An Opportunity to Improve Health Through Improved Wastewater Service

A Health Impact Assessment on Fresno County's Pending General Plan Update

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LEADERSHIP COUNSEL FOR JUSTICE & ACCOUNTABILITY

LOMA LINDA UNIVERSITY
School of Public Health

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About Leadership Counsel for Justice and Accountability

Leadership Counsel for Justice and Accountability fundamentally shifts the dynamics that have created the stark inequality that impacts California's low income, rural regions. Based in the San Joaquin and Eastern Coachella Valleys, Leadership Counsel works alongside the most impacted communities to advocate for sound policy and eradicate injustice to secure equal access to opportunity regardless of wealth, race, income, and place. Through community organizing, research, legal representation, and policy advocacy, Leadership Counsel impacts land use and transportation planning, shifts public investment priorities, guides environmental policy, and promotes the provision of basic infrastructure and services.

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Glossary of Key Terms

Adequate Wastewater Service: A sewage treatment system that reliably prevents any violations of water quality objective or contamination of waters of the state, prevents nuisance and protects humans and pets from exposure to raw sewage.

Centralized Wastewater Service: A series of sewer pipes, tunnels, and pumps that collects wastewater and transport it to a central treatment plant.

Gastrointestinal: Related to the stomach or intestines.

Groundwater: The water found underground in the cracks and spaces in soil, sand and rock. It is stored in and moves slowly through geologic formations of soil, sand and rock called aquifers.

Health Impact Assessment (HIA): A tool that engages stakeholders to help communities and decision-makers identify the potential health effects of decisions; how those impacts might disproportionately affect different racial, income, geographic, and other groups; and how that distribution can influence health outcomes. HIAs use those findings to develop recommendations that can help maximize health benefits and minimize negative health outcomes.

Inadequate Wastewater Service: An onsite sewage treatment system that has the reasonable potential to cause a violation of water quality objectives, to impair present or future beneficial uses of water, or to cause pollution, nuisance, or contamination of waters of the state (pursuant to California State Law) or otherwise fails to prevent exposure to raw sewage.

Local Agency Formation Commission (LAFCO): Regional planning agencies in California that oversee the establishment, expansion, governance, and dissolution of local government agencies and their municipal service areas to meet current and future community needs.

Onsite Wastewater Treatment System: Includes individual disposal systems including septic systems, community collection and disposal systems, and alternative collection and disposal systems that use subsurface disposal.

Pathogens: A bacterium, virus, or other microorganism that can cause disease.

Quantitative Microbial Risk Assessment (QMRA): The process of estimating the risk from exposure to microorganisms.

Reportable Disease: Diseases considered to be of great public health importance. In the United States, local, state, and national agencies (for example, county and state health departments or the United States Centers for Disease Control and Prevention) require that these diseases be reported when they are diagnosed by doctors or laboratories.

Septic System: A septic system generally consists of two main parts — a septic tank and a drainfield. Wastewater flows from the home to the septic tank through the sewer pipe. The septic tank treats the wastewater naturally by holding it in the tank long enough for solids and liquids to separate. The solids remain in the septic tank where bacteria found naturally in the wastewater break the solids down. The solids that cannot be broken down are retained in the tank until the tank is pumped.

The liquid flows from the septic tank to a drainfield (or leachfield) or to a distribution device, which helps to distribute the wastewater in the drainfield.

Sphere of Influence: The planning boundary outside of local agency's legal boundary (such as the city limit line) that designates the agency's probable future boundary and service area.

Unincorporated Communities: Areas that are not within city boundaries.

- **— Disadvantaged Unincorporated Community (DUC):** A fringe, island, or legacy community in which the annual median household income is less than 80 percent of the statewide median household income.
- **— Island Community:** An inhabited and unincorporated territory that is surrounded or substantially surrounded by one or more cities cities or by one or more cities and a county boundary or the Pacific Ocean.
- **— Fringe Community:** An inhabited and unincorporated territory that is within a city's sphere of influence.
- **— Legacy Community:** An inhabited and geographically isolated unincorporated community (i.e. an unincorporated community that is neither a fringe nor an island community) that is inhabited and has existed for at least 50 years.

Executive Summary

Through this Health Impact Assessment (HIA) we evaluate the potential impacts on health that a Fresno County General Plan Update may have if it fails to include effective policies and programs designed to address inadequate wastewater treatment and disposal in disadvantaged, unincorporated communities.

Several urban pockets and rural communities in Fresno County and beyond do not have municipal wastewater service or otherwise adequate wastewater management services and infrastructure and thus we focused our attention on those areas. This HIA includes both an analysis of the health risks that may impact neighborhoods without centralized wastewater service, and recommendations to address these deficiencies and bring greater health, and health equity, to the region.

The health determinants and outcomes we reviewed include:

- Increased risk of exposure to pathogens in soil
- Increased risk of exposure to pathogens and nitrate in drinking water
- Increased stress and anxiety
- Increased illness and/or infection
- Decreased economic and community development opportunities

We found that there were high concentrations of bacteria and pathogens in soils near septic systems that approached or exceeded the levels found in raw wastewater. The bacteria that we found do not normally occur in soil. We also found that there were heightened concentrations of bacteria and nitrates in water supplied by domestic wells in neighborhoods without centralized wastewater service. Our risk assessment model predicts significant and elevated risk of infection and gastrointestinal illness for people — especially small children — living near contaminated soils. Reportable disease data from Fresno County demonstrates that *Campylobacter* infections are the most common; *Listeria* infections are less commonly reported by individuals. We also found that lack of access to centralized wastewater systems causes increased stress and anxiety among residents and decreases — or even eliminates — economic and community development opportunities.

We also found, based on the data available, that lack of access ot centralized wastewater services disproportionately impacts Latino residents.

Finally, we provide several recommendations to Fresno County for programs and policies designed to address the inadequate wastewater service in the county. Several of these programs and policies may be replicated in other jurisdictions throughout the state. Recommendations include:

- Completing a comprehensive assessment of wastewater service needs in Fresno County
- Seeking and allocating funds for capital improvement projects
- Collaborating with community-based organizations to develop and implement wastewater service projects
- Integrating consideration of wastewater-related pathogen exposure into public health efforts
- Establishing timelines to address unmet wastewater service needs

Introduction

Through this Health Impact Assessment (HIA) we evaluate the potential impacts on health that a Fresno County General Plan update may have if it fails to include effective policies and programs designed to address inadequate wastewater treatment and disposal in disadvantaged, unincorporated communities. (California Law defines inadequate wastewater service as an onsite sewage treatment system that has the reasonable potential to cause a violation of water quality objectives, to impair present or future beneficial uses of water, or to cause pollution, nuisance, or contamination of waters of the state. We also consider service to be inadequate if it otherwise fails to prevent exposure to raw sewage). The most recent Draft General Plan Update — published for public review in December of 2017 — included several policies related to wastewater treatment and disposal. Yet none of the relevant policies sufficiently address potential health impacts of inadequate wastewater service in existing neighborhoods and none of the proposed implementation programs address the issue.[1] Policies and implementation programs are more focused on ensuring reliable and sustainable wastewater treatment and disposal for new — generally market-rate — development rather than for existing communities.

One relevant policy in the draft update notes that, "[t]he County shall encourage the installation of public wastewater treatment facilities in existing communities that are experiencing repeated septic system failures and lack sufficient area for septic system repair or replacement and/or are posing a potential threat to groundwater."[2] This is an important placeholder, yet there is insufficient specificity or urgency in this policy to ensure that such projects will come to fruition, and there are no relevant implementation programs necessary to further the policy.

Another policy of note in the existing Draft General Plan Update states that "the County shall limit the expansion of unincorporated, urban density communities to areas where community wastewater treatment facilities can be provided."[3] As will be discussed in greater detail below, this policy could have a crippling effect on the future and sustainability of existing neighborhoods that have not received adequate investment in basic infrastructure over the past decades.

A Health Impact Assessment (HIA) is a tool that engages stakeholders to help communities and decision-makers identify the potential health effects of decisions; how those impacts might disproportionately affect different racial, income, geographic, and other groups; and how that distribution can influence health outcomes. HIAs use those findings to develop recommendations that can help maximize health benefits and minimize negative health outcomes.

HIAs involve six steps. Engagement with the communities and individuals that may be affected, policymakers, and other stakeholders occurs throughout the steps.

Step 1: Screening. Determine whether an HIA is needed, can be accomplished in a timely manner, and would add value to the decision-making process.

Step 2: Scoping. Identify the potential health effects that will be considered and develop a plan for completing the assessment, including specifying their respective roles and responsibilities.

Step 3: Assessment. Evaluate the proposed project, program, policy, or plan and identifies its most likely health effects using a range of data sources, analytic methods, and stakeholder input to answer the research questions developed during scoping.

Step 4: Recommendations. Develop practical solutions that can be implemented within the political, economic, or technical limitations of the project or policy to minimize identified health risks and to maximize potential health benefits.

Step 5: Reporting. Disseminate information including the HIA's purpose, process, findings, and recommendations to a wide range of stakeholders.

Step 6: Monitoring and evaluation. Evaluate the HIA according to accepted standards of practice and develop a plan to monitor and measure the HIAs impact on decision-making and the effects of the implemented decision on health.

We anticipate that Fresno County will draft and circulate a new General Plan Update in early 2020. As of October of 2019, Fresno County was seeking a consultant to support development of the General Plan Update.

A General Plan in California is "more than the legal underpinning for land use decisions; it is a vision about how a community will grow, reflecting community priorities and values while shaping the future."[4] California state law requires each city and county to adopt a general plan "for the physical development of the county or city, and any land outside its boundaries which in the planning agency's judgment bears relation to its planning."[5] The general plan expresses the community's development goals.[6] A general plan, in short, allows a community to create a vision for its future by laying out an enforceable blueprint for growth and development. As the foundational planning document, it will lay out Fresno County's goals, as well as programs and policies designed to achieve those goals. Primary goals of land use planning in California are to promote equity, strengthen the economy, protect the environment, and promote public health and safety.[7] As is clear from inclusion of effective wastewater treatment and disposal among the Draft General Plan Update's goals and policies, adequate wastewater service furthers the overarching goals of a general plan, and thus the County General Plan should include sufficient programs and policies to ensure access to the basic service.

Through community meetings, literature review, interviews, and microbial analyses we conducted an HIA to evaluate the potential health impacts of a County General Plan that fails to include effective programs and policies designed to address inadequate wastewater treatment and disposal. Specifically, we considered how the Fresno County General Plan, if it fails to include aggressive programs and policies to address deprivation from adequate wastewater service, would impact both health outcomes and health determinants. (While there is no legal definition of "adequate" we think a common-sense definition is a wastewater treatment and disposal system that prevents any violations of water quality objectives or contamination of waters of the state, prevents nuisance and protects humans and pets from exposure to raw sewage). The health determinants and outcomes we reviewed include:

- Increased risk of exposure to pathogens in soil
- Increased risk of exposure to pathogens and nitrate in drinking water
- Increased stress and anxiety
- Increased illness and/or infection
- Decreased economic and community development opportunities

Additionally, we evaluated the correlation between access to municipal services and demographic composition of neighborhoods.

Several urban pockets and rural communities in Fresno County and beyond do not have centralized wastewater service or otherwise adequate wastewater management services and infrastructure. We focused our attention for this study on those areas. This HIA includes both an analysis of the health risks that may impact neighborhoods without centralized wastewater service and recommendations to address these deficiencies and bring greater health, and health equity, to the region. The majority of our recommendations are focused on potential general plan programs and policies but we have included others that are more applicable to other county programs and practices.

Understanding the Communities that Form the Focus of This Study

A. Focus on Disadvantaged Unincorporated Communities

We focus this Health Impact Assessment on disadvantaged unincorporated communities in Fresno County that lack centralized municipal wastewater service. Disadvantaged unincorporated communities, as defined by California Law, are unincorporated communities at or below 80% of state median income.[8] We included information and feedback from several other disadvantaged communities in other counties, including Riverside, Tulare, and Madera, to confirm trends we identified in Fresno and expand the applicability of this analysis. We chose to focus on disadvantaged unincorporated communities specifically due to three primary factors and assumptions:

1. People of color represent a greater share of households in disadvantaged unincorporated communities compared to compared to Fresno County as a whole. (See *Table 2*)
2. Disadvantaged unincorporated communities are more likely to have public health based violations in their drinking water systems.[9]
3. Almost every disadvantaged unincorporated community in Fresno County has average parcel sizes that are smaller than two acres,[10] the minimum density identified in Fresno County's Local Area Management Plan[11] as appropriate for new development or proposed secondary dwellings reliant on onsite wastewater treatment systems.

Additionally, state law requires local governments to identify and characterize service deficiencies in disadvantaged unincorporated communities making data regarding disadvantaged unincorporated areas more accessible.

A Basic Overview of Disadvantaged Unincorporated Communities

A Disadvantaged Unincorporated Community (DUC) is defined as an area of inhabited territory located within an unincorporated area of a County in which the annual median household income is less than 80 percent of the statewide median household income.[12] There are hundreds of DUCs throughout California, many of which lack access to basic infrastructure and services, including adequate wastewater services. SB 244 is a law in California that requires counties and cities to identify island, fringe, and legacy unincorporated communities, and if necessary, characterize any needs or deficiencies[13] in basic services including drinking water service and wastewater service.

Island unincorporated communities are substantially surrounded by cities; fringe communities lie beyond city limits but within a city's sphere of influence; and legacy communities are unincorporated communities that (1) are not within a city's sphere of influence and (2) have been in existence for 50 or more years. A city's sphere of influence is a region not in the city's legal boundary, but rather a planning area in which the city projects it will grow and incorporate into its service area. As suggested by the legal definitions, some DUCs are geographically isolated, often serving as the homes and communities of farm-workers and their families; others are closer to cities, often near industrial areas of larger cities or at the edges of smaller cities.

Data Gaps Regarding Existence of and Conditions in Disadvantaged Communities

There was little information regarding DUCs ten years ago when California SB 244 passed, requiring local governments to map them and describe their water and wastewater needs. As a result, there is more data now. However, some local governments have not completed these analyses or have incomplete analyses. Additionally, census data regarding DUCs is uneven at best, since some communities are so small that the margin of error is high (sometimes as high as 100%); and in some cases, DUCs are in the same census data set as other, more affluent unincorporated areas or cities further obscuring a communities' demographic make-up. However, we have more information today with respect to the hundreds of DUCs in California and remain hopeful that we will continue to expand our understanding of the existence, location, and conditions of DUCs — including access to wastewater service — as more local agencies complete and improve their analyses. We have included Fresno County and Fresno City maps that show most DUCs in Fresno County and illustrate the different types (legacy, fringe, and island) of DUCs.

Unfortunately, due to inadequate data regarding access to wastewater service in the state, we do not have comprehensive data regarding the number of households or neighborhoods in Fresno County without wastewater service. However, based on data we do have and explained through tables and maps below, the majority of disadvantaged unincorporated areas in the County lack municipal wastewater service. There are two primary types of wastewater treatment and disposal infrastructure: centralized wastewater service conveys sewage from houses and commercial buildings to treatment facilities or disposal while a septic system is an underground chamber through which sewage flows for basic treatment; septic systems are generally in the same site as the house(s) they serve.

