Why is Aquatic Park So Little Used?: Design Options for an Effective and Aesthetic Soundwall

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Introduction

> Listing: West Berkeley - 100 acre park setting!
> Lake included. Ideal for jogging,
> outings, general recreation. A must see!

If Aquatic Park really were on the real estate market, chances are the seller would have a difficult time unloading the property. Nestled between Interstate 80 and the Southern Pacific Railroad right-of-way, the park comprises over 55 percent of Berkeley's recreational acreage but is not being used to its potential (Figure 1). A key factor in the low turnout of recreational users is the area's high incidence of noise pollution. The railroad contributes noise at intervals but congested Interstate 80, which runs along the park's western edge from Ashby Avenue to University Avenue, ensures a constant transmittance of noise often upwards of 75 decibels (Berkeley Waterfront Plan, 1986). A noise mitigation proposal, long in deliberation, concerns the installation of a 12-foot-high soundwall spanning the park's border with the freeway. This barrier would effectively reduce the sound intensity reaching the park. Opponents of the soundwall contend, however, that it would attenuate the view of the city of Berkeley from I-80, as well as prove a structural eyesore. This paper will examine the options in barrier dimension, design and composition in an attempt to propose a feasible noise barrier that is effective in reducing noise as well as aesthetically suitable.

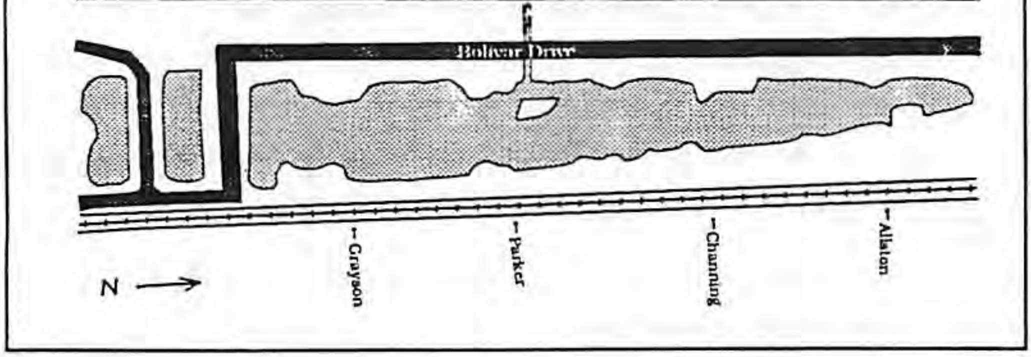


Figure 1. Locational Map of Aquatic Park.
Source. Adapted from Ferlin, 1983. (Figure not drawn to scale)

Past Studies

Much research has been done on the efficiency of sound shields as well as barrier structure and design . The journal *Internoise 80* presented a number of studies on barrier efficiency, implementation (May; Bowlby; Daviss), innovative ideas and technology such as attenuation by double walls (Hayek) and a noise reducing device based on sound wave refraction and interference (Matsumoto). Studies on barrier design in the journal *Noise Control Engineering* discuss the feasibility of soundwall construction: sloped barriers as an alternative to absorbtive barriers (Menge, 1980); earth berms (Hayek, 1982) and vegetative barriers (Harris, 1986). Additionally, the Federal Highway Administration has put out a sound barrier manual as well as a *Handbook of Accoustical Enclosures and Barriers* which covers details on design and performance.

Methodology

To conduct this report several types of information were collected. Firstly, the initial steps involved gathering past reports on successful barrier implementation, on attractive designs and barrier material efficiency. Secondly, the barrier designs most feasible for the Aquatic Park /I-80 site in terms of material composition and aesthetics were considered for closer evaluation. Finally, for the selected barrier candidates, calculations were made for sound attenuation efficiencies as a function of distance from the noise source, I-80.

