2023 FINAL OPERATIONS REPORT

NDCMP

NORTH DAKOTA CLOUD MODIFICATION PROJECT

NORTH DAKOTA ATMOSPHERIC RESOURCE BOARD

WEATHER MODIFICATION INTERNATIONAL

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2023 FINAL OPERATIONS REPORT

Report prepared for

NORTH Dakota Be Legendary. | Atmospheric Resource Board
WATER RESOURCES

State of North Dakota
Atmospheric Resource Board
Department of Water Resources
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By

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EXECUTIVE SUMMARY

This report details the activities of Weather Modification International (WMI) during the 2023 North Dakota Cloud Modification Project (NDCMP) field operations. This was the 63rd consecutive summer season of the NDCMP and the second 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).

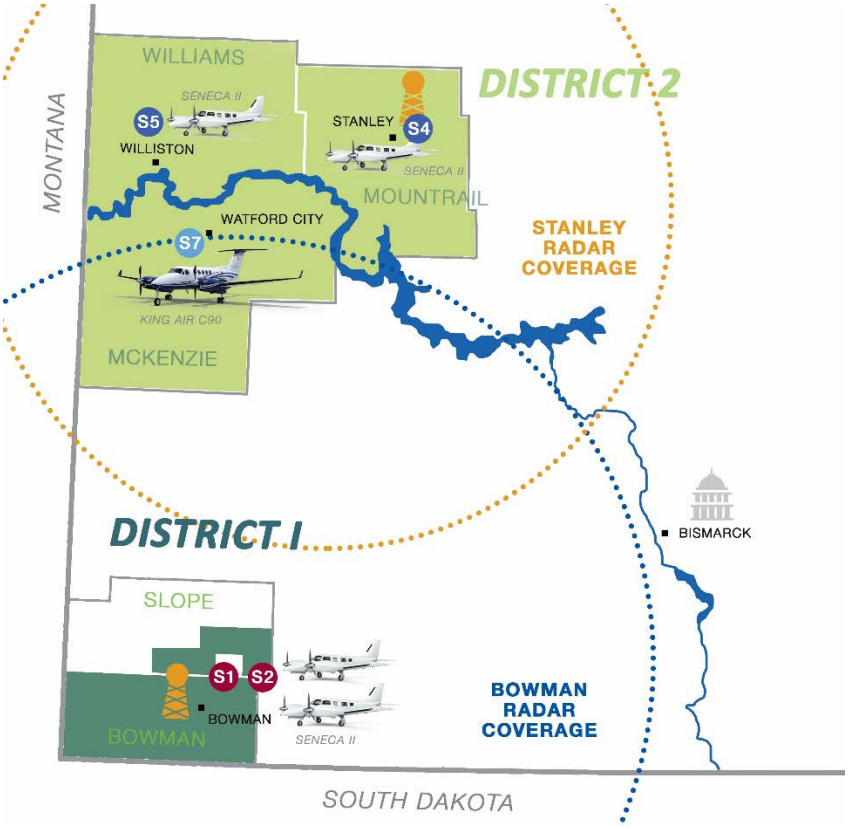

Fig. 1. NDCMP 2023 Operational Target Areas. The circles indicate approximate radar coverage from District I- Bowman (blue) and District II-Stanley (orange). Graphic by WMI.

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 June 1st through August 31st, 2023 for District II, and June 1st through September 8th for District I. The five-project aircraft flew a total of 349.91 hours (Including Maintenance: 119.27 hours in District I and 219.47 hours in District II). A total of 3,832.55 pounds of dry ice pellets were dispensed during the 2023 season.

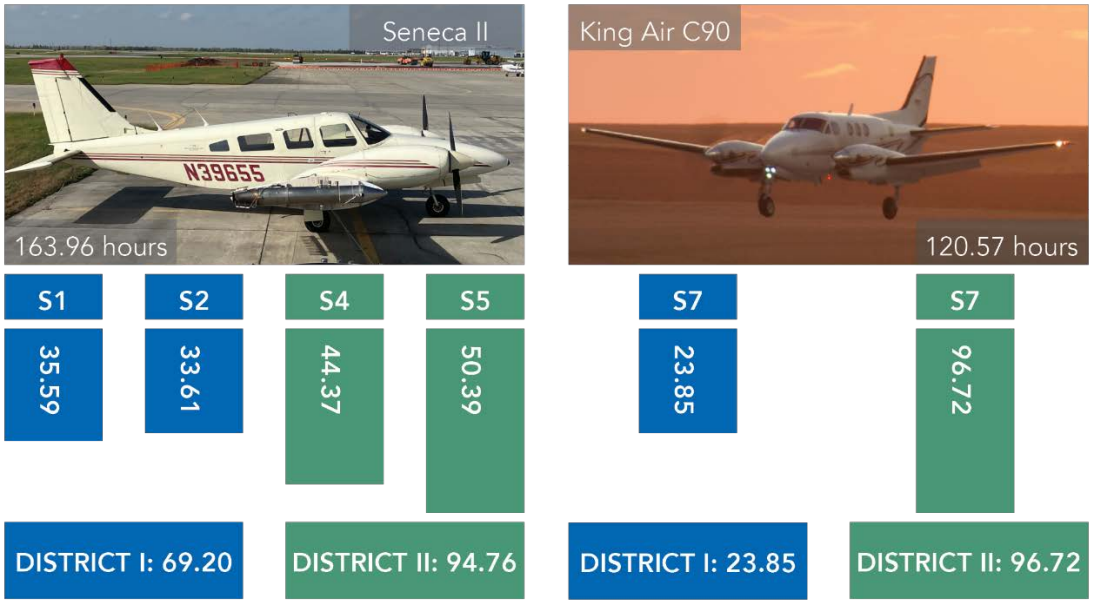

Fig. 2. 2023 NDCMP flight operations categorized by aircraft type, including the least to most flight hours by location. Seneca II photo by Alex Sailsbury and King Air photo by Ryan Starkey. Graphic by WMI.

Winter in North Dakota brought above average precipitation for most of the state except for the northwestern portion, including District 2. This allowed existing drought conditions to significantly wain by springtime. Spring experienced near average precipitation for most of the state keeping additional drought development at bay. By the end of May, only about 21% of the state was experiencing abnormally dry conditions while only 0.04% were in moderate drought, notably in southwestern Bowman County. June ushered in warmer than average temperatures for the entire state but split the state between well above normal rainfall in the south and well below rainfall in the north. This led to drought conditions in the south/southwestern part of the state to disappear while drought conditions persisted and even expanded in the north.

July brought a change to cooler than normal temperatures and mostly below normal rainfall across the state. However, some areas that experienced frequent “hit or miss” showers and thunderstorms were able to pick up much more rain and remain around average at some stations. Generally, near normal temperatures occurred in August with above normal rainfall, especially in southwestern North Dakota. The late start to the growing season in Southwestern North Dakota led the District 1 counties to elect to continue hail suppression operations into early September. Summer ended with near to above average temperatures in September with near to below normal rainfall in west and eastern North Dakota, but much wetter in central North Dakota. Ending September, 26.5% of the state are experiencing some type of drought. This area mainly ranges from the northern tier to the eastern portion of the state including parts of District 2.

Fig. 3. A lush river valley shows off a lovely shade of green in the North Unit of Theodore Roosevelt National Park. Photo by Jake Floyd.

The 2023 season ended with a total of 284.53 flight hours, considerably lower than all calculated statistical averages, including the 25-year average of 560.97hrs, 20-year average of 502.82hrs, the 15-year average of 479.3hrs, the 10-year average of 453.78hrs, and the 5-year average of 355.85hrs. It is very close to last year's total of 285.55 flight hours. 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.

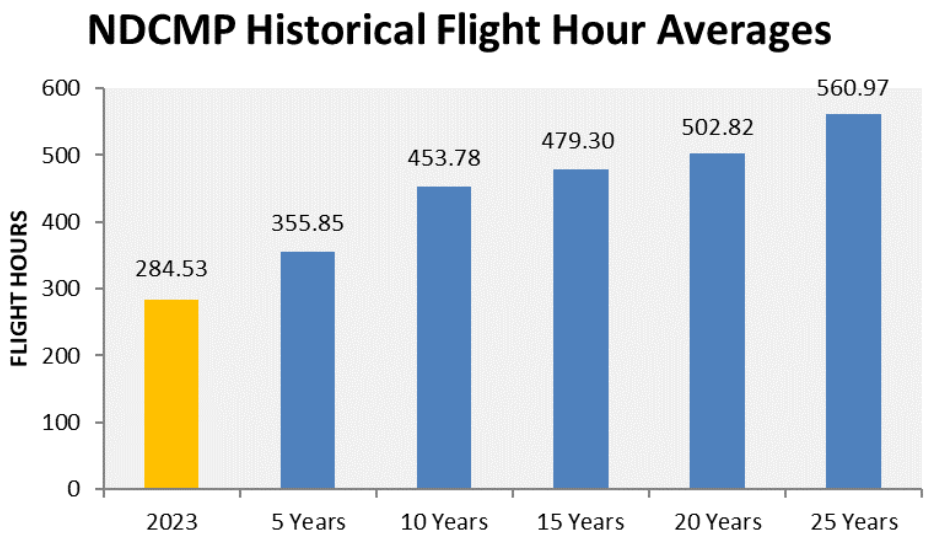

Fig. 4. Flight hour historical average displayed in 5-year increments starting in 1998 inclusive of 2023.

