



REPORT OF WEST PLAINS, MO. LAGOON INCIDENT

EPA - REGION 7
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REPORT OF WEST PLAINS LAGOON INCIDENT

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U.S. ENVIRONMENTAL PROTECTION AGENCY

Region VII

1735 Baltimore

Kansas City, Missouri 64108

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EXECUTIVE SUMMARY

This is a report by Region VII staff on the participation of the U.S. Environmental Protection Agency (EPA) in events following the failure of a 37-acre sewage lagoon cell in West Plains, Missouri. The first of the two major collapses occurred on May 5 with a second occurring on May 15. The EPA regional office was first informed on May 17, 1978. These major collapses allowed about 50 million gallons of sewage to enter the local groundwater. The lagoon failure caused a great deal of concern to all agencies and the press because of the large number of dangerous diseases which could be spread by sewage flowing through the porous limestone rock to wells as far away as Arkansas. Ultimately, about 800 cases of flu-like illness were the only reported type of disease. However, this plus a threat of more serious illness provided the impetus to extensive sampling and public health measures, as well as substantial engineering and geological work on both the interim and long-term solution. In addition, extensive thought was given to similar groundwater endangerment across the entire state.

EPA personnel were on-scene May 18, 1978, and immediately began discussions with local and state officials about possible solutions. Because of the extreme fear of those living in the area plus the possibility of the spread of major diseases, EPA began an extensive sampling effort to determine the extent and seriousness of the groundwater pollution. Up to 38 EPA representatives collected and analyzed 596 samples from public and private wells. The results presented an extremely complex picture because of influences ranging from septic tank pollution to poor well construction, but tended to indicate a wave of the lagoon's contents moving through the groundwater toward Arkansas.

The EPA's position is that all reasonable measures should be taken to increase the reliability of the existing system until a permanent waste treatment facility can be designed and constructed. To this end, a recommendation was made that an interim mechanical waste treatment facility be constructed on an emergency basis. Federal financial assistance for this emergency effort was requested on May 22, but even now, is not assured. The state responded to EPA's recommendation by indicating their concerns about constructing an emergency interim mechanical plant, and by indicating their technical reservations about the effectiveness of the completed system at the capacity which would be possible on an emergency basis. EPA had considered the issues raised in their response to the proposal and maintains a belief that the proposed interim plant could be constructed and operated in such a manner that the risk of additional pollution to groundwater would be minimized. It is recognized that the success of such an endeavor is dependent on the support and cooperation from both the state and the city. Short of that, the chance of an expeditious and successful interim facility becomes lessened with the passage of time.

There are other measures that can be taken to increase the reliability of the existing emergency dike, and EPA supports and encourages any measures necessary to maintain the integrity of the remainder of the existing lagoons. Reinforcement of this emergency dike has been proposed. We support and encourage immediate implementation.

Beyond the immediate problem of the West Plains incident lie the dangers elsewhere, pointed up by this lagoon collapse. This same geology (a limestone full of caves and fractures) lies under much of southern Missouri. All this area has the chance of rapid catastrophic collapse with the rapid movement of pollution to nearby water wells. To prevent this, the EPA Regional Office has examined their files and identified 49 additional municipal lagoons and 212 private lagoons located within the geographical area subject to sinkhole collapse. The Missouri State Geological Survey is in the process of investigating the local geological conditions of 24 of these, and information gathered will be utilized to determine whether and how quickly these lagoons should be replaced so that future disasters such as the West Plains incident can be avoided. EPA is developing plans to evaluate the questionable private lagoons. Maps showing areas of concern are located in the appendix.

One method of further protection for this area which is being very seriously evaluated is using the Sole Source Aquifer provisions of the Safe Drinking Water Act. This designation requires the review of federally-funded projects to prevent their potential pollution of wells in the area. In this area of rapid and serious groundwater pollution spread, this review would make each well a little safer.

To summarize such a complex series of events as the West Plains lagoon failure, one can only note that this emergency cut across organizational lines. Specific knowledge was needed in geology, soil science, reporting, hydrology, epidemiology, water supply, waste treatment, sampling, funding legislation, and construction techniques. This knowledge was partially available at the local, state, regional, and national level. As a result, the response to this emergency has shown a need for communication and cooperation among all concerned. As the quest for interim and ultimate solutions continues, this same spirit of working together will be needed.

The History of West Plains Lagoon

West Plains, Missouri, is located in a karst geologic region, an area where the limestone has a great number of caves and crevices. This geology carries a great deal of groundwater very rapidly, but is very weak and unstable. The result is frequent collapses, allowing a core of rock and dirt to fall into underground streams leaving a cavity at the ground's surface called a sinkhole. To put an earthen lagoon in such a geologic area is to gamble that such a sinkhole will not drain the lagoon. This has happened with several lagoons in the southern Missouri area. One of these was the lagoon serving West Plains, Missouri. Additional geological discussions are located in the Appendix as well as additional demographic data.

The West Plains lagoon had problems with sinkholes before construction was completed. The smaller lagoon cell, which occupies about 12.4 acres, collapsed in two points in 1964. The larger of these two collapses was about 17 feet in diameter and between 10 and 20 feet deep. The sinkholes were plugged with cement, clay and bentonite and apparently no further problem occurred in this location. However, in 1966, a collapse occurred in the larger cell of the lagoon. This cell contained about 45 million gallons of effluent at the time of collapse and all of the water drained out within 52 hours.

This created a whirlpool of such magnitude that the operator was afraid to approach it in a boat. It was later estimated that 13,000 gallons per minute were exiting through the sinkhole. This collapse was repaired by filling the hole with clay and bentonite to the level of the dike wall, and the lagoon was returned to use. At the time, the Assistant City Engineer of West Plains reported that he walked about 4 miles of the Howell Creek Channel below the lagoon collapse but found no evidence of lagoon sewage.

There was no report of well contamination in connection with either the 1964 or 1966 collapse. It was speculated that the water probably appeared at one of the large springs in the region. More complete details about this series of the collapses are available in the Missouri Geologic Survey report on sinkhole collapse listed in the bibliography.

Another minor collapse incident was thought to have occurred in 1974, in the polishing lagoon. No further activity was reported until the most recent disaster, which probably occurred May 5 and was discovered on Saturday, May 6, 1978. On Monday, May 8, the City staff attempted to reach Poplar Bluff and/or Jefferson City to report the incident, but because of a State holiday, were unable to reach anyone in the State Government. Early May 9, they reached the Department of Natural Resources (DNR) Regional Office in Poplar Bluff and reported the incident. Meanwhile, the resident sanitarian for the Missouri Division of Health office in West Plains, was becoming aware of a

health problem in the city. An outbreak of gastroenteritis developed on May 8, and rapidly intensified with a significant number of cases being reported to the Health Department on May 12. An epidemiological study traced the apparent source of illness to the Dairy Queen in West Plains and to the other businesses served by the same well, all of which were located south and east of the lagoon (refer to figure III). However, additional cases of illness not associated with the Dairy Queen well soon began to appear.

Controlling the Emergency

By the time EPA was notified on May 17, the Missouri Division of Health and the Division of Environmental Quality, working with the City Engineer of West Plains and his staff, had taken immediate steps to secure the lagoon to prevent further loss, and to make a preliminary geological analysis which was required before repairs could be made.

The State Division of Health began an immediate notification program to advise citizens how to safeguard their water supplies. A joint plan between the Division of Health and the Division of Environmental Quality was readied to provide chlorination to the public water supplies, with a subsequent plan to assist private suppliers with emergency chlorination.

EPA did not become aware of the lagoon failure until a telephone query was received late in the afternoon of May 17, from a reporter, to find out what EPA's involvement in the crisis would be. When the Regional Administrator, Dr. Kathleen Q. Camin, was informed, she immediately appointed an emergency response coordinator who contacted the DNR in Jefferson City and requested a briefing. Realizing the urgency of the situation, an emergency response team was dispatched to the site.

The next morning, members of that team met with local and state officials to assess the situation as well as discuss emergency solutions. It was determined that EPA's field sampling and laboratory analytical capabilities would be of the most immediate use in determining the magnitude of the problem. This monitoring was deemed urgent because of the public's great fear of the unknown danger, location and movement of the possible harmful bacteria in the groundwater supply. Because of rising sickness rate and the potential of very serious illness, the Regional Administrator made available substantial sampling and analytical resources.

On May 18, an earth and clay dike to isolate the largest sinkholes was begun by the city crews with contract help. This dike was completed on May 21 at the city's expense which was about \$30,000. The sewage inflow was bypassed to a losing stream between the two dates,

but the flow was returned to the lagoon on May 21st.

Virtually all parties have expressed concern about the integrity of the emergency dike, and in the interest of increasing its reliability have recommended its reinforcement. The State's recommendation is to construct an additional emergency dike approximately 100 foot outside of the perimeter of the initial circular dike section. EPA has supported this and has recommended its immediate implementation. It is believed that federal assistance funds will be available to reimburse the City for this additional work. However, the mechanism for funding is yet to be determined.

By June 2, 1978, the rate of occurrence of disease had stabilized to the point that the extensive state and federal involvement could be withdrawn and an 8-week monitoring program was negotiated between EPA and the Missouri Division of Health.

EPA Construction Grants Program Involvement

While emergency response activities went on in West Plains, interim and long-range solutions were being evaluated in the EPA Regional Office.

Long-Range Solution

The West Plains lagoon was constructed in 1964 at an approximate cost of \$358,000. However, the lagoon effluent is not capable of meeting the losing stream requirement of 5 mg/l of BOD and 10 mg/l suspended solids which were adopted in 1974. Therefore, due to the necessity of replacing the lagoon with a facility capable of producing an effluent which would protect the groundwater supplies, the City of West Plains was already involved in the EPA construction grants program prior to the lagoon failure. The facility plan has been completed, recommending an aerated lagoon (using a portion of the existing lagoon cell) followed by a bio-disc and sand filter. The city's consulting engineer, who was designing the facility, estimated that the facility would be completed in 1 year at an estimated cost of \$3 million.

On May 22, 1978, EPA Construction Grants representatives met with the city's consulting engineers, Crane and Fleming, Incorporated, and the Missouri Division of Environmental Quality officials in Jefferson City. In this meeting all parties agreed that the new treatment facility must eliminate any continuous use of earthen holding basins. Therefore, the proposed final treatment facility design was abandoned, since it included continuous use of a portion of the existing lagoon as flow equalization. Considering the sewage flow characteristics, all parties agreed that the most reliable and cost effective alternative was a concrete lined oxidation ditch followed by sand filtration. Due to the infiltration/inflow problem, this plant would require the use of a surge basin to hold stormwater overflows on an infrequent basis. These overflows would be routed back through the treatment plant after the high incoming flow has receded. Accordingly,

the city's engineers were advised by EPA to proceed with this design. EPA also committed to methods of "fast tracking" the design, construction, and administrative handling of the project. The consultants sought and received approval to dike off the westerly end of the largest cell with the use of 10 acres as an overflow to facilitate site soil investigations at the earliest possible date.

