The Human Costs of Nitrate-contaminated Drinking Water in the San Joaquin Valley

March 2011

In Collaboration With

COMMUNITY WATER CENTER
EL CENTRO COMUNITARIO POR EL AGUA

CLEAN WATER FUND

California Rural Legal Assistance Foundation
Advocates For Justice

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In Collaboration With

About the Organizations

Pacific Institute

The Pacific Institute is an Oakland-based independent nonprofit that works to create sustainable communities and a healthier planet. Founded in 1987, we conduct interdisciplinary research and partner with stakeholders to produce solutions that advance environmental protection, economic development, and social equity—in California, nationally and internationally. Our Community Strategies for Sustainability and Justice Program (CSSJ) partners with community-based organizations and coalitions to build community power to create and sustain healthy and thriving environments. Since 1995 this program has worked to overcome the common root causes to economic, environmental, and community health challenges in low-income neighborhoods and communities of color through action research that advances innovative, cross-cutting solutions developed by impacted residents.

Community Water Center

Community Water Center (CWC) is an environmental justice, nonprofit organization whose mission is to create community-driven water solutions through organizing, education, and advocacy in California's San Joaquin Valley. The Community Water Center works directly with a number of low-income, primarily Latino communities to address problems that range from chronic drinking water contamination to barriers to participation in local water governance. The Center employs three primary strategies in order to accomplish our goals: (1) educate, organize, and provide legal assistance to low-income communities of color facing local water challenges; (2) advocate for systemic change to address the root causes of unsafe drinking water in the San Joaquin Valley; and (3) serve as a resource for information and expertise on community water challenges.

Clean Water Fund

Clean Water Fund (CWF) is a national Section 501(c)(3) research and education organization that promotes the public interest on issues relating to water, waste, toxics, and natural resources. CWF's research, technical assistance, training, outreach, and educational programs increase public understanding of environmental issues and promote environmentally sound policies. Since 1974, CWF has helped people achieve cleaner and safer water, cleaner air, and protection from toxic pollution in our homes, neighborhoods, and workplaces. With a headquarters in Washington, D.C. and 17 offices in 11 states, CWF operates national campaigns as well as locally staffed community environmental and health protection programs.

California Rural Legal Assistance Foundation

CRLA Foundation is a statewide, 501(c)(3) nonprofit organization incorporated in 1981 to help rural immigrant workers and their families improve their economic conditions in California. For more than 27 years, we have worked to help people get better education, jobs that pay livable wages, habitable housing, and high quality, no-cost legal representation when they need it to ensure their civil rights. We do this by securing a just and equitable regulatory environment and legislative advocacy in the areas of education, worker safety, environment, and housing; conducting community outreach and education; and providing training and technical assistance to workers and to unions and other community-based organizations that advocate for workers and their families.

About the Project

Our four organizations collaborated to launch a community-based research process in Summer 2009 with the goal of documenting the economic, social, and potential health impacts of nitrate contamination of drinking water in the San Joaquin Valley. The project leverages the combined strength of technically rigorous research, grassroots leadership by affected communities, and seasoned policy analysis and advocacy. The new understanding generated by the research is being applied in community education and organizing, policy development, and advocacy to achieve safe and affordable water for all residents of the San Joaquin Valley.

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Acknowledgments

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Technical Review Process

A panel of independent technical experts reviewed the methods and findings of this research to ensure it held up to standards used by peer-reviewed journals and is based on methods consistent with best practices in related scientific fields. We sent reviewers a draft plan for our research methods in December 2009 and received their comments and finalized the methods in June 2010. The reviewers were provided with a draft of the final report in December 2010, and all comments were addressed before publication. The technical review panel was made up of:

Paul English, Ph.D., MPH
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Executive Summary

Nitrate contamination of California's groundwater presents a preventable threat to human health and economic wellbeing that is not being addressed at the scale needed to meet current or expected future levels. The San Joaquin Valley is the epicenter of the nitrate challenge; 75% of the nitrate exceedances in 2007 occurred in water systems located in the Valley. Groundwater nitrate levels are increasing and if current trends like those in Kern County continue, the number of wells with nitrate levels above the MCL will double by the year 2020. The potentially fatal effect of nitrate exposure on infants and association between exposure and respiratory and reproductive conditions; impacts to spleen, kidney, and thyroid functions; and various forms of cancer make this an urgent public health issue.

Despite the acute health effects of nitrate contamination, some communities in the state have been waiting for more than a decade for measures to restore the safety of their drinking water. In the interim, residents in these communities must replace the contaminated tap water—by purchasing water or installing point-of-use filters—at their own expense. Among community water systems, small ones with less than 200 connections comprise the majority of systems with persistent nitrate violations, and it is widely recognized that these systems cannot afford to independently finance the projects necessary to reduce nitrates and deliver safe drinking water. These communities also tend to be low-income and have a high percentage of Latino households. Although costs to community water systems and the households they serve are significant and directly tied to nitrate contamination of groundwater, public policy and regulatory programs have to-date failed to incorporate those costs in their policy and regulatory programs.

This report provides findings from a study designed to document costs of nitrate-contaminated groundwater to households and community water systems in the San Joaquin Valley. To document costs to households, a survey was conducted in four community water systems with current nitrate violations and representative demographics. Bi-lingual trained surveyors interviewed 37 households using convenience sampling in three communities and exhaustive sampling in one system. To investigate the costs to water systems, we analyze the projects needed in the region to mitigate nitrate contamination. We compare the nitrate water projects that providers have proposed to those that have been funded in order to characterize the unmet needs.

This study finds that households surveyed have water costs above national affordability standards (i.e., 1.5% of median household income) and many lack accurate information on water quality and are consuming tap water that exposes them to unsafe nitrate levels. One third of residents surveyed used their contaminated tap water for drinking or cooking and more than half of those surveyed did not know that their water system had a nitrate problem. Spanish-speaking households were even less likely to know of the contamination. The costs of avoiding unsafe tap water by purchasing alternative water sources and/or using filters represent a significant proportion of household incomes—more than 1.5% of household income for 70% of surveyed households. With the cost of public water service added, the average total household water costs constitute 4.6% of median household income, more than three times the affordability threshold for drinking water recommended by the U.S. Environmental Protection Agency (EPA).

The analysis of costs to community water systems finds that projects to address nitrates have substantial costs and that the vast majority of needed projects remain unfunded. The 14 small community water system projects funded by the California Department of Public Health (CDPH) Drinking Water State Revolving Fund between 2005 and 2009 to resolve nitrate contamination ranged in cost from a low of $100,000 to a high of nearly $7.5 million. Currently 100 projects to address nitrate contamination in Community Water Systems are on the CDPH waiting list, with a total cost of $150 million and an average project cost of just over $1 million. The most commonly funded project is a new well, and while this strategy is problematic due to increasing and fluctuating nitrate groundwater levels, communities often must pursue it to avoid unaffordable operational and maintenance costs of the alternatives. Consolidation, a solution encouraged by the CDPH and by the U.S. EPA, is the second most popular solution, followed by installation of treatment technology.

The findings of this report indicate several areas of needed policy changes. First, changes to required notification procedures should be considered to ensure that residents with contaminated tap water are kept informed of the problem and warned not to use the water for drinking or cooking. Next, new funding mechanisms are needed to fill the shortfall in project funding, as well as to provide interim solutions (such as point-of-use or point-of-entry systems) for users in systems that must endure long waits for solutions. Barriers to consolidation, which may be political, regulatory, and economic, should be addressed at both the state and local level. Finally, state agencies must improve both regulations and incentives to control all sources of nitrate contamination. Unless that is done, it is clear that current programs will not be able to keep up with the increasing demands as new communities are added to the list of those with unsafe drinking water.

This report represents a first effort to quantify the community costs of nitrate contamination. As such, it raises many more question than can be answered here. Several areas of additional research are indicated, including a more comprehensive economic analysis that includes health impacts and incorporates domestic well users, a more detailed analysis of the impact and effectiveness of emergency notification notices and practices, an epidemiological study of the health effects of nitrate exposure in the San Joaquin Valley, and an analysis of the impact of source control efforts.

1.0 Introduction

Image 1. East Orosi resident, Maria Elena Orozco, stands near the water well that serves her community.
Photo credit: Erin Lubin

In Seville in the heart of California's San Joaquin Valley, Becky wakes up worrying about whether she has enough bottled water to make coffee and give her elderly mother a glass to take with her medications. If not, she may have to turn to the nitrate-contaminated water from her tap *(Los Angeles Times*, 11/7/10). Nearby, in the farming town of Orosi, Sara[1] used to try not to get too thirsty during gym class because the fountains at her school were shut off due to nitrates and the only alternative was to purchase a drink she could not afford. And in the tiny town of Tooleville, Maria used to get a ride to buy five-gallon water jugs from a nearby city to bathe her infant without risking her child ingesting water contaminated with nitrates *(Visalia Times*, 8/4/2004). These day-to-day experiences of living with nitrate-contaminated water are not uncommon in the San Joaquin Valley, especially for rural residents in small, unincorporated communities.

While most Californians take for granted that safe water is readily available at the turn of a tap, more and more communities, primarily in the San Joaquin Valley and other agricultural areas of the state, are regularly given notices that their water is not safe to drink due to nitrate contamination. Between 2005 and 2008, 92 drinking water systems in the San Joaquin Valley had a groundwater well with nitrate levels over the legal limit, potentially affecting the water

[1] Pseudonym assigned for confidentiality.

quality of approximately 1,335,000 residents (Balazs 2010). In 2007, violations of the legal limit for nitrate levels in the San Joaquin Valley represented three- quarters of all the state's nitrate violations (Balazs 2010). Nitrate levels in drinking water are regulated because of the potentially fatal effect ingestion can have on infants (U.S. EPA 1974). Studies have also shown that nitrates can harm the respiratory and reproductive systems, as well as the kidney, spleen, and thyroid (Gupta et al. 2000; Weyer et al. 2001; Ward et al. 2005; Manassaram et al. 2006; Ward 2010). Even within the San Joaquin Valley, the effects of nitrate contamination are unevenly distributed, with Latino households disproportionately affected (Balazs et al. 2011).

Reducing nitrate levels in groundwater and ensuring safe drinking water in the San Joaquin Valley is a subject that has received increasing attention among policy makers, researchers, and the public. A 2002 research brief by the Lawrence Livermore National Laboratory concluded that nitrate contamination is "the number-one contaminant threat to California's drinking water supply" (LLNL 2002). In 2008, the California Senate passed SBX21, committing funding to study nitrate contamination and identify remedial solutions and funding options for cleanup or treatment of groundwater. Recent funding from state bonds, federal stimulus, and other sources have prioritized drinking water improvement projects that address contamination from acute contaminants, including nitrate. Additionally, the Central Valley Regional Water Quality Control Board is in the process of developing a long-term regulatory program for irrigated agricultural lands, one of the primary sources of nitrate contamination. Nitrate contamination is preventable and recent studies have found that methods for controlling nitrates at the source can achieve reductions in groundwater nitrates sooner than previously thought (Hansen et al. 2011).

Currently, at least 100 water providers in the San Joaquin Valley are in need of projects to mitigate nitrate contamination. Some have been waiting more than ten years without receiving necessary funding[2] (CDPH 2010). Residents served by systems in violation of nitrate standards are commonly directed to avoid consuming their tap water until nitrate levels are brought down, but are rarely provided with an alternative drinking water source. Anecdotal evidence from these water consumers suggested that in obtaining water from alternative sources residents may face costs that exceed water affordability standards,[3] yet no systematic documentation has been published on these costs.

This report provides findings from research examining the impacts of nitrate contamination on affected households in small community water systems. The following section provides background on nitrates in the San Joaquin Valley and relevant literature and describes the

[2] East Orosi, Tooleville, Seville, Rodriguez Labor Camp, Soults Mutual, Beverly Grand, and many other systems in the region have been without a source of safe drinking water for a decade or more because their wells were contaminated with nitrate and they have not been able to secure money and implement a project to address the problem (CDPH 2010).

[3] The California Department of Public Health designates water costs of 1.5% of median household income as the maximum level for affordability.

research objectives and methods. Section Three reports the methods, results, and analysis from a survey of 37 households in four small community water systems with current nitrate violations. The survey documented respondents' awareness of their tap water quality, consumption of tap water and water from alternative sources, and costs incurred in obtaining potable drinking water. Section Four focuses on what actions small community water systems in the San Joaquin Valley are taking to mitigate nitrate contamination, analyzes the projects proposed by these providers, identifies the projects funded, and discusses the sustainability and health implications of the findings.

2.0 Background and Research Design

2.1. Background on Nitrates in the San Joaquin Valley

Nitrate is the most common chemical contaminant found in the world's groundwater (Spalding and Exner 1993, Harter 2009). While nitrate occurs naturally at low concentrations (generally less than 2 milligrams per liter nitrate as nitrogen (mg/l nitrate-N) (Harter 2009)), high levels of nitrate in groundwater that approach or exceed the drinking water standards (10mg/L nitrate-N) are primarily due to atmospheric deposition and human activities. Human sources of nitrates include wastewater treatment discharge, animal and human waste discharged from septic systems, dairies, feed lots and other confined animal feeding operations, and inorganic fertilizer use. Inorganic fertilizer and animal waste are the dominant source of nitrate in groundwater in the United States southwest (i.e., Southern California, New Mexico, Arizona) (Harter 2009).

Nitrate pollution in the San Joaquin Valley is due primarily to irrigated agriculture and over-application of fertilizer (Gronberg et al. 2004), though confined animal feeding operations are also a key source (U.S. EPA 2002). The San Joaquin Valley accounts for over half of California's thriving agricultural production (CRPTF 2003). Nitrates discharged into groundwater do not for the most part change in form, but some portion may go through a process of attenuation and convert to nitrogen gas, no longer posing a threat to groundwater. Harter (2009) analyzed the use of fertilizers on California farms in 2007 and estimated that on average more than 80 lbs N/acre/year may leach into the groundwater beneath irrigated lands, usually as nitrate. Harter concludes that "without attenuation, 80 lbs N/acre/year would lead to groundwater NO_3-N concentrations at the water table that are two-to-four times higher than the MCL (Maximum Contaminant Level)." Even though subsurface attenuation does occur in some areas, this is a remarkably high amount of unabsorbed nitrate released on irrigated lands.

The eight-county San Joaquin Valley has some of the most contaminated aquifers in the nation (Dubrovsky et al. 1998). University of California researchers reported in 2002 that 10-15 % of California's water supply wells exceeded nitrate standards for drinking water (Bianchi and Harter 2002). Contamination rates in the San Joaquin Valley are higher: 24 percent (21 of 88) of domestic wells tested in Eastern San Joaquin Valley during 1993-95 had nitrate concentrations above the legal limit of 10 mg/L nitrate-nitrogen (nitrate-N) (Dubrovsky et al. 1998). In 2006, the State Water Resources Control Board sampled 181 domestic wells in Tulare County and found that 40% of those tested had nitrate levels above the legal limit (State Water Resources Control Board 2010).

The legal limit or Maximum Contaminant Level (MCL) for nitrate-nitrogen in drinking water, 10 milligrams per liter (equivalent to 45 mg/L, nitrate as NO3 ion), is based on protection of infants from methemoglobinemia, or "blue baby syndrome."[4] Studies have also found that exposure to high concentrations of nitrates can result in serious illness and death for infants and pregnant women, including significant increased risk of neural tube defects, premature birth, intrauterine growth restriction, and anencephaly; and increased methemoglobin levels causing pregnancy complications, central nervous system birth defects, and congenital malformations (Manassaram et al. 2006). Additional known or suspected health effects to children and adults include respiratory tract infections in children, thyroid disruption, pancreatitis, sudden infant death syndrome (SIDS), and cancers of the digestive system, bladder, and thyroid (Gupta et al. 2000; Weyer et al. 2001; Ward et al. 2005; Manassaram et al. 2006; Ward 2010).

No systematic epidemiological study of the health effects of nitrate contamination in the San Joaquin Valley has been conducted. However, a recent compilation of the rates of health conditions potentially caused by nitrate exposure in Tulare County reveals various recent years when these rates were above the rates for California as a whole (CWC 2011). Rates of Sudden Infant Death Syndrome have been high in the region, with seven-out-of-eight San Joaquin Valley counties reporting SIDS death rates above the state average for at least one three-year period during 1999-2008 (CDPH 2010). These seven counties comprise only 12% of the counties in the state, but they are 50% of the counties with above-average SIDS death rates. Understanding any connection between the region's health problems and nitrate contamination merits further research.

[4] Reviews of the nitrate MCL have concluded that the standard is appropriate for the protection of infants (U.S. EPA 1990; NRC 1995; California EPA 1997).

High nitrate levels in groundwater have inevitably affected drinking water quality, since nearly 90% of the San Joaquin Valley residents rely on groundwater as their primary source of drinking water (PICME 2008). An analysis of the Water Quality Monitoring (WQM) and Permits, Inspections, Compliance, Monitoring and Enforcement (PICME) databases used by the California Department of Public Health to track drinking water quality reveals a significant and potentially growing set of threats:

- The number of public drinking water systems in California with nitrate MCL violations has been steadily increasing since at least 1993 when there were 12 such systems, to 2007 when there were 44.
- In 2007, 74% of all nitrate MCL violations in the state were found in the San Joaquin Valley, impacting over 275,000 people.
- Between 2005 and 2008, 14% of community water systems (92 of 671 systems) in the San Joaquin Valley had a well with nitrate levels above the legal limit (Balazs 2010).

