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IDAHO PUBLIC  
UTILITIES COMMISSION

BEFORE THE IDAHO PUBLIC UTILITIES COMMISSION

IN THE MATTER OF THE )  
APPLICATION OF IDAHO POWER )  
COMPANY TO DEFER EXPENSES )  
ASSOCIATED WITH ITS CLOUD )  
SEEDING PROGRAM FOR INCLUSION )  
IN THE COMPANY'S PCA ON AN )  
ONGOING BASIS. )  
\_\_\_\_\_ )

CASE NO. IPC-E-05-36

IDAHO POWER COMPANY

DIRECT TESTIMONY

OF

GARY RILEY

October 2005

1 Q. Please state your name and business address.

2 A. My name is Gary Riley and my business address  
3 is 1221 West Idaho Street, Boise, Idaho.

4 Q. By whom are you employed and in what  
5 capacity?

6 A. I am employed by Idaho Power Company as  
7 Senior Meteorologist in the Water Management department.

8 Q. Please describe your educational background.

9 A. I attended the USAF Weather Observers School  
10 in 1965 and the Weather Forecasters School in 1970-71,  
11 graduating from both with honors. I received a Bachelor of  
12 Science Degree from Longwood College (now Longwood  
13 University) in 1981, graduating *Summa Cum Laude* with a major  
14 in physics and a minor in mathematics. I received a Master  
15 of Science degree in Atmospheric Science from the State  
16 University of New York at Albany in 1984.

17 Q. Please describe your work experience with  
18 Idaho Power Company.

19 A. I was hired by Idaho Power Company in June  
20 2002 to implement and run the Company's cloud seeding  
21 project on the Payette River Basin and to provide weather  
22 forecasting support tailored to the Company's needs and  
23 interests.

24 The cloud seeding project is designed to augment the  
25 wintertime snowpack in the Payette River Basin and thereby

1 increase spring and summer runoff through the Company's  
2 Hells Canyon Complex. The project became operational in  
3 late January of 2003, with the first seeding on February 1,  
4 2003. Operations ended for the season on April 15, 2003 and  
5 resumed between November 1, 2003 and April 21, 2004. The  
6 third season of seeding was operational between November 1,  
7 2004 and April 21, 2005.

8 Q. Please describe your experience in the field  
9 of weather modification.

10 A. Prior to joining Idaho Power, I was Vice  
11 President and Chief Scientist for Atmospherics Incorporated  
12 in Fresno, CA. Founded in the mid 1960s, Atmospherics is  
13 one of the oldest and most respected weather modification  
14 companies in the world. I first began working for  
15 Atmospherics in December 1991, and while there I supported,  
16 operated, and/or managed weather modification projects in  
17 California, Nevada, Colorado, and Texas. Internationally,  
18 projects were conducted in Spain, India, Indonesia, and  
19 Costa Rica.

20 From 1987 through early 1991, I was employed by  
21 Intera Technologies of Calgary, Alberta, Canada as a Senior  
22 Meteorologist and I was the Assistant Manager of the Greek  
23 National Hail Suppression Project.

24 Q. What is the purpose of your testimony in this  
25 proceeding?



1 available water into ice and finally, into snowfall. Cloud  
2 seeding to augment wintertime snowfall works by partially  
3 reducing the deficit by introducing more of these particles  
4 into the storm system.

5 Q. What factors are necessary for cloud seeding  
6 to be effective and provide the benefit of additional  
7 snowfall?

8 A. To be effective, three fundamental and  
9 necessary conditions need to exist in the airmass passing  
10 over the target area - in our case, the Payette River Basin.

11 First, the air must already be producing, or be  
12 about to produce, precipitation (this is snow *enhancement*,  
13 not snow *making*). Such a winter storm can produce a  
14 thermodynamic environment favorable for activation and  
15 transport of the seeding material into the part of the storm  
16 where the precipitation forms.

