CE2 Engineers, Inc.

MEMORANDUM

TO: Kurt Egelhofer, VSW Program Manager

FROM: John Warren, P.E.

SUBJECT: Preliminary Water Well Evaluation - Chefornak, Alaska

DATE: January 8, 2000

This memorandum reports the results of preliminary testing of the well field at Chefornak. The memorandum is organized as follows:

- Background Information;
- Methodology;
- Presentation of Data;
- Conclusions;
- Recommendations.

Background Information:

The community of Chefornak has a population of approximately 408 people as certified by DNR in 1999. Chefornak is located on the south bank of the Kinia River, at its junction with the Keguk River, in the Yukon-Kuskokwim Delta, approximately 7.5 miles from the coast. Mean elevation of the town is approximately 25 feet above sea level. The community originally chose a closed tank and haul utility delivery concept but is presently reconsidering its choice in favor of piped utilities.

Terrasat, Inc. assisted Hefty Drilling in positioning wells WW-6 through WW-11. These 4-inch diameter wells were drilled in 1995 and were logged and evaluated by Terrasat. Terrasat completed a report titled "Ground Water Exploration Report for Chefornak, Alaska" in 1997. Some of the conclusions noted in the report were as follows:

- The water level in the wells is tidally influenced;
- Well water quality data suggests partial recharge from the Kinia River, which is located less than 100 feet to the north;
- Recharge is partially from a deep aquifer because the water level in the wells is above the elevation of the Kinia River;
- The well field consisting of 7 wells (collectively WW-2 and WW-6 through WW-11) should yield between 29 and 35 gpm.

Water quality data collected in August 1995 indicated that the wells contain significant levels of iron, manganese, dissolved solids and possibly dissolved organics.

In 2000, CE2 was charged with assessing the potential of the existing well field to serve as the water source for Chefornak's proposed piped utility system.

Methodology:

Chefornak utility crews installed pumps in wells WW-9, WW-10 and WW-11 in November 2000. A testing plan was developed to pump the wells to waste while monitoring discharge, drawdown, and Total Dissolved Solids (TDS). Air lines with pressure gauges were installed in each well to monitor changes in the water level above the pump intakes. In addition, pressure transducers were installed in the water wells to monitor water level fluctuations on an hourly basis. Pumping of the wells began on November 3, 2000. The local operator was charged with implementing the following test plan:

CHEFORNAK WELL FIELD TEST PLAN

November 2000 – February 2001

1. Start pumping wells WW-9, WW-10, and WW-11 concurrently at 6 gpm, 6 gpm and 9.5 gpm respectively.
2. Collect water level (air line pressure), flow rate, total gallons and TDS daily (record time of sample). The minimum air line pressure in the well must be 10 feet of H_2O (10 feet of water over the pump intake). If the air line pressure drops below 10-feet of water, the pumping rate must be reduced (throttled) with the ¾-inch ball valve by 1 gpm each day until 10 feet of water (minimum) is maintained at the air gauge. Call John Warren at (907) 349-1010 if the air line pressure continues to drop.
3. On November 16 at 4:00 pm, 5:00 pm (extreme high tide) and 8:00 pm, test TDS and record water level (air line pressure).
4. On November 17 at 5:00 pm, 6:00 pm (extreme high tide) and 9:00 pm, test TDS and record water level (air line pressure).

March 2001 – June 2001

1. Increase well pumping rates for wells WW-9, WW-10, and WW-11 to 10 gpm, 10 gpm and 10 gpm respectively.
2. Collect water level (air line pressure), flow rate, total gallons and TDS daily (record time of sample). The minimum air line pressure in the well must be 10 feet of H_2O (10 feet of water over the pump intake). If the air line pressure drops below 10-feet of water, the pumping rate must be reduced (throttled) with the ¾-inch ball valve by 1 gpm each day until 10 feet of water (minimum) is maintained at the air gauge. Call John Warren at (907) 349-1010 if the air line pressure continues to drop.
3. On May 28 at 5:00 am, 6:00 am (extreme high tide) and 9:00 am, test TDS and record water level (air line pressure).
4. On May 29 at 6:00 am, 7:00 am (extreme high tide) and 10:00 am, test TDS and record water level (air line pressure).

