MILLIMETER ARRAY
MEMO NO. 77

Road Feasibility Study for MMA Sites in the Magdalena Mountains

P.J. Napier, 28 January, 1992

Introduction

One of the sites under consideration for the MMA is located on the crest of the Magdalena Mountains near South Baldy Pk. in New Mexico. Most of the site, at an elevation of 10500 ft on the main ridge between South Baldy and Langmuir Laboratory, is flat and it should not be difficult to build roads to allow configuration changes between the three smallest arrays. For the largest array, however, where a north-south extent of 3km is needed, it is necessary to leave the flat area and locate some of the antennas on steeper ridges. To obtain a sufficiently large array antennas can be located on the west side of the main ridge north of South Baldy or south along Timber Ridge. We call these two arrays the North Ridge and Timber Ridge arrays respectively. Walking studies of these two locations during the summer of 1991 suggested that the construction of roads suitable for the MMA antenna transporter could be difficult. Accordingly, it was decided to engage a consultant experienced in mountain road building to perform a feasibility and cost study for the transporter roads needed for the two possible arrays. Mr. George Warnock, President of Todilto Exploration and Development Corp. of Albuquerque, NM, was engaged to carry out the study. The attached list demonstrates Mr. Warnock's considerable experience in mountain road building. Also attached is the specification for the MMA transporter roads given to Mr. Warnock as the basic design requirement. Since a detailed design for the MMA transporter and antenna is not yet available, several of the parameters in the specification were chosen rather arbitrarily, but they are believed to be realistic. To give the consultant a concrete concept to work with, he was given the preliminary designs for the SMA transporter and antenna with all dimensions scaled by a factor of 8/6 (the ratio of antenna diameters for the MMA and SMA). W. Bruckman of CfA is thanked for the use of this information.

Consultant's Report

The consultant's report is attached. The detailed engineering spreadsheets provided by the consultant (referred to as Table 2 in the consultant's report) have not been included but are available in the file containing the original of this MMA memo. Some of the key numbers contained in these spreadsheets are shown below in Table 1:

Table 1. MMA Transporter Roads

Road Route	Length (miles)	Maximum Road Gradient	Maximum Spur Gradient	Cost C/F ($K)	Cost No S/C ($K)
Timber Ridge-Lowest Gradient	4.7	5.3%	9.2%	1058	4556
Timber Ridge-Shortest	3.2	10.%	-	682	3183
North Ridge-Lowest Gradient	3.2	5.0%	5.0%	666	2818
North Ridge-5% Gradient	2.3	5.0%	5.0%	415	1658
North Ridge-Shortest	1.9	7.0%	-	347	1344

Note that the consultant refers to the North Ridge Route as the South Baldy Peak slope. In Table 1 the spurs are short side roads used to get from the main transporter road to an antenna pad, the C/F cost is the total road cost assuming that normal cut and fill (C/F) construction methods are used and the No S/C Cost is the total road cost assuming that side casting (S/C) is not used. Side casting is the process of building up the road by pushing loose material onto the slope below the road. The no-side-casting option has been included because the USFS has suggested that they may not allow side casting for environmental reasons. The extent to which side casting will be allowed will be clarified in the near future.

Conclusions

From this initial study it appears that it is quite feasible to build transporter roads of acceptable gradient for either the North Ridge or Timber Ridge arrays. Provided normal construction methods are allowed by the USFS any of the possible roads have acceptable cost within the proposed site development budget. The road consultant will be asked to perform additional studies to clarify the impact of any special conditions that the USFS will impose on construction and to provide an accurate cost estimate for upgrading the access road from Water Canyon to Langmuir Laboratory.

SUPPLEMENT TO RESUME
GEORGE F. WARNOCK

ROUGH COUNTRY ROAD BUILDING EXPERIENCE

Specific wilderness and rough country road construction done under the responsibility of G. Warnock. All road building was done as access to mining or exploration projects with the exception of several direct contracts to design, or design and build, and State of New Mexico road projects. Highway jobs not included.

1959 Cerro de Pasco Corp., Pioneer Property, Gila County, Arizona. 14 foot wide, 4 miles long, approximately 50% drill & blast and 50% bulldozer cut & fill through extremely hard (50,000 psi) quartzite ridges on slopes of approximately 50% (1:1). BLM administered property.

1960 Dominion Explorers Ltd., JoHoBo Mine, Yukon Terr., Canada. 18 foot wide, 13 miles long, with slope grades up to 50% but averaging approximately 20%. Principally bulldozer cut & fill through heavily forested, boggy, permafrost country. Included building and maintaining ice bridges across snow slides too deep to plow over a cumulative 0.5 miles and minor drill & blast. Canadian Forest Service and Park Service administered property.

1962-1969 W.R. Grace & Co.

1) La Chojilla Mine, Bolivia. 12 foot wide, 3 miles long of extremely difficult road with vertical to 90% cliffs approximately 0.5 miles long. Complete road was on slopes of 50% grade or more and elevations of 11,000 feet. Fee ground (unsupervised by regulatory authorities)

2) Antigua Mine, Bolivia. 16 foot wide, 7 miles long heavy haulage road (25 ton loads) on slopes of 30 to 50%. Approximately half and half drill & blast and cut & fill. Surfaced with ABC equivalent mix for stability. Included grouting to stabilize active talus slopes at elevations of 13,500 to 14,000 feet. Fee ground.