All counties within the project area conducted hail suppression and rain enhancement operations from June 1st – August 31st, with rain enhancement suspensions requested as needed by individual counties (see Table 4). District I elected to extend the project by 8 days. The two Bowman-based Senecas remained in Bowman for the extension. No counties in District II elected to extend. Two district II-based airplanes ferried the night of the 31st, and one ferried on September 1st.

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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, with the exception of 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. 5. WMI aircraft await a NDCMP season on the ramp in Bowman, ND. Image taken by Hans Ahlness, summer of 1984.

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 2023 program was the 49th 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.

2023 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. 2023 NDCMP Board Members.

2023 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. 2023 NDCMP County Authority Members – District I.

2023 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)	Lynn Heinle, White Earth
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. 2023 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.

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 2023 NDCMP. This does not include the local vendors and technicians employed by the ARB and WMI during the season.

Fig. 6. A storm northeast of Bowman airport on July 29th, 2023, marches slowly onwards. Photo by Jacob Azriel.

3 2023 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 200 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. 7. Weather Modification Int'l and Fargo Jet Center LLC headquarters at Hector International Airport, Fargo, ND.

4 PROJECT DESIGN

The design of the 2023 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.

Fig. 8. A view over the left wing of N33144 in District I. July 29,2023. Photo by Brooke Buccowich.

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.

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.

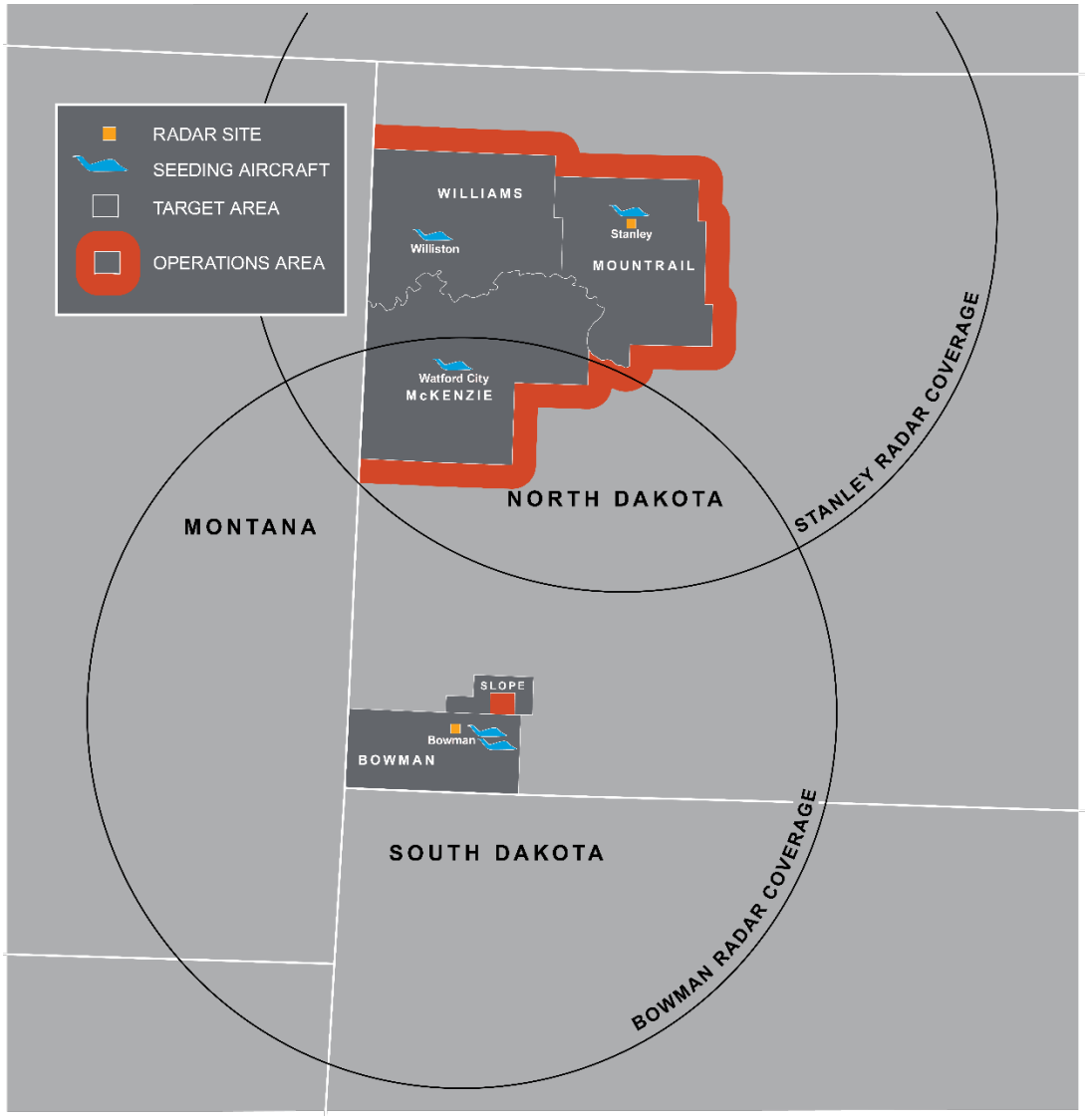

Fig. 9. A representation of the seeding target areas for both districts, aircraft bases, and radar range capabilities for the 2023 NDCMP. Graphic courtesy of the NDARB.

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.

The 2023 season saw the carryover of changes made for the previous season. Seeds 4 & 5, both Piper Senecas outfitted for base seeding, were in Stanley and Williston respectively. Seed 7, a King Air C90 outfitted for top seeding, remained stationed in Watford City. Seed 7 was utilized as a top seeder for District I on a case-by-case storm basis.

Fig. 10. Seed 7 makes its way around a large mature cell while seeking new growth on July 11th,2023. Photo by Ryan Starkey.

Two Piper Seneca II aircraft (US FAA registration N13AG and N33144, later replaced by Seneca N39655)) were based in Bowman, ND for District I operations. District II was operated from three bases: Stanley, Williston, and Watford City. One Piper Seneca II (N121WA) was based in Stanley while one Piper Seneca II (N9798C) was based in Williston. One Beechcraft King Air C90 (N709EA) was based in Watford City.

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. 11. The Bowman radar site keeps vigilant watch as a storm moves through Bowman County. July 29th, 2023. Photo by Jacob Azriel.

6 DAILY OPERATIONS

The 2023 season of the North Dakota Cloud Modification Project became active at noon CDT (11:00 am MDT) on June 1st for both districts. The project ended for District II counties (McKenzie, Mountrail, Williams) at 11:59 pm CDT on August 31st, 2023. The project ended for District I at 11:59pm MDT on September 8th, 2023.

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. 12 WMI Captains Ryan Starkey (left) and Brooke Buccowich (right) conduct some training and troubleshooting in Piper Seneca N33144. N33144 would eventually be replaced by Piper Seneca N39655 late in the summer season.

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.

Fig. 13. N33144 (Seed 2) Seeds an evening storm over District 1 on July 29th, 2023. Photo by Brooke Buccowich.

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.

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.

Fig. 14. Captain Heinrich Adriaanse snaps a selfie as he and Pilot Intern Chris Chederquist wing their way west on an evening mission.

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 2023 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.

The project aircraft were ferried to their respective summer bases at the start of project. Seneca N33144 was ferried to Bowman on May 30th, 2023. Due to an airport closure in Stanley, Seneca N121WA ferried to Williston on May 31st. N121WA was moved to Stanley the following day on June 1st for the start of project. Seneca N9798C ferried to Williston on May 30th. King Air N709EA ferried to Watford City on June 1st, due to a delay in maintenance. N709EA flew a seeding mission the same day the aircraft was ferried to project. The final project aircraft to ferry was Seneca N13AG, which was ferried to Bowman on June 2nd, due to delays in maintenance.

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 June 1st. Aircraft that ferried late due to maintenance delays were loaded with seeding materials as soon as the aircraft landed at their respective project bases. Crews conducted "District Tour" flights at the start of the 2023 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 Alex Sailsbury, UAS Operations Specialist. Sailsbury, Fischer, and Captain Ryan Starkey 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 Starkey, Sailsbury, Fischer, or Kirk Hamilton (Director of Flight Operations) immediately if any unscheduled maintenance was required.

