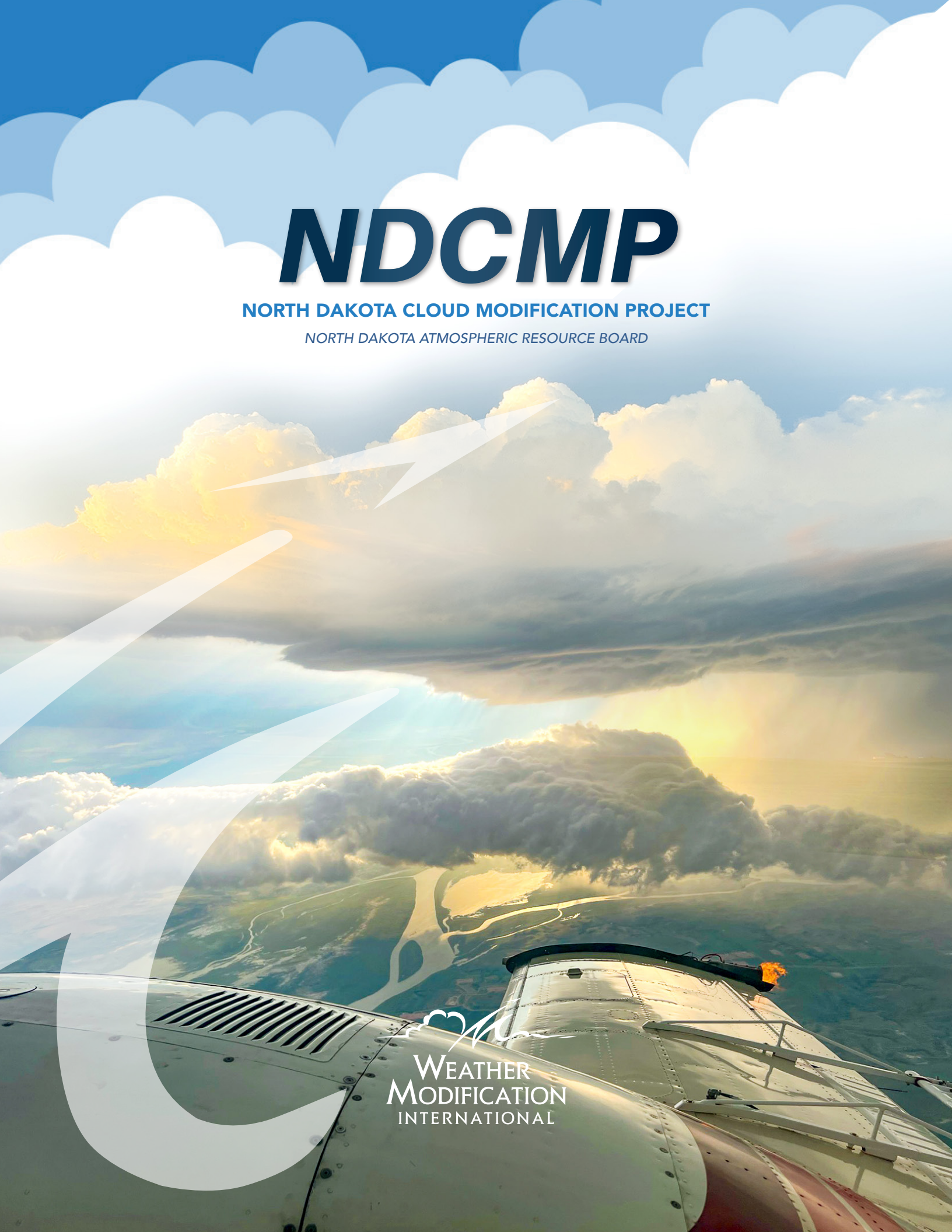
NDCMP

NORTH DAKOTA CLOUD MODIFICATION PROJECT

NORTH DAKOTA ATMOSPHERIC RESOURCE BOARD



NORTH DAKOTA CLOUD MODIFICATION PROJECT
2024 FINAL OPERATIONS REPORT

Report prepared for

NORTH Dakota Be Legendary. | Atmospheric Resource Board
WATER RESOURCES

State of North Dakota
Atmospheric Resource Board
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Cover Credit: Oakley Eagleson

EXECUTIVE SUMMARY

This report details the activities of Weather Modification International (WMI) during the 2024 North Dakota Cloud Modification Project (NDCMP) field operations. This was the 64th consecutive summer season of the NDCMP and the third of a three-year contract with WMI and the NDCMP. WMI provided five specially modified aircraft, cloud seeding equipment, pilots, aircraft maintenance, aircraft tracking and telemetry systems, intern co-pilot training, and communications equipment in the NDARB radar offices.

District I included Bowman County and southern Slope County (Hume, Carroll, Cash, Connor, Sheets, Mineral Springs, and Cedar Creek Townships). Two aircraft were based in Bowman, both capable of conducting cloud base-seeding operations (Piper Seneca II).

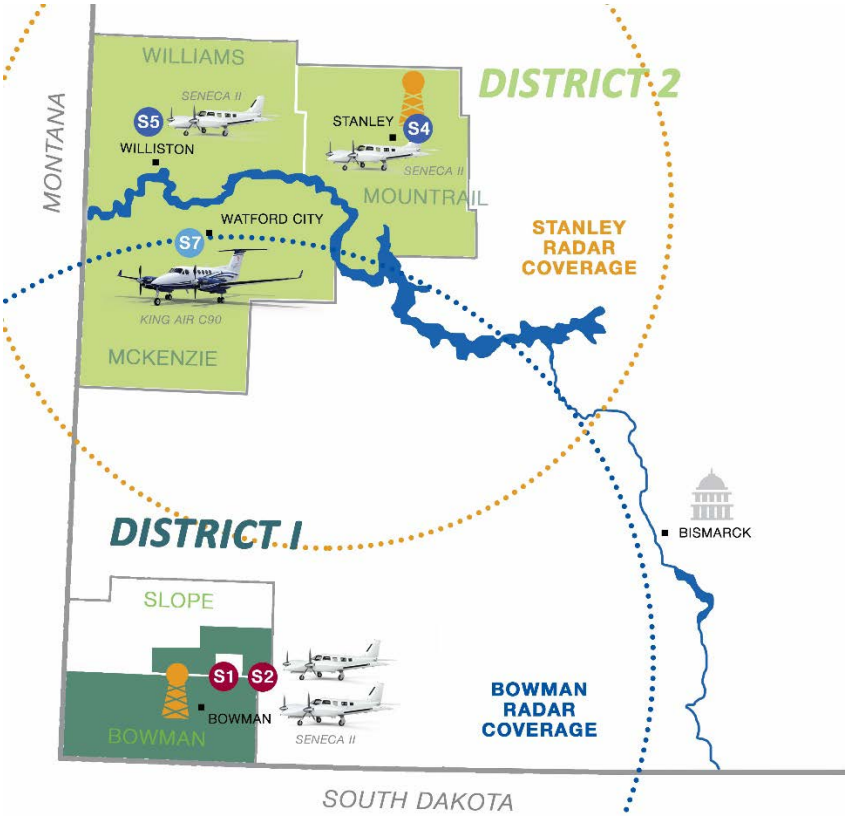

Fig. 1. NDCMP 2024 Operational Target Areas. The circles indicate approximate radar coverage from District I- Bowman (blue) and District II-Stanley (orange). Graphic by WMI.

District II operated in McKenzie, Mountrail, and Williams counties with three project aircraft. Two were equipped for base seeding operations (Piper Seneca II) and stationed in Stanley and Williston, respectively, with a top-seeding aircraft (Beechcraft King Air C90) based in Watford City.

Operations were conducted on a 24-hour per day, 7-day per week basis. The project period ran from 1 June 2024 through 31 August 2024 for District I and McKenzie County, and 1 June 2024 through 8 September 2024 for Mountrail and Williams Counties in District II. The five-project aircraft flew a total of 354.31 hours (including maintenance: 106.6 hours in District I and 240.53 hours in District II). A total of 318.18 pounds of dry ice pellets were dispensed during the 2024 season.

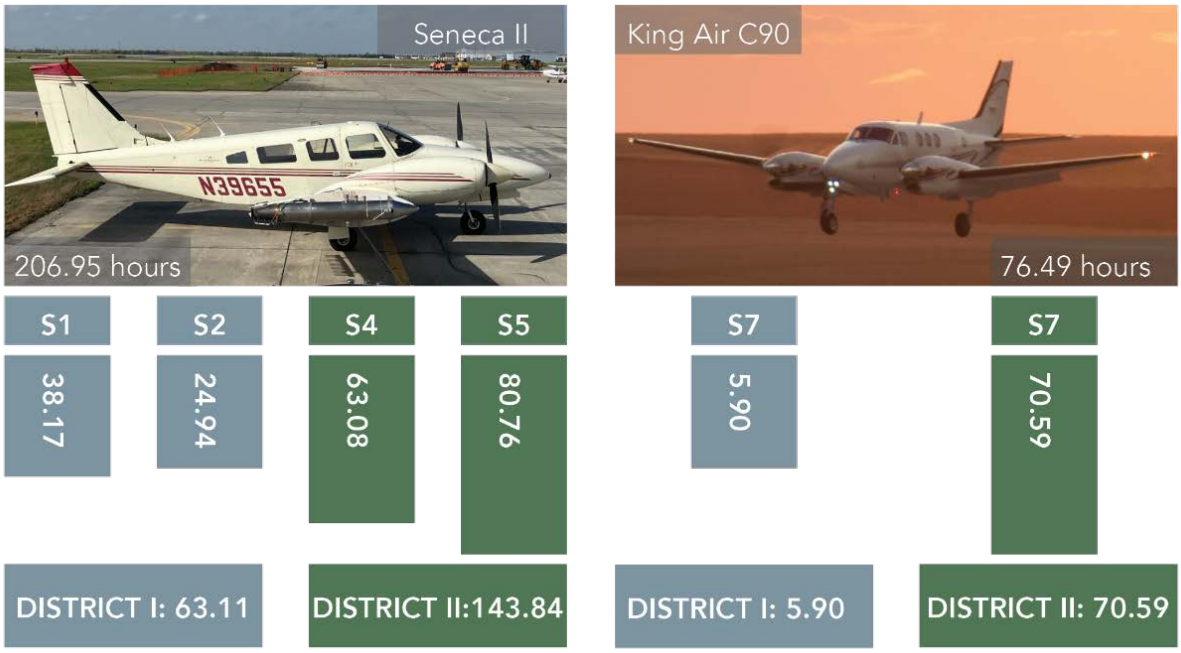

Fig. 2. 2024 NDCMP flight operations categorized by aircraft type, including the least to most flight hours by location. Seneca II photo by Alex Sailsbury and King Air photo by Ryan Starkey. Graphic by WMI.

Winter in North Dakota brought above average temperatures and below average precipitation for most of the state. This allowed existing severe drought conditions in northeastern North Dakota to persist, as well as abnormally dry to moderate drought conditions to build in across nearly the rest of the state. A small portion of west-central North Dakota was spared of drought conditions, including eastern McKenzie County.

Spring experienced above average precipitation for central and eastern portions of the state, and below average precipitation in the west. This helped to erase the drought in all areas except far western North Dakota. By the end of May, 19.77% of the state was under some kind of drought, with abnormally dry conditions persisting in western and northwestern portions of North Dakota, including McKenzie and Williams Counties, and the western half of Mountrail County. A moderate drought was in place in far southwestern North Dakota, including the western four-fifths of Bowman County and western one-third of Slope County.

Fig. 3. The above normal spring precipitation and cooler temperatures is evident in this grassy mid-June photo from the North Unit of Theodore Roosevelt National Park. Photo by Ben Schaefer.

June brought cooler than average temperatures for the state (especially in District 2), and above average precipitation, (near-average for both District I and II). By the end of June, the drought in western North Dakota had eroded slightly, with only 8.27% of the state experiencing some kind of drought. This was especially prevalent for District 2, as abnormally dry conditions were confined to the western borders of McKenzie and Williams Counties. In District 1, moderate drought conditions remained present to the same geographic extent as the end of May.

July ushered in warmer than average temperatures and below average precipitation for the state. This was especially true for western North Dakota, including both districts. Due to below average rainfall, drought conditions increased slightly. By the end of July, 12.96% of the state was experiencing some kind of drought.

August witnessed average precipitation and slightly below average temperatures for the state. However, precipitation varied greatly throughout the state. Central and eastern North Dakota experienced most of the precipitation, while western North Dakota, especially District 2, experienced below average rainfall. The lack of rainfall in the west increased local drought conditions. By the end of August, 35.78% of the state was experiencing some kind of drought conditions, and 4.48% under a severe drought. In District 1, abnormally dry to moderate drought conditions remained, with all of Bowman County and western Slope County in moderate drought conditions. In District 2, abnormally dry to severe drought conditions developed, increasing with westward extent. Eastern Mountrail and McKenzie Counties saw abnormally dry conditions, while western Williams and McKenzie Counties were under severe drought conditions. In District 2, Williams and Mountrail

Counties elected to extend hail suppression operations through 8 September 2024. The month remained dry with above average temperatures.

By the end of September, the drought had increased further. 52.11% of the state was under some kind of drought conditions, with abnormally dry conditions building across southern North Dakota. 3.39% of the state entered extreme drought conditions, including portions of both districts- central Bowman County, southern Slope County and northwestern Williams County.

The 2024 season ended with a total of 283.45 flight hours, considerably lower than many statistical averages, including the 25-year average of 532.24 hrs, 20-year average of 489.78 hrs, the 15-year average of 466.21 hrs, the 10-year average of 420.19 hrs. It is very close to the 5-year average of 317.07 hrs. A decrease in flight hours in the last five years can be partially attributed to the loss of Burke County in 2019, Ward County in 2020, and subsequent removal of the two Cessna 340s and one Seneca from the program between 2019-2021.

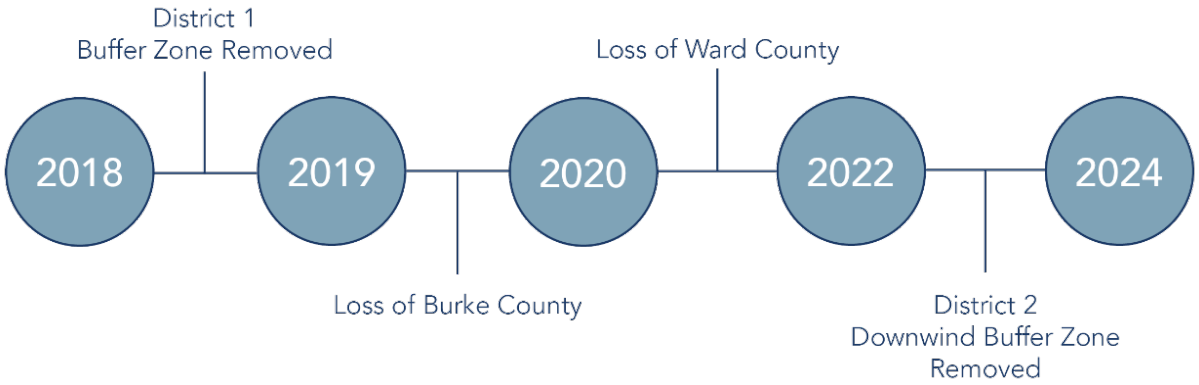

Fig. 4. NDCMP changes from 2014-2024 that have impacted the number of flight hours flown.

