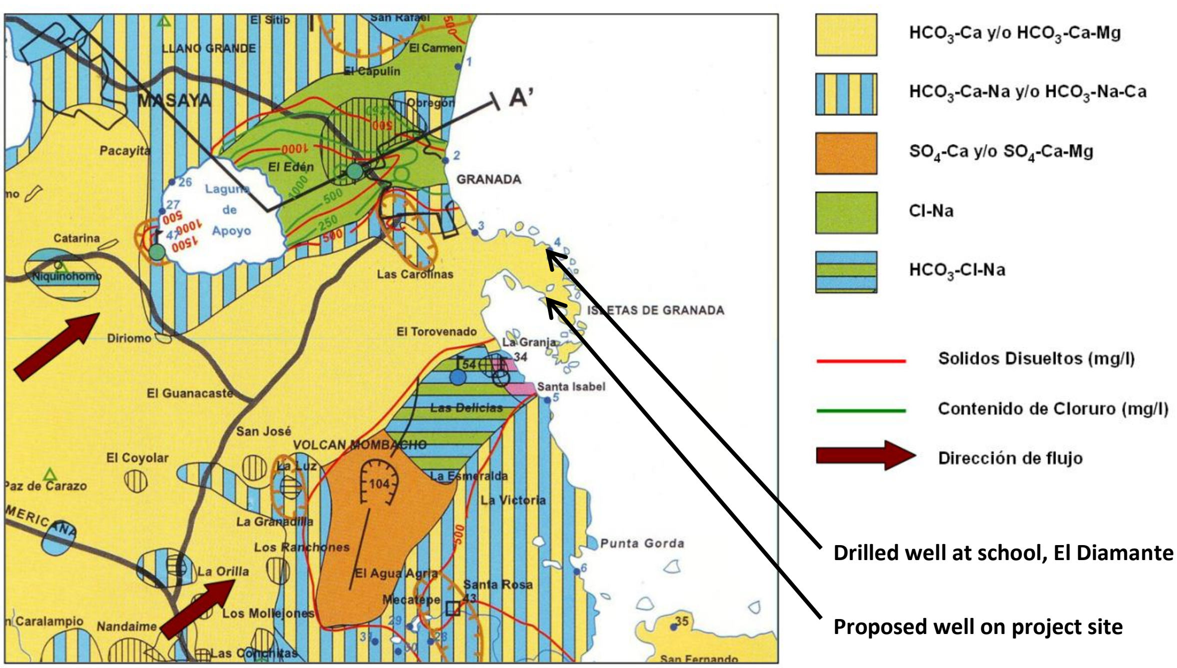
Asese hydrogeological study – update, March 2012

Since undertaking the hydrogeological study for a proposed borehole on the Asese Peninsula, Granada for the social housing project proposed by SIFT, new information from a borehole recently drilled in the community of El Diamante has become available which affects the conclusions of the original study. At the time of the original study, no data was available on the water quality of the principal aquifer and the only water quality analysis included was from a shallow well on the project site. The new drilled well in El Diamante is around 100 feet deep and may therefore be representative of the major aquifer at the proposed project site. A sample was taken from this well in March 2012 and analysed for some basic physico-chemical parameters:

pH	6.71
Conductivity	2,430 µS/cm
Hardness	190 mg/l as $CaCO_3$
Alkalinity	420 mg/l as $CaCO_3$
Chloride	350 mg/l

Total Dissolved Solids (TDS), as estimated from conductivity, are around 1,200 mg/l which is too high for the water to be considered suitable for drinking. This is not so much a health issue as a matter of taste. The Nicaraguan standards for drinking water specify maximum TDS of 1,000 mg/l and a maximum chloride concentration of 250 mg/l. The well in El Diamante is not used for drinking.

The water quality map presented in the original hydrogeological study did not indicate that groundwater on the Asese Peninsula would be unsuitable for drinking as it is shown as being of calcium bicarbonate or calcium magnesium bicarbonate type with a TDS of less than 500 mg/l:



However, as the original study stated:

> *"It is important to note, however, that poorer quality water exists in the area to the north and to the south-west of the peninsula due to upwelling waters of Cl-Na type at both Laguna de Apoyo and Volcán Mombacho…*
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> *… Since groundwater flow is generally from the south-west to the north-east in this area, a 'contaminant' plume of Cl-Na water exists, flowing from the north-east side of Laguna de Apoyo towards Granada. This gives rise to elevated TDS values (>1000 mg/l) and high chloride concentrations in groundwater in parts of Granada. Similarly, groundwater flowing towards the north-east from Volcán Mombacho is of HCO_3-Cl-Na type with TDS values in excess of 500 mg/l. Whilst groundwater in the peninsula of Asese itself is shown as being of suitable quality for potable use, it is unlikely that much data exists for this area and it is probable that water quality assessments are based on samples of surface water or shallow groundwater, if on any sampling at all. There is a risk that at depth beneath the peninsula of Asese, groundwater is affected by this 'plume' and that water abstracted from a deep borehole may not be suitable for drinking due to high concentrations of chloride."*

From the sample taken from the new well in El Diamante, it is possible to determine the water type:

- Chloride: 350 mg/l is equivalent to 9.9 meq/l.
- Alkalinity: 420 mg/l as $CaCO_3$ is equivalent to 8.4 meq/l as bicarbonate, since at pH 6.71, the carbonate ion is likely to be virtually absent.
- Hardness: 190 mg/l as $CaCO_3$ is equivalent to a maximum of 3.8 meq/l of calcium + magnesium (if all hardness was due to calcium).
- The sum of chloride and bicarbonate is 18.3 meq/l which, together with any sulphate present, must be balanced by the cations.
- Since the total of calcium and magnesium is only 3.8 meq/l, at least 14.5 meq/l must be present as sodium and/or potassium. Sodium is likely to be much higher than potassium.
- The water is therefore most likely to be of **Na-Cl-HCO_3** type.

