Evaluación de Impacto Medio Ambiental:

Efectos del Drenaje de Aguas Residuales y Lagunas de Oxidación de Juli en la comunidad de Huaquina, Perú

Investigaciones realizadas por Suma Marka y La Universidad de Loma Linda, el equipo Global Environmental Assessment.

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Los puntos de vista expresados en este documento son enteramente de los autores del mismo. Este material no necesariamente refleja la opinión de La Universidad de Loma Linda, Suma Marka o cualquier otro asociado de este estudio.

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RESUMEN

El acceso a recursos de aguas limpias y mejores en saneamiento básico crea un gran impacto en la salud y la calidad de vida en las comunidades en todo el mundo. El tratamiento de aguas residuales usualmente se pasa por alto en el mejoramiento del saneamiento lo que resulta en materiales potencialmente dañinos que invaden los recursos de aguas locales y afectan la salud pública. Las comunidades de Huaquina y Juli, localizadas en el sureste de Perú, han tenido dificultades en el manejo efectivo de aguas residuales en una forma que sea apropiada cultural y tecnológicamente. Un Estudio de Impacto Medio Ambiental (EIMA) fue llevado a cabo en Julio del 2010 para evaluar sistemáticamente el drenaje de aguas residuales al Lago Titicaca en las comunidades de Huaquina y Juli. El drenaje fue evaluado para cumplir con regulaciones del medio ambiente y de aguas residuales, desarrolladas por el gobierno de Perú, Las metas de sanidad del desarrollo del Milenio y La Organización Mundial de Salud para tratamientos y manejo de aguas residuales. Este reporte resume el EIMA repasando los procedimientos tomados para evaluar el sistema de tratamiento de aguas residuales, los resultados obtenidos y las recomendaciones para mejoramientos en Huaquina y Juli.

Historial

En el pasado, por más de medio siglo, Juli como otras comunidades alrededor de Lago Titicaca, han fallado en mantener los tratamientos y la eliminación de desechos de acuerdo a la dinámica de su población. Juli es sólo una de las comunidades responsables de un estimado de 12,731,147 metros cúbicos de desechos botado en el lago cada año (Ther, 2009). El gobierno regional en Juli construyó dos lagunas de oxidación como una solución por el aumento de desechos y los altos niveles de aguas residuales que eran depositados en el lago. La primera laguna fue construida en 1987 cerca del Lago Titicaca en Juli y el propósito era filtrar las aguas residuales para ser utilizada de acuerdo a las necesidades en la comunidad. En su principio, este sistema fue efectivo y todavía es utilizado hoy día; sin embargo el sistema es ahora anticuado y el agua filtrada no puede ser reutilizada. En 2008, debido al crecimiento demográfico y el aumento en la producción de desechos que ahora agobiaban la primera laguna, el gobierno construyó a menos de dos millas, otra laguna de oxidación ubicada en Huaquina. La construcción de la nueva laguna de oxidación no fue diseñada como originalmente fue indicado por el gobierno. Esto dio como resultado a varios problemas técnicos y posibles filtraciones inadecuadas de las aguas residuales.

Mientras la comunidad de Huaquina no esta satisfecha con el diseño de la laguna construida y las implicaciones sociales conectadas a esta laguna, el gobierno y los residentes en Juli no les concierne. Esta diferencia de opinión ha creado conflicto entre las comunidades y el gobierno teniendo como resultado la destrucción de las tuberías que llevan los desechos a la laguna de oxidación en Huaquina. Para responder a las necesidades expresadas y dar recomendaciones para mejorar el medio ambiente, el Equipo de la Universidad de Loma Linda llamado Global Environmental Assessment Team (LLU GEAT), con la colaboración de Suma Marka (SM), una organización peruana no gubernamental, hicieron una investigación holística por medio de una Evaluación de Impacto Medio Ambiental (EIMA), (Environmental Impact Assessment (EIA) en ingles)

Métodos

EIMA revisó el sistema actual del tratamiento de aguas residuales en Huaquina teniendo en cuenta el impacto medio ambiental y la salud de la comunidad. La investigación fue realizada por estudiantes graduados con maestría en Salud Publica y la facultad de la Universidad de Loma Linda en colaboración con Suma Marka. El equipo de investigación recopiló datos en tres áreas

prioritarias: datos microbiológicos y aguas del lago y residuales, colecta de datos geográficos de la comunidad de Huaquina, trazando específicamente el sistema de la frontera y el alcantarillado; y colecta de datos cualitativos por medio de entrevistas con las partes interesadas en Juli, Huaquina, y en la ciudad más grande de Puno.

Los datos microbiológicos y espaciales fueron colectados de cuatro lugares donde el problema de desagüe de aguas residuales ha sido notado por la comunidad y Suma Marka: (1) el lugar de desagüe de aguas residuales del municipio de Juli en el lago y otras áreas dentro del lago; (2) la laguna de oxidación construida por el municipio de Juli en 1987; (3) los pozos de la comunidad en Huaquina; y (4) la frontera entre Juli y Huaquina. Notas y observaciones no estructuradas fueron tomadas de cada lugar visitado.

Resultados

La investigación ayudó a obtener una mejor comprensión de los impactos de la laguna oxidada, la ubicación de la laguna en relación con la comunidad de Huaquina, y los puntos de vista de la comunidad con respecto al sistema de tratamiento de las aguas residuales.

El análisis espacial que utiliza el método de obtención de coordenadas geográficas (GPS – Global Positioning System) y el Sistema de Información Geográfico proporcionan una representación visual de la frontera de Huaquina, así como el principio de sistema de alcantarillado que inicia en Juli y termina en el Lago Titicaca. Esta representación se encuentra en el Mapa 1 al final de este documento.

El análisis de la microbiología reveló contaminación microbiana del agua en el Lago Titicaca, pozos de la comunidad de Huaquina, y en las aguas residuales en la laguna de oxidación. El agua del Lago Titicaca mostró cantidades significativas de *E. coli* y coliformes fecales, específicamente en el área del lago donde la tubería de desagüe de aguas residuales desemboca.

El nivel de estos patógenos esta sobre el nivel internacional de calidad del agua recomendado por la Organización Mundial de al Salud y la Agencia de Protección del Medio Ambiente de los Estados Unidos. Por lo tanto, el agua en estas ubicaciones no debe ser utilizada para uso recreativo, para tomar, o para lavar. El Mapa 2 al final de este documento muestra la contaminación microbiana de las muestras de aguas obtenidas.

Las entrevistas con las partes claves interesadas revelaron las opiniones de autoridades y miembros de la comunidad referente al sistema del tratamiento de las aguas residuales, a posibles efectos de las lagunas de oxidaciones, y el deseo de mejorar el sistema de tratamiento de tales aguas. Hay preocupaciones comunes dentro de la comunidad de Huaquina relacionada a la tecnología inadecuada, la posible amenaza de desbordamiento e inundación durante la estación de las lluvias, y la falta de mantenimiento suficiente con la laguna de oxidación más reciente. La comunidad se siente que tiene el derecho de ser tratado por igual y ha expresado sus preocupaciones al municipio local para que se hagan mejoras, pero nada ha sido hecho todavía.

Los ciudadanos de Juli argumentan que los miembros de Huaquina son ignorantes de la eficacia de la laguna. Los líderes locales dicen que no hay dinero suficiente en el presupuesto para mejorar la laguna. Estos problemas han creado tensión entre la comunidad de Huaquina, Juli, y el gobierno.

Los miembros de la comunidad de Huaquina desean un sistema de tratamiento de aguas residuales como el de Pomata. El equipo de investigación visitó el sistema de tratamiento de Pomata y determinó que este sistema es más eficaz en el filtrado de aguas residuales que el de Juli

y Huaquina. Sin embargo, hay algunas preocupaciones de mantenimiento con el sistema de Pomata. La infraestructura de este sistema no se ha mantenido y hay varias tuberías con fugas lo cual crea preocupación por posibles daños a la estructura de cemento. El agua de la laguna en Pomata mostró no tener oxigeno disuelto, indicando bajo flujo de aguas residuales. Aunque este sistema es más avanzado que el de Juli y Huaquina, Pomata necesita grandes mejoras y mantenimientos para que pueda funcionar apropiadamente. Ningún parámetro ambiental fue probado con la excepción de los parámetros microbiológicos, del pH, y posiblemente DO (Tabla 1). Para caracterizar completamente la función de los sistemas de tratamiento de aguas residuales, las soluciones de Juli y Pomata necesitan evaluaciones continuas utilizando pruebas como DOB, SOUR, y TSS/VSS.

Recomendaciones

A través de la recopilación de datos y análisis, el equipo de investigadores fue capaz de identificar ineficiencias en el sistema actual de tratamiento de aguas residuales, las cuales llevarían a peligros del medio ambiente y la salud. Varias recomendaciones a corto y largo plazo se han desarrollado para aliviar estos riesgos y preocupaciones.

Las recomendaciones a corto plazo incluyen:

- ✓ Mejorar pozos artesanos
- ✓ Educación para la comunidad
- ✓ Modificaciones a las lagunas

Recomendaciones a largo plazo:

- ✓ Mejorar el sistema de tratamiento de aguas residuales
- ✓ Implementar un sistema de tuberías de saneamiento en Huaquina

Mejoramiento de Artesianos.

Los datos microbiológicos revelaron una contaminación significativa en dos de los pozos comunitarios en Huaquina, que pueden afectar a la salud de la comunidad si llegaran a beber esta agua. Por lo tanto, se recomienda forrar y tapar con cemento cada pozo e instalar una bomba de mano para evitar la contaminación del agua subterránea. El pozo más contaminado debe ser sellado primero y después los demás. También será importante construir una barrera o cerca alrededor de los pozos para reducir la contaminación del agua a través de animales o personas. Además de mejorar los pozos sería importante enseñar a los miembros de la comunidad la manera de mantener los pozos y así controlar la calidad del agua.

La Educación Comunitaria

La educación comunitaria es necesaria para aumentar la concientización pública de problemas del medio ambiente. La educación sobre las implicaciones de salud por aguas de pozos, la importancia del buen mantenimiento, los sistemas de tratamiento de aguas residuales, les da poder a la comunidad para tomar el control de su salud medio ambiental. El modela de los *promotores de salud* pueden entrenar a miembros influyentes de la comunidad para aumentar el conocimiento de salud de la comunidad, la movilización de la comunidad y la utilización de diversos servicios de salud (Ander, Balcazar & Paez, 2006). Primero un grupo de miembros influyentes de la comunidad es entrenado como *promotores de salud* y luego son capacitados para educar a sus colegas en tópicos de salud y salud medio ambiental. La educación de los *promotores de salud* debería incluir tópicos como saneamiento básico, agua potable, prevención de contaminación por cocinar y agua de pozo y sostenibilidad medio ambiental. El entrenamiento de promotores de salud proveerá un método cultural y de sostén para el involucramiento de la comunidad y la salud del medio ambiente en Huaquina.

Al mismo tiempo es recomendable que medidas de concientización pública sean tomadas para informar a miembros de la comunidad sobre aguas contaminadas en Huaquina. Notificaciones y señales deberían ser puestas a orillas del lago de Huaquina y Juli para prevenir a las personas de usar el agua contaminada. Después de varios exámenes, los pozos artesanos con niveles altos de contaminación debieran ser etiquetados como tales con el tiempo que tiene que hervirse el agua para purificarla hasta que futuras mejoras puedan ser realizadas.

La concientización publica es un paso muy importante ya que crea confianza y educación en la comunidad; considerando el historial de mala información y resentimiento en contra de proyectos de agua previos. Es recomendable que Suma Marka coordine estos esfuerzos de educación con el apoyo de la Universidad de Loma Linda y otros socios de la comunidad.

Modificaciones a la Lagunas

Para mejorar inmediatamente las lagunas de oxidación, un compromiso debe ser alcanzado entre los miembros de la comunidad y el gobierno local de Juli. Esto incluiría que las autoridades de Juli mejoren la infraestructura de la laguna, mientras que miembros de la comunidad regresen las tuberías que retiraron anteriormente.

Seria recomendable que las estructuras de la laguna sean modificadas a los estándares de la Organización Mundial de la Salud (World Health Organization, 2006), el Ministerio de Medio Ambiente (2010) y la Autoridad Lago Titicaca. Estas mejoras incluyen revestimiento de las lagunas de oxidación con cemento para proveer una barrera entre las aguas residuales y la tabla de agua natural. Esta barrera impedirá la contaminación de la fuente de agua subterránea. También es esencial construir y mantener sistemas de ventilación capaces de oxidar el agua residual de Juli a un ritmo exigido por el tamaño de la población. Vallas deberían ser construidas alrededor de las lagunas para evitar que los animales locales tengan acceso al agua contaminada. Al completar este paso la tubería por la que las aguas residuales pasan, debe ser permanentemente cubierta y/o eliminada. Estos mejoramientos de corto plazo deberían mantenerse a largo plazo para el mejoramiento de la comunidad.

Mejoramiento de las Aguas Residuales

Un sistema de tratamiento de tecnología avanzada debe ser desarrollado e implementado para reemplazar la laguna de oxidación en Huaquina. Este sistema debe tener suficiente aireación y dispositivos de filtración para purificar las aguas residuales de Juli para reducir el temor de desbordamiento durante la temporada de lluvias. Deberá haber una financiación disponible para implementar un sistema nuevo. La ALT planea completar los mejoramientos de los sistemas con la búsqueda de subvenciones y financiación de donantes externos. Sería recomendable que las autoridades gubernamentales en Juli y la comunidad de Huaquina renueven su relación para colaborar con ALT para mejorar el sistema de tratamiento de aguas residuales. Esta colaboración ayudará a instalar un sistema apropiado para la comunidad y una relación permanente entre la comunidad y ALT.

Aunque la laguna actual está en Huaquina sería beneficioso para el municipio de Juli que construyan un nuevo sistema de tratamiento de aguas residuales más arriba en el Río Salada y al suroeste de la frontera de Huaquina. Este reubicación podría ser preferible porque reducirá la oposición de la comunidad de Huaquina, dándole así la oportunidad a Juli de construir un sistema de tratamiento mejor y evitar los problemas de agua que actualmente tienen. Esta nueva reubicación será posible porque la tubería de aguas residuales de Juli viaja a través de campo abierto sin ningún tipo de conexiones nuevas. Después de la implementación de un nuevo sistema de aguas, las aguas residuales pueden ser reutilizadas para la comunidad agrícola u otras

necesidades a lo largo de Huaquina y Juli. Por ejemplo, un sistema de riego agrícola que utiliza el agua tratada puede ser implementado para que con el tiempo pueda reducir la dependencia de la lluvia.

