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January 2, 2008

I am submitting these documents to become part of the comment on the draft EIR for the Computational Research and Theory (CRT) Facility.

It is inappropriate to consider locating the CRT Facility on the proposed hillside site which is part of the Strawberry Creek Watershed. Please note that the following documents show LBNL to be within the watershed. Offsite alternatives should be seriously considered.

Sincerely,

Phila Rogers

Phila Rogers

List of Documents

1. Strawberry Creek Management Plan. Prepared by Robert B. Charbaonneau, Office of Environmental Health and Safety, University of California at Berkeley. December 1987

2. An Environmental Analysis of Potential Development Sites in the East Hill Area (Strawberry Canyon) of Berkeley, California. Terence O'Hare

3. Management Plan for Strawberry and Claremont Canyons. !979. Prepared by: Joe McBride, Chairman, committee on Conservation and Environmental Quality (1978)

4. An Ecosystem Analysis – Strawberry Canyon - Hal E. Flemming

5. Strawberry Canyon University of California. A land use and vegetative study. By Garrett Eckbo & Associates for the Office of Architects and Engineers. June 1976

Phila Rogers, 1/2/08 Doc 1

An Ecosystems Analysis

-Strawberry Canyon-

Hal E. Fremming

Landscape Architecture 199

Biological Environmental Studies

Winter 1973

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Introduction

Prior to the institution of a resource management stradegy, a great deal of planning should be made in order that the desired objectives are achieved. Very often, the planning of an ecosystem utilization program considers principally the interactions between the various human interests and little is asked about the native biota - both wildlife and vegetation. More seldom is there an analysis of the effects of a plan's implementation upon the soil, geology, and climate, or together - the landscape.

Thus, before recommendations for the management of the Strawberry Canyon Ecological Study Area at the east side of the University campus at Berkeley are established, the state of the ecosystem should and forthwith will be evaluated. Consideration of each of the pertinent state factors - climate, geology, soils, vegetation, wildlife, and time - will be made with particular emphasis being laid upon the most significant phytometer, the vegetation.[1]

Climate and Topography

The climate of the Berkeley Hills and the entire Bay Region is temperate and most closely resembles a Mediterranean coast climate. A diversity of microclimates is produced by the varied topography and landscape cover. Thus, it is a generally cool, even maritime climate on the cismontane slope of the East Bay's Contra Costa Range.

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[1]Stone, Edward C., Ecology of Natural Renewable Resources, Forestry 123A, U.C., Berkeley, Fall, 1972.

The factor most strongly maintaining this relatively thermostatic weather type is the fog. There are principally two sources of the fog which often shrouds Strawberry Canyon and the lower campus - the continental or valley fog and the oceanic or coastal fog. The entry of the largest source of the two is through the Golden Gate. This lowest gap in the coastal hills acts as a gateway for the damp ocean air which most strongly "licks" the shores of Berkeley.[2] This cold air fog sheet crossing the Summer's bay slips beneath the warmed city's air and into the crevasses of the Canyon.

On the cool summer afternoons, fog decks forming near Grizzly Peak Boulevard, on the ridge, funnel down the Canyon and continue to build out toward the bay. This fog in the Canyon condenses on the oak, redwood, and bay leaves and falls on the litter layer beneath keeping it moist.

The fog in combination with the effect of the bay produce a thermostatic effect on the temperature range of the Bay Region. Over successive easterly ridges and valleys the summer temperatures rise.[3] At the time of frost in the Great Interior Valley, during average Winters, the exotic vegetation of the Botanical Gardens in the Canyon is safe due to the fact that frost is infrequent.[4] Similarly, it is believed that work may be carried

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[2]Gilliam, Harold, Weather of the San Francisco Bay Region, #6, U.C. Press, Berkeley, 1970, p.-29.

[3]Holmes, L.C. & J.W. Nelson, "Reconnaissance Soil Survey of the San Francisco Bay Region, California", U.S. Bureau of Agriculture, Bureau of Soils, Field Operations of the Bureau of Soils, 1914, 16th report, p.-2784.

[4]Welch, L.E., "Report and General Soil Map of Alameda County, Calif.", U.S. Dept. of Agrig., Soil Conservation Service, 1966, p.-8.

out throughout the year growing a large range of species and varieties in the Botanical Gardens.[5] Nevertheless, with the coming of the highly variable spring weather types, the growth of the annual grasses on the hills, the saturated riparian woodlands, and the activity of the resident fauna are all beneficially stimulated.

Concommitant with the increased radiation, which during the Winter normally warms the south-facing slope more than the north-facing slope, the warm dry spring winds whipping down the canyons dessicate the exposed grasslands. It was after a dry Summer and the following Fall's northeasterly winds that the grass fire began in the Berkeley Hills in September, 1923 which pushed the fire out of Wildcat Canyon toward and into the residential areas.

The Westerly winds that carry in the fog in the late stages of a storm similarly bring the heaviest load of precipitation to bear on the Berkeley Hills. These moisture laden rain clouds leave a certain amount of rain along the edge of the bay appearing in the annual average rainfall of 13.6 inches at Newark. On reaching the foothills, the clouds are condensed and the rainfall rises to higher annual levels such as shown by Berkeley's annual average of 22.1 inches.

Although man has increased the photooxidant and particulate levels in the Canyon, natural smog accumulations occur against the Berkeley Hills. Particularly in the late Summer and early Fall,

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[5]Vaughn, Adelle Wharton, "A Master Plan for a Botanical Garden Arboretum in Strawberry Canyon, U.C., Berkeley", 1940, p.-8.

inversion layers often act as lids on the boxed-in Strawberry Canyon.

The strongest coincident determinant of the realized climate in the Canyon is the quite diverse topography (Map 1). The vegetation mosaic in this watershed is in large part determined by the variable levels of light, rain, temperature, and wind occurring. There are represented, portions of the landscape facing every direction of the compass. These slopes with varying aspects, rather than receiving an equal regional climatic level, have a diversity of microclimates.

Geology

The Canyon is ridden with numerous synclines and anticlines which extend north to south. As well, it lies between the Hayward and Moraga faults, both of which are major right lateral fissures. Within the area of consideration, there are eight geological units representative of numerous epochs.

Of particular note are the outcrops of dark shale on the south side of the mouth of the Canyon which repose upon the Franciscan series of sedimentary rocks. The dip of these shales is easterly into the hillside at an angle of between thirty and forty degrees. West of the Hayward fault, this latter series is a bluish-gray sandstone which, where exposed, is found to weather to a rusty yellow color.[6]

The beds of the branches of Strawberry Creek at various points expose two classes of intrusive rocks. The first group

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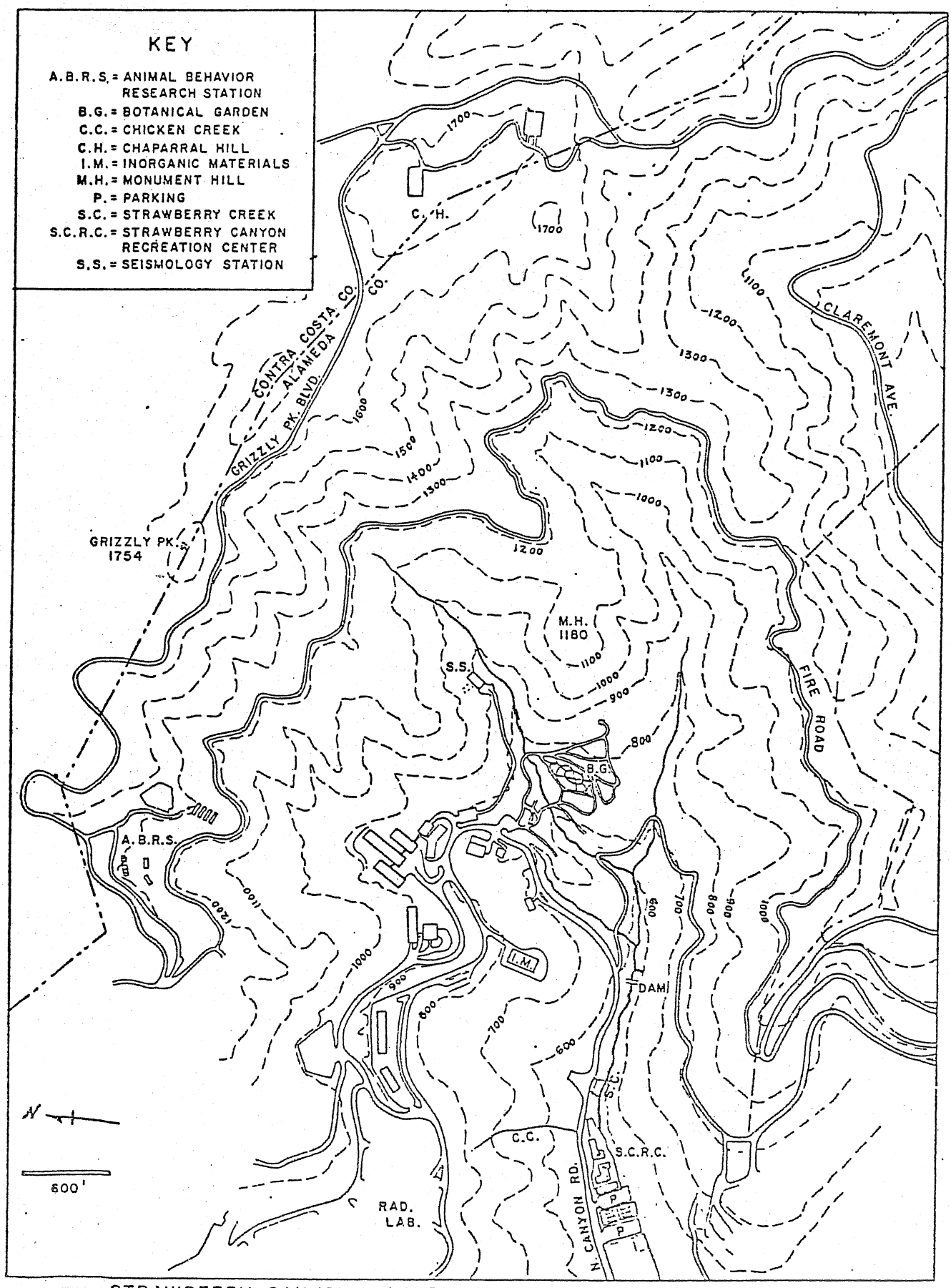
[6]Lawson, Andrew C., U.S. Geological Survey Atlas, San Francisco Folio, No. 193, 1914, p.-353-358.

Map 1



STRAWBERRY CANYON, UNIVERSITY OF CALIFORNIA, BERKELEY

Map 1

of diabases and basalts are spherical, and some show variolitic or pock-marked appearance; whereas, the peridotites and pyroxenites are merely serpentine formations.[7] This area of serpentine was "laid down" at the southern base of Monument Hill, mentioned earlier, in Hamilton Gulch between the Jurassic and Cretaceous periods (Map 2). Further up the hill, a shale formation is hidden from view because of the hills' landslide topography.

There was a deposition of the marine strata during the Cretaceous period which is thought to have been significant in the orogenic deformation and erosion of the early Franciscan series. The later water-laid deposits, which now occupy a position intermediate between the residual and recent alluvial soils, are not thought to extend as far east as the Berkeley Hills.

During the Pliocene epoch and the accumulation of sandstones and intrusives earlier mentioned, there was also a considerable amount of volvanic activity. The lavas that flowed from great fractures and perhaps as well from volcanos, were almost black in color.[8] These lava flows topped both Bald Peak and Grizzily Peak.

Generally, the faults and folds shown throughout the Canyon indicate that during the Pliocene and Pleistocene epochs, there was extensive activity in this area. These major northwest-tending right lateral faults resulted from a north-south oriented maximum compression stress.[9] The original fault displacement was

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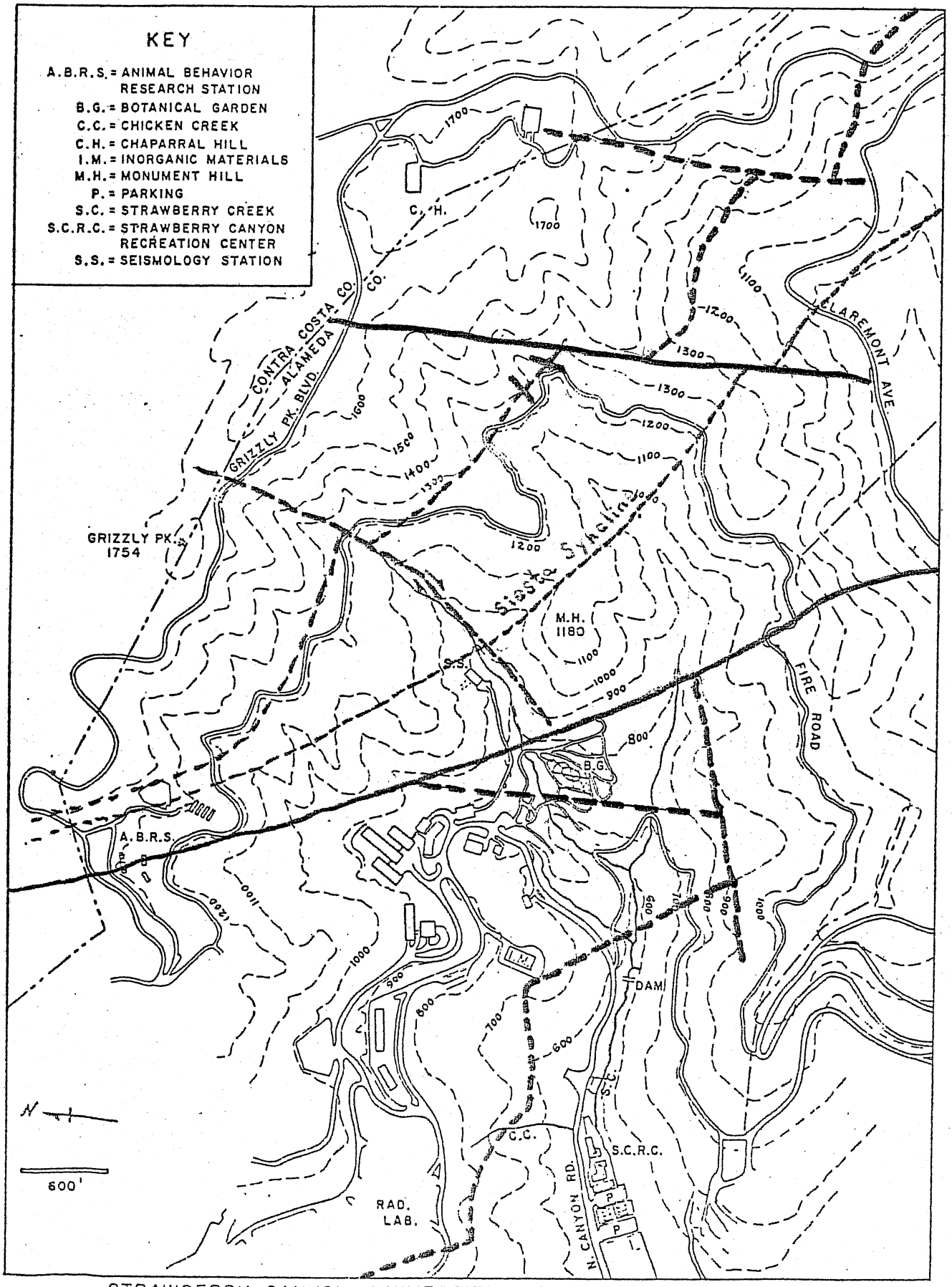
[7]Ibid., p.-448.

[8]Howard, Arthur David, Evolution of the Landscape of the San Francisco Bay Region, U.C. Press, 1972, p.-50.

[9]Case, James E., "Geology of a Portion of the Berkeley and San Leandro Hills", 1963, p.-3.

Map 2



STRAWBERRY CANYON, UNIVERSITY OF CALIFORNIA, BERKELEY

Map 1

vertical and later changed to a horizontal shift. Although there are exposed sediments of sandstone, shale, and conglomerate in the southern portions of the Canyon and basaltic sediments shown more toward Grizzly Peak, Case (1963) concluded that the fault movement has been an insignificant factor in the production of any areas free of vegetation.

Soils

The soils over all parts of the Canyon are primarily residual in nature and vary in type with the character of the substrate. Portions of this substrate appear as outcrops immediately west of Grizzily Peak. In canyons below such direct sources of primary minerals, the more decayed humus is reduced to much smaller particles through the action of weathering and biotic agents.

Holmes and Nelson (1914) originally divided the soils into two basic types (Map 3). The Altamont loam and clay loam (AC) lie in the larger western portion of the Canyon and the Olympic loam and clay loam (O) follow the northwest ridge of the Canyon. This study essentially provided a parent formation which has been "built upon" and modified in later surveys. These soils also have been characterized as being Los Osos adobe clay. Welch (1966), building upon the work of Holmes and Nelson, has attempted to classify soils on the basis of the effects of climate and permanent soil characteristics. Also, he has categorized soils on the gradients of the risk of soil damage, limitation in use productive capacity, and upon soil management requirements. His

"Capability Unit" classification system assign the soils in the Canyon one type - Los Osos-Millsholm 30-70% slopes, eroded. This class is defined as shallow to moderately deep medium and moderately fine textured soils on steep to very steep slopes.[10]

The soils are designated as unsuited for cultivation. The Los Osos silty clay loam surface and subsoils are slightly acid and between twenty and twenty-six inches in depth. The soil beneath the mixed vegetation type has a Precipitation/Evapotranspiration ratio slightly greater than one resulting in some leaching of nutrient sesquioxides and cations. Where oak woodlands tend to alter the Nitrogen content of soils markedly, Baccharis brushlands effect such changes to a far lesser extent.[11] As the waterholding capacity is between 2.0 and 5.0 inches with good to excessive drainage, it is of significance to note that soil slumpage produces vegetation free areas almost every Winter.

The Millsholm soil profile, the second soil type in the Canyon, has a slower infiltration rate on the less steep 30% slopes. These more shallow soils show a less than severe shrinking-swelling behavior as they are between sand and silty texture (without any clay material) and, where the clay is Kaolinite, these are sandy loams.[13]

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[10]op. cit., Welsh, p.-35.

[11]McBride, Joe R., "Plant Succession in the Berkeley Hills", 1969, p.-26.

[12]op. cit., Welch, p.-65.

[13]Ibid., p.-61.

Vegetation

The variety of viable species populations in the Strawberry Canyon would not be significantly reduced were all of the exotic species removed (List 1). It would seem necessary to realize that, in its present state, the Canyon's cohort of species assembled in a vegetative mosaic is of value as the result of many historical factors reflecting the sum of prevailing conditions.[14] More clearly, vegetation provides a most accurate phytometer of the state of the ecosystem as well as a record of historical fluctuations in various state factors.

In order to include all of the vegetation types of the Canyon, one may allude to four major vegetation types. These are, in approximate seral order, grassland, Northern coastal scrub, oak-bay woodland, and conifer forests. (Chart 1) On a map of natural vegetation management regions, the East Bay region in the vicinity of Strawberry Canyon has been mapped as a "Bunch grass" grassland.[15] During the early days of cattle grazing on the Berkeley Hills, nodding needlegrass, Stipa pulchra, a native perennial bunch grass of high forage value, was the dominant grass with fire and grazing as dominant factors. Although there are remnants of this species in areas of the Canyon, the key grassland species today is the annual wild oat, Avena fatua.

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[14] Dansereau, Pierre and Kornelius Lems, "The Grading of Dispersal Types in Plant Communities and their Ecological Significance", No. 71, Institut Botanique de l'Université de Montréal, 1957, p.-6.

[15] Coleman, Edward A., "Vegetation and Watershed Management - An Appraisal of Vegetation Management in Relation to Water Supply, Flood Control, and Soil Erosion", Ronald Press Company, New York, 1953.

The coastal sage units in the Canyon, represented by the species Baccharis pilularis, Artemesia californica, Eriophyllum confertiflorum, and Salvia columburiae, appear to be particularly successful on the steeper more exposed slopes with a southern aspect as well as on the north-facing slopes of a comparable pitch.[16] Although there is an absence of the needed factor, fire, which induces seed scarification, there is an abundance of sclerophyllous California sagebrush (Map 4).

Such representatives of the coastal sage type as Baccharis are merely members of seral stages leading from the grasslands to the climax oak and bay woodlands. Although in most instances oak and bay woodlands prefer the riparian slopes of tributary canyons, there appears to be a preference of such sclerophyllous forest types for the north-facing slopes while the scrub and chaparral tend to succeed on the drier south-facing slopes.

The two environmental factors which most strongly interact are the soil and its respective vegetation type for a given soil type. Vegetation types are successional and will change with time in this region from grass to Baccharis and then to oak over a 100-year interval irrespective of soil type however.

Characteristically on the south-facing slope, the annual grasses are in positive association with oaks on the steep upland Los Osos soils. The grass cover is truly an opportunist with respect to the level of soil moisture. In periods of moisture availability, such as in the Fall and Winter, the rain-

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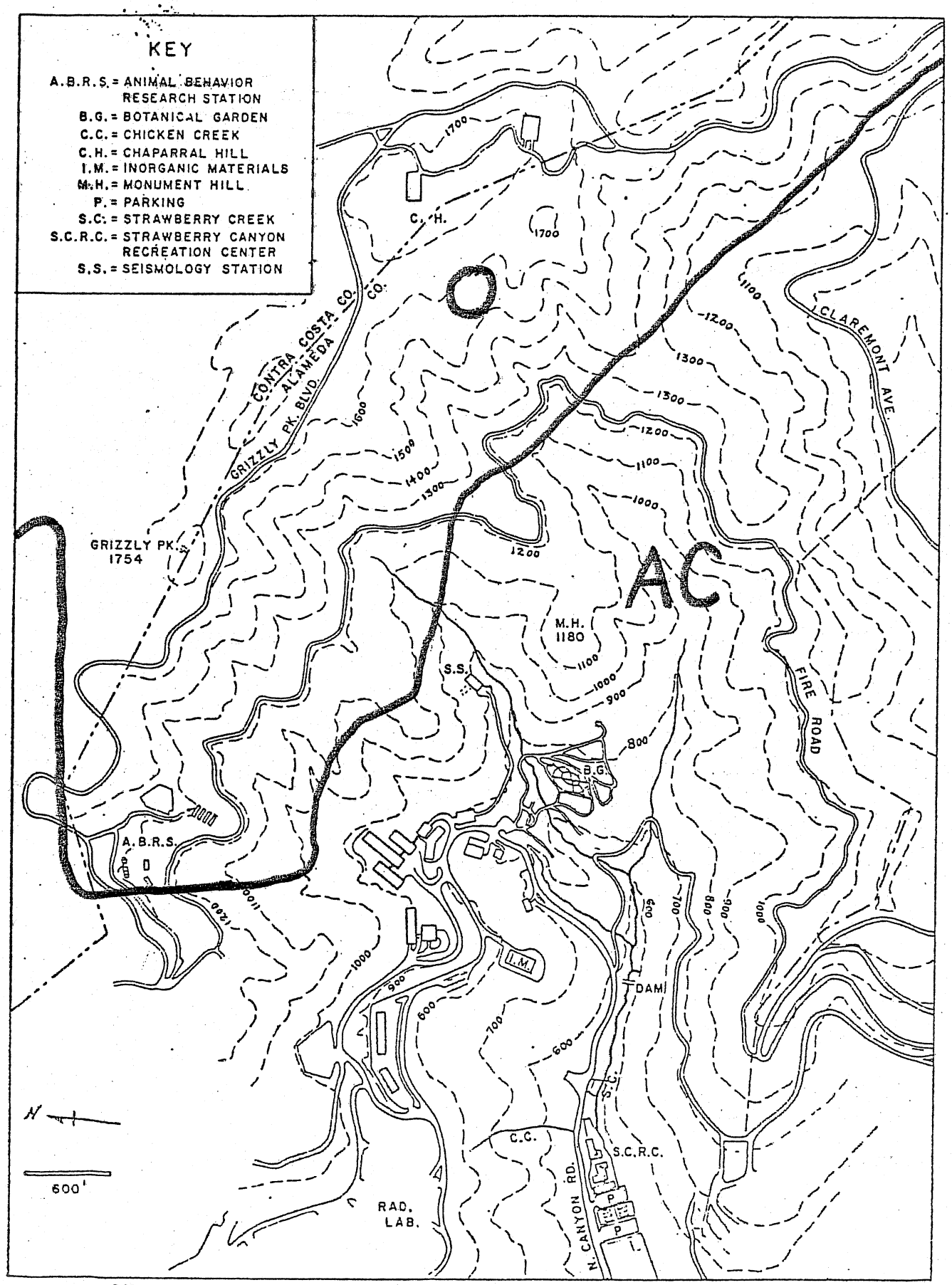
[16]Hermanson, Anne, "All You Ever Wanted to Know about Chaparral", Botany 153, U.C., Berkeley, p.-4.

Map 3



STRAWBERRY CANYON, UNIVERSITY OF CALIFORNIA, BERKELEY

List 1

A Partial List of Native Plants of the Berkeley Hills

This list has been compiled for reference use in the field. It includes only a part of the total flora to be found in the Berkeley Hills, but an effort has been made to list all the common species. The arrangement of families is that of Munz's (1970) "A California Flora" and the number following a family name is a page reference to that manual.

For woody plants, two guides which may prove to be of significant value are "Pacific Coast Trees" by McMinn and Maine (1946) and "Illustrated Manual of California Shrubs" by McMinn (1939).

Local flora's for west-central California are available for Mount Diablo (Bowerman, 1944), Mount Hamilton (Sharsmith, 1945), and Marin County (Howell, 1949). The keys provided by Bowerman and Howell greatly facilitate study of the flora of the Berkeley Hills, which are located between their respective areas.

Special papers aiding study of California grasses are those of Beetle (1947) and Sampson, Chase, and Hedrick (1951).

As well, gratitude is expressed to Prof. Frank A. Pitelka for the use of his Zoology 125c plant list based on Jepson's (1925) "Manual of the Flowering Plants of California".

Symbols are used to indicate the life-form of each species, insofar as known, or the life-form of all members of a family when they are consistently of one type. A - annual, B - biennial, P - perennial herb, S - shrub, SS - semi-shrub, and T - tree. As well several common non-native species are noted by an asterisk.

ACERACEAE (995) Maple
- Acer macrophyllum T
- negundo var. californicum T

ANACARDIACEAE (997) Sumac
- Rhus diversiloba

APOCYNACEAE (449) Dogbane
- Vinca major

ARALIACEAE (999) Ginseng
- Aralia californica P

ARISTOLOCHIACEAE (965) Birthwort
- Aristolochia californica S
- Ascarum caudatum P

ASPIDIACEAE (39)
- Polystichum munitum
- Dryopteris arguta

BERBERIDACEAE (107) Barberry
- Berberis nervosa S
- pinnata S

BETULACEAE (898) Birch
- Alnus rhombifolia T
- rhubra T

BORAGINACEAE (552) Borage
- Amsinckia intermedia A
- Cynoglossum grande P
- occidentalis P
- Myosotis sylvatica P
- Plagiobothrys nothofulvus torreyi A

CAPRIFOLIACEAE (1046) Honeysuckle
- Lonicera hispidula P
- involucrata var. ledebourii S
- Sambucus caerulea (= glauca)
- Symphoricarpos albus S
- mollis S

CARYOPHYLLACEAE (273) Pink
- Arenaria macrophylla
- Silene californica
- gallica A
- Spergula arvensis
- Stellaria media A

CHENOPODIACEAE (366) Goosefoot
- Chenopodium californicum
- multifidum
- murale

COMPOSITAE (1073) Sunflower
- Achillea Millefolium var. lanulosa P
- Agoseris grandiflora
- heterophylla

Anaphalis margaritacea
Anthemis cotula
Artemisia californica S
tridentata
vulgaris P
Aster chilensis
menziesee
radulinus
Baccharis pilularis S
douglasii SS
Baeria chrysotoma
Bellis perennis
Carduus puenocephalus
Carthamus lanatus
Centaurea villosus
Circium californicum
edule B
lanceolatum B
Cotula australis
Cynara cardunculus
scolymus
Erigeron canadensis
Eriophyllum confertiflorum P,SS
Gnaphalum purpureum
decurrens
Grindelia hirsutula
maritima
Helenium puberulum
Hypochoeris radicata
Hemizonia congesta
corymbosa
Lactuca saligna
scariola
Layia hieracoides
Madia citriodora
sativa A
Malacothrix obtusa
Matricaria matricarioides
Micropus californicus var.
substitus
Microseris linearifolia
Monolopia major
Psiolocarphus tenellus
Picris echiodes
Senecio eronicoides P
vulgaris A
Silybum marianum
Solidago californica
spathulata
Sonchus asper A
oleraceus A
Stephanomeria virguta
Taraxacum officinale
vulgare
Tragopogon porrifilius
Wyethia angustifolia
helenioides P
Xanthium spinosum
strumarium

CONVOLVULACEAE (457) Morning-Glory
Convolvulus arvensis P
luteolus P
subacaulis

CORNACEAE (1034) Dogwood
Cornus stolonifera var.
californica S

CRASSULACEAE (718) Stonecrop
Sedum spathulifolium
Tillaea erecta

CRUCIFERAE (210) Mustard
Arabis glabra
Athysanus pusillus
Barbarea vulgaris
Brassica campestris A
kaber (= Sinapsis
arvensis)
nigra A
Capsella bursa-pastoris
Cardamine oligosperma
Dentaria integrifolia
Koniga maritima
Lepidium mitidum
Radicula nasturtium-aquaticum
Raphanus sativus A,B
raphanistrum
Sisymbrium officinale
Streptanthus glandulosus
Thelypodium lasiophyllum

CUCURBITACEAE (1058) Gourd
Echinocystis fabacea P
Marah sp.

CUPRESSACEAE (58) Cypress
Chamaecyperis Lawsonia T
Thuja plicata T

CYPERACEAE (1414) Sedge
Carex barbarae P
senta P
tenuiflorus
Cyperus eragrostis

DIPSACACEAE (1057) Teasel
Dipsacus fullonum B

EQUISETACEAE (26) Horsetail
Equisetum telmateia var.
braunii P

ERICACEAE (410) Heath
Arbutus Andersonii var. pulliata
crustacea
Menziesii T

Vaccinium ovatum	S
EUPHORBIACEAE (159) Spurge	
Euphorbia peplus	A
FAGACEAE (901) Beech	T
Quercus agrifolia	
douglasii	
kelloggii	
lobata	
morehus	
wislizenii	
FUMARIACEACEAE (202) Fumitory	
Dicentra formosa	P
GERANIACEAE (139) Geranium	
Erodium botyrs	A
cicutarium	A
moschatum	A
Geranium dissectum	A
molle	
GRAMINEAE (1462) Grass	
Agrostis diegoensis	P
polustris	P
semiverticillata	
Aira caryophyllea *	A
Avena barbata *	A
fatua *	A
Briza maxima *	A
Bromus carinatus	P
laevipes	P
mollis *	A
racemosus *	A
rubens *	A
Calamogrostis rubescens	P
Cynodon dactylon *	P
Dactylis glomerata *	P
Deschampsia caespitosa	P
danthonioides	A
elongata	P
Elymus glaucus	P
Festuca californica	P
dertonensis *	A
megalura	A
Hordeum leporinum *	A
Koeleria cristata	P
Lolium multiflorum *	A
perenne *	P
Melica imperfecta	P
geyeri	P
torreyana	P
Phalaris californica	P
canariensis *	A
minor *	A
Pleuropogon californicus	A
Poa annua *	A
pratensis *	P
Polypogon monspeliensis *	P
Stipa lepida	P
pulchra	P
Trisetum cernuum var canescens	P
HIPPOCASTANACEAE (994) Buckeye	
Aesculus californica	T
HYDROPHYLLACEAE (515) Waterleaf	
Nemophila menziesii	
parviflora	
Phacelia californica	P
nemoralis	P
IRIDACEAE (1386) Iris	P
Iris longipetala	
macrosaphon	
Sisyrinchium bellum	
JUNCACEAE (1400) Rush	
Juncus patens	P
tenuis	P
xiphioides	P
KRAMERIACEAE (897) Krameria	
Corylus rostrata var	
californica	
LABIATAE (689) Mint	
Lamium amplexicaule	
Melisa officianalis	
Monardella villosa	
Pojogyne serphylloides	
Salvia columburiae	
Satureja douglasii	
Scutellaria tuberosa	P
Stachys bullata	
LAURACEAE (77) Laurel	
Umbellularia californica	T
LEGUMINOSAE (795) Pea	
Cytisus scoparius	
Lathyrus vestitus	P
Lotus americanus	A
humistratus	A
scoparius	
subpinnatus	
Lupinus albifrons	S
bicolor	A,B
densiflorus	
nanus	
succulentis	A,B
Medicago arabica	
hispada	
Melilolotus indica	A,B
Trifolium ciliolatum	
fucatum	
gracilentum	
microcephalum	
microdon	
tridentatum	
variegatum	

Vicia americana P
angustifolia
gigantea P
sativa
crucca (= semicincta)
LILIACEAE (1326) Lily
Allium unifolium
Brodiaea congesta
laxa
pulchella
Calochortus umbellatus
venustus
Chlorogalum pomeridianum
Disporum hookeri
Frillaria lanceolata
liliacea
Smilacina amplexicaulis
stellata var.
sessilifolia
Trillium chloropetalum
ovatum
sessile var. giganteum
Zygadenus fremontii
LYTHRACEAE (922) Loosestrife
Lythrum hyssopifolia A
MALVACEAE (116) Mallow
Malva borealis A,B
nicaeensis A,B
parviflora A,B
Sidalcea malvaeflora P
OLEACEAE (446) Olive
Fraxinus oregana T
ONAGRACEAE (923) Evening-Primrose
Clarkia purpurea
unguieulata
Epilobium paniculatum A
watsonii
Godetia amoena A
Oenothera hookeri B
ovata P
Zauchneria californica P
ORCHIDACEAE (1394) Orchid
Corallorhiza maculata
Habenaria elegans
OROBANCHACEAE (681) Broom-rape
Boschniakia strobilaceae
OXALIDACEAE (146) Oxalis
Oxalis corniculata P
pes-caprea
PAPAVERACEAE (192) Poppy
Dendromecon rigida S
Eschscholtzia californica
Meconella californica
linearis
Papaver heterophyllum A
Platystemon californicus
Stylomecon heterophyllum
PLANTAGINACEAE (405) Plantain
Plantago coronopus A
erecta A
lanceolata P
major P
POLYGONACEAE (320) Buckwheat
Eriogonum canium
lanceolatum
Latifolium ssp. nudum
ssp. auriculattium
Polygala californica
Pterostegia drymariodes
Rumex acetosella
crispus
occidentalis
POLYPODIACEAE (45)
Calandrinia ciliata
PORTULACACEAE (295) Purslane
Montia fontana
linearis
perfoliata
spathulata
PRIMULACEAE (398) Primrose
Anagallis arvensis A
Dodecatheon hendersonii P
Trientalis europaea var. latifolia P
RANUNCULACEAE (78) Crowfoot
Actaea spicata var. arguta P
Aquilegia truncata P
Ranunculus californicus P
Lobbii
repens
RHAMNACEAE (970) Buckthorn
Ceanothus cuneatus S
sorediatus S
thrysiflorus S
Rhamnus californica S
crocea S
ROSACEAE (754) Rose
Acaena californica
Amelanchier pallida
Fragaria californica P
Holodiscus discolor S
Horkelia californica
Osmaronia cerasiformis S
Physocarpus capitatus S
Photinia arbutifolia S,T
Potentilla glandulosa P
Prunus demissa
emarginata
subcordata

Rosa californica	S
gymnocarpa	S
Rubus parviflorus	S
spectabilis	S
vitifolius	S
RUBIACEAE (1037) Madder	
Galium aparine	A
californicum	
nuttallii	P
trifidum	P
triflorum	
Sherardia arvensis	
SALICACEAE (909) Willow	T
Salix laevigata	
lasiandra	
lasiolepis	
scouleriana	
SAXIFRAGACEAE (730) Saxifrage	
Heuchera micrantha	P
Lithophragma affinis	
Ribes californicum	
divaricatum	
malvaceum	
menziesii var. leptosum	S
sanquineum	S
Saxifraga californica	
Tellima grandiflora	
SCROPHULARIACEAE (603) Figwort	
Bellardia trixago	A
Castilleja affinis	P
foliolosa	P
wightii	
Collinsia bicolor	
Diplacus aurantiacus	S
Mimulus guttatus	A,P
Orthocarpus faucibarbotus	S
Scrophularia californica	P
Veronica americana	
SOLONACEAE (590) Nightshade	
Solanum nigrum	P
umbelliferum	P,SS
THYMELAEACEAE (986) Mexereum	
Dirca occidentalis	S
THYPHACEAE (1366) Cat-Tail	
Thypha latifolia *	
UMBELLIFERAE (1000) Carrot	
Angelica tomentosa	P
Carum gairdneri	P
Kelloggii	B
Conium maculatum	
Daucus carota	A,B
Foeniculum vulgare	P
Heracleum lanatum	P
Lomatium utriculatum	P
Oemamthe sarmentosa	
Osmorrhiza chilensis	P
nuda	P
Sanicula menziesii	P
bipinnatifida	P
Scandix pecten-veneris	A
Velaea hartwegii	P
kelloggii	P
URTICACEAE (920) Nettle	
Urtica californica	P
holosericea	
urens	
VALERIANACEAE (1052) Valerian	
Plectritis macrocera	
VERBENACEAE (686) Vervain	
Verbena lasiostachys	
robusta	P
VIOLACEAE (183) Violet	
Viola glabella	
pedunculata	

Chart 1

Strawberry Canyon Ecological Study Area

Partial List of Plants in Approximate Community Occurrences

Grassland[1]

Achillea millefolium (1228)
Acacia melanoxylon (797)
Aesculus californica (993)
Anagallis arvensis (404)
Anaphalis margaritacea (1263)
Aster chilensis (1199)
Avena fatua (1514) *
Baccharis pilularis (1226)
Baeria chrysotoma (1141)
Brassica campestris (236)
Brassica nigra (236)
Briza maxima (1491) *
Bromus rubens (1474) *
Capsella bursa-pastoris (247)
Castilleja foliolosa (671)
Conium maculatum (1011)
Cupressus macrocarpa (61)
Deschampsia caespitosa (1513)
Diplacus aurantiacus (624)
Dipsacus fullonum (1057)
Dodecatheon hendersonii (401)
Erodium cicutarium (145)
Erodium moschatum (144)
Eucalyptus globulus (963)
Festuca megalura (1476)
Foeniculum vulgare (1016)
Grindelia hirsutula (1164)
Heracleum lanatum (1026)
Lolium multiflorum (1510) *
Lolium perenne (1509) *
Mimulus guttatus (616)
Montia perfoliata (302)
Nemophila menziesii (520)
Ranunculus californicus (95)
Rhus diversiloba (998)
Sisyrinchium bellum (1392)
Sisymbrium officinale (231)
Stipa pulchra (1532)

Cirsium edule (1277)

Coastal Chaparral[2]

Artemsia californica (1236)
Avena fatua (1514) *
Baccharis pilularis (1226)
Ceanothus cuneatus (982)
Chlorogalum pomeridianum (1329)
Cytissus scoparius (830)
Eriophyllum confertiflorum (1149)
Eschscholtzia californica (198)
Heracleum lanatum (1026)
Photinia arbutifolia (794)
Quercus wislizenii (903)
Rhamnus californica (972)
Rhamnus crocea (971)
Rhus diversiloba (998)
Ribes malvaceum (749)
Rubus parviflorus (785)
Rubus vitifolius (783)
Salvia columburiae (703)
Sedum spathulifolium (727)
Symphoricarpos albus (1049)
Zygadenus fremontii (1334)

Author's Note: This list is a combined product of numerous author's notes and observations.

Numbers following generic names refer to page references from Munz & Keck, A California Flora, 1970.

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[1]Munz, Philip A. & Daviv D. Keck, "Coastal Prairie".

[2]Ibid., "Chaparral".

Oak-Bay Woodland[3]

Acer macrophyllum (996)
Aesculus californica (972)
Arbutus menziesii (415)
Baccharis pilularis (1226)
Ceanothus cuneatus (982)
Ceanothus thrysiflorus (979)
Cynoglossum grande (557)
Dirca occidentalis (987)
Disporum hookeri (1332)
Dodecatheon hendersonii (401)
Dryopteris arguta (42)
Fragaria californica (776)
Galium aparine (1040)
Galium californicum (1042)
Holodiscus discolor (759)
Lathyrus vestitus (892)
Marah sp. (1059)
Mimulus guttatus (616)
Montia perfoliata (302)
Osmorrhiza chilensis (1009)
Polystichum munitum (40)
Quercus agrifolia (904)
Quercus douglasii (905)
Quercus lobata (904)
Quercus wislizenii (903)
Rhamnus californica (972)
Rhus diversiloba (998)
Rosa californica (787)
Rubus parviflorus (785)
Rubus vitifolius (783)
Salvia columbutiae (703)
Satureja douglasii (708)
Salix lasiolepis (915)
Smilicina racemosa (1331)
Stachys rigida (700)
Symphoricarpos mollis (1049)
Trientalis latifolia (404)
Trillium chloropetalum (1355)
Typha latifolia (1367)
Umbellularia californica (77)
Vicea gigantea (896)

Conifer Forest

Achillea millefolium (1228)
Alnus rubra (900)
Arbutus menziesii (415)
Ascarum caudatum (965)
Berberis pinnata (109)
Ceanothus thrysiflorus (979)
Cupressus macrocarpa (61)
Cynoglossum grande (557)
Chamaecyparis lawsonia (69)
Dicentra formosa (203)
Disporum hookeri (1332)
Dryopteris arguta (42)
Equisetum telmateia (27)
Fragaria californica (972)
Iris macrociphon (1390)
Marah sp (1059)
Montia perfoliata (302)
Polystichum munitum (40)
Rhus diversiloba (998)
Ribes menziesii (752)
Ribes sanguineum (749)
Rubus parviflorus (785)
Sequoia sempervirens (57) *
Satureja douglasii (708)
Smilacina stellata (1331)
Thuja plicata (59)
Trientalis europaea (404)
Vaccinium ovatum (430)
Viola glabilla (185)

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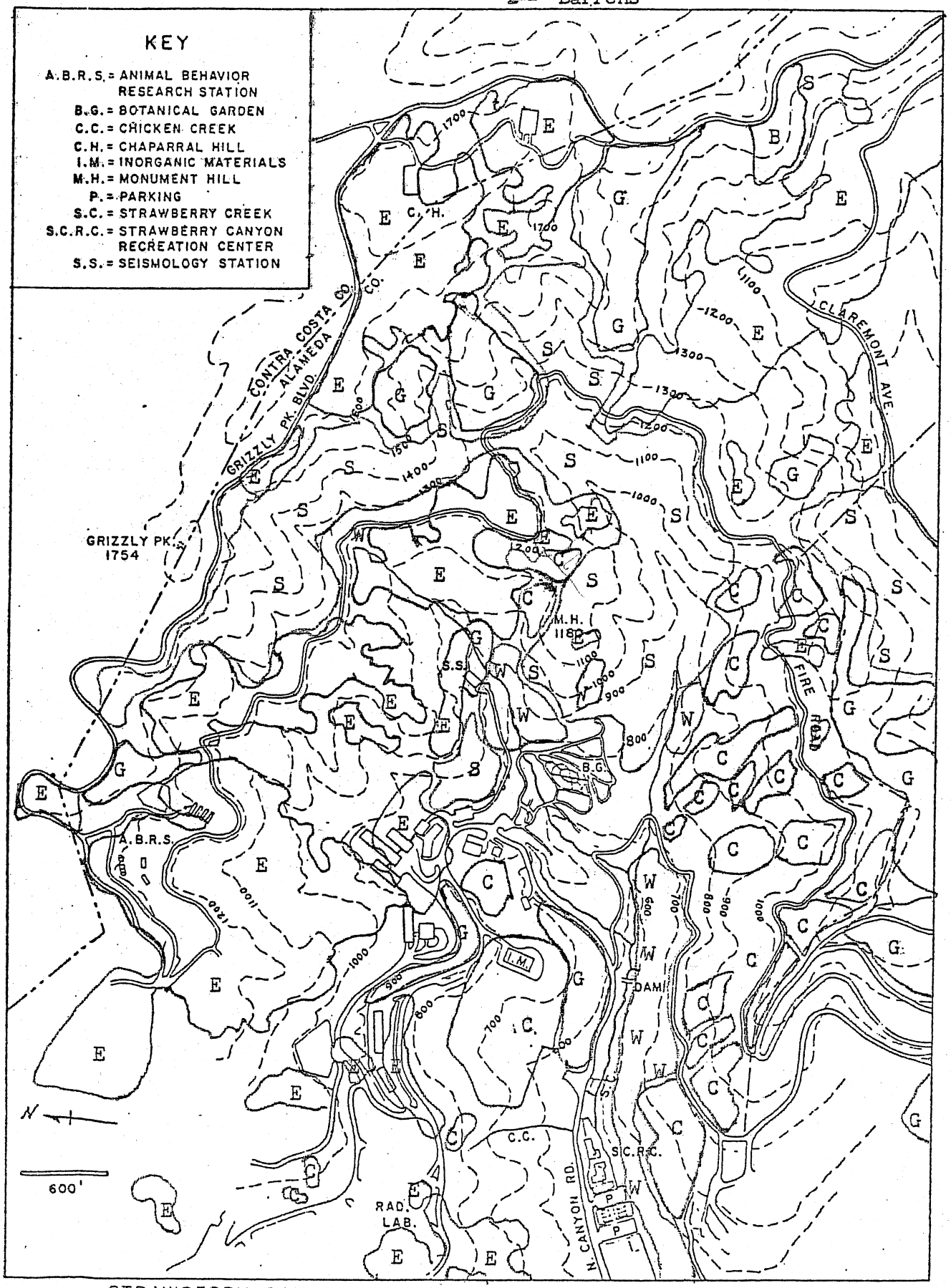
[3]Ibid., "Foothill Woodland".

[4]Ibid., "North Coastal Coniferous Forest".

Key
G - Grassland
S - Northern Coastal Scrub
W - Oak-Bay Woodland
C - Conifer Plantations
E - Eucalyptus Plantations
B - Barrens

Map 4



STRAWBERRY CANYON, UNIVERSITY OF CALIFORNIA, BERKELEY

Map I

waters are quickly assimilated; whereas, in the drier times of the year, the annual vegetation is adapted as there are characteristically fewer individuals.[17]

The slow growth of the perennial vegetation on the very steep north-facing slopes - oak, bay, and some perennial grasses - is accounted for by the shallow or lacking A horizon.[18] Soil slumpage is apparently self-pertuating as coastal sage, like chaparral, does little in terms of the soil holding capacity, for grass growth beneath these sclerophyllous shrubs is compressed.[19] Following the slump, Baccharis establishes preferentially on this bare area rather than on adjacent undisturbed grasslands.[20]

As species of the introduced Genera, Eucalyptus and Pinus, present more formidable management difficulties, a discussion of their biologies will be deferred until later. The coast redwood, Sequoia sempervirens, is native to the East Bay. However, those lying within the Mather Grove, the Botanical Gardens, and various other portions of the Canyon, are plantations.

Differences in the genetic potentials of the key species in the plant succession of the Berkeley Hills are due to differential physiologic tolerance of these species. Foremost such differences occur in the relative seed germination, dispersal, and seedling

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[17]Ibid., p.-5

[18]Sinclair, J. Donald, "Soils and Plant Development", M.S. thesis, Forestry.

[19]Nicols, John, Resource Analyst, East Bay Regional Park District, 1972.

[20]op. cit., McBride, p.-28.

establishment of these species. While it is recognized that seed output is relatively low in shaded habitats as compared with that in open areas, the mortality of the seeds in the open areas is likely to be high among the r-stradegist and opportunist annual grasses, Hordeum leporinum and Poa annua.

The oak, Quercus agrifolia, seeds have among the highest of seed germination potentials. The entry of such acorns into the food chains of gray squirrels and woodrats, which facilitate propagule dispersal, lowers the germination rate of oak seeds. Of notable assistence to oak seedling establishment is the scrub jay who has been seen to bury such acorns as a food reserve. The germination rate of this species is thus an emergent property of several factors.

The prevalence of annual grasses during the period of heavy cattle grazing and fire is explained by the order of viability of the four indicator species - A. fatua, Umbellularia californica, B. pilularis, and the lowest, Q. agrifolia. A. fatua could, in this respect, be called a grazing disclimax assuming the absence of other taxa with access to the system under consideration and the presence or absence of other factors. Billings (1970) has recognized that, "The principle limiting factors to the invasion of the moister grasslands by trees are fire and the occurrence of drought years."[21] Due to the presence of grazing pressure, recurrent fire, and the drought of 1880, perennial grasses were thus succeeded by annual (exotic) grasses.

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[21]Billings, W.D., Plants, Man, and the Ecosystem, Wadsworth, Second edition, 1970, p.-109.

As significant as the impact of biotic agents on plant succession in the Berkeley Hills is the effect produced by the vegetation upon its environment.[22] There have been a number of indications that exocrines secreted by the roots of oak, bay, and Baccharis may, to a degree, suppress the development of understory growth.[23]

The most significant factor in the modification of the environment is that of radiation reduction. Certain herbacious plants are unable to survive in less than optimal incident sunlight whereas other plants require mesic habitats with low evaporative stress. For example, Baccharis seedlings when germinating and developing in a grassland will compete with the grasses on an equal level for light as well as for nutrients to a lesser extent. Soon, however, the Baccharis will dominate and reduce the light intensity to the understory grasses and "succeed" them. Similarly, oak and, to a greater extent, bay, will reduce the understory light intensity for Baccharis as well as grassland communities in which they develop.[24]

Thus, it may be conclude that oak and bay invading grassland and Baccharis brushland will eventually overtop and succeed in the absence of destructive agents. It is observed that oak woodland will be replaced by bay woodland in the absence of fire. Thus, bay woodland is the "climatic climax" (Diagram 1).

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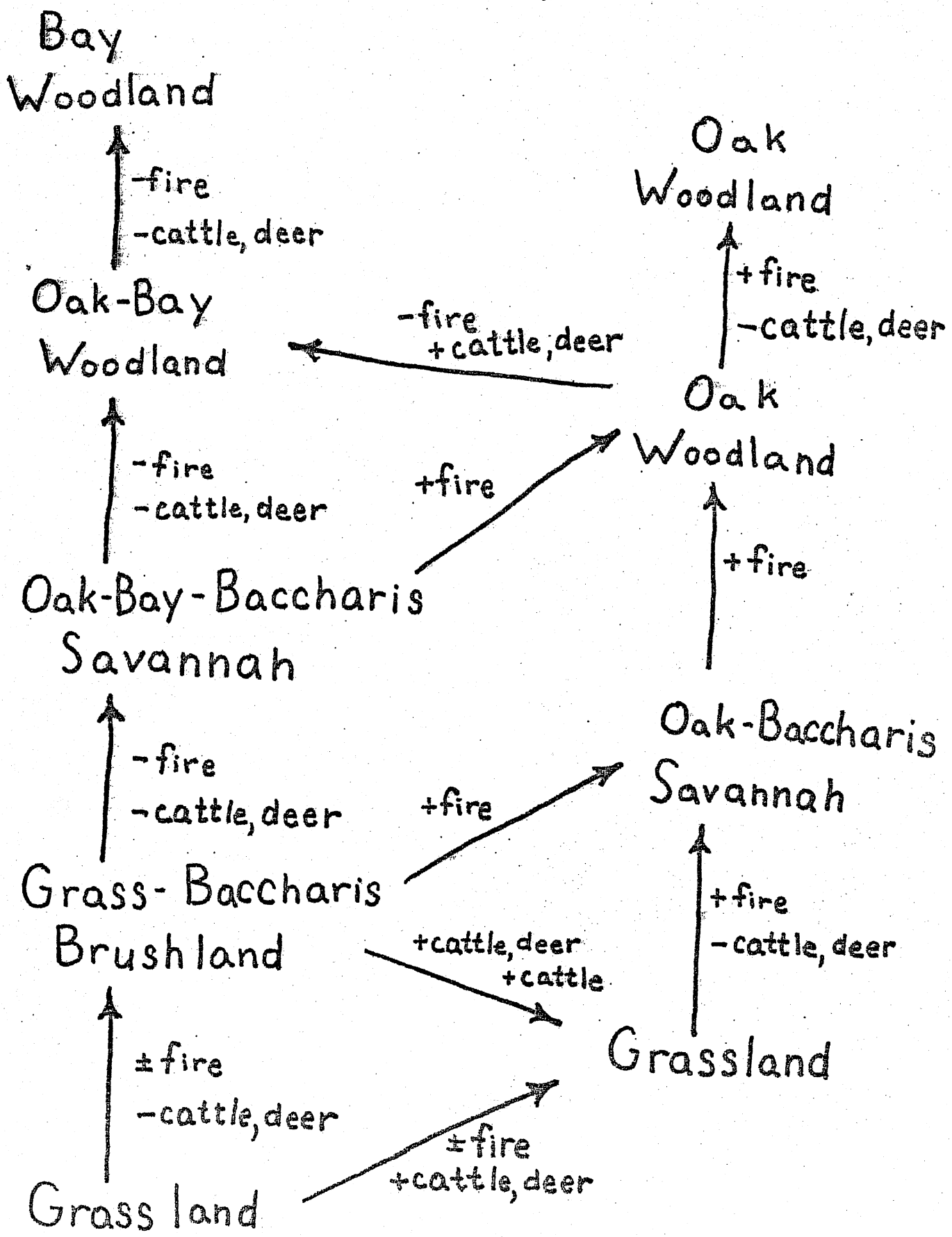
[22]op. cit., McBride, p.-32.

[23]Baker, Herbert G., Department of Botany, U.C., Berkeley, May, 1971.

[24]op. cit., McBride, p.-55-58.



PLANT SUCCESSION DIAGRAM

McBride, Joe R.

Wildlife

The natural stabilizing force in this ecosystem is its diversity. George Grinnell made this one of his considerations in establishing the Strawberry Canyon as a natural or primitive area in 1932 as a refuge for animals. The over 100 species of birds, some 40 species of mammals, 12 species of lizards and snakes, and six species of salamanders and frogs contribute their respective and essential consumer niches maintaining an "intact" biota(Chart 2).

An accurate estimate of a watershed's organic stability is made by examining the character and diversity of the aquatic and riparian fauna of the stream. Although it is known that trout planted in Strawberry Creek have a maximum longevity of three days, there is a gradient of water quality of the creek indicated by the presence of characteristic species. Stream bottoms in open areas, especially near roads, are found to have silty bottoms, a poor habitat for stream fauna. Where stream flow slowed down considerably and lentic or standing water pools formed, various fly and mosquito larvae and pupae were found. Communities of organisms of a healthy lotic stream, as found in portions of the creek, include mainly stonefly, mayfly, and caddis-fly larvae, and often oligochaete (worms) and flatworms (planaria). Stream dwelling organisms, in general were found to prefer cold, well-aerated waters with medium to high levels of hardness.[25]

The stream banks provide suitable habitat for the Prion mouse and the Dusky-footed woodrat whereas the meadow mouse, in

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[25]"Hardness" is an index of nutrient levels in the water.

Chart C

Strawberry Canyon Ecological Study Area

Partial List of Animals and their Respective Habitatat Preferences[1]

Grassland	Coastal Chaparral
Allen Hummingbird	Allen Hummingbird
Anna Hummingbird	Anna Hummingbird
Brewer Blackbird	Bewick Wren
Barn Owl	Brown Towhee
California Quail	Bush-tit
Cliff Swallow	California Quail
Bullock Oriole	Cedar Waxwing
Horned Owl	Fox Sparrow
Loggerhead Shrike	Golden-crowned Sparrow
Red-tailed Hawk	Lazuli Bunting
Red-winged Blackbird	Poor-will
Pine Siskin	Red-tailed Hawk
Robin	Scrub Jay
Sparrow Hawk	Song Sparrow
Turkey Vulture	Sparrow Hawk
Western Meadowlark	Turkey Vulture
	Violet-green Swallow
Western Toad	White-crowned Sparrow
	Wren-tit
Audubon cottontail	
Black-tailed jackrabbit	Arboreal Salamander
California meadow mouse	California Slender Salamander
Coyote	Western Toad
Botta Pocket gopher	
Deer mouse	Big-eared Myotis
Gray fox	California Myotis
Harvest mouse	Coyote
Mule deer	Gray fox
Opossum Raccoon	Long-tailed weasel
Striped Skunk	Opossum
	Raccoon
Western Fence Lizard	Silvery-haired bat
Northern Alligator Lizard	Striped Skunk
Western Skink	Trowbridge shrew
Western Terrestrial Garter Snake	Volant myotis
Western Rattlesnake	Yuma myotis
	Gopher Snake
	Common Kingsnake
	Northern Alligator Lizard
	Ringneck Snake
	Western Fence Lizard
	Western Rattlesnake
	Western Terrestrial Garter Snake

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[1]Stebbins, Robt. C., Seth B. Benson, & Ned K. Johnson, "Field Biology of the Vertebrates", Zoology 107A-B, U.C., Berkeley combined with Williams, John C. & Howard C. Monroe, The Natural History of the San Francisco Bay Area, McCutchan Publishing Corporation, Berkeley, 1970.

Oak-Bay Woodland

Sparrow Hawk
Red-tail Hawk
Great Blue Heron
Violet-green Swallow
Hermit Thrush
Robin
Vaired Thrush
Brewer Blackbird
Red-winged Blackbird
California Quail
Song Sparrow
Bewick Wren
Hutton Vireo
Purple Finch
Brown Towhee
Black Headed Grosbeak
Ruby-crowned Kinglet
Chestnut-backed Chickadee
Stellar Jay
Belted Kingfisher
Downy Woodpecker
Screech Owl
Killdeer
Mourning dove

California Newt
California Slender Salamander
Arboreal Salamander
Western Toad
Pacific Treefrog
Foothill Yellow-legged Frog
Red-legged Frog

Opossum
Trowbridge Shrew
Ornate Shrew
Red bat
Pallid bat
Raccoon
Striped skunk
Fox squirrel

Western Pond Turtle
Western Fence Lizard
Northern Alligator Lizard
Western Skink
Rubber Boa
Western Terrestrial Garter Snake
Ringneck Snake
Sharp-tailed Snake
Gopher Snake

Conifer Forest

Red-tailed Hawk
Screech Owl
Horned Owl
Cooper Hawk
Downy Woodpecker
Stellar Jay
Scrub Jay
Chestnut-backed Chickadee
Oregon Junco
Sharp-shinned Hawk
Vaired Thrush
Hermit Thrush
Ruby-crowned Kinglet
Audubon & Myrtle Warblers
Fox Sparrow
Western Tanager
Band-tailed Pegeon
Red-breasted Nuthatch
Brown Creeper
Purple Finch
Western Flycatcher
Olive-sided Flycatcher
Black-headed Grosbeak

California Newt
California Slender Salamander
Arboreal Salamander
Pacific Treefrog
Red-legged Frog

Silvery-haired bat
Red bat
Hoary bat
Fox squirrel
Beechey Ground Squirrel
Botto pocket gopher
Dusky-footed woodrat

Northern Alligator Lizard
Southern Alligator Lizard
Western Skink
Western Terrestrial Garter Snake
Ringneck Snake
Sharp-tailed Snake
Gopher Snake
Common Kingsnake

the family Cricetidae, prefers the more arid grasslands of the Berkeley Hills. There this species undergoes a three to four year cycle of population fluctuation.[26]

Population levels of such rodents which prey significantly on broadleaf foliage are held in balance by the significant number of feral house cats which occupy the niche of the extinct bobcat.

Frequently, streams on the north-facing slope of the Canyon are bordered by oak woodland with heavy understory. On the south-facing slope, riparian woodlands consist of grassland or herbacious vegetation. In both these habitat types are many birds and mammals. The deer population today is higher than it was prior to the arrival of European hunters.[27] Where, in the past, mountain lions kept the deer population at a stable level, the deer are now so numerous that they are creating problems at the Botanical Gardens.

Wildlife habitat requirements of many species are satisfied by a diversity of vegetation types, and often, in the absence of one form, a specific region may prove unsuitable for a species. This is particularly true for the California Quail. Where the Brown Towhees and Rufous-sided Towhees require brush habitats and the Song Sparrow, Robin, and House Finch depend on the stream community, the Quail need dry grassland areas for dusting, grain fields for a food supply, and cover need be in sufficiently close proximity

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[26]Csuti, Blair, Natural History of the Vertebrates, Zoology 107, U.C., Berkeley, 1973.

[27]op. cit., McBride, p.-46.

as well. Although there is, as such, the greatest diversity of birds at the grassland-stream-woodland interface, the Quail may indeed serve as an indicator of habitat diversity.

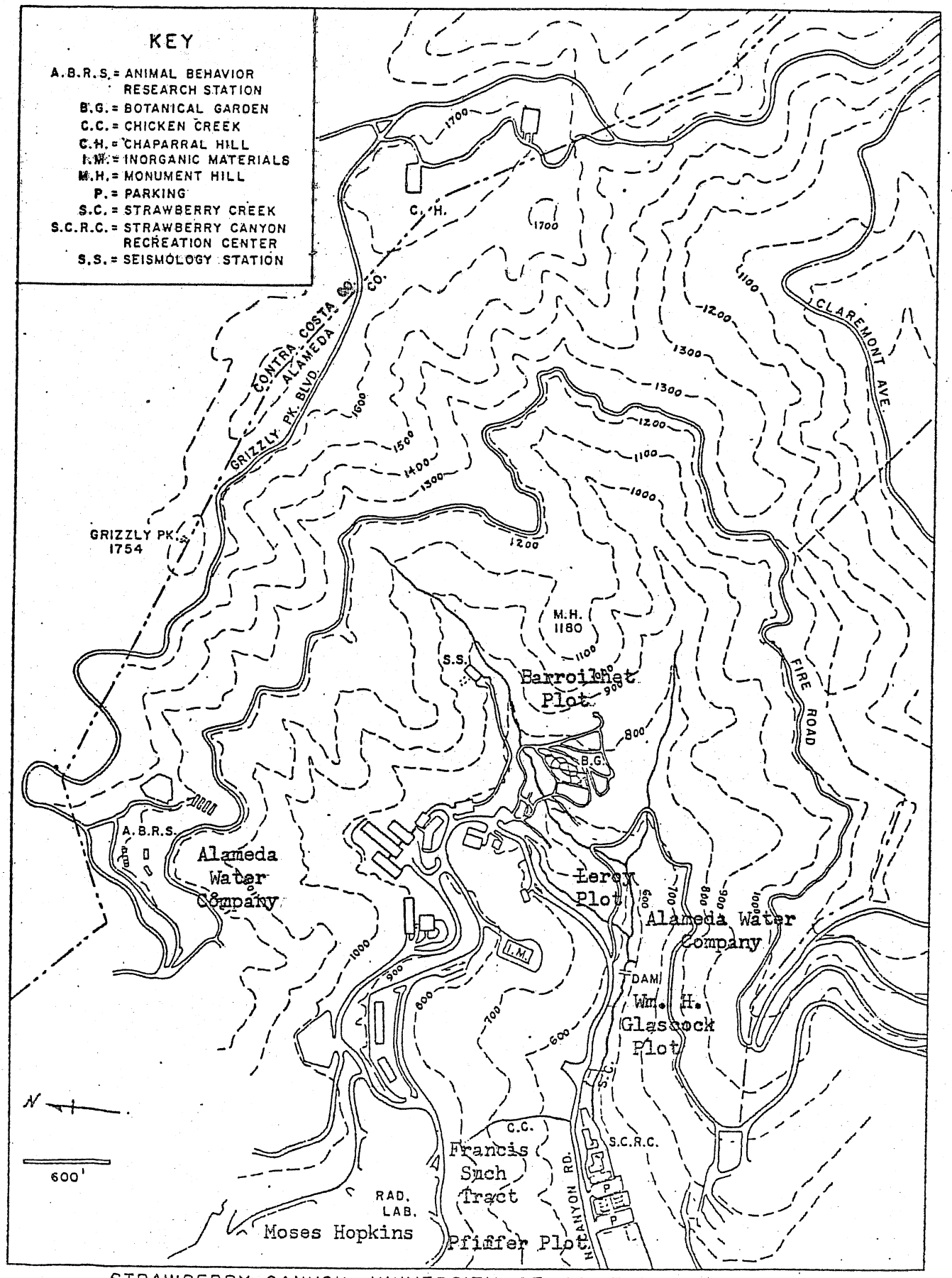
History of Uses

Of the entire spectra of biotic influences on the environment, white-man's manipulation of the ecosystem has begun the greatest number of seres of secondary succession. He has proceeded without hesitation or a brief glance at the complexity and balance which had been achieved by nature or the potential consequences which his actions may invoke. Prior to the entry of European man, the Castanoan Indians had achieved a steady state civilization. This they achieved by gathering the acorns born by the coast liveoaks and harvested the surplus of trout and other fish from Strawberry Creek. As well, the occurrence of herbivorous mammals and periodic fires maintained the oak-grassland savannah.

The first, and seemingly compatible recorded use of the lands of the Canyon was by the ranchoes of Vicente and Domingo Peralta. These were located in positions where today stand the Botanical Gardens. Near the end of the nineteenth century, the Canyon lands seem to have been divided among several individuals and the Alameda Water Company (Map 5). The largest plot of land appears to have consisted of forty-five acres and was the Glascock plot.[28] William T. Such and perhaps several other of the owners made clearings into the oak woodlands to encourage grass growth for

[28]Schultz, Mark, Aerial Photography, Forestry, U.C., Berkeley, 1972.

Map 5



STRAWBERRY CANYON, UNIVERSITY OF CALIFORNIA, BERKELEY

Sandow & Hopkins (1893) Map I-Frank T. Soule, Jr. (1874)

increased pasture lands. As noted earlier, the perennial grasses which were palatable for cows were then succeeded by weed-like annual grasses.

The land holdings owned by the Alameda Water Company were intended to be used primarily as a watershed to supply water for the growing East Bay community. Land acquisition generally encountered little impediment as most of the foothill lands were too rough and broken for agriculture. However, successful crops were grown without irrigation in the hills wherever small tillable areas occurred.[29]

The Alameda Water Company transferred titles assuming the name the East Bay Water Company. This firm later became the East Bay Municipal Utility District. This latter utility district began the development of managed watershed lands by planting the non-native E. globulus and P. radiata on the grass covered ridges around the Canyon in order to increase the water storage capacity following the omen that, "the rain follows the leaf". Somewhat further south, the poet Joaquin Miller similarly began importation and planting policies bringing pines and eucalyptus into the native redwood and oak climax communities on the East Bay Hills.

The developing University had growing needs for space as well as significant needs for a water supply. Thus in 1909, the Regents purchased lands under 55 deeds adding 257 acres. Into many of the newly gained acres, the Forestry Department brought numerous planting of pine and cypress, many of which were made as gifts

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[29]op. cit., Holmes, p.-2784.

from Regent Bowles. The stocks for the 1914-1918 plantings were raised in the Canyon.

The impact of the Great Depression was indeed left on the Strawberry Canyon as the task of the Civilian Conservation Corp camp stationed there was, "..to improve the appearance of the canyon, and to lessen its danger as a fire hazard."[30] Leaving the camp, which was located adjoining the newly located Botanical Gardens, early in the morning, "..examples of American manhood struggled into line in upper Strawberry Canyon, (to begin) clearing poison oak and sumac as well as begin constructing fire breaks and trails in the canyon."[31](Map 6).

There has been, in recent times, an increased use of the lower part of the Canyon with the development and utilization of the Haas recreation area. The infrequent flood in 1958 created $67,000 in damages to roads, drainage, and buildings near the campus. The retention basin was built in 1960 in an effort to avert the recurrence of such a disaster. The construction of the road to the Space Sciences building in 1966 was, four years later, covered with mud slides due to heavy rains and was closed for five months.[32] The development of the recreation plan proposal for the Poultry-Husbandry area is presently being finalized by the Office of Architects and Engineers.

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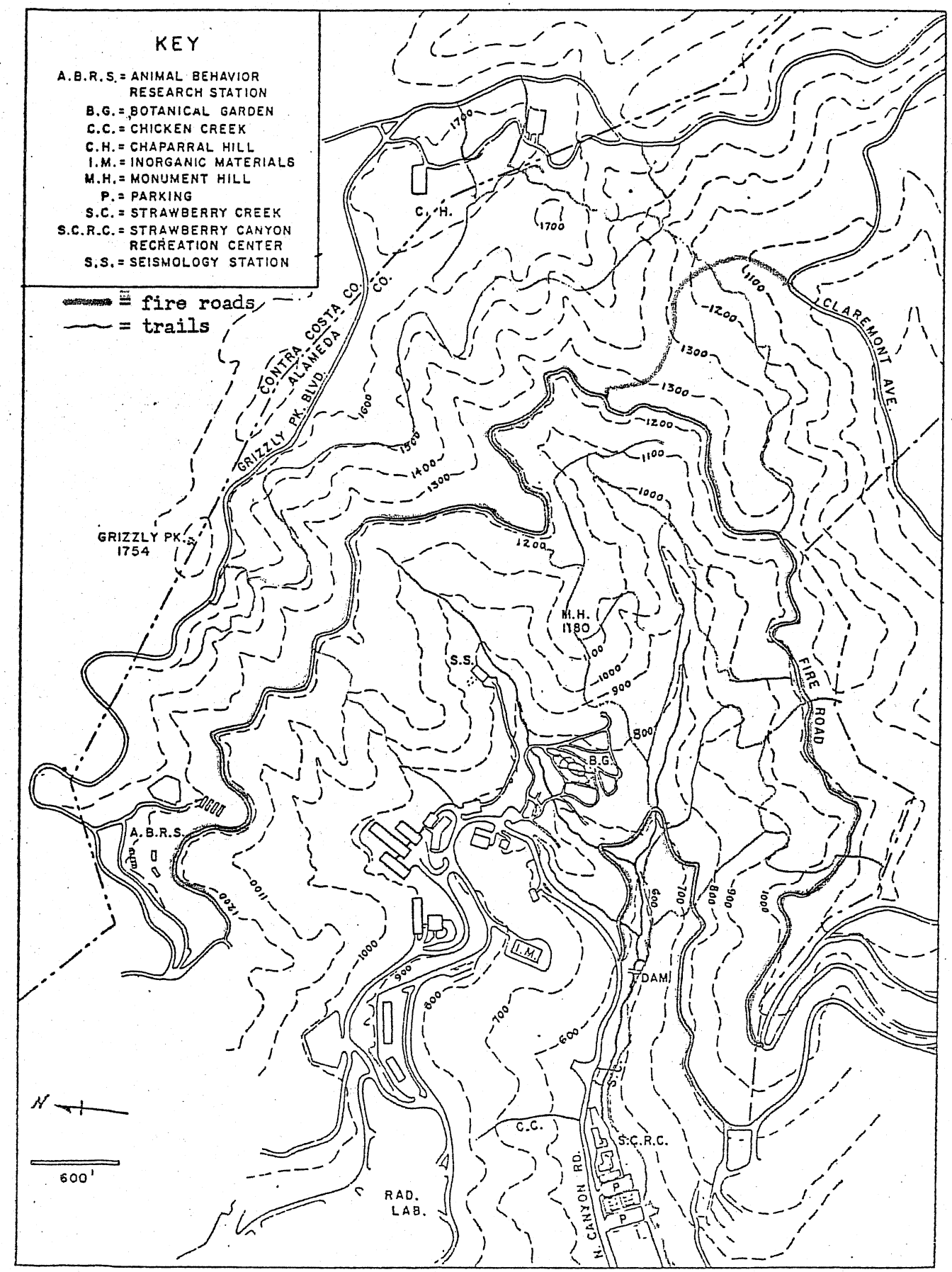
[30]Hughhill, E.A., Superintendent of Buildings and Grounds, Daily Californian, October 9, 1933, p.-1.

[31]Ibid.

[32]Falick, Arnold, Space Sciences Laboratory, U.C., Berkeley.

Map 6

Note: Not all of the roads and trails indicated were constructed by the 1930 CCC crews.



STRAWBERRY CANYON, UNIVERSITY OF CALIFORNIA, BERKELEY

Map 1

Since the Canyon's first establishment as a "Primitive Area" in the 1920's, the dominating land-use value for the Canyon has been as a natural environment amenable to compatible research and educational purposes. With such guidelines to protect existing primitive areas, further non-native plantings by the Forestry Department were to be limited. It was planned that such plantations, as they exist, would be maintained for the enjoyment of the public in general.[33] The Botany Department's past field activities of extensive plant specimen collection has been eliminated in accordance with the present sustained-use policies. It would appear on the basis of past actions and policy declarations that the Campus Planning Committee, which established the Strawberry Canyon Ecological Study Area in 1956, and the Office of Architects and Engineers are commensurate with the needs to maintain the "intact biota".

In 1968, an extensive study, chaired by Howard V. Daly, was conducted to accumulate evidence of the scientific and educational values of the natural areas on the Berkeley campus. A significant number of Master's and Doctoral theses, scientific publications, and regular course studies were found to be based upon the biota of the Canyon. In response to this study as well as to a strong expression for the preservation of the area voiced by the campus community, Chancellor Rodger W. Heyns rededicated a portion of the Canyon as an Ecological Study Area in 1969.[34] Despite its character as an

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[33]Campus Planning Committee and the Office of Architects and Engineers, "Long Range Development Plan", U.C., Berkeley, June, 1962, p.-30.

[34]Siri, William E. & Frank T. Lindgren, Berkeley Campus Committee on Conservation and Environmental Quality, May, 1972.

area of controlled development, the consensus of opinion appeared to be that the Canyon would be best used as an interpretive center, demonstrating the use of this scientific resource and environmental sciences laboratory for the benefit of the University academic community.

B. Purposes and Means of Ecosystems Management

Introduction

The goals of management of an ecological study area involve maintaining the natural features, as described in the preceeding thesis on "characterization", and values for research, education, and compatible recreation for which the reserve was originally established. The Strawberry Canyon watershed contains a diversity of utilizable educational resources. In order to fully employ the potential values for research and education of this ecosystem, the attempt must be made to consider the interests and needs of the various related departments within the University. To preserve and enrich the natural features will often require considerable diplomacy and experience with such matters due to the diversity of departmental needs.[1]

The management needs and respective policy recommendations for the landscape and biota need be given emphasis, for without the maintenance and enrichment of the of the system's stability and diversity, the integrity of the reserve is threatened. A "systems" approach to management is thus essential because programs may differentially affect the various factors of the environment. For this reason, a variety of programs such as prescribed burning, biological, or other 'ecological factor level adjustment' may prove beneficial. Because of the review of the significant activity within the Ecological Study Area by groups such as the Chancellor's committee on Conservation and Environ-

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[1]Daly, Howell V., Chairman, Subcommittee of the Subcommittee, "Final Report on Documentation of Scientific, Educational, and other Uses of the Natural Areas on the Berkeley Campus.", Landscape Architecture Advisory Subcommittee, University of California, Berkeley, 5-1-69, pp.-20-29.

mental Quality, extensive management policy implementation has been minimal.

The purpose of this analysis is to survey the objectives of management of the Ecological Study Area as set forth by various interests and to suggest means by which compatible goals might be attained.

Vegetation

The flora of Strawberry Canyon represents a mosaic of habitat diversity which is of comparable in overall utilizable education value to many reserves within the State. It is necessary to preserve such East Bay watersheds in order to maintain examples of native plant communities and viable forest plantations in the advent of the expanding megalopolis. A valuable instructive exercise may be undertaken in the recognition of the vegetation zones as separate communities since each community type differs in its environmental resistence to factors, productivity, vulnerability to fire and disease, and other aspects(Map 7). A prime objective of vegetation management should thus be the maintenance of native areas in the Canyon with a minimum of non-native introduction, such that, succession, the overall development of a climax formation, might be studied.

The plantations of pine made early in this century by the Forestry department, partially supported by grants from Regent Bowles, and the eucalyptus plantations of the People's Water Company, presently cover over a third of the area.[2] As well, plantings

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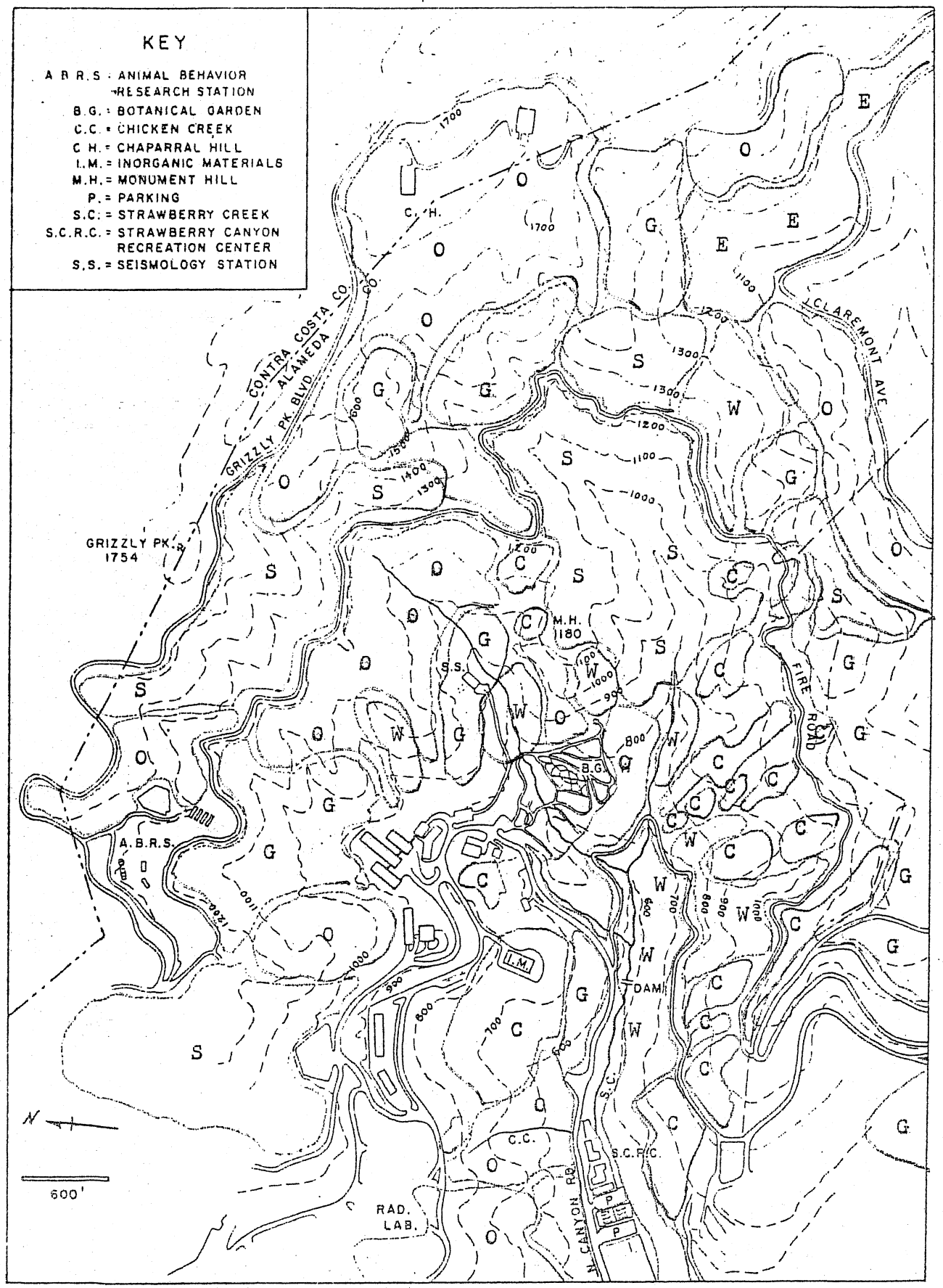
[2]Stebbins, Robert C., "Ecology, Esthetics, and Campus Growth", 6-6-68, p.-9.

Key

G - Grassland
S - Northern Coastal Scrub
W - Oak-Bay Woodland
C - Conifer Plantations
E - Eucalyptus Plantations
O - Oak-Grass Savannah

Map 7



STRAWBERRY CANYON, UNIVERSITY OF CALIFORNIA, BERKELEY

Map I

of coast redwood, spruce, and douglas fir were made on the northeast-facing slope near the top of Monument Hill. While it is thought by many that non-native plantations should not be expanded in size, it has more distinctly been pointed out that, "The vast tracts of man-planted forests in our hills have had a great deal to do with the disappearance of wildflowers from the local scene."[3]

It has been recognized by several Forestry department faculty that little use is presently made of the stands. In the cold spell of December, 1972, one-third of the Canary Island pine plantation in the Canyon was "killed". However, this species sprouts epiquormically from dormant buds after such catastrophes as does Blue Gum.[4]

The apparent mortality of the eucalyptus plantations within the Canyon, which cover approximately 270 acres of University property, will require a long-range use-management program.[5] Were these plantations removed by selected cutting in combination with prescribed burning, the area's establishment with oak and other native hardwood seedlings could be supplemented as needed by the University Botanical Gardens.

Alternatively, "Aside from their value as models of commercial forest stands, the pine plantations are of more general interest in showing what the exotic trees can do over an extended

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[3]Ornduff, Robert, President, California Native Plant Society, 2-20-73.

[4]Stone, Edward C., School of Forestry, U.C., Berkeley, 1973.

[5]Lauer, Donald, Infrared Photography, U.C., Berkeley, 1-22-73.

period of time when planted in this locality. (They also illustrate) the principles of timber stand growth and development."[6] Although there normally is found an increase in wildlife diversity and population density at community ecotones due to the provision of proximal differing habitat requirements, "Too abrupt community boundaries have (occasionally) hindered wildlife."[7]

It may be the case that certain plantations seem vigorous and sufficiently adapted to remain viable indefinitely and, in these cases, associate understory growth for those communities might be introduced. Extreme caution must be exercised in the timing, composition, and spacing of these plantings. Certain difficulties may arise with the invasion of non-natives such as the Red Alder.[8] With suitable management, truly complete examples of other forest biomes could be made available for comparative ecologic studies.

In circumstances similar to those in Strawberry Canyon, "maintaining communities becomes rapidly more difficult as their size decreases and as the number of exotic species or communities increases."[9] A fine example of the local natural sere could be represented if, as selected trimming of the plantations is carried out, the re-establishment of endemic species is encouraged through techniques of fire and the less-easily controlled herbi-

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[6]Stone, Edward C., "Special Report on Strawberry Canyon", Committee on Land Use and Facilities, College of Agriculture, U.C., Berkeley, 1954, pp.-1 & 2.

[7]Zimmerman, J.H., Arboretum Director, University of Wisconsin, 5-18-72.

[8]Ibid.

[9]Ibid.

vorous mammals.

By the encouragement of native species, it would be possible to realize the educational potential of the Canyon through differential management of different areas.[10] Ideally, three regions might developed(Map 1). In one portion, the preservation of the existing vegetation could primarily be used for the appreciation and re-education of the users. In another portion, succession might be withheld. The third region might be enriched with native species.[11] By dealing with native species exclusively, environmental factors can be modified selecting for particular stages of the Berkeley Hills plant succession seres by a qualified "leg-man" or management staff.

Since the four primary indicator Genera, Avena, Baccharis, Quercus, and Umbellularia, differ in their seed dispersal, in growth in different light environments, in ability to modify this environment, and in response to browsing deer, selection pressure can be applied through prescribed burning as well as by herbivore grazing pressure. The absence of grazers, as was the case in the recent fossil past, a natural condition would be at hand for fostering the re-creation of a perennial bunch grass habitat. The conditions would be optimum for the introduction of such natives following the (proposed) removal of the eucalyptus plantations in the Canyon. Significantly, such

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[10] Baker, Herbert G., "Report of the Task Force on the Management of Ecological Areas on the Berkeley Campus", LAAS, U.C., Berkeley, 3-10-70, pp.-1 & 2.

[11] Ibid.

species as the diploid and tetraploid plantations of Erharta erecta and the endemic Deschampsia caespitosa seem to resist the encroachment of Baccharis pilularis without the aid of grazing animals.

By maintaining a portion of the annual grassland, Avena fatua, adjacent to baccharis-brushland, the effects of exocrine influence of such aromatic species at the interface could be analyzed by students of plant physiology. Other needs such as those for soil retention may be coordinated with the encouragement of oak and bay unit replacement of the brushland and grassland units. During the early Spring after a burn following an appropriate prescription, for example, of a coastal scrub unit, the burned area could be innoculated with a perennial rye grass such as Lolium perenne and the appropriate rhizobia.[12] By reburning, to kill seedlings and sprouts of the prior coastal scrubland, an oak-bunchgrass savannah could then be successfully established with minimal difficulty.

It is possible to direct plant succession by careful manipulation of natural environmental factors such that future successional stages can be predicted on the basis of existing vegetation cover. The establishment of a range of representative seral stages will necessarily be a long-term project in need of qualified personnel. This quite feasible approach can be carefully "tailored" to meet the "overall" goals and needs of research and education.

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[12]Biswell, Harold H., Fire Ecology, School of Forestry, U.C., Berkeley, Winter, 1973.

Wildlife

The maintenance of a biota representative of native communities prior to man's influence, an "intact biota", requires that as many parts of the natural ecosystem be represented as possible. The vegetation-soil complex need provide a combination of suitable compliment of habitat requirements in order to maintain a significant carrying capacity for the diverse association of animals essential to the integrity of this reserve. Quite consisely it has been recognized that, "Small creatures out of a dawn world - arboreal salamanders, lungless amphibians, bracken, and ferns - live along North Strawberry Creek but it will take more than a committee recommendation to save them."[13]

In order to vary the habitat carrying capacity for a particular species, the habitat must be modified in such a way as to alter the level of a particular limiting environmental factor. Such a factor, whether it be the supply of food, cover, water, space, or other special requirements, is one in which the slight variation of intensity strongly effects changes in a population's stability.

Due to the rather poor Summer flow of Strawberry Creek, the maximum survival rate of three days for trout planted could be due to their inability to migrate through culverts and across terraces. Creek flow could be maintained all year without augmentation by Utility District sources. This would be possible if a catch basin or small reservoir could be built in the Middle

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[13]Stebbins, Robert C., Campus Report, Vol. II, No. 14, 6-5-68.

Canyon to retain and release slowly the winter run-off. Redesigning culverts into wider gravel-bottom passages, or small bridges would allow aquatic species to migrate the length of the perennial flowing stream. In this form, a catch basin might provide a better habitat for fish and animals.

An index to the levels of diversity of habitat space and the steady state stability of the Canyon ecosystem is the number and size of quail (Laphortyx californica) covies within the watershed. Their habitable landscape requires food, water, nesting and roosting cover, and dusting areas, all within sufficient proximity of one another to allow the presense of a breeding population. For the satisfaction of the frequent limiting requirement, water, a dam and pond established part-way up the Canyon would increase wildlife habitat. The disadvantage in this would be such a pond's use as a mosquito breeding grounds. Paricularly, this would be hazardous today with the potential for an outbreak of encephalitis. The quail in the proper habitat may coexist with predator populations of feral cats which do exist in sufficient number varying in a density dependent manner with the quail and other bird prey population sizes within the Canyon.[14] In certain portions of the Canyon where sufficient areas of seed bearing grasslands, brushland cover, and oak-bay roosting cover may be available in adequate proximity to one another, such as atop Chaparral Hill, water may be the factor limiting the presence

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[14]Schmelzer, Lawrence L., Environmental Health and Safety, U.C. Berkeley.

and growth rate of quail populations. In this case, the installation of a Glading's gallinaceous guzzler to provide water would provide the needed resource for quail as well as for other species.[15] The effects of programs of prescribed burning would be beneficial for quail in that seed providing annual and perennial grasses would be the fire disclimax pioneers with more frequent scattered dusting grounds. As well, a certain amount of brushland cover would be reduced by the use of fire, a natural factor in the Canyon's past. With the cooperation of prescribed burning plans, Forestry department plantation, recreation, and other uses of the Canyon, significant populations of many different vertebrates could be carried by appropriate habitat requirement provisions such as would be compatible with the integrity of the reserve.

One of man's effects upon the wildlife environment has primarily been to reduce the available food supply by his suppression of fires. The frequency of grain and herbaceous shrubs is reduced markedly in the closed canopy morth-facing woodlands. For health reasons, there is vigorous selection against skunks and perhaps other small mammals which have been known to be vectors of rabies and other diseases. This has been known to be the case despite the fact that, "The efficacy of carnivore killing as a measure to control rabies has not been proven."[16] Automobile traffic has introduced a mortality factor for deer and rodents

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[15] Glading, B., "A Self-filling Quail Watering Device", California Fish and Game, 29(4):157-164, 1943.

[16] Leopold, A. Starker, IDS 170, U.C., Berkeley, Fall, 1972.

within the Canyon which does, in a density dependent manner, control the population size of these animals.

Watershed

The interdependence of all of the biota of this ecosystem, which is distributed over a diverse topography, emphasized as all the components are contained within one watershed. In this respect, a landscape change within one portion of the terrain may induce changes in the stability of other components in the system. Thus, the Canyon, "..(forms) an intact hydrological system that is essential to the ecological integrity of the area."[17]

The quantity of rainwater runoff from watershed lands varies with different ground and vegetation cover of the landscape. The maximum annual quantity of water released from a watershed is something less than the annual quantity of precipitation received by it. Other natural factors influencing the rate of runoff include such factors as the periodicity and duration of periods of rainfall. The weather types immediately before and after also influence the transpiration rate of the ground cover, herbacious vegetation, and woodland communities. Thus, there can be exercised some latitude in the management of watershed lands.

Man's activity in the Strawberry Canyon over the past century has involved the compaction and paving-over of many areas, allowing the winter run-off to be higher and the storage lower than in prior times. With impervious surfaces continually being added

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[17]Siri, Wm. E. & Frank T. Lindgren, Chancellor's Committee on Conservation and Environmental Quality, 5-25-72.

to the watershed lands, such as blacktop and rooftops as well as a generally increased soil compaction, there is an increase in the runoff rate and a slowing of the infiltration rate. Soil compaction also slows the rate of transpiration of water by plants per given unit area. An unusual example of the direct consequences of such landscape changes occurred in 1962 when fifteen inches of rain fell in a short period resulting in the washing out of a significant portion of the Botanical Gardens as well as the flooding of the Haas recreation area and the International House lobby.

A short time thereafter, the retention basin was constructed in the Canyon a short distance above the Haas area capable of withstanding the impact of the '25-year flood'. An attempt to alleviate part of the high run-off rate immediately following rains could be accomplished by curtailing further road building, paving, and construction activity within the Canyon as well as by increasing the ground water flow rate through selective vegetation management. With the advent of tree plantations over what by nature would have been chaparral, oak-bay woodland, coastal scrub, and grass-oak savannah, the drainage has been affected.[18] These conifer plantation units have somewhat greater water retention ability.

Directly related to the infiltration rate of water into soils of varying field capacities is the potential for landslide. Almost annually, along various portions of the Jordan fire trail,

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[18]Stebbins, Robert C., Museum of Vertebrate Zoology, U.C., Berkeley, 3-13-73.

slides must either be cleared from or filled by members of the University Police Department Hill Patrol in order to maintain fire and police department accessibility to various portions of the Canyon. Following slides, which occur periodically in the Canyon, gooseberry, blackberry, and coyote brush are opportunistic via propagule dispersal in such areas and begin seres of secondary succession upon such areas. Alternatively, man has often planted ice plant ice plant on graded slopes resulting in soil slumpage with the plants in the next hard rain. Other more substantial means include the plantation of waddlecreek willow and genista which have extensive root systems. These efforts as well as the use of subsurface drainage lines are employed on the south-facing slopes above Centennial Drive.[19]

The Canyon, which has high slumping and erosion hazards, has been recognized as being best suited only for range use.[20] The more intensive land-use programs there have thus been accompanied by proportionate erosive soil displacement. As has been observed in the East stream, pools and creek beds that were heavily silted and their flow reduced, were conducive to simplified communities.[21] Single species such as mosquito larvae predominated, or else just a general paucity of aquatic life prevailed. This has been seen quite readily in the siltation after the retention basin.

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[19]Inouye, Ari, Senior Landscape Architect, U.C., Berkeley, 2-21-73.

[20]Welch, L.E., "Report and General Soils Map of Alameda County, California", U.S. Department of Agriculture, Soil Conservation Service, 1966, p.-51.

[21]Erman, Don C., School of Forestry, U.C., Berkeley, March, 1973.

In addition to the soil holding tree species mentioned, grasses play a vital role in impeding gully erosion. Attempts should also be made to introduce, "..comparatively stable, perennial cover (such as native bunch grasses) rather than an ephemeral cover which, among other things, is of little value in controlling erosion."[22]

Although the quality of the water in Strawberry Creek is likely to be higher than that of the other twenty streams of the East Bay, significant coliform counts have been recorded.[23] The north fork of Strawberry Creek shows more sterility in vegetation and aquatic faunal forms. This may perhaps be due to the heavily shaded and steep California bay woodland at the headwaters and overbearing eucalyptus trees and debris over and near the water. Perhaps also some bacteriological and allelopathic pollution has affected that portion of the Creek. Diversity indices may have been used to detect and evaluate pollution such as from the source at the Animal Bioradiological Laboratory.[24] The health department has concluded that, "If the ultimate goal is to restore the Creek to a state supporting aquatic life, it might become necessary to provide an expensive Campus sewer system to divert street run-off from lawn watering and rains."[25]

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[22]Sinclair, J.D., "Soils and Plant Development", M.S. thesis, Forestry, p.-32.

[23]Noble, John W., "Its Name Was M.U.D.", EBMUD, Oakland, 1970, p.-148.

[24]Grove, John, "First Progress Report: Strawberry Creek Pollution Study", Environmental Health and Safety, U.C., Berkeley, 3-16-71, p.-11.

[25]Ibid., p.-10.

Fire Hazard Management

The impact of the supression of naturally occurring fires within the Canyon ecosystem need be considered in developing a management scheme. However, fire's "natural" context need be altered and used as "prescribed burns" so as not to inflict catastrophe upon any of the surrounding residential areas. In times prior to the purchase of these lands by the University, it is believed that the vegetation was in an oak-grass savannah fire disclimax where periodic fires held back the development of non-fire adapted shrubs and trees such as bay.[26] At this time there was no fear of wood smoke which may have contained poison oak vapors.

Unless certain management precautions are taken immediately, man's impact on this landscape may become self-destructive.. Without prior impact analyses, Frank C. Havens, and others, instigated the plantation of various species of the non-native Genus Eucalyptus. Eucalyptus is prone to fires by the heavy fuel accumulation contributed by its annual shedding of bark and its oil rich leaves.

Since the significant apparent mortality among the Canyon's plantations caused by the cold spell of December, 1972, the likelihood of the ignition of such fuels developing into an unmanageable "firestorm" seem very high.[28]

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[26]McBride, Joe R., "Plant Succession in the Berkeley Hills", 1969.

[27]Monteagle, Monte, "Eucalyptus Installments", East Bay Regional Park District, 1973.

[28]Biswell, H.H., Fire Ecology, School of Forestry, U.C., Berkeley, 1973.

Although the need for preliminary impact studies is apparent, these needs are almost dwarfed by plans of many of the local agencies to immediately log the eucalyptus plantations. There are strong indications, as well, that insufficient investigation will be done prior to the re-plantation of other species which may, in turn, invoke unanticipated difficulties at some later time.

Prior to the completion of fuel combustability analyses on "test burns", the creation of "fuel breaks" by the removal of litter from the understory would seem effective to partially reduce the hazard.[29] The largest portion of combustable materials can be safely removed with ecologic compatibility by the careful use of prescribed burning.[30] (This strategy is presently nearing formal completion by the author.) However, as alluded to earlier in this study, attempts need be made for the restoration of the native bunch grass re-establishment within these extensive partial clearings in the Canyon. Although certain groves of eucalyptus should remain in the more innocuous regions for educational and research purposes, where the potential for ignition of these fuels is the greatest, such as on the borders of Claremont and Grizzly Peak Boulevards, logging operations followed by the removal of six to twelve inches of the stump below the soil surface with burning afterwards should be carried out.

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[29]Chancellor's Committee on Conservation and Environmental Quality, 2-23-73.

[30]Fremming, Hal E., "The Fire Ecology of Eucalyptus in Strawberry Canyon", Forestry 205, U.C., Berkeley, Winter, 1973.

User Impact

Since the onset of fire suppression policies at the time of the University's acquisition of the property, land-use has been primarily designated to educational, research, or recreational purposes with the exception of the property now occupied by the Lawrence Berkeley Laboratory. The landscape has remained in its umanaged and relatively undisturbed state in large part due to its diverse topography and, thus, natural influences predominate.

Although 41 regular courses in 13 departments with an estimated annual enrollment of at least 4,374 students use such natural areas in class work, the impact on vegetation today is insignificant relative to what has been in prior times, when students of botany and zoology were encourged to collect samples of various species as a field exercise.[31] It had been asked in 1954 that the school of Forestry, "....share in the responsibility for the developement of a maintenance policy for the Canyon, inasmuch as the members were competant in the field of fire control, planting and general silviculture." [32]

Graduate students of the natural science departments have compiled research finding pertaining to various portions of the Canyon biota. In total, 39 Masters and Doctoral theses have been based, at least in part, on the areas as well as 110 scientific publications, and faculty member of five departments have based publications and research in the areas.[33]

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[31] op. cit., Daly, p.-21.

[32] op. cit., Stone, p.-4.

[33] op. cit., Daly, p.-22.

In contrast to the more compatible forms of recreation engaged today in the Canyon, the campus youth populus of prior times engaged in periodic activities to make the area more suitable for recreation. Such attempts included the annual Trail Day or "work day" in the Canyon when trail clearing and maintenance efforts were carried out. In 1950, a valid attempt was made on the part of non-allergic and enthusiastic members of the student body to remove a large portion of the poison oak, Rhus diversiloba, growing in the Canyon. Constructive efforts of the student body today include such efforts toward preservation as the annual Spring cleanup which, with the assistance of the Campus Hill Patrol, was successful in removing numerous gunny sacks of litter and refuse left by the more inconsiderate of the Ecological Study Area's users.[34]

Fortunately, the utilization of the Canyon today is of a far more compatible nature exemplified by the ecology students, joggers, hikers, garden visitors, sightseers and, lovers. With the shift in interest among the academic community from molecular biology to the environmental sciences, the use levels of the Canyon fluctuate. Inspite of the more harmonious uses made in the Canyon, the principle of the carrying capacity of the landscape is equally applicable to "people management" as it is to principles of wildlife management.

The tradegy of any "commons" inevitably occurs whereby there is mis-use of any public resource. Presently, vandals as well as motorcyclists inflict injury to the landscape by the defacing of many of the natural features. Planting of poison oak and blackberry

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34 Collins, Patricia, Environmental Health & Frank Lindgren, LBL, 1972.

might prove helpful to inhibit the entry into the Ecological Study Area of motorcyclists by such means as on the sides of the recently erected natural fence on the Claremont fire trail as well as at the various entrances from Grizzly Peak Boulevard to the Chaparral Hill area (see Figure 1).

Although the majority of the recreation traffic is not interested in traveling the steeper portions of the Canyon slopes, the talis on the hills in the Canyon is lightly poised and ROTC boots cause erosion as well as disrupt salamander and lizard habitats.[35] The use-intensity level planned for in the plan for the development of the poultry-husbandry area should significantly influence the use levels of the lower portions of the Canyon.

The traffic which, as noted earlier, introduces a significant mortality factor for wildlife within the Canyon and to a certain degree, is in conflict with the aesthetic and scientific values of the Canyon. As a significant portion of the traffic using this minor access road is for recreational purposes, the possibility of the enclosure of the road to public traffic should be considered. Without significant difficulty, the LBL and Space Sciences shuttle bus lines could be made available for traffic to the Botanical Gardens, the Haas area and, the Lawrence Hall of Science. In this way, there could be a reduction in the present extensive parking facilities in the Canyon allowing for lower rainfall

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[35] op. cit., Stebbins.

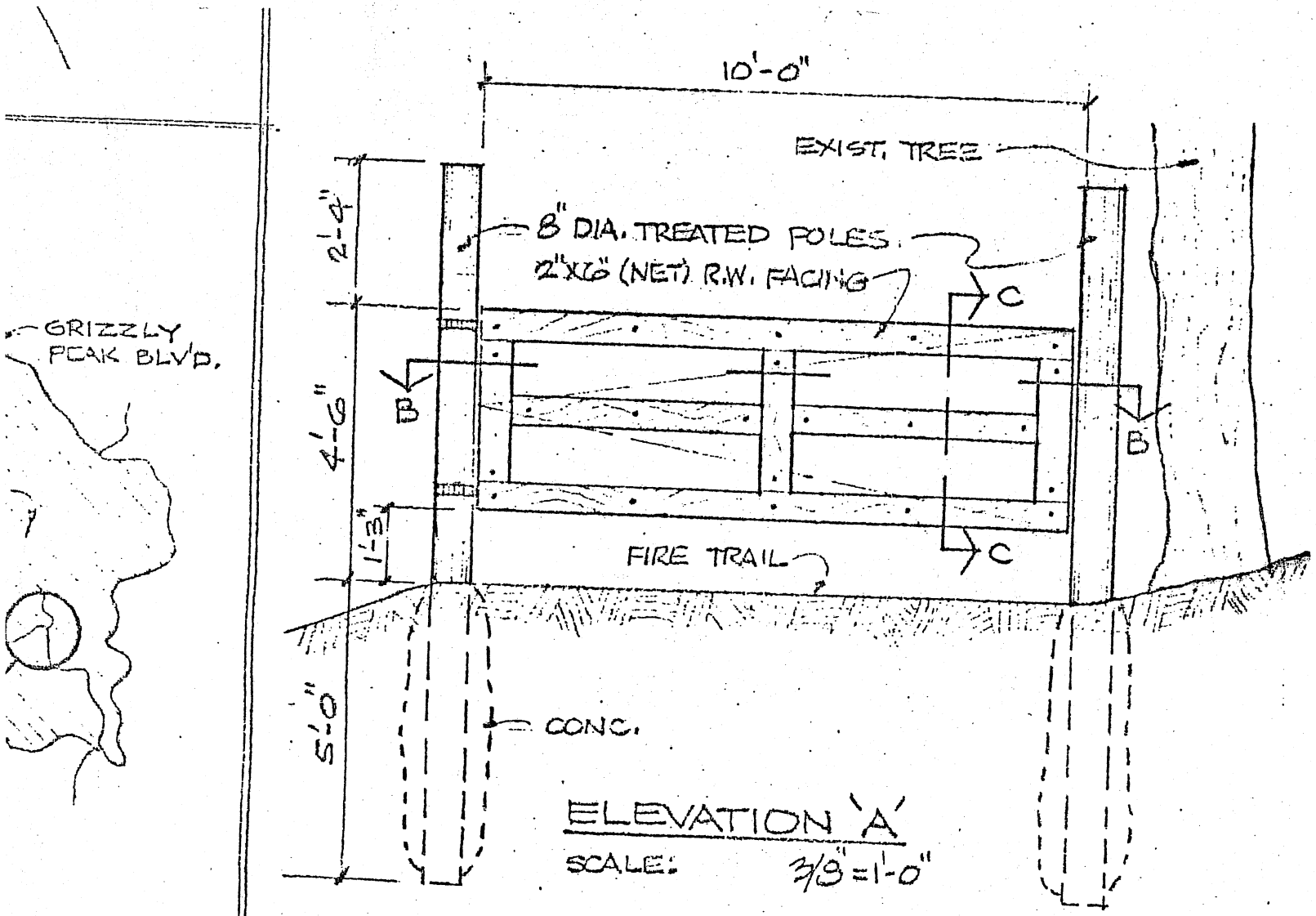

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Figure 1

NO. (190)	UNIVERSITY OF CALIFORNIA DEPARTMENT OF PHYSICAL PLANT 2000 CARLETON STREET BERKELEY, CALIFORNIA	DRAWN HULL CHECKED APPROVED	SHEET TITLE GATE & FENCE DETAILS	CAMPUS BERK SCALE AS NO

runoff rates as well as a slightly lower gasoline consumption and photochemical smog production rates for the Canyon. Particularly, after the results from the recent Institute of Transportation and Traffic Engineering survey of Centennial Drive traffic patterns are analyzed, a determination of the attributes of the installation of a tramway linked to public transportation might be made to the Lawrence Hall of Science.

The objectives of "compatible use" indicate that the best policy would be, "...to maintain a 'living' outdoor laboratory near campus for studying ecological phenomena associated with such academic disciplines as botany, zoology, entomology and others."[36] As such, attempts at management should continue to maintain natural ecological relationships and to suppress the Canyon's use as a recreation area in order that, "...the survival of plant and animal elements is assured in a form to provide maximal educational and research benefits."[37]

An excellent opportunity to inform and educate the public as to the need for the maintenance of such proximal "wilderness" study areas is the developement of brochures describing the purposes of the study area reserve. Such brochures could be placed at the foot of the Libby-Warnke trail near the entrance to the Haas area available for those interested merely in a short "walk in the wilderness." Along this trail could be placed placards identi-

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[36]Cheatam, Norden H., University of California Field Representative, 1-18-73.

[37]Ibid.

fying the local endemic shrubs and vegetation types. The accompanying brochure could point out various of the impacts upon the landscape which have unintentionally altered natural succession patterns occuring in the Canyon.

Particular note could be made regarding the presence of the, "...profusion of exotic species present in the forest plantings having an arboretum-like quality which adds to the resources of the neighboring botanical gardens.".[38] Such trails as this and the lower and upper Jordan fire trails could prove to act as public access corridors for researchers as well as "nature trails" for the interested academic public and aerobics enthusiasts. (Map 6).

The Botanical Gardens, located a short distance futher up the Canyon, has more extensively, through the use of formal plantings, developed programs to inspire public interest in the native and non-native flora of the biosphere. There exists an excellent opportunity here as well to provide information to the public about the various attributes and uses of the Ecological Study Area as well as to act as a field center in providing to qualified graduates and undergraduates proper field information and instrumentation for studies in the Canyon. In this way, "If the Canyon enjoyed limited access,...the Gardens could act as (a gateway to Strawberry Canyon, or) an agent both for maximizing the legitimate use of the Canyon and as a checkpoint for controlling its use.".[39]

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[38] op. cit., Stone.

[39] Laetsch, Watson M., Department of Botany, U.C., Berkeley, 5-4-70.

Implementation

Assuming that the prior recommendations might be considered as guidelines of management, the question remains--"which" of the remaining wild areas limited by "what" boundaries should be managed by "whom"? Presently under the auspices of the Campus Police Department, the two-man Hill Patrol serves a diversity of functions primarily assigned to preserve and maintain the University's 360 acre Ecological Study Area in Strawberry Canyon. This team provides a limited public information service to users of the Canyon as well as to local fire departments and neighboring residents, patrols the premises and, with qualified disgression, selects against incompatible recreation forms as well as maintains accessibility, and when necessary issues enforcement citations. Perhaps to the benefit of only certain factors of this environment it has been admitted by the Department that, "Conservation and use of the Strawberry Canyon Ecology Area depends on what the people want."[42]

There need be a local management committee such as the present CEQ subcommittee to maintain an advisory function, primarily. Representatives to this committee should be drawn from the various departments (Zoology, Botany, Entomology, Soils, etc.) and other legitimate user groups, such as hikers and runners, as well perhaps as ex-officio consulting members from the Haas Recreation area, the LBL, and the Botanical Gardens. The responsibility of such a committee should be to maintain the integrity of the reserve by the review, for example, of experiments involving the manipulation or extraction of plants and animals by users.

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[42]Daily Californian, U.C., Berkeley, April 29, 1971.

"Those who do the deciding must weigh the competing proposals with an eye on the computers, an ear to the immediate needs, and with their thoughts on the future."[43]

Through recognition of the conflicts of interests and the variety of uses that existed, the need became evident for a policy review committee representing the diversity of interests present. This need was met in the formation in 1955 of the Interim Subcommittee for Planning of the Strawberry Canyon Area.[44] With the passage of time, the number of jurisdictions over any piece of land increases nearly geometrically. The resulted has been quite complicated as the land lies within the, at least, partial jurisdiction of no fewer than sixteen agencies.

Suggested to coordinate the utilization of the Ecological Study Area has been the creation of a Land-Use and Vegetation Management liason officer who could relate the objectives of all pertinent groups. He would as well maintain contact with adjacent home owner associations. Secured might be the advice from such groups as the Saratoga Foundation, the University of Wisconsin Arboretum, (~~Appendix 1~~), and authorities qualified to deal with particular problems as they may arise. ~~As described, "This~~ executive ~~or coordinator~~ (~~as he has been~~ called) would need some secretarial assistance or, at least, assistance by a "leg-man" (who might be a graduate student.)"[45]

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[43]Udall, Stewart L., "The Conservation Challenge of the Sixties", Albright Conservation Lecureship, U.C., Berkeley, 4-19-63.

[44]Stebbins, Robert C., Museum of Vertebrate Zoology, U.C., 1-18-55.

[45]op. cit., Baker.

A list of duties of such a coordinator should include the following:

1. Assist graduate and undergraduate research by providing a catalogued annotated annotated bibliography regarding Canyon biota.

2. Direct the maintenance of the "intact biota" as well as that of the forest plantations.

3. Coordinate the operations of various departments and jurisdictions in the Canyon maintaining the integrity of the Ecological Study Area.

4. Assist and remain in contact with the Hill Patrol as necessary more specifically directing and efficiently utilizing their effort.

5. Provide the necessary liason between the CEQ committe and the Physical Plant Department to handle the prescribed enrichment and maintenance of the areas. He should coordinate the zoology and wildlife management as well as other departments' uses of the Canyon with the help of the Botanical Gardens.

6. Remain in close contact with for advice from authorities regarding reserve management.

7. Work with the office of Environmental Health and Safety and the Campus Fire Marshall in conducting controlled burns in the Canyon for both safety and plant succession management objectives which, as all matters, is subject to the review of the CEQ subcommittee on Canyon management.

8. Maintain an accessible file of prospective studies in an office at the Gardens available to all natural science and other students interested in utilizing the reserve.

The three primary zones of natural, manipulative, and administrative dominance might be linked by "access corridors". These corridors would neither endanger the primitive nature nor the progress of activity within the areas. A particularly appropriate site for the latter of these regions would be the Gardens. In its present format, the Gardens could play a more significant role as a resource for instruction and research in biological field work by the provision of laboratories for the analysis of field samples. Native stock supplements and seeds

for various manipulative zones within the Canyon could be supplied by the Gardens. As well, these supplements could be strategically placed coordinated with the timing of transplant as well as the composition and spacing within existing communities.[46] This liason official could be a member of the staff at the gardens who would have experience with the operation of such an arboretum's "interpretive center's" work.

At present, as well, there is close cooperation between the Gardens and the LHS in providing programs for various primary and secondary schools. A strongly needed program should be developed to illustrate, for this audience, the means by which science studies the environment.

