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TECHNICAL MEMORANDUM

To:	Cedar Lake Improvement Lake Board	**Date:**	March 13, 2015
From:	Brian Boyer, K&A Mark Kieser, K&A	**cc:**	File
RE:	**2014 Cedar Lake Groundwater/Surface Water Database Updates**		

This memorandum represents 2014 updates from Kieser & Associates, LLC (K&A) related to the ongoing water level monitoring program at Cedar Lake, Alcona and Iosco Counties, Michigan. K&A staff were again authorized to manage and oversee these data collection efforts in 2014 on behalf of the Lake Board.

Program Background

A volunteer water level monitoring program was initially developed at select groundwater and surface water monitoring sites around Cedar Lake in 2004. Since then, these water level monitoring efforts have expanded to include additional critical areas using automated water level logger equipment in lieu of intermittent volunteer measurements. The 2014 water level monitoring program included 23 level loggers located around the lake (Figure 1). Consistent with previous years, a combination of surface water stations along with shallow and deep groundwater stations were monitored to document surface/groundwater interactions and their influence on Cedar Lake water levels. Sherman Creek, Jones Creek and the King's Corner road culvert were likewise included in the 2014 monitoring program to assist with calculating estimates of surface flows in and out of Cedar Lake. Rain gage data collected and submitted by Rex Vaughn were also evaluated to assess rainfall for 2014 and compare with past rainfall records.

2014 Precipitation and Water Level Data

The 2014 water level data from the near-shore groundwater monitoring sites 1-7, along with Cedar Lake water levels, are graphically illustrated in Figures 2-8. Sites 1, 3, 4 and 5 (Figures 2, 4, 5, and 6, respectively) are in areas of groundwater loss, as reflected in the 2014 piezometer water levels observed below the lake water level. Sites 2, 6 and 7 (Figures 3, 7, and 8, respectively) are located in areas of groundwater recharge, with piezometer groundwater levels near or above those measured in the lake. Site 2, located nearest the wetland complex northwest of the lake, represents an important groundwater source to the lake and further emphasizes the importance of wetland protection in this critical area. Sites 8-11 (Figures 9-12, respectively) document conditions beyond the lake toward the southeast within an area of Lakewood Shores that is well-drained. Water level data for these four sites confirm shallow groundwater loss to Lake Huron with increasing distance from the Lake.

Historic summer precipitation totals for the Cedar Lake area are presented in Figure 13. These data represent precipitation data available from the Harrisville, MI CO-OP Station (#203628), the Oscoda, MI Wurtsmith Airport Station (#14808), and a rain gauge installed at Cedar Lake and monitored by volunteers. Available rainfall data from 1998-2014 (no data for 2006) reflect a 16-year summer average (June-September) of 11.93 inches of rainfall. The observed 2014 rainfall data reflect an above-average year for rainfall, measuring over 14 inches during these summer months. The two previous summers (2012 and 2013) exhibited below-average summer precipitation amounting to 8.61 and 10.35 inches, respectively. The years 2008-2011 each had summer precipitation recorded above this recent average.

More importantly, with respect to rainfall, the Cedar Lake Augmentation Feasibility Study completed by K&A in 2011 revealed that in order to avoid water level decreases greater than 3-inches during the critical summer months (June-September), an average monthly rainfall of 2.75 inches would be necessary. In other words, if natural rainfall patterns result in less than 2.75 inches in a given summer month, a lake level drop of approximately 3 inches is to be expected. Likewise, the June-September target goal of 11 inches of rainfall (i.e., 2.75 inches multiplied by 4 months) can be used to assess each summer season as a whole. This target threshold is also plotted on Figure 13 for sake of comparison.

The 2014 level logger data near the Cedar Lake outflow structures demonstrate that the lake had water levels greater than the established legal lake level of 608.64 feet until mid-June (representing lake outflow conditions). The 2014 Cedar Lake water levels were plotted with April-December recorded rainfall (refer to Figure 14) to observe lake level response to local precipitation. As previously noted, and illustrated in Figure 14, the local precipitation has a direct impact on Cedar Lake water levels with observed responses to corresponding to local rain events. Consistent with the target rainfall threshold data plotted on Figure 13 (i.e., 11 inches per summer season), the Figure 14 2014 Cedar Lake water levels held relatively steady and within inches of the northern lake outflow structures. Due to the relatively small size of the Cedar Lake watershed contributing area, summer rainfall is an important factor in maintaining Cedar Lake levels. Those years with below-average rainfall result in significant drops in Cedar Lake water levels as water losses exceed water gains to the lake.

2014 Estimated Surface Flows

Water level loggers located at the lake outflow area (north end), Sherman Creek, Jones Creek and King's Corner culverts (west side of the lake) were used to monitor incoming and outgoing surface flows of the lake. Both Jones Creek and Sherman Creek, are significant sources of incoming surface water flows to the lake from the wetland complex northwest of Cedar Lake. On the other hand, the King's Corner road culvert diverts water from the immediate watershed to the south toward Phelan Creek and Van Etten Lake, resulting in water loss from the Cedar Lake watershed. The two Cedar Lake outflow structures at the north end of the lake discharge to Lake Huron once water levels exceed the legal lake level. Figures 15-18 illustrate estimated surface inflows and outflows associated with Cedar Lake for spring and summer 2014 at these four monitoring locations. All flow monitoring data are derived from long-term water level stage-discharge relationships specific to each location. Flow data from all four of these critical locations were combined and plotted together as illustrated on Figure 19.

The Jones Creek and Sherman Creek monitoring data exhibit inflows of 151 and 270 million gallons (Mgal), respectively, into Cedar Lake from March 26-July 21, 2014 (refer to Figure 19). During the same time period, 32 Mgal flowed out of the Cedar Lake watershed via the King's Corner road culvert. Measured outflow volume leaving Cedar Lake totaled 0.07 Mgal during this time period. As noted on Figure 17, the magnitude of the recorded lake outflow (based on water levels) is likely inaccurate due to increased observed beaver dam activity at the outflow area this past year, although the total estimated volume of 0.07 Mgal is a reasonable approximation since most discernible lake outflows ceased in mid-June.

Figure 20 is intended to summarize observed flows associated with the Kings Corner culvert location. The plotted flows from April 1-November 7, 2014 reflect a total volume of 45.2 Mgal over 220 days. It is important to keep in mind that these flows reflect "lost inflow" opportunity to Cedar Lake. It is for this reason that we anticipate further discussion for potential Kings Corner modifications this spring (including with the adjacent property owner, K&A, lake level subcommittee and designated Lake Board representatives).

In late August to early September 2014, a total of six railroad culverts passing beneath the Lake State Railway within the northwest wetland complex area were given specific maintenance attention by railroad representatives. These efforts restored flow from the west to the east beneath the railroad tracks at six culvert locations (location information pending).

We recommend the Cedar Lake monitoring program be continued during the 2015 calendar year to further evaluate potential augmentation needs on Lake Board property, Kings Corner impacts, and physical improvements associated with the 2014 culvert flow repair efforts conducted by the railroad in the northwest cedar swamp area.

If you have any questions regarding the information provided within this technical memorandum, please do not hesitate to contact our office at (269) 344-7117.

Site #1 (3 loggers)
north of 4484 E. Cedar Lake Dr.

Site #2 (2 loggers)
3481 W. Cedar Lake Rd.

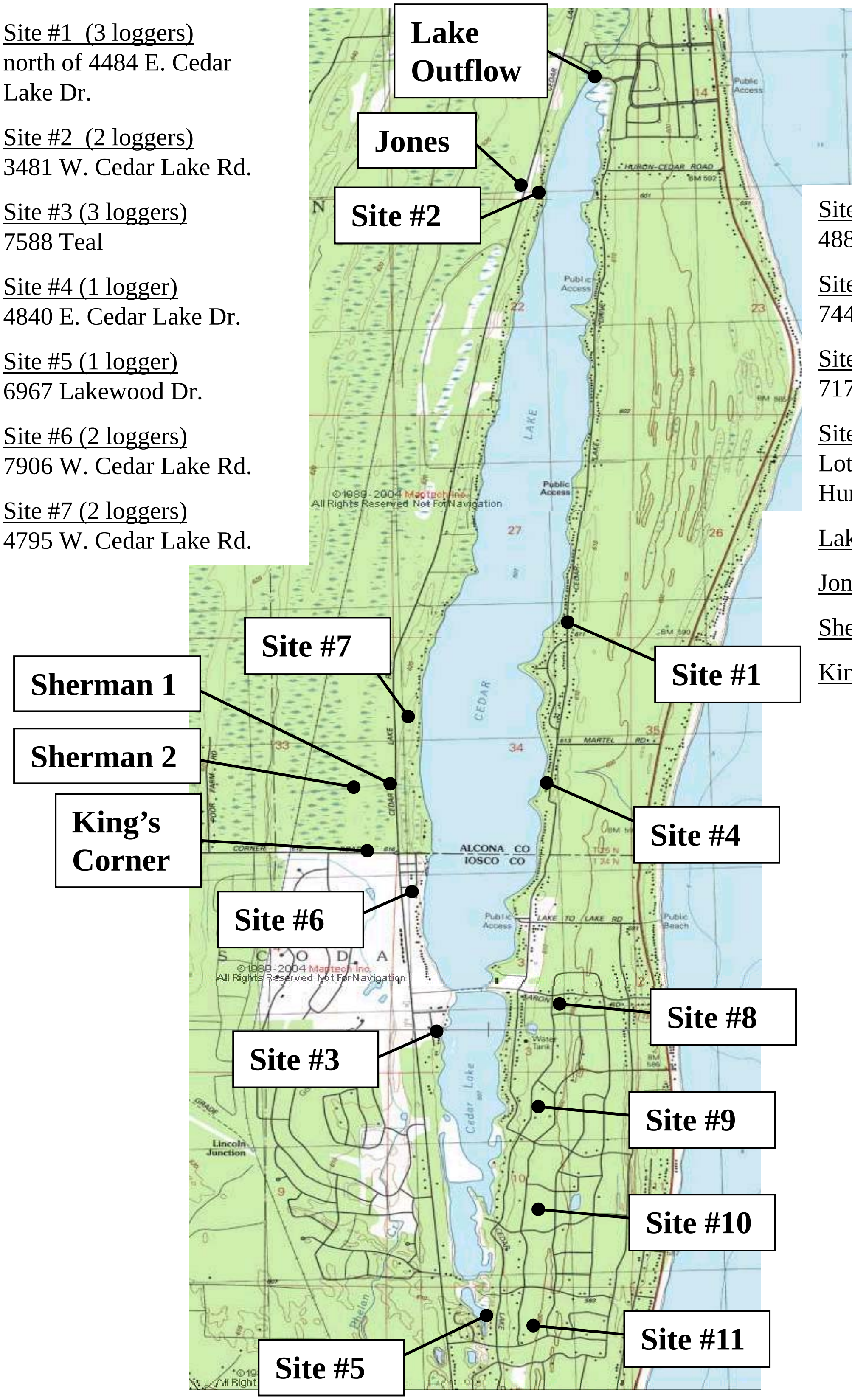
Site #3 (3 loggers)
7588 Teal

Site #4 (1 logger)
4840 E. Cedar Lake Dr.

