

# MISSOURI POLLUTION AND FISH KILL INVESTIGATIONS 2020



Report compiled by  
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## USE OF DATA

Data and information in this report are distributed for communicating incidents of water quality problems and injuries to fish and wildlife throughout the state of Missouri. By doing so, we hope to increase awareness of water pollution and natural causes of mortality in aquatic life. Readers should be aware that this report presents all incident reports received by Department of Conservation, and not all incidents presented in this report were directly observed by state officials. Floating trash, organic foam, and fillet remains are regularly reported as dead fish, so one should not assume a report of dead fish is a verified fish kill. Data from incidents not observed by state officials are not recommended for establishing permit limits or promulgating regulations. The reader may choose to use the data for other purposes beyond facilitating awareness, but the appropriateness of the data for those purposes must be evaluated by the user.

*Cover photographs: Top: Private pond, Audrain County, 5/12/20, Bluegill with a bacterial infection, Photo by landowner. Bottom-Left: Mississippi River, Scott County, 9/8/20, Fish kill in a backwater caused by low dissolved oxygen from receding flood waters, Photo by John West (MDC-Scientist). Bottom-Right: Tributary to Cold Water Creek, St. Genevieve County, 4/28/20, Large mats of diatoms, Photo by Jason Crites (MDC-Fisheries Management Biologist).*

## EXECUTIVE SUMMARY

The Missouri Department of Conservation (MDC) conducts fish kill investigations under the authority of the *Wildlife Code of Missouri* (Section 252.210, RSMo) and has maintained a Fish Kill and Pollution Program since the 1940s. The overarching goals of the program are to protect aquatic resources and to maintain high-quality fishing and recreational opportunities. We work towards these goals by 1) conducting fish kill and water pollution investigations so pollution abatement and mitigation is achieved and 2) increasing awareness of water pollution and mortality in aquatic life through reporting of incidents. The program is a partnership among multiple resource agencies; however, the Missouri Department of Natural Resources (DNR) is the primary partner.

During 2020, MDC personnel investigated 91 fish kill and water quality incidents. Animal mortality was associated with 72 of these incidents. Overall, at least 31,260 fish and other organisms were killed during these incidents. Incidents were placed into one of three major categories: regulated, non-regulated, and unknown cause. Regulated incidents are sub-categorized by pollution source: municipal, agricultural, industrial, transportation, and other. There were 26 regulated incidents, of which 17 involved a kill. An estimated 15,633 animals valued conservatively at \$80,936.86 were killed during regulated source pollution incidents. Municipal pollutants were the most common cause of regulated incidents. Non-regulated incidents are attributable to natural causes, such as disease, spawning stress, and low dissolved oxygen. During 2020, there were 56 non-regulated incidents, 48 of which, were fish kills. An estimated 15,494 animals died during non-regulated incidents. Personnel could not determine the cause of 9 incidents (unknown cause), 7 of which were fish kills. At least 133 animals died due to unknown causes. Monetary values (damages) for non-regulated and unknown fish kills were not calculated because damages for these kills are not reimbursed.

Cause	Total Number Incidents	Number Fish Kills
Regulated		
Municipal	12	11
Agriculture	4	2
Industry	2	0
Transportation	2	0
Other	6	4
Subtotal	26	17
Non-Regulated	56	48
Unknown	9	7
<b>Totals</b>	<b>91</b>	<b>72</b>

The summer season had the greatest number of incidents (26), followed by fall (26), spring (18) and winter (4). Most incidents occurred in ponds (35), followed by streams (30), and lakes (22). One incident was in a river backwater and three did not impact any body of water.

The DNR and the Missouri Attorney General enforced the incidents described in this report. Seven cases were resolved during 2020 through compliance and enforcement actions. Four of these cases involved civil legal agreements and consent judgements, which included reimbursements for natural resource damages and investigative costs totaling \$58,865.81 and civil penalties amounting to \$43,286. Thirty-five potentially enforceable incidents have not been resolved as of December 31, 2020.

An analysis of long-term trends (1988-2020) shows the number of regulated incidents peaked in the mid-1990s and overall declined from the mid-1990's to 2002. Since 2003, the number of regulated incidents has fluctuated between 10 and 40. Across pollution types, municipal pollutants are historically and currently the dominant cause of pollution incidents.

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## INTRODUCTION

The Missouri Department of Conservation (MDC) holds the authority to enforce the *Wildlife Code of Missouri* (Chapter 10, 3 CSR 10). According to the *Wildlife Code of Missouri*, it is illegal to cause or allow any deleterious substance to be placed, run, or drained into any waters of the state in quantities sufficient to injure, stupefy, or kill fish or other wildlife which may inhabit such waters. Under this mandate, MDC maintains a Fish Kill and Pollution Program. The goals of the program are to protect aquatic resources and maintain high-quality fishing and recreational opportunities. We work towards these goals by conducting fish kill and water pollution investigations, so pollution abatement and mitigation is achieved and by increasing awareness of water pollution and mortality in aquatic life through reporting of incidents. The program is a partnership among multiple resource agencies<sup>1</sup>; however, the Missouri Department of Natural Resources (DNR) is the primary partner.

During the investigation, MDC determines the size of the affected area, estimates the number of organisms killed, calculates a monetary value for those organisms, and distributes collected information to interested personnel and agencies. Although MDC has the authority to prosecute responsible parties for killing fish under the *Wildlife Code of Missouri* (Section 252.210, RSMo), compliance and enforcement action is usually deferred to DNR who holds the authority to enforce *Missouri Clean Water Law* (Chapter 644, RSMo). Two additional roles of DNR during investigations are overseeing the clean-up of spills and acting as the incident command center (Missouri's Spill Bill, sections 260.500-260.550, RSMo).

This report is a summary of all fish kills and pollution events involving MDC staff during 2020.

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<sup>1</sup> Missouri Department of Natural Resources, Missouri Department of Health and Senior Services, Missouri Department of Agriculture, U.S. Environmental Protection Agency, U.S. Coast Guard, U.S. Fish and Wildlife Service, and U.S. Army Corps of Engineers are other agencies that may be involved during investigations.



## METHODS

MDC conducts fish kill investigations under the authority of the *Wildlife Code of Missouri* (Section 252.210, RSMo). This is communicated to all MDC staff through a memo distributed by the Deputy Director of Resource Management. The memo states that all MDC employees are responsible for reporting water quality problems, water pollution, and fish kills that are noted during the performance of their normal job duties and for assisting with the investigation, if needed.

MDC and DNR have a cooperative agreement which streamlines investigations. Under the cooperative agreement, the DNR-Environmental Emergency Response (EER), which operates a 24 hour a day environmental emergency spill line, notifies DNR and MDC staff statewide during fish kills and water pollution events which have potential to injure fish and wildlife. As part of the cooperative agreement, MDC Environmental Health Unit supplies EER with contact lists of MDC regional staff for use during normal business hours and a contact list of protection district supervisors for use after normal business hours. In the summer of 2020, MDC Environmental Health Unit also began providing EER with an online application which notifies MDC staff by email and phone text messaging. All DNR and MDC staff learning of or discovering a fish kill are to notify the EER spill line as soon as possible as a precautionary measure. On-scene, DNR collects environmental samples and data for evidence and ensures the pollution is remediated, if possible.

MDC's conservation agents and fisheries management staff are the primary responders to fish kill and pollution incidents where there is potential for fish and wildlife injury; however, any MDC staff may respond to incidents if properly trained. The presence of conservation agents in each county of the state allows for an immediate assessment of the incident and action which may prevent greater injury to the resource. During an investigation when time is crucial and/or DNR personnel cannot respond, these procedures minimize environmental damage and ensure useable evidence that may otherwise be lost.

The objectives of the MDC investigator are to determine the likely cause of the fish kill or water pollution incident, prevent additional damage by containing the pollution (if possible), and to determine the extent of the damage to the resource. The MDC investigator conducts water chemistry screening at the source of the pollution, upstream, and downstream of the pollution source. This procedure aids in determining the cause of the fish kill or water quality problem. Water chemistry measurements include temperature, pH, dissolved oxygen, and unionized ammonia. Water samples are also collected in these three locations if DNR has not arrived on-scene.

During 2020, fish counting procedures outlined in *Investigation and Monetary Values of Fish and Freshwater Mollusk Kills* (Southwick and Loftus 2017) were followed. The species and size of dead fish are recorded within the affected area. If the affected area is subsampled, the Environmental Health Unit (EHU) extrapolates the total number of dead fish and wildlife. These methods are labor intensive and therefore are not usually used for natural fish kills (*non-regulated*) where investigative costs are not reimbursed. Once the total number of dead fish and wildlife is determined, the EHU calculates a monetary value (damage). Damages are not usually calculated for cases with an unidentified responsible party, cases with *unknown* causes, or incidents occurring in private waters. A report of investigative activities, findings, and damages is compiled for each *regulated* incident (incidents with identified pollution sources). Copies of these reports are distributed to DNR and other interested agencies.

Fish kill and pollution cases with a responsible party are typically enforced by DNR under the *Missouri Clean Water Law* (Chapter 644, RSMo) or the *Clean Water Act*. By holding the offender responsible,

restitution is achieved. Restitution consists of reimbursements for fish damages and investigative costs, completion of supplemental environmental projects, and payment of penalties, which DNR assesses. Damages are directed to two separate funds: ninety percent of damage reimbursements are directed to projects benefiting aquatic resources through the Fish Kill Grant fund and ten percent of damage reimbursements are directed to the Chemical Emergency Preparedness Fund (Section 640.235, RSMo). Penalty monies are transferred to the county school system in which the pollution event occurs. This report contains information on case status and reimbursements received as of December 31, 2020.

MDC tracks information on fish kills and pollution incidents in a central database, including incidents that have not been directly reported to MDC. However, the focus of this report is incidents where MDC personnel were directly involved in the investigation. Reports of false kills (e.g. angling mortalities) are not included in this report. Additionally, the main body of this report does not summarize other activities of the Fish Kill and Pollution Program. Highlights of these activities can be found in Appendix A.

## RESULTS AND DISCUSSION

MDC personnel investigated 91 fish kill and water quality incidents during 2020 (Table 1). Fish kills occurred in 72 of the incidents. An estimated 31,260 fish and other organisms were killed. The remainder of the results and discussion is broken down by incident causes, temporal trends, spatial trends, enforcement status, projects funded by fish kill grants, and long-term trends.

Table 1. Summary of fish kill and water quality investigations conducted by MDC staff during 2020. Animals killed include all fish and wildlife species killed during an event.

Cause	Total Number Incidents	Number Kills	Number Animals Killed	Value of Animals Killed
Regulated				
Municipal	12	11	11,925	\$75,307.58*
Agriculture	4	2	1,306	\$1,348.98
Industry	2	0	0	\$0.00
Transportation	2	0	0	\$0.00
Other	6	4	2,402	\$4,280.30
Subtotal	26	17	15,633	\$80,936.86
Non-regulated	56	48	15,494	Undetermined
Unknown	9	7	133	Undetermined
<b>Totals</b>	<b>91</b>	<b>72</b>	<b>31,260</b>	<b>\$80,936.86</b>

\* At the time of publication data for one incident is not available. Total does not reflect all 2020 municipal damages.

### INCIDENT CAUSES

Incidents are placed into one of three major categories: regulated cause, non-regulated cause, and unknown cause. For purposes of this report, incidents with *regulated* causes are those which have a known source of pollution, incidents with *non-regulated* causes are attributable to natural processes, and incidents with *unknown* causes are those which investigators could not determine the source or cause of the problem. A list of regulated incidents, non-regulated incidents, and incidents with unknown causes can be found in appendices B, C, and D.

### Regulated Cause

Incidents falling in the *regulated* category are broken down by the source of pollution: municipal, agricultural, industrial, transportation, and other sources. There were 26 regulated incidents, which accounted for over 29% of all incidents in 2020 (Figure 1). Of the 26 regulated incidents, 17 resulted in fish and wildlife mortality. An estimated 15,633 dead fish and wildlife were recorded for all 17 fish kills. Monetary damages totaled \$80,936.86 (Table 1); this total does not reflect the full total at the time of publication due to injury data being unavailable to calculate damages from one kill. Municipal source pollutants (e.g. municipal wastewater, drinking water, and electric facilities) were the leading cause of regulated incidents in 2020, accounting for 46% of all regulated investigations (Figure 1).