Besides the health risk of nitrate exposure, the presence of high nitrate levels in groundwater has economic impacts related to the costs of necessary mitigation measures and the limits on human activities resulting from reduced water availability. Moreover, those causing the water quality problems are rarely the same people, groups, or communities suffering the consequences. The cost of avoiding or treating nitrate-contaminated drinking water is typically borne by water users (e.g., families, individuals, businesses) and by local government and water providers, and is indirectly incurred by local and state tax payers, through tax revenues that pay for drinking water improvement projects. For example, the community of Grayson, whose system is run by the City of Modesto and which serves approximately 1,100 residents, has installed a nitrate treatment plant at a cost of $800-$900 per acre-foot (Duran 2010).

Already, local and regional economic growth is being affected by the opportunity costs of having to mitigate nitrate contamination and by the limited availability of safe water sources. High nitrate levels in source wells can limit the capacity of a water provider to increase the number of connections served, potentially imposing a limit on new residential or commercial users. In places like the City of Tulare and the town of Orosi, planning officials have stated that economic development in the region may be affected by the lack of adequate water capacity after nitrate-contaminated wells had to be closed.[5]

Increasing concentrations of nitrates in groundwater suggest that risks to San Joaquin Valley drinking water are growing. Looking at information about wells in Kern County (provided by the State Water Board's Groundwater Ambient Monitoring & Assessment Program (GAMA)), we

[5] For example, when considering new housing developments in late 2010, the Tulare County Board of Supervisors discussed constraints related to persistent water quality problems (see Resolution 2010-0865 on 11/2/10).

carried out a regression analysis to estimate the number of wells with nitrate levels currently under the MCL that can be expected to rise above this threshold in the next ten years. If current trends continue, we estimate that the number of wells exceeding the MCL in Kern County will double in the next ten years (see Appendix A).

The distribution of the health risks and costs of nitrate contamination disproportionately affect small community water systems (i.e., those serving fewer than 200 connections—about 600 people) and Latino and low-income communities. Small community water systems are at a particular disadvantage in addressing nitrate contamination, in part because the low numbers of connections in these systems prevent them from achieving the economies of scale that larger systems benefit from in generating the revenue necessary to fund nitrate mitigation projects. Balazs et al. (2011) controlled for the effect of scale and found that in small community water systems, those serving higher concentrations of Latino populations are statistically more likely to have tap water with higher levels of nitrate. Often these communities are in unincorporated county areas, which have been historically marginalized politically and economically (Rubin et al. 2007). This indicates that social status and political power also shape how the costs of nitrate contamination are distributed.

2.2. Literature and Theoretical Framework

In their recent study estimating the incidence and social cost of colon cancer resulting from nitrates in drinking water, Grinsven et al. (2010) state that "the overarching question is at which nitrogen mitigation level the social cost of measures, including their consequence for availability of food and energy, matches the social benefit of these measures for human health and biodiversity." This type of cost-benefit analysis is common practice in the development of regulatory programs; however, these analyses often lack a complete and accurate assessment of the costs to communities of contaminated drinking water and the benefits and avoided costs of clean drinking water. To understand the social benefit of more effective nitrogen mitigation, we must know the impact of the current nitrate levels on human health and wellbeing, ecosystems, and institutions. The development and implementation of solutions to nitrate contamination of drinking water will take a broad public commitment informed by a full recognition of the breadth and gravity of the current problems.

The potential effects of nitrate contamination are diverse and far-reaching, and our study only begins to examine a subset of these. Figure 1 presents a framework of all costs, with the arrows representing a relationship through which the costs of nitrate contamination are passed on. With releases of anthropogenic nitrates, increased concentrations of nitrates occur in groundwater as well as surface water, affecting drinking water sources as well as water bodies with recreational uses and ecosystems (the orange features of Figure 1). Various types of water systems can be affected by high nitrate levels (in dark blue). The effect on private wells are passed on to individual private well owners, who then may incur a range of costs due to needed mitigation measures, health effects of nitrate exposure, or obtaining water from alternative sources (in light blue). The effects on public systems are passed on to the institutions governing and funding these systems, including local, state, and federal government bodies, which incur mitigation costs and pass these on to tax payers and other sources of public revenue. These costs may be passed on to water users in these public systems, who also may incur costs related to increased fees, obtaining water from alternative sources, health costs related to nitrate exposure, or installing their own filters or other protective devices.

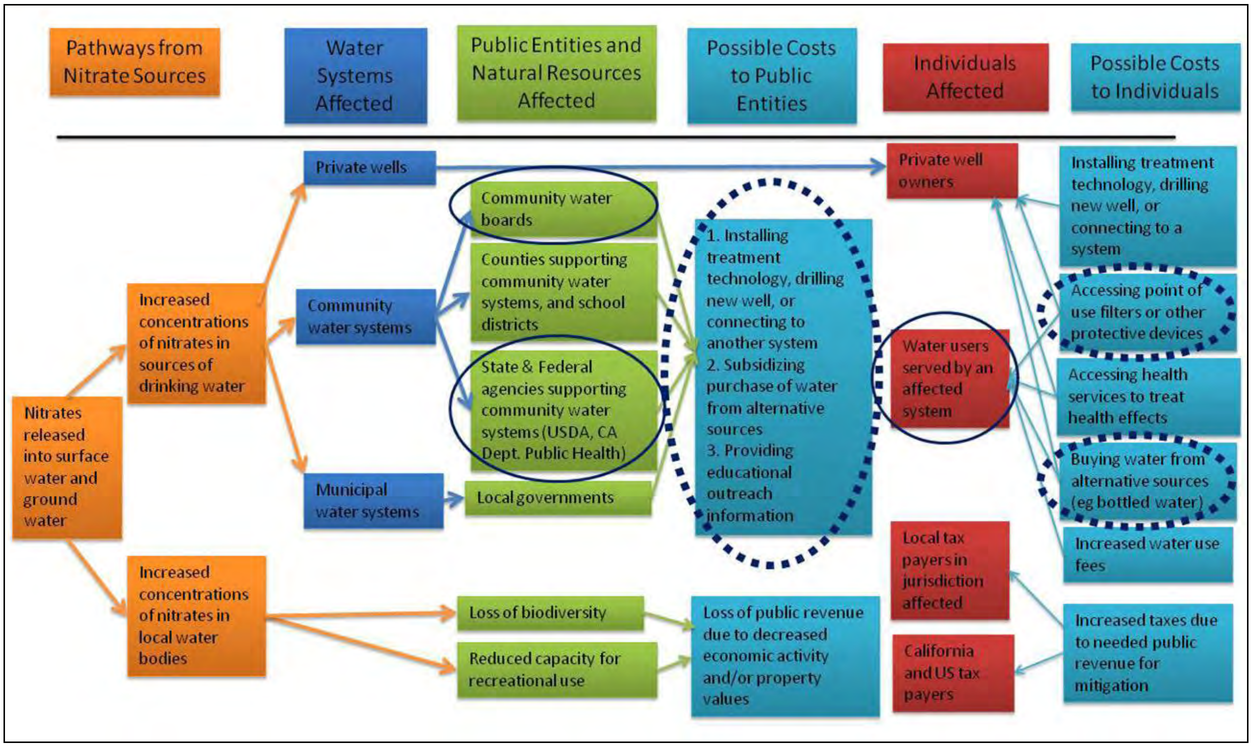

Figure 1. Framework of social cost relationships

This study focuses on the costs to households (connected to community water systems) of avoiding nitrate-contaminated drinking water and the costs to community drinking water systems of removing or avoiding nitrates. In Figure 1, the ovals with continuous lines highlight the public entities and individuals affected by nitrate contamination that our study documents. The dotted line ovals mark the subset of costs incurred by these two actors. The costs to households documented here include those related to purchasing water from alternative sources and installing filters. The costs to systems include those linked to nitrate mitigation projects like drilling a new well, installing a treatment plant, or building connections to another water system with safe water.

The Economic Research Service of the U.S. Department of Agriculture (1995) presents a range of types of benefits resulting from improvements to rural water quality (Table 1). Our study focuses exclusively on consumptive services, and within this set of potential benefits only documents those that may accrue to community water systems and individuals they serve.

Table 1. Types of benefits from improving rural water quality (USDA ERS 1995)

Use Value	In-stream services	Recreational uses, such as swimming, boating, and fishing. Commercial/municipal uses, such as fishing, navigation, and water storage facilities.
	Consumptive services	Drinking water from municipal water systems and private wells. Irrigation and other agricultural uses.
	Aesthetic value	Near-water recreation, such as picnicking and sightseeing. Property value enhancement.
	Ecosystem value	Preservation of wildlife habitat and promotion of ecosystem diversity.
Nonuse Value	Vicarious consumption	Value placed on enhanced use of clean water by others.
	Option value	Desire to preserve opportunity to enjoy clean water at some future time.
	Stewardship value	Protection of environmental quality and desire to improve water quality for future generations.

This study does not look at all costs potentially affecting individuals serviced by water systems with nitrate violations, such as the health outcomes of exposure to nitrates and the associated costs of diagnosis and treatment, and lost work days, pain and suffering, and premature death. Nor does the study analyze the costs related to losses of biodiversity or reduced recreational use capacity due to nitrate contamination. While outside the scope of this study, these are all valuable questions for future research.

No systematic documentation exists on the increased household costs and time spent accessing alternative water sources for the San Joaquin Valley. However, a series of studies on the East Coast have estimated household costs of groundwater contamination using the "avoidance cost method" —that is, "assessing the costs of actions taken to avoid or reduce damages from exposure to groundwater contaminants" (Abdalla 1991). Laughland et al. (1993) surveyed residents of a rural Pennsylvania community to calculate the household costs of purchasing, hauling, and boiling water in response to *Giardia* contamination of tap water. In a similar study in West Virginia, Collins and Steinback (1993) estimated the average, annual economic cost of rural households' responses to bacterial, mineral, and organic chemical contamination of domestic water supplies. In the San Joaquin Valley, there is anecdotal evidence that users of nitrate-contaminated water systems seek alternative sources of water by going to buy bottled or bulk vended drinking water, generating an additional set of costs (CWC 2010). Applying the avoidance cost method could help generate estimates for these household costs of avoiding nitrate-contaminated water.

A similar approach to assessing costs and benefits was undertaken in a 2002 U.S. EPA analysis, The Benefits of Reducing Nitrate Contamination in Private Domestic Wells under CAFO Regulatory Options. For each regulatory option being considered, the EPA reported the Expected Reductions in Number of Households with Well Nitrate Concentrations above 10 mg/L. In this case, staff used existing research on Willingness to Pay for such drinking water quality improvements to estimate the economic benefit to households using domestic wells. A drawback of this use of the Willingness to Pay methodology is that the actual costs, and data on the household income and ability to pay these costs, were not documented. Another general drawback is that inferring actual behavior from stated willingness has had mixed results in research in the water sector (Merrett 2002).

To document household costs of nitrate contamination, we use a survey of households served by a water system in violation for nitrate levels. To analyze the costs of nitrates to community water systems, we look at data from public agencies funding these projects at the state and federal level.

2.3. Research Objectives and Design

The objectives of this research were to systematically document:

1. Measures taken by household water users to avoid nitrate-contaminated water, perception of water quality, and the means of obtaining water quality information;
2. Costs to households of water service, purchasing alternative sources of water, and treating water in the home;
3. The costs of existing and proposed measures undertaken by small community water systems to mitigate nitrate contamination;

The methodology for research objectives 1 and 2 was a survey of households in four community water systems in violation of the nitrate MCL. The sampling methods and survey protocol for the household survey are described in Section 3 below.

The methodology for research objective 3 was to analyze the reports of the California Department of Public Health (CDPH) documenting drinking water improvement projects proposed by public drinking water systems in the San Joaquin Valley. This analysis categorizes the proposed projects by type of mitigation and size of water system and calculates ranges of costs. A comparison with the projects funded by CDPH and the U.S. Department of Agriculture (USDA) allow for an estimate of the gap between the need for nitrate mitigation projects and the current funds for implementation of nitrate mitigation projects. The analysis of types of projects funded also provides a view of the support available to small community water systems, which shapes their approach to addressing nitrate contamination.

3.0 Household-level Costs

Nitrate contamination of tap water can affect San Joaquin Valley households' expenses, risk of health problems, and quality of life and wellbeing. Members of the household may ingest contaminated tap water through cooking or drinking, thereby elevating their risk of developing health conditions associated with nitrate exposure. Households with contaminated tap water often take measures to avoid contaminated tap water, either by purchasing, installing, and maintaining household filters that remove nitrates or, more often, purchasing and using water from alternative sources, such as vended and bottled water. In the water quality literature, these actions are known as avoidance measures, which result in an additional set of costs ("avoidance costs") for the household (Abdalla 1994).

Image 2. Berta Diaz of East Orosi washes her food with bottled water to avoid exposure to nitrate-contaminated tap water.
Photo credit: Eyal Matalon

Several studies throughout the United States have used survey-based methods to document avoidance costs for households impacted by contaminated groundwater supplies. For example, among users of *giardia*-contaminated wells in rural Pennsylvania, Laughland et al. estimate that the cost of purchasing water from alternative sources ranges from $16.50 to $51.18 per household per month (1993). In Maine, among owners of private wells contaminated with arsenic, Sargent-Michaud et al. estimate the cost of using a point-of-use filter at $411 per year (2006). These types of household-level costs can be extrapolated to partially estimate the public cost of contamination for a given region. As noted by Abdalla, values from avoidance cost studies of water have significant implications for environmental policy in that they can be used to "generate lower-bound estimates of an important component of benefits [of groundwater protection], namely the use of groundwater as a drinking water source" (Abdalla 1994).

The extent to which households avoid nitrate-contaminated tap water likely depends on a number of factors: a) households' awareness of nitrate contamination, or at least perception of a problem with tap water safety; b) households' understanding of the health risks of ingesting contaminated water; and c) the capacity, financial or otherwise, of households to expend time and money to avoid contaminated water (Collins and Steinback 1993). The types and costs of avoidance measures undertaken by users (installing filters, seeking alternative water supplies, drinking less water, etc.) will depend on the household's perception of the convenience, cost-effectiveness, and health-protectiveness of the measure (Sargent-Michaud et al. 2006).

In the San Joaquin Valley, there has been no systematic documentation of:

a) the extent to which users of nitrate-contaminated water systems perceive their water to be unsafe and avoid consuming unfiltered tap water.
b) the types and costs of measures households undertake to avoid nitrate-contaminated water and the financial burden of avoidance costs, particularly to low-income families.

The purpose of conducting a household survey was to characterize the social, economic, and potential health impacts of nitrate-contaminated water on households using small community water systems in the San Joaquin Valley.

3.1. Household Survey Methods

We implemented a household survey in four community water systems with recent violations of legal nitrate limits to document the extent to which households undertake measures to avoid nitrate-contaminated water and the associated costs households incur.

3.1.1. Selection of Survey Sample

To select the communities surveyed, we analyzed water quality data from the Permits, Inspections, Compliance, Monitoring, and Enforcement system information database (PICME 2008) and demographic data from the U.S. Census (2000). We identified small community water systems in San Joaquin Valley with recent violations of the nitrate MCL and narrowed this list to those that have race and income demographics typical of these systems. To do so, water system boundaries were joined with 2000 Census data in ArcGIS to determine the income and demographic characteristics of the water system users (see Table 2). The list of systems with nitrate violations was narrowed to the four systems with income and race/ethnicity demographics similar (+/- 10%) to the median of small community water systems in the San Joaquin Valley. The project team then consulted with the District 12 Office of CDPH's Drinking Water Program, which regulates public water systems in Tulare and Kings Counties, to verify which of these community water systems were still in violation (as of 2010). Three systems that had not appeared on the PICME list were in current violation and had been for several years, so these were added to the list of potential systems to survey. Of the seven systems, we selected the four systems (see Table 2) where the organizations affiliated with the project team had no prior relationships with any users or members of the water board. All four systems were in unincorporated regions of Tulare County.

