Heber Valley Corridor
ENVIRONMENTAL IMPACT STATEMENT

APPENDIX 3K

Water Quality Technical Report

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Water Quality Technical Report

Heber Valley Corridor Environmental Impact Statement

Lead agency:
Utah Department of Transportation

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Acronyms and Abbreviations

µg/L	micrograms per liter
AADT	average annual daily traffic
AWQMS	Ambient Water Quality Monitoring System
BMP	best management practice
cfs	cubic feet per second
E. coli	*Escherichia coli*
FHWA	Federal Highway Administration
GIS	geographic information systems
LiDAR	light detection and ranging
$\log_{10}$	logarithm to the base 10
mg/L	milligrams per liter
mi^2	square miles
MS4	municipal separate storm sewer system
ppm	parts per million
R	rule
SELDM	Stochastic Empirical Loading and Dilution Model
TDS	total dissolved solids
TMDL	total maximum daily load
TSS	total suspended solids
UAC	Utah Administrative Code
UDOT	Utah Department of Transportation
UDWQ	Utah Division of Water Quality
US-189	U.S. Highway 189
US-40	U.S. Highway 40
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey

1.0 Introduction

This report documents the water quality modeling methods that were used to understand the expected impacts to both surface water and groundwater quality from each of the action alternatives for the Heber Valley Corridor Project.

A municipal separate storm sewer system (MS4) permit has been issued to the Utah Department of Transportation (UDOT) by the Utah Division of Water Quality (UDWQ). This permit authorizes UDOT to discharge stormwater from its right-of-way to surface waters in accordance with the requirements of the permit. The permit does not authorize discharges that would cause or contribute to in-stream exceedances of water quality standards. To meet the requirements of the MS4 permit, UDOT used the modeling described in this report to compare the expected surface water quality from stormwater discharges from additional impervious areas created by the action alternatives to existing conditions. The results were then compared to applicable surface water quality standards. Both of the action alternatives are located in the Middle Provo River watershed, which has an established UDWQ assessment unit for which historical water quality data are available.

All project elements are located within the contributing area to the Heber Valley Aquifer. This aquifer has been classified as a Class 1A – Pristine aquifer, which is the most protected aquifer class in Utah. The flood-control facilities that UDOT would design and construct as a part of the project would infiltrate most stormwater runoff from the selected action alternative. These facilities are "permitted by rule" under the Utah Administrative Code (UAC R317-6-6.2(A)(5) and R317-6-6.2(A)(7)) and would not require a groundwater discharge permit as long as the groundwater discharge does not cause the groundwater to exceed groundwater quality standards or the total dissolved solids (TDS) limits for a Class IA – Pristine aquifer.

2.0 Highway Stormwater Runoff

The main recurring discharge from many road projects is the highway stormwater runoff that flows off impervious areas of the highway into a surface water body during a precipitation event. Highway stormwater runoff can affect water quality in two ways. First, the volume of runoff can increase compared to existing conditions, which can cause downstream erosion; and second, certain pollutants that are common in stormwater runoff can be discharged into receiving waters. These impacts can usually be mitigated using best management practices (BMPs) for stormwater as required by UDOT's MS4 permit. BMPs are usually located alongside the roadway and include measures for controlling runoff flow rates and volumes and reducing pollutant concentrations.

The impacts to water quality from the action alternatives have been analyzed using the Stochastic Empirical Loading and Dilution Model (SELDM) considering both the increased runoff volume and the potential pollutant concentrations in highway stormwater runoff. Highway runoff characteristics from winter de-icing activities are modeled using UDOT's spreadsheet model (see Section 2.4.1, *TDS Model*).

2.1 Modeling Overview

2.1.1 Stochastic Empirical Loading and Dilution Model

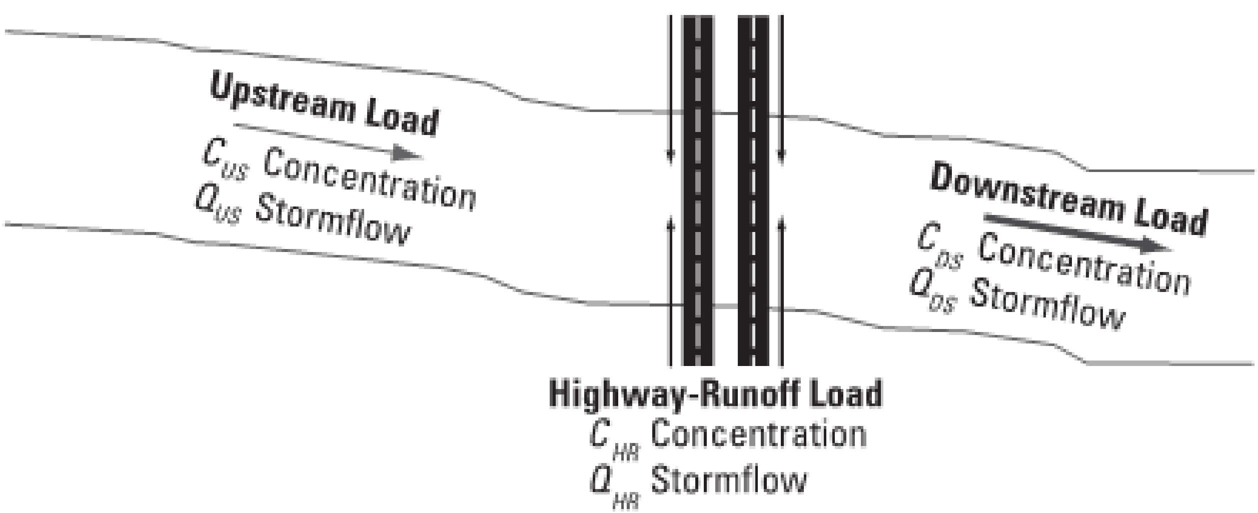
SELDM (USGS 2022) was created through a joint effort by the Federal Highway Administration (FHWA) and the U.S. Geological Survey (USGS) to estimate, using Monte Carlo methods, the effects of mixing runoff from highway projects on an existing water body. SELDM uses a range of measured background pollutant concentrations in the water body, stream flow rates, and an expected range of pollutant concentrations and flow rates from highway stormwater runoff to determine a statistical distribution of a mixed, in-stream pollutant concentration downstream of the highway's surface water discharge point. BMPs can also be accounted for in the model to reduce the expected pollutant concentrations and flow rates from the highway stormwater runoff using observed treatment efficiencies for various BMP options. For this analysis, these factors are not accounted for in the model because the design intent, based on feedback from project stakeholders, is to infiltrate all stormwater runoff from the roadway corridor. Available BMP data do not include efficiencies for pollutant removal through infiltration; therefore, the conservative approach is to not include the effects of BMPs.

What is SELDM?

SELDM is the Stochastic Empirical Loading and Dilution Model. It was developed as a joint effort between FHWA and USGS to estimate the effects of upstream highway projects on an existing water body.

Figure 2-1 shows a basic schematic of how SELDM calculates the results. The model treats the input variables (pollutant concentration and flow rates for both the upstream water body and highway runoff) as random numbers that follow a stochastic distribution and combines them using a mass balance approach and Monte Carlo methods. By using this method, a variety of conditions for the four input values can be combined, resulting in hundreds or thousands of simulations and downstream concentrations and streamflow values.

Figure 2-1. SELDM Schematic



Source: USGS 2013

Section 2.1.2 below describes the pollutants of concern that were chosen for assessment based on their typical presence in highway stormwater runoff and the Provo River's (or its tributaries') impairment status for a particular constituent or water quality characteristic. Section 2.2, *Model Parameter Development*, discusses the development of model parameters, including both those that are constant (site parameters) and those that are observed (empirical), to develop a stochastic distribution (mean, standard deviation, and skew) of pollutant concentrations, flow rates, precipitation, and change with each model simulation run. Section 2.3, *Model Results*, discusses the modeling results for the Provo River.

2.1.2 Pollutants of Concern

UDOT's *Stormwater Quality Design Manual* (UDOT 2021) lists several categories of pollutants of concern that are typically found in highway stormwater runoff, including solids, nutrients, and metals. Each of these categories lists specific pollutants that are common in highway stormwater runoff. For the project's water quality analysis, the following pollutants were analyzed using SELDM:

- Solids
  - Total dissolved solids (TDS)
  - Total suspended solids (TSS)
- Nutrients
  - Dissolved nitrogen
  - Total phosphorus
- Metals
  - Dissolved cadmium
  - Dissolved chromium
  - Dissolved copper
  - Dissolved lead
  - Dissolved zinc
- Other pollutants of concern
  - Dissolved chloride
  - pH

The Provo River fully supports all of its beneficial uses; however, Spring Creek and other tributaries to the Provo River in the upstream watershed as defined in Section 2.2.1, *Upstream Watershed Characteristics*, are impaired for pH and *Escherichia coli* (*E. coli*), both of which are not listed in UDOT's *Stormwater Quality Design Manual* as typical highway pollutants. pH was included in the list of pollutants of concern for this analysis; however, *E. coli* was not modeled because good data on *E. coli* concentrations in highway stormwater runoff are not available, the total maximum daily load (TMDL) study for Spring Creek discusses that stormwater runoff is not a likely chronic source of *E. coli* (UDWQ 2021), and previous studies have shown that highway stormwater runoff does not typically contribute to *E. coli* concentrations in surface water (NCHRP 2019).

What are beneficial uses?

Lakes, rivers, and other water bodies have uses to humans and other life. These uses are called beneficial uses.

Chloride is also not included in UDOT's *Stormwater Quality Design Manual* as a pollutant of concern; however, it was included in the list of pollutants of concern for this analysis because chloride concentrations, when evaluated with TDS concentrations, could represent impacts from UDOT's de-icing activities.

Section 2.4, *TDS Analysis from De-icing Practices*, includes an additional analysis of TDS concentrations that specifically addresses UDOT's de-icing activities before and during snowstorms.

2.2 Model Parameter Development

2.2.1 Upstream Watershed Characteristics

An upstream watershed includes all the area that drains to a specified outlet point when precipitation occurs. For this analysis, the outlet point was chosen as a point just upstream of the Provo River's confluence with Snake Creek. UDWQ has collected historical water quality data at this location since at least 2000 (the first year of data used for this analysis). The upstream watershed was truncated at the Jordanelle Reservoir Dam, because the dam changes the flow rate in the Provo River downstream of Jordanelle Reservoir. The following methods were used to characterize the watershed and develop input parameters for SELDM.

What is an upstream watershed?

An upstream watershed includes all the area that, when a precipitation event occurs, drains to a specified outlet point.

A half-meter light detection and ranging (LiDAR) dataset that covers the Provo River watershed was acquired from the Utah Geospatial Resource Center (gis.utah.gov). This dataset was used to delineate the upstream watershed using geographic information systems (GIS) software.

The basin centroid (geographic center of the basin), longest flow path (the path that a drop of water would take to travel from the point of the basin farthest from the outlet to the outlet), and mean basin slope (defined as the average slope between points representing 10% and 85% of the longest flow path) for each watershed were also determined using GIS software. Approximate percentages of impervious area (not including the roadways) for each upstream watershed were determined using the USGS StreamStats application.

Finally, the basin development factor (an integer value between 0 and 12) for the existing upstream basin was qualitatively determined by analyzing the presence of storm drains, streets with curb and gutter, and channel improvements in the watershed. Attachment A, *Upstream Watershed Map*, includes a map for the East Canyon Creek watershed that shows the outlet point, watershed extents, and longest flow path.

Table 2-1 shows the drainage area, basin centroid, length of the longest flow path, mean basin slope, percent impervious area, and basin development factor that were used in the model for the upstream Provo River watershed.

Table 2-1. Upstream Watershed Characteristics

Watershed	Drainage Area		Basin Centroid	Longest Flow Path		Mean Basin Slope		% Impervious Area	Basin Development Factor
	mi^2	acres		feet	mi	%	ft/mi		
Provo River	113.18	72,434	40.500 N 111.341 W	127,364	24.1	3.39	178.8	1.65	4

Definitions: ft = feet; mi = mile, mi^2 = square miles

2.2.2 Existing In-stream Pollutant Concentrations

UDOT used the Ambient Water Quality Monitoring System (AWQMS) database maintained by UDWQ to obtain existing water quality data for the Provo River. Data were obtained for Site ID 5913630, Provo River above Confluence with Snake Creek at McKeller Bridge, from January 1, 2000, through December 31, 2024. This site was chosen because of its location downstream of the project area and the availability of historical data. In the water quality dataset, several data points had concentration levels that were below the detection limit for the laboratory's analytical method. These values were set at one-half the detection limit, which is standard practice in surface water quality analyses.

For the existing upstream pollutant concentrations, UDOT used all of the data points in the dataset acquired from the AWQMS database and calculated the mean, standard deviation, and skew values for each pollutant of concern. These are the values that SELDM requires to create the stochastic distribution for the model simulations. In addition, UDOT calculated the same statistics (mean, standard deviation, and skew) using a $\log_{10}$ (a logarithm to the base 10) transformation applied to each pollutant concentration in the dataset. To avoid the possibility of negative concentrations in the stochastic distribution, the statistics that were calculated using the $\log_{10}$ transformed values were used in SELDM, as shown in the manual (USGS 2013).

Table 2-2 shows the number of samples for each pollutant of concern and the mean, standard deviation, and skew statistics based on both the untransformed and the $\log_{10}$ transformed values.

Table 2-2. Existing Provo River In-stream Pollutant Concentrations

Pollutant	Units	Number of Samples	Untransformed Values			$\log_{10}$ Transformed Values		
			Mean	Standard Deviation	Skew	Mean	Standard Deviation	Skew
TDS	mg/L	207	169.4	54.67	4.506	2.213	0.1103	0.7561
TSS	mg/L	207	9.515	14.35	5.677	0.7911	0.3610	0.6971
Dissolved nitrogen	mg/L	71	0.5150	0.5609	6.636	–0.3715	0.2366	0.7233
Total phosphorus	mg/L	201	0.03148	0.02153	3.324	–1.577	0.2565	–0.1198
Dissolved cadmium	µg/L	76	0.2506	0.2084	0.3343	–0.7932	0.4304	0.1206
Dissolved chromium	µg/L	78	1.461	0.8637	0.1978	0.0156	0.5565	–3.817
Dissolved copper	µg/L	76	2.819	2.602	0.4022	0.2023	0.4908	0.2005
Dissolved lead	µg/L	76	0.7105	0.6524	0.3503	–0.4458	0.5842	–0.2821
Dissolved zinc	µg/L	76	9.249	4.907	0.2968	0.9031	0.2352	0.2836
Dissolved chloride	mg/L	89	8.795	7.877	7.006	0.8815	0.2021	1.496
pH	—	291	8.325	0.2901	–1.097	0.9201	0.0155	–1.287

Definitions: µg/L = micrograms per liter; mg/L = milligrams per liter; TDS = total dissolved solids; TSS = total suspended solids

2.2.3 Highway Stormwater Runoff Pollutant Concentrations

As a part of developing the SELDM model, USGS and FHWA created the National Highway Runoff Database, which includes measured concentrations of pollutants in highway stormwater runoff from locations across the United States. These locations include various highway types, both rural and urban, with a wide variety of average annual daily traffic (AADT) conditions and climates. This database does not include any sites in Utah; therefore, UDOT chose sites in other states that best represent the conditions of the Heber Valley Corridor, including the U.S. Highway 40 (US-40) and U.S. Highway 189 (US-189) corridors within the project footprint (right-of-way) based on the following criteria:

- Western United States to represent northern Utah's typical climate and precipitation patterns.
- AADT between about 23,600 and 38,500 vehicles per day. A length-weighted average of the traffic volumes forecast by the traffic demand model in 2050 for the No-action Alternative and both action alternatives for the segments of the Heber Valley Corridor, US-40, and US-189 within the project footprint (right-of-way) resulted in average AADT within this range.

Highway stormwater runoff concentration data were used from locations in California, Oregon, Washington, and Nevada for all constituents except dissolved nitrogen. Dissolved nitrogen data are available only for a small portion of the sites in a few states. Only some locations in North Carolina met the AADT criteria above; therefore, these sites were added to the analysis only for dissolved nitrogen. To create the stochastic distribution in SELDM, UDOT used data from the National Highway Runoff Database at the sites that were selected and calculated the statistics (using both untransformed and $\log_{10}$ transformed values) for the mean, standard deviation, and skew. Similar to the existing in-stream pollutant concentrations, the statistics based on the $\log_{10}$ transformed values were used in SELDM to avoid the possibility of negative concentrations in the stochastic distribution. The sample values that had concentrations at levels below the analytical method detection limit were set at one-half the detection limit, similar to the existing in-stream pollutant concentrations, as described above.

Table 2-3 shows the number of samples for each pollutant and the mean, standard deviation, and skew statistics based on the untransformed values and the $\log_{10}$ transformed values.

Table 2-3. Pollutant Concentrations in Highway Stormwater Runoff

Pollutant	Units	Number of Samples	Untransformed Values			Log_{10} Transformed Values		
			Mean	Standard Deviation	Skew	Mean	Standard Deviation	Skew
TDS	mg/L	182	321.0	861.0	4.687	1.717	0.8318	0.0473
TSS	mg/L	442	193.0	441.0	5.822	1.844	0.5787	0.2604
Dissolved nitrogen	mg/L	53	0.3217	0.2960	2.289	–0.6391	0.3753	–0.4296
Total phosphorus	mg/L	306	0.5465	1.732	6.874	–0.7944	0.6404	–0.0063
Dissolved cadmium	µg/L	261	0.1927	0.2991	5.634	–0.9340	0.4269	–0.3950
Dissolved chromium	µg/L	222	3.067	4.550	3.894	0.1852	0.5053	0.2787
Dissolved copper	µg/L	282	7.793	6.818	2.616	0.7451	0.3837	–0.6051
Dissolved lead	µg/L	278	0.9933	1.899	5.591	–0.4286	0.6487	–0.2520
Dissolved zinc	µg/L	283	36.3	47.64	5.501	1.386	0.3685	0.1900
Dissolved chloride	mg/L	87	340.0	669.0	2.919	1.394	1.232	0.1268
pH	—	126	6.265	0.5806	0.0035	0.7951	0.04054	–0.1596

Definitions: µg/L = micrograms per liter; mg/L = milligrams per liter; TDS = total dissolved solids; TSS = total suspended solids

2.2.4 Upstream Flow Rates

UDOT used the USGS streamflow gage data from gage 10155500 (Provo River near Charleston, Utah) to calculate various stream flow statistics for SELDM to use in creating the stochastic distribution on which the mixing calculations are based. This flow gage is located a few hundred feet upstream of the point where the existing in-stream pollutant concentrations were measured. UDOT anticipates that any differences between the actual flow at the upstream point where the existing in-stream pollutant concentrations were measured and the downstream gage location would be minor because the points are close together. Furthermore, SELDM adjusts the flow statistics for actual basin size (statistics are input in units of cubic feet per second per square mile [cfs/mi^2]).

This gage provides the best available data and the longest continuous flow record of mean (average) daily flow rates in the Provo River from October 1991 through the present day. Construction of the Jordanelle Reservoir Dam was completed in April 1993, and UDOT expects that the downstream flow rate was altered by the construction of the dam compared to the preconstruction flow rate. For this reason, UDOT used flow data between October 1, 1993, and September 30, 2022 (water years 1994 through 2022) to calculate the peak streamflow statistics of mean, standard deviation, skew, and median that SELDM uses to create the stochastic distribution of flow rates for the model simulations. In addition, UDOT used the USGS Hydrologic Toolbox software to calculate the low-flow statistics for these creeks, specifically the 7Q10, 1B3, and 4B3 flow rates, that correspond to the minimum 7-day average flow that occurs, on average, once every 10 years; the minimum 1-day average biological flow rate that occurs, on average, once every 3 years; and the 4-day average biological flow rate that occurs, on average, once every 3 years, respectively. The low-flow rates were calculated using date ranges between April 1, 1994, and March 31, 2022, because low-flow rates are typically calculated using date ranges from April through March instead of the typical water year from October through September.

To input the flow statistics in cfs/mi^2 into SELDM, UDOT divided the untransformed mean daily flow statistics and the low-flow rates (7Q10, 1B3, and 4B3) by the area upstream of the flow gage (113.2 mi^2). SELDM also requires the $\log_{10}$ retransformed statistics for the mean daily flow rates to avoid negative flow values. The $\log_{10}$ retransformed statistics were calculated using the following process:

1. Divide each daily mean value in the data set by the area upstream of the flow gage.
2. Calculate the $\log_{10}$ value for each value calculated in step 1.
3. Calculate the mean, standard deviation, skew, and median statistics using the values from step 2.
4. Calculate the inverse logarithm (base 10) for each of the statistics calculated in step 3, except for skew (the statistic for skew in SELDM should be the same as step 3). The results of this step are the retransformed $\log_{10}$ statistics.

Table 2-4 shows the values that were input into SELDM to create the stochastic distribution for Provo River streamflow.

Table 2-4. Upstream Flow Rate Statistics

Date Range	Number of Daily Mean Flow Values	Minimum Flow Value (cfs)	Maximum Flow Value (cfs)	$\log_{10}$ Retransformed Values [Untransformed Values] (cfs/mi^2)				Low Flow Statistics (cfs/mi^2)		
				Mean	Standard Deviation	Skew	Median	7Q10	1B3	4B3
10/01/1993 – 09/30/2022	10,583	21	2,280	1.861 [2.311]	1.830 [2.073]	0.6143 [3.704]	1.599 [1.599]	—	—	—
04/01/1994 – 03/31/2022	10,218	21	2,280	—	—	—	—	0.6137	0.3265	0.5166

Definitions: cfs = cubic feet per second; cfs/mi^2 = cubic feet per second per square mile

2.2.5 Highway Site Characteristics

The highway site characteristics are unique for each of the alternatives that were analyzed for the project. UDOT defined the highway site for each alternative as the existing and new impervious areas associated with the Heber Valley Corridor (for the action alternatives), US-40, and US-189 within the project footprint (right-of-way). The segment of US-40 between 900 North and 1300 South in Heber City was also included because this segment of US-40 would remain as the main travel route if the No-action Alternative is selected.

Table 2-5 shows the highway site characteristics that were calculated for input into SELDM, including the highway site area, length of the longest flow path, mean basin slope, percent impervious area, and basin development factor. For reference, Attachment A, *Upstream Watershed Map*, shows the project footprint in relation to the upstream watershed.

Table 2-5. Highway Site Characteristics

Watershed	Impervious Area (ac)	Longest Flow Path		Mean Basin Slope		% Impervious Area	Basin Development Factor
		ft	mi	%	ft/mi		
No-action Alternative	83.9	47,597	9.01	0.67	35.2	100	5
Alternative A	174.8	47,597	9.01	0.67	35.2	100	5
Alternative B	179.8	47,597	9.01	0.67	35.2	100	5

Definitions: ac = acres; ft = feet; mi = mile

2.2.6 Precipitation Characteristics

According to the Western Regional Climate Center, the average annual precipitation for Heber City from December 1, 1892, through December 31, 2005 (the complete period of record) is 15.99 inches (WRCC 2025). SELDM contains predetermined precipitation statistics for several precipitation gages that surround the upstream watershed. UDOT evaluated various combinations of these precipitation gages to match, as closely as possible, the average annual precipitation in Heber City because there is not a gage with predetermined statistics located in the upstream watershed. Table 2-6 lists the combination of gages that were determined to match, as closely as possible, the average annual precipitation in Heber City, the average number of storms per year, and the average annual precipitation at these gages.

Table 2-6. Precipitation Gages and Comparison to Historical Precipitation Data

Precipitation Gage	Site Description	Average Storms per Year	Average Annual Precipitation (inches)	Average Event Volume (inches)	Average Event Duration (hours)
OAKLEY 3 NE	East of Oakley, Utah	37	14.76	0.40	6.60
ARGENTA	Middle of Big Cottonwood Canyon	49	25.64	0.53	8.43
OLMSTEAD PH	Entrance to Provo Canyon	31	14.19	0.45	7.09
COALVILLE 13 E	East of Coalville, Utah	30	10.50	0.35	5.97
Average of all gages listed above		**37**	**16.27**	**0.43**	**7.02**

The average annual precipitation at the four gages shown in Table 2-6 above is 0.28 inch greater than the historical average in Heber City. Because the average annual precipitation for the four gages is similar to the average annual precipitation in the watershed and the gages are in locations surrounding the watershed, UDOT determined that the average of these gages sufficiently represents the precipitation conditions in the area.

2.3 Model Results

The results from SELDM are presented as a probability distribution of downstream concentrations that result from hundreds of combinations of mixing in-stream pollutant concentrations, highway stormwater runoff concentrations, Provo River flow rates, precipitation events, and BMP removal rates that were determined from the stochastic distributions of the inputs that are presented in Section 2.2, *Model Parameter Development*. This probability distribution is calculated to give the percentage of simulated storms that would result in a downstream concentration greater than or equal to a given concentration, and it allows a comparison of the resulting concentrations for both action alternatives (Alternative A and Alternative B) to applicable water quality standards and to the No-action Alternative to understand the potential risks of impacts that could be expected from both of the action alternatives.

For the Heber Valley Corridor Project, SELDM simulated about 1,365 storms for each project alternative. The SELDM results for the No-action Alternative and the action alternatives are summarized below in Section 2.3.1, *Alternative A*, and Section 2.3.2, *Alternative B*. The results for the No-action Alternative are repeated in each section to provide an easier comparison to understand the expected impacts of each action alternative.

Additionally, the summaries provide a comparison to applicable surface water quality standards for the stream's beneficial uses. These impacts are represented by providing the percentage of simulated storms during which the modeled downstream concentration of each pollutant of concern might equal or exceed the surface water quality standards.

