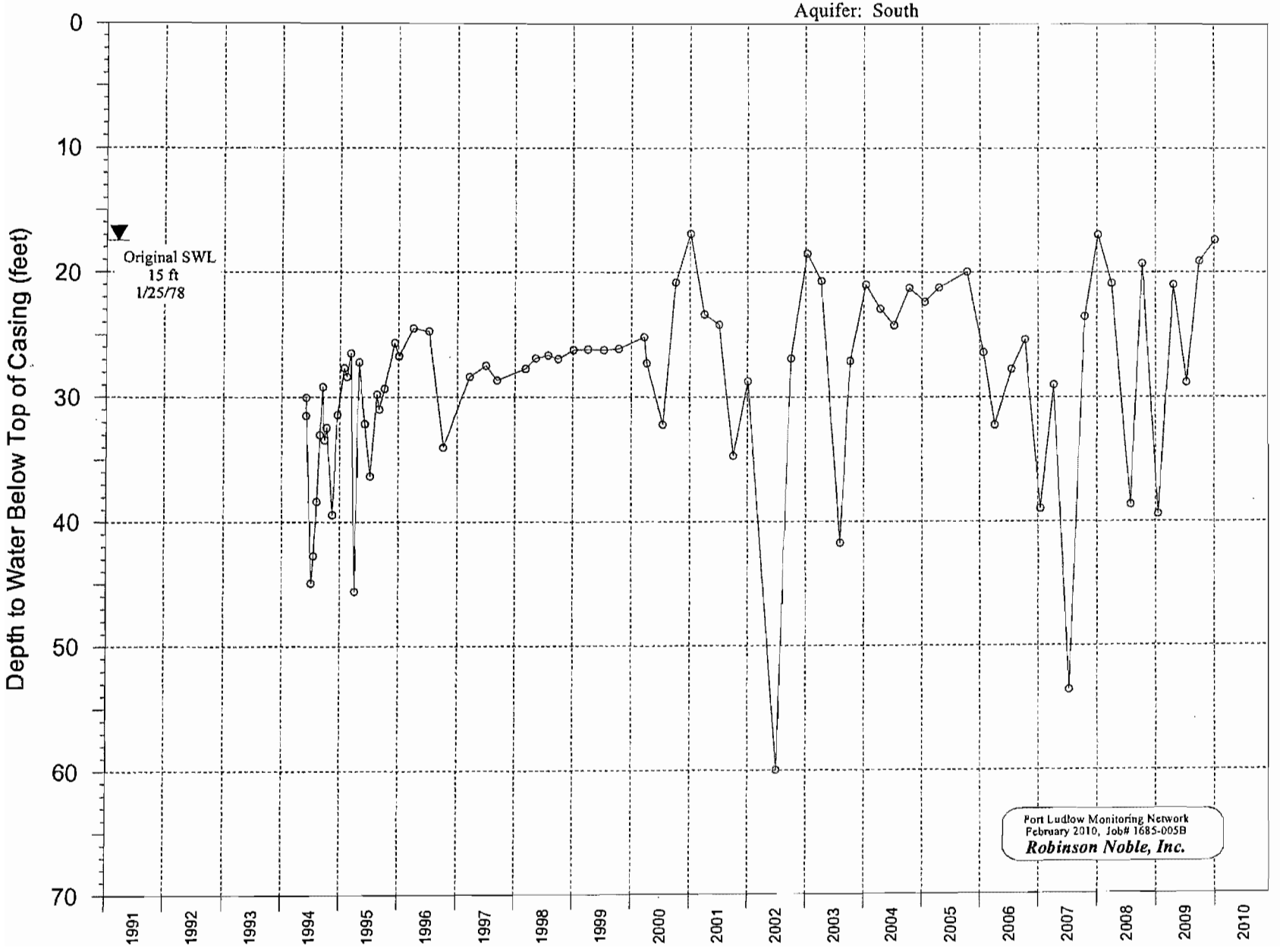


Figure 14

Figure 15: Hendrickson private well water level (28N/01E-34L)
Depth of Well = 200 ft, elevation = 220 ft,
Completion elevation = 20 to 25 ft above MSL
Aquifer: South

