Evaluation of the Indian Health Service Sanitation Facilities Construction Program

Impact and performance of providing drinking water and sanitation projects for American Indian communities

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A research project submitted in partial fulfillment
of the requirements for the award of the degree of
Master of Science
Loughborough University

December 2013

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ACKNOWLEDGEMENTS

The author gratefully acknowledges the support and contributions provided by the following people, without whom this project would not have been possible.

My parents, Robert and Elizabeth Brady, for their continual encouragement and support while I pursue my career goals.

Dr. Lee Bosher, my research project supervisor, for his sound advice, direction, and considerate constructive comments on individual chapters and my research project.

The WEDC Distance Learning Programme for providing a unique opportunity that allowed me to gain higher education in the specialized field of international public health infrastructure while I continued my office work. The WEDC modules were delivered with care and professionalism that has provided me with a great framework of practical and experienced-based knowledge.

The Indian Health Service for giving me the opportunity to take the WEDC modules over the years and support with my research project.

ACRONYMS AND ABBREVIATIONS

American Indians	American Indians and Alaska Natives
ARRA	American Recovery and Reinvestment Act of 2009
BIA	Bureau of Indian Affairs
CDC	Centers for Disease Control and Prevention
CDP	Community Deficiency Profile (STARS)
CWISA	Clean Water Indian Set-Aside Grant Program
DWIG-TSA	Drinking Water Infrastructure Grant Tribal Set-Aside Program
EPA	U.S. Environmental Protection Agency
ETT	Enforcement Targeting Tool
FY	Fiscal Year
GAO	U.S. Government Accounting Office
GI	Gastrointestinal Infections
GPRA	Government Performance and Reporting Act
HHS	Department of Health and Human Services
Housing	IHS funding for new American Indian homes
HUD	Department of Housing and Urban Development
ICD	International Classification of Disease
IDL	Initial Deficiency Level
IHS	Indian Health Service
JMP	Joint Monitoring Program
MCL	Maximum Contaminant Level
MDG	Millennium Development Goal
MDG-7	Millennium Development Goal Target-7
MOA	Memorandum of Agreement
M/R	Monitoring and Reporting
OEHE	Office of Environmental Health and Engineering
O&M	Operation and Maintenance
OMB	Office of Management and Budget
PDS	Project Data System (STARS)
PHS	Public Health Service
PL	Public Law
P.L. 86-121	Indian Sanitation Facilities Act
P.L. 94-437	Indian Health Care Improvement Act
RCAC	Rural Community Assistance Cooperation
RD	Rural Development
Regular	IHS funding for existing American Indian homes
RPMS	Resource and Patient Management System
SDS	Sanitation Deficiency System (STARS)
SDWA	Safe Drinking Water Act
SDWIS	Safe Drinking Water Information System
SFC	Sanitation Facilities Construction Program
SNC	Significant Non-Complier
STARS	Sanitation Tracking and Reporting System
TT	Treatment Techniques
UN	United Nations
UNICEF	United Nations Children's Fund
URI	Upper Respiratory Infections
US	United States
USAID	U.S. Agency for International Development
USDA	U.S. Department of Agriculture
VH	Viral Hepatitis
WHO	World Health Organization

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ABSTRACT

An evaluation of the IHS Sanitation Facilities Construction (SFC) Program's performance and impact from 2003 to 2013 on California American Indians through the provision of drinking water and sanitation projects is presented. The research examined project delivery, interventions, deficiency monitoring, health impact, and tribal capacity using information from the IHS and EPA databases and a tribal organization capacity questionnaire. The project duration goal was met; however, the rate of completed projects is declining. The majority of interventions addressed high-level water transmission and treatment deficiencies. The percentage of homes with adequate facilities increased from 78% to 84%. However, remaining deficiencies have increased by 300%. There was an 18.7% decrease in selected water-related diseases; although, not statistically significant. Seven communities with high initial disease rates had a statistically significant reduction of 44%. The majority of tribal utility organizations had acceptable capacity. The SFC Program is performing at a moderate to high level.

Key words: Sanitation Facilities Construction Program, American Indians, drinking water and sanitation, program evaluation

EXECUTIVE SUMMARY

1. Introduction

The research project evaluated the Indian Health Service (IHS) Sanitation Facilities Construction (SFC) Program's performance and impact on American Indian communities through the provision of drinking water and sanitation projects. The project was justified because no formal California Area SFC Program assessment had been conducted with evaluation of sustainability, effectiveness, equity, efficiency, and replicability issues. The results of this project will provide the SFC Program decision-makers with information to develop a better understanding of performance and impact measures and critical areas for future improvement.

The 566 federally recognized American Indian tribes in the United States and their descendants are eligible for services provided by the IHS. The IHS is an agency within the Department of Health and Human Services (HHS) that provides a comprehensive health service delivery system for a population of approximately 2.1 million American Indians, who live mainly on or near reservations and in rural communities, mostly in the western United States and Alaska (IHS, no date-a). The IHS is organized into 12 administrative regional offices (referred to as Area Offices) located throughout the United States.

The IHS responsibility for providing federal health services to American Indians was initially established in the 1787 Constitution and founded on the special relationship between the federal government and Indian tribes (IHS, no date-a). The IHS is the principal federal health care provider for American Indians and its goal is to raise their health status to the highest possible level. Since 1959, under Public Law 86-121, the IHS has been authorized to provide essential drinking water and sanitation facilities to American Indian communities. The IHS SFC Program has the mission of assisting tribes with the provision of adequate drinking water and sanitation facilities.

The American Indians have long experienced lower health status when compared with other Americans. Lower life expectancy and the disproportionate disease burden are influenced by inadequate education, disproportionate poverty, discrimination in the delivery of health services, and cultural differences. American Indians today have a life expectancy that is 4.1 years less than the United States all races population. Safe and adequate water supply and waste disposal facilities are lacking in approximately 12% of American Indian homes, compared to less than 1% of homes for the United States general population (IHS, no date-a). American Indians with adequate environmental conditions in their homes, which include safe drinking water and sanitation systems, require appreciably fewer medical services and place fewer demands on the IHS and tribal primary health care delivery system.

The SFC Program, in consultation with tribes, identifies water and sanitation needs and collaborates with other stakeholders to provide resources to address those needs. Even though hundreds of projects have been funded, there is a significant portfolio of needed facilities totaling approximately US$1.6 billion. The deficiencies in American Indian communities are likely to grow as a result of inflation, new environmental requirements, existing facilities reaching their design life, and population growth. After projects are funded and completed, the facilities are owned and operated by the tribes.

There have been limited performance measures to evaluate the national SFC Program, and fewer for the Area programs. Currently, the national SFC Program has three program performance indicators, which include: the number of American Indian homes served annually with water supply and sanitation services, the duration to complete a project, and the percentage of American Indian homes with adequate water and sanitation facilities. However, only the project duration measure is carried on to the Area SFC Programs. Previous to this study, there had been no formal Area SFC Program assessment with specific attention to key evaluation issues.

2. Objectives

The primary objective and focus of the research project was to assess the California Area SFC Program's performance and impact on the welfare of the American Indians over a 10 year time span from 2003 to 2013. The program was examined through the following sub-units: 1) project delivery, 2) interventions, 3) deficiency monitoring, 4) health impact, and 5) system sustainability in order to evaluate broad issues of sustainability, effectiveness, equity, efficiency, and replicability. The research project examined national SFC Program issues in order to provide context and comparisons.

Overall objectives of the research project included:

1. Understand, document, and assess the SFC Program's performance.
2. Examine the water and sanitation interventions and distributed by various categories.
3. Examine the water and sanitation level of deficiencies and needs.
4. Analyze the health impacts from the water and sanitation services.

5. Survey, understand, and assess the sustainability of the facilities operated by the tribes.
6. Provide the SFC Program with information to develop a better understanding of its performance and critical areas for improvement and support more informed decisions.

3. Research questions

The primary research question was “How is the SFC Program performing and impacting American Indian communities through the provisions of drinking water and sanitation projects?” The SFC Program was examined through underlying questions related to five key components and their related issues including:

A. Project delivery related to efficiency:

1. How do the annual number of American Indian homes served compare with national trends and target goals?
2. How does the project durations compare with national trends and target goals?
3. What is the cost per home for the water supply and sanitation interventions related to construction and program resources?

B. Water and sanitation interventions related to equity:

1. What water and sanitation interventions have been provided to American Indian tribes and communities?
2. How are the interventions distributed by category, description, type, deficiency level, SDS project score, and among American Indian tribes and communities?

C. Water and sanitation deficiency monitoring related to equity and effectiveness:

1. How are the previous interventions impacting the deficiencies in terms of both cost and percentage of homes with water and sanitation facilities?
2. How do the remaining deficiencies compare across categories for water, sewer, and solid waste?
3. How do different agency monitoring databases corroborate with each other?

D. Health impact related to effectiveness:

1. How have the water supply and sanitation interventions impacted the health of the American Indians; e.g. patients with diarrheal diseases or respiratory infections?

E. Tribal organizational capacity related to sustainability and replicability:

1. What are the tribal organizational technical, managerial, and financial capacities and areas of improvement for sustaining services in the long-term?
2. How is the tribal capacity to operate and sustain the systems related to current system needs and deficiencies?

4. Methodology

The research used a case study strategy to describe and evaluate the SFC Program. A mixed-method approach was employed using multiple qualitative and quantitative data sources such as documentation, records, interviews, and observations. Information from these multiple sources was brought together in the analysis process to converge on key findings.

In particular, the research obtained and examined information from hundreds of projects in the SFC Program's database called the Sanitation Tracking and Reporting System (STARS) in the Sanitation Deficiency System (SDS) and the Project Data System (PDS), compliance data from the U.S. Environmental Protection Agency's database known as the Safe Drinking Water Information System (SDWIS), health data on gastrointestinal infections, viral hepatitis, and upper respiratory infections for 32 American Indian communities from the IHS's principal health and patient monitoring database known as the Resource and Patient Management System (RPMS), and a questionnaire on technical, managerial, and financial capacity administered to 10 tribal organizations.

5. Results and discussion of study findings

The project delivery had a moderate level of efficiency. The number of American Indian homes served was highly variable, and beginning in 2010, the number of homes served has generally declined. The SFC Program has consistently met the 4-year limit project duration goal; however, since 2011 there has been a decline in the rate of completed projects, and if the trend continues, it could increase project durations, impact resources, and project outcomes. In particular, several projects had significantly longer durations due to various constraints. The project cost per home served was significantly more expensive and highly variable when compared to the national trends. The high cost could be influenced by environmental factors, construction costs, site conditions, remoteness, specific deficiencies, and that only a portion of the available resources (e.g. staff) actually perform design and construction-related activities.

The water and sanitation interventions (e.g. funded projects) had a high level of equity, use, and intended impact. The majority of interventions were for water transmission and distribution and treatment facilities. Other interventions were primarily for wastewater, and half of which was for sewer collection and pumping stations. The majority of all interventions were for capital improvements representing new, expansion, or system extensions; which could be a consequence of limited provisions in designs for future growth due to funding constraints. The majority of funded projects addressed high-level needs and deficiencies; which addressed long-term measures for the SFC Program and the EPA. In addition, approximately half of the funding addressed high deficiency levels for five Indian tribes; which represented 24% of the entire American Indian population in the California Area.

The water and sanitation monitoring (e.g. system needs and deficiencies) had a high to moderate level of effectiveness and equity. The percentage of American Indian homes with adequate water and sanitation facilities have increased from 78% to the current level of 84%; which supports an IHS mission goal. However, the remaining drinking water and sanitation deficiencies in SDS are significant and increasing at a large rate. Since 2003, the deficiencies have increased by over 300%. Since 2009, water deficiencies have increased at a higher rate while the cost for sewer facilities decreased. For the first time in 2013, the total cost to address water deficiencies is greater than sewer. Over the past 10 years there has been more funding for water interventions than sewer; however, the rate of growth in remaining water deficiencies has out-paced sewer needs. In the near future, costs to address deficiencies could increase dramatically as many systems originally constructed in the 1960s to 1980s begin to reach their useful design life.

The drinking water and sanitation interventions had a moderate level of health impact. Health indicators for gastrointestinal infections, viral hepatitis, and upper respiratory infections were evaluated for 32 American Indian communities (representing 27 tribes and a total population of approximately 16,800), and while the composite data demonstrated an 18.7% decrease in diseases, the reductions from the initial period was not statistically significant. However, seven of the communities with high initial disease rates were further analyzed, and had a statistically significant reduction in patients by 44%. Of the seven communities, five communities had patterns of disease rates, number of interventions, project type, sequence, and number of patients in the study group that suggested a causal relationship between the interventions and the decrease in disease rates. While difficult to measure, the interventions appear to play a role in the series of connected impacts to improve the health of the community. Caution should be exercised due to a variety of other potential influencing factors that may have caused the disease rates to change.

The systems had a moderate level of sustainability and replicability, and high use. The tribal organizations operating water systems had a majority of acceptable capacity evaluations for technical, managerial, and financial elements. However, the tribal capacity to operate sewer systems was generally lower than water systems. For both water and sewer operations, there was no significant difference in the tribe's levels of technical, managerial, and financial capacity. While the capacities varied from operating water and sewer systems, there were some universal weaknesses for all systems. In particular, the user fee structure and collections did not cover routine expenses. This could suggest opportunities for focused trainings and technical assistance for these elements that could make the largest impact on sustainability. Several tribes had SDS projects ranked at high deficiency levels; however, the majority of projects were to address issues related to capital improvements rather than replacement and upgrades. While there are areas for improvement and capacity building, the tribes are generally providing an acceptable level of operation and maintenance for the systems, and have a solid foundation for sustaining services in the long-term.

6. Conclusions and recommendations

The overall conclusion from the research is that the California Area's SFC Program is providing moderate to high level performance and impact to American Indian communities by providing drinking water and sanitation projects.

Based on the evaluation's findings and conclusions, the SFC Program should consider the following recommendations:

- Additional opportunities to collaborate with tribes and other agencies to fund projects to serve American Indian homes.
- Specific Area-level performance measure for the number of homes served.
- Program and project management initiatives to address the declining rate in completed projects.
- Development and implementation of a cost-tracking system for both construction and program expenses.
- Developing program guidance and policy for future growth in designs.
- Advanced reconnaissance for systems nearing or at design life.
- Continue to improve communication and coordination with other agencies to identify and prioritize deficiencies.
- Continue to improve communication and coordination with other IHS offices and the tribal health departments on disease rate information.
- Collaborative approaches for community outreach on environmental health issues.
- Conduct a prospective study of health impacts from water and sanitation interventions.
- Continue to survey tribal organizations operating water and sewer systems.
- Additional focus and effort to support tribal capacity to operate sewer systems, and training and technical assistance on priority capacity elements.

1 INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

This chapter provides background information relevant to the research on the Indian Health Service Sanitation Facilities Construction Program's performance and impact on California American Indians through the provision of drinking water and sanitation projects from 2003 to 2013. Information in this chapter is presented on American Indians, the Indian Health Service, water and sanitation monitoring, water-related diseases, system sustainability, program evaluations, and an overview of the framework for the research project.

1.2 AMERICAN INDIANS

The history of American Indians in the United States (U.S.) is filled with struggle, violence, and broken promises, along with an enduring spirit. The American Indians also referred to as Native Americans, once made the entire land that is now the U.S. their home. Over the course of many centuries and battles with armies and disease, their populations and land have been reduced. Nowadays, their communities continue to evolve, balancing an ancestral spirit and culture with modern day challenges.

For centuries, large populations of American Indians had lived in all regions of North America with a distinct culture and life. Beginning in the 1500s, European settlers arrived and established villages and farms, and gradually expanded further into Indian land seeking new resources (Calloway, 2009). The continual westward movement brought railroads, mining, and growing population centers into Indian land, which led to clashes between the tribes and U.S. government. Throughout the period of the 1800s, the conflict was generally referred to as the "Indian Wars", and ultimately cost the American Indians most of their land and way of life (Thorton, 1990, p. 48). By the start of the 1900s, many American Indians had been relocated to reservations that were a fraction of the land where they once lived.

As expansion occurred, American Indians came into contact with new diseases brought by the European settlers. In many cases, the diseases overwhelmed the native populations who did not have immunity. Prior to contact with the Europeans, it is estimated that the American Indian population was 2 to 18 million, and by the 1890s, the population had been reduced to only 250,000 (Thorton, 1990, p. 43). In particular, chickenpox and measles, endemic among Europeans, resulted in drastic epidemics decimating the

American Indian populations (Lange, 2003). Currently, there are approximately 5.2 million American Indians in the United States (U.S. Census Bureau, 2012).

The history of California American Indians has a similar narrative as other tribes across North America. Prior to contact with the Europeans, there were many California tribal communities living as independent villages. Influenced by the geography of the area with a mixture of coastal, forested, mountain, and desert areas, the tribal communities developed unique religions, cultures, and had over 100 distinct languages (CTEC, 2009). The Spanish made first contact with California tribes in the 1760s followed nearly a century later by huge populations searching for riches during the California gold rush that began in 1848 (CTEC, 2009). Similar to other American Indian communities in the U.S., settlers to California also brought disease and warfare that destroyed much of their way of life.

A legal framework further unraveled the American Indian society. In 1850, the newly formed state of California passed a series of laws that legalized Indian murder and slavery (CTEC, 2009). In 1851, the U.S. government initiated a policy to end American Indian titles to their land with an objective to transform land from community to individual ownership. Many of the treaties signed during this time with commitments of reservations were never actually passed, and not until 1854 did the U.S. Government begin to establish reservations in California (CTEC, 2009). Much of the traditional American Indian connections with land and culture was intentionally dismantled by the passage of the Dawes Act by the U.S. Congress in 1887, which transferred land held by communal trust to individual allotments with the objective of breaking up the tribal social unit and assimilate Indians into American society. A consequence of this law was that many tribes were forced to live on small areas of land called “rancherias” that were often established on or near the original tribal lands (CTEC, 2009). Then in 1958, the U.S. Congress passed the California Rancheria Termination Act, causing many of the rancherias and their populations to lose federal recognition as American Indians.

Currently, California has 107 federally recognized tribes and is the state with the largest American Indian population at approximately 723,225 (U.S. Census Bureau, 2012). The locations of the federally recognized tribes in California are presented in Figure 1.1.

Figure 1.1 California federally recognized American Indian tribes

Source: BIA (2013)

1.3 INDIAN HEALTH SERVICE

The responsibility of the U.S. government to provide health services to American Indians was initially established in the 1787 Constitution and founded on the unique relationship between the federal government and American Indian tribes, and has continued based on treaties, judicial determinations, and Acts of Congress (IHS, no date-a). In 1849, the responsibility of administering American Indian programs was transferred from the War Department to the Department of the Interior, which initiated an expansion of health care. In 1910, the Bureau of Indian Affairs (BIA), within the Department of the Interior, began a health education and disease prevention campaign centered on messages of improved personal hygiene, waste disposal, and diets. Beginning in 1919, the U.S. Congress began discussions to transfer health programs for American Indians from the Department of the Interior to the Public Health Service (PHS). Legislation in 1955, known as the Indian Health Transfer Act, transferred responsibility to the PHS, and initiated the formation of the Indian Health Service (IHS, 2003a).

From the time of its formation in 1955, the IHS has been the agency within the Department of Health and Human Services (HHS) responsible for the delivery of health services to the federally-recognized American Indians. The goal of the IHS is to raise the health status of American Indians to the highest possible level (IHS, no date-a). The IHS provides primary care and public health services through a system of IHS and tribally operated facilities and programs that include 48 hospitals and 268 health centers (IHS, 2006). The IHS provides health services to approximately 2.1 million American Indians who are members of the 566 federally recognized tribes in the U.S. The annual budget for the IHS is approximately $4.3 billion (IHS, no date-a).

The IHS organizational structure consists of 12 administrative regional offices (referred to as Area Offices) located throughout the U.S. The IHS has seven primary operational offices, and one of which is the Office of Environmental Health and Engineering (OEHE). Under OEHE, the Sanitation Facilities Construction (SFC) Program is responsible for the provision of environmental engineering services and sanitation facilities to American Indians. The IHS headquarters including the SFC Program is located in Maryland (near Washington D.C.) and provides support functions for the Area Offices including policies, guidelines, and overall quality control. The SFC Program’s primary activities are carried out at the Area level by engineers, technicians, and clerical staff.

The California Area provides services to 102 of the total 107 federally recognized tribes in the state. The other 5 tribes are served by the adjacent Phoenix Area Office. The locations of the 12 IHS Area Offices are presented in Figure 1.2.

Figure 1.2 Locations of IHS Area Offices

Source: IHS (no date-a)

The size of the SFC Program at each of the 12 Area Offices is related to the level of sanitation deficiency needs, size and complexity of the construction projects, the population of the American Indians, the location of the tribes, and the method of providing engineering services. The SFC Program within each Area is generally comprised of staff at the Area headquarters and District and Field offices. The Area headquarters is primarily responsible for policy development, allocation of resources, budget formulation, project development, and overall management of the program. The District and Field offices, strategically located near the tribes, implement the projects and provide the direct communications and coordination.

1.4 SANITATION FACILITIES CONSTRUCTION PROGRAM

The background information on the SFC Program is based on two primary guidance documents including the *Criteria for the Sanitation Facilities Construction Program* (IHS, 2003a) and the *MOA Guidelines* (IHS, 2003c).

1.4.1 HISTORICAL PERSPECTIVE

From the early 1900s, there were periodic but often limited efforts to survey and assess the poor sanitation conditions on the reservations. A 1952 survey of environmental conditions indicated that more than 80% of the American Indians were hauling water from unprotected and potentially contaminated sources such as ditches and animal stock ponds, and more than 80% of the homes had inadequate waste disposal facilities. The survey concluded that the environmental conditions were primarily "responsible for the high incidence of certain preventable diseases among Indians, particularly among infants" (SFC, 2003a, p. 3.3).

An outcome from several meetings between federal agencies and tribal groups was a bill introduced to the U.S. Congress in 1956 for funding to provide water and sanitation facilities for American Indians. The bill was approved in 1958 and authorized the first PHS project to construct several watering points for American Indians in Elko, Nevada (SFC, 2003a, p. 3.4).

Based on the success of this first project, documented deficiencies, and support from the Department of Health, Education and Welfare (now the U.S. Department of Health and Human Services), the U.S. Congress passed Public Law (P.L.) 86-121, the Indian Sanitation Facilities Act, and was signed by President Eisenhower on July 31, 1959. The act authorized the PHS to construct water supply and sanitation facilities for American Indians, and created and authorized the SFC Program to provide these essential facilities. Later in 1988, the U.S. Congress reaffirmed the importance of the SFC Program in the Indian Health Care Amendments of 1988, which amended the Indian Health Care Improvement Act (P.L. 94-437), by declaring that "it is in the interest of the United States, and is the policy of the United States, that all Indian communities and Indian homes, new and existing, be provided with safe and adequate water supply systems and sanitary sewage waste disposal systems as soon as possible" (SFC, 2003a, p. 3.4).

1.4.2 SFC PROGRAM MISSION ACTIVITIES

The SFC Program, in partnership with the tribes, has eight primary mission activities (SFC, 2003a, pp. 2.7-2.9). Several are summarized below:

- **Maintain inventory of sanitation deficiencies:** The SFC Program develops and maintains an inventory of sanitation deficiencies in American Indian communities for use by IHS and the U.S. Congress. The inventory of water, sewer, and solid waste needs for existing homes is maintained in the IHS database known as the Sanitation Deficiency System (SDS). The SFC Program is required by P.L. 94-437 to maintain this inventory, prioritize the deficiencies, and annually report them to the U.S. Congress. Since 1989 with the passage of this law, the IHS has reported these needs in the form of community deficiencies and projects to address those deficiencies. The projects are identified in terms of the facilities to be provided, cost, number of American Indian homes to be served, and the initial deficiency level (IDL). The SDS information is updated annually to account for inflation, changing regulations, change in the deficiency levels, new needs, and funded projects to address the deficiencies. The total portfolio of needs typically far exceeds the funding to address them. A needs-based priority scoring system is used in SDS to fund projects, and typically funded projects are only a small fraction of the total list causing many needs remaining on SDS for a long period. The SDS information is used for internal program management, budget justification, and distribution of resources and project funding to the Area Offices and tribes. Besides the IHS and U.S. Congress, the SDS data is also utilized by other federal agencies including the U.S. Environmental Protection Agency (EPA).

- **Provide environmental engineering, planning, and surveys:** The SFC Program provides professional environmental engineering services, which include initial project reconnaissance and planning, sanitary surveys, engineering design, development of plans and technical specifications for the proposed facilities, obtain permits, and construction inspection and management.
- **Project development including multi-agency funding and coordination:** The SFC Program manages project development activities for funding, pre-design planning, and coordination. In some cases, the cost of the proposed facilities exceed the IHS funding levels, and the SFC Program works collaboratively with tribes to identify other funding sources. The SFC Program provides project coordination and planning for activities including archeological clearance, environmental review, easements, and on-going inter-agency coordination. In addition to the IHS and the tribal government, other stakeholders that may participate in a project could include tribal departments, the BIA, EPA, Department of Housing and Urban Development (HUD), Rural Development (RD) within the U.S. Department of Agriculture (USDA), state and county offices, non-Indian communities and cities, and other utility organizations.
- **Project funding:** The SFC Program provides funding for drinking water, sewer, and solid waste projects, and are defined by four categories including: 1) projects to serve new homes such as homes being constructed by individual homeowners; 2) projects to serve existing homes; 3) special projects such as studies and training; and 4) emergency projects. The U.S. Congress appropriates funding for the SFC Program based on the annually reported needs for American Indian homes (e.g. the SDS

inventory of needs). Funding for projects to serve new homes is referred to as "Housing" and funding to serve existing homes is called "Regular". The Regular-funded projects are to address existing needs identified in the SDS database, and projects are funded in priority order according to their total SDS score. The Housing and Regular funds are allowanced to individual projects at the Area Office level. Special and emergency projects are allocated at the headquarters level. The IHS headquarters distributes funding to the Areas based on an allocation formula that factors into account the reported need in SDS with more weight given to the higher deficiency level homes and the cost to address those deficiencies; e.g. more weight given to the higher deficiency IDL-3, IDL-4, and IDL-5 homes (additional explanation on the deficiency levels is provided in the SDS section). Currently, the majority of the SFC Program budget is for existing homes using Regular funds.

- **Operation and maintenance training and technical consultation:** Typically, after the facilities are constructed, they are transferred to the tribe with the responsibility for continual operation and maintenance (O&M). As part of the project, the IHS may provide O&M training, technical assistance, and/or small tools and equipment. During the project start-up, the IHS provides operator training on the new facilities. The IHS also provides assistance to tribes to develop utility organizations; which may include training on user fee structures, preventive maintenance scheduling, and safety programs. However, the IHS does not provide direct financial assistance for the day-to-day operations of the facilities for such items as salaries, water quality testing, electrical power, and routine replacement.

1.4.3 SFC PROGRAM SERVICES

The SFC Program provides a wide variety of drinking water, sewer, and solid waste facilities for American Indian communities and individual homes. Community drinking water facilities could include the water source (e.g. ground water and surface water), treatment, storage, and transmission and distribution. Community sewer system facilities could include sewer collection and sewage pumping stations, treatment, and disposal systems. Solid waste facilities could include containers, collection vehicles, transfer stations, landfills, and open dump closures. In support of community project development, the SFC Program can fund small-scale planning projects to identify critical design information (e.g. soil type, ground water investigations, environmental constraints, etc.). The SFC Program can also provide services for individual homes, which may consist of a water well and pressure system, water service connection, septic tank and drainfield, or sewer service connection.

1.4.4 ELIGIBILITY FOR SERVICES

The SFC Program is required to serve American Indian homes, and there are several eligibility criteria for an IHS-funded project (SFC, 2003a, p. 5.3), which includes:

- **Person:** A person must be a member of a federally-recognized American Indian tribe, band, or community.
- **Homes:** The IHS can only fund facilities for American Indian homes (e.g. residential dwellings), and cannot be used for non-Indian housing, commercial, industrial, or office buildings.
- **Community:** The primary focus of IHS-funded projects is for American Indian communities that are defined as a group of dwellings where the majority of the population is American Indian. Assistance from IHS is limited for non-Indian communities.

1.4.5 FUNDING METHODOLOGY

The allocation of SFC Program funding is based on two primary principals – unmet needs and project-based. Each Area receives Regular funding for existing homes based on the level of needs reported in SDS. The Area then allowances projects in SDS based on a priority order determined by the project score. These projects are the primary driver for the SFC Program, which are used to define the needs and the intervention to correct the deficiencies. Each funded project requires an executed Memorandum of Agreement (MOA) between the tribe and IHS, which obligates the funds, indicates the responsibilities of each party, and identifies the owner of the facilities, which is typically the tribe (SFC, 2003c, p. 1.3).

1.4.6 DATA SYSTEMS

Currently, the SFC Program maintains six data reporting and management systems within the overall web-based system known as the Sanitation Tracking and Reporting System (STARS). Several of the STARS databases are summarized below (IHS, no date-b):

- **Community Deficiency Profile (CDP):** Contains information on the number and type of homes and their initial deficiency level (IDL) for water, sewer, and solid waste. The CDP is also an integral part of SDS in order to evaluate the overall progress of addressing the deficiencies in the communities, and serve as a baseline measure.
- **Sanitation Deficiency System (SDS):** Documents sanitation deficiencies for individual homes and communities and the projects to address the needs (additional information is provided in the SDS section).

- **Project Data System (PDS):** Manages funded projects (e.g. interventions) that contain information on the project milestones, costs, type of service, type of funding and a repository for project-related documents. The PDS is used by IHS and other stakeholders (e.g. the tribes, EPA) to monitor and evaluate progress and perform project management functions (e.g. list of overdue milestones). Information from PDS is also used to calculate the relative workload of a project under the Resource Requirements Methodology (RRM). The RRM (e.g. number of staff-years per project) is based on the total funding and distributed over a five-year project duration based on standard percentages for each major phase (e.g. design, construction, close-out).

1.5 SANITATION DEFICIENCY SYSTEM (SDS)

The background information on the SDS system is based on the *Sanitation Deficiency System, Guide for Reporting Sanitation Deficiencies for Indian Homes and Communities* (IHS, 2003b).

1.5.1 BACKGROUND

Initially, the SFC Program reported deficiencies as part of a combined database for other needs in American Indian communities. Beginning in 1989, the SDS system was created as a separate database in compliance with P.L. 94-437. In 2000, the SDS became web-based and since 2004, all Areas have reported deficiencies directly into the SDS data system. In collaboration with the tribes, the SFC Program conducts annual updates and reports them in the SDS.

The SDS projects fall into two broad categories – those that are feasible based on technical, environmental, and economic considerations, and infeasible because of constraints in one or more of these criteria. Typically, projects are infeasible due high unit cost; e.g. cost per home served exceeds a set threshold amount.

1.5.2 DEFINITIONS

Several of the key terms and definitions pertaining to SDS are defined below:

- **Adequate:** Adequate drinking water and sanitation systems comply with all applicable federal, state, and local public health and environmental laws and regulations.
- **Sanitation deficiency:** A need or deficiency identified for the drinking water, sewer, or solid waste system for existing American Indian home or community. The severity of the deficiency is reported by the initial deficiency level (IDL). Additional details on the IDL are listed in Table 1.2.

- **Projects:** Projects are developed in SDS to correct the identified needs for the homes or communities. Information in a SDS project includes the name of the tribe and community, the cost estimate, homes to be served, descriptions of the deficiency and proposed facilities, and overall deficiency level that the project is addressing. Each SDS project is scored based on eight categories (additional information is provided under the SDS project scoring methodology section).
- **Community and individual facilities:** SDS projects can be developed to address deficiencies for both community and an individual home. Community facilities generally refer to a common system serving a group of homes or service connection to those facilities. Individual facilities typically serve a single home.
- **Feasibility and allowable unit cost:** The SFC Program has developed an allowable unit cost (e.g. cost per home) for each state in the U.S. in order to determine the feasibility of each project. The threshold unit costs vary depending on the severity of the deficiency that needs to be corrected (e.g. initial deficiency level). For California, the feasible costs are provided in Table 1.1. In some cases, a project may also be considered to be infeasible based on environmental constraints (e.g. endangered species).

Table 1.1 California Area feasible unit costs for water, sewer, and solid waste

	Allowable Unit Costs			
IDL	**Water**	**Sewer**	**Solid Waste**	**Total**
IDL 5	$50,500	$50,500	N/A	$101,000
IDL 4	$50,500	$50,500	N/A	$101,000
IDL 3	$35,350	$35,350	$15,150	$85,850
IDL 2	$20,200	$20,200	$10,100	$50,500

Source: IHS (no date-b)

1.5.3 SDS PROJECT SCORING METHODOLOGY

The SDS projects are scored based on eight factors including deficiency level, health impact, adequate previous service, capital cost, O&M capability, contributions, tribal priority, and local condition factors. Points are assigned to each factor based on SDS guidance and policies, and a total score is calculated for each project which determines the rank order in the SDS listing. The highest total score possible is 108 points. A brief description and points allowed for each factor are described below (SFC, 2003b, pp. 18; 25-29).

A. Initial deficiency level: The initial deficiency level (IDL) factor ranges from 0 to 18 points and represents the level of need or condition of the water, sewer or solid waste facilities. The IDL for each project must be determined as required by the P.L. 94-437. The SFC Program has developed guidance to select the appropriate IDL for the project and is summarized in Table 1.2.

B. Health impact: The health impact factor ranges from 0 to 30 points and represents the reporting and likelihood of a disease or other adverse public health effect directly attributable to the deficiencies.

C. Adequate previous service: The adequate previous service factor ranges from 0 to 4 points and represents that adequate (e.g. improved) water and sanitation service was installed for the home by IHS or another federal agency, and the facilities met the standards at that time.

D. Capital cost: The capital costs factor ranges from -20 to 16 points and represents a comparison of the unit cost (e.g. cost per home) of the proposed facilities to the average unit cost in the Area.

E. O&M capability: The O&M capability factor ranges from 0 to 16 points and represents the O&M capacity of the tribe. The evaluation of the tribal organization can be subjective and considerations include past performance, current tribal intent and capability, and tribal resources to sustain the proposed facilities.

F. Contributions: The tribal contributions factor ranges from 0 to 8 points and represents an optional contribution received from other sources for the proposed facilities.

G. Tribal priority: The tribal priority factor ranges from 0 to 16 points and represents tribal priority for the project, and gives the tribe an opportunity to directly influence the project score as part of the consultation process.

H. Local conditions factor: The local conditions factor ranges from 0 to -15 points and represents an unusual condition or risk (e.g. legal disputes) associated with the proposed facilities, and should be used with tribal concurrence. This factor is seldom used.

Table 1.2 IHS initial deficiency levels for sanitation facilities

DL	Description	Facility type	Examples
5	Lacks a safe water supply and a sewer system.	Water and sewer	Deficiencies at IDL-4 for water and IDL-4 for sewer.
4	Lacks either a safe water supply or sewer system.	Water	No piped water in home. Surface water with no filtration or treatment. Unprotected spring or well. Water does not meet EPA primary contaminant regulations. Source provides less than 30gpcd for more than 20 days/year.
		Sewer	No piped sewer in home. Sewage surfacing from failed drainfield. No sewage treatment facility. Backups caused by high groundwater or deteriorating facilities.
3	Inadequate or partial water supply and a sewer system that does not comply with applicable water supply and pollution control laws, or has no solid waste disposal.	Water	Significant problem with water quantity. Significant water leakage due to deteriorated pipe. Water pressure less than 10 psi during peak periods of use.
		Sewer	Periodically incapable of complying with discharge permits. Periodic sewer overflows due to inadequate pipe sizes. Sewage lift station overflows.
		Solid waste	Open dump disposal site in non-compliance with regulations. Scattered open dumping with no facilities reasonably available.
2	Complies with all applicable water supply and pollution control laws, and in which the deficiencies relate to capital improvements that are necessary to improve the facilities.	Water	Facilities do not meet current design standards. Facilities do not meet secondary water quality standards.
		Sewer	Facilities do not meet current design standards. Deteriorated sewer mains or sewage lift station.
		Solid waste	Facilities nearing capacity that need expansion. Inadequate collection equipment.
1	Complies with all applicable water supply and pollution control laws, and in which the deficiencies relate to routine repair or maintenance needs.	Water	Minor replacements and repairs of standby equipment. Repairing minor leaks.
		Sewer	Minor replacements and repairs of standby equipment. Minor repairs to coating and fencing.
		Solid waste	Minor replacements and repairs of equipment. Minor repairs to structures and fencing.

Source: IHS (2003b, p. 18)

1.6 SYSTEM MONITORING BY IHS AND EPA

Monitoring the tribal drinking water and sanitation systems is primarily conducted by the SFC Program and the EPA, in addition to tribal utility organizations providing routine operations and oversight. The SFC Program inventories the system deficiencies and related health impacts in the SDS database previously described. The EPA conducts regulatory monitoring that is administered under several different programs.

The EPA monitors drinking water regulatory compliance, including tribal systems, using the database known as the Safe Drinking Water Information System (SDWIS). The SDWIS tracks public water system information for monitoring, reporting, and compliance requirements (EPA, 2013a). The EPA determines public water system compliance by running specific reports in SDWIS. The EPA uses this data to help identify water systems that are chronically in violation of the Safe Drinking Water Act (SDWA) rules. Violators are placed on the Enforcement Targeting Tool (ETT), which is also called the Significant Non-Complier (SNC) list. The ETT is used to assist water system owners with resource prioritization to address the violations with the highest potential to impact public health. The ETT list is created quarterly by EPA, and scores are calculated to reflect the health based violations for treatment techniques (TT), maximum contaminant levels (MCL), and monitoring and reporting (M/R). A violation is assigned 10 points for acute TT or MCL violations, 5 points for non-acute TT or MCL violations, and 1 point for M/R violations. An SNC is designated for systems with a score of 11 points or higher.

The EPA regulates wastewater systems that discharge directly to surface water under its National Pollutant Discharge Elimination System (NPDES). Currently, there are no tribally operated wastewater systems with this type of disposal in the California Area; the usual method of effluent disposal is by subsurface discharge. The EPA regulates underground liquid disposal under its Underground Injection Control (UIC) Program, which primarily evaluates systems to prevent the contamination of underground sources of drinking water (EPA, 2013b).

1.7 HEALTH AND DISEASES

1.7.1 BACKGROUND

The presence or absence of disease is a key component to the overall health of an individual and the community as a whole. In developing countries and underserved areas, water-related diseases can significantly impact the health status, and effective prevention strategies often include the provision of safe drinking water, sanitation, and improved hygiene practices.

Three generalized groupings of waterborne and water-washed diseases are presented below that are used in the research project. The key facts, causes, and transmission routes for each disease are based on information from the WHO (2013), CDC (2013), Heymann (2004; pp. 159-160; 247-253; 413-424), AWWA (2006, pp.73-74; 161-162; 251-252; 273-277), and Keusch, et al. (2006, pp. 371-384). A more in-depth examination of waterborne and water-washed diseases is presented in Chapter 2.

1.7.2 DIARRHEAL DISEASES

Diarrheal disease is defined as the passage of three or more loose or liquid stools per day. The disease is usually the symptom of an infection in the intestinal tract (e.g. gastrointestinal infection), which can be caused by a variety of bacterial, parasitic, and viral organisms. Common bacterial agents include *Escherichia coli*, *Salmonella*, and *Vibrio cholerae*. Two parasites that have caused numerous waterborne diseases are *Cryptosporidium parvum* and *Giardia lamblia*. Viruses, which are the smallest infectious agent, include rotaviruses and Hepatitis A virus. These infectious agents are both endemic in certain countries or may be introduced to a new area by a host carrier; e.g. infected person.

There are three major types of diarrhea – acute watery diarrhea, persistent or chronic diarrhea, and bloody diarrhea. The specific agent of infection will influence they type of diarrhea, duration, and severity. Acute watery diarrhea is usually caused by rotaviruses or *V. cholerae* (e.g. cholera), and can result in severe dehydration. Infants, children, and the malnourished are especially vulnerable because of the high volume of fluid loss that may not be adequately replenished. Chronic or persistent diarrhea that last for more than two to four weeks in adults may be nuisance or a serious illness especially for someone with a weakened immune system, and in some countries is associated with a disproportionately increased risk in death. Bloody diarrhea, also referred to as dysentery, is associated with intestinal damage and nutritional deterioration.