Background

Although Aquatic Park is situated in a primarily industrial area, recent development trends tend toward the lighter industries of wholesale/retail, restaurants and research and development facilities, as well as some residential units. The onset of development more oriented to service and residential areas calls accordingly for renovation of Aquatic Park. The park should be improved in two related ways--in its recreational utility and in general appeal and ambiance. Goals recognized by the Berkeley Planning Department (West Berkeley Area Working Report, October 1988) include improved recreational opportunities in Aquatic Park, thus alleviating some of Berkeley's need for park space as well as displacing some current park users who contribute to the park's reputation as a crime spot.

These goals may prove difficult to achieve, however, since the current sound levels--between 65 and 75 dB--are normally considered unacceptable for an outdoor recreational environment (U.S. Department of Housing and Urban Development, 1984). Noise pollution studies by the U.S. Environmental Protection Agency show that in addition to creating a disagreeable environment for recreation, sound at this level at constant exposure contributes to the onset of hearing impairment (City of Berkeley, 1977).

The noise generated from the traffic on Interstate 80, the principal noise source, will not be eliminated or de-intensified in the foreseeable future. Traffic volumes on I-80 past the site measured at 204,000 vehicles per day in 1986 (City of Berkeley, 1986). In addition, studies by the California Department of Transportation show that this volume will increase to unacceptable levels by the year 2010 (City of Berkeley, 1986). This traffic increase with its even greater start-stop congestion will inevitably increase further the already high level of noise that reaches Aquatic Park.

Factors that influence traffic noise include the weather, traffic parameters such as compostion--the proportion of automobiles to light or heavy trucks--speed and density, and road parameters such as width, road surface and design (Bugliarello, 1976). In a congested traffic situation, repeated acceleration leads to increased engine noise. On the other hand, in free-flowing traffic, transmission and tire noise caused by the compression and decompression of air between the tire treads and the road surface (Bugliarello, 1976) contribute to the high sound levels.

Additionally, the right-hand lanes of northbound traffic are often occupied by heavy trucks, defined by having more than 26,000 pounds vehicle weight and three or more axles (Department of Housing and Urban Development, 1984). Heavy trucks contribute a significantly higher level of noise than lighter vehicles; moreover, the exhaust system (assumed to be located at eight feet above the pavement surface, but which frequently is even higher), is the major origin of noise in these vehicles. This results in a greater magnitude and spatial extension of noise than from automobiles, where the exhaust system and other noise sources are considered to originate from ground level (Department of Commerce, 1978). The significance of this comes into play when determining the dimensions of the soundwall.

Sound Barrier Design at Aquatic Park

The design and construction of an effective sound barrier results from the satisfaction of several physical criteria which are listed by the U.S. Department of Commerce (1978). A soundwall must block the line of sight between the noise source and the receiver; it should be constructed of a material with a surface weight density greater than 4 pounds per square foot, and the barrier should be as airtight as possible. A barrier at Aquatic Park should be as long as possible given the land constraints since the freeway is a line source of noise and sound will travel around the edges of the barrier and into the park.

To achieve adequate noise reduction at Aquatic Park, a barrier would have to span the entire 3000-foot border between the park and the freeway and would have to be of a height that would, unfortunately, block the view of the city of Berkeley, especially from the northbound lanes between Ashby and University Avenues. The soundwall would not, however, have to loom directly over the freeway lanes because a 30-foot safety zone between the edge of the roadway and the barrier must be maintained in lieu of an additional safety barrier (Bowlby, 1980). Options in wall material and design allow for the possibility of creating an aesthetically pleasing and unobtrusive sound barrier.

The dimensions of the area are crucial for determining appropriate barrier design. The dimensions fall into two categories: road and freeway widths which limit the options in barrier width, and the widths from east to west across Aquatic Park which are used to calculate the effective barrier heights. The northbound and southbound lanes with the clear space between them total 54 feet in width. A 30-foot wide clear space exists east of the northbound road edge and west of the portion of Bolivar Drive that parallels I-80 (Figure 2).

