7 September 2016

Rosalie Woodruff MP
7 Franklin Wharf
HOBART
TAS 7000

By email: rosalie.woodruff@parliament.tas.gov.au

Dear Ms Woodruff,

Right to Information Request 10 August 2016

I refer to your request pursuant to the *Right to Information Act 2009* (RTI Act) received on 10 August 2016 by Hydro Tasmania.

I am authorised to make decisions on behalf of Hydro Tasmania in respect of applications for information under the RTI Act.

1. Your Request
Your request was for:

Part 1 "All correspondence between Hydro Tasmania and the Minister for Energy's office relating to the cloud seeding that took place on 5th June 2016."

Part 2 "The date and time that the report, titled "Cloud seeding flight of 5 June 2016, Background and Event Final Report" was first provided to the office of the Minister for Energy."

Part 3 "All dates of the Final Report previously listed on its cover page, including on previous versions, into the cloud seeding flight of 5th June 2016."

Hereafter referred to as "the Request".

2. Determination and Reasons for Determination of the Request
I have undertaken a search of the information held by Hydro Tasmania to locate any records that may be relevant to the Request and have determined as follows.

2.1 Information relevant to the Request Part 1
In response to part one of the Request, I have determined that the information provided in the following Annexures is relevant:

Annexure A - pages 1 to 15
Annexure B - pages 1 to 15

2.2 Information relevant to the Request Part 2

In response to part two of the Request, I have determined that the following is information is relevant:

The report titled "Cloud seeding flight of 5 June 2016, Background and Event Final Report" was first provided to the office of the Minister for Energy at 3:27pm on Friday 29 July 2016, and the final version with minor amendments (personal information on the cover page removed) was provided at 4:16pm on 29 July 2016.

2.3 Information relevant to the Request Part 3

In response to part three of the Request, I have determined that the following information is information is relevant:

The dates of the drafts of the Final Report were 26 July 2016, 27 July 2016, and 28 July 2016, with the final report on 29 July 2016.

3. Information withheld

The RTI Act provides that some information in our possession is exempt from release for the reasons stated below.

3.1 Relevant sections of RTI Act

Communications between Hydro Tasmania and its legal representatives and materials produced by or on behalf of Hydro Tasmania at the request of Hydro Tasmania's legal representatives is exempt information under Section 31 (Legal Professional Privilege) of the RTI Act, and has not been included in the disclosed information. It is also not subject to the Public Interest Test.

I have also assessed the identified Information in accordance with the RTI Act and I regard the following exemptions as also being relevant:

(a) Section 35(1) (Internal deliberative information); and

(b) Section 36(1) (Personal information of a person).

As required under Section 33 of the RTI Act, I have considered the Public Interest Test assessment criteria under Schedule 1 to the RTI Act in regards to the information ultimately withheld pursuant to sections 35 or 36 and have determined that it was not in the public interest as a whole to disclose the withheld information.

The reasons for the determination are:

- that the release of the information would not contribute to the debate on the matter
- the information would not inform the request about the reasons for a decision
- the disclosure would prejudice the ability of Hydro Tasmania to obtain similar information in the future
- the disclosure would not provide the contextual information to aid in the understanding of Hydro Tasmania's decisions
- disclosure would promote or harm the interests of an individual or group of individuals
- disclosure may harm the business and/or the financial interests of Hydro Tasmania

The other public interest matters set out in Schedule 1 of the RTI Act are considered to not be relevant to the Request.

A copy of this determination will be placed on the Hydro Tasmania website for public information.

Please also see RTI request determinations, including "Information relating to the cloud seeding operation on 5th June 2016", on our website at

http://www.hydro.com.au/about-us/governance/right-information-request-process/right-information-disclosures

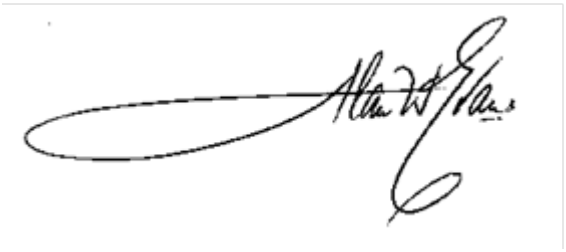
4. Review of Rights

You have a right to seek an internal review of my decision pursuant to section 43 of the RTI Act. If you would like to request such a review, you may write to Hydro Tasmania's Chief Executive Officer within twenty (20) working days from the date of this letter at:

Mr S Davy
Chief Executive Officer
Hydro Tasmania
4 Elizabeth Street
HOBART TAS 7000

This request is now considered closed.

Yours sincerely



Alan W. Evans
Right to Information Officer & Corporation Secretary
Hydro Tasmania
t 03 6230 5300
e alan.evans@hydro.com.au
f 03 6231 4217

Annexure A

Names have been removed under Section 36 of the RTI Act 2009

[redacted]

From: [redacted](DPaC) <[redacted]@dpac.tas.gov.au>
Sent: Friday, 29 July 2016 4:05 PM
To: [redacted](DPaC)
Cc: [redacted]
Subject: RE: [redacted]Analysis shows no impact from cloud seeding flight FINAL.docx

Hi [redacted]

Media release is right to go and we are comfortable for Hydro to release the report at the same time as the media release goes out.

Thanks

[redacted]

From: [redacted] [mailto:[redacted]@hydro.com.au]
Sent: Friday, 29 July 2016 3:01 PM
To: [redacted](DPaC)
Cc: [redacted]
Subject: [redacted]Analysis shows no impact from cloud seeding flight FINAL.docx

Hi [redacted]

Media release attached, report on its way.

Will not release the attached until you hold the report.

