JOHN REDMOND RESERVOIR DIVERSION AND IMPACTS TO DOWNSTREAM CONDITIONS

SYSTEM SIMULATION MODELING

Corps of Engineers, Tulsa District

March 2011

Study Purpose:

Hydrological simulations are performed to determine what effects, if any, Wolf Creek Power Plant withdrawls from John Redmond Reservoir have on Neosho River flows to assist with ESA Section 7 consultation for the Nuclear Regulatory Commission.

Modeling:

The reservoir and basin simulation program RiverWare, version 5.2.2, was used for modeling for this study. RiverWare program was developed and is maintained by The Center for Advanced Decision Support for Water and Environmental Systems (CADSWES) at the University of Colorado, Boulder. For more information about CADSWES and the RiverWare program, view http://cadswes.colorado.edu/riverware/.

Model Development:

A RiverWare model has been developed by Tulsa District Corps of Engineers for the Arkansas River basin that includes many reservoirs on main stem and tributaries. The model also includes stream control points, routing reaches, and confluences. John Redmond Reservoir along with simulation control points at Iola and Parsons on the Neosho River are included in the model. Period of record (POR) for analysis spans from January 1, 1940 to December 31, 2000 with daily time step computations. Reservoirs in the system are being modeled as being operational for this full POR regardless of actual construction and impoundment. Historic daily gauged stream flow, project inflows, and outflows were used to develop the POR headwater

inflow and downstream local flow. Historic evaporation and precipitation are input as net-evaporation and included in the simulation.

Study Approach:

Two general scenarios have been studied. The first scenario represents reservoir and basin conditions without John Redmond Reservoir diversion for Wolf Creek Power and the second scenario depicts reservoir and basin conditions with a constant 41 cfs diversion from John Redmond Reservoir. Locations of interest for evaluation are Neosho River at Iola, Kansas and Neosho River at Parsons, Kansas. These two locations are defined in the RiverWare model as control points and are configured with low flow requirements and channel capacity limits as part of the overall input and computational logic. Low flow requirements at stream control points Iola (40 cfs) and Parsons (50 cfs) were used for both scenarios. Program simulation allows for downstream uncontrolled area flow to satisfy low flow requirements, however if low flow targets are not met, an upstream release is made to meet the targets. Low flow releases for Iola and Parsons are limited to John Redmond Reservoir. Simulations include channel capacity constraints for downstream flood control regulation, 22,900 cfs for Iola and 16.900 cfs for Parsons.

John Redmond Reservoir elevation, area, and capacity data is based on the resurvey that occurred in year 2000. John Redmond conservation pool is configured from elevation 1024 to 1039 with no seasonal variation, i.e. maintained target top of conservation pool elevation 1039.0 throughout the year. Available conservation storage for diversion and low flow release is 50,500 ac-ft. Future capacity projection was not done with this study.

System modeling includes low flow requirements in the Neosho River basin just below Council Grove Lake, Cottonwood River just below Marion Lake, and Neosho River at Iola and Parsons. Monthly low flow target rates for the Neosho River basin in Kansas used for this study are shown in Table 1.

TABLE 1

Neosho River Basin Target Low Flow Rates in Kansas

	Neosho River bl Council Grove Lake (cfs)	Cottonwood River bl Marion Lake (cfs)	Neosho River at Iola (cfs)	Neosho River at Parsons (cfs)
Jan	4.0	1.0	40.0	50.0
Feb	4.0	1.0	40.0	50.0
Mar	4.0	1.0	40.0	50.0
Apr	4.0	2.0	40.0	50.0
May	5.0	7.0	40.0	50.0
Jun	7.0	9.0	40.0	50.0
Jul	8.0	13.0	40.0	50.0
Aug	8.0	13.0	40.0	50.0
Sep	6.0	9.0	40.0	50.0
Oct	4.0	7.0	40.0	50.0
Nov	4.0	2.0	40.0	50.0
Dec	4.0	1.0	40.0	50.0

Simulation Results:

RiverWare has post-processing of output capabilities that include statistical functions, one of which is parameter-duration. For example, using flow at a stream control point, the period of record computed flow is sorted by rank, tabulated, and plotted to show percent of time a flow value is equaled or exceeded. Filtering of data for processing can be done on a monthly basis, as was done for this study. This function was done for Iola and Parson control point computed flows for both scenarios, without and with John Redmond Reservoir diversion. This flow-duration analysis is performed for the full period of record daily computations for each individual month, 1940 through 2000. A desired timeframe can also be specified to filter output and process statistical functions and was done for the critical drought from 1952 through 1957 also with individual months, thus providing concentrated analysis to focus on times of interest.

Tables 2 and 3 show "percent of time" target flows were equaled or exceeded as a result of the simulations and flow-duration computations for Iola and Parsons control points, respectively. Desired spawning flow targets are limited to April, May, and June. In the simulation, no releases were made from John Redmond Reservoir to meet desired spawning flow targets.

Attached to this report is copy of email request describing desired study analysis and output. Also included are the flow-duration plots for Iola and Parsons control points by month, for the full period of record, 1940 through 2000 as well as 1952 through 1957.

For the simulation scenario where John Redmond Reservoir is making the 41 cfs diversion there are intermittent periods in 1954 through 1957 where John Redmond exhausts available conservation storage , as shown on the time series plot in the attachments. Diversion is also shown in this time series plot. Diversion becomes zero when the conservation storage is exhausted.

TABLE 2

Neosho River at Iola, KS: Full Period of Record Jan 1940 thru Dec 2000
Percent of Time Flow is Equaled or Exceeded for Each Month

	Without John Redmond Diversion			
	Desired Minimum Flow 40 cfs	Desired Spawning Flow 60 cfs	Desired Spawning Flow 200 cfs	Full Channel Flow 22,900 cfs
Jan	100			0
Feb	100			0.1
Mar	100			0
Apr	100	88.1		0.5
May	100		87.2	0.16
Jun	100		84.5	0.20
Jul	100			0.05
Aug	100			0.05
Sep	100			0.05
Oct	100			0.32
Nov	100			0.32
Dec	100			0

	With John Redmond Diversion of 41 cfs			
	Desired Minimum Flow 40 cfs	Desired Spawning Flow 60 cfs	Desired Spawning Flow 200 cfs	Full Channel Flow 22,900 cfs
Jan	97.2			0
Feb	97.9			0.1
Mar	98.5			0
Apr	99.2	83.4		0.5
May	100		81.8	0.16
Jun	100		81.7	0.20
Jul	100			0.05
Aug	100			0.05
Sep	100			0.05
Oct	100			0.32
Nov	100			0.32
Dec	97.7			0

Neosho River at Iola, KS: Critical Period of Record Drought 1952 thru 1957
Percent of Time Flow is Equaled or Exceeded for Each Month

	Without John Redmond Diversion			
	Desired Minimum Flow 40 cfs	Desired Spawning Flow 60 cfs	Desired Spawning Flow 200 cfs	Full Channel Flow 22,900 cfs
Jan	100			0
Feb	100			0
Mar	100			0
Apr	100	55.5		0
May	100		47.85	0
Jun	100		41.11	0
Jul	100			0
Aug	100			0
Sep	100			0
Oct	100			0
Nov	100			0
Dec	100			0

	With John Redmond Diversion of 41 cfs			
	Desired Minimum Flow 40 cfs	Desired Spawning Flow 60 cfs	Desired Spawning Flow 200 cfs	Full Channel Flow 22,900 cfs
Jan	71.5			0
Feb	78.8			0
Mar	84.9			0
Apr	91.67	42.2		0
May	95.7		42.47	0
Jun	100		36.67	0
Jul	100			0
Aug	100			0
Sep	100			0
Oct	100			0
Nov	100			0
Dec	76.8			0

TABLE 3

Neosho River at Parsons, KS: Full Period of Record Jan 1940 thru Dec 2000
Percent of Time Flow is Equaled or Exceeded for Each Month

	Without John Redmond Diversion					With John Redmond Diversion of 41 cfs			
	Desired Minimum Flow 50 cfs	Desired Spawning Flow 100 cfs	Desired Spawning Flow 300 cfs	Full Channel Flow (1) 16,900 cfs		Desired Minimum Flow 50 cfs	Desired Spawning Flow 100 cfs	Desired Spawning Flow 300 cfs	Full Channel Flow (1) 16,900 cfs
Jan	100			0.53	Jan	98.3			0.53
Feb	100			0.75	Feb	98.4			0.75
Mar	100			2.1	Mar	98.5			2.1
Apr	100	89.5		3.9	Apr	99.2	86.9		3.9
May	100		87.3	4.0	May	99.95		84.5	4.0
Jun	100		84.6	4.7	Jun	100		83.0	4.5
Jul	100			3.8	Jul	100			3.8
Aug	100			0.58	Aug	100			0.53
Sep	100			1.97	Sep	100			2.02
Oct	100			2.5	Oct	100			2.5
Nov	100			3.1	Nov	100			3.1
Dec	100			0.79	Dec	97.8			0.85

Neosho River at Parsons, KS: Critical Period of Record Drought 1952 thru 1957
Percent of Time Flow is Equaled or Exceeded for Each Month

	Without John Redmond Diversion					With John Redmond Diversion of 41 cfs			
	Desired Minimum Flow 50 cfs	Desired Spawning Flow 100 cfs	Desired Spawning Flow 300 cfs	Full Channel Flow (1) 16,900cfs		Desired Minimum Flow 50 cfs	Desired Spawning Flow 100 cfs	Desired Spawning Flow 300 cfs	Full Channel Flow (1) 16,900 cfs
Jan	100			0	Jan	83.3			0
Feb	100			0	Feb	83.5			0
Mar	100			0	Mar	84.4			0
Apr	100	61.1		0	Apr	100	55.0		0
May	100		56.5	2.69	May	99.5		51.1	2.69
Jun	100		47.8	3.9	Jun	100		43.9	3.9
Jul	100			0	Jul	100			0
Aug	100			0	Aug	100			0
Sep	100			0	Sep	100			0
Oct	100			0	Oct	100			0
Nov	100			2.78	Nov	100			2.78
Dec	100			0	Dec	77.4			0

(1) RiverWare modeling uses regulation stage of 19.0 feet at Parsons control point.

From: Mike_LeValley@fws.gov
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Cc: Nolen, Stephen L SWT; Bo.Pham@nrc.gov; Tam.Tran@nrc.gov; Michele_McNulty@fws.gov
Subject: Data Needs for NRC Section 7 Consultation
Date: Wednesday, August 13, 2008 4:31:15 PM

Dennis et. al. As per our conference call on Monday, Aug. 11, we were to provide a detailed list of data needs for the Tulsa District to run simulations of Neosho River flows with and without the depletions of the Wolf Creek Power Plant. I believe the Corps will need two data sets from NRC which could be actual data or an approximation if actual data do not exist:

1) depletions (actual) or average annual apportioned by month resulting from the impoundment of Wolf Creek. Our Regional hydrologist reviewed the analyses provided by NRC and estimated that average annual depletions were approximately 13,000 acre-feet/year. I do not know if the Wolf Creek operators or the Kansas Division of Water Resources monitor stream flow in Wolf Creek above Coffey County Lake. There is no USGS monitoring gage for Wolf Creek. If the plant monitors streamflows/storage entering Coffey County Lake and also tracks return flows to the river from the lake, actual data for the period of operation would be more useful.

2) withdrawals by the Wolf Creek Plant from the Neosho River system including both direct withdrawals from John Redmond Reservoir and withdrawals from the Neosho River below John Redmond Dam. Again, actual records over the period of plant operation would be most useful if available.

From the Corps model runs we would like the following output:

1) flow-duration curves by month over the period of record at the Iola and Parsons, KS stream gages for a condition with Wolf Creek depletions in place;

2) flow-duration curves by month over the period of record at the Iola and Parsons, KS stream gages for a condition without Wolf Creek depletions;

3) flow-duration curves by month during the 1950s drought (1952 through 1957) at the Iola and Parsons, KS stream gages with Wolf Creek depletions in place;

4) flow-duration curves by month during the 1950s drought (1952 through 1957) at the Iola and Parsons, KS stream gages without Wolf Creek depletions.

We have the Kansas Minimum Desirable Streamflow targets (for both the minimum absolute flow and the minimum spawning flow) at both of the gages, and should be able to use flood stage as these gages as a surrogate for how often the channel-forming (bankfull) flows are attained during a with and without project condition.

I saw John Daylor's message concerning Corps data needs and I assume the KWO and USFW WQ flows of interest he asked for are references to the Kansas MDS flows noted above. At the Iola gage the absolute MDS is 40 cfs year round with a minimum spawning flow recommendation of 60 cfs in April and 200 cfs in May and June. At Parsons, the absolute year-round MDS is 50 cfs with the minimum spawning flow being 100 cfs in April and 300 cfs in May and June. Flood stage on the Iola gage is 15 ft. Flood stage at Parsons is 21 feet.

Hope this helps and please call if you need clarification or have questions.

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U.S. Fish and Wildlife Service 2609 Anderson Avenue Manhattan, KS 66502
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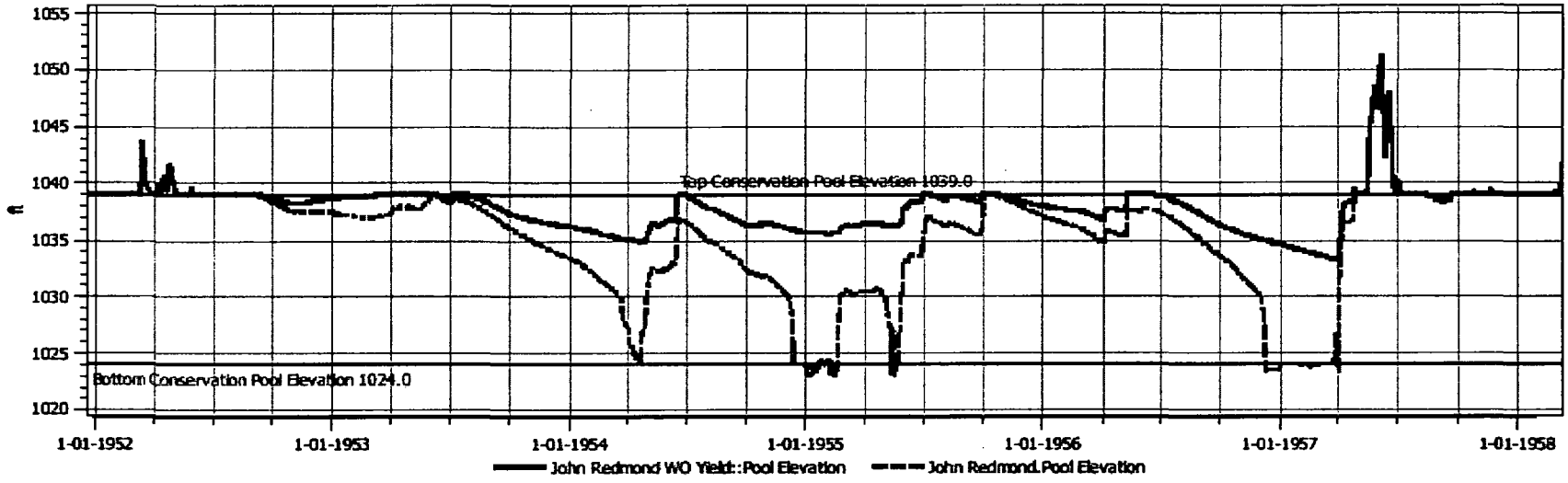
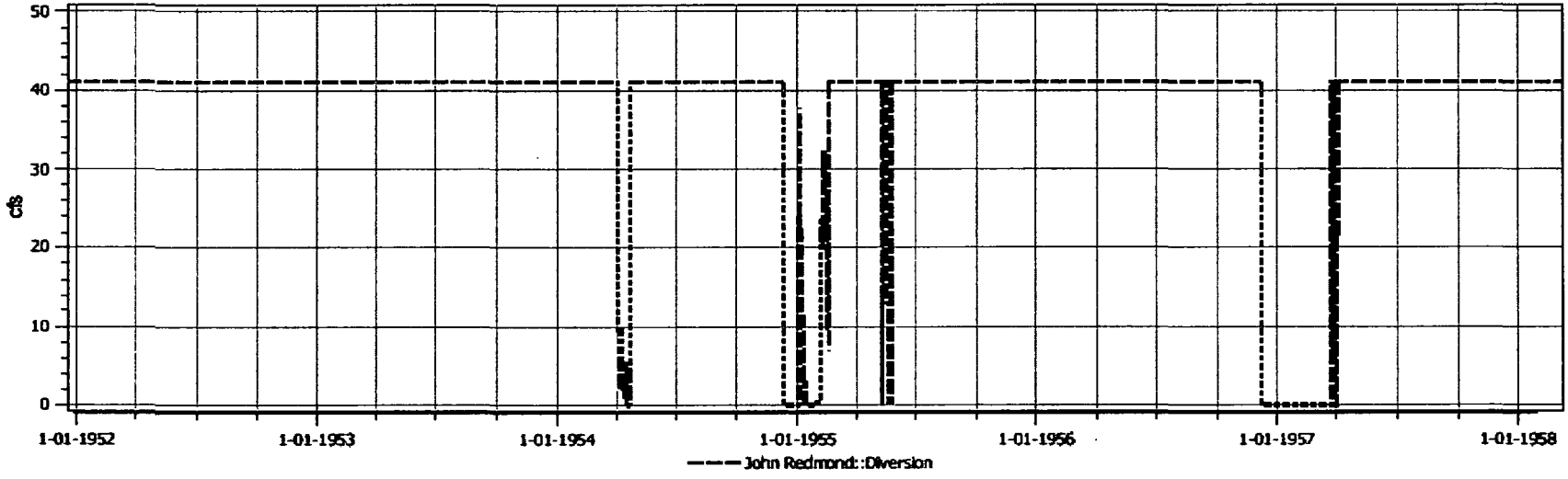
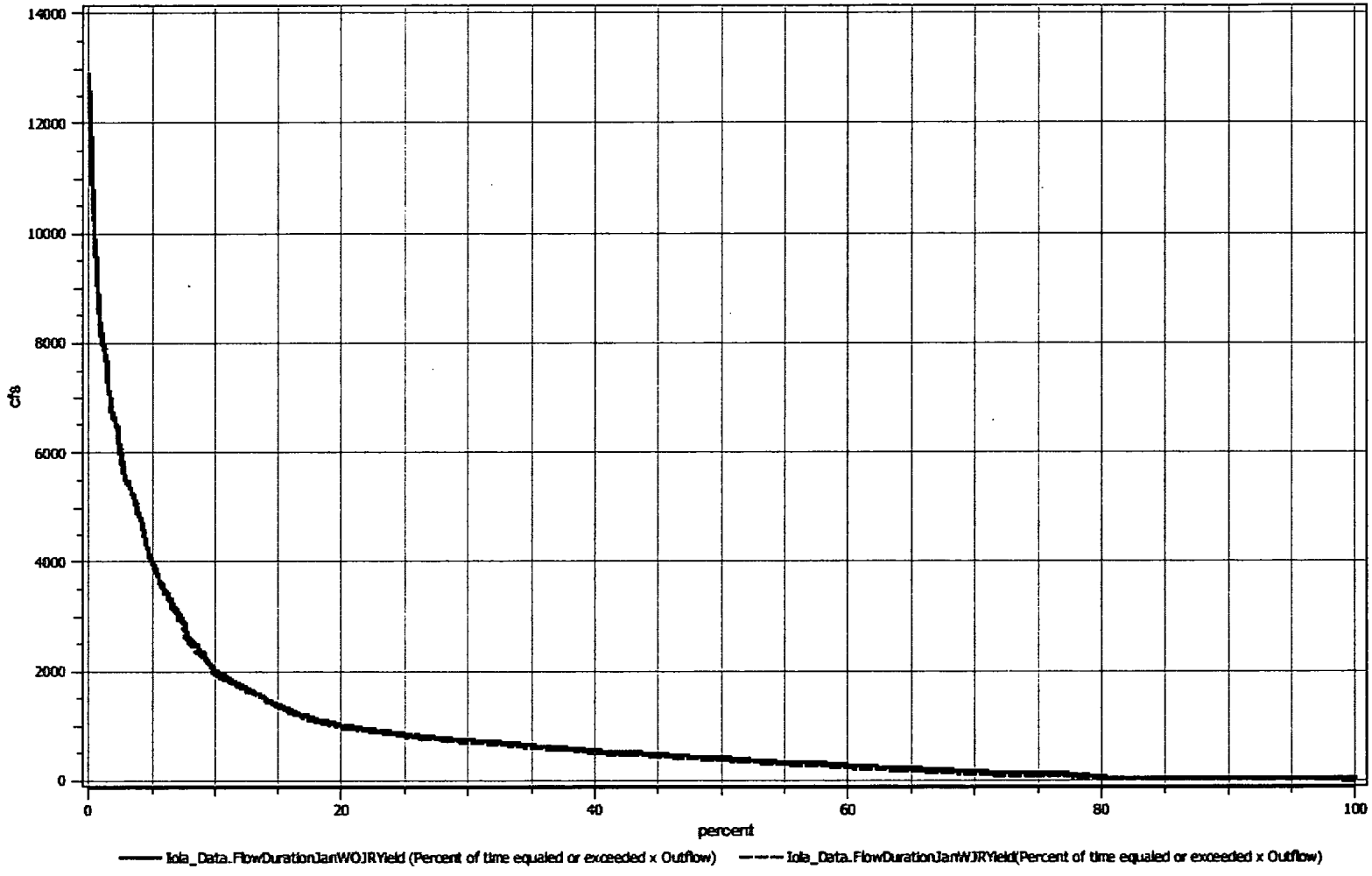
John Redmond Reservoir Pool Elevation



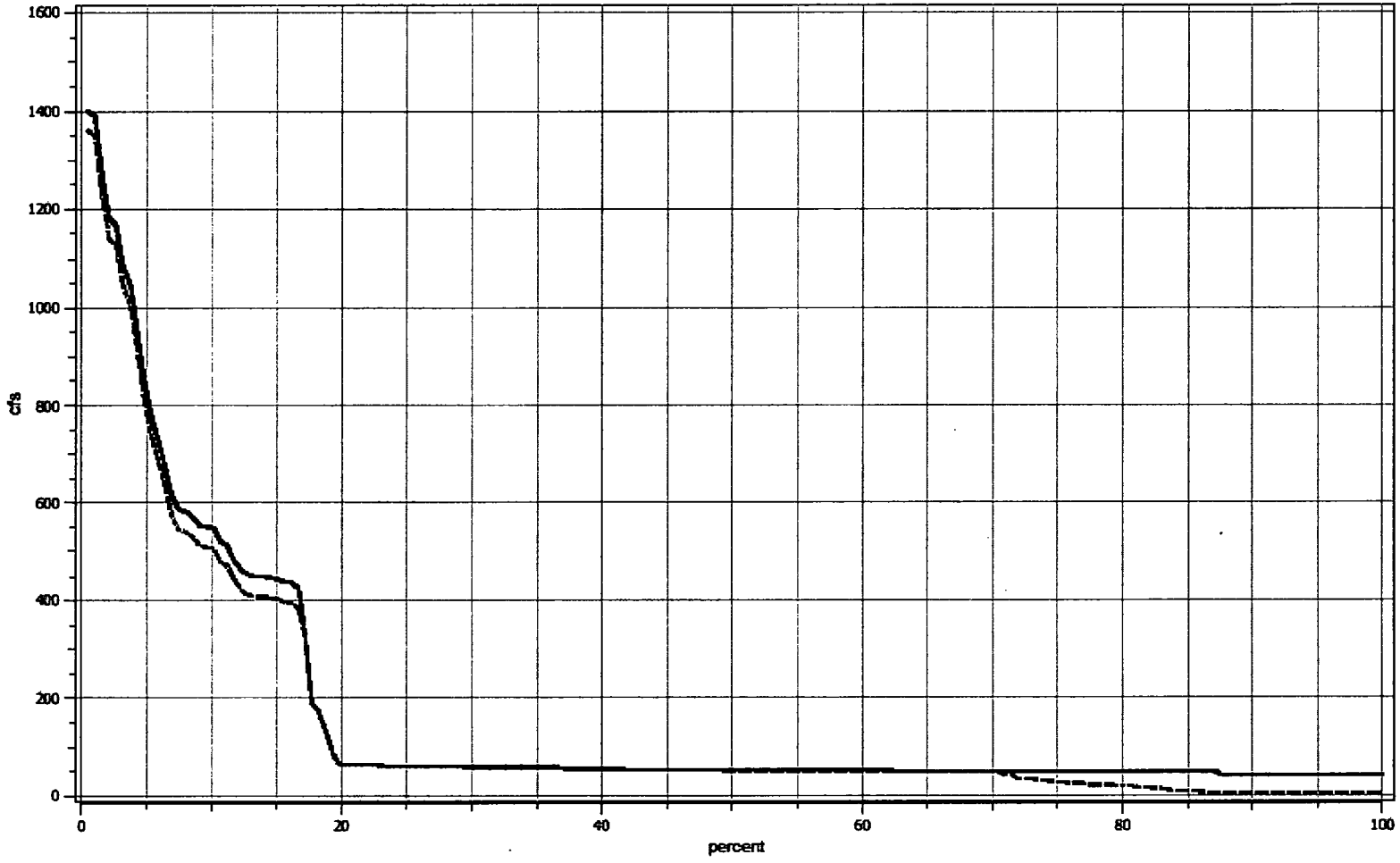
John Redmond Diversion Request at 41 cfs