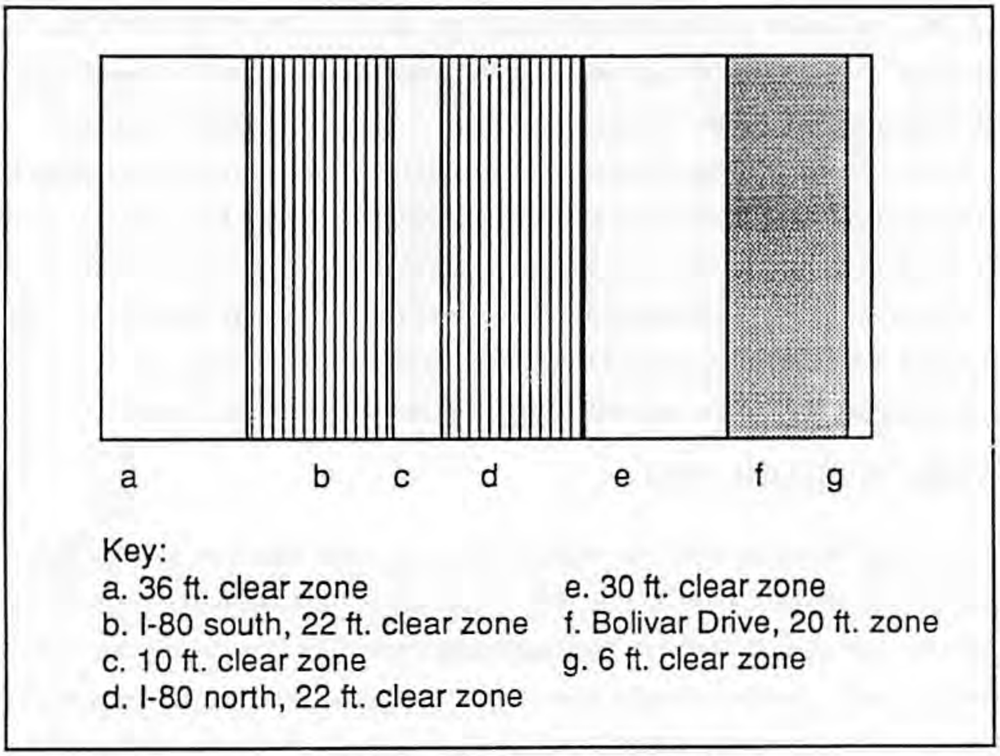


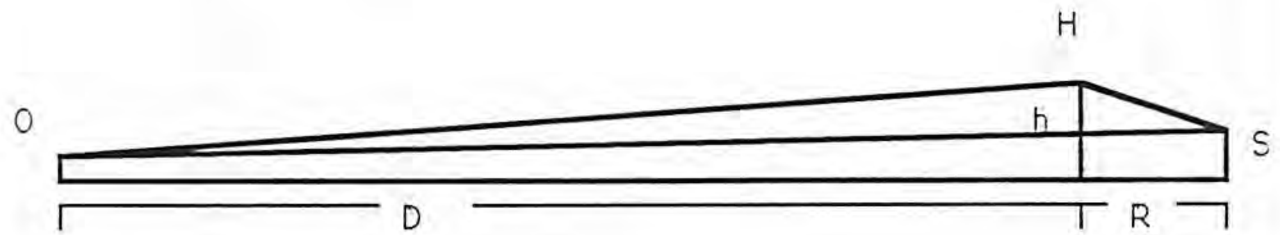
Figure 2. Cross-Sectional View of I-80 at Aquatic Park
Source. Aquatic Park Base Map 1970, Berkeley Public Works Department

Bolivar Drive along most of this stretch has a width of 20 feet. The distance between the west edge of Bolivar Drive and the shoreline on the far side of the lake range from approximately 300 feet at Allston Way, 400 feet at Bancroft Way and Channing Way, to approximately 500 feet at Carlton Street.

For a situation such as Aquatic Park's where the source and reception points are on approximately level terrain, the most effective placement of the sound barrier is at a point closer to the receiver than to the source. Since most of the area between these points in Aquatic Park is covered by water and since a wall established along the east shore of the lake would not be viable, a position along the west edge is the only option. Given the existing space constraints, and the need to maintain a 30-foot clear zone for reasons of safety, Bolivar Drive is the best choice for a barrier location. By utilizing the space occupied by Bolivar Drive, a soundwall could be installed that would still allow for pedestrian or bicycle through-traffic along the park-facing side of the wall.