The summaries also include an expected range of concentrations in the Provo River that could be reasonably expected, for the majority of storms, after combining upstream flows with highway stormwater runoff just upstream of the Snake Creek tributary to the Provo River. These ranges represent the concentration that would be equaled or exceeded for 80% of simulated storms (low end or more frequent) and 20% of simulated storms (high end or less frequent). This central range is used because stochastic analysis typically excludes the results that were calculated at the extremes in the stochastic distributions (relatively very low and very high values) to focus the interpretation of the results on the in-stream concentrations that are expected most often.

Section 2.3.3, *Highway Stormwater Runoff*, summarizes the SELDM distributions of highway stormwater runoff for the project alternatives. These distributions are presented as a concentration range for 20% to 80% of simulated storms compared to the groundwater quality standards for a Class IA – Pristine aquifer to help understand some of the impacts from infiltrating the stormwater runoff from the project alternatives to the Heber Valley Aquifer.

To help UDOT visualize the impacts to water quality, the distribution of modeled in-stream concentrations for the action alternatives and each pollutant of concern after combining upstream flows with highway stormwater runoff have been plotted against the No-action Alternative distribution of modeled concentrations. The distribution of highway stormwater runoff concentrations for the project alternatives have also been plotted to help visualize the impacts to groundwater quality after the highway stormwater runoff has infiltrated into the Heber Valley Aquifer. These plots are included in Attachment B, *SELDM Results Graphs*.

2.3.1 Alternative A

This section discusses the results of the SELDM modeling for the Provo River by comparing the model results for the No-action Alternative to the model results for Alternative A.

Table 2-7 shows the surface water quality standards for the Provo River's beneficial uses and the percentage of simulated storms during which the resulting downstream concentration (upstream of the Snake Creek tributary to the Provo River) of each pollutant of concern is expected to equal or exceed the surface water quality standards.

Table 2-8 shows the central range of concentrations that could be reasonably expected in the Provo River downstream of the project area for the No-action Alternative and Alternative A and the percent change in each end of the central range (80% and 20% of storms) between the No-action Alternative and Alternative A. An example of how to interpret the results shown in Table 2-7 and Table 2-8 is provided following the tables.

Table 2-7. SELDM Results Compared to Surface Water Quality Standards for Alternative A

Pollutant	Units	Surface Water Quality Standards by Beneficial Use				% of Simulated Storms Equaling or Exceeding the Provo River Surface Water Quality Standards Downstream of the Alternatives							
						No-action Alternative				Alternative A			
		1C	2B	3A	4	1C	2B	3A	4	1C	2B	3A	4
TDS	mg/L	—	—	—	1,200	—	—	—	0.00	—	—	—	0.00
TSS	mg/L	—	—	—	—	—	—	—	—	—	—	—	—
Dissolved nitrogen	mg/L	10 (4[a])	—	4[a]	—	0.00 (0.07)	—	0.07	—	0.00 (0.07)	—	0.07	—
Total phosphorus	mg/L	0.05[a]	—	0.05[a]	—	16.41	—	16.41	—	19.58	—	19.58	—
Dissolved cadmium	µg/L	10	—	1.8[b]	10	0.00	—	1.33	0.00	0.00	—	1.02	0.00
Dissolved chromium	µg/L	50	—	16[b,c]	100	0.00	—	0.00	0.00	0.00	—	0.00	0.00
Dissolved copper	µg/L	—	—	65[b]	200	—	—	0.15	0.00	—	—	0.00	0.00
Dissolved lead	µg/L	15	—	65[b]	100	0.22	—	0.00	0.00	0.07	—	0.00	0.00
Dissolved zinc	µg/L	—	—	120[b]	—	—	—	0.00	—	—	—	0.00	—
Dissolved chloride	mg/L	—	—	—	—	—	—	—	—	—	—	—	—
pH	—	6.5–9.0	6.5–9.0	6.5–9.0	6.5–9.0	0.00	0.00	0.00	0.00	0.07[d]	0.07[d]	0.07[d]	0.07[d]

Definitions: µg/L = micrograms per liter; mg/L = milligrams per liter; TDS = total dissolved solids; TSS = total suspended solids

Beneficial-use definitions: 1C – domestic/drinking water with prior treatment; 2B = infrequent primary-contact recreation; 3A = cold-water fishery/aquatic life; 4 = agricultural uses including irrigation of crops and stock watering

[a] Pollution indicator

[b] The 1-hour criterion was chosen because impacts from stormwater runoff typically move downstream and dissipate quickly.

[c] Hexavalent chromium (has a more stringent water quality standard than trivalent chromium [570 µg/L]).

[d] Percent of highway stormwater runoff pH values outside (more acidic or more basic than) the standard range of pH values

Table 2-8. Expected Concentration Ranges in the Provo River and Percent Change with Alternative A

Pollutant	Units	No-action Alternative		Alternative A		% Change in Downstream Provo River Concentration during ____ of Simulated Storms	
		80%	20%	80%	20%	80%	20%
TDS	mg/L	132	199	133	199	0.8	0.0
TSS	mg/L	3.52	12.3	3.95	14.7	10.9	16.0
Dissolved nitrogen	mg/L	0.266	0.663	0.258	0.615	–3.0	–7.8
Total phosphorus	mg/L	0.0183	0.0470	0.0181	0.0496	–0.9	5.3
Dissolved cadmium	µg/L	0.0698	0.369	0.0686	0.361	–1.8	–2.1
Dissolved chromium	µg/L	0.718	2.03	0.701	2.03	–2.4	0.0
Dissolved copper	µg/L	0.665	4.31	0.697	4.22	4.6	–2.2
Dissolved lead	µg/L	0.125	1.10	0.132	1.18	5.5	6.4
Dissolved zinc	µg/L	5.20	12.4	5.37	13.3	3.3	6.4
Dissolved chloride	mg/L	5.50	12.8	5.67	14.1	3.0	9.1
pH	—	7.82	8.37	7.65	8.29	–2.2	–1.1

Definitions: µg/L = micrograms per liter; mg/L = milligrams per liter; TDS = total dissolved solids; TSS = total suspended solids

The following is an example of how to interpret the results shown above in Table 2-7 and Table 2-8. A similar example is not provided for the Alternative B results in Section 2.3.2, *Alternative B*, but the interpretation would be similar to the example provided for Alternative A.

As shown in Table 2-7 above, the dissolved cadmium water quality standard (1.8 µg/L) for beneficial use classification 3A would be exceeded by 1.02% of storms for Alternative A compared to 1.33% of storms for the No-action Alternative. Table 2-8 above shows that the central range for the in-stream concentration of dissolved cadmium (after mixing in-stream flow and highway stormwater runoff) would be expected to be between 0.0686 and 0.361 µg/L for Alternative A and between 0.0698 and 0.369 µg/L for the No-action Alternative. Although the concentration of dissolved cadmium could, statistically speaking, exceed the beneficial use classification 3A water quality standard (1.8 µg/L), it would be exceeded infrequently (for about 1% of storms), and the more commonly occurring central range (0.0686 to 0.361 µg/L) is below the numeric water quality standard. Compared to the No-action Alternative, Alternative A represents a decrease in the number of storms that could exceed the numeric water quality standard, the concentration for more frequent storms, and the concentration for less frequent storms.

In general, the impacts from Alternative A to surface water quality in the Provo River downstream of the project area would be minor compared to the No-action Alternative. The Provo River is not impaired for any constituent; however, of the pollutants of concern that were modeled, the tributaries to the Provo River near the project area are impaired for the level of pH. The Provo River tributaries are also impaired for *E. coli* concentrations; however, *E. coli* was not modeled because good data on *E. coli* concentrations in highway stormwater runoff are not available, the TMDL study for Spring Creek discusses that stormwater runoff is not a likely chronic source of *E. coli* (UDWQ 2021), and previous studies have shown that highway stormwater runoff does not typically contribute to *E. coli* concentrations in surface water (NCHRP 2019).

pH. As shown in Table 2-7 above, 0.07% of modeled storms could cause a pH in the Provo River downstream of the project elements outside the water quality standard for pH in surface water (between 6.5 and 9.0) after mixing stream flows and highway stormwater runoff, compared to 0.00% of storms for the No-action Alternative. Table 2-8 above shows that the central range for the in-stream pH (after mixing stream flows and highway stormwater runoff) was between 7.65 and 8.29 for Alternative A and 7.82 and 8.37 for the No-action Alternative. The central range (7.65 and 8.29) is within the surface water quality standard range (6.5 to 9.0). The model results show a low chance that Alternative A would have an adverse in-stream impact on pH in the Provo River and its tributaries.

2.3.2 Alternative B

This section discusses the results of the SELDM modeling for the Provo River by comparing the model results for the No-action Alternative to the model results for Alternative B. Table 2-9 shows the surface water quality standards for the Provo River's beneficial uses and the percentage of simulated storms during which the resulting downstream concentration (upstream of the Snake Creek tributary to the Provo River) of each pollutant of concern is expected to equal or exceed the surface water quality standards. Table 2-10 shows the central range of concentrations that could be reasonably expected in the Provo River downstream of the project for the No-action Alternative and Alternative B and the percent change in each end of the central range (80% and 20% of storms) between the No-action Alternative and Alternative B.

Table 2-9. SELDM Results Compared to Surface Water Quality Standards for Alternative B

Pollutant	Units	Surface Water Quality Standards by Beneficial Use				% of Simulated Storms Equaling or Exceeding the Provo River Surface Water Quality Standards Downstream of the Alternatives							
						No-action Alternative				Alternative B			
		1C	2B	3A	4	1C	2B	3A	4	1C	2B	3A	4
TDS	mg/L	—	—	—	1,200	—	—	—	0.00	—	—	—	0.00
TSS	mg/L	—	—	—	—	—	—	—	—	—	—	—	—
Dissolved nitrogen	mg/L	10 (4[a])	—	4[a]	—	0.00 (0.07)	—	0.07	—	0.00	—	0.00	—
Total phosphorus	mg/L	0.05[a]	—	0.05[a]	—	16.41	—	16.41	—	18.23	—	18.23	—
Dissolved cadmium	µg/L	10	—	1.8[b]	10	0.00	—	1.33	0.00	0.07	—	0.88	0.07
Dissolved chromium	µg/L	50	—	16[b,c]	100	0.00	—	0.00	0.00	0.00	—	0.00	0.00
Dissolved copper	µg/L	—	—	65[b]	200	—	—	0.15	0.00	—	—	0.07	0.00
Dissolved lead	µg/L	15	—	65[b]	100	0.22	—	0.00	0.00	0.15	—	0.00	0.00
Dissolved zinc	µg/L	—	—	120[b]	—	—	—	0.00	—	—	—	0.00	—
Dissolved chloride	mg/L	—	—	—	—	—	—	—	—	—	—	—	—
pH	—	6.5–9.0	6.5–9.0	6.5–9.0	6.5–9.0	0.00	0.00	0.00	0.00	0.07[d]	0.07[d]	0.07[d]	0.07[d]

Definitions: µg/L = micrograms per liter; mg/L = milligrams per liter; TDS = total dissolved solids; TSS = total suspended solids

Beneficial-use definitions: 1C – domestic/drinking water with prior treatment; 2B = infrequent primary-contact recreation; 3A = cold-water fishery/aquatic life; 4 = agricultural uses including irrigation of crops and stock watering

[a] Pollution indicator

[b] The 1-hour criterion was chosen because impacts from stormwater runoff typically move downstream and dissipate quickly.

[c] Hexavalent chromium (has a more stringent water quality standard than trivalent chromium [570 µg/L]).

[d] Percent of highway stormwater runoff pH values outside (more acidic or more basic than) the standard range of pH values

Table 2-10. Expected Concentration Ranges in the Provo River and Percent Change with Alternative B

Pollutant	Units	No-action Alternative		Alternative B		% Change in Downstream Provo River Concentration during ____ of Simulated Storms	
		80%	20%	80%	20%	80%	20%
TDS	mg/L	132	199	132	202	0.0	1.5
TSS	mg/L	3.52	12.3	3.84	14.2	8.4	13.4
Dissolved nitrogen	mg/L	0.266	0.663	0.270	0.635	1.6	–4.4
Total phosphorus	mg/L	0.0183	0.0470	0.0181	0.0482	–0.9	2.5
Dissolved cadmium	µg/L	0.0698	0.369	0.0739	0.384	5.5	3.9
Dissolved chromium	µg/L	0.718	2.03	0.785	2.03	8.5	0.0
Dissolved copper	µg/L	0.665	4.31	0.620	3.88	–7.1	–11.2
Dissolved lead	µg/L	0.125	1.10	0.133	1.16	6.2	4.7
Dissolved zinc	µg/L	5.20	12.4	5.25	12.8	0.9	3.1
Dissolved chloride	mg/L	5.50	12.8	5.65	14.9	2.7	14.1
pH	—	7.82	8.37	7.64	8.27	–2.3	–1.2

Definitions: µg/L = micrograms per liter; mg/L = milligrams per liter; TDS = total dissolved solids; TSS = total suspended solids

In general, the impacts from Alternative B to surface water quality in the Provo River downstream of the project area would be minor compared to the No-action Alternative. The Provo River is not impaired for any constituent; however, of the pollutants of concern that were modeled, the tributaries to the Provo River near the project area are impaired for the level of pH.

pH. As shown in Table 2-9 above, 0.07% of storms could cause a pH in the Provo River downstream of the project elements outside of the water quality standard for pH in surface water (between 6.5 and 9.0) after mixing stream flows and highway stormwater runoff, compared to 0.00% of storms for the No-action Alternative. Table 2-10 above shows that the central range for the in-stream pH (after mixing stream flows and highway stormwater runoff) was between 7.64 and 8.27 for Alternative B and 7.82 and 8.37 for the No-action Alternative. The central range (7.65 and 8.29) is within the standard surface water quality range (6.5 to 9.0). The model results show a low chance that Alternative B would have an adverse in-stream impact on pH in the Provo River and its tributaries.

2.3.3 Highway Stormwater Runoff

This section discusses the distributions of highway stormwater runoff concentrations that were developed by SELDM using the highway stormwater runoff statistics discussed in Section 2.2.3, *Highway Stormwater Runoff Pollutant Concentrations*. Table 2-11 shows the central range (80% and 20% of storms) of highway stormwater runoff concentrations for the project alternatives and compares these concentrations to the groundwater quality standards for Class IA – Pristine aquifers to help understand what the impacts to groundwater quality would be from directly infiltrating the highway stormwater runoff to the groundwater aquifer through the use of infiltration BMPs. The highway stormwater runoff concentration distribution is slightly different for each alternative; however, these distributions were developed using the same statistics and the small differences can be attributed to the random number generator that SELDM uses to determine the distribution that is used for each unique model run.

Table 2-11. Highway Stormwater Runoff Concentration Ranges with the Project Alternatives

Pollutant	Units	No-action Alternative		Alternative A		Alternative B		Groundwater Quality Standard for Class IA – Pristine Aquifer
		80%	20%	80%	20%	80%	20%	
TDS	mg/L	11.1	278	11.5	277	11.6	248	500
TSS	mg/L	22.7	216	22.5	228	24.1	208	—
Dissolved nitrogen	mg/L	0.110	0.469	0.117	0.484	0.114	0.471	10
Total phosphorus	mg/L	0.0437	0.587	0.0451	0.590	0.0479	0.560	—
Dissolved cadmium	µg/L	0.0493	0.270	0.0525	0.269	0.0484	0.255	5
Dissolved chromium	µg/L	0.586	4.12	0.590	4.07	0.590	4.27	100
Dissolved copper	µg/L	2.67	12.3	2.86	11.6	2.66	12.3	1,300
Dissolved lead	µg/L	0.106	1.40	0.106	1.33	0.111	1.38	15
Dissolved zinc	µg/L	12.5	49.8	12.1	49.8	11.8	49.2	5,000
Dissolved chloride	mg/L	2.36	275	2.28	235	2.82	316	—
pH	—	5.79	6.75	5.77	6.76	5.77	6.75	6.5 – 8.5

Definitions: µg/L = micrograms per liter; mg/L = milligrams per liter; TDS = total dissolved solids; TSS = total suspended solids

In general, the highway stormwater runoff concentrations are lower than the groundwater quality standards for Class IA – Pristine aquifers. The pH levels are generally on the low end or below the appropriate pH range of 6.5 to 8.5. Further analysis and explanation of the impacts to groundwater are included in Section 2.3.5, *Groundwater Impacts from SELDM Modeling*.

2.3.4 Surface Water Impacts from SELDM Modeling

In general, the impacts from both action alternatives to surface water in the Provo River downstream of the alternatives' alignments would be minor compared to the No-action Alternative if highway stormwater runoff were discharged directly to surface water. Of the 11 pollutants of concern that were modeled using SELDM, 5 pollutants exceeded a surface water quality standard or criterion for a simulation that SELDM ran for Alternative A or Alternative B. These pollutants are total phosphorus, dissolved cadmium, dissolved copper, dissolved lead, and pH. In addition to these pollutants, TSS, total phosphorus, dissolved cadmium, dissolved chromium, dissolved lead, dissolved zinc, and dissolved chloride showed an increase in downstream Provo River concentrations for Alternative A or Alternative B over the No-action Alternative of greater than 5% at one end of the expected concentration range (20% to 80% of simulated storms). Although there are many changes to the ends of this range for all the pollutants of concern, a 5% increase in concentration was chosen as an increase that received closer inspection to see how the modeled in-stream concentration compares to water quality standards.

The remainder of this section compares, by pollutant of concern, the model pollutant concentrations in the Provo River downstream of the project area as modeled with SELDM if highway stormwater runoff were discharged directly to surface water. To help the reader more easily compare the values and impacts from both Alternative A and Alternative B side by side, Table 2-12 below includes the same data that was reported in Table 2-7 and Table 2-9 above for Alternative A and Alternative B, respectively, and Table 2-13 below includes the same data that were reported in Table 2-8 and Table 2-10 above for Alternative A and Alternative B, respectively.

Table 2-12. SELDM Results Compared to Surface Water Quality Standards for Alternative A and Alternative B

Pollutant	Units	Surface Water Quality Standards by Beneficial Use				% of Simulated Storms Equaling or Exceeding the Provo River Surface Water Quality Standards Downstream of the Alternatives											
						No-action Alternative				Alternative A				Alternative B			
		1C	2B	3A	4	1C	2B	3A	4	1C	2B	3A	4	1C	2B	3A	4
TDS	mg/L	—	—	—	1,200	—	—	—	0.00	—	—	—	0.00	—	—	—	0.00
TSS	mg/L	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dissolved nitrogen	mg/L	10 (4[a])	—	4[a]	—	0.00 (0.07)	—	0.07	—	0.00 (0.07)	—	0.07	—	0.00	—	0.00	—
Total phosphorus	mg/L	0.05[a]	—	0.05[a]	—	16.41	—	16.41	—	19.58	—	19.58	—	18.23	—	18.23	—
Dissolved cadmium	µg/L	10	—	1.8[b]	10	0.00	—	1.33	0.00	0.00	—	1.02	0.00	0.07	—	0.88	0.07
Dissolved chromium	µg/L	50	—	16[b,c]	100	0.00	—	0.00	0.00	0.00	—	0.00	0.00	0.00	—	0.00	0.00
Dissolved copper	µg/L	—	—	65[b]	200	—	—	0.15	0.00	—	—	0.00	0.00	—	—	0.07	0.00
Dissolved lead	µg/L	15	—	65[b]	100	0.22	—	0.00	0.00	0.07	—	0.00	0.00	0.15	—	0.00	0.00
Dissolved zinc	µg/L	—	—	120[b]	—	—	—	0.00	—	—	—	0.00	—	—	—	0.00	—
Dissolved chloride	mg/L	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
pH	—	6.5–9.0	6.5–9.0	6.5–9.0	6.5–9.0	0.00	0.00	0.00	0.00	0.07[d]	0.07[d]	0.07[d]	0.07[d]	0.07[d]	0.07[d]	0.07[d]	0.07[d]

Definitions: µg/L = micrograms per liter; mg/L = milligrams per liter; TDS = total dissolved solids; TSS = total suspended solids

Beneficial-use definitions: 1C – domestic/drinking water with prior treatment; 2B = infrequent primary-contact recreation; 3A = cold-water fishery/aquatic life; 4 = agricultural uses including irrigation of crops and stock watering

[a] Pollution indicator

[b] The 1-hour criterion was chosen because impacts from stormwater runoff typically move downstream and dissipate quickly.

[c] Hexavalent chromium (has a more stringent water quality standard than trivalent chromium [570 µg/L]).

[d] Percent of highway stormwater runoff pH values outside (more acidic or more basic than) the standard range of pH values

Table 2-13. Expected Concentration Ranges in the Provo River and Percent Change with Alternative A and Alternative B

Pollutant	Units	No-action Alternative		Alternative A: Downstream Provo River Concentration during ____ of Simulated Storms		Alternative A: % Change in Downstream Provo River Concentration during ____ of Simulated Storms		Alternative B: Downstream Provo River Concentration during ____ of Simulated Storms		Alternative B: % Change in Downstream Provo River Concentration during ____ of Simulated Storms	
		80%	20%	80%	20%	80%	20%	80%	20%	80%	20%
TDS	mg/L	132	199	133	199	0.8	0.0	132	202	0.0	1.5
TSS	mg/L	3.52	12.3	3.95	14.7	10.9	16.0	3.84	14.2	8.4	13.4
Dissolved nitrogen	mg/L	0.266	0.663	0.258	0.615	–3.0	–7.8	0.270	0.635	1.6	–4.4
Total phosphorus	mg/L	0.0183	0.0470	0.0181	0.0496	–0.9	5.3	0.0181	0.0482	–0.9	2.5
Dissolved cadmium	µg/L	0.0698	0.369	0.0686	0.361	–1.8	–2.1	0.0739	0.384	5.5	3.9
Dissolved chromium	µg/L	0.718	2.03	0.701	2.03	–2.4	0.0	0.785	2.03	8.5	0.0
Dissolved copper	µg/L	0.665	4.31	0.697	4.22	4.6	–2.2	0.620	3.88	–7.1	–11.2
Dissolved lead	µg/L	0.125	1.10	0.132	1.18	5.5	6.4	0.133	1.16	6.2	4.7
Dissolved zinc	µg/L	5.20	12.4	5.37	13.3	3.3	6.4	5.25	12.8	0.9	3.1
Dissolved chloride	mg/L	5.50	12.8	5.67	14.1	3.0	9.1	5.65	14.9	2.7	14.1
pH	—	7.82	8.37	7.65	8.29	–2.2	–1.1	7.64	8.27	–2.3	–1.2

Definitions: µg/L = micrograms per liter; mg/L = milligrams per liter; TDS = total dissolved solids; TSS = total suspended solids

Total Suspended Solids. There are no surface water quality standards for TSS; however, compared to the No-action Alternative (3.52 to 12.3 milligrams per liter [mg/L]), modeled TSS concentrations increased by 10.9% and 8.4% for 80% of simulated storms and by 16.0% and 13.4% for 20% of simulated storms with Alternative A (3.95 to 14.7 mg/L) and Alternative B (3.84 to 14.2 mg/L), respectively.

Total Phosphorus. For total phosphorus, the surface water quality criterion (pollution indicator) listed is 0.05 mg/L for beneficial uses 1C (domestic/drinking water with prior treatment) and 3A (cold-water fishery/aquatic life). This criterion was exceeded by about 16.4%, 19.6%, and 18.2% of simulated storms for the No-action Alternative, Alternative A, and Alternative B, respectively. In addition, the downstream total phosphorus concentration in the Provo River for the high end of the expected concentration range (equaled or exceeded by 20% of simulated storms) increased by about 5.3% for Alternative A (0.0496 mg/L) compared to the high end of the expected concentration range for the No-action Alternative (0.0470 mg/L). Modeled concentration values are below the surface water quality standard.

Dissolved Cadmium. Of the storms that were simulated by SELDM, 1.33%, 1.02%, and 0.88% resulted in a dissolved cadmium concentration greater than the surface water quality standard for cold-water fishery/aquatic life (beneficial use 3A, 1-hour criterion) of 1.8 micrograms per liter (µg/L) for the No-action Alternative, Alternative A, and Alternative B, respectively. In addition, the downstream dissolved cadmium concentration in the Provo River for the low end of the expected concentration range (equaled or exceeded by 80% of simulated storms) increased by about 5.5% for Alternative B (0.384 µg/L) compared to the low end of the expected concentration range for the No-action Alternative (0.369 µg/L).

Dissolved Chromium. SELDM did not simulate any storms that exceeded the surface water quality standards for dissolved chromium. For Alternative B, the dissolved chromium concentration for the low end of the expected concentration range (equaled or exceeded by 80% of simulated storms [0.785 µg/L]) increased by about 8.5% compared to the low end of the expected concentration range for the No-action Alternative (0.718 µg/L).

Dissolved Copper. For the No-action Alternative, 0.15% and 0.07% of the simulated storms for the No-action Alternative and Alternative B, respectively, had downstream dissolved copper concentrations in the Provo River greater than the surface water quality standard for cold-water fishery/aquatic life (beneficial use 3A, 1-hour criterion) of 65 µg/L. Alternative A did not have a simulated storm that exceeded this water quality standard. With either Alternative A or Alternative B, fewer storms would exceed this surface water quality criterion than with the No-action Alternative. Dissolved copper also has a surface water quality standard of 200 µg/L for beneficial use 4 (agricultural uses); however, no simulated storms exceeded this water quality standard for any alternative.