Neosho River at Iola, KS Month of January: 1940 - 2000 FLOW-DURATION

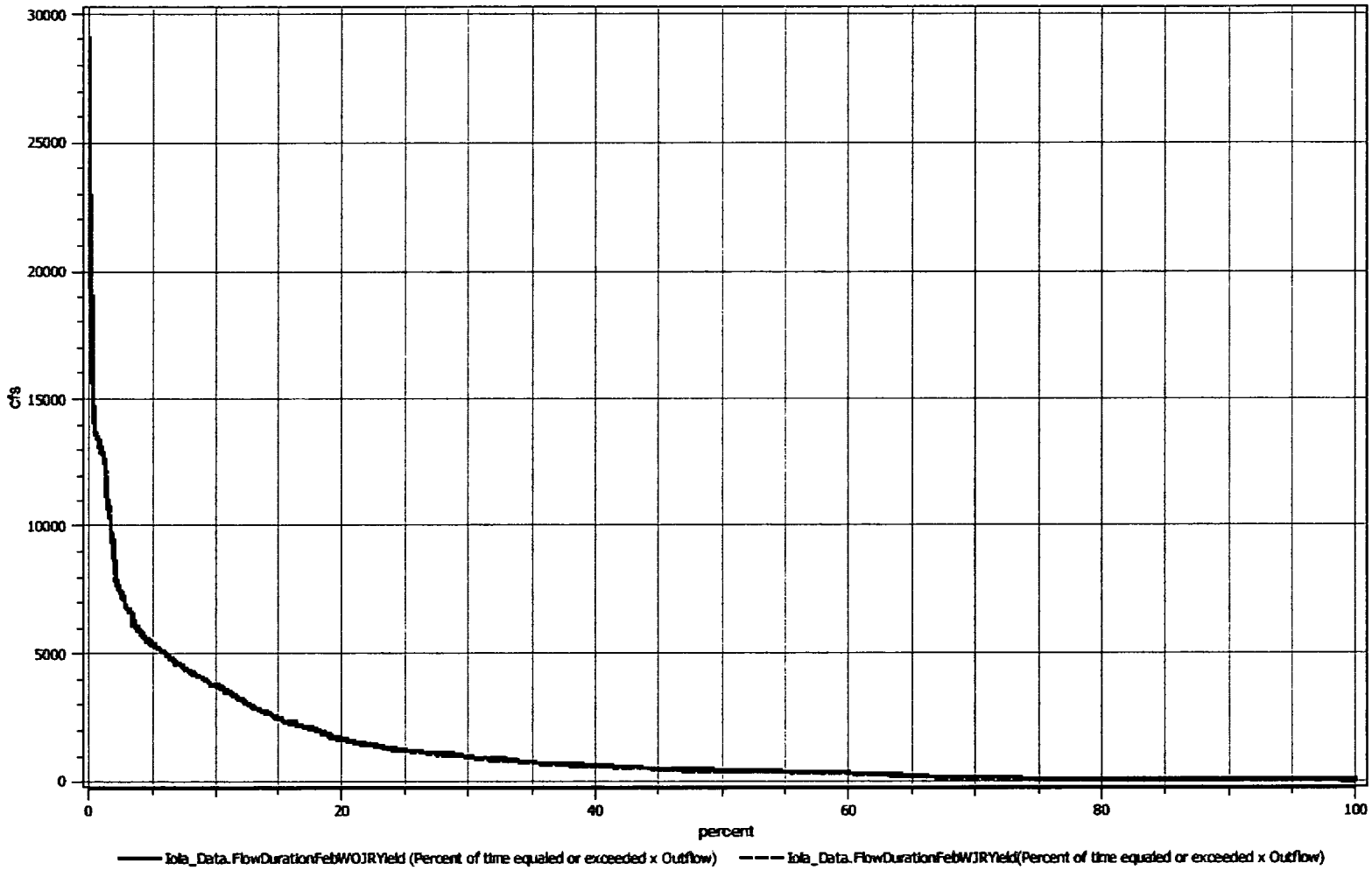


Neosho River at Iola, KS Month of January: 1952 - 1957 FLOW-DURATION

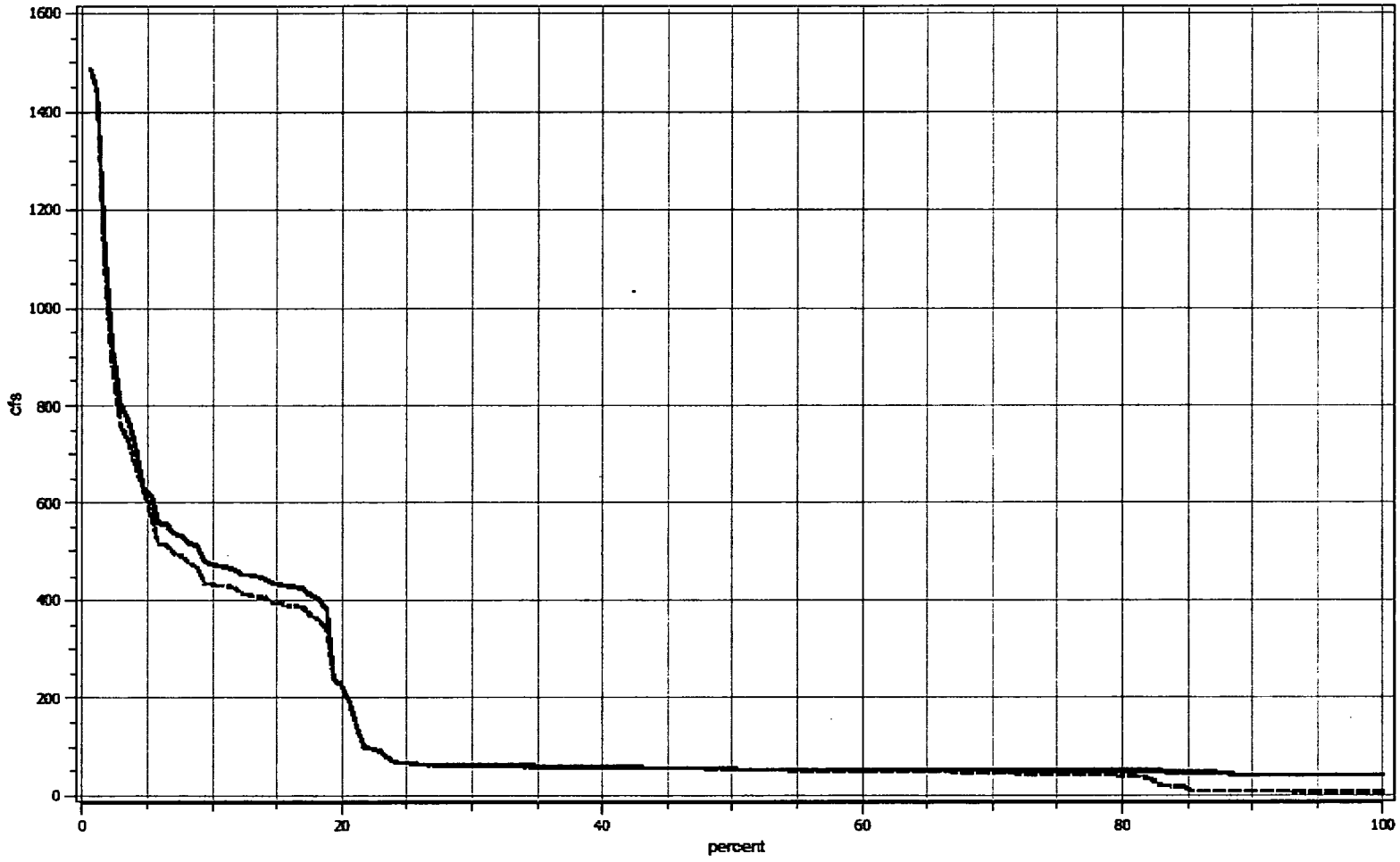


—— Iola_Data.FlowDurationJan52_57WOJRYield (Percent of time equaled or exceeded x Outflow) ---- Iola_Data.FlowDurationJan52_57WJRYield(Percent of time equaled or exceeded x Outflow)

Neosho River at Iola, KS, Month of February: 1940 - 2000 FLOW-DURATION



Neosho River at Iola, KS Month of February: 1952 - 1957 FLOW-DURATION



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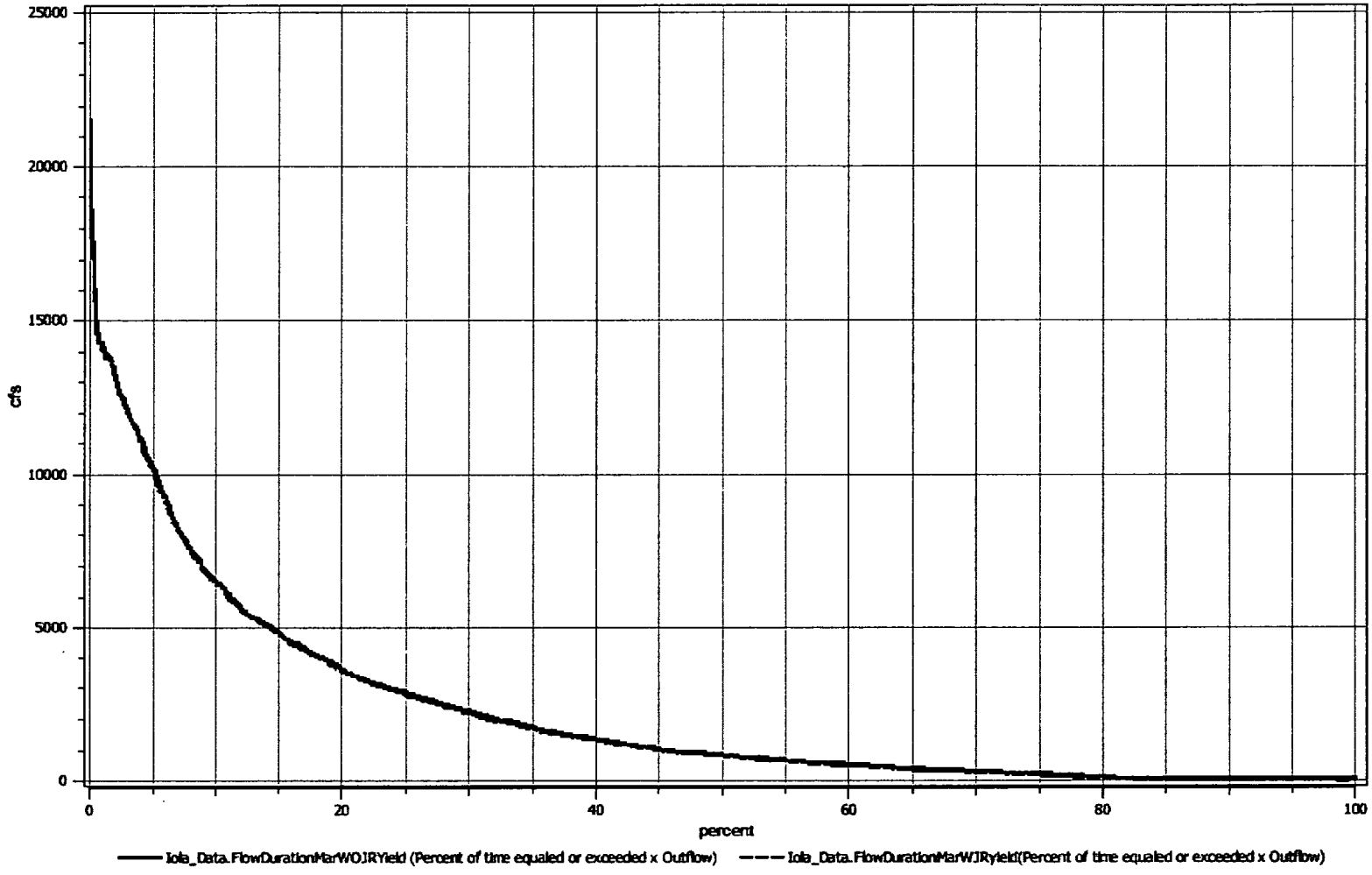
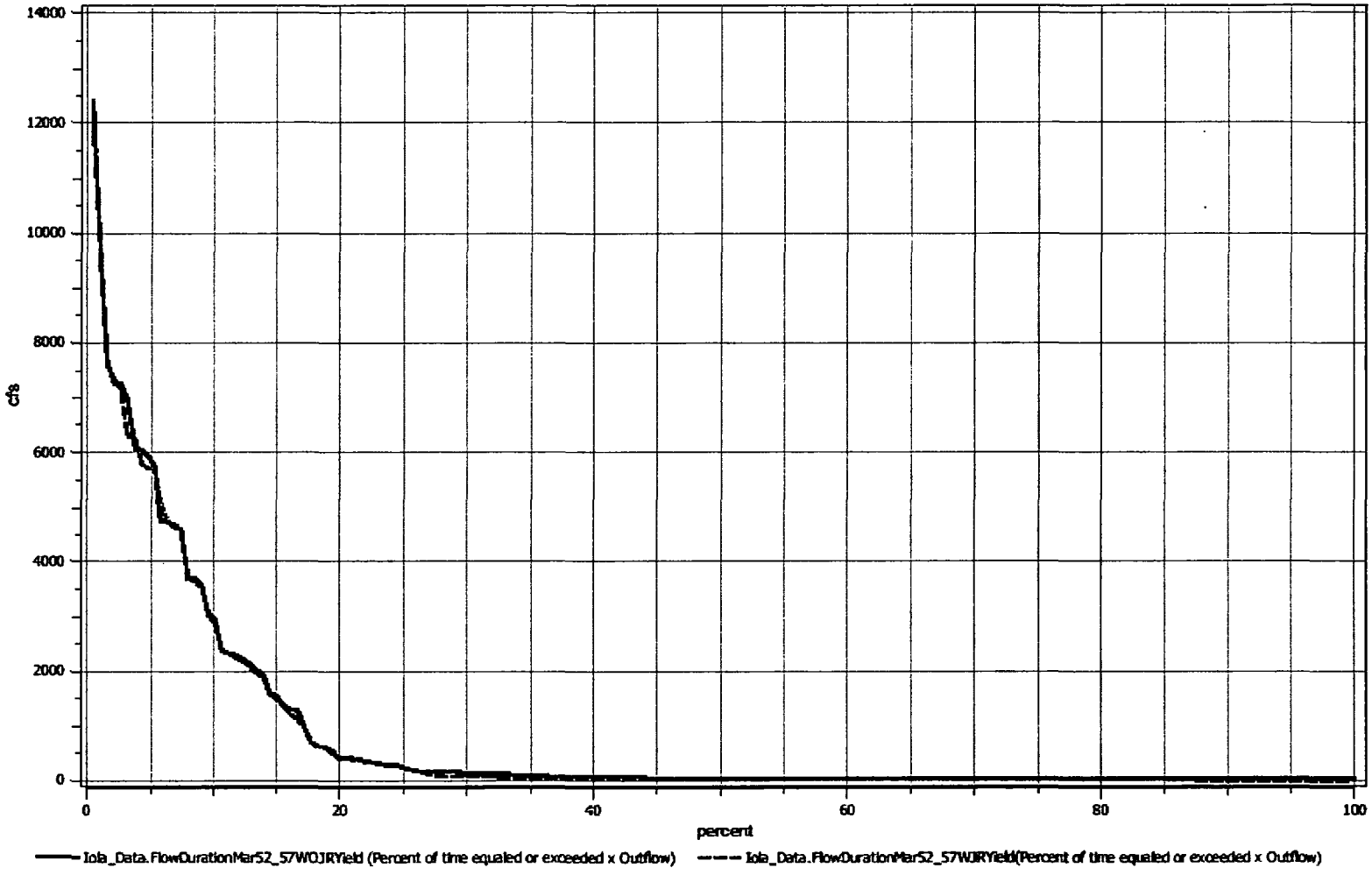
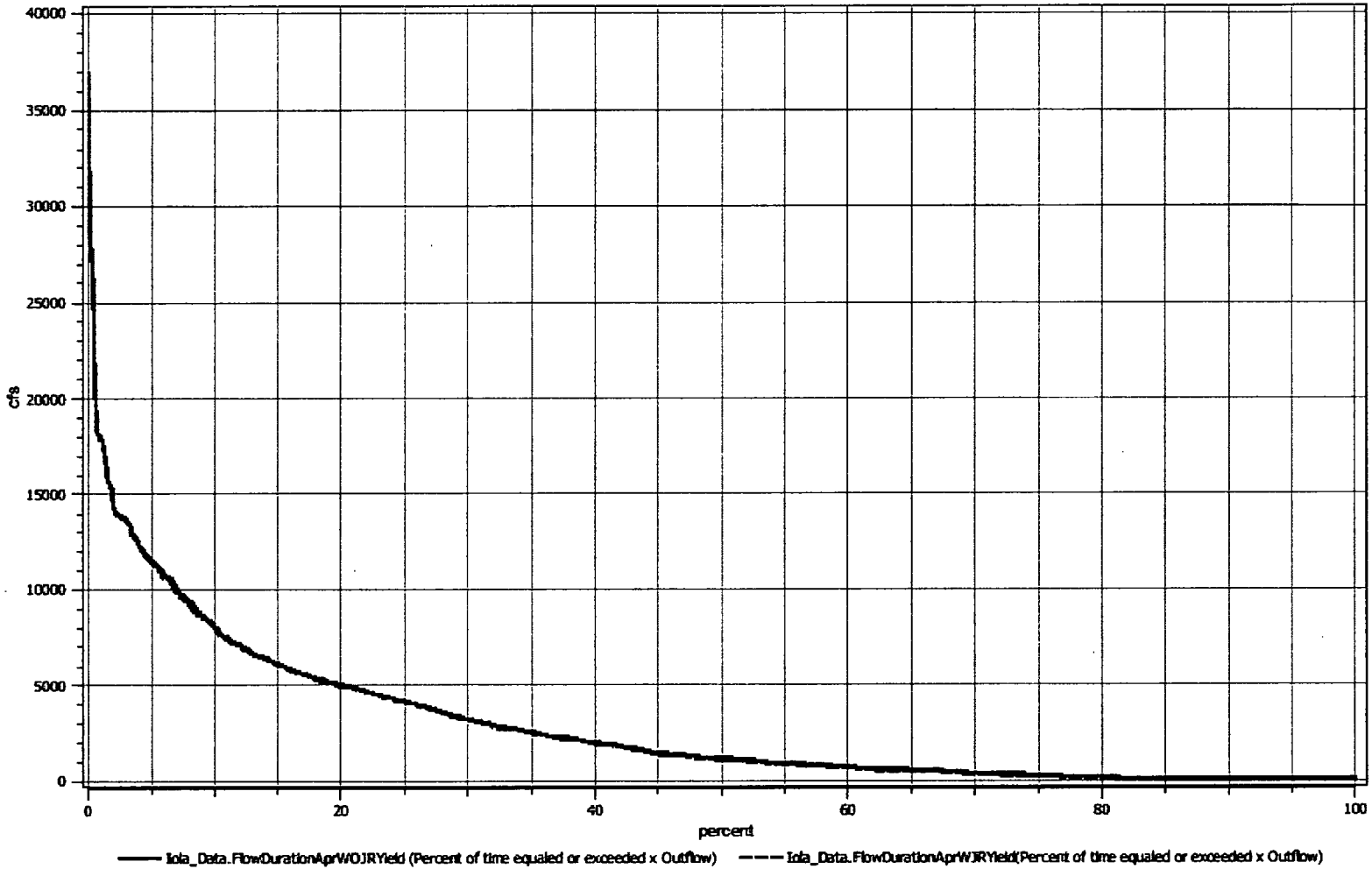
Neosho River at Iola, KS Month of March: 1940 - 2000 FLOW DURATION



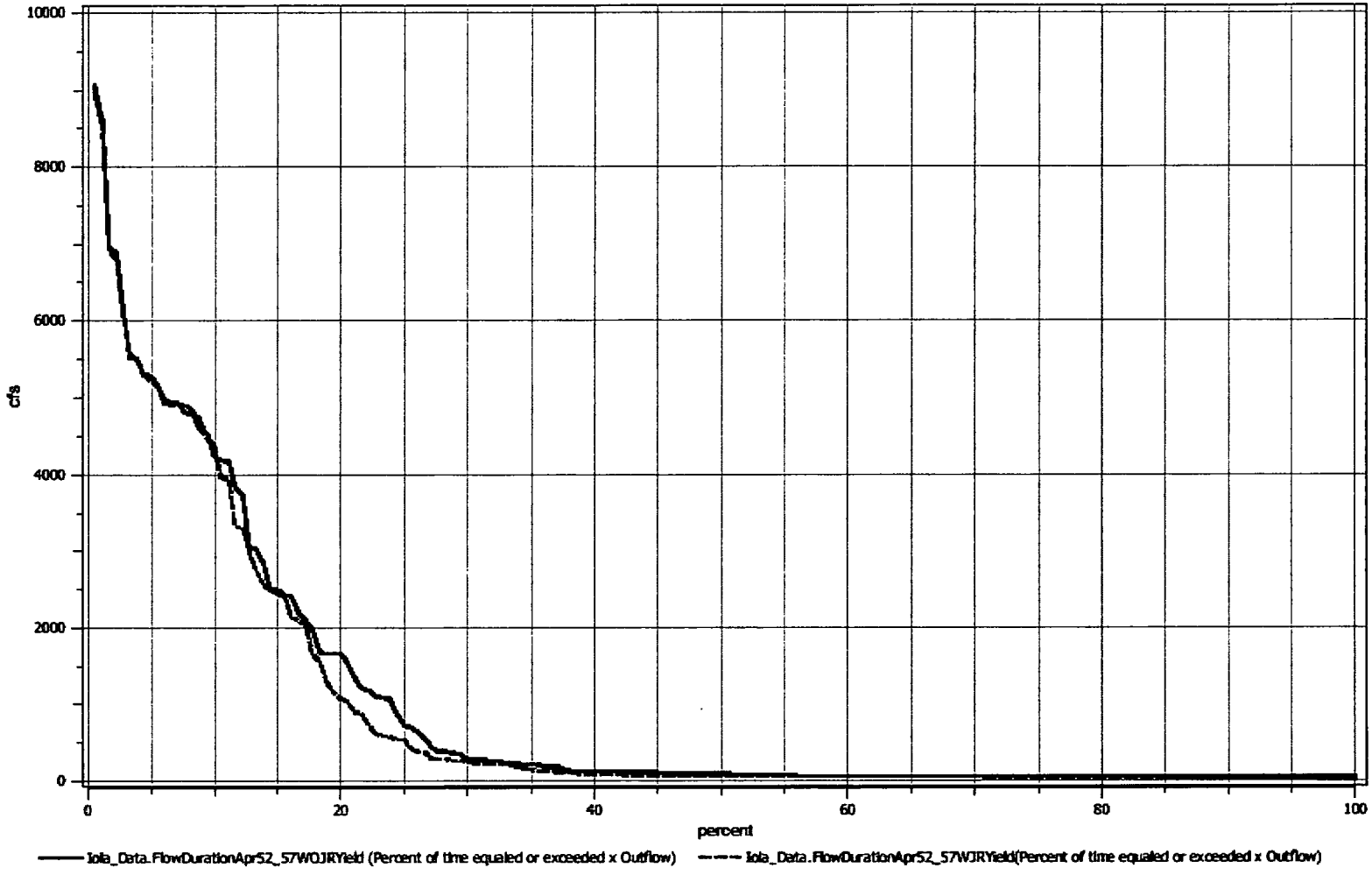
Neosho River at Iola, KS Month of March: 1952 - 1957 FLOW-DURATION



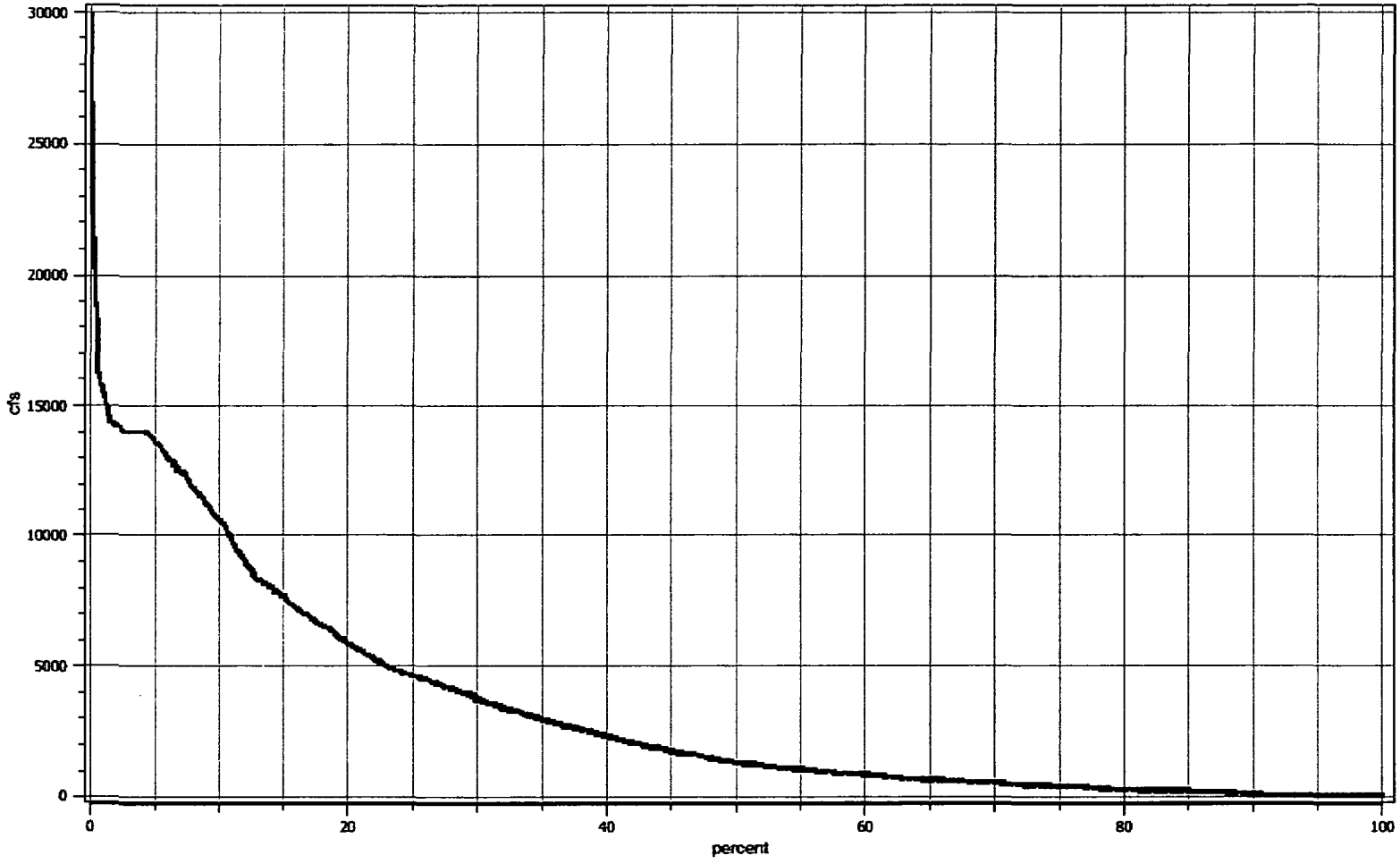
Neosho River at Iola, KS Month of April: 1940 - 2000 FLOW-DURATION