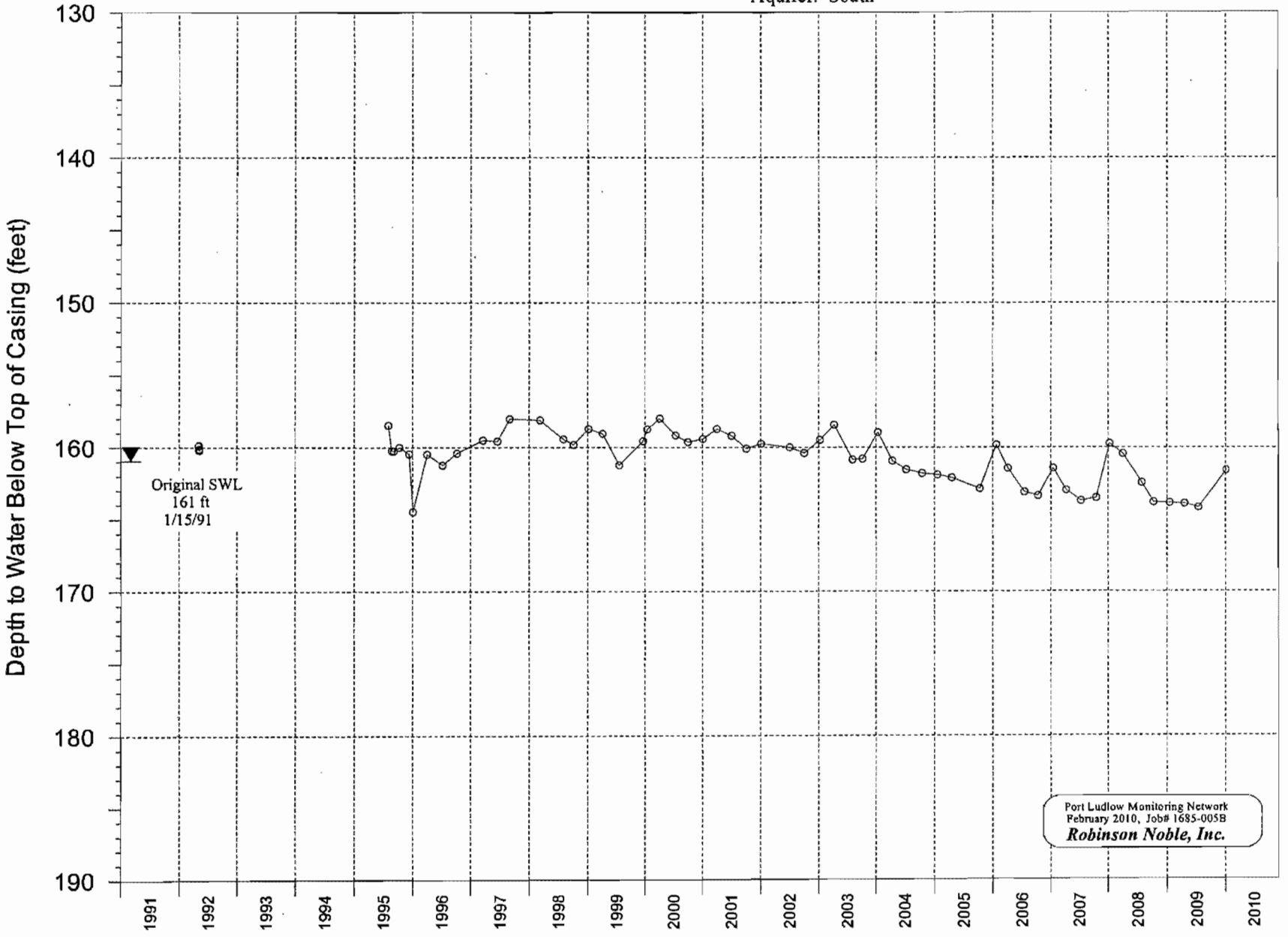


Figure 15

Figure 16: Jefferson County Water D[illegible]t #1 Paradise Bay Well water level and production rate (28N/1E-27G)
Depth of well = 466 feet, surface ele[illegible] = 400 feet MSL.
Completion elevation = 8 to 29 feet b[illegible] MSL
Aquifer: South