Barrier Designs and Sound Attenuation

The height of the soundwall greatly affects the amount of noise that the barrier will block. At barrier heights (H) of 10 feet, 12 feet and 15 feet the results in dB attenuation were derived using workcharts (Figures 3, 4 and 5) from the U.S. Department of Housing and Urban



O = observer: 5.5 ft.
S = source: 8.0 ft
R'= distance from source to barrier: 84.0 ft.
h'=(derived)
H = wall height; @10.0 ft., 12.0 ft. and 15.0 ft.
D'= distance from wall to observer: @ 300.0 ft., 400.0 ft. and 500.0 ft.

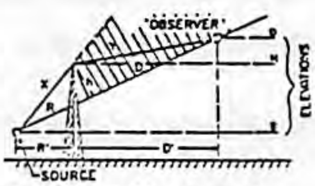
Figure 3. Sketch Showing Dimensions for Barrier Height Calculations.

Development (1984). For these calculations several known inputs were required. The height of the source (S) was taken as eight feet above ground level (the accepted level for truck noise). The height of the observer or receiver (O) was taken at 5.5 feet. The distance from the source to the barrier (R') was taken as 84 feet--the distance from the southbound lane of I-80 to the west edge of Bolivar Drive. The distance between the barrier and the observer (D') was taken as 300 feet, 400 feet and 500 feet. Through the calculation steps of Figure 4, (R) and (D) were calculated where (R+D) is the slant distance from the source to the observer. The amount by which the barrier protrudes above the line-of-sight between source and receiver (h) is also calculated (HUD, 1984). With the values for (h), (R) and (R/D) the graph of Figure 5 yields "barrier

Workchart 5
Noise Barrier
To find R, D and h from Site Elevations and Distances

Fill out the following worksheet (all quantities are in feet):

Enter the values for:
H= 12 ft R'= 84 ft
S= 8 ft D'= 300 ft
O= 5.5 ft



1. Elevation of barrier top minus elevation of source	[H 12]	−	[S 8]	= [1 4]	
2. Elevation of observer minus elevation of source	[O 5.5]	−	[S 8]	= [2 −2.5]	
3. Map distance between source and observer (R' + D')				[3 384]	
4. Map distance between barrier and source (R')				[4 84]	
5. Line 2 divided by line 3	[2 −2.5]	÷	[3 384]	= [5 −6.5×10⁻³]	
6. Square the quantity on line 5 (i.e., multiply it by itself); always positive	[5 −6.5×10⁻³]	×	[5 −6.5×10⁻³]	= [6 4.2×10⁻⁵]	
7. 40% of line 6	[0.4]	×	[6 4.2×10⁻⁵]	= [7 1.7×10⁻⁵]	
8. One minus line 7	[1.0]	−	[7 1.7×10⁻⁵]	= [8 .999]	
9. Line 5 times line 4 (will be negative if line 2 is negative)	[5 −6.5×10⁻³]	×	[4 84]	= [9 −.55]	
10. Line 1 minus line 9	[1 4]	−	[9 −.55]	= [10 4.55]	
11. Line 10 times line 8	[10 4.55]	×	[8 .999]	= [11 4.54]	= h
12. Line 5 times line 10	[5 −6.5×10⁻³]	×	[10 4.55]	= [12 −.028]	
13. Line 4 divided by line 8	[4 84]	÷	[8 .999]	= [13 84.1]	
14. Line 13 plus line 12	[13 84.1]	+	[12 −.028]	= [14 84.07]	= R
15. Line 3 minus line 4	[3 384]	−	[4 84]	= [15 300]	
16. Line 15 divided by line 8	[15 300]	÷	[8 .999]	= [16 300.3]	
17. Line 16 minus line 12	[16 300.3]	−	[12 −.028]	= [17 300.33]	= D

[Note: the value on line 2 may be negative, in which case so will the values on lines 5, 9, and 12; line 1 may also be negative. Remember, then, in lines 10, 14, and 17, that adding a negative number is the same as subtracting: x + (−y) = x−y. And subtracting a negative number is like adding: x−(−y) = x+y.