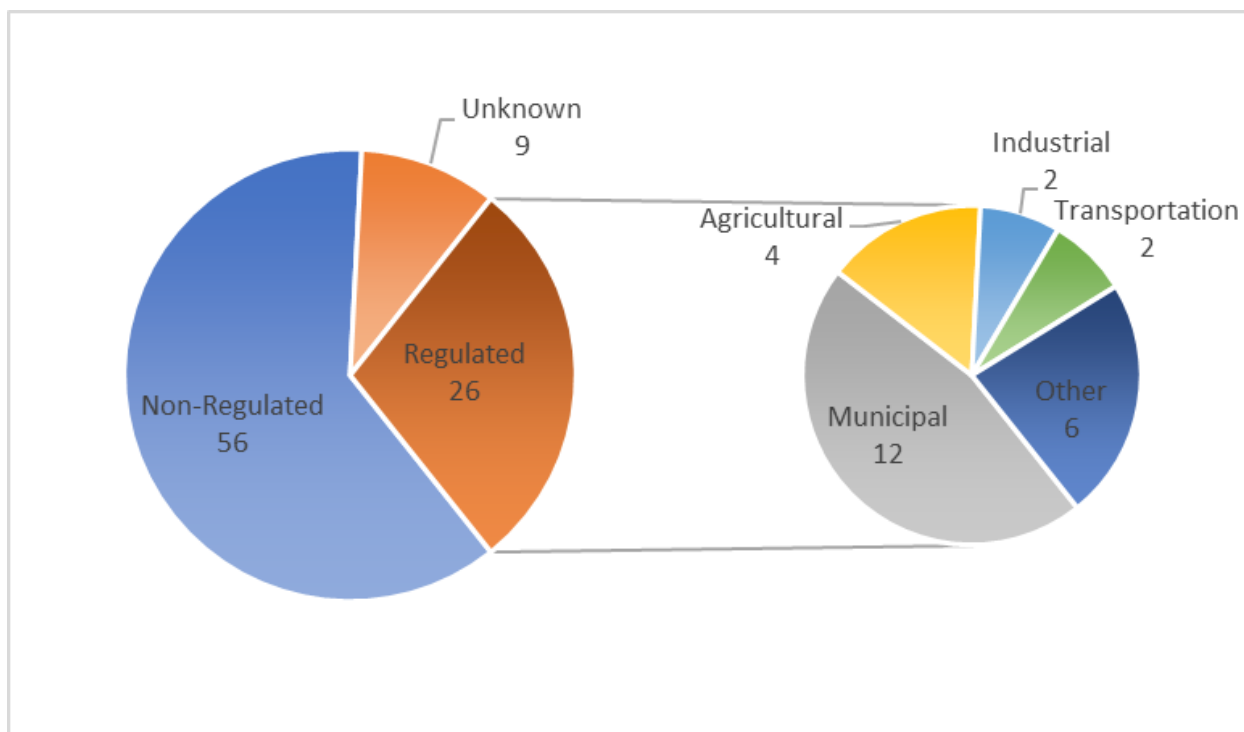


Figure 1. Number of incidents by pollution source in 2020.

### *Municipal Source*

Incidents falling in the municipal source category include, but are not limited to municipal waste, drinking water, and electric facilities. Municipal pollutants were involved in 12 incidents. Eleven of these resulted in the death of at least 11,925 fish and aquatic life valued at \$75,307.58 (Table 1). Municipal pollutants were the leading cause of regulated incidents in 2020, accounting for over 46% of all regulated investigations (Figure 1).

The most significant incident in this category occurred in Henry County on March 28<sup>th</sup>, 2020. Reductions in flow through Montrose Dam, operated by Evergy (formerly Kansas City Power and Light Company), led to fish stranding and hypoxia in Deepwater Creek, the receiving stream. MDC investigated on March 28<sup>th</sup> and documented 2,173 fish valued at \$3,828 in the pool immediately downstream of the dam. MDC observed dead fish up to 1-mile downstream from the dam; however, multiple anglers were present at stream access points and Covid-19 guidelines prevented the assessment of fish throughout this 1-mile zone. Fish counts presented here do not represent all fish mortality. Taxa observed include mostly channel catfish (1,838; 8-25 inches long), crappie, drum, carpsuckers, bluegill, white bass, largemouth bass, and common carp. Evergy is constructing housing for installation of a weather station, elevation gauges, warning sirens, and cameras that will allow them to lower the water level remotely from the power station in Kansas. It is unclear if remote water quality equipment will be installed to ensure dissolved oxygen levels are maintained for aquatic life. A fish kill occurred at this same location in April 2019. In the 2019 event, lack of flow over the dam resulted in low dissolved oxygen in the pool below. Eighty-five dead fish were valued at \$2,771.68 in the 2019, but enforcement action was not pursued.

### *Agricultural Source*

Agricultural source pollutants include, but are not limited to animal waste, fertilizer, and pesticides. During 2020, agricultural source pollution represented 4 incidents, 2 resulted in fish and wildlife mortality. Agricultural sources killed 1,306 fish and wildlife at the value of \$1,348.98. The most significant agricultural incident of 2020 occurred at Emerald Dairy Farm in Barton County on June 15<sup>th</sup>, 2020. A pipe collar broke resulting in the discharge of manure from Emerald Dairy Farm. Manure entered Pettis Creek reducing dissolved oxygen to lethal levels for gilled organisms. MDC staff observed 1,305 dead fish and 1 dead tadpole during this event. Taxa of dead fish included topminnows, stonerollers, darters, common carp, bullheads (129 total count; 3-12 inches long), sunfish (1,110 total count; 2-7 inches long), and largemouth bass (34 total count; 4-15 inches long). Dead fish and wildlife are valued at \$1,348.98. DNR is evaluating this case for enforcement action.

### *Industrial Source*

Industrial source pollutants include but are not limited to organic and chemical wastes generated by industrial operations and habitat destruction related to gravel mining operations. During 2020, two incidents were attributed to industrial pollution. Neither of these events resulted in dead fish or wildlife. One incident involved a large amount of sediment flowing into Sugar Branch, in Boone County on July 27<sup>th</sup>, 2020. A construction company failed to erect sediment fencing and appropriate retention ponds before leveling the property, causing large amounts of sediment to flow in the stream turning a once clear stream into a chocolate milk-like color. It was unclear if any animals were killed due to the lack of visibility. Excessive sediment deposits on a stream bed can significantly alter and degrade habitat, increase water temperature and lead to a decrease in dissolved oxygen which can kill aquatic life, and can affect how well aquatic organisms can see or function. Excessive turbidity is known to clog the gills of fish, interfere with their ability to find food, and bury bottom dwelling organisms and eggs.

### *Transportation Source*

Incidents falling within this category involve pollutants originating from pipelines, aviation, rail, boat, and road vehicle sources. During 2020, MDC was involved in two transportation-related pollution incidents, neither involved fish kills.

The first incident was reported by a private citizen that noticed the creek behind his house was running very high and there had not been any rain recently. The nearby Magellan Pipeline Company had drained its retention pond into the tributary of Gans Creek in Boone County due to its high water levels. The second incident involved a submerged truck in Lawson City Lake in Ray County. The truck was allegedly leaking diesel gas into the water. A conservation agent coordinated the response with local authorities.

### *Other Source*

Other regulated sources of pollution include, but are not limited to dewatering, fire suppression run-off water, and pesticide application in residential areas. "Other" source pollution was associated with six incidents, four of which resulted in a fish kill (Table 1).

On September 10, 2020, the United States Army Corps of Engineers (USACOE) were replacing a bulkhead gate in the spillway tower of the Dam on Long Branch Lake in Macon County. Since the divers would have to be inside the spillway tower, flows through the dam had to stop. These activities during 2019 resulted in a low dissolved oxygen fish kill below the dam. During 2020 to mitigate fish kills the USACOE installed an aeration system with four diffusers and set up a pump to splash water onto the concrete apron of the spillway. By the evening of day 1, the dissolved oxygen levels were 1.9 mg/L and biologists counted a total of 44 dead fish. In response to inadequate dissolved oxygen levels and the fish kill, the

USACOE set up an additional 5 pumps along the apron of the spillway basin increasing dissolved oxygen levels to 2.5-6.0 mg/L and preventing additional fish mortalities. In total, 209 fish were killed during the repairs at an estimated value of \$452.21. Due to the issues from the previous year, a virtual meeting was set up to discuss actions the USACOE needed to take to prevent fish and mussel mortality going forward and how much MDC on-site presence was needed.

### **Non-Regulated Cause**

Incidents within this category include those occurring due to natural causes such as lake inversion, summer and winter kill, disease, and spawning stress. Kills caused by non-point source nutrient pollution often cannot be differentiated from natural dissolved oxygen kills. Therefore, eutrophication from non-point sources is included in this category. Non-regulated incidents commonly present multiple related causes of death. For example, non-point source nutrient enrichment causes algal blooms, which deplete dissolved oxygen at night resulting in fish kills.

Fifty-six non-regulated incidents occurred, which comprised 62% of all incidents during 2020 (Figure 1). Forty-eight of these incidents were fish kills. An estimated 15,493 dead fish and aquatic organisms were observed during non-regulated incidents. However, this is an underestimate as thorough fish counts and damage assessments are not conducted for most non-regulated incidents because investigative time and damages are not reimbursed.

Low dissolved oxygen levels were the primary cause in 2020, comprising 75% of all non-regulated events. Most notable was on Wakenda Creek in Carroll County on August 17, 2020. More than one report was created due to the large number of dead silver carp and the drifting of these carp into the Missouri River. The investigator walked approximately 7 miles of the stream counting dead fish. In total there were upwards of 10,000 dead fish, comprising mostly of 10-inch silver carp. Catfish species and other carp species were also present, but not in exorbitant numbers. Due to the number of reports made of this kill, Communications Branch notified the public of the incident through social media.

### **Unknown Cause**

Personnel were unable to identify the source or cause of the water quality problem for nine incidents (Figure 1). An estimated 133 fish and mussels died in seven of these incidents (Table 1). The most notable incident due to unknown causes was in Franklin County on September 23<sup>rd</sup>, 2020 on the Bourbeuse River. An environmental consultant notified the US Fish and W and MDC of a mussel kill down stream of our Union Access. The consultant noticed thick mats of algae which seemed to be fed by wastewater discharge upstream of the kill site. MDC investigated and confirmed and collected 3 dead mussels at a value of \$473.55. Other pieces of mussel were also collected. All dead mussels collected were common species; however, this incident raised concerns for the federally endangered mussels living in the stream.

## TEMPORAL DISTRIBUTION

Seasonally, the distribution of kills throughout the year presented a bell-shaped pattern similar to previous years (Figure 2, O'Hearn and Abel 2019, 2020). Across seasons, the most regulated, non-regulated, and total incidents occurred during summer and the least occurred during the winter. Across months, the most regulated incidents occurred in September (6 incidents) and the most non-regulated incidents occurred in July (18 incidents).