B. Neighborhoods without Centralized Wastewater Service

Thousands of households in disadvantaged communities live in homes that do not have access to centralized wastewater. Of the disadvantaged, unincorporated neighborhoods and communities in Fresno County, we estimate that more than half have no or minimal access to municipal wastewater service.

Table 1 includes data we have regarding access to municipal wastewater service among disadvantaged unincorporated communities in Fresno County based on data provided by local agencies, including the Fresno Local Agency Formation Commission,[14] Fresno County,[15] and the City of Fresno.[16] The table includes names of communities we could identify from publicly available data and information as to which communities have access (full or partial) to centralized wastewater service to the extent that we could gather that information from publicly available data. Note that we only included communities for which we could obtain information regarding access to centralized waste- water service from personal knowledge or local agency materials. Studies conducted by non-governmental agencies and universities have identified scores of DUCs that do not appear in local agency data. With the exception of three additional communities of which we have personal knowledge — Tombstone Territory, Burrel, and Bowels — our analysis includes those communities included in local agency data. We will work with the appropriate local agencies, including through development of the Fresno County General Plan, to ensure inclusion of all disadvantaged unincorporated communities in maps, data, and analyses as required by California and mandated by state planning goals.

Table 1. Fresno County Disadvantaged Unincorporated Communities that Have No or Partial Access to Centralized Wastewater Service (CWS).

Community	Population[17]	# of Parcels[18] or # of Households[19] without Access to CWS	Level of Access to CWS
Fresno County Legacy Committee			
Easton	approx. 2100	456 parcels	No access to CWS
Lanare	approx. 600	48 parcels	
Monmouth	approx. 150	36 parcels	
Raisin City	approx. 380	68 parcels	
Church Ave / Valentine Neighborhood (West Park)	No data available	110 parcels	
Madera Ave Neighborhood	No data available	22 parcels	
Muscat Ave / Valentine Neighborhood	No data available	51 parcels	
Hayes Road Neighborhood	No data available	35 parcels	
Tombstone Territory	No data available	No data available	
Burrel	No data available	No data available	
Bowles	approx. 200	No data available	
City of Fresno Fringe and Island Areas[20]			
10 Neighborhoods	—	approx. 1250 households	0%- 3% of households in neighborhoods are connected to CWS
2 Neighborhoods	—	approx. 380 households	24% -39% of households in neighborhoods are connected to CWS
3 Neighborhoods	—	approx. 220 households	80%-92% of households in neighborhoods are connected to CWS
Island Fringe Communities Near other Cities in Fresno County			
Parlier: 1 disadvantaged unincorporated fringe area	—	—	Unknown
Sanger: 2 disadvantaged unincorporated fringe areas	—	—	Unknown
Selma: 3 disadvantaged unincorporated fringe areas	—	—	Unknown

It is worth noting that information we rely on for this HIA may exclude some disadvantaged, unincorporated communities in Fresno County due to lack of publicly available data regarding unincorporated communities and their access to wastewater service. In 2013, Policy Link developed a report[21] that mapped the San Joaquin Valley's disadvantaged unincorporated communities. This report identified more disadvantaged unincorporated communities in Fresno than local agencies have identified pursuant to SB 244. As compared to the approximately 40 DUCs we identified through our analysis of local agency materials, PolicyLink identified 93 DUCs.[22] We do not yet know what accounts for the discrepancy and will undertake further outreach to reconcile these two data sets.

The maps below illustrate disadvantaged unincorporated communities that have and do not have centralized wastewater access as well as those that have partial access to centralized wastewater service.

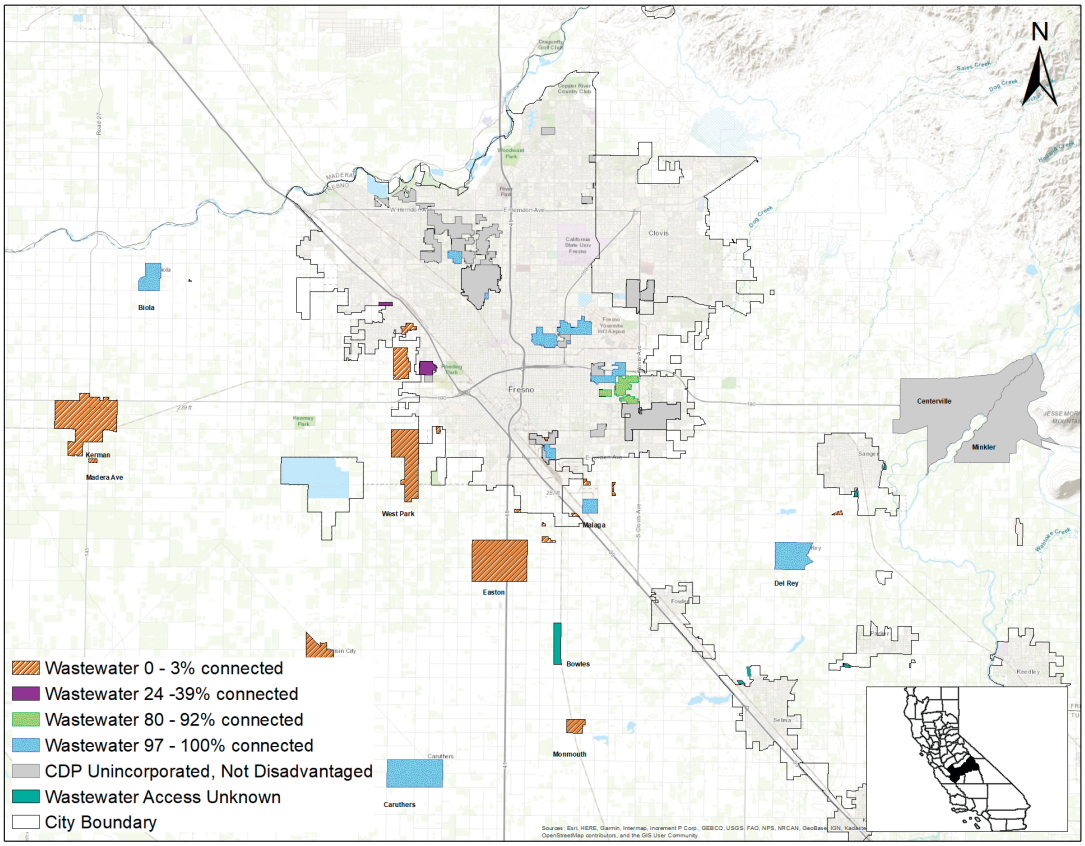

Figure 1. Map of City of Fresno showing DUCs and access to centralized wastewater service.

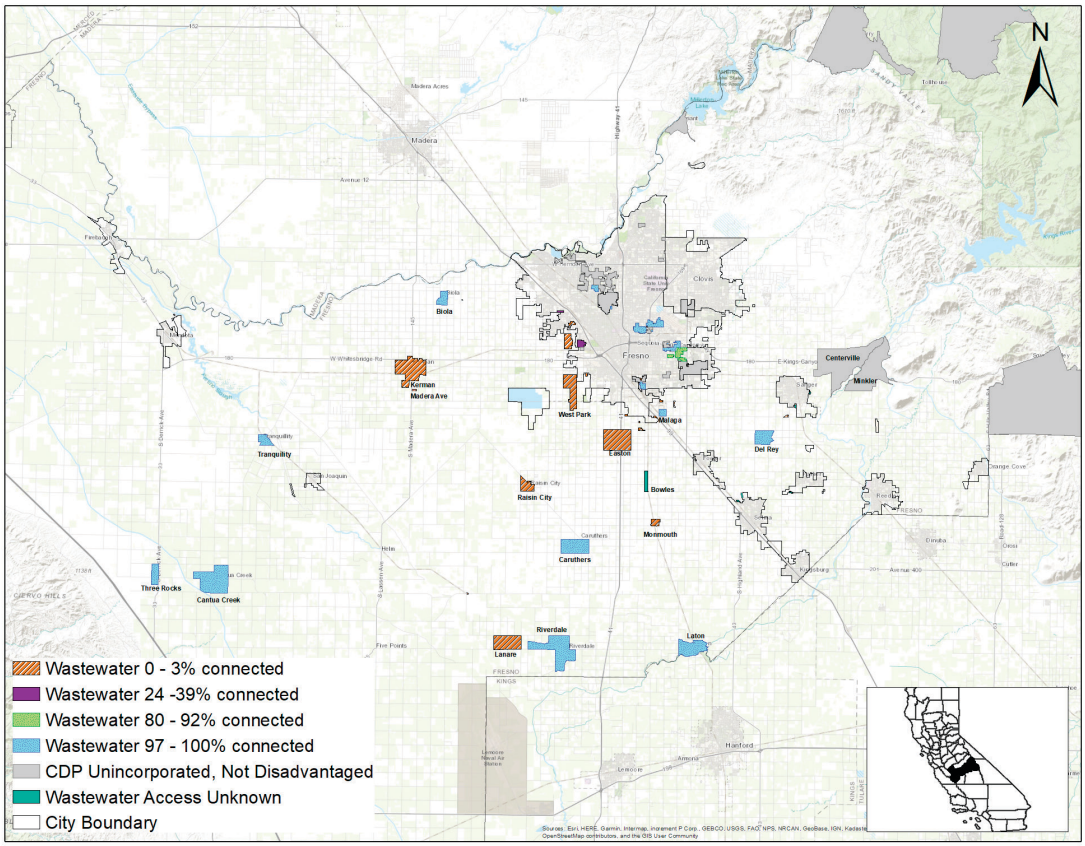

Figure 2. Map of Fresno County showing DUCs and access to centralized wastewater service.

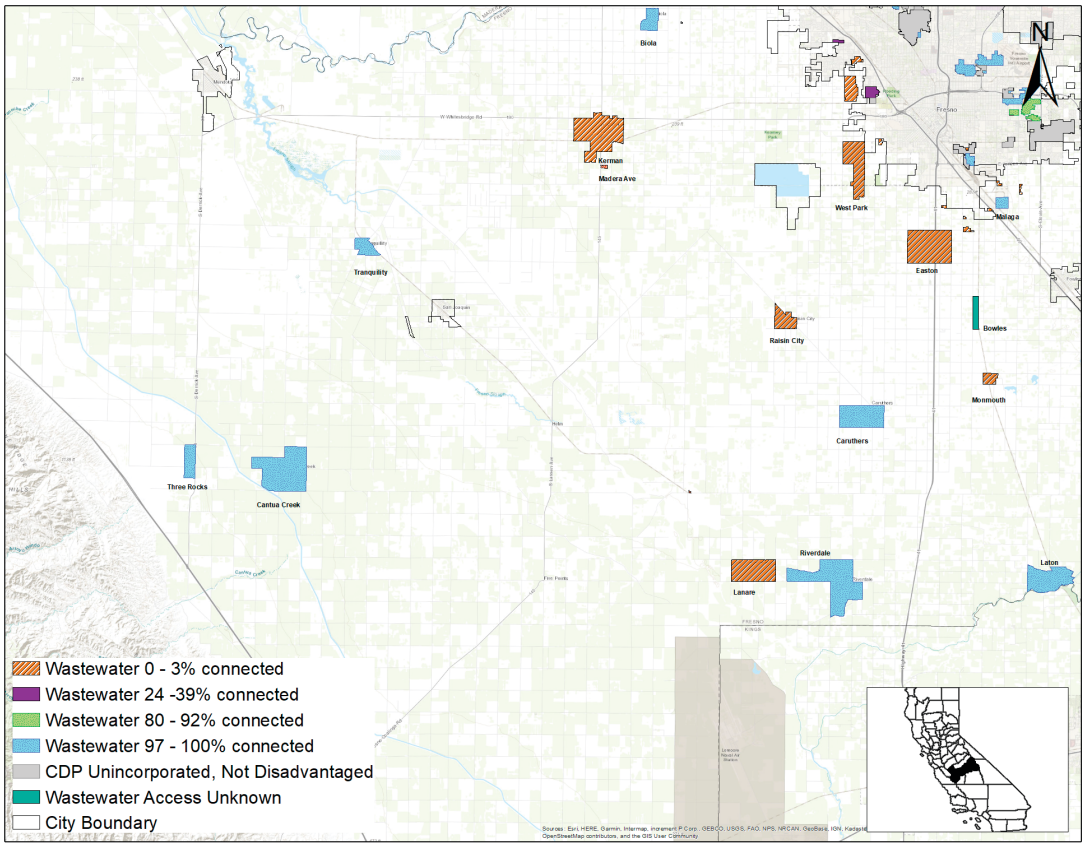

Figure 3. Map of West Fresno County showing DUCs and access to centralized wastewater service.

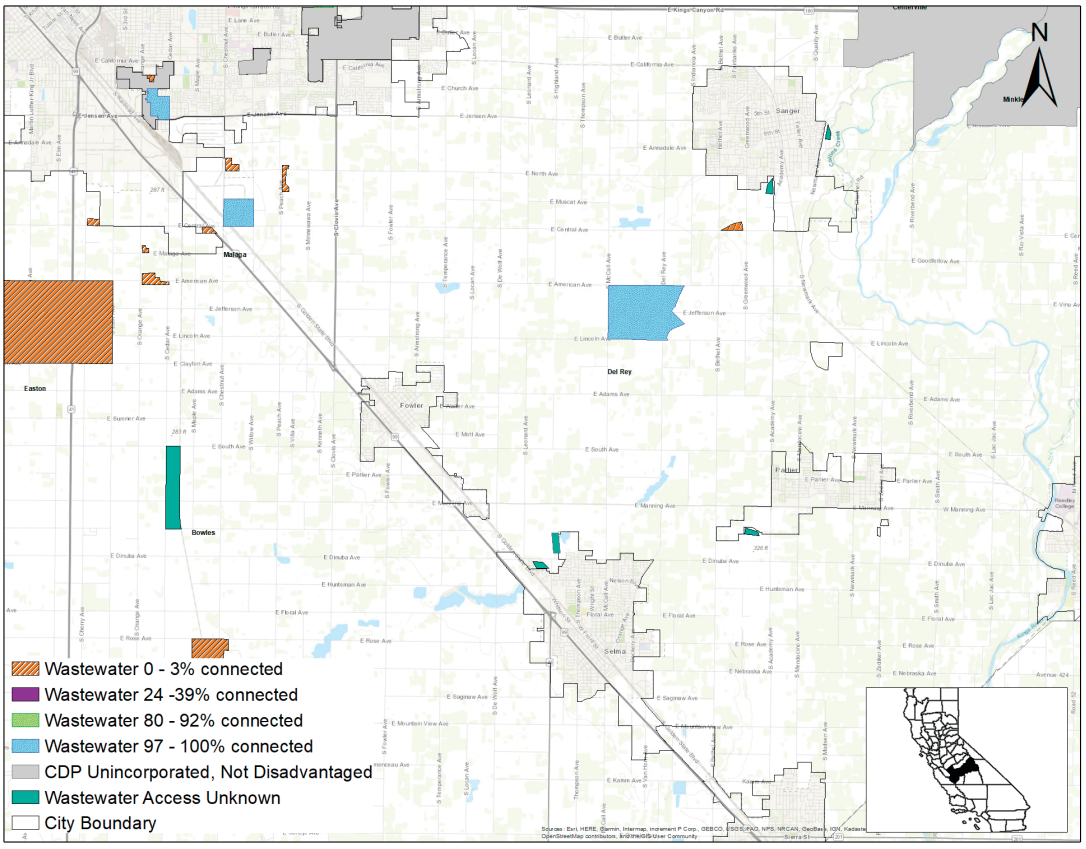

Figure 4. Map of South Fresno County showing DUCs and and access to centralized wastewater service.