Globally, there are an estimated 1.7 billion cases of diarrheal disease annually that account for the deaths of approximately 2.2 million people. The impact is most severe for children under the age of five accounting for around 760,000 deaths every year (WHO, 2013).

Infection is spread by faeces-contaminated drinking water or from person-to-person contact as a result of poor hygiene. Another common pathway for infection is from food when it is prepared or stored using unhygienic practices.

1.7.3 HEPATITIS A

Hepatitis A is a liver disease caused by the hepatitis A virus. The disease varies in severity from a mild illness to a severe condition lasting several months. Globally, there are an estimated 1.4 million cases of hepatitis A every year (WHO, 2013).

The hepatitis A virus is transmitted primarily by the faecal-oral route such as when an uninfected (and unvaccinated) person consumes water that has been contaminated with the faeces of an infected person. In addition, infection could spread by poor hygiene practices during the preparation and handling of food by an infected person.

Most children have asymptomatic or unrecognizable infections, and therefore can be a major source of infection for others. The risk of infection is increased in areas with poor levels of hygiene and sanitary conditions. Hepatitis A viruses persist in the environment.

1.7.4 PNEUMONIA

Pneumonia is a form of acute respiratory infection, and causes the alveoli (small air sacs) in the lungs to fill with fluid and pus, which makes breathing painful and limits oxygen intake. Pneumonia is the single largest cause of death in children worldwide, and every year, kills approximately 1.2 million children under the age of five years (WHO, 2013).

Pneumonia is caused by a number of infectious agents, including viruses, bacteria, and fungi. The most common include *Streptococcus pneumoniae* and *Haemophilus influenzae* type b, both bacterial agents, and the respiratory syncytial virus.

The disease can be spread in numerous ways. The bacteria and viruses that are commonly found in a child’s nose or throat can infect the lungs if they are inhaled. They may also spread via airborne droplets from a cough or sneeze, and indirectly from contact with contaminated surfaces (e.g. related to water-washed diseases). Children carry *S. pneumoniae* more frequently than adults, and it may be asymptomatic.

The occurrence of pneumonia is more frequent in malnourished populations and lower socioeconomic groups. Children with compromised immune systems are at an especially higher risk. Pneumonia can occur in all climates and seasons, however incidence is the highest in winter and spring in temperate areas.

1.8 Operation and Maintenance of Tribal Systems

Tribes are responsible for the operation and maintenance (O&M) of the drinking water, sanitation, and solid waste facilities serving their communities. The SFC Program may assist tribes with technical assistance, training, or small-scale equipment in connection with a new construction project, however cannot provide direct financial support for the day-to-day operations.

While IHS is authorized under P.L. 94-437 to provide financial resources to tribes for O&M, the SFC Program has never been appropriated (e.g. funded) for this authorization. The U.S. Congress has controlled the use of SFC Program funds for construction projects only and never have been designated for direct O&M assistance (e.g. salaries, electrical utility fees, etc.). The situation has become an unfunded mandate. However, beginning in 1994, the U.S. Congress has provided annual funding specifically for O&M training, and is a current service provided by the SFC Program.

1.9 Program Impact Evaluations

1.9.1 Background

An assessment of a project or program is critical in order to obtain information to plan, set priorities, and ensure that the overall objectives are appropriate and achieving the desired results (Reed, 2010, p. 12.2-12.6). Assessments conducted over intervals during the course of a project are referred to as “monitoring” and towards the end is called an “evaluation”. Monitoring occurs throughout the program cycle and provides information for two main purposes – to measure progress against objectives and performance standards, and to enable accountability to project stakeholders (Reed, 2010, p. 12.21). Evaluations are usually conducted after project completion and important to develop lessons learned that can be applied to future or on-going interventions (Reed, 2010, p. 12.25). While the scope of the assessment may vary depending on the time it is conducted in the project cycle, there are common components to all assessments, which include selection of indicators, data collection, data analysis, presentation of the information, and recommendations for follow-on improvements. Guidance on program assessments is provided by DFID (1998), UNHCR (2000), and Sphere (2011).

1.9.2 IMPORTANT ASPECTS OF EVALUATIONS

Typically, evaluations of drinking water and sanitation interventions focus on function, use, and impact of the systems, and these key focus topics form the framework for an evaluation (Reed, 2010, p. 12.26). Function is based on technical, administrative, and resource aspects. Use is composed of sociological, administrative, and technical factors. Impact focuses on the health, sociological, and economic perspective.

Evaluations of projects or the strategic policy of a program should also include a set of issues that includes sustainability, effectiveness, equity, efficiency, and replicability and transferability (DFID, 1998, pp. 31-34). Frequently, a balance needs to be achieved between these objectives, and happens when the stakeholders evaluate the options, identify the trade-offs, and select a preferred course of action in order to achieve the program's goals. Each of the issues is summarized below:

- **Sustainability:** Ensuring that the interventions continue to operate adequately and generate the desired benefit over their design life.
- **Effectiveness:** The degree to which the interventions meet their objectives, which implies the facilities deliver their benefits (e.g. health benefits) and are adequately operated and maintained.
- **Equity:** The interventions target and are used by the disadvantaged groups and underserved populations.
- **Efficiency:** Represents the output per unit of resources. Inefficiencies could result in low coverage rates, high project costs, and a small number of people served per unit invested.
- **Replicability and transferability:** Considers the affordability of the services, cost recovery, coverage levels, improved levels of service (e.g. technical design and performance), and adapting to local contexts and conditions (e.g. partnerships).

The Sphere Project has established core standards for minimum levels of accountability from the humanitarian agencies, and includes Core Standard 5 that describes the need for agencies to evaluate the effectiveness, quality, and appropriateness of the interventions (Sphere, 2011, pp. 68-71). A key action for the agency is to conduct periodic lessons learned exercises and an evaluation with reference to its objectives and principles. The continual monitoring should compare intensions with results and progress against objectives. Evaluations of the agency's performance should measure its achievements along with the effectiveness and efficiency. An essential aspect of humanitarian response, whether is it during a disaster or long-term public health issue, is the assessment of the impact of the agency, which links the contributions from the interventions to the changes in the population being served.

1.9.3 HIERARCHY OF OBJECTIVES

Typically for a mandate-based organization, such as the SFC Program, the ability to compare specific activities within the operation back to the overall goal of the organization is a critical method of assessment. There is a hierarchy of objectives which connects activities back to the basic mandate or strategic policy (UNHCR, 2000, p. 11). A program assessment of the hierarchy of objectives helps to establish and refine the process of developing goals, objectives and outputs of a program in order increase the likelihood that the achievements at the lower levels (e.g. outputs or deliverables) will result in the desired impact at the higher level (e.g. meeting goals and objectives). The general hierarchy and definitions of each level is presented below (Reed, 2010, pp. 11.9-11.13):

- **Mandate and strategic policy:** A clear vision and frequently the binding or legal framework that defines the responsibilities of the organization. The mandate and strategy of the organization focuses on long-term objectives.
- **Goals:** The desired result of the organization that addresses the high-level issue.
- **Objectives:** The desired result at the sector or program level that addresses a specific problem or issue. Objectives should be developed that are based on agreed upon standards and SMART – specific, measureable, achievable, relevant/realistic, and time bound.
- **Outputs:** The specific deliverables which will result in the achievement of objectives and impacts.
- **Activities:** The groupings of tasks necessary to transform inputs into outputs.
- **Inputs:** The human, financial, material, and technical resource requirements necessary to achieve outputs.

1.9.4 USING INDICATORS FOR ANALYSIS OF ASSESSMENT INFORMATION

In order to understand critical needs, resources, constraints, and set priorities for a program (or project), managers and planners generally need information about the situation (UNHCR, 2000, p. 32). Indicators are quantitative and qualitative measurements of data about the situation for use by decision-makers (JHSPH, 2013, p. 223). The selection of an indicator should consider the resources to measure it at the required intervals. Indicators are used as “thresholds above or below which an action or resources are directed in response to the needs, and to measure the resulting impact” (UNHCR, 2000, p. 32). Generally, programs should be monitored by using two levels of indicators:

1) impact indicators at the level of objectives, and 2) performance indicators at the level of outputs (UNHCR, 2000, p. 32). Definitions of the two terms are presented below.

- **Impact:** The impact refers to the higher level effect in quality and intended change that is achieved through the implementation of activities to meet goals and objectives.
- **Indicator:** An indicator is a measure which monitors progress compared to the achievement of key objectives and expected outputs, and can be used at all levels of the hierarchy of objectives.

1.9.5 MEASURING HEALTH IMPACT

Even though adequately functioning drinking water and sanitation systems are being used by a community, achieving the intended health impact is not certain and even more difficult to measure. The health benefits are “often small, notoriously difficult to measure, and even harder to attribute to project interventions, yet they commonly appear in project objectives” (Reed, 2010, p. 12.27). Interventions are often attributed to health improvements in reducing diarrheal disease rates; however other factors can affect the rates including education, nutrition, and climate. While there have been many health impact studies that have associated reduction rates to certain interventions, in some cases the “results are not only unpredictable, they frequently offer no firm interpretation” (Cairncross, no date). The realization of health improvements most likely will not come from one particular intervention, but instead result from a series of connected impacts – construction of the facilities, adequate operation and maintenance, and use in order to support positive changes in hygiene behavior (Cairncross, no date). Ultimately, this series of events will form the basis for disease reduction and improved public health.

1.10 OVERVIEW OF THE RESEARCH PROBLEM

The American Indian people have long experienced lower health status when compared with other Americans. Lower life expectancy and the disproportionate disease burden may be influenced by inadequate education, disproportionate poverty, discrimination in the delivery of health services, and cultural differences. Safe and adequate water supply and waste disposal facilities are still lacking in approximately 12% of American Indian homes, compared to less than 1% of homes for the U.S. general population (IHS, no date-a).

American Indians with adequate environmental conditions in their homes, which include safe water and sewerage systems, require appreciably fewer medical services and place fewer demands on the IHS and tribal primary health care delivery system. The SFC Program is authorized to provide essential drinking water and sanitation facilities to American Indian communities. Once the projects are completed, the facilities are owned and operated by the tribes. Even though hundreds of projects have been funded, there is a significant backlog of needs totaling approximately US$1.6 billion. With inflation, new environmental requirements, aging infrastructure, and population growth, the current appropriations from the U.S. Congress are not reducing the backlog.

There have been limited performance measures to evaluate the national SFC Program, and fewer for the Area programs. Currently, the national SFC Program has three program performance indicators: number of American Indian homes served annually with water supply and sanitation services; duration to complete a project; and percentage of American Indian homes with water and sanitation facilities. However, only the project duration measure is carried on to the Area SFC Programs. To date, there has been no formal Area SFC Program assessment with specific attention to key evaluation issues such as sustainability, effectiveness, equity, efficiency, and replicability.

1.11 Research objectives

The primary objective and focus of the research project is to assess the California Area SFC Program's performance and impact on the welfare of the American Indians over a 10 year time span from 2003 to 2013. The SFC Program will be examined through 1) project delivery, 2) interventions, 3) deficiency monitoring, 4) health impact, and 5) system sustainability in order to evaluate broad issues of sustainability, effectiveness, equity, efficiency, and replicability.

The research project will also examine global drinking water and sanitation issues on an international scale and national SFC Program indicators in order to provide context and comparisons. Overall objectives of the research project include:

1. Understand, document, and assess the SFC Program's performance.
2. Examine the water and sanitation interventions by various categories.
3. Examine the water and sanitation level of deficiencies and needs.
4. Analyze the health impacts from the water and sanitation interventions.
5. Survey and assess the sustainability of the facilities operated by the tribes.
6. Provide the SFC Program with information to develop a better understanding of its performance, critical areas for improvement, and support for informed decisions.

1.12 Research questions

The primary research question is as follows:

> "How is the SFC Program performing and impacting American Indian communities through the provisions of drinking water and sanitation projects?"

The SFC Program will be examined through underlying questions related to five key components and their related issues including:

A. Project delivery (efficiency):

1. How do the annual number of American Indian homes served compare with national trends and target goals?
2. How does the project durations compare with national trends and target goals?
3. What is the cost per home for the water supply and sanitation interventions related to construction and program resources?

B. Water and sanitation interventions (equity):

1. What water and sanitation interventions have been provided to American Indian tribes and communities?
2. How are the interventions distributed by category, description, type, deficiency level, SDS project score, and among American Indian tribes and communities?

C. Water and sanitation deficiency monitoring (equity and effectiveness):

1. How are the previous interventions impacting the deficiencies in terms of both cost and percentage of homes with water and sanitation facilities?
2. How do the remaining deficiencies compare across categories for water, sewer, and solid waste?
3. How do different agency monitoring databases corroborate with each other?

D. Health impact (effectiveness):

1. How have the water supply and sanitation interventions impacted the health of the American Indians?

E. System sustainability (sustainability and replicability):

1. What is the tribal technical capacity and areas of improvement for sustaining services in the long-term?
2. What is the tribal managerial capacity and areas of improvement for sustaining services in the long-term?
3. What is the tribal financial capacity and areas of improvement for sustaining services in the long-term?
4. How is the tribal capacity to operate and sustain the systems related to current system needs and deficiencies?

1.13 JUSTIFICATION OF THE RESEARCH PROJECT

There has been no previous California Area SFC Program assessment that examined key components of project delivery, interventions, deficiency monitoring, health impact, and system sustainability issues. This research project will provide SFC Program decision-makers with information to develop a better understanding of the SFC Program's performance and impact, and critical areas for future improvement.

1.14 ARRANGEMENT OF THE REPORT

The research project is arranged in six separate chapters, which include:

- **Chapter 1:** Provides introduction and background information on the American Indians, the IHS and the SFC Program, tribal system monitoring, health and diseases related to drinking water and sanitation systems, operation and maintenance of tribal systems, overview of program impact evaluations, and the research objectives and question.
- **Chapter 2:** Provides literature reviews of the relevant sources for this research highlighting both international, the IHS, and American Indian perspectives for agency performance indicators, water and sanitation needs, impacts from water and sanitation interventions, and key issues related to sustainability.
- **Chapter 3:** Describes the methodology of the research with an overview of the case study strategy and specific design for the sub-units of the research.
- **Chapter 4:** Provides the results and discussion of the research for the sub-units of program performance, interventions, and deficiency monitoring, and holistically converges back to the main research question.
- **Chapter 5:** Provides the results and discussion of the research for the sub-units of health impact and system sustainability, and holistically converges back to the main research question.
- **Chapter 6:** Draws the results and analysis together forming common themes, and provides conclusions and recommendations.

2 LITERATURE REVIEW

2.1 INTRODUCTION

The literature review examined articles, books, and other sources of information relevant to the research topic in order to provide an overview of the subject, categorize and compare key findings, and identify knowledge gaps (Jones, 2011, p. 5.14). In addition, the literature review created an overall context and direction for the current research, and explained how the research being conducted relates to previous literature and the issues that will be addressed (Denscombe, 2011, p. 314).

This research project is an impact assessment of the SFC Program's drinking water and sanitation interventions. The organization of this chapter first presents issues on a global scale and then relevant to the IHS and American Indians. The literature review focused on the primary topics of:

- Performance indicators for international aid agencies and U.S.-based programs
- Needs on a global scale and for American Indians
- Impact of interventions for disease reductions
- Sustainability key issues in developing countries and for American Indian tribes

No one literature source provided information on all the topics, and therefore a large variety of sources were used in combination to develop a broad framework for the study. Literature searches were conducted in the Medline database, Google Scholar searches, and reviews of specific agency's documentation, policies, and guidelines. Searches were made using key words that paired aspects of 'Indian Health Service', 'Sanitation Facilities Construction Program', 'American Indian', 'Native American', 'water, sanitation, and hygiene', 'performance', 'reviews', 'policies and guidelines', 'needs and deficiencies', 'health status', 'gastrointestinal diseases', 'diarrhoeal diseases', 'upper respiratory infections', 'operation and maintenance', 'capacity', and 'sustainability'.

2.2 GLOBAL PERSPECTIVE

2.2.1 PERFORMANCE INDICATORS OF INTERNATIONAL AID AGENCIES

World Health Organization

In 2000, the United Nations (UN) adopted the Millennium Development Goals (MDGs), with specific importance given to drinking water and sanitation. The MDG-7 (Target-7C), set against a 1990 base year, is to "halve by 2015 the proportion of people without sustainable access to safe drinking water and basic sanitation" (UNICEF, 2012a, p. 2). The targets are measured by using proxy indicators – percentage of populations using 'improved' drinking water supply (e.g. safe drinking water) and 'improved' sanitation facilities (e.g. basic sanitation). In an effort to better define sustainable access, the World Health Organization (WHO) indicated that drinking water should be within 1 kilometer away; the minimum quantity of drinking water is 20 litres per person per day; the drinking water is within WHO guidelines or national standards; and the sanitation system promotes hygienic excreta disposal and a clean environment for the community (WHO, no date). The United Nations Children's Fund (UNICEF) definitions and examples of improved and unimproved drinking water and sanitation facilities are provided in Table 2.1.

Table 2.1 UNICEF definitions of improved and unimproved facilities

	Drinking water supply technologies/use of	**Sanitation technologies/use of**
Improved	Household connection	Connection to a public sewer
	Public standpipe or tap	Connection to septic system
	Borehole	Pour-flush latrine
	Protected dug well	Simple pit latrine with slab
	Protected spring	Ventilated improved pit (VIP) latrine
	Rainwater collection	Composting toilet
Unimproved	Unprotected well	Service or bucket latrines [c]
	Unprotected spring	Public latrines
	Vendor-provided water	Open latrine or pit latrine without slab
	Bottled water [a]	Shared or public facilities of any type
	Tanker truck provision of water	No facilities, bush or field (open defecation)
	Surface water [b]	

[a] Bottled water based on potential quantity issues not the quality.

[b] Surface water includes river, dam, lake, pond, stream, canal, irrigation channel.

[c] Service or bucket latrines where excreta are manually removed.

Source: UNICEF (2000, p. 4)

However, the UNICEF Joint Monitoring Program (JMP), the official UN mechanism tasked with monitoring progress of achieving the MDGs, has indicated that performance measures for the MDG targets are based on the facilities being used and not on other factors (UNICEF, 2012a, pp. 33-36). Even though risks are reduced when using these improved systems, they are not direct measures of MDG target goals. For example, contamination can still occur in improved drinking water sources and during the transport and storage process at the house, and the improved systems do not take into account the availability of water (UNICEF, 2012a, pp. 33-36). The JMP report further indicates that even though 'sustainability' is part of the MDG-7 and is critical for long-term beneficial use of the facilities, currently there is no agreed upon standard or measurable definition.

Recognizing the need to establish a framework for more comprehensive and responsive monitoring and reporting, the UNICEF has begun a process to review and develop proposals for post-2015 targets (UNICEF, no date). The new goals and targets are being formulated in consultation with a wide variety of drinking water, sanitation, and hygiene stakeholders. The targets are being drafted based on several underlying assumptions, principles, and formats including: simple and inspirational; focus primarily on outcomes; three or four targets with a short set of indicators; unambiguous and communicable; and clear and comprehensive. The proposed targets and several of the accompanying indicators are listed in Table 2.2.

Table 2.2 UNICEF proposed post-2015 targets

Targets	Target descriptions	Indicators (examples)
Target 1:	By 2025 no one practices open defecation, and inequalities in the practice of open defecation have been progressively eliminated.	Percentage of population reporting practicing open defecation.
Target 2:	By 2030 everyone uses a basic drinking water supply and handwashing facilities when at home, all schools and health centres provide all users with basic drinking-water supply and adequate sanitation, handwashing facilities and menstrual hygiene facilities, and inequalities in access to each of these services have been progressively eliminated.	Percentage of population using basic drinking water service. Percentage of population with basic handwashing facilities at home.
Target 3:	By 2040, everyone uses adequate sanitation when at home, the proportion of the population not using an intermediate drinking-water supply service at home has been reduced by half, the excreta from at least half of schools, health centres and households with adequate sanitation are safely managed, and inequalities in access to each of these services have been progressively reduced.	Percentage of population using an intermediate drinking water service. Percentage of population using an adequate sanitation facility. Percentage of population living in households whose excreta are safely managed.
Target 4:	All drinking-water supply, sanitation and hygiene services are delivered in a progressively affordable, accountable, and financially and environmentally sustainable manner.	Percentage of population using water and sanitation service providers registered with a regulatory authority. Percentage of population in the poorest quintile whose financial expenditure on water, sanitation, and hygiene is below 3% of the national poverty line. Ratio of annual revenue to annual expenditure on maintenance.

Source: UNICEF (2012b, pp. 7-16)

U.S. Agency for International Development

The U.S. Agency for International Development (USAID) published a guide for the measurement of water and sanitation indicators, which was developed as part of the agency's program monitoring and evaluation system, and intended to provide the technical basis for the indictors and recommended methods for collecting, analyzing, and reporting (USAID, 1999). The USAID guide indicates that the selection of indicators for annual monitoring should be evaluated based on a review of available data sources and needs of the aid agency and national government. While the monitoring indicators provide information for program improvement, they also can provide information for analysis of the health impact from the program-funded interventions. The guide provides four impact and monitoring indicators with accompanying definitions and target values. A summary of the indicators and associated values are provided in Table 2.3.

Table 2.3 USAID impact and monitoring indicators

Level	Indicator	Target value/issues
Impact	Percentage of children under 36 months with diarrhea in last two weeks.	Decrease the rate of diarrheal diseases on the order of 25%.
	Quantity of water used per capita day.	Provide 50 litres/capita/day.
	Percentage of child caregivers and food preparers with appropriate hand washing behavior.	Increase appropriate hand washing by 50% over the baseline.
	Percentage of population using hygienic sanitation facilities.	Increase sanitation usage by 75% over the baseline.
Monitoring	Percentage of households with year-round access to improved water source.	Local conditions to address issue of adequacy.
	Percentage of households with access to a sanitation facility.	Local site-specific criteria for type of facility, access, and proper use.
	Percentage of recurrent costs for water supply services provided by the community served.	The larger the percentage of costs borne by the community the greater the sustainability of the system.
	Percentage of constructed water supply facilities maintained by the community served.	Systems operated and maintained by the community are likely to be more sustainable than by others outside the community.

Source: USAID (1999, p. 22)

2.2.2 WATER AND SANITATION NEEDS ON A GLOBAL SCALE

The UNICEF JMP for water and sanitation is responsible for monitoring and reporting every two years on the progress towards the MDG-7, Target-7C. The most recent JMP update indicates that the MDG target for drinking water has been achieved. At the time of the base year in 1990, there was 24% of the population with unimproved drinking water sources (e.g. a MDG target of 12%). Currently, there is an estimated 11% of the population using unimproved sources, and by 2015, it is projected that it will decrease to 8% (UNICEF, 2012a, pp. 3-7). While there has been significant success in water supply coverage, there has not been the same level for sanitation. In 1990, 51% of the population had unimproved sanitation (e.g. a MDG target of 25%), and by 2015 it is projected to decrease to only 33% (UNICEF, 2012a, pp. 14-17).

Therefore, even though there have been many accomplishments to increase access, there is 780 million people without access to improved sources of drinking water and 2.5 billion people lacking improved sanitation facilities (UNICEF, 2012a, p. 2). A summary of the progress from 1990 to the projected percentages in 2015 is presented in Table 2.4.

Table 2.4 Trends in global drinking water and sanitation coverage

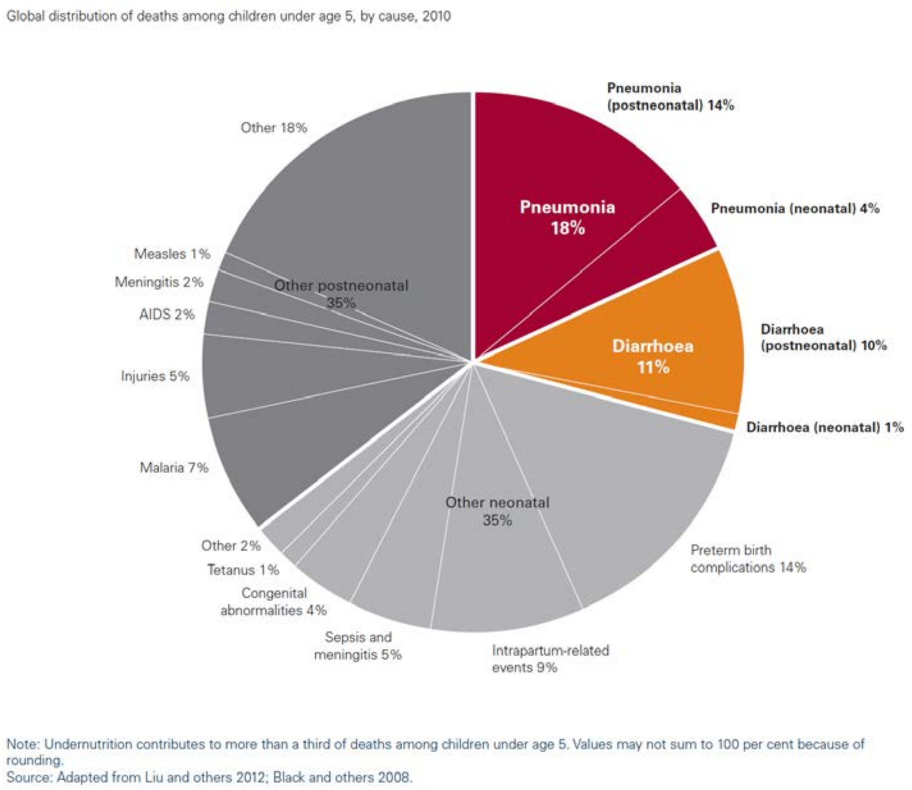
	Source/system	**1990** [a]	**1995**	**2000**	**2005**	**2010**	**2015** [b]
Drinking water	Improved	76%	79%	83%	86%	89%	92%
	Unimproved	24%	21%	17%	14%	11%	8%
Sanitation	Improved	49%	52%	56%	60%	63%	67%
	Unimproved	51%	48%	44%	40%	37%	33%

[a] Base year
[b] Projected

Source: UNICEF (2012a, pp. 3-7; 14-17)

The vast majority of deaths resulting from the lack for improved drinking water and sanitation facilities are children under the age of five years. Of the estimated nine million children under the age of five that die each year, diarrhea is the second leading cause resulting in 1.5 million children deaths every year (UNICEF, 2009, p. 1). The leading cause of death for children is pneumonia, and the two diseases combined account for 29% of deaths among children under five (UNICEF, 2012c, p. 5). A critical aspect of both these diseases is that they are largely preventable and a common prevention strategy includes hand washing with soap, which requires suitable quantity of water supply and hygiene practices. The global distribution of deaths among children under the age of five is presented in Figure 2.1.

Figure 2.1 2010 global distribution of deaths among children under age 5 years



Source: UNICEF (2012c, p. 2)

2.2.3 Impacts of Water and Sanitation Interventions on a Global Scale

The impact of safe water supply and sanitation facilities create both non-health and direct health benefits. For many global communities, the time savings and social benefits from the provision of improved water and sanitation systems may often yield a tangible and sizable benefit. What may be taken for granted in some communities while not being fully appreciated in others are the significant direct health benefits from water and sewer facilities. Unimproved and inadequate water, sanitation, and hygiene are linked to 88% of cases of diarrhoea worldwide and result in 1.5 million deaths each year (Pruss-Ustun et al., 2008, p. 7). Additionally, the global disease burden could potentially be reduced by approximately 10% from improved facilities and practices. The benefits associated with improved facilities come at an economic cost, and aid agencies and communities are challenged with issues related to funding to provide the facilities and follow-on maintenance.

2.2.3.1 NON-DIRECT HEALTH BENEFITS

Even though direct measurements may be difficult, the non-health benefits from improved water supply and sanitation facilities are significant to those communities that enjoy them. Projects that install a new water supply closer to the community provide a substantial benefit of "the savings in time and drudgery of carrying water home from the source is substantial" (Cairncross et al., 2006, p. 773). The adjacent water source saves time from collecting and hauling water that could be devoted to other household tasks or self-improvement activities such as education.

In addition to time savings, other non-direct health benefits are often associated and valued from water and sanitation facilities. A study referenced by Cairncross et al. (2006, p. 780) indicates that there are significant social benefits attributed to sewer facilities (i.e. latrines) that exceed the health benefits. In the study, householders from a rural African community responded that benefits including "avoid discomforts", "gain prestige", "avoid dangers at night", and "have more privacy" had a higher importance than health-related benefits.

2.2.3.2 DIRECT HEALTH BENEFITS

There is a significant and ever expanding body of knowledge pertaining to the direct health impacts from water, sanitation, and hygiene interventions. The primary focus of the literature reviews and meta-evaluations have been in developing countries; however, there are several studies that evaluated the deficiencies and outcomes in developed countries or also referred to as established market economies. The foundational impact studies in developing countries have spanned from Esry et al. (1985) to Waddington et al. (2009), while primary evaluations in developed countries have included Payment (1991) and Hellard (2001). Overall, the conclusions indicate that "one of the most important benefits of water, sanitation, and hygiene is by providing barriers to transmission from the environment to the human body of diarrhoeal disease, and are therefore an important focus of efforts to improve quality of life around the world" (Waddington et al., 2009, p. 8). While literature has reported varying disease reductions and effectiveness from the interventions, it is generally recognized that water quality, water supply, sanitation, and hygiene promotion are effective in reducing diarrheal illnesses and can play a role in other diseases as well.

Important concepts and relationships related to water, sanitation, and hygiene and the barriers they provide are the classifications of disease transmission routes and pathways. There are four primary classifications of travel routes for disease; which are summarized by Cairncross et al. (2006, p. 775) as waterborne (from drinking water), water-washed (resulting from limited quantity of water and poor hygiene practices), water-based (from aquatic invertebrate host), and water-related (from insect vectors). The four classifications are presented in Table 2.5. While all four pathways are important, this study focused on waterborne and water-washed disease transmission routes because the SFC Program primarily provides interventions to create barriers for these pathways.

Table 2.5 Classification of water-related infections

Transmission route	Description	Disease examples	Pathogenic agent
Waterborne	Transmitted when a person ingests water containing the pathogen. Also considered as faecal-oral transmission category.	Diarrhea (E. coli) Diarrhea (rotavirus) Cholera Giardiasis Shigellosis [a] Hepatitis A Typhoid fever	Bacterium Virus Bacterium Protozoon Bacterium Virus Bacterium
Water-washed	Transmitted due to inadequate amounts of water used for personal hygiene. Also considered as faecal-oral transmission category.	Infectious skin diseases [b] Infectious eye diseases Louse-borne typhus	Miscellaneous Miscellaneous Rickettsia
Water-based	Transmitted by a pathogen that spends part of its life cycle in a water snail or other aquatic animal.	Schistosomiasis Guinea worm	Helminth [d] Helminth [d]
Water-related	Transmitted by insects breeding or biting in or near water.	Malaria River blindness Yellow fever [c] Dengue [c]	Protozoon Helminth [d] Virus Virus

[a] Shigellosis (bacillary dysentery)
[b] Infectious skin diseases (scabies)
[c] Yellow fever and Dengue (mosquito-borne)
[d] Helminth (parasitic worms)

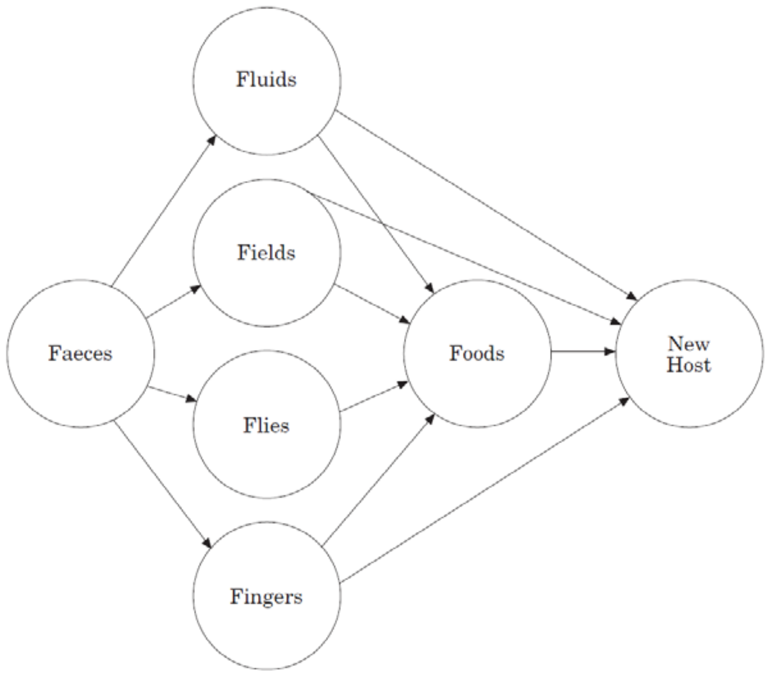
Source: Cairncross and Feachem (1993, pp. 9-13); Cairncross and Valdmanis (2006, p. 775); Mihelcic et al. (2009, pp.16-19); and WHO (2004, pp.121-124)

The multiple pathways of disease transmission by fluids, fields, flies, and fingers are depicted in the F-diagram in Figure 2.2. As represented in the diagram, the objective of the water, sanitation, and hygiene interventions are to create barriers between pathogens in faeces and the body by the four possible routes.

The overall goal of the interventions is to reduce the risk transmission in a two tiered approach (Waddington et al., 2009, p. 13). The first barrier is provided by improved sanitation that protects the overall environment from contamination from faeces. The second barrier is established by water and sanitation efforts to further break the transmission routes. As indicated by the F-diagram, single interventions would only provide barriers along those pathways, and multiple interventions could have expanded impacts.

While providing increased insights into the interaction of various factors, Waddington et al. (2009, pp. 13-15) stressed that the F-diagram is highly simplified, and other factors for disease transmission and risk reduction should be considered as well, including household size, age, nutritional and health status, and personal immunity. The effectiveness of the intervention depends on the "combined action of the behavioral mechanisms underlying it and the context in which it takes place" (Waddington et al., 2009, p. 16). Furthermore, the behavior mechanisms are based on the values, beliefs, and past experiences of the community. It is therefore critical that a proposed intervention not only be designed based on technical requirements, but perhaps even more importantly, on the social environment it will be used in.

Figure 2.2 F-diagram



Source: Curtis et al. (2000, p. 25)

Fecal-oral diseases are considered to be both waterborne and water-washed, and can be transmitted by drinking contaminated water and from inadequate hygiene (Mihelcic, et al., 2009, pp. 16-19). A critical insight provided by Curtis et al. (2000, pp. 23-25) regarding the transmission routes, is the high likelihood that waterborne disease contacted by the feco-oral route can also be transmitted by water-washed pathways such as flies and contamination of food. Furthermore, feco-oral diseases can be transmitted by both waterborne and water-washed routes, and knowing which route generates the greatest risk will be a primary consideration in selecting an appropriate intervention strategy. However, Curtis et al. (2000, p. 30) continue to differentiate that diarrheal diseases are primarily spread by water-washed routes rather than waterborne. Studies on fly-control, hand-washing, and other types suggest that the primary factor of endemic diarrheal disease tends to be hygiene rather than water quality. Therefore, providing a water source close to or at the house can provide substantial impacts because of the higher water consumption; which tends to be used for hygiene. In addition, the nearby water source can have a multiplier effect by also reducing the time needed for collecting water.

2.2.3.3 Developing countries

One of the first studies to review the impacts of water and sanitation interventions was by Esry et al. (1985, pp. 763-766) that described the importance of water quality, water quantity, and excreta disposal. The study indicated that improvements in water quantity and excreta disposal had greater impacts on diarrhea rates than did water quality. In addition, specific focus was placed on relevance of the living conditions of the community and other risk factors have on the overall impact of the interventions. Several years later, Esry et al. (1991, p. 616), concluded that “improvements in one or more components of water supply and sanitation can substantially reduce the rates of morbidity and severity of diarrhoeal diseases”. The study went on to provide specific reduction rates in diarrhoeal morbidity of 22% from all studies reviewed. In addition, observations were made that flush toilets had a greater impact than pit latrines, and there were limited benefits from water quality improvements. The study also provided focus on the importance of hygiene in reducing diarrhea when soap was used to wash hands following defecation and before food preparation.

A study by Cairncross (2003a) entered the conversation of the relative importance of different interventions by indicating that water quality has a limited impact on the disease reduction rates of diarrhea. Based on a systematic review of hand washing with soap, the

study indicated hygiene promotion had a greater impact on morbidity reduction, at 43%, than water quality improvements by disinfection (Cairncross, 2003a, p. 194).
A literature review by Fewtrell and Colford (2004, pp. 35-40) suggested that overall water, sanitation, and hygiene promotion efforts can reduce diarrheal illnesses. Similar to other reviews, this study indicated that sanitation and hygiene promotion interventions are effective, and that specifically hand washing had more of an impact than hygiene education. In addition, the study suggested that water quality interventions, such as household water treatment, storage, and disinfection, can have significant effects in reducing diarrheal diseases. Similar to other studies, there was no conclusive evidence that multiple interventions produced more of an impact than individual interventions because of variables including community involvement and specific interventions. However, this study provides contradictory findings from previous studies for water supply interventions. While water supply interventions can have a significant impact in cholera reductions, the study suggests that there is no beneficial impact on diarrhea.

In the recent study by Waddington et al. (2009, pp. 26-32), the overall findings were consistent with previous evaluations. Sanitation and hygiene interventions were found to be effective in reducing diarrheal morbidity. However, as with the study by Fewtrell and Colford (2004), the results suggested that water quality interventions were more significant that water quantity interventions to improve the water supply. In addition, the study concluded that sanitation and/or hygiene interventions when combined with either water quality or quantity efforts could provide additional reductions in illness rates.

Table 2.6 provides a summary of the findings from reviews and studies by Esry et al. (1991, p. 612), Fewtrell et al. (2004, p. 35), Fewtrell et al. (2005, p. 49), and Waddington et al. (2009, p.9; 29) on the reductions of diarrheal disease morbidity from water supply, sanitation, and hygiene promotion interventions in developing countries. Overall, the range of reductions in diarrhoeal morbidity from the various studies was fairly consistent. The two exceptions were for the water supply (quantity) and water quality interventions. Studies on water supply by Esry and Fewtrell had similar results of reductions between 20% and 25%; however, findings by Waddington only showed a reduction of 2% from the intervention. Improvements in water quality had a positive impact with a spread of 27%; from the low of 15% according to Esry to a high of 42% based on the Waddington study. The other two single interventions were consistent. Diarrhoeal reductions from sanitation interventions ranged from 32% to 37%, and promoting hygiene practices showed a positive impact of 31% to 37%.

Table 2.6 Reductions in diarrhoeal morbidity from interventions for developing countries

Intervention	Esry (1991) [a]	Fewtrell (2004)	Waddington (2009)
Water supply (quantity)	20%	25%	2%
Water quality	15%	31%	42%
Source water quality		11%	21%
Point-of-use water quality		36%	44%
Storage device provided			34%
Sanitation	36%	32%	37%
Sewer connection			31%
Latrine provision			34%
Hygiene	33%	37%	31%
Soap provision		44%	37%
Education		28%	27%
Multiple interventions		33%	38%
Water supply with sanitation/hygiene			19%
Water quality with sanitation/hygiene			57%
Water and sanitation	30%		
Water supply with water quality	17%		

[a] Rigorous studies; of high methodological quality

Sources: Esry et al. (1991, p. 612), Fewtrell et al. (2004, p. 35), Fewtrell et al. (2005, p. 49), and Waddington et al. (2009, p.9; 29)

2.2.3.4 DEVELOPED/ESTABLISHED MARKET ECONOMY COUNTRIES

Even though most of the literature focused on the benefits of water, sanitation, and hygiene interventions for developing countries, there is a need to have a better understanding of the situation for developed countries as well. In the study by Fewtrell and Colford (2004, p. 13), the developed countries are defined as regions in the United States, Canada, Australia, and the United Kingdom, and collectively termed ‘established market economies’. Overall, the studies reviewed by the authors were far fewer than meta-analyses for developing countries; however, the general trends of direct health benefits were similar.

The review by Fewtrell and Colford (2004, p. 38) concluded that sanitation and hygiene interventions (e.g. promoting hand washing) were effective in reducing diarrheal rates. Similarly, impacts from water supply projects installing household connections suggested improvements as well. However, as with studies in developing countries, the effectiveness of water quality interventions had mixed results and was inconclusive.