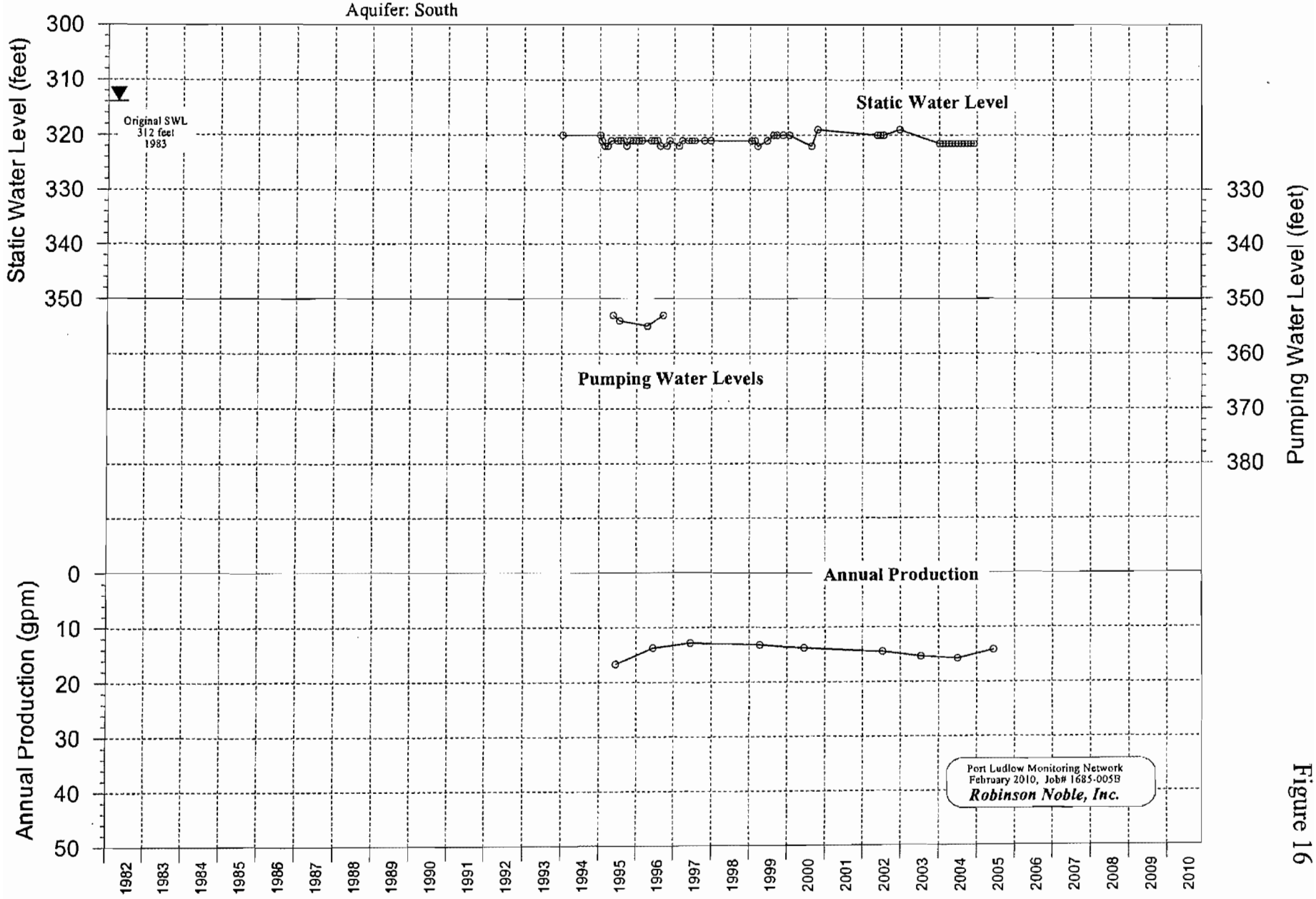


Figure 16

Figure 17: JCPUD Bywater Bay Well 1 water level (28N/01E-34M)
Depth of Well = 295 ft, surface elevation = 215 ft,
Completion elevation = 58 to 66 feet below MSL
Aquifer: South