Round off R and D to nearest integer, h to one decimal place.

Figure 4. Methodology Sample: Calculations for a 12-Foot High Wall at Receiver Distance 300 Feet.
Source. U.S. Dept. of Housing and Urban Development

potential performance" of dB attenuation minus an adjustment to attenuation for loss of ground attenuation. This error is scaled using (D/R) and the equivalence chart at the bottom of Figure 5.

Although a 12-foot-high barrier was proposed by the California Department of Transportation, calculations done according to the HUD workcharts (Figures 3, 4 and 5) show that a 15 foot barrier would result in significantly lower decibels (Figure 6)-- a consideration

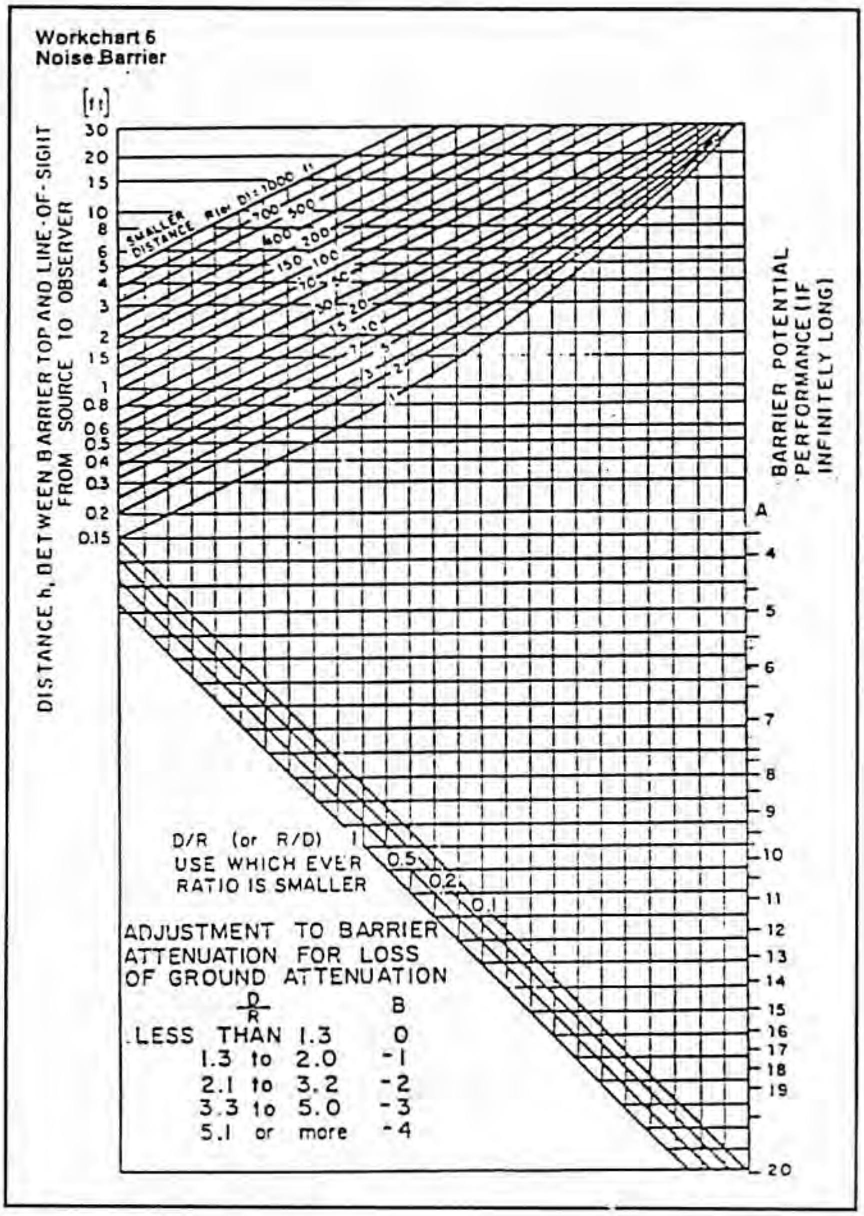


Figure 5. Noise Barrier Worksheet.
Source. U.S. Dept. of Housing and Urban Development

that might be useful in anticipation of Interstate-80's impending traffic volumes. With a 15-foot-high wall in place, sound levels would drop to more acceptable decibels. For example, at 300 feet from the barrier sound at 75 dB would be received at 68.25 dB and sound at 70 dB would be received at 63.25 dB. In contrast, a 12-foot-high wall would attenuate noise to respectively 70.35 dB and 65.35 dB.

