Monitoring Dog Waste

in La Llorona Park at Picacho Bridge in Las Cruces, New Mexico

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This document is the author's conclusions and does not reflect the opinion
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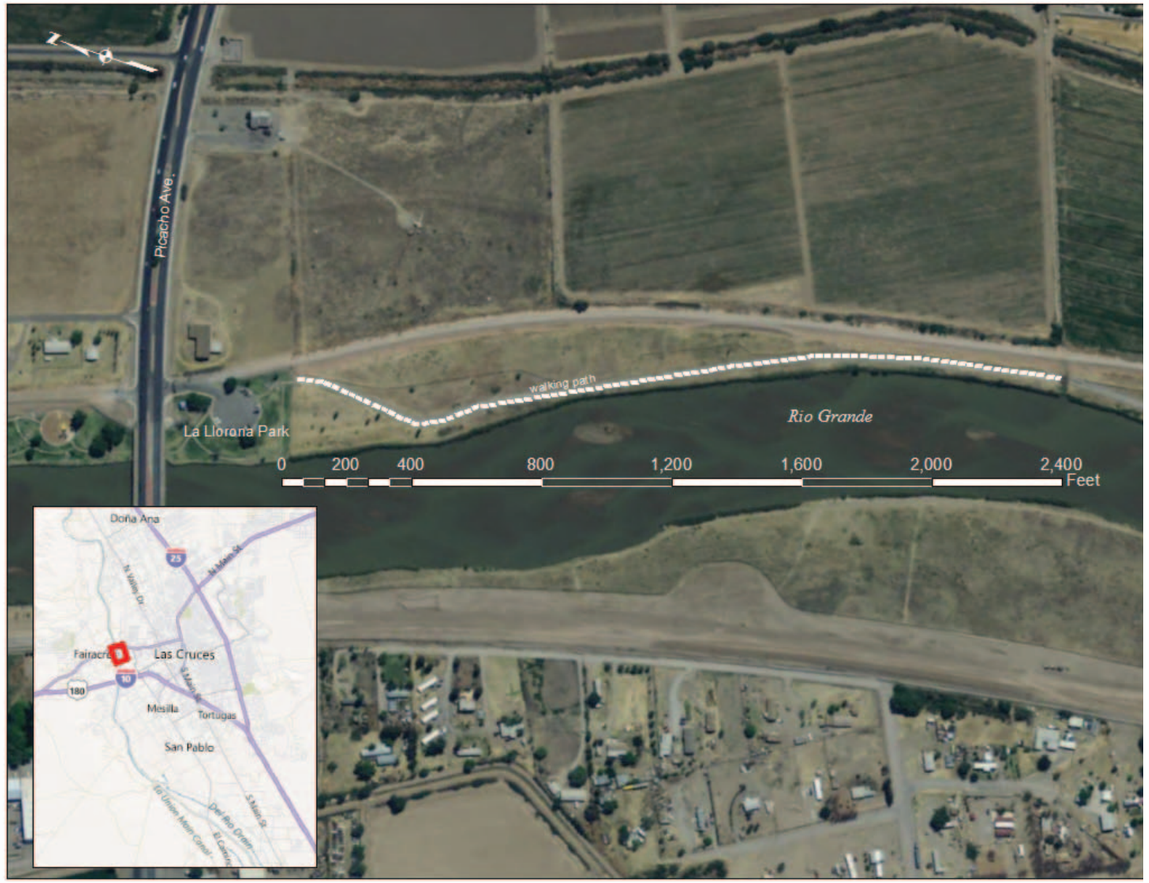
Figure 1: Dog Waste Study Area along the Rio Grande in Las Cruces.



ABSTRACT

Monitoring dog waste in La Llorona Park at Picacho Bridge

To determine the amount of dog waste close to the Rio Grande, the location and weight of dog waste was documented May 24, 2011 to December 12, 2011, on a walking trail south of Highway 70 bridge over the Rio Grande in Las Cruces. (Figure 1). The lower 110 miles of the Rio Grande in New Mexico exceeds state water quality standards for *Escherichia coli (E. coli)* bacteria. *E. coli* is present in dog waste and could be contributing to *E. coli* concentrations in the river. This study can be used to calculate *E. coli* loads from dogs to the river and improve management so that dog waste is reduced.

The study area was next to a walkway along the Rio Grande and dog waste was collected in a 10 foot wide area on both sides of an asphalt path for a length of 2,300 feet. The dry weight of dog waste (in units of 1,000 feet length or 20,000 square feet) ranged from 0.00 to 23.00 ounces per 1,000 feet of trail per day with a mean of 7.59 ounces per 1,000 feet. Most deposits were between 200 and 500 feet, south of the park, (40 sites), 31% of all the sites. Placing a trash can and waste dog dispenser bags at 350 feet would make it easier for a dog owner to dispose of their dog waste. The west side area had the highest weights of 51.55 ounces total compared to 14.50 ounces total for the east side (5 sampling trips August 12 to December 12). There could be many reasons for this, but the primary reasons could be because it is a grassy area and is on the right side of the path as a dog owner walks south from La Llorona Park. Posting of signs and waste bag dispensers may be more effective if they are on the west side of the path. Individual dog waste deposits less than 0.50 ounces accounted for 74% of the total individual weights. This could indicate that some owners of small dogs may not be picking up after their dog. Informing these owners may help reduce dog waste. There are many management options that would reduce dog waste (see the Discussion section). Having a dedicated individual to address this issue would be an effective tool in reducing dog waste.

