APPENDIX A: EVENT SUMMARY TIMELINE

DATE	EVENTS
Wednesday, March 5, 2008	Routine total coliform samples collected by city from well sources and Weber Reservoir. All results are total coliform absent.
Thursday, March 6, 2008	Onset of symptoms in first case.
Wednesday, March 12, 2008	Three cases of salmonellosis reported to the regional epidemiologist from the Alamosa County Nursing Service.
Friday, March 14, 2008	Three cases of salmonellosis reported from the regional epidemiologist to the enteric disease epidemiologist at CDPHE.
Monday, March 17, 2008	CDPHE enteric disease epidemiologist contacted the SDW program to report the outbreak and request assistance with response. The SDW program assembled the Acute Team, a group within the program trained to respond to conditions related to drinking water that may result in acute risk to public health. The team directed city staff to collect total coliform samples from the city's distribution system. Four water samples were collected from the city's distribution system by Alamosa County Nursing Service to be tested for total coliform.

Tuesday, March 18, 2008	By this date, 43 cases including 18 laboratory confirmed cases had been reported.
Wednesday, March 19, 2008	Results from samples collected by city on March 17 are reported in the morning. One sample was total coliform positive and two were noted as "turbid" by the laboratory. Bottled water advisory is issued. CoWARN activated and first request for resources issued. City and county declare emergency.
Thursday, March 20, 2008	Five water samples were collected from city's distribution system by SDW program staff to be tested for *Salmonella*. One additional sample collected from neighboring East Alamosa[1] distribution system, also to be tested for *Salmonella*. CoWARN teams began to arrive in Alamosa to assist.

[1] East Alamosa Water District was a separate water system at the time of the outbreak in March and April 2008. It was not connected to the city of Alamosa's water system. That has since changed and at the time of this writing; the city of Alamosa now serves water to East Alamosa.

Friday, March 21, 2008	Samples of feces collected. Commencement of system disinfection and flushing process, beginning with Weber reservoir. The Weber reservoir is drained and crews begin to clear out sediment. Governor declares emergency.
Saturday, March 22, 2008	Repairs and disinfection of Weber reservoir continue. Crews complete the clean-out of the tank and the interior is sprayed with a 50 mg/L chlorine solution. The solution is left for 24 hours of contact time.
Sunday, March 23, 2008	Repairs and disinfection of Weber reservoir continue. Crews fill the reservoir at 900 gpm with a dose of 25 mg/L of chlorine. 270,000 gallons are held in the reservoir for 24 hours of contact time. CoWARN crews begin surveying the distribution system to develop plans for flushing the tanks and lines and to survey for cross-connections. The Craft Tower is surveyed. Easter Sunday

Monday, March 24, 2008	Results from all five water samples from Alamosa are reported positive for *Salmonella* by polymerase chain reaction (PCR) laboratory analysis. One result from East Alamosa is negative. CoWARN requests additional water distribution system operators to assist with disinfection and flushing. Field crews drain the Craft Tower. It is then filled at 500 gpm with a dose of 25 mg/L of chlorine. 500,000 gallons are held in the tank for 24 hours of contact time.
Tuesday, March 25, 2008	SDW program team and partners commence disinfection of city's distribution system. Fire hydrants are used to create high flow demand on main distribution lines. Flushing begins from north to south. Public were notified using the traffic signal messages and flyers delivered door to door.
Wednesday, March 26, 2008	Disinfection of the distribution lines continues with water from the Weber reservoir and Craft Tower. Crews drain the Ross Tower. Then it is filled at 500 gpm with a chlorine dose of 25 mg/L. 200,000 gallons are held in the tank for 24 hours of contact time.
Thursday, March 27, 2008 - Wednesday, April 2, 2008	Disinfection of the distribution lines continues with water from the Weber reservoir, Craft Tower, and Ross Tower.

Wednesday, April 2, 2008	Disinfection and flushing of system is complete.
Thursday, April 3, 2008	Bottled water advisory is replaced with a boil water advisory.
Wednesday, April 9, 2008	MPA samples collected for giardia/crypto analysis.
Friday, April 11, 2008	Lifted boil water order.

APPENDIX B: SUMMARY OF WATER QUALITY DATA COLLECTED DURING THE OUTBREAK RESPONSE

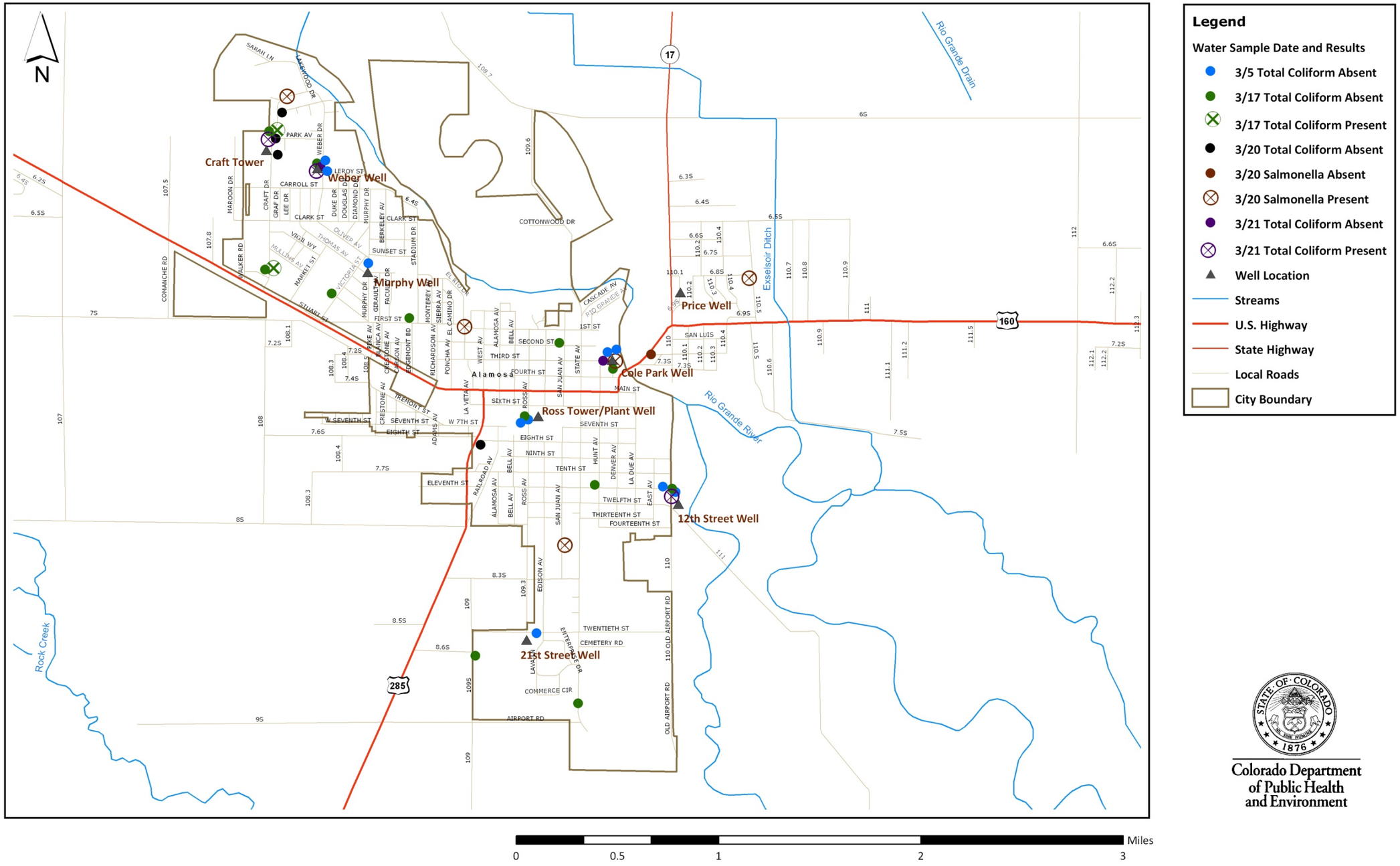
TABLE B-1. SUMMARY OF MICROBIOLOGICAL FIELD SAMPLING DATA COLLECTED BEFORE DISINFECTION AND FLUSH

