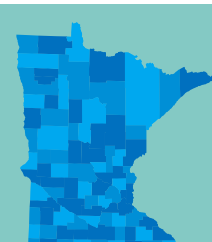
Site-specific standard

June 2019

Technical justification for Minnesota River site-specific selenium standard

MINNESOTA POLLUTION CONTROL AGENCY



Author

Laura Lyle

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520 Lafayette Road North | Saint Paul, MN 55155-4194 |

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Executive summary

As part of Minnesota rule, site-specific standards (SSS) can be developed when available information demonstrates that a site-specific modification to statewide or ecoregion standards is appropriate (Minn. R. 7050.0220 subp. 7). This document describes the process for establishing SSS and proposes site-specific modifications to the selenium standard for a section of the Minnesota River (AUID 07020012-505), downstream of the Seneca wastewater treatment plant (WWTP), to the confluence with the Mississippi River. The standard also addresses Long Meadow Lake (27-0002-00) and Gun Club Lake (19-0078-00), which are floodplain lakes associated with the Minnesota River. In June 2018, Gopher Resource, LLC (Gopher) submitted an application for a selenium SSS downstream of the Seneca WWTP. This application (Wenck 2018) included data collected by Gopher, and proposed a new standard for the site. The SSS proposed in this document was developed using data collected by Gopher, but Minnesota Pollution Control Agency (MPCA) modified the standard submitted in Gopher's application to better ensure protection of the aquatic life designated use. This justification document will frequently refer to the SSS application submitted by Gopher, or contain information that comes straight from the application, where appropriate. This document provides the reasoning for the development of the SSS, but for simplicity, the raw data and additional details can be found in the applications for a SSS (Wenck 2016 and Wenck 2018).

Site-specific standard summary

State: Minnesota
Basin: Minnesota River
Major watershed name: Lower Minnesota
USGS cataloging unit: 07020012
Counties: Dakota and Hennepin
Cities: Eagan, Bloomington, Mendota Heights

Waters:

1. Minnesota River Reach (AUID 07020012-505) starting at the Seneca WWTP effluent outfall to the lower Minnesota River and ending at the Mississippi River confluence
2. Long Meadow Lake (27-0002-00)
3. Gun Club Lake (19-0078-00)

Beneficial use classifications:

1. Minnesota River, (River Mile 22 to mouth): 2Bg, 3C, 4A, 4B, 5 and 6.
   Minn. R. 7050.0470 subp.5 (A)
2. Long Meadow Lake (27-0002-00): 2B, 3C, 4A, 4B, 5, and 6
   Minn. R. 7050.0430 Unlisted Waters
3. Gun Club Lake (19-0078-00): 2B, 3C, 4A, 4B, 5, and 6
   Minn. R. 7050.0430 Unlisted Waters
4. These are not Special Waters, per Minn. R. 7050.0470, Minn. R. 6262.0050, and the January 2004 MPCA Special Waters List.
5. These are not outstanding resource value waters, per Minn. R. 7050.0180.
6. These are not Minnesota DNR Trout Lakes or Trout Streams.
7. "Fishless waters" designation is not applicable.

Parameter: Selenium, total

Existing water quality standard:
Per Minn. R. 7050.0222 subp.4; the chronic standard for total selenium is not to exceed 5 micrograms per liter (µg/L) once every three years as a four-day average and the maximum standard (acute value) of not to exceed 20 µg/L once every three years as a one-day average. The final acute value is 40 µg/L.

Proposed site-specific standard:
The selenium fish tissue values are taken directly from the 2016 United States Environmental Protection Agency (EPA) selenium criterion document (EPA 2016a), and are given as milligrams per kilogram of dry weight (mg/kg dw). The water column criterion was developed using site-specific data, and is a water concentration calculated to protect the tissue standards. The calculation of the water column criterion follows methods outlined in the 2016 EPA selenium criterion document. The proposed SSS is presented in the table below.

Media Type	**Fish Tissue**[1]		**Water Column**[4]
Criterion Element	*Egg/Ovary*[2]	*Fish Whole Body or Muscle*[3]	*Monthly Average Exposure*
Magnitude	15.1 mg/kg dw	8.5 mg/kg dw whole body or 11.3 mg/kg dw muscle (skinless, boneless filet)	11 µg/L in river main channel 5.7 µg/L in oxbows and floodplain lakes
Duration	Instantaneous measurement[5]	Instantaneous measurement[5]	30 days[6]
Frequency	Not to be exceeded	Not to be exceeded	Not more than once in three years on average

1. Fish tissue elements are expressed as steady state.
2. Egg/ovary supersedes any whole-body, muscle, or water column element when fish egg/ovary concentrations are measured.
3. Fish whole-body or muscle tissue supersedes water column element when both fish tissue and water concentrations are measured.
4. Water column values are based on total selenium in water and are derived from fish tissue values via bioaccumulation modeling. Water column values are the applicable criterion element in the absence of steady-state condition fish tissue data.
5. Fish tissue data provide instantaneous point measurements that reflect integrative accumulation of selenium over time and space in fish population(s) at a given site.
6. The bioaccumulation of selenium into fish tissue occurs over a longer time period than with typical acute or chronic toxic effects to aquatic life. Therefore, a longer duration for the averaging period is appropriate for the selenium SSS. Additionally, because of this longer averaging period, the minimum stream flow (see *Minn. R.* 7053.0205, subp. 7) for which wastes must be controlled to meet the SSS will be the $30Q_3$ flow.

Description of the Minnesota River site

The Minnesota River is a seventh order river that flows 320 miles east across southern Minnesota until it discharges into the Mississippi River. The upper 80 miles of the river are periodically dammed and the lower 240 miles are free flowing through a highly developed (agriculture and residential) watershed. The Seneca WWTP discharges to the lower Minnesota River at approximately River Mile 5.9. The extent of the site-specific standard is the approximately six-mile reach that runs from the Seneca WWTP effluent outfall on the lower Minnesota River (AUID 07020012-505) to the confluence with the Mississippi River (AUID 07010206-505). The standard also applies to the two connected floodplain lakes (Long Meadow Lake and Gun Club Lake) and associated oxbow habitats since these lentic systems are connected to the Minnesota River at high flows when the floodplain is engaged (Figure 1). The site consists of open water, oxbow habitats, wetland habitats, and the Seneca WWTP outfall, all of which are surrounded by urban development. The beneficial uses of this reach include aquatic life and recreation (2Bg; aquatic biota and their habitats, aquatic recreation of all kinds, not protected for drinking water), industrial consumption (3C), and agricultural and wildlife (4A and 4B), as designated by the state of Minnesota. Additionally, all waters in the state of Minnesota have a beneficial use class of 5 (Aesthetic Enjoyment and Navigation) and 6 (Other Uses). Long Meadow Lake (27-0002-00) and Gun Club Lake (19-0078-00) are class 2B waters. Since they are unlisted waters, they also are protected for classes 3C, 4A, 4B, 5 and 6.

While the Seneca WWTP is a source of selenium to the lower Minnesota River, selenium is also present in the river upstream of the discharge. Soils in southwest Minnesota have naturally elevated selenium concentrations (USGS 2014), and because of this, periods of runoff of soil can cause increases in selenium loading to the river. Figure 2 shows that selenium concentration in the river upstream of the WWTP discharge is generally higher when flows are higher. Therefore, it is likely that the upstream source of selenium is from runoff from the surrounding land. The WWTP discharge is more likely to influence Minnesota River concentrations at lower flow conditions, when there is less contribution from upstream, and the discharge makes up a larger proportion of the Minnesota River flow.

The amount of flow from upstream also plays an important role in the introduction of selenium to the oxbow and floodplain lake habitats at the site. At lower flows, the Minnesota River is not connected to the oxbows or floodplain lakes. An analysis was completed to determine the flow rates necessary to connect the oxbows and floodplain lakes (Wenck 2016 and Wenck 2018). For the oxbows, the minimum flow rate for connectivity is approximately 6,270 cubic feet per second (cfs). For Long Meadow Lake and Gun Club Lake, they are connected to the Minnesota River at approximately 25,800 and 33,200 cfs, respectively. The flows to connect the lakes have recurrence intervals of 18% and 22% respectively, representing about a 1 in 5 chance the lakes will interact with Minnesota River water. This is consistent with data from 12 years where the Minnesota River flowed into the lakes in only 7 of the 12 years, and in 3 years, the interaction was less than 10 days. In extremely wet years such as 2010 and 2011, the lakes can have long interaction periods ranging from 42 to 77 days (Wenck 2016). Due to the high flows necessary to connect the Minnesota River and the oxbows and floodplain lakes, the impact of the WWTP on these habitats would be minimal, as the flow from the WWTP (52.6 cfs – average dry weather discharge) would make up less than 1% of the total flow in the Minnesota River.

Figure 1. Map of the Minnesota River site.