Dog waste takes about 89 hours to dry and it loses 42.5% of its weight according to this study (sample size of 2). This can be used to calculate wet weight and then calculate *E. coli* loads since the literature has information pertaining to wet weights. Taking the mean weight of dog waste for a 1,000 feet x 20 feet area (7.59 ounces dry weight) and a concentration of *E. coli* of 99 million colony forming units (CFUs) per gram of waste, the number of *E. coli* could be 5,0461 million *E. coli* CFUs per 1,000 feet of trail or 20,000 square feet (see the Discussion section).

The manner of *E. coli* in dog feces entering the river could be direct deposit in the water from a dog, waste that is moved into the river from extreme rainfall or runoff events, people putting the waste in the river, or dog waste on shoes of individuals that enter the water. To document and predict *E. coli* loading to the river for the 110 miles of the lower Rio Grande (the area of *E. coli* exceedence in the Rio Grande), dog waste studies in other parts of the floodplain would help predict possible loading and GIS would be useful.

Concerning the study area, the strip of willows next to the river and the grass in the study area would likely prevent most dog waste from washing into the river. Because of the climate, the *E. coli* is likely to succumb to high temperatures, drying, and ultraviolet light. The vegetation would prevent the movement of dog waste to the river during rainfall events. If other areas along the banks of the river could be vegetated, then it is likely that less dog waste would enter the river.

There are a number of factors that could influence the density of dog waste along the river and the movement to the river (see Discussion Section).

To collect additional dog waste information in the Las Cruces area, suggestions include an exhaustive literature and data search; statistical analyses; monitoring of new management measures; verbal and written surveys of residents; studies of the concentrations of *E. coli* in dog waste; study of the concentration and survival of *E. coli* in dog waste in the Rio Grande; and studies of the mortality rates caused by drying, ultraviolet light, and temperature.

INTRODUCTION

An intensive surface water quality study in the lower Rio Grande by the New Mexico Environment Department (NMED) in 2004 found that the water was impaired for *E. coli* bacteria. The stretch of the Rio Grande in southern New Mexico was from the international Mexico boundary upstream to Percha Dam. The watershed that contributes to the Rio Grande includes 2,292 square miles (Boykin, Ken and Propeck-Gray, Suzanne, 2007). One of the possible sources for bacteria impairment in the Lower Rio Grande is waste from dogs. (NMED, 2007). Other locations have documented that dog waste can be a source for *E. coli* contamination. During a microbial source tracking study in the Middle Rio Grande in Albuquerque, the study found 21.9% of the fecal coliform in the Rio Grande were from canines (Parsons Water and Infrastructure, October 2005). Another study in the Tualatin Sub basin in Oregon found canines were responsible for 13% of the *E. coli* identified (Clean Water Services). A single gram (.035 ounces) of dog waste can have 23 million fecal coliform bacteria (Texas Watershed Steward Online Training 2011, tws.tamu.edu/online-course). Another study in Nevada found an average of 50 million colony forming units (CFU) in 1 gram of feces with a range of 2 million to 200 million CFUs (University of Nevada Cooperative Extension Fact Sheet).

Dog waste could be a contributor to *E. coli* in the Rio Grande. Because of the presence of dog waste on the hiking trail south of La Llorona Park and the close proximity to the Rio Grande, dog deposits were studied in 2011. The overall goal for this study was to document the presence of dog waste and use the data to determine management that would reduce dog waste.

The study area is south of the Picacho Bridge (highway 80/70) over the Rio Grande on the east river bank in Las Cruces. Las Cruces is located in southern New Mexico about 40 miles north of El Paso, Texas. The Rio Grande floodplain in the vicinity of Las Cruces and Doña Ana County is bound by flood control levees on both sides of the river and maintained by the International Boundary and Water Commission. The Rio Grande north of Leasburg and Radium Springs (about 20 miles north of the study area) does not have continuous levees. Walking dogs along the river and on the levee road is common and could be a source of *E. coli* in the river. The city of Las Cruces has a box with plastic bags for dog waste at the beginning of the walking path that goes south at La Llorona Park, along with a posted sign stating it is illegal to not pick up after your dog.

This study is part of a restoration grant to develop a watershed based plan to protect and improve water quality in the lower Rio Grande from Percha Dam (below Caballo Reservoir) downstream to American Dam (near the New Mexico, Texas, and Mexico border). Funding has been provided by the U.S. Environmental Protection Agency through the NMED under the authority of the Clean Water Act, Section 319(h) Nonpoint Source grant program. The Paso del Norte Watershed Council received the grant, and New Mexico Department of Agriculture at New Mexico State University is the fiscal agent. The three-year grant will fund a water quality sampling program, a bacterial source tracking study, subsequent data analyses, and a community outreach and education program. The process is a stakeholder-driven, coordinated, iterative process which will result in a lower Rio Grande watershed based plan. The plan will contain recommendations for best management practices that when implemented, would reduce pathogenic-based pollution in the river.