C. Race Plays a Role in Access to Wastewater Service

As discussed above, we do not have comprehensive data with respect to access to wastewater service in Fresno County. However, thanks to significant analysis conducted by UC Davis regarding disadvantaged communities in Fresno County, we have demographic estimates with regard to disadvantaged unincorporated communities.

Given the predominance of unincorporated communities without access to wastewater service, we provide here information regarding demographic differences between disadvantaged unincorporated areas and the County as a proxy to illustrate differences among racial lines with respect to wastewater service access. *Table 2* illustrates that disadvantaged communities are disproportionately Latino as compared to the County as a whole, and the reverse is true for Caucasians. Just over half of the county's population is Latino, whereas more than two thirds of the population of disadvantaged unincorporated communities is Latino.

Table 2. Populations in Fresno County.[23]

	Total Population	Latino (#)	White Non-Latino (#)	**Latino (%)**	**White Non-Latino (%)**
County Population	930,450	468,070	304,522	**50%**	**33%**
DUC Population	35,138	24,003	6,646	**68%**	**19%**

The Potential Health Impacts of Inadequate Wastewater

A. Methodology and Analytical Process

1. Testing soil and water

Through community outreach and engagement in partnership with the Community Advisory Group, we identified people interested in participating in soil tests and tap water tests to assess the existence and concentration of identified pathogens and contaminants. We collected soil samples in yards that had septic systems. We collected soil from a septic system in a way consistent with the exposure model that we were evaluating for children. The soil was sampled in an area near the septic tank cleanout port or another septic system port that was near an area where children would play. The soil was sampled to a maximum depth of 5 inches with a goal to sample just below the surface in order to avoid sunlight contact with soil microbes. The methods for bacterial analysis followed U.S. Environmental Protection Agency (USEPA) and U.S. Food and Drug Administration (USFDA) protocols and is detailed in the appendix. We collected 28 samples in fifteen neighborhoods and communities, half of which were in Fresno County and half of which were in other areas in California. We then tested the soils in Loma Linda University's laboratory for a variety of contaminants as discussed in greater detail below. We also collected tap water and tested samples at a county lab for contaminants including nitrates and Coliform. We did not collect samples for the purposes of comparison from households connected to centralized wastewater service for this report. Collecting and comparing such samples represents an area for future study.

2. Literature review regarding wastewater and pathogens

We reviewed literature on health impacts related to wastewater access that addressed both domestic and international circumstances and conditions and found the literature that focused on the United States most relevant. We also reviewed scientific materials related to the pathogens and contaminants we found in soils and water, pursuant to tests identified above.

3. Experience of community leaders confronting impacts of inadequate wastewater service

We worked with a Community Advisory Group made up of residents from unincorporated communities from both Fresno County, specifically the community of Lanare and neighborhoods outside of the City of Fresno, and Riverside County, specifically mobile home parks in the communities of Thermal and Oasis, to inform our scope and our analysis. We also engaged in ongoing analysis and reflection, especially with respect to health impacts, through community meetings and dialogues with residents from Fresno County, Riverside County, Tulare County, and Madera County. We did not engage in similar discussions for the purpose of comparison with households and communities connected to centralized wastewater service for this report. Engaging in such discussions represents an area for future analysis.

B. Predictions

We hypothesized that if the Fresno County General Plan Update fails to include policies and implementation programs designed to address wastewater needs in communities that lack access to centralized wastewater service impacted residents would experience the following health impacts:

- ***Increased exposure to pathogens:***
  - — Increased stress and anxiety
  - — Increased illness and / or infection
- ***Decreased economic and community development opportunities:***
  - — Decreased / lack of community development activities
  - — Decreased / static property values
  - — Reduced social cohesion and increased feelings of isolation

C. Health Risk Assessment

1. Exposure to Pathogens in Soils

Literature highlights the potential risk of exposures to pathogens due to inadequate wastewater service. One study, titled *Flushed and Forgotten*, conducted in Alabama identified increased risk of exposure to parasitic and tropical diseases. The study found that the community experienced a resurgence of tropical diseases typically associated with extreme poverty, including hookworm, long thought to have been eradicated in the United States. The Alabama study found that the prevalence of hookworm in Lowndes correlates with the lack of adequate sanitation systems and exposure to open sewage near dwellings. Increased rates of gastrointestinal parasites experienced by Lowndes residents that had raw waste backing up into their homes was also reported.[24] Another recent study found that a toilet, a system for treating human waste, and soap with handwashing facilities are all necessary to reduce fecal pathogen contamination and a disease burden that limits human potential.[25]

Through this HIA we evaluated the presence and concentration of three pathogens — *Campylobacter*, *Listeria*, and *Salmonella* — in the soils of communities where there is a failed on-site wastewater treatment system (e.g. septic system). A leaking on-site wastewater system will likely form puddles or muddy areas as the wastewater is leaking just below the surface of the soil. The areas with the leaking wastewater are often moist and support vegetation growing around them. These areas may be attractive to toddlers and younger children who often play outside their home and dig in contaminated soil.[26] The most infectious of these organisms is *Salmonella*, followed by *Campylobacter* and finally *Listeria*.

a. Salmonella

Salmonella is a bacterium that can cause stomach cramping, diarrhea and nausea in most people. There are several strains of *Salmonella*, and all can cause disease in humans. Most types of *Salmonella* cause illness that will eventually be healed without treatment in healthy immune system individuals. Some specific strains of *Salmonella* can cause outbreaks and attract media attention. Symptoms of *Salmonella* infection include a quickly developing fever, abdominal pain, nausea, diarrhea and vomiting.[27] *Salmonella* is a common component of raw wastewater *(Table 3)* and occurs at moderate concentrations of around 470 organisms per gram of waste. The challenge is that infections of *Salmonella* are usually acquired from only a few organisms (in human volunteer studies). One study estimated the average dose ingested to be 36 bacteria to cause illness.[28] This means that only a few organisms are required to make someone sick.

b. Campylobacter Jejuni

Infection with *Campylobacter* bacteria is the major global cause of stomach cramping, diarrhea and nausea. It is a common bacterium found in raw wastewater and is a common cause of infection in children 0-2 years old. The symptoms of *Campylobacter* infection include diarrhea, fever, headache, nausea and vomiting. It is typically a foodborne illness, but is implicated in this wastewater assessment because it is transmitted via the fecal-oral route. It is common in most warm-blooded domestic animals and usually transmitted via undercooked meat, raw milk, or contaminated milk products. Many cases also result from contact with contaminated water or soil.[29] The amount of organisms required to make a healthy person sick is estimated to be 90,000 bacteria.[30] *Campylobacter* is also a common component of raw wastewater and occurs at moderate concentrations up to 1000 organisms per gram of waste.

c. Listeria

Listeria monocytogenes is a bacteria pathogen that is known for foodborne illness and infections with varying symptoms from an upset stomach and nausea that typically subside in healthy people, to far more serious outcomes including sepsis and meningitis and, in pregnant women, stillbirths or spontaneous abortions. (de Noordhout *et al.* 2014). *L. monocytogenes* is persistent in the environment and a common pathogen found in untreated wastewater that forms resilient biofilms on various types of surfaces.[31] *Listeria* is found to occur at a mean concentration of 57 organisms per gram of waste in a wastewater treatment plant. Most healthy people would need to ingest billions of *Listeria* organisms (1×10^9) to be sick. This number drops down to millions of listeria organisms if the person has a compromised immune system such as in the elderly or young children.[32] To be sick with *Listeria*, a person needs to ingest much more bacteria than *Campylobacter* or *Salmonella*.

Table 3. Soil bacteria test results from samples taken in Fresno, Riverside, Madera and Tulare County homes of California. Results given in organisms per gram of soil.

	E.coli	**Total Coliform**	***Enterococcus***	***Listeria m.***	***Salmonella spp.***	***Campylobacter j.***
Four County average	1,190	1,270,000	320,000	191	226	599
Fresno County average	19,800	2,320,000	585,000	137	51.8	251
Raw wastewater reference	340,000 [*33]	646,000 [34]	320,000 [*5]	57 [35]	471 [6]	1-1,000 [36]

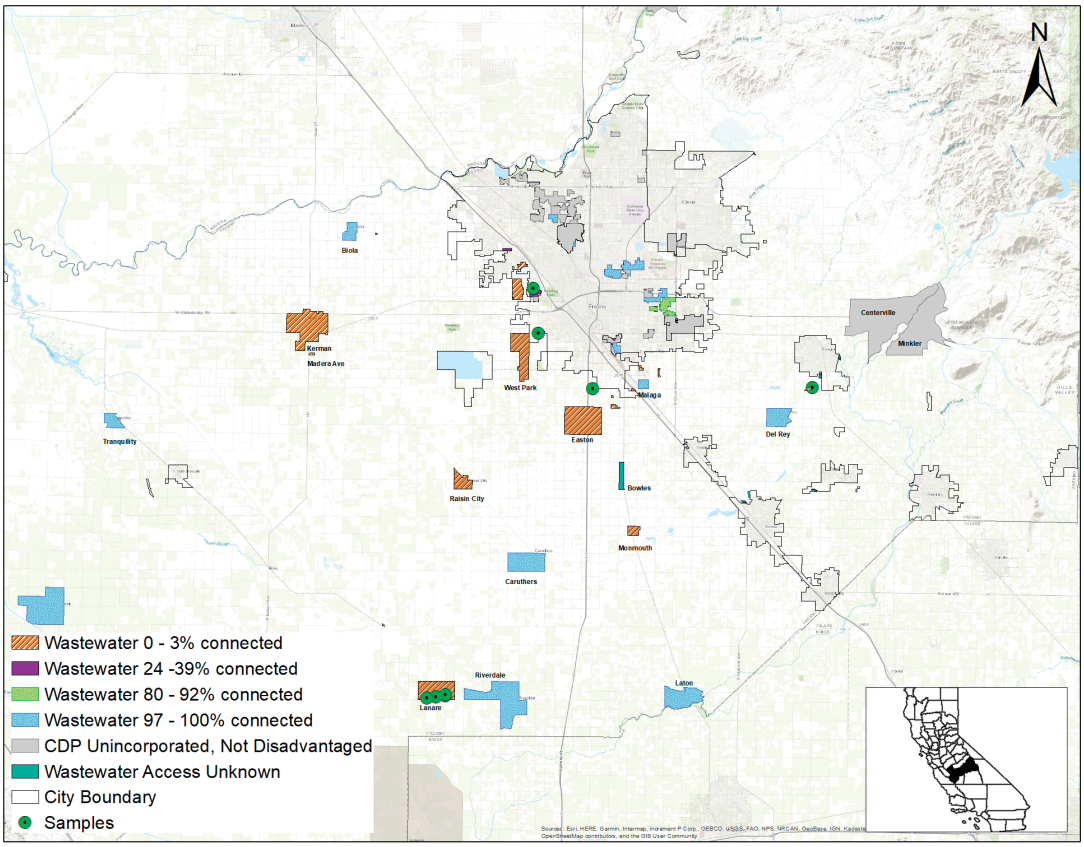

Figure 5. Fresno county showing wastewater coverage and location of samples collected.

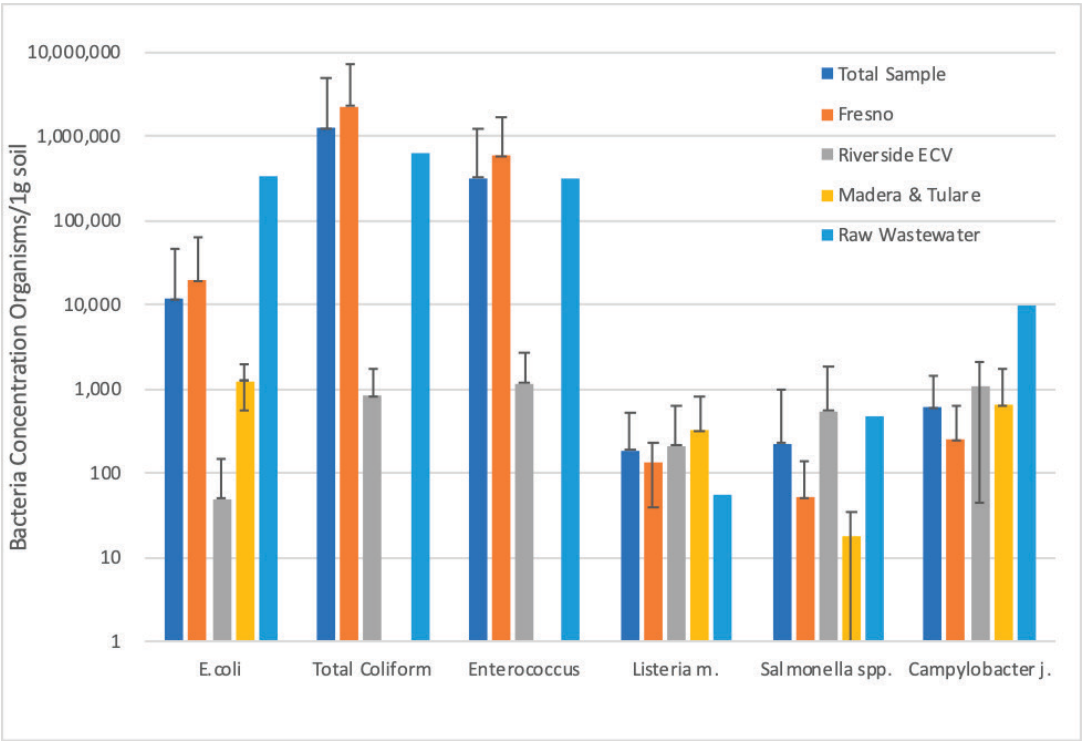

Figure 6. Average concentration of bacteria in soil shown across four counties with standard deviation bars.

Table 4. Summary of all soil samples collected in Riverside County, Fresno County, Madera and Tulare Counties

	E.coli	Total Coliform	*Enterococcus*	*Listeria m.*	*Salmonella spp.*	*Campylobacter j.*
All samples						
Average (organisms*/g)	11,914	1,268,455	319,637	191	226	599
Standard Dev. (organisms/g)	35,480	3,808,371	886,285	320	796	874
Geometric mean (organisms/g)	35.9	352	1370	15.6	4.25	36.3
Number samples	22	11	11	28	28	28
Max	127,095	13,307,800	3,111,540	1,423	4,324	2,523
Fresno						
Average (organisms*/g)	19,751	2,324,796	585,023	137	51.8	251
Standard Dev. (organisms/g)	44,495	4,912,760	1,133,640	96.9	88.2	405
Geometric mean (organisms/g)	65.5	3270	14,534	47.0	0.84	13.6
Number samples	13	6	6	14	14	14
Max	127,095	13,307,800	3,111,540	288	288	1,423
Riverside						
Average (organisms*/g)	51.1	845	1,174	213	554	1,069
Standard Dev. (organisms/g)	102	954	1,566	417	1,264	1,022
Geometric mean (organisms/g)	0.48	24.2	80.6	2.67	56.8	306
Number samples	5	5	5	10	10	10
Max	255	2,010	4,040	1,423	4,324	2,523
Madera & Tulare						
Average (organisms*/g)	1,275	–	–	328	18	640
Standard Dev. (organisms/g)	721	–	–	469	18	1,087
Geometric mean (organisms/g)	1,124	–	–	28	2	5
Number samples	4	0	0	4	4	4
Max	2,523	–	–	1,135	36	2,523

**All organisms are counted through the Most Probable Number (MPN) methodology.*

This study investigates the concentration of *Listeria monocytogenes*, *Salmonella spp.* and *Campylobacter jejuni* in the soil of rural areas that do not have access to a typical sanitary sewer. It is necessary to quantify the environmental concentrations in order to estimate the microbial risk of diseases linked to these environmental bacteria. Contaminated soil is not normally a concern in communities connected to centralized wastewater service. This risk assessment investigates the increased risk of infection with these three organisms for families who live in an area that does not have connection to centralized wastewater service.