Table 2: Socioeconomic and water quality information for four water systems in Tulare County in which a household survey was implemented

Water System	Connections*	Population*	% Below / Near Poverty Level**	% Non-White**	In Violation of MCL Since***	Most Recent MCL Violation (nitrate concentration) ***
Beverly Grand Mutual Water Co.	28	108	45%	35%	2000	Apr. '10 (65 mg/L)
Lemon Cove Water Co.	50	250	24%	13%	1997	Aug. '10 (54 mg/L)
El Monte Village Mobile Home Park	49	100	40%	53%	2007	Sep. '10 (54 mg/L)
Soults Mutual Water Co.	36	100	57%	36%	1996	Mar. '10 (94 mg/L)

*Source: PICME Database **Source: U.S. Census 2000 ***Source: Tulare Co. Water Surveillance Program

3.1.2. Survey Protocol and Questionnaire

The first round of surveys was conducted within the four selected community water systems over five days in May and June of 2010 between the hours of 4:00 PM and 7:00 PM. Due to the limited resources, the convenience sampling method was used, a type of nonprobability sampling in which the sample population is selected because it is readily available and convenient. A given block within the water system boundaries was arbitrarily chosen and all households that were available and willing to participate at the time of the survey were selected. The second round of surveys was conducted within the Beverly Grand Mutual Water Co. system over two days in late August of 2010 between the hours of 11:00 AM and 7:00 PM. All remaining households within the system were sampled; seven households were not present during the time of the survey or declined to participate. We chose Beverly Grand for the additional surveying because its smaller size would allow us to potentially survey every resident in the community.

Selected households were visited in person by bilingual surveyors hired and trained for the project. The surveyor described the research project using a prepared script and asked for an adult familiar with the household's water purchasing and water use practices. Two copies of a consent form were presented, with one copy to be signed and returned before the interview began (see Appendix B for the consent form used in the study). Surveyors were not residents of any area served by the water systems selected for the survey.

Image 3. Surveyors interviewed 21 households connected to the Beverly Grand water system.
Photo Credit: Eyal Matalon

The project team developed the survey instrument through a review of relevant avoidance cost literature, a focus group of community residents, community and technical review, and a pilot survey. The instrument ultimately included seven major sections:

- **Background Information –** to document income and demographic characteristics of the household, as well as household size, duration in the community, and languages spoken.
- **Perception of Contamination –** to establish whether the household perceives a problem with the safety of their water or believes their water to be contaminated. Follow-up questions inquired about the type of contaminant and how households learned about contamination.
- **Water Service Costs –** to assess household expenditures on water service based on a recent bill or to solicit an estimate if a water bill was unavailable.
- **Filter Use and Costs –** to understand the types of filters used in the household and to solicit estimates of the costs of installing and maintaining the filter.
- **Non-Tap Water Costs –** to evaluate the types, quantities, and locations of vended and bottled water purchased by the household in a typical month.
- **Household Water Use –** to understand the types of water (unfiltered tap, filtered tap, vended, or bottled) used by the household for different activities (drinking, cooking, making coffee and tea, etc.) and whether the household undertook other measures to avoid contaminated tap water.
- **Community Attitudes about Water Quality** – to understand household opinions of their water provider and of government agencies charged with protecting domestic water supplies

The survey instrument used in this study is available by request.

3.1.3. Methods for Analysis of Response Data

Household socioeconomic information, perception of water quality, water use, and monthly water-related expenditures were summarized for each surveyed community. We compared self-reported household incomes to the monthly earnings necessary to meet basic needs for a single-parent family ($4,369 per month) or two-parent family with one parent working ($3,791) in Tulare County, as reported by the California Budget Project (2010). Households that reported earning less than *half* of the basic income for their family type were categorized as *very low income*. Households that reported earning between *half* of the basic income and just below the basic income were categorized as *low income*. Table 3 is the household budget necessary to fulfill the needs of a typical two-parent family in Tulare County in which one parent is working, according to the California Budget Project.

Table 3. Expenses per month and as a percentage of income for the basic needs of a typical two-parent family in Tulare County, where only one parent is working

Expense Category	Monthly Expense % of Income
Housing/Utilities	**$674** 17.80%
Transportation	**$393** 10.40%
Food	**$814** 21.50%
Health Care	**$1,134** 29.90%
Miscellaneous*	**$479** 12.60%
Taxes	**$298** 7.80%
MONTHLY TOTAL	**$3,791**
ANNUAL TOTAL	**$45,491**

*Includes clothing, education, personal care, housekeeping supplies, phone bill, etc.

Expenditures on vended and bottled water, tap water service, and household filters were calculated for each household as follows. See Appendix C for a protocol detailing how water-related expenditures were calculated.

- **Vended and Bottled (Non-Tap) Water:** For each household, the type, quantity, and location of water products purchased in a typical month were used as inputs to calculate monthly expenditures on non-tap water based on the following general formula:

$$\sum_{x=1}^{N} Q_x \times C_x = E$$

Where:

- Q_x = *the quantity of product x purchased in a typical month*
- C_x = *the minimum cost of product x, determined based on the location where the household reported purchasing product x*
- N = *the number of different products purchased in a given month*
- E = *expenditures on non-tap water in a typical month*

- **Tap Water Service:** For households connected to the Beverly Grand and Soults water systems, the fixed rates, as reported by most users and confirmed with agencies familiar with local water rates, are assumed for each surveyed household. For households connected to the Lemon Cove system, the mean monthly water bill for all users, as reported by the water provider, was assumed for each surveyed household. For households connected to the El Monte system, the mean self-reported monthly water rate of the five households that provided estimates was assumed for each surveyed household.
- **Household Filters:** For households that had purchased and installed other filters, self-reported capital and maintenance costs were amortized by month over an assumed 10-year lifetime of the filter at an annual discount rate of 5%. For households renting Culligan reverse osmosis systems, the monthly rental rates reported by Lindsay Culligan were assumed.

Monthly expenditures on vended and bottled water, tap water service, and household filters were also calculated as a percentage of monthly income for each household. These percentages were compared to an affordability threshold for drinking water recommended by the U.S. Environmental Protection Agency and used by the California Department of Public Health, in which the "water rate to the average residential user is no higher than 1.5% of the Median Household Income for the community" (CDPH 2010). We summarized the number of households spending more than 1.5% of household income on water-related expenditures.

3.2. Household Survey Results

Thirty-seven (37) households participated in the household survey: 21 households connected to the Beverly Grand Mutual Water Co. system ("Beverly Grand"), or 75% of all users; 5 connected to the Lemon Cove Water Co. system ("Lemon Cove"), or 10% of all users; 7 connected to the El Monte Village Mobile Home Park system ("El Monte"), or 14% of all users; and 4 connected to the Soults Mutual Water Co. system ("Soults"), or 11% of all users. Summary statistics are reported below for Beverly Grand and in Appendix D for Lemon Cove, El Monte, and Soults. We focus on the survey responses from Beverly Grand because the exhaustive sampling of households there allows us to generalize about the community as a whole.

3.2.1. Descriptive Statistics

Surveyed households in Beverly Grand have an average of 5.1 individuals (s.d. 1.8 individuals) and 95% of households consist of at least two adults and at least one minor child. Fifty-seven percent (57%) of respondents reported having an infant in the household. The median household income of the 20 households in Beverly Grand that reported their earnings is $1,343 per month ($16,116 per year). All households earn *low* incomes and 71% of households earn *very low* incomes in comparison to an income sufficient to meet basic needs for a family in Tulare County. Seventy-one percent (71%) of households stated "Latino, Chicano, or Latin-American" as their ethnicity. The remainder stated "White" (14%), multiple ethnicities (10%), or declined to state (5%). While 76% of surveyed households said that English was spoken in the home, the majority of respondents (76%) preferred to sign a Spanish-language consent form and answered survey questions in Spanish. Surveyed households in Beverly Grand have lived in the community for an average of 8.4 years (s.d. 7.4 years).

3.2.2. Perception and Avoidance of Household Tap Water

The majority (71%) of households surveyed in Beverly Grand stated that the safety of their tap water is a problem, with 24% of respondents stating that tap water safety is not a problem and 5% stating they are unsure. Seventy-one percent of households believe their tap water *is* contaminated, and 19% of households believe their water *might be* contaminated. Of these households that were aware of or suspected contamination of their tap water, 50% specifically mentioned nitrate contamination, 11% mentioned heavy metal contamination, and 44% did not know the type of contaminant (see Figure 2). Nearly all households said they had learned about contamination through a notice in the mail. Overall, 43% of households surveyed in Beverly Grand are aware of or suspect nitrate contamination of their tap water.[6]

Of respondents whose preferred language was Spanish, 63% stated that the safety of their tap water is a problem and 31% are aware of or suspect nitrate contamination. Conversely, all respondents whose preferred language was English perceive a problem with water safety and 80% are aware of nitrates.[7]

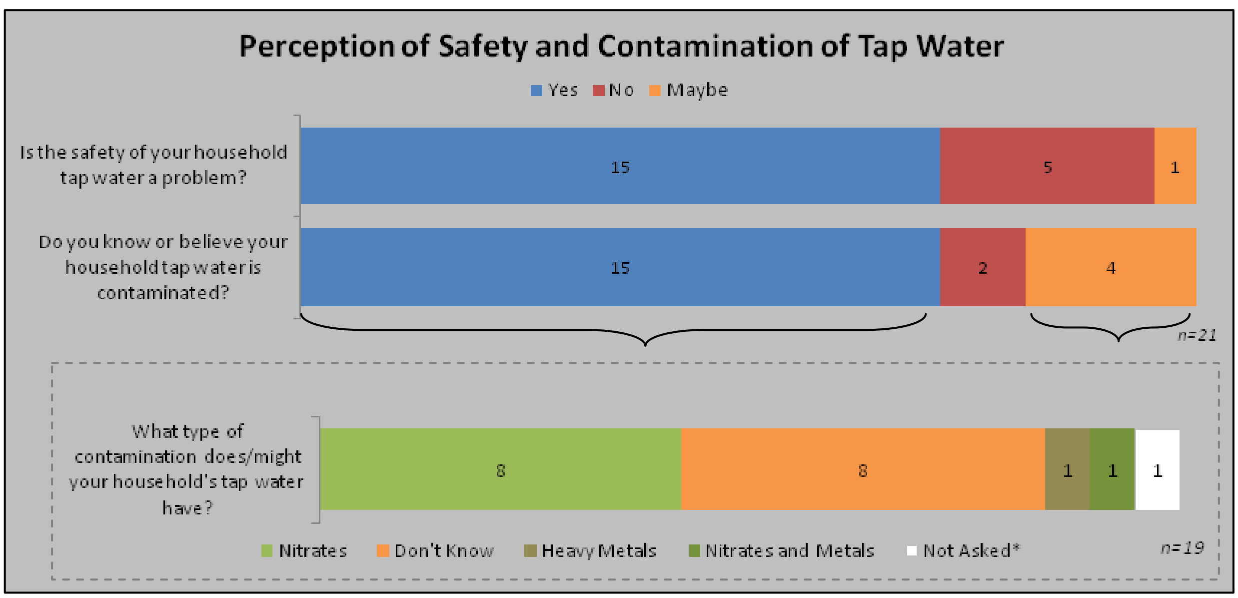

Figure 2: Perception of safety and contamination of household tap water, Beverly Grand

[6] One household was excluded from analyses examining awareness of contamination due to surveyor error.
[7] Preferred language was inferred based on the language in which respondents signed a consent form and answered survey questions.

Nearly all (95%) households in Beverly Grand access alternative sources of water for use in the home. Of these, the majority (75%) purchase *both* vended and bottled water, 19% purchase exclusively bottled water, and 5% purchase exclusively vended water. Five percent (5%) of households receive water through a water delivery service in addition to purchasing vended and bottled water. Overall, households that access water from alternative sources purchase an average of 54.2 gallons of non-tap water per month (s.d 39.5), or 11.0 gallons per person per month (s.d. 8.6).

Two households (10%) in Beverly Grand reported installing and servicing a point-of-use reverse osmosis (RO) filter in the home.[8] A third household in Beverly Grand reported using a "Discovery" brand filter that had not been serviced since 2008.[9]

Households in Beverly Grand reported taking the below actions because of concern about the safety of the tap water. We note that these actions have not been shown to reduce nitrates in tap water and, as in the case of boiling, may actually increase nitrate concentrations (EHIB 2000).

- "boiled the water" – three households (14%)
- "added lye, soap, bleach, or chlorine to the water" – two households (10%)
- "let the tap water run for a moment after turning it on" – six households (29%)
- "refrigerate or freeze the water" – three households (14%)

Table 4: Percentage of households taking measures to avoid contaminated tap water, Beverly Grand

Measures Taken to Avoid Contaminated Tap Water	% of Surveyed Households
Obtain Water from Alternative Sources	**95%**
Purchase *exclusively* vended water	5%
Purchase *exclusively* bottled water	19%
Purchase *both* vended and bottled water	71%
Install Point-of-Use Filter	**14%**
Install Reverse Osmosis Filter	10%
Install "Discovery"-brand filter	5%
Manipulate Tap Water Do one or more of the following:	**38%**
Boil the tap water	14%
Add lye, soap, bleach, or chlorine to tap water	10%
Let tap water run for a moment after turning it on	29%
Freeze or refrigerate the tap water	14%

[8] Households that reported using reverse osmosis filters could not specify the brand and model so we were not able to verify whether the filter was certified by CDPH for removal of nitrates (CDPH 2011).

[9] CDPH does not certify any "Discovery" brand filters for removal of nitrates. Follow-up internet-based research could not find any additional information on this brand.

The majority of surveyed households in Beverly Grand (81%) drink exclusively vended and bottled ("non-tap") water, 10% drink unfiltered tap water, 5% drinking tap water that passes through a reverse osmosis filter, and 5% drink water that passes through an unserviced "Discovery" brand filter. Forty-eight percent (48%) of households cook with non-tap water, 43% cook with unfiltered tap water, 5% cook with tap water that passes through a reverse osmosis filter, and 5% cook with tap water that passes through an unserviced "Discovery" brand filter (see Figure 3). Of the 11 households in Beverly Grand that feed infants baby formula, 91% use exclusively non-tap water, 5% use tap water that passes through a reverse osmosis filter, and 5% use water that passes through an unserviced "Discovery" brand filter. Overall, nearly half (48%) of households are potentially exposed to nitrate-contaminated tap water, primarily through cooking with unfiltered tap water, but also through drinking the water and using filters that have not been adequately serviced.

Two thirds of Beverly Grand households that perceive a problem with tap water safety avoid drinking and cooking with unfiltered water, while one-third of households that do not perceive a problem with tap water safety take these precautions.

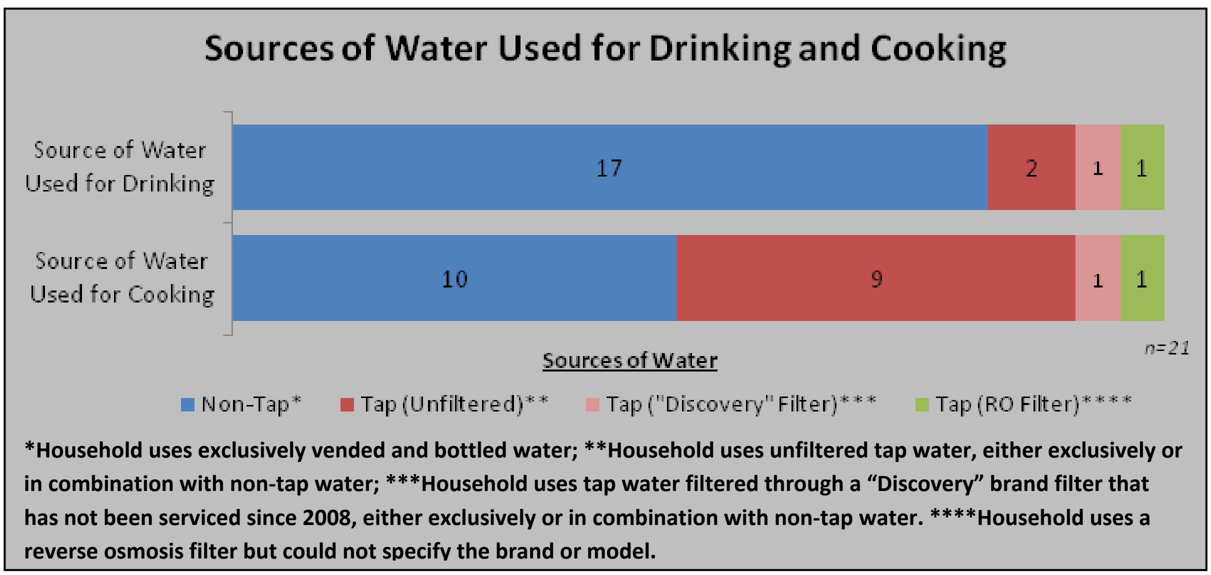

Figure 3: Sources of water used by surveyed households for drinking and cooking, Beverly Grand

3.2.3. Household Water Expenditures

Household Expenditures on Water Service

According to information reported by survey participants and verified by a service agency familiar with water rates of community water systems in Tulare County, households connected to the Beverly Grand Mutual Water Co. system are billed a flat water rate of $50.00 every two months (Self-Help Enterprises, *pers. comm.* 2010). For the purpose of calculating total water costs, all households in Beverly Grand were assigned a monthly tap water cost of $25.00.

Household Expenditures on Water from Alternative Sources

In Beverly Grand, the 20 surveyed households that access water from alternative sources spend an average of $0.26 per gallon on vended water and $1.27 per gallon on bottled water. On average, these households spend $31.63 on non-tap water per month (s.d $26.78), or $6.57 per *person* per month (s.d. $5.79).

