Memorandum

DONOHUE

Date: April 26, 2017

To: David Casper, Commissioner
Bruce Siebers, Commissioner
Kevin Coffey, Commissioner
Patrick Hennessey, Commissioner
John Sundelius, Commissioner
Brian Helminger, District Manager
Chad Giackino, Regulatory Compliance Manager

Copy: John Neumeier and John Sundelius, City of Kaukauna
Jeff Elrick, Village of Little Chute
Joann Ashauer, Darboy Sanitary District No. 1
Dave VanderVelden, Village of Kimberly
Racquel Shampo-Giese, Village of Combined Locks
Dawn Bartel, HOVMSD
Ed Nevers, Donohue & Associates

From: Tracey Webb, Donohue & Associates

Re: **2016 Annual Flow Summary**
Heart of the Valley Metropolitan Sewerage District

The following memorandum documents the analysis and observations of the 2016 clear water (inflow and infiltration) flow component of the overall HOVMSD wastewater flow.

HOVMSD SUSTAINABILTY PROGRAM

HOVMSD has implemented a self-regulated sustainability program to maintain, monitor, and regulate flow to the WWTP. The goal of the sustainability program is to maintain or extend the longevity of the WWTP and interceptor capacity by not increasing the existing level of clear water in the system and decreasing the clear water entering the system where possible.

Performance indicators provide a degree of insight to relative volume of clear water that is entering the system from the HOVMSD member communities and to the impacts of the clear water on the system. For the 2016 yearly evaluation, Donohue reviewed performance indicators from the following sources:

1. Observations at the HOVMSD wastewater treatment plant,
2. Analysis of the clear water components of flow through the Antecedent Moisture Model (AMM),
3. Analysis of the clear water components of flow identified in the Compliance Maintenance Annual Reports (CMAR) for each member community.

The following sections of the memorandum document the observations and analysis of the performance indicators listed above.

OBSERVATIONS AT HOVMSD WASTEWATER TREATMENT PLANT

The performance of the HOVMSD plant is ultimately the issue of greatest concern for the Wisconsin Department of Natural Resources (WDNR). If there are permit violations or steadily increasing secondary treatment diversion events and volumes, the WDNR may increase their oversight or impose/reinstate flow reduction mandates.

PLANT PERFORMANCE

YEAR	PLANT FLOW (million gallons)	ANNUAL REPORTED PRECIPITATION (inches)	NUMBER OF SECONDARY TREATMENT DIVERSIONS	VOLUME OF DIVERTED FLOW (million gallons/year)
2010	2,391.17	32.25	3	14.258
2011	2,359.30	30.08	1	3.998
2012	1,844.61	17.89	0	0
2013	2,014.11	27.14	1	0.562
2014	2,079.44	29.34	2	3.549
2015	1,887.99	29.93	3	2.185
2016	2,020.67	27.71	0	0

In 2016, HOVMSD was able to provide secondary treatment for the total influent volume during every rainfall event. There were no diversions in 2016. The last year that the plant saw no diversions was in 2012 when the annual reported precipitation was 17.89 inches as compared to the 27.71 inches reported in 2016.

PLANT SECONDARY TREATMENT DIVERSION DETAILS

DATE	PLANT FLOW (million gallons)	FOX ENERGY PUMPING (million gallons)	VOLUME OF DIVERTED FLOW (million gallons/event)
July 14, 2010	30.824	2.240	12.304
July 15, 2010	21.535	2.045	1.954
August 11, 2010	19.408	0.832	2.360
April 26, 2011	27.177	0.763	3.998
2012 - None			
April 10, 2013	22.526	2.221	0.562
April 14, 2014	21.435	0.050	1.718
May 28, 2014	21.958	1.505	1.831
June 15, 2015	15.934	3.277	0.800
September 8, 2015	15.346	2.453	0.027
December 14, 2015	30.390	1.877	1.358
2016 – None			

Annual plant flow and reported precipitation in 2016 was very similar to 2013. While the actual treated flow for 2016 was slightly higher than 2013, the number of diversions was reduced to none in 2016. However, the number and volume of the diversions can be greatly dependent on the frequency and intensity of rainfall events.

The top rainfall events are utilized in this evaluation. The criteria used to identify an event is any storm with a rainfall average of more than one inch for the duration of the storm. The average rainfall for the storm occurring on October 26 was slightly below the one inch criteria, but was included because the duration was less than 24-hours. Of the nine identified events none met the intensity of a 1-year recurrence interval.

2016 RAINFALL INTENSITY				
EVENT DATES	STORM DURATION (days)	RAINFALL AVERAGE (inches)	INTENSITY (in/hr)	RAINFALL RECURRENCE INTERVAL
3/13 - 3/16	2.96	1.26	0.018	2-month
5/25 - 5/29	3.86	1.73	0.019	4-month
6/12 - 6/15	2.85	1.80	0.026	6-month
6/25 - 6/26	0.29	1.50	0.214	6-month
8/19 - 8/21	2.30	1.15	0.021	2-month
9/6 - 9/7	1.47	1.46	0.041	3-month
9/21 - 9/22	1.24	1.30	0.044	3-month
10/26	0.70	0.95	0.056	2-month
11/27 - 12/1	4.52	1.07	0.010	< 2-month

Plant flows for March 2016 accounted for 266.9 million gallons, which was over 13% of the annual flow. Rain gauge data was not available prior to March 7, 2016. Between March 2, 2016 and March 6, 2017 the communities had approximately 7-inches of new snow melt, some rain and prior snow melt runoff. This event was not analyzed.

ANTECEDENT MOISTURE MODELING

Donohue used the antecedent moisture model with flow data from 2006-2008 and 50 years of rainfall and temperature data to:

- Calibrate the collection system performance,
- Predict the future plant flows and interceptor performance assuming there were no changes within the system to reduce clear water flow, and
- Extrapolate future plant flows and interceptor performance given completed efforts to reduce the clear water (inflow and infiltration) within the system.

The same model is now used on an annual basis to evaluate the yearly, incremental change in the overall system performance.

The member community scatter plots included at the end of the memorandum depict the AMM modeling results.

1. The results are presented as a comparison of the modeled flow versus the measured flow for given rainfall events.
2. The modeled flow is the flow that is predicted for a rainfall event based on the calibrated model.
3. The measured flow is the actual flow measured by a member community meter station for a rainfall event or the combined measured flow for a community with multiple meter stations.
4. The diagonal, heavy solid line represents the point at which the measured flow matches the modeled flow. This is the baseline (2006-2008 reference line) at the beginning of the program and the line to compare progress.
5. For points above the baseline, the modeled flow over-predicts the measured flow. Therefore, the sanitary sewer system is producing less flow than the model would have predicted for the given storm event. It is assumed that this represents clear water reduction progress.
6. For points below the baseline, an individual storm event produced a greater amount of flow than predicted. It is assumed that this represents more clear water in the system than at the point of original calibration.
7. A trend line is given for each year to summarize the analyzed storm events in that given year.
8. Trend line above the dashed, baseline represents clear water reduction progress compared to baseline year.
9. Tread lines below the dashed, baseline represent an increase in clear water in the sanitary sewer system compared to the baseline.
10. In an ideal, closed system where continual clear water reduction occurs, the annual tread lines would be increasing over the solid baseline.

The model is not calibrated for the conditions surrounding an early spring event. In addition, the rain gauges were not recording data prior to March 7, 2016. Therefore, the rainfall and flow event occurring around March 5th was not modeled. The event that occurred between September 6 and September 7 was also excluded from the model evaluation due to a 2 hour and 15 minute flow data gap for all communities shortly after the peak.