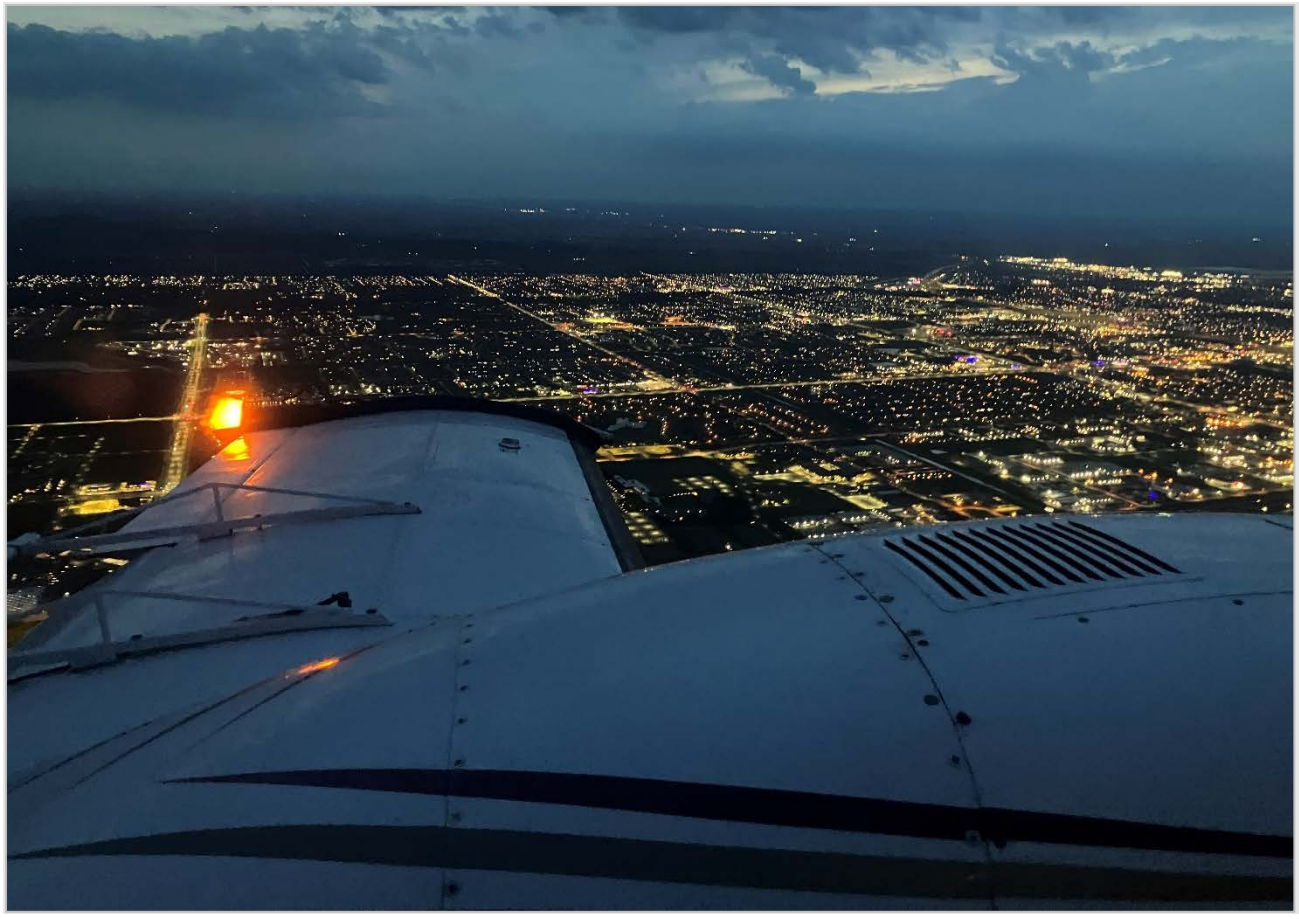

Fig. 15. A rare evening burner test flight over Fargo, ensuring all systems are go before heading out to project. Photo by Alex Sailsbury.

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 2023 NDCMP featuring:

2023 NDCMP AIRCRAFT MAINTENANCE

DATE	AIRCRAFT #	MX SUMMARY
6/1/2023	N709EA	Arrived at Watford City @ 4:45pm. Completed one seeding mission.
6/1/2023	N121WA	Encountered issue with RH engine during operations. Arranged for maintenance technician to arrive on 6/2 for repair on-site.
6/2/2023	N33144	N33144 flew to KFAR to drop off a crew to pick up N13AG. Both aircraft arrived in BWW @ 2pm Central. N13AG was one day late to project.
6/2/2023	N121WA	Maintenance arrived @ 3:30pm (after the Stanley airport opened). N121WA was repaired and operational @ 6pm Central.
6/22/2023	ALL SENECA II	Cable shielding was added to the Seneca's datalogger radio antennas.
6/30/2023	N121WA	Repositioned to Watford City, ND for replacement of a nav light switch.
7/1/2023	N13AG, N33144	Dataloggers replaced on-site.
7/3/2023	N9798C	Repositioned to Bowman, ND for a 50-hour inspection.
7/7/2023	N9798C	Repositioned to Watford City, ND to replace pushrod seals on a RH engine cylinder.
7/11/2023	N13AG	Replaced datalogger radio box.
7/12/2023	N709EA	Repositioned to Fargo, ND to replace radome and wingtip light cover due to hail damage encountered during operations.
7/13/2023	D2 SENECAS	Received datalogger software update.
7/19/2023	N13AG	Replaced landing light and recog light.
7/24/2023	N121WA	Repositioned to Watford City, ND to have alternators paralleled.
7/31/2023	N121WA	Burner control box LH spark wire resoldered.
8/1/2023	N709EA	Dry ice hopper motor replaced. One mission was terminated early due the weather not being sufficient for ejectables (dry ice preferred by NDARB meteorology team).
8/1/2023	N9798C	Hobbs meter replaced; did not repair the issue. Ongoing diagnosis.
8/3/2023	N33144	Oil change and back door hinge replaced.
8/11/2023	N33144	Returned to Fargo for the season due to ongoing maintenance issues. Replaced with N39655.
8/23/2023	N709EA	Pressurization leak during mission. Fixed damaged door seal hose on-site.
8/24/2023	N121WA	50-hour gear inspection.
8/30/2023	N709EA	Pressurization leak during mission. Door seal temporarily repaired for Ferry flight back to Fargo, ND.

Table 4. Summary of WMI aircraft maintenance performed during the 2023 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.

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.

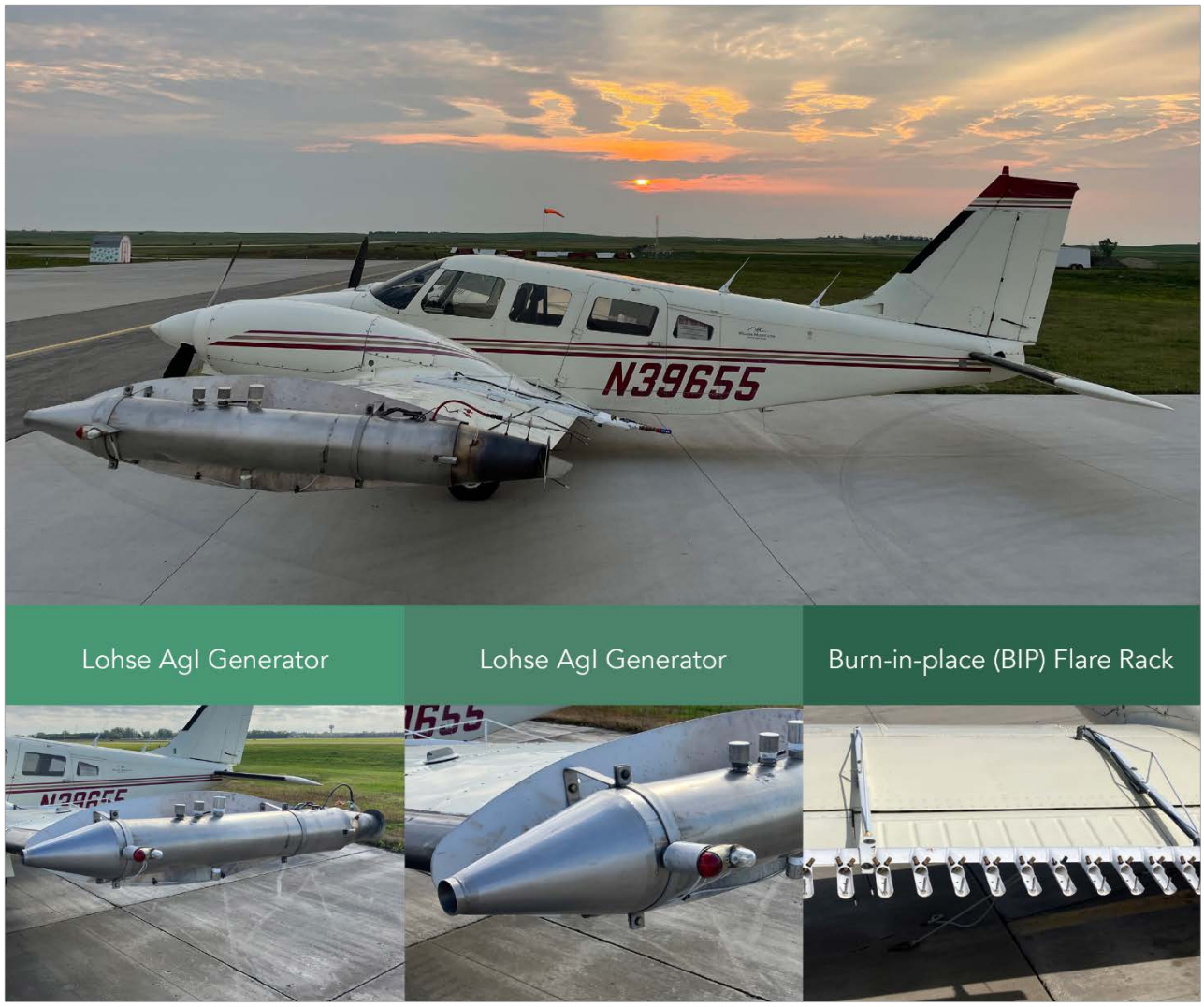

Fig. 16. WMI seeding Piper Seneca II aircraft. Photos by Ryan Starkey (2021 Intern Pilot; 2022 & 2023 Captain), Keisuke Yoshimura (2013 ARB Intern Pilot), and Taylor Exizidis-Meier (2020, 2021 WMI Captain).

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.