While the time and cost of travel to access alternative sources of water were excluded from calculation of total expenditures on non-tap water, we note that households in Beverly Grand live 1-2 miles away from grocery stores and vended water stations in the City of Porterville, CA, the nearest community with alternative water sources. Based on anecdotal information not formally recorded in the survey, households may travel to these locations to access water at least once a week. Additionally, one household reported paying a *raitero*, an individual with a vehicle that provides transportation services to other residents, $150 per month for trips in which vended or bottled water is purchased.[10]

Image 4. Residents avoid drinking nitrate-contaminated tap water and commute to nearby towns to purchase water from vending machines or grocery stores.
Photo Credit: Eyal Matalon

Household Expenditures on Point-of-Use Filters

As noted, three households in Beverly Grand reported using a household filter. The monthly, self-reported, amortized capital and servicing costs of these point-of-use filters, assuming a 10-year lifetime and a 5% annual discount rate, are reported in Table 5.

[10] The household likely conducted other errands during trips in which vended and bottled water was purchased.

Table 5: Self-reported expenditures on three point-of-use filters documented in Beverly Grand

Brand/Model	Upfront Cost (including installation)	Servicing Cost	Servicing Frequency	Amortized Monthly Cost
"Discovery"*	$4700	N/A	N/A	$49.85
Unspecified Reverse Osmosis**	$100	$20	Every 3 months	$7.76
Unspecified Reverse Osmosis**	$300	$75	Every 6 months	$18.42

* Follow-up internet-based research did not find any additional information about "Discovery" brand filters.

** Respondents could not specify the brand and model of reverse osmosis filter used in the home.

Total Household Water Expenditures

Households in Beverly Grand spent an average of $58.79 per month on water-related expenditures (s.d. $25.37, range $29.00–$153.27, median $54.76), or $13.12 per person (s.d. $6.39). This average expenditure on vended and bottled water, household filters, and tap water service account for 4.4% of median household income, or nearly three times the 1.5% affordability threshold recommended by the U.S. Environmental Protection Agency. Avoidance measures alone represent a significant proportion of household incomes—70% of surveyed households spent more than 1.5% of household income on purchasing alternative water sources and/or using point-of-use filters. When household expenditures on tap water service are considered, nearly all (95%) households surveyed in Beverly Grand are spending more than 1.5% of their income on water-related expenditures (see Figure 4). On average, households spend 3.9% of their income (s.d. 1.7%) on water-related expenditures.

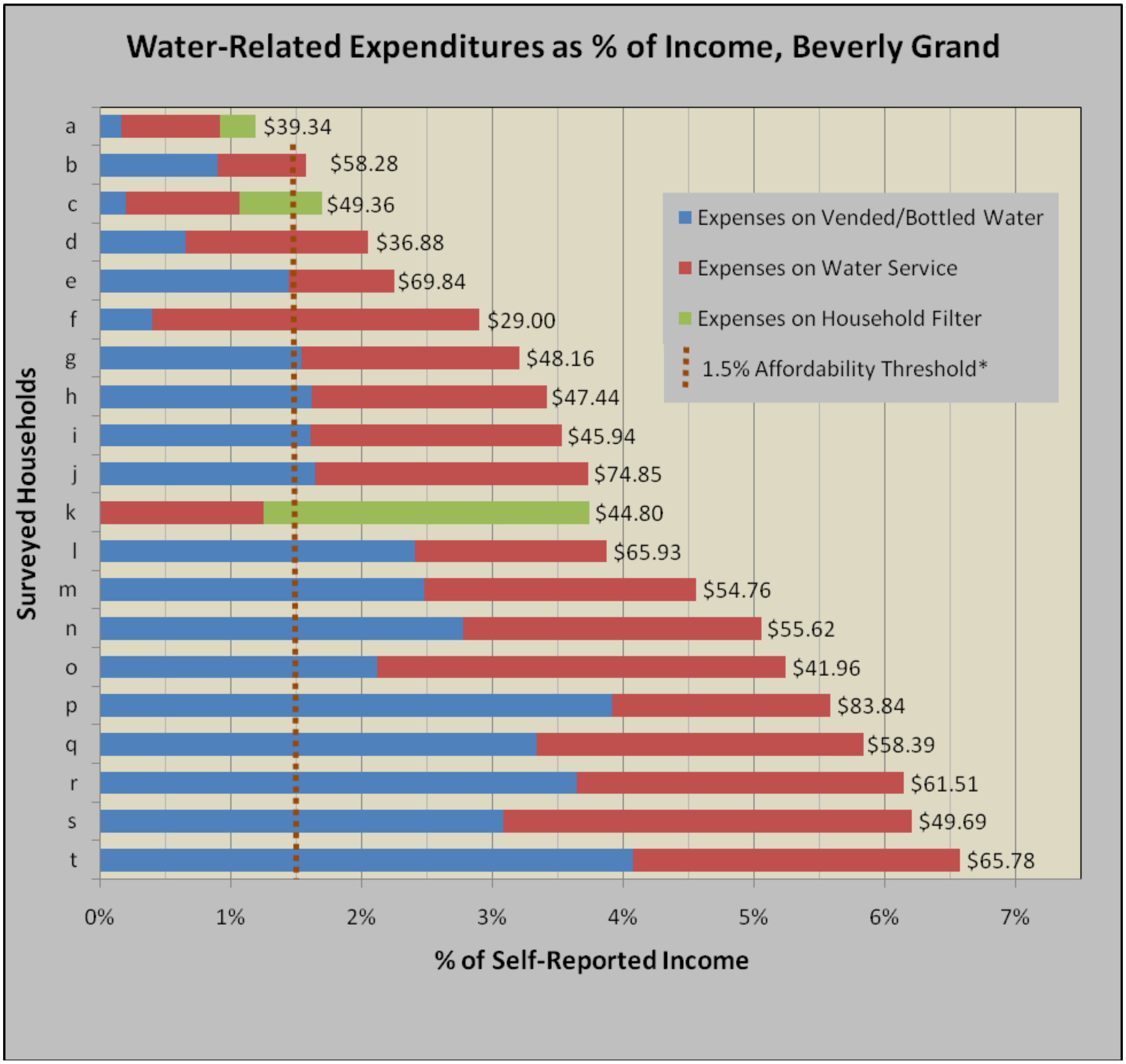

Figure 4: Water-Related expenditures as a percentage of income for the 20 households in Beverly Grand that reported monthly earnings. Dollar amounts to the right of each bar denote the absolute amount spent by each household on water.

Community Attitudes

While over half of surveyed households in Beverly Grand feel that the water provider was adequately providing information about water quality, two-out-of-five households expressed dissatisfaction with the degree to which government agencies were protecting the water in the community. A third of homeowners and a quarter of renters feel that drinking water problems have reduced the value of their property. Finally, nearly half of households feel that drinking water quality has become worse over the last five years (see Figure 5).

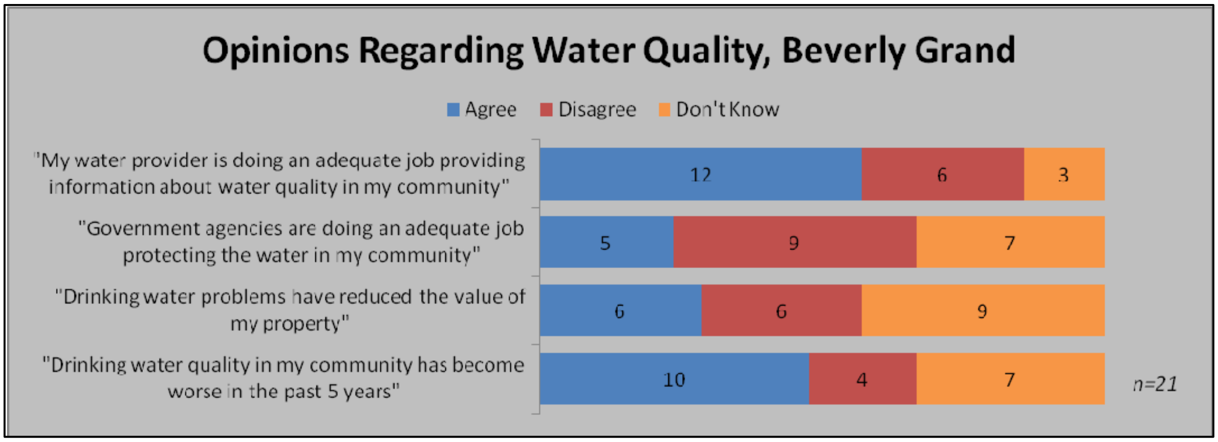

Figure 5: Responses to four questions related to water quality, Beverly Grand

3.2.4. Selected Findings from the Lemon Cove, El Monte, and Soults Communities

Below we summarize results relating to perception of contamination, household water use, and the financial burden of water costs for 16 households surveyed in Lemon Cove, El Monte, and Soults. Consistent with results in Beverly Grand, many households are unaware of nitrate-contamination of their tap water and are using it for drinking and cooking, and a majority of households in all three communities spend more than 1.5% of their monthly income on water expenditures. More detailed results for each community are shown in Appendix D.

Table 6. Perception of contamination, household water use, and water-related expenditures as a percentage of income for 16 households surveyed in Lemon Cove, El Monte, and Soults

Survey Result	Description	Community Lemon Cove n=5	El Monte n=7	Soults n=4
Perception – Any Contamination	Number of households perceiving contamination of tap water	4 (80%)	5 (71%)	3 (75%)
Perception – Nitrate Contamination	Number of households perceiving *nitrate* contamination of tap water	3 (60%)	0 (0%)	3 (75%)
Water Use – Drinking	Number of households drinking unfiltered tap water	2 (40%)	1 (14%)	0 (0%)
Water Use – Cooking	Number of households cooking with unfiltered tap water	2 (40%)	6 (86%)	0 (0%)
Household Water Expenditures	Range of household expenses on vended/bottled water, tap water, and filters	$37.06 - $57.82	$32.15 - $110.91	$48.83 - 83.32
Financial Burden – All Water Expenses	Number of households spending more than 1.5% of income on all water-related expenses (vended / bottled water, tap water, filters)	3 (60%)	5 (71%)	3 (75%)
Financial Burden – Avoidance Measures	Number of households spending more than 1.5% of income on measures to avoid contamination (vended / bottled water, filters)	2 (40%)	4 (57%)	0 (0%)

3.3. Discussion

Findings from the survey of households in nitrate-impacted communities raise concern regarding the economic and quality-of-life impacts and health risk borne by households with nitrate-contaminated tap water. Surveyed households spend a significant portion of their monthly income on alternative sources of water and point-of-use filters. However, that nearly half of households cook or drink with tap water suggests that exposure to nitrates is not altogether avoided. Thus contamination poses a dual burden on both the economic and potential physical wellbeing of affected households. Table 7 summarizes the impacts of nitrate-contaminated tap water in the Beverly Grand community, in which 75% of residential users were interviewed:

Table 7. Major household-level impacts of nitrate-contaminated tap water

1. Lack of awareness of contamination	Almost half (43%) of households are not aware of nitrate contamination of their tap water; Spanish-speaking households are less likely to perceive unsafe or contaminated water.
2. Exposure to nitrate-contaminated water	Nearly half (48%) of households are potentially exposed to nitrate-contaminated tap water, primarily through cooking with unfiltered tap water, but also through drinking the water and using filters that have not been adequately serviced.
3. Costly measures to avoid nitrate-contaminated water, in addition to flat rates for water service.	Obtaining water from alternative sources was the most prevalent means of avoiding contaminated tap water, with 95% of households reporting that they purchased vended and/or bottled water for use in the home. On average, households spend $31.30 every month on vended and bottled water, not including the cost of travel.
	While very few households use point-of-use filters, those that do may have devices that do not reduce nitrates to levels below the MCL or are not adequately serviced. The documented costs of installing and maintaining a household filter is highly variable, ranging from $7.76-$49.85 per household month.
	In addition to expenses on filters and alternative sources of water, households must pay for nitrate-contaminated tap water. Users in Beverly Grand pay a fixed monthly rate of $25.00 for water service.
4. High financial burden to low-income households	The majority of households reported earning less than half the income needed to meet basic needs. 95% of households are spending a percentage of their income on water that exceeds the threshold for water affordability set by the U.S. Environmental Protection Agency. On average, water-related expenditures amount to 4.1% of household income, or nearly three times what is considered affordable.

Below, we offer a brief discussion of each of these household-level impacts.

3.3.1. Lack of awareness about contamination

Notification requirements established by the California Department of Public Health (CDPH) require water providers to inform system users of Safe Drinking Water Act violations as well as the health implications of consuming contaminated water. However, while most surveyed households perceive a problem with the safety of their tap water, less than half are aware of the nitrate contamination, despite reporting that they had received notices in the mail. Perceptions of tap water appear to be influenced by English-language proficiency, with surveyed households whose preferred language was Spanish less likely to perceive unsafe tap water or know about nitrate contamination.

Table 8 summarizes the information that public notices of MCL violations must contain, per the California Code of Regulations (2007).

Table 8: General notice requirements for water providers in the event of a Safe Drinking Water Act violation, per Cal. Code Regs. tit. 22, § 64465 (2007).

Public notice of Safe Drinking Water Act violations, required content*:
1. a clear and readily understandable explanation of the violation, including the date it occurred;
2. the potential adverse health effects of the contaminants present;
3. the population at risk (including particularly vulnerable subpopulations, such as pregnant women and small children);
4. the steps that the water provider is taking to correct the violation and when it expects the problem to be resolved;
5. whether it is necessary to seek alternative water supplies;
6. a telephone number of the water provider where additional information concerning the notice can be obtained;
7. a statement encouraging the reader to distribute the notice to other water users.

*Adopted from Community Water Center's *Guide to Community Drinking Water Advocacy* (Firestone 2009)

The information in the notice must also be displayed so that it catches attention, must be understandable at the eighth-grade reading level, and must not contain language that contradicts or minimizes the required information. The public notice must also contain a section in Spanish, or any other non-English language spoken by a significant subset of water users, explaining the importance of the notice and listing a telephone number where further information can be obtained. For nitrate MCL violations, which are dangerous even at short-term exposure levels, the water provider must use a method of delivery that reaches all water users, such as "radio or television, posting in conspicuous locations, or hand delivery" (Firestone 2009).

The lack of awareness of contaminated tap water suggests that water providers may not be adequately implementing CDPH notification requirements or that the requirements themselves are insufficient. Problems with notifications of MCL violations that are commonly reported by users of other nitrate-contaminated water systems include (Herrera and De Anda, *pers. comm.*):

- not receiving notifications at all;
- the notification is unclear or written in language that is too technical;
- the notification states that residents do not need to obtain alternative water supplies but then states that severe health impacts may occur if they consume the tap water;
- the notification only warns of the health risk of nitrates to children and pregnant women;
- the notification is not provided in Spanish even when the vast majority of residents are primarily Spanish-speaking.

Current regulations do not require information to be provided to consumers on which actions may reduce exposure for the relevant contaminant(s). Given that notices do not include this information, it should not be surprising that residents utilize inadequate measures to mitigate nitrate contamination, such as boiling water or mixing with bleach. Template notices provided by CDPH should include more information regarding appropriate measures to avoid exposure for each type of contaminant as well as a link to the list of CDPH certified filters. Additionally, given the problems reported in even receiving adequate notices, further compliance enforcement, outreach and technical assistance to water providers, particularly small community water systems with volunteer water boards and limited resources, is needed.

3.3.2. Exposure to nitrate-contaminated tap water

That nearly half of surveyed households drink or cook with unfiltered tap water means there is a potential for exposure to elevated nitrates and risk of associated health outcomes. The number of surveyed households consuming unfiltered tap water is particularly concerning when we consider that many systems in the San Joaquin Valley have been in violation of nitrate limits for multiple years; Beverly Grand, for example, has been out-of-compliance for over a decade (*pers. comm.*, Tulare County Environmental Health Water Surveillance Program 2010). The risk of developing health conditions associated with nitrate exposure is especially pronounced among 15 households (41% of those surveyed) with infants and young children and among households that have lived in nitrate-impacted communities for several years. While this study does not attempt to estimate exposure to nitrate-contaminated drinking water, our findings suggest that the potential for exposure and associated health conditions such as premature birth; methemoglobinemia; kidney, spleen, and thyroid problems; as well as various kinds of cancer, may be significant and that a statewide assessment of exposure to nitrate-contaminated water must become a near-term priority.

Image 5. Residents in nitrate-impacted communities must use water from alternative sources to prepare food.
Photo credit: Eyal Matalon

The potential exposure to nitrate-contaminated water in nearly half of surveyed households may be partially explained by gaps in knowledge of water safety, with those that perceive unsafe water appearing less likely to use unfiltered tap water for drinking or cooking. While the size of our sample and limitations of survey methodology bar us from establishing a definitive relationship, the link between household perception of water safety and consumption of tap water has been well documented in the avoidance literature (Collins and Steinback 1993; Um et al. 2002). Given the costs associated with avoidance of contaminated water, minimal disposable income among the majority of *low income* and *very low income* households may also explain the tap water consumption. Prior studies have shown that available time and money influence the extent to which households take measures to avoid unsafe water (Laughland et al. 1993; Larson and Gnedenko 1999). Nevertheless, as this survey and studies elsewhere in the United States have shown, low-income households will still spend a significant portion of their income avoiding contaminated water (Hughes et al. 2005). Other factors that shape household avoidance of contaminated tap water may include proximity to a vended water station or a grocery store, knowledge about and availability of point-of-use nitrate filters, and time available to access safe water (Laughland et al. 1993).