Interim Solution

The EPA Regional Office simultaneously began considering interim alternatives for treatment until the new plant could be constructed. Obviously, there is a degree of risk involved with continued use of the existing lagoon system. The alternatives considered and their associated risks were evaluated by May 19, 1978, and ranged from continued use of the existing two-cell lagoon system without additional construction (maximum use of existing lagoon, highest associated risk) to the replacement of the existing lagoon with a package mechanical-type treatment system (minimum use of existing lagoon, lowest associated risk). Because of high flows received at the treatment facility during storm periods, use of the package plant would require some type of storm surge basin on an infrequent basis for stormwater overflows only. In order to further reduce the risk associated with this holding basin, it is proposed that the holding basin be used essentially as a clarifier with the contents pumped through disinfection units and discharged. It was felt that using a portion of the lagoon as a storm surge basin on an infrequent basis was an acceptable level of risk while continuously using the lagoon was not. One of the middle-of-the-road alternatives considered would use the existing lagoon divided by dikes into smaller cells (up to six). This was discouraged by the State Geological Survey, which feared further collapse could be caused by the use of heavy equipment.

Numerous contacts were made in an effort to locate package plants which could be transported and installed at West Plains in a minimum amount of time. Potential suppliers of package mechanical facilities were located and costs were estimated. An analysis of the available alternatives; including such factors as time to implement, reliability, public acceptability, effluent quality, and estimated costs, was made in order to support a recommendation and request for funding. The EPA Regional Office selected as the preferable interim solution the installation of a mechanical treatment plant in lieu of continued use of the existing lagoon. Although such a facility is more costly, reliability, public health and public acceptability were deemed to be overriding factors. The EPA Regional Office made plans to provide startup and operation and maintenance personnel to the City of West Plains for 6 months.

Because of the large scale of the West Plains emergency, much work has been done by Region VII to locate and request emergency funds. The City

of West Plains, the State of Arkansas, and the State of Missouri have all requested emergency funds (see Appendix). Because of the great need, Dr. Kathleen Q. Camin, Regional Administrator of EPA, made two trips to Washington, D.C. to attempt to gain disaster assistance and to locate sources of emergency funds. The first was an unofficial meeting held with the Office of Management and Budget (OMB) representatives of various EPA offices and OMB representatives to alert them that a request was being prepared under Section 504 of the Clean Water Act which contains an emergency funding provision.

A decision was made to seek OMB approval of Section 504 funding and an official meeting was held June 1, 1978, with OMB officials. An answer was promised by OMB within 1 week from the date of the meeting.

At this time there has been no firm decision on the Section 504 funding. The EPA Region VII office plans to continue to "fast track" the Section 201 construction grant process for the long-range solution using project segmentation, preordering of equipment, priority reviews and minimum time periods for bids.

Such wide ranging efforts to seek all possible solutions and funding reflect EPA's realization that a town on a limited budget is faced with a very serious problem. Yet at the same time it is necessary to have as safe a system as possible during the interim while a long-range treatment plant solution is being designed and constructed. In many discussions and letters, EPA has recommended to the city and state that an interim mechanical waste treatment facility be constructed on an emergency basis. Concerns have been expressed by the State of Missouri about successfully operating such a plant especially during short high flow situations such as storms. EPA had considered such concerns but felt for the interim that successful disinfection to protect groundwater was more important than a continuously very high treatment level. However, all recognize that getting such a plant built and operating depends on a high level of cooperation by all concerned. Without this cooperation, the chance of a successful interim facility becomes less as time passes.

Sampling Program

The sampling program was undertaken in response to the threat of serious illness and the widespread fear of citizens of the West Plains area. For days, they had been hearing of a rapidly growing number of illnesses, an unseen wave of germs moving through their underground water, and dire public health warnings. For these reasons, the public needed the reassurance that a thorough, organized sampling program could bring. For this reason, Dr. Kathleen Q. Camin, Regional Administrator of EPA, chose to bring personnel from other programs to give priority to such a sampling program.

It was apparent from the outset that clear conclusive data were going to be difficult to find. It had been 12 days now since the initial lagoon

drainage. The geology of the area is known to be extremely complex and unstable. Further, Missouri has no well drilling code, which tends to allow private wells to be improperly constructed so as to be contaminated from the surface of the ground. Finally, there is localized groundwater pollution from scattered sinkholes draining, as well as septic tanks drainage.

With all of these drawbacks in mind, a well water sampling program was initiated by the Emergency Response Team at West Plains on May 20, and completed about May 30. The purpose of the sampling program was to define the extent of the contamination caused by the lagoon failure, the direction of travel of the contamination, and some indication of whether the contamination would tend to remain in the area. Prior to the start of sampling, an area of probable contamination and a "control" area were established along with tests to be used. The boundaries of the area of probable contamination were established based upon the direction of flow of the groundwater, the obstructions to the groundwater, and the direction of fractures in the area. A map of these areas is contained within this report.

The Missouri Division of Geology and Land Survey was consulted after the boundaries were established and they concurred with them. The shape of the area of probable contamination was roughly triangular with West Plains at the northern point. From West Plains, one leg of the triangle extended in a southern direction toward the Arkansas state line and intersecting the state line approximately 29 miles west of Mammoth Springs, Arkansas. The other leg of the triangle extended in a southeastern direction from West Plains to the state line, intersecting the state line approximately 10 miles east of Mammoth Springs, Arkansas (see map). The "control" area was established north of Pomona, Missouri and extended to the Willow Springs, Missouri area. This area was chosen because it is situated in an adjacent groundwater basin and because the area is upstream from the lagoon and should not have been contaminated.

Within each area there were certain wells that were tested. These included municipal wells, private wells, and wells designated as sentinel wells. Sentinel wells were wells checked periodically by state agencies and thought to be so well constructed that they had no surface or casing contamination. The state did not have any information on file for private wells. Therefore, the construction details or quality of these wells could not be established. By far, the largest category of wells sampled was the private well.

The tests chosen included total coliform bacteria, fecal coliform bacteria, nitrates and chlorides. Total coliform and fecal coliform were chosen because the contamination from the lagoon would show high bacterial counts. Chlorides and nitrates were chosen as indicators of possible local contamination caused by run-off from septic tanks or leaky well casings, and because chloride and nitrate values for samples of lagoon effluent were low. Samples were taken as close to the wellhead as possible. Municipal

supplies were sampled before and after chlorination. Some repeat sampling was conducted, particularly when the samples revealed high fecal coliform counts.

Data Analysis and Discussion

As was anticipated, so many localized interferences clouded the pattern of sample results randomly that no clear conclusions could be drawn. Fecal coliform test results from the control area averaged 16 per 100 ml. and averaged 50 per 100 ml in the area of probable contamination, but this is not a great difference for this type of test. The chloride and nitrate values in the two areas were almost identical. No pattern could be determined to link the chloride and nitrate data with the coliform results. The chloride and nitrate graphs in the appendix show very similar characteristics. Neither could a pattern be seen to link this test data with epidemiological data. However, using a combination of interviews and microbiological testing of the lagoon and human wastes, both the Missouri Division of Health and the Center for Disease Control were able to show that the large number of illnesses in the area resulted from the lagoon failure.

Despite the interferences and complex results, the data tended to indicate that the sewage followed a very narrow path from the lagoon toward Mammoth Springs. This indication was later strengthened by dye tests run by the Missouri Geological Survey which showed a similar flow pattern.

Most important, the sampling program allayed many fears because it showed that bacteria were not remaining trapped underground and continuing to breed. The sewage contamination was moving through and passing out of the area. By showing this clearing effect, the sampling program relieved many fears.

Other Considerations

The many contaminated wells in this area pointed up by the test results has caused EPA to take a careful look at means of groundwater protection for the West Plains area. One method of further protection for this area which is being very seriously evaluated is using the Sole Source Aquifer provisions of the Safe Drinking Water Act. This provides for the review of federally-funded projects to prevent their potential pollution of wells in the area. In this area of rapid and serious groundwater pollution spread, this review would make each well safer.

Alerted by the events surrounding the West Plains lagoon collapse, the EPA staff searched their files for other public and private lagoons situated in similar geologic areas. Three maps in the appendix outline the geologic areas of concern and the preliminary numbers of lagoons. A total of 49 municipal lagoons was located in areas subject to sinkhole collapse.

The Missouri State Geological Survey is in the process of investigating the local geological conditions of 24 of these on a priority basis, and information gathered will be utilized to determine whether and how quickly these lagoons should be replaced so that future disasters such as the West Plains incident can be avoided. Another 212 private lagoons were also located in counties which showed sinkhole activity. The EPA staff is planning methods to evaluate the private lagoons. The third map shows areas of occasional sinkhole occurrence.

CHRONOLOGY

- April 13, 1978 (Thursday) Missouri Division of Health advised Missouri Division of Environmental Quality that water from West Plains' Dairy Queen well was testing unsafe, by routine analysis.
- April 17, 1978 (Monday) Department of Natural Resources (DNR) representative advised owner of Dairy Queen to install disinfection equipment on well.
- April 18, 1978 (Tuesday)
1. DNR Regional Office received written confirmation of unsafe well at Dairy Queen from Missouri Division of Health.
 2. Department of Natural Resources received copy of report from Missouri Division of Geology and Land Survey advising City of West Plains consulting engineer that a lagoon rupture could occur at any time.
- May 2, 1978 (Tuesday) Missouri Division of Health personnel sampled Dairy Queen well; on analysis, sample was found to contain sheathed algae genera quadrigula, common to farm ponds and lagoons.
- May 3, 1978 (Wednesday) City received request from Dairy Queen owner to connect to city supply. Request put on May 8 City Council agenda.
- May 6, 1978 (Saturday) City employee discovered loss of approximately 1.5 feet of head in wastewater lagoon (28-30 million gallons) from primary cell near site of 1966 failure. Leakage was thought to have occurred the previous evening. Discharge pipe to polishing lagoon opened to reduce level in primary lagoon and reduce loss.

May 8, 1978 (Monday)

1. City apparently attempted to notify Division of Natural Resources at Poplar Bluff of leakage but offices were closed because of State holiday.
2. City Engineer briefed City Attorney of problem prior to City Council meeting.
3. First complaints of water quality came in to city from customers of Dairy Queen about water, and were referred to Division of Health.

May 9, 1978 (Tuesday)

1. West Plains' city representative called Department of Natural Resources Regional Office, advised of steps taken to reduce further discharge to failure area; requested assistance.
2. Department of Natural Resources Regional Director notified supervisors in Jefferson City of problem with lagoon.
3. Department of Natural Resources Regional Director advised City Engineer to request assistance from Division of Geology before attempting repairs, but to implement repairs quickly.

May 10, 1978 (Wednesday)

1. State geologist inspected lagoon with no city employee present; he stated in his written report that the hole had apparently sealed itself.
2. Division of Health received first illness complaints.
3. Arrangements made for hook up of Dairy Queen to city water service; work was completed on May 11.