Site #5 (1 logger)
6967 Lakewood Dr.

Site #6 (2 loggers)
7906 W. Cedar Lake Rd.

Site #7 (2 loggers)
4795 W. Cedar Lake Rd.



NORTH

Site #8 (1 logger)
4884 Arron Dr.

Site #9 (1 logger)
7448 Lakewood Dr.

Site #10 (1 logger)
7173 Huntington Dr.

Site #11 (1 logger)
Lot north of 6933 Huntington Dr.

Lake Outflow (1 logger)

Jones Creek (1 logger)

Sherman Creek (2 loggers)

King's Corner (1 logger)

Sites 1-3 were original Phase I monitoring locations.

Sites 4-7 were added as part of Phase II monitoring efforts.

Sites 8-11 were added as part of Augmentation Feasibility Study efforts.

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Map of groundwater and surface water elevation monitoring sites located around the perimeter of Cedar Lake.

FIGURE 1

Figure 2. 2014 Cedar Lake Groundwater /Surface Water Elevations (Site 1)

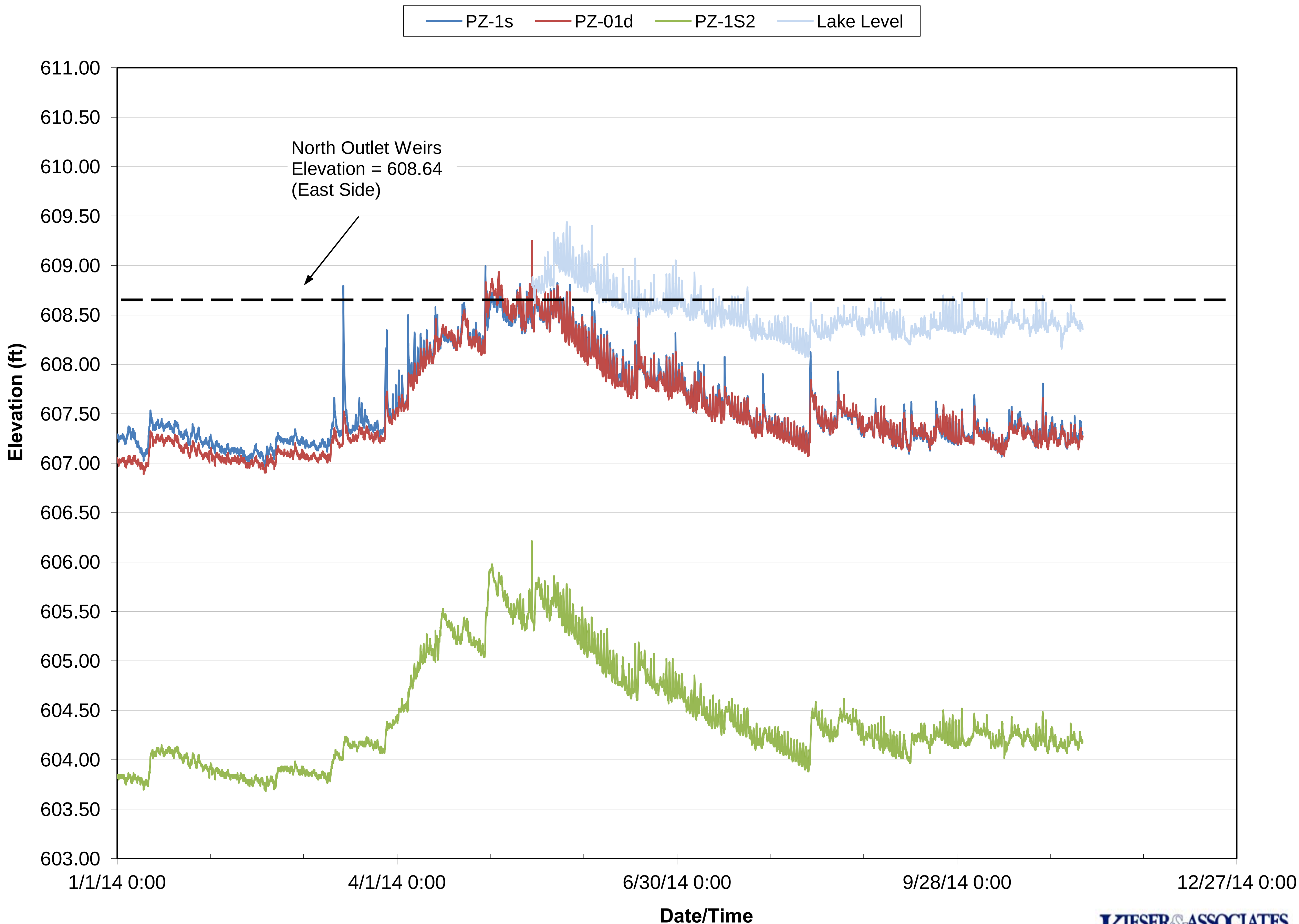

Figure 3. 2014 Cedar Lake Groundwater /Surface Water Elevations (Site 2)

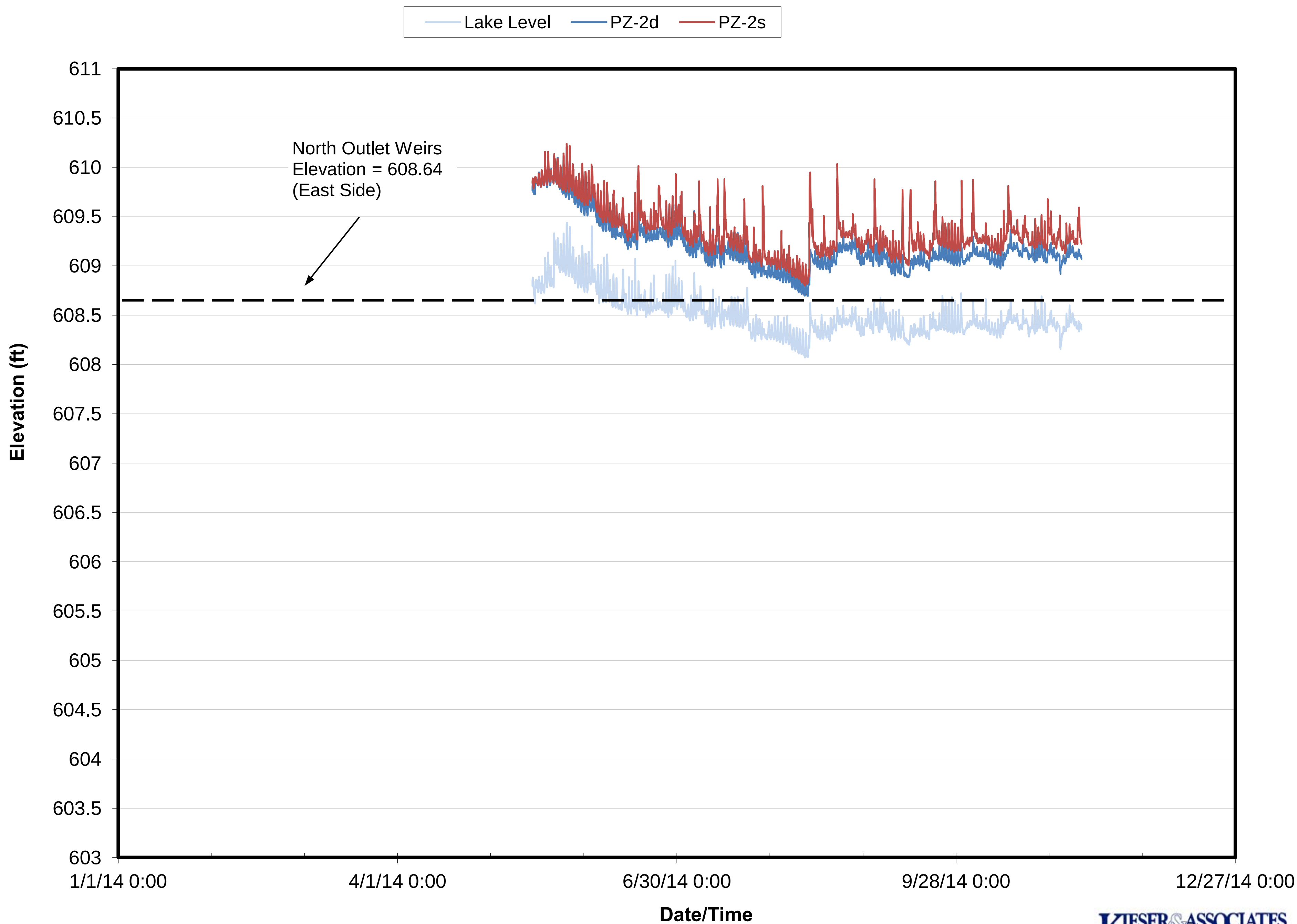

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Figure 4. 2014 Cedar Lake Groundwater /Surface Water Elevations (Site 3)