2. Soil Samples and Comparison with Raw Wastewater

The research team conducted soil sampling in communities and neighborhoods in Fresno County and similar neighborhoods throughout California to assess the impact of lack of centralized wastewater service on the prevalence of pathogens and bacteria in soils near homes. Results demonstrated high levels of bacteria and pathogens in such soils — in fact some bacteria and pathogens demonstrate higher concentrations than raw wastewater.

3. Risk Assessment of Bacterial Infections

We used a Quantitative Microbial Risk Assessment (QMRA) to evaluate the risk of infection to children who live in DUCs reliant on onsite wastewater treatment systems. The QMRA framework is a mathematical model that can be used to assess health based risks from exposure scenario information. The risk assessment was necessary because there may be under-reported epidemiological data to describe community infectious disease occurrence in these disadvantaged unincorporated communities (DUCs). The overall hypothesis of this risk assessment is that the risk of infection is elevated in households where hygiene is compromised due to lack of the necessary infrastructure — i.e. adequate wastewater treatment and disposal that normally provides a safe environment.

Appendix 1 details the QMRA modeling for a child's risk of infection from contacting the soil that is contaminated with one of the three organisms. The results from the risk assessment are described in *Table 5*. The percent chance of becoming sick from one of these organisms is shown for children who play for more than an average of 1.66 hours in contaminated soil. The percent chance of getting sick is normally linked to the high concentration of the pathogen in the soil, but can also be linked to other factors that we described in the model, such as the ability of the soil to stick to the child's hands.

Table 5. Three diseases with the mean percent chance of a child getting sick who plays for more than 1.66 hours in the soil near a failed wastewater septic system. This assumes all other model assumptions are met.

Pathogen	Chance of getting sick	Major factor controlling probability of getting sick
Listeria monocytogenes	11.4%	• The high concentration of the pathogen in the soil • The ability of the soil to stick to the child's hands
Campylobacter jejuni	13.9%	• The high concentration of the pathogen in the soil
Salomonella typhi	0.09%	• The high concentration of the pathogen in the soil

4. Health Data from County Demonstrates Incidence of Communicable Disease

The Fresno County Public Health department collects data from all Fresno County medical providers on reportable infectious diseases. Several infectious diseases are reportable that are also potentially transmitted through inadequate on-site wastewater. In some disadvantaged communities, soil could have sewage infiltration that includes source microbes for the following conditions which

are reportable infection diseases:[37] *Shigellosis*, *listeriosis*, *Salmonellosis* (both typhoid and nontyphoid), *Shiga toxin*, *Q fever*, *Hepatitis A*, *E.coli 0157H7*, and *Campylobacter jejuni* are listed as reportable diseases in Fresno county, CA. *Table 6* shows data reporting that occurred in the county for all possible sewage-related illnesses.

Table 6. Data from the Fresno County on number of cases of disease. Data from 2012–2017 occurrences of diseases recorded with an episode date.

Organism or Disease	Total Records	Episode Between 2012 and 2017
Campylobacter	2165	2158
Listeriosis	8	7
Salmonella spp.	1006	1002
Typhoid	3	3
Shiga Toxin	44	43
E.coli	71	70
Amebiasis	21	20
Giardiasis	163	163
Hep A	31	31
Q fever	13	13

Fresno County released data showing locations of the reported infections to the census tract and block level to better understand a potential relationship between infections and current wastewater and water infrastructure present in those locations.

While one of the areas that shows a high concentration of *Campylobacter* correlates visually with neighborhoods that lack wastewater service, available data related to reported infections do not visually illustrate a relationship between lack of centralized wastewater service and infections. More spatial analysis using these data is necessary to better understand the relationship between contaminated soils and infections. One hypothesis is that rural communities far from medical clinics are less likely to seek medical attention for gastrointestinal infections, especially if symptoms are mild. However, more research is needed to test this hypothesis.

The maps below demonstrate the prevalence of *Campylobacter* in each census tract by assessing reported cases as compared to census tract population. The darker the color, the higher the prevalence of reported cases of *Campylobacter*.

5. Lack of Access to Adequate Wastewater Service May Increase Nitrate Contamination of Drinking Water Sources

Several analyses have identified inadequate wastewater systems as a contributor to nitrate contamination in the San Joaquin Valley.[38] Wastewater from inadequate septic systems along with agricultural discharges impact the quality of groundwater — and thus drinking water — in Fresno County and beyond. Nitrate exposure can impact reproductive health, can cause cancer, and can lead to blue baby syndrome (methemoglobinemia), a potentially fatal condition in infants that decreases the ability of blood to carry oxygen. Communities reliant on domestic wells are the most vulnerable to nitrate contamination due to the depth of wells, lack of information regarding water quality, and lack of resources for treatment. For example, testing of four homes in Tombstone Territory in Fresno County showed high levels of nitrate of 16, 22, 26, and 40 parts per million (mg/L) in drinking water.[39] These concentrations of nitrate — up to four times the legal limit and public health goal of 10 parts per million — are consistent with other measurements such as the Harter study cited above.

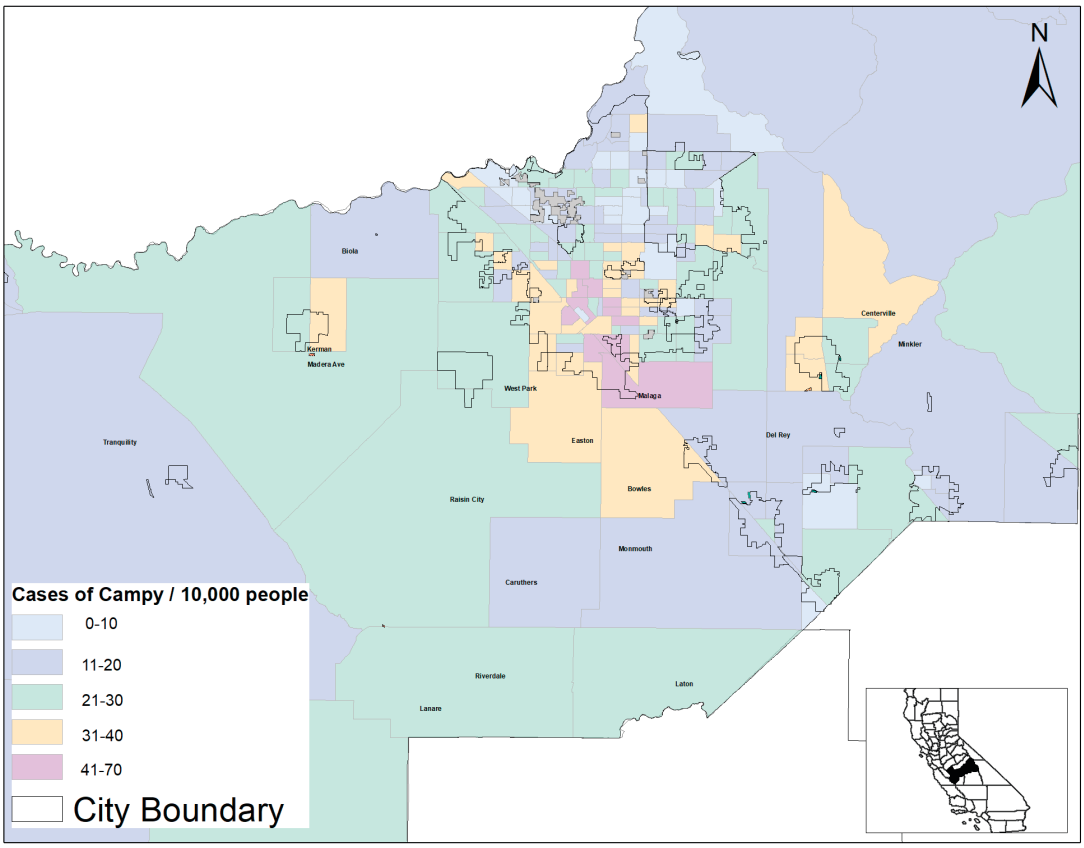

Figure 7. Campylobacter incidence by census tract in Fresno County from 2012–2017.

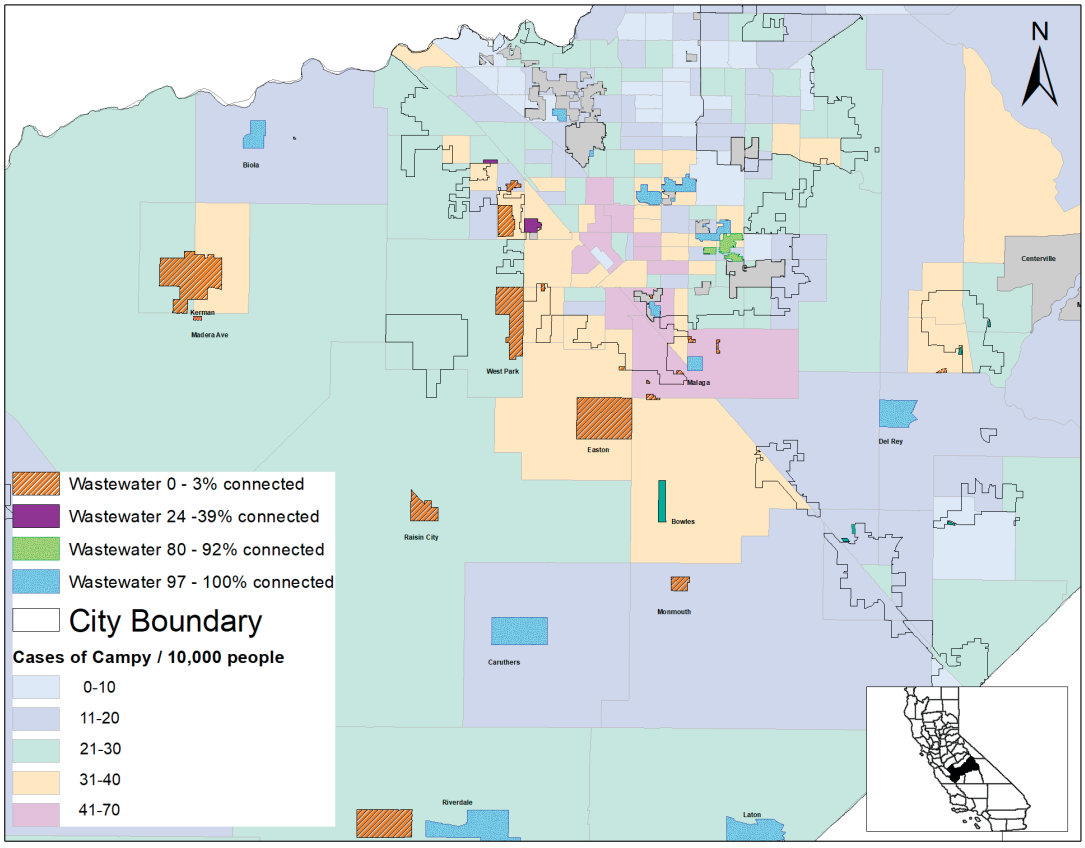

Figure 8. Campylobacter incidence in Fresno county from 2012-2017 shown with wastewater coverage.

Table 7. Water bacteria test results from samples taken within Fresno County homes.

Pathogen	E.coli	Total Coliform	Enterococcus
Tap water from private well (Organisms/100ml)	100,000	870,000	767
Tap water from water district or small system Organisms/100ml)	Non-Detect	64,000,000	Non-Detect
Raw wastewater reference (Organisms/100ml)[40,41]	340,000	646,000	320,000

a. Results from domestic water testing

Table 7 shows the results from testing that the research team did to determine concentration of bacteria in (1) tap water from homes reliant on domestic wells in communities without access to centralized wastewater service, and (2) tap water from homes reliant on public drinking water systems for drinking water and average concentrations. All data to summarize these tables are included in the appendix. The Maximum Contaminant Level (MCL) for all drinking water bacteria indicators is 0 organisms per 100ml. This report presents a summary of drinking water data and we will investigate the water related data in a later analysis.

6. Lack of Access to Adequate Wastewater Service Increases Stress and Anxiety

Through community engagement and education conducted throughout development of this Health Impact Assessment, residents of DUCs expressed that lack of access to adequate wastewater service increases stress and anxiety. In Lanare, a DUC in Fresno County, residents discussed the stress implicit in knowing that dependence on septic tanks could lead to serious health effects. One resident specifically touched on how inadequate wastewater service makes him fear for his health and the future of his community. He emphasized how difficult it is to constantly think about how a basic service has been denied to a community for over 50 years. He discussed how septic tank upkeep is an extra expense for lower income residents. The contamination of water and air quality, and the lack of green space, all contribute to the poor mental health of residents. Another resident spoke of the constant anxiety she felt when considering the potential exposure of her children to pathogens in the soil and the potential costs of repairing or replacing a broken septic system.

Flushed and Forgotten, the report discussed above on inadequate wastewater service in rural areas, highlights the emotional toll of failing wastewater systems. One resident who contributed to that study reported that "[Sewage] was coming back in my bathtub one time. I broke down crying."[42] The constant threat of flooded sewage during rainy days leaves residents in perpetual worry, and pooling sewage in yards prevents families from enjoying daily life. As another resident explained, she is "waiting for the year when spring break comes and her son and grandchildren can go outside and play in their yard. Or for the night when she can fall to sleep to the sound of rain and not fear."[43]

a. Stress and anxiety can impact both mental and physical health

The Mayo Clinic publishes medical information useful to the general public on its website and through newsletters. Its website highlights the impacts of stress on both mental and physical health, shown in *Table 8*.[44]

The Robert Wood Johnson Foundation published a series of reports on the social determinants of health that included an issue brief on stress and health.[45] The report identifies several health outcomes tied to stress including increased risk of obesity among children and adolescents and cardiovascular illness and diabetes among adults.[46]

Table 8. Common Effects of Stress.

Effects of Stress on the Body	Effects of Stress on Mood
Headache	Anxiety
Muscle Tension or Pain	Restlessness
Chest Pain	Lack of Motivation or Focus
Fatigue	Irritability or Anger
Stomach Upset	Sadness
Sleep Problems	Depression

4. Lack of Wastewater Access Impacts Community Development Potential

Several Health Impact Assessments have explored the relationship between community development and health outcomes. For example, *Community Development + Health: A Health Impact Assessment to Inform the Community Investment Tax Credit Program*[47] identifies several linkages between community development and mental and physical health. Increased affordable housing development can expand access to healthy and affordable homes which in turn increase economic security, improved indoor air quality, and access to walkable neighborhoods. Increased commercial space can increase development of healthy food vendors and healthcare facilities, increasing access to healthy foods and healthcare, as well as increased economic security. Increased parks and green space can lead to increased physical activity and social cohesion.[48] Collectively, community-driven community development can improve health, according to the health impact assessment, by reducing cardiovascular disease, cancer risk, respiratory disease, and obesity; reducing injuries and air pollution; improving mental health; and increasing access to preventative care.

a. Local plans and development standards impact community development potential in neighborhoods without centralized wastewater service

Through interviews and analyses of local government policies and practices, we assessed the potential impacts of inadequate wastewater access on community development goals including infill development for housing, goods and services such as small grocery stores and health care clinics, and economic development.

