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"A CRITICAL LOOK AT OUR WATERSHED
MANAGEMENT CONCEPTS & PRACTICES"

A Panel Discussion at the Spring Meeting of the Southern California Section of the Society of American Foresters.

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Following is a tape of the proceedings of the Society of American Foresters Meeting, Southern California Section, April 1, 1960, California Hotel, San Bernardino, California.

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Mt. Baldy Ranger District
Angeles National Forest

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Dept. of Geology
U. C. L. A.

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L. A. County Flood Control District

II. Group Discussion

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E. A. Phillips

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A CRITICAL LOOK AT OUR WATERSHED MANAGEMENT CONCEPTS AND PRACTICES

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Our theme is "A Critical Look at Our Watershed Management Concepts and Practices". A critical look by whom? The logical answer is ourselves - the people in this room who are now managing our mountain watersheds and to whom we must look to furnish and maintain the leadership of the future in this field.

Immediately the question arises, what is a watershed manager? Is he an engineer, hydrologist, ecologist, geologist, or the local water company's manager? It must be admitted that all of these professions cast their shadows over our watersheds. Yet, when we examine the stewards of our wildland watersheds in Southern California, we find very few of these specialists. In their place, we find a group of trained men with a broad working knowledge of many of the above fields, but a specialist in none. To paraphrase medical terminology, they are the "general practitioners" of the profession. It is as one of these that I have come here to talk to you.

Until recently, our job was custodial in character and relatively complacent. Now we find ourselves rudely jolted from a management concept of custodial responsibility to one of active and intensive management. This, by an exploding population which is calling for immediate action to fulfill their demands. Water in a semi-arid region such as ours is the limiting factor in its development. Our population is looking to their watersheds and asking how more water can be squeezed from their skins. Unfortunately, this is only part of the problem. As the population swells and grows, it is creating a civilization built on alluvial plains which are highly vulnerable to flood and erosion damage from the adjacent mountain watersheds.

Consequently, today we find ourselves confronted with conflicts in use and watershed management practices which must be adjudicated in an atmosphere of constantly mounting and changing public pressures. To solve these problems, the watershed manager must look to the specialists for new management techniques and methodology which will enable him to achieve his goals most effectively. The process of reaching goals simply by empirical methods can't be expected to cope with the demands we are now experiencing or those we will face in the future.

The tempo of this educational process of the watershed manager by the specialist must be stepped up if we are to win the race - or perhaps, I should say - even stay in the race. Admittedly, we use the word education rather loosely. What do we mean by this educational process? Briefly, we can divide any educational process into three parts: first, to pass on the accumulated knowledge of the past; second, to apply the knowledge of the past to the solution of modern-day problems;

last, but most important, to pioneer beyond the frontiers of our present knowledge and thereby add to the existing store of knowledge. We have no quarrel with our achievements in the first two aspects of the educational process. However, progress is determined only by the third phase, and herein, must we not take a critical look in order to assess the success or failure of our future progress?

In any educational process, there is the ever-present danger that we tend to stay with the past. One feels safe with accepted methodology and tends to resist change or to accept new ideas. Consequently, progress becomes stifled. Progress depends on seeking new horizons, visionary at first, perhaps, but without vision or imagination, new concepts are difficult to formulate. We should ask ourselves--What is new in watershed management concepts? Are we still tied to the past and have we become provincial in our thinking? Remember, this is a safe procedure and human beings like to feel secure.

On this basis, let us take a critical look at our management concepts and practices in relation to the physiographic complexes that comprise our watersheds and let the chips fall where they may. First, what are these complexes of climate, topography, soils, geology, and vegetation that affect water behavior? What can we do about them? At first glance, climate looks hopeless. Yet, cloud-seeding has appeared as a small cloud on the horizon. Would it be visionary and nebulous thinking to hope that someday we will be able to direct and control rainfall on pre-selected watersheds? If that day does come, are we geared to handle the problem that this excess rainfall may cause? What type of watershed would we select? Do we know what an adequate or perfect watershed is? Do we have such watersheds now? If so, are they delineated on maps and so designated? Is protection of their cover the only management practice needed? Would not such a map show the watershed manager the extent of his problem areas and enable him to do a better job? Do we have the knowledge to so classify and map our watershed areas and, if so, have we done it? If not, why not do it now?

What about topography? Here is a real challenge. Our mountains are characterized by steep and unstable slopes and narrow and steep gradient streams debauching on alluvial fans, which man is usurping for his own use.

Erosion has been going on for geological ages. It is a natural process and must be lived with. How are we to prevent or reduce erosion and damaging flood peaks? We know vegetation is not the complete answer; man-made up-stream structures and other controls are also needed. Through the use of up-stream structures, stream gradients can be reduced, channels stabilized, and peak discharges moderated. Such structures are not new. History records their use in the ancient civilizations of the Mediterranean. Here again, we have taken the knowledge of the past and applied it to our modern-day problems. But, can we stop here? Once such structures have been filled and upstream building sites expended--what then?

What have we done about new designs directed toward a better and more permanent control of peak flows and sedimentation rates, particularly during our major and more damaging floods? As pressures increase, can we continue to provide adequate slope stabilization and upstream debris storage with present methods? Is it not possible to design small up-stream structures to control flood peaks and sediment rates on the same basis as our larger dams do? Would it not be better to handle an annual acceptable erosion increment on a recurrent basis and to place our emphasis on the control of the major and more damaging floods? How much can we reduce the initial and operating costs of these essential mechanical controls through proper up-stream land management and vegetation controls, such as channel clearing, cover improvement, etc.? Should we not be doing more experimentation along these lines?

What about the other values involved, such as fish life and recreation? Have we given any thought to what effect these structures will have on fishing and are any provisions being incorporated in the design of the structures to preserve and maintain fish life? What about the recreationist? How does a hiker or fisherman get over a 20-foot dam? Do we need ladders or trails for accessibility? Visionary thinking perhaps, but is it not important from a multiple use standpoint and a problem that we will have to face in the near future?

Let us examine soils and geology. The soil mantle will store water, the amount dependent on texture and depth. In the fall, when dry, it is the water manager's first defense against run-off. It has been demonstrated that on deep soils, the establishment of shallow-rooted vegetation will result in increased water storage--namely, that water which is beyond the reach of the roots. From a water yield standpoint, this is excellent. However, is this desirable from a flood control standpoint? If the soil mantle is only partially dried out during the summer period, will not its effectiveness as storage medium at the beginning of the next wetting period be seriously impaired? What is our primary objective, water yield or reduction of flood peaks on a given watershed? How is this determined? Will we have to give way to one or the other, or is it possible to have both? What is being done to determine these priorities now?

After water is taken into this soil mantle, the excess gradually percolates through the root zone into the underlying rock formation. In Southern California, many of these are greatly shattered and fractured, ideally suited for the temporary storage of water. Are we making full use of this potential? Is there anything we can do to increase the availability of water storage in these underlying rock formations? What direction is research taking to answer these questions? Is it as important as it seems, or is it merely an interesting conjecture?

We are all agreed that the maintenance of a good vegetative cover is the first objective of a watershed management plan. What is a good vegetative cover? For example, how much duff is needed--for water yield, for flood control? What about cover manipulation? We know that on shallow soils the conversion from deep-rooted to shallow-rooted species offer little possibility of increased water yield. How many acres of shallow soils do we have? Have such areas been mapped out and delineated? From a cover standpoint, are they in optimum condition and acceptable as is? If we do not know the extent of our shallow soils, how do we know the extent of our problem or the potential of management on such areas?

What are we doing about the vegetation on our deeper soils? Can it be converted to shallow-rooted species? Can it be tied into fire-resistant plants? Are we placing too much or too little emphasis on attempts to improve nature's cover by introduced plants?

When we see the wonders of hybridization in the agriculture and horticulture worlds, should we not be encouraged to develop hybrids from our native species which will fulfill our cover objectives? Is this not a virgin field for our geneticists? For example, if we could reduce the height of the vegetative cover by 50%, would it not have a salutary effect on evapo-transpiration losses? Think what it would mean to fire control if 50% of the fuel were removed. Admittedly, this is a relatively unknown field, but should we not be starting now? What do we gain by waiting?

What about applying the principle of "spot farming" to watershed management concepts and practices? Are we not inclined to talk too much in extremes—the whole problem, the whole watershed, etc.? On the other hand, would not "spot farming" of our watersheds, the selection and management of the most lucrative areas first, offer a more realistic and economic approach? For example, from a water yield standpoint, the riparian growth zones offer lucrative possibilities, but what do we know about their management? Does all the vegetative growth have to be removed? What areas of stream bottom offer the greatest yield? How far up the banks do we have to go? Is the growth that shades the stream more useful left or removed? Is the grass that invades the cut-over area effective in controlling erosion? What is the methodology and what are cost-benefit ratios to be expected? What about piping the water out of our riparian growth zones? Is it cheaper than removal of the growth? What are comparable costs and yields? With these questions answered, the watershed manager is ready to go into production on a "spot farming" basis. Do we have this information; if not, when can we expect it? If we are agreed that riparian growth zones offer the most lucrative possibilities from a water yield standpoint, should not the gathering of this information be a number one priority? Are we doing first things first, or are we scattering our shot?

True, the answer to all these questions will cost money, but can anyone doubt that it is economically justified? Isn't the economic picture becoming more favorable day by day? Anyone who has seen land valued at $5,000 per acre subdivided and grown to a value of $60,000 in three short months, through the erection of four $15,000 homes, realizes that the value of our adjacent watersheds is increasing at a commensurate rate. Multiply this process a hundred fold and you have the picture of Southern California.

