STRATUS CONSULTING

Natural Resource Damages Associated with Aesthetic and Ecosystem Injuries to Oklahoma's Illinois River System and Tenkiller Lake

Expert Report for State of Oklahoma, in Case No. 05-CV-0329-GKF-SAJ, State of Oklahoma v. Tyson Foods, et al. (In the United States District Court for the Northern District of Oklahoma)

Volume I

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Executive Summary

This document reports the results of a study commissioned by the State of Oklahoma to measure natural resource damages associated with excess phosphorus from poultry waste and other sources entering the Illinois River system and Tenkiller Lake (hereafter, the river and lake), based on injury studies developed by the State's injury experts. A team of internationally known experts in environmental economics, natural resource damage assessments, and survey methodology conducted the study over a more than two-year period. The study was undertaken within a framework of natural resource damage assessment (NRDA) as presented in the U.S. Department of the Interior's (DOI's) NRDA regulations.

Injuries to Oklahoma trust resources from this excess phosphorus have been documented in several reports by natural science experts. Natural resource damages are the monetary value placed on the changes resulting from injuries to Oklahoma trust resources of the river and lake.

In conducting the analysis reported here, the Team focused exclusively on damages from injuries that will result from past and current land applications of poultry waste and other sources. Furthermore, the Team considered only the aesthetic and ecosystem effects resulting from excess phosphorus. Negative aesthetic effects included algae-related reductions in water clarity and the presence of more algae on the bottom and along the edges of the river and lake than would otherwise have occurred. Excess phosphorus and algae have also affected, and will continue to affect, the fish and other elements of the ecosystem of the river and lake.

To estimate the monetary value of damages, the Team conducted a contingent valuation (CV) study. CV uses carefully crafted surveys to quantify economic values. Since 1963, there have been over 6,000 papers published on CV in the United States and other countries, a significant portion of which has been published in the peer reviewed economics literature. Statistical methods have been developed to estimate CV values, evaluate error bounds, and conduct sensitivity analyses. Based on the literature, guidance on conducting valid CV studies has been developed, including guidelines formulated by the NOAA Blue Ribbon Panel on Contingent Valuation. Results from CV studies have been used to inform many public decisions and to assess natural resource damages. CV is accepted in the DOI's regulations for conducting NRDAs.

The CV survey used in this study was designed and executed to meet the highest scientific standards, including the NOAA Panel's guidelines. A leading survey research firm used in-person interviews to collect the data. Analysis of the data, using well-accepted methods, tested and documented the validity of the results.

A conservative estimate of per household damages is $184.55. There are 1,352,878 households in the study area (63 Oklahoma counties included in the survey) based on the most recent estimates. Accordingly, a conservative estimate of the damages for the injuries to Oklahoma trust resources presented in the survey is $249,673,635 (1,352,878 multiplied by $184.55). The 95% confidence interval for the aggregate estimate is $224,198,942 to $275,148,328. This estimate of damages does not include additional categories of damages such as those resulting from injuries to groundwater or human health, or any damages for the years prior to this study.

1.4 Approach to the Valuation of Injuries

1.4.1 Introduction to contingent valuation

To estimate monetary value of damages, the Team conducted a contingent valuation (CV) study. The CV study used a carefully crafted survey to elicit the monetary value on aesthetic and ecosystem injuries to Oklahoma trust natural resources in the Illinois River system and Tenkiller Lake, as determined by the state's injury experts.

The CV method has been widely applied to measure use and nonuse values around the world. Its use was first suggested by Bowen (1943) and Ciricacy-Wantrup (1947, 1952), who both conceived the idea of applying recent developments in survey research for the purpose of valuing government programs. Early on, the CV method was used to evaluate environmental issues, with the first known application to value hunting opportunities in the Maine woods (Davis, 1963). Other early studies included Hammack and Brown (1974), who valued waterfowl hunting in the western states; Cicchetti and Smith (1973, 1976), who evaluated the effects of congestion on the value of wilderness hiking; Darling (1973), who applied CV to amenities in urban parks; Randall et al. (1974), who applied CV to air quality in the Four Corners region of the United States; and Hanemann (1978), who applied CV to improvement in water quality at beaches.[3] Since 1963, there have been over 6,000 papers published on contingent valuation in the United States and other countries (Carson, Forthcoming). Results derived with this method have been used to develop and evaluate many public decisions[4] and to assess natural resource damages (Carson et al., 1994, 2003).