May 12, 1978 (Friday)

1. About 30 cases of illness reported by Division of Health to City and to DNR, Jefferson City.
2. News releases were provided by City and State agencies. Chlorination was increased on city water supplies and on neighboring city water supplies; plan to provide chlorinators to businesses serving customers from wells was developed by Division of Health and DNR.
3. Arkansas Health Department notified by Missouri Department of Natural Resources of lagoon spill at 4:30 p.m., May 12.

May 15, 1978 (Monday)

1. City received letter from Department of Natural Resources Regional Office confirming May 9 reporting of lagoon failure.
2. City attempted to get word of the May 10 inspection of lagoon and were told that the report was being typed. State action to continue installation of chlorination feed pumps in key locations stepped up.
3. Two holes developed in floor of lagoon, about 3-4 feet in diameter.
4. About 275 people reported sick by Division of Health.

May 16, 1978 (Tuesday)

1. DNR requested neighboring cities to step up chlorination in water supplies.
2. Further deterioration of peninsula berm surrounding first failure was noted. Drain valve for primary cell was opened to reduce the remaining 1 foot of wastewater by draining it into polishing lagoon.
3. A citizen complaint was received on EPA action line from a Dairy Queen customer who was concerned about possible high nitrates in the well water at his location.

May 17, 1978 (Wednesday)

1. A phone call was held between State personnel from Missouri and Arkansas about contamination implications across the state line.
2. The Environmental Protection Agency received word from the news media that the lagoon break had occurred and that there was an apparent connection with the gastroenteritis epidemic.
3. The Environmental Protection Agency contacted Department of Natural Resources, Jefferson City, for confirmation; EPA emergency response team was dispatched.

May 18, 1978 (Thursday)

1. Early morning meeting was held with Environmental Protection Agency, DNR, Division of Health, City representatives and other officials. The Environmental Protection Agency's immediate role was defined as implementation of a well-monitoring effort to attempt to determine extent of groundwater contamination.

2. Complete drainage of lagoon showed one sinkhole 24 feet in diameter, one 18 feet in diameter and one 4 feet in diameter located approximately 75 feet north of original failure. A diking process began.
3. Bypass of lagoon raw influent began and included a relatively ineffective disinfection process. This discharge disappeared into the ground 40 feet downstream.
4. Citizens of West Plains advised to limit individual water usage; major users being notified by telephone.
5. Intensified news media contacts continued.
6. Governor of Arkansas requested emergency assistance from EPA.

May 19, 1978 (Friday)

1. Division of Health reported a total of 520 people ill, of which 219 were directly related to the Dairy Queen incident.
2. Carolyn Ashford, Chief Assistant to Governor Teasdale, other members of the State of Missouri agencies, and Environmental Protection Agency staff met with leaders of West Plains, and neighboring communities.
3. National Guard dispatched with fresh water for pick-up by persons with contaminated wells.
4. Construction activities on levee continued with initial rock layer finished late evening.

May 20, 1978 (Saturday)

1. Environmental Protection Agency encouraged Mayor to telegraph a request for emergency relief to State of Missouri and Environmental Protection Agency Administrator.
2. Discussion was held with Environmental Protection Agency and State staffs as to advisability of attempting to implement Section 504 of Clean Water Act.
3. Plan to chlorinate large private supplies was implemented by Department of Health and DNR.
4. Preliminary samples taken by Environmental Protection Agency showed 47 percent unsafe samples both within and outside of the affected area.

May 21, 1978 (Sunday)

1. Crews began constructing earthen cap over rock levee. Influent flow to lagoon was reestablished and the bypass discharge to the creek was stopped.
2. Chlorinated public water supplies tested were found safe; private wells chlorination installation continuing; public still advised to boil or purify their own water.
3. Discussions with Environmental Protection Agency and DNR explored possibility of an interim package plant to be used pending completion of new sewage treatment plant.

May 22, 1978 (Monday)

1. As result of conference between Environmental Protection Agency representative and Mayor of West Plains, a telegram was prepared from the Mayor to the Administrator of Environmental Protection Agency for emergency funding. However, it was not sent because the State preferred to make the request.
2. The State of Arkansas epidemiologist reported no illness in Arkansas associated with the West Plains incident. There was no indication of increased pollution in Mammoth Spring.
3. Meeting held between West Plains consulting engineers, Environmental Protection Agency engineering program and DNR officials to determine modifications needed for new plant.

May 23, 1978 (Tuesday)

1. Division of Health reported that several people, who were ill had improved and, were ill with a second phase of diarrhea.
2. The City completed filling sinkholes and finished the clay cover over the levee.
3. Discussions with Environmental Protection Agency, Department of Natural Resources, and the City of West Plains continued over whether to request 504 funds. Department of Natural Resources delayed action until a meeting could be held with Jim Odendahl, Director of the Division of Environmental Quality, DNR, Jefferson City, on May 25.
4. Dr. Kathleen Q. Camin, Regional Administrator, Environmental Protection Agency, declared that an emergency existed and flew to Washington to seek emergency funds for placing an interim treatment plant in place for 1 year.

5. In an investigation of Dairy Queen well site, DNR staff found septic water from wastewater sources in bottom of small pond located in sinkhole.

May 24, 1978 (Wednesday)

1. Work on private well data by Environmental Protection Agency field staff showed high percentage of unsafe wells, but little apparent correlation between them and the sewage leak.

2. Missouri Division of Health reported that, as of May 23, the total number of illness cases was 759, of which 306 were associated with the Dairy Queen.

May 25, 1978 (Thursday)

1. DNR officials concluded that 504 funds should be requested for an interim wastewater improvement to service the city until final wastewater plant could be constructed.

2. Meeting at West Plains with Mayor, City Engineer, Consultants, and Environmental Protection Agency resulted in request from Mayor to Governor for assistance in obtaining Environmental Protection Agency emergency funds.

3. Missouri Geological Survey began dye-testing in area, including Dairy Queen well.

4. Missouri Governor Teasdale sent telegram to EPA requesting assistance.

May 26, 1978 (Friday)

Division of Health reported that illness seems to be abating.

May 30, 1978 (Tuesday)

Meeting was held by City, the City's consulting engineer and Environmental Protection Agency engineers agree on an interim plant construction.

May 31, 1978 (Wednesday)

State Geologist reported that dye trace on packets placed in lagoon and recovered showed a very positive trace to Mammoth Spring. Dye had not been found in packets collected from any other location. Arkansas authorities indicated this result was consistent with their monitoring program. They stated that prior to May 15, Mammoth Spring analysis indicated fecal coliform to be 30 colonies/100 ml. It increased that week to a high of 100 colonies/100 ml., and then dropped off to 40 colonies/100 ml. on the 21st. It began to rise the

week of the 22nd to a high of 140 colonies/100 ml. on the 28th, and then dropped back to 30 colonies/100 ml. on May 30, 1978. These increases had not been considered significant earlier because stream standards allow 200 colonies/100 ml.

June 1, 1978 (Thursday)

1. Environmental Protection Agency staff scheduled for withdrawal on June 2, after arranging for an 8-week analysis program to be continued by the Division of Health, with EPA Lab support.
2. Missouri National Guard was withdrawn by the Governor.

June 2, 1978 (Friday)

1. Missouri Geological Survey reported negative dye tract to Dairy Queen well.

A P P E N D I X



STATE OF ARKANSAS
OFFICE OF THE GOVERNOR

19

DAVID PRYOR
GOVERNOR

May 18, 1978

LITTLE ROCK 72201
(501) 371-2345

TELEGRAM TO:

Ms. Adlene Harrison
Regional Administrator
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First International Building
1201 Elm Street, Suite 2800
Dallas, Texas 75270

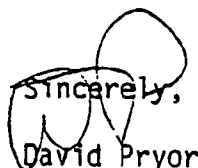
Ms. Kathleen Quinn Camin
Regional Administrator
U.S. Environmental Protection Agency
1735 Baltimore
Kansas City, Missouri 64108

I have today sent the following message to the Honorable
Joseph P. Teasdale, Governor of Missouri:

"The Towns of Ash Flat and Mammoth Spring, Arkansas are now under order from the State Health Department to boil their drinking water as a result of a leak or leaks in a sewage oxidation pond in West Plains, Missouri. Rural private well supplies in the Mammoth Spring area are also under boiling orders. Drinking water supplies are being monitored by the Arkansas Department of Health and the Department of Pollution Control and Ecology. We will have the results of those tests sometime today.

We understand from the Missouri Department of Natural Resources that sewage is continuing to be pumped into this oxidation pond in spite of the leak. If this information is correct, I appeal to you to take the earliest possible emergency action necessary to rectify this situation. I am alerting the U.S. Environmental Protection Agency as to the gravity of this matter and asking for their immediate attention to this problem which is causing grave concern among our citizens".

Whatever assistance you could give us in this regard would be greatly appreciated.

Sincerely,

David Pryor

FROM: City of West Plains, Missouri dated May 25, 1978

Transcript of A Telegram from the Mayor of West Plains to Governor Teasdale

Dear Governor Teasdale:

The City requests your assistance in seeking emergency funds to expedite construction of the final sewage treatment plant and interim measures to minimize the potential for ground water contamination.

Your support will be appreciated.

Very truly yours,

W. G. Roe
Mayor

WGR/eb

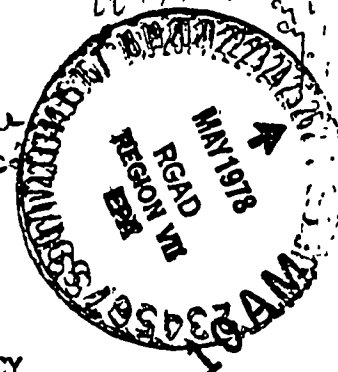


Telegram

KCC174(1721)(4-059285E145)PD 05/25/78 1721

ICS IRRMIZZ CSP

3147513247 TDMT JEFFERSON CITY MO 260 05-25 0521P EST
FMS DOUGLAS COSTLE, ADMINISTRATOR EPA, CARE DR KATHLEEN G CAMIN,
REGIONAL ADMINISTRATOR USEPA REGION VII, RPT DLY BY MCM, (DLR)
1735 BALTIMORE AVE.
KANSAS CITY MO 64108



THE MAYOR OF WEST PLAINS MISSOURI HAS REQUESTED ME TO SEEK EMERGENCY
FEDERAL ASSISTANCE. A CLEAR AND IMMEDIATE EMERGENCY EXISTS FOLLOWING
THE DEVELOPMENT OF A SINKHOLE IN THE BOTTOM OF A 38 ACRE SEWAGE
TREATMENT LAGOON. THE RESULTING GROUND WATER CONTAMINATION AFFECTS A
40 BY 40 MILE AREA. THERE HAVE BEEN 692 CONFIRMED CASES OF ILLNESS
BELIEVED TO BE RELATED TO THIS POLLUTION IN MISSOURI. PUBLIC AND
PRIVATE WELLS IN NORTHERN ARKANSAS ARE ALSO THREATENED. THE MISSOURI
NATIONAL GUARD HAS BEEN FURNISHING EMERGENCY SUPPLIES OF SAFE
DRINKING WATER TO MISSOURI RESIDENTS

8F-1201 (HS-69)

KCC 174/2

CITY FORCES HAVE TAKEN TIMELY ACTION IN CONSTRUCTING EMERGENCY
DIKING TO ELIMINATE THE IMMEDIATE GROUND WATER CONTAMINATION.

