CHARA Technical Report

No. 36 9 September 1996

Directed Initial Reduction of Terrain

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1. INTRODUCTION

One of the most uncertain expenses in the CHARA Array project is the light pipes and their supports. (A rough estimate for this phase of the project was as much as $1.9M!) Therefore, any ideas for reducing this cost should be considered. In this report we consider the feasibility of sculpting the terrain of the site to reduce the heights (and expenses) of the light pipe supports. This project was dubbed "DIRT" (Directed Initial Reduction of Terrain). A preliminary estimate shows that the cost-benefit ratio (CBR) is very favorable.

2. AN APPROXIMATE COST MODEL

The following assumptions have been made in order to get a rough estimate of the costs and benefits to see if the DIRT project is at all feasible.

- The cost of moving dirt on the site to us is $20 per cubic yard. The actual cost is roughly $10, broken down as follows:

— Fill and compact	$4.30
— Excavate	$0.91 – $2.25
— Haul 1 mile	$2.55
— Site grading	$1.80

  (Note that most of the hauling will be less than 100 yards, thus probably reducing the hauling cost.) We conservatively double this to allow for contractor's profits, permits, etc.

- The total cost of the supports for all three arms is roughly $1.0M, determined by scaling the architect's initial estimates down a bit.
- The cost of the supports goes roughly as the cube of the height (similar towers, except in scale). Note that the design complexity will also increase for the higher towers. Towers less than about 10 ft in height can be simple poles, as at the JPL ASEPS-0 Project at Palomar.
- Cuts and Fills should be smooth and leave a slope no greater than 1:2.

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3. WEST ARM

This site is on a hill, with a slope of 5.°57 to the BSF. The greatest height of the light pipe off the ground is about 33.2 ft in the "saddle" area, and there is a region of about 160 ft (50 m) in which the height is greater than 25 ft. This arm is by far the worst problem, and according to the model would absorb some 78% of the support costs.

Figure 1 shows contour maps of the site and the elevation along the West arm. The upper right panel in Figure 1 shows a modified terrain, in which the top of the hill (roughly 8 ft) has been taken off and part of the saddle area has been filled in. In this case the greatest pipe height has been reduced to about 15.5 ft.

Figure 2 shows a 2× "blowup" of the contour map of Figure 1 with the cut and fill areas indicated. Note that the deepest cut and highest fill areas are more than 10 feet. The cut volume is 3156 cu yd, and the fill is 3111 cu yd. (Conservatively estimated cost is about $63,200.) If we assume the above cost model, the net saving in structure on this arm is about $621,000. The cost-benefit ratio is roughly 10.4.

4. THE NORTHEAST ARM

The Northeast arm runs from the side of a large hill upward at about a 2.°5 slope to the BSF. (See Figure 3.) The worst height in the original Northeast arm is about 21.7 ft. It is reduced to 15.8 ft in the proposed modified contours.

About 44 and 889 yards of material are used for cut and fill respectively in this model. The 845-yard deficit in material could be made up by cutting the top of the large hill immediately behind the telescope location. This would have the advantage of a short distance for the fill dirt to move. (Cutting the top of the hill would also provide another possible telescope site.) Figure 4 shows the location of the cuts and (mostly) fills. The fills are confined to a relatively small area. The cost of excavation and net saving in structure on this arm are about $17,800 and $54,500, respectively. The cost-benefit ratio for this arm is roughly 3.6.

5. THE SOUTH ARM

The South arm runs from near the 60-inch dome under a road and up toward the main building at a slope of less than 1.°5 (see Figure 3). Unlike the other two arms, there is a significant tunneling effort than must be done. This cost could also be improved by sculpting the terrain, but this potential improvement is not considered in this preliminary report.

The worst height in the original South arm is about 22.4 ft. This occurs in a relatively small region where the contours start to fall off. It is reduced to 14.8 ft with selective filling. About 553 yards of material are used for fill in this model. This material could be obtained from the large hill mentioned in the previous section or possibly from the removal of the small hill immediately east of the BSF.

