Cloud seeding trial success

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- Snowy Hydro has been conducting a scientific trial of cloud seeding in the Snowy Mountains since 2004.
- An independent evaluation of this trial has shown an average 14% increase in precipitation for seeded events.
- Comprehensive monitoring and assessment shows no evidence of any significant adverse environmental impacts or downwind effects.

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Cloud seeding involves the introduction of a seeding agent into suitable clouds to encourage the formation and growth of ice crystals or raindrops, which in turn, enhance the precipitation from the cloud. The technique has been in use for more than 50 years, and in Australia for more than 40 years. Today, there are more than 150 cloud seeding projects around the world.

Snowy Hydro designed a cloud seeding research project to determine if cloud seeding can be used to increase snow falls, at reasonable cost, and without any significant adverse effects on the environment or downwind of the target area.

An independent evaluation of the project (up to June 2009) showed that when cloud seeding was undertaken during suitable conditions there was a 14% increase in snowfall.

The evaluation also found no evidence of any impact on downwind areas.

A total of 23 ground generators are sited along the western side of the mountains to disperse silver iodide into winter storm clouds as they pass over. On average, the amount of seeding material used each year across the whole project area would fill one domestic water bucket.

History of cloud seeding

The potential for cloud seeding in the Snowy Mountains was recognised as early as the 1950s. A joint experiment between the CSIRO and the Snowy Mountains Hydro-electric Authority (1955–1959) reported an increase in precipitation of 19% for seeded storms. The results, however, were challenged due to claims that proper scientific procedure had not been followed.

Further research into cloud seeding over the Snowy Mountains was undertaken in the late 1970s, in response to a severe drought across the region, and during the winters of 1988 and 1989. By 1993 a second cloud seeding project was proposed but for a number of reasons, it did not proceed.

After corporatisation of the Snowy Mountains Hydro-electric Authority to Snowy Hydro Limited in 2002, there was significant community, stakeholder and political will to find some means of mitigating the impacts of the worsening drought. This put cloud seeding firmly back on the regional and state agenda.

An independent Expert Panel was commissioned in 2003 to undertake a comprehensive assessment of the potential environmental effects of a cloud seeding experiment over the Snowy Mountains. The panel reported to the NSW Government that "any significant adverse environmental impacts would be very unlikely". This resulted in the passing of enabling legislation, the *Snowy Mountains Cloud Seeding Trial Act 2004* (NSW).

The cloud seeding legislation allows Snowy Hydro to undertake the Snowy Precipitation Enhancement Research Project (cloud seeding) over a limited and clearly defined target area in the Snowy Mountains region of NSW (Figure 1). The legislation also imposes a number of mandatory constraints on the project.

The cloud seeding project was conducted in accordance with a formal experimental design and evaluation plan with criteria for success clearly defined and published in advance. This was done to ensure the results would be credible, the process transparent and that the results could be relied upon. Most importantly, the final evaluation and peer reviews of project outcomes were undertaken independently of Snowy Hydro Limited.

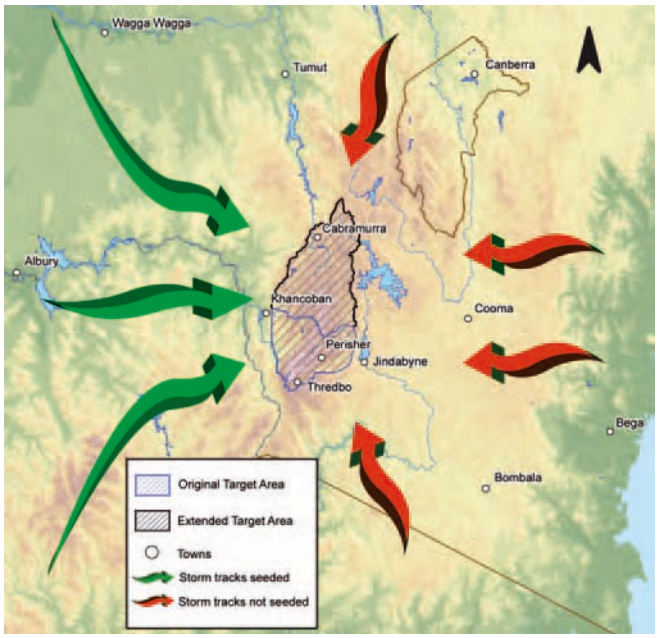

***Figure 1**. The target area of the Snowy Hydro cloud seeding project. Only suitable weather systems that approach the Snowy Mountains from the west are seeded.*

How does it work?