The modeled flows represent the impact of peak flows. Communities continue to reduce the base flow component of their total flow by implementing projects such as repairs or replacement of cracked or damaged pipes, manholes, and connections in the sanitary sewer system. These sources of flow are true I/I sources but have a constant flow of water due to their location below groundwater or in/alongside the river. As a result, they appear to be part of the 'base' flow for the communities.

Member community modeling results showing the *Annual Peak Flows* and *Three Year Rolling Averages of Peak Flows* are included at the end of this memorandum.

Observations:

- Kaukauna, Little Chute, Combined Locks, and Darboy all showed improvement in annual peak flow reduction.
- Kaukauna's showed an improvement in annual peak flow reduction in 2016 to levels similar to 2013. Their 3-year average peak flow deteriorated slightly.
- Kimberly showed a slight deterioration in peak flow reduction but is consistently above the percent peak flow reduction reference line. This is expected given the model was developed prior to removal of peak inflows from the Kimberly Mill from their system.
- Little Chute's annual peak flow percent reduction improved since 2015 but it are still below the reference point. Their 3-year average peak flow deteriorated slightly.
- Combined Locks' annual peak flow improved significantly over the past two years. The 3-year rolling average is generally stable but is showing some continual deterioration.
- Darboy's annual peak flows improved. The three-year rolling average shows substantial improvement over the previous 3-year averages.

MEMBER COMMUNITY CMAR DATA

WDNR requires that member communities and the district prepare annual CMARs and submit them to the WDNR by October of each year. The CMAR has sanitary sewer condition performance indicators that include:

- lift station failures
- sewer pipe failures
- sanitary sewer overflows
- basement backups
- number of complaints
- peaking factor ratio (peak monthly to annual daily average)
- peaking factor ratio (peak hourly to annual daily average)

Annual reported precipitation is provided by HOVMSD based on one regional recording station. Individual community rainfall gages are not used for the annual total precipitation values as they are not in service during frost/freezing susceptible times (late fall to early spring). A summary of the previous performance indicators and CMAR flow data/peaking factor ratios for each community are summarized in the following tables.

CMARs from the communities were reviewed to determine the trend in the performance indicators. CMAR summaries are given on the following pages. Observations of note:

- For all communities, the peak monthly event occurred in March.
- The average daily flow for 2016 was slightly higher but comparable to the previous 3-year average, excepting Darboy.

PREVIOUS 3-YEAR AVERAGE COMPARISON
AVERAGE DAILY FLOW IN MGD

	Kaukauna	Kimberly	Little Chute	Combined Locks	Darboy
2013	2.35	0.68	1.39	0.34	1.02
2014	2.60	0.75	1.45	0.36	1.06
2015	2.25	0.65	1.25	0.31	0.92
Average	2.40	0.69	1.36	0.34	1.00
2016	2.41	0.76	1.36	0.32	0.82

- Because the average daily flows were comparable to previous years the trend of the peak flow value had a greater influence on the trend of the ratio values.
- The 2016 peak monthly flow was higher than 2015 for all communities, causing the monthly peaking factor ratio to increase for all communities.
- The peak hourly flow was lower for all communities, causing the hourly peaking factor ratio to decrease for all communities.
- For Kaukauna, Little Chute and Combined Locks the peak hourly event occurred on June 15. The peak hourly event for Kimberly was March 16. The peak hourly event for Darboy was December 26. All communities, except Kimberly, showed the March 16 event as the second highest peak hourly flow.
- For Darboy the average daily flow was the lowest of the 7 years analyzed which produced the highest monthly peaking factor ratio during the comparison period.

Kaukauna

KAUKAUNA CMAR PERFORMANCE INDICATOR SUMMARY

YEAR	NUMBER OF LIFT STATION FAILURES[1]	NUMBER OF SEWER PIPE FAILURES	NUMBER OF BASEMENT BACKUP OCCURRENCES	NUMBER OF COMPLAINTS
2010	0	1	0	27
2011	0	1	2	26
2012	0	0	3	32
2013	0	0	2	30
2014	0	0	0	27
2015	0	0	0	17
2016	0	0	0	0

[1]Kaukauna has five major (traditional) and two minor lift stations. One of the minor lift stations is a semi-public station at the softball fields/1000 Islands Park. The second minor lift station is manually operated to pump leachate from an old landfill. HOV is notified each time the landfill lift station is operated.

KAUKAUNA CMAR PEAKING FACTOR RATIOS

YEAR	ANNUAL REPORTED PRECIPITATION (inches)	ANNUAL AVERAGE DAILY FLOW (MGD)	PEAKING FACTOR RATIO (MONTHLY: ANNUAL DAILY AVERAGE)	PEAKING FACTOR RATIO (PEAK HOURLY: ANNUAL DAILY AVERAGE)	PEAKING FACTOR RATIO – TOP 10 AVERAGE (PEAK HOURLY: ANNUAL DAILY AVERAGE)
2010	32.25	3.07	1.60	6.58	4.47
2011	30.08	3.53	1.55	4.02	3.14
2012	17.89	2.36	1.44	6.79	3.69
2013	27.14	2.35	1.77	5.51	3.79
2014	29.34	2.60	1.57	6.99	4.19
2015	29.93	2.25	1.60	8.93	4.94
2016	23.59	2.41	1.61	5.19	3.34

Little Chute

LITTLE CHUTE CMAR PERFORMANCE INDICATOR SUMMARY				
YEAR	NUMBER OF LIFT STATION FAILURES	NUMBER OF SEWER PIPE FAILURES	NUMBER OF BASEMENT BACKUP OCCURRENCES	NUMBER OF COMPLAINTS
2010	NA	0	2	2
2011	NA	0	0	0
2012	NA	0	2	2
2013	NA	0	0	0
2014	NA	0	0	0
2015	NA	0	0	0
2016	NA	0	0	0

LITTLE CHUTE CMAR PEAKING FACTOR RATIOS					
YEAR	ANNUAL REPORTED PRECIPITATION (inches)	ANNUAL AVERAGE DAILY FLOW (MGD)	PEAKING FACTOR RATIO (MONTHLY: ANNUAL DAILY AVERAGE)	PEAKING FACTOR RATIO (PEAK HOURLY: ANNUAL DAILY AVERAGE)	PEAKING FACTOR RATIO – TOP 10 AVERAGE (PEAK HOURLY: ANNUAL DAILY AVERAGE)
2010	32.25	1.46	1.66	9.49	5.31
2011	30.08	1.49	2.05	5.65	3.94
2012	17.89	1.16	1.50	5.20	3.71
2013	27.14	1.39	1.75	4.80	3.44
2014	29.34	1.45	1.67	6.01	4.00
2015	29.93	1.25	1.54	9.33	4.27
2016	25.22	1.36	1.65	4.68	3.08

Kimberly

KIMBERLY CMAR PERFORMANCE INDICATOR SUMMARY				
YEAR	NUMBER OF LIFT STATION FAILURES[1]	NUMBER OF SEWER PIPE FAILURES	NUMBER OF BASEMENT BACKUP OCCURRENCES	NUMBER OF COMPLAINTS
2010	0	0	0	0
2011	0	0	0	0
2012	0	0	0	0
2013	0	0	0	0
2014	0	0	0	0
2015	0	0	1	1
2016	0	0	0	0

[1]Kimberly had three lift stations. In 2013, the lift station that serviced part of the Kimberly mill was taken out of commission. It was later eliminated in 2015. In 2014, another lift station was eliminated. Kimberly has one remaining lift station.

