

History of Sea Lamprey in Lake Erie

Sea lamprey found in Canadian waters of Lake Erie in 1921

Sea lamprey found in US waters in 1927

Numbers were limited by:

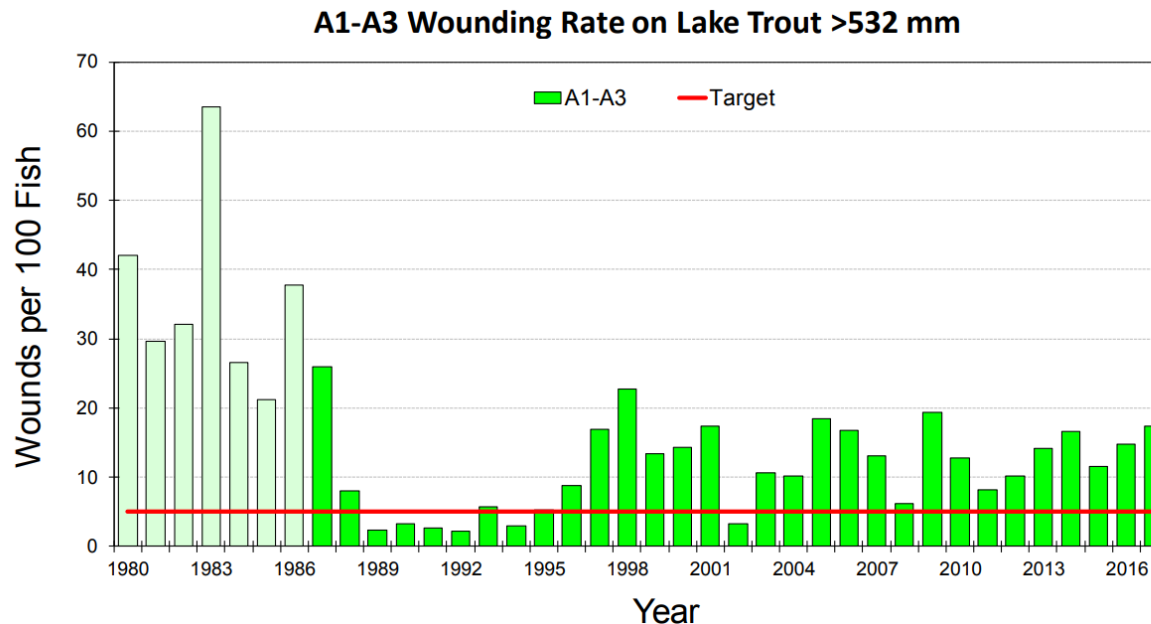
1. Lack of suitable prey
2. Scarce spawning and larval habitat
3. Pollution (including sediment)
4. Water temperature in tributaries



Sea Lamprey at Marquette Biological Station

Sea Lamprey Prey Preference

- Sea Lamprey prefer large lake trout (>532 mm or 21" roughly 3 years old).
- Will feed on Steelhead and other species.



Sea Lamprey Habitat

- Large water body with big cold water fish in parasitic phase
- Gravel spawning area with flow
- Silty area for larval burrows
- USA streams higher gradient with low quantities of prime larval habitat(4%)
- Canadian streams have upper reaches of faster flow and lower reaches with more prime larval habitat.

Pollution

- Agricultural sediment
- Prior to Clean Water Act little pollution control

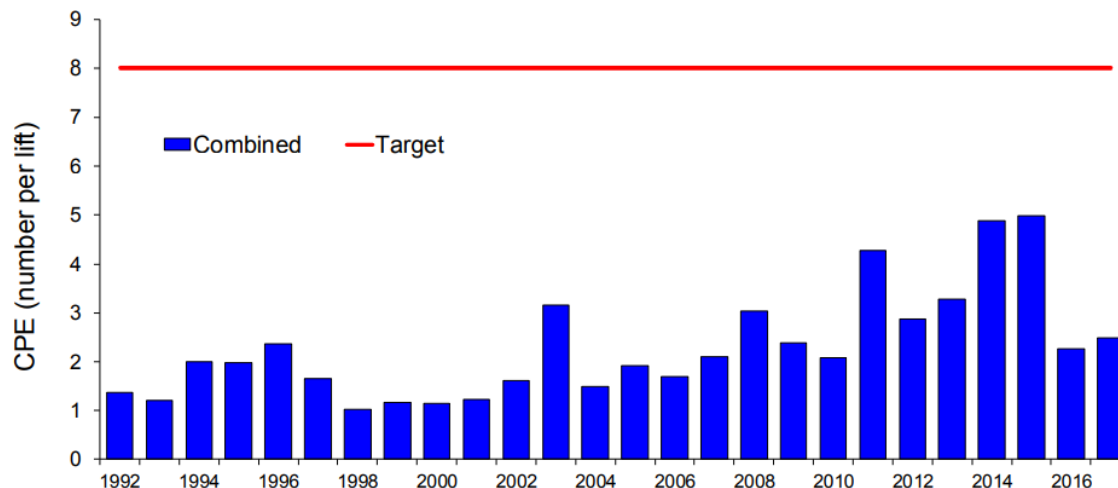


Temperature

- Lake Erie tributaries have the highest temperature in Great Lakes.
- Sea Lamprey grow the fastest and can mature in 3 years.
- Sea Lamprey prefer cool water in all stages.

Lake Trout

- Extirpated from Lake Erie
- Lamprey probably minor factor
- Stocking increased in 1980's
- Now 200,000 yearlings per year stocking goal



Lake Trout

- Harvest <1000 since 1996 usually <500
- In 2017 estimated 269 harvest
- Age is increasing
- No reproduction in 30 years of stocking



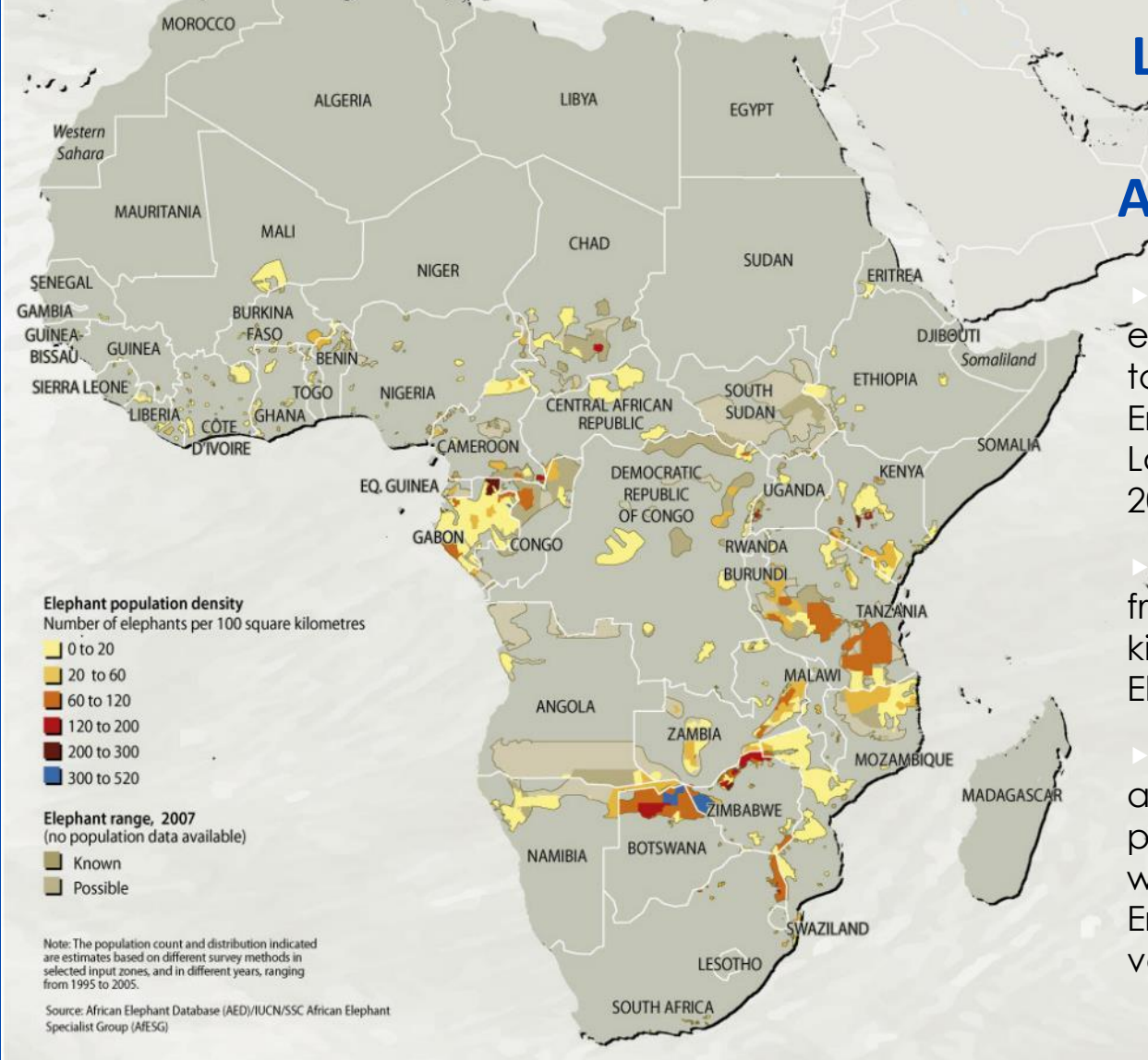
Steelhead

- Stock average of 1,853,558
- Goal is 800-900k
- 300k fishermen spend \$30 million annually
- 90% caught are released
- Wounding rates from lamprey 3-51%
- Reproduction minimal
- Diet smelt and emerald shiners

Lamprey Treatment

- 50 years before sea lamprey had noticeable impact on fish
- Increased numbers from 1979 to 1986
- Treatment started in 1986
- Treat on a cost per lamprey basis
- 2017 estimate 14,743 (95% CI, 8,750-20,736)
- Goal for Lake Erie 3,039

African elephant range and population density



COMPARISON OF LAMPREY DENSITY WITH THAT OF AFRICAN ELEPHANT

- ▶ Lamprey population is estimated at approximately 3x target of 3,000 individuals in Lake Erie based on wounding rate of Lake Trout (Coldwater Task Group 2018).
- ▶ African elephant density ranged from 0 to 520 per 100 square kilometers in 2007 (African Elephant Database).
- ▶ Typical populations of elephants appear to be about 90 animals per 100 km². At that density there would be 23,176 lamprey in Lake Erie. The goal of 3,000 appears very ambitious.

Alternative Control

- Barriers
- Trapping adults
- Phermones
- Sterile males



Current Treatment Plan

- Treat Lake Erie tributaries every 3 years with presence of any sea lamprey.
- Conneaut Creek
- Grand River
- Huron River
- Goal is to achieve lamprey reduction. Nontarget mortality is expected and accepted.
- Most other states are not concerned with nontarget mortality.