Presentation of Data:

Terrasat estimated the 1-day, 1-year, 10-year and 20-year well yields for wells WW-9, WW-10 and WW-11. Terrasat's estimated 10-year well production rates were used for the initial test pump discharge settings. However rates have varied slightly over time due to tidal influences, well field hydraulics and operator adjustments. Table 1 provides Terrasat's estimated well production rates and the average test pumping rates for each well for a 59-day period from November 3, 2000 through January 4, 2001. The actual test pumping rates are based on calculated values from the totalizers on the discharge water meters located at each well.

TABLE 1

WELL FLOW RATES

Well Identification	Terrasat Estimated 10 year Well Pumping Rate (gpm)	Average Test Well Pumping Rate (gpm)
WW-9	5.1	6.3
WW-10	5.8	5.9
WW-11	11.8	9.5

Selected water quality parameters were measured approximately 1 hour after pumping started on November 3, 2000. Measured water quality parameters are provided in Table 2:

TABLE 2

WELL WATER QUALITY PARAMETERS*

November 3, 2000

WW-9		WW-10		WW-11	
PARAMETER	**TEST**	**PARAMETER**	**TEST**	**PARAMETER**	**TEST**
TDS	640 mg/l	TDS	400 mg/l	TDS	320 mg/l
Total Iron	0.91 mg/l	Total Iron	0.31 mg/l	Total Iron	0.23 mg/l
Manganese	0.076 mg/l	Manganese	0.048 mg/l	Manganese	0.032 mg/l
True Color	224 PCU	True Color	258 PCU	True Color	233 PCU
Apparent Color	372 PCU	Apparent Color	260 PCU	Apparent Color	242 PCU
Turbidity	1.18 NTU	Turbidity	3.32 NTU	Turbidity	2.62 NTU

* Measured onsite with a HACH CEL/890 Advanced Portable Laboratory

The data that has been collected from the wells includes instantaneous flow rate, total gallons produced, water column height above the pump intake and TDS in mg/l on a daily basis. Selected

water quality parameters were measured 1 hour after pump startup and transducer data was downloaded after 12 hours of pump operation.

Pumping water depth and TDS have been graphed and are attached for reference (see Figures 1 through 3). In addition, transducer data was also graphed for the first 12 hours of well pump operation (see Figures 4 through 6). The well pump in WW-9 stopped during the first 4 hours of pump operation. The transducer data collected for this well basically indicates recovery after pumping (see Figure 4). The graphs for WW-10 and WW-11 (Figure 5 and 6) show simultaneous fluctuations in pumping water levels.

Water level and TDS data was collected during a storm surge on November 13 and during extreme high tides on November 16 and 17. The information gained during the tidal fluctuations indicated an increase in well water level and little to no change in TDS.

Samples of the raw water were collected and returned to Anchorage. One 350 ml sample from WW-9 was aerated for 7 hours with no visible precipitate formed after aggressive aeration.