Budget

Since all of the lands considered are presently owned by the University, the initial establishment expenditures will be only for appropriate barriers against entry of motorized vehicles at certain points, some trail improvement, and possible an educational brochure. Suggested is the folowing annual budget:[47]

Salary of coordinator	12000
Salary of "legman or secretarial assistance	4000
1 F.T.E. gardener (to be transferred to the Department of Physical Plant)	2000
Rocks, plant materials, etc.	1000
Manipulation in Strawberry Canyon	2000
Office expenses	500
Brochure production	500
Consultation fees	1000
	$ 23000

The source of such funds may exist as a combination of University and external funds.

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[46] Goodspeed, T. Harper, "History of the U.C. Botanical Garden", California Horticultural Society Journal, Jan. 1964, vol. XXV, no. 1, p.-2.

[47] op. cit., Baker.

Author's Note:

Although in every responsible public service position the prime goal should be to meet the will of the public, it cannot be denied that as man has gained the apparent "dominating influence" over his environment, the basis for predicting and evaluating changes in the ecosystem lie to be discovered in the few remaining gems of natural lands around us.

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Appendix A

University of Wisconsin Arboretum

The University of Wisconsin Arboretum provides living examples of the major plant communities of the Midwest- praries, woodlands, marshes, ponds, and lakes- and in this respect must be classified as one of the unique arboreta of the world. The basic concept making the Arboretum so valuable is that it is not a miscellaneous collection of unusual plants, but rather a collection of native plant communities. Some 1500 species of plants now make up this varied complex.

The basic purpose of the Arboretum is ecological. With the great transformations of native vegetation which followed the advent of expanding agriculture, cities, and transportation, areas occipied by native plant communities have assumed great scientific and educational value. Only in this Arboretum can these communities be found in a relatively undisturbed state and in close proximity to one another. For this reason, the University of Wisconsin is endowed with a living natural laboratory for research and instruction which is without parallel anywhere in the world.

Because of the proximity of Madison to the prairies toward the southwest, to the deciduous forest to the east, and both boreal and coniferous-hardwood forests north, the University of Wisconsin is particularly well situated for the development of representative examples of each of these diverse plant and animal groupings. More than 30 different plant communities, examples of original native vegetation of the Midwest, are included in the Arboretum's master plan. Many of these communities are well established; a few are still little beyond the planning stage.

Each association of plants and animals naturally exists in a peculiar habitat, and if that habitat is provided, the plants and animals will take care of themselves. Furnishing the proper habitat for all the communities of the Arboretum requires careful management. When the Leopold Pines were established, for example, the trees were not as tall as the grass in which they were planted, the the Curtis Prairie was once a pasture. These communities have now begun to reach the stage of complexity and maturity typical of those found in pre-settlement times.

East of the Administration Buildings. A COMMUNITY DEMONSTRATION AREA displays, in adjacent plots, examples of sprice and pine forests, sugar maple, oak, and swamp forests, and prairie. Here the community concept may be introduced, and the various tree species found on the Arboretum will be permanently labelled.

The scientific work now being done at the Arboretum includes: population studies on plants and animals; life history studies of birds, mammals, fishes, insects, and the flowering plants; investigation of forest tree genetics and tree diseases; and lond term studies of plant succession, plant communities, micro-environment, and soil development. The area is also used by landscape architects and artists. Because of this wide diversity of use, it is impossible for anyone, even the scientists who use the area, to know everything that is going on. Each plant, animal, and rock is potentially an object of study and should not be disturbed.

Although the Arboretum serves its primary function as an outdoor laboratory, this does not preclude its use as an area for outdoor recreation. Everyone is encouraged to share and help protect its beauty for future generations. Visitors are asked to treat the Arboretum as they would a book. A torn page might not be missed, but it might be the one to ruin the story.

Phila Rogers 1/2/08 Doc 2

MANAGEMENT PLAN FOR

STRAWBERRY AND CLAREMONT CANYONS

1979

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I. INTRODUCTION

Objectives

The purpose of this management plan is to provide guidance for the use and management of those portions of the University of California property in Strawberry and Claremont Canyons which are not now under the management of designated research units or have special designated uses. The management directions given in this plan are focused on the natural features within this area. Specific management prescriptions for vegetation, fauna, fuels, water and stream courses, recreation, ecological study, and land use are developed in this plan. They do not treat such topics as fire suppression, police protection, and waste disposal except as they relate directly to management of the natural features of the landscape.

Area of Application

The provisions of this management plan shall apply to the University property in both Strawberry Canyon and Claremont Canyon as shown in Figure 1. Excluded are designated special units such as the Lawrence Berkeley Lab, the Botanical Garden, the Haas Recreation Area and the Animal Behavior Research Area. It is hoped that those excluded units will endeavor to prescribe management prescriptions similar to those within this plan, especially on the contiguous boundaries which form the interface with the area designated within this plan. This will enhance the naturalness of the canyon landscape and minimize sharply defined boundaries.

The Claremont Canyon portion of the University property outside the Ecological Study Area (Fig. 2) has been suggested as a site for an experimental forest. However, until and unless a specific proposal for an experimental forest is recommended for approval by the Committee on Conservation and Environmental Quality, the vegetation management prescriptions of this plan are to be followed.

Guiding Principle

The guiding philosophy in the development of this plan has been that the primary use of land must be for teaching and research. The precriptions proposed provide for, reinforce, and perpetuate the teaching and research use. All other land uses are considered of secondary importance and have been set aside when they conflicted with teaching and research. The teaching and research use was viewed both in terms of the present and potential activities. Every effort has been made to development management guidance to protect those natural landscape features which have value for potential use in teaching and research.

The Committee on Conservation and Environmental Quality or its designated subcommittee will have the responsibility to oversee the application of this philosophy in the management of the area.

Previous Studies

A variety of reports on natural features and recommendations for land use and management of the area have been prepared. These were reviewed in some detail by Eckbo (1976). Table 1 summarizes the focus of those reports which provide guidance for management planning. Each of these was evaluated in the process of preparing this management plan. Considerable material which describes the natural features of the area can be found in these reports. Such descriptive material has not been repeated in this plan. Reports and journal articles by Eckbo (1976), Stebbins (1975), McBride (1974), and Siri (1972) provide useful descriptions of these natural features.

Priority areas for eucalyptus sprout management should be developed by the Department of Facilities Management in concert with representatives from the Committee on Conservation and Environmental Quality.

II. VEGETATION MANAGEMENT

Objectives

The principal objective of vegetation management in Strawberry should be the reestablishment and maintenance of a mosaic of native vegetation types. Such a mosaic of native vegetation types will maximize the opportunity to study the regional fauna and flora as well as a variety of ecological processes.

Ecological processes, especially plant succession, should be fostered within Strawberry Canyon as a process for study and as a tool of management.

It is recognized that some areas within Strawberry Canyon presently support plantations of forest tree species which are not native to the Berkeley Hills (Fig. 2). These plantations offer limited opportunities for the study of flora and fauna, but are suitable for teaching and research within the Department of Forestry and Resource Management. These existing plantations should not be converted to native vegetation types but should be maintained as existing forest plantations for teaching and research by the Department of Forestry and Resource Management and other departments. As these stands become decadent they should be individually evaluated for replanting or conversion to native vegetation.

Existing Vegetation

The vegetation in Strawberry and Claremont Canyons consists of a mosaic of natural and plantation types. These types include oak-bay woodland, northern coastal scrub, annual grassland, various conifer plantations, and eucalyptus plantations (Fig. 3). Much of the area once occupied by eucalyptus plantations has been logged. These types and their ecology have been described by Barbour and Major (1977), Eckbo (1976), and McBride (1974).

Management Prescriptions

The land area under the jurisdiction of this plan has been subdivided into units for the purpose of prescribing management (Fig. 4). The existing and proposed vegetation type and a vegetation management prescription for each unit is shown in Table 2.

The majority of units will receive no treatment. These units will be allowed to change over time in response to natural successional processes.

The Units which once supported eucalyptus and have been logged are for the most part to be treated to remove eucalyptus sprouts and allow native species to become established. Elimination of the sprouts is to be accomplished by manual removal of sprouts. All sprout material is to be removed from the site. Chipping and spreading of chips is not recommended because of the slow rate of decomposition of the eucalyptus chips. It is recognized that the

procedure suggested will require several years to accomplish and will be more costly in dollar value than control with herbicides. The use of herbicides as a tool of vegetation management is not recommended because of the unknown ecological cost.

A special fuel management zone is to be created along those edges of the University property which adjoins residential areas. Specific vegetation management prescriptions for units within this zone are developed in the fuel management section of this plan.

Three undesirable exotic species (broom, acacia, and artichoke thistle*) have invaded areas of the East Bay Regional Parks. These species compete successfully with native plants and can take over significant areas if unchecked. Invasion of broom has been noted in units C 6 and SG 6. An annual inspection should be conducted each year to identify areas where these plants have become established. The plants should then be removed manually. Herbicides should not be employed in the control of these undesirable species.

Some units are proposed for vegetation type conversion which involves the planting of species not now present on these units (Units EL 6, EL 8, and EL 10). Insofar as possible, the seeds used in these conversions should be collected from plants in Strawberry or Claremont Canyon. The species of perennial grasses proposed for units EL 6 and EL 10 may not now occur in the Canyons. An effort should be made to collect these seeds from the Berkeley Hills before distant seed sources are employed.

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* broom - Cytisus scoparius, C. monspessulanus
acacia - Acacia decurrens, A. melanoxylon, A. longifolia
artichoke thistle - Cynara cardunculus

III. FAUNAL MANAGEMENT

Objectives

The principle objective of faunal management is to provide habitat conditions which will support and protect a wide variety of species. Animal density should be allowed to adjust to the natural carrying capacity of the landscape and no effort should be made to sustain populations above that level through supplemental feeding or watering. Strawberry Canyon and adjacent areas of Tilden Park now serve as a significant refuge for mammals, birds, amphibians, and reptiles in the Berkeley Hills. This refuge must be protected to insure the continued presence of these species for teaching and research.

Existing Fauna

Species lists of fauna observed in Strawberry and Claremont Canyons and adjacent areas have been presented by Siri (1972) and Stebbins (1975). These reports indicate that a significant number of species are using the area either as permanent residents or as migrants. The largest number of species occur in the oak-bay woodland type while the forest plantation types have far fewer species. This distribution is to be expected in view of the exotic nature of the forest plantations.

Management Prescriptions

The Strawberry Canyon area should be managed to promote those natural succession processes which will provide a mosaic of native vegetation types. The management prescriptions developed in the vegetation management section of this plan will achieve this objective.

Refuge Area

Units SG 34, W 8, and W 9 should be designated as a special refuge (Figs. 4 and 5). They represent the largest least disturbed areas of native vegetation in Strawberry Canyon. Their location is along an important dispersal route of many large mammals moving into the lower portions of the canyon. The special status of this refuge is to protect the area from any future construction of structures, trails, or roads. Its use for research or teaching purposes which involve destructive sampling of either plants or animals is to be prohibited. Any development of access to the margins of this special refuge is to be avoided.

IV. FUEL MANAGEMENT

Objective

The purpose of fuel management is to provide protection to both University and private residential property by decreasing the continuity of fuels along certain University property boundaries. By breaking up fuel continuity the rate of spread of wildfire can be reduced. Such a reduction can be of value in fire suppression. More extensive fuel management measures have been proposed (Biswell 1974, Hamlin 1977), but these proposals are viewed in part as being in conflict with the overall management objectives for the area.

Fire Hazard

The Berkeley Hills have experienced serious fires in the last 50 years due to wildfires burning from undeveloped land onto residential areas. This hazard, as it relates to the University, has been discussed in detaitl by Biswell (1974). The University has an obligation to protect its own property from encroachment by fire and to minimize to likelihood of fires spreading from its property to adjacent residential areas.

Management Prescription

A fuel management zone will be established along those boundaries of the University property which are adjacent to residential property (Fig. 6). This zone will be 100 feet wide. Fuel over 3 inches in diameter with the exception of logs over 12 inches in diameter in contact with mineral soil will be removed from the zone. The density of shrubs and trees will be reduced within the zone in order to break up fuel continuity in both vertical and horizontal planes. Lower branches of trees will be pruned to eliminate fuel ladders. Litter and mulch occurring in the zone will be burned on a periodic basis as indicated in Table 3.

Ground fuel over 2 inches in diameter within the logged eucalyptus areas which resulted from the logging of the area should be removed. All sprouts cut from stumps during vegetation management activities should also be removed.

Growth of annual vegetation adjacent to roads (with 6 feet) should be cut and removed each year at the end of the Spring growing season. Any growth of shrubs or tree limbs which would interfere with the use of fire suppression vehicles should also be removed. Likewise, plants growing around fire hydrants should be removed or trimmed on an annual basis when their presence will interfere with the use of the hydrants.

V. WATER AND STREAM COURSE MANAGEMENT

Objective

The purpose of water and stream course management is to minimize flood peaks along the lower portion of Strawberry and Claremont creeks, minimize gully erosion, and maintain a stream environment for aquatic organisms. Peak periods of streamflow present a serious threat to structures in the recreation area along Strawberry Creek and the residential area along Claremont Creek. Management practices and land use must recognize the flood potential of the watersheds. Erosion control is needed to protect the soil resource as well as those characteristics of the stream beds which are important to aquatic species.

Stream System

Two major streams, Strawberry Creek and Claremont Creek, drain the area (Fig. 7). Strawberry Creek has been studied in some detail by Lennert (1972) At his recommendation flood and erosion control structures have been installed along Strawberry and Chicken Creeks. His report identified a serious run-off problem associated with the increase in impervious surfaces in Strawberry Canyon. He also indicated a serious concern for debris in the stream channels above the culverts which carry water beneath Memorial Stadium. His recommendations for extensive engineering alterations of the Strawberry Creek channel above the retention dam were not adopted, however.

Management Prescriptions

It shall be the management policy to minimize any further increase in impervious surface throughout Strawberry Canyon. Future roads must be surfaced with pervious materials such as gravel. A further discussion of this principle is developed in the land use section of this plan.

Erosion control dams should be constructed along any stream channel showing minor accelerated erosion. These dams can be made of brush and eucalyptus poles, obtained from the site or similar materials. An annual inspection of streams and water courses should be made to identify areas of accelerated erosion and repairs needed on erosion control dams.

Culverts should be cleaned at the end of each summer. Each culvert should be inspected and cleaned following each rainstorm during the fall, winter, and spring. Culverts must be provided with suitable splash pads to prevent erosion below the culvert (see Fig. 12 for recommended details). These should be inspected and repaired on an annual basis.

Road cuts and fills should be inspected for erosion and seeded with appropriate species if accelerated erosion is in evidence. Advice on proper seeding mixtures and techniques can be found in Hamilton (1974).

Debris such as brush, small logs, garbage, old tires, etc. which can be moved downstream during peak floods and block culverts should be removed. A channel inspection and cleanup should be scheduled annually.

Streams within the area should be periodically monitored by personnel from Environmental Health and Safety to identify pollution problems. Corrective measures shall be taken in when pollution threatens the survival of stream organisms.

Fire trails should be inspected annually to determine if features designed to insure proper drainage are working. Water bars, drainage ditches, and other features should be cleaned out each year. Skid trails resulting from logging of the eucalyptus should be reseeded and proper drainage provided to prevent erosion.

VI. RECREATION MANAGEMENT

Objectives

The purpose of recreation management is to provide prescriptions which will minimize conflicts between the use of the area for teaching and research and recreation. The primary use of the area is for teaching and research. This should not preclude the use of the areas for certain kinds of recreation. It is not, however, the intent of this plan to encourage recreational use of the area.

Recreational Use

The fire trails in Strawberry Canyon are heavily used by hikers and joggers (Fig. 8). In addition, these and other trails are used by photographers and fauna and flora observers. The activities of these recreationists has not had a serious impact on natural communities in the area. Eckbo (1976) suggested the need to expand and improve the trail system within Strawberry Canyon in order to serve a wider range of recreationists. Arbegast and Newton (1972) and King (1969-73) proposed a specific recreational development in the Chicken Creek area. The expanded recreational use which these proposals suggest is not compatible with the use of the area for teaching and research.

Any proposals for expanded recreational use in this area or other parts of Strawberry Canyon are to be reviewed by CEQ to consider their impact on teaching and research, water runoff, soil and slope stability and visual impact on the adjacent landscape.

Certain recreational uses are injurious to the natural communities or to the trails in the area. These include the use of dirt bikes, motorcycles, and horses. The presence of recreationists may also increase the risk of wildfire during periods of extreme fire danger. A policy of closing the canyon during these periods to all users has been initiated by the Campus Fire Marshal. Enforcement of this policy is encouraged as good management.

Management Prescription

The existing trail system should not be expanded within Strawberry Canyon (Fig. 8). Trail maintenance should be restricted to an annual blading of the fire trails and the removal of vegetative material which significantly impedes movement along foot trails. No major brushing out of these trails is recommended. An annual insepection of all trails should be conducted to identify problems of accelerated erosion associated with use of the trails. Those trails which exhibit erosion problems should be repaired and closed depending on the magnitude of the erosion problem.

Use of bicycles and motorcycles on trails in the area is to be prohibited. Reclamation work to repair damage to unit C 15 from dirt bikes should be

initiated. Leaf litter or chips from chippings should be brought in to cover the exposed soil and water bars should be installed to divert water off the cycle trails.

The occasional use of horses should be restricted to major fire trails because of the destruction they cause to the trail surface.

Patrol of the area should continue to prevent overnight camping.

The area should be closed to recreationists during periods of extreme fire danger as determined by the Campus Fire Marshal.

VII. LAND USE

Objectives

Decisions for land use are developed in this section to insure the protection of areas of significant natural value for teaching and research and to minimize user conflicts. Special land use areas are designated to achieve this objective. Future use of other areas should be evaluated on the basis of impact on natural communities, effect upon flood peaks, and human safety.

Special Land Use Areas

1. Ecological Study Area

In 1969 an Ecological Study Area was established in Strawberry Canyon and a portion of Claremont Canyon (Fig. 9). Justification and management suggestions for this area has been developed by Daly (1969) and Baker (1969). In 1972 the Committee on Conservation and Environmental Quality proposed the inclusion of the Ecological Study Area and adjacent lands in Strawberry and Claremont Canyons in the University-wide Natural Land Water Reserves System (Siri, 1972). The proposed unit was accepted by the Natural Land and Water Reserves System but release of the land was denied by the Berkeley Chancellor. In rejecting the transfer of control of the land, Chancellor Bowker affirmed his support for an Ecological Study Area in Strawberry Canyon (Clifton, 1974), Eckbo (1976) proposed an expansion of the boundaries of the Ecological Study Area to include those additional areas designated for inclusion in the Natural Land and Water Reserves System. In 1977, the controlled burning of a portion of the Ecological Study Area to reduce fire hazard resulted in renewed discussions of the types of management activities which should be allowed in the Ecological Study Area. Stebbins et al. (1977) rejected the use of controlled burning and other active vegetation management techniques in the area. Hamlin (1977) presented arguments in favor of a more active approach.

The Committee on Conservation and Environmental Quality will continue to monitor these issues and recommend appropriate management prescriptions depending upon the specific situations as they arise.

It is proposed that a new boundary be established for the Ecological Study Area and that the management guidelines listed below be enforced within this area to maintain the area for teaching and research. This proposed boundary is shown in Figure 10. It would reduce the existing Ecological Study Area by removing a 100 foot wide strip (measured along the slope) from those portions adjacent to the residential area in Berkeley, roads, or special use areas within Strawberry Canyon. Establishment of the new boundary will provide a buffer for the Ecological Study Area where appropriate fuel management activities can be applied. The effectiveness of this buffer will depend upon its maintenance as a buffer. It should not be used as a site for new structures.

Also, it is proposed that an immediate expansion of the Ecological

Study Area be made along the northwest extent of Strawberry Creek extending from the creek to the ridgeline. This will expand the Study Area to include the upper watershed of the creek (see Fig. 10).

Additional areas are proposed for future consideration as expansions to the Ecological Study Area. The intent is to maintain these areas in their natural states and limit their uses as outlined below. Such areas of expansion will require full discussion and approval as a proposal to the Chancellor by CEQ.

The management guidelines to be enforced within the Ecological Study Area are as follows:

a). Use of vegetation management prescriptions for units within the area as outlined in this plan.

b). Prohibition of any research or teaching activities which involve destructive sampling unless otherwise approved by the Ecological Study Area Committee.

c). Prohibition of soil removal from the area.

d). Prohibition of fuel management and controlled burning.

e). Prohibition of recreational use of area other than hiking, jogging, or photography along trails.

f). Maintenance of a special refuge area as outlined in the section of this plan dealing with faunal management.

g). Prohibition of construction of buildings.

2. Claremont Canyon

The Department of Forestry and Resource Management has expressed the need for an experimental forest and has suggested Claremont Canyon as a suitable site. This Management Plan recognizes the possiblity for such a use and agrees that Claremont Canyon is the most likely site for an experimental forest. Thus the Canyon is not recommended for inclusion in the Ecological Study Area.

Until such time that a proposal which suggests replanting this area as an experimental forest is made and recommended for approval by CEQ, Claremont Canyon is to be managed according to the prescriptions of this plan.

3. Building Sites

Seven areas were identified by Eckbo (1976) as potential building sites on the basis of geological hazard or other areas considered ecologically sensitive areas. Portions of five of these occur within the Ecological Study Area and should not be considered because of the higher value of this area for teaching and research. Two remaining areas may be considered geologically safe and can serve as future building sites (Fig 11). Construction on these sites should recognize the significance of incremental

increases in run-off which will result from construction. Wherever possible, previous surface materials should be used for roads, sidewalks, and parking areas around these future buildings.

Land Use Conflicts

The primary objective intended for land use in Strawberry and Claremont Canyons is teaching and research related to the outdoor environment.

Teaching, research and recreational activities which do not require or relate to the outdoor environment of Strawberry Canyon and Claremont Canyon should be located on University property elsewhere.

The current use of a portion of Strawberry Canyon to store acids and other chemicals is an example of an inappropriate land use. The Acid House should be relocated outside of the Canyon. No area in either Strawberry or Claremont Canyon should be used as a storage area or as a disposal site.

Conflicts may arise in the use of particular areas for research. A committee should be established to oversee research activities. Proposed research projects should be reviewed by the committee. Suitable location could be assigned by the committee to avoid conflicts between research activities.

VIII. ADMINISTRATION

Management of Strawberry and Claremont Canyons should be the responsibility of the Ground Services section of the Department of Facilities Management. The low intensity activities suggested in this plan do not justify a full-time land manager. Field work to control eucalyptus sprouts, maintain trails, and check erosion could be done by a seasonal crew of laborers or cooperatively through an arrangement with the California Conservation Corps.

The Committee on Conservation and Environmental Qualtiy should continue to advise the Chancellor on land use, management and research in the area.

Management considerations or modifications to the canyon lands other than prescribed herein should be directed to the Committee on Conservation and Environmental Quality for consideration and recommendation for action to the Chancellor.

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TABLES

Table 1. Reports on Strawberry Canyon

Table 2. Proposed and existing vegetation types and management prescriptions

Table 3. Fuel management prescriptions

Table 1. Reports on Strawberry Canyon*

Author	Date	Focus of Report
Arbegast and Newton	1972	recreation potential of Poultry Husbandry area
Baker	1969	use and management of Ecological Areas
Biswell	1974	wildlife management
Daly	1969	use of natural areas
Eckbo and Associates	1976	management plan for Strawberry Canyon
Jones	1974	landscape plan for Strawberry Canyon
King	1969-73	recreation use of Chicken Canyon
Lennert and Associates	1972	storm drainage
Lindgren and Sanderson	1969	use of the campus environment
McBride	1976	vegetation management plan for Strawberry Canyon
Provenzano and Associates	1972	roadway soil investigation
Siri	1972	proposal for inclusion of portions of Strawberry Canyon in the Natural Land and Water Reserves System

*See bibliography for title and source of reports.

Table 2. Proposed and existing vegetation types and management prescription

Unit	Vegetation Type	Proposed Vegetation	Vegetation Management Prescription
E1	Eucalyptus	Eucalyptus	no treatment*
E2	"	"	" " *
E3	"	"	" " *
E4	"	"	" "
E5	"	"	" " *
E6	"	"	" "
E7	"	"	" "
E8	"	"	" "
E9	"	"	" "
E10	"	"	" "
E11	"	"	" "
E12	"	"	" "
E13	"	"	" "
E14	"	"	" "
EL1	Eucalyptus (logged)	open eucalyptus forest	thin sprouts to 25 trees/acre
EL2	"	successional	remove eucalyptus sprouts
EL3	"	"	" " "
EL4	"	"	" " "
EL5	"	"	" " "
EL6	"	native perennial bunchgrass	" " " ; cut stump off at ground level; seed with native perennial bunchgrass**
EL7	"	successional	remove eucalyptus sprouts
EL8	"	Oak-Bay Woodland	" " " ; plant coast live oak and bay***
EL9	"	successional	remove eucalyptus sprouts
EL10	"	native perennial bunchgrass	" " " ; cut stumps off at ground level; seed with native perennial bunchgrasses.**

*special treatment of fuel management zone in this unit described in fuel management section.

**specific seeding techniques to be developed by Dr. Jim Bartolome, Dept. Forestry and Conservation

***specific planting plan to be developed by the California Native Plant Society.

Table 2 (cont'd)

Unit	Vegetation Type	Proposed Vegetation	Vegetation Management Prescription
EL11	Eucalyptus (logged)	successional	remove eucalyptus sprouts
EL12	"	"	" " "
EL13	"	"	" " " *****
EL14	"	"	" " "
EL15	"	"	" " "
EL16	"	Redwood Plantation	Maintain desired redwood density by additional planting as needed; remove eucalyptus sprouts.
EL17	"	"	remove eucalyptus sprouts
EL18	"	"	" " " *
C1	Conifer (Bishop Pine)	same	no treatment****
C2	Conifer (mixed plantation of high elevation pine species)	"	" "
C3	Conifer (Monterey Pine)	"	" "
C4	Conifer (Monterey Pine)	"	" "
C5	Conifer	"	" " *; ****
C6	Conifer	"	" " *; ****
C7	Conifer (Norway Spruce)	"	" " ****
C8	Conifer (Western Red Cedar)	"	" " ****
C9	Conifer (Monterey Cypress)	"	" " *; ****
C10	Conifer (Monterey Cypress)	same	no treatment****
C11	Conifer (Monterey Cypress)	"	" " ****

****Replanting prescription to be developed by the Dept. of Forestry and Conservation when unit becomes decadent.

Table 2 (cont'd)

Unit	Vegetation Type	Proposed Vegetation	Vegetation Management Prescription		
C12	Conifer (Monterey Pine)	same	no treatment		
C13	Conifer (Redwood)	"	"	"	****
C14	Conifer (Canary Island Pine)	"	"	"	****
C15	Conifer (Redwood)	"	"	"	****
C16	Conifer (Monterey Pine)	"	"	"	****
C17	Conifer (Canary Island Pine)	"	"	"	****
C18	Conifer (Italian Stone Pine)	"	"	"	****
C19	Conifer (Monterey Pine)	"	"	"	****
C20	Conifer (Canary Island Pine)	"	"	"	****
C21	Conifer (Monterey Pine)	"	"	"	
C22	"	"	"	"	
C23	"	"	"	"	
C24	"	"	"	"	
C25	"	"	"	"	
C26	"	"	"	"	
C27	"	"	"	"	
C28	"	"	"	"	
C29	"	"	"	"	
C30	"	"	"	"	
C31	"	"	"	"	
C32	"	"	"	"	
C33	"	"	"	"	
C34	"	"	"	"	
C35	"	"	"	"	
C36	"	"	"	"	
C37	"	"	"	"	
C38	"	"	"	"	
C39	"	"	"	"	
C40	"	"	"	"	

Table 2 (cont'd)

Unit	Vegetation Type	Proposed Vegetation	Vegetation Management Prescription		
C41	Conifer (Monterey Pine)	same	no treatment		
C42	"	"	"	"	
C43	"	"	"	"	
C44	"	"	"	"	
C45	"	"	"	"	
W1	Oak-Bay Woodland	Oak-Bay Woodland	"	"	
W2	"	"	"	"	
W3	"	"	"	"	*
W4	"	"	"	"	
W5	"	"	"	"	
W6	"	"	"	"	
W7	"	"	"	"	
W8	"	"	"	"	
W9	"	"	"	"	
W10	"	"	"	"	
W11	"	"	"	"	
W12	"	"	"	"	
W13	"	"	"	"	
W14	"	"	"	"	
W15	"	"	"	"	
W16	"	"	"	"	
W17	"	"	"	"	
W18	"	"	"	"	
W19	"	"	"	"	
W20	"	"	"	"	
W21	"	"	"	"	
W22	"	"	"	"	
W23	"	"	"	"	
W24	"	"	"	"	
SG1	Scrub-Grass	successional	"	"	*
SG2	"	"	"	"	
SG3	"	"	"	"	
SG4	"	"	"	"	
SG5	"	"	"	"	
SG6	"	"	"	"	
SG7	"	"	"	"	
SG8	"	"	"	"	
SG9	"	"	"	"	
SG10	"	"	"	"	
SG11	"	"	"	"	
SG12	"	"	"	"	

Table 2 (cont'd)

Unit	Vegetation Type	Proposed Vegetation	Vegetation Management Prescription	
SG13	Scrub-Grass	successional	no treatment	
SG14	"	"	" "	
SG15	"	"	" "	
SG16	"	"	" "	
SG17	"	"	" "	
SG18	"	"	" "	
SG19	"	"	" "	
SG20	"	"	" "	*
SG21	"	"	" "	*
SG22	"	"	" "	
SG23	"	"	" "	
SG24	"	"	" "	
SG25	"	"	" "	
SG26	"	"	" "	
SG27	"	"	" "	
SG28	"	"	" "	
SG29	"	"	" "	
SG30	"	"	" "	
SG31	"	"	" "	
SG32	"	"	" "	
SG33	"	"	" "	
SG34	"	"	" "	
SG35	"	"	" "	
SG36	"	"	" "	
SG37	"	"	" "	
SG38	"	"	" "	
SG39	"	"	" "	
SG40	"	"	" "	
SG41	"	"	" "	
SG42	"	"	" "	
SG43	"	"	" "	

Table 3. Fuel Management Prescriptions

Unit	Vegetation Type	Fuel Management Prescription*
E1	Eucalyptus	Reduce tree density; eliminate fuel ladder; burn litter every 3-5 years depending upon accumulation.
E2	"	-ditto-
E3	"	-ditto-
E4	"	-ditto-
E5	"	-ditto-
EL18	Eucalyptus (logged)	Eliminate sprouts; remove brush; mow and rake grass annually at end of growing season.
C5	Conifer	Reduce tree density, eliminate fuel ladder; burn litter every 5-7 years depending upon accumulation.
C6	Conifer (Monterey Pine)	-ditto-
C9	Conifer (Monterey Cypress)	-ditto-
W2	Oak-Bay Woodland	-ditto-
SG1	Scrub-Grass	Eliminate shrubs; mow and rake grass annually at end of growing season.
SG6	"	-ditto-
SG20	"	-ditto-
SG21	"	-ditto-

*prescription for 100' wide fuel break

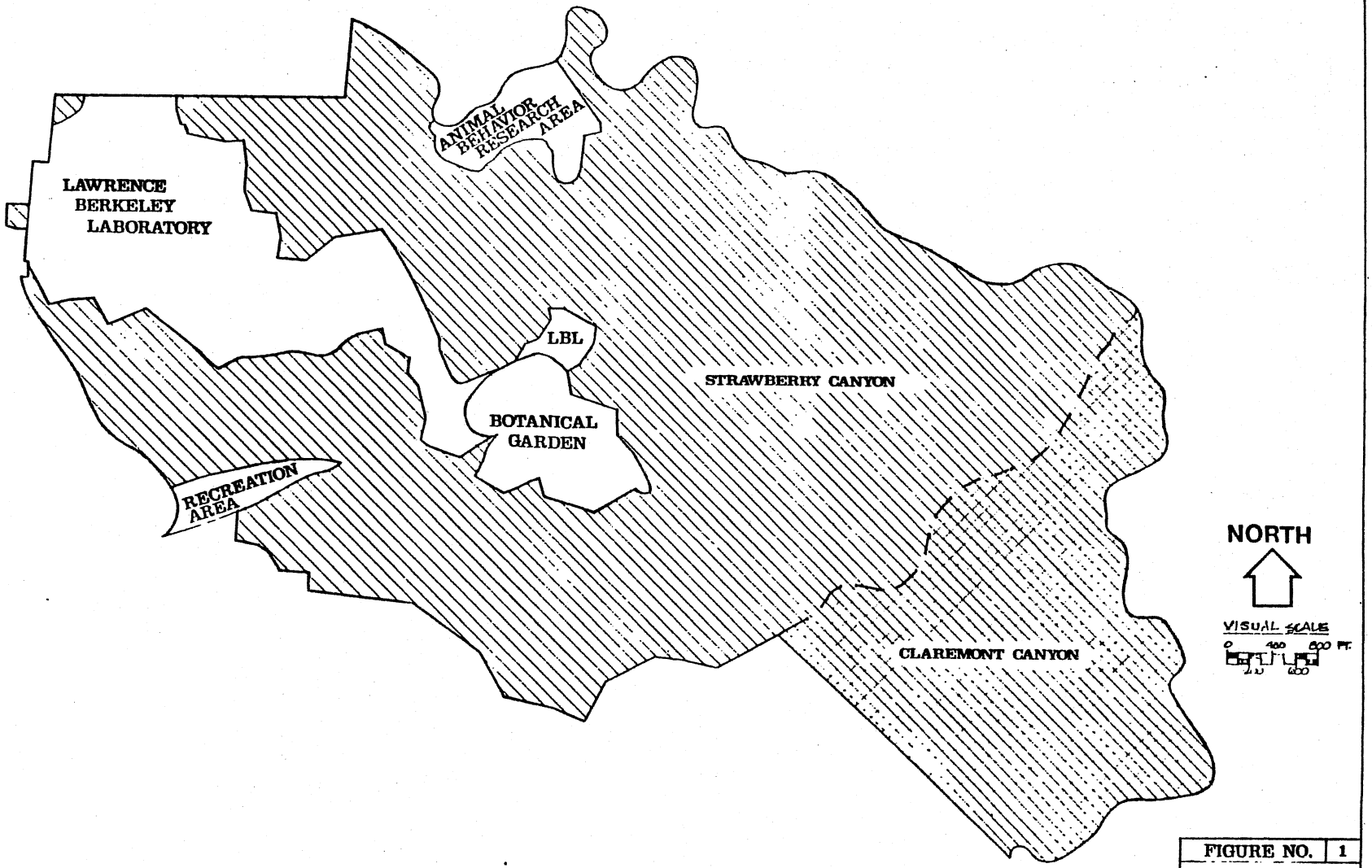


FIGURE NO.	1

AREA FOR APPLICATION OF MANAGEMENT PLAN

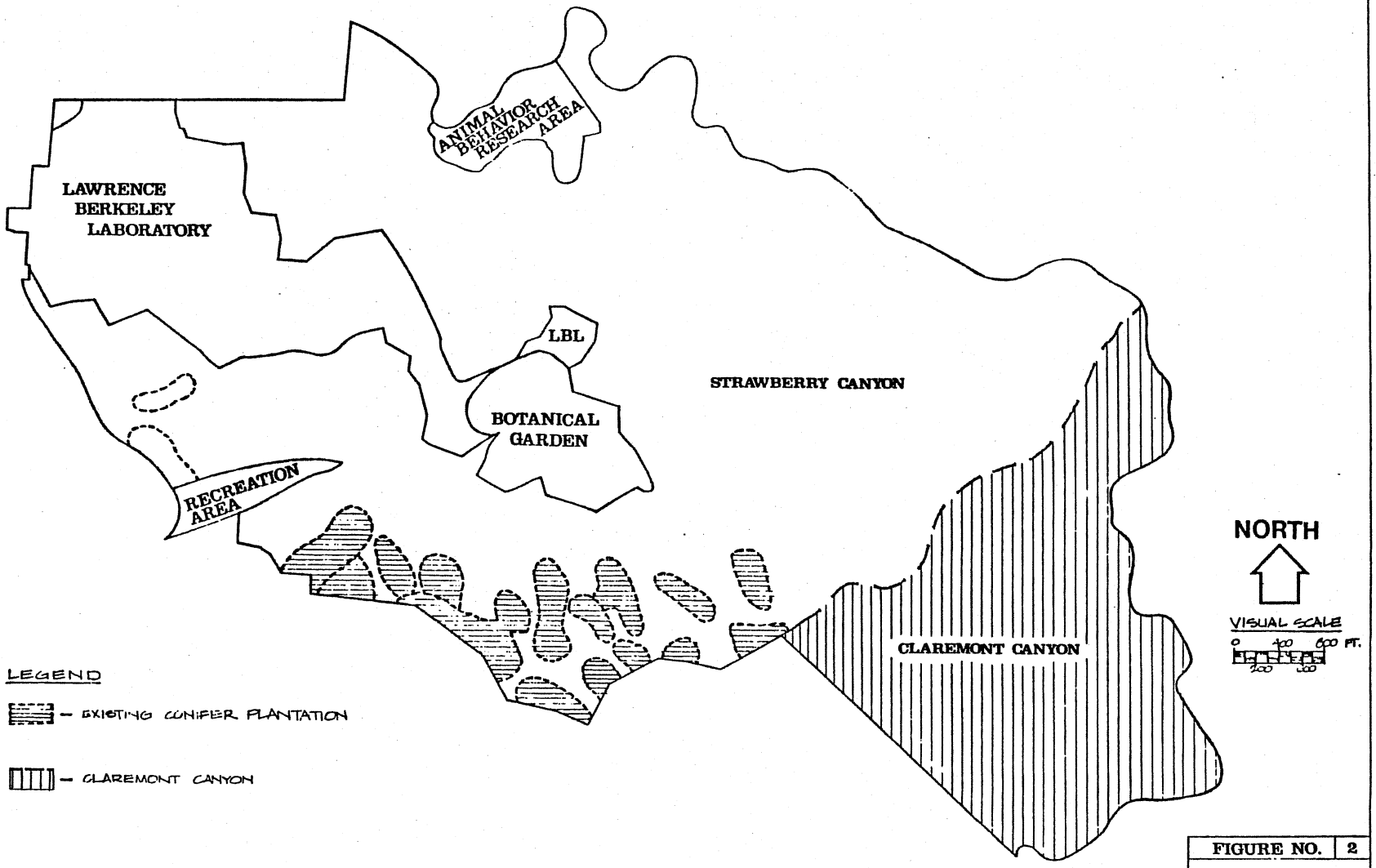


FIGURE NO. 2

FOREST MANAGEMENT AREAS

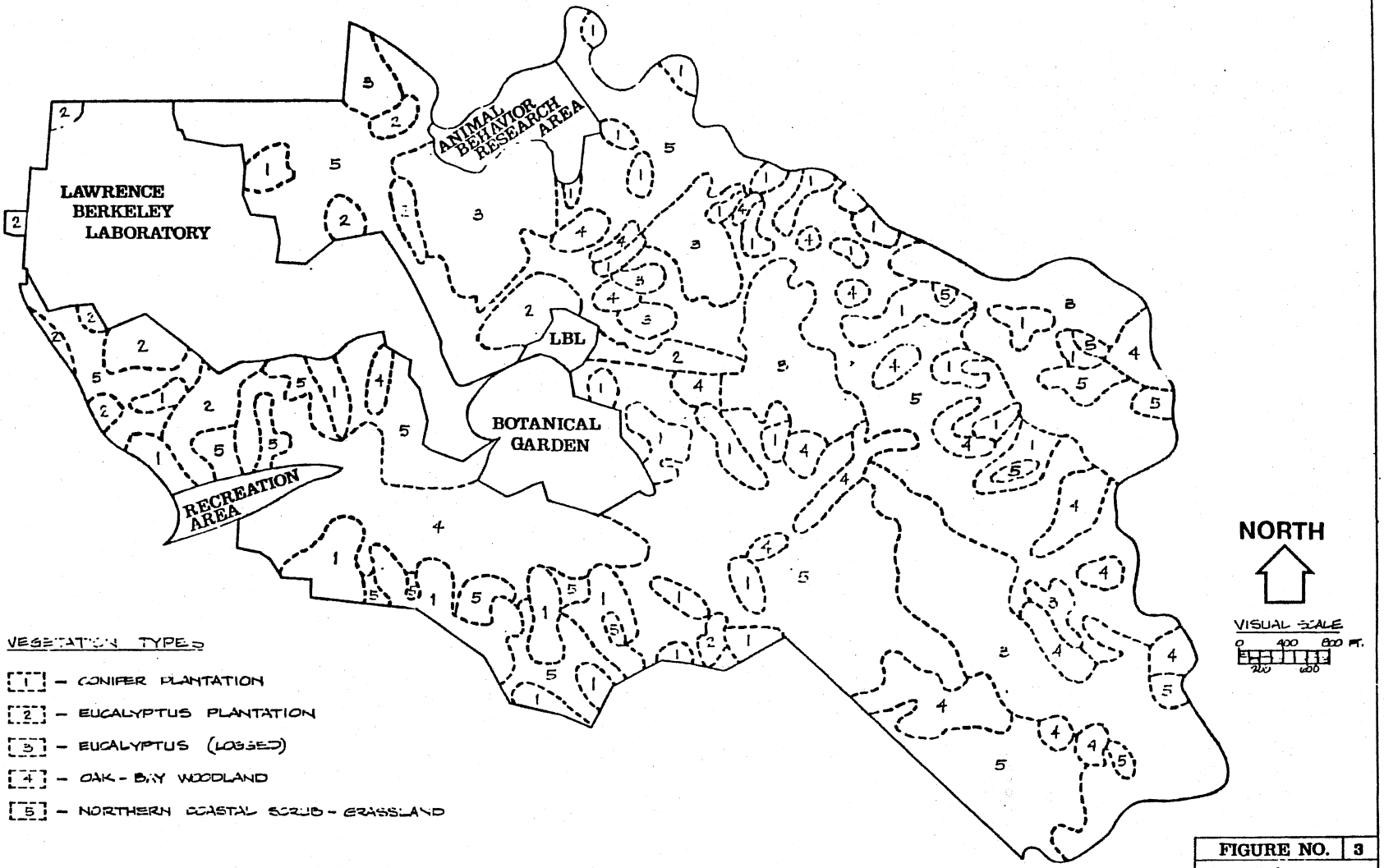
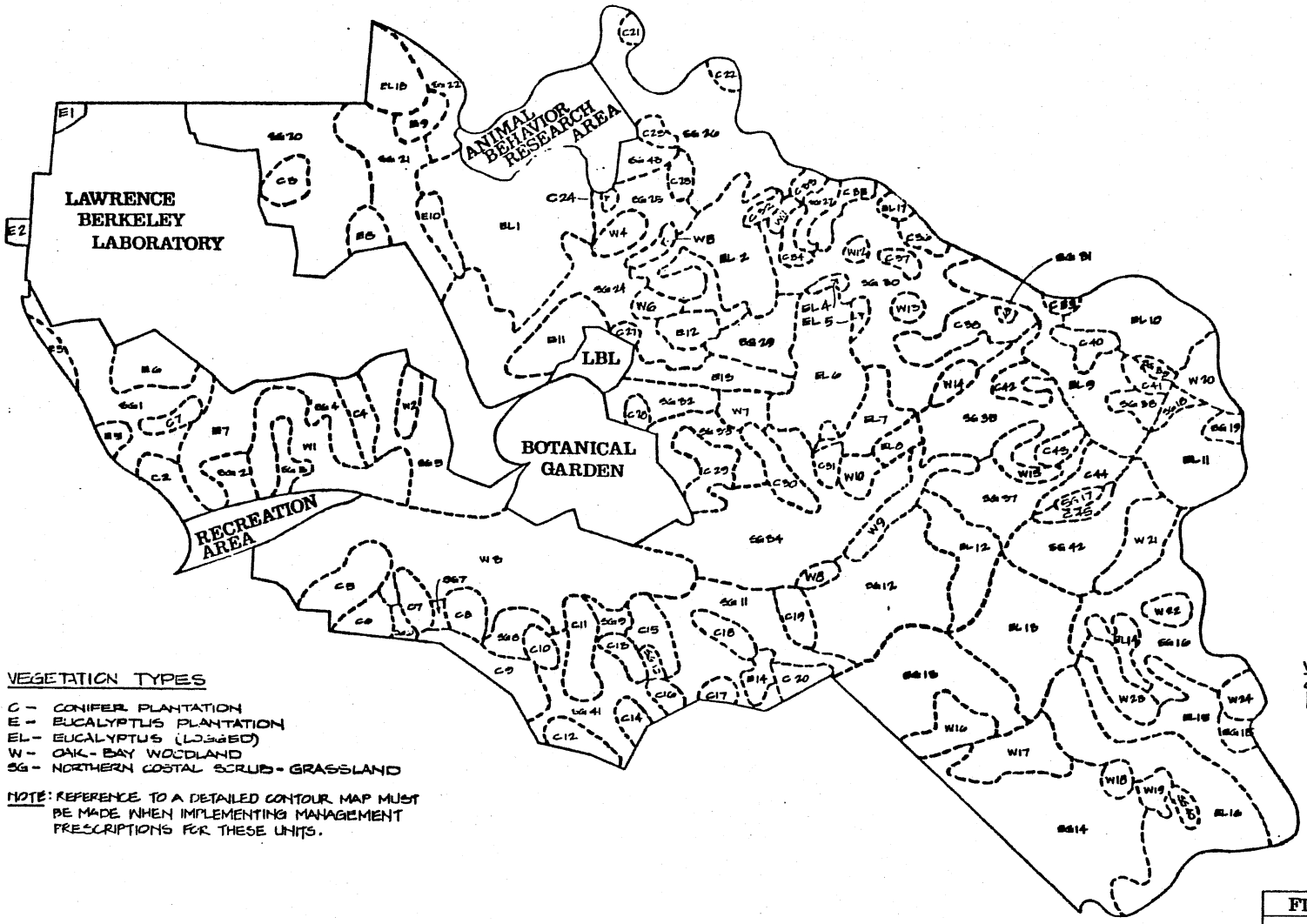


FIGURE NO. 3

EXISTING VEGETATION



VEGETATION TYPES

C – CONIFER PLANTATION
E – EUCALYPTUS PLANTATION
EL – EUCALYPTUS (LOGGED)
W – OAK-BAY WOODLAND
SG – NORTHERN COASTAL SCRUB-GRASSLAND

NOTE: REFERENCE TO A DETAILED CONTOUR MAP MUST BE MADE WHEN IMPLEMENTING MANAGEMENT PRESCRIPTIONS FOR THESE UNITS.

FIGURE NO. 4

VEGETATION MANAGEMENT UNITS

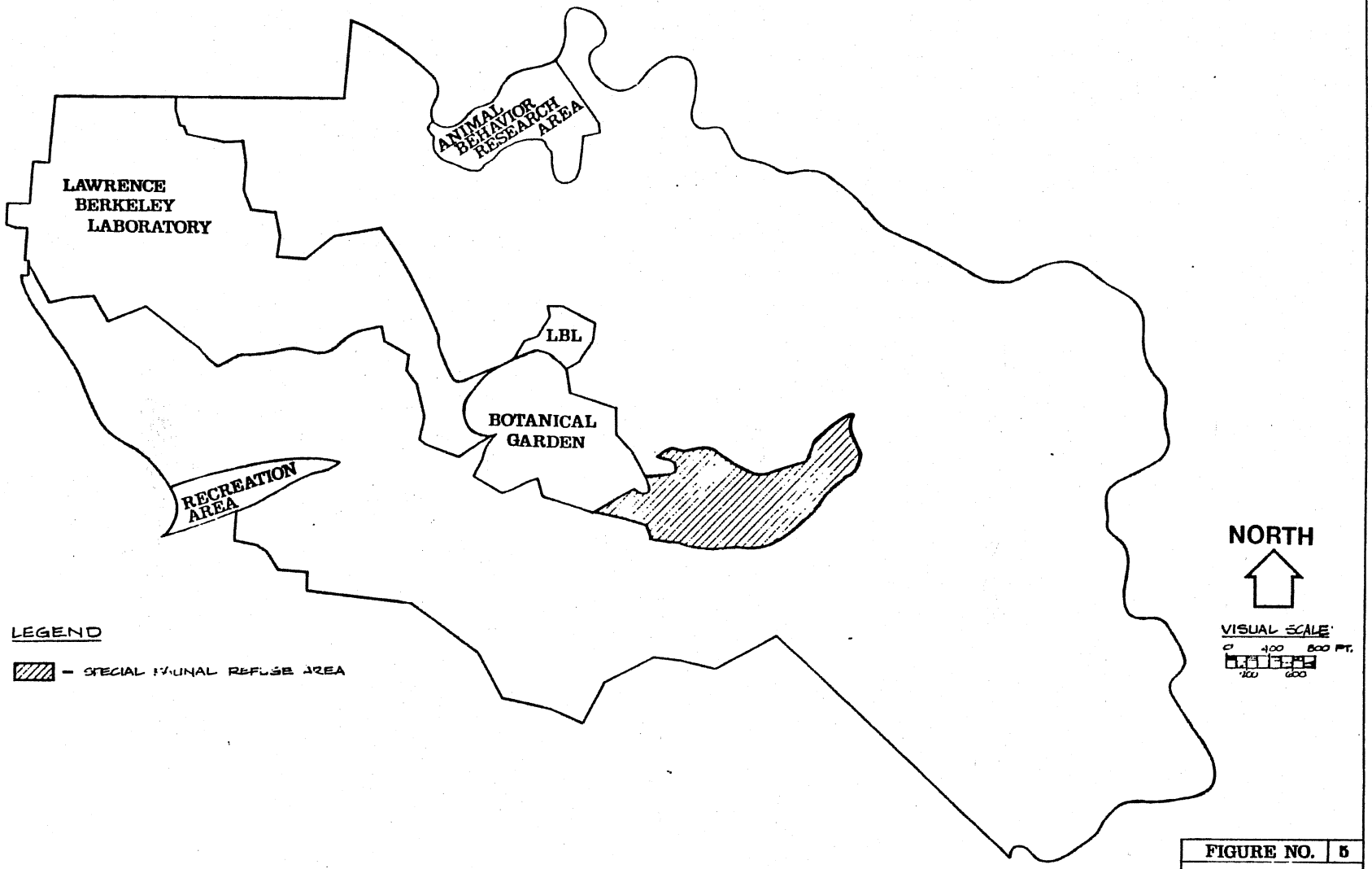


FIGURE NO. 5

SPECIAL FAUNAL REFUGE AREA

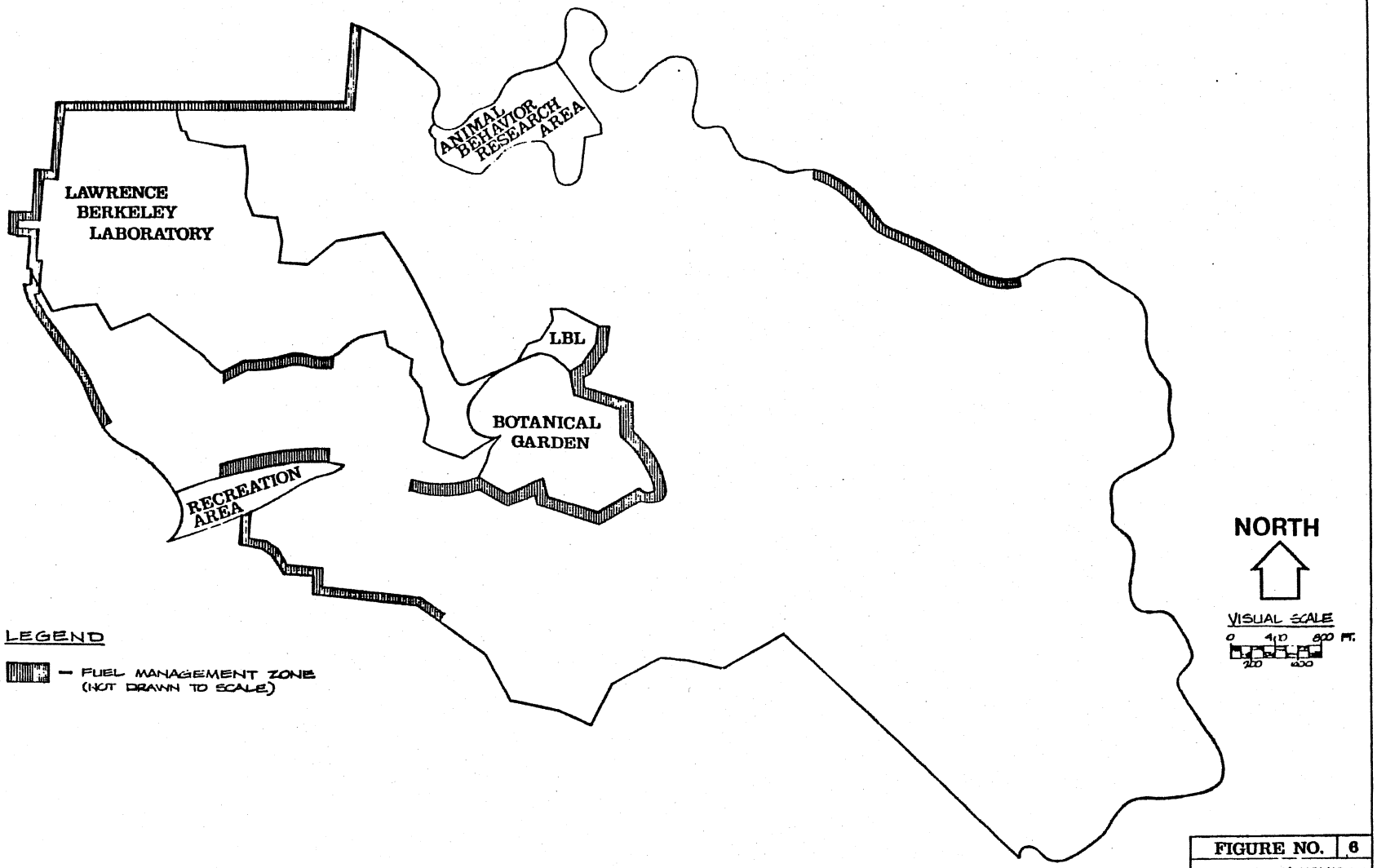


FIGURE NO. 8

FUEL MANAGEMENT ZONE

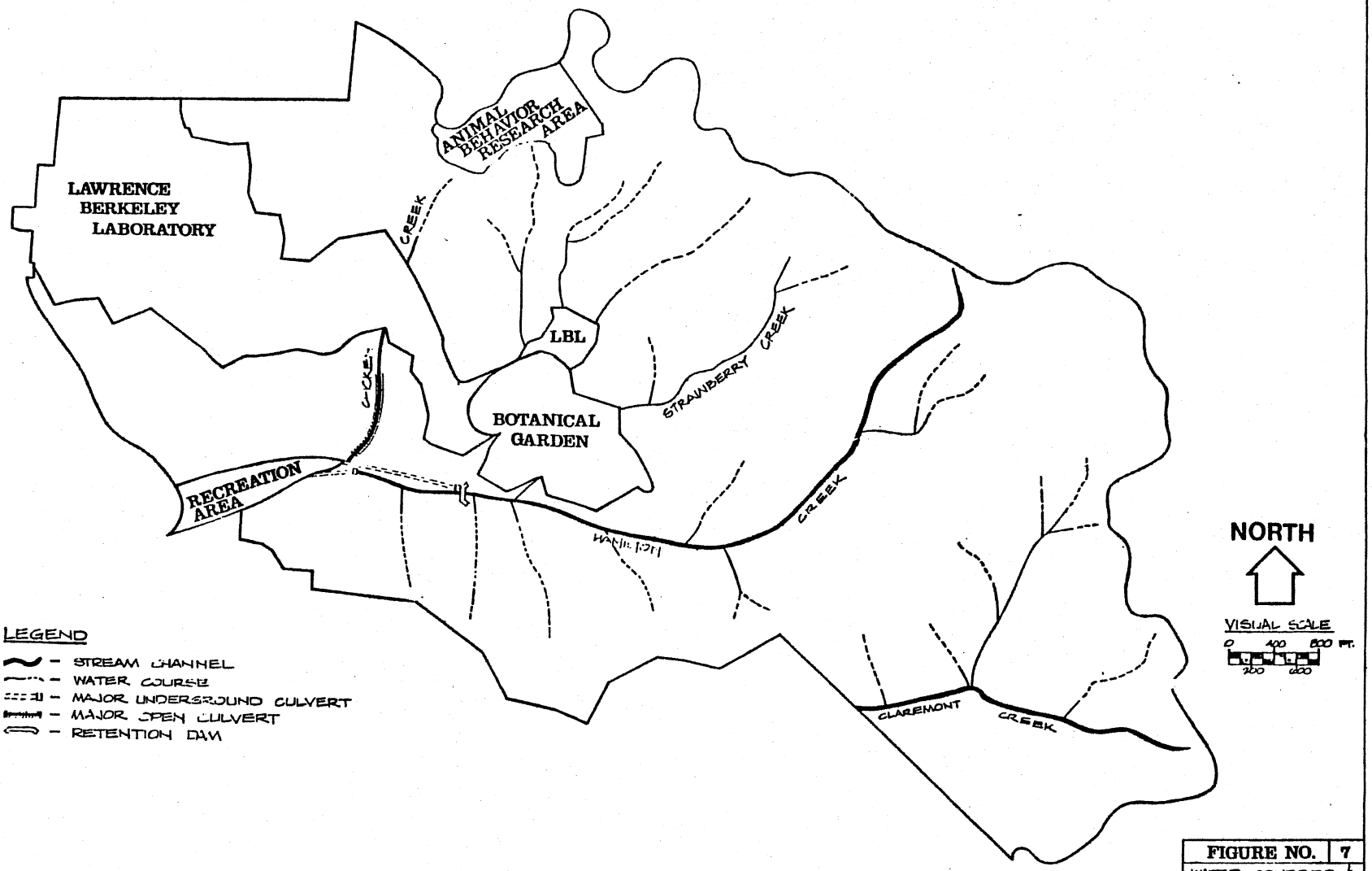


FIGURE NO. 7

WATER COURSES & STREAM CHANNELS

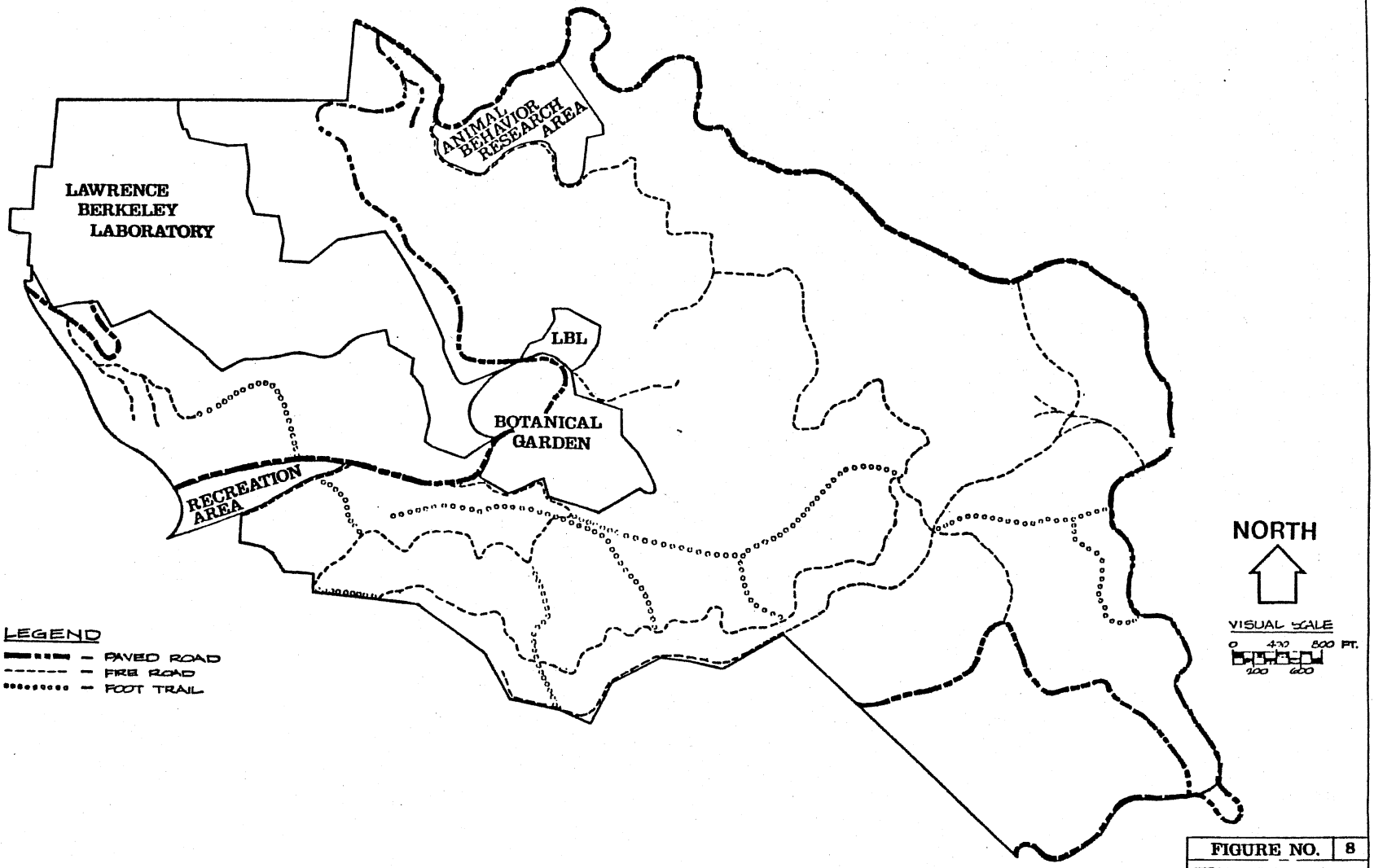


FIGURE NO. 8

TRAIL SYSTEM

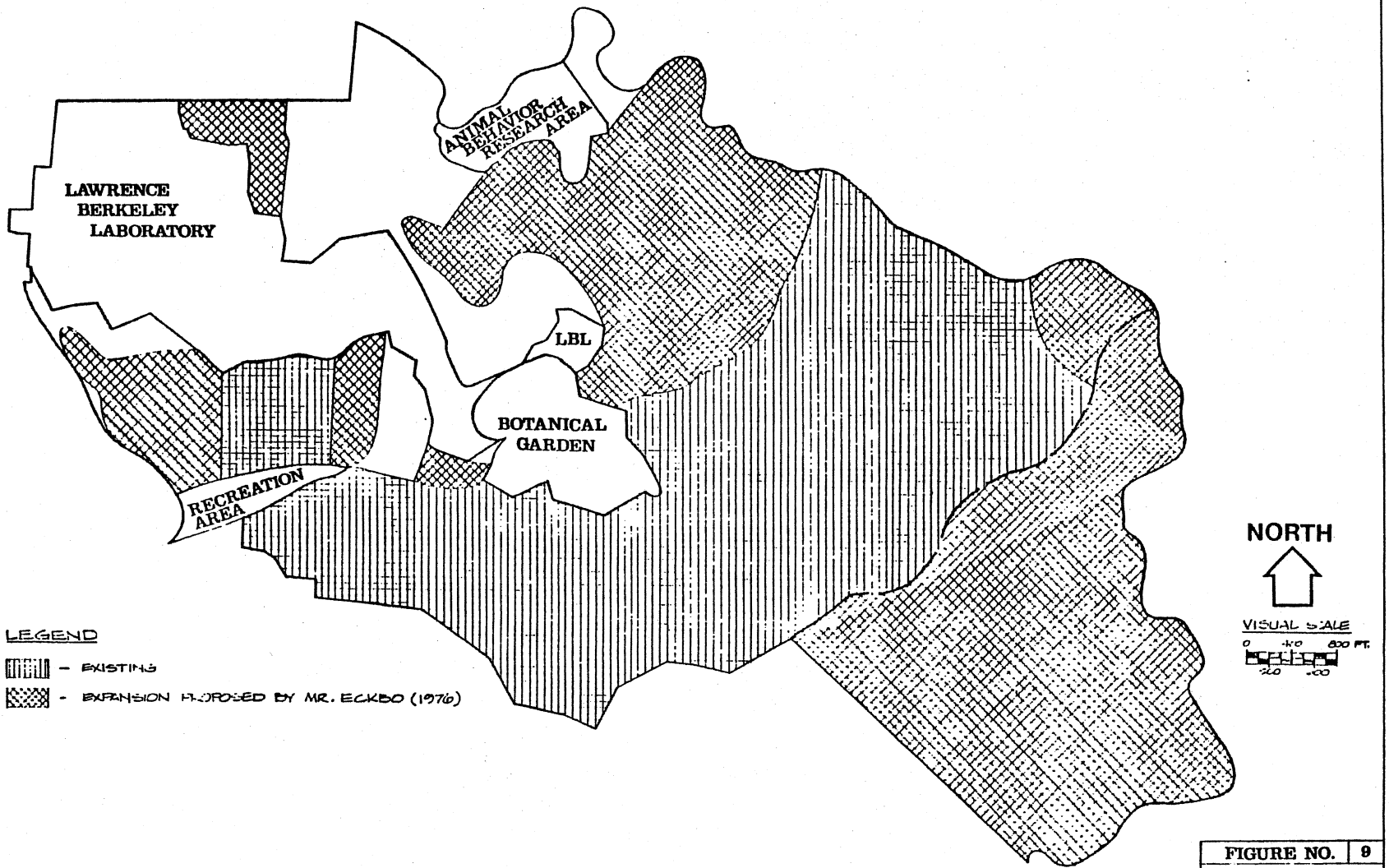


FIGURE NO.	9

ECOLOGICAL STUDY AREA & PROPOSED EXPANSION BY MR. ECKBO (1976)

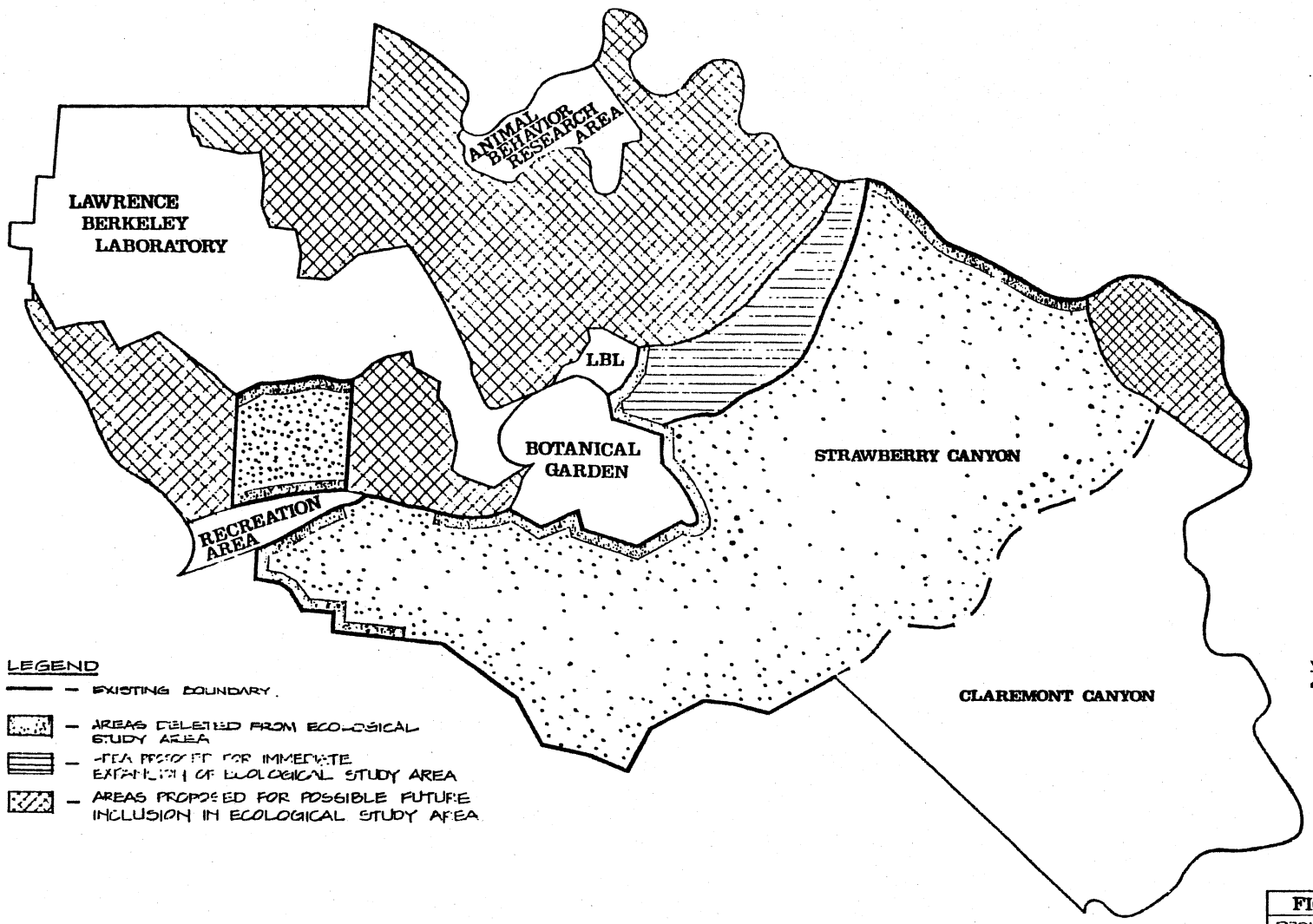


FIGURE NO. 10

PROPOSED MODIFICATION OF ECOLOGICAL STUDY AREA BOUNDARY

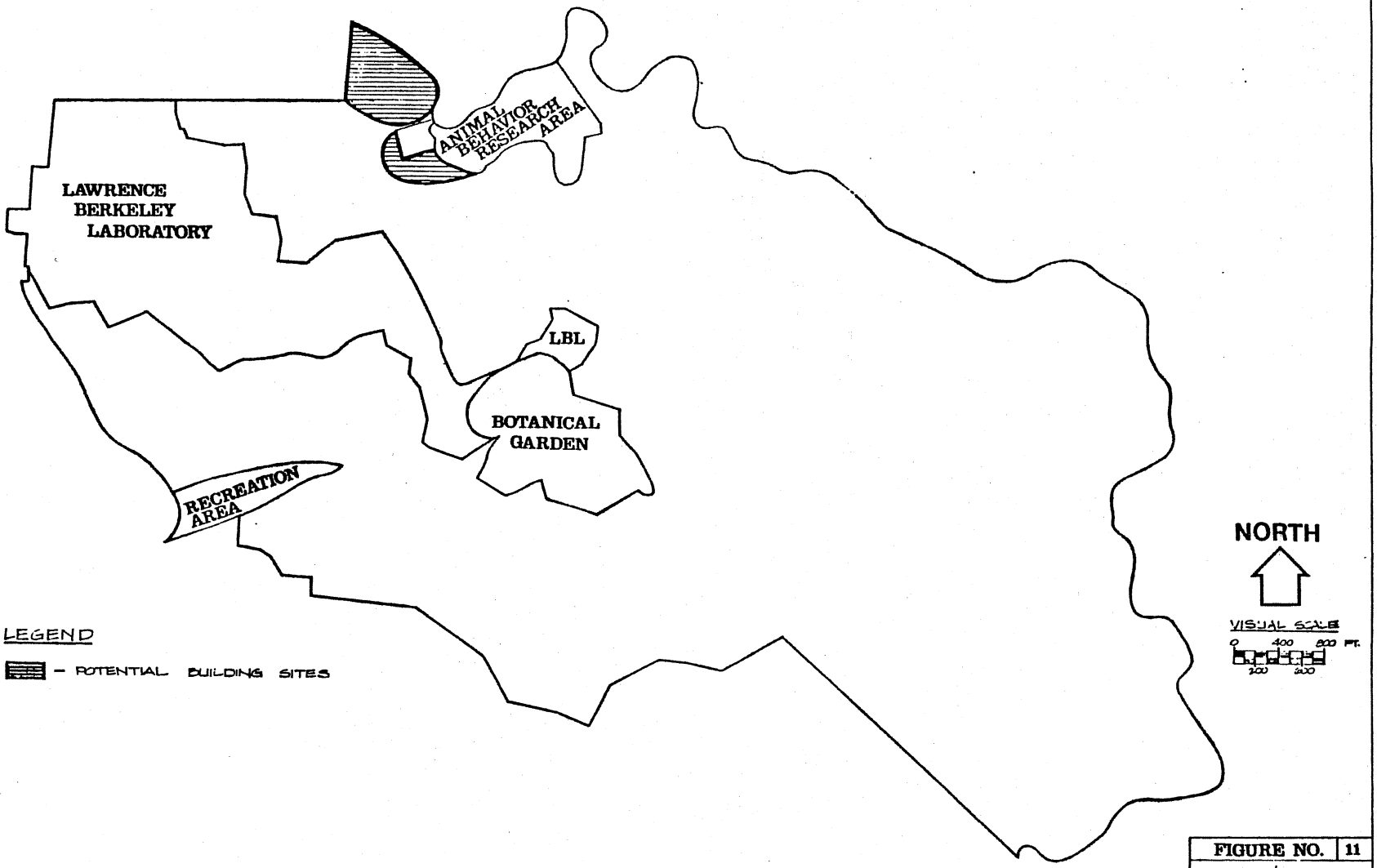


FIGURE NO. 11

POTENTIAL BUILDING SITES

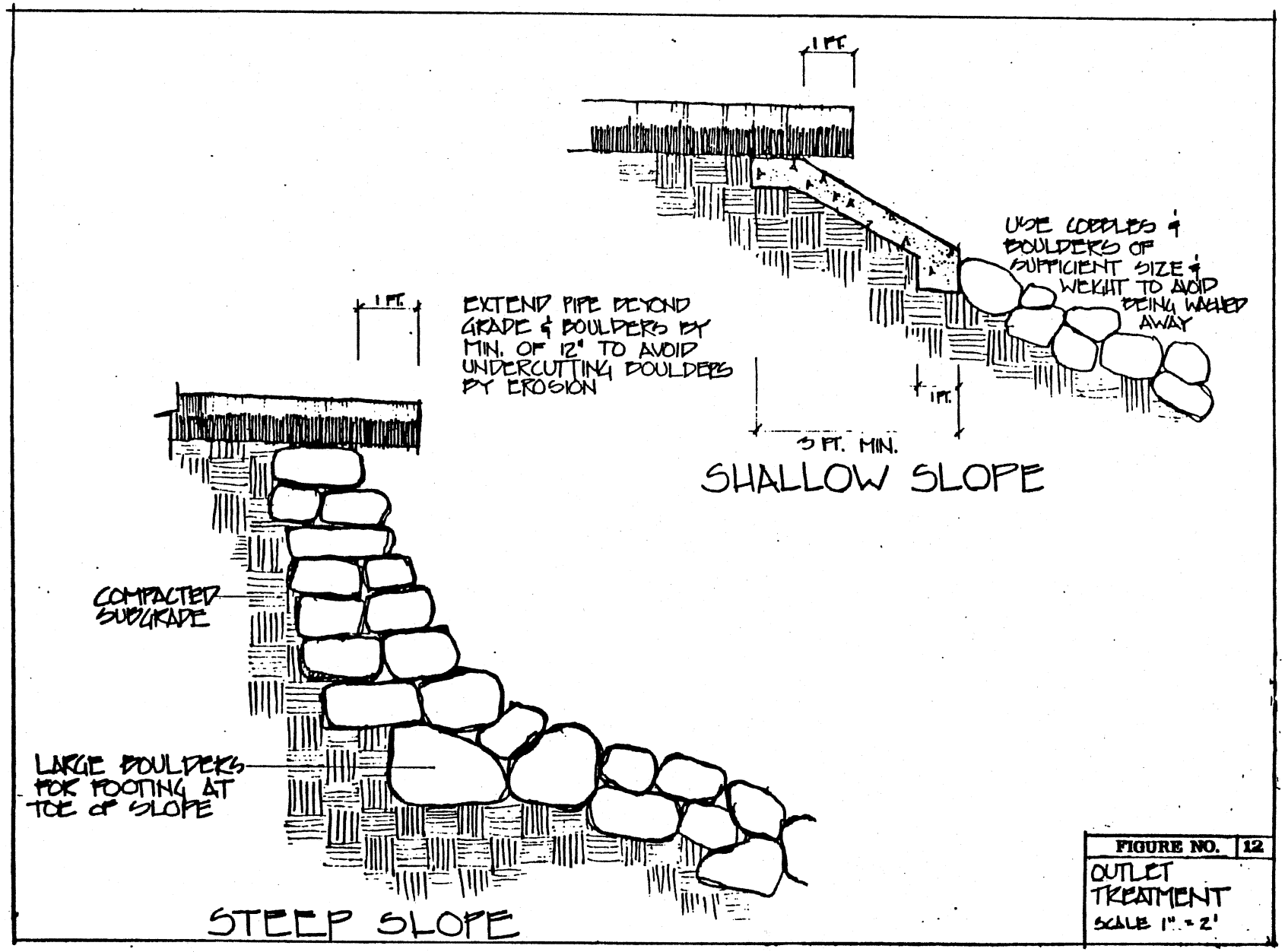


FIGURE NO.	12

OUTLET TREATMENT

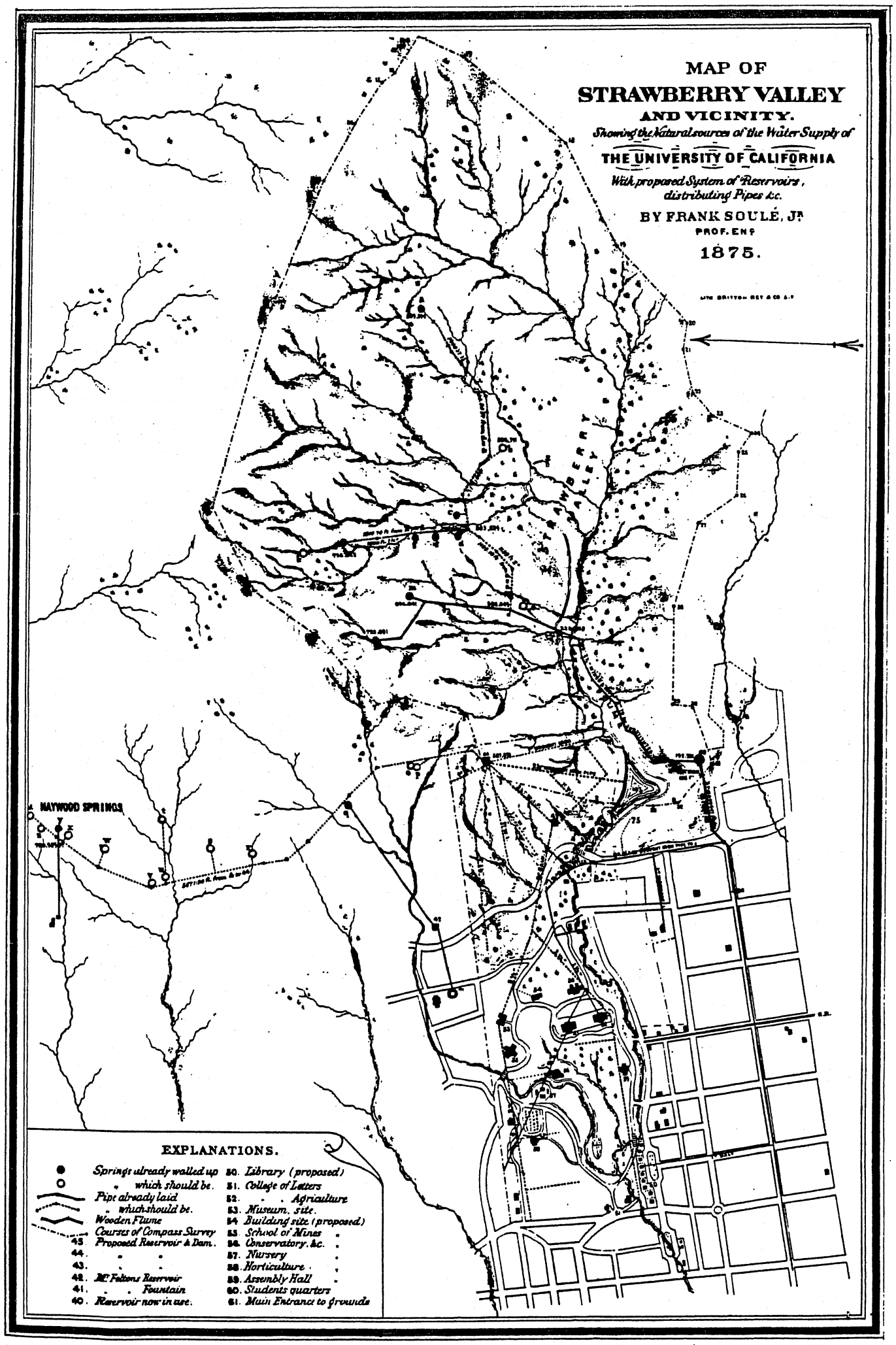
SCALE 1" = 2'

Phila Rogers 1/2/08 Doc 3

AN ENVIRONMENTAL ANALYSIS OF POTENTIAL DEVELOPMENT SITES IN THE EAST HILL AREA (STRAWBERRY CANYON) OF BERKELEY, CALIFORNIA

A Professional Report Prepared in Partial
Fulfillment of the Requirements
For the Degree of Master of Arts,
City and Regional Planning.
Presented to the Faculty of the
University of California,
Berkeley, June 1982

Terence O'Hare


MAP OF
STRAWBERRY VALLEY
AND VICINITY.
Showing the Natural sources of the Water Supply of
THE UNIVERSITY OF CALIFORNIA
With proposed System of Reservoirs, distributing Pipes &c.
BY FRANK SOULÉ, JR
PROF. ENG
1875.
HAYWOOD SPRINGS
EXPLANATIONS.
Springs already walled up
" which should be.
Pipe already laid
" which should be.
Wooden Flume
Courses of Compass Survey
45. Proposed Reservoir & Dam.
44. " "
43. " "
42. Mt Fletons Reservoir
41. " " Fountain
40. Reservoir now in use.
50. Library (proposed)
51. College of Letters
52. " " Agriculture
53. Museum, site.
54. Building site (proposed)
55. School of Mines "
56. Conservatory, &c. "
57. Nursery "
58. Horticulture "
59. Assembly Hall "
60. Students quarters
61. Main Entrance to grounds

COMMITTEE

Donald Appleyard (Chair), Professor, City & Regional Planning and Landscape Architecture, UCB
Fernando Kusnetzoff, Professor, City & Regional Planning, UCB
Thomas A. Koster, Senior Educational Facility Planner, Buildings & Campus Development Committee, Chancellor's Office, UCB

ACKNOWLEDGEMENTS

This report has been prepared under the aegis of the Buildings & Campus Development Committee, UCB (Sami Hassid, Chair), in collaboration with the office of Dorothy Walker, Coordinator - Physical Planning, UCB. The author wishes to thank the members of his Committee, and Tom Koster in particular, for his diligent reading of several drafts of this report and his guidance in its preparation. Thanks are also due to Dorothy Walker and Ralph Gigliello for their helpful suggestions and to Sara Mikesell for the patience and skill she brought to the production of this report. I also wish to thank Sami Hassid for the generous assistance that BCDC gave to the report and Carolyn Curran, Denise Crozier, and Ray Shiflett for their assistance when help was most needed.

FOREWORD

1. Project Definition

The primary objective of this report is to provide a preliminary analysis of the East Hill area of the University of California, Berkeley, that can be used as a basis for the development of policy options regarding the long range development of the area. The major focus is on the identification and evaluation of possible building or development sites in the area with particular attention to the programmatic needs of the Field Station for Behavioral Research, already located in the area.

2. Study Area Definition

The report provides an overview of the prevailing environmental conditions in Strawberry and Claremont Canyons. However, it limits the area of its detailed analysis to the upper eastern section of the canyon area excluding Lawrence Berkeley Laboratory and the Hass-Strawberry recreational facilities. The study area encompasses the University's Botanical Garden, the Lawrence Hall of Science, the Space Sciences Laboratory, the Ecological Study Area, and the Field Station for Behavioral Research.

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1. EXECUTIVE SUMMARY

This report summarizes information relating to existing environmental conditions in the East Hill area of the University of California, Berkeley. It provides an inventory of land use, a discussion of ecological concerns, and some recommendations for future development in the area.

The findings of this report suggest that while development is constrained by topography and environmental issues, specific sites in the area can be usefully developed provided that such development is sensitive to a number of topics. These include the continued primary use of the area for instruction and research as well as relaxation; the protection of existing vegetation and wildlife populations; and the implementation of land and water management techniques to offset the possibility of soil erosion, flooding, and localized landslides.

A further major concern in the area is the danger of fire and the prevalence of hazardous fire conditions which become extreme during certain periods in the late summer and fall. While acknowledging the concerns of conservationists and naturalists that existing wildlife habitats and vegetation ought not be destroyed, this report regards the implementation of a prudent and efficient, if limited, fuel management program as critical to the area's long-term survival as an ecological preserve. The risk of fire in the canyon area grows as the human population of the area increases, and it should be recognized that all the University community values in the area could be lost in a single disastrous fire.

Without the introduction of fire management practices, the Field Station for Behavioral Research is perhaps at greatest risk. The loss of rare animal collections and of productive research may result if fire management proposals are not implemented and maintained. The spatial reorganization of the Station, the need for which provided the initial impetus for this report, offers an opportunity to introduce safeguards against fire risk.

While the potential development of a number of sites has been identified and analyzed in this report, further detailed study is required in order to formulate a viable development plan for the area. Site-specific studies should be carried out to establish the building capacity of each site in terms of gross and assignable square feet, and the design of a preliminary site layout. The area's vehicular circulation system and transportation resources need to be examined to establish potential mass transit requirements. The expansion capacity of the area's existing utility and power lines must also be established. The early development of specific design guidelines for individual sites is also required so that the area's environmental priorities, ecological conditions, and aesthetic qualities are protected, and indeed enhanced, by any development that takes place.

2. INTRODUCTION

The object of this report is to examine the existing and potential land use of that area of University property known as East Hill. Lying immediately to the east of the campus, this area contains both Strawberry and Claremont Canyons, and occupies some 865 acres of mostly steeply wooded hillside. At present the area is used for research and instruction chiefly in the physical and life sciences.

In recent years the area has come under pressure for development and, as land on the central campus becomes filled, this pressure can be expected to increase. However, the impact of future development upon the geological and ecological conditions in the area and on its present use will be significant. In particular, the needs of the Field Station for Behavioral Research (FSBR), a long term user of the area more commonly known as the Animal Behavior Research Station, are likely to be compromised should additional major development take place while this facility remains in its present location. Therefore, this report will, within the range of its broader scope, give particular attention to the function and orientation of the FSBR, taking into account its need for acoustical and visual isolation in conditions that approximate a semi-natural environment.

Although the vast bulk of the land in question has remained in its undeveloped or natural state--indeed 350 acres have been designated by the University as an Ecological Study Area--a number of buildings and research units, some quite large, have been established in the area. They include the Lawrence Hall of Science (1968), the Space Sciences Laboratory (Silver Laboratory, 1966), the Botanical Garden (1926), and various units of the Lawrence Berkeley Laboratory. However, the urgency with which this report is required is dictated by the proposed construction, beginning in the spring of 1983, of a new Mathematical Sciences Research Institute (MSRI). This building, which is to be a structure of about 16,500 gross square feet (plus a potential 3,000 gross square foot addition), will be located immediately to the south of the Silver Laboratory adjacent to the western boundary of

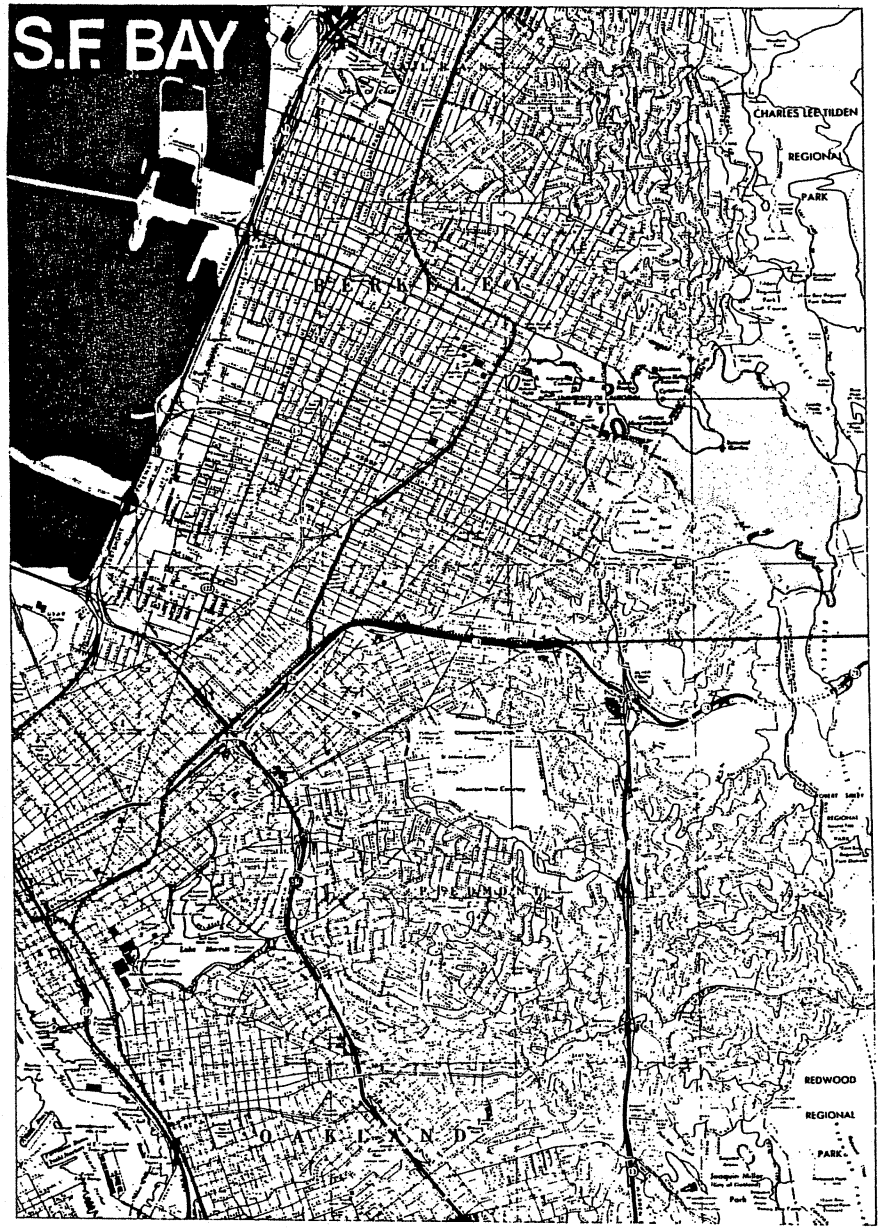
the FSBR. The Institute will be designed as the first of a complex of similar buildings which may be built at the site over the next 10 to 20 years.

The eventual establishment of this research complex is expected to conflict, at least to some degree, with the need of the FSBR to remain a secluded and isolated research unit. While the extent of this conflict is not yet clear, it is likely that the construction of the research complex as now planned will require the physical reorganization of the FSBR. Whether or not this reorganization can take place within the existing confines of the FSBR is a key concern of this report. A general review of development in the East Hill area is therefore now opportune. Current University policy governing the development of land in the area is not firmly in place. This report is intended to provide a basis from which such a policy can be developed.

After first outlining the history of the University's interest in the East Hill area, the report will consider the environmental characteristics of the area. It will then provide a discussion of the administration of the area and an inventory of existing land use before proceeding to identify and evaluate specific sites in order to establish:

> the location of potential building sites, including those previously earmarked for development in earlier reports;
>
> the location of potential "development" sites, that is, sites which may be developed for research and instruction that do not require the construction of large permanent structures;
>
> the location of potential access roads and service or parking areas for new building or development sites; and
>
> the location of potential pedestrian access routes and circulation patterns for new building or development sites.

This report, however, does not constitute a complete environmental study of the area in that it does not take into account such topics as the archaeological character of this area, the socio-economic impact of development, or the provision of human health care services.



location map

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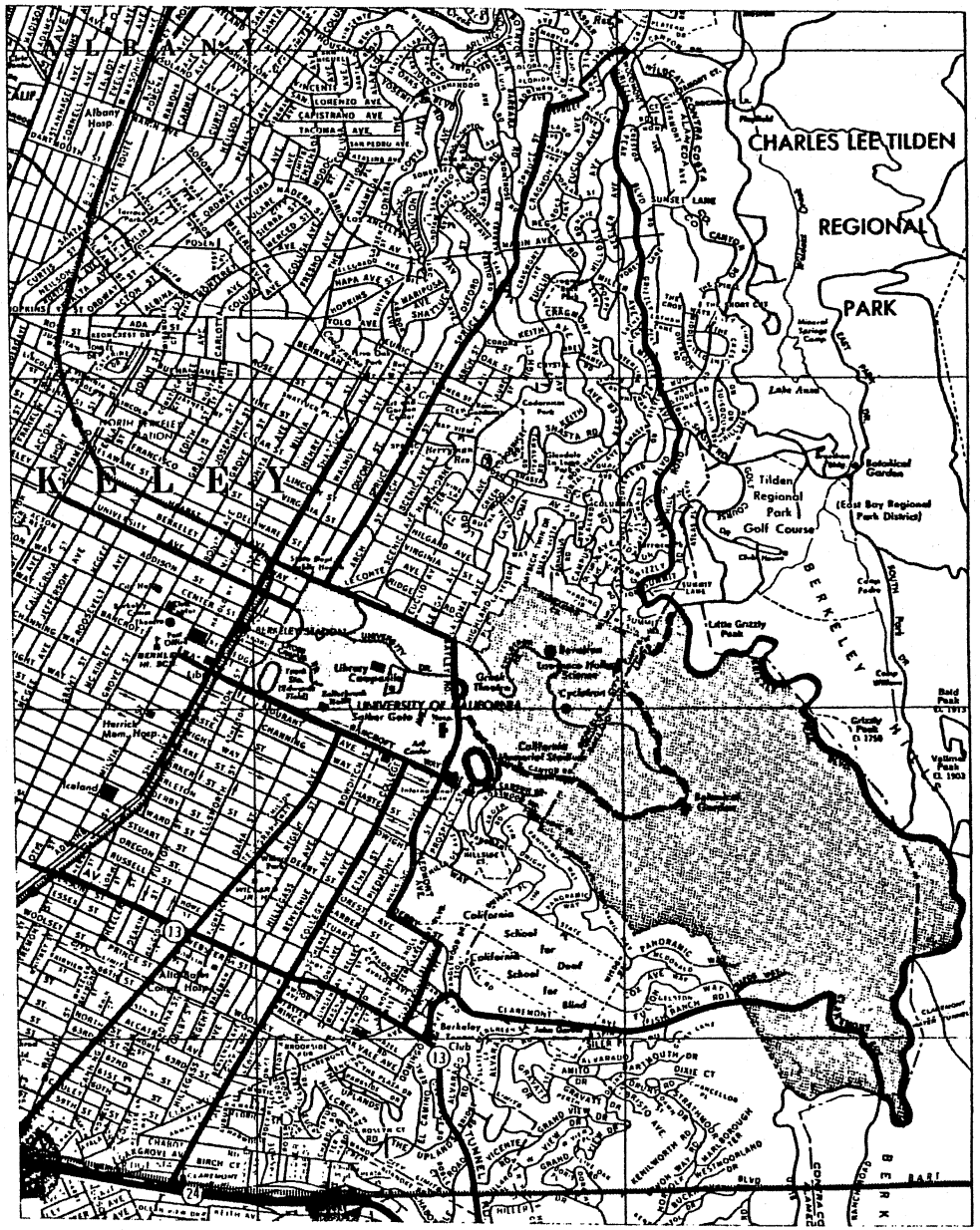
1



area map

0 500 1MILE

2

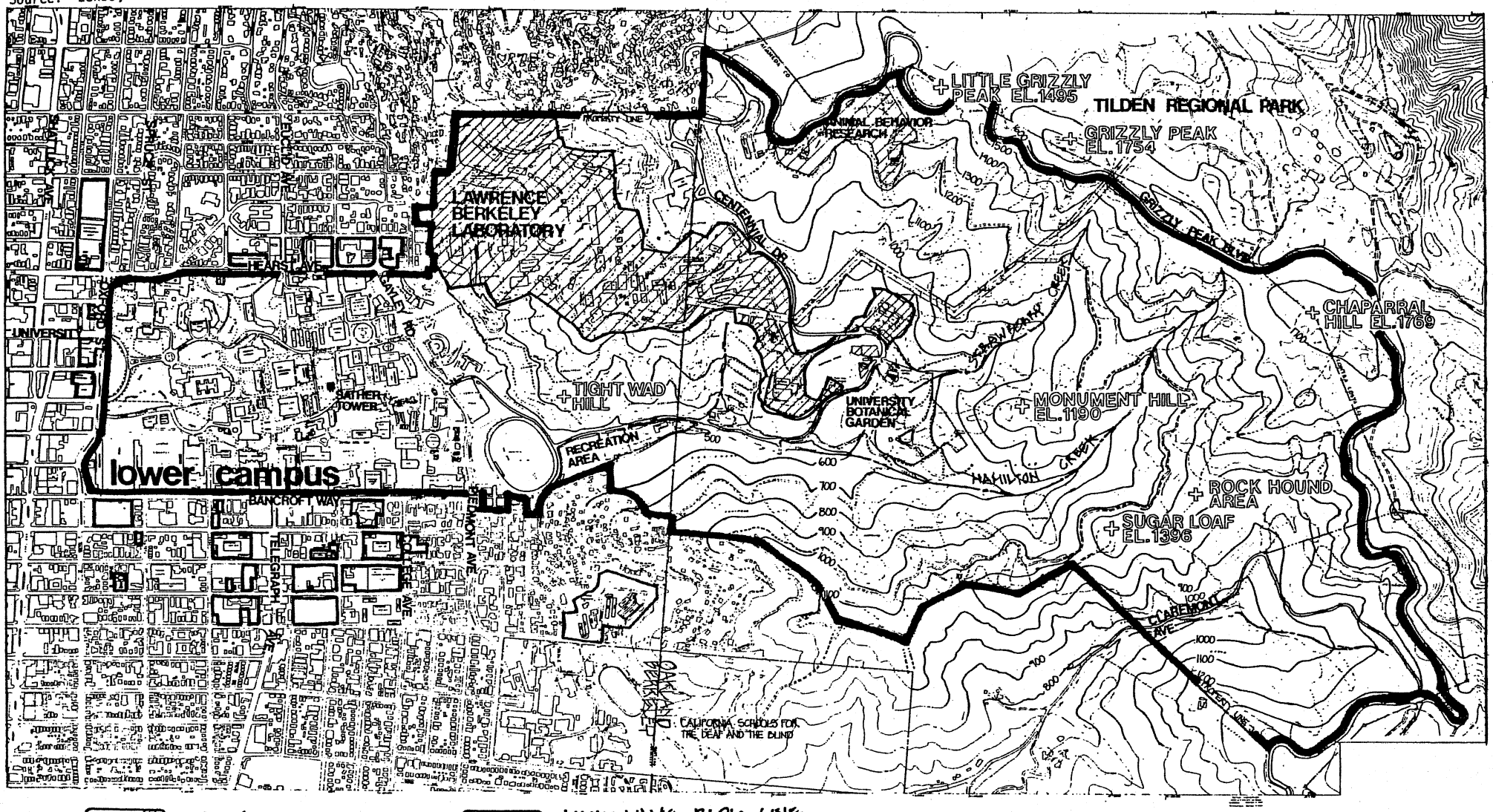
3. BACKGROUND

The East Hill area of the University of California has a history of use for instruction and research that reaches back to the founding of the Berkeley campus.[1] The lower section of Strawberry Canyon was included in the land originally granted to the University at its inception in 1868. The remainder of the East Hill area came under University jurisdiction in 1909.[2] Since that time Strawberry Canyon has served as " a wildland scientific resource and environmental testing ground for faculty, visiting scientists, and students in botany, entomology, zoology, forestry, soil science, plant pathology, genetics, landscape architecture, and military science."[3] For generations of students and faculty the proximity of a wilderness area close to campus has also provided a retreat from the pressures of academic life. Thus a strong sense of identification with the area has grown within the academic community.

In terms of use, appearance, and surface texture the vegetation in the area has changed a good deal since the University first acquired the land. In the early 1800s, the land was mostly open grassland used for grazing cattle, a use that continued well into the 1930s.[4] Few trees and bushes then dotted the area, except along water courses. Since the turn of the century there has been a continual process of change in the landscape in which the original grassland has gradually been supplanted by an oak-bay forest. Many nonindigenous "plantation" species were introduced into the area between 1900 and 1920, and as a result open hillsides have become covered by a denser, taller vegetation. Change in management practices has brought about change in the landscape. As grazing cattle and ranching gave way to ecologically protected zones, the first "primitive area" was established in the mid 1930s and policies favoring natural plant succession took hold. Should current management policies maintain this approach, the expansion of the riparian woodland we see in the area today can be expected to continue. By the beginning of the next century, 60% of the area will be covered by oak-bay woodland, 25% by bushes, and only small areas of open grassland will be left to remind visitors of the area's former use a century or more ago.[5]

PHYSICAL SETTING

Source: Eckbo, 1976.



physical setting

0 200 400 1000 1750 ft.

3

4. PHYSICAL SETTING

The following provides an overview of the existing geophysical and ecological conditions in the East Hill area, placing them in a regional context. This section of the report evaluates the characteristics of the area principally in terms of its topography, vegetation, and public access.

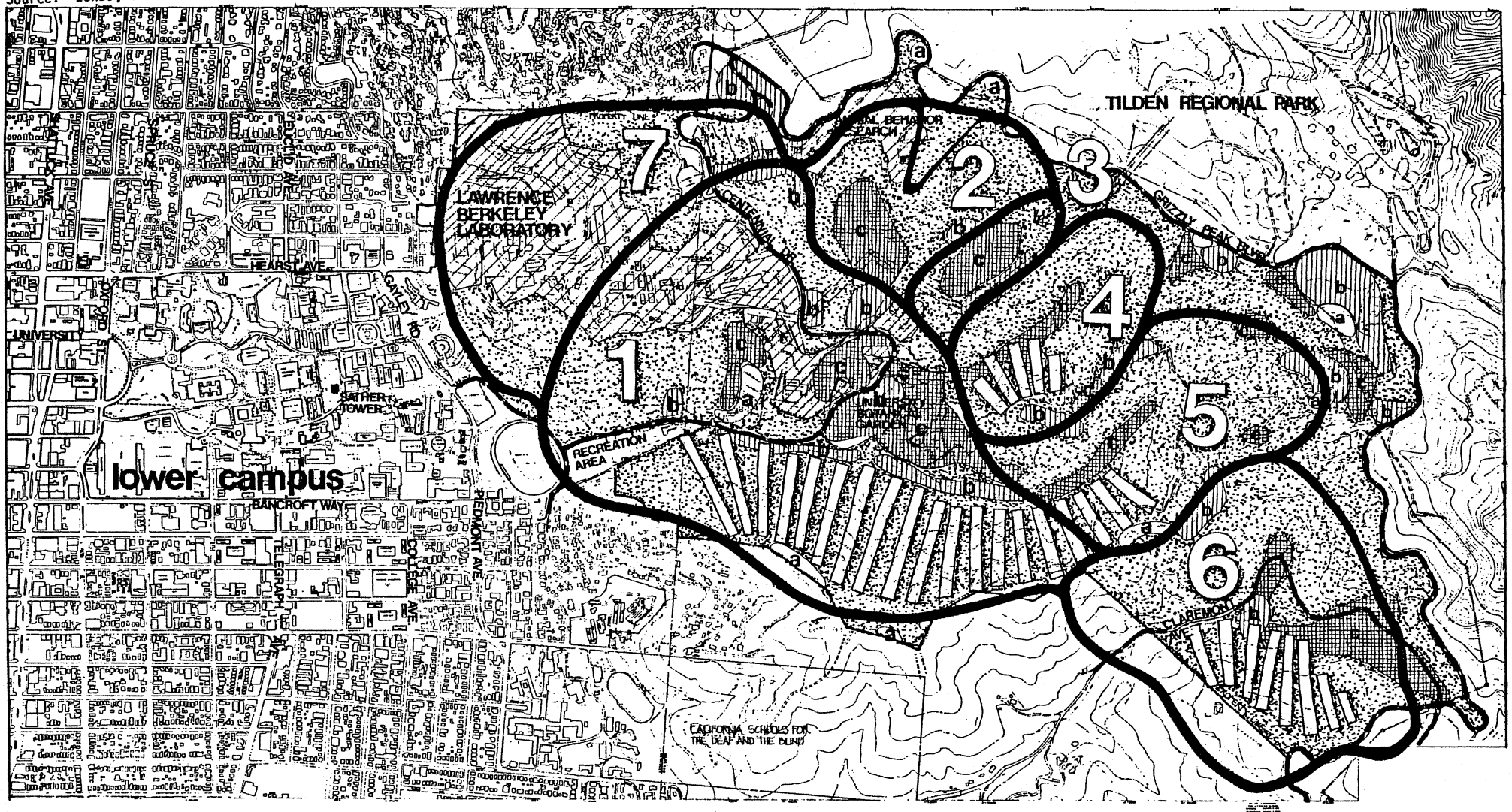
a. Topography

The East Hill area of the University of California covers about 835 acres of steep, irregular, and undeveloped terrain consisting of two well-defined canyon systems. The total land area in the two canyons under University control is about four times the area of the central campus. The southeast corner of the area is occupied by the upper reaches of Claremont Canyon (200 acres). A high ridge line separates this canyon system from Strawberry Canyon (635 acres), the major topographical feature of the area. Strawberry Canyon is essentially a steep sided cone one mile wide at its base and one and a half miles long, that expands from a narrow opening about 500 feet wide at the west to a high open ridge formation at the east. The land rises from approximately 400 feet above sea level at the western toe of the canyon slope to an elevation of 1,769 feet at Chaparral Hill on the northeastern boundary.

Topographically, the total area may be divided into four basic units. A west-facing lower slope bounded by Gayley Road in the west contains the Lawrence Berkeley Laboratory facility. The main bowl of Strawberry Creek occupies the center of the canyon system along with the University's Botanical Garden. Subsystems of minor creeks and valleys, of which Hamilton Creek is the most prominent, take up the northeastern section of the area, while the Claremont Canyon section lies isolated in the southeast corner beyond Skyline Ridge. The north-facing slopes on the south side of Strawberry Canyon are generally smooth and uncomplicated but, to the north and east, canyon sides are irregular and fragmented.

A characteristic of the area is the extent to which its legal boundaries match its

Source: Eckbo, 1976.



TOPOGRAPHIC UNIT

1 ZONE 1 ▫ MAIN CANYON

2345 ZONE 2-5 ▫ SIDE CANYONS

6 ZONE 6 ▫ CLAREMONT CANYON

7 ZONE 7 ▫ VEL WEST SLOPE

NORTH SLOPES ▫ COOL, MOIST

a 0-8% SLOPES

b 8-15% SLOPES

c 15-25% SLOPES

25% + SLOPES

0 200 400 1000 1750ft.

topography and slope

4

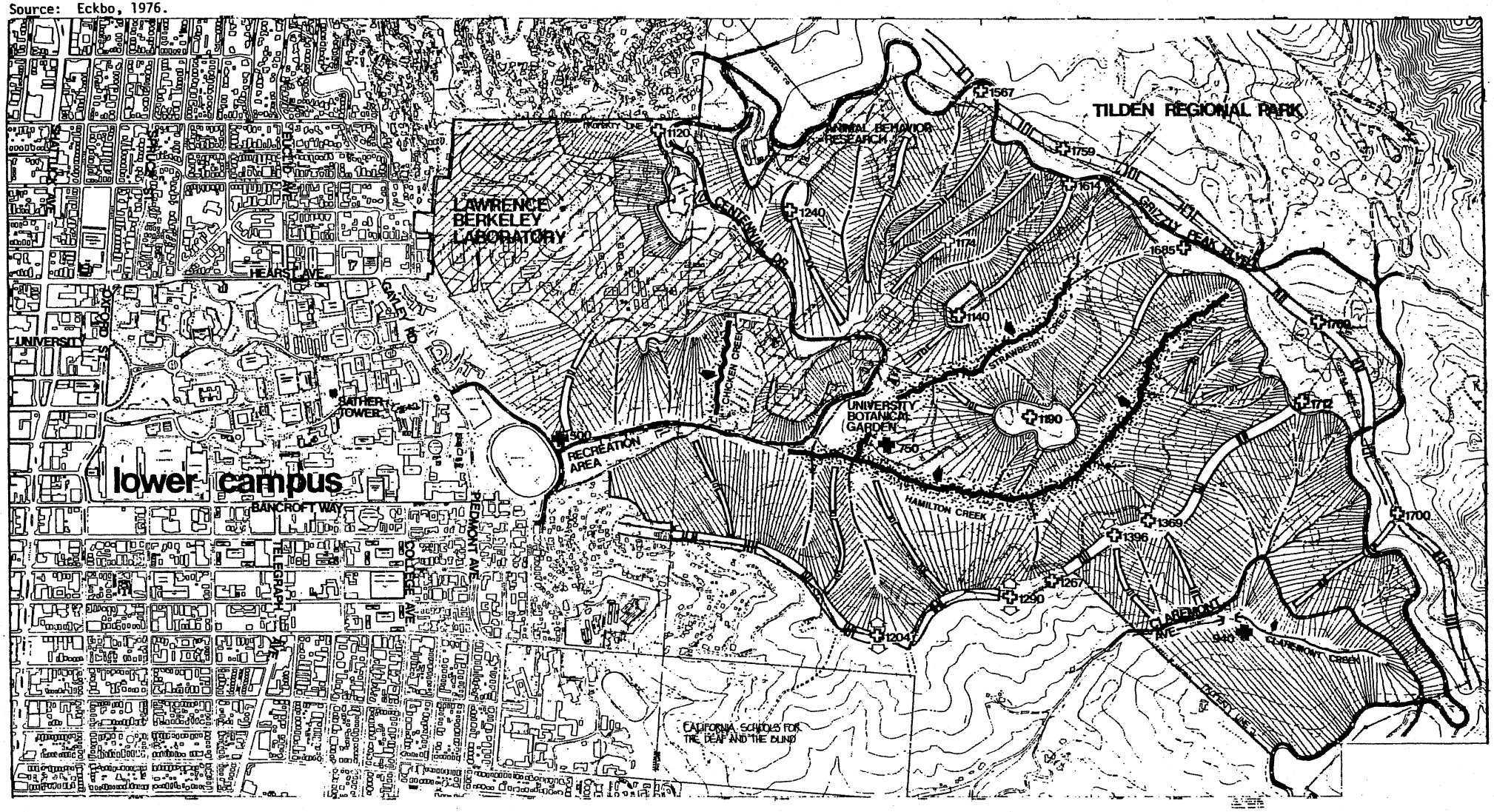
physical configuration. Except for the western and lower section of the area, which lies within the City of Berkeley, 75% of the area is in the City of Oakland. To the north and east the University property line aligns itself with an undulating ridge-top that roughly follows Grizzly Peak Boulevard. This line also marks the division between Alameda and Contra Costa Counties. In the south, the property line continues along Grizzly Peak Boulevard a short distance to the west before crossing Claremont Canyon in a northwesterly direction. The boundary line then turns to follow the crest of Skyline Ridge as it slopes down to the west. Here the land narrows at the foot of Strawberry Canyon, connecting the area to the central campus.