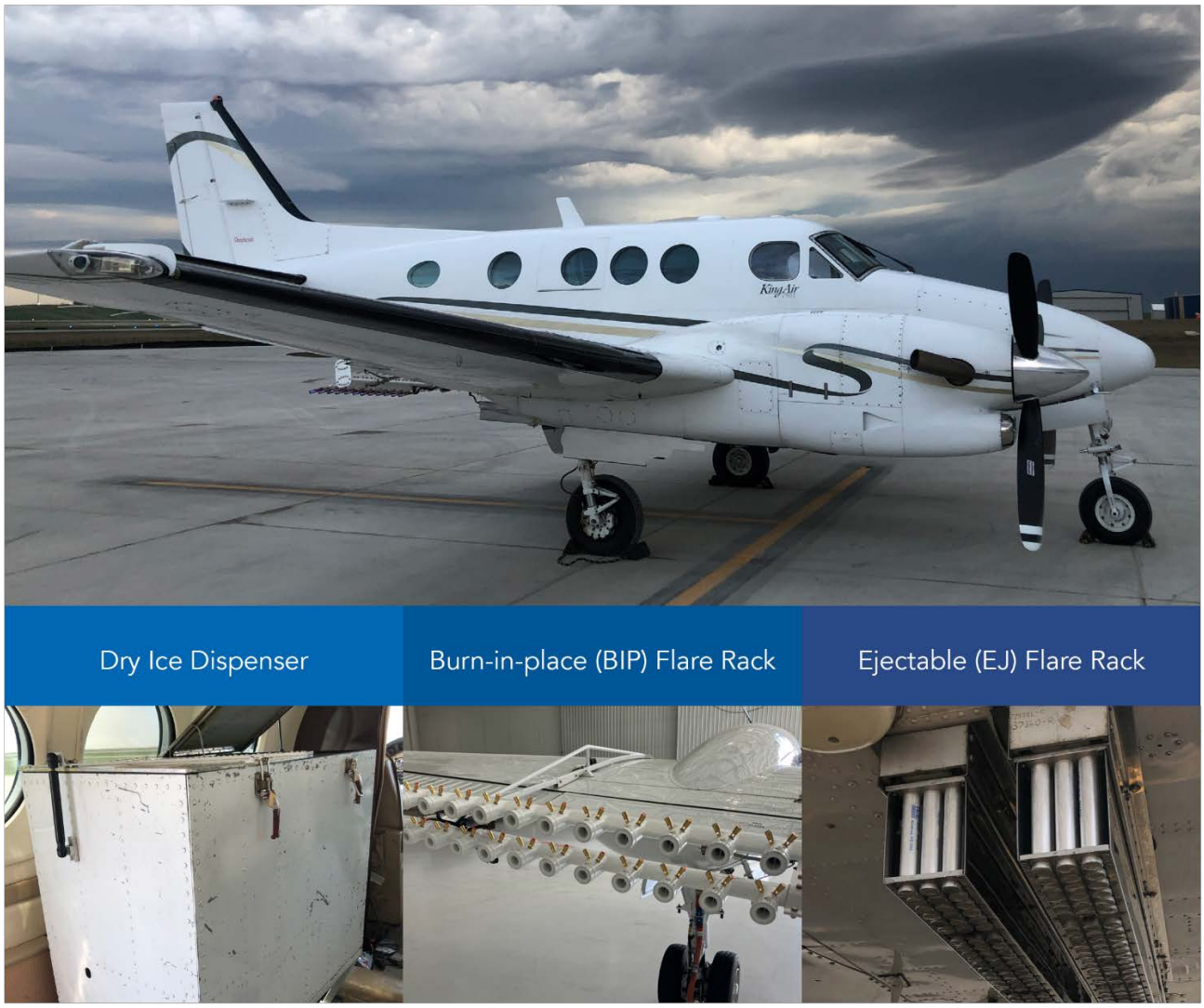

Fig. 17. WMI cloud top Beechcraft King Air C90 aircraft N709EA, Seed 7, in Williston. Photos courtesy of Kirk Hamilton (WMI Chief Pilot), Alex Sailsbury (2018- 2021 WMI Captain), and WMI.

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 4.89%, which was above average with the 10-year average of 2.36%. The high failure rate was due to only four reported failures with limited ops this year.

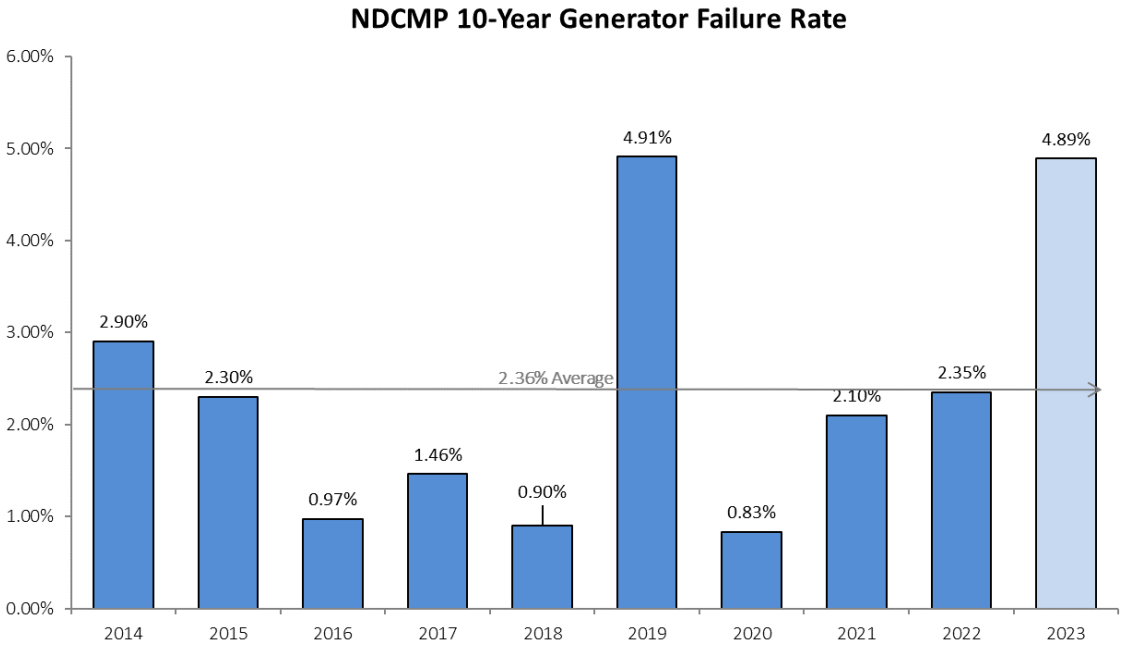

Fig. 18. NDCMP 10-Year Generator Failure Rate chart.

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.

Fig. 19. Intern Pilot Austin Krause scoops a shovel load of dry ice into a sifter in preparation for a seeding mission. Sifting the dry ice is a critical step while preparing Seed 7 for launch. Photo by Ryan Starkey.

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.

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.

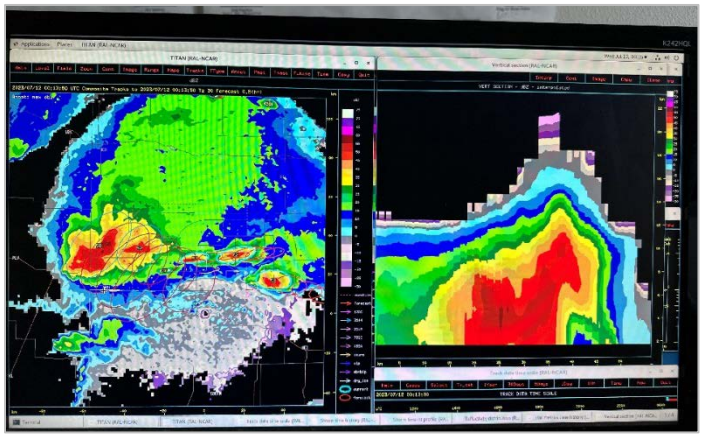

Fig. 20. Photo by Jacob Azriel showing the TITAN display used by Meteorologists. TITAN is the primary radar tool Meteorologists see and use to manage missions and keep aircraft safe.

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. 21. Seed 7 (N709EA) conducts a reconnaissance flight near a developed cell. Photo by Kieran Viggiano.

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 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.

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.

2023 NDCMP RAIN ENHANCEMENT SUSPENSIONS

Date	Bowman	SWMA	McKenzie	Mountrail	Williams
6/1/2023	enhance	enhance	enhance	enhance	enhance
6/5/2023	enhance	enhance	enhance	enhance	enhance
6/12/2023	enhance	enhance	enhance	enhance	enhance
6/19/2023	enhance	enhance	enhance	enhance	enhance
6/26/2023	suspend	suspend	enhance	enhance	enhance
7/3/2023	suspend	suspend	enhance	enhance	enhance
7/10/2023	suspend	suspend	enhance	enhance	enhance
7/17/2023	suspend	did not hear so remained suspended	enhance	enhance	enhance
7/24/2023	suspend	suspend	enhance	enhance	enhance
7/31/2023	suspend - reserve hours for possible extension	enhance	enhance	enhance 1 more week	enhance
8/4/2023	Director ordered suspend RE in D1 until further notice due to Flood Watch & excess rainfall.		--	--	--
8/7/2023	suspend	suspend	enhance	suspend	suspend
8/14/2023	suspend	suspend	enhance	suspend	suspend
8/21/2023	suspend	suspend	suspend	suspend	suspend
8/28/2023	suspend	suspend	suspend	suspend	suspend
9/4/2023	suspend - good rain last night	suspend	X	X	X

Table 5. Rain enhancement suspension dates by county.