MATERIALS & METHODS

Brian Hanson conducted this study from May 24, 2011 to December 12, 2011. The study began by documenting dog waste with yellow flags (a 21-inch-tall wire with a yellow plastic flag (4.5 inches by 4 inches)) and taking photographs to document the problem visually. On June 9 the study area was established by collecting dog waste in the first 1,000 feet south of the wood barriers on the south side of La Llorana Park. The location of each dog waste pile was documented by the distance south of the beginning with a 100 foot tape. The area was further expanded to 2,000 feet on July 31 and another 300 feet was added September 24. Since this study involved dog waste, individuals handling the waste wore latex gloves and washed their hands and equipment with a Clorox spray after each study period.

The study area was marked every 100 feet with a pin on both sides of the asphalt trail. Dog waste was collected in a 10 foot area on both sides of the asphalt walkway. The 10 foot sample area on the east side of the walkway was easily identified by a metal strip that kept the fine sand in place. The western 10 foot sample area adjacent to the asphalt was mostly short-cut grass. If there was a question about the location of a dog waste pile in the sample area, the distance was measured to ensure it was within 10 feet. This particular area was chosen because it was close to the Rio Grande and because of the presence of dog waste. It was easily accessible because of the parking lot.

Dog waste was collected with a scoop with a handle 37 inches long (scoop measured 6.5 inches wide, 6.5 inches deep, and 2 inches high) made for dogs. The waste was placed in a paper bag (11 inches tall x 5 inches x 3 inches) in a 3-gallon plastic bucket. Weights were taken from a Berkley digital fish scale with a 50-pound capacity and a 1-ounce resolution digital readout (June 10 to June 17 samples) and a more precise balance, Dymo digital postal scale, M3 with a .05-ounce resolution. Dog waste was discarded in waste containers onsite.

To document the distance of the trail from the bank of the Rio Grande, the distance was measured every 100 feet for the length of 2,300 feet.

To provide information about the drying time for dog waste, waste from two dogs was weighed until the waste dried and stabilized at the lowest level. The waste was outside exposed to natural conditions in direct sunlight. The dogs included an 80 pound golden retriever (Murphy) and a 50-pound goldendoodle (Teddi). The study was conducted in Albuquerque October 17 and continued in Las Cruces until October 21. Air temperature and humidity were collected at the same time. The dog waste along the trail was dry weight. To calculate possible *E. coli* loads in the dog waste along the trail, the dry weights can be converted to wet weights by using this information.

RESULTS

A quick summary of each day's work follows:

YEAR 2011

May 24	Marked 100 dog waste locations with yellow flags along asphalt trail south of La Llorona Park, 0 to 993 feet south of vehicle barrier (no weights, no collections)
June 9	Collected dog waste deposits in 0 to 1,000 feet south of La Llorona Park in a 10 foot width on both sides of the asphalt trail; marked 100 foot increments, no site locations for each dog deposit; do not know when deposits were made.
June 10	Collected dog waste deposits in 0 to 1,000 feet south.
June 11	Collected dog waste deposits in 0 to 1,000 feet south.
June 13	Collected dog waste deposits in 0 to 1,000 feet south.
June 17	Collected dog waste deposits in 0 to 1,000 feet south.
July 30	Collected dog waste deposits in 1,000 feet to 2,000 feet south; documented the distance south for each location; do not know when deposits were made; did not collect individual weights.
July 31	Collected dog waste deposits in 0 to 1,000 feet south; recorded individual weights.
August 12	Collected dog waste deposits in 0 to 2,000 feet south.
September 24	Established new area 2,000 to 2,300 feet south; did not collect dog waste; added new pins and replaced pins at 100 foot increments where they had been removed.
September 25	Collected dog waste deposits in 2,000 to 2,300 feet south.
September 26	Collected dog waste deposits in 0 to 2,000 feet south.
October 13	Collected dog waste deposits in 0 to 2,300 feet south.
October 16	Collected dog waste deposits in 0 to 2,300 feet south.
December 12	Collected dog waste deposits in 0 to 2,300 feet south.

RESULTS

All data pertaining to collections and measurements are displayed in Appendix A. The data is presented in English measurement units so that it is easier for everyone to understand the results.

The weight of the dog waste is considered to be dry weight since air temperatures were very high and the air was very dry. The weight of dog waste was collected in an area 20 feet wide and 1,000 feet long and ranged from a low of 0 ounces per 1,000 feet to a high of 105 ounces per 1,000 feet (Table 1). The highest weights occurred during the days when dog waste was collected for the first time. The dog waste could have accumulated for many months, and it is likely the majority of the dog waste did not have viable *E. coli.* Therefore, it would be more accurate to exclude those dates. For the rest of the data, the range was 0.00 to 23.00 ounces per 1,000 feet. The mean of the data set was 7.59 ounces. The deposition rate (ounces per day) was calculated and ranged from 0.00 ounces per day to a high of 5.75 ounces per day. The mean of the data set was 1.13 ounces per day.