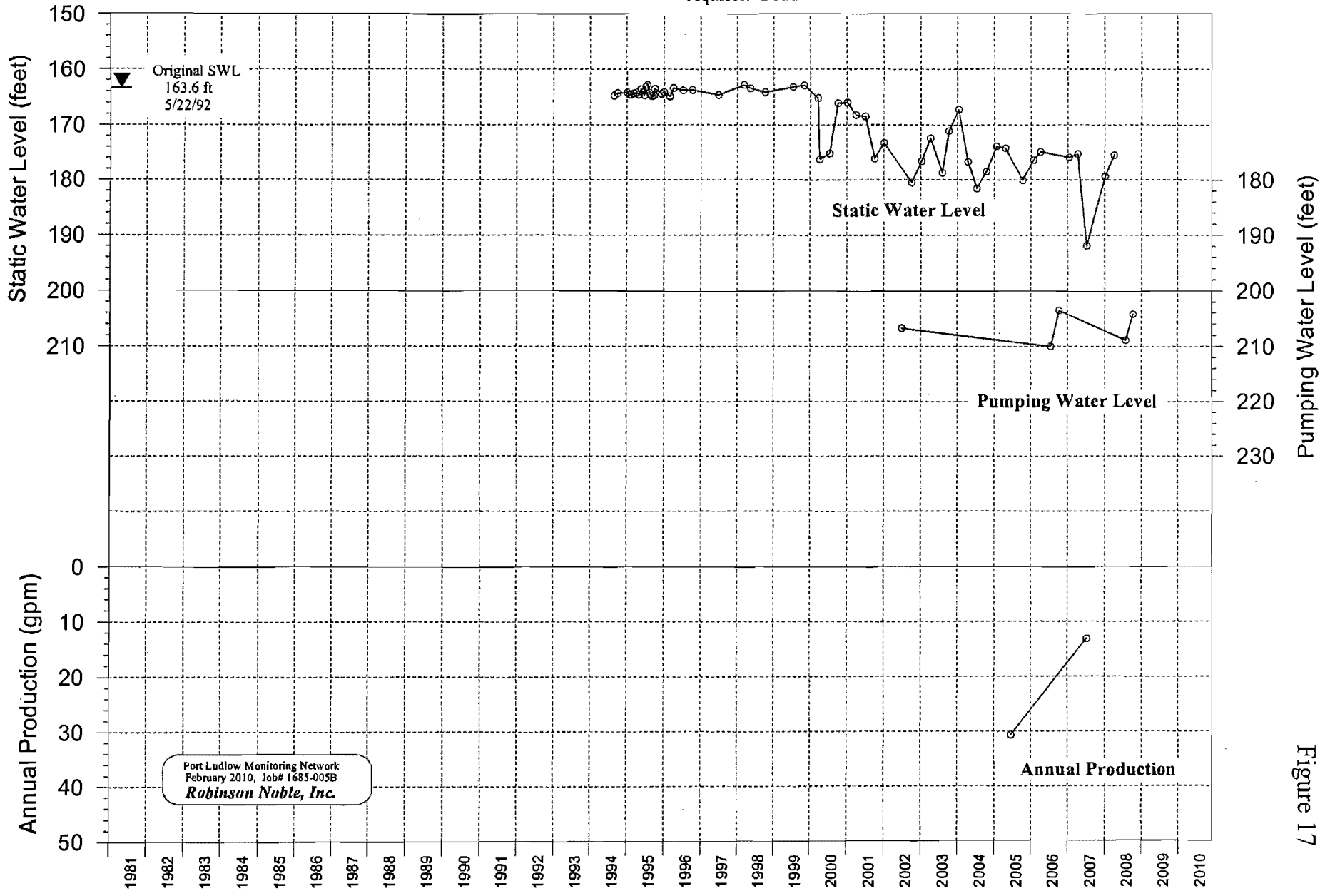


Figure 17

Figure 18: JCPUD Bywater Bay Well 2 water levels and production rate (28N/1E-35D)
Depth of well 252.8 feet, surface elevation = 265 feet MSL.
Completion elevation = 42 to 58 feet above MSL
Aquifer: South

