APPENDIX B

Record of conversations and dictaphone transcriptions
Texas, July 2002

17 July AM
Informal Meeting at Texas Department of Licensing and Regulation, Austin

George Bomar, Tommy Shearer and Jane Lee.

George Bomar: Jane and I worked together over at the Texas Natural Resource Conservation Commission, called TNRCC for short. When that environmental agency was put into place by the legislature nine years ago. Special legislative arrangements were put in place to separate functions in the Texas Department of Agriculture (TDA) and ……

John Forrest: This is State legislation?

George Bomar: Yes. The Weather Modification Program was assigned to that agency and so I left the Water Agency and went to TNRCC and then several years later the legislature began appropriating money on a biennial basis to help projects like Tommy's continue and then procure equipment and so on, and in 1999, was when Jane took a job in the program at TNRCC, and so she and I handled the licensing and the permitting and what little research we had going on at that time, plus the grants with the various projects involving the State money.

Well, last year the legislative session a year ago this Spring, Gary Walker introduced a piece of legislation to move the program out of TNRCC to TDA and to TDLR, and the responsibilities were broken up. Jane took all the money with her and I took the responsibility and doing the licences and permits as well as the R&D part of it. The job pertaining to water modification was actually given to this agency, and so even though we're a few blocks apart now we still work closely together.

John Forrest: What's the total budget scale for the whole of Texas for this weather modification?

Jane Lee: About two point nine … for the biennial.

John Forrest: Two million?

Female Speaker: Yes, about $2.94.

George Bomar: Yes, actually that's per year and the legislature appropriates over a biennial 2 year basis, so there's close to $5-million in her budget for this current fiscal year and the one coming up. Now all the projects have to match that and some even spend a little more, so actually this year all of our projects were costing somewhere in the neighbourhood of five million.

John Forrest: That's a requirement by the legislation that it's matched?

George Bomar: It's matched.

John Forrest: That's good.

George Bomar: It's matched 50/50 up to a point and several years ago we determined, based upon what it would cost per acre, to do a cloud seeding project. At that time we estimated about 8½ cents an acre and we've since gone to about 9 cents, and I think Jane now is providing money for the newer projects at 4½ cents an acre.

John Forrest: And so who are the contributors to the matching funding – the water authorities. Are there any other farming associations or anybody else levied to match?

Tommy Shearer: There's none in my area. It's done a number of ways depending on the area. What we did at a grass roots was to lobby for local support. Where basically, when we wanted to start selling this idea, we went around and took programs to all the local townships and the water districts, so to speak, can be of one county or multiple counties. There's seven counties in my project and one water district has four of the seven counties. They have a tax base, so they're taxing authorities so they're able to tax people at the lower basis, and they match funding with this.

Now in one particular place, the county, which is a local government, pays and in the other two areas they have single counties in one of the districts. But, originally, we did what you just said, we had a volunteer organisation made up of people in the area that voluntarily gave the money to go to cloud seeding. Now, we have since taken them into our water district, and then that's come into the program. But initially it was volunteered, and they had a Ranger's Week,.that's what they had volunteer rangers based on acreage. When you look at it, what will 4½ cents an acreage – generate?, specifically it if you've got 20,000 acres.

John Forrest: I'm going to have a lot of problems motivating a grass-roots driven program like what you have here. I've already come to that conclusion. I think our Federal Government will probably be the funder and raise its revenue some other way. It could take 10 years to get a grass-roots driven program, but that's too late then.

George Bomar: Some other States work their programs that way. The legislatures appropriate the money and the State agency actually administers the project. They locate a contractor, or they run their own program, or hire their own people. Texas is unusual in that all of our programs sprouted from the grass roots.

Tommy Shearer: But that might be indicative of our success, but our local people have responded in the past, and it's ownership. You know, there's something to be said for ownership.

John Forrest: Yes, no doubt about that. I wish I could get that, but we still have people who are very cynical about this technology.

Tommy Shearer: Education's your best asset so get out there and just educate them about what's up. Now we started out with a contractor as in most other programs, but we found out quickly that we could actually operate the programs more efficiently and economically ourselves. As long as we had State funds matching our equipment, we can make capital investments with that equipment. So then we can become self-sufficient. In my particular area, I'm able to operate the program on a year round basis for what a contractor would be charging for five months. And all the equipment here, even if … shut down, it's paid for. I've got assets to sell, but I can return some of the investment money to the constituents.

John Forrest: So it's obviously not something short term here either, is it? I mean, it's a long haul, once you've committed….

George Bomar: Yes. In fact, his program is the third oldest and it's now six years?

Tommy Shearer: We started in '96. In '96 we started putting it together, '97 we started the program.

John Forrest: So this is your sixth year?

Tommy Shearer: Yes. Well now, we took it from travelling round and visiting the them and saying this is not drought-breaking technology. Quite frankly , in drought is the worst time to start the project, because we need clouds and in drought we don't have any. Now you've got to have some weather to work with. That's all we looked at. We looked at it knowing we had to make an investment and we're in this for a minimal of 10 years to evaluate what we have and what we think we've done.

George Bomar: So what they've done over time --- he started with a contractor like everyone else and decided he could have his own program running better at less cost, found a radar system, a surplus radar he got real cheap and he's since bought aircraft and he's hired his own meteorologist. He's had that gentleman for several years, and he's actually running his program for a lot less than 4½ ¢ an acre on 9¢ an acre.

John Forrest: Can you explain to me some of the physics, because I'm going to have to contend with scientists back home. Rosenfelt's argument about the impact of aerosols and smoke and dust --- how does that physically inhibit the clouds from creating raindrops? What are the physics of that?

George Bomar: In order to get a cloud droplet to materialise, you not only have to have moisture, but you have to have some particulate around which the moisture in the air can coalesce to form a tiny droplet, if you have a lot of smoke or dust that is in the air --- in our case, fires several years ago in Mexico – what you end up doing is you capture the available moisture that's in the cloud mass, you create many many tiny droplets because you've got all of this smoke and dust particulate there to serve as a nuclei around which the moisture can form a droplet. You don't want so many cloud droplets that are so tiny because in order for those droplets to grow into a raindrop, they've got to collide with neighbouring droplets innumerable times in a very short time span. And these clouds just clag up. If you've got so many droplets that are so small--- the way Mother Nature grows a load of rain in a convective tower

is by providing some natural ice, and some of these clouds don't rain much, or they don't rain at all because they don't have any natural ice.

And so we seed them with artificial ice – silver iodine – and it's chemical structure is virtually identical to natural ice. When you introduce an artificial ice crystal into a convective tower that's got an abundance of cloud water in the form of tiny droplets, that ice crystal that the vapour pressure of gradient between a water droplet and an ice crystal is less than the vapour pressure of gradient between two adjacent droplets—that cloud droplet more readily will merge with an ice crystal to create a small snow flake, then it will collide with a neighbouring droplet to grow into a somewhat larger droplet.

So when you introduce artificial ice, that ice will capture those droplets and in the process grow into either a snowflake, or what we call very soft hail, globule, which is a mushy ice that will melt into a raindrop. Okay, that's the simplest explanation of how, as our friend Dale Bates likes to say, a lot of these clouds get constipated. They've got the ingredients, they've got the water in the form of a lot of droplets, but they just cannot grow a load of rain because they don't have the nuclei that will attract droplets quickly enough before the cloud begins to rain.

John Forrest: So does it have to be a physical particle like snow called dust—what's the impact of aerosols? That was the thing that Rosenfelt promoted. Because we get a westerly drift from Adelaide,(one of our big cities)…clouds are definitely constipated.

George Bomar: You're talking about man-made pollutants? Smoke from stacks, or hydrocarbons that are generated from automobiles and so on***.*** Well, from the work that Rosenfelt did, and I know he looked at smoke from a number of different sources – one of them from Mexico, another one in Indonesia from fires that broke out over there. I'm not really sure how a smoke particle from a smoke stack behaves differently inside a cloud mass compared to say a natural smoke particle from a burning cornfield. I don't know that there's any difference, I just know that that if smoke is generated, whether it's from a smoke stack or from a field, so much particulate matter is put into a cloud and the available cloud water forms around so many particles, that you end up getting far too many droplets and they never collide enough to go into a raindrop. The time is just not long enough for enough collisions to occur to grow a droplet into a raindrop, say a millimetre in diameter.

John Forrest: It's not rocket-science physics, is it?

George Bomar: No, it really isn't. For some others, it's kind of hard to, you know, handle around, but we've been working on a number of different formulations. We've had a gentleman that lives – he's retired in Nevada – Dr. William Benedict. Worked with the US Navy back in the sixties to develop pyrotechnics, or flares, that were used by the Navy in weather modification operations, and here's a couple of samples, and we've fine-tuned the formulations over and over. In fact, he's still working with a plant in San Angelo that you'll be taken to by Dale Bates tomorrow afternoon, and you'll see how these flares are actually assembled, put together. This is an injectable flare, and you'll see in the video how one of these is used from an aircraft that flies from above cloud top. Those actually hang in a rack on the belly of

the aircraft, and the candle which is inside of the tube is actually ejected and in the process it's lit so that you have the candle falling into the upper portion of the convective tower, and the candle burns up so that you nothing that ever reaches the ground. The tube remains in the rack in the airplane.

John Forrest: Releasing silver iodide?

George Bomar: Silver iodide, yes.

John Forrest: And is that the only agent you use? There are other salts that you have used?

George Bomar: Apparently none.

John Forrest: That's one of my questions. Are there more appropriate agents for different clouds?

George Bomar: Yes, undoubtedly so. The silver iodide is a glaciogenic material, by that I mean that silver iodide, because of its crystal and structure being almost identical to a natural ice particle, is very good at forming ice in a cloud. That's the meaning of the term, glaciogenic. When you have convective tower, then a lot of the cloud mass hits above the freeze level in the atmosphere, and the water in the cloud is chilled to below freezing, but it doesn't turn into ice, it stays in liquid form just like coca-cola in a bottle. You can stick it in the freezer and leave it there for a spell, and when you pull it out, it's still liquid, but when you take the cap off and change the pressure, it immediately turns to ice. Well, in liquid form, that coca cola, is still super cool.

So these types of flares work very well in clouds that have sufficient depth to them, but a lot of the water in the cloud has been super cooled. And in West Central Texas, many of the clouds there have such depth, and so you end up getting a lot of the water to be captured and converted into raindrops in super cool form.

Now, this is the flare that's used most often. (Different flare passed to me)

Now Tommy uses them down in his area, which is more sub-tropical, although where we found from some of his convective clouds that precipitate, some of those clouds develop and rain before they ever get to a tower, because his freeze levels are higher in the atmosphere, because he's closer to the Gulf and his climate's typically warmer than it is in a more continental regime like you'll find in an area like Plains. So at times it may be that a glaciogenic flare like silver iodide will work well on convective towers, there may be occasions when you get clouds this time of year in August when there's a lot more horizontal extent to the clouds, not so much a vertical extent – you don't get a cloud that gets much of its mass above the freeze level, and neither flare is going to work. And so you'll end up using a – what's called a hydroscopic flare – hydroscopic meaning water attracting. So it's hydroscopic and this quickly draws moisture out of the air, and so there are flares now in use – a few are being used in Texas that are hydroscopic, and what we're trying to do is identify climatological systematically from year to year and season to season, and even

month to month, which clouds are which and what seeding material is best fitted for that particular cloud.

John Forrest: I've got an idea that that's the difference from where we are Down Under. We don't have a lot of those really high clouds – our clouds are different. For the last two weeks I've had them drifting over Western Victoria …. And we've had 20 points of rain, which is less than ¾ of an inch of rain a fortnight.

Tommy Shearer: Twenty – when you say points, you mean centimetres?

John Forrest: No, 20 points is ¼ of inch.

Tommy Shearer: That's a little less than an inch.

John Forrest:: And when we need inches, really ..

George Bomar:: What do the top of your clouds get to? Do you know?

John Forrest: Well, I think they'd be probably about 5,000 feet. ……

George Bomar: Probably because those clouds didn't get any of the mass substantial enough of the cloud mass above it to freeze levels. So you don't have any supercool water in that cloud and that type of layer is not going to work. Let me hasten to mention that this type of flare is now more in use than the flare that you're holding. *(I was holding top seeded flare).* This is also a glaciogenic flare -- it's got silver iodide in it, but it's wing mounted rather than ejected from the belly of an aircraft. And you'll see planes with these in on the wings.

John Forrest: And is that a hydroscopic, or is that silver oidine.

George Bomar: It's a glaciogenic, but it's one that's being used more often.

John Forrest: Do you fly it through the cloud, above the cloud or under the cloud?

Tommy Shearer: : I do the base, they fly above the cloud and they penetrate above with that one (I am holding top seeded flare), but with these we do base seeding and we basically fly under the cloud and look for the updraft. When in the updraft -- we burn these – it's just like a low flare – it makes it float in the trailing edge of the airplane .. it actually sucks the agent up into the cloud and that will float.

George Bomar: You'll see one of these burning with the video and you'll also see one of those injected when the plane flies above the top of the convective tower that's coming up from below.

Tommy Shearer: They need to be placed in about the minus five level. And they get that from the ground, and they soon find out where the updraft is

John Forrest: So it sounds like you don't fly through a cloud? You're either above it or under it ?

Tommy Shearer: : You try to stay out of the cloud when ever you can.

John Forrest:: How do you know what cloud to seed?

Tommy Shearer: We look for a minimum of a 500 footer but it's a bit more complicated than that.

John Forrest: Does your radar analysis tell you all that before you go?

Tommy Shearer::The TITAN Radar that we're using has a program within it that's called SSS, and that actually shows where the updraft is supposed to be at. Of course, the pilots involved … you watch your pilots -- and that was something I was going to tell you a while ago. I think what we have found is the importance of continuity in people. You know when you use a contractor, he brings new pilots, and they change every year, and new pilots every year, there's no continuity.

I have in my own program, the same meteorologist for six or seven years, he learns the dynamics of my area, while my pilots know the terrain, they know the cloud structure where we're at, they begin to develop a second sense of where to go and that has really increased our benefits. When a pilot sees a cloud, he has a pretty good idea from past history where he needs to be, and they're usually right. That and my meteorologist also using GPS and the TITAN, he can actually direct the pilot to the right place. We've come a long way in four or five years.

John Forrest: We're going to struggle with that. I mean, we might have to import some of your people.

Tommy Shearer: : You can send people up here and we'll be happy to train them, that's not a problem.