The material of which the soundwall is to be composed is limited by several factors. The site's proximity to the marine environment of San Francisco Bay precludes the use of metal or wood since climatic effects would take their toll on the wall. The other major factor is the limited construction space. The 20 feet available from Bolivar Drive is not ample room for a purely vegetative cover as the sound attenuation capabilities of a vegetative belt are approximately 3 dB of attenuation per 100 feet of vegetation (Harris, 1988).

One possibility in soundwall design does, however, incorporate vegetation in the overall barrier presentation. To promote both aesthetics and sound retention, a 15-foot-high concrete barrier complemented with hanging plants or with a layer of trees lining the freeway side could

	Experimental Soundwall Heights		
	10-foot	12-foot	15-foot
receiver distance from soundwall:			
300 ft.:	(dBA=3.1)	(dBA=4.7)	(dBA=6.8)
@75 dB	71.9 dB	70.3 dB	68.2 dB
@70 dB	66.9 dB	65.3 dB	63.2 dB
400 ft.:	(dBA=2.6)	(dBA=2.4)	(dBA=6.4)
@ 75 dB	72.4 dB	70.6 dB	68.6 dB
@ 70 dB	67.4 dB	65.6 dB	63.6 dB
500 ft.:	(dBA=1.6)	(dBA=3.2)	(dBA=5.0)
@75 dB	73.4 dB	71.8 dB	70.0 dB
@70 dB	68.4 dB	66.8 dB	65.0 dB
		(dBA : dB Attenuation)	

Figure 6. Sound Levels Received in dB for Varying Barrier Heights at Source Transmittances of 70 dB and 75 dB.

be installed (Figure 7). The vegetation would serve several purposes: it would help to scatter some of the approaching freeway noise; it would provide a soothing scenery backdrop; and it would make the concrete barrier less susceptible to soot and exhaust and less accessible to graffiti artists. With or without complementary vegetation, the concrete barrier surface itself could be colored and textured to blend in with or enhance the area's landscape (Bowlby, 1980).