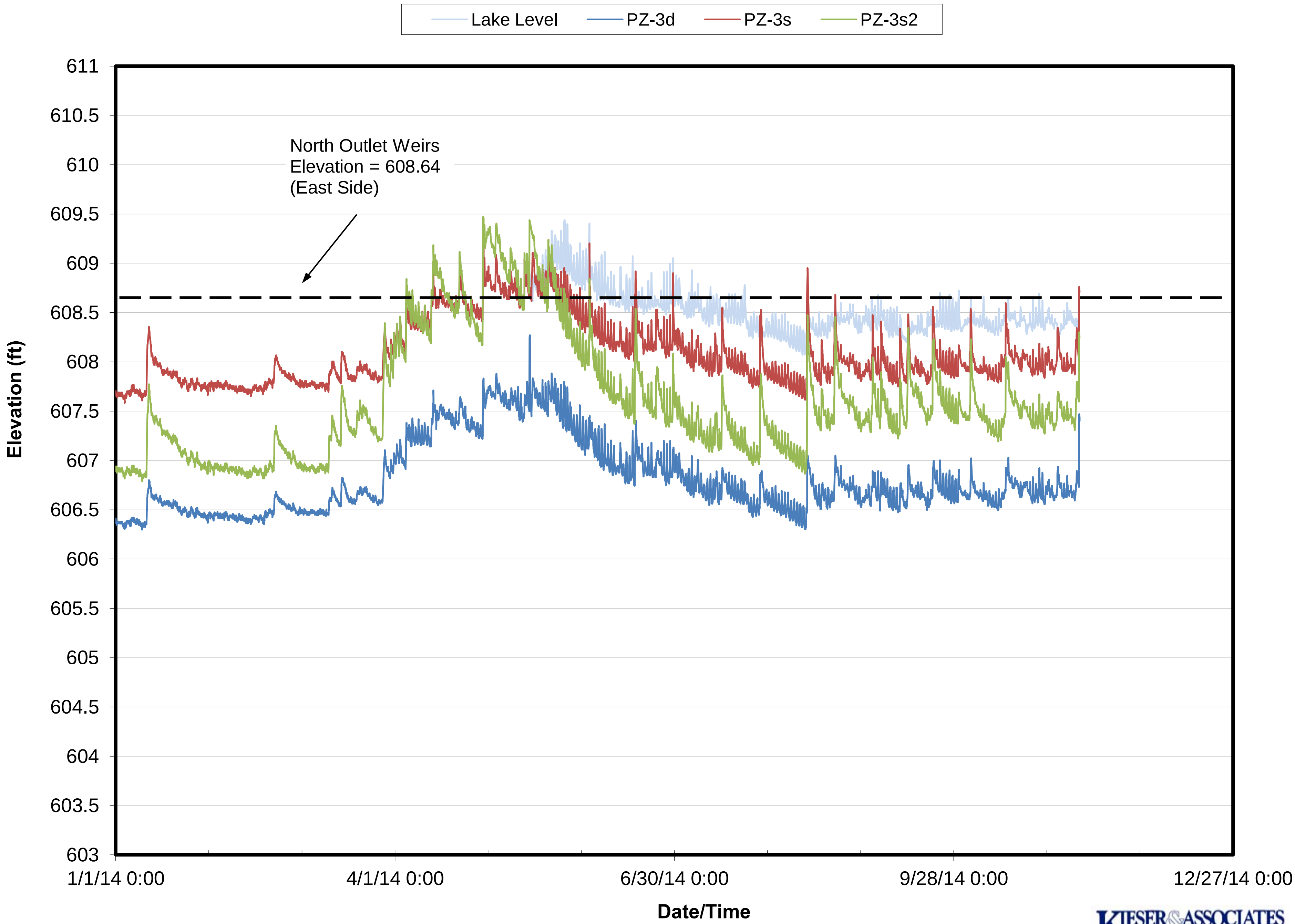

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Figure 5. 2014 Cedar Lake Groundwater /Surface Water Elevations (Site 4)

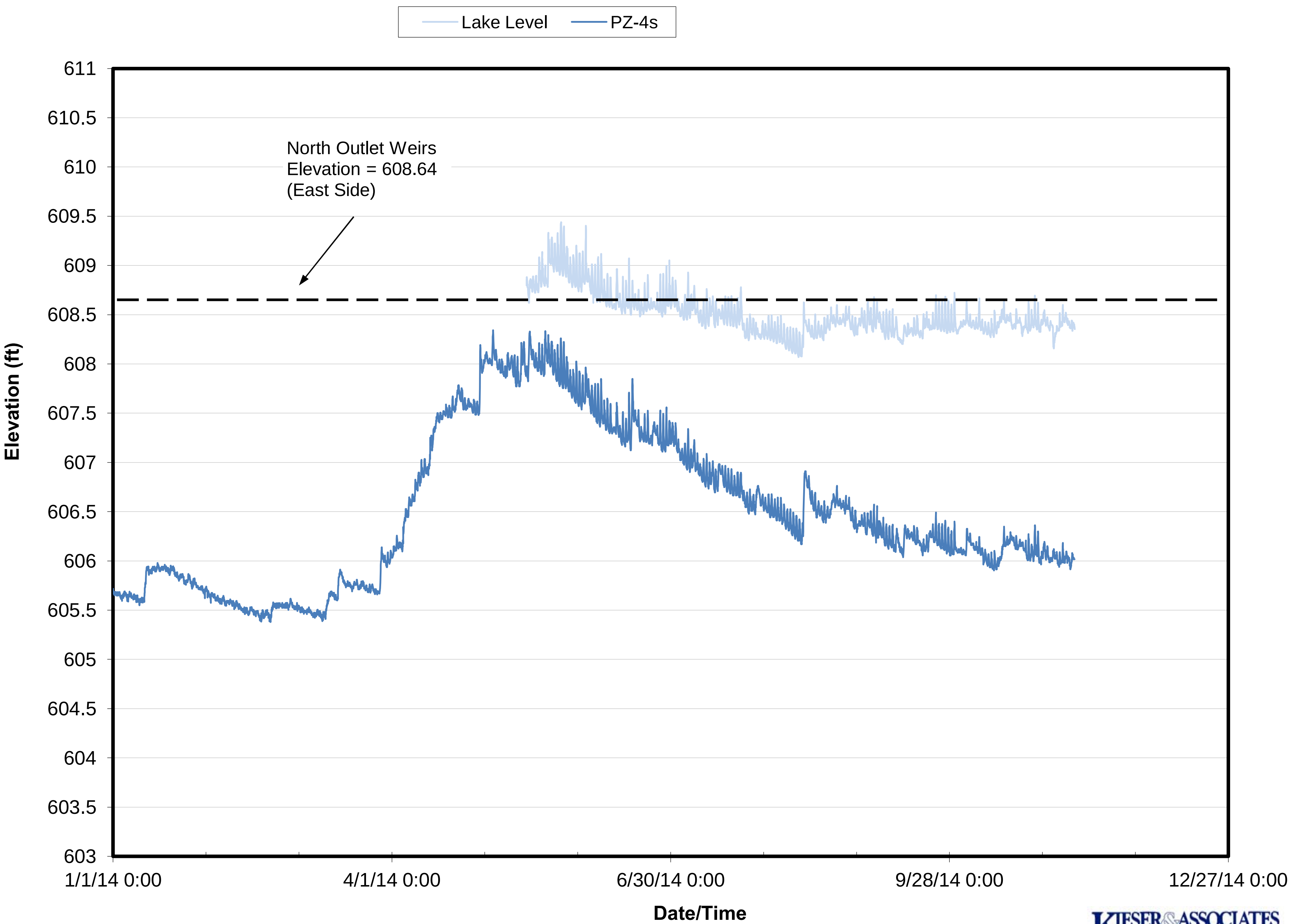

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Figure 6. 2014 Cedar Lake Groundwater /Surface Water Elevations (Site 5)

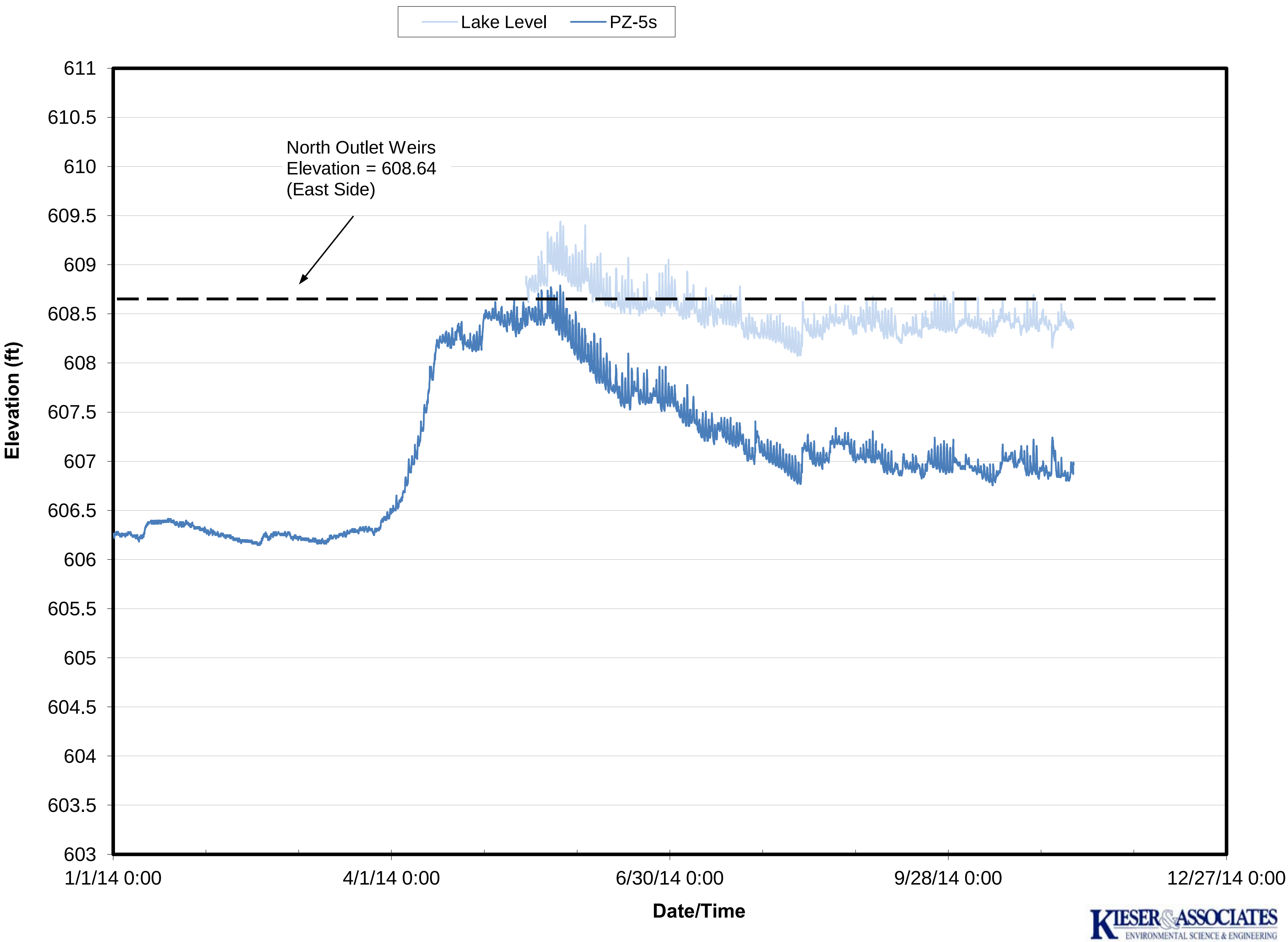

Figure 7. 2014 Cedar Lake Groundwater /Surface Water Elevations (Site 6)