Implementación de un sistema de tubería de saneamiento en Huaquina

Aunque Huaquina actualmente se ocupan de los impactos sanitarios y ambientales de las aguas residuales, es una comunidad que también carece de saneamiento adecuado y tuberías personales para su propio sistema de aguas residuales. Para que la gente tenga el derecho de usar el agua para un uso personal o domestico, la comunidad de Huaquina tiene que mejorar el saneamiento. Las letrinas existentes deberían ser mejoradas y eventualmente reemplazadas por sanitarios y ser conectadas a un sistema de alcantarillado. El gobierno regional debería proveer recursos para colaborar con los esfuerzos de la comunidad para crear un sistema de agua potable y alcantarillado capaz de suplir las necesidades de la comunidad de Huaquina. Este sistema debería conectar todos los sanitarios y el sistema de agua del hogar a una tubería de drenaje dirigido hacia la planta de tratamiento. El financiamiento de este proyecto debe ser provisto a través del presupuesto del gobierno local y posiblemente becas del ALT. La inversión inicial proporcionará un método rentable para mejorar la salud y proteger el medio ambiente en toda la comunidad y en el lago Titicaca.

Estas recomendaciones ayudarán a mejorar el acceso global a fuentes de agua, mejorar el saneamiento en Huaquina y aliviar las preocupaciones de la comunidad con respecto al sistema actual de tratamiento de aguas residuales y lagunas de oxidación. Estas metas a corto y largo plazo sólo serán posibles mediante una comunicación eficaz entre las autoridades gubernamentales, miembros de la comunidad y organizaciones colaboradoras.

Conclusión

Los problemas que actualmente enfrentan las comunidades de Juli y Huaquina tienen muchas etapas. Entre ellas se encuentra el manejo de una dinámica física de la gestión de las aguas residuales, las preocupaciones de salud de Huaquina, y los posibles efectos en el medio ambiente por los lagos de oxigenación. También está el aspecto socio psicológico de la comunidad que siente que no están siendo escuchados y que no tienen un derecho equitativo en un medio ambiente que promueva resultados de salud positivos. Cualquier decisión tomada por los líderes locales debe incluir ambas dinámicas.

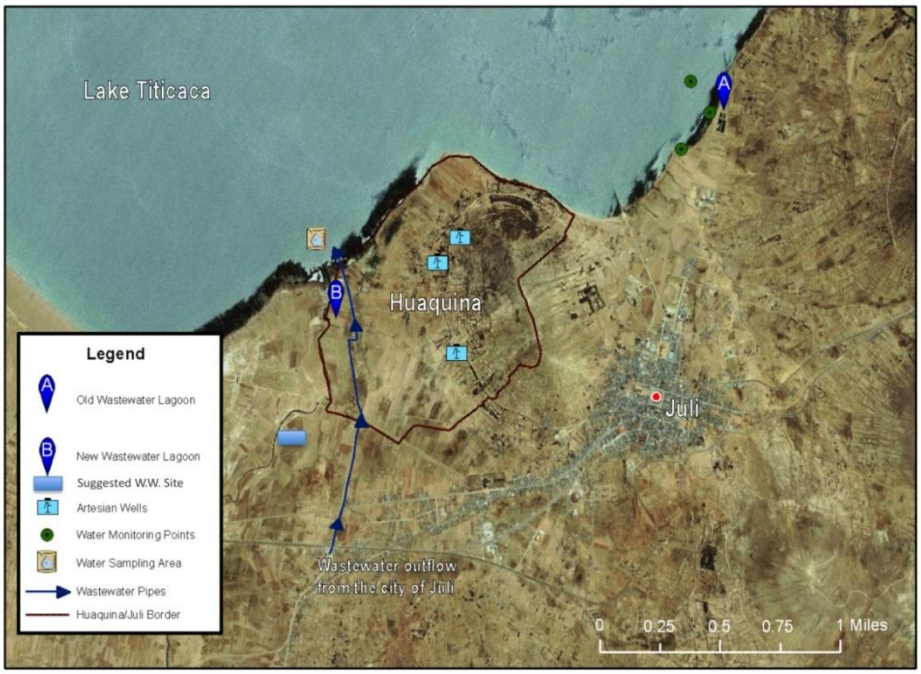
La comunidad de Huaquina quiere soluciones reales y tangibles para el manejo de desechos, pero también quiere ser reconocida con igualdad y respeto. Su descontentamiento debe de ser reconocido como válido y métodos de colaboración deben de ser usados para desarrollar una solución de sostenibilidad para todas las partes interesadas.

EIMA provee un análisis físico de preocupaciones humanas y medio ambientales basado en métodos de recopilación de datos con recomendaciones para estrategias de mitigación utilizando enfoques comunitarios. Las recomendaciones provistas han sido diseñadas para dar poder a la comunidad y facilitar estrategias innovadoras para resolver los problemas de manejo de desechos mientras se promueve un proceso de diseño que facilite resolver los problemas de la comunidad en el futuro. El resultado que se quiere obtener es el de aumentar la capacidad y el mejoramiento de el sistema de tratamiento de aguas residuales para los miembros de las comunidades de Huaquina y Juli.

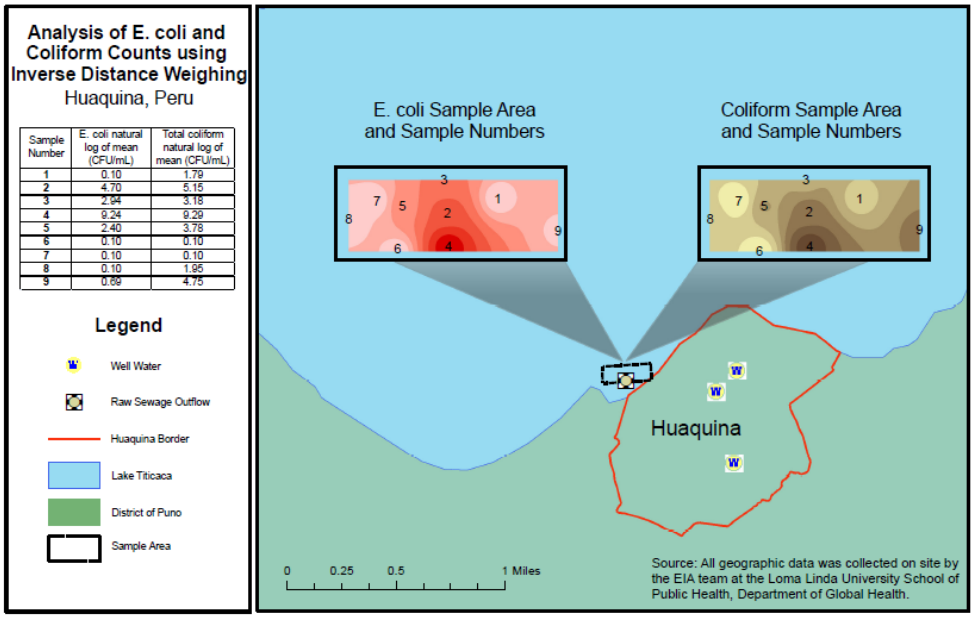
Tabla 1. Valores físicos-químicos de tres muestras de locales, Juli y Pomata, Perú.

Valor	Agua del lago Sitio 2	Julio 1987 laguna	Pomata wwtp	Datos dados por el alcalde sobre la laguna en 1987
Fecha de la Muestra (DD/MM/YYYY)	07/14/2010	07/15/2010	07/15/2010	05/05/2010
Temperatura del Agua (°C)	13	7	9	11.8
Temperatura del Aire (°C)	NT	10	9	NT
O^2 Disuelto(mg/L)	6.8 / 7.0	5.4	0 / 0 / 0	NT
Turbides (JTU)	0	160	70	NT
pH	8.5	8.5	7	7.4
Dureza (mg/L)	280	160	111	141.3
Alcalinidad (mg/L)	80	225	150	196.2
Total Coliformes CL (mg/L)	NT	NT	NT	80.9
Calcio como CaCO3 (mg/L)	NT	NT	NT	109.5
Residual de Chloro (mg/L)	NT	NT	NT	0
E.coli (CFU/100ml)	110 CFU/ml	2720 CFU/ml	NT	NT
Coliformes Total (CFU/100ml)	172 CFU/ml	>3000 CFU/ml	NT	2.1 x 10^7 MPN/100ml

Mapa 1. : Mapa de Sistema de Información Geográfica de Juli y Huaquina



Mapa 2: La frontera de Juli y Huaquina y muestras de la calidad de agua



EXECUTIVE SUMMARY

Access to clean water sources and improved sanitation greatly impacts the health of communities and quality of life. Wastewater treatment has often been overlooked leading to potentially hazardous materials invading local water sources and affecting the public's health. The communities of Huaquina and Juli, located in southeastern Peru, have struggled with effectively managing wastewater in a way that is culturally and technologically appropriate. This Environmental Impact Assessment (EIA) systematically assesses the wastewater drainage through the communities of Huaquina and Juli into Lake Titicaca. The drainage is assessed for compliance with major environmental and wastewater regulations developed by the government of Peru, the Millennium Development Goals sanitation goal, and the World Health Organization's standards for wastewater treatment and management. This EIA will answer selected marker questions outlined in Australia's Agency for International Development's (AusAID) Environmental Management Guide on wastewater treatment.

Field research was conducted by Masters of Public Health graduate students and faculty from Loma Linda University in collaboration with Suma Marka, a local Peruvian non-governmental organization. The research team conducted data collection in three priority areas: microbiological data collection of wastewater and lake water; spatial data collection of the Huaquina community, specifically mapping the border and sewerage system; and qualitative data collection through interviews with key stakeholders in Juli, Huaquina, and the larger city of Puno. Microbiological and spatial data was collected in four locations where the wastewater drainage problem has been noted by the community and Suma Marka: (1) the Juli municipality's wastewater drainage site into the lake and other areas within the lake; (2) the oxidation lagoon constructed by the Juli municipality in 1987; (3) community wells in Huaquina; and (4) the border between Juli and Huaquina. Unstructured observations and notes were taken from each of the sites visited.

Data analysis from research activities in microbiology revealed microbial contamination of the water in Lake Titicaca, Huaquina community wells, and wastewater in the oxidation lagoon. Spatial analysis provides a visual representation of the border of Huaquina as well as the sewerage system beginning in Juli and ending in Lake Titicaca. Contaminated lake water can be seen visually on two maps developed using Geographic Information Systems. Interviews with key stakeholders describe the opinions of community and authority members on the current wastewater treatment system, perceived and potential effects from the oxidations lagoons, and a desire for an improved wastewater treatment system.

Results from the above research activities allowed the team to develop several short- and long-term recommendations for mitigation. Short-term recommendations include: the improvement of artesian wells in Huaquina; community education on water and sanitation health topics; modifications of both oxidation lagoons with possible relocation; and the implementation of monthly community forums and monitoring committees. These short-term improvements should lead to long-term, sustainable investments in community development including: implementation of an improved wastewater treatment system in Huaquina and Juli; and the implementation of a piped sanitation system in Huaquina. Recommended actions should involve collaboration between community members and local municipalities in Juli with the intention of improving wastewater treatment, community health, and well-being in Huaquina and Juli.

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ACRONYMS

ALT	Autoridad Lago Titicaca
AusAID	Australian Agency for International Development
EMP	Environmental Management Plan
GIS	Geographic Information System
GPS	Global Positioning System
LLU	Loma Linda University
LLU GEAT	Loma Linda University Global Environmental Assessment Team
NGO	Non- Governmental Organization
SM	Suma Marka
USAID	United States Agency for International Development
MPH	Masters of Public Health

"Inadequate handling of wastewater has serious consequences for human health, the environment and economic development. It contaminates the water supply, increasing the risk of infectious diseases and deteriorating groundwater and other local ecosystems."

-United Nations, 2007

1. BACKGROUND INFORMATION

1.1. INTRODUCTION

The community of Huaquina, Peru is in close proximity to a wastewater oxidation lagoon project organized by the nearby municipality of Juli. The oxidation lagoon is within the Huaquina village border and is designed to receive sewage from Juli. This Environmental Impact Assessment evaluates the proposed wastewater oxidation lagoon project.

The lack of communication between Juli residents, Huaquina residents, and the government on the actual and perceived effects of the wastewater treatment system has led to local controversy. Recognizing the need for resolution and environmental improvements, the Loma Linda University Global Environmental Assessment Team (LLU GEAT) in collaboration with Suma Marka (SM), a local Peruvian non-governmental organization, conducted holistic investigative research through an Environmental Impact Assessment (EIA).

This EIA examines the current wastewater treatment system in Huaquina considering the health, societal, and overall environmental impact on the community. This assessment uses three methods: a Global Positioning System (GPS) to provide a visual representation of sewage flow, microbiological indicators to evaluate the current and potential impacts of the sewage flow, and uses semi-structured interviews to understand community and authority perceptions of the lagoon project. Data is collected by 6 MPH graduate students from Loma Linda University (LLU), two LLU faculty members, and four SM members. The data collected is then used to answer select marker questions modified from AusAID's Environmental Management Guide (Appendix 1)(AUSAID, 2003). These marker questions assess all aspects of wastewater projects including direct/indirect and positive/negative impacts. Recommendations for mitigation and alternatives are produced in the end of this document as precursors towards an environmental management plan. This document will provide guidance to SM in documenting data as evidence to persuade official government policies and suggest improvements to the wastewater treatment system.

1.1.1. Juli municipality

Juli is the capital city of the Chucuito Province located in southern Peru, on the shore of Lake Titicaca approximately 45 miles south of the city of Puno. Juli was founded by the Spanish on April 2, 1565 and later became the capital of Chucuito on June 3, 1828 (Beltran, 2010). As of 2005, there were approximately 26,000 people living in Juli. Juli is most well known as the "little Rome of the Americas" since the small city houses four independent Catholic churches associated with four surrounding hills topped with religious structures. Much of the city's tourism is based on the churches and the beaches of Lake Titicaca (Miranda, 2010). While many people live in the urban center of Juli, several rural communities are located on the outskirts of the city limits.

