MISSOURI POLLUTION AND FISH KILL INVESTIGATIONS 2018

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. The reader may choose to use the data for other purposes, but the appropriateness of the data for those purposes must be evaluated by the user.

Cover photographs: Left: Haw Creek, Morgan County, 7/19/18, Sediment flows from dredged ponds of a private hatchery, photo submitted anonymously. Top-right: Stephens Lake Park, Boone County, 9/19/18, Large cyanobacteria bloom, photo taken by Brian McKeage (Fisheries Management Biologist). Bottom-right: Tipton Park Lake, Moniteau County, 9/1/18, Fish kill due to low dissolved oxygen caused by ice and snow, photo taken by Scott Williams (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 2018, MDC personnel investigated 79 water quality and pollution incidents. Animal mortality was associated with 45 of these incidents. Overall, at least 67,387 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 13 regulated incidents, of which 4 involved a kill. An estimated 62,630 animals valued conservatively at $48,516.18 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 2018, there were 59 non-regulated incidents, 39 of which, were fish kills. Personnel could not determine the cause of 7 incidents (unknown cause). At least 2,228 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	Number Incidents	Number Fish Kills
Regulated		
Municipal	4	3
Agriculture	3	1
Industry	2	0
Transportation	0	0
Other	4	0
Subtotal	13	4
Non-Regulated	59	39
Unknown	7	2
Totals	**79**	**45**

The summer season had the greatest number of incidents (33), followed by spring (20), fall (16) and winter (10). Most incidents occurred in ponds (30), followed by streams (25) and lakes (24).

The MDC, DNR, and the Missouri Attorney General enforced the incidents described in this report. Twelve cases were resolved during 2018 through compliance and enforcement actions. All these cases involved legal agreements, which included reimbursements for natural resource damages, reimbursements for investigative costs, and civil penalties. Damage and investigative costs reimbursements totaled over $50,000. Penalties calculated by DNR amounted to $43,764, including suspended penalties and supplemental environmental project costs. Forty potentially enforceable incidents have not been resolved as of December 31, 2018.

An analysis of long-term trends (1988-2018) shows the number of regulated incidents peaked in the mid-1990s and declined from the mid-1990's to 2002. Since 2003, the number of regulated incidents has fluctuated between 10 and 28, with 2018 setting a record low of 10 incidents since MDC began electronically recording data in 1988. 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[1]; 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 investigations conducted by MDC during 2018.

[1] Other agencies involved during investigations include: 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.

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 Fisheries, Protection, and Resource Science division chiefs. 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 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. All MDC staff learning of or discovering a fish kill are to notify the EER spill line as soon as possible as a precautionary measure.

MDC's Conservation Agents and Fisheries Division staff are trained to respond to fish kill and pollution incidents where there is potential for fish and wildlife injury. 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 2018, 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, those with *unknown* causes, or those 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, 2018.

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 79 water quality problems during 2018 (Table 1). Fish kills occurred in 45 of the incidents. An estimated 67,387 fish and other organisms were killed. Monetary damages were only calculated in 10 of the 45 incidents involving a kill. Fish and other organisms killed during these incidents were valued at $50,464.44. 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 pollution investigations conducted by MDC staff during 2018. Animals killed include all fish and wildlife species killed during an event.

Cause	Number Incidents	Number Kills	Number Animals Killed	Value of Animals Killed
Regulated				
Municipal	4	3	14,743	$4,556.27
Agriculture	3	1	47,887	$43,959.91
Industry	2	0	0	$0.00
Transportation	0	0	0	$0.00
Other	4	0	0	$0.00
Subtotal	*13*	*4*	*62,630*	*$48,516.18*
Non-regulated	59	39	2,529	Undetermined
Unknown	7	2	2,228	$1,948.26
Totals	**79**	**45**	**67,387**	**$50,464.44**

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 13 regulated incidents, which accounted for over 16% of the incidents (Figure 1). Of the 13 regulated incidents, 4 resulted in fish and wildlife mortality. An estimated 62,630 dead fish and wildlife were recorded for all 4 fish kills. Monetary damages totaled $48,516.18 (Table 1). Municipal source pollutants (e.g. municipal wastewater, drinking water, and hydro-electric facilities) were the leading cause of regulated incidents in 2018, accounting for 31% of all regulated investigations (Figure 1).

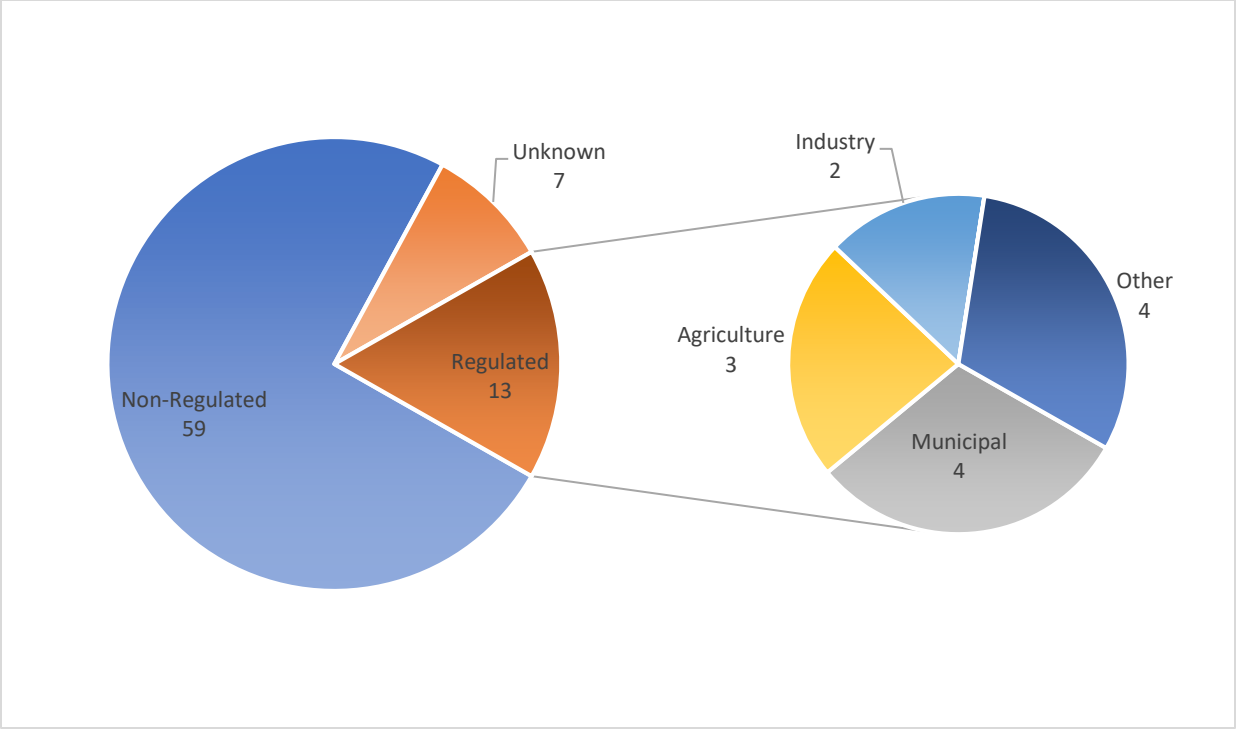

Figure 1. Number of incidents by pollution source in 2018.

Municipal Source

Incidents falling in the municipal source category include, but are not limited to municipal waste, drinking water, and hydropower dams. Municipal pollutants were involved in 4 incidents. Three of these resulted in the death of at least 14,743 fish and aquatic life valued at $4,556.27 (Table 1). Municipal pollutants were the leading cause of regulated incidents in 2018, accounting for over 31% of all regulated investigations (Figure 1).

The most significant incident in this category occurred in Boone County on January 9, 2018. A control valve failure at a pump station in Columbia spilled an estimated 38,000 gallons of chlorinated drinking water into Mill Creek. The spill contaminated 0.7 miles over 2 days, killing an estimated 5,320 fish and other organisms valued at $2,362.62. This incident is significant in that it is the third chlorinated water fish kill in this section of stream within two years. The first incident that occurred in June 2016 also originated at the same pump station (Appendix B). Out of the 4 municipal incidents, three were caused by chlorinated water spills, and two of these occurred in Boone County.

Agricultural Source

Agricultural source pollutants include, but are not limited to animal waste, fertilizer, and pesticides. During 2018, agricultural source pollution represented 3 incidents. Only 1 resulted in fish and wildlife mortality. This mortality incident occurred in Audrain County on April 17, 2018, when an estimated 441,650 gallons of a hog lagoon effluent was discharged into Sandy Creek resulting in ammonia toxicity and hypoxia to aquatic life. The incident was significant due to the duration of the event and the extent of the water body affected by the pollutant. The pollution made stream conditions inhabitable for gill-breathing organisms for at least 4 days and impacted 4 stream miles. Damages accounted for the death of an estimated 47,887 fish and other organisms valued at $43,959.91 (Table 1).

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 2018, two incidents were attributed to industrial pollution. The most significant incident in this category occurred in Stone County on Railey Creek. On April 25, 2018, a call was received about a truck running up and down the banks of Railey Creek. This is significant due to repeated environmental infractions over the past three decades at this site.