Dissolved Lead. For dissolved lead, the surface water quality criteria for beneficial use 1C (domestic/drinking water with prior treatment) of 15 µg/L was exceeded by 0.22%, 0.07%, and 0.15% of simulated storms for the No-action Alternative, Alternative A, and Alternative B, respectively. The surface water quality criterion for beneficial uses 3A (cold-water fishery/aquatic life, 1-hour criterion) and 4 (agricultural uses) of 65 µg/L and 100 µg/L were not exceeded by any simulated storm for any alternative. In addition, the downstream dissolved lead concentration in the Provo River for the low end of the expected concentration range (equaled or exceeded by 80% of simulated storms) increased by about 5.5% and 6.2% for Alternative A (0.132 µg/L) and Alternative B (0.133 µg/L), respectively, compared to the low end of the expected concentration range for the No-action Alternative (0.125 µg/L). For the high end of the expected concentration range (equaled or exceeded by 20% of storms), the dissolved lead concentration increased by about 6.4% for Alternative A (1.18 µg/L) compared to the high end of the expected concentration range for the No-action Alternative (1.10 µg/L).

Dissolved Zinc. SELDM did not simulate any storms that exceeded the surface water quality standards for dissolved zinc. For Alternative A, the dissolved chromium concentration for the high end of the expected concentration range (equaled or exceeded by 20% of simulated storms [13.3 µg/L]) increased by about 6.4% compared to the high end of the expected concentration range for the No-action Alternative [12.4 µg/L].

Dissolved Chloride. There are no surface water quality standards for dissolved chloride; however, the downstream dissolved chloride concentration in the Provo River for the high end of the expected concentration range (equaled or exceeded by 20% of simulated storms) increased by about 9.1% and 14.1% for Alternative A (14.1 µg/L) and Alternative B (14.9 µg/L), respectively, compared to the high end of the expected concentration range for the No-action Alternative (12.8 µg/L).

pH. For the No-action Alternative, SELDM simulated no storms that resulted in a downstream pH value in the Provo River outside the surface water quality criterion of between 6.5 and 9.0 for beneficial uses 1C (domestic/drinking water with prior treatment), 2B (infrequent primary-contact recreation), 3A (cold-water fishery/aquatic life), and 4 (agricultural uses). For both Alternative A and Alternative B, 0.07% of simulated storms resulted in a downstream pH value in the Provo River below (more acidic than) the 6.5–9.0 pH range for the Provo River’s beneficial uses. There is a very minor chance that either action alternative would have a negative in-stream impact on pH due to the discharge of highway stormwater runoff if stormwater were discharged directly to surface water.

2.3.5 Groundwater Impacts from SELDM Modeling

As shown above in Table 2-11, the modeled highway stormwater runoff characteristics were compared directly to the groundwater quality standards for a Class IA – Pristine aquifer. All of the stormwater BMPs selected to manage stormwater from the right-of-way for the Heber Valley Corridor would be designed to infiltrate stormwater to the aquifer instead of detaining and releasing stormwater to surface waters. Flood-control facilities, such as these stormwater BMPs, are "permitted by rule" under the Utah Administrative Code (UAC R317-6-6.2(A)(5) and R317-6-6.2(A)(7)), and UDOT would not be required to obtain a groundwater discharge permit for these stormwater management facilities as long as the groundwater discharge does not cause groundwater to exceed the groundwater quality standards or TDS limits for the applicable class of aquifer.

Table 2-11 above focuses on a comparison of the central range of expected concentrations (20% to 80% of storms) for the project alternatives. These central ranges are generally below the groundwater quality standards for a Class IA – Pristine aquifer. The results of the SELDM model show that the highway stormwater runoff concentration for three pollutants could very infrequently exceed a groundwater quality standard. These pollutants are TDS, dissolved chromium, and dissolved lead. In addition, highway stormwater runoff pH levels could somewhat frequently be below the groundwater quality standard range of 6.5 to 8.5.

The remainder of this section explains, by pollutant of concern, the modeled percentage of storms for which highway stormwater runoff concentrations exceed the groundwater standard. When reviewing the results that are presented, it is important to remember that this analysis compares highway stormwater runoff concentrations prior to stormwater conveyance and infiltration and does not include any pollutant removal or treatment that could occur from stormwater BMPs and filtration through the soil. In addition, this stormwater would mix with the water that is already in the aquifer and would likely cause only a minor increase in the overall pollutant concentration in the aquifer because the volume of the aquifer is much greater than the volume of highway stormwater runoff.

Total Dissolved Solids. Class IA – Pristine aquifers have a groundwater quality standard for TDS of 500 mg/L. According to the SELDM modeling, this TDS concentration in highway stormwater runoff is exceeded by 12.64%, 12.69%, and 11.57% of storms for the No-action Alternative, Alternative A, and Alternative B, respectively.

Dissolved Chromium. For dissolved chromium, 0.15% and 0.07% of the storms simulated by SELDM had highway stormwater runoff concentrations that exceeded the groundwater quality standard of 100 µg/L for Alternative A and Alternative B, respectively. For the No-action Alternative, no storms exceeded this water quality standard.

Dissolved Lead. For dissolved lead, 0.30%, 0.22%, and 0.29% of the storms simulated by SELDM had highway stormwater runoff concentrations that exceeded the groundwater quality standard of 15 µg/L for the No-action Alternative, Alternative A, and Alternative B, respectively.

pH. The groundwater quality standard for pH is the range between 6.5 and 8.5. According to the SELDM modeling, about 66.0%, 64.8%, and 65.4% of the storms that were simulated by SELDM have pH values for highway stormwater runoff that are below (more acidic than) this range for the No-action Alternative, Alternative A, and Alternative B, respectively. No storms resulted in highway stormwater runoff that had a pH above (more basic than) the groundwater quality standard pH range for any of the alternatives.

2.4 TDS Analysis from De-icing Practices

UDOT applies de-icing products, including salt and brine, on state roads to reduce the buildup of ice and snow to keep roads safe and operational. In the Heber Valley, this application would be applied to the Heber Valley Corridor once construction has been completed. To further analyze water quality impacts due to winter operations, UDOT determined the average TDS concentrations in snowmelt runoff using a model based on the amount of salt and brine that would be applied to the roadway during various snowfall events (Bernhard 2005). This analysis assumes that UDOT's practices are the same in the Heber Valley as in the rest of the state; however, note that UDOT can apply a variety of de-icing products based on pavement, environmental conditions, and storm characteristics (UDOT 2025).

Salt and salt products are applied using two different methods at different points in time before and during a storm. The UDOT Meteorological Center, meteorological consultants, and local observations from UDOT maintenance personnel determine when each method should be used. The two de-icing methods analyzed to estimate runoff characteristics are summarized below.

- Starting 24 hours before a storm is forecast to begin up until the actual start of the storm, UDOT applies 30 gallons of 23% salt brine per lane-mile (applied only to the travel and auxiliary lanes).
- When the storm begins, UDOT applies a mixture of 4 gallons of 23% salt brine and 250 pounds of common salt per lane-mile. UDOT applies this mixture again after every 3 inches of additional snowfall. This application is also applied only to the travel and auxiliary lanes.

Some of the salt that is applied to the road during UDOT's de-icing practices is precipitated onto the road surface, and some of the granular salt is redeposited along the road shoulders. Not all of the salt applied to the pavement is dissolved in the runoff from melted snow and ice, and therefore some of the salt does not reach nearby surface waters or BMPs designed for water quality, or infiltrate into the roadside soils with the runoff. To analyze TDS concentrations in highway runoff from UDOT's de-icing operations, UDOT has assumed, for this analysis, that all of the salt that is applied to the roadway is dissolved in the snowmelt runoff, which is typically measured as TDS. UDOT also assumes for this analysis that other types of de-icing products are not applied. Section 2.4.1 below describes the calculation of TDS concentrations in snowmelt due to UDOT's anti-icing operations.

2.4.1 TDS Model

UDOT calculated the potential TDS concentrations in snowmelt runoff from the Heber Valley Corridor using a spreadsheet model that takes into consideration the depth of snowfall (and therefore the number of brine and salt applications), the typical roadway configuration, and the salt application practices described above in Section 2.2, *Model Parameter Development*.

On average, Heber City receives a total of about 70 inches of snow per year; average snow depths are between 1 and 6 inches per snowstorm (WRCC 2025). Using these statistics, a range of total snowfall depths (from 1 to 6 inches) were analyzed to understand the salt application and potential TDS concentrations for a variety of common snowstorms (UDOT applies more brine and salt to the roadway with higher snow depths). This analysis assumes that, if only 3 inches of snowfall occurs, an additional application of brine and salt is not applied, but if more than 3 inches of snowfall occurs, an additional application of brine and salt is applied.

UDOT also analyzed 12 typical proposed highway sections that include various numbers of travel and auxiliary lanes, various widths of roadway shoulders, the presence or absence of a multi-use trail adjacent to the Heber Valley Corridor, and various widths of vegetated area in the right-of-way. Although many additional roadway configurations could be analyzed, the roadway sections shown in Table 2-14 were chosen because they are the predominant cross-sections proposed in the action alternatives.

Table 2-14. Roadway Scenarios for the TDS Model

Roadway Scenario	Action Alternative(s) Represented	Number of Travel and Auxiliary Lanes	Width of Roadway Element (feet)			
			Outside Shoulder	Inside Shoulder	Multi-use Trail	Vegetated Area in Right-of-way
1	A & B	5	18	0	0	10
2	A & B	6	24	0	0	10
3	A & B	4	24	8	0	170
4	A & B	6	47.5	23.5	12	329
5	A & B	7	23.5	19.5	0	10
6	A & B	4	39	15	12	40
7	A & B	2	23.5	15	12	93.5
8	A	6	40	39	0	109
9	A	3	16	28	0	0
10	A	3	8	11	0	45
11	A	8	32	11.5	12	301.5
12	B	3	16	25	0	0

Table 2-15 provides a sample calculation of the TDS concentration that would result from UDOT's typical de-icing practices using salt and brine. This table also lists some of the assumptions that have been made for this analysis regarding the water content of the snow, the runoff coefficients, and salt characteristics.

Table 2-15. Sample Calculation of TDS Concentration Due to De-icing Practices

Variable Type	Variable	Value
Storm event	Total snowfall depth	4.0 inches
Anti-icing salt and brine applications	Number of brine-only applications	1 application
	Number of salt and brine applications	2 applications
Salt specifications	Specific gravity of salt	2.165
	Unit weight of salt	135.1 lb/cu-ft
Coefficients	Runoff coefficient – pavement	0.90
	Runoff coefficient – vegetated right-of-way	0.25
	Snow water equivalent ratio	0.10
	Brine salt concentration ratio	0.23
Brine-only application(s)	Brine application rate	30 gallons/lane-mile
	Salt volume per application	0.92 cu-ft/lane-mile
Brine and salt application(s)	Salt application rate	250 lb/lane-mile
	Brine application rate	4 gallons/lane-mile
	Salt volume per application	1.85 cu-ft/lane-mile
	Salt volume from brine per application	0.12 cu-ft/lane-mile
	Total salt volume per application	1.97 cu-ft/lane mile
Roadway data	Total tributary vegetated width in right-of-way	170 feet
	Total inside paved shoulder width	8 feet
	Total outside paved shoulder width	24 feet
	Total trail width	0 feet
	Width of each traffic and auxiliary lane	12 feet
	Number of traffic and auxiliary lanes	4 lanes
	Total traffic and auxiliary lane width	48 feet
Salt quantity	Salt quantity due to brine-only application(s)	3.69 cu-ft/lane mile
	Salt quantity due to salt and brine application(s)	15.8 cu-ft/lane-mile
	Total salt applied	19.5 cu-ft/lane-mile
Total runoff	Runoff from snowmelt	20,152 cu-ft/mile
TDS concentration	**Estimated TDS concentration in snowmelt**	**967 ppm (mg/L)**

Definitions: cu-ft = cubic foot; lb = pounds; mg/L = milligrams per liter; ppm = parts per million

2.4.2 TDS Model Results

UDOT calculated the estimated TDS concentration for each roadway configuration and snowfall depth (a total of 72 calculations from 6 snowfall depths and 12 roadway configurations). The analysis shows that TDS concentrations in highway snowmelt runoff from de-icing are highest with lesser snow depths, decrease with additional snowfall, and then increase again following the need for another brine and salt application. It is understood that snowstorms with more than 6 inches of snow depth occur in the Heber Valley; however, these storms were not analyzed because the TDS concentrations would be less for these storms than for storms with snowfall depths of 6 inches or less. Table 2-16 shows the estimated TDS concentration for all 72 scenarios and an overall average estimated TDS concentration.

Table 2-16. Estimated TDS Concentrations in Snowmelt Runoff from UDOT's De-icing Practices

Roadway Scenario	Action Alternative(s) Represented	Estimated TDS Concentration (mg/L)						
		Snowfall Depth (inches)						Average
		1	2	3	4	5	6	
1	A & B	4,527	2,263	1,509	1,903	1,522	1,269	**2,165**
2	A & B	4,442	2,221	1,481	1,867	1,494	1,245	**2,125**
3	A & B	2,299	1,150	766	967	773	644	**1,100**
4	A & B	1,781	890	594	749	599	499	**852**
5	A & B	3,945	1,972	1,315	1,658	1,327	1,105	**1,887**
6	A & B	2,338	1,169	779	983	786	655	**1,118**
7	A & B	1,456	728	485	612	490	408	**696**
8	A	2,421	1,210	807	1,018	814	678	**1,158**
9	A	2,742	1,371	914	1,153	922	769	**1,312**
10	A	3,250	1,625	1,083	1,366	1,093	911	**1,555**
11	A	2,487	1,243	829	1,045	836	697	**1,190**
12	B	2,849	1,425	950	1,198	958	798	**1,363**
Average – Alternative A		**2,881**	**1,440**	**960**	**1,211**	**969**	**807**	**1,378**
Average – Alternative B		**2,954**	**1,477**	**985**	**1,242**	**994**	**828**	**1,413**

mg/L = milligrams per liter; ppm = parts per million

Using the 72 scenarios, UDOT calculated an average TDS concentration in snowmelt runoff for both action alternatives. The range of TDS concentrations for both alternatives is between 408 and 4,527 mg/L. For Alternative A, the average TDS concentration is about 1,380 mg/L, while for Alternative B, the average TDS concentration is slightly higher at about 1,410 mg/L. Most of the calculated TDS concentrations are greater than the groundwater quality standard of 500 mg/L for Class IA – Pristine aquifers. These estimates are conservative (likely overestimate the actual concentration) because not all salt would be dissolved in the snowmelt runoff and conveyed to drainage facilities (these assumptions were discussed previously in Section 2.4, *TDS Analysis from De-icing Practices*).

There is also a surface water quality standard for TDS for beneficial use 4 (agricultural use) of 1,200 mg/L, which is below the average TDS concentration for both Alternative A and Alternative B. If this snowmelt runoff were to discharge to a surface water body, it is likely that the resulting downstream TDS concentration after mixing with the in-stream flow would be less than the averages reported in Table 2-16.

2.5 BMP Selection

BMPs are project elements that are designed to manage and minimize the effects of roadway stormwater discharges to surface and groundwater quality by, in this case, reducing the total volume of water that is discharged to a water body and reducing the concentrations of pollutants in the stormwater. UDOT implements various kinds of BMPs to achieve these goals, including detention basins, roadside swales, retention basins, infiltration trenches, filter strips, and many more, in accordance with UDOT's guidance documents and management plans associated with its MS4 permit.

During its coordination with project stakeholders, including Heber City, Wasatch County, and the local irrigation and canal companies, UDOT heard a strong preference that the stormwater BMPs for the Heber Valley Corridor should be designed to infiltrate 100% of the stormwater that comes off the roadway pavement and right-of-way for the selected alternative, and that no stormwater should be directly discharged to surface waters near the alignment for the selected alternative. The BMPs that UDOT is proposing for the Heber Valley Corridor provide 100% infiltration of stormwater include infiltration trenches (both lined with sand and unlined, depending on the location) and large, shallow basins that would allow both infiltration of stormwater and evaporation over time. The specific BMPs that would be used, and their specific locations, would be determined during the final design of the selected alternative.

In general, traditional BMPs can be supplemented to address specific highway runoff contaminants, if necessary. Based on the analysis presented above, UDOT anticipates that traditional conveyance and infiltration BMPs would be implemented and maintained to manage stormwater runoff from the Heber Valley Corridor. Due to the nature of de-icing runoff, traditional BMPs are not highly effective in removing TDS. The U.S. Environmental Protection Agency suggested that UDOT implement additional operational and salt-specific BMPs for managing salt in highway stormwater runoff, including using salt traps and washing the roadway after the winter season. These BMPs are not typically included by UDOT on its projects, and they are not included in UDOT's *Stormwater Quality Design Manual*. Nonetheless, UDOT will consider using these salt-specific BMPs during the final design of the selected alternative. In addition, UDOT will consider the use of alternative de-icing products that contain less salt for use on the Heber Valley Corridor.

3.0 References

Bernhard, Lynn

2005 Email from Bernhard, UDOT, to Terry Hsu of HDR regarding the use of de-icing salt in the Salt Lake Valley. August 9.

[NCHRP] National Cooperative Highway Research Program

2019 NCHRP Research Report 918: Approaches for Determining and Complying with TMDL Requirements Related to Roadway Stormwater Runoff.

[UDOT] Utah Department of Transportation

2021 Stormwater Quality Design Manual. May.

2025 De-icing Dashboard. https://www.udot.utah.gov/connect/about-us/technology-innovation/maintenance-facilities-management/deicing-dashboard. Accessed April 8, 2025.

[UDWQ] Utah Division of Water Quality

2021 Total Maximum Daily Load for Escherichia coli (*E. coli*) in the Spring Creek (Heber) Assessment Unit. December.

[USGS] U.S. Geological Survey

2013 Stochastic Empirical Loading and Dilution Model (SELDM) Version 1.0.0. Chapter 3, Section C, *Water Quality*, Book 4, *Hydrologic Analysis and Interpretation*, page 4.

2022 Stochastic Empirical Loading and Dilution Model (SELDM) Version 1.1.1. Revised December 16.

[WRCC] Western Regional Climate Center

2025 Heber, Utah (423809) Period of Record Monthly Climate Summary. https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?uthebe. Accessed April 3, 2025.

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ATTACHMENT A

Upstream Watershed Map

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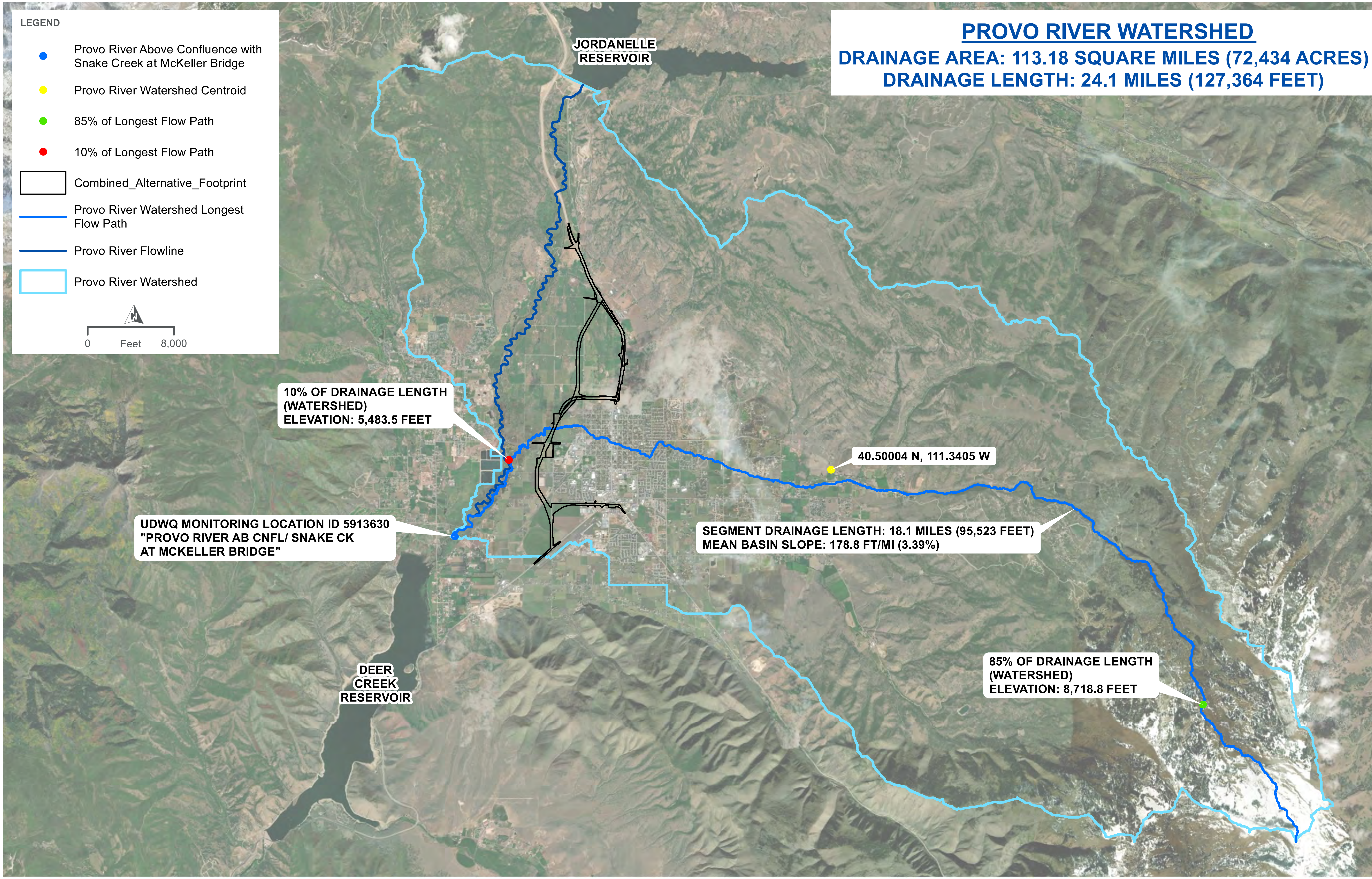