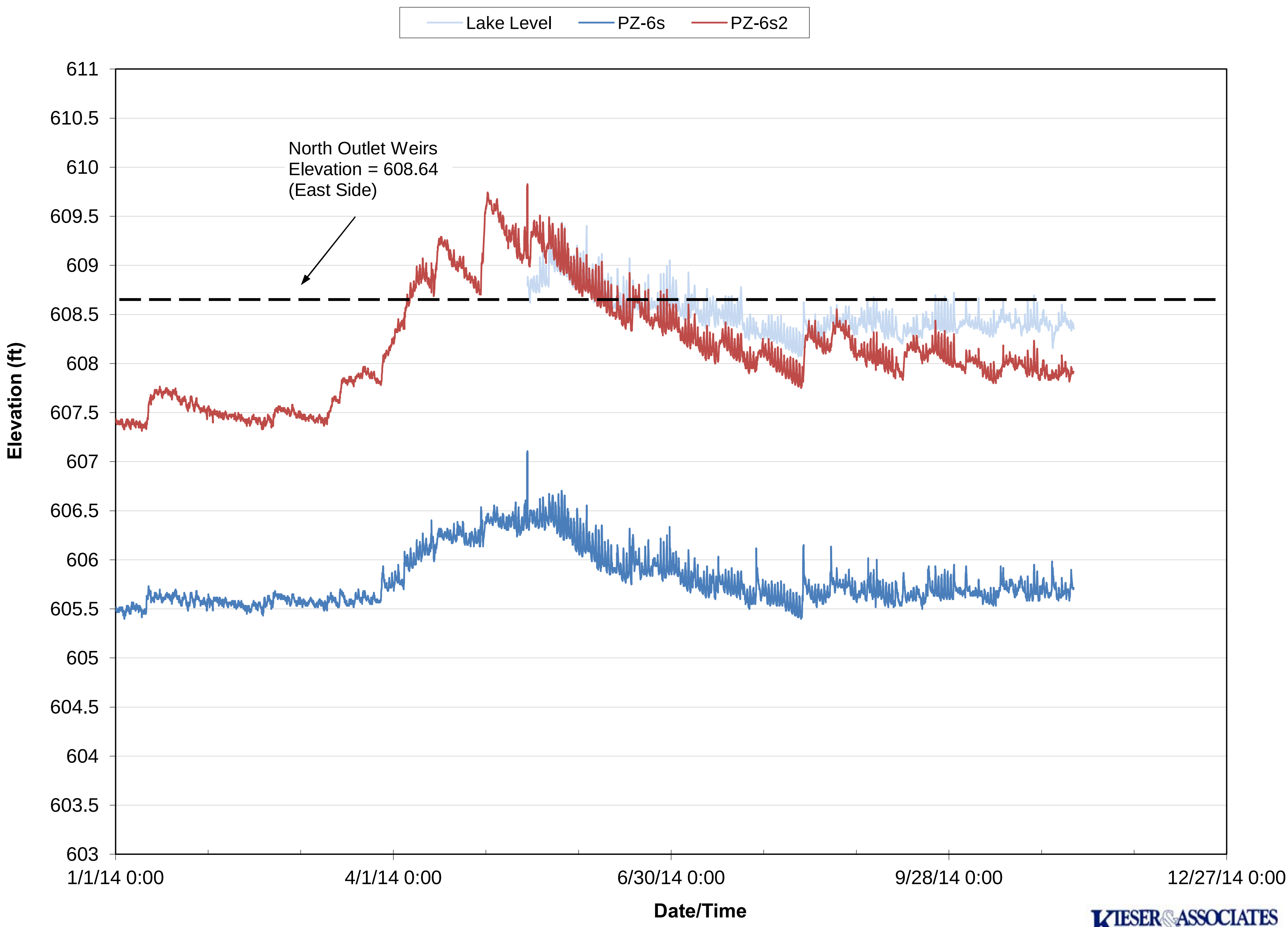

Figure 8. 2014 Cedar Lake Groundwater /Surface Water Elevations (Site 7)

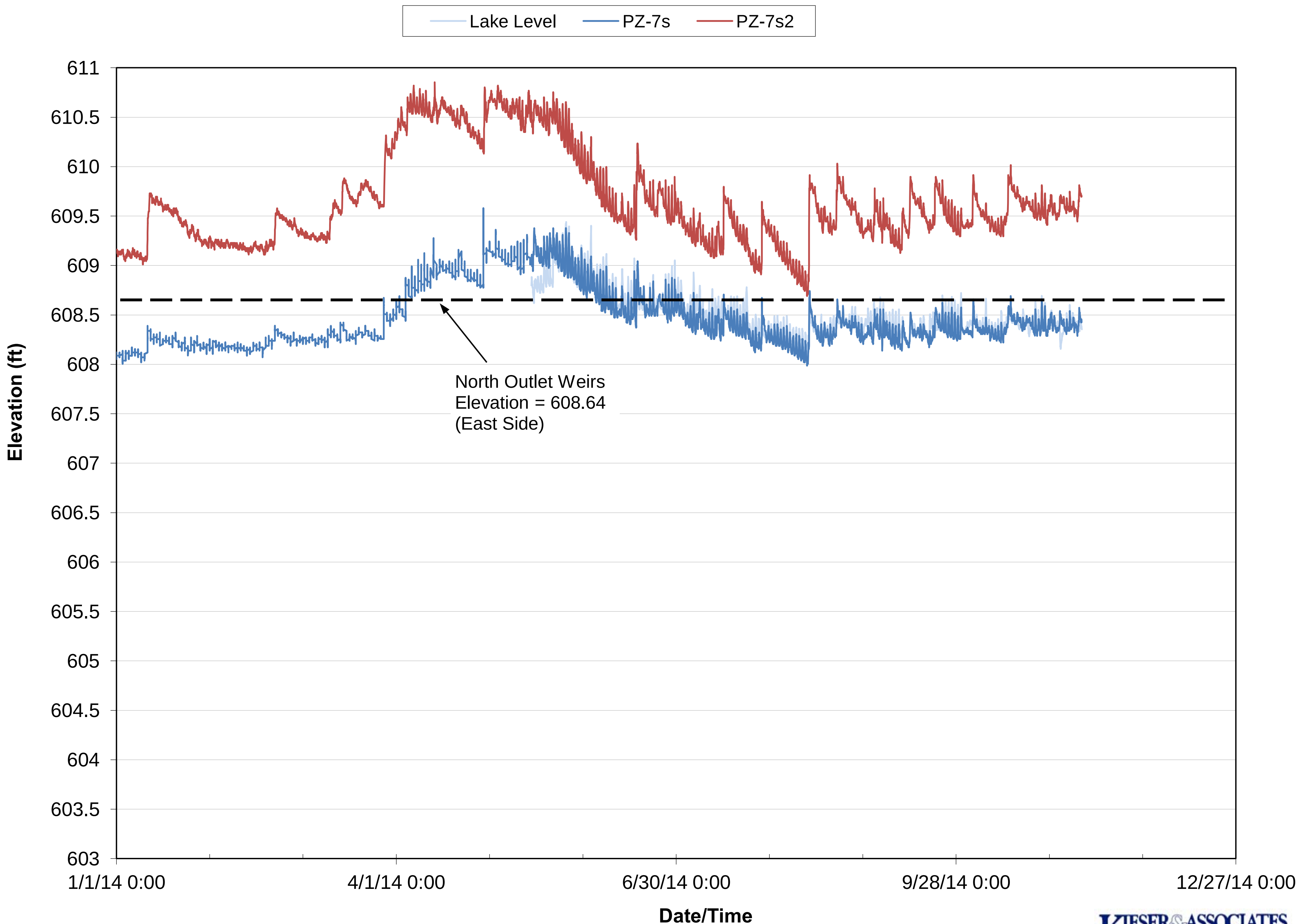

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Figure 9. 2014 Cedar Lake Groundwater /Surface Water Elevations (Site 8)

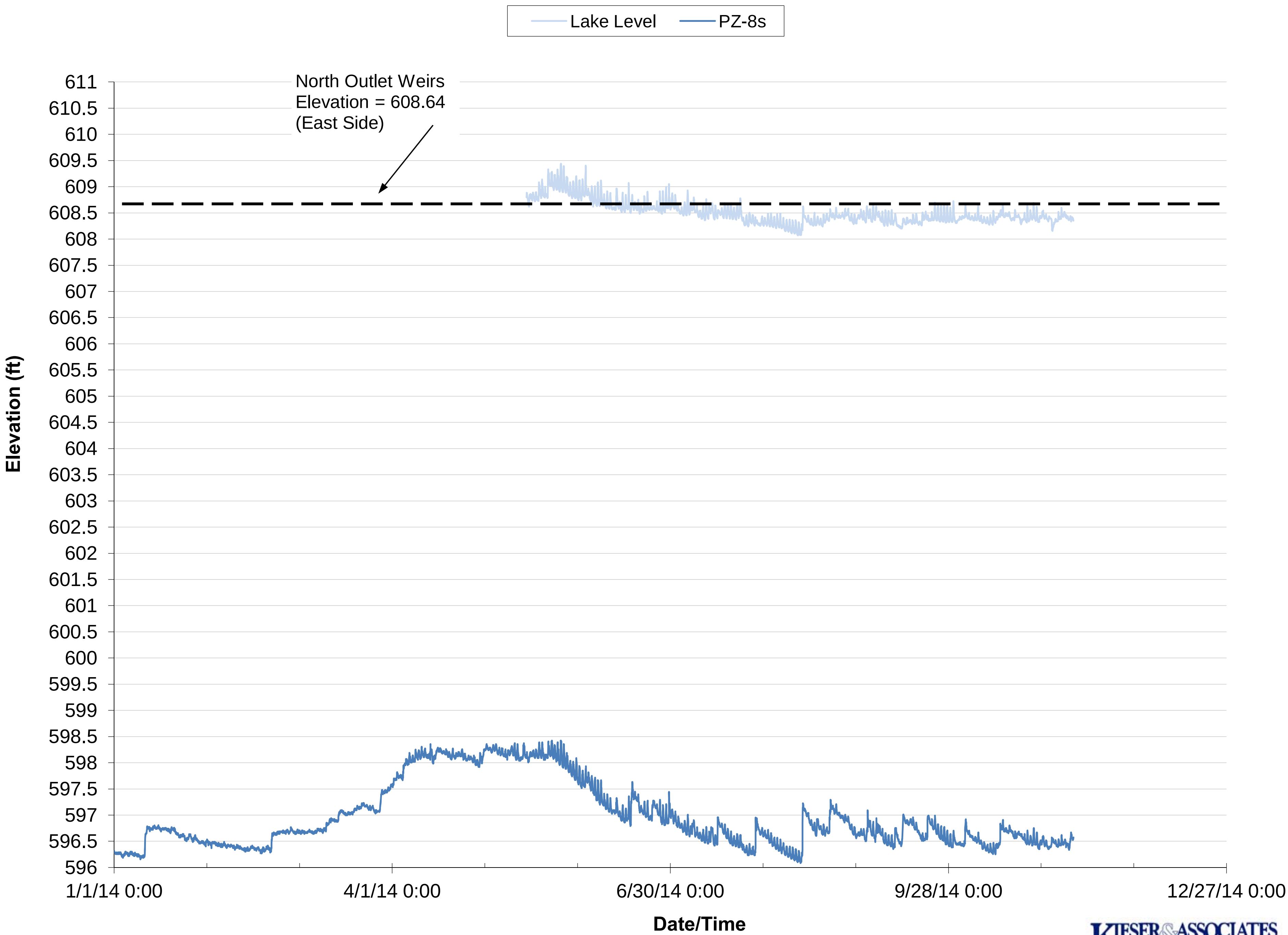

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Figure 10. 2014 Cedar Lake Groundwater /Surface Water Elevations (Site 9)