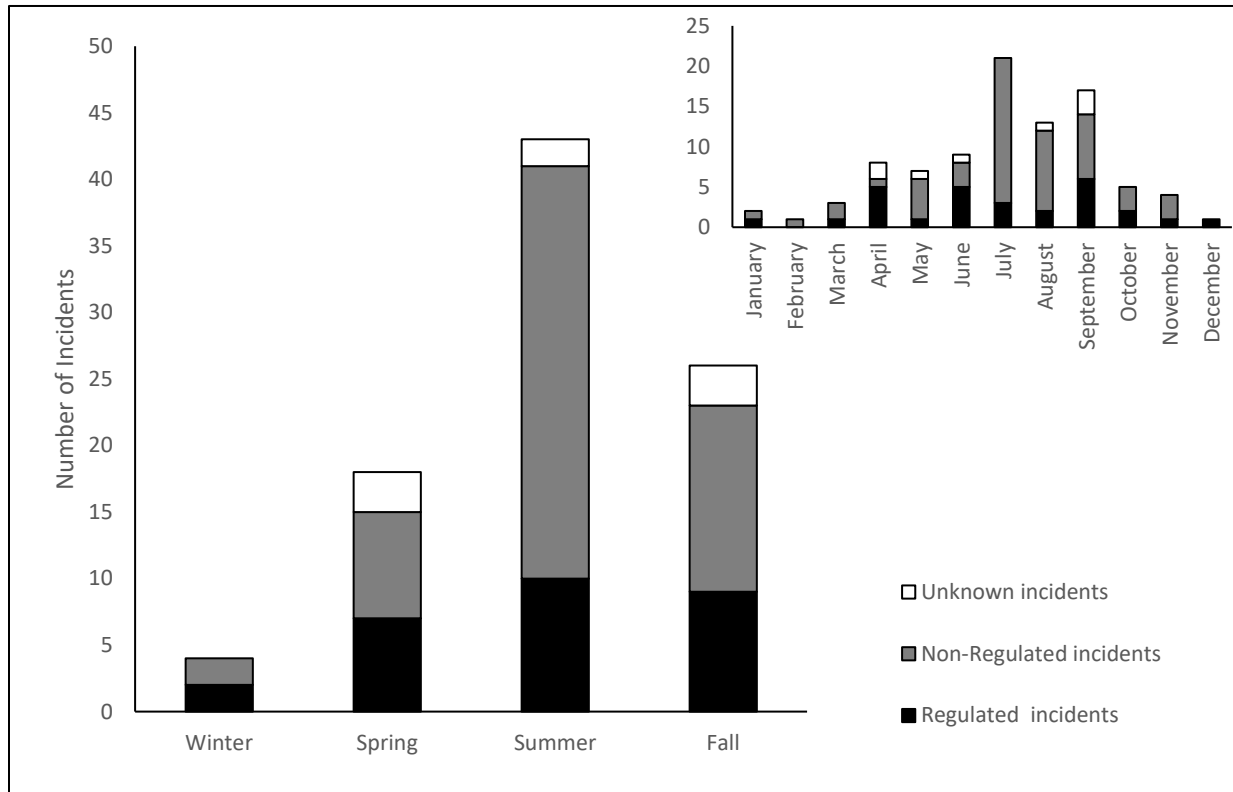


Figure 2. Monthly and seasonal distribution of regulated, non-regulated, and unknown source incidents during 2020.

## DISTRIBUTION OF INCIDENTS THROUGHOUT THE STATE

Investigations took place in 46 of 115 counties. The Department's Central Region experienced the most incidents (28 incidents), while the Ozark experienced only two incidents (Figure 3). Among counties, St. Charles County had the highest number of incidents (9 incidents). Among major source categories, the most regulated incidents (three) occurred in Boone and St. Charles Counties (Figure 4). The most non-regulated incidents occurred in St. Charles County (6 incidents).

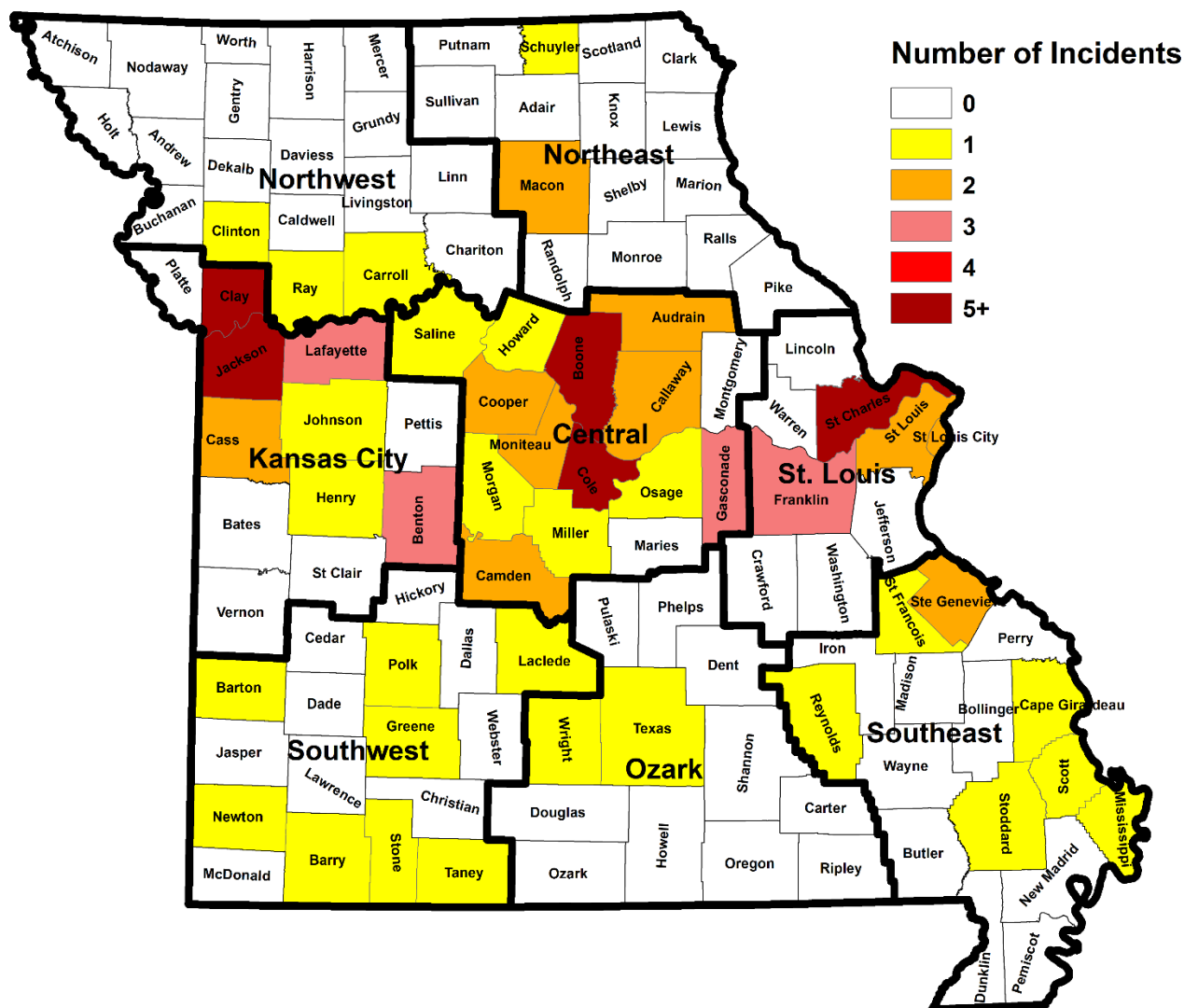


Figure 3. Map of number of incidents per county during 2020. The eight regions for the Missouri Department of Conservation are outlined in bold.



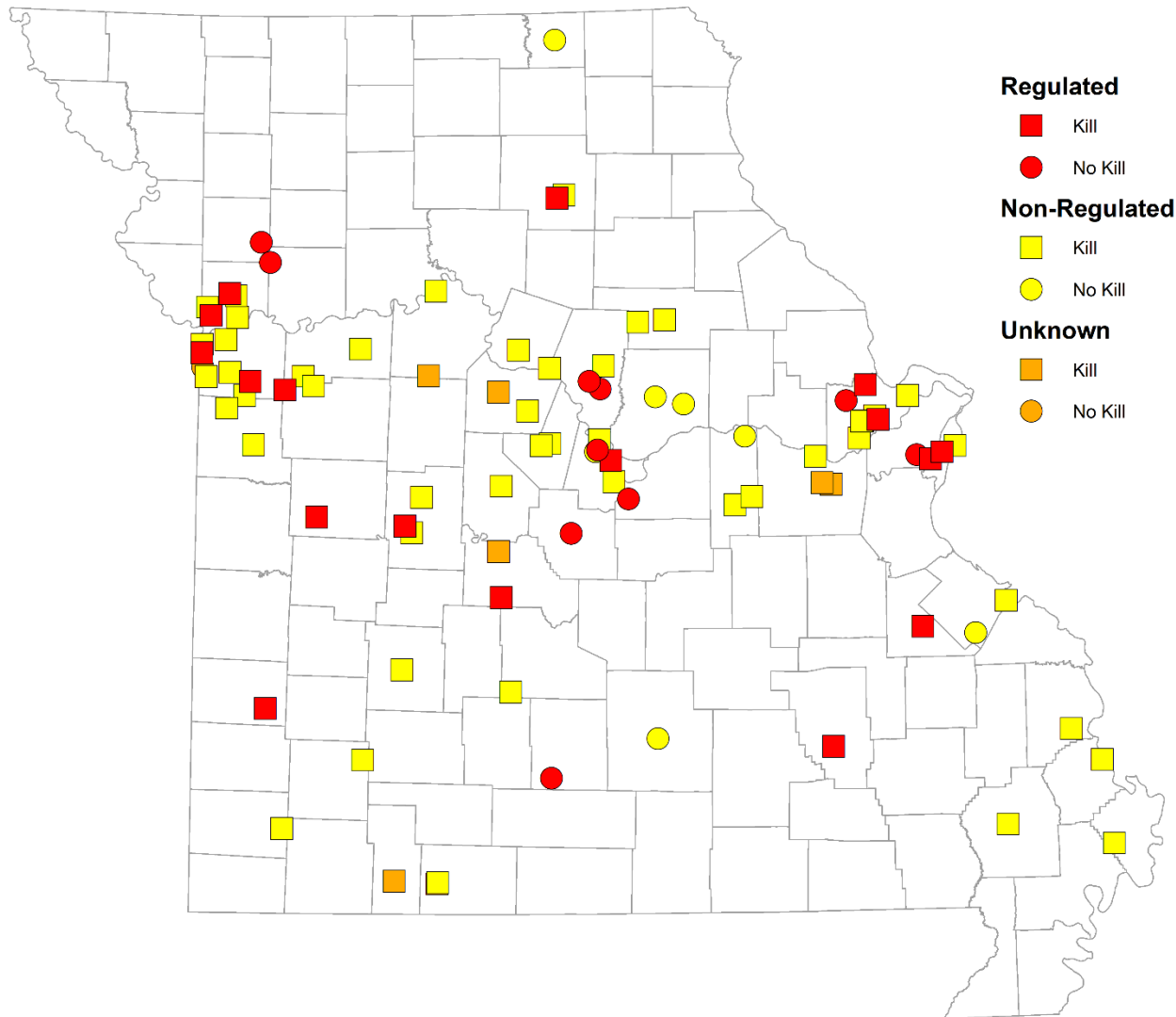


Figure 4. Map of regulated, non-regulated, and unknown source investigations conducted by Missouri Department of Conservation personnel during 2020. Squares indicate fish kills and circles indicate investigations without fish kills.

### DISTRIBUTION BY HABITAT TYPE

Among habitat types, incidents occurred more often in ponds than in streams and lakes (Figure 5). Non-regulated source pollutants were the leading cause of lake and pond incidents, representing 68% and 94% of the incidents in these habitat types, respectively. Regulated causes were the most common type of incident in streams comprising 60% of stream incidents. There were three incidents in 2020 not involving waters (“None Impacted”, Figure 5). These events occurred in areas where the spill was contained before any effluent could spill into a waterbody. There was one incident in a backwater of a river (Figure 5).

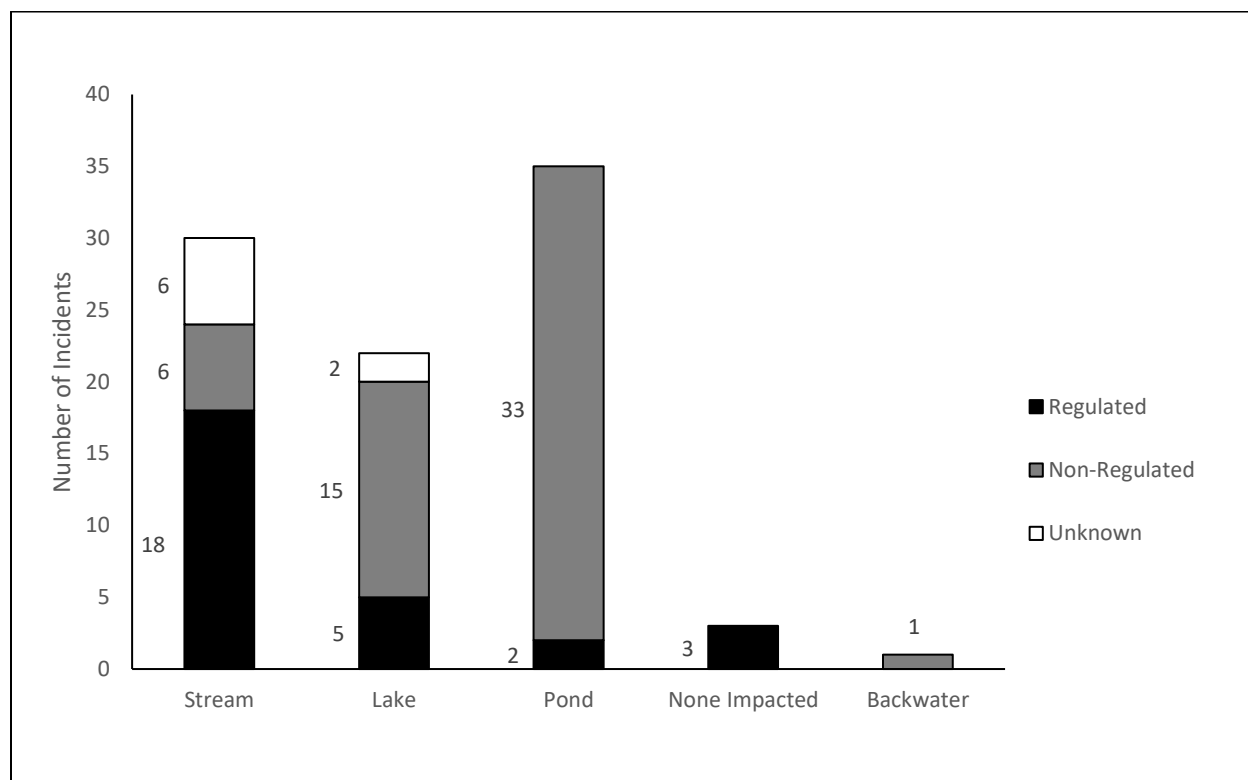


Figure 5. Distribution of incidents during 2020 by habitat type. None impacted indicates an event for which no waters were impacted.