SELDM UPSTREAM WATERSHED MAP

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ATTACHMENT B

SELDM Results Graphs

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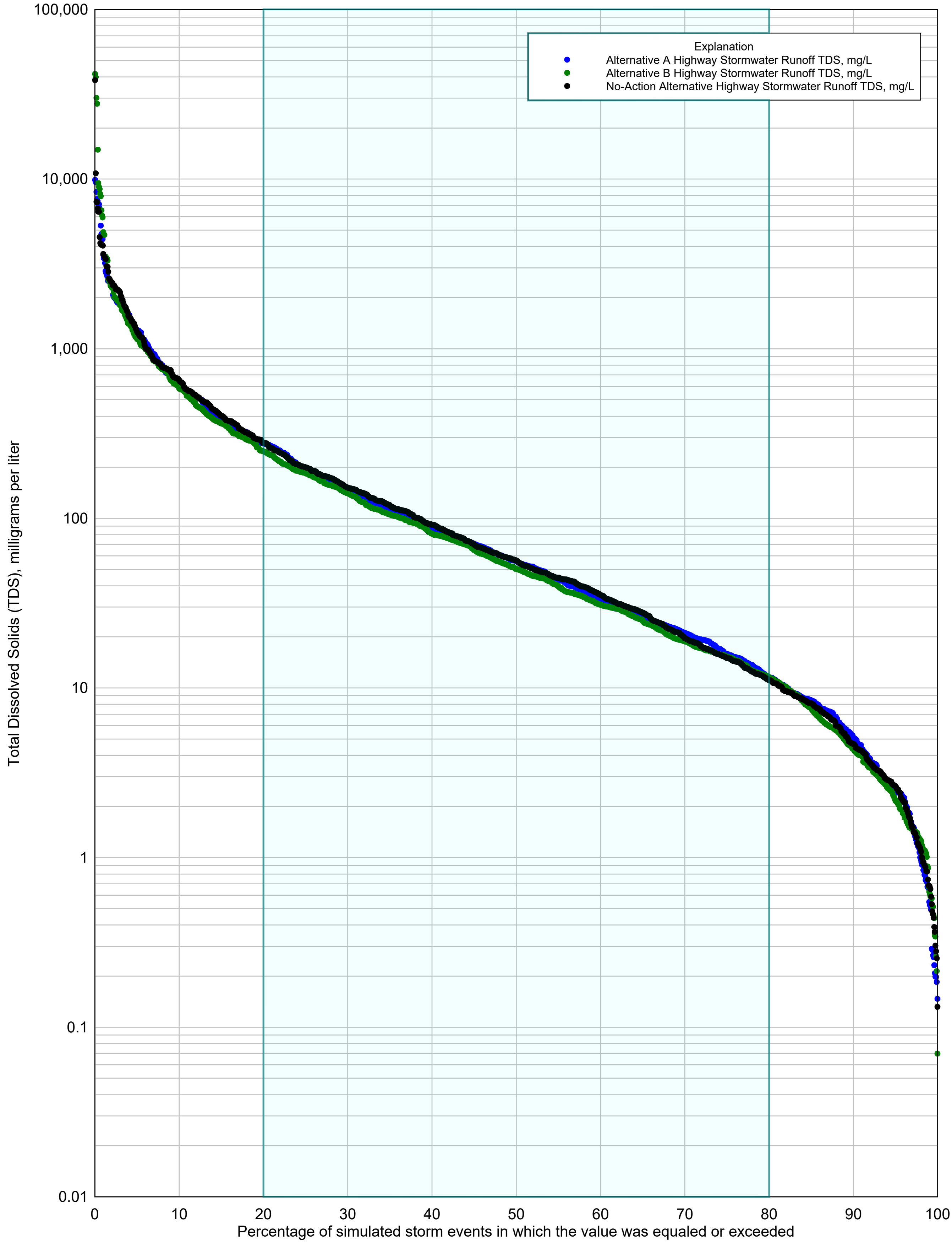
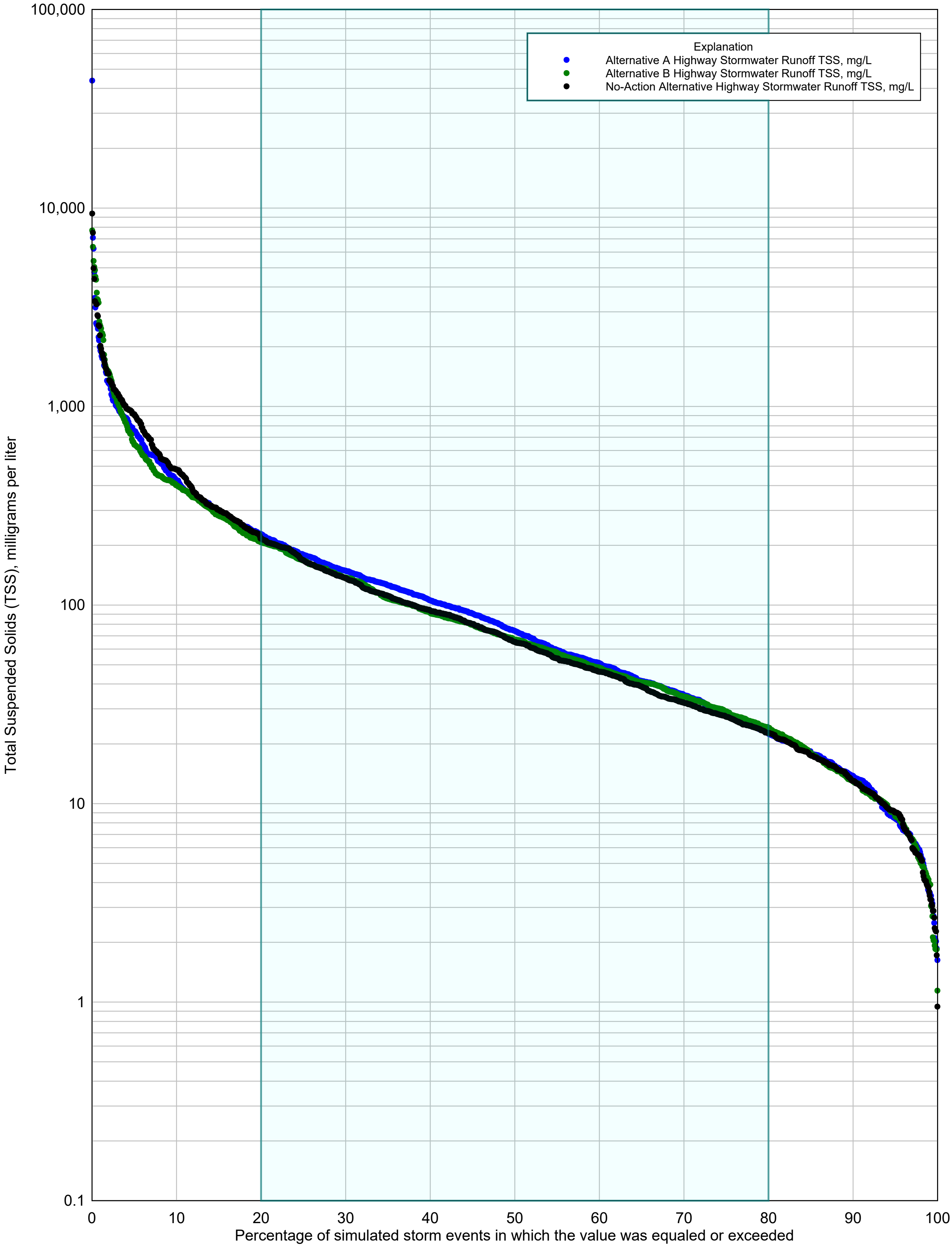
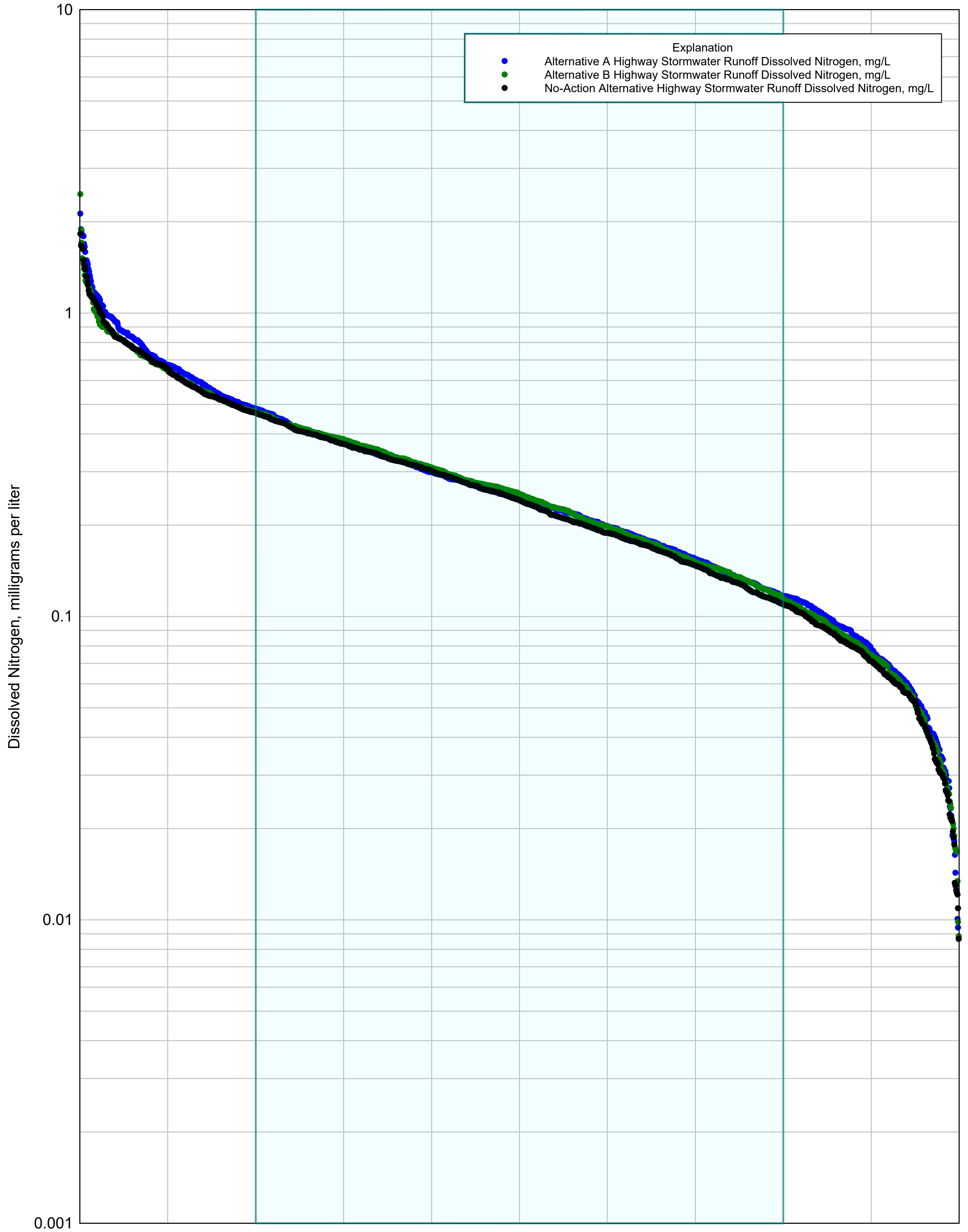
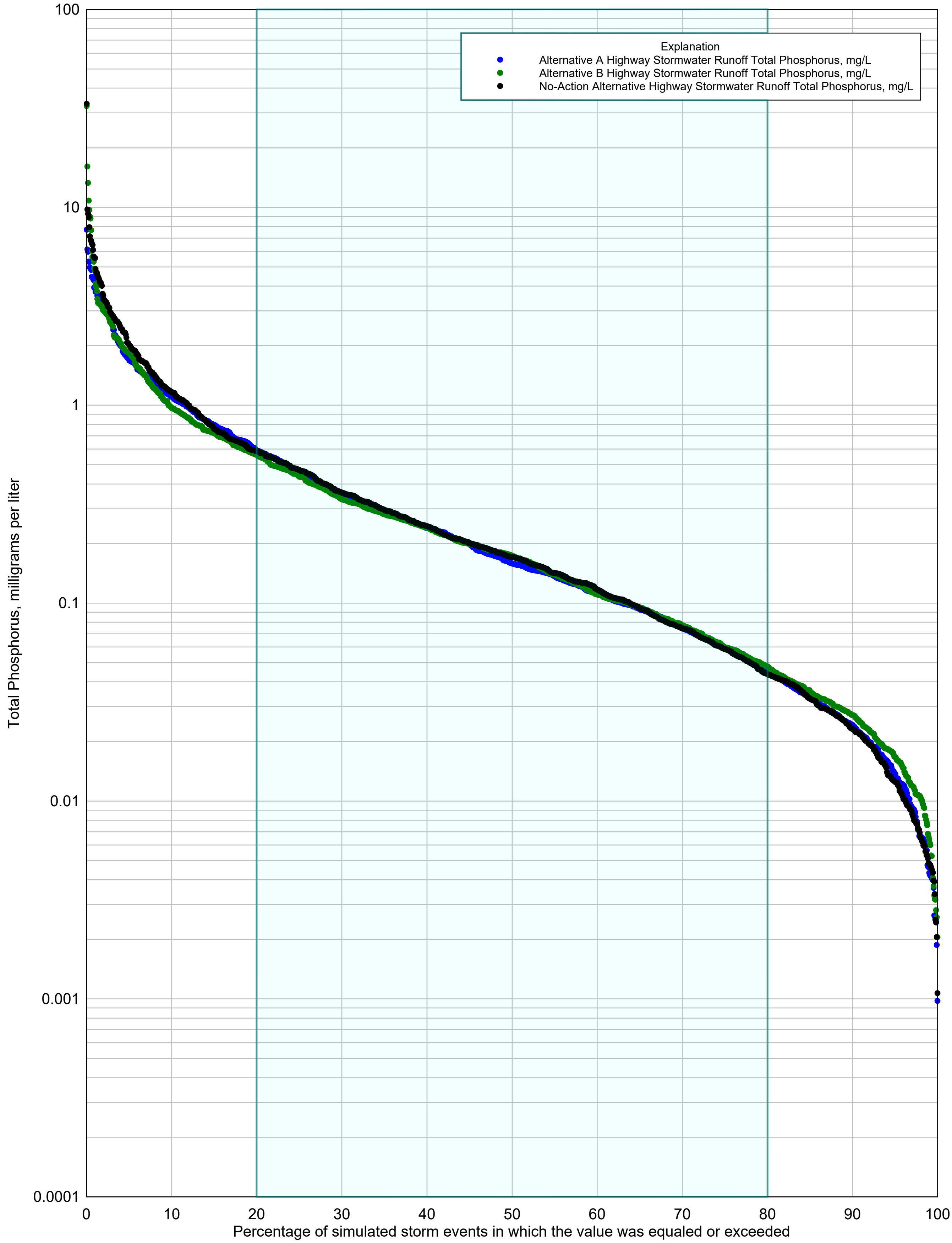
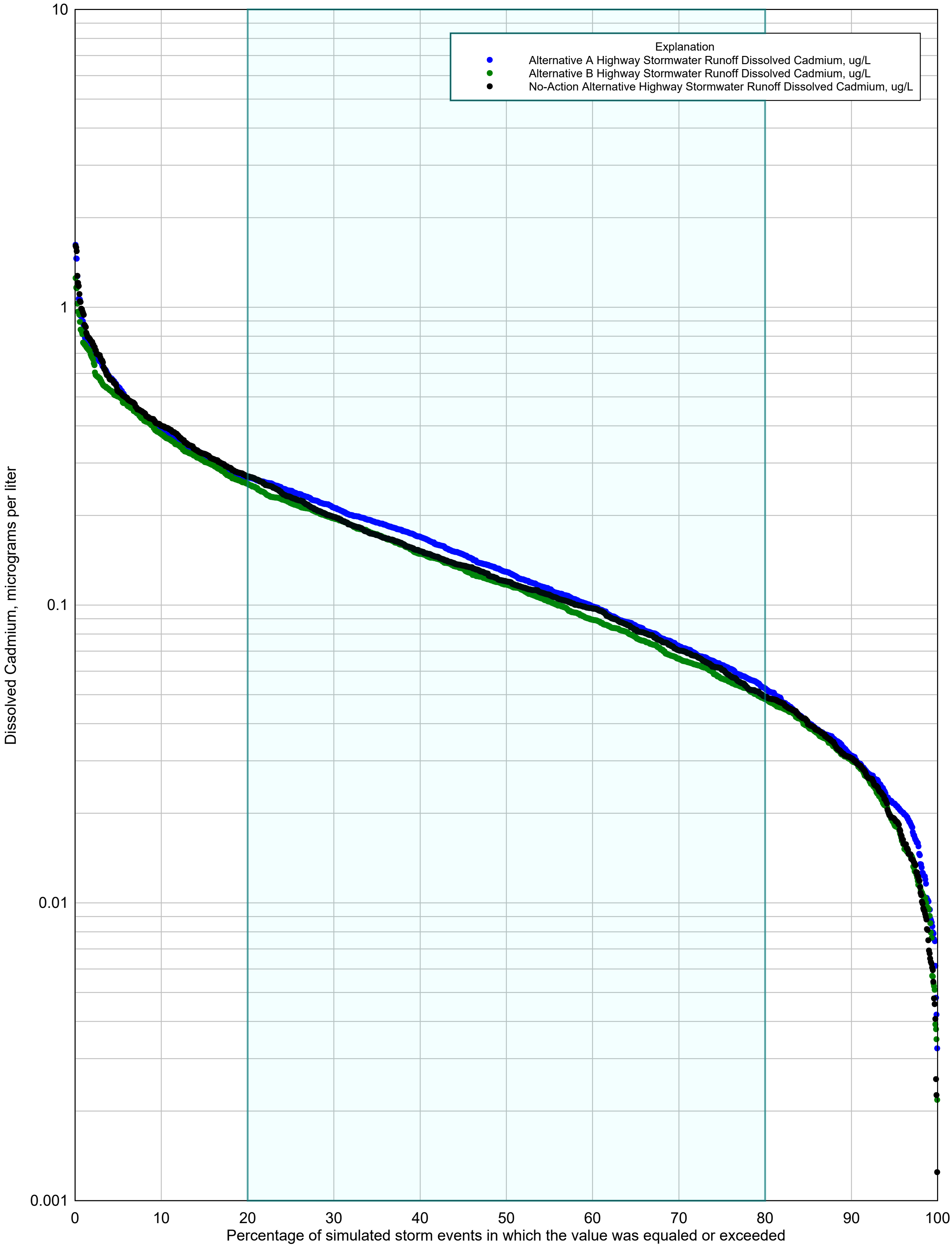

Explanation
Alternative A Highway Stormwater Runoff TDS, mg/L
Alternative B Highway Stormwater Runoff TDS, mg/L
No-Action Alternative Highway Stormwater Runoff TDS, mg/L
Total Dissolved Solids (TDS), milligrams per liter
100,000
10,000
1,000
100
10
1
0.1
0.01
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded

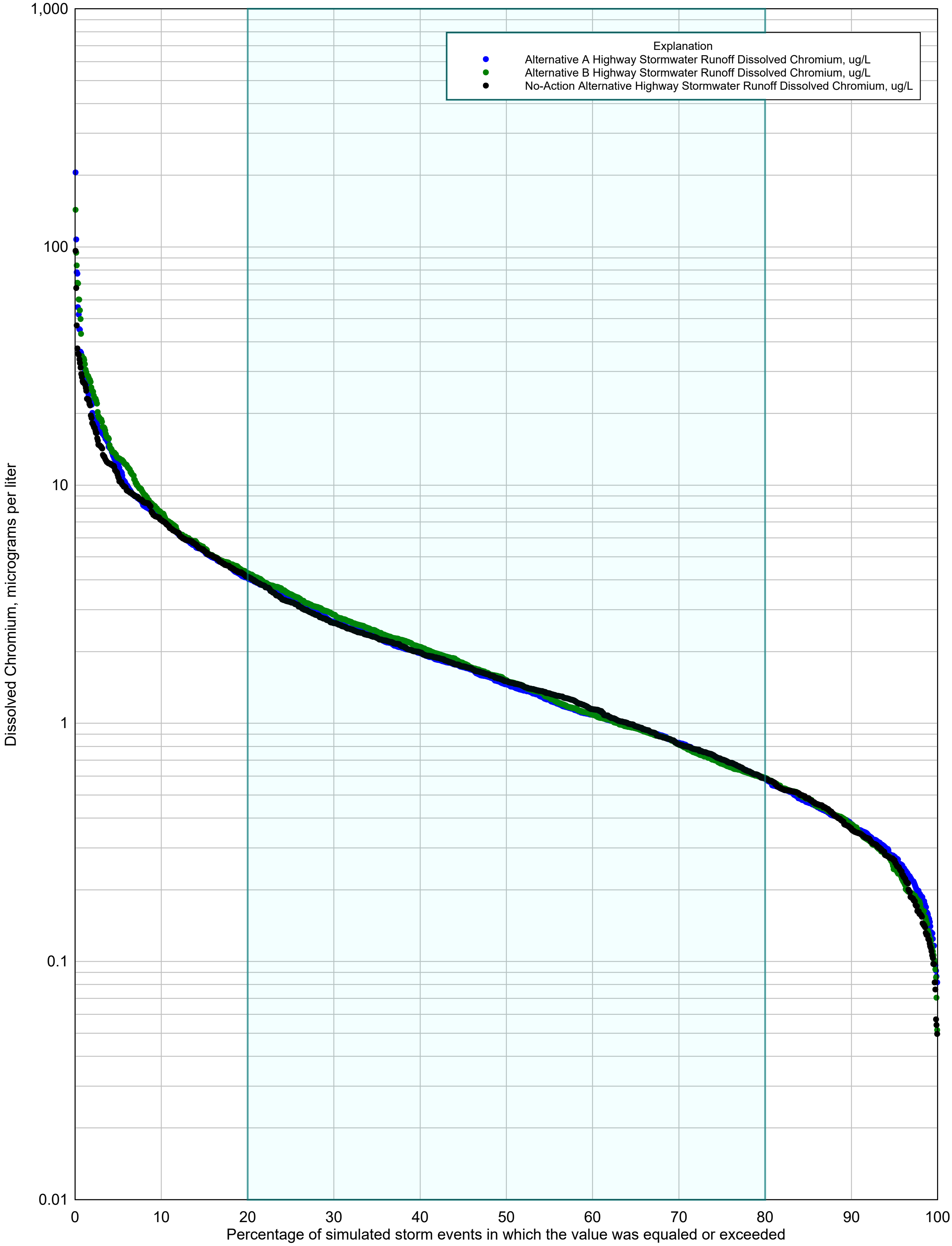

Explanation
Alternative A Highway Stormwater Runoff TSS, mg/L
Alternative B Highway Stormwater Runoff TSS, mg/L
No-Action Alternative Highway Stormwater Runoff TSS, mg/L
Total Suspended Solids (TSS), milligrams per liter
100,000
10,000
1,000
100
10
1
0.1
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded

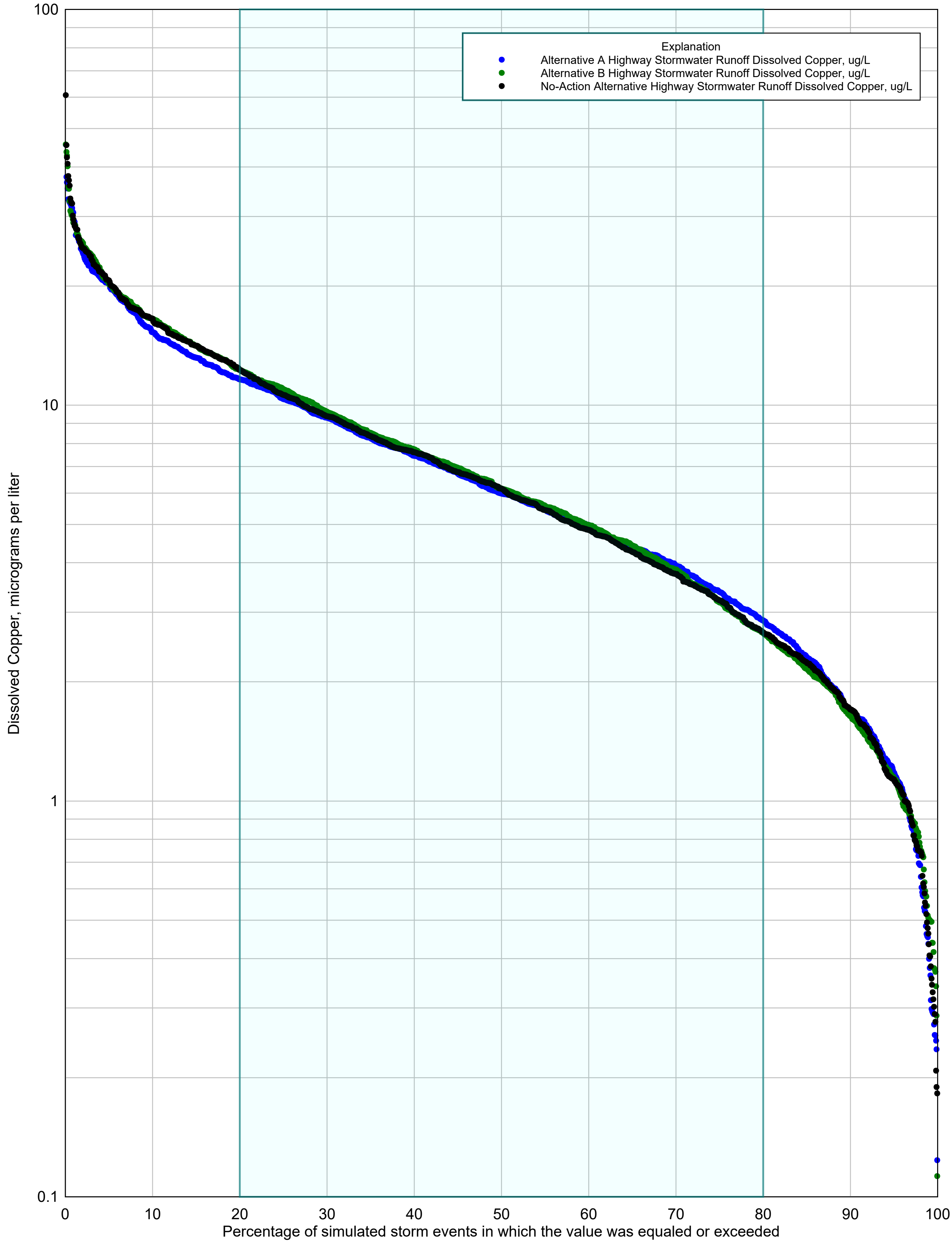


Explanation
Alternative A Highway Stormwater Runoff Dissolved Nitrogen, mg/L
Alternative B Highway Stormwater Runoff Dissolved Nitrogen, mg/L
No-Action Alternative Highway Stormwater Runoff Dissolved Nitrogen, mg/L
10
1
0.1
0.01
0.001
0
10
20
30
40
50
60
70
80
90
100
Dissolved Nitrogen, milligrams per liter
Percentage of simulated storm events in which the value was equaled or exceeded