17 Second, the air must contain an appreciable amount  
18 of supercooled liquid water. Supercooled liquid water is  
19 simply water suspended in the air at temperatures below  
20 freezing, that is below 32 °F or 0 °C. Pure water can exist  
21 in the liquid state to temperatures as cold as -40 °C (or °F  
22 - they are the same at that temperature). This liquid water  
23 is converted, first to ice, and then to snow, by contact  
24 with a nucleating particle by processes called contact and  
25 condensation nucleation.

1           Third, and as is usually the case, there must be an  
2 insufficient number of naturally occurring ice nucleating  
3 particles to efficiently convert the available supercooled  
4 liquid water first into ice crystals and ultimately, into  
5 snowfall. These particles typically consist of dust,  
6 pollens, salts, and clays that have been picked up and  
7 transported into the cloud by the wind.

8           Q.       Given an environment where snow is falling  
9 and surplus supercooled liquid water exists, but there are  
10 insufficient ice nucleating particles, what can be done to  
11 produce additional snowfall?

12          A.       When there is more supercooled liquid water  
13 present than can be converted to ice by the available ice  
14 nucleating particles, the introduction of additional  
15 nucleating particles can convert some of the surplus  
16 moisture into ice crystals. These subsequently grow into  
17 snowflakes and fall to the ground.

18          Q.       What does Idaho Power Company utilize as ice  
19 nucleating material?

20          A.       The primary seeding material used by Idaho  
21 Power Company is silver iodide. It has been known since the  
22 later part of the 1940s that silver iodide acts as a very  
23 effective ice-nucleating particle at temperatures between  
24 about -4 °C and -15 °C. One gram of the material creates  
25 from  $10^{10}$  to  $10^{15}$  ice nuclei, depending on the temperature and

1 composition of the seeding agent. Our network of ground-  
2 based generators each release 20 grams per hour. Depending  
3 on the configuration and other constraints, the project  
4 aircraft can release from 151 to as much as 1500 grams per  
5 hour.

6 Q. Are you able to target where the additional  
7 snow will fall?

8 A. To place this additional snowfall in the  
9 proper place, the target area, requires a clear  
10 understanding of how, and how fast, the process works. For  
11 effective cloud seeding, accurate information about the  
12 temperature and moisture structure and about the wind flow  
13 into and across the target area is needed. The seeding  
14 material must be released so that there is the correct  
15 amount of time available for it to be transported into the  
16 portion of the storm having the proper temperature and  
17 humidity structure and where the factors mentioned earlier  
18 exist.

19 Q. How long does it take to form snow once the  
20 silver iodide has been introduced into the storm?

21 A. The typical timeframe required for the  
22 additional particles to be transported into a suitable  
23 environment, induce freezing and grow into snowflakes is on  
24 the order of twenty to forty minutes, but it can be as long  
25 as 100 minutes. The amount of time required can be

1 controlled to some extent by adjusting the formula of the  
2 seeding material. For the material IPCo uses, the silver  
3 iodide needs to be introduced into the storm system in a  
4 wind regime that will carry it into a zone of favorable  
5 temperatures and moisture and transport it into and across  
6 the target area in a time "window" of fifteen to forty  
7 minutes.

8 Q. How do you know that the snow on the ground  
9 is the result of cloud seeding efforts rather than snow that  
10 would have been present without cloud seeding?

11 A. Cloud seeding projects have, until recently,  
12 relied on statistical analysis of Target - Control, or  
13 seeded area vs. non-seeded area, data sets. Because the  
14 yield from any particular cloud seeding season lies well  
15 within the natural range of variability of precipitation, it  
16 can take many years to obtain statistically significant  
17 results and determine a reliable measure of success or  
18 failure. For that reason, many scientists and statisticians  
19 were reluctant to accept the results indicative of success.  
20 Nevertheless, this procedure is still commonly used.

21 In the last ten to fifteen years however,  
22 significant advances have been made in both our  
23 understanding of the physics involved and in our ability to  
24 confirm and evaluate results through trace chemistry  
25 investigations.



1           Because the materials used for cloud seeding are  
2 known, as is the time of their release, analysis of the  
3 snowpack itself provides information about where the seeding  
4 material fell, how much of the material went towards  
5 additional snowfall, and how much was simply scavenged, or  
6 swept out of the air, by precipitation already occurring.