Transportation Source

Incidents falling within this category involve pollutants originating from pipelines, aviation, rail, boat, and road vehicle sources. During 2018 MDC was not involved in fish kill or pollution incidents related to transportation.

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 4 incidents, none of which resulted in a fish kill (Table 1). On April 5, 2018, MDC protection staff received a call about Mill Creek in Boone County having turned pink. Water mixed with Red Triple Foam soap was pumped from an overflowing discharge basin behind a local carwash into the creek. The soap was not harmful to aquatic life and there were no dead fish or aquatic organisms observed. Other sources of pollution for 2018 included target shooting with lead shot over the James River, a retaining wall collapsing into a stream due to bank erosion, and an abandoned 55-gallon drum of used motor oil leaking into the Bourbeuse River.

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-nine non-regulated incidents occurred, which comprised 75% of all incidents during 2018 (Figure 1). Thirty-nine of these incidents were fish kills. An estimated 2,529 dead fish and aquatic organisms were observed during non-regulated incidents. However, this is an underestimate: thorough fish counts and damage assessments are not conducted for most non-regulated incidents because investigative time and damages are not reimbursed.

The non-regulated incident with the most mortality occurred in Miller County on Lake of the Ozarks on June 26, 2018. A member of the public contacted MDC to report the death of an estimated 820 freshwater drum and a few channel catfish at mile marker 2. Because it was primarily a single species affected, the likely cause for the kill was disease.

Most notable during 2018 for non-regulated incidents were three weather related fish kills in Stoddard County on Cypress Lake in the Otter Slough Conservation Area. On January 22, 2018, an estimated 500 shad died over a few weeks from long-term ice cover. On July 17, 2018, water temperatures throughout the lake were 90^{o}F even with aeration systems functioning properly. This extreme heat caused a thermal fish kill. Eighty-six dead fish, including largemouth bass, crappie, catfish species, bluegill, and gizzard shad, were found along the banks during this incident. On August 24, 2018, cloud cover caused in a phytoplankton die-off which depleted oxygen and resulted in a significant kill. An estimated 500-1,000 fish, including 14-22-inch largemouth bass, 8-12-inch crappie, 7-9-inch bluegill, catfish over 18 inches, and gizzard shad died during this incident.

Unknown Cause

Personnel were unable to identify the source or cause of the water quality problem for 7 incidents, two of which involved the death of fish (Table 1, Figure 1). At least 2,228 fish, with a $1,948.26 value, died due to unknown causes. The most notable incident due to unknown causes was on a private pond in Benton County on August 20, 2018. It is suspected that the Lincoln waste water treatment plant effluents have caused eutrophication in the private pond resulting in algal blooms and hypoxia events. An estimated 2,144 fish died during this incident. MDC responded to an incident in this same pond and its feeder tributary in September 2015 and found the treatment plant responsible for that incident.

TEMPORAL DISTRIBUTION

Seasonally, the distribution of kills throughout the year presented a bell-shaped pattern similar to previous years (Figure 2, O'Hearn and Baker 2017). Across seasons, the most incidents occurred during summer (June through August), followed by spring (March through May), fall (September through November) and winter (December through February). The most regulated incidents occurred in spring, followed by winter. Summer and fall had the least regulated incidents with two each. Across seasons, the most non-regulated incidents occurred in summer, followed by spring and fall, and winter. Across months, the most regulated incidents occurred in April (4 incidents) and the most non-regulated incidents occurred in May, June, and August (10 incidents each).

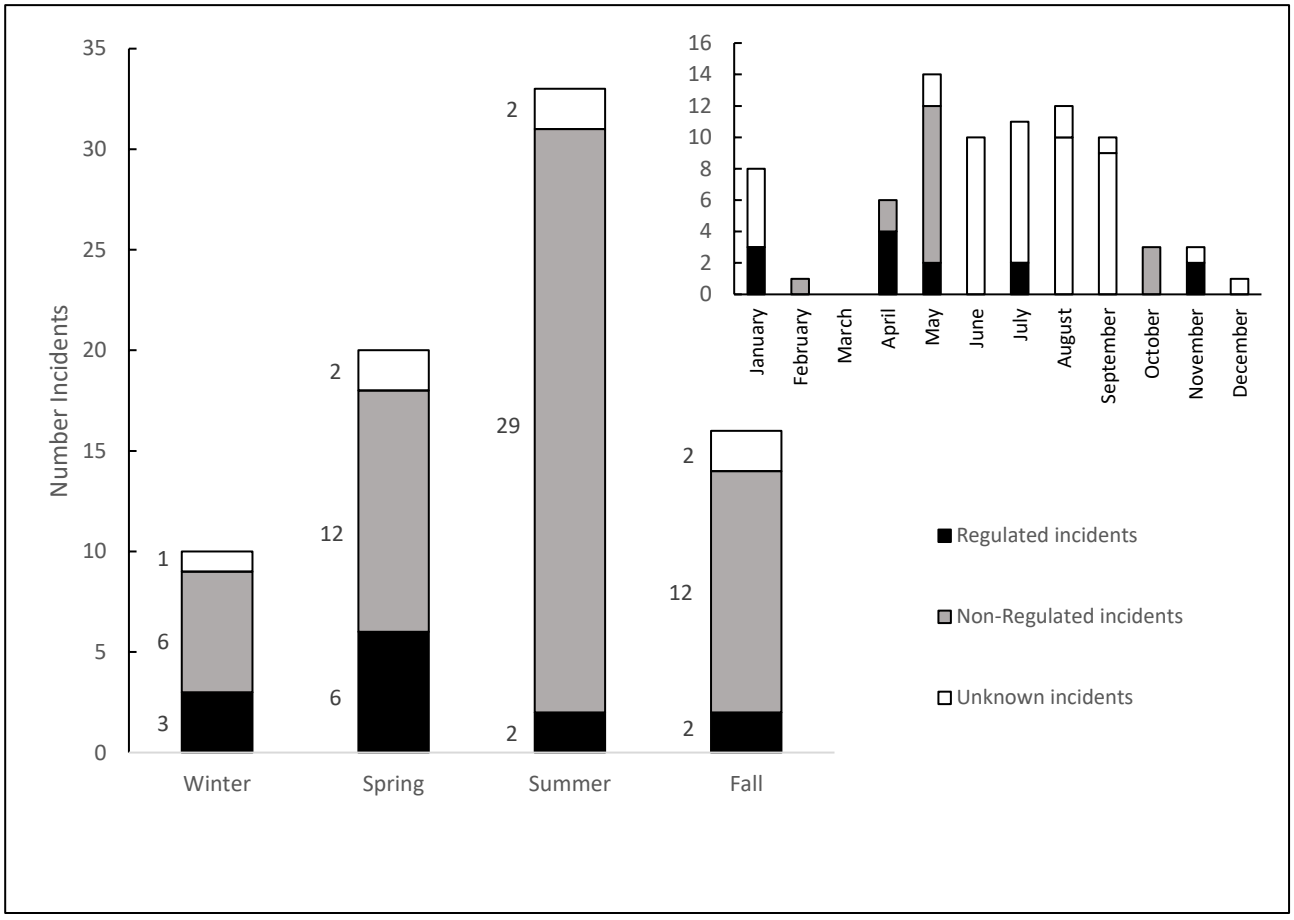

Figure 2. Monthly and seasonal distribution of regulated, non-regulated, and unknown source incidents during 2018.

DISTRIBUTION OF INCIDENTS THROUGHOUT THE STATE

Investigations took place in 40 of 115 counties. The Department's Central Region experienced the most incidents (30 incidents), while the Ozark and Northwest Regions experienced only one incident (Figure 3). Among counties, Boone County had the highest number of incidents (10 incidents). Among major source categories, the most regulated incidents occurred in Boone County with five incidents (Figure 4). The most non-regulated incidents occurred in Jackson County (6 incidents), followed by Boone County (5 incidents) and Cole County (4 incidents).

