Appendix 1. Field Comparison between StablCal and Polymer Turbidity Standards at Neosho River at Burlingame Road near Emporia, Kansas (U.S. Geological Survey Station Number 07179750), May 16 to June 27, 2017

Comparison Description

Station name: Neosho River at Burlingame Road near Emporia, Kansas (U.S. Geological Survey [USGS] station number 07179750).

Equipment: A Yellow Springs Instruments (YSI) EXO water-quality monitor equipped with two YSI EXO turbidity sensors calibrated with different turbidity standards was deployed at the site for comparison between the two standards. The sensors were on the same monitor opposite each other with the central wiper in the middle. The monitor was set to log data every 15 minutes. No datum corrections were applied to either dataset.

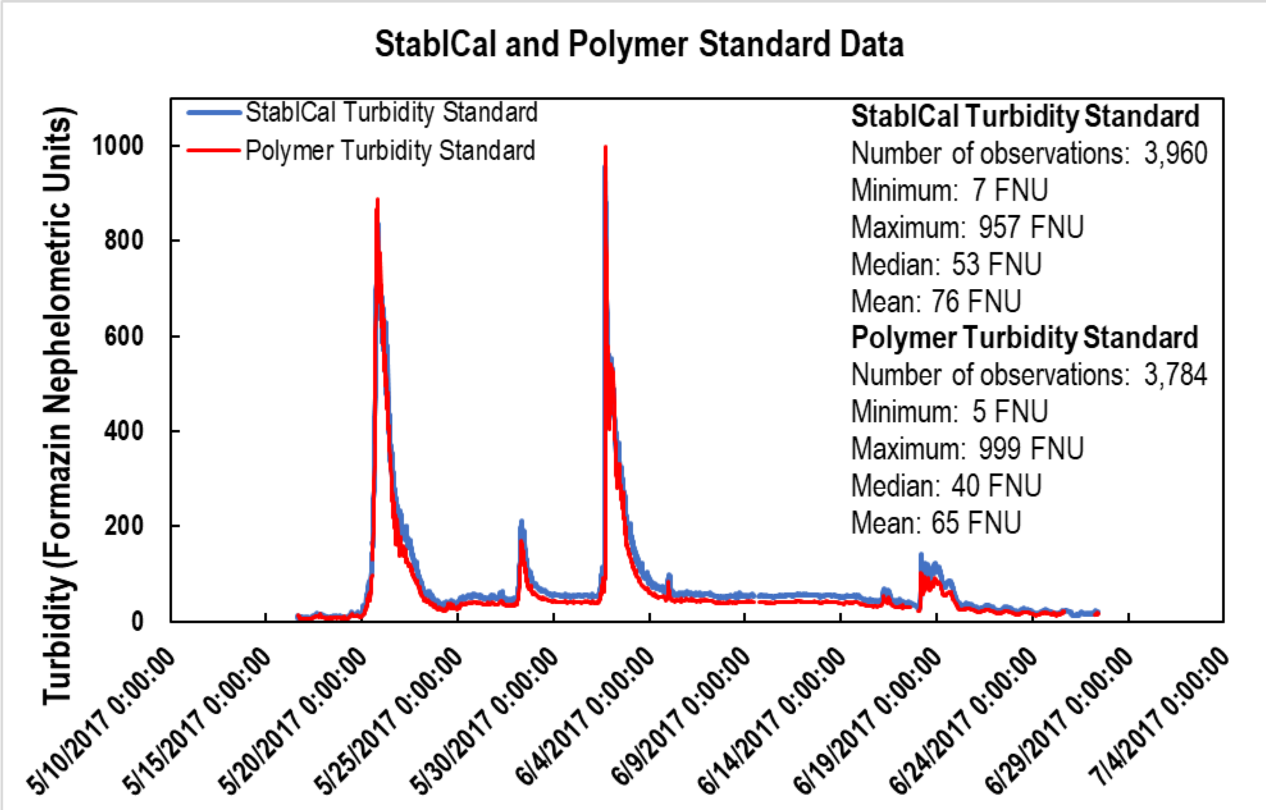
Calibration standard used: One sensor was calibrated with Hach StablCal turbidity standard and one sensor was calibrated with YSI polymer standard.

