FINAL REPORT

GEORG FISCHER CLEAN WATER FOUNDATION

Mountain Rain

Rainwater harvesting for hillside communities,
Volcán Telica & Cerro Rota, Nicaragua

DECEMBER 2009

Project summary

Location:	Volcán Telica and Cerro Rota, Municipality of Telica, León, Nicaragua
Project objectives:	Provide access to safe water in the community of El Ojochal del Listón and promote rainwater harvesting in other hillside communities through the construction of 15 domestic rainwater harvesting systems and 6 communal systems
Project activities:	- Promote community organisation and encourage participation - Map access routes and water sources and carry out house by house surveys - Develop optimised ferrocement tank design for use in remote hillside communities - Train local builders in construction techniques - Transport materials to project sites - Construct domestic rainwater harvesting tanks (El Ojochal del Listón) - Improve roofs to facilitate rainwater harvesting (El Ojochal del Listón) - Construct communal rainwater harvesting systems (other communities) - Train community volunteers with a view to future projects (other communities) - Evaluate impact of project on access to water, quantity available and water quality
Project duration:	July 2008 – November 2009
Budget:	US$ 80,000
Donor:	Georg Fischer Clean Water Foundation

Background

'Mountain Rain' is a long-term integrated programme which aims to encourage the development of sustainable livelihoods in seven hillside communities in an environmentally sensitive and disaster vulnerable area of western Nicaragua. The target area is located on the western side of Nicaragua in the Department of León. The beneficiary communities are Agua Fría, El Ñajo, El Caracol, El Ojochal del Listón, Mata de Caña, El Cacao, and Las Pilas (Map 1). One of the fundamental challenges this project must address is access to water. For remote communities on the slopes of Nicaragua's volcanoes, access to water is a major problem. With the nearest source more than 5 km away for some, these families face a daily four hour journey on foot or horseback to collect water to meet only the most basic needs, consuming time and energy to the detriment of farming and education.

The intended outcomes of the Mountain Rain programme over a three year period are:

1. Improved access to safe water in seven remote hillside communities through rainwater harvesting and protection of spring sources.
2. Improved access to sanitation through construction of latrines and hygiene promotion by women.
3. Improved access to agricultural land through improvements to paths and tracks which allow better access to markets.
4. Diversified land use and farming practices in target area to increase income, improve sustainability and reduce vulnerability to environmental shocks and stresses.

Since 2005, Nuevas Esperanzas has promoted the concept of rainwater harvesting in several communities located within the Maribios volcanoes. Rainwater harvesting is the only viable solution to the water needs of most of these communities. The climate of this area is such that plentiful supplies of rainwater can be collected from roofs during the wet season, but the challenge is to store sufficient water to last for the five months of the dry season and to protect this water from contamination. The systems promoted by Nuevas Esperanzas have large, closed, ferrocement tanks designed to let rainwater in but keep mosquitoes out. The technique used to construct these ferrocement tanks is simple and only locally available materials and basic hand tools are needed. The tanks are robust and can last for thirty years or more. Collection of rainwater is sustainable, environmentally friendly, relatively simple, and cost-effective.

Existing water sources (baseline)

The most important existing sources of water are springs located in the communities of Agua Fría, Las Quemadas, El Ñajo, San Jacinto (El Chorro) and Las Pilas (Maps 2 & 7; Figs. 1-3). Additionally, surface water is used from flowing streams in El Caracol and Agua Fría (Figs. 4-6). The community of El Ojochal del Listón has no spring sources of its own and all families in this community travel significant distances to sources in El Ñajo, Agua Fría or San Jacinto. Many families in Agua Fría, the largest and most dispersed community, also face journeys of more than 4 km to their nearest source of water. Although most of these springs are perennial, the yield of those located at the highest elevations (Agua Fría, El Ñajo) diminishes significantly towards the end of the dry season. In drought years these sources can virtually dry up altogether.

These spring source emerge from the sides of Volcán Telica with the exception of Las Pilas in Cerro Rota. Many springs are influenced by hydrothermal activity associated with this active volcano. Two sources (in El Ñajo and San Jacinto) emerge at temperatures in excess of 40ºC. These thermal waters are only moderately mineralised, however, with most having conductivities in the range 220-450 µS/cm (Table 1). In two sources concentrations of sulphates exceeded 100 mg/l. In both cases these springs were closely associated with fumaroles which emit hydrogen sulphide and/or sulphur dioxide, as evidenced by the growth of native sulphur crystals around the vents. Arsenic was also detected in three samples, but did not exceed the WHO and national standard of 10 ppb. Chemically, no constituent was found in excess of the relevant national and international standards.

The microbiological quality of these spring sources is variable. Analyses were undertaken from all sources for thermotolerant faecal coliforms (*Escherichia coli*) as indicators of faecal contamination. Results ranged from 3 to 490 per 100 ml. These results reflect both the quality of the water emerging from springs and the potential contamination at source. Whilst the WHO *Guidelines for Drinking Water Quality*, adopted as the national standard (*Normas de Calidad del Agua para Consumo Humano*, CAPRE, 1994), consider the presence of any faecal coliforms unacceptable, these stringent standards are widely recognised as unworkable in the context of untreated rural water supplies, especially in the developing world. The World Bank's *World Development Report, 1992* states that "In most developing countries the imperative is to get from "bad" quality (say, more than 1000 fecal coliforms per 100 ml) to "moderate" quality (less than 10 fecal coliforms per 100 ml), not necessarily to meet the stringent quality standards of industrial countries." The WHO *Guidelines for Drinking Water Quality*, 1997 included the following classification of faecal contamination:

Count per 100 ml	*Category*	*Remarks*
0	A	In conformity with WHO guidelines
1-10	B	Low risk
10-100	C	Intermediate risk
100-1000	D	High risk
>1000	E	Very high risk

The most recent version of the document (2006) proposed another classification:

	Proportion (%) of samples negative for E. coli		
Quality of water system	*Population <5,000*	*Population 5,000-100,000*	*Population >10,000*
Excellent	90	95	99
Good	80	90	95
Fair	70	85	90
Poor	60	80	85

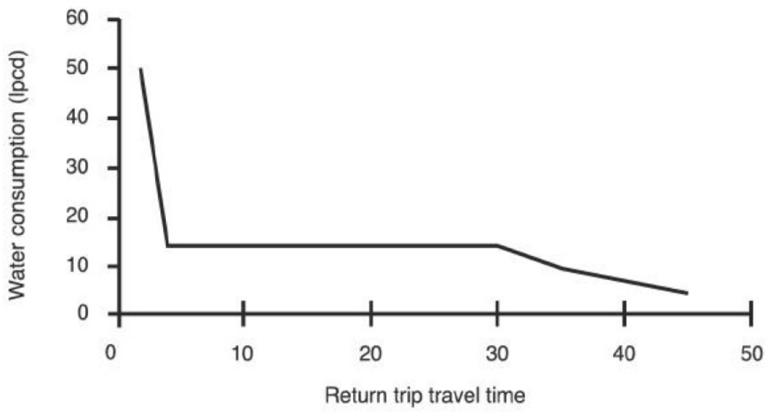
According to the first classification system two sources would be considered low risk (the protected springs at Las Quemadas and San Jacinto), four sources would be considered intermediate risk, three sources would be considered high risk (including the protected spring in Agua Fría, the most widely used drinking water source) and one source would be considered very high risk (the hot spring in San Jacinto – not used for drinking). According to the second classification, the overall quality of existing water sources would be considered as poor as none tested negative for *E. coli.*

In addition to these spring sources, rainwater is currently collected from virtually every roof in the project area. Most existing systems are very rustic and have limited potential for water storage (Figs. 7-9).

An important indicator of access to water is the distance travelled to the closest water source. Where the closest source is vulnerable to drought, another important indicator is the distance to the closest reliable source. Whilst the time taken to fetch water is arguably of greater significance than distance, it is much harder to measure objectively. Distance calculations are more objective and can be easily undertaken using GIS once the locations of houses, access routes and spring sources have been mapped (Map 2). The distances travelled by households to existing spring sources are as follows:

	Numbers of households within each distance category						
Community	*<100 m*	*100 m – 1 km*	*1-2 km*	*2-3 km*	*3-4 km*	*4-5 km*	*> 5 km*
El Ojochal del Listón *(closest spring)*	**0**	**0**	**0**	**8**	**14**	**3**	**0**
El Ojochal del Listón *(closest reliable spring)*	*0*	*0*	*0*	*0*	*4*	*12*	*9*
Agua Fría *(closest spring)*	**0**	**38**	**13**	**7**	**2**	**1**	**0**
Agua Fría *(closest reliable spring)*	*0*	*0*	*0*	*9*	*29*	*13*	*10*
El Ñajo *(closest spring)*	**1**	**7**	**1**	**0**	**0**	**0**	**0**
El Ñajo *(closest reliable spring)*	*0*	*1*	*8*	*0*	*0*	*0*	*0*
El Caracol *(to Las Quemadas)*	**0**	**3**	**14**	**0**	**0**	**0**	**0**
Las Pilas	**1**	**11**	**0**	**0**	**0**	**0**	**0**

The relationship between access to water and water consumption is well documented. The following graph is given in standard texts on the subject (e.g. *Environmental Health Engineering in the Tropics*, Cairncross and Feachem, 1993):



This graph shows that travel time/distance to collect water makes a marked difference on water consumption when the water source is within 100 metres from the house. Beyond that, up to a distance of approximately 1 km, the amount of water consumed is fairly standard. When the distance to water exceeds 1 km (or 30 minutes travel time), distance once again becomes an important factor. Since only two houses within the target communities are located within 100 m of a water source, this part of the graph is not particularly relevant. However, it is likely that there is a significant difference in water consumption between those households which are within 1 km or so of a water source and those which are further away. This is because, at distances greater than 1 km, water collection is very difficult indeed without a horse. At shorter distances, journeys to collect water or to wash clothes are more frequent and are generally undertaken on foot. For example, in the community of Las Pilas, where almost all houses are located between 100 m and 1 km from the spring, it is common to observe women carrying clothes to the spring to wash or walking back to their homes carrying a bucket of water, whereas in El Ojochal del Listón, almost every family has at least two horses which they use every day to carry water from the spring at Agua Fría, or the well at El Ñajo. Data collected from El Ojochal del Listón suggests, however, that the amount of water consumed by those who travel between 2 and 5 km is significantly higher than might be expected, with consumption ranging from 13 litres/person/day to as much as 40 litres/person/day (Table 2), depending more on the number of horses a family has, than the actual distance to the source.