ENGINEERS REPRESENTING EPA MISSOURI DEPARTMENT OF NATURAL RESOURCES
AND THE CITY MET AND DETERMINED THAT ADDITIONAL CONSTRUCTION IS
NECESSARY TO ASSURE CONTINUED PROTECTION OF GROUND WATER AND TO
EXPEDITE CONSTRUCTION OF A PERMANENT PLANT (BEING DESIGNED). THE
CITY EXHAUSTED ALL RESERVE FUNDS AND WE MUST OBTAIN OTHER RESOURCES
TO FUND THE NEEDED INTERIM CONSTRUCTION.

I AM HEREWITH REQUESTING YOUR AID IN OBTAINING FINANCIAL ASSISTANCE
FOR: 1. ADDITIONAL INTERIM CONSTRUCTION 2. REIMBURSEMENT FOR
EXPENDITURES ALREADY INCURRED BY THE CITY 3. PURCHASE AND

SF-1201 (RS-69)

— KCC17413

INSTALLATION OF DISINFECTION EQUIPMENT ON ALL AFFECTED PUBLIC WATER SUPPLIES. SUCH ASSISTANCE IS IMMEDIATELY REQUIRED TO PREVENT, LIMIT AND MITIGATE THIS EMERGENCY OR SUBSEQUENT EMERGENCY THAT MAY OCCUR IF CORRECTIVE ACTION IS NOT TAKEN. THERE IS AN IMMEDIATE SIGNIFICANT RISK TO THE PUBLIC HEALTH AND ENVIRONMENT; AND THIS ASSISTANCE CANNOT OTHERWISE BE PROVIDED ON A TIMELY BASIS. PLEASE ADVISE IMMEDIATELY IF SUCH ASSISTANCE IS AVAILABLE. LETTER WITH DETAILS TO FOLLOW.

GOVERNOR JOSEPH P TEASDALE (CAPITOL BLDG JEFFERSON CITY MO 65101)

NNNN

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

DATE: May 22, 1978

SUBJECT: Region VII Recommendation for Use of Emergency Funds under Section 504(b) of the Clean Water Act in West Plains, Missouri - ACTION MEMORANDUM

FROM: Kathleen Q. Camin, Ph.D.
Regional Administrator, Region VII

TO: Douglas Costle
Administrator

ISSUE

Should the Administrator approve the use of emergency funds under Section 504(b) of the Clean Water Act to install a package sewage treatment plant in West Plains, Missouri, and to provide drinking water to area citizens as necessary?

DISCUSSION

On May 5, 1978, a sink hole occurred in the first cell of a two-cell lagoon system providing sewage treatment for the City of West Plains, Missouri. On May 9, 1978, the City of West Plains notified the State of Missouri of the existence of the sink hole, but the State of Missouri did not realize until approximately one week later, when gastro-intestinal enteritis began occurring in the area in numbers far in excess of the norm, the severity of the situation.

On May 17, 1978, this office first learned of the problem, and dispatched an emergency response team to the site. The original sink hole had filled itself by this time, and a second sink hole had opened. By May 18, 1978, the lagoon was dry, with sewage running directly into both sink holes. The city began construction of a dike to segregate the sink holes from the other lagoon area, and 200 individuals had reported related illnesses.

Currently, the existing sink holes have been sealed off by diking, and the lagoon is filling. The lagoon will be filled in 50 to 70 days, assuming that no new sink holes appear. At best estimation, some 75 million gallons of sewage entered the formation through the sink holes. As of May 22, 1978, Missouri had reports of 692 illnesses directly related to contaminated water supplies, and Arkansas has reports of 150 illnesses, providing a total of over 800 illnesses as a direct result.

Although the state has placed emergency chlorinators into all public water supplies within the affected area in the State of Missouri, and both Missouri and Arkansas have issued orders for the boiling of drinking water, in the 1,600 square miles of Missouri and 800 square miles of Arkansas

which are affected, an estimated 25,000 individuals receive their water supply from 10,000 private wells.

The Missouri National Guard is trucking water to distribution areas for use by individuals supplied by private wells.

No cases of typhoid, cholera, polio, hepatitis, or other diseases have been reported, and there are no registered typhoid carriers in the area. The EPA regional office and the State of Missouri are carrying on a massive sampling program of both public and private wells at the present time.

Estimates by experts are that the ground water contamination which has occurred will be in existence for a period up to one year. Because of the nature of the substrata, the lagoon could be subject to breach by another sink hole at any time.

Both the Governor of Arkansas and the Mayor of West Plains, Missouri, have requested EPA action under Section 504(b) of the Clean Water Act. One of the issues which must be resolved is whether or not such action should be taken in the absence of a request from the Governor of Missouri. It is the opinion of Region VII that no such request is necessary. Section 504(b) of the Clean Water Act authorizes the Administrator to provide emergency assistance when he determines that:

Sec. 504.(b)(5) The Administrator is authorized to provide emergency assistance under this subsection whenever the Administrator determines -

(A) such assistance is immediately required to prevent, limit, or mitigate the emergency;

(B) there is an immediate significant risk to the public health or welfare and the environment;
and

(C) such assistance will not otherwise be provided on a timely basis.

Those determinations are not qualified, either by language of the statute or by the legislative history by a requirement that they must be bolstered by a Governor's request.

Another issue involved is whether or not such aid can be provided prior to a congressional appropriation of \$10 million in support of such Section 504(b) of the Clean Water Act. We suggest that the imminent and substantial endangerment of public health present in the West Plains

situation justifies the usage of other funds in anticipation of such an appropriation, and we point out the language of Congressman Roberts in support of Section 504 during committee consideration:

Nothing is to be done to undermine or delay the use of this authority ... It is the conferees' intent that the Administrator shall not be encumbered by the Office of Management and Budget in carrying out the provisions of Section 69. The Administrator should move immediately where there is need, and concern himself later as to what other agencies might have come in. The key in most cases would be expeditious action to avoid disastrous consequences.

A third issue, assuming authorization to use Section 504(b) funds, occurs, is what alternative action should be taken? It is the opinion and request of Region VII that we be authorized to expend the necessary funds for placement of a temporary package sewage treatment plant. Such a plant could be in place and functioning within the 50 days which it will take for the lagoon to fill up. The City of West Plains has an application for a 1.7 mgd oxidation type plant, but it is impossible for that plant to be on line in less than a year. The temporary package plant will cost approximately \$500,000.

In addition, we request authority to supplement or replace, if necessary, the current efforts by the Missouri National Guard to provide potable water by truck to the individuals whose water supply is in the form of private wells.

In order for expeditious placement of the treatment facility, we request authority to execute contracts immediately with a waiver of the general procurement requirements.

RECOMMENDATION

Region VII finds that provision of a package plant and ability to provide emergency water supplies when necessary in the area of West Plains, Missouri, is immediately required to prevent, limit, and mitigate the emergency. Region VII also finds that there is an immediate significant risk to the public health and welfare and the environment if such assistance is not provided, and that such assistance will not otherwise be provided on a timely basis. Based on the above and the information contained in the appendices hereto, I recommend the immediate authorization of funds for the provision of a package sewage treatment plant to the City of West Plains, Missouri, and the authorization to expend funds for the provision of safe drinking water to the affected area if

necessary under the authority of Section 504(b) of the Clean Water Act. I further recommend that such authorization include authority to execute necessary contracts and make necessary purchases immediately with a waiver of the procurement requirements.

DECISION OF ADMINISTRATOR

Approve: _____

Disapprove: _____

Date: _____

Enclosures:

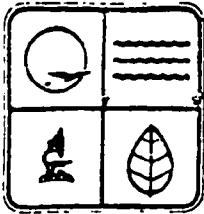
Appendix 1 - Report on West Plains ground water pollution and attached chronology

Appendix 2 - Telegrams from Mayor and Governor, requesting aid

Appendix 3 - Maps

Appendix 4 - Discussion of alternatives

Appendix 5 - Selected newspaper articles



May 18, 1978

MISSOURI DEPARTMENT OF NATURAL RESOURCES
P.O. Box 250 Rolla, Missouri 65401 (314) 364-1752

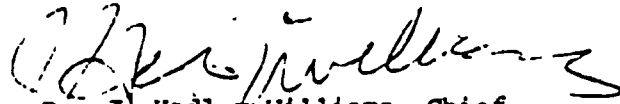
Lowell Patterson
City Engineer
West Plains, MO 65775

Dear Mr. Patterson:

I believe the attached reports emphasize the fact that there is no future, other than one of continued sinkhole collapse, for the West Plains lagoons.

Alternate procedures obviously are needed quickly. Otherwise, you all will be going from one collapse to the next. There is the hazard of machinery working in the lagoon causing a collapse. This has happened before and could be dangerous.

Sincerely yours,


Dr. J. Hadley Williams, Chief
Applied Engineering & Urban Geology
Geology & Land Survey

JHW/dsb

cc: Tom Jones
DEQ, Jeff City

Division of Geology and Land Survey
Dr. Wallace B. Howe Director

Joseph P. Teasdale Governor
Carolyn Ashford Director

ADDENDUM

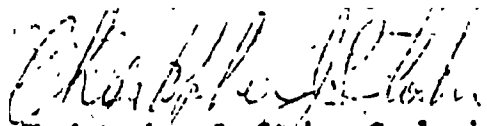
PRELIMINARY ENGINEERING GEOLOGIC REPORT ON THE WEST FLAINS LAGOON

Howell County, Mo.

There is a distinct likelihood of a catastrophic sinkhole collapse occurring beneath the proposed lagoon in the vicinity of Sec. 26, T. 24 N., R. 8 W., West Plains Quadrangle. Three such collapses have occurred since 1964, two in the smaller cell, and one in the larger cell which drained an estimated 136 acre-feet of effluent in 52 hours. This presents a potentially serious hazard to regional groundwater quality.

It is recommended that an alternate method of waste treatment be considered such as a mechanical treatment plant. Sites for irrigation of effluent, or a treatment plant should be investigated by this office.

A copy of a report on the catastrophic sinkhole collapse by Aloy, Williams and Massello (1972) in Groundwater Contamination and Sinkhole Collapse, Engineering Geology Series No. 5, Missouri Geological Survey and Water Resources, Rolla, Mo., is enclosed for your information.


Christopher J. Stohr, Geologist
Applied Engineering & Urban Geology
Missouri Geological Survey
April 15, 1975

cc: Ted Forrester
CWC

Jefferson City, Mo.

ENGINEERING GEOLOGIC REPORT OF THE WEST PLAINS LAGOON

HOWELL COUNTY, MISSOURI

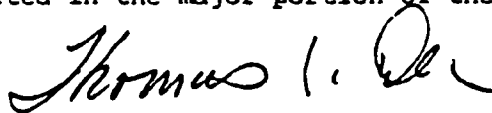
In all probability, considering the past history of collapses in the lagoon system, further collapses in the major portion of the primary cell will not occur.