TABLE 1. *Weight of Dog Waste Collected along the Walkway South of La Llorona Park*

Date	Ounces per 1,000 feet	Ounces per 20,000 square feet	Days of deposition	Deposition rate ounces per day
June 9	105.0	105.0	unknown	unknown
June 10	03.00	03.00	01	01
June 11	00.00	00.00	01	0.00
June 13	05.00	05.00	02	2.50
June 17	23.00	23.00	04	5.75
July 30	43.35	43.35	unknown	unknown
July 31	21.30	21.30	44	0.48
August 12	05.55	05.55	12	0.46
August 12	05.50	05.55	13	0.42
September 25	10.00	10.00	unknown	unknown
September 26	05.02	05.02	45	0.11
October 13	03.40	03.40	17	0.20
October 13	00.00	00.00	19	0.00
October 26	04.02	04.02	13	0.31
December 12	15.24	15.24	47	0.32

- September 25 collection was a 300-feet distance; it was converted for a 1,000-feet distance
- September 26 collection was a 2,000-feet distance; it was converted for a 1,000-feet distance
- October 13 collection was a 2,000-feet distance; it was converted for a 1,000-feet distance
- October 13 collection was a 300-feet distance; it was converted for a 1,000-feet distance
- October 26 collection was a 2,300-feet distance; it was converted for a 1,000-feet distance
- December 12 collection was a 2,300-feet distance; it was converted for a 1,000-feet distance

To evaluate the distribution of dog waste weight in the 2,000-feet distance, the location of each dog waste deposit was grouped into 500-feet increments (east side or west side of asphalt walkway). (Table 2.) Five days of collection were grouped: August 12, September 26, October 13 and 16, and December 12, 2011. In the west area, the further away from La Llorona Park, the higher the dog weights, ranging from 7.35 ounces to 21.6 ounces in the 1,500 to 2,000 foot increment. The east area did not display this trend; however, the highest weight was in the 0 to 500 foot distance area. The west side area had the highest total weight of 51.55 ounces compared to 14.50 ounces for the east side.

TABLE 2. *Weight of Dog Waste Grouped in 500 Foot Increments South of La Llorona Park*

WESTSIDE GRASS				
Date	Ounces of feces 0-500 feet	Ounces of feces 500-1,000 feet	Ounces of feces 1,000-1,500 feet	Ounces of feces 1,500-2,000 feet
August 12	0.65	2.55	1.15	3.20
September 26	2.35	2.15	1.80	1.30
October 13	0.15	0.85	0.00	3.60
October 26	0.00	2.20	0.60	2.40
December 12	4.20	1.25	10.05	11.1
TOTAL	7.35	9.00	13.6	21.6
EASTSIDE GRAVEL				
August 12	0.15	0.85	0.00	1.15
September 26	1.65	0.00	0.15	0.00
October 13	0.90	0.75	0.00	1.20
October 26	0.10	0.45	0.50	0.00
December 12	4.15	0.00	0.45	0.00
TOTAL	6.95	2.05	3.15	2.35

The distribution of weights of individual dog deposits was organized into 0.10 ounce sizes (Table 3). The vast majority of deposits was less than 0.05 ounces; they accounted for 56 out of 216 total samples, or 26% of the deposits. Dog waste less than 0.50 ounces accounted for 74% of the total.

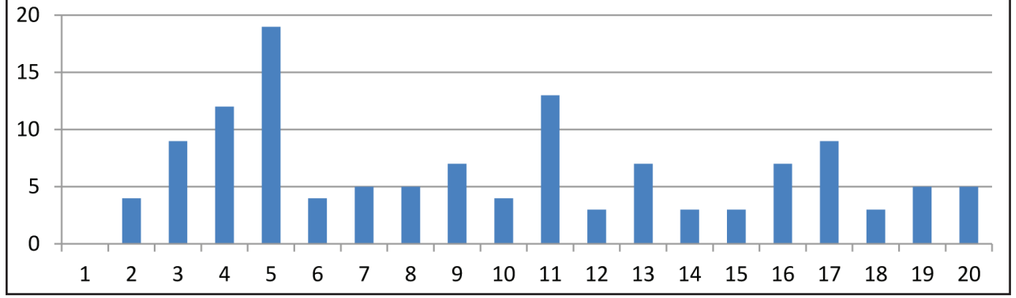
TABLE 3. *Weights of Individual Dog Waste Deposits*

Weight in Ounces	Number of Occurrences	Weight in Ounces	Number of Occurrences
less than .05	56	1.10 - 1.20	03
.05 - .10	04	1.20 - 1.30	00
.1 - 2.0	04	1.20 - 1.30	04
.20 - .30	20	1.40 - 1.50	03
.30 - .40	15	1.50 - 1.60	01
.40 - .50	11	1.90	01
.50 - .60	13	2.00	01
.06 - .70	13	2.15	01
.70 - .80	05	2.30	01
.80 - .90	06	2.45	01
.90 - 1.00	08	3.05	01
1.00 - 1.10	06	3.25	01
		3.45	01