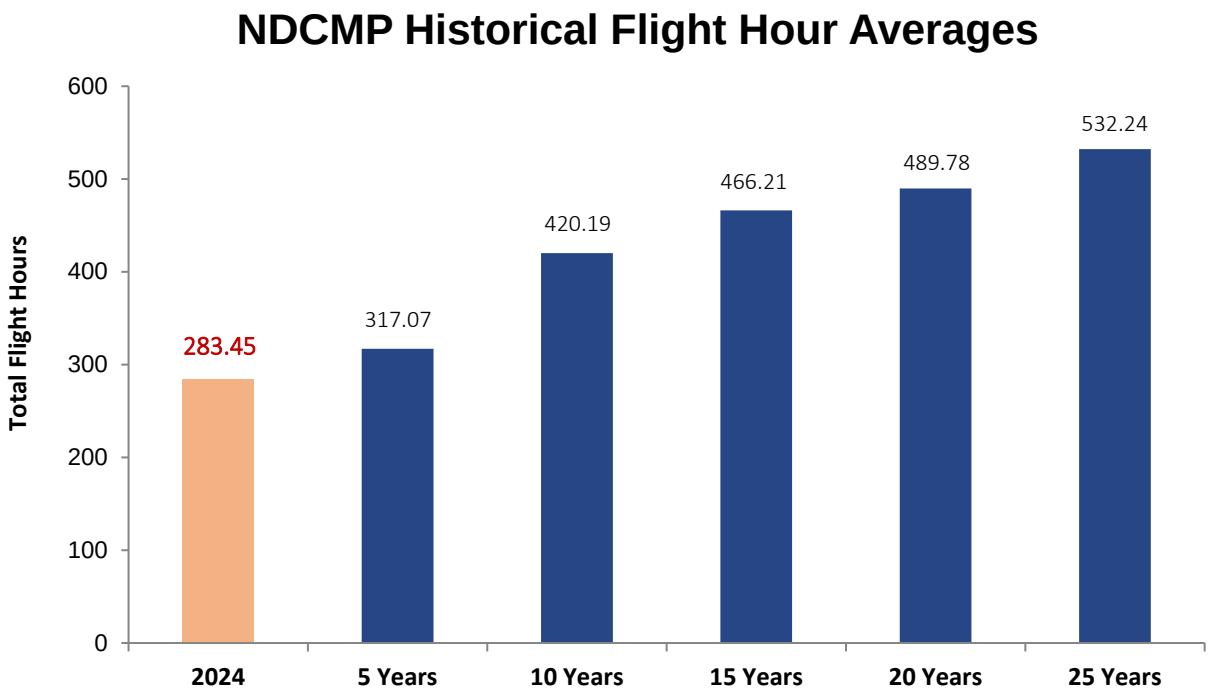

Fig. 5. Flight hour historical average displayed in 5-year increments starting in 1999 inclusive of 2024.

All counties within the project area conducted hail suppression and rain enhancement operations from 1 June 2024– 31 August 2024, with rain enhancement suspensions requested as needed by individual counties (see Table 5). Williams and Mountrail Counties in District II elected to extend the 2024 season by 8 days. The Williston and Stanley-based Senecas remained at their respective bases for the extension along with the King Air, in Watford City. No counties in District I elected to extend.

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1 INTRODUCTION

North Dakota farmers have historically faced above-average crop losses due to hail and drought; these challenges have contributed to reduced crop yields and farm incomes. This led to the search for ways to manage these conditions, which could consequently improve the average North Dakotan's quality of life. One promising new technology was the emerging science of weather modification. The first cloud seeding activities of record in North Dakota occurred in 1951, performed by farmers using ground-based generators.

In 1961, the founders of Weather Modification International began using aircraft for a program to suppress hail in an initial target area of 540 square miles, in the central area of what is now District I. This area has had an active program in some form each year since, apart from 1990 when District I did not participate in cloud seeding operations due to budget constraints.

Operations to the north (currently referred to as District II) started one year later and have remained active in various counties every year since. A third district, including Benson, Nelson, and Griggs Counties, operated from 1974 through the 1981 season. In the mid 1970's, there were as many as 17 counties in North Dakota participating in the cloud seeding program. The number has decreased due to various factors over the years, but currently there are 5 active counties in target areas that cover 8,370 square miles (or, almost 5.4 million acres) – almost 12% of the state's area.

In 1965 and 1969, legislation was passed in North Dakota enabling counties and townships to levy two mills for funding of cloud seeding projects. The source of funds was this 2-mill levy, by township elections under NDCC Chapter 58-03-07, or by voluntary funding. The Program was primarily implemented by emphasizing hail reduction. Rain enhancement operations provided added economic benefits to those counties which had an Authority. Counties or associations of counties pooled resources to finance their local programs. The North Dakota Legislature established the North Dakota Weather Modification Board (NDWMB), later renamed the Atmospheric Resource Board (ARB) in the 1975 legislative session. The State Legislature further provided an appropriation for the remainder of the biennium to implement the 1976 operational program on a cost-sharing basis.

Fig. 6. WMI aircraft on the ramp in Bowman, ND await the 1984 NDCMP season. Photo by Hans Ahlness.

The cloud seeding projects before the creation of the NDWMB had been paid for by voluntary contributions and county appropriations. The 1976 operational program included 50% state matching funds equaling the county appropriations in support of the project in their area. These matched county funds were used specifically for field operational costs. As state matching fund levels dropped through the mid-1980's, many counties dropped out of the program. State funds were also used for research and evaluation, although some federal funds supported UND-trained co-pilots and evaluation data underwritten by the Bureau of Reclamation.

The recently concluded 2024 program was the 50th consecutive season under the Board's direction. The North Dakota Atmospheric Resource Board is comprised of seven members appointed by the Governor of North Dakota. Each member represents a geographic district and serves a four-year term. Weather modification authorities within the districts establish possible candidates through nomination. Ex-officio members also serve on the board.

2024 NDCMP BOARD MEMBERS

DISTRICT I	Steve Kemp	Williston, ND
DISTRICT 2	Gail Yuly (Vice Chair)	Minot, ND
DISTRICT 3	Rep. David Monson	Osnabrock, ND
DISTRICT 4	Chris Theisen (Chair)	Thompson, ND
DISTRICT 5	*VACANT*	
DISTRICT 6	Jessica Magilke	Solen, ND
DISTRICT 7	Thomas Burke	Bowman, ND
EX-OFFICIO MEMBERS:		
Andrea Travnicek, Ph.D.	ND Department of Water Resources, Director	
Kyle Wanner	ND Aeronautics Commission, Director	
Rebekah Pfaff (Secretary)	ND Department of Environmental Quality, Environmental Scientist	

Table 1. 2024 NDCMP Board Members.

2024 NDCMP COUNTY AUTHORITY MEMBERS - DI

DISTRICT I:	
BOWMAN COUNTY	**SEVERE WEATHER MANAGEMENT ASSOC.**
Wayne Mrnak, Bowman (Chair)	Robb Narum, Bowman (Chair)
Wes Andrews, Bowman	Ryan Brooks, Bowman
Ryan Brewer, Bowman	Dan Powell, Bowman
Chad Miller, Bowman	
Wes Miller, Rhame	

Table 2. 2024 NDCMP County Authority Members – District I.

2024 NDCMP COUNTY AUTHORITY MEMBERS - DII

DISTRICT II:		
MCKENZIE COUNTY	**WILLIAMS COUNTY**	**MOUNTRAIL COUNTY**
Eldean Flynn, Cartwright (Chair)	Jeff Knox, Ray (Chair)	Aaron Skarsgard, Stanley (Chair)
Rodney Cross, Alexander	Cierra Aamodt, Williston (Treasurer)	Eric Olson, Plaza
Roger Flatland, Watford City	John Hovde, Epping	Tim Johnson, Stanley
Gary Levang, Watford City	Christian Marshall, Williston	Hayley Jung, Stanley
Luke Taylor, Watford City	Paul Weyrauch, Ray	***VACANT***

Table 3. 2024 NDCMP County Authority Members – District II.

2 NORTH DAKOTA ECONOMIC IMPACT

A study in 2019 from the NDSU Department of Agribusiness and Applied Economics investigated the impact that the NDCMP has on the state's economy. An update of a 2009 analysis, the study considered the value of hail suppression and enhanced rainfall during the growing season. Using the harvested acreage of the top eight crops plus alfalfa, the study combined crop insurance data, production statistics, and NDCMP results to estimate the added value of the project for both the actual target areas and the benefits if the project was statewide. Rain enhancement was figured at two levels, a 5% and a 10% increase (covering the range of results from long-term evaluations of the NDCMP) and combined with a 45% hail reduction estimates to derive the results.

In the NDCMP seeded counties, the direct economic value of cloud seeding specifically to enhance rainfall was estimated to range from $9.19 to $18.15 per planted acre, or $21.2-41.9 million in direct benefits to agriculture production. The hail suppression addition adds another $3.0 per planted acre, or $6.9 million annually. Compared to the cost of the project, those figures would give a benefit-to-cost ratio of 31-to-1 up to 53-to-1, an excellent return on investment. This shows the huge benefit that the NDCMP can provide.

Enhanced agricultural production can affect other areas of North Dakota's economy. Increased crop yields can potentially increase tax revenue between $576,000 – $999,000 annually. Most significantly, this study does not include the considerable benefits that a reduction in hail damage has to property, especially in more populated areas.

A recent study published October 2021 written by Michigan State University, used historical cloud seeding participation over a 30-year period to estimate the effect on wheat and barley yields. They found that the average annual wheat yields in the seeding counties was 13% higher than unseeded counties for the 1989-2018 timeframe. The benefit to cost ratio was shown to be 36 to 1. The authors concluded "In this study we present new evidence that cloud seeding improves wheat yield in participating North Dakota counties as evidenced by the statistically significant effect on wheat yields and insurance loss ratios."

These complete reports and other NDCMP program evaluations are available on the North Dakota Department of Water Resources website at: http://www.dwr.nd.gov/arb. On the navigation panel, click on ND Cloud Modification Project and then Program Evaluations.

Fig. 7. Looking south from Bowman Airport as a complex thunderstorm skirts the edge of District I on 11 July 2024 at 8:33pm local time. Seed 2 flew an early evening mission on this day. Photo by Oakley Eagleson.

Counting ARB staff, ARB Board of Directors, the participating County Weather Modification Boards, Slope County Severe Weather Management Association members, and applicable WMI and FJC staff, there were over 100 people directly associated with some facet of the 2024 NDCMP. This does not include the local vendors and technicians employed by the ARB and WMI during the season.

3 2024 AIRCRAFT CONTRACTOR

Weather Modification International is a global atmospheric sciences company committed to continued advances in the field of weather modification. With over 60 years of successful operations, WMI has pioneered safe and effective techniques for cloud seeding. These advances have made it possible to conduct operations 24 hours per day, seven days a week. These techniques – many formulated in North Dakota operations – have allowed WMI to provide aircraft, seeding and research equipment, radars, personnel, and company expertise in the areas of cloud physics research and atmospheric sampling for various governmental agencies and private entities around the world.

WMI was originally formed in 1961 in Bowman, North Dakota, and the anti-hail program begun at that time was the genesis of the current NDCMP. WMI relocated to Fargo, ND in 1993 and a sibling company, Fargo Jet Center LLC (FJC) was incorporated in 1994. Since then, WMI has grown exponentially. Today, WMI and FJC facilities in Fargo have more than tripled in size and employees and number more than 250 personnel worldwide. FJC adds a wide range of aviation services including a charter flight department, aircraft refueling services, an FAA-approved aircraft maintenance and overhaul facility, avionics shop, aircraft rental and a flight school.

FJC also operates Premier Jet Center, a full service FBO/repair station, paint and upholstery shop, and Exclusive Aircraft Sales based in Eden Prairie, MN. The operating companies frequently share resources, skills, talents, and equipment – each contributes to the success of the other. The synergy realized from several multi-faceted operating companies highlights a strong aviation enterprise that continues to grow.

Fig. 8. Weather Modification Int'l and Fargo Jet Center LLC headquarters at Hector International Airport, Fargo, ND.

4 PROJECT DESIGN

The design of the 2024 North Dakota Cloud Modification Project was based on techniques developed and refined over years of operational programs. These techniques, many developed here in North Dakota, were used in conjunction with seeding criteria evolved by compatible research programs and the comprehensive North Dakota Cloud Modification Project Operations Manual, January 2023. A companion manual, the NDCMP Radar Applications Manual (latest revision May 2012) provides guidance for the project meteorology staff.

As set forth by the NDARB, the project design is a "non-randomized, development and operational program for the purposes of decreasing hail damage, increasing seasonal rainfall, and achieving certain development objectives for improved operations". In summary, the project design is one in which any cloud that meets the criteria for increasing rainfall or decreasing hail is seeded (within the limits of equipment and personnel) rather than clouds being chosen on a random basis for seeding. In theory, any project member can initiate seeding operations, but in practice the ARB radar meteorologists usually direct when and where the WMI pilots operate.

Fig. 9. The sunset reflecting on the backside of a thunderstorm provides a beautiful view with a rainbow from the Bowman Airport on 6 July 2024. Photo by Ashley Cade.

5 OPERATIONAL AREAS

North Dakota weather modification activities were conducted in two operational target areas, or Districts. District I included Bowman County, as well as Hume, Carroll, Cash, Connor, Sheets, Mineral Springs, and Cedar Creek Townships in Slope County. District II encompassed Williams, McKenzie, and Mountrail counties.

District I has operated without a buffer zone since 2018. In District II, the NDARB board approved the removal of downwind buffer zone after the 2023 season. This buffer zone had straddled Mountrail County to the east and northeast.

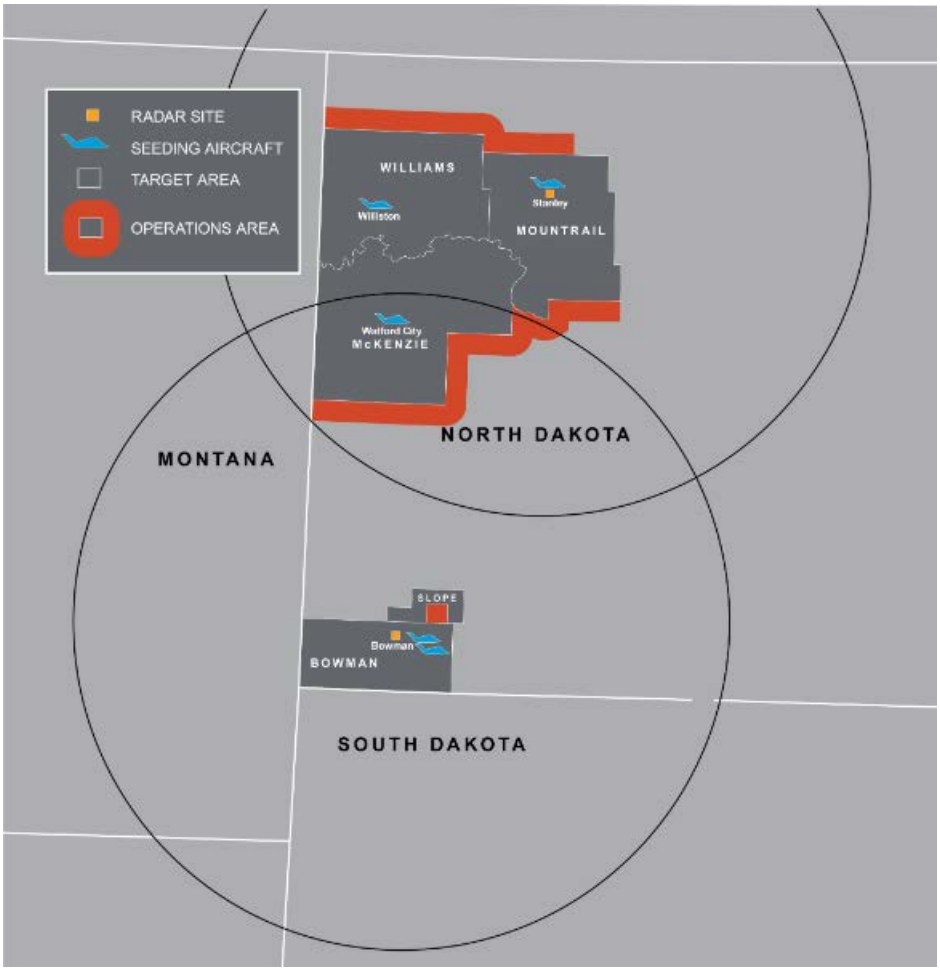

Fig. 10. A representation of the seeding target areas for both districts, aircraft bases, and radar range capabilities for the 2024 NDCMP. Graphic courtesy of the NDARB.