George Bomar: In fact, we have the State Association --- Tommy's an officer in the Umbrella Texas Water Modification Association, and all these projects have people on that Board. With money the TDA is providing, they have conducted schools from time to time, bringing in existing pilots and new pilots and put them through certain programs over several days. And they also do that with the meteorologists, and the whole school which is conducted in San Angelo is certainly available. Tommy did bring in other folks that want to learn these skills.

John Forrest: Can I ask another question? How much interest has Australia shown in what you are doing? When I asked the CSIRO, when was the last time they went to Texas -- they'd never been.

George Bomar: You're the first Australian I know of to show an interest. We have a weather modification association which is international – it's essentially national, We have someone from Spain, we have someone from France, we've had someone from Indonesia participating -- and South Korea. We've never had anyone from Australia. In fact, the only guy that I know who has been in Australia -- I think he may still be there – is Alex Long. Alex is older than I am – in fact, I almost went to work for Alex at NCAR In 1975 when I got out of college. NCAR is the National

Centre for Accident, Research in Texas and so he's moved around. The last I heard, he was in Australia. I don't know that he works for that organisation that you're speaking about ---- Look, I don't know of anybody else other than Walker – Joseph Walker – who is a native Australian – was involved with the Snowy River, probably some years back, and I talked with Joe on Monday and told him that you were coming and he said, well, we're going to try and get the Snowy River project reactivated.

John Forrest: That project was back to 1975 when there was this great big squabble amongst the professionals, and nothing of any success has happened since.

Tommy Shearer: Really? 1975.

John Forrest: Apart from Tasmania which still has an ongoing program.

John Forrest:: There was an argument about the integrity of the outcome and then there were changes in government. The funding's the problem, and because it doesn't seem to have a priority because it's seen as old technology that doesn't work. Now maybe the Australian conditions are slightly different. One of the reasons why I came to Texas because of its dry, arid climate – very similar to ours – I thought, well obviously you've got to use different technology in different locations. And you've got a range here from sub-tropical to dry-arid. That's exactly what Australia is like, you know. Cairns is probably similar to probably south of Houston, Plains and the Panhandle would be similar to where I live. And you've already confirmed that you use slightly different techniques?

George Bomar: You're on the edge of Victoria, aren't you?

John Forrest: Yes. Did you get my CV I sent? I put a map in that just to give you some idea?

George Bomar: Actually, I think -- I got some information about you off the Web Site. There was a map of your district. I couldn't make too much out of that little map

John Forrest: I have a map with me which will give you some idea of the geography – that yellow region is Mallee. See the yellow – that's our desert scrub, and you see there's a fair bit of that in my Electorate, but we can still grow 10 bags of wheat per acre on that ground, provided we get rain at the appropriate time. You can see the green farmland, and then there's the coastal region, which is the darker area. That's about -- 85 percent of Australia's population living on the East Coast. Brisbane to Melbourne mostly. But down the bottom of my Electorate, you can see this region here. That's the water storage for the entire area, and it's supplied by pipes and channelled all the way to the North. That's why I'm here – they're mountain ranges, they're mountain ranges around about 500 metres – 1,500 feet. The storage is down to 10 percent. Next year we'll have no water, and we still can't get some attention.

George Bomar: Sounds similar to the oldest program in the State of Texas at CI&WD – their cloud seeding is for lake storage. That's their whole purpose in

operating and existing, and basically by a large part that's what San Angelo's doing. They do it for some of the ranch lands also, but the August project actually concentrates on lake storage.

Tommy Shearer: It's the project in blue, which started in '71. It's 32 years old *(referring to map of Texas Counties, West Texas Weather Modification Association No.6))*

John Forrest: That's the oldest one. I read that – '71.. This is the interesting part. I found a scientist in Australia that's got some interest in all this. His name's Ian Searle. He works for the Tasmanian Hydro-Electric Authority, which is that State right down the South, it's an island State, and they're the only people where I get a positive reaction in regard to cloud seeding, and they're doing it. Been doing that since the seventies.

Tommy Shearer: Oh, they're still doing it? Are they using aircraft?

John Forrest: Yes, their funding is state – completely State-based through the Hydro Electric Power Authority.

John Forrest: Can I ask about your drought? Drought brings no clouds so how do you get on?

George Bomar: We've had some good years, we've had some not-so-good years. In terms of having cumulus clouds, and we're really at the mercy of the prevailing weather patterns, and whether we get a proliferation of convective towers that we can work. This year's been a fairly good year, at least to this point and we believe we're about to pull out of this 7-8 year drought because historically our droughts run about that long, and we've been in one now for seven-plus years. Some of these folks would say it's longer.

John Forrest: People have said the recent severe rainfall is your fault.

George Bomar: This is very misleading. We've had some torrential rains in a quarter from South of San Antonio up into the Aberline area. Everybody else has gotten very little from this system that's been around now for about two weeks, producing the floods that you've heard about.

John Forrest: I'm already surprised about the green, but I'm not carried away by that either. I mean, our continent can look the same sometimes.

Tommy Shearer: Oh, just add water! Our country can just bound back in a hurry if you can just give it a drink.

George Bomar: When you get to San Angelo tomorrow, what you see there is what this area normally looks like in the middle of July.

John Forrest: How have you been able to counter the argument that says, well, this is God's ways, we've just got to live with it. How have you been able to crack that barrier, because that's my issue?

George Bomar: Well, as Tommy said earlier, these folks in his areas where we now have projects we're aware of the limitations of cloud seeding technology when we're in a drought. We still do have clouds – they just don't occur as often and a lot of the time the clouds just aren't receptive to seeding. They don't have enough vertical growth to – they don't get into air that's colder than freezing. But even in this 7-8 year drought, we have gone through spells where we had lots of clouds to work, and we worked them. We tend to believe that the pendulum is going to swing here fairly soon, and we're going to get back into a fairly normal weather pattern that will last for several years, or might get into a wet weather regime, and then we'll be able to work properly. Our money will run out before we run out of clouds to work.

But what we say to folks is, look, people don't want cloud seeding technology until they're in a bind, until they need the water. You go out right now and try to talk to people about doing cloud seeding in Travers County—they'll run you off. We had somebody call yesterday and say, can you all seed in a way to keep these clouds from rain—we've had enough.

John Forrest: Is it possible, by the way?

Male Speaker: Yes, it is possible. If you had the energy.

John Forrest: What would you use? A hydroscopic salt?

Tommy Shearer: Yeah, you just bang on the clouds --- seed them like you seed them for hail suppression. We found out you can overdose.. you're smoking till you give it too much – so much, you deplete the cloud. We like to laugh and say that, but you give it so much ingredients that it can't shit. But what we said to these folks, and what I think you're colleagues would need to understand is, now you see the weather getting dryer and dryer and your reservoir water drops and you need water, arguably this is not the best time to be doing cloud seeding. You've waited too long, should have been doing this back when you had lots of weather to work.

George Bomar: But we have to take what we've got right now, and that's what these folks did. In the early stages of a long-running drought, they went ahead and started their program, they realised we're going to go through spells that are weeks in duration when we don't have a thing to do. There's nothing to work. They've stayed with it, they have worked when the clouds developed, they're satisfied that this works when we can deploy and do seeding, better times are ahead, we're going to continue this through the drought and then we're going to stay with it when we get into more favourable situations.

Tommy Shearer: We're actually like everybody else, we're into crisis management. You know, we don't think we've got a problem till we're in the big middle of it. When I met George Bomar for the first time I was feeding my cattle with a cactus called prickly pear. I don't know if you have it!

John Forrest: Yes, we know about that.

Tommy Shearer: Okay, well when George Bomar came down in '96 to give a little presentation out in the country, I happened to show up there, and I was burning pear for my cows, burning the needles off – and I don't know if you're all doing it down there – but it's not a fun thing, especially in July. It was this time of year, it was 100 degrees outside, and I've got a blowtorch with a flame about this long, about from here to me in front of me every afternoon trying to feed my cattle. So they didn't take much to get my interest. I was looking for any sign to find an end to the drought. Now that's really how we got all this started because it wasn't hard to find a lot of interest down there.

People were keen on the idea of making it rain. What we had to do was build a foundation that would be there when the better times came. So that's what we've all struggled to do. I think we've been successful at it. Oh, another thing that we're doing that's different to what's been done in the past – and George Bomar may differ with an opinion on this – but a lot of our research and a lot of our effort is business focussed. We're sticking to a businessman's approach in this, which I think is probably the first time that's ever been done.

Maybe Colorado River MWD (area No. 1 on County map of Texas) did, but we do things that we see that we believe are going to benefit us in the short time in the near future, and while it's necessary to take research and look at some long-reaching effects, we're aware that with the legislature with our local constituents and base, we'd end up marketing. You know, we've got to sell ourself everyday, and we've got to give the people something that they use which at least in their mind is a tangible result of what we've done. And I think we've been successful, so I think that's the larger part of our success and Dale Bates, we laugh, and you will understand this after you get to meet him, he can sell ice cubes to Eskimos. And he's really that way, and that's been a lot of it too. It's been a selling job and we've marketed ourself with our own people.

But we are continually, looking at better ways to do what we're doing, and better ways to quantify what we're doing. A part of what you're going to see is a research effort, or valuation effort which we have put together ourselves. So we've had the grass roots of it from South Africa, but we've had to tailor it to ours, and then we've got a Cuban that was a political prisoner of Castro's that had a Masters Degree in Cloud Physics and Mathematics --- and what are we doing – and he's an extremely keen individual and extremely talented. Good with numbers, modelling and stuff, and we're working on valuations, and we're changing some of our timing, we're changing some of seeding tactics, we're changing some of our seeding agents, based on what he tells us.

He can give us a report within 72 hours – three days, four days of when we did the project – when we seeded that cloud. We e-mail the information to him, he runs it through his software program, does his computations and gets back and tells us where he thinks we may have messed up. Based the information we sent him, which is the type of archive data we have, because we've got everything archived in the computer program when we seed. The airplane tracks are in there, the times are in there, the location of the storms are in there, the history of the storm from where we picked it up, to the radar run is in. He takes all that information, may argue something about what we're doing, but my contention is that we start from the same

basis point every time. Whether we're right or wrong, we're consistent. We've had an affect on that cloud -- from this point we've had a positive or negative affect on that cloud. We always start from this point, and we've seen some great results in the last 12 months, or the last year and a half. He's even begin to give us some idea of how much seeding agent to put in the cloud based on the volume of that cloud, and the timing. And boy, we've seen some great numbers have changed since we've started doing that kind of stuff.

George Bomar: You'll see that tomorrow afternoon, and I believe Archimedes Riuz will be there. Is he back? Archie, we call him --- Archie. Over the last 30 or so years we've seen folks go through rather predictable cycles with weather modification. When it gets dry, people are running out of water – they go after anything and everything they can get their hands on to try and get relief, and folks all over, West, South, even North Texas at times over the years, have embraced cloud seeding, and they've brought in a contractor and they've seeded over a multi-county area for a summer.

Tommy Shearer: If there's a very much a droughty summer, not a whole lot of weather to work with, they can get quickly discouraged. After trying it for a year or two, they gave it up. And then we went a number of years, and then we went through another drought, we had the same sort of interest generate again. The contractors over the years have done a very poor job of evaluating their work and then giving the customer an analysis of the work that they did.Their focus has been on "Okay, you want a job done, you want X number of clouds seeded over six months. We'll do it." And they bring in good aircraft, they bring in good people, they do the job and then they leave it up to the public, or the customer, to discern "Hey, it really did rain more this year. That stuff does not work." Very, very subjective.

What we've tried to do since this program started in '96 – and again Dale Bates is to be credited for emphasising if we're going to keep money coming from the legislature, we're going to have to do something other than build programs and do operations. We've got to start assessing that the work that these people are doing, and do our level best to try to quantify our seeded clouds are behaving from non-seeded. It's a very, very formidable challenge to do that, because how in the world do you know on a given day, if you see the cloud and it reacts in a certain way, how do you know you caused that reaction? But you're going to see some evidence tomorrow.

John Forrest: That's the argument that we had 25-30 years ago. We've never been able to prove the efficacy of the outcome, and we've had a scientific argument ever since.

George Bomar: Yes, and we can't prove that yet either, and I don't know that we'll ever get to a point where we can prove it. Here's what we're told by these people that live out here off the land. They say that everything we do is risk-based. We plant a crop every Spring, we apply certain pesticide, we fertilize and we do all sorts of things. We depend on Mother Nature to pitch in and do her part, and some years we have a good crop and some years we don't have as good a crop. But the fact that we can't prove that at the beginning of every growing season, that if we do xy and z we're going to get so much a return. We can't prove that, but we get out there and

we do it anyway, and these folks say “Hey, the cost benefit ratios that these programs have generated is worth the risk.” And I mean we’re looking at anywhere from $350 return on a $1 investment to as much as $700 and we’ve done an assessment of one program to determine of the four major crops run in that area. If we can count on a 21% increase in rain in the growing season, what’s that going to mean to the regional economy?

And the folks at Texas University have generated numbers for us that say, for the amount of money they’re spending to do cloud seeding, if they produce a 21% increase, those four crops will multiply to a point that the economy will gain 700 for ever dollar they’re spending. And when people look at that and say, “Well, maybe they’re off.” But even if it’s only half, or even if it’s only a tenth of it, it’s worth spending the money. In fact, folks laugh at nine cents an acre. They say, “You’re kidding! You can do this for nine cents an acre!”

John Forrest: Have you got any documentation of any attempts at all to justify the efficacy? Like, I mean that’s – I’ve been looking for that – I’m going to need that, because that’s where we’re at – the give-up principle. That’s what we’re looking for. Have you got anything I can rely on?

George Bomar: I’ve got a notebook here full of technical papers and reports and assessments that I’ll be happy to go through and just replicate and give you a copy to take back with you, and you can sift through there and see what’s of use to you and what you want to share with others.

John Forrest: If there are electronic sites too that I could go to rather than take a heap of paper back with me. This is going to take me two or three years. I’ve got a Parliamentary Inquiry starting up. It’ll take a while to get the evidence, but that will be sworn evidence on oath, and I’ll get some of our scientists in the witness seat, by which time our continent will be screaming for rain. We’re very close already – but I’ll try to avoid that and try and show a bit of vision.

George Bomar: I want to give you a copy of a White Paper, or a Policy Statement of the American Meteorological Society on Weather Modification to take back with you, as well as one by the World Meteorological Organisation, and these Policy Statements say – these statements do not say there’s nothing to weather modification. What they say on the other hand is – we still have a lot to learn, but based on how it’s been used today, we see some potential substantial payoff from the use of cloud seeding, given certain circumstances – given certain weather scenarios – and these Policy Statements say we still have to do a better job of identifying what is seedable and what isn’t. We had to do a better job of – and we do seeded cloud compared to one that’s left alone.