A World Health Organisation publication (*Domestic Water Quantity, Service Level and Health*, Howard and Bartram, 2003) proposed the following classification of 'service levels':

Service level description	*Distance/time measure*	*Likely quantities collected*	*Level of health concern*
No access	More than 1,000 m or 30 minutes total collection time.	Very low (often less than 5 l/c/d).	Very high as hygiene not assured and consumption needs may be at risk. Quality difficult to assure; emphasis on effective use and water handling hygiene.
Basic access	Between 100 and 1,000 m (5 to 30 minutes total collection time).	Low. Average is unlikely to exceed 20 l/c/d; laundry and/or bathing may occur at water source with additional volumes of water.	Medium. Not all requirements may be met. Quality difficult to assure.
Intermediate access	On-plot, (e.g. single tap in house or yard).	Medium, likely to be around 50 l/c/d, higher volumes unlikely as energy/time requirements still significant.	Low. Most basic hygiene and consumption needs met. Bathing and laundry possible on-site, which may increase frequency of laundering. Issues of effective use still important. Quality more readily assured.
Optimal access	Water is piped into the home through multiple taps.	Varies significantly but likely above 100 l/c/d and may be up to 300l/c/d.	Very low. All uses can be met, quality readily assured.

Under this classification scheme, 2% of households in the project area would be considered to have 'intermediate access', 47% would be considered to have 'basic access' and 51% would be considered to have 'no access'.

Project objectives

In July 2008, the Georg Fischer Clean Water Foundation approved funding of US$80,000 to support the construction of 21 rainwater harvesting systems. This funding covered the first year of work on improving access to water. The specific outputs envisaged in the project proposal were:

1. *Construction of six communal rainwater harvesting systems*

   It was explained that the construction of communal rainwater harvesting systems provides an opportunity to introduce the technique to a community which does not already have any systems. This provides a 'training opportunity' to teach construction techniques and also raises awareness and builds demand and commitment for the future phases of the project. It was envisaged that the six communal systems would be built in the following communities:

   - Mata de Caña (school)
   - Las Pilas (shared system for four houses)
   - El Caracol (community building)
   - Agua Fría (school)
   - Agua Fría (shared system for six houses)
   - Agua Fría (church – for community use)

2. *Construction of 15 household rainwater harvesting systems*

   The majority of the household systems to be built during the first year of the project were to be constructed in the community of El Ojochal del Listón as a communal system has already been built at the school in this community. It was expected that 14 systems would be built in this community. One additional household system was to be built at El Ñajo where there are no community buildings so that this community can also be trained in the construction technique during the first year of the project.

The measures of success stated in the project proposal for the water component of the Mountain Rain programme include:

- Time spent collecting water reduced from a maximum of four hours per day (baseline) to a maximum of 15 minutes per day by the end of the project.
- Water use increased from an average of <15 litres/person/day (baseline) to >25 litres/person/day (note that the baseline water consumption now needs revising in the light of new information presented above).
- Water consumed contains 0 E.coli /100 ml in 90% of samples of untreated rainwater (based on WHO guidelines which would classify this level of water quality as 'Excellent').

Project implementation

Community organisation

This project, like all community development projects, depended on a close working relationship with the beneficiary communities and also on close working relationships between the members of each community. In most cases organisational structures were either absent or functioned ineffectively. For this reason, a significant investment was made in helping communities to develop effective organisation and leadership structures. Nuevas Esperanzas began this process through the participatory appraisals undertaken from February to June 2008. Numerous planning meetings were held with communities to help organise the voluntary labour necessary to improve access routes and build rainwater tanks. Each community faced different challenges and many additional visits by Nuevas Esperanzas' community development staff were needed to understand the dynamics of each one.

Surveys and site measurements

Visits were also made to each community in the project area to collect census information. It has been found from experience that data is only reliable when collected house by house. Visits to all the houses in the project area were made from October 2008 to October 2009. Photos were taken of each house and locations recorded using GPS. Information collected included the names and ages of everyone living in each house, as well as its dimensions, roof materials, existing types and dimensions of containers for rainwater harvesting and legal documents held such as ID cards and land titles. Existing water sources and access routes were also mapped using GPS. All of this information was entered into the GIS set up to manage the Mountain Rain data.

Rainwater harvesting systems – modifications to tank design

In preparation for the construction of the rainwater harvesting systems, a critical review was undertaken of the technique used to construct all 30 systems previously built by Nuevas Esperanzas in San Jacinto, Gracias a Dios and Casa Blanca to look for ways to improve functionality, reduce costs and construction time and minimise the quantity of materials required. In particular, comparisons were made with an alternative design which used welded mesh for reinforcement and sacking instead of formwork. This alternative design had an obvious appeal as it eliminated the need for the plywood formwork and supporting wooden structure used in previous models, thereby significantly reducing the quantity of materials that would need to be hauled up the mountainside. Quotations indicated that the price would compare favourably with the previous design and so the decision was made to build a trial tank. The construction of this experimental tank was funded separately by the Oxford-León Trust.

The main differences between the new design and the old are as follows:

- The new design uses welded mesh reinforcement cut to shape for the base of the tank instead of rebar arranged in a concentric and radial configuration around the central column. This saves time.
- Welded mesh is used as the reinforcement for the walls. It has sufficient rigidity to be freestanding which allows the tank to be built without the need for formwork. This saves time and cost and reduces the weight of materials required for construction.
- The welded mesh reinforcement for the walls is wrapped in chicken wire to help the mortar to adhere and then tensioned 16 gauge galvanised steel wire. Previously barbed wire provided both the tension and the surface necessary for adhesion of the mortar. The new reinforcement structure is lighter and more manageable than barbed wire which was difficult to tension.
- The new design uses sacking wrapped around the outside of the tank as a mould for the mortar instead of plywood which was previously used to form the inside of the tank. This is cheaper and lighter. As a result of this change, the inside surface is rendered first in the new design rather than the outside.
- The roof of the new model is made of ferrocement instead of the concrete used in the old model. The reinforcement is provided by welded mesh instead of rebar. This is lighter and saves time.
- Previous tanks were fitted with two valves; a 2 inch valve drew water from just above the base of the tank and a 4 inch valve drained the tank completely for cleaning at the end of the dry season. The cleaning valve has been eliminated from the new design. It was found that in order to clean the tank effectively, sediment which collected in the bottom needed to be washed out through the cleaning valve by entering the tank with a bucket of water. The new design simply incorporates an indentation in the base of the tank which enables sediment to be scooped up manually and lifted out through the access hatch. This is just as effective and reduces cost significantly as the cleaning valve has been eliminated.

- An additional gate valve was installed between the outflow of the tank and the tap station. This allows the tap to be isolated in case it has to be changed when the tank is full of water.

Training and contracting of local builders

Rather than build the trial tank in one of the beneficiary communities it was decided that it should be built in Gracias a Dios, San Jacinto where access was more straightforward and where this experimental tank could be used as an opportunity to train local builders from San Jacinto, rather than León. It was considered more appropriate to use builders who already live close to the beneficiary communities to supervise construction in the Mountain Rain project. Eight local builders from the San Jacinto area were invited to participate in the three week training course; seven began the course. Each day the builders, supervised by Nuevas Esperanzas' civil engineer, worked on the construction of a 23 m^3 rainwater harvesting tank at the house of Soila Montes, an elderly lady with two handicapped daughters who was unable to meet the requirement to contribute manual labour in a recently completed rainwater harvesting project in Gracias a Dios.

After construction was completed, the group evaluated the new tank and reviewed the modified features to assess what worked well and could be implemented in future tanks. The group also visited each of the thirty tanks which had previously been built by Nuevas Esperanzas to monitor any problems which had arisen, carry out some minor repairs and consider what improvements can be made to avoid such problems arising in the future. Of the six builders who completed the course, four were contracted by Nuevas Esperanzas to work on the Mountain Rain project.

Movement of materials for tank construction

With access to El Caracol by vehicle made possible early in January 2009, work began on transporting materials for the construction of a 40 m^3 communal rainwater harvesting system at the school. This community is located close to a wide river bed (dry) which provided an excellent source of sharp sand and coarse aggregate. This material was transported to the construction site along with the necessary cement, welded mesh and other materials.

