

# **SANTA ANA RIVER WATERSHED WEATHER MODIFICATION FOR WATER SUPPLY FEASIBILITY STUDY**

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# WxMod Purposes & Process

- “Natural” weather
  - Dust, ash, pollution nuclei
- Precipitation augmentation and snowpack enhancement, hail suppression, fog dispersal
- Super-cooled Liquid Water (SLW)
  - Silver iodide (AgI) as nuclei
- Ground (generators, flares) or aerial based
- 10% increase in precipitation
  - Within range of variability
- Not a drought buster

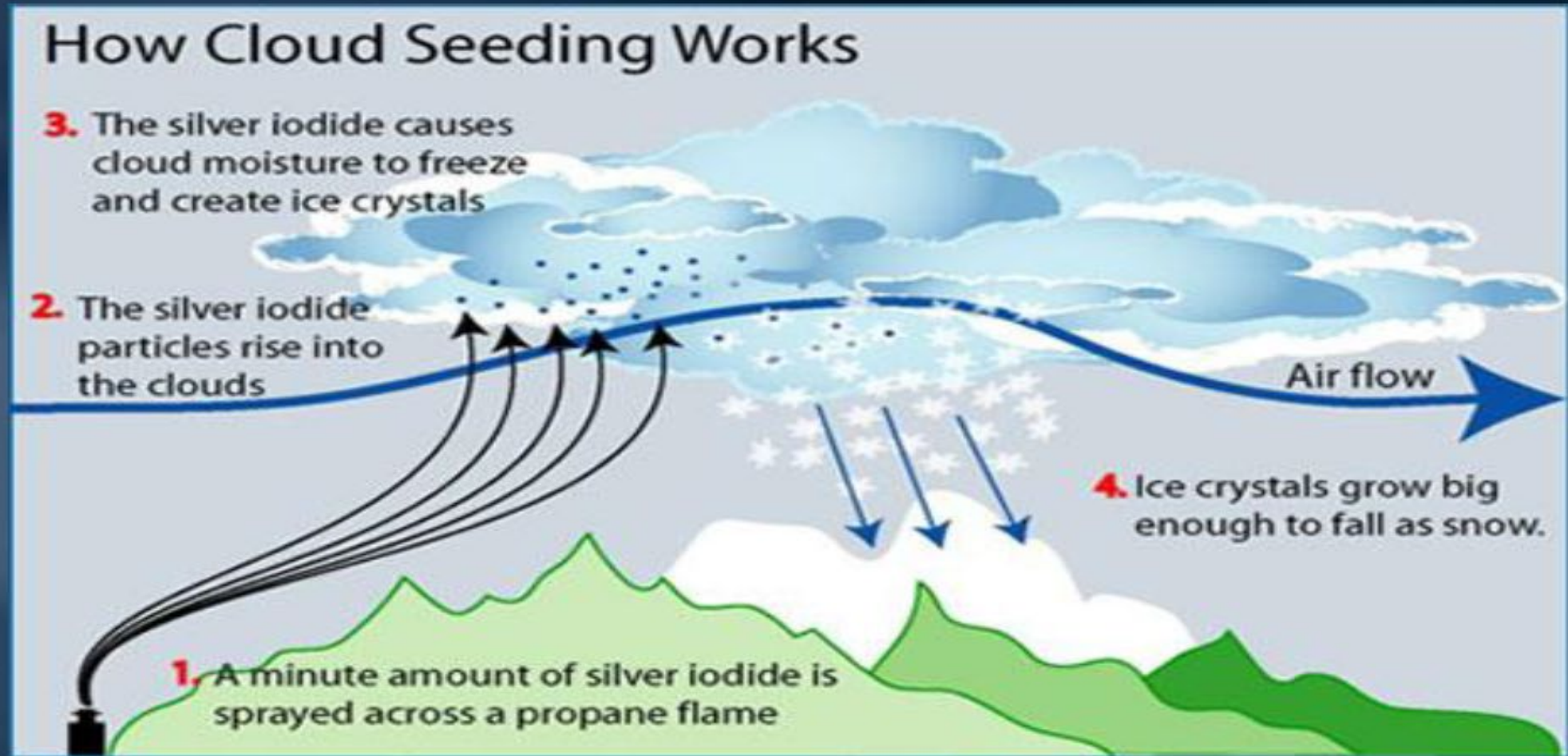


# WxMod History

- Background
  - Started in the U.S. in 1940s
  - Overselling, minimal science
  - Misconceptions remain
- Advances since the 1940s
  - WX forecasting
  - Measurement
  - Computing
  - Seeding methods