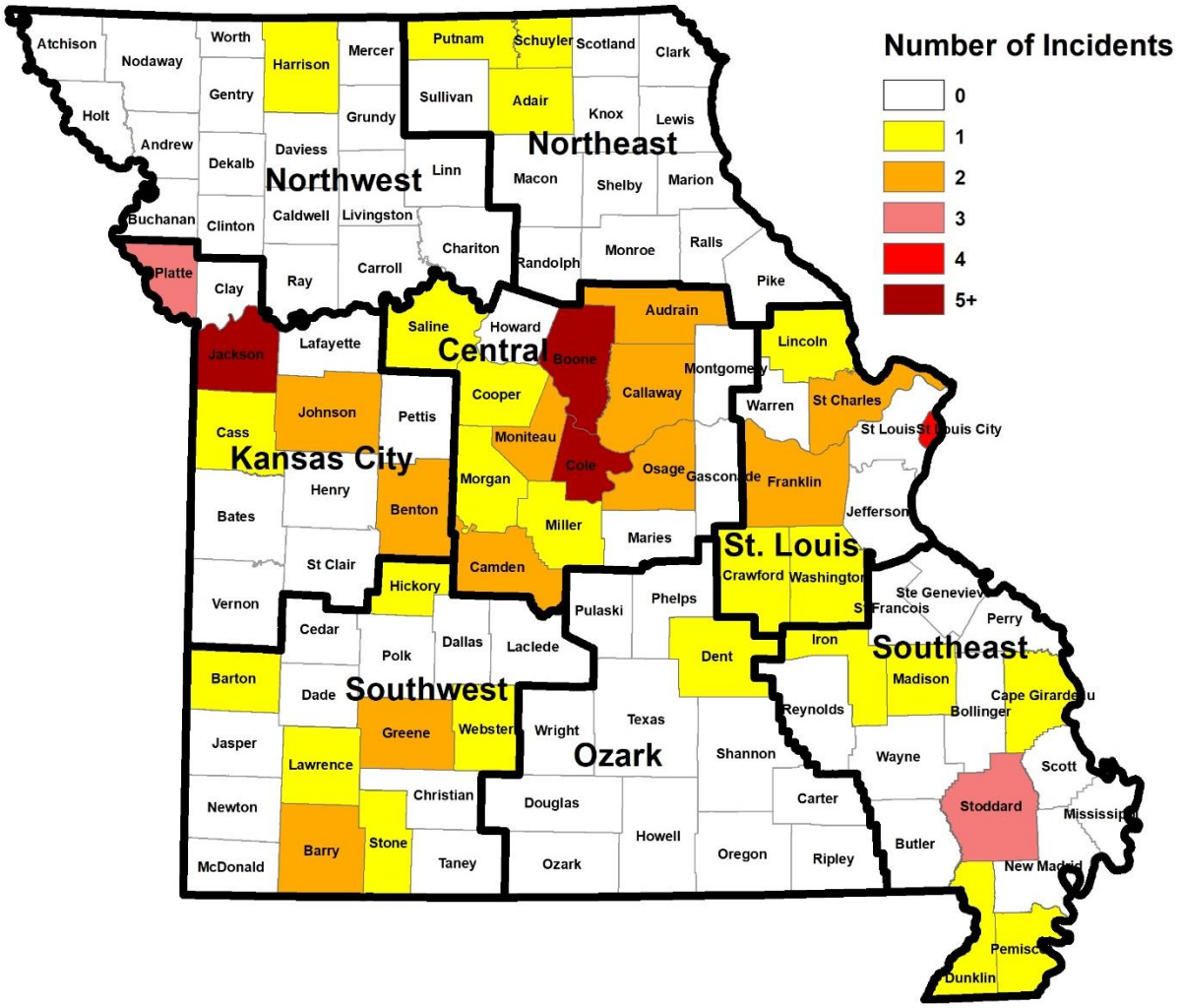

Figure 3. Map of number of incidents during 2018 per county. The eight regions for the Missouri Department of Conservation are outlined in bold.

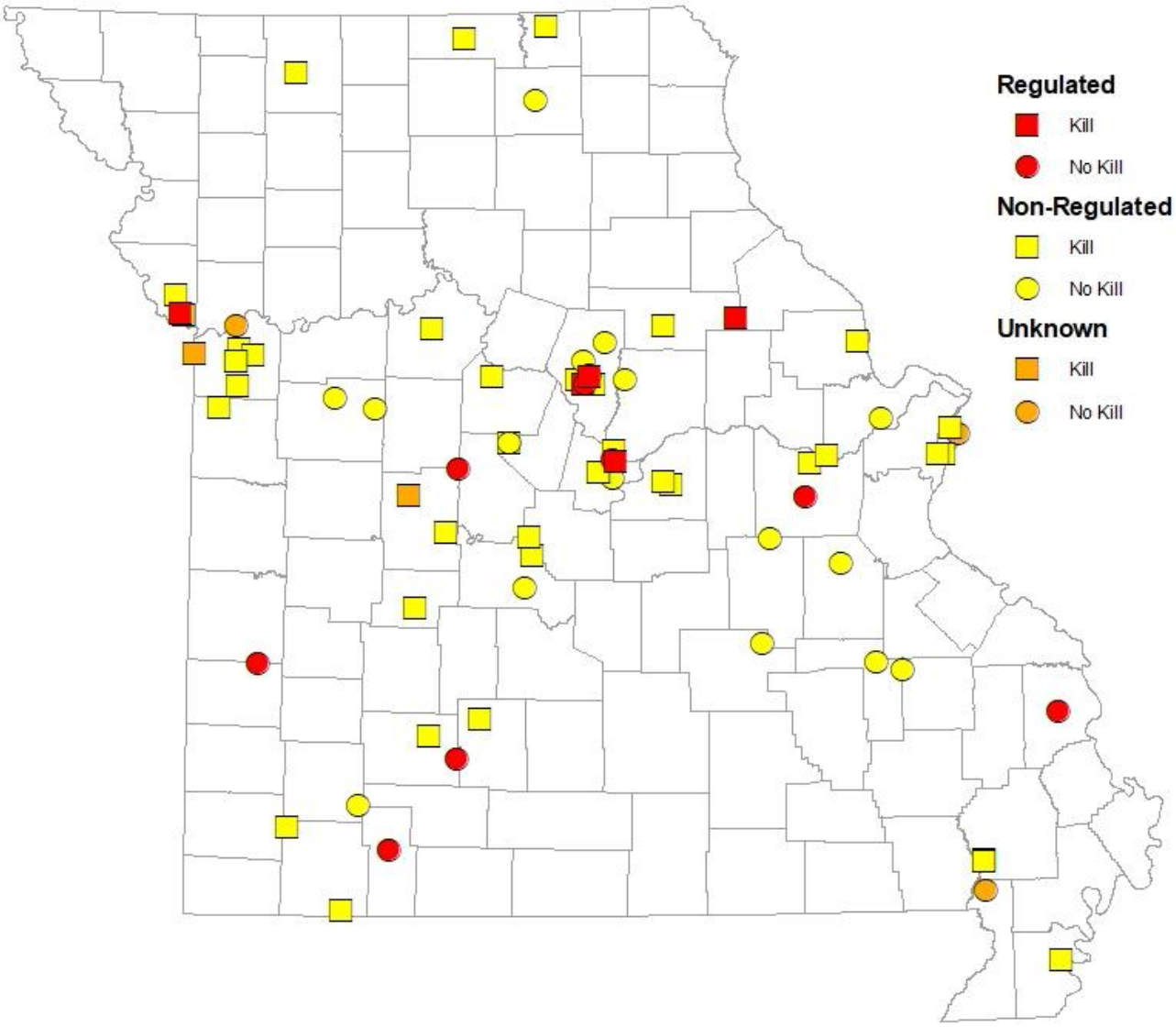

Figure 4. Map of regulated, non-regulated, and unknown source investigations conducted by Missouri Department of Conservation personnel during 2018. Squares indicate fish kills and circles indicate investigations without fish kills.

DISTRIBUTION BY HABITAT TYPE

Among habitat types, incidents occurred more often in ponds than in streams and lakes (Figure 5). This is inconsistent with trends from recent years where streams were the most common habitat for incidents (O'Hearn and McAteer 2015 and 2016, O'Hearn and Baker 2017), this is due to more reports of blue-green algae blooms which is likely the result of better public outreach activities and streamlined reporting procedures among state agencies in 2018. Non-regulated source pollutants were the leading cause of lake and pond incidents (100% and 97%, respectively). Regulated causes were the most common type of incident in streams (52%).