3) San Rafael Mine, Peru. 12 feet wide, 7 miles long for access to upper levels and surface drill sites for exploration. 50 to 70% slopes, principally drill & blast with grout stabilization of active talus slopes. 2 miles of 18 foot wide haul roads surfaced with ABC equivalent mix. All at elevations of 15,000 to 16,500 feet. Fee ground.

4) Various others in South America, Canada and the U.S. in easier country. Principally cut & fill with minor drill & blast. All roads include log, metal or poured reinforced concrete culverts and bridges.

1970 Tenneco Corp., Sar Chesmah Mine, Iran. 14 to 30 foot wide, 23 miles long of open pit haul and exploration roads. Principally cut & fill but with considerable drill & blast. Haul roads surfaced with ABC binder course and 3/8-3/4 inch crushed rock gravel. Major project in extreme desert mountain environment with temperatures up to 120 degrees fahrenheit. Slopes in open pit were 50 to 55%. Fee ground.

1971 Compania Minera Los Angeles S.A., Las Animas Mine, Honduras. 14 foot wide, 3 miles long exploration road on mountainous jungle slopes of 50 to 70%. Approximately half & half drill & blast and cut & fill. A particularly difficult job do to heavily vegetated, wet, steep slopes and excess rainfall. Fee ground.

1977-1981 Todilto Exploration & Development Corp, Haystack Mine, McKinley County, New Mexico. 14 to 20 feet wide, 16 miles of open pit haul and exploration roads, including to top of Haystack mountain at 30 to 50% slopes. Principally cut & fill with minor drill & blast in "soft rock" (shales & sandstones) terrain. BIA & DOE administrated ground.

1982 St Cloud Mining Co., St Cloud Mine, Sierra County, New Mexico. 3 mile upgrade of existing 4X4 mountain trail to 14 foot wide access road and new 20 foot wide, 2 mile long haul road, including 100 by 100 foot, level portal site preparation with extensive drill & blast. (Also developed complete underground rubber tired LHD mine on contract). Slopes averaged 30 to 50%. Principally cut & fill with minor drill & blast and major culvert fill. Gila National Forest ground.

1983-1985 Todilto, Resurrection Mine and Monument Mountain Exploration Project, Mineral County, Colorado. 14 foot wide, 5 miles, of cut & fill with minor drill & blast on 30 to 50% slopes. Extensive active talus slopes which were not stabilized. Rio Grande National Forest property. An appeal was won to mitigate excessive cost requirements in construction design dictated by the Forest Service.

1985-1987 Various small road jobs in difficult terrain for the State of New Mexico, Abandoned Mines Reclamation Program in conjunction with old mine reclamation under contract.

1986-1991 Various contract design, engineering and cost estimates on rough country roads. Sub-contract design, engineering and cost estimates for Chapman Wood & Griswald and others.