Neosho River at Iola, KS Month of April: 1952 - 1957 FLOW-DURATION



Neosho River at Iola, KS Month of May: 1940 - 2000 FLOW-DURATION



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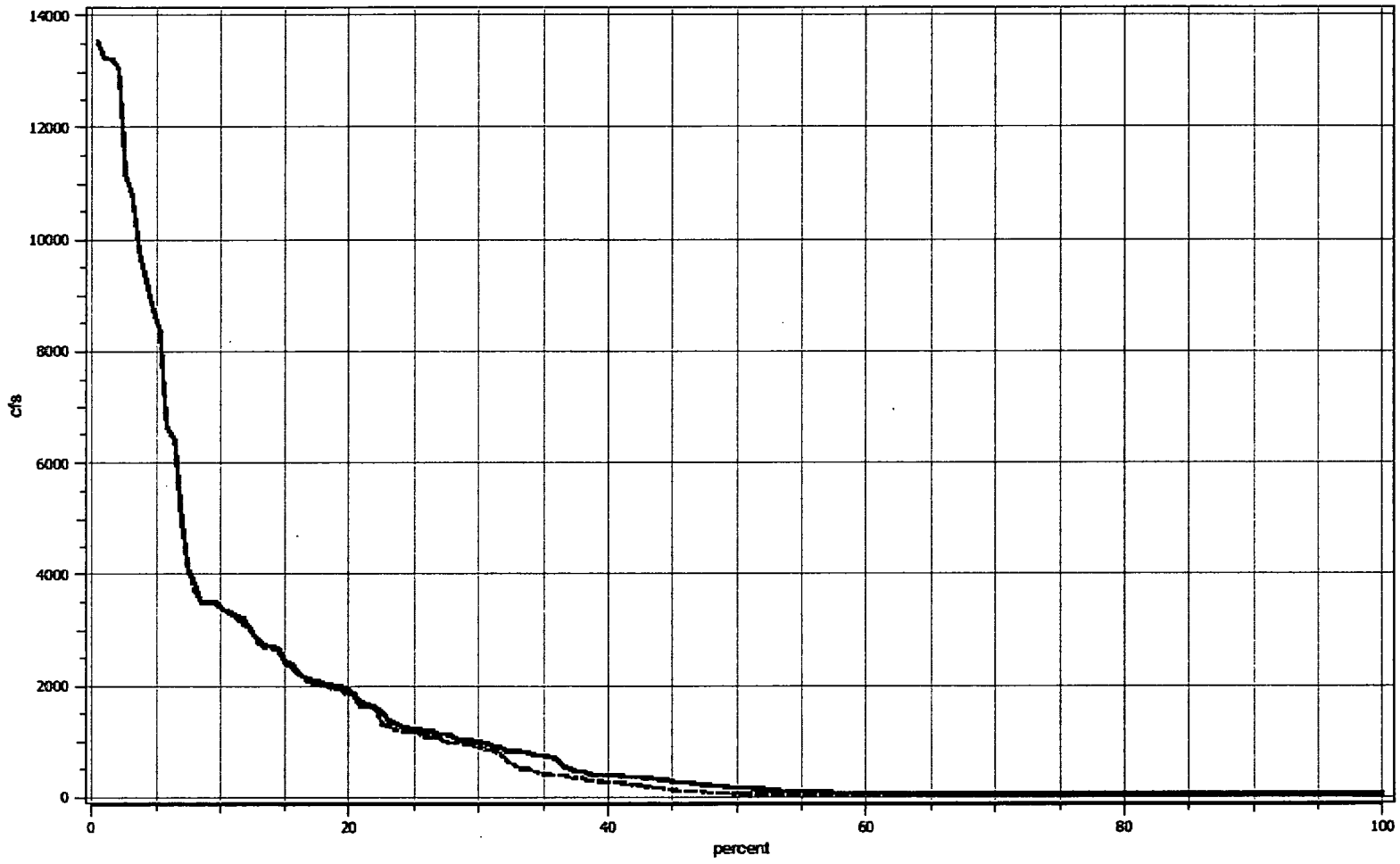
Neosho River at Iola, KS Month of May: 1952 - 1957 FLOW-DURATION



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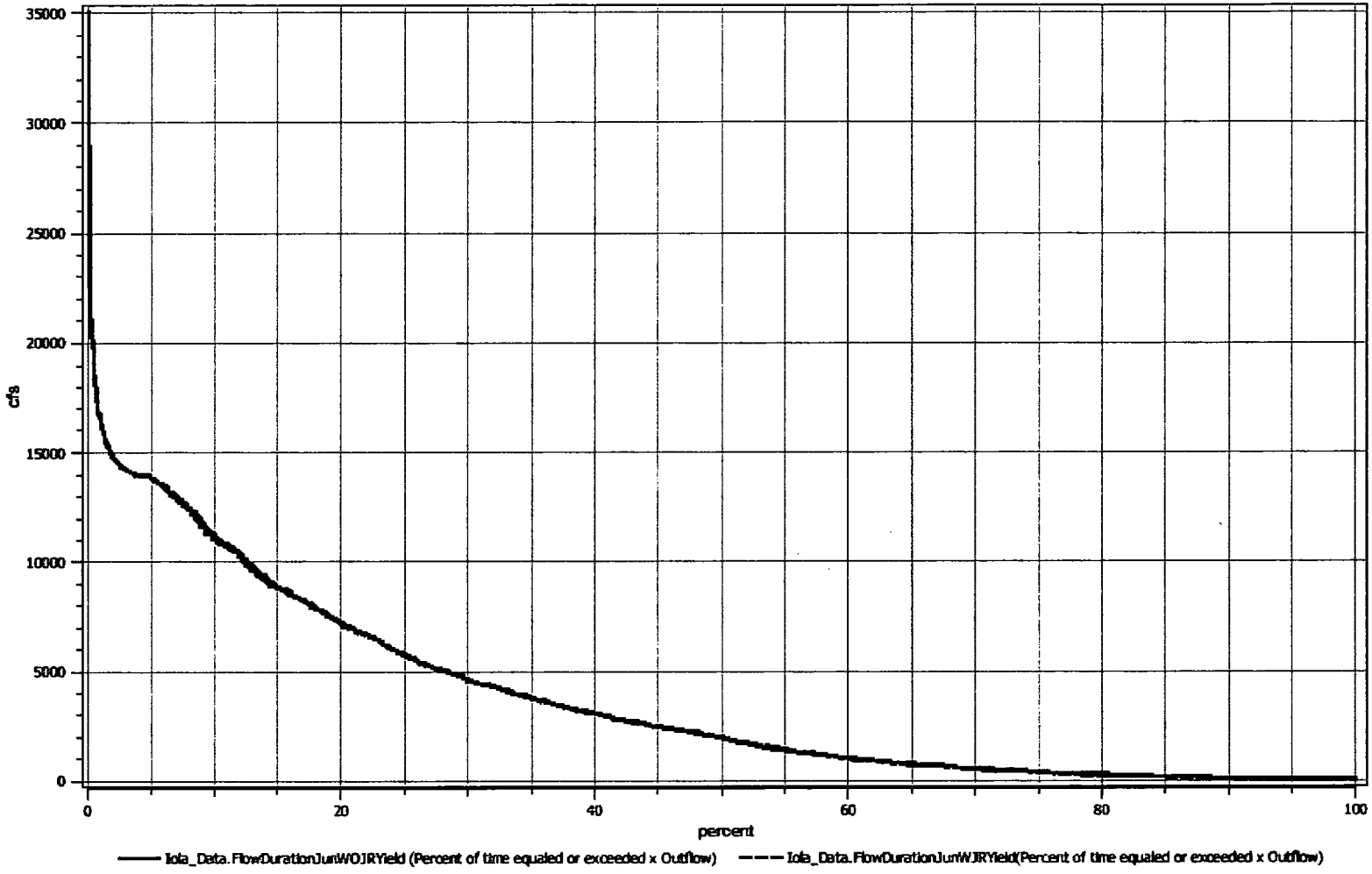
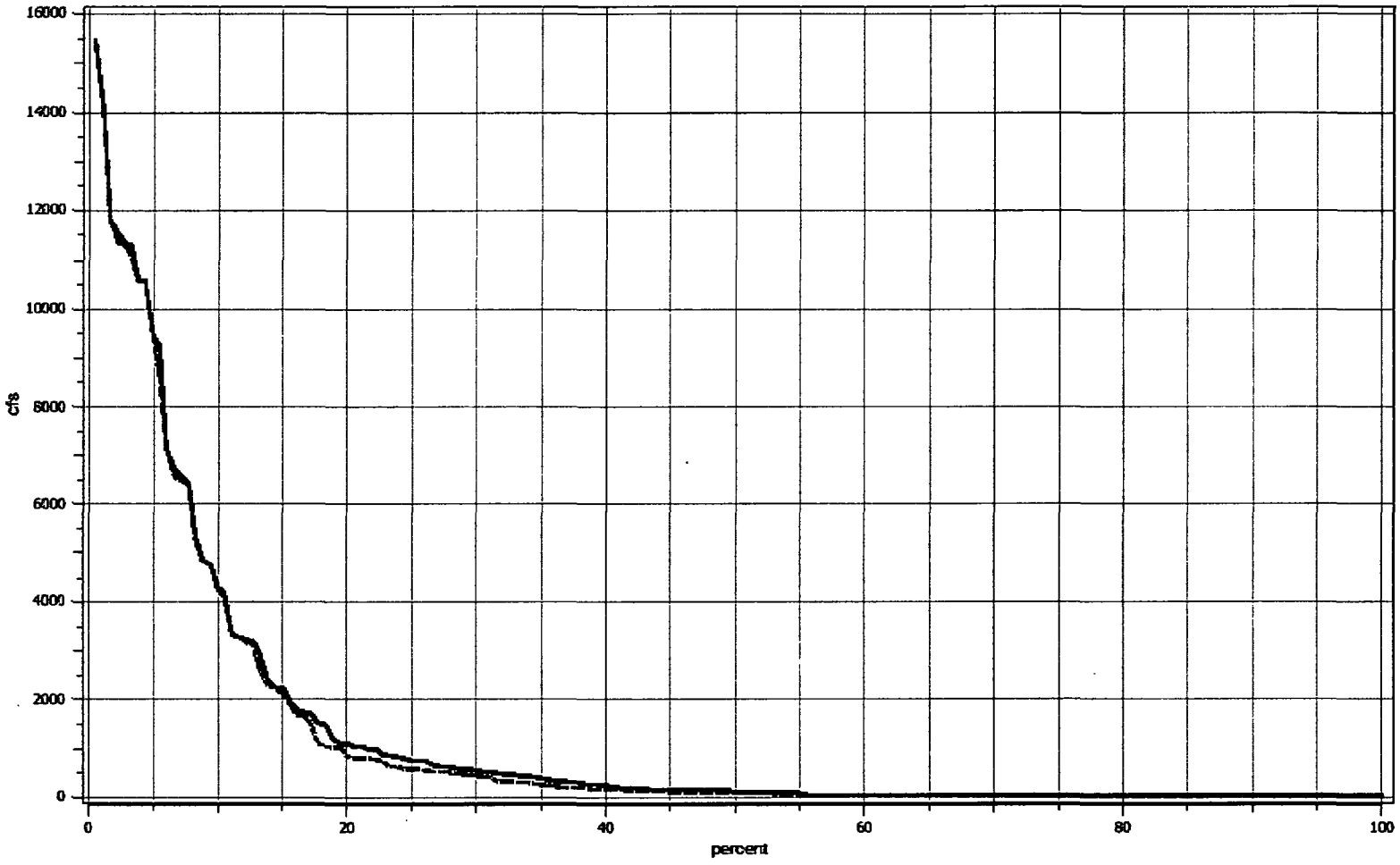
Neosho River at Iola, KS Month of June: 1940 - 2000 FLOW-DURATION



Neosho River at Iola, KS Month of June: 1952 - 1957 FLOW-DURATION



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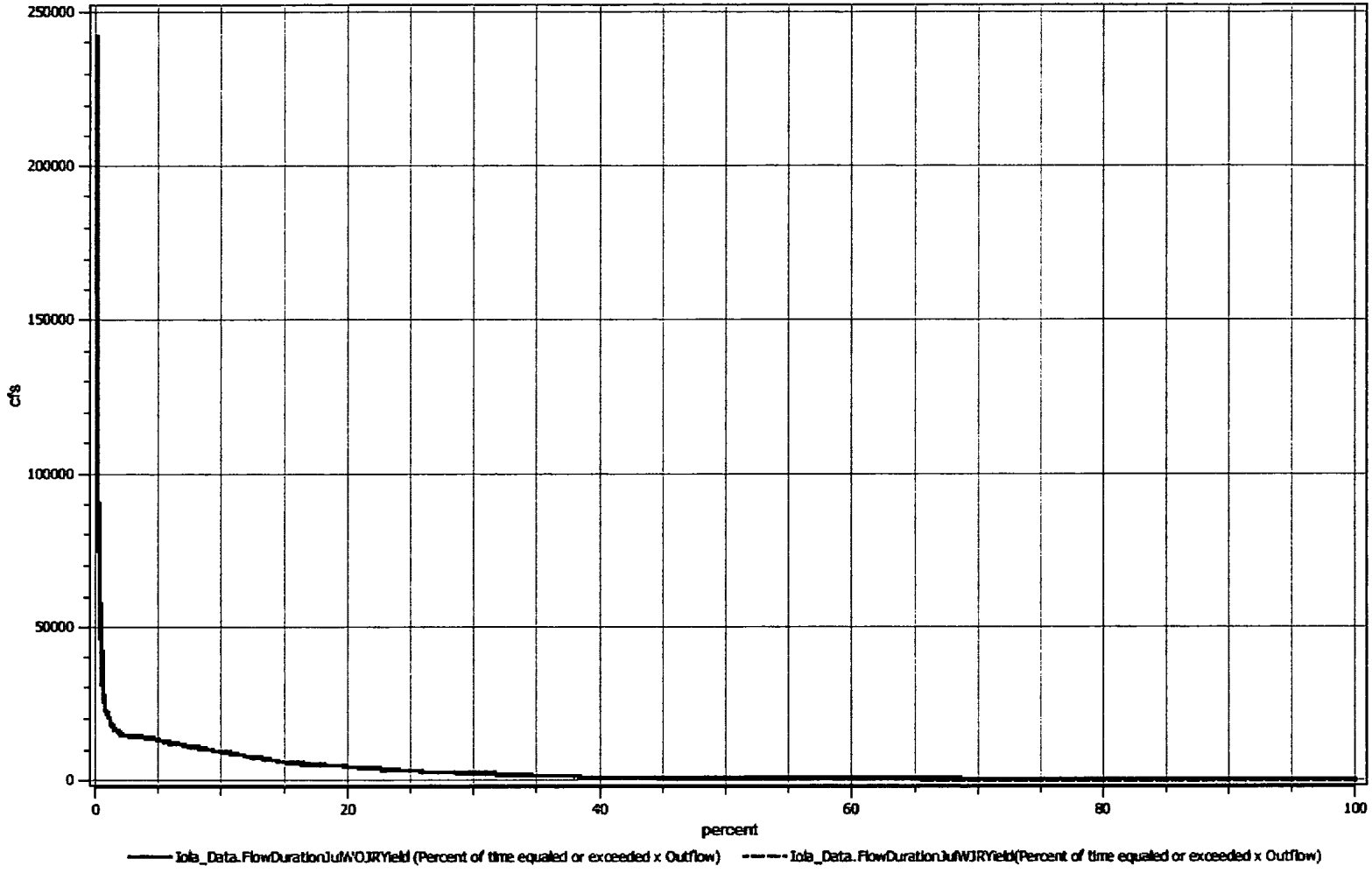
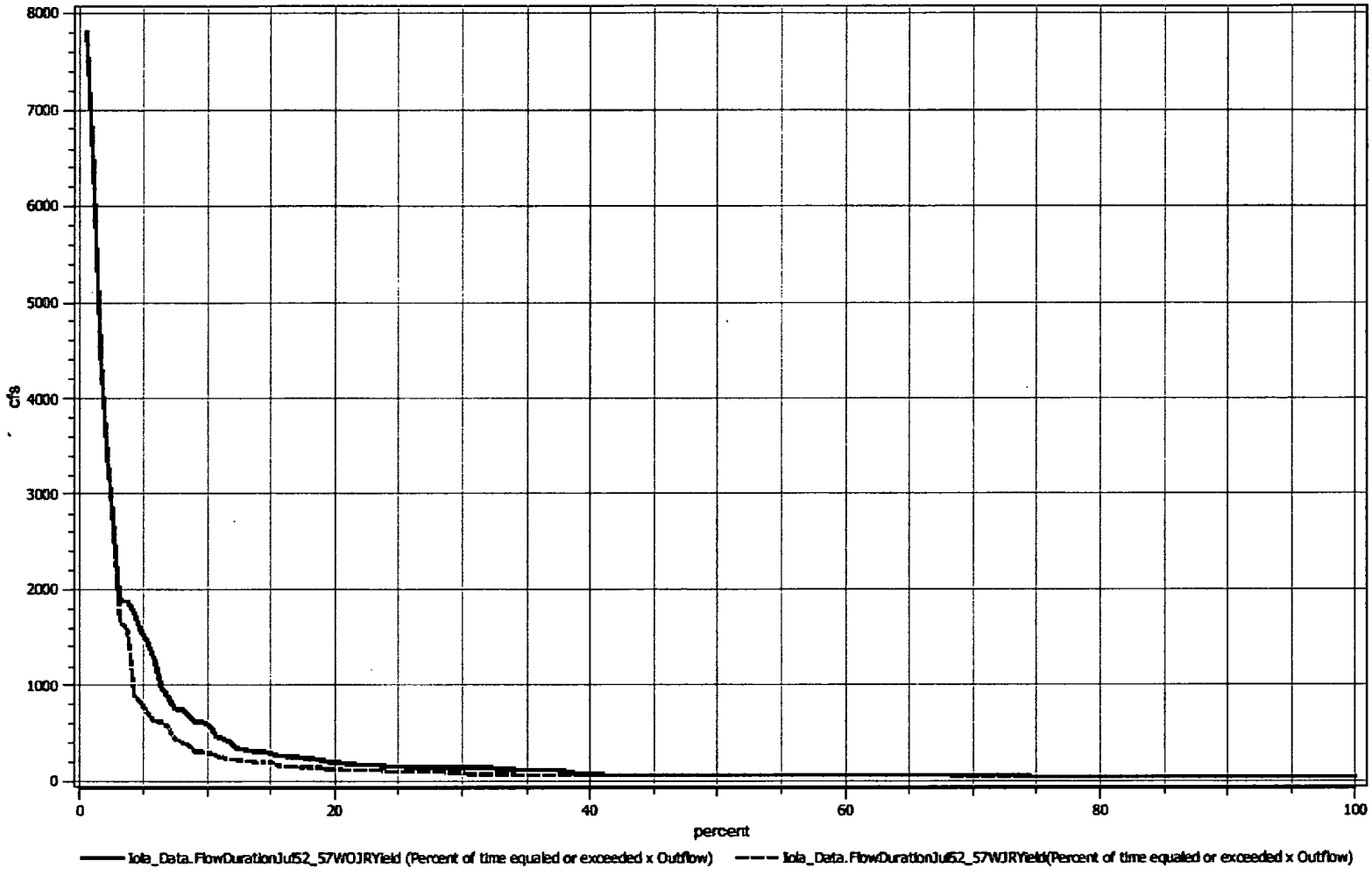
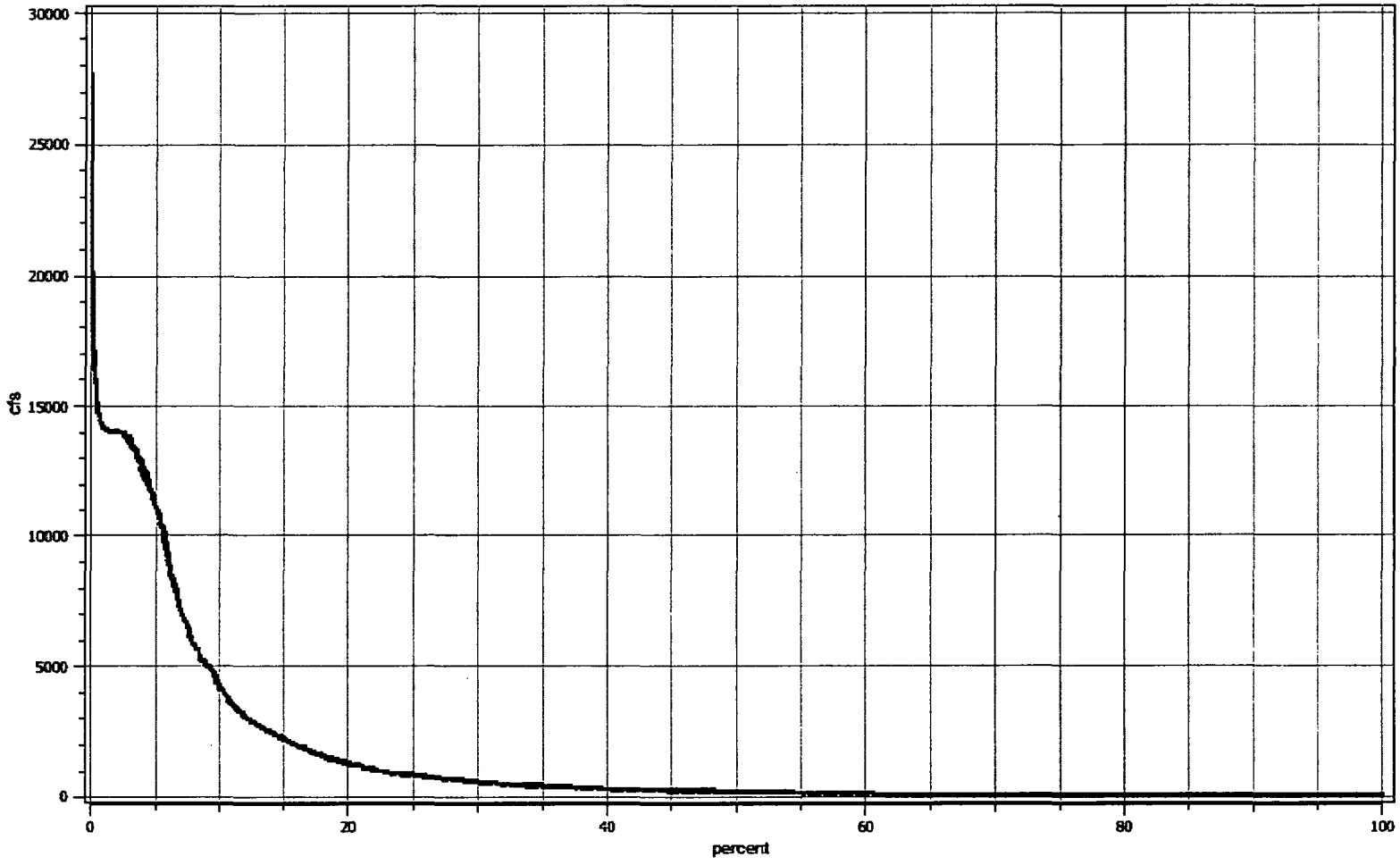
Neosho River at Iola, KS Month of July: 1940 - 2000 FLOW-DURATION