Each county in California is responsible for developing a plan and program called the Local Area Management Plan (LAMP) to regulate onsite wastewater treatment systems such as septic systems to protect groundwater and surface water quality. The process for developing a LAMP is distinct from General Plan development and updates, however General Plans should consider LAMPs when laying out growth projections and development priorities. Fresno County's LAMP includes a policy that "general septic system density will be limited to one system per two acres. Any new development or secondary dwellings will require a nitrogen loading analysis by a qualified professional, demonstrating…that the regional characteristics are such that an exception can be made." Similarly, other local policies including the City of Fresno's water management plan prohibits reliance on septic systems in urban areas.

The vast majority of parcels in disadvantaged unincorporated communities in Fresno County are far smaller than two acres and, as noted, many communities and parcels do not have access to centralized wastewater service. Accordingly, there is a significant barrier to development in communities that lack wastewater service.

b. Communities experience first-hand the community development obstacles associated with lack of wastewater service

Lack of wastewater services often plays a role in the intractable chicken-and-the-egg problem that community members face in their efforts to bring resources and development to their communities in the form of housing, services, and amenities. Often, no development proceeds without centralized wastewater service, yet it is frequently difficult to secure investments for wastewater services without certain development permits in place. Small mobile home parks in the eastern Coachella Valley demonstrate these obstacles. Due to lack of affordable housing in the region, Polanco Parks (small mobile home parks) developed to fill the housing void by providing alternative options to farm workers and low-income families. Many Polanco Parks were and remain unable to secure standard building and use permits due to local policies, bureaucratic obstacles, and high costs. At the same time, county policies prohibit wastewater service providers from connecting services to unpermitted mobile home parks, further hindering the parks' ability to draw resources for improvements.

The Community Advisory Group noted several other obstacles to development and community sustainability as a result of lack of centralized wastewater service. For example, several residents noted that when they advocate for increased investment in housing to address housing need, local agencies respond that nothing can move forward without reliable wastewater service. This reasoning not only prevents the development of affordable housing, but also the development of grocery stores, financial institutions, schools, and other community resources and amenities that are incredibly sparse and desperately needed in lower income, rural and urban communities.

c. Lack of wastewater access impacts affordable housing development

Non-profit housing developers confirmed that lack of wastewater access plays an enormous role in determining if and how to develop in a neighborhood. When asked, "[w]hat impact does lack of municipal wastewater service have on the development potential of a community or neighborhood," one non-profit housing developer simply answered, "[e]verything." He went on to say that access to wastewater service is one of the first questions asked an assessing the suitability of a site for development. In short, affordable housing developers seldom consider building homes in areas without centralized wastewater service. In the words of one developer, "I would say that land that has no sewer availability on the valley floor is worth nothing to us, because we wouldn't ever buy it."

Another non-profit developer highlighted the story of Paradise, California, as an illustration of the importance of wastewater service on development potential. Paradise was reliant on septic systems prior to the fire; however now the community members leading the recovery effort have identified investment in municipal wastewater as *the* fundamental building block to recovery. Without municipal wastewater as a foundation, investment in recovery will not occur.

Recommendations

We lay out below several program and policy recommendations that could and should be incorporated into Fresno County's General Plan and note that several of these recommendations are applicable to other jurisdictions as well. We also include recommendations with respect to research as this HIA has identified areas that require further inquiry and investigation.

A. General Plan Programs and Policies

We recommend that Fresno County add **Universal Access to Adequate Wastewater Service** as a goal in its general plan update in order to demonstrate the County's commitment to addressing this severe deficiency and furthering the vitality of existing and historic communities in the county. We also recommend that the General Plan add background information to describe and discuss the status of wastewater service in communities throughout the County. Most importantly, we recommend that the final General Plan Update include a variety of programs and policies to achieve the recommended goal of Universal Access to Adequate Wastewater Service. Specifically, we recommend that Fresno County add the following programs and policies to the General Plan Update.

Policy 1. Maintain up-to-date data on communities with inadequate wastewater service (Completed within 12 months of plan adoption)

- Program 1.1 – Create a list and map demonstrating which communities do not have centralized wastewater service that meets the requirements of local policies (Public Works and Planning), and those communities that are experiencing contamination from inadequate wastewater treatment and disposal (Public Works and Planning, Department of Public Health, Environmental Health)
- Program 1.2 – Conduct soil sampling in those communities among households that volunteer to participate to determine if wastewater is contaminating the soil (Department of Public Health, Environmental Health)
- Program 1.3 – Conduct drinking water testing among households that volunteer to participate to determine if wastewater is contaminating drinking water supplies (Department of Public Health, Environmental Health)
- Program 1.4 – Develop a proactive and voluntary well and soil testing program, free for lower income residents (Department of Public Health, Environmental Health)
- Program 1.5 – Continually update the list and map of which communities do not have centralized wastewater service (Public Works and Planning)

Policy 2. Secure funding to address wastewater needs

- Program 2.1 – Maintain up-to-date information regarding the unmet funding needs of projects proposed to address wastewater need (To be developed within 12 months of plan adoption and updated continually) (Public Works and Planning)
- Program 2.2 – Maintain up-to-date information regarding available federal, state, and regional funds for wastewater system investments including deadlines and qualifications for programs (Public Works and Planning)
- Program 2.3 – Contribute County funds for emergency wastewater needs and for use as match funds for federal, state, and regional funds for wastewater improvements (County Administrative Office)

- Program 2.4 – Seek state, federal, regional funds to support the development of adequate wastewater service (Public Works and Planning)

Policy 3. Collaborate with other local agencies, residents of impacted communities, and non-governmental entities to support development of adequate wastewater service to ensure that all known wastewater deficiencies are addressed within three years of plan adoption and emerging deficiencies are addressed within three years of their discovery.

- Program 3.1 – Collaborate with local not-for-profit organizations including Self Help Enterprises, Rural Communities Assistance Corporation, and Leadership Counsel for Justice and Accountability and community based organizations including Community United in Lanare to conduct outreach to assess threats of contamination (Public Works and Planning)
- Program 3.2 – Collaborate with local not-for-profit organizations including Self Help Enterprises, Rural Communities Assistance Corporation, and Leadership Counsel for Justice and Accountability and community based organizations including Community United in Lanare to develop projects designed to address wastewater needs (Public Works and Planning)
- Program 3.3 – Collaborate with relevant cities to secure adequate wastewater service in neighborhoods located in the county and within those cities' spheres of influence (Public Works and Planning)
- Policy 3.4 – Collaborate with the Regional Water Quality Control Board to test water quality and implement regional wastewater projects including service extensions and consolidations (Environmental Health, Public Works and Planning)
- Policy 3.5 – Collaborate with the Local Area Formation Commission to ensure appropriate and efficient government reorganization necessary to support wastewater projects (Public Works and Planning)
- Policy 3.6 – Hold a public meeting annually to provide updates on progress toward securing adequate wastewater service throughout Fresno County (Board of Supervisors)

Policy 4. Address and Prioritize Wastewater Service Needs in Existing Communities

- Policy 4.1 – Place a moratorium on development of new towns and / or new wastewater systems until all known unmet wastewater needs have been met in communities without adequate wastewater service (Board of Supervisors)
- Policy 4.2 – Collaborate with local not-for-profit organizations, community based organizations, the Regional Water Quality Control Board, and the State Water Resources Control Board to facilitate mandatory consolidation projects (Public Works and Planning)

B. Additional Recommendations for Fresno County Policies

Increase Attention to and Education Regarding Gastrointestinal Illness in Delivery of Health Services

- Ensure that medical providers consider exposures to pathogens in soils when treating for gastrointestinal illnesses
- Develop intake forms for use by medical providers to improve diagnosis and data collection regarding gastrointestinal illnesses

- Develop and disburse educational materials regarding gastrointestinal illnesses and the importance of treating such illnesses
- Track incidence of reported gastrointestinal infections in neighborhoods unserved by a centralized wastewater system

Integrate Health Considerations into Infrastructure Planning and Development

- Consider the potential public health benefits of infrastructure investments when determining which infrastructure investments to make and where to make them
- Consider health benefits and disadvantaged in short and long term transportation and land use planning processes.

Secure and Allocate Funding to Address and Mitigate Unmet Wastewater Needs

- Allocate discretionary County resources including general fund resources and a percentage of Community Development Block Grants to facilitate wastewater service upgrades and service consolidations
- Seek state and federal grant and loan funding to facilitate wastewater service upgrades and service consolidations
- Fund emergency drinking water supplies to households with water contaminated with acute contaminants including nitrate and bacteria

C. Opportunities for Further Research

This HIA identified several opportunities for future study including basic research regarding neighborhoods in California without access to centralized wastewater service. While we have utilized the best data available to identify lower income communities in Fresno County without centralized wastewater service, we acknowledge that due to gaps in data we have likely mischaracterized one or more as having, or not having, service. It may be most effective for state agencies, local agencies, non-governmental entities, and residents of unincorporated communities to work together to conduct a comprehensive and statewide analysis of wastewater access in California.

Another area for future development is expanded exploration though GIS tools. Our spatial GIS presentations were based on visualization of immediate data. Further research should incorporate advanced geospatial models to further examine the relationship between wastewater service and reports of infectious disease.

Further research analyzing rates of reporting relevant gastrointestinal diseases in different populations would be beneficial. We hypothesize that people underreport gastrointestinal diseases and, more specifically, that residents in rural communities are less likely to report gastrointestinal infections. Further research could confirm or controvert this hypothesis.

Additional research should also further characterize the occurrence of pathogens in a variety of soil types beyond the disadvantaged communities surveyed in this report. Soils from wildlands and uninhabited areas should be tested for the suite of pathogens reported here.

Conclusion

This HIA illustrated the serious health risks that could result in the short and long term from a failure to address lack of adequate wastewater service through direct and a proactive policy interventions. Not only do wastewater deficiencies threaten increased exposure to pathogens, but it also severely hinders the capacity of a neighborhood to thrive. These twin risks, in turn, impact the psychological well-being of inhabitants and further undermine health and wellness. The HIA also reinforced the urgency of developing a better understanding of the breadth and severity of deprivation from centralized wastewater service.

The problem of inadequate wastewater service is widespread in Fresno County, and, accordingly, we recommend that Fresno County take a leadership role in implementing policies and programs that will address the deficiencies and disparities in access to this vital service. We further recommend that counties and cities throughout the state replicate these policies in ways that will be most relevant and effective in each area. Recommendations include maintaining an accurate inventory of wastewater service needs in the county along with an analysis of funds necessary to address those needs: ongoing collaboration with impacted communities and other stakeholders to develop and implement projects that provide sustainable wastewater services; prioritizing wastewater services in existing communities as compared to providing services in new communities; and better integrating assessment of gastrointestinal illness in the delivery of health services.

We look forward to working with policymakers, researchers, and health professionals throughout the state to elevate the importance of reliable wastewater treatment and disposal. Through a collective commitment to addressing this issue, we can end an era when kids are exposed to salmonella in their own back yards, people awaken to sewage back-ups in their tubs, and neighborhoods are prohibited from growing and thriving due to historic and ongoing lack of investment in wastewater service.

Appendix A – Risk Assessment for Children

The risk assessment that we used assumed a specific type of contact with soil that children in rural households will have. The major model parameters that we considered are listed in *Table 9* below. These are variables that could put children at risk for contracting diseases associated with *Listeria monocytogenes*, *Salmonella typhi* or *Campylobacter jejuni*.

We linked all of these items together in a dose equation that considered the concentration that we could obtain from laboratory analysis of 14 different soil samples of houses without a sanitary sewer system in Fresno County. In Fresno County, soil samples were obtained from areas where community partners work with the LCJA staff. These are Lanare, Tombstone Territory, Southwest Fresno, the Jane Addams neighborhood, and Malaga. In the Eastern Coachella Valley, a total of 8 soil samples were collected from Thermal, Oasis, and North Shore.

The Reference Pathogen Level (RPL) that a child playing in the soil would be exposed to is considered in the following equation with the symbols detailed in *Table 9*:

$$RPL = D_i = N * SA * SS * HM * TE * ED$$

We used a Beta-Poisson model to estimate the probability of listeriosis infection for a child who is exposed to soil contaminated with *Listeria monocytogenes*, *Salmonella typhi* or *Campylobacter jejuni*. That equation is:

$$P(infection) = 1 - \left[1 + D\frac{\left(2^{\frac{1}{\propto}} - 1\right)}{N_{50}}\right]^{-\propto}$$

Where,
N_{50} = dose at which
50% of population is expected to be affected
α = fitting parameter from published dose response literature
D = Dose ingested = RPL (reference pathogen level)

The above dose response model was selected from a wiki[50] and publication[51] that suggest animal/human based infection studies for various pathogens.

Table 9. The variables used to build the QMRA model that estimates risk of Listeria monocytogenes, Campylobacter jejuni or Salmonella typhi infection among children who play in contaminated soil.

Variable	Symbol	Units	Distribution (Parameters)	Source/ Reference
Bacteria Concentration	N	Bacteria/grams	MaxExtreme (Listeria m)	This Study
Surface Area (HAND) mouthed	SA	cm^2	Triangular (20, 17 to 24)	USEPA (2006)
Contact Time: Exposure Duration	ED	hour/day	Normal (1.66, -0.4)	Shibata (2017)
Transfer Frequency: Between Soil and Hand	TE	frequency	Triangular (0.16, 0.25)	Kissel (1998)
Frequency Occurance: Hand to mouth	HM	occurance/hour	Normal (9, 5, 2)	Reed et al. (1999)
Adherance: Soil to Skin	SS	$grams/cm^2$	Log-normal (0.0016, 0.0002)	Holmes (1996)

The risk assessment results found that the probability of infection lies between 68% and 75%. That implies that a child who sits in the soil and plays with their bare hands has a 2 out of 3 chance of contracting listeriosis from being exposed in the soil. The assumptions for that model are summarized as:

- The child is 3–4 years old
- HM: The child touches their mouth 9.5 times per hour
- ED: The child plays an average of 1.66 hours in the contaminated soil per day.
- SA: The surface area of a child's fingers that are inserted into their mouth is 20 cm^2.
- TE: The soil that the touches the child's hands has a 16% chance to stay on their hands and are transferred to their mouth.
- SS: About 0.16% of the soil that the child touches will stay on the child's hands long enough to go into their mouth.

Figure 9. A screenshot from the Crystal Ball (Oracle, US) risk assessment software that shows the probability of illness in a child from the ages of 3–4 years old after playing in soil that is contaminated with Listeria monocytogenes. The mean risk of listeriosis is 11.4% chance of getting sick.