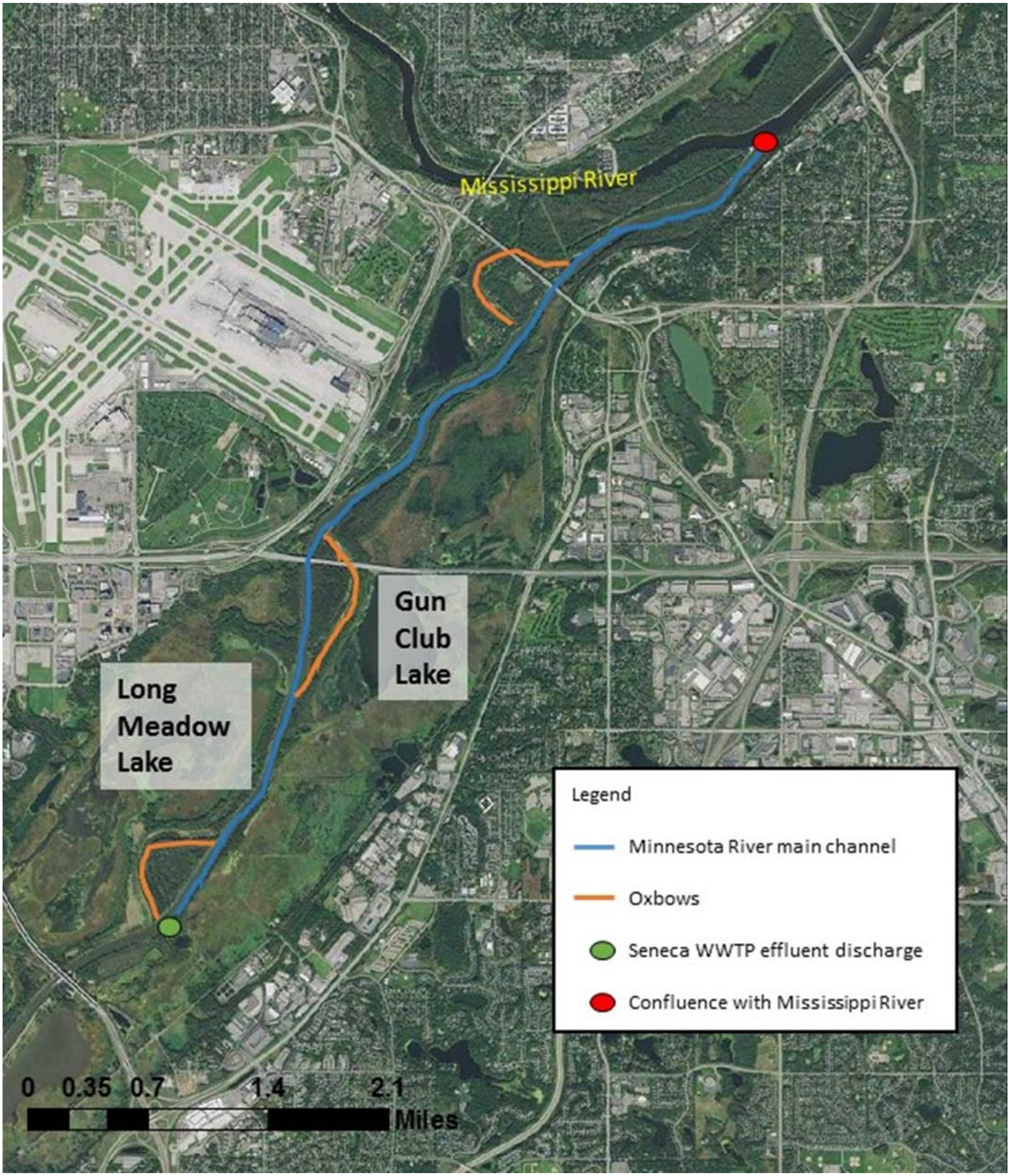
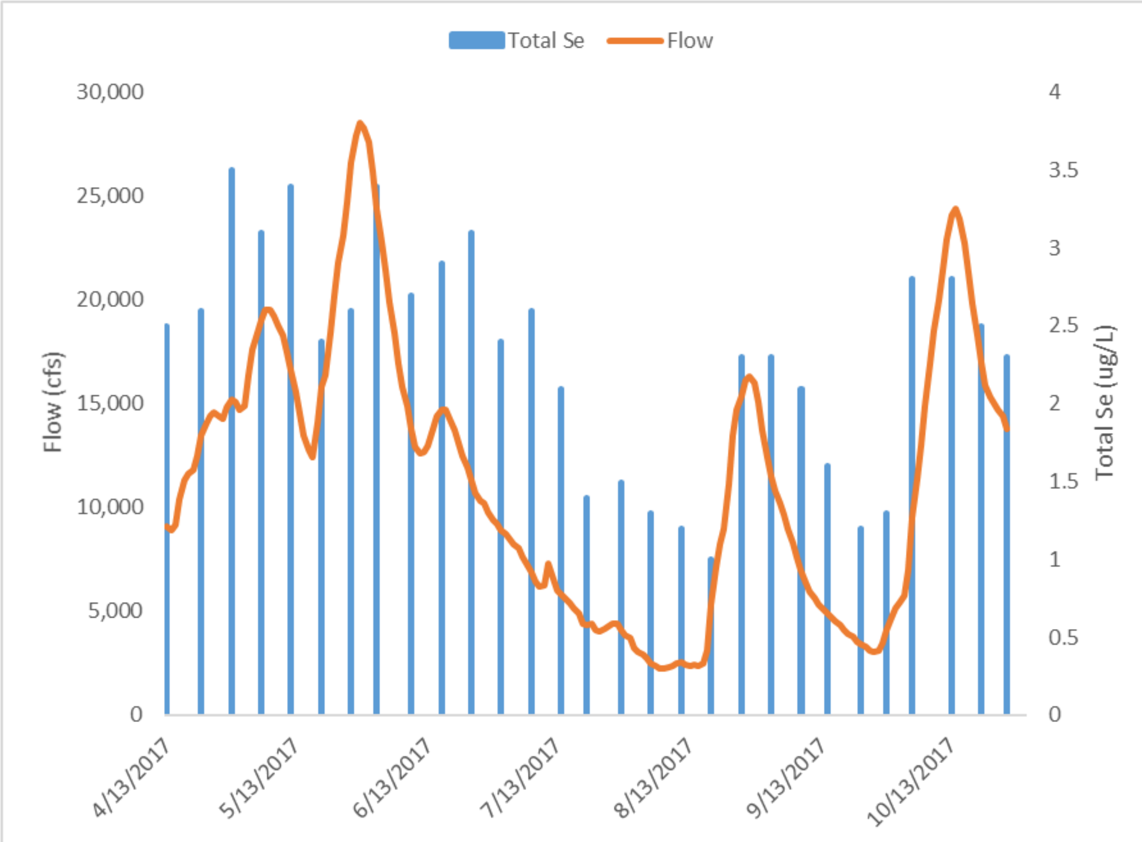


Figure 2. Minnesota River flow rate and selenium concentrations upstream of the WWTP.



Applicable standards

Class 2B selenium standard

The current statewide standard for selenium for Class 2B waters is found in Minn. R. 7050.0222, subp. 4. The acute and chronic standards for selenium are based on the values in the EPA's criteria document from 1987 (EPA 1987), and were adopted by the state of Minnesota in 1990. The chronic standard for total selenium is not to exceed 5 µg/L once every three years as a four-day average and the maximum standard (acute value) is not to exceed 20 µg/L once every three years as a one-day average. The final acute value is 40 µg/L, never to be exceeded as a one-day average at the point of discharge.

Site-specific standards

The following rule governs MPCA's adoption of site-specific standards:

Minn. R. 7050.0220, subp. 7, Items A, B and C:

Subp. 7. ***Site-specific modifications of standards.***

A. The standards in this part and in parts 7050.0221 to 7050.0227 are subject to review and modification as applied to a specific surface water body, reach, or segment. If site-specific information is available that shows that a site-specific modification is more appropriate than *the statewide or ecoregion standard for a particular water body, reach, or segment, the site-specific information shall be applied.*

B. *The information supporting a site-specific modification can be provided by the commissioner or by any person outside the agency. The commissioner shall evaluate all relevant data in support of a modified standard and determine whether a change in the standard for a specific water body or reach is justified.*

C. *Any effluent limit determined to be necessary based on a modified standard shall only be required after the discharger has been given notice of the specific proposed effluent limits and an opportunity to request a hearing as provided in part 7000.1800.*

Criteria for determining whether to develop a site-specific water quality standard

The state of Minnesota promulgated selenium water quality standards for Class 2 waters in 1990 (Minn. R. 7050.0222). Since that time, much has been learned about the toxic effects of selenium and its bioaccumulative potential. The toxic effects of selenium are tied to the amount of selenium in the diet of the organism, rather than the aqueous concentration, and the concentration of selenium that builds up in tissue has been the basis for the updated selenium criterion, which was published by the EPA in 2016.

Minnesota's current selenium standard is based on outdated science, and ultimately will need updating. MPCA has evaluated its priorities through the Triennial Standards Review process and found that other projects were of higher priority than updating the statewide selenium standard at this time. There are limited selenium dischargers in the state, so addressing the updated science on a site-specific basis is a simpler way to ensure the designated use is met. Additionally, even with an updated statewide standard, selenium dynamics are site-specific, and a standard that considers and is protective of the unique characteristics of the site is appropriate. Therefore, because the current standard is based on outdated science, and site-specific factors influence selenium accumulation, consideration of a site-specific standard is reasonable for this site.

Background information

2016 EPA criterion document

The EPA spent several years evaluating the effects of selenium to aquatic organisms, and published an updated Clean Water Act, Section 304(a) water quality criterion for selenium in 2016 (EPA 2016a). The new science and criterion acknowledges that the most harmful effect of selenium on aquatic organisms is due to its bioaccumulative properties. The criterion document outlines how accumulation of selenium occurs primarily through the diet of aquatic organisms, rather than through exposure to selenium in the water. Selenium that is accumulated in the organism can be transferred to the eggs, causing reproductive effects. This effect to reproduction, especially in fish, is the most sensitive endpoint for selenium toxicity, and is the basis of the 2016 criterion (Table 1). These longer-term effects are observed at lower concentrations than acute (short-term) effects.

Because the reproductive effects observed in fish are based on dietary selenium exposure, and ultimately based on toxicity studies evaluating the amount of selenium in fish eggs or ovaries linked to reproductive effects, the first element of the criterion is the egg/ovary tissue concentration. Egg or ovary tissue is not always available for analysis, so the criterion also included an additional tissue element – fish whole body or muscle tissue values. The tissue elements of the standard are based on toxicity testing of a variety of fish species, including species found in the Minnesota River. The observed effects of selenium on these species are dependent upon the concentration of selenium in the tissue.