5.1 WMI Aircraft Base Locations

Aircraft bases are determined by the ARB in cooperation with WMI and the county weather modification authorities. Airports are chosen using location, runway length, fuel availability, and facilities as factors. The top-seeding aircraft needs access to instrument approaches to fully utilize their capabilities. Housing availability for the crews is also important.

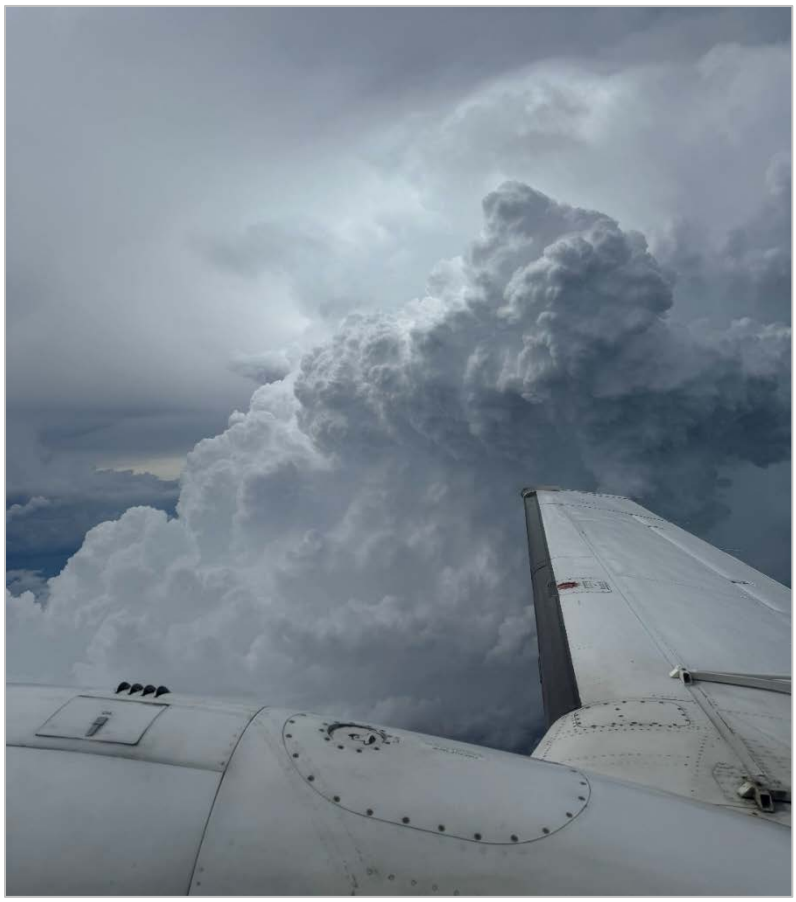

Fig. 11. Seed 7 (King Air, N709EA) makes its way around a large, developed cell seeking new areas of growth on 27 June 2024. Photo by Alex Craven.

The 2024 season saw the carryover of base locations from the previous season. Seeds 1 and 2, both Piper Seneca II aircraft outfitted for base seeding, (US Registration N39655 and N13AG, respectively) operated from the Bowman airport for District I operations coverage. District II operations were covered from three bases. One Piper Seneca II was stationed in Williston (Seed 5, N9798C). A second Piper Seneca II was in Stanley (Seed 4, N121WA). Seed 7, a King Air C90 outfitted for top seeding, remained stationed in Watford City. Seed 7, while based in District II, was also utilized as a top seeder for District I on a case-by-case basis. Priority for its use was given to District II, and meteorologists from both districts coordinated its use depending on forecast conditions across the operations area.

Aircraft tend to arrive at their base and continue operating from that location for the duration of the project, less a few days for events or airport closures. This season, Stanley airport underwent construction for the addition of a grass crosswind runway which considerably interrupted operations from the airport. As a result, Seed 4 was repositioned to Tioga for the duration of July and part of August, and continued operations as normal, while Stanley airport was closed. Radar operation was not affected by the airport construction.

5.2 NDARB Weather Radar Sites

Two Enterprise Electronics Corporation WSR-74C 5-cm weather radars, both owned by the NDARB, were employed on the project. These radars are surplus and upgraded National Weather Service units, purchased and moved to the project sites. One unit each is located at the Bowman and Stanley airports.

Fig. 12. The NDARB team at the Stanley radar site keeps vigilant watch as a supercell thunderstorm moves through Mountrail County on 6 August 2024. Photo by Ben Schaefer.

6 DAILY OPERATIONS

The 2024 season of the North Dakota Cloud Modification Project became active at noon CDT (11:00 am MDT) on 1 June 2024 for both districts. The project ended for District I and McKenzie County of District II at 11:59 pm CDT on 31 August 2024. The project ended for the remainder of District II at 11:59pm MDT on 8 September 2024.

Project forecasts were prepared each morning by the ARB Intern Meteorologists at both Stanley and Bowman on a rotating basis. They were based on National Weather Service data, the UND Weather and Research Forecasting (WRF) model, regional synoptic observations and satellite information. Project staff received the daily forecast either online or by joining, if available, a video conference at approximately 12:00 noon, CDT. Forecast support was additionally provided by ARB staff as needed. In the event of significant changes, updates were furnished to the radar meteorologists by phone and on the website.

Radar meteorologists and pilots all kept an eye out for significant weather activity. Sometimes with input from the aircraft crews, the ARB radar meteorologists launched aircraft for seeding missions. Cloud candidates for seeding were usually chosen by the radar meteorologists, with the pilots making the final determinations based upon storm inflow, cloud structures, flight safety, and other factors.

Fig. 13. Seed 5 flies ahead of a shelf cloud as it passes over Lake Sakakawea on 2 June 2024. Photo by Austin Krause.

7 AIRCRAFT

WMI uses twin-engine aircraft for all flight operations. In addition to their high-performance characteristics, in comparison to smaller, single-engine aircraft, the twin-engine aircraft provide an extra measure of safety in bad weather, in-cloud, and nighttime operations. All the seeding aircraft are owned and modified by WMI.

WMI operated four Piper Seneca II (PA34-200T) aircraft for cloud-base seeding and one Beechcraft King Air C90. WMI's Piper PA34-200T Seneca II aircraft are turbocharged, twin 200-horsepower engine light aircraft. The Beechcraft King Air C90 aircraft was used for cloud-top seeding, though it was also equipped with wing flare racks for cloud-base operations if needed. The WMI King Air C90 has two 550hp turboprop engines with a pressurized cabin.

Fig. 14. N9798C (Seed 5) conducts a base-seeding flight for District II on 14 July 2024. Photo by Oakley Eagleson.

WMI operates C90 aircraft on projects around the world. Besides North Dakota, WMI operates multiple King Air C90 aircraft on projects in Canada in the summer, and multiple King Airs in California, Colorado, Idaho, and Wyoming during the winter. WMI also operates multiple King Air B200s year-round in the Kingdom of Saudi Arabia. Beechcraft King Air Series aircraft have become the desired platform for cloud seeding and atmospheric research industry wide due to their reliability, payload, and maintenance availability both domestically and internationally.

Aircraft must be flown and maintained in accordance with US Federal Aviation Administration (FAA) rules and regulations. WMI's specially modified cloud seeding aircraft, when fitted with seeding equipment, must be operated in RESTRICTED category – meaning that their operations are limited to the special purpose operations for which the equipment installations are certified by the FAA and are bound by extra rules that prohibit these aircraft from carrying passengers who are not part of the project, among other things.

All aircraft must also be inspected and maintained according to approved schedules; the Senecas used on this project must all have a yearly "annual" inspection and certain required maintenance checks at each 50 and 100 hours of operation. The turboprop C90 must be operated under a progressive inspection program and has mandatory 200-hr and yearly inspections. WMI seeding aircraft are equipped for flight in icing conditions should the need arise. In addition to normal aircraft and seeding systems, aircraft furnished for the project were equipped and certified for instrument flight rules (IFR) with GPS navigation equipment.

Prior to the 2024 season, all WMI project aircraft underwent renewed annual inspections (as required by the FAA) and had the appropriate WMI seeding equipment mounted to conform to the project contract requirements. Project pilots assisted WMI and FJC mechanics in Fargo to prepare the aircraft. This provides the pilots with valuable training and hands-on experience with seeding equipment and their aircraft. All seeding generators were flight tested with acetone before delivery to ensure proper operation.

Fig. 15. Seed 7 (King Air, N709EA) parked at Watford City Airport on 5 August 2024. Photo by Peyton Underwood.

The project aircraft were ferried to their respective summer bases at the start of project. Seneca N13AG was ferried to Bowman on 25 May 2024. Seneca N9798C was ferried to Williston the same day. Seneca N121WA and King Air N709EA were ferried to Stanley and Watford City, respectively, on 26 May 2024. The final aircraft to be ferried was Seneca N39655, which was brought to Bowman on 31 May 2024.

Crews ensured all aircraft in the project area were loaded with burn-in-place (BIP) and ejectable (EJ, on applicable aircraft) pyrotechnics, and silver iodide solution prior to the start of project at noon local time on 1 June 2024. Crews conducted "District Tour" flights at the start of the 2024 NDCMP to familiarize themselves with their area of operations, function of the acetone burners, and reliability of the voice and data links with their respective controlling radar sites.

7.1 Aircraft Maintenance

All pre-season, major aircraft, and seeding equipment maintenance was performed by and/or at the direction of Weather Modification International/Fargo Jet Center in Fargo, ND. Jody Fischer, Vice President of Operations, and Kirk Hamilton, Director of Flight Operations, tracked and supervised the required maintenance and support for the aircraft during the summer. The Pilot-In-Command (PIC) of each aircraft was instructed to call Hamilton or Fischer immediately if any unscheduled maintenance was required.

With the 24/7 nature of WMI's commitments for the ARB, when an aircraft has a maintenance problem it needs to be repaired quickly. WMI has developed a working relationship with three maintenance shops during the past seasons: (1) Bottom Line Aviation LLC in Bowman, (2) Overland Aviation in Williston, and (3) Watford Aeroserve in Watford City. These relationships allow WMI to have inspections and limited maintenance performed on-site, which reduces the down time of the aircraft by eliminating travel time to and from Fargo. WMI provided these locations with parts, documentation, and support services. If local shops are unable to perform any maintenance tasks, WMI can fly a mechanic and/or parts to the broken project aircraft or ferry it to Fargo for more extensive work. WMI has always attempted to have smaller items taken care of by local maintenance shops in western ND when possible.

Additional aircraft maintenance outside of routine and/or scheduled inspections occurs yearly, with the 2024 NDCMP featuring:

2024 NDCMP AIRCRAFT MAINTENANCE

DATE	AIRCRAFT #	MX SUMMARY
6/2/2024	N9798C	Aircraft received routine scheduled maintenance in Williston.
6/3/2024	N709EA	Aircraft flew to Fargo for an audio panel issue, returned to Watford City late that afternoon and began seeding upon entering the district.
6/10/2024	N39655	Alternator failed in flight; parts were shipped on 6/11/2024. Aircraft became operational on 6/15/2024.
6/14/2024	N121WA	Aircraft flew to Watford City to have the engine idle adjusted; returned to Stanley the same day.
6/17/2024	N9798C	Aircraft flew to Fargo to have landing light indicators fixed; returned to Williston that afternoon.
6/22/2024	N13AG	Aircraft had bird strike on takeoff; returned to the airport for mechanic to verify aircraft airworthy and no damages.
6/23/2024	N709EA	Dry ice hopper motor became inop. Removed part and sent to third party facility for repairs. Ice hopper became operational again on 8/7/2024.
7/2/2024	N13AG	Aircraft flew to Fargo for maintenance on intercom and oil temp gauge. Returned to Bowman on 7/3/2024.
7/5/2024	N13AG	Aircraft flew to Watford City to have alternator gauge fixed; returned to Bowman later that day.
7/5/2024	N13AG	Aircraft had an issue with the microphone being stuck in transmit mode (hot) and missed a flight. The issue was fixed and aircraft returned to service on 7/9/2024.
7/5/2024	N9798C	Oil temperature gauge was repaired in Williston.
7/10/2024	N121WA	Aircraft flew to Watford City for routine scheduled maintenance; returned to Tioga later that evening.
8/8/2024	N13AG	Aircraft flew to Watford City for scheduled routine maintenance; returned to Bowman same day.
8/12/2024	N13AG	Aircraft flew to Watford City for engine roughness; returned to Bowman same day.
8/16/2024	N9798C	Aircraft flew to Watford City for routine scheduled maintenance; returned to Williston that afternoon.

Table 4. Summary of WMI aircraft maintenance performed during the 2024 NDCMP season.

If any of the project aircraft needed maintenance that would have it removed from service for an extended period, WMI always had a spare Piper Seneca II seeding aircraft on standby to assure uninterrupted service. While a spare aircraft is not required by contract, WMI has the resources to provide this service in case of an emergency.

7.2 WMI Aircraft Telemetry System and Communications - AirLink

The NDARB contracted with WMI to provide the project radars with equipment to track each seeding aircraft's position, altitude and seeding events. Each aircraft was equipped with a WMI "datalogger" system composed of a purpose-built computer running WMI's ADAS (Aircraft Data Acquisition System) software. The computer receives inputs from the aircraft's GPS receiver, ice nuclei generators, and the firing systems from the burn-in-place and belly-mounted ejectable flare racks. All project aircraft were equipped with a datalogger as part of the telemetry systems that provided position and altitude information as well as seeding events. The datalogger systems were designed and are specially built by WMI in Fargo.

The WMI EDAS system logs position from the aircraft GPS (latitude, longitude, altitude, and groundspeed) during the entire flight at a data rate of once per second. The computer also records the time and location of seeding events. A telemetry radio in each aircraft transmits the EDAS information to the WMI *AirLink* computer in the radar. This information is then sent to the radar's TITAN computer to generate the aircraft tracks on the TITAN display. Files are created on the aircraft computer's USB flash drive for later analysis. The NDARB was provided with the AirLink computer software to replay the flight track data for post-flight analysis. The data was downloaded from each aircraft on a regular basis, checked by WMI, and sent to the ARB at the end of the season.