If the present temporary dike can be moved or a new dike built, at least 100 feet + away from the collapse area, no additional collapses would be likely.

The past history of collapse in this lagoon system has been in the secondary cell and in the vicinity of the collapse of May 7 and 16, 1978. Considering the length of time the remaining portion of the primary cell has been in operation, there is no reason to suspect that additional collapses will take place in the 9 month to 1 year period of time probably necessary for construction of the ultimate solution treatment facility.

Subdividing the remaining portion of the primary cell into several cells by the use of dike works etc. would lessen the potential of large volumes of partially treated sewage going underground in the event of an unanticipated collapse. However, heavy equipment necessary for construction of the additional dike works may precipitate collapse. It should also be considered that if the equipment is capable of causing collapse due to vibration etc., it is likely that the collapse would occur for other reasons than the presence of the equipment.

In summary, the history of collapse in this treatment system suggests that near future collapses would not be expected in the major portion of the primary cell.



Thomas J. Dean, Geologist
Applied Engineering & Urban Geology
Geology & Land Survey
May 24, 1978

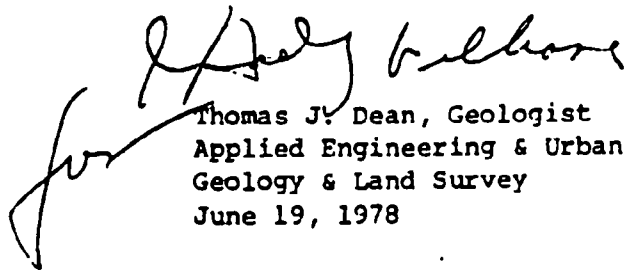
ADDENDUM TO THE WEST PLAINS LAGOON REPORT OF 24 May, 1978

HOWELL COUNTY, MISSOURI

The Engineering Geologic Report of the West Plains lagoon system of May 24, 1978 considered the past collapse history of the lagoon system. The geologic setting of the upstream portion of the primary cell that has not experienced recent collapses is very similar geologically to other karst areas in Howell Valley.

If the geophysical survey or drilling survey now in progress reveals or suggests the presence of large voids within the alluvial or underlying residual soil under the primary cell, it is recommended that some form of structural support be provided for the lagoon bottom during the interim period, or that other forms or methods of interim treatment be provided that do not depend on the water holding capability of the primary cell.

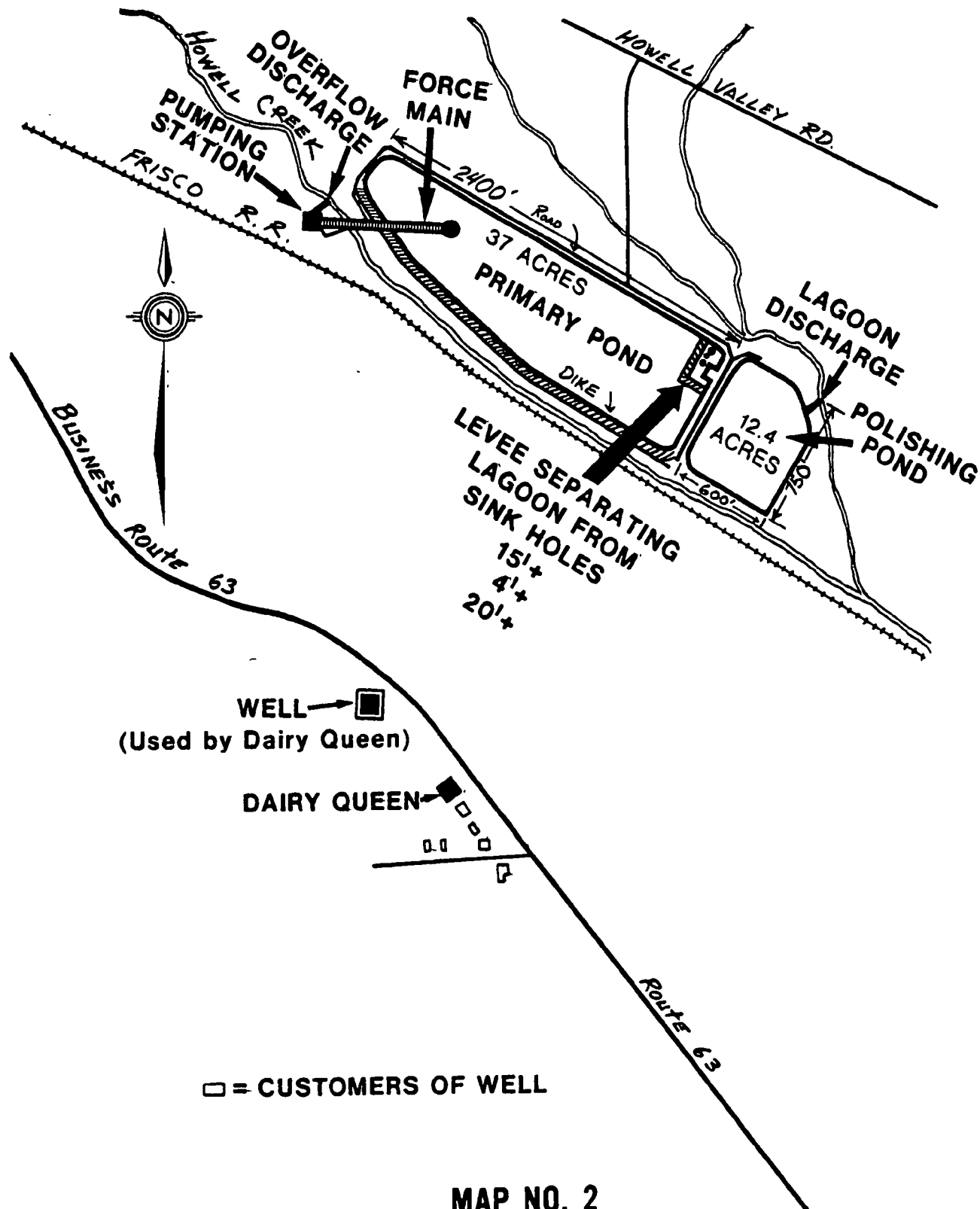
No method of filling and sealing voids or collapses to make them watertight would probably be feasible considering the foundation conditions at the base of the void space.

A handwritten signature in dark ink, appearing to read "Tom J. Dean", is written over the typed name and title.

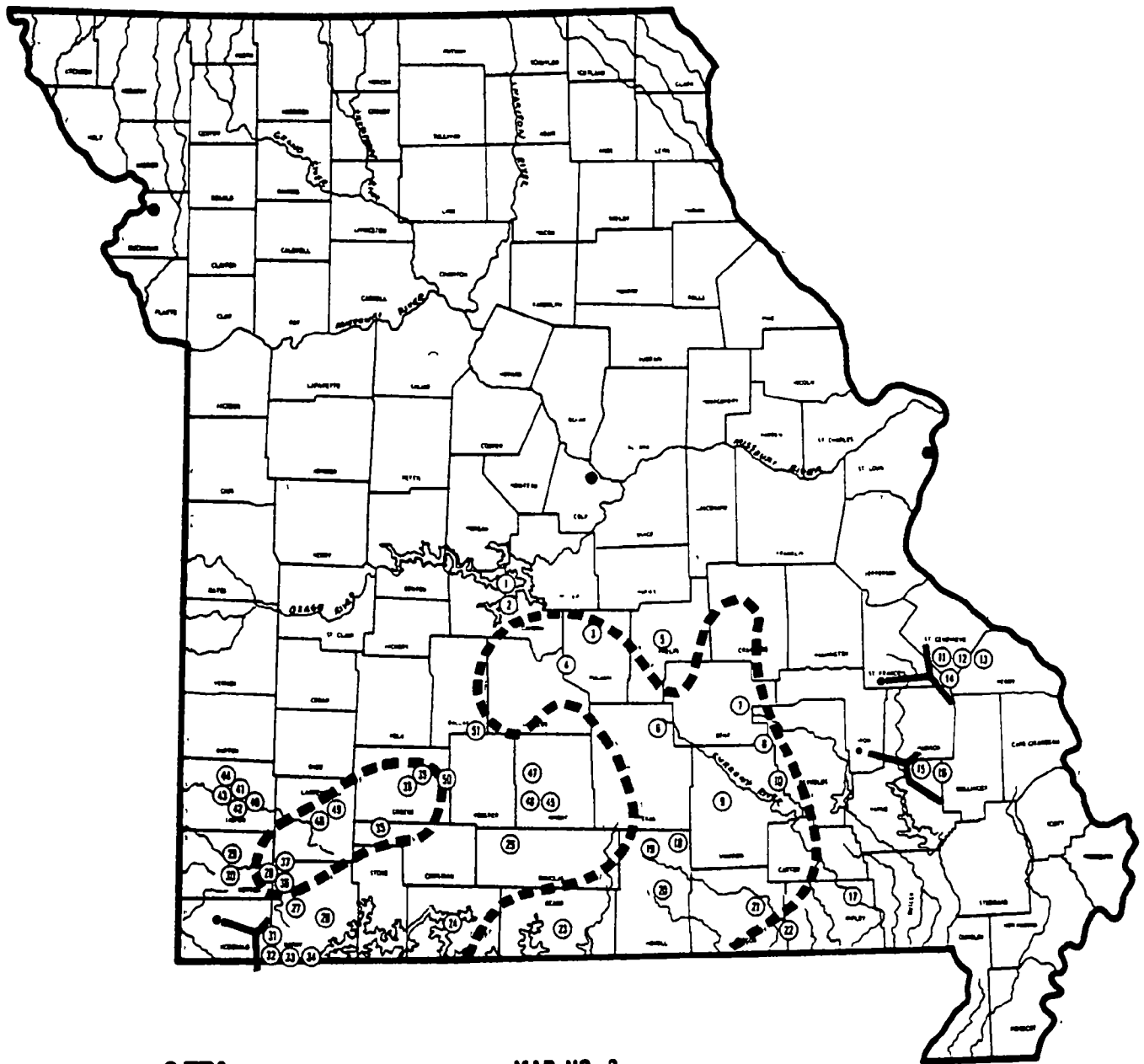
Thomas J. Dean, Geologist
Applied Engineering & Urban Geology
Geology & Land Survey
June 19, 1978

