INTRODUCTION
Safe drinking water is important in a school environment, as children are often vulnerable to water-borne disease. Schools in low income settings present a challenging context for the provision of safe water. There are many environmental (e.g. poor water quality), technological (e.g. little technical knowledge) and practical (e.g. no electricity) challenges to achieving sustained access to safe water.

In 2012, Samaritan’s Purse and Clear Cambodia began implementing intermittently operated slow sand filters as an appropriate, sustainable solution to improve water quality in rural schools in Cambodia. At the end of 2015, 170 of these filters were installed in schools in 7 provinces of Cambodia.

METHODS & MATERIALS
The primary objective of the study was to document the quality of the water produced and the performance of the filtration system to improve microbiological, chemical and physical parameters of the water. E. coli samples were collected for source water, filtered water and stored water were collected by spot checking and were analyzed by an Aquagenx Compartment Bag Test. These samples were collected by field staff during monitoring visits between January 2014 and August 2015 (n=172).

In addition, the following parameters were considered in an independent spot check conducted in January 2015 at 24 schools four provinces (Kompong Chhnang, Kompong Thom, Prey Veng and Svay Rieng): E. coli, turbidity, pH, UV absorbance at 254 nm, nitrate, nitrite, ammonia, conductivity, total hardness, and calcium and magnesium concentrations. Turbidity, pH and conductivity were analyzed onsite. The remaining tests were conducted at the Resource Development International laboratory near Phnom Penh, Cambodia.

RESULTS & DISCUSSION
Filtered Water Quality
- Mean raw water E. coli was 28.2 colonies/100 mL, lower than typically reported in rural Cambodian household water supplies.
- Mean filtered water E. coli was 4.1 colonies/100 mL.
- Mean E. coli removal rate of 97.8% was found when considering only the data where source water E. coli was 5 colonies/100 mL or greater (n = 66).
- This E. coli removal rate is higher than typically reported for household BioSand Filters (e.g. 90%), and is consistent with expectations of approximately 2-log for a slow sand filter based on the literature.
- 75% of the raw water samples had no E. coli, and 95% of the samples (188 of 198) had < 10 E. coli colonies/100 mL.
- Mean filtered water turbidity was 0.56 NTU (n=24), which is below the WHO guideline of 1 NTU.
- The mean turbidity removal was 82%.
- Mean UV absorbance at 254 nm decreased from 0.047 cm⁻¹ for raw water to 0.029 cm⁻¹ for filtered water (38% removal, n = 24), suggesting the sand removal performances.
- Mean calcium concentrations increased from 43 mg/L as CaCO₃ in the raw water to 71 mg/L as CaCO₃ in the filtered water (n=24). As calcium hardness is an aesthetic concern to many users, calcium leaching from the filter sand warrants further investigation.
- No changes in conductivity (p>0.14), total hardness (p>0.14) or temperature were observed across the filter or during storage (n=24).
- No change in ammonia, nitrite or nitrate levels was observed, possibly owing to low ammonia levels in the raw water (Mean < 0.05 mg/L as NH₃, n=24).

Stored Water Quality
- The mean stored water E. coli was 3.8 colonies/100 mL, 75% of the stored water samples had no E. coli and 95% of the samples (188 of 198) had < 10 E. coli colonies/100 mL, similar to the filtered water. Only 14% of stored water samples (27 of 198) had E. coli levels greater than the filtered water. Taken as a whole, there is little evidence of contamination or growth during storage.
- Mean stored water turbidity increased by 0.32 NTU to 0.87 NTU (n=24), but remained below the WHO guideline of 1 NTU for 84% of the samples (21 of 25).

CONCLUSIONS
- An E. coli removal rate of 97.8% was measured across the filter (n = 66); this is better removal than typically reported for household BioSand Filters and is consistent with 2-log removal in the literature for slow sand filters.
- A mean turbidity removal of 62% was observed resulting in a mean filtered water turbidity of 0.56 NTU, below the WHO guideline of 1 NTU.
- Mean calcium levels increased from 43 mg/L as CaCO₃ in the raw water to 71 mg/L as CaCO₃ in the filtered water, warranting further investigation around calcium leaching from the sand medium.
- No changes in conductivity, total hardness, ammonia, nitrate or nitrite levels were observed across the filter.
- No changes in turbidity, conductivity, and calcium leaching.

This data, collected for periods between 1 and 12 months after installation, indicates that the filter meets design expectations for the removal of E. coli and turbidity. The long term (> 1 year) performance of this intermittently operated slow sand filter when raw water E. coli or turbidity levels are higher should be determined.

References

Figure 1. Schematic of an intermittently operated slow sand filter

The intermittently operated slow sand filters considered in this study were composed of three tanks: a 1000 L raw water reservoir, a 1000 L vertical tank with sand as a filter medium and a 1500 L filtered water storage tank. Water is pumped (manually or by motor) to the raw water storage tank. Raw water flows by gravity to the filter. The driving water head above the filter is limited to 20 cm by a float controlled valve. The vertical tank is filled with 75 cm of filtration sand, effective size of 0.10-0.20 mm; uniformity coefficient of 1.5-2.5; silt content < 4%) which is supported by 15 cm of coarse sand. Water is filtered at a peak hydraulic loading rate of 0.2 m/h. This is approximately a quarter of the hydraulic loading rate of a household water supply.

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A mean filtered water turbidity of 0.56 NTU, below the WHO guideline of 1 NTU.

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