Fig. 16. Seed 1 (N39655) conducts a seeding mission on 5 July 2024 for District II. During this 1hr 45min flight both burners were lit, and 8 burn-in-place pyrotechnics were consumed. At the bottom left you can see the pilot utilizing telemetry data. Photo by Peyton Underwood.

AirLink can provide, in real-time, a display of the seeding aircraft flight paths generated from aircraft GPS data. *AirLink* displays position information, seeding status, and atmospheric microphysical information (if the aircraft is equipped with probes), all transmitted via radio modem from each seeding aircraft to a receiver in the radar. The event tracking capability allows the radar meteorologists to determine which thunderstorm complexes were seeded and the number of flares used. If chosen by the radar operator, files can also be created on the ground computers in the radars to enable playback of flight tracks for post-mission analysis.

WMI supplied multi-channel VHF (Very High Frequency) aviation-band communications base station radios that were used at each radar field office for communications in association with *AirLink* with the seeding aircraft. WMI also supplied antennae and low-loss cabling at each site for good reception, and power supplies for the radios that ensured adequate transmitting power. The NDARB maintains the appropriate FCC radio station licenses for the radar sites.

8 CLOUD SEEDING EQUIPMENT

WMI designs, manufactures, and operates a wide variety of cloud seeding equipment. Each PIC received pre-season operation and maintenance training on the seeding equipment. WMI maintains an extensive inventory of seeding equipment spares that were restocked as needed during the project. WMI also keeps an inventory of spares for the airplanes used on the project to avoid downtime waiting for parts.

Each WMI Seneca II aircraft was outfitted with the following equipment:

- 2 WMI-Lohse ram-air pressurized liquid-fueled AgI generators, with a 7-gallon usable capacity, calibrated to a flow rate of 3.0 gallons per hour at 120 mph airspeed.
- 2 Wing-mounted flare racks, each capable of carrying 12-16 burn-in-place flares.

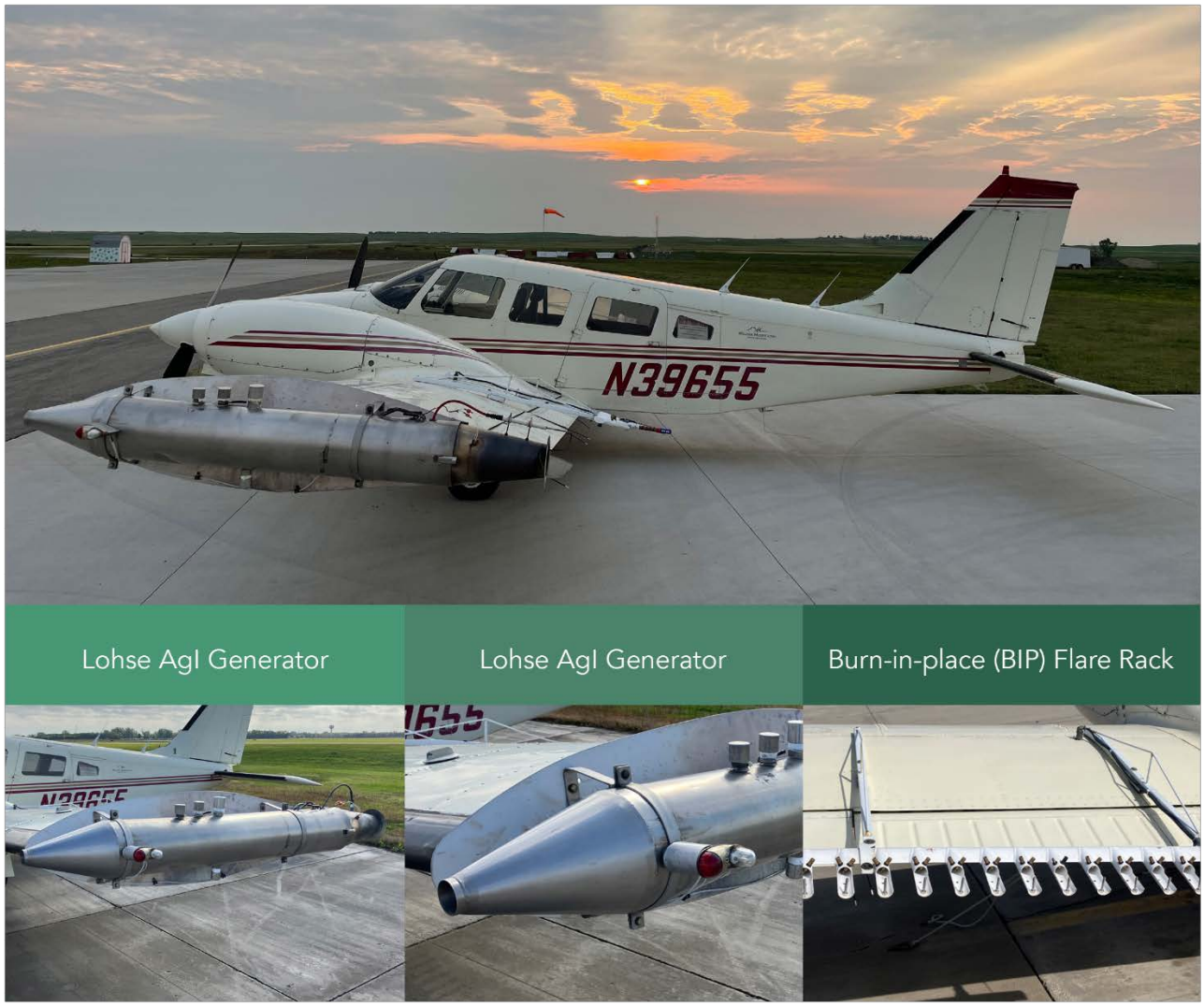

Fig. 17. WMI seeding Piper Seneca II aircraft. Photos by Ryan Starkey (2021 Intern Pilot; 2022 & 2023 Captain), Keisuke Yoshimura (2013 ARB Intern Pilot), and Taylor Exizidis-Meier (2020, 2021 WMI Captain).

The WMI King Air C90 aircraft was outfitted with the following equipment:

- 2 Wing-mounted flare racks, each capable of carrying 24 burn-in-place flares.
- 1 Dry ice dispenser, capable of holding 200 lbs of dry ice pellets.
- 3 Belly-mounted ejectable flare racks, 306 flare capacity total.

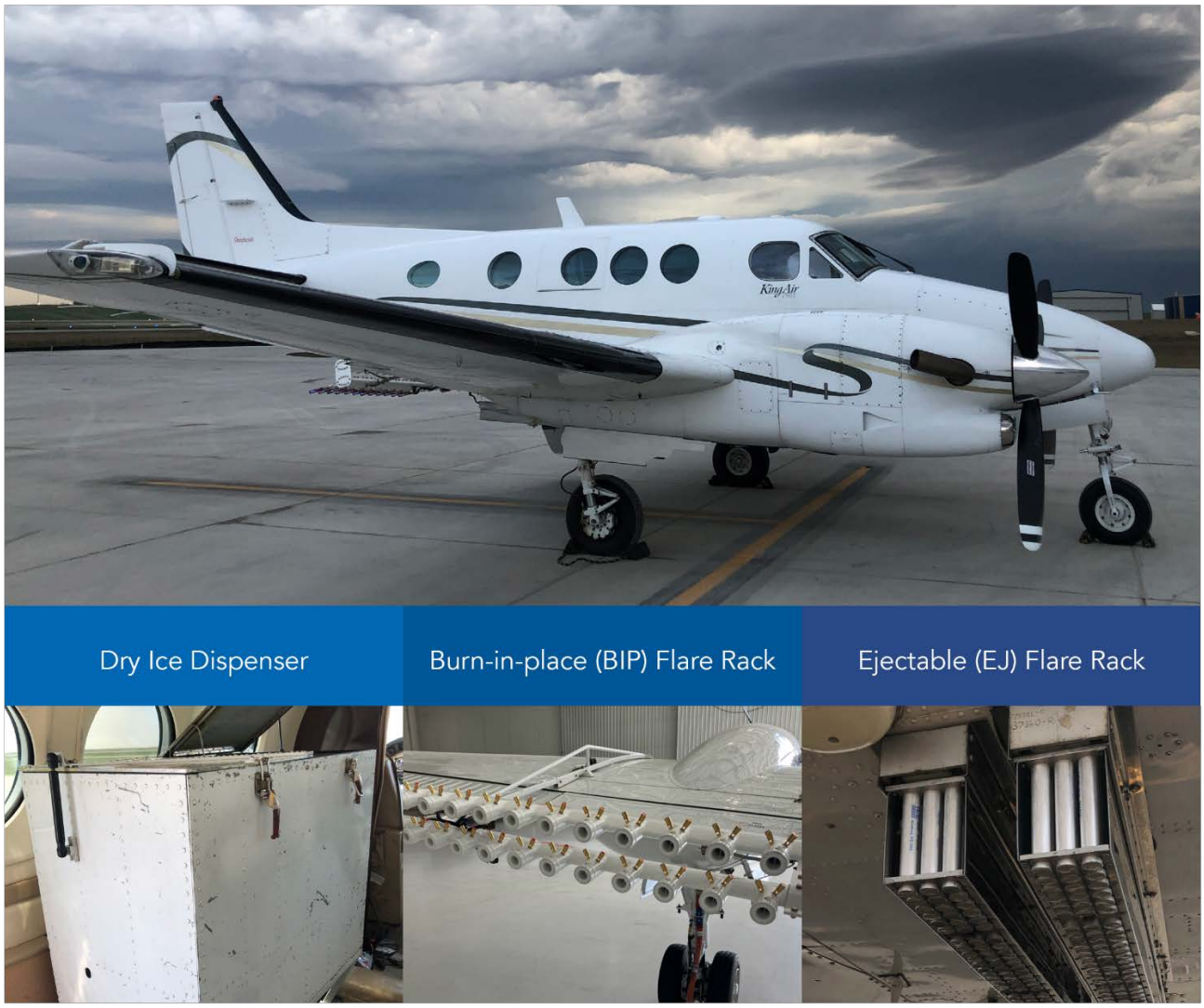

Fig. 18. WMI cloud top Beechcraft King Air C90 aircraft N709EA, Seed 7, in Williston. Photos by Kirk Hamilton, Alex Sailsbury (2018- 2021 WMI Captain), and WMI.

8.1 Seeding Equipment Performance

The generator performance is a measure of the total time that one seeding generator was inoperative during hail missions, when two were required. The following graph depicts an accurate illustration of the percentage that the project aircraft were operating at less than desired capability. This year the burner-failure rate was recorded at 2.06%, which was below the 10-year average of 2.27%.

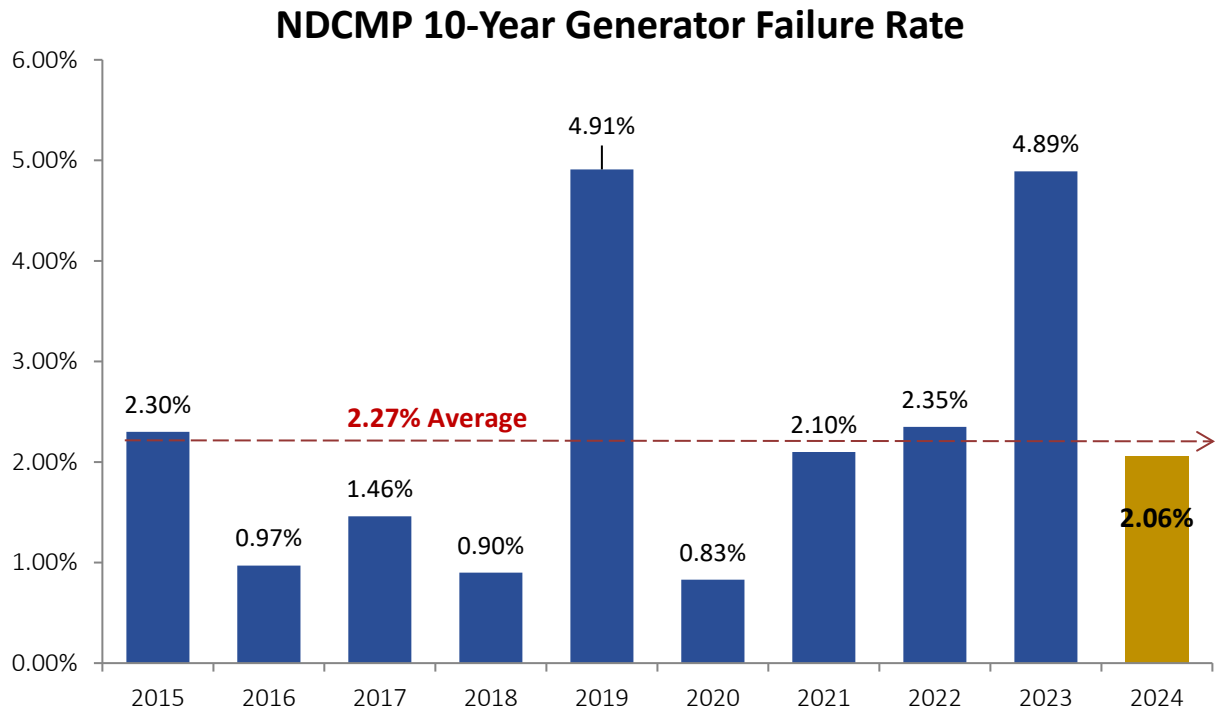

Fig. 19. NDCMP 10-Year Generator Failure Rate chart.

All the seeding materials used during the project were supplied by the ARB. These included dry ice pellets, silver iodide pyrotechnics (20-gram ejectable (ICE-EJ®) and 75-gram burn-in-place (ICE-EB®) flares), and a silver iodide solution. This solution mixture contains silver iodide, ammonium iodide, paradichloro-benzene, and sodium perchlorate, all dissolved in acetone.

Seeding formulations have evolved with research and experience, and now incorporate ingredients that make the formulas faster acting – better for hail suppression operations, where the crews are often working with rapid-growing storms. The seeding solution was mixed at each site by the field crews. The NDARB provided secure storage for the seeding materials at each airport.

Fig. 20. District II aircraft, N121WA (Seed4), ignites the Lohse AgI burner while in continuous inflow on 6 August 2024 at 8:01pm local time. Photo by Oakley Eagleson.

9 WEATHER RADAR SYSTEMS

The NDARB operates two five-centimeter EEC WSR-74C radars, located at the Bowman and Stanley airports. Both radars have been upgraded to Doppler, providing meteorologists in the field with velocity data to forecast rapid storm development from outflow boundaries and to help avoid directing aircraft into areas of turbulence from microbursts. The Doppler upgrade also improves the sensitivity of the radars, allowing them to detect early echoes, which aids in the response time for rain enhancement missions. Another upgrade that is useful for both radar sites is the remote access capabilities, which allow the radar technician or anyone at the NDARB to monitor the radars remotely and fix any software problems.