Over the past several years there have been several reviews of water quality interventions in established market economies that have drawn different conclusions. The study by Payment et al. (1991, p. 707) indicated that 35% of gastrointestinal illness was linked to the drinking water even though the water quality complied with regulations and standards. In another study by Payment et al. (1997, pp. 5-31) the focus was on the distribution system as an area of concern. Tap water that met drinking water quality standards was associated with 14 to 19% of the gastrointestinal illness in the community primarily because the water quality was compromised while in the distribution system. An investigation by Hellard et al. (2001, pp. 776-777) found that there were no significant differences between houses that used water treatment units and those that did not. This study also indicated that while no coliform bacteria were detected after the chlorination points or storage tanks, there were positive tests in the distribution system. These findings are further expanded upon by the study of Hunter et al. (2005, p. 33) that indicated gastrointestinal illness could be associated with water main breaks and areas of low pressure. The study concluded that approximately 15% of the cases of gastrointestinal illness could be linked to drinking water that had been contaminated during water main breaks or periods of low pressure. Therefore, while water sources may have limited exposure to contamination or are adequately treated, there is an elevated risk to the water quality once it enters the distribution system providing water to the houses.

Table 2.7 provides a summary of the findings from reviews and studies by Fewtrell et al. (2004, p. 35) on the reductions of diarrheal disease morbidity from water supply, sanitation, and hygiene promotion interventions in developed/established market economy countries.

Table 2.7 Reductions in diarrhoeal morbidity from interventions for developed countries

Intervention	**Fewtrell et al. (2004)**
Water supply (quantity)	49%
Water quality	2%
Point-of-use water quality	3%
Sanitation	49%
Hygiene	42%

Source: Fewtrell et al. (2004, p. 35)

2.2.3.5 HYGIENE AND RESPIRATORY INFECTIONS

Several studies examined the impacts of hygiene behaviors on disease reductions for both diarrhea and acute respiratory infections (ARIs) such as pneumonia.

An early study on the effects of hygiene education on diarrhea morbidity indicated a reduction in the range of 14 to 48% (Feachem, 1984, p. 473). These initial findings were reinforced by a later study that showed the practice of improving hygiene had a positive impact in young children with a median diarrheal morbidity reduction of 33% (Huttly et al., 1997, p. 166). Furthermore, the hygiene practice of hand washing with soap, according to Cairncross et al. (2006, p. 785), had a significant 43% reduction in diarrheal morbidity. The effect of this behavior was further documented in a review by Cairncross et al. (2010, p. 195) that indicated a slightly higher reduction of 48%.

Reduction of ARIs, that are responsible for millions of child deaths each year, can be achieved in a similar manner. In a review by Cairncross (2003b, p.678), child mortality from ARIs was found to be reduced by hand washing with soap based on two critical factors. The study found that the pathogens that are responsible for diarrheal diseases are also attributed to respiratory infections, and that hands transmit these pathogens from common surfaces to the susceptible parts of the body. The importance of hand washing is expanded upon in a study by Rabie et al. (2006, pp. 258; 263-264) that indicated viral respiratory pathogens are suspected to be transmitted faeco-orally as well as airborne or surface routes. Therefore, hand washing with soap can remove the viruses that are transmitted by the nose, mouth, surfaces, and anus. The review suggested that this behavior can result in a reduction from 16 to 45% in the risk of ARIs. In addition, promoting and encouraging hand washing is listed by UNICEF as a strategy to for pneumonia prevention (UNICEF, 2012c, p. 43).

2.2.3.6 ECONOMICS

There are two primary economic aspects related to water, sanitation, and hygiene – the cost to provide the facilities and the cost-benefit ratio of the interventions. These factors are addressed in studies by Hutton et al. (2008) and Hutton et al. (2004).

There have been numerous studies on the financial needs in order to meet the water and sanitation objectives set in place by the MDG. However, the report by Hutton et al. (2008, pp. 15-16) brings to the forefront the reality of the costs associated with the maintaining the existing coverage levels that is often overlooked in other estimates. The study indicates that in order to meet the MDG, there would need to be an annual budget of US$70 billion, of which, US$18 billion would be targeted toward expanding coverage while the remaining US$52 billion would be needed for maintaining systems previously constructed. In general, this equates to approximately 25% of the total budget for new facilities and 75% for maintenance of previously constructed facilities. The per-capita financial requirement would translate to US$12 per capita annually over a ten-year period.

In terms of an economic benefit to society, the Hutton et al. (2004, p. 23) study summarizes the primary factors to include the value of:

- Deaths avoided
- Healthcare and patient expenses avoided
- Time savings from access to facilities
- Production gained and school attendance from avoiding illness

While there is a range of cost-benefit ratios of water and sanitation interventions, the study determined that there was an approximate US$5 to US$11 of economic benefits for every US$1 invested. In addition, the primary factor in the equation was the benefits gained from the time savings. The study also recognized that the "real economic benefits accruing to the population may not be financial in nature, nor will they be immediate" (Hutton et al., 2004, p. 39).

2.2.4 SUSTAINABILITY IN DEVELOPING COUNTRIES

2.2.4.1 INTRODUCTION

Sustainability of the constructed drinking water and sanitation facilities is a critical global issue today as it was decades ago. Proper operation and maintenance supports the facilities providing the service as designed and the realization of the health benefits. There are many key components to the community's capacity to provide a sustainable system, and while some elements are universal others are unique to the specific community.

Sustainability pertaining to the drinking water and sanitation sectors is defined as "ensuring that services and interventions continue to operate satisfactorily and generate benefits over their planned life" (DFID, 1998, p. 31). In addition, the goal of operation and maintenance is to "ensure a sustainable, reliable service at an agreed standard of quality" (Sohail et al., 2001, p. 41).

There are limited resources to provide drinking water and sanitation interventions, and because many projects fail to provide long-term benefits, “there is little point in carrying out environmental, economic, and other appraisals with a view to subsequent implementation” (Carter et al., 1999, p. 1). Therefore, it is critical to understand the issues involving failed sustainability, and several reasons provided by Carter et al. (1999, pp. 7-8) include:

- Community has no desire for the systems or level of service
- Financial costs are unacceptable, unaffordable, or impracticable
- Community does not have a sense of ownership
- Original project benefits (e.g. economic, health, etc.) have not been realized
- Behavioral change from the intervention requires a long time period or may not be achieved
- Community-level involvement loses interest

2.2.4.2 ELEMENTS OF SUSTAINABILITY

A community’s capacity to provide a sustainable drinking water or sanitation system argues Carter et al. (1999, p. 8) is contingent on four critical elements – motivation, maintenance, cost recovery, and continuing support. Typically, sustainability requires all four, and lack of any one support mechanism could impact the whole system. The first link is community motivation to utilize the new facilities and taking ownership of their benefits. Maintenance is the second link, and involves a community organization that has the structure, resources, and training to conduct the required activities. Cost recovery is the third key component, and centers on the community user fees and other income generating schemes in order to cover the operational costs and long-term replacement costs. The last factor is continuing support for the community by the aid agencies while the utility organization is developing and strengthening their capacity; which often requires multiple years of support.

In order to ensure system sustainability, the technical, institutional, and budgetary needs should be considered throughout all phases of the project (DFID, 1998, p. 32). Similarly, studies on sustainability issues by Sohail et al. (2001, pp. 5; 22-36) focused on three main core elements – technical, institutional, and financial sustainability. Technical sustainability is contingent in large part by the choice of technology, and the resources and skills to operate it. The community must be involved from the initial stages of the project in order to develop the foundation of the institutional requirements, and furthermore, must have the commitment, political will, legal framework, and autonomous organization to be successful. While costs to cover small-scale operational activities can typically be covered by most communities, financial sustainability will be based on a willingness to pay and cost recovery schemes reflecting revenues sources within and outside the community.

2.2.4.3 COMMUNITY MANAGEMENT AND INVOLVEMENT

While there are many important components to sustainable operations, a review of several Asian countries summarizes that “governance is at the core of all solutions” (McIntosh, 2003, p.134). Development of the utility organization is a key building block for success along with policies that give the organizations autonomy to manage the facilities. In particular, the utility organizations should have the authority to establish an appropriate user rate structure to match the income profiles of the community. An active community and good governance create an enabling environment for sustainable operations of the facilities.

Management models to provide on-going operations can be grouped into three general categories: government assumes full control; community assumes full responsibility; and partnerships between the government, community, and other aid agency quality (Sohail et al., 2001, pp. 41-44). The study pointed out that often the government and aid agency promote transfer of the operational responsibility of the facilities to the community because they do not wish to be burdened by the financial costs. However, the community also does not desire to take on these costs, and the reluctance could transform in time into a lack of enthusiasm to provide the proper maintenance for the system. The success of community partnering and involvement in the long-term are according to Sohail et al. (2001, pp. 42-44) based on the importance of the services to the community, and the connection and interest the community has with the facilities. However, the relationship between community participation and sustainability is complex, and “community participation in infrastructure does not necessarily result in sustainable operations” (Sohail et al., 2001, p. 41).

While the concept of community management and participation has many beneficial outcomes, there needs to be a practical and realistic understanding of its limits and needs. Community management has the advantage in that it places “the people in charge of their own systems in a flexible partnership with the supporting agencies” (WHO, 2000b, p. 175). Findings by Sohail et al. (2001, p. 5) indicate that community participation has the potential to improve sustainability and is based on the establishment of committees, strong community leaders, community involvement throughout the project, and sufficient time for the aid agencies to prepare the community for the project. Community participation to operate and manage systems is based on a view of better long-term sustainability at the local level, but also because often the central government lacks the resources to maintain the infrastructure themselves. Seldom does a community have adequate capacity to manage the facilities independently, and "community participation works to the extent that it does because it has to" (Carter et al., 1999, p. 12).

Dissatisfaction may lead to "discontinuance", a situation described by Waddington et al. (2009, p. 43) when users cease using the services provided by the intervention as they perceive the costs outweigh the benefits. Furthermore, in some cases, the costs may exceed the benefits due to improper use of the facilities. In order to minimize the risk of discontinuance, the study promotes five important approaches during community participation for a proposed intervention: explanation of the relative advantage; coherence with values of the community; level of complexity; initial trial period for the community at a small-scale; and ability of the community to actually observe the impacts of the intervention.

Although full involvement of the community during all the project phases is critical for success, governments and aid agencies should continue to provide direct follow-on support after the services are completed. In order to improve sustainability of community-based approaches, Carter et al. (1999, pp. 12-14) recommends new models of institutional, financial, contractual, and legal relationships should be developed between the community and government or aid agency, and a change in the aid agency's approach from short-term to long-term involvement needs to be the new norm. Otherwise, the community's ability to sustain the beneficial impacts of the infrastructure may only be over a reduced time period.

2.2.4.4 CONSIDERING COSTS

The on-going costs for routine and long-term maintenance have often been ignored even by aid agencies. In a review by Pruss-Ustun et al. (2008) it was determined that annual cost to maintain existing services constructed in order to achieve the MDG was substantial. Updated cost budgets to achieve and sustain the MDG are necessary because previous studies have "ignored the costs of maintaining coverage levels including the costs of operating, maintaining, monitoring, and replacing infrastructure" (Pruss-Ustun et al., 2008, p. 25). It is critical to include these maintenance costs not only for the specific community operating the particular infrastructure, but especially for aid agencies in order to develop a realistic accounting for strategic planning purposes.

2.2.4.5 ASSESSMENTS

Assessing the operations of the infrastructure involves developing several performance indicators. The WHO (2000a, pp. 27-28) recommends focusing on a limited number of broad indicators including community management, financial, personnel, materials and equipment, and work control. A core indicator is whether the community has the willingness and capacity to conduct the required operation and maintenance of the facilities. The utility organization should have knowledge of the direct and indirect costs and administer the appropriate revenue collection structure to meet the long-term needs of the system. In addition, there needs to be adequate human resource development, and availability and management of materials and equipment to complete required operation and maintenance functions.

2.3 AMERICAN INDIAN PERSPECTIVE

2.3.1 PERFORMANCE INDICATORS OF U.S. AGENCIES

U.S. Federal Agencies

In 2000, the U.S. agreed to support the MDG to increase global access to improved drinking water and basic sanitation. For the under-served American Indian populations, the U.S. government is also developing new initiatives and targets for access to improved services (EPA, 2010, p. 3). As part of this initiative, in 2003, an infrastructure task force was formed with participation from several U.S. federal agencies including the USDA-RD, EPA, IHS, HUD, and BIA.

Similar to the MDG targets, the U.S. “access goal” defined by the task force is to “strive to reduce by 50% over the 2003 baseline data the number of homes lacking access to safe drinking water and safe wastewater disposal by 2015” (EPA, 2010, p. 3). Lack of access is defined as homes with IDL-4 or higher deficiencies. In 2003, the IHS STARS database reported that of the 319,070 total American Indian homes, there were 44,234 homes at IDL-4 or higher. Therefore, the target for the access goal is to provide improved facilities for at least 22,118 homes (e.g. 50%) by 2015 (EPA, 2010, p. 4).

U.S. Environmental Protection Agency

The EPA has two programs that provide funding to American Indian tribes for drinking water and wastewater projects. The Drinking Water Infrastructure Grant Tribal Set-Aside (DWIG-TSA) Program was established in 1996, and contributes funding for drinking water systems. The Clean Water Indian Set-Aside (CWISA) Grant Program was established in 1987, and provides funding for wastewater infrastructure. The EPA operationalized the "access goal" for American Indian homes in its strategic plan (FY2006-2011 and later updated in FY2011-2015). The EPA three strategic targets related to access are listed in Table 2.8.

Table 2.8 EPA strategic targets

Targets	Target descriptions
Target 1:	By 2015, 88% of the population in Indian country served by community water systems will receive drinking water that meets all applicable health-based drinking water standards (2005 baseline: 86%).
Target 2:	By 2015, in coordination with other federal agencies, reduce by 50% the number of homes on tribal lands lacking access to safe drinking water (2003 baseline: 38,637 lack access). Note: 2011 target update: By 2015, provide access to safe drinking water for 136,100 American Indian homes.
Target 3:	By 2015, in coordination with other federal agencies, reduce by 50% the number of homes on tribal lands lacking access to basic sanitation (2003 baseline: 26,777 lack access). Note: 2011 target update: By 2015, provide access to basic sanitation for 67,900 American Indian homes.

Source: EPA (2011a, p. 3)

The EPA utilizes the STARS SDS database to make program and funding decisions. Specifically, the EPA defines providing "access" to facilities as a change from IDL-4 or IDL-5 to IDL-3 and lower. The EPA DWIG-TSA funded only 36% of the projects to provide service to IDL-4 and IDL-5, and the remaining 64% was for IDL-2 and IDL-3 homes. However, 60% of the CWISA funding was used to provide access to IDL-4 and IDL-5 homes, and the remaining 40% for IDL-2 and IDL-3 homes (EPA, 2011a, pp. 18-23).

Even though the EPA has specific "access" targets that are defined (e.g. IDL-4 and IDL-5 homes), not all the funding is directed to projects to correct the deficiencies. The analysis performed as part of the EPA evaluation report mentions several reasons. Project selection using DWIG-TSA funding for drinking water uses several factors, and the IDL is only one of these (EPA, 2011a, pp. 19). While the CWISA specifically uses the IDL as the primary factor for project selection, it was not until 2008 that EPA formally designated homes at IDL-4 and IDL-5 as lacking access to basic sanitation. Therefore, before this direction, IDL-3 homes were also considered for CWISA funding (EPA, 2011a, pp. 20-23). In addition, under certain conditions access needs are not funded because the project is economically infeasible.

Indian Health Service

The IHS SFC Program currently has three indicators to measure the outcome and efficiency of providing water and sanitation facilities to American Indian homes. Previously, a fourth indicator for the percent of existing homes served at IDL-4 or above was used. The purpose of this indicator had been to evaluate the outcome of serving homes with the greatest deficiencies in order to provide a measure of the cost effectiveness and health impact. However, this measure was discontinued in 2011 (HHS, 2012, pp. 42-45). The three current indicators are listed in Table 2.9.

Table 2.9 SFC Program indicators for American Indians

Indicators	Indicator descriptions	Term	Type	Measure/explanation
Indicator 1:	Number of new and existing American Indian homes provided with water supply and sanitation facilities.	Annual	Outcome	Measure tracks the impact of the program through the number of homes served.
Indicator 2:	Track average project duration from the project Memorandum of Agreement (MOA) execution to construction completion.	Long-term/Annual	Efficiency	Reductions in the length of time a project takes to complete will yield cost savings in both construction inflation costs and project-related staffing costs.
Indicator 3:	Percentage of American Indian homes with potable water.	Long-term	Outcome	Measure tracks the health impact contribution in reduction of infant mortality, gastroenteritis, and other environmentally-related diseases.

Source: HHS (2012, pp. 42-45)

2.3.2 WATER AND SANITATION NEEDS FOR AMERICAN INDIANS

Several studies were conducted on American Indian reservations in the early 1900s that documented deficiencies in water supply and sanitation facilities. These health surveys attributed the high rates of disease to the inadequate housing, drinking water, and sanitation facilities (SFC, 2003a, p. 3.7). However, even with the documentation, much of the improvements remained unmet.

In 1974, the U.S. Government Accounting Office (GAO) conducted a review of the IHS operations at headquarters and four Area offices in order to evaluate progress to reduce health-related issues for American Indians. While the overall health of American Indians had improved since the passage of P.L. 86-121, it was still “significantly worse than that of the general population” (GAO, 1974, p. 1). The GAO report acknowledged significant improvements over a period from 1957 to 1971 including a 41% decrease in the number of families using potentially contaminated water and a 25% reduction in the number of families with inadequate sanitation facilities (GAO, 1974, p. 2).

However, the report went on to stress that based on surveys at total of 9,450 randomly selected houses, there remained a significant number or environmental hazards including unsatisfactory housing conditions, unsafe water supplies, inadequate sanitation facilities, and poorly maintained systems. A summary of the primary findings documented in the report are presented in Table 2.10.

Table 2.10 Environmental-related deficiencies in 1974 for American Indians

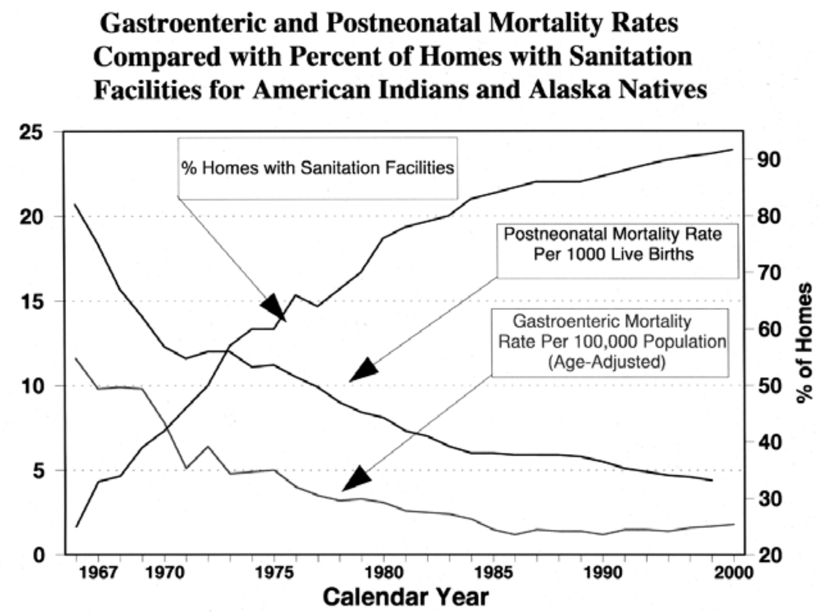
Description of deficiency/situation	Percentage of households
Using water from an unprotected source with potential contamination	63%
No water supply piped into the home	54%
Consuming unsafe water based on criteria from state public health agencies	20%
No flush toilets	65%
Unsatisfactory wastewater disposal facilities	48%
Inadequate food storage facilities	9%
Evidence of fly infestation	26%

Source: GAO (1974, pp. 32-35)

The GAO report highlighted an issue that is still relevant today – the significance of proper operation and maintenance of the systems. The IHS officials acknowledged that “systems were frequently turned over (to the tribe) without assurance the Indians were appropriately organized or were capable of operating and maintaining them properly” (GAO, 1974, p. 35). Out of 45,951 homes with water and sanitation systems, only 14,196 homes, or 31%, had acceptable operation and maintenance (GAO, 1974, p. 35). System failures were commonly attributed to lack of proper maintenance, and in some cases the “tribes did not have enough incentive to properly maintain systems because they know IHS must repair a system if it deteriorates enough to threaten the health of tribal members" (GAO, 1974, p. 35). The report noted that several families had to use river water for approximately four months while the community system was inoperable. Tribes that formed utility organizations were more likely to provide proper operation and maintenance, however they had reluctance because of the need to establish usage rates and collect fees from tribal members (e.g. unaccustomed to paying for water).

Over the decades, significant progress has been made to improve drinking water and sanitation facilities, which has resulted in beneficial health impacts. In 1955, the age adjusted gastrointestinal death (mortality) rate for American Indians was 15.4 per 100,000; which was 4.3 times higher than all other races in the U.S. However, by 2000, the mortality rate had dropped to 1.8 per 100,000 population (SFC, 2003a, p. 3.7). The trend in health improvements indicates that as the American Indian homes gain access to drinking water and sanitation facilities, there is a corresponding decrease in gastroenteric and postneonatal mortality rates. The trend from 1967 to the 2000 is presented in Figure 2.3.

Figure 2.3 Gastroenteric and postneonatal mortality rates compared with percent of homes with sanitation facilities for American Indians



Source: IHS (2011, p. 21)

The IHS Division of Program Statistics is the primary source of American Indian demographic and patient care statistical information. The most current edition of "Trends in Indian Health" for 2002 to 2003 (published by IHS in October 2009), provides basic statistical information on the health status of American Indians. There has been a significant improvement in the infant mortality rate for American Indians, which decreased from a rate of 25.0 per 1,000 live births in 1972-1974 to 8.3 in 2002-2003; however, this rate is 20% higher than the U.S. all-races rate (IHS, 2009, p. 4). A comparison of American Indian death rates to U.S. all-races rates reveals the staggering health disparities that continue, which include higher rates in alcoholism by 524%, motor vehicle crashes by 234%, unintentional injuries by 153%, and pneumonia and influenza by 47% (IHS, 2009, p. 4).

The "Trends in Indian Health" report included specific categories for respiratory system diseases and infectious and parasitic diseases; which can be broadly associated with water-washed and waterborne diseases, respectively. However, within the broad groups are diseases with other transmission routes, such as malaria which is related to the insect-vector route. A summary of the diseases in each category is presented in Table 2.11.

Table 2.11 Categories of respiratory system and infectious and parasitic diseases

Respiratory system diseases	**Infectious and parasitic diseases**
Acute upper respiratory infections Influenza and pneumonia Acute bronchitis and acute bronchiolitis	Certain intestinal infectious diseases (e.g. cholera, salmonella gastroenteritis, shigella dysenteriae, acute amebic dysentery, enteritis due to rotavirus)
Bronchitis, chronic and unspecified	Diarrhea and gastroenteritis of infectious origin
Asthma	Tuberculosis
	Tetanus
	Diptheria
	Whooping cough
	Meningococcal infection
	Septicemia
	Viral diseases (e.g. varicella/chickenpox, measles, mumps)
	Malaria

Source: IHS (2009, pp. 223, and 225)

The ten leading causes for American Indian hospitalizations in 2006 included respiratory system diseases in all eight of the age groups and infectious and parasitic diseases for three of the eight age groups. The highest percentage of cases for both diseases was within the youngest age groups; e.g. 14 years and under (IHS, 2009, pp. 162-169). When combined, both diseases represent 16.0% of the patient hospitalizations in all categories.

In the same year, the ten leading causes for American Indian outpatient (e.g. ambulatory) also included respiratory system diseases in seven of the eight age groups and infectious and parasitic diseases for three of the eight age groups. The highest percentage of cases for both diseases was within the youngest age groups; e.g. 14 years and under (IHS, 2009, pp. 177-184). When combined, both diseases represent 8.9% of the outpatients in all categories.

A summary of the hospitalization and outpatient cases are presented in Tables 2.12 and 2.13, respectively.

Table 2.12 2006 American Indian hospitalization cases for respiratory system diseases and infectious and parasitic diseases

	Respiratory system diseases [a]		**Infectious & parasitic diseases** [a]		
Age	**Number**	**Percent distribution**	**Number**	**Percent distribution**	**Total all categories**
Under 1 year	523	28.6%	84	4.6%	1,829
1 to 4 years	2,517	61.6%	151	3.7%	4,083
5 to 14 years	636	24.6%	123	4.8%	2,588
15 to 24 years	391	3.4%	0	0.0%	11,421
25 to 44 years	1,012	4.6%	0	0.0%	22,110
45 to 54 years	935	8.8%	0	0.0%	10,574
55 to 64 years	1,021	11.5%	0	0.0%	8,875
65 years older	2,726	19.2%	0	0.0%	1,630
Totals	9,761		358		63,110
% of patients with respiratory system diseases to all categories					15.5%
% of patients with infectious and parasitic diseases to all categories					0.6%
% of patients with respiratory system and infectious and parasitic diseases to all categories					16.0%

[a] Numbers and percent distribution are for combined male and female

Source: IHS (2009, pp. 162-169)

Table 2.13 2006 American Indian outpatient cases for respiratory system diseases and infectious and parasitic diseases

	Respiratory system diseases [a]		Infectious & parasitic diseases [a]		
Age	**Number**	**Percent distribution**	**Number**	**Percent distribution**	**Total all categories**
Under 1 year	48,437	18.9%	12,166	4.7%	256,720
1 to 4 years	106,659	20.7%	28,315	5.5%	515,095
5 to 14 years	154,440	17.6%	53,649	6.1%	879,464
15 to 24 years	113,123	8.6%	0	0.0%	1,308,725
25 to 44 years	180,741	6.5%	0	0.0%	2,765,122
45 to 54 years	92,092	5.2%	0	0.0%	1,775,406
55 to 64 years	66,008	4.6%	0	0.0%	1,423,729
65 years older	69,064	0.0%	0	0.0%	1,504,025
Totals	830,564		94,130		10,428,286
% of patients with respiratory system diseases to all categories					8.0%
% of patients with infectious and parasitic diseases to all categories					0.9%
% of patients with respiratory system and infectious and parasitic diseases to all categories					8.9%

[a] Numbers and percent distribution are for combined male and female

Source: IHS (2009, pp. 177-184)

Although many deficiencies have been corrected and disease rates reduced, there remain many unmet challenges and needs for American Indians. As an example, over the past several years there has actually been an increase in the number of American Indian homes without safe drinking water systems (IHS, 2011, p.25). The continual and growing unmet need is due to many factors including: population growth, design life of the existing water and sewer infrastructure, large number of new housing (e.g. American Indians returning to tribal lands), limited suitable land for infrastructure (e.g. poor soil conditions for effluent disposal), and new water quality regulations from states and EPA (e.g. arsenic and surface water treatment).

Based on the SFC Program 2011 Annual Report, a synopsis of deficiencies and needs for American Indian homes at the national level are presented Table 2.14. As indicated in the table, 87.6% of the American Indian homes have improved water and sanitation facilities. However, 12.4% of the homes are an IDL-4 or above, and feasible projects to correct these deficiencies accounts for 32.2% of the total unmet need cost. Overall, the data indicates that significant resources will be required in order to provide service for those without adequate facilities.

Table 2.14 2011 National water and sanitation deficiencies for American Indians

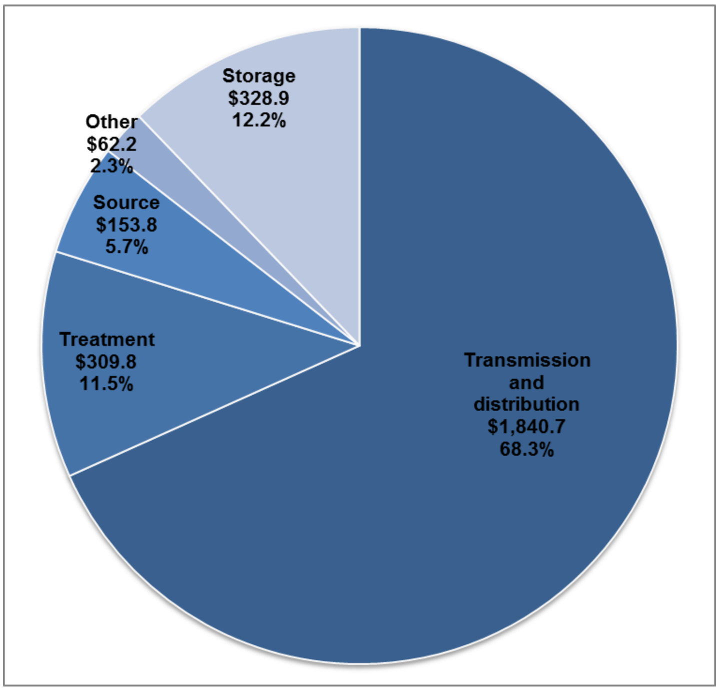
Description of deficiency/situation	Value
Total homes (IDL-1 to IDL-5)	383,750
IDL-4 homes	35,066
IDL-5 homes	12,705
% of total homes at IDL-4 and IDL-5	12.4%
Total cost for feasible projects to address IDL-1 to IDL-5 unmet needs	$1,458,661,659
Cost for feasible projects to address IDL-4 unmet needs	$299,848,599
Cost for feasible projects to address IDL-5 unmet needs	$171,936,448
% of total costs for feasible projects to address IDL-4 and -5 unmet needs	32.3%
Costs for feasible projects to address water needs	$808,984,687
Costs for feasible projects to address sewer needs	$490,845,258
Costs for feasible projects to address solid waste needs	$157,106,957
Costs for feasible projects to address all needs	$1,458,661,659

Source: IHS (2011, pp. 26-34)

In addition to the IHS, the EPA provided an assessment of water system needs for American Indians. In April 2013, the EPA published its fifth report on public water system infrastructure needs in the U.S. that included a specific focus on American Indians. The assessments represent projects necessary from 2011 to 2030 for water systems to continue to provide safe drinking water by addressing needs from deteriorating or undersized existing infrastructure, and to comply with water quality regulations. The cost estimates for the projects include design and construction materials, labor, and equipment.

The EPA report indicates the need for American Indians is $2.7 billion; which is significantly higher than the previous estimate in 1999 primarily due to a more complete method to include long-term needs especially for the rehabilitation and replacement of distribution piping (EPA, 2013c, p. 31). The need also includes costs to connect homes without water to community systems. Similar to the need at the U.S. level, the majority of the costs, at 68%, are for transmission and distribution (EPA, 2013c, p. 31). The high cost not only represents the extensive length of the underground piping network, but also the constraints to construction the projects often in remote areas. The need by project type including transmission and distribution, treatment, storage, source, and other are presented in Figure 2.4.

Figure 2.4 Total 20-year water system needs for American Indians (in US$ millions)



Source: EPA (2013c, p. 31)

In general, the needs for American Indians in the California Area are similar to other Areas. However, in California some additional conditions and constraints include the use of both ground water and surface water, tribal land with limited area and poor soil for wastewater treatment and disposal options, environmental constraints (e.g. endangered species within the project area) and remote communities (e.g. without electrical power).

Based on the most recent SFC Program 2011 Annual Report, a synopsis of deficiencies and needs for California American Indian homes at the national level are presented Table 2.15. As indicated in the table, 81.0% of the California American Indian homes have improved water and sanitation facilities. However, 19.0% of the homes are an IDL-4 or above, and feasible projects to correct these deficiencies accounts for 28.2% of the total unmet need cost.

Table 2.15 2011 California water and sanitation deficiencies for American Indians

Description of deficiency/situation	Value
Total homes (IDL-1 to IDL-5)	13,167
IDL-4 homes	2,113
IDL-5 homes	388
% of total homes at IDL-4 and IDL-5	19.0%
Total cost for feasible projects to address IDL-1 to IDL-5 unmet needs	$92,361,453
Cost for feasible projects to address IDL-4 unmet needs	$21,097,290
Cost for feasible projects to address IDL-5 unmet needs	$4,936,000
% of total costs for feasible projects to address IDL-4 and -5 unmet needs	28.2%
Costs for feasible projects to address water needs	$39,684,630
Costs for feasible projects to address sewer needs	$45,340,296
Costs for feasible projects to address solid waste needs	$7,015,927
Costs for feasible projects to address all needs	$92,361,453

Source: IHS (2011, pp. 26-34)

2.3.3 Impacts of Water and Sanitation Interventions for American Indians

There are limited studies that focus specifically on the effects of disease reduction from water and sanitation interventions for American Indians. However, there are two studies that document the impacts for both waterborne and water-washed diseases.

The study by Rubenstein et al. (1969) evaluates the effects of in-house connections for water and sanitation facilities compared to outdoor facilities. In 1964, the IHS constructed water and sanitation facilities for the upper Moenkopi village on the Hopi Indian Reservation in Arizona. However, due to internal political and traditional factors, the lower Moenkopi village did not accept the facilities and continued to use outdoor latrines and water taps. The study evaluated the effects of Moenkopi infants of both the upper and lower villages over the same time period, and documented that infants from the upper village had fewer patient visits at the local health clinic for diarrheal illness than the lower village infants. The study concluded that the provision of indoor facilities had reduced the infant patient visits at the clinic for diarrheal illness from 2 to 0.85 visits per year (or a reduction of 57.5%). However, the lower village children had visits of 3.1 to 2.6 over the same period Rubenstein et al. (1969, p. 1095). This limited study for one village with indoor and outside water supply and sanitation facilities provided significant findings of the effectiveness of the intervention based on the reduction of patient visits.

A recent study conducted Hennessy et al. (2008), evaluated the effectiveness of indoor water supply in reducing water-washed diseases such as influenza, pneumonia, and skin infections in rural Alaskan villages. Data was used from 12,480 homes with varying levels of water and wastewater service. The study determined that hospitalization rates for infectious diarrhea did not differ between high- and low-service regions. However, there was a significant difference for other diseases. The study found that based on aggregated data from different regions across Alaska, “hospitalization rates for pneumonia, influenza, skin, and soft tissue infections were 2 to 4 times higher in regions with a low proportion of homes with water service than in regions with a high proportion of homes with water service” (Hennessy et al., 2008, pp. 2075-2076).

2.3.4 SUSTAINABILITY FOR AMERICAN INDIAN COMMUNITIES

While the IHS can provide technical assistance, training, and equipment to tribes, the IHS does not provide financial assistance for the reoccurring costs to operate and maintain the facilities. After the infrastructure is constructed, the ownership and responsibility for continual O&M is transferred to the tribe.

In 2003, an infrastructure task force of several U.S. federal agencies was formed to develop strategies and approaches to improve access to improved drinking water and sanitation in Indian country. The task force published a report regarding tribal infrastructure funding opportunities and included several specific items regarding O&M (EPA, 2011b). The report described the current environment where most federal agencies do not have the authority to use their funds for routine or long-term O&M of tribal systems, and that tribes often do not have the resources or capacity to provide suitable operations. As a result, the design life of the system is adversely impacted, which can result in early repairs (e.g. emergency repairs) and system upgrades. The federal agencies indicated that many infrastructure projects are “related to lack of operation and maintenance” (EPA, 2011b, p. 29), and that if the systems were properly maintained, it could result in increased cost efficiencies and extended system life. This would allow for infrastructure funding to be directed to other needs and reduce the capital costs for future replacement of failed systems. However, the federal agencies noted as well that these issues are not tribal-specific, but rather affect all rural and remote communities.

In 2012, the task force held a series of participatory meetings with several tribes to gather lessons learned on specific sustainability approaches used for their facilities. The participants included the Navajo Tribe, Tohono O’odham Tribe, Alaska rural villages, Pyramid Lake Paiute Tribe, Squaxin Island Tribe, and the Nez Perce Tribe. The summary below provides many common issues and best practices for all tribes along with unique conditions. The list only contains minor edits in order to preserve the specific responses provided by the tribes (EPA, 2012, pp. 1-2).

Autonomy of the Utility Organization

- Day-to-day management and funding for the utility should be isolated from politics, either through an independent utility board which provides oversight and high-level direction, or a separate entity.
- Utility must have the ability to set and adjust rates independently from local politics, so that rates are not tied to election cycles, but rather to utility needs.
- Utility must have the authority to disconnect homes and business if fees are not paid.
- Utility funds should be kept and managed separately from general tribal funds. The utility can still partner with the tribe for bonding or other financing.
- Success often hinges on a champion or team of one committed operator and one committed administrator to manage the organization successfully for the long-term.

Train and Retain Operators

- A good operator should be trained to do the job, whether in-house or outside the utility.
- Turn-over makes utility management difficult, and cross-training can help.
- Incentives including salary and benefits can keep an operator at the utility once they are trained. This helps the operator take the job seriously.
- Tribal members trained as operators have more incentive to work for the tribal utility.

Manage the Utility as a Business

- Utility staff should be paid, and provided the tools to do their job (e.g., truck, equipment).
- Customers should be billed and should pay for services, or risk disconnection.
- Rates and revenue should be adjusted to match costs.
- Partnerships should be developed (e.g., with the tribe for financing, with other utilities).
- There can be significant cost savings though economies of scale (e.g. consolidated customer billing among utilities).

Establish a Fair and Accepted Billing and Collection System

- Billing system should be fair and equitable for all customers (i.e., everybody pays).
- Utility should be able to enforce non-payment (disconnects), and allow for payment plans.

- Rates should be reviewed and increased regularly. Consumers are often more accepting of a small rate change on a regular basis, rather than large one-time increases.

Educate Consumers and the Tribe

- Consumers should be educated about the true cost of running the system, and told that water may be free, but the infrastructure for treating and delivering the water is not.
- Consumers should understand the economic consequences to themselves and to the utility of late or non-payment. Disconnection costs are billed to consumers and can cost more than the normal service cost.
- Providing reliable service helps consumers see the value of the service, and pay for it.
- Tribal council and/or the utility board must be regularly educated on the purpose and true cost of the utility. Even when collection and rates are low, the community pays for the true cost of services one way or another.

Subsidies for the Utility

- Many tribes experience high unemployment and low median income. Combined with a rural and sparse environment, the true cost of infrastructure can be unaffordable.
- Tribal industries or enterprises may provide a subsidy for both infrastructure and O&M.
- Combining multiple utility fees such as water, wastewater, gas, telephone, and electricity is a model to cover costs (e.g., some tribal organizations provide several different services).
- Common utility billing systems (for water, sewer, solid waste, electricity, etc.) can allow for one service to subsidize another.
- Tribal council may subsidize the utility from its general funds (e.g., some tribes subsidize a portion of the water and wastewater service).

Manage the Utility Pro-actively

- Operators and managers should stay aware of upcoming regulatory and political changes.
- Coordination with other utilities on projects, services and staffing can benefit the tribe through cost savings when projects are done concurrently and staff support from one utility to another during a vacancy.
- Utilities should plan for replacement costs rather than pay for equipment when it breaks (i.e. asset management).

Identify Savings Opportunities

- Utilities should try to implement energy efficiency measures (e.g., solar panels, variable-frequency drive pumping systems).
- Cost savings can be realized in managing under-utilized assets effectively, such as shutting down an unneeded well to reduce sampling and compliance costs.

Build Trust and Accountability

- Utility organization must gain the trust of the tribe and its members to succeed.
- Utility organization should be accountable to both the tribal council and customers.
- Utility organization must establish a good record with funding agencies.

2.4 SUMMARY OF KEY OBSERVATIONS

2.4.1 PERFORMANCE INDICATORS

While the UNICEF and other international aid agencies have begun to review and update goals and targets for drinking water, sanitation, and hygiene, the current measures of access are based on proxy indicators, creating potential gaps between perceived and realized benefits. The USAID has developed both impact and monitoring indicators that expand upon the MDG targets, providing a simple list of measurable outcomes. The U.S.-based agencies that provide services to American Indians have adopted the overall MDG access goal based on pre-established IHS definitions of deficiency levels.