1.4.2 Thumbnail sketch of the survey

For this study, the Team designed a survey to be completed by a representative sample of adults living in Oklahoma. The survey was administered in the subjects' homes. Details of the survey are provided in Chapters 3 and 4, but a brief summary is included here to illustrate the use of CV and introduce the Team's actions in this study. The survey instrument itself is presented in Appendix A.

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3. For more about the early history of CV, see Mitchell and Carson (1989, pp. 11-12). Many later studies are cited in Boyle (2003).

4. McCollum (2003) summarized many instances where nonmarket valuation studies have influenced federal and state policies and regulations. In the case of EPA, for example, he highlights the roles nonmarket valuation studies have played in analyses related to the Clean Air Act, the Clean Water Act, and the Resource Conservation and Recovery Act, among others. His exposition makes clear that CV is one of the most important tools used by economist to value natural resources. See also Morgenstern (1997) and Bishop and Welsh (1998).

Fundamentally, all CV surveys have three components in common. First, they describe the *problem*. Then, they describe a *solution*. And, finally, they ask a *valuation question* where respondents choose whether or not they are willing to pay the proposed cost to them for the solution to solve the problem.

The Problem: The survey narrative described the Illinois River system, including Tenkiller Lake, and explained how water quality, the ecosystem, and aesthetics have changed since around 1960. Then, it explained that these changes have come about because spreading of poultry waste and other human activities have introduced large amounts of phosphorus into the watershed, which in turn has resulted in excess algae. Next, participants were informed that the State of Oklahoma has asked for an injunction that would ban all future spreading of poultry waste in the basin. It was pointed out that even after a ban is in place, runoff and leachate of large amounts of phosphorus remaining on the land from past spreading would continue to affect the waterways. Therefore, compared with conditions around 1960, algae would continue to be excessive in the river and lake for many years (Engel, 2008a, 2008b, 2008c).

The Solution: The solution introduced in the survey was a program to treat land and waters in the Illinois River watershed with alum, a substance that bonds with phosphorus and makes it unavailable to plants, including algae. The survey noted that many states have successfully used a similar program to reduce algae.[5] The survey narrative explained that with alum treatments, it would take about 10 years for the river and 20 years for the lake to return to 1960 conditions, compared with 50 and 60 years, respectively, if alum was not applied. Hence, alum treatments would reduce the period over which the injuries would be present by 40 years for both the river and lake. Respondents were told that if alum treatments were implemented, the cost would be a one-time tax added to their state income tax bill next year.

The presentation of the alum treatment program allowed respondents to make a choice about a well-defined, realistic tradeoff. Either they could greatly reduce the injury and pay the tax for the alum treatments or accept the natural recovery without the alum treatment and use their money for other purposes. In Chapter 2 we discuss how tradeoffs of this type, which is the standard method used by economists, can be used to measure people's value for improvements to natural resources. While the State is not actually proposing this specific alum treatment program at this time, the choice was posed to the respondent as an actual choice. Posing choices in this manner is standard practice in CV surveys (Mitchell and Carson, 1989; Boyle, 2003).

The Valuation Question: The valuation question was posed as a referendum where respondents were asked to vote "for" or "against" the alum treatments. The one-time tax amount was varied

5. Discussion of alum treatments of lakes and citations to the literature on the topic can be found in Cooke et al. (2005).

randomly across respondents, as described in Chapter 3. The votes across the range of tax amounts then served as the basis for estimating the average value that households in Oklahoma place on a program to reduce the injury. As is common in these studies (Mitchell and Carson, 1989), households were used as the valuation unit.

1.4.3 Validity of the study results[6]

Good science requires an assessment of the validity of results. However, there is no single way to assess the validity of a study. Much research has been conducted to evaluate CV's validity, and federal agencies such as the U.S. OMB (2003) and U.S. EPA (2000) have developed guidelines on implementing CV studies. A national panel of experts, the National Oceanic and Atmospheric Administration (NOAA) Blue Ribbon Panel on Contingent Valuation (NOAA, 1993) (hereinafter the NOAA Panel) investigated this issue and also determined that, if conducted properly, CV studies can provide valid results.