Will not the time come when adequate watershed management for the protection of certain of our valley communities will be a question of life or death to them? What about economics when this time comes? As you know, there is no record of a drowning man questioning or complaining about the cost of the life preserver thrown him.

We are entering into a decade of decision with respect to watershed management concepts and practices in Southern California and we will have an important voice in the decisions that are made. What happens during and after these fateful sixties will depend to a great extent on our vision and leadership.

Are we ready? Do we have the knowledge to do the job? Will we stand by and let demand set the tempo or will we move forward with new knowledge and anticipate these demands? Can the "general practitioner" look to the specialist for the knowledge he needs? Is the specialist getting the right priorities--doing first things first? Can he supply us with the know-how to plan and do the job in time? The arena in which this battle will be fought will be Southern California. We of Southern California are leaders in this field. The public looks to us for answers to their water problems. Will we have the vision, initiative, and courage to supply these answers or will we fail through inertia or lack of aggressive action on our part?

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To try to cover 25 years or so of field work in California as viewed from perhaps the limited philosophical field of a geologist and fit that into a meeting of this sort is going to be a challenge to me. I am going to make this mostly pictures, and my goal is to try and cover what seemed to me to be some of the significant highlights of geology of not only coastal California, but the interior as well. Here there are about four main themes that I will have to try to discuss. First, of course, geology concerns rocks and in a broad sense we should extend that to the soil too. Then the fact that we are dealing with mountains means that we have a certain geometry to consider as well. Mountains don't happen by accident and certainly the study of mountains has been the keystone of geology since its inception. Then we are necessarily confronted with all the faults that one finds in California so I will tell you a little bit about those and the effect they have had upon the landscape. Then last, and most important to me at any rate, have been the processes that shape the landscape; things like lake erosion, stream erosion, and things that have developed slopes. Since we are primarily concerned with slope problems, that would seem to me to be one of the central things that we are confronted with today. Then, on top of that is the vexing problem of climate. Not only do we have the climate of today, but the climate of the past, that is the immediate past, was drastically different from what we are familiar with at the present time. This opens up also a whole vexing vista: is the climate constant or is it undergoing change? There seems to be very compelling evidence that in fact it is. Here I am with five balls in the air: rocks, faults, processes that have shaped the landscape, the effect of the fossil landscape, as it were, things that have shaped the land in the past, but which we enjoy in the present.

Now, in any discussion of California's geology certainly the central theme is the San Andreas Fault. This is an air view of the San Andreas Fault, not far from here, in fact a section that is familiar, I am sure, to practically all of you. Here is the Cajon Pass, right now we are down over that other slope. You can see the rather distinctive break in the middle of the picture which is a section of the San Andreas Fault east of Victorville and west of San Bernardino and it cuts on down along the front of those hills here and out through the San Gorgonio Pass down into the Imperial Valley.

Now this is an air view of the San Andreas rift in a section perhaps not quite so familiar to all of you here. This is in the Cariso plains west of the San Joaquin, about due west of Bakersfield. It brings out very well its most distinctive characteristics and that is its great length, its essential linealty, and the fact that the displacement on it is primarily horizontal. In other words one side has shirred past the other, rather different from the kind of fault I am going to show you a picture of in just a moment, unique perhaps among many of the large faults of the world; but here you can see, for example, its offset streak, you can see its linear pattern, and the fact that although the fault is vertical the displacement on it is essentially horizontal.

This doesn't have much to do with the mountainous landscape of California except it goes through much of the mountainous part of the State. It is a wonderful sight to see it from the air, for example, because features such as these show up along almost its entire length. This is the sort of thing to which we give the name of "Sag Pond". Some are wet and some are dry, but you get the effect of the real linear fracture which runs through the country, not far from Cajon Station, in the San Gabriel Mountains.

This brings up the point that such a thing as the San Andreas Fault certainly has a remarkably strong control over the distribution of ground water. Its much like a rubber diaphragm down through the earth. It acts as a trap, and ground water is brought up to the surface and is responsible in many places for the low depressions we speak of as "Sag Ponds", once again one of those offset streaks. No geologist today knows how much the displacement on this actually is, but that doesn't stop them from a very acrimonious debate about it. We do know at least it is more than 22 feet which is the amount of the offset in the San Francisco earthquake.

This is another one of the "Sag Ponds" along the fault. This is perhaps the place where you will see it best in the so-called "point" on the Cajon Pass road, at least a mile wide zone of extraordinary sheer and almost completely unstable rock. It is a great big fracture, 600 miles or more in length which dominates the structural pattern of the coast of California.

This is a related one, the Garlock Fault, not far from Mojave. This also is the same kind of fault in that its displacement has been horizontal. You can see the degree which it has activated these alluvial fans. You can see the amount of the incision that that particular fan is undergoing in the foreground. These things are by no means static elements in the landscape; they are active, they are living, they are in motion, they have considerable effect on the surrounding terrain.

This shows some slight effects on property values, too. This is down in the region near El Centro. Here you can see the citrus trees are offset just about a half-foot. In 1940 it amounted to something like 15 feet close to the Mexican border.

Now this is a very different kind of fault, and this is the one I think many of you probably are more likely to have in mind. This is the sort of fault pattern in which the displacement instead of being horizontal is essentially vertical. This is the northern end of the Alabama hills, this is the trough of the Owens Valley here just a little bit north of the Mt. Whitney region. You are looking north and you can see the degree of complexity with which we are confronted when we try to talk about the elements that make up the watersheds or the natural terrain. This is the same rock, fortunately, it is essentially granite from top to bottom. Here you are dealing with about the same rock from top to bottom yet down here it has a wholly different aspect from what everyone is trying to sell you as the oldest rocks on earth, which in fact they aren't. The strange looking rounded forms are the same rock that you find in the alpine zone. There is practically no soil here, most of your soil developed in the central section. If you are going to set up a program of management, it certainly has to be very different on this little alluvial fan area or the base of the terrain here than it does in the summit area. Yet the fundamental cause, the underlying mechanism, is responsible for all this array of terrain types. Its vertical displacement along not one but a series of faults have dropped this and raised this and dropped this in very surprisingly recent time. At the present time, we are carrying on a series of studies on deposits here based on pollen analysis. They turn out to have flora almost again to what you have on the summit, not only in the Sierra but on its western slope and well down the western slope as well. This is really a geologically extraordinarily recent happening.

That is another view of the same sort of thing with a view looking south where you see the fault scar. In this case the displacement is essentially vertical, but along more or less a single well localized zone of fracture at the base of the range.

This is a very different kind of occurrence, a more subtle one, a harder one to detect perhaps, but if you have something that gives you a writing on the slate, as it were, while it gives you a series of data on these lines, then you can tell that this is taking place too. This is the San Pedro hills, San Pedro would be around the corner. This is not far from Palos Verdes. Here are a whole series of what look like lines in a bathtub which actually are terraces, all done in times past, but not very far in the past if you compare living mollusks down here with their fossil counterparts on these higher ones, about 1200 feet here, 1/4 of a mile. They turn out to be the same, they turn out to be identical as far as species are concerned. There has been no appreciable degree of extinction. This certainly is an indication of a very recent sort of a change.

So you can see, to very much simplify, we have had here in California examples of three very drastic kinds of geological changes, ones that have occurred recently, ones that to a greater or lesser degree have left an imprint on the landscape: horizontal displacement along certain faults such as the San Andreas and the Garlock, vertical uplifts along vertical faults in the case of the Sierra-Nevada, and regional uplift of the kind that you find along much of the California coast.

Now to discuss some of the processes that have taken place to shape the landscape in modern times. In addition to the instability within your watersheds, we have geological processes operating as well which tend to add their share to the terrain before it is ever modified by any of the processes of erosion. This rather frigid looking scene is Mt. Lassen. Here is the blow-off during World War I where a steam explosion took place. Here you can still see the line of the devastated forest in the foreground. This is cinder cone and here you can see lava flow which has advanced from it and blocked this on either side. We not only have the additions of such things as lava to the surface, a visible sort of thing, but there is much more soil contribution strewn far and wide throughout the Sierra. Volcanic ash which is contributed by cindercones or the other Cascade volcanos adds a very distinctive type of soil and one that presents a great many problems,it seems to me, where attempts have been made to have some type of timber growth established on an ash-covered surface.

This shows more recent contributors of this same sort. What volcanos are those? Yes, Mono Crater. You are looking right down along the axis of the Sierra out this way. Here is the Jeffrey pine forest that surrounds it, and there ash has blanketed the whole summit clear into Red Meadow of the San Joaquin, in fact clear down into the San Joaquin Valley. And ash is strewn far and wide all over the country to the east.

This will give you a pretty fair comparison of what I am talking about here. Here is a distinctive little cindercone, here you can see the lava surrounding it, here is a trail of ash that leads off downwind. This is the Amboy Crater, and here is US 66, Oklahoma City to California.

Let's take a look at some of the processes that have shaped the watersheds too. Here is a relic of the past. This is a process not operating today, but it operated only a surprisingly short period of time ago. When I was in school I was told this happened about 25,000 years ago and now in the post-war period they have just about cut it in half. This is supposed to have taken place about 12,000 years ago. It is hard to conceive that such a thing as the Ice Age could have ended such a short while ago because this gets you into a lot of difficulties. If you had the Ice Age 12,000 years ago you've got to do all sorts of remarkable things in Europe as far as producing Western civilization, that probably most of you swept through when you were in college, but if you consider that our ancestors had to endure the Ice Age it may well be the sort of thing that made them as mean and belligerent as history alleges and they probably were. Here is a trough, excavated by ice, up near Twin Lakes, near Bridgeport. Here are the lakes down in here, and here are moraines, which are deposits left by the ice excavated from up here. So, you have a rather different kind of landscape produced by water in solid form than you do as streams. Actually, though you are taught that this is a "U" shaped canyon, what you are really looking at here is nothing more than a channel filled by water. You have an enormous volume but a very slow rate of discharge.