DATE	NUMBER OF SAMPLES	LOCATION(S)	TOTAL COLIFORM BACTERIA	*SALMONELLA* BACTERIA	COMMENTS
March 5, 2008	10	Six wells plus Weber Reservoir effluent.	All Samples Absent	Not Sampled	Prior to outbreak recognized. Collected by city of Alamosa for Total Coliform Rule compliance. Not collected at proper locations for Total Coliform Rule.
March 17, 2008	14	Twelve samples from distribution system plus Weber Reservoir effluent and Craft Tower.	12 Absent, 2 Present	Not Sampled	Total coliform present samples were at Craft Tower and on Craft Avenue. Samples at wastewater treatment plant and Weber Reservoir were absent, but noted as "turbid". This is a laboratory mechanism to indicate sample water was not "normal" and therefore pathogens may be present.
March 20, 2008	4	Three samples from distribution system plus Craft Tower.	All Samples Absent	Not Sampled	
March 20, 2008	5	Distribution system.	Not Sampled	All Samples Present	
March 20, 2008	1	East Alamosa distribution system.	Not Sampled	Absent	East Alamosa was not connected to the Alamosa water system in March 2008.
March 21, 2008	5	Two wells plus Weber Reservoir, Craft Tower and distribution system.	2 Absent, 3 Present	Not Sampled	Wells were total coliform absent, including the Weber Well. Samples at Weber Reservoir, Craft Tower, and distribution system at wastewater treatment plant were total coliform present.

TABLE B-2. SUMMARY OF FIELD SAMPLING DATA COLLECTED DURING AND AFTER DISINFECTION AND FLUSH MARCH 25 TO APRIL 9, 2008

PARAMETER	NUMBER OF SAMPLES	LOCATION(S)	RESULTS (a)	COMMENTS
Total Coliform Bacteria	90	Distribution system.	All Samples Absent	
Salmonella Bacteria	34	Distribution system.	All Samples Absent	One sample showed presence of *Salmonella* DNA, but this sample did not culture live bacteria. The area was re-flushed, and repeat samples were absent bacteria.
Giardia Cysts	15	Four samples from wells. Eleven samples from distribution system.	All Samples Absent	
Cryptosporidium	15	Four samples from wells. Eleven samples from distribution system.	All Samples Absent	
Arsenic	100	One sample from Weber Well, the rest from distribution system.	0.011 to 0.038 mg/L	Health-based standard is 0.010 mg/L. The city of Alamosa was already beyond this level. The Weber Well was 0.024 mg/L. Flushing did not significantly elevate the arsenic concentration to an acute risk level.
Lead	48	Distribution system.	<0.001 to 0.009 mg/L	All samples below action level of 0.015 mg/L.
Copper	48	Distribution system.	<0.003 to 0.365 mg/L	All samples below action level of 1.3 mg/L.
Total Trihalomethanes	10	Distribution system.	<0.5 to 2.0 ug/L	This is a disinfect by-product. All samples below health-based standard of 80 ug/L.
Haloacetic Acids	6	Distribution system.	1.4 to <5.0 ug/L	This is a disinfect by-product. All samples below health-based standard of 60 ug/L.
Heterotrophic bacterial plate count	14	Distribution system.	<1 to 67 coliform forming units	No specific, health-based standard for this parameter.
Total Organic Carbon	6	Distribution system.	All Samples < 0.5 mg/L	No specific, health-based standard for this parameter.

(a) mg/L = milligrams per liter. ug/L = micrograms per liter.



Colorado Department of Public Health and Environment

Notes: (1) Nine of the ten 3/5/2008 samples were collected at the city's wells. Two samples taken on 3/21/2008 were from the Weber and Cole Park wells. All others represent distribution system samples.
(2) Sample locations are approximate; map symbols are clustered for differentiation of samples taken in close proximity or at the same location.
(3) The 3/20/2008 sample absent for *Salmonella* was collected from the East Alamosa water system. It was not connected to the city of Alamosa's water system at the time of the outbreak.