That’s the real disadvantage to doing cloud seeding on a broad scale operational basis like we’re doing. These folks, everytime clouds develop and appear to be seedable does not mean they want to hit them. Whilst they don’t want to let any opportunity slide by, some clouds are left alone. The scientist would tell you, in order to get to a point when you can provide reasonable evidence, or even proof that this works, you’ve got to do over a long spell, you’ve got to seed some, you’ve got to leave others alone, and if you get a large enough population of seeded and control of

clouds that serve as a comparison, then you can accumulate enough evidence – then it becomes rather overwhelming and compelling, and even the scientist, who are most critical, have to back off and say "Yeah, I think you're right, I think this works a lot of the time."

We've been building those databases with great success and are looking for Federal funding to take this further.

Meeting interrupted to meet Don Dudley, Director of the Licensing and E-Commerce Division in the Agency.

Don Dudley: It's good to meet you.

John Forrest: Thanks for allowing me some time. **(DD: Oh, absolutely**).
I was going to do this all cold, and show up down there at the counter and say, "can you help?" …. First day, and we're right into it.

Male speaker: I've been here nearly a year and this is a great place.

John Forrest: All of those names you've been mentioning – Dale Bates, your own, Bill Woodley – but I didn't know about you and Walker. They're all names I've picked up over the last two years of reading research about it. So you're world famous.

Don Dudley: Well, it's good to know your interest and we want to give you everything we've been able to understand and generate in the way of evidence, how to do the program well. We've got a lot to learn – we think we're going to be doing a lot better in five years than we're doing it today.

George Bomar: Well, you're welcome to sit in if you like.

Don Dudley: I would love to sit in here and talk with you guys but I'll talk to you later.

George Bomar: Do we need to take a break? We thought we might go fairly early for lunch – kinda beat the lunch crowd about 11.30. Would that we all right?

John Forrest: I'm in your hands.

George Bomar: You obviously haven't had any BBQ yet since you've just arrived?

John Forrest: I haven't had a steak yet—no. We tried to sell our steak to the US, but you've put us on this unfair quota ---378 thousand tonnes, which is a bit anti-fair trade No, we're proud of our steak, but I've heard that Texas is just thicker. It's always bigger in Texas.

George Bomar: We've decided to get you some BBQ.

John Forrest: The size of Texas on that map on that scale is probably an area about as big as that East corner of Australia. Big state, Texas.

George Bomar: I don't know whether you all use acres in Australia.

John Forrest: Oh, we're metric. Some of us did our degree in the old system – still talk about inches and pounds ---

George Bomar: We have about 170 million acres in Texas, and we've got 52 million that are engaged in cloud seeding, so we're about 30 percent of the land area of Texas.

John Forrest: And obviously it's not needed over here on the East?

George Bomar: Most of the time it's not needed. Now, these folks were pretty dry this Spring, but we've not had any dialogue with folks East of I35 – the Interestate Highway that runs from Dallas, actually through Austin, San Antonio to Houston. There's been one cloud seeding program over here in North East Texas that was run by a timber company years ago, and they used ground-based generators and it only lasted a few years.

We don't use generators in Texas at all either ground based or aerial. They're very effective in mountainous terrain. In fact, of all the weather modification technologies, the use of ground-based generators in mountainous terrain for snow-pack augmentation is farthest along being proven. In fact, our Federal Bureau of Reclamation got to a point when they said "That's been proven, it will work" and that's when we lost our Federal money for all of our weather modification research when they felt they got to a point where they could prove it worked in mountainous terrain, in the western part of the country where water is even a harder issue than it is in West Texas.

John Forrest: We know that too, we can make it snow on the ski resorts because there's big money involved.

Tommy Shearer: That's the whole deal, isn't it?

George Bomar: Would you like to take a break and view a video that lasts about 20 minutes, and then we can carry on our discussion. There may be some other questions that this video will prompt.

John Forrest: Do you have a cup of tea or coffee?

Male Speaker: Yes, well there's not a place in this --- let me look, there's a coffee pot out here---

John Forrest: (*Question to Jane Lee)* What's your role in all this? You're the Treasurer by the sound of it.

Jane Lee: Yes, I do. Fund the research, the evaluation.

John Forrest: Are you a meteorologist?

Jane Lee:: No, I'm not.

Comments made during presentation of two Video presentations.

Two VCR's presented. Refer digitised copies on CD attached:

Harvest Texas – Best presentation
Harvest West Texas – 1995 (refers to wing generators now not used)

George Bomar: It hangs in a rack like this on the airplane.This is an electrical detonator. They send pulse to it. It will fire the first fire which creates a small explosion at this point – just like a bullet – and it forces the candle out the bottom. is compacted in a monofilm tube about this long that actually incinerates as it burns. It burns over a course of about 45 seconds to a minute as it falls, and it just completely burns up.

These here will actually --- this is the monofilm tube I was talking about. There's also one of these inside here that holds the ingredients in. This will start burning at this end. You've got a little wire here that's coiled around it --- it's kind of like a red hot fire – the same thing that's on the end of a match that starts the … burning, and it will pop this cap off, and this stuff will just burn right up to where it stops. And this part stays on the wing rack and we just throw this in the trash and pop another one on.

John Forrest: But what's that material? Vinyl? *(referring to cap)*

George Bomar: Yes, that's exactly what it is.

John Forrest: What about the hydroscopic seeding? How's that distributed—as salt?

Tommy Shearer: Well, the thing about these is they have a multiplying effect. The silver iodide – and one of the reasons that it's being used so largely here, it tends to have multiplying factor, where your hydroscopic has no multiplying factors ----, so trying to get enough out – enough salt out to have an impact has been the problem with hydroscopic. Now one of the things that we've seen in our evaluations as we have just tested some hydroscopics ourselves in some of the projects, is that it may be so we don't need as much salt as we thought we did. Maybe a little has impact – and our silver iodide flares formula we're using now actually has some salt in it, so we're not sure that we're not covering both bases at the same time. Anyway, that's the case in my area.

John Forrest: But if you just do pure salt, how do you distribute it?

Tommy Shearer: We burn it.

John Forrest: Oh, you burn it as well?

Tommy Shearer: And I've got some of those, but they've not been very effective. I've not seen good results out of it. Well, that's curious to me – I would have thought such clouds would have been higher than the freeze level, the glaciogenic may not work as well.

John Forrest: It would be higher – much higher in the north of – sub-tropical, but down here where I am –

Tommy Shearer: On the coast. What's your elevation?

John Forrest: About 300 metres above sea level. That's flat country -- that's very much like Texas. So the cloud base north of here is up to 10,000 feet? It's higher there--- I can see that.

Tommy Shearer: Well, in this part of the world, typically, and this time of year, our freeze levels are about 18-19 thousand feet. You see, we've got to clouds, and as I understand it for these glaciogenic flares to work, that cloud needs to be in the freeze level, preferably in the –5 so it needs to get to about 22 thousand feet, and we need to 6000 – 8000 thousand foot of thickness to have moisture to actually be worth going after.

George Bomar: This time of the year, the freeze is somewhere about seventeen – seventeen five – and if you've got five thousand of cloud depth to that, then you're right at about where the aircraft flies dropping these injectable flares from the racks. And in that fall through some five thousand feet of cloud mass, the candle in this metal tube will disintegrate, and disperse into the ---

John Forrest: What about the unsuspecting person on the ground? So the whole of that is consumed?

George Bomar: Yes, and the tube stays in the rack on the aircraft, so nothing reaches the ground.

John Forrest: So, even the cap? That just burns up?

Tommy Shearer: Well, that aluminium cap on the end may not, but that is about the thickness of this round here.

John Forrest: Anybody ever complain about debris?

Tommy Shearer: No – we stay out in the rural areas.

George Bomar: Several years ago we were using flares from out of the state and those flares were not properly manufactured and we had a lot of duds. We suspect a lot were reaching the ground and we feared getting phone calls from people saying they had been hit by falling flares or some cow had eaten the candle and poisoned itself or something. Fortunately that never happened.

JF – The candle itself is based around some sort of aluminium core I would be interested to see what is inside.

Tommy Shearer: You will, we will show you the insides of these when you get to the factory in San Angelo. That is the bigger flare that is used for bottom seeding.

JF – That is what it looks like, is it?

George Bomar: Well actually show you in the inside of these flares at the plant tomorrow afternoon in San Angelo.

Texas – 17 July 2002 PM

John Forrest: 3.45pm, where we met Mr Joe Morris, who is the Chief Political Aide to Senator Wentworth, who represents the North-West region of Texas. Senator Wentworth was not available. Senator Wentworth played a pivotal role in the introduction of enabling appropriation of weather modification in Texas, which is all state initiated and state funded. The total budget for the whole state per annum is $US5 Million which is made up roughly half appropriates from legislature and the balance attributed by the water authorities, and in some cases, land users and local government through the rating structures.

Federal funding for weather modification is currently stopped, but initially back in 1995 Federal funding was made available purely for research and development, but not for implementation. Implementation is a responsibility here in Texas by the State legislature and is now on appropriation of roughly $2.5 Million per annum.

During this discussion I asked questions in regard to the significance of Danny Rosenfeld's science in predicting the limitation of clouds from falling precipitation due to the presence of man-made pollutants, and George Bomar spoke very well of Danny Rosenfeld and his work. George Bomar explained the physics of the interaction when cloud consists of particles because of their numerical presence and size prevents droplets from coalescing into raindrops, because what moisture is present tends to collect around the particles, and advise that there is little distinction between dust, airborne aerosols of different kinds, carbon monoxide, solid smoke particles either from fire, grass fire or forest, and supports Rosenfeld's contention in regard to the impacts of pollutants in clouds. He was very clear on this, and again reiterated his respect for Rosenfeld's work. He did indicate that Danny was somewhat forceful in his presentation and this needs to be overlooked because Rosenfeld is so confident in the veracity of his assertions.

There was also discussion regard to the use of radar technology in the observation of cloud behaviour, and the distinction between what is referred as Band C (or as they refer to it, Charlie Radar and Doplar Radar). Doplar allows a three dimensional picture of the cloud formation to be developed, which is very useful in the prediction tool of nominating those clouds under which there is an updraft to assist in the seeding operation. This is clearly a very important element to place the plane in the appropriate position so that the agent is drawn upwards into the cloud so that it could then rise quickly, form supercool water which is the primary stage of rain development.

I need to check of the bandwidth for Australian radar in meteorology when I return. As I understand it, Doplar radar is a 10-centimetre band length — Charlie Band is only five-centimetre — but I need to check that. Some additional information provided by Joe Morris as part of the discussion included the population of Texas at around 20 million people. This is virtually the entire population of Australia contained within an area of 1/20th the size of Australia.

Speaker Laney had earlier boasted that Texas is a State in its own right. It's the 11th largest economy in the world with a GDP in excess of one hundred billion – that's billion dollars – so in essence this confirms its economic comparison with the whole of the nation of Australia.

San Angelo – 18 July 2002
Meeting in San Angelo of Texas Weather Modification Advisory Committee

Mr Chairman ….Weather Modification Advisory Committee Sub-Division of the State of Texas is in order now, and I would like to read this statement. During this meeting we will receive testimony from the public. If you wish to speak and have not filled out a Witness Affirmation Form, please do so at this time. Witness Affirmation Forms are available somewhere there. These proceedings are being recorded, so therefore it is necessary that you state your name and the organisation that you're representing (inaudible) may be included in the reference. Would all persons who filled out this Witness Affirmation Form, please be sworn in at this time. And would you people hold your hands up and say your name, and do swear on a Bible that the testimony you will prepare is the truth.

Okay.. At this time our meeting will be in order to look over the Minutes of our April 28th meeting.

George Bomar: Mr Chairman, we have a number of guests in the room who are attending the Advisory Meeting, I believe, for the first time. We also have a gentleman from Australia who's here, who will take just a moment to summarise his trip to the United States, his visit to this project and other projects, and I'm referring to John Forrest who is a Member of the Parliament of Australia. John arrived Tuesday evening in Austin and spent the day with several of us in Austin yesterday. He's here to become more familiar with the San Angelo program today, and will be moving on to visit at least two other projects – one in Plains and the one in Pleasonton.

John, if you would just give the Committee a sense of what you hope to learn on this fact-finding mission.

John Forrest addressing Texas Weather Modification Advisory Committee
Left to right: Bruce Riglar (Chair), Everett Deschner, Richard Orville

John Forrest: Thank you George, Mr Chairman. Well, it's a real privilege to be here today at San Angelo. It's a long way from my part of the world, I can assure you. But Down Under down there, we've been hearing about the great work that's been done right throughout Texas, particularly the western part of Texas, on weather modification which Australia was very active in after the Second World War, in the late 40's and through the 50's, but the last substantial weather modifications occurred on the mainland continent of Australia was in the mid 1970's.

Meteorologists, scientists argue that the cost benefit's not there – some even argue it doesn't work. And I've got a little bit cranky with that, including my colleagues in Parliament, because I represent a constituency that has its water supply down to 10% of capacity. And it's a trend that's been happening over the last 12 years and it's bigger than just driving the Southern Oscillation Index, which is the measure of El Nino, and like your continent here in America, it affects very much the weather in Australia as well.

So I'm on a fact-finding mission, Mr Chairman, and I've already been impressed. I've been in Texas for not quite 48 hours and I'm very grateful to Gary Walker and George Bomar, for getting me introduced to people on the ground, can-do people making it happen, who in the 70's also found it very difficult to get success with weather modification and I was grateful to Dale Bates earlier to explain that to me,

but didn't give up, and developed some specialist techniques using modern technology.

I'm keen to be seeing more of that here in San Angelo today, and I certainly thank you for the opportunity. I'm very impressed that I'm giving sworn evidence. We in Australia have a reputation for being innovative. We like to borrow from the rest of the world, I like the idea of letting you guys make all the mistakes for us, and we'll pick up on your success. But on this issue of weather modification, we have just dropped the football, and I'm determined to urge that to be remedied.

The Southern part of Australia is in dire consequences as a result of shortage of rain. There's not one storage across the Southern part of the continent that's got more than 50 percent of its capacity stored and it's deteriorating every year. So we've got a crisis on our hands and I'm hoping that my visit here will strengthen my arm and encourage those who control the chequebooks to allocate some research and development to weather modification. So any of the facts that I can glean from today's meeting, I'll be using to maximum advantage down there, but I certainly want to thank all those involved in assisting my program, especially Gary Walker and George Bomar for their assistance so far. Thank you, Mr Chairman.