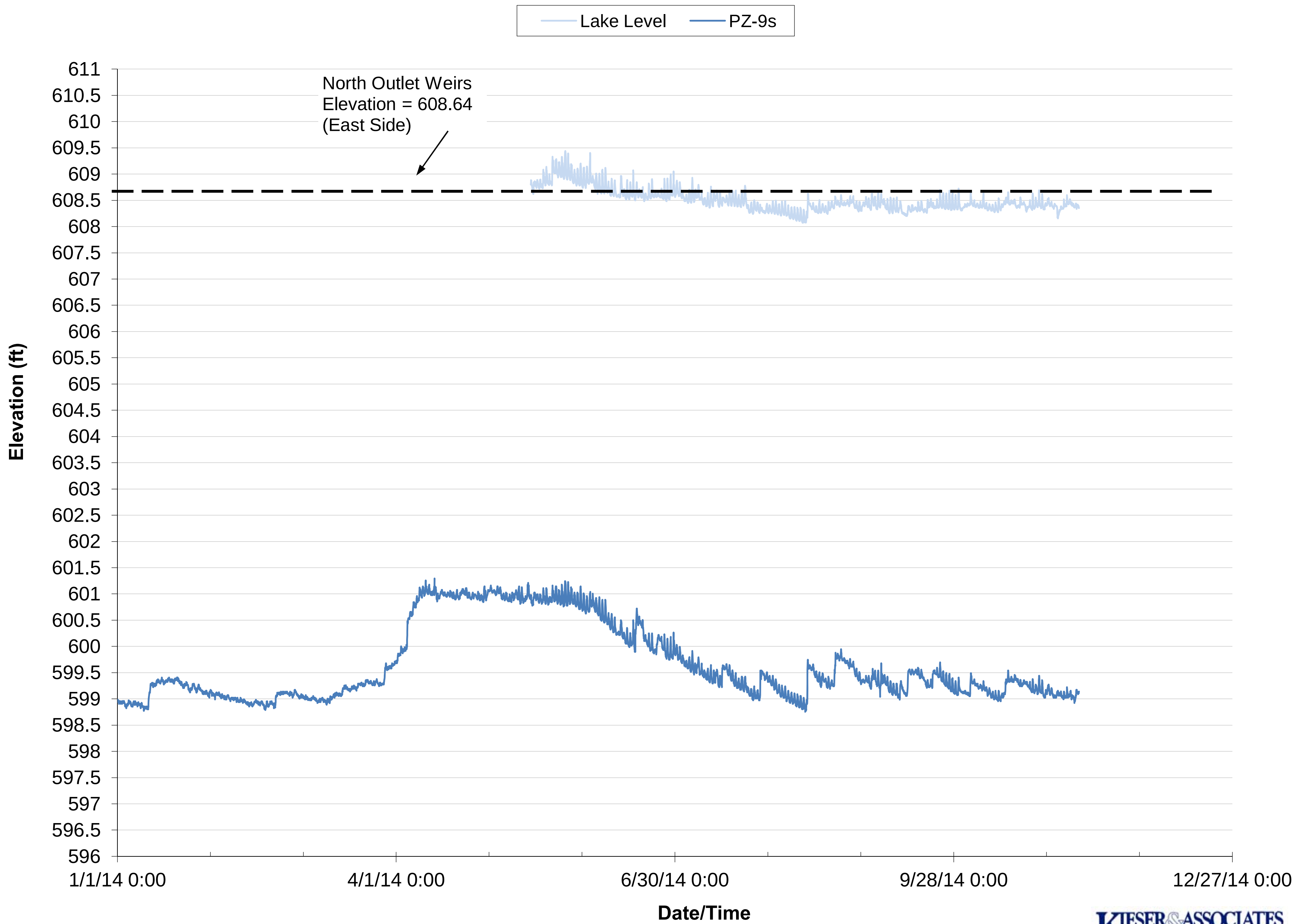

Figure 11. Cedar Lake Water Level and Measured Rainfall for 2014 (Site 10)

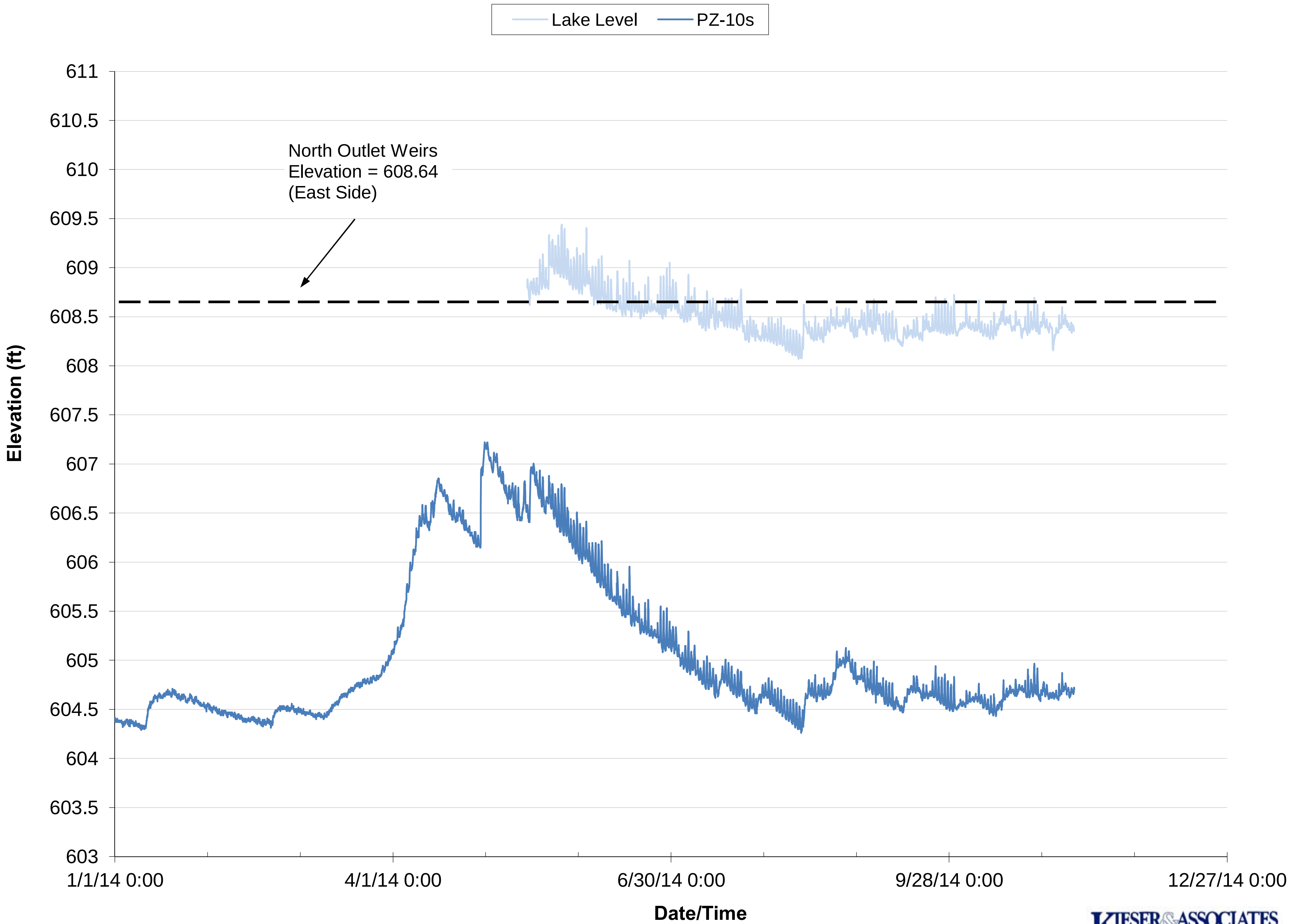

Figure 12. 2014 Cedar Lake Groundwater /Surface Water Elevations (Site 11)