To determine where dog waste was most often deposited, each location was documented in feet south of the La Llorona Park. (Figure 2). To have comparable measurements for locations of dog waste, data was analyzed for 0 to 2,000 feet south for five sampling days: August 12, September 26, October 13 and 16, and December 12, 2011. The data was grouped into 100 foot increments. Out of the 127 dog waste site locations, 35% was located from the beginning of the walking path to 500 feet south (Figure 2). The highest number of dog waste locations in any 100 foot increment, (19) was between 400 and 500 feet south. The second highest (13,) was between 1,000 and 1,100 feet followed by 12 between 300 and 400 feet. Looking at grouping the locations, it appears that most deposits were between 200 and 500 feet, (40 sites), 31% of all the sites. Another high number of occurrences was at 1,000 to 1,100 feet.

Figure 2. Location of Dog Waste South of La Llorna Park along the Rio Grande

Y axis is the number of occurrences;
X axis 1 = 0 to 100 feet south; 2 =100 to 200…



The dog waste drying study began October 17 with weights of 3.75 and 3.15 ounces fresh wet weight. (Table 4). After twenty four hours, they had reduced to 2.60 and 2.00 ounces, a reduction of 69% and 63%, respectively. Complete drying (no more loss of weight) took about 89 hours on October 21 with final dry weights of 1.60 and 1.30 ounces, a total reduction in weight of 43% and 42%, respectively.

TABLE 4. *Time for Dog Waste to Dry*

Date and Time	Murphy Weight oz.	Teddi Weight oz.	Temp. degrees F	Humidity
October 17, 9:05 am	3.75	3.15	48.9	44%
October 17, 11:00 am	3.60	2.95		
October 17, 1:00 pm	3.00	2.55	83.5	0%
October 17, 3:00 pm	2.90	2.30	73.6	0%
October 17, 5:00 pm	2.85	2.20	69.4	0%
October 17, 7:00 pm	2.75	2.10	62.2	21%
October 18, 5:45 am	2.60	2.00	39.4	35%
October 18, 6:45 pm	2.20	1.60	57.2	23%
October 19, 5:00 am	2.20	1.60	37.6	45%
October 19, 9:00 am	2.15	1.60	64.8	24%
October 19, 12:00 pm	2.05	1.55	73.6	22%
October 19, 5:40 pm	1.80	1.40	73.0	0%
October 20, 7:56 am	1.80	1.45	45.3	47%
October 20, 12:28 pm	1.75	1.40	80.8	21%
October 20, 5:21 pm	1.75	1.45	80.4	0%
October 21, 7:15 am	1.70	1.35	41.2	33%
October 21, 12:15 pm	1.60	1.30	79.5	0%
October 21, 5:10 pm	1.60	1.30	84.4	0%

The distance from the Rio Grande river bank to the study area was measured at 100 foot increments from 0 to 2,300 feet south of La Llorona Park (Table 5). The distance from the bank to the western edge of the West study area ranged from 7 feet to 217 feet. The mean distance for the 24 measurements was 45.3 feet. Most of the measurements were less than 50 feet.

TABLE 5. *Distance from Study Area to East Bank of the Rio Grande*

Distance (ft) From Start	Distance (ft) to River Bank	Distance (ft) From Start	Distance (ft) to River Bank	Distance (ft) From Start	Distance (ft) to River Bank
0	217	800	20	1,600	26
100	193	900	6	1,700	17
200	165	1,000	5	1,800	14
300	93	1,100	10	1,900	12
400	55	1,200	14	2,000	7
500	42	1,300	25	2,100	7
600	44	1,400	23	2,200	14
700	36	1,500	23	2,300	20

DISCUSSION

There are a variety of methods to gather information on dog waste. Many studies looked at indirect measures. In Wisconsin the following process was used based on various sources of information (Wade 2011).

- 35% of households in Wisconsin have dogs
- 1.5 dogs per household
- Average size of dogs is 40 pounds
- Average deposit of a 40-pound dog is ¾ pounds per day
- Percent of dog owners who walk their dog, 50%
- Percent of dog owners that pick up their dog waste, 65%
- Percent of dog waste that is washed into a drainage, lake, or river

To gather more accurate information, dog waste was collected and weighed close to the Rio Grande. Determining the amount of dog waste is a good start to determine if this possible source of *E. coli* bacteria in the Rio Grande is significant. Determining the amount of dog waste deposited during a specified time period can yield loads that may be deposited into the Rio Grande.

By assuming that the dog waste was completely dry, information from the study can be used to determine wet weights and then calculate possible *E. coli* concentrations in the dog waste. This study documented a loss of weight of 43% and 42% (mean of 42.5%) for two wet dog waste samples. To calculate wet weights, multiply the dry weights by 2.35. The mean weight of dog deposits per 1,000 feet (or 20,000 square feet) was 7.59 ounces. Converting this to wet weight = 2.35 x 7.59 ounces = 17.84 ounces. A gram of dog waste was found to have 2 to 200 million colony forming units (CFU) of *E. coli* (University of Nevada Cooperative Extension Service). The midpoint of this range is 99 million. For purposes of calculating concentrations, 17.84 ounces is 509.71 grams. The mean concentration would be 509.71 grams x 99 million = 5,0461.29 million CFUs of *E. coli* per 1,000 feet of trail (or 20,000 square feet).