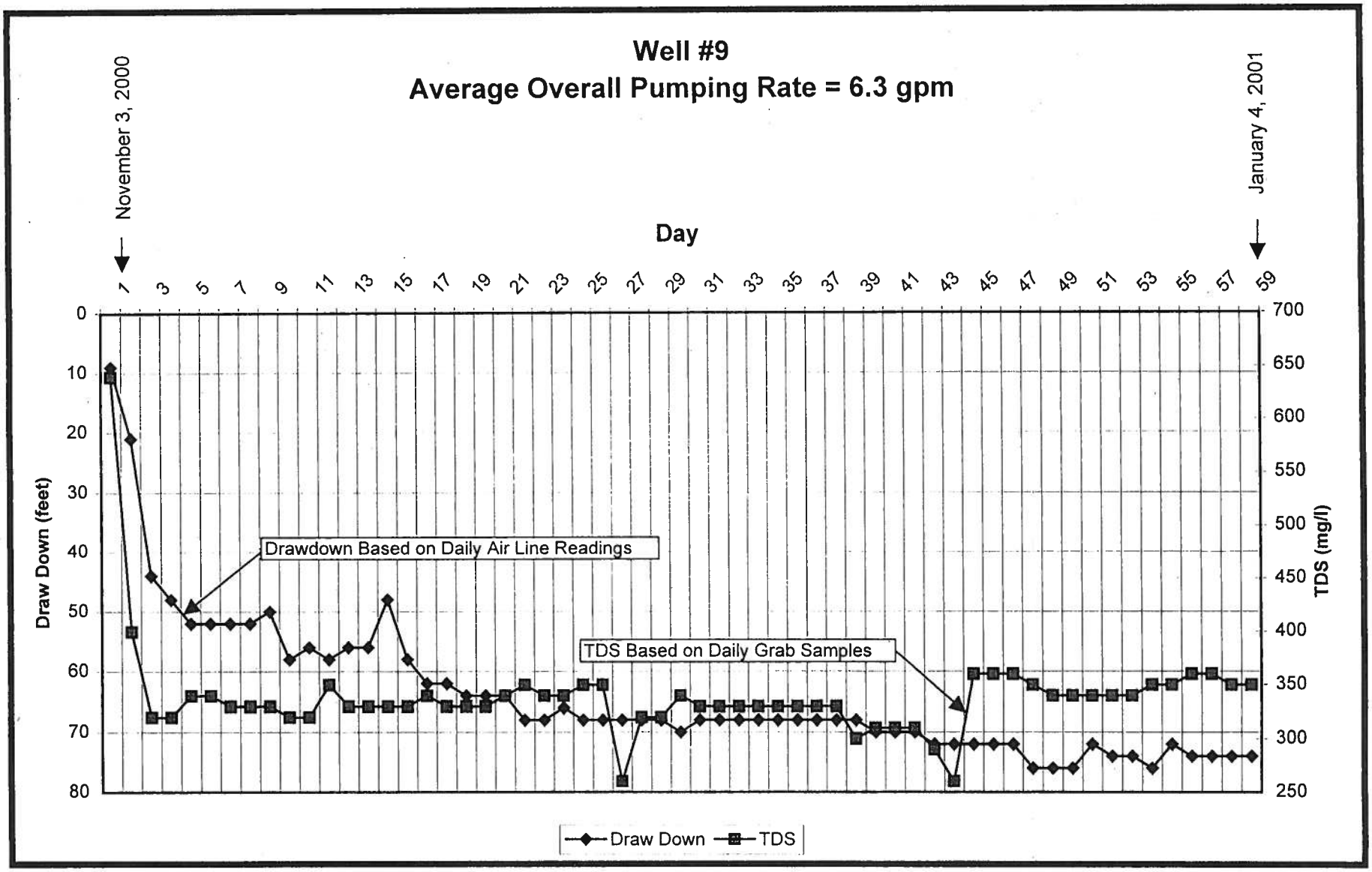
Conclusions:

1. Based on 59 days of data collection, drawdown is continuing to slowly increase in WW-9 and WW-10. The drawdown in WW-11 seems to have stabilized. The pumping rate for WW-11 appears to correspond to Terrasat's estimated 10-year well yield.
2. Figures 1 through 3 indicate a gradual rise in TDS in the wells. Treating the water to obtain palatable drinking water may be difficult and expensive.
3. Figures 4 through 6 indicate similar changes in pumping water depth in WW-9, WW-10 and WW-11 over 6-hour intervals, which correspond to tidal movements. As a result, the pumping water levels in the wells appear to be influenced by tidal fluctuations.
4. In general, the raw water quality in the wells is poor. The slight difference between the reported apparent color and true (dissolved) color indicates that much of the color causing material is in the dissolved size range (smaller than 0.45 micrometers).
5. The high true color measurements in the well water and the fact that iron precipitate was not formed after aggressive aeration of a water sample from WW-9 may indicate that organics are complexing with ferrous iron. Organically bound iron may be difficult to treat.
6. Based on very cursory observations, it is unlikely that this well field will prove to be a viable source of quality water for the community.
7. Based on Terrasat's analysis and our observations it is our opinion that these wells may not be capable of providing the quantity of water required for piped utilities.