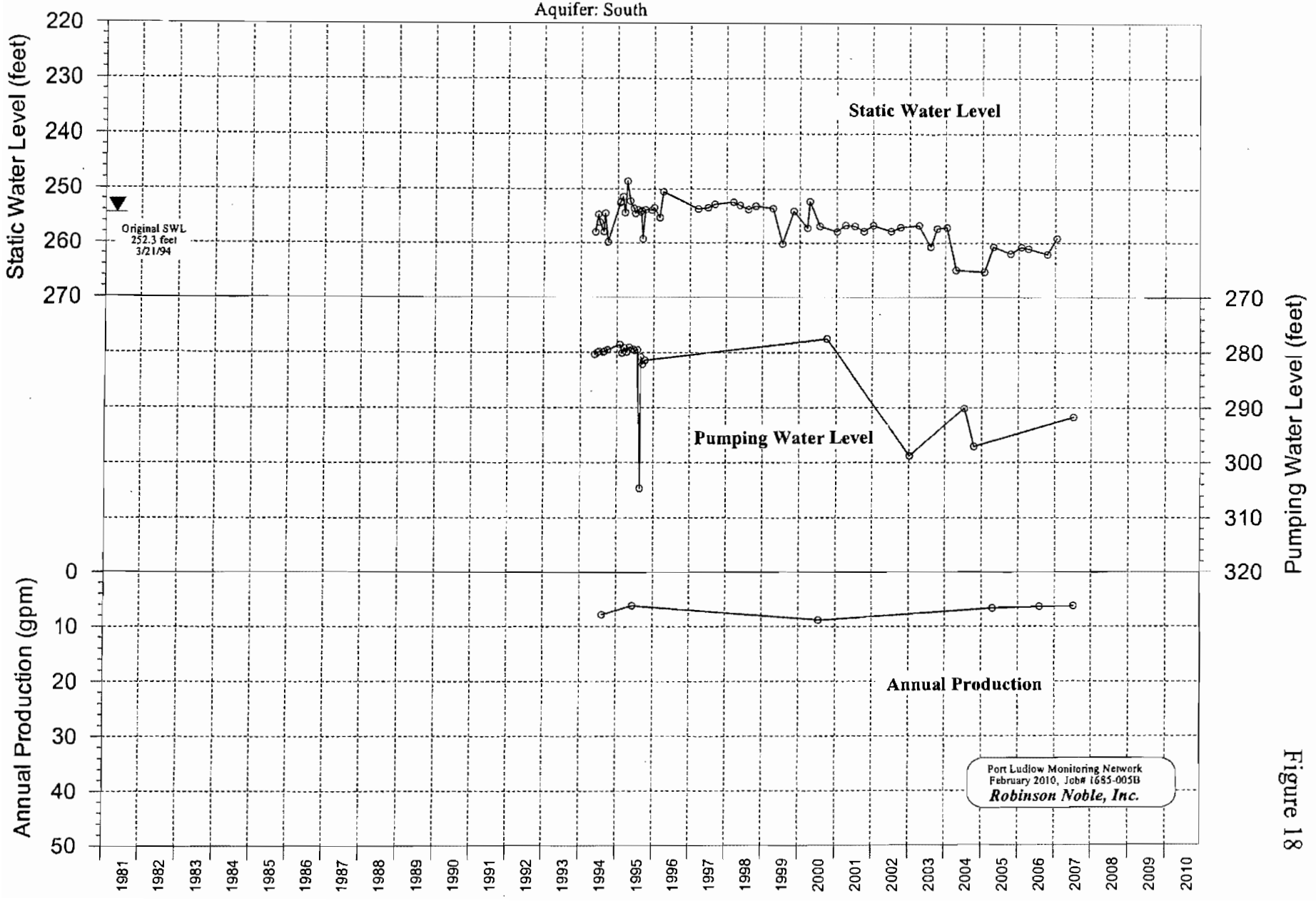


Figure 18

Figure 19: Shine Plat Well 2 water level (28N/01E-33N)
Depth of Well = 77 ft, surface elevation = 32 ft,
Completion elevation = 42 ft below MSL
Aquifer: Undifferentiated