While the IHS and EPA have established national-level targets, there is currently no lower-level targets or tracking of progress at the individual IHS Area level. Similar to the country-level monitoring conducted by the JMP, there is a significant gap by IHS and EPA to measure and assess targets and tends at the Area level. Therefore, in order to monitor program performance, there should be an evaluation of monitoring targets with comparisons to national trends. In addition, there is knowledge gap in literature for both international and domestic trends in program efficiency measured in project durations and resource costs to serve homes with drinking water and sanitation interventions. This research project attempted to examine these issues.

2.4.2 WATER AND SANITATION NEEDS AND DEFICIENCIES

Since 1990, there has been an increase in the percentage of the global population achieving access to improved drinking water and sanitation facilities. The JMP predicts that by 2015, the population with access to improved drinking water and sanitation facilities will increase to 92% and 67%, respectively. Even with this significant progress, millions of people often in the poorest of countries remain without access to improved facilities and millions of children under five die each year from diarrhea and pneumonia. Similarly, while there have been many improvements to the health status of American Indians over the past several decades, there remain many health disparities when compared to the U.S. population at-large. Nationally, there are still 12.4% of the American Indian homes without access to improved facilities at a significant project cost. In addition, there remain a high percentage of American Indian children with respiratory system and infectious and parasitic diseases.

While the SFC Program publishes a report with annual snap-shots of target levels, there is a literature gap in a monitoring program specific to the Area with key trends and indicators over a larger time frame. The EPA study provided a summary of American Indian needs for water supply systems at a national level, however there is a gap in literature for a similar assessment at the IHS Area level for both water and sanitation facilities. The literature review also revealed that even though IHS and EPA maintain databases on needs and deficiencies, there is limited literature or an actual process to compare their results and findings. In addition, while there is information published for American Indian health trends, including respiratory system and infectious diseases, the classifications group a wide variety of conditions that are both related and unrelated to waterborne and water-washed diseases. These issues were examined by the research project.

2.4.3 Impacts from Water and Sanitation Interventions

There is a significant volume of literature over the past several decades on the impacts from water and sanitation interventions on populations in developing countries. While the literature reviews indicated a range of effectiveness for waterborne and water-washed disease reductions, there is a general overall agreement that the interventions can provide barriers to faecal-oral pathways.

However, a key limitation indicated by the literature review is the lack of recent studies on the health impacts from water supply and sanitation interventions for American Indians. The current literature primarily focuses on the initial disease reductions achieved for American Indians following the creation of the SFC Program. However, there is a gap in literature for current assessments of health impacts to American Indian communities, especially at the Area level, and specifically for the California Area. This research project attempted to examine this gap and provide new information.

2.4.4 SYSTEM SUSTAINABILITY

There is a growing body of literature on the sustainability of drinking water and sanitation systems and the capacity of the community to operate and maintain them. There are many common themes that run through the literature on issues faced in developing countries and American Indian communities. Overall, the common themes that drive sustainability is the level of community participation during the project implementation, and the technical, financial, and managerial capacity of the organization to operate the facilities.

However, a key limitation indicated by the literature review is the lack of detailed assessments of the tribal capacities to sustain the facilities. In addition, based on the literature review, there is a gap in studies for American Indian communities analyzing trends between system deficiency levels and the organization's capacity to provide adequate operation and maintenance. While it may seem intuitive that lower capacities would result in growing system deficiencies, there have been few written assessments to link the two factors, and provide a detailed analysis of the technical, financial, and managerial components. This research project attempted to examine these issues.

3 METHODOLOGY

3.1 INTRODUCTION

This chapter provides a review of the research methods used by this project. The primary aim and focus of this project was to assess the impact of the SFC Program's drinking water supply and sanitation interventions on the American Indian populations related to project delivery, interventions, deficiency monitoring, health impact, and system sustainability.

Before the research design was developed and methods selected, a preliminary situational analysis was conducted to determine the most appropriate strategy and overall direction. The situational analysis was comprised of reviewing policy documents, semi-structured interviews with key representatives (primarily with IHS headquarters and SFC Program Director for the California Area), and a cursory review of the information supplied by the databases.

Along with selecting a research strategy that will be feasible (e.g. access to data, time constraints), a key selection criteria is whether it is suitable for the intended purpose. While each strategy comes with advantages and disadvantages, it should be selected based on its likelihood of being "successful in achieving the aims of the research" (Denscombe, 2011, p. 5). Considerations for selecting a suitable research strategy include its intended purpose, and how useful and appropriate it will be. Strategies could include surveys, experiments, grounded theory, and case studies. In particular, case studies can be used for several purposes such as to describe a process or the effects of an intervention, or to explain a complex occurrence, and is a methodology commonly used in program evaluation studies (Kohn, 1997, p. 3). For this reason, and as described in more detail in the following sections, the case study strategy was used for this research.

3.2 CASE STUDIES OVERVIEW

Generally, case studies are categorized as exploratory, explanatory, or descriptive (Baxter and Jack, 2008, p. 547). In particular and applicable to this research are explanatory and descriptive case studies. Explanatory case studies are used to explain the presumed causal links in complex phenomenon, and link program implementation with impacts. Descriptive studies are used to describe an intervention and the context it occurred. This research will utilize elements of both the explanatory and descriptive case study approach.

There are five key components to case study design and include the study's question, proposition, unit of analysis, connecting the data to the proposition, and criteria for interpreting the findings (Yin, 2014, p. 29).

The form of the question the research is attempting to answer is a critical component in deciding which strategy to use, and the case study is favorable for "how" and "why" questions (Yin, 2014, p. 11). Furthermore, once the primary question has been developed, propositions should be developed, which may suggest or propose certain issues, linkages, or connections and point the directions to relevant evidence. Propositions or issues are key elements in case study research, and create a conceptual framework that guides the research, and "serves as an anchor for the study and is referred at the stage of data interpretation" (Baxter and Jack, 2008, pp. 552-553).

A fundamental aspect of the case study is to define the "case" or the unit of analysis. A case is defined as a "phenomenon occurring in a bounded context, and in effect, is the unit analysis" (Baxter and Jack, 2008, p. 545). Binding the case is important so that the research remains reasonable in scope, and suggestions include using time and place or time and activity (Baxter and Jack, 2008, pp. 546-547). In particular, a case may include programs, the implementation process, and organizations (Yin, 2014, p. 31). In addition, even though there is a single case being studied, there may be several embedded units (Kohn, 1997, p. 4). The embedded case study designs may identify a number of sub-units, which are evaluated individually, but then "drawn together to yield an overall picture" (Rowley, 2002, p. 22). The eventual challenge is to develop holistic conclusions with perspectives from each sub-unit of the study.

Case study research makes use of multiple qualitative and quantitative data sources such as documentation, records, interviews, direct observations, participant observations, and incorporates quantitative data for a more holistic understanding. Data from these multiple sources are then brought together in the analysis process, each forming a piece of the puzzle, and the "convergence adds strength to the findings as the various strands of data are braided together to promote greater understanding of the case" (Baxter and Jack, 2008, p. 554).

The final components of the case study are to interpret the findings, establish links, and develop criteria for interpreting a study's findings. In particular, "much of the case study analysis will not rely on the use of statistics and therefore calls attention to other ways of thinking about such criteria" (Yin, 2014, p. 36). Among the many different analytic techniques, the research project primarily utilized pattern matching, explanation building, and time-series analysis (Yin, 2014, pp. 143-154). Pattern matching compares the findings from the case study to a pattern previously postulated; the greater the similarity tends to build internal validity. Explanation building accounts for and clarifies the causal links about the phenomenon; e.g. "how" or "why" something happened. Time-series analysis is a method to identify and analyze patterns and trends over time with attention to "how" or "why" this change may have occurred. Additionally, while there are "no cookbook procedures, good case study analysis makes use of all the relevant evidence" (Rowley, 2002, p. 24). Research conducted using the case study methodology has the opportunity of being able to discover how the many parts affect one another in a holistic manner rather than focus on isolated factors (Denscombe, 2011, pp. 3).

3.3 Research Question and Case

The primary question identified in Chapter 1 is as follows:

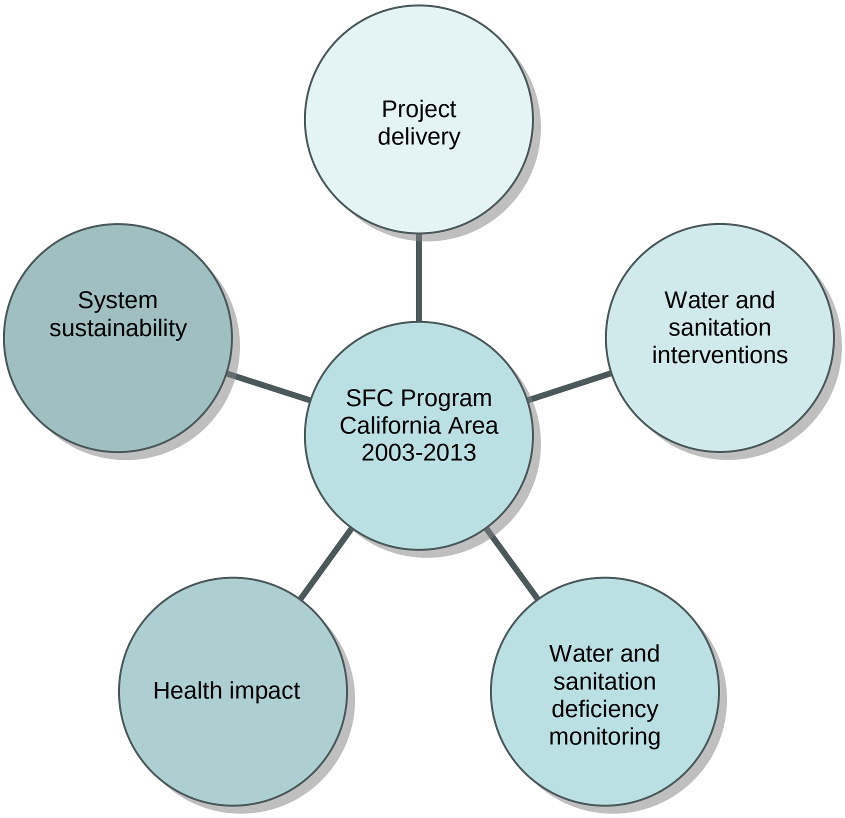
> "How is the SFC Program performing and impacting American Indian communities through the provisions of drinking water and sanitation projects?"

The "case" or unit of analysis of the research project is the "SFC Program" bound by the California Area and the time period of 2003 to 2013. This case is "embedded" and a number of sub-units have been identified including:

- Project delivery (efficiency)
- Water and sanitation interventions (equity)
- Water and sanitation deficiency monitoring (equity and effectiveness)
- Health impact (effectiveness)
- System sustainability (sustainability and replicability)

The case and embedded sub-units are presented in Figure 3.1.

Figure 3.1 Research case and embedded sub-units



Source: Author

3.4 GENERAL DESIGN

There are many different methods to collect data, and generally these are grouped into quantitative and qualitative techniques. Quantitative data is associated with numbers, while qualitative data is more related to words and images (Denscombe, 2011, pp. 241-243; 272-273). Types of quantitative data include questionnaires, interviews, and documents. Whereas, qualitative data includes information gathered from both interviews and observations.

The project utilized a mixed-method approach by employing a combination of quantitative and qualitative research methods to collect and analyze data. Data collection techniques varied from desktop reviews, in-the-field observations, and interviews. The primary techniques used by this project include questionnaires, interviews (primarily semi-structured one-to-one interviews), observation, and documents.

The overall methodology used first collected data and evaluated each of the sub-units, and then performed a holistic analysis for trends, convergence of evidence, and cross-cutting related patterns between them. In particular for case study design, an internal validity test (e.g. for explanatory and causal studies) consisted of pattern matching, explanation building, and addressing rival explanations during the data analysis process (Yin, 2014, p. 45). While the methodology for several sub-units were similar, a detailed review of the specific techniques used are listed below for each, and includes a general description and discussion of the study design, study setting and sites, data collection and quality checks, and data analysis. The data limitations are combined and represent conditions relevant to many of them. A summary of the research objectives and methods are presented in Table 3.1.

Table 3.1 Research objectives and methods

	Research methods			
Research objectives	**Documents**	**Interviews**	**Questionnaire**	**Observations**
Project delivery (efficiency): Understand, document, and assess the SFC Program's performance.	Literature searches IHS STARS database – SDS and PDS	Semi-structured one-to-one: key IHS staff at HQ and Area office	Not used	Not used
Water and sanitation interventions (equity): Examine the interventions and distributed by various categories.	Literature searches IHS STARS database – PDS	Semi-structured one-to-one: key IHS staff at HQ and Area office	Not used	Not used
Water and sanitation deficiency monitoring (equity and effectiveness): Examine the level of deficiencies and needs.	Literature searches IHS STARS database – SDS EPA SDWIS database – ETT	Semi-structured one-to-one: key IHS staff at HQ and Area office, and EPA	Not used	Observations of system conditions.
Health impact (effectiveness): Analyze the health impacts from the interventions.	Literature searches IHS RPMS database	Semi-structured one-to-one: key IHS staff at Area office	Not used	Not used
System sustainability (sustainability and replicability): Survey, understand, and assess the sustainability of the facilities.	Literature searches IHS STARS database – SDS and PDS	Semi-structured one-to-one: key IHS staff, RCAC, and tribal officials	Capacity questionnaire administered in the field	Observations of tribal water and sewer facilities and operations

Source: Author

3.5 Advantages and Disadvantages of Research Methods

As depicted in the table, a principle feature of the case study methodology is the utilization of a mixture of quantitative and qualitative data sources including documents, interviews, questionnaires, and observations. A brief description of the advantages and disadvantages of the methods and approaches to mitigate the weaknesses are presented; which are based on Denscombe (2010, pp. 169-170; 192-194; 213-214; 232-233; 346-349).

Questionnaires provided advantages because they supplied standardized answers on the tribal organizations and provided accurate data. However, in some cases the questions were frustrating for respondents because they limited their opportunity to provide full and complete explanations. Interviews were used for all the research objectives as they provided an opportunity to gain in-depth information and check for validity. While offering these strengths, interviews also were time consuming, required scheduling to set-up, and provided non-standard responses that in some cases were difficult to efficiently analyze. Observations were primarily used for the system conditions and tribal operations and provided an opportunity to gain holistic insights of the actual phenomenon; however, there were limitations due to resources (e.g. travel time to the sites) and representativeness of the situation. Documents were utilized for all the objectives and generally allowed for easy access and were cost-effective. However, the credibility of the source needed to be verified.

The process of information gathering frequently results in gaps, inconsistency, and bias (e.g. from the researcher or respondent). Therefore, a method to provide quality control of both the data gathering and the follow-on analysis is required for more complete and valid conclusions. This method of quality control or cross-checking data is referred to as ‘triangulation’ and involves using different sources or methods of gathering data to validate and confirm the results and conclusions. Generally, triangulation uses a mixed-method approach that incorporates both qualitative and quantitative approaches and draws conclusions between the two. Ultimately, triangulation and the use of the mixed-method approach provide a more complete and stronger analysis that is built on multiple perspectives and positions. A specific strength of the case study approach is the use of multiple qualitative and quantitative data sources, which forms the foundation of a quality control process through triangulation.

3.6 PROGRAM PERFORMANCE

3.6.1 STUDY DESIGN

The study design for this sub-unit provided information on program performance and efficiency changes over time, and the indicators and measures used include:

- Number of homes served with water supply and sanitation facilities

- Project durations
- Cost efficiencies including project cost per home served and resource cost (e.g. program budget) per home served

The study primarily utilized semi-structured one-to-one interviews and documents. The interviews were conducted with key IHS staff from headquarters responsible for managing the SFC Program's principal database known as STARS and the SFC Program Director for the California Area. Data was obtained from STARS reports for the number of homes served and project durations for the California Area and national. Literature searches in the Medline database, Google Scholar searches, and reviews of the SFC Program's documentation, policies, and guidelines were made using the key word searches pairing aspects of 'Indian Health Service', 'Sanitation Facilities Construction Program', 'water and sanitation', 'performance', 'reviews', and 'policies and guidelines'.

3.6.2 STUDY SETTING AND SITES

The study setting and sites represent all projects for American Indian communities in the California Area over a specified time period that is managed in the STARS database. The data included projects funded by all sources – IHS Housing (e.g. new homes), IHS Regular (e.g. existing homes), and outside contributions (e.g. EPA, RD, HUD, etc.). On occasion, a tribe may manage a water supply or sanitation project without IHS involvement, and in these cases, the data is not in STARS and therefore not included in this study. The time period used for project durations was 2007 to 2013, and a period of 2005 to 2012 was used for number of American Indian homes served and efficiency costs.

The two primary indicators are project durations and homes served, along with budget and program costs. Project duration is defined as the time between the execution of the memorandum of agreement for the project (e.g. typically between the IHS and the particular tribe) and construction of the proposed facilities. Project duration is measured in years. The number of American Indian homes served is based on the quantity to be served by the proposed project at the time the project is funded. The budgetary data is based on typical program operational items including: salary, travel, training, equipment, and supplies.

3.6.3 DATA COLLECTION AND QUALITY CHECKS

The data was obtained from the SFC Program's STARS database; which contains information on American Indian community deficiency levels, water and sanitation needs, and active and completed water and sanitation projects. Data was supplied from the

STARS system on project durations and the number of Indian homes served. The data was provided by the IHS headquarters office in both Excel and PDF formats (Hawasly, 2013). Program budget costs were supplied by the SFC Program Director for the California Area.

Steps were taken to ensure for quality checks and validating the data; which primarily included accurate data recording and correct data interpretations. This was accomplished by several reviews of the data to check that the entry was made correctly including spelling, dates, and numbers. This was important because a portion of the data was directly obtained from STARS extracts while some data was recorded by hand based on reviews of project files. For small data sets, this was accomplished by reviewing the entire data set; however, for larger data sets it was performed by reviewing a representative sample of the data. In addition, an overall quality of findings was made by having multiple reviewers provide their conclusions and determine if they were similar.

3.6.4 DATA ANALYSIS

The goal of data analysis is to “gain a better understanding of it”, and to either describe, explain, or interpret the data (Denscombe, 2011, pp. 235-240). The quantitative data was analyzed in a multi-step process that included: 1) organize, group, and present the data, 2) check the data quality, 3) check for any preliminary trends, 4) describe and analyze that data, 5) determine appropriate presentation of data in order to facilitate identification of trends and correlations, and 6) validate and compare the data with other sources of information. The data analysis for this factor included:

- Data presented in table formats.
- Checked the data quality by comparing multiple reports and observing for any outliers.
- Checked for any preliminary trends.
- Described and analyzed data using MS Excel data analysis features (e.g. analysis tools for descriptive statistics), ratios (e.g. cost per home), and compared California Area trends to national levels.
- Presented data using line graphs.
- Validated and compared the data by additional reviews by key stakeholders; e.g. SFC Program Director for the California Area.

3.7 WATER AND SANITATION INTERVENTIONS AND MONITORING

3.7.1 STUDY DESIGN

The study design for these two sub-units provided information on water and sanitation interventions (e.g. funded projects) and deficiencies over time and for target groups, and the indicators and measures used include:

- Project category by total cost and number of projects
- Project descriptions by total cost
- Project type by total cost
- Projects' IDL by total cost and number of projects
- Projects' SDS total score by total cost
- Projects serving community/tribe by total cost and cost per capita
- EPA water quality compliance monitoring
- Deficiencies by total cost, homes, and project category

The study primarily utilized semi-structured one-to-one interviews and documents. The interviews were conducted with key IHS staff from headquarters responsible for managing the STARS database and the SFC Program Director for the California Area. In addition, key EPA staff from Region 9 (e.g. the Region that is responsible for tribes in the California Area) was contacted regarding the EPA Drinking Water Program's database known as the Safe Drinking Water Information System (SDWIS) that contains information on water system compliance, and violations related to water quality monitoring and operations.

The primary data was obtained from STARS reports from both the Sanitation and Deficiency System (SDS) and Project Data System (PDS) sites. The SDS provides data on water and sanitation deficiencies and unmet needs in American Indian communities including the initial system deficiency levels, total SDS scores for a proposed project to correct the deficiencies, and specific subsets for water, sewer, and solid waste related to homes and costs. The PDS provides data on projects that were funded for interventions to improve water supply or sanitation systems. Only projects serving existing American Indian homes were used for the study; which includes project funding from IHS Regular and outside-agency contributions (e.g. EPA, RD, etc.). Projects for new homes (e.g. funded by IHS Housing) were not included in the study. Selected SDS and PDS data was obtained for both the California Area and national (e.g. all the IHS Areas). The EPA SDWIS provided data on tribal drinking water regulatory compliance for American Indian communities in California.

Literature searches in the Medline database, Google Scholar searches, and reviews of the SFC Program's and EPA's documentation, policies, and guidelines were made using the key word searches pairing aspects of 'Indian', 'Native American', 'Indian Health Service', 'water and sanitation', and 'needs and deficiencies'.

The indicators used as part of the analysis for interventions are described in Table 3.2.

Table 3.2 Water and sanitation monitoring indicators

Analysis and description	
1: Project category by total cost and number of projects	
Water projects	Solid waste projects
Sewer projects	Water and sewer projects
2: Project description by total cost	
Water projects	**Solid waste projects**
Other	Collection stations
Source	Open dump closures and clean-up
Treatment	**Water and sewer projects**
Storage	Water supply and septic for individual homes
Transmission and distribution	Water supply and sewer collection and treatment
Water for individual homes	Water source and wastewater disposal
Sewer projects	Water supply and sewer collection
Effluent disposal	
Septic for individual homes	
Sewer collection and pumping stations	
Wastewater treatment	
Combination of collection, treatment, and disposal	
3: Project type by total cost	
Study/planning	
Replacement and upgrade (e.g. water pipe replacement)	
Emergency	
Capital improvement (e.g. sewer collection to replace on-site septic)	
4: Project by Initial Deficiency Level (IDL)	
IDL 5	IDL 2
IDL 4	IDL 1
IDL 3	
5: Sanitation Deficiency System (SDS) project total score by total cost and number of projects	
90 points and above	60 to 69 points
80 to 89 points	50 to 59 points
70 to 79 points	49 points and below
6: Projects for American Indian community and tribe by total cost	
Individual American Indian community/tribe	

Source: Author

3.7.2 STUDY SETTING AND SITES

The study setting and sites represent all projects for American Indian communities in the California Area funded over a 10-year time period of 2003 to 2013. During this time period, a total of 219 projects were reviewed with a total project cost of $86.9 million. On occasion, a tribe may manage a water supply or sanitation project without IHS involvement, and in these cases, the data is not in STARS and therefore not included in this study. The research also utilized as part of the setting the portfolio of remaining deficiencies (unfunded projects) in the California Area over the same time period. As of 2013, the total value of un-met needs was $94.8 million of feasible projects.

3.7.3 DATA COLLECTION AND QUALITY CHECKS

The data was obtained from the SFC Program's STARS database from the SDS and PDS sites for a period of 2003 to 2013 for selected California Area and national measures. For the majority of the projects listed in the STARS reports, additional detailed reviews were conducted from a combination of individual SDS and PDS projects and hard copies of paper documents that included descriptions, category, deficiency level when the project was funded, and milestone dates. The data was retrieved from both the IHS headquarters and the California Area headquarters in both Excel and PDF formats.

The data supplied by SDWIS represented the current status of water system compliance as of April 2013. The SDWIS data is for both tribal and non-tribal systems; however, EPA supplied data only for the tribal systems within the California Area. The data was provided by the EPA Region 9 headquarters in Excel format (Banks, 2013).

Steps were taken to ensure for quality checks and validating the data; which included that the data was recorded accurately and interpretations were correct. This was accomplished by several reviews of the data to check that data entry was made correctly (e.g. spelling, dates, numbers, etc.). This was important because a portion of the data was directly obtained from STARS extracts (e.g. SDS) while a significant amount of data (e.g. PDS) was obtained from reviewing individual project files and recording by hand. For small data sets, a quality check was accomplished by reviewing the entire data set; however, for larger data sets it was performed by reviewing a representative sample of the data. An overall quality of findings was made by having multiple reviewers provide their conclusions and determine if they were similar.

3.7.4 DATA ANALYSIS

In order to gain a better understanding of the quantitative data, an analysis was performed similar to the multi-step process mentioned previously. The data analysis for this factor included:

- Data presented in table formats.
- Checked the data quality by comparing multiple reports and observing for any outliers.
- Checked for any preliminary trends.
- Described and analyzed data using MS Excel data analysis features (e.g. analysis tools for descriptive statistics), percentages, and compared California Area trends to national levels and with EPA SDWIS data.
- Presented data using line graphs and pie charts.
- Validated and compared the data by additional reviews by key stakeholders; e.g. SFC Program Director for the California Area.

3.8 HEALTH IMPACT

3.8.1 STUDY DESIGN

The study design for this sub-unit provided information on the health impact changes over time, and the disease indicators and measures used include:

- Gastrointestinal infections (GI)
- Viral hepatitis (VH)
- Upper respiratory infections (URI)

The study primarily utilized semi-structured one-to-one interviews and documents. The interviews were conducted with key IHS staff including the California Area Chief Medical Officer, Epidemiology Department, and the ICD Analyst primarily responsible for managing the IHS health-related data. In addition, the SFC Program Director for the California Area was consulted regarding previous uses of health data to support and justify water supply and sanitation interventions. Data was obtained from the IHS's principal health and patient monitoring database known as the Resource and Patient Management System (RPMS), which contains information on American Indian patients and their disease diagnosis. The data was supplied by the California Area Epidemiology Department and ICD Analyst for a period of 2000 to 2013 (Martinez, 2013).

The RPMS database uses the International Classification of Disease (ICD) to code and classify diseases. The ICD is an international classification system used to promote standardized comparisons of disease data, analysis, and usefulness of statistics. The

ICD codes are published by the WHO. The ICD is revised periodically, and the ninth revision (i.e. ICD-9) was used for this project. A total of 44 individual ICD codes were used for the GI grouping and included such diseases as cholera, salmonella gastroenteritis, shigella dysenteriae, amebic infection, giardiasis, enteritis, and infectious diarrhea. The VH grouping contained 2 ICD codes for viral hepatitis A. The grouping for URI contained a total of 38 ICD codes including pneumonias and influenzas. In order to simplify the analysis process, the results were combined into two primary categories of 'gastrointestinal and viral hepatitis' (GI and VH) and 'upper respiratory infections' (URI). A summary of the indicators and ICD codes are described in Table 3.3.

Literature searches in the Medline database, Google Scholar searches, and reviews of the SFC Program's documentation were made using the key word searches pairing aspects of 'Indian', 'Native American', 'Indian Health Service', 'water and sanitation', 'health status', 'gastrointestinal diseases', 'diarrhoeal diseases', and 'upper respiratory infections'.

Table 3.3 Disease indicators and ICD-9 codes

ICD-9 [a]	Code Description
Group 1: Gastrointestinal Infections (GI)	
001	Cholera
002	Thyphoid and parathyroid fevers
003	Other Salmonella Infections
004	Shigellosis
006	Amebiasis
007	Other protozoal intestinal diseases
Group 2: Gastrointestinal Infections (GI)	
008.6-008.8	Enteritis due to specified virus, Other organism
009.0	Ill-defined intestinal infections
Group 3: Viral Hepatitis (VH)	
070.0	Viral Hepatitis A with Hepatic Coma
070.1	Viral Hepatitis A without Hepatic Coma
Group 4: Upper Respiratory Infections (URI)	
480	Viral pneumonia
481	Pneumococcal pneumonia [Streptococcus pneumoniae pneumonia]
482	Other bacterial pneumonia
483	Pneumonia due to other specified organism
484	Pneumonia in infectious diseases classified elsewhere
485	Bronchopneumonia, organism unspecified
486	Pneumonia, organism unspecified
487	Influenza

[a] International Classification of Diseases, ninth revision (ICD-9)

Source: Martinez (2013)

3.8.2 STUDY SETTING AND SITES

The study setting and sites represent health data from a total of 32 American Indian communities within the California Area. The American Indian communities were selected based on the criteria that they had at least one funded IHS water or sanitation project within the time frame of 2003 to 2013. The RPMS data was requested from a total of 14 tribal health programs that provide health coverage to these 32 American Indian communities. The total number of patients ranged from 45,000 to 75,000 over the time period. Of the 32 communities, 7 were selected for additional evaluation because they had initial baseline indicators (e.g. GI, VH, and URI) higher than one standard deviation from the mean. The 32 American Indian communities, and the associated 14 tribal health programs, are located throughout the state and representative of many remote and rural tribal populations in California.

Sample size for a study is determined by three general approaches that include statistical, pragmatic, and cumulative (Denscombe, 2011, pp. 40-42). The statistical approach is the preferred method, and typically used for large-scale surveys. However, for smaller scale surveys a more pragmatic approach is frequently used, in part, due to the constraints of resources and challenges in meeting all the strict requirements of a rigorous statistical study. In addition, the selection of sample size should also consider data availability, reliability, and representativeness of the sample (WHO, 2007, p. 4).

Sampling is further defined as two main types – random and purposive sampling (Ferron et al., 2007, pp. 30-31). Random sampling involves objectively collecting a representative segment of a population for statistical analysis, and is not subject to bias. This sampling method is typically used for large populations. Purposive sampling is considered non-probability sampling, and involves methods including participant self-selection and judgment sampling (e.g. an expert selects the sample), and has some possibility of bias. In addition, formal sampling methods based on probability require that random chance be the controlling factor for sampling; however, the informal sampling method (e.g. purposive) are based on non-probabilistic principles and are more subjective (USAID, 1997, p. 24). Furthermore, this method is based on the assumption that the person selecting the sample is knowledgeable about the study group. The intention of this method is to be “free of bias and representative enough for the purposes of the survey” (USAID, 1997, p. 24). A comparison of sample sizes based on various statistical approaches is provided below.

For incidence-rate studies, the WHO (1991, p. 17) suggests calculating the sample size based on the following method:

- Relative precision (ε): 10% (assumed)
- Significance level (α): 5% (assumed)
- Confidence level: 95% (based on 100(1-α))
- Using Table 12, the sample size would be 385.

For small sample sizes, Israel (1992, p. 4) recommends the following simplified formula:

$n = N/(1+N(\varepsilon)^2)$

Where: Sample size (n); Population size (N); Relative precision (ε)

Based on the above simplified formula, the calculated sample size for the tribal health programs would be:

- Population size (N): 31 total tribal health programs
- Relative precision (ε): 10% (assumed)

$n = 31/(1+31(0.10)^2) = 24$ tribal health programs

Based on the above simplified formula, the calculated sample size for the total registered American Indian users at the tribal health programs would be:

- Population size (N): 140,386 total registered users
- Relative precision (ε): 10% (assumed)

$n = 140{,}386/(1+140{,}386(0.10)^2) = 100$ American Indians registered users

For random sample sizes, Ferron et al. (2007, pp. 30-31) provide a simplified estimate in Table 3.4. Using the population size of the 140,386 American Indian register users, a corresponding sample size would be 90 to 100 individuals.

Table 3.4 Random sample sizes

Population size	Sample size [a]
Less than 100	30 to 50
100 to 300	50 to 70
300 to 1,000	70 to 90
Over 1,000	90 to 100

[a] Sample size units include households, groups, or individuals.

Source: Ferron et al. (2007, p. 30)

As would be expected, the statistical sample sizes that range from 385 to 24 tribal health programs are considerably larger than the 14 tribal health programs that were actually evaluated. However, taking into consideration the 140,386 American Indian registered users at the tribal health programs, the total sample size of 45,000 to 75,000 patients from the 14 tribal health programs appears representative of the overall American Indian population in the California Area. In addition, based on the table by Ferron, a recommended sample size based on this population would be 90 to 100 patients. Therefore, it is considered that the sample studied is representative of the larger American Indian population in the California Area.

3.8.3 DATA COLLECTION AND QUALITY CHECKS

The data was obtained from the IHS RPMS database. The patient data is originally entered by staff at the local tribal health program clinics, and the California Area is able to obtain data extracts. The data was supplied by the California Area Epidemiology Department and ICD Analyst for a period of 2000 to 2013. The data was provided by the California Area office in Excel format.

Initially, the ICD Analyst provided a listing of all the standardized ICD codes used in RPMS, and these were reviewed in consultation with the California Area Chief Medical Officer, Epidemiology Department, and ICD Analyst in order to determine suitable health indicators to extract from RPMS closely matched with waterborne and water-washed diseases. It was decided to use health indicators within three broad groupings of gastrointestinal (GI) diseases, viral hepatitis (VH), and upper respiratory infections (URI) because they were best suited to represent typical health indicators for the targeted diseases (Magruder, 2013). It was decided that diseases related to “other food poisoning (bacterial)” (ICD code 005) would not be included in the study because they were more strongly related to food-borne diseases.

Steps were taken to ensure for quality checks and validating the data. In general, these included that the data was retrieved and recorded accurately, and interpretations from the data were correct. This was accomplished primarily by the initial data downloads and reviews by the ICD Analyst, and then follow-on global data checks by reviewing a representative sample of the data (Martinez, 2013). In addition, an overall quality of findings was made by having multiple reviewers provide their conclusions and determine if they were similar. The information for this factor was solely supplied by RPMS database without hand entries.

3.8.4 DATA ANALYSIS

In order to gain a better understanding of the quantitative data, an analysis was performed similar to the multi-step process mentioned previously. The data analysis for this factor included:

- Data presented in table formats.
- Checked the data quality by comparing multiple reports and observing for any outliers.
- Checked for any preliminary trends.
- Described and analyzed data using MS Excel data analysis features (e.g. analysis tools for descriptive statistics and t-Test).
- Presented data using line graphs.
- Validated and compared the data by additional reviews by key stakeholders; e.g. California Area Chief Medical Officer, Epidemiology Department, and the ICD Analyst. In addition, the trends in health data were compared with the timeframes of system deficiency levels and drinking water and sanitation interventions for the American Indian community.

3.9 SYSTEM SUSTAINABILITY

3.9.1 STUDY DESIGN

The study design for this sub-unit provided information on the tribal capacity and sustainability of the water supply and sanitation systems for target groups, and the indicators and measures used include:

- Technical capacity
- Managerial capacity
- Financial capacity

The study primarily utilized semi-structured one-to-one interviews, questionnaires, and documents. The interviews were conducted as part of the questionnaire and separately with key IHS O&M Program staff. A questionnaire for tribal O&M and system sustainability was developed based on an original template from the Rural Community Assistance Cooperation (RCAC), a nonprofit organization based in California that provides technical assistance and training for rural and American Indian communities (Harvey, 2013).

The questionnaires were customized by IHS for specific tribal considerations. A separate questionnaire was developed for water and wastewater systems, and contained sustainability issues under three broad groupings of questions for technical, managerial, and financial aspects. There were 88 questions on O&M capacity for water systems and 51 questions on O&M capacity for wastewater systems. The questionnaire used primarily 'closed' questions; e.g. 'Yes' or 'No'; and lists such as 'What are the sources of raw water for your water system?' However, there was a comment field at the end of each question to enter specific information pertinent to the assessment of the system's capacity. In addition, some questions were for informational purposes only.

The questionnaires were administered in the field over period of November 2012 to September 2013 by staff from RCAC with assistance by IHS. Each questionnaire required 2 to 4 days to administer depending on the size of the system and availability of the tribal staff to provide responses and supporting information. Four different staff from RCAC administered the questionnaire depending on the location of their office relative to the location of the tribe. The staff from RCAC and IHS completed the questionnaires by conducting semi-structured interviews with the tribal O&M staff and performed observations of the facilities and system operations. The findings and scores from the survey were reviewed by the IHS O&M Program staff. A final written report with key recommendations was provided to the tribes.

Literature searches in the Medline database, Google Scholar searches, and reviews of the SFC Program's documentation were made using the key word searches pairing aspects of 'Indian', 'Native American', 'Indian Health Service', 'water and sanitation', 'operation and maintenance', 'capacity', and 'sustainability'.

3.9.2 STUDY SETTING AND SITES

The study setting and sites represent tribal O&M organizations within the California Area that were requested and agreed to participate in the questionnaire. Of the 102 federally recognized tribes in the California Area, 25 agreed to participate, and of these, a total of 10 tribes have been surveyed at this time. The questionnaire has been administered to the following tribes: Torres-Martinez; Big Sandy; Cold Springs; Redwood Valley; San Pasqual; Big Valley; Upper Lake; Hopland; La Jolla; and Stewarts Point.

All 10 tribes are among the 32 American Indian communities used for the health impact information mentioned previously. The 10 tribes are located throughout the state and representative of rural tribal O&M organizations.

As previously discussed above, there are several approaches to sampling and determining the appropriate sample size. A similar design approach was followed for this study factor. A comparison of sample sizes based on various statistical approaches is provided below.

Based on the WHO suggested formula for incidence-rate studies mentioned above, the sample size would be:

- Relative precision (ε): 10% (assumed)
- Significance level (α): 5% (assumed)
- Confidence level: 95% (based on 100(1-α))
- Using Table 12, the sample size is 385.

Based on the simplified formula from the Israel (1992) method, the calculated sample size for tribes would be:

- Population size (N): 102 federally recognized tribes
- Relative precision (ε): 10% (assumed)

$n = 102/(1+102(0.10)^2) = 50$ tribes

Using the table by Ferron, a population size of 107 tribes would require a sample size of 50 tribes.

As would be expected, the statistical sample sizes that range from 385 to 50 tribes are considerably larger than the 25 tribes that have agreed to participate and the 10 tribal organizations actually evaluated. However, as mentioned previously, the 10 questionnaires administered were based on a practical and pragmatic basis, primarily based on resource constraints (e.g. time and funding) and agreement by the tribes to participate. Although the sample size may be small in comparison to recommended values, it reflects the current availability of tribes for the survey, and appears to be representative of other tribal organizations in the California Area.

3.9.3 DATA COLLECTION AND QUALITY CHECKS

After the questionnaire was administered in the field, each response was evaluated whether it was 'acceptable', 'in progress/not complete' or 'deficient'. At the end of the questionnaire, the responses were reviewed for each of the three main categories, and totals were provided (e.g. total number of 'acceptable', total number of 'in progress/not complete', etc.). In addition, there was a summary of assessment findings and additional comments that described critical elements from the semi-structured interviews. After the questionnaire was reviewed by RCAC and IHS, a final form was provided in Excel format.

Steps were taken to ensure for quality checks and validating the data. In general, these included that the data was recorded accurately in the field, and appropriate post-processing interpretations were made. After the questionnaire was completed in the field, it was further reviewed by the surveyor and the tribal staff, and the tribe provided a signature of acknowledgment. The findings were then reviewed and analyzed by RCAC and IHS for post processing.

During the review, the rankings of 'acceptable', 'in progress/not complete' or 'deficient' were evaluated in comparison to the comments, and in some cases there were inconsistencies. In those cases, the responses were further evaluated and a judgment made as to which was more reliable (Dewees, 2013).

3.9.4 DATA ANALYSIS

In order to gain a better understanding of the quantitative and qualitative data, an analysis was performed similar to the multi-step process mentioned previously. The data analysis for this factor included:

- Data presented and organized in table formats, which was the primary organizational method of the questionnaire that arranged the questions in groupings of technical, managerial, and financial capacity.
- Checked the data quality by comparing multiple reports and observing for any outliers.
- Checked for any preliminary trends.
- Described and analyzed data using MS Excel data analysis features (e.g. analysis tools for descriptive statistics).
- Presented data using bar graphs.
- Validated and compared the data by additional reviews by key stakeholders; e.g. tribal officials, RCAC staff, and IHS staff. In addition, overall comparisons were made between tribal utility organizations to determine if there were any extreme outliers.

3.10 DATA QUALITY ISSUES

The data quality issues for all the factors are summarized below. While certain issues are more relevant to some factors than others, they are presented together because most are applicable to multiple factors. The data quality issues and limitations include the following:

- **Lack of baseline.** This study did not have a well-established control or baseline group to compare the changes and impacts in health outcomes as a result of the water supply and sanitation interventions. A baseline group using an average of health data from 2000 to 2003 was used; however, it does not represent a true comparison group as the selected group had various water and sanitation interventions installed previously and may also contain other factors.