Improved management of areas that have dog feces could reduce deposits. Additional studies of available options could reveal effective management. For example, a quick web search found a useful article concerning management of dog waste "Public Open Space and Dogs, a Design and Management Guide for Space Professionals and Local Government" (Harlock Jackson, PTY LTD 1995).

Some management based options in the document include:

- Emphasize a more positive message
- Add signage in parks such as entry and exit point messages
- Create long grass areas to encourage dogs to defecate
- Construct poles surrounded by sand with close by bins for dog waste disposal
- Construct pet waste disposal units in the ground where decomposition occurs naturally
- Place deodorizers under the lid of garbage cans to minimize odors

Any management should be coordinated with the land management agency. The city of Las Cruces, Stormwater Pollution Prevention Program, along with the Parks Department, has posted numerous signs and provided free disposal bags and garbage cans at many locations. A Watershed Restoration Action Strategy (Middle Rio Grande-Albuquerque Reach Watershed Group, December 2008) was developed for the Rio Grande at Albuquerque and recommended continuation and expansion of "Scoop the Poop" campaign and convenient placement of pet cleanup tools and aids. The Paso del Norte Watershed Council (PDNWC) produced the Watershed Restoration Action Strategy (Paso del Norte Watershed Council, 2007) that recommended additional *E. coli* studies and development of best management practices to reduce *E. coli* with a local stakeholder group. During 2010 through 2012, the PDNWC developed these strategies with the stakeholders. The key organizations to work with in this watershed include the city of Las Cruces, Doña Ana County, New Mexico Environment Department and the PDNWC (www.pdnwc.org). To develop an effective strategy a dedicated individual to explore options for reducing dog waste should produce excellent results.

A sampling design needs to be developed that accurately predicts total loads along the Rio Grande. Loads likely vary depending upon the proximity to easy access sites for residents that walk their dogs. Dog waste loads might be higher near bridges and parks, rather than areas that are far removed from vehicle access. The floodplain next to the river in other areas is used by pet owners and could contribute *E. coli* to the Rio Grande. Documenting human and dog use could be an indirect measure of dog waste that would be easier and more economical to collect. To increase the accuracy, additional monitoring areas should be established. For example, a floodplain area that is far removed from a parking lot might be selected to determine what the dog use is and what the waste load might be in similar areas in other places along the river. This information can be applied for other places, and with GIS more accurate predictions can be made in the entire reach of the 319 project (110 miles) from Percha Dam to the boundary with Mexico.

To collect additional dog waste information in the Las Cruces area suggestions include:
An exhaustive literature and data search could reveal valuable ways to collect and interpret data. This would improve data collection and could allow comparisons with other studies.

Consulting with an expert in statistics to evaluate the present information and developing new studies would be very helpful.

To improve upon measures that will reduce dog waste, the immediate area should be monitored before and after new management or facilities are put in place. For example, measures could be new locations for trash cans and dog collection bags. Having a dog scoop with a small shovel near a trash can be something that could be effective. Establishing study areas in other sections adjacent to the river would be useful in determining *E. coli* loads to the river. Collecting information for at least two weeks before and after new measures would be useful. Collection of data for longer periods to monitor new management would introduce many other variables such as climate and other activities that could affect results. Because weekends may change the dog waste deposits, the sampling period should include at least two weekends before and after. If year round monitoring occurs, consideration of the seasons and

climate should be included. For example, extremely cold or hot times may change use patterns of the area.

Conducting verbal and written surveys of the public before and after installing new facilities could reveal effectiveness of the new facilities.

Collection of dog waste weights should include the drying of the waste to ensure that it is standardized between samples and allow valid comparisons with other studies.

To link *E. coli* concentrations to dog waste, studies of the concentrations of *E. coli* in dog waste could be studied. Wet samples could be evaluated for concentrations, and then, the samples could be dried to allow analyses of dry dog waste collections. Drying in natural conditions outside could reveal how long feces would contain live *E. coli*. The number of samples should be statistically valid.

Since the concern is the concentration of *E. coli* in the Rio Grande, the survival of *E. coli* in the river could be studied. This could include laboratory analysis of water samples obtained in the Rio Grande or placing waste in the Rio Grande and monitoring the concentration over time. To achieve better accuracy, the temperature in the river should be measured and the water in the laboratory could mimic those temperatures. These data would assist in the analyses of data collected in river samples since *E. coli* would float downstream and affect concentrations in down-stream samples. Knowing the mortality rates of *E. coli* would help investigations into where *E. coli* is coming from.

The role of ultraviolet light in the mortality of *E. coli* could be studied. Dog waste would be evaluated for the concentrations over time by exposure to ultraviolet light.