This is probably a somewhat more familiar scene to most of you. Here is U.S. 395, this is Convict, Duff Lake, Mammoth Lakes are off around here. This has happened not only once but many times in the past history of California. Here is a record of the last advance, here is a record of the advance preceeding it, here is a record of the third Ice Age before that and up here on these high surfaces, which is the most concern to me, are the records of the 4th or the oldest age that we have had here in the Sierra-Nevada. What interests me is that these stages are all only the very last part of the glaciers of the Ice Age. They are much more recent than the ones that are recorded back east. As you can see they measure 1/2 mile of the uplift of the Sierra-Nevada.

The counterpart of these glacier deposits up here are now buried far below the surface of Long Valley. So, this reinforces the point I made some time ago; not only are you dealing with a geologically unstable region, one in which processes are going on actively as we know in the case of San Andreas Fault, but ones that have been compressed in a very short period of time. Superimpose on that climatic changes as drastic as the ones which produced the alpine scenery which you see here and which are no longer operating today.

This, of course, is the kind of thing one sees in the High Sierra as a consequence of this sort of process here. Here is Cathedrd Peak, a broadly excavated glacier.

Here is a pretty good contrast in the several kinds of patterns that one sees in our watersheds. Here is ice flux or ice excavated, here are glaciated regions, here are non-glaciated ones, here is the San Joaquin Valley, there is Fresno smog out there, they are doing pretty well too.

Here is a contrast between the various kinds of glacier erosion, so that you can get a little notion of the relative rates and, it seems to me, the recency of the processes we are talking about. This is a surface smoothed by ice, here is the Tuolumne River and there is a measure of the amount of excavation that such a rapidly surging stream as that has been able to accomplish in only the few thousand years since this has been free from its burden of glaciers.

Now here is the kind of process, it seems to me, much neglected but of extra-ordinary importance. It's awfully hard to apply any quantitative values to this kind of thing, but it seems to me it is fundamental in any study of watershed or anything concerned with erosion control. This is mass movement. Here is the kind of thing that you see repeatedly throughout the California coast range. In this case we call it earthflow, where stream erosion has over-steepened this slope and you have a mass slump of this solid material down the hill slope. What can we do about things of that sort? That's what I am going to be very interested to find out this afternoon. To a considerable degree this is a natural process and something, perhaps, that we can't do much about. Maybe, on the other hand, it's something that we can do a good deal about. It certainly does happen.

This will show what I think was the biggest happening, that I know of, in California. This is an aerial view of what tremendous landslide? Any of you recognize it from this perhaps unfamiliar view? I think a lot of you have seen it from along this road here. This is in the Lucerne Valley, and this is the road between Lucerne Valley by Old Woman Springs and 29 Palms. This is looking towards Big Bear. This is Blackhawk Canyon here and I think you can get an idea that this enormous load of debris has come several miles out from the mountain front. It is the Blackhawk Canyon slide, if you put a man in here you wouldn't even see him. It's a couple of miles along, I think it is perhaps two or three here. It gives you some idea of what some of these geologic processes can be like in the not too very distant past. We're not going to worry about restraining that, the taxpayers would never get over it.

Here is a closer view of it, but it looks more like a lava flow than actually anything else that you have probably ever seen. When you drive along the road here you will see this rampart in the distance. It looks perhaps like almost any low running range of desert hills, but you ought to look at it closely, then you will see this amazing jumbled-up mass of material. It must have come down very violently. It must have been cushioned in its own blanket of trapped air and the whole thing slid out practically intact so that you can take the rocks here and put them back, much like a gigantic jigsaw puzzle. They fit the rocks back up in the source, in fact you can see how it washed around this low range of hills in the foreground, so that it is mass movement that really is mass movement.

This is the kind of thing that has always puzzled me. This is the erosion that one sees just west of the ridge route not far from Gorman. Here are these low, rounded, grass-covered hills, here is a valley which was once in adjustment, and here is this sort of thing eating its way up the canyon floor. I've always wondered about that and I'm sure most of you in the room have, depending upon what degree you want to indulge in special pleading or due to your adversarism at the moment. You can take it out on the sheepmen or on the cattle growers, or on tourists or on the climate, or on recent rejuvenation, or perhaps on all of them. But here this sort of thing occurs, and what the cause of it is has always been a source of speculation. I somehow feel that perhaps these very recent climatic changes may have some slight influence on this, plus, of course, a kind of instability I've been talking about so hastily.

This brings us then to what is really the unique contribution of watershed problems in California, and the kind of problem that is unique here and to which there has been no real European experience. I think when you take geology, for example, or when you take the pattern that most of us have been raised under or the experiences we have learned in school, it is based largely on tradition carried forward from Western Europe to the Eastern United States, and it falls down to some degree when you come to the canyon and alluvial fan landscape of the Southwestern United States. It's true you see it in the Mediterranean, but it's also true that when it comes to mis-management of ranges the Mediterranean world is the most, and we don't want to end up with a landscape looking like this. Here, at any rate, is the alluvial fan pattern stripped. There isn't a bush in sight on this, but you can see the kind of thing that has developed here. The canyon's steep slope, the spread of debris, the occurrence of ground water, and the branching and rebranching of channels. The thing that is crucial, it seems to me, is that many of the problems of developing alluvial fans are some of the problems that take place at the apex. This last picture was taken in Death Valley not far from Bad Water and this is across Death Valley looking towards the Panamint Range. Here you can see the single stream, then the braided pattern and the part developed by the intersection of overlapping fans, and then the incision of the upper end. Down here is the kind of rejuvenation that is rather characteristic of the alluvial fans in the desert part of the State at any rate.

This shows a better example of what I was talking about there. What has happened right here? They have a little fault that cuts across the alluvial fan, so here is the thing which was once in adjustment. This would have been the constructional surface, here it has been broken by a fault, this side up, this side down. So these things have been rejuvenated. Now you can see they are in the process of reconstituting that surface and, given time, this may be built up, this torn down and you will have a new equilibrium established.

Here is a good example of the very thing that I was talking about a moment ago, the incision that takes place on the apex of such a fan as this. Here is the spreading ground in San Antonio Canyon, a device that really goes back to Spain. I think in some parts of Mediterranean World they learned this trick long ago. It took us quite a while to discover it. Well, what is the cause of this? Is that the result of uplift, the result of climatic change, result of denudation of the mountain slopes, or is it something that just happened? Well, I think it is just probably all those things plus a good deal of the last factor as well. I think you can demonstrate pretty well that as one of these things extends its length then inevitably you have down-cutting going on at the upper end. In southern California our unique problem, it has always seemed to me, has been construction on these fan surfaces. You not only have things which we can control, but you have instabilities which are inherent in the structure itself.

That is Cucamonga Canyon. Well, this sort of capitulates my little story because it brings all of these elements together. Here are the mountains, a product of instability. We ought to be grateful for that because it gives us the scenery that we have in California. Here is a great variety of rock types. There is the effect of altitude. You are going through all kinds of environmental conditions. Here are the alluvial fans at the base.

That's it.

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"VEGETATIVE ASPECTS OF WATERSHED MANAGEMENT"

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I'm a Plant Ecologist out of the U. of Michigan. Being a Plant Ecologist I naturally would like to hit the vegetation a little harder than most of the other people here on the panel and we might start out by saying what is "ecology." We could answer that by saying it is the study of vegetation. Well, vegetation needs definition then perhaps, and I'd like to emphasize vegetation as meaning combinations of species. Now these species will, of course, differ in size, shape, number and density and all things like this. We can in a sense make up a recipe of vegetation in a given area. Now if you are going to make a mixture of concrete you have a different mixture for each purpose for which this concrete is going to be used. I think the same is true in vegetation management of any kind, you have to fix up a recipe. The first job is to determine what the natural recipe is and the second one is to devise a better recipe to do what we want it to do. Now ecology is also, of course, environment in the plants. Most of our research, most of our studies have been upon the effect of the environment on the plant. We should also turn this around and study what the effect of the plant is on the environment a little bit more I believe. In ecology this particular phase is called "reaction," in forestry it is known as "forest influence", as most of you know. Incidentally, one of the best books I know of still on this field is Kittredge's book on "Forest Influences", and I read it every so often again just to get some good ideas from it. At the same time I'm struck by the fact that we do not know a great deal not only about the influences of forests but I find that by tradition we must include chaparral in the forest and chaparral is again one of the neglected phases, I think, in our research in comparison to some of the other studies.

I think I read a couple of years ago, for example, that of the snow cover in the Sierras there is more chaparral and more brush than there is trees, there is about 25% trees and 33% brush, but the brush is rather important. Well, what is the basis then for the management of vegetation for watersheds. I suppose that you could say, in general, if you are interested in erosion and floods that just protection of the natural vegetation, at least this seems to be true in the past whether its true or not research will eventually tell, at least fire protection of the natural vegetation is probably pretty good for erosion and floods providing you have still got the natural vegetation there, that is.