1986 Conneaut Treatment

- 464,431 larvae estimated
- 137,202 metamorphosing larvae
- 4% Conneaut suitable habitat
- Collected 1742 larvae (sea?)
- 423 mudpuppies
- 25 stonecat madtoms

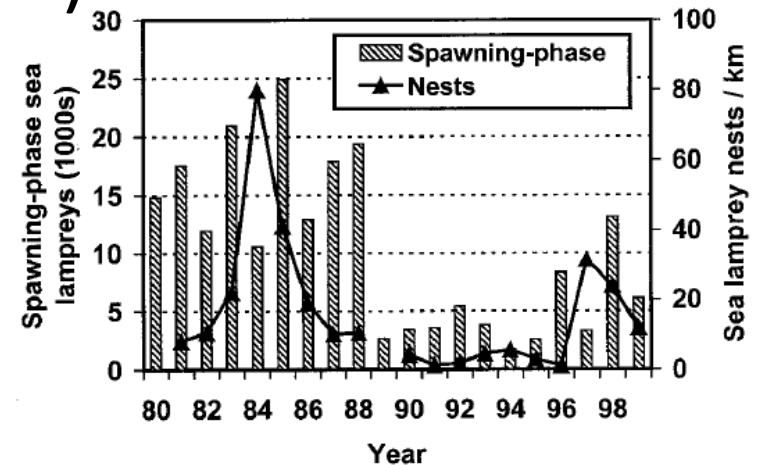
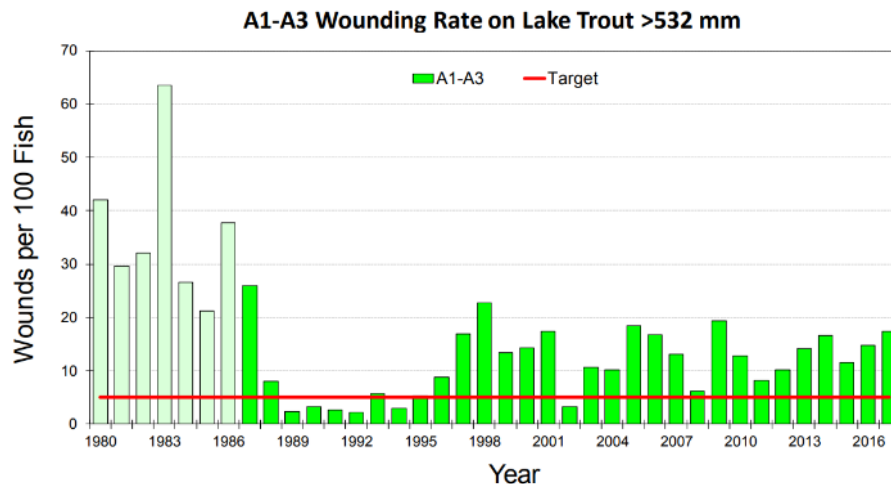


FIG. 6. Lake-wide estimate of Lake Erie spawn-ing-phase sea lamprey abundance (Mullet et al. 2003), and mean nest counts per km of standard stream section, 1980 to 1999 (Culligan et al. 2000).

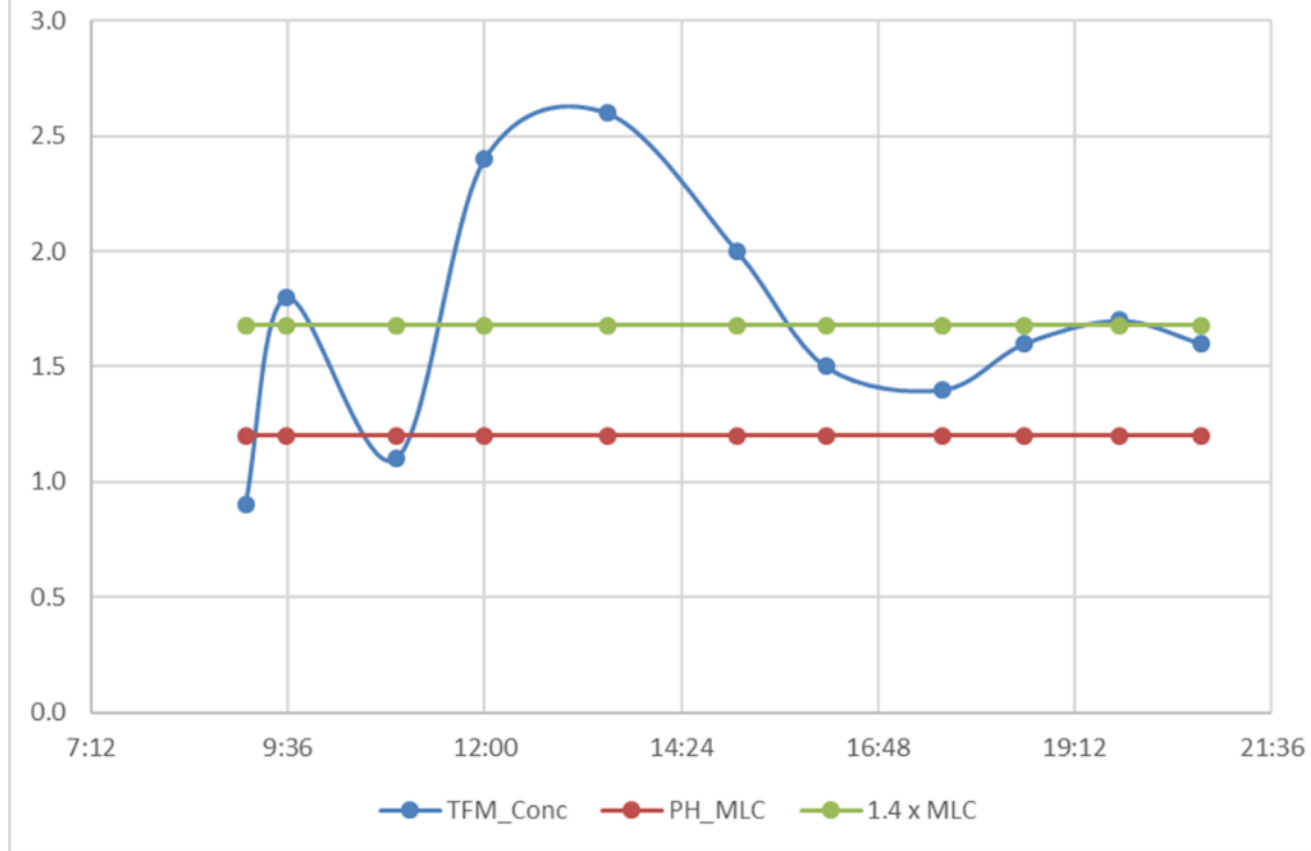
Estimates vs. Recovered

- Conneaut 2000 estimate 35,529
- Collected 16
- Grand 1999 estimate 29,773
- Collected 135
- At this ratio, Huron treatment killed 113,358 to 1,141,337 native lamprey

Nontarget Toxicity

- Native lamprey similar concentrations to sea lamprey
- Mudpuppy adults (NOEC 1.6 x MLC)
- Mudpuppy juveniles and spawners may be more sensitive
- Grand River 1987 treatment estimated mortality of 29% mudpuppies.
- Stonecat madtoms
- Literature appears to support 1.3-1.4 x MLC as protective

Grand R. at N. end of Brandt Rd.



Original data did not provide MLC calculated for the pH of each sample. I do not know why this particular number was chosen for the MLC. TFM maximum concentration was 2.17 x the provided MLC. The average for a roughly 9 hour period was 1.54 x provided MLC.

Species	Harpersfield - 528
Blackside darter	54
Bluntnose shiner	60
Brindled madtom	1
Creek chub	1
Fantail darter	20
Green side darter	63
Hog sucker	14
Logperch	39
Rainbow darter	11
River chub	4
Rock bass	2
Rosyface shiner	13
Silver jaw minnow	1
Spotfin shiner	23
Stonecat	66
Stoneroller minnow	13
Troutperch	2
Yellow bullhead	4
Sea lamprey (larvae)	1
Mudpuppy	9
Mudpuppy (live & saved)	9
Stonecat (live & saved)	3
Total	413

NONTARGET MORTALITY IN THE GRAND RIVER BETWEEN THE HARPERSFIELD DAM AND 528

The high flows only allowed collection of nontarget organisms in shallows near the bank. It is likely that the majority of organisms were not collected.

Many of the species collected are relatively tolerant of TFM so their presence indicates concentrations of TFM that greatly exceed MLC.

Only one sea lamprey larvae found.

TFM maximum concentration was 2.17 x the provided MLC. The average for a roughly 9 hour period was 1.54 x provided MLC.

Grand River 2017

- In 1987 the Grand collected 88 mudpuppies, 1098 sea lamprey, and 19 stonecats.
- The 2017 Grand River nontarget survey collected 5 sea lamprey larvae, 530 stonecats, 3 other lamprey, and 39 unknown lamprey larvae.
- Today we only find a fraction of the mudpuppies, it is uncertain if stonecat populations reduced and almost no sea lamprey.

First Huron River Treatment

- The Huron River nontarget survey collected 3 sea lamprey larvae, 2,157 stonecats, 514 native lamprey, and three unknown lamprey larvae.



Future

- USFWS will treat for sea lamprey.
- Literature indicates sea lamprey can be controlled with lower impacts to nontargets.
- Need better/quicker/faster TFM mixing in stream.
- Reduce maximum concentrations of TFM
- Attempt to relocate mudpuppies prior/during treatment

Improvements

“in my discussion with Dorance (Brege), it is his opinion that stream pH didn’t factor into the previous fish kills...there was simply too much chemical applied in those circumstances.” (Michael Fodale (FSW) email to Paul Anderson (OEPA) 4/2/2013)

“This work ensures that non-target mortality is very small, with only a few of the weakest individuals of any species being affected.” (Gavin Christie (Sea Lamprey Program Manager GLFC) Great Lakes Fishery Commission Forum Fall 2000)

Thank You

- Scott Winkler
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- (330) 963-1220

The TFM concentration ratio decreased from an average of 1.22 x MLC in the 1980s to 1.13 x MLC in the 1990's and still showed a 99% reduction in lamprey (Brege 2003).

Target TFM concentration is near MLC (Berge 2003).

Occasionally, Lampricide may be applied at 1.5 x MLC at selected points to compensate for attenuation downstream. This level represents the highest concentration that might be encountered during a treatment (Boogaard 2003).

"Based on the studies conducted during 2011 on logperch (host fish for snuffbox), TFM treatments are "likely to adversely affect" the fish at concentrations $\geq 1.4 \times \text{SLMLC}$. (Boogaard 2015).

"in my discussion with Dorance (Brege), it is his opinion that stream pH didn't factor into the previous fish kills...there was simply too much chemical applied in those circumstances." (Michael Fodale (FSW) email to Paul Anderson (OEPA) 4/2/2013)

From the literature, It appears that it is possible to comply with the permit limit of $<1.4 \times \text{MLC}$.

“The Sea Lamprey Control Program (SLCP) is committed to the protection of the snuffbox mussel within the action areas. The following conservation measures would be implemented to minimize adverse impacts to the endangered mussel and its host fish, the logperch, during TFM treatments of streams where the mussels exist”....”To reduce the risk to logperch, the SLCP would apply TFM at concentration ratios $\leq 1.30 \times$ predicted SLMC at application sites. Target concentration ratios would therefore be ≤ 1.3 SLMC downstream of and between APs. Where feasible, lower concentration ratios would be applied ($1.1 \times$ to $< 1.3 \times$ SLMC) to further reduce risk to the logperch. (Boogaard 2015).

No Observed Effect Concentration (NOEC) on adult mudpuppies was 1.6 X MLC TFM (Boogaard 2003).

NOEC for TFM/1% niclosamide was 1.5 x MLC for mudpuppy adults (Boogaard 2003).

Stress from spawning/mating may make mudpuppies more sensitive (Boogaard 2003).