The topography of the canyon system has directly influenced land use both within and without University property. To the west, the buildings of the Lawrence Berkeley Laboratory, technically outside of the canyon system proper, retain fine views to the south and west. Within the canyon system the Lawrence Hall of Science and the Silver Laboratory both command sites on the major promontories looking west. Along the north and south boundaries of the East Hill area, hillside residences and narrow lanes mark the lines of the canyon system. The eastern boundary of this system is defined by a high and relatively level ridge line that provides spectacular views of the Berkeley campus and San Francisco across the bay. Beyond this line to the east the expanse of Tilden Regional Park, which adjoins University land at this point, extends the undisturbed character of the area's natural terrain and vegetation.

b. Physiography

Geologically the East Hill area consists of a recently uplifted front of the Berkeley Hills that slopes downward in a general east-west direction. However, the underlying rock strata of the hill front run perpendicular to this direction. Several different rock types are therefore exposed as the land falls from east to west. In geological terms the area is divided into two sections of roughly equal size by a trace line of the Wildcat Fault.

Source: Eckbo, 1976.



EXISTING VEHICULAR CIRCULATION

RIDGELINES

HILLSIDES

1976 HIGH POINT

1975 LOW POINT

CREEK

0 200 400 1000 1750ft.

physiography

5

Part of a secondary earthquake fault system (discussed later in the report), this fault runs north and south from the main entrance of the Botanical Garden in the center of the canyon system. West of this line the rock strata consist of mostly shale and occasional interbeds of sandstone belonging to the Shaota-Chico formation. To the east of the fault line the rock is primarily chert of the Monterey formation. This latter rock type is geologically resistant to erosion and, over time, three significant knolls of this material, two of them quite prominent, have appeared. Situated in the northeast section of this area, their geomorphic characteristics have been described in a report completed in 1974.

> The southernmost (knoll), called Sugar Loaf, occurs on Skyline Ridge and rises abruptly some 200 feet to an elevation of just over 1,400 feet. North of Sugar Loaf and separated from it by the south fork of Strawberry Creek, stands the second prominent point, known as Monument Hill. This hill rises steeply behind the Botanical Garden to a height of 1,200 feet.[6]

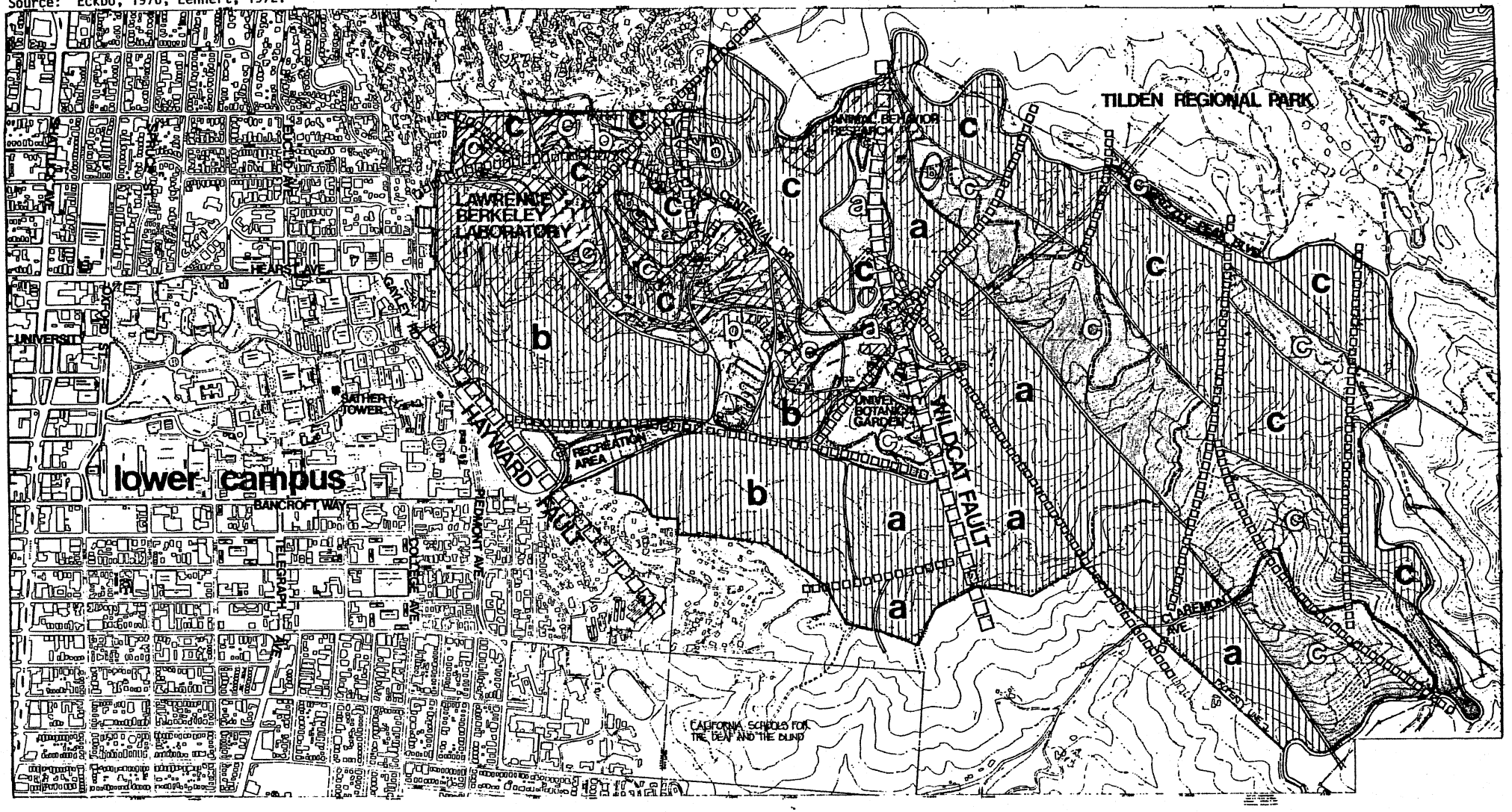
The third chert knoll is to the north of Monument Hill and, because it is only slightly lighter than its surrounding soils, it does not stand out so prominently as the others.

At the northern and eastern edges of the University's property geologic formations slope steeply upwards to form the crest of the Berkeley Hills. Here the land is composed of volcanic rocks of the Berkeley formation comprised largely of basalt, rhyolite, and tuff formations. These rocks are highly resistant to erosion and they make up the highest and steepest section of the Berkeley Hills. Contiguous with, but not part of, the University property at this point are Grizzly Peak (1,754 feet) and the adjacent Little Grizzly Peak (1,495 feet). The highest peak in the Berkeley Hills, Chaparral Hill (1,769 feet), is a little further south, standing wholly within the northwestern corner of the University's property.

c. Seismology

The East Hill area can be seismologically defined in general as a fault-controlled canyon and drainage system east of the Hayward Fault. The Hayward Fault is an active member of the San Andreas Fault System and as such is the major seismological feature

Source: Eckbo, 1976; Lennert, 1972.



UNFAVORABLE SOILS

- a — RECENT - ALLUVIUM, COLLUVIUM & LOCAL FILL
- b — RECENT TO LATE PLEISTOCENE - LANDSLIDE BODIES
- c — MID TO LATE PLEISTOCENE - ORINDA & SIESTA FORMATIONS COMMONLY UNSTABLE

FAVORABLE SOILS

- a — MIOCENE - CLAREMONT & SOBRANTE GENERALLY STABLE
- b — CRETACEOUS - KNOXVILLE & CHICO SANDSTONES & SILTSTONES GEN. STABLE
- c — LATE PLIOCENE - MORAGA, GRIZZLY & BALD PEAK, TUFFACEOUS SEDIMENTS GENERALLY CLAYEY, POTENTIALLY UNSTABLE

0 200 400 1000 1750ft.

seismology and soils

6

of the area. The line of the Hayward Fault, which aligns itself along the north-south direction of Gayley Road, marks the western boundary of the canyon system. It also defines the edge of a continental plate along which tectonic activity occurs. Seismologic shifts along this plate line have caused the uplifted formation of the Berkeley Hills over time.[7]

A study of the Hayward Fault made in 1972 found that the western side moves at a rate of about 0.1 inches per year to the northwest. According to this measurement a two mile geological dislocation has occured along the fault line since its inception about two million years ago. Defined as a right lateral fracture in the earth's crust, the Hayward Fault has created a clear geological separation in the rock strata between the lower campus area of the University and the East Hill area.

Another right lateral seismic fault which also follows a north-south direction, this one in the center of the canyon area, is the Wildcat Fault. A secondary member of the San Andreas System, this fault traverses the hill area at approximately midslope, dividing the whole of the East Hill area roughly into two halves, one section to the east, another to the west. Structural discontinuity along this fault is thought to have caused a two and a half mile dislocation in the rock strata since the fault first appeared in the Pleistocene Epoch. Structural movement in the bedrock has continued in relatively recent geologic time.

Tectonic movement in the area between the Hayward and Wildcat Faults has produced a subsidiary set of tension and compression faults that run in an east-west direction. The western section of Strawberry Creek occupies one such fault in its lower reaches. Activity along this and similar fault lines has produced a complex pattern of minor cross-faults and thrust faults that have both lateral and vertical discontinuities within adjoining rock strata. The bedrock in the western portion of the East Hill area is therefore divided into a series of separate blocks, each with the capacity for independent movement.

To the east of the Wildcat Fault, tectonic formations are less well-patterned but no less well-defined. Formational members of similar material appear on either side

of Wildcat Fault, displaced by the 2 ½ mile distance mentioned above. Therefore, the nonconforming faces of these formations do not exhibit depositional continuity. In general, the upper hill areas of Strawberry and Claremont Canyons are less prone to seismic activity than the lower western slopes since the upper fault lines are minor in nature and their patterning less interconnected. The area is also further away from those locations in which seismic activity is expected to occur.

The possibility of major seismic movement in the East Hill area cannot be discounted. A report prepared for the University by Harding-Lawson Associates in 1979 stated that an earthquake of 7.0 on the Richter Scale could occur along the length of the Hayward Fault during the life of any new construction. If the epicenter of such an event were located in the Berkeley area, ground shaking could be as high as modified Mercalli Intensity Scale IX, and considerable building damage could result. The impact of more distant earthquakes along the Hayward, San Andreas, or other active faults in the region could be less intense. However, the occurrence of minor earth movement along these faults is likely to be more frequent.

d. Soils

The Vegetative Management Plan (J. R. McBride, 1974) prepared by the Vegetative Management Committee of the University provides a good overview of the soils in the area.

> The soils along the ridge of the Berkeley-Oakland Hills have formed from sandstone and shale. They are loams and clay loams, very porous and strongly structured. Depth of soil to weathered sandstone ranges from less than 12 inches to over 5 feet, although most soils range from 12 to 24 inches deep. Shallow soils occur along the very top of rocky ridges and on some very steep slopes such as on Grizzly Peak. Very deep soil occurs in the upper portions of canyons on north and east facing slopes. The depth of plant roots-particularly trees and shrubs-is not limited to the soil depth but extends many feet into the weathered and fractured sandstone for water and nutrients.[8]

Soil erosion in general is not a serious problem in the East Hill area where the ground has remained in its undisturbed natural state. Erosion in fire-damaged areas that have remained exposed to several months of rain in the main only causes localized problems. Similarly soil stability in the lower reaches of the hill area is generally good. However, in certain areas where soil conditions are poor in the East Hill area and where construction has taken place without adequate regard to good engineering practice, landslide activity is a major problem.

The bulk of large scale slide movements in the area has taken place in the upper sections of the hill area and have involved material belonging to the Orinda formation. Most existing slopes of the Orinda formation are thought to be "critical" in terms of their capacity for movement and in many areas the Orinda soil mantel is presently experiencing slow "creep" movement. Where the soil has been degraded by tectonic shearing or intense surface weathering, its potential for rapid movement is greatly enhanced.[9]

Other landslide bodies composed of different but equally unstable materials have been identified in this canyon area. Defined as only marginally stable in some cases, these slide bodies are moving in the area of 1/4 inch to 1 inch per year. Perhaps the most dramatic slide body in the canyon area occupies the west-facing slope of Chicken Creek. Located immediately above the Botanical Garden and some 60 feet in depth, this slide has been "creeping" slowly forward for a number of years. It is a particularly problematic slide since a portion of Centennial Drive, the major access route through Strawberry Canyon, has been built across it. Recently a section of the road abutting the concrete span of an overpass has slipped below the level of the road surface, exposing a 21 inch deep concrete "step" across the road making it impassable. Major repair, which will clearly take some time, may involve a significant redesign of this section of Centennial Drive. In the meantime direct access to the upper hill area remains closed. The road has been closed several times in the past for similar, if less dramatic, reasons.

e. Hydrology

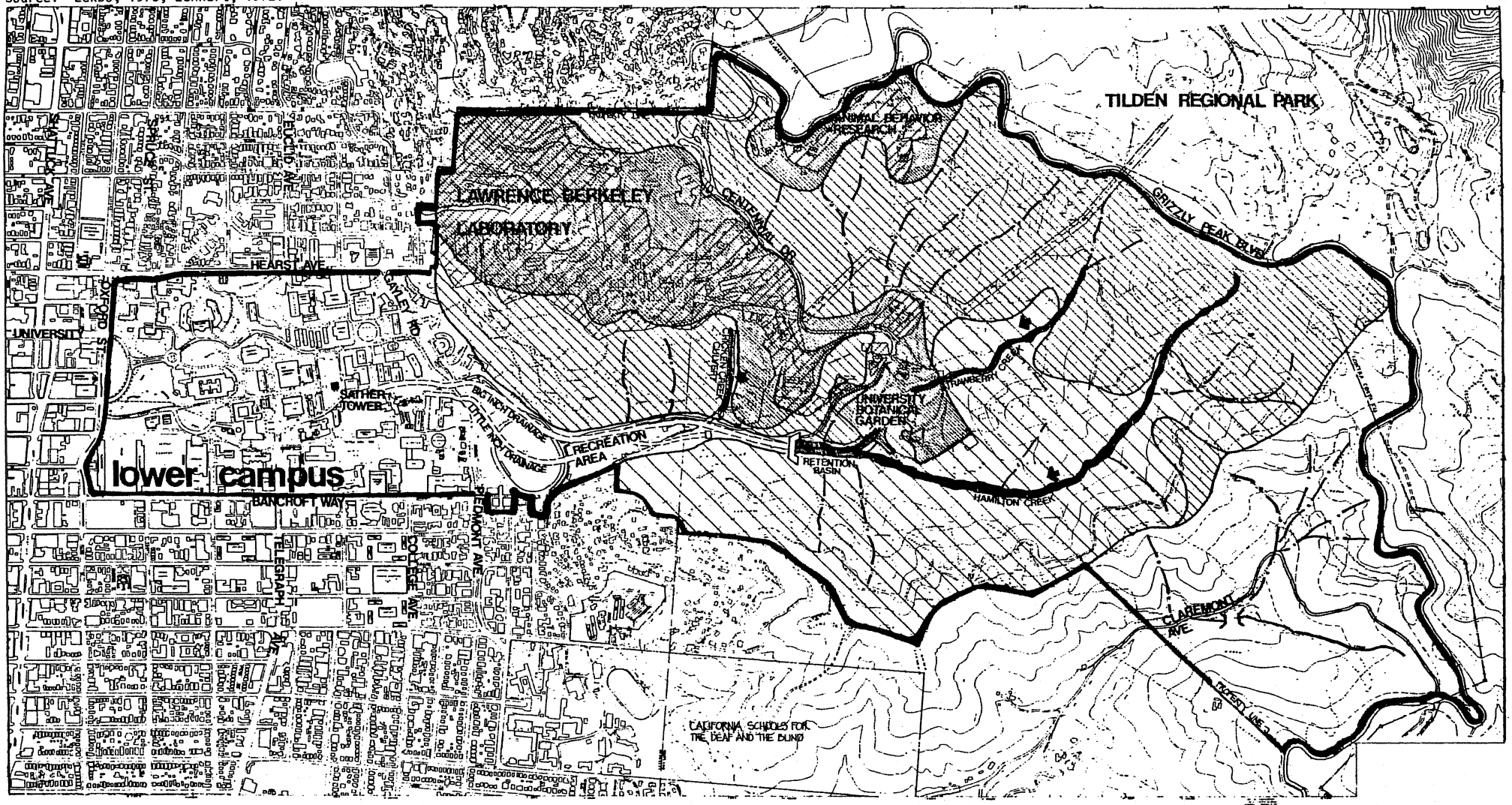
The East Hill area is served by two major streams, Strawberry Creek and Claremont Creek, each independently draining its respective canyon area. Both rise a short distance below the rim of the area's eastern watershed before running to the west down the slope of the canyon system. Claremont Canyon is a self-contained drainage basin with only one principal channel, Claremont Creek. Strawberry Canyon, by contrast, is drained by a stream of the same name and two main tributaries, Hamilton Creek and Chicken Creek.

Hamilton Creek is the longer and more extensive water course system. It originates at the eastern head of a valley formed by Sugar Loaf Hill to the south and Monument Hill to the north. In length this creek is almost as long as the upper section of Strawberry Creek located in the next valley north. By contrast, Chicken Creek is much shorter and less impressive but perhaps more important since it carries surface runoff from the developed areas of Lawrence Berkeley Laboratory into the lower drainage channel of Strawberry Creek. The headwaters of Strawberry Creek spring from the northern flank of Monument Hill immediately below Grizzly Peak Boulevard. The main line of the creek joins with Hamilton Creek at about the center of the Botanical Garden, and meets Chicken Creek further to the west. At the foot of the canyon system, Strawberry Creek empties into its South Fork and passes beyond Gayley Road before entering the central campus and running the length of the University's property to the west.

f. Vehicular Access

Centennial Drive, a sinuous two-lane collector road, is the only direct access that connects the East Hill area to the central campus. A more involved and indirect route through Lawrence Berkeley Laboratory is not open to public use for security and safety reasons. Centennial Drive follows the line of Strawberry Creek to the entrance to the Botanical Garden located in the center of the area, before turning north as it climbs to the Lawrence Hall of Science and Silver Laboratory. Above these buildings the road

Source: Eckbo, 1976; Lennert, 1972.



hydrology

joins with Grizzly Peak Boulevard. Currently closed because of road subsidence and collapse, Centennial Drive route requires major re-engineering in order to make it usable and safe.

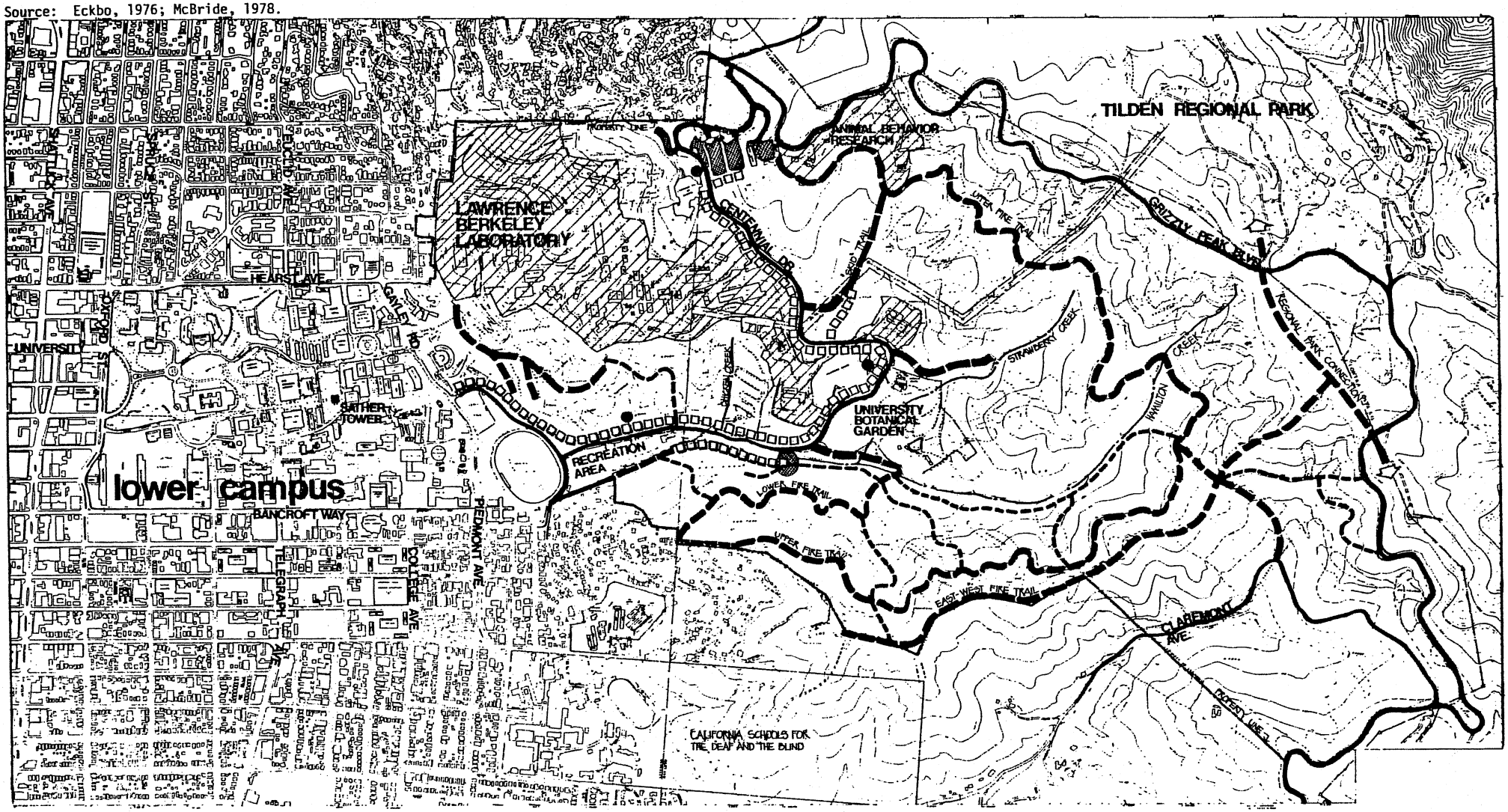
Two other roads give access to the area but do not connect it with the University campus. Grizzly Peak Boulevard on the northern and eastern boundary and Claremont Avenue, which parallels Claremont Creek in the southeast, are both well maintained arterials. Rather than connect directly with the University, they act as circulation routes diverting traffic away from University property. Both of these roads, as well as Centennial Drive, are characterized by steep grades, limited road visibility, and narrow shoulder conditions.

Centennial Drive carries about 4,000 vehicles each weekday. About 11% of this volume travel during the morning peak period (7 - 9 a.m.), while 34% travel in the afternoon peak period (4 - 6 p.m.).[10] A 24-hour trip-pattern survey conducted in 1979 determined that 16% of all vehicles using Centennial Drive terminated their journeys in the North Berkeley Hills; 13% at Lawrence Berkeley Laboratory; 10% at Lawrence Hall of Science and the Botanical Garden combined; 8% at the lower canyons; and 3% at Tilden Park. The percentage of cars associated with University destinations was 52%.[11] During a 12-hour survey period, eastbound traffic amounted to 1,964 cars while 2,042 vehicles traveled westbound.[12]

Several unpaved, minimum-standard fire trails provide internal access for emergency and police vehicles throughout Strawberry Canyon. Closed to all unauthorized vehicles and motorcycles, these 10-feet wide trails are maintained to ensure minimal environmental impact. Although open for use for class instruction or individual recreation on a year-round basis, fire trails and hiking trails are closed on certain days when fire danger is extreme.

This report recommends that an existing hiking trail on the south side of the Strawberry Canyon recreation area be extended to the east to join with an existing parking lot at the junction of the lower fire trail and Centennial Drive. Presently access to this point

Source: Eckbo, 1976; McBride, 1978.



VEHICULAR CIRCULATION

TRANSIT STOP

VEHICULAR PARKING

EXISTING FIRE TRAIL

EXISTING HIKING TRAIL

PROPOSED PEDESTRIAN PATH

circulation system

0 200 400 1000 1750ft.

8

by way of a narrow path along Centennial Drive is both hazardous and constrained. A short trail or path linking Lawrence Hall of Science and Silver Laboratory is also recommended as is the development of new terrace parking lots on this site to accommodate the Lawrence Hall of Science's expanding need. A longer pedestrian path that follows the length of Centennial Drive is also recommended by this report. Pedestrian access to the upper hill area is hazardous at present because of the intermittent character of sidewalks and pathways. A separate bike-way along Centennial Drive, linking the area to existing bike-way systems beyond University property, is also recommended. A general expansion of the existing fire trail and hiking trail system in the undeveloped portions of Strawberry and Claremont Canyons is not recommended for ecological and fire hazard reasons.

ECOLOGICAL CONTEXT

5. ECOLOGICAL CONTEXT

a. Climate

The East Hill area enjoys a Mediterranean-coastal climate with moderate temperature year round. The mean annual temperature is 54° Fahrenheit, but temperatures in the summer can reach into the nineties and in the winter drop to just above freezing. Temperatures below freezing do occur but they are rare and usually of short duration, although a two-day freeze in December 1972 recorded temperatures at 20°F. This freeze had a serious impact on vegetation in this area, top-killing many eucalyptus trees. A subsequent fire hazard that resulted because of this freeze is discussed elsewhere in the report (see Fire Hazard section).

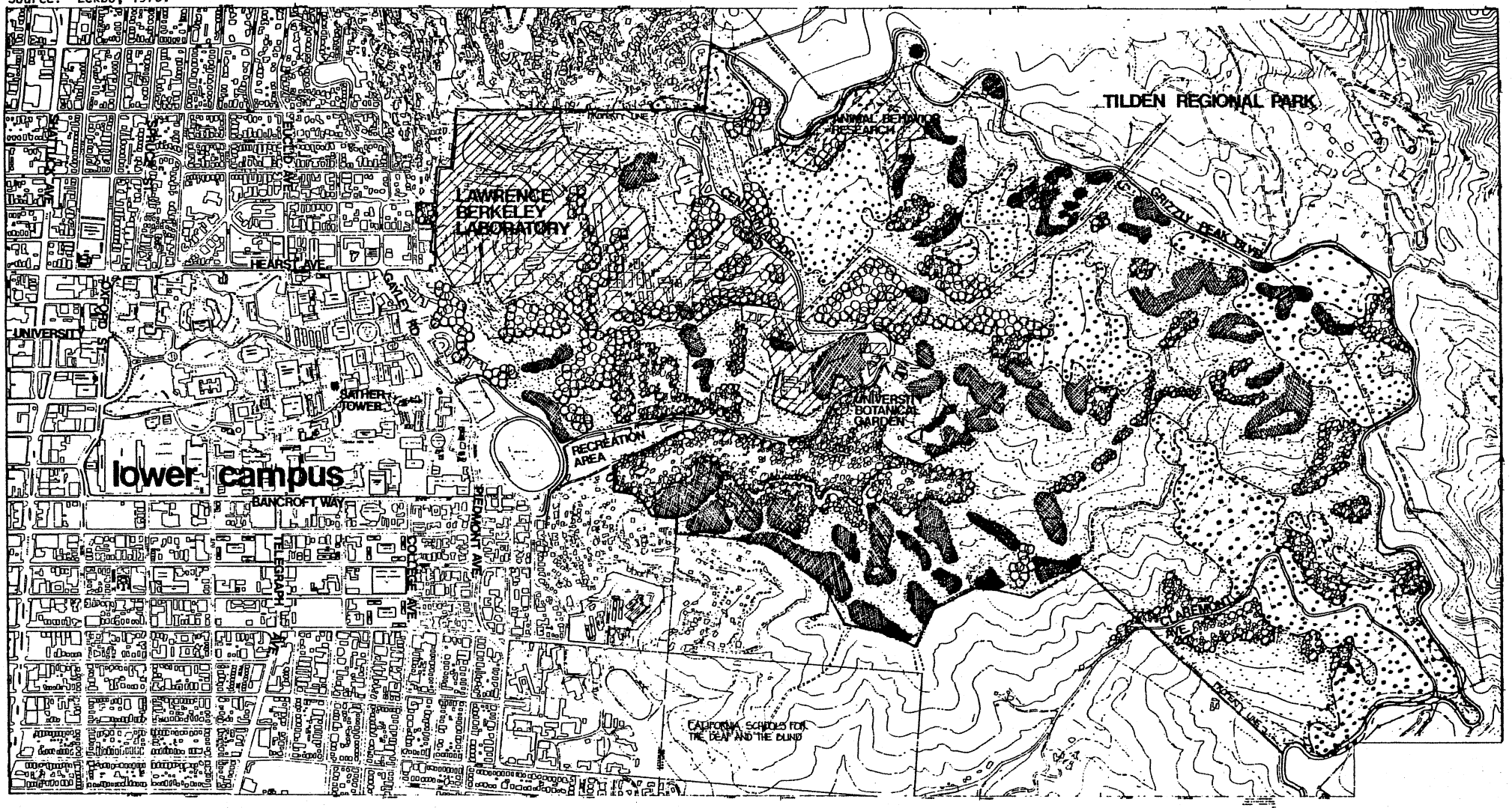
The annual rainfall in the area is 28 inches but snowfall is rare. Fog, however, is a factor in the area from May to September creating hazardous driving conditions. Winds are usually of moderate strength out of the west, except on days in the summer and late fall when hot dry winds from the northwest contribute to the fire danger in the area.

b. Vegetation

The rugged and varied topography of Strawberry and Claremont Canyons provides a richly textured pattern of vegetation in the East Hill area. According to a 1979 report on management and conservation, indigenous and imported vegetation types found in the canyon area include oak-bay woodland, northern coastal scrub, annual grassland, and various species of conifer and eucalyptus. In general, clusters of these plant types are distributed throughout the canyon system.[13]

The generally uncomplicated north facing slopes of the south side of Strawberry Canyon are covered by indigenous oak-bay woodland and associated dense undergrowth which includes poison oak; along the upper section of these slopes and extending east throughout Skyline Ridge, mature stands of spruce, pine, fir, cypress, and cedar can be found. None of these latter species, with the possible exception of some fine redwood stands also found there, are indigenous to the area. Areas of mixed vegetation extend

Source: Eckbo, 1976.



CONIFERS
OAK/BAY WOODLAND
EUCALYPTUS STAND
EUCALYPTUS SPROUTS
SOFT CHAPARRAL W/ GRASS OPENINGS
VEHICULAR ACCESS

existing vegetation

0 200 400 1000 1750 ft.

9

into and across the valley of Strawbery Creek. The Botanical Garden's Mather Redwood Grove, on the north side of Strawberry Creek, is perhaps the finest stand of redwoods in the Berkeley area.

To the east of the forested lower canyon section of Strawberry Creek, higher and more irregular slopes are covered by grass, low chaparral, and small groups of bay and oak clustered alongside drainage channels. Species of eucalyptus and mature groves of Monterey pines are also found throughout the higher sections of the eastern canyon area. Similar vegetation occurs on the slopes of both sides of Claremont Canyon. As in Strawberry Canyon, the higher open ground here has less of the dense undergrowth found in forested areas, and sections of more exposed hillsides contain only scrub brush.

In the main, vegetation in the East Hill canyon system has flourished in an environment protected both by the physical character of the area and by management policies that emphasize conservation. However, in some places the impact of human activity in the area has altered the process of natural plant succession and modified the pattern of vegetation cover. This has been especially true in the developed portions of the canyons and particularly in the Lawrence Berkeley Laboratory. Undeveloped sections of the area have fared relatively well from exposure to public access. Recreational use of the fire trail system and local mechanical grading along fire roads, for example, have had only a minor impact on the process of vegetative succession. Furthermore, areas closed off to the public and restrictions placed on activity in research and study areas have helped balance the effect of unrestricted public access in the lower and more recreational sections of the canyon.

The problem of fire in the area remains a continual concern. The possibility of fire is intimately linked to the prevalence of highly flammable material, heavy underbrush, and eucalyptus trees. The 1979 management report mentioned above recorded that in recent years 75% of all eucalyptus trees in the area had been cut to stumps. Personal observation confirms that a good deal of slash material still remains uncollected and uncleared on the ground. New growth from old stumps and new seedlings now reaches a

height of 10 to 15 feet, a condition that constitutes a fire hazard of considerable magnitude. It is clear that a comprehensive maintenance program to mitigate against the possibility of fire damage ought to be followed by the University. (See Fire Hazard section for a discussion of this topic.)

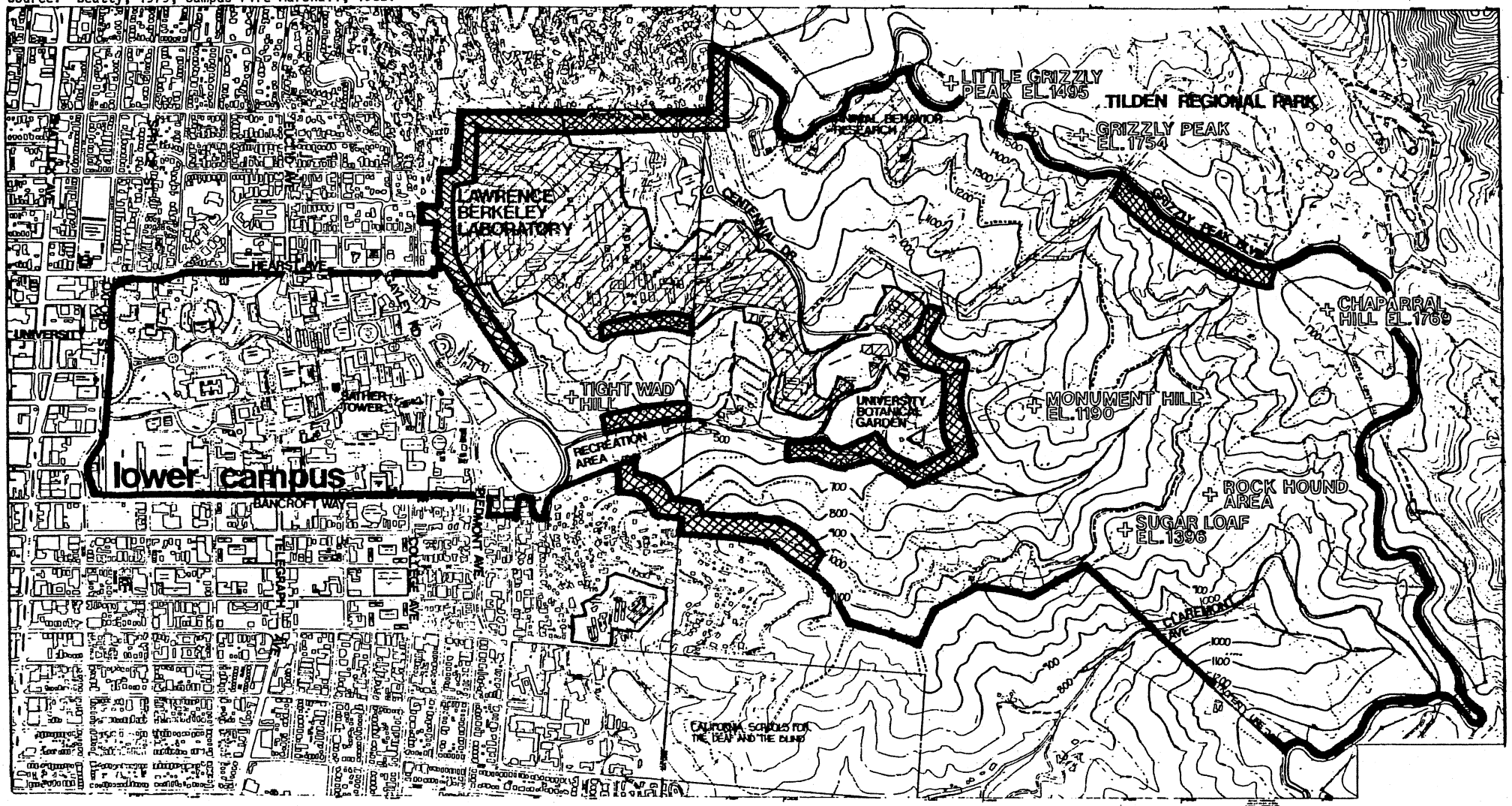
c. Fire Hazard

The potential of fire in the East Hill area is a matter of critical concern. In the undeveloped sections of Strawberry and Claremont Canyons, topography, climate, and vegetation combine to produce "ideal" fire conditions, particularly in the late summer "fire season." The intermixing of tall grass openings, surrounded by areas of eucalyptus or oak, with steep sided canyon slopes creates optimal fire conditions from midsummer to the beginning of the rainy season in late fall. During this period an average of 4 or 5 days can be considered "fire weather" days. On these days, hot dry northeast winds up to 60 mph (with gusts up to 90 mph) unite with high temperatures, clear skies and low humidity to create grave fire conditions. Given the abundance of "fuel-loaded" vegetation in the East Hill area, particularly in eucalyptus groves, and the fact that more people than ever now use the area for recreation and exercise, fire risk on these days is extreme.[14]

The capacity of fire to destroy property under fire weather conditions ought not to be underestimated. In September 1923, fire in Tilden Park rapidly spread through a eucalyptus grove north of the University's property, then burst suddenly into a residential section of Berkeley below. Within two and a half hours, 625 houses on 60 city blocks were destroyed. In 1968 a fire on the golf course at Tilden Park burned over 200 acres. Two years later a fire along Claremont Boulevard destroyed 37 houses and 204 acres of vegetation in a three-hour period. In the fall of 1981, 3 houses on the western boundary of Tilden Park burned to the ground under fire weather conditions.

While the University cannot control wind or high temperatures, it can take steps to control the prevalence of fuel-loaded vegetation in canyon areas. The presence of

Source: Beatty, 1979; Campus Fire Marshall, 1982.



FUEL MANAGEMENT ZONE
(NOT TO SCALE)

proposed fuel management

0 200 400 1000 1750ft.

10

pines, chaparral, and annual grasses constitute a significant fire danger during the dry weather season. However, new growth in eucaluptus groves, along with bark and other kinds of debris, contain the greatest fire risk. Fire at ground level in a eucalyptus grove creates convection currents that carry flames high into the air or cause "firebrands" to race horizontally far ahead of the main fire line. Under fire weather conditions, firebrands could move quickly down the slope from Strawberry Canyon into the Lawrence Berkeley Laboratory, the central campus area or surrounding residential areas. Fire moving onto University property from residential areas is also a possibility the University has to contend with.

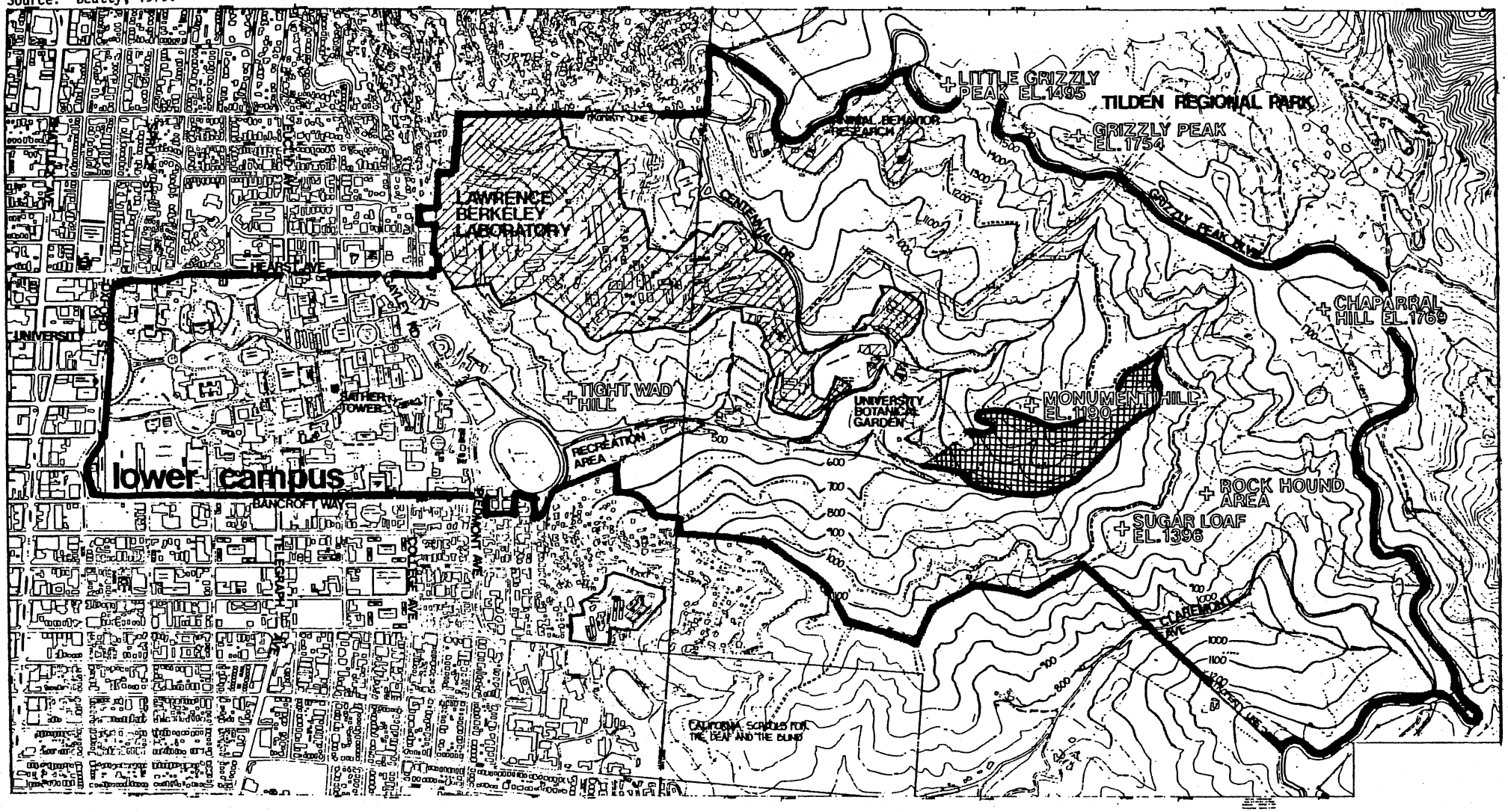
d. Wildlife

There are a large number of animals, mammals, insects, and birds within the canyon areas of the East Hill, both permanent residents and passing migrants. The Ecological Study areas contain approximately 150 species of vertebrates and a myriad of invertebrates.[15] Free living communities found in the area include over 40 species of mammals, 12 species of lizards and snakes, 6 species of salamanders and frogs, and over 100 different kinds of birds.[16]

Mammals resident to the canyon area or who use its habitat regularly include the broad-footed mole, badger, California vole, mule deer, and fox. A confirmed sighting of a bobcat was recorded in 1979. Reptiles in this area include the western fence Lizard, western skink, and common kingsnake. Isopods, millipedes, and anthropods are also to be found. Bird species observed include the red tail hawk, cliff swallow, California thrasher, and western meadowlark.

The vast majority of land in the East Hill area has been set aside for the study of the animal biomass and the processes of natural plant succession. Both areas of study are intimately linked to the ecology of this area and its food chain. Larger vertebrates depend directly on invertebrates, such as spiders or insects, for their existence, and the latter are in turn dependent on the habitat in which they exist. Thus the diversity and

Source: Beatty, 1979.



FAUNAL REFUGE AREA

faunal refuge area

0 200 400 1000 1750ft.

11

size of vertebrate populations in the area indicate the amount and diversity of invertebrate fauna found there, and therefore the diversity and richness of the area's plant life.

Oak-bay woodland, the native climax vegetation in the area, is the richest habitat in terms of animal life. Animal biomass is probably a hundredfold greater than in soft chaparral or Conifer groves in the area.[17] Surprisingly, the non-native eucalyptus groves are much richer in invertebrate species than areas of redwood or Monterey pine. Here, as in other habitats, vegetation has been shaped and used by animals and invertebrates in their search for food, water, and protective cover. Animal densities adjust to the natural carrying capacity of the area's biomass. Any management plan that ignores or disturbs the delicate balance that exists between animal and plant life signals disaster for the wildlands in the canyon area. A proposal to designate a section of canyon land east of the Botanical Garden a special faunal refuge area should be encouraged (see Map 11).

e. Erosion and Flooding

A study of campus storm drainage conducted by Lennert and Associates in 1972 concluded that serious erosion and flooding problems exist in the upper canyon areas of Strawberry Canyon. The study divided the Strawberry Canyon area, exclusive of Claremont Canyon, into three different drainage areas.

Area 1 -- Runoff rate 100 feet per minute. Developed areas, primarily Lawrence Lab, Botanical Garden, and Animal Behavior Research. 284 acres.

Area 2 -- Runoff rate 75 fpm. Grass cover areas, including some soft chaparral. 400 acres, primarily south slope.

Area 3 -- Runoff rate 40 fpm. Heavy cover areas, primarily north slope and Monument Hill, plus two small areas on Grizzly Peak at Centennial Drive and Chaparral Hill. 300 acres.[18]

Runoff rates in the Lennert study were based on a 25-year storm pattern, and assumed the completion of the University's development plan. However, recent experience highlights

the danger and expense that optimal flood conditions bring at the present level of development. After a week of heavy rain in January 1982, water saturation induced numerous mudslides in the vicinity of the Hass recreation area and closed Centennial Drive briefly. More seriously saturated ground and deficient drainage in association with a well-established landslide area caused a "slough-off" below part of Centennial Drive above the Botanical Garden, closing the road for the near future.

Concern has been expressed by a number of writers about the impact of new development in the upper canyon area and a consequent increase in run-off from impervious surfaces. When combined with the amount of "natural" debris and brushwood found in stream channels, development in the area may further exacerbate stream erosion and flooding. A drainage retention basin, constructed in 1963 and located immediately below the confluence of Hamilton and Strawberry Creeks with a capacity of 1,500,000 cubic feet, may not be large enough to control widespread flooding given peak run-off rates and continued development.[19] However, engineering recommendations to control flow rates in Strawbery Creek above the retention basin have not been adopted because of resistance from conservationists to the alteration of a natural water course.[20]

The imposition of severe restrictions on all new buildings and paved areas within the Strawberry Canyon watershed has been suggested in several reports (Siri, Beatty, Lennert). Most of these reports agree that the object of any water course management program must be to minimize the threat of flooding to buildings and homes along the lower reaches of Strawberry and Claremont Canyons. Management prescriptions should as far as possible maintain existing water course quality and continue to contribute to maintenance of varied habitats for the existing animal biomass as suggested in the Management Plan for Strawbery and Claremont Canyons, 1979. The guiding principles of these prescriptions should be to minimize water channel erosion while maintaining the best possible environment for aquatic organisms.

MANAGEMENT & ADMINISTRATION

6. MANAGEMENT AND ADMINISTRATION

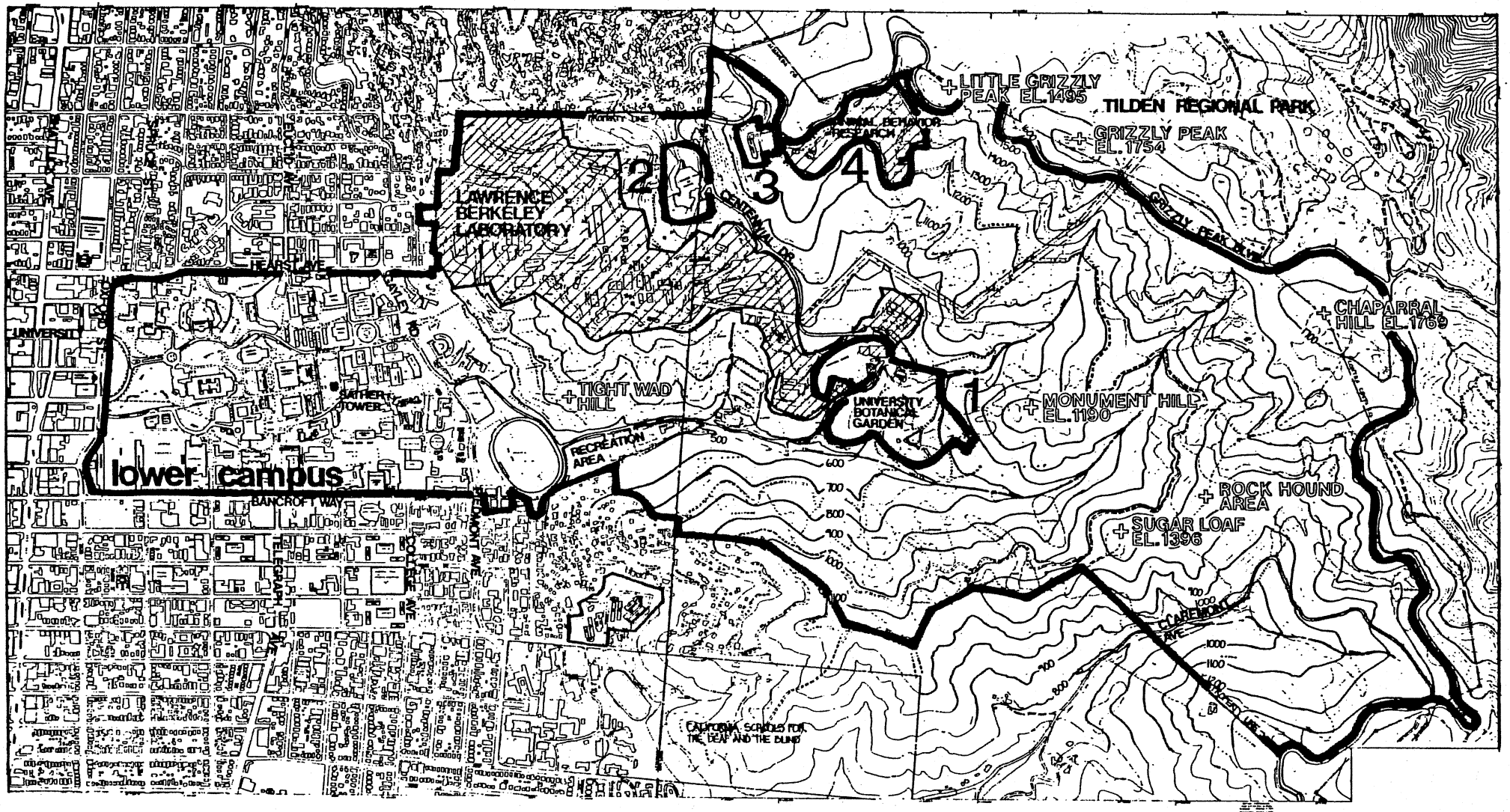
a. Administration

The overall jurisdiction of much of the East Hill area, under the general direction of the Berkeley campus Chancellor, includes three Organized Research Units (ORUs) of the University and one campus planning advisory committee, the Conservation and Environmental Quality Committee (CEQC). A further administrative unit, the Botanical Garden, is under the jurisdiction of the Botany Department. Another major University presence in the area, Lawrence Berkeley Laboratory is administratively separate from the Berkeley campus, and therefore beyond the purview of this report.

The three ORUs occupying the area are the Lawrence Hall of Science, the Space Sciences Laboratory, and the Field Station for Behavioral Research. Each unit has a Director as its chief administrative officer who is responsible for the day-to-day operations as well as long range planning and development of the unit. Although the ORUs are ultimately responsible to the Chancellor, they can attain a degree of autonomy in fiscal and programmatic terms by securing funds from non-University sources.

The Ecological Study Area, the largest consumer of land in the canyon area, does not have a director or an administrative structure. It is under the stewardship of the CEQC which has a supervisory role in the study area. Although the exact limits of this committee's role have never been sufficiently defined, all matters concerning activities in the area are usually directed toward the committee, if in a somewhat informal way.

Plans and development proposals concerning land use decisions in the East Hill area may involve five different planning advisory committees on campus. They are, besides the CEQC, the Campus Planning Study Group (CPSG), the Buildings and Campus Development Committee (BCDC), the Campus Planning Steering Group (CPSG), and the Chancellor's Physical Planning Group (CPPG). While all the committees can make recommendations, the CPPG has the final decision-making authority. The committees are helped in their work by the Department of Facilities Management (DOFM) which provides technical



1 BOTANICAL GARDEN
2 LAWRENCE HALL OF SCIENCE
3 SPACE SCIENCES LABORATORY
4 FIELD STATION FOR BEHAVIORAL RESEARCH

administrative areas

0 200 400 1000 1750 ft.

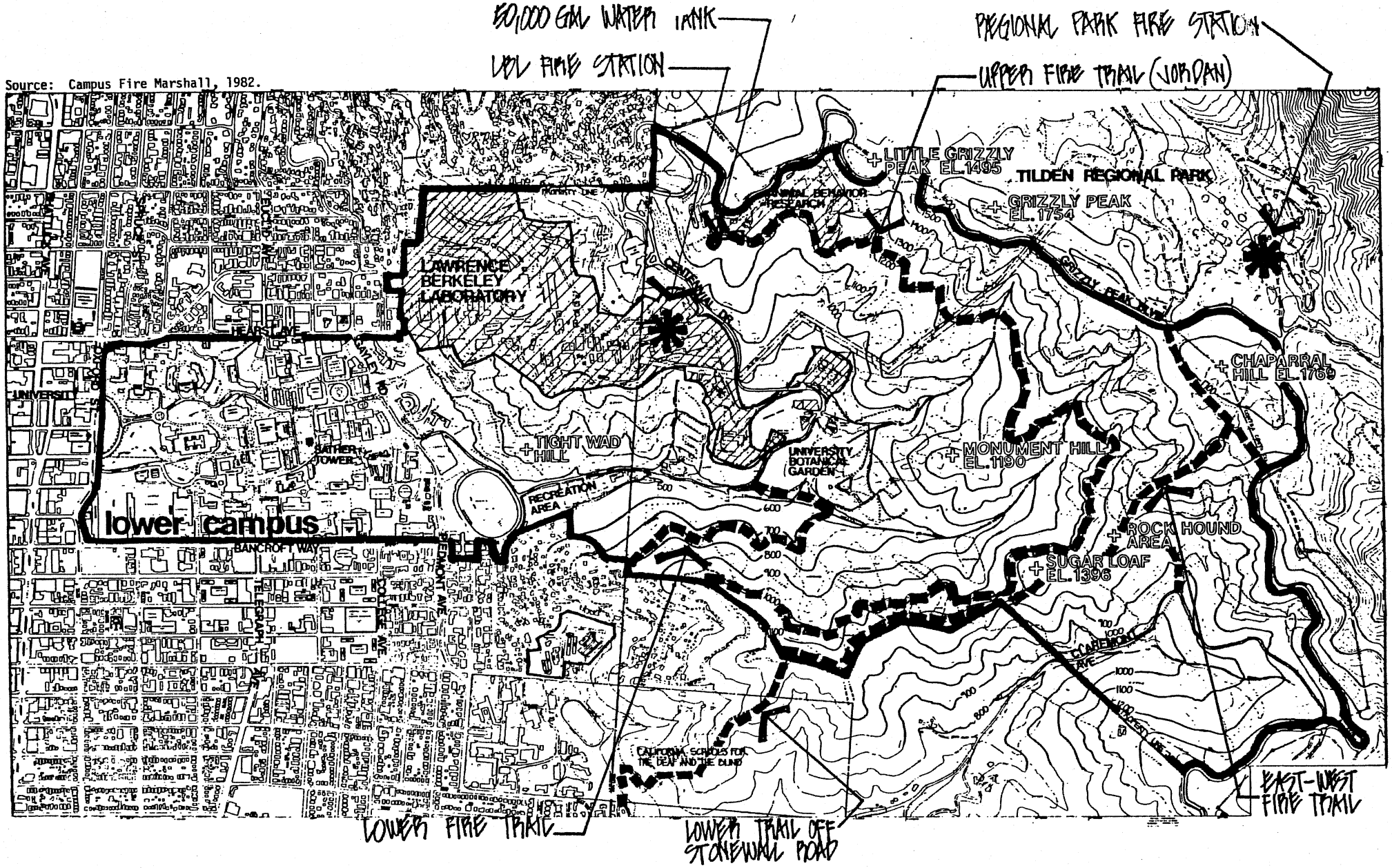
and professional input and which also has the responsibilities of managing construction projects and maintaining the University's physical plant, utilities, and services.

b. Fire Protection

Fire control procedures on campus are the responsibility of the Campus Fire Marshal within the Office of Environmental Health and Safety (EH&S).[21] While individual buildings are provided with requisite fire protection devices required by State law, the University does not have the equipment or manpower to fight a major fire in the East Hill area. The University has a charter agreement with the City of Berkeley governing the outbreak of fire on the lower campus but much of the land in Strawberry and Claremont Canyons is in the City of Oakland. Because of the configuration of land and access routes, should fire occur in the area a set of mutual aid protocols between Oakland and Berkeley will come into force with the result that the initial response to fire would come from the Berkeley Fire Department, which can respond in about half the time it would take the Oakland Fire Department. However, since fire equipment is stationed at Lawrence Berkeley Laboratory and in the Tilden Regional Park Ranger Station, it is unlikely that the Berkeley Fire Department would be first on the scene. The close proximity of these fire fighting units afford the canyon areas good protection, but if fire occurs at a time when other areas are ablaze, resources could be diverted away from the area and serious consequences result.

In order to offset the danger of massive fire in the East Hill area, fuel management programs have been advocated by the Campus Fire Marshal, Environmental Health and Safety, and a number of authors and consultants who have studied the area. These proposals have traditionally met with strenuous objections from members of the academic community and conservationists who stress that any intrusion into ecologically sensitive areas would be a disaster for the flora and fauna of the area. They also point out that any expansion of the fire trail system would not only cause further soil erosion, but would also encourage greater human activity in the area, thereby increasing the fire risk. While these arguments

Source: Campus Fire Marshall, 1982.



* FIRE STATION

fire trail access

0 200 400 1000 1750ft.

are well-founded and persuasive, the fundamental problem of grave fire risk in the area remains. Provided that existing fire trails are maintained and accessible to fire fighting equipment, the expansion of the fire trail system appears unwarranted at this time. The contentious issue of fuel management requires urgent, detailed study.

c. Police and Emergency Services

The University Police have the primary responsibility of providing security and emergency services in the East Hill area.[22] Currently the police schedule a two-officer "Hill Patrol" in the area, offering 10-hours-a-day, 7-days-a-week protection. Equipped with a 4-wheel drive vehicle and two motorcycles, the patrol is meant to traverse the entire area at least once a day. Unfortunately, because the Police Department is 13 officers short of its full complement and because the lower campus area is considered to have first priority, the "Hill Patrol" is not currently functioning. In its absence, one police officer drives the paved roads of the campus area each day and, when the situation warrants, extra forces are brought in. But to all intents and purposes, and for the foreseeable future, the bulk of the area is essentially unpatroled.

University emergency medical response procedures for the Strawberry Canyon area require that all requests for assistance be directed to the Berkeley Fire Department's rescue unit.[23] The University Police are expected to aid in an emergency with special equipment and knowledge of the area, as is Lawrence Berkeley Laboratory's emergency unit. The East Bay Regional Park Police are also able to respond to a request for assistance with manpower and a helicopter unit if required. Emergency practice drills are periodically carried out in the area and coordination in these activities is based on the philosophy of mutual help.

EXISTING LAND USE

7. EXISTING LAND USE

a. Ecological Study Area

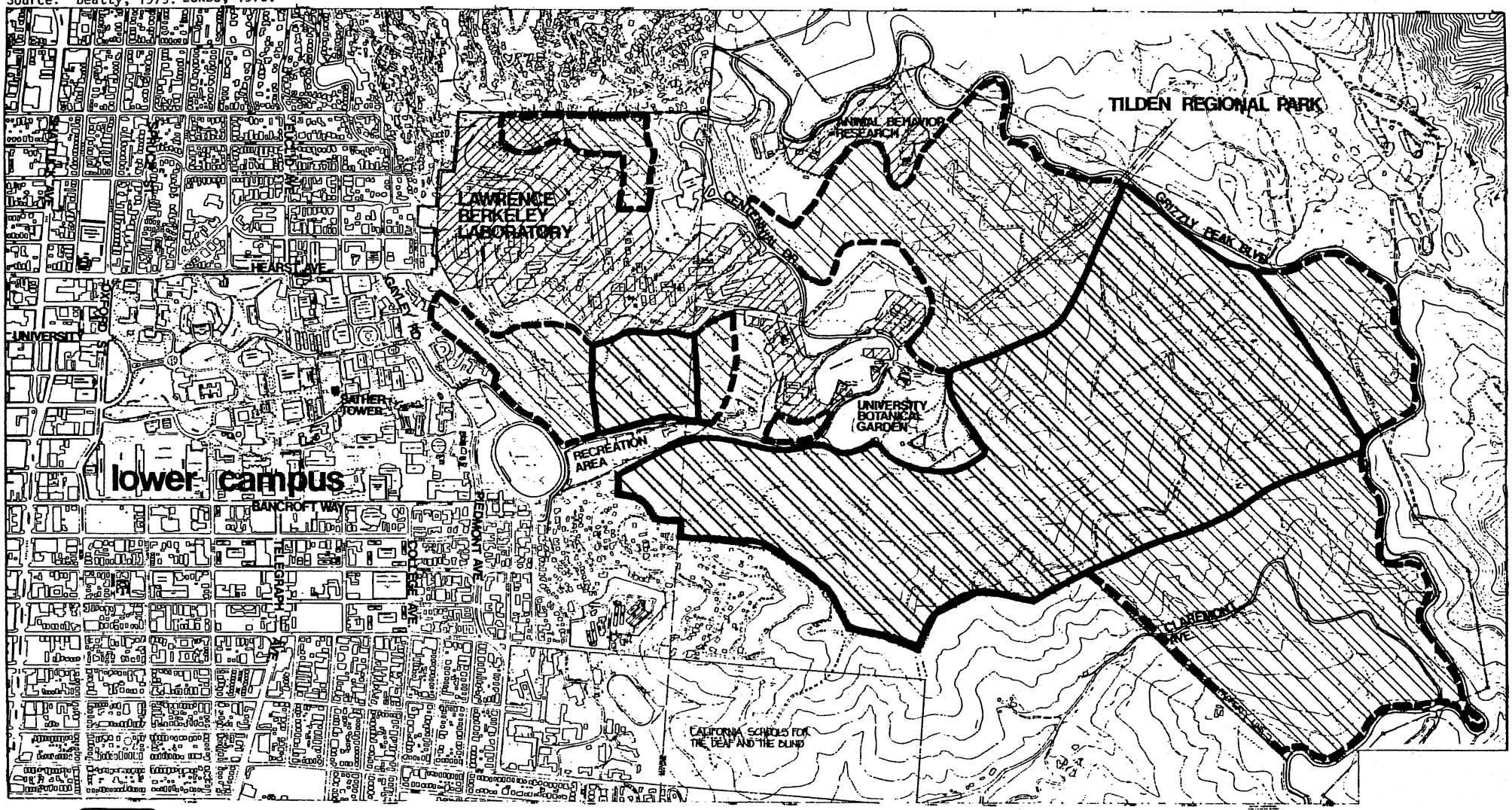
The use of Strawberry and Claremont Canyons for teaching and research related to the outdoor environment has been a long standing policy of the University. That these canyons should remain primarily in an undisturbed and natural state has also been University policy since the establishment of the first ecologically "primitive area" in the mid 1930s. To further these policies, in 1967 the Campus Planning Commitee recommended the creation of two ecological study areas in Strawberry Canyon. After an 18-month experimental period, both of these study areas were given official administrative status in 1969.[24] They are under the administration of the Conservation and Environmental Quality Committee.

The smaller of the two ecological study areas, 250 acres, is situated on the north side of lower Strawberry Creek. It has occupied the same site since its inception and it appears likely that it will remain within its current boundaries for the forseeable future. The larger study area now occupies 325 acres stretching from the western end of Strawberry Creek valley to the upper eastern section of the canyon area (see Map 14). This latter area has been subject to expansion since it was first established, and there has been some controversy over the practices of its fuel management program.

In 1979 the Management Plan for Strawberry and Claremont Canyons proposed the expansion of the larger study area to include the northwest watershed of Strawberry Creek.[25] This proposal would increase the ecological study area by about 100 acres. The same report also proposed a number of other areas for inclusion in an expanded ecological study area system. As a result, ecological study areas would occupy approximately 500 acres of Strawberry Canyon, totaling some 60% of the East Hill area. To date, however, the expansion of the ecological study area has not occurred.

The creation of the Ecological Study Areas was intended to ensure that these areas remain environmentally unimpaired. It was also intended that they provide a wilderness reserve for plants and animals within walking distance of the central campus. To this

Source: Beatty, 1979. Eckbo, 1976.



EXISTING BOUNDARY

PROPOSED EXTENSION (ECKBO, 1976)

ecological study areas

0 200 400 1000 1750ft.

14

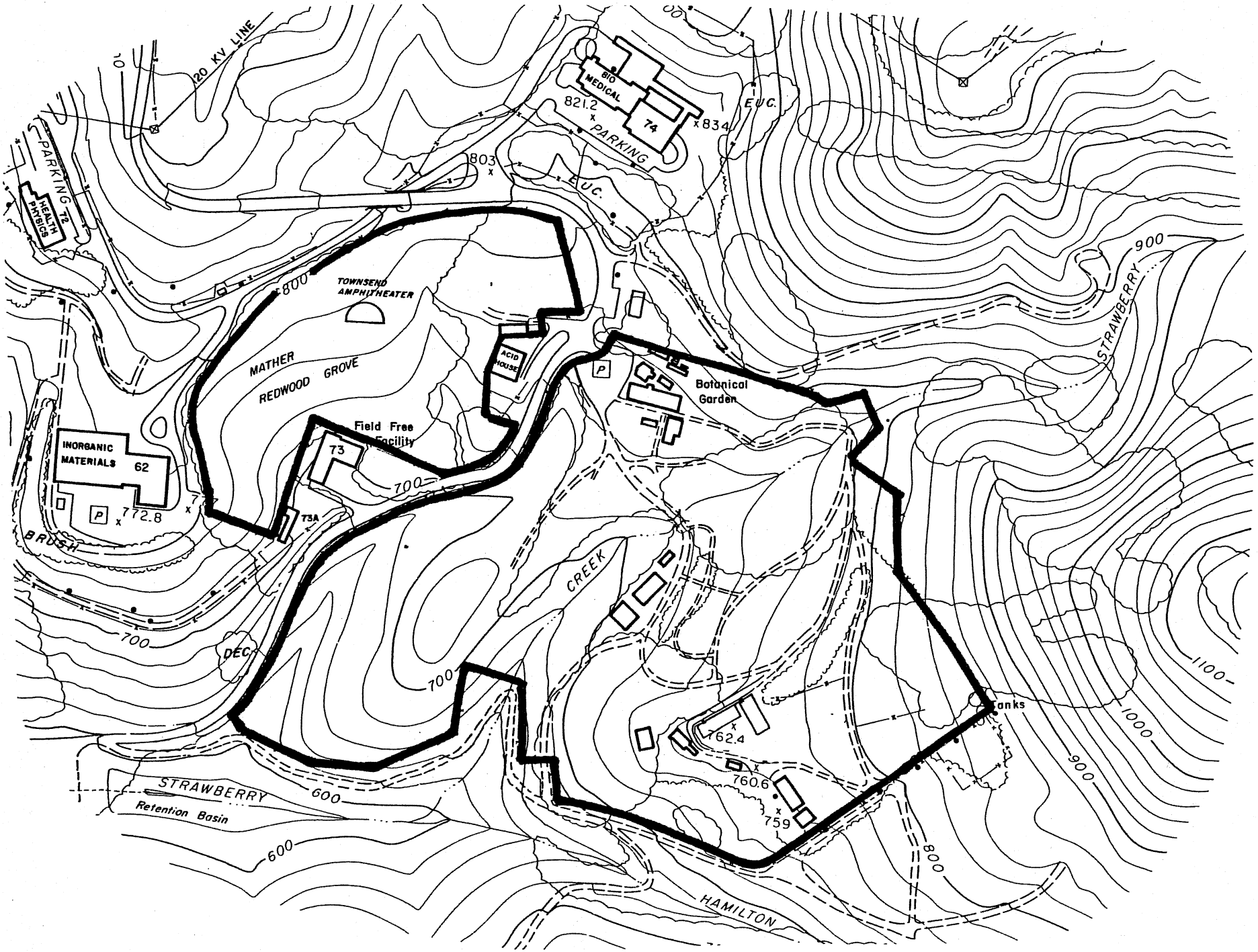
end, instruction or research that causes the destruction and loss of vegetation, soil, or animal life is strictly prohibited within the study areas unless special approval is granted by the Ecological Study Area Committee. Recreational use of the study area other than biking or jogging on marked trails is also not allowed, nor is the erection of any structure. In this vein special refuge areas within ecological study areas for large mammals have been proposed (see Map 10).[26]

A more controversial issue concerning the study areas has been fire prevention. Prohibitions have been placed on the removal of vegetation, underbrush, and other fire fuel - except within a 100-foot-wide fire-management strip along parts of the boundary. Controlled burning, used to prevent the uncontrolled spread of wildfire, is also not allowed within the ecological study areas except under the direct supervision of the Campus Fire Marshall. The whole matter of fire prevention and fuel management in the canyon areas is now under administrative review.

In the Claremont Canyon section of the hill area, the Department of Forestry and Resource Management has expressed an interest in establishing an experimental forest, which would preclude the incorporation of this area into the ecological study area system.[27] This proposal has not yet come to fruition and the Claremont Canyon area, although not part of the ecological study area, remains an integral part of the natural and undisturbed resources of the canyon area.[28]

b. Botanical Garden

The University's Botanical Garden, located at the confluence of Strawberry Creek and Hamilton Creek in the center of the East Hill area, is the oldest campus-associated botanical garden in the country. It is also, in terms of plant species, the largest. Established on the central campus in 1891 to provide "a place to grow, study and appreciate living plants" the Garden moved to its present location in 1926. Since that date the Garden has expanded to contain over 8,000 plant species ranging from the exotic to the familiar.



botanical garden

0 50 100 200 300ft

15

This range of plant life has been made possible by the unique combination of mild climate and rugged topography found in Strawberry Canyon.[29]

Situated between 660 to 860 feet above sea level, over half the Botanical Garden area is composed of slopes greater than 25%. Average temperatures in the area range between 55°F to 80°F during the day, dropping to 45°F at night. The annual rainfall is about 26 inches a year. These factors, together with a complex drainage system and an intermixing of different soils, result in an ecology that contains discrete sets of growing conditions and microclimates in which diverse collections of plants coexist. In close proximity, mountain plants from the Himalayas or New Guinea are found a short distance from desert plants from Sonora or tropical species from South America.

The plant collections on the site, which are arranged by geographic affinity rather than taxonomic consanguinity, cover 14.5 acres of the Garden's 23 acre area. The Mather Redwood Grove is the largest single collection occupying the bulk of a 7 acre site west of Centennial Drive which also contains a 250-seat amphitheater (see Map 15). The remainder of the area, which lies to the east of Centennial Drive, is taken up by 3.5 acres of undeveloped land and about 5 acres of buildings and structures. Buildings on the site comprise an Information Center at the entrance to the Garden, a number of small single story administrative buildings, and various greenhouses, plant buildings, maintenance units and lath houses spread throughout the site. A parking lot at the entrance to the Garden which has space for 30 cars, has been described in one report as aesthetically poor and functionally inadequate.[30] Most of the buildings on the site received a similar evaluation. The plumbing and irrigation system serving the Garden was also reported in need of major repair and the same report noted a serious soil erosion problem along pathways between the plant collections.

Programmatically, the object of the Garden is to provide opportunities for research, education, and enjoyment to students, faculty and the nearby community. The Botanical Garden's goals emphasize the broadest possible programming to meet the needs of the University and the public at large. Currently the Garden provides 100,000 plant samples a year to the central campus and over a dozen classes use the site annually, studying

botany, biology, forestry, and landscape architecture. Students and faculty from other colleges also visit the Garden on a regular basis. In total, approximately 20,000 visitors enter the site each year, either in organized groups or individually. Activities at the Garden, including faculty research, are coordinated and supervised by a relatively small staff of 27 people which includes 17 part-time positions. The work of the staff is complemented by volunteers organized through the Friends of the Botanical Garden, without whose help, it is reported, many programs could not function.

A preliminary draft of the Long Range Development Plan for the Botanical Garden identifies the problems regarding staffing and physical infrastructure and suggests ways in which the programmatic intent of the Garden can best be carried out. The need for new classrooms, laboratories, office buildings, and support facilities is addressed in this document which also stresses the importance of providing adequate parking for both visitors and staff. The report recommends the provision of a secondary access road to the site along its southern boundary and the removal of two small structures with incompatible use, the Acid House (a Berkeley campus structure) and the Atmospheric Aerosols Research Laboratory (LBL Building 73), both located in the Mather Grove area. Apart from a small expansion of the eastern boundary of the Garden area into an existing ecological study area, the report confines development proposals to the internal reorganization of the Botanical Garden. These latter proposals are not likely to have a negative impact on other users of the East Hill area.

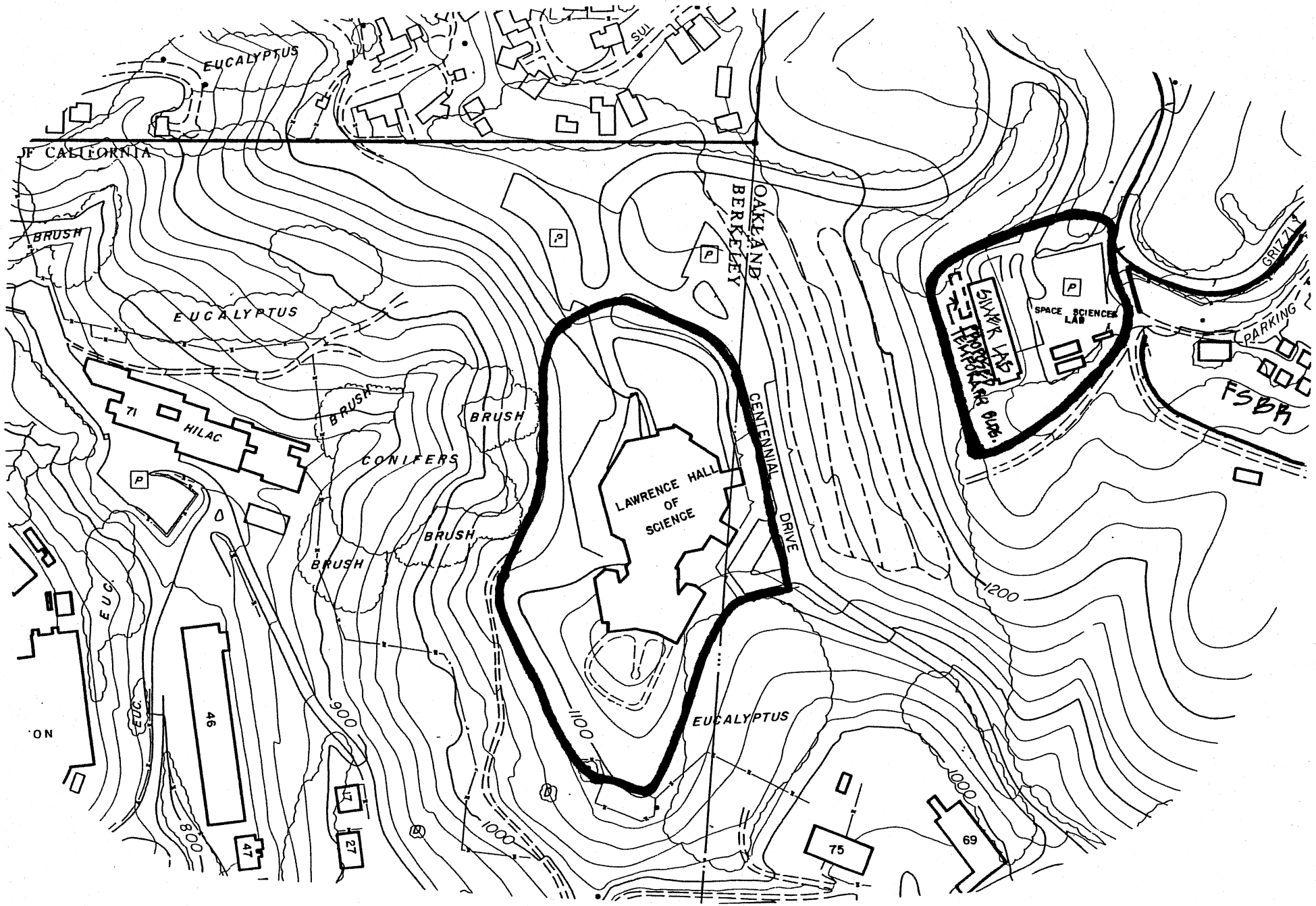
c. Lawrence Hall of Science

The Lawrence Hall of Science (LHS) is located on a four acre site at an elevation of 1,150 feet in the northern section of Strawberry Canyon. Commanding sweeping views of the Bay Area, the building was completed in 1968 as a memorial to Ernest O. Lawrence. Though formally an Organized Research Unit, the major thrusts of its programs are teaching and public service. Charged to inform and instruct the UC community and the public

at large about the sciences, LHS functions as a resource center for Bay Area schools and residents and for educational institutions throughout the country. As a science education facility engaged in research and development, LHS provides a wide variety of public education classes and science offerings to both children and adults. It also provides a distinguished teacher education program, and a 29,000 square foot exhibition space complete with exhibits and displays that involve active public participation and "self-discovery."[31]

The Lawrence Hall of Science is a large, four-level, multi-faceted, concrete structure designed by Aushen and Allen as an integrated part of its surrounding landscape. The building has 75,000 square feet of assignable area and nearly 135,000 gross square feet that represents only 40% of the original master plan for the site. It is not anticipated that the original plan will be completed. Future development on the site envisions the enclosure of the south lawn area, some development at the plaza level, and expanded parking areas. At present three parking areas serve the building. A staff parking area to the west holds 30 cars while parking for visitors, divided into two locations north of the building, contains space for a total of 60 cars. Approximately 10% of these spaces are reserved for the disabled.

Presently the LHS houses a staff of 250 researchers, administrators, and designers engaged in developing courses and exhibits covering a wide range of scientific activity. The number of public school children visiting LHS on an organized basis has increased sixfold in recent years and now stands at 45,000 a year. Attendance in after-school, night and summer classes has risen from 988 in 1973 to 2,700 in 1978 and the number of classes offered has grown from 122 to 300 during the same period. Visits by the general public increased tenfold from 1968 to 1978 and a five-year forecast made in 1981 projects a 12-15% increase yearly. In 1981, 240,000 people visited the LHS exhibits. An average of 200 site visits were made on a week day and up to 1,000 visitors came each weekend day. These numbers are by no means academic. As a self-supporting institution, higher attendance means higher revenue. In this regard, an early reopening of Centennial Drive, the major public access route to LHS from the Bay Area, is of paramount importance to the operation of the facility.



lawrence hall of science and space sciences laboratory

0 50 100 200 300ft

16

d. Space Sciences Laboratory

The Space Sciences Laboratory (SSL) occupies about two and a half acres in the northern East Hill area close to the junction of Grizzly Peak Boulevard and Centennial Drive adjacent to the western edge of the Field Station for Behavioral Research. The SSL, an Organized Research Unit of the Berkeley campus, is a multidisciplinary laboratory engaged in basic research in the physical, engineering, biological, environmental, and social sciences. Research done at SSL is motivated by the exploration of space and the application of technology developed in space research.

A short, steep access road from Centenial Drive leads south to the parking lot of the SSL facility which can accomodate 76 cars, and includes 5 spaces for the disabled. Directly west of the parking lot is the largest building of the SSL facility, Silver Laboratory. Named after the founder of the SSL, Dr. Samuel Silver, this building is a three-story structure some 208 feet long by 40 feet wide, containing 28,787 assignable square feet.[32] Completed in 1966, Silver Laboratory faces west on one of the most significant promontories in the East Hill area. Southeast of Silver Laboratory, six "temporary" trailer units provide 4,942 square feet of assignable office space. These trailers, which are vulnerable to seismic activity, were added to the facility in 1967. Plans for removing or relocating all or some of them are now being actively considered. These plans have been made necessary by the proposed construction of the Mathematical Sciences Research Institute on a site immediately south of the SSL. Access to this site will likely be through part of SSL's existing parking lot.

A new long-term "temporary" addition to the Silver Laboratory in the form of a single-story office building of 2,422 assignable square feet is proposed for a site immediately west of the laboratory. The construction of this addition, which is expected to begin in the fall of 1982, will relieve some of the pressure for extra space now felt in Silver Laboratory. The problem of space, or the lack of it, is likely to worsen with the proposed reorganization of existing trailer space.

Currently some 400 researchers and staff make up the population of the SSL with about the same number of scholars and students visiting the Laboratory each month. Most employees and visitors arrive at the facility by car, and about 100 cars a day use the parking lot. It is believed that joggers and other users of the hill area also park in the lot, particularly on weekends. A special shuttle bus with direct service to the central campus twice an hour bring 45-50 people to the laboratory daily. The bus route runs through Lawrence Berkeley Laboratory, for which special permission has been granted (see note in Vehicular Access section).

Other than the proposed addition to the Silver Laboratory described above, there are no firm plans to build other permanent structures on the site in the near future. However, the draft Long Range Development Plan for the SSL identifies a need for a 5,000 to 10,000 gross square foot building to be constructed by 1986. This building is expected to be sited northwest of Silver Laboratory, although a specific location has yet to be determined. The construction of this building would permit removal of all the nearby trailers as well as the new temporary addition of 2,500 assignable square feet.

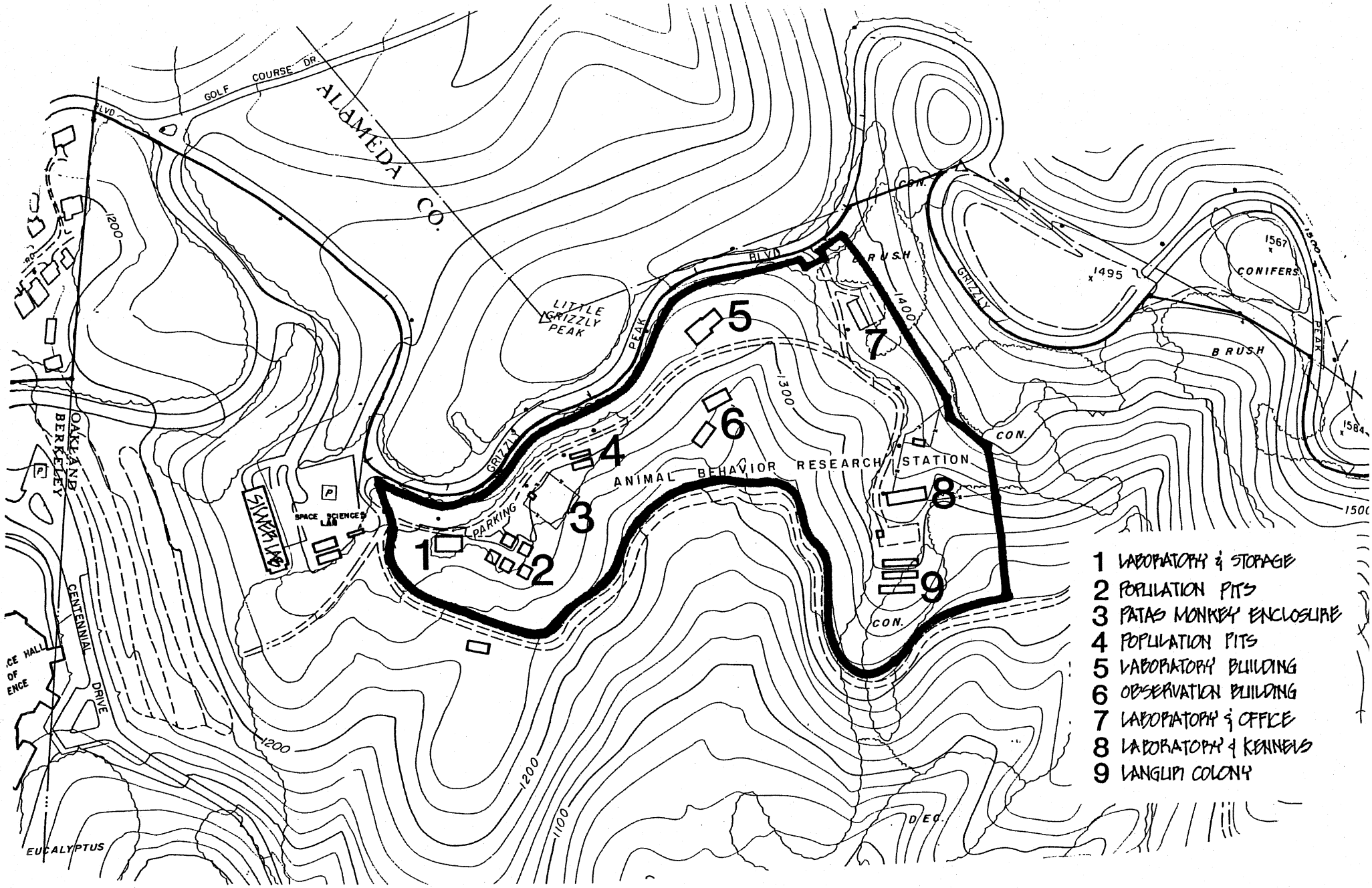
e. Field Station for Behavioral Research

The Field Station for Behavioral Research (FSBR) is located in the northern part of the upper hill area. Situated at the edge of the University's property, the FSBR occupies an area of 18 acres bounded on the north by Grizzly Peak Boulevard. The FSBR has occupied this site since it was established in 1961. The FSBR is an Organized Research Unit that conducts research on animal behavior which cannot be done in an enclosed laboratory setting. Over the past twenty years, it has been used by various University departments, among them, Zoology, Anthropology, Microbiology and Immunology, and Physiology-Anatomy, for research requiring semi-natural conditions.

In a report submitted to the University in 1981, the director of the FSBR, Dr. R. L. Caldwell, provided the following description of the facility:

> The FSBR consists of nine distinct units, each serving a different general function, but designed with sufficient flexibility so that they can meet the needs of a variety of investigators. Unit #1 is a general enclosed laboratory and storage building. Unit #2 consists of five large enclosed concrete population pits that can be filled with dirt to provide a natural habitat for small animals such as snakes or rodents, can be filled with water to form ponds, or can be emptied to hold larger animals or serve as observation arenas. Unit #3 is a large enclosed grassy meadow with an associated building currently being used to house the Patas monkey troop. Unit #4 consists of 20 small enclosed concrete population pits. Unit #5 is a large laboratory building with a series of indoor/outdoor flight cages used mainly for birds and bats. Unit #6 includes two identical buildings each containing 12 observation rooms with one wall open to the outside. Unit #7 is a laboratory and classroom structure that also houses the Director's office. Unit #8 consists of a battery of indoor/outdoor kennels, a laboratory, an observation tower, and three fenced compounds. Unit #9 centers around three large primate runways and a laboratory building and is now being used to house the Langur colony. Placement of the units was made so that most are visual(ly) isolated from one another and from public view. Local vegetation has been allowed to grow throughout the facility except along roadways and within the animal compounds where plantings may be made to suit specific needs. The resulting animal behavior station was one of the largest, most versatile, and most convenient anywhere in the world.[33]

The value of the FSBR's location lies in the fact that it is at once isolated and relatively undeveloped, yet convenient to the lower campus area. The site is also considered ideal for the needs of the FSBR because:



field station for behavioral research

0 50 100 200 300ft

a. the site is large enough to contain a large number of different animals, some indigenous to the area and some imported;

b. the climate of the site is mild enough so that these animals can be kept in open, natural, or semi-natural conditions throughout the year. The moderate climate also means that operating energy costs are kept low;

c. the site is contiguous with a large tract of undisturbed woodland and grass slopes now designated as an Ecologial Study Area that act as a "buffer zone;"

d. the proximity of the site to the campus means that permanent caretaker staff and housing are not required (though a regular caretaker is really needed to maintain the site). In a similar way specialized on-site laboratories and support facilities also are not needed; and

e. the topography and vegetation of the site provide visual and acoustical isolation between different units and areas of observation within the station.

All these factors are considered vital to the functioning of the FSBR by its users, particularly as they relate to cost effectiveness.[34] However, the construction of a new Mathematical Sciences Research Institute on a site adjacent to the western boundary of the Station is likely to compromise the need of the FSBR to remain secluded and undisturbed. This issue is discussed later in the report (see Proposed FSBR Development Plan).

POTENTIAL LAND USE

8. POTENTIAL LAND USE

Introduction

The University's Long Range Development Plan (LRDP), 1962, declares that the bulk of the East Hill area should be used for a variety of teaching and research activities.[35] Current programmatic activity in the area is consistent with this objective. However, the expansion of facilities involving substantial construction in the area is constrained by topography, access, and University policy designating the area primarily as an ecological preserve. Within these constraints, areas offering themselves as potential development sites are few and far between.

Four areas of potential development are identified in this report on the basis of their geologic stability, their proximity to existing access routes, and the relatively minor impact their development will have on the general environmental conditions in the area (see Map 18). Parts of all these areas have already been identified as potential development sites in previous reports.[36] This report redefines the limits of development for each area before evaluating its environmental context, land use characteristics, and functional relationship with existing facilities. Site evaluation criteria include the following categories, where applicable:

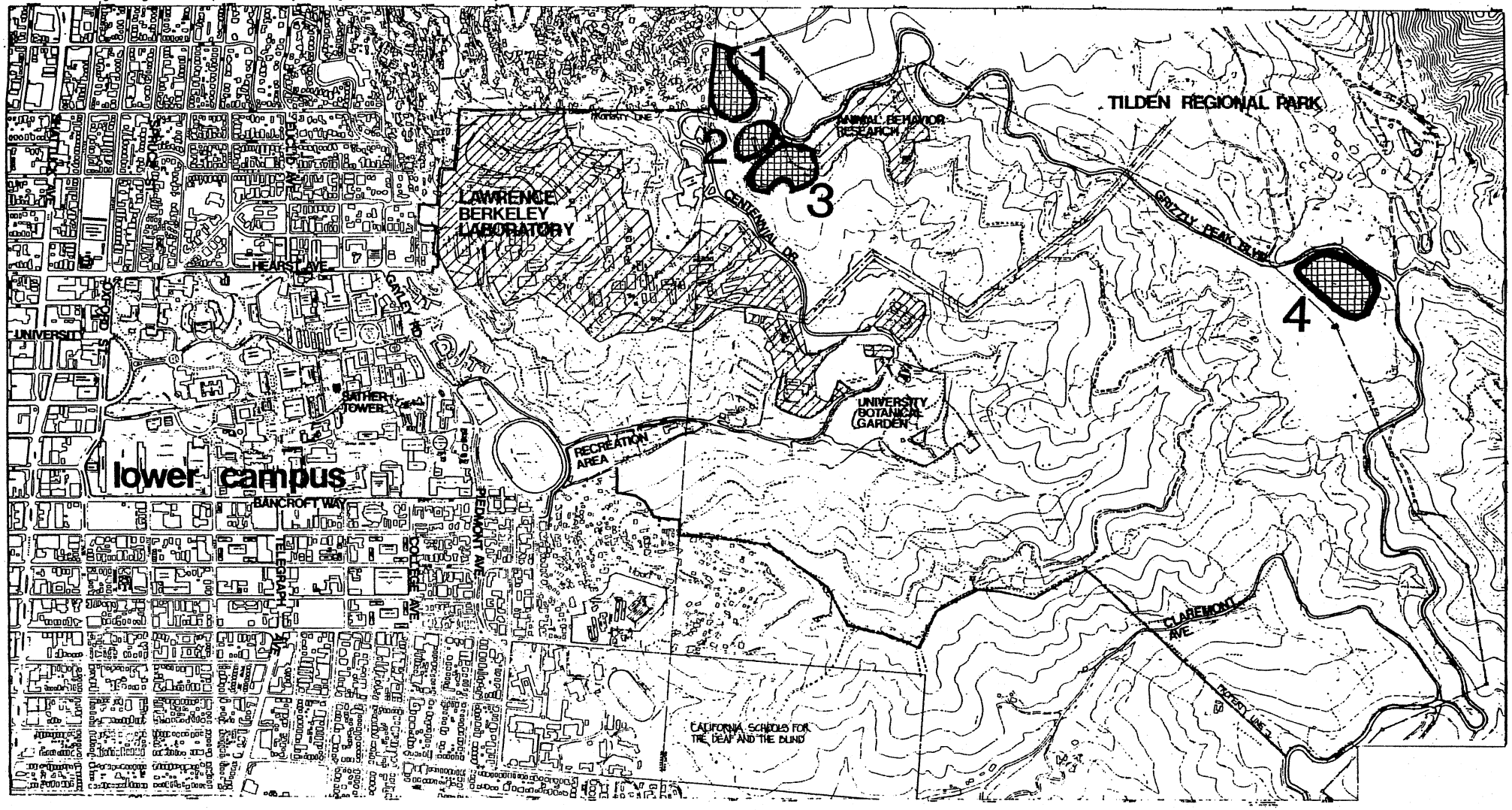
Environmental Context

Topography
Geology
Hydrology
Ecology

Land Use

Vehicular access
Pedestrian access
Access to utilities
Solar access
View orientation
Visual isolation
Acoustical isolation
Aesthetic impacts
Fire protection and fuel management

Source: Long Range Development Plan, 1962; Ishimaru & O'Neill, 1981.



POTENTIAL BUILDING SITES 1 THROUGH 4.

potential building sites

0 200 400 1000 1750ft.

Functional Relationships

Compatibility with existing plans
Use of shared facilities
Reallocation of existing facilities
Disposition of new facilities

This section of the report will also provide a proposed development plan for the Field Station for Behavioral Research which takes into account the eventual spatial reorganization of this unit made necessary by the proposed construction of a mathematical sciences research complex on its western boundary.

Site Analysis: Site 1

Located at the junction of Centenial Drive and Grizzly Peak Boulevard in the northern section of the canyon area, this site lies about 500 feet northwest of the Space Sciences Laboratory and 1,000 feet northeast of the Lawrence Hall of Science.

Environmental Context

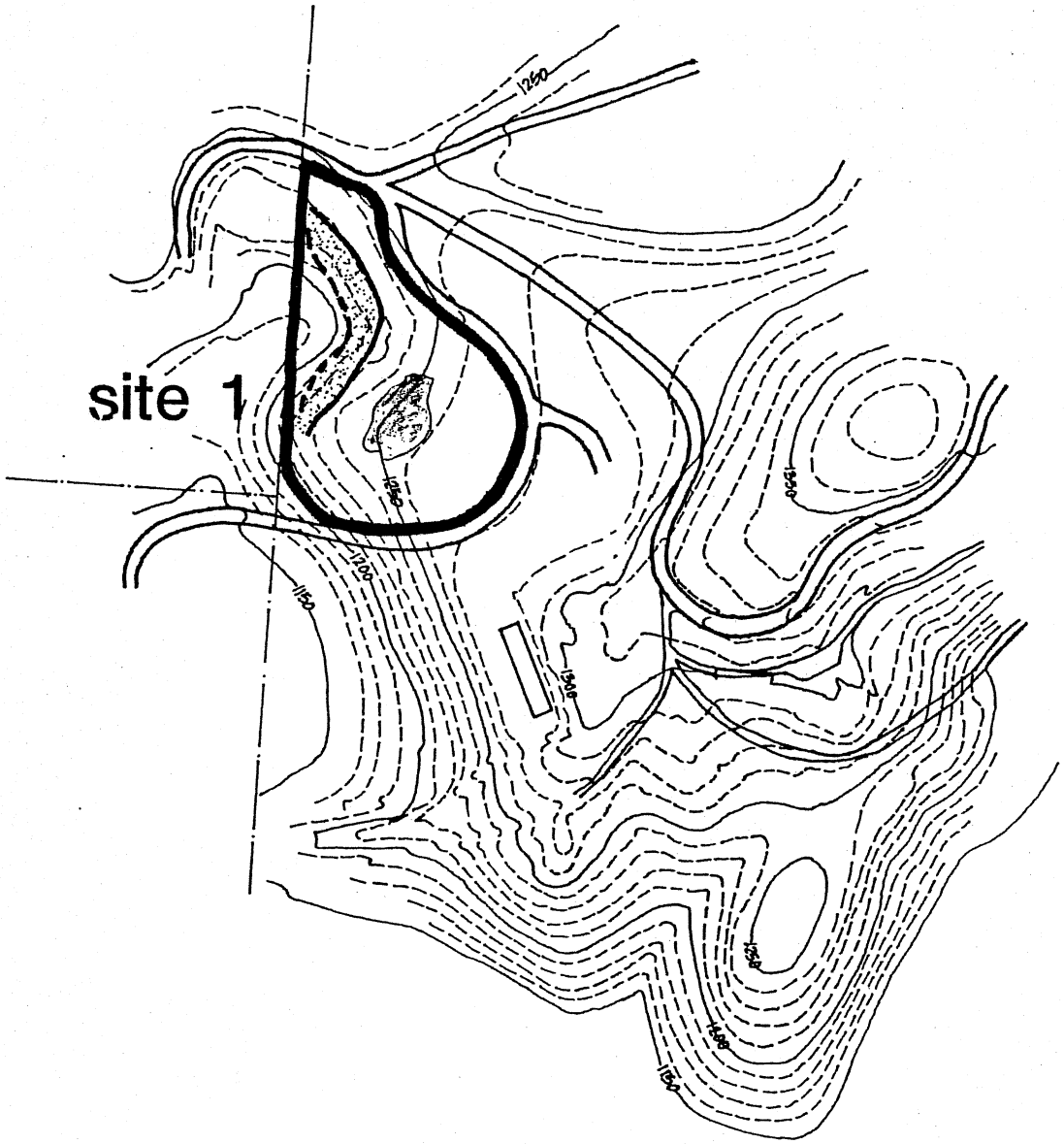
The site occupies about four and a half acres of generally open land that slopes from an elevation of 1,265 feet in the east to an elevation of 1,200 feet in the west. Beyond the western boundary of the site, which coincides with the University property line, are residential homes. In general, because of its slope, drainage on the site is excellent and in geological terms the area is stable. Lennert and Associates report:

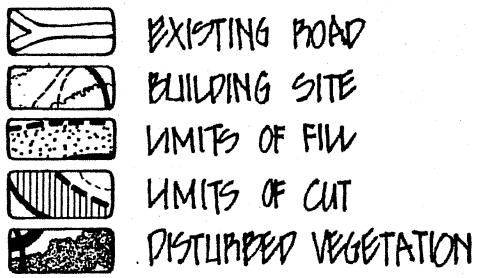
> "...rocks are stable and present no problems for site development...the rock provides excellent foundation conditions and will make excellent fill material...One minor fault is known to transect the site; this fault poses no hazard to site development..."[37]

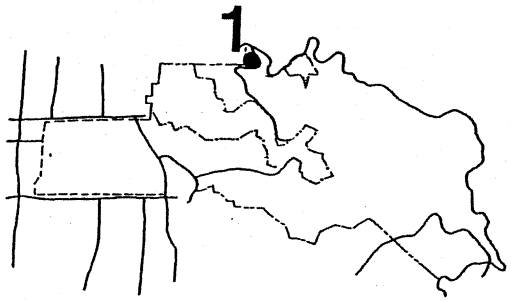
Vegetation in the area consists of open grass areas and low bushes with a number of young eucalyptus trees grouped about a small rock knoll in the center of the site. Except for the remains of several large eucalyptus stumps, there is no major growth vegetation in the area.

Land Use

The site is bounded to the south and east by Centennial Drive and contiguous grades along the roadway allow good vehicular access at a number of points. However, the steep

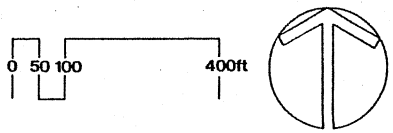






key map

site analysis: site 1



sweeping curve of the road along the site boundary is somewhat hazardous as well as a design constraint. Suggestions for improving the alignment of this road are contained in a later section of the report (see Proposed Circulation Plan). Pedestrian access to the site is at present nonexistent but, if well planned, future access should present few problems. Rather than detract from potential development, the irregular character of the site may aid new buildings in blending into existing land configurations, mitigating any visual or environmental impact. Mass transit connections to the site are good. An AC Transit bus delivers passengers about 400 feet from the top of Centennial Drive along Grizzly Peak Boulevard. Access to utilities serving Lawrence Hall of Science and the Space Sciences Laboratory is available in Centennial Drive.

In terms of solar access, the site has unrestricted exposure to the east, south, and west. Similarly, views out from the site are excellent. If development is closely related to existing contours and maintained at a low scale, the visual and aesthetic impact of new building forms can be minimal. Acoustically, however, the site has potential problems owing to the level of traffic on Centennial Drive and the steepness of its grade. Noise impacts can be mitigated by the judicious disposition of building on the site, the planting of screen vegetation, and acoustical insulation. Fire danger on the site is perhaps no greater than elsewhere in Strawberry Canyon, but the site's exposed location to easterly winds necessitate care in site design, landscaping, and the provision of fire prevention equipment.

Functional Relationship

The development of this site is in agreement with recommendations of the Long Range Development Plan (1962), and consistent with proposals outlined by Eckbo (1976), McBride (1978), and Ishimaru and O'Neil (1981). Previously considered as a site for the Naval Biosciences Laboratory in the 1960s, the area has been suggested for residential development.[38] Although such a proposal is attractive from a land use view, faculty or student housing on the site would not be compatible with the current University policy

of maintaining Strawberry Canyon for activities directly related to instruction and research. Additional "permanent" population in the area may have an undue negative impact on the ecological and biotic character of the canyon area as an environmental refuge. This may be particularly so if families with children are introduced into the area. In such a case, it would seem likely that greater unsupervised use of the fire roads and hiking trails could result in damage to existing natural habitats. Greater use of the trails could also result in greater fire risk and could seriously negate the secluded environment required by the Field Station for Behavioral Research. The impact of greater traffic volumes on Centennial Drive may also run counter to University policy concerning the use of this road as a thoroughfare. Present traffic capacity on Centennial Drive may not tolerate an increase.

b. Site Analysis: Site 2

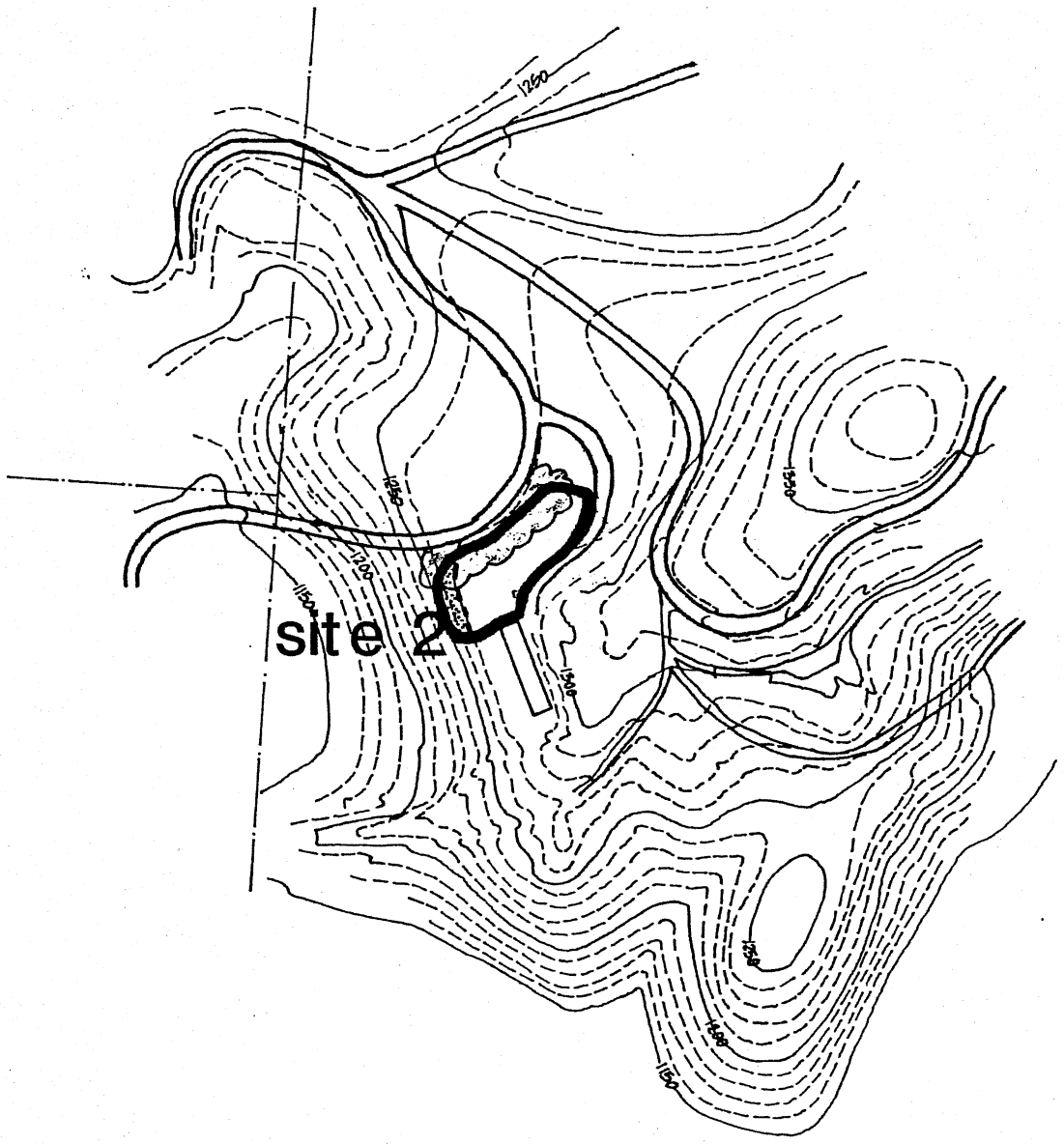
This site is located immediately north and west of the Space Sciences Laboratory (SSL), and has been identified as a possible development site for the future expansion of SSL.

Environmental Context

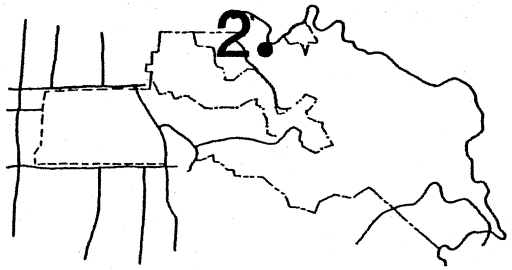
Bounded by the access road from Centennial Drive to SSL in the east, the sweep of Centennial Drive in the north, an escarpment in the west, and Silver Laboratory to the south, Site 2 covers about 2 acres of open grass and oak-bay woodland. The area is generally flat with a slight slope to the northwest, is well-drained, and sits at an elevation of 1,275 feet. Soil conditions are stable, although steep slopes at the boundary of the site leading down to road surfaces are subject to erosion and potentially unstable.

Land Use

Vehicular access to the site from Centennial Drive is good, but redesign of the access road and adjacent parking lot will be required if development occurs on Sites 2 and 3. Public mass transit connections are distant and vanpool or carpool services, particularly to the lower campus, can be expected to increase to absorb new demand when development occurs. Direct pedestrian access to the site is good from Silver Laboratory, but more



EXISTING ROAD
BUILDING SITE
LIMITS OF FILL
LIMITS OF CUT
DISTURBED VEGETATION



key map

site analysis: site 2

0 50 100 400ft

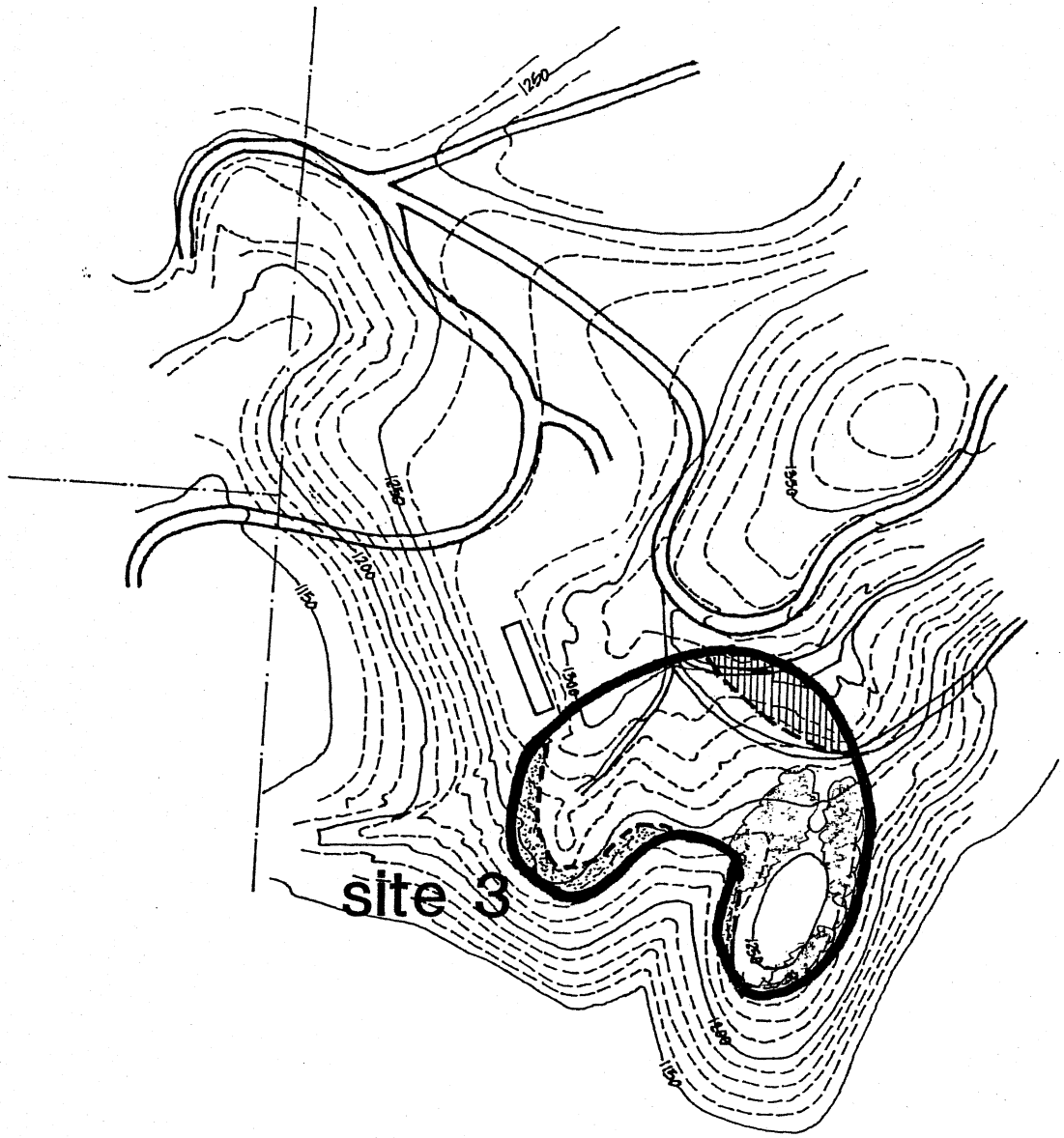
constricted from either the existing parking lot or "temporary" trailers within the Space Sciences complex. Access to utilities is not expected to pose problems for future development given the closeness of Silver Laboratory. Available capacity should be clarified. Solar access is constrained to the east by tall vegetation and to the south by the bulk of Silver Laboratory. Visual orientation to the west can provide splendid views of the Bay Area, but the siting of any building to ensure solar and visual access must not inflict unnecessary damage to existing vegetation. Skillful site design and planning should allow new development to merge with its background. For aesthetic and geological reasons, development should be kept some distance from the escarpment line. No building should be taller than the crown of existing trees or appear in silhouette against the skyline. Traffic noise on Centennial Drive, which can impair the acoustical quality of the site, can be offset by careful plant screening. For these reasons, development should be placed closer to Silver Laboratory than Centennial Drive. Fire management techniques and fuel control programs will be required to protect any future development on the site. However, the contiguous nature of the area's surrounding vegetation should be maintained by careful design.