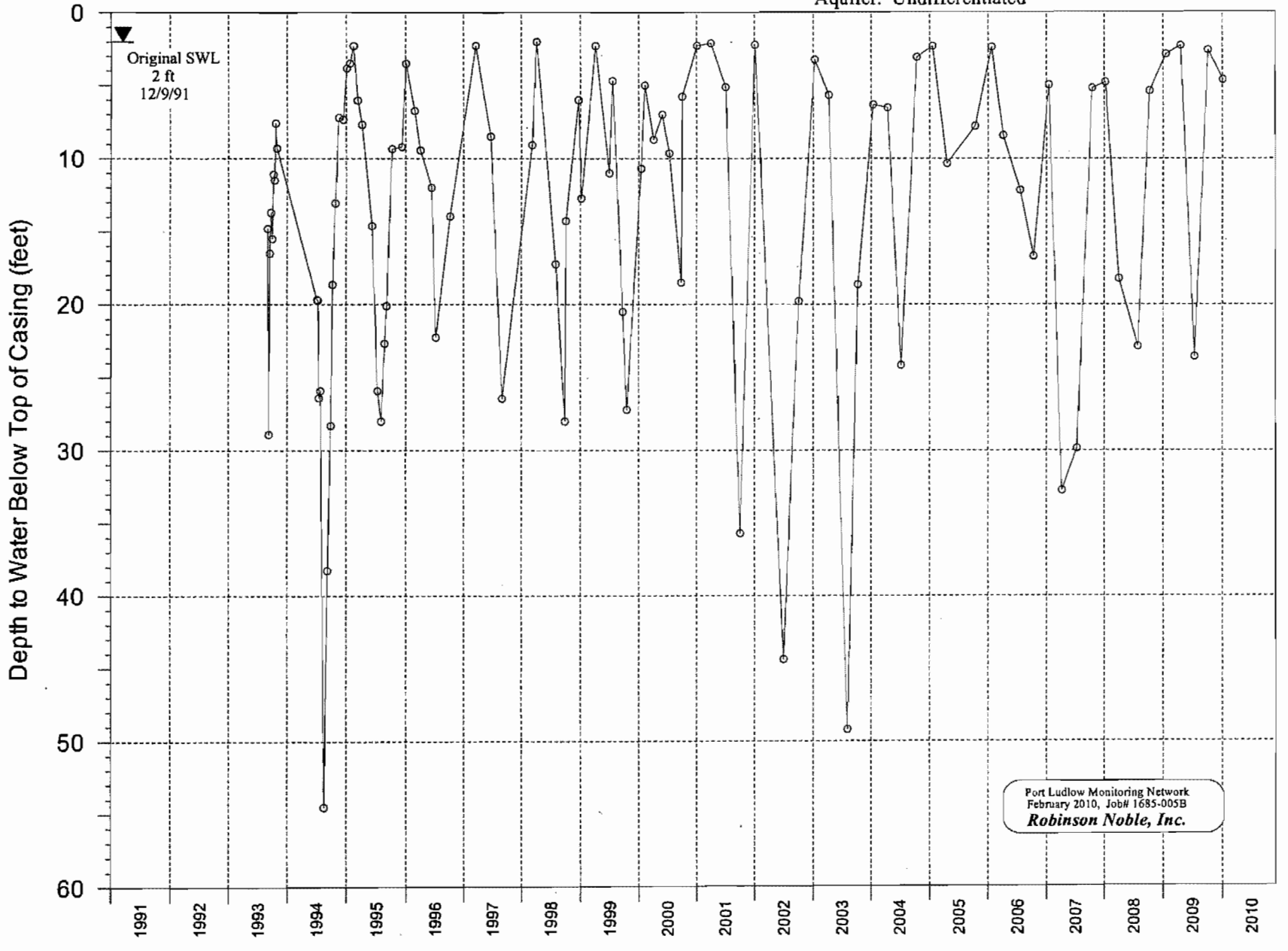


Figure 19

Figure 20: Hill private well water level (28N/01E-33Q)
Depth of Well = 77 ft, surface elevation = 52 ft,
Completion elevation = 20 to 25 ft below MSL
Aquifer: South