1.1.2. Huaquina village

Huaquina is a small rural community near the city of Juli located at about 12,700 feet above sea level and a border of approximately six kilometers in length. There are an estimated 50 families living within the limits of Huaquina, but the current census is only an estimate because of recent emigration to urban centers. The people of Huaquina speak both the indigenous language of Aymara as well as Spanish. Huaquina's terrain is composed of flat plains surrounded by four major hills with many of the residents living in the mountainous areas. A majority of community members are involved in agriculture, raising farm animals for food and profit, as well as trout

farming for profit. The community is well organized with a Lieutenant Governor (*teniente*) and a community President. The Huaquina and Juli communities have cultural differences and sometimes do not agree on environmental or social issues. One local NGO reported that the rural Huaquina residents are often perceived as ignorant and less intelligent than the people living in Juli. This social tension has created further problems between the two communities, specifically related to wastewater drainage and the implementation of oxidation lagoons. Two large drainage pipes leading to the lagoon were removed as a protest to the perceived insufficient design.

1.2. TERMS OF REFERENCE

Terms of reference for the consultant group working on this project were discussed with the Suma Marka NGO and the community during the first day site-visit. Items discussed include the following:

- ✓ The proposed study schedule; the timeframe for completion of the EIA process;
- ✓ The activities and responsibilities of the study team;
- ✓ The studies to be carried out (e.g. Approach, time & space boundaries);
- ✓ The information and data to be included in the EIA report;
- ✓ The impacts and issues to be studied;
- ✓ The expected outputs or deliverables from the study team; and
- ✓ Statement of need for and objectives of the proposal;
- ✓ Study area or impact zone(s) (e.g. The affected environment and community);
- ✓ Provisions for public involvement;
- ✓ Alternatives to be examined;
- ✓ The means for making changes / additions to the EIA if necessary.

1.3. PROBLEM INTRODUCTION

The term "wastewater" can be applied to water of varying qualities including urban wastewater drainage, treated wastewater, reclaimed or recycled wastewater, fecal sludge, or biosolids (Jimenez, 2010). Wastewater is both a commodity and a waste, however it is often only thought of as a nuisance waste to be disposed of at the least possible cost. This has resulted in a global practice of dumping wastewater in landfills, holes, or any unoccupied surface and/or drainage system. The use of wastewater as a commodity has been used for centuries to improve agriculture or aquaculture in Asia and many other societies (Jensen, 2005). When properly managed and treated, wastewater is an appropriate fertilizer. Unfortunately wastewater management in many developing countries has largely been mismanaged and has increased the risk of infection by various bacterial and parasitic pathogens, such as *Trichuris* spp., *Ascaris* spp. and *Taenia* spp.

The complex interactions of wastewater, environment, and community development can only be addressed in a format that brings together all social, political, and environmental issues. Improper management of wastewater causes direct environmental degradation of lake water and increased disease risk to local communities. The longer-term indirect problems include advancing lake water eutrophication and robbing communities of future productivity of their freshwater fisheries. Untreated wastewater from the city of Juli is being deposited into Lake Titicaca, imposing multiple health and environmental threats to surrounding communities, specifically Huaquina. The community has expressed direct and indirect impacts related to this misused wastewater as well as the social implications of the oxidation lagoons.

1.4. CURRENT WASTEWATER MANAGEMENT PLAN FOR JULI AND HUAQUINA, PERU

The regional government in Juli constructed two oxidation lagoons as a solution to its growing production of waste and concern for the increasing levels of untreated wastewater deposited in the lake. The first lagoon was built in 1987 near Lake Titicaca in Juli and was intended to filter wastewater that could then be utilized for community needs. At inception, this system was effective and is still used today; however the system is out of date and treated water cannot be reused. Over the past half century, Juli, like other communities around Lake Titicaca, have failed to maintain waste disposal and treatment in proportion with population dynamics. Juli is just one of the communities responsible for the estimated 12,731,147 cubic meters of which waste are dumped into the lake each year (Ther, 2009). In 2008, due to the population growth and increased waste production overwhelming the first lagoon, the government built a second oxidation lagoon located in Huaquina less than two miles from the original lagoon. The construction of the new oxidation lagoon was not executed as originally stated by the government resulting in various technical problems and inefficient filtration for the population size.

The community of Huaquina is dissatisfied with the design of the most recently constructed oxidation lagoon as well as the social implications connected to this lagoon. There are shared concerns within the community relating to the inadequate technology, potential threat of overflow and flooding during the rainy season, and lack of sufficient maintenance with the lagoon. The community feels it has the right to be treated equally and has voiced its concerns and desire for improvements to the local municipality, but nothing has yet been done. The citizens of Juli argue that members of Huaquina are ignorant to the effectiveness of the lagoon, and local leadership states that there is not enough money in the budget to facilitate the improvements that Huaquina's citizens demand. These community concerns and lack of appropriate construction of the new lagoon has created tension between the community of Huaquina, the community of Juli, and the government. In order to facilitate an accurate evaluation of the situation, qualitative and quantitative methods conducted by third party members are needed.

1.5. A REVIEW OF LOCAL PROJECTS

1.5.1. Suma Marka

While limited progress has been made on improving Huaquina's wastewater treatment system, several organizations have worked on environmental concerns in the communities surrounding Lake Titicaca. Suma Marka is a local non-governmental organization (NGO) dedicated to studying and improving environmental conditions throughout Peruvian communities, as well as the conservation of biodiversity surrounding Lake Titicaca. The organization is composed of young professionals in the fields of science and sociology who collaborate with communities and regional governments to improve the environment. The organization also collaborates with external partners such as Global Water Watch, the Chijnaya Foundation, and Pomona College in the United States. SM seeks to test environmental indicators through low-cost technologies and to examine social impacts on the environment. SM is currently coordinating projects in communities around Lake Titicaca with four main areas of focus: 1) the conservation of flora; 2) the conservation of fauna; 3) monthly water quality evaluations; and 3) environmental education (Suma Marka, 2010). SM began working with the communities of Juli and Huaquina in 2008 to address the growing environmental concerns around the two existing oxidation lagoons. The NGO conducts monthly microbiological, physical and chemical analyses on the water in both lagoons and in Lake Titicaca. SM has also been working with community members and the government in Juli to determine a more effective solution for wastewater treatment.

1.5.2. Autoridad Lago Titicaca (Lake Titicaca Authority)

Autoridad Lago Titicaca (Lake Titicaca Authority) is a bi-national organization working to conduct and promote activities, projects and programs concerning water management of Lake Titicaca. The organization works in Peru and Bolivia to enforce rules for the protection of lake water, reporting directly to the Ministry of Foreign Affairs in both countries. They implement sustainable water solutions that protect the biology and integrity of the lake as well as the surrounding communities. ALT coordinates with multiple public, private, governmental and multinational organizations to secure funding for project implementation (Autoridad Lago Titicaca, 2010). Previous efforts have been initiated to improve water management in the vicinity of Juli, however, there is no current program working in this area.

1.5.3. Other organizations working in the area

The communities of Juli and Huaquina have seen various health and development projects in the past ranging from sexual and reproductive health promotion to environmental assessments. Outside of the SM projects, there has been one other major environmental project in Huaquina. Several years ago, the United Nations funded a water management project that involved contracting a third party to conduct research. The results of this research were not disseminated to the citizens of Huaquina nor did they see any resulting changes from the project. As of now, SM is the only organization working in the field of environmental health with the Huaquina community.

1.5.4. Collaboration between Suma Marka and LLU SPH

While SM is routinely monitoring environmental indicators in Huaquina and Juli, assistance was needed in determining future recommendations to improve the oxidation lagoons and provide more efficient wastewater treatment. Ann Stromberg and Heather Williams, both board members of the Chijnaya Foundation, work to connect local Peruvian organizations with collaborating partners in the United States. Ms. Stromberg, a professor at Loma Linda University, is actively involved in partnering with local Peruvian organizations to improve community health. She has previously taken public health students on trips to Peru to work with the Chijnaya Foundation in various rural communities. Her collaboration with both the University and the Foundation initiated the connection between LLU and SM. Ms. Stromberg, Ms. Williams and other LLU faculty proposed to assist SM by sending Masters of Public Health students to Huaquina. Through an overseas class called Integrated Community Development, this group of students would partner with SM in assessing the environmental concerns of the oxidation lagoons, while putting didactic skills into practice. Contact between Dr. Ryan Sinclair of LLU and the organizing members of SM, Javier and Maria, was initiated through electronic communication to discuss the partnership, get a baseline of the environmental situation, and determine an action plan. The LLU GEAT and SM agreed to conduct an EIA on both oxidation lagoons and Lake Titicaca. The project seeks to educate LLU students on working with community health and development projects, while assisting the community's needs.

1.6. Scope and objectives of the Environmental Impact Assessment

The overall goal of the project is to provide a third party EIA of the wastewater treatment system in Huaquina, Peru through quantitative and qualitative methods.

The objectives of the EIA are as follows:

1. By July 16, 2010 the LLU GEAT will collect GPS coordinates for the border of Huaquina, the above-ground sewer pipes, monitoring points, drinking water wells, jaulas (trout cages), and waste management system location(s).

2. By July 16, 2010 the LLU GEAT will collect and quantify 14 water samples from areas identified as at-risk for microbial contamination.
3. By July 16, 2010, the LLU GEAT will conduct interviews with the following key informants to understand their viewpoints on the wastewater treatment system and lagoons:
    a. Two male and two female authority figures from Huaquina
    b. Five community members of Huaquina
    c. Three authorities from Juli: the Mayor, and officials in charge of environment, lake water, or sewage.
    d. Two authority figures from Autoridad Lago Titicaca (ALT)
    e. Five households from Juli
    f. Five fishermen whose business operates near the wastewater treatment system
    g. Three women selling fish in the market of Juli
4. By July 20, 2010, the LLU GEAT will compile results and report preliminary findings from the spatial, microbial and interview data.
5. By September 23, 2010 the LLU GEAT will provide a complete map of all collected geographic data points, corresponding microbial counts, and provide coordinates for suggested water monitoring locations.
6. By September 23, 2010, the LLU GEAT will offer recommendations to the Huaquina community, Suma Marka, and appropriate authorities regarding the wastewater treatment system and lagoons.

1.7. LIST OF APPROPRIATE INTERNATIONAL CONVENTIONS

The security of clean water and proper sanitation is an international concern with multiple stakeholders involved. Various conventions have been developed to provide guidelines for water and sanitation measures, create international goals, and promote advocacy for improved resources. The following conventions are of significant importance to environmental concerns and wastewater treatment.

1.7.1. Millennium Development Goal on Sanitation

The Millennium Development Goals (MDGs) were established and signed by all United Nations states in 2000 with the intention of assisting impoverished nations around the world. These eight goals seek to improve health, reduce poverty and gain environmental sustainability by 2015. The seventh MDG is directed to improve and ensure environmental sustainability in all countries with a specific target to "halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation" (United Nations, 2010). While many nations have successfully been able to improve access to water in their communities, significant gains are yet to be made in more vulnerable regions. The 2015 target for sanitation is of larger concern and may be out of reach since a majority of the developing world lacks basic sanitation. These setbacks in reaching improved water and sanitation are worse in rural regions of the world, including communities throughout Latin America. People living in rural communities have half the amount of piped water available than their urban-dwelling counterparts (United Nations, 2010). Major efforts to improve water and sanitation are needed in rural communities throughout the world in order to reach these 2015 goals.

1.7.2. The UNECE Water Convention

The United Nations Economic Commission for Europe (UNECE) Water Convention was developed in 1992 to effectively manage surface and ground water resources in European countries with water quantity and quality in mind. The convention seeks to understand local

water resources and how the management of these assets affects natural ecosystem and their surrounding communities (UNECE, 2010).

1.7.3. Stockholm Convention

The Stockholm Convention on persistent organic pollutants is a global treaty developed to reduce the amount of chemicals that affect both human health and the environment. The treaty was adopted in 2001 and took effect in 2004 by encouraging individual countries to eliminate the amount of persistent organic pollutants that are released into the environment. The treaty specifically impacts the condition of local water sources and calls for reducing contaminated water sources. Peru developed a National Implementation Plan in 2007 committing to reduce environmental contaminants and chemicals (Stockholm Convention, 2008).

1.7.4. Convention on Biological Diversity

The Convention on Biological Diversity was formally initiated in 1993 to promote sustainable development internationally by preserving the environment and natural resources. The main objectives of the Convention include: the conservation of biological diversity, using biologically diverse components in a sustainable matter, and the fair and equitable sharing of the benefits that arise from using genetic resources (Convention on Biological Diversity, 2010).

1.7.5. The Strategic Environmental Directive

The European Commission adopted the Strategic Environmental Directive to ensure that environmental consequences of certain plans and programs are identified and assessed during their preparation prior to implementation. Within this Directive, the Urban Wastewater Directive was adopted in 1991 to protect the environment from the adverse effects of wastewater discharge, both domestic and industrial. The Directive outlines principles for planning of wastewater management, regulation and monitoring of these systems, and guidelines for reporting information (European Commission, 2010).

1.8. PERU ENVIRONMENTAL LEGISLATION

Environmental legislation in Peru is impacted by multi-sector organizations guiding the legal framework. Government offices such as the Ministry of Health and the Ministry of the Environment develop and regulate national laws regarding the environment; however, organizations such as Autoridad Lago Titicaca retain control and legislation of local natural resources.

The Peruvian National Office for Natural Resources Evaluation (Oficina Nacional de Evaluacion de Recursos Naturales – ONERN) is an autonomous organization with the responsibility of assisting the National Institute of Planning (Instituto Nacional de Planificacion –INP). This office has the mandate to develop policies and perform studies of the human environment with a target towards environmental conservation. The Ministries of Health, Mining and Housing also have environmental directorates. Peru outlines various areas of legislation in regards to environmental conditions and maintenance of environmental sustainability. The following demonstrates some of the more prominent legislations:

- ✓ Peruvian General Law of the Environment No. 28611 (Peru Ministry of Environment, 2010)
- ✓ Environmental Law: Environmental Policy and its Enforcement (Global Legal Group, 2006)
- ✓ Environmental Law: Waste (Global Legal Group, 2006)
- ✓ Environmental Law: Contaminated Land (Global Legal Group, 2006)
- ✓ The National Biodiversity Commission and the Biodiversity Law (Peru Ministry of Environment, 2010)

- ✓ The Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Peru Ministry of Environment, 2010)
- ✓ The Organic Law Governing Municipalities Law No. 23853
- ✓ The Environmental Code- Legislative Decree 613 (1990) (Peru Ministry of Environment, 2010)
- ✓ Law for the National System of Environmental Management No. 28245 (Peru Ministry of Environment, 2010)
- ✓ Law for the National System of Environmental Evaluation and Management No. 20325 (Peru Ministry of Environment, 2010)
- ✓

Although there are many legislative tools to safeguard the environment in Peru, the enforcement of these laws is lacking. The capacity of the government to act on these laws with community support may not exist to an effective and comprehensive extent. The following are three areas where more detailed legislation is needed.