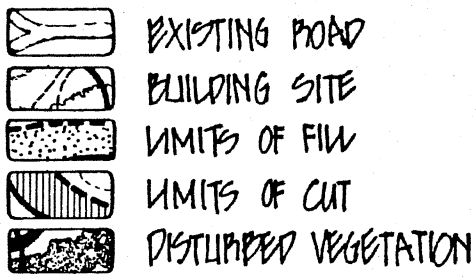
Functional Relationship

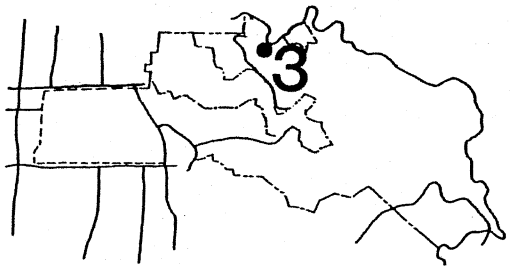
Development on the site is clearly compatible with the long range development proposals of SSL and it is unlikely that any use other than that proposed by SSL will be envisaged for the area. Development would help in the reallocation of space lost when "temporary" trailers and a planned "temporary" building are removed from the SSL facility. The location of the latter "temporary" building, a single-story construction to be erected in 1983, should not be a design constraint on long term development plans.

c. Site Analysis: Site 3

Located to the south and east of the Space Sciences Laboratory, Site 3 covers approximately 6.5 acres of mostly gently sloping land. Parts of the site have been identified by the University for the development of a Mathematical Sciences Research Institute (MSRI).[39]

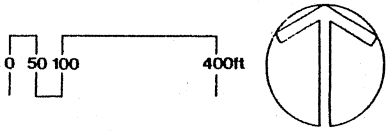






key map

site analysis: site 3



Environmental Context

Topographically this site slopes downward from an elevation of 1,280 feet in the northeast to 1,240 feet in the southwest, shaped in plan like an inverted horseshoe. Steep slopes mark the site boundary along three sides, but in the north the land merges with the more level contours of the Space Sciences Laboratory site. Slopes fall dramatically away from the site below the 1,200 foot level. A steep-sided gully, which carries the main drainage away from the area, thrusts into the side along its western edge and east of this point a small plateau makes up the southeastern portion of the site. In the northeast, the bank of a high escarpment runs sharply up to the level of Grizzly Peak Boulevard.

In the main, soil and geological conditions in the area are favorable to development, although landslide bodies exist on the steep west-facing slopes beyond the site boundary. A well-developed tension fault also exists in the area. Running east-west through the center of the site, this fault is not considerd a "credible life hazard" in the opinion of Lennert and Associates, soils engineers. Given normal site development, the engineers report that the fault should not deter development.[40] The expression "normal site development" is not, however, defined in the soil engineers' study, and therefore any development needs to be examined for possible seismic impact.

Land Use

Vehicular access to the site is presently gained by way of an unimproved fire trail leading from Grizzly Peak Boulevard that skirts the eastern edge of the Space Sciences Laboratory parking lot. The general location of this road and its grade are well-suited to serving development on the site and the road could be upgraded to access road standards. However, a hazardous "blind curve" condition exists along Grizzly Peak Boulevard at the point of egress of the fire trail and extensive redesign of this area will be required if this function is to provide access to the site. Design proposals outlining a solution to this problem are contained in a separate section of this paper. Access to the site for pedestrians and cyclists could be provided along this improved fire trail and direct access

to the fire and hiking trail system beyond the site would also be maintained. Mass transit access to the site could be improved if service were extended to where the fire trail joins Grizzly Peak Boulevard, or alternatively, brought into University property (see Proposed Circulation Plan).

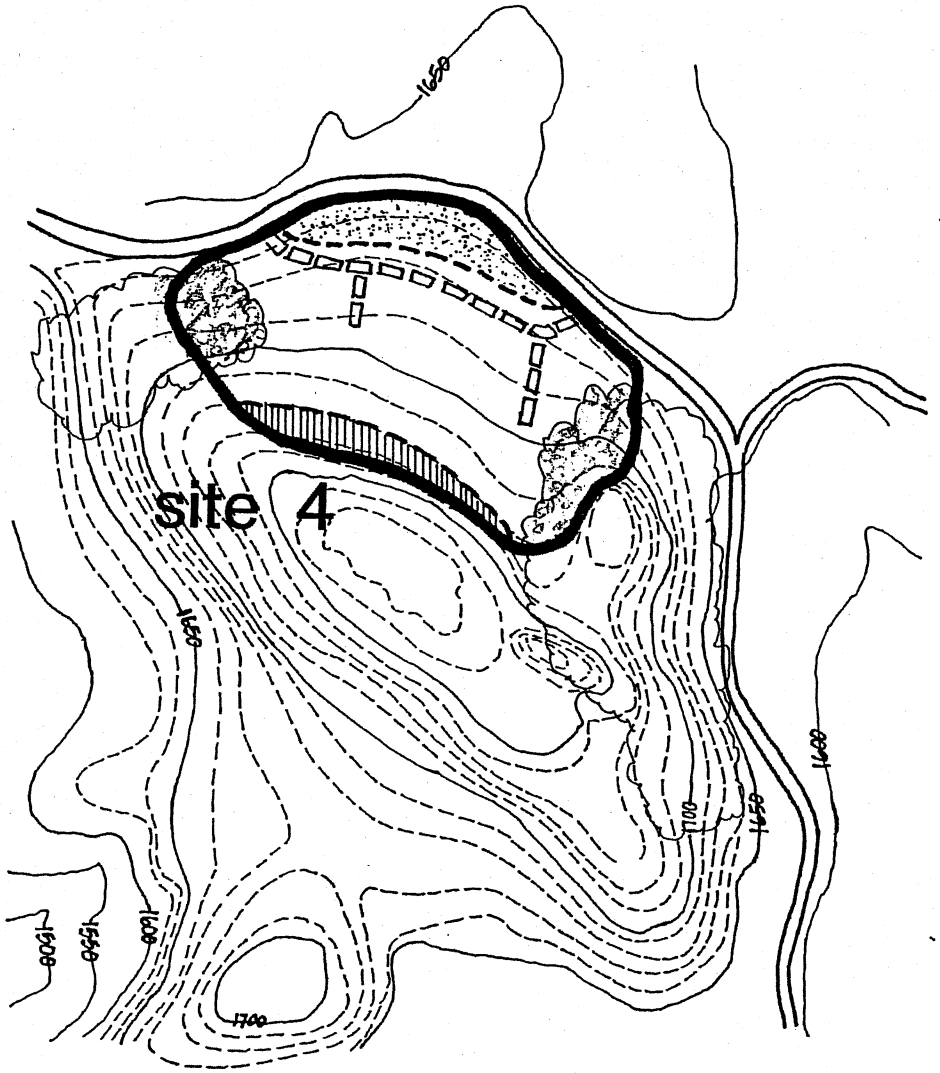
Because of the proximity of the Space Sciences Laboratory and the Lawrence Hall of Science, access to utilities is considered good, and because of the site's topography, solar access to the east, south, and west is excellent. Available utility capacity should be clarified. Views from the site are sweeping and panoramic to the west and south, but some screen planting will be required to isolate visually and acoustically the Field Station for Behavioral Research (FSBR) to the east. Except for occasional distant traffic noise, acoustic values on the site are good to excellent, and aesthetically the area is conducive to contemplative research. In order to maintain the visual character of the area, buildings should be set back from existing ridge lines and placed against a screen of natural vegetation. Buildings should be inserted into the landscape rather than made to dominate it, and no development should appear in silhouette above the height of existing trees. Because development on the site may place buildings at a "dead end" in terms of access, it is critical that a thoughtful fuel management program be carried out consequent with development.

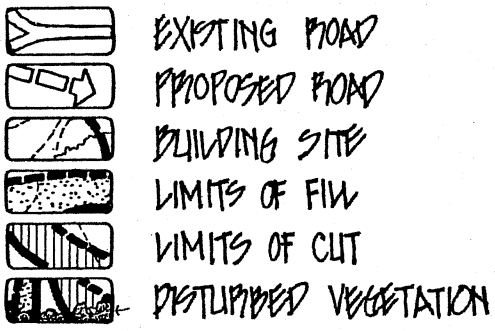
Functional Relationships

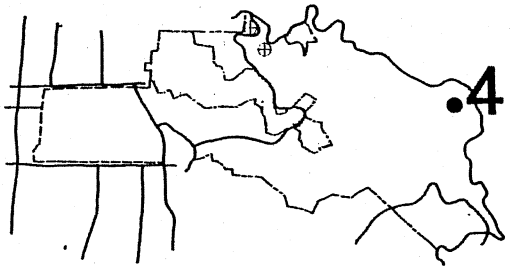
Development of this site is in concert with the recommendations of the Long Range Development Plan (1962), and with conclusions reached by Eckbo (1976) and McBride (1978). However, this report extends the eastern boundary of the site into an area presently occupied by the FSBR. This expansion has been made because a) contours and soil conditions in the area allow for development, and b) the requirement to minimize visual and acoustical impact of construction of an MSRI complex on a portion of the site necessitates FSBR's spatial reorganization (see proposed FSBR Development Plan).

d. Site Analysis: Site 4

Situated on the northern flank of Chaparral Hill (1,769 feet) at the eastern extremity of the East Hill area, Site 4 covers an area of about 6 acres of gentle open slopes.

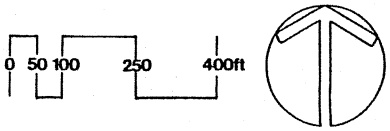






key map

site analysis: site 4



Environmental Context

Site 4 slopes downward in a northeasterly direction from an elevation of 1,720 feet on the side of Chaparral Hill to 1,660 feet at the line of Grizzly Peak Boulevard. Regularly sloping open grassland extends to a ridge line in the northwest and to the line of oak-bay woodland in the southeast. The site is constrained by visual amenity, access, and geological factors. Soil in the area is generally favorable for development, but a tension fault line occurs on the southwestern boundary, and on steeper slopes slide movement can take place. The area is well-drained to the north and east where part of the land is outside the Strawberry Canyon watershed. Because of its remote location, the ecology in the area is largely undisturbed and any development may have a negative impact on the migration of animals moving between the University's canyon land and the expanse of Tilden Regional Park.

Land Use

The site is well served in terms of vehicular access and entry into the area can be made at a number of points along Grizzly Peak Boulevard. Hiking trails along the ridge of Chaparral Hill give pedestrian access to the site but, because of its remoteness, these trails are unlikely to be used by the casual walker. Mass transit to the site does not exist, necessitating car-pooling or a shuttle mini-bus service to other campus locations if development occurs. Splendid views to the northwest and northeast are afforded by the area's high altitude but solar access is limited because of site orientation. Development on the site will be within the shadow of Chaparral Hill part of the day.

Acoustically the area is well-isolated and traffic noise on Grizzly Peak Boulevard has little impact on the interior of the site. Visually buildings should be kept as low as possible and integrated into the area's topography. No development should appear above the ridge line or be visible by an observer looking eastward, out of the canyon area. Because of its exposed position, the site is subject to occasional strong winds from the west and

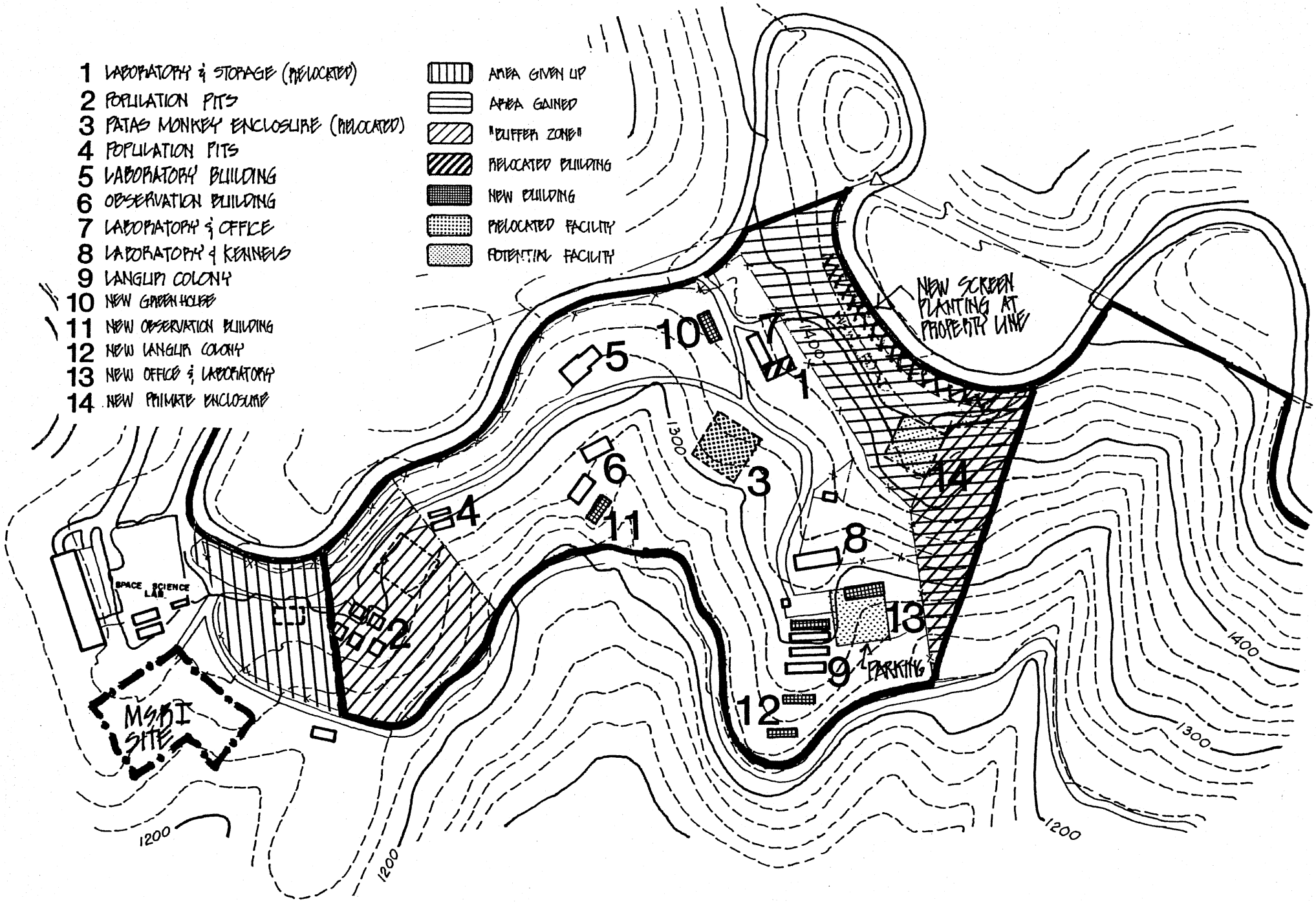
hot dry winds from the east during late summer and fall, posing a considerable fire threat. The remoteness of the site is less a problem for fire protection as the East Bay Regional Park Fire Station is immediately north of the site. The major drawback to development is the lack of available utility lines. The nearest existing University utilities are located at the Space Sciences Laboratory. The possibility of sharing park service utility lines should be investigated.

Functional Relationships

Development of the area was identified in the Long Range Development Plan (1962), designated as the site for a humanities institute and conference center.[41] Eckbo (1976) recommended a two-site development in the area, a recommendation rejected by Beatty (1979) on the grounds that both sites should be incorporated into an expanded Ecological Study Area. Beatty's report, which was intended as a "guiding philosophy" for development throughout the Strawberry Canyon area, has not been officially adopted by the University.[42] The two-site development suggested by Eckbo is also rejected in this report since one of the sites is situated on the west-facing slope of Chaparral Hill and involves development on unstable soils as well as loss of visual amenity from the canyon area.

e. Proposed FSBR Development Plan

Since its inception in the early 1960s, the Field Station for Behavioral Research (FSBR) has remained essentially undisturbed by development in other parts of the East Hill area. The present physical layout and function of the Station reflect this condition, remaining very much the same as when first constructed and operated. However, the proposed development of a new Mathematical Sciences Research Institute (MSRI) on the western boundary of the FSBR is expected to impact both the function and layout of the Station. With the construction of the MSRI, increased numbers of people and increased noise, external lighting, pedestrians, and vehicular traffic brought to the area will be in close acoustical and direct visual proximity to existing observation areas within the Station. In particular the Patas monkey enclosure and a number of population pits will



fsbr development plan

0 50 100 200 300ft

be exposed to public view compromising the secluded environment required to conduct research at these two locations. It should also be remembered that the construction of the MSRI is planned as the first installment of a number of similar buildings that may be erected on adjacent sites over the next 10-20 years. The spatial reorganization of the FSBR is therefore necessitated not by internal programmatic need but as a response to external events. It is important that this reorganization take place well in advance of any future development along its boundaries so that the function of this Station can remain undisrupted.

A preliminary version of the proposed development plan, shown on Map 23, has been discussed with Dr. R. L. Caldwell, the Director of FSBR, Thomas Koster of the Buildings & Campus Development Committee, and Ralph Gigliello from the Coordinator-Physical Planning's Office. While all three of the above have tentatively reviewed the contents of the plan, the development proposals contained in this report carry no official University status, and are the sole responsibility of the author.

The spatial reorganization of the FSBR would take place mostly within the confines of its existing area. A minor extension of the Station's area to the east is proposed to provide space for possible future expansion and to reconcile land use jurisdiction in the area by aligning the boundary of the FSBR with that of the Ecological Study Area. The section of land to be incorporated into the FSBR is not included in the expanded Ecological Study Area proposed by Eckbo (1956), McBride (1978), and Beatty (1979). The bulk of this added land, which roughly compensates for land given up to development by FSBR on its western boundary, will form a "buffer zone" between the station and other land use entities. A similar and more crucial "buffer zone" is envisaged in the western part of the FSBR site (see Map 23).

Environmental Context

The FSBR site spans the head of a minor valley system and its adjacent hillsides on the northern boundary of the University's property. The site is bounded by the irregular

line of Grizzly Peak Boulevard to the north and a graded fire trail to the west and south. On its eastern boundary a wire fence, which bounds the entire site, is the only feature that differentiates the Station's area from its contiguous land mass.

The land occupied by the FSBR slopes rapidly down to the west from approximately 1,480 feet in the northeast corner to about 1,220 feet along the fire trail. Sections of precipitous grades in the southern area of the site isolate the station from public view. Slope and configuration throughout the Station mean that land suitable for building is limited in terms of sites and acreage. This factor works to the advantage of the FSBR in that it discourages development on the site or a change in programmatic use while at the same time reinforcing the Station's traditional "low-profile" in terms of equipment and plant. Topography ensures that major building cannot take place on the site, and development is further constrained by the presence of Wildcat Fault which runs north-south through the eastern portion of the site. On those sites which are relatively level, soil conditions favor development but landslide activity along the southern boundary attest to the potential instability of the soil. Generally the area is well drained by at least three small creeks.

Ecologically, the area is rich in animal and plant life which consists of a mixture of soft chaparral, oak-bay woodland, and eucalyptus trees. Because the site is fenced and humans are kept out, many native animals have become "permanent residents" of the FSBR and some have prospered to the point of becoming a nuisance.

Land Use

Direct vehicular access to the site from Grizzly Peak Boulevard is good and in the proposed development plan existing fire trail access on the western and southern boundary will be maintained as secondary or emergency access points. The existing paved road on the site will remain unaltered with expansion of the internal circulation system envisaged in the new eastern portion of the site. A new service supply road from Grizzly Peak Boulevard, which can function as an emergency exit, is also suggested for this area.

The hazardous nature of Grizzly Peak Boulevard at this point suggests that entrance to the site at this location be restricted to eastbound traffic.

Pedestrians and cyclists will continue under the new plan to follow the essentially traffic free internal road with no special provisions required. Parking areas will be increased, but only incrementally and in certain selected areas. Since overall site development will remain at about its present level, no increase in the capacity of existing utilities is anticipated. The solar access of various units is excellent, and the installation of solar panels to meet unit-specific light and energy requirements ought to be explored.

In terms of slope and aspect, the site has excellent visual amenities. Views to the west, south, and east are possible from several locations. But since the aim of the FSBR is to remain secluded from public view, buildings and structures are set against the existing vegetation and slope. Within the site visual and acoustical isolation between units is essential to the work of researchers. The station attempts to provide semi-natural conditions that replicate as near as possible conditions in the wild. Since animals under observation often come from different countries or continents, the re-creation of their natural habitat dictates that alien noise and sights be guarded against.

Because the area in which the FSBR is located is so prone to fire risk, prudent and controlled use of fuel management techniques is advocated. Underbrush along roadways and trails should be cleared, and in the vicinity of structures a fire break should be created, particularly in areas of eucalyptus growth. An improved sprinkler system for all building areas should be provided. At present there are few outside building lights and no street lighting in the area, and none are wanted by researchers working at the site. Artificial light would be alien to the natural environment provided for the animals and would conflict with nocturnal observation programs. However, since much of the observation work at the station is carried out at night, the provision of an emergency response system in all buildings is highly recommended for reasons of both security and fire protection.[43]

Functional Relationships

The use of the FSBR site for research in animal behavior is consistent with recommendations in the Long Range Development Plan (1962), and has not been questioned in any of the consultants' reports on land use conditions in the East Hill area since that time. However, the recent approval by the Chancellor for the construction of the first phase of the Mathematical Sciences Research Institute has caused a reexamination of the physical layout of the station. Construction activity and subsequent daily use of a facility on the western perimeter of the FSBR will impact the requirement of the station for visual and acoustical isolation during the day and night.

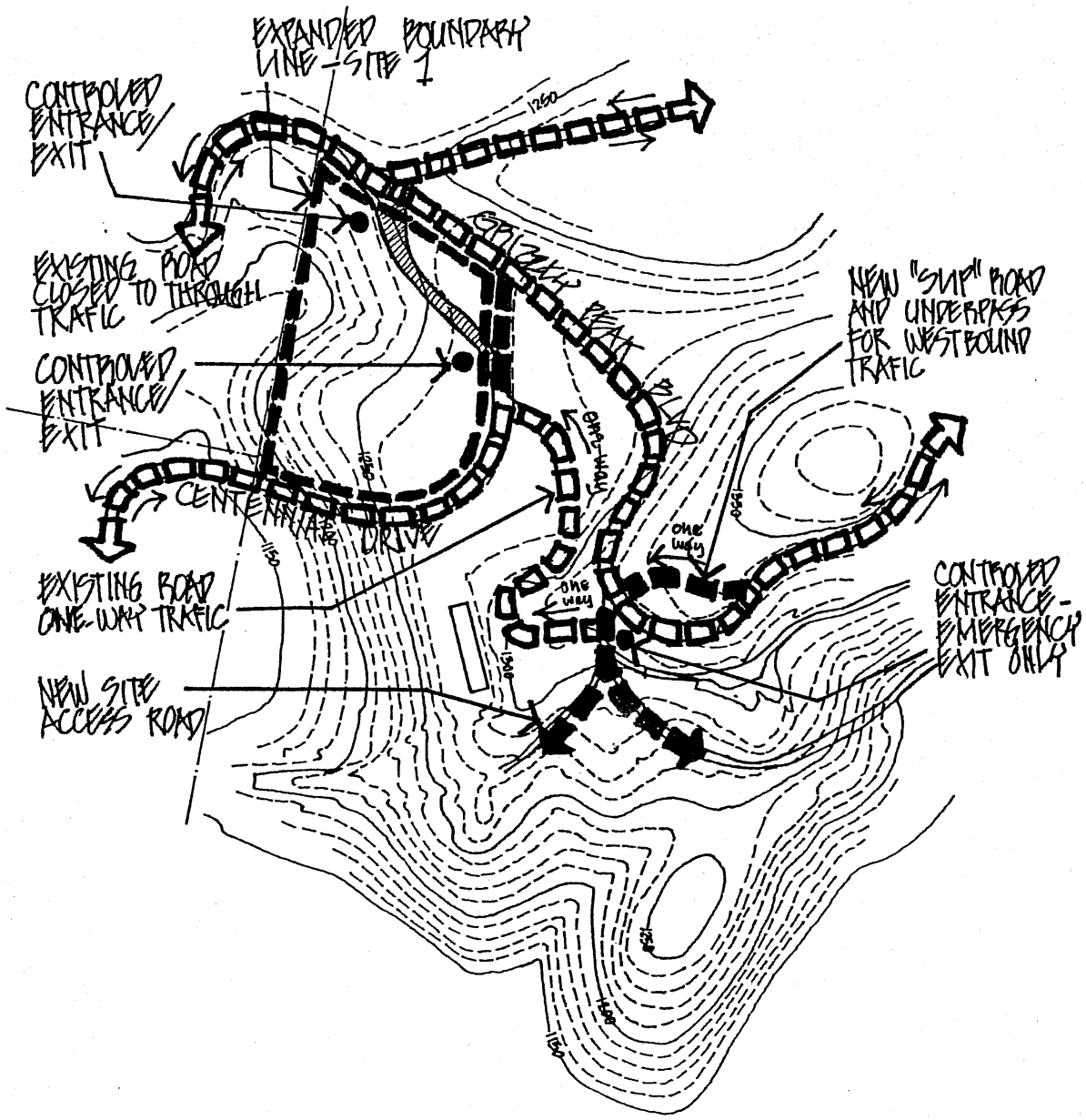
The development plan for the FSBR presented in this report acknowledges that site development west of the station will take place, perhaps over the next 10 to 20 years. It therefore proposes that FSBR "cede" land suitable for development to other University departments or units with the proviso that any structures or functions of the Station lost in this way will be replicated as necessary in a reorganization of the FSBR site. This reorganization is shown on Map 23, Proposed FSBR Development Plan.. A new fence line, originating at the line of the existing population pits, would form the western boundary of the site. An existing laboratory-storage building west of this line and an open enclosure for Patas monkeys east of the new line would be relocated as shown. New population pits would be constructed as required by the FSBR, perhaps to a new design and size, but the existing pits would not be abandoned entirely. While the broad range of use which these pits once had will be curtailed, they still may be used for research concerning insects, invertebrates, and perhaps aquatic organisms. The relocation of the Patas monkey enclosure will cause the most severe disruption in scientific observation, possibly lasting as long as a year. Studies can recommence about six months after all disturbance has finished and the animals reestablished with their new surroundings and reacquainted within their social groupings.[44] In this regard, the timing of the move is critical to its success. A further elaboration of the development plan proposal must therefore take into account the temporal as well as spatial requirements of the FSBR in terms of research.

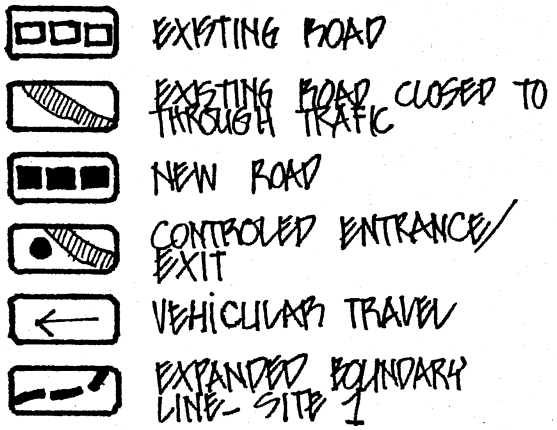
f. Proposed Circulation Plan

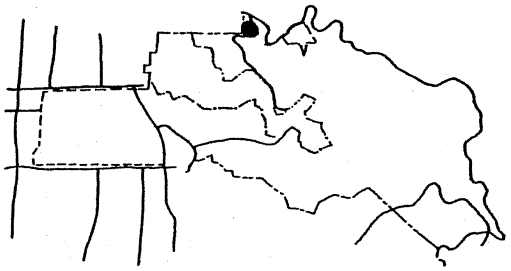
The Proposed Circulation Plan, shown on Map 24, illustrates in a schematic fashion the possible reorganization of traffic patterns in the northern section of the East Hill area. The area in question lies between the Lawrence Hall of Science (LHS) and the Field Station for Behavioral Research (FSBR) close to the present junction of Centennial Drive with Grizzly Peak Boulevard. The proposed reorganization of the surface roads in the area is predicated on an increase of vehicular traffic of all types - passenger cars, buses, service vehicles - that can be expected with the completion of development proposals on several sites in the area. These developments include the construction of a mathematical sciences research complex, a new permanent addition to the Silver Laboratory and the Space Sciences Laboratory (SSL), the completion of new parking facilities to serve the LHS and SSL, and the development of Site 1 noted earlier in the report, possibly for housing. With the completion of all these developments, it will become imperative that fire and emergency vehicles have direct access to buildings in the area, some of which are to be located at the "dead-end" of existing circulation routes.

In its essentials the proposed plan calls for the realignment of Centennial Drive above its present junction with the existing access road to SSL. Existing contours indicate that this realignment will provide a level road surface leading to a new junction with Grizzly Peak Boulevard. This realignment will alleviate the danger of a rather hazardous curve in Centennial Drive and at the same time expand the amount of land available for development in Site 1, giving the site a more "logical" northeast boundary. It is proposed that the existing section of Centennial Drive west of the realigned roadway be closed to through traffic. Controlled entrance and exit points can be established at either end of this section of road which will still be available for internal circulation on the site.

To the east of the junction of Centennial Drive and Grizzly Peak Boulevard an existing fire trail, which currently follows the western perimeter of the FSBR, offers the only reasonable approach in terms of grades and access from Grizzly Peak Boulevard to the new mathematical







key map

proposed circulation plan

0 50 100 400ft

research complex and the SSL site. It is proposed that this fire trail be upgraded to access road standards to provide entry to the area. Access for eastbound traffic along Grizzly Peak Boulevard will not present a problem, but the topography in the area dictates that westbound traffic entering the site will require the construction of a new "slip" road and underpass below Grizzly Peak Boulevard. Because hazardous conditions will still obtain, it is proposed that traffic not be allowed to exit the area to the east or west, except in emergency.

The internal traffic pattern of the area will be dependent on individual site layout and building design but the proposed plan envisages that existing traffic be directed in a one-way pattern along the existing SSL access road leading to Centennial Drive. It is anticipated that increased traffic volume will make the present two-way pattern along this road unfeasible and create traffic blockages at this junction with Centennial Drive. If the proposed scheme is implemented, traffic to the lower campus will travel on the south side of this two-lane road with traffic heading for Grizzly Peak Boulevard traveling on the north side. A manned control point can also be established at the junction of Centennial Drive, again for both traffic control and security reasons.

Traffic arriving from the lower campus would be required, in this plan, to circulate along Grizzly Peak Boulevard in order to reach the MSRI complex and Silver Laboratory. Public transportation systems and University-provided mass transit would also be required to follow the same route and circulate through the area in a one-way direction, avoiding difficult turn-outs or possibly dangerous reversals of direction.

The proposals outlined above are schematic and tentative and have not been discussed or reviewed within the University administration. They assume full development of all sites in the area and look to the long term rather than the short. The proposed plan offers no thoughts on phasing implementation and will no doubt be expensive to accomplish. However the main intent of these proposals is to highlight the problems and complexities that full development, and consequent increased traffic density, may bring to the northern canyon area and to suggest a schematic approach to their solution.

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25. Beatty, 1979, p. 11.
26. Ibid., p. 5.
27. Ibid., p. 12.
28. Minutes: Landscape Architecture Advisory Subcommittee, Item 2, Nov. 19, 1969.
29. Information in this section of the report drawn in part from the Master Plan for the Botanical Garden (draft), 1981.
30. Ibid., p. 39.
31. Information in this section of the report drawn in part from the PPG, 1981, Lawrence Hall of Science Alterations, Step 1.
32. Information in this section of the report drawn in part from the PPG, 1981, Silver Laboratory Addition.
33. Initial Study Environmental Assessment: Mathematical Sciences Research Institute, 1981, Appendix A, p. A-2.
34. Ibid., pp. A-3 to A-8.
35. Long Range Development Plan (LRDP), 1962, p. 30.
36. See LRDP, 1962; Beatty, 1979, Ishimaru and O'Neil, 1981.
37. Lennert and Associates, 1981, quoted in Ishimaru and O'Neil, Appendix A, 1981.

38. Initial Study Environmental Assessment: Mathematical Sciences Research Institute, 1981, p. 27.
39. Ishimaru and O'Neil, 1981, pp. 29-33.
40. Lennert and Associates, 1981, quoted in Ishimaru and O'Neil, Appendix A, p. 1.
41. LRDP, 1962, Pocket Map - Upper Hill Area.
42. BCDC Minutes, March 13, 1981.
43. These recommendations have the support of Dr. R. L. Caldwell, Director of the FSBR.
44. Information provided by Dr. Thelma Rowell, behavioral research scientist, FSBR, May 1982.

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STRAWBERRY CREEK MANAGEMENT PLAN

prepared by

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for the

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STRAWBERRY CREEK MANAGEMENT PLAN

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PROFESSIONAL REPORT

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of

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1.0 EXECUTIVE SUMMARY

Strawberry Creek represents an irreplaceable natural resource that is highly valued by both the University and community at large. The riparian corridors along the creek are the focus of central campus open space. These areas offer natural contrast to the urban hardscape, acting as a buffer zone which provides visual amenity and variety. The creek corridors also provide essential places for educational, recreational, social and individual activites. Strawberry Creek's value as an educational resource is enhanced by its accessibility and proximity to classroom facilities.

The upper Strawberry Creek watershed located above Oxford Street in Berkeley, CA is composed of two major branches, the North and South Forks. The total watershed area is 1163 acres or 1.8 mi^2. Stormwater routing as well as stream culverting and channel confinement have significantly altered the natural drainage courses of both forks. The two forks converge at the Eucalyptus Grove on the central campus to form the Main Branch.

The watershed is approximately 40% urbanized, primarily by institutional land uses in the western portion of the watershed. Urbanization has had a profound impact on the hydrologic regime of Strawberry Creek. A significant amount of impervious surface area in the watershed in addition to culverting and confinement of the natural creek channels and stormwater routing have combined to create a very flashy hydrologic regime. The resulting high peak storm flows have accelerated streambank erosion and led to the destruction of aquatic habitat.

Low flow water quality of Strawberry Creek is fairly good in the canyon areas but has been degraded in the urbanized downstream reaches by eutrophic nutrient levels and fecal bacterial contamination. Sewage contamination on the central campus is a major problem. Point source effluent also significantly alters the water chemistry of the North Fork on the central campus. This is due to extensive dilution of natural streamflow levels with point source effluent, predominantly cooling water. Streamflows are doubled by the addition of point source effluent on the central campus during low flow periods.

Stormwater runoff from the entire watershed is routed directly into Strawberry Creek causing significant degradation of water quality . Runoff from streets, parking lots and other urban land surfaces concentrates debris and pollutants deposited by a myriad of sources in the urban environment. This results in substantial increases in chemical oxygen demand, suspended solids, turbidity, organic nitrogen, phosphorus, total and fecal coliform bacteria, as well as trace metals in Strawberry Creek during wet weather. Non-point sources of pollution have a significant short-term "shock loading" effect on the water quality of the creek.

Creek management strategies consist of point source pollution controls, grade contyrol and streambank stabilization measures, as well as riparian and aquatic habitat restoration techniques. The sources of direct discharges into Strawberry Creek need to be further investigated. All wastewaters should be routed to the sanitary sewer system. Rehabilitation of existing grade control structures is essential to prevent further downcutting of the streambed which leads to streambank undercutting and scouring of the streambed. Biotechnical streambank stabilization techniques should be applied in applicable areas to deal with existing bank erosion problems. Management guidelines need to be evaluated and implemented for the designated central campus nature areas which coincide with the riparian corridors of Strawberry Creek.

Best management practices need to be instituted for non-point source pollution control. Priority should initially be given to implementing non-structural stormwater management techniques. An annual monitoring program would enable the continuing evaluation and redefinition of water quality problems.

Environmental management of Strawberry Creek must be far-sighted and comprehensive in scope in order to adequately protect and enhance the creek and its associated riparian areas. The recently formed Creek Environmental Quality Committee should form the basis for long-term management. A multitude of approaches including the updated Long Range Development Plan, environmental impact reports, RFP conditions, and Department of Facilities Management policies and directives can be utilized to ensure consideration of the environmental concerns identified in this report in the campus planning process and operations.

2.0 INTRODUCTION

Strawberry Creek has been neglected for many years and subsequently the environmental quality of the creek and its associated riparian areas has continued to deteriorate. The degradation of this sensitive area is evident on the central campus of the University (Figure 1). This is manifested by a marked absence of diverse flora and fauna in the creek itself and along its banks. The water is periodically discolored, foaming occurs, and other obvious signs of pollution are evident. The streambanks are undercut, threatening walls, bridges, and other structures built in close proximity to the creek. Sedimentation and turbid waters are commonplace. The variety of wildlife in the riparian areas is limited and has reportedly been steadily declining over the years (Siri, 1972).

Until the present time there has been little attempt to consider Strawberry Creek in the campus planning process. A general lack of knowledge by the Department of Facilities Management (DOFM) and the Campus Planning Office concerning the problems facing the creek and the impacts of past, present, and future activities and development has resulted in the degraded conditions apparent today. This situation has been compounded by fiscal constraints that have been placed on campus operations in recent years. A great need exists to incorporate environmental concerns surrounding the creek into the operations, maintenance, and planning processes within the University.

The Office of Environmental Health and Safety (EH&S) recognized the deteriorating environmental quality of Strawberry Creek and the lack of any comprehensive management plan. This study was subsequently initiated at the request of EH&S. The study began as a water quality management plan with the following objectives:

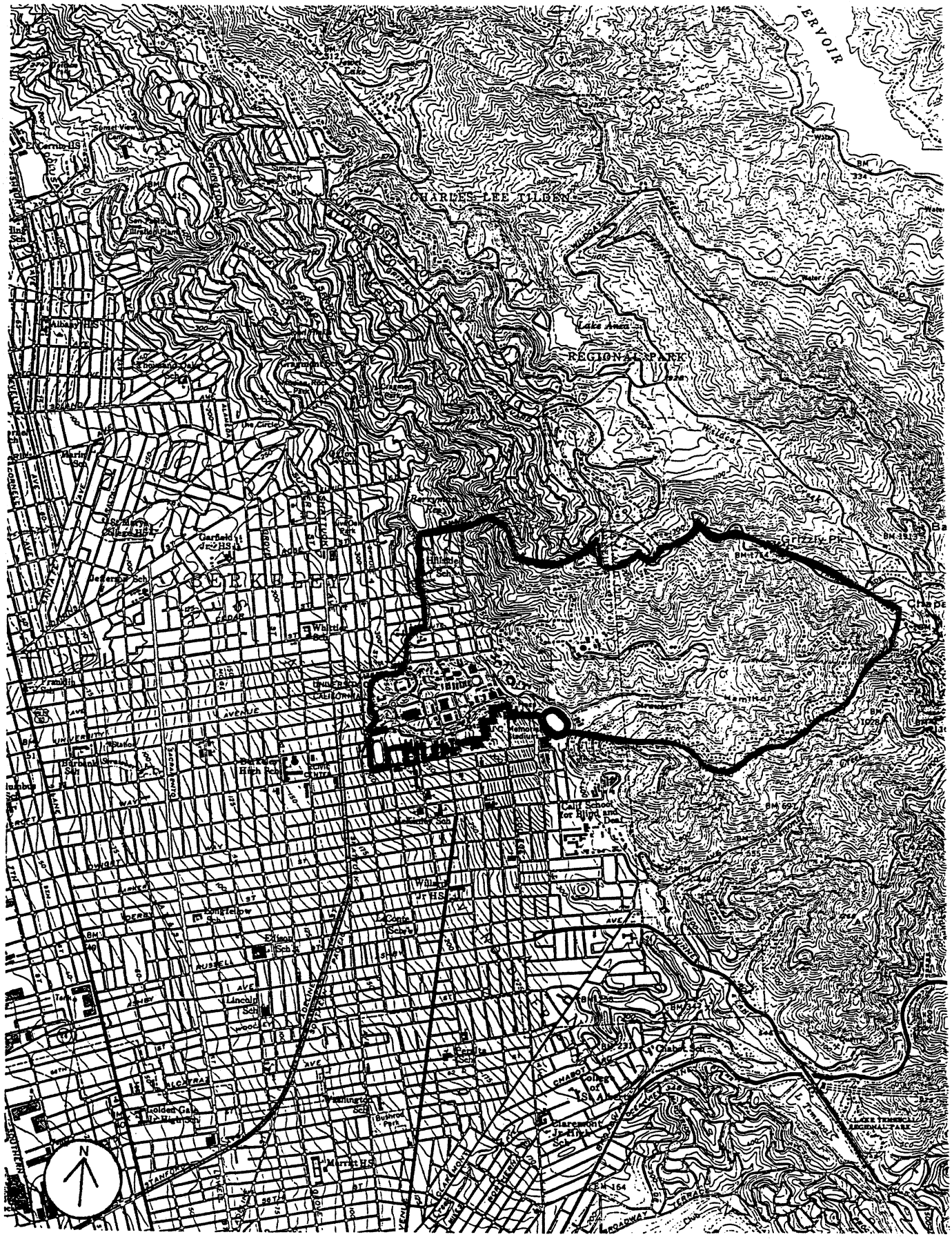
- Evaluate present water quality of the creek.
- Identify point and non-point sources of pollution.
- Develop creek and watershed mitigation strategies.
- Produce a resource document on which future evaluation and management decisions could be based.
- Provide an overview of historical data.

In order to formulate a truly comprehensive management plan, the scope of the study necessarily expanded from strictly a water quality management plan into the areas of urban creek and riparian habitat preservation and restoration.

The benefits of preserving and enhancing Strawberry Creek and its riparian areas are multi-faceted. The visual and experiential image of the Berkeley campus is manifested by its physical setting which is dominated by the features and character of its landscape. The natural areas on the central campus consist primarily of the riparian zones along both forks of Strawberry Creek. These areas offer natural contrast to the urban hardscape, acting as a buffer zone which provides visual amenity and variety. The creek is the major focus of campus open space and therefore establishes both the form and character of its landscape. Preservation is essential if the unique image and qualities of the campus are to be sustained.

The riparian corridors of Strawberry Creek provide essential places for educational, recreational, social, and individual activities. The creek functions as an integral part of instruction in the social sciences, natural sciences, and engineering. The courses listed in Table 1 have been named by faculty utilizing the natural areas of campus in formal instruction. A conservative estimate of the number of students using these areas annually is about three thousand. Siri (1972) also found that at least eighteen courses in ten different departments utilized the natural areas on campus. Siri also documented the use of the riparian areas for faculty and graduate student research.

The value of Strawberry Creek as an educational resource is enhanced by its accessibility. The financial and logistical constraints of field trips, especially in introductory classes with large enrollments, are not a problem when the use of Strawberry Creek is considered. The time limitations of travel elsewhere also promote the increased utilization of the creek areas. The creek is also valuable for spontaneous use for the purposes of illustration, demonstration, and repeated observations. In addition, Strawberry Creek offers everyone an informal educational opportunity through exposure, experience, and chance observation. It is obvious that the creek and its associated riparian corridor represent a significant teaching resource that warrants attention, maintenance, and enhancement.



STRAWBERRY CREEK MANAGEMENT PLAN	FIGURE 1 SITE LOCUS

Table 1. Curricula Utilizing Natural Areas for Formal Instruction

Department	Course Number	Enrollment [o]
Biology	1	400-500
	11	NA
	150	240
Botany	10	150-200
	115	NA
	120	20
	125	15
	154L	30
	224	20
Civil Engineering	10	90*
	21	140*
	100	10
Conservation and Natural Resources	49	NA
	149	NA
Ecology	123	80
Entomology	10	30
	100	67
	105	NA
	108	10
	110	20
Environmental Design	1	160
Forestry	10	500
	104	30
	106	NA
	120	NA
	121	35
	122	NA
	123A	80
	123B	80
	170	100
	176	20
	178	45
IDS	10	300-500
Landscape Architecture	11	70*
	110	40-60
	111	15*

Table 1. (Continued)

Department	Course Number	Enrollment [o]
Landscape Architecture	112	55
	140	100
	203B	15
	220	25
	222	15
Paleontology	2	NA
	20	25-30
	120	4-10
Plant Pathology	120	60-70*
Zoology	1	100
	107A	100-130
	107B	100-130
	135L	12

Notes:

[o] Estimated average student enrollment.

* Course given more than once a year; figure represents average annual enrollment. Figures for some courses not readily available.

Source: Bolton, 1981.

3.0 CREEK AND WATERSHED DESCRIPTION

This section provides a description of the physical and natural setting of Strawberry Creek and its upper watershed. Section 3.2 gives an historical overview of development in the watershed and its subsequent impacts. Descriptions of the watershed soils and geologic conditions can be found in Sections 3.3 and 3.4. Land use patterns and vegetative cover types are discussed in Section 3.5. A description of the creek's hydrologic regime is given in Section 3.6.

3.1 General Description

This study deals with the upper Strawberry Creek watershed which lies east of Oxford Street in Berkeley (Figure 2). This area includes all lands owned by the University of California that may influence the water quality of Strawberry Creek. The entire runoff from the 1163 acre (1.8 mi^2) watershed is delivered to the entrance of the city culvert at Oxford Street which runs underground in a westerly direction, eventually emptying into San Francisco Bay near University Avenue.

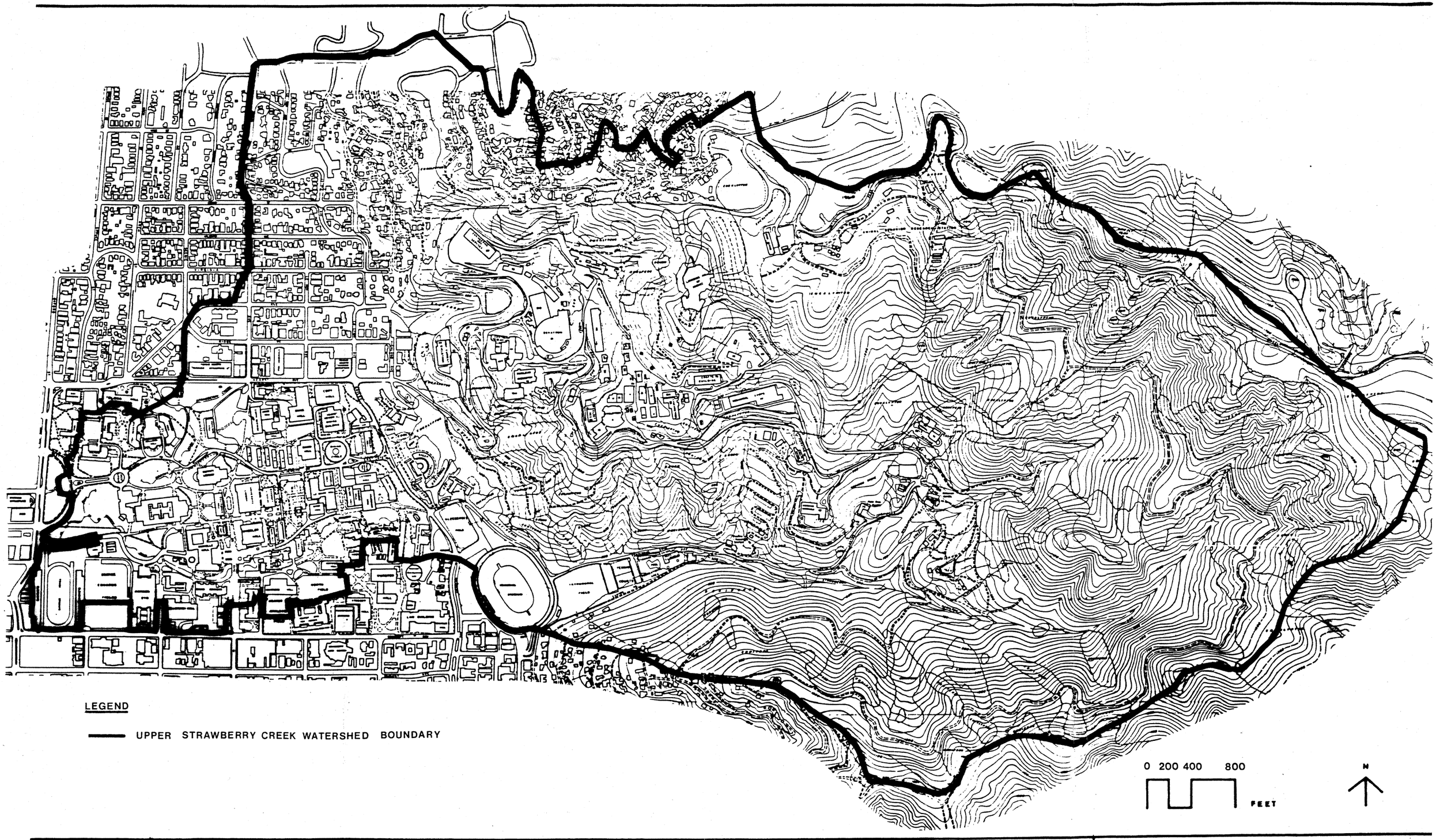
Strawberry Creek has two main branches, the North and South Forks. The South Fork is a fourth order stream, whereas the North Fork is a third order tributary. The confluence of the two forks is located in the Eucalyptus Grove at the western edge of the central campus about 400 feet east of Oxford Street. On the central campus alone there is approximately 6270 linear feet of streamcourse. Stormwater routing and stream channel culverting has greatly altered the natural drainageways in both the North and South Fork subwatersheds.

The South Fork subwatershed comprises 759 acres (1.2 mi^2). It is bounded by the Panoramic-Sugar Loaf ridge on the south, Frowning Ridge (Grizzly Peak) on the east and the North Fork subwatershed to the north. Hamilton Creek drains the southeastern portion of this watershed and joins Strawberry Creek below the Botanical Garden. Another unnamed branch drains the area from Grizzly Peak to the Animal Behavior Research Station and joins Strawberry Creek just above the retention dam.

An earthen retention dam is located at the entrance to the lower fire trail in the canyon. Its function is to protect the central campus and Haas Recreation Area from flood damage. The "Big Inch" bypass culvert begins at the dam and carries all upper canyon drainage underground to its outlet adjacent to the Faculty Club on the central campus. Chicken Creek and two other unnamed tributaries which drain the western portion of the Lawrence Berkeley Lab (LBL) complex and the central canyon area are routed directly into the Big Inch bypass culvert.

The original Strawberry Creek channel continues downstream of the retention dam and becomes the "Little Inch" bypass culvert when it enters a drop inlet located just above Haas Recreation Area. The Little Inch culvert travels underneath the stadium and empties adjacent to the Women's Faculty Club. A small open channel then connects this culvert to the South Fork at the outlet of the Big Inch culvert next to the Faculty Club. Flow in the original creek channel below the retention dam is supplied solely by local runoff. A low flow bypass once diverted flow through the retention basin dam to the former creek channel, but the pipe inside the dam has collapsed. A subdrain which underlies the old creek bed from the retention dam to the drop inlet above Haas draws groundwater out of the channel during dry periods, resulting in this section of channel drying up most of the year.

The South Fork on the central campus is therefore made up of flow carried by the two bypass culverts from the canyon. This fork meanders through the southern side of the campus and eventually meets the North Fork in the Eucalyptus Grove to form the Main Branch of Strawberry Creek. The South Fork travels about 3670 linear feet on the central campus, dropping about 110 feet in elevation for an average gradient of 3 percent. Likewise, the Main Branch runs about 450 linear feet from the Eucalyptus Grove the entrance of the city tunnel at Oxford Street, dropping 15 feet, or about a 3 percent grade.



STRAWBERRY CREEK MANAGEMENT PLAN	PREPARED FOR THE OFFICE OF ENVIRONMENTAL HEALTH AND SAFETY UNIVERSITY OF CALIFORNIA, BERKELEY SEPTEMBER 1987	FIGURE 2 UPPER WATERSHED

The North Fork subwatershed comprises 388 acres (0.6 mi^2). It is bounded by Little Grizzly Peak on the east, Rose Street on the north, and the South Fork subwatershed to the south. The North Fork, which originally drained just Blackberry (Woolsey) Canyon, has also been identified as Blackberry Creek, although this is a misnomer because another creek in North Berkeley has that name. Due to stormwater routing, the channel above Highland Avenue now drains a large portion of the LBL complex, Lawrence Hall of Science, and Space Sciences Laboratory, extending all the way to Grizzly Peak Boulevard. Much of the North Fork has been culverted underneath the LBL complex and North Berkeley. An extensive artificial fill area is located in the original creek channel north of the Lawrence Hall of Science and cut and fill operations also obliterated the original North Fork channel throughout the LBL complex. Open channels along the North Fork still exist in Blackberry Canyon below LBL, between a few blocks in North Berkeley, and on the central campus.

The open channel in Blackberry Canyon dumps into a drop inlet above Highland Avenue. During low flow periods, the creek is directed into an open channel south of Le Conte Avenue which enters a tunnel under Northside and empties into the central campus at North Gate. At times of high flow, most of the water in the North Fork is diverted into a 48"- 60" storm drain culvert which runs down Ridge Road to Euclid Avenue and thence to the creek at North Gate.

The North Fork watershed has been extended beyond its natural drainage area to the north due to stormwater routing. Euclid Avenue and La Loma Avenue storm drain lines extend as far north as Rose Street. These storm lines eventually dump into the North Fork city tunnel which empties into the open channel on the central campus at North Gate.

The North Fork then meanders through the northwest portion of the central campus and is routed underneath West Circle into the Eucalyptus Grove where it meets the South Fork. The North Fork travels approximately 2150 linear feet on the central campus, dropping about 80 feet in elevation for an average grade of 4 percent. This is slightly steeper on the average than the other central campus reaches of the creek. The cross-campus culvert empties into the North Fork just above the University Drive vehicle bridge. This culvert drains the northeastern section of the central campus, continues eastward under Gayley Road by Stern Hall, and across Cyclotron Road to the Cafeteria Creek channel which drains a small portion of the LBL complex. The cross-campus culvert is the single largest point source on campus in terms of both drainage area and volume of effluent.

The remaining 16 acres of the upper Strawberry Creek watershed drain directly into the Main Branch of the creek above Oxford Street. Much of this area consists of Evans Field and Edwards Track Stadium drainage which is routed directly into the Main Branch.

The upper Strawberry Creek watershed generally lies in the California Coast Ranges section of the Pacific Border physiographic province. The steep southwestward-facing front of the Berkeley Hills trend northwestward at the head of Strawberry Canyon. The Hayward Fault roughly parallels Gayley Road, forming the toe of the hill slope. West of Gayley Road the land surface including the central campus gently slopes west-southwestward towards San Francisco Bay.

The topography of Strawberry Canyon is almost totally fault-controlled. Along with related severe erosion this has formed the existing canyon and drainage system east of the Hayward Fault. Canyon topography consists generally of a complex pattern of relatively small secondary ridges and nosings separated by an intricately branching canyon system which resulted from a combination of faulting and erosion. Except for lower Strawberry Canyon, the area is generally steeply sloping, averaging about twenty-five percent. The existing extensive level areas in the canyon are a result of construction grading activities. Elevation ranges from about 1760 feet at the crest of the Berkeley Hills down to 200 feet at the west end of the central campus (Oxford Street), constituting a drop of over 1500 feet in elevation in the upper watershed.

3.2 Historical Perspective

This abbreviated history gives an indication of the adverse impacts development has had on Strawberry Creek. A long history of water quality problems, flooding, and erosion becomes apparent. Extensive diversions and stream course channelization and alterations have occurred over the past eighty years. Construction costs for storm drainage systems and flood damage to the University over time has been quite significant.

Prior to the arrival of the Spanish and other white setters to California in the late 1770's, native Indians of the Huchiun-Ohlone group lived in clustered settlements along streams such as Strawberry Creek. They once maintained a summer camp near the present site of the stadium. The Indians were hunter-gatherers who managed their land by controlled burning of the underbrush to facilitate acorn gathering and the growth of seed-bearing annuals. The landscape appeared as an open oak woodland and grassland filled with perennial bunch grasses and herbaceous flowering plants. Much of the tree cover was limited to the stream channels, and strips of riparian vegetation closely followed the steam corridors from the crests of the hills down to the alluvial flatlands. Deer, elk, bear, and mountain lions were abundant in the hills. Salmon and trout spawned in the upper reaches of the creeks.

On March 27, 1772, a Spanish scientific expedition led by Don Pedro Fages stopped along the banks of Strawberry Creek just upstream of present-day Oxford Street. From this future site of the University, diarist Juan Crespi described the beauty of the Golden Gate vista. Legend has it that the creek got its name from the abundant strawberry vines that lined its banks. Spanish explorers named the East Bay area "Contra Costa" or "opposite coast". In the early 1800's much of the East Bay was partitioned into land grants by the last Spanish governor of California. The boundaries of these tracts were often delineated by streams because they were the most obvious landscape elements. The Rancho San Antonio tract which was deeded to Don Luis Maria Peralta in 1820 encompassed the present cities of Albany, Berkeley, Emeryville, Alameda, Oakland, Piedmont, and San Leandro. In 1842, Peralta divided the Rancho among his four sons, and gave his son Jose Domingo the area now called Berkeley.

The Gold Rush of 1849 opened the East Bay to land development booms. The Berkeley area bore the brunt of the influx of American settlers as development spread across the Bay from San Francisco. Jose Domingo Peralta resisted the first American squatters, but soon realized he could not maintain control over such desirable land. In 1853, Peralta sold off most of his land and the next year Orrin Simmons, a sea captain turned farmer, acquired squatter's rights to 160 acres of land between Strawberry Creek and the present Clark Kerr campus. In 1857, he obtained full title and purchased two more tracts of land, giving him ownership of 700 acres including the future site of the University campus.

In 1860, the College of California moved to its present site from Oakland. Strawberry Creek was one of the main reasons the founders chose Simmons' property. "All the other striking advantages of this location could not make it a place fit to be chosen as the College Home without this water. With it every excellence is of double value" (Willey, 1887). Even during a drought in 1864 the stream continued to flow the entire year, yielding about 100,000 gallons a day or about 0.16 cfs. Three forks of Strawberry Creek meandered through the college site at that time. The middle fork was drained in the early 1870's to create a dry level area for a cinder running track now occupied by the Life Sciences Building Annex. To protect the track from strong westerly winds, the Eucalyptus Grove was planted.

The central campus at this time was a sloping grassy plain dotted with coast live oaks. Oaks, sycamores, bay trees, and shrubs lined both forks of Strawberry Creek. Old photographs reveal considerable tree planting during the 1860's and 1870's in an apparent effort to improve the barren landscape. Cattle were introduced into the hill area in the 1850's and grazed on imported annual grasses which quickly established themselves. Eventually these grasses out-competed the native perennial bunch grasses which could not survive the impacts of heavy grazing. Dairy farms were located in Strawberry Canyon before the land

became part of UC holdings in 1909 and cattle continued grazing in the hills until the 1930's. Grass-oak savannah was the vegetative cover in the canyon as shown in photographs taken in 1870 and 1901. The East Bay creeks supported a growing timber trade that significantly depleted the tree cover of the upper creeks. This was especially true during the rebuilding period which followed the 1906 San Francisco earthquake and fire. Eucalyptus was often planted throughout the East Bay hills in the early 1900's by small private water companies as a means of profiting from the shortage of California hardwood lumber at the time.

Waterworks were constructed in Strawberry Canyon in the 1860's to supply water to farms and speculators. Springs were developed, pipes laid, and wooden flumes constructed to carry the water. In 1867, a brick reservoir was constructed in the canyon and waterworks placed to deliver more water. Up until this time the cleared land in the canyon was divided amongst a few farmers. As additional land was cleared in the canyon, runoff from the hills increased, causing severe erosion downstream. In October of 1882 the University built five check dams along Strawberry Creek in an attempt to stop streambed incision and subsequent bank erosion on the central campus.

In 1883, the first large culvert was installed in a small stretch of streambed in the vicinity of Oxford Street to facilitate the passage of horses and wagons. Cement box culverts were installed along the creek throughout its entire length in Berkeley during the late 1800's and early 1900's. This culverting continued until the 1930's when the Works Progress Administration (WPA) finished culverting the last open reaches. The entire length of Strawberry Creek through the city of Berkeley was now underground.

The first report of water quality problems appears in the Berkeleyan in 1895. An article complains of the "unsightly appearance of sewer-begrimed water and filthily discolored banks." Strawberry Creek was noted as being an easy means of removing sewage. In 1900, the Benard Plan for the campus layout originally called for the removal of the creek from the grounds, but was later revised after objections were raised. A storm in March 1904 caused $300 damage to culverts on the central campus and extensively damaged streambanks. This prompted rock and concrete work in many locations along the creek to stabilize the banks. USGS experiments conducted in 1907 estimated that one ton of soil was being carried away for every 12,000 gallons of winter storm flow.

Extensive concrete work was performed on the entire creek in 1907 to protect streambanks and trees. Both the creek sides and bottom were lined with concrete. The creek was also deepened five feet in the reach upstream of Oxford Street in an attempt to avert the flooding of downstream commercial areas which occurred the previous winter. The construction of Memorial Stadium in 1923 necessitated the first major diversion of Strawberry Creek. The stadium obliterated waterfalls that once cascaded down the toe of the hillslope and resulted in the construction of the "Little Inch" bypass culvert to carry the creek underneath the stadium and Strawberry Field. The construction of Stephens Hall that same year also required the rerouting of the original creek channel.

The "Big Inch" bypass culvert was built in 1951 at a cost of $225,000 due to the possibility of structural failure of the Little Inch bypass. Cracks were discovered in the old culvert from the stress caused by the Hayward fault zone. At that time, the Big Inch culvert began just above the Haas pools and emptied out next to the Faculty Club on campus.

Rains in April 1958 caused $70,000 damage to Canyon roads and drainage systems. International House was flooded and landslides blocked Canyon fire trails. Only four years later in October 1962, 15 inches of rain fell in four days, making it one of the heaviest storms ever recorded in the San Francisco Bay area. The Big Inch bypass inlet clogged with debris and the torrential creek overflowed through the Haas complex and down Centennial Drive. Damage to campus buildings and grounds was estimated at over $200,000. As a result of flooding of the Dining Commons in 1963, a 300 foot reach of the South Fork from Sather Gate to the Dwinelle Annex was widened to ten feet and a concrete retaining wall was built along the south bank. In Fall 1964, the University spent $519,000 on storm drain improvements. This action was necessary because of the development in Strawberry Canyon that had reportedly reduced the

lag time (the time response of runoff to precipitation) to the bypass culvert entrance in the canyon from about two hours to fifteen minutes, posing a great threat to the campus by significantly increasing the peak storm flow.

In 1966, the University extended the Big Inch bypass inlet to an earthen retention dam built in the canyon at the entrance to the Lower Fire Trail. The retention basin would act to store flood waters during winter storms and flow could be regulated into the bypass culvert by means of a hydraulically operated gate. This structure would act to prevent the extensive flooding and damage that occurred in 1962. Also in 1966, a high flow bypass was built into the North Fork city tunnel system to relieve the flooding threat caused by increased runoff from LBL development in the canyon. These storm drain improvements were done at a cost of $145,000 which was shared by the City and the University.

Various newspaper articles in the 1970's and 1980's relate the continuing water quality problems in the creek. A 1973 article tells of fecal bacteria contamination entering the North Fork from the Northside area. Continued erosion of stream banks is also mentioned. A 1981 article states that the creek is treated as a sewer contaminated by urban runoff, chemicals, drains, and sewage. Berkeley Health Department officials advised not to enter the creek at that time.

3.3 Soils

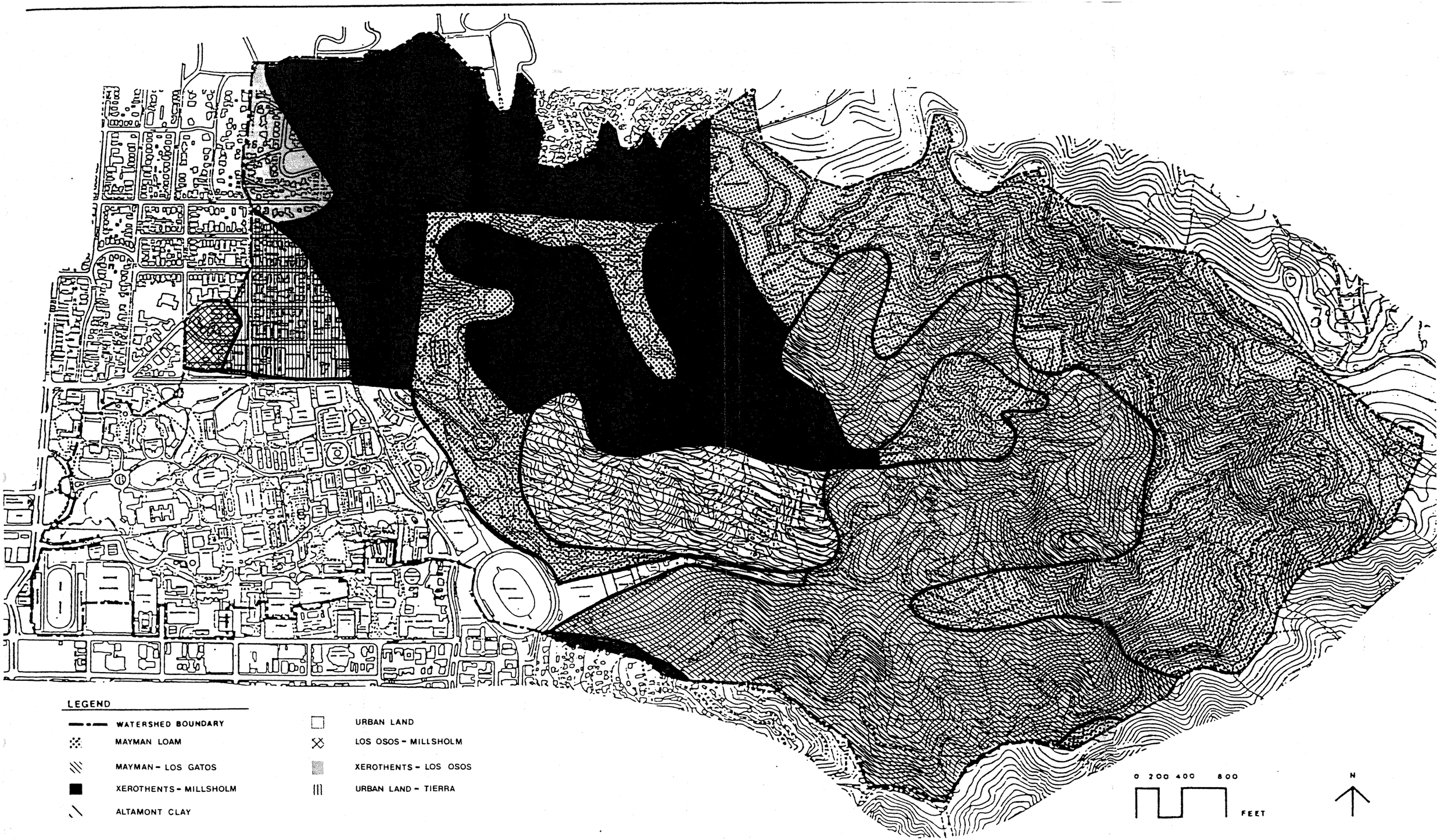
The USDA Soil Conservation Service Soil Survey of Western Alameda County was used to delineate the soil types of the upper Strawberry Creek watershed. The soil types are presented in Table 2 and shown on Figure 3. Soil series may be assessed for their runoff potential, risk of erosion, and other parameters of concern in the management of Strawberry Creek and its watershed. In general, the upper watershed soils are highly impermeable and have a high runoff potential as well as a high risk of erosion. Strawberry Canyon is the site of numerous landslide bodies that will easily slide when undercut or flow when saturated. Development on the Canyon soils is severely constrained by steep slopes and shallow depth to bedrock.

Hydrologic soil groups as defined by the SCS can be used to estimate runoff potential of each soil type in the watershed based upon its infiltration capacity. Infiltration rates decrease and surface runoff potential increases as soil types are classified A through D. Approximately 38% (431 ac) of the watershed consists of soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. Soils having a very slow to slow infiltration rate comprise about 23% (234 ac) of the watershed, whereas 1% (18 ac) of all the watershed soils have a slow infiltration rate. Soils with a very slow to moderate infiltration rate account for 20% (234 ac) of the watershed. The remaining 18% (209 ac) of the watershed area is unsuited to the hydrologic soil classification system because it is covered by urban structures or comprised of heterogeneous artificial fill materials.

Three different soil types account for 75% (736 ac) of the upper Strawberry Creek watershed area. Maymen loam is the predominant soil type in the watershed (366 ac or 32%). This is a shallow (10-20 in) somewhat excessively drained soil with rapid to very rapid runoff potential and high to very high risk of erosion. It is found on upland areas with slopes of 30-75%. The pH range of Maymen loam is strongly acid (4.5-6.5). This soil type formed in material that weathered from sedimentary rock. It is generally underlain by sandstone, siltstone, and conglomerate.

The Maymen-Los Gatos complex is another dominant soil type in the watershed, comprising 265 acres (23%). This complex consists of steep and very steep soils on uplands. Slopes range from 30-75%, but are mainly 50-75%. This soil complex is composed of 50% Maymen soils and 35% Los Gatos soils. The remaining 15% of this soil type are small areas of Millsholm silt loam and some rock outcrop. Depth to bedrock ranges from shallow to moderately deep (10-40 in). Runoff and erosion characteristics are identical to Maymen loam. The pH of this complex ranges from strongly acid to neutral (4.5-7.3). The Maymen-Los Gatos complex formed in material that weathered from sedimentary rock and is underlain predominantly by sandstone and shale.

The last major soil type is the Xerorthents-Millsholm complex which comprises 20% of the watershed area. This complex is on hills at slopes ranging from 30-75%. It consists of about 70% loamy Xerorthents (altered soil or fill material), 20% Millsholm clay, and 10% of small areas of Maymen loam, Los Gatos loam, and Los Gatos silty clay loam. Depth to bedrock ranges from shallow (10-20 in) to over 20 inches. This complex is well to somewhat excessively drained. Runoff is rapid to very rapid and risk of erosion is high to very high. The pH of this complex ranges from medium acid to slightly alkaline (5.6-7.8). The xerorthents in this complex consist of soil materials that have been altered by cutting or filling for urban development and, as a result, they have variable soil characteristics. The Millsholm soil formed in material that weathered from fine-grained sandstone. This soil complex is generally underlain by sandstone, siltstone, and undivided Quaternary deposits.



STRAWBERRY CREEK MANAGEMENT PLAN	PREPARED FOR THE OFFICE OF ENVIRONMENTAL HEALTH AND SAFETY UNIVERSITY OF CALIFORNIA, BERKELEY SEPTEMBER 1987	FIGURE 3 SOILS

Table 2. Upper Strawberry Creek Watershed Soils

Soil Type	Hydrologic Class	Texture	Permeability	Location
Maymen	D	Loam over shale bedrock	Moderate	Northeast canyon uplands and narrow band northeast of central campus
Maymen-Los Gatos	D/C	Loam over shale and sandstone	Moderate to moderately slow	Central and southern areas of canyon lower slopes
Xerothents-Los Gatos	C	Variable - mostly loam with silty clay loam	Slow	One pocket north of Cedar Street
Xerothents-Millsholm	B/D	Variable - mostly loam with silty clay loam and shale-sandstone fragments	Moderate	Northern area of watershed and LBL complex
Los Osos-Millsholm	C/D	Silty clay loam and silty loam	Slow to moderate	Small pocket east of Scenic Avenue
Altamont	D	Clay over sandstone and shale	Slow	Area between Centennial Drive and LBL complex
Urban Land-Tierra	-	Loam, clay, sandy clay loam and fill	Very slow	One pocket north of Hearst Avenue
Urban Land	-	Heterogeneous fill	-	Central campus

3.4 Geology

The upper Strawberry Creek watershed consists mostly of the geologically very recently uplifted Berkeley Hills which hinge along the northwest trending Hayward fault zone. In general, the steep hill area is unstable and bedrock is close to the surface, resulting in numerous landslides and extensive soil erosion. The hill area is part of a very complex volcanic vent structure that has been truncated and displaced northward by the Wildcat Fault. West of the Hayward fault zone is a gently westward sloping older alluvial plain which has been altered in the Central Campus and LBL areas by cut and fill construction activity. The subsoil in the Central Campus consists of soft, highly erodable stream sediments grading from clayey silts to cobbles and boulders. These sediments exhibit very poor stability along the banks of Strawberry Creek. The geologic units of the watershed are presented in Table 3 and shown on Figure 4.

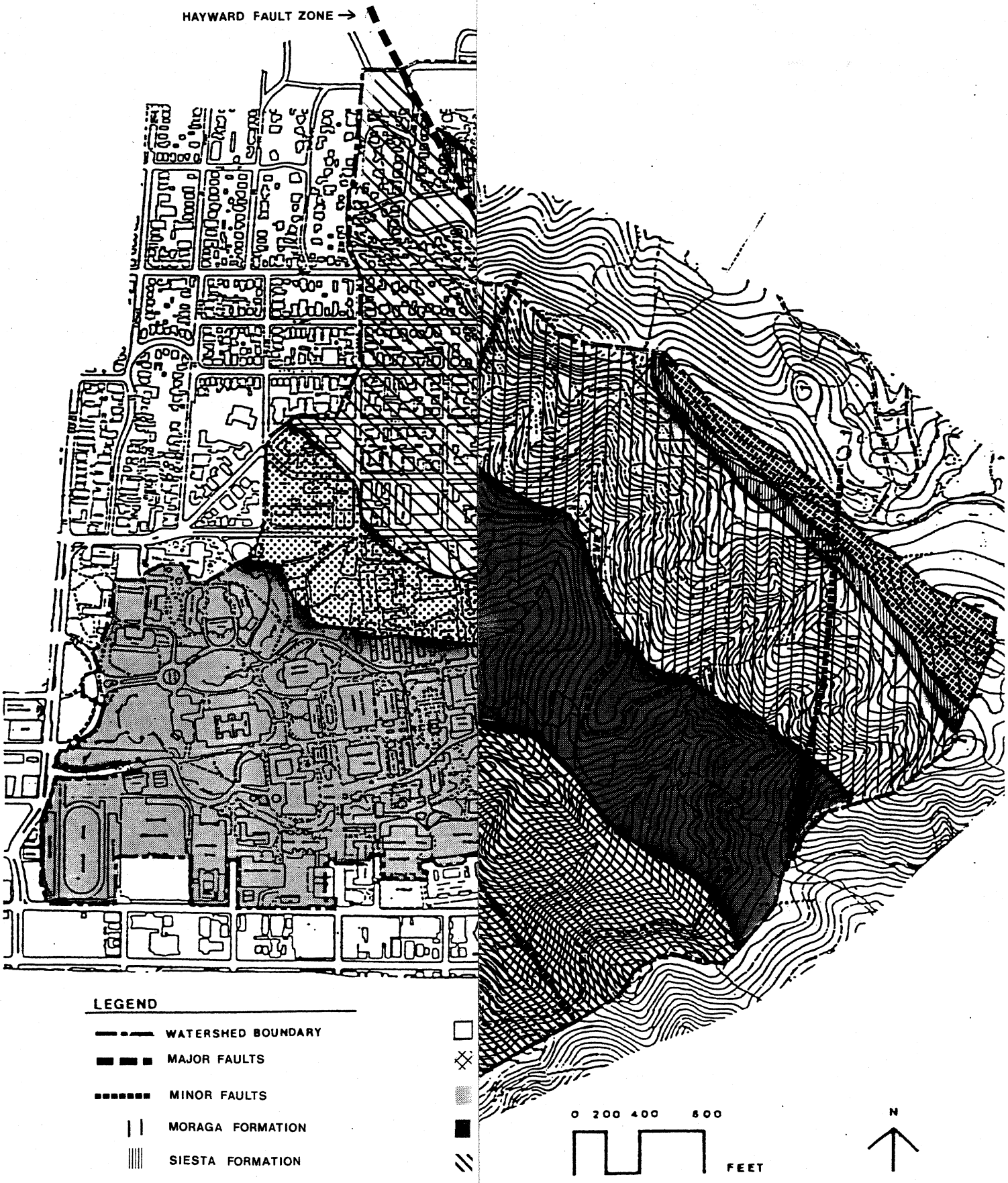
The bedrock in the Canyon grades time-wise from Upper Cretaceous marine sediments through Miocene sediments (Claremont Formation) to the late Pliocene sediments and volcanics of the Orinda, Moraga, Grizzly and Bald Peak Formations. A series of earth movements extensively folded and faulted these formations and massive volcanic intrusion has further altered the bedrock. The resultant formational contacts are steeply sloping to vertical and the time sequence is thus commonly horizontal rather than lying in vertical succession. The character of the rocks varies widely, ranging from fairly hard sandstones in the Cretaceous series to soft and clayey semi-shales of the late Pliocene deposits. The volcanic members vary from extremely hard but generally intensely fractured basalts to soft tuffaceous sediments.

The Upper Cretaceous rocks underlie about 16% (186 ac) of the watershed between the Hayward and Wildcat Faults bordering both sides of Strawberry Creek. These sediments are the oldest rocks in the hill area, consisting of fragments of older rocks which have been significantly altered and fractured by tectonic movements. These rocks are moderately to highly weathered, soft to medium hard, and locally folded. This unit weathers fairly easily, producing thick residual soils that often migrate downhill by landslides or by colluvial processes.

Most of the northern area of the watershed between the Hayward and Wildcat Faults is underlain by the Moraga-Grizzly Peak-Bald Peak Formations (180 ac). These are extrusive igneous rocks that have been altered by shearing and weathering, and are highly fractured. These formations are permeable enough to permit rapid and extensive water circulation. Generally, the rocks are medium to completely weathered, soft to medium hard and very thickly bedded. The Grizzly Peak unit is slightly weathered and very hard with medium-spaced (8-24 inches) fractures.

East of the Wildcat Fault lies the Claremont Formation (163 ac) which consists mainly of thin bedded shales and siltstone of moderate hardness. The rocks are generally fairly siliceous or have an appreciable calcite content and are thus relatively hard, resistant to erosion, and stable at quite steep slopes. Although porous, these rocks are not very permeable because pore openings are very small and poorly interconnected.

The Orinda Formation (154 ac) lies to the east of the Claremont Formation and also occurs in pockets between the Hayward and Wildcat Faults. These rocks are soft and relatively easily eroded so they are unstable at steep slopes, especially when saturated. These rocks have been extensively degraded by both tectonic shearing and intense surface weathering. The majority of the numerous large landslides in the canyon have been based in Orinda Formation materials. Hillslopes are commonly covered with a mantle of landslide debris that will easily slide when undercut or flow when saturated. Debris or mudflows in the canyon pose a major hazard because obstructions may clog inlets to the storm drain system and divert flow out of normal channels, resulting in extensive damage. Much of upper Centennial Drive and parts of the Lawrence Hall of Science are located on the Orinda Formation, as well as most LBL facilities.



STRAWBERRY CREEK

MANAGEMENT PLAN

FIGURE 4

GEOLOGY

Table 3. Upper Strawberry Creek Watershed Geology

Geologic Unit	Lithology	Area (ac)
Upper Cretaceous rocks, undivided	Fine to coarse-grained sandstone; shale. Alternating beds of sheared, fractured, and contorted sandstone, shale, and siltstone.	188.7 (16%)
Moraga-Grizzly-Bald Peak Formations	Mainly basalt and basalt-andesite flows with interbeds of conglomerate and tuff and minor beds of sandstone, siltstone, and agglomerate.	160.4 (14%)
Undivided Quaternary deposits	Composition varies - mostly gravel, clayey; clay, sandy, silty and sand-clay-silt mixtures. Also recent alluvium, colluvium and artificial fill.	219.5 (19%)
Claremont Formation	Chert, finely laminated and shale, rhythmically bedded; also thin beds of sandstone. Bituminous in places.	163.1 (14%)
Orinda Formation	Conglomerate, sandstone, siltstone, and claystone; sheared and fractured, numerous joints.	168.2 (15%)
Moraga Formation	Basalt and andesite flows with interbeds of conglomerate, tuff, sandstone, siltstone, and rhyolite.	126.3 (11%)
Older Alluvium	Composition varies - mostly silty clay loam with loam and fragments of shale and sandstone due to artificial fill.	74.9 (6%)
Landslide bodies	Disturbed soil/earth material similar to composition of surrounding map units; associated colluvium.	13.1 (1%)
Franciscan Group	Fine to very coarse-grained fractured sandstone (graywacke), with some shale beds. Sand grains consist mostly of quartz, feldspar and shale, with some chert and biotite.	27.9 (2%)
Bald Peak Basalt	Basalt with minor amounts of sedimentary rocks.	14.7 (1%)
Siesta Formation	Silty claystone and very fine-grained to medium-grained sandstone. Minor pebbly conglomerate, cherty limestone, impure tuff, and basalt.	5.9 (<1%)

The last major geologic unit in the watershed is the Moraga Formation (126 ac) which is located mainly in the steep northeastern hill area. These rocks are generally hard, but intensely fractured due to both natural shrinkage processes upon cooling and tectonic movements which occurred after deposition. Permeability is therefore generally high. The Moraga Formation is stratigraphically and topographically the highest bedrock unit in the hill area, capping the upper hills and the Grizzly Peak ridgeline on the northeastern boundary of the watershed.

Numerous landslides occur in the hill area, especially in the vicinity of the LBL complex. These slides are composed of substantial soil and rock masses that have slid downslope along a failure plane. They may occur rapidly in a single major event or slowly through repeated small failures. New or old slides may be precipitated by high groundwater levels, ground shaking, or changes in slope geometry and loading. Slides can often be recognized by a bulging, cracked "toe" at the lower end, and by arched headscarps and topographic depressions at the upper end. In the Berkeley Hills some thick mobile accumulations of colluvium (soil and rock fragments transported downslope by gravity) closely resemble shallow landslides, making it difficult to distinguish between them. Most older landslides are marked by heavy brush and tree cover because the vegetation prefers the relatively soft wet soil found there.

The Hayward fault zone is a member of the San Andreas Fault system which is a major geologic feature and plate boundary along which massive continental drift is presently occurring. The Hayward fault zone forms a distinct geologic break between the Central Campus area to the west and the hill area to the east. The Wildcat Fault is another significant geologic feature in the watershed, and is probably a secondary member of the San Andreas system. This fault traverses the Canyon in the vicinity of the Botanical Garden.

The Hayward fault exhibits right-lateral movement, with the westerly side moving to the northwest in comparison to the easterly side. Slow tectonic creep (movement) is presently continuing along the fault at the rate of about 0.1 inch per year in the area of Memorial Stadium. The "Little Inch" Strawberry Creek drainage culvert under the stadium has been previously damaged by this movement.

Tectonic creep has produced major tension and compression faults east of the Hayward fault zone and the tectonic movements which caused the uplift of the Berkeley Hills has produced thrust faulting as well. The result is a complex system of cross-faults with both vertical and lateral movement. One such secondary fault has formed the canyon of the South Fork of Strawberry Creek above the stadium. These faults range in size from very small breaks to the Hayward fault zone, which is several hundred feet wide.

The Hayward fault zone can be assumed to the active along its entire length. Severe earthquakes were caused by movement along faults within the Hayward fault zone in 1836 and 1868. Ground rupture was reported across the west side of the Clark Kerr campus and northwestward between Prospect and Warring Streets. Future movement within the Hayward fault zone may or may not follow the specific fault trace shown on Figure 4. The trace should not be construed as indicating the only line within the zone where movement has taken place in the past, nor is it necessarily the line where movement will occur in the future.

Structures which lie within or across the Hayward fault zone may not only be damaged by sudden movement, offset, and rupture along a fault in the event of an earthquake originating in the fault zone, but may also be subject to constant strain and damage due to opposite sides of faults within the zone continuously moving very slowly in opposite directions.

The Wildcat Fault is also a right-lateral fault with apparently local vertical movements. This constitutes another major structural non-conformity in the watershed. This fault has undoubtedly been active in relatively recent geologic time. Whether creep is currently occurring along the fault or whether there is currently any hazard of displacement is not known with any degree of certainty. East of the Wildcat Fault the secondary fault pattern continues with less expression, apparently reflecting lesser total long-term movement. These secondary faults are presumably currently inactive. The fractured rocks along any of these faults form numerous passages for groundwater.

The most recent geologic studies of the complex hill area (Converse Assoc., 1984) suggest that a single deep groundwater table may exist in combination with numerous perched groundwater tables. The perched groundwater areas may exist seasonally or only after periods of heavy rainfall. The local presence of groundwater in the hill area is also strongly influenced by the presence of seepage barriers such as faults and the numerous Orinda-Moraga formational contacts. The primary sources of groundwater in the hill area were deduced to be surficial (runoff and infiltration) as well as the volcanic flow rocks east of the Wildcat Fault.

Groundwater may move relatively freely through the highly fractured Moraga rocks, but is impeded by the relatively impermeable contact zone and less permeable nature of the Orinda rocks. This restriction of groundwater flow results in an accumulation of water at and above the contact zone of these two formations. Flow occurs along these contact zones when gradients are sufficient and often exits the hillsides in the form of springs or seeps. A strong correlation exists between spring locations and Orinda-Moraga contacts. These contacts are highly irregular because of the interbedded nature of these formations, so springs do not occur at any given elevation on the hillsides.

3.5 Land Use

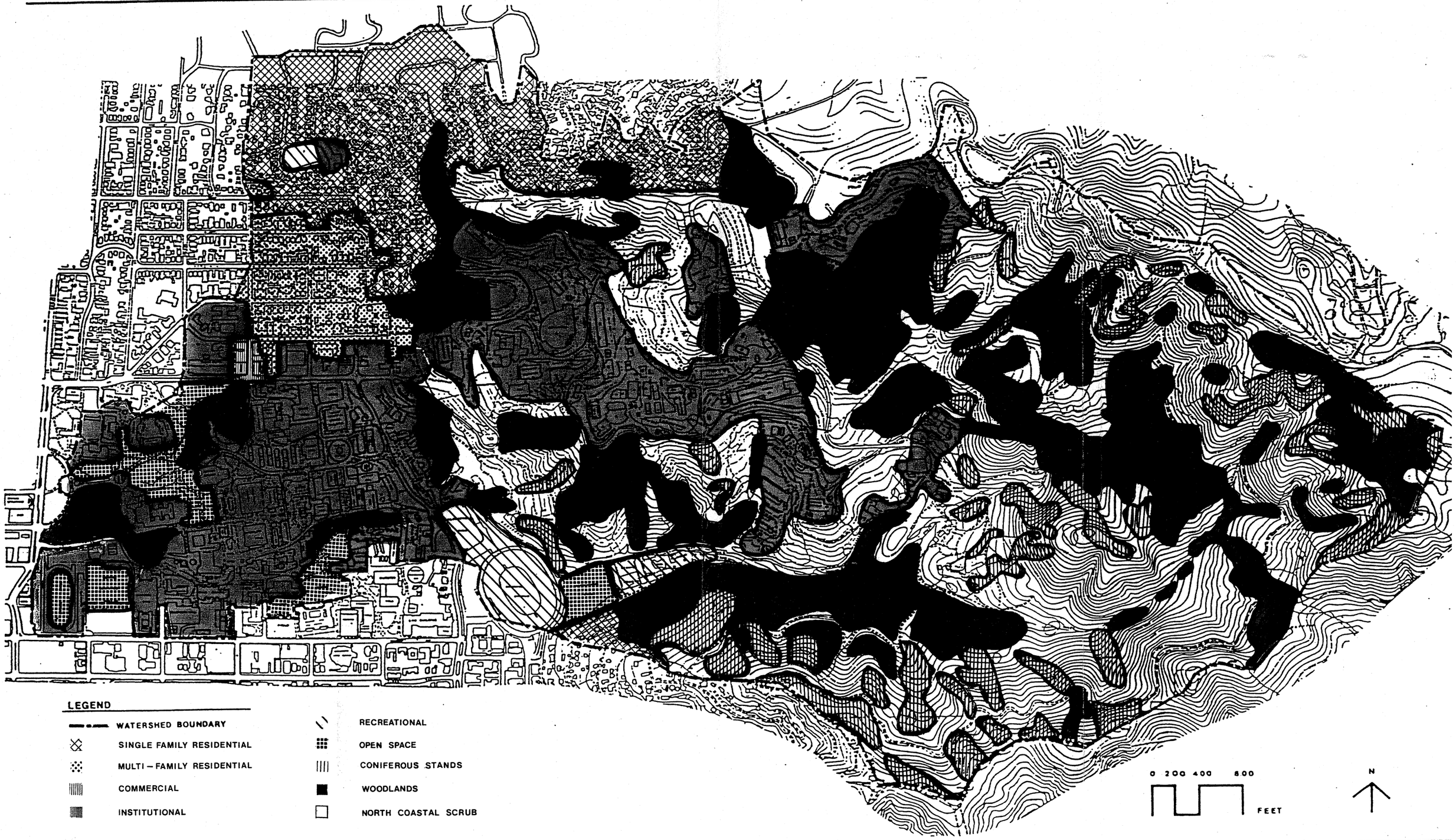
The built environment in the upper Strawberry Creek watershed is dominated by institutional activities (Figure 5). The Berkeley central campus and Lawrence Berkeley Labs account for most of this area. Buildings, parking lots, small lawn and open areas, as well as roadways and walkways are included in this category. Twelve percent of the watershed is comprised of residential land uses, one-third of which are multi-family units in North Berkeley (Table 4). The only commercial area is the compact Euclid Avenue district on Northside.

Recreational land uses consist of impervious artificial surfaces such as Kleeberger Field, Memorial Stadium, and the Haas Recreation Area. Open space refers to large turf areas such as playing fields and extensive lawns. Urbanized areas in the watershed include institutional, residential, commercial , and recreational land uses which comprise about 425 acres (37%) of the total watershed area.

The upper canyon portion of the watershed is predominantly undeveloped. Vegetative cover in the canyon consists primarily of north coastal scrub which is extremely dense and rich in species composition. This vegetation type occurs in three phases commonly found in the hill area. First, coyote bush (Baccharis pilularis) invades previous grasslands. The second phase occurs on drier south facing slopes and often is found among rocky outcrops. It consists of a mixture of coyote bush, lupine (Lupinus sp.), sage (Salvia sp.), monkeyflower (Mimulus sp.), and nine-bark (Physocarpus capitatus). The last phase of north coastal scrub is the most dense and is made up of poison oak (Toxicodendron diversalobum), coffeeberry (Rhamnus californica), blackberry (Rubus vitifolia), nine-bark, rose (Rose sp.), ocean spray (Holodiscus discolor), thimbleberry (Rubus parviflorus), hazelnut (Corylus cornuta), currant (Ribes sp.), gooseberry (Ribes sp.), blueblossom (Ceanothus thyrsiflorus) and elderberry (Sambucus sp.). This scrub and mixed grassland is generally found on ridgetops and areas with shallow soils, such as south and west facing slopes.

The second major vegetative type is woodlands which consists of oak-bay woodlands and eucalyptus stands. Oak-bay woodlands are comprised of California bay (Umbellularia californica), California buckeye (Aesculus californica), and coast live oak (Quercus agrifolia). Bigleaf maple (Acer macrophyllum), madrone (Arbutus menziesii), Monterey pine (Pinus radiata), and red and blue gum (Eucalyptus spp.) are also present. This vegetation type possesses a variable but frequently rich understory containing poison oak, blackberry, hazelnut, elderberry, madrone, and numerous other shrub and herbaceous species. The oak-bay woodland occurs on moist valley bottoms and in deeper soils, generally north and east facing slopes. Eucalyptus (E. globulus) plantations include uncut trees as well as stands reestablished from stump sprouting. The understory in eucalyptus stands is commonly restricted to poison oak and a light cover of grass and thistles. Numerous slopes were planted with eucalyptus in the early 1900's.

The final vegetative type is coniferous plantations which were planted in small groves throughout the canyon. The majority of the stands are monterey pine. Plantations planted along Panoramic Hill along the southern edge of the watershed consist of ponderosa pine (Pinus ponderosa), coast redwood (Sequoia sempervirens), and monterey cypress (Cupressus macrocarpa). The understory of densely spaced plantations is essentially open and covered with thick litter. As the forest matures it may become more open, allowing poison oak, coffeeberry, french broom (Cytisus monspessulanus), and other shrub species to become established.



STRAWBERRY CREEK MANAGEMENT PLAN	PREPARED FOR THE OFFICE OF ENVIRONMENTAL HEALTH AND SAFETY UNIVERSITY OF CALIFORNIA, BERKELEY SEPTEMBER 1987	FIGURE 5 LAND USE

Table 4. Upper Strawberry Creek Watershed Land Use

Land Use/Cover Type	Acres (%)
Institutional	258.7 (22%)
Single Family Residential	102.9 (9%)
Multi-Family Residential	36.8 (3%)
Recreational	23.5 (2%)
Commercial	2.9 (< 1%)
Open Space	26.5 (2%)
North Coastal Scrub	349.8 (30%)
Woodlands	251.4 (22%)
Coniferous Stands	110.2 (9%)
TOTAL	1162.7 (100%)

3.6 Hydrology

Urbanization in the watershed has had a profound impact on the hydrology of Strawberry Creek. A significant increase in the amount of impervious surface area in the watershed along with extensive channel alteration and confinement has drastically altered the creek's hydrologic regime. This has resulted in accelerated streambed degradation or incision and subsequent bank erosion as well as the destruction of aquatic habitat. Urbanization has also caused a deterioration in water quality.

The extensive amount of impervious surface area in the watershed has had two major impacts. Less rainwater can infiltrate into the ground to recharge groundwater levels so the water table has dropped over time and consequently the baseflow of Strawberry Creek is quite low throughout most of the year. Secondly, an excessive amount of surface runoff occurs during storms resulting in a very short response or lag time (interval between precipitation and runoff) in both forks of the creek. Lag time is further reduced by the construction of storm sewers which increase the rate of runoff transmittal to the remaining open channels. The increased peak flows cause scouring and incision of the streambed, accelerated streambank erosion and pose a greater flooding potential.

Increased development in the Strawberry Creek watershed has led to the culverting and diversion of significant reaches of the creek to accommodate stormwater flows and additional construction. Figure 6 shows the culverted reaches of the creek drainage system. Two major bypass culverts carry South Fork drainage from Strawberry Canyon underneath the Haas Recreation Area, Memorial Stadium, Kleeberger Field, and Gayley Road. Both culverts empty out near the faculty clubs at the east end of the central campus where the South Fork reappears. The creek has also been extensively culverted at the LBL complex in the canyon and in North Berkeley's Northside district to handle stormwater flows. Culverting of these creek channels has destroyed their inherent ecological and aesthetic qualities. Culverting also promotes higher peak flood flows.

Strawberry Creek has become very "flashy" meaning the flood peaks are higher whereas the baseflow between storm events is lower than it would be under natural conditions. Most of the sediment moved by the creek occurs during high peak flows. This produces highly turbid water that interferes with recreational use and aesthetic enjoyment of Strawberry Creek. In extreme cases, sediment may degrade aquatic habitat or even smother benthic macroinvertebrates. On the other hand, reduced baseflow decreases available habitat which is also deleterious to aquatic life. In general, decreased streamflows also lower the assimilative capacity of the creek to dilute pollutants.

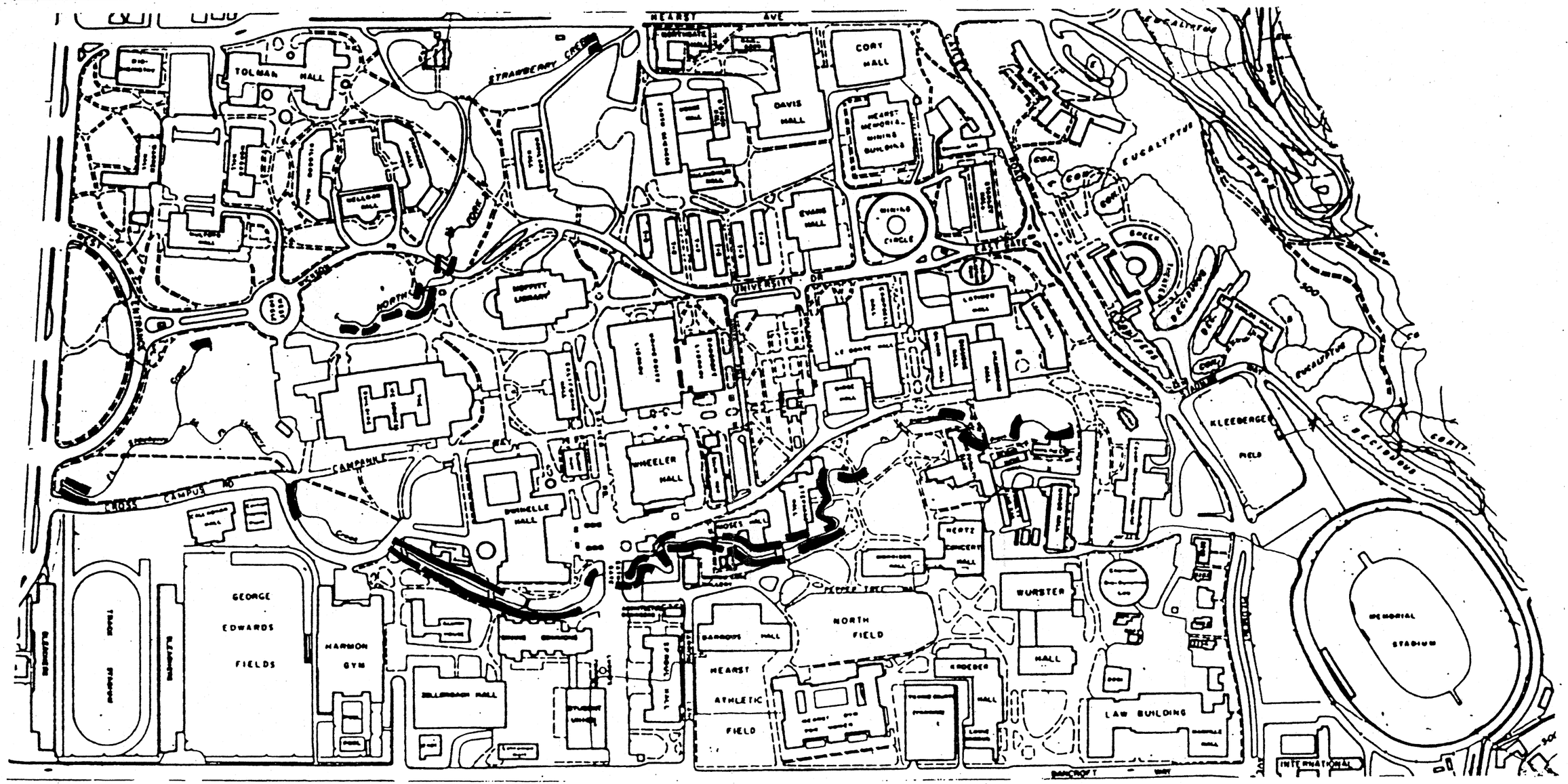
The equilibrium process of streambed incision or downcutting led to channelization and channel confinement of Strawberry Creek as long ago as 1907 in an attempt to stabilize the eroding banks. Channel confinement has had several major impacts. Scouring of the streambed is accelerated because both peak flow velocities and streamflows have increased and lateral channel confinement concentrates this energy downwards. This scouring effect obliterates many of the natural pool areas within the creek, resulting in a significant loss of aquatic habitat and destruction of winter cover from peak storm flows. In addition, streambanks downstream of channelized reaches are extremely vulnerable to accelerated undercutting and erosion. Extensive reaches of Strawberry Creek have been laterally confined (Figure 7).

3.6.1 Low Streamflow Characterization

The 1986 baseline study of the creek coincided with the sixth driest weather year on record in the San Francisco Bay area (EBMUD). Therefore, the creek channels observed to be flowing in the Fall of 1986 can be considered to be perennial channels under most circumstances. Figure 6 shows the locations of the ephemeral and perennial channels in the Strawberry Creek system.

The Strawberry Creek channel passing through the Botanical Garden dries up quickly above the Garden. Flow in this branch is augmented by EBMUD water several times a week from February through December or throughout the year if it is especially dry. This is done to support the goldfish

STRAWBERRY CREEK MANAGEMENT PLAN	PREPARED FOR THE OFFICE OF ENVIRONMENTAL HEALTH AND SAFETY UNIVERSITY OF CALIFORNIA, BERKELEY SEPTEMBER 1987	FIGURE 6 STRAWBERRY CREEK DRAINAGE SYSTEM



STRAWBERRY CREEK MANAGEMENT PLAN	PREPARED FOR THE OFFICE OF ENVIRONMENTAL HEALTH AND SAFETY UNIVERSITY OF CALIFORNIA, BERKELEY SEPTEMBER 1987	FIGURE 7 CHANNEL CONFINEMENT

pond in the Rhododendron Dell and for aesthetic purposes. The unnamed branch of Strawberry Creek just northwest of the Botanical Garden along Centennial Drive flows at about 0.005 cfs. This branch is fed primarily from a groundwater dewatering well located at the Animal Behavior Research Station. This well is pumped continuously to prevent landslides in the area that may occur due to saturated soil conditions and the overflow is dumped into the creek channel. DOFM is currently looking at the feasibility of using this groundwater supply for flow augmentation and irrigation purposes at the Botanical Garden. Hamilton Creek was found to be flowing at the rate of about 0.003 cfs out of the upper canyon.

The other perennial channels in the watershed include Chicken Creek and an unnamed creek that drain the central portion of the canyon including LBL. Both of these channels had very low summer flows, about 0.002 cfs. The perennial North Fork drains the northern part of the watershed encompassing most of the LBL complex as well as Lawrence Hall of Science, Math and Space Sciences complexes and extends all the way to Grizzly Peak Boulevard. The LBL stream reaches are culverted underground, making identification of the exact sources of these waters difficult. However, much of this water is drainage from hydraugers (drilled underground horizontal drains) that dewater the hill area around the LBL complex.

Table 5 presents summer baseflow measurements taken in conjunction with the baseline water quality sampling program. This shows that about two-thirds of the Main Branch streamflow came from the South Fork, whereas one-third was North Fork flow. The average combined flow of Strawberry Creek ranged from 0.50 - 1.13 cfs, averaging 0.89 cfs. The flow in both forks approximately doubled through the central campus due to the contribution of point source effluent.

The point sources on campus contribute a significant volume to the total summer baseflow of Strawberry Creek. North Fork point sources comprise an average of 0.14 cfs, or about 50% to the average low flow streamflow of 0.28 cfs in the North Fork. Point sources in the South Fork also contribute an average of 0.29 cfs or about 50% to the average summer baseflow of 0.58 in the South Fork. Therefore, about half (0.43 cfs) of the average baseflow (0.89 cfs) of the Main Branch of Strawberry Creek is comprised of central campus point source effluent.

3.6.2 High Streamflow Characterization

Urbanization of the Strawberry Creek watershed has resulted in greater peak flows and higher flood stages in the downstream reaches. Channel culverting and confinement as well as stormwater routing have also promoted higher peak flows and flood stages. In addition, buildings and other structures have been constructed in close proximity to the creek in numerous locations, posing a potential for extensive property damage.

Figure 8 shows the 100-year floodplain on the central campus as delineated on the FEMA contractor's work maps for Berkeley (1978). The 100-year flood is not necessarily a flood with a recurrence interval of 100 years. It is a statistical extrapolation based on existing records of a storm event that has a 1% probability of occurring in any given year. The accuracy of this extrapolation is dependent on many variables so it must be considered as only an estimate.

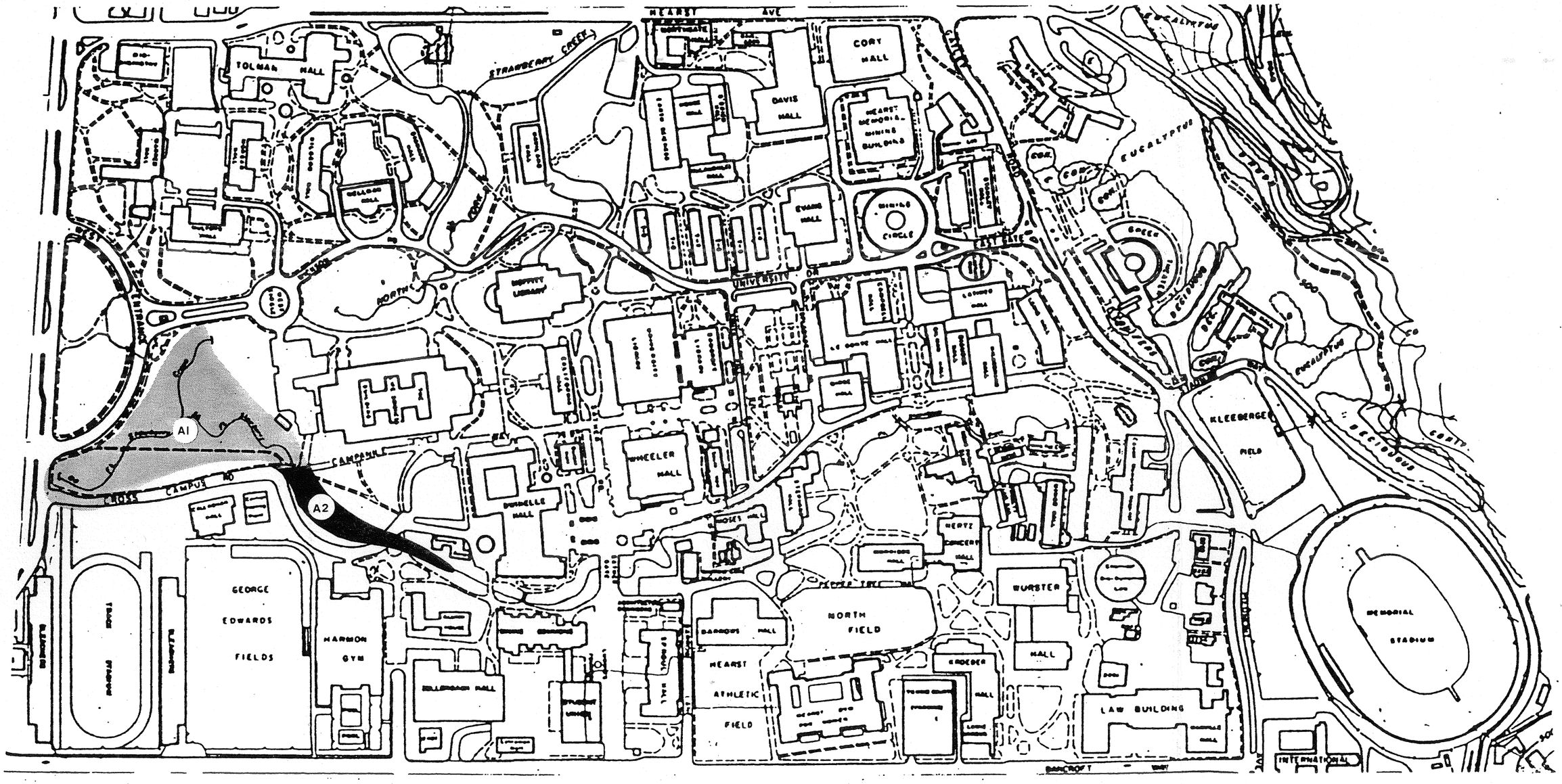
Two flood hazard zones are defined on Figure 8. The two zones are based on flood hazard factors which are derived by taking the difference of the weighted average water surface levels of the 10 and 100 year floods. The lower the difference, the higher the flood hazard. Zone A2 on the map is a higher flood hazard area than A1. Most of the Strawberry Creek areas are designated Zone C which indicates that minimal flooding will occur during a 100-year storm event.

Overtopping of the confined creek banks on the central campus normally occurs in several areas each winter. The North Fork overflows its low rock walls onto the adjacent lawn area north of LSB. Likewise, the South Fork overtops its southern bank onto the lawn opposite Dwinelle Annex. The North Fork also overflows into the Eucalyptus Grove near its confluence with the South Fork. Finally, the Main Branch has overflowed its banks in the past at the entrance to the city culvert at Oxford Street because of debris clogging the trash rack in the channel and subsequently diverting flows. Previous

Table 5. Strawberry Creek Discharge Data (cfs)

Location		Date 5/27/87	6/19/87	7/22/87	8/19/87	Mean
#1 -	South Fork above retention dam	0.20	0.12	0.48	0.18	0.24
#2 -	South Fork at Faculty Club	0.29	0.44	0.59	0.22	0.38
	Old South Fork channel at Women's Faculty Club	0.07	0.04	0.03	0.03	0.04
#3 -	South Fork at Eucalyptus Grove	0.46	0.61	0.92	0.32	0.58
#4 -	North Fork above Highland Avenue	0.04	0.05	0.07	0.02	0.04
#5 -	North Fork at North Gate	0.10	0.10	0.09	0.06	0.09
#6 -	North Fork at Eucalyptus Grove	0.34	0.38	0.21	0.20	0.28
	Main Branch above Oxford Street	0.88	1.04	1.13	0.50	0.89

Note: Flow measurements performed using a Pygmy current meter, Time of Travel (float) or Bucket tests.



LEGEND

ZONES A1-A2: AREAS OF 100-YEAR FLOODPLAIN
ALL OTHER CREEK AREAS DESIGNATED ZONE C (MINIMAL FLOODING)
SOURCE: FEMA FLOOD INSURANCE RATE WORK MAPS (1978)

0 80 160 320 FEET

N

STRAWBERRY CREEK MANAGEMENT PLAN	PREPARED FOR THE OFFICE OF ENVIRONMENTAL HEALTH AND SAFETY UNIVERSITY OF CALIFORNIA, BERKELEY SEPTEMBER 1987	FIGURE 8 100-YEAR FLOODPLAIN

overtopping has caused erosion of the northern bank at this location. None of these areas of frequent bank overtopping pose a significant hazard at this time.