If we assume the above cost model, the cost of excavation and net saving in structure on this arm are about $10,600 and $29,400, respectively. The cost-benefit ratio for this arm is roughly 3.3.

TABLE 1. Summary of Proposed Cut/Fill

Arm	Cuts	Fills	Max Height (before)	Max Height (after)	Net Saving ($)	CBR
West	3156	3111	33.2	15.5	621,000	10.4
N.E.	44	889	21.7	15.8	54,500	3.6
South	0	553	22.4	14.8	29,400	3.3
Total	3200	4553	33.2	15.8	704,900	8.2

6. DISCUSSION

This preliminary estimate suggests that large savings in cost are possible with selective cutting and filling of the terrain. The overall estimated CBR is 8.2, with a net savings of about $705,000. Thus, this method seems economically feasible even if it turns out that much cheaper supports are possible. Another agument in favor of DIRT is that only 15-ft high supports are needed instead of 33-ft towers. Structures as high as 15 ft could be relatively simple, as used at Palomar for the JPL interferometer or at the NRL Anderson Mesa interferometer. A 33-ft structure might involve a lengthy design process, a complexity we could eliminate. Another consideration is safety: would you would rather be up a 15-ft structure or a 33-ft one? A lower maximum height would also make it possible to use simple "cherry-pickers" for pipe maintenance, et cetera.

The remaining questions are basically environmental and aesthetic. We think that a good case can be made for sculpting the terrain and having lower, simpler structures for pipe support rather than a series of larger towers. No drainage patterns would be disrupted. Also, both hills that would provide the fill are essentially barren now. Funds could be budgeted for grass or natural chaparral seeding. Few if any additional trees would need to be removed compared to the current plan. Finally, if it is difficult to obtain the requisite permission(s) to alter the site, we could concentrate on the West arm only. One could argue for leveling the top of the hill for installation of this telescope and shelter. The resulting dirt could be conveniently deposited in the saddle area.