- **Pre-intervention disease and behaviors.** This study did not have access to information pertaining to pre-existing health status levels or behaviors specifically related to hygiene such as the practice of hand washing and food preparation. Fewtrell and Colford (2004) indicate that diarrhea rates can vary in a community due to seasonal or annual patterns or for other undermined reasons. Furthermore, if baseline levels are not determined, there will be challenges to link any changes in health status to the intervention.
- **Health indicator definition and prognosis.** The health impact information relied on data entry from 14 different tribal health programs, and there is likelihood that data may have been entered incorrectly or based on inconsistent diagnosis.
- **Accurate data entry in the STARS system.** The data entered in the STARS system is made by individual project engineers and support staff. While there is review of the data at various levels, there is a potential that data may not be accurate including categories such as cost, dates, homes. In addition, some projects in SDS and PDS are for a variety of facilities, and by making project descriptions concise there have been certain details that were inadvertently removed or dropped.
- **Timeline of funded project and service.** For IHS, even though a project is funded, it may take several years to be constructed and therefore a delay in the community from receiving the health benefits from the intervention. In addition, although a project may be well-designed, if the community does not have the capacity to provide operation and maintenance, the full intended health benefit and outcome may not be achieved.
- **Adequate study size and comparison to non-tribal communities.** Although this study provided a broad analysis and comparison among California Area tribal communities, there were no comparisons made with non-tribal communities in the State of California.
- **Objectivity and biases.** In some cases, there may have been a lack of objectivity and lack of neutrality when the tribal O&M questionnaire was administered in order to preserve the surveyor's good relationship with the tribe, and therefore, an unwillingness to give a non-acceptable evaluation (Dewees, 2013).
- **Reliability.** There were multiple administrators of the tribal O&M questionnaire, and while this may have increased the objectivity, it may have created inconsistencies in the evaluation due to a variety of interpretations of the responses such as 'acceptable' or 'deficient' (Dewees, 2013).

4 RESULTS – PERFORMANCE, INTERVENTIONS, AND MONITORING

4.1 INTRODUCTION

This chapter provides results and discussion of the research findings for the sub-units of program performance, interventions, and deficiency monitoring; which are all intertwined with the impact of the SFC Program's interventions on the American Indian populations. The information was obtained through multiple methods including desktop reviews of documents, in-the-field observations, and interviews. The tables and graphs presented in this chapter were generated by the author using data from IHS STARS, except where otherwise noted.

4.2 PROGRAM PERFORMANCE

4.2.1 NUMBER OF AMERICAN INDIAN HOMES SERVED

The total number of American Indian homes served was assessed for the time period of 2005 to 2012. Nationally across all IHS Areas, the total number of American Indian homes served ranged from a low of 18,639 in 2010 to a high of 24,073 in 2005. There were 45,326 homes served in 2009, however this was an atypical year due to the higher than normal project funding received from the American Recovery and Reinvestment Act of 2009 (ARRA). The average number of homes served per year, excluding the 2009 outlier value, is 21,690 and the standard deviation is 2,082.

In the California Area, the total number homes served ranged from a low of 352 in 2006 to a peak of 1,627 in 2007. Unlike the national trend, the largest number of American Indian homes served did not happen in 2009. The average number of homes served per year, excluding 2009, is 856, and the standard deviation is 457. The number of homes served nationally and in the California Area is presented in Table 4.1.

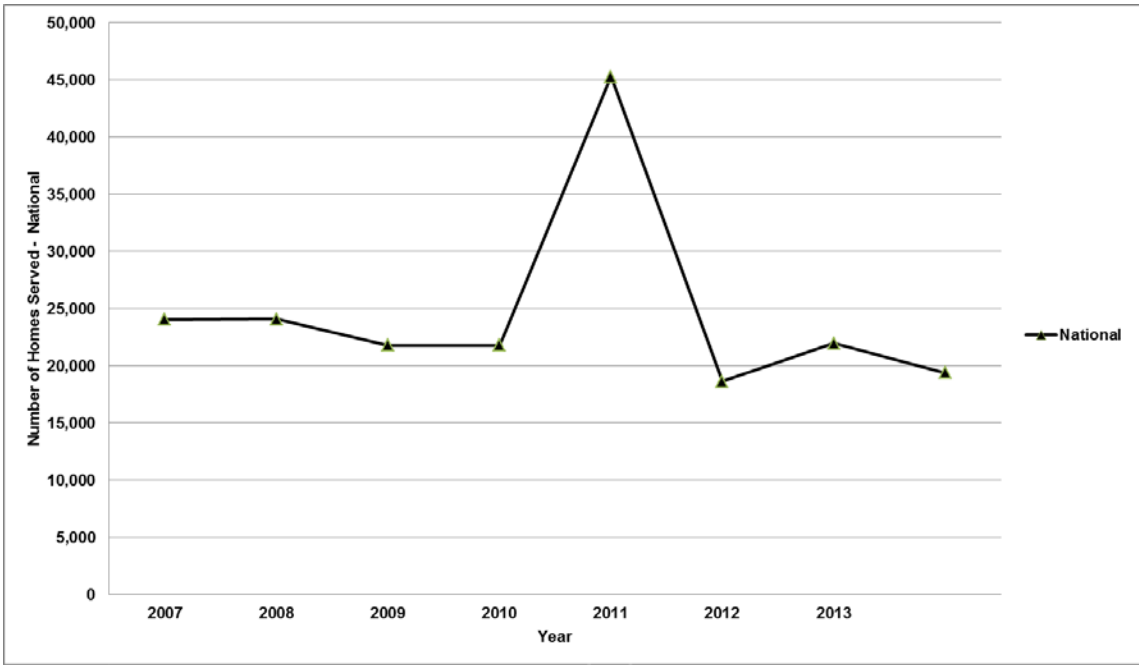
Table 4.1 Number of American Indian homes served

Location/Year	2005	2006	2007	2008	2009	2010	2011	2012
California Area	899	352	1,627	702	1,090	1,302	577	532
National	24,073	24,090	21,819	21,811	45,326	18,639	21,984	19,419

Source: IHS STARS (2013)

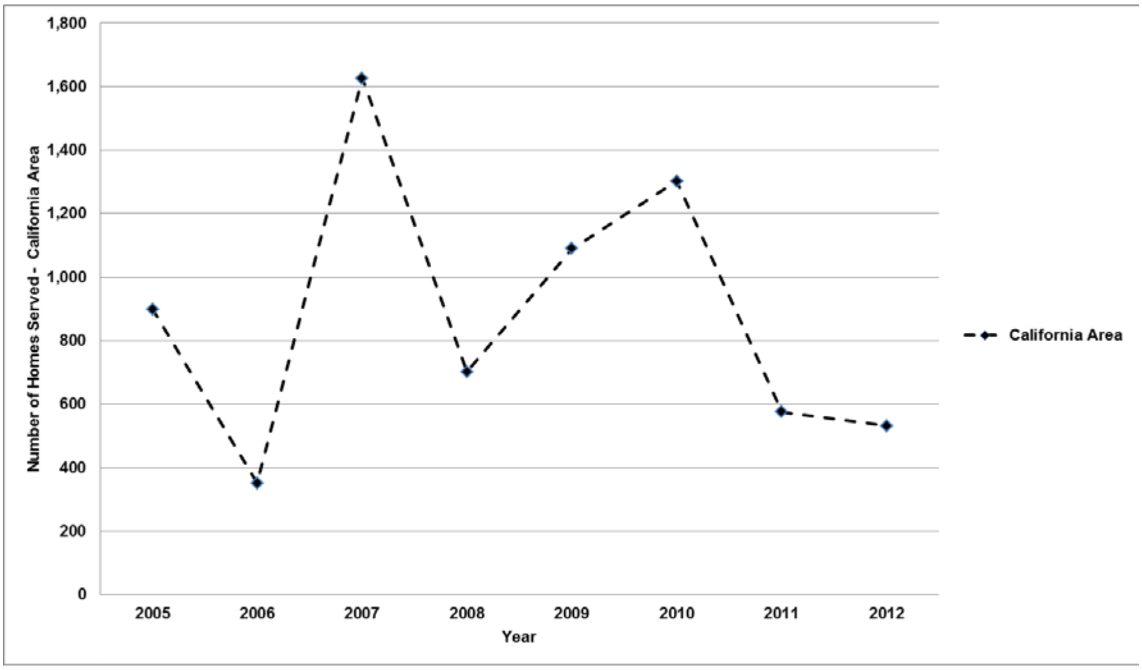
Excluding the spike in homes served in 2009, the standard deviation and trend lines in Figures 4.1 and 4.2 suggest that the annual number of homes served nationally is more constant than in the California Area. The number of homes served is entirely based on project funding, and while the annual allocation of IHS Regular funds to the Areas has been fairly constant, the amount of outside contributions (e.g. EPA funding) received each year is more variable (Brafford, 2013). The variability may result in part because other agency funding is distributed out to multiple IHS Areas (e.g. EPA Region 9 covers four Areas) based on internal agency formulas, and the U.S. Congress establishes different appropriation levels from year to year for the agency programs. Beginning in 2009 to 2010, both the national and California Area homes served was on a downward trend (Brafford, 2013). The large fluctuations in annual project funding could create challenges to plan and manage for future projects and program operations (e.g. staffing levels).

Figure 4.1 National number of American Indian homes served



Source: Author

Figure 4.2 California Area number of American Indian homes served



Source: Author

A comparison of the actual homes served nationally and the SFC Program indicator for this measure is presented in Table 4.2. The goals have been achieved for each year except in years 2007 and 2010 when there were fewer homes than the goal by 1,181 and 3,172, respectively. Currently, there is no specific Area goal for this measure.

Table 4.2 Number of American Indian homes served: actual vs. SFC Program goals

Measure	Fiscal year	Target	Result/actual
1: Number of new and existing American Indian homes provided with sanitation facilities.	2012	15,500	19,419
	2011	18,500	21,984
	2010	21,811	18,639
	2009[a]	37,500	45,326
	2008	21,800	21,811
	2007	23,000	21,819
	2006	22,000	24,090
	2005	20,000	24,073
	2004	22,000	24,928
	1999	Baseline	16,571

[a] Target was increased from original of 21,500 to 37,500 homes as a result of additional ARRA funds.

Source: HHS (2012), IHS STARS (2013), and OMB (2013)

4.2.2 PROJECT DURATIONS

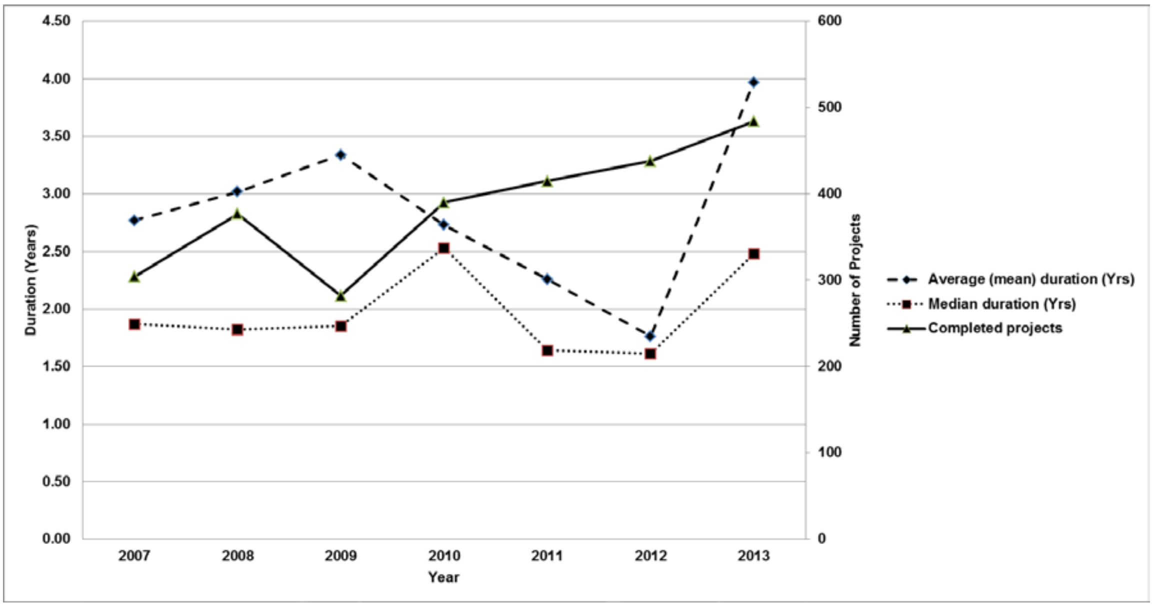
The project durations, which is the time between the executed MOA and the construction completion, was assessed for the time period of 2007 to 2013. Nationally, the shortest duration occurred in 2012 with an average (mean) of 3.35 years, and a median value of 2.31 years. The longest duration occurred in 2008 with an average (mean) of 4.13 years, and a median value of 3.58 years. The average duration during this time period is 3.68 years and the standard deviation is 0.24 years. The national trends in completed projects, average durations, and median durations are presented in Table 4.3 and Figure 4.3.

Table 4.3 National project durations

Parameter/year	2007	2008	2009	2010	2011	2012	2013
Completed projects	304	377	282	390	415	438	484
Average duration (Yrs)	3.60	4.13	3.70	3.72	3.53	3.35	3.73
Median duration (Yrs)	3.12	3.58	3.12	3.24	2.67	2.31	3.10

Source: IHS STARS (2013)

Figure 4.3 National: project durations



Source: Author

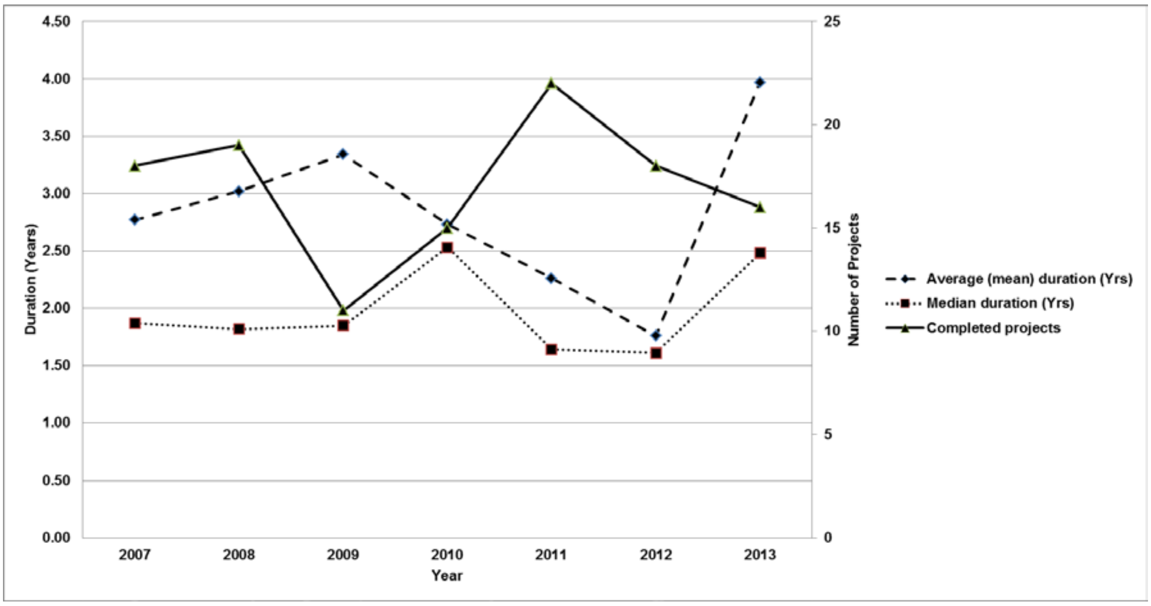
In the California Area, the shortest duration occurred in 2012 with an average (mean) of 1.76 years, and a median value of 1.61 years. The longest duration occurred in 2013 with an average (mean) of 3.97 years, and a median value of 2.48 years. The average duration during this time period is 2.84 years and the standard deviation is 0.72 years. This standard deviation indicates a higher variability of project durations in the California Area in comparison to national levels, which may benefit from a dampening effect from the multiple Areas. The California Area trends in completed projects, average durations, and median durations are presented in Table 4.4 and Figure 4.4.

Table 4.4 California Area project durations

Parameter/year	2007	2008	2009	2010	2011	2012	2013
Completed projects	18	19	11	15	22	18	16
Average duration (Yrs)	2.77	3.02	3.34	2.73	2.26	1.76	3.97
Median duration (Yrs)	1.87	1.82	1.85	2.53	1.64	1.61	2.48

Source: IHS STARS (2013)

Figure 4.4 California Area: project durations



Source: Author

A comparison between the actual project durations for national-level and California Area and the SFC Program indicator for this measure are presented in Tables 4.5 and 4.6. Nationally, the goal has been achieved for each year except in 2008 when the average duration was 4.13 years. Substituting the national indicator as an equivalent California Area goal indicates that the Area has achieved its objectives each year. While the California Area has met this measure, a glaring trend was the rate of completed projects has declined since 2011. However, nationally since 2010 the rate has increased. Part of the reason may be related to data entry in STARS, but may only be a small factor in the overall situation of a decrease in number of projects being completed. This is significant because as the rate of completed projects each year decreases, a corresponding consequence may be an increase in project durations.

Table 4.5 National project durations: actual and SFC Program goals

Measure	Fiscal year	Target	Result/actual
2: Track average project duration (years) from the project MOA execution to construction completion.[a]	2013	4.0	3.73
	2012	4.0	3.35
	2011	4.0	3.53
	2010	4.0	3.72
	2009	4.1	3.70
	2008	4.0	4.13
	2007	3.9	3.60

[a] New measure added in 2007.

Source: HHS (2012), IHS STARS (2013), and OMB (2013)

Table 4.6 California Area project durations: actual and SFC Program goals

Measure	Fiscal year	Target	Result/actual
2: Track average project duration (years) from the project MOA execution to construction completion.[a]	2013	4.0	3.97
	2012	4.0	1.76
	2011	4.0	2.26
	2010	4.0	2.73
	2009	4.1	3.34
	2008	4.0	3.02
	2007	3.9	2.77

[a] New measure added in 2007.

Source: HHS (2012), IHS STARS (2013), and OMB (2013)

While the average project duration in the California Area has been below the current threshold of 4 years, there are outliers that signal challenges and constraints for some projects. Of the 125 completed projects used to calculate durations during the study period, there were 15 projects that had longer durations that one standard deviation above the mean. The durations of these 15 projects ranged from 4.8 to 11 years. Projects with exceedingly long durations had significant environmental constraints (e.g. threatened and endangered species), complex designs (e.g. surface water treatments), and extensive scopes (e.g. projects covered multiple categories).

Other factors for variations in project durations included land issues (e.g. easements and rights-of-way), initially poorly scoped projects, and project staff change-over. The project duration measure, while useful, does not depict a real-time indicator of project constraints and delays because it is not recorded until the project completion (Brafford, 2013).

Identification of potential and occurring project delays requires continual monitoring through the life of the project.

4.2.3 PERCENTAGE OF AMERICAN INDIAN HOMES WITH ADEQUATE FACILITIES

The percentage of American Indian homes with adequate sanitation facilities, which is the total number of homes at IDL-1 to IDL-3 compared to the total homes at IDL-1 to IDL-5, was assessed for the time period of 2003 to 2013. Homes at IDL-4 and IDL-5 are considered not to have adequate drinking water and sanitation facilities. Nationally, the percentage has ranged from 84% to 88%.

A comparison between the actual national-level percentage and the SFC Program indicator for this measure indicates that the goals have not been achieved, and has fallen slightly short of the target of 90% set for 2010 and 2012. The future goal is to achieve 94% coverage by 2015. Currently, there is no specific Area-level goal for this measure. The actual percentage of homes with drinking water and sanitation facilities compared with the national goals is presented in Table 4.7.

Table 4.7 National: percentage of American Indian homes with sanitation facilities

Measure	Fiscal year	Target	Result/actual
3: Percentage of AI homes with sanitation facilities.[a]	2015	94%	Future goal
	2014	N/A	Future goal
	2013	N/A	88%
	2012	90%	88%
	2011	N/A	88%
	2010	90%	84%
	2009	N/A	87%
	2008	N/A	87%
	2007	N/A	87%

[a] This long-term measure had no targets until 2010.

Source: HHS (2012), IHS STARS (2013), and OMB (2013)

4.2.4 PROJECT COST PER AMERICAN INDIAN HOME SERVED

The project cost per American Indian home served was evaluated for the time period of 2005 to 2012, which is a measure calculated by the total project funding divided by the total number of homes served for a given year. The project cost is generally defined as the cost to construct the facilities and includes the materials, labor, and equipment and inspection services. Nationally across all IHS Areas, the cost to serve a home ranged from a low of US$5,018 in 2006 to a high of US$10,590 in 2010. The average cost per home served is US$6,664 and the standard deviation is US$1,811. The cost per home served nationally is presented in Table 4.8.

Table 4.8 National: project cost per American Indian home served

Parameter/Year	2005	2006	2007	2008	2009	2010	2011	2012
National homes served	24,073	24,090	21,819	21,811	45,326	18,639	21,984	19,419
IHS Housing funds [a]	$45.1	$45.3	$46.0	$46.0	$47.0	$47.4	$47.2	$35.5
IHS Regular funds [a]	$45.7	$45.9	$47.0	$47.3	$47.9	$47.0	$47.0	$42.4
Outside contributions [a]	$40.4	$29.7	$41.1	$30.0	$162.0	$103.0	$68.8	$65.4
Total funding all sources [a]	$131.2	$120.9	$134.1	$123.3	$256.9	$197.4	$162.9	$143.2
Project cost per home	$5,450	$5,018	$6,146	$5,652	$5,668	$10,590	$7,412	$7,376

[a] Funds expressed in million US$

Source: Author

In the California Area, the cost to serve an American Indian home ranged from a low of US$4,087 in 2007 to a high of US$21,225 in 2006. The average cost per home served is US$11,971 and the standard deviation is US$6,021. The cost per home served in the California Area is presented in Table 4.9 and Figure 4.5.

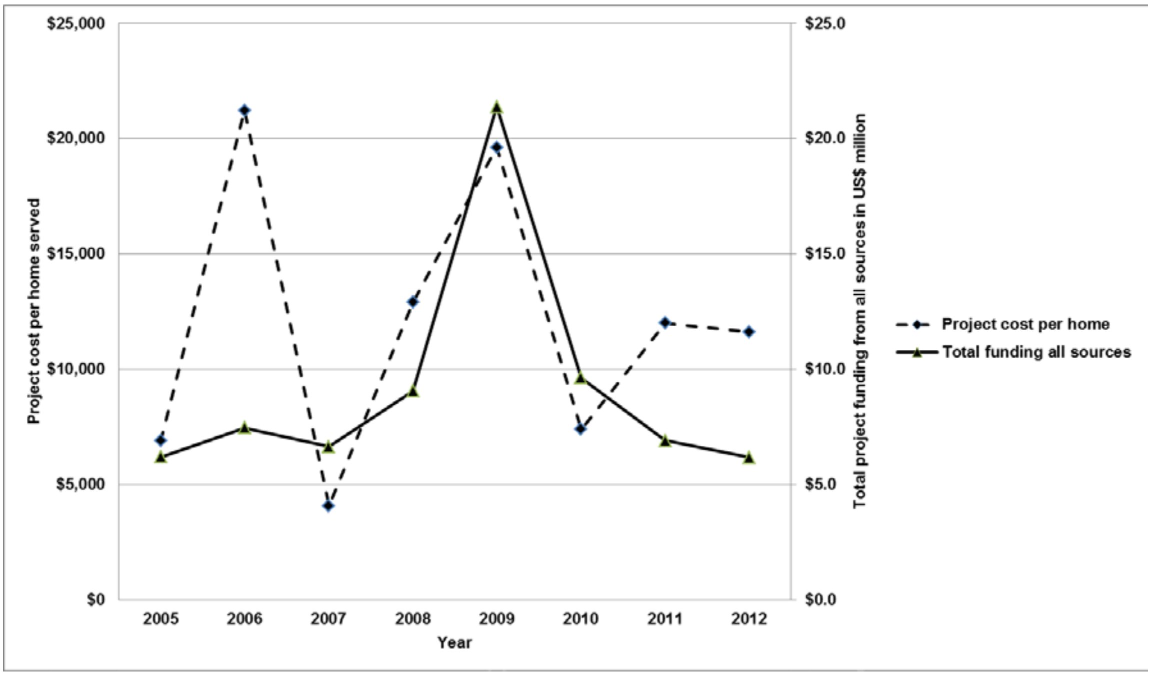
Table 4.9 California Area: project cost per American Indian home served

Parameter/Year	2005	2006	2007	2008	2009	2010	2011	2012
California homes served	899	352	1,627	702	1,090	1,302	577	532
IHS Housing funds [a]	$1.9	$2.0	$2.0	$2.0	$2.1	$2.0	$2.0	$1.5
IHS Regular funds [a]	$2.2	$2.6	$2.8	$2.6	$2.9	$2.6	$2.4	$2.3
Outside contributions [a]	$2.1	$2.9	$1.8	$4.5	$16.5	$5.1	$2.4	$2.4
Total funding all sources [a]	$6.2	$7.5	$6.6	$9.1	$21.4	$9.6	$6.9	$6.2
Project cost per home	$6,907	$21,225	$4,087	$12,906	$19,615	$7,397	$12,001	$11,627

[a] Funds expressed in million US$

Source: Author

Figure 4.5 California Area: Project cost per American Indian home served and total project funding from all sources



Source: Author

The project cost per home served in the California Area is significantly more expensive and highly variable when compared to the national trends. For the most expensive year, the cost to serve a home in the California Area is approximately 100% more than the national cost. Nationally, the average cost per home served is US$6,664 and the standard deviation is US$1,811. However, for the California Area, the average cost per home served is US$11,971 and the standard deviation is US$6,021. The high cost per home served and variability may be a result of a variety of project constraints in the California Area, which include environmental factors, higher construction costs (e.g. materials and labor), site conditions (e.g. subsurface soils), remoteness, method of procurement, and specific deficiency and proposed facilities for the given project. In particular, the construction cost in California has increased significantly over the past 10 years with an estimated rise of 132% (IHS, no date-b). Currently, there is no national or Area-level performance measure for the cost per home served.

4.2.5 Program resource cost per American Indian home served

The program resource cost per American Indian home served was evaluated for the time period of 2005 to 2012, which is a measure calculated by the total program resource cost divided by the total number of homes served for a given year. The program resource cost is generally defined as the operating budget for the program and includes the costs for personnel, travel, training, and office supplies for project development, design engineering, management, and administration. The total annual California Area SFC Program operating budget is approximately US$4.4 million, and is summarized in Table 4.10 along with the cost per home.

A significant portion of the program budget is allocated to staff salaries, and staffing levels have remained relatively constant over the past several years (Brafford, 2013). Therefore, assuming that the overall program operating budget was relatively constant, the program resource cost per home ranged from a low of US$2,724 to a high of US$12,591, and an average of US$5,008. Combing the project and program costs to severe American Indian homes reveals the actual resources required. The costs vary from a low of US$6,811 to a high of US$33,816 with an average of US$16,979. On average, approximately 30% of the total cost to serve a home is for program-related expenses and the remaining 70% is for the actual construction and installation of the facilities.

While the program cost per home is a useful measure of efficiency, it needs to be viewed not only in context with the variable project funding to serve homes, but perhaps even more so with the fact that the role of the SFC Program is a public health agency rather than a public works organization (Brafford, 2013). For example, there may be a significant level of SFC Program resources involved to address a situation for a limited number of homes with a high deficiency level (e.g. IDL-4 or IDL-5), while few resources over a shorter period of time are utilized for projects to address a large number of homes with a lower deficiency (e.g. IDL-2 or IDL-3). The mission of the SFC Program is what sets it apart from other engineering firms and organizations that may base their decisions more on profitability (Brafford, 2013).

In addition, resources assigned to projects may in fact only be able to devote a portion of their time for actual design and construction management to complete the projects. The SFC Program engineers may only spend 40% of their time on project-related activities, while the remaining 60% of time is allocated to non-project tasks such as training, populating databases, report writing, field reconnaissance, meetings with tribes and other agencies, and leave (i.e. vacation). This remains a critical challenge for the SFC Program (Brafford, 2013).

The data suggest that the program resource cost per home served is variable and is influenced by a number of factors including the complexity and site specific context of the intervention to serve the homes. The research project evaluated the measure for the

California Area only. Currently, there is no national or Area-level performance measure for the program resource cost per home served.

Table 4.10 California Area SFC Program operating costs and homes served

Parameter	Value
California Area SFC Program budget	
Salary	$3,917,779
Travel	$257,173
Training	$101,173
Vehicles	$85,752
Office equipment, supplies, and phones	$70,300
Total program operating budget	$4,432,176
Homes served	
Low	352
High	1,627
Average	885
Program cost per home served	
High	$12,591
Low	$2,724
Average	$5,008

Source: Author

4.2.6 SUMMARY

The number of American Indian homes served by the California Area is highly variable primarily because it is based on annual funding allocations. However, the variability appears to be more pronounced than the national trend. Beginning in 2010, the number of homes served by the California Area has generally declined. While the national measure for the number of homes served has been achieved the majority of the time, there is no corresponding measure for the California Area. Given that the number of homes served is tied with annual funding levels, the California Area should consider opportunities to collaborate with tribes and other funding agencies to serve homes that would satisfy the mandates of all the stakeholders.

Even though the California Area has consistently met the project duration goal, there has been a significant decline in the rate of completed projects since 2011, which is not apparent nationally. While there may be various reasons, the occurrence should be further evaluated because if the annual rate of completed projects were to continually decrease, it would tend to increase the project durations and impact resources and project outcomes. In addition, while the average project duration in the California Area has been below the 4 year limit, there were several projects that had significantly longer durations. These exceedingly long durations may point to constraints that could be planned for and mitigated for future projects.

The project cost per home served in the California Area is significantly more expensive and highly variable when compared to the national trends. The average construction cost to serve a home was US$11,971, and when adding the program resources, the cost increased to US$16,979. If the funding trend continues to decrease, the high cost per home will impact the number of homes that can be served per project. The high cost to serve homes in the California Area is influenced by environmental factors, higher construction costs, site conditions, remoteness, specific deficiencies, and that only a portion of the available resources actually performs design and construction-related activities. Tracking the cost per home in terms of both construction and program costs are new efficiency measures, and could serve as monitoring indicators in the future.

4.3 WATER AND SANITATION INTERVENTIONS

4.3.1 PROJECT CATEGORY BY TOTAL COST AND NUMBER OF PROJECTS

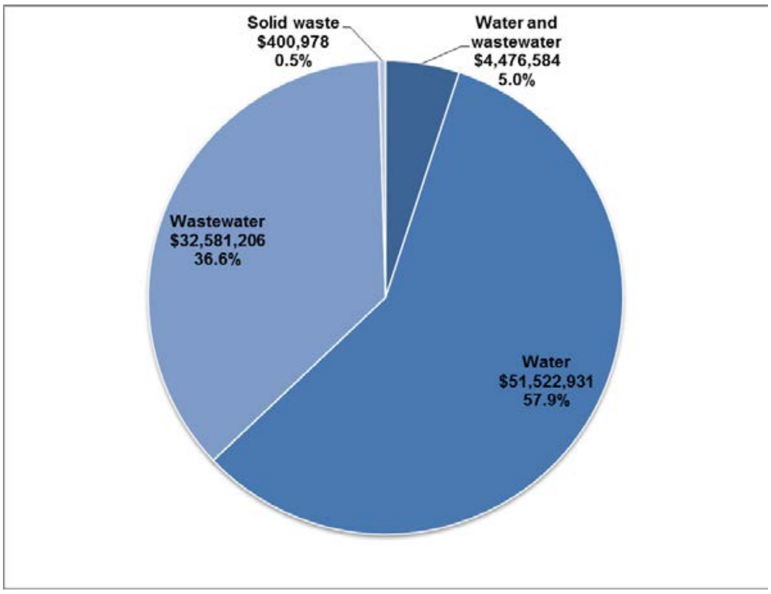
Projects funded from 2003 to 2013 were grouped in four broad categories for water, wastewater, water and wastewater combined, and solid waste for total cost and number of projects, and are summarized in Table 4.11 and Figures 4.6 and 4.7. The figures demonstrate that projects funded for water interventions are the majority at 57.9% of the total funding and 55.8% of the total number of projects. Wastewater projects represent 36.6% of the total cost and 30.7% of the total number of projects. After these categories, only a very small percentage of funding and projects are for water and wastewater combined and solid waste (0.5 to 5.0% and 1.3 to 12.1%), respectively.

Table 4.11 Project category by total cost and number of projects

Project category	Total cost	Number of projects
Water and wastewater	$4,476,584	28
Water	$51,522,931	129
Wastewater	$32,581,206	71
Solid waste	$400,978	3

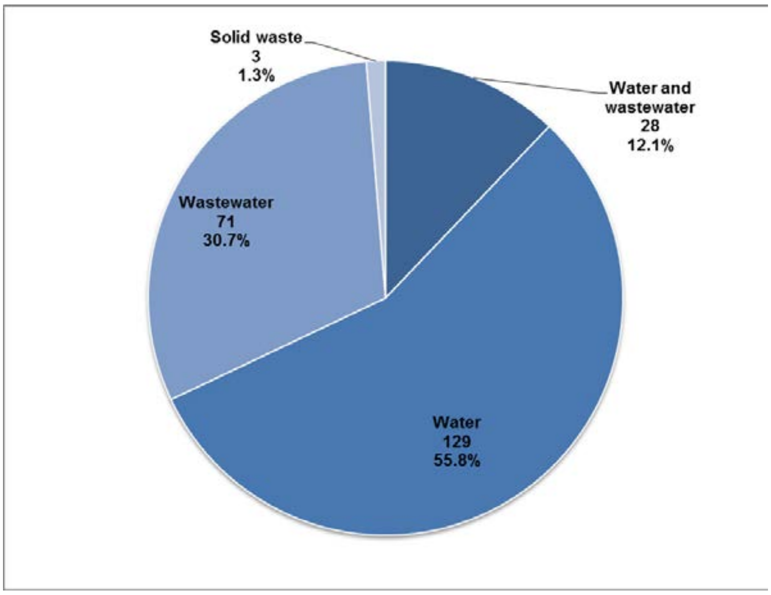
Source: Author

Figure 4.6 Project categories by total cost



Source: Author

Figure 4.7 Project category by number of projects



Source: Author

4.3.2 PROJECT DESCRIPTION BY TOTAL COST

From the initial broad groupings, the projects were further divided into categories based on a more detailed description and are summarized in Table 4.12 and Figures 4.8, 4.9, 4.10, and 4.11.

Projects were grouped into six major categories for water infrastructure based on project type; which are source, treatment, storage, transmission and distribution, water for individual homes, and other. The “other” category is composed of projects that do not fit into one of the other categories and primarily consists of smaller-scale activities (e.g. minor repairs to pump control systems). The tables and figures demonstrate that the two categories of transmission and distribution and treatment represent the majority of the costs at 36.2% and 33.3%, respectively. The categories of storage and source represent the majority of the remaining costs at 15.7% and 12.5%, respectively. Project costs for water for individual homes and the other category are relatively minor.

In the California Area, the cost associated with water transmission and distribution needs was not as high as presented by the EPA (2013c). The percentage of the total costs in California is 36.2% while EPA indicates nationally it was approximately 68% for American Indian communities. The percentage of the costs for treatment in California is substantially higher than the national estimates.

Projects for wastewater infrastructure were grouped into five major categories based on project type; which are sewer collection and pumping stations, wastewater treatment, effluent disposal, combinations of collection, treatment, and disposal, and septic for individual homes. The “combination” category was created because there were a significant number of projects for wastewater infrastructure that contained facilities in all the other categories. The tables and figures demonstrate that the category of sewer collection and pumping stations represents the majority of the costs at 49.9%. This is closely followed by the category of combination of collection, treatment, and disposal at 36.8%. Project costs for the remaining categories are relatively minor and range from 6.7% to 1.4%.

While there were only three solid waste infrastructure projects, these were grouped into two major categories based on project type; which are collection stations and open dump closures and clean-up. The tables and figures demonstrate that the category of open dump closures and clean-up represents the majority of the costs at 66.2%. The other category of collection stations had the remaining 33.8% of the project costs.

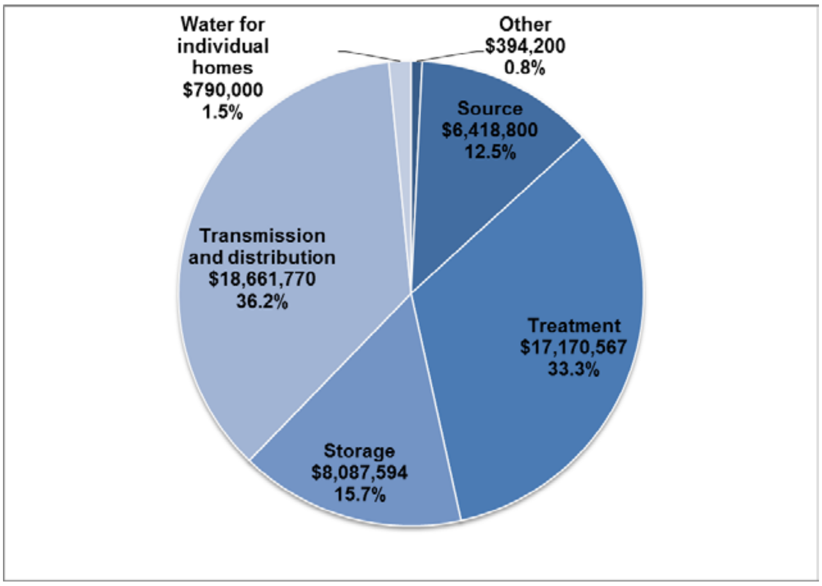
There were a significant number of projects that contained facilities for both water and wastewater infrastructure, and these projects were grouped into four major categories based on project type; which are water supply and septic systems for individual homes, water supply and sewer collection and treatment, water supply and sewer collection, and water source and wastewater disposal. There were no solid waste facilities included in any of these projects. The tables and figures demonstrate that the category of water supply and septic for individual homes represents the majority of the costs at 88.0%. Project costs for the remaining categories are relatively minor and range from 8.2% to 1.1%.