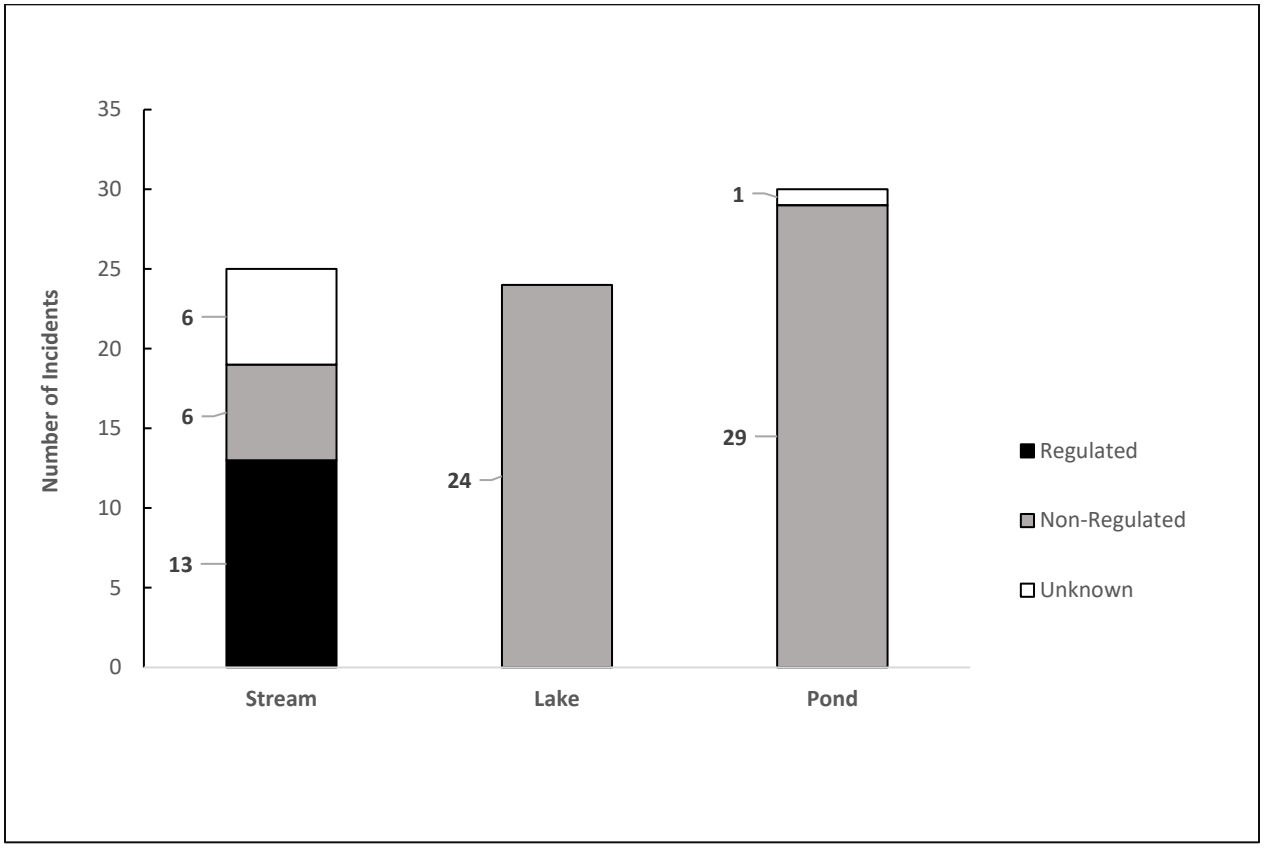

Figure 5. Distribution of incidents during 2018 by habitat type.

ENFORCEMENT STATUS OF FISH KILL AND POLLUTION CASES

Twelve incidents were resolved through compliance and enforcement actions during 2018. One of these incidents occurred during 2014, five in 2016, and six in 2017. DNR, MDC, and the Missouri Attorney General enforced the cases described in this section. All twelve of these cases were resolved through civil legal agreements, which included reimbursements of natural resource damages, reimbursements of investigative costs, payments of civil penalties, and completion of supplemental environmental projects.

Reimbursements for fish damages and investigative costs totaled $50,948.96. Damages totaled $7,185.32 for these cases. Of the reimbursed damage funds, $6,466.79 was transferred to the MDC Fish Kill Grant Fund, which will be spent on projects benefiting aquatic resources in Missouri. The remaining damage funds ($718.53) were transferred to the DNR Chemical Emergency Preparedness Fund and Natural Resources Damages Fund. MDC received $6,045.67 in reimbursements for investigative costs, which was also transferred to the MDC Fish Kill Grant Fund. Penalty monies assessed by the DNR amounted to $43,764. Penalty monies were transferred to the school district of the county in which the pollution occurred.

Forty potentially enforceable cases remain open: one from 2010, 2011, and 2012, six from 2013, three from 2014, four from 2015, four from 2016, fifteen from 2017, and five from 2018. Among these forty open cases, seven entities caused fish kills or pollution events on multiple occasions: US Army Corps of Engineers (12 incidents); City of Columbia (4 incidents); City of Kansas and Missouri American Water (3 incidents each); University of Missouri, City of Jefferson, and Metropolitan Sewer District (2 incidents each).

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 the Fisheries Division. Project proposals are solicited in July on an annual basis from Fisheries, Protection, and Resource Science divisions. Eligible projects benefit aquatic resources. No proposals were awarded during 2018 due to a low fund balance.

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, data for events prior to 1988 are not completely digitized. Two major categories of incidents are not included in this section. The "unknown" and regulated-other categories are not included 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. Since 2003, the number of regulated incidents has fluctuated between 10 and 28, with 2018 setting a record low of 10 incidents since MDC began electronically recording data in 1988. (figures 6 and 7A-C, Appendix G). Municipal pollutants were and continue to be the dominant cause of regulated incidents over time (for 24 out of 30 years, Figure 6).

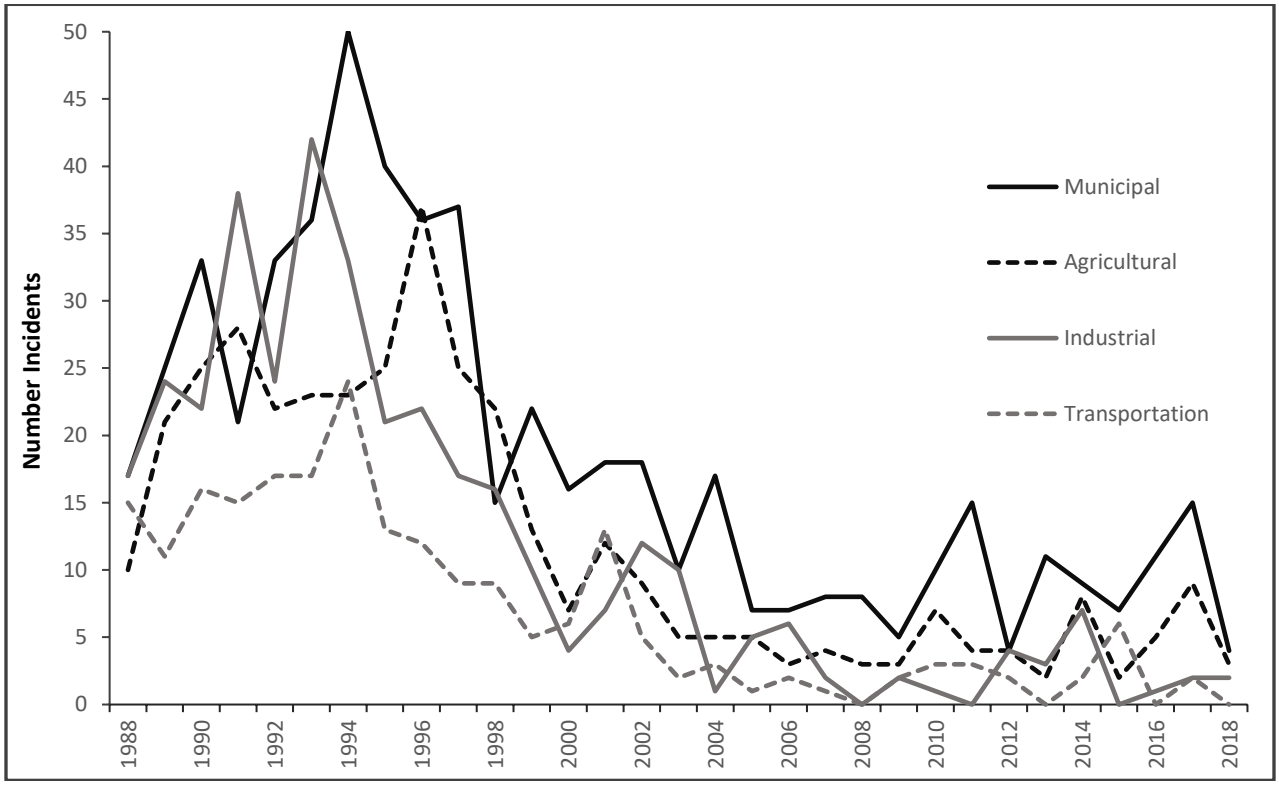

Figure 6. Long-term (1988-2018) trends in regulated incidents. The "other" source category involves miscellaneous pollution sources and is not included in the figure.