In the canyon areas and portions of the North Fork upstream of Haviland Hall, the creek has become deeply incised, resulting in a high terrace. Streambank erosion is more pronounced in these reaches because the steep banks become undercut and eventually topple into the channels, causing sedimentation downstream. Another significant source of sediment is the sand and gravel which tends to accumulate upstream of the retention basin on the South Fork. During peak flow periods this bed material is scoured out and transported downstream through the Big Inch bypass culvert and subsequently deposited in the South Fork channel on the central campus. The sand and gravel accumulates in existing pool areas and along the margins of the stream channel, resulting in a more homogeneous riffle regime which degrades aquatic habitat.

Wet weather streamflows presented in Table 15 were measured in conjunction with the storm sampling round on October 27, 1987. All flow measurements were performed within an hour of each other and it was found that the flow in fork increased about sixfold between the canyon sites and the Eucalyptus Grove. Discharge in the South Fork ranged from 2.3 cfs in Strawberry Canyon to 14.6 cfs in the Grove, whereas streamflow in the North Fork ranged from 7.9 cfs in Blackberry Canyon to 45.0 cfs in the Grove. The North Fork exhibited higher flows than the South Fork, especially further downstream. This is due to the highly urbanized nature of the North Fork subwatershed and extensive stormwater routing in these areas. The peak flows resulting from this storm event were not determined but at the time of observation about 60 cfs was entering the city culvert at Oxford Street.

3.6.3 Storm Drainage System

Development in the Strawberry Creek watershed has resulted in extensive alterations to the natural hydrologic regime of the creek as previously discussed. A complicated storm drainage system has been constructed to handle the increased peak flows and volume of storm runoff from the watershed (Figure 6). Bypass culverts have been installed on both the North and South Forks to carry this storm flow under developed areas.

An earthen retention basin has been constructed on the South Fork of the creek at the entrance to the lower fire trail to control downstream flooding. The retention basin has a flood storage capacity of 1,500,000 cubic feet (11,220,000 gallons). The dam outlet serves to control the flow of water into the "Big Inch" bypass culvert. The outlet mechanism is a 48" x 42" hydraulically operated slide gate which is controlled from a station located at the entrance to the lower fire trail just above the earthen dam. Operation of the gate is supervised by the DOFM Grounds Manager.

Potential problems at the retention basin include siltation and debris collection at the outlet, which could clog the entrance to the bypass culvert. The entire canyon storm drain system is highly susceptible to debris or mudflows which could clog inlets and consequently divert flows out of normal channels, resulting in extensive damage. The location of the retention basin is less than ideal because it receives runoff from predominantly undeveloped portions of the watershed. The basin would have been more effective further downstream because it could have helped mitigate the rapid peak storm flows from the LBL complex. However, due to financial and other constraints at the time of its construction, the basin was situated further up into the canyon.

The retention basin outlet is the only means available at this time for controlling peak flows on the central campus. Therefore, flows into the bypass system from the basin should be regulated as much as possible. Lennert (1972) estimated that the maximum peak flow rate potentially entering the bypass system was 1650 cfs based on a storm event with a 25 year recurrence interval. It was further estimated that by limiting the flow into the bypass system to 850 cfs, damage to the central campus could be avoided. The remaining runoff could be held in the retention basin until it reached its capacity. Additional runoff would overflow onto Centennial Drive.

A reinforced concrete wall was constructed on the south side of Centennial Drive to a point just west of the Haas Recreation complex to divert overflow water past the clubhouse and pool areas. Wooden gates providing access to the Haas area must be closed for the system to operate correctly. The diverted

water will then spread across Strawberry Field and follow Rimway Drive down to the Piedmont Avenue area. Lennert estimated that this would happen about once every ten years. In order to avoid this to the extent possible, the dam outlet gate should not be excessively closed, nor should debris be allowed to accumulate in the retention basin. At the present time, there are no formal DOFM standard operating procedures for the gate, although standing policy has been to leave the gate open about 10 inches. This would allow about 100 cfs to enter the Big Inch bypass culvert at this point if the retention basin was filled to capacity.

The Big Inch (60"-72") bypass culvert begins at the retention basin dam and travels approximately 4300 feet underground to its outlet adjacent to the Faculty Club on the central campus. Chicken Creek and two other unnamed tributaries that drain the LBL complex are piped directly into the Big Inch bypass culvert. The Stadium Hill area, Kleeberger Field, and the Greek Theater also drain directly into this culvert. The Big Inch bypass culvert was built in 1951 due to the possibility of structural failure of the older "Little Inch" bypass culvert.

Extensive channel work was performed on Chicken Creek in the 1960's and 1970's. The accelerated peak runoff from the LBL complex caused substantial erosion and incision in this channel because of the steep slope and unstable soils. The channel bottom and sides were artificially hardened with concrete. In addition, rock and concrete groins and check dams were installed. However, the creek channel has since broken out of its artificial confinement and has continued to erode its banks and incise. At the bottom of the Chicken Creek channel adjacent to the Poultry Research building, a self-cleaning inlet structure was designed and constructed to accept peak flows. The inlet leads to a 54" RCP which connects directly to the 72" Big Inch bypass culvert near the Haas Clubhouse. The capacity of this inlet is approximately 500 cfs.

The original Strawberry Creek channel continues downstream of the retention dam and enters the Little Inch (30") bypass culvert at a drop inlet located just above the Haas upper pool. Storm flow in this channel is confined to local runoff from the hillsides. The Little Inch culvert was the first major diversion of Strawberry Creek and was necessitated by the construction of Memorial Stadium in 1923. The Little Inch culvert travels approximately 3500 feet and empties next to the Women's Faculty Club on the central campus. A small open channel then carries this water past Senior Hall and the Faculty Club and joins the South Fork at the outlet of the Big Inch bypass culvert. Most of the Haas Recreation Area as well as Memorial Stadium and the Cowell Hospital area drain directly into this culvert. The capacity of this culvert is about 180 cfs.

The North Fork drainage system has been significantly altered by development and stormwater routing. The upper reaches of the North Fork were obliterated by construction of the LBL complex. Drainage in the upper portion of the North Fork watershed is therefore culverted completely underground. A 48" CMP/RCP now extends from Grizzly Peak Boulevard and the Lawrence Hall of Science to the LBL outlet structure and another 30" CMP drains the northern hill area. The 48" RCP has been lined with steel cylinder pipe and an energy dissipation chamber has been constructed at the common outfall of the 48" RCP and 30" CMP in Blackberry Canyon. Three concrete energy dissipation structures were also installed in the 48" culvert between Lawrence Hall of Science and LBL. All inlets to the extensive underground drainage system in the North Fork watershed are protected with bar grates. Inlet structures in the main stream channels are protected by primary screens (trash racks) located upstream of the inlets.

The North Fork channel above Highland Avenue was regraded and reconstructed in the 1960's. In addition, five check dams were installed. This channel between the LBL fence and outlet structure has experienced both erosion and incision into highly erodible colluvium and soils. A drop inlet structure to the city drainage system is located just above Highland Avenue at the end of Le Conte Avenue. During periods of low flow, drainage travels underground along Le Conte Avenue and resurfaces in an open channel south of Le Conte Avenue between La Loma and Le Roy Avenues. This narrow confined channel continues a short distance west of Le Roy Avenue before disappearing back into the city storm drainage system.

In 1966, a high flow storm drain bypass system was installed to relieve the flooding threat caused by development at the LBL complex. During storm events, peak flows pour into a 48"- 60" RCP at the

drop inlet above Highland Avenue and is routed from Le Conte Avenue to La Loma Avenue to Ridge Road to Euclid Avenue and empties into the North Fork open channel at North Gate (Figure 11). Lennert estimated that the maximum theoretical peak flow into the drop inlet above Highland Avenue would be 500 cfs based on a 25-year storm event. It appears that present peak flows could approach this threshold. Major storm drain lines along La Loma Avenue and Euclid Avenue also empty into the North Fork at North Gate.

Kuntz (1980) calculated that the lag time in the North Fork at the entrance to the city culvert above Highland Avenue was only 15 minutes. The lag time for the South Fork at the retention basin was similarly calculated to be 25 minutes. Data collected by Dr. Luna Leopold in 1977 also indicated that the lag time of the North Fork at Haviland Hall was less than 15 minutes. Data presented for lag times in rural areas of the San Francisco Bay region (Dunne and Leopold, 1978) indicate that a drainage area the size of the North Fork subcatchment above Highland Avenue (388.1 ac. or 0.22 mi^2) would have a lag time of about 45 minutes if it was not urbanized. Likewise, a drainage basin comparable in size to the subcatchment upstream of the retention basin (485 ac. or 0.75 mi^2) would have a lag time of over an hour if it was not developed. Lag times on both forks of Strawberry Creek in the lower canyons are about three times faster than they would be under natural conditions and are even shorter further downstream. The impact of development on the hydrologic regime of the creek is evidenced by these drastically reduced lag times.

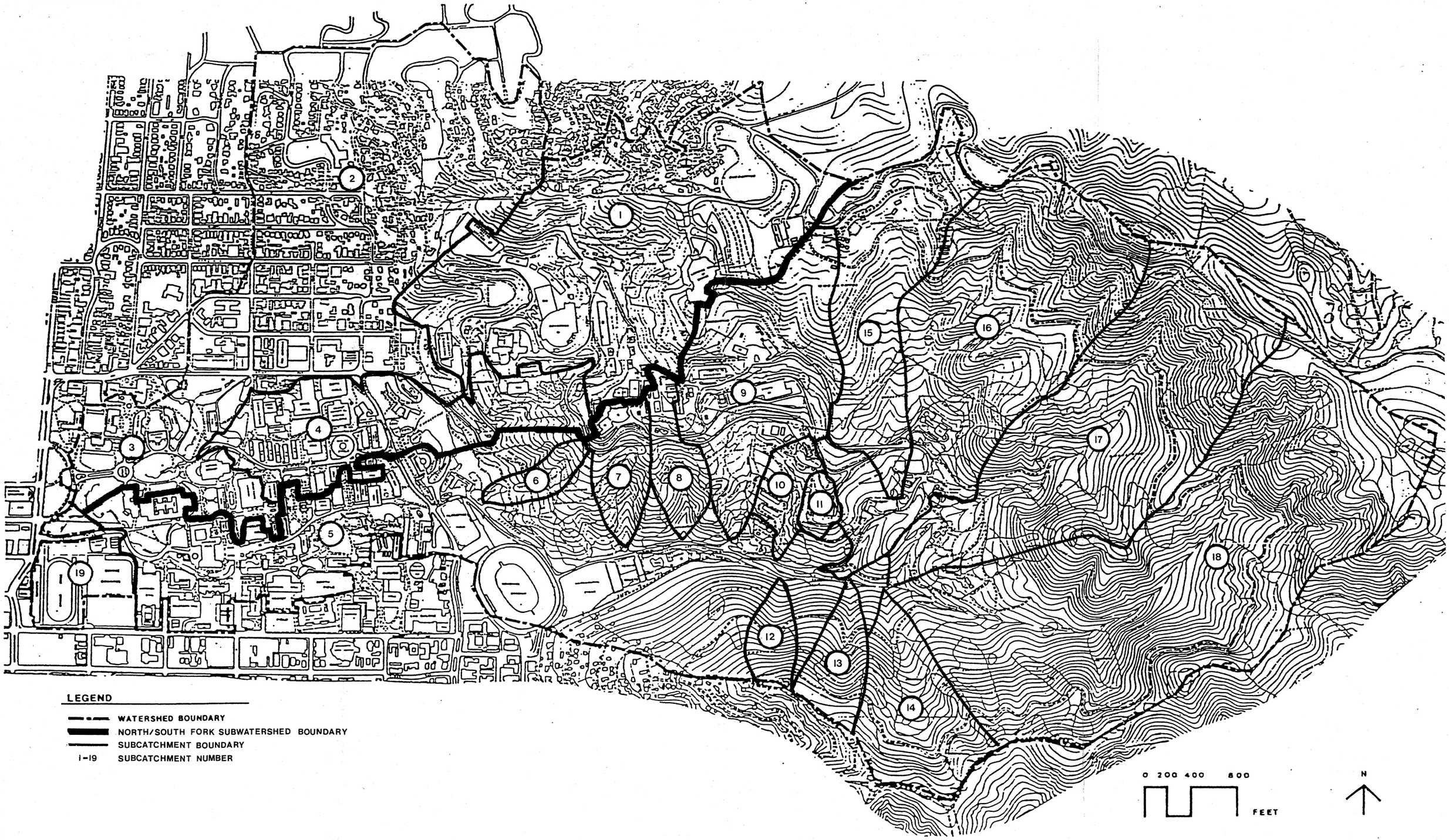
In conjunction with this study, the DOFM storm sewer maps were updated for the central campus and outlying areas. Drainage subcatchment areas were delineated for all major tributaries and culverts in the watershed through the use of DOFM, LBL, and city storm drain maps as well as extensive field inspections. Figure 9 and Table 6 define these subcatchment areas. These subcatchments may be used to identify possible sources of pollution, or to perform extensive hydrologic calculations.

3.6.4 Future Development

As previously discussed, urbanization of the watershed has had profound effects on Strawberry Creek. Continued development will create additional impervious surfaces that will further increase runoff and peak flows into the creek drainage system. This could pose both a flooding and erosion hazard to the central campus area if enough impervious surface was added. Due to these considerations, a full buildout scenario was constructed based on future development projections for the University, LBL, and North Berkeley.

At the present time, the upper Strawberry Creek watershed encompasses about 137.2 areas (78%) of the total central campus area of 177 acres. Impervious areas on the central campus consist of buildings, roads, parking lots, walkways and turf areas. Turf areas are considered impervious because they are at or near saturation due to irrigation, and during heavy rainfall these areas will quickly become saturated, resulting in excessive surface runoff. At this time, approximately 105.2 acres (77%) of the central campus watershed area is comprised of impervious surfaces. Table 7 presents a breakdown of the existing and proposed amounts of impervious areas by their respective subwatersheds.

The southwestern section of the central campus drains directly into the Main Branch of the creek. This small subcatchment area has a higher percentage of impervious surface than the rest of the campus because of the large relatively impermeable turf areas at Evans Field and Edwards Track Stadium whose drainage is routed into the Main Branch. Table 7 shows no net change in the amount of projected impervious surface in the central campus watershed. Future development on the central campus will add a minimal amount of impervious surface because almost all the sites being considered are already impervious areas such as parking lots. The relatively small amount of additional impervious surface added can be offset by the replacement of the Agriculture parking lot and the temporary buildings in the Central Glade with previous landscaping. The amount of previous landscaping will depend upon the extent of additional impervious turf areas placed in these areas. If relatively little turf is used, these additional landscaped areas will offset the impervious surfaces added by projected development on the central campus.



STRAWBERRY CREEK MANAGEMENT PLAN	PREPARED FOR THE OFFICE OF ENVIRONMENTAL HEALTH AND SAFETY UNIVERSITY OF CALIFORNIA, BERKELEY SEPTEMBER 1987	FIGURE 9 DRAINAGE SUBCATCHMENT AREAS

Table 6. Drainage Subcatchments

Subcatchment Description (#)		Area (acres)
	North Fork	
1	Upper North Fork above Highland Avenue	138.2
2	North Berkeley area	157.3
3	Central campus excluding cross-campus culvert drainage	38.2
4	Cross-campus culvert drainage area	54.4
	TOTAL	388.1
	South Fork	
5	Central campus	59.5
6	Ephemeral creek draining Stadium Hill	5.9
7	Ephemeral creek draining area south of Cyclotron	13.2
8	Ephemeral creek north of Haas Clubhouse	11.8
9	Chicken Creek drainage	57.3
10	"Poultry Creek" drainage	8.8
11	LBL Building 62 and 66 area	4.4
12	Ephemeral creek	7.1
13	Ephemeral creek	11.6
14	Ephemeral creek	30.1
15	Ephemeral creek draining Animal Lab area	51.4
16	Branch of South Fork north of Botanical Garden	95.6
17	South Fork northeast of Botanical Garden	104.4
18	Hamilton Creek	183.7
--	All other overland drainage areas into South Fork	113.9
	TOTAL	758.7
	Main Branch	
19	Evans Field - Edwards Track area	13.4
--	All other overland drainage into Main Branch	2.5
	TOTAL	15.9
	TOTAL WATERSHED AREA	1162.7

Note:

See Figure 9 for subcatchment locations.

Table 7. Central Campus Impervious Surfaces

EXISTING	PROJECTED
North Fork Subwatershed	
Drainage Area - 61.8 acres	same
Impervious surface area - 45.6 acres (74%)	45.3 acres (73%)
South Fork Subwatershed	
Drainage Area - 59.5 acres	same
Impervious surface area - 45.7 acres (77%)	45.9 acres (77%)
Main Branch Subwatershed	
Drainage Area - 15.9 acres	same
Impervious surface area - 13.9 acres (87%)	14.0 acres (88%)

Total Central Campus Drainage Area - 137.2 acres

Total Existing Impervious Surface area - 105.2 acres

Total Projected Impervious Surface area - 105.2 acres

According to the UC Campus Planning Office, the following projects and potential construction sites within the central campus creek watershed are either currently being considered, will be considered in the future, or are already under construction:

- Genetics/Plant Biology buildings and parking structure under construction between Morgan and Warren Halls.
- Future Chemistry building in parking lot #48 west of Latimer Hall.
- Future Student Services building in the vicinity of Building T-4. Plans are to remove all the temporary buildings and landscape that area.
- Future underground expansion connecting Moffitt and Doe Libraries. Some previous areas will be removed and replaced by a roof structure.
- Future Business School building at the present site of Cowell Hospital. Cowell will be either renovated with an addition on the east site or demolished.
- Agriculture parking lot (#1) will be removed and the courtyard areas between Giannini, Wellman, and Hilgard Halls restored.
- New building to replace Callaghan Hall.
- Future potential development site at North Gate parking lot #66 on Observatory Hill.
- Future potential development site at Stanley Hall parking lot #80.
- Future potential development site at Dwinelle parking lot #20.
- Future potential development site at Hellman Tennis complex north of Edwards Track Stadium.
- Future additions to Morrison and Kroeber Halls.
- Tentative future development site at Haviland Hall parking lot #41.

Other potential University development sites being considered in the rest of the watershed include:

- Addition to Bowles Hall
- Future Computer Science building at parking lot #26 between Etcheverry Hall and Le Roy Street (Northside).
- Botanical Garden parking lot opposite the LBL gate on Centennial Drive.
- Possible additions to the north and south sides of the Lawrence Hall of Science.
- Additional parking lot above the Lawrence Hall of Science off Centennial Drive.
- Hill Housing student resident complex along La Loma Avenue.
- Future addition to the north end of Stern Hall.
- Future limited expansion in the area of the Math and Space Sciences buildings.
- Possible utilization of the Animal Behavior Research Station as a future development site.

No plans yet exist for these projects so it is speculative as to how much impervious surface these projects will add. It is estimated that about 3.2 acres of impervious surface will be added by these projects assuming that the Animal Behavior Research Station is not developed. All of these sites except the Botanical Garden parking lot (about 0.5 ac.) will drain into the North Fork subwatershed. This amount of development should not significantly affect the hydrologic regime of Strawberry Creek.

According to the LBL Long Range Development Plan of 1987, there is a projected 4% increase (6.1 acres) in the amount of impervious surface added to the LBL complex over existing conditions. Currently, 49.5 acres (38%) of the 129.7 acre facility consists of impervious surfaces such as structures, roads and parking areas. In the future, this is projected to increase to 55.6 acres (42%) of impervious surface in an expanded site of 133.4 acres. Open space within the complex will diminish from 80.2 to 77.8 acres, or from 62% to 58% of the total area. Of the projected 6.1 acre increase in the total amount of impervious surface at LBL, approximately 4 acres will be located at the Life Sciences Research area at the eastern end of LBL north of the Botanical Garden. This area drains into the South Fork of Strawberry Creek and should not significantly affect its hydrologic regime.

According to the City of Berkeley Planning Department, no significant development plans are currently being considered for the area of North Berkeley within the watershed. It appears that the residential areas bordering University and LBL property are at or near full buildout potential.

Based on this analysis, it is estimated that about 4.4 acres of impervious surface could be added to the North Fork subwatershed, whereas 4.6 acres could be added to the South Fork subwatershed in the

foreseeable future. This relatively small amount of additional impervious surface should not significantly impact the hydrologic regime of the creek drainage system. However, the cumulative impacts of continued development in the future will likely produce deleterious effects over the long term. In the near future it is possible that some accelerated streambank erosion may occur in the unnamed branch of Strawberry Creek west of the Botanical Garden and in the North Fork channel on the central campus, as these channel reaches will bear the brunt of the additional storm runoff from the projects previously outlined.

4.0 ENVIRONMENTAL ASSESSMENT

This section analyzes the existing water quality of Strawberry Creek. Water quality considerations include a summary of past studies, an analysis of baseline low flow water quality, storm sampling results, and sediment sampling in both forks of the creek. Information on the existing biota of Strawberry Creek and its watershed is given in Section 4.2. Biological information is especially useful in the evaluation of long-term trends in water quality. Finally, the results of central campus point source investigations are given in Section 4.3.

4.1 Water Quality

4.1.1 Historical Water Quality Studies

A variety of student projects have dealt with various aspects of Strawberry Creek water quality. Historical low flow water quality data is summarized in Table 8, whereas wet weather sampling data is presented in Table 9.

The pH measured in past studies of the creek was similar to that observed during this baseline study. The pH generally decreased in the downstream reaches of the creek. No trends in pH were discernable in the historical wet weather sampling data.

Conductivity was high during past storm sampling and increased downstream. Turbidity was high in the South Fork in past low flow studies and increased about 200% during storm periods. Turbidity during dry weather was higher in the past than the concentrations observed in this study. Likewise, suspended solids levels were moderately high in the South Fork in past studies and were elevated over the concentrations observed during this study.

Historical dissolved oxygen concentrations in Strawberry Creek were more than adequate to support aquatic life and increased during storm periods, possibly because of turbulence. The dissolved oxygen concentrations in the past were lower than those measured during this study.

Nutrient levels measured in past studies were high in the creek. Total phosphate concentrations generally increased further downstream. Both phosphate and nitrate concentrations were higher in the South Fork than in the North Fork. Historical ammonia levels in the creek were high before reaching the central campus, but only moderate to slightly elevated on campus. Ammonia concentrations during wet weather were very high and increased further downstream.

Total coliform bacteria concentrations were high in the central campus reaches in past studies, and tended to increase downstream. Bacteria concentrations in the North Fork and in the Main Branch above Oxford Street increased about tenfold over low flow levels during past storm sampling.

Grab samples taken during past wet weather sampling showed low lead concentrations, elevated cadmium concentrations, and very high mercury concentrations in the South Fork and in the Main Branch of the creek above Oxford Street. Concentrations of all these heavy metals increased slightly in the downstream reaches of Strawberry Creek.

Table 8. Summary of Historical Low-Flow Water Quality Data (1976-1986)

Location	n	Parameter: pH (std. units)	Dissolved Oxygen	Turbidity (FTU)	Suspended Solids	Total Phosphate	Nitrate-Nitrogen	Ammonia-Nitrogen	Total Coliform (MPN) #/100 ml.	Sources
Hamilton Creek	2-7	8.3	-	10	13 (0-38)	0.46	3.52 (2.64-4.40)	0.33	-	(Wischemann, 1979) (Sloane, 1985)
Tributary to South Fork east of Botanical Garden	1-5	8.5	-	15	26	0.54	-	-	-	(Wischemann, 1979) (Sloane, 1985)
Strawberry Creek above retention dam	6-17	8.2 (7.7-8.5)	8.4 (3.5-11.0)	16 (10-30)	22 (10-35)	1.04 (0.38-2.95)	3.40 (0.71-8.00)	0.48	-	(Wischemann, 1979) (Frazier, 1983) (Sloane, 1985) (Cornwall, 1986) (Lang, 1976) (Ochsner, 1976) (Cole, 1977) (Pratt, 1978)
Old South Fork channel by Women's Faculty Club	5-11	8.4	7.9 (7.1-8.7)	-	28	0.30 (0.12-0.42)	2.51 (2.10-2.92)	0.19	6083	(Pratt, 1978) (Cheung, 1985) (Sloane, 1985) (Hunter, 1986)
South Fork near Faculty Glade	2	-	-	-	-	0.38 (0.27-0.49)	0.86 (0.72-1.00)	-	-	(Frazier, 1983) (Hunter, 1986)
South Fork near Sather Gate	4-12	8.0 (7.8-8.4)	7.5 (6.3-9.5)	-	-	0.51	3.35	0.07	14250 (10500-18000)	(Pratt, 1978) (Cheung, 1985) (Cheung, 1986)
South Fork at Eucalyptus Grove	1-2	8.2	5.8	15	-	0.59 (0.34-0.84)	3.30	-	-	(Ochsner, 1976)
North Fork below University Drive	1-4	7.4 (7.0-7.8)	8.8 (8.5-9.2)	-	-	0.28	1.80	-	18422 (467-51300)	(Herrera, 1977) (Cole, 1977) (Lee, 1982) (Cheung, 1986) (Hunter, 1986)
Main Branch above Oxford Street	1-17	8.0 (7.6-8.4)	8.3 (6.5-11.1)	9	-	0.64 (0.18-1.09)	2.16 (1.20-3.11)	0.04	26806 (13917-36000)	(Gerber, 1976) (Lang, 1976) (Pratt, 1978) (Frazier, 1983) (Cheung, 1985 and 1986) (Hunter, 1986)

Notes:

n = total number of observations from all sources listed (varies according to parameter).
All results in mg/l unless otherwise noted.
Where applicable, data is average of mean values from sources listed; range of data in parentheses.

Table 9. Summary of Historical Wet Weather Water Quality Data (1978-1986)

Location	Precip. (in.)	n	Parameter: pH (std. units)	Conductivity (umhos/cm)	Dissolved Oxygen	Turbidity (FTU)	Organic Nitrogen	Ammonia Nitrogen	Total Cadmium	Total Lead	Total Mercury	Total Coliform (MPN/100 ml)	Fecal Coliform (MPN/100 ml)	Sources
Old South Fork channel at Women's Faculty Club	1.64	2-7	10.0	-	11.0	-	-	1.3	-	-	-	4250	-	Cheung, 3/26/85
South Fork above Haas clubhouse	1.07-2.22	1-2	7.6 (7.4-7.9)	245 (240-250)	10.3 (8.9-11.7)	60 (52-68)	1.4	-	0.01	0	0.95	-	-	Frazier, 3/3/83 Frazier, 3/18/83
South Fork at Sather Gate	1.64-2.00	1-2	8.0 (7.9-8.1)	-	8.2	-	-	>2.0	-	-	-	11250 (7500-15000)	-	Cheung, 3/26/85 Cheung, 2/20/86
North Fork below University Drive	2.00	1	8.0	-	-	-	-	-	-	-	-	120000	-	Cheung, 2/20/86
Main Branch above Oxford St.	1.07-2.22	1-4	7.9 (7.6-8.0)	360 (330-390)	10.1 (9.1-11.4)	41 (34-48)	-	>2.0	0.03	0.01	1.10	402333 (45000-1100000)	2300	Gerber, 4/18/78 Frazier, 3/3/83 Frazier, 3/18/83 Cheung, 3/26/85 Cheung, 2/20/86

Notes:

n = number of observations from all sources listed (varies according to parameter).

All results in mg/l unless otherwise noted.

Where applicable, data is average of mean values from all sources listed; range of data in parentheses.

Precipitation indicates 24 hour total during sampling period.

4.1.2 Baseline Low Flow Water Quality

One of the main objectives of this study was to evaluate the current water quality of Strawberry Creek during low flow conditions. Reliable baseline data is essential to document future changes in the environmental quality of Strawberry Creek and to assess the effects of urban runoff during wet weather periods. The creek's waste assimilative capacity is generally at its lowest during the extended low streamflow period because dilution cannot be counted upon to dissipate wastes. Strawberry Creek is therefore most vulnerable to point and non-point sources of pollution at this time. Baseline data also serves as the basis for water quality management recommendations.

Baseline data was collected monthly from May through August of 1987. Grab water samples for chemical and bacteriological analysis as well as dissolved oxygen determination were collected at six locations on both the North and South Forks. Grab samples were taken at the middle of the stream channels at mid-depth. Grab samples for heavy metals analysis were collected during the July and August sampling rounds. Metals samples were preserved with concentrated nitric acid. All samples were kept cold in a cooler immediately following collection and delivered within five hours to the California Department of Health Services Sanitation and Radiation Laboratory in Berkeley for chemical and bacteriological analyses according to the procedures set forth in the APHA Standard Methods for the Examination of Water and Wastewater (1985). These methods are summarized in Table 10.

Dissolved oxygen determinations were made by the author using the Winkler iodometric titration method. In conjunction with the water samples, streamflow was determined by measuring water velocity with a Teledyne Gurley Model 625 Pygmy current meter and multiplying the velocity by the cross-sectional area of the flowing water. Where low flow conditions did not permit use of the Pygmy meter, bucket flow or time of travel (float) measurements of stream velocity were performed. A summary of streamflow measurements is presented in Table 5.

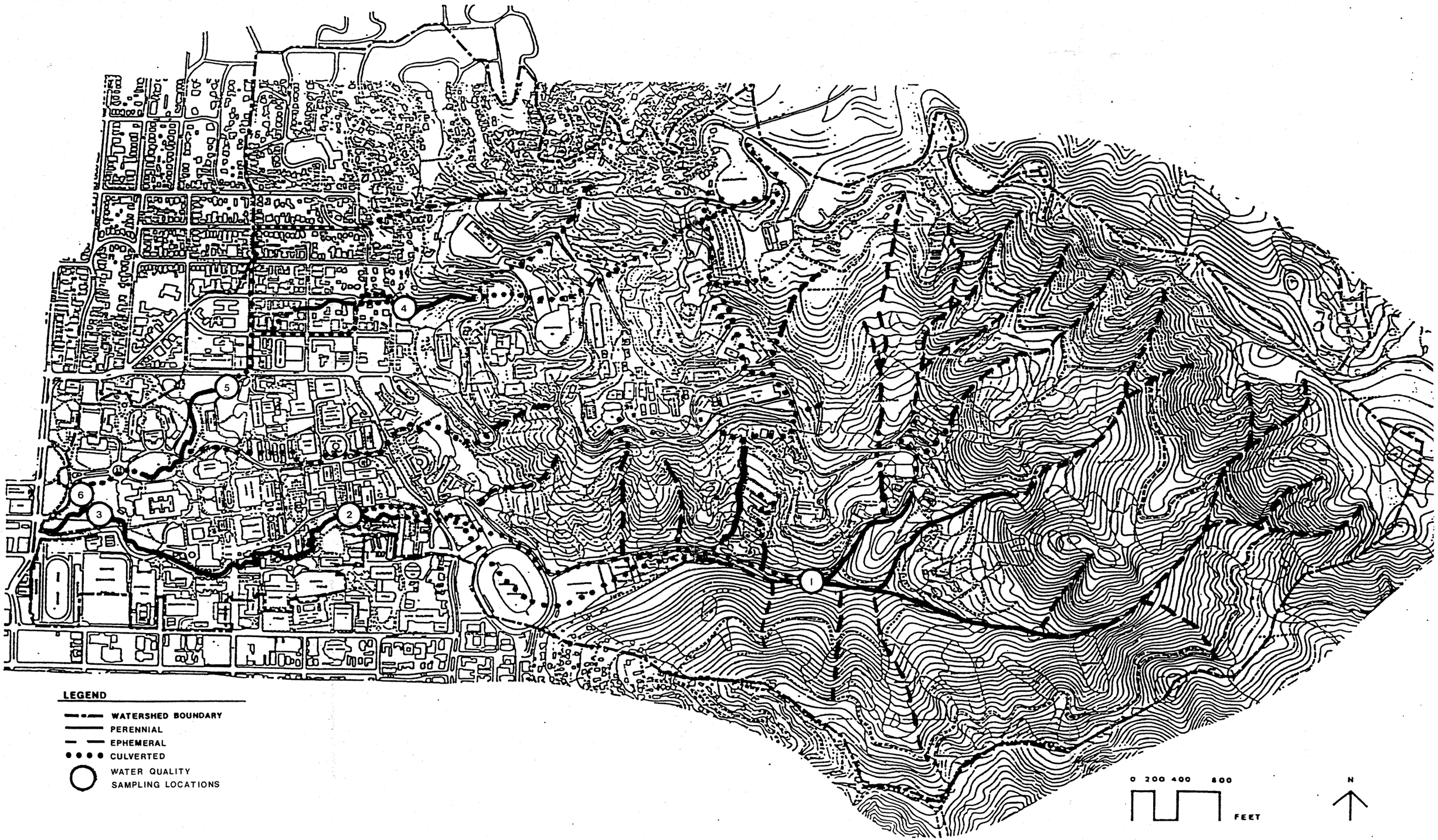
Sampling locations are shown on Figure 10. Stations #1-3 are located on the South Fork, whereas stations #4-6 are on the North Fork. Station #1, located above the retention dam, receives drainage from the upper canyon areas via Hamilton Creek as well as Strawberry Creek and its tributaries. The majority of the flow is comprised of overflow from a groundwater pumping well and EBMUD water used to augment flow in the Botanical Garden. A smaller portion is natural baseflow from Hamilton Creek which drains upper Strawberry Canyon.

Station #2 is located on the South Fork at the Faculty Club, downstream of the confluence of the Big and Little Inch bypass culverts. Water quality at this location is influenced by Chicken Creek drainage from LBL, local drainage from the former Poultry Research area, as well as the fact that the creek is routed underground for approximately three-fourths of a mile. In addition, any discharges from the Haas pool complex, Memorial Stadium, Cowell Hospital, or the Greek Theater would be evident here.

The last station on the South Fork (#3) is located in the Eucalyptus Grove just upstream of its confluence with the North Fork. Central campus point and non-point source discharges will greatly affect the water quality at this station. Changes in the physical, chemical, and bacteriological parameters between the sampling stations can be examined to identify possible sources of pollution and evaluate their impacts.

Station #4 is located on the North Fork above Highland Avenue. Most of the dry weather streamflow here originates from groundwater dewatering wells and drains around the Lawrence Berkeley Laboratory (LBL) complex.

Station #5 is located at the North Fork's entrance onto the central campus from the city culvert. Dry weather water quality here is influenced by drainage from the Northside district of the city. Minor flows from the upper Euclid Avenue storm drain system and Etcheverry Hall also enter the city tunnel.



STRAWBERRY CREEK MANAGEMENT PLAN	PREPARED FOR THE OFFICE OF ENVIRONMENTAL HEALTH AND SAFETY UNIVERSITY OF CALIFORNIA, BERKELEY SEPTEMBER 1987	FIGURE 10 WATER QUALITY SAMPLING LOCATIONS

Table 10. Analytical Methods Used at DOHS Sanitation and Radiation Lab

Parameter	Method	Reported As
pH	Electrometric	Standard Units
Alkalinity	Acid titration to pH 4.5	mg/l as $CaCO_3$
Hardness	EDTA titrimetric	mg/l as $CaCO_3$
Conductance	Electrometric	umhos/cm
BOD	5 day oxygen depletion at 20° C	mg/l
COD	Dichromate reflux	mg/l
Dissolved solids	Filtration through glass fibre filter, evaporation at 180° C	mg/l
Suspended solids	Filtration through glass fibre filter, drying at 103° - 105° C	mg/l
Turbidity	Nephelometric	Nephelometric, Turbidity Units
Color	Visual comparison	Pt - Co units
Chloride	Mercuric nitrate titrimetric or Ion Chromatography	mg/l
Oil and Grease	Gravimetric on freon extractables	mg/l
Kjeldahl nitrogen	Acid digestion with Hg and Se. Distillation of NH_3 and colorimetric determination by Nessler's	mg/l as N
Ammonia nitrogen	Distillation of NH_3 and colorimetric determination by Nessler's	mg/l as N
Nitrate nitrogen	Cadmium reduction, colorimetric	mg/l as N & NO_3
Total Phosphorus	Acid digestion with persulfate. Colorimetric by ascorbic acid reduction of phosphomolybdate	mg/l as P
Total Coliform Bacteria	Multiple tube fermentation	MPN/100 ml
Fecal Coliform Bacteria	Multiple tube fermentation	MPN/100 ml
Fecal Streptococci Bacteria	Multiple tube fermentation	MPN/100 ml

Table 10. (Continued)

Parameter	Method	Reported As
Cadmium, copper, chromium, iron, lead, manganese, nickel, zinc	Atomic absorption spectrophotometry; Flame or graphite furnace	ug/l
Mercury	Atomic absorption spectrophotometry; cold vapor	ug/l

Source: California Department of Health Services Sanitation and Radiation Laboratory, Berkeley

The last station on the North Fork (#6) is located in the Eucalyptus Grove just upstream of its confluence with the South Fork. The low-flow water quality here is influenced by discharges and runoff from the central campus. The cross-campus culvert, a major campus storm drain system, empties into the North Fork just above the University Drive vehicle bridge. As in the South Fork, changes in water quality can be examined in terms of the different activities along the creek. The sampling sites were designed to isolate different areas of the North Fork subwatershed in order to assess the water quality impacts and pollution sources in different areas.

Water quality parameters will be analyzed in terms of apparent trends and threshold levels. The concentrations of various water quality constituents will also be compared to USGS analyses of other East Bay creeks as well as ABAG data for Bay area creeks at large. Tables summarizing these low flow comparative water quality data can be found in Appendix B. Historical low flow studies of the creek will also be considered for comparison. The baseline data will also be discussed in terms of RWQCB objectives for surface waters where applicable. Baseline water quality data is presented in Appendix A. RWQCB water quality standards are given in Table 11.

Dissolved oxygen refers to the uncombined oxygen in solution which is available to aquatic organisms for respiration. Solubility of oxygen in water is primarily a function of water temperature. Solubility decreases from 11.3 mg/l at 10° C to 9.2 mg/l at 20° C. Summer low flow periods are the most critical times for aquatic life in terms of oxygen levels because the water temperature is warmest, resulting in lower oxygen solubilities at the same time metabolic rates (oxygen demand) of aquatic organisms are at their highest. The ability of a stream to assimilate organic materials (waste assimilative capacity) is also dependent upon the amount of dissolved oxygen present in the water. Creeks may assimilate more biodegradable organic material without significant water quality degradation if hydraulic reaeration rates are high.

Dissolved oxygen (D.O.) concentrations were quite high in both forks of Strawberry Creek. Concentrations decreased slightly in the downstream reaches of both forks. The North Fork had slightly lower overall D.O. concentrations than the South Fork. D.O. was often supersaturated at the headwater stations of both forks and was at or near saturation downstream.

The D.O. concentrations measured in Strawberry Creek were more than adequate to support the aquatic organisms indigenous to the creek and could even support salmonid fisheries. The D.O. exceeded the RWQCB minimum criteria for surface waters as well as the D.O. concentrations measured in other East Bay creeks. The D.O. also equalled or exceeded the concentrations measured in past studies of Strawberry Creek.

The supersaturated D.O. concentrations observed in the creek are probably due to physical aeration caused by the creek cascading down steep gradients over numerous check dams, entering drop inlets, and splashing out of culverts. Biological interactions do not appear to be a factor in the high D.O levels. The slight decline in D.O. downstream is insignificant and due to a combination of factors such as increased water temperature, leveling off of stream gradients, and a slight increase in organic loading. The high D.O. saturations indicate a low level of biodegradable organic wastes.

As previously discussed, water temperature is the main factor controlling the solubility of oxygen. The creek's assimilative capacity is therefore strongly influenced by water temperature. Water temperature also influences the rate of biological activity and affects the physical properties of water such as density and viscosity.

Strawberry Creek water temperatures increased slightly downstream compared to the canyon headwater stations. The South Fork was slightly cooler than the North Fork. Over the summer months, a slight warming trend was observed at all stations. Temperatures at the headwater stations ranged from 11.0 - 15.6^{o} C, whereas the downstream temperatures ranged from 14.2-18.6^{o} C over the summer. The largest consistent temperature change between consecutive stations was observed in the North Fork at

Table 11. Annotated RWQCB Surface Water Quality Objectives

Parameter	Objective
pH	Not be depressed below 6.5 nor raised above 8.5. Changes in normal ambient pH levels not to exceed 0.5 units.
Dissolved Oxygen (a)	Absolute minimum of 5 mg/l. Lower ten percentile value shall not be below 7 mg/l @ 16° C.
Biostimulatory Substances	Waters shall not contain substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses.
Turbidity	Discharges may not cause visible, aesthetically undesirable contrast with the natural appearance of the water. Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses.
Coliform Bacteria (b)	Mean fecal coliform (MPN) <2000/100 ml. 90 percentile <4000/100 ml.
Floating Material	Waters shall not contain floating material, including solids, liquids, foams, and scum, in concentrations that cause nuisance or adversely affect beneficial uses.
Suspended Material	Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.
Oil and Grease	Waters shall not contain oils, greases, waxes, or other material in concentrations that result in a visible film or coating on the surface of the water or on objects in the water
Color	Waters shall be free of coloration that causes nuisance or adversely affects beneficial uses.
Temperature (a)	Natural receiving water temperature shall not be altered unless it can be demonstrated to the Regional Board that such alteration does not adversely affect beneficial uses. At no time or place shall the temperature be increased more than 5° F above natural receiving water temperature.
Toxicity	All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life.
Radioactivity	Radionuclides shall not be present in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life nor result in the accumulation of radionuclides in the food web to an extent that presents a hazard to human, plant, animal, or aquatic life.

Notes:
(a) Warm freshwater habitat criteria.
(b) Non-contact water recreation criterion.
Source: Water Quality Control Plan for the San Francisco Bay Basin (RWQCB, 1986).

downstream stations #5 and #6. Temperatures at station #6 were 1.5-4.4° C higher than at station #5. This was probably due in great part to the input of effluent from the cross-campus culvert (Point #92) at University Drive which discharged a large volume of water averaging 21.0° C over the summer months. The streamflow of the North Fork was approximately doubled by the flow from this culvert over the summer.

Water temperatures in Strawberry Creek were adequate to support the indigenous aquatic life and could even support coldwater (< 20° C) fisheries. The apparent elevation of ambient water temperature by the cross-campus culvert discharge could have a deleterious impact on the suitability of downstream waters for aquatic habitat, but the magnitude of temperature elevation generally did not exceed the RWQCB criterion which prohibits a direct elevation of more than 5° F.

Biochemical oxygen demand (BOD) is a measure of the amount of oxygen required by bacteria to stabilize decomposable organic matter under aerobic conditions. Through recurrent use, the five day BOD test has become accepted as the standard. Approximately 70-80% of the ultimate BOD, which is exerted over the period of a month or more, is exerted within five days. BOD is used to determine the pollutional strength of waters in terms of the oxygen required to decompose organic matter. BOD is important only insofar as it produces deoxygenation resulting in detrimental anaerobic conditions.

The BOD_5 in both forks of Strawberry Creek was low. The South Fork had slightly lower downstream BOD_5 values than the North Fork. Slight increases in BOD_5 were observed at North Fork stations #5 and #6 , suggesting organic loading from the North Berkeley city tunnel area and point source loading on the central campus. Hilgard Hall sanitary sewage is probably responsible for the central campus loading (see Section 4.3.1).

The BOD_5 measured in the creek was lower than levels observed in other East Bay creeks. It does not appear that organic contamination of the creek is a significant problem. The low BOD_5 concentrations correlate with the high dissolved oxygen concentrations observed in the creek.

Chemical oxygen demand (COD) measures the amount of oxygen required for the chemical oxidation of organic matter. Some types of organic materials such as cellulose are biologically resistant to bacterial decomposition, but almost all organic compounds can be chemically oxidized. Since some organic material in any water is non-biodegradable, COD is almost always higher than BOD. Chemical oxidation of 95-100% of organic material is achieved by this test.

COD concentrations on the average were about three times higher than the BOD_5 levels in both forks of Strawberry Creek. COD tended to increase downstream in both forks, but the COD levels were similar in each fork. COD concentrations observed in the creek were much lower than those found in other East Bay creeks. It appears that most of the organic loading in the creek is of a non-biodegradable nature and does not have a significant effect on the water quality of Strawberry Creek.

pH is a measure of hydrogen ion activity in water as measured on an inverse logarithmic scale ranging from 0-14. pH < 7.0 indicates higher hydrogen ion concentrations, or acidic conditions. Natural waters exhibit a wide range of pH depending on their chemical and biological characteristics. pH has a direct effect on aquatic organisms and may also indirectly affect aquatic life by increasing the toxicities of certain pollutants such as ammonia and various metals under acidic conditions.

The pH of Strawberry Creek was slightly alkaline, averaging 8.1 in the South Fork and 8.0 in the North Fork. The pH tended to decrease slightly downstream in the South Fork and noticeably decreased downstream in the North Fork. The pH of the creek was similar to that observed in past low flow studies and was higher than the average pH found in other East Bay creeks.

The pH range of Strawberry Creek provides a suitable environment for most aquatic life. The lowered pH downstream in the North Fork approximates the pH of EBMUD water (7.7). This suggests that the

decreased pH is due to dilution of the creek with point source effluent from the central campuespecially the cross-campus culvert. RWQCB standards do not allow the ambient pH level to be changed by more than 0.5 units. pH consistently decreased by 0.4 units between North Fork stations #5 and #6.

Alkalinity is commonly defined as the capacity of solutes in water to neutralize acid. In natural waters alkalinity is primarily caused by bicarbonates-carbonates and, to a lesser extent, by hydroxides, borates, silicates, phosphates, and organic ligands. Alkalinity is a practical measure of the buffering capacity of a water body which is important because of the direct and indirect effects of pH on aquatic organisms.

Similar trends as observed with pH were found in the alkalinity of Strawberry Creek . On the average, alkalinity decreased from 140 to 106 mg/l downstream in the South Fork, whereas it decreased from 164 to 86 mg/l in the North Fork. The significant drop in the North Fork occurred along the central campus reach of the creek. This appears to be due to dilution of the creek with effluent similar to EBMUD water. EBMUD water has an alkalinity of only 22 mg/l.

The alkalinity of Strawberry Creek was equal to or generally less than the alkalinity found in other East Bay creeks. The significant reduction in the buffering capacity of the North Fork could have adverse effects on aquatic life, but the alkalinity was still adequte to support a diversified aquatic community.

Hardness is a measure of the polyvalent metallic ions dissolved in water. In freshwater, calcium and magnesium are the primary ions responsible for hardness, but iron, manganese, and other trace elements also contribute. Hardness is directly related to the total dissolved solids content of a water body. The toxicity of many metals decreases as carbonate hardness increases. Aquatic organisms may also be affected by the specific ions causing hardness.

Hardness follows the same trends observed with pH and alkalinity, based on the results of a single sampling round (8/19/87). Similar decreasing trends were found in both the North and South Forks. Hardness dropped significantly between the central campus sampling stations on both forks. Hardness ranged from 92-170 mg/l in the North Fork and 100-156 mg/l in the South Fork.

Strawberry Creek can be considered to be "moderately hard to hard" in terms of hardness. In general, the toxicity of most heavy metals in the creek would be lessened if the creek had "softer" water. The decrease in hardness on the central campus can again be attributed to dilution with effluent similar to straight EBMUD water which has a hardness of 24 mg/l.

Conductivity is the measure of the ability of water to conduct electrical current. It is related to the number and types of ions in solution as well as the dissolved solids content of the water.

South Fork conductivity decreased consistently downstream, averaging 382 umhos/cm in the canyon and 326 umhos/cm at the Eucalyptus Grove. On the other hand, conductivity averaged about 411 umhos/cm in the North Fork until it flowed through the central campus where it dropped to an average of 238 umhos/cm. The conductivity of Strawberry Creek was generally less than what was observed in other Bay area creeks. The significant drop in conductivity of the North Fork can be explained by dilution with point source effluent similar to EBMUD water which has a conductivity of 63 umhos/cm.

Dissolved solids are those that remain in solution after filtration. They are comprised of inorganic ions such as sodium, carbonates, sulfates, nitrates, potassium, calcium, and magnesium as well as small amounts of organic matter such as humic acids, and dissolved gases. Dissolved solids concentrations generally range from 55-75% of the total conductivity. Dissolved materials may reduce the toxicity of certain heavy metals and organic compounds.

Total dissolved solids (TDS) content of Strawberry Creek followed similar trends as observed with hardness and conductivity. In the South Fork, a steadily decreasing trend was apparent whereas an abrupt decline occurred in the North Fork on the central campus. TDS concentrations were similar in the upstream stations of both forks. Overall, the TDS content of the creek is fairly low compared to USGS

and ABAG data for Bay area creeks. The sharp decrease in TDS in the North Fork can again be attributed to the addition of a large volume of point source effluent similar to EBMUD water which is very low (46 mg/l) in TDS.

In contrast to TDS, suspended solids consist of organic and inorganic particulate matter which floats on the surface or is held in suspension in the water. Suspended solids are related to turbidity and may interfere with recreational uses and affect aesthetics. If the particulate matter is of organic origin, it may exert a high BOD. Solids may also smother benthic macroinvertebrates and detract from aquatic habitat in general.

Total suspended solids (TSS) were low in both forks of Strawberry Creek but tended to increase downstream. TSS were slightly higher in the North than in the South Fork. Average TSS content in the creek was generally lower than in other Bay area creeks and also lower than historically reported levels. The low suspended solids concentrations should not adversely affect aquatic organisms or beneficial uses of Strawberry Creek. It appears that the suspended material was of inorganic origin because the BOD and COD levels were low.

Turbidity is a measure of water clarity and is related to the TSS content. It is caused by a wide variety of suspended and colloidal matter that diminish light penetration into the water. Like TSS, turbidity interferes with recreational uses as well as aesthetic enjoyment of water bodies and can have an adverse effect on aquatic organisms.

Turbidity exhibited the same trends as suspended solids in Strawberry Creek. Similar low levels which tended to increase downstream were observed in both forks. These concentrations were generally lower than those reported for other Bay area creeks and lower than previously observed levels.

Color is due primarily to complex organic compounds originating from the decomposition of organic matter. It is usually not harmful to aquatic life, but may restrict light penetration, resulting in effects similar to high turbidity. Surface waters may also appear highly colored because of suspended material.

Overall, the color of Strawberry Creek was very low. No trends were observed in the South Fork, but color increased downstream in the North Fork. The low color content suggests a low organic content which correlates with the BOD and COD analyses. In general, the low color of the creek should not adversely affect any beneficial uses or organisms.

Chlorides occur in all natural waters in widely varying concentrations depending on soils and geology as well as proximity to the ocean. It is a conservative water property that fluctuates very little seasonally and only slowly over time. Chlorides are quite soluble so they may pass through pervious soils and rocks for great distances without diminution. Sewage is the primary cultural source of chlorides.

The chloride content of Strawberry Creek was fairly low. Chloride levels in both forks were similar. The South Fork levels were fairly consistent, but the North Fork exhibited a significant decrease in chloride content on the central campus. The chloride concentrations in the creek were similar to levels found in other East Bay creeks. The decline in chlorides in the North Fork can be explained by dilution from effluent similar to EBMUD water which is quite low (3 mg/l) in chloride content.

Oil and grease includes thousands of organic compounds with varying physical, chemical, and toxicological properties. Grease consists of a mixture of hydrocarbons, esters, oils, fats, waxes, and free fatty acids. These compounds may or may not be volatile, soluble, or persistent. Both petroleum and non-petroleum oils cause harmful effects by forming a sheen, film, or discoloration on the water surface. Oils may also be emulsified in the water column, solubilized, or settle to the bottom as sludge. Animal and vegetable oils are generally non-toxic to humans and aquatic life.

Oil and grease concentrations were generally low in Strawberry Creek. Levels in both forks were consistently quite low except for moderately high concentrations which were observed in the North Fork

at stations #4 and #6 on July 22, 1987. Sources of this oil and grease would have been LBL and point source effluent from the central campus. Average oil and grease concentrations were generally lower than levels observed in other Bay area creeks.

Nutrients are substances which are essential for the growth and reproduction of living organisms. In aquatic habitats, algae and vascular plants depend on dissolved nitrogen and phosphorus compounds as primary nutrients. Excessive nutrient loading of a water body increases the net productivity of aquatic ecosystems resulting in eutrophication. Eutrophication is manifested by excessive weed or algal growth which can have a deleterious effect on the beneficial uses of a water body. Decomposing vegetation also exerts a high oxygen demand on the water which adversely affects aquatic habitat.

Nitrogenous compounds exist in a variety of forms such as particulate matter, inorganic ions, soluble organic substances, and cellular components. Oxidation and reduction of these compounds is closely related to the metabolic processes of many types of microorganisms. The bacterial decomposition of nitrogenous matter is known as nitrification and is carried out through a fixed sequence of oxidation reactions. Organic nitrogen is oxidized to ammonia which is converted to nitrite which is rapidly oxidized to nitrate. Organic nitrogen in the form of protein, urea, or amino acids occurs in waters containing organic wastes such as sewage. By assessing the relative amounts of various nitrogenous compounds present, the extent and timing of any organic pollution can be determined.

Total Kjeldahl nitrogen (TKN) includes both organic nitrogen and ammonia, and is a measure of the potential for oxygen consumption of the nitrogenous matter in water. It is also a reliable indicator of recent sewage contamination. TKN concentrations in both forks of Strawberry Creek were low. South Fork levels were consistently low, whereas a small increase in TKN concentrations were observed downstream in the North Fork on the central campus. The TKN concentrations found in the creek were generally lower than those reported for other East Bay creeks. Small amounts of organic wastes appear to be emanating from the North Berkeley city tunnel and from a central campus source, probably Hilgard Hall (see Section 4.3.1).

Ammonia is the initial decomposition product of organic nitrogen. It may be used directly by plants with the excess oxidized to nitrite and ultimately nitrate. Un-ionized ammonia (NH_3) is the principal toxic form of ammonia to many aquatic organisms. Ammonia is also important because it exerts high oxygen and chemical demands on a water body. Surface waters with high concentrations of organic and ammonia nitrogen are indicative of recent organic pollution and may pose a health hazard.

Average ammonia concentrations in both forks of Strawberry Creek were generally low, ranging from <0.04-0.13 mg/l in the South Fork, and from 0.06-0.22 mg/l in the North Fork. Concentrations were consistently low in the South Fork, whereas a slight increase in ammonia levels was observed downstream in the North Fork. This coincides with the results of the TKN analyses. The ammonia concentrations found in Strawberry Creek were in the range of previously reported levels and similar to other East Bay creek concentrations. A comparison of the TKN and ammonia analyses for the downstream reaches of the North Fork reveals that most of the relatively low TKN content is comprised of organic nitrogen rather than ammonia. This suggests very recent organic loading.

Nitrate nitrogen is the end product of the aerobic decomposition of organic nitrogenous matter. Nitrate is the most directly available form of nitrogen for uptake by vascular aquatic plants and algae. Therefore, its presence often increases the net productivity of aquatic systems, contributing to eutrophication. Nitrate may be indicative of previous pollution that has already undergone the natural oxidation processes of self-purification. Nitrate is seldom abundant in natural surface waters.

Nitrate concentrations were consistently high in the South Fork and very high in the North Fork, especially downstream. South Fork average nitrate levels ranged from 1.7-2.0 mg/l, whereas average North Fork concentrations ranged from 2.2-4.7 mg/l. These levels were generally higher than the nitrate concentrations found in other East Bay creeks and similar to previously reported levels. The nitrate concentrations in Strawberry Creek are indicative of eutrophic conditions. This appears to be due to the

presence of nitrogenous matter of natural origin from the canyons which is compounded by organic loading downstream, especially in the North Fork.

Algae and vascular aquatic plants also rely on phosphorus as an essential nutrient. Phosphorus is frequently the key limiting nutrient in the process of eutrophication and is usually easier than nitrogenous compounds to control. Phosphorus may be present in dissolved, colloidal, or particulate states as orthophosphate, polyphosphate, or as organic compounds.

Average total phosphorus concentrations were consistently high in the South Fork and also high downstream in the North Fork. Average phosphorus ranged from 0.20-<0.26 mg/l in South Fork, whereas average North Fork levels ranged from 0.10-0.50 mg/l. The highest concentrations were consistently measured at the North Gate sampling station. The phosphorus levels found in the creek are indicative of eutrophic conditions. The source of the high phosphorus at North Gate could be sewage or decaying urban runoff material in the storm drain system. Total phosphorus concentrations in Strawberry Creek are similar to levels reported by USGS for other East Bay creeks.

Total coliform bacteria counts measure the presence of both soil-vegetation bacteria and intestinal bacteria from warm-blooded animals, including man. Coliform bacteria are not normally considered disease organisms and are comprised of the genera Eschericia, Serratia, Erwinia, Klebsiella, and Enterobacteria. Coliforms are used as indicators of sanitary pollution because they are inexpensively detected by relatively simple test procedures and are non-pathogenic. These water-borne organisms accumulate in bottom sediments as they settle out of the water column.

Total coliform concentrations in Strawberry Creek were generally within expected naturally-occurring ranges. Coliform levels increased downstream in both forks, especially the North Fork. These bacteria concentrations were within the range of previously reported results and similar to the levels found in Castro Valley Creek in Hayward. In order to determine the sources of these coliform bacteria, fecal bacterial analyses were also performed.

Although not a serious health hazard themselves, fecal coliform and fecal streptococcus bacteria are the primary indicators of fecal contamination. These bacteria are found exclusively in the intestinal tract of warm-blooded animals including man. Their presence indicates that other potentially pathogenic bacterial, viral, protozoan, or fungal species may also be present. Greater numbers of these bacteria generally indicate an increased health risk. Fecal streptococci indicate fresh pollution because they quickly die off outside their host. Fecal strep bacteria are much more abundant in animals than in man.

The ratios between concentrations of fecal coliform and fecal streptococci bacteria are commonly used to differentiate between human and animal fecal contamination. Human wastes will generally have a fecal coliform : fecal streptococcus ratio of greater than 4.0 (EPA, 1980).

Fecal coliform concentrations were low at the canyon sampling stations in both forks but increased to high levels downstream, especially in the North Fork. Average fecal coliform concentrations ranged from 260->11,000/100 ml in the South Fork, whereas average North Fork levels ranged from 825->34,500/100 ml. These fecal coliform concentrations violate the RWQCB criterion for surface waters (mean < 2,000/100 ml).

Average fecal streptococcus concentrations in the South Fork ranged from 1,275-11,025/100 ml, whereas average levels in the North Fork ranged from 4,475->51,750/100 ml. Both fecal coliform and fecal streptococcus bacteria concentrations were generally higher than those observed in other East Bay creeks.

Fecal coliform : fecal streptococcus ratios indicate probable sewage contamination in the North Fork at North Gate, and to a lesser extent downstream at the Eucalyptus Grove in both forks. The FC : FS ratios at North Gate ranged from 1.0 to 20.0, whereas the ratios in both forks at the Grove generally ranged from 1.0 to 3.2. Sewage contamination of the North Fork from Hilgard Hall explains the

elevated downstream bacteria counts in that fork, and EH&S/DOFM is currently investigating the possibility of sewage contamination from Point #68 downstream in the South Fork.

Additional fecal bacteria samples were taken on August 19, 1987 in an attempt to further define the sources and types of bacterial contamination emanating from the city storm drain tunnel under the Northside district. Figure 11 shows the specific sampling locations and the results are presented in Table 12. FC:FS ratios indicated abundant animal fecal material at that time rather than sewage contamination. This may indicate an intermittent sewage problem at this location because FC:FS ratios at most other times indicated sewage contamination. Fecal coliform counts increased significantly downstream of the old creek tunnel south of Euclid Avenue (Figure 11). This section of old tunnel is a suspect area for sewage infiltration or illegal connections. The high fecal streptococcus concentrations suggest animal activity and was confirmed by the observation of several raccoons in the tunnel. Berkeley DPW Engineering Department is currently investigating possible sources of sewage contamination in the North Fork tunnel.

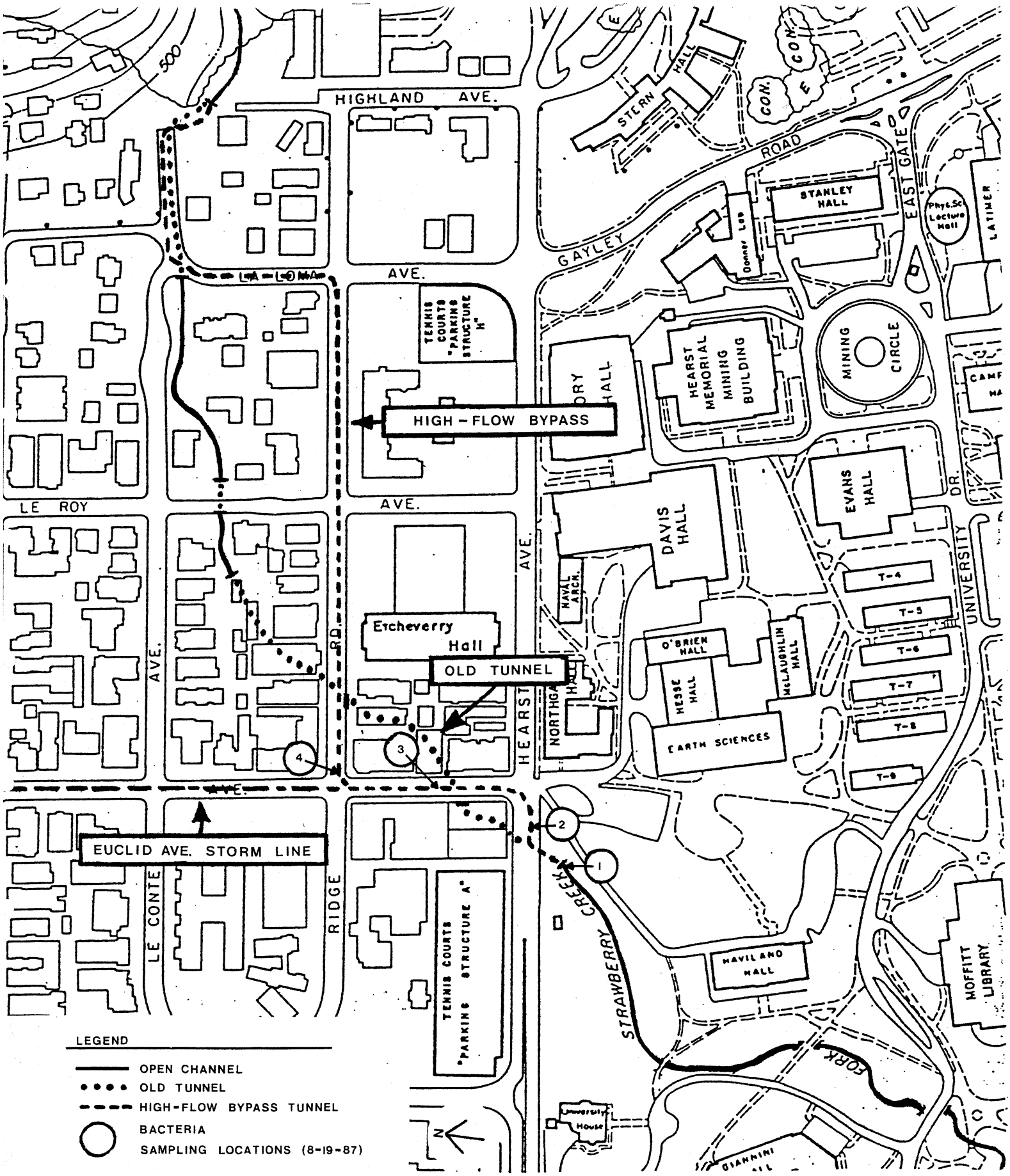
Heavy metals are present in trace quantities in the natural environment and also originate from a wide variety of sources in the urban environment. Metals are toxic to aquatic organisms when present in sufficient concentrations. Toxicity of various metals is dependent upon a variety of environmental factors including chemical state (speciation) of the metal, chemical properties of the water such as pH and hardness, and synergistic/antagonistic effects. Metals may bioaccumulate in aquatic organisms and often concentrate in bottom sediments. Metals content can limit the beneficial uses of a water body.

In general, trace metals concentrations in both forks of Strawberry Creek were low compared to natural background levels found in California rivers (Table 13), and concentrations observed in other East Bay creeks. Average metals levels were similar in both forks and were generally higher downstream compared to the canyon sampling locations. Elevated mercury concentrations were found at different times in the South Fork at Strawberry Canyon and also in the North Fork at North Gate. An elevated lead concentration was also observed in the South Fork at the Eucalyptus Grove. Metals levels in Strawberry Creek were generally within the RWQCB standards for surface waters (Table 14).

Beta radiation is the emission of electrons from the nucleus of a radioactive substance. It is the form of radiation exhibited by the majority of radioactive materials used in research at the University. Beta radiation is readily detectable using liquid scintillation counting techniques and can be used to determine the quantity of radioactive material in a water sample.

Liquid scintillation counts were performed by EH&S personnel on grab water samples in conjunction with the July and August water quality sampling rounds of Strawberry Creek. The analyses showed no beta radiation in excess of naturally occurring background levels. This indicated that no significant radioactive contamination was present in the creek at the time of sampling.

In summary, the water quality of Strawberry Creek is fairly good in the canyon areas, but has been degraded in the urbanized downstream reaches by point source effluent and bacterial contamination. The dissolved oxygen concentrations in the creek are high and the oxygen demand levels are coincidentally low. A significant alteration in pH, alkalinity, hardness, conductivity, and dissolved solids content occurs in the North Fork on the central campus because of point source dilution of the natural baseflow. Nutrients in the form of nitrate and phosphorus are high and indicate eutrophic conditions. Fecal bacteria concentrations were high in the downstream reaches of the creek, especially in the North Fork. This may pose a public health hazard. Trace metals in Strawberry Creek were generally low.



STRAWBERRY CREEK MANAGEMENT PLAN	FIGURE 11 NORTH FORK CITY TUNNEL SYSTEM

Table 12. Additional Bacteria Sampling at North Fork City Tunnel

Sample #	Location	Fecal Coliform	Fecal Streptococci
1	North Fork entrance to campus	92,000	≥ 240,000
2	Tunnel upstream of old tunnel	7,900	≥ 240,000
3	Tunnel upstream of old tunnel	11,000	≥ 240,000
4	Tunnel under Ridge Road	3,300	14,000

Notes:

All results MPN/100 ml.

Grab samples taken 8/19/87.

See Figure 11 for sampling locations.

Table 13. Natural Background Levels of Trace Metals in California Rivers

Parameter	Mean	Maximum
Total Cadmium	0.9	19.0
Total Chromium	10.0	100.0
Total Copper	14.0	81.0
Total Lead	10.0	520.0
Total Nickel	11.0	120.0
Total Zinc	35.0	270.0

Notes:

All concentrations in ug/l.

All data from California Water Resource Control Board's Primary Monitoring Network, based on 72 stations on 28 rivers 1980-1984.

Source: Harte et al, 1985.

Table 14. RWQCB Water Quality Objectives for Toxic Pollutants in Surface Waters Upstream of San Pablo Bay (1986)

Parameter [o]	4 day avg.	1 hour avg.	24 hour avg.	Instant. max.
Arsenic	0.19	0.36	-	-
Cadmium*	0.0011	0.0039	-	-
Chromium (VI)	0.011	0.016	-	-
Copper	0.0065	0.0092	-	-
Lead*	0.0032	0.083	-	-
Mercury	0.000025	0.0024	-	-
Nickel	-	-	0.056	1.1
Silver	-	-	-	0.0012
Zinc	-	-	0.058	0.17

Notes:

[o] all objectives expressed in mg/1

* standard based on hardness of 100 mg/1 as $CaCO_3$

Source: Water Quality Control Plan for the San Francisco Bay Region (RWQCB, 1986).

4.1.3 Wet Weather Sampling

Urban development in the upper Strawberry Creek watershed has produced a substantial amount of impervious surface area. Stormwater accumulates the debris and pollutants deposited by vehicles, pedestrians, commercial and institutional operations, atmospheric deposition, and a wide variety of other sources. These pollutants flow into the watershed storm drain system which is routed directly into Strawberry Creek.

Strawberry Creek is especially vulnerable to short-term urban pollutant "shock loading" because of the creek's limited assimilative capacity to attenuate these pollutants. Water quality degradation related to urban runoff is most pronounced following the first autumn rains when land surfaces are flushed of pollutants that have accumulated over the long dry season. The extent of wet weather water quality degradation depends on many variables such as extent and type of urban development, duration and intensity of the storm event, storm intervals, land surface porosity, and implementation of mitigative measures such as street sweeping.

Water quality sampling of Strawberry Creek was performed during the first significant rainfall (1.07 in) of the season on October 27, 1987. This was done to assess the impacts of urban runoff and to identify areas of non-point source pollution. Sampling methodologies and locations were identical to those used for the baseline monitoring program. Results of the storm sampling round are presented in Table 15. These will be compared to the baseline low flow water quality results and also to USGS and ABAG wet weather data for other Bay area creeks (Appendix B). Historical wet weather studies of Strawberry Creek (Table 9) will also be considered where applicable.

Dissolved oxygen concentrations were slightly lower than those found during the baseline study, although they were still high. Similar levels and slightly decreasing trends were observed in both forks. D.O. concentrations were similar to those reported in previous wet weather studies and also similar to average wet weather D.O. concentrations observed in other East Bay creeks.

Biochemical oxygen demand (BOD) increased slightly over baseline levels. BOD was still much lower than the average concentrations reported in other East Bay creeks during wet weather. In contrast, chemical oxygen demand (COD) increased significantly over low flow baseline levels and followed the same trends as BOD. COD was still lower than those levels reported by USGS for other East Bay creeks. The large increase in COD indicates that abundant non-biodegradable material such as plant matter was washed into the creek during wet weather.

In comparison to baseline levels, the dissolved solids content of Strawberry Creek decreased due to dilution of more naturally concentrated baseflow with runoff. However, suspended solids increased significantly in both forks, especially downstream. Downstream South Fork concentrations were higher than in the North Fork. Suspended solids levels approximately doubled in both forks through the course of the central campus. Downstream suspended solids concentrations were higher than average wet weather levels observed in other Bay area creeks.

Turbidity concentrations were also highly elevated over baseline levels and followed the same trends as suspended solids. Turbidity concentrations tripled in both forks along the course of the central campus. Similar high levels were observed in both forks. The turbidity concentrations in Strawberry Creek were higher than reported in previous studies, and also higher than average wet weather levels reported by ABAG for other Bay area creeks.

Oil and grease concentrations increased slightly over baseline levels. Slightly higher amounts were found in the North Fork compared to the South Fork. A slightly increasing downstream trend was apparent in both forks. Oil and grease concentrations were generally lower than the average wet weather levels reported for other Bay area creeks.

Total Kjeldahl nitrogen (TKN) increased significantly over low flow levels in Strawberry Creek. Similar concentrations and increasing downstream trends were observed in both forks. TKN was consistently higher than average wet weather levels found in other East Bay creeks. Ammonia

Table 15. Storm Sampling Results (10/27/87)

Parameter	South Fork 1	South Fork 2	South Fork 3	North Fork 4	North Fork 5	North Fork 6
Total Dissolved Solids	30	200	190	120	130	150
Total Suspended Solids	150	520	980	150	380	760
Turbidity (NTU)	65	90	290	73	93	260
Total Kjeldahl nitrogen	1.9	4.2	6.3	2.0	3.2	7.3
Nitrate nitrogen	1.2	2.1	1.8	1.6	1.8	1.9
Ammonia nitrogen	0.22	0.81	0.58	0.70	0.77	0.95
Total Phosphorus (as PO_4)	1.9	2.0	3.4	1.0	2.3	3.6
Oil & Grease	<5	7	5	7	10	12
BOD_5	2	9	5	7	8	9
COD	53	115	59	64	81	86
Total Coliform bacteria (MPN/100 ml)	35,000	160,000	92,000	92,000	≥240,000	160,000
Fecal Coliform bacteria (MPN/100 m1)	3,300	4,900	54,000	7,900	4,900	4,900
Fecal Streptococcus bacteria (MPN/100 m1)	7,900	11,000	92,000	7,900	54,000	24,000
Total Cadmium (ug/l)	0.3	2.7	2.6	1.5	2.2	4.4
Total Chromium (ug/l)	14	49	52	36	64	90
Total Copper (ug/l)	13	110	280	110	180	450
Total Iron	6.3	13.0	33.0	7.4	13.0	33.0
Total Lead (ug/l)	28	150	200	53	170	440
Total Manganese	0.15	1.10	1.40	0.31	0.66	1.50
Total Mercury (ug/l)	<0.1	0.6	2.5	0.4	0.6	8.8
Total Nickel (ug/l)	35	63	100	29	53	120
Total Zinc (ug/i)	20	460	580	380	810	1400
Water Temperature (^oC)	15.0	17.0	17.5	16.2	17.5	17.8
Dissolved Oxygen (% saturation)	9.6 (94%)	8.0 (82%)	7.6 (79%)	9.2 (92%)	8.4 (88%)	7.2 (76%)
Flow (cfs)	2.3	11.8	14.6	7.9	25.4	45.0

Notes:

All results in mg/l unless otherwise noted.
24-hour precipitation total for 10/27 - 10/28/87 (4 pm - 4 pm) was 1.09 inches at Oakland according to U.S. Weather Service.

Station Locations:
#1 - South Fork above retention dam
#2 - South Fork at Faculty Club
#3 - South Fork at Eucalyptus Grove
#4 - North Fork above Highland Avenue
#5 - North Fork at North Gate
#6 - North Fork at Eucalyptus Grove

concentrations moderately increased over baseline levels. Ammonia followed the same trends as TKN and was also consistently higher than average storm levels reported by the USGS for other East Bay creeks. Ammonia concentrations were lower than previously recorded wet weather observations, however. The large increase in TKN can be attributed mostly to organic nitrogen loading based on the low levels of ammonia present.

Nitrate concentrations actually decreased from the average baseline levels. Similar concentrations were found in all reaches of both forks. Nitrate was also similar to average wet weather levels reported in other East Bay creeks. The decrease in nitrate concentrations can be explained by the nature of the nitrogenous material and the flushing effect of the storm in flashy Strawberry Creek. Nitrate is the end product of the decomposition of organic nitrogenous matter. Although organic nitrogen loading during the storm was high, most of it was non-biodegradable material based on the results of BOD/COD analyses. In addition, the biodegradable matter did not have sufficient time to undergo nitrification because of the extremely short retention time of water in the creek under storm conditions. Existing nitrate-laden water was flushed downstream by the high peak storm flows in the creek.

Total phosphorus concentrations increased significantly over low flow baseline levels. Similar high concentrations and increasing downstream trends were observed in both forks. Phosphorus was generally higher than average wet weather levels reported for other East Bay creeks.

Total coliform bacteria concentrations in Strawberry Creek increased significantly over baseline levels. The highest concentrations were observed at the sampling sites located at the entrance to the central campus on both forks. North Fork levels were consistently higher than in the South Fork. Total coliform concentrations were similar to average wet weather levels observed in other East Bay creeks and generally higher than reported in previous studies.

Fecal coliform bacteria concentrations increased in the South Fork but decreased downstream in the North Fork compared to baseline levels. Fecal streptococcus concentrations increased in both forks over baseline levels. A large increase in both fecal coliform and fecal strep concentrations was observed in the South Fork at the Eucalyptus Grove and fecal strep counts were elevated in the North Fork at North Gate. Fecal coliform concentrations in Strawberry Creek were similar to levels reported for other East Bay creeks, whereas fecal strep concentrations were generally lower. The FC:FS ratios indicate that the fecal matter was of animal origin. The decrease in fecal coliform concentrations downstream in the North Fork was due to dilution of the normally high bacteria levels with surface runoff.

Trace metal concentrations in Strawberry Creek generally increased significantly over baseline levels. All metals increased with the exception of iron and manganese which decreased due to surface runoff dilution of their naturally-occurring levels. Increasing downstream trends were observed in both forks. Metal concentrations were generally much lower in the canyons than in the urbanized downstream reaches. In general, the North Fork had higher metals concentrations than the South Fork. The metals in Strawberry Creek were generally higher than average wet weather concentrations reported for other East Bay creeks. During the storm event, metals concentrations greatly exceeded the RWQCB standards for surface waters.

In summary, wet weather water quality of Strawberry Creek was impacted by urban runoff and deteriorated over baseline low flow water quality conditions. Significant increases in COD, suspended solids, turbidity, TKN, phosphorus, total and fecal bacteria as well as trace metals concentrations were observed compared to baseline levels. Dissolved solids and nitrate concentrations actually decreased due to dilution. Non-point sources of pollution have a significant impact on the environmental quality of Strawberry Creek.

4.1.4 Sediment Sampling

Sediment samples were taken for trace metals analysis from the lower North and South Forks on August 13, 1987. In aquatic systems the concentration of trace metals in suspended sediment and the top few centimeters of bottom sediment is generally greater than the concentration of dissolved trace metals in the water column (Horowitz, 1985). Trace metals are ubiquitous and persistent in the environment. Although many trace metals are essential to plant and animal life, all are potentially toxic to aquatic life at varying threshold exposure levels. Short-term exposure to relatively high metals concentrations can cause immediate acutely toxic effects, whereas long-term low level exposure can result in chronic effects such as impaired growth and reproduction as well as cancer.

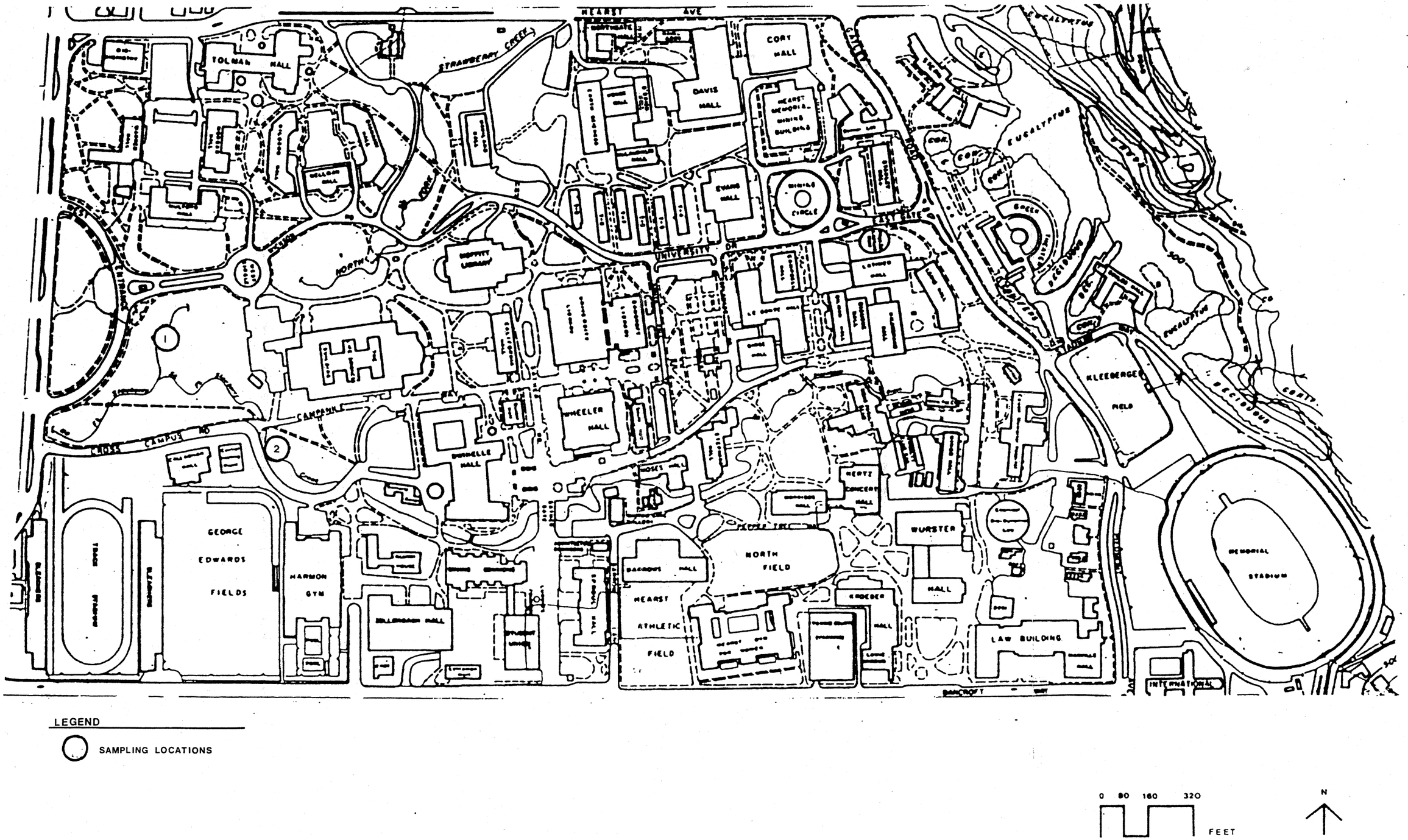
Bottom sediments often act as a sink or reservoir for many trace metals. Dissolved metals in the water exhibit a strong tendency to bind to sediments through adsorption processes. Many physical and chemical factors affect a sediment's capacity to collect and concentrate trace metals. Increases in metal concentrations are strongly correlated with decreasing grain size and increasing surface area, surface charge, cation exchange capacity, as well as increasing concentrations of iron and manganese oxides, organic matter, and clay minerals (Horowitz). Bottom sediments are the primary source of suspended sediment in the water column. During peak flow periods in Strawberry Creek, the streambed is scoured and the bottom sediments are flushed downstream. In this manner a localized pollution problem may become widespread and result in significant environmental impact. Under certain conditions, trace metals may dissolve into the water column, possibly enter the food chain, and have an adverse impact in this manner as well. The tendency for trace metals to bioaccumulate and biomagnify in aquatic organisms can result in toxic concentrations higher in the food chain even though initial concentrations in water are at or below apparently safe levels.

Both forks were sampled as far downstream as possible to assess the impacts of upstream sources of heavy metals. Sampling locations are shown on Figure 12. The South Fork sample was taken upstream of the LSB Annex construction to avoid siltation from that site. The top few centimeters of silt and organic material along an approximately 50 foot stretch of each fork were collected to make up a composite sediment sample at each location. The sediment samples were brought immediately to a state certified laboratory for analysis. Results of the analyses are presented in Table 16.

The trace metal concentrations found in Strawberry Creek sediments were generally within expected naturally-occurring ranges. For comparative purposes, Table 17 presents USGS sediment analysis data from the South Bay and the Clarke Number (CN) for each trace metal. The USGS analyses were the latest available comprehensive trace metal data for freshwater sediments close to the East Bay. On the other hand, the CN is a value calculated by geochemists that represents the average abundance of a trace element throughout the earth's crust. Since the CN reflects an average of all geologic formations within the earth's crust, some deviation can be expected at any given location. However, metal concentrations higher than the CN may indicate that pollution has occurred.

Lead and zinc concentrations exceeded the CN in both forks of Strawberry Creek and mercury exceeded the CN in the North Fork. In addition, mercury and zinc concentrations were higher than the average levels observed in urban Santa Clara County. Water quality experts from the USGS Water Resources Division and the S.F. Bay Regional Water Quality Control Board agreed that the mercury level found in the North Fork sediment was high and that the lead concentrations were also somewhat elevated. A 1972 USGS study reported mercury levels in various tributaries and margins of central San Francisco Bay ranging from 0.08 - 0.75 ppm based on dry weight. The average mercury concentration in the Bay sediments was 0.26 ppm.

Lead is a very common constituent in urban runoff, and zinc is also commonly found in urban environments. However, mercury does not commonly occur in the environment which suggests a source of significant pollution in the North Fork subwatershed. Highly toxic methylmercury can be formed by bacterial action in bottom sediments under anaerobic conditions. Further investigation into the source or sources of mercury pollution in the North Fork is warranted due to its significant environmental impacts.



STRAWBERRY CREEK MANAGEMENT PLAN	PREPARED FOR THE OFFICE OF ENVIRONMENTAL HEALTH AND SAFETY UNIVERSITY OF CALIFORNIA, BERKELEY SEPTEMBER 1987	FIGURE 12 SEDIMENT SAMPLING LOCATIONS

Table 16. Strawberry Creek Sediment Analyses

Parameter	North Fork	South Fork
Cadmium	< 0.5	< 0.5
Chromium	27	21
Copper	31	37
Iron	13000	11000
Lead	52	35
Manganese	400	300
Mercury	2.1	< 0.4
Nickel	24	19
Zinc	150	110

Notes:

All results in mg/kg (ppm) based on wet weight.

Samples taken August 13, 1987 on lower reaches of central campus.

Table 17. Comparative Sediment Analyses

Parameter	----------USGS Data---------- Mean	S.D.	Range	Clarke Number
Cadmium	<1.0	0.6	0-3.0	0.1
Chromium	156	279	10-1200	100
Copper	38	33	10-180	55
Iron	17014	9964	4500-45000	56000
Lead	62	167	0-1000	12.5
Manganese	525	271	150-1600	950
Mercury	1.7	3.2	0.02-16.00	0.08
Nickel (ug/l, dissolved)	<61	48	0-<100	75
Zinc	88	130	20-810	70

Notes:

All concentrations in mg/kg (ppm) based on dry weight unless otherwise noted.

USGS data based on 12 sediment samples from each of these creeks: Llagas Creek (Morgan Hill), Guadalupe Creek (Guadalupe), and Guadalupe River (San Jose) in Santa Clara County, from February 1980 - July 1986.

Clake Number is average (mg/kg) for earth's crust.

S.D. = standard deviation

4.2 Biological Communities

4.2.1 Bioassays

Through the cooperation of the San Francisco Bay Regional Water Quality Control Board, personnel from the U.S. Environmental Protection Agency's Duluth Environmental Research Lab performed bioassays using water from the South Fork of Strawberry Creek. Bioassays are widely used to evaluate what deleterious effects ambient surface water has on sensitive aquatic indicator organisms. Bioassays are an excellent water quality diagnostic tool because they take into account all site-specific environmental factors inherent in a given water body.

Two bioassays were performed on two different sensitive aquatic indicator organisms. The survival and growth of fathead minnows (Pimephales promelas) was clinically observed, as well as survival and reproduction of Ceriodaphnia sp., a sensitive crustacean. Both bioassays were seven day static renewal tests. The test organisms were placed in separate tanks containing creek water and the water was replaced daily by fresh creek water collected every morning from the South Fork at the Eucalyptus Grove. This location was chosen as a water sampling site because the South Fork supplies two-thirds of the total streamflow under low flow conditions and by sampling far downstream all upstream factors would be taken into account. This site also coincided with a baseline water quality sampling station (#3).

Water samples for chemical analyses were collected at the same time creek water was collected for the bioassays on the first day of the week-long bioassay water sampling. By coordinating this sampling, water quality data was made available for one of the seven water samples used in the bioassays. This data could be used to approximate the concentrations of various water quality constituents at that location during the week and could help correlate any observed detrimental effects in the indicator organisms to a specific water quality parameter. The bioassays were performed July 22-28, 1987. Water quality data for July 22 at station #3 is given in Appendix A.

Both bioassays were conducted according to procedures described in Short-term Methods for Estimating Chronic Toxicity for Effluent and Receiving Waters to Freshwater Organisms (EPA, 1985). No mortality was observed in either the fathead minnows or the Ceriodaphnia sp.. Growth of the juvenile (5-7 day old) fathead minnows was not impaired in comparison to the control groups, based on dry weight analyses. Furthermore, reproduction of the Ceriodaphnia sp. was not impaired in comparison to the control group, based on brood size. This indicates that during the week of July 22, South Fork ambient water had no adverse acute or chronic effects on these sensitive widely-used indicator organisms.

4.2.2 Macroinvertebrates

Macroinvertebrates are animals which inhabit the substratum of streams, lakes, and other waters. They are considered by definition to be visible to the unaided eye and are retained by Standard No. 30 mesh netting. The composition density (number of individuals per unit area) and relative abundance of each macroinvertebrate taxa in streams are useful indicators of environmental quality. Macroinvertebrate response to organic loading and substrate alteration have been well documented. Severe organic pollution usually results in a restriction of the diversity of macroinvertebrates to only the most pollution tolerant and a corresponding increase in the density of tolerant organisms. Siltation and chemical pollution may not only reduce but eliminate the entire community from affected areas. A common method of assessing the impact of a possible pollution source is to compare macroinvertebrate community structures from suspect and unaffected areas.

The latest comprehensive macroinvertebrate survey of Strawberry Creek was done by Stephens during October-November 1986. Four to fifteen samples were taken from midstream in both riffle and pool areas at each of eight locations (Figure 13). Substrate consisted primarily of mixed gravel, pebbles, and cobbles. Samples were taken using a one minute kick method. A triangular D-frame net was placed against the creek bottom and the substrate was subsequently disturbed three feet upstream for one minute to dislodge the macroinvertebrates.

The results of the survey are presented in Table 18. The three upper South Fork sites above the retention dam had the highest diversity (number of species), and were characterized predominantly by animals that occur in unstressed environments. The site above the Botanical Garden (#8) had the greatest abundance of organisms found in the survey and was dominated by the caddisfly Lepidostoma sp. The other two canyon sites (#6 and #7) were both dominated by the stonefly Amphinemura sp.

The lower South Fork sites (#4 and #5) on central campus exhibited much lower diversity and had the lowest abundance of any of the sites sampled on both forks of the creek. Less than half as many species and less than one-fifth the total number of organisms were observed here as compared to the canyon sites. More pollution tolerant organisms generally dominated these sites. These are organisms that can frequently tolerate moderate levels of organic pollution. The largest form of aquatic life observed by the author in the South Fork over the past year has been adult crayfish. It is evident from this analysis that the macroinvertebrate community is stressed in the South Fork on campus.

The North Fork was sampled both on campus and in the city below La Loma Avenue (#2 and #3, respectively). Diversity and abundance of macroinvertebrates were slightly better than the South Fork on campus, but still much lower than in the canyon. These communities were made up of facultative and intolerant forms. Orthocladius sp. and Argia sp. were the dominant organisms on campus and in the city, respectively. Oligochaetes, aquatic earthworms, were commonly found in the North Fork, especially on campus. An abundance of Oligochaetes often indicates a stressed condition. Oligochaetes are favored by organic enrichment and are often the dominant invertebrates in severely polluted areas. The most highly stressed community was sampled in the main branch of Strawberry Creek above Oxford Street. Only four different kinds of organisms were observed here. Some of these organisms are indicators of organic contamination. This site had the lowest diversity and abundance of any of the sites sampled. Either discharges in the lower reaches of Strawberry Creek or habitat destruction, or possibly a combination of these two factors, could produce the highly stressed condition exhibited by the macroinvertebrate community upstream of Oxford Street.

STRAWBERRY CREEK MANAGEMENT PLAN	PREPARED FOR THE OFFICE OF ENVIRONMENTAL HEALTH AND SAFETY UNIVERSITY OF CALIFORNIA, BERKELEY SEPTEMBER 1987	FIGURE 13 MACROINVERTEBRATE SAMPLING LOCATIONS

Table 18. Macroinvertebrate Analysis of Strawberry Creek

Taxa	Total per taxa	Sample Location 1	2	3	4	5	6	7	8
Collembola									
Entomobryidae	3	0	0	0	0	0	1	1	1
Ephemeroptera									
Baetidae									
Baetis sp.	87	0	4	0	0	1	34	17	31
Heptageniidae									
Epeorus sp.	36	0	0	0	0	0	11	1	24
Leptophlebidae									
Paraleptoplebia sp.	37	0	0	0	0	0	16	6	15
Odonata									
Coenagrionidae									
Argia sp.	50	0	5	12	17	11	2	2	1
Plecoptera									
Chloroperlidae	7	0	0	1	0	0	0	4	2
Nemouridae									
Amphinemura sp. (N)	277	0	0	6	0	0	93	152	26
Amphinemura sp. (A)	2	0	1	1	0	0	0	0	0
Hemiptera									
Gerridae									
Gerris remigis	-	X	X	0	X	0	0	X	0
Veliidae									
Microvelia sp.	10	0	0	0	2	0	2	1	5
Megaloptera									
Sialidae									
Sialis sp.	1	0	0	0	0	1	0	0	X
Trichoptera									
Hydropsychidae									
Hydropsyche sp.	11	0	0	0	4	1	1	5	0
Parapsyche sp.	14	0	0	3	0	0	4	7	0
Lepidostomatidae									
Lepidostoma sp.	134	0	0	0	0	0	8	8	118
Odontoceridae									
Parthina sp.	17	0	0	0	0	0	0	0	17
Psychomyiidae									
Tinodes sp.	12	0	0	0	0	0	5	4	3

Table 18. (Continued)

Taxa	Total per taxa	Sample Location 1	2	3	4	5	6	7	8
Coleoptera									
Dytiscidae									
Agabus sp. (A)	1	0	0	0	0	0	0	0	1
Agabus sp. (L)	4	0	0	0	0	0	0	4	0
Colymbetinae sp. (A)	1	0	0	0	0	0	1	0	0
Hydaticus sp. (A)	2	0	0	0	0	0	0	0	2
Hydroporinae sp. (A)	12	0	0	1	0	0	1	5	5
Other Dytiscidae (L)	2	0	1	0	0	1	0	0	0
Hydrophilidae									
Ametor sp. (A)	3	0	0	0	0	0	0	3	0
Helophorous sp. (L)	1	0	0	0	0	0	0	1	0
Scirtidae (Helodidae)									
Elodes sp (L)	84	0	0	0	0	0	1	0	83
Diptera									
Arthericidae	4	0	0	0	0	0	3	1	0
Chironomidae									
Chironominae									
Chironomini sp. #1	23	0	0	2	0	0	6	14	1
Chironomini sp. #2	2	0	0	2	0	0	0	0	0
Tanytarsini sp. #1	6	0	0	0	0	0	3	2	1
Tanytarsini sp. #2	7	0	0	0	0	0	2	5	0
Orthocladiinae	15	0	15	0	0	0	0	0	0
Tanypodinae									
Species #1	32	0	10	0	11	0	1	3	7
Species #2	12	0	0	10	2	0	0	0	0
Species #3	6	0	0	0	0	0	3	0	3
Other Chironomidae (P)	7	0	3	1	2	0	0	0	1
Dixidae									
Dixa sp.	2	0	0	0	0	0	0	2	0
Psycodidae									
Pericoma sp.	1	0	1	0	0	0	0	0	0
Simuliidae									
Simulium sp.	79	0	3	0	0	0	54	22	0
Tipulidae									
Tipula sp.	1	0	0	0	0	0	0	0	1
Species #2	1	0	0	0	0	0	0	1	0
Other diptera (P)	1	0	1	0	0	0	0	0	0
Platyhelminthes									
Turbellaria (Planaria sp.)	-	0	X	X	X	0	0	0	0
Annelida									
Oligochaeta	-	X	X	X	X	X	X	X	0
Mollusca									
Gastropoda	-	X	X	X	X	0	0	0	0

Table 18. (Continued)

Taxa	Total per taxa	Sample Location 1	2	3	4	5	6	7	8
Arthropoda									
Crustacea									
Amphipoda									
Gammaridae	-	X	0	0	0	0	0	0	0
Isopoda	-	0	0	0	0	0	0	0	X
Copopoda									
Haraptacoida	-	0	0	0	0	0	0	0	X
Arachnida									
Hydracarina	-	0	0	0	0	0	0	0	X
TOTAL ORGANISMS	1007	0	44	39	38	15	252	269	350
TOTAL TAXA	48	4	14	13	10	6	22	26	25
NUMBER OF SAMPLES	-	10	10	11	10	15	6	5	4

Notes

Sample locations:

1 = Main Branch above Oxford Street
2 = North Fork above University Drive
3 = North Fork below La Loma Avenue
4 = South Fork above LSB
5 = South Fork above Anthony Hall
6 = South Fork below Hamilton Creek
7 = South Fork above Hamilton Creek
8 = South Fork above Botanical Garden

X = organism present, but not counted.
N = nymph
A = adult
L = larvae
P = pupae

Source: Stephens, 1987

4.2.3 Periphyton

Periphyton is commonly defined as the community of microorganisms that are attached to or live upon submerged surfaces. This analysis considers algal growth only. The upper Strawberry Creek watershed channels were surveyed for algal growth on July 30, 1987. Visible algal growth was sampled at a dozen different representative locations (Figure 14). The unpreserved algal samples were taken immediately to University Herbarium personnel for identification. Results are presented in Table 19.

Due to the ephemeral (intermittent) nature of the upper canyon reaches of the creek, no algal growth was observed. Hamilton Creek did not support visible algal growth because of its shaded channel conditions. All of the sites sampled had fairly little canopy cover and exhibited quite shallow flow conditions. Most of the substrates were epilithic (rock), but some organic substrates consisting of wood or plant materials were also sampled for algal growth. All of the algae identified in Strawberry Creek were green algae (Chlorophyceae) and all were branched filamentous algae except for the coccoid colonial alga Chlorella sp., found in the North Fork at North Gate.

The most abundant alga found in the watershed was Cladophora glomerata. This was observed at nine of the twelve sites sampled in both forks of Strawberry Creek. This alga is generally indicative of "clean" waters, but may produce a septic odor when abundant (Palmer, 1977). Cladophora glomerata is symptomatic of eutrophication (nutrient enrichment) of surface waters. Large growths such as those observed in the creek are found only in waters that have a relatively high nutrient content (Whitton, 1970). Cladophora glomerata growths also usually indicate low heavy metals content of the water (James and Evison, 1979). These observations correlate well with the results of the baseline water quality results (Section 4.1.2). Another more coarsely-branched species of Cladophora was found in Chicken Creek and in the North Fork below University Drive. Vaucheria sp., a "clean" water alga, was found in the South Fork Botanical Garden stream channel.

Chlorella sp., an alga commonly observed in organically enriched areas, was found in the North Fork at North Gate. This alga is the most common and widespread alga seen in sewage ponds and may produce a musty odor when abundant (Palmer, 1977). Its presence in the North Fork correlates with the baseline water quality data (Section 4.1.2). Spirogyra sp., a slime-producing alga also observed in sewage ponds, was found in a branch of the South Fork just north of the Botanical Garden. This alga may produce a grassy odor when abundant.

STRAWBERRY CREEK MANAGEMENT PLAN	PREPARED FOR THE OFFICE OF ENVIRONMENTAL HEALTH AND SAFETY UNIVERSITY OF CALIFORNIA, BERKELEY SEPTEMBER 1987	FIGURE 14 PERIPHYTON SAMPLING LOCATIONS

Table 19. Periphyton Sampling Results

Site	Location	Water Temp.(°C)	Substrate	Organism
1	Branch of South Fork above confluence with Hamilton Creek	14.0	epilithic	Cladophora glomerata
2	South Fork @ Botanical Garden	16.0	organic	Vaucheria sp.
3	Branch of South Fork at entrance to Botanical Garden	16.0	epilithic and organic	Spirogyra sp.
4	Lower Chicken Creek	14.0	epilithic	Cladophora sp.
5	South Fork @ Faculty Glade	17.8	epilithic	Cladophora glomerata
6	South Fork @ Sather Gate	17.8	epilithic	Cladophora glomerata
7	South Fork @ Dwinelle Annex	17.8	epilithic	Cladophora glomerata
8	South Fork @ Eucalyptus Grove	17.9	epilithic	Cladophora glomerata
9	North Fork @ Eucalyptus Grove	18.2	epilithic	Cladophora glomerata
10	North Fork below University Drive	18.2	epilithic	Cladophora spp.
11	North Fork @ North Gate	18.8	epilithic	Chlorella sp.
12	North Fork above Highland Avenue	14.0	epilithic and organic	Cladophora glomerata

Notes:

Samples taken July 30, 1987.

See Figure 14 for sampling locations.

4.2.4 Wildlife and Fisheries

The Siri report done in 1972 contained detailed descriptions of the wildlife found on both the central campus and Strawberry Canyon. The report indicated that a significant number of species were using the Canyon at that time either as permanent residents or as migrants. The largest number of species occurred in the oak-bay woodland type (Figure 5), whereas the forest plantation types had far fewer species because of their exotic nature.

The South Fork in the vicinity of the Faculty Glade had a high concentration of fox squirrels. This species is quite tame and congregates where people offer it food. Uncemented rock walls and hollow trees provided habitat for arboreal salamanders. Slender salamanders were also found mainly in the area above the Big Inch bypass outlet by the Faculty Club. The bird life of this shaded area included varied thrush, creeper, winter wren, and the russet-backed thrush. Both Steller and scrub jays occurred here as well as brown towhees and other less shade-dependent species.

The lower portion of the South Fork across from Harmon Gym and the Eucalyptus Grove was a particularly favorable place to observe birds. Steller and scrub jays, juncos, brown towhees, mourning doves, and robins were conspicuous most of the year. There were also many less obvious species. Horned owls occasionally foraged and roosted in the area and were known to feed on Norway rats which are still common campus pests. Both arboreal and slender salamanders were scarce. At the present time, fox squirrels are abundant in the Eucalyptus Grove area.

In 1972, the shaded North Fork above University Drive provided habitat for bird life similar to those found near the Faculty Glade. Uncemented rock walls harbored arboreal salamanders. The upper North Fork area in Woolsey (Blackberry) Canyon provided diverse wildlife habitat for a wide variety of species. Wild mammals and birds were abundant and reflected on a smaller scale much of the variety that occurred in Strawberry Canyon at the time. Motile species such as fox, deer, mountain lion, bobcat, and coyote ranged into this area from Strawberry Canyon. Deer are presently abundant in the lower canyon most of the year as they search out sources of succulent vegetation and water.

The diversity of animal life on the central campus has consistently diminished with the increased urbanization of the campus over the years. Wildlife found on campus today consists primarily of birds, but small mammals and nocturnal scavengers can also be found. Fox squirrels, mice, and Norway rats make up the small mammalian population. Transient nocturnal animals include raccoons, opossums, and even deer that occasionally wander down from the hills. Resident birds on the central campus include scrub jays, Stellar jays, robins, chickadees, brown towhees, mourning doves, house finches, black phoebes, starlings, and various sparrows. Migratory birds also utilize the campus area during the winter (Cicero, 1987).

Wildlife in Strawberry Canyon is associated with the various vegetation types (Figure 5). Havlik (1978) states that oak-bay woodland is the most valuable wildlife habitat in adjacent Tilden Park, but Stebbins (1975) contends that eucalyptus forests also support a wide variety of wildlife. Wildlife habitat in the eucalyptus groves depends on the density of the forest. Densely planted trees have lower habitat value than more widely spaced stands. Eucalyptus flowers produce an abundant food source for birds, insects, and some mammals. A variety of birds feed on the seeds. Red-tailed hawks and horned owls commonly nest in eucalyptus as well.

Siri reported in 1972 that Strawberry Canyon provided habitat for over 100 species of wild birds, 40 mammalian species, 12 species of lizards and snakes, and 6 species of salamanders and frogs. Today, Strawberry Canyon provides habitat for several large predatory species which are dependent on extensive undeveloped tracts of land. These include mountain lion, bobcat, coyote, golden eagle, and prairie falcon. All these species are regularly observed in Tilden Park.

The California Department of Fish and Game's Natural Diversity Data Base was consulted for listings of rare or endangered species that may occur in the watershed. Strawberry Canyon provides suitable habitat for the Alameda striped racer which is listed as threatened by California and is also a candidate for federal listing. This snake is restricted to open brushland in Alameda and Contra Costa counties and has been sighted in adjacent Claremont Canyon as well as Tilden Park. A newly discovered rare arachnid, Sitalcina sp., occurs in Blackberry Canyon below LBL. This animal inhabits grassy areas or oak savanna and requires a native overstory. It lives under rocks on well-drained slopes in developed topsoil. Undisturbed rocks are the most critical component of its habitat. Three other locally rare or unique species that occur in the Berkeley Hills are the grasshopper sparrow, saw-whet owl, and Berkeley kangaroo rat. The grasshopper sparrow is a locally depleted species found along the crests of grass-covered ridges. The saw-whet owl is a small woodland or forest-associated owl found in stands of redwood and Monterey pine. Finally, the Berkeley kangaroo rat is a locally unique species also found in the hills. None of these locally rare species has any formal listing.

No fisheries exist in Strawberry Creek today. According to California Department of Fish and Game reports, the creek supported steelhead in the 1930's. The disappearance of fisheries over time is probably due more to the extensive physical alterations of the creek channel itself than to the degradation of water quality. Many physical barriers to fish migration such as culverts were installed. Both channelization of the creek and culverts altered the hydrology and fish habitat of the creek. Baseflow in the creek became more shallow and the water velocity increased. Areas such as pools that provided rest areas were obliterated and cover from the high winter peak flows disappeared. In addition, anadromous fish are reluctant to migrate through totally dark passages such as culverts. All these factors, in combination with the deterioration of water quality over time, resulted in the loss of fisheries in Strawberry Creek.

4.3 Point Source Investigation

A walking survey of both forks of Strawberry Creek on the central campus identified over 100 pipes on its banks (Table 20). An effort was made using DOFM underground utilities maps and field checking to determine the sources of these pipes. The locations of these pipes are shown on Figure 15. It was found that only about a dozen of these pipes flow continuously. Physical data on this continuously flowing effluent based on repeated field observations is presented in Table 21.

Of the dozen pipes that flow continuously, eight were targeted for chemical analyses based on their flow characteristics and sources. Generally the pipes with the highest flows and largest subcatchment areas, or those which physically presented signs of possible pollution were chosen for water quality sampling. Chemical analyses of the targeted point sources was conducted once during the summer (June-July), and again while full classes were in session (November-December) in order to assess the chemical composition of the effluent under different campus operating conditions. The cross-campus culvert (#92) was sampled twice during the summer because of its extensive drainage area and large volume of effluent.

An ISCO model 2700 automatic water sampler was used to obtain 24 hour composite samples of the major point sources. The sampler was programmed to extract a 100 ml. aliquot from the flowing pipes every 30 minutes for 24 hours. The composite water sample was kept cold by surrounding the sample bottle held inside the ISCO sampler with ice packs.

The glass sample bottle was previously rinsed out with the effluent to be sampled to remove any foreign residue that might have been present. The composite water samples were placed in appropriate containers upon retrieval. Volatile organics vials used for the TOC analysis were preserved with sulfuric acid. All samples were kept refrigerated until delivered on ice to a state certified laboratory for chemical analysis. All samples were sent to the lab within four days of collection.

The composite water samples were analyzed for total organic carbon (TOC) and chemical oxygen demand (COD) to assess total organics content. A semiquantitative ICP (inductively coupled plasma) scan for trace elements including many metals was also performed on the summer round of composite samples. Analyses of selected common heavy metals were performed on the November-December samples at lower detection limits than were possible with the ICP scan. Results of these analyses are presented in Table 22.

COD refers to the amount of oxygen required for the chemical oxidation of organic matter. Oxidation of >95% of organic compounds is achieved by this test (Std. Methods, 1985). COD is significant because the assimilation of large amounts of organic waste severely depletes the oxygen concentration of the receiving body, rendering it unsuitable for the existence of aquatic organisms. The COD concentrations of the point source effluent were consistently higher in November-December than during the summer sampling round. The COD levels of all the point sources tested during the summer were below the detection limit (1.0 mg/l) except for the Heating Plant (#106) effluent which was slightly elevated (11 mg/l). However, COD concentrations of the point source effluent ranged from 10-63 mg/l during the November-December sampling round. In general, COD levels were quite low during the summer and elevated in the fall. Specifically, the COD of effluent from point #68 was high (63 mg/l), whereas point sources #15 and #106 had elevated (29-31 mg/l) concentrations.

The organic carbon in wastewater is composed of a variety of organic compounds. Some of these compounds do not respond to the COD test, so TOC is a more direct expression of total organic carbon than COD. Both extractable organics and biogenic humic substances contribute to TOC (Std. Methods, 1985). However, TOC does not measure organically bound elements or inorganics that can contribute to the oxygen demand measured by COD, so TOC measurement does not replace COD analysis. The results of TOC analyses generally correlate with the trends observed with COD. TOC was low at all times in all the point source effluent except for point #68 which was high (26 mg/l) in November. From the results of the COD and TOC analyses it appeared that there was an intermittent non-volatile organic pollution problem at point source #68. This helped to prompt further investigation into this storm line (see Section 4.3.1).

Table 20. Central Campus Point Sources

Point #	Description	Source
	South Fork	
1	12" RCP	Giauque Hall
2	7" CIP	CB's below Cowell
3	10" clay	Lewis Hall drains
4	4" CIP	CB by Lewis Hall
5	4" CIP	Women's Faculty Club?
6	3" PVC	Women's Faculty Club?
7	4" CIP	old pumphouse?
8	3" CIP	CB's above Faculty Club
9	5" clay	Faculty Club
10	3" CIP	Faculty Club roof drains
11	6" clay?	CB's opposite Gilman Hall
12	6" clay	electrical manhole drain?
13	4" clay	CB's near Le Conte Hall
14	10" clay	Le Conte Hall?
15	8" clay	Le Conte Hall
16	6" CIP	active?
17	6" clay	Birge Hall?
18	1.5" CIP	drinking fountain drain
19	10" tile	CB's by Birge Hall
20	4" tile	Stephens Hall?
20A	2" CIP	Stephens Hall?
21	10" RCP	CB's and Morrison/Hertz Halls
22	6" clay	Stephens Hall?
23	6" clay	Stephens Hall
24	(2) 4" CIP	footbridge drains
25	4" PVC	CB @ lawn below Morrison Hall
26	4" CIP	active?
27	4" CIP	active?
28	5" CIP	Stephens Hall
29	4" CIP	CB by Stephens Hall
30	6" clay	trench drain and CB
31	4" CIP	CB on bridge
32	3.5" CIP	CB on bridge
33	(2) 3.5" CIP	CB's on bridge
34	8" clay	CB's above Barrows Hall
35	2.5" CIP	Moses Hall roof drain
36	6" fibre	Moses Hall?
37	6" CIP	Moses Hall?
38	4" PVC	Anthony Hall?
39	7" clay	Moses Hall?
40	10" clay	CB by South Hall and ?
41	6" CIP	?
42	3" CIP	electrical substation
43	4" clay	CB by Wheeler Hall
44	8" CIP	Wheeler Hall?
45	8" clay	Wheeler Hall?

Table 20. (Continued)

Point #	Description	Source
46	6" CIP	?
47	8" clay	Wheeler Hall
48	6" CIP	CB's by Bike Bureau
49	2.5" CIP	electrical manhole drain?
50	8" CIP	Barrows Hall
51	12" clay	active?
52	5.5" CIP	Sproul Plaza trench drain
53	8" CIP	Sather Gate CB's?
54	10" clay	active?
55	6" CIP	Sproul Plaza CB and fountain
56	3" CIP	?
57	12" CMP	Dining Commons?
58	6" CIP	Dwinelle Hall?
59	8" CMP	Dining Commons?
60	15" clay	Dwinelle Hall and CB's
61	6" fibre	CB's by Alumni House
62	6" PVC	Alumni House?
63	(3) 2" CIP	Dwinelle Annex?
64	12" CMP	Alumni House and CB's
65	6" CIP	CB by Alumni House
66	8" CIP	CB's @ Cross Campus Road
67	12" RCP	CB's below Dwinelle Hall
68	30" RCP	Zellerbach Hall, CB's, and ?
69	15" clay	Harmon Gym and ?
70	4" clay	active?
71	8" clay	Heating Plant and CB
72	4" fibre	Heating Plant?
73	10" clay	CB @ Campanile Way
74	18" CIP flap valve	LSB?
75	24" clay	LSB?
76	12" CIP flap valve	LSB?
	North Fork	
77	8" CIP	CB's @ Haviland Road
78	3" CIP	steam manhole drain?
79	6" CIP	electrical manhole drain
80	8" clay	CB below University House
81	8" clay	CB's @ Giannini Hall
82	4" clay	electrical manhole drain
83	18" CMP	Haviland Hall?
84	(2) 2" CIP	?
85	10" clay	Giannini Hall?
86	(2) 3" CIP	active?
87	3" clay	steam manhole drain?
88	3" clay	?
89	6" clay	CB @ University Drive
90	3" CIP	?