KIMBERLY CMAR PEAKING FACTOR RATIOS					
YEAR	ANNUAL REPORTED PRECIPITATION (inches)	ANNUAL AVERAGE DAILY FLOW (MGD)	PEAKING FACTOR RATIO (MONTHLY: ANNUAL DAILY AVERAGE)	PEAKING FACTOR RATIO (PEAK HOURLY: ANNUAL DAILY AVERAGE)	PEAKING FACTOR RATIO – TOP 10 AVERAGE (PEAK HOURLY: ANNUAL DAILY AVERAGE)
2010	32.25	0.98	1.71	11.07	7.45
2011	30.08	0.84	2.39	8.36	5.19
2012	17.89	0.68	1.53	7.56	5.14
2013	27.14	0.68	2.00	6.62	4.69
2014	29.34	0.75	1.76	9.32	6.32
2015	29.93	0.65	1.46	14.25	5.96
2016	24.51	0.76	1.64	5.43	3.69

Combined Locks

COMBINED LOCKS CMAR PERFORMANCE INDICATOR SUMMARY				
YEAR	NUMBER OF LIFT STATION FAILURES	NUMBER OF SEWER PIPE FAILURES	NUMBER OF BASEMENT BACKUP OCCURRENCES	NUMBER OF COMPLAINTS
2010	NA	0	2	2
2011	NA	0	0	1
2012	NA	0	0	0
2013	NA	0	0	1
2014	NA	0	0	0
2015	NA	0	0	0
2016	NA	0	0	0

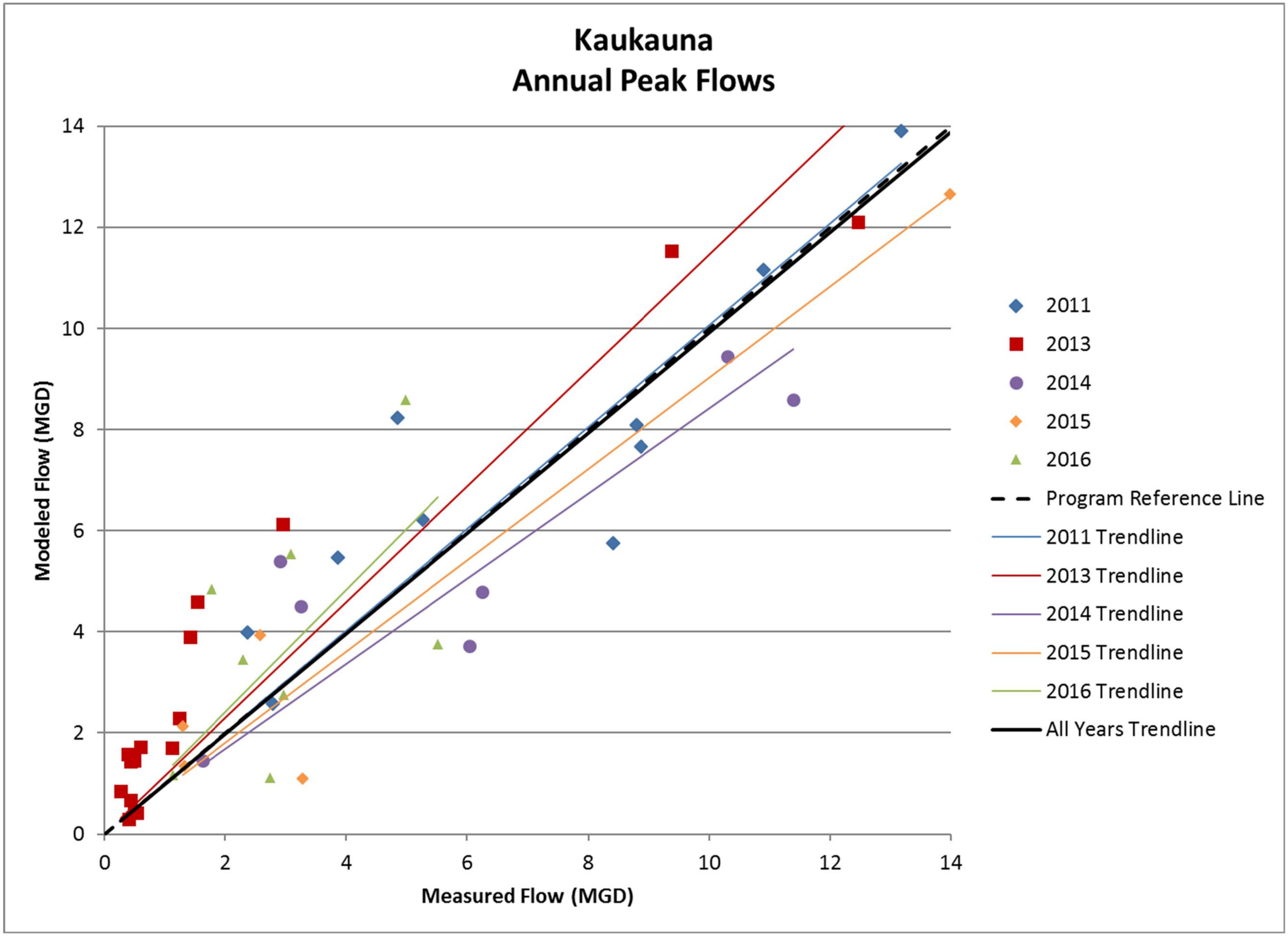
COMBINED LOCKS CMAR PEAKING FACTOR RATIOS					
YEAR	ANNUAL REPORTED PRECIPITATION (inches)	ANNUAL AVERAGE DAILY FLOW (MGD)	PEAKING FACTOR RATIO (MONTHLY: ANNUAL DAILY AVERAGE)	PEAKING FACTOR RATIO (PEAK HOURLY: ANNUAL DAILY AVERAGE)	PEAKING FACTOR RATIO – TOP 10 AVERAGE (PEAK HOURLY: ANNUAL DAILY AVERAGE)
2010	32.25	0.38	1.78	10.77	6.55
2011	30.08	0.38	2.13	6.65	4.24
2012	17.89	0.30	1.56	7.74	4.65
2013	27.14	0.34	1.83	6.26	4.03
2014	29.34	0.36	1.75	7.64	5.34
2015	29.93	0.31	1.79	12.04	5.72
2016	24.51	0.32	1.81	5.53	3.81

Darboy

DARBOY CMAR PERFORMANCE INDICATOR SUMMARY				
YEAR	NUMBER OF LIFT STATION FAILURES	NUMBER OF SEWER PIPE FAILURES	NUMBER OF BASEMENT BACKUP OCCURRENCES	NUMBER OF COMPLAINTS
2010	NA	0	0	0
2011	NA	0	0	0
2012	NA	4	0	4
2013	NA	0	0	0
2014	NA	0	0	0
2015	NA	0	0	0
2016	NA	1	0	1

There was one reported overflow into a nearby creek on March 15, 2016. It was due to displacement of a manhole casting by system surcharging. The structure has since been replaced and several other maintenance activities were implemented during 2016 to reduce infiltration and plugging in the system.