Winter precipitation over the Snowy Mountains is largely associated with moist westerly weather systems. As these systems approach the mountains, the air mass is lifted and condenses further to form orographically enhanced clouds – clouds formed by wind movement up the side of the mountain. These clouds are composed of tiny water droplets.

Under certain conditions the water droplets in the cloud (that would otherwise form snowflakes), remain in liquid form, even at temperatures well below zero degrees Celsius. Water in this form is known as ***super cooled liquid water***. To fall out of the clouds as snow, the super cooled liquid water droplets need to form ice crystals. This naturally occurs through interaction with tiny airborne particles (like dust or other ice crystals), or when cloud temperatures are very cold, for example at least minus 30°C. If there are not enough of these particles, or the temperatures are not cold enough, then not all the super cooled liquid water droplets are converted into ice crystals to form snow flakes.

These systems can be described as naturally inefficient. Under normal circumstances (that is, if left unseeded), these clouds pass across the mountain range and the moisture in them evaporates as the clouds descend on the leeward side of the mountain. The result is the well understood, naturally occurring phenomena known as a rain shadow.

The predominant weather systems that bring precipitation to the Monaro are those from the north, east or south. These systems are never seeded, and there are no cloud seeding generators in place which could operate under these wind directions. Figure 1 shows the area where the cloud seeding trial is conducted. It also shows storm tracks for the Snowy Mountains area.

To improve the precipitation efficiency of inefficient clouds coming from the west, additional particles can be introduced for the excess super cooled liquid water droplets to freeze onto, allowing ice crystals to form and grow, and fall to the ground as snow. This process is known as glaciogenic cloud seeding (Figure 2).

Silver iodide is used as the seeding material because it has physical properties very similar to natural ice crystals. The project uses ground based generators arranged along the western side of the mountains to disperse very small quantities of the silver iodide into winter storm clouds as they pass over the mountain range. These particles are invisible to the human eye – so small that more than 300 million particles would fit on the head of a pin. On average the amount of seeding material used each year across more than 2150 km^2 could be contained within an average domestic water bucket or kitchen tidy.

The infrastructure for the cloud seeding project includes:

- an extensive network of high resolution meteorological instruments (for monitoring weather conditions and recording meteorological data)
- a weather balloon launching facility near Khancoban
- two remote sensing facilities, with special instrumentation designed for measuring super cooled liquid water. These instruments identify and target inefficient systems for seeding, ensuring that efficient systems are left to snow naturally
- a total of 23 ground generator sites along the western side of the mountains.

The Snowy Hydro cloud seeding project is run very much like a medical trial where some patients randomly receive the active treatment and others a placebo. This method is used to avoid inadvertent bias. In the case of this project, some cloud seeding experiments are seeded, and others not. The present randomisation of seeding means that less 50% of the suitable weather systems are actually seeded.

The costs for the first six years of the project were more than $20 million. Just over $16 million was provided by Snowy Hydro. Early promising results were sufficient for the Federal Government to also provide $4 million funding.

Environmental management & care

Snowy Hydro implemented a comprehensive Environmental Management Plan (EMP) for the cloud seeding project. The plan was developed in collaboration with experts from the NSW Department of Environment, Climate Change and Water (DECCW) and in consultation with the NSW Natural Resources Commission (NRC).

Impact of infrastructure

Audits of infrastructure by Snowy Hydro, DECCW and the NRC over the duration of the trial have not identified any significant adverse environmental impacts associated with the cloud seeding infrastructure installed in the mountains.