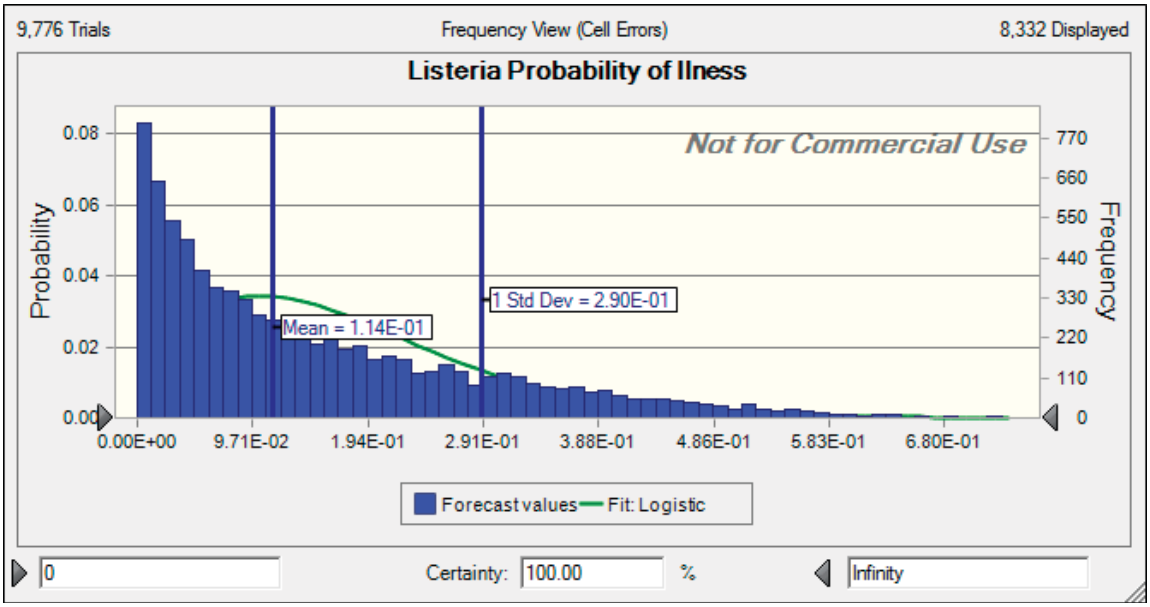

Figure 10. A screenshot from the Crystal Ball risk assessment software that shows the probability of illness in a child from the ages of 3–4 years old after playing in soil that is contaminated with Salmonella. The mean risk of getting sick from Salmonella typhi is 0.09%.

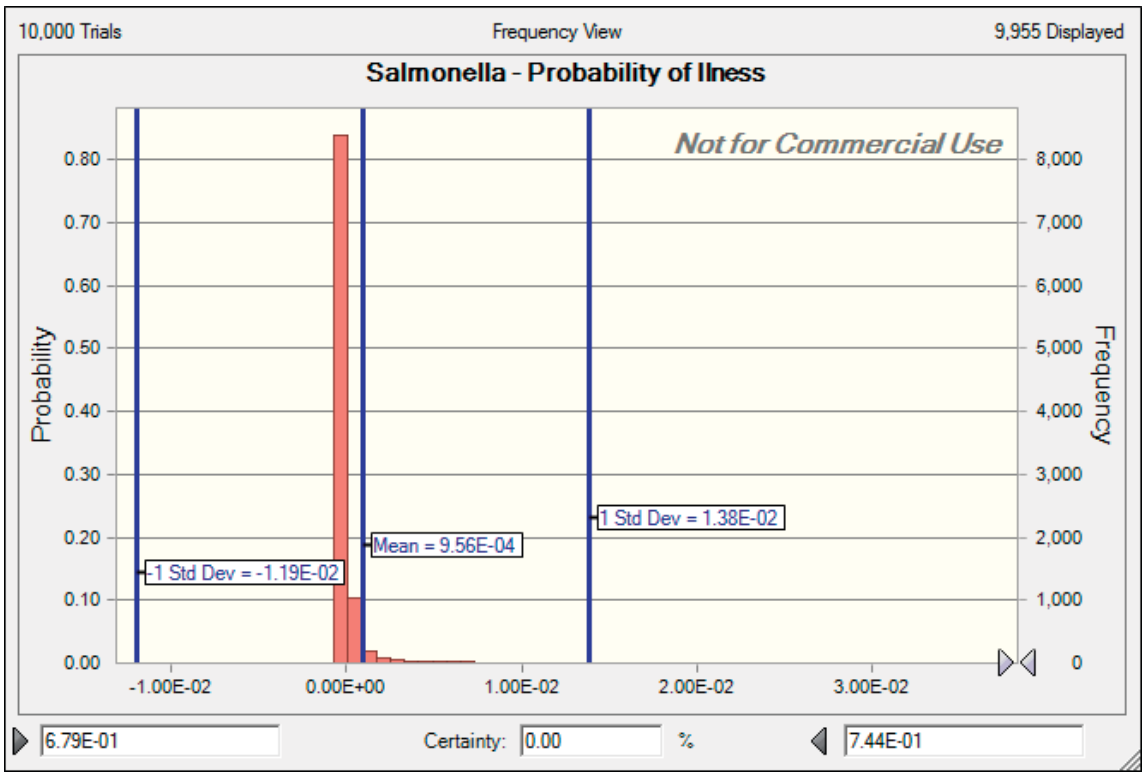

Figure 11. A screenshot from the Crystal Ball risk assessment software that shows the probability of illness in a child from the ages of 3–4 years old after playing in soil that is contaminated with Campylobacter. The mean risk of getting sick from Campylobacter jejuni is 13.9%.

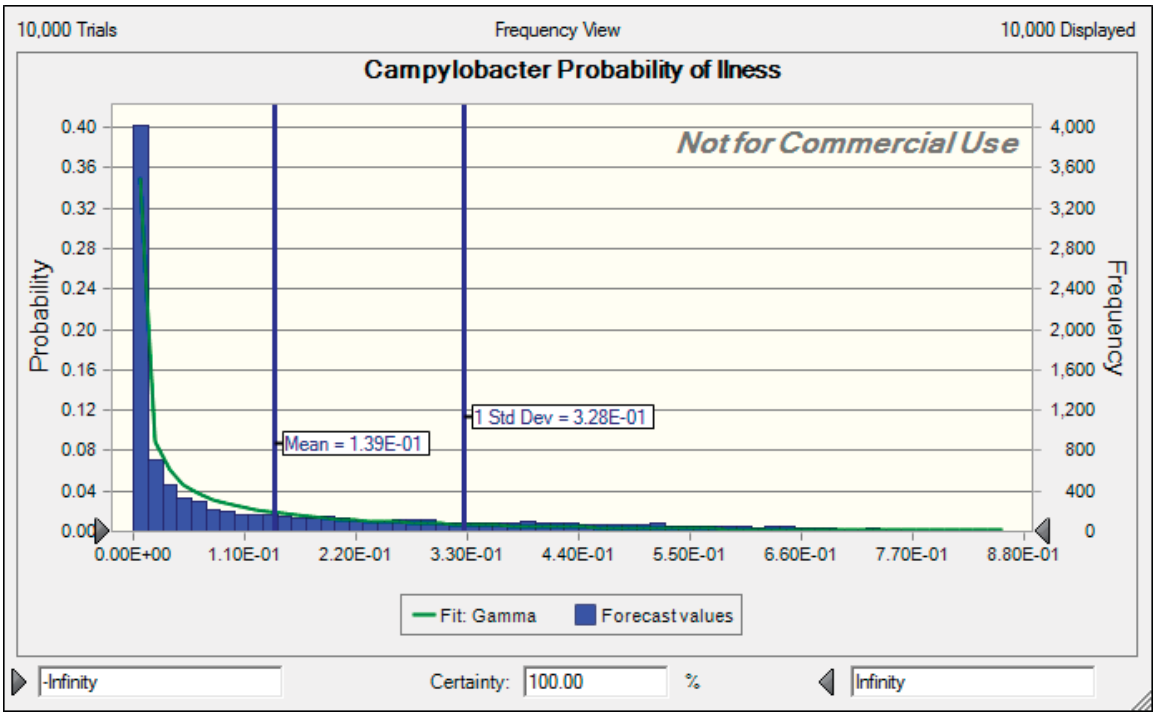

Figure 12. Sensitivity charts for the three organism models. These detail the model parameters that contribute to the most variation. For Listeria, the variable concentration (N) in the soil drives the risk assessment. The secondary variable is the soil to skin adherence (SS). The Campylobacter and Salmonella models are driven by the soil concentration without a secondary variable.

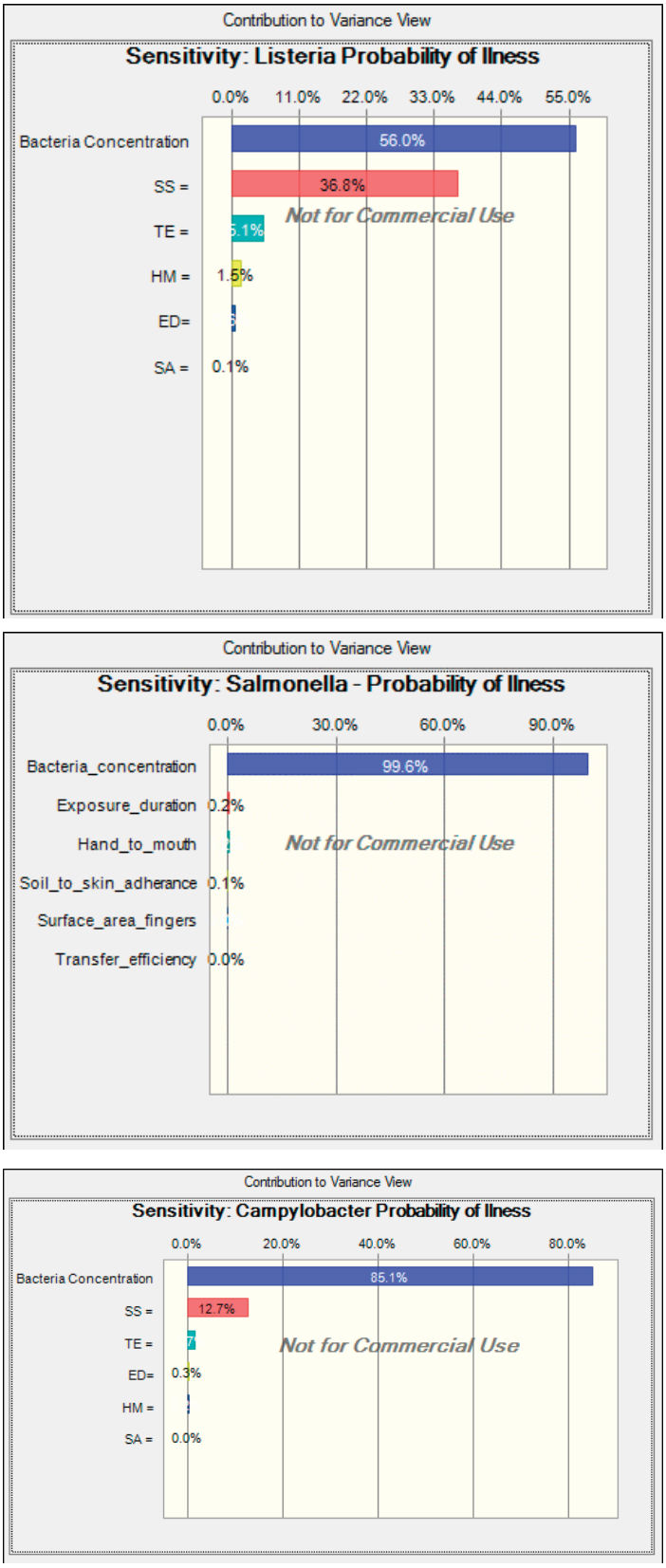

Table 10. The average, standard deviation (SD) and sample number (N) of bacteria concentrations from samples collected in Fresno, Tulare, Madera and Riverside county disadvantaged communities. Bacteria are counted in Most Probable Number (MPN) per 100ml of water for drinking water or in MPN per 1 gram of soil.

	E.coli	Total Coliform	*Enterococcus*	*Listeria m.*	*Salmonella spp.*	*Campylobacter*
All County Average Soil Bacteria Concentration (Organisms/1 gram)	$1.19x10^4$ N=22	$1.27x10^6$ N=11	$3.20x10^5$ N=11	191 N=28	226 N=28	599 N=28
Fresno County Average Soil Bacteria Concentration (Organisms/1 gram)	$1.98\ x10^4$ N=13	$2.32\ x10^6$ N=6	$5.85\ x10^5$ N=6	137 N=14	51.8 N=14	251 N=14
Raw wastewater reference	$3.4x10^5$ (Raw wastewater per 100ml)[52]	$6.46x10^5$ (Raw wastewater per gram)[53]	$3.2x10^5$ (Raw wastewater per 100ml)[5]	57 (Raw wastewater per gram)[54]	471 (Raw wastewater per gram)[6]	1–1,000 (Raw wastewater per gram)[55]

Results from Soil Testing: *Table 10* Table 10above shows the concentrations of bacteria in soil from all the samples collected in Fresno, Tulare, Madera and Riverside counties. All soil samples were taken from the soil directly above the household's septic tank system. The average concentration is high and presents a health risk. There is also raw wastewater concentrations listed on the bottom row of the table for comparison. The table lists common indicator bacteria and three frank pathogens. The indicator bacteria indicate that the soil or water is contaminated with human fecal pollution, while the frank pathogens also indicate that there is human fecal contamination and a risk of disease transmission. The three pathogens listed are *Listeria monocytogenes*, *Campylobacter jejuni* and *Salmonella typhi*. All bacteria in *Table 10* were collected in the field and processed using cultivable microbiology and followed common methods in the Standard Methods for Water and Wastewater[56] as well as the FDA's laboratory manual.[57] The positive results were confirmed with molecular qPCR.

Table 13 shows four houses out of 22 houses on district provided tap water that had total coliform readings higher than expected. This may be due to faulty premise plumbing in the house (from the septic system) or a contamination issue in the water district. None of these samples were positive for the *E.coli* indicator.

Appendix B – Microbial Sampling Methods

Sample Collection:

The LLU team traveled to locations in Fresno, Madera, and Riverside Counties between August 2018 and March 03, 2019. Soil and water samples were collected in all locations and analyzed for Total Coliforms, *E.coli*, *Campylobacter* and *Listeria monocytogenes* and *Salmonella typhimurium*. These three pathogens and two indicators were chosen as indicators of mammal fecal contamination and potential health risk for children who may play near overflowing septic tanks or nearby contaminated soil.

The LLU team collected water samples from the resident's indoor kitchen tap and water cooler tap and/or refrigerator filter tap. The team also swabbed the inside of the kitchen faucet spigot, the water cooler spigot and/or the refrigerator spigot. The team swabbed the inside neck of a 5 gallon water jug in two households. Chlorine and temperature were also assessed.

Laboratory Analysis Methods:

The LLU team uses food microbiology methods to determine the presence and possible concentrations of *Salmonella* and *Listeria*.[58] Soil samples were collected in the field using gloves and a scoop to obtain a 300 gram portion of soil from a moist area that local residents had labeled as potentially contaminated with sewage. This sampling scheme allowed a soil sample to represent an area that was potentially contaminated with pathogens. The sampling scheme also allowed for a participatory method where the household resident is made aware of a potential public health hazard for them and their family. The Standard method of wastewater sampling would not be appropriate for this report because family members and children do not usually have direct contact with the liquid wastewater that is inside of the septic system.