Neosho River at Iola, KS Month of July: 1952 - 1957 FLOW-DURATION



Neosho River at Iola, KS Month of August: 1940 - 2000 FLOW-DURATION



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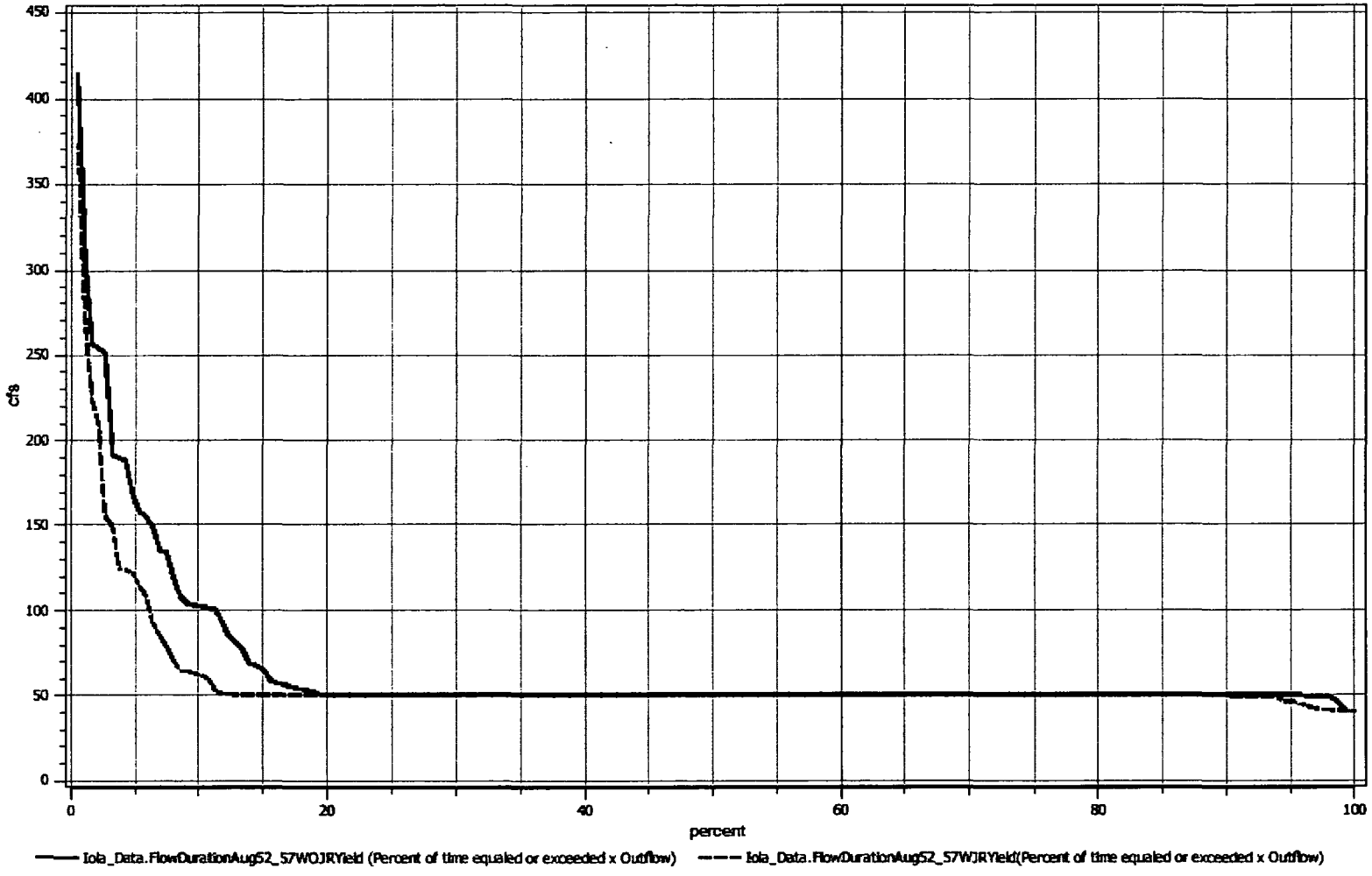
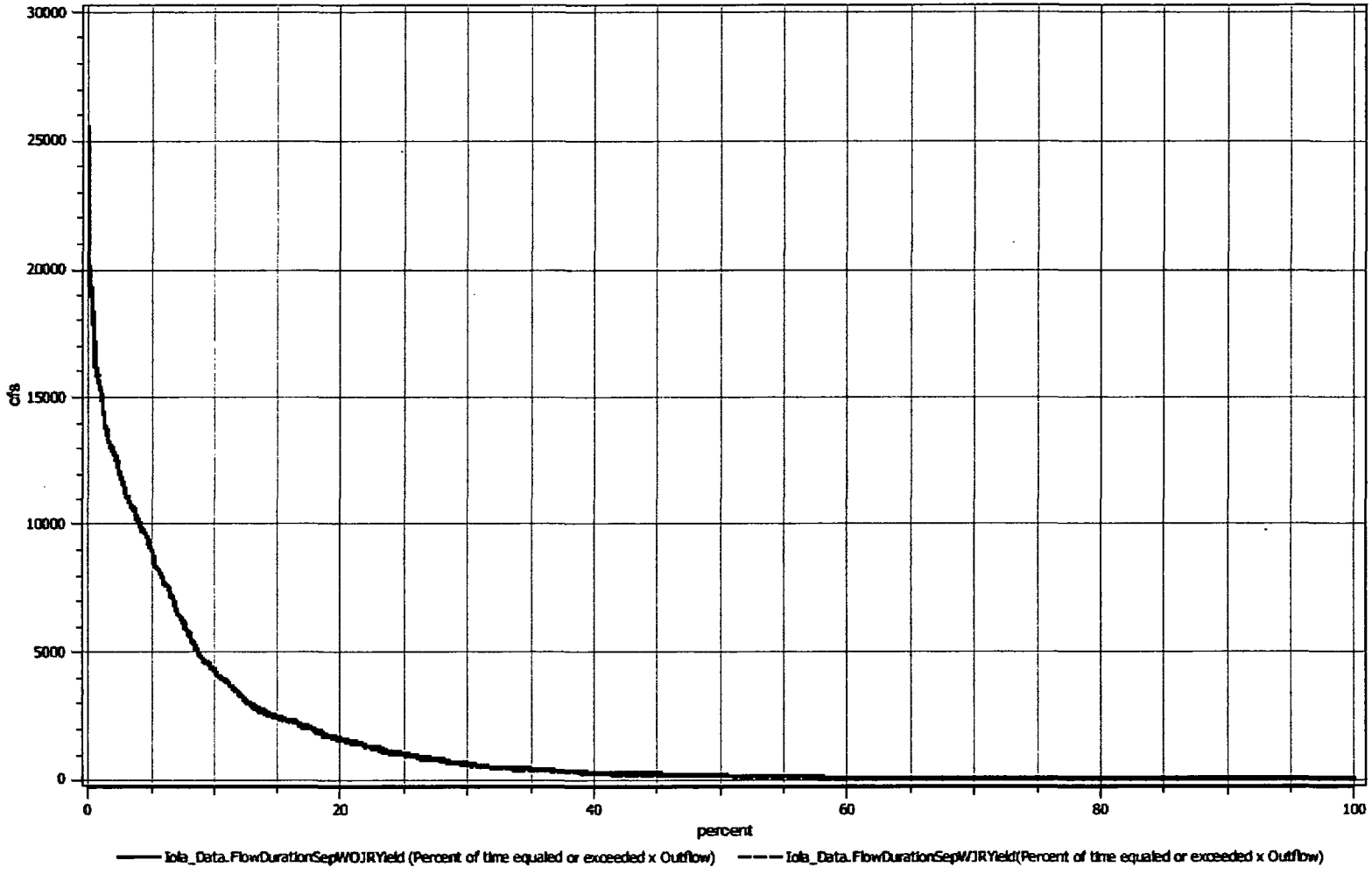
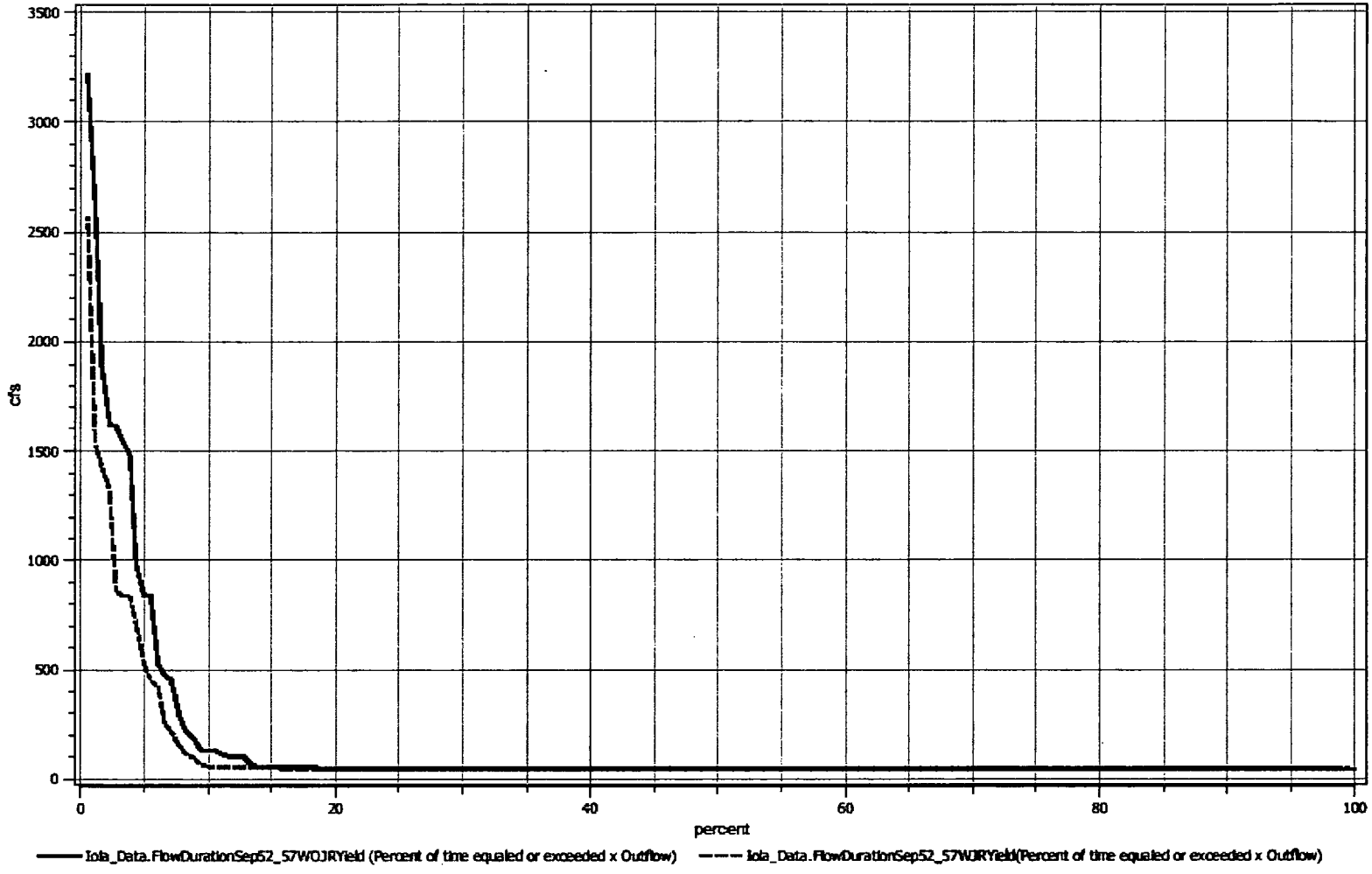
Neosho River at Iola, KS Month of August: 1952 - 1957 FLOW-DURATION



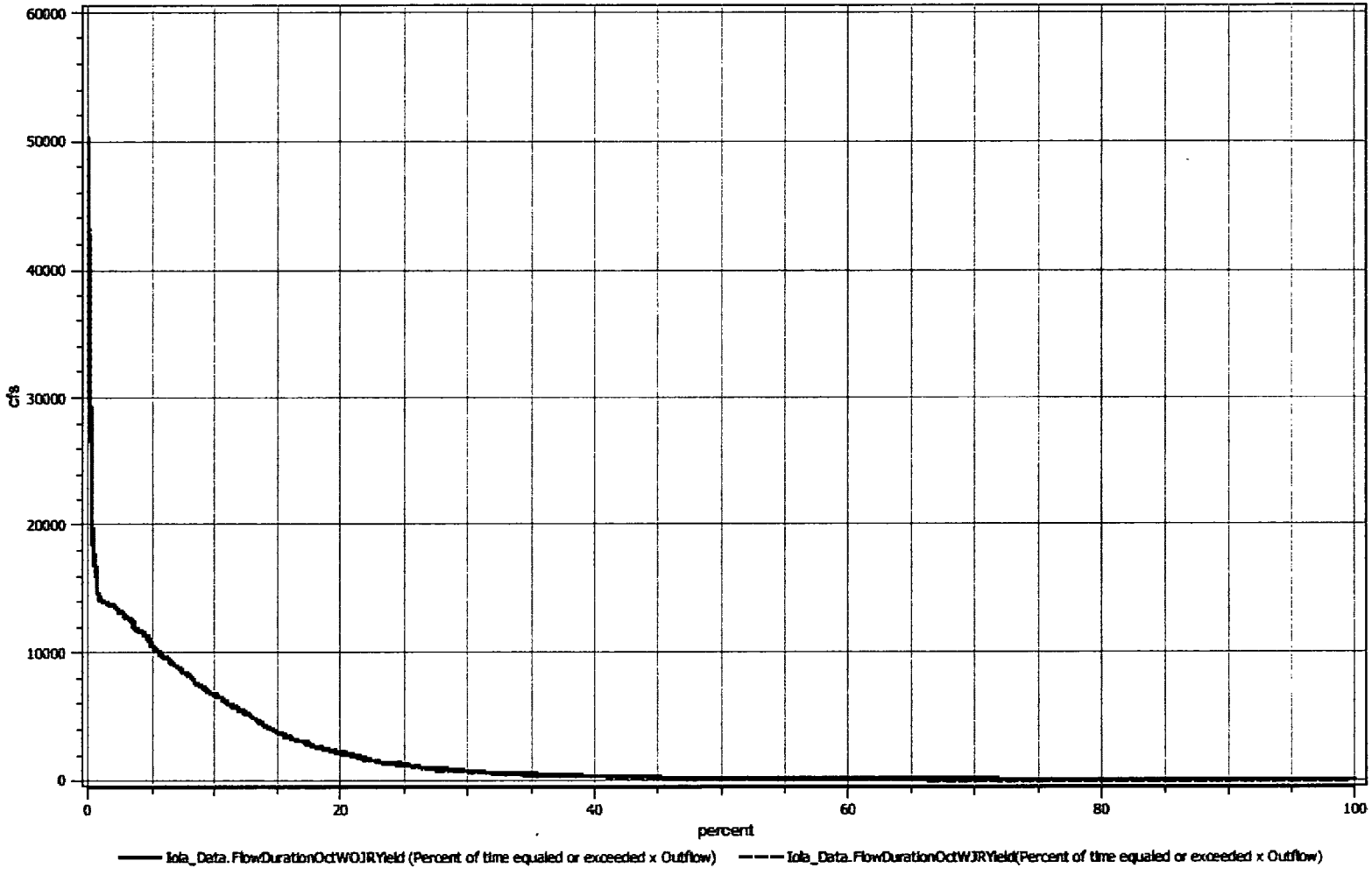
Neosho River at Iola, KS Month of September: 1940 - 2000 FLOW-DURATION



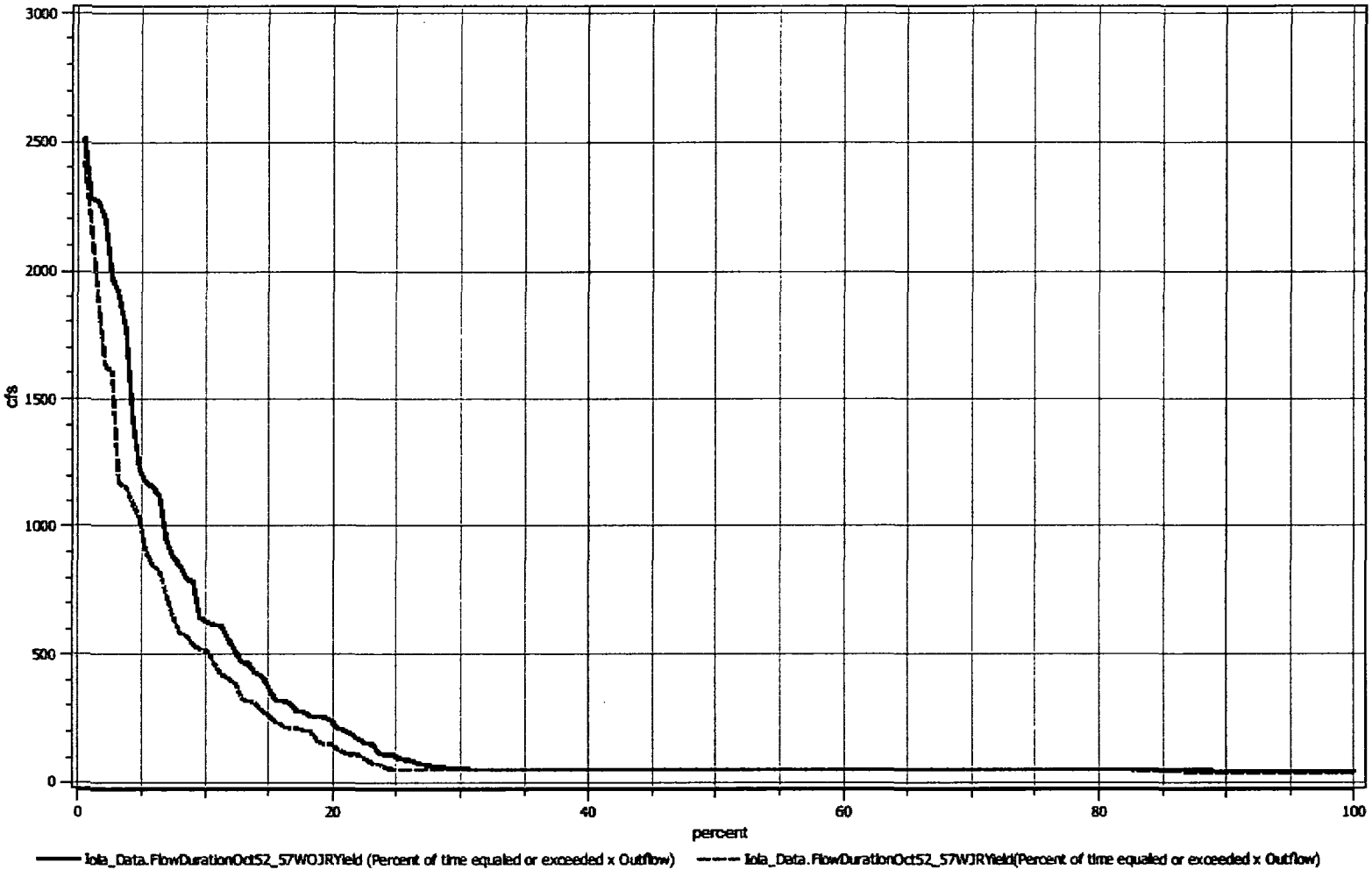
Neosho River at Iola, KS Month of September: 1952 - 1957 FLOW-DURATION



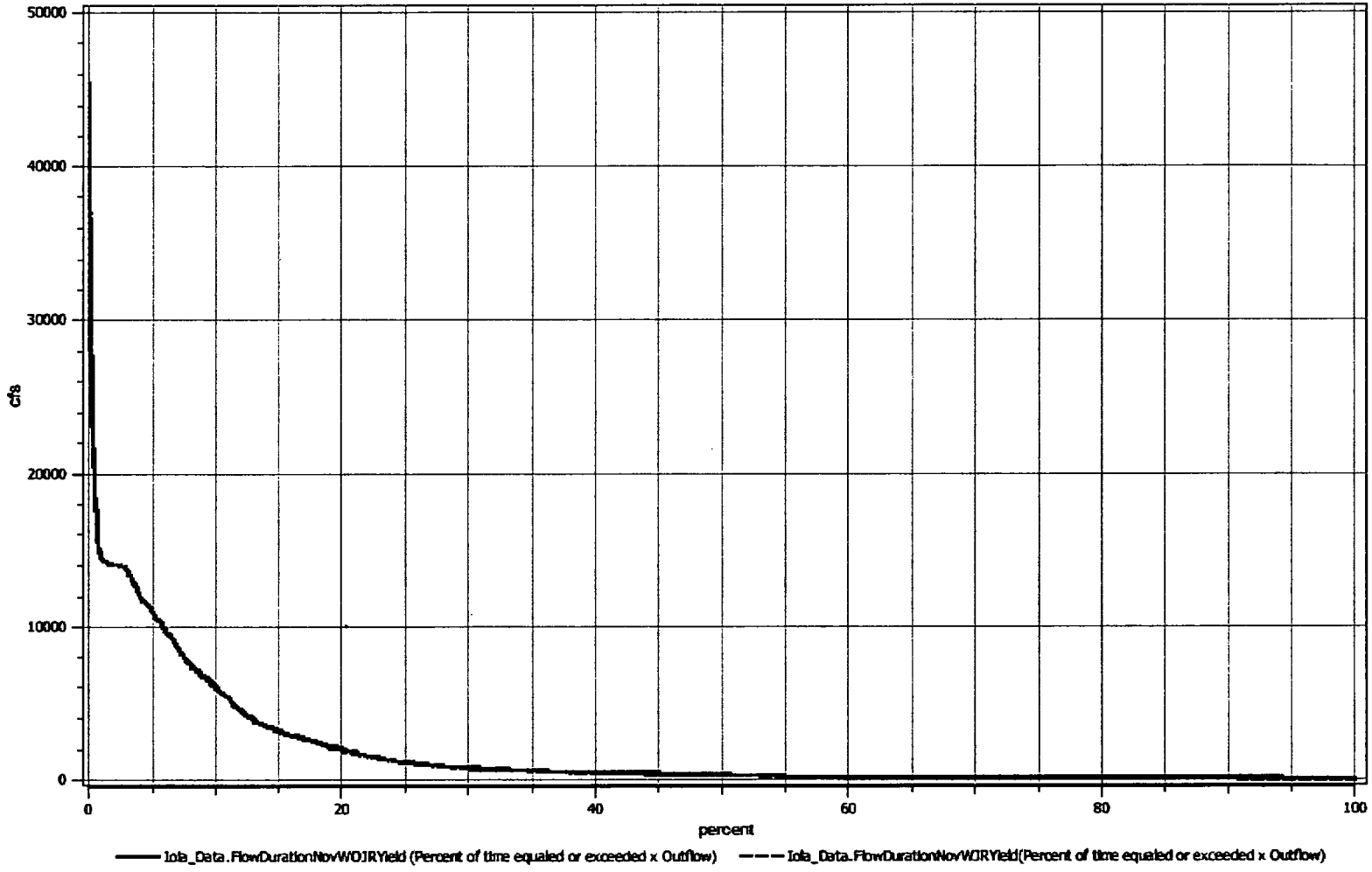
Neosho River at Iola, KS Month of October: 1940 - 2000 FLOW-DURATION



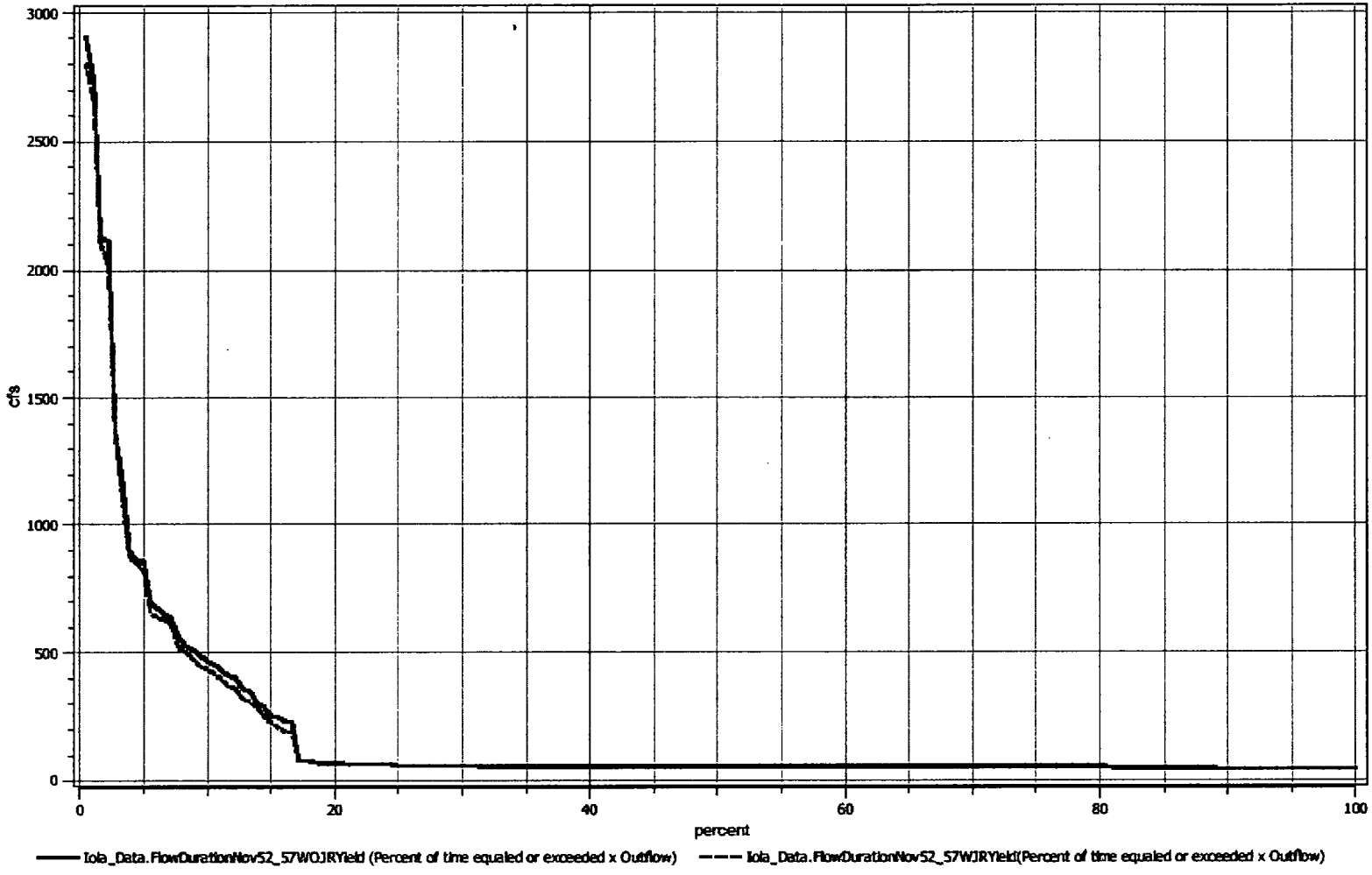
Neosho River at Iola, KS Month of October: 1952 - 1957 FLOW-DURATION