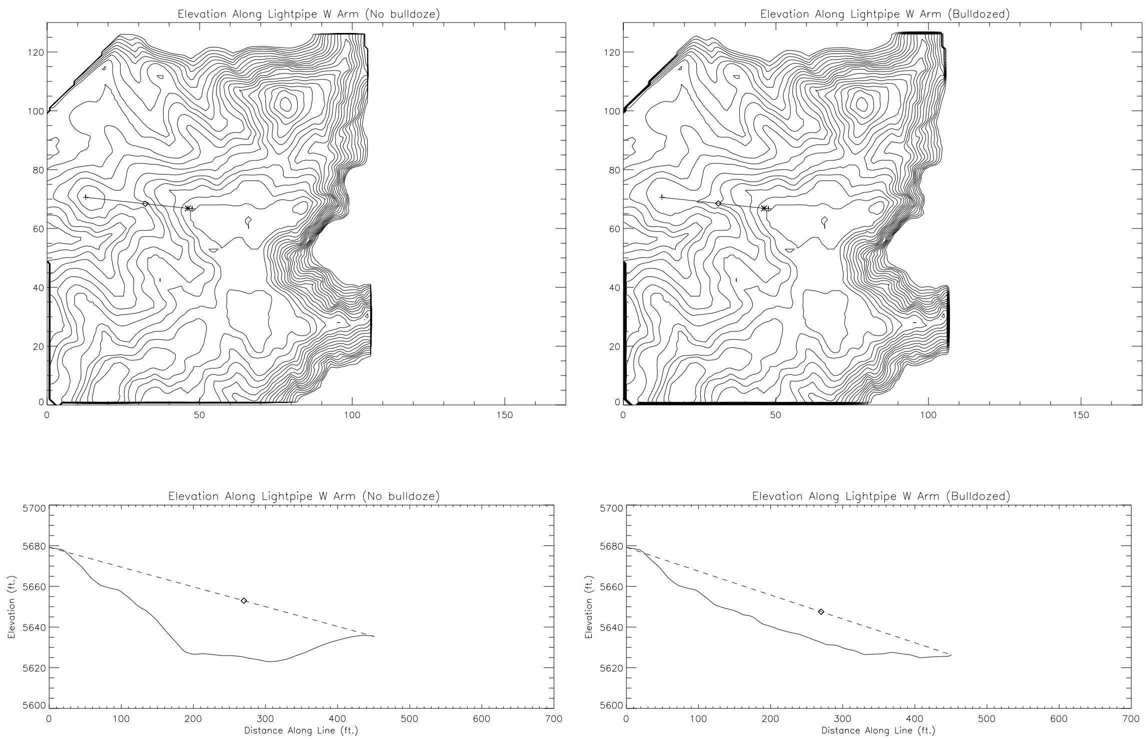

FIGURE 1. Terrain maps for West arm. Top left: Unmodified contour map. Top Right: Modified contours. Bottom Left: Elevation along unmodified arm. Bottom Right: Elevation along modified arm. Note large reduction in maximum pipe height.

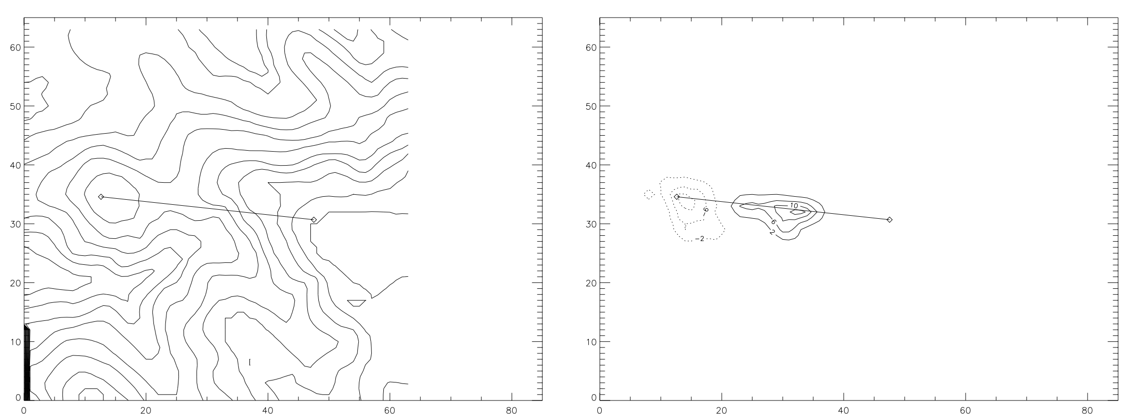

FIGURE 2. Cut/fill maps for West arm. Left: Unmodified contour map (2× blow up). Right: Modifications to terrain. Four-foot contour intervals. Cuts denoted by dotted contours.