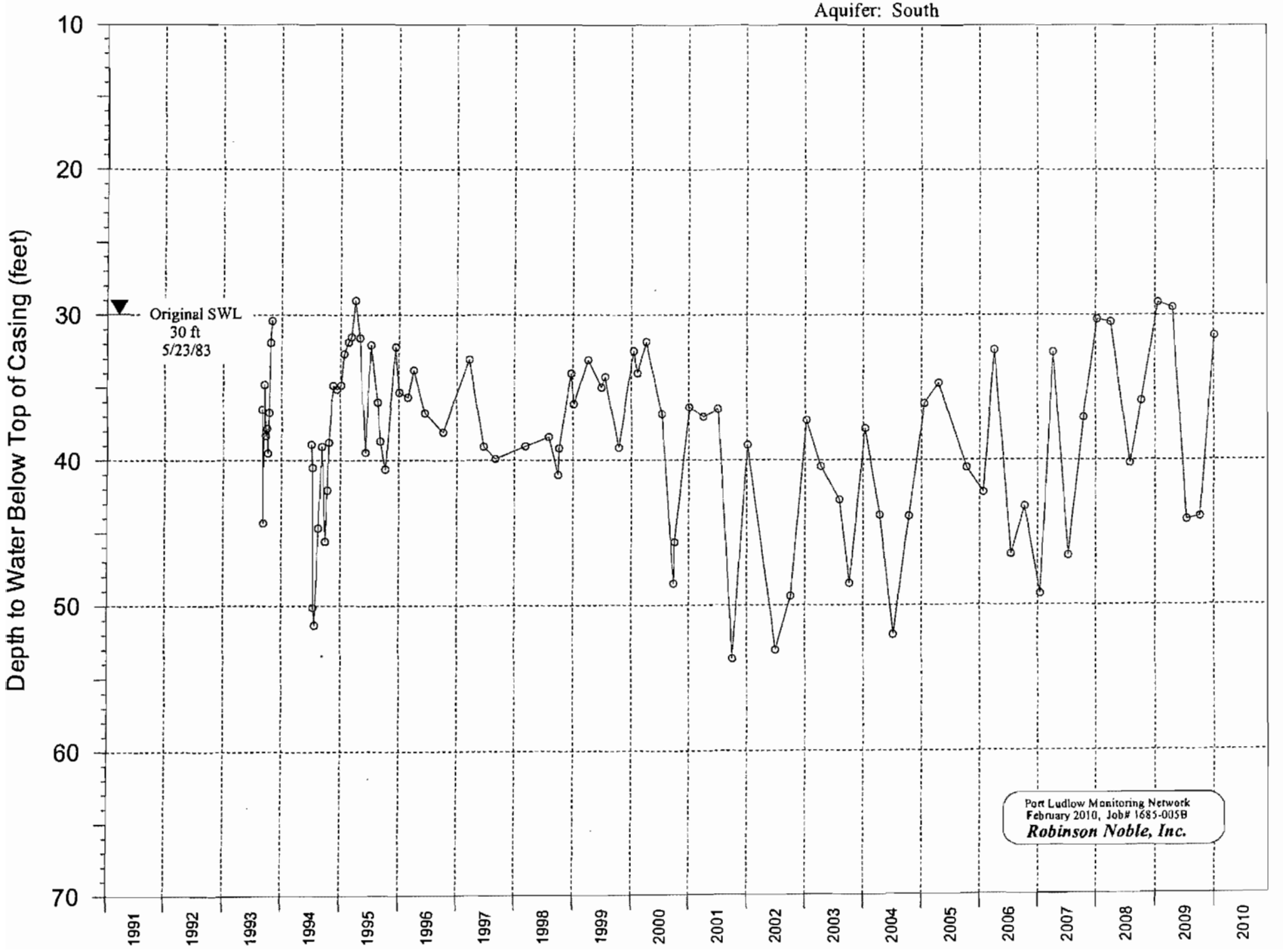


Figure 20

Figure 21: Annual precipitation at the Olympic View Water & Sewer office (28N/1E-8) from 1979 to 2009, the NOAA Chimacum 4S Station (29N/1W) from 1979 to 2008, and the South Bay Gage from 1991 to 2009.