The role of drying feces in the mortality of *E. coli* could be studied. Concentrations of live *E. coli* could be evaluated over a drying period.

Factors that could influence dog waste loads along the river.

- Areas that do not have an established trail may have less use.
- The time of year may be a factor since very hot times or in cold weather dogs may not be walked as often. More waste may be deposited on weekends than weekdays when residents are not working thus have more time to walk their dogs.
- Areas that have dog disposal bags, garbage cans, and posted signs recommending dog owners pick up after their dog will have less dog waste.
- Residents that pick up after their dogs and other dogs, would also influence waste loads. On June 13, 2011, at a walking trail one resident disclosed that she does pick up after other animals. If this occurs in one floodplain area and not others, then studies and predictions could be inaccurate.
- At selected sites along the river, dogs may make deposits while in the river.
- Dog use is likely affected by the proximity to Las Cruces since there are more individuals that will walk their dog.

Factors that influence concentrations of *E. coli* in the river could be:

- How often dogs defecate directly into the water.
- The distance from the dog deposit to water. The farther the distance, the less likely it will be transported to the river by natural sources such as rain.
- There may be barriers in the floodplain between the dog deposit and the river, such as vegetation, pipelines, berms, etc.
- Rainfall is the likely mechanism of this waste entering the river. Calculation of possible deposits in the river should consider the number of rainfall events that are large enough to move these particles.
- The likelihood of dog waste containing living *E. coli* is a factor. If *E. coli* in waste dies very quickly, then dog waste that enters the Rio Grande may not contain harmful *E. coli*. The time of year (i.e. temperature) may influence *E. coli* mortality rates by causing drying and mortality of *E. coli*. Ultraviolet light does cause mortality of *E. coli*. The location of the bacteria would influence mortality rate (i.e. in water or on land). One study found that *E. coli* in dog waste had complete mortality after 60 hours of exposure with an evaporation rate of .08 inches per day and complete mortality after 15 hours with an evaporation rate of 0.30 inches per day (University of Nevada Cooperative Extension Service).
- The concentration of *E. coli* bacteria in dog waste. Concentrations of *E. coli* were found to range from 2 million to 200 million CFUs in one gram of waste in one study in Nevada (University of Nevada Cooperative Extension Service).

CONCLUSION

Analyses of the data result in the following conclusions:

- Most of the dog waste along the asphalt trail was deposited between 200 and 500 feet south of La Llorona Park.
- The collection area along the west side of the asphalt trail had almost four times more waste compared to the east side.
- Most of the individual dog waste deposits were less than 0.50 ounces.
- Fresh dog waste takes 89 hours to dry and loses 42.5% of its weight.
- In the study area, a strip of willows and a grassy area would likely prevent dog waste movement to the Rio Grande.

RECOMMENDATIONS

To reduce dog waste and improve future studies, recommendations are:

- Concerning the results of this study, a trash can and waste bag dispenser should be placed 350 feet south of the wood posts along the west side of the asphalt walking trail. The trash can and waste dispenser should be monitored to determine if they are being used.
- To address dog waste concerns, additional studies should occur along the Rio Grande and in a laboratory that will develop site specific information so improved effective strategies can be developed.
- To expand site specific data to a larger area, GIS should be used.
- Watershed management strategies should be thoroughly explored. A specific suggestion includes ensuring there is a vegetative strip near the streambank to prevent movement of dog waste to the water.
- Management practices should be implemented and the results monitored.
- A dedicated individual should address dog waste either through contracts or being an employee of a city, county, or state agency.

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Appendix A. Location and Weight of Dog Waste along the Walking Trail South of Picacho Bridge, East Bank of Rio Grande in Las Cruces, New Mexico

West of Asphalt Path 10 feet wide	West of Asphalt Path	East of Asphalt Path 10 feet wide	East of Asphalt Path
Distance (ft) south of wood posts at park	Weight of dog waste (ounces)	Distance (ft) south of wood posts at park	weight of dog waste (ounces)
June 10, collected	waste 0 to 1,000 ft.		
		90	1
		505	2
Total weight 3 ounces			
June 11, checked	0 to 1,000 ft., none		
Total weight 0 ounces			
June 13, collected	0 to 1,000 ft.		
299	2.00	263	less than 1 ounce
364	less than 1 ounce	289	less than 1 ounce
881	1.00 horse pile		
Total weight 5 ounces, weighed in bag			
June 17, collected	0 to 1,000 ft.		
49	less than 1 ounce	321	1
88	less than 1 ounce	331	less than 1 ounce
290	less than 1 ounce	364	less than 1 ounce
418	less than 1 ounce	459	1
439	less than 1 ounce	460	3
517	6	590	less than 1 ounce
517	less than 1 ounce	759	1
527	less than 1 ounce		
550	1		
585	less than 1 ounce		
637	less than 1 ounce		
780	1		
785	1		
Total weight 23 ounces, weighed in bag			
July 30, collected	1,000 to 2,000 ft.	did not collect	individual weights
1003		1067	
1008		1125	
1022		1156	
1038		1219	
1050		1245	
1065		1246	
1087		1298	