Water production on the other hand I think, is a little more complicated problem. In this particular instance I think we not only need fire protection of native vegetation but now we really are coming down to the basic thing we need, management. Much more management perhaps that we have been able to do so far. The basis for this management, I would like to suggest, is ecology, and largely plant ecology. This is a small part of a larger study, I think the larger study is really the study of protection as it has come down through the various centuries. I would like to very briefly review a little bit about the study of forest influences. One of the very first examples was a decree by Louis VI of France when he had a decree called "The Decree of Water and Fjords." Some of the very first protection of forests on the other hand were in Switzerland. About 1342 they started the first protection or "banned" forests as they were called, to protect the land against avalanche and from the years

1535 to 1777 there were 322 such forests established. Actually the first statements about the forests and precipitation was attributed to Christopher Columbus by his son, writing in 1571, Columbus was supposed to have said that the great high rainfall in the West Indies was due to the forests that was still there in comparison to the Canary Islands which had been deforested and where the rainfall he thought was a lot less. In 1840 the silting of the Venice lagoons was attributed to deforestation of the headwaters of the Poe River. 1683 was the time when Japan first started to try controlling their torrents, their waterfalls, their erosion in the mountains, with establishment of forests. The United States - I guess the first example of this kind was in Truro, Mass. where there was a grazing penalty established on the over-grazing on the sanded areas and, therefore, the consequent sand erosion which you've got there. In 1799 Noah Webster was supposed to have made a speech before the Connecticut Academy of Science in which he pointed out that there was no question that the climate of New England was less constant in his time than it was when the settlers came there and he attributed this to the removal of the forest.

In 1876, as most of you are aware, there was an Agricultural Appropriation Act. There was a rider of this act which set aside the magnificent sum of $2,000 for research on the study of forest influence and climate. Part of this project was supposed to be a study of what measures it applied in foreign countries. A man by the name of Hough got up a report in which he put in quite a few of the problems which would be quite appropriate today. He said, for example, what is the part the forests play in shelter against winds, in retarding evaporation, in adding moisture to the atmosphere, what is the effect on precipitation and the distribution of the rainfall through the year. What are the effects on forests of temperatures, on the preservation of mountains and slopes and what is the effect of forests on public health. He was very much aware of the problem.

In 1882 a municipal forest was started in Mass. to protect the watershed, and I think this was the first example, in America at least, of a municipal watershed protection forest.

In 1885 there was a California State Board of Forestry established and one of the first reports they put out was this one: "The result of torrent action in reduced springs consequent upon forest fires in Southern California", so that they were aware of the problem back in those days too. In 1891 there was an Act in Congress which authorized the President to reserve public reservations and in the next two 17 million, 500 thousand acres of land was set aside, including the present Angeles National Forest and also part of the San Bernardino. I'm sure you are familiar with the recent history so I won't bring it up any further. What I'll do next is emphasize ecological research and then mention a few of the problems as I see them which need the most research in this particular field. I would like to say that I think what we need in the Forest Service is more Ecologists. I say this categorically and I say also that I think we need more research, no matter what research we're doing we can always do more. There isn't a successful company in this country that is manufacturing or producing anything that doesn't have a large research budget. It's impossible to compare the budget in the Forest Service to any of these because they are not really comparable, but I would venture to say that no matter what we would spend it would not be enough. The other thing I would like to do would be to see more research going on at the ranger level than at the supervisor level. I know that we traditionally have our research set off aside, way off in the corner somewhere at a station or at a place where these people are researchers. Then we have the other people who are management people, supervisors, etc., so I would like to make a plea, I think, for more diversified research, for the possibilities of a ranger to do some research on basic vegetation or basic water supply or anything else he is particularly interested in. One of the things I think this would do would be to keep up the interest in the work and what he is doing. It seems to me if you can set up some experiments to give you answers to the things and problems that you recognize as you go around in your work that this would have a great deal of influence on the enjoyment of your job, if nothing else. Well now some of the areas then, which it seems to me we need research in, you are all familiar with the dilemma of plants. In the first place they are great for protection, they are great for protection against flood and erosion. At the same time they lose a lot of water, they intercept it, a lot is lost thru evaporation not from transpiration, so what we need in a sense I suppose is to study transpiration more than we have, although we have some very excellent studies in this field much more remains to be done. Transpiration, I'm not quite sure whether you all know this or not, its been suggested that it has lots of different uses for plants. One of the uses that has been suggested is that it cools the leaves. Measurements of leaf temperature drops due to evaporation by transpiration is very little, when you stop to think a desert plant in the hot summer sun could use a lot of transpiration if this were an important use of transpiration; yet there is no transpiration going on, there is no water available for transpiration.

Some people suggested we need transpiration to keep the membranes moist so that gases could be exchanged back and forth. Once again, "a" little reflection, we show you that the water is there it doesn't have to be locked in the plant in order to be useful to keep those membranes moist. A big use for transpiration has always been one that pulls water up the plant. You need a transpiration screen to pull water up the plant. Once again, you can see that if for any reason water is lost at the top of the plant, more water will come up or be pulled up to take its place and so let's say you close up the hole, then water is lost by photosynthesis, more water is pulled in and once again, where is the most luxurious vegetation in the world, probably in the tropical rain forests, how much transpiration goes on there in so humid an atmosphere, very little you see. We are then faced with the conclusion I think that transpiration, in general, is detrimental to the plants just as it is to the water. Well now, if this is true why have plants put up with it? Well, of course, they have to have the holes for this CO^2, carbon dioxide has to get in there for photosynthesis. However, we know for a fact that photosynthesis does not occur at the same rate during the whole year. As a matter of fact, it's quite questionable if much photosynthesis of any kind goes on in the summer. I would like to suggest then the possibility of using, and this is an old pet of mine, transpiration retardants as they are called, particularly during these unfavorable summer months. What are these? These are simply vinyl latex compounds, sort of rubbery things we can spray on a plant and it will effectively cover these holes for about a 3 month period. They have been very effectively proven so far in transplant experiments. They are, if you spray the plant before you transplant them, they will not lose water for about 2 or 3 months and by that time the roots have become established in the new place and this has made the survival rate of transplants much higher because of use of this. One of the difficulties, however, is the actual measuring what this does to the stoma, what does it do to photosynthesis and respiration. I would like to suggest too, that the forestry service use all the modern techniques of plant physiology, chemistry and physics that are available. This seems like a big order. On the other hand there are lots of things which you could use right now; for example, I know that Cal Tech has just transferred to Pomona the remains of what was once the desert mobile lab and with this equipment we can now measure transpiration, photosynthesis and respiration of plants in the field by taking and placing over part of the plant, while it is still in the ground a little plexiglass chamber circulating the air through it, taking samples of the air and running them through, in one case for CO^2 we have an infra-red CO^2 analyzer which absorbs the CO^2 and we have that on a recorder so that you can go and let it go for 24 hours, a week or a month, when it gets going well and then you can tell exactly when that plant is respiring, when it was photosynthesizing, etc. The humidity is a little bit tougher but we do use these Aminco (sp?) sensing elements which are quite similar to the Coleman soil moisture blocks in principle. These are simply two electrodes which determine the flow of current between and depending upon how moist the air is. What we do in this little chamber is to dry the air down to say 30% relative humidity and then on the recorder it tells how long it takes that plant, by transpiring, to increase that humidity to 40%. When it gets to 40% the drying cycle cuts in and it dries it down to 30%, the plant wets it, and as many times as this happens is a function of how much transpiration is going on. I will just point this out as a way of doing it. Now defoliation experiments have been proven very promising and I think these should be extended for defoliating the plant at certain seasons of the year to cut down this transpiration loss.

Now other types of research that I think should be extended include the research like Dr. Henry Helmers is doing. Most of you know that Henry is working on pine, he has worked on lots of other things too. He is following it right through from the varying stages of seedlings. Naturally this is one of the important critical points if you want to establish some new types of vegetation. Now Helmers has also, I think, established quite well, Helmers and others who have worked in this field, the benefit of using control conditions, greenhouses like they have at Cal Tech the "Vitatron." I would like to suggest, however, that there have now been developed plant growth cabinets, small size cabinets in which the conditions can be very carefully and rigidly controlled. In fact you can put a growth on this and have it go thru a cycle as it would outside except that you know exactly what is happening. This can save years and years of research quite often, narrowing it down to the species you then want to field test. I think you all are aware of this. Once again, I don't see any reason why the CO^2

equipment, the humidity equipment, why some of these controlled condition cabinets could not be placed throughout a different ranger station. I know that you are all busy, but once again, it seems to me that I think someone has given the figure of 5% of your time ought to be spent in research and if it were possible to have some of this equipment at various places, I think you men might have lots of ideas that the people in the research stations, being where they are, don't have, and so I think this might be a great way of furthering this whole field.

I could suggest a lot of other things which I think are important but I want to hit hardest at setting up more research and then I want to give a picture of the future as I might see it here. I'll now draw upon my immunity perhaps as a college professor in an ivory tower, impractical and idealistic, and say that we certainly must keep on our research in connection with water production. However, I will say what is going to happen in the next few years. I think it is, without question, possible that our use of the water, that is our management of these watersheds for water production, will become less important in the future. I say that because I think the time is coming when ocean-sea water is going to be used to produce fresh water in large quantities. In other words, I think the influx of population is going to be so great that we cannot continue to get water just from here and the unwilling Northern Californians. Not only that, we are going to, I think, progress very far in the use of waste water, reclamation of waste water. We put a lot of it in the ocean now, which is kind of ridiculous I think, and if we can get people over the idea of drinking sewage perhaps I think we will be a long way towards using our water to a much greater advantage than we are now. Therefore, I picture our slopes as being largely managed in the future, and this is admittedly in the future, we still have to go on with our water supply research, but in the future I think that one of the most important advantages of these slopes will be for recreation. I was just talking to Paul Zenke and he mentioned the tremendous number of Southern Californians who have been using the Northern California forests. Well, if we could somehow or another produce forests down here which could then be used for recreation I think this would be probably very economically possible in the future, so I see these hillsides around here covered with forests. Now, there is prejudice in my lack of appreciation for chaparral, at any rate I see forests, waterfalls coming down, lakes and parks and things of this kind. Now, how do we get this established? Well, I see us using irrigation water even for some of these slopes. I see us using all sorts of plants, which we have found by these experiments I have mentioned, that use less water. Perhaps as you say, cutting down the size of the vegetation in half so they use less water, and remember too we don't really know what the influence of these forests would be in So. Calif. Can you picture all of these hillsides you came over today, from wherever you came, just covered with forests rather than what we have now. Certainly the soil would build up in many places. Certainly it would have affect, take for example that a forest has the same effect upon the climate as a lake. Well, you can imagine what would happen to the climate of So. Calif. with these forests. You can see I'm indulging in a pipe dream here but again I'd like to make the point that what I'd like to see is more research in the future, seeing what direction the trends do, don't hang on to something here in the past just because it is traditional, but go on ahead.