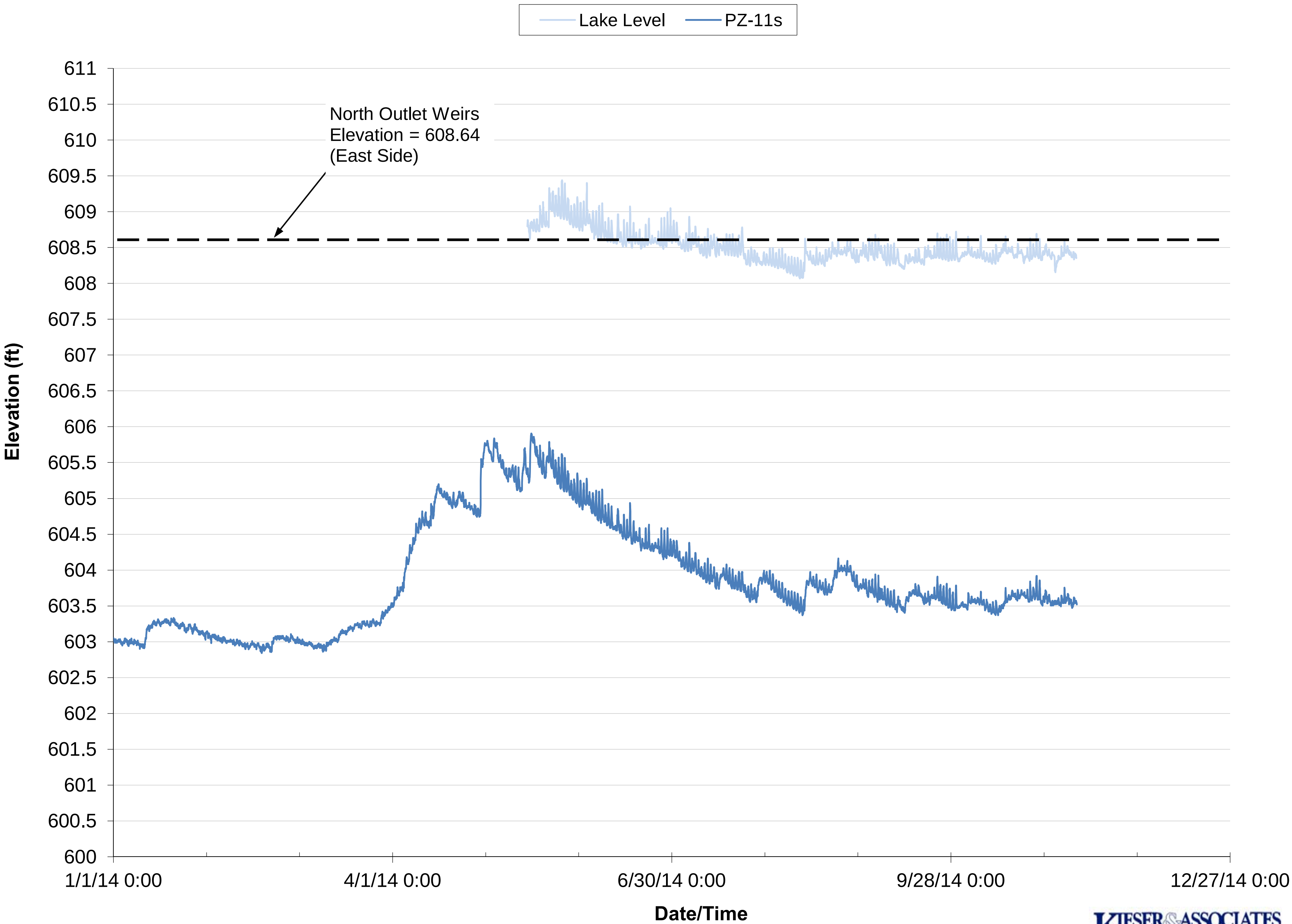

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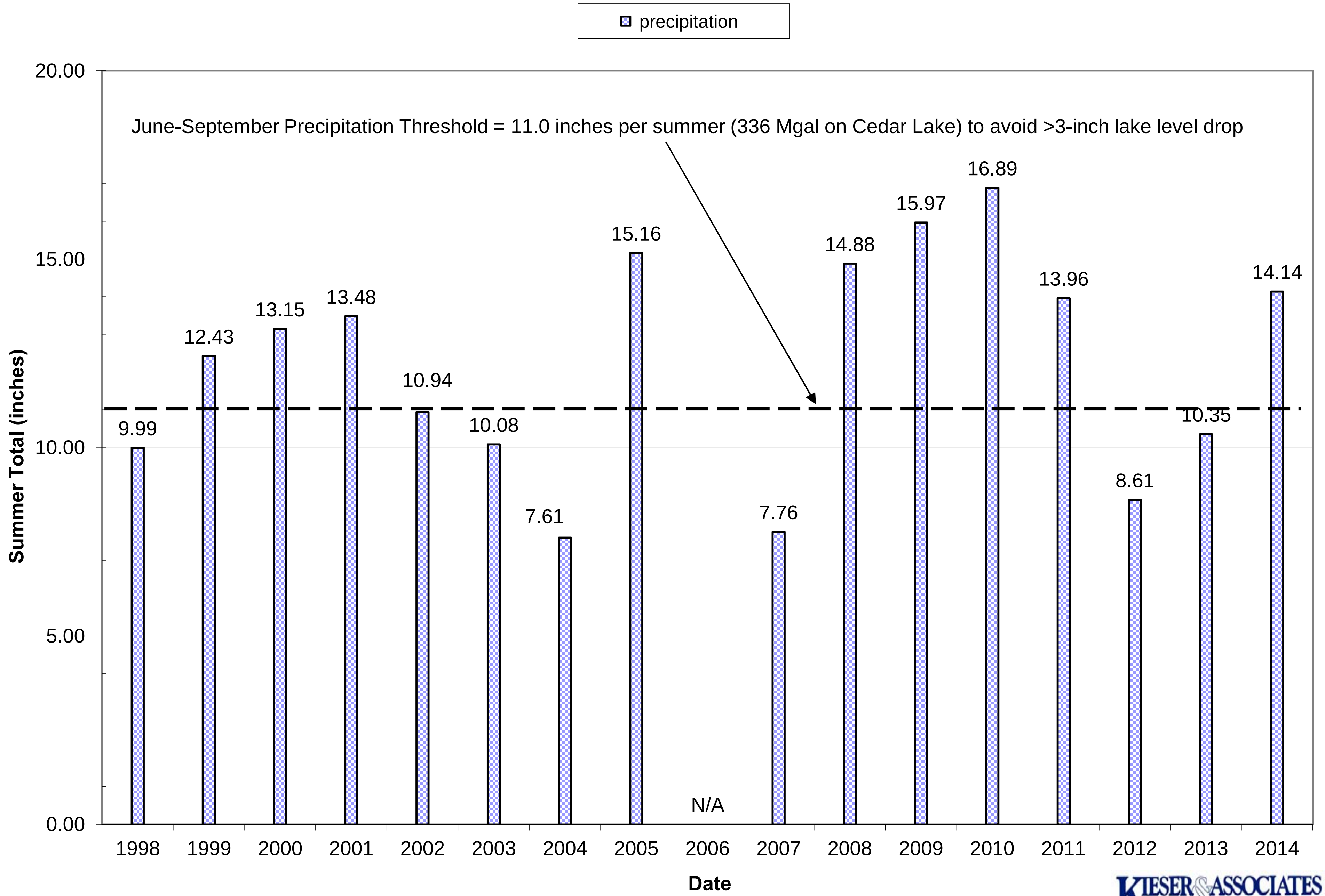
Figure 13. Summer (Jun - Sept) Precipitation Totals for Cedar Lake
(Precipitation Source: Harrisville, MI, CO-OP Station #203628,
Alcona County Cedar Lake Rain Gauge,
Oscoda, MI Oscoda Wurtsmith Airport Station #14808, Iosco County)



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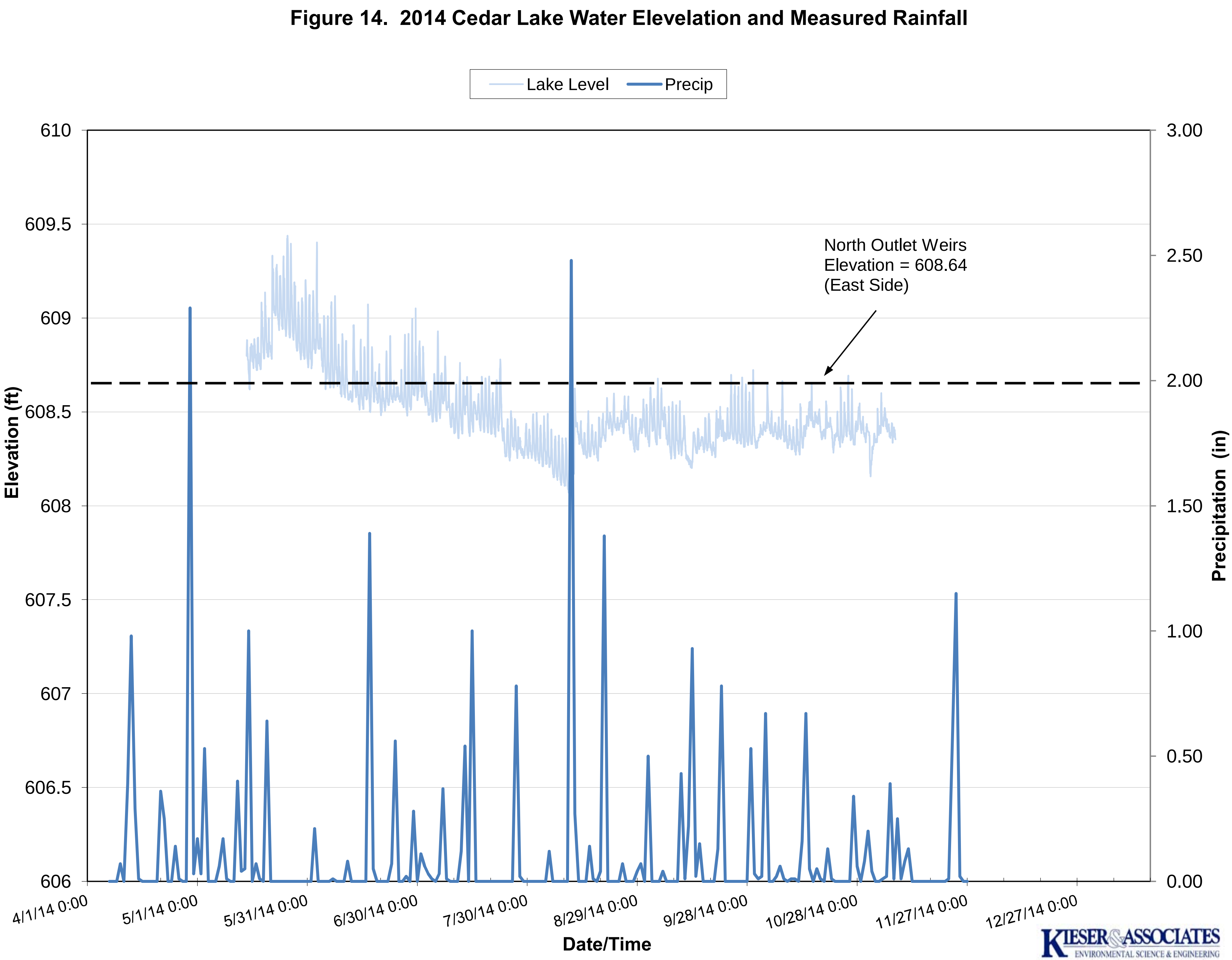
Figure 14. 2014 Cedar Lake Water Elevelation and Measured Rainfall
Lake Level
Precip
North Outlet Weirs
Elevation = 608.64
(East Side)
Elevation (ft)
Precipitation (in)
610
609.5
609
608.5
608
607.5
607
606.5
606
3.00
2.50
2.00
1.50
1.00
0.50
0.00
4/1/14 0:00
5/1/14 0:00
5/31/14 0:00
6/30/14 0:00
7/30/14 0:00
8/29/14 0:00
9/28/14 0:00
10/28/14 0:00
11/27/14 0:00
12/27/14 0:00
Date/Time
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Figure 15. 2014 Estimated Jones Creek Flows