7           The presence of enhanced silver in the target area  
8 snowpack indicates accurate targeting, but it says nothing  
9 about whether it was deposited in the form of additional  
10 snow or scavenged. Releasing an inert, non-nucleating  
11 tracer simultaneously with the active seeding agent makes it  
12 possible to determine if the source was additional  
13 precipitation or scavenging. That information, when  
14 combined with density variations within the snow samples,  
15 allows quantification of the amount of additional snow  
16 falling on the area.

17           Q.       Did Idaho Power Company take steps to measure  
18 the effect of its cloud seeding program using this new,  
19 sophisticated approach?

20           A.       Yes. Idaho Power contracted Desert Research  
21 Institute (DRI), an extension of the Community College of  
22 Nevada, to perform an analysis of snowpack samples from the  
23 Payette River Basin the past two winters. The tracer used  
24 was indium sesquioxide ( $In_2O_3$ ), whose particles are similar  
25 in size and dispersion characteristics to the nucleating

1 silver iodide (AgI). However, unlike the active material,  
2 the tracer is non-nucleating and is removed from the air  
3 only by scavenging. Therefore, any change in the ratio of  
4 silver to indium from what it was at the point and time of  
5 release gives a measure of how many of the silver particles  
6 went into making additional snow and how many were  
7 scavenged.

8 Q. Did Idaho Power measure the success of its  
9 cloud seeding efforts in the winter of 2002-2003?

10 A. Yes. The original project plan did not  
11 include an evaluation of benefit for the first season. The  
12 combination of start-up operations and a short operational  
13 season, only 2 ½ months, severely limited the amount of data  
14 available. However, two direct, and one indirect, analyses  
15 were conducted, and all produced similar results. All three  
16 of the analyses were independent. No Idaho Power Company  
17 personnel involved in seeding decisions took part in the  
18 evaluation.

19 Q. Please describe the two direct analyses of  
20 the cloud seeding effort during the winter of 2002 - 2003.

21 A. The first was by an Idaho Power employee not  
22 otherwise involved in the project. The second evaluation  
23 was done by an independent consultant (RHS Consulting of  
24 Reno, NV). A traditional Target - Control analysis,  
25 consisting of a linear regression of precipitation at sites

1 inside and outside of the target area indicated a 17%  
2 increase in precipitation during the 2 ½ month period  
3 between February 1 and April 15, 2003. That translates to  
4 2.4 inches of additional water when averaged over the  
5 Payette River Basin. Given a target area of approximately  
6 938 square miles, that works out to 120,000 acre-ft of  
7 water.

8 The precipitation data was also provided to RHS  
9 Consulting who determined that the project would likely have  
10 produced a 9% increase had it been operational for the  
11 entire winter. Using the quality controlled data available  
12 now that number rises to 11%

13 Q. Please describe the indirect evaluation of  
14 the cloud seeding effort during the winter of 2003 - 2003.

15 A. An indirect evaluation was provided by North  
16 American Weather Consultants of Sandy, UT. North American  
17 operates a snow enhancement project on the adjacent Boise  
18 River Basin for the Boise Project Board of Control. Their  
19 initial analysis of the Boise Basin 2002 - 2003 season data  
20 indicated a "no effect" result until it was realized that  
21 the "non-seeded" Control sites being used for the Boise  
22 project were seeded Target sites for Idaho Powers' Payette  
23 project. After developing a new set of unseeded Control  
24 sites, North American arrived at a 13% increase for the  
25 Boise project, and by inference, for Idaho Power's project

1 as well.

2 Q. Did Idaho Power measure the success of its  
3 cloud seeding efforts in the winter of 2003 - 2004?

4 A. Yes. Similar to the analysis done on the  
5 2002 - 2003 season, a Target - Control analysis indicated a  
6 6% increase in precipitation in the Payette River Basin for  
7 that season. This reduced yield - 6%, down from 17% - was  
8 expected because it was a dryer than normal year and the  
9 inclusion of the trace chemistry analysis mentioned earlier  
10 placed several constraints on operations. Still, even with  
11 only 80% of normal precipitation, the yield represents an  
12 additional 85,000 acre-ft of water.