orig: Jim Burris
DEQ, Poplar Bluff

WEST PLAINS, MISSOURI LAGOON SITE



MUNICIPAL LAGOONS IN AREAS SUBJECT TO GEOLOGICAL COLLAPSE



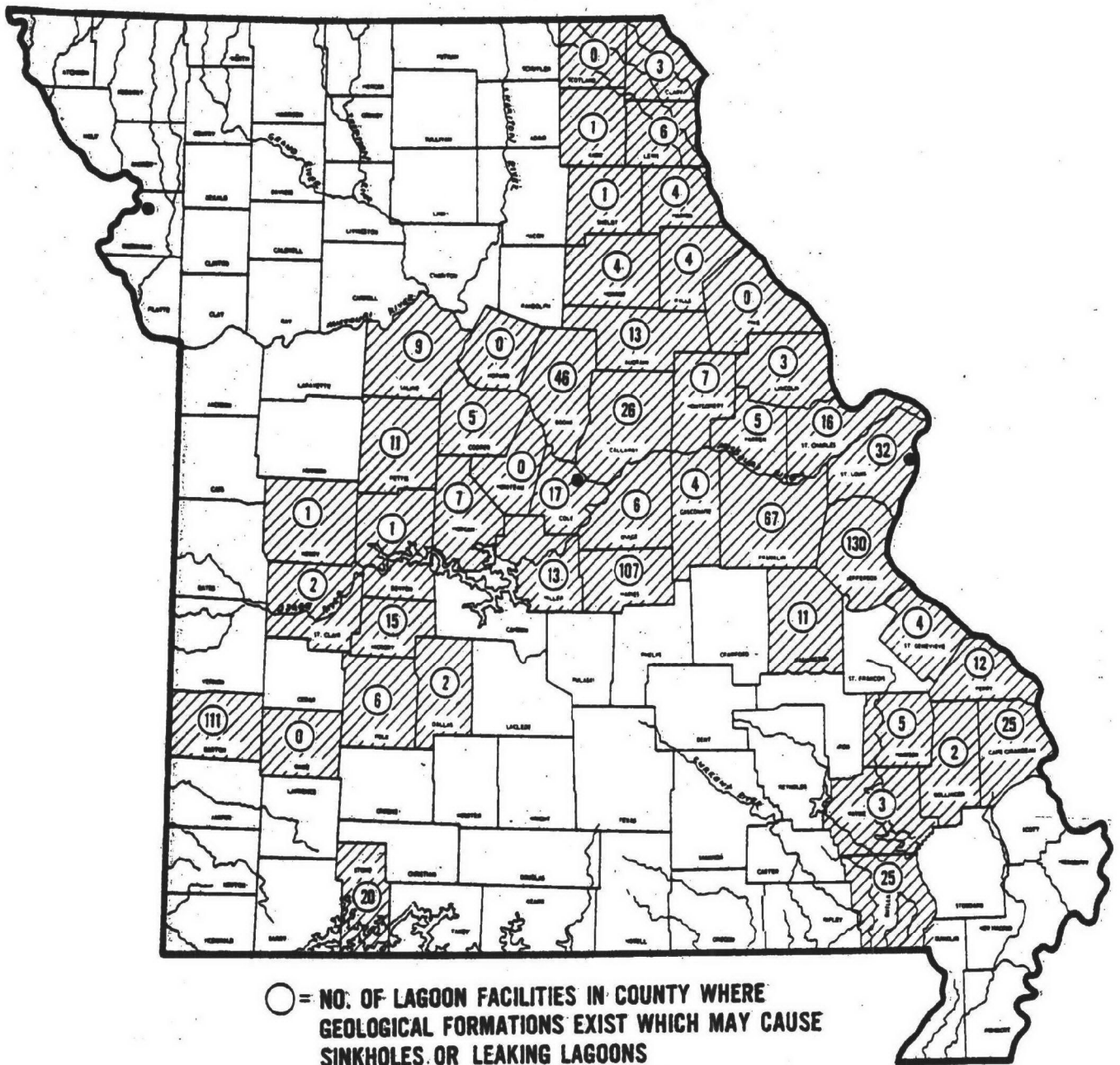
Municipal Lagoons In Area Subject To Geological Collapse

- | | |
|--------------------|--------------------|
| 1. Linn Creek | 25. Ava |
| 2. Camdenton | 26. Cassville |
| 3. Dixon | 27. Purdy |
| 4. Richland | 28. Diamond |
| 5. Rolla | 29. Stella |
| 6. Licking | 30. Wheaton |
| 7. Salem | 31. Landerson |
| 8. Bunker | 32. Noel |
| 9. Eminence | 33. Goodman |
| 10. Ellington | 34. Southwest City |
| 11. Bismarck | 35. Billings |
| 12. Bdnne Terre | 36. Omit |
| 13. Desloge | 37. Omit |
| 14. Flat River | 38. Republic |
| 15. Arcadia | 39. Springfield |
| 16. Viburnum | 40. Sarcoxie |
| 17. Doniphan | 41. Jasper |
| 18. Mountain View | 42. Webb City |
| 19. Weldon Springs | 43. Carterville |
| 20. West Plains | 44. Carl Junction |
| 21. Alton | 45. Mountain Grove |
| 22. Thayer | 46. Mansfield |
| 23. Gainesville | 47. Hartville |
| 24. Branson | 48. Aurora |
| | 49. Marionville |
| | 50. Marshfield |
| | 51. Conway |

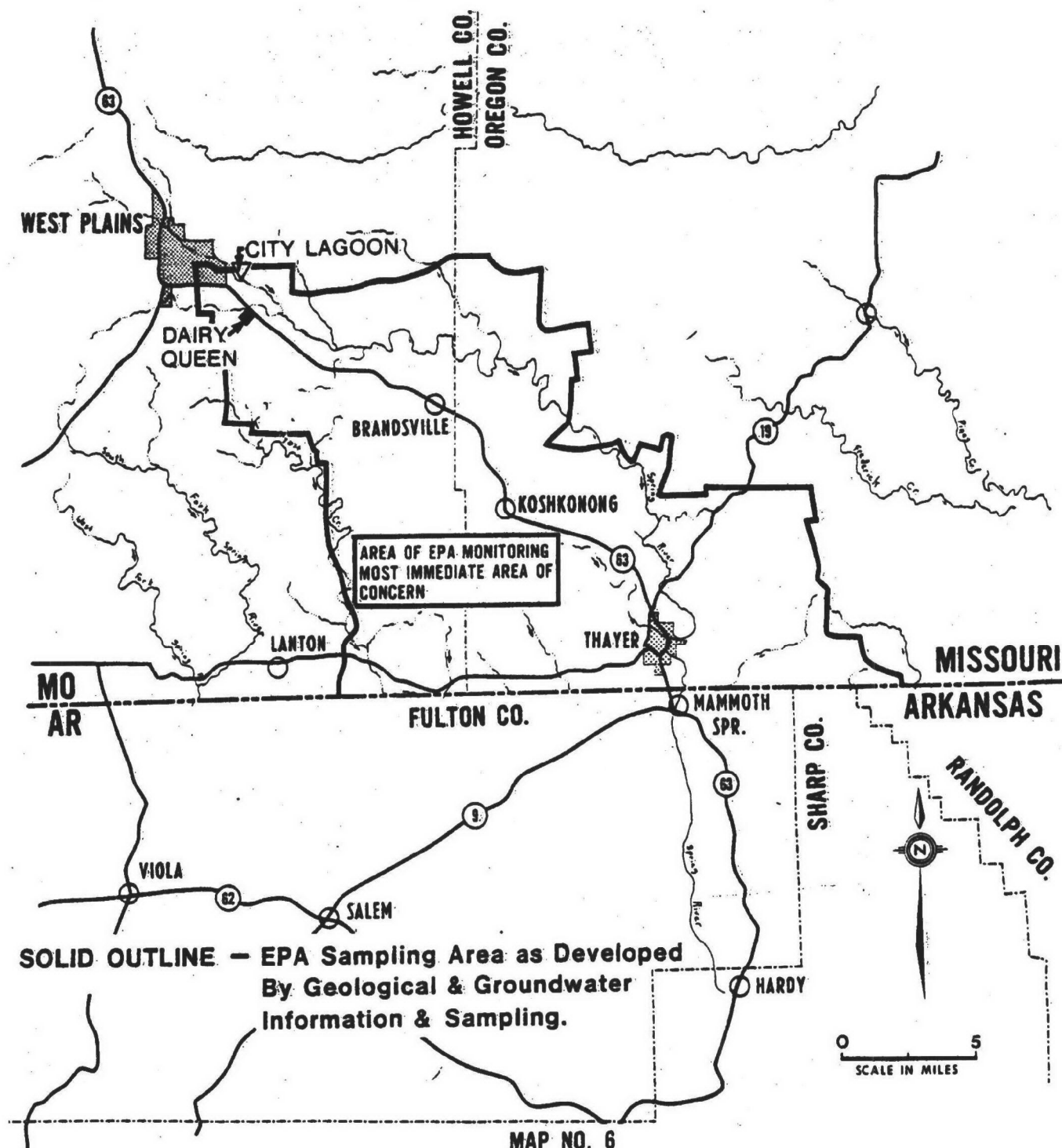


MAP NO. 4.

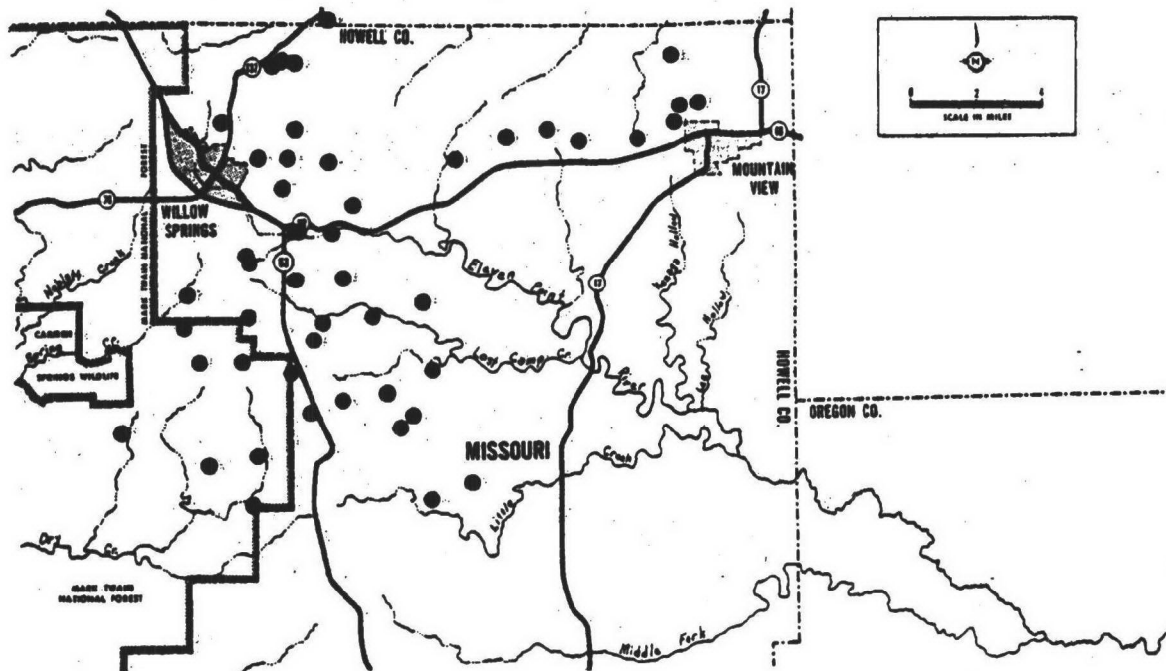
SUMMARY OF PRIVATE LAGOON FACILITIES IN AREAS WHERE GEOLOGICAL FORMATIONS EXIST WHICH MAY CAUSE SINKHOLES OR LEAKING LAGOONS