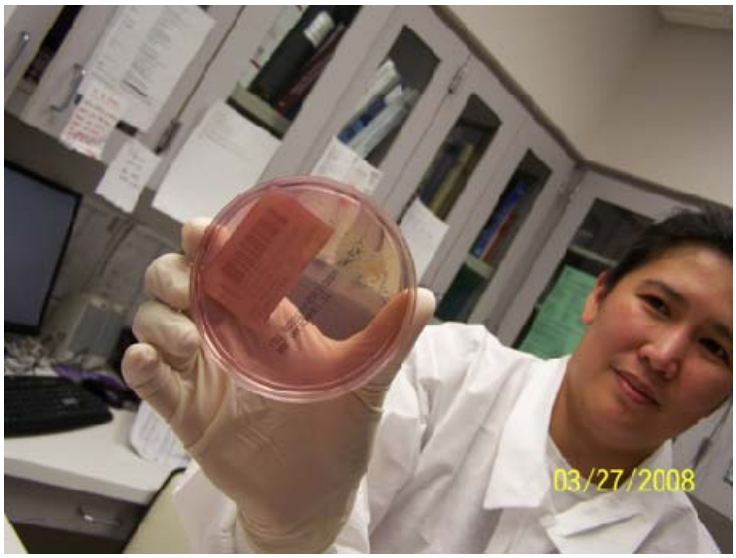
APPENDIX D: A PHOTO JOURNAL SUMMARY OF THE SALMONELLA OUTBREAK IN ALAMOSA, COLORADO

Colorado Department of Public Health and Environment

November 2009

A Photo Journal Summary of the *Salmonella* Outbreak in Alamosa, CO

Photo Journal: The Outbreak Begins



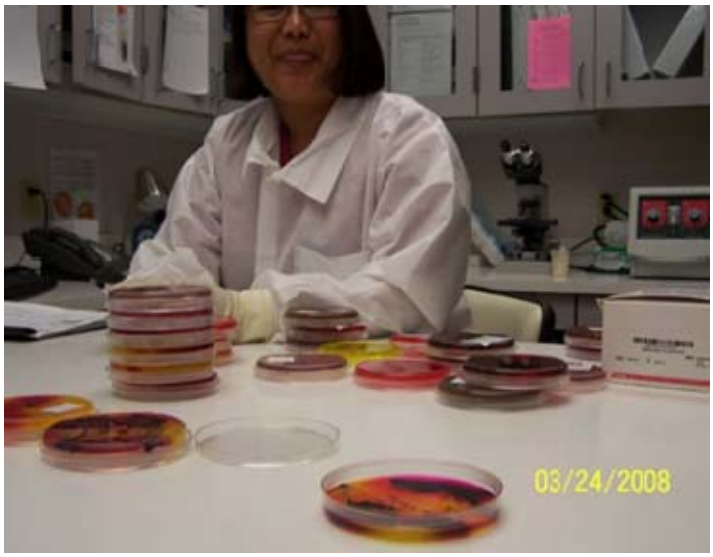


Photo 1: When people started getting sick, stool samples were processed and analyzed by health laboratories.

Photo 2: A State Health Department employee collected samples confirming that the drinking water was contaminated with *Salmonella* bacteria.

Photo 3: Fliers, signs, and other community outreach efforts advised the public to drink bottled water.

Photo 4: Multiple agencies worked together in response to the outbreak at an Emergency Operation Center established by the Alamosa County Nursing Services.

Photo 5: The State Health Department also established an Emergency Operation Center in Denver, CO.

Photo 6: The outbreak gained both state and national media attention.

Photo 7: Governor Ritter declared a Public Health Emergency on March 21, 2008. National Guard troops were deployed to provide assistance.

Photo 8: Several Colorado water utilities, members of a network called CoWARN, responded to help Alamosa.

Photo Journal: Bottled Drinking Water was Provided to Residents

Photo 9: Volunteers also helped distribute bottled water to Alamosa residents.

Photo Journal: Bottled Drinking Water was Provided to Residents

Photo 10: Tanker trucks brought in fresh drinking water supplies.

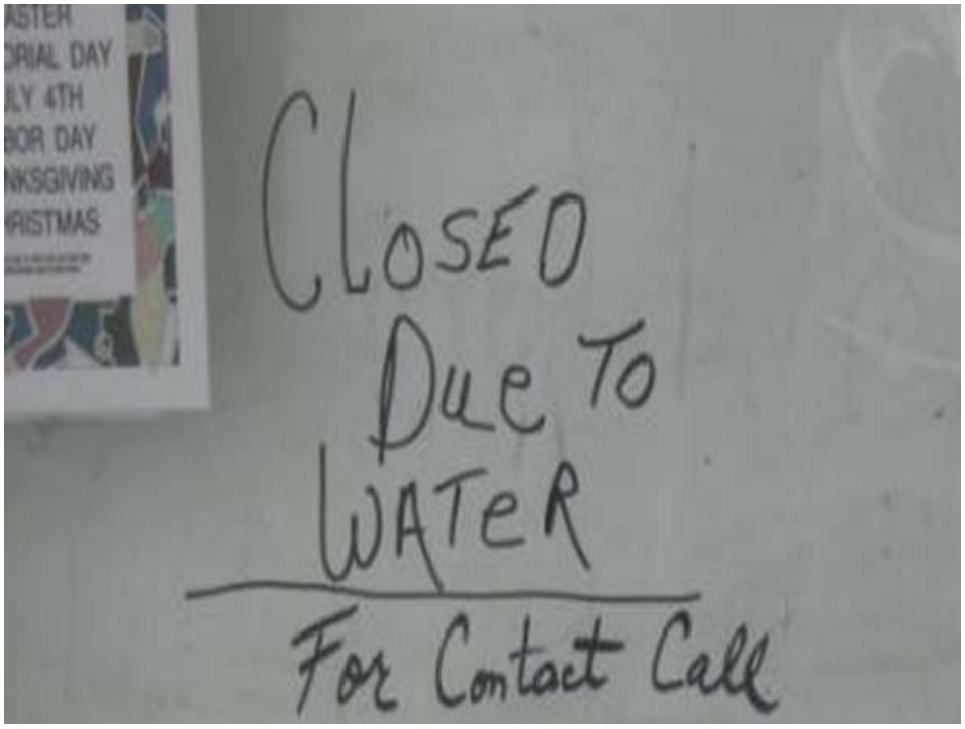


Photo 11: In addition to the illnesses, restaurants, day care centers, schools, and other businesses in Alamosa were impacted.

Photo 12: Governor Bill Ritter, Senator Ken Salazar, and Congressman John Salazar met with local officials on Easter Saturday.

Photo 13: Governor Ritter pitched in to help provide bottled water to Alamosa residents.