Juvenile mudpuppies are believed to be more sensitive than adults (Boogaard 2003).

"The key to a successful TFM application is to apply the lampricide at exactly the concentration necessary to kill larval sea lamprey while not affecting other organisms." (Gavin Christie (Sea Lamprey Program Manager GLFC) Great Lakes Fishery Commission Forum Fall 2000)

"This work ensures that non-target mortality is very small, with only a few of the weakest individuals of any species being affected." (Gavin Christie (Sea Lamprey Program Manager GLFC) Great Lakes Fishery Commission Forum Fall 2000)

"Scientists were able to carry out laboratory studies that defined new lower concentrations of TFM that would not harm mudpuppies, but would still kill sea lamprey larvae." (Gavin Christie (Sea Lamprey Program Manager GLFC) Great Lakes Fishery Commission Forum Fall 2000)

TFM Lethal Concentration for 50% (LC50) of Tadpole Madtoms was about 1.48 x MLC (Boogaard 2003). This paper did not test Stonecat Madtoms.

LC50 for TFM/1% niclosamide was 1.17-1.26 for Tadpole Madtoms (Boogaard 2003).

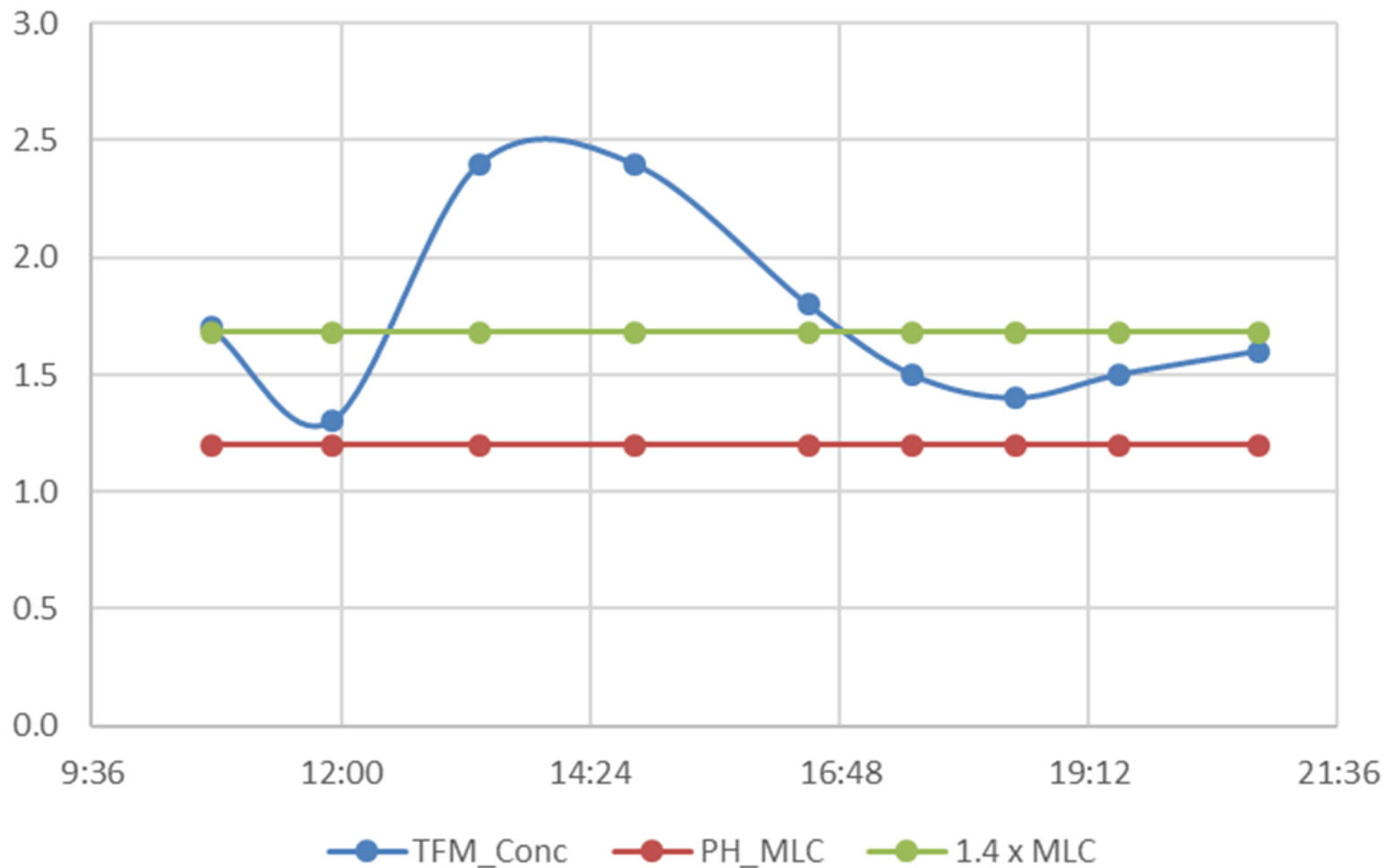
Although sensitive, these species (Channel Catfish and Tadpole Madtom) would be minimally impacted if TFM concentrations were held at or just above the MLC (Boogaard 2003).

Significant mortality may occur among Tadpole Madtoms and Channel Catfish if concentrations exceed 1.3 x MLC (Boogaard 2003).

Logperch mortality was 15% at 1.0 x MCL, 65% at 1.3 x MLC, and 95% at 1.6 x MLC (Boogaard 2015). This indicates that lampricide treatments will kill Logperch, however, studies and OEPA nontarget collections seem to indicate that Logperch are not as sensitive in the field.

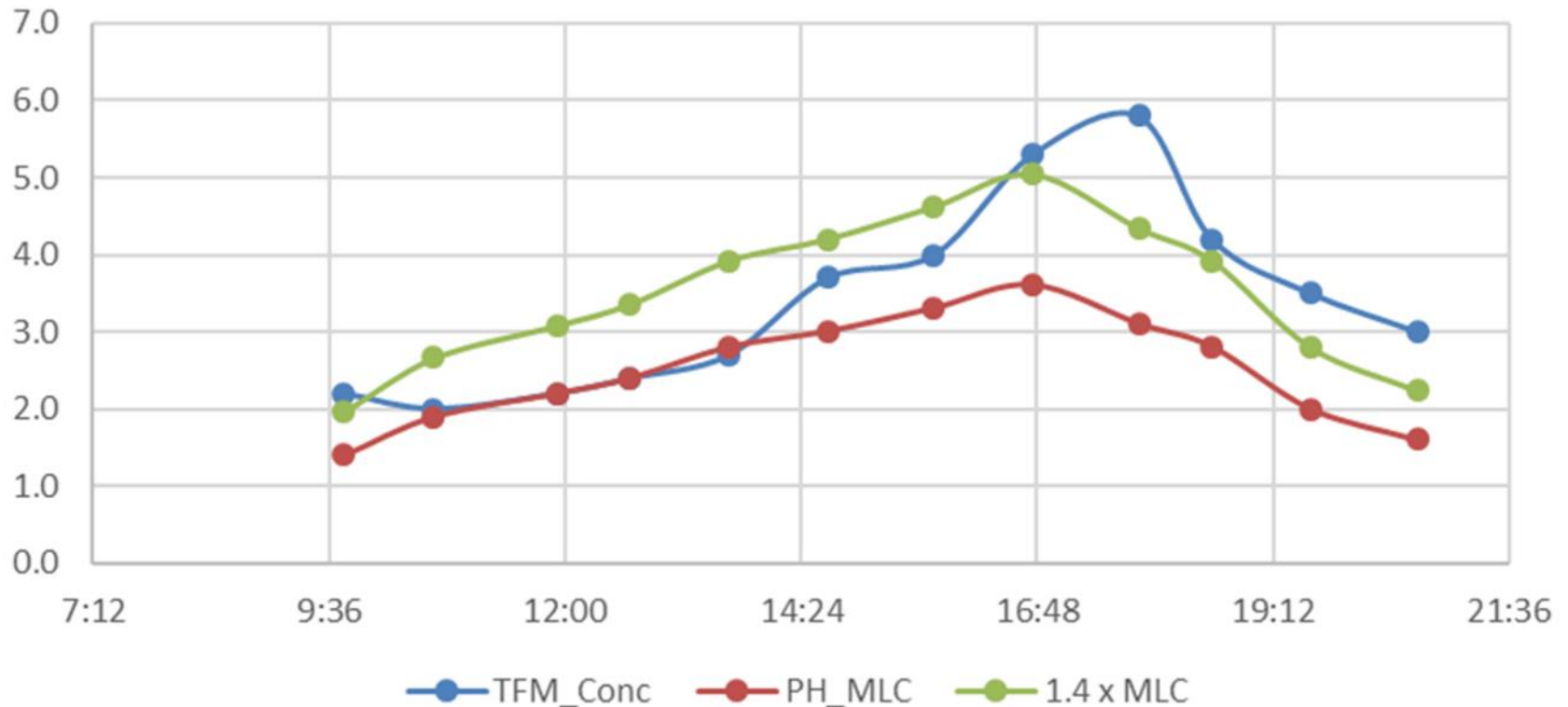
An anomaly did occur during one stream treatment where 100 percent (n=5) of the caged logperch died. This was due to high lampricide concentrations ($>1.5 \times \text{SLMLC}$ or $5.4 \text{ mg} \cdot \text{L}^{-1}$) that occurred for 4.5 hours of the treatment (Boogaard 2015).

Grand R. at County Line Rd. (T141)



Maximum TFM concentration was 2 x provided MLC.
Average for roughly 9 hours was 1.44 x MLC.

Lower Mill Cr. at Doty Rd.



This site is a tributary to the Grand River. The pH appears to have changed drastically during the treatment. Maximum concentration was 1.88. Average for a roughly 9 hour period was 1.39 x MLC. TFM still in excess of permit limits at the time data becomes unavailable.

Species	Mill Creek
Blackside darter	41
Black redhorse	3
Bluntnose minnow	13
Black bullhead	3
Brown bullhead	5
Yellow bullhead	3
Fantail darter	3
Green side darter	4
Hog sucker	7
Logperch	12
Rainbow darter	52
Sand darter	1
Steelehead	28
Stripped Shiner	1
Stonecat	318
Stoneroller minnow	60
White sucker	11
Sea lamprey (larvae)	4
Ichthyomyzon sp. (larvae)	4
Sea lamprey (adult)	2
Northern brook lamprey	2
Twolined salamander	218
Total	795

NONTARGET MORTALITY IN MILL CREEK

The high flows only allowed collection of nontarget organisms in shallows near the bank. It is likely that the majority of organisms were not collected.

Many of the species collected are relatively tolerant of TFM so their presence indicates concentrations of TFM that greatly exceed MLC.

Four sea lamprey larvae found.

TFM maximum concentration was 1.88 x the provided MLC. The average for a roughly 9 hour period was 1.39 x provided MLC.