Recommendations:

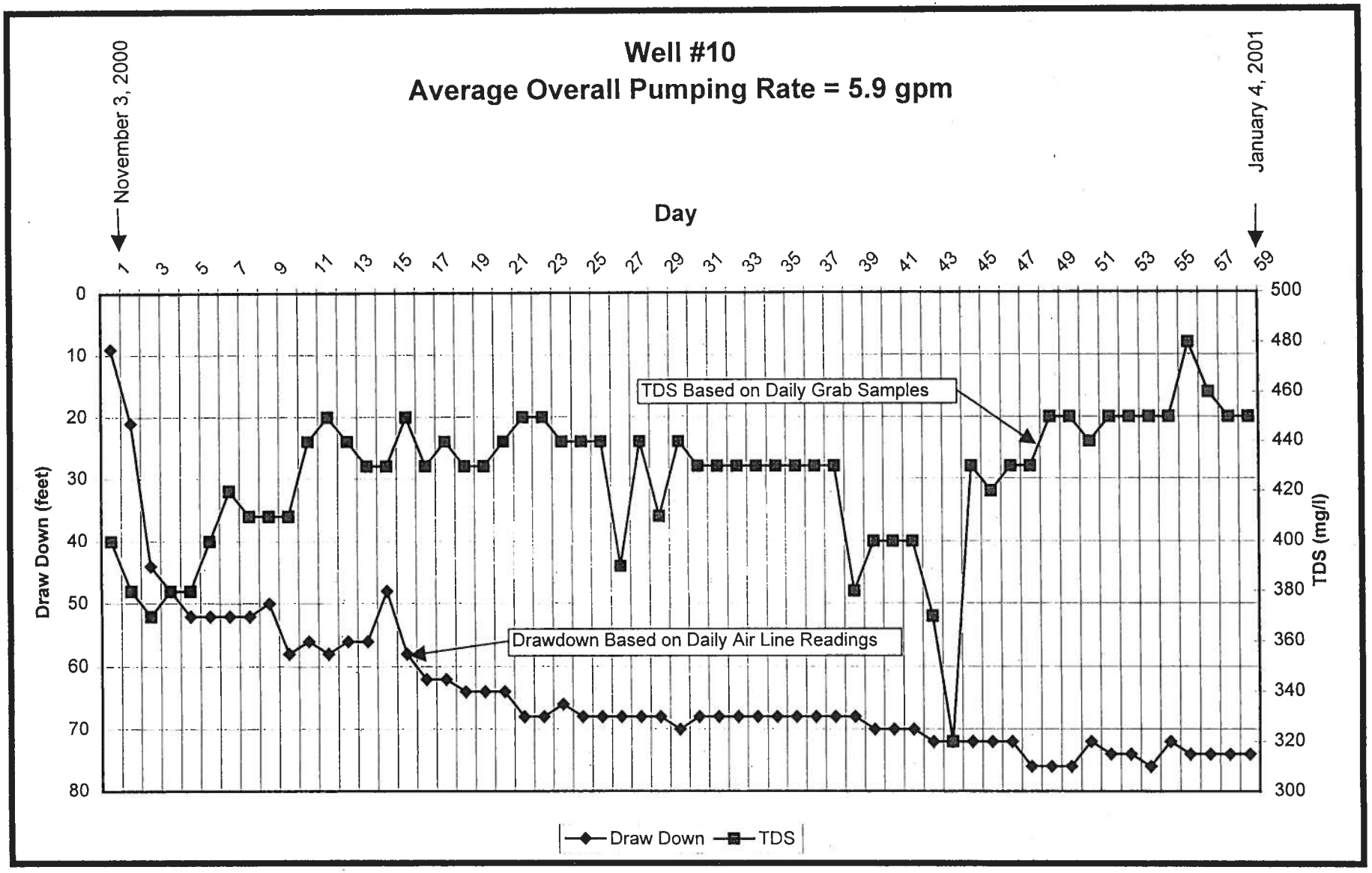
A river intake may be an option to address both water quality and water quantity requirements for the community. An intake located near the upstream end of the well field should be investigated. Analysis of surface water quality including a thorough analysis of contaminants and monitoring for brackish water influence is recommended.