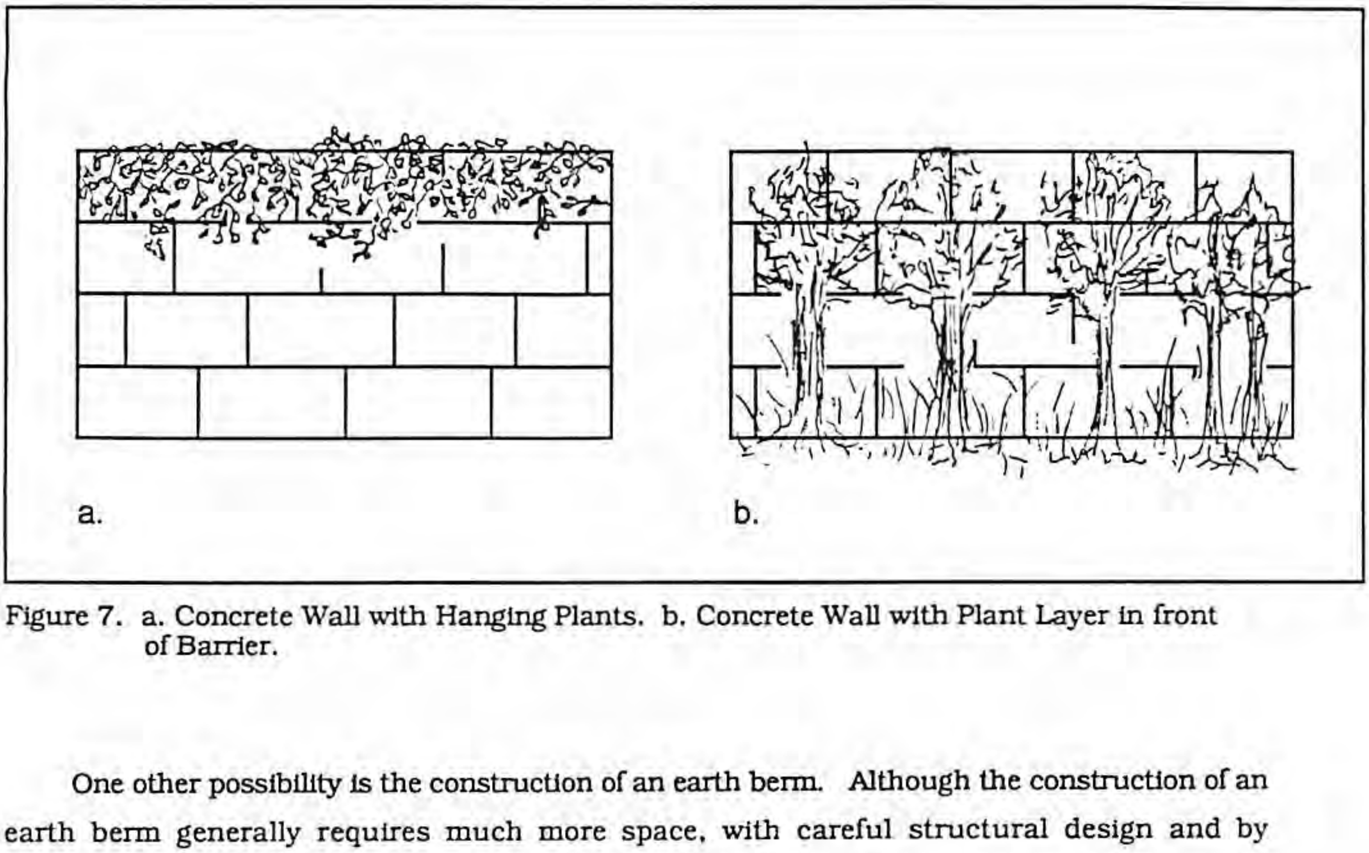


Figure 7. a. Concrete Wall with Hanging Plants. b. Concrete Wall with Plant Layer in front of Barrier.

One other possibility is the construction of an earth berm. Although the construction of an earth berm generally requires much more space, with careful structural design and by combining the right construction materials, one could design a berm that would commence within the 30-foot clear-zone but would have a slope gentle enough so that automobile hazards would be minimized. According to the Federal Highway Administration Highway Traffic Noise Prediction Model, earth berms are more efficient in sound attenuation than normal wall barriers by about 3dB due to the berm's absorbtion or edge effects (Hajek, 1982). The earth berm between I-80 and Aquatic Park could therefore be constructed at a lesser height--a 12 -foot barrier rather than the 15-foot example for a solid wall barrier (Figure 3). Another option in line with the earth berm would include a pedestrian/jogger path cut into the side of the berm facing Aquatic Park. Earth berms nevertheless do have their drawbacks; they require active maintainance against the erosive effects of climate.