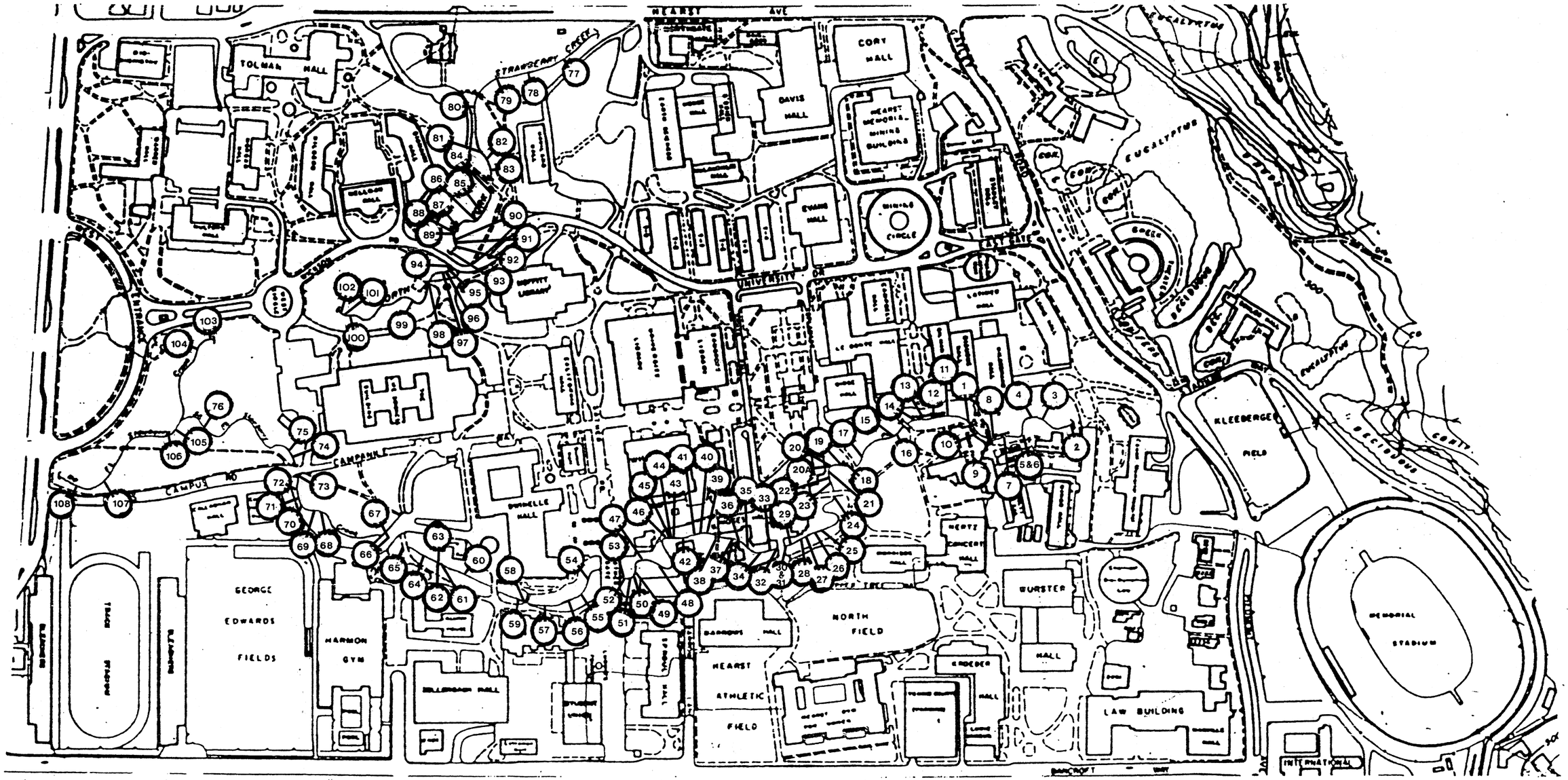
Table 20. (Continued)

Point #	Description	Source
91	4" clay	?
92	27" RCP	Cross-Campus culvert
93	6" clay	University Drive CB
94	6" clay	University Drive CB's
95	12" PVC	University Drive CB's
96	12" PVC	Moffitt and Doe Libraries and CB's
97	10" clay	CB @ Moffitt
98	(3) 3" CIP	manhole drains?
99	12" clay	CB's @ LSB
100	6" clay	CB's @ LSB
101	6" clay	CB's @ Wellman Hall
102	6" clay	University Drive CB's
103	10" clay	Mulford Hall (and Morgan?) &CB's
104	10" clay	CB's @ West Entrance
	Main Branch	
105	6" clay	active?
106	10" clay	Heating Plant and Evans Field
107	3" CIP	pumphouse?
108	12" clay	Edwards Track and ?

Notes:

CB = catch basin
RCP = reinforced concrete pipe
CIP = cast iron pipe
CMP = corrugated metal pipe
PVC = polyvinyl chloride pipe
? = source uncertain or unconfirmed
active? = pipe appears abandoned

List does not include two drain lines from CB's in West Circle and a drain line from Hilgard and Morgan Halls that empty into the North Fork West Circle tunnel.



LEGEND

1-108 POINT SOURCE NUMBER

0 80 160 320 FEET

N

STRAWBERRY CREEK MANAGEMENT PLAN	PREPARED FOR THE OFFICE OF ENVIRONMENTAL HEALTH AND SAFETY UNIVERSITY OF CALIFORNIA, BERKELEY SEPTEMBER 1987	FIGURE 15 CENTRAL CAMPUS POINT SOURCE LOCATIONS

Table 21. Mean Physical Data for Major Point Source Effluent

Point ID #	Source	Temp.(°C)	pH (std. units)	Flow (gpm)
	South Fork			
#1	Giauque Hall	20.5	8.2	52
#15	Le Conte Hall	21.5	8.0	13
#21	Morrison/Hertz Halls and CB's	19.5	7.8	1.4
#42	Electrical Substation	26.0	8.3	16
#46	?	19.0	7.4	2.6
#50	Barrows Hall	24.0	8.3	10
#68	Zellerbach Hall, CB's and ?	19.0	7.8	7.5
#74	LSB ?	19.0	7.2	2
#76	LSB Annex ?	18.5	7.3	8.4
	North Fork			
#92	Cross-campus culvert	21.0	7.7	42
#96	Moffitt and Doe Libraries and CB's	20.8	7.6	18
#103	Mulford Hall and CB's and ?	18.5	7.6	0.8
	Main Branch			
#106	Heating Plant	44.8	8.3	101

Notes:

Data based on repeated field observations May - August 1987.
CB = Catch basin
? = Source uncertain or unconfirmed

Table 22. Chemical Analyses of Point Source Effluent

	#1		#15		#68		#92			#96		#103	#106	
Parameter *	6/22	11/19	6/23	11/20	6/24	11/24	7/1	7/3	12/3	6/30	12/2	6/29	6/25	11/25
COD	<1.0	15	<1.0	29	<1.0	63	<1.0	<1.0	10	<1.0	21	<1.0	11	31
TOC	1.0	2.2	2.0	4.3	4.0	26.0	4.0	3.0	3.8	3.0	4.3	3.0	6.0	3.8
Aluminum	<0.2	---	<0.2	---	<0.2	---	<0.2	<0.2	---	<0.2	---	<0.2	<0.2	---
Antimony	<0.3	---	<0.3	---	<0.3	---	<0.3	<0.3	---	<0.3	---	<0.3	<0.3	---
Arsenic	<3.0	<0.002	<0.002	<0.002	<3.0	<0.002	<3.0	<3.0	<0.002	<3.0	<0.002	<3.0	<3.0	<0.002
Barium	0.01	---	0.01	---	0.05	---	0.03	0.02	---	0.03	---	0.02	0.01	---
Beryllium	<0.001	---	<0.001	---	<0.001	---	<0.001	<0.001	---	<0.001	---	<0.001	<0.001	---
Cadmium	<0.02	<0.0001	0.0012	<0.0001	<0.02	0.0008	<0.02	<0.02	0.0002	<0.02	0.0001	<0.02	<0.02	0.0001
Calcium	9.0	---	10.0	---	40.0	---	20.0	20.0	---	20.0	---	10.0	9.0	---
Chromium	<0.04	<0.01	<0.04	<0.01	<0.04	0.03	<0.04	<0.04	<0.01	<0.04	<0.01	<0.04	<0.04	<0.01
Cobalt	<0.04	---	<0.04	---	<0.04	---	<0.04	<0.04	---	<0.04	---	<0.04	<0.04	---
Copper	<0.02	0.019	0.006	0.014	<0.02	0.024	0.03	0.02	0.02	0.02	0.02	0.03	<0.02	0.0069
Iron	<0.02	0.09	<0.02	<0.03	0.04	0.13	0.05	0.02	0.23	<0.02	0.17	0.02	<0.02	<0.03
Lead	<0.2	0.003	0.006	0.002	<0.02	0.009	<0.02	<0.02	0.003	<0.02	0.003	<0.02	<0.02	0.003
Magnesium	1.0	---	1.0	---	10.0	---	5.0	5.0	---	7.0	---	2.0	1.0	---
Manganese	<0.005	<0.01	<0.005	<0.01	0.01	0.02	0.01	<0.005	<0.01	<0.005	<0.01	0.01	<0.005	<0.01
Mercury	---	0.0003	0.0003	0.0002	---	<0.0001	---	---	<0.0001	---	<0.0001	---	---	<0.0001
Molybdenum	<0.2	---	<0.2	---	<0.2	---	<0.2	<0.2	---	<0.2	---	<0.2	<0.2	---
Nickel	<0.04	<0.05	<0.001	<0.05	<0.04	0.006	<0.04	<0.04	<0.001	<0.04	<0.001	<0.04	<0.04	0.004
Potassium	<1.0	---	<1.0	---	<1.0	---	<1.0	<1.0	---	<1.0	---	<1.0	<1.0	---
Selenium	<5.0	---	<5.0	---	<5.0	---	<5.0	<5.0	---	<5.0	---	<5.0	<5.0	---
Silicon	4.0	---	4.0	---	20.0	---	7.0	7.0	---	7.0	---	5.0	4.0	---
Silver	<0.01	<0.0001	<0.0001	<0.0001	<0.01	<0.0001	<0.01	<0.01	<0.0001	<0.01	0.0001	<0.01	<0.01	<0.0001
Sodium	<1.0	---	<1.0	---	6.0	---	2.0	2.0	---	2.0	---	<1.0	<1.0	---
Strontium	0.04	---	0.04	---	0.20	---	0.09	0.09	---	0.10	---	0.06	0.05	---
Thallium	<0.2	---	<0.2	---	<0.2	---	<0.2	<0.2	---	<0.2	---	<0.2	<0.2	---
Tin	<2.0	---	<2.0	---	<2.0	---	<2.0	<2.0	---	<2.0	---	<2.0	<2.0	---
Titanium	<0.03	---	<0.03	---	<0.03	---	<0.03	<0.03	---	<0.03	---	<0.03	<0.03	---
Vanadium	<0.03	---	<0.03	---	<0.03	---	<0.03	<0.03	---	<0.03	---	<0.03	<0.03	---
Zinc	0.03	<0.01	<0.01	0.01	0.03	0.12	0.08	0.03	0.11	<0.03	0.03	0.03	0.04	0.02

Notes

* Results in mg/l.
Point source #103 was not sampled during the November-December (1987) sampling round due to negligible flow from the pipe.
Only selected heavy metals were analyzed during the November-December sampling round (at lowered detection limits).

Metals may originate from a wide variety of sources in wastewater discharges. Metals content may limit the beneficial uses of a water body and may cause acute or chronic toxicity in aquatic organisms. Most of the trace metals and constituents analyzed during the summer sampling round were below the detection limits of the ICP scan in all the point source effluent tested. However, the lower detection limits used in the November-December metals analyses generally showed small but measurable amounts of cadmium, copper, iron, lead, and zinc. In general, the metals concentrations were within the Regional Water Quality Control Board's (RWQCB) standards for surface waters (Table 14).

All the metals concentrations in the point sources sampled were below the Maximum Contaminant Levels (MCLs) set forth in the National Primary and Secondary Drinking Water Regulations (Table B-1). Arsenic, cadmium, nickel, and silver concentrations were all at or below the chronic toxicity criteria for freshwater aquatic organisms recommended by the EPA (1986). Likewise, all the lead, mercury, zinc, and iron concentrations were at or below the acute toxicity criteria offered by the EPA.

Hexavalent chromium concentrations were below the detection limit (0.01 mg/l) of the analysis in all of the point source effluent except for point #68. A concentration of 0.03 mg/l was measured here in November, which violates the RWQCB standards set at 0.011 and 0.016 mg/l over a four day and one hour average, respectively. Even though the measured concentration is below the drinking water MCL (0.05 mg/l), it is in violation of surface water quality objectives.

Zinc concentrations were generally detectable in all of the point source effluent in trace amounts. The RWQCB standard of 0.058 mg/l (over a 24 hour average) was exceeded at point sources #68 and #92 (0.11-0.12 mg/l), although these levels are below both the EPA acute toxicity criterion for freshwater aquatic life (0.32 mg/l), and the SMCL for drinking water (5.0 mg/l).

The RWQCB surface water criterion for copper is 0.0092 mg/l over a one hour average or 0.0065 mg/l over a four day average. This objective was consistently exceeded in almost all of the point source effluents tested. However, the highest observed concentration (0.03 mg/l at point sources #92 and #103) is still well below the SMCL for drinking water (1.0 mg/l).

Based on the physical and chemical data for the point sources investigated, it appears that most of the effluent is cooling water. Chemical analyses of EBMUD water supplied to the city of Berkeley are presented in Table B-1 for comparative purposes. The central campus point source effluent is chemically and physically quite similar to straight EBMUD water. Priority was given to investigating point source #68 because of the elevated hexavalent chromium and zinc concentrations observed there as well as the apparent organic contamination (see Section 4.3.1). Besides this point source, the cross-campus culvert (#92) generally had higher trace metal concentrations than the other point sources tested, so this warrants further investigation in the future. In addition, the Heating Plant (#106) poses a thermal pollution threat because of the high temperature and large volume of the effluent discharged into the creek above Oxford Street (see Section 4.3.1).

The point sources on central campus contribute a significant volume to the total low-flow stream discharge leaving the campus. North Fork point sources contribute an average of 0.14 cfs (63 gpm) to an average low flow streamflow of 0.28 cfs in that fork. This is approximately half of the total average summer baseflow of the North Fork. Point sources in the South Fork contribute an average of 0.29 cfs (130 gpm) or 50% of the average low-flow streamflow of 0.58 cfs. Therefore, during the course of this study, approximately 48% (0.43 cfs) of the total average summer baseflow (0.89 cfs) of Strawberry Creek was comprised of central campus point source effluent.

4.3.1 Site Specific Investigations

Further intensive point source investigations were performed in certain areas in cooperation with DOFM personnel. These sites were targeted because of past complaints or reports, results of bacteriological testing, information from faculty and other personnel, as well as visual appraisals. A DOFM sanitary sewer system map updating program done simultaneously with this study was also useful in discovering some problems.

Through dye testing it was discovered that sewage from Hilgard Hall was emptying into the North Fork. Through a combination of extensive deterioration and dislocated joints, the sanitary line coming from Hilgard Hall was leaking sewage into an adjacent storm sewer line. This storm line emptied directly into the North Fork at the West Circle tunnel. Based on the badly deteriorated condition of the sanitary line, this situation could have existed for as many as ten years. This sanitary line will either be replaced or inversion lined as soon as possible.

Dye testing also uncovered a potential contamination problem at Le Conte Hall. It was found that all the laboratory sink drains in the old section of Le Conte were routed directly into the South Fork of the creek near the Faculty Glade (Point #15). This was a result of both changing building codes since the building was built in 1924 and deteriorated piping. Chemical sampling of this continuous effluent showed no chronic chemical contamination problem at the time of sampling. This effluent will be rerouted to the sanitary sewer system as soon as possible.

Acting on information supplied to EH&S, a massive sewage contamination problem was uncovered at Memorial Stadium. Extensive deterioration of the sanitary sewer lines coming from the stadium was causing considerable infiltration of sewage into the Little Inch bypass culvert which also runs underneath the stadium. The bypass culvert emptied the sewage into the South Fork of the creek at the Faculty Club. This situation was occurring every time the Stadium was in use.

To determine the extent of sewage contamination, bacteriological sampling was conducted during three football games in the Fall. Results of this sampling is given in Table 23. This shows massive surface water contamination, especially on 9/5/87. A section of sanitary sewer was inversion lined before the 9/26/87 football game. It appears that the sewage contamination was somewhat mitigated by this action, but not solved. Further evaluation of this problem was hindered by lack of manhole access in this area. A manhole has since been constructed and investigation of the problem is continuing.

Results of chemical analyses (Section 4.3) and visual signs of possible sewage contamination prompted investigation into a 30" RCP storm line emptying into the South Fork by Harmon Gym (Point #68). The storm line was electronically traced and sewage was noted in a catch basin along the line in the Zellerbach parking garage. Further dye testing revealed that bathrooms in the Bear's Lair Pub which were installed about two years ago had been mistakenly routed to the storm sewer rather than the sanitary sewer system. The bathrooms have been shut down pending repair of this plumbing problem.

The heating plant discharge (Point #106) into the Main Branch of the creek also poses a problem. This constant discharge of hot water has sporadically been a source of thermal pollution, depending on the temperature and volume of effluent. Elevating the temperature of a water body reduces the solubility of oxygen and can also have an adverse effect on aquatic organisms. The discharge has averaged about 44.8^{o} C (Table 21), but has been observed to be as high as 60° C (140° F). On July 22, 1987 the ambient temperature of the Main Branch was raised from 18° C to 32° C, a rise of 14° C (25° F). This is in violation of the RWQCB standard which prohibits the elevation of ambient water temperature by more than 5° F. The hot water originates from a still used to make distilled water for laboratory use in the Life Sciences Building. A drainage line then returns this water to the heating plant, but the heated water is not pure enough to be recycled through the new high pressure cogeneration boiler system so it is discharged into a storm drain at the plant. This thermal discharge should be rerouted to the sanitary sewer system.

Table 23. Stadium Bacteriological Sampling

Date	Sample	Time	Water Temp.(°C)	Flow (gpm)	Total Coliform	Fecal Coliform	Fecal Strep.
9/5/87	1	1345	18.5	9.9	80,000	50,000	8,000
	2	1430 (halftime)	20.0	10.5	500,000	500,000	50,000
	3	1630 (post-game)	18.0	7.5	500,000	300,000	80,000
9/26/87	1	1150 (pre-game)	19.5	7.5	24,000	13,000	13,000
	2	1435 (halftime)	20.0	7.5	92,000	92,000	4,900
	3	1620 (post-game)	20.0	7.5	54,000	35,000	13,000
	4	1705	20.0	6.75	>240,000	54,000	92,000
11/14/87	1	1145 (pre-game)	18.5	18.0	54,000	54,000	22,000
	2	1345	19.0	-	4,900	2,200	490
	3	1500 (halftime)	19.0	-	24,000	24,000	4,900
	4	1610 (post-game)	19.0	22.5	13,000	13,000	2,200

Notes:

All grab samples taken in creek channel near Women's Faculty Club.

All bacteriological results are #/100 ml (MPN).

Attendance on 9/5 was 37,000 ; 9/26 was 62,000 ; 11/14 was 38,000

4.3.2 Cooling Towers

Cooling towers are used to air condition computer and animal research facilities as well as to provide cooling water for laboratory use. To save money on a short-term basis, sometimes no cooling towers are constructed and/or no back-up cooling systems are put in place. In these instances, straight EBMUD water is piped through the system for cooling purposes. This results in excessive water consumption as well as scaling of the piping, and is fairly expensive over the long term. Some cooling towers also constantly overflow to control excessive slime and solids which float to the top of the towers and are subsequently flushed out.

A variety of chemicals are added to some or all of the cooling towers to prevent clogging or scaling of the piping systems. These chemicals currently include:

polyethylene ethylene dichloride
tributyl tin neodecanoate
potassium phosphonobutane
potassium diphosphonate
polymeric, cationic electrolyte
triazole inhibitor
surfactants
aliphatic glycol
sodium hydroxide
sodium dichloro-S-triazine trione, dihydrate
chlorine (phasing out)
sodium nitrite (phasing out)
sodium chromate (phasing out)
5-chloro-2-methyl-4-isothiazolin-3-one (phasing out)
2-methyl-4-isothiazolin-3-one (phasing out)

Blow-down of the cooling towers is done once a week to maintain a low solids content. Small towers are only blown down about once a month. This purging discharge contains a high solids content and the various treatment chemicals. A significant number of the cooling towers on campus discharge into the storm sewer system and hence, the creek.

There are approximately 36 University operated cooling towers in the watershed, 16 of which were reported to discharge into the storm sewer system (Grove, 1970). This does not include any possible cooling tower discharges from LBL. Grove reported the following building cooling towers discharged to the storm sewer system:

Campbell Hall (2)
Space Sciences
Donner Lab
Cory Hall
Davis Hall - (3rd floor)
Etcheverry Hall (4)
University Hall
Moffitt Library
Life Sciences Building (2)
Latimer Hall
Birge Hall

In addition to these reportedly discharging to the storm sewer system, another 11 towers were reported to be possibly discharging to the sanitary sewer system, but this was not certain. The remaining tower discharges could not be identified. It is not accurately known how many towers discharge into the creek or what the water quality impacts of these discharges are at this time.

5.0 MANAGEMENT STRATEGIES

Management strategies can be differentiated into those which pertain strictly to Strawberry Creek and its riparian areas and those which broadly apply to the entire watershed. Section 5.1 outlines recommendations on several aspects of creek management including control of point source pollution as well as creek and riparian area stabilization and restoration. Watershed management techniques focus on the control of non-point source pollution, erosion control, and stormwater management.

5.1 Creek Management

This section outlines recommendations for point source pollution control, channel stabilization and grade control, as well as riparian habitat restoration. These recommendations are focused on the central campus reaches of the creek, but are applicable to all stretches of Strawberry Creek.

5.1.1 Point Source Controls

The sources of direct discharges to the creek need to be further investigated. Evaluation of building discharges into the cross-campus culvert should be a priority. All wastewaters should be routed into the sanitary sewer system. Updating and verification of the DOFM storm sewer maps needs to be done as soon as possible to better delineate the creek drainage system and detect sources of contamination. Existing problems with the sanitary sewer system should be corrected as soon as possible.

Periodic comprehensive evaluation of the campus sanitary sewer system should be done at least once every ten years. This would consist of dye testing performed from both inside the campus buildings and from the sanitary sewer manholes. Bacteriological sampling could also be conducted to evaluate suspected areas of sewage leakage. Televising of selected sections of sewer line could then be done to pinpoint the sources and extent of the problem.

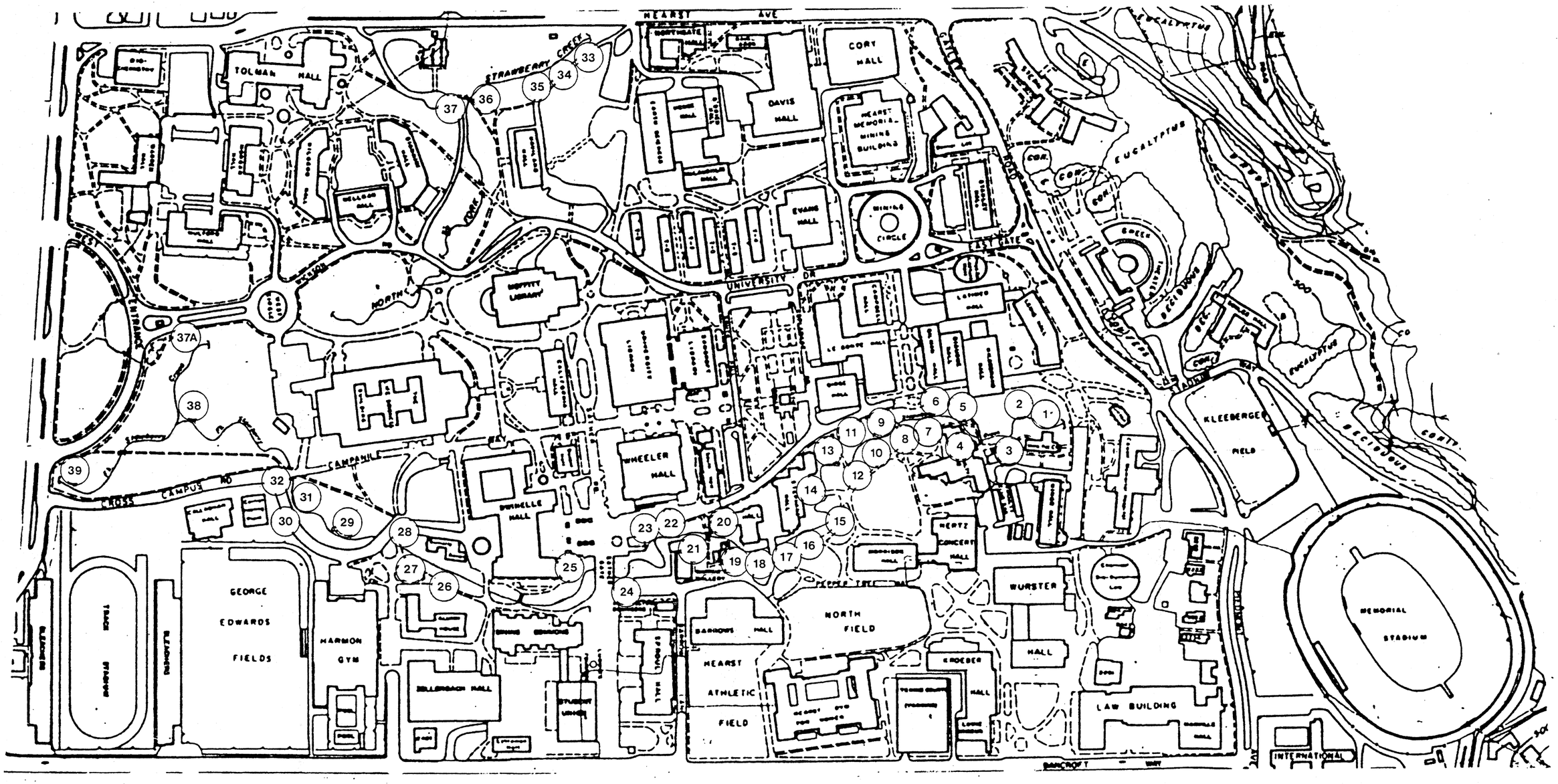
Blow-down from building cooling towers or other sources should be routed to the sanitary sewer system. The thermal discharge from the heating plant should also be routed to the sanitary system. Cooling towers and appropriate backup systems should be installed in buildings where cooling water is needed. Straight EBMUD water should not be used for cooling purposes for conservation reasons.

The design and construction process for major campus projects should be revised to incorporate more internal review from DOFM engineers. The present process has the design, construction, and supervision of major projects being done solely by outside contractors with insufficient opportunity for internal review by DOFM personnel. The result is short-sighted, incremental, and often inferior design and construction. This approach leads to premature deterioration and problematic design of the entire campus infrastructure. Consequently this results in degraded water quality of Strawberry Creek from both point and non-point sources of pollution.

5.1.2 Channel Stabilization

Strawberry Creek has been degrading or downcutting into its streambed for some time due to natural equilibrium processes. This has caused considerable undercutting of streambanks. Bank erosion has been accelerated by the high peak storm flows in the creek. In addition, channelization and channel confinement have resulted in further downstream erosion and scouring of the streambed, contributing to loss of aquatic habitat. Streambanks in narrow confined areas should be stepped back if space permits and the confining walls replaced with "biotechnical" bank stabilization techniques. All areas of "hardened" concrete streambed should be removed. Central campus creek sites in need of rehabilitation or stabilization are shown on Figure 16 and described in Table 24.

The use of biotechnical solutions for bank erosion are emphasized in this report because of their cost effectiveness, durability, and environmental compatibility compared to strictly structural methods. The engineering and aesthetic aspects of these methods improve over time in contrast to strictly structural methods which tend to deteriorate over time. Biotechnical methods allow plants and structures to function together in an integrated and complimentary manner. Biotechnical or "bioengineering" systems



LEGEND

REHABILITATION / STABILIZATION SITE

0 80 160 320 FEET

N

STRAWBERRY CREEK MANAGEMENT PLAN	PREPARED FOR THE OFFICE OF ENVIRONMENTAL HEALTH AND SAFETY UNIVERSITY OF CALIFORNIA, BERKELEY SEPTEMBER 1987	FIGURE 16 REHABILITATION SITES

Table 24. Strawberry Creek Rehabilitation/Stabilization Sites

Site	Description
	Old South Fork channel
1	Undercut (<1') stone wall at Women's Faculty Club
2	Construct apron for drainage pipe
3	Undercut stone wall opposite Senior Hall
4	Remove "hardened" bed 15' reach at Faculty Club
5	Old check dam at Faculty Club undermined and bypassed, deflecting flow into opposite streambank.
	South Fork
6	"Hard bed" 5' section upstream of utility overcrossing by Faculty Club
7	Undercut footing for utility overcrossing upstream of Phoebe's Bridge
8	"Hard bed" 5' section above Phoebe's Bridge next to old stump
9	Rehabilitate old check dam below Phoebe's Bridge
10	Repair apron for Le Conte drain pipe?
11	Check dam splash plate rehabilitate?
12	Extend existing concrete wall below creek bed
13	Cement chunk (12' x 4') below Faculty Glade Bridge & undermined inside bank
14	Stone wall undercut @ Stephens footbridge (severe > 2')
15	Undercut stone wall around wooden footbridge (>1')
16	"Hard bed" upstream of Stephens Bridge and around footings
17	Steep 12' soil bank eroding slowly south side upstream of Stephens Bridge
18	"Hard bed" downstream of Stephens Bridge & undercut walls
19	Major undercutting "hard bed" Moses-Pelican area and walls
20	Major undercut Moses footbridge footing & opposite rock wall
21	Major undercut (>2') of footings for retaining wall upstream of Substation
22	Minor undercut footing utility crossing by Substation
23	"Hard bed" @ entrance to bypass downstream of Substation
24	Rehabilitate check dam upstream of Sather Gate
25	Undercut (1.5')streambank and 20' section of stone wall downstream Gate
26	"Hard bed" opposite Dwinelle Annex (100' reach)
27	"Hard bed" 30' reach just downstream of above stretch
28	Bay tree in footbridge severely undermined
29	Chunk (10' x 5') aggregate concrete in channel (old dam)
30	Undercut bank opposite rock wall (20' reach >2') & stabilize toe of rock wall
31	Undercut check dam splash plate
32	Stabilize toe of rock wall
	North Fork
33	(2) Bay trees undercut; two chunks (cement 8'x2' and rock wall 6'x6') in channnel
34	Undercut banks; remnant rock wall standing & big chunk also
35	Steep banks undercut; chunk old wall deflecting flow into bank
36	Undercut footbridge footings; "hard bed" underneath
37	Severe undercut (2') banks below check dam downstream of footbridge
37A	Undercut stone wall (minor)
	Main Branch
38	Undercut check dam at confluence of two forks bypassed; needs repair
39	Erosion northern streambank @ entrance city tunnel @ Oxford Street

Note: Generally minor streambank undercutting is apparent along most of the Main Branch and North Fork channels.

generally combine live native vegetation with indigenous natural structural materials such as wood, stone, or brush. The following methods are recommended for future use in Strawberry Creek.

1. Revegetation: This is one of the simplest methods and has many advantages. The flexibility and resilience of vegetation increases surface roughness and reduces water velocity. This reduces streambank erosion and provides an opportunity for sediment filtration and deposition. The binding network of plant roots increases the shear strength of the soil which further reduces erosion. Vegetation provides a canopy which shades the creek and provides cover which enhances both wildlife and aquatic habitat. The high regenerative capacity of many riparian species allows vegetative stabilization techniques to be self-healing and self-supportive in contrast to traditional structural methods. Vegetation also provides an aesthetically pleasing appearance over a long time period. In addition, vegetative cover intercepts precipitation, reducing the impact of direct rainfall on soil and thereby reducing compaction and erosion.

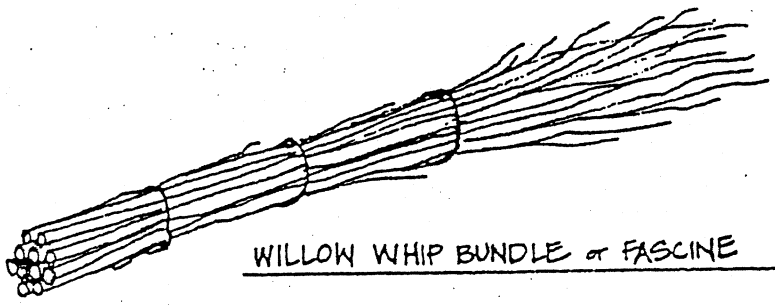
   When selecting vegetation for streambank stabilization or erosion control, a range of riparian vegetation should be considered. Pioneer or invasive species are particularly suitable for disturbed sites. Willows, alders, and other native riparian species have been used successfully and inexpensively in urban stream restoration projects. Another factor to consider in vegetation selection is the length of time needed for the plants to become established. Species selection should be based on soil compatibility, moisture holding capacity of the soil, and streambank slope. In scoured areas, woody plants established at the toe of the streambank in conjunction with grass planted above the toe have proven to provide good bank protection.

   The list of native riparian vegetation given in Appendix C should be used as a guide for revegetation and restoration of riparian plant communities. These are most effective for streambank stabilization if planted during the autumn dormant period. Vegetation can be combined with a variety of other biotechnical stabilization techniques.

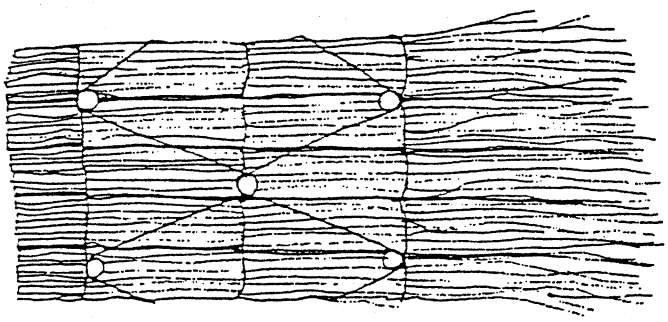
2. Live fascines (wattles): This is a flexible simple method that requires little soil disruption and grows into a natural aesthetic installation. Fascines are bundles of live plant cuttings which are wired together and secured into a streambank with live or dead stakes. These bundles are often placed on slopes parallel to the contour and can be used in combination with other vegetative stabilization techniques. Fascines are ideal for protecting streambanks from undercutting and seepage. They are particularly effective at the toe of banks subjected to scour and in situations where water level fluctuation occurs. At the water's edge at the toe of banks this method is durable even before the live cuttings have rooted. Willows are ideal plants to use in fascines.

3. Live cuttings/Brush matting or layering: This method involves planting rows of live riparian species cuttings to protect eroding streambanks or to modify a stream meander (Figure 16). This technique also includes "Palmiter" methods of staking dead trees or limbs (brush matting) to eroding banks in order to slow water velocities on outside bends to allow for volunteer plant growth to establish itself. Live cuttings can also be planted in the brush matting. Matting may also employ live plant materials stacked on the streambanks. Brush layering techniques use live branches of riparian shrub or tree species inserted perpendicularly into the banks so that rooting occurs back into the slope of the bank rather than parallel to the slope as in brush matting. The established vegetation then stabilizes the bank through the root system which resists shear failures or slippage.

4. Gabions: These are rock filled wire mesh baskets which are wired together and filled in place with rock and soil to form a continuous bank stabilization structure (Figure 17). This method may be used in narrow channels or in situations where the banks are too steep for other types of protection. However, use of gabions is recommended only if it supports revegetation of the channel. Gabions are flexible and porous, therefore they eliminate hydrostatic pressure buildup by allowing streambank seepage. Soil may be mixed with the rocks during filling of the gabions and subsequently planted with cuttings of native riparian species. If necessary, filter cloth can be used to help retain the soil in the gabions. As the vegetation matures, the durability and permanency of the installation will increase.

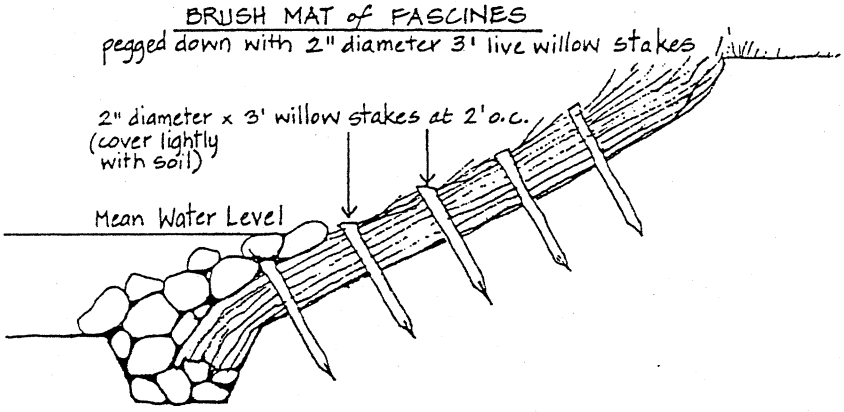


WILLOW WHIP BUNDLE or FASCINE



PLAN VIEW

BRUSH MAT of FASCINES
pegged down with 2" diameter 3' live willow stakes



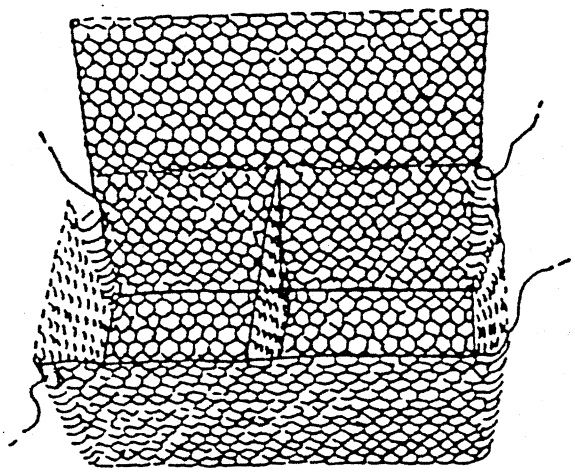
SECTION
wire down mat with criss-cross wires

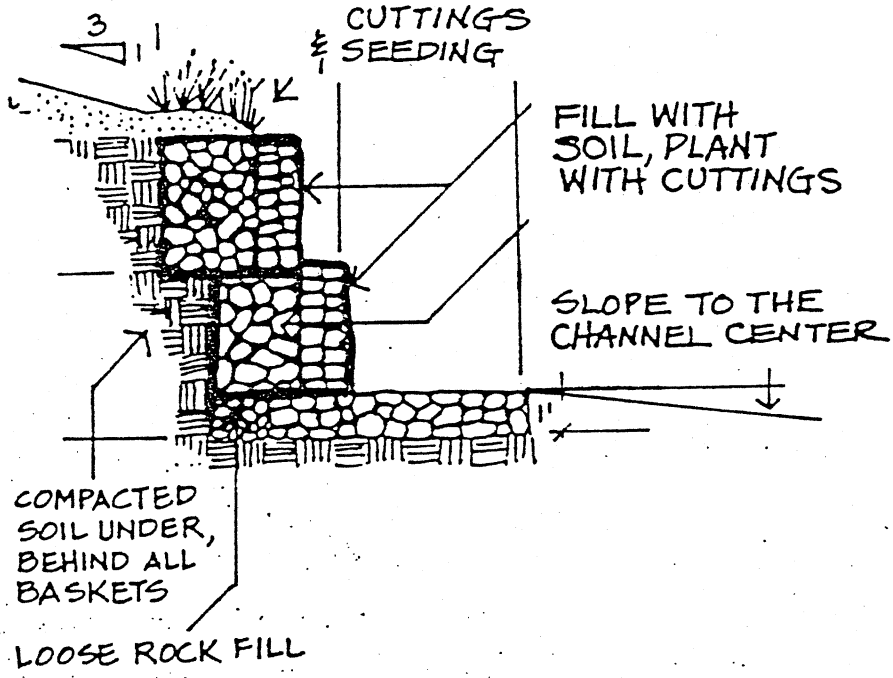
BRUSH MATTING - SCHEMATIC DETAIL

SOURCE: STONE, 1985

STRAWBERRY CREEK MANAGEMENT PLAN	FIGURE 17 BRUSH MATTING

TYPICAL GABION CAGE





GABION BASKETS STACKED IN STAIRSTEP FASHION TO FORM A CONTINUOUS REVETMENT

SOURCE: RILEY, 1987

STRAWBERRY CREEK MANAGEMENT PLAN	FIGURE 18 GABIONS

5. Wooden crib walls: These structures are built sloping back against steep streambanks in situations where a retaining wall is needed for stability. Crib walls are particularly effective in areas with steep banks that experience high velocity flows. A rectangular framework of timbers or logs is assembled in log cabin fashion (Figure 19). The void spaces between the wooden members are filled with soil and rocks to provide strength and weight. Vegetation can be incorporated into crib walls by planting through the slats in the cribwork. This will result in an installation that achieves slope stabilization while retaining a natural appearance. By the time the wooden members rot out, the plant materials will have taken over the structural function of bank stabilization.

6. Concrete crib walls: These crib walls are constructed of reinforced concrete structural members. Most crib walls in use today are built in this manner. Concrete crib walls are generally more durable and can be built to greater heights than wooden timber cribs. The basic construction and vegetation planting principles are identical to those employed in wooden cribs. Several concrete crib wall systems or designs are available. These systems differ in the shape of the structural members, wall configuration, structural connections, and erection procedures. Two examples of the range of designs available are the Hilfiker Concrib wall and the Humes Pincrib or Minicrib walls.

7. Welded wire walls: These are composite wire and granular fill structures built by placing welded steel wire mats between successive layers of fill material. The L-shaped form of the wire mats is designed to both reinforce the fill material and contain the face of the structure. The wire mats are lightweight and may be easily prefabricated. In addition to their low cost, flexibility, and ease of construction, welded wire walls can be planted with vegetation that will grow through the wire mesh. Plant roots help bind the structure together as well as providing aesthetic amenity.

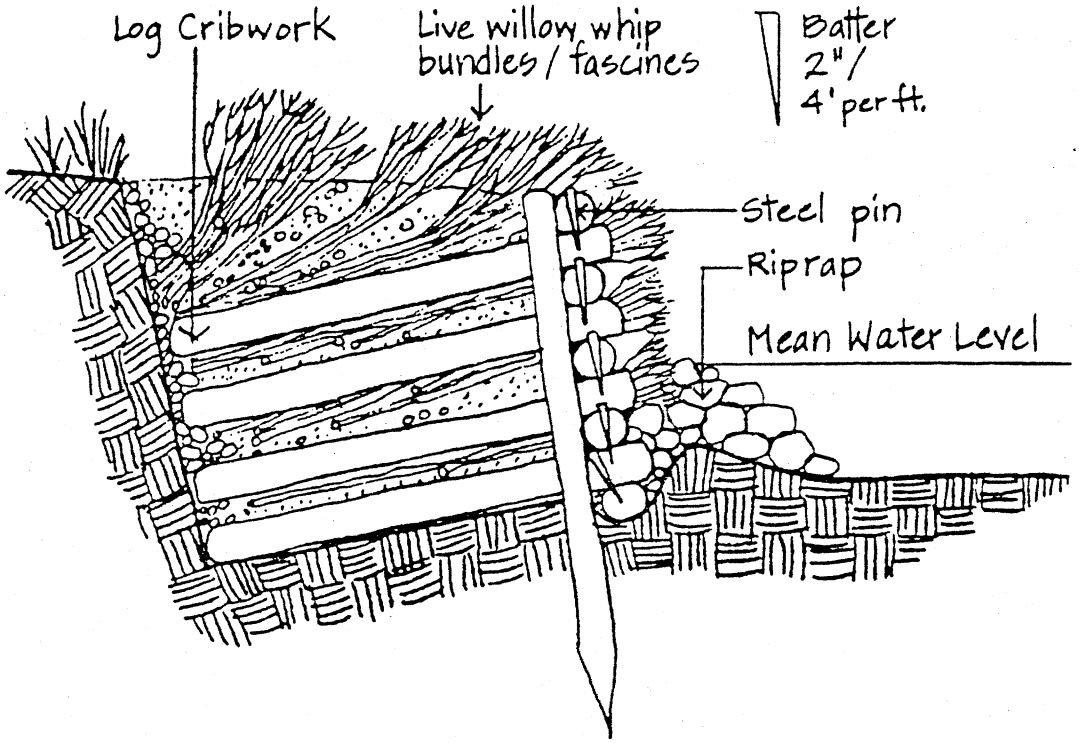
8. Dry stone walls/Rock walls/Wooden plank walls: In particularly difficult areas characterized by steep or vertical banks, confined working space, and high velocity flows these techniques may be useful. Extensive hand labor and skill is required to build a mortarless dry stone wall, but they are quite effective and durable. The rocks can be interplanted with native vegetation that serves both an aesthetic as well as an important structural function.

9. Riprap (stone dikes): Riprap consists of carefully placed layered stones or boulders generally placed parallel to the toe of the bank to deflect flows and provide toe protection. It is one of the most common and effective methods of bank protection and is applicable under most conditions where bank erosion occurs. Riprap may be placed along the bank slope's natural angle of repose to help control the erosion and induce sedimentation behind the riprap. It is flexible enough to settle and conform to the final streambed contour if scour is a problem. Riprap may also protrude from the bank as a "hard point" which provides some degree of flow deflection, allows sedimentation, and acts as a tieback to riprap placed along the bank to prevent flanking. Areas not covered by riprap may be protected by vegetation. Limitations to the use of riprap include the availability of suitable rocks as well as the difficulty and expense of rock placement.

10. Chemical stabilization: A number of chemical substances such as acetates, resins, latexes, and lime can be used to help prevent erosion of streambank soils by increasing the cohesiveness of the soil. Researchers found that when lime was mixed with clay, complex calcium and aluminum silicates formed as reaction products which imparted hydrophobic or impervious properties to the soil (U.S. Army Corps, 1981). A thin layer of topsoil can then be placed over the soil-lime mixture to permit the growth of vegetation.

5.1.3 Grade Control / Protection

Control of the stream channel gradient is essential to stop further incision or downcutting of the streambed and to prevent streambank undercutting and erosion. This section gives some examples of structures which reduce and maintain channel gradients and/or reduce the excess energy of flowing water. By reducing the channel gradient, a reduction in water velocity is achieved which prevents bank erosion and streambed scouring, especially during peak flow periods. Likewise, energy dissipation structures may be installed temporarily or permanently as culvert appurtenances or at the foot of steep slopes to dissipate the energy of peak flows.



CRIBWALL - SCHEMATIC DETAIL

SOURCE: STONE, 1985

STRAWBERRY CREEK MANAGEMENT PLAN	FIGURE 19 WOODEN CRIBWALL

1. Check dams: These structures may be used to stabilize grades and control headward erosion in either natural or artificial channels (Figure 20). The existing check dams along Strawberry Creek have significantly reduced streambed degradation on the central campus. Check dams prevent bank erosion by reducing flow velocities and dissipating excess energy through the formation of a waterfall. Sediment accumulates above these small dams to some extent, helping to produce slightly gentler upstream gradients. Aquatic habitat is also improved because of the formation of pools upstream of the dams. Check dams may be constructed of logs, planks, rocks, staked brush, or staked hay bales. Rock weirs with accompanying rock sills have also been successfully employed. Rehabilitation of the approximately thirty deteriorating check dams on the central campus can be easily and economically accomplished in most cases. This should be done as soon as possible to control further streambed incision.

2. Drop structures: These are either inlets or weirs in which flow passes over or through an opening and then drops to an approximately level basin or apron and thence into the downstream channel. These structures may be used to control steam gradients in either artificial or natural channels. They may be more costly than some other types of structures where the required discharge capacity is less than 100 cfs and the total head/drop is greater than 8-10 feet (Amimoto, 1978). Drop inlets are already located at the entrance to the Little Inch bypass culvert above Haas and at the entrance to the city tunnel above Highland Avenue in North Berkeley.

3. Energy dissipators: Examples of strictly energy dissipating devices include:

   A. Hydraulic jump: This is a permanent concrete structure used to dissipate the energy of concentrated runoff flowing down very steep slopes. This structure occupies a rather small area, but unless continually maintained, sediment deposits inside the structure will decrease its effectiveness. Formal engineering design is required. Several of these are in place in the North Fork drainage system at the LBL complex.

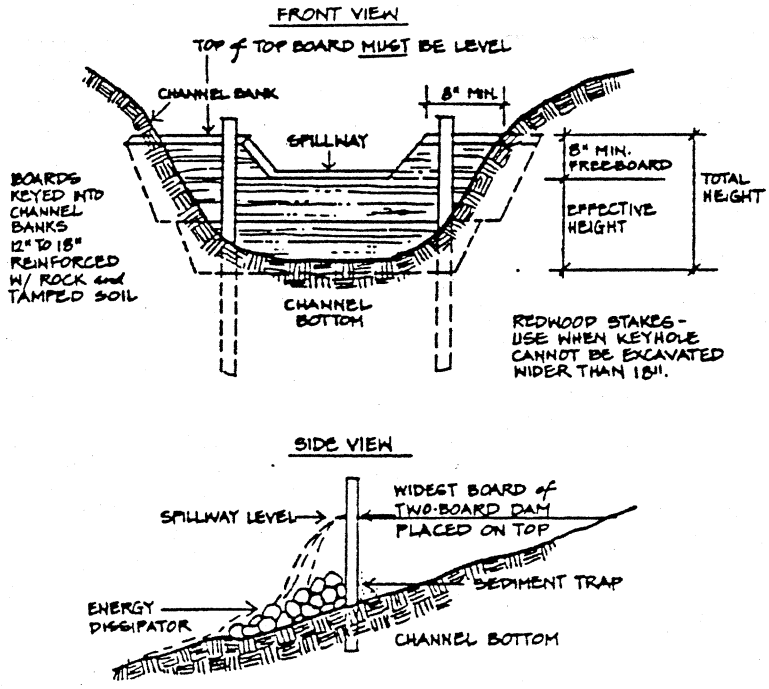
   B. Discharge aprons: These are used to reduce the velocity of water flowing from a culvert or pipe or in other situations where flow is concentrated on a small area. Riprap or smaller hand-placed rocks are often used. Individual rocks must be of sufficient size to remain in place under a heavy flow of water. At least two layers of rocks are often needed to provide sufficient depth to prevent undercutting. Very heavy or continuous flows should be discharged onto a concrete or prefabricated metal apron.

5.1.4 Aquatic Habitat Restoration

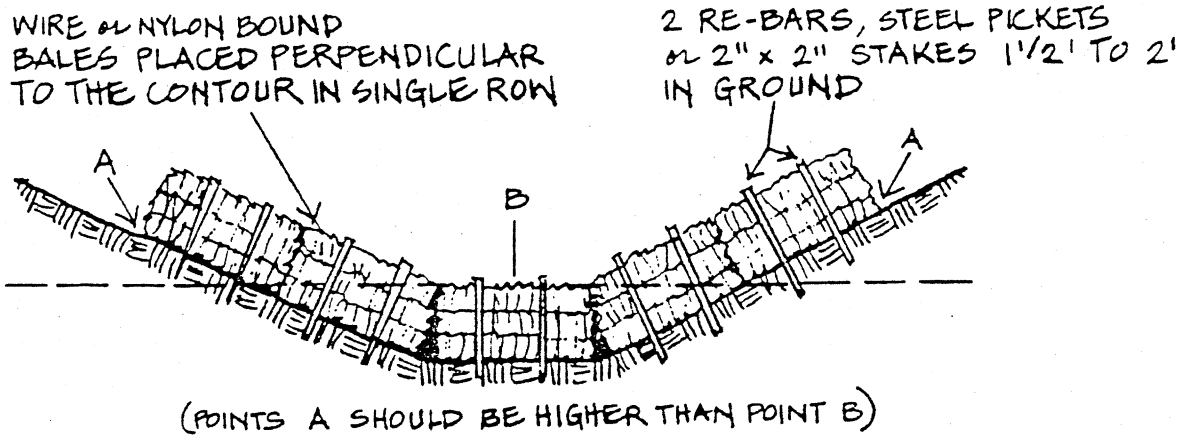
Urbanization has resulted in a very "flashy" hydrologic regime in Strawberry Creek. Channelization and channel confinement of the creek on the central campus has compounded the problem. Baseflows are quite low most of the year and the shallow flow is dispersed over the streambed. Wet weather peak flows scour the streambed and flush aquatic organisms downstream. The natural pool-riffle sequence of the creek has been destroyed along with aquatic habitat and cover.

It is necessary to restore the natural pool-riffle sequence to provide habitats for the feeding, breeding, and cover of aquatic life. Artificially smooth cement walls that accelerate streamflow should be removed and replaced with biotechnical streambank stabilization methods that incorporate natural riparian growth along both sides of the channel. Check dams are effective in restoring a more natural pool-riffle sequence but also act as physical barriers to migration for aquatic life. Other techniques that can be employed to improve habitat in modified channels include submerged spillways and sills (low structures that create upstream pools and downstream riffles), deflectors and rock clusters used to develop pools (Figure 21), and cover devices such as previously described brush matting or layering.

Reestablishment of desired aquatic species should gradually occur as water quality improves in Strawberry Creek. Actual reintroduction of species will have to be evaluated in the future and will depend upon the water quality and suitability of habitat in the creek. Important physical habitat factors include amount of shading, water depth and velocity, water temperature, substrate conditions, organic material, establishment of vegetation, and the development of a pool-riffle regime.



SCHEMATIC DRAWING of SPLIT REDWOOD BOARD CHECK DAM

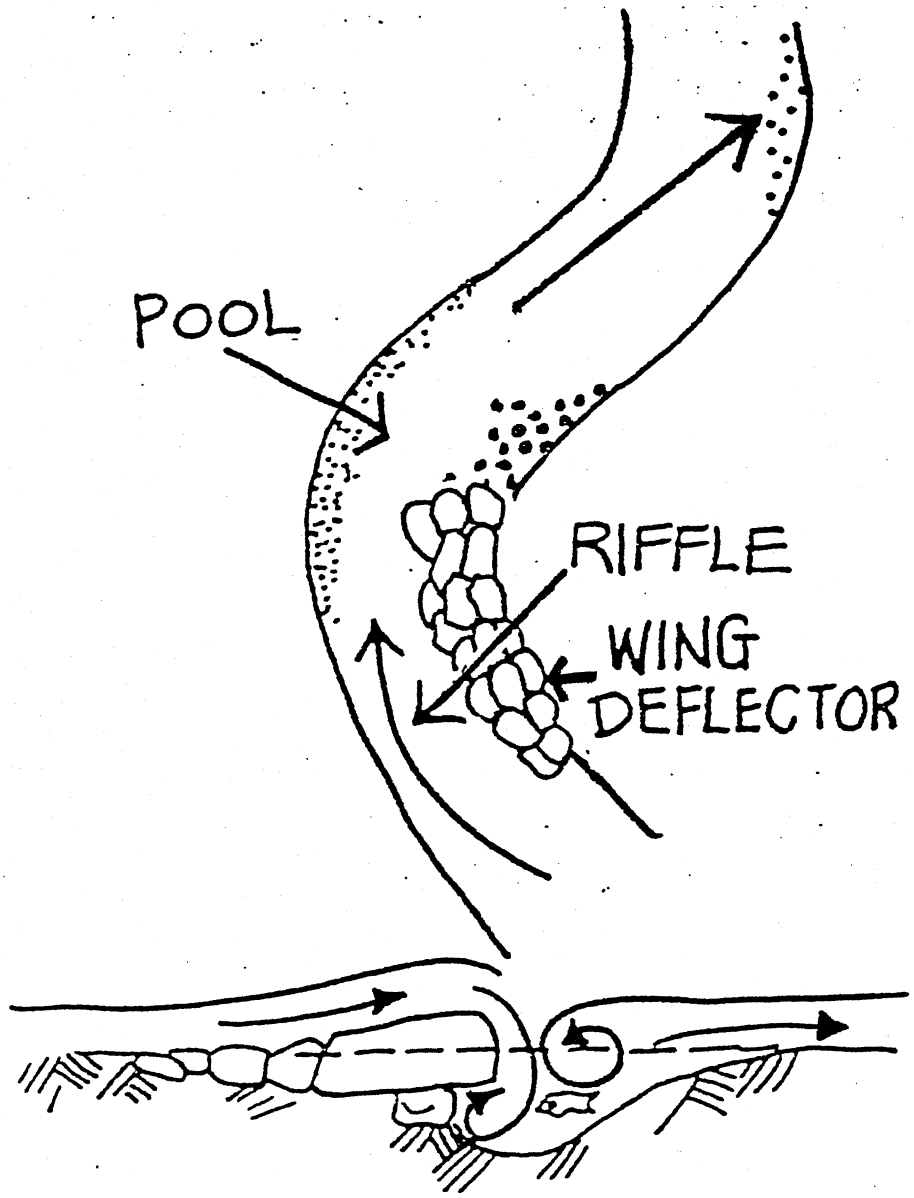


(POINTS A SHOULD BE HIGHER THAN POINT B)

STRAW BALE CHECK DAM

SOURCE: STONE, 1985

STRAWBERRY CREEK MANAGEMENT PLAN	FIGURE 20 CHECK DAMS



DEFLECTORS AND ROCK CLUSTERS FOR DEVELOPING POOLS AND RIFFLES

SOURCE: RILEY, 1987

STRAWBERRY CREEK MANAGEMENT PLAN	FIGURE 21 WING DEFLECTOR

5.1.5 Riparian Habitat Restoration

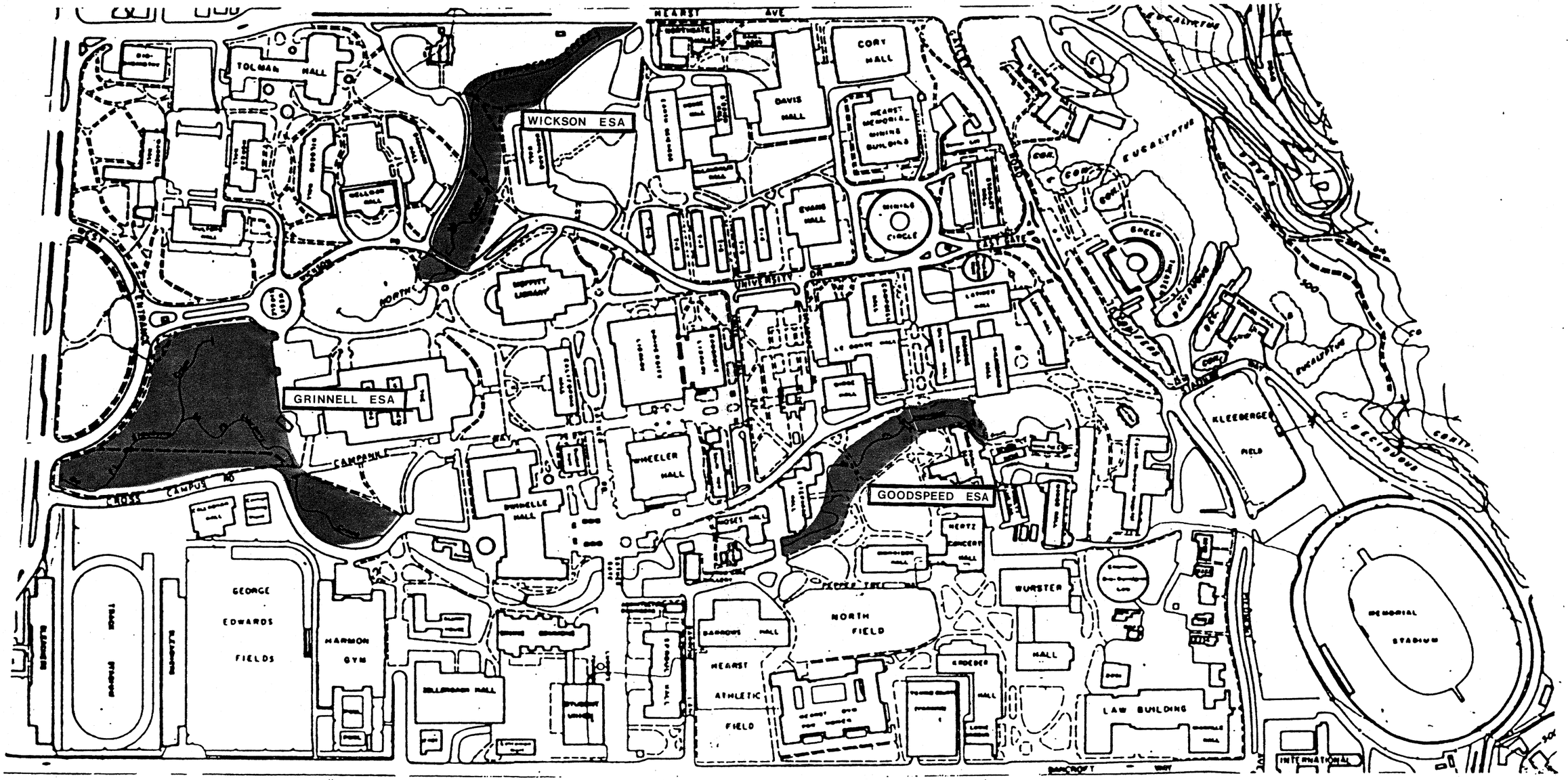
At the present time, the riparian corridors along the central campus show the effects of both long term lack of ecological management and heavy use. Overall, there has been a drastic reduction in both animal life as well as the ecological integrity and diversity of these riparian areas. Many exotic (non-native) species have been introduced into areas that were once exemplars of native vegetation. In addition, manicured institutional landscape management techniques have been previously applied to the natural areas resulting in the disturbance of these ecosystems. Although an urban campus cannot be expected to maintain truly wild settings, there is a need and use for natural areas for instructional, aesthetic, and ecological reasons. In their present condition, the riparian areas have not fulfilled their potential as a valuable teaching/learning or ecological resource.

In 1969, the University permanently established the Goodspeed, Grinnell, and Wickson "natural areas" along Strawberry Creek on the central campus (Figure 22). These three areas were dedicated to preserve "green space" on an increasingly urbanized campus and to protect and satisfy instructional needs in the natural sciences. In 1970, the Landscape Architecture Advisory Subcommittee (LAAS) renamed the central campus natural areas "nature areas" in recognition of the fact that these areas were not at all "natural." These nature areas may also be referred to as "ecological study areas."

In 1970, the LAAS recognized that a management policy of almost total neglect was neither appropriate or accomplishing the original objectives, and subsequently formulated recommendations for management appropriate to the nature areas. Their goal was to structure a program that would preserve wildlife habitat while enhancing the ecological integrity of the plant communities. However, these guidelines were never implemented because no funds were allocated and their recommendations faded into obscurity after the LAAS was phased out in the mid-1970's. Subsequently, the Committee on Conservation and Environmental Quality (CCEQ) formulated management recommendations which have remained in draft form to the present time. The following recommendations pertaining to the central campus nature areas are based upon the original LAAS Task Force recommendations and subsequent CCEQ management guidelines.

The following general guidelines should be considered in the management of the nature areas:

- Nature areas should be clearly defined and accorded the same stature as other teaching and research facilities.
- A faculty advisory committee should be formed to oversee long-term management and enforcement of guidelines.
- A detailed management plan that includes a public education program should be formulated for each nature area.
- Emphasis should be on replacing exotic (non-native) vegetation with indigenous plants over an extended period.
  Exotics could then be cut out gradually. Stripping of vegetation should be avoided.
- Some introduced native vegetation (such as redwoods) will have to be thinned or removed in appropriate areas to open up the understory for the establishment of a more diverse natural habitat.
- Restoration of native vegetation should be limited to the species listed in Appendix C.
- Native plant communities should be enhanced by the planting of appropriate understory and groundcover species as indicated in Appendix C. Concerns over security in these areas can be accommodated by the use of low-growing vegetation such as herbs and forbs in the redwood stands. In addition, discrete and skilled management along with barrier plantings should mitigate any concerns over safety.
- Biotechnical streambank stabilization methods as outlined in Section 5.1.2 should be used where appropriate rather than structural methods.
- A system of informational signs should be provided to inform the public of the management techniques and for species identification.
- The UC Botanical Garden and campus nursery should be utilized to propagate native vegetation.
- Detrital material such as dead trees and decaying ground cover should be left in place unless it poses a safety hazard to enhance wildlife habitat and allow for the study of natural processes.



STRAWBERRY CREEK MANAGEMENT PLAN	PREPARED FOR THE OFFICE OF ENVIRONMENTAL HEALTH AND SAFETY UNIVERSITY OF CALIFORNIA, BERKELEY SEPTEMBER 1987	FIGURE 22 CENTRAL CAMPUS ECOLOGICAL STUDY AREAS

- Diversity of vegetation should be maximized within the limits of appropriate native plants.
- No spraying should be allowed except as absolutely necessary.
- Appropriate paths should be laid out to reduce disturbance and compaction.
- Plants, animals, or other materials should not be removed from the nature areas without permission of the faculty committee.
- rock clusters should be introduced in certain areas for habitat diversity.
- Groundskeepers should be trained in ecological management techniques and supervised by the campus Landscape Architect or another person trained in natural landscape management.
- A walking tour of the central campus should be established for public education and enjoyment of the nature areas.
- A review mechanism should be provided to assess the impacts of proposed campus development or other changes in the natural landscape.

The following recommendations pertain to the specific nature areas:

Goodspeed Nature Area

- This nature area lies in the heart of a formally landscaped, heavily used portion of the campus so this area will need to be compromised between a natural and more formally developed landscape more so than the other nature areas.
- Area west of Church footbridge is basically cultivated and should remain so.
- Dead limbs and shrubs should be removed in the area west of Church Bridge and thinning performed as plants become overcrowded and overshaded. The arrangement and trimming of plant material in this area should permit views of the creek and environs over the groundstory planting and under the tree canopy.
- Understory west of Church Bridge should be enhanced with redwood associates due to the stand of mature redwoods present here.
- The rhododendrons and azaleas east of Church Bridge are nearing the end of their life span. These shrubs and other invasive understory vegetation should be phased out and replaced with native plants. The various non-invasive understory plants should be preserved for botanical and aesthetic variety.
- Middlestory plantings east of Church Bridge should remain high (10 feet or more) to preserve the backdrop and privacy of Faculty Glade.
- Diseased and declining trees east of Church Bridge should be phased out and replaced with native riparian species.
- Streamside border plants such as sedges, horsetail, and water parsley should be preserved and enhanced as they rarely grow downstream due to scouring of the channel.

Grinnell Nature Area

- The Eucalyptus Grove should be enhanced through tree maintenance and replacement.
- Fallen trees should be left alone and vegetation remain thick to provide a solid border to the Eucalyptus Grove and creek.
- The LeConte Pine Grove area should remain in an uncultivated condition. A few dead pines and oaks should be left both for visual interest and educational purposes unless they pose a safety hazard or interfere with healthy growth.
- Invasive species and diseased shrubs should be removed form the Pine Grove area. Overcrowded and overshaded vegetation should be thinned in favor of the pines and oaks. Native grasses should be planted here as this is one of the only amenable habitats on the central campus for grasslands.
- The Oak Grove south of LSB should be enhanced by tree maintenance and replacement. The Grove and oak leaf mulch ground layer should remain as is. Additional varieties of beech could be planted north of this Grove for teaching purposes and to extend the life of the Oak Grove.
- Creekside planting should be cleared of invasive species which are dead, diseased, or interfering with more important native species. Shrubs should be kept solid but trimmed to prevent overcrowding or interference with specimen native vegetation.

Wickson Nature Area

- In the area between Wickson Road and the University House footbridge by Haviland Hall invasive species should be phased out and replaced with redwood associates.
- All trees and shrubs south of the footbridge should be pruned to allow light penetration for understory growth. Weak specimens that have been overcrowded or overshaded should be removed.
- The variety of plant species south of the footbridge should be preserved and the various specimen trees enhanced by careful trimming of the plants around them.
- The creek south of the footbridge should be about 50% visible, and shrubs should not be higher than eight feet.
- The area between the footbridge and North Gate has a less cultivated appearance and should remain this way.
- Diseased trees and overcrowded specimens north of the footbridge should be removed. Important trees should be pruned and encroaching plants trimmed.

In creek areas outside the nature areas, exotic vegetation should be permitted to maximize the diversity of the campus landscape. These areas already contain a number of exotic species which serve to attract birds and other wildlife that would not ordinarily inhabit these areas. Exotics may be planted along the North Fork from University Drive to the West Circle and along the South Fork from Cross Campus Road to Stephens Hall. Aging and stagnant plantings should be renewed to enhance the appearance and functionality of these areas.

5.2 Watershed Management Techniques

5.2.1 Non-Point Source Controls

This section presents recommendations on non-structural Best Management Practices (BMP's) for the control of surface runoff from various sources. A BMP is a practice or combination of practices determined to be the most effective and feasible means to prevent or reduce water quality degradation. BMP's specifically pertaining to stormwater management and soil erosion control are discussed in Section 5.2.2.

1. Control direct discharges into storm drains: Recurring problems have been noted with contractors and maintenance personnel disposal practices of leftover materials. Personnel performing cement, stucco, or painting activities have disposed of slurry and paint materials by dumping them down into catch basins. Surface runoff of excess cement slurry material into catch basins has also been noted. Once having entered the storm drain system, these materials will eventually be flushed out into Strawberry Creek when sufficient runoff flow occurs. Problems have also occurred in the past with backflushing of the Haas area pools. When more than one tank was backflushed at a time, overflow of chlorinated pool water ran into the storm drain system and hence, the creek. Chlorine may combine with ammonia-nitrogen in the creek to form chloramines (combined chlorine residuals) which are deleterious to aquatic life. Personnel at Haas were advised of the situation and their practices were modified. Disposal of used crankcase oil and various other chemicals into the North Berkeley storm drains is also a concern. Anti-dumping ordinances and regulations should be enforced. Dumping of any materials into catch basins should be expressly prohibited in all applicable DOFM and LBL policies and contracts.

2. Evaluate chemical use practices: The following herbicides and pesticides are currently in use on University grounds:

   Herbicides (active ingredients)

   Buctril (octanoic acid ester of Bromoxynil or 2, 6-dibromo-4-cyanophynloctanoate)
   Brush-B-Gone (3, 5, 6-trichloro-2-pyridinyl-oxyacetic acid)
   Roundup (n - phosphonomethyl glycine)
   Turflon (3, 5, 6-triohloro-2-pyridinyl-oxyacetic acid and butoxy ethyl ester)
   Fusilade (fluazifop-p-butyl)
   Fusilade 4E (oxyl propanoate)
   Surflan (3, 5-dinitro-N, N-dipropylsulfanilamide)

   Pesticides (active ingredients)

   Sevin (1-naphthyl-N-methylcarbamate)
   Malathion (S-[1, 2-dicarbethoxyethyl]-0, 0-dimethyldithiophosphate)
   Orthene (acephate or O, S-dimethyl acetylphosphoramidothioate)
   Mecomec 2.5 (4 chloro, 2 methyl-phenoxy propionic acid)
   Diazinon-5OW (0, 0-diethyl-0-[2-isopropyl-6-methyl-4 pyrimidinyl]-phosphorothioate)

   In addition, Chem Lawn Corporation treats 435,000 ft^2 of turf, mostly in the Central Glade area, six times per year. Chem-Lawn applies the following chemicals to the "Priority 1" turf areas:

   Ureaform base fertilizers

   1.5 lbs. N/1000 ft^2 (3 liquid and 3 dry applications annually)
   0.44 lbs. PO_4/1000 ft^2 (ammonium polyphosphates, 3 wet applications annually)

Herbicides

A. Broadleaf Weed Control (post-emergent, 3 applications annually)

Banvil 45 (Dicamba)
Turflon (see above)
Maintain CF 125 (growth retardant, chloryl slurenol methyl esters)

These three chemicals are applied at a rate of 0.13 lbs. active ingredient/acre.

B. Pre-emergent Weed Control (2 applications annually early in the year)

Pre-Em (pendamethylin)

This is applied at a rate of 1.5 lbs. active ingredient/acre. Chem-Lawn also applies iron sulfate (chelating agent) twice annually at a rate of 0.1 lbs. active ingredient/1000 ft^2.

The amounts of these various pesticides and herbicides applied to central campus areas should be documented in order to assess the significance of chemical usage. If significant amounts of these chemicals are being applied, then the extent of runoff of these chemicals either directly into the creek or into the storm drainage system due to irrigation or other means should be assessed. If this appears to be a problem, the water quality impacts should be further investigated. Alternatives to heavy chemical usage should also be evaluated. Implementation of an integrated pest management program could significantly reduce chemical usage. The areal application of various chemicals in North Berkeley and at LBL and other sites should be further investigated.

3. Continued evaluation and maintenance of sanitary sewers: Detailed exfiltration studies should be conducted in North Berkeley and on the UC campus to further investigate and evaluate sewage contamination in Strawberry Creek. The DOFM sanitary sewer evaluation and rehabilitation program should continue until problems are resolved. Televising and dye testing of sanitary sewer lines has proven to be a valuable tool in discovering specific problems. The storm sewer system is also in need of updated mapping and evaluation. Possible sewage exfiltration problems into the North Berkeley creek tunnel should be further investigated.

4. Control littering: An anti-litter program should be established to determine means of reducing trash and debris accumulation in the creek in North Berkeley and on the central campus. This could include public information programs, provision of additional trash receptacles, and enforcement of existing ordinances or regulations. Litter control would help reduce nutrient loading and bacterial contamination as well as maintain capacity of the storm drain system.

5. Establish public education/information programs: Different programs should be initiated to educate the public and applicable UC and LBL maintenance/grounds personnel about their activities and subsequent water quality impacts. The general public needs to be informed of the effects of dumping materials into storm sewers and the home use of various chemicals. Property owners and residents along the North Fork in the city should especially be contacted. Grounds personnel should be knowledgeable about the impacts of applying various chemicals and should be properly trained and supervised. Likewise, maintenance personnel should be made aware of problems caused by dumping materials into catch basins or allowing them to run off into storm sewers.

5.2.2 Stormwater Management

Storm runoff from urbanized portions of the watershed adversely affects both the water quality and hydrologic regime of Strawberry Creek. An increase in trace metal, suspended solids, turbidity, COD, organic nitrogen, phosphorus, and bacterial concentrations occurred during wet weather. High peak storm flows accelerate streambank erosion and streambed scouring on the central campus as well. Emphasis for non-point controls should be placed initially on non-structural methods that do not require capital expenditures. These amount to no more than good "urban housekeeping" practices and management techniques to prevent pollution and mitigate the effects of urbanization. The following Best Management Practices (BMP's) should be considered for their applicability and implementation in the upper Strawberry Creek watershed.

I. Non-Structural Techniques

1. Improve street sweeping: Sweeping is the most common method used to reduce pollutant loading from streets and parking lots. Vacuum sweeping has proven to be much more effective than conventional broom sweeping for collecting fine particulates which contain a high percentage of pollutants. The effectiveness of present street sweeping practices should be evaluated. Guidelines should then be established and sweeping frequency, scheduling, or protocols modified as necessary. Special parking regulations can be instituted to allow sweeper access to curb and gutter areas. Operator training alone can significantly increase sweeping effectiveness. Emphasis should be placed on collecting fine curb-side materials, proper broom positioning, and operating speeds. Efficient sweeping can significantly reduce contamination by heavy metals, nutrients, organics, and bacteria. Typical removal rates are: 30-50% of total solids, 25-40% of BOD, 25-40% of TKN, 8-20% of phosphates, and 25-60% of heavy metals (ABAG, 1977).

2. Clean storm drain system: If cleaned regularly, catch basins are effective in removing approximately 56% of the total solids and 40% of the BOD from stormwater (EPA, 1977). However, if not cleaned on a regular basis, they fill with decomposing debris and become sources of nutrients, oil and grease, heavy metals, and bacteria. Catch basins should be cleaned with vacuum apparatus rather than flushing or other methods that purge solids down-gradient into the creek. Flushing lines in this manner also increases the probability of clogging storm lines. Preferably, catch basins and storm drain lines should be cleaned twice a year or at least once a year prior to the rainy season.

3. Preserve and enhance riparian areas: Riparian vegetation serves to uptake and filter out pollutants found in stormwater. Vegetation also slows the velocity of streamflow and runoff. Natural floodplain areas should be preserved because they act as natural stormwater storage reservoirs. A buffer strip surrounding the riparian corridors should be maintained.

4. Floodplain management: This technique includes all measures for planning and action which are needed to determine, implement, or revise plans for land use management of floodplain areas. Land use controls include implementation of design measures, floodplain regulations or acquisition, subdivision regulations, and the control of water or sewer extensions. Encroachment upon the floodplain should not be allowed. Riparian buffer strip requirements and performance standards for development in sensitive areas can be established. Efforts should be taken to control the amount of impervious surface over the entire watershed or to mitigate the impacts through structural techniques. Planning which controls development in the watershed is more effective than mitigation measures taken after development has occurred.

5. Erosion control: The following are non-structural methods for controlling erosion:

A. Protective coverings and mulches: Substances used include straw/hay, wood products, chemicals, and other materials which prevent soil erosion by reducing the effects of rainfall impact and runoff as well as providing a suitable environment for the development of vegetative cover. These should be used until grass or other ground cover is firmly established. Specific materials include:

Polyethylene sheets
Straw and hay
Punched straw
Net-anchored straw
Tackifiers with straw
Wood chips or sawdust
Gravel and stones
Mulch blanket
Wood fiber
Washed dairy waste
Chemical mulch (organic or plastic)
Wood excelsior mat
Fiberglass
Jute netting
Sod
Building blocks

B. Land grading practices: Where grading is necessary for construction purposes, grading practices should minimize erosion potential and facilitate vegetative establishment. Development should fit existing topography as much as possible to minimize land disturbance. Slope gradients and lengths should be kept to a minimum and terraces should be installed on long slopes. A terrace should be graded back towards the slope and drain with a gentle gradient to a stable outlet. The surfaces of cut and fill slopes should be left rough or be serrated so that they hold seeds well and allow for good vegetative establishment.

C. Establishing vegetation: This practice consists of planting trees, shrubs, vines, grasses, or legumes on critical areas. These areas are commonly severely eroded sediment-producing sites that require special management to establish and maintain vegetation in order to stabilize soil conditions. Permanent vegetative cover should be maintained on slopes. Fast-growing vegetation such as grasses are usually planted to initially stabilize disturbed areas. Factors to consider in plant selection include: erosion control effectiveness (fast growth, complete ground coverage, fibrous root mat); availability; drought tolerance/irrigation requirements; fire hazard; fertilizer requirements; application and maintenance costs.

D. Irrigation water management: This entails the use and management of irrigation water to prevent oversaturation of soils and to reduce erosion. Quantity should be determined by soil moisture holding capacity and the needs of the vegetation. Irrigation water should not be applied in excess of plant needs to prevent oversaturation of soils. Water should be applied efficiently to prevent erosion and excessive runoff which degrade the water quality of Strawberry Creek. At the present time, excessive runoff from the central campus turf areas is commonplace. The existing irrigation system is antiquated and almost completely manually controlled. High volume sprinkler heads and compacted soil conditions along with the lack of close supervision of the system's operation all combine to create excessive runoff from the turf areas. The irrigation system will be updated in the future as funds permit. Automation of the system would alleviate the need for manual operation by the overburdened gardeners. Aeration of the turf areas should be done to the extent that staffing permits. Vegetative cover other than turf should be considered to reduce the possibility of soil saturation by over-irrigation.

II. Structural Techiques

1. Diversion: Stormwater can be diverted to retention/detention areas or rerouted to bypass critical areas such as the central campus. The feasibility of rerouting stormwater from both forks, especially the North Fork, to the city storm drain system downstream of the central campus should be investigated. This would help mitigate the water quality and erosion problems on the central campus, but would require substantial capital expenditures. On a smaller scale, portions of the storm drain network in North Berkeley and on the central campus could be diverted to accomplish the same goals.

2. Detention: Temporary storage of runoff can reduce peak flows and subsequently ameliorate erosion and water quality problems. Many options exist for the construction of storage facilities by simply modifying existing sites and facilities. Detention facilities may be located on-site, upstream of highly developed areas, in the storm drain system itself, dispersed throughout the watershed, or even downstream of intense development. Here are some of the options:

   A. Rooftop storage: This is often economically achieved because roofs are usually designed to support the required loads. Maximum depth of rooftop ponding is usually ≤ 4 inches which applies a load of about 20 lb/ft^2 (Sheaffer et al, 1982). Structural engineers should verify roof loading capacities of existing buildings. A simple perforated ring placed around existing roof drains can easily regulate the flow from the roof.

   B. Detention ponds: Usually located on-site, these are normally dry except during storm events when runoff is detained and slowly released. These ponds can have aesthetic value and can be incorporated into recreational and open space elements. Ponds may also be coupled with filtration systems to remove particulates. Natural or artificial mediums such as sand filters and gravel berms can be employed in this capacity. A possible location for such a pond is along the North Fork immediately below the LBL complex outfall.

   C. Retention ponds: These are more permanent ponds that act as infiltration basins rather than just detaining and releasing stormwater. They probably have limited applicability in the watershed due to the relatively impermeable soil conditions.

   D. Parking lot storage: Significant amounts of highly polluted runoff can be detained through grading and/or controlled outlets such as undersized catch basins and curb cuts. Often particulates will settle out and can be cleaned up later by conventional sweeping practices. If properly designed, conflict with lot users is not a significant problem as appreciable storage would occur on the average of several times every ten years and maximum storage would occur for only a short time about once every 100 years.

   E. Driveway/street storage: As with parking lots, runoff can be collected in depressed areas and outlets could regulate the discharge as desired.

   F. Cistern storage: Underground tanks with appropriate release outlets can be placed in-line or on-site. These may discharge into the storm drain system or infiltrate into the ground.

   G. Open space storage: Storm runoff can be diverted or held in bermed open areas such as lawns, median strips, grass swales, or playing fields. These areas would probably require installation of french drains (subsurface drains) due to the generally impermeable soils in the watershed. These areas would be compatible with recreational/open space/parks uses. Greenbelt areas can also be constructed around parking lots to receive runoff. Buffer strips should be maintained around developed sites and urbanized areas to receive runoff. A typical greenbelt strip would consist of a layer of topsoil underlain by a layer of sand on top of a thick bed of gravel or other porous fill. Aesthetic benefits could help defray the cost of construction and maintenance.

3. Porous pavement: Pervious surfaces produce less runoff and attenuate adverse water quality impacts. Porous asphalt, concrete block-type materials interspersed with grass, and unpaved gravel surfaces are alternatives to conventional asphalt. The performance, cost, practicality, and durability of these surfaces varies. They have limited applications because of these constraints.

4. Catch basin modifications: A variety of methods to reduce pollutant loading from catch basins are available. Leaching catch basins can be installed instead of conventional catch basins where soil conditions permit. The bottom of leaching basins are underlain by gravel or porous fill that allows percolation of stormwater into the ground to facilitate natural soil filtration and attenuation of various pollutants. Oil/water separators or oil sorption/trap systems can be installed on catch basins to reduce oil contamination. These systems would require that debris be removed from the catch basins on a regular basis. Gooseneck outlets installed above the bottom of catch basins can prevent accumulated debris and pollutants from being flushed out into the creek.

5. Erosion control: Many structural methods exist to control runoff and reduce the amount of sediment and other pollutants carried by runoff. Stream channel erosion control and stabilization techniques are discussed separately in Section 5.1.2. Erosion control methods include:

   A. Diversion dike: A dike is a ridge of soil or non-erodable material constructed at the top of cut or fill slopes or around the perimeter of a disturbed area to divert overland flow from small areas and prevent runoff from leaving the disturbed area. Diversions are commonly used at the head of slopes if runoff from higher areas is a problem. Daily construction of temporary dikes during construction will greatly reduce erosion from unexpected storm events or other sources of runoff. Dikes remain in place until permanent drainage facilities are installed and/or slopes are stabilized.

   B. Interceptor ditch: These are permanent structures located on top of a cut slope. They divert drainage away from the slope of the cut to prevent erosion.

   C. Slope drain: Down drains are temporary or permanent conduits which convey drainage from slopes to stable points of discharge down-gradient. Drains may be a pipe drop, flume (chute), or flexible down drain. These should be installed immediately after completion of the cut or fill and before revegetation of the slopes.

   D. Diversion: This is a temporary or permanent structure consisting of a channel or ditch and a ridge constructed across a sloping land surface along a contour or with predetermined grades to intercept and divert surface runoff before it gains sufficient volume and velocity to create erosion. The runoff is then collected and conveyed laterally along the diversion at slow velocity and discharged onto a protected area or into an outlet channel.

   E. Check dam: This is a small temporary dam constructed across a swale, drainage ditch, or other low flow area. It reduces the velocity of concentrated stormwater flows and reduces erosion of drainageways. Check dams also trap small amounts of sediment flowing in the channel but should not be used as a sediment trapping device. These temporary dams are used in small open channels that drain ten acres or less. Check dams may be constructed of stone, sand bags, hay bales, logs, staked brush, or other materials.

   F. Grade stabilization structure: These structures stabilize a grade or control the eroding heads of gullies or stream channels cutting back upstream. Such structures serve to reduce environmental and pollution problems by reducing or eliminating erosion and subsequent sedimentation in the specific area being controlled. Structures range from simple dams using brush and wire, staked brush, riprap, gravel, hay bales, or prefabricated materials to major structures of reinforced concrete, masonry, compacted fill, or similar materials. Some of the minor structures may be temporary until stabilizing vegetation is established.

G. Erosion checks (stops): These consist of flexible porous long-lived mat-like materials such as fiberglass, plastic, or jute. These mats are installed in a slit trench perpendicular to the direction of flow in a swale or ditch. They provide positive grade control in shallow unlined drainageways. Erosion checks prevent the formation of rills and gullies by permitting subsurface water migration without removing soil particulates. These may also be used on critical slopes where severe sheet flow problems may occur.

H. Water ladder: These are wooden structures similar to a stairway that convey water across a steep slope while preventing downcutting. They serve the same purpose as half-round culverts, sluiceways, or swales that rout water over steep slopes onto vegetated and/or slash-covered areas. Water ladders are essentially energy dissipation devices that can effectively handle concentrated runoff. They work well in conjunction with check dams or at the downstream end of cross-road drains.

I. Sediment traps: These are structural or vegetative measures which trap sediment from disturbed areas to prevent clogging of drainage control structures and reduce sediment runoff. Traps can be installed in a drainageway, at a storm drain inlet, or at points of discharge from disturbed areas. Examples of traps include filter berms, sandbag or hay bale barriers, filter inlets, vegetative filter strips, culvert risers, small temporary basins, and silt fences.

J. Sediment detention basin: This is a reservoir which retains peak flows sufficiently to cause deposition of suspended sediment. Basins may be either temporary or permanent structures which prevent off-site transportation of sediment generated from construction activities or other land disturbance. Basins can be excavated or formed by a combination of earthen fill dam and excavation. An ungated pipe through the dam with a perforated riser within the basin above the sediment storage level permits the release of runoff waters. Some basins may serve a dual function by storing both debris and stormwater. A number of small basins are more effective than one large basin.

K. Subsurface drain: This is a conduit such as pipe, tile, or tubing that is installed beneath the ground to collect and/or convey water. In areas with a high water table where the benefits of lowering or or controlling groundwater or surface runoff justify installing a subdrain, the following benfits can be realized: improvement of soil conditions; interception and prevention of water movement into undesirable areas; removal of surface runoff; and relief of artesian pressure. Subdrains can also serve as outlets for other drains and as dewatering devices for detention basins. Subdrains may also take the form of french drains which are trenches filled with stones or other porous materials.

L. Heavy use area protection: This method consists of installing applicable structures, surfacing with suitable materials such as gravel, stone, and mulch, or establishing vegetative cover to protect heavily used areas. It applies to urban, recreational, or essential facility areas which are subjected to heavy use by people, vehicles, or animals.

M. Drip irrigation systems: These systems consist of facilities that are installed for efficient application of water directly to the root zone of plants by means of applicators (orifices, emitters, porous tubing, perforated pipe, etc.) operated under relatively low pressure. Use is adapted to steep slopes where other irrigation methods would cause excessive erosion and to the irrigation of gardens, flowers, and shrubs in urban settings. Advantages include low flow rates over long periods of time, the use of small diameter pipe, and a reported savings in water compared to other irrigation methods.

5.2.3 Hill Area Fire Management Plan

The UC Hill Area Fire Management Plan is a long-range (1987-1991) plan designed to reduce the fire hazard in the hill area by reducing the fuel volume as well as restoring a more "natural" vegetative community such as existed prior to the arrival of Spanish settlers. The plan is to use prescribed burns, pruning, and selective herbicide treatment to reduce north coastal scrub and eucalyptus sprouts and subsequently seed these areas with native perennial grasses. The conversion of brush and eucalyptus to grassland should result in increased groundwater recharge in the hills which could subsequently beneficially increase the baseflow of Strawberry Creek.

Specific vegetative management prescriptions vary according to the vegetative cover type. In conifer stands, 50% of the duff will be removed by burning and a minimal understory will be maintained. North coastal scrub areas invading grasslands will be limited to 20% cover mainly on rocky areas of shallow soil. This will be acheived by prescribed burns and subsequent seeding with native perennial grass. North coastal scrub on wet north aspects will be replaced with coast redwood in areas of convex topography. Eucalyptus sprouts will be eliminated by felling the boles and treating the stumps with herbicide. Cutting will be concentrated from September through January and slash will be burned as soon as practicable. Native perennial grass will be seeded after the burn. In mature eucalyptus stands, the shrub tree understory will be eliminated by burning and seeded with native perennial grass. No burning will be done below the lower fire trial.

The Hill Area plan presents several water quality concerns. The primary concern is that increased soil erosion will occur. The hill area soils are generally heavy clay soils that have high runoff and erosion potential. Numerous landslide and colluvial bodies are also located in the canyon. Erodibility of these soils is primarily a function of vegetative cover. The Hill Area plan will result in a reduction of canopy cover and shrubby ground cover as well as a reduction in the depth of the litter or duff layer in some areas. All these factors will serve to reduce the amount of woody vegetation and organic material available to intercept rainfall. The overall effects of these practices will generally be to increase rainfall energy at the ground surface resulting in soil compaction and increased surface runoff. Therefore, infiltration will decrease and the soil erosion potential will increase.

The roots of woody vegetation increase the cohesiveness of the soil which in turn increases the shear strength of the soil. The rotting of root systems and stumps over time could decrease the shear strength of the soil, resulting in higher erosion and landslide potential. In addition, the stems of woody vegetation tend to break up the velocity of overland flow more effectively than grass which could result in greater distances of relatively unimpeded surface flow causing higher erosion potential.

Prescribed burning also poses some hazards. Burning may consume the litter or duff layer and expose bare soils, especially if the fuel is heavy and/or conditions are quite dry. Extremely hot fires can possibly result in hydrophobic soil conditions where soils become more impermeable because of condensation of volatile organic compounds during burning which leaves a thin waxy impervious layer in the soil. Although prescribed burning is a valuable vegetation management tool, its improper or untimely use can result in increased surface runoff and subsequent soil erosion.

Vegetative cover such as seeding of native perennial grasses should be established as soon as possible after prescribed burning or other vegetative removal. Areas where management activities have occurred should be carefully monitored for soil erosion and appropriate actions including ongoing evaluation of the management practices should be undertaken. Prescribed burning should be conducted under carefully controlled conditions to prevent the exposure of bare soil. Finally, management activities resulting in removal of vegetation should be avoided during the rainy season to allow time for revegetation before heavy rainfall occurs.

5.2.4 Future Monitoring

A regular water quality monitoring program should be established to assess the environmental quality of Strawberry Creek on a long-term basis. This will allow the water quality of the creek to be periodically re-evaluated and problems to be redefined, especially with respect to the bacterial contamination. Changes in ambient water quality and constituents can be determined with respect to the baseline data presented in this report. The effectiveness of implemented control measures can also be evaluated. Point source monitoring of additional suspected contamination sources should be conducted.

Regular water quality sampling stations should be identical to those used for the baseline and wet weather sampling rounds performed in this study. Water quality parameters chosen should be targeted to specific objectives, but should also be comprehensive enough in scope to enable evaluation of overall water quality. Comprehensive water quality monitoring enables the determination of future appropriate "beneficial uses" of Strawberry Creek in terms of aquatic life, recreation, and educational value. A comprehensive round of water quality sampling at all six stations should be performed at least annually under low flow conditions. Storm sampling can be conducted to assess the effectiveness of non-point source and stormwater management techniques.

Staff gauges capable of measuring both low and peak flows should be installed on both forks of the Strawberry Creek. Rating curves (graphs that correlate stream discharge to the water surface elevation read on the staff gauge) for each fork could then be compiled. This requires repeated observations of the staff gauge in conjunction with measurements of streamflow at varying water levels, especially during the rainy season. Once rating curves are established, the instantaneous discharge of the creek can be ascertained simply by reading the staff gauge.

Rating curves are a fundamental tool in hydrologic analysis. Pr. Luna Leopold had established staff gauges on the North Fork near Haviland Hall and on the Main Branch upstream of Oxford Street. The Main Branch gauge is now missing, and the Haviland gauge needs to be surveyed for accuracy. Dr. Leopold had established rating curves for each gauge. Lag time (interval between rainfall and runoff) can be easily determined by simultaneously recording rainfall amounts and streamflow. Decreasing trends in lag time due to further development in the watershed or increases in lag time due to stormwater detention practices can then be identified and evaluated in terms of changes in peak flows, flood stage, or streambank erosion. Hydrologic analyses can be a useful tool in assessing the impacts of development or evaluating the effectiveness of stormwater management practices in the watershed. In addition, monitoring of streamflow is an excellent teaching tool in engineering and applied natural sciences.

6.0 IMPLEMENTATION

Implementation of the creek and watershed management strategies oulined in this report requires delegation of responsibilities and action on the part of the Department of Facilities Management (DOFM). Environmental management of Strawberry Creek must be far-sighted and comprehensive in scope in order to adequately protect and enhance the creek and its associated riparian areas. This will require the cooperation of the University, LBL, and the City of Berkeley. The responsibility for long-term management rests with the Creek Environmental Quality Committee which was recently approved by the Chancellor's Office. In addition to the committee, several other approaches are available to incorporate consideration of the environmental quality of Strawberry Creek into the campus planning process and operations.

The Strawberry Creek Environmental Quality Committee includes academics, administrative staff, and a student representative who have professional experience and/or a concern in the quality of the creek. The Committee is interdisciplinary in nature and was appointed by the Chancellor to address the following issues:

- Review and evaluate all activities that impact the environmental quality of the creek.
- Develop a master plan for the improvement and maintenance of the environmental quality of the creek.
- Provide campus departments (EH&S, DOFM, Planning Office) with technical guidance and direction to minimize adverse environmental impacts on the creek.
- Review existing and pending state and federal water quality regulations.
- Review and evaluate environmental studies related to the creek.

The Committee should review various DOFM grounds practices concerning chemical use, irrigation, vegetation management, streambank stabilization, and standard operating procedures to assess their impacts on the creek and its riparian areas. The Committee should review both ongoing activities as well as projected development and new protocols. Recommendations on existing practices should be directed to the appropriate campus department, whereas input on new development should be forwarded to the Campus Planning Office. A report on the recommendations and subsequent actions should be given to The Vice Chancellor and the Vice Chancellor for Business and Administrative Services (BAS). Both DOFM and EH&S fall under BAS. The Campus Planning Office must notify the Committee of proposed development projects in order to solicit input.

DOFM plays a major role in the environmental management of Strawberry Creek. Personnel should further investigate the sources of point source effluent and evaluate its impact on water quality. Applicable point source controls should be implemented. DOFM engineers should continue to evaluate the sanitary sewer system and correct problems on a continuing basis. EH&S can assist DOFM with these tasks if necessary.

DOFM should undertake an aggressive streambank stabilization program employing the various biotechnical methods outlined in this report. Design and supervision of this work should be done by qualified consultants. Guidelines should be formulated for vegetation management in the designated central campus natural areas and implemented by DOFM grounds personnel. DOFM policies and contracts should address illegal disposal of materials into catch basins and the institution of standard erosion control measures.

Best management practices (BMP's) for stormwater management and control of non-point source pollution should be implemented by DOFM, LBL, and the City of Berkeley. A handbook of BMP's should be developed by DOFM and all projects, plans, and practices should comply with the guidebook. The City of Berkeley should be encouraged to formulate a similar document and implement the BMP's as well. LBL can work in cooperation with DOFM as identical practices would be applicable in their canyon facility. Low cost non-structural methods outlined in this report including improved street sweeping and cleaning of catch basins should be emphasized initially.

Environmental impact statements on discrete projects should address all possible adverse environmental effects on Strawberry Creek and its riparian corridors. This is an effective means of identifying specific

impacts, but does not consider cumulative impacts in the entire watershed. A list of impact assessment criteria for the creek and its watershed is given in Appendix D.

RFP's issued by DOFM Design and Construction Services for new projects should include best management practices pertaining to impervious surface areas. These can either require that peak runoff from the site in question should not be increased over existing conditions or limit the percentage of impervious surface area allowed. These conditions will help mitigate the adverse hydrologic and water quality impacts of additional development in the watershed. The RFP's should also stipulate a minimum of land and vegetation disturbance as well as implementation of erosion and runoff control measures during actual construction.

The Long Range Development Plan for the UC Berkeley campus is currently in the process of being updated. This document must incorporate concerns about the environmental quality of Strawberry Creek into the long-term campus planning process. The LRDP should consider the creek and watershed management strategies discussed in this report as well as the recommendations of the Strawberry Creek Environmental Quality Committee.

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APPENDIX A

BASELINE WATER QUALITY DATA

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A-1. Dissolved Oxygen Determinations

A-2. Results of Biochemical Oxygen Demand (5 day) Analyses

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A-5. Results of Total Alkalinity Analyses

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Table A-1. Strawberry Creek

Dissolved Oxygen Determinations

Station		5/27/87	6/19/87	7/22/87	8/19/87
			South Fork		
1	*	0930	0930	0930	0915
	**	11.0	12.0	13.0	14.0
	***	12.4	15.4	13.9	11.4
	****	112	142	131	110
2		1000	1030	1000	0945
		14.0	15.8	16.0	15.8
		11.0	12.0	10.9	11.3
		106	120	109	113
3		1100	1100	1045	1015
		14.5	14.2	16.5	17.8
		12.6	12.4	9.0	10.8
		122	116	91	114
			North Fork		
4		1230	1200	1130	1220
		13.0	13.8	14.0	15.6
		11.0	9.8	10.0	10.3
		104	94	96	102
5		1330	1245	1200	1100
		15.5	14.2	16.5	16.6
		9.8	11.0	9.9	10.0
		97	106	100	102
6		1130	1130	1100	1035
		16.0	18.6	18.0	18.2
		9.2	8.3	9.8	9.3
		92	88	103	98

* Time
** Water Temperature (^{o}C)
*** Dissolved Oxygen Concentration (mg/l)
**** Percent Saturation

Table A-2. Strawberry Creek

Results of Biochemical Oxygen Demand (5 day) Analyses (mg/1)

Station	5/27/87	6/19/87	7/22/87	8/19/87	Mean
			South Fork		
1	< 3.0	< 2.4	< 2.4	< 2.4	< 2.6
2	< 3.0	< 2.4	< 2.4	< 2.4	< 2.6
3	< 3.0	< 2.4	< 2.4	< 2.4	< 2.6
			North Fork		
4	< 3.0	< 2.4	< 2.4	< 2.4	< 2.6
5	< 3.0	2.4	< 2.4	3.7	< 2.9
6	< 3.0	5.3	< 2.4	< 2.4	< 3.3

Table A-3. Strawberry Creek

Results of Chemical Oxygen Demand Analyses (mg/1)

Station	5/27/87	6/19/87	7/22/87	8/19/87	Mean
			South Fork		
1	< 5	13	8	< 5	< 8
2	< 5	4	8	10	< 7
3	9	22	12	10	13
			North Fork		
4	< 5	4	12	10	< 8
5	< 5	9	< 5	19	< 10
6	< 5	18	< 5	10	< 10

Table A-4. Strawberry Creek

Results of pH Analyses (std. units)

Station	5/27/87	6/19/87	7/22/87	8/19/87	Mean
			South Fork		
1	8.0	8.1	8.2	8.2	8.1
2	8.2	8.2	8.3	8.2	8.2
3	7.9	8.0	8.1	8.0	8.0
			North Fork		
4	8.3	8.2	8.1	8.1	8.2
5	8.1	8.2	8.2	8.1	8.2
6	7.7	7.8	7.8	7.7	7.8

Table A-5. Strawberry Creek

Results of Total Alkalinity Analyses (mg/1 $CaCO_3$)

Station	5/27/87	6/19/87	7/22/87	8/19/87	Mean
			South Fork		
1	153	120	145	144	140
2	115	87	122	151	119
3	107	101	121	96	106
			North Fork		
4	180	162	152	163	164
5	166	173	135	157	158
6	90	85	84	86	86

Table A-6. Strawberry Creek

Results of Hardness Analyses (mg/l)

Station	8/19/87
South Fork	
1	144
2	156
3	100
North Fork	
4	170
5	159
6	92

Table A-7. Strawberry Creek

Results of Conductivity Analyses (umhos/cm)

Station	5/27/87	6/19/87	7/22/87	8/19/87	Mean
			South Fork		
1	442	286	412	390	382
2	374	242	390	442	362
3	350	288	392	276	326
			North Fork		
4	460	412	366	406	411
5	454	438	344	416	413
6	270	226	222	236	238

Table A-8. Strawberry Creek

Results of Dissolved Solids Analyses (mg/1)

Station	5/27/87	6/19/87	7/22/87	8/19/87	Mean
			South Fork		
1	280	207	258	264	252
2	210	157	238	275	220
3	203	188	225	174	198
			North Fork		
4	252	271	221	247	248
5	260	282	212	245	250
6	150	164	139	148	150

Table A-9. Strawberry Creek

Results of Suspended Solids Analyses (mg/1)

Station	5/27/87	6/19/87	7/22/87	8/19/87	Mean
			South Fork		
1	4.4	3.0	4.2	4.6	4.0
2	2.0	5.4	11.6	4.0	5.8
3	1.4	6.2	3.0	1.1	2.9
			North Fork		
4	5.6	4.8	< 1.0	1.4	< 3.2
5	2.8	7.8	12.2	12.3	8.8
6	4.6	8.4	4.2	34.0	12.8

Table A-10. Strawberry Creek

Results of Turbidity Analyses (NTU)

Station	5/27/87	6/19/87	7/22/87	8/19/87	Mean
			South Fork		
1	2.4	2.0	2.9	3.5	2.7
2	1.5	2.5	3.2	4.4	2.9
3	1.5	2.1	2.4	1.6	1.9
			North Fork		
4	0.9	1.1	1.0	1.5	1.1
5	2.2	2.1	4.5	4.8	3.4
6	3.3	6.5	4.5	25.0	9.8

Table A-11. Strawberry Creek

Results of Color Analyses (c.u.)

Station	5/27/87	6/19/87	7/22/87	8/19/87	Mean
			South Fork		
1	21	16	10	12	15
2	9	20	16	15	15
3	12	16	8	17	13
			North Fork		
4	7	12	6	12	9
5	23	10	20	22	19
6	18	20	25	23	19

Table A-12. Strawberry Creek

Results of Chloride Analyses (mg/1)

Station	5/27/87	6/19/87	7/22/87	8/19/87	Mean
			South Fork		
1	11.2	9.0	23.9	21.0	16.3
2	26.0	22.0	33.0	34.0	28.8
3	23.0	18.0	35.0	18.0	23.5
			North Fork		
4	17.0	19.0	9.4	18.0	15.8
5	22.0	21.0	14.5	20.0	19.4
6	9.6	9.5	9.4	12.0	10.1

Table A-13. Strawberry Creek

Results of Oil and Grease Analyses (mg/1)

Station	5/27/87	6/19/87	7/22/87	8/19/87	Mean
			South Fork		
1	< 0.5	< 0.5	1.3	1.6	< 1.0
2	< 0.5	< 0.5	2.5	1.7	< 1.3
3	1.2	< 0.5	1.9	3.1	< 1.7
			North Fork		
4	3.2	0.6	19.3	1.6	6.2
5	< 0.5	< 0.5	2.5	1.7	< 1.3
6	< 0.5	< 0.5	31.8	1.4	< 8.6

Table A-14. Strawberry Creek

Results of Total Kjeldahl-Nitrogen Analyses (mg/1)

Station	5/27/87	6/19/87	7/22/87	8/19/87	Mean
			South Fork		
1	0.21	0.74	0.08	0.08	0.28
2	0.17	0.36	0.79	0.19	0.38
3	0.28	0.82	0.14	0.11	0.34
			North Fork		
4	0.13	0.20	0.45	0.14	0.23
5	0.53	0.60	0.44	0.32	0.47
6	0.86	1.00	0.42	0.31	0.65

Table A-15. Strawberry Creek

Results of Ammonia-Nitrogen Analyses (mg/1)

Station	5/27/87	6/19/87	7/22/87	8/19/87	Mean
			South Fork		
1	0.04	< 0.02	0.05	0.05	< 0.04
2	0.07	< 0.02	0.09	0.07	< 0.06
3	0.09	0.28	0.09	0.07	0.13
			North Fork		
4	0.03	0.02	0.08	0.10	0.06
5	0.31	0.20	0.09	0.09	0.17
6	0.26	0.12	0.42	0.08	0.22

Table A-16. Strawberry Creek

Results of Nitrate-Nitrogen Analyses (mg/1)

Station	5/27/87	6/19/87	7/22/87	8/19/87	Mean
			South Fork		
1	2.4	2.6	0.8	1.0	1.7
2	2.2	1.5	1.9	1.9	1.9
3	2.5	2.5	1.3	1.6	2.0
			North Fork		
4	1.6	2.3	2.0	2.8	2.2
5	3.9	3.2	3.7	7.9	4.7
6	4.9	3.8	2.0	3.5	3.6

Table A-17. Strawberry Creek

Results of Total Phosphorus Analyses (mg/1)

Station	5/27/87	6/19/87	7/22/87	8/19/87	Mean
			South Fork		
1	< 0.01	0.46	0.29	0.30	< 0.21
2	0.17	0.28	0.19	0.16	0.20
3	0.39	0.24	0.18	0.13	0.24
			North Fork		
4	0.07	0.13	0.08	0.10	0.10
5	0.28	0.44	0.42	0.88	0.50
6	0.33	0.32	0.24	0.46	0.34

Table A-19. Strawberry Creek

Fecal Coliform Bacteria (Number per 100 ml)

Station	5/27/87	6/19/87	7/22/87	8/19/87	Mean
			South Fork		
1	300	140	300	300	260
2	3,000	170	300	140	902
3	3,000	≥16,000	≥16,000	3,000	≥11,000
			North Fork		
4	500	700	700	1,400	825
5	300	5,000	≥16,000	≥16,000	≥10,825
6	≥16,000	>16,000	≥16,000	90,000	≥34,500

Note: MPN method.

Table A-20. Strawberry Creek

Fecal Streptococci Bacteria (Number per 100 ml)

Station	5/27/87	6/19/87	7/22/87	8/19/87	Mean
			South Fork		
1	3,000	800	500	800	1,275
2	1,700	16,000	≥16,000	1,300	≥8,750
3	>16,000	>16,000	5,000	1,100	>11,025
			North Fork		
4	300	800	800	16,000	4,475
5	130	1,700	800	≥16,000	≥4,658
6	≥16,000	9,000	≥16,000	160,000	≥51,750

Note: MPN method.

Table A-21. Strawberry Creek

Results of Heavy Metals Analyses (ug/l)

	South Fork						North Fork					
Station:	#1		#2		#3		#4		#5		#6	
Date:	7/22	8/19	7/22	8/19	7/22	8/19	7/22	8/19	7/22	8/19	7/22	8/19
Parameter												
Cadmium	< 1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chromium	1.0	2.0	<1.0	1.0	1.0	<1.0	2.0	1.0	3.0	2.0	1.0	1.0
Copper	1.0	3.0	3.0	2.0	6.0	2.0	4.0	6.0	9.0	7.0	11.0	15.0
Iron	50.0	111.0	100.0	93.0	6.0	62.0	30.0	58.0	150.0	163.0	170.0	93.0
Lead	9.0	<10.0	<2.0	<10.0	31.0	<10.0	<2.0	<10.0	8.0	15.0	<2.0	<10.0
Manganese	10.0	13.0	60.0	34.0	20.0	7.0	10.0	64.0	40.0	44.0	40.0	72.0
Mercury	0.55	0.04	0.02	0.03	0.06	0.04	0.01	0.01	0.38	0.03	0.06	0.08
Nickel	4.0	<2.0	<2.0	4.0	4.0	4.0	<2.0	4.0	5.0	<2.0	2.0	<2.0
Zinc	2.0	2.0	6.0	4.0	6.0	8.0	8.0	6.0	30.0	25.0	15.0	24.0

All Analyses in ug/l

APPENDIX B

COMPARATIVE WATER QUALITY DATA

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Table B-1. EBMUD Berkeley City Water Analyses (1986)

Parameter	EBMUD Water	MCL/SMCL
pH (std. units)	7.7	6.5-8.5
Alkalinity (as $CaCO_3$)	22	-
Total Hardness (as $CaCO_3$)	24	-
Conductivity (umhos/cm)	63	900
Total Dissolved Solids	46	500
Color (c.u)	4	15
Nitrate	<0.01	10.0
Phosphate (as PO_4)	<0.02	-
Chloride	3	250
Total Arsenic	<0.003	0.05
Total Cadmium	<0000.1	0.01
Total Chromium	0.0051	0.05
Total Copper	<0.007	1.0
Total Iron	0.02	0.3
Total Lead	<0.003	0.05
Total Manganese	<0.0006	0.05
Total Mercury	<0.0002	0.002
Total Nickel	<0.003	-
Total Silver	<0.0003	0.05
Total Zinc	<0.01	5.0

Notes:
All analyses in mg/l unless otherwise noted.

Samples collected May 1986.

MCL/SMCL = National Drinking Water Regulations Maximum Contaminant Levels or Secondary Maximum Contaminant Levels.