FIGURE 1



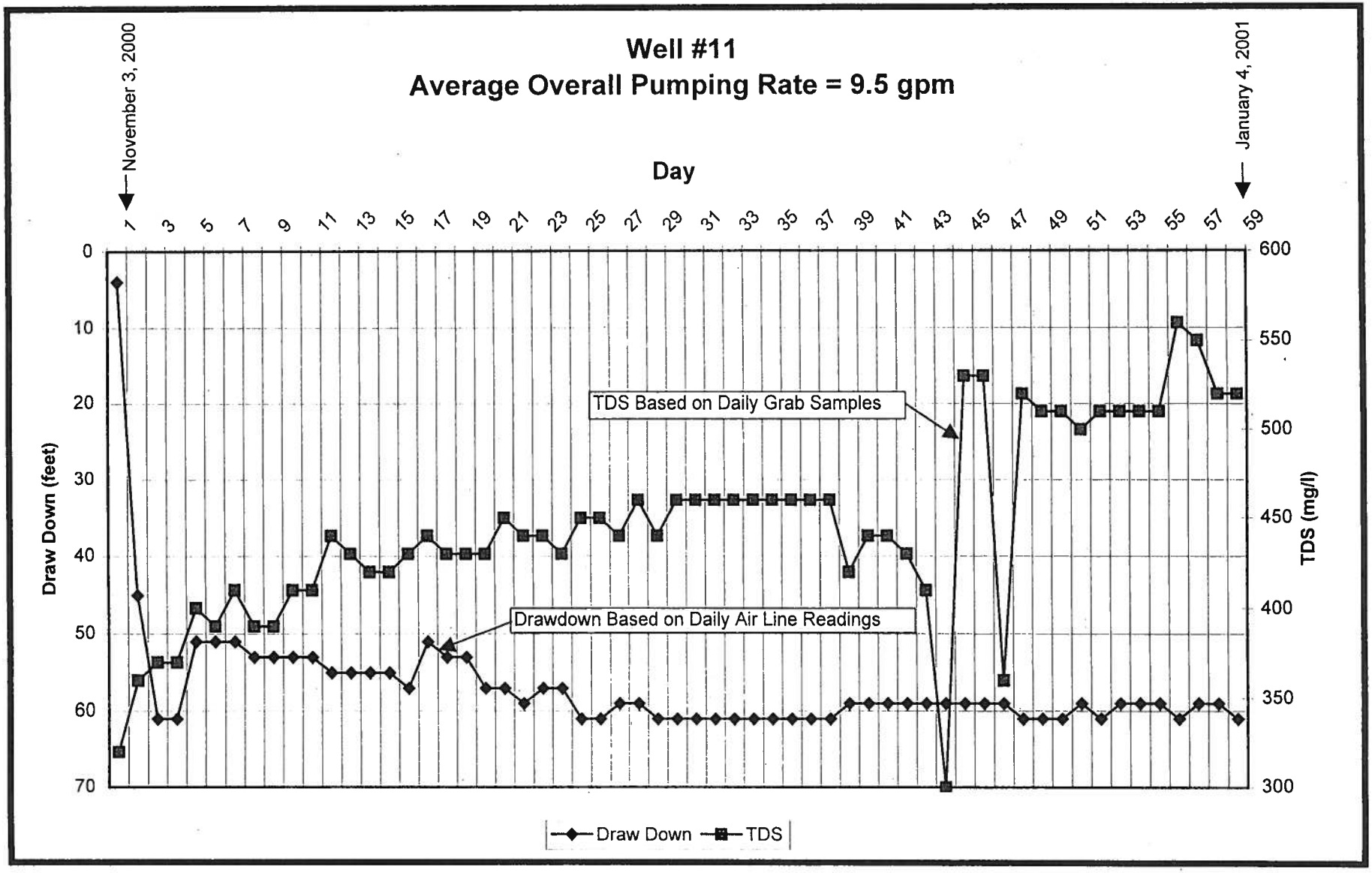
Well Test Data
Chefornak, Alaska
November 3, 2000 - January 4, 2001