- ✓ Legal instruments regarding environmental impact assessment procedures
- ✓ The management of specific pollution issues, e.g. toxic waste storage and disposal, water quality and sewerage treatment, emission standards and air quality;
- ✓ Natural resource conservation, including forests, fish, mangroves, fauna and flora.

2. METHODS

Identification of environmental impacts was completed by investigating environmental markers (Appendix 1) adapted from the AusAID environmental guidelines (AusAID, 2003). To assess the environmental markers outlined in the guidelines, this research gathers data from activities including: document review; meetings with NGO partners; GPS data collection and use of Geographic Information Systems (GIS) mapping; microbiological water quality data collection and review of past data; semi-structured interviews with villagers living near the project sites and authorities working in related field or government positions; and unstructured observations of all project sites. Data collection was accomplished using three research teams. The first team was composed of two graduate students collecting GPS coordinates with the help of one SM member and a local Huaquina community member to guide them. The second team was composed of one graduate student, one water quality specialist and LLU faculty member, and one SM member collecting both water samples and corresponding GPS coordinates. The third team consisted of three graduate students, one LLU faculty member and two SM members conducting key informant interviews throughout the cities of Puno, Juli and Huaquina. This section will describe the data collection processes in further detail.

2.1. DOCUMENT REVIEW

Prior to departure for Peru, a literature and document review was conducted to gain further knowledge on wastewater standards and methods used to conduct wastewater treatment EIAs. Previous EIAs reviewed for this analysis include those conducted in developing countries on wastewater treatment, broader international papers, some concept papers, and a variety of other national level documents related to wastewater. By reviewing previously written EIAs, it is possible to gain an overview of the environmental impacts discovered, relevant interview questions/topics, and potential environmental markers among similar projects. The environmental management plans (EMPs) from each EIA reviewed is summarized in Appendix 2. All lessons learned, and best management practices defined in the reviewed papers were considered when collecting and analyzing data for this project.

The following related EIAs were reviewed for this document:

- ✓ Environmental Impact Assessment: Solid Waste Treatment Center "Jbeil-Hbaline" Unione of Municipalities of Jbeil, Caza of Jbeil.(Prepared by Earth Link and Advanced Resources Development- ELARD, 2004)
- ✓ Small Towns Rural Water Supply and Sanitation Project- Kenya (Prepared by the Department of Water and Sanitation, OWAS- 2009)
- ✓ Summary of Environmental Impact Assessment: Henan Wastewater Management and Water Supply Project in the People's Republic of China (2005)

2.2. MEETINGS WITH SUMA MARKA AND OTHER NGOS

Before arriving in Huaquina and Juli, informational meetings were conducted in the city of Puno with Suma Marka as well as other organizations operating water-related development projects around Lake Titicaca. LLU GEAT first met with Javier and Maria of SM to understand the background of Juli and Huaquina as well as gain a broader perspective of the oxidation lagoons. LLU GEAT then met with a chemical engineer working as a water consultant for the Peruvian Ministry of the Environment, and a sociologist investigating the socio-cultural practices related to water. Javier secured further meetings for the research team including the following: a meeting with four biology professors from the Universidad Nacional Altiplano Puno; a meeting with two authorities from the Instituto Del Mar Del Peru (IMARPE); and a meeting with three employees from ALT. The choice of individuals for each meeting was based on the contact's knowledge of water related issues, the relevance to the project and their availability.

2.3. GPS/GIS DATA COLLECTION AND ANALYSIS

Vital to the success of the EIA is the understanding of the geographical barriers between the city of Juli, the originating site of the wastewater, and the community of Huaquina, as well as the location of wastewater disposal. Due to the lack of existing detailed geographical data and the importance of this information to the overall understanding of the wastewater treatment system, GIS is included as part of the data collection methods.

Prior to departure for Peru, a basemap (Appendix 3) was created by georeferencing several JPEG images of Juli and Huaquina from Google Maps. Identifiable structures on these satellite images were located both in Juli and Huaquina and used as reference points for calibration while the research team was in the area.

In order to better understand the exact deviation between the communities of Juli and Huaquina, a local villager from Huaquina was recruited to lead the team along the border. During this two-day hike along the border, the team took geographical coordinates using ArcPad 7.0.1 on a GPS enabled ToughBook. These points were used to create a new shapefile representing Huaquina's community limits. Geographic data for the above ground sewer pipes, monitoring points, artesian wells, jaulas (trout cages), and wastewater treatment system was also collected by the team using a GPS-enabled camera which recorded both images and geographic coordinates.

Upon return to Loma Linda, all geographic data and corresponding digital images were uploaded onto ArcGIS 9.2 for full visual representation. A map was developed to display the location of the Huaquina-Juli border, the pathway of the sewage pipes, and the community artesian wells. This map utilizes geographic coordinates to display water quality data within specific regions of Huaquina and Juli. The map was used to analyze the current environmental conditions and determine effective solutions for wastewater management.

2.4. WATER SAMPLE COLLECTION, ANALYSIS, AND REVIEW OF HISTORIC DATA

Prior to the research team's arrival in Huaquina, SM suggested several locations for microbial testing based on previous monitoring sites and identified at-risk areas for microbial contamination. Upon arrival, LLU GEAT identified several additional, potentially contaminated areas to test water quality.

Water samples were collected from 14 locations in Huaquina and Juli including local artesian wells, bordering lake areas, and the first oxidation lagoon. Table 2 displays the location of each sample taken.

Table 2: Water quality samples taken within Huaquina and Juli

Sample Number	Sample location			GPS Coordinates (latitude, longitude)
	Lake	First lagoon	Well	
1	X			-16.202028 S, -69.479261 W
2	X			-16.202261 S, -69.480104 W
3	X			-16.201718 S, -69.480159 W
4	X			-16.202156 S, -69.480857 W
5	X			-16.202830 S, -69.480088 W
6	X			-16.202913 S, -69.480935 W
7	X			-16.202074 S, -69.481285 W
8	X			-16.202373 S, -69.481759 W
9	X			-16.202565 S, -69.478251 W
10		X		-16.197360 S, -69.454326 W
11		X		-16. 197674 S, -69.453957 W
12			X	-16.209112 S, -69.472678 W
13			X	-16.203983 S, -69.473594 W
14			X	-16.202625 S, -69.471978 W

Approximately one liter of water was collected from each sample location and corresponding GPS coordinates were recorded with a GPS capable smart phone. Water samples were stored in ice chests and platted in-field less than 12 hours post-collection.

Each water sample was tested using the Coliscan Easygel method (Micrology Laboratories, Goshen, IN) to determine total coliform and *Escherichia coli* counts. One milliliter of each water sample was added to pure Coliscan solution, inverted three times, poured onto a labeled petri plate, and immediately covered to avoid contamination. Duplicate plates were made to ensure accuracy of data. The petri plates were stored in temperature-controlled, portable incubators for 48 hours at 37° Celsius and transported to another location for analysis.

Total coliform and *E. coli* counts were manually quantified by members of the research team. Numbers were recorded and analyzed in combination with geographical data.

Historical data from SM's monthly water quality monitoring reports were also reviewed for relevance to the wastewater outflow into Lake Titicaca. The data was used to describe the outflow characteristics of the sewage along with any significant seasons or remediation efforts.

2.5. INTERVIEWS WITH KEY STAKEHOLDERS

2.5.1. Community Forum in Huaquina

Upon LLU GEAT's arrival in Huaquina, a previously scheduled community forum to discuss the collective opinions regarding the wastewater treatment lagoon was held. The President, Justina, and the Lieutenant Governor, Alberto, invited all residents of the community. The forum was conducted similarly to an informal focus group, with a main moderator and several

co-moderators facilitating the conversation. All other team members were present and acted as recorders. One person actively translated the conversation, aiding monolingual team members involved in recording field notes. The format of the forum followed select questions from the semi-structured interview guidelines (Appendix 4) with the intention of understanding the effects of the wastewater treatment system from a community wide perspective.

2.5.2. Huaquina Community and Political Leader Interviews

Individual interviews were conducted in various locations throughout Huaquina by three interview teams: two teams consisted of one interviewer and one recorder, and the third team consisted of a single person interviewing and recording. Immediately following the community forum, the interview teams approached the remaining willing community members for individual interviews. Interviews conducted with community members were formatted to be semi-structured interviews with select quantitative questions and qualitative questions to initiate discussion. The interview guidelines (Appendix 4) used both quantitative and open-ended questions to explore explanations and domains of perceptions, attitudes, and facts about environmental conditions and the impact of the wastewater treatment system and lagoon on the community. Once all community members at the forum were interviewed, the community President and Lieutenant Governor recommended other community members willing to be interviewed. The interview teams also interviewed all Huaquina political leaders.

2.5.3. Juli interviews

Interviews with Juli community members and authorities were conducted on a separate day using the same interview guidelines as those used in Huaquina. Community member interviews were conducted using a random, convenience sample of those people willing to speak to LLU GEAT members. Two teams worked separately to find community members, fishermen, and authority figures in Juli for the interviews. One team consisted of three members, one person to translate in Aymara, one person to translate in Spanish, and one to record the interview. This team began at the marketplace to interview fishermen and women selling fish. During the two hours in which the interviewers were at the marketplace, each vendor at the market was solicited for an interview. Juli community members not involved in the fishing business were also sought out at the marketplace.

The second team was comprised of two persons, an interviewer and a recorder. The target interviewees were political leaders and authority figures in Juli. Two meetings previously arranged through Javier with the mayor of Juli and the environmental health specialist at the MINSA (Ministerio de Salud) Hospital. Final interviews with citizens of Juli were completed by both teams using Javier's contacts throughout the town.

Descriptive data obtained from all interviews was used to detail certain environmental markers for this report and understand the impact of the wastewater treatment system on community members in Juli and Huaquina.

2.6. OBSERVATIONS

Unstructured observations and notes were taken by each team visiting the various locations throughout Juli and Huaquina. Many of the environmental markers and checklists require no interviewing but observation of relevant environmental markers. The observation guide is provided in Appendix 5. Observations were used to answer marker questions related to environmental conditions, community housing conditions, water availability and basic sanitation in the communities.

2.7. Environmental Markers

A list of environmental markers obtained from the AusAID guidelines and other wastewater EIAs were adapted to fit the unique needs of this project. The above methods of document review, interviews, observations, and water quality data collection are used to answer this EIA's environmental markers listed in appendix 1.

3. RESULTS

3.1. Results: Potential Environmental Impacts of the Lagoon

Through the above-described document review, GPS data collection, microbiological analysis, and interviews the LLU GEAT was able to gain a broader perspective on the wastewater treatment system in Huaquina and Juli. Microbiological data revealed areas of high contamination in Lake Titicaca as well as in Huaquina's community wells. GPS collection and GIS analysis was able to provide a visual representation of the community border, sewage system, and water quality testing sites. Interviews conducted with 29 key stakeholders (Table 3) provided background on the wastewater treatments system along with current and perceived effects of this treatment system. These results are described in detail within the following topic headings obtained from a list of suggested marker questions (AusAID, 2003).

Table 3. Total number of interviews conducted for EIA field research.

Stakeholder Interviews	Amount
Huaquina community members	11
Juli community members	10
Fishermen	3
Authorities	5
Total	29

3.2. Description of the current environment in Juli and Huaquina

Juli and Huaquina are located at about 12,700 feet above sea level with a daytime temperature around 25° Celsius year round, however the temperature falls significantly after sunset. While the temperature may be consistent, the amount of rainfall greatly varies depending on the season. The rainy season in Juli usually starts in September and lasts until about April or May, with the months of January, February and March yielding the most rainfall. The air quality in Juli and Huaquina is decent with minimal amounts of smog, as opposed to the capital city of Lima. However, the air quality in community member's homes is of some concern due to the type of stoves used for cooking often filling the kitchen with smoke and fumes.

3.3. Resource use and socioeconomic impacts

3.3.1. Water supply

The quantitative questions from the interviews conducted in Juli and Huaquina reveal common water sources for both drinking water and those sources used for agriculture (if agriculture was indicated as a means of income in the household). The following tables demonstrate the results obtained from 23 different interviews.

Table 4: Water source used for drinking and household use.

Water Source	Juli	Huaquina	Total
Piped water	2	0	2
Well water	3	11	14
Other*	7	0	7

*Other includes: local springs

Table 5: Water source for agricultural means.

Water Source	Juli	Huaquina	Total
Rainwater	10	11	21
Other*	1	0	1

*Other includes: municipal greywater

According to community members surveyed in Juli, local spring water is the main source for drinking and household use. Other sources include municipal piped water and water from surrounding wells. All community members surveyed in Huaquina indicated using community wells for their drinking and household water.

The majority of Juli community members involved in agricultural work of some sort indicated using rainwater as their main source of irrigation while one community member indicated using municipal greywater for agriculture. In Huaquina, all community members were involved in agricultural production and all indicated using rainwater for irrigation.

These results demonstrate the differences between available water sources in Juli and Huaquina. Community members living in Juli have more variety in the water sources available to them. While many residents decide to use spring or well water that is in close proximity to their houses, some areas of the city have piped water available for their disposal. Huaquina lacks any form of piped water sources; therefore community members rely on the three local wells for drinking water.

The majority of people involved in agricultural work rely on rainwater to sustain their crops throughout the year. This method poses risks for the community in seasons with little rainfall. Therefore, the majority of agriculture is done when rain is more plentiful. This is a difficult process since the climate has been changing over the past few years and rain is unpredictable. Improved irrigation systems and more reliable water sources for agriculture are needed in these communities.

3.3.2. Water and wastewater quality

The first oxidation lagoon in Juli is periodically monitored by the Ministry of Health to determine the level of coliforms along with biophysical components of the water. LLU GEAT obtained the most recent water quality report conducted in May 2010 from the Ministry of Health (Appendix 6). The results from this report were compared with the information collected during water sampling by LLU GEAT and SM.

Water samples taken by the LLU GEAT from Huaquina, Juli and Lake Titicaca were analyzed to determine quality and contamination levels. Table 6 illustrates the results of the water samples collected following plating and incubation. Colonies formed on the plates were analyzed to determine both total *E. coli* and coliform concentrations.