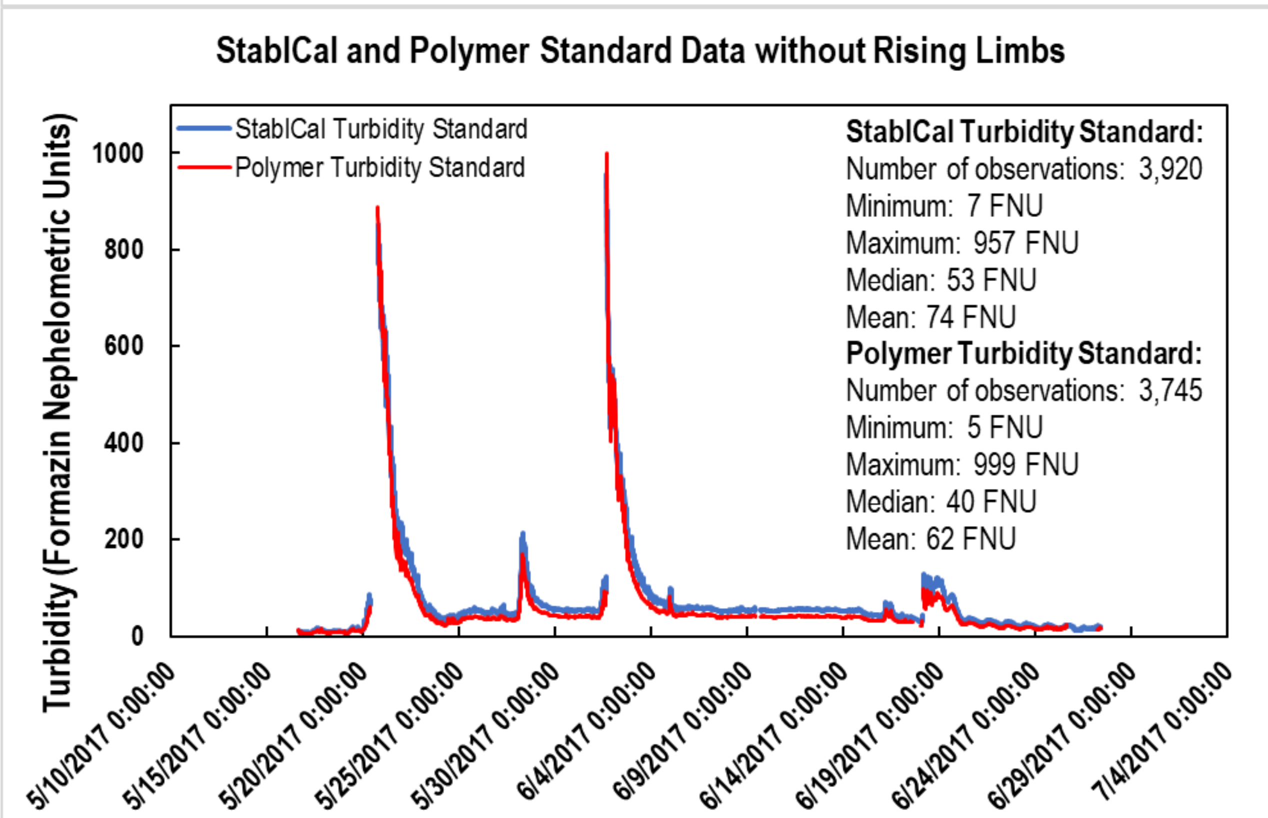
Side-by-side comparison data period: May 16 to June 27, 2017.

Datasets

All data were collected using USGS protocols (U.S. Geological Survey, variously dated) and are published in King (2021). Data were analyzed in three ways: (1) the entire dataset (0–1,000 formazin nephelometric units [FNU]) with only clearly erroneous data edited out, (2) 0–99 FNU with the rising limbs removed, and (3) 100–1,000 FNU with the rising limbs removed. Rising limbs were removed (on the basis of visual inspection, when the hydrograph became vertical to near vertical) to eliminate the effect of the highly variable turbidity readings commonly observed during this part of the hydrograph.