Photo 14: A local church expressed a common sentiment during Easter weekend.

Photo 15: Alamosa had three operating storage tanks: the Weber Reservoir (top), the Ross Tower (bottom left), and the Craft Tower (bottom right). The drinking water was not chlorinated at the time of the outbreak.

Photo 16: CoWARN crews drained sediment from the Weber Reservoir prior to disinfecting the reservoir with chlorine.

Photo 17: The Weber Reservoir required many repairs and ultimately was disconnected from Alamosa's water supply.

Photo 18: Crews used a mobile chlorination unit to disinfect the Weber Reservoir.

Photo 19: This chlorination treatment unit provided continuous disinfection of Alamosa's drinking water.

Photo 20: CoWARN crews and State staff established a base of operations in a Mobile Training Unit trailer.

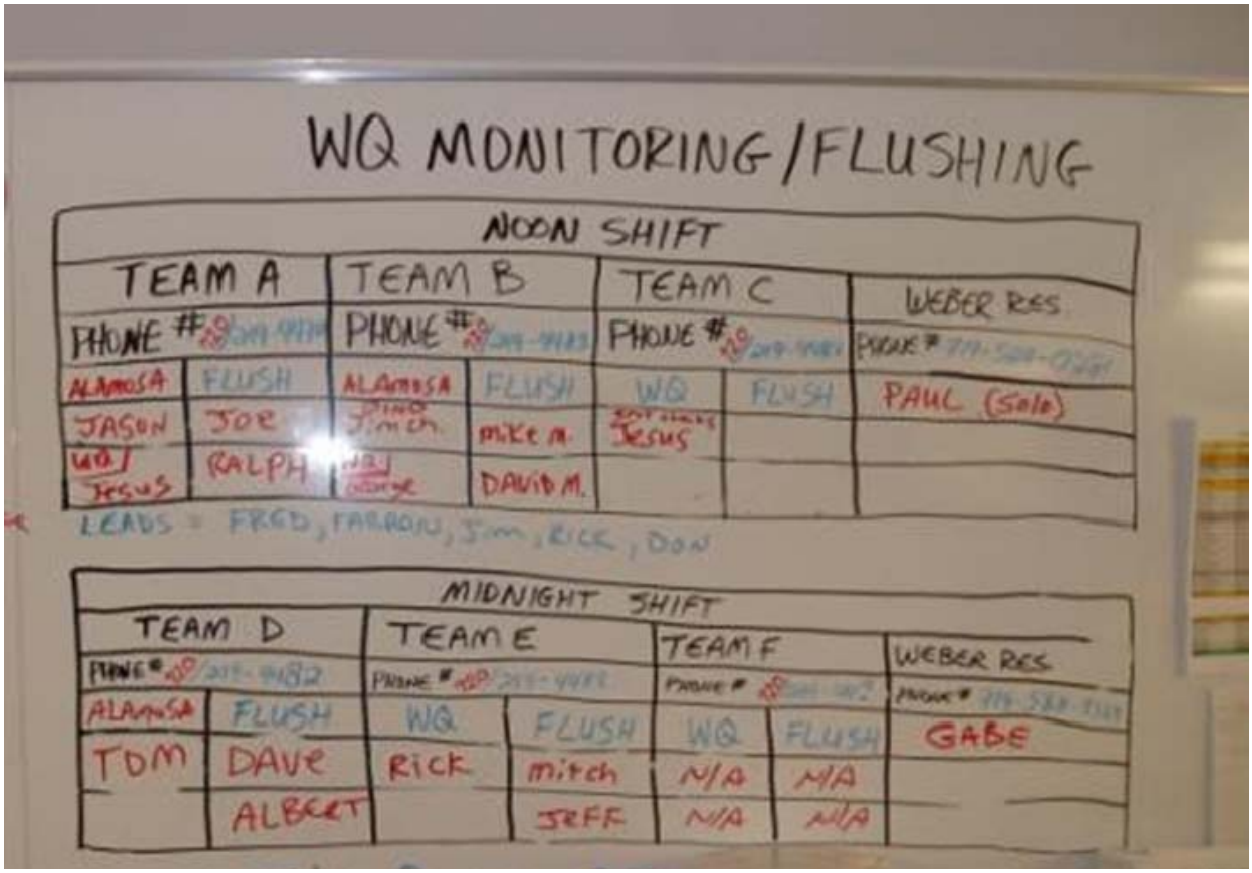


Photo 21: Multiple CoWARN crews teamed up to provide 24-hour assistance.

Photo 22: CoWARN crews worked through the night to disinfect and flush all the drinking water pipes.

Photo 23: Chlorinated water was flushed throughout the distribution system by opening fire hydrant valves one block at a time.

Photo 24: State personnel tested water samples for chlorine.

Photo 25: Over 200 local volunteers from the San Luis Valley helped out on Easter Sunday.

Photo 26: These volunteers distributed red flyers notifying residents of initial high chlorine levels.

Photo 27: Later, Alamosa volunteers distributed yellow flyers informing residents that water may be used for limited purposes, such as washing.

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Alamosa's Water In Clear; Boil Order Lifted

Ritter Praises Town For Resilience

POSTED: 2:49 pm MDT April 11, 2008
UPDATED: 4:28 pm MDT April 11, 2008

ALAMOSA, Colo. -- It is now safe to drink the water in Alamosa, the governor declared Friday.

Three weeks after a salmonella outbreak linked to the city's tap water sickened nearly 400 people, the warning to residents to boil all of their tap water has now been lifted.

The state issued a "bottled water" order on March 19 and modified it to a "boil water" order on April 3 after the city flushed its 51 miles of water line with a heavy amount of chlorine.