Species	Main Grand/Mill*
Blacknose dace	6
Blackside darter	76
Black redhorse	7
Bluegill	2
Bluntnose minnow	341
Black bullhead	4
Brown bullhead	9
Brindled madtom	28
Creek chub	112
Fantail darter	62
Gizzard Shad	2
Green side darter	60
Hog sucker	14
Johnny darter	19
Logperch	51
Rainbow darter	41
River chub	12
Rosyface shiner	47
Silver Redhorse	2
Silver jaw minnow	21
Spotfin shiner	131
Steelehead	1
Stripped Shiner	426
Stonecat	95
Stoneroller minnow	126
White sucker	3
Yellow bullhead	17
Unidentifiable fish	38
Total	1753

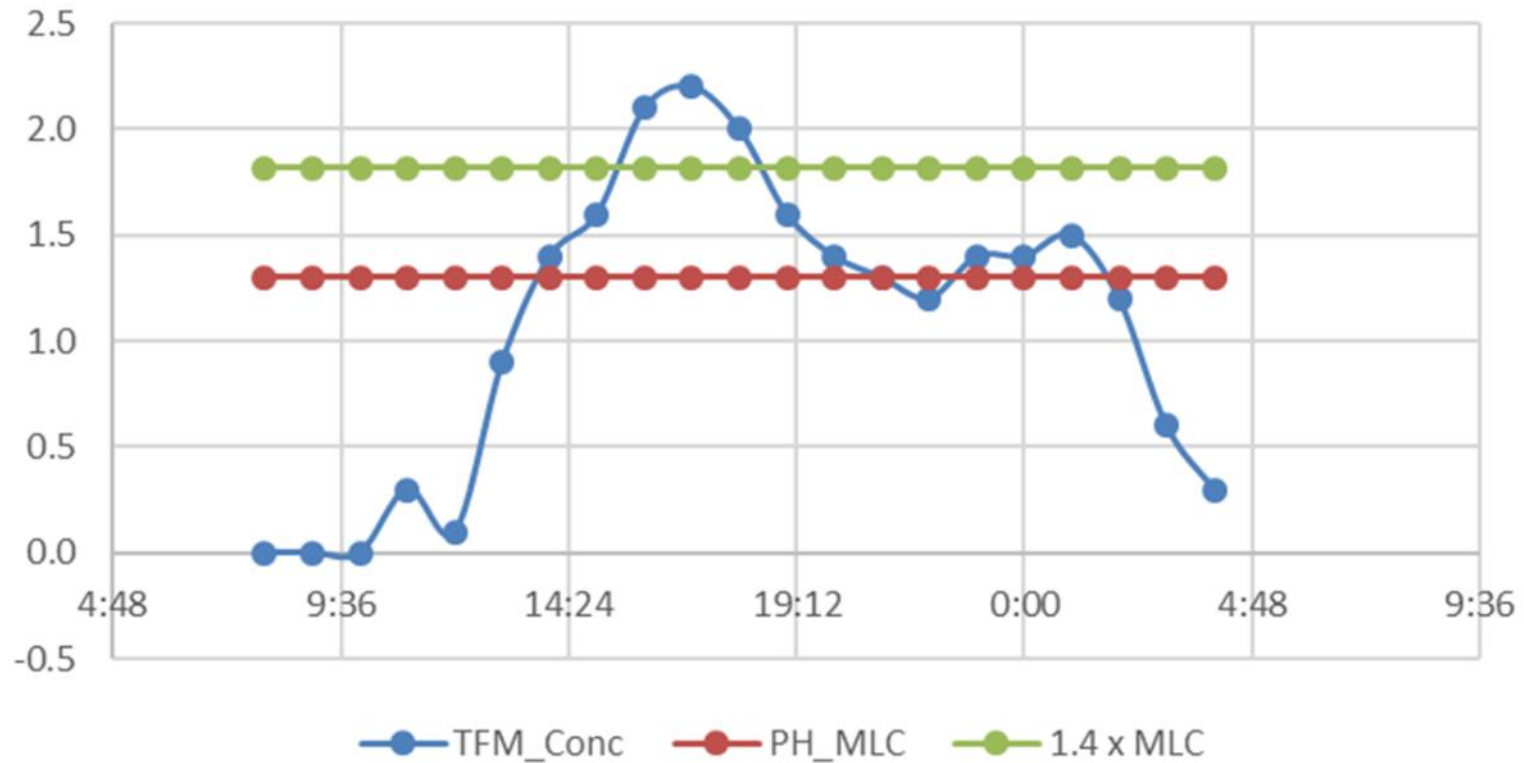
NONTARGET MORTALITY IN THE GRAND RIVER AT THE MOUTH OF MILL CREEK

The high flows only allowed collection of nontarget organisms in shallows near the bank. It is likely that the majority of organisms were not collected.

Many of the species collected are relatively tolerant of TFM so their presence indicates concentrations of TFM that greatly exceed MLC.

No sea lamprey larvae noted at this location.

Grand R. at Hidden Valley Park



Maximum concentration was 1.69 x provided MLC. Average TFM was 1.26 x provided MLC for roughly 9 hours.

NONTARGET MORTALITY IN THE GRAND RIVER BETWEEN 528 AND VROOMAN ROAD

Species	528 - Vrooman
Brindled madtom	5
Gizzard Shad	3
Hog sucker	5
Stonecat	51
Ichthyomyzon sp. (larvae)	35
Sea lamprey (adult)	2
Chestnut lamprey (adult)	1
Mudpuppy	3
Total	105

The high flows only allowed collection of nontarget organisms in shallows near the bank. It is likely that the majority of organisms were not collected.

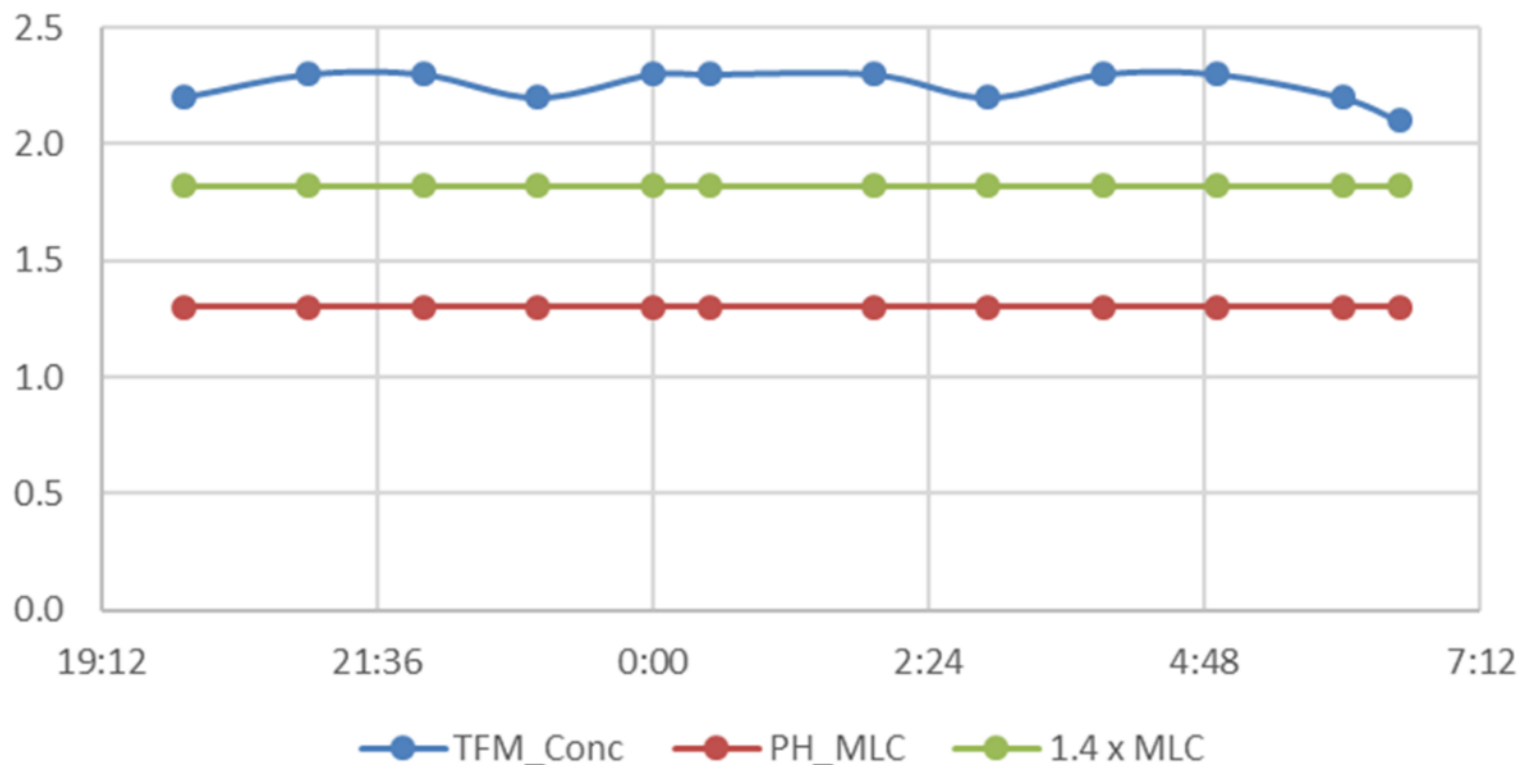
Even though it is believed that only a small fraction of the individuals were collected, the species found are some of the least tolerant to TFM.

The lack of tolerant species indicates that the concentrations of TFM were not greatly elevated above MLC or were not elevated for long periods of time.

35 lamprey larvae found but were not identified to species.

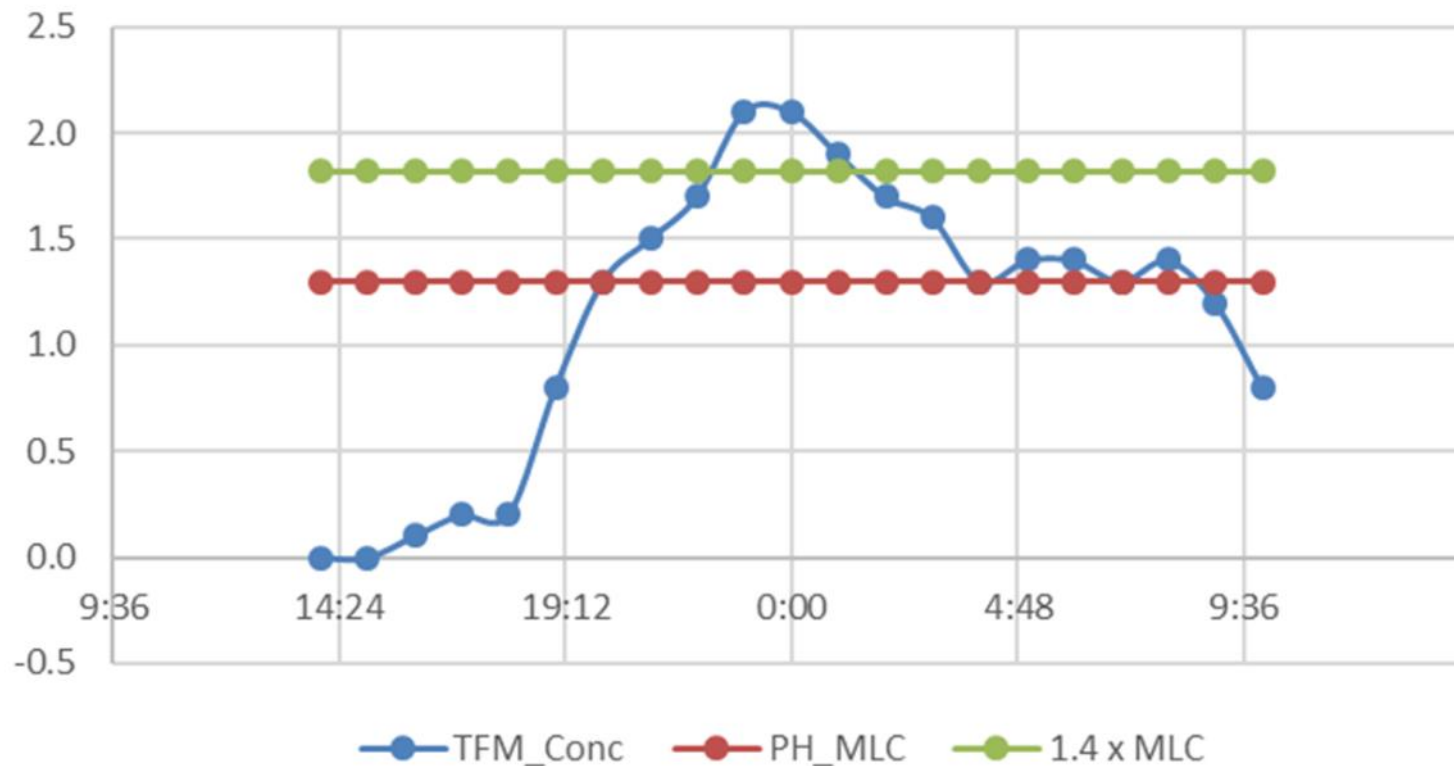
The TFM concentration only exceeded permit limits for approximately 3 hours and the maximum concentration was 1.69 x MLC.