DARBOY CMAR PEAKING FACTOR RATIOS					
YEAR	ANNUAL REPORTED PRECIPITATION (inches)	ANNUAL AVERAGE DAILY FLOW (MGD)	PEAKING FACTOR RATIO (MONTHLY: ANNUAL DAILY AVERAGE)	PEAKING FACTOR RATIO (PEAK HOURLY: ANNUAL DAILY AVERAGE)	PEAKING FACTOR RATIO – TOP 10 AVERAGE (PEAK HOURLY: ANNUAL DAILY AVERAGE)
2010	32.25	0.95	1.19	3.60	2.93
2011	30.08	0.96	1.31	2.71	2.36
2012	17.89	0.94	1.11	3.29	2.45
2013	27.14	1.02	1.25	2.76	2.35
2014	29.34	1.06	1.27	2.99	2.29
2015	29.93	0.92	1.14	4.27	2.62
2016	24.64	0.82	1.43	2.82	2.50


Kaukauna
Annual Peak Flows
Modeled Flow (MGD)
Measured Flow (MGD)
0
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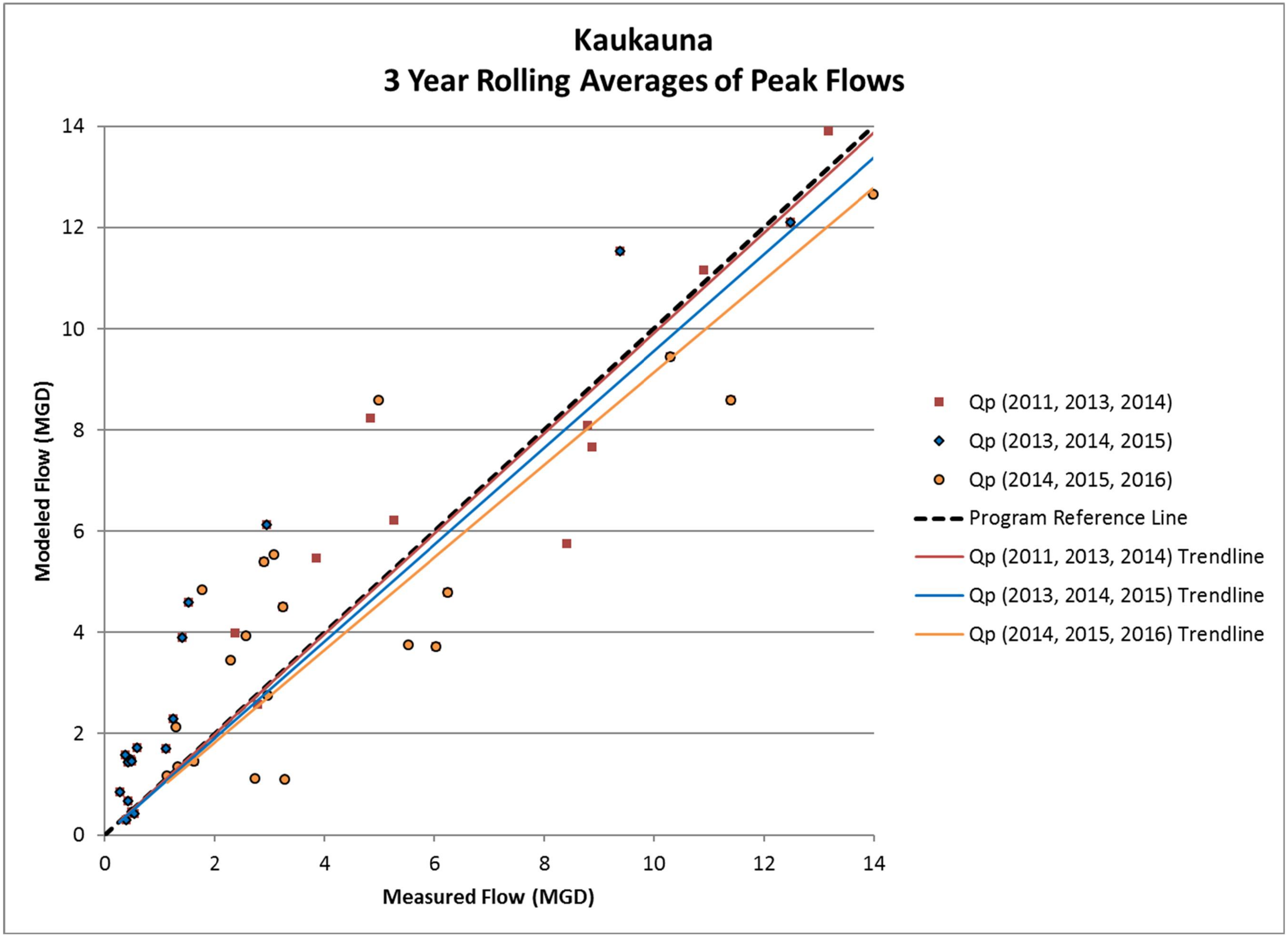
2011 Trendline
2013 Trendline
2014 Trendline
2015 Trendline
2016 Trendline
All Years Trendline


Kaukauna
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Measured Flow (MGD)
0
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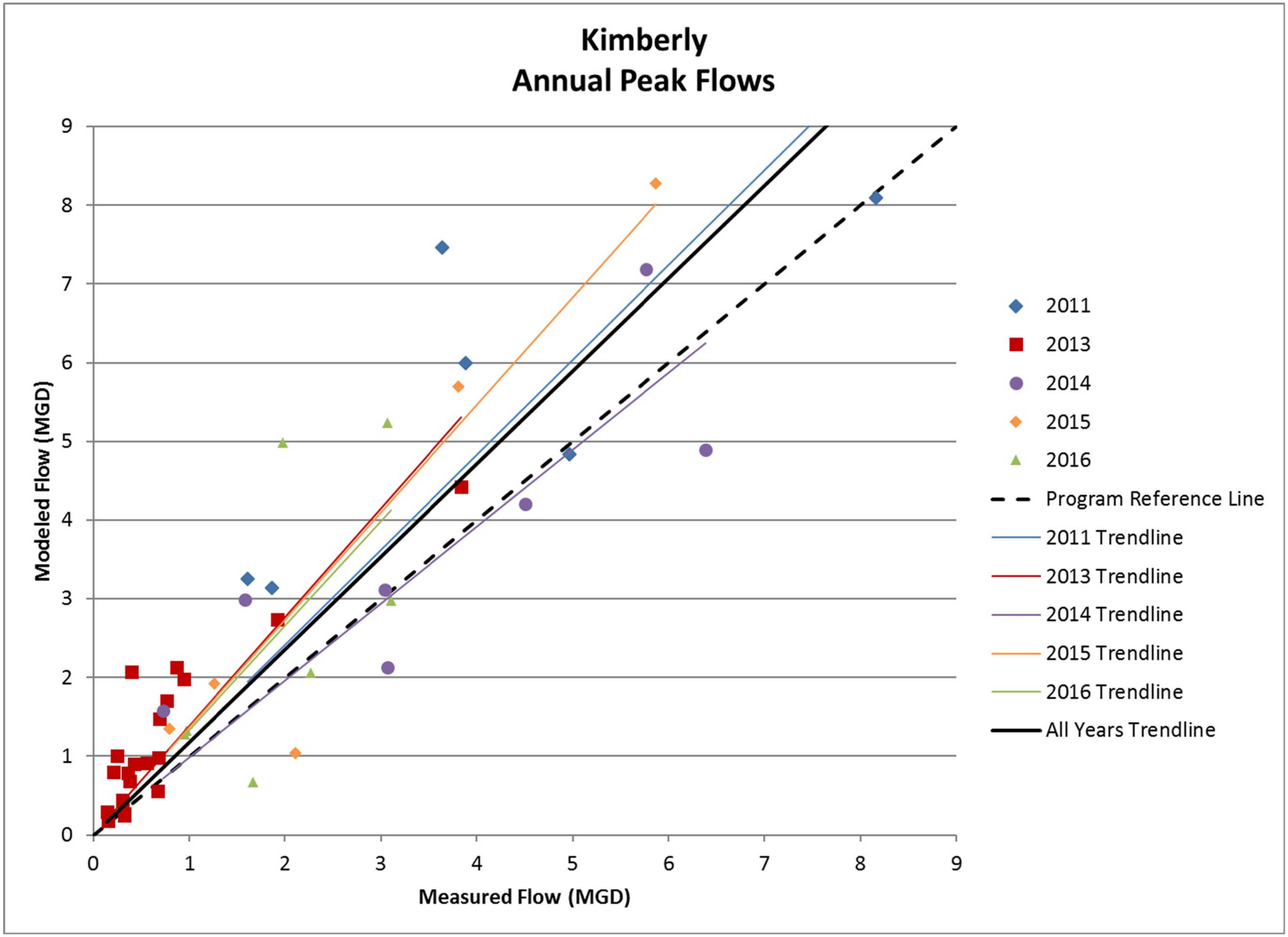
Qp (2011, 2013, 2014)
Qp (2013, 2014, 2015)
Qp (2014, 2015, 2016)
Program Reference Line
Qp (2011, 2013, 2014) Trendline
Qp (2013, 2014, 2015) Trendline
Qp (2014, 2015, 2016) Trendline