# Winter Conceptual Model





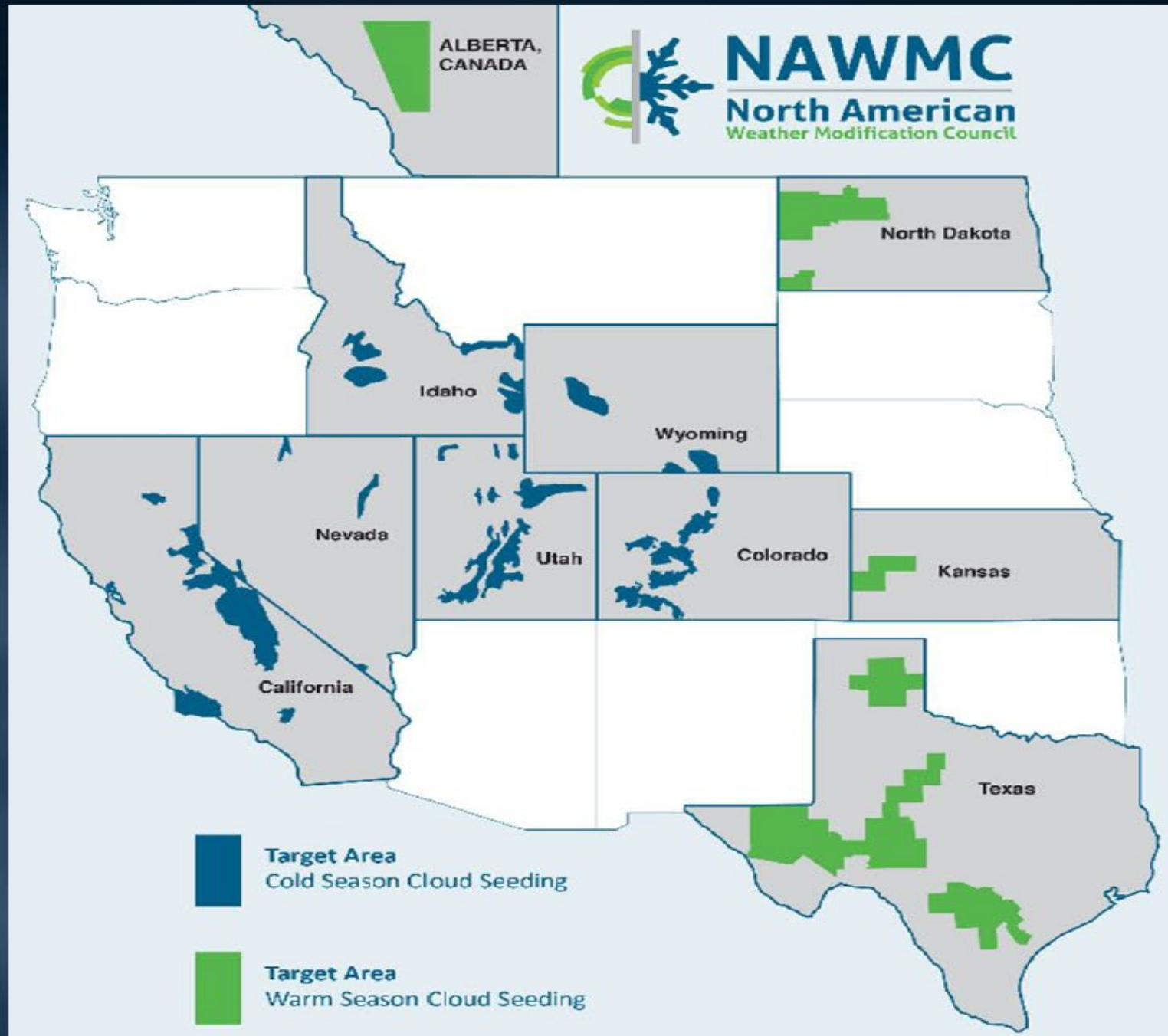
# WxMod Users & Costs

- 150 programs in 40 countries and 11 states
  - Ski areas, Power utilities
  - Insurance companies
  - Water resources agencies
  - Conservation, and Irrigation districts
  - Research institutes
- Costs
  - \$4-40/AF, including planning