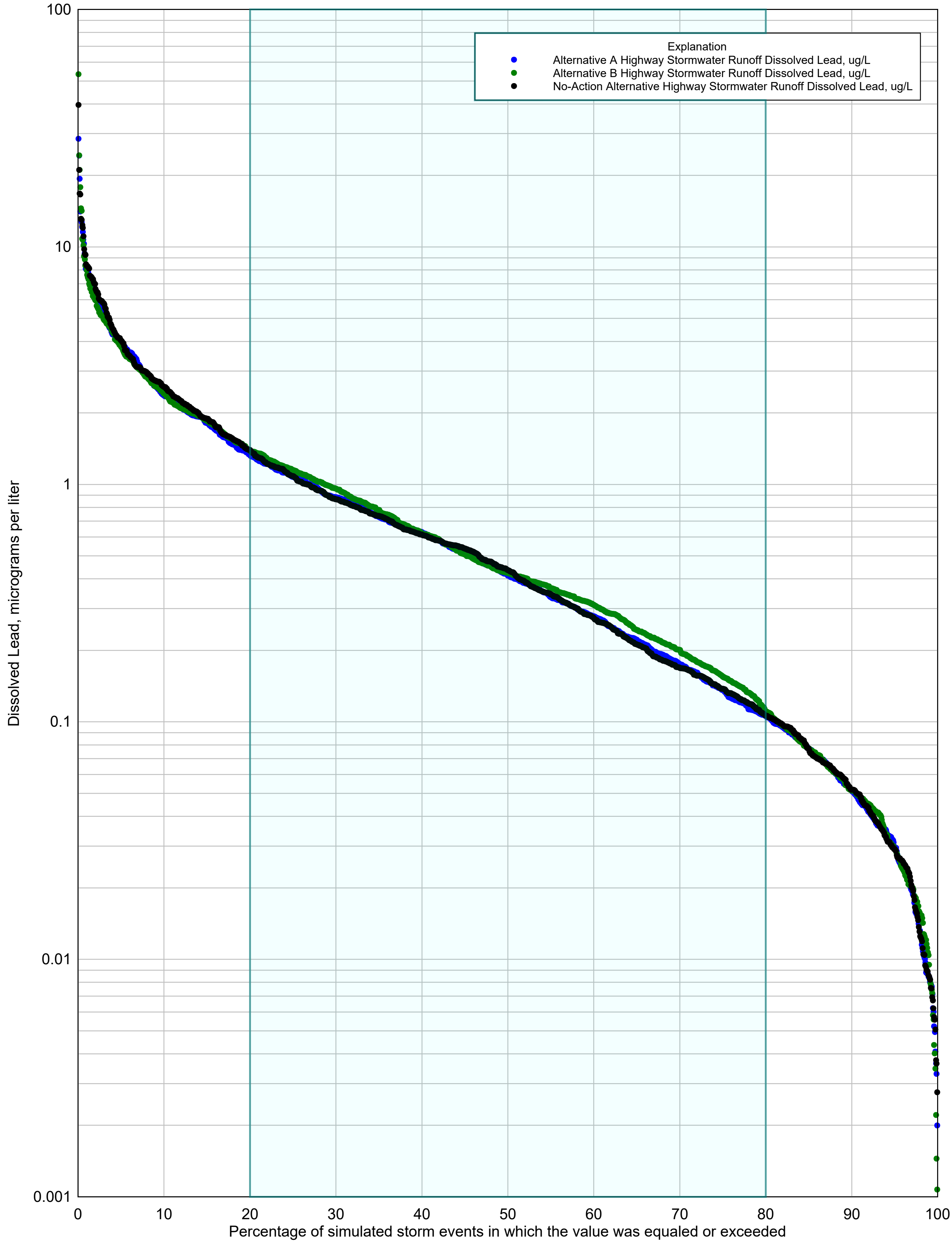

Explanation
Alternative A Highway Stormwater Runoff Total Phosphorus, mg/L
Alternative B Highway Stormwater Runoff Total Phosphorus, mg/L
No-Action Alternative Highway Stormwater Runoff Total Phosphorus, mg/L
Total Phosphorus, milligrams per liter
100
10
1
0.1
0.01
0.001
0.0001
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded


Explanation
Alternative A Highway Stormwater Runoff Dissolved Cadmium, ug/L
Alternative B Highway Stormwater Runoff Dissolved Cadmium, ug/L
No-Action Alternative Highway Stormwater Runoff Dissolved Cadmium, ug/L
Dissolved Cadmium, micrograms per liter
10
1
0.1
0.01
0.001
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded

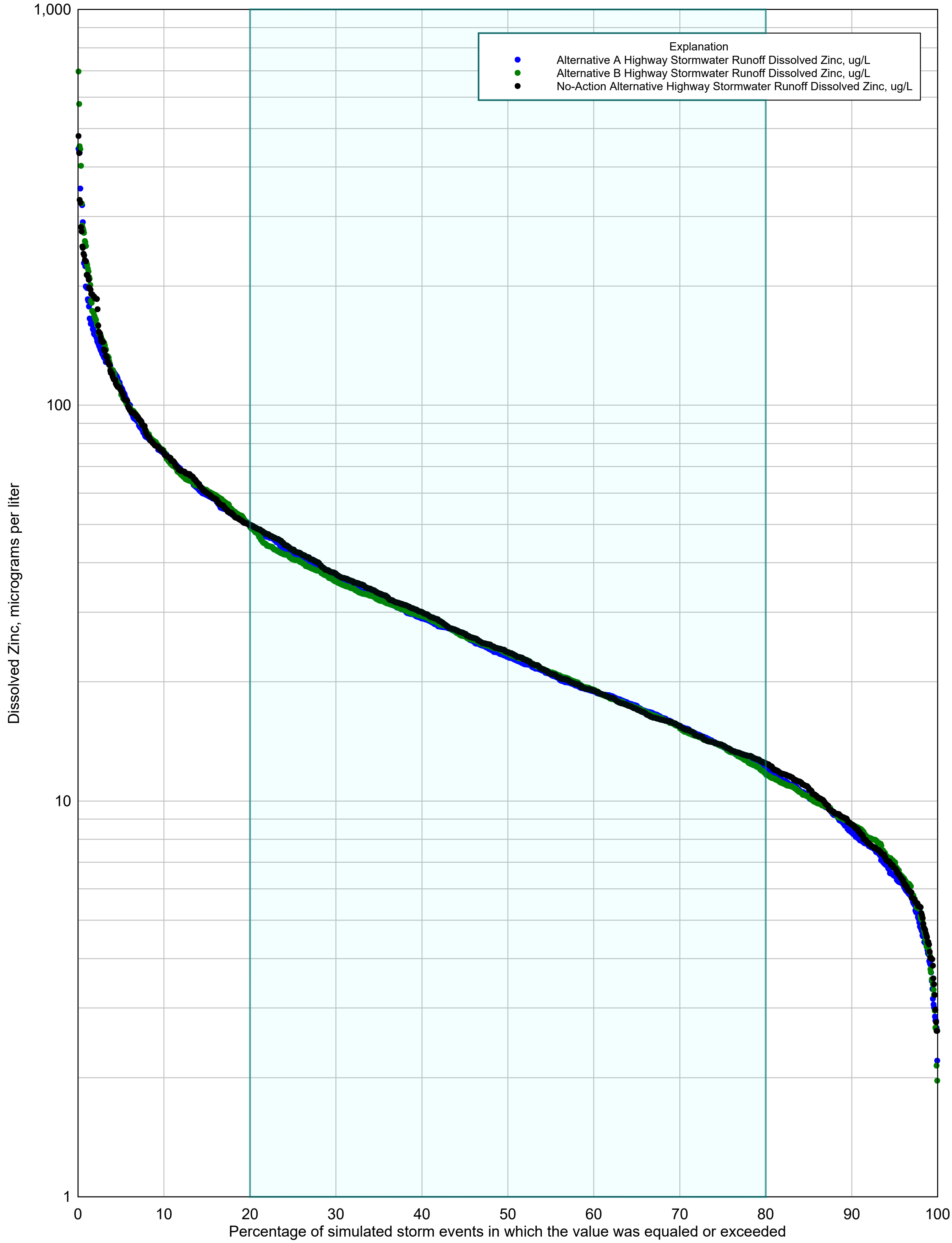

Explanation
Alternative A Highway Stormwater Runoff Dissolved Chromium, ug/L
Alternative B Highway Stormwater Runoff Dissolved Chromium, ug/L
No-Action Alternative Highway Stormwater Runoff Dissolved Chromium, ug/L
1,000
100
10
1
0.1
0.01
0
10
20
30
40
50
60
70
80
90
100
Dissolved Chromium, micrograms per liter
Percentage of simulated storm events in which the value was equaled or exceeded



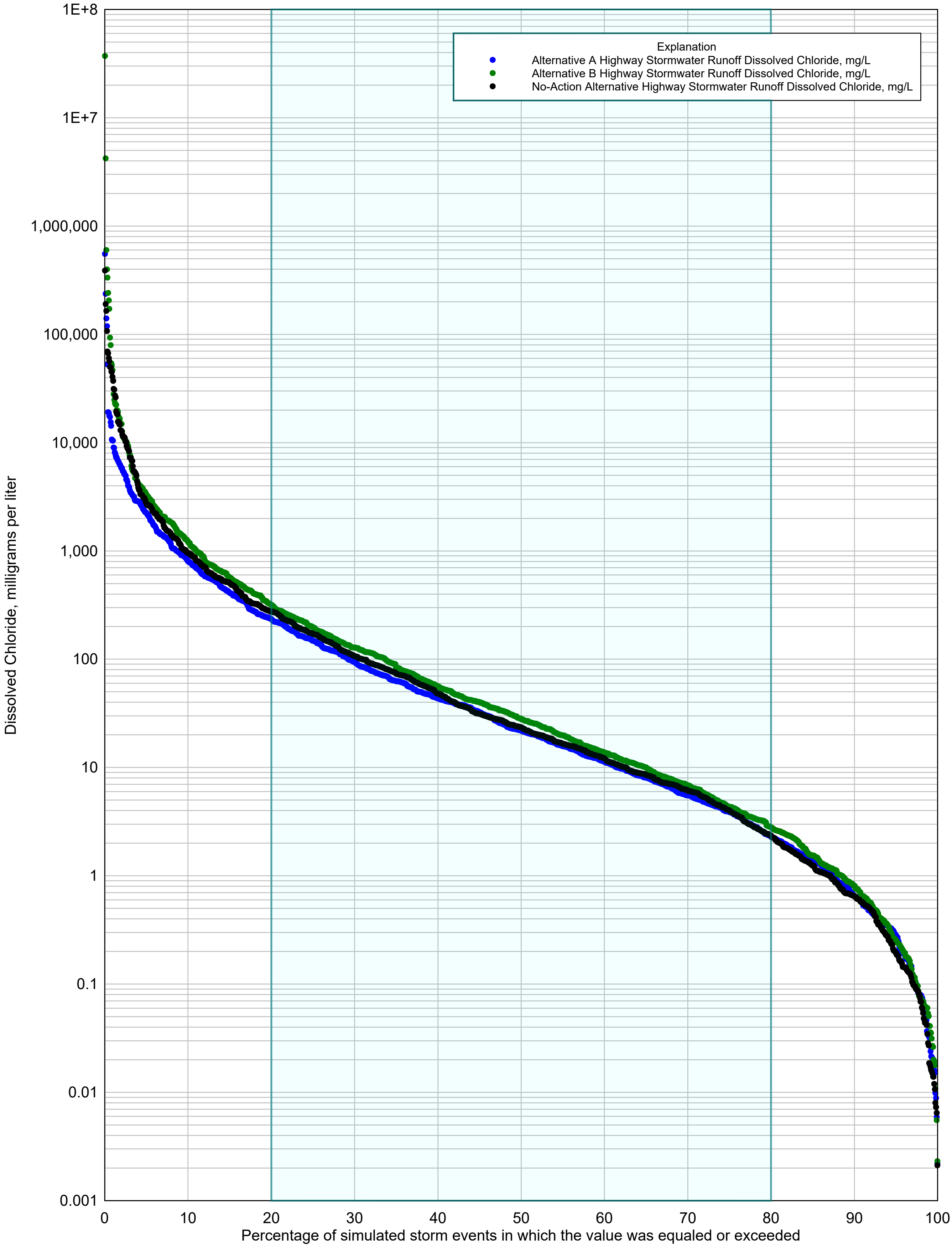
Explanation
Alternative A Highway Stormwater Runoff Dissolved Copper, ug/L
Alternative B Highway Stormwater Runoff Dissolved Copper, ug/L
No-Action Alternative Highway Stormwater Runoff Dissolved Copper, ug/L
Dissolved Copper, micrograms per liter
100
10
1
0.1
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded



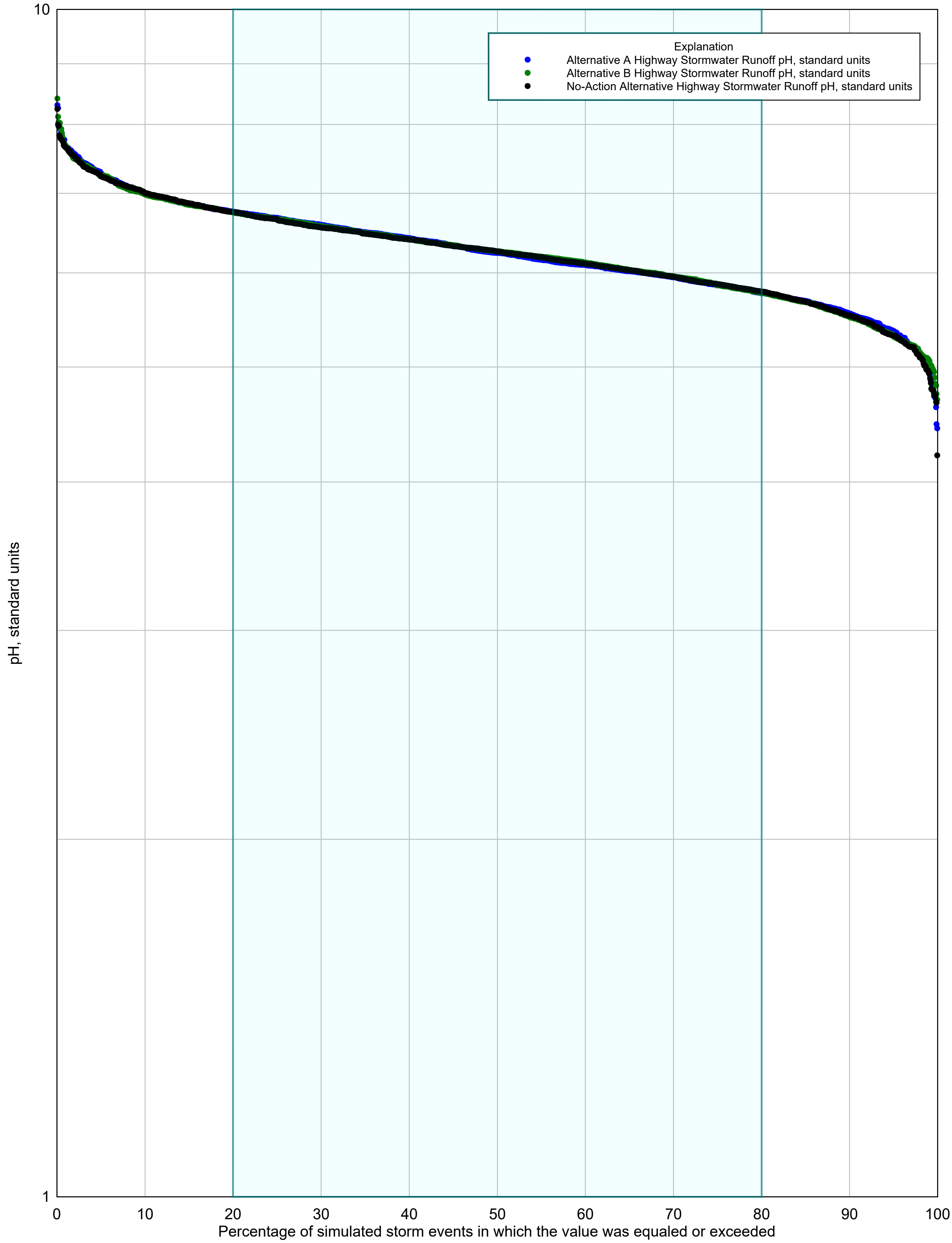
Explanation
Alternative A Highway Stormwater Runoff Dissolved Lead, ug/L
Alternative B Highway Stormwater Runoff Dissolved Lead, ug/L
No-Action Alternative Highway Stormwater Runoff Dissolved Lead, ug/L
Dissolved Lead, micrograms per liter
100
10
1
0.1
0.01
0.001
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded



Explanation
Alternative A Highway Stormwater Runoff Dissolved Zinc, ug/L
Alternative B Highway Stormwater Runoff Dissolved Zinc, ug/L
No-Action Alternative Highway Stormwater Runoff Dissolved Zinc, ug/L
Dissolved Zinc, micrograms per liter
1,000
100
10
1
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded



Explanation
Alternative A Highway Stormwater Runoff Dissolved Chloride, mg/L
Alternative B Highway Stormwater Runoff Dissolved Chloride, mg/L
No-Action Alternative Highway Stormwater Runoff Dissolved Chloride, mg/L
Dissolved Chloride, milligrams per liter
1E+8
1E+7
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
0.001
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded



Explanation
Alternative A Highway Stormwater Runoff pH, standard units
Alternative B Highway Stormwater Runoff pH, standard units
No-Action Alternative Highway Stormwater Runoff pH, standard units
pH, standard units
10
1
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded

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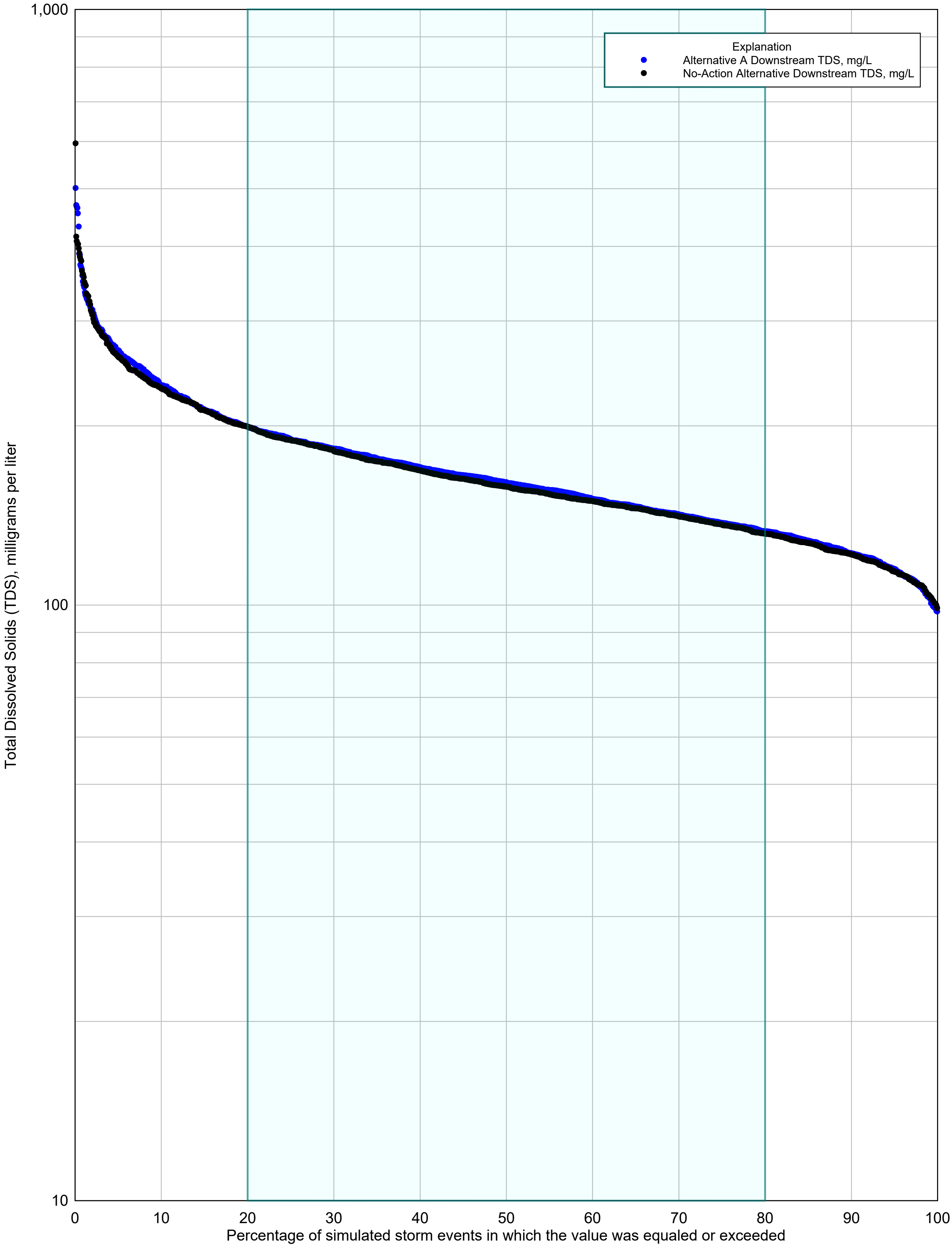
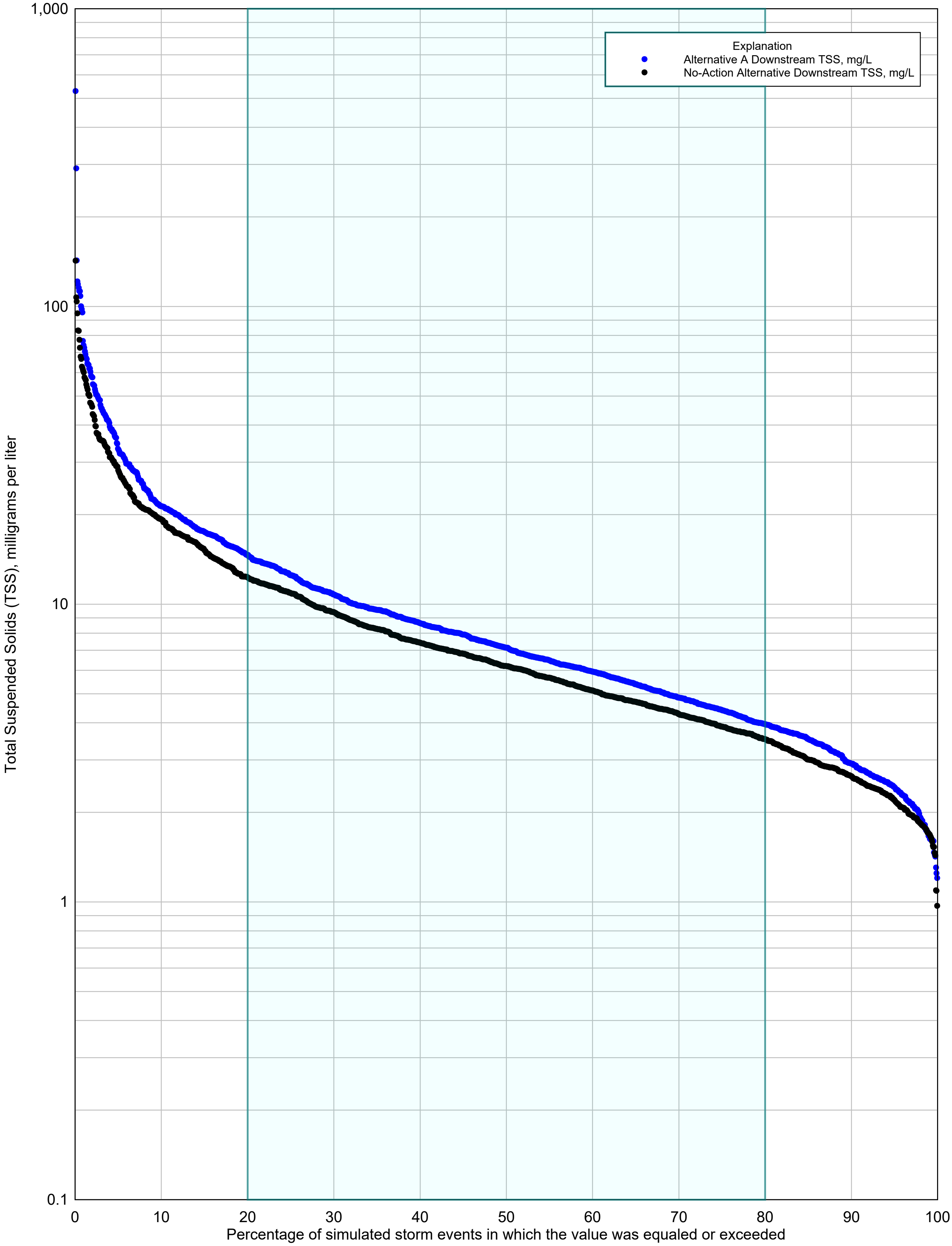
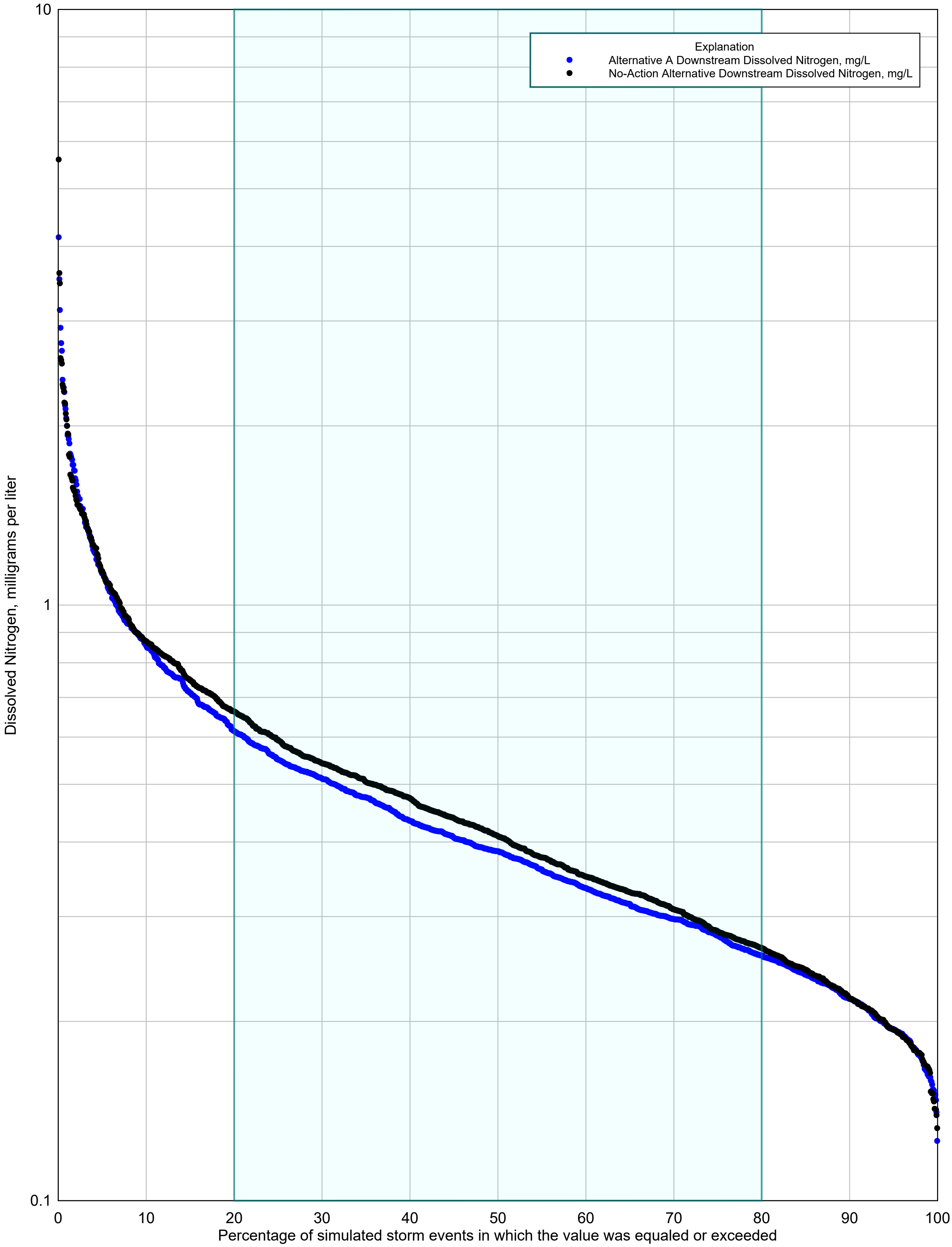