Impact of seeding agent

In addition to the seeding agent (silver iodide), an inert tracer agent indium (III) oxide is also released from each generator site. Snow samples are collected from the target area after cloud seeding experiments, and these are analysed to provide scientists with information on targeting and cloud seeding effectiveness.

A large number of soil, lake and stream sediments, moss, peat and water samples were collected prior to the commencement of the cloud seeding trial in 2004. Analysis of these samples confirmed silver and indium to be present in measureable – sometimes quite high – concentrations well before any cloud seeding operations took place.

More than 2000 environmental samples are collected each year to determine if concentrations of the seeder and tracer compounds are increasing above background levels, or approaching the relevant environmental guideline trigger values for investigation. Expert analysis of all of the monitoring data collected (2004–2009) shows average concentrations of silver and indium remain unchanged or very low compared to the relevant environmental guidelines.

All potable (drinking) water supplies within the cloud seeding target area are regularly tested, and show an average concentration of silver of one part per trillion (that is, one part in one million, million parts). Every single sample collected has been almost 100,000 times lower than the level specified in the National Health and Medical Research Centre Australian Drinking Water Guidelines. In comparison, commercial distilled water supplied from a local supermarket was found to have a concentration of around 40 parts per trillion of silver.

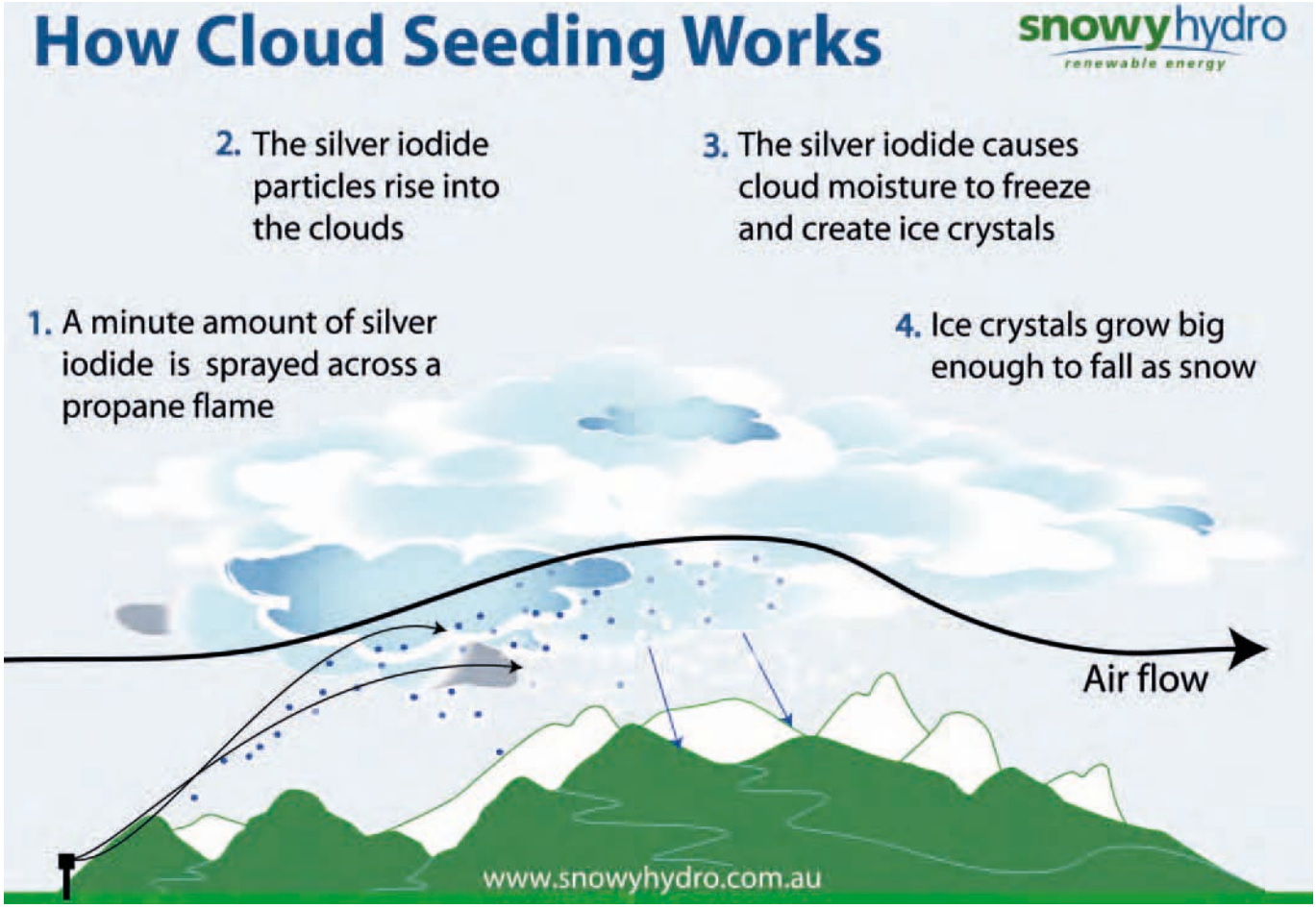

Figure 2. *The glaciogenic cloud seeding process introduces silver iodide particles into clouds bearing super cooled liquid water, to bring about precipitation that might not otherwise occur.*

Impact of precipitation

Monitoring of precipitation impacts includes assessments of both the aquatic and terrestrial environments. Data from these programs has shown no evidence of any significant adverse impact associated with cloud seeding activities.

Overall, and most importantly, the environmental investigations conducted over the last six years support the conclusion of the Expert Panel, providing compelling evidence that cloud seeding has not had, and is unlikely to have, a significant adverse environmental impact.

More or less rain downwind?

From time to time, questions are raised by some stakeholders to the east of the Snowy Mountains as to whether the seeding is adversely impacting on rainfall downwind of the project. Their concerns are based on the idea that increasing precipitation in one area can only be done at the expense of a decrease in precipitation in another area.