William Farrell, Engineer, Los Angeles County Flood Control District:

"Gentlemen:

There is a reason why we engineers always end up on the tail end of a program like this, but it is indeed a pleasure to be a part of this panel and to speak to such a large group of foresters.

I think, to set myself in proper retrospect with some of this group, I'd like to read a little excerpt I pulled from a February 1959 Sierra Club Bulletin. It goes like this.....'The engineer is a special breed. Like Beavers, engineers are born knowing what is wrong with the earth and what to do about it. Since their reactions to geologic stimuli are instinctive they must not be questioned, running water makes them nervous. Any mountain valley is a challenge for road location and since each engineer alone has the proper instincts the number of roads and the number of relocations are limited only by the number of available dollars and the number of engineers. The engineer is too one-sided to cast a shadow, but somehow still manages to cast the darkest shadow to be seen on our hopes for saving something natural.' That's what I have to begin with.....

Well, we're going to change the pace a little bit. People who sign my pay check I have a feeling they don't give a damn about what's going to happen 50 years from now, they don't want to get buried ten feet under right now. So, I'm not saying research isn't important, it is important and we are carrying on research, but we also have the responsibility of doing something right now. I've heard mentioned several times today because something was used in Europe, why are we still using it. Well, there are a lot of things that were used in Europe that we are still using. I'm sure some of you are doing it. The thought came to my mind in this regard, I don't think there is hardly any of us that cross the interchange down in the heart of downtown Los Angeles that don't cuss the thing out. The inadequacy of the design and the people who designed it, couldn't they see what it was going to cause. Yet, they did something and it was the first one and that pattern is now used throughout the United States. It has been improved yes, but it still set the standards and I think that is the position we're in right now. With that I think I'll proceed.

The influx of population into our Southern California, you've all heard about it, but its important because it is one of the activating things that is causing our problems right now. We feel that in Los Angeles County that we will be collecting over 80% of all the debris that comes out of the watersheds by 1970. I don't know how much that means to some of you but in a 50 year capital storm which we use as a design storm, this could amount to 6 to 8 million cubic yards of debris. It has been computed, and I think quite accurately, that if we had a normal 50 year period of storm occurrence coupled with our fire occurrences that we would have to handle in excess of 400 million cubic yards of debris in a 50 year period. Now, couple this with the fact that the cost of handling debris in 1958 was \$.33 per cubic yard, today it is \$1.50 per cubic yard and if we go by projection figures in 1970 it will be \$3.00. Start multiplying those figures together and you will see that it will cost us 25 million dollars to get out of a 50 year capital storm and this is not including the damage that is done directly by debris going onto property, this is what we will have to catch and take care of. With this as a background then, upstream engineering is necessary and essential right now whether we like it or not, it just has to be done, pure economics states so.

Next question is...What is upstream engineering? I think a good definition as far as we engineers are concerned would be....work designed to help Mother Nature effect a stability between topography, vegetation, soil and run-off. Now I think you foresters, if you just add a few more terms to that, would come up with watershed management, and that's right, that's what it amounts to. Maybe it is a little more specialized but it is certainly a part of watershed management.

Now, what causes us all of our problems in Southern California? Dr. Putnam who showed us the slides to give us the geologic phenomenon which gives us a problem to begin with, but the thing that really upsets our applecart is our fires. We get along pretty good until we get a severe burn then everything goes loose. Now, I think if I could have that first slide I could show you the importance of this situation....

This is a graph depicting average annual burning in the frontal watersheds of Los Angeles County for the past fifty years. Now you foresters have been working very diligently on fire control, but I want to point out the point of which us engineers have to look at this whole problem. The incidence of fire is increased at approximately the same rate as you foresters ability to put them out and this is shown very clearly here. In 1906-07 we didn't have as many fires but when we had one it was a big one. Now we're getting a lot of little fires but they are totalling the same acreage. That slope indicates an average annual burn of around 5,000 acres per year and it appears to be just as constant as the day is long so we have to face that figure to look into the future, that we are going to have continued burnings and to us, whether it is a big burn or a little burn, every acre contributes the same amount.

After we have a fire and we get a severe rain we have what we call a fire-flood sequence. I'm sure they are not new to you, but they are the major causes of our main problems to start. We get a surge of flood flow down the channel, it cuts out the channel and, as Dr. Putnam mentioned, it leaves these slopes in the side, slumps, etc., because we have our hillsides away above the annual repose, in fact above an annual repose that even vegetation will hold, and so it starts caving in and slumping in and our problems are then started. What can we do to stop this cycle or better still prevent it? Much work and much study has gone into it and I'm glad to see that Mr. Paul Bauman is here today because he is the father of this program as far as we are concerned. We have studied this from all standpoints that we feel feasible and any way we stack it we come up with the answer that check dams are the first things that we should do in a watershed to stabilize it, to manage it. What does this do for us? Now, if I could have the next slide we'll talk about that for a minute.

Here we have two identical terrains, the upper one has been subject to a fire-flood sequence, we have our stream bed running down through here, we have a slump or scarp up here from previous sluffing, sluffs down here and piles up down here in the bottom of the stream and as soon as the flood comes it cleans it all out and next year we're all ready to start over again. These things all work their way up farther and farther until pretty soon they look like this and you see them all around, I think Dr. Putnam mentioned that. Down below we've come in and stabilized our channel bottom. Now, whether this type of structure or another type of structure or procedure is used it is immaterial, the effect is still the same, this happens to be the most economical presently available. We elevate, first we stop channel down-cutting. Now that is one of our large sources of debris, this amount that comes out of this increment in here each year after each fire-flood sequence.

We've halted that, that can no longer happen because we've made an artificial channel gradient throughout each stabilized. These dams maybe range from 10 to 20 feet, you see they toe out, one upon the other and as they fill up there is an immediate benefit right there in that we don't get that debris down below. These hillsides over here now have a toehold upon which talus and other material coming down can rest, vegetation can start to grow and we start our healing process, you see that represented here, you see that our sluff area is starting to heal over. Now this isn't wishful thinking, I'll show you some slides later that will show you that it is practical and actually exists.

I think it is important, as far as I'm concerned anyway, to get the picture that stabilization is the first step in stabilizing your watersheds. I think there have been too many cases where somebody thought they could stabilize a watershed by going up on a little hillside and planting it or doing other work to it, and finding it sliding right out from under them. We first have to get this channel bottom stabilized, then you can start building above it once you get it so it will stay. I think that is one of the important things that we should consider here.

Now, to show you how these systems actually work, I've got a series of 5 or 6 slides here that I would like to run through, of two projects that are actually installed. One if the Brand Canyon Project which was erected by CCC labor in 1936-38. We've had 20 years plus of experience on this system and the other is the Cook's Canyon system installed in 1956 as a part of the present research program that the District, working in full partnership with the Forest Service, is undertaking.

This is a picture of Brand Canyon near Glendale in 1938. It is a mess. Here we have a block masonry check dam, you can see the side slopes are caving in and sluffing all along. The dam is not yet filled and is newly constructed. Now, bear in mind this is 1938.

This was taken last year and you can see what the watershed looks like now and it is that way throughout. We haven't cleaned our debris basin out in the mouth of Brand Canyon for 20 years and there is still nothing in it. The debris production in this watershed has almost been stopped. Granted, we haven't had any big winters or anything like 1938 but we've gotten debris from our other watersheds without it, but we haven't from this one.

This is a pictorial of what has happened up in Brand Canyon. We were fortunate enough that when they put the system in in 1938 they had a very precise survey taken of the watershed and channel bottom. We repeated that survey some two years ago run from the same traverse and we also were fortunate in other watersheds, Dunsmure Canyon near Montrose and La Canada where they had the real problems in 1934, of having had a survey made just before the flood for the purpose of putting check dams in and we rerun that survey also for comparison. The top one represents the two Dunsmure surveys, the red represents downcut to the channel bottom. It is very severe, each one of these represents 10 feet,so you see in many places it is in excess of 16 or 17 feet straight down in the channel bottom. These are cross-sections, the top is the 1934 cross-section,the bottom is the 1957 cross-section, so you can see what has happened.

Contrary to this in Brand Canyon, the bottom line was the 1938 survey and the top was the 1957 survey sluff having elevated our channel bottom throughout to an artificial gradient of approximately 7/10 of the natural which has a terrific effect on the carrying power of the water because it varies somewhat as a sixth power of the velocity so a small change in grade does a terrific thing to the carrying capacity and that was evidenced in Dr. Putnam's slides, as soon as you hit the mouth of the canyon the grade changed a little bit and it just dumps.