Kimberly
Annual Peak Flows
Modeled Flow (MGD)
Measured Flow (MGD)
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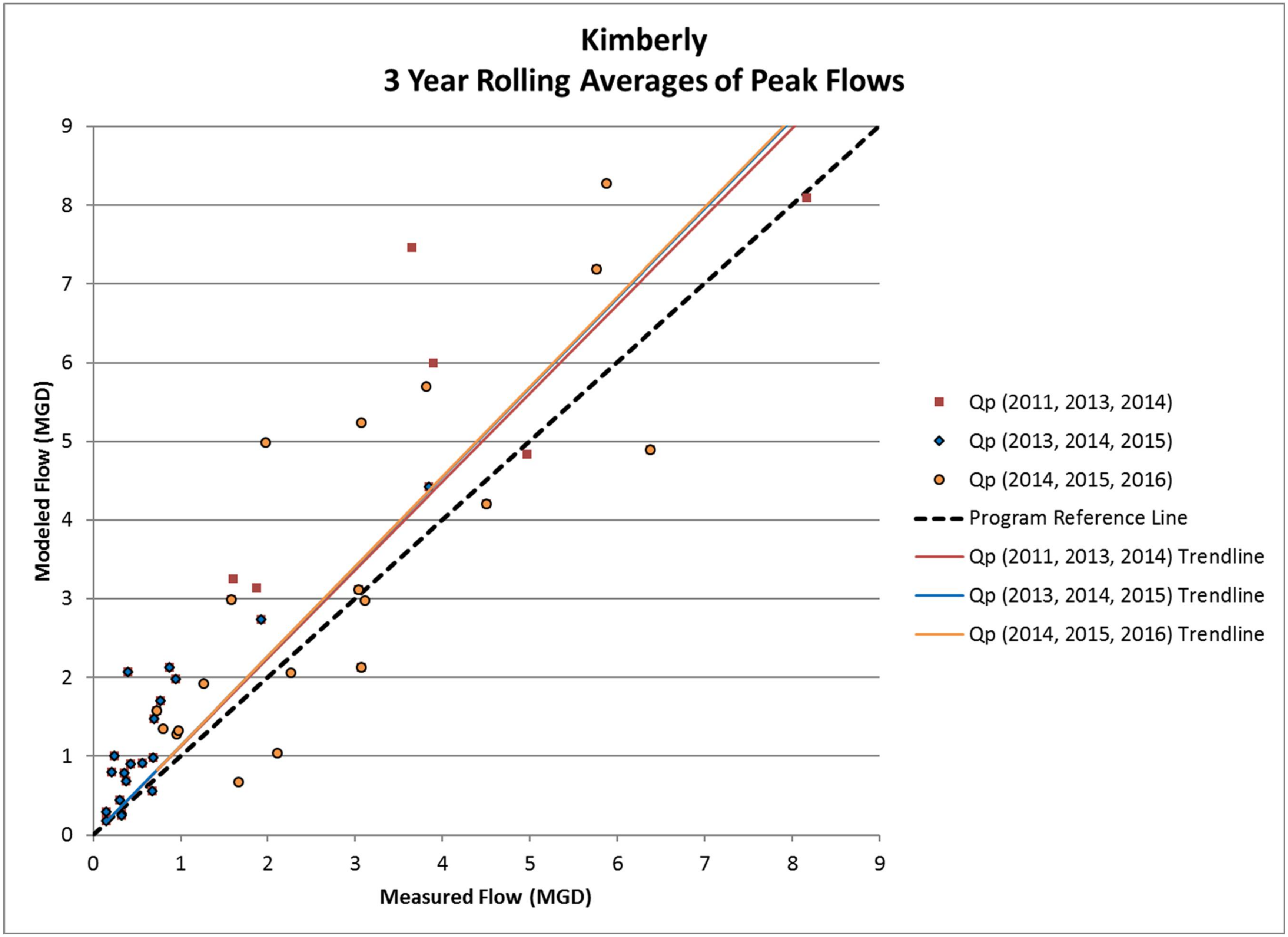
Program Reference Line
2011 Trendline
2013 Trendline
2014 Trendline
2015 Trendline
2016 Trendline
All Years Trendline


Kimberly
3 Year Rolling Averages of Peak Flows
Modeled Flow (MGD)
Measured Flow (MGD)
0
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Qp (2011, 2013, 2014)
Qp (2013, 2014, 2015)
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Program Reference Line
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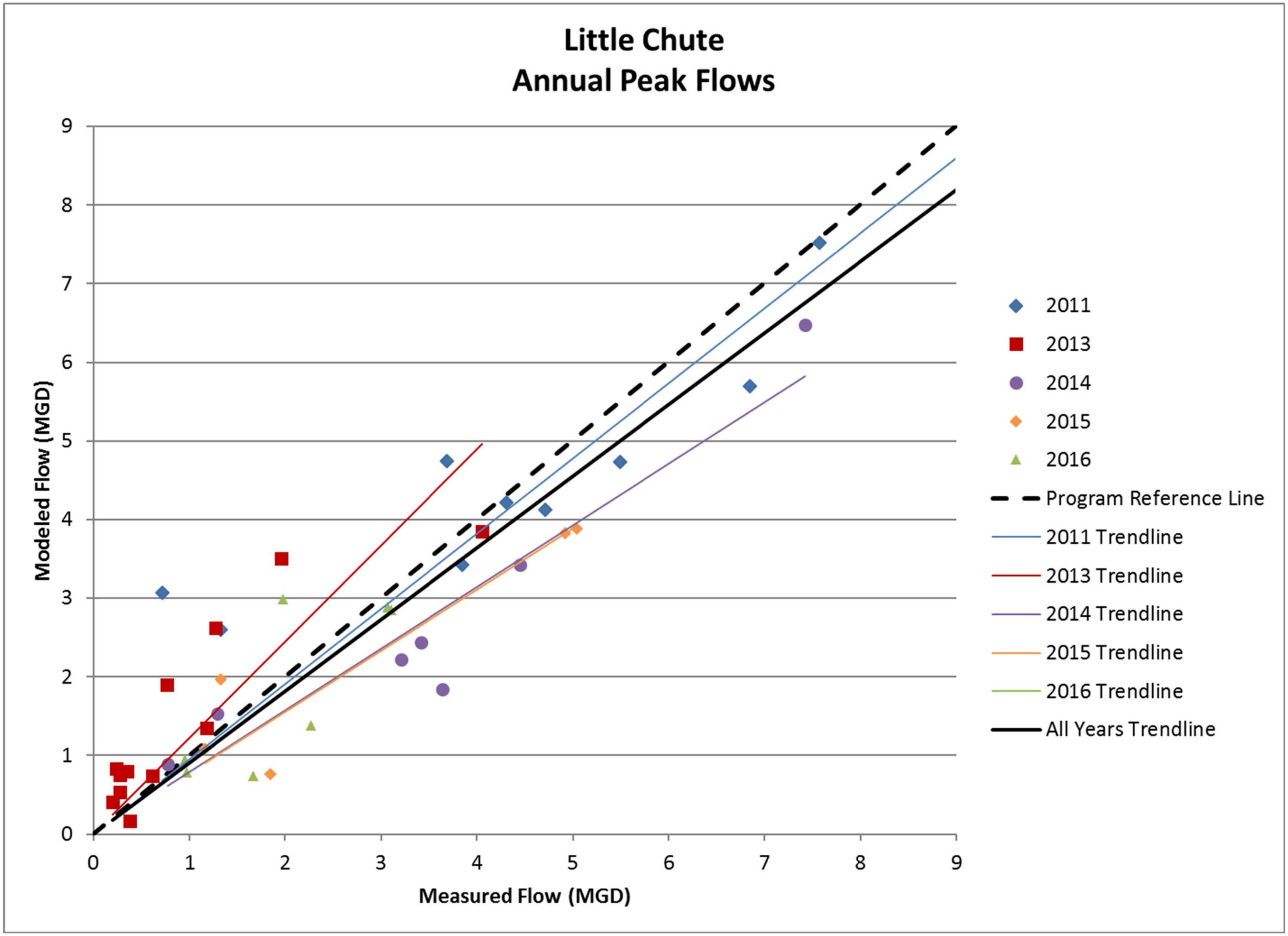
Qp (2014, 2015, 2016) Trendline