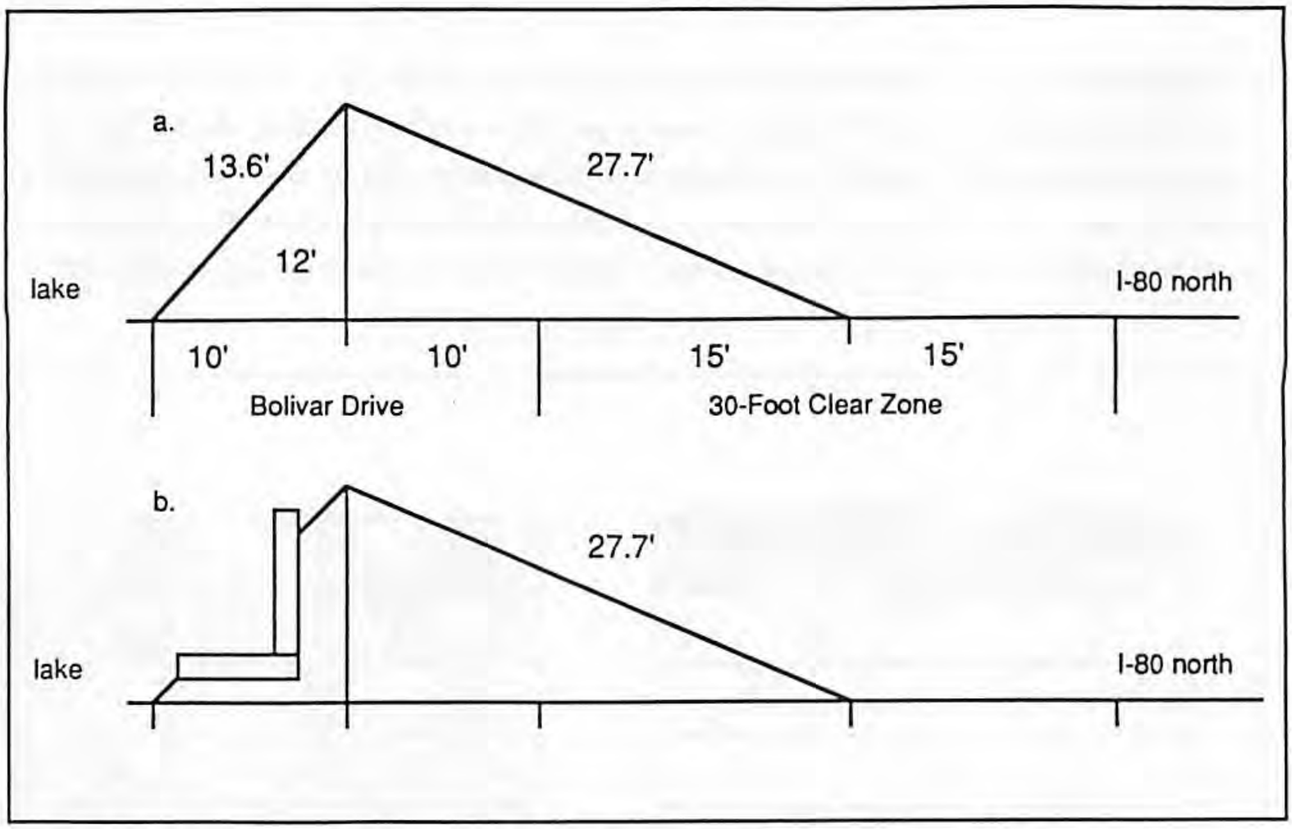


Figure 8. a. Earth Berm Barrier. b. Earth Berm Barrier with Pedestrian Path.

Conclusion and Recommendations

If Aquatic park is projected to become a neighborhood or citywide recreational area in the near future, some form of sound barrier must be constructed between the park and I-80 so that the park can actually be perceived as user-amenable. I feel that the most practical option in barrier structure and design would be a 15-foot high concrete wall with a lining of vegetation in the form of either trees or hanging vines. Due to the constraint of limited space, several barrier options must be ruled out. A purely vegetative belt would not be possible and an earth berm might, unfortunately, prove too costly and difficult to maintain. Although an earth berm would tend to blend in better with the environment, a concrete sound shield could be colored and textured to melt in with, or even enhance, the surroundings.

The major complaint about a soundwall is that it would block the view of Berkeley from the freeway. So why do I propose a 15-foot high wall rather than a 12-foot high one? A 12-foot high wall would already unavoidably block the view from the northbound lanes. The extra three feet of sound-barrier height would not change matters from this perspective yet it would considerably reduce the noise level at Aquatic Park. Travelers on the southbound lanes have the Berkeley waterfront and San Francisco Bay to gaze at during their commutes. Finally, as I-80 traffic volumes will rise steadily in coming years, a wall would be a nice shield for users of Aquatic Park against not only the noise, but also the pollution and the general ugliness of the freeway.

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