# North American Projects

- Local sponsorship
- Education
- Outreach





# Cloud Rustling

- Downwind Effects Misconception
  - “Robbing Peter to pay Paul”
  - WxMod activates precipitation otherwise unavailable
  - Long-term research (44+ studies) consistently shows no precipitation decreases; some downwind increases shown



# Potential Environmental Effects

- Agl is not soluble or biologically available
- 50 years of physical, biological, aquatic, soils & vegetation studies found:
  - Subtle or indiscernable effects
  - Potentially beneficial (more runoff)
- Strong studies with credible results
- Newer assessment methods and regulations suggest continued research
- Consider cumulative effects, monitoring



# Potential Health Effects

- Silver Iodide (AgI)
  - Not been measured above background
- Human effects
  - No effects found in 50 years
  - More silver exposure in tooth fillings
  - More iodine in salt on food
- Concentrations
  - EPA drinking water quality 0.1 mg/l
  - U.S. Public Health Service level 0.5 mc/l
  - Seeded rainfall is 0.1 mc/l

# Increased Snowload

- Avalanche
  - Suspension criteria
- Snow removal
  - Similar amount of effort required
- Flooding potential
  - Agency coordination
- Crop yield / pasture value
- Economic trade-offs
  - Snow removal v. water supply / tourism





# Licensing and Permitting

- Operators licensed
- Project permits issued
  - Conditions and safeguards
  - Record keeping and annual reporting
- State statutes
  - Governmental immunity
- Liability insurance
- Separate from environmental
- Few legal challenges



# ASCE Guidance

- Design and Operation of Precipitation Enhancement Projects (42-17)
- Manual on Engineering Practice #81, Guidelines for Cloud Seeding to Augment Precipitation (3rd edition)
- Design and Operation of Hail Suppression Projects (39-15)
- Design and Operation of Supercooled Fog Dispersal Projects (44-13)



# California Projects

- Since the 1950s
- 12-15 per year
- Winter orographic
- Water and power
- Described in California Water Plan





# Wyoming WxMod Pilot Program

- State funded \$15 million over 10 years
- Randomized cross-over experiment
- Independent evaluation by NCAR
- Radiometers, snow chemistry, high resolution precipitation gauges





# WWMPP Conclusions

- Statistical, physical, and modeling analysis shows cloud seeding is a viable technology
- Climatology study demonstrates that 30% of wintertime precipitation fell from seedable storms
- Half the time that seedable conditions were met there was no precipitation, indicating cloud seeding opportunities

# Summary

- Advances since the 1940s, misconceptions remain
- +5-15% increase within range of variability
- Cost-effective part of water operations portfolio
- None or positive downwind effects
- No environmental or health effects
- Local leadership, education, support is important
- Number of projects increasing
- Recent research answering key questions



# On June 4, 2019 Tom Ryan from MWDSC discussed ongoing weather augmentation for water supply – cloud seeding programs with SAWPA Commission



# RFP and Consultant Selection

- SAWPA directs staff to issue RFP for Santa Ana River Watershed Weather Augmentation Feasibility Study
- Two consultants responded to feasibility study RFP
  - North American Weather Consultants Inc.
  - RHS Consulting, Ltd.
- Proposal Review Team
  - SBVMWD, WMWD, OCWD, SAWPA, MWDSC
- - North American Weather Consultants Inc. recommended and awarded contract for \$75K to conduct feasibility study





# Ground Based Seeding Methods

## CNG's (Cloud Nuclei Generators)



- Ideal for orographic lift (winds caused by land barriers)
- Create a continuous plume
- Inexpensive to install and operate

## AHOGS (Automated High Output Ground Seeding) Systems



- Depend on strong convective storm attributes (turbulence)
- Deliver a higher concentration of Silver Iodide – rapid release
- Operated remotely

# Aerial Seeding



## Technical Feasibility

- Unlike commercial air traffic that quickly leaves an area of high traffic, cloud seeding aircraft occupy the same airspace for an extended period of time
- Flight tracks for the eastern target areas are more likely to receive FAA approvals during times of high traffic, and during periods of storm activity.