On the hydrogeochemical map, two distinct contaminant plumes were identified, one of Na-Cl type from Laguna de Apoyo and the other of HCO_3-Cl-Na type from Volcán Mombacho. It is not entirely clear from the above analysis which of these is more likely to be affecting the water in the well at El Diamante. The dominant ions are Na and Cl, which is more consistent with the water from Laguna de Apoyo, but the moderately high levels of HCO_s suggest that this water might be affected by the plume from Volcán Mombacho. If the water at El Diamante is affected by the chloride water from Laguna de Apoyo, it is possible that the proposed borehole site might still be just outside this influence of this plume. However, if the water at El Diamante is affected by the plume from Volcán Mombacho, there is virtually no chance that the proposed well would be unaffected. Either way, it is clear from this new information that there is a high risk that water from a deeper borehole at the project site would be unsuitable for drinking. Given the complexity and cost of the proposed borehole (complicated further by the risk of overflowing artesian conditions), **it is recommended that an alternative solution be sought to provide water for the proposed housing project.**

Alternative sources of water

The original hydrogeological study proposed that a borehole be drilled because it was seen as the best option to provide a source of clean water (less vulnerable to pathogenic contamination) whilst addressing the concerns of MARENA with respect to the potential impact of an abstraction on the wetland within the project site. Since this option is no longer viable in the light of the new information described above, an alternative solution must be proposed. It should be noted, however, that no alterative solution is likely to be entirely satisfactory from all points of view, since these options were all considered and rejected at the time of the original study. The following table lists the alternative options with their advantages and disadvantages. No specific recommendation is made because the selection of the preferred option will depend on balancing the need for an adequate water supply (in terms of quality and quantity) with potential environmental impact and cost. It is recommended that a decision is taken after consultation with all stakeholders (beneficiaries, SIFT, MARENA, ANA, Alcaldía, etc). Note that no specific calculations or designs have been undertaken to support the evaluations below. The advantages, disadvantages and costs of each option are based on experience of similar projects and professional judgement.

Report prepared by:

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	Option	Description	Advantages	Disadvantages	Risks	Cost
1	Shallow borehole with distribution system	Shallow well replaces proposed borehole but otherwise follows original plan with tank, distribution system and metered domestic connections	• **Provides running water at each house** • Chlorination simple • Easier to protect from contamination than hand-dug wells	• **Possible negative impact on wetland** from drawdown • Requires electricity • Treatment essential • Could cost users around C$100/month	• Well may not produce adequate yield • Repairs could be expensive	$50k - $70k (needs detailed design to estimate cost more accurately)
2	Individual hand-dug wells	Wells with cover slabs and handpumps for each house or for every two houses (managed by families)	• **Individual ownership** (no monthly fee) • Provides abundant water at each house • No need for electricity	• **Most vulnerable to contamination** • Limited options for site selection • Difficult to guarantee good hygiene and/or chlorination	• May not be possible everywhere (rocks) • Floods could make some wells unusable • Families may not have cash to fix pumps	$116k (one well per family) or $58k (one well shared between two families) @ $2k per well
3	Communal hand-dug wells	Wells with cover slabs and handpumps at distance of <100 metres from each house (managed by water committee)	• **Simplest option to implement** • Simple to supervise (allows chlorination) • Low monthly maintenance cost (but enough for repairs)	• **Only option which does not provide water at each house** • Vulnerable to contamination	• If contaminated, diseases would spread more quickly (communal use)	$16k (based on eight wells at $2k each with well surround, cover slab, apron and handpump)
4	Lake water with treatment plant and distribution system	Water pumped from lake and treated (filtration and/or flocculation, then chlorination) before distribution as in option 1	• **Provides running water at each house** • Treatment managed centrally • No negative impact on wetland	• **Requires significant use of technology** and competent operator • May be difficult to treat water at certain times • Requires electricity • Most expensive for users	• System could be difficult to repair • Chemicals may not be available • Floods could make lake water unusable	Would need specialist design to estimate cost, but probably at least $70k
5	Rainwater harvesting	Rainwater harvesting from roofs to enclosed ferrocement tanks of 20 m^3 capacity (one per family) or 40 m^3 capacity (one between two families)	• **Least vulnerable to contamination** • No harm to wetland • Helps reduce runoff • No need for electricity • Individual ownership (no monthly fee)	• **Quantity limited** to around 30 litres/person/day in the dry season • If tanks are shared between two families, difficult to regulate consumption	• No supply for months if water is lost or contaminated during dry season • Drought years may provoke water scarcity	$200k (one 20 m^3 tank per family) or $140k (one 40 m^3 tank shared between two families)