Cheers,
[redacted]

[redacted]

From: [redacted]@hydro.com.au>
Sent: Tuesday, 14 June 2016 9:30 AM
To: [redacted]
Subject: FW: ABC and cloud seeding

fyi

From: [redacted]
Sent: Tuesday, 14 June 2016 9:14 AM
To: [redacted]@dpac.tas.gov.au
Subject: ABC and cloud seeding

[redacted]

FYI. ABC Launceston ran this story this morning.

It is wrong. He said no such thing and the ABC has admitted it is wrong and will run a correction.

The ABC found the mistake themselves last night and pulled the story from Southern news bulletins but forgot to do the same up North.

I rang them this morning and they apologised and agreed to run a correction which I am now now doing!

[redacted]

Hydro Tasmania has all but admitted its cloud seeding program add...

14 Jun 2016 7:34AM • ABC Northern Tasmania, Launceston (07:30 News) hosted by Newsreader

Hydro Tasmania has all but admitted its cloud seeding program added to the raging water levels in the Ouse River last week. An 81yo man from Ouse was swept away by flood waters. Trevor Foster hasn't been seen since. Steve Davy, CEO, Hydro Tasmania, says cloud seeding above the Derwent catchment, two days before the flood, contributed to the extra water into the river.

Brief: Hydro Tasmania - Radio & TV • ASR: n/a • Duration: 0 mins 42 secs • Market: TAS • Country: Australia • Item ID: X00066354396

Interviewees: Steve Davy, CEO, Hydro Tasmania

Audience: N/A (all people)

Demographics: N/A (male 16+) • N/A (female 16+)

[redacted] | [redacted]

Hydro Tasmania
The power of natural thinking

[redacted]
e [redacted]@hydro.com.au
w www.hydro.com.au
GPO Box 355
4 Elizabeth Street, Hobart TAS 7000

[redacted]

From: [redacted](DPaC) <[redacted]@dpac.tas.gov.au>
Sent: Thursday, 21 July 2016 1:51 PM
To: [redacted]
Subject: Fwd: RE:

FYI

Sent from my iPhone

Begin forwarded message:

> **From:** "[redacted](DPaC)" <[redacted]@dpac.tas.gov.au>
> **Date:** 21 July 2016 at 1:44:28 PM AEST
> **To:** "[redacted](DPaC)" <[redacted]@dpac.tas.gov.au>, "[redacted](DPIPWE)" <[redacted]@dpipwe.tas.gov.au>
> **Subject: RE:**
>
> I also spoke to the CEO. They are taking it to their Board next week and then we should have it late next week.
>
> -----Original Message-----
> From: [redacted](DPaC)
> Sent: Thursday, 21 July 2016 1:32 PM
> To: [redacted](DPIPWE)
> Cc: [redacted](DPaC)
> Subject: Re:
>
> Thanks [redacted]
>
> Checked today and hydro are still undertaking a detailed review into the event and operation overall.
>
> Cheers
>
> [redacted]
>
> Sent from my iPhone
>
> On 21 Jul 2016, at 1:27 PM, [redacted](DPIPWE) <[redacted]@dpipwe.tas.gov.au> wrote:
>
> > FYI - media have just approached Minister asking for update on cloud seeding We have declined to answer any questions but Minister asked me to let you know
> >
> > Sent from my iPhone

[redacted]

[redacted]

Attachments: Brief for Minister Groom cloud seeding report 29 July 2016.docx; Cloud Seeding Final Report to Minister - 29 July 2016.pdf

---

From: [redacted]
Sent: Friday, 29 July 2016 3:27 PM
To: [redacted] (DPaC); [redacted]@dpac.tas.gov.au)
Cc: [redacted]
Subject: cloud seeding report

Hi [redacted]

Please find attached the cloud seeding report as promised.

Cheers

[redacted]

Hydro Tasmania
The power of natural thinking

HYDRO TASMANIA

Dept. Ref _____

Critical Date _____

APPROVED/NOT APPROVED/NOTED
SIGNED: _____
DATE:

Minute to the Minister for Energy

SUBJECT: REPORT OF CLOUD SEEDING FLIGHT OF 5 JUNE 2016

Minister's notation:

Purpose:

To provide the Minister with a copy of a final Hydro Tasmania report for the purpose of advising the Minister of the background to, and impact of, the cloud seeding flight undertaken on Sunday 5 June 2016.

Recommendation:

That you note the information attached to this briefing note and provide comments (if any).

Summary:

- Hydro Tasmania conducted a cloud seeding flight on Sunday 5 June 2016 with the intent of enhancing rainfall in the hydro storages in the Upper Derwent catchment (including Lake Echo). Had the seeding flight been successful it was possible there would also have been an effect in the Great Lake catchment, Arthurs Lake and Woods Lake.
- This flight occurred at a similar time to unprecedented rainfall that subsequently caused significant flooding in northern Tasmania.
- The cloud seeding operation took account of current flood warnings and the Bureau of Meteorology's forecasts. There were no flood warnings in effect for the Upper Derwent or Great Lake catchments at the time of the flight.
- There have been community concerns expressed that the cloud seeding flight may have contributed to the flood events experienced in northern river catchments.
- In response, the Government requested Hydro Tasmania provide it with a report.
- A draft Hydro Tasmania report was provided on 4 July 2016.
- A final Hydro Tasmania report is attached to this brief.

- Analysis of all available information concerning the cloud seeding operation has determined that the operation had no measurable impact on rainfall on 5 June 2016 because the cloud that was seeded already contained significant ice and was already precipitating freely.

29 July 2016

Prepared by:	[redacted]	Cleared by:	[redacted]
Position:		Position:	
Email:	[redacted]@hydro.com.au	Email:	[redacted]@hydro.com.au
Phone:	[redacted]	Phone:	[redacted]

Hydro Tasmania

The power of natural thinking

Cloud seeding flight of 5 June 2016

Background and event final report

29 July 2016

Contents

[redacted]

Hydro Tasmania
The power of natural thinking

Statement of Purpose

This report has been prepared by Hydro Tasmania for the purpose of advising the Minister for Energy of the background to, and impact of, the cloud seeding flight that Hydro Tasmania undertook on 5 June 2016.