Time Series


StablCal and Polymer Standard Data
StablCal Turbidity Standard
Polymer Turbidity Standard
StablCal Turbidity Standard
Number of observations: 3,960
Minimum: 7 FNU
Maximum: 957 FNU
Median: 53 FNU
Mean: 76 FNU
Polymer Turbidity Standard
Number of observations: 3,784
Minimum: 5 FNU
Maximum: 999 FNU
Median: 40 FNU
Mean: 65 FNU
Turbidity (Formazin Nephelometric Units)
0
200
400
600
800
1000
5/10/2017 0:00:00
5/15/2017 0:00:00
5/20/2017 0:00:00
5/25/2017 0:00:00
5/30/2017 0:00:00
6/4/2017 0:00:00
6/9/2017 0:00:00
6/14/2017 0:00:00
6/19/2017 0:00:00
6/24/2017 0:00:00
6/29/2017 0:00:00
7/4/2017 0:00:00


StablCal and Polymer Standard Data without Rising Limbs
StablCal Turbidity Standard
Polymer Turbidity Standard
StablCal Turbidity Standard:
Number of observations: 3,920
Minimum: 7 FNU
Maximum: 957 FNU
Median: 53 FNU
Mean: 74 FNU
Polymer Turbidity Standard:
Number of observations: 3,745
Minimum: 5 FNU
Maximum: 999 FNU
Median: 40 FNU
Mean: 62 FNU
Turbidity (Formazin Nephelometric Units)
0
200
400
600
800
1000
5/10/2017 0:00:00
5/15/2017 0:00:00
5/20/2017 0:00:00
5/25/2017 0:00:00
5/30/2017 0:00:00
6/4/2017 0:00:00
6/9/2017 0:00:00
6/14/2017 0:00:00
6/19/2017 0:00:00
6/24/2017 0:00:00
6/29/2017 0:00:00
7/4/2017 0:00:00

Statistical Analyses – All Data

Slope Comparison

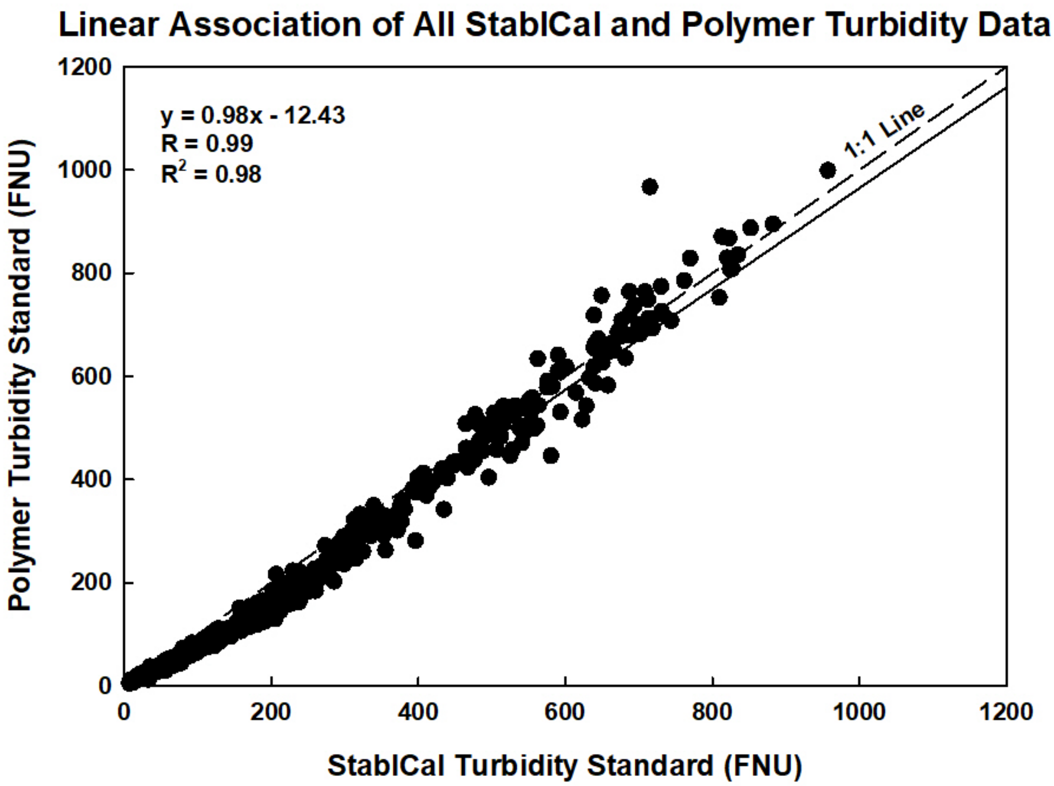
The following is a summary of final regression analysis for sensor-measured turbidity from two identical YSI EXO turbidity sensors calibrated by using two different turbidity standards at Neosho River at Burlingame Road near Emporia, Kansas, May 16 to June 27, 2017:

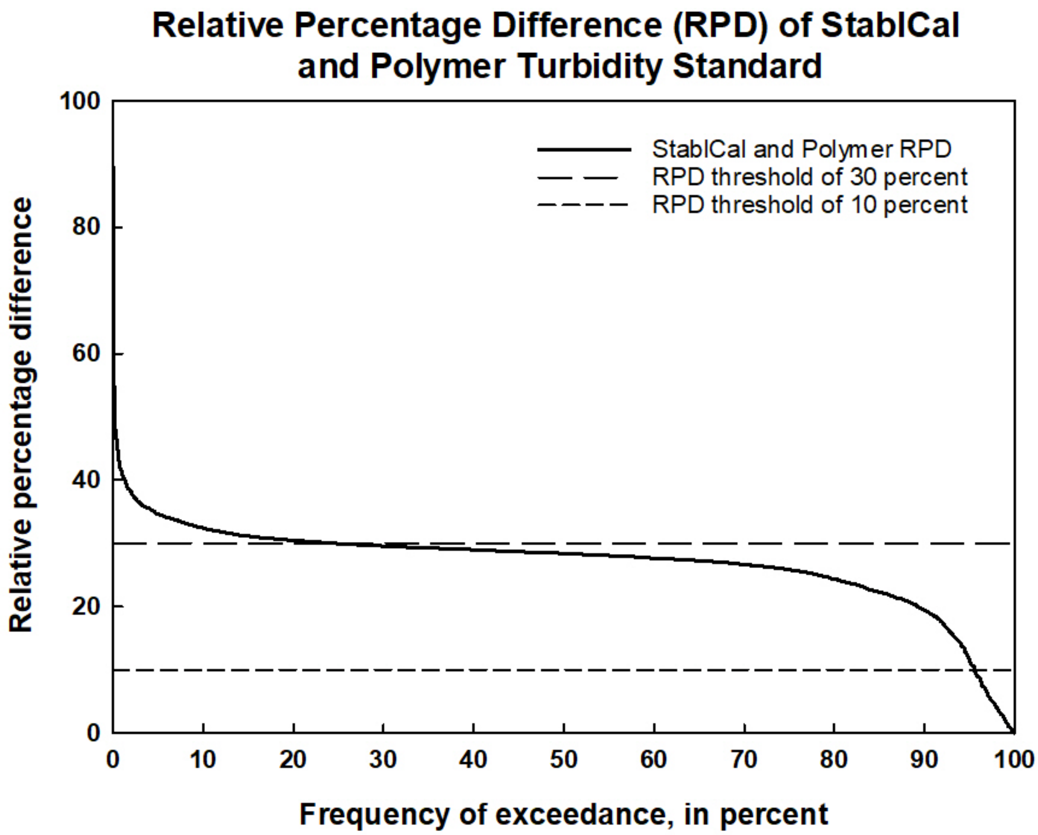
$$y = 0.98x - 12.43$$

where

y = turbidity measured with polymer turbidity standard (FNU)

x = turbidity measured with StablCal turbidity standard (FNU).





Wilcoxon Signed-Rank Test for All Data

SigmaPlot Statistical Output:

Normality Test (Shapiro-Wilk): Failed (P < 0.050)

Group	N	Missing	Median	25%	75%
StablCal	3764	0	53.720	37.692	63.150
Polymer	3764	0	40.285	27.678	47.288

W= -6833219.000 T+ = 126255.500 T-= -6959474.500

Z-Statistic (based on positive ranks) = -51.242

(P = <0.001)

The change that occurred with the treatment is greater than would be expected by chance; there is a statistically significant difference (P = <0.001).

R Statistical Output:

```
Wilcoxon Signed-Rank test with continuity correction

data:  Polymer and StablCal
V = 126255.5, p-value < 2.2e-16
alternative hypothesis: true location shift is not equal to 0
95 percent confidence interval:
 -13.24497 -12.88997
sample estimates:
(pseudo)median
     -13.07497
```

Summary of Results

There is a strong linear association between measurements made with the two sensors (R = 0.99). Twenty-four percent of the time the relative percentage difference in turbidity values measured with the two sensors was greater than 30 percent. The data did not pass the Shapiro-Wilk test for normality (P<0.05); therefore, a Wilcoxon signed-rank test was performed. The difference between median values for the StablCal and polymer turbidity standards was statistically significant (P<0.05).