Each radar set has an antenna pedestal and a dish. The antenna pedestal is the elevation-over-azimuth type. The dish is parabolic, 8 ft. (2.4 m) in diameter, constructed of aluminum and installed within a 12 ft. (3.7 m) diameter fiberglass radome, which protects the radar from wind, precipitation, and hail damage and allows it to operate continuously. The antenna assembly is positioned on a steel tower at the Bowman Airport and atop the radar building in Stanley, at an adequate height to provide the best possible radar coverage for the target areas.

The data collected by the radar are analyzed through an IRIS/TITAN system. The Interactive Radar Information System (IRIS, a Sigmet/Vaisala product) and the Thunderstorm Identification, Tracking, Analysis, and Nowcasting (TITAN) system developed by scientists from the National Center for Atmospheric Research (NCAR) are software/hardware systems provided to each radar site by NDARB. A clone of the software setup is also kept in Bismarck for remote data analysis.

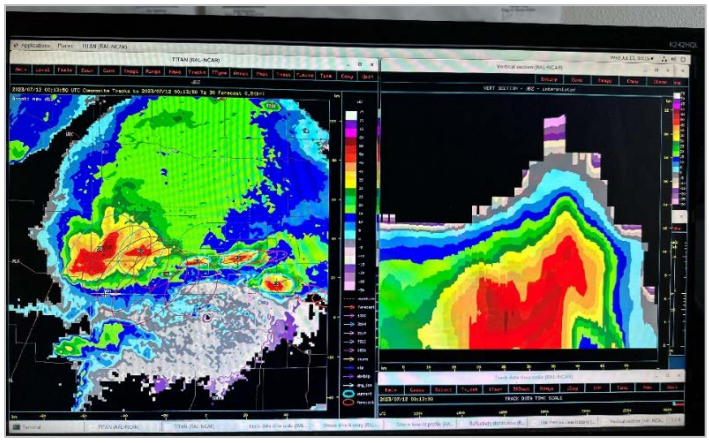

Fig. 21. Photo by Jacob Azriel (NDARB Radar Meteorologist 2023) showing the TITAN display TITAN is the primary radar tool used by meteorologists to direct flight operations.

IRIS is very useful for meteorologists in that it provides the real-time display of the radar data. Along with displaying the reflectivity detected at each elevation angle in real-time, IRIS also has tools available to do cross sections on the most recently completed scan data (cannot do cross sections on real-time display data). IRIS is not as useful when directing aircraft, since it does not display aircraft and their position. IRIS is a great tool to use to determine if a storm is increasing or decreasing in intensity, and it is a good backup tool for cross sections if the TITAN machine is inoperable.

While IRIS is valuable, the TITAN system is the main software used when running operations. The TITAN system provides 16 levels of contoured color radar reflectivity data, zooming capabilities, custom target overlays, instant playback, and real-time aircraft flight track/seeding event superimposition. TITAN software runs on a LINUX operating system, and the TITAN system displays constant altitude plan position indicator (CAPPI), vertical storm cross section, storm history, storm time-height profile and reflectivity distribution. The history of storm motions (yellow circles) and forecast storm motions (red circles) are also displayed. A CAPPI display can be selected for various altitudes starting at 2 kilometers above the surface and stepping up in 1 kilometer increments. It is also possible to create a “composite PPI” display, which plots the strongest radar reflectivity at any altitude in a PPI (radar display) format. A zoom function allows the radar operator to zoom-in on

interesting features, such as hail cores, on the display. The vertical cross section capability enables a radar operator to produce a two-dimensional slice through a thunderstorm. Unlike conventional radar Range Height Indicators (RHI), the vertical cross section option permits cross sections to be made along any two points on a PPI display and not just along the azimuth from the radar.

Fig. 22. Seed 7 (King Air, N709EA) sets up to conduct a top-seeding pass using ejectable flares. New development is evident by the tall crisp tops and feeder cloud below flight level. Photo by Jake Floyd.

Aircraft flight tracks can be superimposed upon the TITAN display, and the field offices and project aircraft have the equipment to do so (see the previous section describing the WMI datalogger system). Superimposed flight tracks aid the radar meteorologists in directing the cloud seeding aircraft to the most suitable seeding candidates. An electronic overlay generated by a computer file displays the project target area as well as county boundaries and prominent cities and geographical features.

Radar maps and flight track data are saved automatically in approximately 5-minute increments. The time required to complete a volume scan varies dependent upon the RPM setting of the radar. The large volume of graphical data being recorded and stored is the reason for the necessity of upgrading to a specialized computer. The weather radar data is recorded onto hard-drive disks for storage and playback later, and the storms can be replayed for future analysis.

The composite PPI radar maps are automatically sent to the ARB website when a scan has been completed providing access to recently recorded data. The links (accessible from the ND Department of Water Resources website, http://www.dwr.nd.gov/arb) can be viewed using any device with an internet connection and show current radar maps displaying reflectivity data and aircraft flight tracks.

Using additional funding from surrounding counties in the offseason the Bowman radar operates year-round, while the Stanley radar is only used during the project season.

Airplane tracks were depicted when airplanes were flying. GPS tracks showed individual colors when airplanes were flying but not seeding, and turned gold when aircraft were seeding. The only exception was when displaying “ejectable flares”, which were denoted by an asterisk. GPS flight tracking of airplanes on the North Dakota Cloud Modification Project has been provided on project radar images since 2004.

10 METEOROLOGICAL SUMMARY

10.1 NDCMP Cloud Seeding Criteria

Radar meteorologists employ a set of guidelines to determine the most promising storms for seeding. These guidelines, established by the NDARB, include but are not limited to:

Rain Enhancement:

- Cloud bases lower than 10,000ft MSL
- Radar reflectivities at or higher than 35dbz at a 5km vertical height
- Obvious convective storm behavior
- Pilot reported rain shafts reaching the surface
- Pilot reported inflow between 100-500fpm

Hail Suppression: All the same criteria for rain enhancement **plus:**

- Radar reflectivities of 45dbz or greater, 5,000ft, or ~1.5 km above the freezing level
- Pilot reported inflow between 500-800fpm and/or
- Hail reports from the public/law enforcement

10.2 NDCMP Suspension Criteria

According to the project design and standard operating procedures, seeding operations are suspended for specific cells and/or project regions under certain circumstances. Suspension criteria include:

- Tornado Warnings or Funnel-Bearing Clouds
- Flash Flood Potential/Warnings/Flood Warnings/Areal Flood Advisories
- County Determinations (at the discretion of local weather modification authority)

Tornado Warnings issued by the National Weather Service (NWS) or funnel clouds/tornadoes observed by project personnel trigger the halting of seeding activities for a storm. In the case of NWS Tornado Warnings, nearby pilots may perform reconnaissance of the cell to confirm the presence of a funnel. If pilots are unable to confirm a funnel, seeding operations may immediately resume. However, if a tornado or funnel is confirmed by project personnel, there is an immediate 30-minute suspension of seeding for the funnel-bearing cell. Seeding may only resume 30-minutes after the funnel has dissipated. According to the NDARB operations manual, studies have not demonstrated that cloud seeding causes or intensifies tornadoes.

Fig. 23. A cold funnel cloud visible over the wing of Seed 5 (N9798C) on 27 June 2024. Operations were suspended on this storm, but the pilots kept a close eye on this rare event. Photo by Austin Krause.

Flood Potential may also trigger the suspension of seeding activities under several scenarios. A partial summary of the official NDARB Flood Suspension Criteria follows: If the National Weather Service issues a Flood Warning/Flash Flood Warning in a specific area, seeding is suspended. This usually means that an area has already experienced sufficient rainfall accumulation and additional heavy rain is expected. If that is the case, seeding is generally suspended for a region of the district and cannot be resumed within the warning area until the flood threat subsides. A second scenario is if a storm exhibits flash flooding potential as determined by the project radar meteorologists. This can be determined by investigating the rainfall rate (derived from the radar reflectivity values) and the storm motion. If the storm is stationary, a reflectivity value greater than 54.5 dBZ (indicating a rainfall rate greater than 2 inches per hour) would meet the criteria for seeding suspension. If the storm is in motion, the meteorologist must determine the flood potential based on cell speed, intensity, and expected rainfall rate. Seeding in this case may only be resumed when the storm system is no longer a flood threat. Seeding operations may be suspended at any time at the request of the local weather modification authorities for entire districts or on a county-by-county basis. Rain-enhancement activities are frequently suspended late in the season as crops reach maturity.

2024 NDCMP RAIN ENHANCEMENT SUSPENSIONS

Date	Bowman	SWMA	McKenzie	Mountrail	Williams
6/1/2024	enhance	enhance	enhance	suspend	suspend
6/3/2024	enhance	enhance	enhance	suspend	suspend
6/10/2024	enhance	enhance	enhance	suspend	suspend
6/17/2024	enhance	enhance	enhance	suspend	suspend
6/24/2024	enhance	enhance	enhance	suspend	suspend
7/1/2024	enhance	enhance	enhance	suspend	suspend
7/8/2024	enhance	enhance	enhance	suspend	suspend
7/15/2024	enhance	enhance	enhance	suspend	suspend
7/22/2024	enhance	enhance	enhance	suspend	suspend
7/29/2024	enhance	enhance	enhance	suspend	suspend
8/5/2024	enhance	enhance	enhance	suspend	Suspend
8/12/2024	suspend	suspend	enhance	suspend	suspend
8/19/2024	suspend	suspend	enhance	suspend	suspend
8/26/2024	suspend	suspend	enhance	suspend	suspend
9/3/2024	X	X	X	suspend	suspend

Table 5. Rain enhancement suspension dates by county.

Fig. 24. A developing thundershower was clearly visible just northeast of Stanley on 22 June 2024. All five members of the Stanley crew were ready at the airport in case of operations. Good ground visibility on a storm can further help meteorologists determine if and when they should launch aircraft. Photo by Ben Schaefer.

Fig. 25. A mature thunderstorm clearly visible southwest of Williston outside of district on 7 July 2024. Good visibility from aircraft bases can help notify meteorologists of arriving conditions outside of radar coverage. Photo by Austin Krause.

10.3 Climatological Project Overview

10.3.1 JUNE

June is typically the most active month for strong-to-severe convective activity in western North Dakota, and consequently typically experiences the most precipitation out of all summer project months. This held true for the 2024 season, although there was variability between the districts in both average temperature and precipitation. District 1 experienced near-average temperatures, and below-average precipitation. June in District 2 could be described as “cool and rainy.” Below average temperatures were present across the entire district. Above average precipitation occurred across most of the district, except for western Williams County and northwestern McKenzie County. June was dominated by a variable weather pattern, with frequent shortwave troughs followed by ridges that passed through western North Dakota. This created a “hit or miss” precipitation pattern, and the precipitation variability seen in District 2. Although many of the thunderstorms that occurred in June were not exceptionally strong, the low-freezing levels present created a higher hail threat on any given storm, yielding opportunities for hail suppression. The near-to-below average precipitation in District 1 kept the abnormally dry to moderate drought conditions in place throughout the month. The above average precipitation in District 2 helped to erode the abnormally dry conditions, which were present in only western McKenzie and Williams Counties by the end of the month.

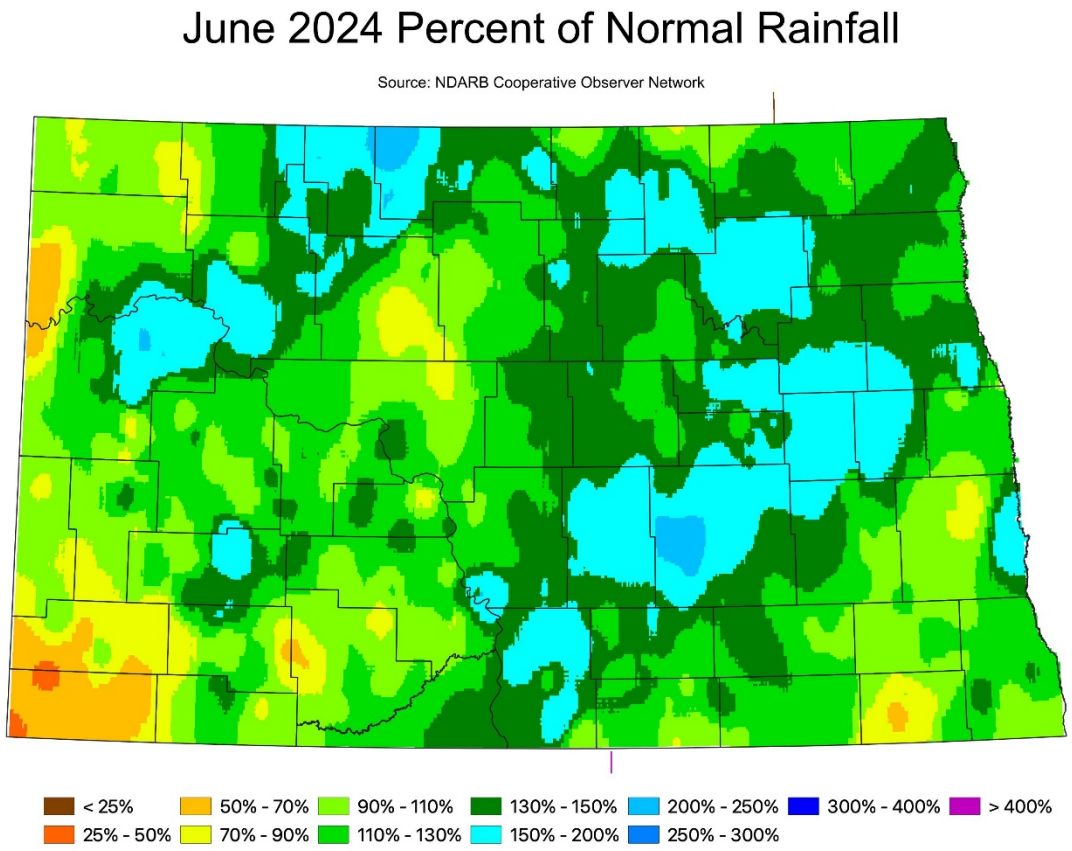

Fig. 26. Percent of Normal Rainfall map for the month of June. Graphic produced by the NDARB through their Cooperative Observer network.

10.3.2 JULY

July is typically the hottest month of the year in North Dakota, and average precipitation wanes from what is experienced in June. This held true for July 2024. Temperatures were largely above average and precipitation below average across both districts. Monthly temperatures were average to above average for everywhere in the project area except for northeastern Williams County near Tioga, and southeastern Slope County. A maximum temperature of 111 degrees Fahrenheit was recorded north of Watford City. Some variability existed in the weather pattern. July began with numerous "hit or miss" rain and thunderstorms across western North Dakota. This led to a few rain-enhancement opportunities for District 1 and McKenzie County in District 2. By the middle of month, an upper-level ridge built in southwest of the region and dominated the pattern through the end of the month, with occasional shortwave troughs riding along the northern side of the ridge. This helped to calm down the weather in western North Dakota, with occasional chances for hail suppression operations if a shortwave was present over the region. The below-average precipitation helped to maintain abnormally dry to moderate drought conditions in District 1 and expanded abnormally dry conditions slightly back east to near Williston and Watford City in District 2.