GW/GBR
RESSUPPL.LTR

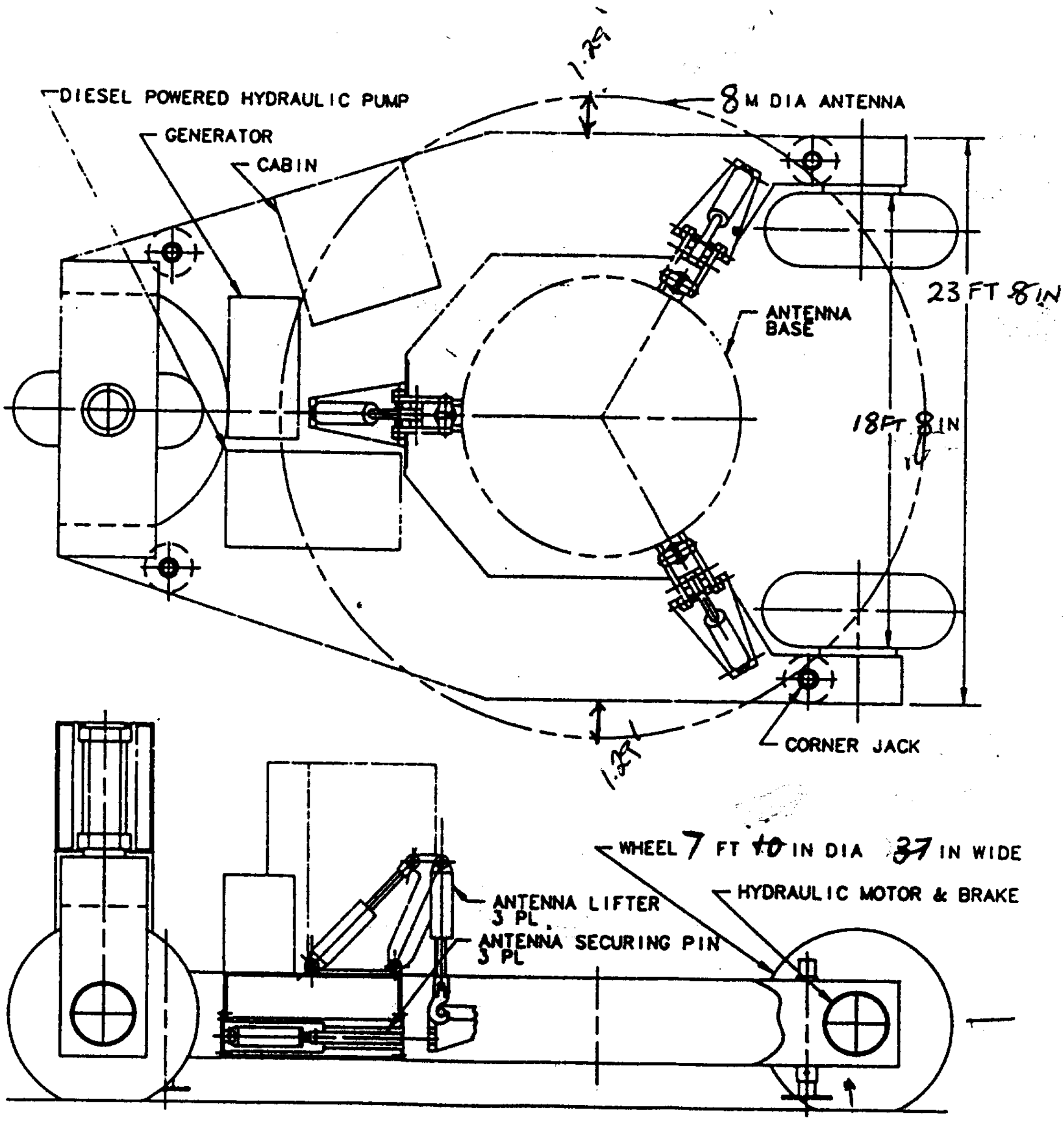
Appendix 1

Specification: MMA Antenna Transporter Road

P.Napier, 24 Sept., 1991.

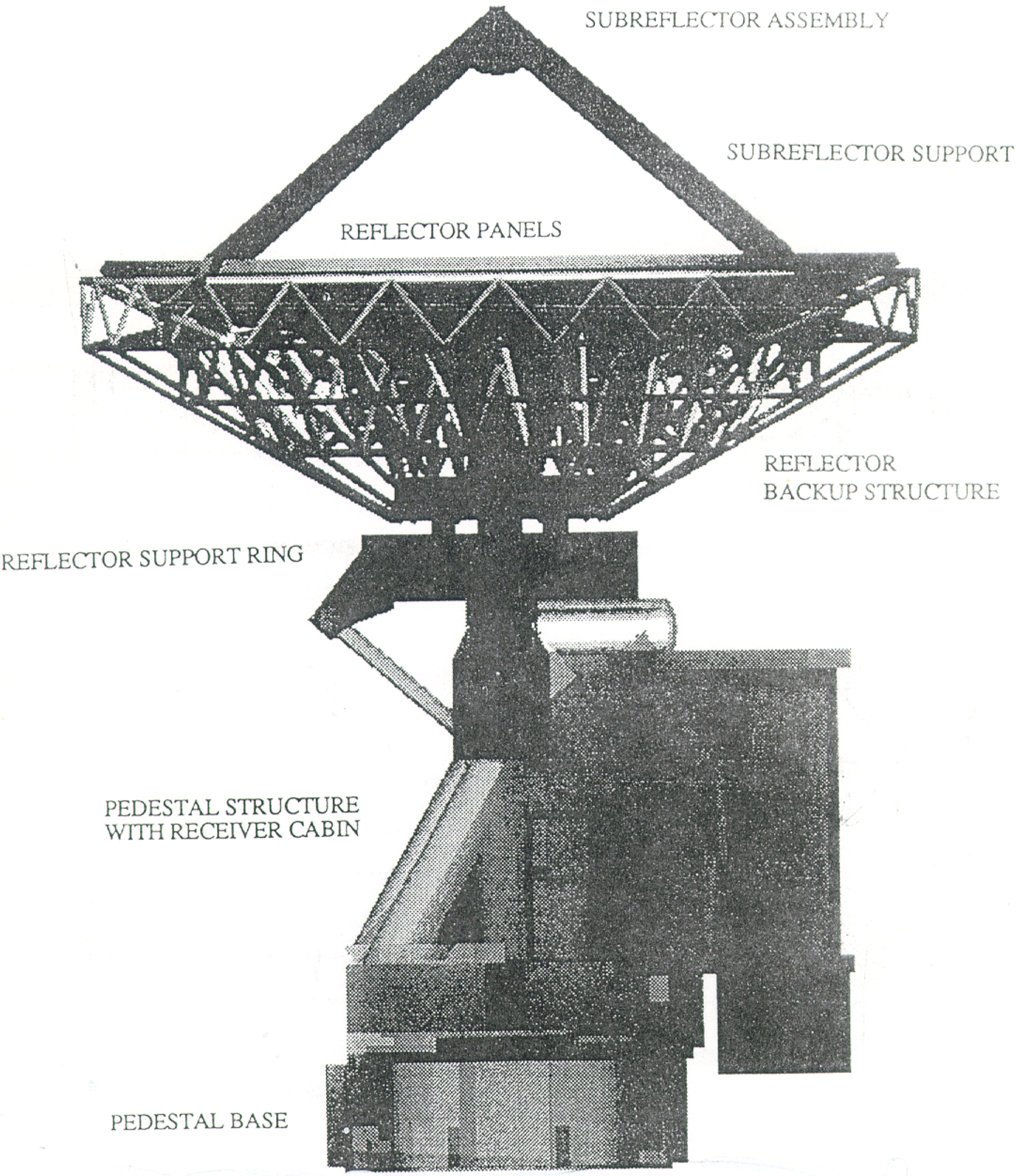
Width: 20 ft operating surface plus any additional width needed for drainage, stabilization and buried utilities.
Loading: 70 Tons
Surface finish: Compacted gravel sloped to drain.
Maximum allowable grade: 10% continuous, 15% for short distances.
Minimum allowable turning radius: 35 ft.
Frequency of use: This is a low usage road. The 70 Ton load will be run over the road 20 times a year. Pickup trucks will use the road approximately twice a day for 3 months of the year.
Winter Use: The road will receive its major use during the winter months and must have guard rails where needed and allow for snow removal.
USFS Requirements: It is probable that the USFS will place the following requirements on the construction of the road:

- (a) No side hill casting allowed.
- (b) No construction during March-July due to threatened and endangered species.
- (c) Particular care must be taken with drainage. USFS has preference for an outward sloping road.