The validity of a CV study begins with the development of a high quality questionnaire and the procedures to administer it to a sample of respondents. The survey developed for this investigation described a subset of the injuries identified by the State's natural scientists in clear, understandable ways; presented a realistic solution; and asked a valuation question that was both consistent with the economic theory and tractable for respondents. Additional questions to support data analyses and validity assessment were incorporated into the survey and carefully tested. The Team verified that the study conformed to applicable NOAA Panel guidance on validity assessment. Chapters 3, 4, and 5 of this report present details on survey design and administration. Chapter 6 presents statistical procedures and sensitivity analyses used to assess validity of the survey. Considering the evidence from all the applicable tests, the study met the standard for validity.

6. At several points in this report, we considered the degree to which the procedures we followed produced accurate results. In slightly more technical terms, we sought to assess the *validity* of our results. Even among social scientists, there is confusion about the meaning of the terms "reliability" and "validity." They are sometimes used as synonyms, but they have distinct meanings in most social sciences. "Reliability" refers to the consistency of the results produced by a measure applied to the same person. "Validity" refers to the degree to which a measurement tool accurately quantifies the underlying constructs. For example, the validity of an IQ test is whether or not it accurately measures a person's true intelligence. The reliability of the test would be whether the same test given to the same person multiple times gives the same result. We adhere to those definitions in this report.

> Water from the river flows into Tenkiller Lake (**POINT**) and is stopped by the dam here. (**POINT TO DAM AND CIRCLE AROUND THE LAKE LABELED "LAKE"**)

Respondents next learned more about the geography and characteristics of the river and lake.

> The part of the Illinois River (**POINT**) within Oklahoma above the lake is about 60 miles long.
>
> Tenkiller Lake is about 28 miles long. Many miles of creeks flow into the river and lake.
>
> Near the river and lake are the city of Tahlequah (**POINT**), smaller cities, farms, ranches, and private homes.
>
> **STOP UNTIL R IS FINISHED LOOKING AT CARD C**
>
> **FLIP CARD TO NEXT, BLANK PAGE**[9]

Interviewers then gave respondents some basic information about the river and lake and described the clarity of the water and the types of species living in the river and lake in the late 1950s and early 1960s. First, respondents learned about baseline conditions in the river.

> In the late 1950s and early 1960s, the water in the river was clear most of the time, and it was easy to see rocks on the bottom.
>
> Smallmouth bass and other fish had lived in the river for centuries. They ate small animals and insects living in the river.[10]

Then, interviewers told respondents about baseline conditions in the lake.

> In the lake, the water was clear enough so you could see down about 10 feet.
>
> Many largemouth bass, smallmouth bass, and other fish were there, and they also ate small animals, insects, and plants living in the water and on the bottom.[11]

---

9. This instruction was used when an interviewer was to flip to a blank page so the respondent would stay focused on the oral presentation rather than the visuals.

10. Stevenson (2008a, p. 44; 2008b; 2008c).

11. Cooke and Welch (2008a, pp. 1-2, 34, 43, 48, and Figure 9).

This narrative concluded with a statement about recreational use of the river and lake.

> Many people visited the area around the river and lake for sightseeing, fishing, canoeing, boating, and other activities.

Following the discussion about baseline conditions, respondents were asked several questions about visiting the Illinois River and Tenkiller Lake.

> **Q14**. Have you ever visited the Illinois River or the creeks flowing into it?
>
> **Q14A**. In what year did you first visit there? **(PROBE[12]: What year would you like me to type?)**
>
> **Q14B.** In what year was your most recent visit? **(PROBE: What year would you like me to type?)**
>
> **Q15**. Have you ever visited Tenkiller Lake?
>
> **Q15A**. In what year did you first visit there? **(PROBE: What year would you like me to type?)**
>
> **Q15B.** In what year was your most recent visit? **(PROBE: What year would you like me to type?)**

Answers to Q14 and Q15 were recorded "yes" and "no." If the respondent said "yes" to Q14, he/she was asked Q14A and Q14B; otherwise, the interviewer skipped to Q15. If the respondent said "yes" to Q15, he/she was asked Q15A and Q15B; otherwise, the interviewer skipped to Part 2. For questions 14A, 14B, 15A, and 15B, interviewers were instructed to record the exact word(s) used by respondents when answering the question.