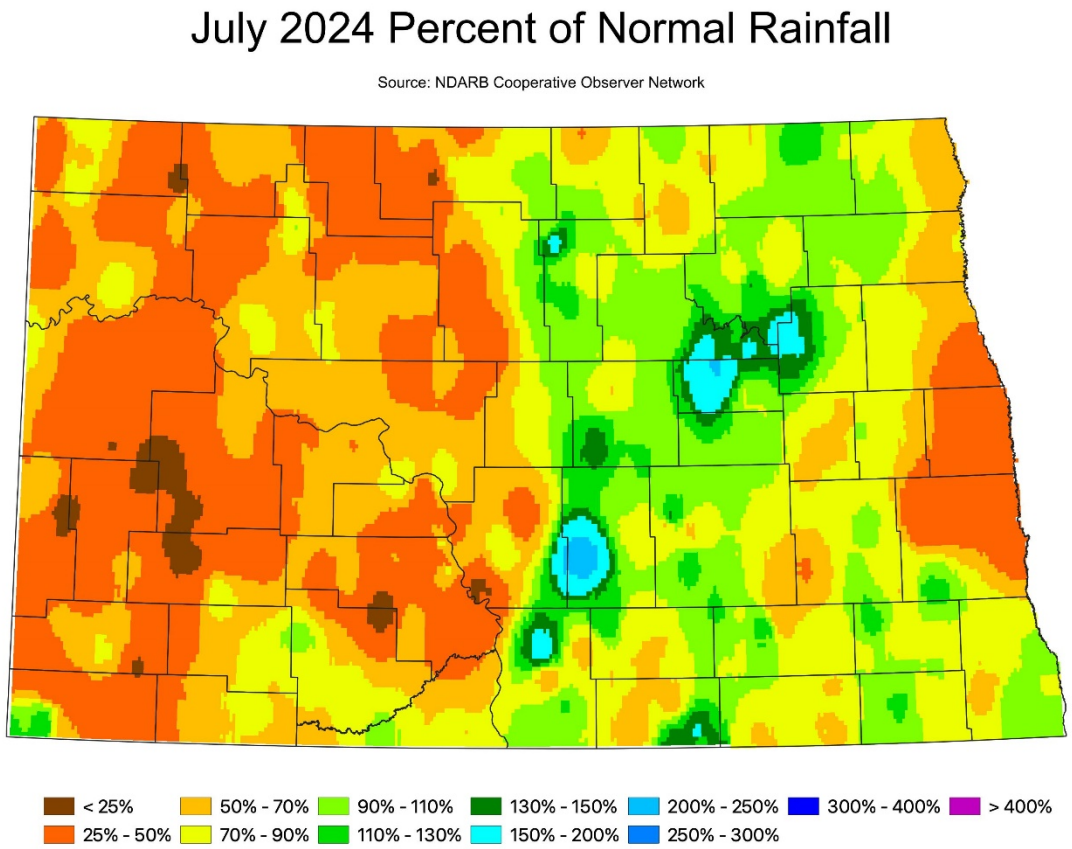

Fig. 27. Percent of Normal Rainfall map for the month of July. Graphic produced by the NDARB through their Cooperative Observer network.

10.3.3 AUGUST

August is typically the driest of all summer project months. This held true for the 2024 season. Temperatures were near to slightly below average across both districts. As for precipitation, recorded rainfall was near average across District 1, however well-below average for many places in District 2, particularly in northwestern District 2. Despite the overall lack of precipitation, the weather pattern was variable throughout the month. During the first week of August, western North Dakota sat under the influence of an upper-level ridge, keeping active weather at bay. However, this ridge began to break down by the end of the first week, allowing for off and on afternoon and overnight hail suppression opportunities through the middle of the month. By the end of August, another upper-level ridge had built in, leading to a quiet conclusion to the month. Williams and Mountrail Counties elected to extend hail suppression operations through 8 September 2024. The ridging pattern remained largely in place. A few subtle shortwave troughs moved through, however, as typical in the late summer, a strong warm air inversion was present right above the surface, which helped to suppress convective activity. No operations were conducted during extension. The drought increased across western North Dakota. By 10 September 2024, both districts were under an abnormally dry to severe drought pattern. In District 1, a moderate drought was present in southeastern Slope County, and western and northern Bowman County. A severe drought was present in central and southeastern Bowman County. In District 2, abnormally dry conditions were present in the southeastern two-thirds of Mountrail County and eastern McKenzie County. A moderate drought was present in central McKenzie and Williams Counties, and northwestern Mountrail County. A severe drought was present in western McKenzie and Williams Counties.

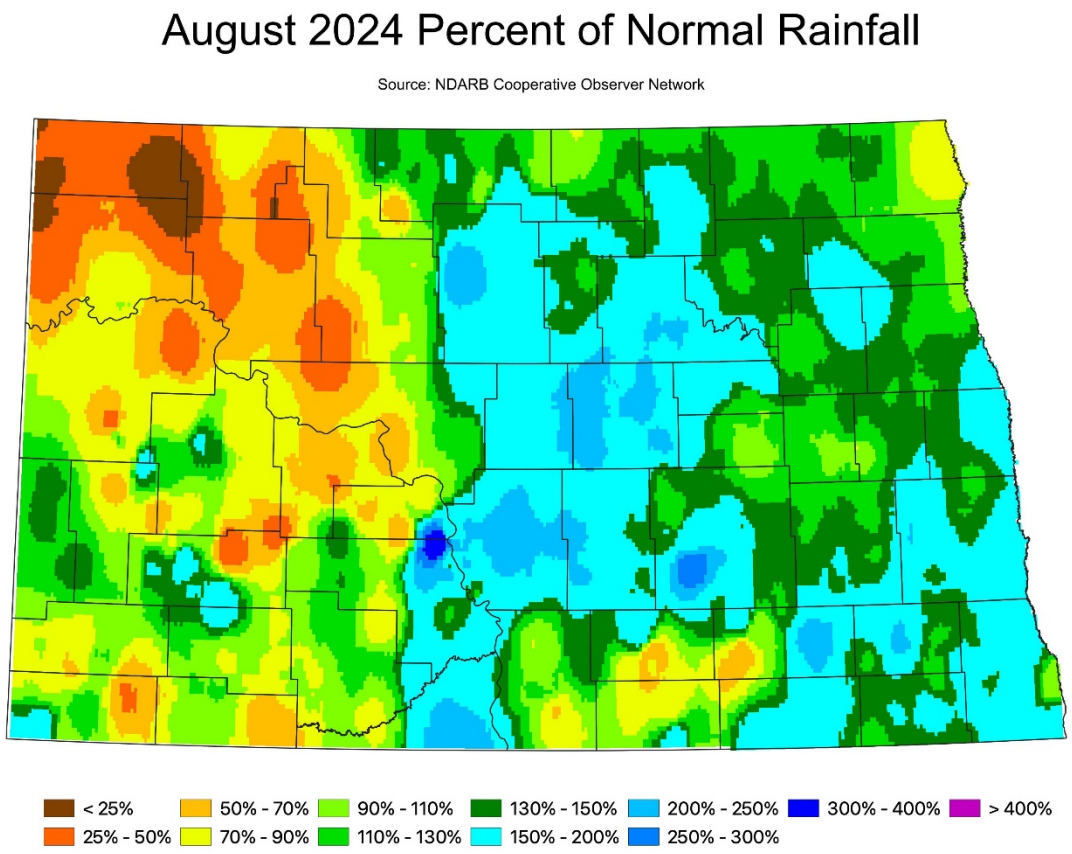

Fig. 28. Percent of Normal Rainfall map for the month of August. Graphic produced by the NDARB through their Cooperative Observer network.

11 PROJECT RECORD KEEPING

NDCMP record keeping is completed on the Apple iPad. The iPad is widely used by many aviation companies, including WMI who have used it to replace the need for bulky paper charts. The iPad features the ARB's "PARS" (Pilot Aircraft Recordkeeping System) software and can track position and altitude data. The iPad receives this data from its built-in GPS. This data is used to create the flight form as well as accurate maps, with seeding areas depicted as entered by the flight crew. Two additional programs, *ARBSync* and *ChemInv*, are included on the iPad to execute data uploads to the ARB database, and to monitor seeding chemicals and flares at NDCMP field sites. The iPad allows for speedy uploads of the data to ARB's database via Wi-Fi.

All aircraft were equipped with an ADS-B receiver (Automatic Dependent Surveillance - Broadcast) to access the FAA weather information provided by this network. The weather information can be displayed on *ForeFlight* using either the ARB or WMI provided iPad. While the radar depictions available from ADS-B are delayed, they are still an excellent tool for the flight crews to aid in situational awareness and communications with the radars.

Fig. 29. A night view of the King Air cockpit (N709EA, Seed 7) during a mission for District II. Visible in the co-pilot's lap is the iPad with weather radar imagery for guidance. Photo by Jake Floyd.

12 WMI AND NDARB PROJECT PERSONNEL

12.1 Ground School

The 2024 North Dakota Cloud Modification Project Ground School was conducted 29-31 May 2024 at the Department of Water Resources temporary office located at the Bank of North Dakota in Bismarck, ND. All aspects of the program were discussed, including responsibilities of personnel, cloud physics, opportunity recognition, use of seeding chemicals, project documentation, safety procedures, PARS iPad training, and selected examples from prior projects that helped illustrate efficient cloud seeding procedures.

Numerous questions typically surface during the project as problems arise, and remedies are explored. It is invaluable to have experienced personnel in the field during the season to resolve these problems. ARB Director Darin Langerud and ARB Chief Meteorologist Mark Schneider were always available for advice and answers whenever their radar meteorologists needed guidance; all project personnel were provided a link to online copies of the NDCMP Operations Manual and Radar Applications Manual prior to the season start.

Jody Fischer (WMI Vice President of Operations) and Kirk Hamilton (WMI Director of Flight Operations) provided support for WMI pilot personnel during the season. Fischer started on the NDCMP project as an intern in 1999 and has been involved with the project since. Hamilton started on the NDCMP project as a PIC in 2016.

12.2 WMI Pilots

The NDCMP welcomed many new Captains this summer, Camron Pflueger, Derek Winkelhaus, and Max Langerud 2023 Intern Austin Krause also returned to the project as a captain along with returning captain Jake Floyd. All NDCMP captains received training in Fargo prior to the start of the project. Flight training was conducted primarily by Jake Floyd and Ryan Starkey. Training focused on safe aircraft operations, emergency procedures, seeding procedures, and aircraft mastery.

WMI training pilots were Jake Floyd and Ryan Starkey. During training, all pilots got to fly with at least one of the two instructors to ensure that they were familiar with the airplane systems and the operation of the seeding equipment. The pilots were instructed on airspeeds and power settings used during seeding missions, as well as safe operating procedures. These flights provided quality assurance to standardize the WMI procedures for each pilot. All the pilots were involved in the pre-season maintenance and flight-testing of the aircraft and seeding equipment.

Due to the elimination of the vacation rover intern pilot position, PICs and interns were given flexibility regarding vacation dates. As part of WMI's commitment to provide uninterrupted service, relief pilots were made available for such occasions. Oakley Eagleson was brought on and trained by WMI to provide coverage for intern vacations during the 2024 season. Former WMI Captain Lucas Castro provided coverage as well.

2024 NDCMP RELIEF PILOT ASSIGNMENTS

START DATE	END DATE	WMI RELIEF PILOT	Location / Seed	CAPTAIN or INTERN REPLACED
6/5/2024	6/11/2024	Lucas Castro	08D - S4	Max Langerud
7/6/2024	7/11/2024	Oakley Eagleson	BWW - S2	Payton Belzer
7/14/2024	7/20/2024	Oakley Eagleson	XWA - S5	Alex Craven
7/22/2024	7/28/2024	Oakley Eagleson	BWW - S1	Peyton Underwood
8/1/2024	8/6/2024	Oakley Eagleson	08D - S4	Alessandro McDonald
8/9/2024	8/12/2024	Oakley Eagleson	BWW - Rover	Jackie Venters

Table 6. Pilot vacation dates and relief pilot assignments for the 2024 NDCMP.

12.3 Co-Pilot Internship

The Pilot Internship Program was initially begun in 1974 by the Bureau of Reclamation. A Memorandum of Understanding (MOU) between the ARB and the University of North Dakota has been in place since 1975.

Ms. Kelli Schroeder, as in past seasons, oversaw the program for the ARB. The intern pilots were paid an hourly wage and were required to maintain a timesheet of their project activities. At the completion of the 2024 program, the program has provided training and experience for 412 pilots. Co-pilot interns are also students and must fulfill that duty as well. This season, all but one of the co-pilot interns returned to school before the end of August. A copy of the NDCMP Pilot and Meteorologist Internship Final Report can be found at https://www.dwr.nd.gov/arb/ndcmp/pdfs/InternFinalReport.pdf.

WMI provides, for a nominal charge, each season's co-pilot interns with flight instruction and endorsements for High Altitude and or High-Performance training to give them the proper US Federal Aviation Administration certifications to act as pilots in the WMI aircraft used on the NDCMP. This allows the interns to log flight time in the aircraft, giving them hands-on experience that is far more beneficial for them. These certifications are not normally earned during flight training at UND. The flights involve several takeoffs and landings as well as flight operations at 25,000 feet.

WMI Captain Jake Floyd conducted flight training with the ARB Co-Pilots prior to the start of project. Training included aircraft operations, airport operations, and project specific procedures.

Fig. 30. Alex Craven, NDCMP Intern Co-Pilot, receives in-flight training from Austin Krause. Photo by Austin Krause.

12.4 NDARB Staff

All radar and intern meteorologists were employed by the NDARB. Three meteorology interns were chosen to spend the season as assistant meteorologists on project. In District 1, Meteorologist Ashley Cade and Intern Meteorologist Joseph Russell were selected to conduct operations out of the Bowman radar. In District 2, meteorologist Ben Schaefer, and two interns Grand Peterson and Parker Alvstad, were selected to conduct forecasting and operations from the Stanley radar site. Each intern meteorologist was given the opportunity to rotate through both radar locations. The NDCMP Meteorology Internship Program began in 1996 and to date has provided hands-on radar, operations and forecasting experience for 73 meteorology undergraduates.

12.5 NDARB Administration

Director Darin Langerud oversees the NDCMP operations for the ARB. Chief Meteorologist Mark Schneider manages the radar and intern meteorologists. Program Manager, Ms. Kelli Schroeder handles the program funding, contracts, and the pilot intern program. Mr. Daniel Brothers, Meteorologist, trains and oversees the intern forecasters as well as performing office duties including record keeping, iPads, the ARB rain gauge network, and record quality control. Mr. Langerud and Mr. Schneider are Weather Modification Association (WMA) Certified Weather Modification Managers, and Mr. Brothers is a WMA Certified Operator.

ND Department of Water Resources IT technician, Paul Moen handled issues with the TITAN software and hardware systems in both radars. Moen was also the architect behind the iPad aircraft data recording software.

Fig. 31. NDARB Administration Team located in Bismarck, ND.

12.6 Weather Modification International Administration

Jody Fischer, WMI Vice President of Operations was the Primary Project Manager for the 2024 season. Mr. Fischer has been involved with the project since 1999 when he joined the team as an intern pilot in Watford City. He returned the following two years as a Seneca captain, then as C340A captain and continued that role for the next 4 seasons until he was assigned on other WMI's international projects. Fischer has worked at WMI full-time since 2000.