Here is what our cross sections looked like then and now. The bottom, of course, being the 1938 period and the top being the present. You have nice, broad "U" shaped canyon practically all of the way. We feel that in a major flood we would not have any serious problems in Brand Canyon and more important, if we have a fire in Brand Canyon sure, we'll get sheet erosion, we don't intend to stop that. In fact, we, at the Flood Control District, I'm not saying this to shock you, have a beach erosion problem also, so if the sheet erosion gets on down the channel to the beach that doesn't make us cry too much either, although I realise you foresters would like to keep that up there too, but, it will keep the channel there and it will keep the toes of these slopes there so that they have something to immediately start regrowing on.

Last year was one of the driest years on record in California, it wasn't the driest, but one of the driest. We had a quick little flash flood out in Cook's Canyon near La Crescenta, and as I mentioned we had a check dam system there, put in in 1956. Now I'm going to give you a series of 5 or 6 slides showing what happened in this watershed. Unfortunately, we did not have enough money to go all the way up because this was a pilot project and had specific limits set to it.

This picture was taken approximately one-half to one-quarter of a mile above the uppermost check dam in this watershed. There are 9 check dams which stabilize a total of 4,300 feet of channel, this was above it. This mud flow came out of this canyon and, as you can see, gutted this whole region. There isn't a tree or rock standing all the way down through there and it headed down to the check dam system that is down below. Now, keep in mind the picture of this completely gutted out bottom of this canyon, there were nice trees, etc., in there prior to this.

This is a picture of a bend in the stream just above the uppermost check dam. The channel is over in here. The mud flow climbed clear up out of this channel,came up on this hillside and gouged out several hundred yards of debris from that hillside, curved and came back into the channel down here. Now, you see this scar that has been created here. Well, that's going to be in a few years clear on up here and you are going to have these trees and stuff all down here in the bottom.

This was taken at Check Dam #6, second one downstream. It caught most of the mud flow that came out. See the size of those rocks, they are 4 and 5 feet in diameter, completely filled that dam. The spillway of that structure was designed for a 50 year capital flood which has a spillway section 36 feet wide and 12 feet high. It topped the structure and here is the high water line,by some 6 to 8" in passing but the thing that is significant is that it dropped its load here but it didn't disturb this edge over here at all. It is still completely intact. You can almost see the little talus slides still coming right down the toe of the canyon.

This is Dam #8 again showing the talus slides continuing right on down but this whole picture shows what I'm talking about and what Professon Putnam mentioned. That started some time past, very recently I guess geologically, but it started probably as a little sluff in the bend of that stream and look what it worked to. Now we can't do too much to help that one although we have a talus slide built and right now it is becoming very well vegetated, but we can prevent future ones like that and ones we catch small we will stop.

This is taken from Dam #5 which is half way down the system. You are looking from the spillway of Dam #5 down toward Dam #3 and the debris basin there in the background. What a contrast you see here as compared to that upper reach above our system. This same flood passed through here. Here is an old eroded area which we have stabilized now and, as you can see, it is all grown over and is doing very well, but the thing of importance is that flood went thru there and the grass isn't even torn up, it is still in there. The energy of that flow was completely knocked out. The system is effective and does work!

Los Angeles County has caught fire on this type of work, we've presented it to the Forest Service and they are all for it, we hope...we have chosen 35 watersheds that we feel should be included as rapidly as we can do it and this will be complete treatment. We have one watershed under complete treatment now, which is Santa Anita Canyon, I think some of you fellows have seen it. We have 25 more watersheds that we feel will need treatment within the next ten years or that we feel will be scheduled within the next ten years, but all of our problems aren't over and I think this is one we should stress at this point. I don't know how many of you I have convinced but in case I have convinced you, we do have some problems yet and one is that when we get a major fire like say the Arroyo Seco Fire of last year, it would really be nice if we were able to go to work in Arroyo Seco that fall as soon as the fire was out, but unfortunately we are still trying to get plans ready and money appropriated to go to work in Sawpit, which was burned two years ago. We had our Sawpit Dam nearly put out of commission by a storm last year, we spent many thousand dollars sluicing and pulling debris out of it to get it back in operation for flood control purposes. We had many new scars started up this canyon that will take many years to heal and if we don't get busy it never will heal, so the problem then is to get in a position where we can move in immediately after one of these fires. Engineering and planning is no great problem, we are overcoming that and we can overcome that, but how are we going to get people in Washington and elsewhere that have control of the budget to recognize the necessity of moving into these watersheds after we've had a fire. They spend money like crazy to put the fire out, which they mainly get on the ridge and wait for it to come to them but they don't want to spend any money to get busy in the watersheds.

I think another thing we should look at and its been mentioned before, we must work together on this. It is realized by all that there are other related benefits and influences in this type of work. In Santa Anita Canyon there is an equestrian trail being incorporated right with the construction of the project so that when the project is finished there will be a horseback trail right up the canyon. We made special effort to dislodge m few cabins as possible. We only had to dislodge 2 or 3 cabins and that took a lot of extra planning and a lot of coordinating to do that. We are getting a fire road up the bottom of the canyon which has been needed for many, many years and we've never been able to get the emphasis to do it before, so there is multiple use of benefit from these projects going on and I think we're trying to fit them in and recognize them where they are and maybe we'll get some new ideas from the discussion that will come out here today. Anyway, from my standpoint as an engineer this is my critical look at upstream engineering. Thank you."

The following discussion was led by W. E. "Ted" Silverwood:

Silverwood: I would first like to put a question to Dr. Putnam and see if he has and recommendations or any advice he might give us other than not to build houses in certain locations, on watershed management, as a result of his very fine presentation here on the geology of our forested area.

Putnam: I don't want to get out of my little corral, so if you see a lot of things and you are impressed with what does seem good management and what does seem poor management as you travel around the State. I often wonder sometimes if what's lacking in a good deal of the problem, the way we approach problems, isn't just plain ordinary common sense. A good deal of mismanagement seems to arise from poor planning or from arbitrary planning or from not heeding the environment, you don't like to draw from your own experience perhaps but some observations I think might be relevant in this matter. A lot of people who don't have perhaps the degree of sophistication that we do, or don't perhaps have the degree of formal education that we possess oftentimes do much better in attacking a problem of this sort. I think the thing in this vein that impressed me during the war is that the Japanese were far better, in many respects, than we were with all the degree of equipment and engineering skill and practice that we might have brought to the problems of slump control in tropical islands for example. This arises, I felt, because they were essentially a peasant nation, they lived much closer to the soil than perhaps we do. Any Japanese farm boy, for example, learned what water was when he was about so high, it might have made him nervous too, but he had learned about ditches, rice paddies and built terraces and if you've ever seen the terrace agriculture in the Phillipines or seen pictures of terrace agriculture of Peru you are much impressed with what very simple people with very primitive means at hand have been able to do over centuries in conveying water off slopes and preventing it from building up high velocity. The point that was made a moment ago is a very telling one that transporting ability of water goes up at a fantastic rate with increase of velocity. This is a thing perhaps not too well appreciated by the people who have come to California in the last decade or so. We really had a drought of more than normal magnitude and those of you may remember this State in the 20's and 30's even allowing for distortions of age, but a lot of things happened then that haven't happened now and a lot of tracks are built today that wouldn't be in sites possibly back in that more bucolic age. I think all of you were impressed with the transfer over here in 1928 of the transporting ability of running water to solve the somber after effect of the St. Francis Dam and the blocks of concrete that would weigh as much as 10,000 tons moved considerable fragments of a mile. I remember too, the flood in the Tehachapi Valley in 1933 and the Santa Fe had a locomotive sitting there on a trestle and the flood came by, the flood went down and no locomotive. They made a thorough search for the thing and there it was some distance downstream buried pretty deeply under gravel. So, thinking out the good many problems that you see in hillside developments and watershed management, I'm often impressed with hillside developments you see here in California that were put in in the 20's when they had a great big expansion. Now, many of these roads were built on contours, slope wasn't too greatly disturbed, most houses at that time were built with a succession of floors, nobody wants to stagger up and down. I've been in houses where no two bodily functions could be performed on a single floor so you spent all your time trotting up and down stairs, but now when you have a big cut, then a bench, then a fill beyond it then you've god three very different kinds of situations all in one spot. The same is true of many of the things that one sees in the forest or on hill slopes. I'm kind of impressed with the sort of lumbering that you see today with the kind that was carried on when I was a boy and I'm not too sure that perhaps the balance doesn't lie a little bit perhaps in the days past when it was all done with animals or long elaborate railroads, trestles, steam engines and things of that sorts, as compared to the kind of logging you see today, which, of course, all that emerges there is a mass of splintered-up logs and caterpillar tracks and things of that sort. But, to return to my bailiwick, it just seems to me that in many design problems that are laid out perhaps in an environment distant from where the actual site is concerned, too little attention was paid to the actual conditions on the ground and this is to close the circle once more, people who have perhaps less margin of safety to operate within than we do are possibly a little more aware of this intuitively and that's an embankment perhaps from our standpoint because the knowledge is here. Its very large in part a matter of communication, a matter of plain ordinary common sense. It impressed me, for example, as not too bright to lay an airfield out on the basis of soil samples that were taken every 500 feet or so and then set up the design standards for that and between the two drill holes would be a thing like a creek, a ditch, a swamp or a great change in variety of bedrock for the nature of material that you are working with. The point too I think I made in the slides that I showed you is that so much of the California landscape is an inherited one and if you are in a region such as the scenic parts of the Sierra where the imprint of glaciation is still present there, there you have slopes which are very steep and are quite out of harmony with the sort of rainfall and climatic pattern that is superimposed on it today. So, a good deal more attention ought to be paid to slope control and to slope management and to the reduction of velocity of streams, a point though (I introduce this, therefore betraying my ignorance) on controlling flood hazard by the construstion of check dams. What happens when all these dams are filled?