Paine Cr. at Indian Point Park



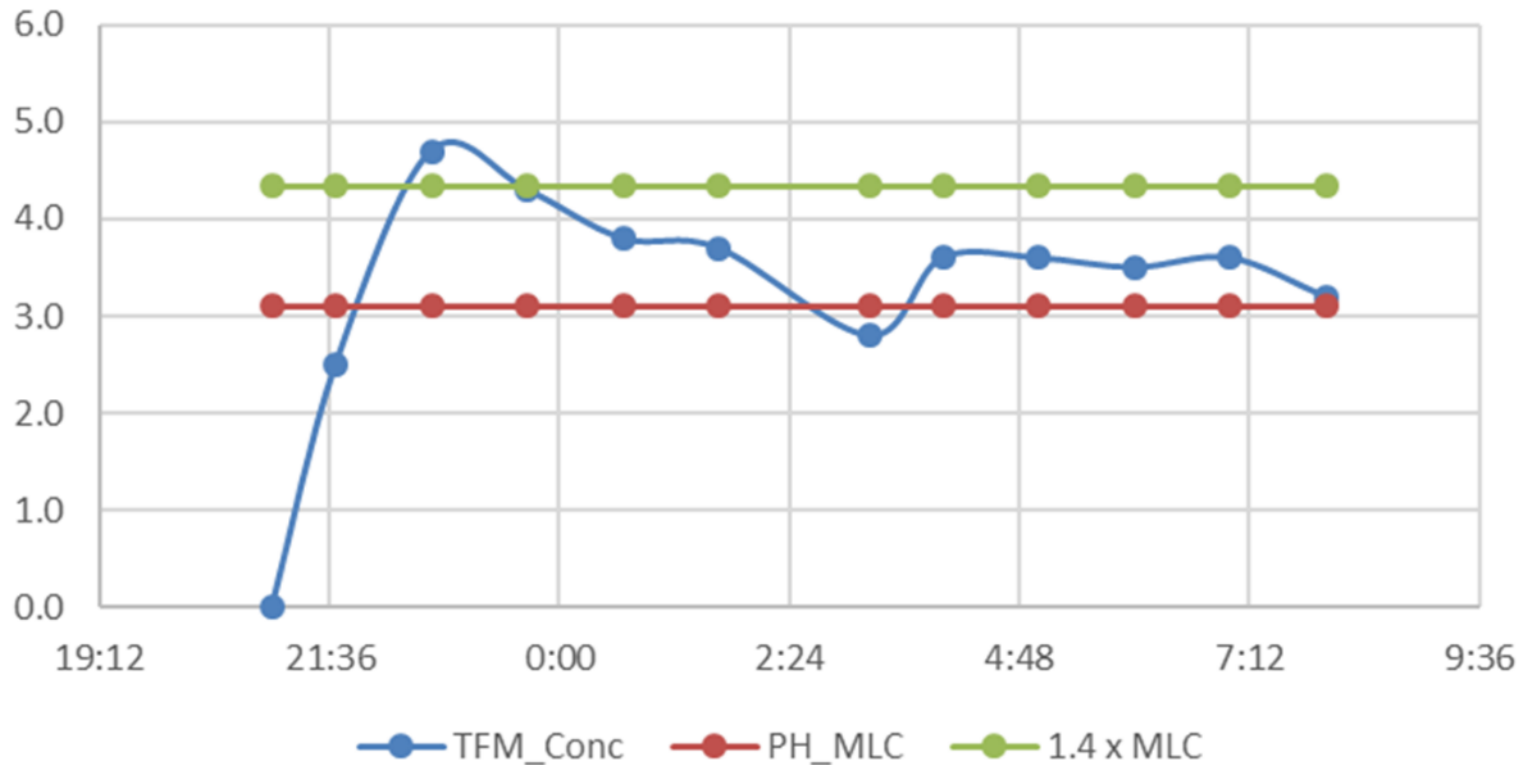
Maximum concentration was 1.77 x provided MLC. Average TFM was 1.7 x provided MLC for roughly 9 hours.

Grand R. at Vrooman Rd. Bridge



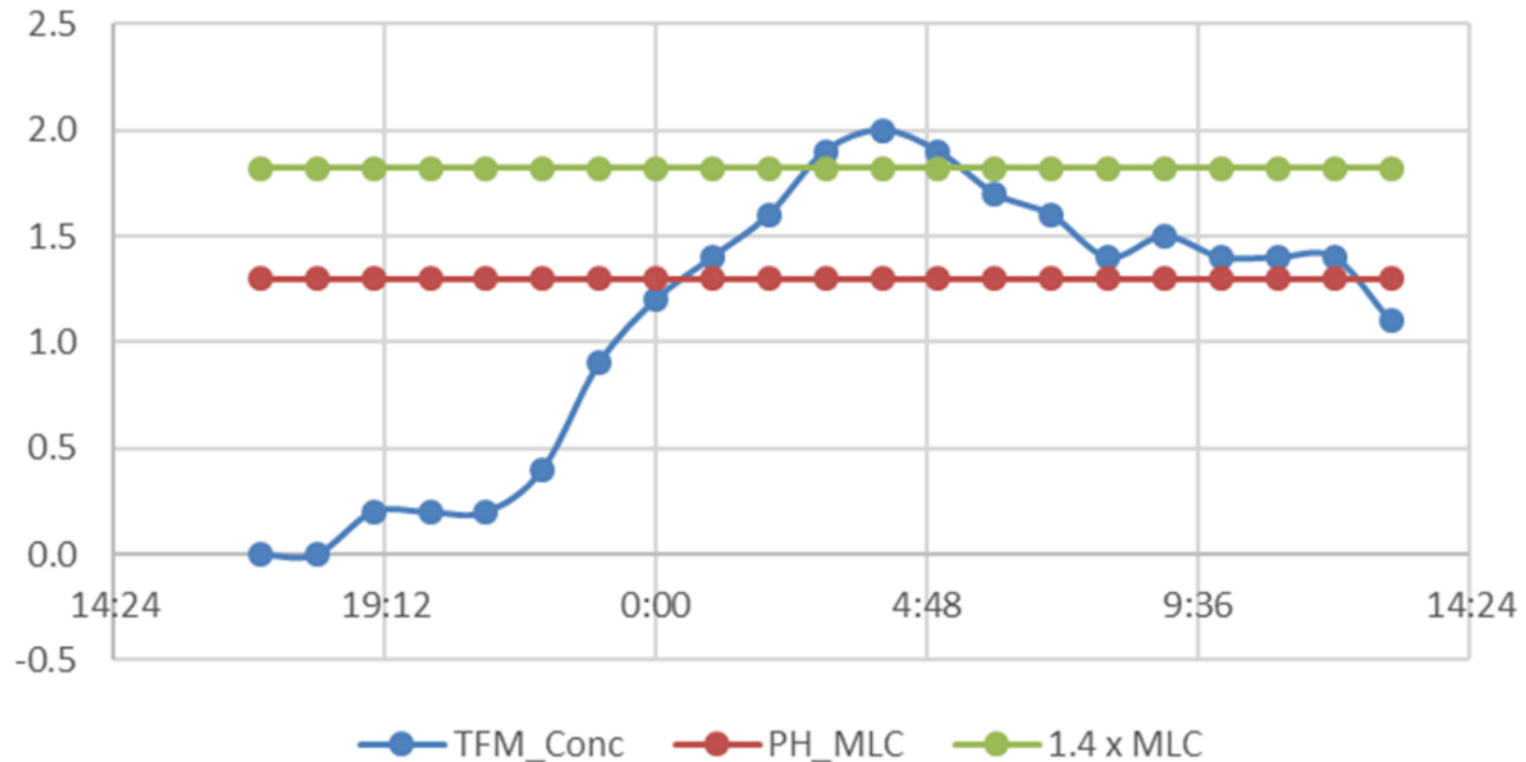
Maximum concentration was 1.62 x MLC and average for a roughly 9 hour period was 1.08 x MLC.

Big Cr. at jct. Kellogg Cr.



Maximum concentration was 1.52 x provided MLC. Average TFM was 1.15 x provided MLC for roughly 9 hours.

Grand R. at Walnut Ave. (SR 84) USGS guage



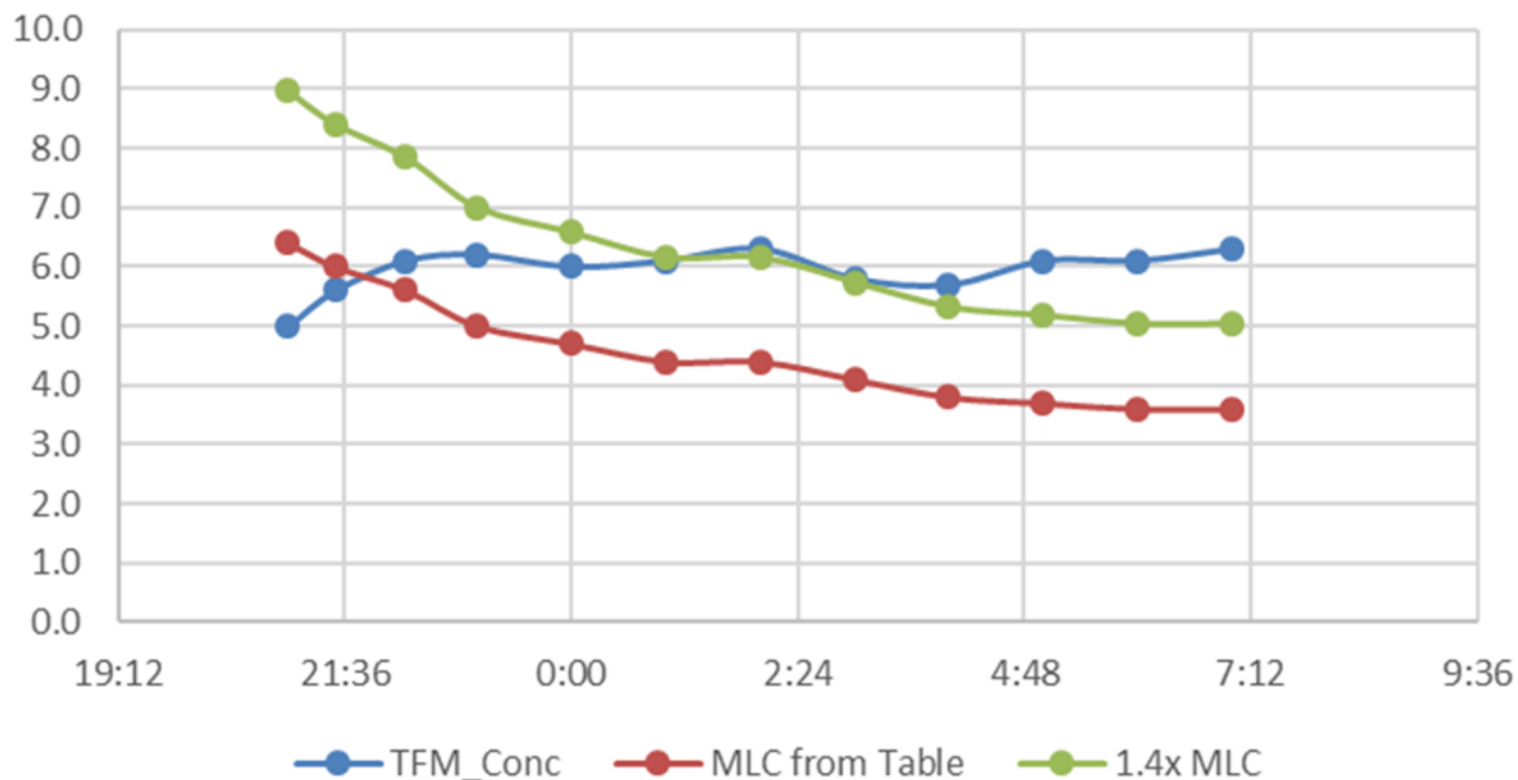
Maximum concentration was 1.54 x provided MLC. Average TFM was 1.28 x provided MLC for roughly 9 hours.