Table 4.12 Project descriptions by total cost

Project description	**Cost**
Water	
Other	$394,200
Source	$6,418,800
Treatment	$17,170,567
Storage	$8,087,594
Transmission and distribution	$18,661,770
Water for individual homes	$790,000
Wastewater	
Effluent disposal	$2,187,301
Septic for individual homes	$465,500
Sewer collection and pumping stations	$16,268,360
Wastewater treatment	$1,685,150
Combination of collection, treatment, and disposal	$11,974,895
Solid waste	
Collection stations	$135,455
Open dump closures and clean-up	$265,523
Water and wastewater	
Water supply and septic for individual homes	$3,941,080
Water supply and sewer collection and treatment	$367,304
Water source and wastewater disposal	$48,200
Water supply and sewer collection	$120,000

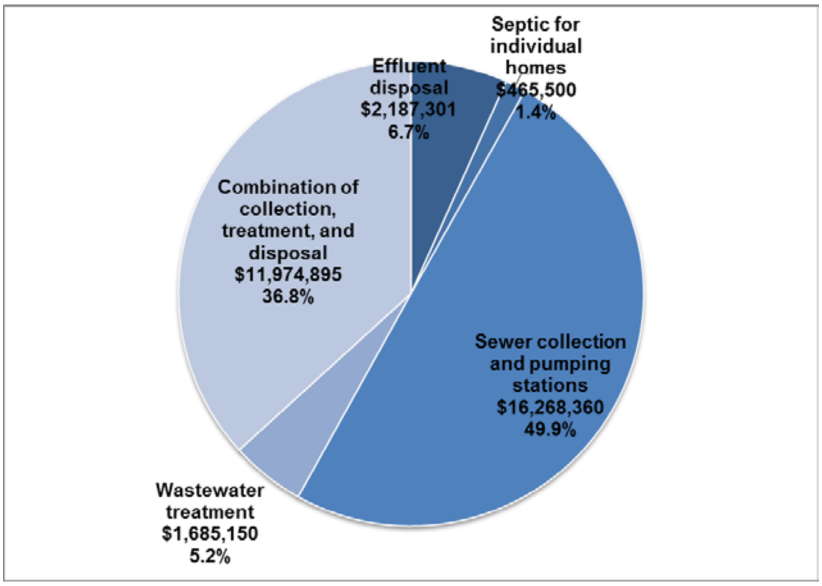
Source: Author

Figure 4.8 Water project category by total cost and percentage



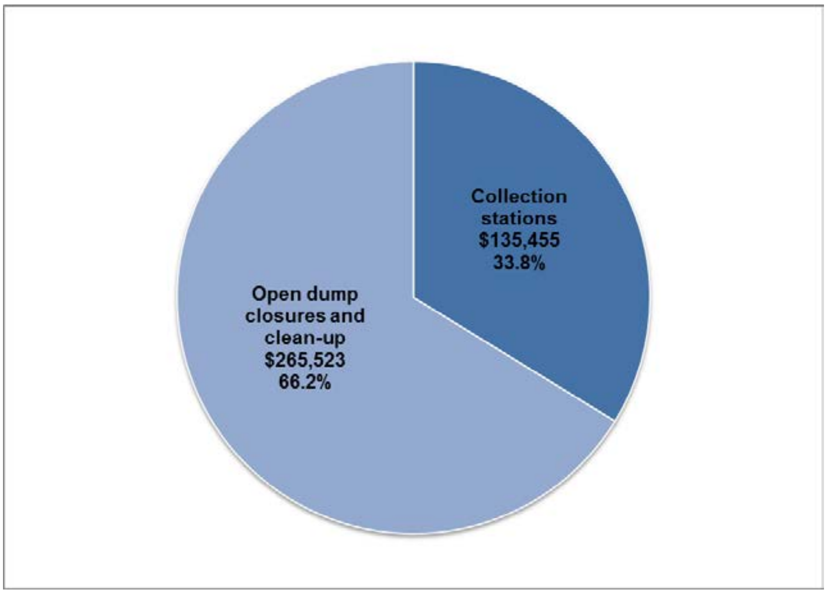
Source: Author

Figure 4.9 Wastewater project category by total cost and percentage



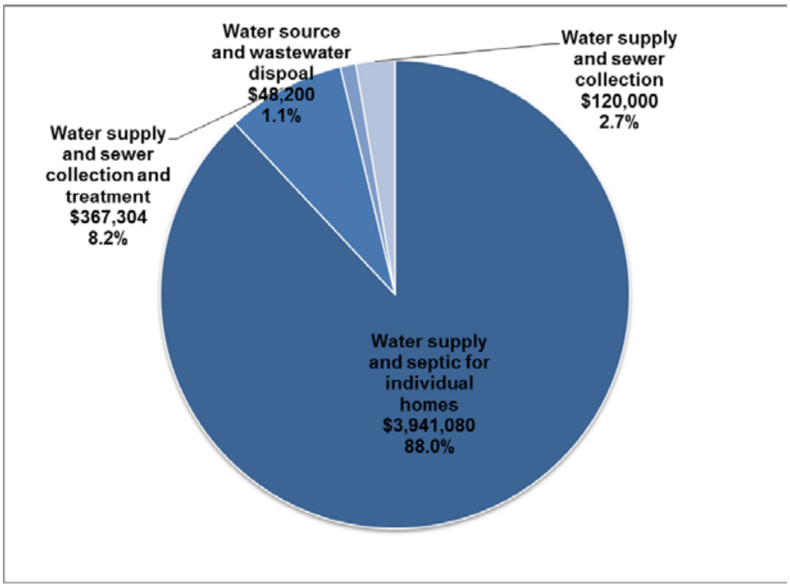
Source: Author

Figure 4.10 Solid waste project category by total cost and percentage



Source: Author

Figure 4.11 Water and wastewater project category by total cost and percentage



Source: Author

4.3.3 PROJECT TYPE BY TOTAL COST

The projects were further divided into four broad categories based on the type of project pertaining to whether it was a capital improvement, replacement and upgrade, study/planning, or emergency, and presented in Table 4.13 and Figure 4.12. The "capital improvement" category represents projects for new, expansion, or system extensions. In addition, this category also includes an increase in service level while addressing system deficiencies. For example, a project may construct a community sewer collection system for homes that have failed individual septic systems. The category of "replacement and upgrade" generally describes projects for replacement of existing facilities without a significant expansion or upscale of the system. The table and figure demonstrates that the category of capital improvement represents the majority of the costs at 54.1%, while replacement and upgrade projects are also a significant cost at 42.2%. Project costs for the remaining categories are relatively minor and range from 2.5% to 1.3%.

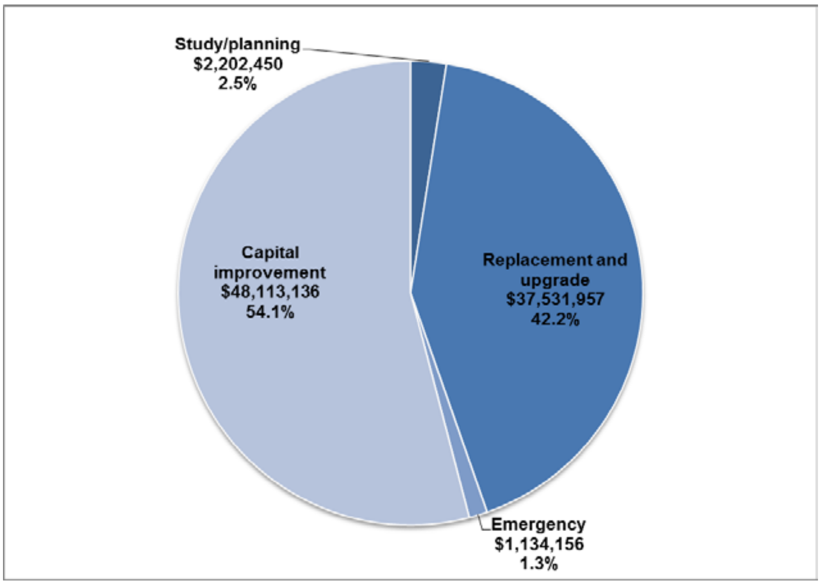
A challenge for the SFC Program is to design adequate facilities to meet the immediate system deficiencies while incorporating provisions for future growth and expansions with the constraint of limited project funding (Brafford, 2013). Typically, projects are designed for the existing homes, and when funds are available, a reasonable percentage for growth (e.g. 15 to 20%) is incorporated into the design. In some cases, however, long-term plans may be an unknown at the time of design. Situations for future upsizing would require a capital improvements project.

Table 4.13 Project types by total cost and number of projects

Project type	Total cost	Number of projects
Study/planning	$2,202,450	34
Replacement and upgrade	$37,531,957	116
Emergency	$1,134,156	24
Capital improvement	$48,113,136	57

Source: Author

Figure 4.12 Project types by total cost and percentages



Source: Author

4.3.4 PROJECT BY INITIAL DEFICIENCY LEVEL

Projects were grouped based on their initial deficiency level (IDL), a main scoring category used in SDS and representative of the overall need for the project, and presented in Table 4.14 and Figure 4.13. Full descriptions and examples of IDLs are provided in Chapter 1, and summarized below:

- **IDL-5:** Lacks a safe water supply and a sewer system.
- **IDL-4:** Lacks either a safe water supply or sewer system.
- **IDL-3:** Inadequate or partial water supply and a sewer system that does not comply with applicable water supply and pollution control laws, or has no solid waste disposal.
- **IDL-2:** Complies with all applicable water supply and pollution control laws, and in which the deficiencies relate to capital improvements that are necessary to improve the facilities.
- **IDL-1:** Complies with all applicable water supply and pollution control laws, and in which the deficiencies relate to routine repair or maintenance needs.

The table and figure demonstrate that IDL 4 projects represent the majority of the funding and number of projects at 67.0% and 60.6%, respectively. The high portion of funded projects for IDL-4 deficiencies is good to see as this is a primary goal for the SFC Program (Brafford, 2013).

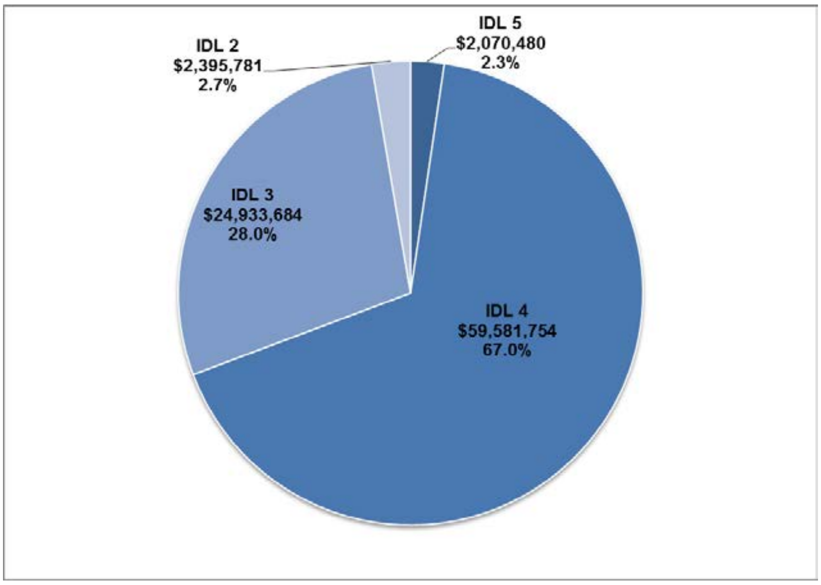
This is closely followed by the IDL 3 projects that represent 28.0% of the funding and 31.2% of the number of projects. Project funding and the number of projects for IDL 2 and 5 are relatively minor at 2.3% and 2.7% for funding and 3.9% and 4.3% for number of projects, respectively. There were no IDL 1 projects. While funding IDL-2 projects only seldom occurs, it does indicate that SDS projects having high scores in other factors could rise into the funding range (Brafford, 2013).

Table 4.14 Project initial deficiency level by total cost and number of projects

IDL	Total cost	Number of projects
IDL 5	$2,070,480	10
IDL 4	$59,581,754	140
IDL 3	$24,933,684	72
IDL 2	$2,395,781	9
IDL 1	$0	0

Source: Author

Figure 4.13 Project initial deficiency levels by total cost and percentage



Source: Author

4.3.5 SDS PROJECT SCORE BY TOTAL COST AND NUMBER OF PROJECTS

Projects were grouped based on their sanitation deficiency system (SDS) project total score, and presented in Table 4.15 and Figures 4.14 and 4.15. The SDS project total score is comprised of eight scoring categories and is the basis of project selection and funding. The highest total score possible is 108 points. The projects were placed into six categories of 90 points and above, 80 to 89 points, 70 to 79 points, 60 to 69 points, 50 to 59 points, and 49 points and lower.

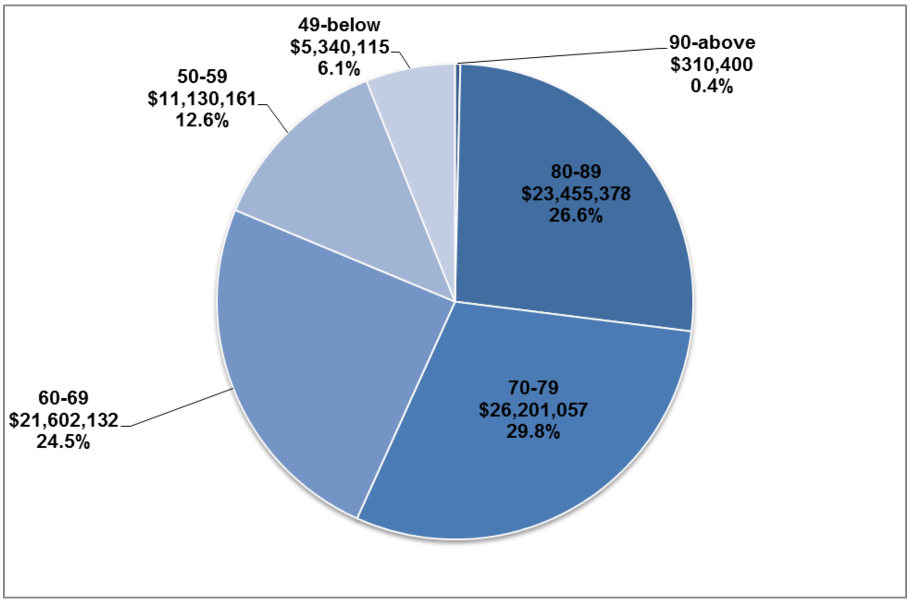
Overall, the figures demonstrate that 80.9% of the funding and 77.8% of the number of projects is for SDS projects with scores in three categories that together range from 60 to 89 points. The funding for SDS projects with scores of 70 to 79, 80 to 89, and 60 to 69 points are fairly evenly distributed at 29.8%, 26.6%, and 24.5%, respectively. However, the number of projects in the categories of 70 to 79 and 60 to 69 make-up the majority at 31.9% and 31.4%, respectively. The number of SDS projects with a score of 80 to 89 points represents 14.5%. Project funding and the number of projects for SDS scores of 90 and above, 50 to 59, and 49 and lower are relatively minor at 0.4% to 12.6% for funding and 1.0% to 14.0% for number of projects, respectively.

Table 4.15 SDS project total score by total cost and number of projects

SDS total point score	Total cost	Number of projects
90-above	$310,400	2
80-89	$23,455,378	30
70-79	$26,201,057	66
60-69	$21,602,132	65
50-59	$11,130,161	29
40-49	$3,111,937	7
30-39	$1,416,900	5
20-29	$811,278	3

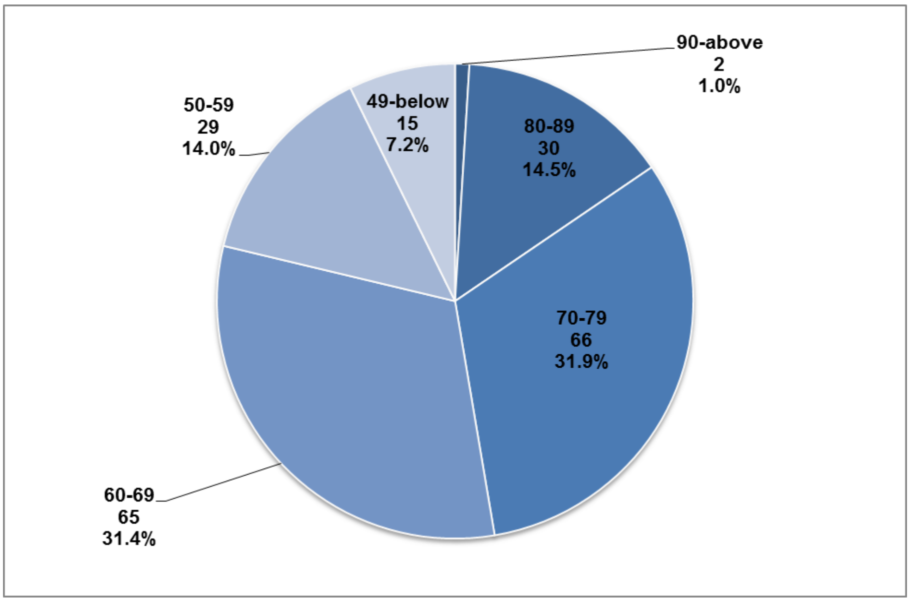
Source: Author

Figure 4.14 SDS project total point scores by total cost and percentage



Source: Author

Figure 4.15 SDS project total point scores by the number of projects and percentage



Source: Author

4.3.6 PROJECTS BY TOTAL COST AND COST PER CAPITA

Projects were grouped based on which American Indian community and tribe they were funded for, and presented in Table 4.16 and Figures 4.16 and 4.17. There were a total of 219 projects funded for 66 Indian communities associated with 51 Indian tribes (e.g. California tribes typically have one main community; however several tribes have multiple communities). The projects served a total of 6,920 homes or an approximate population of 34,600 American Indians. In some cases during the study time period, an American Indian home may have been served by multiple projects; e.g. separate projects for water and sewer service. The total cost of the projects was $86.9 million.

The five Indian tribes that received the highest amount of project funding are in order: Tule River Indian Tribe, Santa Rosa Indian Community, Hoopa Valley Indian Tribe, Yurok Indian Tribe, and the Covelo Indian Community of the Round Valley Indian Reservation. Within this group, the highest amount went to the Tule River Indian Tribe that received 9 projects at a total cost of $17.8 million while the Covelo Indian Community received 12 projects at a total cost of $4.9 million. Of the total $86.9 million in project funding during the study time period, $43.8 million was awarded to projects for the top five Indian tribes listed above; which represents 50.4% of the total project funding being directed to the those five tribes. The remaining 46 Indian tribes received the balance of the project funding; which varied from the lowest amount of US$10,000 to US$1 to 3 million.

While the portion of funding for a particular tribe and community is based on the SDS project scores (e.g. needs in terms of deficiency and health impact levels), it is also important to consider the relative population size of each tribe. The top five tribes listed above that received 50.4% of the project funding have a combined 3,139 of the total 13,208 American Indian homes in the California Area or approximately 24% of the total homes. In addition, the 3,139 homes of the five tribes represent 45.4% of the total homes of the 51 tribes served during the study period. Therefore, while population size is not a specific consideration for funding, it does provide some perspective that a significant portion of funding impacted a large percentage of the SFC Program's service area.

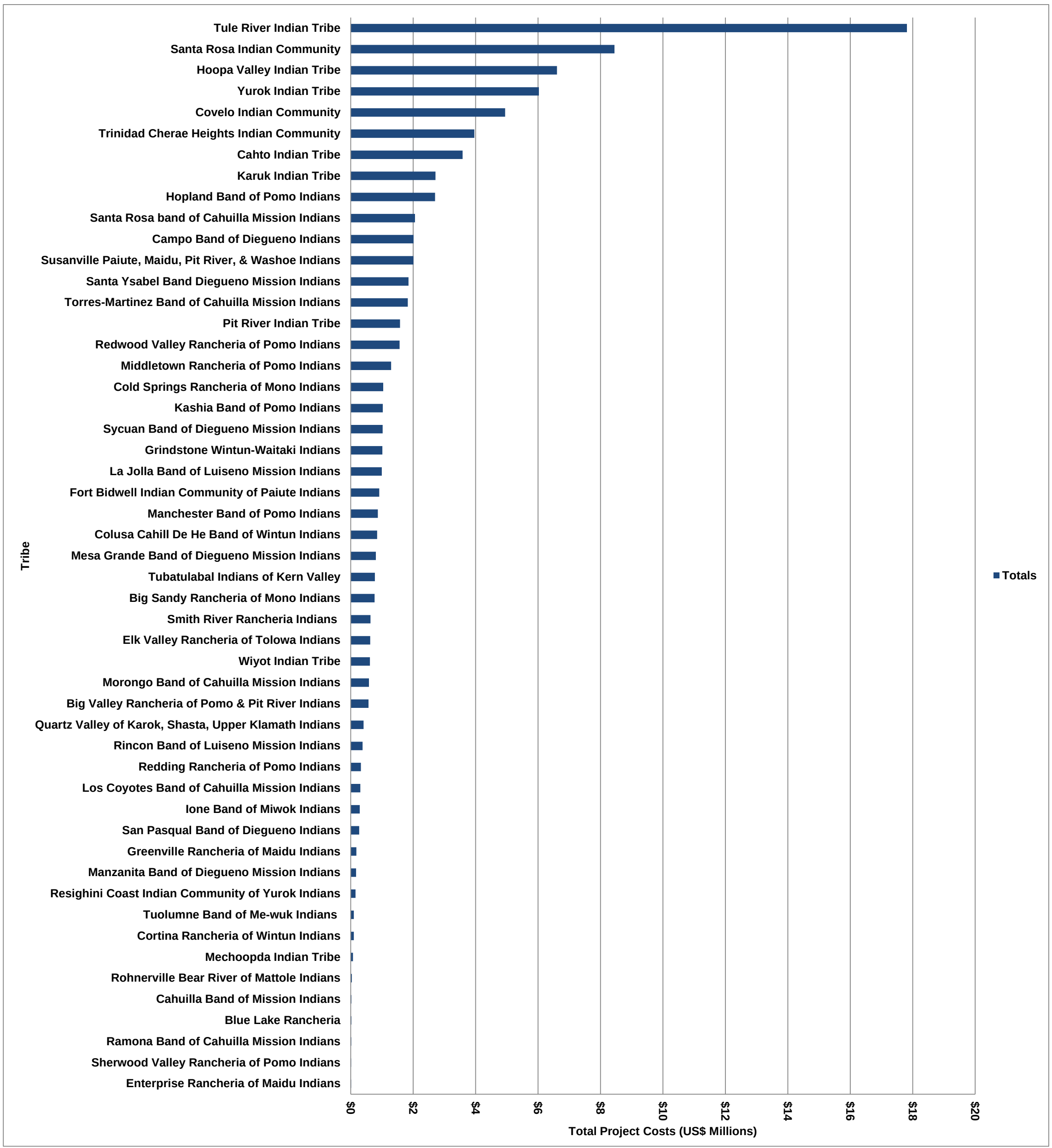
Projects for the tribes were also examined by the cost per American Indian served (e.g. cost per capita). The cost per capita ranged from a high at the Trinidad Cherae Heights Indian Community at $17,216/capita to a low of $36/capita for the Sherwood Valley Rancheria. For the five tribes that received the highest funding, the cost per capita ranged from $7,097/capita to $1,222/capita. The wide range of cost per capita among the 51 tribes is due to a variety of factors. In some cases, projects had a high expense to serve a relatively limited number of homes due to the complexity of the facilities (e.g. water treatment), large scope (e.g. construction of a sewer collection system to replace failed individual septic systems), and constraining site conditions (e.g. limited usable area, poor soil conditions).

Table 4.16 Projects for American Indian tribes by total cost and number of projects

American Indian Reservation	Total cost	No. of projects	No. of homes	Population	US$/capita
Tule River Indian Tribe	$17,812,832	9	502	2,510	$7,097
Santa Rosa Indian Community	$8,445,000	3	264	1,320	$6,398
Hoopa Valley Indian Tribe	$6,605,439	10	1,081	5,405	$1,222
Yurok Indian Tribe	$6,025,924	32	981	4,905	$1,229
Covelo Indian Community	$4,942,270	12	311	1,555	$3,178
Trinidad Cherae Heights Indian Community	$3,959,800	6	46	230	$17,217
Cahto Indian Tribe	$3,580,000	3	116	580	$6,172
Karuk Indian Tribe	$2,711,302	15	472	2,360	$1,149
Hopland Band of Pomo Indians	$2,701,866	5	62	310	$8,716
Santa Rosa band of Cahuilla Mission Indians	$2,058,300	2	38	190	$10,833
Campo Band of Dieguenо Indians	$2,013,177	5	98	490	$4,109
Susanville Paiute, Maidu, Pit River, & Washoe Indians	$2,005,600	5	252	1,260	$1,592
Santa Ysabel Band Diegueno Mission Indians	$1,848,643	9	102	510	$3,625
Torres-Martinez Band of Cahuilla Mission Indians	$1,828,000	5	94	470	$3,889
Pit River Indian Tribe	$1,577,707	8	123	615	$2,565
Redwood Valley Rancheria of Pomo Indians	$1,563,558	4	32	160	$9,772
Middletown Rancheria of Pomo Indians	$1,294,402	1	20	100	$12,944
Cold Springs Rancheria of Mono Indians	$1,040,870	4	49	245	$4,248
Kashia Band of Pomo Indians	$1,024,756	5	18	90	$11,386
Sycuan Band of Diegueno Mission Indians	$1,023,000	2	62	310	$3,300
Grindstone Wintun-Waitaki Indians	$1,012,110	4	37	185	$5,471
La Jolla Band of Luiseno Mission Indians	$993,000	5	178	890	$1,116
Fort Bidwell Indian Community of Paiute Indians	$914,200	6	53	265	$3,450
Manchester Band of Pomo Indians	$865,200	6	79	395	$2,190
Colusa Cahill De He Band of Wintun Indians	$845,100	2	37	185	$4,568
Mesa Grande Band of Diegueno Mission Indians	$801,600	4	56	280	$2,863
Tubatulabal Indians of Kern Valley	$770,056	5	27	135	$5,704
Big Sandy Rancheria of Mono Indians	$764,000	2	46	230	$3,322
Smith River Rancheria Indians	$631,016	4	86	430	$1,467
Elk Valley Rancheria of Tolowa Indians	$625,000	1	17	85	$7,353
Wiyot Indian Tribe	$613,000	2	35	175	$3,503
Morongo Band of Cahuilla Mission Indians	$584,000	2	521	2,605	$224
Big Valley Rancheria of Pomo & Pit River Indians	$570,000	2	92	460	$1,239
Quartz Valley of Karok, Shasta, Upper Klamath Indians	$408,000	1	45	225	$1,813
Rincon Band of Luiseno Mission Indians	$380,000	3	138	690	$551
Redding Rancheria of Pomo Indians	$322,570	3	26	130	$2,481
Los Coyotes Band of Cahuilla Mission Indians	$308,000	3	39	195	$1,579
Ione Band of Miwok Indians	$288,750	1	14	70	$4,125
San Pasqual Band of Diegueno Indians	$272,000	3	217	1,085	$251
Greenville Rancheria of Maidu Indians	$180,000	1	107	535	$336
Manzanita Band of Diegueno Mission Indians	$170,000	1	34	170	$1,000
Resighini Coast Indian Community of Yurok Indians	$150,000	2	41	205	$732
Cortina Rancheria of Wintun Indians	$100,000	2	6	30	$3,333
Tuolumne Band of Me-wuk Indians	$100,000	1	66	330	$303
Mechoopda Indian Tribe	$68,927	1	12	60	$1,149
Rohnerville Bear River of Mattole Indians	$35,000	1	23	115	$304
Cahuilla Band of Mission Indians	$21,000	2	75	375	$56
Blue Lake Rancheria	$20,000	1	13	65	$308
Ramona Band of Cahuilla Mission Indians	$15,000	1	6	30	$500
Enterprise Rancheria of Maidu Indians	$10,000	1	16	80	$125
Sherwood Valley Rancheria of Pomo Indians	$10,000	1	55	275	$36
Totals	$86,909,975	219	6,920	34,600	

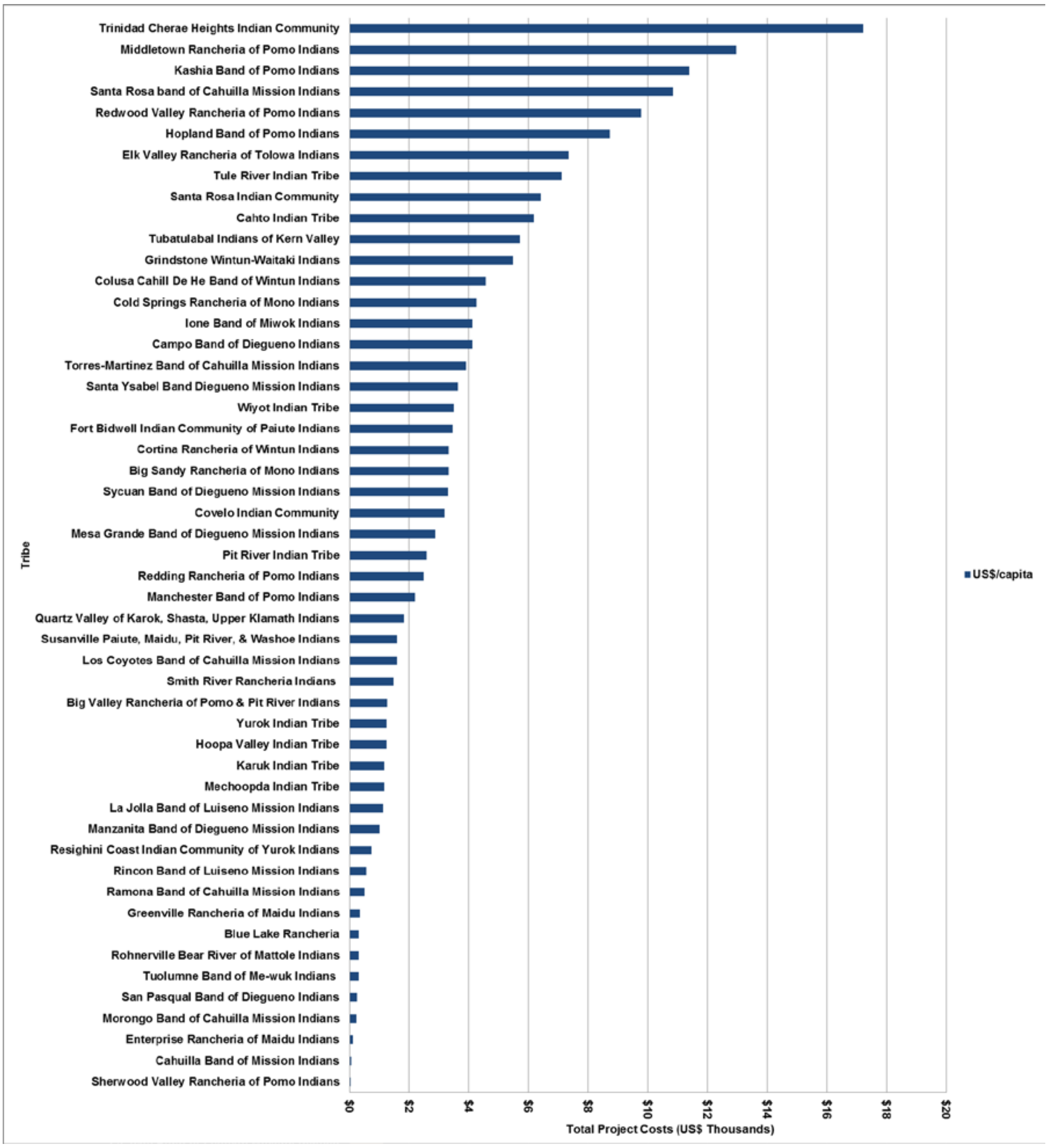
Source: Author

Figure 4.16 2003-2013: Projects for American Indian tribes by total cost



Source: Author

Figure 4.17 2003-2013: Projects for American Indian tribes by cost per capita



Source: Author

4.3.7 SUMMARY

The majority of the SFC Program's projects have been funded for water interventions, and within this broad category, approximately 70% has been for transmission and distribution and treatment facilities. In the California Area, the percentage of the total cost associated with water transmission and distribution needs was not as high as national trends; however the local need for water treatment exceeded national levels. Within the wastewater category, approximately 50% of the funding was for sewer collection and pumping station projects. The majority of all the funded projects were for capital improvements representing facilities for new, expansion, or system extensions. This may in part be a consequence of projects that are designed for limited future growth due to funding constraints or from a lack of information regarding long-term planning.

In most cases, projects are selected to receive funding based on the SDS (e.g. with some exceptions for outside agency funding). The majority of the funded projects addressed IDL-4 deficiencies, which is a long-term measure both for the SFC Program and the EPA. In addition, the majority of the projects had high SDS scores indicating that they generally had significant contributing factors.

Of the nearly US$90 million in project funding during the study period, approximately half was for projects to address deficiencies for five Indian tribes. While this suggests that a significant portion of the funding was for a small portion of the total number of tribes, a perspective based on total American Indian population indicates that these five tribes alone make up approximately 24% of the entire population in the California Area. In addition, the trend that a significant portion of the funding was for IDL-4 and high scoring SDS projects provides weight that the interventions addressed high health impacts for these homes.

4.4 Water and sanitation monitoring

4.4.1 Sanitation deficiency system trends

Key national (e.g. for all IHS Areas) sanitation deficiency data from SDS was assessed for the time period of 2004 to 2013 (data was not available for 2003), and is presented in Table 4.17 and Figures 4.18 and 4.19. The national data indicates that the total feasible project costs (e.g. funding plan) to correct the deficiencies increased from US$859.2 million in 2004 to US$1,637.9 million in 2013, or an increase of 90.6%. The SDS costs to correct deficiencies in water, sewer, and solid waste facilities increased by 70.8%, 126.7%, and 103.8%, respectively. The rate of the increases for all facility types was fairly constant over the time period with a slight spike in 2010.

The total number of American Indian homes at all IDL levels (e.g. IDL-1 to IDL-5) increased from 255,550 in 2004 to 405,586 in 2013, or a rise of 58.7%. The total number of American Indian homes at IDL-4 and IDL-5 (e.g. inadequate facilities) increased from 44,234 in 2004 to 47,835 in 2013, or a growth of 8.1%. Currently, 88% of the American Indian homes have adequate water and sanitation facilities.

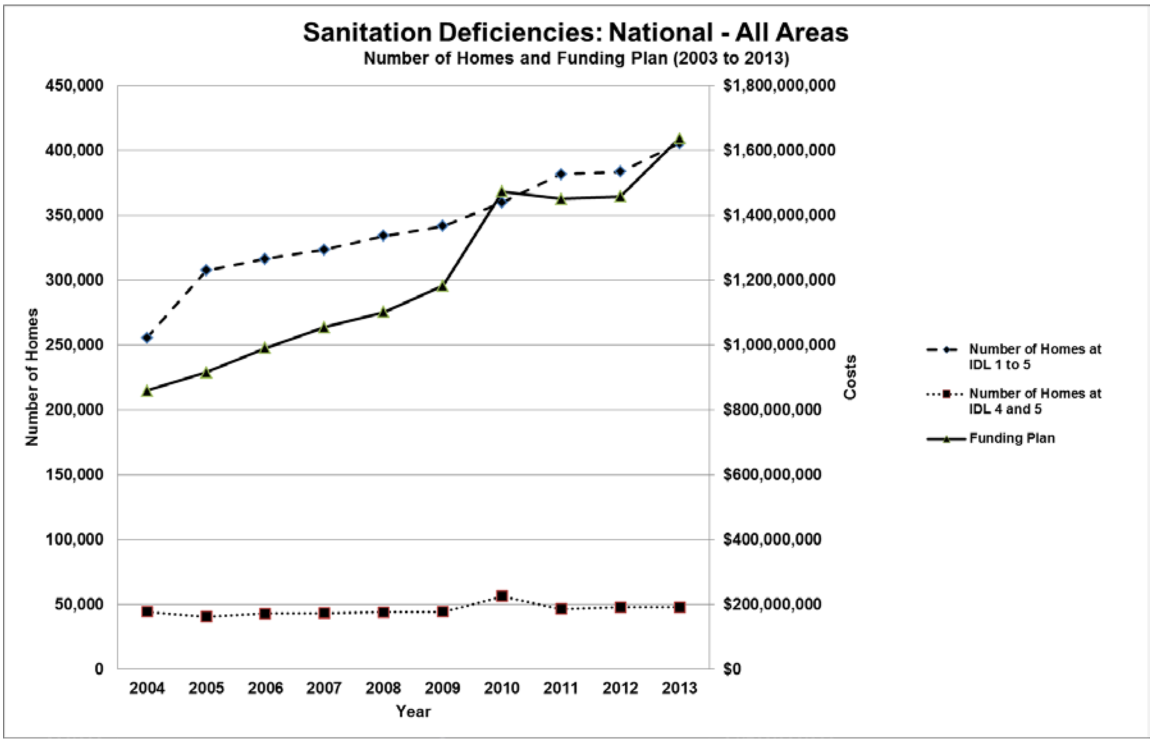
Table 4.17 National SDS data for total costs and homes in 2004 to 2013

Parameter/year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Feasible costs (funding plan) [a]	No data	$859.2	$916.0	$990.5	$1,054.5	$1,102.1	$1,183.7	$1,474.0	$1,450.4	$1,458.7	$1,638.0
Number of homes at IDL 4 and 5	No data	44,234	40,299	42,772	43,032	43,862	44,199	56,148	46,392	47,771	47,835
Number of homes at IDL 1 to 5	No data	255,550	307,584	316,624	323,521	334,218	341,909	359,976	381,692	383,750	405,586
% of homes with sanitation facilities	No data	83%	87%	86%	87%	87%	87%	84%	88%	88%	88%

[a] Funds expressed in million US$

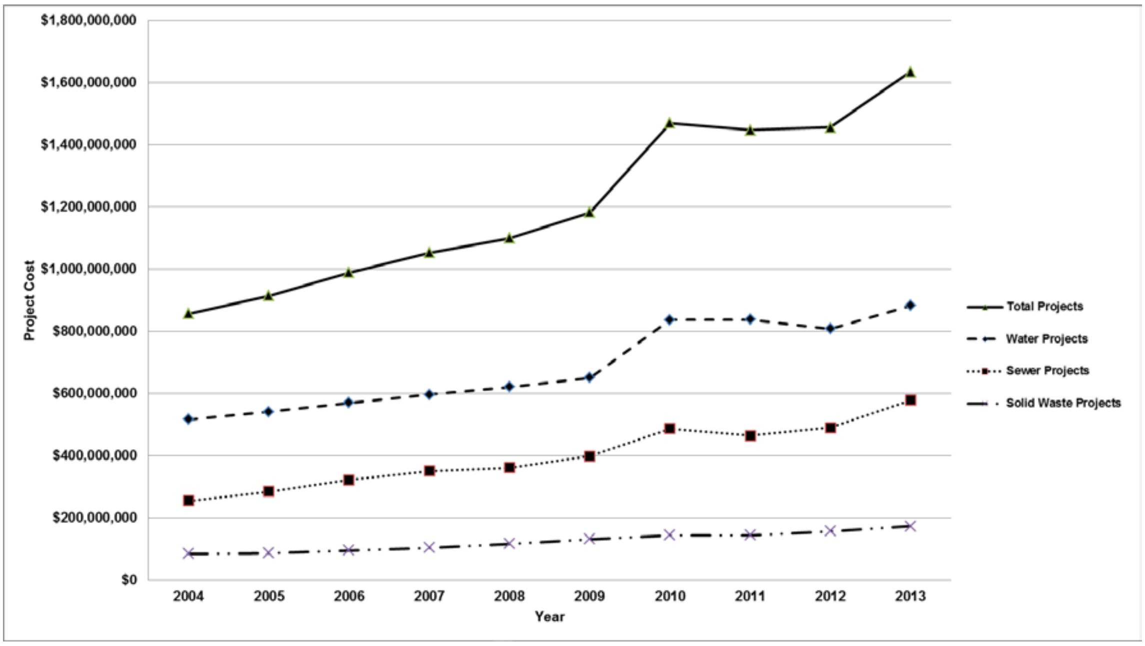
Source: Author

Figure 4.18 National SDS trends for total costs and homes in 2004 to 2013



Source: Author

Figure 4.19 National SDS trends for total costs by facility type in 2004 to 2013



Source: Author

The California Area SDS data for the time period of 2003 to 2013 is presented in Table 4.18 and Figures 4.20 and 4.21. The total feasible project costs increased from US$23.2 million in 2003 to US$94.8 million in 2013, or an increase of 307.8%. The SDS costs to correct deficiencies in water, sewer, and solid waste facilities increased by 318.4%, 374.1%, and 111.6%, respectively. The rate of the increase for water facilities was fairly constant over the time period with a slight spike in 2009. The cost for sewer facilities had a constant increase up to 2009, and then decreased over the past several years. The rate of the increase for solid waste facilities was fairly constant over the time with no significant spikes.

The total number of American Indian homes at all IDL levels increased from 12,545 in 2003 to 13,208 in 2013, or an increase of 5.3%. The total number of American Indian homes at IDL-4 and IDL-5 decreased from 2,751 in 2003 to 2,171 in 2013, or a reduction of 21.1%. Currently, 84% of the American Indian homes in California have adequate water and sanitation facilities.

Over the past 10 years in the California Area there have been more funded projects for water interventions than sewer. Even with these efforts, an opposing trend has occurred that indicates unmet needs for water continue to grow while the rate of sewer needs have decreased. This would suggest that the water system assets across California American Indian communities are numerous, and while much has already been accomplished to address many needs, water system interventions may remain a priority for many more years.

While the rate of SDS sewer costs has decreased since 2009, it may be an unrealistic trend due to many facilities, especially individual septic systems, that are reaching their expected design life (Brafford, 2013). Many systems in American Indian communities were constructed in the 1960s to 1980s following the passage of P.L. 86-121. As many of these original systems now begin to reach the end of their useful life, signs of failure will begin to appear which will create significant deficiencies in many communities. This is applicable for water systems as well. For example, water storage tanks and transmission structures (e.g. pipes) have a design life of approximately 30 to 35 years (EPA, 2004, p. 4). Therefore, these systems constructed in the 1980s may soon be having signs of failure.