Mr Chairman (Mr Bruce Riglar): Yes, thank you, Mr Forrest. I'd just like to make one comment there. When you said that we made all the mistakes and you want to learn from them, we're still making mistakes but we're hoping they're improving and developing while we're uncovering mistakes making and everybody likes to envisage. Nobody has all the answers yet and we're aiming to keep improving weather modification programmes.

George Bomar: Mr Chairman, there are several here I believe representing elected officials. If you folks would care to introduce yourselves.

Various speakers introduce themselves

Bruce Riglar: Okay, now that we have everyone duly introduced from where you're from and we hope that you will find this meeting interesting and have some information that you can use and illustrate and head on down the road. At this time I would ask that George Bomar take care of some of the staff reports.

Dale Bates (West Texas): We're having a most interesting year. For those of you there not real familiar with what we do. We have three separate programs that make up about 54 million acres in the State, and some of these programs have been inundated with rainfall this year, and they did a lot of seeding earlier and of course seeding stopped, but we are still in a very difficult situation from moisture starting from San Angelo going west. San Angelo has had enough rainfall to kind of green things up but west of here it is still very dry. When you get out to Reagan county and Glascott County, it's exceptionally dry from there on. So we're doing everything – we're doing our job. We're flying a lot, we're expending a lot of flares, so we've had what I consider to be a very successful year actually, considering all of the different types of weather that we've been confronted with here.

I do want to bring up that we have got some very interesting things that are happening. The TDA, (Texas Department of Agriculture) was invited to appear before the Federal Senate Inquiry.

We have been invited to negotiate with a country that formerly was the Soviet Union, and we're in the process of those negotiations right now with the State, and that is quite interesting. It appears that everything is extremely favourable up to this point anyway. So we're entering kind of another phase of what we're doing. We've stayed down here for seven or eight years and nobody seemed to realise we were here, and now all of a sudden we've probably got the attention of increasing number of people.

We are developing, as always, new concepts, new ideas that we're working on. So if anybody after this meeting is over would like to know anything specifically, we are going to be touring. Westex's Weather Modification facilities which are right here. Now there's two separate identities housed in this office over here. One is the Westex Water Modification Association which is made up of Southern Counties, plus the city of San Angelo. And then the Texas Water Modification Association. Each one of the nine of the ten programs make up the Texas Water Modification Association.

Now for our guests, I would like to say that we, starting last year, developed a technique whereby a cloud is seeded any place in the State, then that data is transmitted here on the Internet, and we analyse what we think happened. We have a software program that can give us a really good analysis, in our opinion, of what was done in the seeding. So we try to turn that data around three days after we've seeded, so if the program gets it in here early enough within three days, they can be looking at the results.

Now the person who does that is Archie Ruiz in the back of the room, so somebody may want to spend a little time with Archie today and go into more detail with how that particular analysis works. The analysis has given us a great deal of cloud physics data that lets us make better decisions. It's answered a lot of questions for him.

George Bomar: Mr Chairman, there's a map showing the location of the active rain enhancement projects in Texas, and there are eleven delineated on the map (copy of map in appendix A). Two of them don't show up very well at all on a black and white map, so keep in mind that there are projects based in Del Rio and also in Pleasanton. Of course, the one in Pleasanton and the total acreage is 51.67 acres. And the map reflects the fact that the efforts offered by authorities target area is deduced from next year, and in fact, that deduced target area has now been started by two other projects, one based in Pleasanton and the one based in Tuscon.

George Bomar: Yesterday's newspaper article concerning renewed interest in cloud seeding in the State of Montana. Now that's far removed from Texas, but I just wanted you to be aware of some revaluation that's going on far to the North, and some interest is now beginning to surface again in Montana. Montana …. has been at odds for a number of years over the use of cloud seeding on the eastern edge of Montana for the benefit of the farmers and rangers in North Dakota.

And this article illustrates how the two sides are talking again and there seems to be some loosening up of their rather stringent requirements that anyone outside of Montana who might be seeding in Montana should have a $10 million surety bond to cover any errors

Bruce Rigler: Now I don't see paper relating to a cooperative agreement.

George Bomar: Yes sir, a cooperative agreement was handed in to the Texas Department of Licensing and Regulation and the Oklahoma Water Resources Board on June 20, and this directly impacts on the rain enhancement projects in Texas. This Agreement has been in the works for some time and what it does, it provides for the use of air space along the Texas/New Mexico border for any operation that's based in Oklahoma bars any operation that's based in Texas. Before we entered into this agreement, in order for the State of Texas, or any of the projects in Texas to use Oklahoma air space, or for the Oklahoma Water Resource Board to use air space in Texas for their operations, a permit has to be applied for. In New Mexico with a common border that runs from Colorado all the way to Texas.

It can be a very elaborate and expensive process to get a permit simply to make use of some ten miles of air space inside the adjacent State's territory...And what this new agreement does – and this is an offshoot of the Weather Modification program being assigned away from TNRCC to the Texas Dept of Licensing and Regulations. TDLR was very open to the idea of doing this agreement, which no longer requires that Oklahoma to use ten miles of airspace, get a permit from them, and likewise if we choose to seed clouds in Oklahoma that are moving in Texas, then we will not have to get a permit to operate in Oklahoma air space. And this agreement provides for a width up to ten miles wide in either of the two States.

We're negotiating now with the interstate training mission in New Mexico for a similar agreement, but that's going to be much more difficult to obtain, one reason being that some of us are aware of there is a cloud modification initiative that is essentially insert for some 35 years, and that was recently activated in order to allow two of our projects placed in Lubbock and Plains to get access to air space in New Mexico to free systems that are in Texas, and there may have to be a change in New Mexico law before they are able to get a change of agreement with us. So for the time being, folks like Gary Walker and the High Plains Water District Department are having to continue to get licences from the state of New Mexico which are one year in duration, and in the past it required a public appearance in New Mexico.

Somehow, someway, the two projects were able to avoid having to have a public hearing issue in order to have their licences renewed. If we could get an agreement in place that would alleviate having to keep getting the licences renewed.....But that probably is going to be long time in coming. But Oklahoma and Texas now is working

Bruce Riglar: Now this new contractual agreement with Archie Ruiz and his firm to continue to receive, process, analyse and make available results due to considerable output from the various radars at our projects. The Texas Department of Agriculture has recently gone out to bid for two different facets of research and assessment activity.

Jane Lee is here today and she is going to bring us to speed on where we are with the invitation for bids and even the award of a contract or contracts.

Jane Lee: Yes, Archie, and new company, Active Influence and Scientific Management, was awarded the Evaluation Contract from TDA and that began on July 1st. and that will continue until August 31st 2003. The evaluation will be based on the TITAN Software, then all the programs used right now. And by the end of the month we will be accepting bids on satellite imagery for evaluation contracts.

We have been invited by the National Academy of Science to attend their workshop at Massachusetts, and Archie and myself will be giving presentations and Dale and Tommy will also be attending the workshops, and that will be July 31st through August 2nd.

George Bomar: Okay. And also under Item 3C US Bureau of Reclamation, I am delighted to report that we have managed to extricate up to $2.million from the Bureau of Reclamation to get the Weather Damage Modification Program under way. I am referring to the North American Interstate Weather Modification Council. The Commissioner has agreed to activate this program and the manager who is in the Denver Office Bureau is going to be the lead administrator of that project, and no later than tomorrow, the solicitation from the Bureau of Reclamation should be posted and that's going to enable States – that is, State agencies who are involved in Water Modification to prepare comprehensive proposals to use some of this ostensibly $2.million – I think in reality, we're looking at closer to $1.3 million …… and TDLR is going to be submitting a proposal soon and we are planning to engage interest in New Mexico and Oklahoma in that proposal, that is field research that we can do next Spring that will involve this money from the Bureau of Reclamation, and it will be located somewhere in Westex, in New Mexico and Oklahoma to participate to the extent that they're prepared to do something.

One of the stipulations for getting this money from the Bureau is the States must be able to show a 50-50 match. This was done when the Bureau was doing weather modification research back in the 1980's and at the moment there is State money in Oklahoma being spent to do weather modification, and the only money in New Mexico that's made available at this time is about $150,000 from the Interstate Stream Commission, which is to say if these other two States are going to participate in this program, they've got to link up with Texas because obviously we're spending nearly $5.million of public money this year for weather modification, I anticipate there will be at least two other proposals – one from North Dakota, and one from Nevada where snowpack observations are being done on extensive places. The vision is to actually open the door and to use some available Federal money to do some research, and Council is working now to get the Congress to appropriate some new money for next year. And we're asking for $3.5 million. We'll see how the Congress treats that request.

It's been seven years since we've had any Federal money to do weather modification research, and we think the pipeline has been restored. Although the money coming down is certainly not going to be quite as substantial as we had back in the early 90's.

Bruce Riglar: There is one new project in Prospect (No. 12 on Map) and that's west of the Colorado River. Tom Manson is with the Twin Town Irrigation District and he's been spearheading that effort entirely. Tom has been working for months in order to identify some other entities – other governmental participants. For instance, Culverson County, Reeds County, and Loving County. Tom is pursuing equipment. I note that Dale Bates and Archie Ruiz were there the first of this month, I believe. Do you have any late word on where he stands with regard to progress.

Tom Mason: No, I think the real problem is that we got is that none of the counties have intended to budget …Now their budget process, if I understand counties correctly, is September and October. Is that not so?

Jane Lee: They're doing it right now.

Dale Bates: They're doing it right now. What he's confronted with right now.. he's trying to get money into the next year's budget and he's one of the County's Judges and there's a full court press at this point, and I think that he's got a couple of counties that have tentatively agreed to go with him. And there are one or two others that he's trying to secure. His irrigation district evidently has a good amount of money and they're going to be the front of the move for our thinking, and so it looks to me like it's probably going to go together. Now whether or not they have much more of a problem next year, that remains to be seen.

But the interesting thing is, the Kansas problem – about half of the Kansas problem one way – and then the State of Kansas money that they were giving – not a great deal of money to the problem, but they were giving some money and they had to suspend that. So Kansas has a lot of equipment for sale, such as radar and a couple of free airplanes, and so what they're trying to do right now is to get enough money to secure the radar and the airplanes from Kansas, and if they can get that done, well then I think we're probably looking at a program out there next year. Because these things are going to be priced. The radar right now costs like $230,000 or more to buy new, and I think they can get into that radar considerably cheaper. Same thing with airplanes.

Dale Bates: The three of us have conducted about six meetings with county commissions and interested citizens over the last several months, and Tom Manson is moving into new territory in the hope that he can get a target that will need at least four million acres. Culverson County has got about 2½ million, so it by itself will make up half of the new target, and I also believe that TDA has set aside enough money left in this year's budget to be able to match money that we raised at the local level.

George Bomar: I thought there's a possibility we might have a permanent application from that organisation. By the way, they're calling themselves the Trans Texas Weather Modification Association. Now we do have a licence application on the Agenda for the Committee to consider today and that's Item No. 5 and we can talk more about that when we get to that.

Male Speaker: I think the real problem that they're confronting is that is so far west that it is in a different weather pattern from the rest of us, which I think it is, and they may have a very short season. That's something that we probably don't know a whole lot about right now, but at first glance you would have to think their season would be considerably shorter than the seasons say here in San Angelo and Plains, or Pleasant. So they're wondering if that's the kind of hold up on their making the decision. Would it be worth it going into, because it would still cost them the same really make a lot more rain in a very short period of time.

Male Speaker: Well, that about sums up the status quo.

Male Speaker: You talked about Texas having their money, so there's been money, there's TDA --- the TDA has to match the locals – there's that money what counts towards the match.... so it would have to be additional dollars to do a research program in addition to what we're already doing with out program.

Male Speaker: No – no additional money yet. If any money is being spent to do operational cloud seeding, whether it's a … district revenue or state agency revenue, that qualifies as a match. If the money were in the Bureau's budget, we can ask for a timely another research program.

Male Speaker: My question is … If Oklahoma has no money and New Mexico has very little, are we going to be the driving force as far as what gets done?

Male Speaker: Is going to come from TDLR – they're not going to be able to show .

Male Speaker: Yes, Mr Chairman. We have of course for Committee today for removal of existing weather modification licences. This renewal will affect the fiscal year 2003 which will begin on September 1, State Law, … … which was passed last year … 77 Texas Legislation provides for the continuance of permits as long as individuals and organisations doing weather modifications, maintain valid licences. And the Weather Modification Licence is issued for the fiscal year, so renewal must happen every year. Permits that are in place every four years. We have renewal applications from all of the operational rain enhancement projects in Texas, plus a licence for a renewal application from one contractor and that's weather modification... We also have licence renewal applications from two organisations that are using.....

Male speaker: Would you care to say something about your project, and your intentions for next year?

Voting on various motions regarding renewals of licences etc. and highlights the important regulation which occurs to ensure a robust legal framework.

John Forrest: When do you know you've had enough rain?

Bruce Riglar: Just say we don't need any at the present time. We just want it in moderation. You can never give farmers enough rain.

John Forrest: Who controls the air space and where you can fly and not?

Tommy Shearer: When we went to look at the map and we looked at the eastern side from San Antonio back up to the San Marcus area, population was a confirmed problem to be honest about it. It's not as much in the recharge area,Medina County and Bandero County actually carry about 60-70 percent of the recharge for the …. So it made sense for me to concentrate over that area. So what we did in negotiating with them is that we have purchased one additional aircraft and a pilot we dedicate to that, and that of course we'll despatch more if needed. Brings our program up to Border Plains.

Dale Bates: We have a policy that if at all possible, and it always is possible, we do not seed in congested areas of people. We don't want the liability of actually putting an aircraft over it, and also you have airport restrictions around San Antonio would be impossible to work around just because an international airport is there, so each area we pretty much avoid conflicting air traffic.

John Forrest: One of the licence applications talked about a hail cannon?

Dale Bates: It is an apparatus that is fired with a centre fire and it goes off with a report of a 155 howitzer. Now this is very very loud. And on Sunday morning when you have just rolled and going back to sleep and one of these things starts shooting a couple of miles from the house and you go out there for peace and quiet and birds singing you can get some idea of that Congress want some regulation here!

Jim Conkwright, Manager, High Plains Underground Water Conservation District Reported on public relations difficulties in the High Plains District

It is important to keep all elected State officials briefed to prevent any efforts to reduce funding. We need to do the best job of documentation specially of our successes and our works that we have ever done because, well you'll see how easy it is to lop off from the TDA.