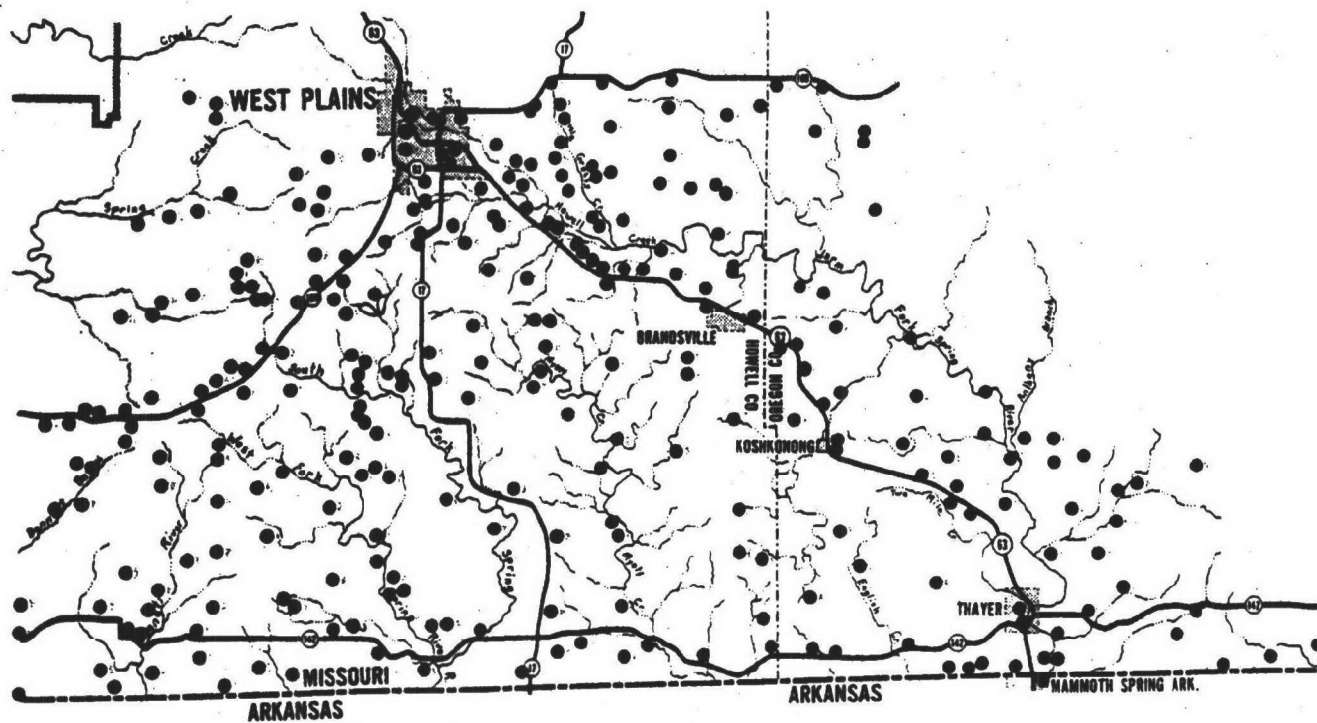
WEST PLAINS, MISSOURI AREA OF PROBABLE CONTAMINATION



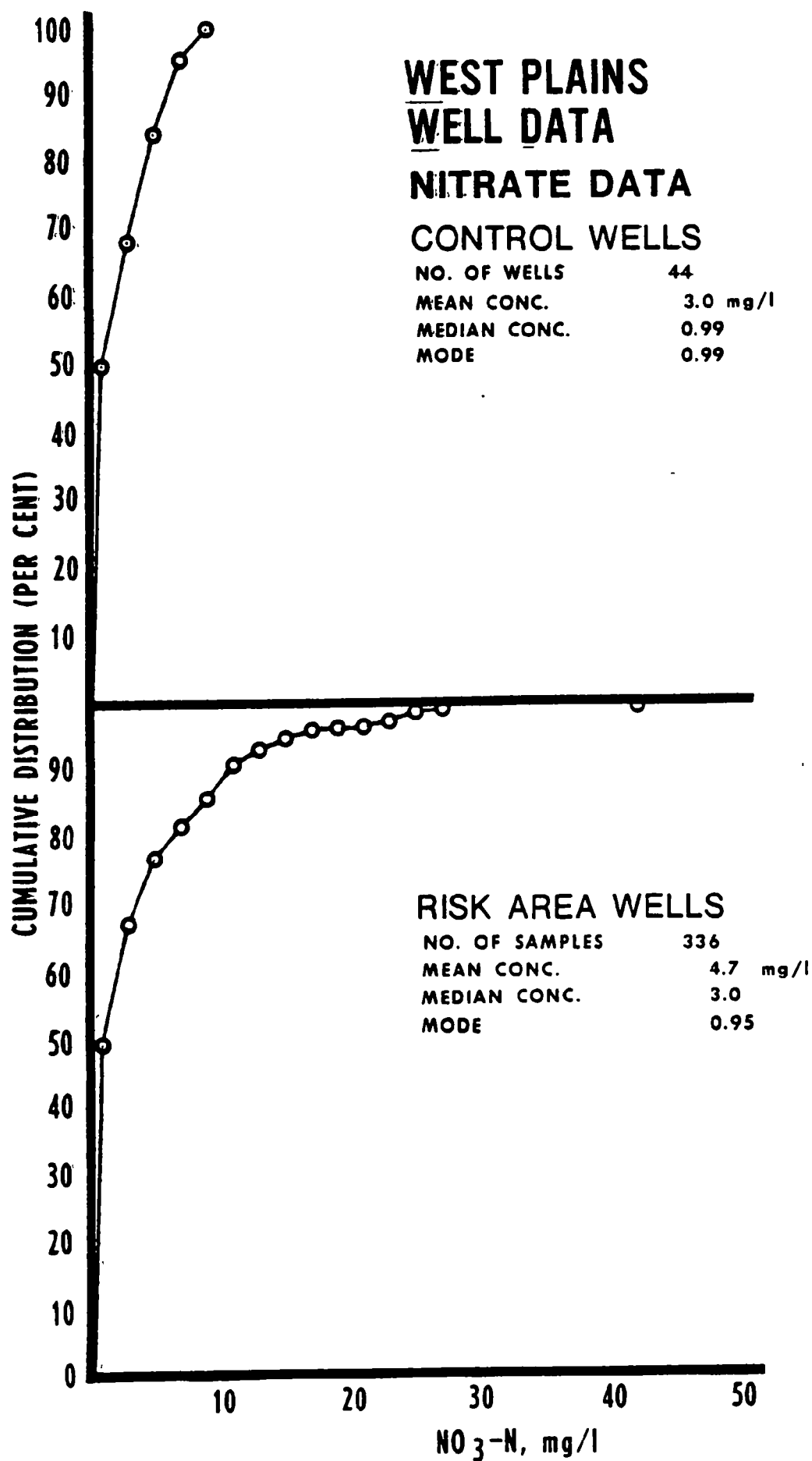
CONTROL AREA
WEST PLAINS, MO. - WELLS SAMPLED MAY 20-JUNE 2, 1978



AREA OF PROBABLE CONTAMINATION



MAP NO. 7



50

WEST PLAINS WELL DATA

NITRATE DATA-FREQUENCY DISTRIBUTION

CONTROL DATA

NO. OF SAMPLES	44
MEAN CONC.	3.0 mg/l
MEDIAN CONC.	0.99
MODE	0.99

40

30

20

10

40

30

20

10

0

RISK AREA WELLS

NO. OF SAMPLES	336
MEAN CONC.	4.7 mg/l
MEDIAN CONC.	3.0
MODE	0.95

10

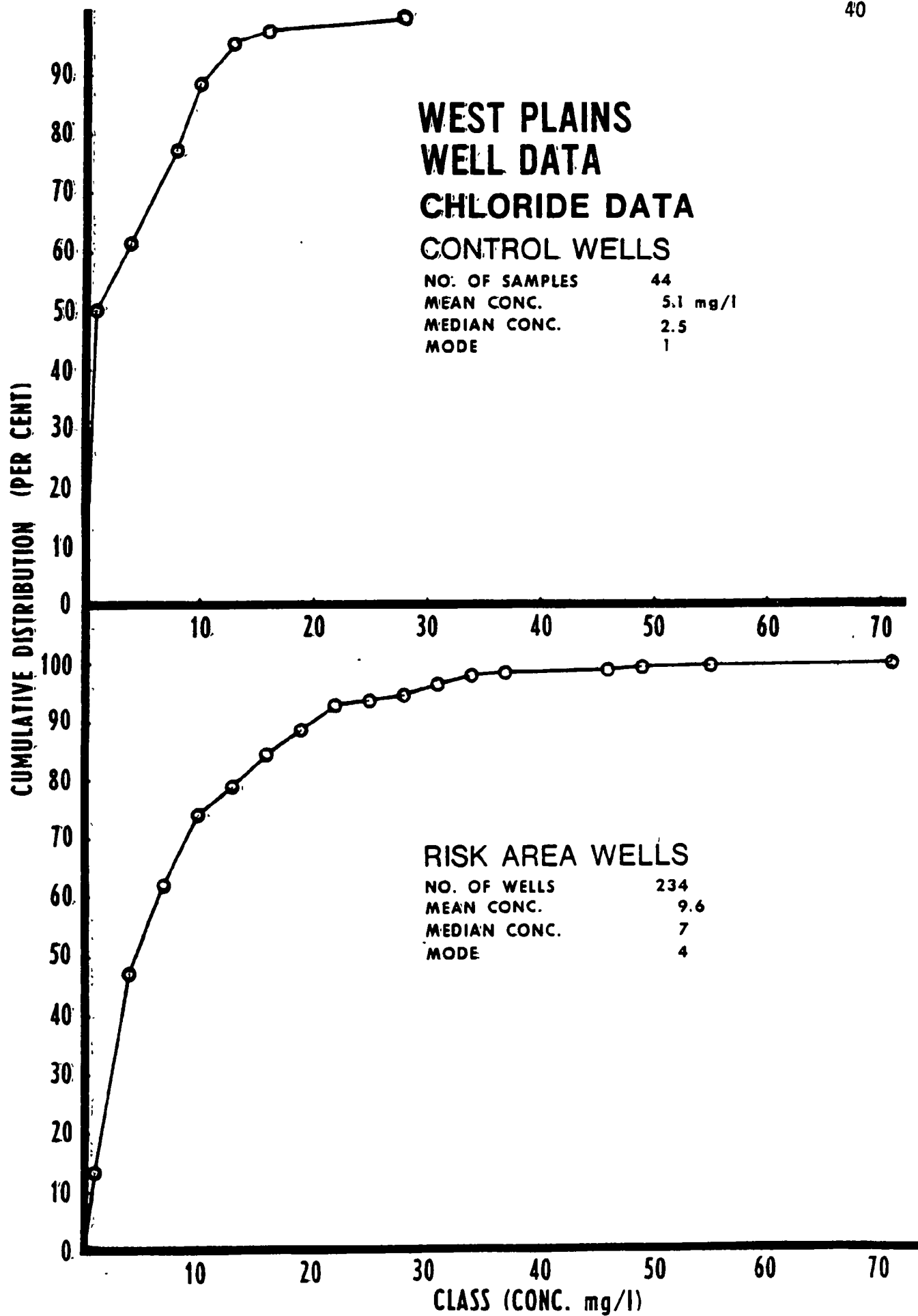
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30