FIGURE 2



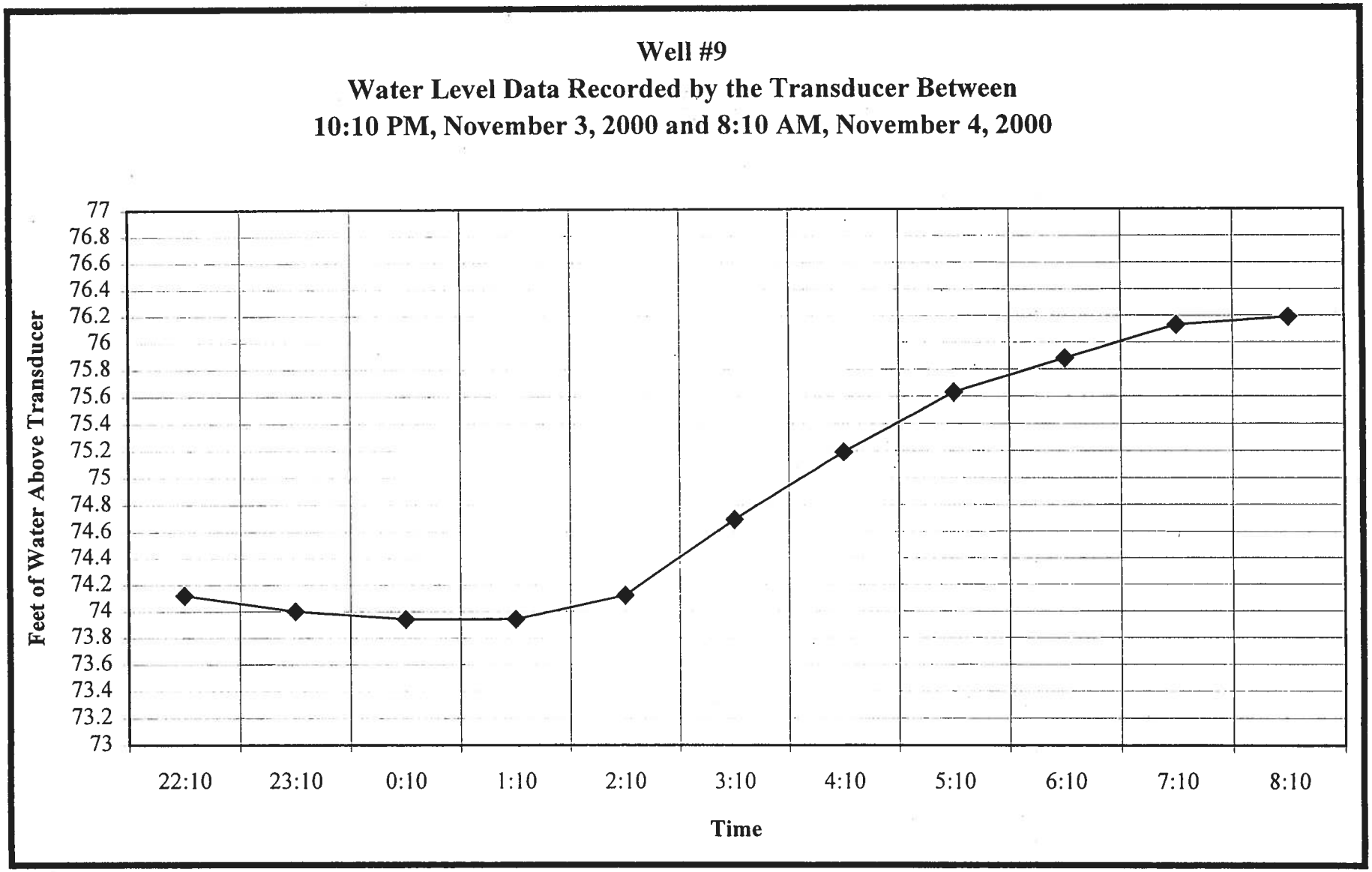
Well Test Data
Chefornak, Alaska
November 3, 2000 - January 4, 2001