In addition to the fish tissue elements, the EPA derived protective water column values from the tissue concentrations as additional elements of the criterion, when fish tissue may not be available to assess whether the criterion is being met (Table 1). These values can also be used to determine whether a facility has the reasonable potential to exceed a state standard and to develop a water quality based effluent limit (WQBEL), if necessary. The water column elements are a translation of the protective fish tissue concentrations into a water column value that should prevent an exceedance of the tissue concentrations. There are monthly average exposure criterion elements for lotic and lentic habitats, and also an intermittent exposure equation. The intermittent exposure equation allows for the calculation of a protective selenium concentration for when selenium is not discharged continuously. For this site-specific standard, this is not a necessary element to include because selenium is continuously discharged from Gopher Resource, LLC (Gopher), the facility requesting the SSS, and Seneca WWTP. There are also selenium inputs from upstream on the Minnesota River. Therefore, the aquatic community is continually exposed to selenium, and the monthly average exposure value is the most appropriate value to protect against adverse effects.

Of all of the criterion elements, the egg/ovary element supersedes any other element, when measured egg/ovary data are available. Fish whole body or muscle elements supersede the water column element, when measured whole body or muscle data are available.

Table 1. Summary of EPA's 2016 recommended freshwater selenium ambient chronic water quality criterion.

Media Type	Fish Tissue[1]		Water Column[4]	
Criterion Element	*Egg/Ovary*[2]	*Fish Whole Body or Muscle*[3]	*Monthly Average Exposure*	*Intermittent Exposure*[5]
Magnitude	15.1 mg/kg dw	8.5 mg/kg dw whole body or 11.3 mg/kg dw muscle (skinless, boneless filet)	1.5 µg/L in lentic aquatic systems 3.1 µg/L in lotic aquatic systems	$WQC_{int} = \dfrac{WQC_{30\text{-}day} - C_{bkgrnd}(1 - f_{int})}{f_{int}}$
Duration	Instantaneous measurement[6]	Instantaneous measurement[6]	30 days	Number of days/month with an elevated concentration
Frequency	Not to be exceeded	Not to be exceeded	Not more than once in three years on average	Not more than once in three years on average

1. Fish tissue elements are expressed as steady state.
2. Egg/Ovary supersedes any whole-body, muscle, or water column element when fish egg/ovary concentrations are measured.
3. Fish whole-body or muscle tissue supersedes water column element when both fish tissue and water concentrations are measured.
4. Water column values are based on dissolved total selenium in water and are derived from fish tissue values via bioaccumulation modeling. Water column values are the applicable criterion element in the absence of steady-state condition fish tissue data.
5. Where WQC_{int} is the intermittent exposure element of the criterion; $WQC_{30\text{-}day}$ is the water column monthly element, for either a lentic or lotic water; C_{bkgrnd} is the average background selenium concentration, and f_{int} is the fraction of any 30-day period during which elevated selenium concentrations occur, with f_{int} assigned a value ≥0.033 (corresponding to 1 day).
6. Fish tissue data provide instantaneous point measurements that reflect integrative accumulation of selenium over time and space in fish population(s) at a given site.

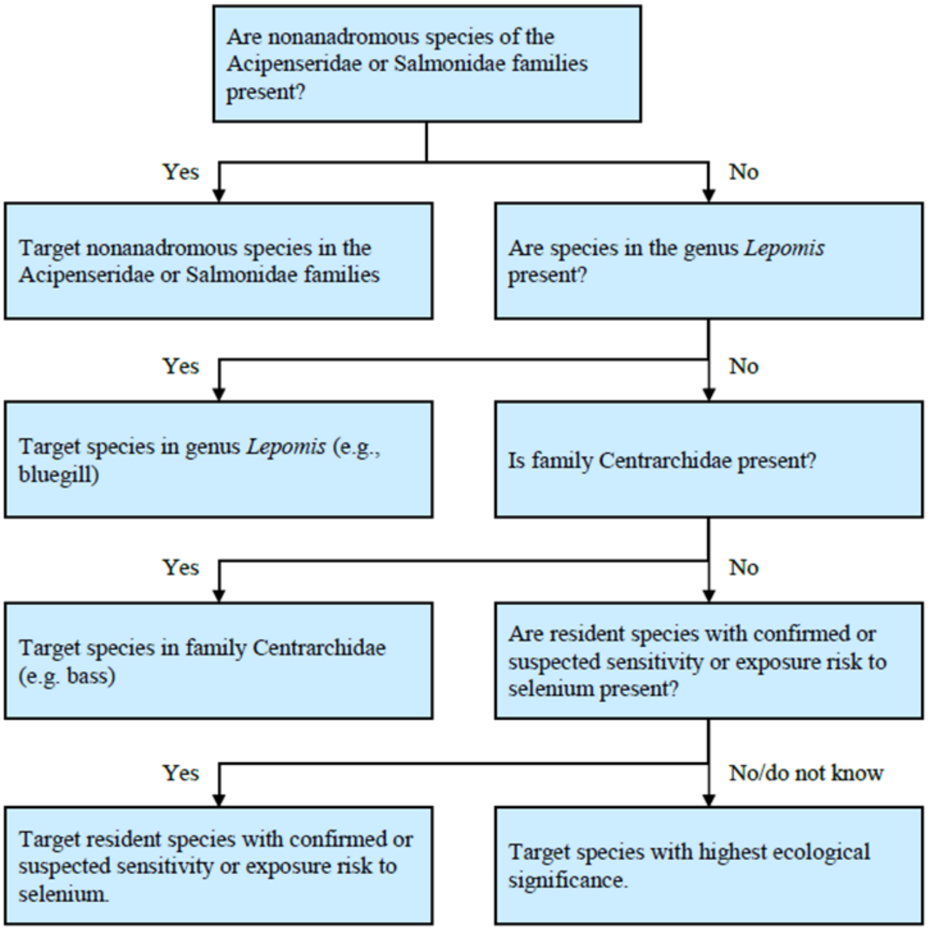
The research that has been conducted on selenium accumulation has also demonstrated that the accumulation of selenium in fish tissue is site-specific. The species of fish, the prey items the fish eat and proportion of prey types, the type of habitat (lotic, or flowing water, habitats have shorter residence times, and less accumulation than lentic, or still water, habitats), and biogeochemical factors all can affect the degree of selenium bioaccumulation. Within EPA's 2016 selenium criterion document, an appendix is dedicated to information regarding calculation of a site-specific water column concentration (Appendix K). The appendix considers two methods for determining a water column concentration, with the bioaccumulation factor (BAF) approach used for this site-specific standard. The BAF is a descriptor of how much selenium is entering into fish tissue, as compared to the concentration of selenium in the water column. The BAF method establishes this relationship by directly measuring selenium concentrations in both fish tissue and water. The BAF is then calculated as the ratio between the two concentrations. The BAF serves as a translator to convert the protective fish tissue standard into a protective water column value for the site that incorporates the degree of selenium bioaccumulation that is occurring at that location. The development of the water column aspect of the SSS is based on the BAF guidance provided in Appendix K of the 2016 criteria document published by the EPA (EPA 2016a).

The fish tissue elements of the standards are not influenced by the unique aspects of the individual site, but are the concentrations that should be protective of most species. The water column element is the site-specific element of the standard, as it evaluates the degree of accumulation at individual sites via, for instance, the BAF. The BAF translates the protective tissue concentrations to a water column concentration that should prevent exceedance of those tissue concentrations. Therefore, the fish tissue criterion elements were taken directly from EPA's 2016 criterion document, and included in the site-specific standard for the Minnesota River site, to ensure protection from reproductive effects. The water column element of the criterion provides the water concentration to protect for those tissue concentrations. The rest of this document will discuss the development of the protective water column value. The tissue standards take precedence in determining compliance with the standards, but a water column protective value was still calculated for this SSS to use in determination of reasonable potential, as well as a WQBEL, if necessary.

Choice of target fish species

To derive the site-specific water column value, data collected from fish tissue at the site is necessary when calculating the value using the BAF. The EPA has recommendations on which species to target for collection when developing the BAF. Several fish species were collected in 2015, but bluegill were ultimately chosen as the target species, reflecting Appendix K (development of site-specific criterion) of EPA's 2016 criterion document (EPA 2016a). The flow chart that is presented in Appendix K for choosing a target species is provided in Figure 3. The first box concerns the presence of Acipenseridae or Salmonidae families. Fish surveys by the Minnesota Department of Natural Resources (MNDNR) have demonstrated that Salmonidae species are not found in this stretch of the Minnesota River (Wenck 2018). There is some evidence that Acipenseridae species may exist or travel through this stretch of river. However, Acipenseridae, which includes sturgeon species, are not commonly found in this reach, and it is not fully understood whether they live or only travel through the area (personal communication with MNDNR 2018). Additionally, lake sturgeon is on Minnesota's list of species of special concern. Because of their conservation status and the challenge of obtaining large quantities of sturgeon, it was a reasonable decision to exclude them from the target species list. Without using Salmonidae or Acipenseridae, the next group of target species is fish of the genus *Lepomis*. This genus includes bluegill, green sunfish and orange-spotted sunfish, all of which are found in this area of the Minnesota River. These species are found in large enough quantities to be able to derive a robust BAF. They are also found in both the main channel and oxbow areas, allowing for the opportunity to determine if fish accumulate selenium differently in these two habitats.

Figure 3. Flow chart for selection of target species (from EPA 2016a)



History of site-specific standard development

The dominant source of selenium loading to the Seneca WWTP is a lead-acid battery recycler named Gopher Resource, LLC (Gopher). Gopher is permitted by the Seneca WWTP as a significant industrial user. The Seneca WWTP performed a local limit analysis and found that little to no removal of selenium occurs at the Seneca WWTP and it should be considered a conservative parameter at the WWTP.