Table 6: E. coli and total coliform counts for water samples collected.

Sample Number	*E.coli* Geometric mean (CFU/mL)	Total coliform Geometric mean (CFU/mL)
1	1	6
2	110	172
3	19	24
4	10,344	10,817
5	11	44
6	<1	<1
7	1	<1
8	<1	7
9	2	116
10	100	>3000
11	2,720	527
12	<1	1
13	<1	17
14	3	>300

Amongst the samples from the lake, all showed the presence of *E. coli* and coliforms in varying concentrations. Sample 4, taken from near the wastewater drainage pipe, showed the highest concentration of both *E. coli* and coliforms with more than 10,000 CFU/mL. Several samples had concentrations of *E. coli* and coliforms greater than 300 CFU/mL indicating the possibility of water above the USEPA's and WHO's international criteria for recreational water. Therefore, the water in these locations should not be used for recreational use, drinking water, or washing.

Water samples taken directly from the first constructed oxidation lagoon (samples 10 and 11) both demonstrated the presence of *E. coli* and coliforms. Sample 10 showed a greater proportion of coliforms than *E. coli* and sample 11 demonstrated the reverse with the presence of more *E. coli* colonies. Overall, the high levels of *E. coli* and coliforms present in this oxidation lagoon represent the inefficiencies in the technology used for wastewater treatment. For a complete assessment of the wastewater lagoon's efficiency at removing contaminants, solids, and nutrients from the wastewater, more methods are needed. The NGO SM reported that the community adds malachite green to the 1987 oxidation lagoon on the east side of Juli. The purpose of the malachite green is to.

The samples taken from the artesian wells (samples 12-14) also demonstrated levels of *E. coli* and coliforms; however, only sample 14 indicated a concentration of contaminants that is potentially harmful. The presence of *E. coli* and coliforms in the well water samples could signify the presence of pathogens posing potential health risks to the Huaquina population, as the wells are used as the primary source for drinking water.

Table 7. Physical Chemical values for three sample locations in Juli and Pomata, Peru.

Value	Lake Water site 2	Juli 1987 lagoon	Pomata WWTP	Data from Mayor on 1987 lagoon
Date Sampled (DD/MM/YYYY)	07/14/2010	07/15/2010	07/15/2010	05/05/2010
Temperature water (^oC)	13	7	9	11.8
Temperature air (^oC)	NT	10	9	NT
Dissolved O^2 (mg/L)	6.8 / 7.0	5.4	0 / 0 / 0	NT
Turbidity (JTU)	0	160	70	NT
pH	8.5	8.5	7	7.4
Hardness (mg/L)	280	160	111	141.3
Alkalinity (mg/L)	80	225	150	196.2

Cloruros como CL (mg/L)	NT	NT	NT	80.9
Calcio como CaCO3 (mg/L)	NT	NT	NT	109.5
Residual Chlorine (mg/L)	NT	NT	NT	0
E.coli (CFU/100ml)	110 CFU/ml	2720 CFU/ml	NT	NT
Total Coliforms (CFU/100ml)	172 CFU/ml	>3000 CFU/ml	NT	2.1 x 10^7 MPN/100ml

The above samples measured on 7/14 and 7/15 measured physical chemical parameters using colimetric methods in the LaMotte water quality kit. Microbiological samples from 7/14 and 7/15 were cultured using the coliscan method (Micrology Labs, Wisconsin) and incubated at 35°C for 48 hours. The data obtained from the Mayor's office was prepared by the Ministerio de Salud laboratory DIRESA (Appendix 6). All alkalinity and hardness measurements used titrametric methods, The pH was measured using a potentrimetric pH probe, while the chlorine and iron were measured using colimetric methods. This water quality report did not include any parameters typically measured in wastewater and was inappropriate for the lagoon. Neither the Suma Marka report or the Mayor's office water quality report were successful in measuring the efficiency of the 1987 wastewater lagoon or the Pomata wastewater treatment system (Table 7).

For a complete assessment of the wastewater lagoon's efficiency at removing contaminants, solids, and nutrients from the wastewater, more methods are needed. Suggested methods useful for these wastewater lagoons are the biochemical oxygen demand (BOD) method, the total suspended solids (TSS) method, volatile suspended solids (VSS) method and the specific oxygen uptake rate (SOUR) method. Additional tests could include Nitrate, Nitrite, Phophate, and Ammonia.

Interviews at the ALT indicated success in less than 30% of all wastewater treatment projects initiated by their program. For perspective of a successful treatment system to compare to the Juli system, the EIA team made a site visit to the nearby Pomata wastewater treatment system. Serving a smaller community, the Pomata system was reported as a success by the ALT. The system is a unique gravity flow system incorporating 2 settling basins, gravel filter beds, and a lagoon. The following observations and physical chemical measurements obtained in Table 7 describe the system as a success in appearance but potentially unsuccessful in operation due to a lack of system maintenance.

The system is an impressive energy-free solution using no electricity and having over three different biosolids treatment methods. Upon visit, the team found three potential problems with the wastewater system:

1. The sludge diversion valves were leaking and the sludge was not routinely removed (Figure 1). This is problematic for the cement structure that is not designed to have a constant pool of water around it.
2. Pipes leading to the filter beds were leaking and water was pooling around the cement structures, posing a risk for further deterioration of the cement basins (Figure 2).
3. The lagoon water was measured and double validated to have a dissolved oxygen level of 0 mg/L (Table 7). A dissolved oxygen value of zero indicates low flow of the wastewater and an improper environment for the aerobic digestion that is intended to occur in a lagoon.

The Pomata system is a successful ALT model in terms of money spent by the community, system design, and location. The most novel design component is the system location. The community of Pomata is located on a hill above the treatment system that is visible from the

perimeter of the city, but not an eyesore. The use of gravity from the city on the hill appears to work well to deliver sewage for treatment. Upon visit by the EIA team, the system did not have a notable odor, but seemed somewhat neglected. The following is a list of suggested maintenance:

Maintenance required:

- ✓ Repair leaks in sludge valve
- ✓ Repair leaks in filter system
- ✓ Trouble shoot low dissolved oxygen in lagoon by conducting microbial indicator tests (Total Coliform etc) BOD, TSS and VSS measurements on effluent and influent.
- ✓ Check flow of wastewater effluent to lake for blockages. The pipe from the wastewater treatment system to the lake has to travel over 500 meters on land with a low slope.

Figure 1. Leaking sludge diversion valves on primary and secondary settling tanks in Pomata, Peru on July 16, 2010.

Figure 2. Leaking wastewater system pipes around the gravel filter bed treatment processes in Pomata, Peru on July 16, 2010.

3.3.3. Wastewater reuse and productivity (use biosolids for energy)

Based on the interviews conducted with community members of Juli and Huaquina as well as government officials, the following results have been obtained regarding the current and projected effects of the oxidation lagoons.

The community of Huaquina firmly believes that the lagoon built in 2008 was poorly constructed with outdated technology. Initially, the community opposed the construction of the treatment system, but was convinced by the newly elected mayor that the oxidation lagoon would have a working and efficient filtration system. While the government had discussed these intentions with the community before implementing the new oxidation lagoon, community concerns and suggestions on the project appeared to be disregarded in the final construction.

After witnessing the faulty construction, Huaquina community members made efforts to discuss their concerns with local authorities in Juli and determine possible improvements; however their efforts were either ignored or dismissed. The community has received little to no support from the municipality, and although a previous environmental impact assessment was conducted by an outside organization, no improvements have been made to the lagoon. Community members decided to take action into their own hands and responded by disconnecting the two sewage pipes entering the lagoon from Juli and re-directed them into Lake Titicaca. This was stated to be a community-wide effort where all members were consulted and agreed on the response action.

Due to the lack of appropriate technology in the oxidation lagoons and the damage to the pipes by community members, the Huaquina area oxidation lagoon is not functioning. The area remains an open trench without fencing or barriers around it. The incomplete trench is dug into the groundwater, so the four trenches have up to one meter of water in them. This was perceived as an ineffective wastewater treatment system, so the community diverted the wastewater directly to the lake.

The oxidation lagoon built in 1987 is in use; however, it is not functioning as an appropriate means of wastewater filtration. High levels of *E.coli* and coliforms (Table 7) demonstrate the lack of sewage treatment to create a water source that can be drained to the lake without an environmental impact. Further modifications are needed to improve both oxidation lagoons.

According to ALT project members who organized the wastewater project, Lagoons are not the preferred technology for wastewater treatment. The climate is not appropriate for wastewater treatment in a lagoon that requires an aerator and a long residence time before being discharged to the lake.

The planned discharge from the Huaquina lagoon project was from the lagoon to the Rio Salado, and then to the lake. The delta of the Rio Salado is an area rich in biodiversity with a reed bed and many species of birds.

3.3.4. Population increase / increased access to project location

Community members throughout Huaquina and Juli expressed that the increasing amount of youth moving from rural towns to more urban cities, such as Lima. This migration has changed the demographics of both communities leaving fewer youth in this region and a growing number of older residents. While youth may be migrating towards urban regions, there was no migration reported as a result of the oxidation lagoon location and its proximity to the community member's homes.

3.3.5. Impact on livelihood or economic activities

The initial community forum in Huaquina and subsequent interviews reveal that the current wastewater treatment system has had minimal impacts on the livelihood and economic activities

of the community members. The first lagoon has been perceived to pollute the lake; however, fishermen have not reported seeing a change in the quality or quantity of their trout. Huaquina community members have also indicated that they see no immediate effects on their economic activities or means of generating income.

While few immediate effects from the oxidation lagoons are seen, community members perceive that the lagoons will create more problems in the future, especially if the pipes are reconnected without improvements to technology and infrastructure. Many community members believe that the current location and condition of the oxidation lagoons will impact their ability for economic gain related to tourism. The community of Huaquina desires to expand into the field of tourism, however they believe the aesthetics of the community will be hindered by the oxidation lagoons and they will not be able to prosper economically as a result.

3.3.6. Domestic animals

Huaquina community members own a variety of domestic animals including dogs, llamas, sheep, cattle and pigs. These animals graze in open fields close to the community wells, the oxidation lagoons, and the lake. Open defecation from these animals may contribute to contamination of the water sources throughout Huaquina, however this has not been confirmed. The community did not express any current concerns linking their animals to the oxidation lagoon, nor did they express immediate impacts on their animals as a result of the oxidation lagoon location. Community members did express the fear that contaminated water resulting from the oxidation lagoon will contribute to an increase of diseases infecting the animals.

3.4. BIOPHYSICAL / LANDSCAPE IMPACTS

3.4.1. Conditions of Lake Titicaca

While community members did not express concerns on the condition or quality of the lake water, microbiological data reveals key areas of contaminated water in Lake Titicaca. Based on the water samples collected and analyzed, the water at the shore of Lake Titicaca has above normal concentrations of *E.coli* and coliforms (Table 7). The sewer pipe that Huaquina community members disconnected from the second oxidation lagoon flows directly into the lake contributing to the higher amounts of contamination in the lake. The map in Appendix 7 shows a visual representation of this contamination. The contamination may be confined to the lakeshore due to the presence of reeds growing in the lake that prevent the contaminated water from flowing very far.

3.4.2. Crops

All Huaquina community members and a majority of residents in Juli are involved in agriculture for income producing mainly potatoes, yucca, and quinoa. Community members in this region rely heavily on rain to farm, which has become increasingly difficult due to changing weather patterns and shorter rainy seasons. There was no indication that community members were interested in utilizing other water sources, including treated wastewater, for agricultural production. The ALT had mentioned that the practice of using treated wastewater for irrigation was not performed in this area because it is too complicated. ALT representatives did not explain these complications or other solutions, just the fact that this was not practiced in the high altitude region. With improved wastewater treatment there is potential to grow more crops using treated water for irrigation in the dry season reducing the reliance of farming only in the rainy season.

3.4.3. Change in vegetation cover from the downstream effects of the activity

Currently there are no stated concerns with vegetation surrounding the oxidation lagoons or in Lake Titicaca. While there may not be any obvious changes in vegetation, the effects on aquatic ecology resulting from untreated wastewater entering the lake cannot be determined without further investigation. The increase of raw sewage entering Lake Titicaca could contribute to further eutrophication of the lake and disrupt the natural habitat. There is also a possibility of decreased diversity in aquatic vegetation that can survive in the lake due to the high levels of contamination. Further investigation on this topic is needed to determine the exact effects on the aquatic vegetation.

3.4.4. Important species / habitats / ecosystems that can be affected.

There are many important species and sensitive habitats in close proximity to the oxidation lagoon as well as in Lake Titicaca. There are potentially hazardous effects on the biodiversity of these habitats if untreated wastewater continues to drain into the lake.

Lake Titicaca is thought to be between two and three millions years old and is home to a variety of organisms including freshwater fish, vegetation, and mammals. The major species of indigenous fish include the Karachi, boga, and ispi. Trout and mackerel were introduced into Lake Titicaca in the 1930s as a means for economic production. The introduction of trout and mackerel has affected the population of native fish and led to the extinction of the Karachi fish. The lake also has many shrub formations which are the primary vegetation in the lake. Species include: *Baccharis incarum*, *Baccharis boliviensis*, *Parastrebia lepidophylla*, *Fabiana densa* (LakeNet, 2004).

While the habitats within Lake Titicaca are still surviving, human impacts have led to the endangerment of many species. A Peruvian biodiversity prospectus (UNEP, 2010; WRI, 2003) contains over 100 mammals, birds, and reptiles which are categorized as endangered, threatened, or vulnerable. Lake Titicaca has primarily been impacted by organic and bacteriological contamination from urban waste and mining. Poor waste disposal and sewage discharge has increased the eurtrophication process in the lake (World Water Assessment Programme, 2010). These changes in the lake also affect the fish and mammals that rely on lake vegetation for survival. While no direct impacts on fish population have been documented as a result of wastewater contamination into the lake, the potential effects could be devastating to the biodiversity of Lake Titicaca. Further investigation is needed to determine the impacts on lake habitats due to improper wastewater drainage.

3.5. ENVIRONMENTAL HEALTH

3.5.1. Latrine use and sewerage use

The majority of residents in Juli indicated having a flush toilet in their homes or using a public flush toilet in their community. These residents have greater access to the sewerage system that runs throughout Juli leading to the oxidation lagoons or into the lake. Community members in Huaquina do not have access to the sewerage system. Therefore, the majority of community members use personal or public latrines. While community members are fairly satisfied with their latrines, they did express the desire to have personal flush toilets with access to the sewerage system. These flush toilets are too expensive for community members to afford and are not a viable solution without support from the government or other organizations.