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ALAMOSA WATER

• Video: Alamosa In Second Day Of

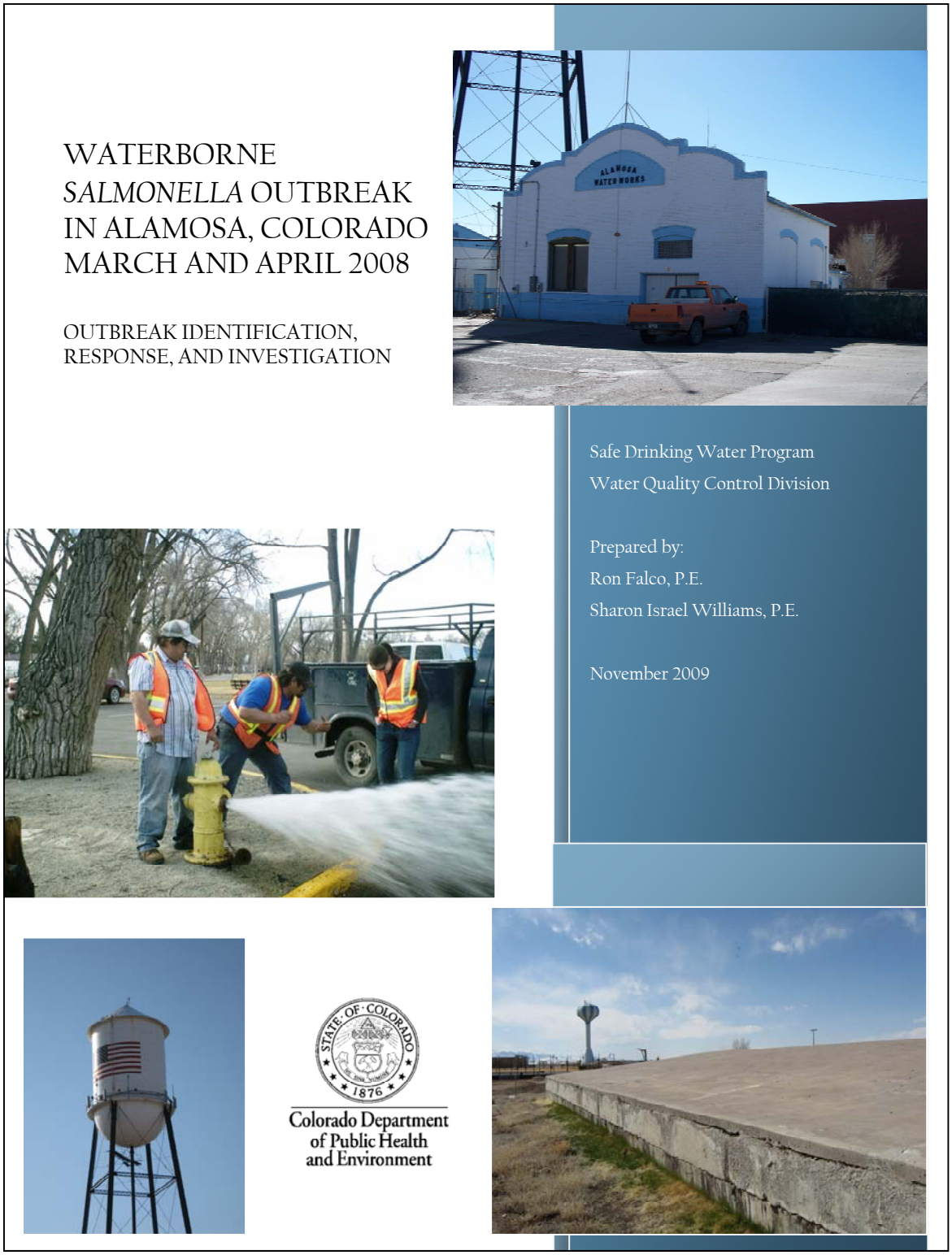
Photo 28: Three weeks after the outbreak, it was safe to drink the water in Alamosa again.

Photo 29: Governor Ritter thanked State Health Department employees for helping Alamosa recover from Colorado's worst waterborne disease outbreak in over 20 years.

Photo 30: The Weber Reservoir showed signs of age and disrepair.

Photo 31: Evidence of animal footprints near the Weber Reservoir (photos taken in January 2009, nine months after the outbreak.)

Photo 32: Bird droppings on the Weber Reservoir, including a repaired corner of the reservoir where there previously had been a hole (photos taken in July 2009).



WATERBORNE
SALMONELLA OUTBREAK
IN ALAMOSA, COLORADO
MARCH AND APRIL 2008

OUTBREAK IDENTIFICATION,
RESPONSE, AND INVESTIGATION

Safe Drinking Water Program
Water Quality Control Division

Prepared by:
Ron Falco, P.E.
Sharon Israel Williams, P.E.

November 2009

Colorado Department
of Public Health
and Environment

Photo 33: The State Health Department's investigation concluded that the most likely cause of the outbreak was that the Weber Reservoir became contaminated with animal waste. The final report can be found at http://www.cdphe.state.co.us/wq/drinkingwater/index.html.

Photo 34: Alamosa's new drinking water treatment plant came online October 2008. The treated water is continuously chlorinated to provide disinfection.

CDPHE WOULD LIKE TO THANK ALL OF THE VOLUNTEERS AND RESPONDERS FOR THEIR DEDICATION AND ASSISTANCE TO THE CITY OF ALAMOSA DURING THE OUTBREAK

Colorado Department
of Public Health
and Environment

Safe Drinking Water Program
Water Quality Control Division
4300 Cherry Creek Drive South
Denver, CO 80246

APPENDIX E: LITERATURE REVIEW

As indicated earlier in this report, the SDW Program became very interested in prior reports of similar disease outbreaks and other related literature very early during this incident. We worked closely with CDC to assemble the most relevant material that could provide useful information. During the outbreak and over the subsequent months, numerous literature articles from multiple sources were reviewed. In this appendix we summarize only those references deemed most relevant to the Alamosa outbreak cause investigation.

REFERENCE SUMMARY

<u>*Salmonella* Outbreak at Riverside, California in 1965</u>

1. Ross, E.C., Campbell, K.W., & Ongerth, H.J. (1966). *Salmonella* Typhimurium contamination of Riverside, Calif., Supply. JOURNAL OF THE AMERICAN WATER WORKS ASSOCIATION, 58, 165-174.

2. Greenberg, A.E., & Ongerth, H.J. (1966). Salmonellosis in Riverside, Calif. JOURNAL OF THE AMERICAN WATER WORKS ASSOCIATION, *58, 1145-1150*.

3. Riverside County Health Department, California State Dept. of Public Health, Center for Disease Control, & National Center for Urban and Industrial Health (1971). A waterborne epidemic of Salmonellosis in Riverside, California, 1965. AMERICAN JOURNAL OF EPIDEMIOLOGY, 8(1), 33-48.