12. For some questions, the Team asked interviewers to probe respondents if their answers were vague or did not address the question.

4.3 Survey Part 2. Description of the Injury

Part 2 of the survey started with interviewers telling respondents about the scenic river status of the river.

> In 1970, Oklahoma passed a law naming some rivers in the state "Scenic Rivers." The lawmakers said that these rivers possessed such unique natural scenic beauty, fish, wildlife, and outdoor recreational values that they deserve special protection for the benefit of the people of Oklahoma.

Interviewers showed respondents a map of all the rivers in Oklahoma that have been designated as scenic rivers.

> STOP **SHOW CARD D**
>
> This map shows all the rivers in Oklahoma that have been officially named Scenic Rivers.
>
> Flint Creek (**POINT TO FLINT CREEK ON CARD D**),
>
> the Illinois River (**POINT TO ILLINOIS RIVER ON CARD D**),
>
> and Barren Fork Creek (**POINT TO BARREN FORK CREEK ON CARD D**)
>
> were all named "scenic rivers" by the State.
>
> The lawmakers also named three other rivers as "scenic rivers:"
>
> Little Lee Creek, (**POINT**),
>
> Lee Creek (**POINT**),
>
> and Upper Mountain Fork River (**POINT**).
>
> STOP **UNTIL R IS FINISHED LOOKING AT CARD D**
>
> **FLIP CARD TO NEXT, BLANK PAGE**

Interviewers then asked respondents the following question:

> **Q16.** Before today, did you know that the Illinois River had been named a Scenic River?[13]

At this point, the interviewer began to tell the respondent how the river and lake have changed.

> During the years since around 1960, people have continued to visit the river and lake, but the river and lake have changed a lot over the last 50 years.

Interviewers used visual displays to help respondents think about how the river looked in around 1960 and how it looks now. Respondents learned about the river first.

> **STOP SHOW R CARD E**
>
> Here are two pictures that show you how the river has changed.
>
> On the left is a picture showing what the river looks like when the water is clear and there is little algae. (**POINT TO PICTURE ON LEFT**). This is just meant to give you an idea of what the river usually looked like in around 1960.
>
> The picture on the right shows another part of the river recently with algae in it (**POINT TO PICTURE ON RIGHT**). This kind of algae grows along the edges and on the rocks at the bottom of the river. This amount of algae is most often seen between March and June. During the rest of the year there is usually a lot less. Algae can grow in water that stands still and in water that is flowing, as shown in the picture.[14]
>
> **STOP UNTIL R IS FINISHED LOOKING AT CARD E**
>
> **STOP SHOW R CARD F**
>
> Here are a couple of recent pictures of the river showing closer views of rocks on the bottom.
>
> (**POINT TO PICTURE ON LEFT**) The picture on the left shows a close view of the river's bottom with little algae.

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13. Answers to Q16 were recorded "yes" and "no."

14. Stevenson (2008a, p. 21-22; 2008b).

(**POINT TO PICTURE ON RIGHT**) The picture on the right shows a place where algae has grown on the rocks at the bottom.

WAIT FOR R TO FINISH REVIEWING

FLIP CARD TO NEXT, BLANK PAGE

Algae also floats in the water and can make the water look murky. The water in the river used to be clear most of the time. Now, during summer, the water is sometimes murky because of algae.[15]

Algae on the bottom and in the water has changed the types of plants and animals that live in the river. There are now fewer of the smallmouth bass, other fish, and small plants than used to live in the river. In some places, the algae uses up most of the oxygen in the water. Low oxygen causes fish to grow more slowly. And in some places, some species have probably disappeared completely because of the algae.[16]

Respondents then learned how the lake has changed since around 1960. Interviewers used pictures to show how the lake has changed.