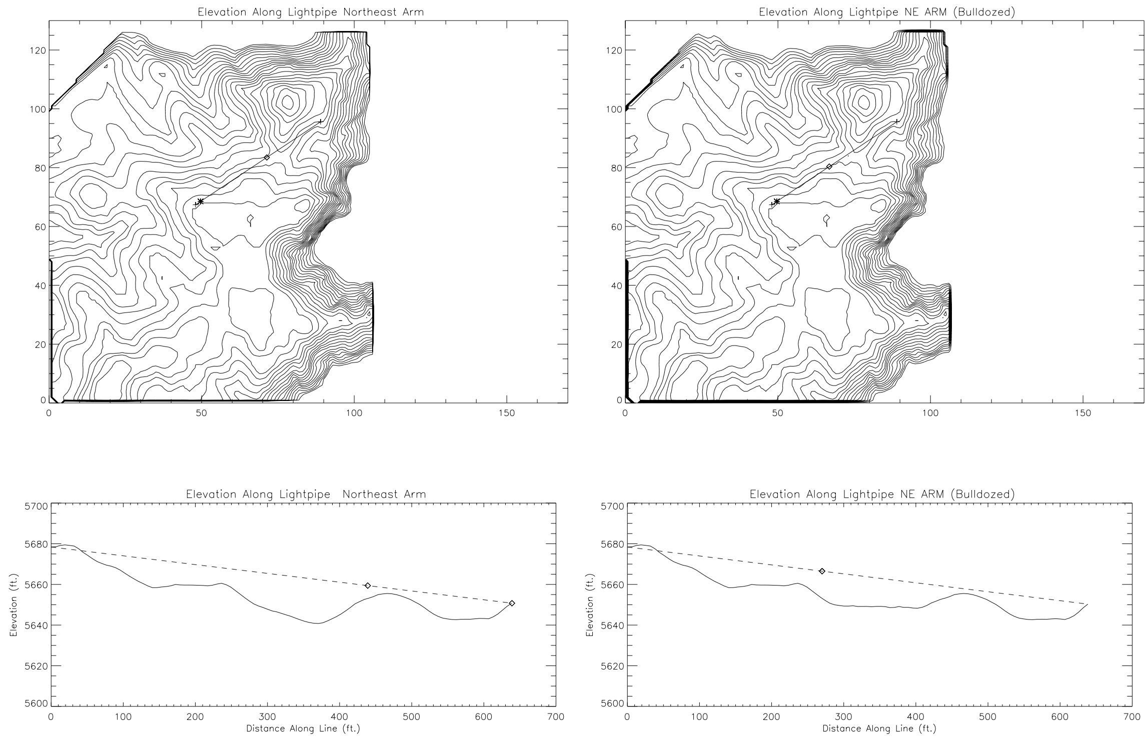

FIGURE 3. Terrain maps for NE arm. Top left: Unmodified contour map Top Right: Modified contours. Bottom Left: Elevation along unmodified arm. Bottom Right: Elevation along modified arm. Note reduction in maximum pipe height in saddle area.

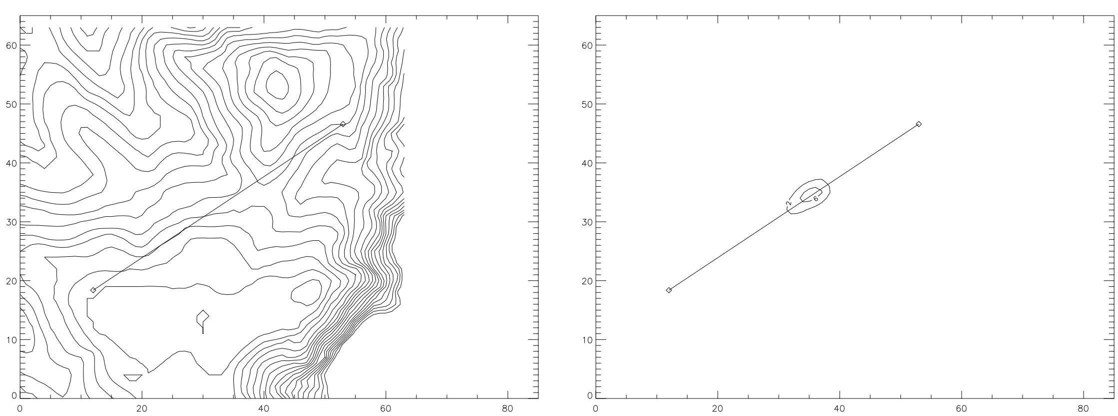

FIGURE 4. Cut/fill Maps for NE Arm. Left: Unmodified contour map (2× blow up). Right: Modifications to terrain. Four-foot contour intervals. Cuts denoted by dotted contours.