4. Boring, J.R., Martin, W.T., & Elliott, L.M. (1971). Isolation of *Salmonella* Typhimurium from municipal water, Riverside, California, 1965. AMERICAN JOURNAL OF EPIDEMIOLOGY, 93, 49-54.

Summary of articles:
A very large outbreak of *Salmonella* Typhimurium sickened approximately 18,000 people in and near Riverside, California in 1965 and three persons died. Routine water samples were negative for total coliform. Five of 74 samples collected throughout the system were positive for *Salmonella*, and those samples came from areas with the highest incidence rates, served by wells in the northern part of town. Overall, 1,500 samples for *Salmonella* were collected from the wells, the distribution system, and other nearby water systems. Only 16 positive samples were found, and they were found both in and out of the Riverside water system. Studies of the survival of *Salmonella* in the Riverside drinking water were also undertaken. It was concluded that after a massive dose of *Salmonella*, the bacteria could be recovered for months thereafter. After small doses as low as 30 cells per milliliter, die-off occurred in about one week. The outbreak epidemiology suggested that the infective does for *Salmonella* was 1,000 organisms or less; in fact a composite of the 74 samples showed only 17 organisms per liter. The infective

dose may have been considerably lower than previously suggested for food borne outbreaks. This water system utilized more than 30 untreated wells and a relatively small percentage of treated (filtered and chlorinated) water from the Colorado River, though surface water was not used during the epidemic. The system had several storage tanks as well. Prior to the outbreak, construction work occurred on a raw water line that served much of the system, and the water supply during that time frame, came primarily from the wells in the northern part of town. However, extensive investigations did not find any problems with the construction project, the wells in the northern part of town, or the distribution system in that area. Despite extensive investigations, the exact cause was never determined.

Salmonella Outbreak at Gideon, Missouri in 1993

5. Angulo, F.J., Tippen, S., Sharp, D.J., Payne, B.J., Collier, C., Hill, J.E., Barrett, T.J., Clark, R.M., Geldreich, E.E., Donnell, H.D., & Swerdlow, D.L. (1997). A community waterborne outbreak of Salmonellosis and the effectiveness of a boil water order. AMERICAN JOURNAL OF PUBLIC HEALTH, 87(4), 580-584.

6. Clark, R.M., Geldreich, E.E., Fox, K.R., Rice, E.W., Johnson, C.H., Goodrich, J.A., Barnick, J.A., Abdesaken, F., Hill, J.E., & Angulo, F.J. (1996). A waterborne *Salmonella* Typhimurium outbreak in Gideon, Missouri: results from a field investigation. INTERNATIONAL JOURNAL OF ENVIRONMENTAL HEALTH RESEARCH, 6, 187-193.

7. J. Baker, personal communication, April 9, 2008

Summary of articles:
A large outbreak of *Salmonella* Typhimurium sickened approximately 650 people in Gideon, Missouri in late 1993 and seven patients died. Water samples collected just prior to the outbreak, and early in the outbreak were all negative for total coliform. As the outbreak continued, some but not all water samples were total coliform positive and fecal coliforms were also detected in some samples. Computer modeling showed that the water in the storage tanks serving this community usually remained stagnant, however, a flushing event occurred just prior to the outbreak and this likely flushed contamination from a storage tank into the distribution system. Disease onset began two days after the flushing event. A 100,000-gallon storage tank had an improper roof vent and uncovered hatch that allowed bird feces to enter the tank during rain events, and large quantities of bird feathers were observed inside the tank. Thus, the most likely cause of the contamination was from bird feces or feathers inside a mostly stagnant water storage tank that was subsequently flushed into the distribution system.

Additional Information:
Based on a discussion with Jack Baker of the Missouri Department of Natural Resources, in response to the outbreak, a continuous chlorination system was installed to eradicate the *Salmonella*. The chlorine level was about 1 mg/L at the well, and then a relatively low level of chlorine was flushed throughout the system. However, one line was not flushed that served a few houses, and some additional illnesses did occur until that area was flushed.

Salmonella Outbreak on the Island of Trinidad in 1976

8. Koplan, J.P., Deen, R.D., Swanston, W.H. & Tota, B. (1978). Contaminated roof-collected rainwater as a possible cause of an outbreak of Salmonellosis. THE JOURNAL OF HYGIENE, 81(2), 303-309. Article summary:

An outbreak of *Salmonella* Arechevalata sickened 63 persons attending a church camp on the Island of Trinidad in April 1976. Part of the water supply at the camp was used in the kitchen and for drinking, and came from a storage tank that used the roof surface as a water catchment. This water was also used to prepare some of the food. The water from this tank was not disinfected. Water samples from the kitchen and food samples prepared with the tank water tested positive for *Salmonella* Arechevalata. The roof surface was covered in bird feces. However, bird feces collected in the area and water in the tank itself were negative for *Salmonella* Arechevalata. The most likely cause of the water contamination in this case was postulated to be rainwater falling on the roof becoming contaminated with *Salmonella* Arechevalata due to the animal feces on the roof.

Salmonella Outbreak at Queensland, Australia in 1999

9. Taylor, R., Sloan, D., Cooper, T., & Hunter, I. (2000). A waterborne outbreak of *Salmonella* Saintpaul. COMMUN DIS INTELL, 24(1), 336-340. Article summary:

An outbreak of *Salmonella* Saintpaul sickened 28 persons at a construction work camp in Central Queensland, Australia in March 1999. Possible sources of the disease included septic tank overflows, sharing drinks, manual ice handling, mouse infestation, faulty lunch box storage and drinking water. Most of the water at the site was truck-hauled from a safe water supply, chlorinated, and then stored in several tanks on the site. However, two interconnected storage tanks were supplemented with rainwater collected from the roof of a workshop. A significant rainfall occurred two days prior to the onset of 23 of the 28 cases. Based on the epidemiological investigation there was a strong indication that an ongoing source of contamination caused the disease and there was a strong association with ice made from the drinking water. All water and ice samples initially collected showed total coliform contamination. Three of six water samples collected 10 days later cultured positive for *Salmonella* Saintpaul. Bacteria could have washed into the tank during the rainfall, but no dead mice were found inside the tank during cleaning. However, live tree frogs were found inside the tank. The most likely cause of the water contamination in this case was postulated to be rainwater falling on the roof becoming contaminated with mice (or other animal) feces or directly from the tree frogs.

