SNOWY PRECIPITATION ENHANCEMENT RESEARCH PROJECT: UPGRADING NOAH II PRECIPITATION GAUGES WITH AN AUTO-SIPHONING SYSTEM

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Abstract. The Snowy Precipitation Enhancement Research Project (SPERP) is a cloud seeding trial currently being undertaken in the Snowy Mountains Regions of New South Wales, Australia. The project has an extensive surface meteorological monitoring network distributed across a study area of 2,150 km^2. The network includes 32 ETI NOAH II All-Weather Precipitation Gauges, used for accurate measurement of snowfall liquid equivalent and rainfall at higher elevation sites. Many of these gauges are located at remote places in the landscape, and are only accessible by helicopter or oversnow travel during the winter months. Fitting a simple automatic siphoning system protects the load cell by limiting the amount of liquid that can be contained within the collection chamber. While the system does not maintain anti-freeze concentrations following siphoning, the starting concentration is sufficient to protect the gauge through several siphoning cycles, allowing additional time for field visits to be scheduled. The simple design of this system makes onsite manual draining of the collection chamber more effective, significantly reduces costs and safety risks, and increases overall productivity.

1. INTRODUCTION

The Snowy Precipitation Enhancement Research Project (SPERP) is a cloud seeding trial currently being undertaken in the Snowy Mountains Regions of New South Wales, Australia (Manton et al., 2011; Manton et al., 2009). The trial commenced in 2004 with an initial target area of 1,000 km^2 and 24 ETI NOAH II All-Weather Precipitation Gauges. In 2009, the target area was expanded to 2,150 km^2, and ten additional ETI NOAH II All-Weather Precipitation Gauges were installed. Two of the original gauges were decommissioned leaving 32 gauges distributed across the expanded target area and control area. Continuous reliable meteorological data collection during the winter is critical for the robust statistical evaluation of the project. Many of these gauges are located at remote places in the landscape, and are only accessible by helicopter or difficult oversnow travel during the winter months *(Figure 1).*

The NOAH II precipitation gauge uses a diaphragm and pressure plate depressing a load cell to measure the hydrostatic pressure due to precipitation collected in a 12-inch (305 mm) orifice cylinder. The resulting electrical signal is then measured and filtered by a microprocessor which calculates an equivalent depth in inches. The gauges used in the SPERP have a maximum capacity of 19 inches (483 mm) of precipitation (not including initial antifreeze charge), and require periodic servicing to manually drain the collection chamber and replenish antifreeze. If the fluid level in the gauge is allowed to exceed the maximum depth, severe damage to the load cell will result. The NOAH II precipitation gauge features a 54 in. (1372 mm) tall cylindrical assembly for precipitation collection; the bottom of the collection cylinder is located 40 in. (1016 mm) below the 12 in. (305 mm) diameter inlet orifice. The electronic weight measurement assembly is installed in the cylinder base (ETI Instrument Systems Inc.). Antifreeze (50% Propylene Glycol, 50% Alcohols) is used in the collection chamber to prevent any captured rainfall or snow from freezing; and a layer of food grade oil minimizes evaporation. A pump operates periodically during precipitation events, to pump fluid from the bottom of the collection cylinder through a jet at the top of the cylinder to wash any solid precipitation from the walls. Although the load cells can theoretically measure up to 30 in. (762 mm) of precipitation, the initial addition of 11 in. (279 mm) of antifreeze effectively reduces the precipitation measuring capacity to 19 in. (483 mm) before the load cell fails. Careful and systematic management is required to avoid failure of the instrument and loss of data, while containing costs.