Undertaking avoidance measures (e.g., installing a filter, purchasing vended water, etc.) does not, in and of itself, ensure that members of the household are protected against the health risks of water contamination. For example, the safety of consuming water from alternative sources will depend on the quality of the alternative water source. It has been noted anecdotally that vended water stations are connected to systems that source their water from contaminated wells, and are not licensed to remove contaminants over drinking water standards (Firestone, *pers. comm.* 2010).[11] Assuming the alternative source of water is safe, our survey demonstrates how households use water from alternative sources in combination with tap water. Many households exclusively drink bottled or vended water but regularly use contaminated tap water for things like boiling potatoes, preparing soup, or making coffee and tea. Households that purchase and

[11] Although vended water machines are not licensed to remove contaminants to meet drinking water standards, many vended water machines do use reverse osmosis and carbon filter technology that can remove contaminants below drinking water standards (Firestone *pers. comm.*).

install water filters are acting on concerns about water safety, but these filters do not always effectively remove nitrates or are not adequately maintained and serviced. As our findings also show, in some cases, households use "home remedy" treatments that have no impact on reducing nitrates, and may only increase them (i.e. boiling). Thus, in the worst of cases, households may attempt to reduce exposure, but actually elevate the risk of associated health conditions. As stated above, this further suggests that health notice regulations may need to be updated to include such exposure mitigation information along with information on the health hazard.

3.3.3. Costly measures to avoid nitrate-contaminated water

Nearly all (95%) of surveyed households in Beverly Grand obtain water from an alternative source, with nearly half reporting that they use exclusively vended and bottled water for drinking and cooking. The majority of households (71%) purchased *both* bottled and vended water although, on average, vended water was five times more cost-effective (price per gallon) than bottled water. This may be explained by the relative convenience of both accessing bottled water—it may be easier for households to pick up bottled water along with other items at the grocery store than make an additional trip to a vended water station—and using bottled water in the home—it is less cumbersome to drink water out of a small bottle than to manipulate heavy five-gallon jugs. The propensity to buy more expensive bottled water may also be due to lack of awareness about the relative cost-effectiveness of different sources of water, or a perception that bottled water is of better quality.

Using water that comes out of the household tap is arguably more convenient and certainly less expensive than using water from alternative sources. According to the California Water Rate Survey, Californians paid, on average, $36.39 per month for 1500 cubic feet of water in 2006, including various monthly service charges (Black & Veatch 2006). This amounts to a rate of $.0032 per gallon: over 80 times less than the average cost of vended water purchased in Beverly Grand and nearly 400 times less than the average cost of bottled water. Given that households in Beverly Grand already pay a substantive fixed rate for their tap water, our findings suggest that households could potentially save hundreds of dollars every year if domestic water supplies were not contaminated. We note that our study excludes an important component of the costs of avoiding contaminated water: transportation. Accessing water from an alternate source includes "the operating costs of the automobile and the opportunity cost of travel time," which in other studies has been estimated to amount to an additional $7-14 per month (Laughland et al. 1993). Because nitrate contamination disproportionately impacts small water systems in unincorporated communities, many affected households must travel long distances to the nearest grocery store or vended water station to purchase alternative sources of water (Balazs 2010).

Passing tap water through point-of-use filters was an avoidance measure documented in six surveyed households. The monthly amortized costs of purchasing, installing, and maintaining point-of-use filters were self-reported and highly variable, ranging $7.76 to $49.85 per month.

While we do not offer an analysis of the cost-effectiveness of water treatment devices relative to accessing water from alternative sources, other research has demonstrated that installing a point-of-use filter may be the most cost-effective avoidance measure for a four-person household. That relatively few surveyed households pursued this measure may be explained by the observation that lower-income households are "less likely to install filters because it requires a higher initial investment" (Sargent-Michaud 2006). Because many communities have been dealing with nitrate-contaminated tap water for over a decade, there is need for widespread community outreach and education about the most cost-effective, as well as health-protective, measures to avoid exposure to nitrates.

The cost of these measures to avoid nitrate-contaminated water is added to the cost of tap water service. The monthly cost of tap water ranged from $17.45 to $37.50 in the four water systems we surveyed, but water rates in other systems in violation of the nitrate MCL may be significantly higher. For example, users of the Tooleville Water Co. system pay $40 per month for nitrate-contaminated water that has been out of compliance for over a decade. Residents of Seville, CA pay $60 every month for nitrate-contaminated tap water in addition to expenditures on filters and vended or bottled water. Many small community water systems have a fixed rate for tap water service, so users cannot realize even the minimal savings from reductions in tap water usage (Firestone *pers. comm.*).

Image 6. Because nitrate contamination is most common in small, unincorporated communities, affected households often must travel considerable distances to purchase alternative sources of water.
Photo Credit: Eyal Matalon

3.3.4. Financial burden to low-income households

The survey findings show the tremendous financial burden borne by low-income households with nitrate-contaminated water. The high cost of accessing water from alternative sources coupled with the low earnings of households suggests that low-income families disproportionately shoulder the burden of nitrate-contaminated water. The U.S. Environmental Protection Agency and the California Department of Public Health suggest that average household expenditures on water service not exceed 1.5% of median household income (MHI) in any water system (EPA 2003; CDPH 2010). Among surveyed households in Beverly Grand, average-household-related expenditures on water were three times greater than this affordability threshold. Ninety-five percent of all surveyed households in Beverly Grand spend more than 1.5% of their low income on water-related expenditures. Even more striking was the share of households (70%) that exceeded the affordability threshold in terms of their expenditures on filters and alternative sources of water alone.

The majority (75%) of surveyed households in Beverly Grand earn less than *half* the income needed for a typical two-parent family in Tulare County, suggesting that, at best, these households have little-to-no disposable income, and, at worst, these families are living without basic necessities. That the average household spends 4.1% of their income on water begs the question: what basic expenses are low-income households foregoing to access safe water? Perhaps households are spending less on healthcare, education, or even food in order to avoid exposure to nitrate contamination. Our study does not document the trade-offs made by households that are spending a significant portion of their earnings on water, but the lack of disposable income in many of these households means that the additional cost of water likely comes at the expense of other basic necessities. While water-related expenditures documented here cannot *entirely* be attributed to nitrate-contaminated tap water, and may in part be due to individual preferences, it is important to remember that households in nitrate-impacted communities *must* incur these additional types of costs in order protect their health.

3.3.5. Implications for the San Joaquin Valley

Survey results from Lemon Cove, El Monte Mobile Home Park, and Soults Mutual Water Company systems suggest that gaps in knowledge about water quality, exposure to nitrate-contaminated tap water, and high water-related expenditures are not unique to Beverly Grand (see Table 7). While the small sample size prevents us from drawing any definitive conclusions about these communities, our findings raise significant concern about the health, economic, and quality-of-life impacts of nitrate-contaminated water throughout the region.

This survey of 37 households in four communities is the only known study that systematically documents the household-level costs of nitrate contamination in the San Joaquin Valley. The method we used to document these costs, the avoidance cost method, can be rigorously applied in nitrate-impacted communities throughout the San Joaquin Valley to better inform an estimate of the full costs of nitrate contamination. Such analyses will allow policy and regulatory decision-making to more fully account for the economic impact of nitrate contamination of groundwater.

4.0 Costs to Community Water Systems

4.1. Introduction

Ensuring safe drinking water when sources have high nitrates often involves costly mitigation projects. The costs of actions by community water systems are a potentially significant component of the economic impact of nitrate contamination of groundwater. To analyze this impact we examined proposals for nitrate mitigation projects and records of funded nitrate projects. In this section we examine the projects that have been proposed and those that have been funded to remove nitrates in community water systems in the San Joaquin Valley.

Drinking water systems that find nitrate levels above the legal limit in source wells are required within 24 hours to notify customers and begin consulting with the Department of Public Health about measures to ensure residents' health.[12] This may entail various approaches (see Table 9 below), such as shutting off the well or blending the water from the contaminated well with water from other sources. Systems may also drill a new well, deepen an existing well, or install pipelines and other infrastructure to connect to and secure water from a nearby water system. If a system cannot take immediate action by shutting down the well or blending, and it must continue using the contaminated well, it must advise the users not to consume the water until further notice.

[12] CA Code of Regulations, Title 22, Division 4, Chapter 15, Article 18, section 64432.1

Table 9. Types of drinking water improvement projects responding to elevated nitrate levels

Project Type	Primary Components	Advantages	Disadvantages
Blend with another source	- Pump and storage capacity - Regular monitoring of blended water - Make adjustments to blend as needed	- Low-cost and relatively quick if a nearby source is available - No waste disposal or certification needed as with treatment	- Fluctuating nitrate levels may make option unreliable - Increasing nitrate levels may make option unsustainable
Drill a new well	- Research new site Drill test well(s) - Drill production well - Build storage and hypochlorinator - Connect to system	- Relatively low capital and ongoing costs - Public grants and loans available	- Deeper well may tap higher arsenic levels, or nitrate levels may increase within a few years -Costly to test whether new well will yield safe water
Consolidate with another system	- Political process to obtain permission - Install pipelines and pumps - Possible ongoing connection fees	- Increases number of users, improving economy of scale - Public grants and loans available - Highly sustainable if new system has treatment capacity or safe water source	- Political barriers can be insurmountable - Local board may lose its authority, reducing venues for community input
Install a treatment plant	- Feasibility study and design - Certification as treatment plant operator - Construction - Ongoing operations and monitoring	- Guarantees capacity to deliver water with safe nitrate levels, assuming adequate technical, managerial and financial capacity	- High initial and ongoing costs - Public funding not available to mitigate continued high costs of operation and maintenance - Difficult waste disposal
Wellhead protection	- Identify wellhead protection area and potential nitrate sources - Implement program to change land use practices - Monitor effects on groundwater	- Long-term sustainability of addressing the root cause of nitrates in groundwater	- May take years before groundwater quality is affected - Existing regulations constrain possible efforts - Without near-term solutions, on its own it does not reduce near-term/current exposure

Source: Washington Department of Health 2005; Boyer 2010.

The adequacy of these mitigation strategies in providing a sustainable solution to high nitrate concentrations depends on local conditions, but general strengths and weaknesses have been well-documented. Blending water with high nitrate levels with water from cleaner sources can provide a relatively low-cost and convenient approach, yet it can be unreliable and comprise a short-term fix due to fluctuating and increasing groundwater nitrate levels, and may not be feasible if there is no source to blend with. Deepening an existing well or establishing a new one is also less expensive than treatment, though it is still costly, and is unsustainable where nitrate levels are increasing or if other water contaminants (e.g. arsenic) are present and above legal limits. Connecting a system to another water system that has safe water can be a sustainable approach and improve economies of scale, but political barriers to consolidation can limit implementation of this approach, or add years to solving the problem. Treatment ensures safe water independent of changing groundwater quality, but disadvantages include the high capital, operations, and maintenance costs, as well as the need to dispose of the hazardous waste products generated by the treatment method. Wellhead protection can improve groundwater quality, providing long-term benefits, but political barriers in implementing source controls as well as hydrological and geological conditions that may delay the groundwater quality benefit are challenges to this approach. Furthermore, it does not on its own address near-term exposure issues.

There is no comprehensive source of information on the number of or costs of nitrate mitigation projects in the San Joaquin Valley, yet records of nitrate levels in drinking water source wells provide a useful indicator of how many systems have had to take some action to avoid delivering nitrate-contaminated water. To estimate the number of public drinking water systems with nitrate problems in the San Joaquin Valley, Balazs (2010) analyzed the California Department of Public Health Water Quality Monitoring (WQM) database of source-level (i.e. surface water intakes or groundwater wells) water quality monitoring results during 2005-2008, and identified the community water systems with wells whose quarterly nitrate levels were above the Maximum Contaminant Level (see Table 10). These preliminary results indicate that 1.3 million people served by drinking water systems with nitrate-contaminated source wells comprise 35% of the total 3,774,319 residents in the San Joaquin Valley.[13]

Table 10. San Joaquin Valley community water systems with monitored source-level nitrate concentrations above the maximum contaminant level, 2005-2008

Size of system by number of connections	Number of systems with at least one source with quarterly nitrate samples above the MCL	Population within these systems	Average number of sources
Above 10,000	6	1,039,208	21.5
1,000-10,000	17	263,472	5.1
200-1,000	13	21,566	2.5
Under 200	56	10,816	1.7
Total	**92**	**1,335,062**	

Source: Preliminary results from Balazs, 2010, analysis of monitoring results from the Water Quality Monitoring (WQM) database.

[13] Not all of these water users may have had tap water with nitrate levels above the legal limit if their water providers took action that immediately reduced nitrate levels (e.g. shutting off the contaminated source).

Preliminary results indicate that of the 92 systems (14% of all systems active in 2007) with high nitrate wells during this time period, 61% were small systems with fewer than 200 connections. The number of water sources that PICME lists for these small systems highlights the limited alternative sources available when a well has unsafe nitrate levels. With less than an average of two drinking water sources, these small systems have limited options for shutting down a contaminated well or blending it with other sources. While water from these sources did not necessarily enter into the system, the results are useful in that they indicate the potential number of systems that would have had to take some action to prevent delivering nitrate-contaminated drinking water.

4.2. Methods

For our analysis of nitrate contamination costs to community water systems in the San Joaquin Valley, we looked at the project proposals submitted by community water systems in the region to the California Department of Public Health (CDPH) for various grants and loans, as well as the projects funded by the CDPH and the U.S. Department of Agriculture (USDA). These two datasets provide estimates of how much it would cost to meet the current need for nitrate projects, and how much was spent in recent years to assist community water systems with nitrate contamination.

To assess the costs of projects needed, we analyzed the proposed projects on the CPDH Project Priority Lists for potential funding from the State Revolving Fund (SRF) and Proposition 84. We focus on the Proposition 84 and SRF lists because they are the primary sources of funding for drinking water projects for Community Water Systems in California. The USDA also funds community water system projects, although far fewer, and responded to inquires stating that they do not maintain a list of proposed projects and cannot provide such information (USDA, pers. comm. 4/15/10). The versions of these lists used for this report were the State Revolving Fund Project Priority List published August 2010, and the Proposition 84 (Section 75022) Draft Project Priority List published February 2011.

We combined the two lists, removed duplicate listings, and filtered out proposed projects that were outside the San Joaquin Valley or did not address nitrates. We then divided the projects into those that address nitrate contamination alone and those that are proposed to address nitrates and other drinking water problems as well. We categorized the projects by type of mitigation strategy, using the types described in Table 9. The very brief project descriptions in the lists frequently lack enough information to determine the mitigation strategy, and in some project descriptions, the system is still considering multiple options on what type of project to implement. In these cases, potential projects type are noted, e.g., “Consolidation or drill.” Then, using the costs of the proposed projects in each category, we calculate the average, minimum, and maximum projects costs, and the total costs of all projects in the category.

Because the project descriptions are so brief, the numbers cannot be used to estimate the full cost of a typical project. A second limitation is that the community water systems in the Project Priority List do not include all community systems in need of improvement projects related to nitrates; it only includes systems that have applied for assistance. Small community water systems have such limited capacity that for many of them even the application process is unfeasible. Despite these two limitations, our estimate gives an overall snapshot of the stated need for projects addressing nitrate-contaminated drinking water sources in the region, and likely is an underestimate.

We then turn to the projects that have been funded during 2005-2009 to estimate the actual costs of nitrate-related drinking water projects in community water systems in the San Joaquin Valley. Our analysis of projects funded relies on information from the CDPH and the USDA. The CDPH distributes grants and loans toward these projects using funding from Proposition 84, the State Revolving Fund, the American Recovery and Reinvestment Act, and other sources. The USDA provides funding to community water systems through the Rural Development Rural Utilities Service program, as well as funding from federal earmarks. Often, larger and other types of water systems have a wider array of funding sources available to them. We categorized these projects in the same way as with the proposed projects, and again calculated the average minimum, maximum, and total project costs.

4.3. Results

Costs of Proposed Projects

The 100 projects in the CDPH Project Priority Lists proposed by Community Water Systems indicate that a mix of nitrate-mitigation strategies are pursued, with wellhead protection and blending being the least represented (see Tables 10 and 11). Of the 63 proposed projects that would address nitrate alone, 27% (17) applied for assistance with treatment alone or in combination with another strategy; a third (21) propose drilling a new well; and about one fourth (15) propose consolidation alone or as an option considered with other potential strategies. The descriptions for ten of the projects are insufficient to determine what mitigation strategies they will involve. For projects addressing other drinking water issues as well as nitrates, the types of proposed projects are slightly different, with only 10% (4 of 37) proposing treatment, one fourth (9) proposing to drill, and one third proposing projects that would consolidate the system with another system (see Table 11). Nine projects lacked information on the specific mitigation measures being proposed. Wellhead protection is not named in any proposed projects.