Mechanical interface between the antenna and the transporter.

SMA Transporter Concept - Scaled to MMA



The Antenna Assembly

SMA Antenna Concept

November 18, 1991

FEASIBILITY AND PRELIMINARY COST ANALYSIS
ANTENNA ARRAY ROAD ALTERNATIVES
NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO COUNTY, NEW MEXICO

G. Warnock

1. SUMMARY & CONCLUSIONS

1.1 The two main alternative antenna array roads proposed by the National Radio Astronomy Observatory (NRAO) personnel are 1) south from the Water Canyon to Langmuir Laboratory road following the Timber Peak ridge line, south and, 2) leaving the same road near Langmuir Laboratory traversing northerly along the west slope of South Baldy Peak. Road building to either array location is easily feasible if somewhat expensive. The increased expense is caused by normal alpine (high altitude) conditions of considerable rock outcrop and the presence of frost heave talus slopes. Summarized estimated cost are shown on Table 1 on the following page with full details on Table 2 attached.

1.2 This road construction should be compared to the many existing, two lane graveled highways traversing mountain terrain anywhere in the Rocky Mountains. The elevation and alpine conditions only add a talus component cost to the construction not normally found at lower elevations. Talus terrain is easily traversed using standard cut and fill - side hill casting methods with only somewhat higher unit costs than soil work as shown on Table 2. The biggest problem with alpine roads through talus is continuing upkeep due to frost heave each winter. This can be easily handled by a routine grading maintenance program each spring after the thaw.

1.3 The alternative routes for both arrays, two for the Timber Peak ridge and three for the South Baldy Peak slope are an attempt to give NRAO the flexibility of considering gradient of the alternative roads vis a vis the expected winter operations on snow packed, steep roads where 70 ton loads will be moved. While it adds materially to the costs due to the length of the roads and necessary spurs to antenna sites, the longest and least gradient alternatives may be worth while if consideration is given to safety of the antennas and personnel.

TABLE 1

NATIONAL RADIO ASTRONOMY OBSERVATORY
ACCESS ROADS, SOUTH BALDY PEAK AREA, SOCORRO COUNTY, NEW MEXICO

COST SUMMARY AND COMPARISON

TIMBER PEAK RIDGE, SOUTH

Distance Miles	Total Cost Cut/Fill	Total C/F /Mile	Total Cost No Side Cut	Total NSC /Mile	Difference /Mile	Ratio /Mile
Alternative # 1, Longest and Lowest Gradient						
4.65	$1,058,283	$227,375	$4,556,284	$978,929	$751,554	4.31
Alternative # 2, Shortest and Steepest						
3.15	$681,799	$216,535	$3,183,034	$1,010,912	$794,377	4.67
SOUTH BALDY, NORTH RIDGE						
Alternative # 1, Longest and Lowest Gradient						
3.18	$666,536	$209,483	$2,818,808	$885,911	$676,428	4.23
Alternative # 2, Holding 5% Grade						
2.25	$414,785	$184,039	$1,657,831	$735,576	$551,537	4.00
Alternative # 3, Shorteast and Steepest						
1.86	$347,276	$186,723	$1,344,106	$722,696	$535,973	3.87
WATER CANYON UPGRADE						
8.22	$1,220,348	$148,466	$2,218,846	$269,943	$121,477	1.82

1.4 Cost for side hill casting for all alternatives are as follows:

	Miles	Total	Per Mile
Timber Peak Ridge, south			
Alternative 1	4.65	$1,058,283	$227,375
Alternative 2	3.15	$681,799	$216,535
South Baldy Peak, north			
Alternative 1	3.18	$666,536	$209,483
Alternative 2	2.25	$414,785	$184,039
Alternative 3	1.86	$347,276	$186,723
Water Canyon road	8.22	$1,220,348	$148,466

Buried utilities, guard rails and widening for sites are not included in these cost estimates.

1.5 Of possible grave economic concern is Cibola National Forests request to build the roads using a "no side cast" construction method. They apparently visualize using a large, front shovel type, hydraulic back hoe to dig the road bench directly in a frontal attack and load out trucks behind the back hoe, transporting the material to a fill area or stock pile somewhere along the Water Canyon road (FS-235). This method would increase costs dramatically. Per Table 1, following page 1, this would be more than four times more expensive than standard side hill casting. This is caused by the need to take the full road width out of the cut as opposed to the side casting construction which takes full advantage of the spill material for part of the road bench and increase unit cost for this type of road construction.

1.6 The existing Water Canyon road upgrade difference of only 1.82 times more for no side casting is caused by there being less overall cut and lower unit prices. This is due to the existing approximately 15 foot cut and my estimate that approximately 30% of the existing road will only require resurfacing.