Executive Summary

Between 5 to 9 June 2016, Tasmania was affected by an extreme weather event that caused major flooding in Tasmania, including in the South Esk, Ouse, Mersey and Forth rivers. Unprecedented rainfall occurred over a significant time and geographical area.

Between 10.57am and 12.31pm (1 hour and 34 minutes) on 5 June 2016, Hydro Tasmania conducted a cloud seeding operation over the Western Tiers, just north of Great Lake.

The operation was undertaken with the intent of enhancing rainfall into the Hydro storages in the Upper Derwent catchment (including Lake Echo). Had the seeding flight been successful it is possible there would also have been an effect in the Great Lake catchment, Arthurs Lake and Woods Lake. The operation took account of issued flood warnings and the Bureau of Meteorology forecasts.

The glaciogenic cloud seeding employed by Hydro Tasmania operates by introducing ice nuclei to clouds with high levels of super-cooled liquid water and low or no ice content, with the aim of converting the super-cooled liquid water droplets to ice, which will then fall as precipitation (rain or ice crystals).

Analysis of all available information concerning the cloud seeding operation has determined that the operation had no measurable impact on rainfall on 5 June 2016. The cloud that was seeded on 5 June 2016 already contained significant ice and was already precipitating freely, meaning that any seeding effort to initiate precipitation was redundant.

Background to Seeding Operation

Cloud seeding program at Hydro Tasmania

Hydro Tasmania has been involved with experimental and operational cloud seeding since 1964, and in its current format since 1999.

The program generally operates over the late autumn (May) to spring (end October) each year ("seeding season"), as this is considered to be the period when the most suitable conditions exist for effective cloud seeding.

The objective of the program is to enhance rainfall in hydro catchments.

Energy supply challenge

The sustained and record low inflows to hydro storages over the 2015-16 spring / summer

and the extended forced outage of Basslink that commenced on 20 December 2015 (and concluded on 13 June 2016) required a major response by Hydro Tasmania to ensure continuation of supply to the Tasmanian electricity system.

The primary response came through the Energy Supply Plan which involved maximising generation output from gas-fired turbines at the Tamar Valley Power Station, voluntary load reductions agreed commercially with major industrial customers and installing approximately 220 MW of temporary diesel generation.

An additional response by Hydro Tasmania was to commence the cloud seeding program on 1 April, a month earlier than planned.

Catchment targeting

Initially all hydro catchments were targeted at the commencement of the 2016 cloud seeding season, reflecting the low hydro storage position in early April.

On 12 May 2016, the hydro catchments of Upper Pieman and Mersey Forth were removed from the target list, due to the strong inflows to hydro storages, and spill occurring at a number of dams (including Lake Parangana on the Mersey River and Lake Paloona, Lake Gairdner, Lake Cethana and Lake Barrington on the Forth River).

At the start of June, the targets for cloud seeding, in order of priority, were identified as the Great Lake, Gordon, and Upper Derwent catchments

Flood warnings applicable to 5 June cloud seeding flight

During the morning of 5 June 2016 and prior to the cloud seeding flight, the following flood warnings had been issued by the Bureau of Meteorology (BoM) and were applicable for Hydro Tasmania's hydro catchments.

Table 1: Status of flood warnings issued prior to and applicable to the cloud seeding flight on 5 June

BoM warning	Time/date last issued	River	Hydro catchment
Moderate	6:45am, 5 June	Mersey River	Mersey-Forth
Moderate	6:54am, 5 June	South Esk River	South Esk
Minor	9:38am, 5 June	Meander River	South Esk
Minor	9:40am, 5 June	Forth River	Mersey-Forth
Moderate	9:54am, 5 June	South Esk River	South Esk
Moderate	10:03am, 5 June	Mersey River	Mersey-Forth
Minor	10:12am, 5 June	Macquarie River	South Esk

There were no flood warnings in effect for the Upper Derwent or Great Lake catchments at the time of the flight.

The seeding operation

The cloud seeding flight of 5 June 2016 took off from Hobart airport at 10:04am and flew

northwest to meet the strong north-easterly weather front that was coming down from the Australian continent. The Flight Log records that the Upper Derwent catchment was the primary target area. Had the seeding flight been successful it was possible there would also have been an effect in the Great Lake catchment, Arthurs Lake and Woods Lake.

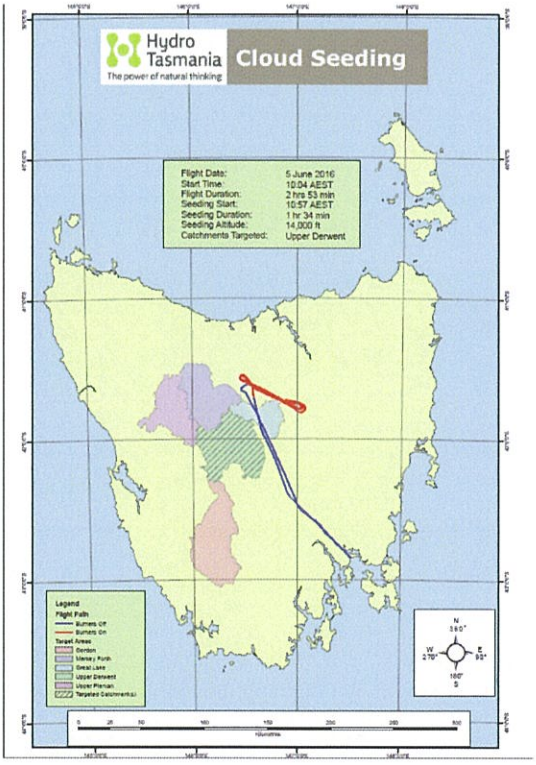
The Flight Log also records that at 10:33am the seeding track was drawn for the Upper Derwent, and located having regard to flood warnings on northern rivers.[1]

The assessment of the suitability of a cloud for seeding can only be undertaken when airborne, as vital parameters (such as supercooled liquid water content, wind speed and direction) must be measured on location, in cloud.