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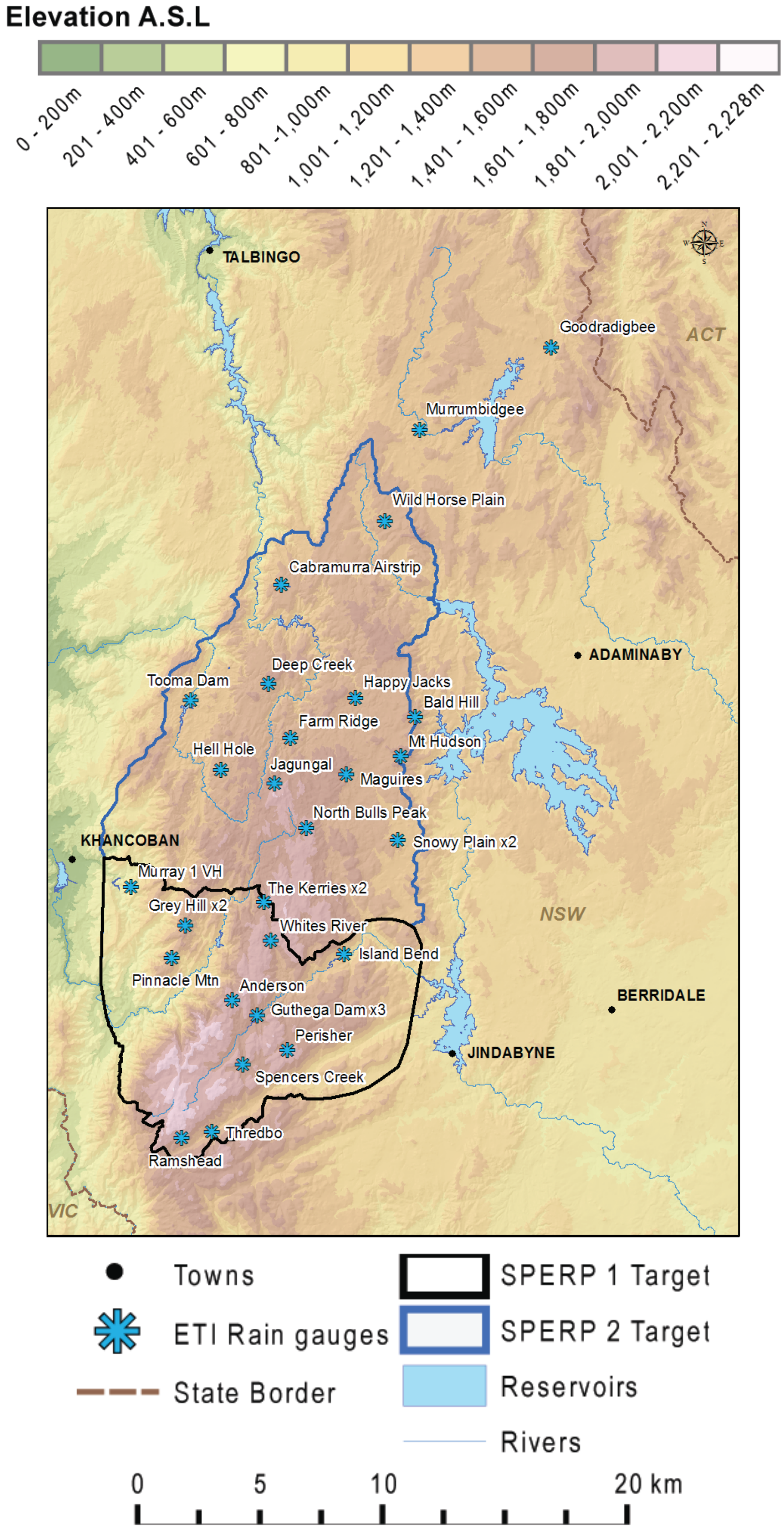

Figure 1: SPERP 1 and SPERP 2 target areas with 32 ETI rain gauges distributed across the target area and control area.

The new and improved NOAH III and NOAH IV precipitation gauges do not require antifreeze for operation and the NOAH IV can be fitted with an IR precipitation sensor for improved detection of the onset of precipitation. However, they have a smaller precipitation capacity, consequently requiring more onsite maintenance visits than the NOAH II precipitation gauges. The SPERP project has not upgraded to the improved NOAH IV gauges due to the cost and logistics of upgrading 32 gauges. Furthermore, upgrading to the newer NOAH gauges would introduce a change of measurement systems part way through the scientific trial.

Snowy Hydro has managed the risk to the NOAH II instrument network in several complementary ways. Wherever telecommunications are reliable, gauges have been retrofitted with this capability to allow remote download of data, and routine surveillance and monitoring of fluid levels. Software interpolation is used to predict fluid levels in gauges where communications are unreliable or unavailable. This information is then used for scheduling field maintenance in the most cost effective way.

Extended precipitation events and unsuitable flying conditions have at times prevented timely gauge maintenance, pushing some gauges to the maximum fluid limits, with the occasional load-cell failure resulting. To provide more flexibility with scheduling and to reduce safety risks to personnel, a simple auto-siphoning device has been retrofitted to all NOAH II gauges to prevent fluid reaching critical levels.

2. CONCEPT AND DESIGN

The siphoning system initiates automatic draining when the fluid depth reaches 25 in. (635 mm) and a vent tube to the siphon stops the draining at a depth of 20 in. (508 mm). Once the siphon has drained enough liquid to reach the lower depth, air is automatically entrained, neutralizing the pressure difference and breaking the siphoning *(Figure 2)*.