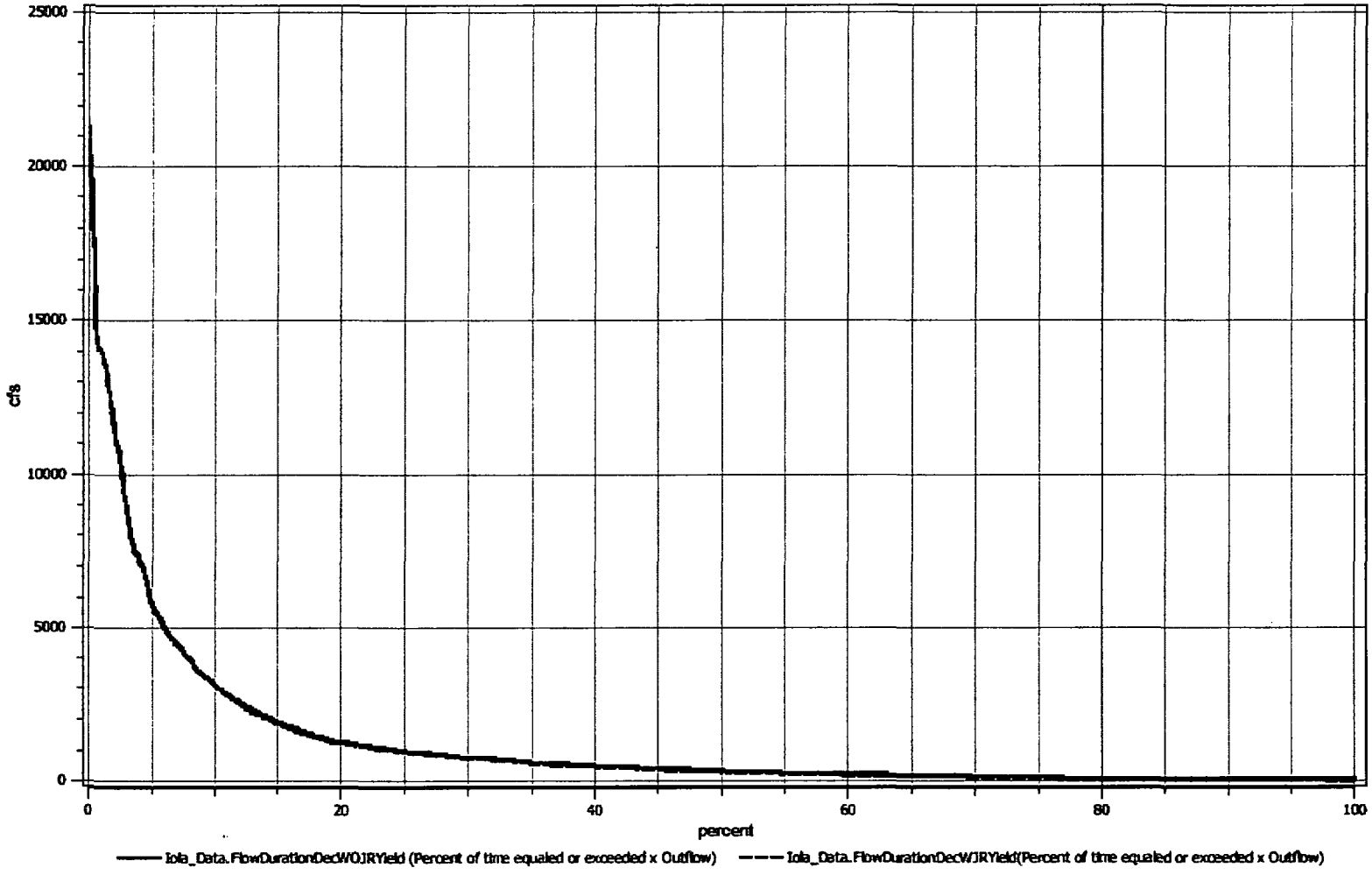
Neosho River at Iola, KS Month of November: 1940 - 2000 FLOW-DURATION



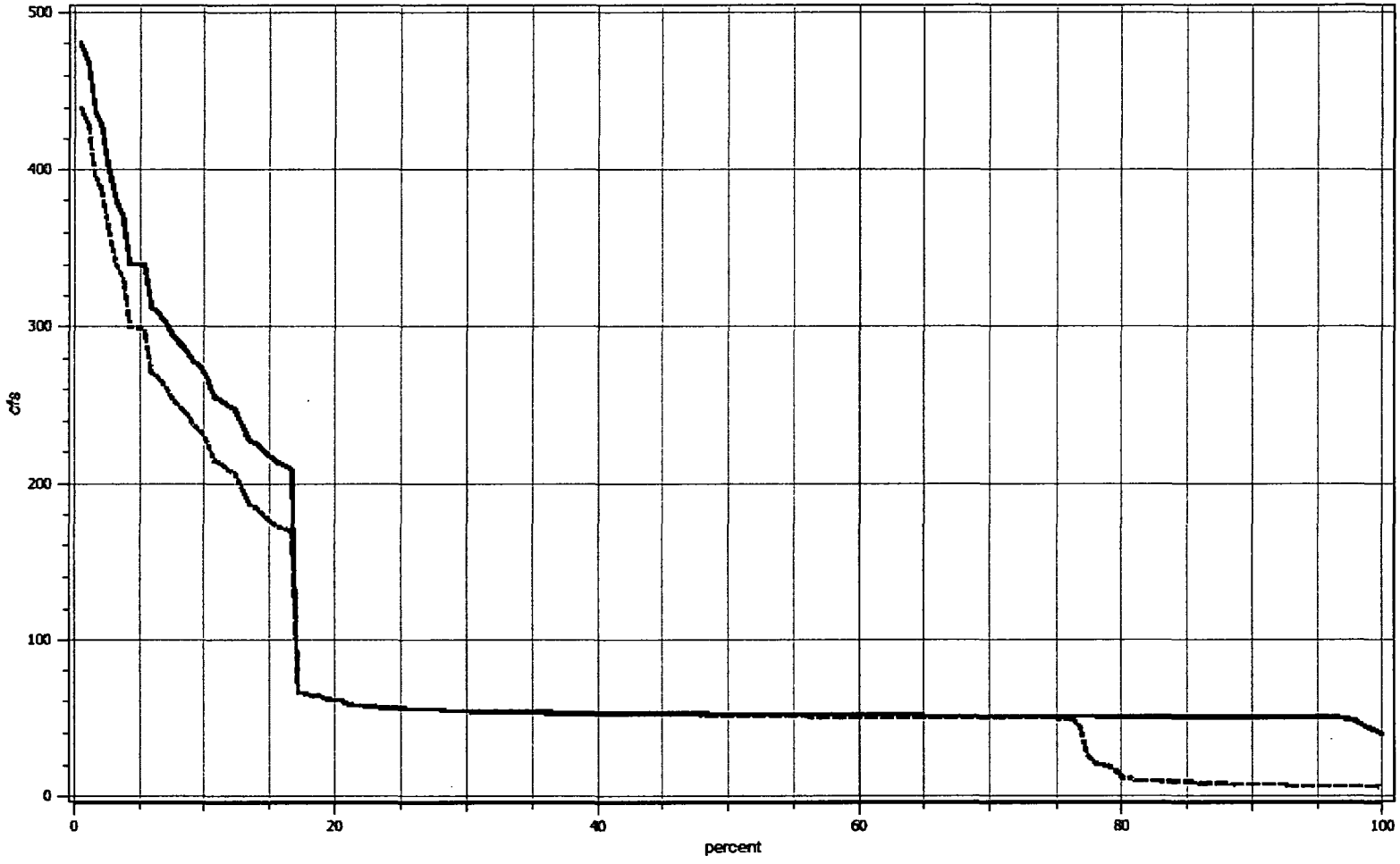
Neosho River at Iola, KS Month of November: 1952 - 1957 FLOW-DURATION



Neosho River at Iola, KS Month of December: 1940 - 2000 FLOW-DURATION

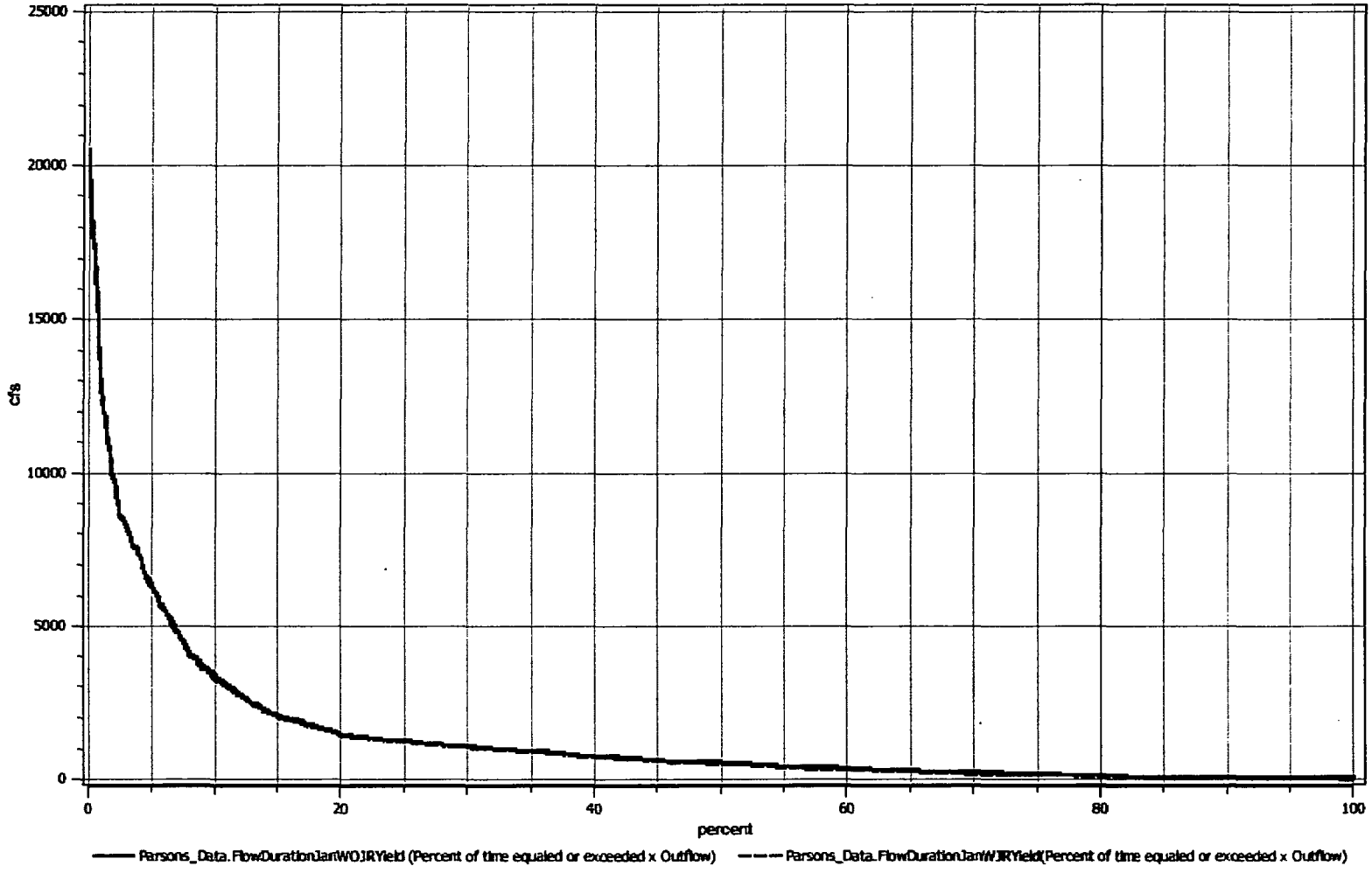


Neosho River at Iola, KS Month of December: 1952 - 1957 FLOW-DURATION

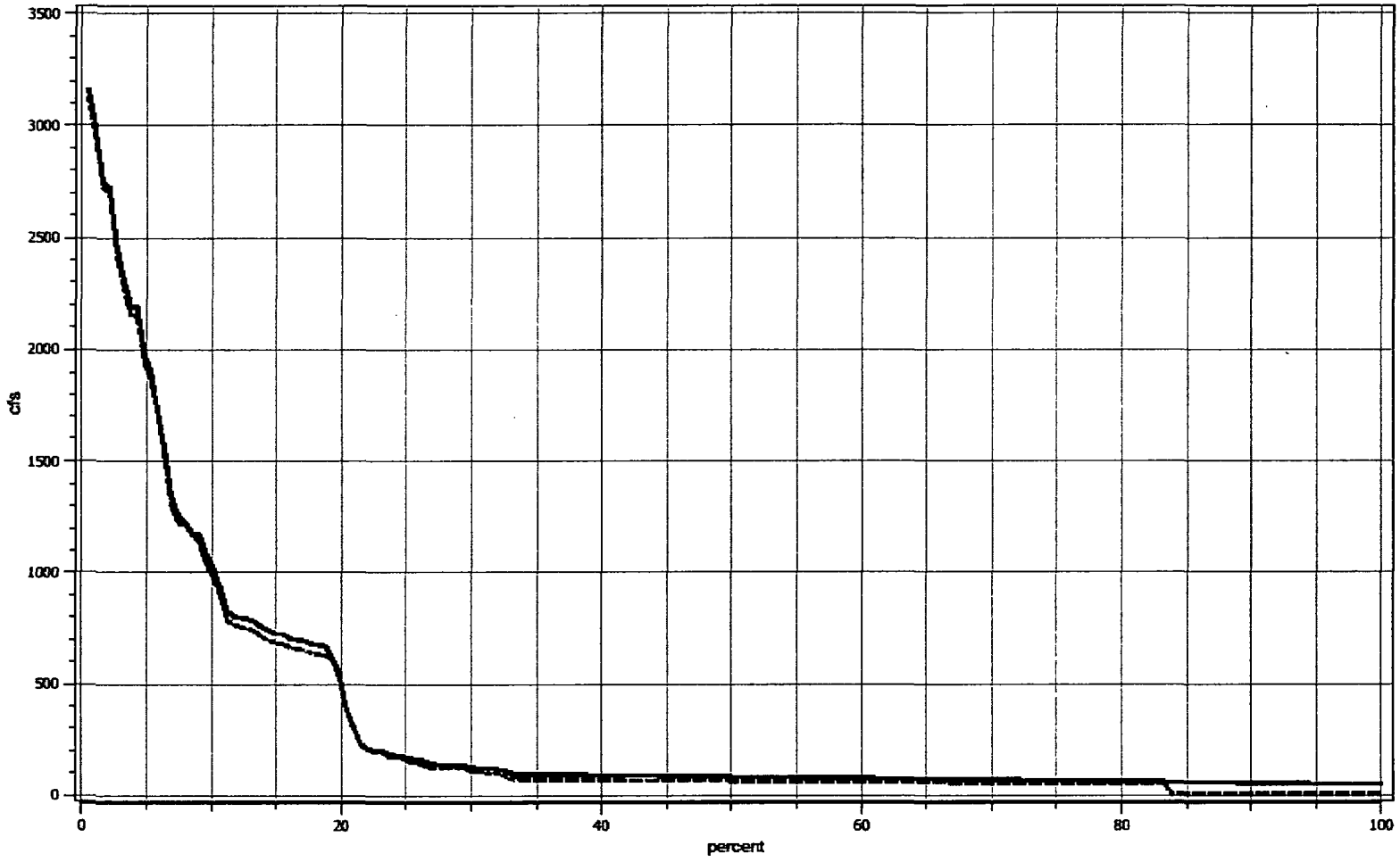


—— Iola_Data.FlowDurationDec52_57WOJRYield (Percent of time equaled or exceeded x Outflow) – – – Iola_Data.FlowDurationDec52_57WJRYield(Percent of time equaled or exceeded x Outflow)

Neosho River at Parsons, KS Month of January: 1940 - 2000 FLOW-DURATION



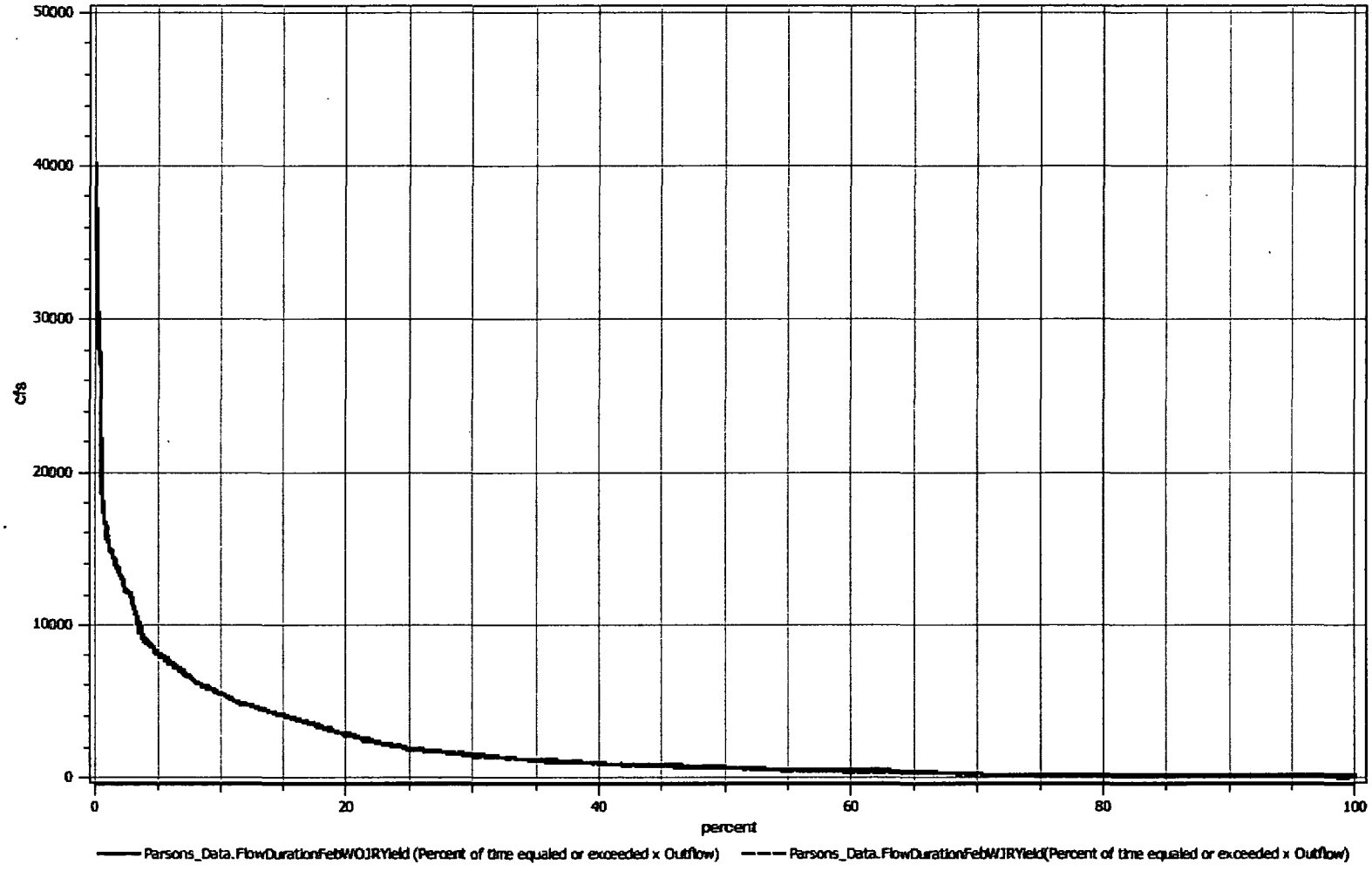
Neosho River at Parsons, KS Month of January: 1952 - 1957 FLOW-DURATION



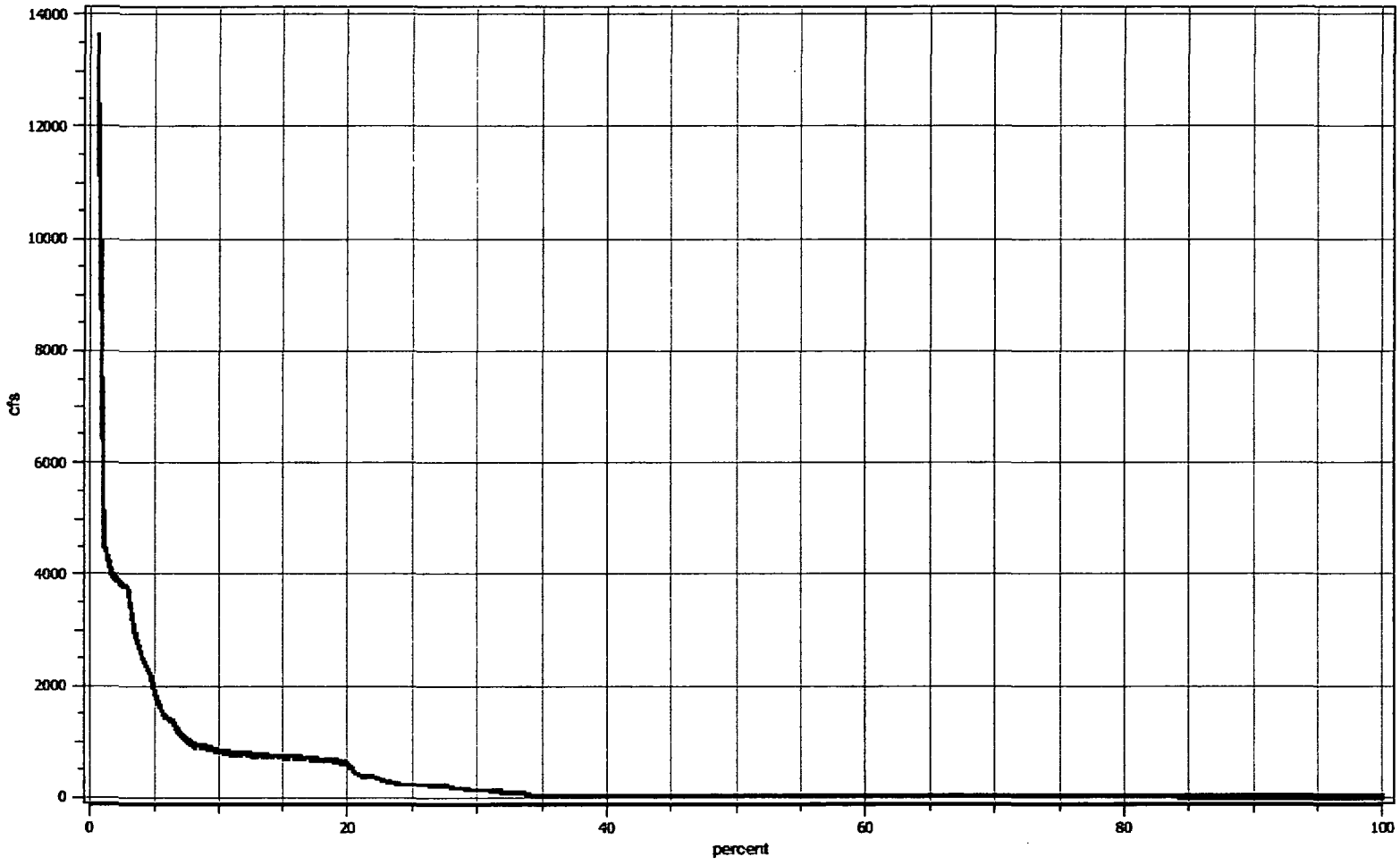
Parsons_Data.FlowDurationJan52_57WOJRYield (Percent of time equaled or exceeded x Outflow)

Parsons_Data.FlowDurationJan52_57WJRYield(Percent of time equaled or exceeded x Outflow)

Neosho River at Parsons, KS Month of February: 1940 - 2000 FLOW-DURATION



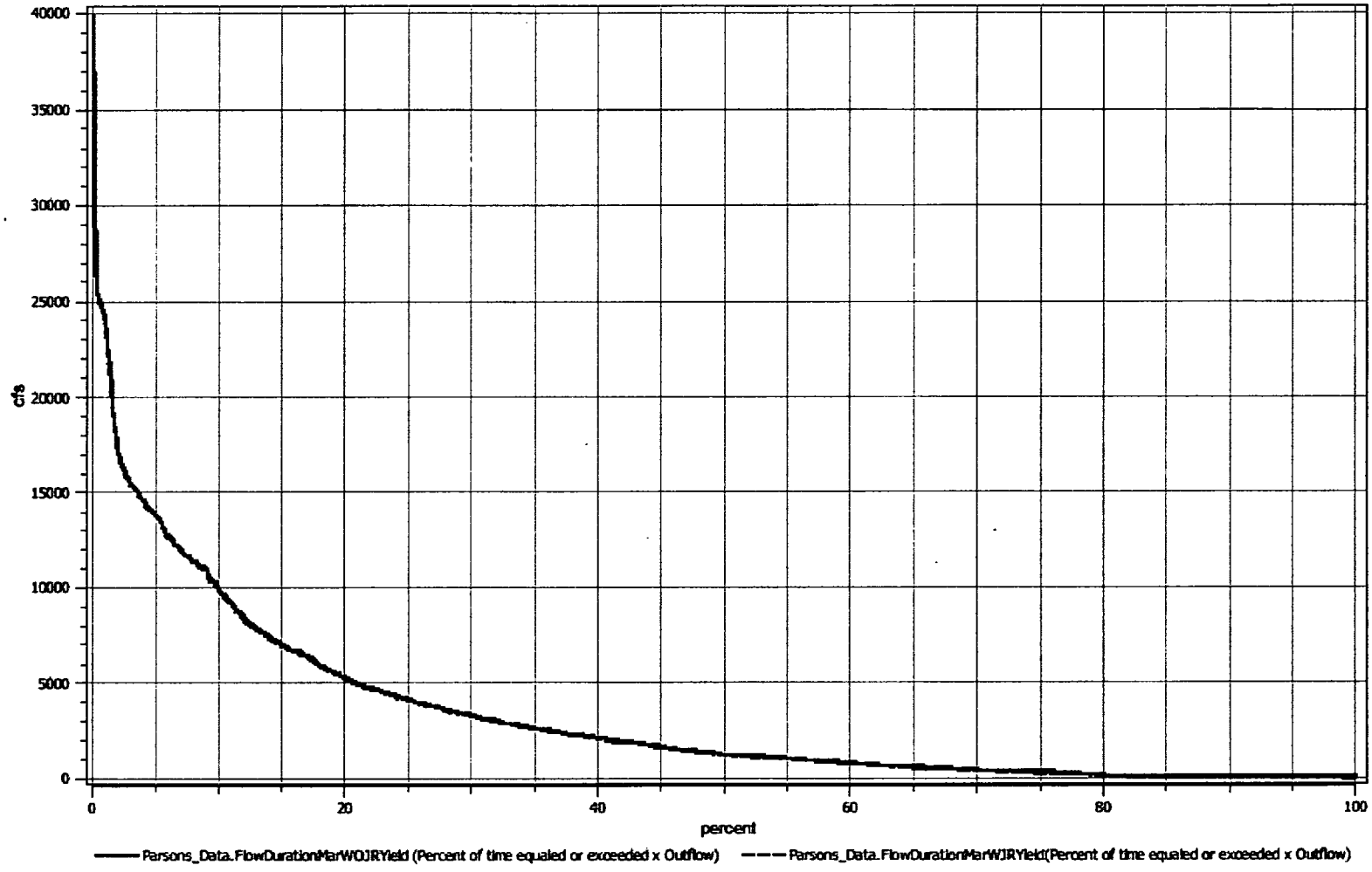
Neosho River at Parsons, KS Month of February: 1952 - 1957 FLOW-DURATION