Gopher employs a ferrihydrite adsorption and iron co-precipitation treatment technology at the Eagan facility, which is the best available technology for selenium removal from water (identified by the EPA). In the early 2000's, Metropolitan Council Environmental Services (MCES) approached Gopher about selenium in their discharge. Gopher subsequently began a process review to identify sources of selenium and research/bench test selenium removal technologies. In 2013, the MPCA recommended that the Seneca WWTP (operated by MCES) receive permit effluent limits protective of the 5 µg/L Class 2B aquatic life and recreation selenium criterion. In order to comply with the proposed effluent limits, MCES developed a compliance schedule for reduction of Gopher's selenium discharge. By 2013, Gopher had completed reviews of approximately forty potential selenium treatment technologies that could be implemented and found three proprietary technologies to be evaluated further. However, on August 30, 2013, Gopher notified MCES that it would not be able to meet the compliance schedule requirements to submit design plans by December 31, 2013, because it had not been able to identify a viable treatment technology for removing selenium. From 2013 to 2015, Gopher implemented various process changes to reduce selenium loading and meet requirements put in place in a MCES Stipulation

Agreement (Feb. 2015). They also began daily monitoring and reporting of selenium concentrations to MCES.

The Stipulation Agreement provided a schedule by which Gopher was to undertake certain efforts to reduce selenium in its effluent. Gopher is pursuing the selenium reduction schedule, as well as pursuing an application for a site-specific selenium standard in the Minnesota River. Gopher applied for a site-specific selenium standard in December 2015 (Wenck 2015), based on data collected in 2015, consisting of selenium concentrations in fish tissue, surface water, sediment and suspended particulate matter. MPCA had some concerns about the suitability of the data to properly characterize the Minnesota River site.

Based on data provided by Gopher in 2015, there was some uncertainty as to whether the fish tissue data were representative of, and therefore protective for, fish residing in the Minnesota River during different seasons and in different habitat types. Data from fish collected in the spring of 2012 (preliminary sampling that was not used in the 2015 application) and in the spring of 2015 indicated that selenium tissue concentrations were significantly higher than selenium tissue concentrations collected in the fall of 2015. This left unanswered questions regarding why the tissue concentrations varied. Selenium reduction efforts at Gopher had been underway between 2012 and 2015, which could have led to reductions in fish tissue for the 2015 fish, compared to those collected in 2012. However, because the spring 2015 tissue concentrations were also elevated, compared to the fish collected in fall 2015, there was still uncertainty about what was causing the variability. In addition to the seasonal difference, the fish collected in the spring were collected from the oxbow habitat. The question remained as to whether season or habitat, or both, were influencing selenium accumulation. Therefore, MPCA urged Gopher to conduct additional sampling to try to determine if seasonal or habitat differences exist for selenium concentrations in fish tissue at the Minnesota River site.

Based on those conversations, Gopher undertook additional sampling in both the main channel and the oxbows in 2017. Gopher attempted to sample the same number of fish in the different habitats and seasons, in contrast to previous sampling where very few fish were collected in the spring and oxbow, as compared to the fall and main channel, to help answer some of the questions raised in the original dataset. Guidance that was available from the EPA was used to make decisions on sampling (EPA 2000, EPA 2016a). The sampling that occurred in 2017 formed the dataset that is the basis of the site-specific water column standard.

The data that were collected in previous years were not used to develop the SSS, but were used in initial phases of development of the standard to better understand trends and variability. The 2017 dataset is representative of the spring and fall seasons, as well as the main channel and oxbow habitats. The previous years' data did not evaluate both habitats or seasons equally, and therefore, those data are not as representative as the 2017 data. Additionally, water temperatures were monitored in the spring of 2017 to ensure the temperatures did not reach those that induce spawning in bluegill, to ensure spring samples were taken prior to spawning (selenium is released in the eggs and collection after spawning under-represents the selenium load in the fish that could impact reproduction). Additionally, fall samples in 2017 were taken later in the year, to allow bluegill time to replenish after spawning. Bluegill can spawn into August (MNDNR 2018), so allowing the fish time to replenish would result in the most representative samples of replenished concentrations. In previous years, it is not clear that the spring samples were collected prior to spawning or that fall samples were collected after the fish had time to replenish. This could skew the data, if selenium concentrations were lower in the spring due to the release of selenium in the eggs or if selenium concentrations in the fall were lower because fish had recently finished spawning and had not replenished for the winter. Therefore, the 2017 dataset was viewed as the most reliable to develop the SSS for the site.

Selenium concentrations in water and tissue at site

The following section is a high-level summary that describes the data, sampling locations, data collection methods, etc., used in the development of the SSS. For a more detailed description of the data and collection methods, refer to Wenck 2018. Sampling occurred in numerous years, but only the water and tissue data collected in 2017 were used to develop the SSS.

Sampling sites and methods

Over three years (2015-2017), Gopher collected surface water samples from several locations on the Minnesota and Mississippi River. These data were collected at locations upstream of the Seneca WWTP, downstream of the Seneca WWTP, at the Seneca WWTP outfall, within Minnesota River oxbow habitats, and in the Mississippi River. The floodplain lakes at the site are less often inundated by the Minnesota River, and not as easily accessed, so the oxbows were sampled to represent lentic (slow moving or still water) habitats. The focus of this document will be on the 2017 data, which were collected from a Minnesota River site upstream of the Seneca WWTP, downstream of the WWTP, and from two oxbow sites that are downstream of the WWTP (Figure 4). In 2017, each site was sampled on a weekly basis, using a Van Dorn sampler to collect the water sample at a depth of 2-3 feet below the surface. Temperature, conductivity, pH, oxidation reduction potential and dissolved oxygen were also measured at the time of water sample collection. From the water sample, both dissolved and total selenium were measured. The standard operating procedures from 2017 are located in the application for the SSS (Wenck 2018), and contain additional details about the sampling methods and laboratory analysis of selenium.

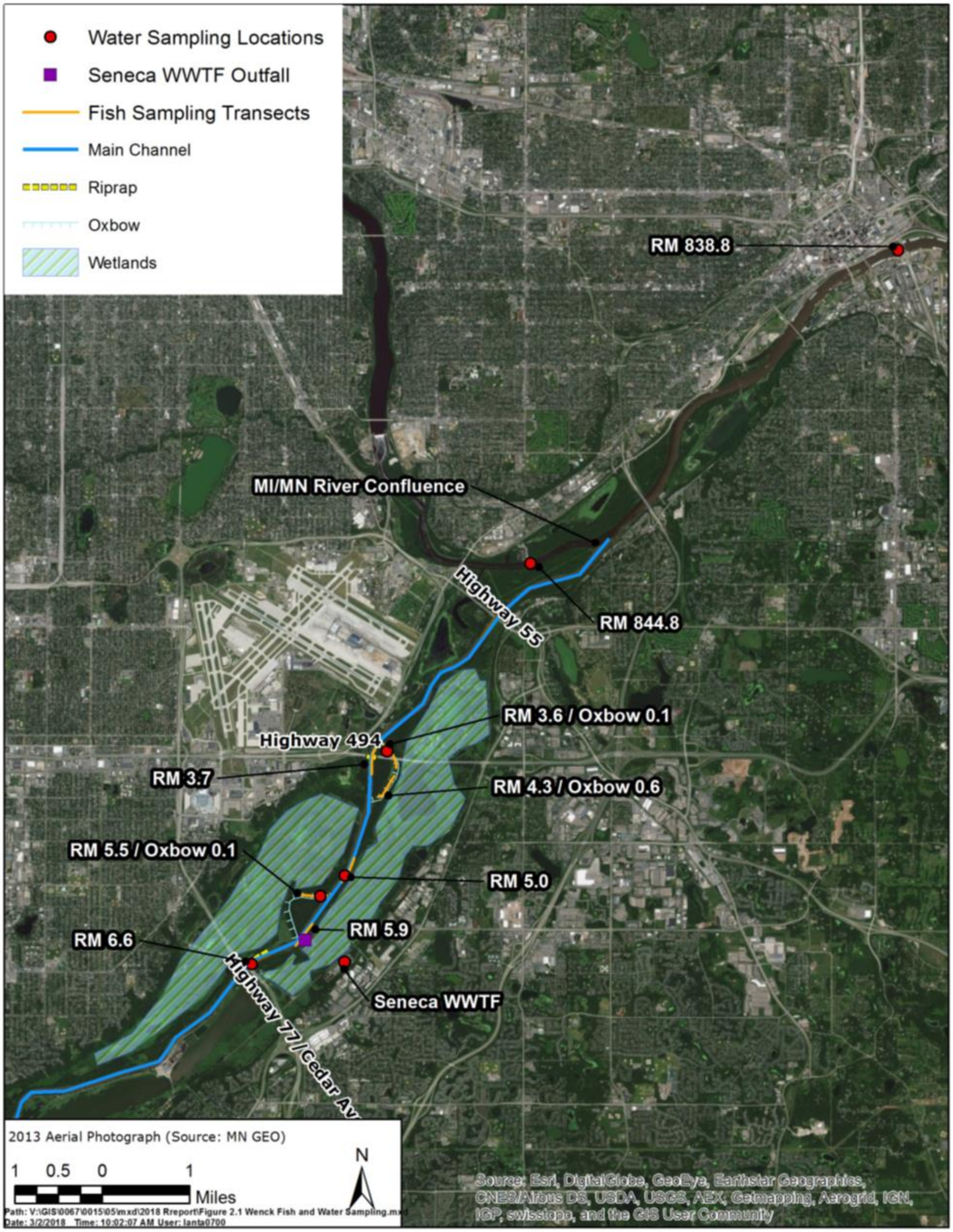
Fish tissue samples were collected from the study reach in 2012, 2015, 2016 and 2017. Sampling in 2017 was developed to target fish from the main channel and oxbow habitats, and to characterize any seasonal differences. Sampling intervals were completed that targeted the pre-spawn period in the spring, as well as the post-spawn, replenishing period of the fish reproductive cycle. An attempt was made to collect equal sample sizes in the different seasons and habitats, and the number of fish tissue samples collected are presented in Table 2. Locations of the sampling sites are presented in Figure 4. Fish were collected by boat electrofishing, seining, and/or using traps. The standard operating procedures from 2017 are located in the application for the SSS (Wenck 2018), and contain additional details about sampling methods and the laboratory analysis of selenium.