1.7 In summary, roads to either array location are completely feasible with normal construction costs for these alpine conditions and specifications using standard side casting methods. The no side casting method of construction is prohibitively expensive.

1.8 A possible legal access problem exists in the South Baldy Peak slope area due to the presence of an old patented mining claim.

2. SCOPE

2.1 I was contacted in July by Mr. John Fehr of the Cibola National Forest to determine my interest in estimating road construction for NRAO near Magdelena. He apparently obtained my name from Chapman, Wood and Griswold for whom I have done previous road construction estimates. After a call from Mr. Peter Napier of NRAO, bid documents were received on August 22, 1991 and a bid returned to NRAO on August 24th. The job was awarded by a purchase order dated September 23rd. After telephone discussions with Dr. Napier concerning scheduling, the site inspections were made on September 25th. and 26th..

2.2 A draft calculation for the Timber Peak ridge and South Baldy Peak slope sites was sent to Dr. Napier on October 25, 1991. Due to time restraints, it was decided to expedite the final report by only "guesstimating" the Water Canyon road upgrade and submitting the work map only, without having it formally drafted. A revised purchase order was received on November 12th. A total of 14 days were spent on the project.

2.3 Stereographic air photo coverage, air photo enlargements, metric contour maps and USGS 7.5 minute topo maps blown up to a scale of 1 inch = 500 feet were supplied by NRAO. These were used in estimating the physical quantities and the road alternatives were plotted on and calculated from the 1 inch to 500 feet topo enlargements.

2.4 The final cost estimates are materially higher than the first draft due to a change in the surfacing cost and several minor problems with the spread sheet (Table 2) input.

3. CONSTRUCTION CRITERIA AND ESTIMATING PARAMETERS

3.1 The revised road specifications and antenna transporter drawings indicate a 70 ton load, minimum center line turning radius of 35 feet with mostly winter usage of the roads. The transporter is 23.67 feet wide and is contemplated as a tricycle arrangement using 7.83 foot diameter and 3.08 foot wide tires. Outside tire width is 18.67 feet. The antenna dish is 8 meters or 26.25 feet in diameter and this maximum width will ride high on the transporter, some 28 feet above ground level. The original specifications are attached as Appendix 1.

3.2 Both buried utilities and guard rails are required to all antenna sites and along the access roads - as necessary for safe vehicle passage on icy roads, in the case of guard rails. Due to the utilities not yet being specified and lack of time, neither of these items are included in the cost estimates. Also, there will be some additional minor cost for either widening the road to make on-road antenna sites, an additional

10 feet to allow vehicle passage, or constructing wider pads at the end of spurs. These also have not been estimated.

3.3 Based on these specifications, an operating graveled surface width of 25 feet was designed for the roads. The sub-base width is 27 feet and a total cut and fill width of 30 feet is used. This will allow both the buried utilities and guard rails to be placed in the outside 5 feet of fill and will require no further rock blasting to install either, in the case of the side hill casting method. It will also allow for the normal minor slumping of the fill on the outside edge of the bench over time due to natural compaction and erosion The sub-base is 6 inches compacted thickness and surface gravel is 2 inches compacted. Swell volume of 1.3 was used for all types of construction, soil, talus and rock even though these will vary with the type of material. For the cut and fill - side casting construction, experienced based unit of production costs were used for each type of material from a similar job in southern Colorado increased for inflation by using the Consumer Price Index inflator. That is, no detailed machine, manpower and materials time and cost study was done.

3.4 In the case of the no side cast option, a detailed time and materials study was calculated because I have never heard of this method of road construction in mountainous terrain and have no experience costs to use. On a unit of production basis, the two methods compare as follows:

	Side Casting	No Side Casting
Rock Costs /Cubic foot	$0.73	$1.82
Talus Costs /Cubic foot	0.29	0.63
Soil Costs /Cubic foot	0.21	0.41

While the unit of production cost for no side casting are only about double the side casting, the four times increase in the final estimates is caused by the almost double amount of cut that has to be made with the no side cut option. This construction method will also require further blasting for installation of the buried utilities and guard rails, again doubling or tripling the cost for that phase of the construction, as no fill will be available in which to install them through the rock and talus sections of the road.

3.5 Due to the size and height of the transporter, the bench banks are laid back at a 70 degree angle to the horizontal. The fill sections are calculated at an angle of repose of 50 degrees, even though this will again vary depending on the type of material involved. With these two design parameters and the 30 foot bench width, cut and fill volumes may be calculated for any given percent or degree slope by using simultaneous and quadratic equations to solve for x, the actual cut width and y, the horizontal fill width. The area of the cut is then calculate by using the simply area of a triangle formula. A diagram demonstrating this calculation is on page 1 of Table 2.

3.6 In the case of the no side cast cut, the triangle formed by the slope of the side hill is solved for the area of the cut. One point that should be made is that the further one has to cut into a side hill in very steep terrain, the more rock can be expected. The percent rock used in both calculations is based on the side casting method and materially more, conceivably double the amount of expensive rock work may be encountered in the no side casting option.

3.7 The percent rock and talus used over any given segment of the road is an estimate of the percent of the material in the length of that segment. The percent estimate was arrived at based on notes from observation during the field inspection, studying the stereo air photos and the air photo enlargements - particular in the case of talus. This type of "guesstimating" is fraught with inaccuracies and is usually used only as a preliminary step to select the preferable route. It is then followed up by a second field trip with a helper wherein that route is chained with a preliminary center line flagged and the measured distance of the rock, talus and soil sections are used for the detailed estimating. At the same time, accurate side hill slope angles are measured at set intervals rather than relying on the generalized topo map contours to determine slope.