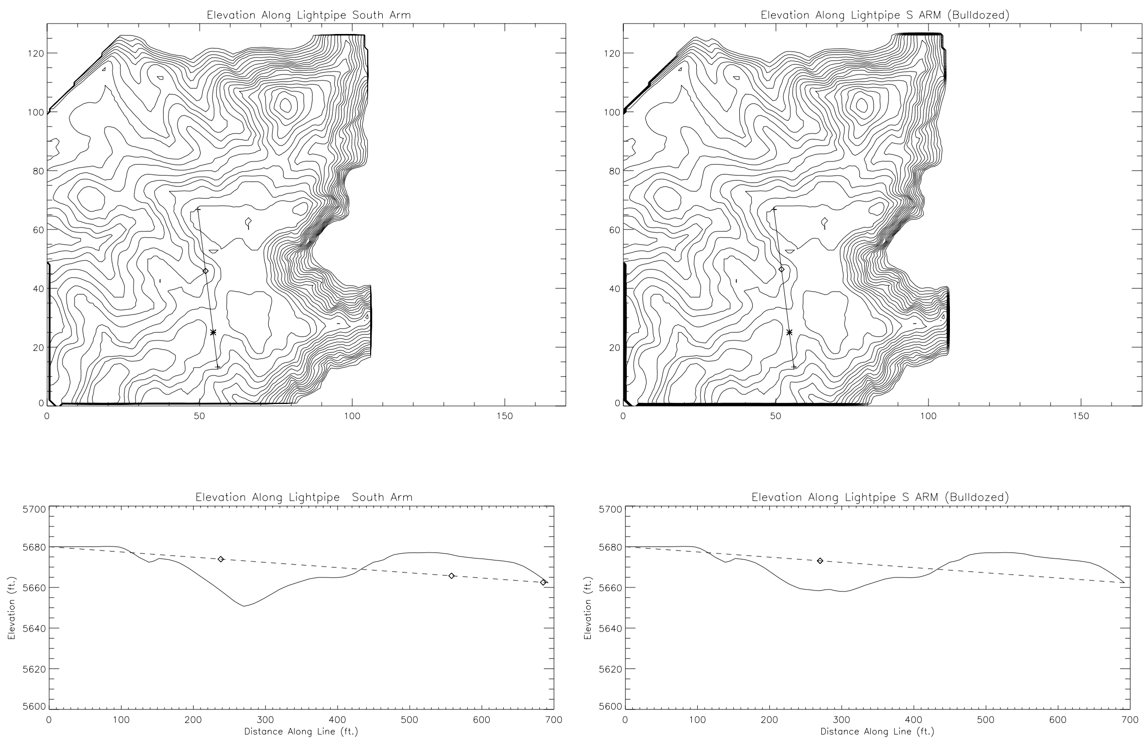

FIGURE 5. Terrain maps for South arm. Top left: Unmodified contour map. Top Right: Modified contours. Bottom Left: Elevation along unmodified arm. Bottom Right: Elevation along modified arm. Note reduction in maximum pipe height in the 'notch' area.

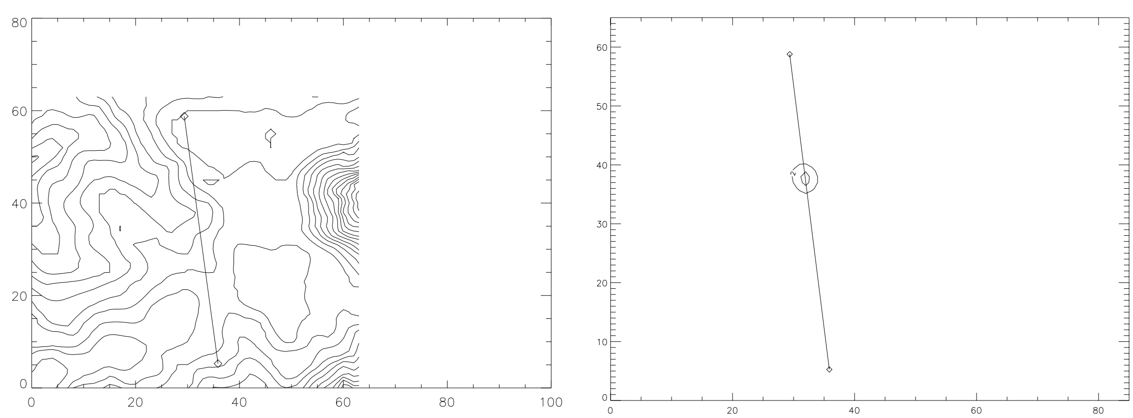

FIGURE 6. Cut/fill maps for South arm. Left: Unmodified contour map (2× blow up). Right: Modifications to terrain. Four-foot contour intervals. Cuts denoted by dotted contours.