Huaquina also has a significant amount of animal waste from domestic pigs, llamas, cows, and dogs observable throughout the community. These stables for these domestic animals are located near the lake and the community wells. Environmental pollution in these villages including sewage water and animal waste translates into polluted natural water sources and drinking water sources.

3.5.2. Solid waste

Although the traditional Peruvian home generates little rubbish, plastic bags and containers are often discarded on the ground near the home and rarely in a central location. These plastic bags and containers often pollute the community as well as Lake Titicaca. Fishermen interviewed working by the lake stated that pollution entering the lake water was one of their biggest concerns. There are few efforts aimed at reducing the amount of pollution from plastic bags and containers, which in turn affects the water quality throughout the community and in the lake.

3.5.3. Odor/aesthetics

While the Huaquina community perceives a multitude of negative effects from the oxidation lagoons, the odor from the lagoons is of particular concern. The first oxidation lagoon has a bad odor affecting the aesthetics of the area in which it is located. Huaquina community members are concerned that if the second lagoon returns to function, there will be a similar odor in their community, in close proximity to their homes. This odor will affect the aesthetics of Huaquina as well as impair the community's potential to invite tourists into the community.

3.6. GIS RESULTS

Using ArcGIS software the location of each oxidation lagoon and the current sewage outflow from Juli was determined. The location of the sewage pipe, the two oxidation lagoons, the locations of each water sample taken and the community wells are mapped out for visual representation (Appendix 7). Geographic information collected using ArcPad software was uploaded and converted on ArcGIS to develop the border of Huaquina. Geographically referenced points taken along the border were imported into ArcMap and converted to points and polygons using ArcMap extension creating the border of Huaquina. GPS points of current SM water quality monitoring locations are shown along with expanded sampling sites from the LLU GEAT research.

The map in Appendix 7 also displays the water quality samples taken in the lake near the effluent from the sewage system. The corresponding microbiological data is shown with the total amount of E.coli and coliforms found at each site.

3.7. COMMUNITY AND SOCIAL IMPACTS

3.7.1. Cultural or archeological significance

The community of Huaquina adheres to the traditional Aymaran language and culture, with some Spanish influence. Aymara is one of the native indigenous languages spoken by the Aymara people who live primarily in the Andes Mountains of South America. There are over one million people who speak Aymara; a majority of these people live in Peru and Boliva with a couple thousand living in parts of Chile and Argentina. In Peru, Aymara is one of the three official languages, along with Spanish and Quechua. The Aymara culture and language was more widespread in the early days of the country. However, after the Spanish conquest, many tribes migrated and adapted to the newly influential Spanish culture. The amount of indigenous Aymara tribes in Peru has slowly dwindled and many of the existing tribes continue to live in rural regions of the Andes (Aymara, 2010).

3.7.2. Attitudes of villagers towards wastewater treatment system and lagoon

Interviews with community members and fishermen in Huaquina and Juli revealed similar opinions on civil organization as well as control over environmental decisions. Juli and Huaquina citizens expressed that they have a lack of control over externalities including political decisions concerning the environment. While these communities may be knowledgeable on local issues,

they are often disregarded by municipal authorities when environmental decisions need to be made. Community members have stated their concerns about the environment and oxidation lagoons to authorities, but have received no support. This lack of ability to make decisions regarding their community and lack of control over externalities, has increased Huaquina's frustration with local government resulting in community protest, such as removing sewage pipes, to receive attention from authorities.

Community members in Huaquina have expressed few immediate effects from the oxidation lagoons; however they perceive the lagoon as a possible focal point for infection and contamination that may impact both human and animal life. All speculate that the effects of the functioning second lagoon would be detrimental to their community's health and well being. They foresee increased illnesses such as colds and diarrhea from larger amounts of waste being deposited in close proximity to their homes. The community also expressed concerns of future floods during rainy seasons. Since the oxidation lagoon is at the same level as the lake, they believe during the rainy season the oxidation lagoon will overflow leaving waste products all over their land. They believe this will perpetuate illness and increase odor within their community.

Finally, Huaquina community members expressed the desire for improvements to the current oxidation lagoons as well as a longer-term solution to the increasing wastewater needs of the community. Community members suggested implementing updated technologies currently found in surrounding communities, such as Pomata, that could be used as a model for improvements in their community. They feel that the improvements should be carried out and monitored by Juli's municipal authorities.

Interviews conducted with Juli community members reveal differing views on the wastewater treatment system and oxidation lagoon in Huaquina. The majority of community members live approximately three kilometers from the oxidation lagoon in Huaquina, however, many are unaware of the social unrest the lagoon has caused. Those interviewees who understand the conflict have expressed the Huaquina community's lack of knowledge and incapability to conceptualize environmental issues as reasons why the community sees the lagoon as problematic. One interviewee said that Juli has been undergoing a water shortage partly because Huaquina community members have tampered with the treatment system. Interviews from Juli indicated that the current location of the lagoon poses no threat to the surrounding environment; however the technology in the lagoon needs to be improved.

Overall, residents throughout Juli and Huaquina may disagree on the current effects from the oxidation lagoons, but both communities have seen the need for improved oxidation lagoons with technologically advanced infrastructure. While the community desires change and improvement, the regional and local government has a strong influence on these goals.

3.7.3. Attitudes of traditional and governmental authorities towards wastewater treatment system and lagoon

Interviews conducted with authorities and government personnel throughout the region revealed varying opinions on the wastewater treatment system in Huaquina. Authority interviews in Puno with the Universidad Nacional Altiplano Puno and IMARPE exposed larger concerns with the Lake Titicaca water system rather than concerns with the oxidation lagoon in Huaquina. Both interviews also demonstrated the need for improved laboratories to test water quality throughout Peru.

The interview with ALT authorities in Puno revealed two major water-related concerns: regulations regarding water quality and contamination; and the regulation of community water sources and sanitation around Lake Titicaca. In regards to the implementation of the oxidation lagoon in Huaquina, ALT representatives were opposed to its construction since it is not seen as a technologically appropriate treatment system. The ALT representatives described oxidation

lagoons equipped with aerators as effective methods for wastewater treatment, but not desirable due to the high altitude. The organization also discussed an oxidation plant project designed to assist thirty different municipalities surrounding Lake Titicaca, including Juli. ALT initially planned to implement an improved wastewater treatment system in Juli by 2009; however the project was terminated due to lack of funding. ALT is currently seeking funding to complete all wastewater treatment systems in the thirty municipalities by 2015, including capacity building for municipal technical teams.

The interview with the mayor of Juli indicated awareness of current community concerns related to the oxidation lagoon and Huaquina's response to the problem. The mayor agreed that the lagoon needs to be improved and Huaquina residents need to be informed about the improvement process. However, the mayor stressed that any improvements need to be funded by local governments who have insufficient funds for the extensive repairs needed. In order for any improvements to be implemented, funding must be obtained and allocated for the wastewater treatment system. The mayor seemed positive on community involvement for future wastewater solutions, but his term ends in December 2010 leaving potential solutions at the discretion of the next elected official.

The environmental health specialist at the MINSA hospital in Juli had limited knowledge about the oxidation lagoon; however he mentioned that the lagoon was constructed with little technical support. He stressed that the improvement and maintenance of the lagoon is under full control of the municipality in Juli and it would be very difficult to make quick improvements. His concerns on environmental decision-making mirrored those of Huaquina community members. Overall, authority officials from Juli were aware of the deficiencies in the oxidation lagoon in Huaquina but offered no immediate solutions for the problem.

4. RECOMMENDATIONS

Through data collection and analysis, the LLU GEAT was able to identify inefficiencies in the current wastewater treatment system leading to potential health hazards and environmental concerns. Interviews with key stakeholders revealed broader concerns of the oxidation lagoons and the desire for improved infrastructure. LLU GEAT has developed several short- and long-term recommendations for the Huaquina community and Juli government based on the data collected from GPS mapping, microbiological analysis, and interviews. These recommendations are intended to implement culturally relevant and appropriate solutions for wastewater treatment systems and community empowerment. The following is an overview of the recommendations:

Short-term recommendations

- ✓ Artesian well improvements
- ✓ Community education
- ✓ Lagoon modifications
- ✓ Community forums and monitoring committee
- ✓

Long-term recommendations

- ✓ Improved wastewater treatment system
- ✓ Implementing piped sanitation system in Huaquina

4.1. ARTESIAN WELL IMPROVEMENTS

Microbiological data revealed contamination in all three of the community wells sampled in Huaquina. Since this contamination has the potential to affect the health of the community, it is

recommended to immediately improve these wells. Each well should be lined and capped with cement and a hand pump should be installed to prevent contamination of the ground water source. The most contaminated well in the community should be lined first to protect the community's drinking water from further contamination followed by the other community wells. It will also be important to develop an effective barrier around the wells to reduce further animal and human pollution. In addition to well improvements, the institution of weekly well water monitoring by community members is recommended. Monitoring teams will be implemented and community members will be taught how to analyze the quality of the well water and add disinfecting chemicals when necessary. A community group of interested members will need to be arranged and several community members will be in charge of these monitoring teams to insure community ownership and proper management of the wells. The monitoring teams will need to be supported and trained by Suma Marka partners.

4.2. COMMUNITY EDUCATION

Community education and capacity building is essential to increase public awareness of environmental issues. Education on the health implications of contaminated well water, the importance of weekly monitoring, wastewater treatment systems, and basic sanitation will empower the community to take control of their environmental health.

The model of *promotores de salud* (health promoters) can be used to educate influential community member and implement community based participatory research strategies. The use of *promotores de salud* has been shown to increase knowledge, mobilization and utility of various health- related services within families and communities (Anders, Balcazar & Paez, 2006). A group of influential community members is first trained as *promotores de salud* and are then able to educate their peers on key environmental and health issues. Education for *promotores de salud* should be conducted on topics such as sanitation, potable water, contamination prevention for cooking and well water, and environmental sustainability. Training *promotores de salud* will provide a culturally relevant and sustainable method of community involvement to improve environmental health in Huaquina. Community education on environmental health topics will also aid in ensuring community "buy-in" to improve the current wastewater treatment system in Huaquina.

Concurrently, it is recommended that public awareness measures be taken to inform community members about contaminated water in Huaquina. Proper notifications and signs should be posted along shorelines within the borders of Huaquina and Juli to warn potential water users of contamination. The artesian wells with hazardous levels of contamination should also be labeled as hazardous along with necessary boiling time for purification until further improvement can be made. Public awareness is an important step to increase trust and education within the community considering the history of misinformation and lingering resentment against previous water projects. Vital to the success of community education and public awareness is the continuing line of trust been the community of Huaquina, Suma Marka, and Loma Linda University. It is recommended that SM coordinate community education efforts with the support of LLU and other collaborating partners.

4.3. LAGOON MODIFICATIONS

The current wastewater treatment system and oxidation lagoons are not functioning properly due to improper construction and the actions taken by the Huaquina community. To immediately improve the use of the oxidation lagoons, compromise must be reached between community members and local government in Juli. This would include the authorities in Juli conducting essential improvements to the infrastructure of the lagoon, while community members return the pipes they previously removed.

It is recommended that both oxidation lagoon structures be modified to comply with the international standards of wastewater management, treatment and reuse set forth by the World Health Organization (World Health Organization, 2006). The modification of the oxidation lagoons should also comply with all applicable national regulations from the Ministry of the Environment (2010) and regulations recommended by ALT for effective wastewater treatment and management of environmental concerns. These improvements include lining the old and new oxidation lagoons with cement to provide a barrier between the residual wastewater and the natural water table in order to prevent further contamination of ground water sources. It is also essential to build and maintain aeration systems capable of oxidizing the wastewater from Juli at the pace demanded by population size. Fences or other barriers should also be built around the oxidation lagoons to prevent local animals from accessing the contaminated water. Once this step is completed, the pipe releasing untreated wastewater directly into the lake must be permanently capped and/or removed.

The location of the lagoon is another topic of contention. Although the current lagoon is in Huaquina, it may be beneficial for the municipality of Juli to build a new wastewater treatment solution further upstream on the Rio Salada and southwest of the Huaquina boundary (see appendix 3). This relocation of the project to the municipality of Juli may be preferred because it will avoid the Huaquina communities approval, will give Juli another chance to build an improved wastewater treatment system, and will avoid the ground water problems that the current lagoon faces. An uphill / upstream solution is possible because the sewage pipe from Juli travels across much open land that without any new inputs or connections.

4.4. COMMUNITY FORUMS AND MONITORING COMMITTEE

Equally important to the reinstatement of these oxidation lagoons is the community's acceptance of all short-term solutions to subdue current tensions and the possibility of vandalism. It is recommended that all interested parties from both Juli and Huaquina, including government authorities, participate in jointly organized community meetings. These meetings will be able to provide concerned citizens with a platform for questions, suggestions, and to vocalize concerns over the project. This will also promote community involvement and investment in the wastewater treatment system improvements.

The establishment of a community-led monitoring system for each oxidation lagoon and Lake Titicaca should be implemented to assist SM's current monitoring reports. The educational and training component of this step will mirror that of the well monitoring training and should be conducted by SM. These committees will conduct analyses of water quality in the oxidation lagoons and lake. Communication of these results to the government will ensure that the oxidation lagoons are functioning properly and maintenance is provided when necessary. Community-led committees will also ensure community ownership and involvement in the maintenance of the oxidation lagoons. The initiation of these short-term goals should continue to provide further long-term solutions for wastewater treatment.

4.5. IMPROVED WASTEWATER TREATMENT SYSTEM

Further recommendations are considered that will need to be conducted on a longer-term basis to continually improve the wastewater treatment systems in Huaquina and Juli. A technologically advanced treatment system needs to be developed and implemented to replace the second oxidation lagoon in Huaquina. This treatment system should have sufficient aeration and filtration devices to purify the wastewater from Juli and reduce the fear of overflow during the rainy season. In order to implement a new, technologically advanced wastewater treatment system, funding must be available. The ALT plans to complete improved oxidation treatment systems in communities around Lake Titicaca by seeking grants and funding from outside

donors. It is recommended that the government authorities in Juli and the community of Huaquina renew their relationship and collaborate with ALT to improve the wastewater treatment system. This collaboration will assist in providing a technologically appropriate system and the potential for a continued relationship between the community and ALT. After implementation of an improved treatment system, the wastewater can be used as a commodity for agricultural needs throughout Huaquina and Juli, reducing the community's reliance on rainwater. An agricultural irrigation system that utilizes the treated wastewater can be developed and implemented over time.