Table 2. Number of fish whole body tissue samples collected at two habitat types, during two seasons

Season	Main Channel	Oxbow
Spring	15	9[a]
Fall	15	15

[a] The desired number of fish (15) were unable to be obtained in the oxbow during spring sampling.

Figure 4. Location of water and tissue sampling stations in Minnesota River and surrounding waters (from Wenck 2018).

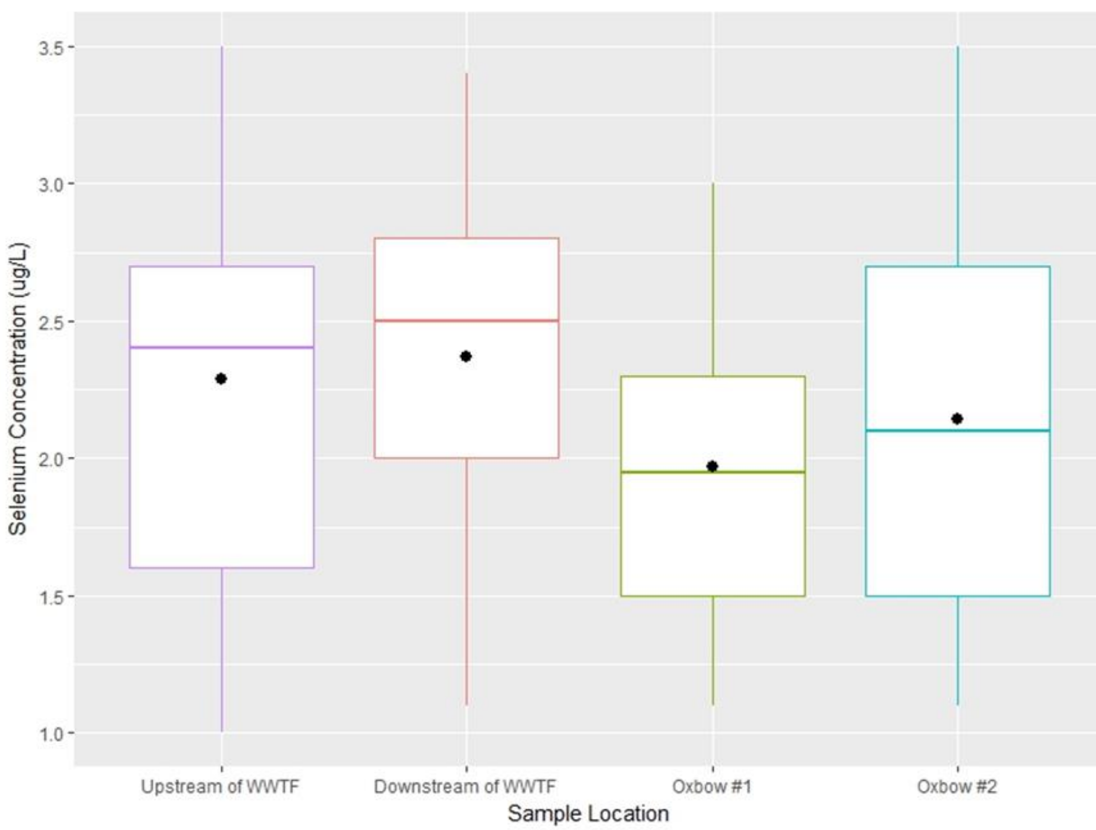


Selenium in water

Both total and dissolved selenium were measured for all of the samples collected in 2017. Total selenium, rather than dissolved selenium, is presented in this document and in the calculation of the site-specific standard. This was done for a couple of reasons. First, both particulate and dissolved selenium can have negative impacts on aquatic life, so using total selenium (the combination of particulate and dissolved) may better account for the selenium in the environment that is impacting aquatic life. Secondly, WQBELs require that metals be expressed as total recoverable metals (40 CFR § 122.45(c)). Often, the measured concentrations for metals are dissolved concentrations, requiring a conversion to total metal. However, because measured total selenium concentrations are available for this site, it eliminates the need to convert from dissolved concentrations, which would add extra uncertainty from the conversion factor. Calculating the BAF using total selenium would result in a standard for the water column that is based on total selenium, avoiding the need to convert WQBELs from a standard that was based on dissolved selenium.

The results from 2017 surface water sampling indicated that mean total selenium concentrations in the main channel of the Minnesota River downstream of Seneca WWTP are slightly higher (2.4 µg/L) than mean selenium concentrations upstream of Seneca WWTP (2.3 µg/L) (Figure 5). Mean selenium concentrations in both oxbow sites were lower than main channel selenium concentrations (Figure 5). This is likely due to particulate selenium settling as velocity decreases through oxbow habitats. Because fish were collected from both oxbows, the selenium water concentrations from both oxbows were combined to calculate the mean oxbow selenium concentration (2.1 µg/L). For the full dataset, including individual selenium data points for each site, refer to Gopher's SSS application (Wenck 2018).

Figure 5. Total selenium concentrations in water at the different sampling sites in 2017; data collected weekly from April through October. Black dots indicate the mean concentration for each site; box plots indicate median, 25th and 75th percentiles for each site, with ranges indicated by vertical lines.



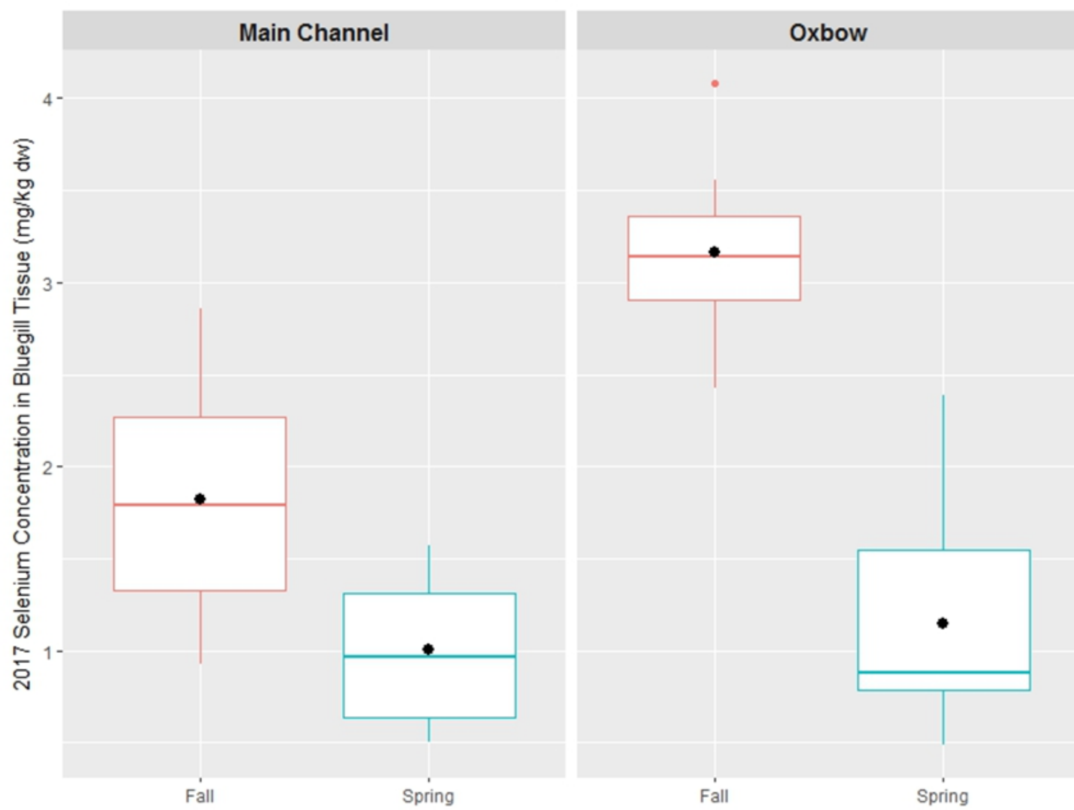
Selenium in fish tissue

The results from 2017 fish tissue sampling indicated that mean selenium concentrations in the main channel of the Minnesota River downstream of Seneca WWTP are significantly ($p < 0.05$) lower (1.41 µg/L) than mean selenium concentrations in the oxbow habitats (2.41 µg/L) (Table 3). This is likely due to the longer residence times in oxbows that allow for particulate selenium settling as velocity decreases through oxbow habitats, allowing for accumulation up through the food chain. Additionally, food web complexity and organic content and reduction potential of the sediments can create more bioaccumulation potential (EPA 2016a). When broken down by season, fall tissue concentrations were significantly ($p < 0.05$) higher than spring tissue concentrations, for both habitats (Figure 6). Fish frequently will have increased whole body tissue concentrations in the fall, due to increased consumption, replenishing reserves after spawning and in preparation for the winter. For the full dataset, including selenium concentrations in individual fish, refer to Gopher's SSS application (Wenck 2018).

Table 3. Average bluegill whole body tissue concentrations

	Spring (mg/kg dw)	Fall (mg/kg dw)	Average of both seasons (mg/kg dw)
Main Channel	1.01	1.82	1.41
Oxbow	1.15	3.16	2.41

Figure 6. Selenium concentrations in bluegill collected in 2017, split by habitat and season. Black dots indicate the mean concentration for each site; box plots indicate median, 25th and 75th percentiles for each site, with ranges indicated by vertical lines and points that fall outside of 1.5 times the interquartile range.



Habitat and seasonal variations

EPA guidance discusses the effect of habitat on selenium accumulation (EPA 2016a). Slow-moving or still water bodies generally have greater selenium accumulation than flowing waters. Therefore, the sampling was split between two habitats – the main channel (to represent lotic habitats) and the oxbow (to represent lentic habitats, including the floodplain lakes). The oxbows are inundated by the Minnesota River at much lower flows than the oxbow lakes, and are therefore more impacted by selenium concentrations from the Minnesota River. The oxbows were more accessible for sampling and more often inundated, so the oxbow concentrations served as surrogates for samples from the floodplain lakes.