Little Chute
Annual Peak Flows
Modeled Flow (MGD)
Measured Flow (MGD)
0
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Program Reference Line
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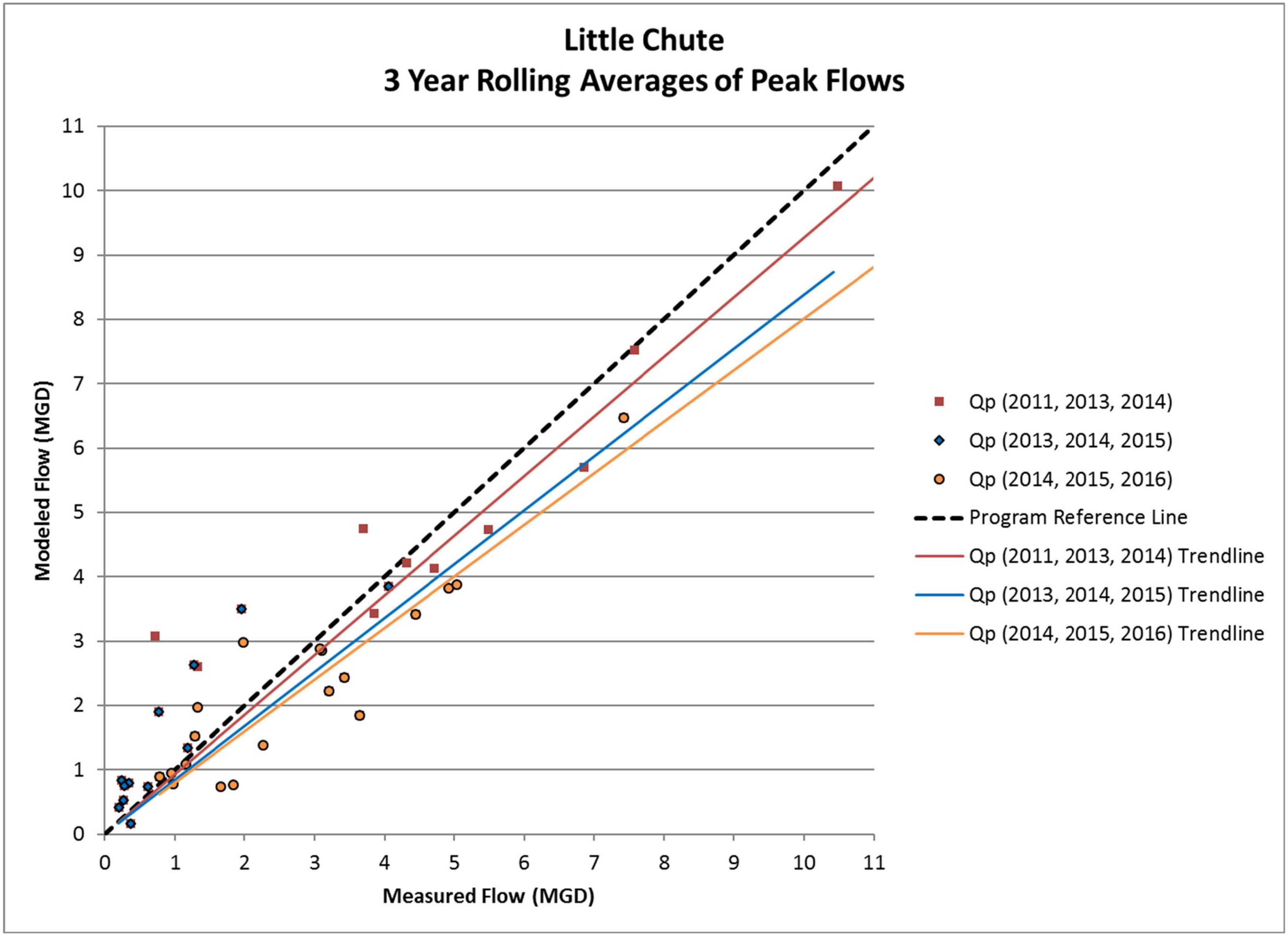
2015 Trendline
2016 Trendline
All Years Trendline