I think that all of the comment we have been receiving is based on emotion I have not found any based on any scientific data or evidence yet. Certainly, I think at this time the proponderous of evidence is on the side that it has helped. However, I have really really warned ….that we have go to do the best job we can because it is not totally safe in this legislative session….. I think it would be unfair to come to this group and not say that. We also had inquiries from environmental health and university health sciences and major environmental groups out of Houston to tackle some major issues. It appears that the most likely thing from the State perspective in that. Just thought that while people were here, it was a time to bring it up.

The last time I did talk to George Bomar I believe the opposition to programmes in the State is heavy in our region compared to anywhere else. I do know we have our critics out there and it behoves us to do the best job we can. That's all I have.

Gary Walker: Last week in my Board meeting my Board approved and as you all know and in the redistribution process, I did not win my seat. My Board approved expenditures of $'s for me to stay in Austin for most of the spring and my primary goal will be that I'll be in members offices in both the House and Senate side to make sure the documentation Jim's talking about that we can provide that we give those members plenty of ammunition and plenty of reason for us to keep the $5 million. $5 million is an easy target no question as it is just hanging our there in a line item and every one of these city folks in Huston and Dallas as we go looking for a $5Billion shortfall …….$5 Million is not much of $5 Billion but most generally the way the appropriations process works is the Chairman will say if you find some money we could do away we'll let you spend that money in your district. As soon as it is committed it's in our baseline budget which does not mean the legislature and the goofy legislature I might add some times, could take it out because he can only request it be there. I'm going to be there, he can call me a lobbyist if your want to. It's important for those of us out here to have somebody down there working on that issue because Jane Lee can't do it she can't lobby the legislature.

Bruce Rigler: Jim what is the basis that they are protesting up there at grassroots level? Are they saying you are hurting some other people by seeding in summer?

Jim Conkwright: Yes, they are saying we are hurting others, we are hurting them, we are breaking up their clouds, and that we are entering cloud structures too soon, damaging them, breaking them up, they are also saying that the extreme is happening that in the major hail storms of the season that we have precipitated those and caused those in disproportion to our district.

We've even have had a couple of calls that say that they have monitored our work and feel like we are creating tornados. So it's an emotional thing. The area that calls most frequently and has the Senators and Congressional representatives up tight is all the same, there is an inter-connection and inter-relationship between those three areas. Mr Walker knows that very well. It's the same area these people come from and I guess ….anyone else, at least for three years I had their backs against the wall economically, severe drought, low crop prices, I think they feel pushed into the wall a little bit from that standpoint I think you could give a longer history of some of those areas that I certainly can – goes back a long way to some old programmes back of the 70's – hail suppression programmes – but basically they are saying we make the hail worse the drought worse – we are blamed for both extremes, so that's what they are saying.

Bruce Rigler: There was something about the nature of the complaint from the Houston Law firm?

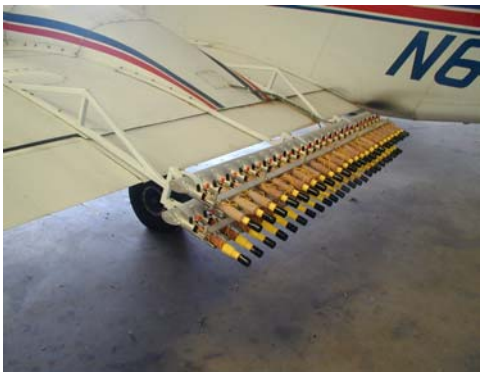
Jim Conkwright: No – I'm glad you mentioned that because they asked my secretary about silver iodine …. And that was the nature of the request from the environmental people……..They are looking at health issues – silver iodine in the clouds.

Gary Walker: We'll need to keep our public relations active on all these issues.

Lunch served after meeting – fresh water catfish in batter, which was different.

Afternoon was spent inspecting firstly the fitting of the pyrotechnic flares to the aeroplane. Inspected two aeroplanes which tend to be used in the operation out of San Angelo – one twin engine Aztec aircraft for bottom seeding because it is not pressurised they cannot top seed although they have done it and the plane has to be fitted with an oxygen tank and mask for the pilot to get up any excess of 20,000 because the plane is not pressurised.

Wing Tip Fitted Flares



Wing fitted Flares

The fitting of the flares is to both left and right wing tips and attached to the wings over the ailerons which equips the aircraft with 150 pyrotechnic flares fixed to the aircraft which they ignite with electronic ignition which is operated on 12 volts and clearly the adaptation of the flares has been a major investment in research effort by the association.


Drop Flares on underbelly of aircraft

The Cessna 340 aircraft is pressurised and is the one they use for top seeding, is fitted with drop flares made out of aluminium with special percussion ignition to an electronic fuse. It's a special shotgun like pellets made of aluminium. Once the flair is ignited it then drops and is shown in the 2 VCR's provided to me back in Austin

After the inspection of the aircraft we then went to the factory where the flares are made from components sourced from ex-military equipment but developed by the groups themselves and made under contract to an ammunition-manufacturing group.

This group is a couple of young fellows who make bullets for the police force and a whole range of other things as well as working for the association.

Quite a deal of effort trial and error has been undertaken and clearly it would be a wise thing if ever we were to consider the development of this technology not to bother reinventing the wheel and simply purchase the flares manufactured by the association who have done some good research on all of this in terms of the right kind of flare for reliability, the prevention of moisture ingress into the flare and a whole range of other things they have had to think about and are continuing to think about and develop these flares.

After the inspection of the plant we then attended for dinner at Dale Bates's home in San Angelo. Dale is quite a character. Being an ex-rancher with an interest in the need for rain his lack of technical education is a great asset because he is a broad thinker always thinking out of the box and quite a promoter of the whole concept of weather modification.

He has some challenging ideas for the professional meteorologist in terms of the operation of physics and I am going to try and get him on tape tomorrow after visiting Plains.

After dinner Gary Walker then flew me on to Plains where we stayed at his home overnight.

Tomorrow we will visit some of the horticultural and irrigation pursuits around Plains which is an interesting part of Texas, not unlike western New South Wales and even parts of the Mallee in fact where the only source of water is artesian bores of which there is a massive simply massive concentration, similar to what is in South Australia and the country is very much the same as the limestone country of SA which has formed the ground water aquifers with tremendous storage capacity. However the operation out of Plains is the focus of the weather modification activity out here this far western Texas virtually right on the border with New Mexico. This operation is managed by Gary Walker and is the SOAR operation referred. Southern Ogallala Aquifer Recharge project.

They have one Aztec and two 340's Cessna aeroplanes and Gary has his own private Aztec. Gary is not only the representative for the district of Plains in the State legislature, he also works for the water district of this region and interestingly enough owing to a redistribution unable to hold his seat at the last election and at the swearing in of the new Parliament in January next year he will not longer be the representative.

He provided hospitality with accommodation overnight at his home in Plains on Thursday 18 July. Tomorrow we will inspect the details of his operation and there may be opportunity to participate in a cloud seeding operation. Today they flew operations to the South and seeded clouds with a positive outcome of rainfall.

Friday, 19 July – Presentation by SOAR Project

Duncan Axisa (meteorologist), Gary Walker (Chairman), John Forrest, Bruce Riglar (High Plains Underground Water Conservation District), Shane Johnson (Pilot)

A powerpoint presentation was presented by Duncan Axisa which is included in the report as TITANMN.ppt and can be viewed in conjunction with these notes

Slide 1. Title page showing inserts of computer console, radar, and EMWIN

Slide 2.

Duncan Axisa: This is the cloud seeding aeroplane we recently bought to give us two aeroplanes. We actually bought it for the New Mexico programme and, because we own the aeroplane and, if we have additional clouds in Texas, we can fly both Cessna's in Texas. We don't fly the other one in New Mexico; it's strictly a Texas aeroplane.

Slide 3

Duncan Axisa This is the Cessna 340 fitted with wing tip flares, wing flares, and drop flares for top seeding. Top seeding is the reason why we prefer pressurized aircraft.

John Forrest Those are very expensive

Gary Walker We err on the safe side because we're flying sometimes to 25 thousand feet

Slide 4

Duncan Axisa This is the drop flare used for drop seeding and is electronically ignited by the pilot in the cockpit at my instruction

Slide 5

Duncan Axisa This is the layout for the SOAR facilities. The radar is over here obviously. The TITAN ingests the data via the computer and this is just a personal computer, but the way it is set up the radar information is powered, is actually powered by the transmitter and then the receiver receives the data and the data goes to the computer and it converts the data from digital and ingested into TITAN where you can evaluate the clouds on TITAN. What TITAN also does it is connected to a radio modem and aircraft information which is also equipped by radio modem and GPS you get the position of the aircraft via the GPS, that position is transmitted by radio received by the UHS antenna ingested by modem and then adjusted by TITAN. The objective here is that TITAN ingests the aircraft information and the radar information.

Another important thing we have here which is unique to our programme is EMWIN. EMWIN ingests the data from GOES east or GOES west (Geostationary Orbit Environmental Satellite). Is just a weather satellite that takes weather pictures and also acts as a transmission source. We receive the data, we have a 3ft dish on the south side of the hangar and that is connected to the computer. We also have internet service connected to the Computer by a high speed internet where we could access weather information on the World Wide Web. We also use the net to send our results to San Angelo for analysis. So that is the set up. That is the way it looks.

Slide 6

Duncan Axisa This is EMWIN – this is the way it looks on the screen is just a programme that runs on your personal computer. What it does is it is ingesting meteorological products from every national weather service in the country also we set it up to ingest information from Mexico and Canada, so basically it ingests data from the north American continent. This data is received within seconds of the issuance. So if the data is actually transmitted at 5pm you get the data 5pm plus 30 or 40 secs. Which is really fast. The importance of this are several. One of them is if we are seeding a cloud and it is raining we ….. increase the rainfall. And the national weather service which is the Government weather service determines that out of that particular clouds there are floods rains then they issue a flood warning. When a flood warning is issued we have to stop seeding the clouds because our priority is safety so we get information within seconds and we stop seeding that cloud and sometimes we vacate the county.

Slide 7

Duncan Axisa These are the alarms. It is essential to have such data. Ideal programmes relying on weather radios that are not very reliable and some of them just don't keep track of the warnings ……. Because you need special equipment for that. Out situation was kind of a sensitive one where we needed information from three national weather services offices so we are kind of special in that way.

This data as I've said is received from the GOES centre satellite, there is also an alarm configuration that you can set up to sent e-mail and also page – it has a paging system. This is the EMWIN alarm set-up where when projects are received they will be compared against the alarm setting appropriately, for example this over here means an area forecast discussion for this location CLE. It's a code for National Weather Service office. If that code was for …… for example it would be KFB LBB and here you can set it up to print automatically to display it on your screen it can be set to put up an audio alarm, it can be set to send e-mail to several people, it can be set up to page several people and you can set these over here, very simple software. It is county specific so you can set it up for Yokum County and Terry County but you can leave out Lyn county. So if the Lovak national weather office services tend counties it does not mean you will be receiving data from all the 10 counties.

Slide 8, & 9

Duncan Axisa: You know this I think about what cloud seeding is. We use essentially glaciogenic seeding in Texas with siver iodine as the agent. It is important to know that not all clouds are proper to be seeded. This we have had to learn.

Seedable clouds look like a cauliflower. So, after sending the pilot out there, his visual information is important. We need supercooled conditions, ie at or below freezing, and no ice. If it has ice then nature is acting efficiently and we need an updraft of at least 200 ft/min.

John Forrest I know all this; I need to know what TITAN does

Duncan Axisa OK, let me just continue a bit.

Slide 10

There are the two processes of seeding. On top seeding and base seeding. When we are seeding on top we need to be in the cloud in the first third of the cloud lifetime. This is very important from all the work now in Texas. Like we have a lifetime a cloud also has a lifetime. Our lifetime may be 80/90 years and most of you here are past your lifetime. I'm not…..

JF Lucky you

Anyway the clouds also have a lifetime and we try to get to the cloud on top before the first third of the lifetime at base we try to get there in the first half of the lifetime. These are two difference processes. I call on top seeding to be a very surgical

procedure. Why do I call it surgical procedure? Because you are actually at the level where the super cooled water is. That's the difference between on top seeding and base seeding. On top seeding you are actually at the level where the super cooled water is. You are actually putting the agent surgically into the cloud where the super cooled water is. So what you do normally is you penetrate the cloud, the skin of the aircraft is below freezing, so what is going to happen to the water, to the super cooled water when it finds the skin of the aircraft below freezing, it will freeze instantly on the aircraft and that is how we test that super cooled water is present by actually building some ice on our aircraft. But that's a good test and the dosages are one dose per updraft. At base we are looking for the inflow and this is harder because you need an experienced pilot and you need to find the inflow to carry the seeding agent at this temperature where the super cooled water is most active. The concentration that we try to put in is 1 flare (40 gms) per 5 kilometres cubed of super good volume and what we do is have equations we come up with and we know how much material we need to put in. OK, let's show you TITAN

Slide 11

Duncan Axisa This is a cloud that I decided was proper last month. You see the plane is already out there. Here's the track. TITAN gives me in real time all this information shown here. I've got time, I've got height, and I've got volume. You see it here a day later ***(Slide 12)***. So TITAN is giving a lot of information, including the aircraft track, where seeding occurred which makes an after analysis very easy. All of this I can look at from all sorts of directions just by playing with the mouse which I'll show you in the next slide.

John Forrest What's the pilot doing while you fiddling with the data?

Duncan Axisa He's talking to me on the radio and providing confirming information. It's real teamwork. Between the two of us we are trying to find the right place to burn the flares.

Shane Johnson I'm also trying to fly the plane because it can get a bit rough out there

Slide 13

Duncan Axisa I put this slide in to show you a comparison of seedable cloud to a non-seedable cloud. This is where I made the slice in this picture on the left and that's the information it shows on the right. There are two factors we need to consider which we meteorologists need to consider to evaluate the success of the seeding operation. One of them is Convective Available Potential Energy. In simple words it is the energy available for convection and we call it the CAPE. The other factor is cap – like a hat. When you wear a hat it shields you from the sunlight. When there is a cap in the atmosphere it shields the clouds from growing. We don't like that because what we need, what we target is super cooled water and super cooled water is found in the upper levels of the cloud and if that is not present then we cannot conduct our seeding operations.

John Forrest : What causes the cap?

***Duncan Axisa*:** There are several things. One of them is warm temperatures aloft. Say at the upper level we have a southerly steering wind – called a steering wind because it steers the clouds or a southerly upper level wind, warm air from lower latitudes is going to move into upper latitudes, that is going to warm up the temperatures aloft. What you need is colder temperatures so that your cloud would be warmer than your environment, so that it can be buoyant. Now if you kill that buoyancy, you have a cap. And that's what we are dealing with today. The reason for that is a southerly wind bringing in warmer temperatures from lower latitudes these last five days and another one is a persistent strong ridge which has been over us, very strong ridge, very strong high pressure that has been over us and that inhibits convection because high pressure has air descending. In a seedable cloud what you have is a strong convective energy with relatively no cap so that cloud builds to higher altitudes.