Table B-2. Mean Water Quality Data (ABAG)

Parameter (units)	Low-Flow Data (Mean)
pH (std. units)	7.7
Turbidity (NTU)	6.0
Conductivity (umhos/cm)	753
Suspended Solids (mg/l)	11.1
Dissolved Solids (mg/l)	738
Oil and Grease (mg/l)	3.0

	Wet Weather Data (Mean)		
	During Storm	Following Storm	Day After Storm
pH (std. units)	7.0	7.3	7.6
Turbidity (NTU)	37	34	24
Conductivity (umhos/cm)	143	455	414
Suspended Solids (mg/1)	495.0	97.0	43.7
Dissolved Solids (mg/1)	191	516	513
Oil and Grease (mg/1)	9.7	7.4	4.0

Note: Data taken from Evaluation of Hydrocarbons in Runoff to San Fransisco Bay, (ABAG, 1985). Data was collected from 15 creeks around S.F. Bay on seven occasions from April 1984 - March 1985.

Table B-3. Castro Valley Creek Low Flow Water Quality Data

Parameter (units)	n	Mean	SD	Range
pH (std. units)	34	7.8	0.5	6.7-8.6
Alkalinity (mg/l as $CaCO_3$)	20	262	33	180-310
Conductivity (unhos/cm)	36	1215	763	340-4410
Dissolved Oxygen (mg/l)	5	7.2	3.1	2.6-12.2
BOD_5 (mg/l)	15	12.3	15.8	0.9-57.0
COD (mg/l)	26	51.6	62.2	<4-250
Suspended Solids (mg/l)	21	44	85	2-410
Dissolved Solids (mg/l)	15	731	151	510-1000
Oil and Grease (mg/l)	5	2.6	1.0	1.0-4.0
Total Kjeldahl Nitrogen (mg/l as N)	28	1.4	1.0	0.12-4.5
Ammonia Nitrogen (mg/l as N)	8	0.15	0.13	0-0.36
Dissolved Nitrate Nitrogen (mg/l N)	11	2.0	1.2	0.7-4.8
Dissolved Nitrate Nitrogen (mg/l as $N0_3$)	9	10.6	5.3	3.1-21.0
Total Nitrogen (mg/l as $N0_3$)	16	21.6	7.8	2.9-39.0
Total Organic Nitrogen (mg/l as N)	10	0.94	0.34	0.41-1.40
Total Inorganic Nitrogen (mg/l as N)	16	3.1	1.5	0.03-5.40
Total Phosphorus (mg/l as P)	16	0.49	0.38	0.08-1.10
Total Coliform Bacteria (MPN/100 ml)	4	203,756	169,756	5,000-460,000
Fecal Coliform Bacteria (MPN/100 m1)	5	4,278	3,614	90-9,300
Fecal Streptococci Bacteria (MPN/100 m1)	3	28,333	13,021	15,000-46,000

Table B-3 (Continued)

Parameter (units)	n	Mean	SD	Range
Dissolved Calcium	12	22	19	6.5-67.0
Dissolved Magnesium (mg/1)	9	8.4	8.0	1.7-27.0
Dissolved Sodium (mg/1)	14	21.6	24.7	3.8-92.0
Dissolved Chloride (mg/1)	15	21	17	4.9-69.0
Dissolved Iron (ug/1)	14	84	60	40-270
Total Arsenic (ug/1)	83	4	2	1.10
Total Cadmium (ug1)	85	<3	8	<1-50
Total Chromium (ug/1)	96	31	52	0-480
Total Copper)ug/1)	18	115	106	20-360
Total Lead (ug/1)	121	208	227	0-1200
Total Mercury (ug/1)	103	<1.8	2.7	0.1-14.0
Total Nickel (ug/1)	18	84	70	5-200
Total Zinc (ug/1)	117	169	116	30-720
Precipitation (daily inches)	144	0.67	0.67	0.01-4.66

Notes

n = number of observations
SD = standard deviation

All data collected by USGS October 1971 - February 1986 at Hayward, CA.

Table B-4. Peralta Creek Low Flow Water Quality Data

Parameter (units)	n	Mean	SD	Range
pH (std. units)	4	7.2	0.4	6.8-7.7
Conductivity (umhos/cm)	4	364	125	270-580
Alkalinity (mg/l as $CaCO_3$)	4	126	55	82-220
Dissolved Oxygen (mg/1)	1	(7.4)	-	-
BOD_5 (mg/l)	4	5.1	2.4	1.6-8.4
COD (mg/1)	3	21.7	9.6	13-35
Total Organic Nitrogen (mg/l as N)	4	0.55	0.22	0.30-0.90
Ammonia Nitrogen (mg/l as N)	1	(0.08)	-	-
Kjeldahl Nitrogen (mg/l as N)	4	0.70	0.31	0.54-1.20
Total Phosphorus (mg/l as P)	4	0.28	0.07	0.19-0.37
Total Dissolved Solids (mg/l)	2	259	71	188-330
Dissolved Chloride (mg/l)	1	(36)	-	-
Dissolved Iron (ug/l)	1	(20)	-	-
Total Cadmium (ug/l)	1	(1)	-	-
Total Lead (ug/l)	1	(1)	-	-
Total Mercury (ug/l)	1	(0.5)	-	-
Fecal Coliform (#/100 ml)	1	(350)	-	-
Streamflow (cfs)	4	1.36	0.86	0.15-2.40

Notes

n = number of observations
SD = standard deviation
( ) = value based on one sample

All data collected by USGS September - December 1972 at Oakland

Table B-5. Caldecott Creek Low Flow Water Quality Data

Parameter (units)	n	Mean	SD	Range
pH (std. units)	4	6.4	0.3	6.1-6.7
Conductivity (umhos/cm)	4	1445	64	1350-1530
Dissolved Oxygen (mg/l)	3	7.1	0.6	6.6-7.9
Total Organic Nitrogen (mg/l as N)	3	0.91	0.64	0.31-1.80
Total Nitrate Nitrogen (mg/l as N)	3	0.32	0.15	0.15-0.52
Total Nitrogen (mg/l as NO_3)	3	5.7	2.6	2.8-9.2
Total Ammonia Nitrogen (mg/l as N)	3	0.02	0.03	0-0.06
Total Kjeldahl Nitrogen (mg/l as N)	3	0.95	0.68	0.32-1.90
Total Ammonia Nitrogen (mg/l as NH_4)	3	0.95	0.03	0-0.07
Total Inorganic Nitrogen (mg/l as N)	3	0.34	0.16	0.17-0.55
Total Phosphorus (mg/l as P)	3	0.03	0.01	0.02-0.04
Fecal Coliform (#/100 ml)	4	>1635	2523	20->6000
Fecal Streptococci (#/100 ml)	4	1132	64	130-2500
Streamflow (cfs)	2	0.05	0.01	0.04-0.06

Notes:

n= number of observations

SD = standard deviation

All data collected by USGS October - December 1979 above Lake Temescal, Oakland.

Table B-6. Temescal Creek Low Flow Water Quality Data

Parameter (units)	
pH (std. units)	7.7
Conductivity (umhos/cm)	921
Dissolved Oxygen (mg/l)	8.6
Suspended Solids (mg/l)	10
Total Organic Nitrogen (mg/l as N)	0.12
Total Nitrate Nitrogen (mg/l as N)	0.58
Total Nitrogen (mg/l as NO_3)	3.4
Total Ammonia Nitrogen (mg/l as N)	0.03
Total Ammonia Nitrogen (mg/l as NH_4)	0.04
Total Kjeldahl Nitrogen (mg/l as N)	0.15
Total Inorganic Nitrogen (mg/l as N)	0.62
Total Phosphorus (mg/l as P)	0.24
Fecal Coliform (#/100 ml)	16,000
Fecal Streptococci (#/100 ml)	9,200
Streamflow (cfs)	0.12

Note:

Sample taken above Lake Temescal, Oakland on September 20, 1979 by USGS.

Table B-7. Castro Valley Creek Wet Weather Water Quality Data

Parameter (units)	n	Mean	SD	Range
pH (std. units)	228	7.3	0.5	5.4-87
Conductivity (umhos/cm)	246	287	210	59-1170
Alkalinity (mg/l as $CaC0_3$)	124	57	54	< 1-271
Dissolved Oxygen (mg/1)	24	8.5	1.7	4.4-10.4
BOD_5 (mg/l)	100	31.3	22.5	1.7-100.0
COD (mg/1)	203	124	118	< 9-810
Suspended Solids (mg/l)	148	320	356	10-1810
Dissolved Solids (mg/l)	63	189	172	34-734
Total Organic Nitrogen (mg/l as N)	136	1.7	0.9	0.15-5.40
Total Inorganic Nitrogen (mg/l as N)	124	1.6	1.0	0.09-5.0
Ammonia Nitrogen (mg/l as N)	116	0.22	0.25	0.01-1.80
Total Kjeldahl Nitrogen (mg/l as N)	211	2.8	2.3	0.1-13.0
Dissolved Nitrate Nitrogen (mg/l as N)	35	1.2	0.9	<0.07-4.20
Dissolved Nitrate Nitrogen (mg/l as NO_3)	37	4.9	3.9	0-19
Total Nitrogen (mg/l as NO_3)	148	21	11	4.1-65.0
Total Phosphorus (mg/l as P)	152	0.52	0.29	0.05-2.10
Total Coliform bacteria (MPN/100 ml)	17	107,241	127,506	5,200-460,000
Fecal Coliform bacteria (MPN/100 ml)	22	34,304	50,739	2,500-240,000
Fecal Streptococci bacteria (MPN/100 ml)	7	121,857	102,570	24,000->240,000
Oil and Grease (mg/l)	24	14	22	0-91
Dissolved Chloride (mg/l)	4	96	20	72-120
Dissolved Iron (ug/l)	3	43	5	40-50
Total Cadmium (ug/l)	2	0.5	0.5	0-1
Total Chromium (ug/l)	8	16	11	3-40

Table B-7. (continued)

Parameter (units)	n	Mean	SD	Range
Total Copper (ug/l)	8	26	11	9-42
Total Lead (ug/l)	9	78	98	6-310
Total Mercury (ug/l)	9	0.9	0.5	0.3-2.2
Total Nickel (ug/l)	8	40	65	0-200
Total Zinc (ug/l)	9	151	139	30-460
Streamflow (cfs)	36	4.06	5.10	0.17-26.0

Notes

n = number of observations
SD = standard deviation

All data collected by USGS October 1971 - April 1980 at Hayward CA.

Table B-8. Peralta Creek Wet Weather Water Quality Data

Parameter (units)	n	Mean	SD	Range
pH (std. units)	19	7.0	0.5	6.3-7.7
Conductivity (umhos/cm)	19	190	109	93-524
Alkalinity (mg/l as $CaCO_3$)	19	62	40	27-191
Dissolved Oxygen (mg/l)	6	8.7	0.9	7.7-10.0
BOD_5 (mg/l)	18	>21.2	13.2	4.3->47
COD (mg/l)	14	84	39	34-160
Oil and Grease (mg/l)	3	83	97	12-220
Total Organic Nitrogen (mg/l as N)	16	1.5	0.6	0.9-3.3
Ammonia Nitrogen (mg/l as N)	8	0.18	0.10	0.11-0.44
Kjeldahl Nitrogen (mg/l as N)	16	1.8	0.6	1.1-4.0
Total Nitrogen (mg/l as NO_3)	3	13	6	7.8-21.0
Inorganic Nitrogen (mg/l as N)	3	1.21	0.92	0.46-2.50
Total Phosphorus (mg/l as P)	16	0.75	0.43	0.28-2.20
Dissolved Magnesium (mg/l)	4	6.1	1.6	4.1-8.3
Dissolved Chloride (mg/l)	4	6.4	2.4	3.6-9.6
Dissolved Iron (mg/l)	4	270	352	60-880
Total Dissolved Solids (mg/l)	15	136	77	50-317
Fecal Coliform (#/100 ml)	5	15100	6515	9500-27000
Total Cadmium (ug/l)	4	<10	9.5	1-<20
Total Lead (ug/l)	4	455	227	210-800
Total Mercury (ug/l)	4	<0.9	0.8	<0.05-2.3
Precipitation (daily inches)	7	0.78	0.75	0.05-2.05

Notes
n = number of observations
SD = standard deviation
All data collected by USGS September - December 1972 at Oakland.

Table B-9. Caldecott Creek Wet Weather Water Quality Data

Parameter (units)	n	Mean	SD	Range
pH (std. units)	5	7.5	0.1	7.45-7.6
Conductivity (umhos/cm)	5	704	192	410-930
Suspended Solids (mg/l)	9	291	262	26-934
Total Organic Nitrogen (mg/l as N)	9	1.50	0.48	0.59-2.2
Total Nitrate Nitrogen (mg/l as N)	9	0.92	0.44	0.41-1.80
Total Nitrogen (mg/l as NO_3)	9	11.6	3.0	8.4-18.0
Total Ammonia Nitrogen (mg/l as N)	9	0.09	0.10	0-0.29
Total Kjeldahl Nitrogen (mg/l as N)	9	1.58	0.52	0.66-2.50
Total Ammonia Nitrogen (mg/l as NH_4)	9	0.11	0.12	0-0.35
Total Inorganic Nitrogen (mg/l as N)	9	1.03	0.42	0.45-1.80
Total Phosphorus (mg/l as P)	9	0.39	0.24	0.10-0.91
Precipitation (daily inches)	9	0.23	0.18	0.05-0.53

Notes

n = number of observations
SD = standard deviation
All data collected by USGS October - December 1979 above Lake Temescal, Oakland.

Table B-10. Temescal Creek Wet Weather Water Quality Data

Parameter (units)	n	Mean	SD	Range
pH (std. units)	6	7.7	0.2	7.4-8.2
Conductivity (umhos/cm)	6	336	88	240-480
Suspended Solids (mg/l)	12	289	164	37-722
Total Organic Nitrogen (mg/l as N)	10	1.9	0.69	0.92-3.2
Total Nitrate Nitrogen (mg/l as N)	11	1.43	1.00	0.71-4.3
Total Nitrogen (mg/l as NO_3)	10	15.7	5.1	8.2-27
Total Ammonia Nitrogen (mg/l as N)	11	0.06	0.06	0.01-0.23
Total Ammonia Nitrogen (mg/l as NH_4)	11	0.07	0.07	0.01-0.28
Total Kjeldahl Nitrogen (mg/l as N)	10	2.0	0.72	0.95-3.4
Total Inorganic Nitrogen (mg/l as N)	11	1.52	0.96	0.82-4.3
Total Phosphorus (mg/l as P)	12	0.35	0.15	0.06-0.65
Total Phosphorus (mg/l as PO_4)	12	1.07	0.47	0.18-2.0
Precipitation (daily inches)	12	0.50	0.54	0.05-1.71

Notes:

n = number of observations

SD = standard deviation

All data collected by USGS October 1979 - February 1980 above Lake Temescal, Oakland.

APPENDIX C

BAY AREA NATIVE RIPARIAN VEGETATION

Trees

Acer macrophyllum - Bigleaf maple
Acer negundo - Box elder
Aesculus californica - California buckeye
Alnus rubra - Red alder
Alnus rhombifolia - White alder
Cornus nuttalli - Pacific dogwood
Fraxinus latifolia - Oregon ash
Juglans hindsii - California black walnut
Platanus racemosa - Western sycamore
Populus fremontii - Western cottonwood
Quercus agrifolia - Coast live oak
Quercus kelloggii - California black oak
Quercus garryana - Oregon white oak
Quercus lobata - Valley oak
Salix laevigata - Red willow
Salix lasiandra - Yellow willow
Salix lasiolepis - Arroyo willow
Salix scouleriana - Scouler willow
Sambucus caerulea - Blue elderberry
Sequoia sempervirens - Coast redwood
Umbellaria californica - California bay

Shrubs

Baccharis viminea - Mule fat
Calycanthus occidentalis - Spice bush
Clematis lasiantha - Pipe-stem clematis
Clematis ligusticifolia - Wild clematis
Cornus glabrata - Smooth dogwood
Cornus occidentalis - Western dogwood
Cornus stolonifera - Redtwig dogwood
Corylus cornuta - Western hazelnut
Dirca occidentalis - Leatherwood
Euonymus occidentalis - Native euonymous
Gaultheria shallon - Salal
Holodiscus discolor - Ocean spray
Lavatera assurgentiflora - Malva rose
Lonicera involucrata - Twinberry honeysuckle
Lupinus arboreus - Yellow bush lupine
Myrica californica - Pacific wax myrtle
Nicotiana glauca - Tree tobacco
Physocarpus capitatus - Ninebark
Rhamnus californica - Coffeeberry
Rhododendron occidentale - Western azalea
Rhus trilobata - Squawbush

APPENDIX C. (Continued)

Ribes aureum - Golden currant
Ribes divaricatum - Gooseberry
Ribes menziesii - Canyon gooseberry
Ribes sanguineum - Red flowering currant
Ribes sanguineum var. glutinosum - Pink flowering currant
Rosa californica - California rose
Rubus parviflorus - Thimbleberry
Rubus spectabilis - Salmonberry
Rubus vitifolius - Blackberry
Salix coulteri - Velvet willow
Salix hindsiana - Sandbar willow
Salix lasiolepis - Arroyo willow
Sambucus callicarpa - Red elderberry
Sambucus caerulea - Blue elderberry
Sambucus velutina - Mexican elderberry
Symphoricarpos rivularis - Snowberry
Toxicodendron diversiloba - Poison oak

Grasses / Sedges / Rushes

Calmagrostis nutkaensis - San reed grass
Carex nudata - Sedge
Eleocharis macrostachya - Spike rush
Elymus triticoides - Blue rye
Elymus condensatus - Blue rye
Equisetum hyemale - Common horsetail
Equisetum telmateia - Giant horsetail
Festuca californica - Fescue
Glyceriz leptostachya - Manna grass
Hystrix californica
Juncus effusus - Rush
Muhlenbergia nigens - Muhley grass
Phalaris californica - Canary grass
Scirpus microcarpus - Bulrush

Ferns

Adiantum pedatum - Five-finger fern
Athyrium filix-femina - Lady fern
Blechnum spicant - Deer fern
Dryopteris arguta - Coastal wood fern
Pityrogramma triangularis - Goldback fern
Polypodium californicum - Ground fern
Polystichum munitum - Western sword fern
Woodwardia fimbriata - Giant chain fern

APPENDIX C. (Continued)

Herbs

Achillea millefolium - Common yarrow
Aralia californica - Elk clover
Artemisia douglasiana - Sagebush
Asarum caudatum - Wild ginger
Caradmine digosperina - Bittercross
Dicentra formosa - Western bleeding heart
Epipactis gigantea - Stream orchid
Fragaria californica - Strawberry
Mimulus cardinalis - Scarlet monkey flower
Mimulus guttatus - Seep-spring monkey flower
Oxalis oregana - Redwood sorrel
Tellima grandiflora - Fringecups
Tolmiea menziesii - Piggy-back plant
Trillium spp. - Wake robin
Viola glabella - Stream violet

Sources: Stone, 1985.
Siri, 1972.
Sunset, 1983.

APPENDIX D

IMPACT ASSESSMENT CRITERIA

The following list of criteria can be used to identify activities, situations, or other conditions that could potentially have an adverse effect on the environmental quality of Strawberry Creek and its associated riparian corridors.

I. Water Quality Impacts

A. Point Source Pollution
1. Building cooling water discharged to creek?
2. Thermal discharges to creek?
3. Other drainage / discharge / overflow to creek?
4. Building floor drains routed to creek?
5. Boiler blowdown routed into creek?
6. Swimming pool backflush routed to creek?

B. Non-point Source Pollution
1. Additional storm drains routed to creek?
2. Contamination hazard from spillage / storage of chemicals or other hazmats?
3. Increased siltation, sedimentation, or turbidity?
4. Areal application of herbicides, pesticides, fungicides, fertilizers, etc. pose a surface runoff hazard to creek?
5. Septic systems or other sewage disposal systems located in close proximity to creek?
6. Additional auto-related land uses (parking lots, roadways, service areas, junkyards, etc.) drain into creek?
7. Increased rate or volume of irrigation?
8. Increased discoloration, foaming, or unpleasant odors in the creek?

II. Impingement on Creek Corridors

1. New building or structure located within close proximity to creek?
2. Additional bridging or overhead structures (utilities, etc.) over the creek?
3. Construction activities occur within close proximity of creek?
4. Storage of materials, chemicals, or equipment close to creek?
5. Possible increase in debris or trash accumulation along creek corridors?
6. Increased noise levels in creek areas?
7. High-rise structures built in vicinity of creek corridors?
8. Detract from visual amenity or variety of creek corridors?
9. Affect open space or buffer zone functions of creek corridors?
10. Hinder the recreational use of the creek or its corridors?
11. Decrease the educational opportunities or use?
12. Degrade wildlife habitat?
13. Attract annoying pests (rodents, insects, etc.) ?
14. Pose an increased flooding hazard?

III. Physical Alteration of Creek Channels

1. Additional channelization, channel confinement, or lining the streambed or banks with concrete or other artificial materials?
2. Diversions or bypasses required?
3. Culverting?
4. Excavation or filling within creek channels?
5. Alteration of creek bed gradient?
6. Alteration of physical composition of bed or banks?
7. Installation or construction of any structures in streambed or on the banks?

IV. Alteration of Hydrologic Characteristics

1. Decrease low flow water levels?
2. Increase magnitude of peak flows?
3. Increase flood stage?
4. Decrease lag time?
5. Additional surface runoff?
6. Increase point source discharge volume?
7. Produce stagnant conditions?
8. Alter pool or riffle habitat?
9. Change drainage flow patterns or areas?
10. Additional impervious surface?
11. Alter existing storm drainage system?

V. Soil Disturbance

1. Exposure of bare soil?
2. Stripping or excavation of soil?
3. Ground compaction?
4. Alter existing grades?
5. Trenching?
6. Alter soil drainage characteristics?
7. Produce hydrophobic soils?
8. Slope disturbance?
9. Disturb colluvium or landslide bodies?
10. Increase mechanical loading or water saturation of slopes?

VI. Vegetation Disturbance

1. Removal or stripping of vegetation?
2. Thinning or removal of any part of the overstory, understory, or herbaceous layers?
3. Change composition of vegetative cover type or layer?
4. Removal of detritus / litter/ duff?
5. Burning of vegetation?
6. Spraying with any chemicals?
7. Introduction of exotic (non-native) species?
8. Make more susceptible to insects or diseases?
9. Cover root systems with impervious surface?
10. Disturb root systems?
11. Alter soil moisture content?
12. Increase or alter irrigation?

Garrett Eckbo and Associates

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23 June 1976

Mr. F.F. Warnke, Senior Landscape Architect
Office of Architects and Engineers
University of California at Berkeley
Berkeley, California

Account No. 918181
Reg. No. AE 26B

Dear Mr. Warnke,

We take pleasure in transmitting herewith the final report on our study of Strawberry Canyon Development, as authorized June 13, 1975.

The program for this study specified certain elements in its content:

1. Evaluation and assimilation of existing reports for the area.
2. Vegetative maintenance policy and revegetation plan.
3. Final ecological study area boundaries.
4. Fire hazard reduction.
5. Land use priorities.
6. Future non-vegetative management policies.

In order to respond to these specifics we felt that we must look at the Canyon area as a total landscape in which interaction between people and nature has produced a complex with precise characteristics and qualities.

This holistic approach necessitated some reordering of the specified elements. Vegetative and natural area management and maintenance policy must be formulated on the basis of overall land use priorities and policies. These must deal with four basic types of use:

1. Institutional, requiring construction and generating motorized traffic for access and service.
2. Educational and research, primarily concerned with natural or manipulated landscape conditions.
3. Recreational, concerned with active facilities and/or semi-wilderness conditions.

Desirable basic policies governing these uses seem likely to be as follows:

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Phila Rogers 1/2/08 Doc 5

Rush

Y4 Bd.
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STRAWBERRY CANYON

UNIVERSITY OF CALIFORNIA

BERKELEY

A land use and vegetative management study

by Garrett Eckbo & Associates

for the Office of Architects & Engineers

June 1976

Institutional uses cannot expand much beyond their current areas. One substantial and reasonably acceptable building site is available above the Lawrence Hall of Science on either side of Space Sciences. However, anything proposed there should be subjected to intensive environmental design study, in terms of its visual impact on the Canyon landscape from within and without. Two other sites which are feasible from an engineering point of view are undesirable because of ecological, access, or utility problems.

Educational and research uses should continue to dominate the Canyon area. This seems to justify an expansion of Ecological Study Area boundaries, and to require a more carefully structured management. Academic uses must focus on the conservation of the resources they are using.

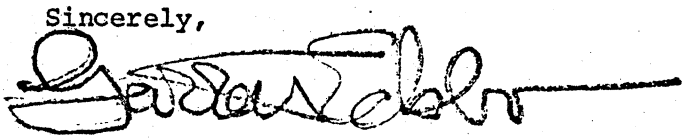
Recreational uses, primarily for the campus community, should continue in a hopefully symbiotic relationship with academic uses. Questions of convenience and access, for the non-campus public and for the less agile or energetic members of the campus community, remain to be worked out.

The larger question, which is central in these recommendations, is that whoever uses the Canyon area, for whatever purposes and in whatever part of it; and whoever looks at or into the Canyon from outside, or passes through or over it; are all experiencing it as a total landscape structure or complex, a total people/nature artifact. Its impact on all of these experiences, visually and through the other senses, is one of its primary functions. Therefore we have viewed the Canyon as a potential work of landscape art, including and transcending all of its multiple technical, functional and cultural aspects. We believe that the comprehensive view will enhance relations between all of these component aspects, and improve each one.

The report endeavors to deal with existing conditions, proposals by others and recommendations as to further action and ongoing policies within this comprehensive framework.

I would like to acknowledge substantial help and cooperation in the preparation of this report from your office; from Engineer Ben Lennert, who provided the descriptions of Geography and Geology and of Rock and Soils Conditions, the storm drainage reports and the analysis of feasible building sites, all included in his appendices to this report; and from the Committee on Environmental Quality, particularly Professor Joe McBride. His aid in developing guidelines for vegetative management was invaluable.

Sincerely,



Garrett Eckbo
:cg

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SUMMARY OF PROPOSALS

1. Vegetation management recommendations for specific vegetation units are shown in Table 1. These recommendations were developed to enhance the visual quality of the canyon, reduce erosion, reduce fire hazards, and maintain a variety of vegetation types for teaching and research.

2. Fuel management recommendations for specific vegetation units are shown in Table 1. Fire as a tool is recommended for reducing fuel loads in many vegetation types.

3. Future building construction should be restricted to the area between the Lawrence Hall of Science and Grizzly Peak Blvd. The two other possible sites in the Canyon are geologically stable but present problems due to the lack of existing utilities or the aesthetic and ecological disruption which would occur if buildings were constructed on them (see Map 6).

4. An improved trail system is proposed which will provide several round trip hiking routes, improve access in the canyon for fire suppression, and improve access for teaching purposes (see Map 12).

5. This report proposes the closing of Centennial Drive above the Lawrence Hall of Science to reduce traffic, air, and noise pollution in the Canyon (see Map 12a).

6. Expansion of the Ecological Study area boundaries to include those

areas proposed in the Siri/Lindgren Report (see Map 10).

7. Slight expansion of area of the Botanical Garden to facilitate boundary maintenance and provide additional space for research (see Map 13c).

8. A vegetation management expert should be hired to direct the re-vegetation of the canyon, supervise trail construction and maintenance, manage fuel load, and monitor use of the canyon.

9. Each one of these proposals will require further, more detailed and intensive study on the ground in order to implement it. These studies may be carried out by any or all of the following:

a. The architect/engineer office

b. Consultants

c. The management team.

The further studies might be set up as follows:

a. Establishment of management office and team.

b. Improved and expanded trail system.

c. Closing and re-design of Centennial Drive.

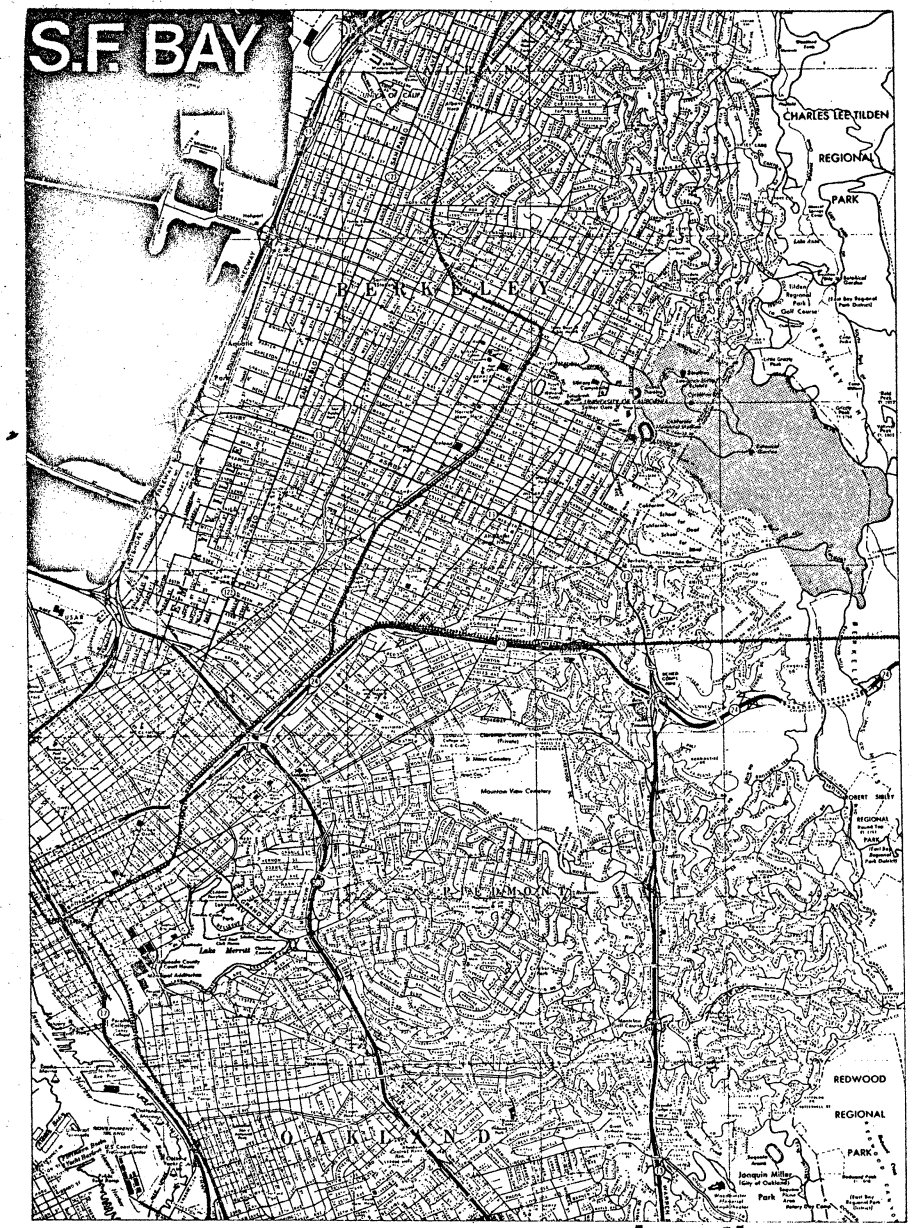
d. Re-vegetation.

e. Vegetation and fire hazard management.

f. Building construction on a per site basis when and if need and/or demand emerge.

g. Expanded Ecological Study Area definition in relation to demands for education, research, recreation, and Botanic Garden proposals.

EXISTING CONDITIONS



location map

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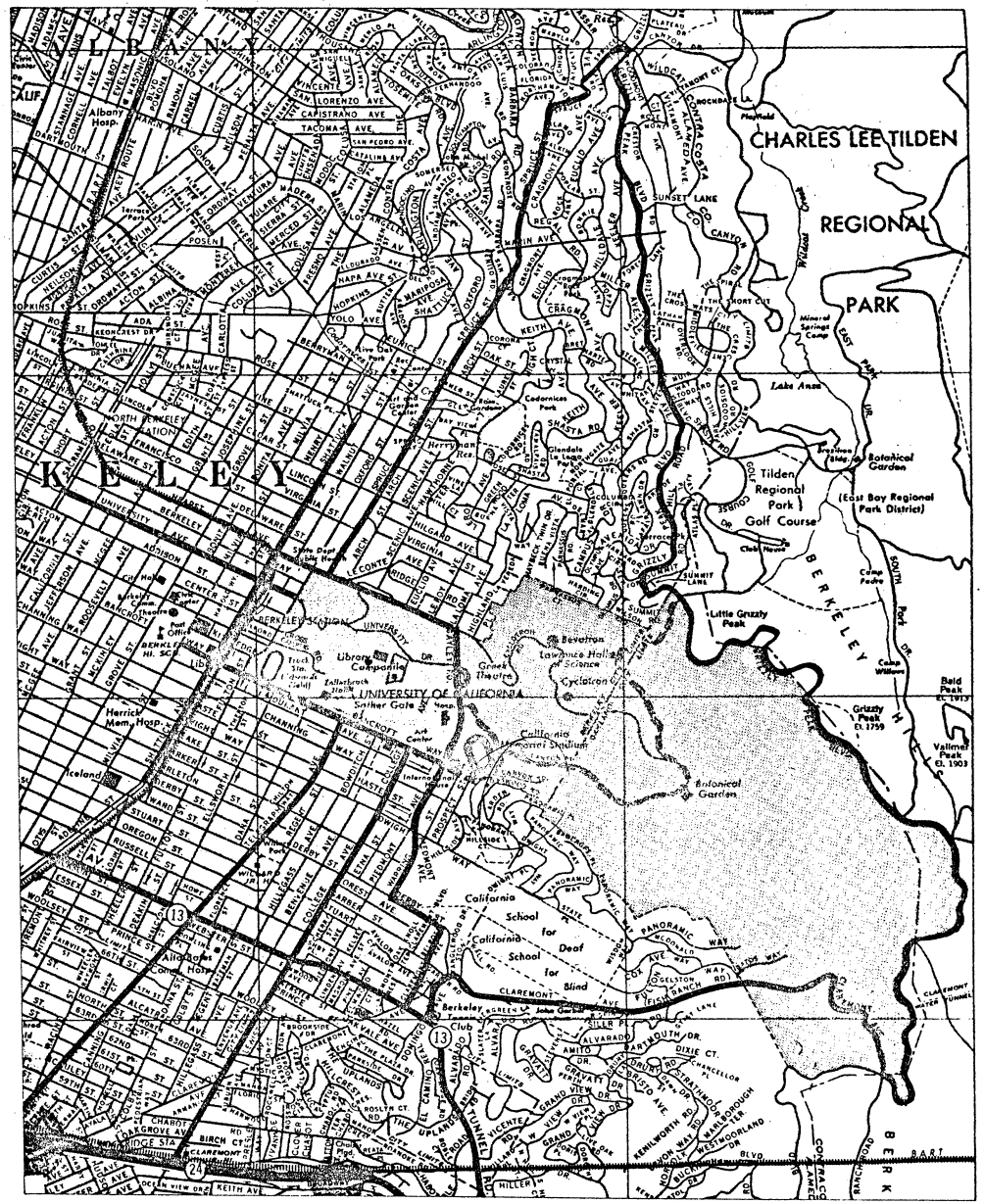

area map

0 500 320 MILE

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1

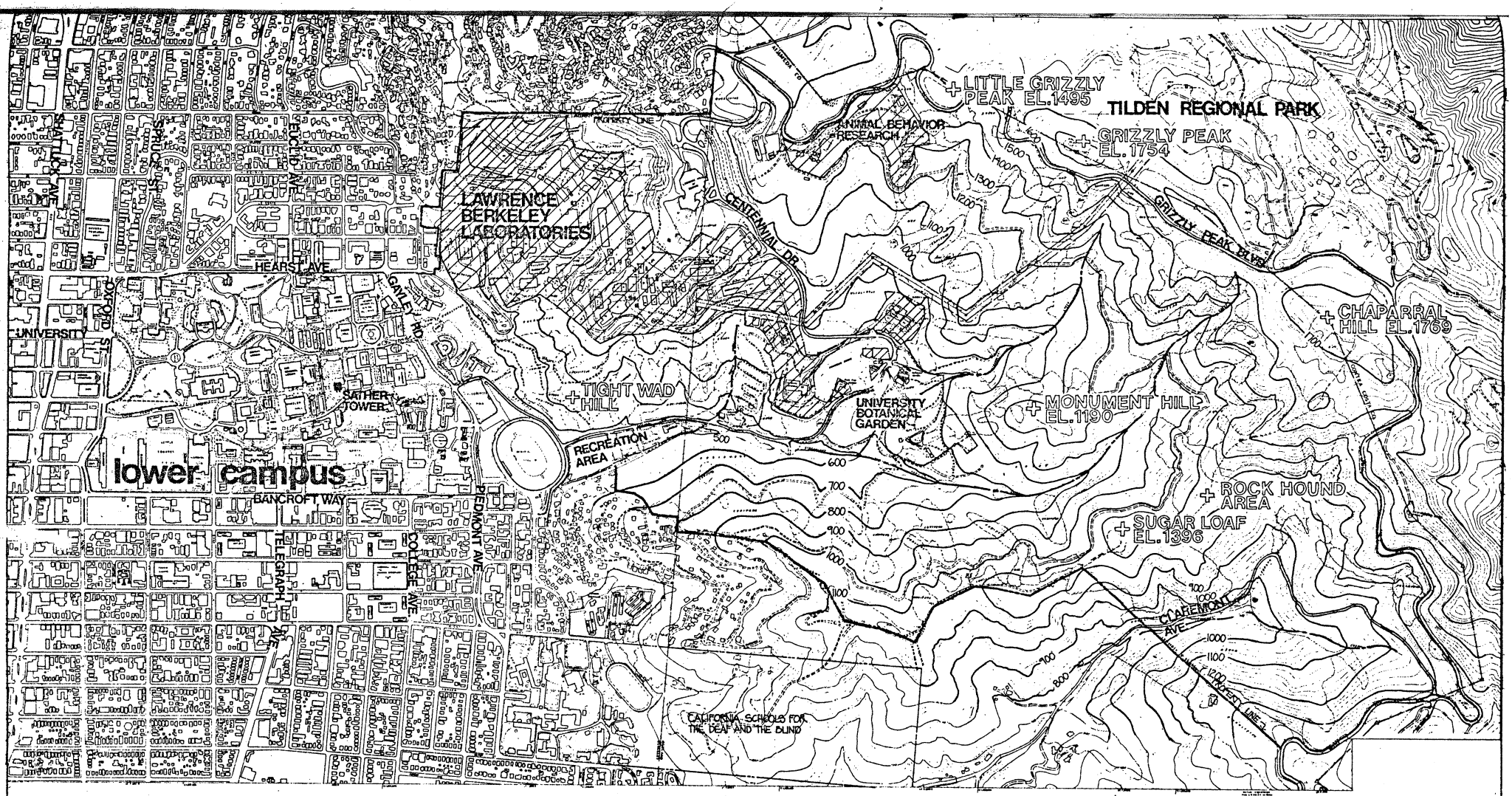
I. EXISTING CONDITIONS

REGIONAL RELATIONS

Strawberry Canyon is the uphill major portion of the University of California lands in Berkeley/Oakland. It comprises roughly 1000 acres of steep and largely undeveloped land above and east of Gayley Road. The main campus occupies about 150 acres of more gently sloping land below and west of Gayley. The lower quarter of the Canyon lands lies within the City of Berkeley, the upper three quarters within the City of Oakland.

The main lower campus is a central element in the physical structure of Berkeley. The upper canyon lands connect the campus and the city with the ridge-top intersection of Alameda and Contra Costa Counties (roughly marked by Grizzly Peak Boulevard) and their regional park system. Tilden Park abuts along the northeast boundary of Strawberry Canyon. West of the Park hillside residences follow the boundary closely down into the city. On the south side of the campus lands hillside housing in the Panoramic Way area abuts the University closely. Further east, over into Claremont Canyon and around the east side to Tilden Park, the neighboring lands are undeveloped.

South of the campus lands, between Dwight Way and Derby Street east of Warring, about 125 acres of the California School for the Deaf and the Blind extend 4200 feet back into the hills. Their northeast corner is only some 200 feet from the University's south boundary, and is



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CAMPUS & TOPOGRAPHIC MAP

0 200 400 1000 1750ft.

2

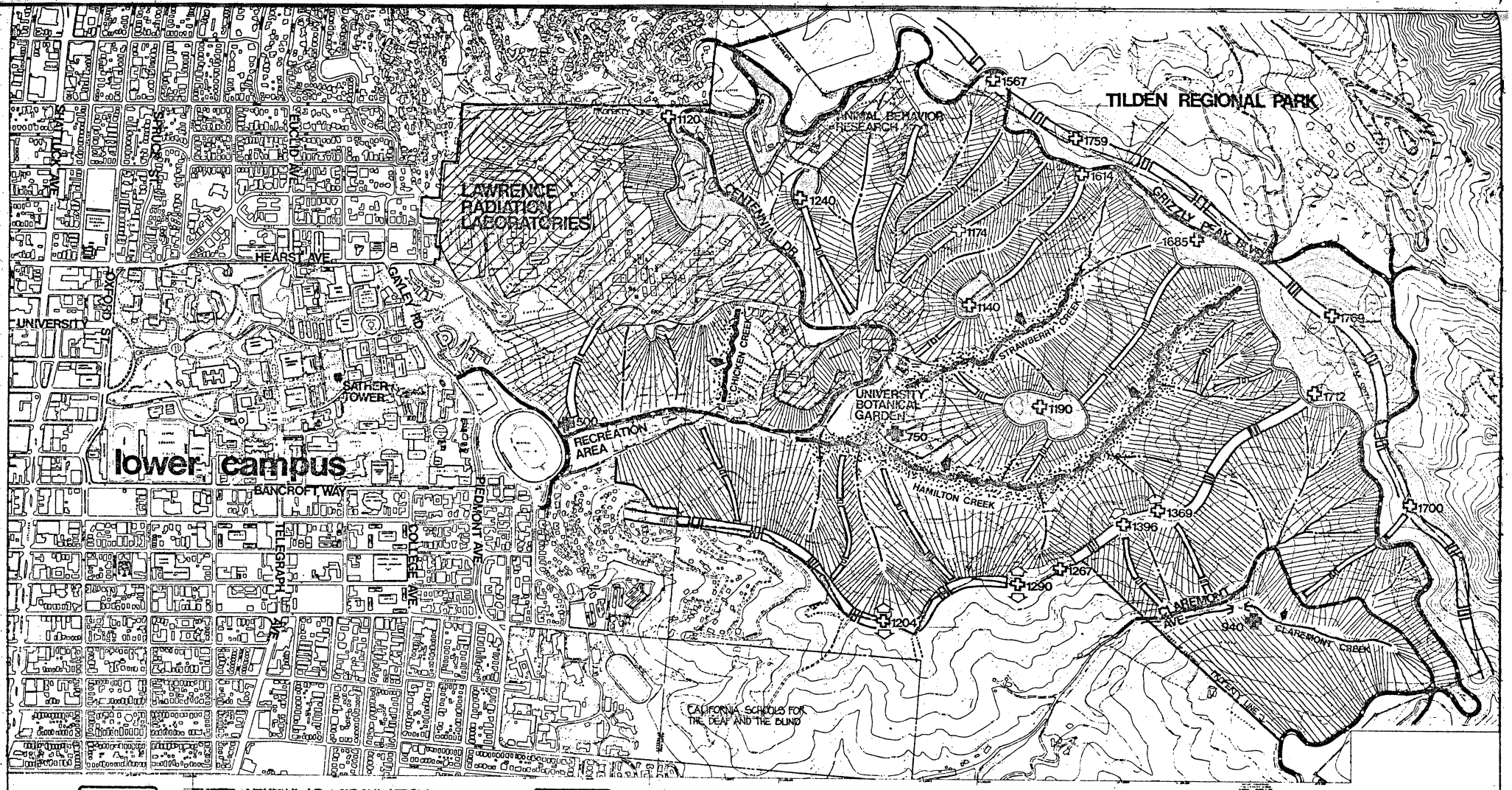
connected by a dirt road. The fact that the School has been condemned as unsafe and is to be rebuilt elsewhere may have some relevance to University planning. The central entrance to the School is 2000 feet from the Gayley Avenue entrance to the University.

EXTERIOR ACCESS

In terms of access the main lower campus is the hub of a network of arterials which connect it with the Bay Area north, south and west -- Spruce/Oxford Streets, University Avenue, Telegraph and College Avenues. Grizzly Peak Boulevard along the upper northeast border of Strawberry Canyon connects the campus with the hill parks and areas north and south, and the Orinda/Walnut Creek area east via Fish Ranch Road. Centennial Drive through Strawberry Canyon is the only direct connection from lowlands to hilltops between Claremont Avenue and Spruce Street. The lowland spread is about one mile either way from Centennial to Spruce/Oxford or Claremont/Ashby. Along Grizzly Peak the spread is about two miles either way.

TOPOGRAPHY

Topographically the Canyon is a large bowl which tapers down to a narrow neck entrance -- about 500 feet wide -- just behind the Stadium. This hilly bowl is simple in form on the southside for about two-thirds of its total length. The north side is subdivided by a series of projecting ridges, such as Monument Hill, into four sub-valleys. This means that, in a circuit around the canyon, the southwestern two-thirds is generally



EXSTG. VEHICULAR CIRCULATION

RIDGELINES

RIDGETOPS
DRAINAGE DIRECTION

1976 HIGH POINT

1975 LOW POINT

CREEK

DRAINAGE SWALE

RIPARIAN AREA

DIRECTION OF DRAINAGE

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PHYSIOGRAPHY & HYDROLOGY

0 200 400 1000 1750ft.

3

visible as an overall unit, dominated by Lab construction and north slope vegetation, with views into the three western sub-valleys. On the north side one is cut off from complete views into the main bowl. The north side circuit is therefore much wilder and more variable visually, with occasional partial views of Lab, City and Bay.

About 165 acres of the northwest corner, occupied by Stern and Bowles Halls, the Greek Theatre and some Lawrence Berkeley Lab buildings, are geographically outside of the north Canyon ridge line on a west-facing slope. About 200 acres of the southeast corner lands lie over the upper ridge line in Claremont Canyon. Thus the actual Strawberry Canyon area is about 635 acres. The east ridge-top zone is a very strategic strip with spectacular views both east and west. It connects the large potential future development site at the northeast corner with the relatively level fire road/promenade which connects with the top of Panoramic Way along the south side. This ridge-top has some fine groups of specimen trees.

The total Canyon lands are divided into seven topographic units:

The northwest slope above Gayley Road

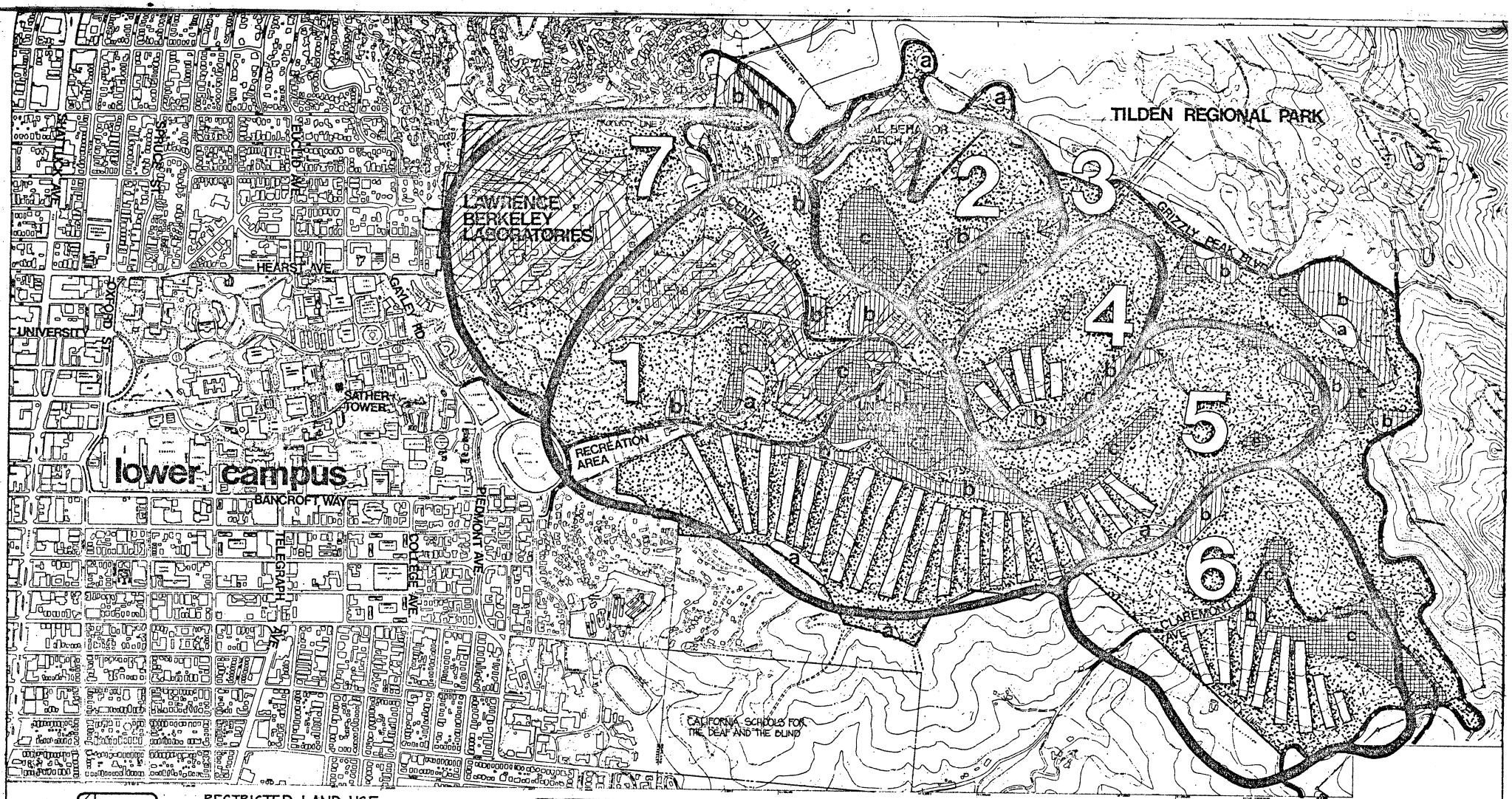
The main southwestern bowl

The four sub-valleys northeast

The Claremont Canyon sector.

USE

The uses of these upper University lands are basically education, research, and recreation, in keeping with its mission. Along Gayley



RESTRICTED LAND USE

EXSTG. VEHICULAR CIRCULATION

LIMITS OF VISUAL ZONES 1-7

ZONE 1 - MAIN CANYON

ZONES 2-5 - SIDE CANYONS

ZONE 6 - CLAREMONT CANYON

ZONE 7 - WEST SLOPE

NORTH SLOPES - COOL, MOIST

SLOPES 0-8%

SLOPES 8-15%

SLOPES 15-25%

SLOPES 25% +

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SLOPES & TOPOGRAPHIC UNITS

0 200 400 1000 1750 ft.

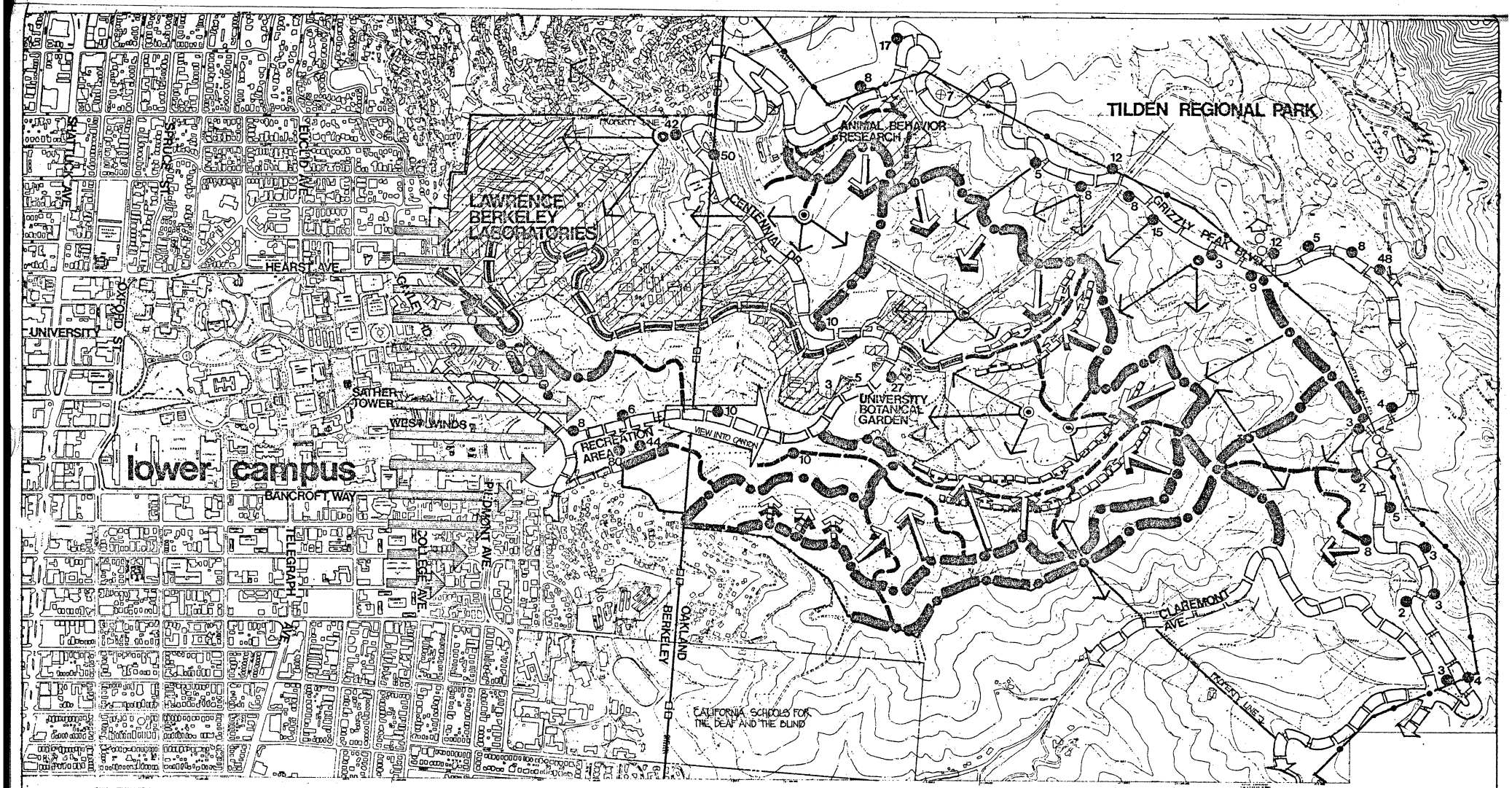
4

Road these include Stern and Bowles Halls and International House (residential), California Memorial Stadium and Kleeberger Field (athletic/recreational) and Hearst Greek Theatre (performance/recreational/ceremonial). About 130 acres in the northwest sector are occupied by Lawrence Berkeley Labs. On up the canyon are the Strawberry Canyon Recreational Area (pools, courts, play field), the Botanic Garden, the Lawrence Hall of Science, the Space Science Laboratory, and the Animal Behavior Research Station. About 390 acres is now set aside and posted as an Ecological Study Area. The 1968 Daly Report stated that 13 University departments have 41 regular courses with at least 4374 students who use the natural areas of the Canyon in their course work. Another six departments use the Canyon as site or staging area for class work.

INTERNAL ACCESS

Considering the importance of the Canyon lands to the main campus and through it to the general public, access between the two is extraordinarily difficult. Westward connections from Gayley Road are mostly vehicular drives. Gayley itself carries substantial north/south traffic. One pedestrian pathway connects from the Stadium Rimway west to Campanile Way, the main east/west pedestrian corridor on the lower campus.

East of Gayley there are only two ways into the Canyon, both difficult. The north entrance, between Kleeberger Field and Bowles Hall via Stadium Rimway to Centennial Drive, is narrow and difficult for both



VEHICULAR CIRCULATION

CONTROLLED VEHICULAR CIRCULATION

PARKING AREAS

FIRE TRAILS & OTHER USES

INDIAN TRAILS

VIEW INTO CANYON

FILTERED VIEWS THROUGH TREES

SEQUENTIAL VIEWS ALONG FIRE TRAIL

INWARD VIEWS - STREAMS

LONG OVERVIEWS

PANORAMIC VIEWS

PREVAILING WIND

EXSTG. P.G.&E. POWER EASEMENT

EXSTG. LAND USE UNITS

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EXISTING CONDITIONS

0 200 400 1000 1750ft.

5

vehicles and pedestrians. South of the Stadium the Rimway connects back down to Gayley/Piedmont Avenue via Orchard Street, also narrow and tortuous. Pedestrians may find their way up between Stadium and International House, around a complex of parking terraces, behind the Recreation Area field house and across the play field to the narrow path along Centennial Drive. Another path which runs along the hillside south of the Haas Pool complex as an extension of Canyon Drive ends at the upper pool, although an Indian trail goes on uphill from there. The Recreation complex is some 1600 feet long, and there is another 800 feet of narrow walk along Centennial Drive before one reaches the beginning of the fire road behind the dam. Here one can at last escape the traffic and visual confusion of the entire 2400 foot entrance corridor from Rimway into natural quietude.

Driving into the Canyon is no great improvement, because parking between Haas Recreation Complex and Botanic Garden is very limited. There are only seven small parking areas including that at the Garden.

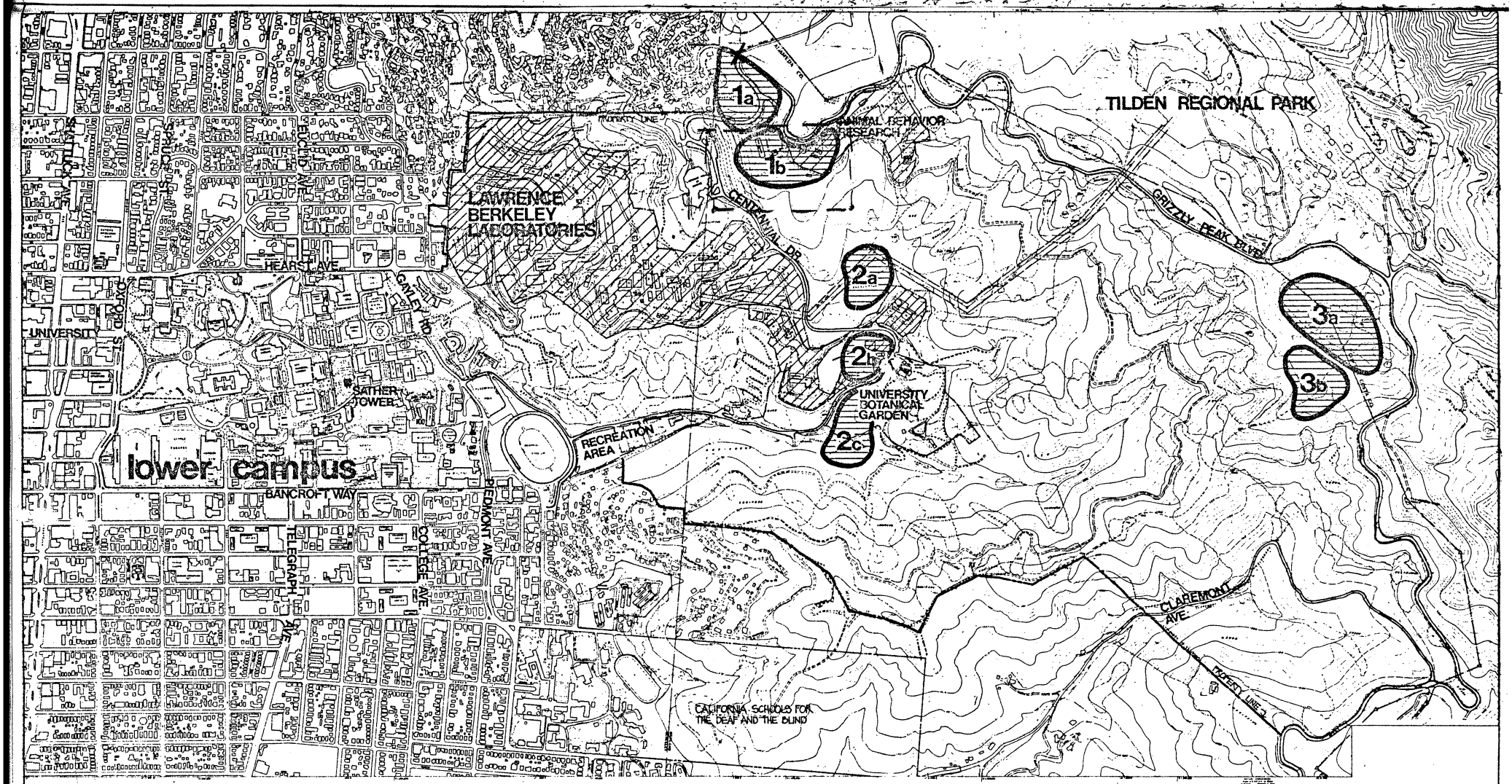
The fire road takes one alongside the Botanic Garden and on up to the top of Panoramic Way through fine oak woodlands and coniferous groves. This is a total of 4000 feet from the dam. From this point a rough steep path climbs 160 feet in 600 to the previously mentioned upper fire road/promenade which carries one almost level entirely around the Canyon bowl. This is a distance of about 14,000 feet or almost three miles. It is a magnificent walk, up in the vertical center of the bowl space, with constantly changing views up and down the Canyon and out over City and Bay. The north end of this fire road connects with

Grizzly Peak Boulevard east of Centennial at the Space Science Building. Neither the north nor south ends of this upper fire road/ promenade are easy for the campus community or general public to find. Parking is very limited when they do find them. Centennial Drive is the only easy connection from the north end back down to the Botanic Garden area.

CONSTRUCTION

Most building construction in the Canyon area has occurred in the northwestern quadrant between Centennial and Gayley Drives in the Lawrence Lab complex. This is an area of roughly 130 acres completely enclosed by security fencing and inaccessible to most of the campus community and general public. The area is expanded to perhaps 200 acres by the need for clear space outside the fence. The importance of the work within the complex is belied by its external architectural mediocrity (except for the serene dome of the Cyclotron), careless and irresponsible site planning, ecological destruction and hydrological devastation. (The bed of Strawberry Creek eroded down about ten feet as a result of the increased runoff from the Lab complex.)

The Lawrence Hall of Science is outside the security area. It is the public relations liaison for the campus scientific community. High up on Centennial Drive near Grizzly Peak, it is a handsome architectural complex with spectacular views of the Bay. However it is built



1a,b — ACCEPTABLE

2a,b,c — UNACCEPTABLE ECOLOGICALLY

3a,b — UNACCEPTABLE - ACCESS/UTILITIES

LENNERT AND ASSOCIATES CONSULTING ENGINEERS

STRAWBERRY CANYON STUDY
U.C. BERKELEY · JUNE 1976
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BUILDING SUITABILITY

0 200 400 1000 1750 ft.

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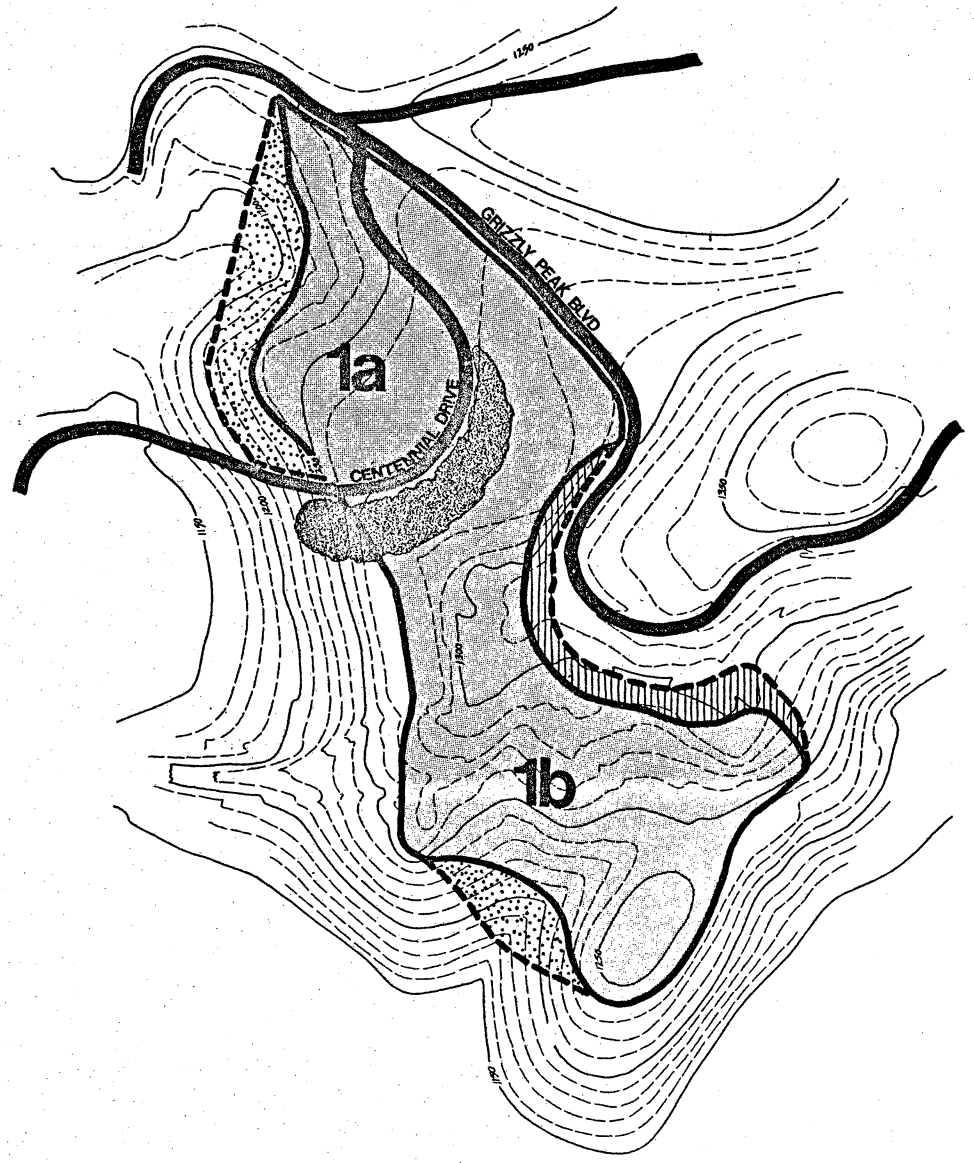
across a geologic fault line and had major engineering problems during construction.

Other construction within the Canyon area is minor, non-obtrusive, or transient. The possibility of future needs for building sites led this study to locate the only three reasonably feasible site areas within these upper Canyon lands. They are described in detail herewith. Three specific sites, spaced from the lowest between Strawberry Creek dam and the Botanic Garden to the highest northwest of the BioMedical Building, are probably unacceptable for ecological/esthetic reasons. Two sites at the upper northeast corner are inaccessible except from Grizzly Peak Boulevard and lack near utilities. The most feasible site (one large or two small) is therefore just above Lawrence Hall next to Grizzly Peak Boulevard.

GEOLOGY AND SOILS

Neil Havlik, Consultant to Ralph Jones in his 1974 Campus Landscape report, describes the Canyon geomorphology nicely:

> The canyon is bounded on the south by the east-west trending ridge known as Skyline Ridge, and on the north by the ridge whose most prominent point, Fog Bluff, today contains the Lawrence Hall of Science and a fine lookout point overlooking the campus, Berkeley, and San Francisco Bay.
>
> Strawberry Canyon runs more or less perpendicular to the direction of the rock strata underlying it, so that several different rock types are exposed. To the west of a line running north and south from the main entrance to the Botanic Garden is the Shasta-Chico formation, which is mostly shale with occasional interbeds of sandstone. The above-mentioned line is more than just that; it is the approximate trace of a fault, sometimes called the Strawberry Canyon fault, or just Canyon fault. To the east of this fault the rock is primarily



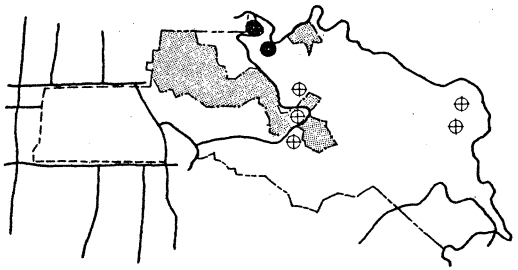
EXSTG. VEHICULAR CIRCULATION

POTENTIAL BUILDING

LIMITS OF FILL

LIMITS OF CUT

DISTURBED TREES BY CUT, FILL OR BUILDING



key map

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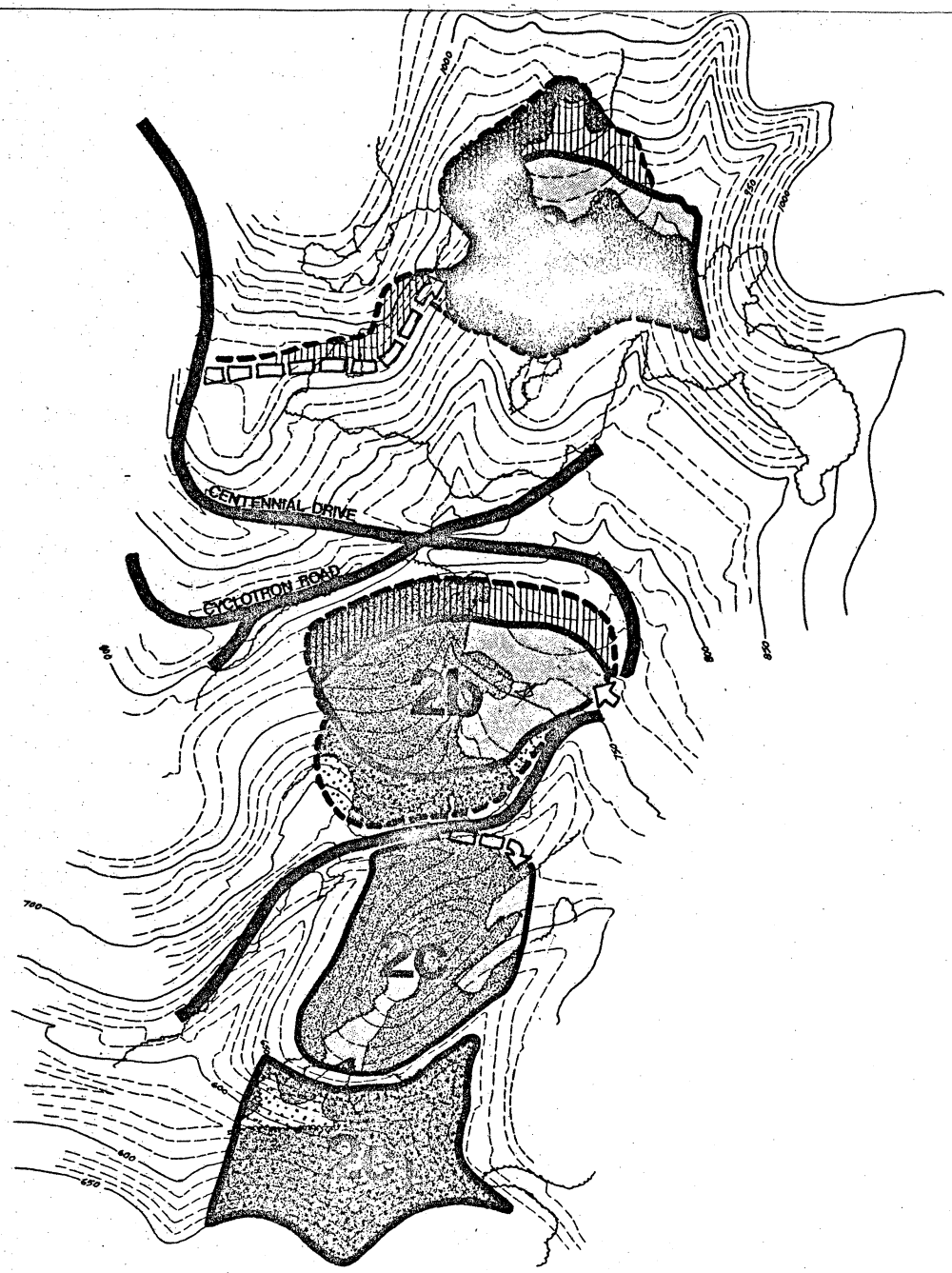
BUILDING SUITABILITY · SITE 1

0 50 100 400ft

6a



EXSTG. VEHICULAR CIRCULATION

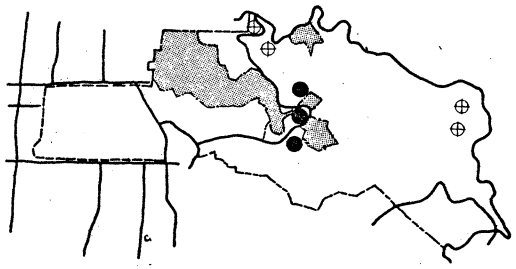
PROPOSED VEHICULAR ACCESS

POTENTIAL BUILDING SITE

LIMITS OF FILL

LIMITS OF CUT

DISTURBED TREES BY CUT, FILL OR BUILDING



key map

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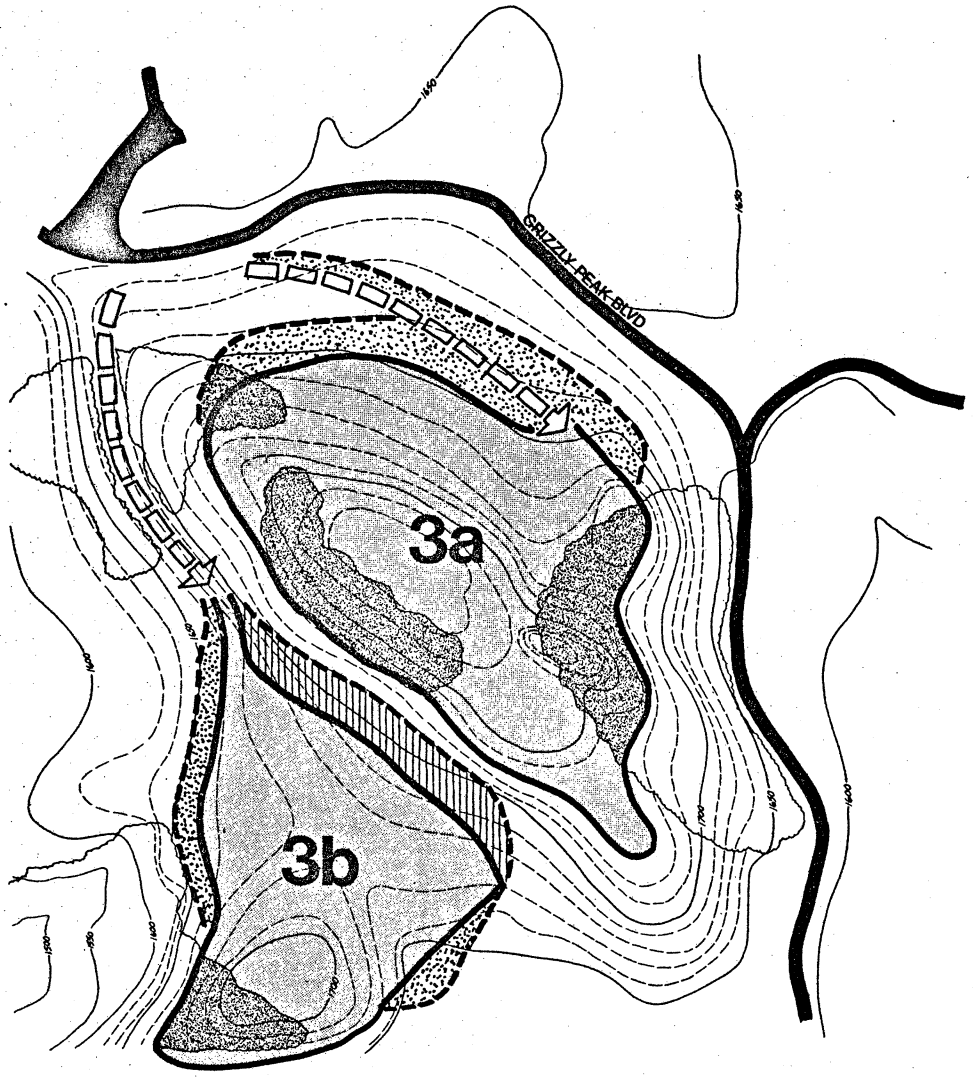
BUILDING SUIT-ABILITY · SITE 2

0 50 100 400ft

6b



EXSTG. VEHICULAR CIRCULATION

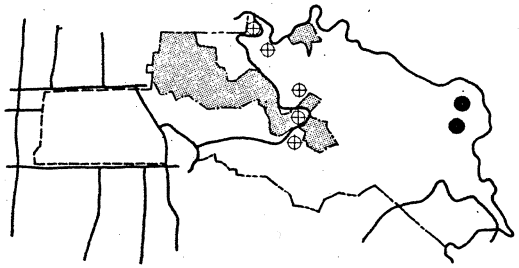
PROPOSED VEHICULAR ACCESS

POTENTIAL BUILDING SITE

LIMITS OF FILL

LIMITS OF CUT

DISTURBED TREES BY CUT, FILL OR BUILDING



key map

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BUILDING SUIT-ABILITY · SITE 3

0 50 100 250 400ft

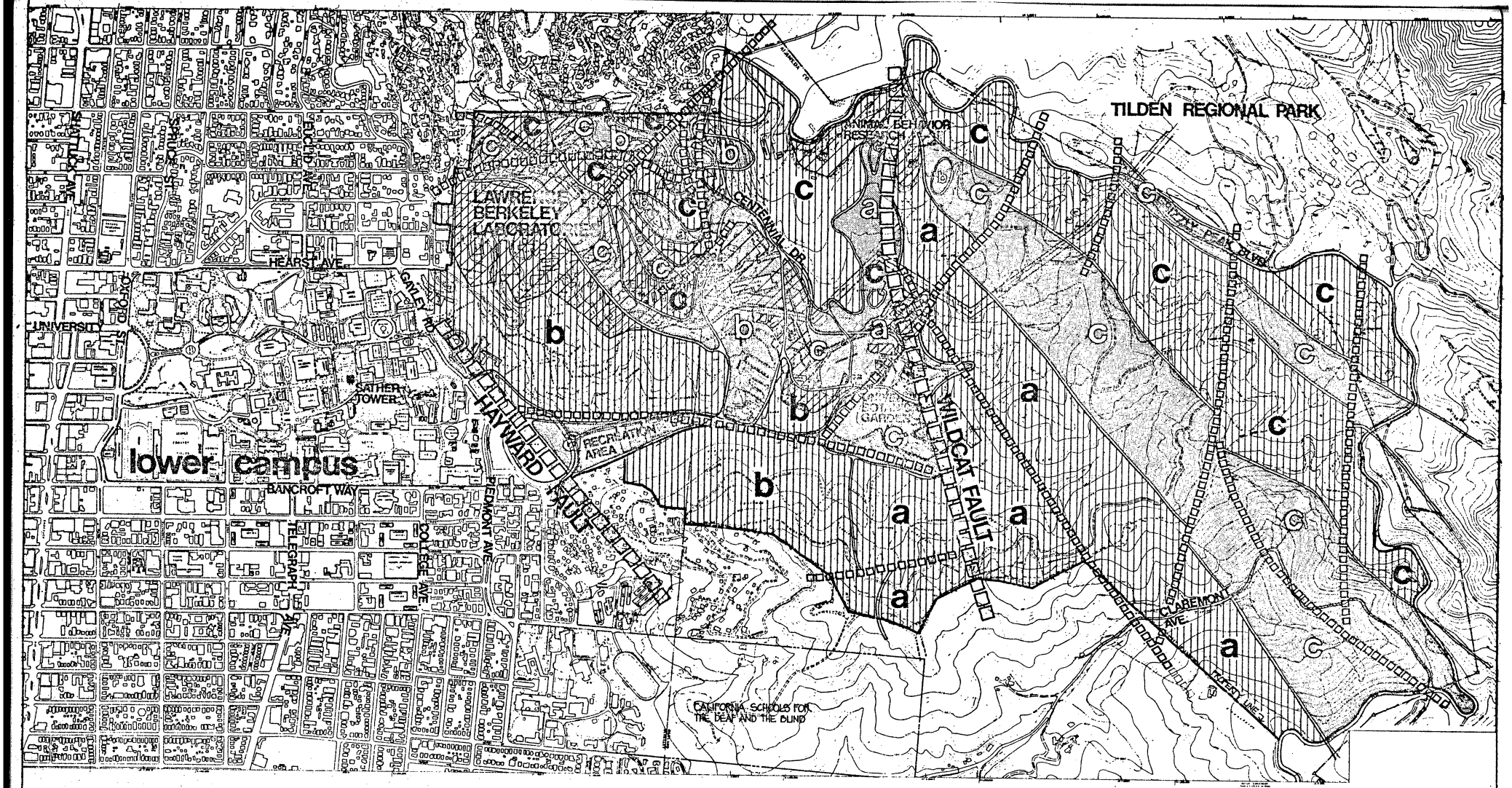
6c

chert of the Monterey formation. This rock is quite resistant to erosion and has formed three knolls within the canyon, two of them quite prominent. The southernmost, called Sugar Loaf, occurs on Skyline Ridge and rises abruptly some 200 feet to an elevation of just over 1400 feet. North of Sugar Loaf and separated from it by the south fork of Strawberry Creek, stands the second prominent point, known as Monument Hill. This hill rises steeply behind the Botanic Garden to a height of 1200 feet. To the east of these peaks their respective ridges drop as the softer shale and conglomerate Orinda formation is encountered. (The northern chert knoll does not stand out as prominently as the others, and is only slightly higher than the Orindan soils.) The slope then begins to climb again, and soon the volcanic Berkeley formation, which comprises the crest of the Berkeley Hills and is composed largely of basalt, rhyolite, and tuff, is encountered. These resistant rocks form the steepest part of the Berkeley Hills as well as the highest, including (north to south) Little Grizzly Peak (1380 feet), Grizzly Peak (1760 feet), Frowning Ridge (1740 feet) and Chaparral Peak (1750 feet). The varied and rugged topography of Strawberry Canyon has discouraged development and favored the establishment of a rich diversity of plant and animal life, such that Strawberry Canyon today is one of the finest natural areas of comparable size in the Bay Area.

The Vegetative Management Committee provides a good general description of area soils:

The soils along the ridge of the Berkeley-Oakland Hills have formed from sandstone and shale. They are loams and clay loams, very porous and strongly structured. Depth of soil to weathered sandstone ranges from less than 12 inches to over 5 feet, although most soils range from 12 to 24 inches deep. Shallow soils occur along the very top of rocky ridges and on some very steep slopes such as on Grizzly Peak. Very deep soil occurs in the upper portions of canyons on north and east facing slopes. The depth of plant roots -- particularly trees and shrubs -- is not limited to the soil depth but extends many feet into the weathered and fractured sandstone for water and nutrients.

With the exception of the few shallow soil areas, the soils present no limitation to a rather wide range of plants. Erosion is not a serious hazard in the area unless the soils are mechanically disturbed or remain bare throughout the winter



UNFAVORABLE

- **a** — RECENT = ALLUVIUM, COLLUVIUM & LOCAL FILL
- **b** — RECENT TO LATE PLEISTOCENE = LANDSLIDE BODIES & ASSOCIATED COLLUVIUM
- **c** — MID TO LATE PLEISTOCENE = ORINDA AND SIESTA FORMATIONS, CLASTIC SEDIMENTS COMMONLY CLAYEY WITH LITTLE INDURATION, COMMONLY UNSTABLE

FAVORABLE

- **a** — MIOCENE = CLAREMONT & SOBRANTE FORMATIONS. CLASTIC SEDIMENTS, MODERATELY INDURATED, GENERALLY STABLE
- **b** — CRETACEOUS = KNOXVILLE & CHICO FORMATIONS. CLASTIC SEDIMENTS, MAINLY ARCHOSIC SANDSTONES & SILTSTONES. WELL INDURATED, GENERALLY STABLE
- **c** — LATE PLIOCENE = MORAGA, GRIZZLY & BALD PEAK FORMATIONS, FLOW ROCKS AND TUFFACEOUS SEDIMENTS. MAINLY BASALTIC OR ANDESITIC WITH LOCAL RHYOLITIC MEMBERS. FLOW ROCKS ARE GENERALLY HARD & STABLE. TUFFACEOUS MEMBERS ARE GENERALLY CLAYEY & POTENTIALLY UNSTABLE

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GEOLOGY & SOILS

0 200 400 1000 1750 ft.

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months after a fire. Reseeding with annual ryegrass on large burns is recommended, however, it may not be necessary on small burns surrounded by grassland because these areas will be seeded by the local grasses.

See the much more detailed reports on GEOGRAPHY and GEOLOGY and on ROCKS AND SOILS CONDITIONS by Engineer Ben Lennert, in the appendices which accompany this report.

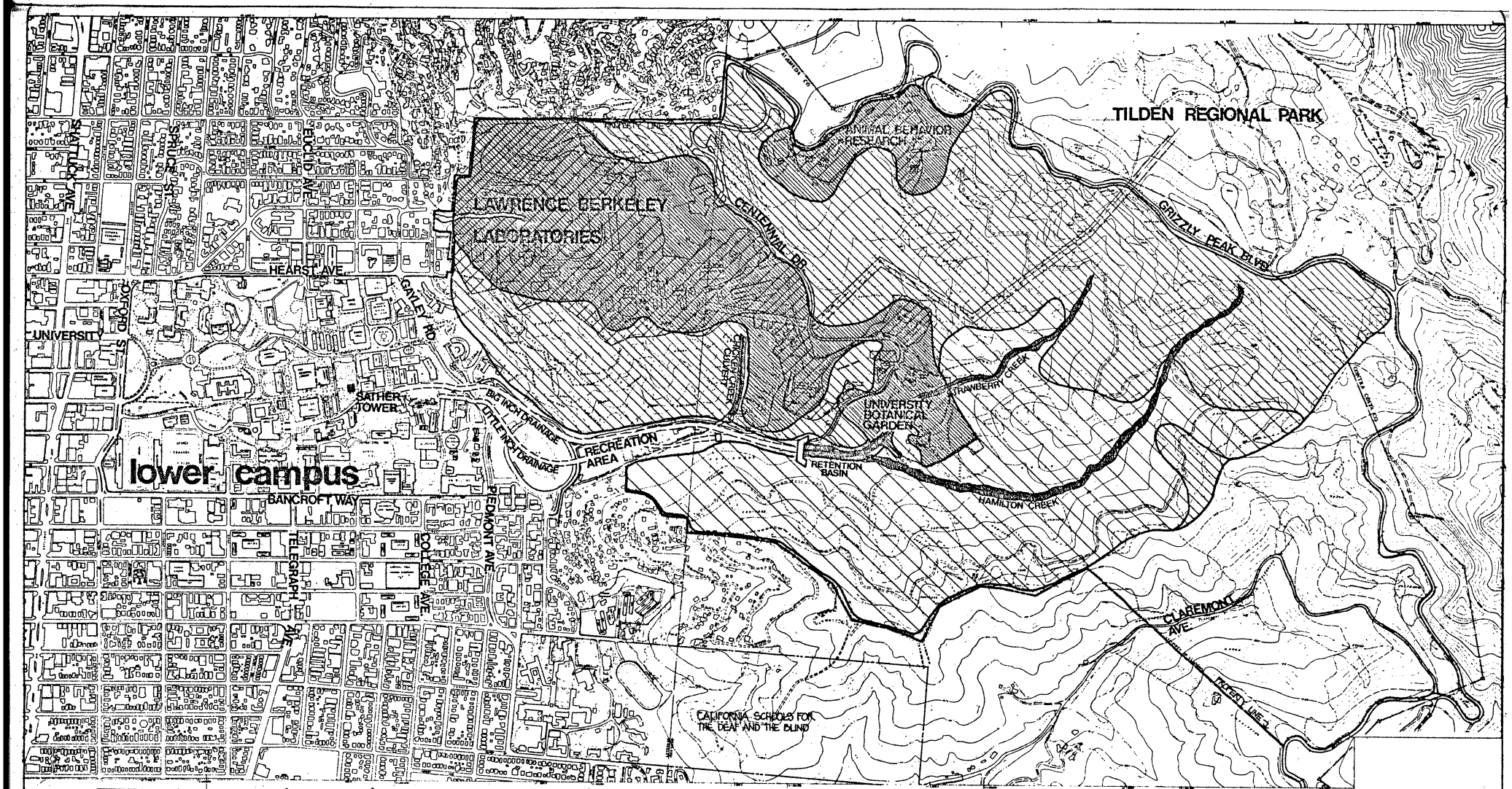
DRAINAGE AND HYDROLOGY

We have reviewed the Lennert and Associates report, in four folders, of May 12, 1972. This tells us that the main drainage from the Canyon is via the South Fork of Strawberry Creek (combined with Hamilton Creek and Chicken Creek). This goes through a retention basin and earth fill dam below the Botanic Garden and from there underground through the Old Stadium and New South Fork Bypass Culverts. The old culvert drains only the Haas Recreation Area and the stadium. It feeds the creek in the upper part of Faculty Glade. The New Culvert takes all other drainage with overflow provisions on Centennial Drive.* Plans have been made to solve siltation and debris collection problems in the retention basin above the dam with new gate construction. Plans have also been made to raise the water table between the dam and Haas Recreation Area (about 1,000 feet) so as to rehabilitate the riparian vegetation in the old creek channel. This will be done by holding the hydraulic gate open 6 inches, constructing a new bypass and plugging the subdrain to return the creek flow to the surface.

The North Fork of Strawberry Creek originates above the northwest sector of the Canyon lands, on the west slope which is outside the Canyon proper. It has been almost entirely undergrounded by Lawrence Lab construction.

The Canyon lands -- excluding Claremont Canyon -- now divide into three drainage rate type areas:

*This feeds back into the Creek at the Men's Faculty Club.



1 AREA 1 - (DEVELOPED) RUN-OFF @ 100 FPM

2 AREA 2 - (GRASS COVER) RUN-OFF @ 75 FPM

3 AREA 3 - (HEAVY COVER) RUN-OFF @ 10 FPM

CREEK - NATURAL WATERCOURSE

DEVELOPED DRAINAGE CHANNELS

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DRAINAGE

0 200 400 1000 1750ft.

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Type 1 -- Runoff rate 100 feet per minute. Developed areas, primarily Lawrence Lab, Botanic Garden, and Animal Behavior Research. 284 acres.

Type 2 -- Runoff rate 75 fpm. Grass cover areas, including some soft chaparral. 400 acres, primarily south slope. * Tend to be drier

Type 3 -- Runoff rate 40 fpm. Heavy cover areas, primarily north slope and Monument Hill, plus two small areas on Grizzly Peak at Centennial Drive and Chaparral Hill. 300 acres.

Pertinent quotes from Folder 2, Sec. 2, South Fork Drainage System Planning: "The maximum peak flow rate, from a 25-year storm and at full planned campus development, potentially entering the bypass system above the Haas Recreation Center is 1650 cfs. In order to reduce problems in the lower campus area, it was decided to limit the maximum peak flow injected into the culvert systems. . . . to about 850 cfs in the South Fork Bypass culvert and 50 cfs in the Old Stadium Bypass culvert. The remaining 750 cfs is either held at the retention basin and/or diverted down North Canyon Road. . . . with a frequency of about once in ten years."

Initial plans for "filling the canyon, above the Haas Recreation Area and below the retention basin embankment, to a level approximately that of North Canyon Road" or "filling an average of about 10 feet above the existing channel grade" were rejected on the basis of drainage to a "natural area".

"The new culvert was finally constructed. . . . to a line-and-grade. . . . essentially identical to the pre-existing geometry."

"It was proposed that nearly all bed-load materials would be eliminated from the system by construction of stabilizing check drains in both Chicken Creek and in the channels above the retention basin. This was largely accomplished in Chicken Creek . . . . however, the permanent stability of the present section is somewhat questionable. . . . the area above the inlet was declared a permanent and absolutely untouchable natural area. . . . and the planned check dams could not then be installed. . . . trash-sacks. . . . to intercept large materials only. . . . was prevented above the retention basin. . . . and. . . . then never attempted in Chicken Creek."

This engineering language describes a surprisingly illogical sequence for an intellectual institution to follow:

1. The South Fork existed as a balanced natural system in which water flow and topography were stable.
2. Stadium construction at the lower end required putting the same water flow underground.
3. Lawrence Lab construction accelerated upper system runoff and caused extensive unnatural erosion above and below Gayley Road.
4. Remedial works -- basin, dam, and bypasses -- were constructed to stabilize the new water flow/topography relations. These works are unnatural. They have not corrected the unnatural erosion which took place before they were built.

5. Proposals to construct additional works which would return the stream channels to their original natural profile are rejected as "unnatural."

Pertinent quotes from Folder 3: The North Fork Channel "extends from the inlet to the city culvert just above the upper end of Le Conte Avenue to the outlet facility of the Lawrence Radiation Laboratory storm drainage system. The Channel has been totally obliterated above this point, and all major flow is carried in culverts which eventually drain to the LRL outlet facility.

"The theoretical peak flow rate at the inlet to the city culvert for a 25 year storm is about 500 cfs, reducing to 450 cfs at the LRL outlet. . . . The present peak flow rates are approaching the maximum rates for full projected watershed development."

"The channel (city inlet to LRL level --- approximately 350 feet) was completely regraded and reconstructed. . . . 5 check dams were required . . . . the new channel is completely stable."

"This office considers this channel to be an example of what can be done to improve a previously inadequate, rubbish and debris lined, severely eroded and unstable, ugly and unnatural, and esthetically offensive channel which has been 'overloaded' by watershed development."

By contrast the "open channel ---LRL fence to LRL storm drain outlet

facility (about 450 feet). . . . The creek consists of a deep and narrow central channel eroded into slide debris and colluvium. . . . This office was not permitted to reconstruct this channel. . . . We were, however, permitted to remove the "down wood" and dead trees. . . . The only major question is the amount of erosion, and the amount of bedload and float load materials injected into the system. . . . The process will . . . . resume as heavy limbs and logs again accumulate alongside and in the channel."

"The LRL area constitutes a major development in the watershed of the North Fork, with roughly 50 acres of almost totally developed area tributary to the creek. Together with a highly developed City area and the Lawrence Hall of Science area, it provides the bulk of the peak rate flow in the channel above Le Conte Avenue."

Visual observation confirms that this channel appears pleasant and stable, with good cribbing, lush vegetation, and well-weathered concrete check dams above Le Conte. However higher up, off the end of Highland Place, there is bad erosion undermining the Lab fence.

Pertinent quotes from Folder 4, Planning (campus wide): "The original concept of the master drainage plan was to define the entire storm drainage system within the campus. . . . then. . . . to prepare a master plan for improvements which would make the system capable of handling peak runoff rates at full projected watershed development, thus solving the basic campus drainage problems for the forseeable future. . . . decisions were not permitted to be made solely by this office, nor only on an engineering basis, but required lengthy

perusal and approval by both Administration and Faculty groups.

"At the conclusion of our work. . . . many basic decisions had been made with respect to the main interceptor system in the upper campus area; a master plan was informally achieved. . . in the lower campus area. . . . The basic decisions were never made."

In recent conversations Mr. Lennert has told us that: Lawrence Lab diverted the major part of its construction-expanded runoff into Chicken Creek and the South Fork of Strawberry Creek. This created substantial erosion problems which have been controlled but not solved. During storms the accumulation time in Strawberry Creek is now 20 minutes, where it was formerly two hours. This creates a large accumulation of combustible debris. There are now 76 slides coming into the stream.

New problems are developing in the Chicken Creek Area. The lower part seems stabilized. But near the top one section of the Creek has escaped its broken concrete channel and has cut a wider and lower bow, which endangers the road. The stream could be re-channeled. Farther up in the terraced area, there is a very large wet inflow, above the manhole, apparently from the Labs, running over the bank and down the road and causing substantial soil movement.

VEGETATION

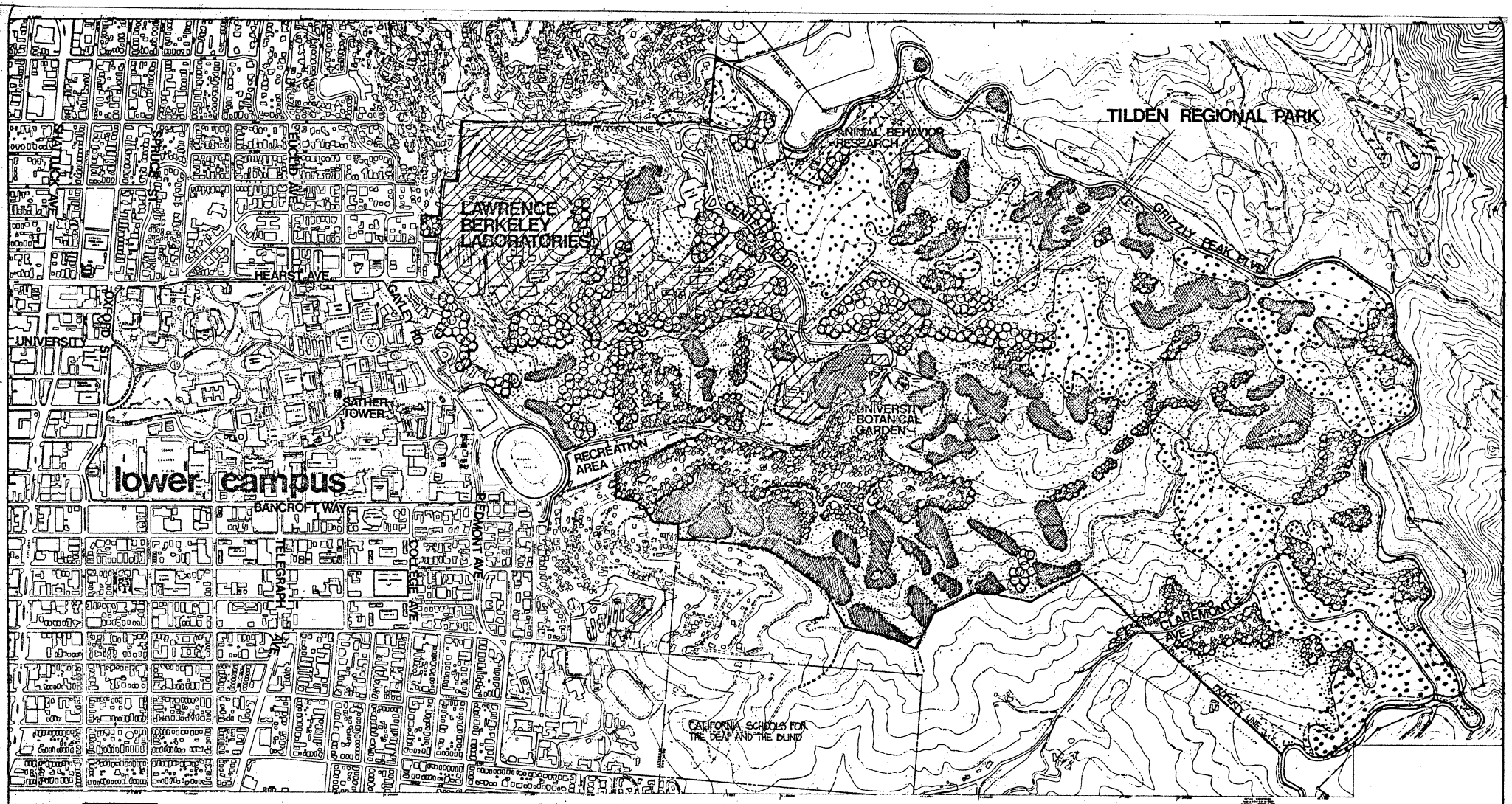
Vegetation in any area is dependent on a number of factors:

Climate
Geology
Topography
Soils
Hydrology
Orientation
Natural Succession
Human Intervention

A study of vegetation in the Strawberry Canyon area must therefore consider the first six factors as they exist, and the current results of the last two as they have interacted to date.

Topography, hydrology and orientation, geology and soils information has been assimilated. Human intervention in the original natural succession of the areas has resulted from programmed demands for land use of institutional, educational, research and recreational types. Institutional demands have generated the structural modifications which dominate the northwestern quadrant of the Canyon area. Educational and research demands, formalized as Ecological Study Areas, dominate most of the balance of the area, although it is not totally dedicated to them. Recreation in its active forms is inserted in wedge form as the Strawberry Canyon Recreation Area complex. In more passive forms it uses all of the fire roads and trails, and all available open space, throughout the balance of the area.

The vegetative pattern which has resulted from those interventions to date divides into two primary areas. One, the north-facing south slope of the Canyon, an area of some 200 acres, is dominated by indigenous oak-bay woodland, mostly oak, with associated dense undergrowth. Throughout the top half of this slope and extending irregularly down into the lower portions are substantially mature plantations of many



RESTRICTED AREAS

SPECIAL LAND USES

1 CONIFERS

2 OAK/BAY WOODLAND

3 EXSTG. STAND OF EUCALYPTUS

4 EXSTG. EUCALYPTUS SPROUTS

5 SOFT CHAPARRAL W/GRASS DOMINATED OPENING

EXSTG. VEHICULAR ACCESS

PG&E POWER EASEMENT 80' R.O.W.

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EXISTING VEGETATION

0 200 400 1000 1750ft.

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coniferous trees -- pine, spruce, fir, redwood, cypress, cedar. With the possible exception of the redwood, none of these are indigenous.

These north slope plantings reach across the valley in the Botanic Garden area and include the Mather Redwood Grove.

The other 800 acres of the area, comprising the convoluted east, west and south slopes of the north side of the Canyon, are covered by an irregular pattern of grass and soft chaparral, with groups of bays and some oaks in the drainage channels. To this (approximately) native base have been added extensive groves of Monterey pine and several species of Eucalyptus. These plantings have matured.

The eucalyptus were badly damaged by the exceptionally cold winter of 1972-73. Fear of the fire hazard embodied in the dry tops produced by freezing resulted in an extensive program of cutting. At least three-quarters of the eucalyptus in this area have been cut down to stumps. Most of the heavier trunks and branches were hauled out and sold for firewood. A great deal of slash material remains on the ground, however, and constitutes in itself a fire hazard. New sprouts from old stumps, and perhaps seedlings, are up as high as ten to fifteen feet, and doing well. The most substantial grove, comparable in scale to that at the Oxford entrance to the lower campus, located just above the Canyon entrance to Lawrence Labs, is undamaged and uncut.

Changes in, or additions to, this existing vegetative cover may occur for any or all of three types of reasons: technical, functional, experiential (esthetic).

Technical reasons include any inherent in the cultural requirements of the plants or plant communities themselves. The cutting of eucalyptus as a fire hazard is a technical reason, as is the damage which is occurring in the Stone Pine grove at the east end of the north slope. This seems to result from a massive soil creep downhill, yet it is strange that the adjacent Monterey pines are not affected.

Functional reasons derive from land use or programmatic demands. All of the conifer plantings along the upper north slope seem to have been developed for educational/research, or functional, reasons. The Botanic Garden is likewise a functional facility. However Mather Redwood Grove, and probably the eucalyptus and pines on the south slopes, seem less functional and more experiential, esthetic, or cultural in content.

Experiential reasons have to do with how plantings will look, how they will make us feel, how we will react to the landscape they will create as they grow. This is the more subjective area of planting decision making, as the first two are more objective. Yet subjectivity and objectivity overlap strangely, particularly in the relations between indigenous and introduced plants. For instance we are told that eucalyptus and French broom are serious fire hazards and should be removed completely. Yet although we are also told that Monterey pine, baccharis, elderberry and bay are serious fire hazards, we are not told to remove them. Are eucalyptus and broom that much worse? Or is there perhaps a little subjectivity at work? We are told that eucalyptus areas are gloomy and unattractive to wildlife and people. But what could be gloomier or more barren than the Monterey cypress grove on Sugar Loaf? And Dr. Stebbins tells us that "Eucalyptus habitat is far richer in

vertebrates than either redwood or Monterey pine and vies with dry chaparral and grassland in species diversity and attractiveness." A eucalyptus grove with a clean floor will probably attract as many people as a comparable redwood grove in a similar situation.

In Australia the Monterey pine has been imported and planted over thousands of acres as a softwood timber tree to replace the less useful native bush (eucalyptus). Nature-lovers in Australia attack Monterey pine planting in about the same way that nature-lovers in California have attacked eucalyptus planting for many years.

All of this tells us that assumptions about the mood or atmosphere which planting will generate are not reliable guides to the selection of species.

Experiential quality in the landscape results from plantings done for technical or functional reasons as much as for esthetic or cultural reasons. This means that all three types of reasons must be considered when any new plantings are to be made, or old ones changed.

MAINTENANCE AND CHANGE

Maintenance and/or change of existing vegetative patterns may take place for any or all of the three kinds of reasons just described. They, and their relations, should be clear in the minds of those who establish policy and make decisions about Canyon vegetation.

Current questions whose answers will impact upon vegetative maintenance

and change include:

1. Identification of land use priorities and future management policies
2. Establishment of ecological study area boundaries
3. Reduction of fire hazards
4. Specific proposals which may be forthcoming but have not yet appeared

LAND USE

Institutional uses embodying substantial construction do not seem likely to expand beyond the areas which they presently occupy. Three possible building areas established and described in this report, in descending order of priority, will be known as available for possible future needs or demands. Criteria for response are suggested. Therefore the present Canyon area of planting in relation to existing construction is not likely to be reduced. It is more possible that it may be expanded into inadequately planted areas close to existing construction. Special considerations involved in planting in such complex situations will apply. They are probably not predictable in this report. They should probably be the subject of a special detailed follow-up study of landscape development around all existing construction.

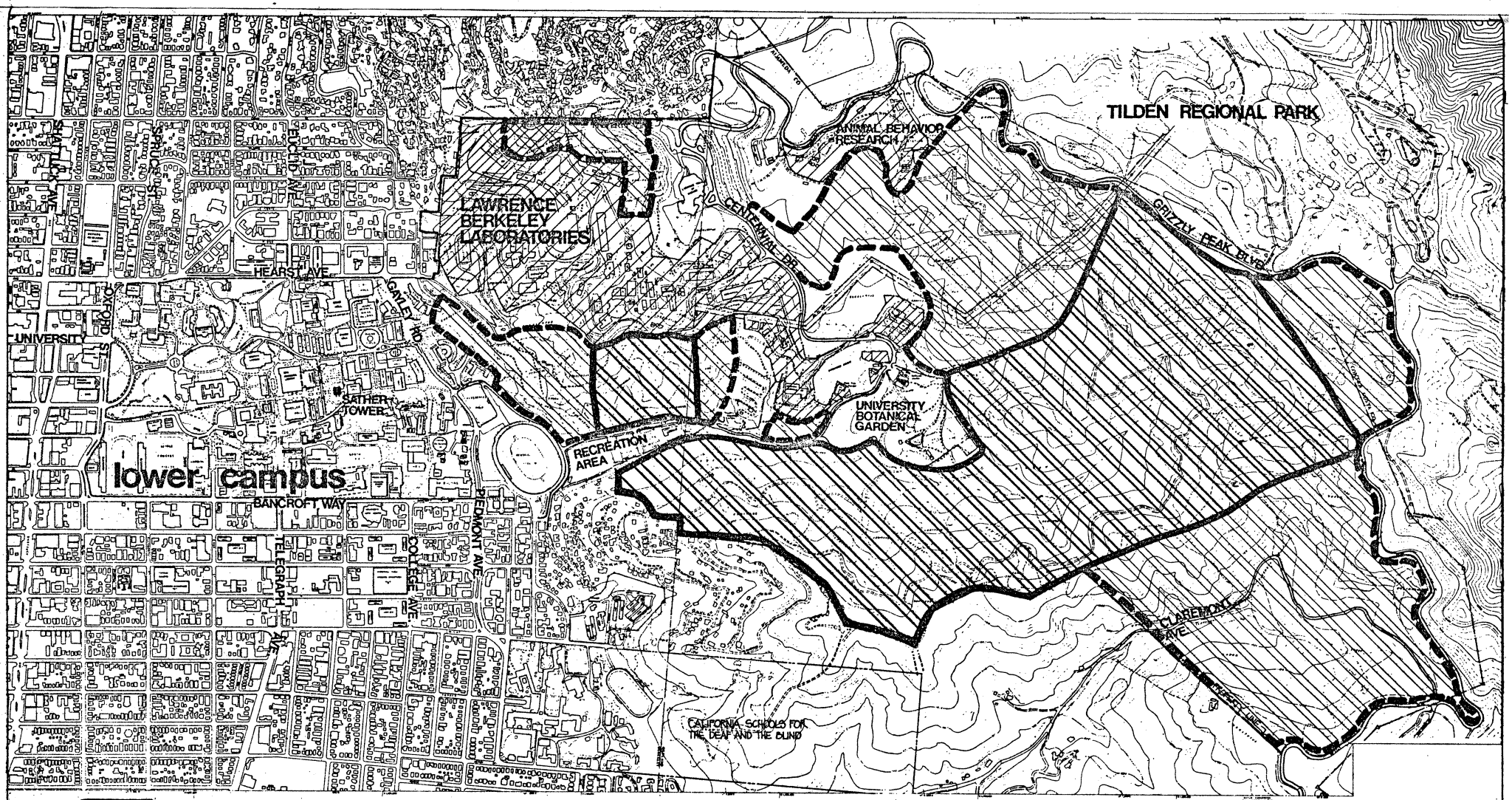
Education/research uses are generally summed up in proposals for the expansion and delineation of Ecological Study Area boundaries. Jones in 1974 is more cautious and restricted than Siri/Lindgren in 1972.

Yet, insofar as the Strawberry Canyon area is not dedicated to other uses, it seems that it should be kept in a state of nature for ecological study. Siri/Lindgren propose to add 746 acres of Strawberry/Claremont Canyon lands to the University's Natural Land and Water Reserves System. Their recommended management policy includes:

1. Keeping the area open to all University personnel and the general public, subject to conditions of time and manner of use.
2. Patrolling the area to ensure public safety and enforce prohibitions on certain uses, such as camping, fires and motorized vehicles.
3. No fencing of the area except to control motor vehicle access.
4. Use of "prescriptive burning" for fire control and research.
5. Control of manipulation of parts of the area or significant extractions from it by a management committee.
6. Keeping the reserve unit open for all reasonable uses, including recreational uses that have no impact on the natural qualities of the area.

This leaves open the definition of "natural qualities." For instance, are eucalyptus and French broom natural? Is the Monterey pine (indigenous to the Monterey Peninsula only) natural? No doubt there are many non-natural grasses and herbs at large within the area. What do we do about them?

The above Ecological Study Area proposal will respond to the needs of 13 of the 19 departments or groups that use the area for academic or other purposes. The other six -- Landscape Architecture, Athletic, Military Science, East Bay Regional Parks, the public, and Civil En-



EXISTING E.S.A. BOUNDARY

PROPOSED E.S.A. BOUNDARY

STRAWBERRY CANYON STUDY
U.C. BERKELEY · JUNE 1976
GARRETT ECKBO & ASSOCIATES

ECOLOGICAL STUDY AREA

0 200 400 1000 1750ft.

10

gineering -- tend to use it in terms of manipulation for external purposes. The manipulation practiced by Landscape Architecture and Civil Engineering is almost entirely theoretical, hence has no actual impact on the land. The requirements of the other four approximate recreational use requirements, and can be considered with those uses.