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. This was proven when on the first day of the project there were hail suppression operations in District 1. Conditions in June were contrasting between the two districts. District 1 received rainfall of up to twice the monthly average at some locations. However, in District 2 most locations barely received half their monthly average rainfall. This can be credited to the strong upper-level ridge that was in place for much of the month. It was located directly over the southern half of the state allowing for many shortwaves to ride along it bringing rain and even thunderstorms. Additionally, this allowed for warmer than average temperatures over the project areas. Starting June, western counties, including McKenzie, Slope, and Bowman, were labeled as "abnormally dry," the lowest drought classification. By the end of the month, any drought conditions in District 1 had disappeared, while some abnormally dry conditions developed and continued in Williams and McKenzie Counties.

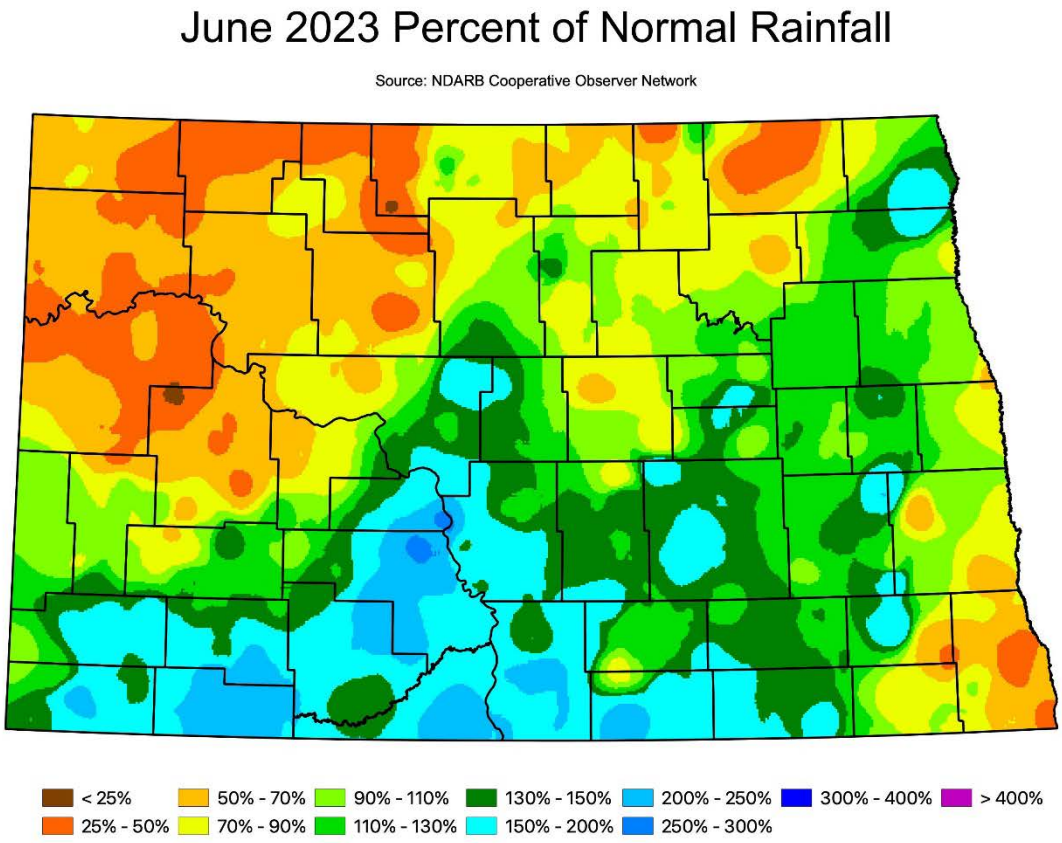

Fig. 22. Percent of Normal Rainfall map for the month of June. Graphic produced by the NDARB through their Cooperative Observer network.

10.3.2 JULY

July is normally the hottest month of the year in North Dakota; however, this year that was not the case with below average temperatures experienced in the project areas. This also brought drier and less convective weather for both districts. The ridge that had been bringing warm weather and allowing for disturbances to ride along it had broken down leading to conditions not suitable for widespread convective weather. While most areas received only about half of their normal rainfall, some localized areas did receive near normal amounts of rain. This is due to the lack of supportive synoptic weather patterns affecting North Dakota, pulse type showers and thunderstorms were able to develop. These pulse storms are often short-lived, but slow-moving allowing for significant rainfall accumulation for areas under them. These brought opportunities for rain enhancement and even hail suppression missions. Starting the month, only parts of Williams and McKenzie Counties were experiencing abnormally dry, drought conditions. However, by the end of the month the entirety of District 2 was experiencing abnormally dry conditions with part of Williams County classified as experiencing moderate drought.

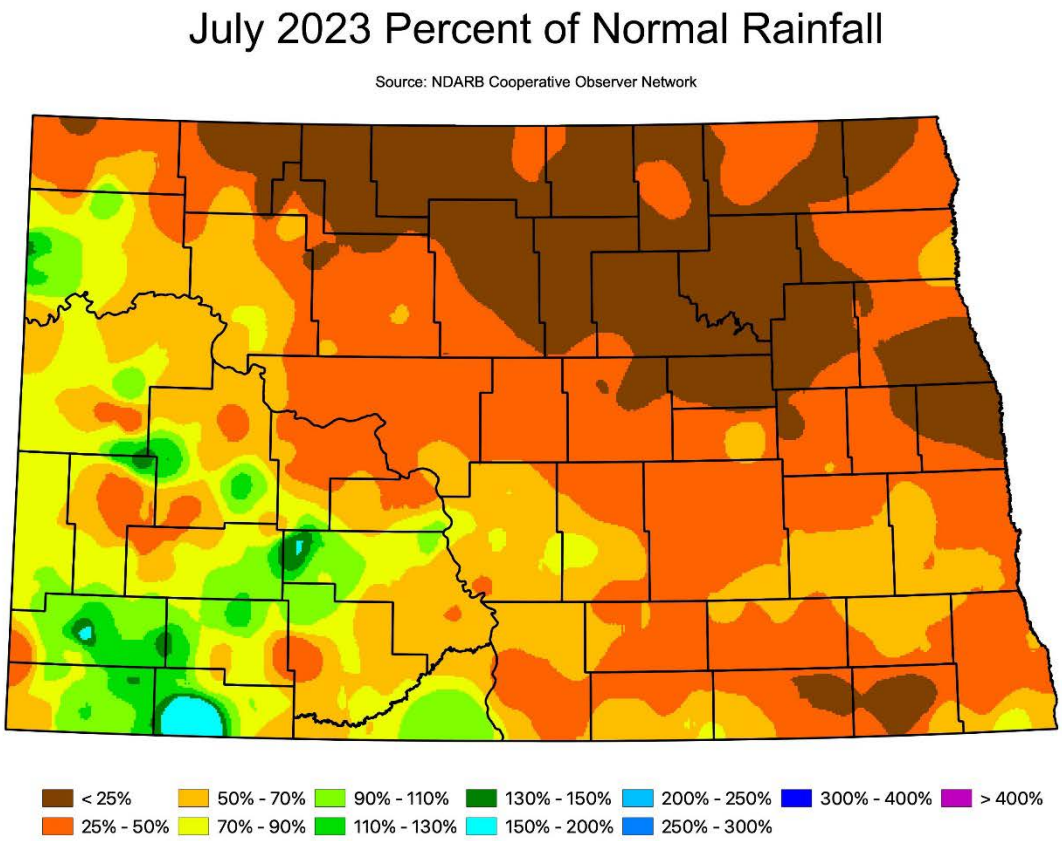

Fig. 23. Percent of Normal Rainfall map for the month of July. Graphic produced by the NDARB through their Cooperative Observer network.

10.3.3 AUGUST

August brought widespread rainfall and near normal temperatures to both project areas. Several low-pressure systems and even some enhanced moisture from long dissipated Tropical Storm Hilary allowed for multiple soaking rain events. The nature of these events were generally embedded or non-convective in nature, not allowing for many operational opportunities. An upper-level ridge returned early in the month allowing for warmer conditions and chances for isolated showers and thunderstorms. By the middle of August, the ridge was dominating the weather allowing for no chances of convective weather. A few hail suppression and enhancement missions were able to occur. Much needed rain at the beginning of the month helped the drought wain in District 2 with no longer 100% coverage of the counties. However, the area of moderate drought in Williams County persisted. Unfortunately, the wet start to the month was not enough to keep parts of Williams and Mountrail Counties from developing moderate drought conditions, while most of McKenzie County remained drought free. The late start to the growing season in District 1 led to delayed harvests, causing the counties of District 1 to elect to extend hail suppression through September 8th. Unfortunately, no operations were conducted, but the district did receive a couple rain events during this period preventing drought conditions from developing.