The lake has also changed. Although in around 1960, people could usually see down about 10 feet in the lake, now in the summer people can often see down less than 3 feet where the river comes in. As you move closer to the dam, there is less and less algae. Near the dam, people can still see down about 6 feet most of the time in the summer. In the winter, the water is clearer and people can usually see down about 10 feet throughout the lake.[17]

SHOW R CARD G

Here are some pictures that show how the lake has changed.

(**POINT TO PICTURE ON LEFT**) On the left is a recent picture to give you an idea of how the lake used to look most of the time in around 1960.

15. Stevenson (2008a, pp. 21-22).

16. Stevenson (2008a, pp. 27, 34-36, 38-41).

17. Cooke and Welch (2008a, Figure 9).

(**POINT TO PICTURE ON RIGHT**) The picture on the right shows how the lake sometimes looks these days, because the water is murky from algae.

STOP UNTIL R IS FINISHED LOOKING AT CARD G

FLIP CARD TO NEXT, BLANK PAGE

In the shallow areas around the edge of the lake, the bottom is often covered with algae between spring and fall.[18]

In many parts of the lake where the oxygen and temperature were ideal for smallmouth bass and other types of fish people catch, there is now so little oxygen during the summer that these areas are no longer ideal for these fish. Under such conditions, smallmouth bass and the other types of fish grow slower and there are fewer of them.[19]

In large areas on the bottom of Tenkiller Lake, there are a lot fewer insects and small animals than are in lakes with less algae.[20]

Some other types of fish, such as largemouth bass, have increased in numbers and are growing more quickly.[21]

Following all the information about current conditions in the river and lake, interviewers asked respondents the following question:

Q17. Before today, had you heard anything about the changes in the river or lake that I just described?

Answers to Q17 were recorded “yes” and “no.” If respondents answered “yes,” they were asked this question:

Q17A. What had you heard?

18. Cooke and Welch (2008a, pp. 2, 29-33).

19. Cooke and Welch (2008a, pp. 3, 8-9, 37-41, and elsewhere).

20. Cooke and Welch (2008a, pp. 4, 44, 50).

21. Cooke and Welsh (2008a, pp. 40, 43).

If respondents said "yes" to either Q14 or Q15, interviewers asked the following question:

> **Q18.** Have you personally seen any of these changes in the river or lake, or have you not seen any of these changes?

Answers for Q18 were recorded as "yes, I have seen these changes" and "no, I have not seen them." If the respondent said "yes, I have seen these changes," he/she was asked this question:

> **Q18A.** What changes have you seen?

Interviewers then showed respondents a card summarizing the information presented previously in Part 2.

> STOP **SHOW CARD H**
>
> This card shows what I just told you.
>
> (**POINT TO ROW 1**) Around 1960, the water was usually clear, and now, during the summer, it is sometimes murky from algae.
>
> (**POINT TO ROW 2**) Around 1960, there was little algae on the bottom of the river and now, between March and June, there is more algae.
>
> (**POINT TO ROW 3**) Around 1960, there was little algae around the edges of the lake, and now, during the summer, there is more algae.
>
> (**POINT TO ROW 4**) Around 1960, species that live most easily in water with little algae were common and now they are less common.
>
> (**POINT TO ROW 5**) Around 1960, there was plenty of oxygen in the water. Now, in large parts of the river and lake, there is not enough oxygen, so some fish grow slower and there are fewer of them.
>
> STOP **UNTIL R IS FINISHED REVIEWING CARD H**
>
> **FLIP CARD TO NEXT, BLANK PAGE**

To adhere with the NOAA Panel's recommendations (NOAA, 1993), several different checks on respondent understanding and acceptance of the scenario were implemented throughout the questionnaire. One type of question, exemplified by Q19 below, gave the respondent the opportunity to ask that a part of the narrative be read to him/her again.

Q19. Is there anything I have told you about the river or lake that you would like me to repeat?

Answers were recorded "yes" or "no." When respondents answered "no," the interviewer skipped to Part 3. Respondents who said "yes," they would like something repeated, were asked the following question:

Q19A. What is that?

Interviewers recorded respondents' comments verbatim.

4.5 Survey Part 4. Recovery Program

In Part 4, respondents learned about the state's proposed actions to reduce phosphorus in the river and lake.