13 Snow samples collected by DRI and analyzed in their  
14 ultra-clean laboratory in Reno showed very high levels of  
15 silver present and very little indium. Further, comparison  
16 of the depth at which the silver was found with data from  
17 nearby SNOTEL sites shows it to be consistent with seeded  
18 events. Degradation of the snowpack prior to sample  
19 collection prevented the laboratory from quantifying the  
20 yield in augmented precipitation, but the 2002 - 2003 data  
21 indicate scavenging was not a significant factor and Idaho  
22 Power has an effective project.

23 That conclusion is substantiated by the results of  
24 measurements made by an aircraft especially modified for  
25 airborne cloud physics data collection. Measurements were

1 made prior to, during, and after a seeding flight on March  
2 26, 2005. The data indicate water production from the  
3 aircraft alone to have been in excess of 600 acre feet per  
4 hour.

5 Q. What were the results of the cloud seeding  
6 program undertaken during the winter of 2004 - 2005?

7 A. This last season's SNOTEL data indicate a 26%  
8 increase in precipitation for the Payette River basin.  
9 While a percentage increase of that magnitude is possible,  
10 the number seems very high and should be viewed in the  
11 context of an ongoing effort to obtain a statistically  
12 significant evaluation of the cloud seeding project.  
13 However, the results from the second year of trace chemistry  
14 evaluation performed during the 2004-2005 season are very  
15 positive and similar to those of the preceding years and  
16 they are consistent with results obtained by other  
17 successful programs.

18 Samples collected by both DRI and RHS Consulting  
19 found positive evidence of an effective project. Using  
20 newly developed procedures and sampling equipment, DRI was  
21 able to correlate the silver, indium, and cesium in the snow  
22 with density gradients, allowing a quantitative estimate of  
23 augmentation. This makes it possible to distinguish between  
24 the seeding material released by the ground-based and  
25 airborne equipment and mathematically determine how much

1 additional snow fell on the sampling site. The data provide  
2 clear evidence of an effective program.

3 Q. Can you provide examples from this analysis  
4 to help the Commission understand how the silver and indium  
5 relate to each other and how they relate to seeded snowfall?

6 A. Yes. As an example, I would like to offer  
7 Exhibit 1. These figures were provided by Dr. Ross Edwards  
8 of DRI. The first shows the concentrations of silver and  
9 indium detected in a snow sample from the east side of the  
10 Payette River Basin target area. The sample was collected  
11 on Mount Zumwalt at an elevation of 8,225 feet. Note the  
12 different scales for silver (left side) and indium (right  
13 side). Three seeding events are depicted and the silver to  
14 indium ratios show that for every silver iodide particle  
15 scavenged, between 6 and 19 other silver iodide particles  
16 contributed to additional snowfall.

17 The second figure graphically shows enhanced levels  
18 of both cesium and silver in a sample collected in December  
19 of 2004. Recall that ground-based units release only silver  
20 iodide while the airborne generators released a solution  
21 that included the cesium tag. Superimposing these diagrams  
22 (third figure, prepared by IPCo for purposes of  
23 demonstration) allows one to distinguish between silver  
24 released by the aircraft and that released at ground level.

25 The fourth figure shows how the presence of enhanced

1 silver content that coincide with a layer of anomalous  
2 density can be evaluated for the amount of augmented snow in  
3 the sample. In the example shown, there is a 13% increase  
4 due to seeding. DRI found augmentation values ranging from  
5 13 to 34%, with a mean of 22%. Consequently, this is a  
6 conservative example. DRI concluded that the overall  
7 augmentation in the target area for this past season was  
8 between 7 and 9%.

9 Finally, the fifth figure shows where the samples  
10 were taken and gives an indication of how the degree of  
11 silver content departs from what would be expected in  
12 pristine snow. As noted by Dr. Edwards, this provides  
13 evidence of effective targeting of the watershed.