2.1 Testing

The auto siphoning system was initially tested in ideal laboratory conditions, with an in-field trial over the following several months. Initial test rigs where flow restrictors were used yielded long draining times of up to 2 hours *(Figure 3)*. Further tests were carried out without flow restrictors and it was found that the siphoning system was inducing a significant vacuum at the T intersection of the drain hose. This resulted in the ingress of air through the vacuum break on the siphon, which also slowed the siphoning process, albeit less than when using

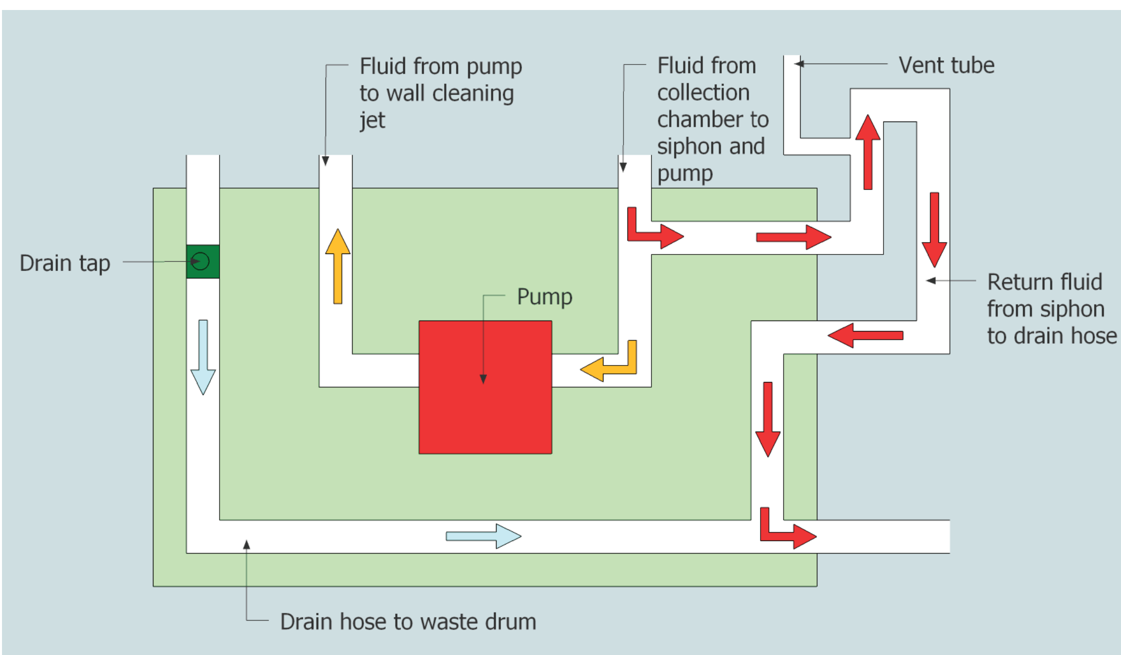

Figure 2: Schematic diagram of the auto siphon system. Red arrows representing the flow of fluid during a siphon event, orange arrows showing fluid flow when the wall cleaning jet is operating and blue arrows showing the flow of fluid during a manual drain.

a flow restrictor. An adequate balance between the strength of the vacuum and siphon times is a subject of further improvement to this system. More tests have suggested that the longer the vertical drop of the drain hose from the T intersection to the waste drum, the stronger the vacuum. The implication for the SPERP is that depending on the height difference between the T intersection and the waste drum, the siphon times will be different for each gauge. *Figure 3* shows the different times taken at different gauges for the siphoning system to drain 5 in. (127 mm) of fluid. In both cases, precipitation data is missing during the siphoning process; however, the gauge is operational again following siphoning. This is a much better outcome compared to complete failure of the load cell, and the loss of data until repairs have been undertaken.

Figure 3: Field test of a siphon event at two different gauges, one with a flow restrictor (red trace) and the other without (blue trace).

2.2 Calibration

When retrofitting the NOAH II precipitation gauges with the automatic siphoning system, the change in volumetric capacity of the collection chamber is less than 0.05%, which is equivalent to 0.01 in. (0.25 mm) over 20 in. (508 mm) of precipitation. This represents two orders of magnitude smaller than the maximum calibration error allowed, so the load cell does not need to be re-calibrated.

2.3 Anti-freeze Use

As discussed earlier, anti-freeze, a 50:50 mixture of Propylene Glycol and Alcohols, is used in the collection chamber to prevent precipitation from freezing. *Figure 4* shows the amount of anti-freeze required in the collection chamber as a function of the expected minimum temperature. An adequate layer of food grade oil is added to the collection chamber to inhibit evaporation.