3.8 Due to the press of time, the Water Canyon road upgrade slope was not estimated from the enlarged topo maps as were the new road alternative. It was only "guesstimated" at using the average side hill slope, 47.31 percent, of all the new road alternative. The Secondly, the length of the rock section (there is no material talus) was not estimated from the air photos but was guessed at by using the average rock section on the new roads, 25 percent, and memory from driving up and down the road. The estimated 30 percent of the road not requiring widening was also guessed at from memory.

3.9 Costs for surfacing the new roads and resurfacing the Water Canyon road, are based on cost of material in Socorro, transportation to the site and spreading and compacting. As some near surface mixing to avoid as much loose gravel as possible is desirable, a sheep's foot compactor should be used on the base course followed by a roll compactor on the gravel surface.

3.10 Antenna site locations were describe as flexible within 50 to 100 feet but with a preference for positions, when near steep sloped ridges, that would allow them to "see" over the ridge at a relatively flat angle. This flexibility was taken advantage of in many cases, where relocating the sites would allow them to fall close enough to the access road that a widening of the road would serve as a site. This is the major distance saver of the steepest access road alternatives.

4. WINTER OPERATING PROBLEMS

4.1 The specified winter usage at this altitude, even in south central New Mexico, is going to create severe traction problems for 70 ton loads on a tricycle configured carrier. I do not know whether the transporter can be redesigned with four wheels for a stable base but would highly recommend that for operating on ice and snow. I also do not know if it is self propelled or towed, but if it is moved by being towed by a tracked vehicle in the winter chained closely together, it will be much less likely to get away in a skid. Can the tires be custom made with snow treads and can custom webbed, non-slip snow chains be designed for them? These will help going in going both uphill and down hill on ice or packed snow if the carrier is self propelled. Whether the timing of moves is important or not should also be considered. If it is not, then day time thawing plus the opportunity to get a grader or plow on the roads prior to a move may allow for a steeper gradient verses cost of construction.

4.2 Based on experience with heavy (up to 100 ton) mining loads in open pit truck operations in northern climates, I would strongly recommend that the road gradient be kept as low as possible. Heavy load production roads in mining are generally held to maximum 5 to 6 percent gradients for a number of reason in addition to traction on snow and ice and always have a full contingent of support vehicles available for assistance. This is a different situation in that the roads will not be traversed multiple times daily except by pickups, but a 70 ton load on ice being moved down grade, even at two to three miles an hour, will have sufficient inertia to create a definite safety hazard if not anchored to some type of heavy tracked equipment.

4.3 These winter operating conditions led me to seek the lowest possible road grade to access the desired sites as first preference alternatives. Where possible, such as on spurs, a maximum of 5 percent gradient was sought. For comparison sake, the shortest routes, regardless of grade, were estimated. These steepest routes are obviously the lowest cost to build but this must be weighted against the hazards of winter operations.

5. TIMBER PEAK RIDGE, SOUTH

5.1 Both the Timber Peak ridge, south alternatives leave the Water Canyon to Langmuir Laboratory road at station A marked on the attached work map at an elevation of 9,860 feet. The first segment traverses southeasterly to station B in the saddle immediately south of Timber Peak at a steady gradient of 3.73 percent to an altitude of 10,120 feet. This alternative is colored orange on the work map. It then proceeds south to the next saddle, station C, at an almost level gradient of 0.84 percent. From C, it traverses a southerly slope with two switchbacks through stations C1, C2 C3 to station D holding as close as possible to a 5 percent grade. The segment from D to E is essentially level going around the east slope of a small hill on the ridge and up at 5 percent from E to F, the last antenna site.

5.2 This is the longest and least gradient alternative for the Timber Peak ridge area. It is also the most expensive at total road building cost of $1,058,283 or $227,375 per mile for 4.65 miles. The no side cast equivalent is $4,556,284 - 4.3 times more than the side cast method. The extra distance is caused by the long spurs as plotted on the work map from A1 to A2 to A3 and A4 to A5 to A6 to A7 and A8. The spurs add one mile to the road length and cost $319,716 of the total $1,058,283. The spurs were laid out attempting to hold the maximum 5 percent gradient when possible and vary from 1.82 percent to 6.67 percent near the antenna sites on the ridge. The short, 650 foot long, spur from station B to B1 has a gradient of 9.23 percent. As this site is isolated from the others on the ridge, it would require at least a half mile spur to access it. Depending on the final design of the transporter and a judgement on its safety capabilities on this high a gradient under winter conditions, it may be prudent to add the costs of an extension from A8 to B1 (the dark green segment on the work map) to access this site or possibly, move the site.

5.3 The second alternative for the Timber Peak area is to head directly up the ridge southeasterly from station A to the antenna sites just under the ridge on the southwest slope. This alternative is colored dark green on the work map where it varies from alternative 1. It also eliminates one switchback on the south end of the road between stations C and D. It does not change the 9.23 percent gradient between B and B1 because the main access road would continue down the decline from B1 to B. Maximum grades of 10 percent are used on this alternative and it reduces the length to 3.15 miles costing $681,799. The no side cast option costs $3,183,034 or 4.7 times more. The side cast costs are approximately 60 percent of the cost of alternate 1 and this reduction is accomplished by eliminating the spurs by accessing the antenna sites directly up the ridge. Again, the $400,000 savings may be false economy.