Huron River TFM Treatment 2018

Every station exceeded the permit limit of 1.4 x MLC in at least one sample.

Four stations average TFM concentration exceeded the permit limit of 1.4x MLC for a roughly 9 hour period.

E. Br. Huron R. just below low-head dam



The concentration is relatively stable but the MLC is decreasing which means the TFM is more toxic at that concentration. Maximum concentration was 1.75 x MLC and increasing when data stops. We have no data beyond what this graph shows.

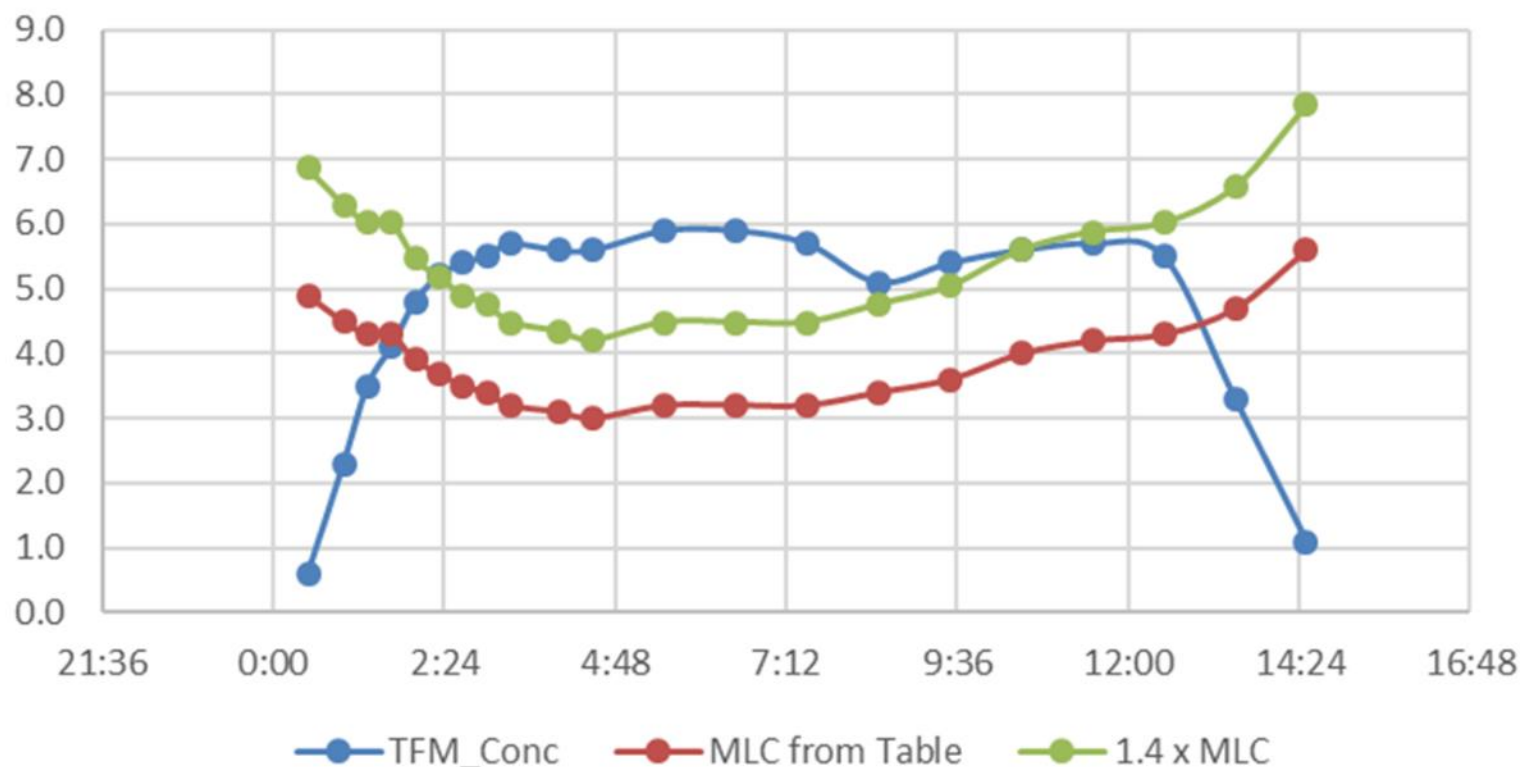
Species	Count
Blacknose dace	3
Bluntnose minnow	37
Bluntnose shiner	1
Yellow bullhead	2
Fantail darter	16
Hog sucker	1
Johnny darter	1
Logperch	1
Rainbow darter	2
Sand shiner	14
Silver jaw minnow	1
Spotfin shiner	2
Stonecat	1,427
Stoneroller minnow	176
White sucker	7
Ichthyomyzon sp. (larvae)	3
American brook lamprey (larvae)	431
Mudpuppy	2
Silver lamprey (adult)	1
Big eyed chub	703
Common shiner	3

NONTARGET MORTALITY ON THE EAST BRANCH OF THE HURON RIVER FROM THE LOW HEAD DAM TO LOVERS LANE

Nontarget mortality included 1,427 Stonecats and 431 American Brook Lamprey larvae. Only 3 unidentified lamprey larvae could be sea lamprey.

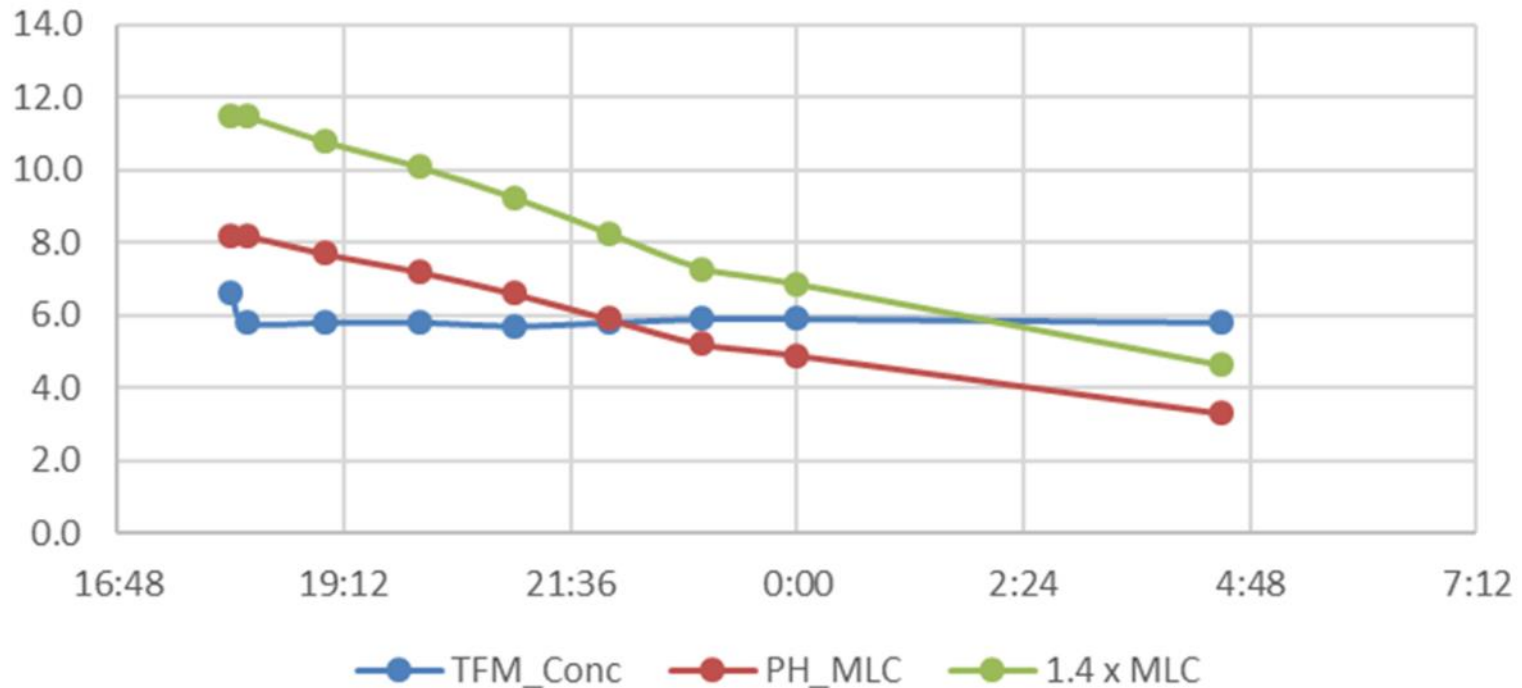
There is a possibility that more mudpuppies were present in this sample but were delivered to the Museum of Natural History and included in the total count for the Huron River.