What we see here is obviously a cross section of this cloud here. This is cloud, plan view of a cloud, as you see it on radar, and I am cutting it here and viewing it from the side, this point here. Another thing that we look for is the VIL. VIL is vertically integrated liquid, in simple words it's how much moisture, how much liquid there is in the clouds. See this non seeded cloud has a very low liquid content, 12, while the one we seeded has a high liquid content of 82. And when we are seeding we look for numbers 13, 14 and those numbers should grow with the seeding process.

John Forrest What are the names?

Duncan Axisa All the clouds we enter to the data base are named with forename and surname for identification Usually, we have a numerical system. These have got county names.

So, from all this I have to decide where to seed

Slide 14

Duncan Axisa There is other information available. This is a national weather service radar and you see we have three cells here – target one, target two and target three. And you look at them on radar, this is the radar at Cannon Air Force base in New Mexico – you look at them on radar and you say oh wow! these clouds have high intensity, you can see the reds, start getting excited, you see lots of moisture. Then you switch TITAN on and that excitement goes away because TITAN is a rainfall radar, its designed for cloud seeding purposes, so it is designed to cut the cloud echoes that are not really convective, to cut them out.

Slide 15

Duncan Axisa So, we go back to TITAN again. You see, the only convective clouds are here, this is target two and that what we try to seed. There is the aircraft track and that's the cloud, it has a VIL of 30.5 so it has a good VIL but that moisture can be at lower levels because the atmosphere is capped which we were able to see from a vertical cross section.

Now, to try and seed that cloud, we need to go in it. I can do this at the desk to save the pilot flying in there.***(Slide 16)***. So here the VIL is 26.9.

John Forrest So this is all real time?

Duncan Axisa This is real time, see, the time is 20:25 and the previous slide was 20:22. So the pilot can wait for me to make a decision and not have to fly in the cloud.

So the Vil actually decreased to 26.9, which is not a good sign, and you can see from the next slide the cells split ***(Slide 17)***. This is also not a good sign. You see, 27.9 and 10.9. If the cells split further, and this one actually did as you can see on this slide ***(Slide 18).*** See the time, 20:44, and the northern part actually dissipated. Look, 4.6, 2.0, and 14.1. So we really just went there just to scout the cloud and we did not seed on that day.

John Forrest Is that one you messed up on?

Duncan Axisa We may have got there too late which just emphasis the importance of timing. You see here ***(Slide 19)*** how it just broke up into many clouds with VIL too low to seed. Maybe we should have got to it earlier.

We don't like that, but the water districts we work with need to realise we are monitoring the clouds and we try to seed when the conditions are appropriate and this turned out to not be one of them. It was a New Mexico operation. We did have clouds on the Texas side, they were the same kinds of clouds, non seedable.

Slide 20

Duncan Axisa This issue of cloud lifetime is important. Just to show you what a seedable cloud look like. This is a lifetime through a seedable cloud. The first thing that jumps at you is you have three differences here but at the end you have one or two big cells.

John Forrest What's a cell?

Duncan Axisa That's the individual localised area of high VIL. See, at time 4:56PM, there are actually four of them, although really three. One of the things we are doing we are managing to create the energy to actually put those clouds together so you get one meaningful rain instead of three little showers. You can see the time progression and the track of the aircraft with time. Seeding in the right place helps it develop in to one cloud. See, here at 5:13PM and it moves through to 6.57PM. Another important criteria is the volume. See this slide……

Slide 21

What we are doing is we are increasing the volume of the cloud. This is a comparison of a seeded case compared to a case that was not seeded. The researches down in San Angelo grabbed a seeded case and compared it to a case

in the same environment that developed at the same time and they compared the values. I have values for the volume and the slides are in an interval of about 20 minutes. So this is the seeded case at the top. At 5:58 PM, we have already started seeding, you can see the flight track, and the cloud has a volume of 1384 cubic Km. The unseeded case has a volume of 1542 cubic Km developed an hour earlier and it was non seeded.

As we track these two in time we can see the non seeded case its volume peaked after 20 minutes at 2955 and it started to dissipate after 40 minutes. See, its 1890. The seeded case has its volume still growing after 40 minutes. See its up to 2444.

So it is apparent we are increasing the lifetime. Its apparent also we are increasing the volume because when you compare the volume after 40 minutes it is apparent the seeded case has larger volume than the non-seeded case.

Slide 22

Duncan Axisa This is the case study after an hour, the seeded clouds have a lifetime, we have stopped seeding, the volume has decreased, but after one full hour the seeded case its volume has doubled the non-seeded case.

Where precipitation plot its like when you pull out the precipitation, when you compare the precipitation plot here, the first thing you notice is you have a core of rain in the seeded case while you have three maxima or even more of rainfall which means that we had showers in the non seeded case and while you had a big rain in the seeded case you also can see a large area of rainfall, while here you have only a small area of meaningful rain, or measurable rain.

When you compare the rainfall rate to the volume in both cases, I calculated a 68% increase in the rainfall rate, and 22% increase in the volume.. And this is what the researchers do for us at San Angelo.

***Gary Walker*:** The seeded cloud started right up here in the north east and moved over into Terry County and then kinda went south, the non-seeded cloud was a cumulus and if you back up one more time you can kinda tell where the clouds are based on the rains of our radar so you can tell that the bottom cloud is north of our radar somewhere because of the curve of the rains. Those clouds were from the very same day, he did no go and pick a cloud from two weeks earlier that did something, did not get seeded, that would make it look like what we are doing is really good. Those two clouds happened the very same day and an hour apart so the environment was the same and this is the result of a seeded cloud versus a non-seeded cloud. If we had gone to New Mexico and flown that cloud then it might have been reversed.

Slide 23

***Duncan Axisa*:** This is what researchers do. We have researchers at San Angelo that evaluate the clouds and last year they evaluated 731 seeded clouds and compared them to 731 non-seeded clouds and these are clouds that developed around Texas and 10 seeding programmes in Texas. The data was collected and analysed and you can see the increases here. 48% increase in the lifetime, 22% increase in the area and the volume, no increase in top height maximum. I'll explain these later, and 26% increase in the volume above 6 kms. Which means an increase of the super cooled water the volume of the super cooled water. 25% increase in the rain rate (what we call flux) and 79% increase in the precipitation mass. This is the most valuable number, the 79% increase in the precipitation mass. There are limitations and that number may actually be a little bit smaller round 50-60% but the 50% is still a very significant increase.

What about the increases here – or the absence of increases here. What has the maximum reflectivity in a cloud. Ice, or hail has the maximum reflectivity in a cloud. When hail is apparent in a radar echo it shows up as a bright band and that is what reflectivity is – reflectivity is the unit of how bright the radar echo is, so if during the seeding process the echo wasn't brighter that means that we didn't increase the hail. That is a big misconception that's hurting our programmes and my job is to educate the people that seeding does not cause hail, or does not increase the hail.

So that is a very important point that everyone should keep in his mind. We are keeping track of the maximum reflectivity and to date we don't have any data that says we do increase. Actually there are programmes that the objective is to decrease the hail – they use the same method but they put a larger amount of dosage maybe twice or three times the dosage, I'm not in touch with the methodology of the hail operations programmes but they put a very large dosage in there. Our objective is not to suppress the hail but to increase the rainfall so we have to put the right doses to actually increase the rainfall.

John Forrest: What's going to cause this? Warmer temperatures?

***Duncan Axisa*:** The system is moving to the east. That's promising because the rotation of the high pressure is clockwise. So when the system moves to the east instead of having southerly winds now you are going to have more of a northerly flow, so that's actually going to move the other way. It is going to cause a northerly flow to bring all the temperatures and the colder temperatures will destabilise the atmosphere so the clouds would be warmer than the environment.

***Gary Walker*:** Judgement is needed. When Duncan has the radar on, but for a week we have only had clouds west of the state line, we have not had a cloud in Texas, in about a week.

***Duncan Axisa*:** When the cloud is on the Texas side and they weren't there, we don't like this situation. What I like is 4 days with 4 good seedable clouds and 4 days with no clouds at all. Because these clouds keep you on the edge and it is very stressful.

***Gary Walker*:** Looking for the chance of rain on the TV screen, that's a tough job for Duncan because they are just a little spec. We spend money to go and try to do it , especially in New Mexico, because it is our hope that if we build those clouds in New Mexico we can get them to come this way, that's why we will spend some time in New Mexico trying to increase. As you saw in the last slide, the lifetime of a cloud 48% increase – if we can make a cloud last 50% longer and it's moving 20 miles per hour we can get some more rain.

***John Forrest*:** How far into New Mexico do you go?

***Gary Walker*:** Our buffer area for this programme is 30 miles. But then we have a part of what we really call the New Mexico programme goes all the way up to Roosevelt County. See the little red line right there so we have all of Roosevelt County then we come done part of Charlise and Eddy County and then we get the South part, that is not in our buffer area, so if clouds are moving to the north east, we certainly want to work on there here. If they are moving to the southeast, we certainly want to work on them here and of course if they are moving west we have a pretty good chance. If you just think our target area 30 miles over here we have a pretty small bulls eye if we have clouds moving over. We could not go into so when the planes cross into Mexico because of the track of the clouds these two areas are pretty important as the thing travel north east or south east.

But is mostly Roosevelt County, this little part, down here. New Mexico is talking about parking a radar down here to where it does this, it does not overlap. Of course their interest is providing some water to run into the Pecos River because of the water debt that New Mexico has to Texas. They wont run water off into the Pecos River. New Mexico will want to continue working with us because of our proximity to the right arm area. If they are going to spend their money they are going to put that right.

John Forrest – How does the contract work Gary? Do you get paid per flight time, or do you have an annual contract?

Gary Walker – We contract with them on a per acre basis the second aeroplane that's dedicated to SOAR it's our aeroplane so if we had a set of clouds in Texas and none in New Mexico, then we would fly both planes over here. This is the break up of the cost sharing ***(Slide 24).*** It's simply on an area basis as a percentage. See, for example, Dawson county is up for about $11,000.

John Forrest – Obviously you don't have a lot of time. Do you have some idea of the life of the cloud before you take off?

Duncan Axisa - We don't have a lot of time that's true. In situations like today we do need to spend time on the ground to evaluate because we know they are not really seedable. So we try to evaluate them first.

When I know there is a strong convective, then I as soon as I see the first convection developing even by eyesight. I look at the radar, then I send the aeroplane, we don't have any time at all. So it depends on the atmospheric conditions.

If the atmospheric conditions look weak we try to evaluate first. But the time frame we need to be in the air within 10 minutes.

John Forrest – And what about top seeding and base seeding? Which is your preference?

Duncan: My preference is always on top because it is very safe, you are at the level where the super cooled water is, you know where the agent is going, you turn around and go back to the same spot you see the cloud growing thicker so the results are more visible to the pilot so it's a very, it's kind of more safe. When you at base you are putting the agent in the updraft and you are relying on the updraft and hope that it is going where the super cooled water is. See the difference. Researchers didn't really come up with any ideas whether we need to be on top more, we need to be at base more, there is no difference.

John Forrest – I've already picked that up. Let me ask a different way? Roughly proportionally, how much of your operation would be top seeding as against base seeding?

Duncan: It depends on the atmospheric conditions. Right now we are going to spend more time evaluating so I have less time for the pilot to get at top. So what do I do, I go base.

John Forrest – So basically the majority of your seeding would be base seeding?

Duncan**:** Well, if you are in good time, you go at top, if you are late you go at base. Within maybe 40 operation – 36 operation, maybe 25 times at base and the rest at tops, so a little more at base.

Gary Walker**:** Maybe I could give an example. If the cloud were going to 60 miles away it takes you time to get across the ground – while you are getting across the ground you can climb and he is going to send me to the top. If the cloud is right out here and you can just fly up there 10 miles away, light one of these flares and start getting the agent in the cloud, he's gonna send me to base because it is so much quicker to get there and start getting the agent – even thought the agent has to get through the updrafts into the super cool water, but if the cloud is further away and it is suitable, he is probably going to send me to the top first.

John Forrest: I'm surprised at that. I thought you would say well it's less fuel so it cheaper to get to the base and therefore our preference would be the base, but meteorologically the preference is the top.

Gary Walker**:** We're not worried about the amount of gas, overall we probably do but what we are interested in is getting the aeroplane to a place where we can put the chemical in and get some water over the ground. Gas is expensive but over the whole course of the year we probably won't spent $15,000 on fuel and one half inch of rain out here on a couple of sections is worth more than that. We don't worry about the amount of gas – we worry about the amount of gas we have as far as the time we stay up but the efficiency as far as the economics of getting to a cloud at the right time or on top is absolutely nothing to do with our decision.

John Forrest: What Duncan has presented, you are going to give me as CD's. That control cloud comparison that's just perfect. The more of those you have in the data base you are going to challenge the cynics back home. You said 731 cases – I thought we heard yesterday it was up to 850 now.

***Gary Walker*:** That was how many clouds, but they threw out 120 because some of them made it look too good and they did not want to just act like it – some they threw out some of the upper end stuff.

John Forrest: Well you have got a few cynics out there. That's the first accusation they make. Especially down under where I'm from.

John Forrest – (notes)

It's now 2pm Friday 19 July. I'm still in Plains, West Texas, accompanied by Gary Walker who has just provided and hour and half's tour of the district. It's a flat country over top limestone, not unsimilar to much of the Mallee – a very strong absence of trees and centre pivot irrigation from ground water growing peanuts, water melons, a little bit of wine grapes, cotton and Gary's job is the district manager of the water district and we enjoyed the company of Bruce Rigler who chaired yesterday's meeting of the Texas Weather Modification Advisory Committee. We are now heading back to the airport to travel back to San Angelo and after that we will work out what we do after that.

Bruce Riglar makes a product called peanut brittle which is peanuts immersed in a caramel and its delightful.

West Texas Weather Modification Association
San Angelo – 19 July, Afternoon.
Present: Gary Walker, Dale Bates, Tommy Shearer, Archie Riuz

Archie Riuz (making presentation on Australian opportunities): Because in this map you have here now you have the annual average of thunderstorms, so this is in Victoria one of the possible target areas. So along the River Murray Valley we will have sometimes 15 days with excellent conditions. Thunderstorms, we will see a good difference. We believe that we can do a good job, even if we cannot use TITAN – so it's a kind of – it's exciting – seems we could work with you.