## **ENFORCEMENT STATUS OF FISH KILL AND POLLUTION CASES**

Seven incidents were resolved through compliance and enforcement actions during 2020. These incidents occurred from 2014 to 2020. DNR and the Missouri Attorney General enforced the cases described in this section. Four of these cases were resolved through civil legal agreements and consent judgement, which included reimbursements of natural resource damages, reimbursements of investigative costs, and payments of civil penalties. These four cases are summarized in Appendix E.

Payments made during resolution of these infractions totaled \$102,651.81 in damages, investigative costs, and penalties. Reimbursements for damages and investigative costs totaled \$58,865.81. Damages included fish damages calculated by MDC (\$945.94) and water quality damages calculated by DNR (\$39,285.00). Of the reimbursed damage funds, \$851.34 was transferred to the MDC Fish Kill Grant Fund, which will be spent on projects benefiting aquatic resources in Missouri. The remaining damage funds (\$39,379.59) were transferred to the DNR Chemical Emergency Preparedness Fund and Natural Resources Damages Fund. MDC received \$3,388.44 in reimbursements for investigative costs, which was also transferred to the MDC Fish Kill Grant Fund. Penalty monies assessed by the DNR amounted to \$43,286, excluding stipulated penalties. Penalty monies were transferred to the school district of the county in which the pollution occurred.

Four incidents were referred to other agencies for resolution or scheduled for further inspection by DNR. Two of these incidents involved private ponds and pesticides and were referred to Missouri Department of Agriculture for evaluation of the Federal Insecticide, Fungicide, and Rodenticide Act violations. MDC referred a third incident to Missouri Department of Health and Senior Services for evaluation of human health and safety. For this third incident, MDC lacked proper personal protective equipment to investigate dead fish and wildlife on-site. A fourth incident occurred in a stream harboring federally endangered species, where investigators could not conclusively determine the source of pollution. For this fourth incident, the affected stream was included on DNR's waste load allocation project schedule.

Thirty-five potentially enforceable cases remain open. Incidents involved in these cases occurred during 2012 to 2020. Among these thirty-five open cases, three entities caused fish kills or pollution events on multiple occasions: US Army Corps of Engineers (13 incidents); City of Columbia (5 incidents); City of Kansas (3 incidents). US Army Corps of Engineers incidents involved fish and wildlife mortality related to operations at Truman, Stockton, and Clarence Cannon dams. City of Columbia incidents all involved fish mortality from failing drinking water infrastructure. City of Kansas incidents involved fish mortality from wastewater overflows and bypasses.

A breakdown of settlement funds and brief descriptions of open and closed cases are located in appendices E and F.

## **PROJECTS FUNDED BY FISH KILL GRANTS**

Reimbursements for MDC investigative costs and 90% of fish and wildlife damages are directed to a Fish Kill Grant Fund that is administered by Resource Management Branch. Project proposals are solicited in July on an annual basis from Resource Management, Protection, and Science branches. Eligible projects benefit aquatic resources, preferably those that have experienced fish kills caused by pollution.

During 2020, no project proposals were received. The balance stands at \$105,142.71.

## LONG-TERM TRENDS

Data are presented in this section to examine long-term trends dating back to 1988. The Fish Kill and Pollution Program stores information for incidents occurring prior to 1988; however, most data for events prior to 1988 are not electronic and readily available to summarize. The “unknown” and regulated-other categories are not included in this section because they contain incidents with wide ranging pollution sources and causes. Non-regulated incidents are not included because temporal variability for these incidents has been due to changes in reporting procedures (O’Hearn and Martin 2013).

The number of regulated incidents peaked in the mid-1990s and declined from the mid-1990’s to 2002 (figures 6 and 7). Since 2003, the number of regulated incidents has fluctuated between 10 and 40, with 2018 setting a record low of 10 incidents since MDC began electronically recording data in 1988 (O’Hearn and Abel 2019). Municipal source incidents were and continue to be the dominant cause of regulated incidents over time, for 24 out of 33 years.

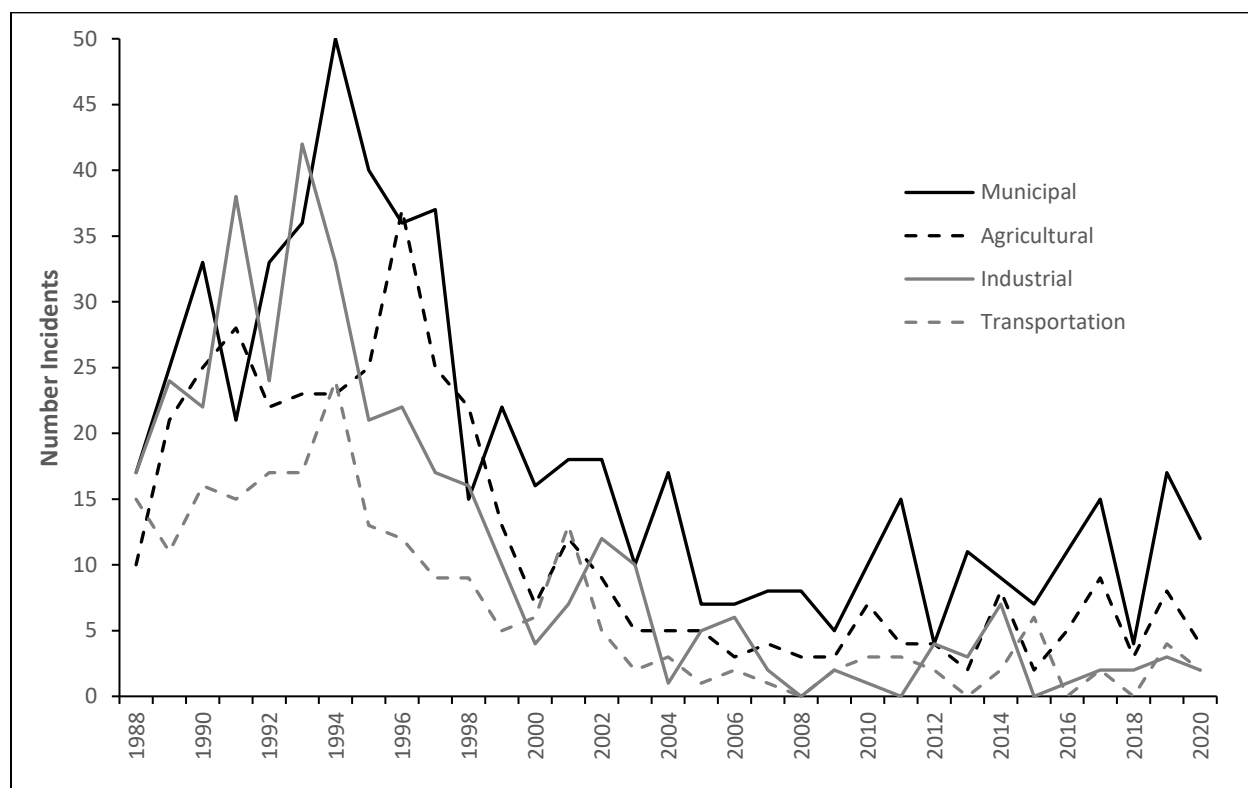


Figure 6. Long-term (1988-2020) trends in regulated incidents. The “other” source category involves miscellaneous pollution sources and is not included in the figure.

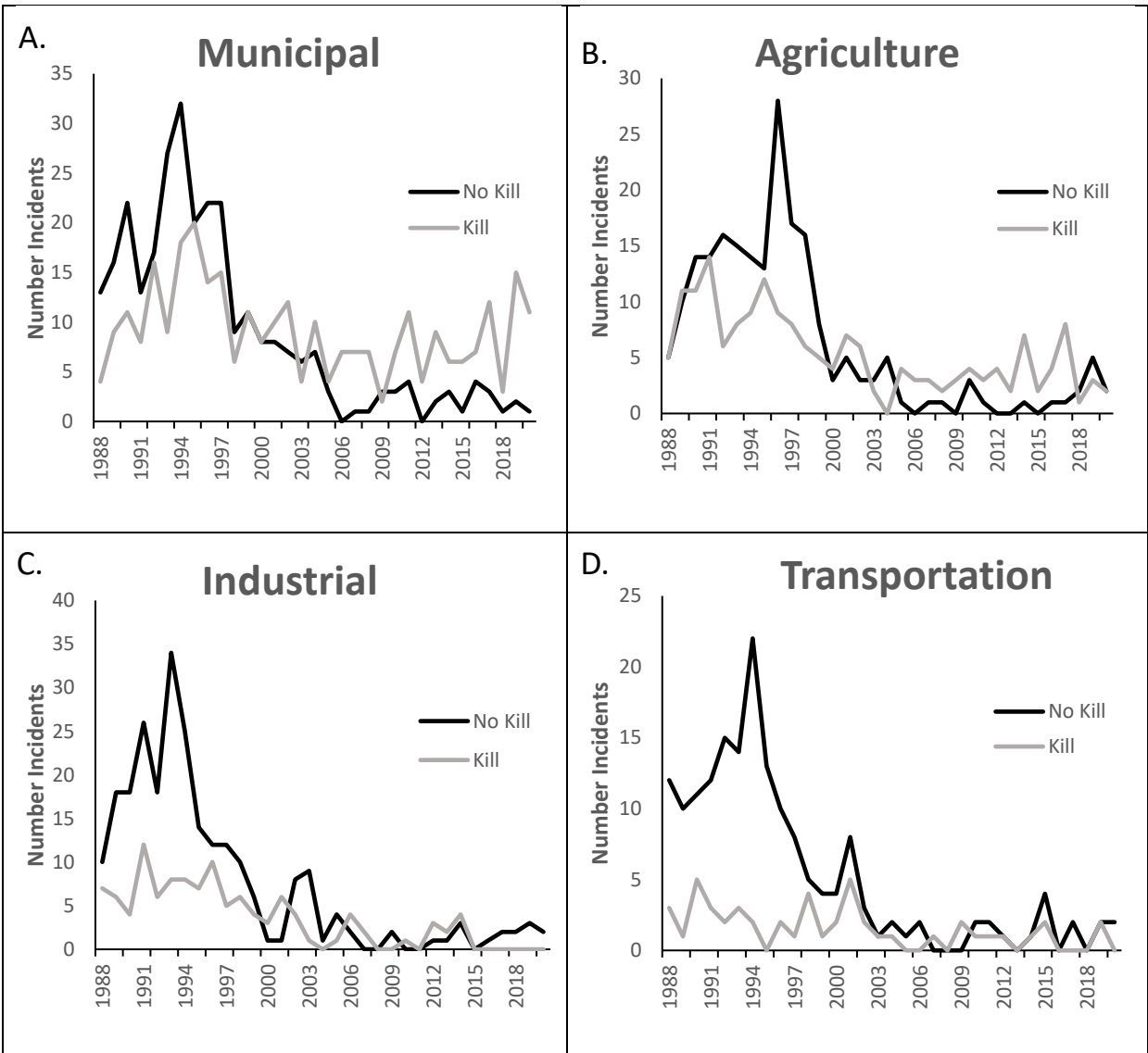


Figure 7. Long-term (1988-2020) trends for regulated fish kill and pollution incidents caused by municipal (A), agricultural (B), industrial (C), and transportation (D) sources. The “unknown” and “other” categories are not included in this figure because they contain incidents with wide ranging pollution sources and causes. Non-regulated incidents are not included because trends reflect changes in reporting procedures (O’Hearn and Martin 2013).