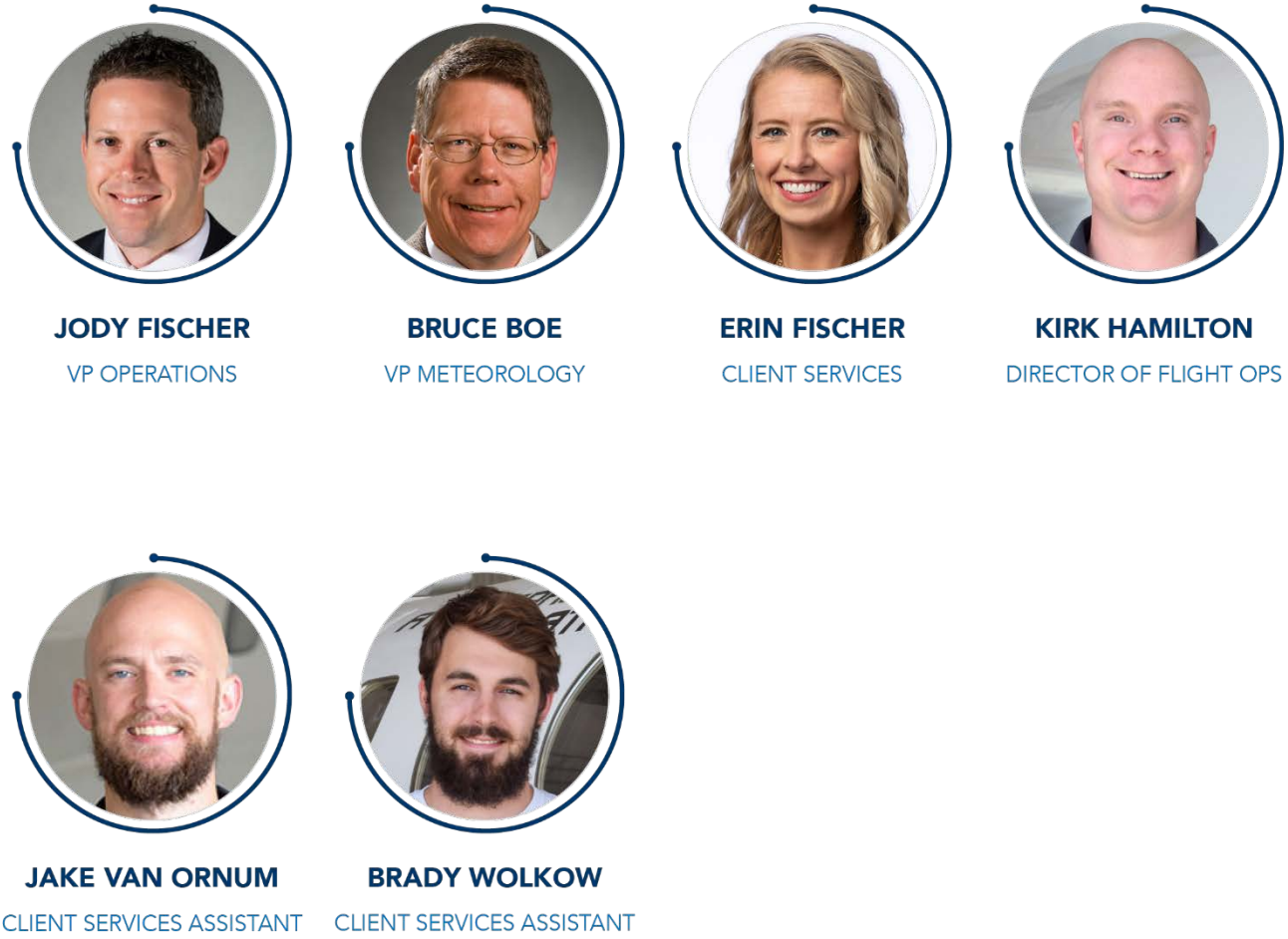

Fig. 32. WMI - NDCMP Administration Team located in Fargo, ND.

Kirk Hamilton, WMI Director of Flight Operations, served as the Project Manager for WMI during the season. This was his ninth season on the North Dakota Cloud Modification Project. Hamilton has also been a PIC for WMI on winter projects in Wyoming and California, as well as a PIC on a rainfall enhancement project in India and The Kingdom of Saudi Arabia.

Hamilton and Fischer were responsible for hiring and training the project pilots, overseeing aircraft operations, aircraft and equipment maintenance, and providing relief pilot duties.

Bruce Boe, WMI Vice President of Meteorology, served as Co-Project Manager in case Mr. Fischer needed to travel outside the state. Mr. Fischer is a Weather Modification Association Certified Weather Modification Operator and Mr. Boe is a WMA Certified Manager. Mr. Boe assumed his present position at WMI in 2001. Prior to coming to WMI he served as Director of the ARB for 12 years.

Dennis Afseth, WMI Director of Electronics, oversaw the installation and maintenance of the datalogger computers and electronics in the aircraft, including *AirLink*.

12.7 NDCMP Project Personnel Pictures

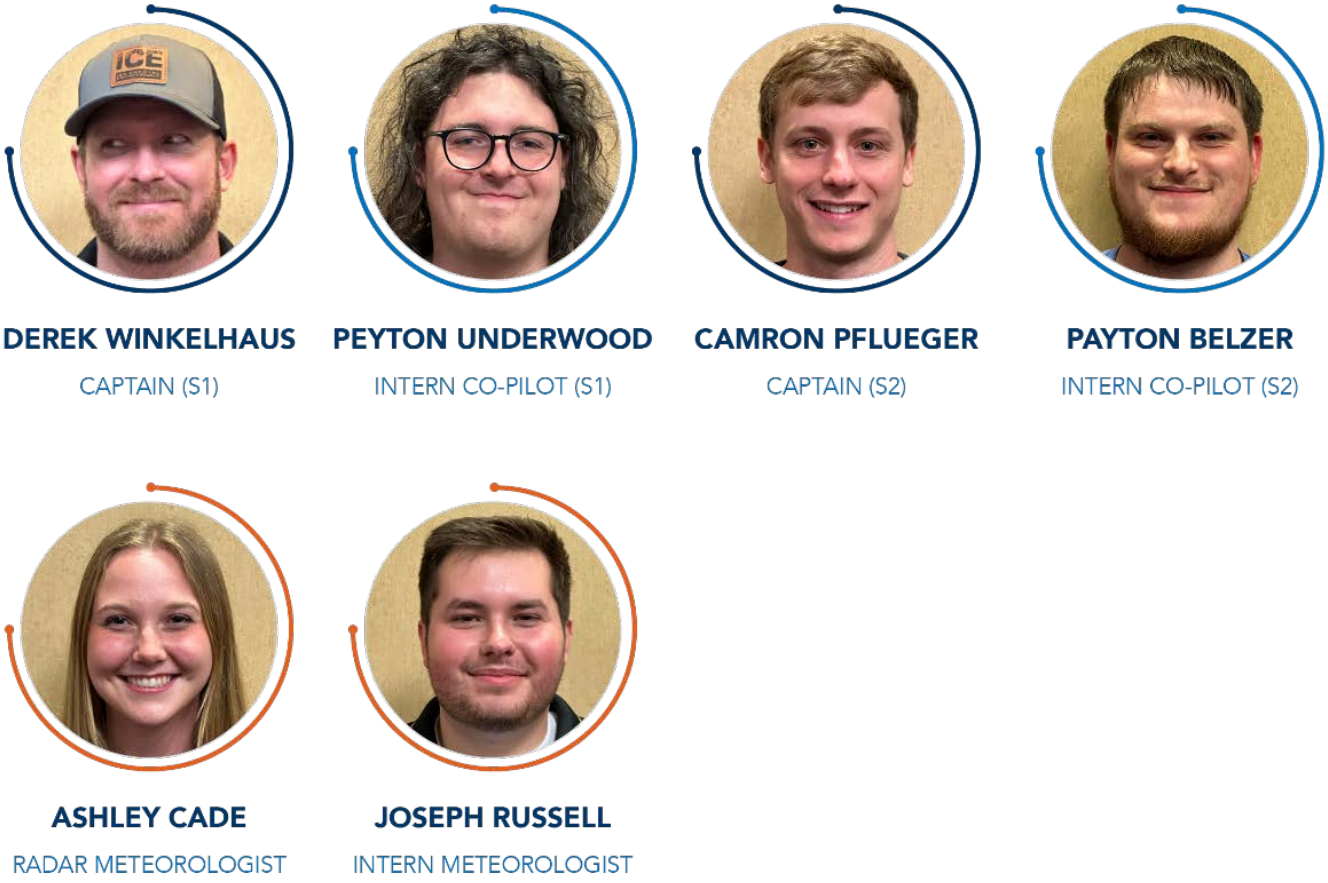

Fig. 33. 2024 District I flight crew and meteorology team. Photos by Dan Brothers, ARB.

Fig. 34. 2024 District II flight crew and meteorology team. Seed 4 was based in Stanley, Seed 5 in Williston, and Seed 7 in Watford City. Photos by Dan Brothers, ARB.

13 PUBLIC RELATIONS

The North Dakota Cloud Modification Project has a rich history of community event participation, education, and public outreach. Bowman airport held a fly-in hamburger lunch on 29 June 2024 where the WMI aircraft were on static display and crews were available for questions for the duration of the event. Bowman also held the annual County Fair from 10-14 July 2024. Pilots and meteorologists, along with ARB meteorologist Dan Brothers, manned the North Dakota Weather Modification Association (NDWMA) booth. With the Stanley airport closure, a fly-in breakfast was not held this year; however, crews arranged a few cookouts with local hangar tenants and friends of the airport. Williston Air Show was held on 3 August 2024. The Seed 5 crew was weather-free during the airshow and took the opportunity to keep the aircraft on location as a static display. Throughout the show, the crew was present to answer questions and show the unique seeding equipment to airshow attendees.

Along with opportunities for community engagement, personnel in both districts continued their acts of volunteerism at their respective airports. Pilots and meteorologists took turns mowing, spraying weeds, assisting with aircraft fueling, and providing general hospitality to airport and radar visitors. Their professionalism, willingness to pitch in, and positive attitude is an example for future projects to look upon.

Fig. 35. Kelli Schoeder (NDCMP Program Manager), Patrick Sweeney (WMI CEO), Darin Langerud (NDCMP Program Director), and Kirk Hamilton (WMI Director of Flight Ops) take a break from District visits on 7 August 2024 for a selfie. The administration team visited Williston, Watford City, and Bowman. Photo by Kirk Hamilton.

14 PROGRAM AWARDS

NDARB recognizes field personnel professionalism and dedication to the project with the presentation of the following project awards. Nominations are taken from project personnel, WMI administration, and ARB staff the last week of project and are carefully considered. This season two awards were presented – the Wilbur E. Brewer Professional Award and the Hans P. Ahlness Outstanding Intern Award.

Wilbur E. Brewer Professionalism Award

Named in honor of one of the founders of WMI and longtime NDCMP advocate, this award was presented to Meteorologist Ben Schaefer. Well familiar with the NDCMP and in his fourth year of service, Ben has shown true professionalism as a supervisor when mentoring and training intern meteorologists. Ben treated his interns as equals and made sure to rotate radar duties during missions so every intern was competent with the TITAN radar system and radio communications with pilots – so much so they could run missions effectively without his help. Aircraft crews in District II agree that Ben was outstanding at communicating and coordinating operations and logistics throughout the summer. Ben went above and beyond what was required of him and consistently demonstrated the level of professionalism everyone should aim for on the NDCMP.

Fig. 36. Ben Schaefer, NDARB Radar Meteorologist, pictured as an intern running operations for the first time in 2021 (left), and as the Radar Meteorologist teaching operations in 2024 (right). Congrats Ben! Photos submitted by Ben Schaefer.

Hans P. Ahlness Outstanding Intern Award

A desire to learn and further their education attracts interns to the NDCMP. This award is given to the intern who had the greatest positive impact on the project and its daily operations and was awarded to Pilot Intern Jackie Venters. Throughout the summer, Jackie showed clear dedication to all aspects of the intern co-pilot job, including maintenance. She always made sure any required work was completed and had the initiative to involve herself in other areas whenever she could. Jackie's desire to know more and drive are an excellent example for other interns to follow. Jackie will be joining the WMI team for winter operations in Idaho in November 2024. Congrats Jackie!

Fig. 37. Jackie Venters, the 2024 NDCMP Hans P. Ahlness Outstanding Intern Award winner. Photo submitted by Jackie Venters.

15 CONTRACTOR'S SUMMARY

This summer was Weather Modification International's 64th season providing operational cloud seeding services for the North Dakota Cloud Modification Project. There was little change from last season with regards to the aircraft and base locations – four Piper Senecas for base seeding and one King Air for top seeding were deployed.

As in past years, operating the King Air from Watford City has proven to be advantageous for the whole of the project. Placed centrally in District II, response time is short to any mission location in the northern district with the additional benefit of being only 45 minutes to District I if needed. 32 takeoffs took place from here for missions in District II, and just 3 for District I, totaling 35. This was nearly identical to the 2023 season. WMI has also built an excellent relationship with the on-site maintenance technician, who is experienced with Beechcraft King Air platforms, reducing the need for flights to Fargo to receive repairs.

WMI operates under a two-crew flight policy. While the aircraft used during the program can normally be operated by one crew member, a second provides WMI and the program (Client) with enhanced cockpit safety and helps to build experience and retain pilots. This year eliminated the vacation rover intern position meaning WMI was responsible for covering all pilot absences and scheduled vacations. WMI would like to thank those relief pilots who ensured these breaks were adequately staffed, especially during periods of seedable weather.

Shortly after closing out the 2024 NDCMP season, Mountrail and Williams counties voted during the November 5th elections to discontinue cloud seeding operations in their respective counties. The loss of these two counties will greatly impact the program moving forward. WMI will work with the NDARB to find the best solution possible, so that the program can continue to serve its constituents with one of the world's most cost effective water resource tools, cloud seeding. A reinvestment in this technology is taking place across multiple western states and it will be critical that ND legislators and its water policymakers are educated on the science and technology.

WMI would like to recognize ARB staff members - Darin Langerud, Mark Schneider, Kelli Schroeder, and Dan Brothers for their consistent management and program direction. Personnel must be hired and trained, equipment maintained and improved, seeding chemicals and flares obtained, and procedures put in place to allow for smooth project operations. The ARB staff members have several years of experience and WMI appreciates working with such professionals.

In closing, WMI invites comments from the ARB regarding this summer's project and improvements for continued operations. Thank you for another great season!

Fig. 38. Derek Winklehaus gives the thumbs up on the first mission for the 2024 summer season, early morning on 2 June 2024. Photo by Oakley Eagleson.