Cloud seeding began at 10:57am, in seeding conditions that were described on the Flight Log as "marginal" with "mixed-phase" clouds[2] and "generally low LWC"(meaning supercooled liquid water content), and continued for 1 hour and 34 minutes, to 12:31pm.

The flight then returned to Hobart airport at 12:57pm.

The flight and seeding track is shown in the figure below.



Hydro Tasmania's decision to undertake the 5 June 2016 cloud seeding flight had regard to water levels in key Hydro Tasmania storages, the forecast weather conditions on the day and the flood warnings issued by the Bureau of Meteorology.

[1] The cloud seeding track is set at least 30 minutes upwind of the desired target catchment, based on CSIRO studies in Tasmania that showed that it takes between 30 and 45 minutes from cloud seeding to precipitation reaching the ground (although a number of factors can affect this period).
[2] Containing a combination of ice and supercooled liquid water.

The flight was undertaken as part of Hydro Tasmania's usual practice of seeking to enhance rainfall during the seeding season and having regard to the need for storage recovery following drought and the then current Basslink outage.

The seeding track for the flight was set, taking account of issued flood warnings and the Bureau of Meteorology's forecast wind speeds, to avoid targeting areas subject to flood warnings and to be sufficiently upwind of the target area so that rainfall that might be initiated through seeding would reach the ground at the target.

The Impact of Seeding

Cloud seeding is a physical process which depends on the existence of particular cloud conditions.

Cloud seeding science

The theoretical development of precipitation in non-glaciated (i.e. no ice processes) clouds is well understood:

- Starting with small liquid droplets, the droplets will initially grow through condensation in a saturated environment.
- Once the droplets have grown to a size of roughly 20 microns (μm), the bigger ones will begin to fall relative to smaller droplets.
- Smaller droplets within the path of bigger droplets commonly become collected by the bigger droplets (collision and coalescence), which allows the bigger droplets to grow even more rapidly, fall more rapidly and collect even more smaller droplets.
- Once droplets reach 100 μm in size, they can be said to be precipitating.
- A positive chain reaction is set off that allows the big droplets to grow to sizes of at least 200 μm.

If a cloud consists of small supercooled liquid water droplets, the initial growth by condensation may be relatively slow. Clouds can persist in this state for long periods of time and may not develop to a stage of precipitation.

Glaciogenic cloud seeding is a process of introducing ice nuclei to clouds containing supercooled liquid water. Hydro Tasmania's cloud seeding program utilises an aircraft fitted with a specialised external burner that releases a vaporised silver iodide solution to create the ice nuclei.

In a suitable seeding environment, these ice nuclei will convert the supercooled liquid water into ice crystals. The ice crystals are able to grow efficiently through condensation (often at the expense of the supercooled liquid water). Once the ice crystals are big enough, they will fall relative to the supercooled liquid water droplets. Collision and coalescence will follow, similar to the process that occurs in non-glaciated clouds, and precipitation will follow.

If a cloud is readily precipitating (whether as liquid, ice or mixed phase), the collision and

collection process is already underway. Introducing further ice nuclei will not enhance this process.

Even if cloud seeding were to convert some smaller supercooled liquid water droplets into ice, they would still be quite small in comparison to the larger drops/ice crystals that are already present. These larger drops/crystals will continue to collect the smaller droplets/ice crystals, regardless of whether they have begun to aggregate around introduced ice nuclei or not.

Further information about the program, including the science and process of cloud seeding can be found on the Hydro Tasmania website - http://www.hydro.com.au/water/cloud-seeding

Post-flight data analysis

The cloud seeding operation had no measurable impact on rainfall on 5 June 2016 because the cloud was already heavily glaciated (i.e. ice) along the seeding track and precipitation was already present. Thus, adding further ice nuclei did not enhance this process.

Data was collected during the flight which has been subsequently analysed as part of this investigation.

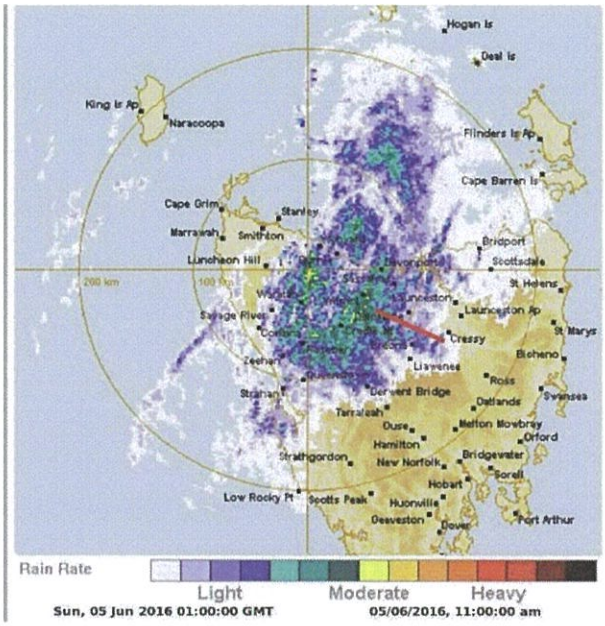
The average total water content (TWC) for the duration of the seeding was 0.39g/kg, and the average liquid water content (from the LWC083 probe) was 0.09 g/kg. On these figures, on average 86% of the total water content in the cloud during seeding was ice. These figures indicate that the seeded clouds were, on average, heavily glaciated (i.e. mostly ice). This is consistent with the airborne observations that the clouds had generally low supercooled liquid water content.