## CONCLUSION

The success of the Fish Kill and Pollution Program relies on partnerships with state and federal resource agencies, especially the DNR (the clean water authority in Missouri). MDC's strong partnership with DNR plays a crucial role during all stages of the investigative process. Without this partnership, many polluters would not be held responsible for damaging Missouri's aquatic resources.

Although the program has documented decreases in the number of incidents over time, there remain areas of concern. Municipal pollution continues to be the leading cause of pollution-related fish mortality in Missouri. Similar to previous years, electric facilities, dams, and chlorinated water releases were the predominate culprits in the municipal category.

Missouri has multiple hydroelectric facilities. Some of these facilities have been documented releasing anoxic water into receiving waters causing fish kills, trapping fish on external structures and internal chambers, and entraining fish through turbines. Other facilities with dams such as Montrose Dam and Long Branch Dam harm fish and wildlife by reducing or eliminating the flow of water in receiving waters. MDC has been working for decades on mitigation of fish kills caused by these facilities. Within the last several years, DNR has joined MDC in this effort, and have begun working collaboratively with US Army Corps of Engineers at multiple dams to mitigate some of the fish kills caused by dam operations. Success of these efforts relies on quality partnerships between agencies, which includes trust, transparency, and adaptive management to changing natural resource needs and funding. During 2020 MDC also had success mitigating fish and wildlife kills during dam maintenance at Tunnel Dam, owned and operated by Sho-Me Power Cooperative. Due to the advanced notification of flow reduction below the dam, MDC was able to minimize mortality through rescue of stranded fish and wildlife.

During 2020 Montrose Dam, owned and operated by Evergy, caused a fish kill in the receiving waters of Deepwater Creek. This was unfortunate because in recent years the state and Evergy had signed an agreement outlining requirements of Evergy to prevent further fish kills at this location. Terms of the agreement have expired just as Evergy transitions to a reduced employee presence at the dam. MDC is concerned fish kills will continue or become more common with a reduced employee presence at the facility. MDC has recommended the company install remote water quality monitoring equipment and the ability to remotely increase flow through the dam once employees are no longer stationed at this site.

MDC documented five chlorinated water kills during 2020. Three of these occurred in state waters and were enforceable. One was resolved with compliance action and three are pending enforcement action. With these new chlorinated water kills, the total number of open chlorinated water enforcement cases stands at seven. Chlorine helps make water suitable for human consumption but is extremely toxic to gilled-aquatic life at low concentrations and persists in the environment when combined with ammonia to form chloramines. MDC has observed complete kills in streams where large, chlorinated water releases occur. In some chlorinated water kills, the solution is repairing and replacing aging infrastructure to reduce the number of water main breaks. Other cases can be largely prevented through proper training of contractors and city employees working on construction sites. And for some cases, like the case in St. Louis County (page 28), outreach and education to the public is the solution to preventing fish kills. Many citizens are unaware that simple activities like washing a car in the driveway, draining their private pool, or overwatering their lawn can result in fish kills in small suburban streams downgradient of their property.

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\* For readers outside MDC that desire a copy, please contact the Fish Kill Program Manager at 3500 East Gans Road, Columbia, Missouri 65201.

## **Appendix A. Program accomplishments during 2020.**

As part of a continuous effort to achieve complete and thorough investigations, more efficient and rapid response to pollution incidents by MDC personnel, and enhanced protection of the fish and wildlife resources of the state, the following accomplishments were achieved by the Pollution and Fish Kill Program during 2020:

### **Monitoring**

#### *Tunnel Dam Project*

The Pollution Program continues to monitor water quality in Lake Niangua and the Niangua River to assess conditions prior to potential changes to management of Tunnel Dam during Federal Energy Regulatory Commission relicensing. Changes to management of Tunnel Dam may impact the federally listed Niangua Darter in the watershed and sports fisheries in Lake Niangua. Monitoring from 2018 through 2020 suggests low dissolved oxygen levels between the dam and the generation station's relative to upper segments of the river are related to reduced spillway flow; dissolved oxygen is lower at the generation station and downstream of the generation station relative to upstream of this location, suggesting the generation station may reduce dissolved oxygen levels in the river; and water temperature increases within Lake Niangua and does not return to reference conditions throughout the 11 mile study reach.

#### *Predictive Modeling of Algal Toxins in Fish and waters in Missouri*

The Environmental Health Unit began collaborating with the University of Missouri, DNR, and Missouri Department of Health and Senior Services to monitor for algal toxins in fish tissues and waters in Missouri. During 2017 we initiated a pilot project in University of Missouri's hyper-eutrophic Dairy Farm Lake number 1. The objective of the pilot project is to determine if Missouri needs to conduct statewide monitoring for algal toxins in fish to set fish consumption advisories. Samples were collected in 2018 by MDC, Missouri Department of Health and Senior Services, and MU. Lab and data analysis will be completed in 2021 by a PhD candidate in MU's Limnology Laboratory. In 2019, MDC and DNR began opportunistically collecting water samples and fish specimens during routine monitoring if an algal bloom was observed. These samples and specimens were analyzed in 2020 and offered to the PhD candidate for a supplemental data source for interpretation of data collected in Dairy Farm Lake.

#### *Dissolved oxygen project*

The Pollution Biologist continues to participate on the research project team for a project evaluating minimum dissolved oxygen reference conditions in headwater prairie streams. Monitoring began during the summer of 2020 and preliminary results indicate headwater prairie streams in least disturbed watersheds display dissolved oxygen profiles supportive of aquatic life.

#### *Aquatic Snail Distributional Monitoring*

The Pollution Program, Malacology Program, and Stream Team Program, continued to opportunistically collect aquatic snails through citizen and staff volunteers; and to collate existing MDC, DNR, and museum snail records into a central database. The objective of snail monitoring is to improve Missouri's snail distribution map. Improving the distributional map will ensure Clean Water regulators have the best information when developing and implementing changing water quality standards in the future related to stream nutrients and ammonia.



### *Bacterial source tracking-Perry County Karst*

During 2020 the Pollution Biologist joined a project team with the goal of identifying sources of fecal pollution in the Perry County Karst watershed. This watershed is home to the federally endangered Grotto Sculpin and identifying the source of fecal pollution will help prioritize management actions to reduce water pollution impacting this species' habitat.

## **Training & Lectures**

### *Fish Kill Procedures Training*

A recorded virtual training on water pollution and fish kill investigation procedures was made available to all MDC staff beginning in the winter of 2020. This training is conducted to familiarize MDC field staff with investigation procedures which must be followed during investigations to ensure reliable collection of evidence and legal defensibility. MDC Protection and Regional Resource Management staff are invaluable to MDC's ability to respond to pollution problems statewide in a professional and timely manner.

### *Guest Lecturer- University of Missouri- Aquatic Ecology Class*

Lectured University of Missouri's Aquatic Ecology undergraduate students on Missouri's water pollution and how it impacts fish and wildlife.

## **Co-organizer & co-author**

The Pollution Biologist and Contaminants Biologist co-organized a One-Health Symposium for the Southeastern Association of Fish and Wildlife Agencies annual conference and co-authored "One Health: A Framework for Conservation" with lead author Chris Kennedy, Diversity and Inclusion Coordinator.

## **Operational Changes**

### *New Fish Kill Application and Database*

MDC's new fish kill database was completed in May 2020. The database is paired with three applications. The first application provides the public and external agencies the ability to directly report fish kills through MDC's website. A new fish kill page on MDC's public website hosts this application in addition to providing the public a venue for learning about fish kill events around the state of Missouri and their causes. The second application notifies regional fish kill responders when the public reports through MDC's website. The third application allows MDC staff to directly enter their investigative data into the fish kill database which reduces potential for data entry errors resulting from re-entering data multiple times. Virtual training on the use of these new applications was provided to MDC staff in May 2020.

### *Harmful Algal Bloom Response*

The Environmental Health Unit finalized and communicated a harmful algal bloom notification and response protocol to MDC staff. The response protocol reflects the recommendations of the Missouri Department of Health and Senior Services, includes input from Regional Resource Management staff, and incorporates specific guidance related to fish and wildlife mortality associated with harmful algal blooms.

## **Organizational Changes**

### *Department Reorganization*

MDC began transitioning to a new organizational model in the fall of 2019. The new organizational model shifts resource decision-making to a regional level and promotes better collaboration between traditional resource divisions of Private Lands, Fisheries, Forestry, and Wildlife. Fisheries regional supervisor positions were formerly fish kill duty officers during business hours. Under the new

organizational model, regional supervisor positions were combined and shifted to supervising multi-disciplinary work-teams. Duty officer positions have now been reassigned within regions, and staff serving in this role now have a variety of disciplinary backgrounds ranging from fisheries to forestry. Protection district supervisors remain the duty officers during non-business hours.

#### *Environmental Health Unit Reorganization*

Under the reorganization, the Environmental Health Unit was placed in a larger Ecological Health Unit. The larger Ecological Health Unit also includes Wildlife Health Unit, Forest Health Unit, and the Resource Assessment and Monitoring (RAM) program.

#### *New Fish Kill Program Assistant*

One of the most notable changes to the Pollution Program is the addition of a salaried assistant, the Aquatic Health Specialist. Steffanie Abel officially transferred from the small impoundments fisheries program in July 2020. Steffanie's expertise in age and growth and fish sampling techniques and interest in public outreach is a great asset to the Environmental Health Unit.

Appendix B. Summary of regulated source incidents during 2020. Data is listed alphabetically by county. Confirmed events are defined as those visually verified by qualified fish and wildlife professionals. ND= not determined, NC= not calculated. Event Confirmed = Y indicates events directly observed by natural resource government professionals.

County	Waterbody	Incident Date	Source	Cause	Number Animals Killed	Value	Event Confirmed
Barton	Pettis Creek	6/15/2020	Agriculture	Low dissolved oxygen	1,306	\$1,348.98	Y
Benton	Lake of the Ozarks	6/1/2020	Municipal	Low dissolved oxygen	1,475	\$74,468.78	Y
Boone	Tributary to Hinkson Creek	10/9/2020	Other	Swimming pool drainage (chemical deactivated)	0	-	Y
Boone	Sugar Branch	7/27/2020	Industry	Silt/sediment	0	-	Y
Boone	Tributary of Gans Creek	9/23/2020	Transportation	Elevated flow	0	-	Y
Camden	Niangua River	9/4/2020	Municipal	Rapid declining water levels	1,152	ND	Y
Clay	Fishing River	10/2/2020	Municipal	Low dissolved oxygen/high ammonia (suspect)	21	\$9.30	Y
Clay	Rock Creek	7/9/2020	Municipal	High ammonia and low dissolved oxygen (suspected)	114	\$15.32	Y
Cole	Tributary to Wears Creek	4/20/2020	Municipal	Chemical in culvert sealant	2,246	\$602.54	Y
Henry	Deepwater Creek	3/28/2020	Other	Low dissolved oxygen (suspected)	2,173	\$3,828.09	Y
Jackson	Brush Creek	6/1/2020	Municipal	Hypoxia or ammonia toxicity (suspected)	5	-	N
Jackson	Mills Creek HOA Lake	9/1/2020	Other	Low dissolved oxygen (suspected)	ND	-	Y
Johnson	Tributary of East Branch Crawford Creek	5/15/2020	Agriculture	Sodium chlorate and citric acid	ND	-	N
Macon	East Fork Little Chariton River	9/10/2020	Other	Hypoxia	209	\$452.21	Y
Miller	Private Pond	4/28/2020	Agriculture	Corn silage runoff	0	-	N
Osage	Painted Rock Conservation Area	11/10/2020	Municipal	Raw sewage	0	-	N
Ray	Lawson City Lake	8/19/2020	Transportation	Petroleum	0	-	N

Appendix B. Continued

County	Waterbody	Incident Date	Source	Cause	Number Animals Killed	Value	Event Confirmed
Reynolds	WWTF Lagoon	4/7/2020	Municipal	Chlorine toxicity	6,003	-	Y
St. Louis City	Wilmore Park South Lake	12/20/2020	Municipal	Chlorine toxicity	149	-	N
St. Charles	Tributary of Crooked Creek	9/6/2020	Municipal	Chlorine toxicity	47	\$23.82	Y
St. Charles	Parking Lot	1/17/2020	Agriculture	Methamidophos & Bifenthrin	0	-	Y
St. Charles	Private Pond	9/13/2020	Municipal	Herbicide toxicity/low dissolved oxygen (suspected)	49	\$64.68	Y
St. Francois	Blankshire Branch	6/2/2020	Municipal	Chlorine toxicity	664	\$123.14	Y
St. Louis	Meramec River	4/7/2020	Industry	Oily substance seeping onto sand	0	-	Y
St. Louis	Gravois Creek	6/29/2020	Other	Chlorine toxicity	20	ND	Y
Wright	Tributary to Fry Creek	7/21/2020	Other	Chlorinated water and organic oils	0	-	N

Appendix C. Summary of non-regulated source incidents during 2020. Data is listed alphabetically by county. Confirmed events are defined as those visually verified by qualified fish and wildlife professionals. ND=not determined. Event Confirmed = Y indicates events directly observed by natural resource government professionals.