6. <u>SOUTH BALDY PEAK, SLOPE</u>

6.1 Alternative 1 for the South Baldy Peak area, the longest and least gradient option, commences from the Langmuir Laboratory road at station A. This point is at an elevation of 10,450 feet on the grassy ridge south of South Baldy Peak and very near the Laboratory. It also is colored orange on the work map. It has a maximum gradient of 5 percent from B to C and varies between 1 to 4 percent over the remainder of the segments. The road branches at station D and ends at stations F and H respectively. It requires to long spurs to access the antenna sites on the west slope of South Baldy Peak from C1 to C2 and C3 to C4 which add 0.76 miles to the distance. The total length of 3.18 miles costs $666,536 of which $193,366 is for the spurs. The no side cast method is 4.2 times higher at $2,818,808. One possible negative point of this otherwise best alternative is that it traverses a strong steep knob of outcropping rock immediately below station C2 that can be avoided by alternative 3.

6.2 The second alternative in this area departs from the Langmuir road at station I at an elevation of 10,540 feet. It is colored dark green on the map where it varies from alternate 1. It is located to hold a steady 5 percent grade from station J to D and varies between 2.67 and 4.21 percent on the other segments. It requires only one short spur from J1 to C2 which adds 0.23 miles to the length. The total distance of 2.25 miles cost $414,785 of which $44,057 is for the spur. No side casting cost $1,657,831, an increase of 4 times. It also still encounters the rock outcrop below C2.

6.3 Alternative 3 for this area, the shortest and steepest gradient, is colored blue on the map where it varies from alternate 1. It commences at station K on the Langmuir road at an elevation of 10,560 feet. It has no spurs on the upper segment but requires a move of <u>150 feet</u> downhill for the first antenna site at station C2. It has a maximum gradient of 6.99 percent over 3,720 feet between stations M and D, a long stretch of high gradient. The cost of this alternative is $347,276, the lowest of the three in this area. By comparison, the no side hill option is 3.9 times more expensive at $1,344,106. The 3720 feet of 7 percent grade is a serious disadvantage for winter operations. However, it has the advantages of no spurs on the upper segment and, less rock work as it moves the road above the prominent rock point on the slope below station C2 and the sidehill slope at that point is noticeable less steep. This possible advantage should be carefully investigated in the field before a decision is made on the three alternatives in this area.

Unless it is a very distinct advantage, the 7 percent grade on this alternative would be dangerous for the safety of the antenna transporter with ice and snow on the road.

6.4 An apparent legal access problem exists with all three alternatives in the South Baldy Peak area. The Cibola National Forest map for this area shows an old patented mining claim covering the old shaft and prospect workings near the saddle at station D. A copy of the Forest Service map is on the following page with the claim marked in red. It has also been approximately located on the work map, colored pink. These old patented claims are privately held fee simple ground and should be researched at the County recorder's and tax office to attempt to determine the person or entity owning it, tax status and etc.. The workings on the claim are extremely old as evidenced by 4 to 6 inch butt tress growing on the dump. However, as fee simple ground, old patented mining claims never expire but may have been sold for back taxes or otherwise, many times. It also could be in the possession of the County assessor with a tax lien on it that no one wanted to redeem.

6.5 The old workings, particularly the vertical shaft, are a dangerous safety hazard and a potential liability for the current property owner in case of an accident of someone falling into the shaft. If the owners can be identified, they might be willing to grant permanent access across the claim to NRAO for NRAO in turn filling in the workings while the road is under construction and equipment is handy. The cost would be nominal, a few hundred dollars, with the equipment already there working on the road. It would be legally and economically imprudent to proceed with the construction over the claim without an access agreement with the owner.