From the aircraft's Cloud Imaging Probe (CIP) of the Cloud Aerosol and Precipitation Spectrometer (CAPS), it is clear that rain-sized droplets and large ice particles were present along the seeding track. These airborne observations are consistent with pre-existing on-ground precipitation and the Bureau of Meteorology's (BoM) ground-based radar observations at West Takone, the Himawari-8 satellite imagery and the BoM's operational weather forecast.

As mentioned above, cloud seeding is intended to work on small supercooled liquid water droplets, generally of size 10 µm or less, whilst drops and crystals above ~100 µm radius are commonly classified to be already precipitating.

Images from the CIP show that large liquid drops and ice crystals (many in excess of 500 µm radius) were frequently observed over the course of the cloud seeding operation. The average effective radius of drops and/or crystals from the CIP probe was 247 µm, well above size for precipitation.

The BoM's radar image (below) from the West Takone site at the commencement of seeding, at 11 AM (local time) on 5 June (with the approximate position of the seeding track added in red) demonstrates that precipitation is evident across the track prior to the commencement of the seeding. This precipitation is completely natural and could not be caused by cloud seeding, as this image is taken at the time the seeding commenced.



Next steps

Late on the afternoon of 6 June 2016, all hydro catchments were removed from the target list due to the heavy rainfall and strong inflows being received into hydro catchments, and as a result of concerns regarding the cloud seeding flight undertaken on 5 June.

Having undertaken an initial review of the cloud seeding program, Hydro Tasmania has identified areas of the program and the procedures that we follow that require more detailed review and potential improvements, including in relation to seeding when there is a risk of floods. Hydro Tasmania's cloud seeding program remains on hold and will not resume until a full internal review of the program has been completed, any appropriate improvements have been implemented, and extensive stakeholder engagement has been undertaken.

It is not expected that cloud seeding will be undertaken again this season.

Annexure B
Names have been removed under Section 36 of the RTI Act 2009

[redacted]

From: [redacted]@hydro.com.au>
Sent: Friday, 29 July 2016 10:06 AM
To: [redacted] (DPaC); [redacted]
Subject: RE: HI

Ok. Just spoke to [redacted] about report. Am about to go into a meeting on same.

Will get back to you!

From: [redacted] (DPaC) [mailto:[redacted]@dpac.tas.gov.au]
Sent: Friday, 29 July 2016 10:04 AM
To: [redacted]
Subject: HI

Hi [redacted]

I am phone free today so if you need me please call on [redacted] or email and I'll get back to you ASAP.

How's cloud seeding report looking ?

[redacted]

[redacted]

Office of the Hon. Matthew Groom MP
Minister for State Growth
Minister for Energy
Minister for Environment, Parks and Heritage

Level 10, 15 Murray Street, Hobart, TAS 7000

Phone: [redacted]
Mobile: [redacted]
e-mail: [redacted]@dpac.tas.gov.au

[redacted]

From: [redacted]@hydro.com.au>
Sent: Friday, 29 July 2016 3:01 PM
To: [redacted] (DPaC)
Cc: [redacted]
Subject: [redacted] Analysis shows no impact from cloud seeding flight FINAL.docx
Attachments: [redacted] Analysis shows no impact from cloud seeding flight FINAL.docx

Hi [redacted]

Media release attached, report on its way.

Will not release the attached until you hold the report.

Cheers,
[redacted]

Analysis shows no impact from cloud seeding flight

Analysis of data from a cloud seeding flight undertaken on 5 June 2016 shows the operation had no measurable impact on rainfall on that day.

The June floods had a devastating impact. Hydro Tasmania extends its sympathies to all who have been affected. Hydro Tasmania understands community concern about the possibility that the 5 June flight may have contributed to the flood event.

A preliminary report on the flight was provided to the Tasmanian Government on 4 July and significant analysis has been undertaken since that time, resulting in a final report being delivered to government today.

Key points:

- Hydro Tasmania brought forward the start of its cloud seeding season this year as part of efforts to rebuild storages after an unprecedented dry Spring and Summer.
- The cloud seeding operation on 5 June took account of current flood warnings and the Bureau of Meteorology's forecasts.
- The operation was undertaken with the intent of enhancing rainfall into hydro storages in the Upper Derwent catchment (including Lake Echo). Had the seeding flight been successful it was possible there would also have been an effect in the Great Lake catchment, Arthurs Lake and Woods Lake.
- There were no flood warnings in place in the Upper Derwent or Great Lake catchments at the time of the flight.
- Cloud seeding began at 10:57am, in seeding conditions that were described on the Flight Log as "marginal", and continued for 1 hour and 34 minutes to 12:31pm.
- Post-flight analysis of data has demonstrated that the cloud seeding operation had no measurable effect on rainfall on 5 June because the cloud that was seeded already contained significant ice and was already precipitating freely.

The 5 June flight was undertaken both as part of Hydro Tasmania's usual practice of seeking to enhance rainfall and also having regard to the need for storage recovery following drought and the then current Basslink outage.

"Cloud seeding works by using silver iodide to introduce ice nuclei to clouds with high levels of super-cooled liquid water and low or no ice content," said Hydro Tasmania CEO, Steve Davy.

"The process aims to convert the super-cooled liquid water droplets to ice, which will then fall as precipitation – rainfall or ice crystals. If a cloud has high levels of ice content and is already readily precipitating, introducing further ice nuclei will not enhance this process."