The road to El Ojochal del Listón was completed at the end of January 2009 and the logistical challenge of transporting materials to this community for the construction of 18 tanks began the following month. As El Ojochal had no source of water whatsoever in the dry season, all water necessary for construction was taken to the community in barrels. To begin with the only vehicle used was a Toyota Land Cruiser 4.2 litre 4x4 pickup truck with a 1.5 tonne payload (on the level), equivalent to around 33 bags of cement. For the 6 km steeply inclined road to El Ojochal, the maximum carrying capacity was considered to be around 25 bags of cement or 6 barrels of water. For the construction of each 20 m^3 domestic tank in El Ojochal, the following pickup loads were needed:

- 1 journey of aggregate
- 1 journey of steel (welded mesh, chicken wire and rebar)
- 2 journeys of cement
- 4 journeys of water
- 6 journeys of sand

Whilst most of materials for the first few tanks were transported using the pickup truck, it soon became apparent that additional resources were necessary to accomplish the necessary journeys and in March a local tractor driver was contracted to take materials up the road from San Jacinto to El Ojochal, paid by the journey. This freed up the pickup truck to transport materials to other communities. Also, a local source of sand was identified in El Ojochal del Listón which eliminated the need to transport sand up the mountain. The owner was one of the project beneficiaries and the use of his sand was negotiated for a nominal fee regardless of how much sand was extracted. The sand was transported to the construction site of each tank using a combination of the pickup truck and ox and cart.

In the community of Las Pilas, work began in February 2009 on hauling materials. In this community access by vehicle to the construction site was not possible. The community did, however, improve access from Rota to the first house in the community (Map 7) so that materials could be brought by vehicle some of the journey. Materials for the communal tank in this community were delivered to Rota and then transported by pickup to the first house in the community. From there they were carried up the hill to the construction site by horse. In April, work began on transporting materials to Agua Fría, the most challenging of all in terms of access. Although a track exists from Cristo Rey to Agua Fría (Map 1), access was not possible to the two construction sites. Work was undertaken for one of these sites to cut a new access route, but the other was deemed too difficult and so materials were taken the last kilometre by horse and ox and cart. Finally, in May, materials were transported to El Ñajo by pickup truck, making the most of the very dry weather to drive up the normally muddy footpath, generally impassable by vehicle.

Construction of domestic rainwater harvesting systems, El Ojochal del Listón

One of the recommendations of the evaluation of the experimental tank constructed using the new technique was that a standard domestic system should be 20 m^3 rather than 23 m^3. This is because the walls of the 23 m^3 tank required a little more than two complete sheets of welded mesh to form the circumference. The gap between the two sheets required an extra piece which was harder to manage when trying to form a perfect cylinder. The volume sacrificed is relatively small. Eleven individual domestic tanks in El Ojochal were constructed at 20 m^3 using two complete sheets of mesh to form the walls. Shared tanks of 40 m^3 required just under three complete sheets of welded mesh to form the cylindrical tank walls. Two tanks of 30 m^3 were also constructed, one of which was for an individual domestic tank for a larger family (of seven) and the other was for a tank shared between two smaller families (totalling six people).

Construction began on the first domestic tank in El Ojochal del Listón in the first week of February 2009 with around half the community participating. The idea behind this was to use this opportunity to train as many people as possible in the construction technique. There is no shortage of manual labour in this community and participation is almost always excellent. Once the walls of this tank were complete, the community volunteers divided themselves between the next three tanks to start work while the mortar dried on the first tank. This process was then repeated as work progressed to other parts of the community. The construction process is shown in Figures 16-30 and Drawings 1-6 and the figure captions give details of each step.

Improvements to roofs, El Ojochal del Listón

A significant need identified in El Ojochal del Listón was to improve roofs. Rainwater harvesting is possible from corrugated galvanised iron, tile and even asbestos-cement roofing (see caption to Figure 34), but it is not advisable from traditional palm roofs which have a much lower yield and an adverse effect on water quality. Around a third of houses in El Ojochal del Listón had only palm roofs and more than two thirds had less than the minimum area of appropriate roofing needed. Houses in these hillside communities are generally very rustic and the cost and effort of rebuilding a house to provide a better roof catchment is considerably less than the cost and effort of building a ferrocement tank. Obviously there are benefits to improving roofs other than just increasing the potential for rainwater harvesting and several families took the opportunity to rebuild their houses completely (Figs. 31-33).

Improvements to roofs were made with two objectives in mind:

- To ensure that each household has a minimum area of approximately 40 m^2 of corrugated galvanised iron roof or equivalent from which to harvest rainwater.
- To provide an incentive, through providing roofing sheets at reduced cost, to increase the area available from 40 m^2 to 60 m^2.

These figures are based on Nuevas Esperanzas' experience of other rainwater harvesting projects implemented in the area. Whilst theoretical calculations of cumulative rainfall versus demand were used in the early projects, these have been replaced by a 'rule of thumb' drawn from experience rather than theory which suggests that the volume of the tank should not exceed one third of the total amount of water which could be collected in an average year (mean annual precipitation x roof area). If the tank is built larger than this it is unlikely to fill completely most years. Conversely this means that the roof area should be at least three times the tank volume divided by annual precipitation, estimated as around 1,500 mm in the project area. For a tank of 20 m^3, this would mean the roof should be no less than 40 m^2. There is additional benefit in increasing the roof area by up to 50% to ensure the tank is completely full at the end of the wet season, but if the roof is much larger than this with respect to the tank, it will only benefit water availability in the wet season as the tank volume becomes the limiting factor instead of roof area.

The entitlement of each household to roofing sheets was calculated from census data already collected which included the area and material of existing roofs. Those without corrugated galvanised iron roofs received 16 sheets. Many households received additional sheets to extend their existing roofs whilst some did not receive any as their roofs were already sufficiently large. This was an area of the project in which it was also possible to secure a contribution from the local mayor, as funds were available for five families to receive 10 sheets of corrugated galvanised iron. These 50 sheets complemented the 128 sheets provided by Nuevas Esperanzas, delivered to the beneficiaries in June. In September, a further 32 sheets were sold to five community members at half their market value to increase their roofs from 40 m^2 to 60 m^2.

Final connections, El Ojochal del Listón

Once the roofs had been rebuilt or extended as necessary, and the tank completed, the task of connecting gutters began (Figs. 35-39). This was not as straightforward as it might seem as most houses are far from level and many were found to slope in the opposite direction from the tanks! After checking levels, a scheme to collect and channel rainwater was designed for each house. In many cases adjustments were needed to the heights and slopes of roofs (Fig. 36). Alongside the guttering, tap stations were built for each tank, using natural gradients wherever possible to ensure good drainage from the water collection area. Each tap station included a high quality self-closing tap (Fig. 40-41) and a protected shut-off valve so that the tap can be replaced or repaired when there is water in the tank. By the end of September, four rainwater harvesting systems were complete and had begun to collect water. The remaining systems were finished and collecting water by the beginning of November.

Construction of school rainwater harvesting system, El Caracol

Work began in February on the first communal system, at the school in El Caracol (Figs. 43-48). The makeshift school is the only community building and although it is very basic it did at least have a reasonable area of corrugated galvanised iron roof. This roof was removed and the wooden frame rebuilt as part of the project but as the roofing sheets were in reasonably good condition they were reused. A significant challenge at this site was the availability of manual labour. It is common for young men in rural areas in Nicaragua to migrate during the dry season looking for work, but in El Caracol, the situation was quite extreme and almost all the young men of the community were currently working away. This created significant challenges as although women were willing and able to provide manual labour, most had to care for young families. As an additional incentive to boost work at El Caracol, Nuevas Esperanzas provided some basic food (rice and beans) for the community volunteers. This minimal extra help enabled some of the volunteers to work on the tank most days of the week, instead of taking shifts. The project in El Caracol was completed in July.

Construction of community rainwater harvesting system, Las Pilas

In March work began in Las Pilas (Figs. 49-51). In this community there was no school, church or other public building which could be used to collect rainwater. However, an area of land was donated by one of the community members on which a purpose-built roof structure was erected. Since the roof is an integral part of the rainwater harvesting system, this was considered a justifiable expense. In Participatory Rural Appraisals, the community had identified the need for a pre-school and/or primary school and the construction of the rainwater harvesting system was seen as a big step towards having a school. Additional funding will be needed to build walls and a floor, but the well-built roof is a good start. In the case of this tank, some work was necessary to stabilise the slope above which the tank was built. Two retaining walls were constructed and terraces formed (Fig. 50) and this system was finally completed in November.

Construction of rainwater harvesting systems at two churches, Agua Fría

In meetings with the community in Agua Fría, it was decided that the most suitable locations for communal rainwater harvesting systems were at the two churches on opposite sides of the community (Fig. 52, Map 5). Not only were their roofs the largest, but they also provided opportunities for residents of different sectors of this dispersed community to participate. Work on the first tank began in August and on the second in September. Whilst the existing roofs were adequate at both sites, the location of the tank at the top of a slope at one of the sites presented some additional challenges. Although the slope was relatively modest (15-17º), a house was located at the bottom and there were signs of erosion at the base of the tank. In order to prevent erosion and improve slope stability, two retaining walls were built to create terraces below the tank (Figs. 53-54). These walls were permeable and included PVC drains extending back into the slope to improve drainage. Both rainwater harvesting systems in Agua Fría were completed in the first few days of November.

Construction of community rainwater harvesting system, El Ñajo

The final tank to be built was in the small community of El Ñajo. Like Las Pilas, this community had no public building which could be used to collect rainwater. However, with only nine households, most of which were from the same extended family, it was decided that there was no justification to build a new roof structure as had been the case in Las Pilas. Also, a few of the houses in El Ñajo had very large roofs, sufficient to fill a large communal tank. One of these houses was selected as a good location to serve the houses furthest from the spring and work began in September. Whilst this rainwater harvesting system was built at one of the houses, it was clearly understood that this was to be a communal system and community participation was not a problem. The tank was completed and gutters connected at the end of October (Figs. 55-57).