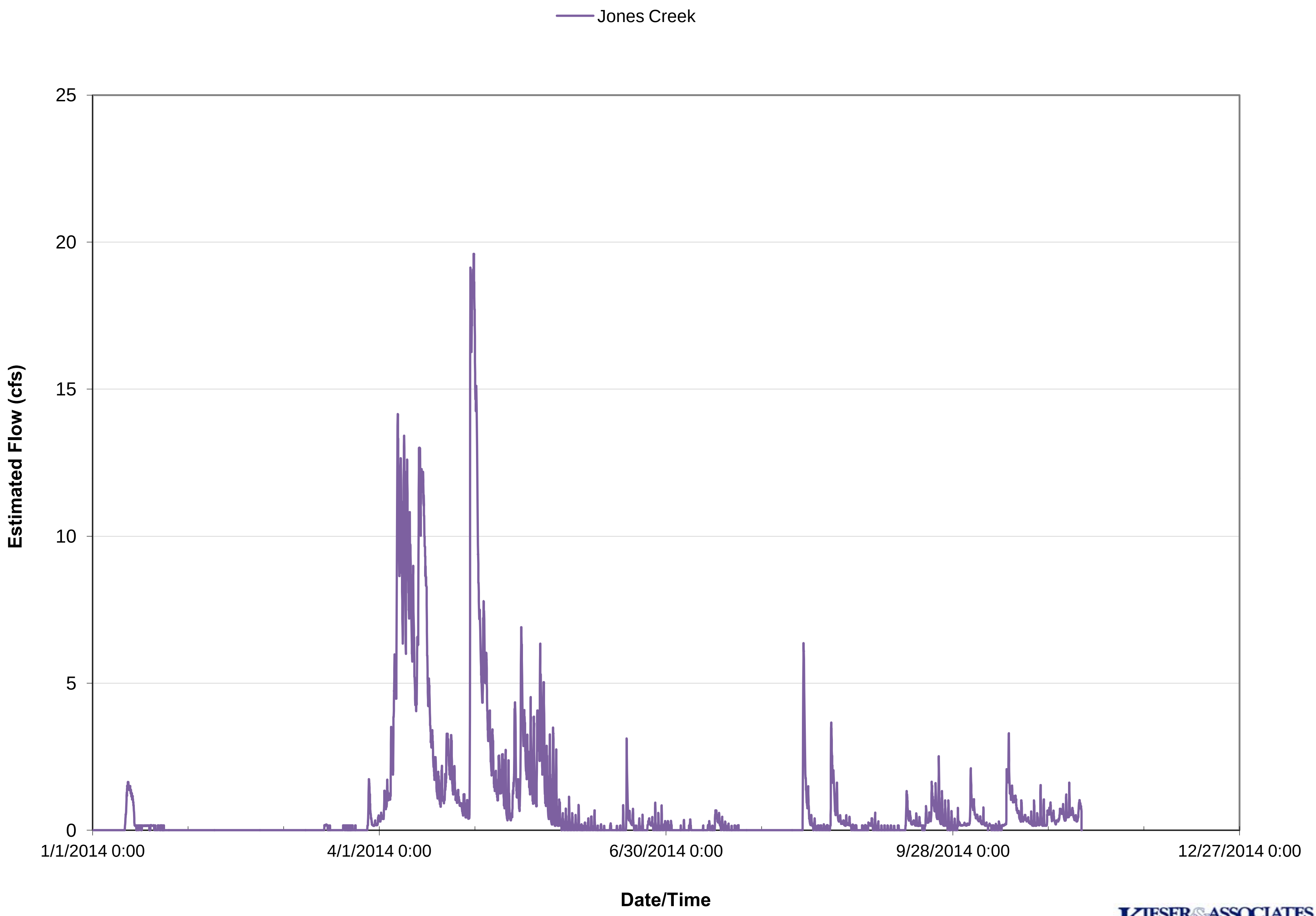

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Figure 16. 2014 Estimated Sherman Creek Flows

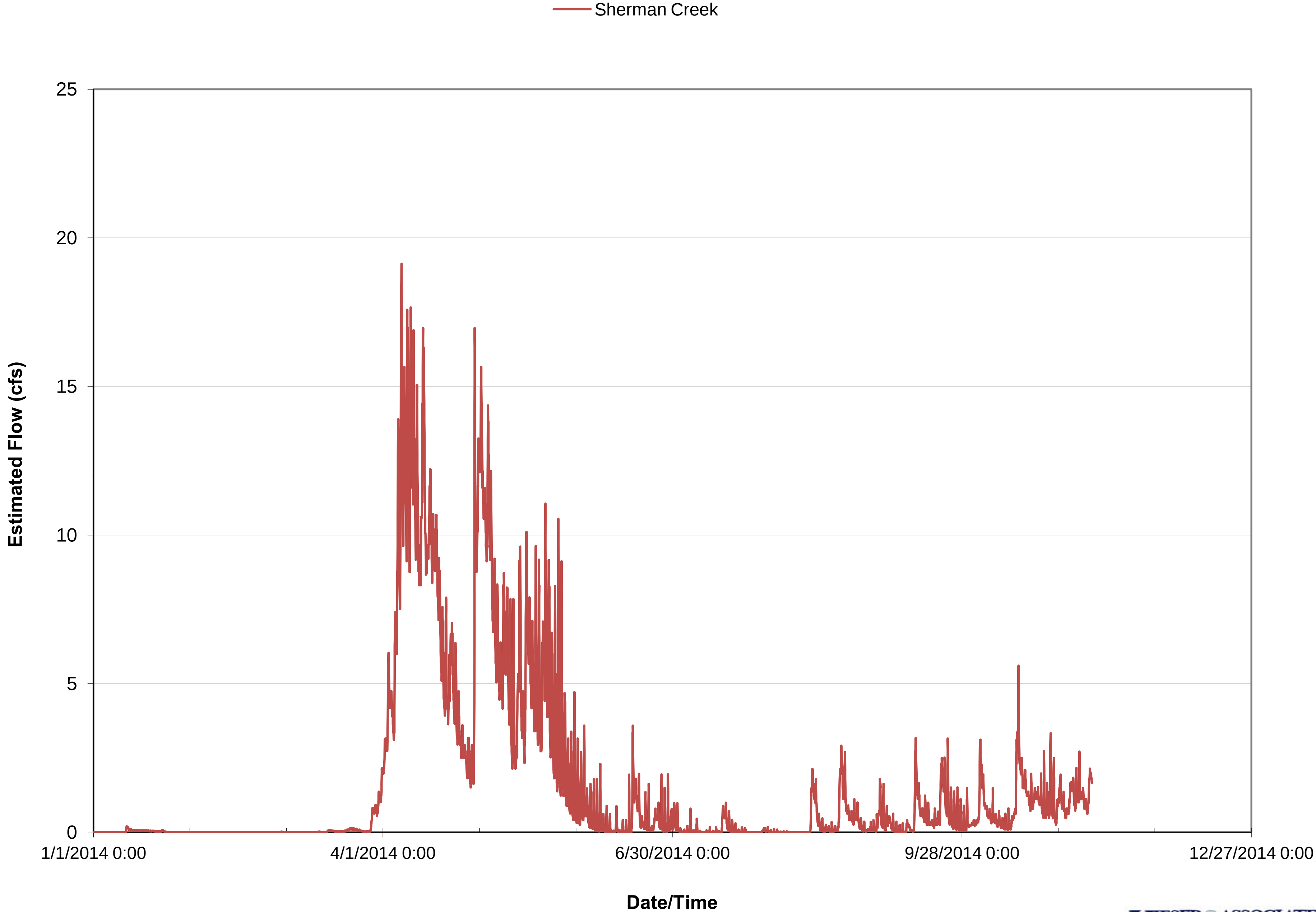

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Figure 17. 2014 Estimated Cedar Lake Outflows

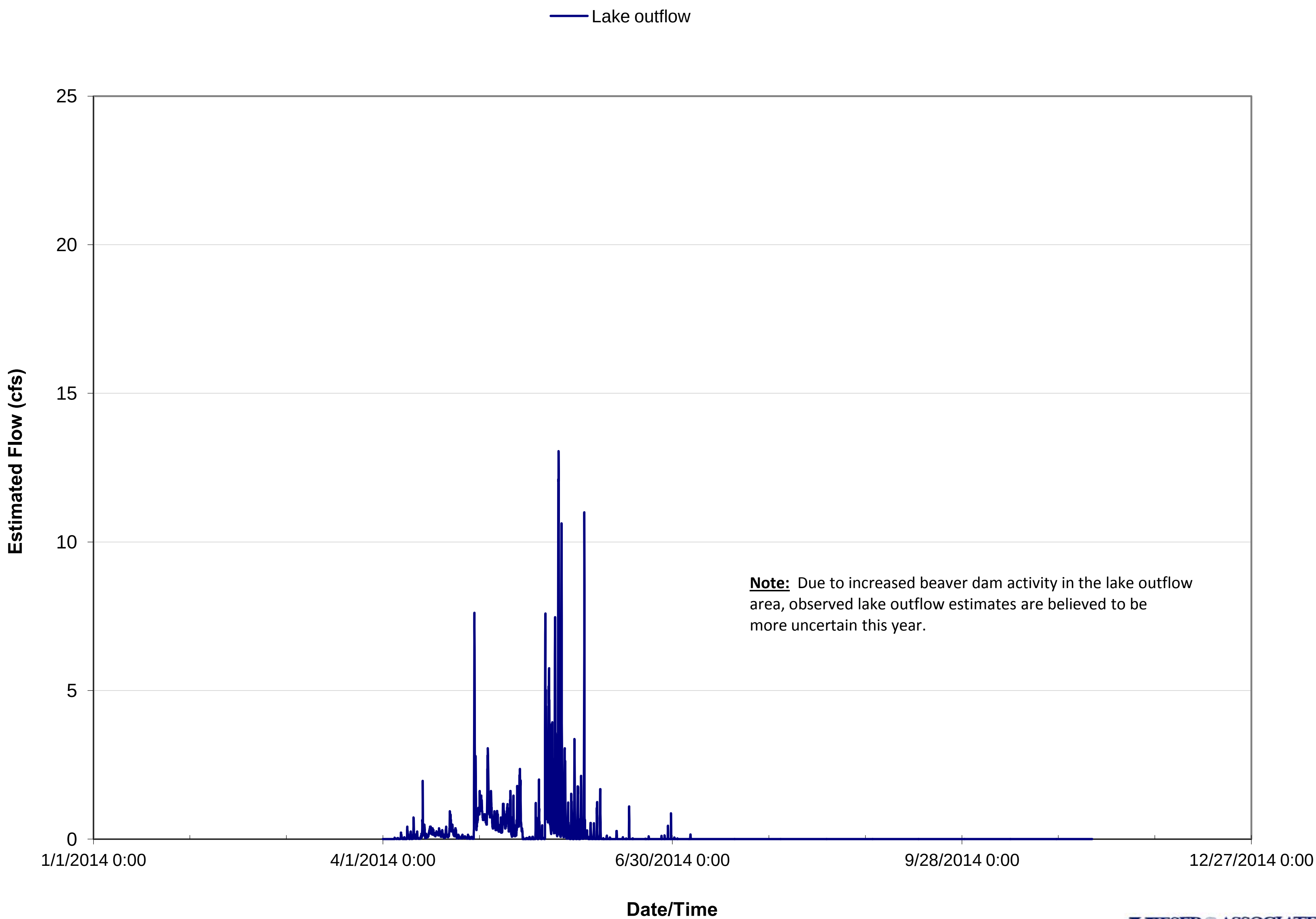

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Figure 18. 2014 Estimated Kings Corner Flows