## Economic Feasibility

- Land barriers must be of an appropriate size to benefit from aerial seeding
- Annual runoff must support the investment of an aerial component
- Preference should be given to areas with greater potential increases



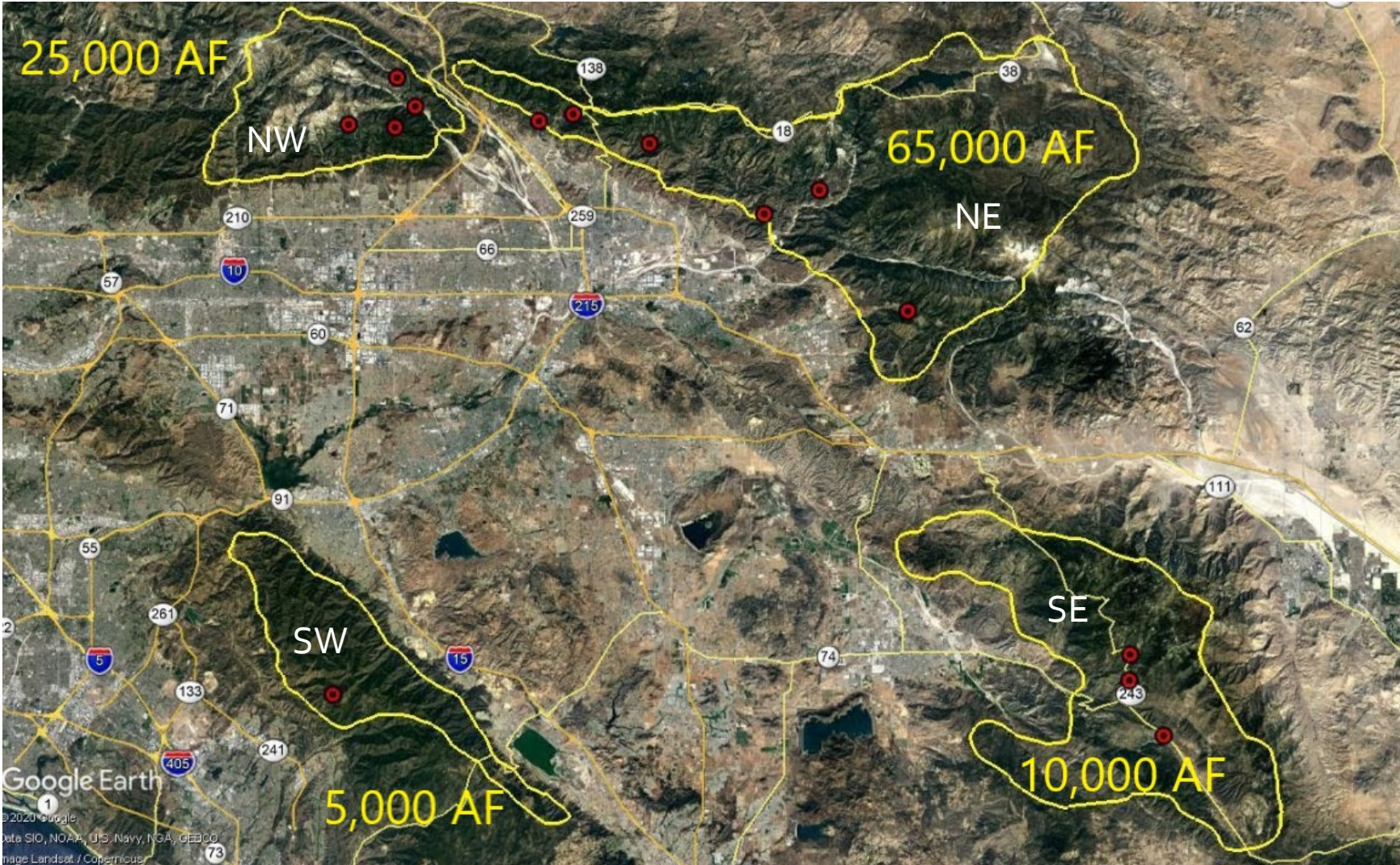
## Refined – Ground Seeding Sites



**Yellow Pins = AHOGS**  
**Red Bullseyes = CNG's**



# Estimated Natural Annual Streamflow





# Total Projected Increases

## Ground Only Seeding

Target Area	Seasonal Precip. Increase (inches)	Percent Increase	Avg. Natural Streamflow (AF)	Streamflow Increase (AF)	Percent Increase
NW	0.41	3.5%	25,000	2,043	8.2%
NE	0.49	4.1%	65,000	4,330	6.7%
SW	0.59	3.7%	5,000	447	9.0%
SE	0.49	4.5%	10,000	1,373	13.7%
<b>TOTAL w/ Ground Only</b>			<b>105,000</b>	<b>8,193</b>	<b>7.8%</b>

## With Aerial Support in the NE Target

Target Area	Seasonal Precip. Increase (inches)	Percent Increase	Avg. Natural Streamflow (AF)	Streamflow Increase (AF)	Percent Increase
NW	0.41	3.5%	25,000	2,043	8.2%
NE	0.89	7.3%	65,000	7,772	12%
SW	0.59	3.7%	5,000	447	9.0%
SE	0.49	4.5%	10,000	1,373	13.7%
<b>TOTAL</b>			<b>105,000</b>	<b>11,635</b>	<b>11.1%</b>

# Estimates – Ground and Aerial Seeding

	Rate	Frequency	
Annual Operations			
Set Up	\$ 40,000	1	\$ 40,000
Take Down	\$ 31,000	1	\$ 31,000
Reporting	\$ 10,000	1	\$ 10,000
Monthly Operations			
Fixed Services	\$ 55,000	5	\$ 275,000