The sample was collected and stored on ice and processed in the laboratory within 24 hours. Soil samples were homogenized and then 10 grams of the mud/soil was dried in a 105°C oven for 30 minutes to obtain the dry weight of the soil. Another 1 gram of the soil was taken and diluted into

5.33 ml of PBS which was vortexed for 10 seconds. The vortexed PBS was divided into 15 tubes of enrichment broth in duplicate for both the *Listeria* and *Salmonella* using the 15-tube MPN method where 5.55ml was distributed into 5 (1ml) tubes, 0.1 ml into 5 tubes and 0.01ml into 5 tubes until the 5ml of liquid sample was finished. The *Salmonella spp.* enrichment was with Buffered Peptone Water which was incubated and then transferred to RV broth, incubated and transferred onto *Oxoid Salmonella/Shigella* plates using appropriate antibiotic supplements. Positive plates were confirmed and serotypes were determined using the Wellcollex *Salmonella* latex test confirmed by a qPCR test.

Listeria samples were processed identically and used the UVM broth in MPN tubes incubated at referenced temperatures for 24 hours. The tubes which changed color were plated onto Difco Palcam plates and incubated in a microaerophillic environment at a referenced temperature for 48 hours. A qPCR and motility test were used to confirm the *Listeria monocytogenes*.

The ATCC positive controls of *Listeria monocytogenes* and *Salmonella typhimurium* were run parallel with all assessments. All samples were processed in duplicate and averages taken from the MPN method as referenced by Jarvis.[59]

All water and swab samples were processed for *E.coli*, *Enterococcus* and Total Coliform with the IDEXX Quanti-Tray system.[60] All samples were processed in duplicate for each soil and water assessment.

Field Sampling Methods and Results:

Samples were collected by project personnel and transported on ice to the Loma Linda University Environmental Microbiology Research Laboratory. The samples were processed within 24 hours of collection. All samples were also concentrated and archived for further molecular testing.

Table 11. Summary of all soil samples collected in Riverside County, Fresno County, Madera and Tulare Counties

	E.coli	Total Coliform	*Enterococcus*	*Listeria m.*	*Salmonella spp.*	*Campylobacter j.*
All samples						
Average (organisms*/g)	11,914	1,268,455	319,637	191	226	599
Standard Dev. (organisms/g)	35,480	3,808,371	886,285	320	796	874
Geometric mean (organisms/g)	35.9	352	1370	15.6	4.25	36.3
Number samples	22	11	11	28	28	28
Max	127,095	13,307,800	3,111,540	1,423	4,324	2,523
Fresno						
Average (organisms*/g)	19,751	2,324,796	585,023	137	51.8	251
Standard Dev. (organisms/g)	44,495	4,912,760	1,133,640	96.9	88.2	405
Geometric mean (organisms/g)	65.5	3270	14,534	47.0	0.84	13.6
Number samples	13	6	6	14	14	14
Max	127,095	13,307,800	3,111,540	288	288	1,423
Riverside						
Average (organisms*/g)	51.1	845	1,174	213	554	1,069
Standard Dev. (organisms/g)	102	954	1,566	417	1,264	1,022
Geometric mean (organisms/g)	0.48	24.2	80.6	2.67	56.8	306
Number samples	5	5	5	10	10	10
Max	255	2,010	4,040	1,423	4,324	2,523
Madera & Tulare						
Average (organisms*/g)	1,275	–	–	328	18	640
Standard Dev. (organisms/g)	721	–	–	469	18	1,087
Geometric mean (organisms/g)	1,124	–	–	28	2	5
Number samples	4	0	0	4	4	4
Max	2,523	–	–	1,135	36	2,523

**All organisms are counted through the Most Probable Number (MPN) methodology.*

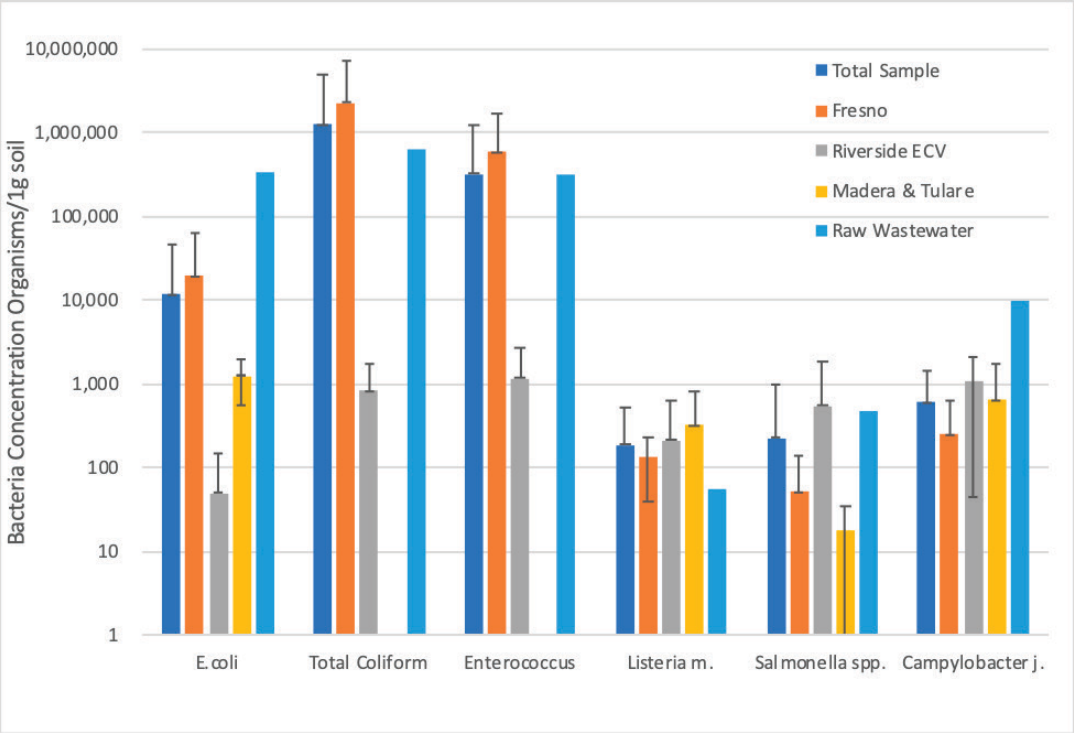

Figure 13. Average concentration of bacteria in soil shown across four counties with standard deviation bars. The "Total Sample" is the average of the bacteria concentration for all areas including Madera, Tulare, Fresno and the ECV.

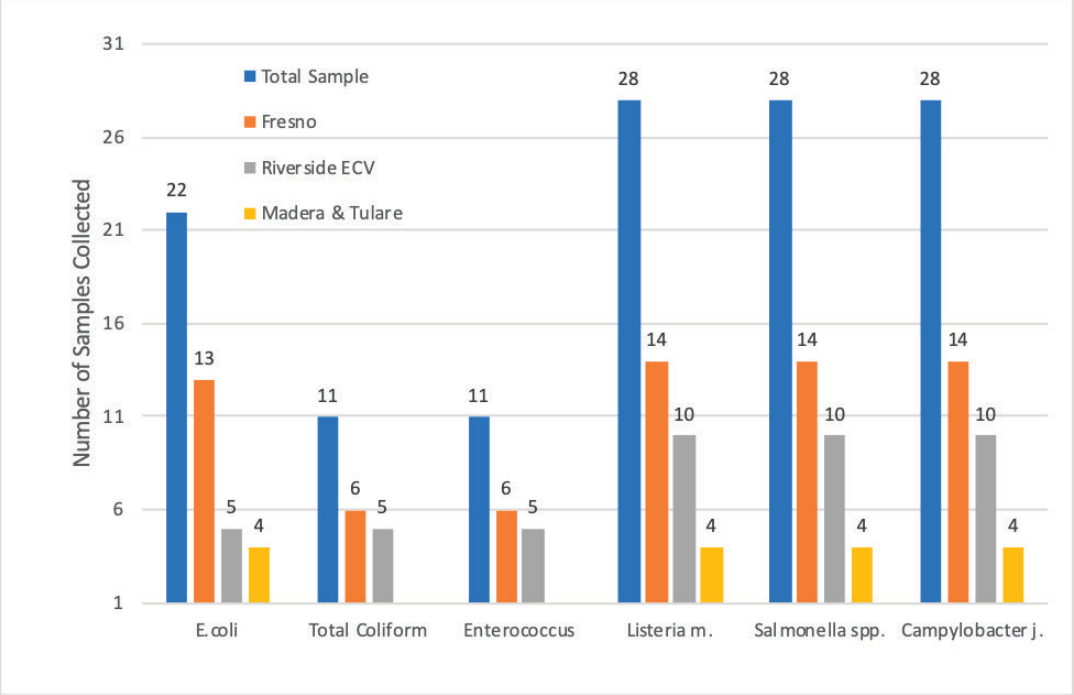

Figure 14. Number of soil samples taken in each county. The "Total Sample" is the total number of samples for each organism.

Table 12. Final concentrations of bacteria counts for 28 different samples and 6 organisms across four different counties.

Sample ID	County	*E.coli*	Total Coliform	*Enterococcus*	*Listeria m.*	*Salmonella spp.*	*Campylobacter j.*
1948	Fresno	127,095	13,307,800	–	288	146	5
20620	Fresno	–	–	–	288	<1	<1
20755	Fresno	<1	241,960*	155,310	145	146	23
20786	Fresno	<1	–	520	145	<1	<1
20810	Fresno	<1	–	310	154	<1	<1
20852	Fresno	3,600	<1	500	151	<1	22
25528	Fresno	120,980	241,960*	3,111,540	288	288	<1
3852	Fresno	<1	<1	–	148	<1	4
1415	Fresno	<1	157,055	241,960*	156	144	144
7236	Fresno	1,423	–	–	81	<1	378
65830#12	Fresno	1,423	–	–	32	<1	1,423
65830#6	Fresno	883	–	–	<1	<1	396
2046S	Fresno	883	–	–	36	<1	882
2046FY	Fresno	469	–	–	<1	<1	234
19341	Madera	811	–	–	1135	36	36
20278	Madera	2,523	–	–	36	<1	2,523
87842	Riverside	–	–	–	234	4,324	2,342
66700	Riverside	–	–	–	234	81	595
88855	Riverside	–	–	–	<1	<1	1,982
SunBird1	Riverside	–	–	–	234	67	2,342
SunBird2	Riverside	–	–	–	1,423	450	2,522
6975	Riverside	<1	<1	50	<1	1.5	1
99200 (North shore)	Riverside	<1	<1	<1	<1	35	37
Freemont (Thermal)	Riverside	<1	205	100	<1	148	288
Garcia (Thermal)	Riverside	255	2,010	1,680	<1	146	288
Chicanita (Oasis)	Riverside	<1	2,010	4,040	<1	288	288
256	Tulare	882	–	–	141	36	<1
522	Tulare	882	–	–	<1	<1	<1

**The lower limit of detection was designated by "<1" and is converted to "0.1" to calculate averages. The upper method detection limit of the IDEXX QuantiTray system was used to calculate averages.*

Table 13. Final concentrations of bacteria testing for all water samples collected in Fresno, Riverside, Madera and Tulare counties.

Location	Sample ID	Water District?	Detail	*E.coli*	Total Coliform	*Enterococcus*
Riverdale	20810BWD	small system	private community well	<1	<1	<1
	20810BWD	no	fridge carbon filter of well	<1	<1	310
	20810BWT	no	Community well source	<1	<1	100
Fresno City fringe	1948BWD	small system	from vending machine: 5 gallon	8.15E+05	9.35E+06	<1
	1948BWT	small system	Contaminated well water from trailer park owner	>1600	1.96E+04	<1
Lanare	20620BWD (or 20755)	small system	Tap water from community system	<1	310	<1
	20620BWT (or 20755)	small system	Vending machine: 5 gallon	<1	<1	1950
Riverdale	20786BWD	small system	Tap water from community system	1	1115	1935
	20786BWT	small system	from vending machine: 5 gallon	<1	100	<1
Riverdale	20852BWD	small system	from vending machine: 5 gallon	<1	1.50E+04	360
	20852BWT	small system	Tap water from community system	<1	980	410
Sanger	3858BWD	no	from vending machine: 5 gallon	<1	<1	<1
	3858BWT	no	private well water	<1	568	100
Fresno City fringe	2528BWT	yes	water from tap	<1	1.96E+08	<1
Fresno City fringe	415BWT	no	Water from delivery truck	<1	<1	<1
Fresno City fringe	2046BWD	no	Well water from fridge filter	<1	<1	–
	2046BWT	no	Water from private well	<1	<1	–
Fairmead	20278BWD	no	from vending machine: 5 gallon	<1	410	–
	20278BWT	no	Water from well	<1	9310	–
Tulare	522BWD	no	from vending machine: 5 gallon	<1	<1	–
	522BWT	yes	District water is reported to be contaminated with chemical	<1	<1	–
Tulare	256BWD	no	from vending machine: 5 gallon	<1	200	–
	256BWT	no	Sink water from well	<1	<1	–

Appendix C – Screening Summary

**Note re Screening Summary: We included here the Screening Summary we developed for this HIA in the early summer of 2018. The timelines for release of an updated Fresno County Draft General Plan have shifted substantially during the course of the development of this HIA and as a result the timeline included in this Screening Summary are no longer correct. As discussed in the HIA, we now anticipate release of an updated Draft General Plan Update in early 2020.*

The Health Impact Assessment will assess the Fresno County General Plan, including the draft Environmental Impact Assessment that will support the General Plan. While there were several potential decisions that would have benefited from HIA, we determined that the Fresno County General Plan was the best focus due to a variety of factors including interest of the Community Advisory Group to develop strong research tools to support advocacy on the General Plan, timing of the General Plan review and adoption, and relevance of recommendations derived through this HIA to other decisions in the near future that could impact health and well-being.

Fresno County General Plan

Fresno County is updating its general plan for the first time in almost 20 years. A General Plan is often referred to as the constitution of a jurisdiction so far as land use is concerned. It lays out both the goals and policies of a jurisdiction with respect to growth in development and, to those ends, sets goals and policies with respect to land use designations, investments, and infrastructure standards. Following adoption of a general plan, all land use decisions in the jurisdiction must demonstrate consistency with the general plan.

The general plan also includes implantation measures designed to effectuate the adopted goals and policies and may attach timelines to those implementation measures. Securing strong implementation measures in a general plan can be an effective way of ensuring that community-identified goals are in fact implemented.

There are several elements and components in the General Plan that should impact wastewater service including the land use element which sets out minimum standards for different housing types, the public facilities section which includes goals and priorities for public facility investment, the housing element which includes an inventory of sites available throughout the county for housing, and the environmental justice element. General plans must be internally consistent — meaning goals in policies in one chapter must be consistent with goals and policies in another. Accordingly, if the environmental justice element includes increased access to reliable wastewater service as a goal, the public facilities and land use policies must also reflect that goal. The inclusion of environmental justice in the General Plan provides a heightened opportunity to integrate programs and policies throughout the Plan that reflect the need for better basic services, including wastewater service.