Evaluation of project outcomes

Number and location of rainwater harvesting systems constructed

As the specific plans for each community developed, a number of minor changes were made to the locations and sizes of the 21 rainwater harvesting systems to be built. The table below shows the actual systems built:

Community	*Type*	*Size*	*Number*
El Ojochal del Listón	Domestic (individual)	20 m^3	11
El Ojochal del Listón	Domestic (individual)	30 m^3	1
El Ojochal del Listón	Domestic (shared)	30 m^3	1
El Ojochal del Listón	Domestic (shared)	40 m^3	3
Agua Fría	Communal (2 churches)	40 m^3	2
El Caracol	Communal (school)	40 m^3	1
El Ñajo	Communal (house)	40 m^3	1
Las Pilas	Communal (purpose-built community building)	40 m^3	1
		TOTAL	21

The changes to the original plan were made in order to ensure that the project achieved its objectives of building communal systems to provide an opportunity for training and awareness raising in target communities where no work had previously been undertaken whilst providing an adequate supply of safe water to meet the needs of the community of El Ojochal del Listón. The rainwater harvesting systems shown in the table above were sufficient to meet these objectives with two exceptions:

- No work was undertaken in the community of Mata de Caña. This was because the construction of a rainwater harvesting system was not considered the highest priority by community members who would instead prefer to improve their existing spring source. Funds for this work are being sought by Nuevas Esperanzas.
- One family in El Ojochal del Listón was not included in the rainwater harvesting project as they were living in Costa Rica at the time the project started. It is common for men to spend several months of each year as migrant workers in Costa Rica, but in this case the whole family went, leaving the house apparently abandoned. They have now returned and have been included in a proposal for additional rainwater harvesting systems for a small group of houses close to El Ojochal del Listón in an area known as La Joya.

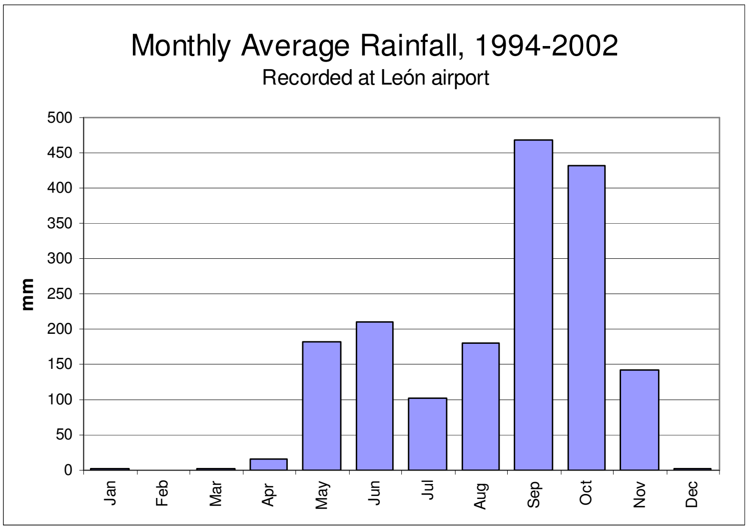
Generating community interest (communal tanks)

As stated above, one of the objectives of this project was to generate interest in rainwater harvesting in communities where no work had previously been undertaken, with a view to future projects of a similar scale to that which was implemented in El Ojochal del Listón. Although quantitative analysis of the degree of interest generated is difficult, anecdotal evidence was gathered and one of the most interesting sources of information was from a debrief with the building supervisors at the close of the project. The building supervisors worked closely with community volunteers on a daily basis and their perception of community interest was therefore based on many hours of informal discussions.

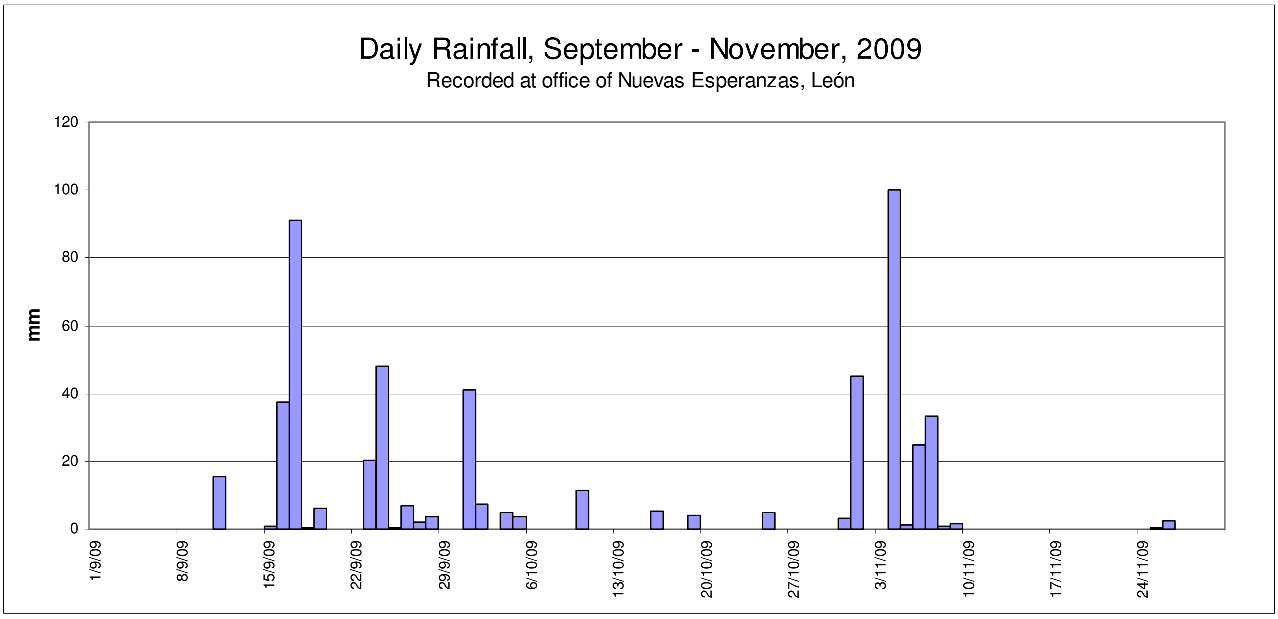
The building supervisors noted that community participation in the construction of tanks varied by community and according to whether or not the tanks were communal, shared or for individual households. During construction of individual tanks, participation was high and consistent. Family members were so eager to see their tanks built that they would find other workers to fill in for them if they were absent for a day of work on the family tank. However, participation tended to be lower for the five communal tanks which depended on general participation from the community. En Las Pilas and El Ñajo participation was relatively good and more consistent than for the two tanks built in Agua Fría and El Caracol. These differences were interpreted by the building supervisors as differences in attitude and willingness between the respective communities. It certainly does not appear to be correlated with differences in the level of need as the distances travelled to existing sources are actually greater in the two communities where participation was worse (Agua Fría and El Caracol). However, they did note that the generally lower community participation for construction of communal tanks, compared to individual family tanks, reflected initial doubts that community members, unfamiliar with the technology, expressed about the viability of rainwater harvesting systems. Ways to increase initial participation need to be investigated, but the fact that participation does increase dramatically between the construction of a communal tank and the following phase of individual tank construction supports the view that the gradual introduction of rainwater harvesting into a community is important for the successful acceptance of the technology in the long term.

Initial rainwater harvesting

All 21 rainwater harvesting systems had started to collect water by the beginning of November. As the wet season normally ends around the middle of November, it was not anticipated that much water would be harvested in the first year, especially as 2009 was a drought year as a result of the 'El Niño' Southern Oscillation. The graph below shows long term monthly averages for León:

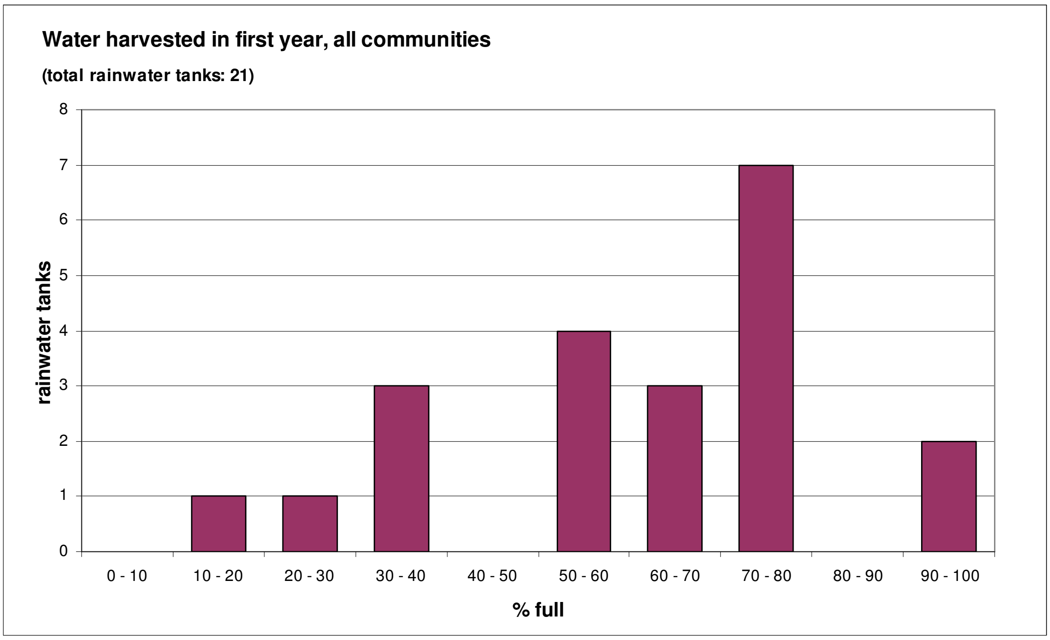


As over 50% of the annual rainfall typically falls in September and October, these two months were considered the most critical. However, in 2009, September's rainfall was only 50% of the September average and October's was less than 20% of the long term average, whilst a tropical storm late in the season brought some heavy rain in the first week of November pushing Novembers rain up to 147% of its long term average. Rainfall from September to November 2009 is shown in the graph below:



In the first week in November, after all 21 rainwater harvesting systems had been connected, 207 mm of rain fell, nearly 40% of the total for the three month period. This meant that a significant amount of rainwater was harvested in the first year, sufficient to undertake a preliminary evaluation of the project. It should be noted, however, that 2009 was nonetheless a year of significant drought with the total rainfall from September to November only 50% of the long term average for these months.