County	Waterbody	Incident Date	Cause	Number Animals Killed	Event Confirmed
Audrain	Private pond	7/2/2020	Hypoxia (suspected)	ND	N
Audrain	Private Pond	5/12/2020	Bacterial infection with fungus	0	N
Benton	Private Pond	9/8/2020	Low dissolved oxygen	ND	N
Benton	Lake of the Ozarks	2/18/2020	Bacterial septicemia/general parasitosis	1,000	Y
Boone	Private Pond	7/5/2020	Low dissolved oxygen (suspected)	ND	N
Boone	Private Pond	7/9/2020	Low dissolved oxygen	ND	Y
Callaway	Truman Park Lake	8/1/2020	Potential HAB	0	Y
Callaway	Canyon Lake	7/21/2020	Potential HAB	0	N
Cape Girardeau	VFW North Lake	7/1/2020	Low dissolved oxygen (suspected)	100+	N
Carroll	Wakenda Creek	8/17/2020	Low dissolved oxygen	10,000	Y
Cass	Private Pond	7/4/2020	Low dissolved oxygen (suspected)	ND	N
Cass	Private Pond	7/6/2020	Low dissolved oxygen (suspected)	9	N
Clay	Private Pond	9/11/2020	Low dissolved oxygen	ND	N
Clay	Fountain Bluff Pond 8	9/10/2020	Low dissolved oxygen	ND	Y
Clay	High View Creek	9/13/2020	Low dissolved oxygen (suspected)	ND	Y
Cole	Terrestrial (Original report Dickerson Creek)	8/11/2020	Other	1	Y
Cole	Private Pond	8/22/2020	Low dissolved oxygen	ND	Y
Cole	Workman Creek	3/27/2020	Planktonic algae bloom and declining water levels	ND	Y
Cole	Binder Lake	10/9/2020	Cyanobacteria	0	Y

Appendix C. Continued

County	Waterbody	Incident Date	Cause	Number Animals Killed	Event Confirmed
Cooper	Private Pond	6/15/2020	Low dissolved oxygen	ND	Y
Franklin	Lions Lake	7/16/2020	Low dissolved oxygen	10+	Y
Gasconade	Private Pond	1/7/2020	Possible thermal distress	23	Y
Gasconade	Private Pond	5/29/2020	Low dissolved oxygen (suspected)	0	N
Gasconade	Private Pond	8/31/2020	Low dissolved oxygen	ND	N
Greene	Private Pond	7/1/2020	Low dissolved oxygen (suspected)	ND	N
Howard	Private Pond	9/10/2020	Low dissolved oxygen (suspected)	ND	Y
Jackson	Private Pond	7/3/2020	Low dissolved oxygen (suspected)	ND	N
Jackson	Penn Valley Lake	10/8/2020	Low dissolved oxygen	ND	Y
Jackson	private pond	8/18/2020	Low dissolved oxygen	ND	N
Jackson	Crisp Lake	8/31/2020	Low dissolved oxygen	ND	N
Jackson	Alex George Lake	6/22/2020	Low dissolved oxygen (suspected)	ND	N
Laclede	Private Pond	7/4/2020	Low dissolved oxygen (suspected)	ND	N
Lafayette	Private Pond	5/26/2020	Hypoxia	808	N
Lafayette	Private Pond	7/4/2020	Low dissolved oxygen (suspected)	ND	N
Lafayette	Higginsville City Lake	3/26/2020	Low dissolved oxygen (suspected)	ND	Y
Macon	Private Pond	6/28/2020	Hypoxia (suspected)	40	N
Mississippi	K.S. Simpkins Park Pond	8/2/2020	Low dissolved oxygen	418	Y
Moniteau	Private Pond	8/30/2020	Low dissolved oxygen	ND	N

Appendix C. Continued

County	Waterbody	Incident Date	Cause	Number Animals Killed	Event Confirmed
Moniteau	Private Pond	5/28/2020	Low dissolved oxygen (suspected)	ND	N
Morgan	Private Pond	5/22/2020	Bacterial infection (suspected)	ND	N
Newton	Shoal Creek	7/18/2020	Temperature shock (possible)	ND	N
Polk	Private Pond	7/1/2020	Low dissolved oxygen (suspected)	ND	N
Schuyler	Private pond	7/2/2020	Blue-green algae	0	N
Scott	Mississippi River backwater	9/8/2020	Low dissolved oxygen	2,000	Y
St. Charles	Subdivision Lake	7/16/2020	Low dissolved oxygen (suspected)	ND	N
St. Charles	Busch Area Lake #7	11/11/2020	Low dissolved oxygen	ND	N
St. Charles	Stormwater Pond	9/3/2020	low dissolved oxygen	ND	N
St. Charles	Private Pond	7/6/2020	Low dissolved oxygen (suspected)	ND	N
St. Charles	Busch Area Lake #7	11/6/2020	Low dissolved oxygen	ND	Y
St. Charles	Busch Area Lake #7	10/11/2020	Unknown	ND	Y
St. Louis City	Benton Park Lake	11/28/2020	Low dissolved oxygen (suspected)	50	Y
Ste. Genevieve	Mississippi River Backwater	7/18/2020	Low dissolved oxygen (suspected)	1,026	Y
Ste. Genevieve	Tributary to Coldwater Creek	4/28/2020	Diatoms	0	Y
Stoddard	Brown Pond	8/21/2020	Low dissolved oxygen	ND	N
Taney	Lake Taneycomo	9/14/2020	Low dissolved oxygen	9	Y
Texas	Private Pond	8/24/2020	Euglena bloom	0	Y

Appendix D. Summary of incidents caused by unknown sources during 2020. Data is listed alphabetically by county. Confirmed events are defined as those visually verified by qualified fish and wildlife professionals. ND=not determined. Event Confirmed = Y indicates events directly observed by natural resource government professionals.

County	Waterbody	Incident date	Cause	Number Animals Killed	Value	Event Confirmed
Barry	White River	4/6/2020	Unknown (Possible angler related)	ND	-	N
Camden	Lake of the Ozarks	4/23/2020	Unknown, unable to respond on site	30	ND	N
Clinton	Private Pond	4/14/2020	Unknown	ND	0	N
Cooper	Petite Saline Creek	5/27/2020	Unknown	ND	-	N
Franklin	Bourbeuse River	9/23/2020	Unknown	3	\$473.55	Y
Franklin	Birch Creek	6/14/2020	Unknown	ND	-	N
Jackson	Tributary to the Blue River	9/18/2020	Unknown (original report of sewage & turbidity)	0	-	Y
Saline	Blackwater River	8/10/2020	Unknown	ND	-	N
Stone	Table Rock Lake	9/16/2020	Unknown	100+	ND	Y



Appendix E. Summary of Clean Water Law settlements reached by the State of Missouri during 2020 for incidents involving MDC, including penalties and damages (monetary value of animals). Data is listed alphabetically by county. This table does not include investigative costs for DNR or stipulated penalties. Cr=creek, Br=branch, trib=tributary

County	Waterbody	Event Date	Responsible Party	Cause	Reimbursements			Water Quality damage <sup>+</sup>
					Fish Damages*	MDC Investigative Costs	MDC Total	
Boone	Bear Cr, trib	7/13/2019	City of Columbia	Chlorine toxicity from pool water leak	\$438.46	\$604.07	\$998.68	Information Not Available
Newton	Hickory Cr	3/8/2019	City of Neosho	Chlorinated water line break	\$500.31	\$408.74	\$859.02	
Vernon	Kitten Cr	6/8/2014	Kitten Creek Dairies	Dairy cow manure	\$2.61	\$1,148.13	\$1,150.48	\$39,285.00
Vernon	Coal Br	4/23/2014	Kitten Creek Dairies	Dairy cow manure	\$4.56	\$1,227.50	\$1,231.60	

\*Ten percent of damages are transferred to an emergency response fund at DNR.

<sup>+</sup>Water quality damages calculated by DNR.

Appendix F. Brief descriptions of closed and open cases listed alphabetically by county for 2020.

### **Closed Cases (resolution achieved)**

Case closed after resolution was reached. Resolution is compliance or enforcement actions.

#### Boone County (7/13/19), City of Columbia

A cap on a pipe which diverted water from Albert-Oakland Aquatic Center from the storm water system to the wastewater system cracked resulting in chlorinated water being discharged into a tributary of Bear Creek in Columbia. Investigators counted 1,437 fish valued at \$438.46. The City of Columbia will be required to permanently direct flows from the aquatic center into the sanitary sewer.

#### Newton County (3/8/19), City of Neosho

A broken water main resulted in the discharge of chlorinated water into Hickory Creek resulting in a fish kill of at least 134 fish valued at \$500.31. An Abatement Order on Consent was signed in January 2020. The Abatement Order requires the City of Neosho to notify DNR regional office within 24 hours of becoming aware of non-compliant conditions, reimburse the State of Missouri for damages and investigative costs, and pay stipulated penalties up to \$500 per day if the City of Neosho does not comply with the terms agreed upon in the Abatement Order.

#### Macon County (9/10/19; 9/10-11/20), U.S. Army Corps of Engineers

On September 10, 2019 dam operators ceased flow through Long Branch Dam while conducting maintenance and repairs. This dewatering event led to oxygen depletion in the receiving waters resulting in a significant fish kill. Multiple fish species were observed dead, including channel catfish, freshwater drum, gizzard shad, bluegill, crappie, and hybrid striped bass. MDC investigators were able to enumerate only a small fraction of the dead fish. Damages for the 366 fish that MDC investigators were able to count totaled \$4,695.26. DNR is not pursuing enforcement actions because the cause of fish mortality was low dissolved oxygen. However, because low dissolved oxygen was caused by actions of the U. S. Army Corps of Engineers, MDC continues discussions on mitigating future fish kills of this origin with U.S. Army Corps of Engineers.

On September 10<sup>th</sup> and 11<sup>th</sup> of 2020, the U.S. Army Corps of Engineers eliminated flows to the lower East Fork Little Chariton River to conduct maintenance on the bulkhead gate in the dam's spillway. The elimination of flow caused dissolved oxygen levels in the river to decrease below 4 mg/L (0.5-4.0 mg/L) throughout the area of impact. MDC investigators observed 209 dead fish valued at \$452.21 as the result of these operations. Species included buffalo, sunfish, channel catfish, crappie, redhorse, drum, hybrid-striped bass, and silver carp, with most of the dead fish consisting of silver carp. During this event, the U.S. Army Corps of Engineers made efforts to increase dissolved oxygen as requested by Department staff. However, this fish kill event and future events could be prevented with better coordination and planning prior to maintenance activities. MDC, DNR, and the U.S. Army Corps of Engineers participating in coordination and planning meetings following this event and are working together to mitigate and prevent aquatic organism mortality when this maintenance work is conducted during 2021.

#### St. Louis County (6/29/20), private resident/Metropolitan Sewer District

On June 29<sup>th</sup> a resident who lives along Gravois Creek reported an unusual volume of water flowing through the stream and dead fish and crayfish in about 200 yards of stream. DNR's investigation revealed chlorinated water caused the fish kill. It is suspected source of chlorinated water was traced to a residential pool discharge. According to a previous agreement between the state and Metropolitan

Sewer District (MSD), MSD is responsible for stormwater pollution in the St. Louis area. DNR requested MSD distribute stormwater pollution educational materials to the homes in the area, focusing on homes with swimming pools.