The sampling was also split between time periods – the spring, before spawning; and the fall, after spawning, while fish are replenishing for the winter. Based on the results of the sampling in 2017 (Figure 6), both seasonal and habitat differences existed for bluegill. Because of this, Gopher proposed two standards – one for the main channel and one for the oxbow. In calculating the two standards for the two habitats, Gopher averaged the spring and fall tissue concentrations for each habitat to derive the corresponding BAF and water column standard.

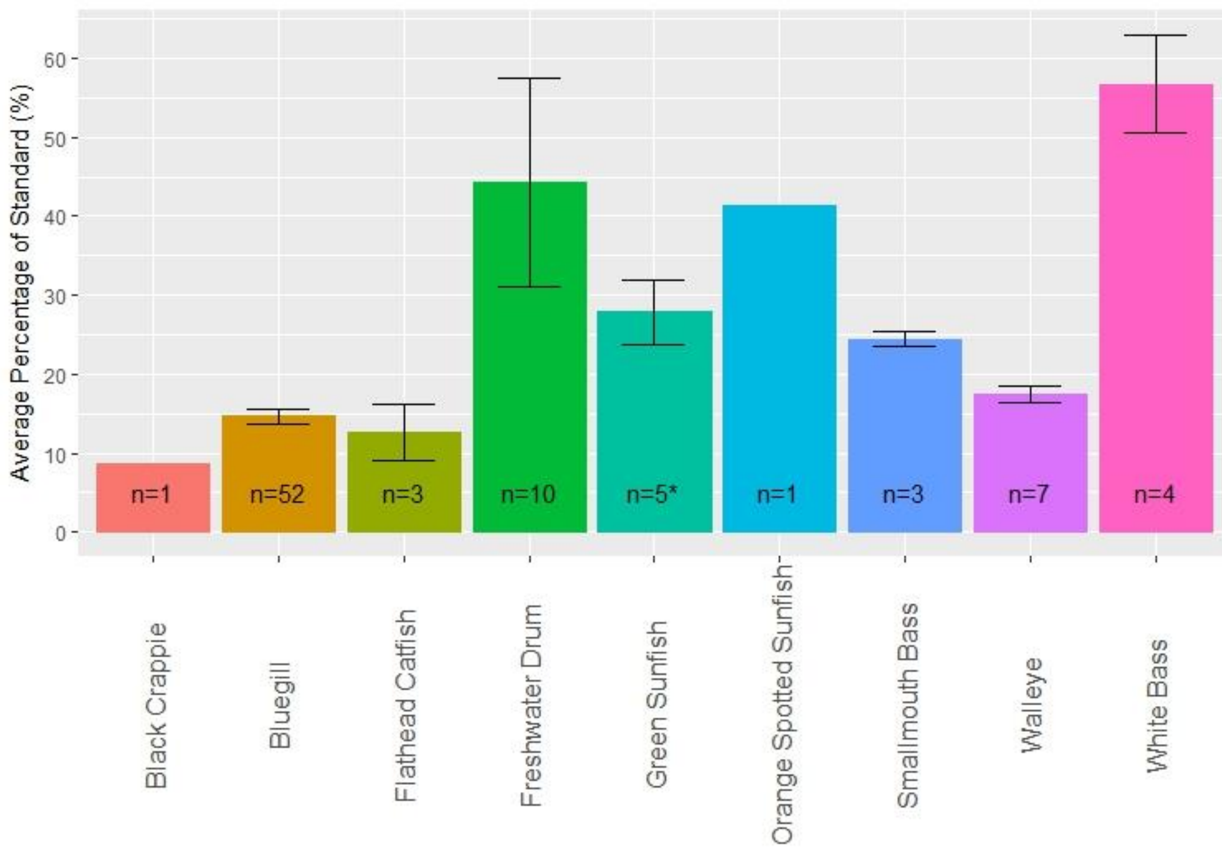
However, when evaluating the tissue concentrations between different seasons, the differences in concentrations in the fall and spring were statistically significant in both habitats (Figure 6). Because the sampling events are statistically different between the seasons ($p < 0.05$), using the average tissue concentration from both seasons may not appropriately represent the data if adequate protection during the fall is desired. If the two seasons had not been significantly different, an average concentration would be more appropriate. If the BAF is calculated with the spring tissue concentrations included, we run the risk of the water column value not being protective of accumulation in tissue in the fall. Because the tissue standards are instantaneous measurements never to be exceeded, the water column standard should be protective of the season where greater accumulation occurs. MPCA is proposing that tissue sampling to determine compliance with the tissue component of the standard will occur during the fall (see section titled "Implementation and proposed permit conditions"). Therefore, a BAF that is protective of that season ensures compliance with the tissue component of the standard. To achieve this, MPCA used the fall tissue data to calculate the BAF and protective water column value.

Variability in selenium concentrations in different fish species

In 2015 and 2016, tissue samples were collected from species other than bluegill and included samples from eggs, filets and whole bodies, depending on the species and availability of reproductive tissues (eggs/ovaries). The concentrations in tissue of the different species collected varied, but the raw data cannot be compared directly, because of the differences in tissue types sampled. The raw data must be normalized to compare between tissue types. Because selenium more readily accumulates in eggs or ovaries, the concentration in those tissues are not directly comparable to whole body tissue samples, for example, where the concentration in reproductive organs is diluted by the other tissues present in the body that do not accumulate selenium to the same extent. Therefore, to compare the concentrations in the different fish species, the tissue concentrations were compared to the respective EPA tissue criterion value as a percentage of the appropriate tissue criterion value (Figure 7).

Figure 7 demonstrates the differences in selenium concentrations in different fish species collected from the Minnesota River site from 2015 to 2017. The differences could come from the diet of the species – for example, freshwater drum consume mussels, which are known to accumulate larger amounts of selenium than other invertebrates (EPA 2016b). Small sample size could also account for some differences. Where only one individual was collected for a species, that one individual may not be representative of the entire population of that species. Ultimately, it is not possible to know for certain why some species had higher concentrations of selenium than others, but regardless of why, all of the species need to be protected. While EPA guidance recommended developing the water column element of the standard using the species that are more sensitive to the toxic effects of selenium, which in this case was bluegill, MPCA recognizes that other species may accumulate selenium to a greater extent than bluegill. Therefore, MPCA is proposing implementation strategies to help ensure that species other than bluegill do not exceed the tissue standards. This issue and these strategies are described later in this document.

Figure 7. Comparative selenium concentration in fish tissue (as percentage of respective tissue standard) for different fish species collected from the main channel, 2015 to 2017. Percentages are shown as the average of all individual fish of each species. The number of fish (n) collected for each species is indicated on each bar (*one of the five samples for green sunfish was a composite sample consisting of three fish). Where two tissue types were collected from one individual fish, the egg sample was used, as this standard would take precedence.



Calculation of protective water column value

The following section examines the relationships between the concentration of selenium in the water column and the concentration in fish tissue, calculated as a BAF. The BAF is then used to translate the protective fish tissue concentration into a protective water column value. This methodology was taken from EPA's 2016 criterion document, which outlines the calculation of a site-specific water column value to protect for the tissue concentrations given in the criterion document.

Bioaccumulation factor

The BAF is the ratio of selenium concentration in fish tissue to the concentration of selenium in the water at the site of interest (Equation 1).

$$\text{Equation 1: } BAF = \frac{C_{wholebody}}{C_{water}}$$

Where,
BAF = bioaccumulation factor (L/kg)
$C_{wholebody}$ = concentration of selenium in fish tissue; in this case, whole body samples were collected for bluegill, so whole body tissue concentrations (mg/kg dry weight)
C_{water} = concentration of selenium in water (µg/L)

Because selenium accumulation varies by site, and by type of habitat, samples were collected from both the main channel of the river and the oxbows. The average water column selenium concentration from 2017 for each habitat (C_{water}), along with the average 2017 fall bluegill whole body tissue concentration for each habitat ($C_{wholebody}$), were used to calculate each BAF, using Equation 1. Average values were used, following EPA guidance on the development of site-specific BAFs (EPA 2000). Averages of the water concentrations help determine the integrated concentration the fish are exposed to over the sampling period, rather than a single value that may not be as representative of cumulative exposure. Table 4 presents the BAF for each habitat, in addition to the average water and fish tissue concentrations used to calculate it. The longer retention times of the oxbows were apparent in increased accumulation observed in those areas, as compared to the main channel.

Table 4. Selenium concentrations in water and fall fish tissue used in bioaccumulation factor (BAF) and water column standard calculations

Habitat	2017 Average Water Column Concentration (µg/L total selenium)	Fall 2017 Average Bluegill Whole-Body Tissue Concentration (mg/kg dw)	BAF	Site-specific Water Column Standard (µg/L total selenium)
Main Channel	2.4	1.82	0.76	11
Oxbow	2.1	3.16	1.5	5.7[1]

[1]The oxbow standard will also apply to the floodplain lakes, which have non-flowing waters and longer residence times, similar to the oxbow habitats.

Translation to water column standard

Using Equation 2, and the BAFs calculated previously, a water column criterion that is protective of the appropriate fish tissue standard can be calculated.

$$\text{Equation 2: } C_{watercriterion} = \frac{FishTissueCriterion}{BAF}$$

Where,
$C_{watercriterion}$ = water column concentration protective of fish tissue criterion; site-specific water column standard (µg/L)
Fish tissue criterion = appropriate fish tissue criterion; in this case, whole body samples were collected for bluegill, and used in the BAF, so the whole body fish tissue criterion (8.5 mg/kg dry weight) is used.
BAF = bioaccumulation factor (L/kg)

Because the BAF was calculated using whole body tissue values, the whole body fish tissue criterion (8.5 mg/kg dry weight; taken from EPA's 2016 criterion document) was used to translate to the water column criterion. The resulting site-specific water column criteria for the main channel and lentic habitats are presented in Table 4.