We also see the General Plan as an opportunity to develop analyses and recommendations that can be replicated in General Plans throughout the state as well as other land use and investment decisions that impact lower income communities throughout the state. Fresno is one of the first jurisdictions developing a general plan in the context of the new law that requires environmental justice elements but several will soon follow. If we are able to build a strong case for including improved policies in this general plan, we are hopeful that we can advocate for inclusion of similar policies in other plans. Similarly, the analyses that we will conduct will hopefully inform decisions with respect to wastewater, land use and infrastructure investment in other communities, including those communities that make up the Community Advisory Group.

Fresno County has released a draft General Plan to which we submitted comments in early May. The County will hold workshops during the summer of 2018 on the Draft and we will continue to comments on its strong points and deficiencies in those workshops. The County will then develop a draft Environmental Impact Report (EIR) to accompany the General Plan. The County is set to release the Draft EIR in the late summer or early fall of 2018. The EIR provides a more formal comment and response period which will extend through the late fall. Our plan is to conduct the HIA prior to the opening of the comment period for the EIR and include recommendations — and supporting analyses — in our comments to the EIR. The County must respond to each comment submitted in response to the EIR prior to adoption of both the EIR and General Plan and can make changes to the General Plan to respond to and conform with submitted recommendations. We estimate a spring 2019 adoption of the general plan.

Opportunity to Impact the Fresno County General Plan

The General Plan includes several policies related to infrastructure and wastewater service, yet does not assess the relationship between wastewater service and health. The HIA presents an opportunity to ensure inclusion of health considerations in the County's goals, policies, and programs with respect to wastewater service, infrastructure priorities, and development goals. In general, land use policy, including general plans, is supposed to further public health. Thus, this HIA can help fill the gap that the General Plan currently maintains with respect to the relationship between and among wastewater service, public health, community health, and equity.

The EIR process provides a good opportunity to impact the General Plan for several reasons. Review of the EIR is conducive to in depth analysis and recommendations as it is based on scientific assessment and this will provide a strong platform for the HIA. Additionally, there is a statutory framework that both ensures a written comment period and public engagement opportunities as well as the county's obligation to respond to submitted comments and make changes to the General Plan in response to comments. Finally, the timing and timeline of the EIR and General Plan review and adoption fits well within the timeline of this HIA. The Draft EIR is scheduled to come out in the late summer or early fall and will be followed by a comment period. General Plan adoption is set for the early spring of 2019.

Engagement in the Screening Process

We engaged both the Community Advisory Group and the Technical Advisory Committee in the Screening Process. Two of the primary reasons that we chose the Fresno County General Plan as the target for our HIA are (1) the interest among Fresno County community residents who make up the Community Advisor Group in increasing and deepening engagement on the Fresno General Plan, and (2) the interest among community residents in both target regions (Fresno and the Coachella Valley) to develop recommendations with respect to land use and wastewater service that could be employed in other decision-making processes that will take place in both regions in the next year or two.

Fresno County residents have been engaged in general plan analysis to date and are extremely excited about the opportunity to strengthen their understanding of the General Plan and its implications through development of the HIA. They are also confident that an HIA can help strengthen their advocacy with County decision-makers to further consider health and equity in General Plan development and implementation. Residents from both regions — Fresno County and the Coachella Valley — feel that the General Plan also provides an opportunity to take a broad look at

wastewater access and related policies that can be applied to other decisions. Both the Community Advisory Group and the Technical Advisory Committee considered several decision-making processes apart from the Fresno County General Plan. While this HIA will not focus on those processes, the Community Advisory Group felt that findings and recommendation from the HIA could help advocacy in those other contexts.

The Technical Advisory Committee was much more concerned with the Scoping, Assessment and Recommendations phases of the HIA and were less concerned with the decision-making process that we were going to target as long as the HIA could inform meaningful changes and the HIA's analysis and recommendations could be applied to other processes.

Appendix D – Scoping Summary

We developed our HIA Scope through a series of community meetings, a regional meeting, a regional training and communications with our Technical Advisory Committee (TAC)[61] but will continue to seek feedback to ensure that the Scope is complete and accurately represents the priorities of the Community Advisory Group (CAG)[62] and reflects best available data and information. The HIA goals and research questions reflect the CAG's desire to address both risks and opportunities in Fresno and develop public information and policies that can impact health throughout the state.

HIA Goals

There are several interrelated goals of this HIA. Primary goals include:

- Developing local policy interventions that will be incorporated into the Fresno County General Plan
- Ensuring meaningful community engagement in development of the Fresno County General Plan
- Developing local policy interventions that can be incorporated into other local and regional plans throughout California
- Increasing knowledge among the public and policy-makers of the potential health impacts of lack of adequate wastewater management.[62]

Who will conduct and review the HIA?

Leadership Counsel staff will develop the HIA with coordinated research from Ryan Sinclair from Loma Linda University. Primary staff will include Amanda Monaco and Grecia Elenes who will lead both community engagement in Fresno and analysis of local plans, Rebecca Zaragoza and Lesly Figueroa who will lead community engagement in the Coachella Valley, and Phoebe Seaton who will lead literature review and oversee other components of project implementation. Additionally, Ryan Sinclair will work with Leadership Counsel staff and community members to collect soil and water samples and will analyze those samples.

We anticipate that members of the Technical Advisory Committee will contribute information as well toward development of the HIA. Some likely contributions include Fresno County infrastructure data and health data from Joe Prado (Fresno County Public Health) and information from interviews with non-profit housing developers including RCAC and Self Help Enterprises.

The Community Advisory Group and Technical Advisory Committee will also contribute to and review the HIA at different stages of development and provide feedback. The Community Advisory Group helped guide and drive the screening and scoping components of the HIA and the TAC provided input as well. The CAB and TAC will also review the scoping plan and provide feedback that we will incorporate. The CAG will participate in the assessment and, as noted above, TAC members will contribute to the assessment as well. We will review the assessment with the CAG through community meetings and with the TAC through email and a conference call in draft form and seek input that we will incorporate into a final draft. We anticipate that the CAG will be heavily involved in developing recommendations, and we will seek input from the TAC as well through email and conference calls. We anticipate that the CAB will help lead reporting but will seek support from the TAC as well. Finally, we will engage both the CAG and TAC in Monitoring and Evaluation activities.

Geographic boundaries

We will focus on communities, neighborhoods, and households in Fresno County and the City of Fresno that do not have access to municipal wastewater service as well as policies and programs related to wastewater management in Fresno County. We will also include data from communities, neighborhoods and households in Riverside county that do not have access to municipal wastewater service. We will consider existing and potential future impacts of inadequate wastewater management.

Hypothesized project impacts on health or health determinants

We will consider how a Fresno County General Plan that fails to include aggressive programs and policies to address deprivation from adequate wastewater service would impact both health outcomes and health determinants. We developed a broad list of priority health impacts of health determinants with the Community Advisory Group through community meetings, individual conversations, and regional/cross-regional trainings and meetings. Specifically, we developed a broad list of determinants and impacts through community meetings and a cross regional (Fresno and Coachella Valley meeting). We then identified highest priorities among the identified impacts/determinants through a regional training and community meetings. We will seek further review or input from the Technical Advisory Committee, however do not anticipate changes to prioritized health impacts/determinants.

Some of the impacts on health determinants and outcomes we highlighted include the following (with the priority areas bolded):

- **Increased exposure to pathogens**
  - **— Increased stress and anxiety**
  - **— Increased illness and/or infection**
- **Decreased economic and community development opportunities**
  - — Decreased property values
  - **— Reduced social cohesion and increased feelings of isolation**
- Reduced outdoor play
- Increased bad odors
- Increased prevalence of flies and mosquitos

Existing conditions

The current scenario is that several urban pockets and rural communities in Fresno County and beyond do not have municipal wastewater service or otherwise adequate wastewater management services and infrastructure. As a result, we have identified some of the following relevant existing conditions/potential existing conditions:

- Pathogens in soil
- Pathogens in tap water
- Increased odor levels
- Inability to develop in certain neighborhoods due to regulations regarding septic systems
- Wastewater rising to the surface and backing into homes (more research needed)

- Possible disproportionate impact on immigrant communities and communities of color (more research is needed)
- Possible increased prevalence of flies and mosquitos (more research is needed)
- Possible depressed property values (more research is needed)
- Possible increased exposure to pathogens and nitrates among residents (more research needed)
- Differential health outcomes in impacted neighborhoods (more research needed)

Research Questions/Data Sources/Methodology

We have developed several research questions, however as we conduct more outreach and more research, more questions emerge. Laid out below are the research questions and potential data.

Table 14. Research questions, data sources and experts.

Research Question	Data Source	Experts and Agency Resources	Notes/Details
Which/how many communities/households are not served by municipal wastewater service in Fresno County and the Eastern Coachella Valley?	Maps of municipal wastewater service lines in Fresno County	• Fresno County Public Health (Joe Prado) • Fresno County Planning • Fresno County Local Agency Formation Commission	
	Municipal wastewater service maps from individual cities and service providers	• Municipal planning departments • Municipal public works departments	
	Parcel Maps for Fresno County	• Fresno County Planning	
	Maps of municipal wastewater service lines in East Riverside County	• Coachella Valley Water District • IRWMP reports and mapping (Ryan Sinclair) • CVWD Disadvantaged Community Task Force	
	Parcel maps of Riverside County	• Riverside County Transportation and Land Management Agency	
Is there disproportionate representation based on race, ethnicity, income / wealth, or immigrant status households with municipal wastewater service as compared with households without municipal wastewater service?	Census Data		
	Third Party Surveys	• Pacific Institute • Self Help Enterprises • Rural Communities Assistance Corporation	
	Literature Review		
What local policies/ practices/programs currently in place either perpetuate or remediate the phenomenon of unserved communities and households?	Fresno County General Plan	• Interviews with county staff	
	Local Area Management Plan	• Interviews with regional water quality control board staff	
	Municipal General Plans		

Research Question	Data Source	Experts and Agency Resources	Notes/Details
What policies/practices/ programs proposed in the General Plan either perpetuate or remediate the phenomenon of unserved communities and households?	Proposed Fresno County programs and policies (Draft Fresno County General Plan Update)		
How does lack of adequate wastewater management service and infrastructure contribute to pathogens and nitrate in soil, groundwater, or drinking water?	Soil and Water samples		• Samples will be collected and analyzed by Ryan Sinclair of Loma Linda along with impacted community residents
		• Community level expertise	• Community meetings • Conversations with community members • Oral and written declarations/ statements from impacted residents • Surveys that have already been conducted of/with community members
	Literature Review		
What are the health outcomes of exposure to pathogens in soil and groundwater?		• Community level expertise	• Community meetings • Conversations with community members • Surveys that have already been conducted of/with community members • Oral and written declarations/ statements from impacted residents
	County health data	• Interviews with County staff • Available data collected by county staff (Joe Prado) • CHIS data	
	Literature Review		
How does lack of wastewater service impact people's daily lives and long term decisions?		• Community level expertise	• Community meetings • Conversations with community members • Surveys that have already been conducted of/with community members • Oral and written declarations/ statements from impacted residents
		• Expertise of developers	• Interviews with developers, in particular non-profit housing developers
	Existing Policies that impact to Fresno County	• Fresno County General Plan • Interviews with county staff • Local Area Management Plan • Relevant Fresno County LAFCO policies • LAFCO Municipal Service reviews • Interviews with regional water quality control board staff • Interviews with LAFCO staff	

Research Question	Data Source	Experts and Agency Resources	Notes/Details
What impact does lack of municipal wastewater service have on property values?	Property sales/listings	• Websites such as Zillow, Redfin, etc. • Interviews with realtors • Assessed property values • Interviews with realtors • Interviews with assessors	
	Literature Review		• Determine if there is any existing research on this
What policies and programs, if in place, would address the impacts of inadequate wastewater management services and infrastructure?	Programs and Policies from other jurisdictions		
	Model programs and policies		
	Literature Review		

Potential alternatives or mitigations

Potential alternatives and mitigations to address inadequate wastewater service would include both programs and policies that encourage increased access to adequate wastewater management service and infrastructure and increased resources to expand access to adequate wastewater management.

- Programs/Policies that encourage increased access to adequate wastewater management, including, through:
  - Extension of municipal wastewater service into a community or neighborhood from an existing service provider
  - Development of small community wastewater treatment systems
  - Improved onsite, individual septic systems
- Increased resources/funding allocations for increased access to adequate wastewater management
- Increased public health interventions including increased monitoring of unsafe wastewater service in communities by public health officials

References

1 Fresno County General Plan Review and Revision Public Review Draft December 2017. Available at: https://www.co.fresno.ca.us/home/showdocument?id=22794), pp. 1-228, 3-18

2 Ibid at 1-228

3 Ibid

4 General Plan Guidelines, page 1. California Office of Planning and Research. Available at http://www.opr.ca.gov/docs/OPR_C1_final.pdf

5 California Government Code § 65300.

6 General Plan Guidelines, page 10. Available at http://www.opr.ca.gov/docs/OPR_C2_final.pdf

7 California Government Code §65041.1

8 California Government Code §65302.10(a)

9 Allaire, Maura, Haowei Wu, and Upmanu Lall. "National Trends in Drinking Water Quality Violations." Proceedings of the National Academy of Sciences of the United States of America 115, no. 9 (February 27, 2018): 2078–83. https://doi.org/10.1073/pnas.1719805115.

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11 Each county in California is responsible for developing a plan and program called the Local Area Management Plan (LAMP) to regulate onsite wastewater treatment systems such as septic systems to protect groundwater and surface water quality.

12 California Government Code §65302.10(a)

13 While there is no agreed upon definition of what may be considered a deficiency with respect to wastewater service, we would consider the following deficiencies: reliance on onsite wastewater treatement systems at densities greater than suggested by local policies; wastewater systems that do not prevent potential leakage of untreated wastewater into surrounding soils, nearby surface water, or underlying aquifers; wastewater systems that lack capacity to manage all domestic wastewater including water from toilets, washing machines, sinks, and dishwashers; incidents of wastewater backing up into homes.

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16 Maps and table available at https://www.fresno.gov/darm/wp-content/uploads/sites/10/2016/10/ProposedAmendmenttoChapter3oftheGeneralPlan.pdf

17 U.S. Census Data, available at https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml

18 Fresno County General Plan Background Report

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20 The City of Fresno illustrates disadvantaged communities on a map, as seen in Figure 3, represents each DUC with a number, and in a table describes the municipal services available in each of the numbered neighborhoods.

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61 The Technical Advisory Committee incudes: Jennifer Clary, Clean Water Fund; Laura Feinstein and Anne Thebo, Pacific Institute; Yaneth Andrade-Magaña and Sergio Carranza, Pueblo Unido CDC; Jessi Snyder and Paul Boyer, Self Help Enterprises; Laurel Firestone and Jonathan Nelson, Community Water Center; Greg Pierce, Luskin Center Stan Keasling and Ari Neumann, Rural Communities Assistance Corporation; Aaron Lewis, EKI; Chione Flegal, PolicyLink; Joe Prado, Fresno County; Alexander Williams, UC Hastings

62 The Community Advisory Group includes residents from communities that lack access to wastewater service in Fresno and Riverside Counties including Lanare (Fresno), Daleville (Fresno), Jane Addams (Fresno), Tombstone Territory (Fresno), and Thermal (Riverside).

63 For the purposes of this project, adequate wastewater management means infrastructure and services that treat and dispose of wastewater sufficiently so that there is minimal risk of a violation of water quality objectives, impairment of present or future beneficial uses of water, or pollution, nuisance, or contamination of waters of the state.