14 Q. Is DRI preparing a final report containing  
15 the analysis that supports your testimony?

16 A. Yes. The report is in the final stages of  
17 completion and will be filed with the Commission as  
18 Exhibit 4 to my testimony as soon as it is received from  
19 DRI.

20 Q. Were the results of your measurement of cloud  
21 seeding success consistent with those for other projects and  
22 entities?

23 A. Yes. The yields I have indicated, 6 to 17%,  
24 are within the range of expectations from wintertime  
25 orographic cloud seeding contained in statements from the

1 World Meteorological Organization, the American  
2 Meteorological Society, the American Society of Civil  
3 Engineers, the Weather Modification Association, and even  
4 the Idaho Department of Water Resources. All of these  
5 indicate cloud seeding to augment wintertime snowpack can  
6 produce increases of from 5 to 20% when done correctly.  
7 Both RHS Consulting and DRI have said the results of their  
8 trace chemistry evaluations are consistent with and similar  
9 to those from investigations of this type in California and  
10 Nevada and elsewhere. Two of the comparable projects in  
11 California are operated by power companies (Pacific Gas and  
12 Electric and Southern California Edison) for the same  
13 purpose as Idaho Power's program. The results of trace  
14 chemistry evaluations of the Lake Almanor project run by  
15 Pacific Gas and Electric and those from Southern California  
16 Edison's project on the San Joaquin River have appeared in  
17 peer reviewed publications of the American Meteorology  
18 Society and the North American Hydroelectric Industry.

19 Q. Can you provide one of these articles that is  
20 written in non-technical language that is easier to  
21 understand by someone not familiar with weather and cloud  
22 seeding?

23 A. Yes. I have here a copy of an article by  
24 Brian McGurty reporting on the results of the study on the  
25 San Joaquin River project that appeared in *Hydro Review*. I



1 think the Commission will find it very readable, and I offer  
2 it as Exhibit 2.

3 Q. Given a quantification of additional snow  
4 resulting from the Company's cloud seeding efforts, have you  
5 quantified how the additional snow translated into  
6 additional stream flows at the Company's hydro facilities  
7 over the past three winters?

8 A. Yes. The process is complex and requires a  
9 review of what was done in each of the three individual  
10 years to fully describe the process. First, the preliminary  
11 data from the 2002 - 2003 Target - Control evaluation was  
12 fed into the CHEOPS hydrological model to determine the  
13 generation potential of the augmented water when it passed  
14 through the Hells Canyon Complex. That allowed the  
15 determination of the benefit gained from the augmented water  
16 to be evaluated under several scenarios of seeding  
17 effectiveness and varying losses of the augmented water  
18 prior to reaching the Hells Canyon Complex. The model  
19 indicated increased generation capacities ranging from  
20 approximately 14,000 MWh if only 25% of the additional water  
21 reached the power plants to as much as 56,000 MWh if all of  
22 the water passed through the complex. These numbers would  
23 be expected to increase if the model was re-run with the  
24 quality controlled numbers available now.

25 The preliminary SNOTEL data from the 2003 - 2004

1 season was entered into the National Weather Service River  
2 Forecast System Model, and the inflow into the reservoirs on  
3 the Payette River was calculated for Seed and No-seed  
4 scenarios. The computer simulation determined that an  
5 additional 67,700 acre-ft of water flowed through the  
6 Payette drainage in the seeded scenario. That is in very  
7 good agreement with the 68,000 acre-ft determined from the  
8 Target - Control regression that was also based on the  
9 preliminary data. The difference is easily accounted for,  
10 in that the model takes losses to soil moisture and  
11 evaporation into effect and these factors are not included  
12 in the simpler regression analysis. Also, software  
13 limitations caused the input data to be cut off near the end  
14 of March. Consequently, precipitation after that was not  
15 included.

16 Q. Did you quantify the financial benefit of the  
17 additional stream flow at the Company's hydro facilities?

18 A. Yes. Along with the calculation of  
19 additional generation capacity, the CHEOPS data for the 2002  
20 - 2003 season places the dollar value of the water at \$ 1.5  
21 million if only 50% of the augmented water reaches Hells  
22 Canyon Complex. However, the Payette River Basin was chosen  
23 for the cloud seeding project in part, because the river's  
24 reservoirs have a high probability of refill. Hence, the  
25 actual value would be closer to the 100% expectation with a

1 value of \$2.1 million.