Proposed site-specific standard

Using the site-specific values calculated in the previous section, along with the selenium fish tissue elements taken directly from the 2016 EPA Selenium Criterion document (EPA 2016a), the proposed site-specific standard for the lower Minnesota River is presented in Table 5. The water column values were developed using site-specific data, and are water concentrations calculated to protect the tissue standards in two different habitat types – lotic (main channel) and lentic (oxbows and floodplain lakes) waters. The calculation of the water column values follows methods outlined in the 2016 EPA selenium criterion document.

Table 5. Site-specific standard for the Minnesota River below the outfall of the Seneca WWTP, ending at the confluence with the Mississippi River

Media Type	Fish Tissue[1]		Water Column[4]
Criterion Element	*Egg/Ovary*[2]	*Fish Whole Body or Muscle*[3]	*Monthly Average Exposure*
Magnitude	15.1 mg/kg dw	8.5 mg/kg dw whole body or 11.3 mg/kg dw muscle (skinless, boneless filet)	11 µg/L in river main channel 5.7 µg/L in oxbows and floodplain lakes
Duration	Instantaneous measurement[5]	Instantaneous measurement[5]	30 days[6]
Frequency	Not to be exceeded	Not to be exceeded	Not more than once in three years on average

1. Fish tissue elements are expressed as steady state.
2. Egg/Ovary supersedes any whole-body, muscle, or water column element when fish egg/ovary concentrations are measured.
3. Fish whole-body or muscle tissue supersedes water column element when both fish tissue and water concentrations are measured.
4. Water column values are based on total selenium in water and are derived from fish tissue values via bioaccumulation modeling. Water column values are the applicable criterion element in the absence of steady-state condition fish tissue data.
5. Fish tissue data provide instantaneous point measurements that reflect integrative accumulation of selenium over time and space in fish population(s) at a given site.
6. The bioaccumulation of selenium into fish tissue occurs over a longer time period than with typical acute or chronic toxic effects to aquatic life. Therefore, a longer duration for the averaging period is appropriate for the selenium SSS. Additionally, because of this longer averaging period, the minimum stream flow (see Minn. R. 7053.0205, subp. 7) for which wastes must be controlled to meet the SSS will be the $30Q_3$ flow.

As with the EPA criterion, the fish tissue elements supersede the water column element, with egg/ovary data having precedence over the other fish tissue values, when both data are available. In practice, this would mean that if data were available for both fish tissue and water column, as long as the fish tissue standards were being met, the water body would be in attainment with the standard, even if the appropriate water column value were exceeded. The reason the fish tissue element takes precedence is because the toxic effects of selenium are not from direct water exposure, but through uptake of selenium in the diet of the organism. The toxic effects were measured as a fish tissue concentration, not as the concentration of the surrounding water during the exposure. Therefore, if the tissue levels remain below levels that have been demonstrated to elicit toxic effects to fish reproduction, the standard would be met because the designated use would not be impaired.

The duration and frequency of this site-specific standard are taken from EPA's 2016 criterion document and differ from the current statewide selenium standard. For the fish tissue values, the duration is the instantaneous measurement, rather than an average over a given time, due to the nature of a fish tissue measurement. The fish tissue concentration is an accumulation of an extended exposure to selenium in the environment. Because of this, the fish tissue values should never be exceeded, because selenium has already accumulated to the point of potential toxic effects. For the water column element of the standard, the duration and frequency components are a 30-day average, not to be exceeded more than once in three years on average. The presence of selenium in the water column ultimately results in bioaccumulation into fish tissue with accumulation occurring at each trophic level. The bioaccumulation process into fish tissue thus occurs over a longer time period than the typical duration of acute or chronic effects to aquatic life. Therefore, a longer averaging period is appropriate. The frequency aspect of the water column element is the same as most water quality standards – not to exceed more than once every three years on average. This frequency allows for population recovery after an exceedance. Additional information regarding the determination of the appropriate duration and frequency components can be found in EPA 2016a.

Because of the unique duration of this site-specific standard, the default $7Q_{10}$ minimum stream flow given in Minn. R. 7053.0205, subp. 7 is not appropriate for this site-specific standard. The $7Q_{10}$ is the lowest seven-day average flow with a once in ten-year recurrence interval. This flow rate is overly conservative for the selenium SSS, which is averaged over a 30-day duration, with a three year frequency. Therefore, MPCA is proposing using the $30Q_3$ flow rate, which is the lowest 30-day average flow with a once in three-year recurrence interval, to coincide with the duration and frequency components of the site-specific standard.

Implementation and proposed permit conditions

Given that the data collected following EPA's criterion document (EPA 2016a) resulted in some uncertainty as to whether the water column value derived using bluegill would be protective of other species that accumulate more selenium, MPCA has developed some implementation strategies and permit conditions that will help ensure that the fish tissue standards continue to be met in the Minnesota River for all species. The implementation strategies and permit conditions described here do not encompass all measures that may be included at permit issuance, but rather include those that will help ensure achievement of the tissue standard values. Additional opportunity for public comment on the specific permit conditions will be available at the time of Seneca WWTP's draft permit re-issuance.

According to the EPA's 2016 criterion document (EPA 2016a), the process for the selection of the target species in development of a site-specific water column value (Figure 3) was intended to protect for the most sensitive species to selenium toxicity. The three most sensitive tested species in the 2016 criterion document were white sturgeon (Acipenseridae), brown trout (Salmonidae) and bluegill (*Lepomis*). Because the first two most sensitive species are either not present or infeasible to sample at the Minnesota River site, the third most sensitive species (bluegill) was chosen as the target species for sampling, as recommended in EPA guidance. However, if sturgeon, which are known to be sensitive to selenium, were not a species of concern and were also more readily found at the site, sturgeon would have been chosen to develop the site-specific water column value (Figure 3). Sturgeons' diets consist of benthic invertebrates, which tend to have greater amounts of selenium. Because of this, sturgeon can receive larger doses of selenium than other species (EPA 2016b). Sturgeon would also have been chosen as the target species to monitor for compliance with the standard, given its sensitivity and bioaccumulative potential.

Because EPA's fish tissue protective values were calculated in a fashion to be protective of most species, including those sensitive to selenium, any fish species that has tissue concentrations below the tissue standard should be protected from adverse effects. When MPCA implements the site-specific standard, which includes EPA's protective tissue values, MPCA must ensure that the tissue values are being met, regardless of species sampled, to be in compliance with the standard. The standard does not indicate that the tissue values only need to be met in species that are sensitive to selenium. If all species are meeting the tissue standard, most, if not all, species should be protected from adverse effects from selenium. If the tissue standards are exceeded, adverse effects could be anticipated, especially if the species is sensitive to selenium. For the protective tissue values to be met in all species, to be in compliance with the site-specific standard, the target species for tissue monitoring should consider species that have greater bioaccumulation potential.

Given that all species should comply with the tissue standard, and that sturgeon are sensitive to selenium and have a high bioaccumulation potential, a species with greater bioaccumulation potential than bluegill should be targeted for future sampling events, especially when determining compliance with the fish tissue standard. Because sturgeon cannot be sampled, the priority species are freshwater drum and white bass. These two species had the highest tissue accumulations of the species collected in 2015 (Figure 7). Of the species that have been tested for selenium toxicity, freshwater drum and white bass are most closely related to bluegill and largemouth bass (they are all in the same order – Perciformes). Compared to the species that have been tested for selenium sensitivity, bluegill and largemouth bass are sensitive to selenium, so ensuring that the two related species that accumulate selenium more readily (freshwater drum and white bass) remain below the fish tissue standards is a priority. The fish that accumulate more selenium than bluegill may be less sensitive to its effects, and therefore not need as protective of a value to ensure they are not affected. However, the reverse may be true, and they may be as or more sensitive to selenium. We do not have the information to answer that question with certainty (additional testing would be needed). Without that information, MPCA is choosing to target tissue monitoring from these species to ensure the species with unknown sensitivity to selenium meet the tissue standards. Additionally, freshwater drum have similar diets as sturgeon, which can lead to similar bioaccumulation potential. Sturgeon have known sensitivity to selenium, and freshwater drum can serve as a surrogate for the bioaccumulative potential in sturgeon, to ensure sturgeon protection.

MPCA is proposing that the WWTP permit will require monitoring for fish tissue (targeting white bass and freshwater drum) in the fall. MPCA anticipates allowing for some flexibility for tissue collection, as sampling for certain species does not always yield the targeted species. Given previous years' data, sampling late in the fall (October – early December) would provide the most conservative data. Sampling later in the fall allows sufficient time for fish to feed and replenish after spawning. The additional specifics of the fish tissue monitoring will be spelled out in the permit when it is re-issued. MPCA will consult the most recent version of the technical guidance for fish tissue monitoring published by the EPA when making decisions about fish tissue monitoring (currently this guidance has not been finalized, and is the draft that was released for public comment in 2016; EPA 2016b). Because habitat differences (such as flowing water compared to slow-moving or still waters) can influence the amount of selenium accumulation in fish tissue, the different habitats in which the site-specific standard applies will need to be sampled for fish tissue concentrations. Therefore, to ensure compliance with the site-specific standard in all habitats, fish tissue monitoring will need to be conducted in the Minnesota River main channel, as well as the oxbow and floodplain lakes.