Salmonella Outbreak at Victoria, Australia in 2007

10. Franklin, L.J., Fielding, J.E., Gregory, J., Gullan, L., Lightfoot, D., Poznanski, S.Y. & Vally, H. (2008). An outbreak of *Salmonella* Typhimurium 9 at a school camp linked to contamination of rainwater tanks. EPIDEMIOLOGICAL INFECT., August 8, 1-7. Article summary:

An outbreak of *Salmonella* Typhimurium sickened 27 persons at a school camp in Victoria, Australia in March 2007. The drinking water was supplied by rainwater collection tanks attached to the main building in the camp. The tanks collected rainwater from the roof of the main building, and the water was not chlorinated. The two tanks used for drinking water supply were situated in dense brush at the side of the building. Tank openings were covered with gauze, but the tanks were nevertheless susceptible to contamination from dirt, leaf debris and animal droppings. A significant rainfall event occurred prior to 25 of the 27 cases. Based on the epidemiological investigation there was a strong indication that drinking water was the source of

the outbreak and two water system samples showed the presence of *Salmonella* Typhimurium. The most likely cause of the water contamination was that the rainwater collection tanks became contaminated directly due to their location and inadequate protection, or that rainwater falling on the roof was contaminated by animal waste or debris, and then washed into the tanks.

Salmonella Outbreak Affecting One New Zealand Family in 1996

11. Simmons, J., & Smith, J. (1997). Roof water probable source of *Salmonella* infections. *New Zealand Public Health Report*, *4*(1), 5. Article Summary:
A family of four in New Zealand all suffered from Salmonellosis. The family lived in a beach house with roof-fed tank water as their drinking water supply. It was determined that their water was contaminated. The likely source of contamination was animal feces on the roof, including possibly feces from their pet cat, washing into the water storage tank. The water was not chlorinated. After shock treating the storage tank with chlorine, subsequent samples were negative for bacteria.

Salmonella Outbreak at Keota, Iowa in 1977

12. Currier, R.W., Grant, H., Wintermeyer, L.A., Bullis, M., & Guely, M.J. (n.d.). Salmonellosis outbreak investigation, Keota, Iowa July, 1977. Article summary:
An outbreak of *Salmonella* Typhimurium sickened about 290 persons in Keota, Iowa in 1977. The drinking water was suspected to be the source of the outbreak; however, no deficiencies in the system could be confirmed. The system consisted of one deep well and a storage tank. The only unusual event around the time of the outbreak was that the chlorine supply may have been disrupted. An animal source of the bacteria was strongly suspected.

Salmonella Outbreak at Utah, in June 1986

13. CDC. Waterborne Disease Outbreaks 1986-1988. MMWWR 1990;39:SS-1. Summary:
A *Salmonella*-related outbreak sickened 61 people at a youth camp. One patient's isolate serotype was identified as *Salmonella* Dublin. This outbreak was suspected of being caused by ingestion of water hauled to the area in a tanker truck that was not disinfected and likely contaminated by irrigation water. There were other issues at this camp that could have contributed to the outbreak.

Salmonella Outbreak at Mississippi, in August 1986

14. CDC. Waterborne Disease Outbreaks 1986-1988. MMWWR 1990;39:SS-1. Summary:
A gastroenteritis outbreak due to *Salmonella* Newport and other species of *Salmonella* sickened nine to twenty people at a community water system that used untreated well water that fed directly into a pressure tank. A sewer line was noted as being constructed too close to a water line, but a direct link was not found. Additionally, well head protection needed to be improved, there was a manhole near the well, and there had recently been major rainfall in the area with some flooding.

Salmonella Outbreak at Suffolk County, New York in March 1976

15. Zaki, M.H., Miller Jr., G.S., Sheppard, R.J., Harris, D., & McLaughlin, M.C. (1979). An extensive *Salmonella* Typhimurium outbreak of probably waterborne origin. JOURNAL OF AMERICAN WATER WORKS ASSOCIATION, 71, 287-291. Article summary:

An outbreak of *Salmonella* Typhimurium sickened an estimated 700 to 800 persons after attending various banquets at a large catering facility in Suffolk County, New York in 1976. The drinking water was suspected to be the source of the outbreak, although the possibility of the outbreak being food borne could not be fully disproven. A plausible scenario resulting in drinking water contamination occurred after a sewer backup was mopped up. The mop water was contained in a clogged sink in a janitor's closet that had a submerged discharge pipe that carried drinking water through a refrigerator compressor. It was possible that backflow occurred when an irrigation system was tested.

<u>*Salmonella* Outbreak at Island Pond, Vermont in November 1963</u>

16. Gastroenteritis, North Vermont. NATIONAL COMMUNICABLE DISEASE CENTER: EPIDEMIC AID REPORT, 64-32. Article summary:
An outbreak of *Salmonella* Typhimurium sickened about 480 people in Island Pond, Vermont during November 1963. The drinking water was suspected to be the source of the outbreak, however milk could not be ruled out as the cause. The system used untreated surface water and had one closed reservoir. Prior to the outbreak, 63 water samples collected during the year were all negative for total coliforms. From November 8 to 18, eight of twenty four samples were total coliform positive, and some citizens claimed that the water was muddy during this time. No cross connection issues or backflow events were reported.

<u>*Salmonella* outbreak at Galilee, Israel in 1961-1962</u>

17. Seligmann, R., & Reitler, R. (1965). Enteropathogens in water with low Escherichia coli titer. JOURNAL OF AMERICAN WATER WORKS ASSOCIATION, 57, 1572-1574. Article summary:
An outbreak of *Salmonella* Montevideo occurred at a collective settlement in Galilee, Israel during the winter of 1961 to 1962. The drinking water was suspected by the residents as the cause of the outbreak, but water tests were either negative or showed only low levels of E. coli. However, *Salmonella* Montevideo was detected in the drinking water. Subsequent testing showed the presence of several different types of *Salmonella*.