SHOW CARD I

Many of the other rivers and lakes in Oklahoma do not have excess algae. These are shown in blue on this map (**POINT TO BLUE AREAS**). These include the other Scenic Rivers: Little Lee Creek, Lee Creek, and Upper Mountain Fork River (**POINT TO OTHER SCENIC RIVERS**).

Some rivers and lakes do have excess algae. These are shown in yellow on this map (**POINT TO YELLOW AREAS**).[25] The excess algae has caused changes in those places like the changes that have happened in the Illinois River and Tenkiller Lake. In nearby states, there are also some water bodies that have excess algae, and some water bodies that are clear.

The excess algae in the rivers and lakes shown in yellow on the map is caused by phosphorus coming from various sources, and the state of Oklahoma is taking actions to reduce the amount of new phosphorus that goes into these rivers and lakes from these other sources.

For example, sewage treatment plants are being improved. And State environmental agencies will enforce new rules so that other fertilizers do less harm.

FLIP CARD TO NEXT, BLANK PAGE

The state is doing additional things to reduce phosphorus in the Illinois River, Flint Creek, and Barren Fork Creek, because Oklahoma law requires that these Scenic Rivers be kept clean. Tenkiller Lake is also a very popular place for people to visit and for recreation, so the State is putting extra effort into reducing phosphorus there as well.

The state has asked a federal court to stop all future spreading of poultry litter on land around the river and lake. The court is expected to make a decision about the

25. The Team generated the yellow areas on this map by using a geographic information system (GIS) layer provided by The Oklahoma Water Resources Board.

ban by the end of the year. The ban would immediately stop spreading in both Oklahoma and Arkansas.

At this point in the questionnaire, the base and scope instruments begin to diverge. For parts where the text is different, we show the base text first followed by "BASE:" and the scope text second in italics following *"SCOPE:"*

BASE:

The ban and the other things being done will greatly reduce the amount of new phosphorus put onto land and in the river and lake in the future, but a lot of phosphorus that was spread on the land in the past will remain there. For many years, it will continue to wash into the river and lake when it rains.

SCOPE:

The ban and the other things being done will greatly reduce the amount of new phosphorus put onto land and in the river and lake in the future. The excess phosphorus will quickly wash out of the river, but much of the phosphorus that's in the lake now will remain there.

Respondents then learned that alum treatment of the river and lake could reduce the excess phosphorus faster. Interviewers told respondents they would have to decide whether to vote "for" or "against" the alum treatment program.

BASE:

The purpose of this interview is to find out whether you think the State should or should not do something else as well. The excess phosphorus could be removed by putting alum on the land and in the water. I will tell you about what alum is and how it could be used to remove the excess phosphorus in a moment.

After I tell you about the situation, I will ask you to vote on whether the state should or should not put alum on the land and in the water in order to return the river and lake to around 1960 conditions faster. Your vote will help state officials to decide whether to carry out the alum treatments.

SCOPE:

The purpose of this interview is to find out whether you think the State should or should not do something else in the lake. The excess phosphorus in the lake could

be removed by putting alum in the water. I will tell you about what alum is and how it could be used to remove the excess phosphorus in the lake in a moment.

After I tell you about the situation, I will ask you to vote on whether the state should or should not put alum in the lake in order to return the lake to around 1960 conditions somewhat faster. Your vote will help state officials to decide whether to carry out the alum treatments.

The next question asked respondents about their prior knowledge about alum. Answers were recorded as "yes" or "no."

Q21. Before today, had you ever heard of alum?

Interviewers told respondents more about alum and its uses. Additionally, respondents learned that alum does not harm humans and that humans have been using alum for many years. The paragraphs below demonstrate how the information was presented.

Alum is a naturally occurring mineral. Deposits of it are in the ground in many places around the world.

Alum is safe for humans.

STOP **SHOW CARD J**

Alum is in many products that people use, including food. For example, alum is used to keep pickles crisp, and you can buy alum powder at the grocery store for many uses, including cooking and making "play dough" for children.

WAIT UNTIL R IS FINISHED REVIEWING CARD J

FLIP CARD TO NEXT, BLANK PAGE

Also, water treatment plants in the U.S. and other countries have used alum to clean drinking water for more than 80 years.