Data collected by the aircraft's instruments and data obtained from the Bureau of Meteorology, and analysed post-flight, show the cloud that was seeded on 5 June 2016 already contained significant ice and was already precipitating freely, meaning that any seeding effort to initiate precipitation was redundant.

"We appreciate there has been a high level of community concern that we undertook a cloud seeding flight on that date," said Mr Davy.

"We will now review the cloud seeding program to make improvements in our processes, including in relation to seeding when there is a risk of floods, so that future decisions about cloud seeding are more in line with community expectations.

"Hydro Tasmania's cloud seeding program remains on hold and will not resume until a full internal review of the program has been completed and any appropriate improvements have been implemented.

"We will also be engaging with stakeholders prior to any resumption of the program."

Mr Davy said it is not expected that cloud seeding will be undertaken again this season.

"Given the unfortunate loss of life during the floods, we anticipate that there may be formal inquiries in the future in relation to the floods, including the cloud seeding flight, and we look forward to co-operating with any such processes and explaining our conclusions further at that point."

Ends.

[redacted]

From: [redacted]@hydro.com.au>
Sent: Friday, 29 July 2016 4:16 PM
To: [redacted](DPaC); [redacted]@dpac.tas.gov.au)
Cc: [redacted]
Subject: cloud seeding report final
Attachments: Cloud Seeding Final Report to Minister - 29 July 2016 clean.pdf

Thanks [redacted] for the heads up.

Final Report attached.

Cheers

[redacted]

Hydro Tasmania

The power of natural thinking

Cloud seeding flight of 5 June 2016

Background and event final report

29 July 2016

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Hydro Tasmania
The power of natural thinking

Statement of Purpose

This report has been prepared by Hydro Tasmania for the purpose of advising the Minister for Energy of the background to, and impact of, the cloud seeding flight that Hydro Tasmania undertook on 5 June 2016.

Executive Summary

Between 5 to 9 June 2016, Tasmania was affected by an extreme weather event that caused major flooding in Tasmania, including in the South Esk, Ouse, Mersey and Forth rivers. Unprecedented rainfall occurred over a significant time and geographical area.

Between 10.57am and 12.31pm (1 hour and 34 minutes) on 5 June 2016, Hydro Tasmania conducted a cloud seeding operation over the Western Tiers, just north of Great Lake.

The operation was undertaken with the intent of enhancing rainfall into the Hydro storages in the Upper Derwent catchment (including Lake Echo). Had the seeding flight been successful it is possible there would also have been an effect in the Great Lake catchment, Arthurs Lake and Woods Lake. The operation took account of issued flood warnings and the Bureau of Meteorology forecasts.

The glaciogenic cloud seeding employed by Hydro Tasmania operates by introducing ice nuclei to clouds with high levels of super-cooled liquid water and low or no ice content, with the aim of converting the super-cooled liquid water droplets to ice, which will then fall as precipitation (rain or ice crystals).

Analysis of all available information concerning the cloud seeding operation has determined that the operation had no measurable impact on rainfall on 5 June 2016. The cloud that was seeded on 5 June 2016 already contained significant ice and was already precipitating freely, meaning that any seeding effort to initiate precipitation was redundant.

Background to Seeding Operation

Cloud seeding program at Hydro Tasmania

Hydro Tasmania has been involved with experimental and operational cloud seeding since 1964, and in its current format since 1999.

The program generally operates over the late autumn (May) to spring (end October) each year ("seeding season"), as this is considered to be the period when the most suitable conditions exist for effective cloud seeding.

The objective of the program is to enhance rainfall in hydro catchments.

Energy supply challenge

The sustained and record low inflows to hydro storages over the 2015-16 spring / summer

and the extended forced outage of Basslink that commenced on 20 December 2015 (and concluded on 13 June 2016) required a major response by Hydro Tasmania to ensure continuation of supply to the Tasmanian electricity system.

The primary response came through the Energy Supply Plan which involved maximising generation output from gas-fired turbines at the Tamar Valley Power Station, voluntary load reductions agreed commercially with major industrial customers and installing approximately 220 MW of temporary diesel generation.

An additional response by Hydro Tasmania was to commence the cloud seeding program on 1 April, a month earlier than planned.

Catchment targeting

Initially all hydro catchments were targeted at the commencement of the 2016 cloud seeding season, reflecting the low hydro storage position in early April.

On 12 May 2016, the hydro catchments of Upper Pieman and Mersey Forth were removed from the target list, due to the strong inflows to hydro storages, and spill occurring at a number of dams (including Lake Parangana on the Mersey River and Lake Paloona, Lake Gairdner, Lake Cethana and Lake Barrington on the Forth River).

At the start of June, the targets for cloud seeding, in order of priority, were identified as the Great Lake, Gordon, and Upper Derwent catchments

Flood warnings applicable to 5 June cloud seeding flight

During the morning of 5 June 2016 and prior to the cloud seeding flight, the following flood warnings had been issued by the Bureau of Meteorology (BoM) and were applicable for Hydro Tasmania's hydro catchments.

Table 1: Status of flood warnings issued prior to and applicable to the cloud seeding flight on 5 June

BoM warning	Time/date last issued	River	Hydro catchment
Moderate	6:45am, 5 June	Mersey River	Mersey-Forth
Moderate	6:54am, 5 June	South Esk River	South Esk
Minor	9:38am, 5 June	Meander River	South Esk
Minor	9:40am, 5 June	Forth River	Mersey-Forth
Moderate	9:54am, 5 June	South Esk River	South Esk
Moderate	10:03am, 5 June	Mersey River	Mersey-Forth
Minor	10:12am, 5 June	Macquarie River	South Esk

There were no flood warnings in effect for the Upper Derwent or Great Lake catchments at the time of the flight.