Little Chute
3 Year Rolling Averages of Peak Flows
Modeled Flow (MGD)
Measured Flow (MGD)
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Qp (2011, 2013, 2014)
Qp (2013, 2014, 2015)
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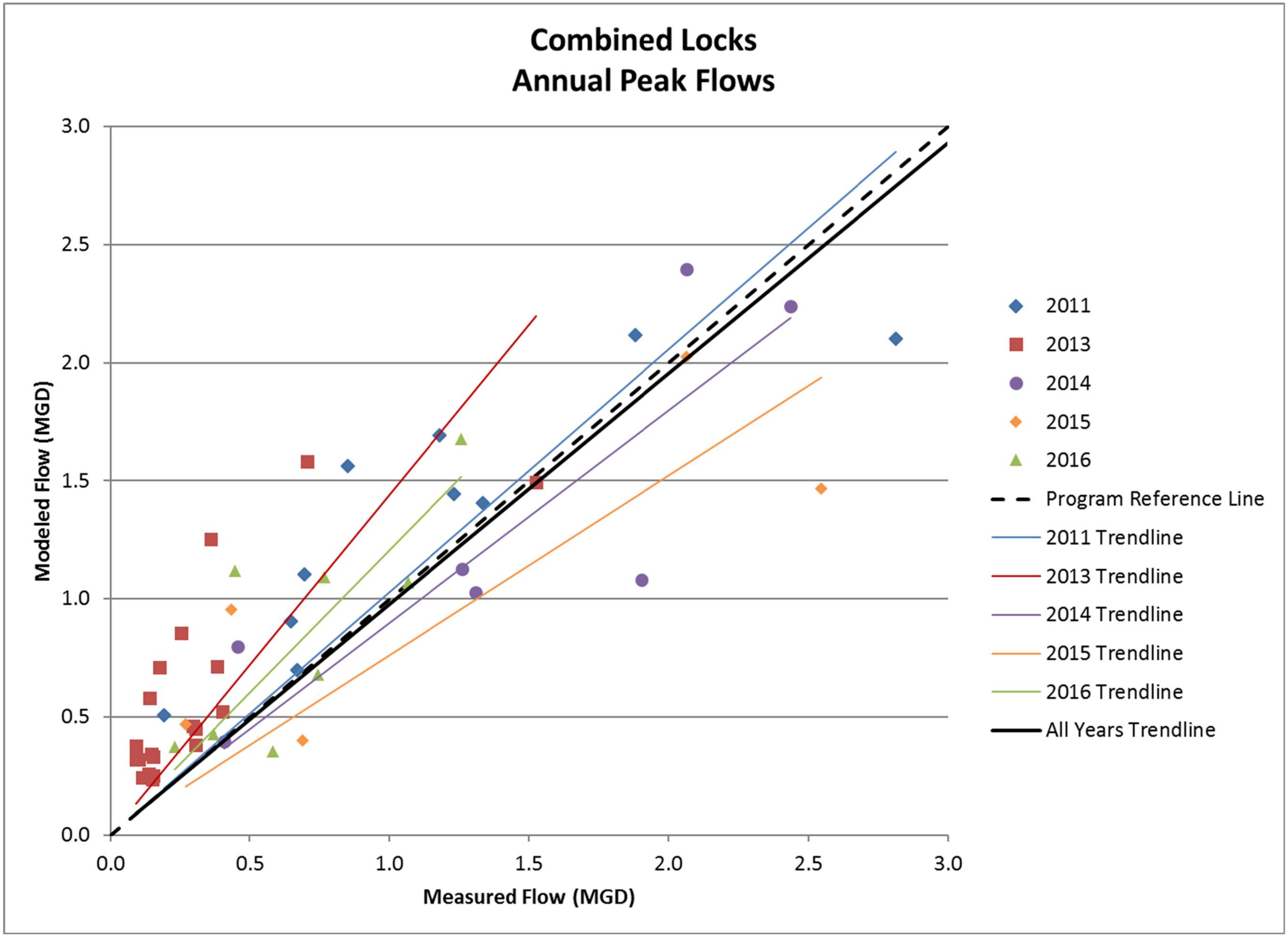
Qp (2014, 2015, 2016) Trendline


Combined Locks
Annual Peak Flows
Modeled Flow (MGD)
Measured Flow (MGD)
0.0
0.5
1.0
1.5
2.0
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2011
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Program Reference Line
2011 Trendline
2013 Trendline
2014 Trendline
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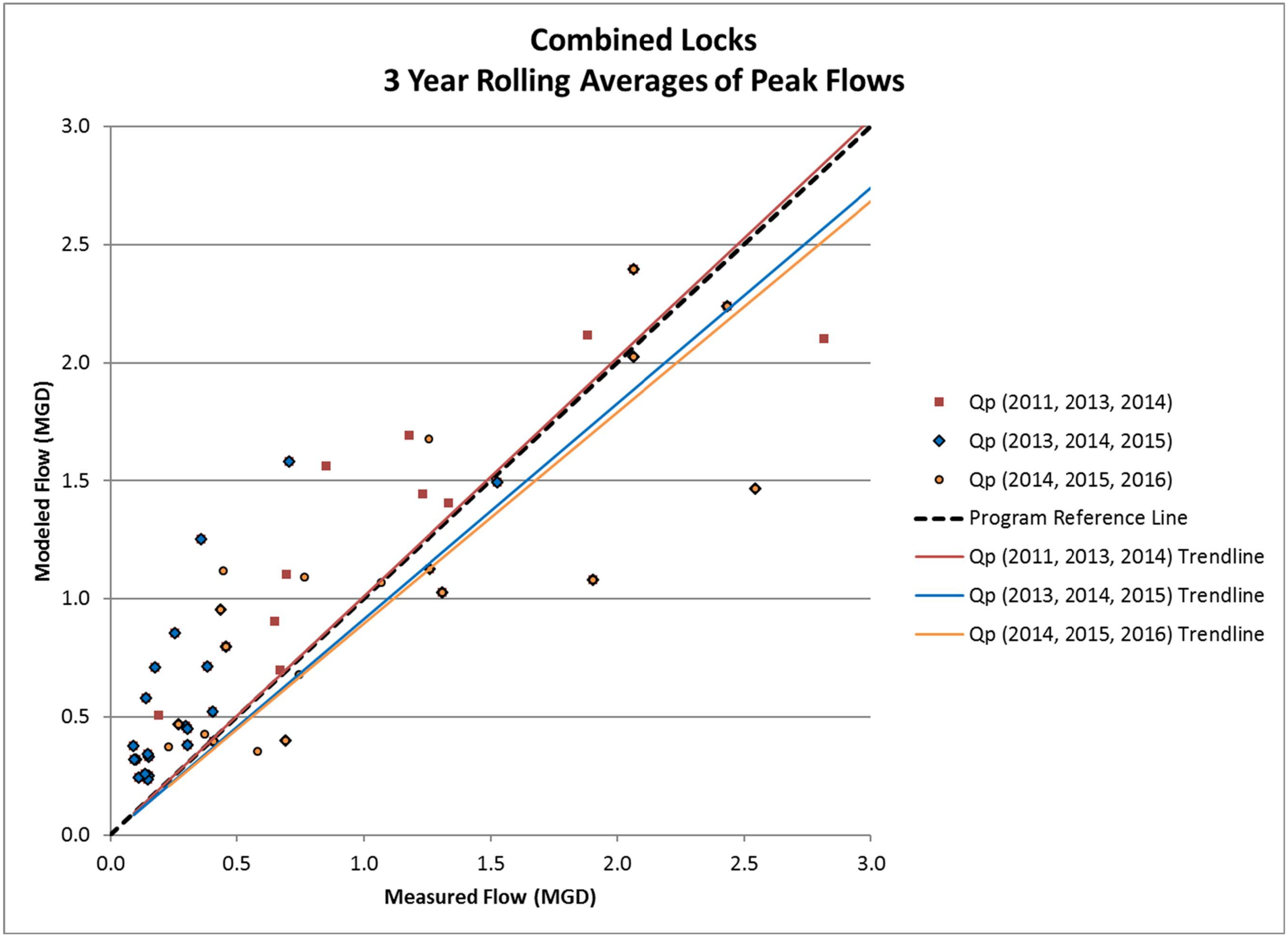
2016 Trendline
All Years Trendline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3 Year Rolling Averages of Peak Flows
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Measured Flow (MGD)
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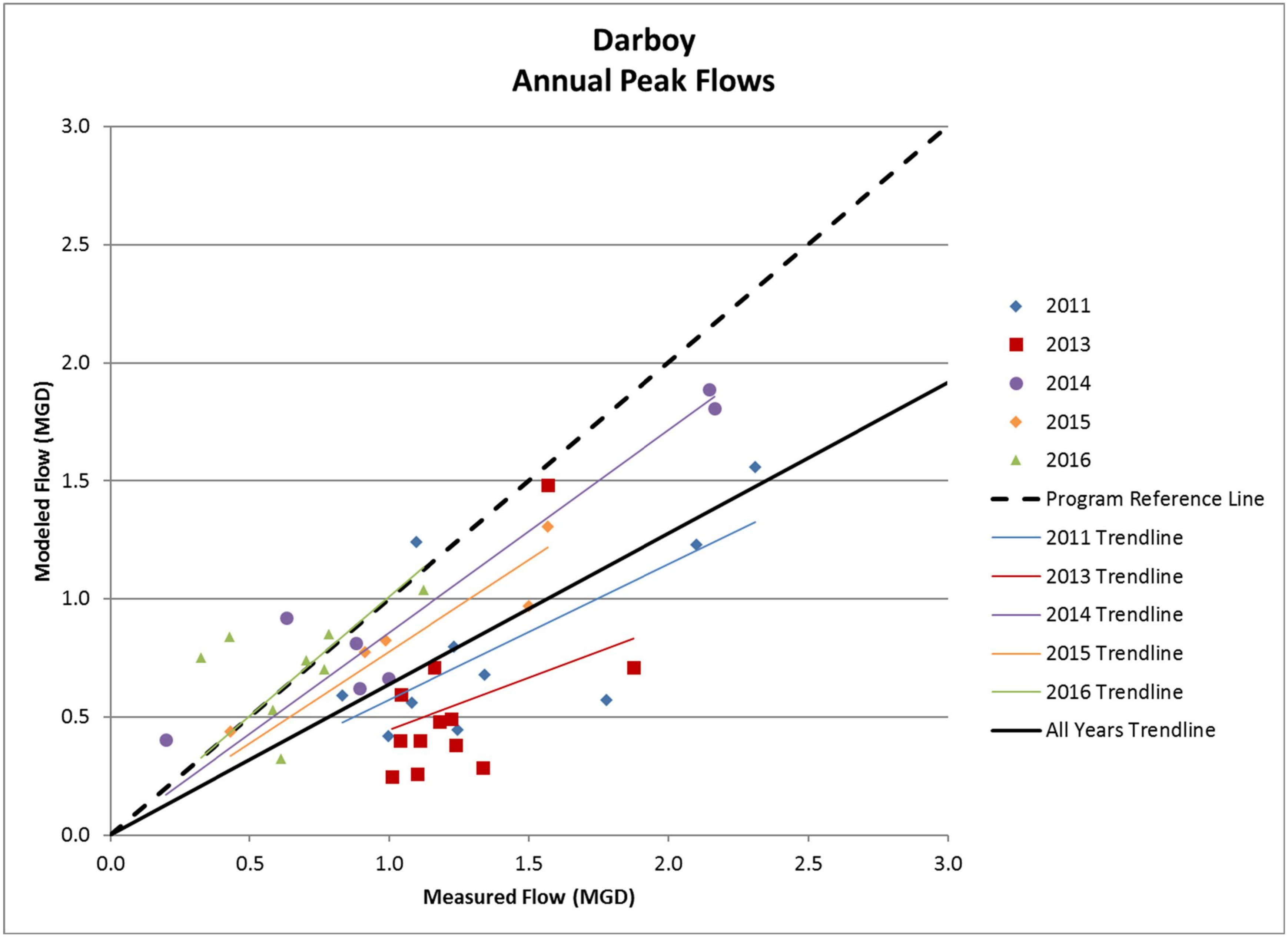
Qp (2011, 2013, 2014)
Qp (2013, 2014, 2015)
Qp (2014, 2015, 2016)
Program Reference Line
Qp (2011, 2013, 2014) Trendline
Qp (2013, 2014, 2015) Trendline
Qp (2014, 2015, 2016) Trendline