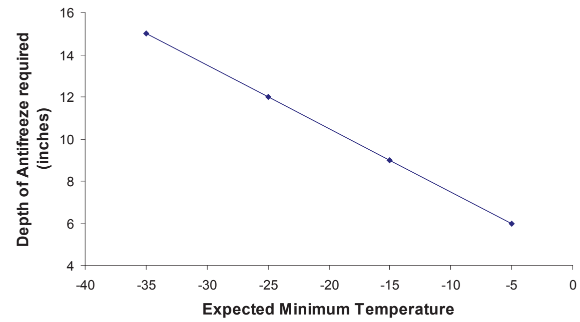

Figure 4: Amount of antifreeze required as an initial charge in the collection chamber depending on the expected minimum temperature.

For the SPERP, temperatures can potentially drop to -20°C, requiring approximately 11 in. (279 mm) of antifreeze to be used initially. This means that the measuring range of actual precipitation after the initial charge of antifreeze is between 11 in. (279 mm) and 30 in. (762 mm). As a result, the measuring capacity of the gauge has been reduced to 19 in. (482 mm). The SPERP uses a trigger depth of 25 in. (635 mm) for siphoning and the vent tube is fitted at 20 in. (508 mm) to allow 5 in. (127 mm) of liquid to be drained from the collection chamber. These particular depths can be modified to suit specific needs as required; however, the plumbing specifications will change accordingly.

One disadvantage of the auto-siphon system is the dilution of anti-freeze following siphoning, which increases the operating temperature of the gauge. This can be detrimental to the load cell if very cold conditions are experienced after siphoning. While the auto siphoning system protects the gauge in times of severe unexpected precipitation events, it is imperative that personnel perform a site visit as soon as conditions are safe enough to replenish the gauge with anti-freeze.

3. RETROFITTING THE SIPHONING SYSTEM ON NOAH II GAUGES

The siphoning system requires additional plumbing to the interior and exterior of the NOAH II. The siphon, drain and vent tubes are fitted to the outside of the NOAH II gauge using ¼ in. (6.35 mm) stainless steel pipes (*Figure 5*). The interior and exterior drain pipes are connected by a T piece inside the load cell chamber and directed to a waste container stored in a hazardous waste drum on site.

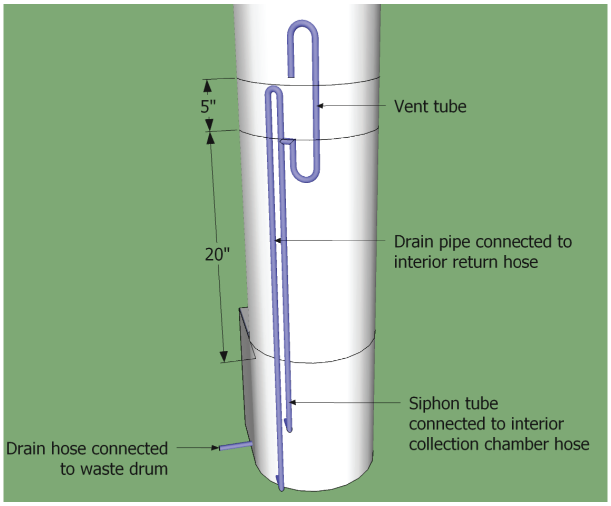

Figure 5: Exterior plumbing arrangement fitted to a NOAH II precipitation gauge.

4. DISCUSSION

The design of this siphoning system provides three major benefits for effectively managing the NOAH II precipitation gauges. Firstly, the load cell is constantly protected from being overloaded with too much liquid in the collection chamber. This is a significant advantage when operating a large network of widely distributed gauges, where the cost of replacing failed load cells becomes significant.

Secondly, unexpected high precipitation events will not cause the collection chamber to overflow or spill, discharging anti-freeze polluted water and oil to the environment. This is particularly useful for NOAH II precipitation gauges that are located in sensitive areas and for remote sites where access can be limited during winter.

Finally, the design of the system facilitates onsite manual draining of the collection chamber. This is particularly useful during the winter, when snow drifts may have buried the waste drums deep under the snowpack. With the auto-siphon system, the drainage hose inside the load cell chamber is connected directly to the drainage drum. Opening the tap inside the load cell chamber is all that is required to start draining.

These advantages collectively decrease the amount of time and money spent to maintain sites, thereby increasing overall productivity when servicing a large amount of gauges.

The major disadvantage of this system is the loss of data during the 2-hour period of siphoning; however, this is preferred to losing longer periods of data (possibly days) as a result of instrument failure. There is also the added problem of the dilution of antifreeze after the siphoning. Because of these drawbacks the automatic siphoning system is used as part of a package of protection measures in the Snowy Hydro network.

The auto-siphon system has been in operation on SPERP gauges for over a year, and has shown reliable performance in draining liquid out of the collection chamber at the desired level.

Acknowledgements: The authors would like to thank Shane Bilish, Snowy Hydro Limited, for his work with the initial concept development and field testing.

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