APPENDIX ITEMS

Appendix A: Aircraft Activity Tables

District I	Cloud Top Aircraft, King Air
District I	Cloud Base Aircraft, Seneca II
District II	Cloud Top Aircraft, King Air
District II	Cloud Base Aircraft, Seneca II

Appendix B: Aircraft Specifications

Piper Seneca II
King Air C90

Appendix C: NOAA Final Operations Reporting

Appendix A

District I – Cloud Top Aircraft, King Air

2024 DISTRICT I FLIGHT SUMMARY
CLOUD - TOP (TURBO-PROP ONLY)

DATE	DUAL	HAIL	RAIN	RECON	OTHER	DAILY TOTAL	RUNNING TOTAL	MAINTENAI (Contractor Expense)	DRY ICE (pounds)	FLARES (grams)
06/10/24				1.59		1.59	1.59			
06/22/24	4.31					4.31	5.90		58.20	
						0.00	5.90			
						0.00	5.90			
						0.00	5.90			
						0.00	5.90			
						0.00	5.90			
						0.00	5.90			
						0.00	5.90			
						0.00	5.90			
						0.00	5.90			
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						0.00	5.90			
						0.00	5.90			
						0.00	5.90			
						0.00	5.90			
						0.00	5.90			
						0.00	5.90			
						0.00	5.90			
						0.00	5.90			
						0.00	5.90			
						0.00	5.90			
TOTALS	**4.31**	**0.00**	**0.00**	**1.59**	**0.00**	**5.90**	**5.90**	**0.00**	**58.20**	**0**

TOTAL AgI RELEASED BY C90 AIRCRAFT:	0	grams
TOTAL DRY ICE USED ON PROJECT:	58.20	pounds

District I – Cloud Base Aircraft, Seneca II

2024 DISTRICT I FLIGHT SUMMARY
CLOUD - BASE (Seneca)

						DAILY	RUNNING	MAINTENANCE	GENERATORS - Seneca		GENERATORS - Seneca		FLARES
DATE	DUAL	HAIL	RAIN	RECON	OTHER	TOTAL	TOTAL	(Contractor	ONE	TWO	ONE	TWO	
		(——all flight times in hundredths of hours——)						Expense)	(hours burned)		(grams burned)		(grams)
06/01/24						0.00	0.00	3.18					
06/02/24	1.52			0.96		2.48	2.48		0.35	0.19	70	76	
06/03/24	4.92					4.92	7.40		1.46	0.97	293	390	600
06/07/24						0.00	7.40	0.58					
06/10/24	1.51		2.04		0.79	4.34	11.74		0.80	0.33	161	133	
06/11/24					0.59	0.59	12.33						
06/13/24						0.00	12.33	0.27					
06/14/24						0.00	12.33	0.32					
06/15/24				2.28		2.28	14.61	1.62					
06/16/24				1.03		1.03	15.64						
06/19/24						0.00	15.64	1.98					
06/22/24	1.41			0.44		1.85	17.49			0.76		306	675
06/27/24	4.12			1.38		5.50	22.99	1.31		0.82		330	
06/28/24					3.60	3.60	26.59						
07/01/24			2.70			2.70	29.29		1.94		390		
07/02/24						0.00	29.29	1.87					
07/03/24						0.00	29.29	3.24					
07/04/24			4.38			4.38	33.67		2.24		450		
07/05/24				0.52		0.52	34.19	2.11					
07/06/24	3.12			0.92		4.04	38.23	0.23	0.44	1.37	88	551	600
07/07/24				0.80		0.80	39.03						
07/10/24						0.00	39.03	0.71					
07/11/24	2.94					2.94	41.97		0.32	1.89	64	760	450
07/12/24	4.63					4.63	46.60		0.10	2.54	20	1,021	
07/13/24				0.94		0.94	47.54						
07/14/24	3.51				1.82	5.33	52.87			1.47		591	675
07/17/24						0.00	52.87	1.02					
07/18/24						0.00	52.87	0.63					
07/19/24				1.08		1.08	53.95						
07/21/24				2.00		2.00	55.95						
07/26/24						0.00	55.95	1.99					
07/29/24				1.66		1.66	57.61						
08/02/24						0.00	57.61	0.97					
08/03/24						0.00	57.61	0.62					
08/07/24	3.86				2.36	6.22	63.83			2.01		808	
08/08/24						0.00	63.83	2.23					
08/11/24				1.05		1.05	64.88	0.61					
08/12/24						0.00	64.88	0.98					
08/13/24						0.00	64.88	1.06					
08/16/24						0.00	64.88	0.98					
08/18/24						0.00	64.88	0.87					
08/20/24						0.00	64.88	1.06					
08/22/24		1.54				1.54	66.42	0.96		0.67		269	
08/25/24						0.00	66.42	0.98					
08/27/24						0.00	66.42	0.88					
08/28/24						0.00	66.42	0.94					
						0.00	66.42						
						0.00	66.42						
						0.00	66.42						
						0.00	66.42						
TOTALS	31.54	1.54	9.12	15.06	9.16	66.42	66.42	34.20	7.65	13.02	1,538	5,234	3,000

TOTAL AgI RELEASED BY BASE AIRCRAFT 9,772 grams

District II – Cloud Top Aircraft, King Air

2024 DISTRICT II FLIGHT SUMMARY
CLOUD - TOP (TURBO-PROP ONLY)

DATE	DUAL	HAIL	RAIN	RECON	OTHER	DAILY TOTAL	RUNNING TOTAL	MAINTENAI (Contractor Expense)	DRY ICE (pounds)	FLARES (grams)
06/01/24						0.00	0.00	1.16		
06/02/24		2.35				2.35	2.35		63.62	80
06/03/24	1.55					1.55	3.90	3.58		220
06/10/24				1.61		1.61	5.51			
06/14/24		2.18				2.18	7.69		24.42	
06/15/24				1.16		1.16	8.85			
06/16/24	2.31					2.31	11.16		42.68	
06/17/24				1.12		1.12	12.28			
06/18/24					0.92	0.92	13.20			
06/20/24				1.55		1.55	14.75			
06/22/24		1.69				1.69	16.44			80
06/24/24				2.00		2.00	18.44			
06/27/24	2.71					2.71	21.15			260
07/03/24		3.26				3.26	24.41			300
07/04/24	2.56					2.56	26.97			360
07/06/24	2.17					2.17	29.14		6.40	240
07/07/24			1.62			1.62	30.76			40
07/12/24		3.34				3.34	34.10			580
07/13/24		1.72		1.14		2.86	36.96			240
07/15/24	4.32					4.32	41.28			920
07/20/24		3.10				3.10	44.38			180
07/22/24				1.31		1.31	45.69			
07/29/24				1.52		1.52	47.21			
07/30/24				2.20		2.20	49.41			
08/06/24		3.49				3.49	52.90			1000
08/11/24			3.00			3.00	55.90		16.92	
08/13/24	3.34					3.34	59.24		62.26	
08/14/24	3.55			2.42		5.97	65.21		43.68	160
08/19/24				1.58		1.58	66.79			
08/20/24	2.96					2.96	69.75			480
08/22/24				0.84		0.84	70.59			
08/31/24						0.00	70.59	2.44		
						0.00	70.59			
						0.00	70.59			
						0.00	70.59			
						0.00	70.59			
						0.00	70.59			
						0.00	70.59			
						0.00	70.59			
						0.00	70.59			
						0.00	70.59			
						0.00	70.59			
						0.00	70.59			
						0.00	70.59			
						0.00	70.59			
						0.00	70.59			
						0.00	70.59			
						0.00	70.59			
TOTALS	25.47	21.13	4.62	18.45	0.92	70.59	70.59	7.18	259.98	5,140

TOTAL AgI RELEASED BY C90 AIRCRAFT: 5,140 grams
TOTAL DRY ICE USED ON PROJECT: 259.98 pounds

District II – Cloud Base Aircraft, Seneca II

2024 DISTRICT II FLIGHT SUMMARY
CLOUD - BASE (Seneca)

						DAILY	RUNNING	MAINTENAN	GENERATORS - Senecas		GENERATORS - Senecas		FLARES
DATE	DUAL	HAIL	RAIN	RECON	OTHER	TOTAL	TOTAL	(Contractor	ONE	TWO	ONE	TWO	
		(---------all flight times in hundredths of hours---------)						Expense)	(hours burned)		(grams burned)		(grams)
06/01/24						0.00	0.00	2.20					
06/02/24		6.37		1.53		7.90	7.90		0.14	3.82	28	1,536	1200
06/03/24	3.47	3.52				6.99	14.89	0.42	0.52	3.27	105	1,315	825
06/04/24	1.95				1.70	3.65	18.54		0.46	0.23	92	92	
06/06/24						0.00	18.54	1.23					
06/08/24						0.00	18.54	0.98					
06/09/24						0.00	18.54	1.10					
06/10/24				1.82		1.82	20.36						
06/11/24	1.03					1.03	21.39			0.19		76	
06/14/24		5.71				5.71	27.10	0.69	0.29	3.38	58	1,359	2400
06/15/24				1.63		1.63	28.73						
06/16/24		5.49			2.35	7.84	36.57			3.51		1,411	2775
06/17/24				1.18		1.18	37.75	4.71					
06/18/24					1.14	1.14	38.89						
06/21/24						0.00	38.89	0.59					
06/22/24				1.42		1.42	40.31	1.22					
06/23/24		2.76				2.76	43.07			0.93		374	
06/24/24		4.72			1.66	6.38	49.45		0.02	1.74	4	699	450
06/27/24	6.7					6.70	56.15			2.49		1,001	1125
06/28/24					1.46	1.46	57.61						
07/01/24		2.54			1.01	3.55	61.16			1.57		631	
07/02/24					0.47	0.47	61.63						
07/03/24	7.41					7.41	69.04		2.30	2.28	462	917	150
07/04/24		5.61			0.49	6.10	75.14			3.16		1,270	
07/05/24	2.71					2.71	77.85		0.51	0.39	103	157	
07/06/24	2.53	4.40			0.71	7.64	85.49		0.48	3.37	96	1,355	225
07/10/24						0.00	85.49	1.69					
07/11/24						0.00	85.49	0.55					
07/12/24		5.41				5.41	90.90			2.96		1,190	2775
07/13/24		3.71		1.41		5.12	96.02			1.16		466	675
07/15/24	3.38	3.62				7.00	103.02		0.17	4.38	34	1,761	2850
07/18/24						0.00	103.02	2.04					
07/20/24				0.80		0.80	103.82						
07/23/24						0.00	103.82	0.93					
07/24/24						0.00	103.82	1.00					
07/27/24						0.00	103.82	0.89					
07/28/24						0.00	103.82	1.05					
07/29/24				1.38		1.38	105.20						
07/30/24		1.67				1.67	106.87			0.60		241	
08/04/24						0.00	106.87	0.99					
08/06/24		5.17				5.17	112.04			3.14		1,262	1725
08/11/24			2.68			2.68	114.72	1.10	1.66		334		
08/13/24	3.26					3.26	117.98		1.93	0.41	388	165	
08/14/24	3.62	2.67		1.91		8.20	126.18		0.69	2.89	139	1,162	1725
08/16/24						0.00	126.18	2.55					
08/18/24					0.39	0.39	126.57						
08/19/24	3.58					3.58	130.15			1.49		599	
08/20/24	1.81				0.38	2.19	132.34			0.34		137	
08/21/24				0.96		0.96	133.30						
08/22/24	3.46	3.78				7.24	140.54			3.43			375
08/28/24						0.00	140.54	1.10					
09/01/24						0.00	140.54	1.06					
09/02/24						0.00	140.54	0.88					
09/08/24						0.00	140.54	0.43					
						0.00	140.54						
TOTALS	**44.91**	**67.15**	**2.68**	**14.04**	**11.76**	**140.54**	**140.54**	**29.40**	**9.17**	**51.13**	**1,843**	**19,175**	**19,275**

TOTAL AgI RELEASED BY BASE AIRCR 40,294 grams

Appendix B

Piper Seneca II

PIPER SENECA II SPECIFICATIONS
4,570 lbs maximum gross weight
3,200 lbs typical empty weight
1,370 lbs typical useful load
Turbocharged, 200HP engines
Portable supplemental oxygen system
200 hp per engine at sea level
215 hp at 12,000 ft
225 mph max cruise speed
185 mph recommended cruise speed
70 mph stall in landing configuration
93-123 gallons usable fuel capacity
25,000 feet all engine service ceiling
14,000 feet single engine service ceiling
1,200 feet per minute all engine rate of climb
190 feet per minute single engine rate of climb
1,030 feet for takeoff over 50-ft obstruction
750 feet for takeoff ground roll
950 feet landing ground roll
28 ft. 07 in. length
9 ft. 11 in. height
38 ft. 11 in. wingspan

King Air C90

KING AIR C90 SPECIFICATIONS
Full de-icing capabilities
Turboprop twin engine PT6A-21 engines
10,100 lbs gross weight
5,765 lbs typical empty weight
3,010 lbs typical useful load
550HP per engine
240 kts max cruise speed
384 gallons usable fuel capacity
30,000 feet all engine service ceiling
15,600 feet single engine service ceiling
2,137 feet per minute all engine rate of climb
626 feet per minute single engine rate of climb
3,100 feet for takeoff over 50-ft obstruction
2,250 feet for takeoff ground roll
1,730 feet land over 50-ft obstruction
800 feet landing ground roll
35 ft. 06 in. length
14 ft. 03 in. height
50 ft. 03 in. wingspan

Appendix C

NOAA FORM 17-4A (4-81) — U.S. DEPARTMENT OF COMMERCE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Form Approved OMB No. 0648-0025 Expires 01/31/2018

INTERIM ACTIVITY REPORTS AND FINAL REPORT

This report is required by Public Law 92-205; 85 Stat. 735; 145 U.S.C. 330b. Knowing and willful violation of any rule adopted under the authority of Section 2 of Public Law 92-205 shall subject the person violating such rule to a fine of not more than $10,000, upon conviction thereof.

NOAA FILE NUMBER

[ ] INTERIM REPORT [x] FINAL REPORT

Complete in accordance with instructions on reverse and forward one copy to:
National Oceanic and Atmospheric Administration
Office of Oceanic and Atmospheric Research
1315 East-West Highway SSMC-3 Room 11554
Silver Spring, MD 20910

REPORTING PERIOD: FROM 06/01/2024 TO 09/08/2024

MONTH	(a) NUMBER OF MODIFICATION DAYS	(b) NUMBER OF MODIFICATION DAYS PER MAJOR PURPOSE				(c) HOURS OF APPARATUS OPERATION BY TYPE		(d) TYPE AND AMOUNT OF AGENT USED				
		INCREASE PRECIPITATION	ALLEVIATE HAIL	ALLEVIATE FOG	OTHER	AIRBORNE	GROUND	SILVER IODIDE GMS	CARBON DIOXIDE LBS	UREA	SODIUM CHLORIDE	OTHER
JANUARY												
FEBRUARY												
MARCH												
APRIL												
MAY												
JUNE	11	7	11			45		10,154	189			
JULY	13	10	12			63		13,818	6			
AUGUST	8	7	7			33		5,844	123			
SEPTEMBER	0	0	0			0		0	0			
OCTOBER												
NOVEMBER												
DECEMBER												
TOTAL	32	24	30	0	0	141	0	29,816	318	0	0	0
TOTALS FOR FINAL REPORT	32	24	30	0	0	141	0	29,816	318	0	0	0

DATE ON WHICH FINAL WEATHER MODIFICATION ACTIVITY OCCURRED *(For Final Report only.)* 08/22/2024

CERTIFICATION: I certify that all statements in this report on this weather modification project are complete and correct to the best of my knowledge and are made in good faith.

NAME OF REPORTING PERSON: Kelli Schroeder

AFFILIATION: ND Atmospheric Resource Board

SIGNATURE: Kelli Schroeder

STREET ADDRESS: 1200 Memorial Hwy

OFFICIAL TITLE: Program Manager

CITY: Bismarck STATE: ND ZIP CODE: 58504

DATE: 10/2/2024