<u>Campylobacteriosis outbreak at Greenville, Florida in May 1983</u>

18. Sacks, J.J., Lieb, S., Baldy, L.M., Berta, S., Patton, C.M., White, M.C., Bigler, W.J., & White, J.J. (1986). Epidemic Campylobacteriosis associated with a community water supply. AMERICAN JOURNAL OF PUBLIC HEALTH, 78(4), 424-428. Article summary:
A Campylobacteriosis outbreak sickened about 865 people at Greenville, Florida in May 1983. The drinking water system consisted of deep wells followed by an open-top settling tank with pre-chlorination, post-chlorination and filtration. The chlorination system failed, and birds were observed perching and defecating on the open-top settling tank. Birds were also found to harbor *Campylobacter* Jejuni. Thus, this outbreak appeared to be caused by bird fecal matter contaminating a water tank during a time period when the disinfection system was not working properly.

<u>*Salmonella* Outbreaks in Norway from 1987 to 1992</u>

19. Kapperud, G., Stenwig, H., & Lassen, J. (1998). Epidemiology of *Salmonella* Typhimurium O:4-12 infection in Norway: evidence of transmission from an avian wildlife reservoir. AMERICAN JOURNAL OF EPIDEMIOLOGY, 147(8), 774-782.

20. Kapperud, G., Gustavsen, S., Hellesnes, I., Hansen, A. H., Lassen, J., Hirn, J., Jahkola, M., Montenegro, M. A., and Helmuth, R. (1990). Outbreak of *Salmonella* Typhimurium infection traced to contaminated chocolate and caused by a strain lacking the 60-Megadalton virulence plasmid. *Journal of Clinical Microbiology*, 28, 2597-2601.

Summary of Articles:
These articles describe an outbreak of *Salmonella* Typhimurium caused by contaminated chocolate in Norway in 1987, and the ensuing years of elevated *Salmonella* cases in that nation. It appears that *Salmonella* found a reservoir for ongoing infection in the avian population. Additionally, it was concluded that the infective does may be 10 organisms or less, and that children may be particularly vulnerable to becoming sick when exposed to low doses of *Salmonella*. Environmental factors including drinking untreated water, having direct contact with wild birds or their dropping, and eating snow, sand, or soil were found to increase the risk of infection.

<u>Study Involving Storage Reservoir Contamination by Birds</u>
21. Fennel, H., James, D.B., & Morris, J. (1974). Pollution of a storage reservoir by roosting gulls. WATER TREATMENT EXAMINATION, 23, 5-24. Article summary:
This article describes significant *Salmonella* contamination occurring in a raw water storage reservoir in England. The volume of the reservoir was 276 million gallons. The gull population roosting on the center of the reservoir surface for many hours each day ranged from about 100 to 10,000 birds during time periods when the water collected near the side of the reservoir contained 2 to 14 *Salmonella* per liter. It is interesting to note that only low levels of *Salmonella* were detected in the bird feces samples collected on the banks of the reservoir, yet the entire reservoir was apparently contaminated.

<u>Information on *Salmonella* in Wild Bird Populations in the U.S.</u>
22. Friend, M., & Franson, J.C. (1999). *Field manual of wildlife diseases: general field procedures and diseases of birds. Information and technology report 1999-001*. Washington, D.C.: U.S. Geological Survey, Biological Resources Division. Chapter 9 Summary:
Wild bird mortality at bird feeding stations due to *Salmonella* Typhimurium has increased since 1980. Colorado is shown to have had eight large-scale outbreaks of Salmonellosis in birds from 1983 to 1997. Outbreaks appear to occur most frequently in winter and spring. Small rodents and mice are also listed as common sources of *Salmonella*.

<u>Case-Control Study of Salmonellosis in Tasmania</u>
23. Ashbolt, R., & Kirk, M.D. (2006). *Salmonella* Mississippi infections in Tasmania: the role of native Australian animals and untreated drinking water. *Epidmiol. Infect., 134*, 1257-1265. doi:10.1017/S0950268806006224 Article Summary:
Compared to the rest of the world, *Salmonella* Mississippi infection rates in Tasmania are relatively high and local wildlife including skinks, quolls (native cats), Tasmanian devils and kangaroos are known to carry the bacteria. A case control-control study on the island showed that exposure to an environment with native birds, drinking untreated water, and travel within the state was most strongly associated with illness. The article concludes that Tasmanian wildlife are a reservoir for *Salmonella* Mississippi contaminating the land and water; lower infection

rates would result if water supplies were treated and if people washed their hands after being outside and before eating.

Analysis of Infective Dose for *Salmonella*

24. Blaser, M.J., & Newman, L.S. (1982). A review of human salmonellosis: I. infective dose. REVIEW OF INFECTIOUS DISEASES, *6*(4), 1096-1106.

25. D'Aoust, J.Y. (1985). Infective dose of *Salmonella* Typhimurium in cheddar cheese – brief report. AMERICAN JOURNAL OF EPIDEMIOLOGY, 122(4), 717-720.

26. Lipson, A. (1976). Infecting dose of *Salmonella.* THE LANCET I, 969.

Summary of Articles:
These articles describe various efforts after original studies conducted in the 1950s regarding the infective dose of *Salmonella* in humans. The early studies concluded that at least 100,000 organisms were necessary to cause illness. Studies done in the early 1980s showed that only about 1,000 organisms were needed to infect a person. The study involving cheddar cheese demonstrated that ingesting fewer than ten organisms made people sick. It is thought that the lower does may have been be due to improved organism survival through the stomach's acidic environment when the *Salmonella* are present in a fatty food like cheese. It is also possible that the limited time that water spends in the stomach could contribute to a relatively low infective dose for water.

Additional Information Regarding *Salmonella*

27. B. Benson, personal communication, August 5, 2009

28. R.V. Tauxe, personal communication, August 16, 2009

29. Ciara O'Reilly, personal communication, August 17, 2009

Summary of Communications:
Experts at the federal Center for Disease Control and Prevention and EPA were contacted regarding the possibility for *Salmonella* to grow and propagate in Alamosa's drinking water, and the numbers of *Salmonella* Typhimurium organisms that could be present in animal feces. It was thought that the alkaline water in Alamosa could help the organisms survive through the stomach's acidic environment. Infective doses ranging from 10 to 1,000 organisms were discussed. *Salmonella* would be unlikely to grow in the water. However, *Salmonella* could grow in the sand at the bottom of the storage tanks and in the biofilms that may exist in the water pipes. Additionally, ranges for numbers of organisms in animal feces can vary widely. Animals in the acute phase of an infection can shed 10 million to 1 billion organisms per gram of feces, whereas animals that are recovering or carriers may shed 10,000 to 100,000 organisms per gram of feces, or even less.