***Dale Bates*:** It looks like you've got good potential because we have to tell some people that's why we're working with a programme right now, that's right out here and we are having to tell them, this ain't got much working for it, but we are still going to try it. But it is so dry in that area right there that even we're concerned about it. So everybody is not told by us that we think they got real good. Archie could develop other thunderstorms there on an average basis in your area to make us think you got good possibilities. I think it is only important if you tell them that we are telling other people even in our own state –

John Forrest: 10 – 15 thunderstorms per year?.

***Archie Riuz*:** You are 2/3rds of what we are here with 20 inch rainfall.

***Dale Bates*:** Well, you're better off than we've got here – you're having more thunderstorm days that we do in the upper panhandle.

John Forrest: *W*hat about this part of the Australian continent? ***(Southern Qld)***

Archie Riuz: Look at this. You have more days here than here. And this in the middle of nowhere you have good thunder days. The only trouble here is we need to be ready to use every condition.

John Forrest: We don't need it north of the tropic of Capricorn. But basically from Rockhampton south yes we do. Biloela – there numbers are up 15-20?

Dale Bates: You can liken them when you know that we are 25 here you can liken your areas to us at San Angelo and we are not the least bit marginal, in other words that's a good shot is what we're saying for you folks in Australia.

John Forrest: We are not short of statistics on the net, it's all there, we just don't seem to have the professional nor political will.

Archie Riuz: People in Australia didn't receive good signal because they were using generators**.** We don't use generators anymore. One of the things we need to do to reach this dynamic seeding, is to use flares in the right doses at the right time in all the seedable clouds, so remember we want the luxury of this opportunity, we don't want the luxury of bad timing and we don't want the luxury of tornadoes.

Archie Ruiz: The main targets to do a good job is as follows. This is TITAN you see what has happened which reinforces the importance of timing. But we have here the history of the cloud, so for the real cloud imagery with time only see this part of the cloud, this is the real time. What it looks like to me that he was going to seed this cloud but when I see it there was no reaction look at this, the real vertical integrated liquid which is the amount of water in the cloud. This profile of an unseeded cloud so it looks to me he approached this cloud, he was late to seed, because he was after the half lifetime because it was already dying and he was here trying to put the material. This is another bad cloud situation. No you have here a case in Catoosa that they have seeded a cloud at this time and you see it's really early enough to obtain the result.

Dale Bates: Now, John, this is really important for you to follow to track this particular line because anytime we can set up that line in the cloud we have changed all of the cloud's dynamics. We think that this is secondary seeding because you see the cloud continues to curve back all on its own because we think that inside we made a lot of ice and then the ice fragment and becomes like 100 little pieces for each one piece. And that the recedes so the cloud is now reseeding itself, so when this happens we are going to get tremendous longevity, see how much longer this cloud lived than those two you saw previously that were seeded late. This one

seeding properly at the early part of the cloud when the cloud was still growing, it set up its own system of seeding itself.

Archie Riuz: Look at one thing that is important in this physics right now – when they seed the cloud with that level of vertically integrated liquid, when they seed the cloud the liquid will become ice so the vertical integration will decrease for a moment so the cloud will take more moisture from the environment and will have more moisture to make …… so we are triggering this thing. It's like you have a seesaw.

Dale Bates: Our objective, John, is that profile you are looking at right now is our total objective. If we could do that hopefully someday we may learn how, but if could seed and put every cloud we seed in the profile, then we have really rung the bell because now what we did is we took a processing unit that would have died probably just about like that and now you have extended its longevity three or four times – think about this stuff as a living thing, this is a processing unit to us, so the longer we can keep the process going, the more moisture we are taking out of the atmosphere and potentially putting on the ground. We know the ultimate we can reach is to get the cloud to go into this profile. Now that is a properly seeded cloud profile.

John Forrest: So every time it is going down you know it's forming ice?

Dale Bates: Yes

Archie Riuz: When it is going down or when it's coming up

Dale Bates: Here is another seeded cloud, but you can see there was only one surge.

Archie Riuz: If we don't seed these clouds properly the natural evolution would be this way from here and down. You see, this is another TITAN non-seeded cloud this way, …way and going down. After seeding the cloud is able to build probably more cells to stay alive because the cloud reaches a kind of self-fulfilling stage with environment and is capable to live longer by producing more cells.

Dale Bates: This is the other seeding signature. Because, in the unseeded cloud, what you have is it starts, it lives its life and it dies. Now in a seeded cloud, if early enough you always have a second or third rejuvenation. The beautiful one is the one you saw a while ago where you're getting them real often. No that cloud is very dynamic when it reaches that point.

Archie Riuz: Nature made this deal. Nature can make this deal but this was the only cloud around the only cloud that was the seeded cloud. Of course nature can do this to – you can help nature to do this a little better and this is the thing we are trying to do. Now this is another case that we seeded a cloud really early and look, it went down. But later on the secondary association make all this increase.

***John Forrest*:** What's that time scale in hours – the life of that cloud there?

Dale Bates: From 22:00 to 03:00 –is that the cloud? The 43 cloud? - that was just the start of the seeding and not the start of the building.

***John Forrest*:** That clock is 22:00, so that's when you seeded. I'm wondering how it looked two hours later?

Dale Bates: We are always under a timetable and a lot of things had to be left out in that sequence.

Tommy Shearer: You only did two flares in that whole cloud and got all that result?

Dale Bates: I can't talk about that, I think we probably put more flares in.

Archie Riuz: This analysis that we are doing now didn't start in the way we are presenting it. TITAN was used first as a tool to handle the information, the radar information in a more human way. But later we discovered that TITAN can be used not only to help the scientists and individuals to do a better job.

Dale Bates: Now you see here that we have got another software programme that takes the data from TITAN and then it turns this clouds into 10 dimensions – we have 9 variables so the cloud is living as far as we are concerned within these variables. Now this is the average of 857 clouds that we have enough data from all over the state, this was from all of the different programmes, this is the total. What we're going to do right now, it is very important here to say that we know we have a totally different dynamic in a very large cloud than we do from all the rest of them. And the very large clouds when seeded give us a completely different world, all of their own which we are still trying to understand.

Archie Riuz: We seeded in Texas 1031 clouds in the whole state last year. But not all the clouds received analysis to run software so from this 1031 we got 857 clouds. So we run software for these 857 clouds.

Discussion re possible contamination etc in some of the data. Only chose reliable data and exhausted bias. Archie's accent not good for recording.

Dale Bates: If you come across here on lifetime of 857 clouds you can see the seeded samples lasted 109 minutes the controlled samples only lasted 58 but now the modelling that we do changed that 58 to 64, so the modelling built the controlled cloud up larger and we are trying to make it as reliable as we know how. Because after seeding these clouds separate dramatically.

Archie Riuz: We need to deal this thing and we need try and make it work, this initial bias that we are taking we best keep for our team. And this is what the model is doing. The model is saying the cloud worked better that time, the model is improving because it is eliminating this initial bias. So we are trying to exclude any bias.

Dale Bates: No, 58, so now you've got a 70% increase in the lifetime the seeded clouds over the controlled clouds.

Dale Bates: All you got to do is look right down here at the bottom, 17,082 kilotons difference per cloud from seeded as opposed to the others, so if you multiply that times 857 you get some sort of idea of how many more tons of water – now that's an awesome figure when you're talking about 17,082.

The area covered by the seeded cloud is 60% larger, the volume is 79% larger, now that's what's interesting – look at the increase you have got here in lifetime, area and volume. Then you get down here at the top height in all this becomes even more interesting because the top height only increased 5% which means that no they did not become super cells and very severe storms so out of 857 clouds the top height only went up 5%. The maximum dBZ reflectivity only went up 3%. The top height of the maximum dBZ increased only by 2% . No the most interesting thing that we have found is right here – the one thing you really need to talk about Archie is to talk about your masthead.

John Forrest: What's a masthead?

Archie Riuz: These figures going above 6 kilometres is really new information about how big is the cloud above zero, about freezing and supercooling. And this is the ideal target. We are targeting the super cool water to help the super cool water to be ice because ice has the capacity to multiply. But it is not only the ice it is the latent heat that would be released and will warm the whole process.

Dale Bates: Growth is coming from the latent heat.

Archie Riuz: The growth is coming from the latent heat for this fuel for the agent in the wrong spot – because the updraft is the place where the water is mainly stored. The updraft would be not only this mechanism or this. The updraft will be the mechanism the ventilation mechanism to take heat away from the place where it was released. If you don't have this ventilation the latent heat will be against the ice and will melt the ice again. So it will be a counter productive So the updraft is crucial The right place for the water to be, the right ventilation mechanism.

Dale Bates: The speed of the updraft is very important so we don't to put it in at 200ft per minute we want 800ft per minute.

Archie Riuz: ***Y***ou will lose a lot of water in the upper levels. If its too weak it won't work.

John Forrest: Duncan said this morning in Plains that 100 – 200 ft per minute updraft was optimum – you're saying the higher the better?

Archie: Yes, the higher the better.

John Forrest: I wrote down these questions as a result of three days. Top seeding versus base seeding, legal settings, functions of satellites, atmospheric variations northern hemisphere/southern hemisphere, the function of latent heat (the thermal dynamics) so I was thinking about helping you think outside the box.

Dale Bates: Latent heat to us is the growth mechanism, that's the energy the cloud uses because it is in a very cold environment – heat if you change the form of water.

John Forrest: Changing from liquid to ice?

Archie Riuz: If you have the down draft it will melt the ice again because you have the ventilation factor ….

Dale Bates: You want the heat that goes from coming from the vapour, that's also giving off heat and then you want the heat that's going from liquid.

Archie Riuz: These two things I know very clearly from the books – this information is from the experiments. This thing about the latent heat layers calculations is not really clear in books, but now we are clear about it.

John Forrest: I was just thinking it might have something to do with us back home because we have a hell of a lot of heat coming from all that dry desert – heaps of it! You only have to get a north wind day to feel the heat. We would have no hope in summer but anyway, we need to seed in winter.

Archie Riuz: I will show you the aerial map in Australia and one of the big problems in Australia is that your air mass for different places in one day – it is different for me – Pacific, or tropical – Chicago or Illinois - you have air masses for different places – one day is one thing, another day is another.

John Forrest: That kind of averages all of that out.

Dale Bates: This is where we think all of the rain is generated, So the larger it is the more rain potentially you've got. So what pleases us about these numbers is we have increased the part of the cloud that needed increasing to give us more moisture back out of the processing system, so that's why I said the first thing I normally look at on anything Archie hands me is this, because that's telling me how well we seeded those clouds if that volume above 6 kilometres gives up like 100%, we're doing a good job. No here this is the amount of rain that falls out per second and this is the total amount of rain the radar thinks falls out of the base of the cloud. Now these two figures are extremely controversial.

John Forrest: Is that real rainfall?

Dale Bates: No. This is what the radar can see coming out and …… coming out of the base of the cloud based on the reflectivity and I said this is extremely controversial. However, main gauge networks are just as controversial because you can't ever get advanced number of them so any way you are going to major rainfall becomes terribly controversial, so what we have to do, is the only thing we've got is the radar analysis. The radar estimation. Now what you've got here is a pure estimation. However when you measure the seeded clouds against the control clouds they are both estimations and they both have the same bias on them There is a 131% increase out of 857 clouds, now that is a very substantial increase. We are not saying we are getting so many inches of rain on the ground because we don't know that, but what we are saying is that radar thinks that when it compared a

seeded cloud against the control cloud 857 times the average was 131 times more. The other thing that is so fascinating is this number here because that is per cloud. You multiple 857 times 1782 metric tonnes and get a huge volume.

John Forrest: So what you are saying is the doubt about what hits the ground does not affect the efficacy of your comparisons?

Dale/Archie/Tommy/Gary: No

Archie Riuz: We work always with seedable clouds and we reach at least light rain, maybe 50% gets to the ground and, in any case, whatever the proportion is, it's the same for the control cloud with which we're comparing.

John Forrest: So this is academic? Anyway, even if you got half of it would be enough

Dale Bates: You have still paid for his programme, any way you want to do it and our comparisons still stand up cause it's the same for the control cloud .Anyway, we want to show you the summary of our results.

TWMA research

(courtesy of TWMA San Angelo)

Comparison between Seeded and Control clouds for small cells
Sample size: 731 seeded & 731 control clouds

VARIABLE	SEEDED	CONTROL	INCREASE (%)
Lifetime (min)	83	56	48
Area (km sq.)	54.5	44.6	22
Volume (km cu.)	175.3	143.2	22
Top height (km)	8.1	7.9	3
Max dBz	48.7	48.3	1
Top height of max dBz (km)	4.4	4.4	0
Volume above 6km (km cu.)	54.1	43.1	26
Precip. Flux (m cu./s)	375.8	300.5	25
Precip. Mass (kton)	1731	969.7	79

TABLE 2

Archie Riuz: This table illustrated the comparison for those 857 seeded clouds against comparable control clouds. But in this sample of seeded cloud we have big storms. Bigger storms means that the precipitation mass of the storm was bigger than 10 thousand kilo tonnes. More than 10 million tonnes. These clouds are really rare. These clouds are only 12% of the clouds in Texas last year. Another 10% of the clouds were really big and TITAN really good for big cloud, because in South Africa, because of the South African climate that is very Mediterranean, clouds are

smaller so TITAN sees our relationships that way – the precipitation flows, the precipitation mass are no good really with big storms. And you will see the analysis of a big storm later.

But we took away this bigger storm to make a comparison that I was telling you. 731. This is only for small clouds and a small cluster with precipitation mass less than 10 million tonnes. And these are the results of the same comparison as done before. You see the smaller value, we have an estimation of our big clouds

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TABLE 2

John Forrest: You went back to 731 to remove all bias?

Dale Bates: Yes, you're taking what is more average clouds because only 12% of our clouds are super big so we pull all those out. Now you are looking at a lot more average the cloud you are seeding. In other words up to 857. Of these, 731 fell into this category which is a lot more of the clouds that what the super large ones were. But you see how it changed these numbers here, because the super big ones are the ones that give you the greatest percentage return. Above 6 kilometres is only 26% increase. See how much better the large clouds – in other words the large clouds is what we are beginning to think we're here for. Because they're the ones that really reward us – the reward us by far the best for the $'s spent. And we have designed our aircraft, our flares, our hail suppression, everything in order to seed the big clouds. To seed them unrestricted.

Archie Riuz: We have the data from the north that is only using the big clouds. The meteorologists is worried that the clouds are getting bigger.

Dale Bates: They wont even seed a cloud that was on this data.