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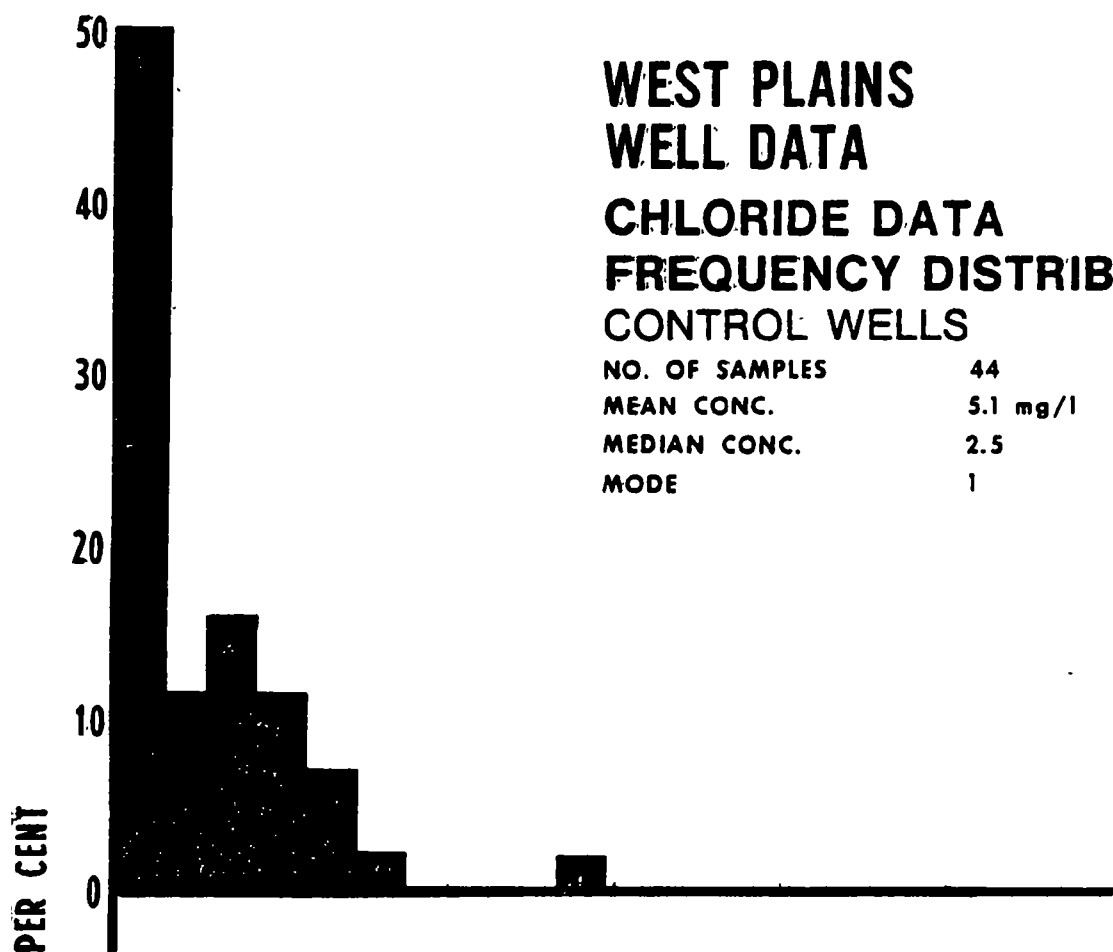
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 $\text{NO}_3\text{-N}$ (mg/l)



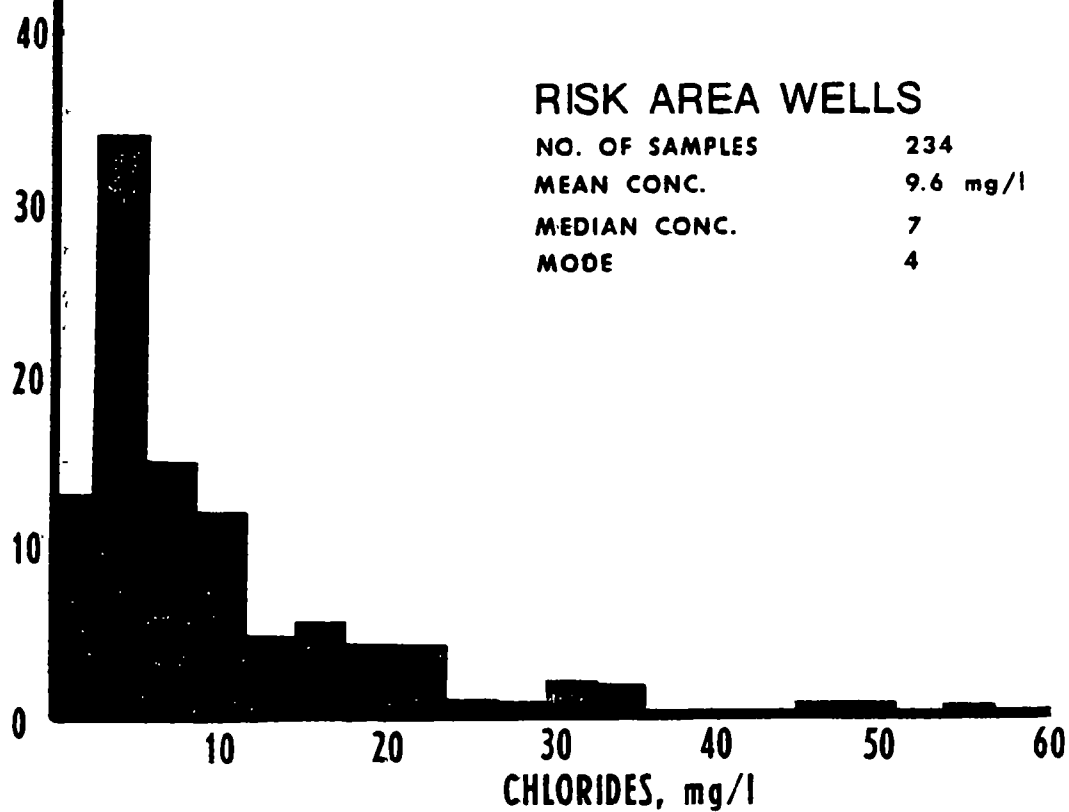
**WEST PLAINS
WELL DATA
CHLORIDE DATA
FREQUENCY DISTRIBUTION
CONTROL WELLS**

NO. OF SAMPLES	44
MEAN CONC.	5.1 mg/l
MEDIAN CONC.	2.5
MODE	1



RISK AREA WELLS

NO. OF SAMPLES	234
MEAN CONC.	9.6 mg/l
MEDIAN CONC.	7
MODE	4



Demographics

West Plains, Missouri, is located approximately 112 miles southeast of Springfield, Missouri, 18 miles from the Arkansas border northwest of the Mammoth Spring, Arkansas, resort area (See figure II).

The population is about 7,000. The city serves as a significant trade center for a rural population engaged in agriculture and livestock production. There are several small manufacturing industries employing, on the average, less than a hundred people each; the exception being the International Shoe Company, which employs about 580 people.

The city is the county seat of Howell County and also serves as the major urban center for the neighboring counties of Douglas, Texas, and Shannon.

Because of the low salaries common to this part of the Ozarks, the tax base is low and about 75 percent of the population falls below the Federal poverty guidelines of \$7,500 per year per family of four. This makes a large portion of the community eligible for assistance through various Federal programs. This low income also works a serious hardship on the community when faced with a large potential bonded indebtedness.

Geology-Hydrology of the Area

All of the bedrock formations in the West Plains-Mammoth Spring area contain groundwater and all are used for water supply. The City of West Plains obtains water from six wells that end in the Lower Gasconade, Eminence, and Potosi Formations. The City of Koshkonong obtains water supplies from the Roubidoux and Upper Gasconade Formations, and the City of Thayer obtains water from four wells in the Roubidoux through the Potosi Formations. Private wells obtain water from shallow wells in the Jefferson City Formations and Roubidoux Formations. (The ground water flows through aquifers from recharge sites to springs, which are points of discharge through solution-enlarged fracture systems, including caverns). Because of the extreme variability of the aquifers and the hydraulics of flow through them, it is very difficult to predict the movement of ground water from recharge to discharge sites. For example dye studies have indicated that Mammoth Spring is recharged by Grand Gulf practically instantaneously during heavy rainfall. The Missouri Division of Geology and Land Survey has kept accurate records of precipitation and water levels in a 477 m (1550 ft.) observation well. Casing depth is down to approximately 308 m (1000 ft.). The lag time between the precipitation input and the water level response in most cases is less than 1 week. In some cases, it is even less than 4 days.

BIBLIOGRAPHY

PUBLICATIONS:

"Groundwater Contamination and Sinkhole Collapse Induced by
Leaky Impoundments in Soluble Rock Terrain"

Thomas J. Aley, James H. Williams, James W. Massello

Missouri Geological Survey and Water Resources
Rolla, Missouri 1972

EPA REGION VII PERSONNEL WHO PARTICIPATED IN THE WEST PLAINS, MISSOURI
EMERGENCY RESPONSE

<u>Region VII Headquarters</u>		<u>Reg. Time</u>	<u>Overtime</u>
Regional Administrator	Kathleen Q. Camin		
Principal Contact	G. E. Stigall		
Construction Grants	Paul Walker		
	Jim Foil		
	Lynn Harrington		
Water Supply	Rick Weller	48	
	Hank Bunczewski	16	
	Al MacFarlane	85	
Misc. Offices	J. Crane	48	48
	John Carpenter	40	41
	Betti Harris	48	37
Water Supply	Randal Garten	32	40
(Jeff. City)	Bill McFerrin	44	40
Emergency Response	Harry Gilmer	192	
(O.S.C.)	W. Pedicino	48	40
SVAN - Field	Dan Harris	192	
	J. Hopkins	32	52
	B. Littell	48	46
	M. E. Pluta	100	56
	G. Snodgrass	32	44
	S. Koken	40	43
Laboratory	Bill Keffer	30	
	Carl Bailey	60	5
	S. Roberdes	80	20
	L. Mosby	40	8
	R. Rodriques	32	13
	C. Lunte	80	40
	J. Joslyn	40	
	D. Simmons	40	
	G. Beemont	20	
	W. Bunn	28	
	B. Haas	4	
	T. Schlich	4	4
	J. Heiman	60	16
	C. Hensley	35	
		<u>1,598</u>	<u>633</u>

This represents about 1.4 person-years.