Darboy
Annual Peak Flows
Modeled Flow (MGD)
Measured Flow (MGD)
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1.0
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2011
2013
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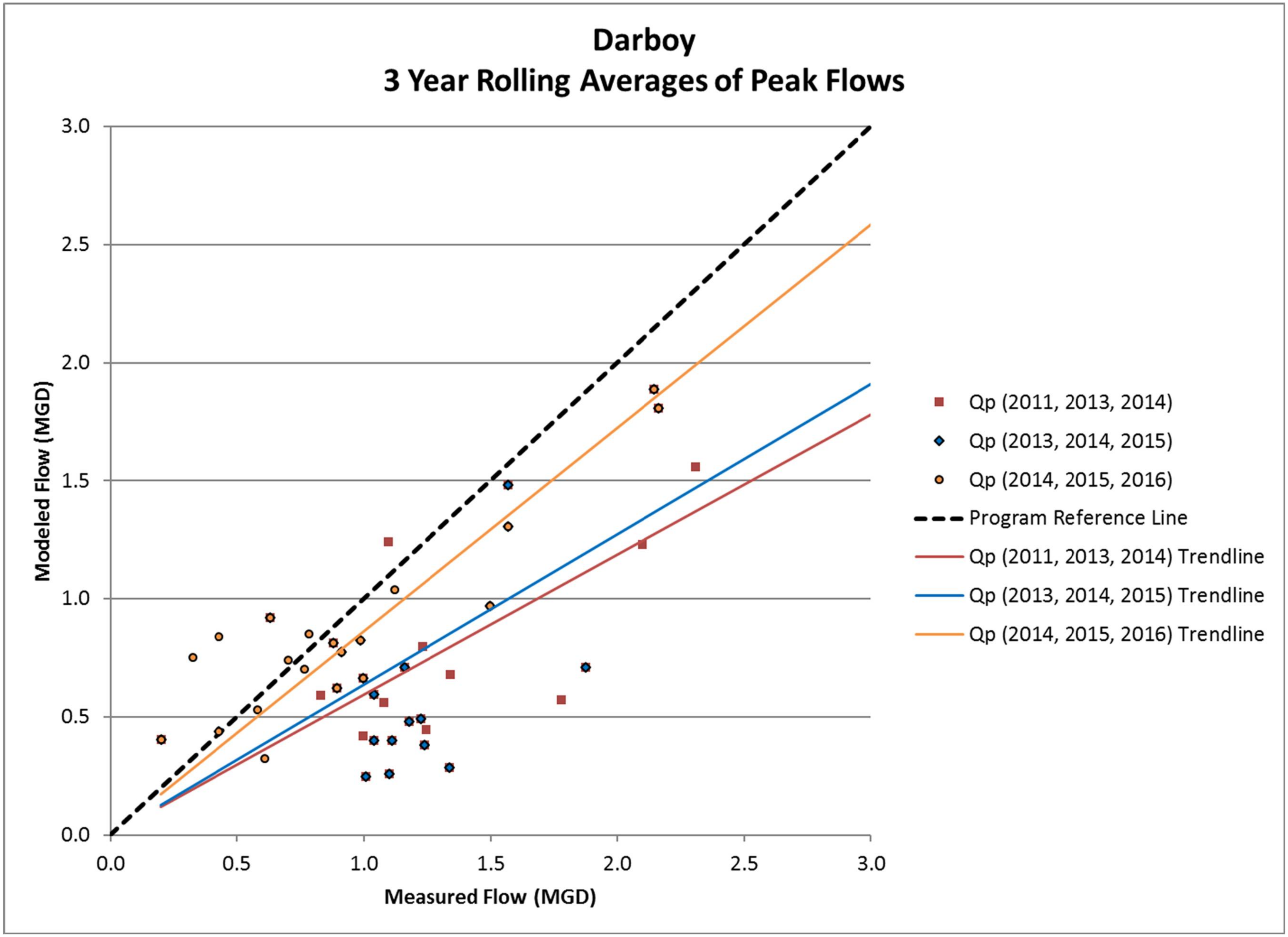
2016
Program Reference Line
2011 Trendline
2013 Trendline
2014 Trendline
2015 Trendline
2016 Trendline
All Years Trendline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0.5
1.0
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3.0
Qp (2011, 2013, 2014)
Qp (2013, 2014, 2015)
Qp (2014, 2015, 2016)
Program Reference Line
Qp (2011, 2013, 2014) Trendline
Qp (2013, 2014, 2015) Trendline
Qp (2014, 2015, 2016) Trendline