7. WATER CANYON ROAD UPGRADE

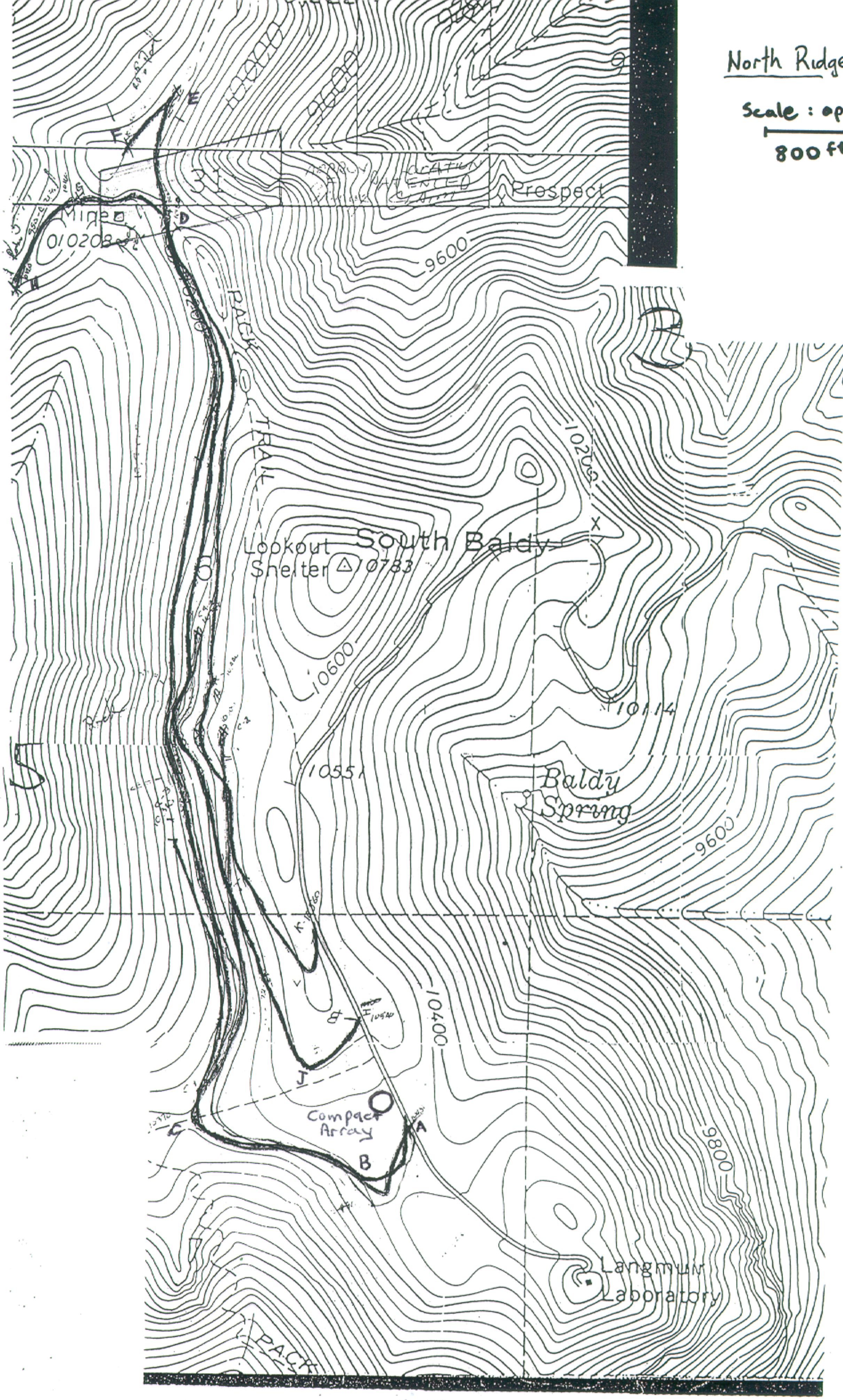
7.1 The Water canyon road is 8.22 miles long from the camp grounds to station A near Langmuir Laboratory. It is grossly estimated to cost $1,220348 or $148,466 per mile to upgrade the road to the specifications herein. The no side cast method would cost $2,218,846 only 1.8 times more. The relative low cost per mile is caused by the presence of the existing road bench estimated to average 15 feet in width. The advantage of working off of the existing road rather than having to make a new cut is estimated to result in a savings of 25 percent on the unit costs. Further, only 70 percent of the total distance is estimated to require widening while all of it would be resurfaced.

7.2 Not included in the Water Canyon "guesstimate", are several necessary culverts, including one for a major water flow at the crossing at the camp grounds. This road upgrade definitely needs to be carefully surveyed and estimated. The "guesstimated" numbers presented cannot be relied upon as even close.

Lake Canyon
AUXILIARY
Council Rock Arroyo
Telephone
Jencia
Granite Mountain
VABM 7244
Bird Spr
Goat Spr
Creek
BM 6021
FIRST
LINE
Montosa
Silver Hill
Magdalena
MAGDALENA
ATCHISON
TOPEKA
BM 6041
BM 6281
BM 6441
Airstrip
Sawmill
Hale Driveway
Arroyo
Gato
Rabbe
Gosey
Cedar
BM 7083
Landavaso Res
Boxcar
FS WAREHOUSE
Magdalena Peak
FRIO
VABM 8152
North Peak
Kelly
Chihuahua Gul
Mistletoe Gul
Pony Spr
Elephant Mtn
Elephant Spr
Hop Canyon
McDonald Spr
Garcia Can
USLM NO 1
USLM NO 4
Strozzi Su Spr
Shakespear Spr
Upper Garcia Can Spr
North Baldy
VABM 9858
Cabin Spr
Cerro Pelon
Palome
Agua Fria Spr
Wet Weather Spr
Rock Can
Sprs
Dark Can
North Fork
Water Canyon
USLM NO 3
Water Can Mesa
EASY 7322
Texas Spr
Rowdon
Texer
Copper
Stallings
WEST
Springs
McDaniel
Barnet
Mill
Turkey
Bear Canyon
South Baldy Peak 10783
Baldy Spr
Timber Pk
Langmuir Lab Cable
South Buck Peak
Upper Gay Water
Sixmile Spr
Buttercup Spr
Hardy Spr
Martin Spr
MAGDALENA
MERIDIAN
GUIDE
T. 4 S.
Rock
Hill Place
Deer Plot
Canyon
HARDY RIDGE
West Spr
East Fork
Rock Slide Spr
Ryan
Molino Peak
Italian Peak
Italian Spr
Ryan Hill Spr
Squaw Peak
Medina
Gap
Gap Well
Horseshoe
Alameda Spr
Chocle
MILLIGAN
Sawmill Spr
MOUNT
Pipeline Spr
Puertecito Spr
PATENTED CLAIM

North Ridge Road

Scale : approx.
800 ft



Timber Ridge Road

Scale : approx

900 ft