An important component of the alum story is how alum neutralizes phosphorus in the river and lake. The following narrative was used to describe this process.

BASE:

When alum is put into river or lake water that contains phosphorus, the alum attaches to the phosphorus to form harmless particles that fall to the bottom and

blend into the dirt there. So if alum were put into the river and lake, the phosphorus there could no longer help algae to grow and there would then be a lot less algae in the water.

If alum is put on land, it attaches to phosphorus in the soil to form harmless particles. When these particles wash into rivers and lakes, the particles sink to the bottom and do not help algae to grow.

So to reduce algae in the river and lake, alum could be spread on the land and on the water.

SCOPE:

When alum is put into lake water that contains phosphorus, the alum attaches to the phosphorus to form harmless particles that fall to the bottom and blend into the dirt there. So if alum were put into the lake, the phosphorus there could no longer help algae to grow and there would then be a lot less algae in the water.

Alum treatments will not be needed for the river. The natural flow of water in the river will remove the excess phosphorus there. After the ban is in place, the river will naturally return to what it was like in around 1960 in 10 years. Phosphorus will remain in the lake much longer because the lake is large and the water moves through it very slowly.

Interviewers told respondents that the Army Corps of Engineers would work with the Oklahoma Department of Environmental Quality to spread alum.

BASE:

Here's how the alum treatments could be done.

The Army Corps of Engineers operates the lake, and they would work with the Oklahoma Department of Environmental Quality to spread the alum.

Crews of people would be hired and trained to use trucks to put alum on the land.

Specially designed boats would spread alum on the lake.

Alum would also remove phosphorus from river water flowing into Oklahoma from Arkansas. Dispensers would be put near the border to spread alum on the water when sensors find lots of phosphorus in it.

SCOPE:

Here's how the alum treatments would be done.

The Army Corps of Engineers operates the lake, and they would work with the Oklahoma Department of Environmental Quality to spread the alum.

Specially designed boats would spread alum on the lake.

The questionnaire described past experience with using alum and discussed its negative impacts.

BASE:

For more than 35 years, alum has been used successfully and safely to remove phosphorus and reduce algae in many states, such as Colorado, Texas, Missouri, South Dakota, Florida, Wisconsin, and Washington. Those states had some rivers and lakes with lots of algae like the Illinois River and Tenkiller Lake. Experiences in those states have convinced scientists that alum does not harm fish or other things living in water, and that alum treatments here in Oklahoma could safely return the river and lake to what they were like in around 1960.

Putting alum on the land and in the water would have some undesirable effects. The alum would be a white powder on the land surface until rains carry it down into the soil. After alum is put into the river and lake, it would make the water cloudy for a few hours until it settles to the bottom. And if anyone were to drink the lake water in the first hour, it might taste bitter.

Alum treatments would be needed for 5 years to remove all the excess phosphorus now on the land and in the water.

SCOPE:

For more than 35 years, alum has been used successfully and safely to remove phosphorus and reduce algae in lakes in many states, including Colorado, Texas, Missouri, South Dakota, Florida, Wisconsin, and Washington. Those states had some lakes with lots of algae like Tenkiller Lake. Experiences in those states have convinced scientists that alum does not harm fish or other things living in lakes, and that alum treatments here in Oklahoma could safely return the lake to what it was like in around 1960.

Putting alum in the lake would have some undesirable effects. After alum is put into the lake, it would make the water cloudy for a few hours until it settles to the

bottom. And if anyone were to drink the lake water in the first hour, it might taste bitter.

Alum treatments would be needed for 5 years to remove all the excess phosphorus in the lake.

Next, respondents were shown a card summarizing the main points in Part 4.

SHOW R CARD K[26]

This card summarizes what I just told you.

BASE:

(**POINT TO ROW 1**) A court-ordered ban would stop spreading of poultry litter near the river and lake in Oklahoma and Arkansas. This will occur even if alum treatments are not done.

(**POINT TO ROW 2**) Alum could be spread on land from trucks.

(**POINT TO ROW 3**) Alum could be spread on the lake from boats.

(**POINT TO ROW 4**) Alum could be sprayed in river water flowing into Oklahoma from Arkansas.