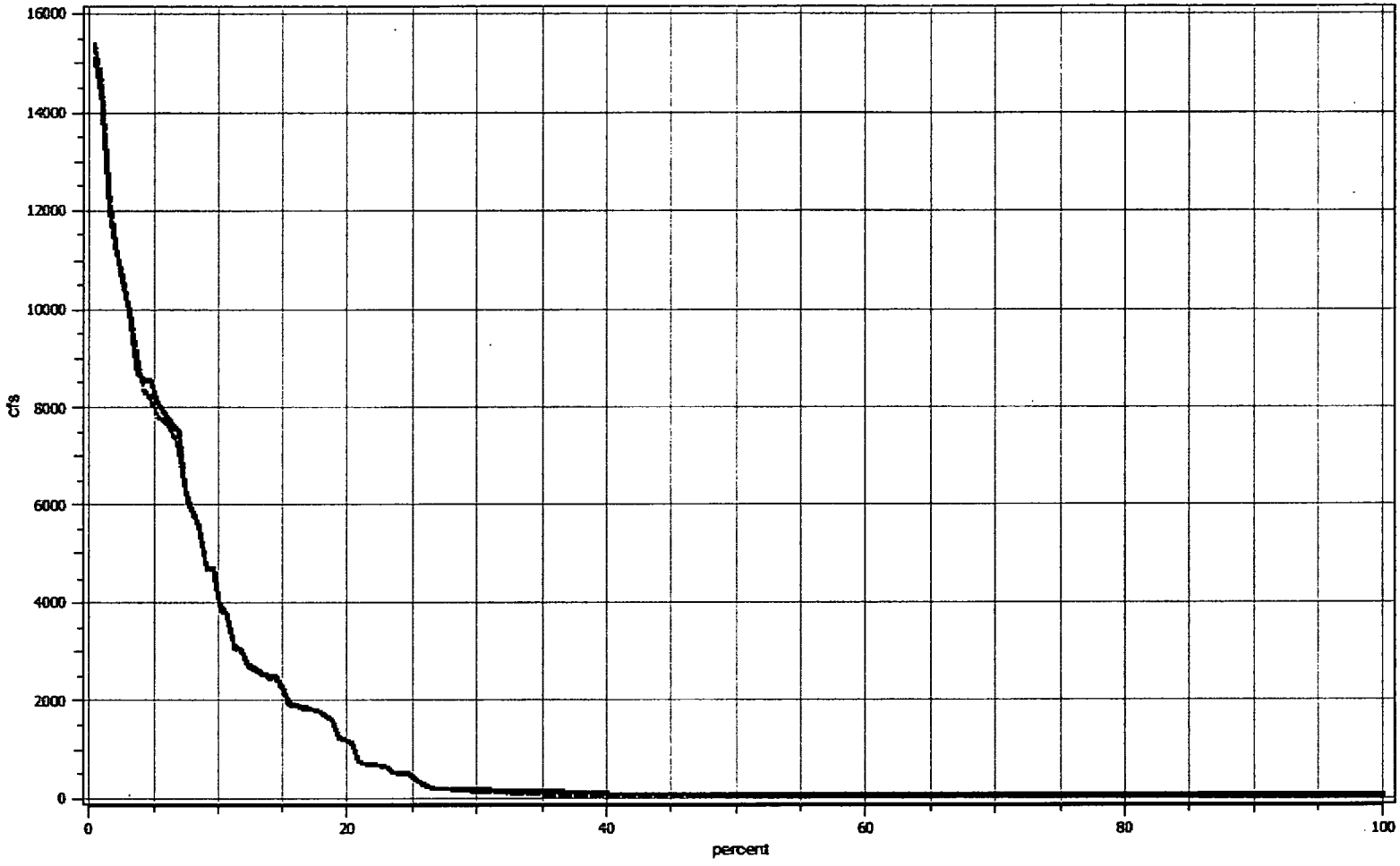
Parsons_Data.FlowDurationFeb52_57WOJRYield (Percent of time equaled or exceeded x Outflow)

Parsons_Data.FlowDurationFeb52_57WJRYield(Percent of time equaled or exceeded x Outflow)

Neosho River at Parsons, KS Month of March: 1940 - 2000 FLOW-DURATION

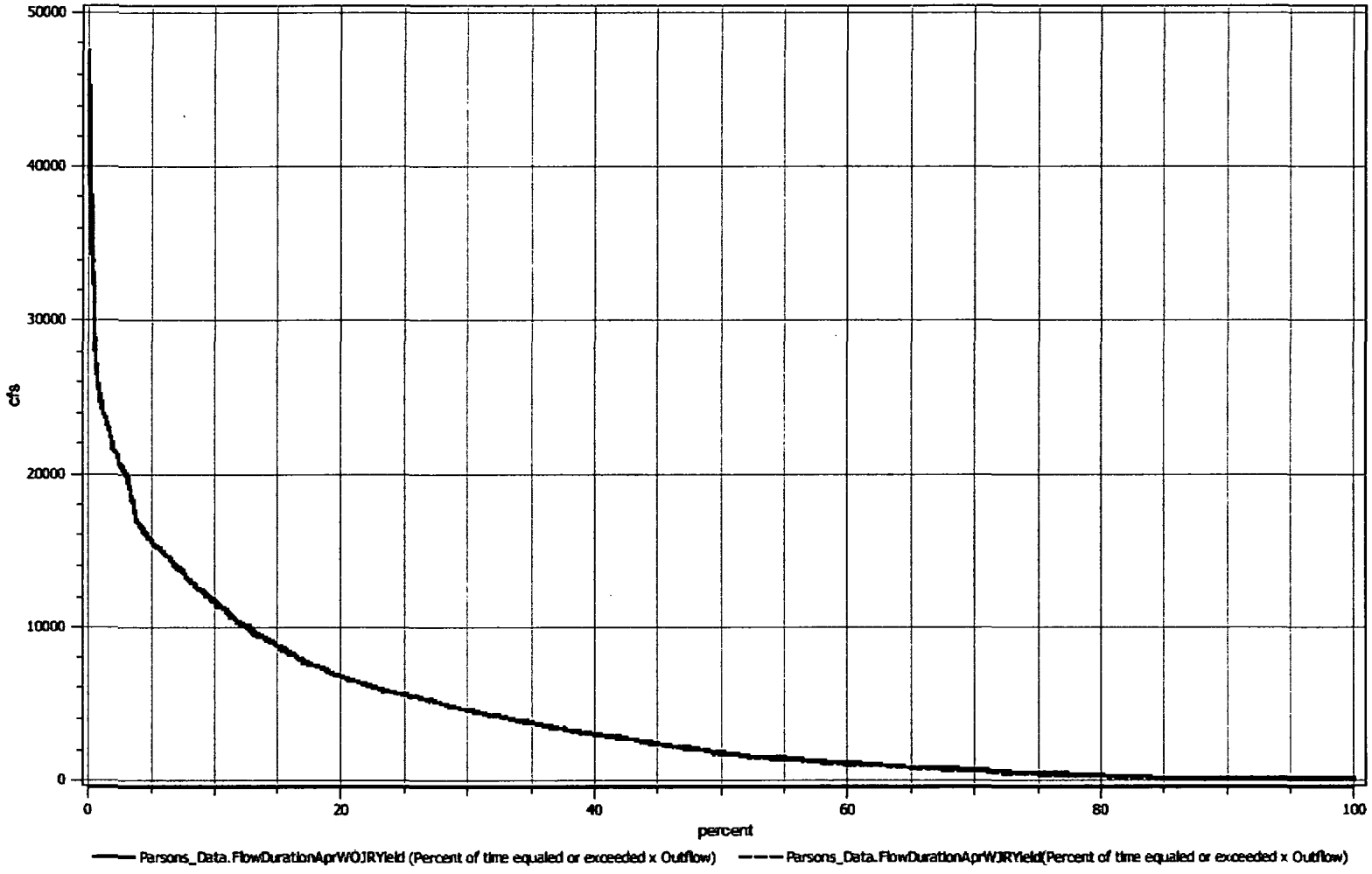


Neosho River at Parsons, KS Month of March: 1952 - 1957 FLOW-DURATION

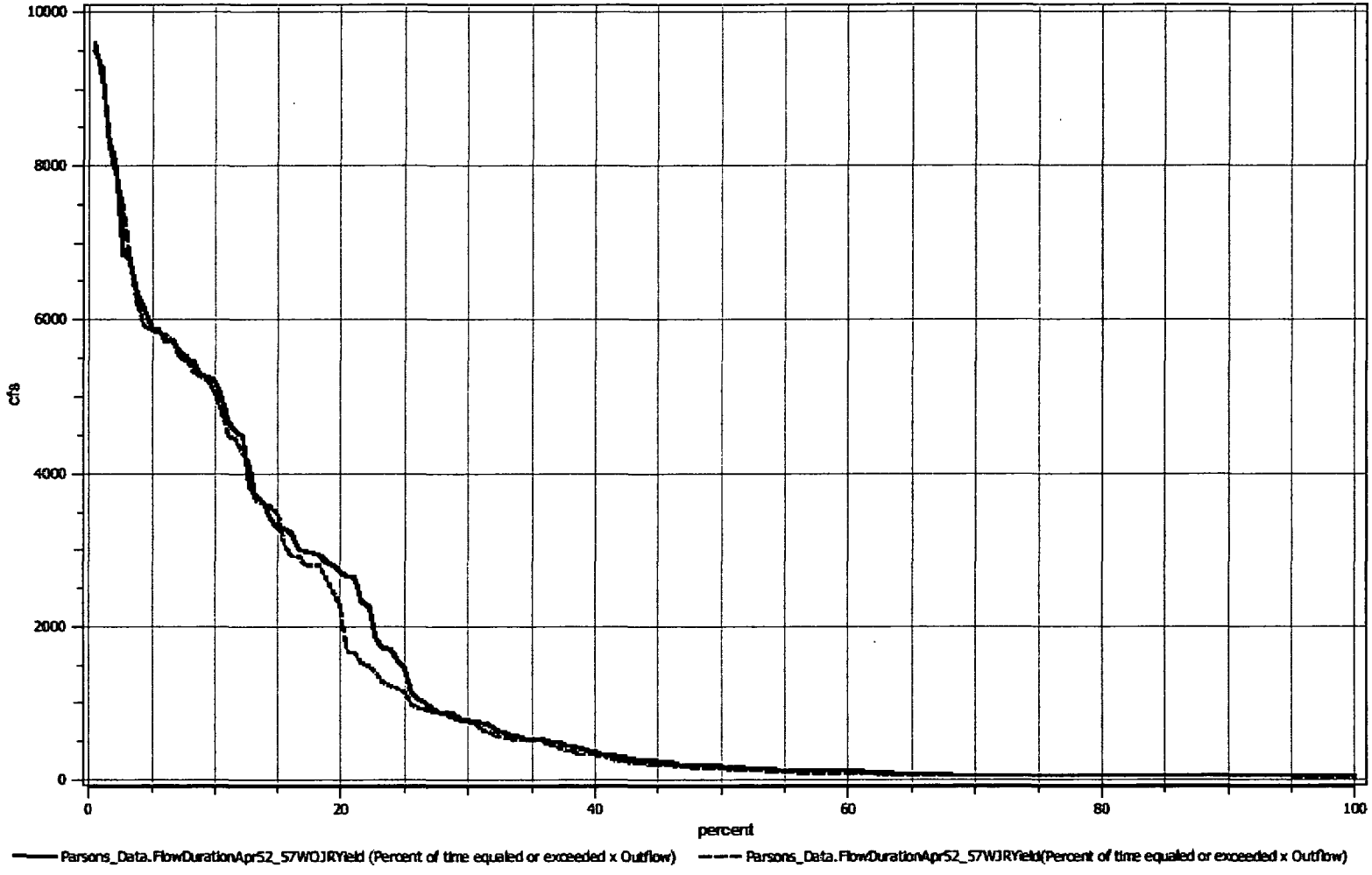


——— Parsons_Data.FlowDurationMar52_57WOJRYield (Percent of time equaled or exceeded x Outflow) – – – Parsons_Data.FlowDurationMar52_57WJRYield(Percent of time equaled or exceeded x Outflow)

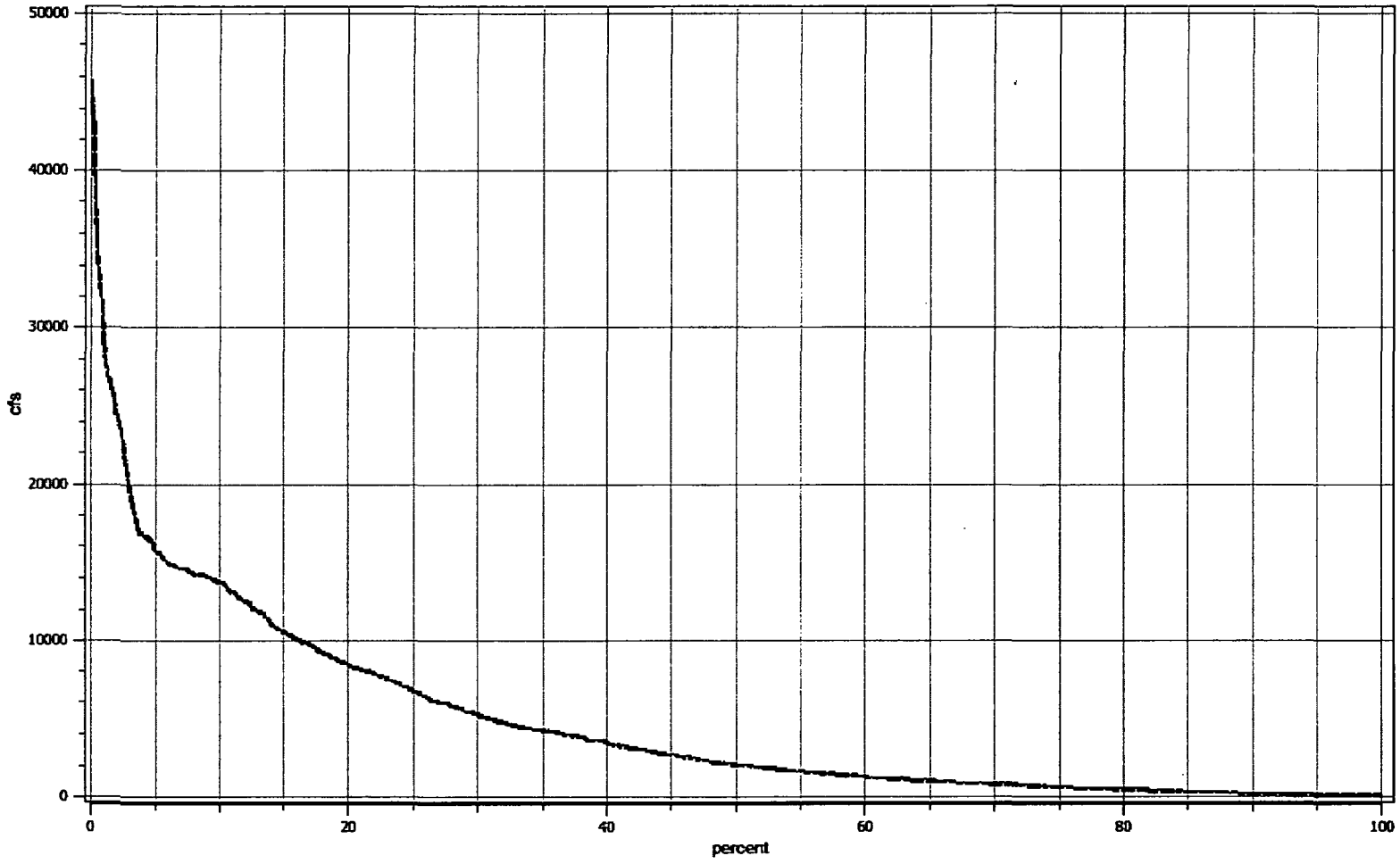
Neosho River at Parsons, KS Month of April: 1940 - 2000 FLOW-DURATION



Neosho River at Parsons, KS Month of April: 1952 - 1957 FLOW-DURATION

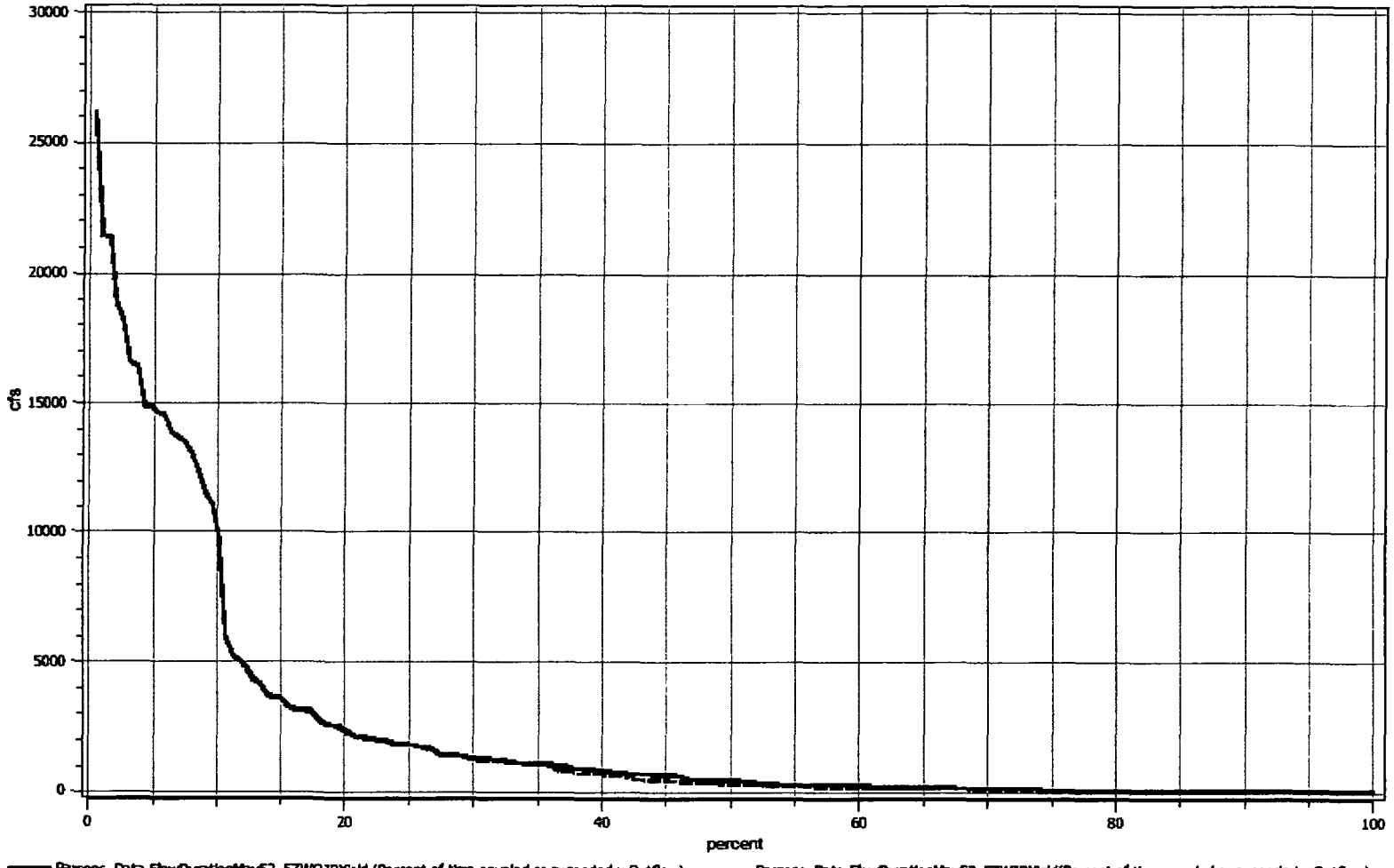


Neosho River at Parsons, KS Month of May: 1940 - 2000 FLOW-DURATION



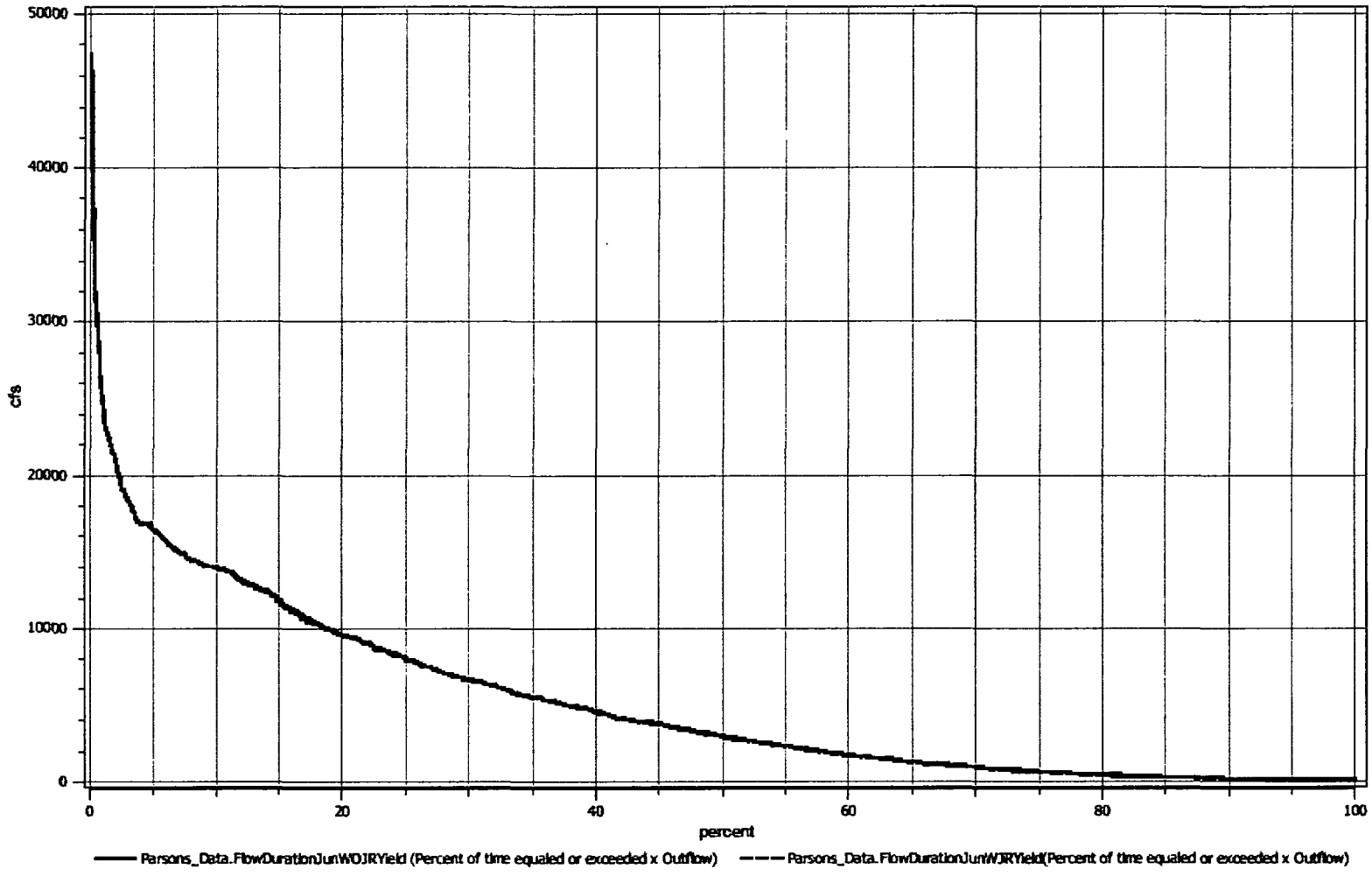
—— Parsons_Data.FlowDurationMayWOJRYield (Percent of time equaled or exceeded x Outflow) ——— Parsons_Data.FlowDurationMayWJRYield(Percent of time equaled or exceeded x Outflow)