The rate of reported deficiencies, expressed as SDS project costs, increased significantly more in California than nationally; 307.8% compared to 90.6%. It may be unrealistic to suggest that this increase is the result of a more pronounced system failure rate in California as compared to national levels. Generally, the IHS constructs facilities in all Areas according to similar standards, specifications, and quality controls. In addition, the increase in water deficiencies does not appear to be specifically related to compliance with EPA regulations (e.g. new treatment systems). Since 2000, the EPA has released only two water quality related regulations – for radionuclides and arsenic (EPA, no date). Instead, the difference in growth between the California Area and national levels may have resulted in part due to additional emphasis and priority the California Area placed on collaborating with the tribes for deficiency identification, reconnaissance, and SDS project development. These efforts began in 2004, and appear to have resulted in significant SDS project development to address system deficiencies. In support of this initiative, the California Area developed supporting guidelines and procedures for their staff.

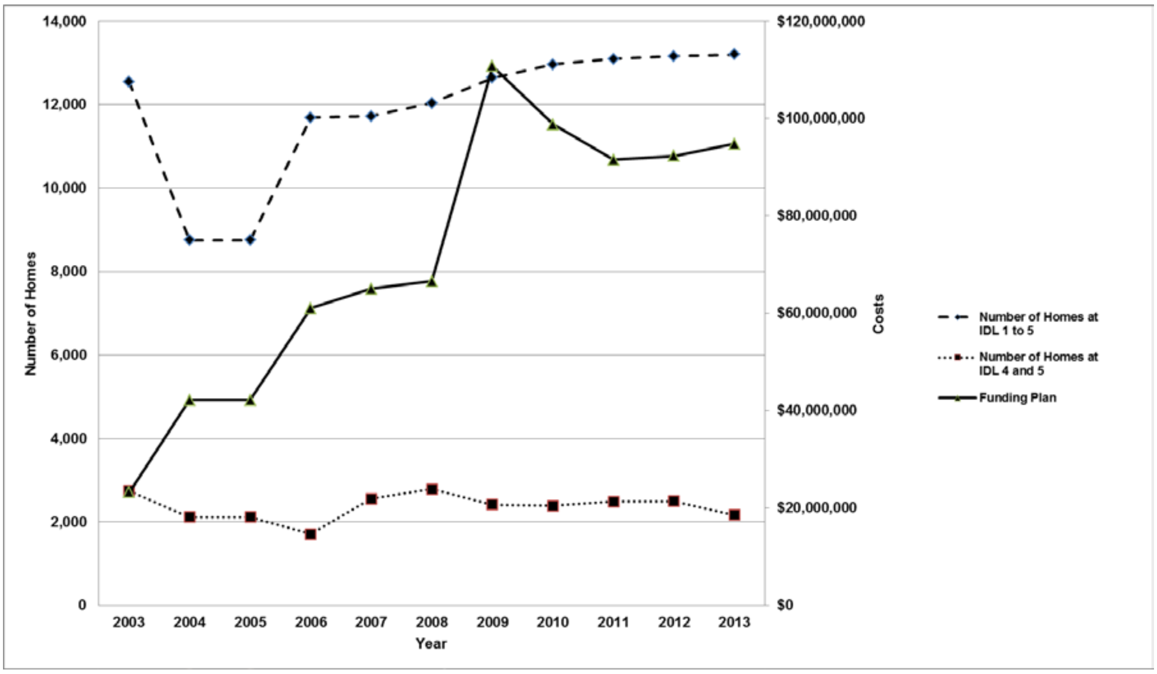
Table 4.18 California Area SDS data for total costs and homes in 2003 to 2013

Parameter/year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Feasible costs (funding plan) [a]	$23.3	$42.2	$42.2	$61.1	$65.1	$66.6	$110.8	$98.8	$91.6	$92.4	$94.8
Number of homes at IDL 4 and 5	2,751	2,121	2,121	1,713	2,557	2,788	2,416	2,391	2,488	2,501	2,171
Number of homes at IDL 1 to 5	12,545	8,759	8,759	11,697	11,725	12,040	12,646	12,972	13,099	13,167	13,208
% of homes with sanitation facilities	78%	76%	76%	85%	78%	77%	81%	82%	81%	81%	84%

[a] Funds expressed in million US$

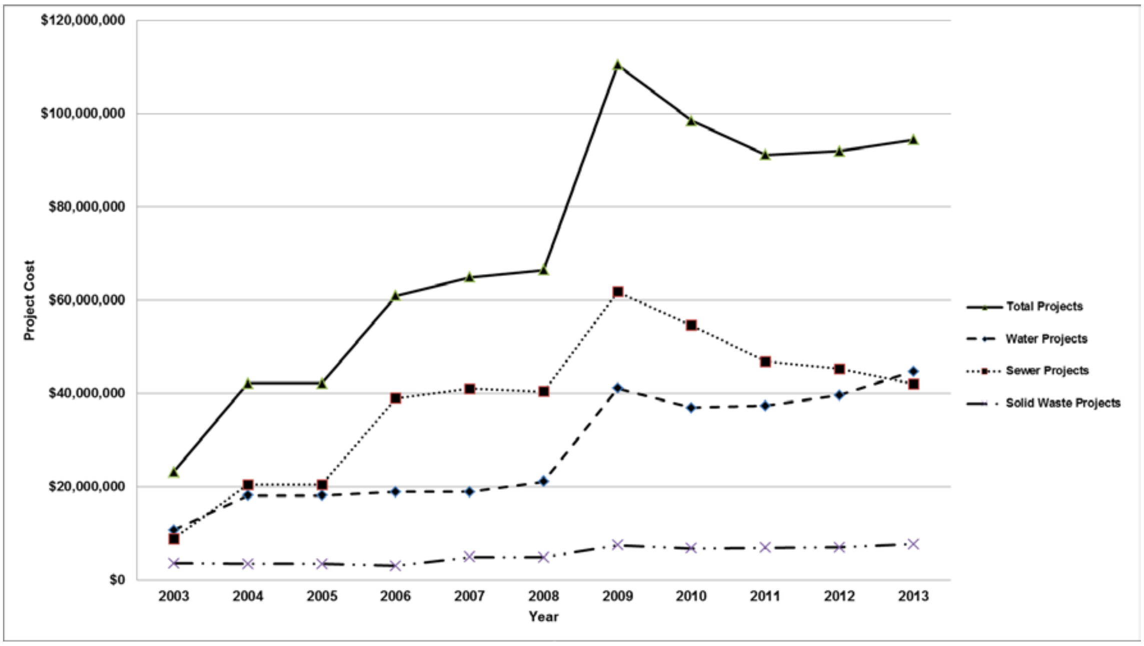
Source: Author

Figure 4.20 California Area SDS data trends for total costs and homes in 2003 to 2013



Source: Author

Figure 4.21 California Area SDS trends for total costs by facility type in 2004 to 2013



Source: Author

4.4.2 EPA MONITORING WITH THE SAFE DRINKING WATER INFORMATION SYSTEM

The EPA monitors tribal public water systems using the database known as the SDWIS, which contains water system information and compliance history with the EPA water quality regulations under the SDWA. A total score is calculated for each system based on their open violations and compiled into an ETT list. A water system with a score of 11 or higher is considered a Significant Non-Complier (SNC). Upon request, the EPA provided the most current ETT list to the IHS for review. A full description of the SDWIS and ETT is provided in Chapter 1.

The April 2013 ETT list for systems with a score of 11 or higher is presented in Figure 4.22. The list indicates that seven tribal public water systems are in this category, and of these, two are community water systems that serve American Indian homes, while the others are either privately operated by non-tribal entities or separate systems that provide water to tribal enterprises and business; e.g. non-residential systems. The two tribal systems on the ETT are the Torres-Martinez (clinic) water system with a score of 75 and the Fort Bidwell Reservation with a score of 19. The Torres-Martinez system compliance issues involve monitoring and reporting (M/R) violations for elevated arsenic levels above the Maximum Contaminant Level (MCL) of 0.010 mg/L (or 0.010 ppm). The Fort Bidwell Reservation water system compliance issues involve M/R violations for the Total Coliform Rule, which requires monthly sampling of total coliform at sites which are representative of water quality throughout the system, and repeat sampling for positive routine samples.

Figure 4.22 EPA ETT list for tribal water systems with a score of 11 or higher

Region	Summary Statistics >>>>>		#PWS >threshold	21	Total Tier 1 Violators:	Total PWS with Compliance Plan in place:
09	Annotated ETT Report Date	6/18/2013	From Data up to:		2	
IHS	ETT Report Date	4/26/2013	12/31/2012			

PWSID	PWS Name	Owner Type	Class	Population	ETT Trend - Reflects updates since 12/31/2012	Current ETT	First Previous ETT	Second Previous ETT	Third Previous ETT
090605130	**Torres-Martinez Clinic**	Tribe	NTNC	266	+	75	20	75	75
090605159	**Duro Mobile Home Park (Desert)**	Private	CWS	25	-	44	36	26	17
090600128	**Fort Bidwell Reservation**	Tribe	CWS	90	-	19	6	0	2
090605160	**DD Mobile Home Park**	Private	CWS	300	-	15	10	5	5
090605109	**Jackson Rancheria Casino & Hotel**	Tribe	CWS	4500	=	15	10	5	1
090605177	**Round Valley Hidden Oaks Casino and Restaurant**	Tribal utility	NTNC	175	+	13	13	13	18
090605113	**Round Valley Health Clinic**	Tribe	NTNC	102	+	11	6	5	5

Unaddressed Violations in Date Range

PWSID	Total Coliform Rule Acute MCL	Nitrate/Nitrite MCL	Inorganics MCL	Radionuclides MCL	SOCs MCL	VOCs MCL	Asbestos MCL	Stage 1 Disinfection By Products Rule MCL	Lead and Copper TT	Surface Water Treatment Rule TT	Surface Water Treatment Rule M/R	Total Coliform Rule MCL
090605130			X									
090605159			X									
090600128												
090605160												
090605109												
090605177												
090605113												

PWSID	Total Coliform Rule M/R	Ground Water Rule Compliance Monitoring M/R	Nitrate/Nitrite M/R	Inorganics M/R	Radionuclides M/R	SOCs M/R	VOCs M/R	Asbestos M/R	Stage 1 Disinfection By Products Rule M/R	Lead and Copper M/R	Public Notice Rule PN	CCR Distribution and Reporting
090605130				X								
090605159	X			X								X
090600128	X								X			
090605160												
090605109												
090605177				X					X	X		
090605113			X							X		

PWSID	Tier1	Date first on list with ETT > threshold	Target RTC Date (best case)	OnPath	Type of Compliance Problem (Infrastructure, Operations & Maintenence, Monitoring and Reporting, Financial, Managerial)	Compliance Status Update - Date Posted
090605130		10/1/2009		Not on Path	IN, MR	Plan to address high As with alternate supply by construction of transmission main from CVWD treated water. Survey and pot holing completed; engineered plans have been reviewed by IHS; staff meetings with BIA on right of way issues
090605159		4/1/2012		Not on Path	IN, MR	Park under federal court orders to close; status of closure schedule (had been 12/31/2012) unknown. CP expired.
090600128		3/31/2013	Target RTC Date (best case): RTC on all but DBPR,	New		Infrastructure: IHS has project for some repairs that should allow them to meet requirements. Plant is now running.
090605160		3/31/2013		New	IN, MR, M	Compliance Plan (CP), schedule allows for correction expired jan 2013; System has been targetted for enforcement, and an inspection completed. Final inspection report not completedSystem has set funds for constructing treatment, but stalled.
090605109		3/31/2013		New		Jackson Rancheria is a community water system - consecutive on a regional state regulated surface water system.
090605177		4/1/2011	Target RTC Date (best case): RTC	Not on	MR	Will be sending a Compliance Plan for Monitoring with Sanitary Survey.
090605113		3/31/2013		New		

Source: EPA SDWIS/ETT (2013) and Banks (2013)

The deficiencies documented in the ETT are also recognized by the IHS. There is an SDS project for the Torres-Martinez system to construct a transmission main to an adjacent non-tribal public system with acceptable water quality. The IHS has a small-scale project to make minor repairs to the Fort Bidwell water treatment system that would bring it into compliance.

4.4.3 SUMMARY

The remaining deficiencies for California American Indian communities are significant and increasing at a large rate. Since 2003, the deficiencies, expressed as feasible SDS project costs, have increased by 307.8%, which is larger than national trends. In particular, costs to correct deficiencies in water and sewer have increased by over 300%. In 2009, a change occurred when water deficiencies increased at a higher rate while the cost for sewer facilities decreased. For the first time in 10 years, the total cost to address water deficiencies is greater than sewer.

It is therefore surprising that even though over the past 10 years the California Area has funded more projects for water interventions than sewer, the rate of growth of remaining water deficiencies out paces sewer needs. This suggests that water system assets across California American Indian communities are numerous, and while much has been accomplished, there remains a significant water need. Accomplishments in achieving the IHS mission goals are reflected in that percentage of American Indian homes with adequate water and sanitation facilities have increased from 78% to the current level of 84%. In addition, many systems originally constructed in the 1960s to 1980s will begin to reach their useful design life, and show signs of failure.

A critical component of addressing system deficiencies is site reconnaissance, documentation, and developing a feasible SDS project to correct the need. It appears that the California Area has been active and made a significant impact in this effort as demonstrated by the large increase in the SDS project portfolio of documented needs.

Based on a review of the EPA's ETT database, water systems with compliance issues have also been recognized by IHS in the form of projects to address the issues. However, there is no connection between the two agency databases, and there is no established protocol to share and coordinate information. While it is encouraging that the two identified systems with issues are being addressed by the IHS, it appears to have happened more by chance than design.

5 RESULTS – HEALTH IMPACT AND SYSTEM SUSTAINABILITY

5.1 INTRODUCTION

This chapter provides results and discussion of the research findings for the sub-units of health impact and system sustainability; which are all intertwined with the impact of the SFC Program's interventions on the American Indian populations. The information was obtained through multiple methods including desktop reviews of documents, in-the-field observations, and interviews. The tables and graphs presented in this chapter were generated by the author using data from IHS STARS, IHS RPMS, and the findings from the capacity questionnaire, except where otherwise noted.

5.2 HEALTH IMPACT

5.2.1 INTRODUCTION

Health indicator data for patients diagnosed with gastrointestinal and viral hepatitis diseases (GI & VH) and upper respiratory infections (URI) were evaluated for 32 American Indian communities, which represent 27 different tribes. The communities combined have a total of 3,355 American Indian homes or an approximate population of 16,800; which represents approximately 25% of the total American Indian population served by the IHS California Area.

The health data is from 2000 to 2013 (to May only), and represents a composite from all 14 tribal health programs. The names of the tribal health program, community, and associated tribe are listed in Table 5.1.

A composite of the health data for all 14 tribal health programs is summarized by year in Table 5.2 and Figure 5.1. The table provides the number of patients diagnosed with GI & VH, URI, their totals, and the total number of patients for a given year along with the percentage of patients diagnosed with the diseases.

Over this time period, the 14 tribal health programs had a mean of 210 patients per year with GI &VH and URI and a standard deviation of 57 patients. The table and figure demonstrate an overall decrease from the initial time period to 2009 when there was a significant spike primarily in the URI diseases. The spike in URI cases is associated with the 2009 H1N1 influenza (e.g. flu) pandemic that occurred (CDC, 2010). More cases of the flu were reported in 2009 than other years because of H1N1 (Brennan, 2013). After 2009, the rates generally decreased again to the present values.

Table 5.1 Tribal health program, community, and tribe

Tribal health program	Community	Tribe
Central Valley Indian Health	Aub-Big Sand	Big Sandy Rancheria of Mono Indians
	Cold Spgs Ar	Cold Springs Rancheria of Mono Indians
Consolidated Tribal Health Project	Hopland Rnch	Hopland Band of Pomo Indians
	Redwood Valley Rnch	Redwood Valley Rancheria of Pomo Indians
	Sherwd V. Rn	Sherwood Valley Rancheria of Pomo Indians
Indian Health Council, Inc.	La Jolla Rsv	La Jolla Band of Luiseno Mission Indians
	Los Coyotes Resv	Los Coyotes Band of Cahuilla Mission Indians
	Mesa Grande Resv	Mesa Grande Band of Diegueno Mission Indians
	Rincon Resv	Rincon Band of Luiseno Mission Indians
	San Pasqual Resv	San Pasqual Band of Diegueno Indians
	Santa Ysabel Resv	Santa Ysabel Band Diegueno Mission Indians
Karuk Tribe	Happy Camp	Karuk Indian Tribe
K'ima:w Medical Center	Ext. N. To Joh. Vil.	Yurok Indian Tribe
	Hoopa Valley East	Hoopa Valley Indian Tribe
	Salyer Area	Karuk Indian Tribe
Lake County Tribal Health	Big Valley	Big Valley Rancheria of Pomo & Pit River Indians
	Upper Lake	Upper Lake Band of Pomo Indians
Northern Valley Indian Health	Cortina Rnch	Cortina Rancheria of Wintun Indians
	Grindstone	Grindstone Wintun-Waitaki Indians
Pit River Health Service, Inc	Burney	Pit River Indian Tribe
	Lookout Rnch	Pit River Indian Tribe
	Montgomery Crk Rnch	Pit River Indian Tribe
	Roaring Crk	Pit River Indian Tribe
	X-L Ranch Rn	Pit River Indian Tribe
Quartz Valley Program	Quartz Valley Rnch	Quartz Valley Karok, Shasta, Upper Klamath Indians
Riverside/San Bernardino County Indian Health	Snta'Rosa Rs	Santa Rosa Band of Cahuilla Mission Indians
	Torres-Martinez Resv	Torres-Martinez Band of Cahuilla Mission Indians
Round Valley Indian Health	Round Valley Res	Covelo Indian Community
Sonoma County Indian Health	Point Arena	Manchester Band of Pomo Indians
	Stewarts Point	Kashia Band of Pomo Indians
Southern Indian Health Council	Campo Resv.	Campo Band of Diegueno Indians
Tuolumne Me-Wuk Indian Health	Tuolumne Rnch	Tuolumne Band of Me-wuk Indians

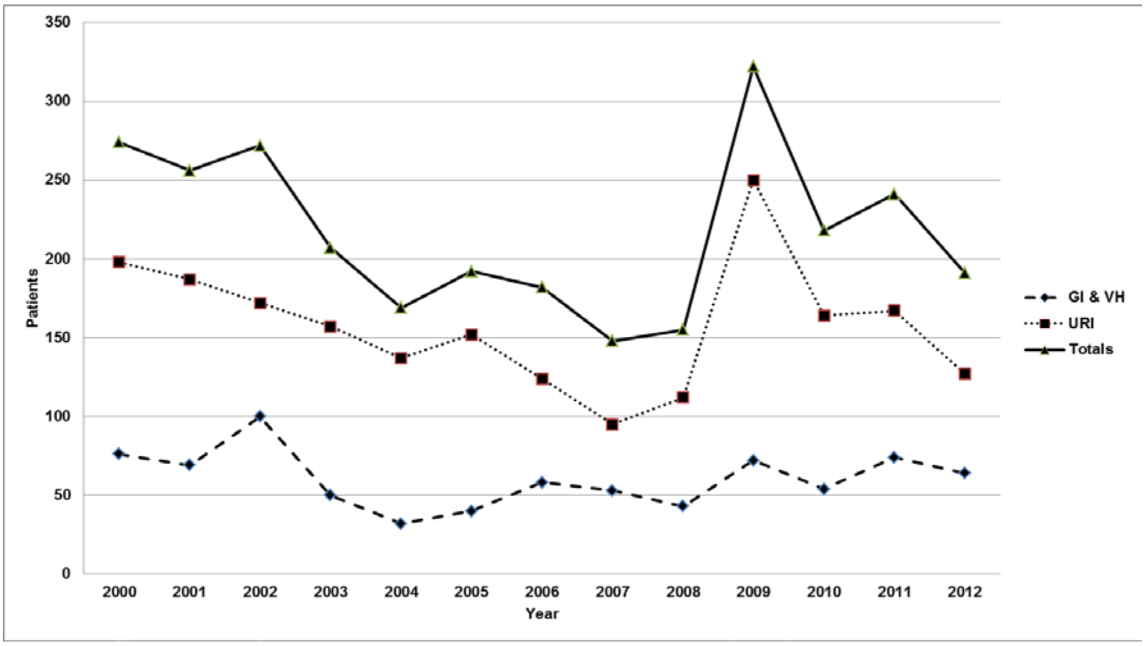
Source: IHS RPMS (2013) and IHS STARS (2013)

Table 5.2 Health indicators for California American Indian communities 2000 to 2013

Year	GI & VH	URI	Total	Patients	Percent
2000	76	198	274	45,232	0.61%
2001	69	187	256	47,474	0.54%
2002	100	172	272	51,556	0.53%
2003	50	157	207	53,675	0.39%
2004	32	137	169	54,474	0.31%
2005	40	152	192	56,899	0.34%
2006	58	124	182	57,263	0.32%
2007	53	95	148	58,305	0.25%
2008	43	112	155	63,922	0.24%
2009	72	250	322	68,976	0.47%
2010	54	164	218	70,037	0.31%
2011	74	167	241	71,428	0.34%
2012	64	127	191	75,276	0.25%
2013	42	79	121	62,813	0.19%
Totals	827	2,121	2,948	837,330	

Source: Author

Figure 5.1 Health indicators for California American Indian communities 2000 to 2013



Source: Author

For data comparison, a “baseline” or initial period was defined as the average of health data from 2000 to 2002, and a present period defined as the average of values from 2011 to 2012, which are presented in Tables 5.3, 5.4, and 5.5. The tables demonstrate a decrease from the initial time period to the present. The total number of GI & VH and URI patients decreased from an average of 267 to 217, a reduction of 50 patients per year or 18.7%. However, despite this overall trend, there was a significant spike in 2009 with a total of 322 patients. The increase in 2009 is associated with the 2009 H1N1 flu pandemic.

While there was a decrease in patients from the initial to the present period, it may not be statistically significant. By convention, studies consider a p-value (i.e. probability value) of less than 0.05 to indicate that the observed differences are statistically significant (Yin, 2014, p. 36). The statistical p-value summarizes how much agreement there is between the data and the null hypothesis (Wonnacott, 1985, p. 263). For this data, the p-value was 0.27, which indicates the difference between these two periods was not statistically significant.

Table 5.3 Initial health indicators 2000 to 2002

	Average of 2000 to 2002				
Tribal Health Program	**GI & VH**	**URI**	**Total**	**Patients**	**Percent**
Central Valley Indian Health	1	5	7	5,890	0.11%
Consolidated Tribal Health Project	2	5	7	2,883	0.23%
Indian Health Council, Inc.	43	47	90	3,980	2.25%
Karuk Tribe	2	9	11	2,800	0.40%
K'ima:w Medical Center	20	17	37	3,839	0.96%
Lake County Tribal Health	2	2	4	1,803	0.24%
Northern Valley Indian Health	0	0	1	4,073	0.02%
Pit River Health Service, Inc	6	55	61	1,106	5.49%
Quartz Valley Program	0	0	0	0	0.00%
Riverside/San Bernardino County Indian Health	0	0	0	9,937	0.00%
Round Valley Indian Health	3	37	40	2,121	1.89%
Sonoma County Indian Health	0	4	4	3,939	0.11%
Southern Indian Health Council	3	3	6	5,713	0.11%
Tuolumne Me-Wuk Indian Health	0	0	0	2	0.00%
Totals	82	186	267	48,087	0.56%

Source: Author

Table 5.4 Present health indicators 2010 to 2012

	Average of 2010 to 2012				
Tribal Health Program	**GI & VH**	**URI**	**Total**	**Patients**	**Percent**
Central Valley Indian Health	1	8	9	7,766	0.11%
Consolidated Tribal Health Project	3	8	11	3,255	0.34%
Indian Health Council, Inc.	8	24	32	4,936	0.66%
Karuk Tribe	2	18	19	4,259	0.45%
K'ima:w Medical Center	21	5	26	3,769	0.69%
Lake County Tribal Health	0	2	2	3,547	0.06%
Northern Valley Indian Health	0	0	0	13,371	0.00%
Pit River Health Service, Inc	4	12	16	1,323	1.21%
Quartz Valley Program	0	5	5	808	0.66%
Riverside/San Bernardino County Indian Health	0	0	0	11,837	0.00%
Round Valley Indian Health	5	42	47	2,034	2.29%
Sonoma County Indian Health	2	4	6	6,103	0.10%
Southern Indian Health Council	9	15	24	5,034	0.47%
Tuolumne Me-Wuk Indian Health	8	11	19	4,206	0.46%
Totals	64	153	217	72,247	0.30%

Source: Author

Table 5.5 Trend in health indicators 2000/2002 to 2010/2012

	Avg 2000 to 2002		Avg 2010 to 2012		Change	
Tribal Health Program	**Total**	**Patients**	**Total**	**Patients**	**Total**	**Percent**
Central Valley Indian Health	7	5,890	9	7,766	2	0.00%
Consolidated Tribal Health Project	7	2,883	11	3,255	4	0.11%
Indian Health Council, Inc.	90	3,980	32	4,936	-57	-1.60%
Karuk Tribe	11	2,800	19	4,259	8	0.05%
K'ima:w Medical Center	37	3,839	26	3,769	-11	-0.27%
Lake County Tribal Health	4	1,803	2	3,547	-2	-0.18%
Northern Valley Indian Health	1	4,073	0	13,371	0	-0.01%
Pit River Health Service, Inc	61	1,106	16	1,323	-45	-4.28%
Quartz Valley Program	0	0	5	808	5	0.66%
Riverside/San Bernardino County Indian Health	0	9,937	0	11,837	0	0.00%
Round Valley Indian Health	40	2,121	47	2,034	7	0.41%
Sonoma County Indian Health	4	3,939	6	6,103	2	-0.01%
Southern Indian Health Council	6	5,713	24	5,034	17	0.36%
Tuolumne Me-Wuk Indian Health	0	2	19	4,206	19	0.46%
Totals	268	48,087	217	72,247	-51	-0.26%

Source: Author

During the baseline time period of 2000 to 2002, the analysis discovered that 7 of the 32 American Indian communities had GI & VH and URI patient totals higher than one standard deviation (15 patients) above the mean (8 patients). The 7 communities are La Jolla, Rincon, San Pasqual, Santa Ysabel, Hoopa Valley, Burney, and Round Valley, and are presented in Table 5.6.

For these seven communities, there was a total decrease from 199 patients in the initial period to 111 patients in the present period, a reduction of 88 patients or approximately 44%. In addition, the decrease in patients was statistically significant. The p-value between the two periods was 0.039; which is less than 0.05 that generally indicates that the observed differences are statistically significant.

The seven communities were evaluated individually. In particular, the analysis examined the changes in disease rates compared to water and sanitation interventions over the same time period, and described the causal relationship based on the disease pattern to the number of projects, project type, and sequence. Caution was used to associate a causal relationship for communities with less than 20 patients as the variation in disease rates may also be influenced by other factors including normal variance, patient health status, and a tribal health program's resources and priorities, such as administering the annual flu vaccinations (Brennan, 2013).

Table 5.6 Indian communities with health indicators exceeding standard deviation

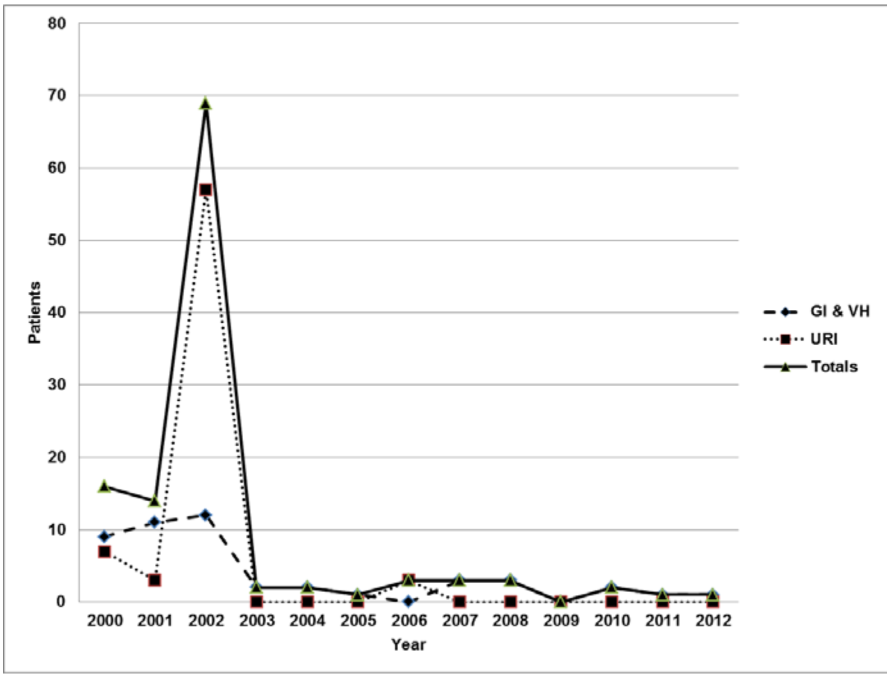
	Avg 2000 to 2002			**Avg 2010 to 2012**			
Community	**GI & VH**	**URI**	**Total**	**GI & VH**	**URI**	**Total**	**Change**
La Jolla Rsv	10.67	22.33	33.00	1.33	0.00	1.33	-31.67
Rincon Resv	12.67	10.67	23.33	2.67	10.67	13.33	-10.00
San Pasqual Resv	10.33	5.67	16.00	1.67	6.67	8.33	-7.67
Santa Ysabel Resv	4.67	7.33	12.00	2.00	4.33	6.33	-5.67
Hoopa Valley East	18.67	5.67	24.33	20.00	1.67	21.67	-2.67
Burney	5.00	45.33	50.33	4.33	9.67	14.00	-36.33
Round Valley Res	3.00	37.00	40.00	5.00	41.67	46.67	6.67

Source: Author

5.2.2 LA JOLLA INDIAN COMMUNITY

The La Jolla Indian community had an average of 33 patients with GI & VH and URI during the initial time period. The totals improved to an average of 1 patient at present; which represents a reduction of 96.9%. Figure 5.2 generally represents a sharp decrease in patients after 2002, and then followed by a relatively constant rate to the present time.

Figure 5.2 La Jolla Indian community health indicators for 2000 to 2012



Source: Author

During the time period, there were a total of 4 interventions – 3 water projects and 1 sewer project, which are summarized in Table 5.7. The water projects primarily addressed deficiencies in the source and the sewer project was for effluent disposal. Beginning in 2000, the projects occurred over fairly even intervals up to 2010. The number of projects, project type, sequence, and number of patients in the study group in relation to the disease pattern suggests an impact from the interventions.

Table 5.7 La Jolla Indian community interventions for 2000 to 2012

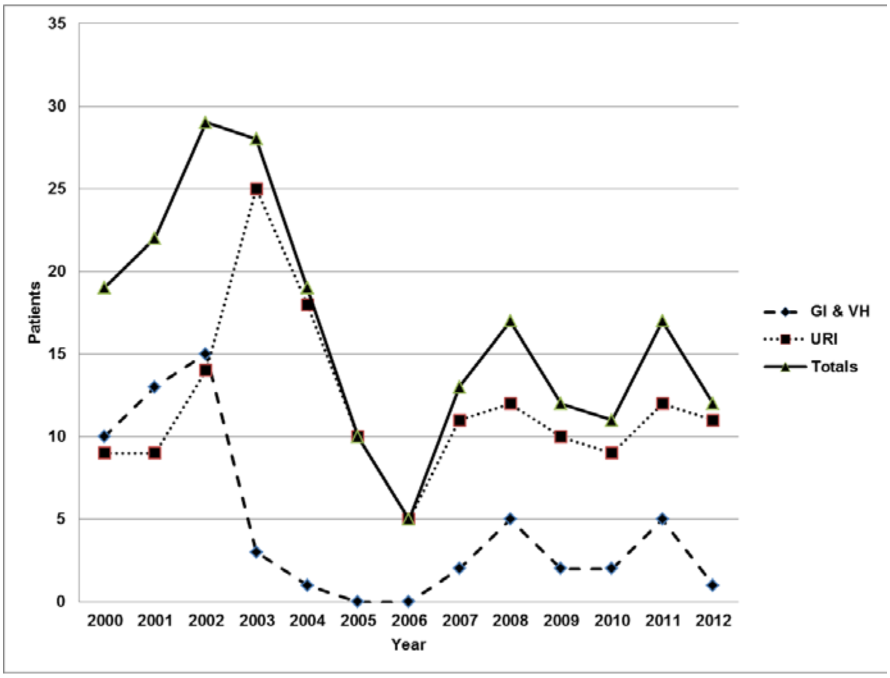
Year	Number	Project category	Project description
2000	O43	Water	Source, treatment
2005	L59	Sewer	Effluent disposal
2007	O71	Water	Source
2010	E10	Water	Source

Source: Author

5.2.3 RINCON INDIAN COMMUNITY

The Rincon Community had an average of 23 patients with GI & VH and URI during the initial time period. The totals decreased to an average of 14 patients at present; which represents a reduction of 37.7%. Figure 5.3 generally represents a steady decrease in patients after 2002 to 2006 when there were some fluctuations to the present time period.

Figure 5.3 Rincon Indian community health indicators for 2000 to 2012



Source: Author

During the time period, there were a total of 3 interventions for water, which are summarized in Table 5.8. The water projects primarily addressed deficiencies in the source, treatment, storage, and transmission and distribution. Beginning in 2000, the projects occurred over fairly even intervals up to 2010. The number of projects, project type, sequence, and number of patients in the study group in relation to the disease pattern suggests a moderate impact from the interventions. In particular, there were decreases in disease following each intervention. However, there were steep disease spikes shortly after.

Table 5.8 Rincon Indian community interventions for 2000 to 2012

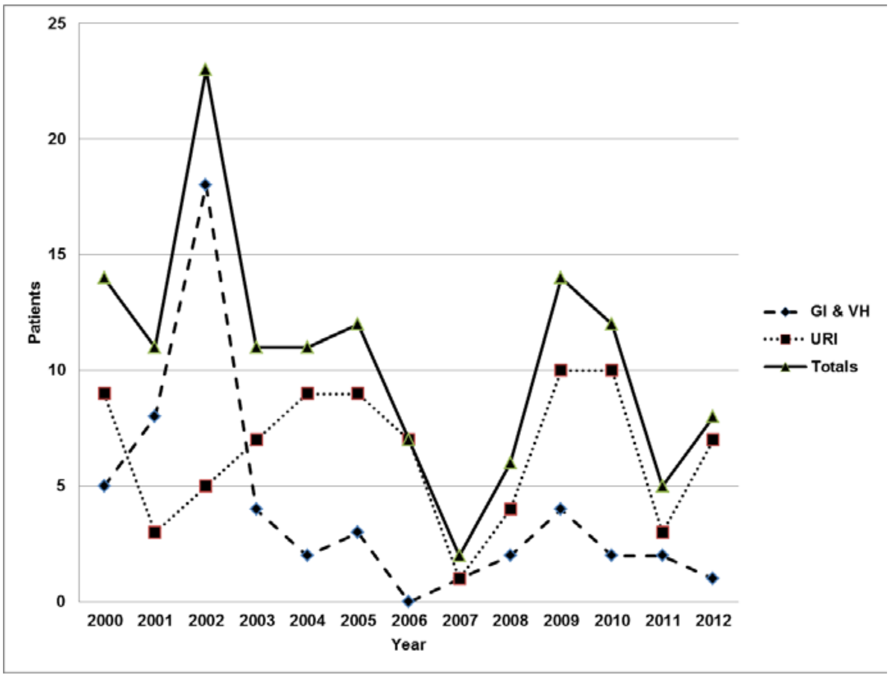
Year	Number	Project category	Project description
2000	O38	Water	Source, treatment
2007	L95	Water	Storage
2010	M19	Water	Transmission and distribution

Source: Author

5.2.4 SAN PASQUAL INDIAN COMMUNITY

The San Pasqual Community had an average of 16 patients with GI & VH and URI during the initial time period. The totals improved to an average of 6 patients at present; which represents a reduction of 59.3%. Figure 5.4 generally represents a steady decrease in patients after 2002 to 2008 when there were some fluctuations to the present time period. This community did have a significant increase during 2009, spiking to 14 patients.

Figure 5.4 San Pasqual Indian community health indicators for 2000 to 2012



Source: Author

During the time period, there was 1 intervention for water and sewer, which is summarized in Table 5.9. The project primarily addressed deficiencies in the water source and sewer effluent disposal. The project occurred in 2000, which was followed by a decrease in the disease rate until 2007 when there was a significant increase in 2009 followed by another drop in the rate. The number of projects, project type, sequence, and number of patients (e.g. less than 20) in the study group in relation to the disease pattern does not suggest an impact from the interventions, and therefore, no strong causal relationship.

Table 5.9 San Pasqual Indian community interventions for 2000 to 2012

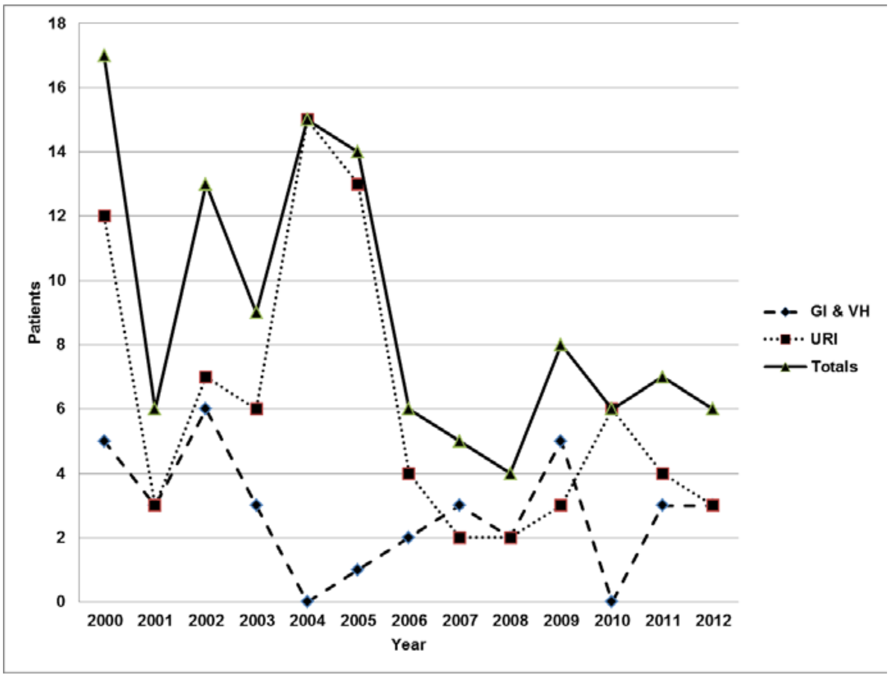
Year	Number	Project category	Project description
2000	O42	Water and sewer	Water source and sewer effluent disposal

Source: Author

5.2.5 SANTA YSABEL INDIAN COMMUNITY

The Santa Ysabel Community had an average of 12 patients with GI & VH and URI during the initial time period. The totals decreased to an average of 6 patients at present; which represents a reduction of 45.8%. Despite the overall decreasing trend, the Figure 5.5 demonstrates several significant fluctuations including spikes in 2004 and 2009.

Figure 5.5 Santa Ysabel Indian community health indicators for 2000 to 2012



Source: Author

During the time period, there were a total of 8 interventions – 7 water projects and 1 sewer project, which are summarized in Table 5.10. The water projects primarily addressed deficiencies in the source, treatment, storage, and transmission and distribution, and the sewer project was for septic systems for individual homes. Beginning in 2000, the projects occurred over fairly even intervals up to 2010. The number of projects, project type, sequence, and number of patients (e.g. less than 20) in the study group in relation to the disease pattern does not suggest an impact from the interventions. While there were numerous interventions for this community, there is not a strong case for a causal relationship. While there were decreases in disease following interventions, there were also sharp disease spikes throughout this time period particularly in 2002, 2004, and 2009.