4.6. IMPLEMENTING PIPED SANITATION SYSTEM IN HUAQUINA

Although Huaquina is currently dealing with the health and environmental impacts of wastewater, they are a community which also lacks proper sanitation and pipes for their own personal wastewater system. Therefore, in order to extend the right for personal and household water use into the community of Huaquina, improvements in sanitation should be made throughout the community. Existing latrines should be improved and eventually replaced with plumbed toilets and linkage to a sewage system. The regional government should also provide resources for a community-wide effort to create a piped water and sewage system capable of supplying all Huaquina community members with potable water and a wastewater disposal system. This system would connect all plumbed toilets and household water systems to a drainage pipe directed towards the treatment plant. Funding for this project can be sought through ALT and the regional government budget. The initial investment will provide a cost-effective method to improve health outcomes and protect the environment throughout the community and in Lake Titicaca.

These recommendations will help to improve the overall access to clean water sources, improve sanitation in Huaquina and alleviate community concerns regarding the current wastewater treatment system and oxidation lagoons. These short- and long-term goals will only be attainable through effective communication between government authorities, community members, and collaborating organizations.

5. CONCLUSION

The current issues facing the communities of Juli and Huaquina have many layers. There is the physical dynamic of wastewater management, Huaquina's concern for their health, and the potential effects of the oxidation lagoons on the environment. There is also the psychosocial aspect from the community that feels that they do not have a voice or the equal right to an environment that promotes positive health outcomes. Any actions taken by local leadership moving forward must account for both dynamics of the situation. The community of Huaquina wants real, tangible solutions to waste management, but they also want to be recognized as equals and treated with respect. Their discontent should be acknowledged as valid and collaborative methods should be utilized to develop a sustainable solution for all stakeholders.

This EIA provides a physical analysis of human and environmental concerns based on data collection methods with recommendations for mitigation using community-based approaches. The recommendations provided are designed to empower the community and facilitate innovative approaches to solve waste management issues while promoting a process design that facilitates community problem solving for the future. The desired outcome is increased community capacity and an improved wastewater treatment system for community members in Huaquina and Juli.

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APPENDIX 1. ENVIRONMENTAL MARKERS AND CHECKLISTS

The following checklists are from AusAID and the TNMA as mentioned above. The AusAID questions below have been reviewed and only the appropriate questions are listed in this appendix. A full checklist is available in the "Environmental Management Guide for Australia's Aid Program 2003".

Resource use and socioeconomic impacts

- ✓ Is the local population living a basically traditional lifestyle? If so, how will the activity affect resources (drinking and washing water, lake or land food, fuel, medicines, building materials, shells, lime) that local people take from the natural environment?
- ✓ Will the activity add to demands on local water supplies or other local resources? Or will it restrict people's access to natural resources? What plans are there to provide additional resources to meet increased needs?
- ✓ Will the activity affect downstream users of resources, especially water? If so, how will these resources be protected?
- ✓ Will future opportunities to use natural resources be lost? If so, what compensation will be offered?
- ✓ Will the activity require land or water use leases or changes in tenure?
- ✓ Will the activity require any residents to be resettled?
- ✓ Will the activity result in construction workers or other people moving into or having access to the area? How many people will be involved? Is this a large increase on the normal population of the
- ✓ area? How will this affect local resource availability?
- ✓ Will the activity create jobs locally? If so, will some be for women and some be for local youth?
- ✓ Will the activity provide safe reliable transport to and from the workplace, and a safe working environment?
- ✓ Will some activity outputs meet the needs of special groups in the community (women, youth, elderly or infirmed people)?

Biophysical/landscape impacts

- ✓ What is the local vegetation?
- ✓ Will vegetation cover be changed by the immediate or 'downstream' effects of the activity?
- ✓ Are there important species, habitats or ecosystems in the area to be affected? Or is the area ecologically sensitive or fragile?
- ✓ Can construction areas be located away from sensitive ecosystems and on flat or very gently sloping land?
- ✓ Are there areas of limestone karst? Or are there areas of wetlands? If so, has special consideration been given to their management?
- ✓ Will the activity remove any vegetation? Will it leave any surface bare? If so, what impact will the clearance have? How will sediment be prevented from entering streams?
- ✓ Will the activity affect coastal areas, wetlands or swamps directly or through 'downstream' effects?
- ✓ Will the activity affect slope or soil stability or involve heavy machinery?
- ✓ Will a large land area (or a high proportion of one community's land) be affected?
- ✓ Will the activity develop or operate quarries or borrow pits?

- ✓ Will the activity alter the present landscape by, for example, removing rock or soil, dumping spoil or removing timber?
- ✓ Is the area culturally or archaeologically sensitive? For example, is it behind a beach or headland, on a low ridge, near a creek or waterhole, on a ridge or saddle in hilly country or along a traditional walking route? Are rock shelters or caves present? Is the area named in stories? Or is it a burial area? (Note: If the area is culturally or archaeologically sensitive, a survey may need to be carried out to locate such sites.)
- ✓ Will the activity affect traditional cultural (men's or women's) or archaeological sites? If so, what steps will be taken to protect or salvage information from the sites?

Forested areas

- ✓ Is the local vegetation mainly lowland forest, montane forest or mangrove forest?
- ✓ Are there important species, habitats or ecosystems in the area that can be affected (immediately or 'off site')? Or is the area ecologically sensitive or fragile?
- ✓ Are any unmodified forested areas locally important hunting or restricted access areas?
- ✓ Will the activity remove any vegetation? Will it leave any surface bare? If so, what impact will the clearance have? How will sediment be prevented from burying vegetation, entering streams or reaching the shoreline?
- ✓ Can construction areas be placed to avoid disturbing local habitats?
- ✓ Will the activity alter the forest landscape by, for example, removing rock or soil, dumping spoil or removing timber?

Water and air quality

- ✓ Will the activity generate waste products (including increased sewage or solid wastes)? Will waste products be disposed of locally?
- ✓ How will sewage be treated? How will solid waste be treated? How will rock or soil waste or chemically contaminated soil be treated?
- ✓ Does the activity have site-specific erosion and sediment control plans for each sector of the site?
- ✓ Will the activity or its waste disposal affect the quality of local streams or the ground water? What steps are being planned to minimize sedimentation in streams or contamination of ground water?
- ✓ Will toxic chemicals (including herbicides, tar, oils, paints and other industrial chemicals) be used or disposed of in the area?
- ✓ Will hazardous substances (including large quantities of fuels) be used or stored in the area? What plans are there to contain these substances? How will fuel, oil or other hazardous chemicals be delivered, transferred and stored to prevent any leakage into the soil, streams, limestone karst areas or the coastal zone?
- ✓ Will heavy machinery create dust or noise problems, or reduce safety for pedestrians? What plans are there to minimize these impacts or separate heavy machinery from residential areas?
- ✓ How will batching areas (for concrete or bitumen) and other construction sites be contained while in use and cleaned and rehabilitated after use?

Environmental health and natural and construction hazards

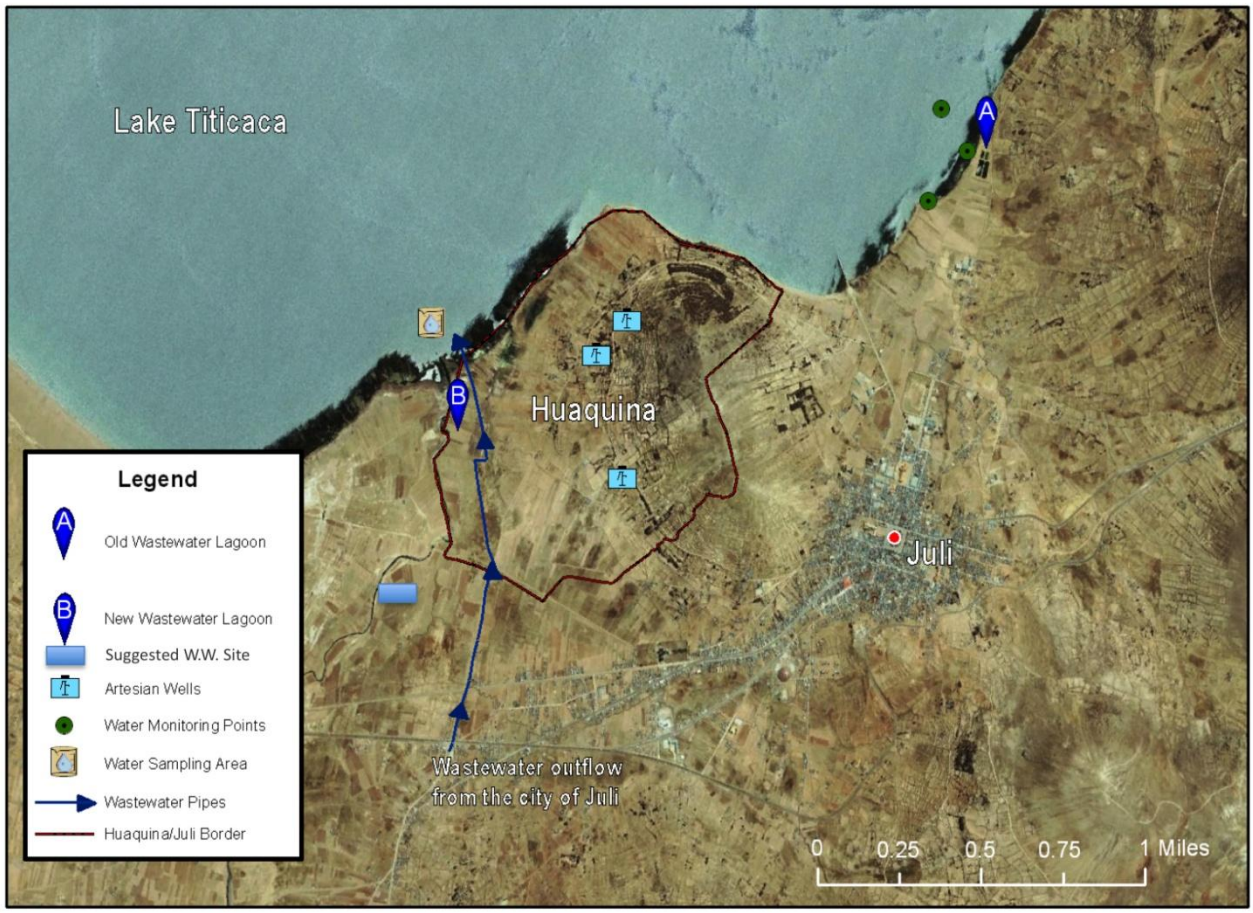
- ✓ Will the activity create a need to protect the environment or repair environmental damage (especially after the activity ceases)? If so, has the cost of this work been built into the activity's budget?

- ✓ Will water pond at the activity site? What steps will be taken to provide disease vector (especially mosquito) control?
- ✓ Is the environment naturally unstable (prone to coastal erosion, within a zone that would be affected by any rise in sea level or in an area of known earthquake or landslip activity, cyclones or severe
- ✓ storms, floods or droughts)?
- ✓ What plans are there to protect the activity against natural hazards?
- ✓ Will the presence of the activity cause increased environmental damage should hazardous natural events occur? If so, what environmental protection measures will be implemented?
- ✓ Will any used machinery be brought to the site from other regions or from another country? If so, what steps will be taken to avoid the entry of noxious organisms? How will it be cleaned? How will the washing water be disposed of?
- ✓ Are safety measures in place to protect the workforce? Is the necessary safety clothing/equipment available to all workers? Have they been trained in its use?
- ✓ Is there a contingency (emergency) plan to deal with spills of hazardous chemicals (including oil products) in the area?
- ✓ Are firefighting materials and spill clean-up chemicals (water, sand, detergents, acid and alkali) available for use at the site?

APPENDIX 2. SUMMARY OF EMPS DEVELOPED FOR RELATED WASTEWATER EIAS.

Name	Project	Potential Positive Impacts	Potential Negative Impacts	Management
Solid waste treatment in Jbeil-Hbaline (ELARD, 2004)	Implementation of an aerobic composting plant for proper solid waste management in the Caza of Jbeil, Lebanon. The project will serve 85 villages.	Eliminate open dumping; reduce solid waste; promote use of compost and recycling; generate income activities and employment.	Construction of the plant will cause noise, dust and waste; loss of biodiversity due to plant; possible contamination of natural resources.	"Reduce waste volume, recover recyclable material, achieve better quality compost, and develop the recycling and compost markets". The EMP proposed to achieve these tasks through public awareness campaigns, community education and development of markets for compost and recyclables.
Water supply and storage in Kenya (OWAS, 2009)	Contribute to improved water supply and sanitation in small towns of Western Kenya. Provide water storage for irrigation and domestic use.	Increased business opportunities; improved sanitation facilities; improved water quality from nutrient loading.	Increased dust, exhaust and noise from construction; increased demand for land; displacement of 50 families.	Develop soil erosion measures; construct waste screens and sediment traps; limit use of machinery to certain areas; conduct water quality monitoring at nearby rivers; avoid interfering with wildlife.
Wastewater management and water supply in Henan (2005)	A comprehensive wastewater management plan for pollution control and treatment. Promotion of water conservation, water reuse and sustainability.	Interception of industrial and domestic wastewater; improved water quality; improved sanitation.	Airborne pollution; noise; traffic from construction; increased land usage for construction.	Enclose construction site to reduce air and water pollution; comply with relevant emissions standards; implement sound barriers; replant vegetation and trees.

APPENDIX 3. GIS BASEMAP OF JULI AND HUAQUINA.



APPENDIX 4. INTERVIEW GUIDELINES FOR KEY STAKEHOLDERS

The instrument developed for this EIA is a semi-structured interview guide with select questions emphasized as quantitative indicators. Qualitative methods have been chosen because they allow room for the wide variety of unpredictable responses into this unstudied domain. The descriptive data collected with this study can later be used to formulate environmental monitoring indicators and values which can be administrated quantitatively at a future date.

The following interview guide includes three question types. The (1) quantitative survey questionnaire items and (2) semi-structured interview topics are labeled with appropriate probes, while the (3) free list questions are labeled as "(*freelist*)". The quantitative interview questions are closed questions with controlled answer fields of possible answers. *Freelist* questions should be completed as a list with the first mentioned term listed first with all others following. The order in which these free listed items are spoken is important and recorded. Semi-structured interview questions are designed to leave room for a wide range of possible answers on the topic.