Neosho River at Parsons, KS Month of May: 1952 - 1957 FLOW-DURATION

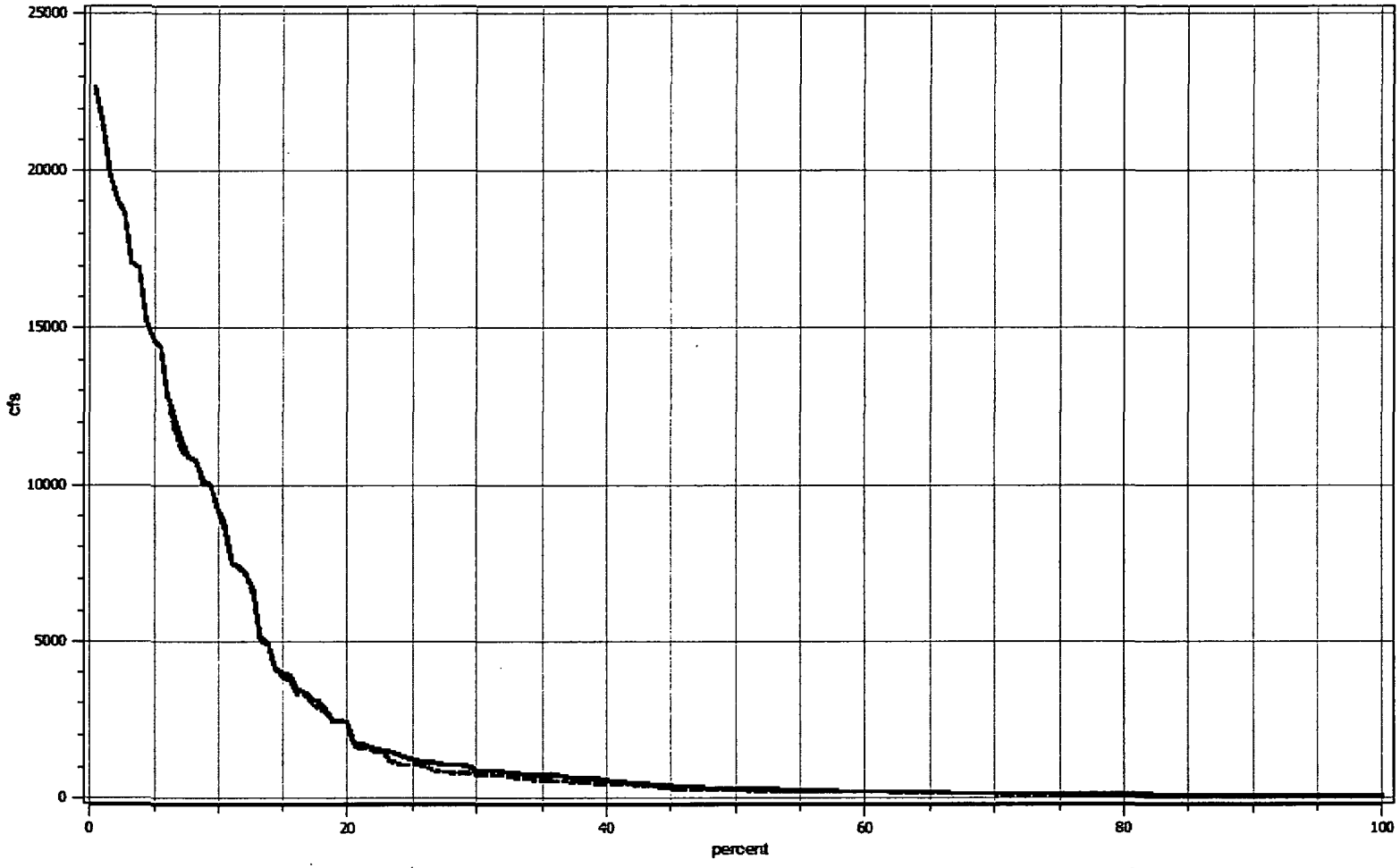


Parsons_Data.FlowDurationMay52_57WOJRYield (Percent of time equaled or exceeded x Outflow) — Parsons_Data.FlowDurationMay52_57WJRYield(Percent of time equaled or exceeded x Outflow)

Neosho River at Parsons, KS Month of June: 1940 - 2000 FLOW-DURATOIN

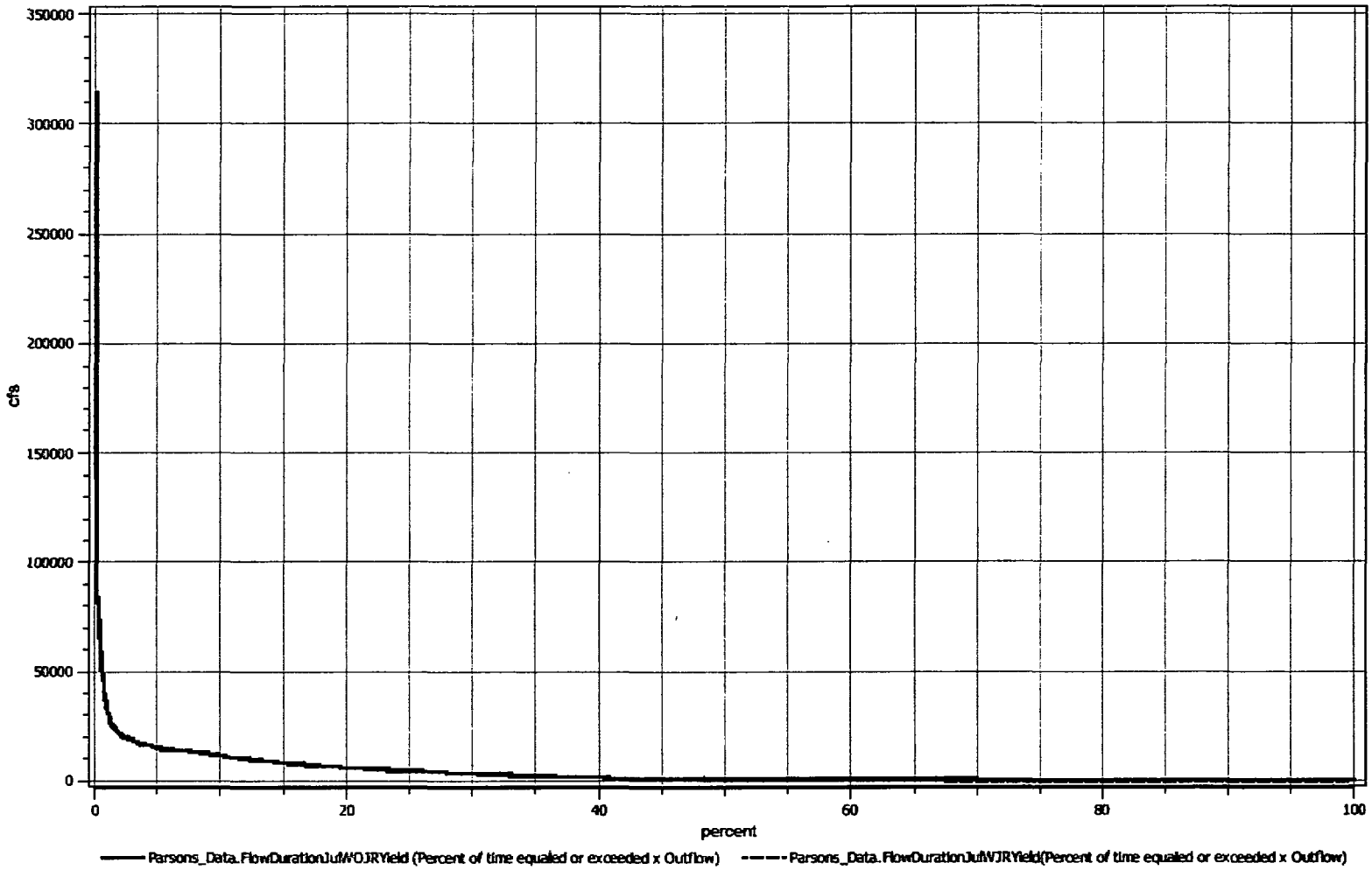


Neosho River at Parsons, KS Month of June: 1952 - 1957 FLOW-DURATION

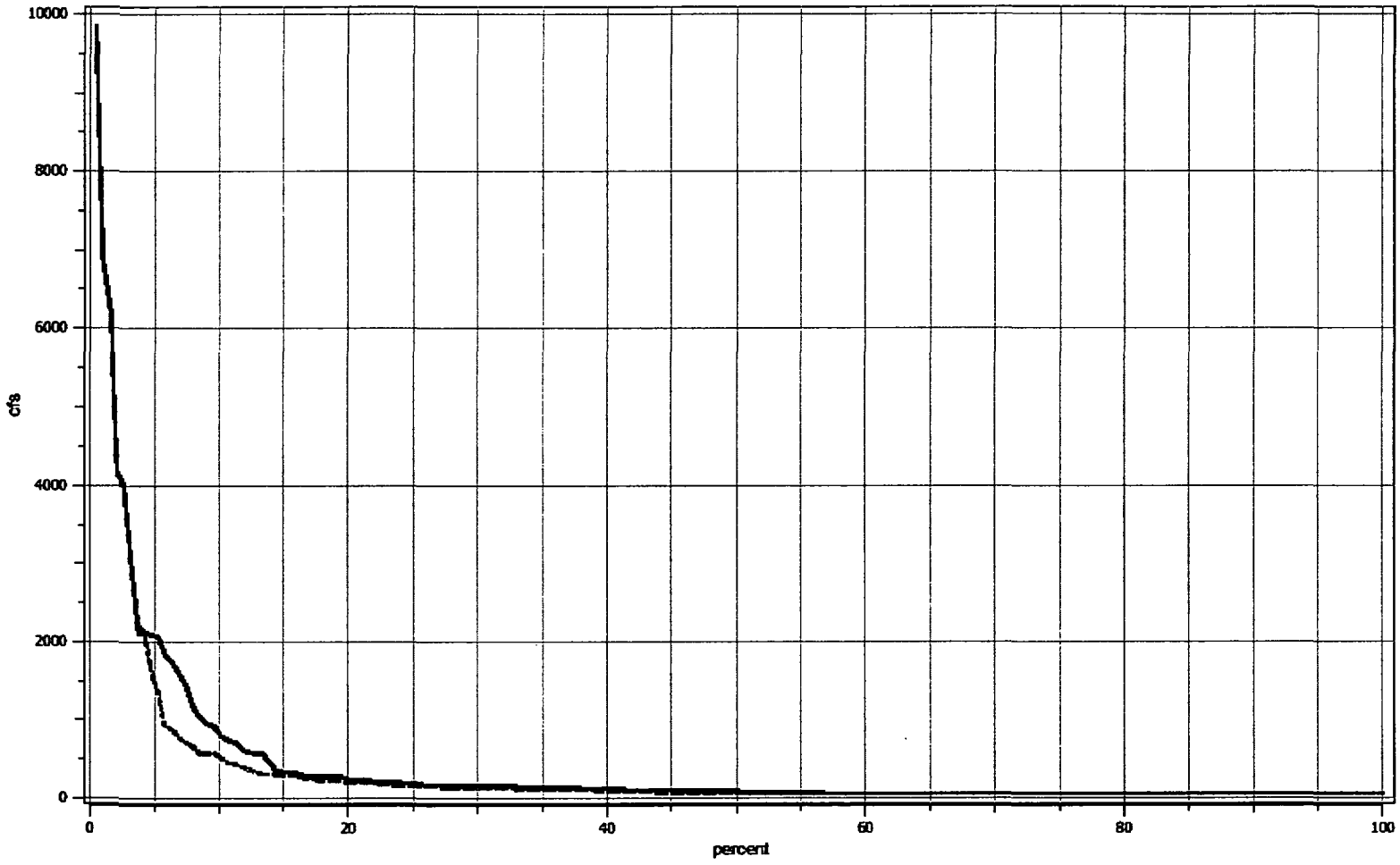


—— Parsons_Data.FlowDurationJun52_57WOJRYield (Percent of time equaled or exceeded x Outflow) – – – Parsons_Data.FlowDurationJun52_57WJRYield(Percent of time equaled or exceeded x Outflow)

Neosho River at Parsons, KS Month of July: 1940 - 2000 FLOW-DURATION

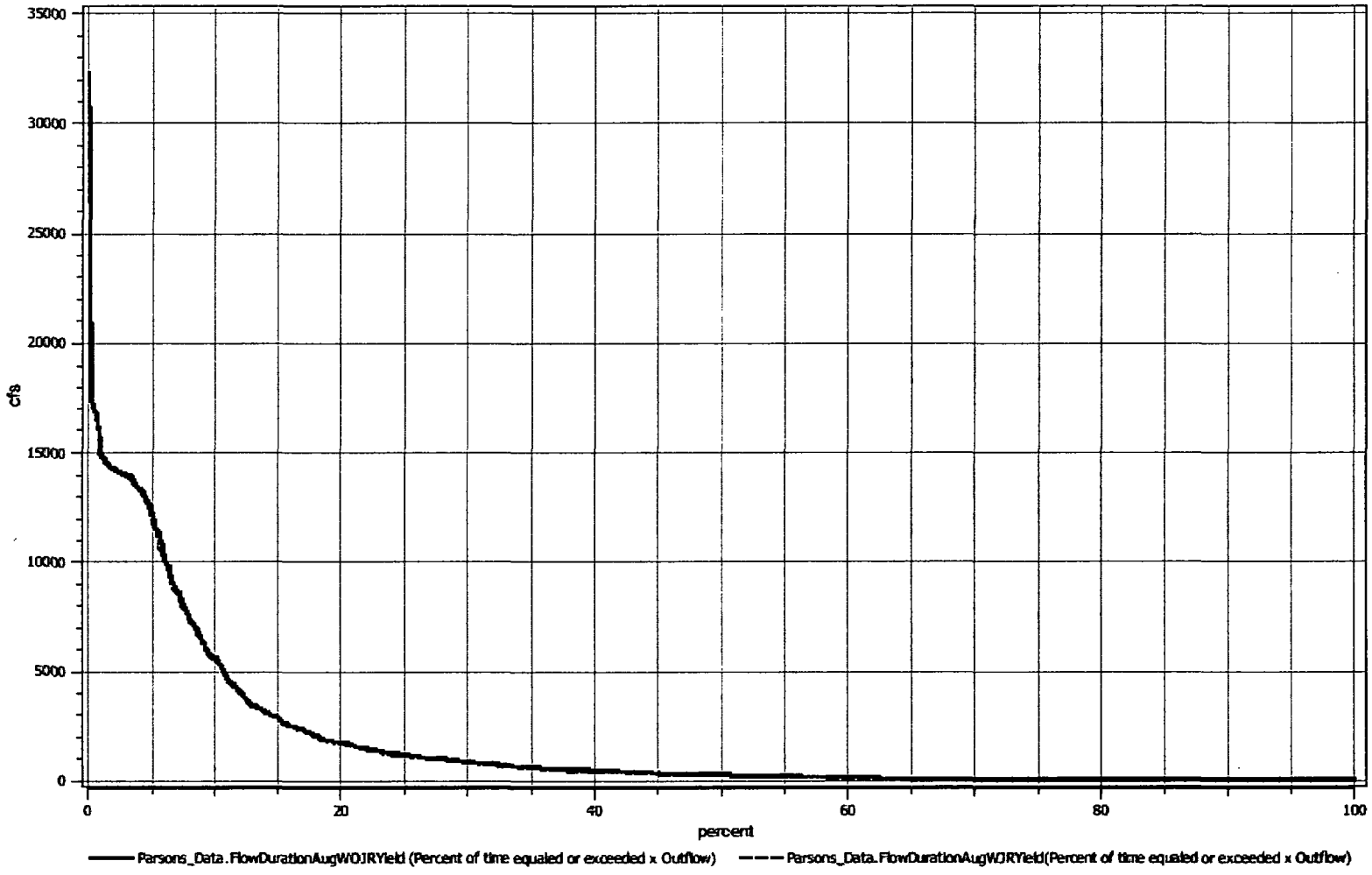


Neosho River at Parsons, KS Month of July: 1952 - 1957 FLOW-DURATION

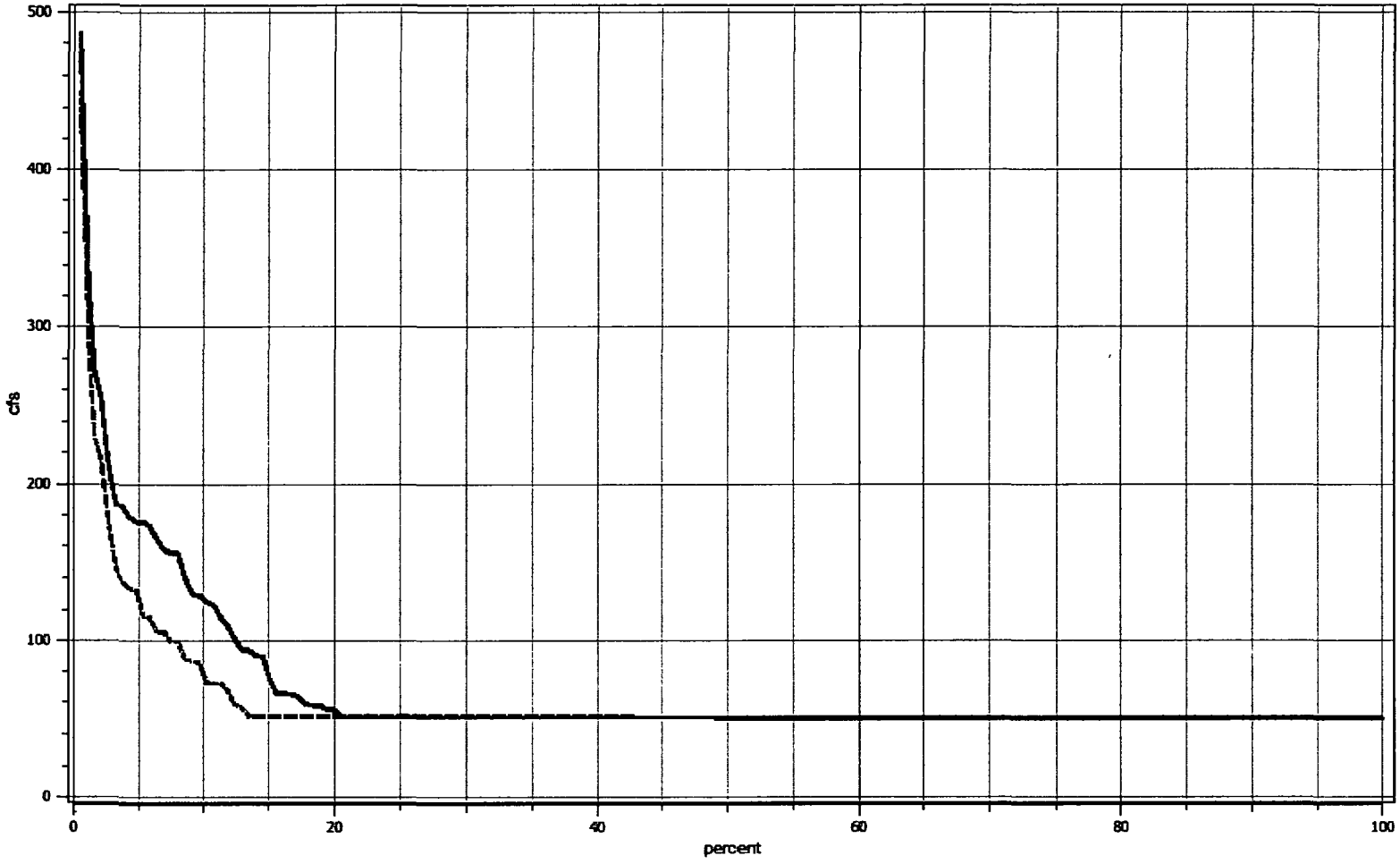


——— Parsons_Data.FlowDurationJul52_57WOJRYield (Percent of time equaled or exceeded x Outflow) – – – Parsons_Data.FlowDurationJul52_57WJRYield(Percent of time equaled or exceeded x Outflow)

Neosho River at Parsons, KS Month of August: 1940 - 2000 Flow-Duration

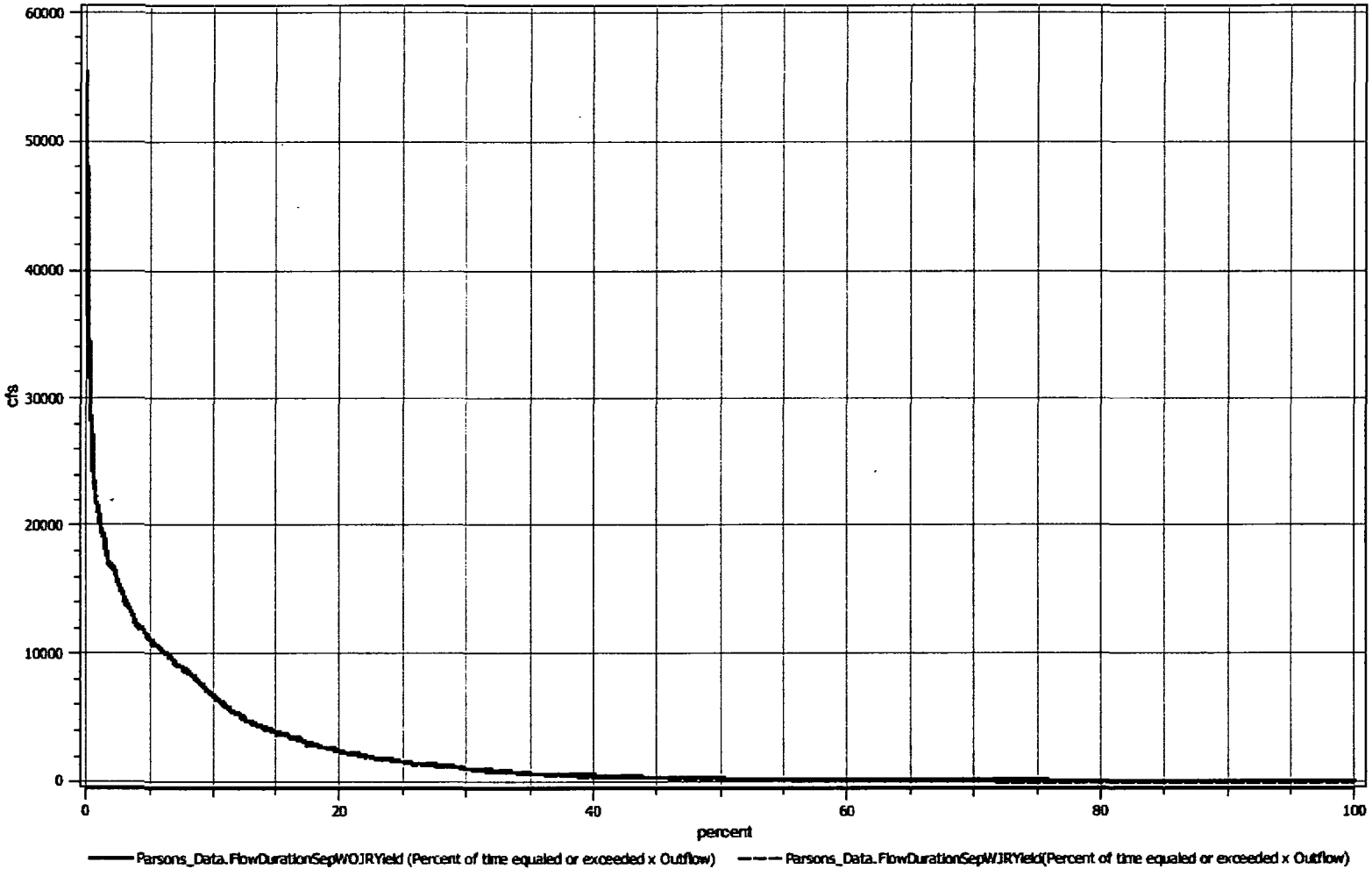


Neosho River at Parsons, KS Month of August: 1952 - 1957 FLOW-DURATION

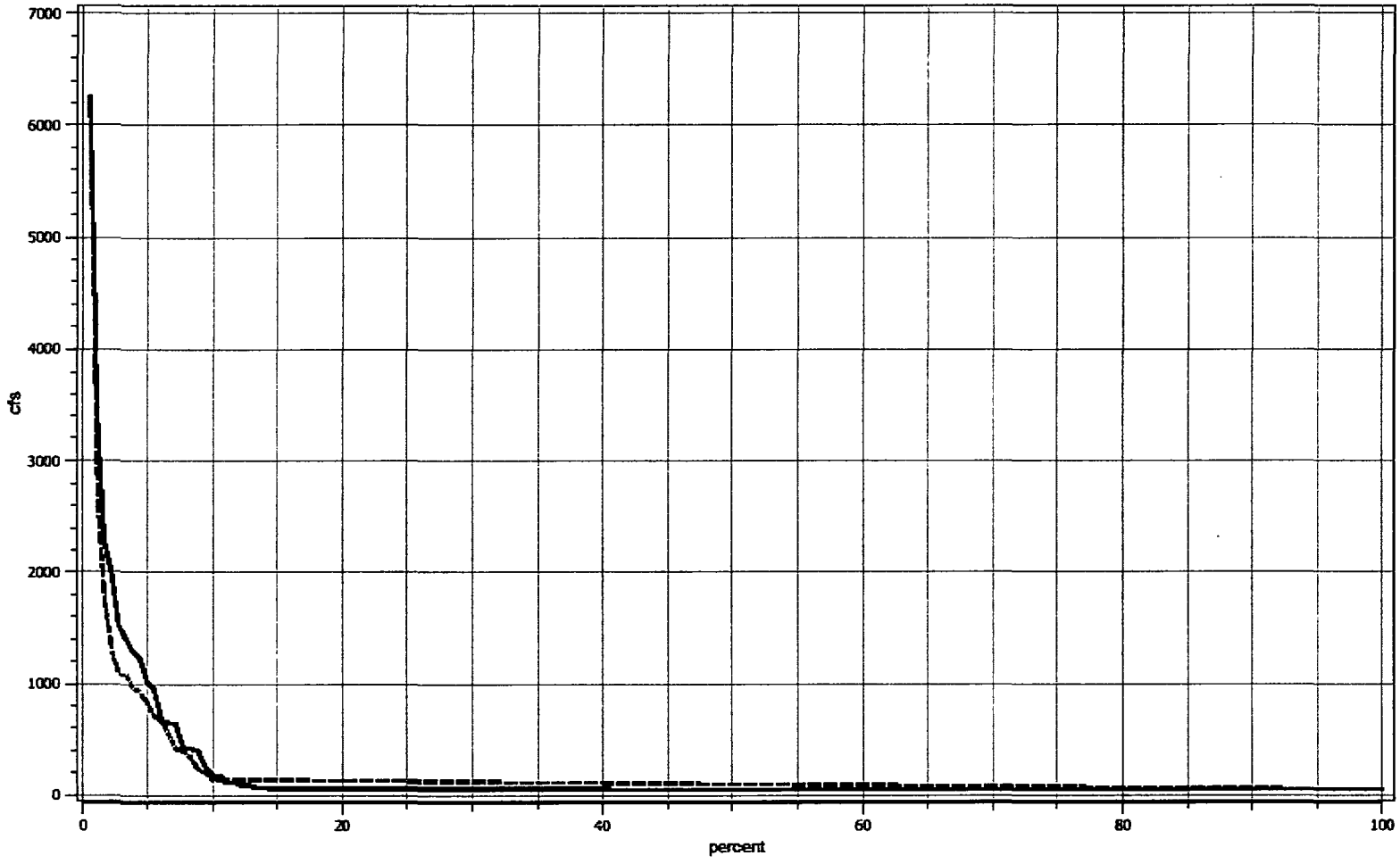


Parsons_Data.FlowDurationAug52_57WOJRYield (Percent of time equaled or exceeded x Outflow)
Parsons_Data.FlowDurationAug52_57WJRYield(Percent of time equaled or exceeded x Outflow)