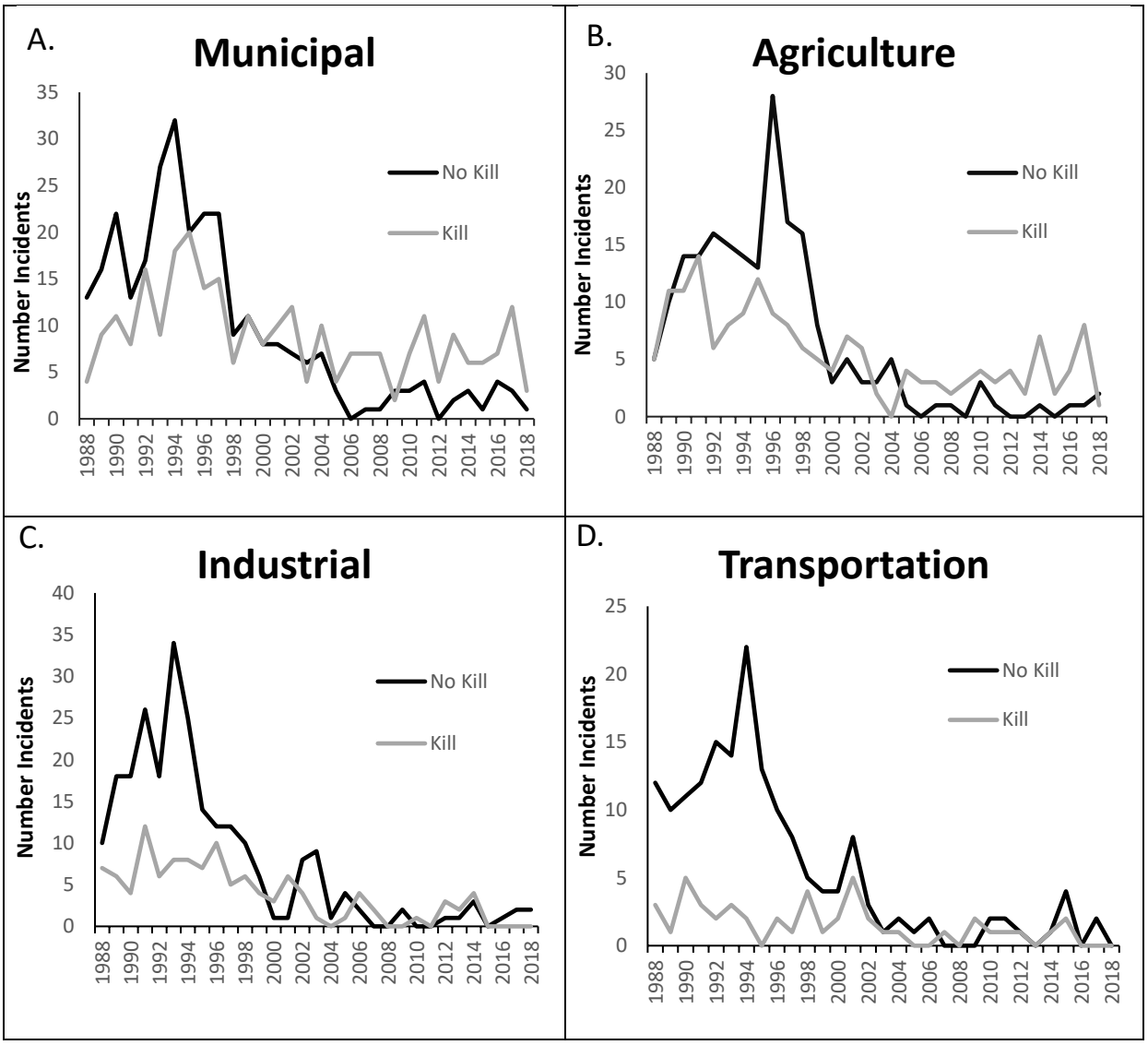

Figure 7. Long-term (1988-2018) trends for regulated fish kill and pollution incidents caused by municipal (A), agricultural (B), industrial (C), and transportation (D) sources. The "unknown" and "other" categories are not included in this figure because they contain incidents with wide ranging pollution sources and causes. Non-regulated incidents are not included because trends reflect changes in reporting procedures (O'Hearn and Martin 2013).

CONCLUSION

MDC has a statutory responsibility and authority to protect fish, forest, and wildlife in Missouri. Conducting fish kill and pollution investigations is an activity that partially fulfills this responsibility. 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, from initial notification, on-scene response, damage and penalty assessment, enforcement, and finally appropriating reimbursed funds to benefit natural resources. Without this partnership, many polluters would not be held responsible for damaging Missouri's aquatic resources.

During 2018, MDC was involved in 79 water quality and pollution investigations. Over 67,387 fish and other animals valued at $50,464.44 died during these incidents. Twelve incidents which occurred during previous years have been resolved through compliance actions and civil legal agreements. Damage and investigative costs reimbursements from civil agreements totaled over $50,000, and penalties and supplemental environmental project costs amounted to $43,764.

Forty potentially enforceable cases remain open: one from 2010, 2011, and 2012, six from 2013, three from 2014, four from 2015, four from 2016, fifteen from 2017, and five from 2018. Among these forty open cases, seven entities caused fish kills or pollution events on multiple occasions: US Army Corps of Engineers (12 incidents); City of Columbia (4 incidents); City of Kansas and Missouri American Water (3 incidents each); University of Missouri, City of Jefferson, and Metropolitan Sewer District (2 incidents each).

Despite the partnership's successes, there remain areas of concern. Municipal pollution (i.e. waste water, chlorinated drinking water, and hydro-electric power generation) continues to be the leading cause of fish pollution-related mortality in Missouri, followed by agricultural pollution (i.e. fertilizers, animal wastes, and pesticides). Similar to previous years, during 2018 both municipal and agricultural sources caused extensive damage to Missouri aquatic resources, most notably multiple chlorinated water kills (Appendix B and pages 5, 15, 30, 31, 32, and 33) and multiple kills caused by livestock waste effluent.

The number of chlorinated water kills in the City of Columbia over the last three years is significant when evaluated from a state-wide perspective. The addition of 2 new chlorinated water incidents in Columbia in 2018 brings the total of open chlorinated water cases in Columbia to 6 over the last three-years. Chlorine is extremely toxic to gilled-aquatic life at low concentrations and when combined with ammonia forms chloramines which persists in the environment for up to one week (DNR, personal communication). MDC has observed dead zones in streams where large chlorinated water releases occur, including streams in the City of Columbia.

Large releases of livestock waste effluent also result in a similar dead zone effect in streams. Livestock waste contains high levels of ammonia which is toxic to gilled-organisms in low concentrations. Decomposition of livestock waste also decreases dissolved oxygen levels in streams creating hypoxic zones where gilled-organisms asphyxiate. The program documented 3 fish kills in 2018 resulting from discharges of livestock waste into streams (Appendix B and pages 5 and 30).

LITERATURE CITED

Cooperative Agreement between the Missouri Department of Natural Resources and the Missouri Department of Conservation for investigating fish kills in Missouri waters. From Missouri Department of Conservation SharePoint*

Fish Kill and Water Pollution-Procedures for Notification and Action. From Missouri Department of Conservation SharePoint*

O'Hearn, R. and S. McAteer 2015. Missouri pollution and fish kill investigations 2014. Missouri Department of Conservation. 28 pp. From Missouri Department of Conservation SharePoint*

O'Hearn, R. and S. McAteer 2016. Missouri pollution and fish kill investigations 2015. Missouri Department of Conservation. 27 pp. From Missouri Department of Conservation SharePoint*

O'Hearn, R. and J. Baker 2018. Missouri pollution and fish kill investigations 2017. Missouri Department of Conservation. 36 pp. From Missouri Department of Conservation SharePoint*

Southwick, R. I. and A. J. Loftus, editors. 2017. Investigation and monetary values of fish and freshwater mollusk kills. American Fisheries Society, Special Publication 35, Bethesda, Maryland.

∗ 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 2018.

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 Fish Kill Program during 2018:

Monitoring

Clear Creek Recovery Monitoring

Clear Creek in Barry and Lawrence counties experienced a heavy to total fish kill in May 2014. The fish kill was caused by Tyson Foods, who discharged a solution of Alimet to the Monett wastewater treatment plant which killed the plant's denitrifying microbes. This resulted in the discharge of waste water with a high ammonia concentration to Clear Creek. The ammonia caused a fish kill for over 5 stream miles, and fish morbidity & mortality was observed for several days. At least 108,809 fish and crayfish valued at $130,988.26 died during this incident. Due to the severity of the kill, MDC began monitoring for live fish shortly after the kill. One year after the kill, MDC observed fish recolonization occurring throughout the entire 5-mile kill zone. However, the number of fish, species richness, and size composition indicate the stream is not fully recovered.

Tunnel Dam Project

The Environmental Health Unit continued to monitor water quality in Lake Niangua and the Niangua River to assess baseline 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 river and sports fisheries in Lake Niangua. Initial findings indicate power generation de-stratifies Lake Niangua in the summer months. Monitoring in the lower Niangua River indicated low dissolved oxygen levels in certain segments of the river.

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 analysis will be completed in early 2020 by a PhD candidate in MU's Limnology Laboratory.

Training

Fish Kill Procedures Training

Refresher training on water pollution and fish kill investigation procedures was given to Southeast Region's Conservation Agents and Fisheries staff. 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 Fisheries divisions are invaluable to MDC's ability to respond to pollution problems statewide in a professional and timely manner. Without their assistance, the task would be overwhelming. Two water pollution and fish kill awareness trainings were given to MDC staff as part of MDC's Water Quality 101 course.

Hazardous Waste Operations and Emergency Response Training
The Environmental Health Unit was asked by the Missouri Department of Health and Senior Services to assist with the 8-hour annual certification training for Hazardous Waste Operations and Emergency Response for county health professionals in the St. Louis metropolitan area. A 1-hour presentation on water pollution and fish mortality events in Missouri and contaminants bioaccumulation was given as part of this training.

Presentations
Missouri Natural Resources Conference- One Health Workshop
Presented on water pollution in Missouri as part of a One Health Workshop. The One Health Initiative and movement promotes collaboration between the environmental health, medical, and veterinary fields with an understanding that environmental, human, and animal health are reliant on each other.

Guest lecture- University of Missouri Water Quality Class
Presented Missouri fish kills and pollution types and case studies to University of Missouri's Water Quality students.