Vernon County (3/8/10, 12/14/10, 4/1/11, 4/23/14, 6/8/14), Kitten Creek Dairies (formerly Focal Dairies)

Water pollution and foul odors have been observed in Kitten Creek, Coal Branch, and their tributaries dating back to 2007. A settlement agreement was signed in 2008 to resolve these issues, but MDC continued to receive complaints from the public about pollution in the area. MDC also observed and documented water pollution on site, a few fish kills, and tributaries dominated with pollution tolerant macroinvertebrates. DNR continued to inspect the facility after MDC's last reported fish kill in 2014. These inspections led to a Consent Judgment being signed between the Attorney General, Missouri Clean Water Commission, DNR, and the responsible party in March 2019. The responsible party was ordered to pay \$99,000.14, which included \$43,286 in penalties, \$39,292 in natural resource damages, and \$16,422 for costs incurred during the state's investigation. Reimbursements for natural resource damages are going to be used to remove manure from streams and regrade stream banks.

**Closed (referred)**

Camden County (9/4/20), Sho-Me Power Electric Cooperative

Flow was cut off from the bypass loop of the lower Niangua River during a planned lake drawdown for repairs below Tunnel Dam. The lake drawdown began on September 3rd and ended on October 9th. Lowered water levels stranded fish, mussels, and other aquatic animals. Stranded and dead animals were observed from September 10th until to the 8th of October. Seven-hundred and fifteen mussels were found dead during monitoring efforts and additional 3,431 stranded mussels were moved back into the stream. Four-hundred and thirty dead fish and seven tadpoles were also counted during monitoring efforts. These injuries have not been given a value. This is an underestimate because fish length data was not factored into the damage assessment and MDC did not continue to monitor in the months following the event to ensure stranded mussels that were rescued had not died due to stress from the event. This information will help the state develop flow requirements to include in the state's comments to Sho-Me Powers relicensing application to protect aquatic life downstream of Tunnel Dam.

Johnson County (5/18/20), Valley Oaks Meat facility (alleged)

MDC received a call from a USDA inspector reporting improper use of chemicals which allegedly resulted in health issues for facility workers. The caller reported the improperly mixed chemicals were poured down a storm drain which emptied into a lagoon. The caller observed dead moss, frogs, and fish in the lagoon and dead grass around the lagoon. MDC is not equipped with proper PPE to verify the dead frogs and fish on site. This issue was referred to DNR for evaluation of hazardous materials violations and to the Missouri Department of Health and Senior Services for evaluation of human health violations.

Lafayette County (5/26/20), adjacent landowner (alleged)/overstocking

A landowner called MDC reporting a total fish kill in his pond. The landowner suspected the fish kill was caused by pesticide drift (Xtendimax, Astonish, and dicamba mixture) from the adjacent landowner's farm 2 days prior to the fish kill. The landowner also noted garden and tree damage from the alleged pesticide drift. MDC investigated and found no conclusive evidence linking the dead fish to pesticides

but did obtain information from the landowner that suggested the fish kill may have been caused by oxygen depletion as the result of overstocking. MDC referred the case to the Missouri Department of Agriculture for evaluation of pesticide application violations concerning the tree and garden damage.

St. Charles County (9/13/20), Landscaping company suspected

Two residents reported a fish kill in their O'Fallon subdivision lake. The callers reported fish dying shortly after pesticides were applied near the shore of the lake by a landscaping company. MDC does not have jurisdiction over private lakes and pesticide regulations. This case was referred to the Missouri Department of Agriculture for evaluation of pesticide misapplication.

**Closed (no resolution)**

Franklin County (9/23/20), unknown responsible party

An environmental consultant reported dead mussels in the Bourbouse River close to the City of Union wastewater treatment plant. MDC staff responded on site and verified dead mussels, but were unable to determine a source of pollution that caused the kill. DNR were also unable to collect evidence linking the dead mussels to pollution sources. This stream is home to both federally listed mussels and state species of conservation concern, making this a high priority aquatic resource for conservation. DNR will conduct environmental monitoring around this site during 2021 or 2022, pending available monitoring equipment.

**Open**

The following cases are currently being evaluated for compliance and enforcement actions by DNR and MDC.

Audrain County (4/17/18), Harold Kroft

A large volume of hog lagoon effluent was discharged into Sandy Creek, depleting oxygen, and introducing levels of ammonia that were toxic to gilled aquatic life. A 4-mile long dead zone was observed from the time of the initial investigation to end of the investigation which concluded after four days. Staff did not revisit the site after the fourth day of investigation to determine when water quality improved. An estimated 47,887 aquatic animals valued at \$43,959.91 died due to this release. This case is open pending enforcement action.

Audrain County (7/28/19), Wayne Windmann (suspected)

The Audrain County Conservation Agent received a water pollution complaint from a landowner. Upon inspection, the agent identified the pollution originating from confined animal feeding operation upstream owned by Wayne Windmann. Windmann indicated a pipe had been damaged on July 27th resulting in the release of an unknown volume of manure from one of his lagoons. Manure entered a tributary of West Fork Cuivre River. The agent observed discolored (black) water for approximately 1.5 stream miles from the point of entry. We estimate at least 3,347 fish valued at \$1,326.09 were killed during this incident. This case is open pending enforcement action.

Barton County (6/15/20), Emerald Dairy Farm

A pipe collar broke resulting in the discharge of manure from Emerald Dairy Farm. Manure entered Pettis Creek reducing dissolved oxygen to lethal levels for gilled organisms. MDC staff observed 1,305 dead fish and 1 dead tadpole during this event. Taxa of dead fish included topminnows, stonerollers, darters, common carp, bullheads (129 total count; 3-12 inches long), sunfish (1,110 total count; 2-7

inches long), and largemouth bass (34 total count; 4-15 inches long). Dead fish and wildlife are valued at \$1,348.98. DNR is evaluating this case for enforcement action.

Benton County (5/29/13, 8/26/13, 5/25/16, 5/6/17, 6/1/20), U.S. Army Corps of Engineers under direction of Southwest Power Administration

- During May 2013, a hypolimnetic release of low dissolved oxygen water caused a fish kill in Lake of the Ozarks. Trauma from passing through Truman Dam and physical injury from flood gate releases also contributed to the kill. An estimated 2,723 fish valued at \$15,196.71 died. Low dissolved oxygen issues in the tailwaters have largely been addressed through continuous dissolved oxygen and temperature monitoring and manipulating spillway releases. Discussion between DNR, MDC, and U.S. Army Corps of Engineers concerning turbine mitigation are paused to address other fish injury and mortality issues surrounding the dam, some of which are described in the following event descriptions.
- In August 2013, an emergency shutdown and dewatering of a turbine chute in Truman Dam caused the death of at least 3,368 fish worth \$4,950.97. The trapped fish likely died from overcrowding and subsequent low dissolved oxygen. Discussions between DNR, MDC, and U.S. Army Corps of Engineers are ongoing concerning this source of mortality. A large barrier to achieving mitigation for this issue is safety concerns for staff entering the turbine chutes to remove fish.
- On May 25, 2016 a U.S. Army Corps of Engineers employee notified MDC of a fish kill below Truman Dam consisting of approximately 40 fish. The fish were primarily hybrid striped bass. Lengths were not recorded for these dead fish; therefore, we were unable to calculate a monetary value. The cause of the kill was determined to be turbine trauma and low dissolved oxygen. Discussions between DNR, MDC, Southwest Power Administration, and U.S. Army Corps of Engineers are ongoing.
- During May 2017 there was a large fish kill below Truman Dam caused by releases of flood waters. Paddlefish were the most commonly observed injured and/or dead fish during this fish kill. The fish kill lasted nearly two months. Preliminary estimates of damages are over \$146,000. This should be considered an underestimate because MDC staff actively searched for only 36 hours during this two-month period. Discussions between DNR, MDC, Southwest Power Administration, and U.S. Army Corps of Engineers are ongoing on mitigation solutions to avoid spillway mortality. One possible solution that has been discussed is diverting a portion of the spill discharge to the turbines to discourage fish from entering the spillway section of the dam where there are high velocity flows.
- In June 2020 lack of flow through Truman Dam resulted in fish becoming trapped inside the turbine gate slots and dying due to oxygen depletion. An estimated 1,475 dead fish, primarily white and hybrid striped bass were observed. These fish are valued at \$74,468.78. This case is open pending confirmation of a potential mitigation solution by U.S. Army Corps of Engineers.

Boone County (6/9/16, 9/1/17, 1/10/18, 7/17/18, 4/26/19), City of Columbia

Five open City of Columbia fish kills caused by drinking water were combined into one enforcement action. Descriptions of each fish kill follow:

- 1) 6/9/16- City of Columbia drinking water lift station malfunctioned discharging 320,000 gallons of chlorinated water into Mill Creek. The release of chlorinated water killed over 10,000 fish and aquatic worms valued at \$3,295.36.
- 2) 9/1/17- A drinking water line ruptured discharging an unknown volume of chlorinated water into Mill Creek. Staff observed nearly 2,000 dead fish and tadpoles valued at \$573.69. It is unlikely the fish community in this stream had recovered since the previous kill in June 2016.

- 3) 1/10/18- A failure at a drinking water lift station caused the release of 38,000 gallons of chlorinated water. The chlorinated water entered Mill Creek causing a fish kill. Dead fish were observed for approximately 1-mile downstream of the release. An estimated 5,320 fish and aquatic worms valued at \$2,362.62 died because of the release. This was the third chlorinated water fish kill occurring since June 2016 in this reach of Mill Creek. The first fish kill in June 2016 was also caused by a failure at the lift station.
- 4) 7/17/18- A broken water line released a large volume of chlorinated water into Hominy Branch in the City of Columbia. Investigators documented at least 2,595 dead fish throughout 1.2 stream miles. Dead fish were valued at \$693.43.
- 5) 4/26/19- Chlorine detected in Flat Branch Creek in Columbia resulted in a fish kill. Investigators counted 1,552 aquatic organisms valued at \$257.89. It is suspected that chlorine detected in the stream originated from a water main break identified upstream of the kill zone.

Boone County (7/27/20), Emory, Sapp and Sons

A construction project caused an unknown amount of sediment to flow into Sugar Branch during heavy rain events. Silt fencing and retention ponds were set up, and grass was planted. The landowner adjacent is asking for Sugar Branch to be cleaned of the silt. This case remains open pending DNR's evaluation of evidence for enforcement action.

Callaway County (6/4/17), Frederick Kerr Atkinson

A large volume of liquid nitrogen was discharged into McKinney Creek killing all aquatic life for 8 stream miles. Dead fish, crayfish, macroinvertebrates, aquatic worms, and tadpoles were observed during the investigation. These animals are valued at \$19,351.60. During follow up visits, toxic levels of ammonia were detected for miles downstream of the initial kill zone and for weeks after the initial discharge. Based on previous kills of this severity, the aquatic life in this stream will not fully recover for several years. This case is pending enforcement action.

Cape Girardeau County (4/1/19), Shawneetown Feed and Seed Company

A truck hauling liquid nitrogen tipped over releasing 1,000 gallons of 32% liquid nitrogen and 50 gallons of diesel fuel which entered a tributary of Cane Creek. Investigators counted a total of 794 fish valued at \$55.42. DNR is discussing whether to pursue this case for reimbursements for damages and investigative costs.

Cedar County (6/9/17), United States Army Corps of Engineers

MDC received a call from a private citizen on June 12<sup>th</sup> concerning Stockton Dam lowering water levels in the receiving waters of the Sac River and its tributaries. The private citizen lives on Bear Creek, a tributary of the Sac River and reported that when generation was altered on the 9<sup>th</sup> that mussels were left stranded out of the water in Bear Creek. The caller indicated this had occurred on other occasions. Discussions between MDC, DNR, and U.S. army Corps of Engineers are ongoing.

Clay County (11/15-16/12), City of Kansas

A sewage sludge release from a Kansas City sewage treatment facility caused a heavy fish kill in 5.5 miles of Fishing River. Low dissolved oxygen conditions and suspected ammonia toxicity led to the death of at least 1,520 fish. Total fish damages were \$8,055.52.

Clay County (7/9/20), City of Gladstone

A sewer line ruptured during construction. Sewage entered Rock Creek causing a fish kill. Our investigator observed 114 dead fish valued at \$15.32. This case remains open pending DNR's evaluation of evidence for enforcement action.