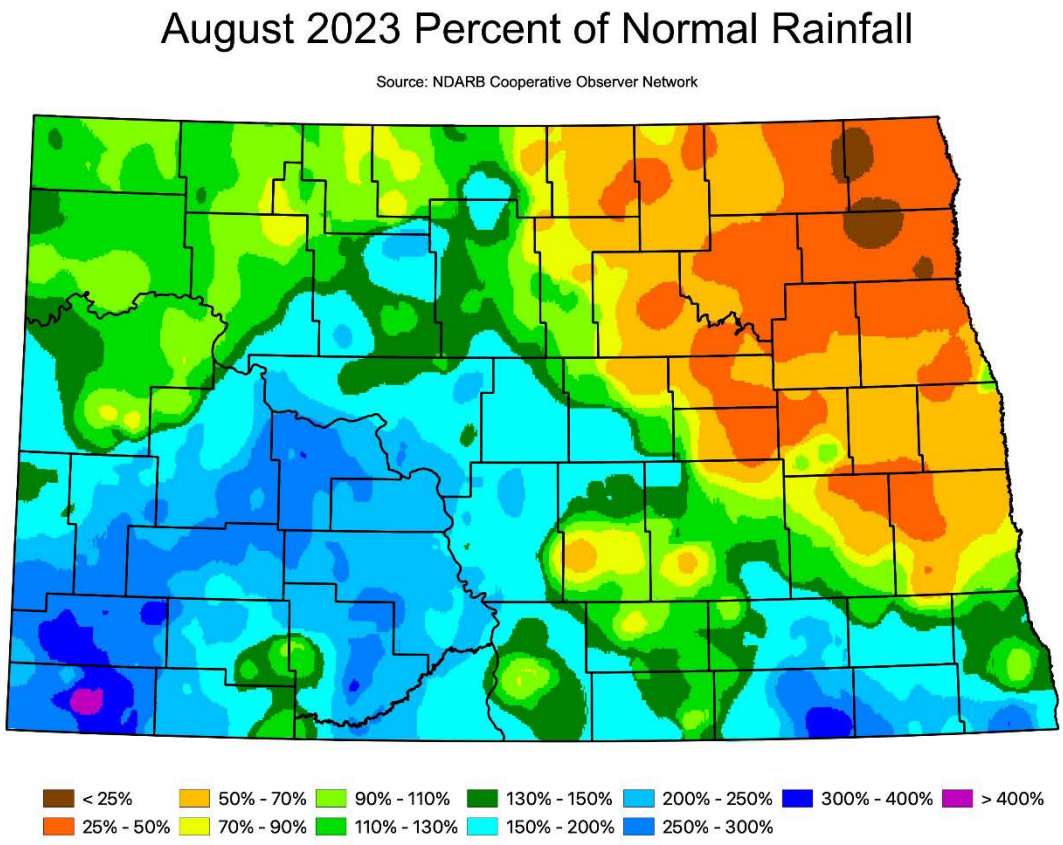

Fig. 24. Percent of Normal Rainfall map for the month of August. Graphic produced by the NDARB through their Cooperative Observer network.

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.

Fig. 25. WMI Captain Lucas Castro at the controls of N121WA (Seed 4) during a maintenance flight over Stanley. Photo by Alex Sailsbury.

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.

12 WMI AND NDARB PROJECT PERSONNEL

12.1 Ground School

The 2023 North Dakota Cloud Modification Project Ground School was conducted May 24th-26th, 2023 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.

Fig. 26. ARB Meteorologist Dan Brothers gives an overview of the PARS record system to the NDCMP staff during ground school. Photo by Kirk Hamilton.

Jody Fischer (WMI Vice President of Operations), Kirk Hamilton (WMI Director of Flight Operations) and Alex Sailsbury (WMI UAS Operations Specialist) 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. Sailsbury was an intern on the NDCMP in 2017 and has worked as a PIC since 2018.

12.2 WMI Pilots

The NDCMP welcomed two new Captains this summer, Heinrich Adriaanse and Brooke Buccowich. Both flew as PICs in Bowman. Adriaanse and Buccowich, along with the rest of the NDCMP captains, received training in Fargo prior to the start of the project. Flight training was conducted by Jake Floyd and Ryan Starkey. Training focused on safe aircraft operations, emergency procedures, seeding procedures, and aircraft mastery.

Fig. 27. Captain Ryan Starkey landing the C90 to pick up ferry pilots in Williston. Photo by Nathaniel Baligad.

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. Ryan Kram was an intern pilot in 2021, and relief pilot in 2022, Alex Sailsbury is a fulltime WMI Captain based in Fargo, ND, and Tyler Couch, WMI Captain since 2019, were utilized to cover for Henrich at the beginning of the season. Jordyn Carrabre was brought on and provided training as a co-pilot prior to project start.

2023 NDCMP RELIEF PILOT ASSIGNMENTS

START DATE	END DATE	WMI RELIEF PILOT	SEED	CAPTAIN or INTERN REPLACED
6/3/2023	6/8/2023	Tyler Couch	S1	Henrich Adraanse
6/8/2023	6/12/2023	Alex Sailsbury	S1	Henrich Adriaanse
6/9/2023	6/11/2023	Jordyn Carrabre	S1	Chris Chederquist
6/25/2023	6/27/2023	Jordyn Carrabre	S4	Kieran Viggiano
7/20/2023	7/23/2023	Jordyn Carrabre	S1	Chris Chederquist
7/26/2023	7/29/2023	Ryan Kram	S4	Lucas Castro
8/5/2023	8/8/2023	Jordyn Carrabre	S5	Austin Krause
8/9/2023	8/11/2023	Jordyn Carrabre	S7	Laura Standen

Table 6. Pilot vacation dates and relief pilot assignments for the 2023 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. 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. As of the completion of the 2023 program, the program has provided training and experience for 407 pilots. All but two 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.

Fig. 28. (Top) Intern Pilot Kieran Viggiano refills a Lohse Generator after a mission. Photo by Lucas Castro. (Bottom) Ryan Starkey poses with ARB Pilot Intern Kieran Viggiano prior to a seeding flight in 709EA. Photo by Ryan Starkey.

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

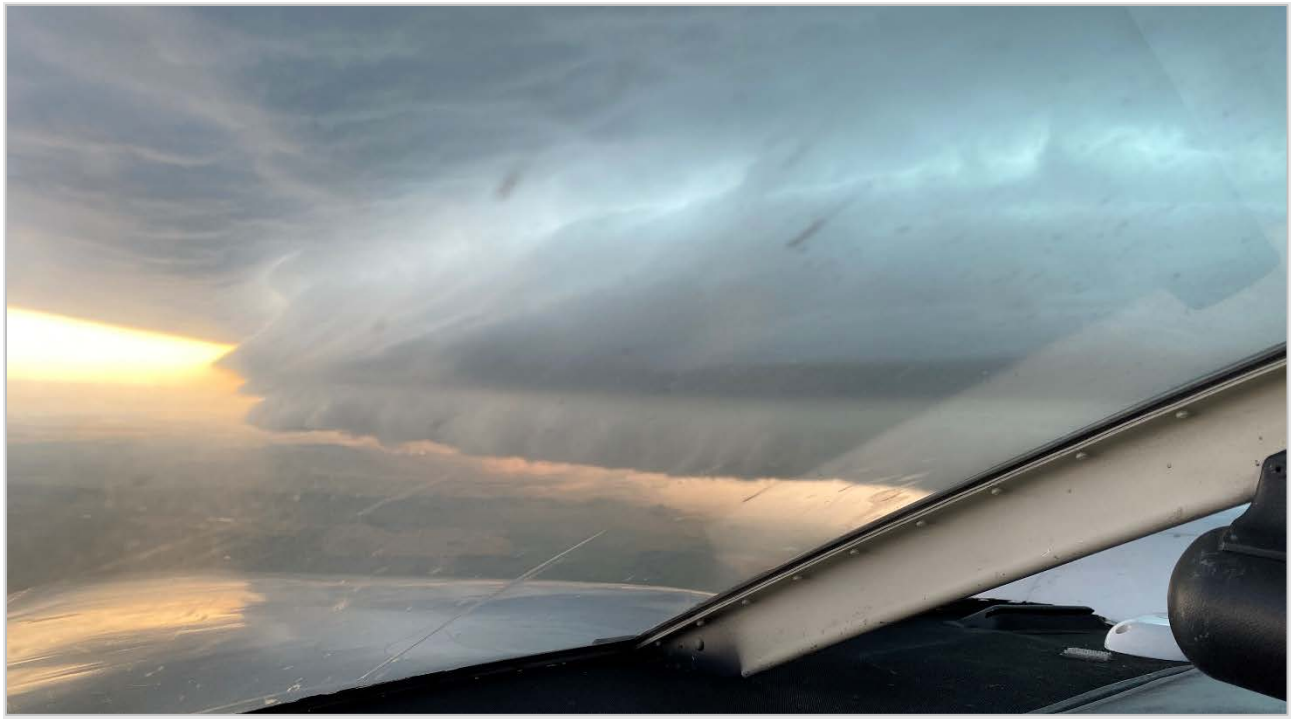

Fig. 29. Seed 1 flies along a well-defined shelf cloud in Bowman County on July 29th, 2023. Photo by Heinrich Adriaanse.

Fig. 30. Visible behind the Stanley Radar is a storm as it passes out of the district on June 1st, 2023. Photo by Cody Cameron.

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 I, Meteorologist Jacob Azriel and Intern Meteorologist Eliza Fries were selected to conduct operations out of the Bowman radar. In District II, meteorologist Ben Schaefer, and two interns Danielle Harr and Cody Cameron, 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 70 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 2023 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 seventh 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.

Alex Sailsbury, WMI UAS Operations Specialist, provided overall project support. Sailsbury functioned as a training and fill-in pilot, was available 24/7 for on-call support, coordinated aircraft maintenance scheduling, and provided project documentation support. He was integral in pre and post-project coordination. Sailsbury started as an intern pilot in 2017 and was an NDCMP Captain for five subsequent seasons.