Archie – I was talking with Jim yesterday and this is the main reason.

John Forrest: They are not interested in an extra half an inch?

Dale Bates: John, they are in the business of selling water. Their whole goal is to put more water in the lake. They are not interested in general rains, they want something good. What we want you to see is the fall off between this one with the big cloud and only 12% more clouds went into this type and look at the difference in the numbers. And then this is more what you are going to see.

John Forrest; And that's got to be a good number too.

Dale Bates: You see these big ones up here, a lot of them were super violent in the beginning. But they still only went up 2% even through they were very violent when we started.

Archie Riuz: You will see now another thing. Where you see this, this is important to decreasing the hail of the cloud. It is not very substantial the variation in cloud. But in some places we have this idea that we are dropping the top height of the maximum of thermal activity. In top seeding we are watching a little up and in base seeding we are watching a little down. So it is a kind of game this. Probably later we work in this way – a little clue in favour of base seeding because now our top seeding and base seeding are very similar.

Dale Bates; Need to understand that hail, ice, has a higher reflectivity ddv than water because you are restricting the reflection of the moving cloud so the higher that number is typically the higher cloud – more than 55 is hail, in some places more than 50.

Archie Riuz: But for the same size particle with the same size ice against water, water has more reflectivity.

Dale Bates: If you want ….. because above 55

Archie Riuz: Table No 1 – Here is the below the hail level. The hail level is 55 or more and in some places 52. We have some 57.

John Forrest: These numbers, are you able to publish them? You need to get this information in to mainstream scientific venues

Archie Riuz: I gave you the papers where all this is reported.

Dale Bates: It is not reviewed. We did not have a chance. We are working so rapidly we did not have a chance to get anything reviewed. So don't tell them that's a review publication because it is not. What we are beginning to think is we cannot understand how you can have a cloud, a big super cloud, and it is putting currents off You put an aeroplane here in an updraft and the aeroplane is putting the top flare right in here in an updraft, you have not seeded this cloud. Now, they all tell us they have, but the heck with them. They can't prove to us at this point how, because now when that gets into the downdraft it falls out as rain. That does not go back into

this other cell. I'm not buying that. But they're going to try and tell you you can fly in here on top and see these curves and seed this main body of this cloud. Now this does not make sense to us. So here's what we think, and Archie very beautifully did this. This is much more an artificial method of seeding. You are placing your flare right where you want it but not where nature does not seed the cloud right up above this 6 kilometre point, nature seeds its clouds from the up flow that's coming in the bottom. And that is a much more natural way, so we think any flare put in up here is the equivalent of two put in down here because you don't have any waste. Your waste is cut way down but it is still a much more artificial way of seeding. Now we also think that if you put in too many flares up here, you really stand a chance of damaging all of this growth area back here. We are not seeing any damage at all – we cannot find an upper level for putting material into place. We don't know yet how many is too many but we know you can sure have too many real quick when you start putting them on top. So this is a much more sophisticated and expensive method of seeding. We are also thinking that it's not nearly as effective as base seeding. We don't think right now that you can probably adequately seed a cloud on top. Cause you never seeded the portion over here. Whereas when you put a base seeder down here going round you have seeded the whole thing.

John Forrest: If I was to ask you what's the preference, top seeding or bottom seeding, you're going to tell me base.

Dale Bates: We're going to tell you that for the dollar and when you got any experienced people go with base seeding. No when you get very sophisticated pilots and very sophisticated meteorologists then you bet, let's get over here on top because now what this does do and what Craig can do so beautifully is if we don't have an available base seeder here, Craig will come in here and start seeding these turrets and then they just continue to grow and he will keep seeding these turrets – this all this dying off and so he is holding this cloud in a young position until we can get a base seeder to come in at the bottom, but the base seeder is going to really do a good job. If we never get a base seeder then yes he's done because he is still a new cloud back here that all is seeding. But I fear is that you cannot adequately seed a cloud from on top because you can't ever get anything over here. Whereas a base seeder could have.

John Forrest: That's interesting because I asked Duncan Axisa in Plains this morning what's your preference and he said top seeding.

Dale Bates: He has got six months experience John and that's all. And they don't have base seeders, so all he could tell you is top seeding. All those people up there are talking about top seeding, but it is interesting to us they are beginning to talk more to us about base seeding. It takes a long time to climb up there – how long does it take you to altitude …. 45 minutes to get to that altitude. Then when he has to come down to 12,000 feet to melt the ice of him, he still has to climb back up again. The horrible truth about top seeding is it got sold to everybody for years and because it costs a lot more and the more money you've got running through your programme the more money he is going to make.

John Forrest: I worked that out myself.

Dale Bates: I'm not knocking them. I'm just saying if your put together a programme and it is base seeding it will probably do it for 50% or less than what a top-seeding programme would cost.

John Forrest: Provided you can predict the updraft you get some ideas in at the radar then the pilot does the rest?

Dale Bates - Pilot can find the updraft, if you don't have problems the pilot can find the updraft.

John Forrest: It's no good if he finds an updraft that's in completely the wrong position. You've got to have some way….. 1 mile square or something

Dale Bates: Well when you get to the cloud your working on the backside of the cloud –

John Forrest: Where will I get the pilots trained?

Dale Bates: In the beginning you send us the pilots! Gary Walker he can do that, he can't stay right that long. Gary can come over and stay a week in Australia you don't need that. You need to send us a pilot over here for a full season or two or three months that we are making rain the co-pilot with ours and sure enough they are going to learn a whole lot. You take them home you are right for the rest of your pilots. Send us the good boys upfront for a period of time and I guarantee you, we'll get them trained.

Dale Bates: You leave them for a whole season. Remember, what I want you to understand about Texas. Texas is the greatest laboratory that anybody ever built because there four distinctly, five actually types of weather in one state. We've got the tiny woods in the east, got up to 54 inches of rainfall a year. We've got the gulf coast down towards …… all of that coastal plains area and that's a totally different type weather than us. The high plains is a completely very continental very different world Where we are right here we get some of both, we get a whole lot of space, so we kind have a swing both ways. Now west of here is just a dang desert. So what I'm telling you is I don't care what your weather is and Australia I think a pilot could work in one of the programmes here and pretty much duplicate what he is going to see in any part of Australia. Because you've got the same kind of situations. But now the top seeding – there is nothing wrong with top seeding Top seeding is beautiful, its great but its terribly expensive. If you've got to have a bunch of press releases then this becomes important. We are going to talk tonight about marketing. Now marketing is the absolute number one thing that you are personally going to be confronted with. This has got to be packaged and its got to be marketed, just the same as that bottle of wine. So press releases are terribly important, you may want to buy a quarter million dollar aeroplane just let any paper take a picture of it. Or if you've got a great big ego, what we notice is that big egos really love these $200,000/$300,000/$400,000 aeroplanes cause it looks good and they talk about it at the coffee shop and all that, whereas these poor old planes we are using, one of them cost $49,000 and we had to put an engine in it, but they can be bought for about $70,000 and that's not something you want to brag about ……. But it's so much cheaper, you can buy three base seeders and operate them for

what it costs for that pretty boy. Now which one is going to do you the best job – not going to ice up, they've only gong to climb up to about 7-8,000 feet, they are going to fly 150 knots and they are going to be out there ready to go when the real interesting plane … about…. They're just almost indestructible. Every time we get ready to fly the Comanche starts to go and some of these real sophisticated planes give trouble.

Tommy Shearer: One other thing –so you can hire pilots cheaper and be a whole lot more effective and they don't have to be licensed for twins.

Dale Bates: you can train them so much quicker because Craig has been working for three years trying to figure out top seeding, he's developed his own methods and he's way into this but look at how long, how many hours, he's got so many hours and can fly any kind of planes.

Archie – I want to use the opportunity to talk about the experience of imagery in cloud seeding during 12 years. During 12 years the average time for flying in Cuba was 2 hours and 30 minutes. This is the average of a flight. For this 2 hours and 30 minutes we only seeded a cloud for one hour because we used 30 minutes to go one hour to seed and one hour to check what is the precipitation and we have TITAN in the area at that time and to come back and plot it on the map this scene and wait next year, or next day or wait for rain gauge information. So we use only on average one hour to seed the cloud. This is the only window we have. We're flying recently for three days and we have two days with 55-minute windows to work and 45 minutes the next day and I say it is not working. Top seeding here is …. Because the cloud it bubbles, the top of the cloud becomes really invaded in 45 minutes. So it is almost impossible to approach this … without invading. It is impossible for the pilots, it is very risky so, or should you have longer temporary window to work in this cloud it does not matter if it is invaded or not.

John Forrest: If they get there within one third of the half life of the cloud for base seeding, but for top seeding you got half the half life, is that right?

Dale Bates: As long as it is putting out turrets, if you get there and there is no turrets coming out of it you can't seed. The big thing about top seeding and why I think everybody likes it is they can see what they are doing. It's beautiful, because it's beautiful to look at and you can see what you are doing and you can watch the progress whereas the poor old base seeder is just like driving the dump truck – he's down in the dark and he's really looking for tornados and all kind of things that are going to eat him alive, he can't have any idea about it ain't pretty down there is what we're saying.

John Forrest: I think most of what we have been doing, especially in Tasmania, is top seeding… they're scared of running into the hills.

***Tommy Shearer*:** With wing generators, are they still using generators?

John Forrest: Yes, and ground generators…..well they have got a bit of both. … predominately… that's how backward we are….. and we still fly through clouds

Dale Bates: Well it ain't backward but it is sure dangerous!

Tommy Shearer: We have long since discarded the generators. They weren't good enough for intermittent use and kept clagging up. We threw them out. Accurate dosage is needed and the on and off operation kept blocking with ice and clag. We've got them all over Texas lying in hangers now.

Tommy Shearer But, can I go back to where to seed. I can have up to three base seeders for the price of one top seeder but that one top seeder will do the work of three. No one to this day can convince me otherwise. However, in my operation at Pleasanton, I only bottom seed. I can use single engine Comanche's, have no trouble getting pilots, and I can get to the cloud quicker. To compensate, however, I have to fit a 80 gm flare to carry enough agent. I don't like to much drag on the Comanche. It's slow enough as it is. Every one else uses 40 gm flares.

Dale Bates: On this bottom seed, top seed thing John, we're not trying to hurt some of the people you have been riding around with, or anything, but we are just seeing numbers that make us think that Now when I went into this I had to go into this under George Bomar and .. so I was a top seeder advocate because they told me to be one. I've become a base seeder advocate because it works so beautifully and it is so much cheaper and I am the $ and cents guy, I'm the guy that's down trying to get the money out of Austin. I'm happier trying to get the money out of these counties and it is easier to get less money. And if I can do the same job with less money then my job is made a lot easier.

John Forrest: you could not do that job without the TITAN.

***Dale*:** No….. There never has been a research programme run on base seeding until we started this one. And we were told in the beginning that base seeding is terrible and that it did not work, well that's not so. What we found here is that base seeding works like a charm if anything it works every bit as well as top seeding. We had no data to make a decision when we started but we do now. And if you follow the numbers and his programme is always running first or second in the state, and sure he has got a little bit better opportunity cause he is closer to the Gulf, but without any top seeder your number one or two programme every year is a totally base seeding operation. And even though his adjacent programme next to him he's got a 340 but they use it to seed at base, they don't even use each other … and then the one next to that, in other words you come across, there's not a top seeder in the deal, there are no top seeders until you get here. Now you've got some numbers and when somebody starts weighing this up you tell them to call Texas cause they've got a set of numbers to show that base seeding is every good as top seeding. Actually we can tell much difference, but what we can tell is it is sure a lot cheaper.

John Forrest: Do you put a meteorologist in the plane?

Dale Bates: Well the Russians put a meteorologist in every plane so you can go seeding like Archie … from the right hand seat of an aeroplane, he had no radar, so that's possible but its real hard then to develop any numbers because you are back to I wish and I think and I saw and this kind of thing which is not nearly as good as when you are looking at a set of numbers. The reason why we are quelling some of the controversy is because of the number of clouds we've got there and that's just an average data … But also that particular chart right there is almost identical to the results from the land…. Experiments that have been run which becomes the model which everyone shoots at, they would go up and try and find the perfect cloud to seed and then they would open up a box and inside that would be an envelope and they would open the envelop and it would say seed or no seed. If it says no seed, they would go through the cloud and they go through all the motions of seeding but they are firing a dummy flare, so nobody on board except one guy knows whether or not he's the one shooting in the right place. Everything is done exactly as if you were seeding the clouds and then you compare the result analysed by a critic.

John Forrest: Have you done that within your group?

Dale – 192 separate times…. Gave us 92 seeded clouds and 91 unseeded clouds, so what these numbers here almost identical to that - that was done over a three year period

John Forrest: So you had control clouds to compare?

Dale - they were all the same size, other words, every cloud had to be a seedable cloud before it was even looked at. If the envelope said seed they flew through it and they seeded that cloud. This meant all the same human foibles would be the same. There's still a lot of judgment in all this you know. We want the numbers to stack up without criticism.

John Forrest: This is the argument the CSIRO had with the Snowy Mountains Authority in 1970 about the efficacy of the results.

Dale - This is where you can spend all the money. Proving your case. You got to. You will also have people like Danny Rosenfeldt, Bill Woodley and all these other people on high dollar payrolls and then you've got an aeroplane that is only seeding every other of your clouds and this costs a tremendous amount of money. The numbers from that we are still using, in other words that's the one thing nobody quarrels with. The consultants quarrel with us because they took three years and only came up with 91 seeded clouds and in one year we came up with 857 seeded clouds so by sheer volume they're having to hush to us because of the number of clouds that we have got. And we're being real cautious by only presenting 731 to keep them of our case. We think that what we've done here is real close to a randomised deal because we have modelled the control clouds to be the same size as seeded clouds up until seeding takes place. In other words, we're comparing clouds that really would have been seeded not just picking out the poor ones to make the comparison.

July 20 Pleasanton

John Forrest: 10.30am, Saturday, the 20th July. Just flown from San Angelo to Pleasanton with Tommy Shearer to check out the Pleasanton operation. Down here they use 80gram flares, bottom seeding. No top seeding at all. Three Piper Comanche aircraft based at Pleasanton and another Comanche coming from another direction. Larger flares are used here because of the need for high dosage. Flares are 80 kilograms wing flares, whereas 40 grams flares are used in other programs in Texas.

Piper Comanche aircraft fitted only with wing flares and no tip flares

Only bottom seeding operations are conducted from Pleasanton, and larger flares (80 gm) mean that wing tip flares are not fitted. This provides better aerodynamics for smaller Comanche aircraft