Table 5.10 Santa Ysabel Indian community interventions for 2000 to 2012

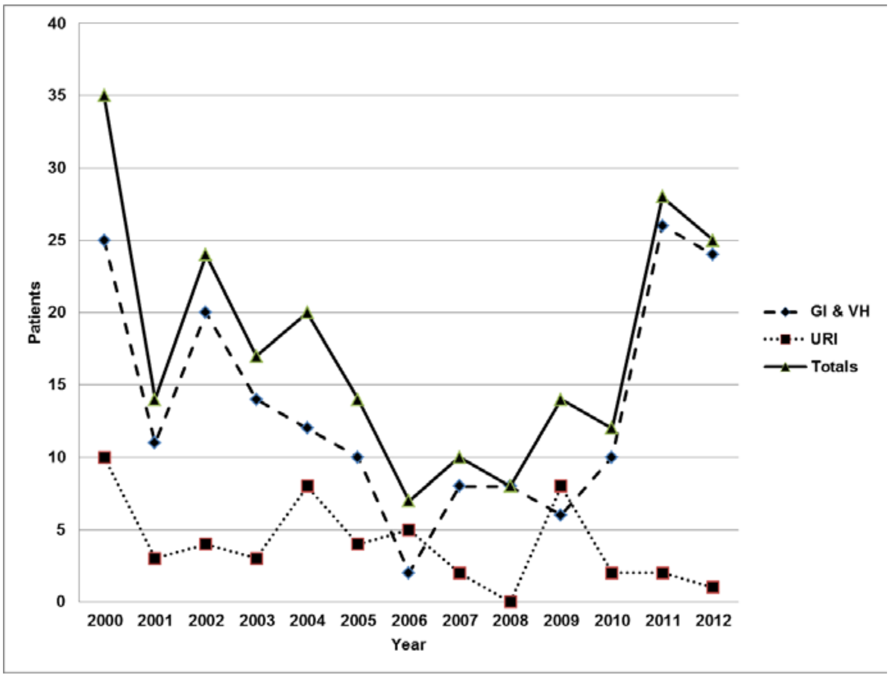
Year	Number	Project category	Project description
2000	O39	Water	Source, treatment
2006	L76	Water	Storage
2006	O67	Water	Storage
2007	C06	Water	Source
2008	O80	Water	Transmission and distribution
2008	M09	Water	Transmission and distribution
2010	M17	Sewer	Septic systems for individual homes
2010	M52	Water	Treatment and storage

Source: Author

5.2.6 HOOPA VALLEY INDIAN COMMUNITY

The Hoopa Valley Community had an average of 24 patients with GI & VH and URI during the initial time period. Significantly, the totals increased to an average of 26 patients at present; which represents an increase of 9.1%. In addition, Figure 5.6 demonstrates several significant fluctuations including spikes in 2004 and 2009.

Figure 5.6 Hoopa Indian community health indicators for 2000 to 2012



Source: Author

During the time period, there were a total of 7 interventions for water, which are summarized in Table 5.11. The water projects primarily addressed deficiencies in the source, treatment, storage, and transmission and distribution. Beginning in 2002, the projects occurred over fairly even intervals up to 2011. The decrease in disease rates in the early period coincides with the water source and treatment projects. The 2009 spike in URI disease coincides with the 2009 H1N1 flu pandemic, and the recent spike in GI & VH coincides with a high number of water main leakage and breaks particularly with the transite (i.e. asbestos-cement) pipe (Ferris, 2013). There is a current IHS-funded project under construction to replace the transite pipe with new PVC water main. Even though the present total diseases are higher than the initial period, the numerous water interventions, project type, sequence, and number of patients in the study group in relation to the disease pattern suggests an impact from the interventions. While there are spikes in disease rates, they can be generally associated with other factors that are unique occurrences (e.g. the 2009 H1N1 pandemic) or deficiencies that are currently being addressed by a water intervention.

Table 5.11 Hoopa Indian community interventions for 2000 to 2012

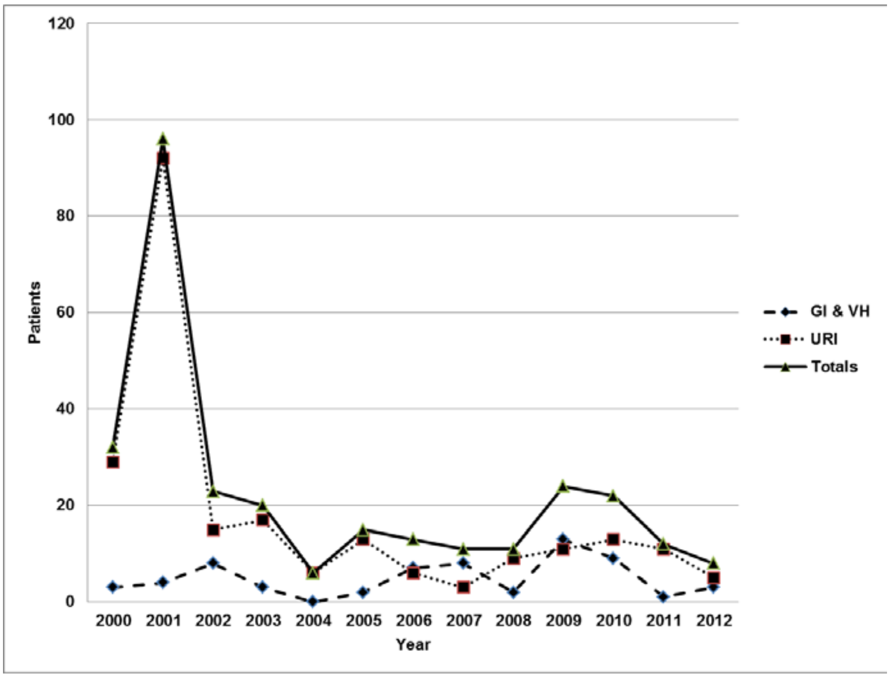
Year	Number	Project category	Project description
2002	X15	Water	Source and treatment (surface water)
2005	X20	Water	Transmission and distribution (Bald Hill area)
2005	X22	Water	Source (surface water)
2005	X24	Water	Transmission and distribution (Telescope area)
2007	X25	Water	Treatment (upgrades to surface water treatment)
2010	X31	Water	Storage and transmission and distribution
2011	X34	Water	Transmission and distribution

Source: Author

5.2.7 BURNEY INDIAN COMMUNITY

The Burney Community had an average of 50 patients with GI & VH and URI during the initial time period. The totals decreased to an average of 10 patients at present; which represents a reduction of 80.1%. Figure 5.7 generally represents a steady decrease in patients after 2001 to 2009 when there was a significant spike to 24 patients.

Figure 5.7 Burney Indian community health indicators for 2000 to 2012



Source: Author

During the time period, there were 2 interventions for water and sewer, which are summarized in Table 5.12. The projects primarily addressed deficiencies in the water supply and septic systems for individual homes. The projects occurred over a narrow time frame from 2006 to 2007, which was followed by a fairly constant disease rate with no significant increase. The number of projects, project type, sequence, and number of patients in the study group in relation to the disease pattern suggests an impact from the interventions.

Table 5.12 Burney Indian community interventions for 2000 to 2012

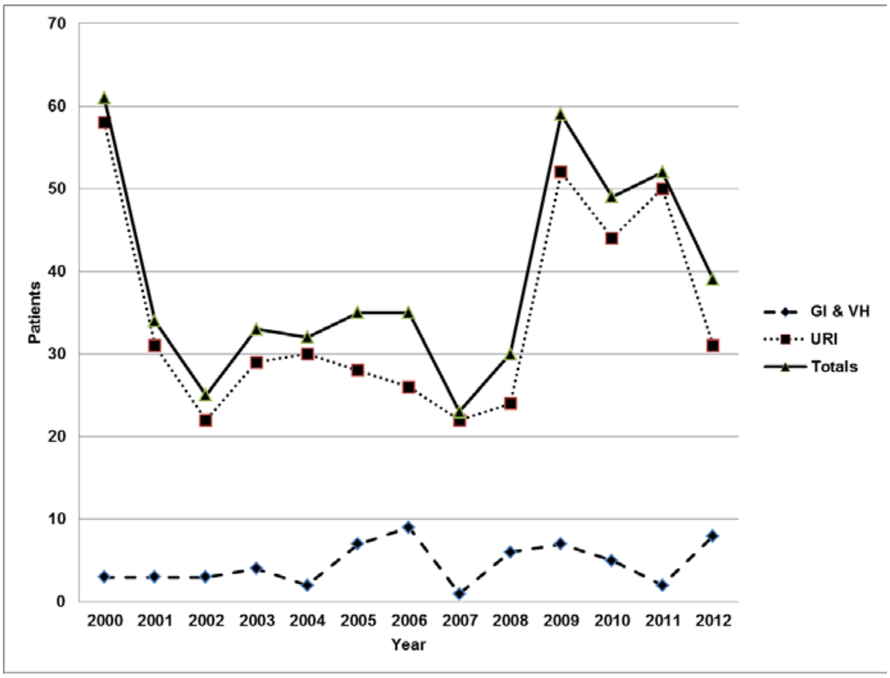
Year	Number	Project category	Project description
2006	L64	Water and sewer	Water supply and septic for individual homes
2007	L72	Water and sewer	Water supply and septic for individual homes

Source: Author

5.2.8 COVELO INDIAN COMMUNITY

The Covelo Community had an average of 40 patients with GI & VH and URI during the initial time period. Significantly, the totals increased to an average of 45 patients at present; which represents an increase of 13.8%. In addition to the overall increasing trend, Figure 5.11 demonstrates several fluctuations including a significant spike in 2009 to 59 patients.

Figure 5.8 Covelo Indian community health indicators for 2000 to 2012



Source: Author

Over the time period, there were a total of 8 interventions – 2 water and 6 sewer projects, which are presented in Table 5.13. The water projects primarily addressed deficiencies in the storage and transmission and distribution, and the sewer projects were for collection, treatment, and effluent disposal. Beginning in 2001, the projects occurred over fairly even intervals up to 2011. Even though the present value of the total diseases are relatively high, the numerous projects, project type, sequence, and number of patients in the study group in relation to the disease pattern suggests an impact from the interventions. While there are spikes in disease rates, they can be generally associated with other factors – primarily the high URI rates in 2009 during the 2009 H1N1 flu pandemic.

Table 5.13 Covelo Indian community interventions for 2000 to 2012

Year	Number	Project category	Project description
2001	C01	Sewer	Sewer collection
2004	L48	Water	Transmission and distribution
2004	O61	Sewer	Sewer collection
2005	C02	Water	Storage
2005	O63	Sewer	Wastewater treatment and disposal
2008	O75	Sewer	Wastewater treatment and disposal
2009	O96	Sewer	Wastewater treatment, disposal and sewer collection
2011	E03	Sewer	Sewer collection on Hopper Lane

Source: Author

5.2.9 Summary

Health indicators for GI & VH and URI were evaluated from 2000 to 2013 for 32 American Indian communities, which represent 27 different tribes and a total population of approximately 16,800, or 25% of the total American Indian population served by the IHS California Area. The composite data demonstrated a decrease in diseases over the time period by 18.7%. However, while there was a reduction in the number of patients, the p-value of 0.27 indicated the difference between the two periods was not statistically significant.

The community health data was further examined during the baseline time period of 2000 to 2002, and discovered that 7 of the 32 communities had total diseases higher than one standard deviation above the mean. Over the study time period, the seven communities of La Jolla, Rincon, San Pasqual, Santa Ysabel, Hoopa Valley, Burney, and Round Valley had a total reduction of 88 patients or approximately 44%. The p-value between the two periods was 0.039; which indicated the differences in patients with these diseases are statistically significant.

The seven communities were further evaluated individually based on the changes in disease rates compared to the number of interventions, project type, sequence, and number of patients in the study group in relation to the disease pattern. Of the seven communities, a causal relationship between the interventions and the disease rates may have occurred in La Jolla, Rincon, Hoopa Valley, Burney, and Round Valley. There was no strong causal relation in the San Pasqual and Santa Ysabel communities.

While a causal relationship is suggested for several communities, caution should be exercised due to the limited number of patients, differences in disease patterns from natural occurring variance, patient health status, tribal health program's resources and priorities for a given community, and unique occurrences such as the spike in 2009 associated with the 2009 H1N1 flu pandemic.

5.3 System sustainability

5.3.1 Introduction

The technical, managerial, and financial capacity to operate and maintain community water and sewer systems were evaluated based on responses from the questionnaire administered to 10 and 6 tribal organizations, respectively. The 10 organizations operate a total of 14 water systems while the 6 organizations operate one system each.

Each response on the questionnaire was evaluated whether it was ‘acceptable’, ‘in progress/not complete’, or ‘deficient’. Of those that were found to be ‘deficient’, a special designation was provided for the number of ‘critical’ factors. At the end of the questionnaire, the responses were reviewed and totaled for the three main capacity categories. In addition, a total score was calculated to establish a relative rank of the tribal organizations based on specific weights given to the responses.

5.3.2 TRIBAL WATER SYSTEMS

Taken as a combined group, the 10 tribal organizations operating water systems had significantly more ‘acceptable’ than the ‘deficient’ elements. The ‘acceptable’ elements for the technical, managerial, and financial capacity ranged from 61% to 63%, whereas the ‘deficient’ responses were 31% to 36%. The similar acceptable levels across all three elements seemed surprising, and initially it was believed that the tribal organizations had higher technical capacities than the other two as O&M training had primarily focused on technical issues (Schulte, 2013).

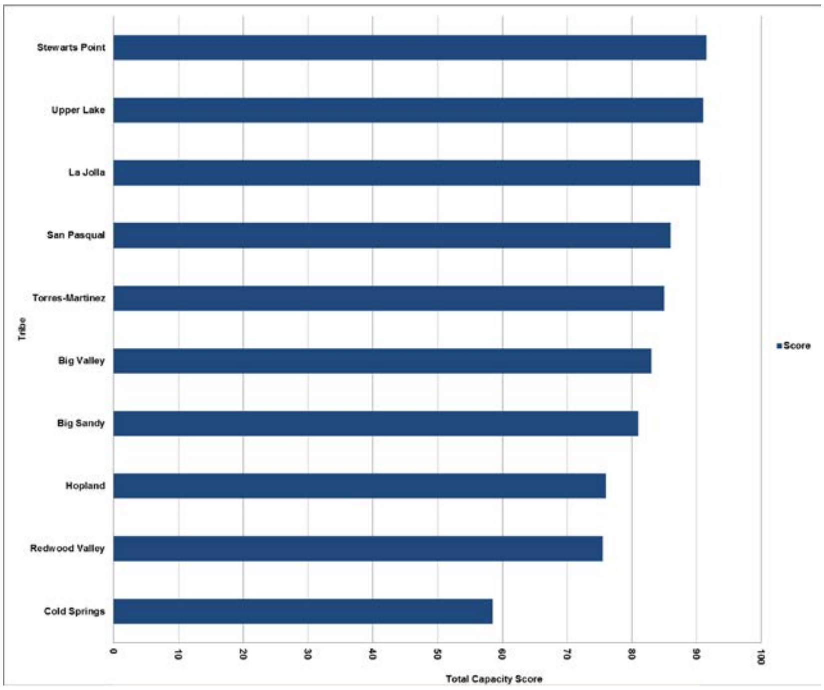
Of the 10 tribal organizations, two tribes (Cold Springs Tribe and the Big Valley Tribe) had more ‘deficient’ responses than ‘acceptable’ in one or more of the three capacity components. The capacity scores for each tribal organization operating a community water system are presented in Table 5.14 and Figure 5.9.

Table 5.14 Tribal organization capacity scores for water system operations

	Capacity																
	Technical				Managerial				Financial				Total				
Tribe	**A**	**IP**	**D**	**C**	**A**	**IP**	**D**	**C**	**A**	**IP**	**D**	**C**	**A**	**IP**	**D**	**C**	**Score**
Torres-Martinez	33	6	14	0	12	2	5	0	9	0	6	0	54	8	25	0	85.0
Big Sandy	33	7	14	0	10	2	6	0	8	0	7	0	51	9	27	0	81.0
Cold Springs	20	4	29	1	8	0	10	0	11	0	4	0	39	4	43	1	58.5
Redwood Valley	29	1	19	0	11	0	7	0	10	0	5	0	50	1	31	0	75.5
San Pasqual	35	5	10	0	12	2	4	0	8	0	7	0	55	7	21	0	86.0
Big Valley	38	4	11	0	9	0	9	0	7	0	8	0	54	4	28	0	83.0
Upper Lake	35	4	12	0	12	1	5	0	12	0	2	0	59	5	19	0	91.0
Hopland	28	2	24	0	14	0	4	0	8	0	7	0	50	2	35	0	76.0
La Jolla	32	5	17	0	15	1	2	0	11	1	3	0	58	7	22	0	90.5
Stewarts Point	36	6	12	0	13	0	5	0	10	0	5	0	59	6	22	0	91.5
Totals	319	44	162	1	116	8	57	0	94	1	54	0	529	53	273	1	
A: acceptable	D: deficient						Total capacity score = (1.5 X A) + (0.5 X IP) + (0 X D) - (2 X C)										
IP: in progress	C: critical																

Source: Author

Figure 5.9 Tribal organization total capacity score for water system operations



Source: Author

A more detailed review of the individual responses suggests several tribal capacity and sustainability strengths and weaknesses, which are listed in Tables 5.15 and 5.16. The percentage given for each description indicates the approximate proportion of the tribal organizations with that particular strength or weakness.

In particular, the reported high level of components reaching their deign-life is very believable and needs to be further investigated (Schulte, 2013). The IHS O&M Program has initiated efforts to conduct asset inventories in collaboration with the tribes in order to determine critical facilities that have reached their design life and warrant an SDS project to address the issue.

While it is encouraging that many tribes have a formal rate policy and charge user fees, it is also understandable that the income collected does not cover routine expenses (Schulte, 2013). Tribes may be using an outdated rate structure and not realize the full cost of the services. In addition, in some cases the user fees are hard to collect as there is a belief that water should be free. The tribal systems are also relatively small and remote and do not enjoy the economies of scale that are realized by larger systems. Another constraint along with this is that typically tribal communities have a large portion of families in the lower household income level. Therefore, a significant portion of the family's income would have to be allocated toward user fees that were structured to cover the full operating costs (Schulte, 2013).

A review of the current SDS for the 10 tribes indicated that several tribes had IDL-4 projects; however, the majority of projects are to address issues related more for capital improvements than replacement and upgrades. Therefore, this suggests an overall acceptable level of O&M for the facilities.

Table 5.15 Strengths for tribal capacity and sustainability of water systems

- Majority of customers drink the water (78%). However, the majority of the customers on the Torres-Martinez clinic system and the Big Valley main system reported they do not consume the water for drinking purposes.
- Formal rate policy (57%).
- Charge user rates (64%).
- Use of metered rates (43%).
- Prepare an annual budget (93%).
- Maintain a separate bank account for the utility (50%).
- Written O&M plans (43%).

Source: Author

Table 5.16 Weaknesses for tribal capacity and sustainability of water systems

- Majority of components older than 15 years; e.g. many may be reaching their anticipated design life (86%).
- Significant difficulty meeting water demand (36%).
- No emergency back-up power sources (79%).
- Routine system failures (14%) – Cold Springs and Hopland systems.
- No active safety program (93%).
- Income from user rates does not cover routine expenses (79%).
- No capital improvement plans (93%).

Source: Author

5.3.3 TRIBAL SEWER SYSTEMS

Taken as a combined group, the 6 tribal organizations operating sewer systems had more 'acceptable' than the 'deficient' elements. The 'acceptable' elements for the technical, managerial, and financial capacity ranged from 51% to 62%, whereas the 'deficient' responses were 34% to 48%. Of the 6 tribal organizations surveyed, three tribes (Cold Springs Tribe, Big Sandy Tribe, and Stewarts Point Tribe) had more 'deficient' responses than 'acceptable' in one or more of the three capacity components. The capacity scores for each tribal organization operating a community sewer system are presented in Table 5.17 and Figure 5.10.

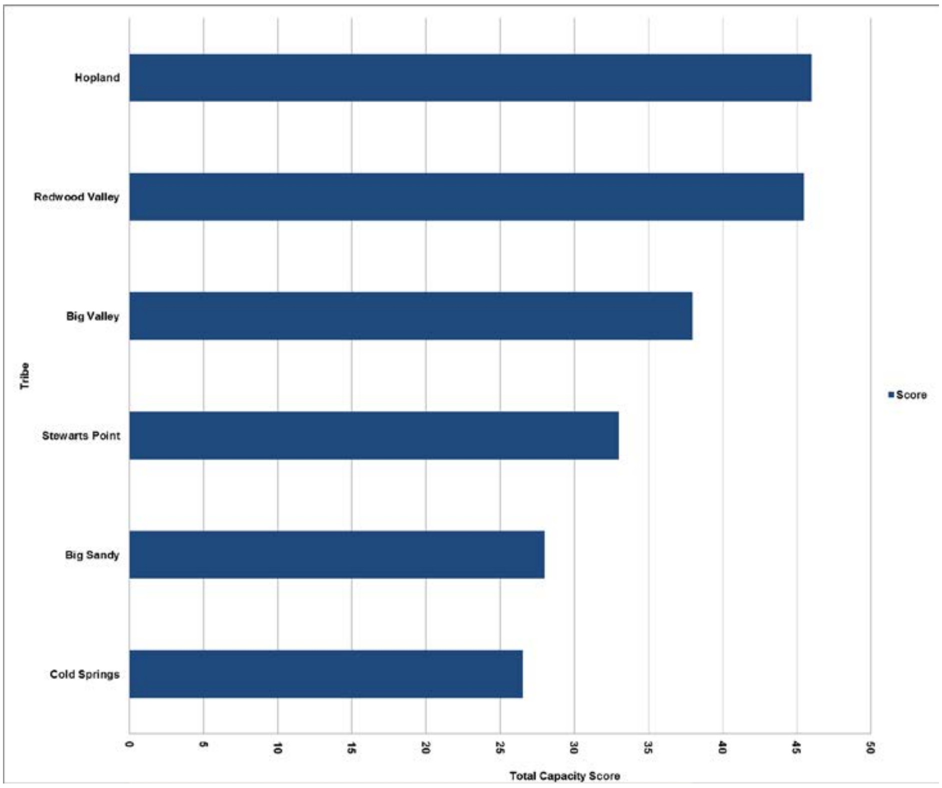
Table 5.17 Tribal organization capacity scores for sewer system operations

	Capacity																
	Technical				Managerial				Financial				Total				
Tribe	**A**	**IP**	**D**	**C**	**A**	**IP**	**D**	**C**	**A**	**IP**	**D**	**C**	**A**	**IP**	**D**	**C**	**Score**
Big Sandy	7	2	6	0	4	0	5	0	7	0	9	0	18	2	20	0	28.0
Cold Springs	8	2	6	0	4	0	8	0	5	0	11	0	17	2	25	0	26.5
Redwood Valley	10	1	8	0	9	0	3	0	11	0	5	0	30	1	16	0	45.5
Big Valley	12	2	3	1	6	0	6	0	8	0	8	0	26	2	17	1	38.0
Hopland	11	3	3	1	10	0	2	0	10	0	6	0	31	3	11	1	46.0
Stewarts Point	6	2	10	2	10	0	2	0	8	0	7	0	24	2	19	2	33.0
Totals	54	12	36	4	43	0	26	0	49	0	46	0	146	12	108	4	

A: acceptable; D: deficient; Total capacity score = (1.5 X A) + (0.5 X IP) + (0 X D) - (2 X C)
IP: in progress; C: critical

Source: Author

Figure 5.10 Tribal organization total capacity score for sewer system operations



Source: Author

A more detailed review of the individual responses suggests several tribal capacity and sustainability strengths and weaknesses, which are listed in Tables 5.18 and 5.19. The percentage given for each description indicates the approximate proportion of tribal organizations with that particular strength or weakness.

In general, the tribal organizations demonstrated higher capacity to operate water systems than sewer systems. The tribal organizations operating the sewer systems had lower capacity levels and a greater proportion of weaknesses. This situation may be due in part to more attention and priority being placed by the tribes on water systems rather than sewer systems (Schulte, 2013). It is suspected that a greater portion of tribal resources is allocated to water system operations than for sewer systems. In addition, while it may be universally difficult to collect user fees, it appears that it may even more difficult to collect for sewer service than water service (Schulte, 2013).

A review of the current SDS for the 6 tribes indicated that several tribes had IDL-4 projects; however, the majority of projects are to address issues related more for capital improvements than replacement and upgrades. Therefore, this suggests an overall acceptable level of O&M for the facilities.

Table 5.18 Strengths for tribal capacity and sustainability of sewer systems

- Financial records are audited regularly (83%).

Source: Author

Table 5.19 Weaknesses for tribal capacity and sustainability of sewer systems

- No emergency back-up power source (67%).
- Operator on call at all times (50%).
- No written O&M plans (83%).
- No formal policies on rates and collection (67%).
- No monthly sewer user fees (67%).
- No reserve funds in budget (100%).
- Income from user rates does not covers routine expenses (79%).
- No capital improvement plan (100%).

Source: Author

5.3.4 SUMMARY

The tribal organizations operating water systems had a majority of acceptable capacity evaluations for technical, managerial, and financial elements. Only two tribes had more ‘deficient’ responses than ‘acceptable’ in one or more of the three capacity components. However, the tribal capacity to operate sewer systems was generally lower than water systems. The situation may be due to more attention, priority, and resources given by the tribes for the water systems. Three tribes operating sewer systems had more ‘deficient’ responses than ‘acceptable’ in one or more of the three capacity components. While the capacities varied from operating water and sewer systems, some of the weaknesses were universal for all systems. In particular, the user fee structure and collections did not cover routine expenses. For both water and sewer operations, generally, there was no significant difference in the tribe's technical, managerial, and financial capacity.

A review of the current SDS for the tribes indicated that several tribes had IDL-4 projects; however, the majority of projects are to address issues related to capital improvements rather than replacement and upgrades (e.g. tending to be associated with inadequate O&M). Therefore, the evidence suggests that while there are areas for improvement and capacity building, the tribes are generally providing an acceptable level of O&M for the systems, and have a solid foundation for sustaining services in the long-term. The IHS does not provide direct day-to-day operations of the systems, however training and technical assistance could be prioritized and focused on areas that would make the largest impact on sustainability; e.g. user fee rate structure and collection strategies.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

The principal goal of this research project was to answer the following question:

> "How is the SFC Program performing and impacting American Indian communities through the provisions of drinking water and sanitation projects?"

This case was bounded by the time period of 2003 to 2013, and specifically focused on the California Area. The answer to the question was constructed from an evaluation and analysis of five critical components or sub-units to the SFC Program – project delivery, water and sanitation interventions, water and sanitation monitoring, health impact, and system sustainability. Each sub-unit forms a key building block for the entire program and its overall performance and impact. Bringing these inter-related components together indicates that the SFC Program in the California Area is providing moderate to high level performance and impact to American Indian communities by providing drinking water and sanitation projects.

A critical evaluation of performance and impact is not to diminish the significant accomplishments the SFC Program has made and continues to strive for by providing drinking water and sanitation services to a historically underserved population. The SFC Program has been and continues to be a lead actor in delivering this "basic right" of water and sanitation services. "The human right to water entitles everyone to sufficient, safe, acceptable, physically accessible, and affordable water for personal and domestic uses" (WHO, 2003, p. 12), and as a federal agency of the U.S. Government, the SFC Program has a "primary responsibility for ensuring the realization of human rights" (WHO, 2003, p. 28).

The analysis and evaluation included sustainability, effectiveness, equity, efficiency, and replicability issues that impacted and influenced the sub-units and the SFC Program. Summary conclusions regarding each sub-unit and the relationships to the overall California Area SFC Program are presented; which form the basis for the recommendations.

6.2 CONCLUSIONS

6.2.1 PROJECT DELIVERY

Conclusions regarding this sub-unit and the relationship to the overall SFC Program are:

- Overall, the project delivery had a moderate level of efficiency.

- Number of American Indian homes served was highly variable. Beginning in 2010, the number of homes served has generally declined. Since the output is dependent on the annual funding levels, the SFC Program could consider additional opportunities to collaborate with tribes and other funding agencies to satisfy mandates of all stakeholders.
- No specific Area-level performance measure for the number of American Indian homes served.
- California Area has consistently met the 4-year limit project duration goal. However, since 2011 there has been a decline in the rate of completed projects, and if the trend continues, it could increase project durations, impact resources, and project outcomes.
- Several projects had significantly longer durations due to various constraints.
- Project cost per home served is significantly more expensive and highly variable when compared to the national trends. The high cost could be influenced by environmental factors, construction costs, site conditions, remoteness, specific deficiencies, and that only a portion of the available resources (e.g. staff) actually perform design and construction-related activities.
- Tracking cost per home in terms of both construction and program costs could provide new efficiency measures and serve as future monitoring indicators.

6.2.2 WATER AND SANITATION INTERVENTIONS

Conclusions regarding this sub-unit and the relationship to the overall SFC Program are:

- Overall, the water and sanitation interventions (e.g. funded projects) had a high level of equity, use, and intended impact (health is covered separately below).
- Majority of interventions are for water, and for transmission and distribution and treatment facilities.
- Other interventions are primarily for wastewater, and half of which was for sewer collection and pumping stations.
- Majority of all interventions were for capital improvements representing new, expansion, or system extensions; which could be a consequence of limited provisions in designs for future growth due to funding constraints.
- Majority of funded projects addressed high-level needs and deficiencies (e.g. IDL-4) and had high SDS scores; addressing IDL-4 deficiencies is a long-term measure for the SFC Program and the EPA.
- Approximately half of the funding addressed high IDL deficiencies for five Indian tribes; which represented 24% of the entire American Indian population in the California Area.

6.2.3 WATER AND SANITATION MONITORING

Conclusions regarding this sub-unit and the relationship to the overall SFC Program are:

- Overall, the water and sanitation monitoring (e.g. system needs and deficiencies) had a high to moderate level of effectiveness and equity.
- Remaining drinking water and sanitation deficiencies in SDS are significant and increasing at a large rate. Since 2003, the deficiencies, expressed as feasible SDS project costs, have increased by over 300%. The SFC Program has been successful and made impact in field reconnaissance, collaborating with tribes, and developing feasible SDS projects to correct needs.
- Since 2009, water deficiencies have increased at a higher rate while the cost for sewer facilities decreased. For the first time in 2013, the total cost to address water deficiencies is greater than sewer.
- Over the past 10 years there has been more funding for water interventions than sewer; however, the rate of growth in remaining water deficiencies has out-paced sewer needs. Suggests water system assets are numerous, and there remains a significant water need. In the near future, costs to address deficiencies could increase dramatically as many systems originally constructed in the 1960s to 1980s begin to reach their useful design life.
- Percentage of American Indian homes with adequate water and sanitation facilities have increased from 78% to the current level of 84%; which supports an IHS mission goal.
- Deficiencies consistently reported in the SFC Program's and the EPA's databases. Agencies could explore establishing a protocol and standardized process for data sharing either by periodic meetings or database connection.

6.2.4 HEALTH IMPACT

Conclusions regarding this sub-unit and the relationship to the overall SFC Program are:

- Overall, the interventions had a moderate level of health impact.
- Health indicators for GI & VH and URI were evaluated for 32 American Indian communities (representing 27 tribes and a total population of approximately 16,800), and while the composite data demonstrated an 18.7% decrease in diseases, the reductions from the initial period was not statistically significant.
- Seven of the communities with high initial disease rates were further analyzed, and had a statistically significant reduction in patients by 44%.
- Of the seven communities, five communities had patterns of disease rates, number of interventions, project type, sequence, and number of patients in the study group that

suggested a causal relationship between the interventions and the decrease in disease rates.

- While difficult to measure, the interventions appear to play a role in the series of connected impacts to improve the health of the community. Caution should be exercised due to a variety of other potential influencing factors that may have caused the disease rates to change.

6.2.5 SYSTEM SUSTAINABILITY

Conclusions regarding this sub-unit and the relationship to the overall SFC Program are:

- Overall, the systems had a moderate level of sustainability and replicability, and high use.
- Tribal organizations operating water systems had a majority of acceptable capacity evaluations for technical, managerial, and financial elements.
- Tribal capacity to operate sewer systems was generally lower than water systems. The situation may result from the tribes placing higher attention, priority, and resources for the water systems.
- For both water and sewer operations, there was no significant difference in the tribe's levels of technical, managerial, and financial capacity.
- While the capacities varied from operating water and sewer systems, there were some universal weaknesses for all systems. In particular, the user fee structure and collections did not cover routine expenses. This could suggest opportunities for focused trainings and technical assistance for these elements that could make the largest impact on sustainability.
- Several tribes had SDS projects ranked at IDL-4; however, the majority of projects are to address issues related to capital improvements rather than replacement and upgrades (e.g. tending to be associated with inadequate O&M).
- While there are areas for improvement and capacity building, the tribes are generally providing an acceptable level of O&M for the systems, and have a solid foundation for sustaining services in the long-term.

6.2.6 SUMMARY OF CONCLUSIONS

A summary of the main conclusions of the five sub-units related to the performance and impact of the California Area SFC Program is provided as a matrix in Table 6.1.

Table 6.1 Summary of conclusions

	Evaluation of program issue		
Sub-unit	**Strengths**	**Weaknesses**	**Impact issues**
Project delivery	▪ Measure for project durations has been achieved each year.	▪ Since 2010, number of homes served per year has declined. ▪ No Area-level measure for number of homes served per year. ▪ Since 2011, rate of projects completed has declined. ▪ Several project durations longer than 4 years.	▪ Moderate efficiency. ▪ Technical and administrative improvements for project durations and completions. ▪ Administrative improvements to leverage outside agency funding and monitor costs.
Water and sanitation interventions	▪ Majority of projects addressed high deficiencies (e.g. IDL-4).	▪ While limited, several projects were funded at IDL-2.	▪ High level of equity, use, and intended impact.
Water and sanitation deficiency monitoring	▪ Field reconnaissance and collaboration with tribes increased reported deficiencies. ▪ Increased % of homes with adequate water and sanitation. ▪ Common issues reported in different agency's databases.	▪ Unmet water needs exceed sewer needs even though majority of funded projects have been for water interventions. ▪ Limited routine and standardized coordination of agency's databases.	▪ Moderate to high level of effectiveness and equity.
Health impact	▪ 7 communities with high initial diseases had a statistically significant 44% reduction. ▪ 5 communities with causal relationships between reductions and interventions.	▪ 32 communities had a disease reduction of 18%; however was not statistically significant.	▪ Moderate level health impact from interventions; while there was a reduction in diseases; it was not entirely statistically significant.
System sustainability	▪ Acceptable capacity to operate systems in technical, managerial, and financial components. ▪ System needs more related to capital improvements rather than replacement/upgrades.	▪ Capacity to operate and sustain sewer systems not has high as water systems.	▪ Moderate sustainability and replicability. ▪ High use of systems by tribes.

Source: Author

6.3 Recommendations

6.3.1 Project delivery

Recommendations based on the evaluation's findings and conclusions for this sub-unit are:

- **Consider additional opportunities to collaborate with tribes and other agencies to fund projects to serve American Indian homes**. The additional funding could mitigate the variability and correct the recent decline in the number of homes served. In addition, multi-agency projects to address drinking water and sanitation deficiencies could satisfy mandates for all the stakeholders. This effort could involve a wide survey of all potential stakeholders and funding agencies, determine funding requirements, application process and due dates, and collaborate with tribes to decide which projects to submit for consideration.
- **Consider specific Area-level performance measure for the number of American Indian homes served**. While the number of homes served has been variable, a measure that is achievable and provides an incentive for funding collaborations could be beneficial. In addition, the specific measure could feed directly into the national goal. For example, an annual goal for the number of homes served could be a percentage increase from the previous year or a set amount to be achieved over a time period (e.g. number of homes served over three years). Develop new measure referencing the process used by the UNICEF (2012b).
- **Consider program and project management initiatives to address the declining rate in completed projects**. Potential activities could include detailed analysis of the issues that may range from inaccurate data entries, project monitoring, assessing resource gaps (e.g. staffing), design and construction constraints, and project scope. The analysis could focus on specific projects that have longer durations and project phases that have significantly exceeded critical milestones. Corrective actions should be implemented for specific projects, and lessons learned incorporated into new or revised operating procedures.
- **Consider development and implementation of a cost-tracking system for both construction and program expenses**. The information could allow future detailed analysis of high construction costs and the influencing factors (e.g. environmental, remoteness, category type, etc.), and program operating costs. Information could support planning and feed into new efficiency measures and monitoring indicators. The future analysis could compare findings with calculated project resources using the PDS RRM (see Chapter 1, Data Systems).

6.3.2 WATER AND SANITATION INTERVENTIONS

Recommendations based on the evaluation's findings and conclusions for this sub-unit are:

- **Consider review of technical support and guidance documents for primary interventions**. The majority of interventions were for water transmission and distribution, water treatment facilities, and sewer collection and pumping stations. While this research project did not identify any issues related to technical design or construction of interventions, the large number of these project could warrant a review to develop lessons learned and follow-on necessary corrections (e.g. technical specifications, detail drawings, etc.).
- **Consider developing program guidance and policy for future growth in designs**. The policy could clarify and establish parameters for incorporating future growth in designs; which may address future capital improvements projects and increase efficiency of resources.
- **Consider developing a periodic review and evaluation of key parameters of future interventions**. Evaluate interventions for deficiencies addressed (e.g. IDL-4), SDS scores, tribes and communities served, project category and description, and cost data to support future planning and long-term measures. Future evaluations could be over a short (e.g. 2 to 5 years) and long (e.g. 10 years) time period.

6.3.3 WATER AND SANITATION MONITORING

Recommendations based on the evaluation's findings and conclusions for this sub-unit are:

- **Consider advanced information gathering and reconnaissance for systems nearing or at design life**. There could potentially be a significant need to address deficiencies of systems that were originally constructed in the 1960s to 1980s and have begun to reach their useful design life. Develop a strategic approach to review systems and conduct an asset inventory in order to identify critical facilities that are close to or at their design life. Develop corresponding SDS projects to document and identify deficiencies with corresponding deficiency levels (IDLs) to match the failure signatures.
- **Continue to improve communication and coordination with other agencies to identify and prioritize deficiencies**. While there is periodic exchange and review of each agency's information, the process is not standardized. Consider establishing set information exchanges and reviews coordinated with agency's selection process for interventions. In particular, there could be more enhanced use of the EPA's SDWIS to support documentation and identification of deficiencies for the IHS SDS database.

6.3.4 HEALTH IMPACT

Recommendations based on the evaluation's findings and conclusions for this sub-unit are:

- **Continue to improve communication and coordination with other IHS offices and the tribal health departments on disease rate information**. Establish procedures for periodic exchange and review of information for waterborne and water-washed diseases in American Indian communities (e.g. from RPMS). The health data could be analyzed by a team including representatives from the SFC Program, IHS Epidemiology Office, IHS Chief Medical Officer, the tribal health programs, and the tribal utility organizations. In addition, the analysis could also involve comparisons of disease rate trends between those in California American Indian communities with IHS national levels and the State of California. The information could support SDS projects and establish appropriate deficiency levels and health impact scores.
- **Consider collaborative approaches for community outreach on broad environmental health issues**. The collaborative approach on analyzing health data for potential drinking water and sanitation interventions in the communities could be broadened to include other environmental health issues such as interventions for healthy homes (e.g. issues related to home water, sewer, airborne quality, hazardous chemicals, etc.), foodborne illness, and positive changes in hygiene behavior).
- **Consider conducting a prospective study of the health impacts from water and sanitation interventions**. This research conducted a retrospective study; e.g. using historic records to exam health outcomes and impacts over a designated time span that have already occurred before the study. However, it may be beneficial to conduct a prospective study; which would identify the subjects, establish baselines, and then follow the subjects into the future while recording key health indicators and outcomes. In particular, this could be appropriate for groups of homes currently without adequate water and sanitation facilities, and then to study them over a specified period of time.

6.3.5 SYSTEM SUSTAINABILITY

Recommendations based on the evaluation's findings and conclusions for this sub-unit are:

- **Continue to survey tribal organizations operating water and sewer systems**. At the time of this research, 10 tribal organizations were reviewed. In order to obtain a broader perspective, additional tribal organizations should be surveyed on their level of technical, managerial, and financial capacity. The additional information could support more focused and appropriate follow-on trainings and interventions.

- **Consider additional focus and effort to support tribal capacity to operate sewer systems**. The tribal organizational capacity to operate the sewer systems was generally lower than water systems. Further evaluate and develop strategies to support tribal capacity through a combination of trainings, awareness campaigns, and technical support in technical, managerial, and financial elements.
- **Consider additional training and technical assistance on priority capacity elements**. Conduct an analysis of current and any future tribal capacity surveys to determine the high priority weaknesses, and develop strategies to provide support for both short and long-term sustainability. For example, this could include review and revisions of the user fee structure and collections in order to cover routine expenses. In addition, long-term strategies could consider partnerships between tribal and non-tribal organizations to provide enhanced support mechanisms to sustain the systems.

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