Statistical Analyses – Low-Turbidity Conditions (0 to 99 FNU)

The data from the side-by-side comparison were separated into low- and high-turbidity conditions. The following statistical analyses are for low-turbidity conditions (between 0 and 99 FNU).

Slope Comparison

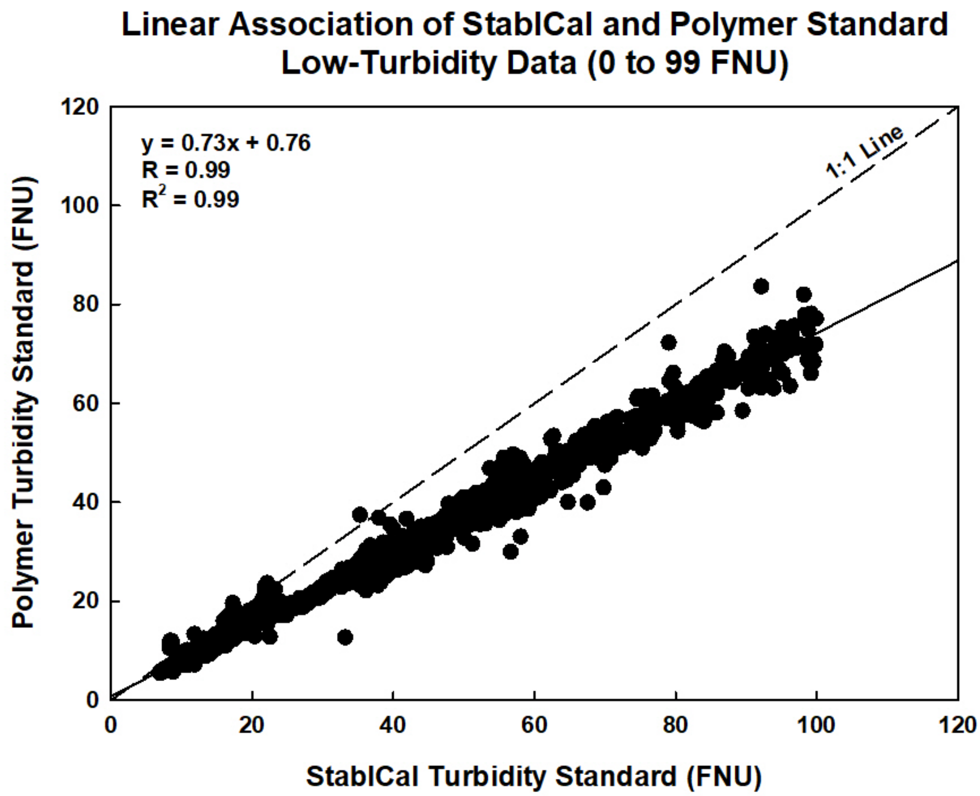
The following is a summary of final regression analysis for sensor-measured turbidity from two identical YSI EXO turbidity sensors calibrated by using two different turbidity standards at low-turbidity conditions (0–99 FNU) at Neosho River at Burlingame Road near Emporia, Kansas, May 16 to June 27, 2017:

$$y = 0.73x + 0.76$$

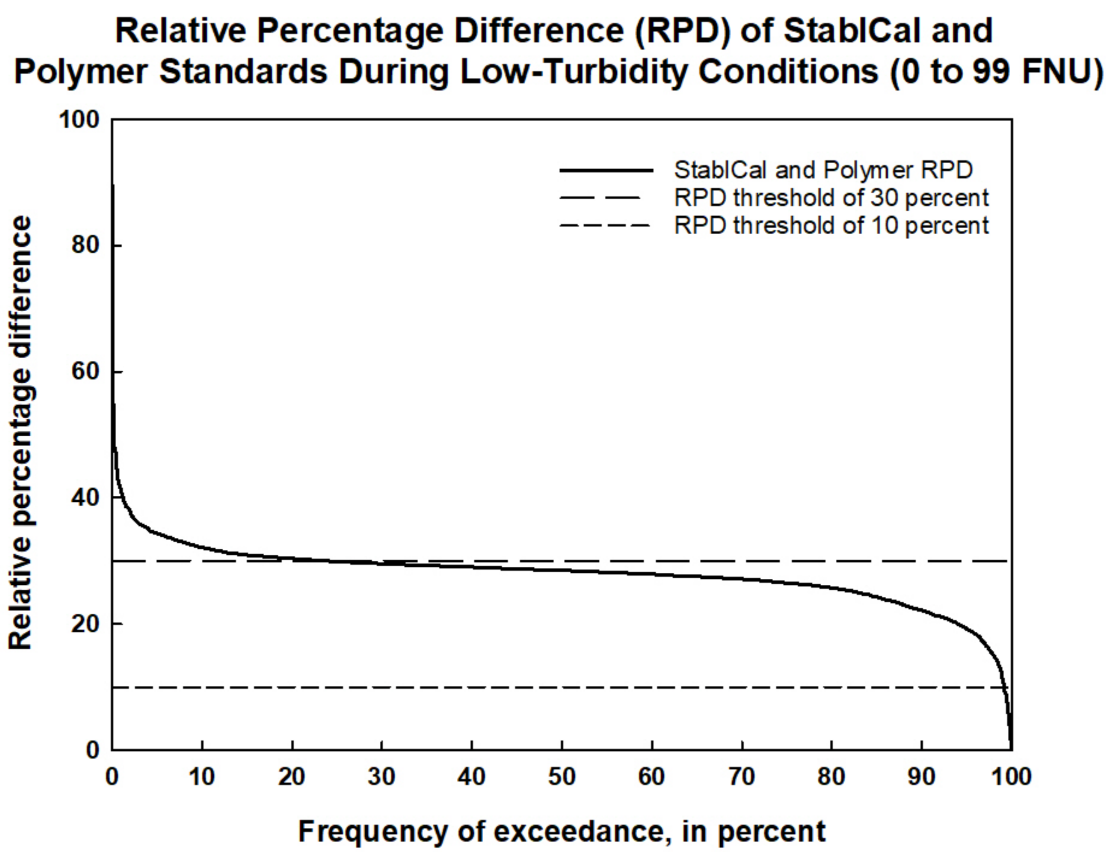
where

y = turbidity measured with polymer turbidity standard (FNU)

x = turbidity measured with StablCal turbidity standard (FNU).



Linear Association of StablCal and Polymer Standard
Low-Turbidity Data (0 to 99 FNU)
y = 0.73x + 0.76
R = 0.99
R^2 = 0.99
1:1 Line
Polymer Turbidity Standard (FNU)
StablCal Turbidity Standard (FNU)
0
20
40
60
80
100
120



Relative Percentage Difference (RPD) of StablCal and
Polymer Standards During Low-Turbidity Conditions (0 to 99 FNU)
StablCal and Polymer RPD
RPD threshold of 30 percent
RPD threshold of 10 percent
Relative percentage difference
Frequency of exceedance, in percent
0
10
20
30
40
50
60
70
80
90
100

Wilcoxon Signed-Rank Test for Low-Turbidity Data

SigmaPlot Statistical Output:

Normality Test (Shapiro-Wilk): Failed (P < 0.050)

Group	N	Missing	Median	25%	75%
StablCal	3204	0	52.500	32.743	55.988
Polymer	3204	0	39.235	23.985	41.907

W= -5128599.000 T+ = 2905.500 T-= -5131504.500

Z-Statistic (based on positive ranks) = -48.969

(P = <0.001)

The change that occurred with the treatment is greater than would be expected by chance; there is a statistically significant difference (P = <0.001).

R Statistical Output:

```
Wilcoxon Signed-Rank test with continuity correction

data:  Polymer and StablCal
V = 2905.5, p-value < 2.2e-16
alternative hypothesis: true location shift is not equal to 0
95 percent confidence interval:
 -12.07995 -11.64992
sample estimates:
(pseudo)median
     -11.86503
```

Summary of Results

There is a strong linear association between measurements made with the two sensors (R = 0.99). Twenty-four percent of the time the relative percentage difference in turbidity values measured with the two sensors was greater than 30 percent. The data did not pass the Shapiro-Wilk test for normality (P<0.05); therefore, a Wilcoxon signed-rank test was performed. The difference between median values for the StablCal and polymer turbidity standards was statistically significant (P<0.05).