Farrell: Well, that's when they become operative, until they fill its in a transition stage, we're getting benefits downstream, of course, because we're not getting the debris but when the dam is filled we anticipate that the size of the material that comes over will be sand and, not much larger than pea gravel in most cases. As I stated earlier, we, in many cases , welcome that because we can pass that on to the ocean and we are doing research in that regard to try to get this material passed directly through our debris basins so we don't retain it and there are several experiments along this line being undertaken right now, so the fine material that I think you foresters call "sheet erosion", we are not trying to stop that, that is something that will come in the vegetative category I think or hillside stabilization and that doesn't hurt us, its just the big stuff three and four feet in diameter and six inches up in diameter that we're trying to stop and we think we will do that.

Question: "You're not worried about the downstream side?

Farrell: Well, let me go ahead a little bit. I mentioned, I think, that the system stabilized from structure to structure. Now, that means that we assume we will get roughly 7/10 of the natural slope upon stabilization. In other words, we knock off 3/10 of the slope, 30%. So, we design on that basis. In spacing, the structures are set so that when they are filled they toe out from one to the other. Now to help that, during this period we put in what we call a "sill" down the stream from the spillway, roughly the spillway hieght plus five feet which, if you'll pardon the expression, is something that Mr. Bauman brought back from Switzerland on spacing that happens to work very nicely, even if it is old. So, we hold the structures artificially until the filling becomes completed then these "sills" become buried and then they operate on their own elevated slope.

Summation by Silverwood:

Well gentlemen, I'll try to make a little quick summation of what happened. I don't think I'll need to say too much about Anselmo's comments. I think he has more ideas than Carter has pills...and I think he should, very frankly, be put on a research team and put to work. I'm very much in favor of the idea that was expressed here of perhaps giving each member in the Forest organizations an opportunity to do a little research on their own. I know if we farmers were not sort of inventive as we go along in the many obstacles, elements, markets and what not in doing a little research on the problems we have, we wouldn't stay in business very long. I think it behooves any organization to think very seriously about considering something of that kind and I think you will have a lot more enthusiasm and come up perhaps with some very sound ideas.

Dr. Farrell gave a very excellent portrayal and narration of the geology of our watersheds here and he added some comments that expressed a little personal philosophy on how some of these watersheds were treated in the Orient and what might be done in the land treatment phase of control.

Getting on to Professor Ed Phillips, he commented on how important it was, that we needed much more management than is possible at present and the first of which he felt was plant ecology was most important to trace the history of some of the first recognized efforts in modern history from 1342 when the "bann" forests were adopted in Switzerland and how Chris Columbus' son observed that the heavily forested West Indies, the reason perhaps that they had greater rainfall than the Canary Islands was perhaps because of the forested areas. Going down he mentioned the changes and the recognition of these by some of the earlier settlers in this country, Noah Webster, for example, commenting on the change in the New England climate from the first settlers and the first recognition of the effects of the change by the Forest Service here in 1885. He stressed very definitely the need for more research particularly, even down to the rangers which I mentioned a minute ago, and particularly the importance of additional transpiration research. He felt that 5% of the time of these rangers might be devoted to this sort of thing. I think that that could be increased quire a little bit and still be able to get the job done because usually people that have a definite interest in something will put in a great deal more effort. He stressed the probability that sea water will be used for domestic use, which undoubtedly is true, in the future. If we understand some of the forecasts that have been made by some of the organizations including this recent publication put out by the

Southern California Research Council and the State Department of Water Resources. He visualized his dream of lots of forests in Southern California and they will probably be used very heavily for recreation in the future. Might even be successful in our cloud seeding or other means, perhaps additional means of irrigating to get this started.

We then heard from Engineer Farrell and I'd like to ask him first...Was that 1938 picture of Brand prior to the flood?

Farrell: Yes, it was prior to the flood because the dam was not filled and most of those structures were pretty well filled in the 1938 flood. However, it was after, in the interim between the time of the flood and the fire, that burned out that watershed, so that there had been some action on it by small storms.

Silverwood: In other words, the dam was built before the 1938 flood?

Farrell: Right.

Silverwood: Now, the question I'd like to ask...you had a series of slides showing the variation downstream of amount of erosion as you went on down, no check dam high up, etc. What was the name of that canyon?

Farrell: Cook's Canyon.

Silverwood: Cook's Canyon. Now, did this Cook's Canyon....what was that a result of? Was that a fire upstream?

Farrell: Yes, 1956-57. In fact, we had to move our equipment out of there, it just about got burned out. We were finishing up that project when the canyon burned over. In fact, some people accused us of doing it to test it, but that wasn't the case. The watershed had two years of growth on it and that doesn't mean too much because we have ten years of problems after a fire and they had a very severe, short duration storm up there and I think another point that should be made, the thing I want to stress is, if that system had been all the way up that canyon that mud flow would never have been allowed to generate. It would have generated in the canyon bottom. And so, it generated up above where we had to stop and that is the area which we showed in that first slide.

Silverwood: Thank you very much. Now, Engineer Bill also brought out some very interesting points and I think the people in Southern California in particular should be very interested in and that is the increased cost of this debris removal. They estimated that this cost in ten years may be increased as much as $3.00 per yard and that very possibly in the fifty year period might amount to 400 million cubic yards. You can see why protection-preventive measures in particular is all important. The thing he stressed also was the works designed to help Mother Nature are most important and a little special observation I'm going to mention for a minute or two. I'd like to stress that also, I think that is an excellent statement. Fires are really the things that upset the engineering applecart, when it comes to flood control engineers at least. Stabilization was the first step and they have now picked out 35 watersheds to be treated, however, when he made the critical observation of spending all kinds of money for fires and nothing else for protective work, perhaps that all the Forest Service people were doing was spending money, waiting on the ridge for the fire to come to them and somebody asked him if he had ever been on a fireline.

I think one of the most important things we have ahead of us, those of us concerned with this overall problem, is to get public awareness of the importance of conserving our natural resources. One of the finest things that has been done to date has been the development of "Smokey the Bear" and I want to give you a little personal illustration of what I mean. I have a small apple acreage in Oak Glen and each fall we have a great many hundred visitors who come up there to buy a few apples and some cider and for the last couple of years the Forest Service have provided us with some actual size bear cut-outs and painted properly and in order to portray this one Smokey Bear they left with us I placed a 4x8 panel of plywood painted white,so it would show up better, right in front of the cider stand and set up a little table with the brochures they furnished us in front of it. It was amazing to me to see every little youngster from Kindergarten age on up, the minute they hit the deck "Mommy, Daddy, come look. Here's Smokey Bear" and they began to give them quite a talk about it. Well sir, we don't realize it but they pick up the little songs and jingles. They were constantly replacing this informative material. We don't realize today that we or our youngsters when they grew up, had the opportunity of learning that symbol of conservation, but its a thing that the youngsters now in the grade schools will understand and from there we can help to engender and encourage them to understand the importance of conservation of our natural resources. I want to give you one other personal observation since I've had a little peak at something that will be presented to you tonight and I won't be able to be here, but I think its a wonderful thing and if I can just comment a little about some of these field trips and the importance of getting the public or anyone to understand these problems by taking a field trip I think is a very fine thing, just as the very excellent narration and field trip we had a chance to observe with you on the slides here Dr. Putnam.

You will recall about three or four years ago Clair Engle was very very critical of the Forest Service because of some of the tragedies that resulted from fires and loss of life, particularly in San Diego County, and he made some statements that I was confident that he didn't thoroughly understand some of these problems. I felt determined that something should be done to give him a better understanding of just what our problems were so we persevered and we arranged to meet his committee when they were touring here in the west and holding hearings prior to the hearing in Los Angeles. Sim Jarvi and I boarded the plane at Norton, flew to Phoenix, picked up his Congressional party and we had arranged with the pilot to fly over this heavily burned terrain from Cajon to Mill Creek and showed him the tremendous growth and the amount of residential use in the upper portion, of the debris problems coming down out of these canyons into the fast growing urban development on the valley floor and the importance of this particular watershed which produces the most water of any watershed in Southern California to the economy of Southern California due to the fact that 65% of our water that is used here in Southern California still comes from local supplies. Sim had one group of the Congressmen in one end of the plane and I had the other group in the other end of the plane and I am confident that as a result of their being able to get a firsthand, birdseye view of that problem that they were to understand testimony of the two day hearing that followed in Los Angeles much better. Because the results, the observations and the recommendations of those hearings were apparent, I don't believe you've ever had a Congressional Committee that has ever made an outstanding recommendation of things that you have been pushing for, Charlie, as that Committee has and they've been very helpful, succeedingly so, in this present session of the Congress to get additional funds to make possible the carrying on of this land treatment program, that I want to speak to you about now for just one minute.

As a Soil Conservation District Director, it is the objective of the Soil Conservation Districts to encourage each landowner or operator to learn the capabilities of each acre of ground and to treat it for its conservation needs. This means not only the agricultural areas but also the entire watershed areas and as a result we have endeavored to push for the 566 Small Watershed Program, which unfortunately the present criteria doesn't apply too well to California. Due to the extreme, steep mountainous ranges immediately adjacent to the fast changing urban development of the agricultural land in so many localities, consequently, many of the applications that we have had before us at the State Soil Conservation District will not qualify, yet the need for that land treatment work is far greater with the urban development downstream than it is with agricultural land downstream because of the potential of being buried by the debris that Engineer Bill speaks of. Now, one of the most important things that we need to work for and help the public understand and that is the importance of getting sufficient funds so that in addition to these various mechanical means on check dams, etc., we will be able to stabilize the terrain and protect the present cover so that we can have the greatest water yield and recreation potential in the future so that we can quickly cope with and bring into control these fire outbreaks. The best way to do thatis to have sufficient money for adequate access roads, helicopter ports, etc., to be able to reach these fires, because if you can't reach these fires you can never put them out, and whereas the air arm has been a wonderful improvement,an additional means to accomplish this, you've still got to have the land treatment program of these access roads and other means to help the Forest Service to bring these under control. When they have that then they won't have to wait on the ridges for the fire to reach them.