Pat Sweeney, President of WMI and Bruce Boe, WMI VP of Meteorology served as Co-Project Managers 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. Sweeney began his career in Weather Modification in Bowman, ND in 1975. He currently serves as the CEO, after gaining controlling interest of the company in 1990. 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

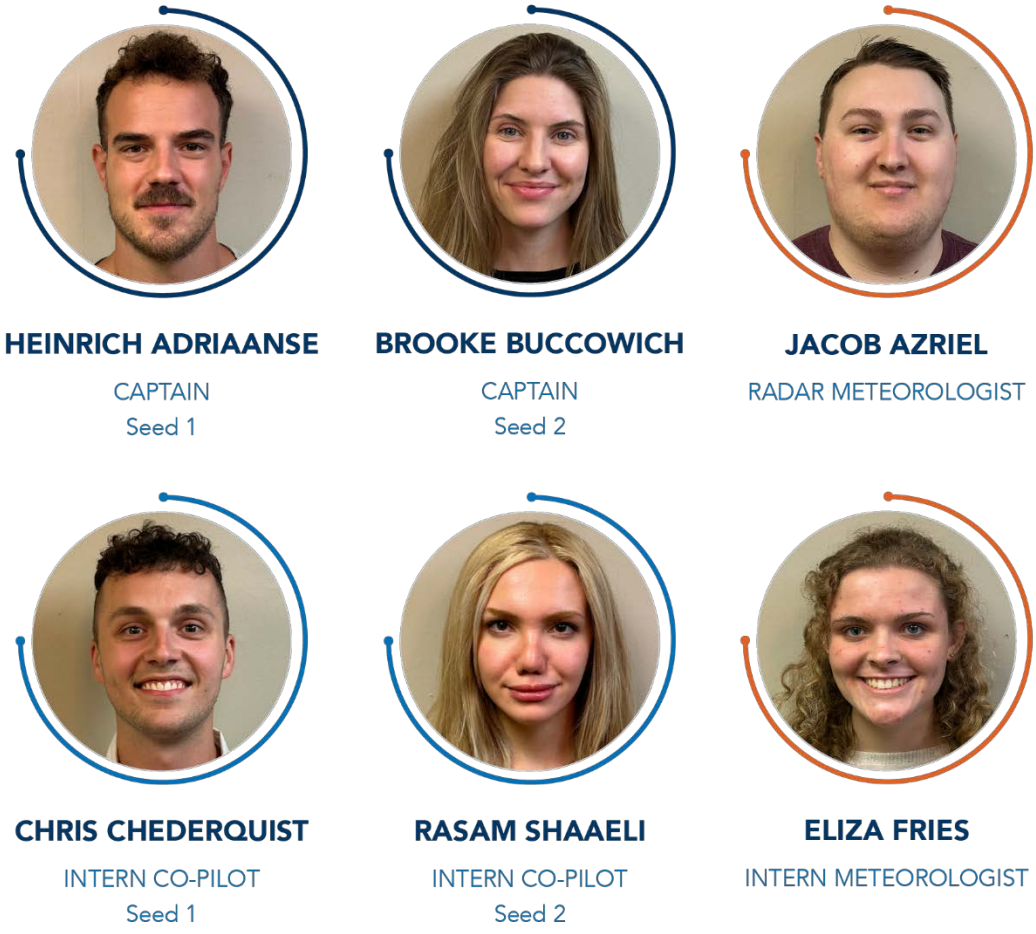

Fig. 33. 2023 District I flight crew and meteorology team. Photos by Dan Brothers, ARB.

Fig. 34. 2023 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. The Bowman Airport Poker Run was held on June 17th, the Bowman County Fair was held on July 12-16th, the Stanley Fly-in Breakfast was held on August 5th, and the Williston Summerfest Air Show was held on August 19th. Additionally, the Seed 7 crew was asked to give a presentation on the NDCMP to members of the rotary club of Watford City on July 18th. The WMI aircraft were on static display at each site and the crews were available for questions. Dan Brothers, ARB Meteorologist, and the Bowman crew answered questions at the North Dakota Weather Modification Association (NDWMA) booth.

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. Stanley Radar stands alert and ready for action in front of an approaching storm on August 1st, 2023. Photo by Danielle Harr.

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 Seneca Captain Lucas Castro. Lucas displayed dedication to the project by always doing an excellent job and by looking out for his teammates to keep everyone safe. He also worked hard to learn all aspects of the project by learning meteorology duties when he could not be launched. Lucas was an excellent role model and consistently demonstrated the level of professionalism everyone should strive for on the NDCMP.

Fig. 36. Lucas Castro, WMI (Seed 4) Captain pictured with a few of the 2023 Pilots: Ryan Starkey, Austin Krause, and Kieran Viggiano. All smiles from the cockpit, congrats Lucas!

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 Austin Krause. Austin went above and beyond, helping his captain and a mechanic troubleshoot and repair issues. He picked up top seeding very quickly and was an excellent crew member. Finally, he agreed to rotating to Bowman for their project extension.

Fig. 37. Austin Krause (right) in the captain's seat of N9798C. Congrats, Austin! WMI wishes you the best of luck in your future endeavors! Photo by Jake Floyd.

15 CONTRACTOR'S SUMMARY

This summer was Weather Modification International's 63rd 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.

Operating the King Air from Watford City has proven advantageous to both District I and District II. Watford City is centrally located in District II and within 45 minutes of District I. A total of 41 takeoffs in the King Air took place from here this season – 8 missions for District I and 33 missions for District II. Watford City Airport also has an experienced Beechcraft King Air maintenance technician with whom WMI has built an excellent relationship with.

WMI has a two-crew flight policy. This provides WMI and the program (Client) with enhanced cockpit safety, as well as increasing pilot experience and retention. The elimination of the vacation rover intern pilot position posed challenges during the 2023 season. WMI would like to thank its relief pilots who ensured these breaks were staffed adequately, which was especially important during periods of seedable weather.

Prior to the start of this season, North Dakota House Bill No. 1166 passed on February 14th, 2023 by the ND House of Representatives. It could have had significant impacts on the 2023 program and its overall future. WMI, North Dakota Water, ARB Staff, and several other interested parties put in a tremendous effort to educate the public leaders on the program, and its benefits to the state and communities that participate. On April 3rd, 2023, the Senate voted it down in a 14-33 decision and the program remains as it is today. WMI would like to thank everyone for their extensive efforts in promoting the program and its benefits to the state.

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. N121WA with a burner lit seeds a storm over McKenzie County on a late summer evening (July 30th, 2023). Photo by Laura Standen.

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

2023 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)
06/04/23	1.75					1.75	1.75		59.00	
06/09/23	3					3.00	4.75		195.54	450
06/24/23	2.34					2.34	7.09		112.14	
06/28/23		2.02			1.24	3.26	10.35			1180
07/04/23		3.09				3.09	13.44		77.80	
07/11/23		2.96				2.96	16.40		78.37	2180
07/30/23		2.40				2.40	18.80			700
08/01/23		5.05				5.05	23.85			4000
						0.00	23.85			
						0.00	23.85			
						0.00	23.85			
						0.00	23.85			
						0.00	23.85			
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						0.00	23.85			
						0.00	23.85			
						0.00	23.85			
						0.00	23.85			
						0.00	23.85			
TOTALS	**7.09**	**15.52**	**0.00**	**0.00**	**1.24**	**23.85**	**23.85**	**0.00**	**522.85**	**8,510**

TOTAL AgI RELEASED BY C90 AIRCRAFT:	8,510	grams
TOTAL DRY ICE USED ON PROJECT:	522.85	pounds

District I – Cloud Base Aircraft, Seneca II

2023 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)
06/01/23	1.7					1.70	1.70			0.98		394	75
06/02/23					0.79	0.79	2.49	6.86					
06/04/23	1.4					1.40	3.89			0.56		225	150
06/07/23				1.04		1.04	4.93	0.49					
06/08/23	4.06					4.06	8.99		0.10	2.36	20	949	
06/09/23	6.36			0.99		7.35	16.34		0.34	4.41	68	1,773	450
06/10/23	0.93				0.57	1.50	17.84			0.50		201	
06/13/23						0.00	17.84	0.96					
06/16/23						0.00	17.84	1.54					
06/19/23						0.00	17.84	0.97					
06/20/23	0.88					0.88	18.72			0.28		113	
06/22/23				0.48		0.48	19.20						
06/24/23	1.09					1.09	20.29			0.47		189	
06/26/23		2.20				2.20	22.49			1.54		619	150
06/27/23		1.98		1.02	0.66	3.66	26.15		0.02	1.07	4	430	
06/28/23		3.89			1.35	5.24	31.39			2.14		860	
06/30/23		2.41				2.41	33.80			0.76		306	
07/03/23		0.88				0.88	34.68			0.34		137	
07/04/23		3.78			1.46	5.24	39.92		1.03	1.08	207	434	150
07/06/23		2.15				2.15	42.07			1.27		511	225
07/09/23						0.00	42.07	1.12					
07/11/23		6.06				6.06	48.13		0.37	3.74	74	1,503	1575
07/12/23				0.29		0.29	48.42						
07/17/23						0.00	48.42	1.67					
07/18/23		1.25				1.25	49.67			0.20		80	
07/22/23				0.52		0.52	50.19						
07/28/23						0.00	50.19	0.93					
07/29/23		4.47				4.47	54.66			2.66		1,069	1275
07/30/23		3.20				3.20	57.86			2.24		900	525
08/01/23		4.30		0.66		4.96	62.82		0.13	3.23	26	1,298	375
08/03/23	1.86					1.86	64.68			0.90		362	
08/04/23					0.99	0.99	65.67						
08/07/23						0.00	65.67	1.10					
08/11/23						0.00	65.67	2.22					
08/12/23						0.00	65.67	3.66					
08/13/23						0.00	65.67	0.82					
08/18/23						0.00	65.67	0.87					
08/22/23						0.00	65.67	0.84					
08/24/23		1.72				1.72	67.39	0.89		0.84		338	
08/31/23		1.81				1.81	69.20			0.59		237	
09/06/23						0.00	69.20	1.26					
						0.00	69.20						
						0.00	69.20						
						0.00	69.20						
						0.00	69.20						
						0.00	69.20						
						0.00	69.20						
						0.00	69.20						
						0.00	69.20						
						0.00	69.20						
TOTALS	18.28	40.10	0.00	5.00	5.82	69.20	69.20	26.22	1.99	32.16	400	12,928	4,950