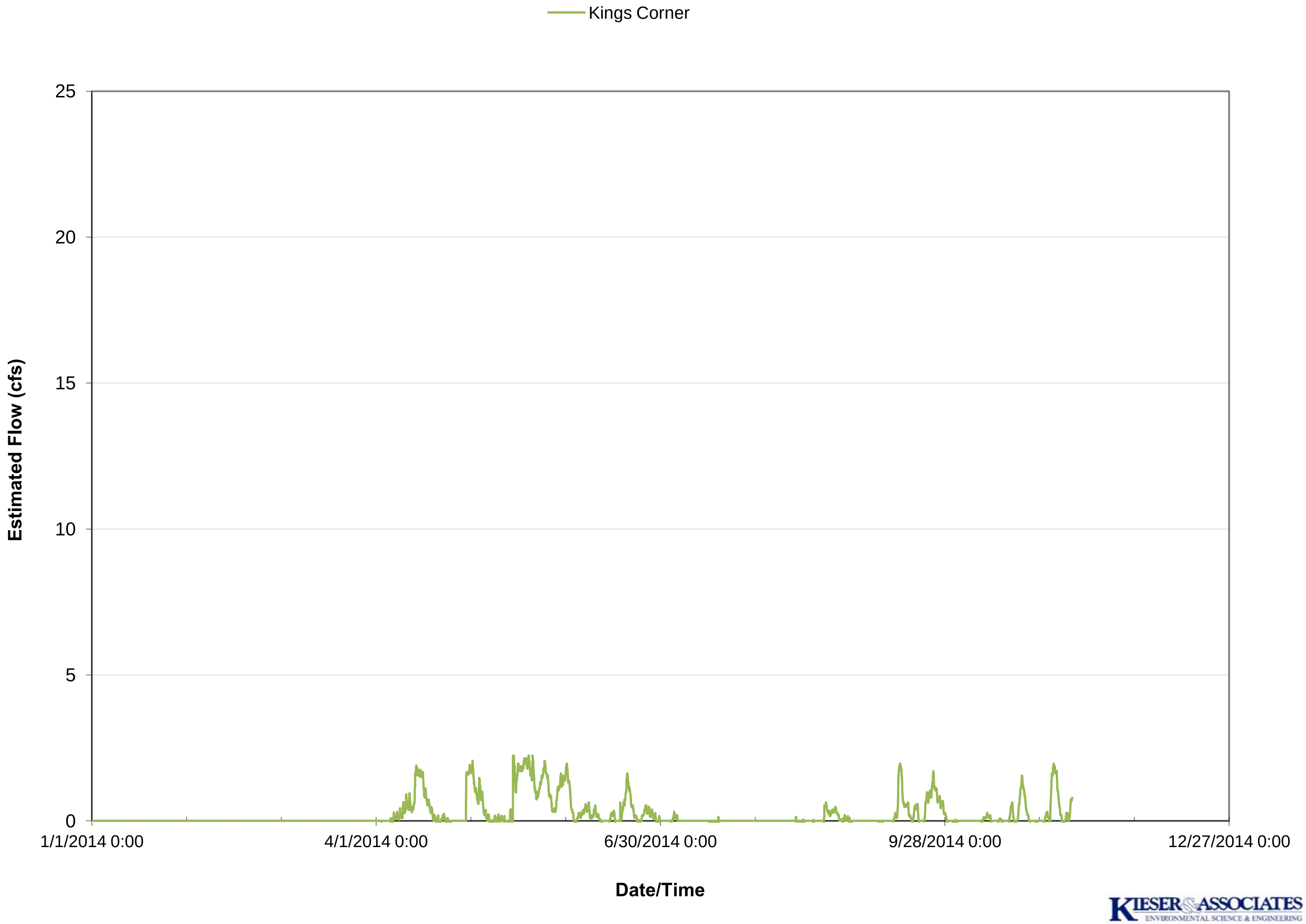

Figure 19. 2014 Estimated Cedar Lake Inflows/Outflows

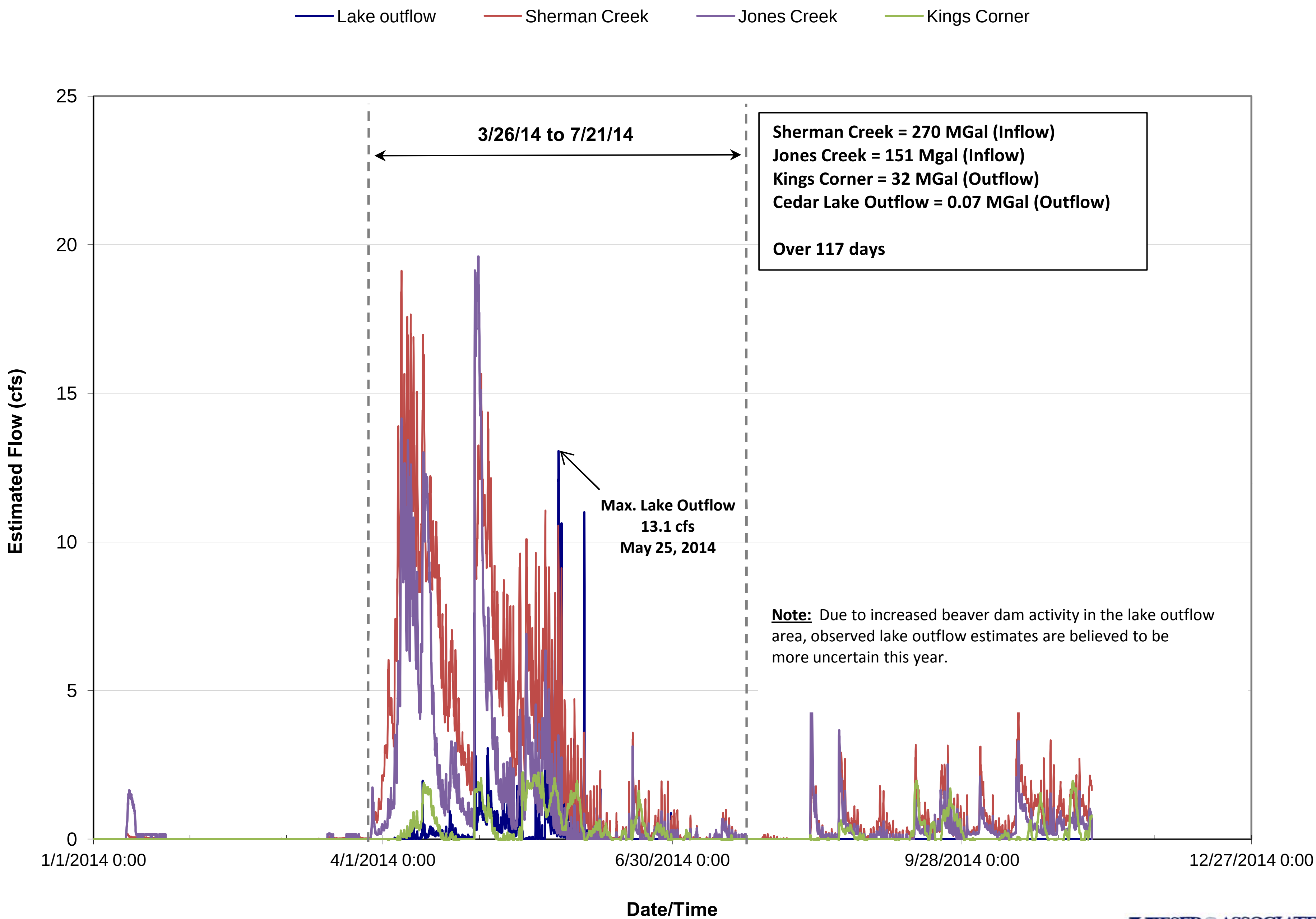

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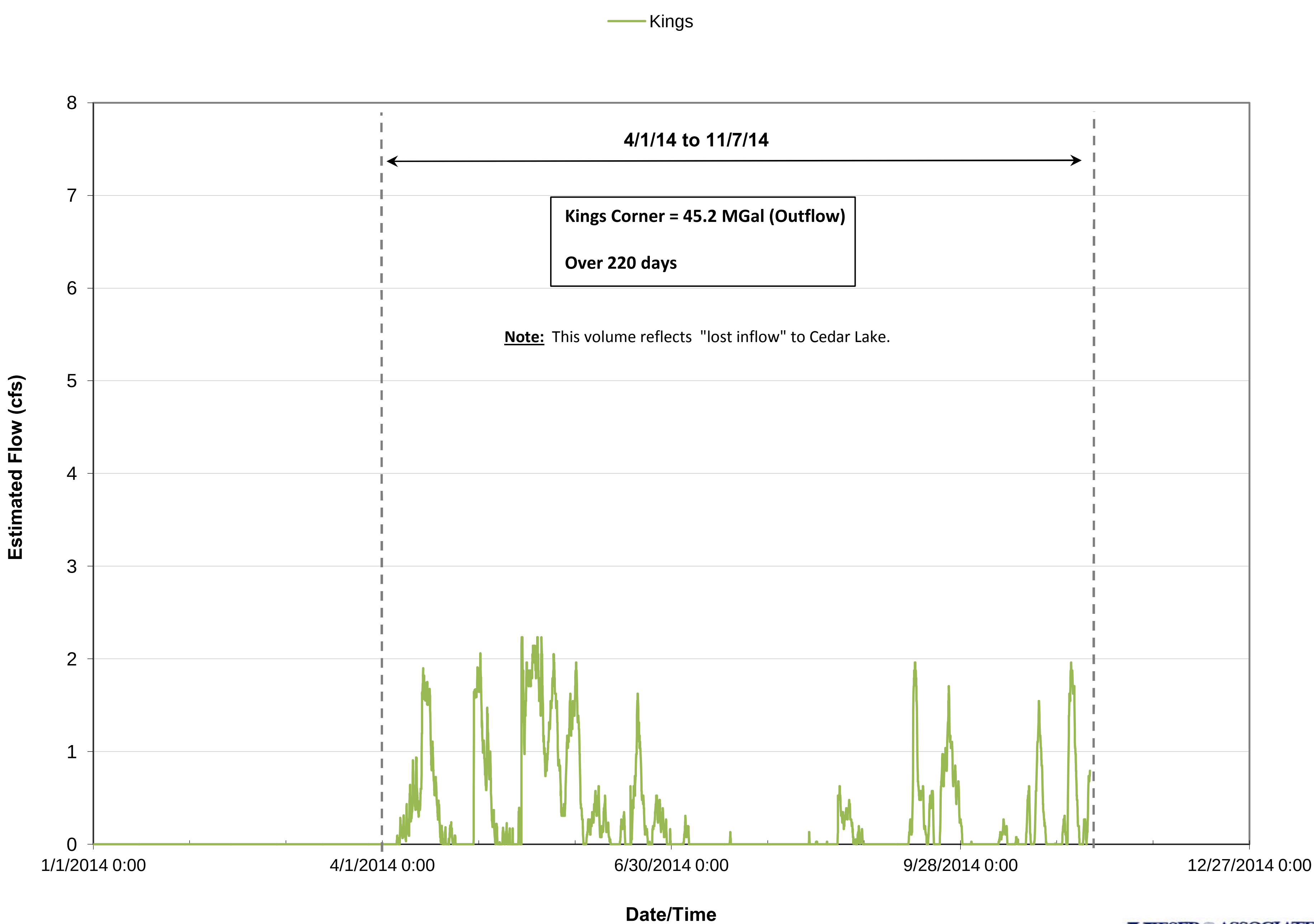
Figure 20. 2014 Estimated Kings Corner Total Outflow Losses



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