The following discussion guide will be translated to conduct interviews in Spanish with local villagers and community leaders or political officials.

The following discussion guide will be translated to conduct interviews in Spanish with local villagers and community leaders or political officials.

COMMUNITY MEMBERS

Consent Statement

This interview is being conducted to obtain information on the wastewater treatment system in Juli and the nearby treatment lagoon. We are members of the Loma Linda University environmental assessment team and are not affiliated with any local NGOs or governments. We would like to understand the impacts that this treatment system and lagoon have had on the community. The interview will be anonymous: nobody will know your answers. We will attempt to have a private interview by conducting the interview in a location where your neighbors and other non-family members cannot hear our discussion. Would you like to answer some questions about the environment and the impact of the treatment system and lagoon?

Survey Questionarre

General information (completed by interviewer)

1. Date	2. Start time: _____
3. End time:	4. Location of the interview:
5. Interviewer:	

6. What is your relationship to the household head?

1.self	2.wife	3.husband	4.daughter	5.son	6.grandmother	7.grandfather	8.cousin	9.unlce/aunt
10. Father	11. Mother	12.Other_____						

7. What is your age in years? _____

8. Gender? 0. Male 1.Female
9. What is the family size including yourself and all extended family living in the house? ___
10. Is the household head literate? 1. Yes 0. No
11. Is the informant literate in Spanish? 1. Yes 0. No
12. What is your water source for drinking?

1.rainwater	2.buy water	3.bottled	4.lake	5.surface	6.piped	7.well	8.Other_____

13. What is the quality of the drinking water? 1. Excellent 2. Good 3. Average 4. Poor
14. Is the water clear or muddy? 1. Yes 0. No
15. Does the water smell bad? 1. Yes 0. No
16. Where do you and your family use the toilet? 1. Community latrine 2. Private latrine 3.In the field 4. Water toilet in house 5. other
17. What is your occupation? _____
18. What is your water source for agriculture? _____
19. What is the quality of the water used for agriculture? 1. Excellent 2. Good 3. Average 4. Poor
20. Is the water clear or muddy? 1. Yes 0. No
21. Does the water smell bad? 1. Yes 0. No
22. How many meters do you live from the wastewater treatment system and lagoon? _____
23. Do you feel there is a problem in the community with Juli's sewage? 1. Yes 0. No (Lead question to qualitative conversation)

QUALITATIVE QUESTIONARRE

Environmental components

1. How has the community changed in the last ten years?
   Probe: How has the population changed? What about the solid waste, sewage, availability of food etc?
2. Do you have any concerns with the conditions of the environment?
   Probe: If so, what?
3. Do you think the community has control over the decisions made about the environment?
   Probe: If not, who do you think has control over these decisions?
4. Is the community safe from floods, erosion, and similar problems?
5. How does your community resolve disputes over the use of natural resources (forest, pasture and land use) water or other natural resources.
   Probe: Who makes the decisions about these things in your community?
6. Are there any development activities currently working with the community and/or environment?
   Probe: If so, what do they do?

Quality of life issues

7. What diseases or illnesses has your family encountered lately? (*freelist: Write in order of spoken diseases*)
8. What do you think are the causes of the diseases your family and community have encountered? *(freelist)*
9. Do you seek medical care for these diseases or illnesses after they occur?

Views on wastewater treatment system

10. Have you or your family been impacted by the municipal wastewater treatment system or lagoon?

Probe: If so, how? If not, why not?

11. Has the wastewater treatment system or lagoon impacted the community?
    Probe: If so, how? If not, why not?
12. Has the treatment system impacted your economic activities or ability to perform your work?
    Probe: If so, how? If not, why not?
13. Does the impact of the wastewater treatment system or lagoon change during the different seasons?
14. Do you believe the community was consulted during the planning of this project?
    Probe: If so, how? If not, why not?
15. What has the community done in response to the wastewater treatment system or lagoon?
16. Have you been involved personally?
17. Do you think that this has been effective?
18. What would you like to see changed about the current wastewater treatment system or lagoon?

Thank you for you time and willingness to talk to me about this issue. We appreciate all of your comments and participation in this study!

COMMUNITY LEADERS / POLITICAL OFFICIALS

CONSENT STATEMENT

This interview is conducted to obtain information on the wastewater treatment system in Juli and the nearby treatment lagoon. . We are member of the Loma Linda University environmental assessment team and are not affiliated with any local NGOs or governments. We would like to understand the government's decision to develop the system as well as the impacts that this treatment system and lagoon have had on the surrounding communities. Would you like to answer some questions about the wastewater treatment system?

SURVEY QUESTIONARRE

1. Date	2. Start time: _____
3. End time:	4. Location of the interview:
5. Interviewer:	

6. How long have you been a leader in the community or in political office? _____ (years)
7. What is the main water source for drinking in the community?

1.rainwater	2.buy water	3.bottled	4.lake	5.surface	6.piped	7.well	8.Other

8. Where do community members use the toilet?
   1. Community latrine 2. Private latrine 3.In the field 4. Water toilet in house 5. other

9. Were you involved in the planning or development of the wastewater treatment system and lagoon? Yes 0. No (Lead question to qualitative conversation)

DISCUSSION QUESTIONS

Environmental components

10. Do you have any concerns with the conditions of the environment? If so, what? *(freelist: Write in order of spoken problems*)
11. Do you think the community has any concerns about the environment?

Probe: If so, how? If not, why not?

12. Who controls the environmental resources and how they are used throughout the community?
13. Are community members consulted in this process?

Human and economic components

14. What is the nature of the community's livelihood or economic activities?

Probe example: herding, farming, fishing, industry, other wage labor, etc.

15. What do community members do for work? *(freelist: Write in order of spoken jobs)*
16. Are there any development activities currently working with the community?

Probe: If so, what do they do?

Quality of life issues

17. What diseases or illnesses are common in the community? (*freelist: Write in order of spoken diseases*)
18. What do you think are the causes of the diseases the community has encountered? *(freelist: write in order of spoken causes)*

Views on wastewater treatment system

19. What are the political and social impacts of the municipal wastewater treatment system or lagoon?
20. Has the wastewater treatment system or lagoon impacted the community?

Probe: If so, how?

21. Has the treatment system impacted the economic activities of the community?
22. Does the impact of the wastewater treatment system or lagoon change during the different seasons?
23. Do you believe the community is supportive of this treatment system and lagoon?

Probe: If so, how?

Probe: If not, what prevents the community from supporting your plan for the lagoon?

24. What has the community done in response to the wastewater treatment system or lagoon?
25. Do you have future plans or modifications for the current wastewater treatment system or lagoon?
26. Do you have anything else you would like us to add to this study?

Thank you for you time and willingness to talk to me about this issue. We appreciate all of your comments and participation in this study!

APPENDIX 5. FIELD OBSERVATION GUIDELINES

Observations were taken throughout the community, the town and around the lake while conducting the EIA. The following guidelines were given to team members.

Observation guidelines for interview teams surveying in the communities

24. Type of housing material 1.brick/cement wall 2.adobe wall 3.wood 4.other_____
25. Roof material 1.tile 2.corrugated iron 3.other_____
26. Overall condition of house and roof. 1. Excellent 2. Good 3. Average 4. Poor
27. Do the household members use community wells? 1. Yes 0. No
28. Do the household members use community latrines? . Good 3. Average 4. Poor
29. Do the household members use community wells? 1. Yes 0. No
30. What type of domestic animals exist in/around this household? _____
31. Is there highly observable animal waste from poultry, pigs, dogs, and cows around the household? 1. Yes 0. No
32. What is the distance of the household to the wastewater treatment system or lagoon.
33. What is the distance of the household to Lake Titicaca.
34. Is the community clean of human/animal waste and garbage? 1. Yes 0. No

Observation guidelines for interview teams surveying authorities

27. Location of the government office
28. Proximity to local Huaquina and Juli (Meters to Huaquina____Meters to Juli____)
29. Condition of the building and roof. 1. Excellent 2. Good 3. Average 4. Poor
30. Are there any wells, latrines, or other infrastructure near the building? 1. Yes 0. No
31. Solid waste and sewage sanitation surrounding the building. _____

Observation guidelines for water sampling and GIS teams at the wet market and around town

Data recorder:	Date:
GPS coordinates	Photo taken?
Where is the photo data?	

1. The market has poor hygiene because of: ((Circle if true)

1.meat hanging uncovered	2.flies on food	3.poor drainage	4. ponding of drainage water	5.Trash and debris	6. poor ventilation	7.Dogs in Market	8.Other live animals
9.food is on ice	10.other hygiene issue						

2. Do workers in wet market wash their hands? 1.yes 0.no
3. What is sold at the wet market?
4. Other _____

Observation guidelines for water sampling teams surveying the lake

Data recorder:	Date:
GPS coordinates	Photo taken?
Where is the photo data?	

1. The following is present at the lake, lagoon, or river (Circle if true)

Homes or dwellings within 100m	Open defecation	Fence to keep people out	Latrines	Businesses or stores	People swimming
People working	Trout farms	Animals roaming the shore	Tourists	Trash in water	Trash on beach
An organized sewage flow	River junction	logging	Erosion	Drought Conditions	Cleared areas
Domestic Farm animals	Burning land for agriculture				

2. Tap water inlet for the town of Juli? GPS Coordinates_____
3. Where is the wastewater drainage? GPS Coordinates_____
4. How far away is the tap water inlet from the wastewater effluent drainage? _____
5. Map the trout farms
6. Other notes or observations

Observation guidelines for water sampling and GIS teams surveying the lagoon

Data recorder:	Date:
GPS coordinates	Photo taken?
Where is the photo data?	

1. The following is true for the lagoon (Circle if true)

Functional aerator	Dogs	Raw Sewage	Dry lagoon	Fence to keep out animals and humans	Domestic Farm animals
A functional plan for sludge removal	Community latrines	Communities within 100m	Vegetation	Erosion	Drought conditions
Felling land	Cleared areas	logging			

APPENDIX 6: WATER QUALITY REPORT FROM THE PERUVIAN MINISTRY OF HEALTH

Ministerio de Salud
Personas que atendemos personas

DIRECCION REGIONAL DE SALUD - PUNO

Jr. José Antonio Encinas 145-165 – Puno – Telf.(051)-351519 – Cel 951-992220

RESULTADOS DE ANÁLISIS MICROBIOLOGICO DE AGUA
INFORME N° 174/2010.

SOLICITANTE : MUNICIPALIDAD PROVINCIAL DE CHUCUITO - JULI.
PUNTOS DE MUESTREO : SALIDA PLANTA DE TRATAMIENTO
FECHA DE RECEPCION : 05.05.2010
FECHA DE ANÁLISIS : 05.05.2010
LOCALIDAD : PROVINCIA CHUCUITO.
REFERENCIA : MUESTRA RECIBIDA EN LABORATORIO DIRESA – PUNO

RESULTADOS:

N.O	PUNTOS DE MUESTREO	LUGAR	METODO ANALITICO	RESULTADOS
				COLIFORMES Totales (35 °C)
01	MUESTRA N° 01, SALIDA PLANTA DE TRATAMIENTO	PROV. CHUCUITO	NMP/100 Ml	2.1×10^2 NMP/100 Ml

DONDE: < 1.8 = SIGNIFICA AUSENCIA.
NMP/100 ml = Numero Mas Probable por cien mililitros.

METODO DE ENSAYO: NUMERACIÓN COLIFORMES TOTALES, COLIFORMES FECALES y E.Coli: METODO ESTANDARIZADO DE TUBOS MULTIPLES , APHA, AWWA, WEF.Par.9221B.E. 21th ed. 2005

Puno, Mayo 11, del 2010

MINISTERIO DE SALUD – LABORATORIO REFERENCIAL – DIRESA Puno

Lic. Reynaldo Borda Sucasaca
DIRECTOR
Laboratorio Referencial de Salud Pública
DIRESA - PUNO

Ministerio de Salud
Personas que atendemos personas

DIRECCION REGIONAL DE SALUD - PUNO

Jr. José Antonio Encinas 145-165 – Puno – Telf.(051)-351519 – Cel.951-992220

RESULTADOS DE ANÁLISIS FISICO QUIMICO DE MUESTRA DE AGUA
INFORME N° 173/2010

SOLICITANTE	: MUNICIPALIDAD PROVINCIAL DE CHUCUITO - JULI.
PUNTOS DE MUESTREO	: SALIDA PLANTA DE TRATAMIENTO
VOLUMEN DE MUESTRA	: APROX. 800 mL C/U, ENV. VIDRIO.
FECHA DE RECEPCION	: 05.05.2010
FECHA DE ANÁLISIS	: 05.05.2010
LOCALIDAD	: PROVINCIA CHUCUITO.
REFERENCIA	: MUESTRA RECIBIDA EN LABORATORIO DIRESA – PUNO

RESULTADOS

PARAMETROS	METODO ANALITICO	MUESTRA N° 02 SALIDA PLANTA DE TRATAMIENTO
TURBIEDAD (NTU)	TURBIDIMETRICO	N.D.
TEMPERATURA EN LAB - (°C)	TERMOHIDROMETRO	11.8
PH	POTENCIOMETRO	7.24
DUREZA TOTAL COMO $CaCO_3$ (mg/L)	TITULOMETRICO	141.3
ALCALINIDAD TOTAL COMO $CaCO_3$ (mg/L)	TITULOMETRICO	196.2
CLORUROS COMO Cl (mg/L)	TITULOMETRICO	80.9
CALCIO COMO $CaCO_3$ (mg/L)	TITULOMETRICO	109.5
HIERRO TOTAL como Fe++ (mg/L)	COLORIMETRICO	N.D.
CLORO RESIDUAL LIBRE (mg/L)	COLORIMETRICO	0

Referencia Bibliográfica: Métodos Normalizados para el Análisis de Aguas Potable y Residuales, American Public Health Association, American Water Works, Association Water Pollution Control Federation 20th Edition

N.D = No Determinado.

MINISTERIO DE SALUD – LABORATORIO REFERENCIAL – DIRECCION – Región de Salud Puno

Puno, Mayo 11, del 2010

Ing. Reynaldo Barra Sucasaca
DIRECTOR
Laboratorio Referencial de Salud Pública
DIRESA - PUNO

APPENDIX 7: GIS MAP DEMONSTRATING JULI-HUAQUINA BORDER AND WATER QUALITY SAMPLES