(**POINT TO ROW 5**) Alum treatments would need to be done for 5 years to remove all the excess phosphorus.

SCOPE:

(POINT TO ROW 1) *A court-ordered ban would stop spreading of poultry litter near the river and lake in Oklahoma and Arkansas. This will occur even if alum treatments are not done.*

(POINT TO ROW 2) *Alum could be spread on the lake from boats.*

(POINT TO ROW 3) *Alum treatments would need to be done for 5 years to remove all the excess phosphorus from the lake.*

UNTIL R IS FINISHED REVIEWING CARD K

26. Card K was different for the base and scope instruments. See Appendices A.1 and A.2.

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Next, respondents learned how effective the alum treatments would be at reducing phosphorus in the river and lake. Interviewers showed respondents a timeline to illustrate how soon the river and lake would return to around 1960 conditions with alum treatments.

If the federal court bans spreading of litter, alum treatments could begin soon after that.

SHOW CARD L (TIMELINE 1)

BASE:

As a result of alum treatments, the river would be back to what it was like in around 1960 (**POINT TO 1960**) about 10 years from now (**POINT TO 10 YEARS**). And the lake would be back to what it was like in around 1960 (**POINT TO 1960**) about 20 years from now (**POINT TO 20 YEARS**). Water in the river and lake would then be clear nearly all the time, and there would be little algae in the water and on the bottom. There would then be plenty of oxygen in the water. Species of fish, insects, small animals, and small plants that used to be common would slowly increase in numbers, replacing those that live in water with lots of algae. There would be fewer of some species, such as largemouth bass.

SCOPE:

*As a result of alum treatments, the lake would be back to what it was like in around 1960 (**POINT TO 1960**) about 50 years from now (**POINT TO 50 YEARS**). Water in the lake would then be clear nearly all the time, and there would be little algae in the water and on the bottom. There would then be plenty of oxygen in the water. Species of fish, insects, small animals, and small plants that used to be common would slowly increase in numbers, replacing those that live in water with lots of algae. There would be fewer of some species, such as largemouth bass.*

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Alum would only do this if much less new phosphorus is put on the land and in the water in the future. So no alum would be put out until after a court bans spreading of poultry litter.

Respondents were then asked about their prior knowledge about using alum to reduce algae. Answers to Q22 were recorded as “yes” or “no.”

Q22. Before today, had you heard that alum could reduce algae in water?

If respondents said “yes,” they were asked Q22A. Interviewers were instructed to record answers verbatim.

Q22A. What had you heard?

6.3 Scenario Acceptance

This section describes how respondents perceived the scenario presented in the survey and discusses how their perceptions are related to their votes. The results show that, item-by-item, most respondents accepted the various aspects of the scenario and that as perceptions varied, votes varied accordingly.

All percentages in this section are based on weighted data. Numerical results (the *N*'s) are based on unweighted data.

6.3.1 Program effectiveness

Respondents were asked, "When you decided how to vote, how well did you think that alum treatments would work at reducing algae in the water?" (Q31) Fifteen point nine percent of respondents answered "extremely well," and 45.0% said "very well." Another 25.5% said "moderately well, 7.1% said "slightly well," and 3.0% said "not well at all" (see column 2 of Table 6.5).

As expected, the more effective the respondent thought the program would be, the more likely he or she was to vote "for" it (see column 3 of Table 6.5). For example, whereas 83.3% of people who thought the program would work extremely well voted "for" it, 69.0% of people who said it would work very well voted "for" it, 42.1% of people who thought it would work moderately well voted "for" it, and smaller proportions of people who thought it would work less well voted "for" it. The relation between beliefs about the program's effectiveness and votes is statistically significant [$F(4.75, 322.80) = 28.64$, $p < 0.001$].

Table 6.5. How well alum treatments would work

Response	% of the sample (N = 1,093)	% of respondents voting "for" (base unweighted N)
Not well at all	3.0%	27.0% (32)
Slightly well	7.1%	22.4% (89)
Moderately well	25.5%	42.1% (255)
Very well	45.0%	69.0% (502)
Extremely well	15.9%	83.3% (171)
Don't know/refused	3.6%	27.5% (44)
Total	100.0%	