Statistical Analyses – High-Turbidity Conditions (100 to 1,000 FNU)

The data from the side-by-side comparison were separated into low- and high-turbidity conditions. The following statistical analyses are for high-turbidity conditions (between 100 and 1,000 FNU).

Slope Comparison

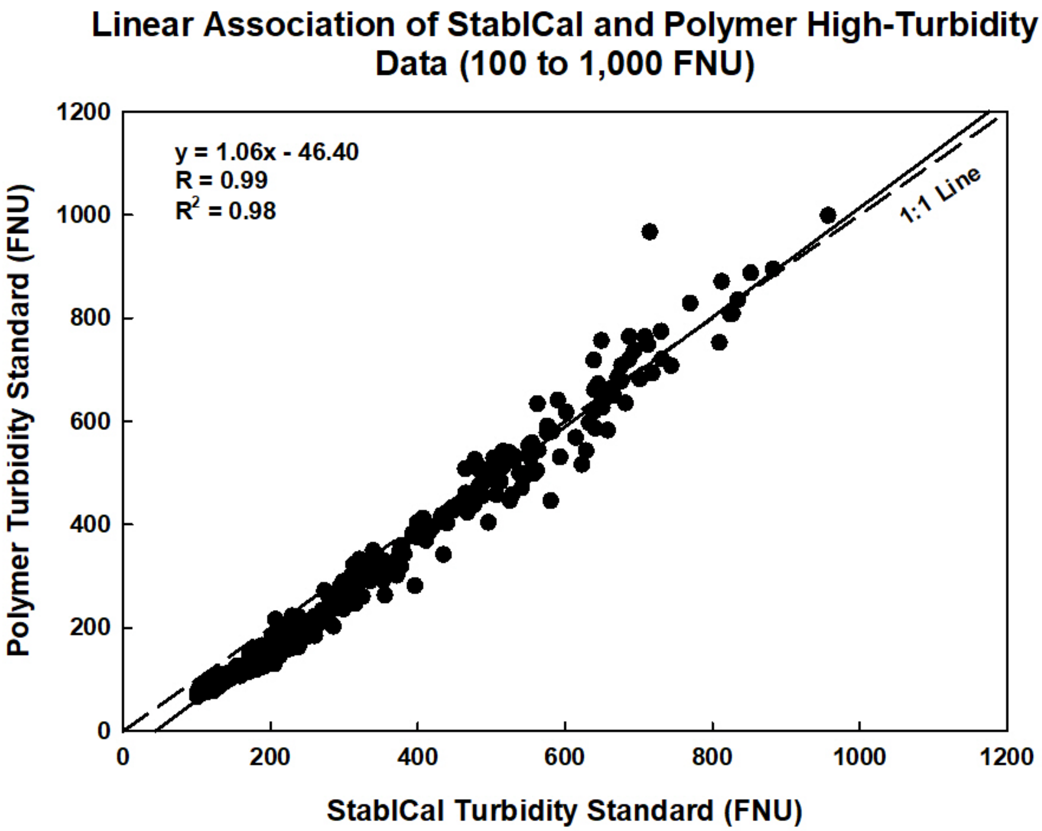
The following is a summary of final regression analysis for sensor-measured turbidity from two identical YSI EXO turbidity sensors calibrated by using two different turbidity standards at high-turbidity conditions (100 to 1,000 FNU) at Neosho River at Burlingame Road near Emporia, Kansas, May 16 to June 27, 2017:

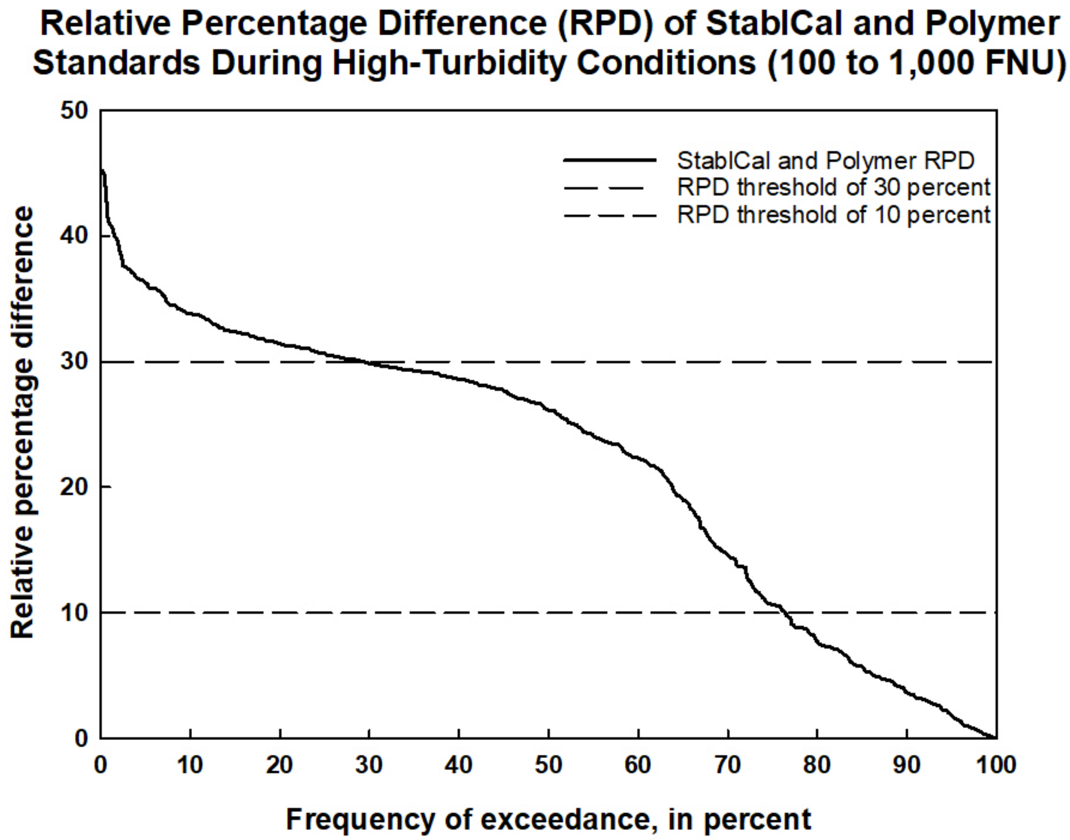
$$y = 1.06x - 46.40$$

where

y = turbidity measured with polymer turbidity standard (FNU)

x = turbidity measured with StablCal turbidity standard (FNU).





Wilcoxon Signed-Rank Test for High-Turbidity Data

SigmaPlot Statistical Output:

Normality Test (Shapiro-Wilk): Failed (P < 0.050)

Group	**N**	**Missing**	**Median**	**25%**	**75%**
StablCal	521	0	184.190	121.620	335.385
Polymer	521	0	141.570	89.665	304.800

W= -118725.000 T+ = 8628.000 T-= -127353.000

Z-Statistic (based on positive ranks) = -17.267

(P = <0.001)

The change that occurred with the treatment is greater than would be expected by chance; there is a statistically significant difference (P = <0.001).

R Statistical Output:

```
Wilcoxon Signed-Rank test with continuity correction

data:  Polymer and StablCal
V = 8628, p-value < 2.2e-16
alternative hypothesis: true location shift is not equal to 0
95 percent confidence interval:
 -34.67004 -31.75001
sample estimates:
(pseudo)median
     -33.23003
```

Summary of Results

There is a strong linear association between measurements made with the two sensors (R = 0.99). Twenty-nine percent of the time the relative percentage difference in turbidity values measured with the two sensors was greater than 30 percent. The data did not pass the Shapiro-Wilk test for normality ($P<0.05$); therefore, a Wilcoxon signed-rank test was performed. The difference between median values for the StablCal and polymer turbidity standards was statistically significant ($P<0.05$).

Selected References

Cleveland, W.S., 1979, Robust locally weighted regression and smoothing scatterplots: Journal of the American Statistical Association, v. 74, no. 368, p. 829–836.

Helsel, D.R., and Hirsch, R.M., 2002, Statistical methods in water resources—Hydrologic analysis and interpretation: U.S. Geological Survey Techniques of Water-Resources Investigations, book 4, chap. A3, 522 p. [Also available at https://doi.org/10.3133/twri04A3.]

King, L.R., 2021, Laboratory and field data for selected turbidity standard and sensor comparisons, October 2014 to September 2017: U.S. Geological Survey Data Release, https://doi.org/10.5066/P9EVSDHH.

U.S. Geological Survey, variously dated, The national field manual for the collection of water-quality data: U.S. Geological Survey Techniques and Methods, book 9, chaps A1–A10. [Also available at https://water.usgs.gov/owq/FieldManual/.]