FIGURE 3



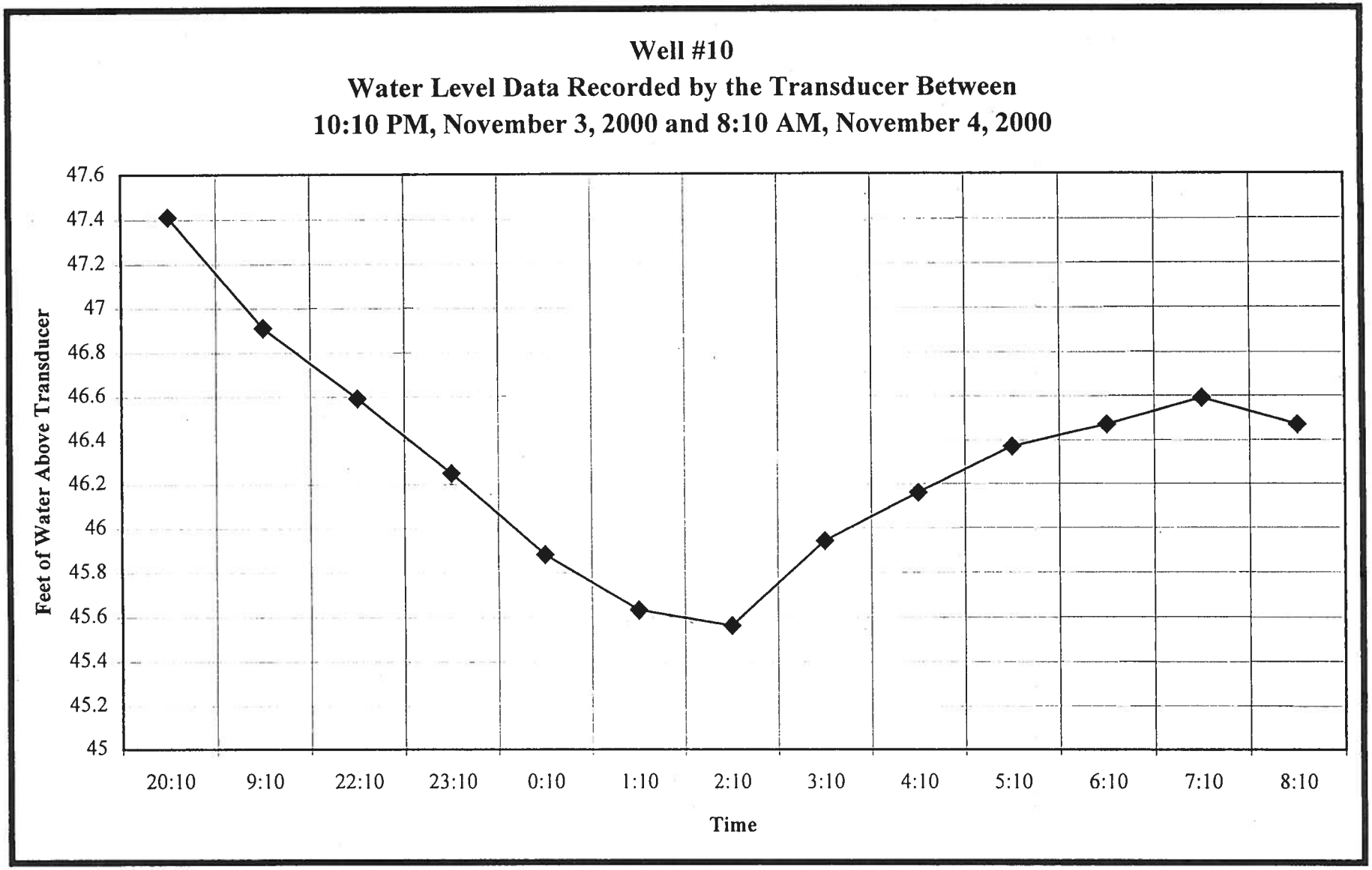
Well Test Data
Chefornak, Alaska
November 3, 2000 - January 4, 2001