E. Br. Huron R. at Washington Rd.



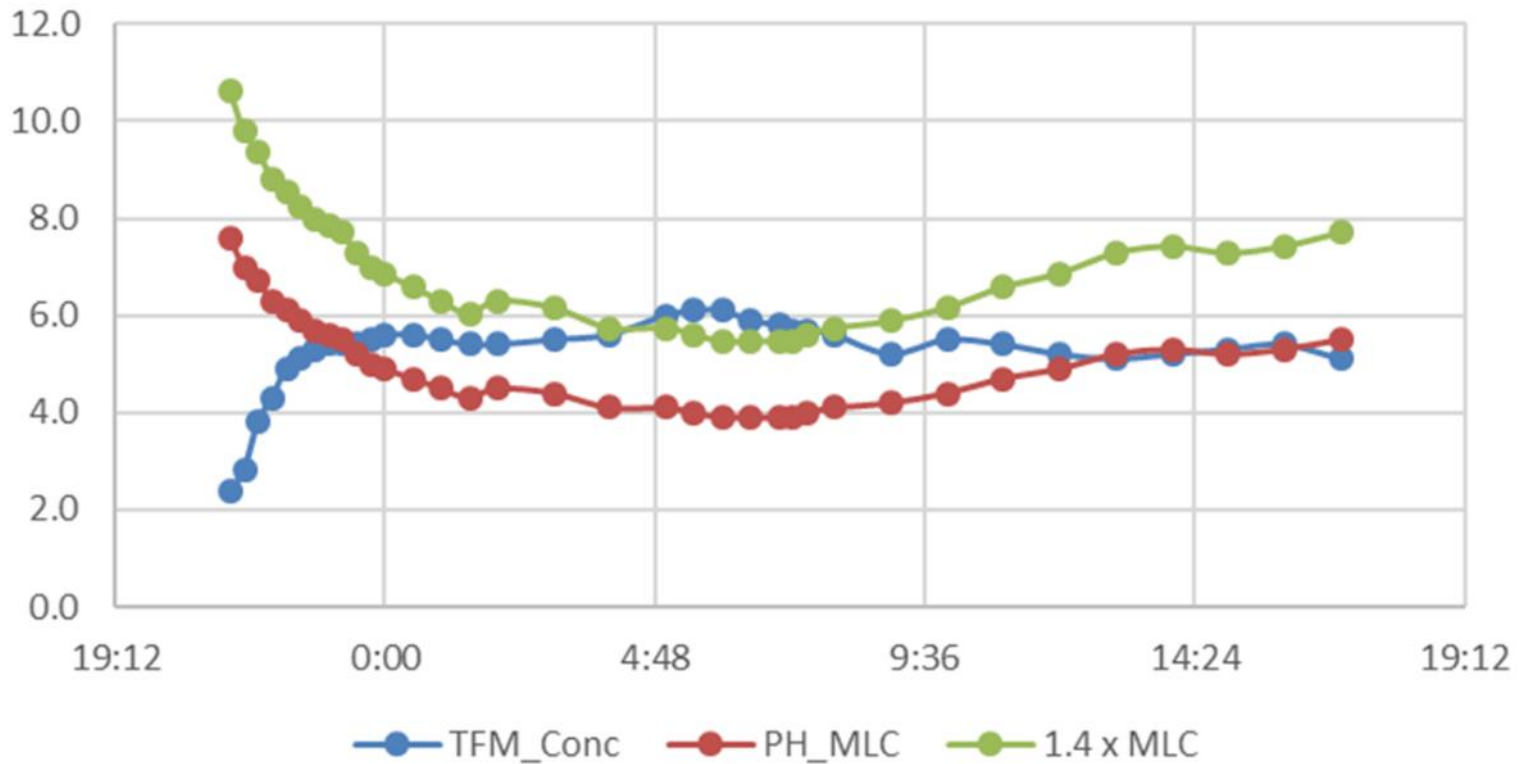
TFM concentration average 1.61x MLC for a roughly 9 hour period.
Permit limit is 1.4 x MLC maximum.
Maximum concentration is 1.87x MLC.

E. Br. Huron R. to Huron R. just below Washington Rd.



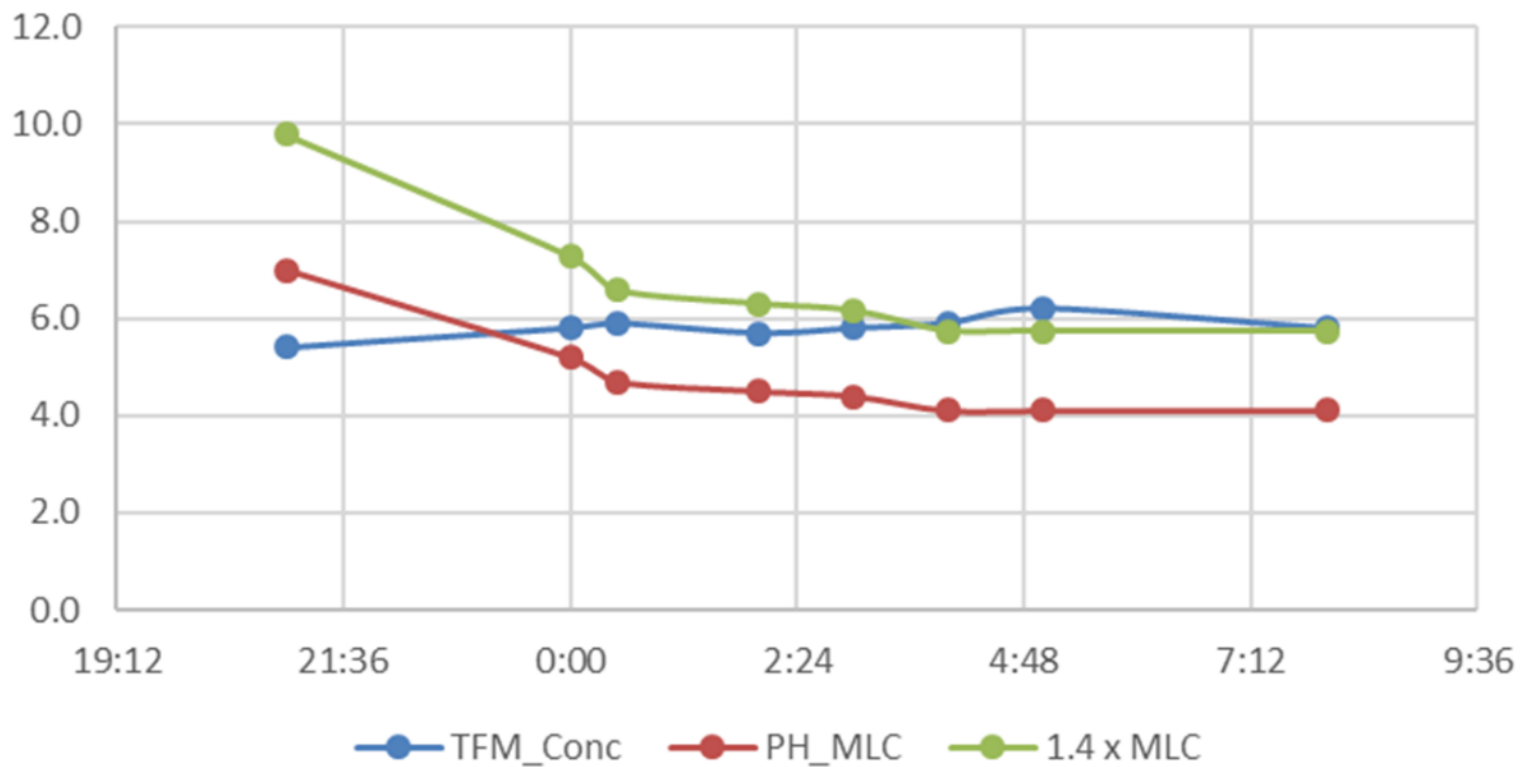
I do not understand why this graph looks so different from the previous slide since data was collected very close to this site. This slide indicates that the concentration remained relatively consistent while the MLC dropped causing increased toxicity. Toxicity is increasing at the end of the data. We do not have data after the last point on the graph.

E. Br. Huron R. at Schaefer Rd.



Maximum concentration was 1.56x MLC and average for a roughly 9 hour period was 1.17x MLC.

E. Br. Huron R. just below Schaefer Rd.



Maximum TFM concentration was 1.51x MLC.

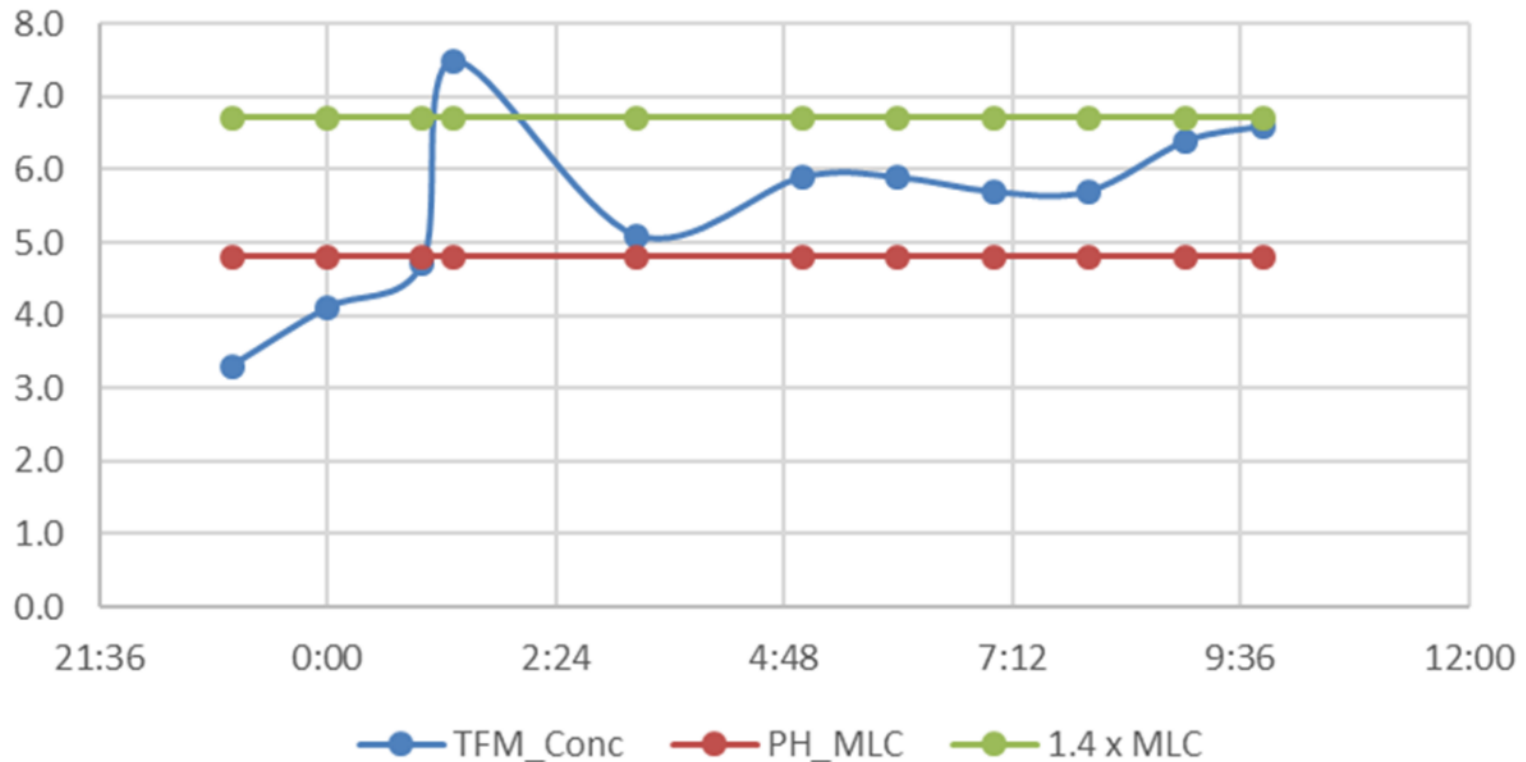
NONTARGET MORTALITY ON THE EAST BRANCH OF THE HURON RIVER FROM SHAEFFER ROAD TO MOUTH

Nontarget mortality included 598 stonecats (approximately 427 per mile) 114 bigeye chubs and 80 native lamprey larvae. Only three sea lamprey larvae found.