The average costs of proposed projects addressing nitrate alone is just under $1 million, and projects for nitrate and other issues average $2.3 million. This average of projects with multiple issues is $1.5 million when we exclude the abnormally high cost of the $34 million upgrade to a treatment plant proposed by the Kern County Water Agency. Each project type has a fairly wide range of costs, and lack of information on factors influencing costs prevents conclusions on how the costs of each type compare to each other. The total sum of project costs for all 100 projects is $150 million, including $62 million for those proposing to mitigate nitrate contamination, and $88 million for those addressing nitrate and other concerns.

Table 11. Costs of proposed projects noting nitrates as the sole problem

Project Type	Number of Proposals	Average Project Cost	Minimum Project Cost	Maximum Project Cost	Total Project Cost
Blending or Consolidation	1	$1,500,000	$ 1,500,000	$ 1,500,000	$ 1,500,000
Consolidation	8	$1,169,128	$ 250,000	$ 5,008,020	$ 9,353,020
Drill	17	$1,203,529	$ 100,000	$ 4,700,000	$ 20,460,000
Drill or Consolidation	2	$631,250	$ 262,500	$ 1,000,000	$ 1,262,500
Infrastructure to blend	1	$100,000	$ 100,000	$ 100,000	$ 100,000
Feasibility Study	6	$55,500	$ 25,000	$ 80,000	$ 333,000
Treatment	11	$1,372,659	$ 150,000	$ 4,500,000	$ 15,099,250
Treatment or Consolidation	4	$1,030,250	$ 621,000	$ 1,500,000	$ 4,121,000
Treatment or Drill	2	$581,500	$ 300,000	$ 863,000	$ 1,163,000
Unclear	11	$774,718	$ 100,000	$ 2,000,000	$ 8,521,900
Total	**63**	**982,757**	**$ 25,000**	**$ 5,008,020**	**$ 61,913,670**

Source: CDPH SRF Project Priority List (August, 2010) and CDPH Proposition 84 Draft Project Priority List (February, 2011)

Table 12. Costs of proposed projects noting multiple sources of contamination or system-level needs, including nitrates

Project Type	Number of Proposals	Average Project Cost	Minimum Project Cost	Maximum Project Cost	Total Project Cost
Consolidation	10	$2,106,080	$ 115,000	$ 15,000,000	$ 21,060,800
Drill	8	$1,697,619	$ 100,000	$ 3,500,000	$ 13,580,950
Drill and Consolidation	1	$1,813,000	$ 1,813,000	$ 1,813,000	$ 1,813,000
Infrastructure to blend	2	$1,050,000	$ 500,000	$ 1,600,000	$ 2,100,000
Feasibility Study	3	$200,000	$ 20,000	$ 500,000	$ 600,000
Treatment	2	$800,000	$ 300,000	$ 1,300,000	$ 1,600,000
Treatment or Consolidation	1	$1,500,000	$ 1,500,000	$ 1,500,000	$ 1,500,000
Unclear	9	$1,332,985	$ 150,000	$ 4,322,750	$ 11,996,862
Upgrade treatment plant	1	$34,000,000	$ 34,000,000	$ 34,000,000	$ 34,000,000
Total	**37**	**$2,385,179**	**$ 20,000**	**$ 34,000,000**	**$ 88,251,612**

Source: CDPH SRF Project Priority List (August, 2010) and CDPH Proposition 84 Draft Project Priority List (February, 2011)

Together, the USDA and the CDPH funded 16 nitrate-related drinking water projects during the four-year period of 2005-09, which totaled $21 million. Of the 14 nitrate mitigation projects funded by the CDPH during 2005-09, approximately half entailed drilling new wells and the other half involved system consolidation (see Table 13). Total CDPH project costs were $19,628,377. Both the USDA-funded projects involved drilling new wells, with a total cost of $1,375,000 (see Table 14). The sum of projects funded by the two agencies represents 13.3% of the costs of proposed projects on the current CDPH project priority lists.

Table 13. CDPH funding for projects involving nitrate mitigation, 2005-2009

Project Type	Number of Projects Funded	Average Project Cost	Minimum Project Cost	Maximum Project Cost	Sum Project Costs
Consolidation	6	$ 910,114	$200,000	$1,505,367	$5,480,472
Well	6	$ 1,017,090	$492,955	$2,290,000	$5,535,455
Well and Consolidation	2	$ 4,306,225	$1,150,000	$7,462,450	$8,612,450
Total	**14**	**$ 1,481,966**	**$200,000**	**$7,462,450**	**$19,628,377**

Source: CDPH public records release (2010)

Table 14. USDA funding for drinking water projects involving nitrate mitigation, 2005-2009

Project Type	Number of Projects Funded	Average Project Cost	Minimum Project Cost	Maximum Project Cost	Sum Project Costs
New Well	2	687,500	375,000	1,000,000	1,375,000

Source: USDA public records release (2010)

Of the 29 San Joaquin Valley community water systems that received a nitrate MCL violation between 2005 and 2007 (PICME and County Annual Reports), only three were funded by the CDPH and/or the USDA between 2005 and 2009. Other funded projects during this time period went to drinking water systems for schools and Community Water Systems that do not appear in PICME and County Annual Reports. Twenty-four of the 29 systems in violation during 2005-2007 have proposed projects listed on current CDPH Project Priority Lists.

4.4. Discussion

Data from the CDPH and the USDA on funded nitrate projects suggests that 90% of community water systems in violation of nitrate contamination during 2005-2007 did not obtain funding for nitrate mitigation as of 2009, and 82% have proposed projects currently listed by the CDPH. The fact that only 3 of the 24 systems with an MCL violation were funded points to a significant gap between financing needed and that which is available to these systems with official violations of the Safe Drinking Water Act.

During the same period that 100 community water systems in the San Joaquin Valley submitted applications to the CDPH for projects to reduce nitrate levels, 16 projects of this type were funded by the CDPH and the USDA, leaving more than 80% of water systems waiting for projects to ensure safe drinking water. That nitrate project costs are too high to be independently financed by rate payers in community water systems, combined with the inadequate funding assistance to these systems, begins to explain why many systems have been waiting for years without a solution to nitrate contamination. Current and projected state budget cuts threaten to reduce even more the limited resources available for these critical drinking water projects.

While these results present a snapshot of current and potential costs to community water systems, a more detailed analysis might look at past funding from all public sources (including bond measures and community development block grants) for small water system infrastructure to determine: a) how stated funding priorities impacted the types of projects funding; b) whether these public investments have resulted in long-term benefit; and c) what impact, if any, public investment has had on the community's ability to obtain safe and affordable drinking water.

The limitations of these results must, of course, be considered. All of these are projects proposed by water providers before being funded must go through several planning phases that may lead to revisions in cost estimates. The lack of publicly available estimates of project costs prevents us from knowing the specific scope of work that each project cost refers to. Therefore, there is some uncertainty in our estimate of total project costs. However, the data serves as the best available indicator for estimating a major portion of current Valley-wide costs of addressing nitrate contamination at the water system-level (among CWS). Data on the projects that have been funded by the CDPH and the USDA provide a record of the types and costs of projects funded and undertaken by community water systems.

5.0 Conclusions and Recommendations

Nitrate contamination of groundwater has wide-reaching effects on California's health, economic vitality, and environmental wellbeing. The impact of nitrate-contaminated drinking water on residents in small community water systems is pronounced; their health and wealth are compromised when they consume their tap water or obtain water from safer sources. The distribution of nitrate contamination and its costs reveals that the problem is most dire in some of the areas of the state with the least capacity to cope with its effects and invest in sustainable solutions. This research points to several policies and further research to be pursued to better understand and resolve this entrenched challenge.

Conclusions

Residents are at high risk of health problems resulting from nitrate exposure. One-third of residents surveyed used tap water for drinking or cooking, despite years of existing nitrate contamination. Almost one-third of respondents did not realize the safety of their tap water was in jeopardy. More than half of those surveyed did not know that the problem with their water was due to nitrates.

The average cost of water for households exceeds affordability standards, and the cost of purchasing water adds a substantial economic burden. The costs of buying bottled and vended water and filters amount to more than 1.5% of household income for 70% of those surveyed. The total average household water costs constitute 4.6% of median household income in Beverly Grand, more than three times the affordability threshold for drinking water recommended by the U.S. EPA.

The health and economic burden of nitrate contamination and potential health risks due to exposure disproportionately affect low-income households and Spanish-speaking residents. Spanish-speaking households were less aware of nitrate contamination and the compromised safety of their tap water. Nearly all households surveyed earn less than what is necessary to meet basic needs, meaning the significant added costs of securing alternative water supplies likely force them to make trade-offs between fulfilling basic needs, which higher income households do not have to make.

Groundwater nitrate levels are increasing and the number of wells with nitrate violations may double within ten years. If current trends like those in Kern County continue, the number of wells with nitrate levels above the MCL will increase from 5% to 10% of monitored wells by the year 2020.

Public funding for nitrate mitigation in Community Water Systems remains inadequate and projects funded may not be providing sustainable solutions. An estimated $150 million in funding is needed to make drinking water in Community Water Systems safe from nitrates in the San Joaquin Valley, and 90% of the systems with nitrate violations between 2005-2007 had not received needed funding as of 2009. The most common approach for mitigating nitrates is drilling new wells, a strategy vulnerable to being unsustainable due to fluctuating and increasing nitrate levels in groundwater.

Policy Recommendations

Ensure nitrate-affected communities are well-informed about their water quality and appropriate measures to protect their health. Means to improving notification include: distributing notices in appropriate languages, increasing the frequency of notices, delivery to renters who do not receive the water bill, standardizing a more easily understandable format for notices, and providing clear information on effective exposure avoidance and in-home mitigation measures (including a link to the CDPH's list of certified filters for the appropriate contaminant), as well as the cost-effectiveness of actions households can take to access safe water.

Provide sufficient, targeted funding for short- and long-term solutions to ensure safe drinking water. Short-term measures such as point-of-use treatment or vouchers for purchased water are needed to ensure that communities with high nitrates do not have to wait years before having access to safe and affordable drinking water. Sustainable solutions such as system consolidation must be funded at levels at least sufficient to meet the costs of proposed projects on the CDPH project priority list. The CDPH should target funding to develop sustainable solutions for systems based on need, rather than passively waiting for systems with chronic violations to navigate complex application and funding processes and compete with larger, better financed systems for public financing.

Remove political barriers to consolidating small community water systems. Consolidation is an approach to addressing nitrate contamination that is sustainable in light of both the rising and fluctuating nitrate levels and the limited financial resources of small systems. Yet consolidation relies on the voluntary willingness of larger systems to join with smaller neighbors, and political resistance has made consolidation a rare occurrence. State legislation providing incentives and/or mandates to encourage consolidation are needed to achieve greater adoption of this type of solution.

Prioritize source control to reduce current and prevent new contamination. Although the federal Safe Drinking Water Act recognized the need for source water protection, no federal requirements were adopted. As a result, the CDPH has neither regulations nor funding or even advice for systems interested in protecting their drinking water sources from contamination. The State and Regional Water Boards, which are tasked with protecting water quality through the state's Porter-Cologne Act, have to date taken only limited steps to protect drinking water supplies from the largest contributor of nitrates: agriculture. The Central Valley Regional Water Board adopted a regulatory program to control discharges from dairies in 2007, but results have been difficult to ascertain due to data and oversight limitations. In April of this year, the Central Valley Regional Water Quality Control Board is scheduled to vote on a staff proposal to regulate discharges from irrigated agriculture. In order to be effective at protecting the Central Valley's major source of drinking water, this program must contain effective measures to protect groundwater.

Research Recommendations

Assess the impact of existing water quality notification systems on water-user awareness and behavior. The limited awareness of water quality in a water system in violation for nitrates for a decade suggests a serious flaw in existing systems for community education. A study of existing practices in multiple systems with diverse approaches could identify specific areas for improvement and best practices.

Conduct an epidemiological study of the health effects of nitrate exposure in the San Joaquin Valley. Our survey revealed a significant number of households consuming tap water from a system that has had nitrate levels above the legal limit for ten years. The exact levels of exposure to nitrates in such communities and resulting health outcomes have not been documented. An epidemiological study is needed to understand the full breadth of the public health dimensions of this widespread water-quality problem.

Carry out a more comprehensive economic study of the costs of nitrate contamination. Various types of potentially significant costs of nitrate contamination were beyond the scope of this study, including the costs of health impacts, effects on ecosystems, and costs to domestic well owners. A full picture of impacts of nitrate contamination will not be possible until these costs are accounted for.

Review the effects on groundwater quality of nitrate source control efforts in California. An analysis of changes in groundwater quality where source control projects have been implemented will provide valuable data on the time lapse and effectiveness of these efforts, allowing for strategic planning to address nitrate contamination at the source.

6.0 Appendices

Appendix A. Trend Analysis of Kern County Nitrate Groundwater Levels

Using a database including all nitrate measurements from 1980 to present in the GAMA database for Kern County, we selected wells that had ten or more samples recorded (678 wells), and fit a trend line of nitrate concentration versus time, using ordinary least squares regression. We used the uncertainty associated with this relationship to calculate the percent likelihood of exceeding the 45 mg/L threshold in 2010, 2015, and 2020.

Table 14. Trend analysis of nitrate levels in Kern County wells

Groundwater Basin	Total number of Wells	Number of wells with greater than 75% likelihood of exceeding MCL in 2010	Number of wells with greater than 75% likelihood of exceeding MCL in 2015	Number of wells with greater than 75% likelihood of exceeding MCL in 2020
Antelope Valley (6-44)	29	0	0	0
Brite Valley (5-80)	4	0	0	0
Castac Lake Valley (5-29)	6	0	0	0
Cuddy Canyon Valley (5-82)	5	0	0	0
Cuddy Ranch Area (5-83)	4	0	0	0
Cuddy Valley (5-84)	6	0	0	0
Cummings Valley (5-27)	14	2	2	3
Fremont Valley (6-46)	11	0	0	0
Indian Wells Valley (6-54)	36	0	0	0
Kern River Valley (5-25)	55	4	7	8
Mil Potrero Area (5-85)	2	0	0	0
No Basin Found	67	1	2	2
San Joaquin Valley - Kern County (5-22.14)	417	24	37	50
Tehachapi Valley East (6-45)	3	0	0	0
Tehachapi Valley West (5-28)	18	2	2	2
Walker Basin Creek Valley (5-26)	1	0	0	0
TOTAL	**678**	**33**	**50**	**65**

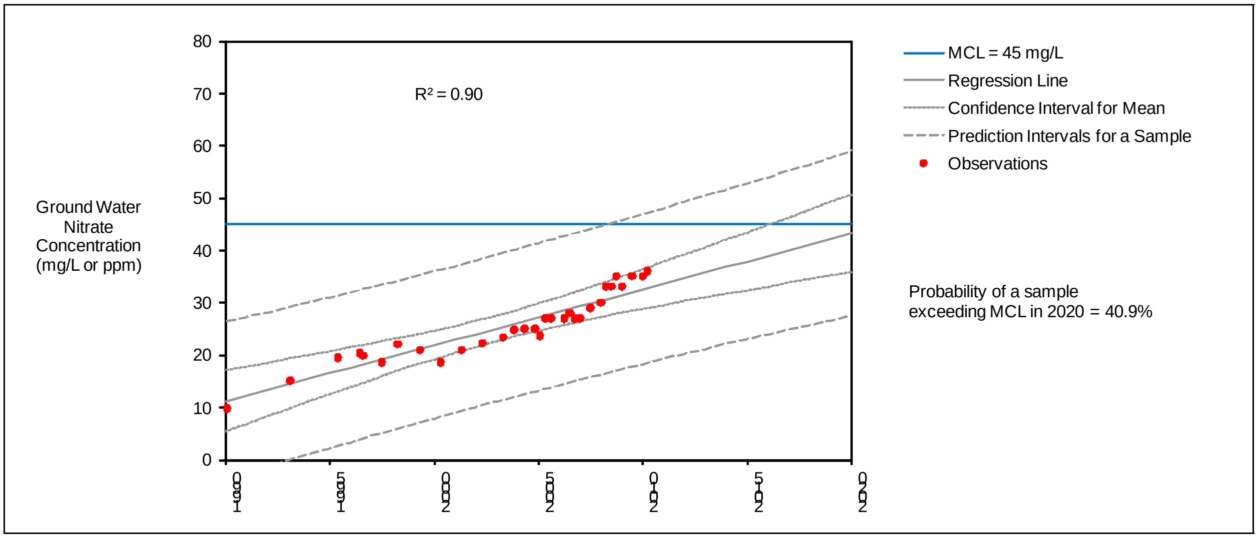

Figure 6. Predictions of nitrate level versus time at well 1500096-001 in Kern County. The outer dashed lines are the 90% prediction interval for the regression equation of nitrate concentration versus time. In the year 2000, the likelihood of a sample exceeding the MCL is very low, far less than 1%. Under current trends, by the year 2020, there will be a 40% chance of a sample exceeding the MCL.