APPENDIX A PAGE 2			
West of Asphalt Path 10 feet wide	West of Asphalt Path	East of Asphalt Path 10 feet wide	East of Asphalt Path
Distance (ft) South of Wood Posts at Park	Weight of Dog Waste (ounces)	Distance (ft) South of Wood Posts at Park	Weight of Dog Waste (ounces)
July 30 continued			
1087		1302	
1108		1326	
1110		1364	
1126		1371	
1144		1383	
1146		1429	
1204		1439	
1237		1550	
1239		1580	
1247		1599	
1270		1603	
1280		1625	
1315		1709	
1401		1712	
1441		1890	
1457			
1496			
1531			
1587			
1590			
1596			
1608			
1630			
1644			
1656			
1663			
1668			
1743			
1758			
1758			
1761			
1789			
1839			
1847			
1888	***a horse deposit was documented at 1376 westside; 4.6 ounces***		
1950	***Total weight 43.35 ounces, weighed in bag***		
1953	***first time collection in this area***		
1975			

APPENDIX A PAGE 3			
West of Asphalt Path 10 feet wide	West of Asphalt Path	East of Asphalt Path 10 feet wide	East of Asphalt Path
Distance (ft) South of Wood Posts at Park	Weight of Dog Waste (ounces)	Distance (ft) South of Wood Posts at Park	Weight of Dog Waste (ounces)
July 31 collected	0 to 1,000 feet		
57	0.10	16	0.20
74	0.10	129	0.00
86	0.05	131	0.15
89	0.20	186	0.00
91	0.05	188	0.25
136	0.05	197	0.00
139	0.85	198	0.15
194	0.80	253	0.10
200	0.90	306	0.45
244	0.00	325	0.25
285	0.85	336	0.20
301	0.00	367	0.00
303	0.00	395	0.15
306	0.00	449	0.00
336	0.70	452	0.00
341	0.10	458	0.00
426	1.40	484	0.25
432	0.50	525	0.00
440	0.00	569	0.00
441	0.00	622	0.00
444	0.00	638	0.00
452	0.00	651	0.10
471	0.15	669	0.00
499	0.50	674	0.05
502	0.00	727	0.00
546	0.00	730	0.00
574	0.00	757	0.10
593	0.45	796	0.00
705	0.00	848	0.00
732	2.05	850	0.00
860	0.65	898	0.25
870	0.00	960	0.00
900	0.55	964	0.95
901	1.05	993	0.55
904	0.45		
908	0.15		
944	0.15		
945	1.05		
948	0.10		

APPENDIX A PAGE 4			
West of Asphalt Path 10 feet wide	West of Asphalt Path	East of Asphalt Path 10 feet wide	East of Asphalt Path
Distance (ft) South of Wood Posts at Park	Weight of Dog Waste (ounces)	Distance (ft) South of Wood Posts at Park	Weight of Dog Waste (ounces)
July 31 continued	0 to 1,000 feet		
974	0.75		020
992	0.10		
1000	0.35		
Total weight 21.3 ounces weighed in bag			
0.00 weight, means it is less than 0.05 ounces, the scale minimum weight			
August 12 collected	0 to 2,000 feet		
194			
276			
420			
436			
676			
717			
748			
815			
1000			
1029			
1049			
1054			
1055			
1125			
1259			
1374			
1603			
1607			
1609			
1669			
1850			
1950			
westside weight, 7.45 ounces weighed in bag			
eastside weight, 3.44 ounces weighed in bag			
Total weight, 10.9 ounces weighed in bag			
0.00 weight means it is less than 0.05 ounces, the scale minimum weight			

APPENDIX A PAGE 5			
West of Asphalt Path 10 feet wide	West of Asphalt Path	East of Asphalt Path 10 feet wide	East of Asphalt Path
Distance (ft) South of Wood Posts at Park	Weight of Dog Waste (ounces)	Distance (ft) South of Wood Posts at Park	Weight of Dog Waste (ounces)
September 25 collected	2,000 to 2,300 feet		
2083	0.30	2008	0.55
2092	0.50	2033	1.10
2234	0.10	2236	0.15
westside weight, 1.05 ounces, weighed in bag			
eastside weight, 1.95 ounces, weighed in bag			
Total weight, 3.00 ounces, added west and east			
0.00 weight means it is less than 0.05 ounces, the scale minimum weight			
September 26 collected	0 to 2,000 feet		
101	0.35	101	1.40
201	0.15	419	0.00
290	0.65	420	0.00
296	0.25	421	0.25
323	0.25	1132	0.15
334	0.35	1269	0.00
335	0.35	1499	0.00
399	0.00		
567	0.85		
568	0.30		
599	0.15		
780	0.15		
905	0.70		
1018	0.30		
1336	1.50		
1558	0.00		
1598	1.30		
1619	0.00		
1824	0.00		
westside weight, 2.15 ounces, weighed in bag			
eastside weight, 7.90 ounces, weighed in bag			
Total weight, 10.05 ounces, added west and east			
0.00 weight, means it is less than 0.05 ounces, the scale minimum weight			