While the Expert Panel concluded there would be no adverse impact, the evaluation plan for the project included a scientific assessment of potential downwind effects to confirm this opinion. The independent evaluation of the cloud seeding project and case studies reported to the NSW Government included an assessment of precipitation from gauges in downwind areas including Cooma, Berridale, Dalgety, Popong, Bombala, Bega and Braidwood. The assessment found no evidence of any impacts – positive or negative – downwind of the target area.

It is worth noting that some projects around the world have reported marginal increases in precipitation downwind of the cloud seeding target area.

Where to from here?

The Snowy Hydro cloud seeding project set out to answer the question: "Can cloud seeding can be used to increase snow falls, at reasonable cost and without any significant adverse effects on the environment or downwind of the target area?"

The independent analysis shows where the overall target was effectively covered and *"applied to the overall target area the precipitation increase is 14% at the 3% significance level"*. In other words, there was only a 3% probability that the outcome could have resulted from chance alone. The evaluation also showed no evidence of any downwind effects.

Two independent peer reviews of the evaluation noted that the trial was *"well designed"* and *"particularly well executed"*, and most importantly that *"...the evaluation can be accepted with confidence"*.

Environmental monitoring over the six years of the trial has shown no evidence of any significant adverse environmental impacts.

This question asked above has been answered in the affirmative, and transition from a trial to an ongoing operation is now an urgent priority. This would mean that all suitable cold fronts would be seeded, delivering further benefit to stakeholders.

Snowy Hydro has formally requested that the NSW Government now make the necessary arrangements for a continuing cloud seeding operation. The NSW Government is currently considering the request, and the active support of stakeholders at this time is important and will affect the future of the program.

Further information

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More than 2000 samples of snow, soil and water are collected each year to measure concentrations of the seeder and tracer agents in terrestrial and aquatic environments. Six years of data provides compelling evidence that cloud seeding has not had any significant adverse environmental impact.