Water levels were monitored in each of the rainwater tanks at least once after the heavy rains and these measurements are given in Table 2 in the appendices. The highest recorded level of water in each tank was used to calculate the amount of rainwater harvested in the first season by multiplying the depth of water by the base area of the tanks. This is expressed as a percentage of the design volume of each tank in the graph below:



Despite being a drought year, this graph shows that 75% of tanks were at least 50% full. Nine tanks were at least 70% full and two filled to the overflow pipe.

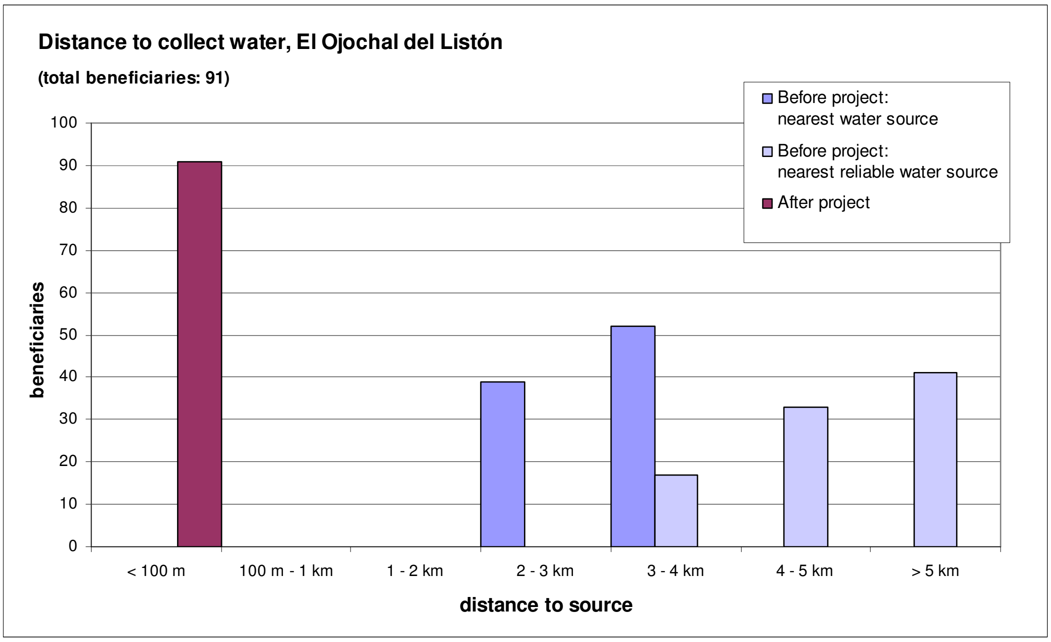
The tanks in El Ojochal del Listón were also monitored during the week of heavy rain and this data can be used to determine the relative efficiency of the tanks. The amount of rain harvested was calculated from the change in water level, the base area of the tank and the roof area from which water is harvested. Note that this calculation assumes that the amount of water consumed during this period is negligible.

Tank	*Roof Area (m^2)*	*Tank base (m^2)*	*Date of measurement*			*Rain harvested, 4/11 - 5/11 (mm)*	*Rain harvested, 29/10 - 5/11 (mm)*
			29/10/09	*04/11/09*	*05/11/09*		
Marcial Reyes	80	18.1	0.50	1.09	1.16	16	149
Santos Reyes	39	13.2	0.30	0.70	0.75	17	151
José Ramón Durón	97	13.2	0.38	1.27	1.40	18	139
Ascención Reyes	68	18.1	0.20	0.75	0.80	13	159
Justo Delgadillo	42	17.3	0.07	0.39	0.44	21	152
Mercedes Tercero	79	8.8	0.35	-	1.67	-	146
Jery Alvarado	64	9.6	0.48	-	1.63	-	174
Nelson Alvarado	62	9.6	0.62	-	1.62	-	156
Bernabé Alaníz	88	9.3	0.80	-	2.12	-	139
Natividad Alvarado	73	10.2	1.18	-	1.95	-	107
Sebastián Alvarado	55	10.5	0.46	1.25	1.38	25	175
Carlos Alvarado	56	10.2	0.36	0.93	1.00	13	116
Gilmer García	42	10.7	1.04	1.25	1.30	13	66
Gerald Arman	38	10.2	0.87	1.25	1.32	19	119
Alejandro Silva	39	9.6	0.68	1.15	1.31	39	155
Wilber Mayorga	60	9.6	0.29	1.09	1.32	37	165
				Average		*21*	*142*
				Rainfall recorded in León		*101*	*149*

With one or two exceptions, the amount of rain harvested is consistent between tanks. There is a significant difference between the rain harvested on the 4th/5th November and the recorded rainfall in León, indicating that the very heavy rain which fell in León that night did not fall in El Ojochal del Listón.

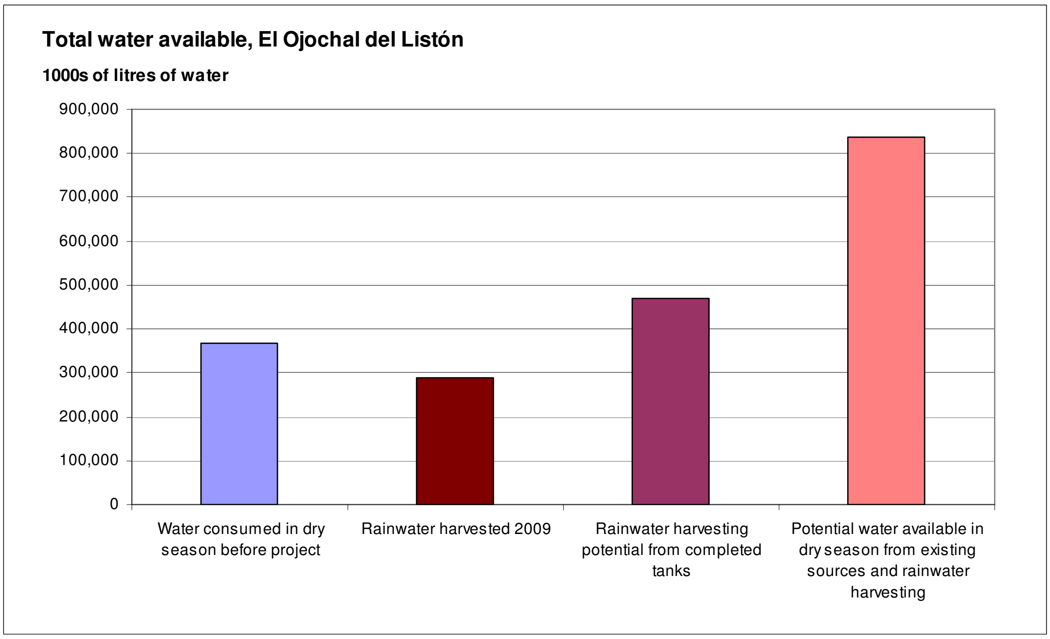
Distance to collect water

A key indicator for this project is the distance to collect water as outlined in the baseline. An objective for the Mountain Rain programme is to reduce the time spent collecting water from a maximum of four hours per day to a maximum of 15 minutes per day. This indicator can only be used to measure the success of the work in El Ojochal del Listón, since the communal tanks built in other communities are a pilot for the second phase project which will aim to meet these targets for all communities. Distances to sources were calculated for each household in El Ojochal del Listón using GIS and are given in Table 2. As explained previously, distance is a more objective indicator than time taken, but it is possible to state that a distance of less than 100 m to a source is equivalent to a round trip of less than 15 minutes, whilst a distance of 5 km is equivalent to a round trip of 4 hours. A graph to demonstrate the impact of the project in terms of distance to collect water is shown below:

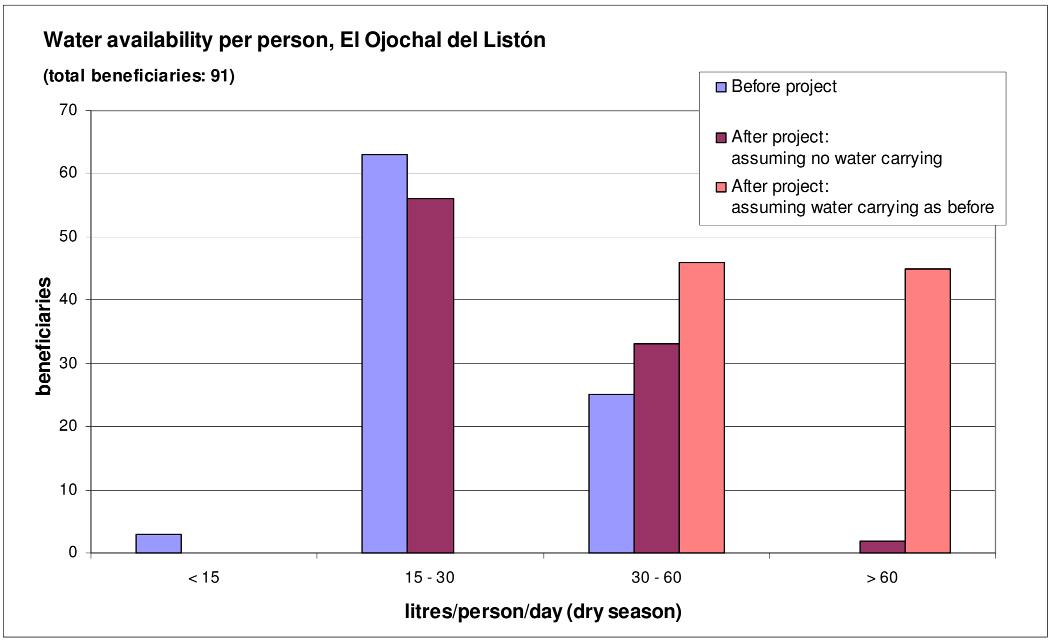


Water available

The total water available before and after the project in El Ojochal del Listón was calculated using both the volume of rainwater actually harvested in the first year and the potential in a year when all the tanks are full at the end of the wet season. The baseline is based on journeys made by horse to spring sources. The comparison is shown in the graph below:



The graph shows that while the amount of water harvested in the first year is a little less than the amount carried from spring sources, in future years it is anticipated that the amount of water harvested will exceed the amount currently consumed from springs. The final bar on the chart shows the amount of water available if the beneficiaries continued to carry water as before in addition to harvesting rainwater. A similar graph below shows the change in the distribution of water available per beneficiary, highlighting some of the variation between families in El Ojochal del Listón not apparent from the graph above:



These graphs raise a very interesting question: will the beneficiaries cease to collect water from springs, or will they continue to travel for water and have more water available in the house? Anecdotally, it seems as though the beneficiaries themselves are expecting to reduce their journeys for water but not to eliminate them altogether. Only time will tell, but it is likely that the true impact of the project is likely to be a significant increase in water consumed as well as a significant reduction in journeys for water. It cannot be claimed, however, that the project will achieve both a doubling in the amount of water available *and* the elimination of the journey to collect water.

The indicator stated in the project proposal was that water use would increase from an average of <15 litres/person/day to >25 litres/person/day. As shown in the graph above, the baseline was actually found to have a mean of 28 litres/person/day. Assuming that journeys to collect water were eliminated completely, the mean amount of water available during the dry season from rainwater harvesting would be around 35 litres/person/day. The mean amount of water available from rainwater harvesting as an average of the whole year (including wet and dry seasons) is 54 litres/person/day.

Water quality

Rainwater is widely considered in the literature to be a good source of drinking water. There are, however, a number of myths surrounding rainwater quality and also some unanswered questions. Unfortunately some of the myths are widely accepted in Nicaraguan culture and any rainwater harvesting project faces the challenge of convincing users that rainwater is suitable for drinking. One such myth is that rainwater causes osteoporosis. The origin of this myth is in the misleading advertising of bottled mineral water which claimed that highly mineralised water reduces the risk of diseases such as osteoporosis (an assertion which has very little evidence to support it). This prompted the misconception that the converse is true: water with low mineral content *causes* osteoporosis. Ironically, the highly mineralised water which supposedly reduces the risk of osteoporosis is itself considered by most Nicaraguans as harmful as high concentrations of calcium in drinking water are erroneously believed to cause kidney failure.

Other concerns raised are whether rainwater collected from roofs is contaminated by bird droppings or whether rain falling close to active volcanoes contains harmful chemicals. Ironically, much less concern is ever expressed about the effect of cement mortar on water quality even though this, in practice, probably has the greatest influence of all on the chemistry of harvested rainwater. All these issues are considered through the analyses undertaken in November 2009 from the newly completed rainwater harvesting tanks.

Analyses of water quality from the rainwater harvesting tanks are presented in Table 2. The locations of samples taken, along with some of the results, are shown on Map 8. These analyses were undertaken as far as possible in the field using portable equipment. The parameters measured were as follows:

Physical characteristics:

- Measurements were made of Conductivity, Total Dissolved Solids (TDS), temperature and pH using a calibrated combined probe (Hanna Instruments HI 98129).
- Turbidity was measured using a calibrated portable turbidity meter (Wagtech potalab turbidimeter WT3020) based on the nephelometric principle and designed to meet the criteria specified in the ISO 7027 standard.

Biological characteristics:

- Analysis for thermotolerant faecal coliforms (*E. coli*) was carried out using a portable laboratory based on membrane filtration (Oxfam DelAgua). Samples of 10 ml and 100 ml were filtered and incubated at 44° on a Lauryl Sulphate culture medium for 18 hours.

Chemical characteristics:

- A range of chemical parameters were measured using a precision electronic colorimeter (Wagtech potolab photometer 7100). The parameters measured were Total hardness, Calcium, Magnesium, Potassium, Iron, Total Alkalinity, Sulphate, Chloride, Fluoride and Nitrate.
- Arsenic was measured with the Wagtech Visual Arsenic Detection Kit.

In addition to these analyses, one sample was sent to Laboratorios Laquisa in León for comparison with the field-based measurements.

All measurements from the tanks conformed to international and national standards with the exception of the following:

Turbidity

Most samples showed low turbidity (<1 NTU). Two samples, however, were found to exceed the national and international standard of 5 NTU. In one case, the turbidity was measured as 32.1 NTU. This tank appeared to be contaminated and the owner admitted that it had not been cleaned before starting to collect rainwater. Also the tank had not been fitted with the short length of tube inserted in the outlet pipe within the tank which ensures that water is drained off from above the bottom of the tank. This means that the water was drawn from the very bottom of the tank where sediment settles. The other tank had water with turbidity of 12.9 NTU. There was no apparent contamination of the water in the tank, but it was suspected that in this case, some plant material had become trapped in the outlet pipe. Neither of these problems can be resolved while the tanks contain water, but both will be investigated at the end of the dry season when the tanks are empty.

pH

Whilst rainwater is always acidic, the water collected in ferrocement water tanks always has a high pH when the tanks are new. This is a product of the cement which is highly alkaline. The average pH of the water in all tanks was 9.66 and the highest recorded value 11.05. Whilst the WHO *Guidelines for Drinking Water Quality* state that there are no health based limits, the national standard (*Normas de Calidad del Agua para Consumo Humano*, CAPRE, 1994) proposes a recommended range of 6.5 – 8.5. This is probably because chlorination is only effective within this range. Water with a high pH can have a sour taste. It should be noted that the pH of water in ferrocement tanks diminishes over time. The water in the tank at the school in El Ojochal del Listón, built in 2006, had a pH of 7.95 in November 2009. To reduce the pH of the water in the new tanks, they would ideally have been washed and the first water to fill the tanks discarded, but the demand for water is such that this would have been highly inappropriate. This issue needs no attention, but will be monitored over time.

Potassium

Of the all the parameters determined, concentrations of potassium were probably the most surprising. The average concentration of potassium from all rainwater samples was around 10 mg/l. Although the WHO *Guidelines for Drinking Water Quality* give no limit, the national standard (*Normas de Calidad del Agua para Consumo Humano*, CAPRE, 1994) gives a maximum permissible level of 10 mg/l. No explanation of this limit has been found and it is doubtful that this has any scientific basis given that potassium is an essential dietary requirement at levels much higher than the intake which would be derived from drinking water with 10 mg/l. However, the origin of these high levels of potassium deserved some consideration. Published analyses of rainwater in Nicaragua show that levels of potassium in rainwater are generally <3 mg/l (*Estudios Hidrogeológicos e Hidroquímicos de la Región del Pacífico de* Nicaragua, Krasny & Hecht, 1998), and there is no evidence of elevated levels of potassium in studies of rainfall chemistry around volcanoes. An analysis of rainwater collected from the office of Nuevas Esperanzas in León found concentrations of 1.9 mg/l. It must therefore be concluded that the potassium originates from the rainwater harvesting tanks themselves. This was somewhat surprising as if the water quality had been affected by the cement mortar sufficiently to explain the high levels of potassium, high levels of calcium and other ions would also have been expected. The average calcium concentrations in the harvested rainwater is 6 mg/l.

In order to investigate this further, an attempt was made to reproduce the chemical composition of the water in the tanks using demineralised water and some of the construction materials. First, the water was shaken vigorously with cement and then filtered. This increased the potassium to 11.3 mg/l, but also increased calcium to 195 mg/l and conductivity to 1,168 µS/cm. The same procedure was followed for a sample of the sand used to make the mortar. Whilst this barely caused any change in the calcium concentration, it only increased the potassium to 3.8 mg/l whilst increasing the conductivity to 238 mg/l. The pH only increased slightly. Another experiment was undertaken allowing crushed blocks of mortar to soak in demineralised water for 24 hours. This gave rise to the greatest increase in potassium, but also significantly increased calcium concentrations. Finally, demineralised water was left to soak with a mixture of crushed mortar and sand for 5 days. A sample was then draw off from the water column and diluted to achieve a conductivity which was consistent with the rainwater in the tanks. This produced water with 6.1 mg/l of potassium, 4 mg/l of calcium, conductivity of 87 µS/cm and pH of 10.25, all of which are consistent with the values typically found in the rainwater. The results of this experiment are shown in the table below:

		Demineralised water	Demineralised water shaken with cement for 5 minutes, then filtered	Demineralised water shaken with sand for 5 minutes, then filtered	Demineralised water after fragments of mortar were allowed to soak for 24 hours	Demineralised water after fragments of mortar and sand were allowed to soak for 5 days; sample drawn off water column with syringe, then diluted 1:2 with demineralised water.
pH		6.93	8.15	7.60	11.57	10.25
Conductivity	*µS/cm*	1	1,168	238	971	87
Calcium	*mg/l*	2	195	4	60	4
Magnesium	*mg/l*	0.3	2.0	0.3	0.4	0.4
Potassium	*mg/l*	0.3	11.3	3.8	26.3	6.1

This experiment demonstrated that contact with the building materials used to construct the tanks is sufficient to explain the chemistry of the harvested rainwater. There is no evidence to suggest that the ionic composition of the rainwater is significantly affected by the volcano. Gaseous emissions from active volcanoes are known to have a significant impact on air quality, and aerosols containing sulphates contribute to volcanically induced acid rain. The most significant emissions from volcanoes are SO_2, CO_2, HCl and HF, all of which could potentially influence rainwater chemistry. However, the ions produced in aqueous solution from these gases are sulphate, bicarbonate, chloride and fluoride, none of which was found at significant concentrations in the samples analysed.