Recreational uses are intensive in the Canyon recreation complex of courts and pools, and extensive throughout the balance of the area. While recreational activities have specific technical and functional requirements, they are fundamentally experiential, esthetic or sensory in nature. That is, among other reasons, we recreate in order to change, improve, broaden and deepen our experience of the world. This means that the environment for recreation should be designed in terms of those criteria, as well as others more specific.

This has not been done in Strawberry Canyon. The recreational facilities appear to have been designed and installed in second-class deference to institutional and educational research. It is difficult to get into the area, either by foot or car. Once in, it is difficult to get around within it. The pools, courts and field complex function well and are pleasant within themselves, although their total area is quite restricted. There are reciprocal relations between the crowding of the pool areas and of the parking areas, in spite of the difficulties of access.

Extensive recreational use of the larger Canyon area seems to exist by

the tolerance or generosity of the dominant uses. None of the basic facilities normal to extensive passive natural parks at this scale are available. There are no continuous systems of pedestrian, bicycle or equestrian movement, related to easy entrance and parking. There are no picnic facilities, sanitary facilities, or free play facilities. There is a security patrol. Night use is not considered appropriate.

It may be that the University is not so far into the provision of recreation for campus community and general public that it should consider these questions. And yet it already has a recreational facility of regional scale and significance, closely related to Tilden Park, although quite different from it in program and character. Insofar as Tilden and other nearby regional parks provide the normal facilities, they are probably unnecessary in Strawberry Canyon. Very likely it should be seen as a wilderness reserve rather than as a park.

There is a variable range in concepts of form and arrangement when considering Strawberry Canyon as a recreational area. Now, as several studies have pointed out, the upper and eastern parts of the Canyon -- perhaps half of its 1000 acres -- are a wilderness reserve within walking distance of a major urban campus. This is a rare and exceptional piece of good fortune and/or good planning. As that perhaps it needs difficulty of access and internal movement and use to maintain its isolation and resist invasion by too many people. Yet current inconvenience of access and difficulty in use seems more accidental than planned. It does seem that ease and character of access and movement could be designed as part of a coherent conceptual plan.

Early reactions from vocal wilderness preservers seem to say that difficulty of access should be preserved to limit the number of people using the area. Yet does this tend to preserve it for a young and energetic elite, excluding those without those vital qualities. What about those older, less agile or adventurous? Should we consider the handicapped?

A two-hour interview with Peter Benenson, whose interests are in the economics of environmental/energy questions, provided an excellent statement of the natural wilderness-oriented approach to Strawberry Canyon. The following points were made:

Strawberry is a unique natural resource. Tilden Park exists next door. The Canyon should not be developed to equal the Park. They should offer different kinds of experience.

New paths or trails may create additional scars. (This is not necessarily true. Good design can eliminate them.)

Limited traffic preserves the area. More may spoil it. (We do not feel that the amount generated by our proposals will do this.) *

More structure would be detrimental to the natural experience.

Pedestrian use of grass or meadow areas might cause compaction and erosion. (This does not seem likely).

Chain link fencing is a visual problem in conflict with natural qualities. If necessary, it should be painted black or dark brown, and planted out.

The difficulty of getting in and around is expected in a natural area and is part of its charm.

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*Note: The ultimate control of the use of the Canyon derives from the number of unrestricted car parking spaces provided in or near it. We are not recommending any additions to these, except at Lawrence Hall of Science and possibly in Chicken Canyon.

Is ease consistent with a wild area?

Fire roads and Indian trails provide two different kinds of experience. On the former one is secure and comfortable, can walk freely while enjoying the landscape and views around. On the latter movement is more difficult and arduous, requires constant attention to immediate elements along the trail. The surroundings can only be viewed when the brush opens up, and by stopping at convenient points. The Canyon needs both kinds of experience. The balance between the two is suggested in this report, but must develop from more intensive planning and design on the land.

Is there a contradiction between natural quality and accessibility? (Not necessarily.)

From the natural wilderness point of view additional fire trails, possible building sites in the Botanic Garden area and on Chaparral Hill,and park-type facilities should be eliminated from consideration.

The plan should probably embody suggestions for total circulation/access patterns for the entire Canyon area and its environmental connections. Perhaps it should also suggest some minimum picnic/free play/sanitary facilities. These will all have some impact upon existing vegetation patterns, particularly in the heavily grown over north slope. Such impacts may involve some clearing and opening of paths, some movement of earth that will require stabilization of exposed slopes. A sensitive pruning crew could open up careful vistas across the Canyon without serious reduction in the abundance of growth.

VEGETATION SPECIFICS

Within the framework of likely needs and demands, the following vegetation programming seems likely:

Detailed proposals in the Jones and Baker reports can be reasonably integrated into the comprehensive plan we propose.

Biswell's fire management proposals seem reasonable insofar as they embody maintenance procedures. But the recommendations the eucalyptus be removed and replaced by Monterey pine, Monterey cypress and redwood should be scrutinized very carefully. The relative flammability of the four species, the amount of debris removal, annual burning and clearing needed to keep them relatively safe, should be analyzed in detail.

It may be more reasonable to follow the Vegetation Management Committee's advice: "Live and healthy eucalyptus should be thinned to approximately 50 trees per acre (30 x 30' = 50 T/A) in varying diameters. Trees will be left in an irregular pattern for aesthetics and discontinuity of fuels."

These technical analyses should be related to the visual/experiential impact of each specie on the Canyon landscape. This impact should be in terms of an overall coordinated tree plan.

Visually the four species run a gamut in ranges of heaviness/openness

and darkness/lightness. The cypress is the heaviest, darkest, and most somber and oppressive. The pine is also dark, also heavy, but opens up by losing its lower limbs to become a rugged and picturesque skyline tree. The redwood is dear to Californians' hearts, vertical, erect yet graceful, of an openness between pine and cypress and a shade of medium green that is lighter than either of them and closer to eucalyptus coloration. The eucalyptus is most open, most light, most graceful, runs a range of browns and greys through various species now growing on the site. All of these factors are important in deciding where to use which trees for what desired effects.

On the north slope the relative longevity of the various conifer species should become a measure for determining the future of those groves. Intensive attention should be paid to the slowly destructing Stone Pine grove. The Monterey pines have a life expectancy of about 50 more years.

Throughout the Canyon a continuous and consistent program of deadwood and debris cutting, clearance and disposal should be initiated.

It appears that the existing pattern of consistent enclosure of the upper reaches of the Canyon with groves of Monterey pine and associated conifers should be maintained and reinforced by developing groupings of more convincing size and position. Below these on the north side the eucalyptus groves, if fire control seems feasible, make a light

and pleasant contrast with the darkness of the pines. Below them the relations between grass and dry or moist chaparral might be modified by some controlled grazing.

The various successional relations between grassland, brushland, woodland, and between the various specific types of each -- Baccharis, Blackberry and Elderberry brushland; oak, bay, pine and riparian woodland -- can become the bases for specific long-term studies of natural, manipulated, arrested or distorted successions.

It is hoped that all of the various technical, functional and detailed experiential proposals incorporated in this report can be subsumed within large overall coherent vegetation pattern concepts which relate closely to the scale of the topography.

PREVIOUS PROPOSALS

II. PREVIOUS PROPOSALS

We have reviewed a substantial list of reports and proposals dealing with various aspects of the Strawberry Canyon lands. In chronological order these are:

1969 -- January/February -- article in The California Monthly titled The Future of the Campus Environment by Frank T. Lindgren and Kenneth M. Sanderson. Impelled by a controversy over a new road around the new Moffitt Library, the article went into detail on the relations between natural ecology and structural development on the campus. In conclusion it said, "In addition to understanding natural ecology, the subtle and delicate relationship of man and his natural environment of plant and animal life, we should also consider physical ecology. By this we suggest an addition frame of reference, namely man's relationship to buildings, sidewalks, paths, and his means of transportation. . . . Perhaps a revolution in thinking about the latter, particularly transportation, is needed to avoid relentless encroachment on all natural areas within our still beautiful campus."

1969 -- Landscape Architecture Advisory Subcommittee, Paul D. Hurd, Jr., Chairman. Subcommittee of the Subcommittee, Howell V. Daly, Chairman.

Documentation of scientific, educational and other uses of natural areas on the Berkeley campus.

Response to article in Campus Report, June 5, 1968. 161 letters of support; 884 petition signatures (permanent preservation of natural areas).

Response to article in Daily Californian, February 18, 1969 (Campus Ecology: Nature on Trial). 23 letters; 4172 petition signatures.

Response to article in California Monthly, January/February 1961 (The Future of the Campus Environment -- Natural Areas). 14 letters; 1 interview.

Response to questionnaires and interviews re scientific educational values of natural areas, Spring 1964. 90 staff members in 20 departments contributed information.

The final bound volume, including a Daily Californian article by Sim Van Der Ryn and numerous responses to that and to the California Monthly article, generally supports the preservation and conservation of natural areas on campus.

Baker Report of December 1969, reporting on a three-meeting task force, incorporates by reference Joseph McBride's Ph.D. thesis on East Bay Hills brush and forest succession and recommends that the University:

Preserve or enrich natural plant communities, delimit small experimental areas to test methods;

Develop a more appropriate system of Indian trails;

Prohibit Botanical Garden from taking any more potting soil from the E.S.A.;

E.S.A. committee approval of any classroom plant or animal gathering;

Research manipulation of vegetation must be closely governed by E.S.A. committee;

Incorporates by reference the Daly-Stebbins Task Force Report;

Map and inventory Strawberry Canyon;

Establish a representative .E.S.A. committee;

Appoint an executive director of E.S.A. to provide continuing policy enforcement;

Publish an E.S.A. policy illustrated information brochure (including lower campus)

Information exchange by all users through executive director.

1972 -- In March Provenzano and Associates, Engineers, submitted a report on Soil Investigation Recommendations and Specifications for Centennial Drive Reconstruction. This is referred to in more detail elsewhere.

In March also Arbegast and Newton, Landscape Architects, submitted plans for the Poultry Husbandry (Chicken Canyon) area. These suggested:

Schematic A

Day Care Center

Group Picnic

Picnic

Turf Area

Mini-Conference Center

Multi-Use Terrace

Parking

Schematic B

Putting Green

Golf Driving Cages

Picnic

Badminton/Volley Ball

Archery

Tennis

Student Rec Center

Schematic C

Garden or Picnic

Student Garden

Schematic D

Day Care Center

Pre-School Play/Picnic-Mini-Conference

Revised Schematic

Multi-Purpose Building

Multi-Use Turf

Picnic-Free Play-Group Picnic

Volleyball

Horseshoes

In May 1973, the Arbegast/Newton proposals were reinforced in a report from the CNR/IDS Joint Recreation and Environmental Quality Committee

to the Campus Recreation Committee to "effect restoration, caretaking and initial recreation use of designated facilities according to purposes specified in March 14, 1973." In December , 1975, the Chancellor's Advisory Committee on Campus Recreation concluded that development of the Poultry Area had "low priority when compared with other facilities being considered. Therefore we did not give further consideration to the plans."

From 1969 to 1973 Dr. Van King, open space planner for the City of Berkeley, made a series of proposals for Chicken Canyon which were analagous to the Arbegast/Newton proposals. They included:

1. "Heritage Hill"
   a) Pioneer settlement
   b) Open games
   c) picnic area
   d) playground
   e) horseriding center
2. Day Care Center
3. Student Garden
4. Conference Center (for "away-from-it-all" meetings)
5. Interdisciplinary Strawberry Canyon Information, Resource and User Coordination Center

Today Chicken Canyon and its terraces are fenced off, inaccessible, weed-covered, and quietly deteriorating. There are still poultry in one house. There is a handsome barn and a usable office structure empty on the top terrace. The Creek, under the impact of the heavy Lawrence Lab runoff, is beginning to erode new channels and to bypass the improvised broken concrete channel provided some years ago. There are surface drainage problems from the Labs. Soon there will be a need for a new comprehensive plan for this entire area, even if it is no more than an alternation of paved terraces for parking, grass terraces for picnicking, trees for shade, bank stabilization planting, and stream stabilization.

1972 -- In May Lennert and Associates submitted a four-folder report on the campus storm drainage system. This, too, is discussed elsewhere in this report.

1972 -- Also in May Will Siri and Frank Lindgren submitted a report which proposed a new unit of the Natural Land and Water Reserves System of the University. Essentially it recommended putting all areas not now called Ecological Study Areas or developed areas into ESA's. The NLWRS suggestion was rejected, but the expanded ESA proposal is supported in this report.

In October 1974, Ralph Jones, Landscape Architect, submitted a review of the campus landscape. While most of its 228 pages dealt with the lower campus, it did have sixteen pages on Strawberry Canyon. These

include the following very perceptive and sensitive recommendations. Aside from some differences about indigenous plantings, we feel that these should all be considered a part of this report.

STRAWBERRY CANYON POLICY RECOMMENDATIONS BY RALPH W. JONES

1. Re-design and reconstruct the entrance to the canyon at Rimway Road and Centennial Drive.
2. Close off Centennial Drive to through traffic. Study feasibility of phasing out car traffic between Haas recreation area and the Botanical Garden.
3. Re-study quality of north banks of Centennial Drive from Rimway Road to Haas Recreation Area parking lot.
4. Screen chain link fences around ballfield and tennis courts.
5. Landscape the parking lots in the athletic area with trees, shrubs, vines and ground covers.
6. Prohibit any further expansion of Haas area parking and athletic facilities. Prohibit any further encroachment on the Canyon South slope and Strawberry Creek flora.
7. Enlarge the north slope Ecological Study Area to extend to Mather Grove east of the Inorganic Materials Building.
8. Prohibit car parking in the area of the retention basin. Plant earth dam with native trees indigenous to the area.
9. Provide adequate water supply to sustain alders downstream of retention basin dam.
10. Remove defunct poultry research facilities and restore area to grass and native trees. Preserve Chicken Creek riparian habitat.

Develop limited parking by Centennial Drive and Chicken Creek and carefully enhance grotto for viewing only at Chicken Creek culvert.

11. Plant steep portion of bank on north side of road opposite the retention basin.

12. Along Centennial Drive and the Botanical Garden, place the chain link fence down the slope farther away from the road. Plant native shrubs between road and fence.

13. Include in Ecological Study Area management procedures that unpaved fire road will not be paved, widened or straightened.

14. Preserve creek area in its natural state without technological improvements of any kind.

15. Have continuous trail maintenance program for steep, erosion-prone trails.

16. Correct drainage problem along the top of the south ridge and distribute runoff over larger area of north-facing slope.

17. Provide suitable barriers to prevent motorcycles from entering on to the south ridgetop and the fire trail from the end of Panoramic Drive.

18. Investigate potential threat, if any, imposed on the Haas recreation complex by the above-ground water storage tank at the end of Panoramic Way.

19. Preserve slope and natural ravine ecology directly below and to the southwest of Lawrence Hall of Science. Consider designating this area an ecological study area.

20. Adopt a formal management policy for canyon including staff per-

sonnel associated with a multi-disciplined advisory group.

21. Restrict new plantings to those endemic to Strawberry Canyon or indigenous to similar California coastal canyons.
22. Preserve natural basalt rock outcroppings on Chaparral Hill near Grizzly Peak.
23. Preserve and maintain pine and cypress groves on top of Monument Hill and the unique native shrub colonies on the north and south sides.
24. Preserve the entire Strawberry Canyon viewshed in its present natural state, free of further development such as roads, fences, buildings, signs, grading, dams and exotic plant materials.
25. Create sense of "entry" to canyon.
26. Recommended ecological study areas.

Recommendations added to Jones Report by Havlik:

Control erosion along the fire road.

Eliminate "dreary" eucalyptus groves by controlling new trees and allowing natives to return, so that animals will return and hikers will have greater esthetic experience.

Plant pine forest along ridge top.

In December of 1974 Harold Biswell, Forester, made a very influential report on the wildfire problem and the reduction of fire hazards in the hill area. This led to the cutting of most of the eucalyptus trees in the Canyon area (and elsewhere) and, indirectly, to this current report and its Vegetative Management Plan. Biswell's recommendations were:

Remove eucalyptus sprouts in logged area (method proposed).

Remove French broom (method not known).

Remove remaining debris in logged area.

Annual control burning (method proposed).

Prune dead limbs up to 12-15' (method proposed).

Remove understory trees that act as ladders to crowns of tall trees.

Plant groves of redwood, Monterey pine and Monterey cypress.

Plant continuous forest band on north facing slope.

Plant redwoods on right side Claremont.

Interplant existing groves of Pinus radiata.

Reactions to and extensions of these recommendations are embodied in our Vegetative Management Plan.

At about the same time the Vegetative Management Committee (13 members from natural resource disciplines) produced the Vegetative Management Plan for the Eucalyptus Freeze Affected Areas in the Berkeley/Oakland Hills. This plan, aimed at reducing the fire hazard in these hills, described the area and its vegetation and soils. It then discussed problems of immediate concern:

Fuel break along Grizzly Peak/Skyline;

Eucalyptus seed germination and sprouting/poison oak control;

Fuel modification to break up larger blocks of eucalyptus;

Fuel breaks around water tanks and structures, and

Fuel reduction around homes

all in terms of purpose, location and specifications.

Problems of long term concern include:

Ground fuel management;

Suggestions for various vegetation types;

Recovery of eucalyptus stands;

Future planting in the hills;

Residential planting to reduce fire hazard;

Vistas.

This plan makes approximately the same recommendations as Biswell. It is somewhat more moderate in that it allows for maintenance of high fire hazard plantations, such as eucalyptus and Monterey pine, by ground fuel removal, periodic controlled burning and thinning to more open spacing. The plan also makes the normal genuflection toward native plants.

In August and September of 1975 Dr. Robert Stebbins, Professor of Zoology, submitted a report on The Use of Habitats in the East Bay Regional Parks by Free-Living Vertebrate Animals. In a letter to Dr. Joe McBride he made these observations:

"Several years have passed now and we seem to be no closer to a management program for the Canyon than when I left the committee (on Conservation and Environmental Quality). . .Protection of the Canyon and sound management plans are needed now more than ever before.

"The concensus was that there should be no significant further expansion of the forest plantations. . . . The forest stands of

redwoods and Monterey pines are extremely depauperate habitats with respect to local vertebrates."

Dr. Stebbins' study ranks habitats as follows for all vertebrates (156 species) with most-used first:

69.2%	oak-bay woodland
64.1	moist chaparral (east and north slopes)
51.3	dry chaparral (west and south slopes)
48.7	grassland
39.7	eucalyptus
4.5	redwood
2.6	Monterey pine

We also had access to Dr. Joseph McBride's thesis and subsequent publications and reports dealing with plant succession in the Berkeley Hills. From these we learn that the normal succession is from grassland through chaparral of varying content to oak-bay woodland and ultimately bay woodland. Other types of vegetation, primarily conifer and eucalyptus plantations, appear to be too limited or special to affect the overall succession pattern.

In 1974 Dr. McBride published the following table:

VEGETATION TYPES IN THE BERKELEY HILLS

Vegetation Type	% Area Covered	Dominant Species
Grassland	43.0	Avena fatua, Bromus mollis, Lolium multiflorum
Baccharis Brushland	21.0	Baccharis pilularis, Rhus diversiloba
Oak Woodland	17.2	Quercus agrifolia

Bay Woodland	7.4	Umbellularia californica
Redwood Forest	2.3	Sequoia sempervirens
Riparian Woodland	0.5	Salix lasiolepis
Knobcone Pine Woodland	0.5	Pinus attenuata
Manzanita-Chamise Brushland	0.4	Arctostaphylos crustacea, Adenostema fasciculatum
Coastal Sagebrush	0.1	Artemisia californica
Plantations:		
Eucalyptus	6.8	Eucalyptus globulus
Monterey Pine	0.8	Pinus radiata

We have also used Appendix A Map, UC Office of Architecture and Engineering, January 1958, and Appendix D, Composition of Tree Plantations, from the Strawberry Canyon Study in the Report of the Committee on Land Use and Facilities, College of Agriculture, Berkeley (covering letter, Smith to Ryerson, November 20, 1953).

RECOMMENDATIONS

III. RECOMMENDATIONS

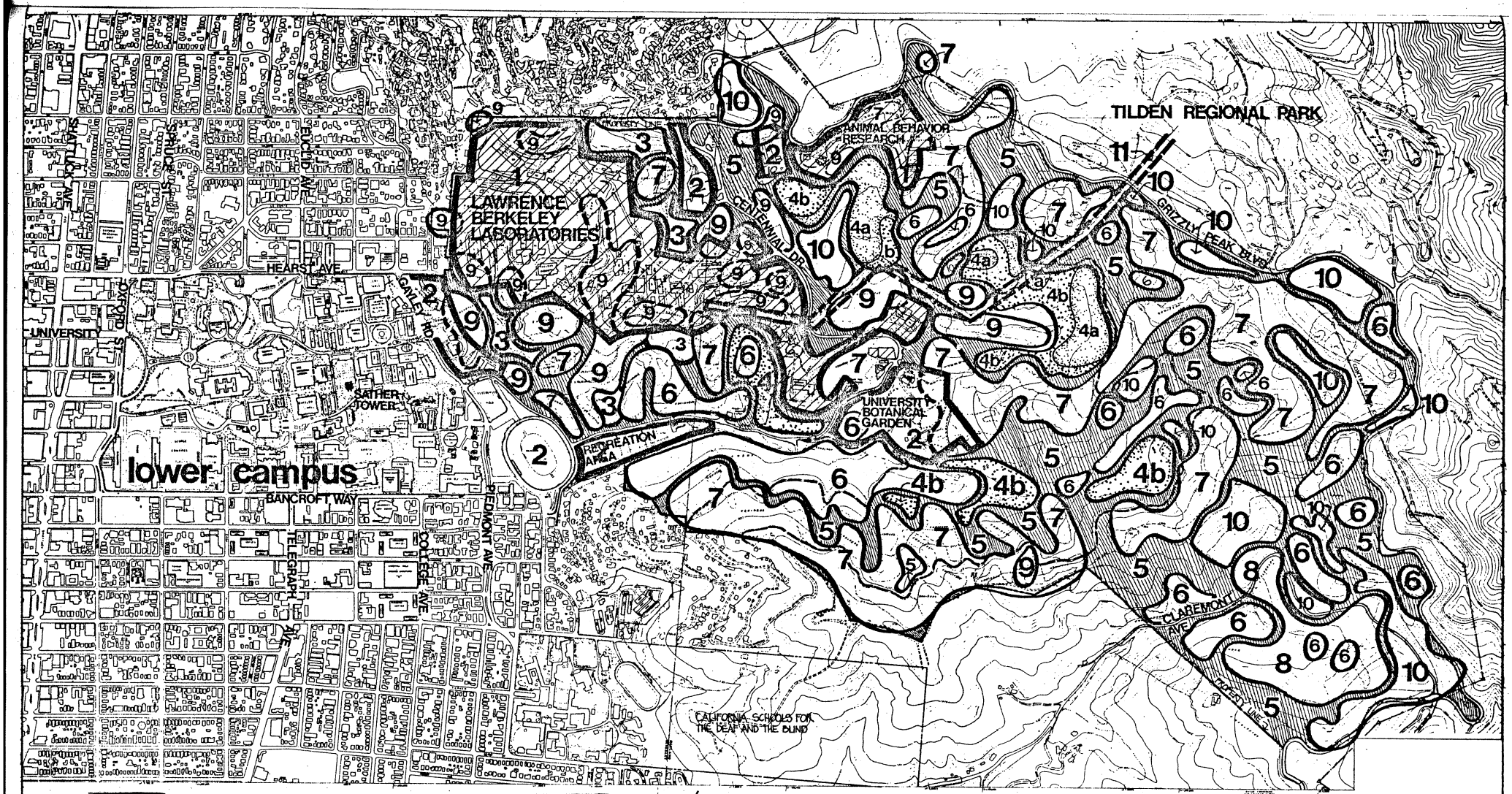
RE-VEGETATION AND EXPANDED CIRCULATION PROPOSALS

The overall plan proposes strengthened pattern relations between four basic vegetation types:

- woodland
- groves
- brushland
- grassland

It must be emphasized that all of the following proposals are general policy proposals which we feel can be implemented. Possible detail and process for implementation of each vegetation management unit is shown in Table 1. The success of this proposed revegetation program will depend upon the appointment of a vegetation management specialist to supervise field work continuously.

In general, throughout the Canyon area, we propose that all slopes less than or close to 25%, and above the riparian vegetation, be maintained in, or converted to, grass. These areas are shown in loosely delineated form on the plan. Their actual boundaries would have to be determined on the ground. Those parts of them which are now covered by soft chaparral--primarily Baccharis -- would have to be cleared and seeded to grass. Clearing could be by hand or by goats. Once converted to grass, the area could be maintained by occasional cutting or by grazing.



1	RESTRICTED AREAS
2	SPECIAL LAND USES
3	MIXED VEGETATION AREAS
4	GRASS CONVERSIONS a. GRASS W/ EUC. SPROUTS b. GRASS WITHOUT SPROUTS
5	SOFT CHAPARRAL
6	OAK/BAY WOODLANDS INCLUDING RIPARIAN AREAS
7	CONIFERS
8	PROPOSED REDWOOD PLANTING
9	EXSTG. STANDS OF EUCALYPTUS
10	EXSTG. EUCALYPTUS SPROUTS
11	P.G.&E. POWER EASEMENT

NOTE- PATTERNS & NUMBERS SHOWN ARE FOR MANAGEMENT GUIDANCE ONLY. ALTHOUGH PREPARED WITH REASONABLE CARE, NO ACCURACY AS TO LOCATION OF EXSTG. VEGETATION IS GUARANTEED. VEGETATION LOCATIONS ARE BASED ON VISUAL SURVEY & 1972 AERIAL PHOTOS. ASIDE FROM THE DIFFICULTIES OF PRECISE SURVEYING ON ROUGH GROUND, THE PASSAGE OF TIME AFTER COMPLETION OF THIS PLAN MAY PRODUCE MAJOR UNPREDICTABLE CHANGES IN ANY OR ALL AREAS.

IT IS RECOMMENDED THAT MANAGEMENT WORK WITH THE LANGUAGE DESCRIBING DESIRED CONTINUITIES OR CHANGES IN VEGETATION ON PARTICULAR SLOPES, & APPLY THOSE TO THE ACTUAL CONDITIONS ON THE GROUND, USING THIS PLAN AS A GUIDE & MONITOR. IT WOULD BE WELL TO REFER TO THE CAMPUS LANDSCAPE ARCHITECT, GARRETT ECKBO & ASSOCIATES, AND/OR TO DR. JOSEPH MCBRIDE FOR INTERPRETATIONS OF THE PLAN ON THE GROUND.

STRAWBERRY CANYON STUDY
U.C. BERKELEY · JUNE 1976
GARRETT ECKBO & ASSOCIATES

VEGETATION MANAGEMENT

0 200 400 1000 1750 ft.

13

This conversion of substantial areas to grass would have a number of advantages:

It would open up both visual and physical -- combined as psychological -- movement through those areas. On a 4 to 1, or 25% slope, a diagonal line of movement will follow a tolerable 2 to 1, or 12.5% slope. As slopes get steeper the line must, of course, get flatter. But within the areas suggested it appears possible to create hillside meadows through which people could wander.

Both of our fire authorities agree that Baccharis is highly flammable, while grass is less so. Therefore expanding the latter by reducing the former would also reduce the fire hazard.

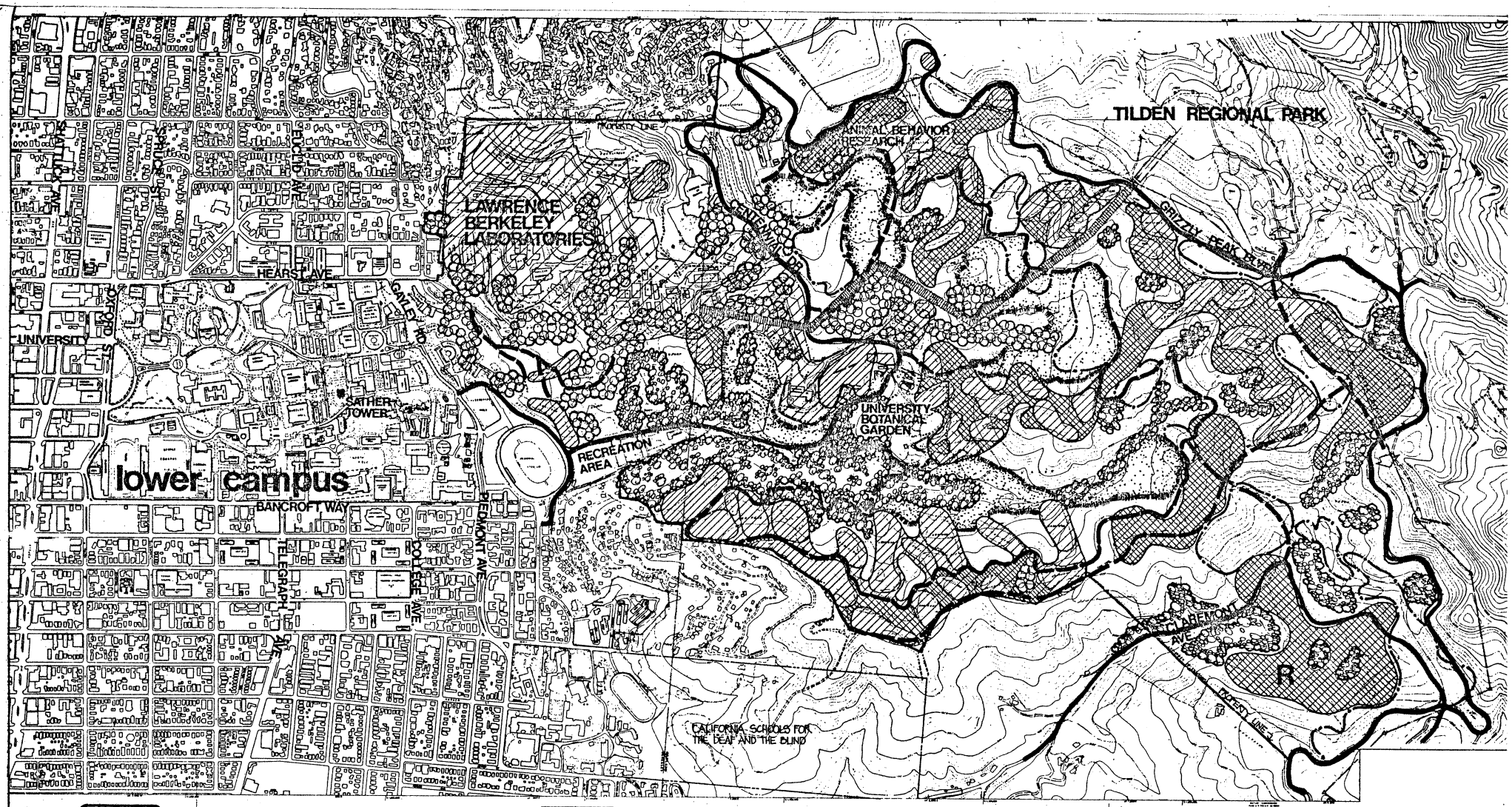
Ecologically the meadows would be arrested at the first stage of succession. They would, however, provide the possibility of substantial wild flower displays. They could continue through pine and eucalyptus groves if the latter were thinned to the open spacings suggested by the VMC.

If control by grazing were elected interesting possibilities both educational and esthetic would open up. Large animals in the landscape add another dimension to its experience.

TREE PLANTING

Three basic types of tree planting now exist within the Canyon area:

Oak-bay woodland on the north slope, valley bottom and south slope



EXSTG. LAND USE UNITS

EXSTG. VEHICULAR CIRCULATION

EXSTG. PEDS. & FIRE TRAILS

EXSTG. OAK/BAY WOODLANDS

EXSTG. STAND OF EUCALYPTUS

EUCALYPTUS SPROUTS

EUCALYPTUS & GRASS

EXSTG. CONIFERS

PROPOSED CONIFERS

R PROPOSED REDWOODS

PROPOSED GRASS CONVERSIONS

SOFT CHAPARRAL

STRAWBERRY CANYON STUDY
U.C. BERKELEY · JUNE 1976
GARRETT ECKBO & ASSOCIATES

REVEGETATION DESIGN

0 200 400 1000 1750ft.

11

drainage channels.

Conifers -- primarily Monterey pine -- in groups around the upper slopes and ridges and in some lower areas.

Eucalyptus -- primarily blue and red gum -- in a broad belt through the center of the south slope including Lawrence Labs, over into Claremont Canyon and on Chaparral Hill. About 75% cut but sprouting vigorously.

We propose that:

The oak-bay areas be protected and preserved.

The conifer plantings be protected and extended as suggested in plan to form a more continuous - less spotty enclosure around the upper levels of the Canyon bowl. New plantings should be Redwood, Giant Sequoia and Incense Cedar. The University should be prepared to replant periodically to replace old trees as they die and supplement natural reproduction if it is inadequate. Species of pines should be avoided because of their high flammability and the fire risk they present. Colors should be green or gray.

The eucalyptus groves provide an additonal dimension to the Canyon experience. They are upright like the conifers in contrast with the spreading oaks and bays. They are more open and graceful, grayer or browner in color, than most of the conifers. They are naturalized to the extent of reproducing themselves. If we eliminate simplistic preconceptions about good natives and bad exotics, they are examples of much more interesting and complex relations world-wide between plants from similar environments. There are plants indigenous to the locality -- oaks and bays; plants native to other California localities -- Monterey pine and cypress, and some of the conifers

as Incense Cedar; introduced plants which naturalize and reproduce -- eucalyptus and other Australians; introduced plants which naturalize but do not reproduce; introduced plants which will succeed with varying degrees of aid.

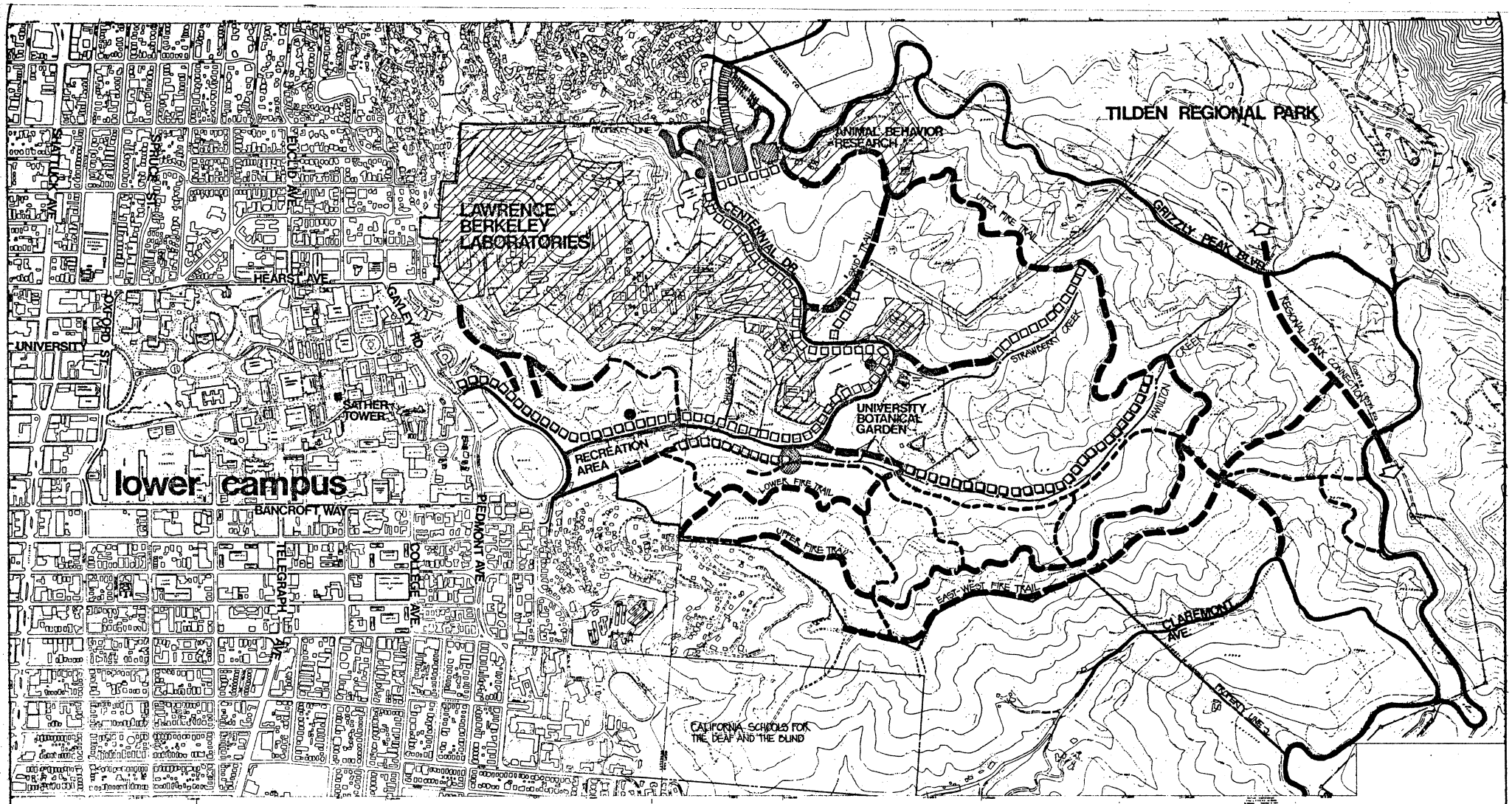
Biswell's suggestion that a redwood grove be planted in the lower bowl of the Claremont Canyon lands is excellent and is embodied in our plan.

As for the fire hazard, it appears that the combined advice of Biswell and VMC tells us to clear up the flammable debris regularly and to thin out the trees to an average, though irregular, 30 x 30 foot spacing. With these provisos the cut over grove areas can be allowed to grow back to something like their original character. Specific fuel management prescriptions for each vegetation management unit are included in Table 1.

TRAIL SYSTEM

The planting pattern relations are designed to work with proposed expanded and integrated trail and meadow circulation patterns to open up the entire canyon as a more complete and coherent experience of landscape space, closely coordinated with ecological study programs. This is thought of as a time-space movement system, without specifying the rate of movement through it. Some may ride horses, bicycle, or jog, while others hike, stroll, loiter or linger.

One may enter such a system at any time (daylight) at any accessible point and move through it in either direction and any combination of long or short loops. The high percentage of relatively steep slopes in the Canyon area



EXSTG. VEHICULAR CIRCULATION

PROPOSED VEHICULAR ACCESS

DELETION OF ROAD

VEHICULAR OVERPASS

VEHICULAR PARKING

INTERNAL TRANSIT STOP

EXSTG. FIRE TRAIL

EXSTG. INDIAN TRAIL

PROPOSED PEDESTRIAN

STRAWBERRY CANYON STUDY
U.C. BERKELEY • JUNE 1976
GARRETT ECKBO & ASSOCIATES

MOVEMENT SYSTEM

0 200 400 1000 1750 ft.

12

(about 80% steeper than 1 in 4, or 25%) limits the flexibility of such a system, but increases its dramatic and challenging aspects. From this point of view it is necessary to describe circulation and vegetation patterns together.

Entering the system primarily from the west, the lower campus, we begin as we cross Gayley Drive and enter Stadium Rimway north of Kleeberger Field. We propose that the inadequate and unpleasant walk to Centennial Drive and along it to the dam be supplemented by a comfortable 6 to 8 foot wide pedestrian way cut into the slopes above Rimway and North Canyon Road from Bowles Hall to Chicken Creek, Poultry Station and the dam.

From the south side we propose that Rimway be closed between Centennial Drive and Canyon Road. Pedestrian movement from the campus can filter between the Stadium and International House, around the upper terraces and through Canyon Road to the excellent broad walk which runs to upper Haas pool. This path should be extended above the pool, the dam and retention basin until it intersects the lower fire road south of Hamilton Creek. From here the road climbs westerly up the north slope.

North of the creek a branch fire road continues eastward parallel to it. Because of massive soil movement the Botanical Garden fence above the road has failed. A new fence has been built along the road bed some 4 to 5 feet in from its outer edge. Although there is a gate at its western end the road has not been maintained for vehicles. It has grown up with heavy Baccharis and some scrub oak until it is difficult to distinguish the original road. However it is still there as a basic graded form.

We propose that the old fence be removed and the new fence be moved back to the toe of the slope above the road bed. Baccharis and other brush, except oaks, should be removed and the roadway opened up to almost its original comfortable scale. It should then be extended on up the gulch to meet the upper fire road as comfortably as possible. This will open up the eastern end of the canyon to pedestrian movement.

Returning to the Botanic Garden area, on its north side a paved service road runs eastward about 1,000 feet up Strawberry Creek to a seismic installation. This is a paved road with a locked gate approximately 150 feet from Centennial Drive. However it is possible to squeeze around the end of the gate. The walk is pleasant, with first the varied growth in the Botanic Garden and then lush native canyon vegetation below it, and fine groves of Monterey pine and eucalyptus above. The road terminates at two seismic installations, one set in a bowl quarried from the hillside. Beyond one can see the valley of Strawberry Creek opening up northeastward. We propose that this road also be extended up the valley as a dirt trail to the upper fire road. The seismic installations can be fenced in for protection, and pedestrian access through or around the gate made easier.

The other major up-down connection now exists in the north-south valley below Animal Behavior Research. The skid road which was developed to remove cut eucalyptus now provides a comfortable walk down from the upper fire road to the power line service road which leads north, over the ridge in a steep and awkward hum, to Centennial Drive. It would be possible, however, to clear a continuation of the skid road as path through the substantial eucalyptus grove west of the BioMedical Building directly south of North Canyon.

(There is a bad gully eating into that grove.) The path would connect with Centennial Drive.

In this valley, now quite open because of eucalyptus cutting and full of resurgent growth including eucalyptus sprouts, slopes are such that a good part of it could be converted to grass.

Of the three most feasible up-down connections we have proposed, only the first, up Hamilton Gulch, connects directly with existing and proposed pedestrian ways. The other two require the use of Centennial Drive as a lower or westward connector. Walking along this drive is again narrow, unpleasant, and hazardous both above and below the Botanic Garden. As to the scale of these walk/fire roads they should run from 6 to 12 feet. As a practical matter, 12 can be maintained with a motor patrol. Indian trails are, of course, much narrower.

CENTENNIAL DRIVE

It seems no more reasonable for the University to provide a thoroughfare for through traffic in its upper campus than in its lower campus. That issue was thoroughly debated at the time of Moffitt Library planning. We recommend that Centennial Drive be closed to through traffic. The road is steep, narrow and dangerous, particularly when used by through drivers rather than campus drivers. Above the Botanic Garden it inhibits pedestrian and bicycle use. It was not designed to adequate standards for through traffic. The University is liable for accidents which may occur along it. Stanford University does not allow through traffic in its campus.

As mentioned before, up to two miles detour north or south via Claremont or Spruce is no great inconvenience for motor vehicles. Both are better roads. The idea that cars and trucks must always have the most direct and convenient route is no longer defendable as we become more environment and pedestrian conscious.

The Provenzano report found that Centennial Drive from Rimway Road to the upper Tennis Court parking lots is in good condition, showing little or no distress. However above that section to a point approximately 150 feet above the Botanical Gardens entrance the roadway showed numerous signs of distress from moderate to heavy. These were embodied in considerable cracking parallel to the roadway and localized settlements of varying magnitude and size. The probable causes were numerous utility trenches which have seriously undermined the structural integrity of the subgrade soils to depths of 5 to 6 feet; sidehill cut-fill sections in which some of the fills are in a variable loose uncompacted state; and intermittent subsurface seepage. In addition, portions of the hill above and adjacent to the roadway appear very susceptible to mud flows during periods of prolonged rainfall.

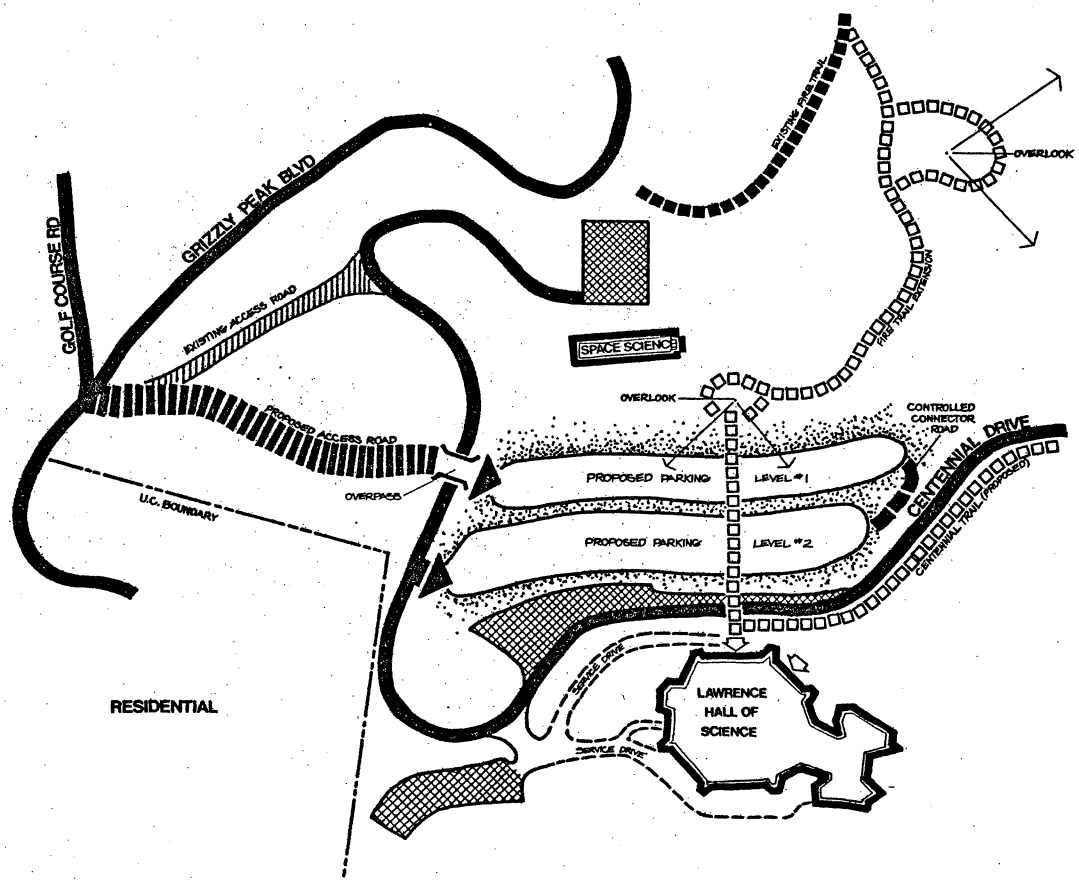
To correct these conditions the report recommends resurfacing the lower portion and rehabilitating the upper with an elaborate program of reconstruction, drainage, retaining and slope walls, and vegetal stabilization. Although this report was made in March 1972, none of its recommendations appear to have been implemented.

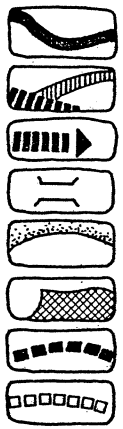
The visual impact of such major road reconstruction upon the landscape

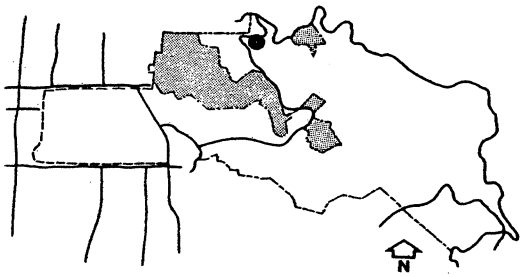
quality along it would be substantial, although subject to gradual healing with careful planting. It is not known just what relations there may be between current traffic, strictly intra-campus traffic, the rate of deterioration of the roadway, and the ultimate deadline for reconstruction. But it seems obvious that the roadway will last longer and deteriorate more slowly with less traffic. Accurate counts of through and campus traffic may help in the final decision-making.

Such a closing of Centennial Drive would require much more detailed study. It has already been proposed in the Jones Report. We feel that the upper end could be re-designed to provide for all needed intra-campus circulation and public access to Lawrence Hall of Science and Botanic Garden while blocking through traffic. It might work about as follows:

> By closing Centennial above the Space Science entrance, through traffic would be blocked while campus traffic could reach SS and Grizzly Peak if necessary. Gates or barriers could keep external traffic out of this section.
>
> Centennial from above could be reconstructed to terminate at a new upper Lawrence Hall parking lot, crossing the road to Space Science via overpass. The lower parking lot terraces presently graded east of Lawrence Hall and Centennial could be completed to receive public visitors from below, who would not be able to go farther. The Botanic Garden could only be reached from below- but that is probably no problem for most visitors.







key map

LENNERT AND ASSOCIATES · CONSULTING ENGINEERS

STRAWBERRY CANYON STUDY
U.C. BERKELEY · JUNE 1976
GARRETT ECKBO & ASSOCIATES

MOVEMENT SYSTEM

0 50 100 250ft

12a

The reduction in traffic, particularly truck traffic, on Centennial would reduce maintenance costs, perhaps eliminate the reconstruction proposed by Provenzano, and make possible much more comfortable pedestrian provision along it. There should be a good pedestrian walk all the way up to Lawrence Hall, connecting from there to the upper fire road. Tree groves should be planted along the slope below Centennial to screen the more industrial sections of the Lawrence Labs.

The opening up of these three valleys with pedestrian ways and grass areas would create a system of loops:

lower fire road, upper fire road, Centennial Drive,
Hamilton, Strawberry and Animal Research Valleys
a total of nine different possible loops.

To these can be added other shorter connections shown on plan, particularly along the upper ridges and over into Claremont Canyon. The so-called Indian trails are more special because they seem to be so steep, narrow, overgrown and difficult as to be primarily for the young and the athletic. Furthermore, because many of these trails are approximately perpendicular to the slope they cause erosion. There are places along the fire roads where trails are breaking down their edges.

MISCELLANEOUS

Along the upper Grizzly Peak frontage the gullies tend to be filled with junk. Access to them by car should be blocked.

Next to the redwoods on the north slope there is a bad erosion gully which should be controlled.

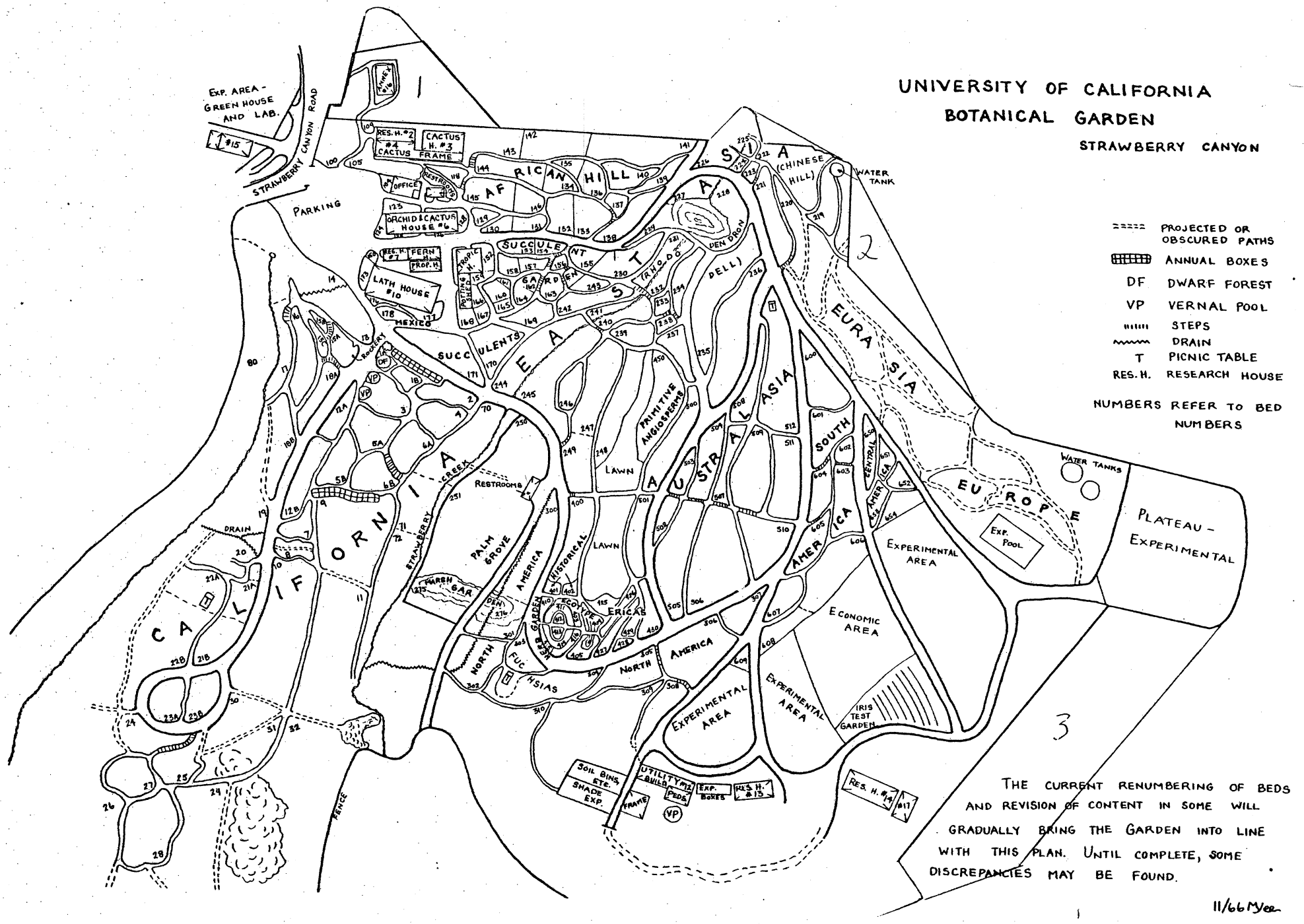
Along the skid road on the south slope a creek channel has been filled in. This disperses the drainage. This channel should be opened up.

As a result of past overgrazing and concentrated corrals there is an invasion of thistles and wild artichokes. These are difficult to manage. Research on control means is badly needed.

BOTANICAL GARDEN

The following additions to the Botanic Garden from Robert Ornduff, Department of Botany, seem reasonable and are incorporated in this plan:

> There are three modifications of the existing fence around the Botanical Garden that we would like to be considered for possible inclusion in the Strawberry Canyon Report. These areas are indicated on the attached map.
>
> Area 1 is a small area bounded by the seismograph road, Centennial Drive, and the Botanical Garden. This area would enclose the building that houses our educational program. Most of this area is already part of the Botanical Garden but is outside our fence, and the reason for enclosing this area is for security of the educational building and for the protection of the existing plantings in this area.
>
> Area 2 is above our Asian and European Areas and would allow for an expansion of these areas by the straightening out of the existing fence. The present fence is at the top of a steep slope, and the area outside this fence is a much gentler slope. The new location of the fence would be at the upper edge of this gentle slope where it again becomes steep. Area 2 is essentially unaccessible except through the Botanical Garden, and we believe that the new location of the fence would be a much more logical boundary for this part of the Botanical Garden.
>
> Area 3 would move the existing fence farther down the slope toward Hamilton Gulch. This change would also straighten out the existing



THE CURRENT RENUMBERING OF BEDS AND REVISION OF CONTENT IN SOME WILL GRADUALLY BRING THE GARDEN INTO LINE WITH THIS PLAN. UNTIL COMPLETE, SOME DISCREPANCIES MAY BE FOUND.

11/66 MYee

Botanical Garden boundary. This area would be used for a research area and would allow us to move all the research activities of the garden to the back of the Botanical Garden and away from the areas open to the public.

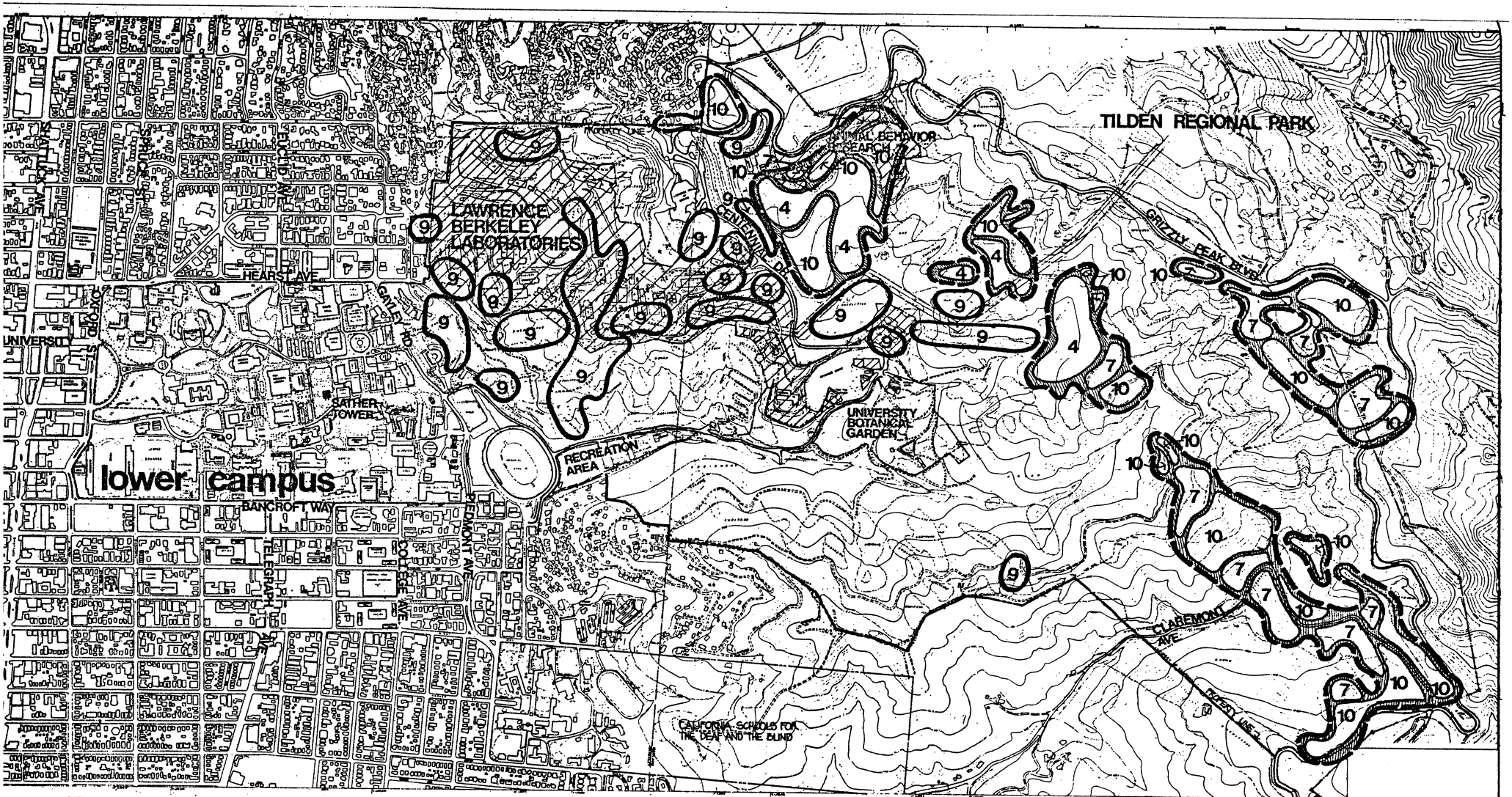
VEGETATIVE PLAN - IMPLEMENTATION RECOMMENDATIONS

Prepared by Dr. Joseph McBride
Transcribed by Garrett Eckbo and Associates

These recommendations for re-vegetating Strawberry Canyon and for its continous management will require the hiring of a professional vegetation manager with experience in wildland fuel management. To accomplish the re-vegetation proposals at a reasonable rate, the manager should be provided with two full-time assistants, and several part-time assistants during the planting season and those times of the year when ground fuels can be burned. In addition to vegetation management responsibilities the manager and his crew would also be charged with trail construction and maintenance, erosion control and stream channel maintenance. The vegetative manager should also be made responsible for monitoring the use of the canyon for teaching and research, in order to minimize potential conflicts between users, and between users and resources.

Note

Patterns and numbers shown are for management guidance only. Although prepared with reasonable care, no accuracy as to location or existing vegetation is guaranteed. Vegetation locations are based on visual survey and 1972 aerial photos.



LIMITS OF CUT EUCALYPTUS

9 EXSTG. STAND OF EUCALYPTUS

10 EXSTG. EUCALYPTUS SPROUTS

7 PROPOSED CONIFER CONVERSION

4 GRASS & EUCALYPTUS

STRAWBERRY CANYON STUDY
U.C. BERKELEY • JUNE 1976
GARRETT ECKBO & ASSOCIATES

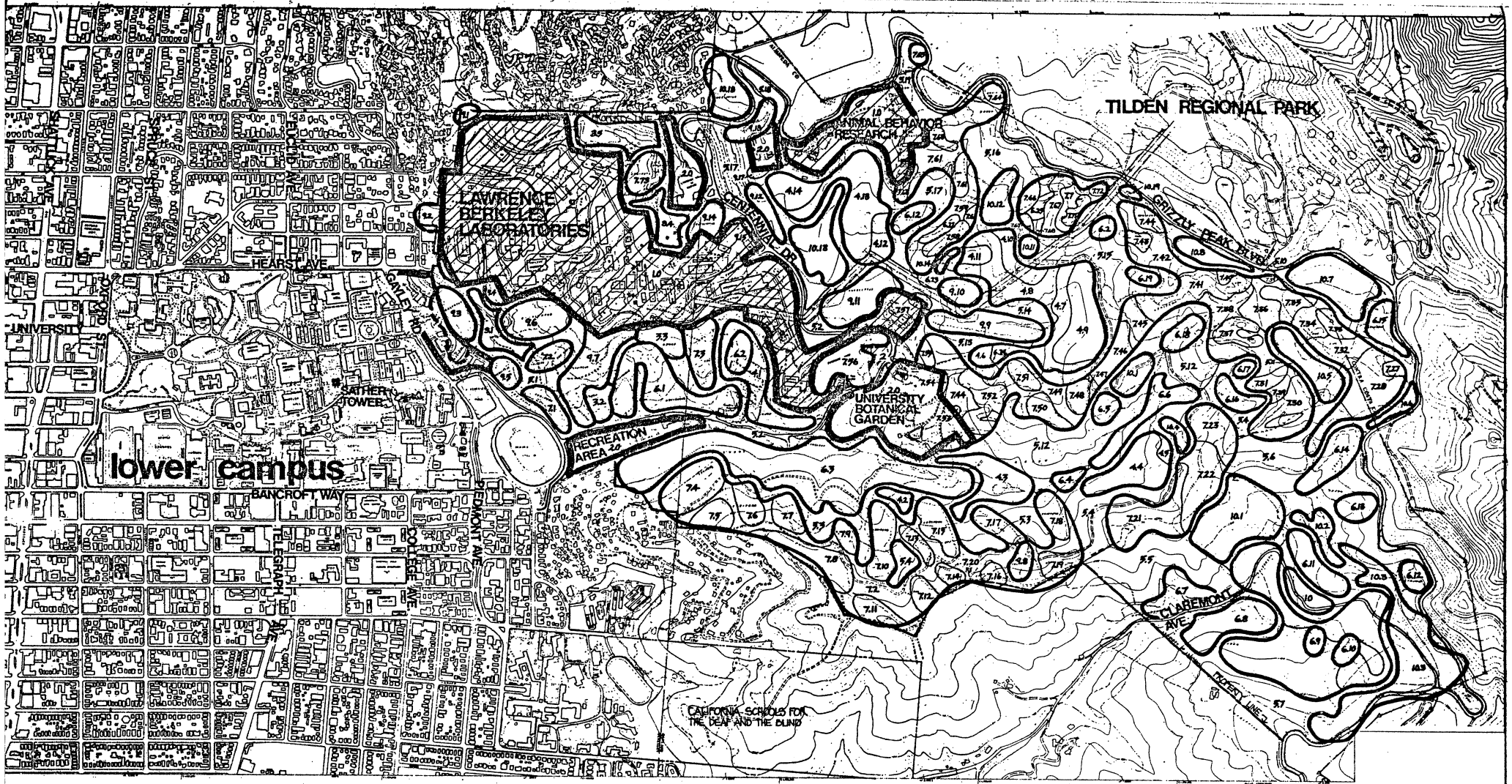
EUCALYPTUS MANAGEMENT

0 200 400 1000 1750ft.

13b

Aside from the difficulties of precise surveying on rough ground, the passage of time after completion of this plan may produce major unpredictable changes in any or all areas.

It is recommended that management work with the language describing desired continuities or changes in vegetation on particular slopes, and apply those to the actual conditions on the ground, using this plan as a guide and monitor. It would be well to refer to the Campus Landscape Architect, to Garrett Eckbo and Associates, and/or to Dr. Joseph McBride for interpretation of the plan on the ground.



NOTE - PATTERNS & NUMBERS SHOWN ARE FOR MANAGEMENT GUIDANCE ONLY. ALTHOUGH PREPARED WITH REASONABLE CARE, NO ACCURACY AS TO LOCATION OF EXISTG VEGETATION IS GUARANTEED. VEGETATION LOCATIONS ARE BASED ON VISUAL SURVEY & 1972 AERIAL PHOTOS. ASIDE FROM THE DIFFICULTIES OF PRECISE SURVEYING ON ROUGH GROUND, THE PASSAGE OF TIME AFTER COMPLETION OF THIS PLAN MAY PRODUCE MAJOR UNPREDICTABLE CHANGES IN ANY OR ALL AREAS.

IT IS RECOMMENDED THAT MANAGEMENT WORK WITH THE LANGUAGE DESCRIBING DESIRED CONTINUITIES OR CHANGES IN VEGETATION ON PARTICULAR SLOPES, & APPLY THOSE TO THE ACTUAL CONDITIONS ON THE GROUND USING THIS PLAN AS A GUIDE & MONITOR. IT WOULD BE WELL TO REFER TO THE CAMPUS LANDSCAPE ARCHITECT, GARRETT ECKBO & ASSOCIATES AND/OR TO DR. JOSEPH MCBRIDE FOR INTERPRETATIONS OF THE PLAN ON THE GROUND.

JOSEPH McBRIDE VEGETATION MANAGEMENT CONSULTANT

STRAWBERRY CANYON STUDY
U.C. BERKELEY · JUNE 1976
GARRETT ECKBO & ASSOCIATES

VEG. MANAGEMENT IMPLEMENTATION

0 200 400 1000 1750 ft.

13a

TABLE 1: VEGETATION MANAGEMENT UNITS

LEGEND (The following symbols are used in this table to designate specific management practices)

A. No manipulation

B. Pile and burn all dead ground fuel 1" to 4" in diameter every 25 years

C. Maintain existing grassland units by manual clearing of shrub and tree seedlings

D. Eucalyptus Units:
   1. Pile and burn all dead ground fuel 1" to 4" in diameter every 25 years
   2. Broadcast burn ground fuels every 5 to seven years

E. No manipulation of eucalyptus

F. Clear soft chaparral

G. Grassland Units: No treatment

H. Broadcast burn ground fuels every 10 years, providing sufficient ground fuel has accumulated

I. Hand clear, pile and burn soft chaparral

J. 1. Plant redwood in a clumped pattern with 400 trees/acre (see clumped pattern planting design)
   2. Thin to 200 trees at end of 20 years (maintain clumped pattern)

K. Broadcast burn ground fuel every 25 years after redwood becomes established

L. Cut sprouts and treat with 2,4-D to kill stumps

M. Plant Giant Sequoia in a random pattern with 500 trees/acre (see random pattern planting design,500 trees/acre)

N. Thin to 200 trees/acre at end of 25 years

O. Plant Incense Cedar in a random pattern with 600 trees/acre (see random pattern planting design, 600 trees/acre)

P. 1. Hand clear shrubs from area designated, pile and burn
   2. Remove all shrub seedlings and sprouts every 2 years

LEGEND (cont'd.)

Q. Broadcast burn every 10 years

R. 1. Fence area shown on map
2. Graze with goats until brush is eliminated or hand clear
3. Graze with cattle

S. 1. Fence area shown on map
2. Cut off stumps to within 2" of the ground, treat with 2,4-D
3. Hand clear all shrubs, pile and burn
4. Sow with annual grass seed mixture
5. Graze with cattle

T. Burn every ten years

U. Broadcast burn every year a 10' wide strip along property line

V. 1. Select 30 stumps per acre as potential trees, mark distinctly and cut all but tallest sprouts on each stump
2. Cut sprouts and treat with 2,4-D on all remaining stumps

W. No treatment until oak/bay wookland has developed then "B"

*Note: Clumped and random pattern planting design sketches available in consultant's files when needed.

AREA	EXISTING VEGETATION	PROPOSED VEGETATION	VEGETATIVE MANAGEMENT PRESCRIPTION	FUEL MANAGEMENT PRESCRIPTION
1.0	Restricted Area, vegetation management to be developed by Lawrence Berkeley Laboratory			
2.0	Special Land Use Area, vegetation management to be developed by special land use authority			
3.1	Mixed Vegetation (Small scale mosaic of grassland and eucalyptus)	Mixed Vegetation C,E	D,G	
3.2	Mixed Vegetation (small scale mosaic of grassland, eucalyptus and soft chaparral)	Grassland with eucalyptus C,E,F	D,G	
3.3	Mixed Vegetation (small scale mosaic of grassland and soft chaparral)	Oak/Bay Woodland A	B	
3.4	Mixed Vegetation (small scale mosaic of grassland and soft chaparral)	Grassland	C	G
3.5	Mixed Vegetation (small scale mosaic of grassland and soft chaparral)	Grassland and eucalyptus	C,E,F	D,G
4.1	Soft Chaparral (with grassland openings)	Grassland	P	Q
4.2	Soft chaparral (with grassland openings, if oak woodland do not convert)	Grassland	P	Q

AREA	EXISTING VEGETATION	PROPOSED VEGETATION	VEGETATIVE MANAGEMENT PRESCRIPTION	FUEL MANAGEMENT PRESCRIPTION
4.3	Soft chaparral (with grassland openings)	Grassland	R	Q
4.4	Soft chaparral	Grassland	R (fence should enclose both units 4.4 and 4.5)	Q
4.5	Cut over eucalyptus without sprouts	Grassland	S	Q
4.6	Cut over eucalyptus without sprouts	Grassland	S	Q
4.7	Cut over eucalyptus without sprouts	Grassland	S (fence should include units 4.7 through 4.11)	Q
4.8	Soft chaparral	Grassland	R	Q
4.9	Eucalyptus sprouts	Grassland	S	Q
4.10	Eucalyptus sprouts	Grassland	S	Q
4.11	Eucalyptus sprouts	Grassland	S	Q
4.12	Cut over eucalyptus without sprouts	Grassland	S (fence should include units 4.12 through 4.14)	Q
4.13	Eucalyptus sprouts	Grassland	S	Q
4.14	Cut over eucalyptus without sprouts	Grassland	S	Q
5.1 - 5.8	Soft chaparral	Soft chaparral	A	W
5.9	Soft chaparral	Soft chaparral	A,T	W

AREA	EXISTING VEGETATION	PROPOSED VEGETATION	VEGETATIVE MANAGEMENT PRESCRIPTION	FUEL MANAGEMENT PRESCRIPTION
5.10 - 5.20	Soft chaparral	Soft chaparral	A	W
5.21	Soft chaparral	Grassland	P	U
6.1 - 6.25	Oak/Bay Woodland	Oak/Bay Woodland	A	B
7.1	Conifer (mixed plantation of high elevation of pine species)	Conifer (same)	A	B,H
7.2	Conifer (Bishop Pine)	Conifer (same)	A	B,H
7.3	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.4	Conifer (mixed plantation of high elevation of pine species)	Conifer (same)	A	B,H
7.5	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.6	Conifer (Spruce)	Conifer (same)	A	B,H
7.7	Conifer (Western Red Cedar)	Conifer (same)	A	B,H
7.8	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.9	Conifer (Monterey Cypress)	Conifer (same)	A	B,H
7.10	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.11	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.12	Conifer (Canary Island Pine)	Conifer (same)	A	B,H

AREA	EXISTING VEGETATION	PROPOSED VEGETATION	VEGETATIVE MANAGEMENT PRESCRIPTION	FUEL MANAGEMENT PRESCRIPTION
7.13	Conifer (Redwood)	Conifer (same)	A	B,H
7.14	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.15	Conifer (Redwood)	Conifer (same)	A	B,H
7.16	Conifer (Canary Island Pine)	Conifer (same)	A	B,H
7.17	Conifer (Italian Stone Pine)	Conifer (same)	A	B,H
7.18	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.19	Conifer (Canary Island Pine)	Conifer (same)	A	B,H
7.20	Soft chaparral	Conifer (Redwood)	I,J	K
7.21	Soft chaparral	Conifer (Redwood in north facing slope and Incense Cedar on south facing slope)	I,J,N,O	K
7.22	Eucalyptus sprouts	Conifer (Giant Sequoia)	I,L,M,N	K
7.23	Soft chaparral	Conifer (Giant Sequoia)	I,J,N	K
7.24	Eucalyptus sprouts	Conifer (Redwood on west and north facing slopes; Incense Cedar on south facing slope)	I,J,L	K
7.25	Soft chaparral	Conifer (Redwood)	I,J	K
7.26	Soft chaparral	Conifer (Redwood)	I,J	K
7.27	Soft chaparral	Conifer (Giant Sequoia)	I,M,N	K
7.28	Eucalyptus sprouts	Conifer (Giant sequoia)	I,L,M,N	K

AREA	EXISTING VEGETATION	PROPOSED VEGETATION	VEGETATIVE MANAGEMENT PRESCRIPTION	FUEL MANAGEMENT PRESCRIPTION
7.29	Soft chaparral	Conifer (Giant Sequoia)	I,M,N	K
7.30	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.31	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.32	Soft chaparral	Conifer (Giant Sequoia)	I,M,N	K
7.33	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.34	Eucalyptus sprouts	Conifer (Giant Sequoia)	I,L,M,N	K
7.35	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.36	Eucalyptus sprouts	Conifer (Giant Sequoia)	I,L,M,N	K
7.37	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.38	Soft chaparral	Conifer (Giant Sequoia)	I,J	K
7.39	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.40	Soft chaparral	Conifer (Incense Cedar)	I,N,O	K
7.41	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.42	Soft chaparral	Conifer (Incense Cedar)	I,N,O	K
7.43	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.44	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.45	Soft chaparral	Conifer (Redwood)	I,J	K
7.46	Eucalyptus sprouts	Conifer (Redwood)	I,J,L	K

AREA	EXISTING VEGETATION	PROPOSED VEGETATION	VEGETATIVE MANAGEMENT PRESCRIPTION	FUEL MANAGEMENT PRESCRIPTION
7.47	Soft chaparral	Conifer (Redwood)	I,J	K
7.48	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.49	Soft chaparral	Conifer (Redwood)	I,J	K
7.50	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.51	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.52	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.53	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.54	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.55	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.56	Conifer (Redwood)	Conifer (same)	A	B,H
7.57	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.58	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.59	Soft chaparral	Conifer (Incense Cedar)	I,N,O	K
7.60	Eucalyptus Sprouts	Conifer (Incense Cedar)	I,L,N,O	K
7.61	Soft chaparral	Conifer (Incense Cedar)	I,N,O	K
7.62	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.63	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.64	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.65	Conifer (Monterey Pine)	Conifer (same)	A	B,H

AREA	EXISTING VEGETATION	PROPOSED VEGETATION	VEGETATIVE MANAGEMENT PRESCRIPTION	FUEL MANAGEMENT PRESCRIPTION
7.66	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.67	Eucalyptus Sprouts	Conifer (Redwood)	I,L,J	K
7.68	Soft chaparral	Conifer (Redwood)	I,J	K
7.69	Soft chaparral	Conifer (Redwood)	I,J	K
7.70	Soft chaparral	Conifer (Redwood)	I,J	K
7.71	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.72	Conifer (Monterey Pine)	Conifer (same)	A	B,H
7.73	Conifer (Monterey Pine)	Conifer (same)	A	B,H
8.1	(see Unit 7.25)			
8.2	(see Unit 7.26)			
8.3	(see Unit 7.24)			
9.1 - 9.17	Eucalyptus	Eucalyptus	A	D
10.1 - 10.14	Eucalyptus Sprouts	Eucalyptus	V	D

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APPENDIX

LENNERT AND ASSOCIATES
SOILS ENGINEERS

3309 Browns Valley Road
Napa, California 94558
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Job No. 756

16 June 1976

Garrett Eckbo & Associates
1045 Sansome Street
San Francisco, CA 94111

Subject: University of California at Berkeley
Future Development Study
Upper Campus Area

Gentlemen:

Transmitted herewith is our report covering engineering consultation in connection with your planning study for future development of the campus area easterly of Galey Road.

The scope of our services has included preparation of a campus geologic map showing the area geology and fault system, preparation of a generalized evaluation of rock and soils conditions keyed to the geologic map, identification and evaluation of potential building sites, and provision of some general information regarding the storm drainage system and present ecologic conditions in the stream channel system. The results of our studies, including the geologic map and drawings of potential building sites, have been presented as "work sheets" without being drafted into reproducible form. Information regarding the hydrology, storm runoff conditions and storm drainage system of the campus has been provided by our report dated 12 May 1972. This report formalizes transmission of these materials, and presents the basis for the drawings transmitted to you along with explanatory comments and supplemental opinions.

The body of this written report is presented in four appendices, listed as follows:

APPENDIX A: GEOGRAPHY AND GEOLOGY

APPENDIX B: ROCK AND SOIL CONDITIONS

APPENDIX C: POTENTIAL BUILDING SITES

APPENDIX D: SUPPLEMENTAL INFORAMTION

Due to the large area covered and the limited scope of work, our analyses are cursory and represent only a general planning level of definition. This office has sufficient information in its files to prepare a schematic level evaluation, with reasonably dependable cost estimates, for any of the potential development sites identified in this report; this would be done as a supplemental service, for a specific site, if this is found to be desirable.

A massive amount of data has been reviewed in preparation of this report, and extensive analyses were performed. This report, and the accompanying drawings, represent a very brief summation of the results of this work. This office is prepared to discuss the basis for the transmitted materials, and for our conclusions and opinions, in much more detail than is presented in this report if you so request.

Respectfully submitted,

B.J. Lennert
REC #9232

BJL/ct

Encl.

APPENDIX A

GEOGRAPHY AND GEOLOGY

The area under consideration consists of that portion of the campus lying easterly (uphill) of Gayley Road. This area lies on the west-facing slope of the Berkeley Hills, extending from approximately the toe of slope to the most westerly ridge crest at Grizzly Peak Boulevard, thus covering the entire hill slope. The area topography consists basically of a complex pattern of relatively small secondary ridges and nosings, separated by an intricately branching canyon system, resulting from a combination of faulting and erosion associated with the geologically very recent uplift of the Berkeley Hills. Excepting for the lower portion of Strawberry Canyon, the ground slopes relatively steeply throughout, averaging around 25 percent, and there are no natural large flat areas. The area is thus generally steeply sloping, with access severely restricted by topographic relief; present development has been strongly controlled by difficulties of producing adequate building sites and acceptable access, as will future development.

The only access from the lower Campus to the area above Gayley Road is via Centennial Drive or Cyclotrone Road, and excepting for traffic to and from the Lawrence Berkeley Laboratory all major circulation is along Centennial Drive. There is limited access to the uppermost portion of the area from Grizzly Peak Boulevard, but this is severely restricted by the steep slopes and serrate topography which severely limits the areas which can be served by secondary roads; further, Grizzly Peak Boulevard is relatively remote from the lower campus area. For these reasons, excepting for the Lawrence Berkeley Laboratory which has its own inefficient and tortuous circulation system, all present development has been oriented to Centennial Drive; the location and geometry of future development is also likely to be so oriented unless another major access route is created at very appreciable cost.

Geologically the area consists of a very recently uplifted hill front, "hinging" roughly along the Hayward Fault which forms the local toe of slope near Gayley Road, with a steep thrust scarp just east of the main ridge which is locally traversed by Grizzly Peak Boulevard. To the west the slope is abutted by a relatively flat alluvial plane, in which the lower campus is located; to the east the main ridge is bounded by Siesta Valley, from whence the hill system then extends a considerable distance

in an easterly direction. In the area of interest the basic topography is almost totally fault-controlled; with related severe erosion this has formed the existent canyon and drainage system easterly of the Hayward Fault. The bedrock is relatively shallow in most areas, with a residual soil mantle generally in the range of a few feet in thickness; only relatively minor occurences of alluvial and colluvial soils are found, generally confined to the canyon areas and abutting lower slopes.

The bedrock in the area grades time-wise from Cretaceous sediments of the Knoxville and Chico formations, through Miocene sediments of the Claremont and Sobrante Formations, to the late Pliocene sediments and volcanics of the Orinda, Moraga, Grizzly and Bald Peak Formations. In some areas the sediments lie in vertical succession in accordance with the age of deposition; however, due to major faulting and folding, and to massive volcanic intrusion, the bulk of the formational contacts are steeply sloping to vertical and the time sequence is thus commonly horizontal. The character of the rocks varies widely, ranging from fairly hard and competent archosic sandstones in the Cretaceous series to soft and clayey semi-shales of the late Pliocene deposits; the volcanic members vary from extremely hard but generally intensely fractured basalts to soft and soil-like tuffaceous sediments which are locally contemporaenous to the Orinda Formation.

The upper campus area is bounded to the west by the Hayward Fault, a member of the San Andreas Fault system which is a major geologic feature and a plate boundary along which massive continental drift is presently occurring. The Hayward Fault thus forms a geologic break with virtually no similarity between the lower campus area to the west and the hill area to the east. The Wildcat Fault, which is also a significant geologic feature and is probably a secondary member of the San Andreas System, traverses the site at approximately midslope and forms another structural discontinuity; while formational members cross the Wildcat Fault, they have been displaced by distances measured in miles and show no depositional continuity. Between the Hayward and Wildcat Faults, and easterly of the Wildcat Fault, there are numerous secondary faults which have produced large displacements in the formational members; the overall structure appears to reflect a complex pattern of compression and tension faults associated with the large right-lateral movements along the Hayward and Wildcat Faults, combined with thrust faulting during the recent uplift which has formed the Berkeley Hills system. In addition, major slump-planes associated with an ancient caldera in the northeasterly portion of the area exhibit large vertical movements and further complicate the fault structure.

The topography and geology of the area is presented on a geologic map accompanying this report, whereon is shown the various rock members, the faults, and the major colluvial and slide bodies. This geologic map is the first ever prepared for the entire campus area, and was assembled by the writer of this report from existing information plus very limited additional surface mapping; it thus omits much detail and in some areas is considerably oversimplified. However, on this map the general geographic and geologic conditions described above can be clearly seen, and the relationship between the fault and rock structure and the area topography is readily apparent.

A complete presentation of the geologic characteristics of the area is far beyond the scope of this report; however, referring to the geologic map a brief description of those elements deemed important to overall planning is given as follows:

The Hayward Fault is a major crustal feature, showing right-lateral movement, with the westerly side moving to the northwest in comparison to the easterly side. Studies made by the writer in connection with the soils engineering for Wurster Hall indicate that northwesterly movement along the fault has been at least 2 miles during Pleistocene time, a period of about two million years. Movement is presently continuing along this fault, with "creep" at Memorial Stadium in the range of 0.1 inch per year. This has produced major tension and compression faults to the east of the Hayward, and the tectonic movements which caused uplift of the Berkeley Hills has produced thrust faulting east of the Hayward; the result is a complex system of cross-faults with both vertical and lateral movement, dividing the bedrock into a complex series of blocks with generally non-conforming interfaces. One such secondary fault has formed the canyon of the South Fork of Strawberry Creek above Memorial Stadium, and another such fault crosses the northwesterly side of the site in the area of Cyclotron Road.

The Wildcat is also a right-lateral fault, with apparently local vertical movements, which has experienced right-lateral northwesterly movement of the westerly side in the range of 2½ miles since the rocks were formed. The Wildcat Fault thus constitutes another major structural non-conformity in the bedrock system which, while not as major as that of the Hayward, is of fundamental importance in local areas. The Wildcat Fault has undoubtedly been active in relatively recent geologic time; whether "creep" movements are currently taking place along the Wildcat Fault, or whether there is currently hazard of overt displacement, is not known with any degree of certainty.

To the east of the Wildcat the secondary fault pattern continues with less expression, apparently reflecting lesser total long-term movement; these secondary faults are presumably currently inactive.

Between the Hayward and Wildcat Faults the Orinda sediments lie conformably on the much older Cretaceous sediments, representing the remnants of a much larger deposit the bulk of which has been removed by erosion resulting from uplift of the Berkeley Hills. In this area the surface of the Orinda formation locally forms a synclinal structure, on which has been deposited tuffaceous sediments and lava flows of the Moraga formation, the bulk of which apparently derived from an outlet presently marked by a volcanic plug called Little Grizzly Peak. The resulting structure thus consists of "basal bedrock" formed by the Cretaceous sediment: overlain by the Orinda sediments, and thence overlain by tuffaceous sediments and lava flows of the Moraga formation which form the ridge crest in this area.

To the east of the Wildcat Fault the rock sequence reflects the synclinal structure of Siesta Valley, with the beds being sharply upturned in the Campus area and striking roughly northwesterly. Immediately abutting the Wildcat Fault lies the Claremont Formation, consisting mainly of thin bedded shales and porcelainities of moderate hardness; the Claremont Formation is thence abutted by softer and generally more clayey sediments of the Siesta Formation, which is thence abutted by tuffaceous sediments and lavas of the Grizzly and Bald Peak Formations. This rock structure thus appears in surface expression as a series of elongate beds with the oldest lying against the Wildcat Fault and becoming progressively younger towards the axis of the syncline which forms Siesta Valley.

One large colluvial deposit is seen on the geologic map, running parallel to the Wildcat Fault; this deposit lies in a fairly steep "swale like" structure which probably results from movements along the Wildcat Fault. The depth of the colluvial soils is highly variable, apparently ranging from a few feet to over 25 feet; in some areas the soils are probably presently unstable and the classification would be gradational to landslide debris.

There is a major slide body in the valley of Chicken Creek, toeing-out at Centennial Drive. This slide body ranges to over 60 feet in depth and is believed to be presently undergoing very slow "creep" movements. In addition, there are other slide bodies shown on the geologic map and there are undoubtedly more smaller slides which have not been mapped.

APPENDIX B

ROCK AND SOILS CONDITIONS

The mechanical characteristics of the shallow rocks and soils are extremely variable and complex, reflecting the complex geologic structure from which they derive. It is thus impossible to provide general parameters for planning or site development which apply throughout; however generalizations can be made, keyed to the underlying rock as shown on the geologic map, which can be most valuable in pre-schematic or planning level evaluations. On this basis, and referring to the geologic map presented previously, generalized criteria are given with respect to each of the major geologic units hereafter.

Red spot

The Cretaceous rocks are clastic sediments, generally consisting of archosic sandstones, siltstones and shales, which have been severely altered and fractured due to techtonic movements. Surface weathering is generally relatively deep and intense, producing montmorillonite clays and thus relatively undesirable soils and shallow rock conditions. Where less weathered and massive, the rock is generally stable with excellent mechanical characteristics; where severely weathered and/or badly degraded or fractured the rock is relatively unstable with poor mechanical characteristics. Residual soils from these rocks are generally clayey, weak when wet, and expansive, with relatively poor mechanical characteristics. Existing slopes in the Cretaceous rocks are generally "critical", having eroded or slid to present configurations; the residual and colluvial soil mantle is thus generally creeping and is subject to shallow local sliding if stability conditions are worsened as by excavating cut slopes or producing unusually severe seepage conditions.

Red stripe

The Claremont formation rocks consist mainly of thin-bedded shales and siltstone of moderate induration; however, they are generally fairly siliceous or have an appreciable calcite content and are thus relatively hard and stable. Soils derived from the Claremont rocks generally show low to moderate plasticity, reasonably good mechanical characteristics, and better than average slope stability. Conditions of soil mantle creep are minimal in the Claremont formation, and no large slide movements are known to have occurred in this formation in the Campus area. Rock and soils conditions in the Claremont formation are thus relatively favorable.

Green

The Orinda formation sediments are generally only partially indurated, with mechanical characteristics intermediate between those of "rock" and those of "soil" where not degraded by techtonic movements or surface weathering. Where these rocks had been severely degraded, such as by shearing or by intense surface weathering, they possess very undesirable mechanical characteristics and are weak and unstable when saturated. The bulk of the large slide movements experienced in the upper Campus area, of which there have been many, have been based in Orinda formation materials which have been degraded by techtonic shearing and/or intense surface weathering. Most existing slopes in the Orinda formation are "critical", with the soil mantle presently experiencing slow creep movement. Further, if stability conditions are appreciably worsened, as by artificial excavation or filling, or by natural changes in stability conditions such as increased seepage due to creep along the local fault system, this formation is subject to massive sliding. In general terms construction of new improvements in the Orinda formation, which will perform adequately and are safe with respect to soil instability, can be accomplished only at considerable penalty in construction cost.

The massive tufaceous sediments of the Moraga formation are similar or somewhat superior in mechanical characteristics to the sediments of the Orinda formation and thus the same comments may apply. However, where they contain appreciable quantities of breccia or lava, or where they have been protected from weathering, their mechanical characteristics are much superior to those of the Orinda sediments and approach those of the Claremont formation. Since at most potential building sites the tufaceous sediments are interbidded with flow rocks and are relatively heavey in breccia content, rock and soils conditions in the tufaceous portions of the Moraga formation are generally relatively favorable, with only isolated problem areas comparable to the Orinda formation.

The flow rocks of the Moraga formation are generally basalts or andesites, with minor rhyolitic members. These rocks are generally hard, but intensely fractured due both to natural shrinkage processes upon cooling and to the techtonic movements which have occurred after deposition. Where unweathered these rocks are hard and resistent, stable, and present excellent conditions for development. Where severely weathered, these rocks produce montmorillonite clays and thus relatively poor soils conditions which can result in local embankment instability. Soils derived from weathering products of these rocks are generally highly plastic, expansive, and weak when wet, and have undesirable mechanical characteristics; however, due to

the resistance to weathering of these rocks, and progressive erosion, the soil mantle in areas in which the lavas form the bedrock is generally thin and inconsequential to site development. but Consequently, in areas occupied by the flow rocks of the Moraga formation rock conditions are generally excellent, and soils conditions are favorable excepting for a generally shallow weak surface soil horizon in some areas.

The sediments of the Siesta formation are somewhat older than the Orinda formation but are generally no better indurated. They are thus comparable to the Orinda formation and show about the same mechanical characteristics; for practical purposes the same comments regarding mechanical characteristics and stability conditions apply to the Siesta formation as to the Orinda formation. The residual soils formed by weathering of the Siesta formation, and secondary deposits formed by erosion of the Siesta formation, generally show very poor mechanical characteristics comparable to those exhibited by soils derived from the Orinda formation, and the same comments apply.

The landslide bodies are generally either marginally stable or marginally unstable; this means that they pose the potential of massive slide movement, and in some cases they are currently creeping with yearly movement in the range of ¼ to 1 inch. In general terms, the landslide bodies are unsuitable for development without extensive and very expensive corrective measures; no buildings or other major facilities can be founded thereon without greatly increased construction cost and/or unacceptable performance of the facilities and hazard of severe damage due to sliding.

Brown

The alluvial, colluvial and residual soils generally show poor mechanical characteristics, and commonly are at least marginally unstable in their natural condition. Where they can be reworked, and seepage eliminated, they will show reasonable mechanical characteristics and can be assuredly stabilized. Thus, where these soils are found at shallow depth they can be reworked and rendered suitable to development without appreciable increase in construction costs; where the depth of such soils exceeds, say, 10 feet, considerable extra costs will be incurred for required reworking and subdrainage.

For definitive evaluation each specific site, and the unique rock and soils conditions which pertain therein, must be considered individually; however, for general planning studies some useful overall generalizations can be made, keyed to the rock types as shown on the geologic map. These generalizations are presented hereafter in summation of the information given in Appendix C.

Areas underlain by the Knoxville and Chico formations, and by the Claremont formation, can be considered to be generally superior with respect to overall stability and rock and soils conditions for development. While shallow instability or other local soils problems may be encountered in these areas, they will be generally limited in severity and will not produce excessive construction costs.

In areas underlain by the Moraga, Grizzly and Bald Peak formations rock and soils conditions will generally be very favorable where the dominant rock type is a flow rock or heavy breccia and where tufaceous sediments are minor in occurance. In those areas in which tufaceous sediments dominate, and particularly if they have been severely altered by shearing or weathering, stability and soils conditions may grade to moderately poor but are still superior to those seen in areas underlain by the Orinda and Siesta formations. Since at most of the potential building sites occupied by these formations the bedrock is predominantly flow rocks and heavy breccias, for general planning purposes those areas shown on the geologic map as Moraga, Grizzly or Bald Peak formation can be assumed to be superior with respect to overall stability and rock and soils conditions for development.

In areas occupied by the Orinda or Siesta formations stability, rock and soils conditions are generally poor to unfavorable. While in some areas overall stability conditions are acceptable for generally planning purposes those areas shown on the geologic map as occupied by the Orinda or Siesta formations can be considered to be less favorable and it can be assumed that appreciable extra construction costs will be required for site development.

For purposes of general planning, in those areas occupied by alluvium, colluvium, deep residual soils or landslide bodies it can be assumed that soils and stability conditions will be unfavorable. While some such areas can be stabilized and rendered usable by remedial grading and installation of sub-drainage, on a general basis these areas are deemed undesirable as building sites and will probably entail appreciable extra construction costs even for development of parking or similar subsidiary uses. In those areas occupied by major landslide bodies, such as the valley of Chicken Creek, major building construction is unfeasible and at best only light structures with expected marginal performance can be constructed at carefully selected locations.

Reference is made to the geologic map for delineation of the areas described above. It is again emphasized that each potential building site must be considered individually, with its own unique rock and soils conditions, for definitive evaluation; but for overall planning, use of the general classifications given above will produce valid conclusions for most site areas and for most forms of major building development. For construction of major roads through such areas, where existing ground slopes are relatively steep, the comments given above are even more valid and applicable and can be used with considerable confidence in predicating potential stability problems and costs for construction in planning new access facilities.

APPENDIX C

EVALUATION OF POTENTIAL BUILDING SITES

With expenditure of sufficient money, and without constraints on degradation of the environment, virtually any area can be used as a building site. As a result, in order to provide a meaningful basis for relative evaluation of potential building sites it has been necessary to establish limiting parameters which reflect probable requirements and limitations inherent in future campus development. The limiting parameters chosen for these analyses cover costs for development, minimum usable area, maximum cut and fill embankment heights, and practicability of development as related to existing ground slopes and difficulties of developing road access. In addition, the same design and cost standards must be used in evaluating all sites, in order to make comparative site evaluation meaningful. We have established and used the same limiting parameters and standards for site development throughout. These parameters and standards are presented as follows.

If the existing ground slope is 2½ horizontal to 1 vertical or steeper development is not practicable and the area is considered unusable for normal development.

At least one acre of usable area must be available to produce a valid building site.

If cost for developing road access and/or to handle off-site storm drainage exceeds $50,000 per usable acre the area is not an acceptable potential building site.

Cut or fill slopes must not exceed 40 feet in vertical height excepting for local "points" as in narrow canyons or steep nosings. Fills must be sloped at 2 horizontal to 1 vertical. Cuts must be sloped at 2 horizontal to 1 vertical, excepting that in sound rock cuts may be sloped at 1 horizontal to 1 vertical.

Exported excavated material, or imported fill material, is priced at $4.00 per cubic yard. Cut to fill on-site is priced at $2.00 per cubic yard.

New access roads not requiring major grading are priced at $50.00 per linear foot. New access roads requiring major grading are priced at $100.00 per linear foot.

Using the foregoing standards and parameters, the entire campus area east of Galey Road was investigated, by trial and error design, to define potential building sites which meet these conditions. The process consisted of cursory design of cut and fill embankments, access roads and storm drainage facilities, at 1"=100' scale, and then determining whether or not the limiting conditions were met. In some areas two or more potential areas were defined and evaluated individually, and then a "composite site", encompassing the smaller areas, was evaluated to reflect the results of balancing cut and fill on-site and/or of considering the maximum practicable area size. A total of ten building sites were so defined, and we have concluded with considerable confidence that there are no other such sites within the University property east of Galey Road.

The developed area was shown on the plan for each building site, with the bench elevation, and the usable area was given in square feet. Road access to an existing thoroughfare was shown for each site. All access roads were assumed to be thirty feet in total width, with a 24 foot wide pavement; it was assumed that no sidewalks, curbs and gutters, or other such amenities were to be provided. The toes of all fill slopes, and tops of all cut slopes, were shown for both the building sites and major new access roads to permit visulaization of the size and configuration of the area that would be excavated to develop the site; at steeper locations the total area graded, thus ecologically altered, is approximately double the usable area. The total excavation or fill quantity was shown for each building site, including the amount hauled in or hauled out, to permit consideration of impact on the area and environment due to hauling over existing thoroughfares. The lengths of new access roads, and lengths of culverts, were shown for each building site. The cost of development for each building site was roughly estimated, using the parameters given above; in order to permit comparison of the building sites on a cost-benefit basis, the total cost per usable acre was also given for each building site. Using these data it is possible to evaluate each potential building site on the basis of the area which would be ecologically altered due to development, and on the basis of cost-benefit ratio as expressed in terms of the cost per usable acre. In addition, with the building sites shown in plan form on the 1"=100' scale drawings, the visual impact of the building site, and its geographic amenities as relating to proposed usage, can also be evaluated on a subjective basis.

The bedrock type was given for each building site, keyed to the geologic map, to permit judgement regarding probable rock and soil conditions for development, as described in other sections of this report. Sites were further classified as to presence or absence

of fault hazard, based upon the faults shown on the geologic map and the cursory judgment of the writer of this report as to the probable results of a definitive fault hazard study at each site location.

In order to provide some relative judgmental standard for comparison of the various sites from the engineering standpoint, these sites were classified as excellent, fair or poor. The basis for this classification is a cursory and somewhat subjective summation of conditions for site grading, probable difficulties in embankment stabilization, conditions for construction, and probable cost for building construction.

Availability of adequate utilities immediately off-site is a most important parameter in relative site evaluation from the cost standpoint, since at some potential building locations the cost of bringing in utilities would probably be so great as to foreclose the use of the site except under very special considerations. Evaluation of availability of utilities, and of the adequacy of these utilities to serve a projected type of building development, is far beyond the scope of this report; however, based on the knowledge of the writer as to the general location of campus utilities, we have indicated whether or not utilities are available nearby at each building site. It must be clearly understood that this evaluation is not definitive, and adequacy of the existing services is not known; however, this information is given because we believe it may be of value in cursory comparison between potential sites.

All of the information described above was presented in "work sheet form", as pencil and color drawings on prints of campus topographic sheets at 1"=100' scale. Supplemental information, such as quantities and calculations, are presented on the drawings or attached sheets. These drawings are not reproducible, and have been deposited in the Architect's files.

Based on both engineering and architectural considerations, one large site was selected as being a "prime site" and the probable most desirable and most economical site for future facilities development, and also as entailing the least ecological damage in comparison to the developed usable area. This site is located in the area of the Space Sciences Laboratory, immediately above and easterly of the Lawrence Hall of Science, and is an excellent site for major facilities development from the engineering standpoint. Good access is immediately available via Centennial Drive at little or no additional cost, all major utilities are available, and access to the lower campus by vehicle is relatively efficient. In addition, loss of existing trees or other major flora will be minimal, and there will be relatively little environmental impact.

Any of the potential building sites can be more definitively evaluated, to about the schematic level, using the voluminous information available in this office and the University's files. This might include such matters as more precise grading plans and site development costs, availability of utilities or the cost to bring utilities to the site, precise costs for storm drainage facilities and access road development, traffic impact on existing connecting roads, and similar engineering considerations. Particularly, for the "prime site" described above, available file information is probably adequate for schematic level design of any proposed development.

APPENDIX D

SUPPLEMENTAL INFORMATION

FAULT HAZARD

While evaluation of potential fault hazard must be based upon detailed investigations for any specific site, for purposes of overall planning certain generalizations can be made based on the geologic map presented in this report. For this purpose any site transected by the Hayward fault should be considered to be suspect with respect to hazard due to overt fault movement, and should be given low development priority from the standpoint of this criterion. While it is not now known whether the Wildcat fault is presently active, and thus constitutes a hazard to site development, it is the opinion of the writer that it will eventually be proven that the Wildcat fault has moved in geologically Recent time and must be considered to be potentially hazardous; it is thus recommended that any site which is transected by the Wildcat fault be considered to be suspect with respect to hazard from fault movement. There is no definitive information presently available regarding movements in Recent geologic time along secondary faults associated with the Hayward and Wildcat; however, it is the opinion of the writer that such movements have occurred, and may be presently continuing, particularly with respect to the more major secondary faults which extend from the Hayward to the Wildcat fault and displace faults of lesser expression. It is therefore the opinion of the writer that any site which is transacted by a secondary fault whose expression extends from the Hayward to the Wildcat should be viewed with some suspicion with respect to potential fault hazard, and should not be considered to be an acceptable building site until the question of fault hazard has been resolved.

Application of these criteria to overall planning is certainly subject to review with respect to any specific site, by detailed studies. However, it is believed that when considering the relative merits of various sites from the standpoint of overall planning, the use of these criteria is valid in drawing overall and generalized conclusions as to the comparable desirability of various potential sites.

PARKING DEVELOPMENT

In addition to the potential building sites identified in this report, which can obviously be used for parking facilities, three

areas suitable for major parking development have been defined in the studies made for this report. Two of these areas could serve the Haas Recreation Area, and one could serve the Lawrence Hall of Science and Space Sciences Laboratory.

The two potential parking areas which could serve the Haas Recreation Area consist of the canyon of the South Fork of Strawberry Creek above the upper Haas Pool and below the existing storm drainage retention basin, and the valley of Chicken Creek previously occupied by poultry facilities but now essentially unused. Development of parking in the canyon of the South Fork of Strawberry Creek would entail filling the canyon to approximately the existing grade of Centennial Drive, and would produce sufficient parking space to adequately serve the Haas Recreation Area for all present and reasonably conceivable future development; further, development costs would be relatively modest. The major disadvantage of this site lies in destruction of the only presently stable "stream ecological area" presently existent in the Campus outside the heavily developed areas. Development of parking in the valley of Chicken Creek would entail little ecological damage or environmental impact, and would be relatively economical due to the present graded configuration of the area. Sufficient parking area could be created to serve the Haas Recreation Area for all present and reasonably conceivable future development; however, access to and from the parking area, both vehicular and pedestrian, would be less convenient than would be obtained by placing the parking in the canyon of the South Fork of Strawberry Creek. On balance, it is the judgment of the writer that from the engineering standpoint development of parking in either area is equally feasible, and costs will be essentially the same; there is thus no major difference in engineering merit between the areas.

The potential parking development at the Lawrence Hall of Science consists of the area previously graded for future construction of a parking structure. The cost of development of new on-grade parking in this area would be minimal, and resulting parking facilities would provide reasonably efficient access to both the Lawrence Hall of Science and the Space Sciences Laboratory; however, the number of spaces which can be obtained without construction of a major structure, at great cost, will probably not be adequate for all future requirements of the two facilities.

The areas suitable for parking development in the canyon of the South Fork of Strawberry Creek, and immediately abutting the Lawrence Hall of Science, have been shown on the referenced "work sheets". The potential parking development in the valley of Chicken Creek is not so shown, but consists basically of the existing roads and benches which are clearly defined on the existent campus topographic maps.

CLOSURE OF CENTENNIAL DRIVE

One of the Architect's recommendations is that Centennial Drive be closed to non-campus traffic, coupled with provision of additional parking at the Lawrence Hall of Science, serving both Centennial Drive and Grizzly Peak Boulevard.

This office has provided, in "work sheet" form, a pre-schematic design entailing use of the existing graded area easterly of the Lawrence Hall of Science as a new on-grade parking area, coupled with a grade-separation of Centennial Drive at this location. In this design the upper two existing benches will provide two rows of single-tier diagonal parking, connected to Grizzly Peak Boulevard by a nominal structure overpassing existing Centennial Drive which will continue to the Space Sciences Laboratory using the present road. The overpass structure will connect to a new road alignment to the existing intersection at Grizzly Peak Boulevard; the portion of Centennial Drive from this intersection to the road to the Space Sciences Laboratory will be closed with bollards, to prevent through traffic but permit passage of emergency vehicles and authorized Campus personnel. The lower three existing graded benches will be used to provide two rows of double-tier diagonal parking connected to Centennial Drive at present grade.

In the design presented above a 15 foot wide "planting area" is provided at the westerly side of each parking area, to permit planting trees which will prevent seeing the parking areas from the Lawrence Hall of Science, the Campus, or the City area to the west. The visual impact of this development will thus be negligible. Since the area was previously graded, and is essentially "bare dirt" at this time, the ecological and environmental impact of the proposed development is negligible. There will be no increase in traffic on Centennial Drive, but instead a considerable reduction.

The cost of the new facilities described above will be minimal, since the existing Centennial Drive is preserved and new construction consists only of about 500 lineal feet of new roadway, a nominal overpass structure, and the cost of the new parking. Grading is limited to that required for the new road to Grizzly Peak Boulevard and limited re-grading of the existing benched area to accommodate the new parking geometry. The existing storm sewer system is adequate to handle the increased peak runoff rate.

The parking areas will be relatively convenient for users of both the Lawrence Hall of Science and the Space Sciences Laboratory, with maximum grade differences of less than 60 feet to the Lawrence Hall of Science and 100 feet to the Space Sciences Laboratory. While no parking studies have been made, it appears probable that the amount of parking which can be obtained by on-grade development

will not be adequate for future demands of the subject facilities. The design is, however, compatible with future construction of a parking structure, as originally planned, which will presumably provide sufficient parking for full future demand.

The parking area described above abutts the "prime building site" described in Appendix C, and the new road lies along the westerly periphery of this site. The designs presented above were made compatible with future development of the "prime area"; and in fact, such road and parking relocation and development will probably be a prerequisite to development of the "prime area".

Much of the area proposed for parking development lies in a massive Pleistocene slide body. While a "shear key" was installed at the toe of this slide body during construction of the Lawrence Hall of Science, it is the cursory opinion of the writer that this area would not be found to be suitable as a building site by present standards due to potential instability during earthquake. Use of this area for parking, rather than reserving it as a future building site, is thus indicated.

STORM DRAINAGE AND STREAM CONDITIONS

The storm drainage regime, and existent storm drainage facilities, are described in great detail in a report prepared by this office dated 12 May 1972. Reference is made to this report for detailed information concerning the area hydrology, the Campus storm drainage regime, the channel geometry and conditions, and the existent storm drainage system and major channel flow conditions; a copy of this report was provided to the Architect for use in connection with this study. The purpose of this subsection is to provide a very brief resume of a few matters of greatest importance with respect to the ecological and environmental affects of the creek system, making reference to the detailed background information presented in the referenced report.

Those creek channels with permanent flow (sufficient flow to maintain an aquatic environment even at the end of a dry season), and intermittent major creeks, were shown on the 1"=100' scale drawings on which the building site studies were presented. These are the only channels within the campus with permanent flow that have not been put underground into culverts, or with sufficiently sustained intermittent flow such that water-oriented flora and fauna are supported thereby. All other channels experience flow only during and immediately after rainfall and are essentially "dry creeks".

All "permanent" stream channels within the campus receive appreciable flow from the Lawrence Berkeley Laboratory area and are subject to very high peak flow rates, greatly exceeding "original natural" flow rates prior to upstream development, excepting only that portion of the South Fork of Strawberry Creek below the retention basin and above the Haas Recreation Center. These channels thus do not support the normal complement of water-oriented flora and fauna, since the "unnatural erosion" which now occurs scours these channels at least several times in the average winter. As a consequence, the only channel with permanent flow which could now be considered to approximate the "original stream channels" from the standpoint of low peak runoff rates and maintenance of permanent water-oriented flora and fauna, is that portion of the South Fork below the retention basin, in which flow is supplied solely by very local runoff and a "low-flow bypass" which diverts flow through the retention basin dam. It is thus believed that preservation of this area as a "natural preserve" may be unusually important due to the unique peak storm flow rate conditions which pertain therein.

The function of the channel below the retention basin as a unique environment is considerably negated by continual malfunction of the low-flow bypass system, which cannot handle the very large bedloads coming down the South Fork of Strawberry Creek and thus plugs every year, and by a subdrain which underlies the creek from the retention basin to the upper Haas Pool. Malfunction of the low-flow bypass eliminates surface flow from this channel during most of the year, and the subdrain "draws the water out" of the creek channel thus producing dry conditions. This can be remedied by construction of a low-flow bypass system which will survive the large bedloads in the creek channel at the retention basin, and by stopping the subdrain so that the seepage flow will be returned to surface flow within the stream channel.

FIRE CONDITIONS

The area considered in this report is in large part covered by trees, heavy brush and other dense vegetation. It is indicated that no major fire has occurred in this area for at least 50 years; historical evidence, and general studies, indicate that such areas probably burned, on average, at least once every 10 years prior to intervention by man. As a result, an extremely heavy "fuel load" has now accumulated in this area; any major fire which now starts in a lower slope is thus virtually certain to turn into a major conflagration which will both seriously threaten any included improvements, and totally sterilize the watershed, producing heavy runoff conditions and major mud-flows in the following winter.

As a result of these conditions, we believe that any future development in the upper campus area should include a definitive study covering fire hazard, and storm flow and mud flow hazards which will occur in the winter following a major fire. In this regard it is noted that the existing retention basin was designed so as to protect the lower campus area in the event of a major fire in the watershed of the South Fork of Strawberry Creek; no such protection is now available for new facilities constructed above the retention basin.

The recommended "prime building site" in the area of the Space Sciences Laboratory is not subject to the hazards described above to appreciable degree, since it lies near the crest of the ridge and there is thus very little tributary watershed, and since it is abutted by only very limited heavy growth and will be relatively easy to protect in the case of a major conflagration. All other sites in the upper campus area which appear to be viable building sites from the engineering standpoint appear to entail considerable risks with respect to a major conflagration in the watershed.

CHICKEN VALLEY

The valley of Chicken Creek, which rises northerly of Centennial Drive just east of the upper Haas Pool, is occupied by a major Pleistocene slide body and is thus not suitable for major building development. A relatively limited facility, such as a swimming pool complex, could be built in a very small portion of this area, with suitable protective design and construction; the only other potential development appears to be as a recreational area, or as a parking area serving the Haas Recreational Area, or a combination of the two.

Chicken Creek is a permanent stream, in that there is some minimal flow at the end of a dry season; it will thus support a permanent population of water-oriented flora and fauna, and could have considerable value as a natural recreation area. The stream channel is scoured each year by excessive peak runoff rates originating in the Lawrence Berkeley Laboratory, but these conditions are not as severe as found in most major channels within the campus. Attention is thus called to the apparent potential for development of the valley of Chicken Creek as a natural area with a permanent stream and/or a recreation area, possibly involving construction of a swimming pool and tennis courts or similar facilities.