General Observations by Mr. Bauman, Retired - Los Angeles County Flood Control District - while in Switzerland:

Here's a good example of what can happen when you have no stabilization in a watershed. Before 1499, as far as anybody knows there was no systematic upstream engineering performed, and this cloudburst caused a terrific free movement in this area which in fact to this day is still noticeable as to where it came from. It produced so much debris at the mouth of this canyon there was a castle about 30 meters or 100 feet above the stream bed that was buried during that debris fall. The lake which is known as the "Lake of Dreams", which is one of these famous alpine lakes, was pushed down as far as the shore went, about five miles. What's remarkable is that the originator of the check dam was not an engineer but a Justice of the Peace and they conceived of the idea of building these checks and each district donated a man and so much time each year. That's how they build these structures originally, you might say voluntarily. Gradually they crept into more substantial construction, this was mainly timber construction and it was heavy. They used the timbers from neighboring forests and built them up and filled them with rock. They, of course, wouldn't last any length of time and they had to be replaced gradually with stone masonry and now predominantly concrete, but for Dr. Putnam I might mention, if you do something over a long period of time you find out things that you don't find out over a short period of time, necessarily and in some of these canyons where they build these very sturdy check dams with nothing less than two feet in thickness they find that some of these dams were crushed due to mountain pressure. That was because of the growing mountains and they were crushed exactly like a cylinder in a testing machine and these are things that, so far as I know, we have not experienced in the upper mountains near here, or in the Sierras or in the Rockies, mainly because there hasn't been as much development, but there are some freaks of nature that can happen which can only be found out over the ages such as, say 500 years or something like that.

Question: What is the durability of long span usage of check dams?

Bauman: I think one feature should be brought out, it was implied that a by-product of the check dams were the quieting of flood flows, in other words, the taming of flood flows, "wild waters" you might call it and these are "wild waters" in these canyons that come off of the watersheds, even in our mountains. They have a tendency to entrench themselves and if you give them half a chance to entrench themselves they will keep right on digging and the deeper they go the more they dig and this, incidentally, cannot be explained by ordinary hydraulic formulas such as we use to design channels, it can only be explained by means that is known as 'drag' and the 'drag' is simply that component over a column of water which is in the direction of the stream bed. That is always accurate, it makes no difference how wide the trench. As we know in the matter of trench and the deep trench, even if the slope is steep the velocities are low because of the fact we have a lot of friction but the 'drag' is still there and that is the thing that keeps on digging. Now when you prevent this entrenchment, and this you do by putting the barriers across, then you not only prevent this action you also force the flow to stretch over a much wider width of canyon and naturally the depth of water is most important when it comes to its power for moving things. So, it is this combined with the slackening of the slope, the widening of the canyon bottom, the dissipation of energy each time that water drops over one of the structures where Dr. Putnam indicated it is important to watch your toe and protect it properly from that impact and force of the water, but these combinations are important, it helps to understand the mechanics.

Silverwood: Thank you very much. I think Professor Ed you have another good argument for some of these foresters becoming researchers and possibly ecologists, because when a Justice of the Peace can become an engineer why you have possibilities. Another question?

One more, Ed Phillips, if I can. I share this concern over transpiration retardant. Is there a feasible product available now under which we give those tree seedlings protection?

Silverwood: I'd like to know what I could do with my deciduous trees like that too.

Phillips: There is a product on the market now called 'Wiltagrus'. I know for a fact that you can get it at an Armstrong Nursery and you can get it at most any other nursery and we used some of this as an experiment in some of the pine trees before we transplanted them. They are using it, for example, on Christmas trees to increase the time before they get dried out and they use it also to some extent on the floral arrangements. It is a clear liquid when it is sprayed on. You can either dip the tree in it or spray it.

It is available.

Question: Do you have any idea of cost?

Answer: No, we don't.

Question: Is it fireproof?

Answer: I suppose it is relatively fireproof. It has a plastic base, it is vinyl latex.

Question: Do you have any data on whether it will cut down transpiration 50%?

Phillips: There's no question but that it cuts down transpiration. The only difficulty is that there is just not enough research to tell how to use it practically at this point, except that a good many of the nurseries are using it for transplants within the nurseries. The greatest amount of research is being done at Michigan State University.

Question: Mr. Farrell dismissed reseeding efforts rather abruptly... I'd like to direct this question to Dr. Phillips. Are we wasting our time trying to reseed these burns, or, if there is anything better?

Phillips: Well, I think Bill would not say we are wasting our time. I would be very strong in saying that there is no question but that we've got to stabilize these things the best way possible, some with seedlings and, in this case, there has got to be check dams. There's no question in my mind about that.

Statement from the floor: I think we all know that we can't make anything grow in unstable slopes. Witness the La Guardia fire recently which we, of course, reseeded right away. We had a tremendous amount of dry erosion occur, it moved actually much faster before the first rain than it did afterwards.

Silverwood: I'd like to add that you can't grow any seed either when the top soil has all gone down to stabilize beach erosion.

Farrell: I might add that there are a lot of places that planting is good, but there is one thing that bothers me and I'll go back to old Gus Juhren, who is gone now, but when he was here he fought this also. Where I was raised one of the greatest problems was keeping the mustard out of the oats, the mustard out of the barley, the mustard out of the peas and anything else we grew and here, seeing you put mustard out kind of hurts me. Gus used to maintain that this mustard had a noxious effect and retarded the growth, that it would normally come back a lot faster if we had not put noxious weeds in the ground.

Lynn Biddison: I'd like to ask Dr. Phillips a question. Some people have expressed an interest in introduced plants, that is, from other countries, to take the place of some of our native plants. Other people have expressed the thought that this was not possible, that it just couldn't be done, you could not improve on Mother Nature. What is your thought on that?

Phillips: I think there is no question but that you can find some plants in other parts of the world which are very useful. For one reason, there are fifty other parts of the world with the same problem, the same climate, same physiographic conditions and a lot of these places are older than our area here so plants have had a longer chance to evolve in these areas and, if they have had a chance to evolve perhaps that type of plant is better for that type of climate and those conditions and, therefore, with this longer evolution possibility it may be possible to find some things which have gone beyond our plants who have had a relatively short time in a young area.

Question: Could I ask Dr. Putnam what he thinks a life history of a stabilized channel by check dam stabilization would be geologically speaking?

Putnam: Well, I worried about it, it was in the back of my thinking when I asked what happened on the toe of the dam with the increased acceleration and I was tremendously interested in the remarks you made about the check dams in the Alps because some of those I've seen and they are extraordinary structures and they certainly do show the passage of centuries. Many of them, of course, are far more elaborate than anything we build here today because stone masonry is an art that has long vanished in this country and these were elaborate things and marvelously fitted masonry. I rather think there must be a thing for the moment but I'm speaking in terms of 5,000 to 10,000 years but what worries me a little bit is what is going to happen to the alluvial fan and to the constructional slope beyond the front of the mountains, when you catch the debris and fill up these stepping stones, you've essentially got clear water, you've taken out most of the heavier sediment and inevitably then I think there would be a fair amount of scouring in the downstream channel. That's going to send a wave of rejuvenation upstream and when we all come around here again in the year 50,000 or so it ought to be a rather different looking set-up than we have today.

Farrell: I think this is a rather reasonable question and we've got a reasonable answer. First, I'm not interested in 10,000 years, if I can get 50 out of them I'm happy. These structures are all justified on a cost basis. We're working on a better one to one cost ratio to fill them in and that's on a 50 year basis. Well, if we can squeeze out 100 or 200 then we can put another system on top of the one that's in there so we're not particularly worried about the life of them because there are any number of systems that can go in.

Second, we do not put in a check dam system above a watershed, or in a watershed which at the mouth there is not a debris basin and a concrete or otherwise improved channel for the overflow, so that when the system is in the check dam system stabilizes the watershed, the debris basins at the mouth of the canyon protect the populace from this big flood and anything that might happen, the overflow from the debris basin goes by channel to the ocean or to the water conservation spreading ground. One of the many things that we obtain from these dams is the conservation of water. All these grottos store water in these check dams and let it out at a time when we can use it and hold it at a time of high water. We are running check on the best structure that we have right now which is more research, up in the canyon where we are testing out a metal type of structure and we've been trying to get it to fail, but we can't make it fail, so we've run a water flow test on it now for three weeks to try and find out why we can't get water over the spillway of that structure. We've got fifty gallons a minute coming into that structure, we have the spillway sandbagged and closed off, we have twenty gallons a minute coming out of the structure and we can't account for the other thirty, and that has been going on for three weeks. This is in solid bedrock, its going down that's all there is to it.

It might be interesting to Dr. Putnam to observe that in the Flood Control District Reservoir that some two-thirds of the material is fine. This is material that cannot be caught by the check dams but will keep on going down, like the material in the sands on the beach, and will come into the debris basins or reservoirs. Its the very heavy rock that has always been the danger point and the thing to worry about.

Silverwood: And, this is the thing that we want to keep up on the top too my friend, so we can grow Ed's trees.