Appendix B1. Consent Form Signed by Participants in the Household Survey

Survey on Water Quality and Costs

Consent to Participate in a Research Study

Introduction

This community survey asks about your perceptions of the quality of your tap water, how you use it, where else you get water, and how much of your income goes to buying water. The survey is part of a project that involves four non-profit and community organizations dedicated to improving drinking water: the Community Water Center, the Pacific Institute, Clean Water Fund, and the California Rural Legal Assistance Foundation. Below is a description of the research procedures and an explanation of your rights as a research participant. If you agree to participate, please sign in the space provided to indicate that you have read and understand the information on this consent form. You are entitled to and will receive a copy of this form.

Purpose of Study

The purpose of this research project is to document the social and economic impacts of contamination of groundwater. The study will focus on households and communities using small water systems in the San Joaquin Valley of California.

Household Survey Procedures

You will be asked a series of background questions, followed by more specific questions about your household's water use and purchases. You may choose to respond or not respond to any of the questions asked of you.

Duration of the Household Survey

Your participation in this focus group will last approximately 30 minutes.

Benefits of Participation

The findings from this study will be written into a report that will be distributed to policymaker and community audiences. Your participation will contribute to the public's understanding of how groundwater contamination affects households in your community.

Risks and Discomforts from Participation

We do not anticipate any risks or discomfort to you from being in this study.

Confidentiality

Information and quotes contributed during this survey may be used in the report. You will not be identified by name in any report or publication of this study or its results. Every effort will be taken to protect your identity as a participant in this study.

If you have questions or concerns, please contact the Susana De Anda and Maria Herrera at the Community Water Center, (559) 733-0219.

- -

Participant's Agreement:

I have read the information provided above. I have asked all the questions I have at this time. I voluntarily agree to participate in this research study.

____ ________________

Signature of Research Participant Date

____

Printed Name of Research Participant

Appendix B2. Consent Form for Spanish Speakers Signed by Participants in the Household Survey

Encuesta Sobre la Calidad y el Costo de Agua

Consentimiento para participar en una investigación

Introducción

Esta encuesta de la comunidad le pregunta sobre su percepción de la calidad de su agua de la llave, como la usa, y cuánto de su ingreso se gasta en comprar agua. La encuesta es parte de un proyecto que involucra a cuatro organizaciones comunitarias y sin fines de lucro dedicadas a mejorar el agua potable: el Centro Comunitario por el Agua, Pacific Institute, Clean Water Fund, y California Rural Legal Assistance Foundation. A continuación se muestra una descripción de los procedimientos de investigación y una explicación de sus derechos como participante en la investigación. Si usted acepta participar, por favor firme en el espacio provisto para indicar que ha leído y comprendido la información en este formulario de consentimiento. Usted tiene derecho a, y recibirá una copia firmada del formulario.

Objeto de Estudio

El objetivo de este proyecto de investigación es documentar el impacto social, económica, y a la salud de la contaminación de las aguas. El estudio se centrará en los hogares y las comunidades que utilizan sistemas pequeños de agua en el Valle de San Joaquín de California.

Lugar y la duración de la Encuesta

Su participación en esta encuesta durará aproximadamente media hora.

Procedimientos de la Encuesta

Se le pedirá una serie de preguntas específicas sobre el uso del agua de su hogar y las compras. Usted puede optar por responder o no responder a cualquier de las preguntas.

Beneficios de la participación

Los resultados de este estudio será escrito en un informe que será distribuido al público. La participación de usted contribuirá al conocimiento del público sobre los impactos de contaminación y los costos del agua.

Riesgos y molestias de la Participación

No anticipamos ningún riesgo o molestia a usted por participar en este estudio.

Confidencialidad

La información y comentarios contribuidos durante la discusión se puede utilizar en el informe. Usted no será identificado por su nombre en ningún informe o publicación de este estudio o sus resultados. Todos los esfuerzos se tomarán para proteger su identidad como participante en este estudio.

Si usted tiene preguntas o preocupaciones, por favor, póngase en contacto con Susana De Anda o Maria

Herrera con el Centro Comunitario por el Agua al (559) 733-0219.

- --

He leído la información proporcionada anteriormente. He expresado todas las preguntas y dudas que tengo en este momento. Yo voluntariamente acepto participar en este estudio.

_______________________________________ ________________
Firma del participante de Investigación Fecha

____
Nombre del Participante de Investigación

Appendix C. Protocols for Calculating Water Volumes and Expenses

On question #30 of the survey, respondents were asked if they purchase water from alternative sources for the home. If the respondent replied yes, they were asked to estimate the amount they expect to spend on non-tap water in a typical month in Question #31. Then the household was asked about expenditures on non-tap water in three different categories:

- ***Domestic Water Service:*** Respondents were asked if the household receives non-tap water from a delivery service, the company that provides the water service, the quantity of gallons received in a billing period, and the amount paid for each billing period.
- ***Vended Water:*** Respondents were first asked about locations where the household usually buys vended water. The respondent was then shown pictures of three different sizes of jugs (5 gallon, 3 gallon, and 1 gallon) that can be filled at a vended water station and asked to estimate the quantity of each jug refilled in a given month.
- ***Bottled Water:*** Respondents were then shown four different-sized water bottles that can be purchased at a grocery or convenience store (large, medium, small, and mini) and asked whether the household purchases any size individually or in bulk. Respondents were then asked to estimate the quantity of each individual or bulk item purchased in a typical month in addition to the vended water purchased. Respondents were then asked where the household purchases the aforementioned bottled water.

  Respondents were then shown pictures of four different sizes of jugs that can be purchased already filled with water at a grocery or convenience store (5 gallon, 3 gallon, 2-2.5 gallon and 1 gallon) and asked to estimate the quantity of each pre-filled jug purchased in a typical month in addition to the vended and bottled water purchased. Respondents were then asked where the household purchases the aforementioned pre-filled jugs.

On Question #27 of the survey, respondents were asked if a water filter was used in the home. If the respondent replied yes, they were asked to state the type of filter (including brand and model, if known) and to estimate the upfront costs (including installation), the frequency in which the filter is serviced, and the cost of servicing the filter.

Protocol 1A: Calculating Household Expenditures on Non-Tap Water

For each household, the type, quantity, and location of water products purchased in a typical month were used as inputs to calculate monthly expenditures on non-tap water based on the following general formula:

$$\sum_{x=1}^{N} Q_x * C_x = E$$

Where:

- ***Q_x*** *= the quantity of product x purchased in a typical month (product per month)*
- ***C_x*** *= the verified cost of product x, determined based on the locations where the household reported purchasing product x (price per product)*
- ***N*** *= the number of different products purchased in a given month*
- ***E*** *= expenditures on non-tap water in a typical month*

Q_x = the quantity of product x purchased in a typical month (product per month)

Respondents' self-reported estimates were assumed to be the quantity of a given product purchased in a typical month.

- If the respondent estimated the quantity of products purchased in a typical week, the estimate was multiplied by 4.2, the number of weeks in a typical month.
- If the respondent offered a range for the quantity of products purchased in a given time period, the midpoint of the range was assumed (e.g. "2-3 five-gallon jugs per month" becomes 2.5 five-gallon jugs per month).
- For vended water, many respondents first estimated the number of trips made by the household in a typical month to buy vended water (trips per month), followed by the quantity of different sizes refilled in a typical trip (jugs per trip). The number of jugs refilled per month was then calculated by multiplying the two variables.

C_x = the verified cost of product x (price per product)

Respondents were asked to state the location where households purchase vended and bottled water. Each location was visited in-person or contacted by phone and several different prices (including the cheapest option) were recorded for all products mentioned by the respondent for that location. Each product was then matched with a verified price:

- If respondents only mentioned one location for a given product, the product was assigned the lowest price at the location.

- If respondents mentioned multiple locations for a given product, the product was assigned the average of the lowest prices at each location at which the product was in stock.

The monthly cost of water delivery service was obtained by visiting the vendor's website, entering the household's zip code, and adding a room-temperature cooler and the quantity of water reported by the respondent to the online cart.

Protocol 1B: Calculating the Volume of Non-Tap Water Consumed by the Household

For each household, the type and quantity of water products purchased in a typical month were used as inputs to calculate monthly expenditures on non-tap water based on the following general formula:

$$\sum_{x=1}^{N} Q_x * V_x = B$$

Where:

- $\boldsymbol{Q_x}$ *= the quantity of product x purchased in a typical month (product per month)*
- $\boldsymbol{V_x}$ *= the volume of water in product x, (gallons per product)*
- ***N*** *= the number of different products purchased in a given month*
- ***B*** *= volume on non-tap water purchased in a typical month*

$\boldsymbol{Q_x}$ = the quantity of product x purchased in a typical month (product per month)

Respondents' self-reported estimates were assumed to be the quantity of a given product purchased in a typical month.

- If the respondent estimated the quantity of products purchased in a typical week, the estimate was multiplied by 4.2, the number of weeks in a typical month.
- If the respondent offered a range for the quantity of products purchased in a given time period, the midpoint of the range was assumed (e.g. 2-3 five-gallon jugs per month becomes 2.5 five-gallon jugs per month).
- For vended water, many respondents were first estimated the number of trips made by the household in a typical month to buy vended water (trips per month), followed by the quantity of different sizes refilled in a typical trip (jugs per trip). The number of jugs refilled per month was then calculated by multiplying the two variables.

***V_x* = the volume of water in product x (gallons per product)**

The following volumes were assigned for each water product:

- *5-gallon Jug (vended or pre-filled):* 5 gallons
- *3-gallon Jug (vended or pre-filled):* 3 gallons
- *2-2.5-gallon Jug (pre-filled):* 2.25 gallons (average of two possible sizes)
- *1-gallon Jug (vended or pre-filled):* 1 gallons
- *"Large" Bottle:* 0.4623 gallons (average of two possible sizes, converted to gallons)
  - Could be perceived by respondent as a 1.5-liter bottle, or 2-liter bottle
- *"Medium" Bottle:* 0.2258 gallons (average of two possible sizes, converted to gallons)
  - Could be perceived by respondent as a 24-oz. bottle, or 1-liter bottle
- *"Small" Bottle:* 0.1129 gallons (average of two possible sizes, converted to gallons)
  - Could be perceived by respondent as a 12-oz. bottle, or 16.9-oz bottle
- *"Mini" Bottle:* 0.0703 gallons (average of two possible sizes, converted to gallons)
  - Could be perceived by respondent as an 8-oz. bottle, or 10-oz bottle

If the product reported by the respondent was a bulk item, the volume in an individual container was multiplied by the number of containers reported in the product.

Protocol 2: Calculating Household Filter Costs

For each household, the upfront and servicing costs of the filter were used as inputs to calculate monthly costs of using the filter in the home using the following formula Microsoft Excel:

PMT(*rate,nper,pv*) = Monthly Filter Costs

Where:

- ***rate*** *= the monthly discount rate*
- ***nper*** *= the number of months over the assumed lifetime of the filter*
- ***pv*** *= the present value of all upfront and servicing costs over the assumed lifetime of the filter*

***rate** = the monthly discount rate*

A monthly discount rate of 0.417% (equivalent to an annual discount rate of 5%) was assumed for all filters.

***nper** = the number of months over the assumed lifetime of the filter*

Filters were assumed to have a lifetime of 10 years, or 120 months.

pv* = *the present value of all upfront and servicing costs over the assumed lifetime of the filter

For households that owned the filter, the present value of upfront costs was assumed to be the upfront costs reported by the respondent at the time the filter was purchased (unknown, assumed to be recent). For households that rented the filter, the cost of installation was verified with the vendor.

The present value of servicing costs was calculating using the following Excel formula:

PV(*rate,nper,pmt*) = Monthly Filter Costs

Where:

- ***rate*** **=** *the monthly discount rate*
- ***nper*** **=** *the number of ongoing payments made over the assumed lifetime of the filter*
- ***pmt*** **=** *the value of the ongoing payments*

For households that owned the filter, the number and value of ongoing payments were assumed to be those reported by the respondent. For households that rented the filter, the number and value of ongoing payments were assumed be the monthly rental rate.

Appendix D1. Results of the Household Survey, Lemon Cove

Background Information

Five households were surveyed in Lemon Cove, Ca in the afternoon of May 24, 2010.

- **Duration in the Community:** *Three* households have lived in Lemon Cove for 5-10 years. *Two* households have lived in the community for 10-15 years. Lemon Cove has been violation of the Nitrate Maximum Contaminant Level since 1997 (Heman, *pers. comm.*)
- **Race:** *Four* respondents stated "White" as their race and *one* stated "Latino, Chicano, or Latin-American."
- **Preferred Language:** All *five* respondents preferred to sign an English-language consent form and answer survey questions in English.
- **Household Income:** Self-reported income for the *five* surveyed households ranged from $983 to $6000. *One* household reported a *low* income compared to a typical household in Tulare County and *two* households reported *very low* incomes[14].

Perception of Contamination

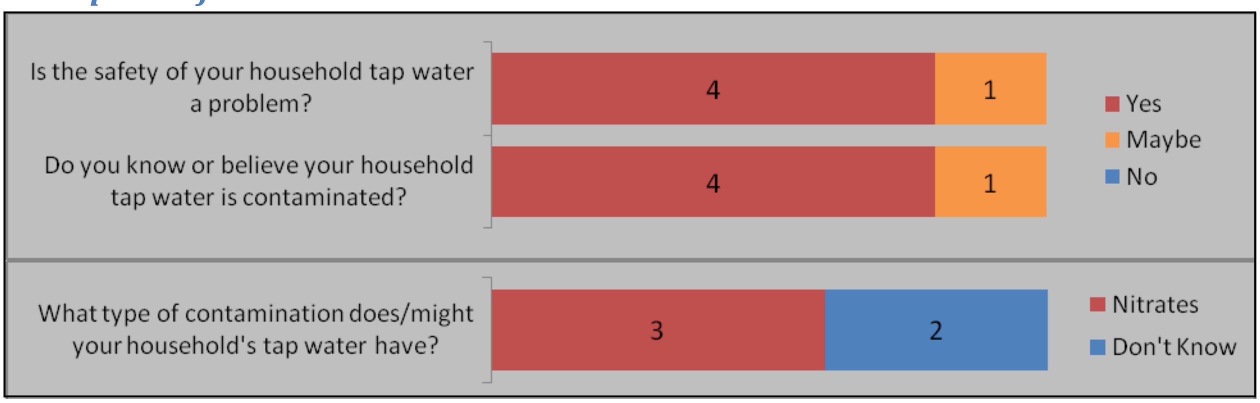

Figure 7. Household responses to survey questions addressing perception of contamination. Digits within colored bars denote the number of households that gave each response.

[14] See the 'Methods' section of Chapter 3 for a description of how we categorized households based on income.

Household Water Use

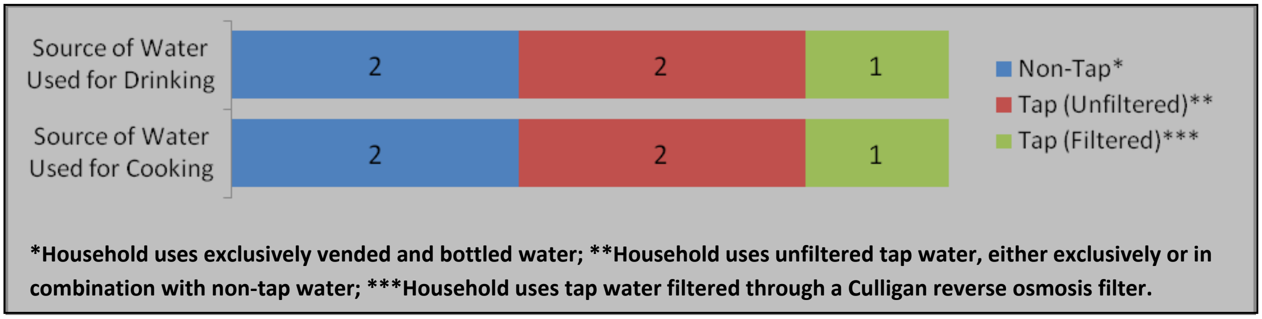

Figure 8. Sources of water used for cooking and drinking within the household, as reported by survey respondents. Digits within colored bars denote the number of households that gave each response.