There is a possibility that more mudpuppies were present in this sample but were delivered to the Museum of Natural History and included in the total count for the Huron River.

Species	No.	Comment
Silver Lamprey	11	Two adults and nine ammocetes
Sea Lamprey	6	Three adults and three ammocetes
Am. Brook Lamprey	71	All ammocetes
White Sucker	1	
Golden Redhorse	1	
Black Redhorse	2	
N. Creek Chub	1	
Bigeye Chub	114	Among affected native cyprinids, this species appeared most susceptible to TFM.
Sand Shiner	8	
Mimic Shiner	2	
Spotfin Shiner	10	
Central Stoneroller	21	
Bluntnose Minnow	8	
Stonecat	598	209 vouchered, 389 field counted
Yellow Bullhead	2	
Log perch	26	
Rainbow Darter	1	
Fantail Darter	5	
Total: Species (18)	888	
Mudpuppy	3	Nearly all material given to Cleveland Museum of Natural History for further study. Hopefully will receive total count shortly.
American Toad	1	

W. Br. Huron R. at Lovers Lane



Original data did not provide MLC calculated for the pH of each sample. I do not know why this particular number was chosen for the MLC. Maximum concentration was 1.56 x MLC with only one sample above permit limits.

NONTARGET MORTALITY ON THE WEST BRANCH OF THE HURON RIVER JUST UPSTREAM OF THE EAST BRANCH

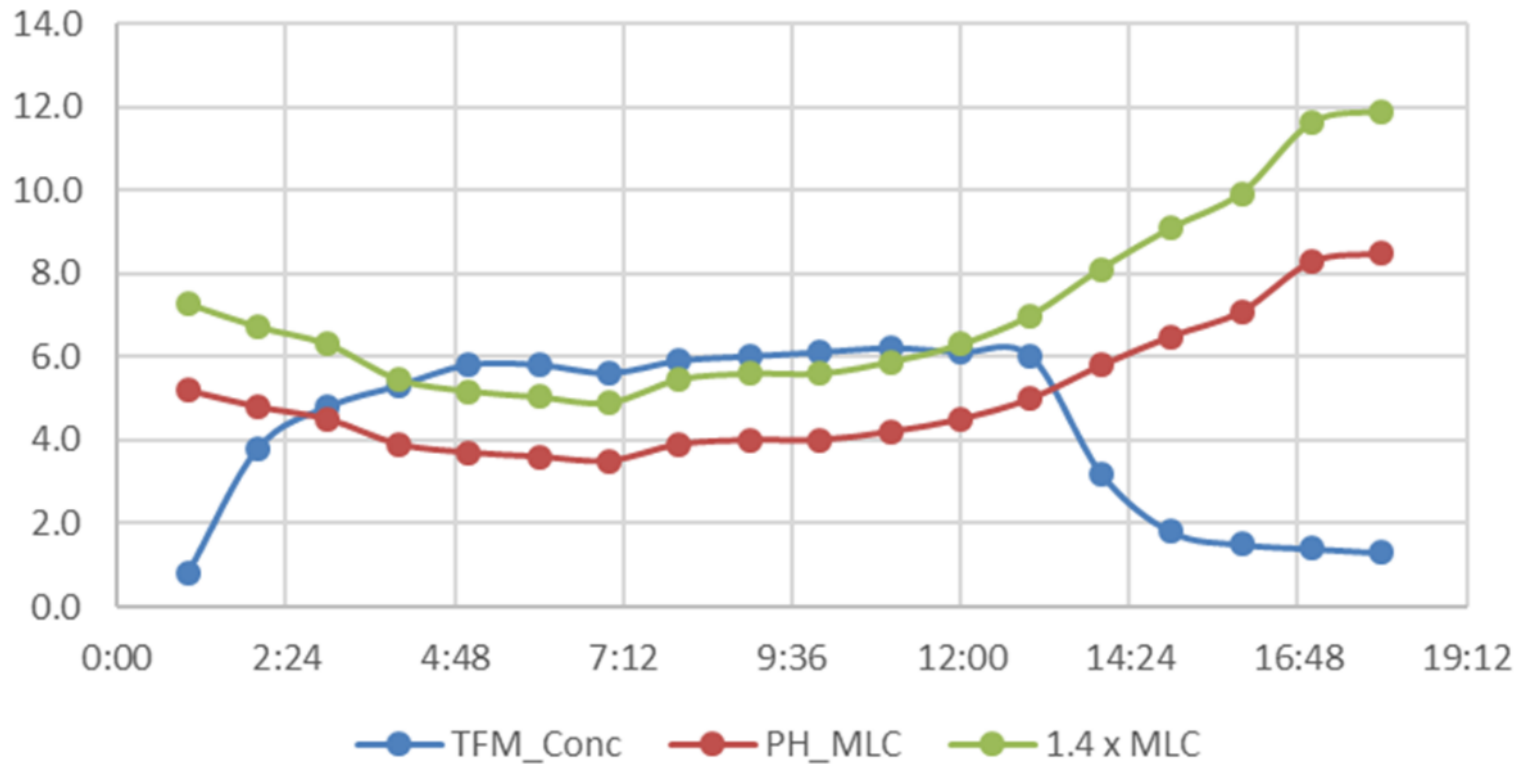
132 stonecats were collected in 0.4 miles which would correlate to approximately 330 per mile. No lamprey larvae of any species were collected.

There is a possibility that more mudpuppies were present in this sample but were delivered to the Museum of Natural History and included in the total count for the Huron River.



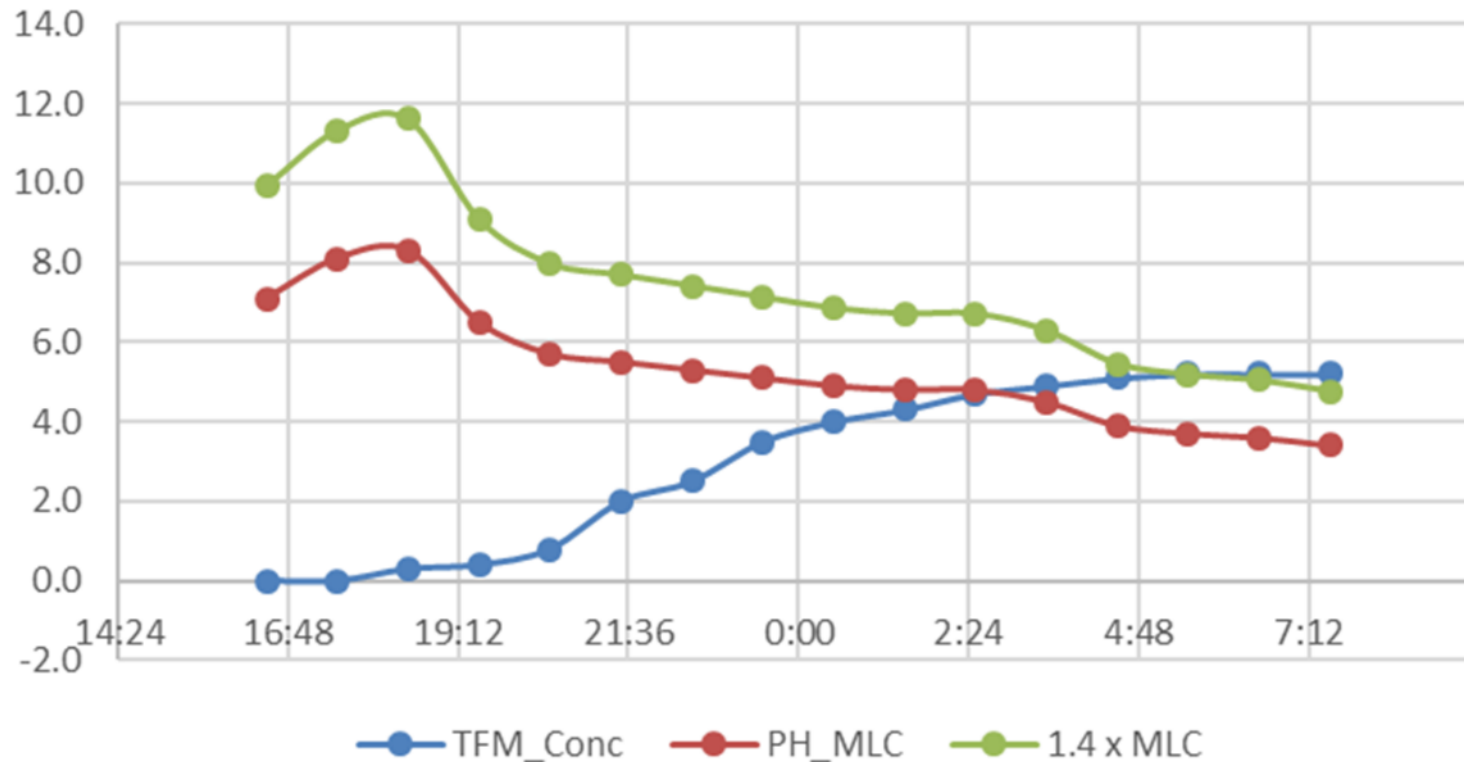
Species	No.	Comment
Northern Hog Sucker	6	
Bigeye Chub	27	Among affected native cyprinids, this species appeared most susceptible to TFM.
Common Shiner	1	
Sand Shiner	4	
Mimic Shiner	1	
Silverjaw Minnow	1	
Central Stoneroller	5	
Stonecat	132	Calculated to 330 per mile
Log Perch	47	
Greenside Darter	3	
Rainbow Darter	67	
Fantail Darter	12	
Total: Species (12)	306	
Mudpuppy	4	Post larval juvenile
Note: Lower West Branch sample processed on-site.		

Huron R. at US-250



This site is on the main river downstream of the confluence of the east and west branches. Maximum concentration was 1.61. Average for a roughly 9 hour period was 1.47 x MLC.

Huron R. at Mason Rd.



Mason Road is at the downstream end of the treatment and the concentrations were expected to be non lethal. TFM concentrations were still rising when the data was no longer collected. MLC is decreasing while TFM concentration is rising so toxicity may be increasing.

Coldwater Task Group. 2018. Report of the Lake Erie Coldwater Task Group, March 2018. Presented to the Standing Technical Committee, Lake Erie Committee of the Great Lakes Fishery Commission. Markham, Ontario, Canada.

Brege DC, Davis DM, Genovese JH, McAuley TC, Stephens BE, Westman RW. 2003. Factors responsible for the reduction in quantity of the lampricide, TFM, applied annually in stream tributaries to the Great Lakes from 1979 to 1999. *J Great Lakes Res* 29:500–509.

Boogaard et al., 2015. M.A. Boogaard, T.J. Newton, T.D. Hubert, C.A. Kaye, M.C. Barnhart. Evaluation of the acute toxicity of 3-trifluoromethyl-4-nitrophenol (TFM) to multiple life stages of *Epioblasma triquetra* and its host fish (*Percina caprodes*). *Environ. Toxicol. Chem.*, 34 (2015), pp. 1634-1641

M.A. Boogaard, T.D. Bills, D.A. Johnson. 2003. Acute Toxicity of TFM and a TFM/Niclosamide Mixture to Selected Species of Fish, Including Lake Sturgeon (*Acipenser fulvescens*) and Mudpuppies (*Necturus maculosus*), in Laboratory and Field Exposures. *J. Great Lakes Res.* 29 (Supplement 1):529–541