Future Operational Changes
New Fish Kill Application and Database
In July 2018 MDC began working towards replacing the outdated fish kill and pollution database. The future database will be paired with three applications. The first application will provide the public to directly report fish kills they observe through MDC's website. A new fish kill page on MDC's public website will host this first application in addition to providing the public a venue for learning about fish kill events around the state of Missouri, their causes, and how they can be part of the solution. The second application automatically notifies regional fish kill responders when the public reports through MDC's website. The third application will allow MDC staff to directly enter their investigative data into the fish kill database which will eliminate data entry errors caused by re-entering data multiple times. The new application and database will be completed in early 2020.

Appendix B. Summary of regulated source incidents during 2018. Data is listed alphabetically by county. ND= not determined, NC= not calculated

County	Waterbody	Incident Date	Source	Cause	Number Animals Killed	Value
Audrain	Sandy Creek	4/17/2018	Agriculture	Hypoxia & ammonia toxicity-hog lagoon overflow	47,887	$43,959.91
Barton	Tributary to Clear Creek	1/2/2018	Agriculture	Land-applied manure	0	-
Boone	Mill Creek	1/9/2018	Municipal	chlorine toxicity-pump station failure	5,320	$2,362.62
Boone	Mill Creek	4/5/2018	Other	Red Triple Foam-car wash discharge	0	-
Boone	Hominy Branch	7/16/2018	Municipal	Chlorine toxicity-broken water line	2,595	$693.43
Cape Girardeau	Unknown Spring	5/3/2018	Other	Fallen retaining wall	0	-
Cole	Tributary to MO River	5/4/2018	Municipal	Chlorinated water-water main break	ND	NC
Cole	Wears Creek	1/26/2018	Industrial	Milk	0	-
Franklin	Bourbeuse River	11/24/2018	Other	Likely used motor oil from abandoned drum		-
Greene	James River	4/2/2018	Other	Lead shot-target shooting	0	-
Morgan	Haw Creek	7/19/2018	Agriculture	Sediment from pond construction	0	-
Platte	Walnut Creek	11/22/2018	Agriculture	Ammonia toxicity, low dissolved oxygen (suspected)	6,828	$1,500.22
Stone	Railey Creek	4/25/2018	Industrial	Driving in stream	0	-

Appendix C. Summary of non-regulated source incidents during 2018. Data is listed alphabetically by county. ND=not determined

County	Waterbody	Incident Date	Cause	Number Animals Killed
Adair	Private Pond	9/11/2018	Cyanobacteria	0
Audrain	Private Pond	4/29/2018	Low dissolved oxygen	ND
Barry	Farm Pond	5/27/2018	Low dissolved oxygen	0
Barry	Table Rock Lake	8/13/2018	Suspect low dissolved oxygen due to rain event	ND
Benton	Lake of the Ozarks	6/25/2018	Cause undetermined	ND
Boone	Henry Pond	8/28/2018	Cyanobacteria	0
Boone	Private Pond	5/25/2018	Possible fish cancer	0
Boone	South Farm R-1 Lake	8/20/2018	Low dissolved oxygen-lake drawdown	ND
Boone	Stephens Lake	9/19/2018	Cyanobacteria	0
Boone	Twin Lake	1/31/2018	Temperature or low dissolved oxygen	ND
Callaway	Tributary to Owl Creek	10/22/2018	Suspected Dye	0
Callaway	Turkey Creek Golf Course Lake	5/1/2018	Disease Likely	250
Camden	Lake of the Ozarks	6/14/2018	Low dissolved oxygen or temperature stress	ND
Camden	Private Pond	5/17/2018	Cyanobacteria	0
Cass	Shadowood Pond	7/13/2018	Low dissolved oxygen	ND
Cole	Private Pond	6/26/2018	Low dissolved oxygen	ND

Appendix C. Continued

County	Waterbody	Incident Date	Cause	Number Animals Killed
Cole	Private Pond	6/26/2018	Low dissolved oxygen	ND
Cole	Private Pond	6/26/2018	Low dissolved oxygen	ND
Cole	Neighborhood Pond	5/28/2018	Cyanobacteria	0
Cooper	Lamine River	6/27/2018	Possible disease	ND
Crawford	Private Pond	8/6/2018	Cyanobacteria	0
Dent	Blackwell Lake	7/17/2018	Blue green algae	0
Franklin	Meadow Oak Lake	10/15/2018	Cause undetermined	ND
Greene	Fellows Lake	8/2/2018	*Columnaris* bacterial infection	ND
Harrison	New Bethany Reservoir	6/10/2018	Post-spawn or heat stress	0
Hickory	Pomme de Terre Lake	7/3/2018	Ich/Aeromonas/Flavobacteria infection	ND
Iron	Snow Hollow Lake	5/7/2018	Cyanobacteria	0
Jackson	Blue Springs Country Club Lake	9/13/2018	Low dissolved oxygen-lake turnover	ND
Jackson	Detention Pond	7/27/2018	Low dissolved oxygen	ND
Jackson	Horseshoe Lake	1/27/2018	Low dissolved oxygen-ice cover	ND
Jackson	Private Pond	9/14/2018	Low dissolved oxygen	ND
Jackson	Private Pond	9/14/2018	Low dissolved oxygen	ND
Jackson	Private Pond	9/14/2018	Low dissolved oxygen	ND

Appendix C. Continued

County	Waterbody	Incident Date	Cause	Number Animals Killed
Johnson	Hazel Hill Lake	8/22/2018	Cyanobacteria	0
Johnson	Private Pond	7/17/2018	Cyanobacteria	0
Lawrence	Rader Pond	7/18/2018	Potential HAB	0
Lincoln	Jake's Pond	2/18/2018	Shallow lake frozen solid	506
Madison	Stouts Creek	4/4/2018	Unconfirmed algae/bacteria/fungi (suspected)	0
Miller	Lake of the Ozarks- mile marker 2	6/26/2018	Infection likely	820
Moniteau	Tipton Park Lake	1/19/2018	Low dissolved oxygen	ND
Moniteau	Tipton Park Lake	6/27/2018	Potential HAB	0
Osage	Osage Pond	1/2/2018	Low dissolved oxygen likely	ND
Osage	Private Pond	8/15/2018	Low dissolved oxygen	ND
Pemiscot	Tributary to Mississippi River	9/21/2018	Low dissolved oxygen due to decaying vegetation and falling river levels	200
Platte	Brasilia Lake	5/1/2018	Low dissolved oxygen	ND
Platte	Riss Lake silt basin	5/15/2018	Low dissolved oxygen-low water levels	250
Putnam	Richardson Pond	9/6/2018	Cyanobacteria	0
Saline	Harrison Pond	8/24/2018	Low dissolved oxygen (suspected)	ND
Schuyler	Old Lancaster City Lake	9/1/2018	Low dissolved oxygen	ND

Appendix C. Continued

County	Waterbody	Incident Date	Cause	Number Animals Killed
St. Charles	Stormwater Lake	5/6/2018	Exhaustion/starvation-back stabilization materials catching wildlife	ND
St. Charles	Private Pond	8/3/2018	Low dissolved oxygen (suspected)	ND
St. Louis City	Boathouse Pond	5/24/2018	Possible cyanobacteria	ND
St. Louis City	O'Fallon Park Lake	7/25/2018	Low dissolved oxygen	ND
St. Louis City	River Des Peres	10/8/2018	Low dissolved oxygen (suspected)	ND
Stoddard	Cypress Lake	1/23/2018	Low dissolved oxygen	500
Stoddard	Cypress Lake	7/16/2018	Low dissolved oxygen (suspected)	ND
Stoddard	Cypress Lake	8/23/2018	Low dissolved oxygen	ND
Washington	Hi Pointe Lake	6/25/2018	Cyanobacteria	0
Webster	Greer Creek	7/12/2018	Low dissolved oxygen	ND

Appendix D. Summary of incidents caused by unknown sources during 2018. Data is listed alphabetically by county. ND=not determined, NC=not calculated

County	Waterbody	Incident Date	Cause	Number Animals Killed	Value
Benton	Private Pond	8/20/2018	Undetermined	2,144	$1,948.26
Boone	Flat Branch	11/21/2018	Murky water	0	-
Boone	Grindstone Creek	12/14/2018	Unknown "slick"	0	-
Dunklin	Unknown Ditch	9/13/2018	Organic sheen	0	-
Jackson	Brush Creek	5/7/2018	Undetermined	84	NC
Jackson	Mill Creek confluence with MO River	5/9/2018	No dead animals confirmed	0	-
St. Louis City	Mississippi River	8/7/2018	Suspected crude oil	0	-

Appendix E. Summary of Clean Water Law settlements reached by the State of Missouri during 2018 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.