TOTAL AgI RELEASED BY BASE AIRCRA 18,278 grams

District II – Cloud Top Aircraft, King Air

2023 DISTRICT II FLIGHT SUMMARY
CLOUD - TOP (TURBO-PROP ONLY)

DATE	DUAL	HAIL	RAIN	RECON	OTHER	DAILY TOTAL	RUNNING TOTAL	MAINTENA (Contractor Expense)	DRY ICE (pounds)	FLARES (grams)
06/01/23						0.00	0.00	1.60		
06/02/23	6.33					6.33	6.33		238.84	440
06/04/23	2.79					2.79	9.12		141.00	640
06/05/23	1.43		4.10			5.53	14.65			1135
06/08/23	4.52		2.39			6.91	21.56		302.91	640
06/13/23	3.66					3.66	25.22		200.00	200
06/17/23				1.83		1.83	27.05			
06/19/23				0.40		0.40	27.45			
06/20/23	7.96					7.96	35.41		122.63	860
06/26/23	4.3					4.30	39.71		200.00	715
06/27/23	3.36					3.36	43.07		106.79	375
06/28/23	3.47					3.47	46.54			1680
06/30/23	3.32		2.04			5.36	51.90		284.04	1095
07/01/23	3.02					3.02	54.92		128.26	80
07/03/23	1.95					1.95	56.87		57.80	
07/08/23	4.49					4.49	61.36		200.00	260
07/11/23	1.83					1.83	63.19		121.63	1210
07/12/23				1.65		1.65	64.84	1.59		
07/13/23						0.00	64.84	2.71		
07/14/23			2.08			2.08	66.92		91.86	
07/18/23	2.1					2.10	69.02		63.70	
07/23/23	3.43					3.43	72.45		77.50	
07/25/23	2.16					2.16	74.61	1.24	200.00	
07/26/23						0.00	74.61	1.65		
07/29/23				0.43		0.43	75.04			
07/30/23	5.79					5.79	80.83			1755
07/31/23				2.62		2.62	83.45			
08/01/23	3.48					3.48	86.93		198.16	2700
08/03/23	2.11					2.11	89.04		174.58	140
08/10/23						0.00	89.04	0.83		
08/20/23						0.00	89.04	0.57		
08/23/23		3.68				3.68	92.72		200.00	1680
08/24/23						0.00	92.72	0.98		
08/30/23		4.00				4.00	96.72		200.00	2240
						0.00	96.72			
						0.00	96.72			
						0.00	96.72			
						0.00	96.72			
						0.00	96.72			
						0.00	96.72			
						0.00	96.72			
						0.00	96.72			
						0.00	96.72			
						0.00	96.72			
						0.00	96.72			
						0.00	96.72			
TOTALS	**71.50**	**7.68**	**10.61**	**6.93**	**0.00**	**96.72**	**96.72**	**11.17**	**3,309.70**	**17,845**

TOTAL AgI RELEASED BY C90 AIRCRAFT: 17,845 grams
TOTAL DRY ICE USED ON PROJECT: 3,309.70 pounds

District II – Cloud Base Aircraft, Seneca II

2023 DISTRICT II FLIGHT SUMMARY
CLOUD - BASE (Seneca)

						DAILY	RUNNING	MAINTENANC	GENERATORS - Senecas		GENERATORS - Senecas		FLARES
DATE	DUAL	HAIL	RAIN	RECON	OTHER	TOTAL	TOTAL	(Contractor Expense)	ONE	TWO	ONE	TWO	
		(---------all flight times in hundredths of hours---------)							(hours burned)		(grams burned)		(grams)
06/01/23	1.54			1.24		2.78	2.78			0.57		229	
06/02/23	2.53		2.18			4.71	7.49	0.32	0.34	0.35	68	141	
06/04/23	5.92					5.92	13.41		0.34	1.92	68	772	150
06/05/23	1.99				0.59	2.58	15.99			0.69		277	600
06/08/23	6.56					6.56	22.55		0.61	2.92	123	1,174	675
06/09/23					0.56	0.56	23.11						
06/13/23						0.00	23.11	1.41					
06/18/23						0.00	23.11	0.88					
06/19/23				1.10	0.73	1.83	24.94						
06/20/23	6.76				0.73	7.49	32.43			1.60		643	900
06/24/23						0.00	32.43	1.64					
06/26/23			0.71			0.71	33.14		0.13		26		
06/28/23						0.00	33.14	0.70					
06/30/23	2.88					2.88	36.02	1.48	0.16	1.70	32	683	375
07/01/23	4.22					4.22	40.24		1.15	1.28	231	515	675
07/02/23	2.75					2.75	42.99			2.06		828	600
07/03/23						0.00	42.99	1.28					
07/04/23						0.00	42.99	1.26					
07/05/23						0.00	42.99	0.97					
07/07/23						0.00	42.99	1.21					
07/08/23	5.42					5.42	48.41			2.78		1,118	525
07/11/23	4.3					4.30	52.71		0.62	0.71	125	285	450
07/12/23						0.00	52.71	0.41					
07/14/23				0.81		0.81	53.52						
07/17/23						0.00	53.52	0.74					
07/18/23				0.88		0.88	54.40						
07/20/23						0.00	54.40	0.73					
07/22/23						0.00	54.40	0.78					
07/23/23	1.65				0.87	2.52	56.92			0.56		225	225
07/25/23						0.00	56.92	0.75					
07/26/23						0.00	56.92	4.21					
07/27/23						0.00	56.92	0.67					
07/30/23	4.58			0.97		5.55	62.47			1.77		712	450
07/31/23	1.7					1.70	64.17			0.45		181	
08/01/23	6.53					6.53	70.70			4.22		1,696	2550
08/02/23					1.00	1.00	71.70						
08/03/23	1.72					1.72	73.42			0.95		382	225
08/05/23						0.00	73.42	0.61					
08/07/23						0.00	73.42	0.40					
08/09/23	1.67					1.67	75.09			0.89		358	
08/11/23						0.00	75.09	1.19					
08/12/23						0.00	75.09	0.49					
08/13/23				1.94		1.94	77.03						
08/17/23						0.00	77.03	1.11					
08/18/23						0.00	77.03	0.52					
08/19/23					1.08	1.08	78.11						
08/22/23						0.00	78.11	0.91					
08/23/23		7.75				7.75	85.86		0.13	3.75	26	1,508	1050
08/24/23		1.28				1.28	87.14	1.33		0.58		233	675
08/28/23						0.00	87.14	1.05					
08/29/23						0.00	87.14	0.94					
08/30/23		2.39				2.39	89.53			1.48		595	600
08/31/23		4.53			0.70	5.23	94.76			1.74		699	750
						0.00	94.76						
						0.00	94.76						
						0.00	94.76						
						0.00	94.76						
						0.00	94.76						
						0.00	94.76						
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						0.00	94.76						
						0.00	94.76						
						0.00	94.76						
						0.00	94.76						
						0.00	94.76						
TOTALS	62.72	15.95	2.89	6.94	6.26	94.76	94.76	27.99	3.48	32.97	699	13,254	11,475

TOTAL AgI RELEASED BY BASE AIRCRA 25,428 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: none provided

[ ] 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 06/01/2023 TO 09/08/2023

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		OTHER	AIRBORNE	GROUND	SILVER IODIDE	CARBON DIOXIDE	UREA	SODIUM CHLORIDE	OTHER
			HAIL	FOG								
JANUARY												
FEBRUARY												
MARCH												
APRIL												
MAY								11,765.26				
JUNE	14	14	14			51.68		~~11,757.27~~	1,962.89			
JULY	14	11	13			45.45		10,505.04	~~896.92~~ 1,096.92			
AUGUST	7	3	7			38.6		9,567.50	772.74			
SEPTEMBER	0	0	0			0		0	0			
OCTOBER												
NOVEMBER												
DECEMBER								31,837.80				
TOTAL	35	28	34			135.73		~~31,829.81~~	~~3,632.55~~ 3,832.55			
TOTALS FOR FINAL REPORT	35	28	34			135.73		~~31,829.81~~	~~3,632.55~~ 3,832.55			

DATE ON WHICH FINAL WEATHER MODIFICATION ACTIVITY OCCURRED *(For Final Report only.)* 8/31/2023

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: 10/3/2023