FIGURE 4



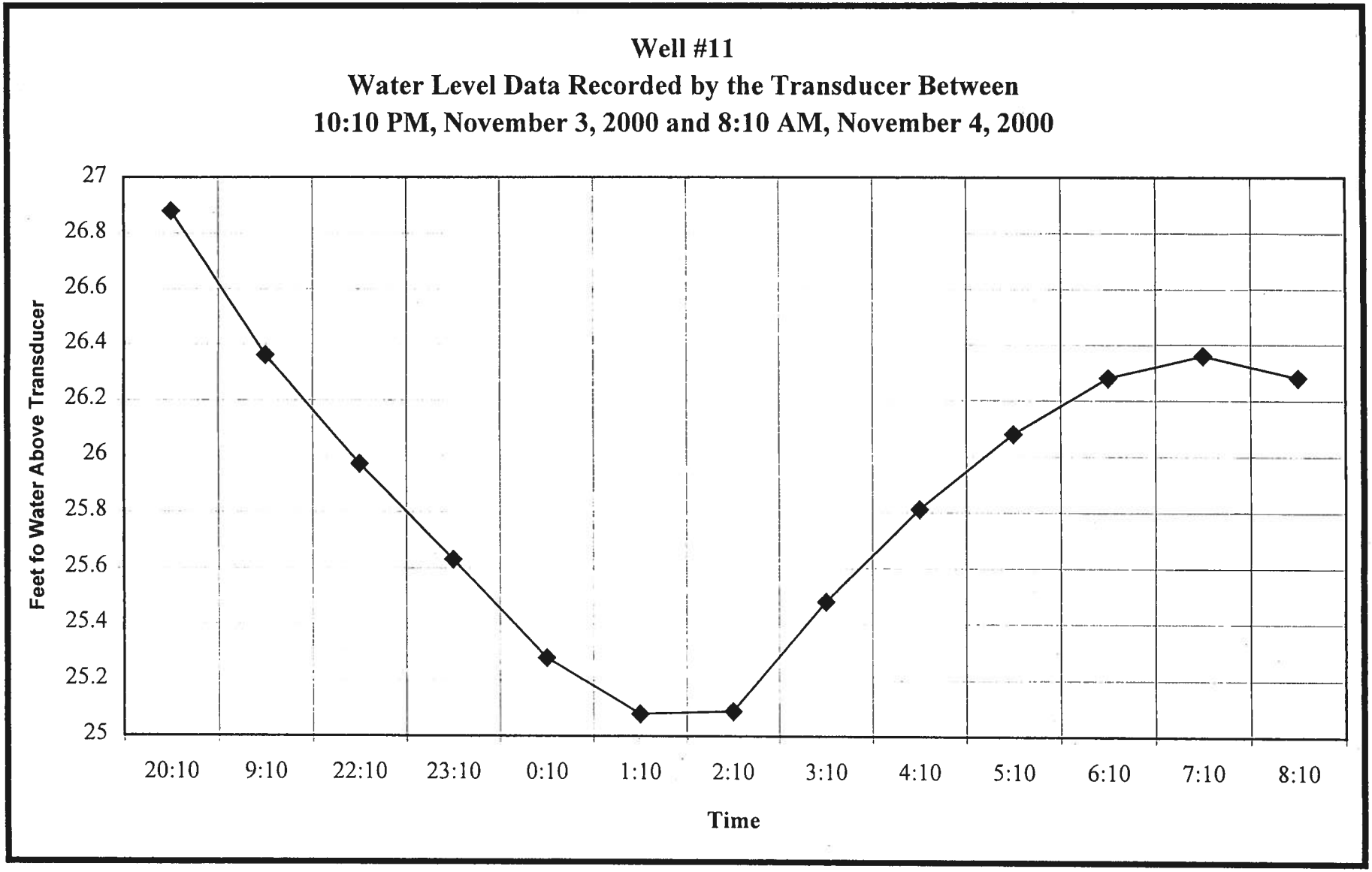
Well Test Data
Chefornak, Alaska

FIGURE 5



Well Test Data
Chefornak, Alaska

FIGURE 6



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