Faecal coliforms

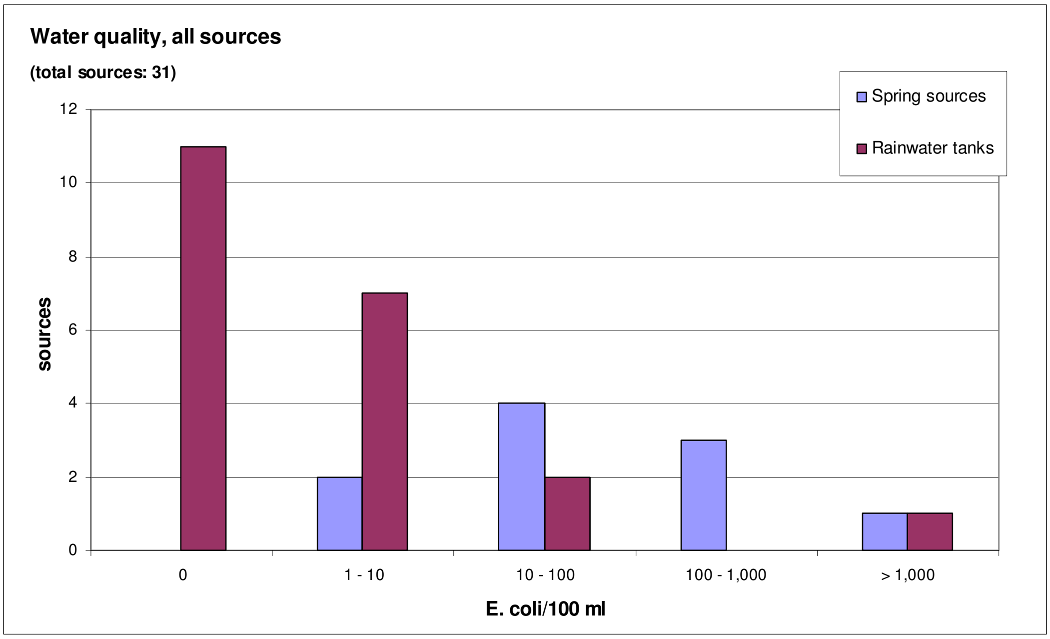
Of much greater significance to health than any of the above are the levels of faecal coliforms. Analyses were undertaken from all sources for thermotolerant faecal coliforms (*Escherichia coli*) as indicators of faecal contamination. Results ranged from 0 to 2,000 per 100 ml. As stated above in the discussion about the baseline, of greater interest than the compliance or otherwise with the official standard of 0 *E. coli*/100 ml, is the level of risk. According to the risk based classification, 11 of the 21 tanks showed no coliforms (in conformity with WHO guidelines), 7 tanks showed 1-10 *E. coli*/100 ml (low risk), 2 tanks 10-100 *E. coli*/100 ml (intermediate risk) and one tank with >1,000 *E. coli*/100 ml (very high risk). These results are a considerable improvement on the baseline but do not yet meet the target set in the proposal (>90% of samples with no coliforms).

The tank with >1,000 *E. coli*/100 ml was investigated in more depth and additional samples were taken after two weeks. The results were as follows:

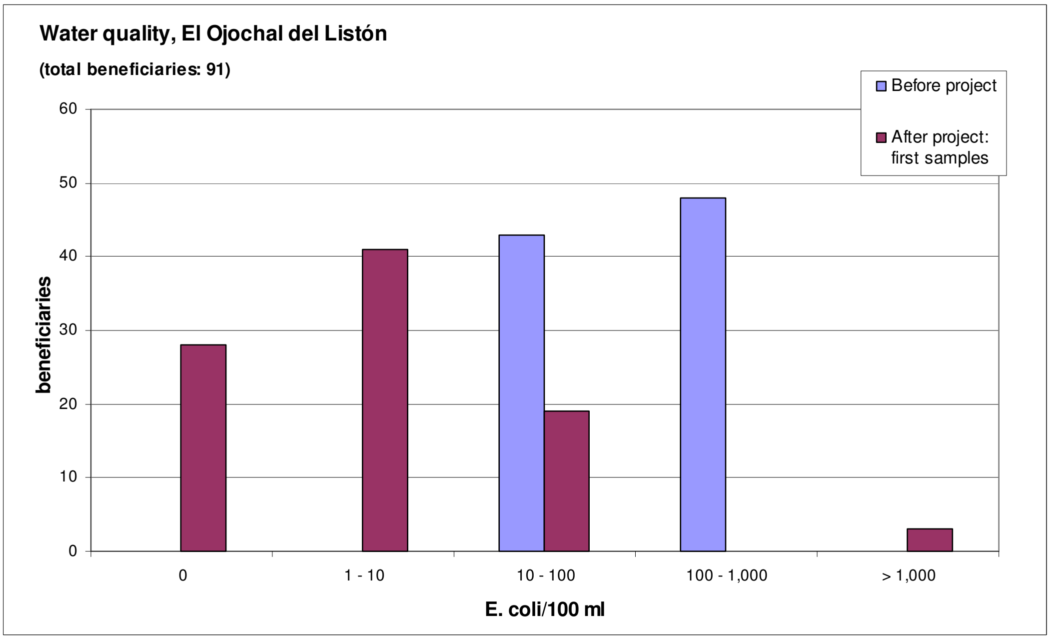
	Date	*E. coli*/100 ml	*Risk*
Original sample (taken from tap)	5/11/09	2,000	Very High
Repeat sample (taken from tap)	18/11/09	180	High
Repeat sample (taken from cover)	18/11/09	2	Low

This was the same tank which showed the highest levels of turbidity and which had not been cleaned prior to filling. The fact that the water sample taken from the water column in the tank shows low levels of faecal contamination suggests that the sediment which caused the high turbidity also contains faecal matter. As it is most likely that the contamination was introduced during construction, the faecal coliform counts are likely to diminish over time. This appears to have already happened and further sampling will be undertaken to monitor the decay of the bacteria. *E. coli* is moderately persistent in water which means that it can survive for between a week and a month, depending on many different factors.

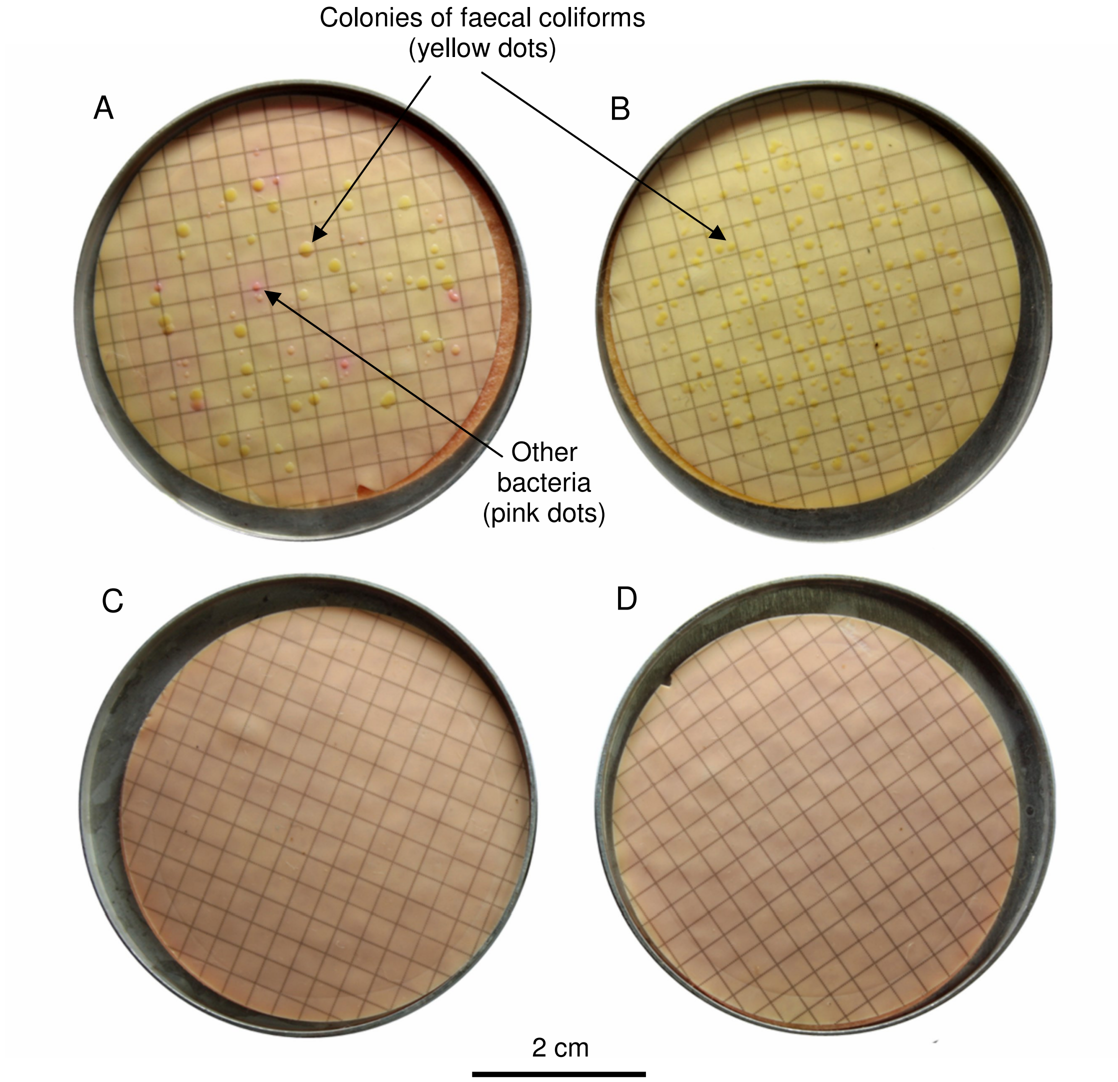
In spite of the very high levels of contamination of one tank, the results of the bacteriological analyses are very encouraging, especially considering that samples were taken in some cases only a week or so after the tanks were finished. The results for all 21 rainwater harvesting systems compared with the 10 samples taken of baseline spring sources are shown in the graph below:



Considering the existing sources used by families in El Ojochal del Listón, a comparison of the water quality 'before' (springs) and 'after' (rainwater) is given below:



A somewhat more dramatic way to represent the improvement in water quality is to view the plates of the bacterial colonies themselves. These plates are from samples taken on the same day of the most used source in the project area (the protected spring in Agua Fría), compared with the closest rainwater harvesting tank in Agua Fría which has no faecal coliformes at all:



A - 10 ml sample of water from the protected spring in Agua Fría
B - 100 ml sample of water from the protected spring in Agua Fría
C - 10 ml sample of water from a rainwater harvesting system in Agua Fría (Church of God)
D - 100 ml sample of water from a rainwater harvesting system in Agua Fría (Church of God)

Conclusion

In summary, the project evaluation has shown that the project has met or exceeded expected outcomes in virtually all respects. Due to a late season storm, the 21 systems constructed are all in use. The quantitative analysis has shown that rainwater harvesting is sufficient to eliminate the need to carry water or may be used to increase the amount of water available by more than 100%. The qualitative analysis has shown that the rainwater collected is of better quality than existing sources, although the bacteriological quality has not yet quite achieved the target values. It is possible that this was due to contamination during construction and further monitoring will be undertaken to see if the water quality improves over time as expected.

Future work

Monitoring

Nuevas Esperanzas is committed to ongoing monitoring of all its completed projects. Monitoring and feedback contribute valuable information to the design of new projects. This project benefited considerably from the experience of previous projects, including the first rainwater harvesting project in San Jacinto in 2005, also financed by the Georg Fischer Clean Water Foundation. Specific ongoing monitoring of this project will include:

- Ongoing monitoring of water levels. The analysis of water levels in this report provided useful information on rainwater harvested in response to a specific storm. Regular monitoring of water levels after the end of the wet season will provide equally valuable data on water use.
- Ongoing water quality surveillance. Of particular interest will be the decay rate of bacteria present in the tanks, but changes in water chemistry over time will also be of interest.
- Structural performance of the tanks. Tanks will be monitored for cracks or seepage or unexplained loss of water. Ferrocement tanks can leak, but they can also easily be repaired once leaks are detected. Although repairs must obviously wait until the tank is empty, repair needs can be identified through ongoing monitoring.
- Lifestyle changes. It will be important to note how the rainwater tanks affect people lives. Will they continue to collect water from springs?
- Feedback. As part of the ongoing process of participation, creative means of generating feedback from beneficiaries will be applied.

Operation and maintenance

As with all previous rainwater harvesting projects, Nuevas Esperanzas will train beneficiaries in the operation and maintenance of their systems including cleaning and repairs, valve replacement, maintenance of gutters and PVC tubes, roof cleaning and the diversion of the 'first flush' (the first rains which carry dirt accumulated on roofs during a dry spell). Women and men will be trained and the timing and location of sessions planned to ensure high levels of participation. Household water treatment options will also be considered as part of the training although there are no specific plans to introduce any formal method of treatment for all.

Other projects

Coinciding with the completion of this project, a new project to train women from El Ojochal del Listón in organic family gardening has begun. This project will use drip irrigation from buckets, along with other water saving techniques, to enable vegetables to be grown during the dry season for the first time in the community. This project will make use of some of the harvested rainwater to irrigate crops. Two other projects have also just been approved: conservation and reforestation of the protected area and a project to train communities in beekeeping. The completion of the rainwater harvesting project in El Ojochal del Listón now means that, in this community, the focus can shift away from basic infrastructure towards projects which will help secure the long term livelihoods of these hillside families.

Further rainwater harvesting projects

A proposal has been submitted for a small project to build five more rainwater harvesting systems in El Ojochal – La Joya and Agua Fría. However, the need for more is still very great and funding is being sought for the second phase (domestic tanks) in Agua Fría, El Caracol, El Ñajo and Las Pilas. Some 38 families still travel for more than 1 km to their nearest source of water. In addition to rainwater harvesting tanks, funding is also being sought to improve existing spring sources, including some of those mentioned in this report.

Financial statement – construction of 21 rainwater harvesting systems

All values in US$

INCOME

Donations received (Georg Fischer Clean Water Foundation)	*69,790.08*
Tax reimbursements on purchases	*3,743.66*
Community contribution to corrugated roofing sheets	*186.46*
Total income (1st July 2008 - 30th November 2009)	***73,720.20***
Outstanding final payment from Georg Fischer Clean Water Foundation	*10,000.00*

EXPENSES

Materials costs				
Tank materials				
Cement (1,228 bags, 42.5 kg)			10,019.59	
Sand			452.39	
Gravel			587.79	
Welded mesh (112 sheets, 6 m x 2.4 m x 6.2 mm)			8,375.01	
Chicken wire (30 rolls, 30 m x 1.8 m)			1,305.89	
Rebar, galvanised wire, tie wire, etc			1,364.78	
Hessian sacking			289.30	
PVC - columns and outflow pipes			749.68	
Valves			552.62	
Total tank materials				*23,697.06*
Roofs, gutters and tubes				
Corrugated galvanised iron (187 sheets, 3.6 m x 0.7 m x 0.36 mm)			2,200.68	
PVC gutters (77 high capacity gutters, 6 m long)			1,606.23	
PVC tubes and fittings			1,299.54	
Wood			563.16	
Nails, screws and bolts			250.59	
Total materials for roofs, gutters and tubes				*5,920.19*
Tools				
Construction tools and hand tools			265.88	
Total tools				*265.88*
Manpower costs				
Nuevas Esperanzas staff costs	*hours*	*rate*	*cost*	
Project Manager	575.0	12.23	7,033.98	
Civil Engineer	1,291.0	4.54	5,863.81	
Community Coordinator (July 2008 - April 2009)	377.0	4.54	1,712.36	
Community Coordinator (April - November 2009)	544.0	3.63	1,976.71	
Logistician	1,447.0	3.18	4,600.66	
Coordinator for Women	446.0	2.95	1,316.75	
Agroecologist	298.0	6.13	1,827.28	
Administrator	204.0	6.30	1,286.10	
Subsistence			1,292.59	
Cellphones			204.91	
Total Nuevas Esperanzas staff costs				*27,115.15*
Building supervisors				
Salaries			9,195.76	
Social security			1,379.37	
INATEC (government training scheme)			183.92	
Redundancy payments			322.94	
Provision for 13th month and redundancy payments			1,270.84	
Subsistence			2,333.91	
Personal equipment			172.02	
Total building supervisors costs				*14,858.75*
Community volunteers				
Refreshments			293.32	
Cellphones for community leaders			46.39	
Total community volunteers costs				*339.71*

continued…

…continued

	km	rate	cost	
Transport costs				
Vehicle use costs	*km*	*rate*	*cost*	
Toyota Land Cruiser pickup	16,287	0.40	6,545.94	
Chevrolet Blazer SUV	3,210	0.29	932.20	
Total vehicle use costs				*7,478.14*
Direct transport costs				
Haulage (transport of materials, León to San jacinto)			434.36	
Tractor (transport of materials, San Jacinto to El Ojochal del Listón)			2,447.75	
Horse expenses			699.02	
Public transport			141.01	
Bicycle expenses			77.91	
Total direct transport costs				*3,800.04*
Other direct project costs				
Stationery and office supplies			102.76	
Maps			70.83	
Laboratory analysis of water sample			57.49	
Project sign			47.24	
Total other direct project costs				*278.32*
Indirect project costs				
Includes rent, utilities, support staff, etc		@ 6%		*5,025.19*
Total costs (1st July 2008 - 30th November 2009)				***88,778.44***
Project overspend				*5,058.23*
				6%

Notes

- Note that all transactions in currencies other than US$ are calculated using the official exchange rate on the day of the transaction.
- The full accounts for this project are given in a spreadsheet submitted with this report.