The seeding operation

The cloud seeding flight of 5 June 2016 took off from Hobart airport at 10:04am and flew northwest to meet the strong north-easterly weather front that was coming down from the Australian continent. The Flight Log records that the Upper Derwent catchment was the primary target area. Had the seeding flight been successful it was possible there would also have been an effect in the Great Lake catchment, Arthurs Lake and Woods Lake.

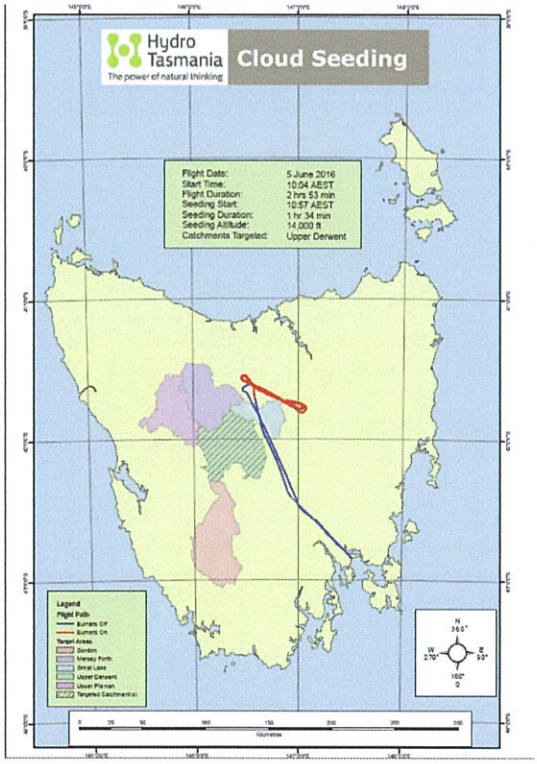
The Flight Log also records that at 10:33am the seeding track was drawn for the Upper Derwent, and located having regard to flood warnings on northern rivers.[1]

The assessment of the suitability of a cloud for seeding can only be undertaken when airborne, as vital parameters (such as supercooled liquid water content, wind speed and direction) must be measured on location, in cloud.

Cloud seeding began at 10:57am, in seeding conditions that were described on the Flight Log as "marginal" with "mixed-phase" clouds[2] and "generally low LWC"(meaning supercooled liquid water content), and continued for 1 hour and 34 minutes, to 12:31pm.

The flight then returned to Hobart airport at 12:57pm.

The flight and seeding track is shown in the figure below.



[1] The cloud seeding track is set at least 30 minutes upwind of the desired target catchment, based on CSIRO studies in Tasmania that showed that it takes between 30 and 45 minutes from cloud seeding to precipitation reaching the ground (although a number of factors can affect this period).
[2] Containing a combination of ice and supercooled liquid water.

Hydro Tasmania's decision to undertake the 5 June 2016 cloud seeding flight had regard to water levels in key Hydro Tasmania storages, the forecast weather conditions on the day and the flood warnings issued by the Bureau of Meteorology.

The flight was undertaken as part of Hydro Tasmania's usual practice of seeking to enhance rainfall during the seeding season and having regard to the need for storage recovery following drought and the then current Basslink outage.

The seeding track for the flight was set, taking account of issued flood warnings and the Bureau of Meteorology's forecast wind speeds, to avoid targeting areas subject to flood warnings and to be sufficiently upwind of the target area so that rainfall that might be initiated through seeding would reach the ground at the target.

The Impact of Seeding

Cloud seeding is a physical process which depends on the existence of particular cloud conditions.

Cloud seeding science

The theoretical development of precipitation in non-glaciated (i.e. no ice processes) clouds is well understood:

- Starting with small liquid droplets, the droplets will initially grow through condensation in a saturated environment.
- Once the droplets have grown to a size of roughly 20 microns (µm), the bigger ones will begin to fall relative to smaller droplets.
- Smaller droplets within the path of bigger droplets commonly become collected by the bigger droplets (collision and coalescence), which allows the bigger droplets to grow even more rapidly, fall more rapidly and collect even more smaller droplets.
- Once droplets reach 100 µm in size, they can be said to be precipitating.
- A positive chain reaction is set off that allows the big droplets to grow to sizes of at least 200 µm.

If a cloud consists of small supercooled liquid water droplets, the initial growth by condensation may be relatively slow. Clouds can persist in this state for long periods of time and may not develop to a stage of precipitation.

Glaciogenic cloud seeding is a process of introducing ice nuclei to clouds containing supercooled liquid water. Hydro Tasmania's cloud seeding program utilises an aircraft fitted with a specialised external burner that releases a vaporised silver iodide solution to create the ice nuclei.

In a suitable seeding environment, these ice nuclei will convert the supercooled liquid water into ice crystals. The ice crystals are able to grow efficiently through condensation (often at the expense of the supercooled liquid water). Once the ice crystals are big enough, they will

fall relative to the supercooled liquid water droplets. Collision and coalescence will follow, similar to the process that occurs in non-glaciated clouds, and precipitation will follow.

If a cloud is readily precipitating (whether as liquid, ice or mixed phase), the collision and collection process is already underway. Introducing further ice nuclei will not enhance this process.

Even if cloud seeding were to convert some smaller supercooled liquid water droplets into ice, they would still be quite small in comparison to the larger drops/ice crystals that are already present. These larger drops/crystals will continue to collect the smaller droplets/ice crystals, regardless of whether they have begun to aggregate around introduced ice nuclei or not.

Further information about the program, including the science and process of cloud seeding can be found on the Hydro Tasmania website - http://www.hydro.com.au/water/cloud-seeding

Post-flight data analysis

The cloud seeding operation had no measurable impact on rainfall on 5 June 2016 because the cloud was already heavily glaciated (i.e. ice) along the seeding track and precipitation was already present. Thus, adding further ice nuclei did not enhance this process.