County	Waterbody	Event Date	Responsible Party	Cause	Reimbursements			Penalty (MDC does not calculate)**
					Fish Damage*	MDC Investigative Costs	MDC Total	
Boone	Philips Lake	4/2/14	P1316 LLC	Sediment runoff- land disturbance	$0	Not reimbursed	NA	$175,716
Callaway and Audrain	South Fork Salt River	12/3/17	Dale Brinkler	livestock waste-lagoon failure	$774.42	$1,450.26	$2,147.24	$2,500
Camden	Sellars Creek	4/11/17	Ozark Fisheries	rotenone	$442.82	$804.66	$1,203.19	$4,000
Cape Girardeau	Foster Creek	7/5/16	Kelvin Birk	cattle manure runoff-improper storage	$2,182.05	$2,325.41	$4,289.26	$12,000
Cape Girardeau	Hubble Creek, tributary of	7/12/16	Kelvin Birk	cattle manure runoff-improper storage	$173.55	$1,081.16	$1,237.36	$0
Franklin	Flat Creek	8/8/17	Gateway Extrusions	High pH-caustic chemical spill	--	Not reimbursed	NA	$8,000
Greene	Pea Ridge Creek	10/1/16	City of Springfield	human sewage-manhole overflow	$270.92	$472.86	$716.69	$4,000
Montgomery	Little Bear Creek	4/11/17	Davis meat processing LLC	meat processing lagoon waste	$9.72	$641.28	$650.03	$1,000
Pemiscot	Half Moon Bayou, tributary of	1/9/17	City of Caruthersville	sewer line break	$2,986.46	$1,524.96	$4,325.30	$2,500
Warren	Charrette Creek	7/3/17	Innsbrook owners association	human sewage	$285.93	$625.41	$882.75	$3,000
Warren	Peruque Creek	5/26/16	Wright City	sewer overflow-dry weather bypass	$59.45	$236.81	$289.91	$1,763.64

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

**Includes suspended penalties and supplemental environmental project costs

Appendix F. Brief descriptions of closed and open cases listed alphabetically by county for 2018.

Closed Cases (Resolution)

Cases closed after resolution was reached.

Boone County (4/2/14), P1316 LLC (construction company)

Land disturbance in southern Columbia caused a substantial amount of sediment to enter Phillip's Lake, at a rate more than 2-3 times what is typical for reservoirs in Missouri. Significant sedimentation may have a negative impact to fish communities via more frequent and severe algal blooms, lower survival of larval fish, and irritation of the gills. A substantial amount of sediment was also deposited in the floodplain areas of Phillip's Lake and Gans Creek. Gans Creek is an outstanding state resource water and flows into a cave system where rare species have been documented. Deposited sediment in the floodplain areas of both Phillip's Lake and Gans Creek acted as a source of water pollution during rain events. Sediment found in the floodplain of Gans Creek may have a negative impact to stream macroinvertebrates and fish in the stream. Sink holes are also present in the area and contain sediments from this activity. A Settlement Agreement was signed in April 2018. P1316 LLC paid investigative costs reimbursements to the state of Missouri totaling $21,039.92 and a $5,000 penalty to the State of Missouri (Boone County). Agreed to complete projects valued at $170,716.26 within 1.5 years of execution of agreement. Projects include: trench drain repair, headwater improvements to Philips Lake, additional treatment of water to Gans Creek). RP will enter into agreement with City of Columbia Parks and Recreation to join that agency's Volunteer Commitment Program to maintain designated areas for a period of ten years. Monetary value of this commitment is approximately $6,000 per year (a total of $60,000 over ten years).

Callaway County and Audrain County (12/3/17), Dale Brinkler

A livestock lagoon overflowed into a tributary of the South Fork Salt River on November 30th and was not discovered until December 2nd. Notifications from EER indicate that around 300,000 gallons of lagoon waste had been discharged over the course of a few days. MDC responders observed at least 330 dead fish and tadpoles in South Fork Salt River and its tributary (a total of 2.5 stream miles). Dead fish and tadpoles were valued at $774.42. These numbers should be considered conservative given the volume of waste discharged, observations of the remnants of scavenged fish carcasses, and the lag time between the spill date and the date the Department was notified. An Abatement Order on Consent (AOC) was signed in July 2018. Brinkler was ordered to pay fish damages, investigative costs ($3,272.71 total), and a penalty of $4,000 ($2,500 to Callaway County School Fund and $1,500 suspended). The portion of the penalty that is suspended is for a period of two years from the execution of the AOC. Ordered to install automatic timer on recharge pump with maximum run time of one hour. Two visual alarms will be installed alerting the recharge pump is running. Also agrees to maintain operation and maintenance log on site to document facility maintenance activities. Agrees to report all future discharges of animal waste within 24 hours of discovery. Stipulated penalties up to $250 per day if they don't meet deadlines in the AOC.

Camden County (4/11/17), Ozark Fisheries

Ozark Fisheries applied Rotenone (a piscicide) to their hatchery ponds on April 11th. Measures to prevent the migration of rotenone from the ponds into waters of the state were ineffective resulting in a fish kill in Sellars Creek. Over 1,000 fish valued at $442.82 were killed as a result of the discharge. An Abatement Order on Consent was signed in July 2018. Ozark Fisheries agreed to pay fish damages, costs incurred by the state during the investigation. The DNR assessed a penalty of $4,000. Ozark Fisheries and DNR agreed that the $4,000 penalty would be suspended for a period of two years from the execution of the agreement upon the condition that Ozark Fisheries does not violate the terms of the agreement. Ozark Fisheries also agreed to discontinue the use of mud and turkey litter to form a seal in front of the stop-log drain system for the facility's impoundments and agrees to use hand-tite plugs as an alternative. They also agree to report all future discharges of water contaminates within 24 hours of discovery.

Cape Girardeau (7/5/16 & 7/12/16 & 12/27/16), Kelvin Birk

Manure was discharged from the Birk cattle farm into Foster Creek on July 5th. The discharge negatively impacted over 3 miles of stream. MDC investigators observed 7,023 dead fish valued at $2,182.05. MDC suspects this discharge resulted in a heavy to total kill in this stream. Black manure laden water was discharged from the Birk cattle farm into a tributary of Hubble Creek on July 12th. The discharge depleted oxygen in the stream forcing a migration of low dissolved oxygen tolerant aquatic worms out of the stream sediment. MDC investigators observed 1,170 dead fish, snails, and crayfish valued at $173.55. MDC suspects this discharge resulted in a total kill of this tributary. In December 2016, MDC received a call from a concerned local citizen regarding a discharge of manure from the Birk cattle farm into a tributary of Hubble Creek after a rain event. The caller did not report any observations of dead aquatic life. MDC forwarded the report to DNR Compliance and Enforcement Section. An Abatement Order on Consent was signed in October 2018. Mr. Birk was ordered to pay fish damages, costs incurred by the state during the investigations ($6,423.03), and to pay a $12,000 penalty. For the penalty, $6,000 was paid to the Cape Girardeau County School Fund and $6,000 was suspended for a period of two years from the date of execution of the agreement upon the condition that Mr. Birk does not violate terms of the agreement or clean water law. Birk also agrees to store manure so that there is not exposure to rain, snow, snow melt, or runoff. If there is failure to meet terms in the agreement, Birk faces stipulated penalties up to $250 per day.

Franklin County (8/8/17), Gateway Extrusions

MDC was notified by DNR-EER regarding a caustic chemical spill that had been discharged into Flat Creek. EER reported that frogs were observed dead in the creek. MDC responded on site and observed a pH of 14 in the stream. MDC did not observe dead fish or dead animals while on site. An Abatement Order on Consent was signed in August 2018. Gateway Extrusions agreed to reimburse the state for investigative costs incurred in the amount of $2,901.55 and to pay a civil penalty of $8,000. For the penalty, $5,000 was paid to the Franklin County School Fund, and $3,000 was suspended for a period of two years from the execution of the agreement upon the condition the company does not violate the terms of the agreement, clean water law, or their permit.

Greene County (10/1/16), City of Springfield

A manhole malfunction resulted in a sewage discharge into Pea Ridge Creek. MDC observed 1,027 dead fish as a result of this discharge. Fish were valued at $270.92. Reported fish injuries and values should be considered underestimates because cleanup activities flushed fish downstream into inaccessible areas prior to MDC being notified about the incident. An Abatement Order on Consent was signed in July 2018. The City was ordered to pay investigative time incurred by state in the amount of $1,780.17, pay fish damages, and pay an administrative penalty of $4,000 that would go to the Greene County School Fund.

Montgomery County (4/11/17), Davis meat Processing LLC

On April 11th as a means to reduce the costs of a waste hauler, Davis Meat Processing disposed of lagoon waste onto their property which drained into Little Bear Creek resulting in a fish kill. Many dead fish had been scavenged by the time the Department was notified three days post-spill; therefore, damages observed by MDC responders are underestimates. During the investigation, MDC observed 25 dead fish and 1 dead frog valued at $9.72. An Abatement Order on Consent was signed on April 19, 2018. Investigative costs and damages of $2,634.52. Administrative penalty of $4,000 ($3,000 suspended; $1,000 payable to county schools). The $3,000 suspended penalty is for two years from execution of AOC.

Pemiscot County (1/9/17), City of Caruthersville

A sewer line break near the waste water treatment plant on January 9th discharged an unknown quantity of sewage into a tributary of Half Moon Bayou. Our responders observed 351 dead fish valued at $2,986.46 and noted visibility of dead fish was limited due to ice cover and leaf litter. An Abatement Order on Consent was signed in April 2018. The City agreed to reimburse the state for fish damages, investigative costs incurred by the state ($1,973.55), and to pay an administrative penalty of $2,500 to the Pemiscot County School Fund. The City also agreed to report non-compliance within 24 hours from the time the City becomes aware of the circumstances.