Traditional WQBELs are calculated considering receiving water dilution and applied to prevent an exceedance of the numeric water quality standard. A limit is placed in the discharge permit to prevent high concentrations in effluent causing a water column value exceedance in the receiving water. A fish tissue standard is more complicated because the tissue concentration is influenced by the wastewater effluent concentration, but more indirectly than a traditional water column standard. Nevertheless, the MPCA has an obligation to ensure that an exceedance of the selenium fish tissue standards will not occur because of a wastewater discharger. There is no formula to use to determine what effluent concentration will cause a specific tissue concentration, especially when fish species accumulate selenium differently. Based on the data collected to date, the average tissue concentrations in the fish sampled from the lower Minnesota River do not exceed a tissue standard. The concentration in the water of the river, however, is generally below 4 µg/L. If the loading of selenium increases from the WWTP because the water column standard (based on bluegill bioaccumulation) is raised, it has the potential to cause selenium exceedances in other species that accumulate more selenium than bluegill. Given that there is some uncertainty that the water column standard calculated from the bluegill BAF will be protective of other species, an "intervention concentration" for monitored tissue concentrations is a reasonable alternative to establishing strict effluent limits until it is better understood whether increased discharges would cause exceedances in species that accumulate more selenium than bluegill. This intervention concentration for monitoring is not a part of the site-specific standard, but an implementation measure to be added to the National Pollution Discharge Elimination System (NPDES) permit.

An intervention concentration in the permit would not set a distinct effluent concentration limitation, and would be based entirely on fish tissue data. For the intervention concentration, MPCA is proposing that if average fish tissue concentrations reach 90% of the appropriate tissue standard, the permit should be re-evaluated, with a more appropriate site-specific water column value applied. The data collected from fish tissue and water column monitoring could be used, along with additional data, to calculate a more protective BAF and water column site-specific standard. MPCA is proposing 90% because at this point, there would be no exceedance of the standard and the water would not be impaired for the aquatic life use, but it allows the MPCA to re-evaluate prior to an exceedance happening. Based on 2015 data, the average tissue concentrations in white bass and freshwater drum ranged from 35 to 50% of the appropriate standard. Therefore, the average tissue concentrations would need to increase significantly to exceed the intervention concentration. The updated water column value would likely result in effluent limits needing to be added to the permit.

As with all permits, antidegradation rules (*Minn*. *R*. 7050.0250 to 7050.0335) will apply in the permit re-issued to Seneca WWTP. Any future increase to the selenium loading would require an antidegradation review. MPCA plans to numerically quantify the existing loading, and use that value to assess whether an antidegradation review may be needed in the future.

Protection of downstream beneficial uses

The site-specific standard for selenium in the Minnesota River ends where the Minnesota River meets the Mississippi River. At that point, the statewide acute and chronic standards of 20 and 5.0 µg/L, respectively, will continue to apply. Minnesota is obligated to ensure that downstream standards will be protected (*Minn*. *R*. 7050.0155, 40 CFR § 131.10(b)), so a mass-balance analysis was completed to determine the maximum effluent concentration allowable that still maintains the 5.0 µg/L standard in the Mississippi River. Mass balance, for this exercise, is calculated using the following equation:

$$Cb \ = (QsMinn * CsMinn) + (QsMiss * CsMiss) + (Qe * Ce) \ / (QsMinn + QsMiss + Qe)$$

Where:

C_b = downstream selenium concentration (µg/L)
Ce = Seneca WWTP selenium concentration (µg/L)
Qe = Seneca WWTP average dry weather flow (cubic feet per second [cfs]) (Source: MCES)
CsMinn = Total selenium data from Minnesota River (µg/L); Data record 2000-2017 (Source: Gopher; MCES)
QsMinn = Flow from the Minnesota River USGS Gauge Station near Jordan, MN (cfs); Data record 1934-2017 (Source: United States Geologic Survey, USGS)
CsMiss = Total selenium data from Mississippi River (µg/L); Data record 2000-2017 (Source: Gopher; MCES)
QsMiss = Flow from the Mississippi River USGS Gauge Station near Brooklyn Park, MN (cfs); Data record 2004-present (Source: United States Geologic Survey, USGS)

Table 6. Values used in the mass balance analysis

Parameter	Main channel input values[1]
$7Q_{10}$ flow of Minnesota River (QsMinn)	247 cfs
Minnesota River upstream total selenium, during low flow conditions (CsMinn)	1.3 µg/L
$7Q_{10}$ flow of Mississippi River (QsMiss)	1341 cfs
Mississippi River upstream total selenium (CsMiss)	0.7 µg/L
Seneca WWTP ADW discharge (Qe)	52.6 cfs (34 mgd)
Total selenium Mississippi River standard (Cb)	5.0 µg/L
Seneca WWTP maximum estimated total selenium concentration (Ce)	x

[1]For details about the calculation of these individual values, refer to Wenck 2018. The $7Q_{10}$ flow rates were recalculated from those in Wenck 2018, to include the most recent non-provisional flow rate data, so they differ slightly here from Wenck 2018.

Substituting the appropriate values from Table 6 into the mass balance equation:

$$5\ \mu g/L = (247\ cfs * 1.3\ \mu g/L) + (1341\ cfs * 0.7\ \mu g/L) + (52.6\ cfs * Ce) \ / (247\ cfs + 1341\ cfs + 52.6\ cfs)$$

$$\mathbf{132\ \mu g/L} = \ Ce$$

To exceed the Mississippi River chronic standard of 5.0 µg/L, Seneca WWTP would have to discharge 132 µg/L of selenium into the Minnesota River.

The main channel standard will not result in exceedances of the downstream Mississippi River standard. The Mississippi River contributes a large amount of dilution of the selenium load coming from the Minnesota River, resulting in lower concentrations, even if the main channel concentration was as high as the new proposed standard. Seneca WWTP would have to discharge 132 µg/L total selenium to exceed the Mississippi River standard of 5.0 µg/L, when the two rivers are at their $7Q_{10}$ flows (low flow rate associated with standards that are averaged over a shorter duration). The highest recorded discharge from Seneca is 79.1 µg/L. This means a 1.7x increase in their highest selenium discharge would be necessary to exceed the Mississippi River standard. Additionally, if Seneca discharged 132 µg/L, they would exceed the site-specific main channel standard (11 µg/L) during low flow conditions ($30Q_3$). Therefore, the conditions necessary to cause an impairment to the Mississippi River would result in an exceedance of the main channel standard at low flows, and reasonable potential in their next permit from the higher maximum measured effluent value. To avoid exceeding the standard in the Minnesota River, the permittee is limited to a maximum effluent concentration that is less than the concentration necessary to exceed the Mississippi River standard. Therefore, the Mississippi River will be protected from exceeding the 5.0 µg/L standard, even with the main channel standard being twice the magnitude.

Proposed site-specific standard for Minnesota River site

The following summarizes the findings of this study:

1. Gopher discharges selenium to Seneca WWTP, which discharges to the Minnesota River. A SSS for the Minnesota River, downstream of the WWTP, is warranted to ensure protection of the designated use, using the most current science.
2. The current selenium standard found in Minn. R. 7050.0222 is based on outdated science. Effects of selenium on fish have been demonstrated to be caused by its bioaccumulative properties, with toxicity primarily occurring as reproductive effects, after transfer of selenium to offspring in the eggs.
3. The 2016 EPA criterion document utilizes the more recent knowledge about selenium toxicity to develop criteria values for selenium concentrations in fish tissue, as well as a translation into a water column criterion. The document also outlines methods for developing site-specific water column standards for selenium.
4. The fish tissue values from the 2016 EPA criteria document were determined to be protective of the aquatic community of the Minnesota River, and therefore, those values are proposed as the fish tissue components for this site-specific standard.
5. The amount of accumulation into fish tissue is both site- and species-specific. Therefore, a site-specific water column value was developed for the Minnesota River site, rather than adopting the water column values provided in the 2016 EPA criteria document.

Following is a summary of pertinent criteria setting considerations and site-specific standards:

- **Egg/ovary tissue concentration:** An instantaneous measurement concentration of 15.1 mg/kg dry weight, never to be exceeded, should be maintained in egg or ovary tissue of fish from all waters where the SSS applies. This concentration is based on protection from reproductive toxic effects to fish species, and comes directly from EPA's 2016 selenium criterion document.
- **Fish whole body or muscle tissue concentration:** An instantaneous measurement concentration of 8.5 mg/kg dry weight, never to be exceeded, should be maintained in whole body fish tissue from all waters where the SSS applies. An instantaneous measurement concentration of 11.3 mg/kg dry weight, never to be exceeded, should be maintained in fish muscle tissue from all waters where the SSS applies. These concentrations are based on protection from reproductive toxic effects to fish species, and come directly from EPA's 2016 selenium criterion document.
- **Water column total selenium:** A 30-day mean total selenium concentration of 11 mg/L should be maintained in the main channel of the Minnesota River (downstream of the Seneca WWTP, until the confluence with the Mississippi River), not to be exceeded more than once in three

years on average. A 30-day mean total selenium concentration of 5.7 mg/L should be maintained in the associated lentic habitats – oxbows and floodplain lakes (Gun Club Lake and Long Meadow Lake), not to be exceeded more than once in three years on average.

- The water column standard is based on site-specific conditions and takes into consideration the varying accumulation rates of selenium in the lotic and lentic habitat types. The standard utilized fish tissue data from fish collected in the fall, resulting in a more conservative standard than one developed using all fish collected during the year. This will help ensure that the tissue standard is met during time periods where selenium is accumulated to higher amounts.
- Downstream standards will be attained, even with a higher standard upstream, due to the dilution from the Mississippi River.
- Monitoring of fish tissue will be required to determine compliance with the new SSS. MPCA proposes targeting fish species that have shown to accumulate selenium at higher concentrations (freshwater drum and white bass) to ensure that all species are meeting the tissue standards, and not just bluegill. Water column sampling from the Minnesota River will also be required, but as described in the standard, the fish tissue results will supersede water column results in determining compliance with the standard.
- Available evidence suggests that the current discharge condition is not preventing attainment of the aquatic life use. However, since this standard is unique, with fish tissue standards, and the water column element of the standard is higher than the Minnesota statewide standard, this SSS should continue to be evaluated to ensure that aquatic life uses are protected. To ensure that there is not an exceedance of the tissue standards as a result of increased loading, fish tissue monitoring data will be evaluated for any increases in tissue concentrations. If tissue concentrations increase to 90% of the corresponding tissue standard, the water column standard value will be re-evaluated and likely reduced to prevent exceedances of the tissue standards.

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