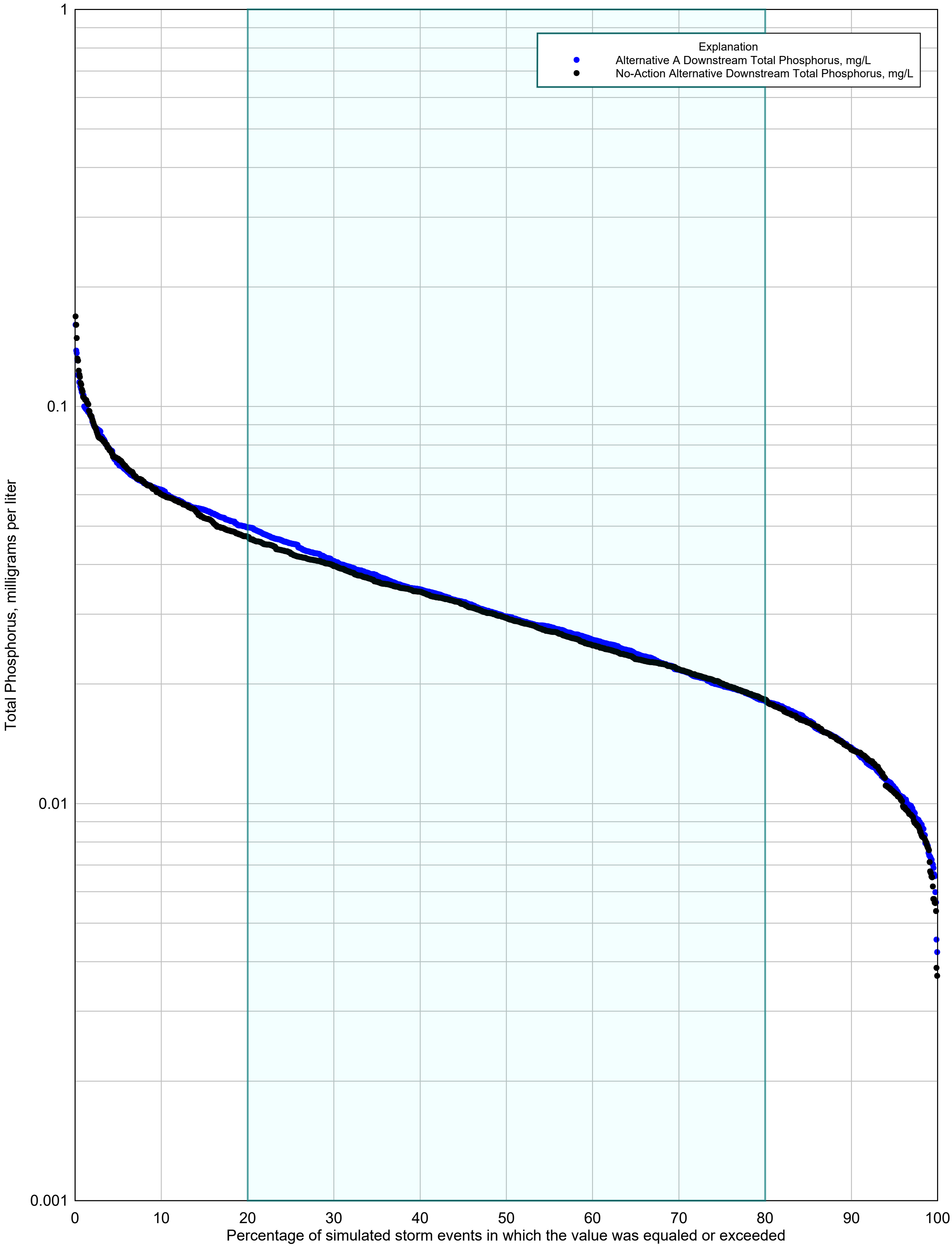
1,000
100
10
Total Dissolved Solids (TDS), milligrams per liter
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded
Explanation
Alternative A Downstream TDS, mg/L
No-Action Alternative Downstream TDS, mg/L

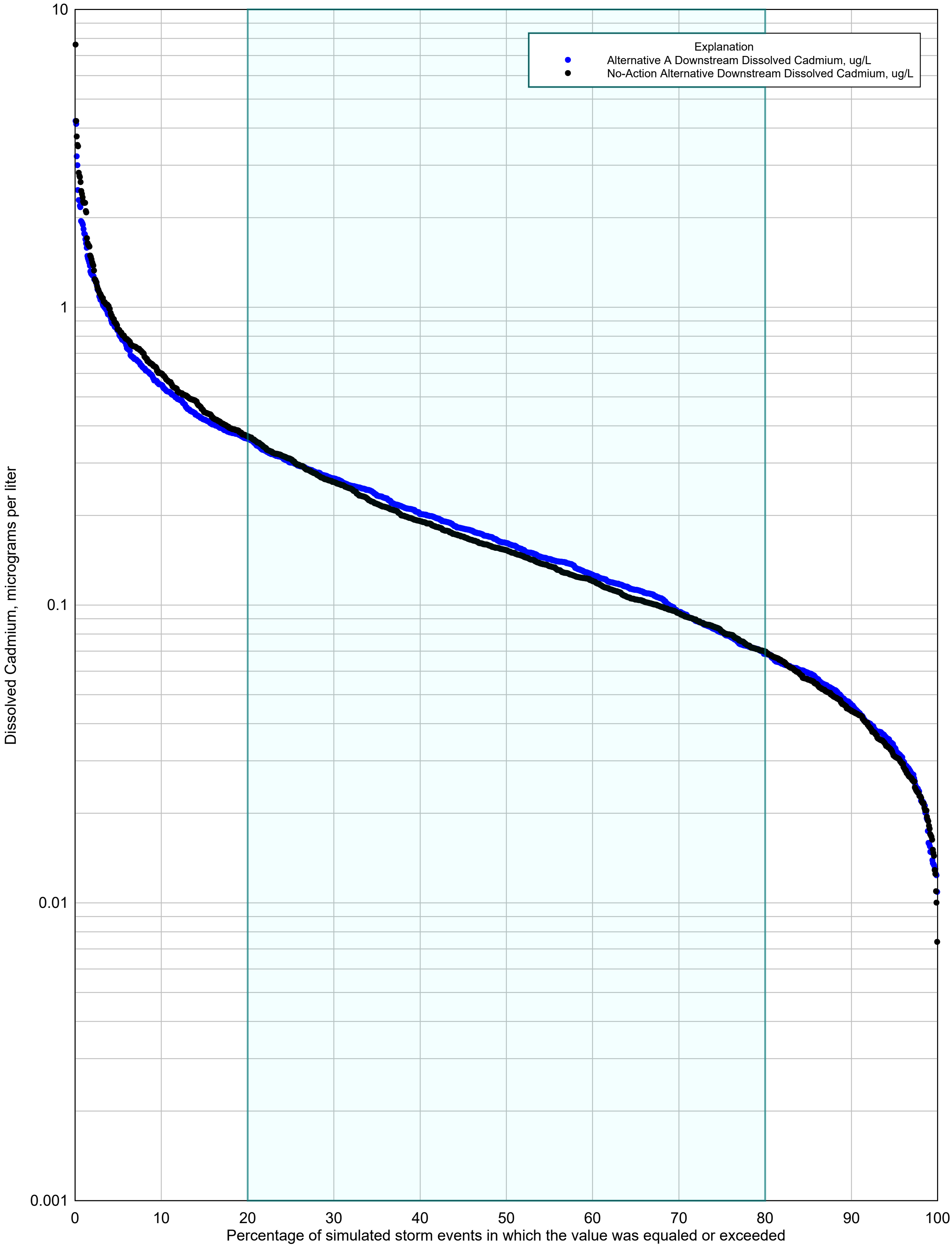


1,000
100
10
1
0.1
0
10
20
30
40
50
60
70
80
90
100
Total Suspended Solids (TSS), milligrams per liter
Percentage of simulated storm events in which the value was equaled or exceeded
Explanation
Alternative A Downstream TSS, mg/L
No-Action Alternative Downstream TSS, mg/L

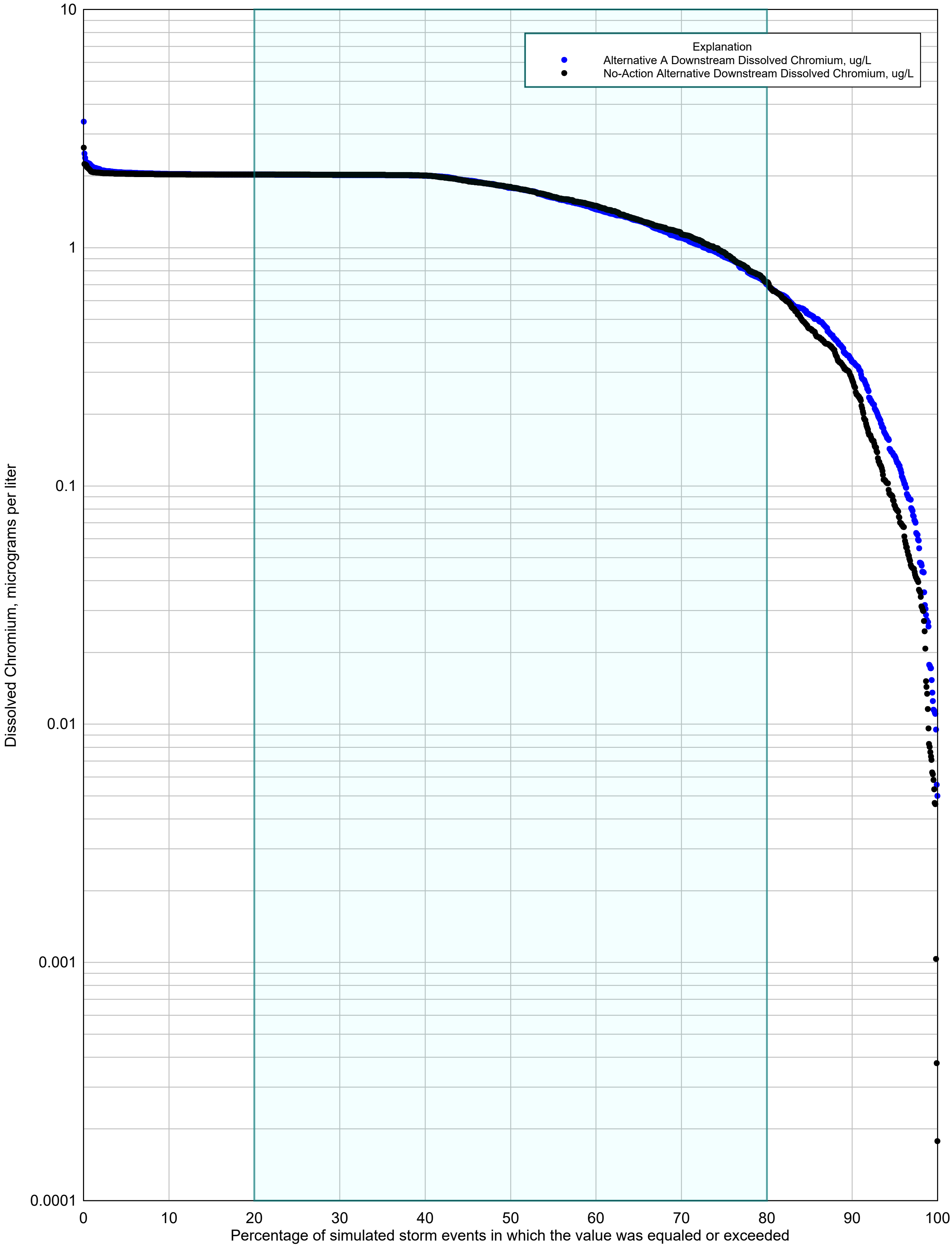


Explanation
Alternative A Downstream Dissolved Nitrogen, mg/L
No-Action Alternative Downstream Dissolved Nitrogen, mg/L
10
1
0.1
Dissolved Nitrogen, milligrams per liter
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded

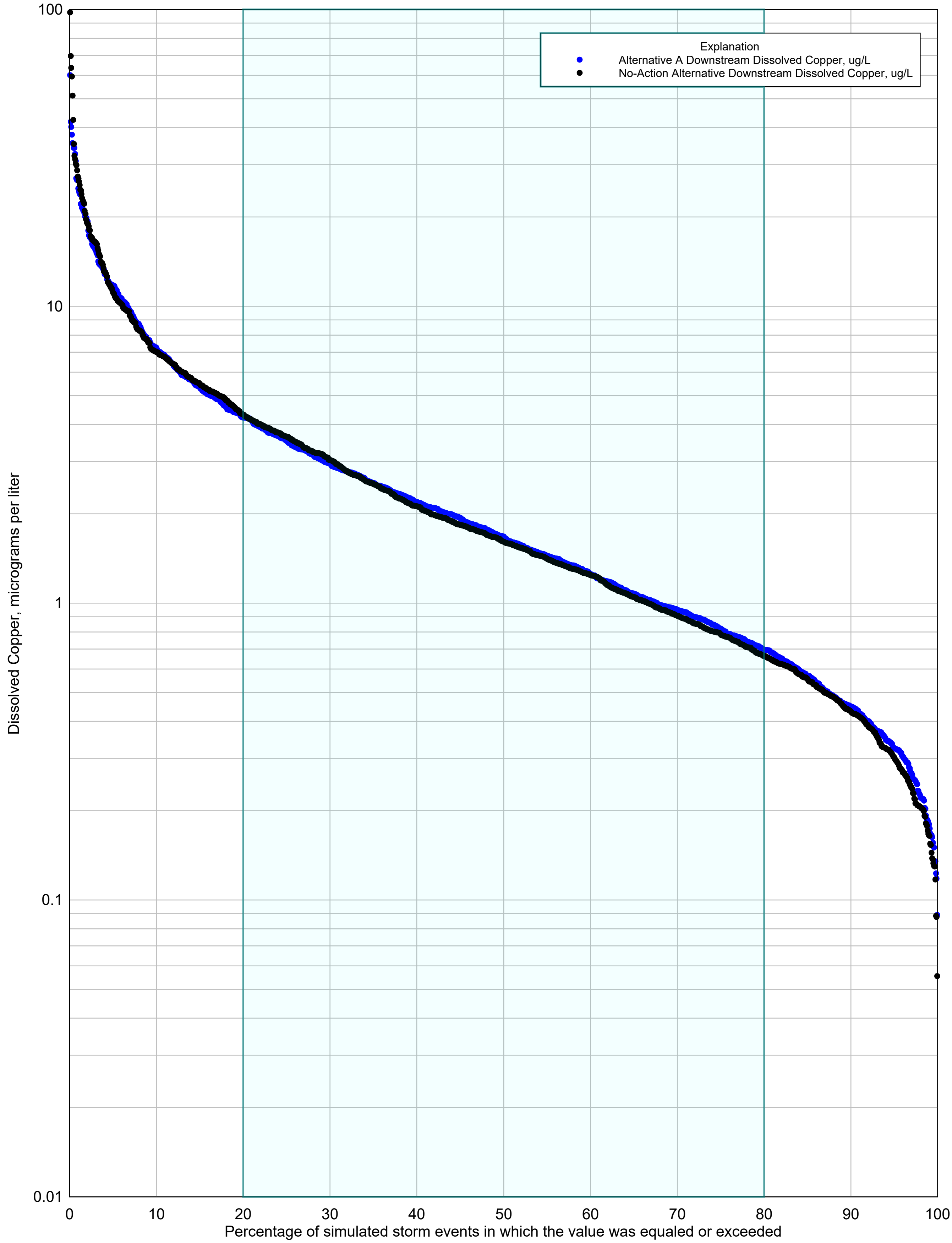

Explanation
Alternative A Downstream Total Phosphorus, mg/L
No-Action Alternative Downstream Total Phosphorus, mg/L
Total Phosphorus, milligrams per liter
1
0.1
0.01
0.001
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded

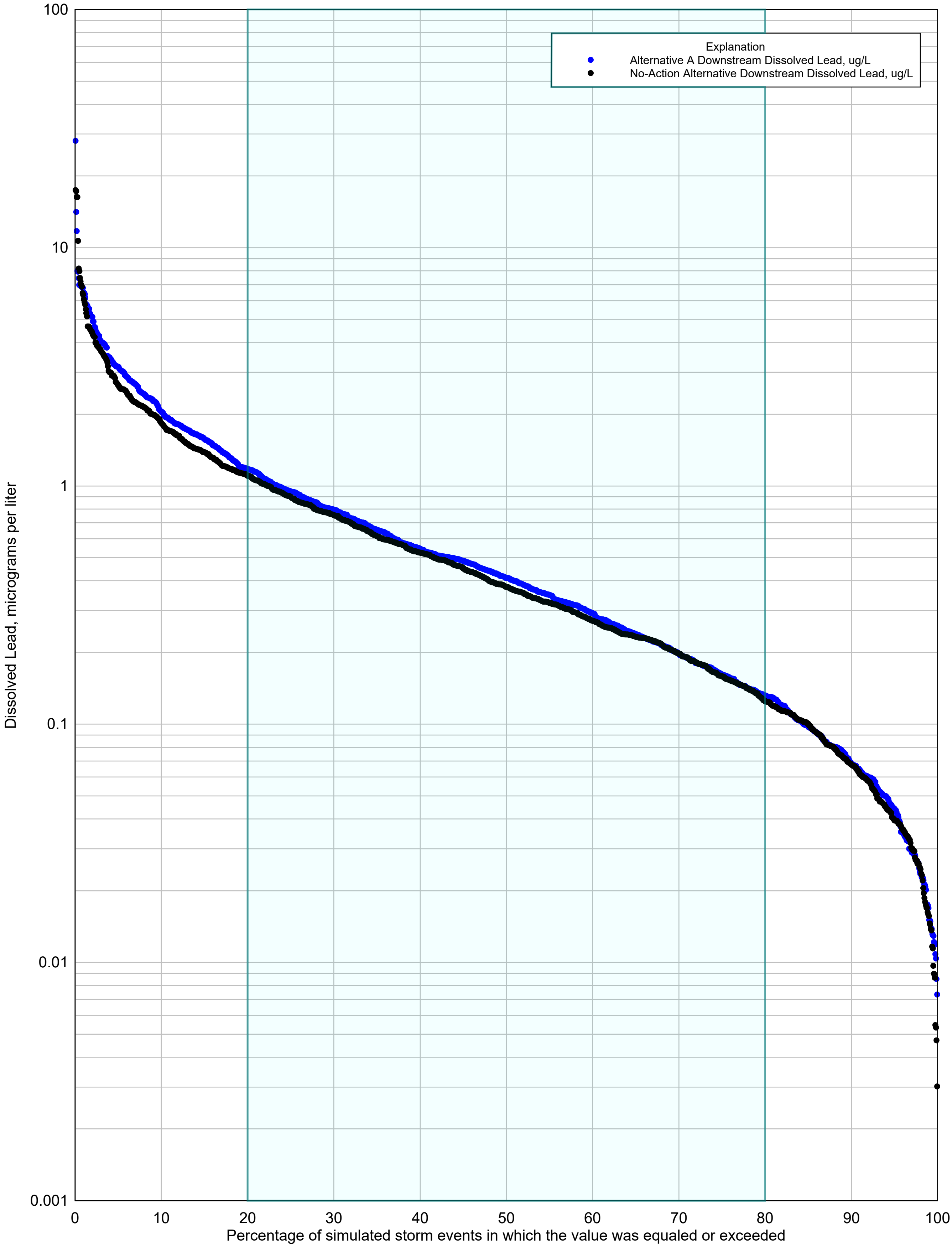


Explanation
Alternative A Downstream Dissolved Cadmium, ug/L
No-Action Alternative Downstream Dissolved Cadmium, ug/L
Dissolved Cadmium, micrograms per liter
10
1
0.1
0.01
0.001
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded

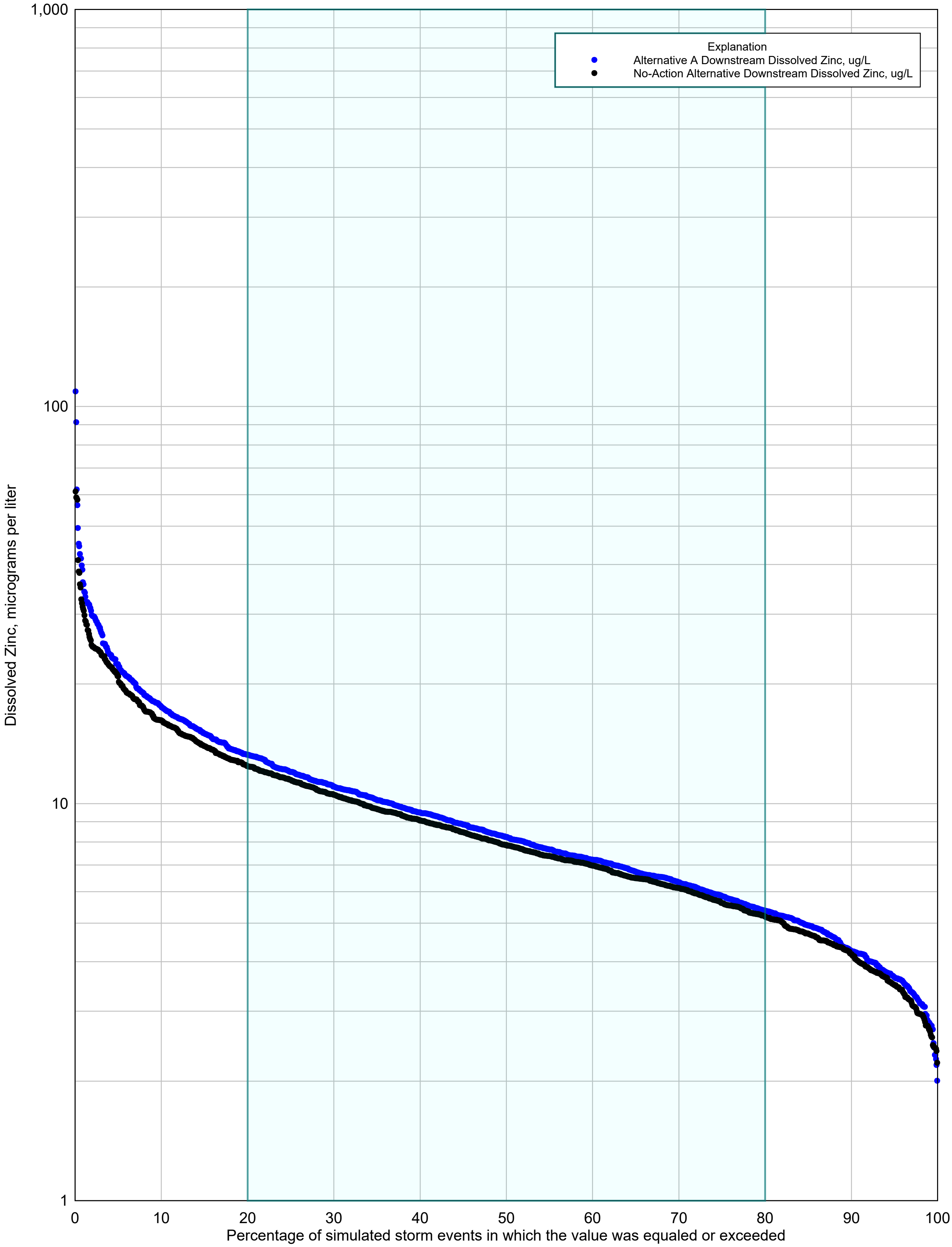


Explanation
Alternative A Downstream Dissolved Chromium, ug/L
No-Action Alternative Downstream Dissolved Chromium, ug/L
Dissolved Chromium, micrograms per liter
10
1
0.1
0.01
0.001
0.0001
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded

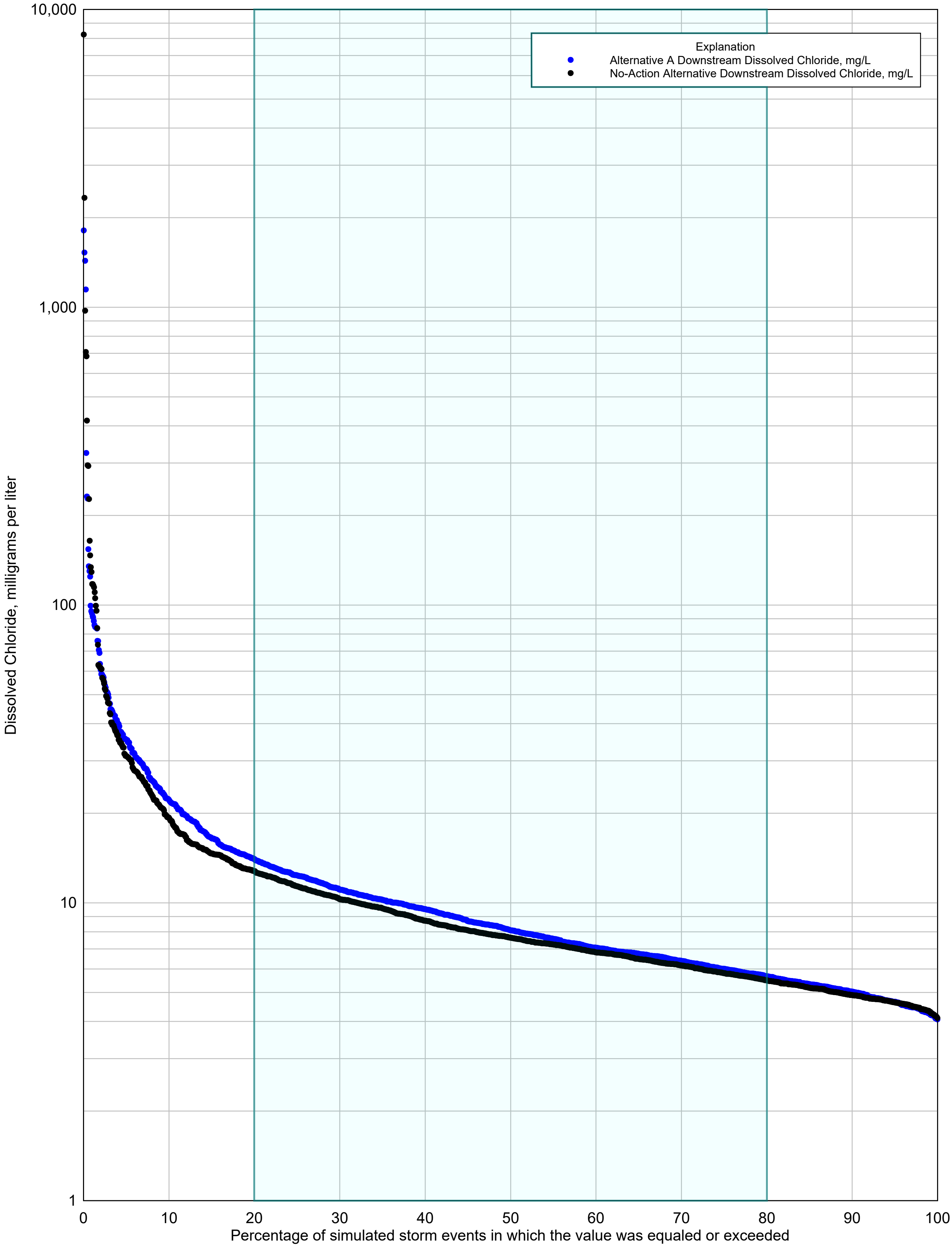

Explanation
Alternative A Downstream Dissolved Copper, ug/L
No-Action Alternative Downstream Dissolved Copper, ug/L
Dissolved Copper, micrograms per liter
100
10
1
0.1
0.01
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded



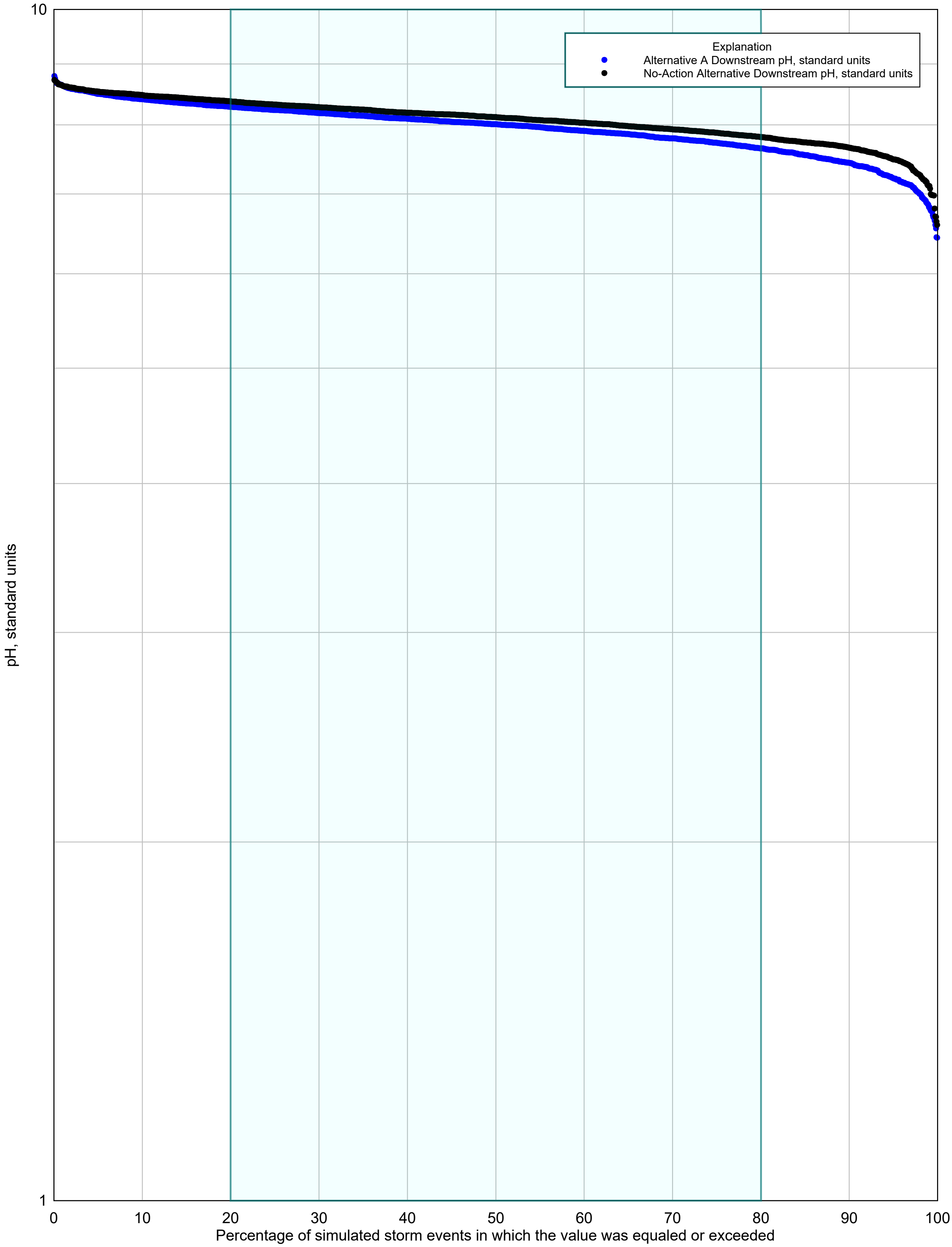
Explanation
Alternative A Downstream Dissolved Lead, ug/L
No-Action Alternative Downstream Dissolved Lead, ug/L
Dissolved Lead, micrograms per liter
100
10
1
0.1
0.01
0.001
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded



Explanation
Alternative A Downstream Dissolved Zinc, ug/L
No-Action Alternative Downstream Dissolved Zinc, ug/L
1,000
100
10
1
Dissolved Zinc, micrograms per liter
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded



Explanation
Alternative A Downstream Dissolved Chloride, mg/L
No-Action Alternative Downstream Dissolved Chloride, mg/L
Dissolved Chloride, milligrams per liter
10,000
1,000
100
10
1
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded


Explanation
Alternative A Downstream pH, standard units
No-Action Alternative Downstream pH, standard units
pH, standard units
10
1
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded

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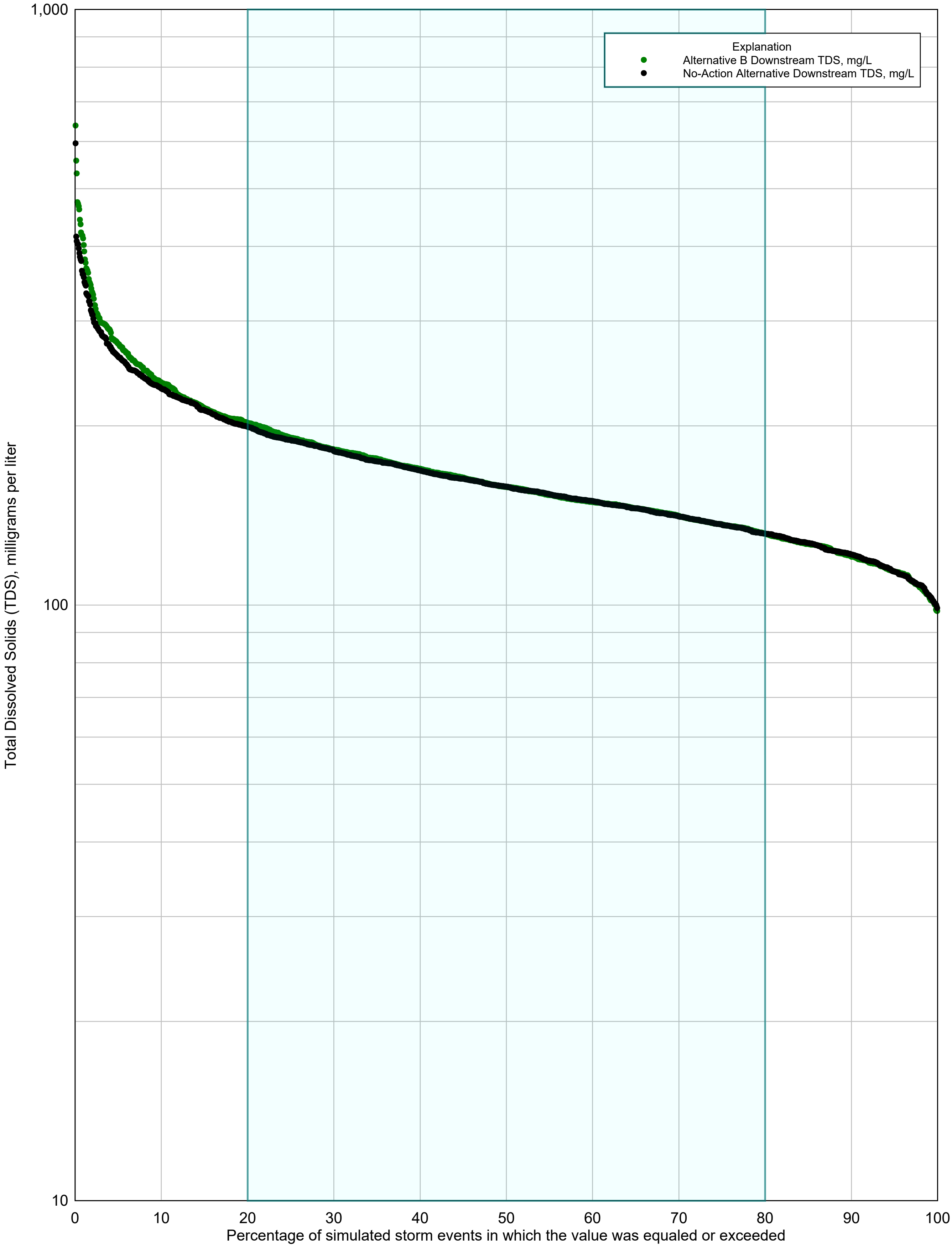
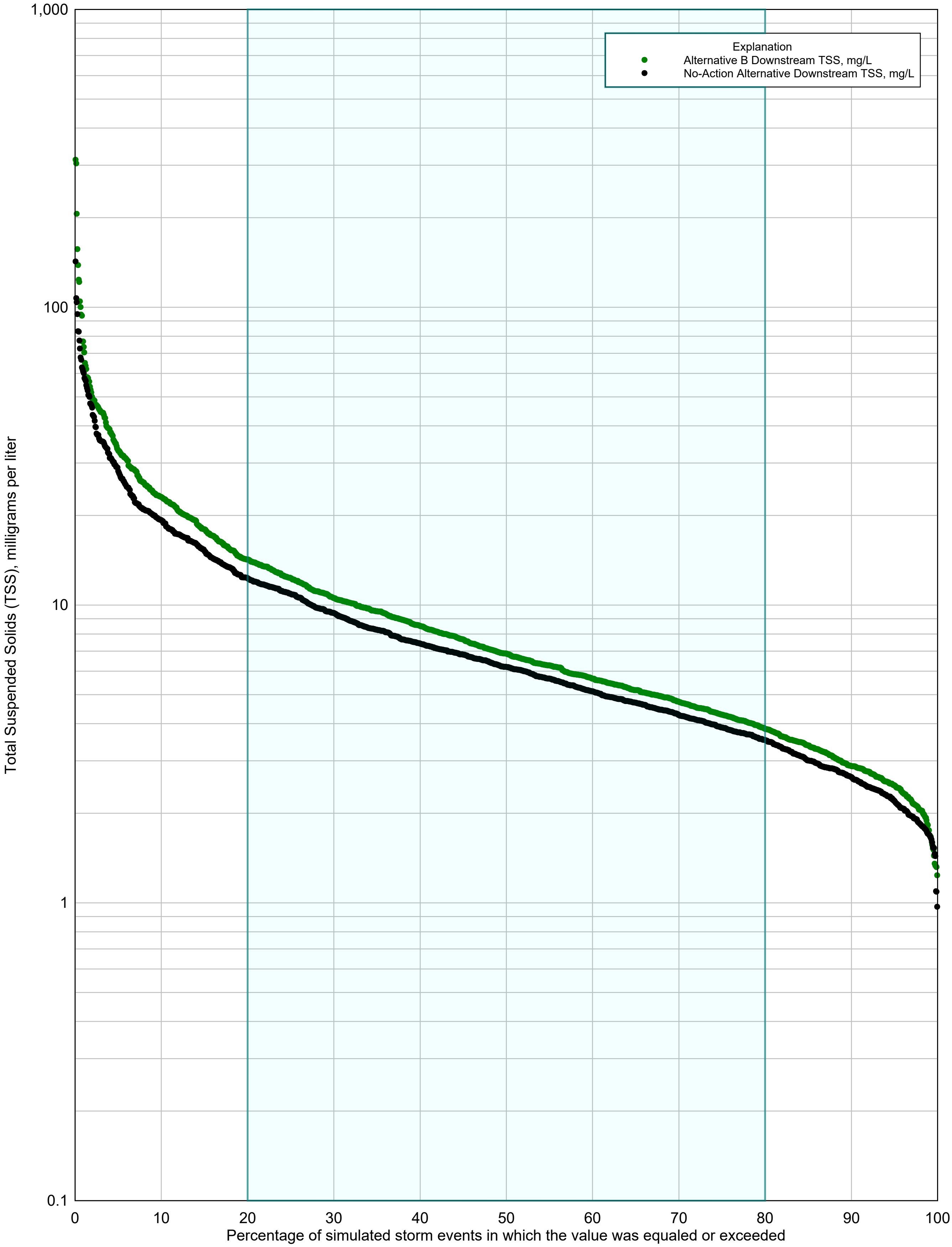
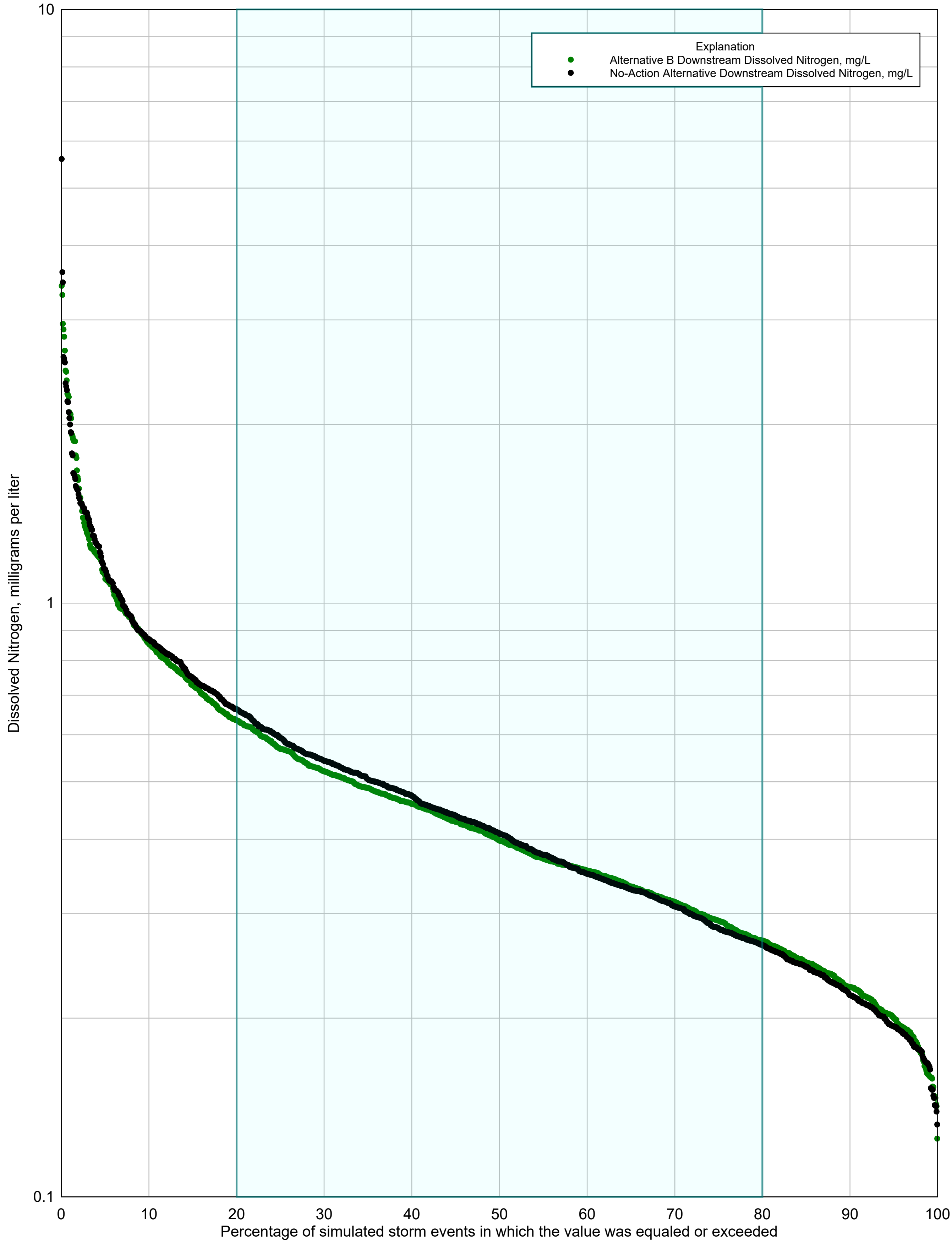
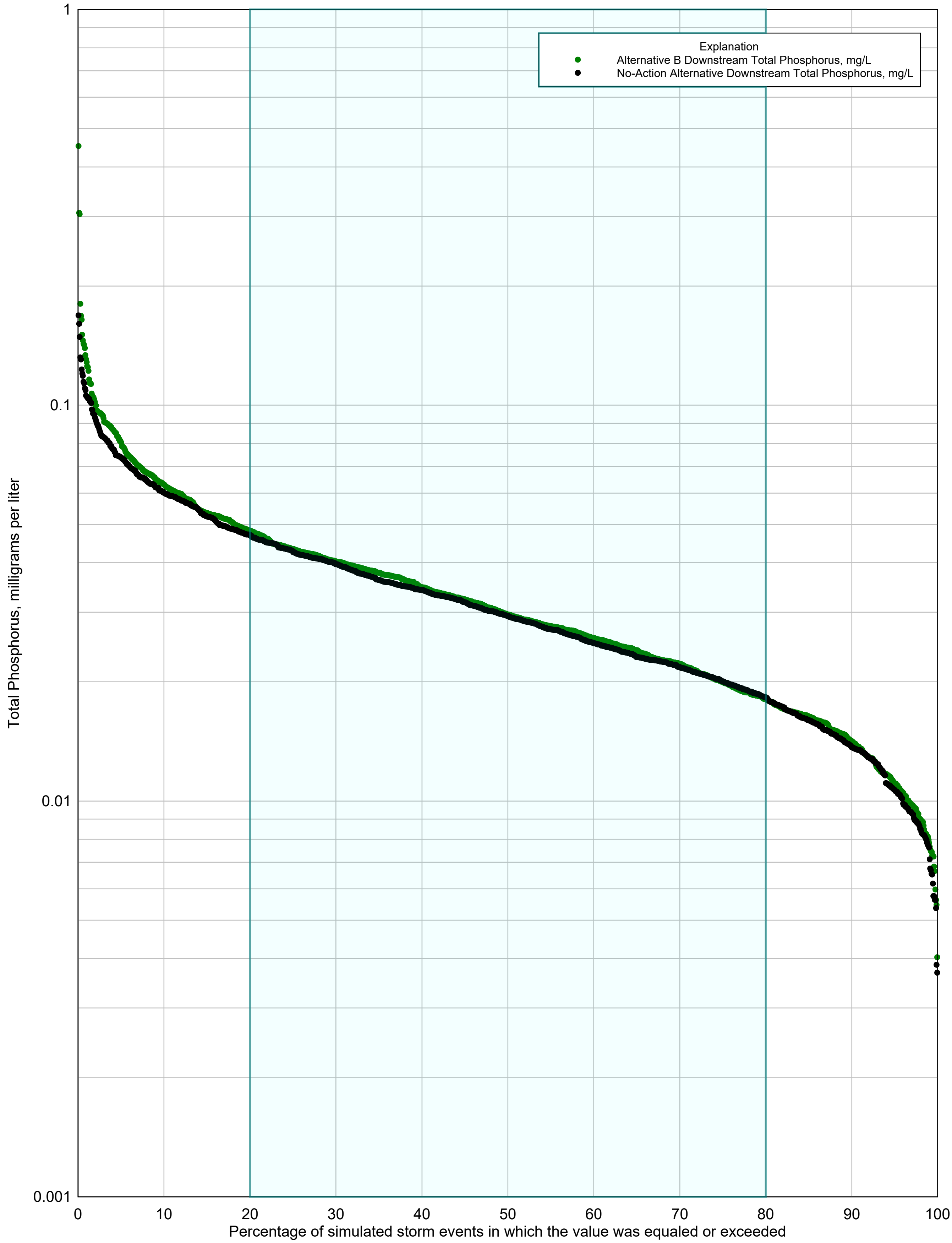


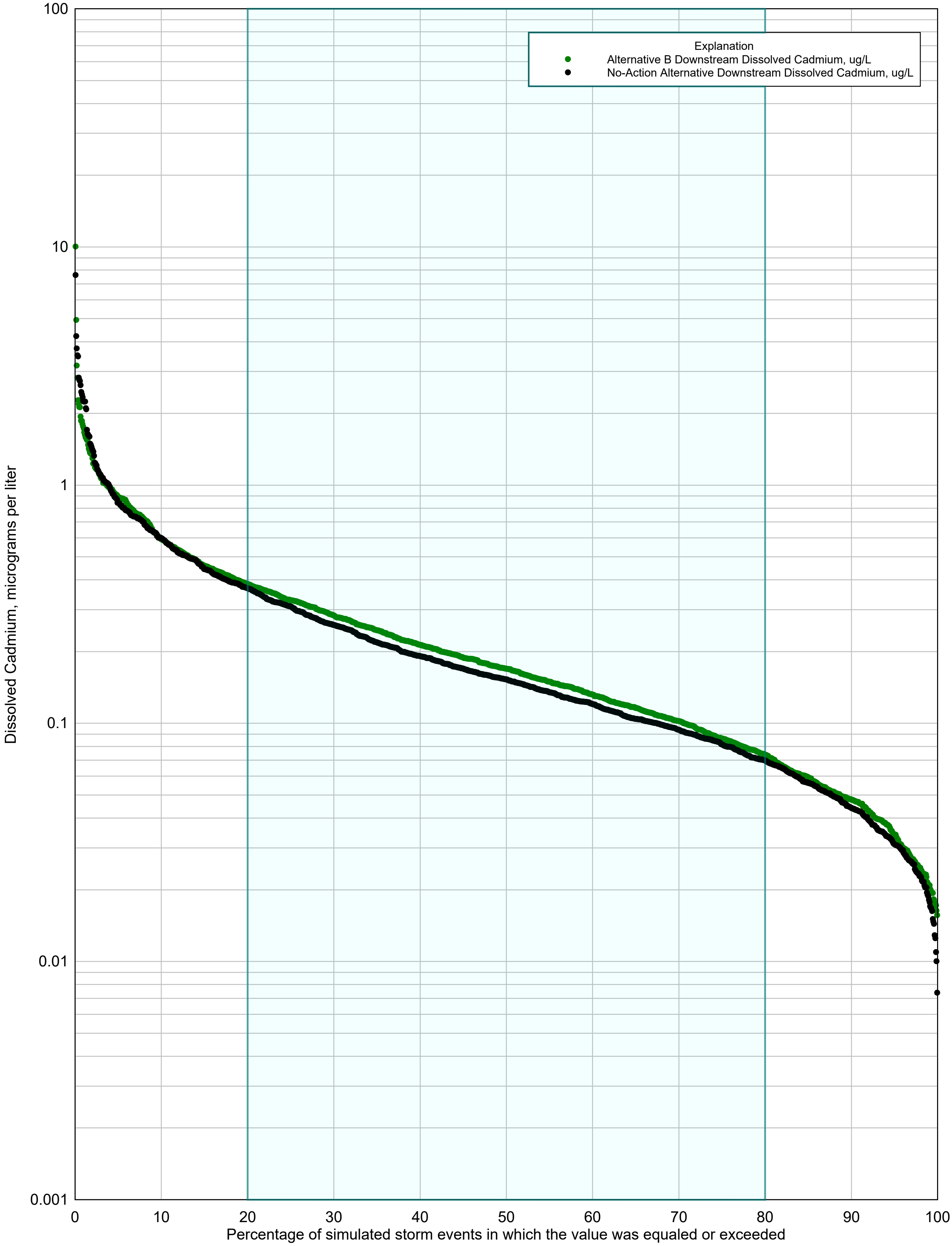
1,000
100
10
Total Dissolved Solids (TDS), milligrams per liter
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded
Explanation
Alternative B Downstream TDS, mg/L
No-Action Alternative Downstream TDS, mg/L