Variable Items (timed expenses are billed on a per hour basis)			
Ground Flares	\$ 110	60	\$ 6,600
Generator Run Time	\$ 19.50	600	\$ 11,700
Flight Time	\$ 375	30	\$ 11,250
Aerial Flares	\$ 110	150	\$ 16,500
<b>TOTAL</b>			<b>\$ 402,050</b>
<b>COST PER ACRE-FOOT</b>			<b>\$ 35.61</b>
<b>Benefit to Cost</b>			<b>7.16</b>



# Pricing Estimates – Ground Based Seeding Only

	Rate	Frequency	
Annual Operations			
Set Up	\$ 33,500	1	\$ 33,500
Take Down	\$ 24,000	1	\$ 24,000
Reporting	\$ 10,000	1	\$ 10,000
Monthly Operations			
Fixed Services	\$ 24,500	5	\$ 122,500
Variable Items (timed expenses are billed on a per hour basis)			
Ground Flares	\$ 110	60	\$ 6,600
Generator Run Time	\$ 19.50	600	\$ 11,700
Flight Time	\$ 375	N/A	-
Aerial Flares	\$ 110	N/A	-
<b>TOTAL</b>			<b>\$ 208,300</b>
<b>COST PER ACRE-FOOT</b>			<b>\$ 25.42</b>
<b>Benefit to Cost</b>			<b>10.03</b>

# Next Steps

- Continue briefings to interested governing bodies and agencies in watershed
- Recommendations on next steps will be brought to SAWPA Commission upon review of new SAWPA GM.
  - Study of Ground Based Seeding Unit Sites and Access
  - CEQA/Permits
- Potential cost share partner agencies and companies who may benefit are being approached by SAWPA





# Recommendation

- Receive and file the SAWPA feasibility study results as well as SAWPA's continued investigation and CEQA preparation for a Santa Ana River Watershed Weather Modification Program.