Data was collected during the flight which has been subsequently analysed as part of this investigation.

The average total water content (TWC) for the duration of the seeding was 0.39g/kg, and the average liquid water content (from the LWC083 probe) was 0.09 g/kg. On these figures, on average 86% of the total water content in the cloud during seeding was ice. These figures indicate that the seeded clouds were, on average, heavily glaciated (i.e. mostly ice). This is consistent with the airborne observations that the clouds had generally low supercooled liquid water content.

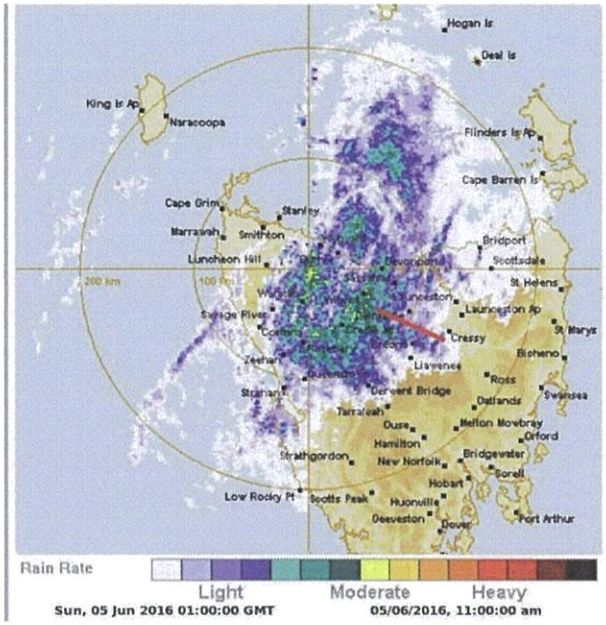
From the aircraft's Cloud Imaging Probe (CIP) of the Cloud Aerosol and Precipitation Spectrometer (CAPS), it is clear that rain-sized droplets and large ice particles were present along the seeding track. These airborne observations are consistent with pre-existing on-ground precipitation and the Bureau of Meteorology's (BoM) ground-based radar observations at West Takone, the Himawari-8 satellite imagery and the BoM's operational weather forecast.

As mentioned above, cloud seeding is intended to work on small supercooled liquid water droplets, generally of size 10 µm or less, whilst drops and crystals above ~100 µm radius are commonly classified to be already precipitating.

Images from the CIP show that large liquid drops and ice crystals (many in excess of 500 µm radius) were frequently observed over the course of the cloud seeding operation. The average effective radius of drops and/or crystals from the CIP probe was 247 µm, well above size for precipitation.

The BoM's radar image (below) from the West Takone site at the commencement of seeding, at 11 AM (local time) on 5 June (with the approximate position of the seeding track

added in red) demonstrates that precipitation is evident across the track prior to the commencement of the seeding. This precipitation is completely natural and could not be caused by cloud seeding, as this image is taken at the time the seeding commenced.



Next steps

Late on the afternoon of 6 June 2016, all hydro catchments were removed from the target list due to the heavy rainfall and strong inflows being received into hydro catchments, and as a result of concerns regarding the cloud seeding flight undertaken on 5 June.

Having undertaken an initial review of the cloud seeding program, Hydro Tasmania has identified areas of the program and the procedures that we follow that require more detailed review and potential improvements, including in relation to seeding when there is a risk of floods. Hydro Tasmania's cloud seeding program remains on hold and will not resume until a full internal review of the program has been completed, any appropriate improvements have been implemented, and extensive stakeholder engagement has been undertaken.

It is not expected that cloud seeding will be undertaken again this season.

[redacted]

From: [redacted]@hydro.com.au>
Sent: Tuesday, 5 July 2016 4:14 PM
To: [redacted] (DPaC) ([redacted]@dpac.tas.gov.au); [redacted] (DPaC)
Cc: [redacted]@dpac.tas.gov.au; [redacted] (DPaC) ([redacted]@dpac.tas.gov.au)
Subject: Cloud seeding

Importance: High

Hi [redacted] and [redacted]

As discussed with [redacted], below are lines approved by legal and A / CEO for release to Mercury.

Need to know you have released your lines first so that we are confirming (not announcing) that we have provided a report to govt.

Any idea when lines will go?

Note that [redacted] request to us was this:

> I'm doing an update on storage levels, which obviously continue to rise, I was hoping to get something from Hydro on what the rainfall outlook is like for the next couple of months, where storages are at and if there's a need for any more cloud seeding and if so when that may start again

Cheers,

[redacted]

At Monday 4 July total energy in storage was 29.7 per cent.

The Bureau of Meteorology's current Seasonal Outlook as at 30 June indicates a strong likelihood of a wetter than average July and a moderate chance of a wet August. The combined July-September outlook is for above average rainfall. The Bureau has also noted the start of a strong negative Indian Ocean Dipole (IOD) event, expected to persist through to September at least. The Bureau says that a negative IOD typically enhances rainfall over southern Australia during winter and spring. You can read more here:
http://www.bom.gov.au/climate/model-summary/#tabs=Indian-Ocean

Hydro Tasmania has provided a preliminary report to the Tasmanian Government on the cloud seeding flight undertaken on Sunday 5 June 2016.

Hydro Tasmania understands the community concerns about the possibility that this cloud seeding flight may have contributed to the recent flood event. We are aware of the devastating impact of the flooding and extend our sympathies to all who have been affected.

Hydro Tasmania is currently investigating what impact, if any, the cloud seeding flight may have had on the flood events of 5 June 2016. This analysis relies upon a range of data which is not normally collected in the routine course of cloud seeding flights and we are continuing to collect and analyse that information.

Hydro Tasmania's cloud seeding program remains on hold.

[redacted]

Hydro Tasmania
The power of natural thinking

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