Household Expenditures on Water (as a percentage of household income)

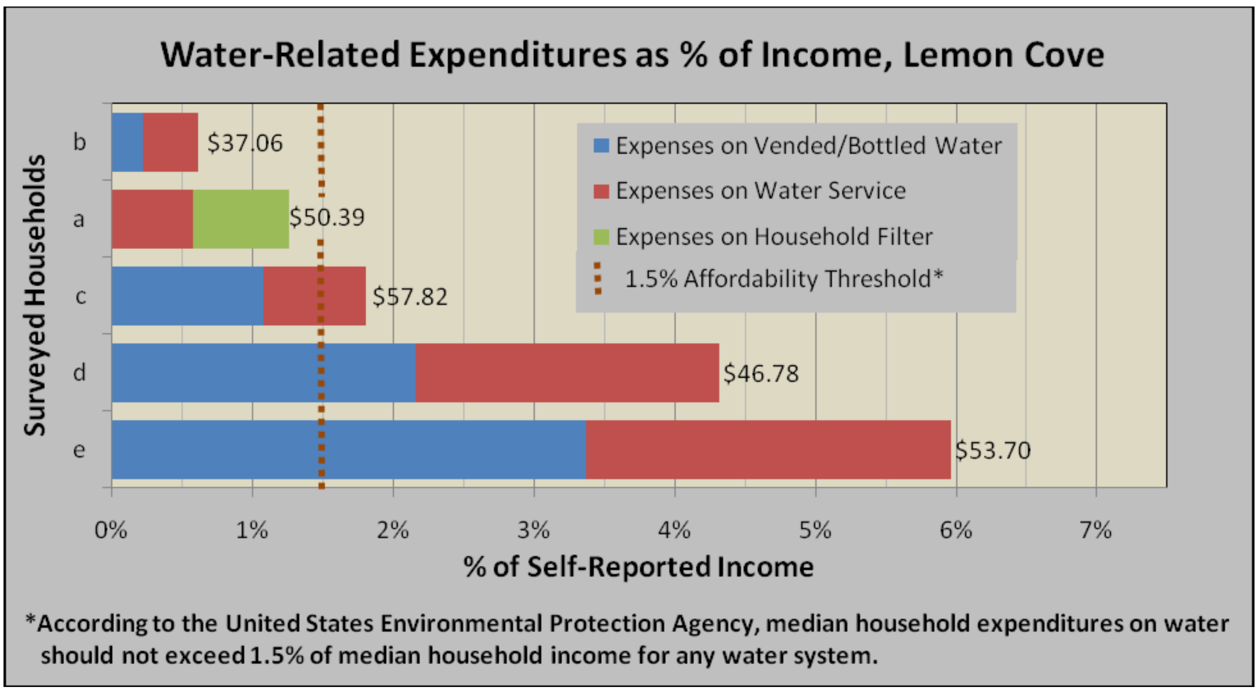

Figure 9. Water-related expenditures as percentage of income for five surveyed households in Lemon Cove. Dollar figures to the right of each stacked bar denote monthly total water-related expenditures for each surveyed household.

Appendix D2. Results of the Household Survey, El Monte Village Mobile Home Park

Background Information

Seven households were surveyed in the El Monte Village Mobile Home Park ("El Monte") in the evening of May 24 and the afternoon of June 4, 2010.

- **Duration in the Community:** Nearly all surveyed households have lived in El Monte for over ten years. The El Monte water system Cove has been violation of the Nitrate Maximum Contaminant Level since 2007 (Heman, *pers. comm.*)
- **Race:** *Five* respondents stated "Latino, Chicano, or Latin-American" as their race, *one* stated "White", and *one* stated "Multiple races".
- **Preferred Language:** *Six* respondents preferred to sign a Spanish-language consent form and answer survey questions in Spanish. *One* household preferred to conduct the survey in English.
- **Household Income:** Self-reported income for the seven surveyed households ranged from $500 to $3600. *Three* households reported *low* incomes compared to a typical household in Tulare County and *four* households reported *very low* incomes[15].

Perception of Contamination

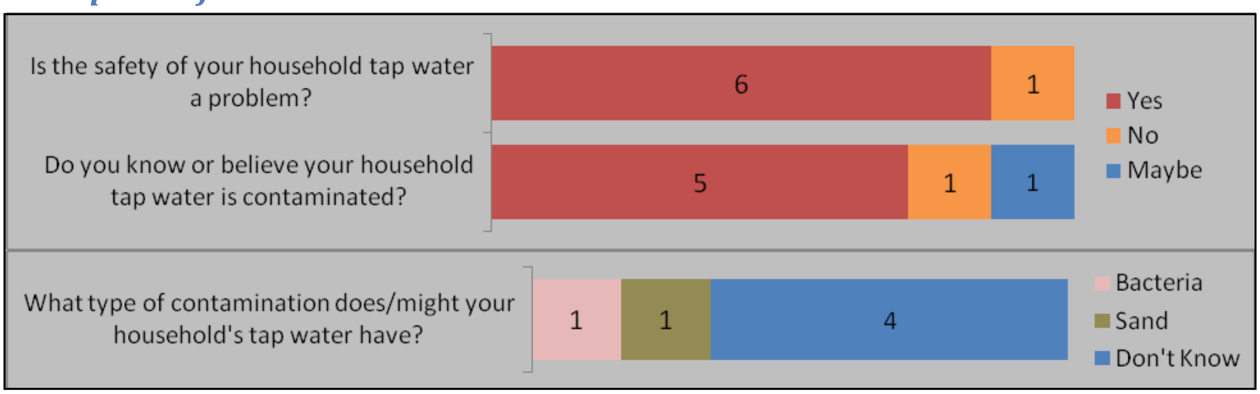

Figure 10. Household responses to survey questions addressing perception of contamination. Digits within colored bars denote the number of households that gave each response.

[15] See the 'Methods' section of Chapter 3 for a description of how we categorized households based on income.

Household Water Use

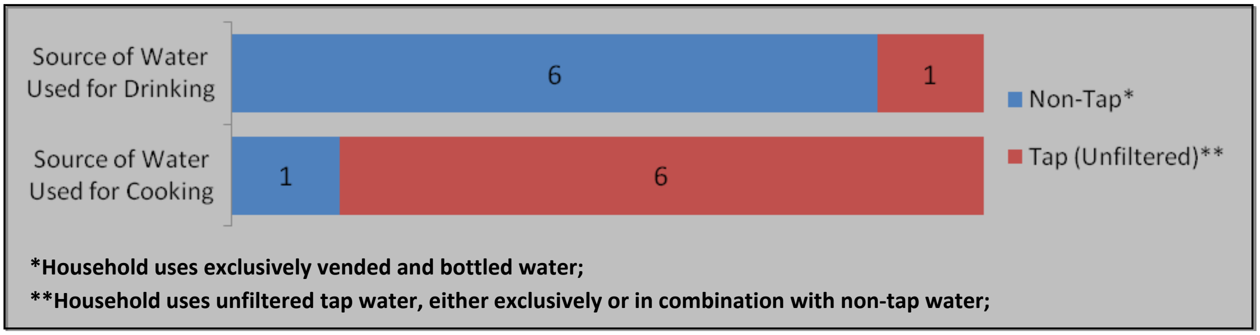

Figure 11: Sources of water used for cooking and drinking within the household, as reported by survey respondents. Digits within colored bars denote the number of households that gave each response.

Household Expenditures on Water (as a percentage of household income)

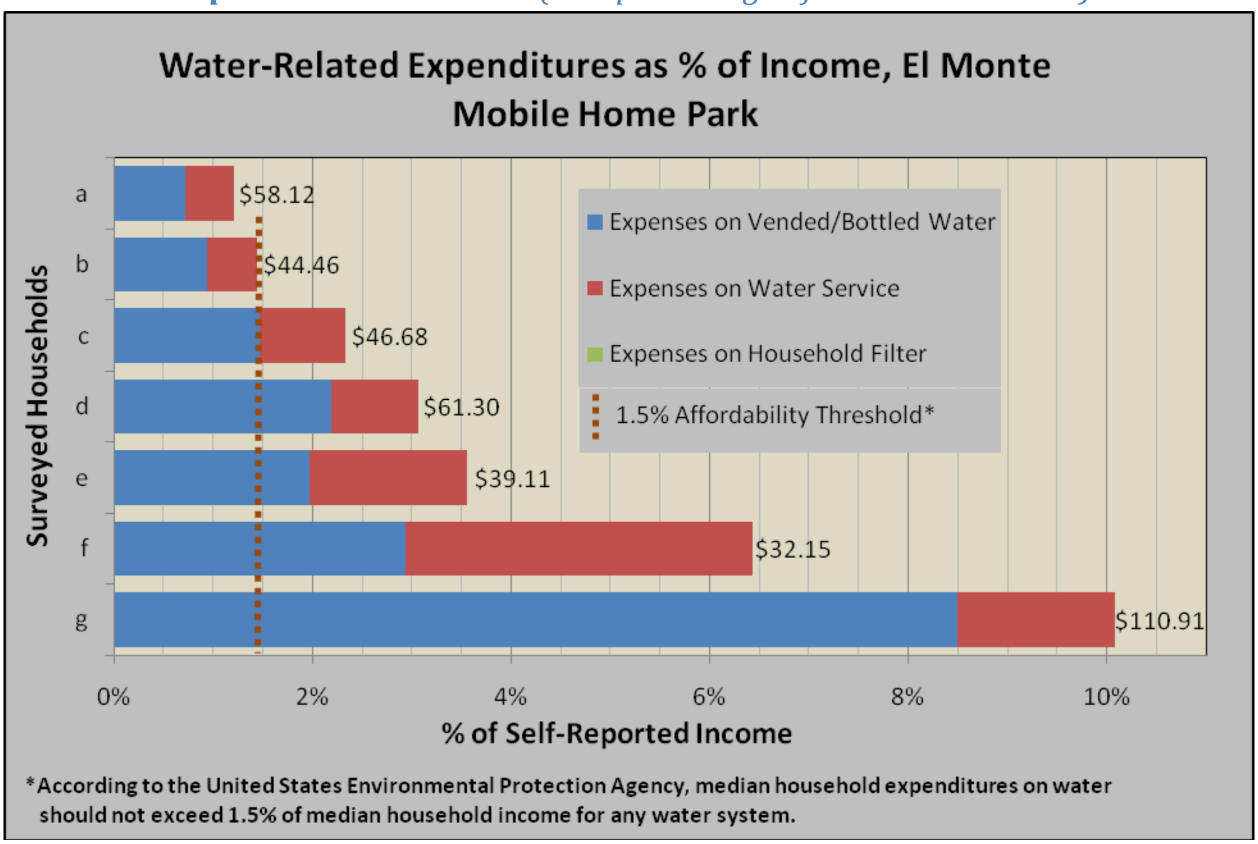

Figure 12. Water-related expenditures as percentage of income for five surveyed households in Lemon Cove. Dollar figures to the right of each stacked bar denote monthly total water-related expenditures for each surveyed household.

Appendix D3. Results of the Household Survey, Soults

Background Information

Four households connected to the Soults Mutual Water Company system ("Soults") were surveyed in the afternoons of May 25 and June 9, 2010.

- **Duration in the Community:** *Two* households have lived in Soults for less than 5 years and *two* households have been residents for over 30 years. Soults has been violation of the Nitrate Maximum Contaminant Level since 1996 (Heman, *pers. comm.*).
- **Race:** *Two* respondents stated "White" as their race, *one* stated "Latino, Chicano, or Latin-American", and *one* stated "Multiple races".
- **Preferred Language:** *Three* respondents preferred to sign an English-language consent form and answer survey questions in English. *One* household preferred to conduct the survey in Spanish.
- **Household Income:** Self-reported income for the four surveyed households ranged from \$2000 to \$4600. *Two* households reported *low* incomes compared to a typical household in Tulare County[16].

Perception of Contamination

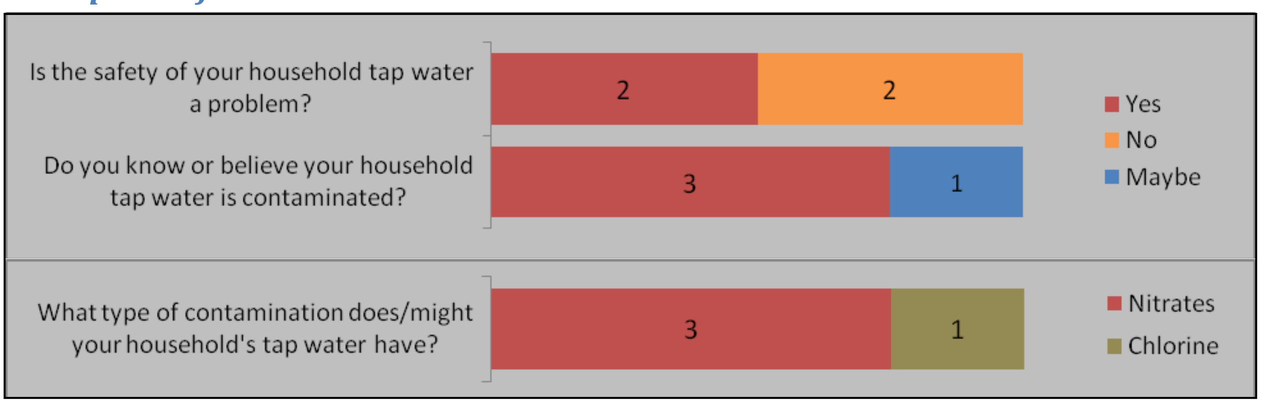

Figure 10: Household responses to survey questions addressing perception of contamination. Digits within colored bars denote the number of households that gave each response.

[16] See the 'Methods' section of Chapter 3 for a description of how we categorized households based on income.

Household Water Use

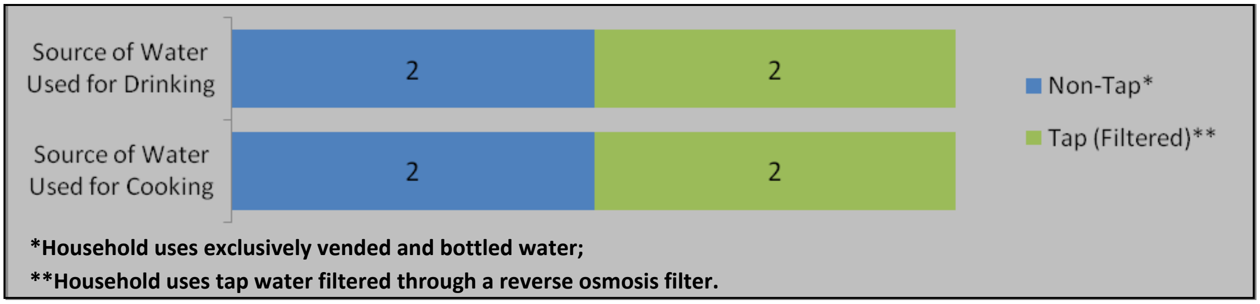

Figure 11: Sources of water used for cooking and drinking within the household, as reported by survey respondents. Digits within colored bars denote the number of households that gave each response.

Household Expenditures on Water (as a percentage of household income)

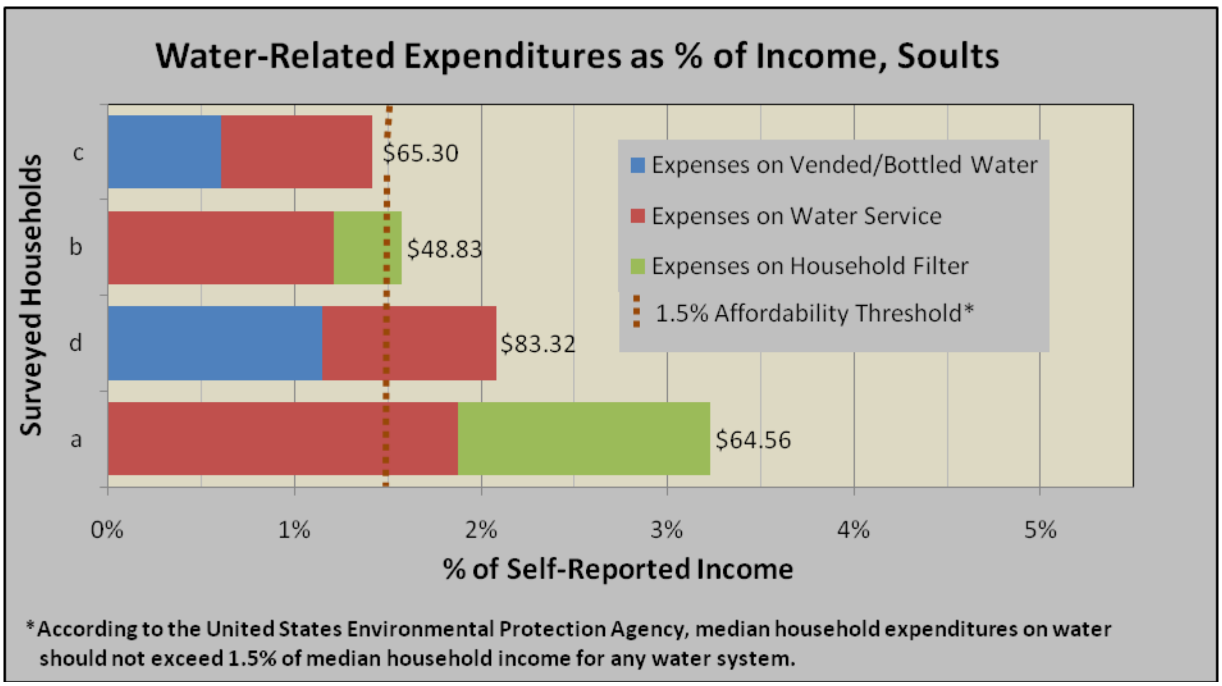

Figure 12: Water-related expenditures as percentage of income for five surveyed households in Lemon Cove. Dollar figures to the right of each stacked bar denote monthly total water-related expenditures for each surveyed household.

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