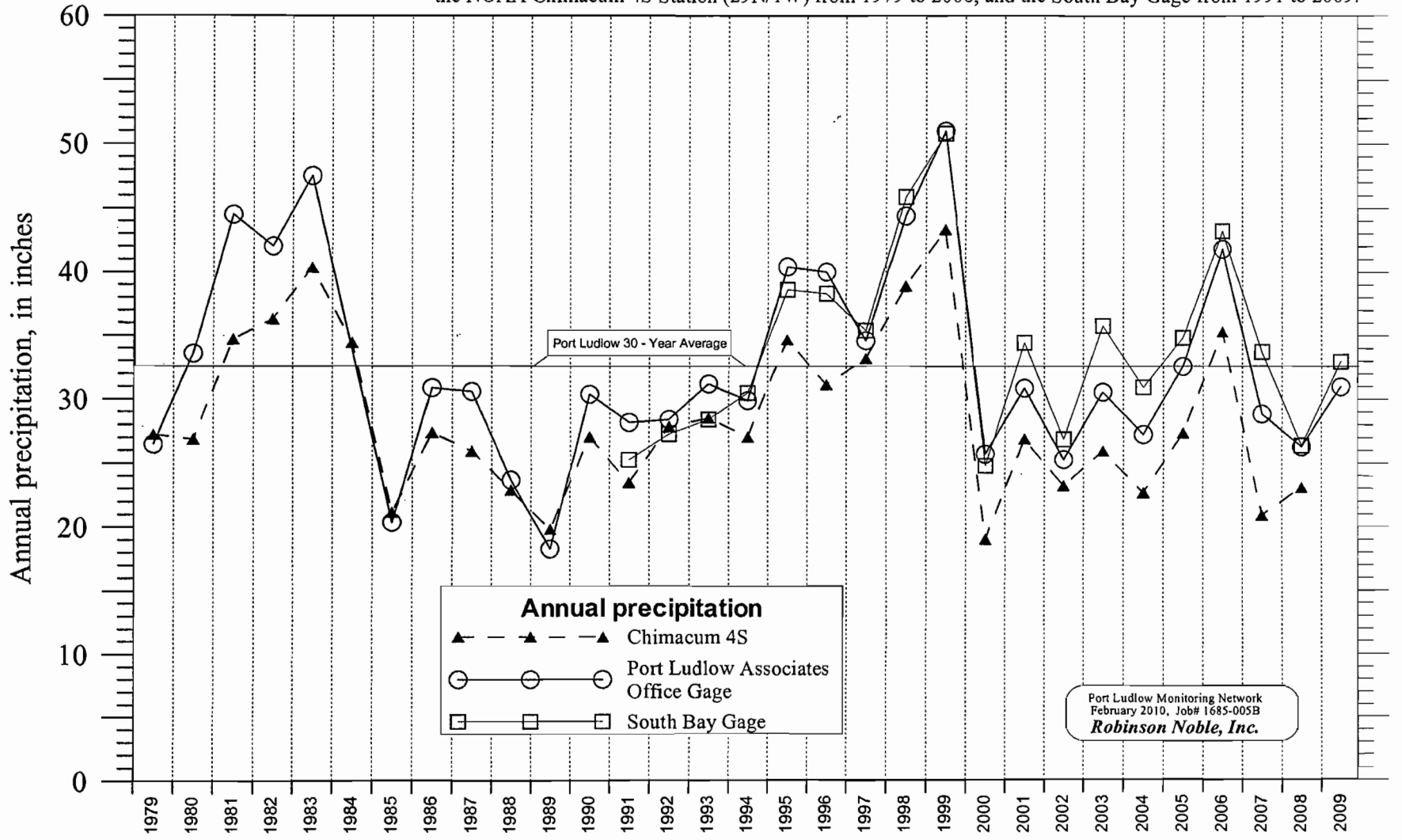


Figure 21