Warren County (5/26/16), City of Wright

A Wright City sanitary sewer overflow dry-weather bypass resulted in a discharge of 5,000 gallons of waste water into Peruque Creek. MDC documented 81 dead fish as a result of the discharge. Fish were valued at $59.45. An Abatement Order on Consent was signed in November 2018. Wright City was ordered to pay a $1,763.64 civil penalty to the Warren County School Fund and to reimburse the state for fish damages and investigative costs incurred in the amount of $1,218.60.

Warren County (7/3/17), Innsbrook Owners Association

On July 4, 2017 MDC was notified by DNR-EER of a fish kill in Charrette Creek. EER had been forwarded the complaint from a 911 dispatcher who had received a call from a private citizen. The initial complaint described sewage discharge and odors that were especially bad on the night of July 3rd. MDC responded on site and verified the spill and fish kill. MDC identified and counted 694 dead fish valued at $285.93 during the investigation. An Abatement Order on Consent was signed in August 2018. Innsbrook Owners Association agreed to pay an administrative penalty of $3,000 to the Warren County School Fund, and to reimburse the state for fish damages and expenses incurred during the investigation ($5,512.48 total). They were ordered to submit a Facility Plan developed and prepared by a professional engineer within 30 days of the execution of the agreement. The Facility Plan would evaluate the waste water treatment facility and recommend corrective actions to prevent future bypasses and achieve compliance with

permitted effluent limitations for Ammonia as Nitrogen. They were ordered to submit an application for a construction permit to implement improvements that result in compliance within 60 days of DNR approving the Facility Plan. They were ordered to complete construction within 180 days of DNR issuing a construction permit. Innsbrook Owners Association will be subject to pay up to $250 per day in stipulated penalties if they fail to meet the terms of the agreement, including the deadlines.

Open Cases

The following cases are currently being evaluated by DNR Compliance and Enforcement group in the Water Pollution Control Branch of the Water Protection Program or are still under investigation.

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 beginning 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.

Benton County (5/29/13), U.S. Army Corps of Engineers under direction of Southwest Power Administration

A hypolimnetic release of low dissolved oxygen water caused a fish kill in Lake of the Ozarks. Physical 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.

Benton County (8/26/13), U.S. Army Corps of Engineers

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.

Benton County (5/25/16), U.S. Army Corps of Engineers under direction of Southwest Power Administration

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.

Benton County (5/6/17), U.S. Army Corps of Engineers under direction of Southwest Power Administration

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.

Boone County (5/18/14 & 8/22/15), University of Missouri
Runoff from land applied manure in the areas adjacent to Dairy Farm Lake No. 1 depleted oxygen. MDC staff observed 50 dead fish valued at $150.46 during May 2014 and 410 dead fish valued at $822.42 during August 2015. There is a history of kills of this nature at this lake and Dairy Farm Lake No. 3 dating back to 2005 in our records. These two incidents are two of five fish kills resulting from land application of manure at this site. An effective aeration system and a vegetated buffer zone, or removal of nutrient-rich sediments is needed to avoid future fish kills. MDC awarded money from the Fish Kill Grant Fund to purchase and install an efficient aeration system at lakes 1 and 3. MU did not accept funding for the purchase and installation at Lake No. 1.

Boone County (7/3/14), University of Missouri
Runoff from land applied manure in the areas adjacent to Dairy Farm Lake No. 3 depleted oxygen. MDC staff observed 3,945 dead fish valued at $7,808.26. There is a history of kills of this nature at this lake and Dairy Farm Lake No. 1 dating back to 2005 in our records. MDC awarded money from the Fish Kill Grant Fund to purchase and install an efficient aeration system at lakes 1 and 3. MU has not accepted funding for the purchase and installation at Lake No. 1.

Boone County (6/9/16), City of Columbia
A 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.

Boone County (9/1/17), City of Columbia
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.

Boone County (1/10/18), City of Columbia
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.

Boone County (7/17/18), City of Columbia
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.

Callaway County (1/3/17), City of Holts Summit
The City of Holts Summit reported a grease blockage caused a manhole overflow sometime on January 3rd or 4th resulting in a discharge of 134,000 gallons of raw sewage into a tributary of Rivaux Creek. MDC was notified of the overflow and fish kill on January 10th, six to seven days after the initial spill. The MDC responder found very few dead fish during the investigation due to the delay in notification, ice cover, and leaf litter in the stream. Thirty darters and minnows were observed and valued at $6.20.

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.

Camden County (7/11/17), Sho-Me Power
MDC staff observed mussel and fish stranding while conducting normal work duties in the Niangua River below Tunnel Dam. The stranding was caused by an abrupt reduction in flow over Tunnel Dam for a spillway inspection. Stranded mussels were translocated to water, but many fish and stream macroinvertebrates died as the result of this dewatering event (60,666 dead fish and macroinvertebrates valued at $7,954.92). Survival of the translocated mussels in the days and weeks following this event are unknown.

Cedar County (6/9/17), United States Army Corps of Engineers
MDC received a call from a private citizen on June 12th 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 9th that mussels were left stranded out of the water in Bear Creek. The caller indicated this had occurred on other occasions.

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.

Cole County (8/21/11), Jefferson City Wastewater Utility Services
A sewage overflow occurred in a tributary to Moreau Creek due to a power failure at a pumping station. At least 1,289 fish valued at $173.13 were killed.

Cole County (2/14/13), City of Jefferson
Roughly 3,500 gallons of raw sewage flowed from a manhole into Wears Creek. At least 376 fish valued at $52.19 died in a 2,000-foot section of stream.

Cole County (2/18/16), Missouri American Water
A water line broke in Jefferson City which discharged chlorinated water into a tributary of Wears Creek. Chlorine is extremely toxic to gill breathing aquatic organisms. Our Conservation Agent observed 266 dead fish as a result of this discharge. The dead fish were valued at $34.78.

Cole County (12/19/17), Missouri American Water
MDC was notified by DNR-EER of a fish kill in a tributary of Wears Creek near Central Dairy in Jefferson City. Chlorine was detected by DNR in the tributary. MDC observed 160 fish valued at $345 as a result of this chlorinated water discharge.

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.

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.

Henry County (6/30/17), Kansas City Power and Light (suspected)

MDC was notified in August about a fish kill on Montrose Lake that had occurred in late June. By the time MDC learned of the fish kill, all evidence was gone. MDC suspects low dissolved oxygen discharged in the warmwater discharge channel from the plant caused the fish kill. The suspected responsible party signed an agreement recently that stated any fish kill caused by dam operations would prompt installation of automated water quality equipment to measure dissolved oxygen and temperature conditions in real-time. DNR is currently evaluating this incident for compliance action.

Jackson County (6/13/17), City of Independence

A fire hydrant rupture resulted in a chlorinated water discharge to Camp Creek. MDC responders observed 4,411 fish valued at $4,780.93 as the result of the discharge.

Lafayette County (7/17/15), Cedar Ridge Aviation

A trailer containing a mixture of pesticides went off road. A large volume of its contents, which included 8-gal Mustang Maxx, 63 gal CropKarb, 20-gal Quilt Xcel reached Dyer Rock Creek and caused a severe kill of fish, crayfish, and amphibians.

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

On June 7th, 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.

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

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.

St. Louis County (8/10/10), St. Louis Metropolitan Sewer District

Sewage overflowed from a manhole into Martigney Creek killing an unknown number of fish.

St. Louis County (7/9/13), St. Louis Metropolitan Sewer District

Raw sewage from a discharge pipe impacted 2,500 feet of Deer Creek causing the death of at least 546 fish valued at $386.08.

St. Louis County (7/13/15), Missouri American Water

A chlorinated water release occurred in Grand Glaize Creek. Chlorine is highly toxic to gill-breathing organisms. MDC observed at least 308 dead fish valued at $82.32.

Ste. Genevieve County (7/22/17), Mississippi Lime Company

MDC received complaints from several residents in the area about a smell and sheen in the creek near Mississippi Lime Company. Upon investigation MDC found a sheen in South Gabouri Creek. Mississippi Lime was contacted and instructed to place boom in the creek. MDC did not observe any stress wildlife. The case was referred to DNR for compliance and/or enforcement action.

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.

Appendix G. Summary of pollution investigation, fish kills, and estimated mortality (1970-2018) 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
TOTAL	**666**	**472**	**2,169,677**	**444**	**350**	**1,777,301**	**424**	**222**	**1,796,041**	**290**	**96**	**397,687**	**546**	**441**	**1,399,229**	**3,090**	**3,170**	**2,229,968**
YEARLY AVG	**14**	**10**	**45,202**	**9**	**7**	**37,027**	**9**	**4**	**37,418**	**6**	**2**	**8,285**	**11**	**9**	**29,151**	**64**	**66**	**46,548**
Avg # per kill	**4,520**			**5,290**			**9,355**			**4,143**			**3,239**			**705**		