Explanation
Alternative B Downstream TSS, mg/L
No-Action Alternative Downstream TSS, mg/L
1,000
100
10
1
0.1
0
10
20
30
40
50
60
70
80
90
100
Total Suspended Solids (TSS), milligrams per liter
Percentage of simulated storm events in which the value was equaled or exceeded

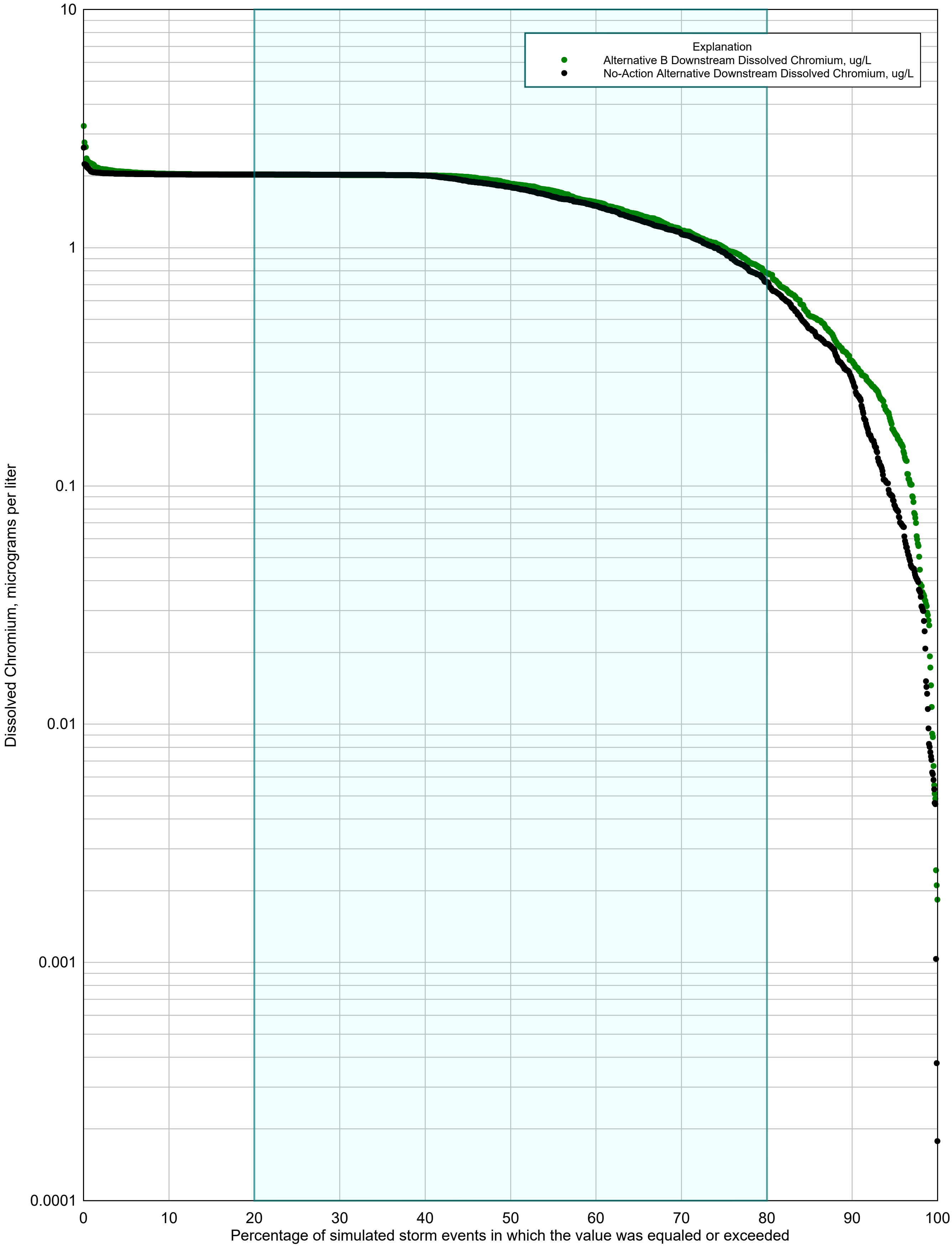


Explanation
Alternative B Downstream Dissolved Nitrogen, mg/L
No-Action Alternative Downstream Dissolved Nitrogen, mg/L
10
1
0.1
Dissolved Nitrogen, milligrams per liter
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded

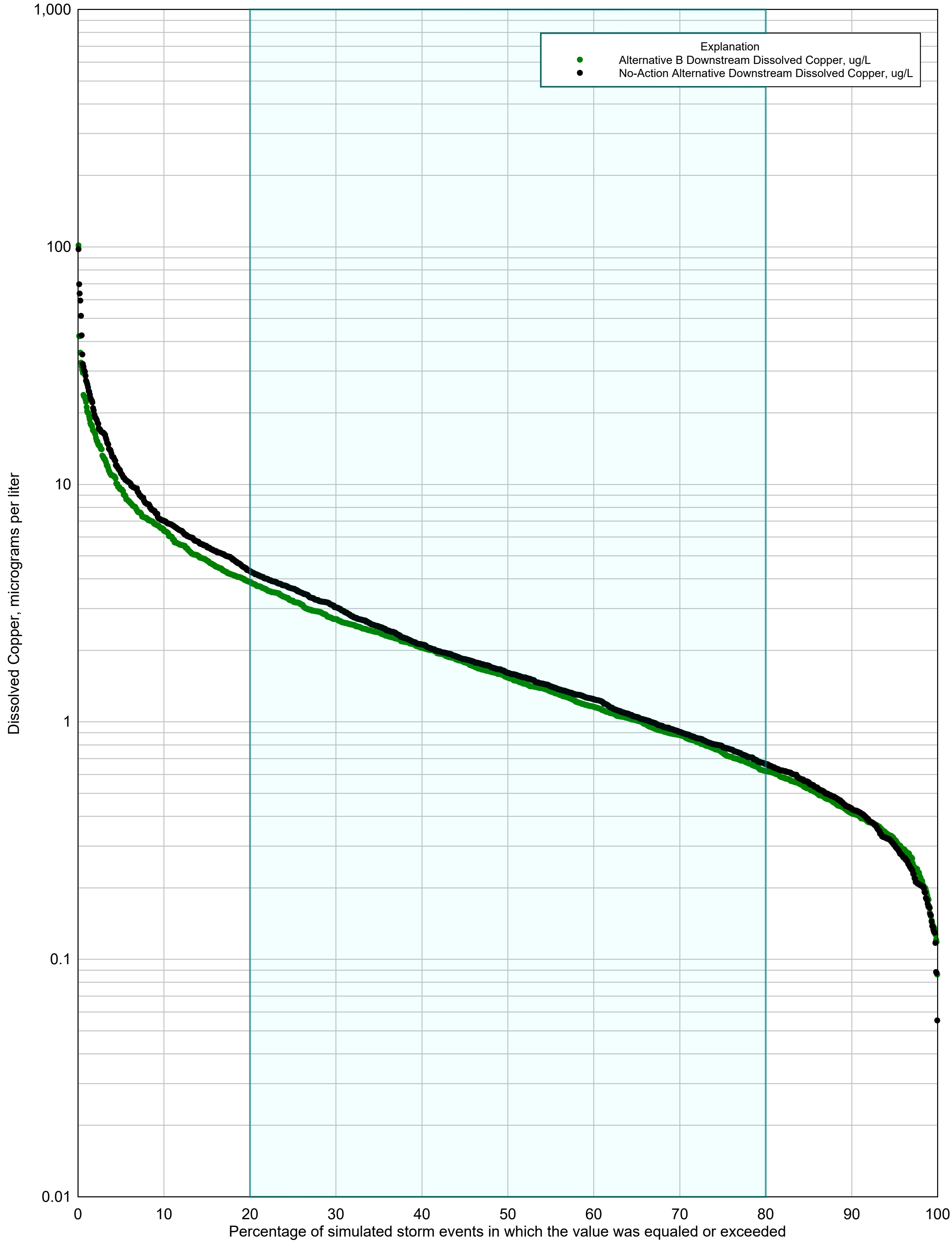

Explanation
Alternative B Downstream Total Phosphorus, mg/L
No-Action Alternative Downstream Total Phosphorus, mg/L
Total Phosphorus, milligrams per liter
1
0.1
0.01
0.001
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded

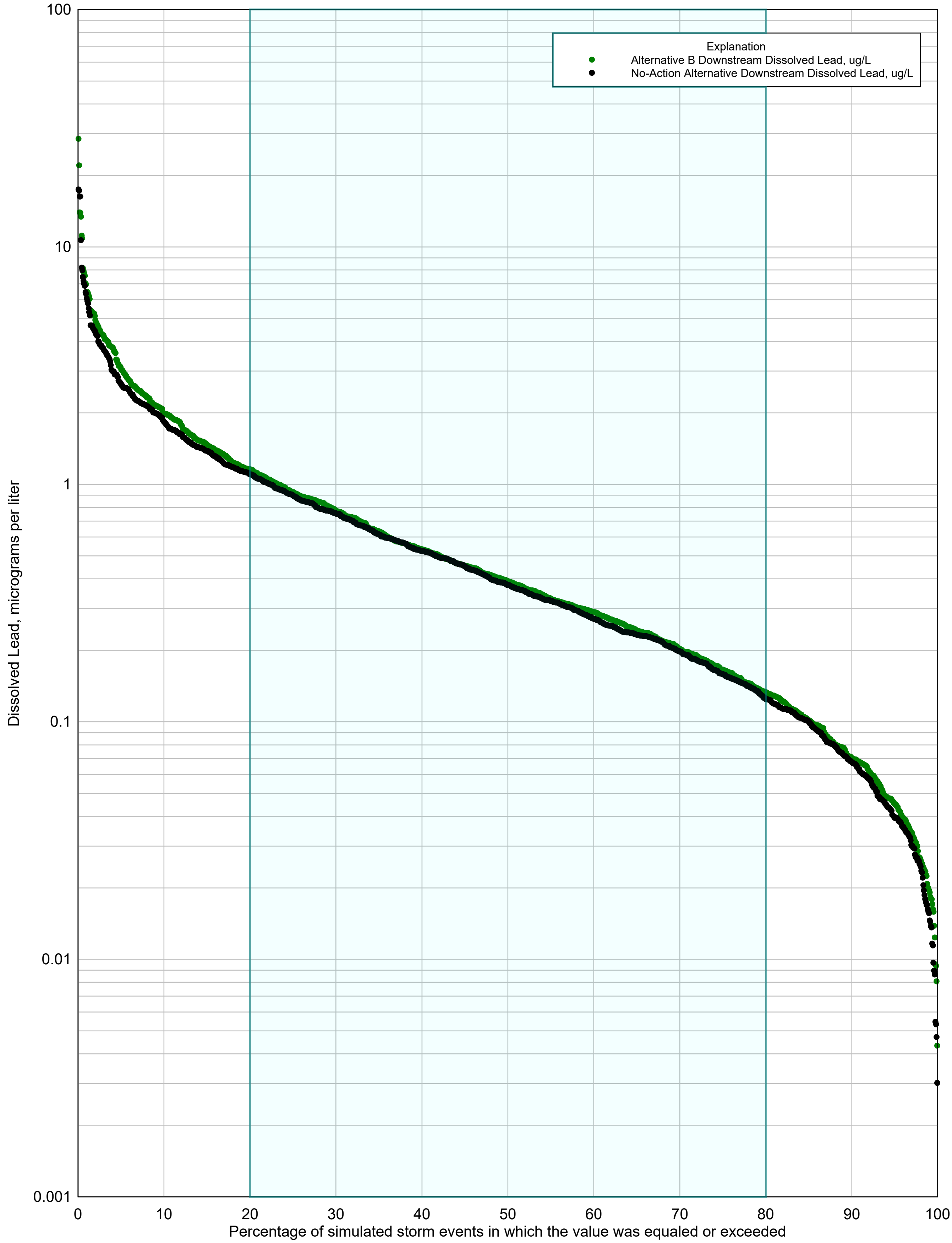


Explanation
Alternative B Downstream Dissolved Cadmium, ug/L
No-Action Alternative Downstream Dissolved Cadmium, ug/L
100
10
1
0.1
0.01
0.001
Dissolved Cadmium, micrograms per liter
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded

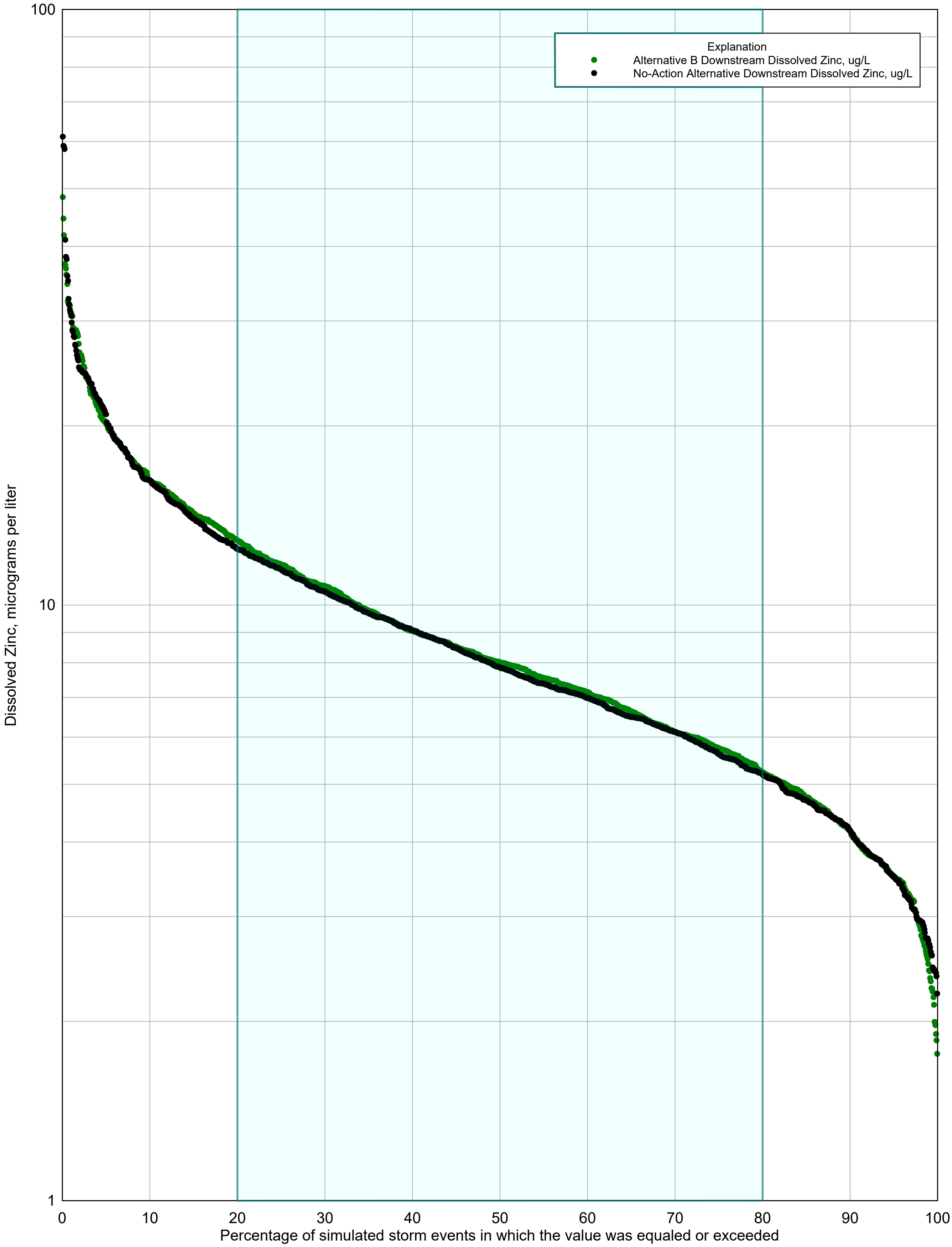


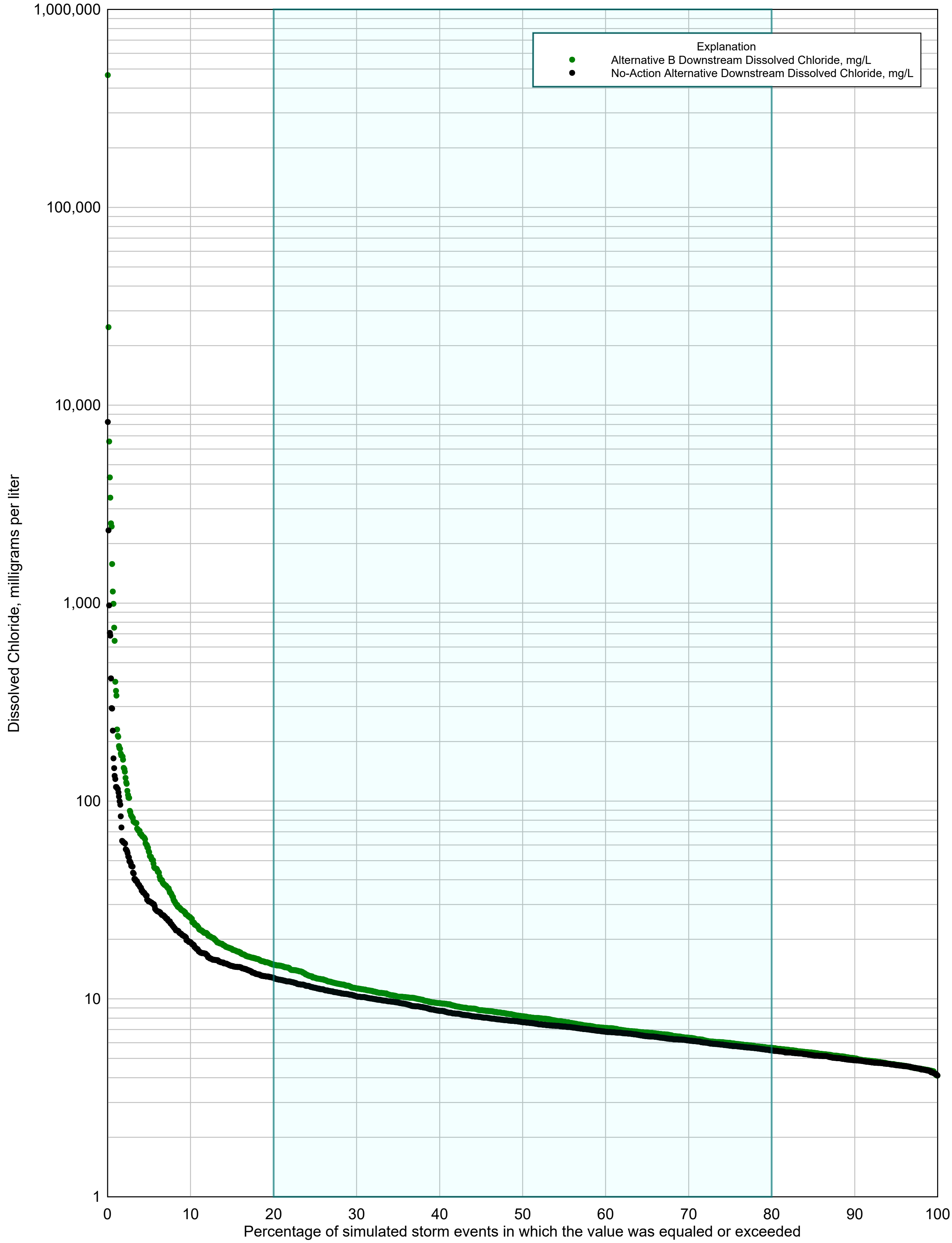
Explanation
Alternative B Downstream Dissolved Chromium, ug/L
No-Action Alternative Downstream Dissolved Chromium, ug/L
Dissolved Chromium, micrograms per liter
10
1
0.1
0.01
0.001
0.0001
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded


Explanation
Alternative B Downstream Dissolved Copper, ug/L
No-Action Alternative Downstream Dissolved Copper, ug/L
Dissolved Copper, micrograms per liter
1,000
100
10
1
0.1
0.01
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded

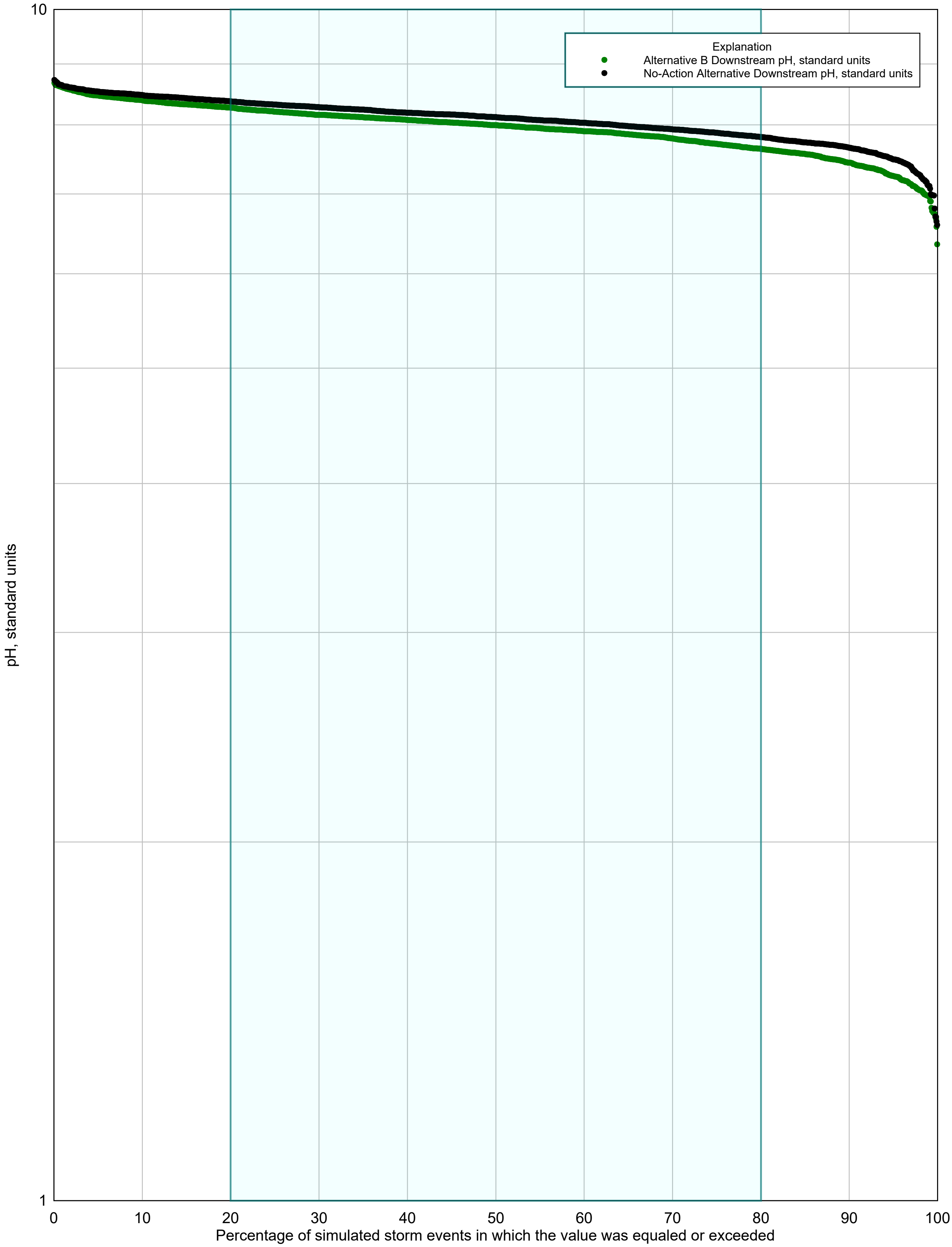


Explanation
Alternative B Downstream Dissolved Lead, ug/L
No-Action Alternative Downstream Dissolved Lead, ug/L
100
10
1
0.1
0.01
0.001
Dissolved Lead, micrograms per liter
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded


Explanation
Alternative B Downstream Dissolved Zinc, ug/L
No-Action Alternative Downstream Dissolved Zinc, ug/L
100
10
1
Dissolved Zinc, micrograms per liter
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded



Explanation
Alternative B Downstream Dissolved Chloride, mg/L
No-Action Alternative Downstream Dissolved Chloride, mg/L
1,000,000
100,000
10,000
1,000
100
10
1
Dissolved Chloride, milligrams per liter
0
10
20
30
40
50
60
70
80
90
100
Percentage of simulated storm events in which the value was equaled or exceeded


10
1
0
10
20
30
40
50
60
70
80
90
100
Explanation
Alternative B Downstream pH, standard units
No-Action Alternative Downstream pH, standard units
pH, standard units
Percentage of simulated storm events in which the value was equaled or exceeded

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