Cole County (4/20/20), SAK Construction

A sealing product was applied to a culvert pipe on a tributary to Wears Creek. The extra sealing material was cut off the end of the pipe with a chainsaw causing the material to fall into the stream, killing 2,246 fish valued at \$602.54. the construction company pumped the material out of the pool below the culvert pipe and removed 6 trash bags of material from the stream.

Cooper County (8/29/15), Missouri Better Beans

A fire at the Missouri Better Beans facility resulted in the release of 50,000 gallons chlorinated water and over 27,000 gallons of various chemicals, including glycerin. This release resulted in oxygen depletion in Stephen's Branch for at least 16 days. MDC observed 4,332 dead fish valued at \$829.99 during this incident. This case is pending enforcement action by the Missouri Attorney General's Office.

Franklin County (3/7/13), local manufacturer

A dark brown oily chemical was found in the city of Union's wastewater treatment plant. Sorbent booms were placed at the treatment plant outfall on Bourbeuse River as a preventative measure. No dead fish or mussels were found. This case is pending enforcement action against the responsible party, Cloud Manufacturing.

Henry County (3/28/20), Evergy (formerly Kansas City Power and Light Company)

Reductions in flow through Montrose Dam, operated by Evergy (formerly Kansas City Power and Light Company), led to fish stranding and hypoxia in Deepwater Creek, the receiving stream. MDC investigated on March 28<sup>th</sup> and documented 2,173 fish valued at \$3,828 in the pool immediately downstream of the dam. MDC observed dead fish up to 1-mile downstream from the dam; however, multiple anglers were present at stream access points and Covid-19 guidelines prevented the assessment of fish throughout this 1-mile zone. Fish counts presented here do not represent all fish mortality. Taxa observed include mostly channel catfish (1,838; 8-25 inches long), crappie, drum, carpsuckers, bluegill, white bass, largemouth bass, and common carp. Evergy is constructing housing for installation of a weather station, elevation gauges, warning sirens, and cameras that will allow them to lower the water level remotely from the power station in Kansas. It is unclear if remote water quality equipment will be installed to ensure dissolved oxygen levels are maintained for aquatic life. A fish kill occurred at this same location in April 2019. In the 2019 event, lack of flow over the dam resulted in low dissolved oxygen in the pool below. Eighty-five dead fish were valued at \$2,771.68 in the 2019, but enforcement action was not pursued.

Osage County (11/10/20), private citizen

MDC's Central Region staff reported an on-going raw sewage discharge on a conservation area in Osage County. The source of the raw sewage is a single residence sewage system adjacent to the conservation area. MDC is in consultation with Osage County Public Health Department and DHSS to determine how to eliminate the discharge on the conservation area.

Platte County (6/7/16, 11/22/18), City of Kansas

DNR is pursuing enforcement action with two City of Kansas cases:

- 1) 6/7/16- A Kansas City Wastewater lift station failure resulted in the discharge of wastewater into a tributary of Rush Creek. MDC observed 108 dead fish valued at \$28.29 as a result of this discharge.
- 2) 11/22/18- An estimated 549,000 gallons of raw sewage was discharged into a tributary of Walnut Creek by a Kansas City Wastewater Treatment facility during a sewer bypass. Sewage that entered the tributary resulted in lethal levels of ammonia causing a fish kill. Investigators observed dead fish in 4 miles of stream but were unable to determine the most downstream extent of the fish kill. Water clarity was poor during the investigation due to the pollutant, and fish injury and damages of 6,828 fish valued at \$1,500.22 are considered underestimates.

Ralls County (7/8/13, 7/21/14; 2015: 6/22, 8/3, 8/8, 9/8; 6/14/17), U.S. Army Corps of Engineers under direction of Southwest Power Administration

Since the 1980s, hypolimnetic releases of poor quality water have been the cause of recurring fish kills below Clarence Cannon Dam, which impounds Mark Twain Lake. Water released from the dam does not contain enough dissolved oxygen to support aquatic life. Within the last five years MDC staff documented six fish kills at this location, four of these fish kills occurred during 2015. Dam operations during 2015 resulted in at least 23,174 dead fish valued at \$40,687.11. Since 2010, there have been efforts to mitigate fish injury for low dissolved oxygen levels below the Clarence Cannon Dam; however, none of these efforts have produced a permanent long-term solution. Discussions between MDC, DNR, and the U.S. Army Corps of Engineers are ongoing.

Stone County (3/1/18), Partridge Sand and Gravel

MDC conducted a site visit of Partridge Sand and Gravel in Stone County to monitor improvements or further decline of conditions in Railey Creek, James River, and Table Rock Lake. MDC and DNR have been monitoring this site since the 1990's and working to prevent future injury and stop the destruction of habitat. Documented negative impacts include destruction of stream habitat, changes in hydrology, and sediment pollution of downstream water. Efforts have included verbal and written requests from MDC to the responsible party and Notices of Violation from DNR. In 2019 DNR issued an order for payment of penalties and remediation of the area, but the respondent failed to follow the order. The case is pending further enforcement action.

St. Charles (9/6/20), Missouri American Water

Chlorinated water was discharged into a tributary of Crooked Creek resulting in a fish kill. Forty-seven fish, mostly green sunfish, were observed dead in the stream. Dead fish were valued at \$23.82. This case is open pending evaluation of evidence for enforcement.

St. Francois County (6/2/20), City of Farmington

A City of Farmington water park flushed chlorinated water into a drainage pipe which flowed into Blankshire Branch killing 664 aquatic animals, which included aquatic worms, stonerollers, other minnows, darters, and sunfish. These animals were valued at \$123.14. DNR is evaluation this case for enforcement actions under Missouri Clean Water Law.



Appendix G. Summary of pollution investigation, fish kills, and estimated mortality (1970-2020) Data are incomplete prior to 1988. I=number incidents, K=number kills, #=number of dead animals, N/A=not available or not applicable

	MUNICIPAL			AGRICULTURAL			INDUSTRIAL			TRANSPORTATION			OTHER			NON-REGULATED		
Year	I	K	#	I	K	#	I	K	#	I	K	#	I	K	#	I	K	#
1970		7	72,850		10	353,482		8	218,075		3	605		2	6,035			
1971		9	306,050		9	93,856		6	70,050		3	40,750		10	46,081			
1972		11	9,960		8	9,322		8	494,801		5	626		2	22,171			
1973		6	46,125		4	8,203		9	49,355		3	5,455		8	11,965			
1974		10	20,242		8	13,730		10	120,637		4	4,472		6	4,145			
1975		9	43,035		9	118,564		8	109,713		6	29,500		7	10,535			
1976		10	9,323		3	2,260		6	14,400		N/A	N/A		5	3,825		1	52,000
1977		9	8,017		3	500		6	1,568		3	130,907		1	N/A		5	226,000
1978		8	436,206		12	16,739		7	13,953		3	855		8	11,008		20	16,003
1979		17	25,057		15	14,442		6	89,314		3	44,733		17	161,772		29	9,155
1980		14	114,817		10	16,476		5	98,729		N/A	N/A		10	39,953		35	26,443
1981		10	200,463		20	22,366		4	2,317		2	37,000		10	17,213		39	9,495
1982		8	4,728		12	14,693		2	4,424		1	N/A		12	20,462		18	7,074
1983		9	20,023		9	6,328		6	12,730		4	6,227		21	10,834		9	4,765
1984		13	12,433		10	65,522		3	853		3	1,285		12	43,635		11	105,578
1985	22	9	3,854	24	13	41,599	25	2	2,843	22	3	21,118	18	13	15,277	21	19	52,817
1986	40	18	68,010	25	13	12,086	26	7	4,236	28	2	N/A	44	18	955	42	41	28,848
1987	39	18	38,333	22	8	11,033	19	7	7,915	24	1	200	39	19	19,679	45	43	45,641
1988	17	4	13,006	10	5	32,263	17	7	20,925	15	3	1,112	23	10	12,286	35	35	113,016
1989	25	9	1,015	21	11	27,546	24	6	13,684	11	1	186	16	12	5,991	37	36	35,122
1990	33	11	7,462	25	11	49,983	22	4	36,496	16	5	12,334	25	14	17,089	31	28	281,161
1991	21	8	20,436	28	14	14,639	38	12	55,114	15	3	2,952	36	23	5,962	223	220	60,864
1992	33	16	16,018	22	6	14,063	24	6	31,006	17	2	57	20	8	69,211	207	203	30,934
1993	36	9	6,288	23	9	26,234	42	8	17,646	17	3	5,500	17	8	23,950	137	135	89,748
1994	50	18	78,385	23	9	59,603	33	8	106,743	24	2	9,684	23	8	247,272	206	196	83,017
1995	40	20	30,419	25	12	293,642	21	7	16,176	13	N/A	N/A	33	17	17,080	238	236	87,718
1996	36	14	10,875	37	9	54,999	22	10	373	12	2	10,875	30	11	3,899	139	136	105,031

Appendix G continued.

	MUNICIPAL			AGRICULTURAL			INDUSTRIAL			TRANSPORTATION			OTHER			NON-REGULATED		
Year	I	K	#	I	K	#	I	K	#	I	K	#	I	K	#	I	K	#
1997	37	15	8,481	25	8	1,504	17	5	2,404	9	1	14	31	22	7,127	229	222	55,984
1998	15	6	5,155	22	6	92,052	16	6	40	9	4	13,206	27	12	24,905	148	146	31,893
1999	22	11	28,841	13	5	3,038	10	4	22,993	5	1	43	18	7	31,589	192	187	42,829
2000	16	8	36,405	7	4	55,160	4	3	524	6	2	1,042	11	7	43,206	153	153	163,051
2001	18	10	22,711	12	7	1,588	7	6	1,043	13	5	4,696	10	9	14,752	233	233	68,829
2002	18	12	81,960	9	6	45,028	12	4	3,615	5	2	74	6	5	1,519	121	121	33,461
2003	10	4	1,022	5	2	8,068	10	1	523	2	1	1,374	12	9	15,821	113	113	163,179
2004	17	10	82,183	5	N/A	N/A	1	N/A	N/A	3	1	1,146	1	1	18,476	71	71	8,253
2005	7	4	73,785	5	4	12,020	5	1	3,436	1	N/A	N/A	1	1	4,334	154	154	69,466
2006	7	7	22,643	3	3	4,489	6	2	10,479	2	N/A	N/A	3	2	10,822	3	3	2,957
2007	8	7	26,582	4	3	11,599	2	2	25,796	1	1	477	4	4	3,771	5	5	1,460
2008	8	7	2,504	3	2	381	N/A	N/A	N/A	N/A	N/A	N/A	6	6	2,144	5	5	2,232
2009	5	2	2,231	3	3	509	2	N/A	N/A	2	2	116	5	5	433	4	4	3,207
2010	10	7	3,373	7	4	2,625	1	1	41	3	1	N/A	12	9	270,926	20	18	2,537
2011	15	11	4,888	4	3	11,175	N/A	N/A	N/A	3	1	4,822	15	12	13,186	28	27	11,008
2012	4	4	5,063	4	4	7,067	4	3	1,230	2	1	1,286	17	15	77,790	36	35	43,462
2013	11	9	7,703	2	2	647	3	2	108	N/A	N/A	N/A	7	6	3,154	33	31	9,760
2014	9	6	4,311	8	7	11,758	7	4	109,733	2	1	2,720	8	5	1,177	50	47	10,330
2015	7	6	28,746	2	2	41,273	N/A	N/A	N/A	6	2	238	10	4	5,397	32	26	21,553
2016	11	7	12,438	5	4	9,328	1	N/A	N/A	N/A	N/A	N/A	10	7	275	27	21	7,540
2017	15	12	70,479	9	8	15,932	2	N/A	N/A	2	N/A	N/A	5	1	140	32	27	4,571
2018	4	3	14,743	2	1	47,887	1	N/A	N/A	N/A	N/A	N/A	3	N/A	N/A	40	26	1,706
2019	17	15	10,246	8	3	3,347	3	N/A	N/A	4	2	810	3	2	422	32	16	6,365
2020	12	11	11,925	4	2	1,306	2	N/A	N/A	2	N/A	N/A	8	4	2,402	55	48	5,493
TOTAL	695	498	2,191,848	456	355	1,781,954	429	222	1,796,041	296	98	398,497	557	447	1,402,053	3,177	3,234	2,241,826
YEARLY AVG	14	10	42,977	9	7	35,691	9	4	35,921	6	2	7,970	11	9	28,041	64	65	44,837
Avg # per kill	4,298			5,099			8,980			3,985			3,116			690		