2 Using the yield from the quality controlled Target -  
3 Control data, 120,000 acre-ft of water, and the in-house  
4 rule that for every hour one acre foot of water passes  
5 through Hells Canyon Complex, 0.5 MW can be generated, the  
6 value can be readily estimated. Taking the average high  
7 (\$32.13/MWh), the average low (\$29.47/MWh), and the average  
8 average (\$30.47/MWh) price of power for the period May  
9 through August 2003 gives a comparable value between \$1.77  
10 and 1.93 million. For example, using the average price:  
11 120,000 acre-ft times 0.5 MWh/acre-ft times \$30.47/MWh  
12 indicates the water to be worth \$1.83 million for hydropower  
13 generation alone. This number does not consider any  
14 monetary value of ancillary benefits to the region in the  
15 form of improved water conditions for fish and wildlife,  
16 recreation and navigation, irrigation, or additional  
17 drinking water, although these benefits also exist.

18 With the above-described results in hand, the value  
19 of the 2003 - 2004 yield was estimated by taking the yield,  
20 85,000 acre-ft, and using the approach identified above.  
21 The generation potential from last season would be \$1.78  
22 million at an average price of \$41.76/MWh. (85,000 acre-ft  
23 times 0.5 MWh/acre-ft times \$41.76/MWh = \$1.77 million.)  
24 That value is obtained by using the average of the On Peak  
25 and Off Peak Mid-C prices for the period from 1 May through

1 31 August 2004. The value is closer to \$ 1.95 million if  
2 the higher Border prices are used.

3 Similarly, using the 7 to 9% yield determined by DRI  
4 for the 2004 - 2005 season and applying this same procedure  
5 at an average price of \$36.71: the yield for 2004-2005 is  
6 between 85,000 and 105,000 acre-ft of water, or between  
7 43,000 and 53,000 MWh of additional production. That would  
8 be worth \$1.5 to 1.9 million.

9 Both of the computer simulations reveal one  
10 additional benefit from cloud seeding. The flow in the  
11 Payette River is not only increased, the peak flow is  
12 shifted later into the year and higher flows are maintained  
13 longer. This means that more water will be available to the  
14 Hells Canyon Complex as heavier summertime loads begin to  
15 become a significant factor for operations.

16 Q. Can you provide an example of the computer  
17 model output that illustrates this later peak in streamflow  
18 and the enhanced flow duration?

19 A. Yes. Exhibit 3 was prepared using the model  
20 output and shows the peak flow is shifted from late May into  
21 June and that higher flow levels are maintained into early  
22 July. Note that the figure does not include data for all of  
23 July and August.

24 Q. Over the past three years, how have the  
25 financial benefits of cloud seeding compared to the costs of

1 cloud seeding?

2 A. The answer to this question will depend to  
3 some extent on the accounting period chosen. Because most  
4 of the activity associated with the project is based on the  
5 water year (October through the following September) rather  
6 than the calendar year, the accounting period was defined as  
7 July 1 through June 30.

8 The project expenses between July 1, 2002 and June  
9 30, 2003 were:

10	Capital:	\$ 23,723 and
11	O & M:	<u>\$ 802,348</u>
12	Total:	\$ 826,071.

13 The project yield, based on the average results  
14 already discussed was \$1.83 million. That gives a benefit  
15 to cost ratio of 2.2 to 1.

16 For the twelve month period of July 1, 2003 through  
17 June 30, 2004, the project incurred significant additional  
18 expenses in association with the trace chemistry evaluation.  
19 These included not only the direct costs of the evaluation  
20 in payments to DRI, but the added burden of building and  
21 maintaining seven additional ground-based generator units to  
22 release the tracer. Consequently, the expenses during this  
23 timeframe were:

24	Capital:	\$ 237,067 and
25	O & M:	<u>\$1,066,408</u>