Neosho River at Parsons, KS Month of September: 1940 - 2000 FLOW-DURATION



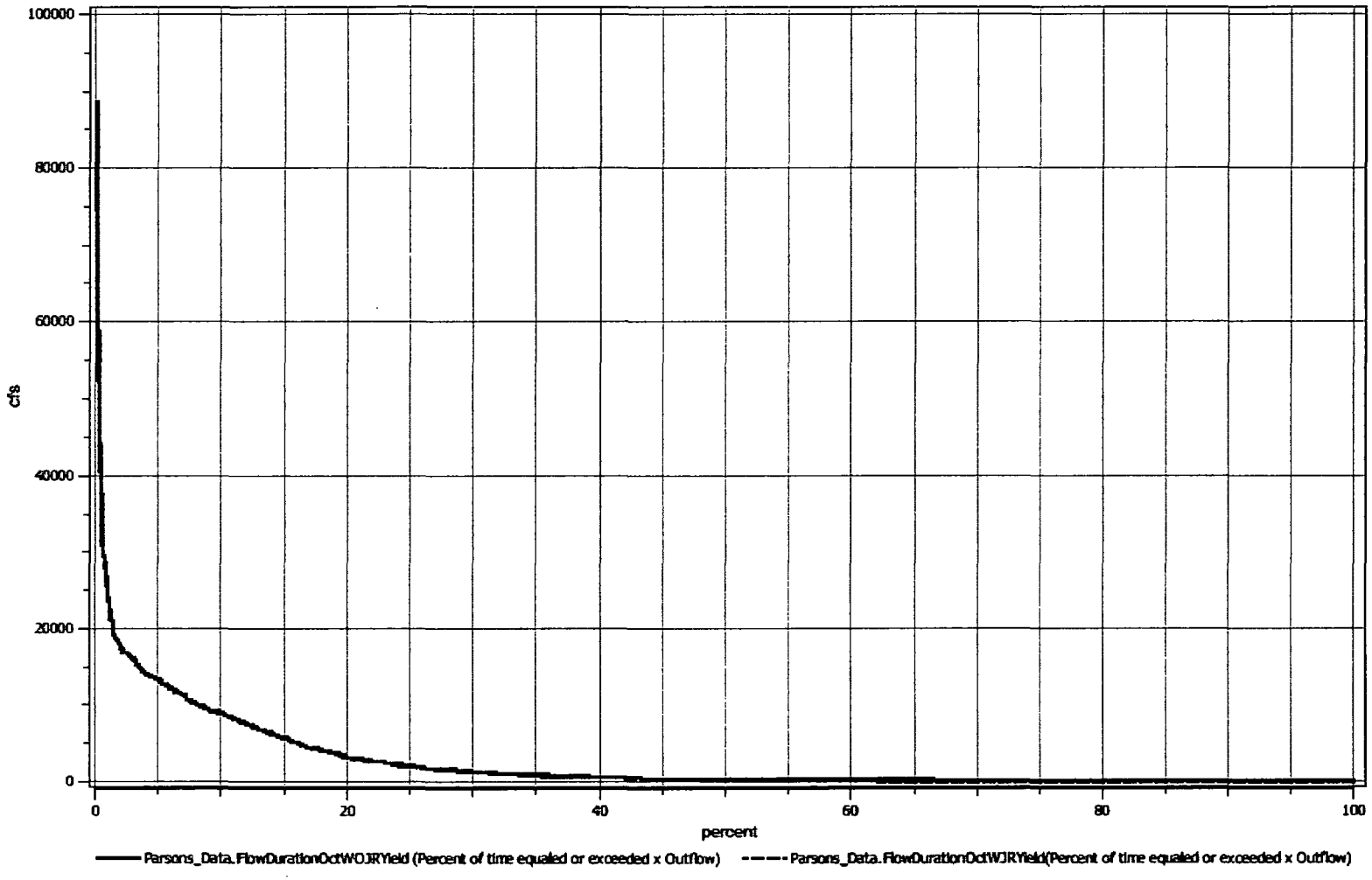
Neosho River at Parsons, KS Month of September: 1952 - 1957 FLOW-DURATION



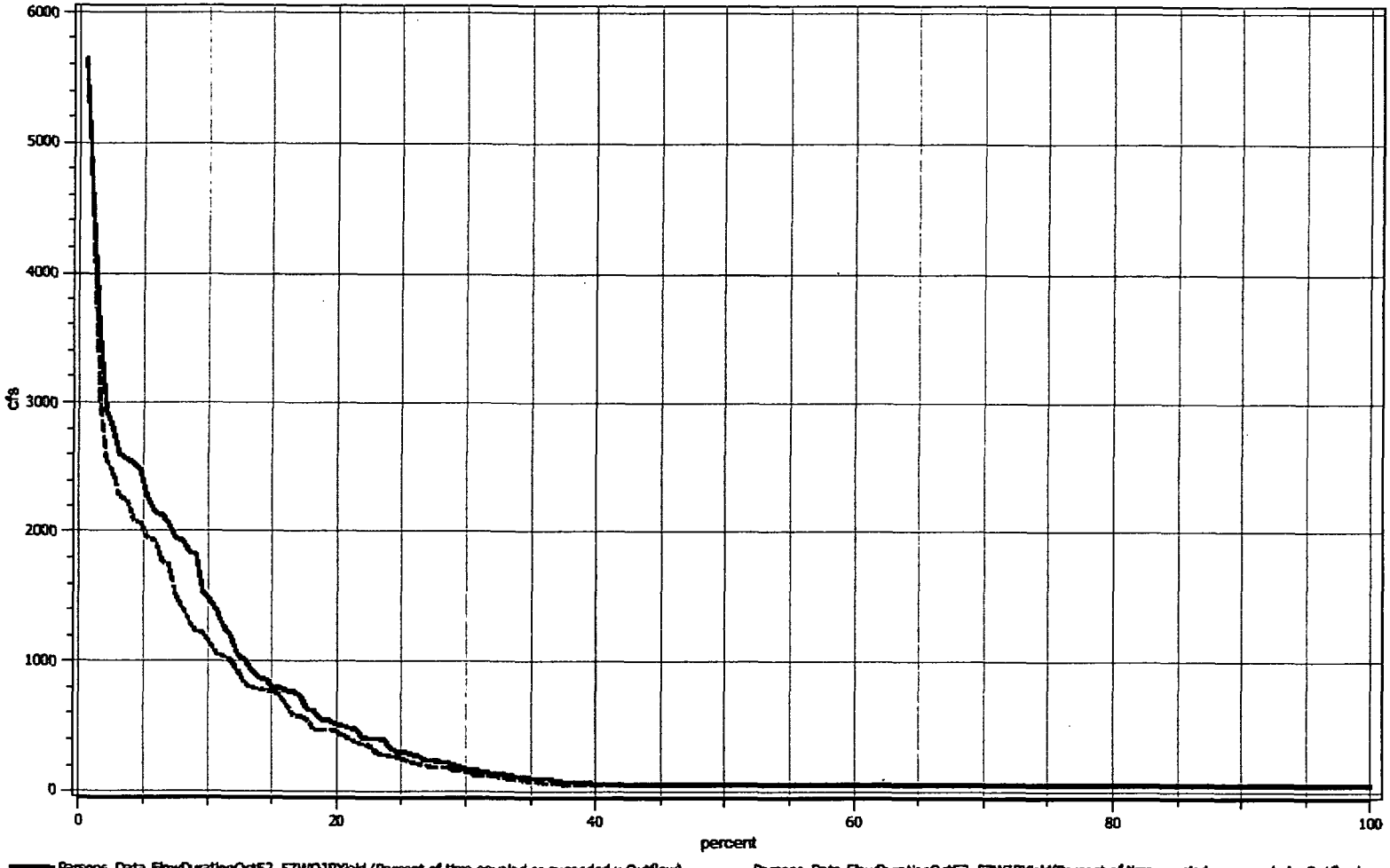
Parsons_Data.FlowDurationSep52_57WOJRYield (Percent of time equaled or exceeded x Outflow)

Parsons_Data.FlowDurationSep52_57WJRYield(Percent of time equaled or exceeded x Outflow)

Neosho River at Parsons, KS Month of October: 1940 - 2000 FLOW-DURATION



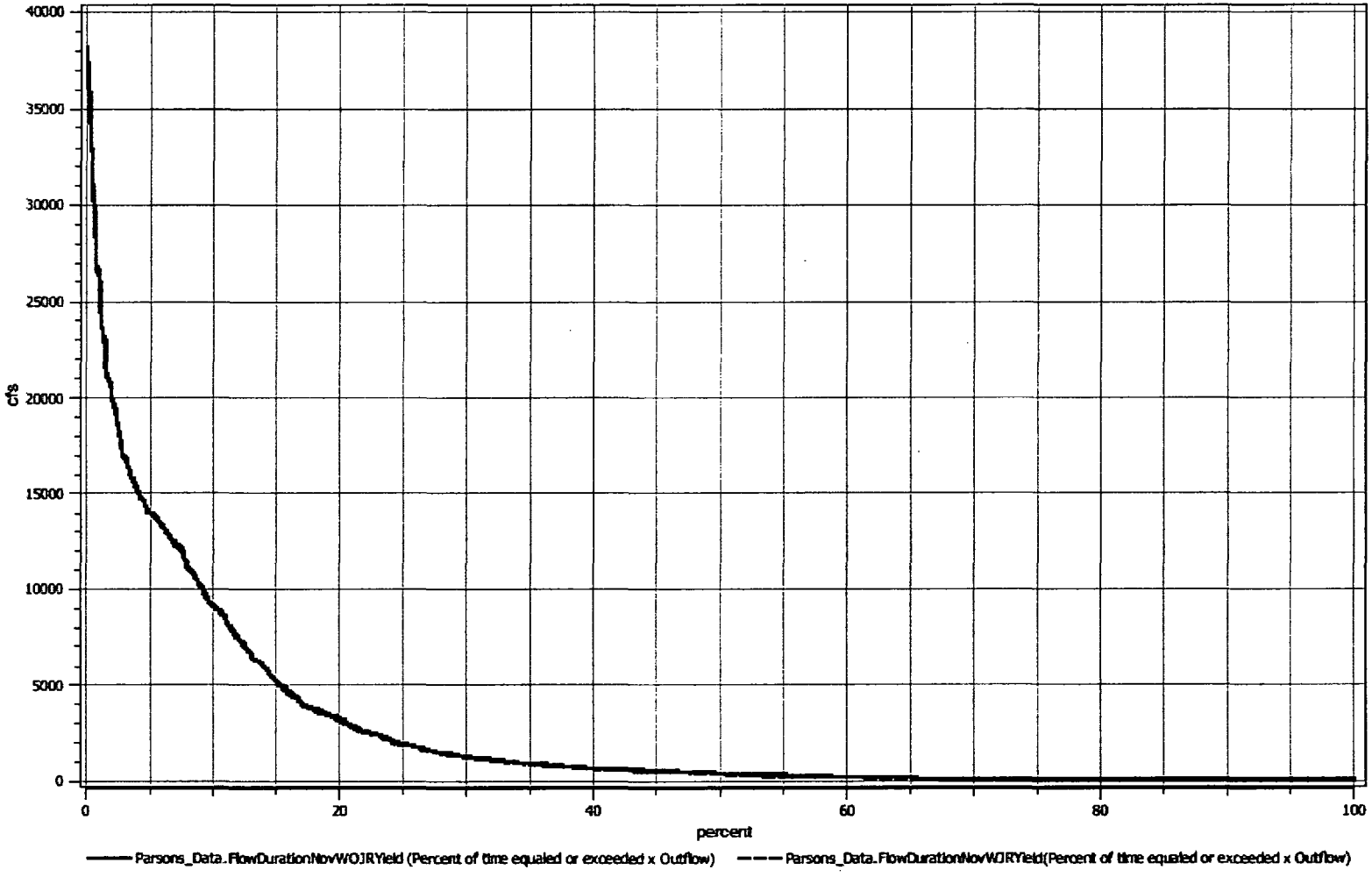
Neosho River at Parsons, KS Month of October: 1952 - 1957 FLOW-DURATION



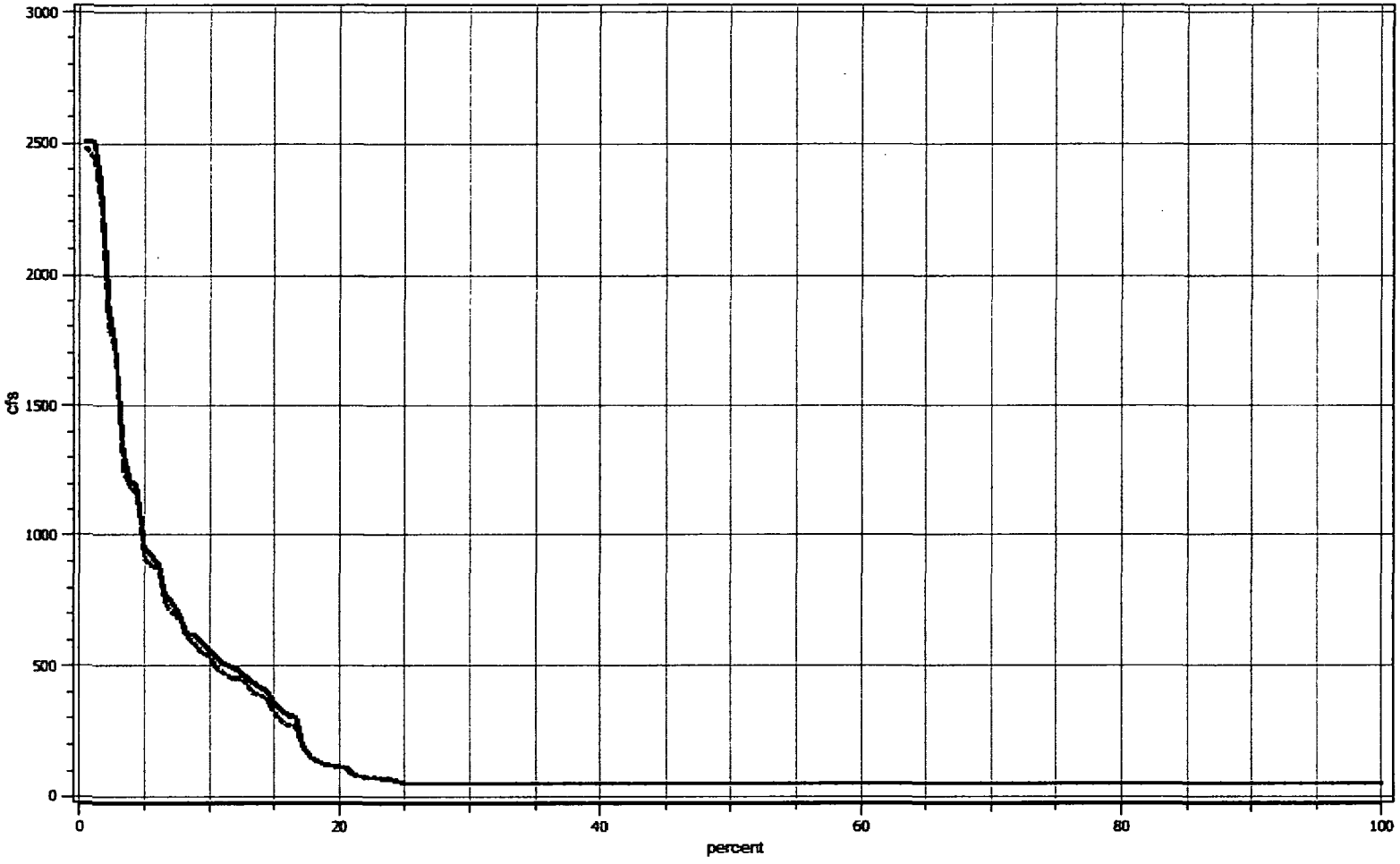
Parsons_Data.FlowDurationOct52_57WOJRYield (Percent of time equaled or exceeded x Outflow)

Parsons_Data.FlowDurationOct52_57WJRYield(Percent of time equaled or exceeded x Outflow)

Neosho River at Parsons, KS Month of November: 1940 - 2000 FLOW-DURATION

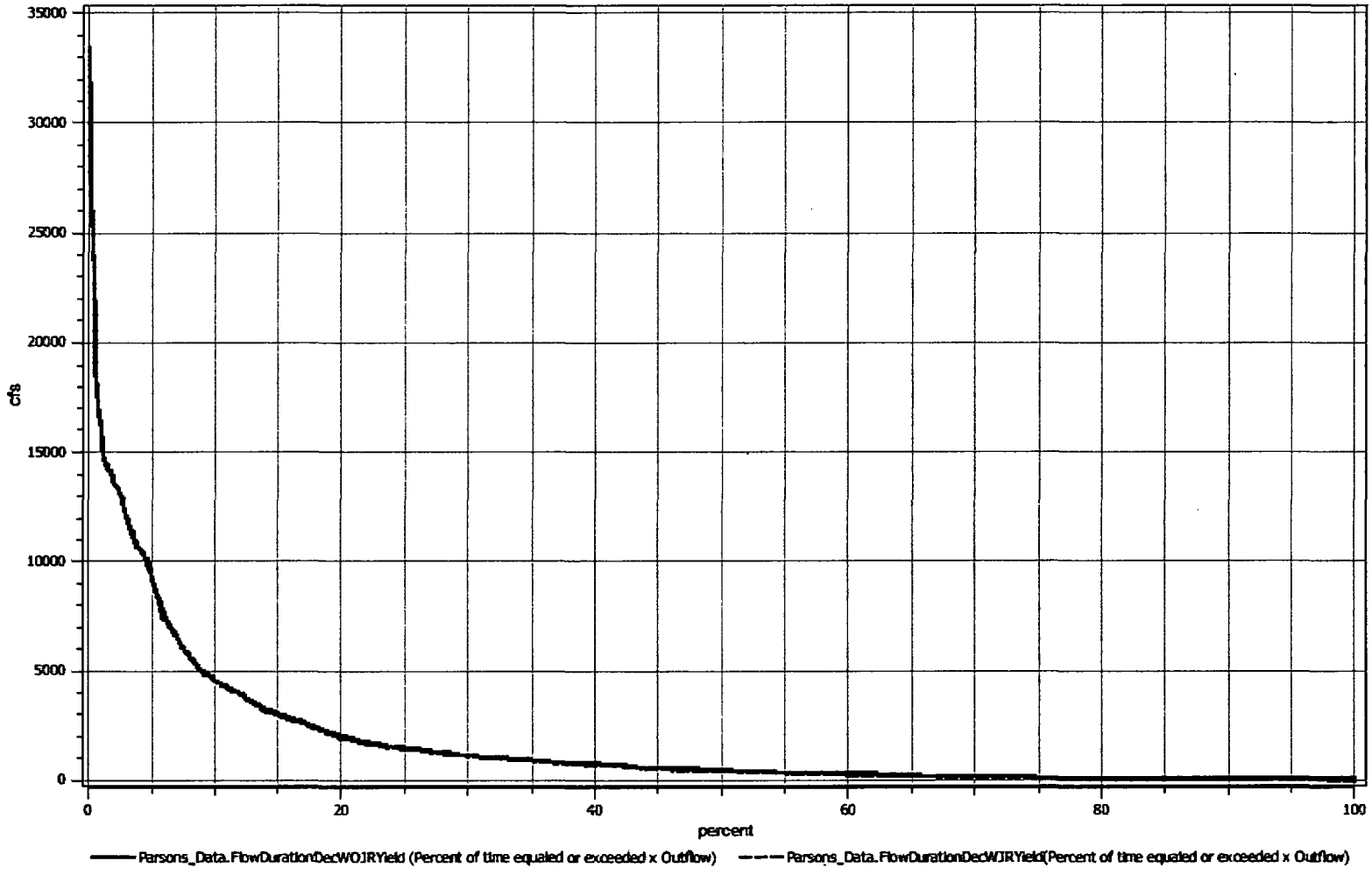


Neosho River at Parsons, KS Month of November: 1952 - 1957 FLOW-DURATION

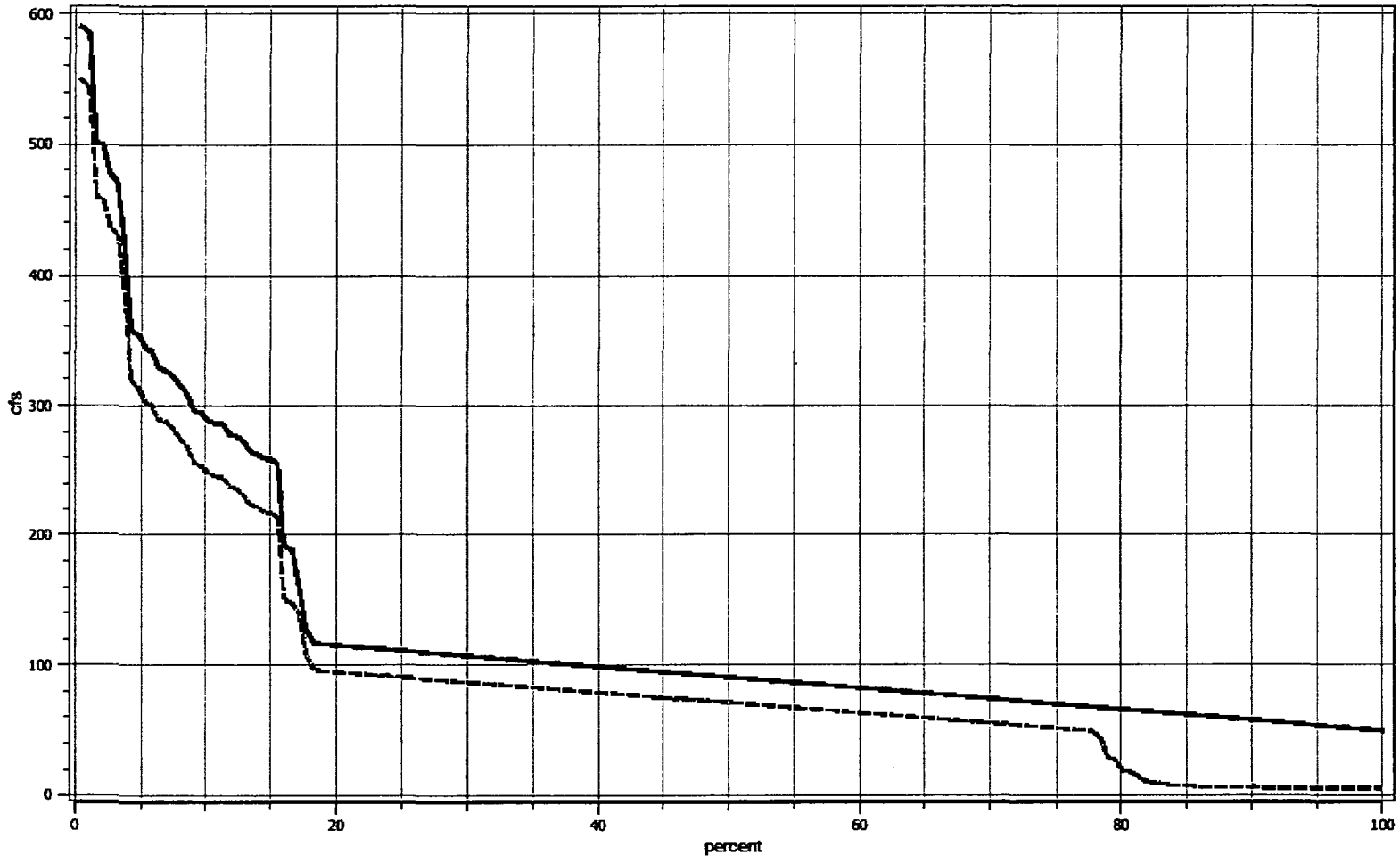


Parsons_Data.FlowDurationNov52_57WOJRYield (Percent of time equaled or exceeded x Outflow)
Parsons_Data.FlowDurationNov52_57WJRYield(Percent of time equaled or exceeded x Outflow)

Neosho River at Parsons, KS Month of December: 1940 - 2000 FLOW-DURATION



Neosho River at Parsons, KS Month of December: 1952 - 1957 FLOW-DURATION



Parsons_Data.FlowDurationDec52_57WOJRYield (Percent of time equaled or exceeded x Outflow)
Parsons_Data.FlowDurationDec52_57WJRYield(Percent of time equaled or exceeded x Outflow)

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