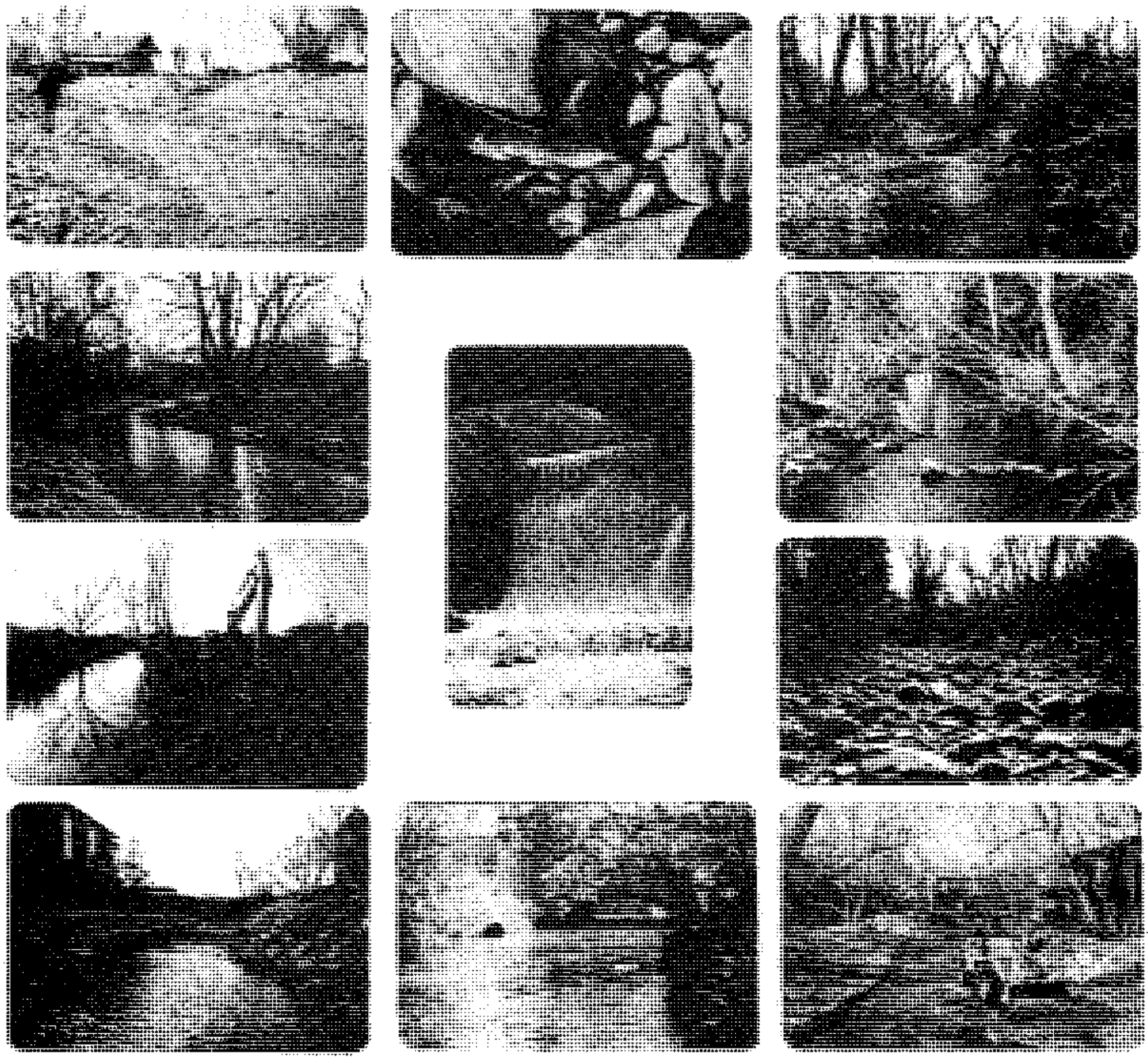
SALT LAKE COUNTY DEPARTMENT OF PUBLIC WORKS
DIVISION OF FLOOD CONTROL & WATER QUALITY



ASSESSMENT OF SALT LAKE VALLEY TRIBUTARIES: BENEFICIAL USE IMPAIRMENT & OPPORTUNITIES

FEBRUARY, 1984

SALT LAKE COUNTY PUBLIC WORKS
DIVISION OF FLOOD CONTROL & WATER QUALITY

Preliminary Review Draft

ASSESSMENT OF SALT LAKE VALLEY TRIBUTARIES: BENEFICIAL USE IMPAIRMENT & OPPORTUNITIES

STEVEN F. JENSEN
FEBRUARY 22, 1984

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Region VIII, Environmental Protection Agency

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I. INTRODUCTION

This study was undertaken as an inquiry into factors which presently impair the beneficial use of water flowing in three natural tributaries to the Jordan River - Millcreek, Big Cottonwood Creek, and Little Cottonwood Creek. Because these streams are classified by the State and County as coldwater fisheries and recreation/aesthetic resources, present management of water quality and quantity prompted Salt Lake County to propose the inquiry under a federal grant from the Environmental Protection Agency. The grant was awarded to the County in 1980, and provides inventory and analysis of available data that describe how uses are impaired by present management, and what policies are needed to eliminate impairment and optimize the uses for which the streams are protected.

The issues raised by the study involve the concept of balancing policies in the expenditure of public tax dollars, examining which policies realistically capitalize present management strategies, estimating initial economic gains that may be realized from implementing a more balanced policy, and describing strategies for achieving that balance.

Intrinsic to the discussion is an assumption - based on factual observation - that imbalance presently exists. The cause for such imbalance is for the most part a product of insufficient information, awareness, and historic public expenditures to address the problems in an integrated, coordinated, and responsible manner. Past land use policies have resulted in gross channelization of each valley creek, which in turn have forced flood control efforts into a less than optimum management position. The public, because of historic channelization policies, must now resign itself to subsidizing those living adjacent to channelized creek environs. Flood control loss offers the public a clear and present danger which must be dealt

1) BACKGROUND QUALITY: SEASONAL CANYON FLOW

Canyon water quality is typically very high during [illegible]. Larger loads of pollution produced by spring snowmelt are mitigated by large flows. Table 7 displays the relative quality of canyon water compared to other sources in the basin,[21] while Figure 10 illustrates seasonal variability of coliform bacteria in Big Cottonwood Canyon. The Nationwide Urban Runoff Program (NURP) carried out jointly by Salt Lake County and USGS since 1979 include baseline conditions (usually represented by the low values) and peak storm/runoff conditions (represented by the high values) and are displayed in Table 8, statistical means/extremes. It is noted that the two standards for the most toxic metals, mercury and cadmium, are often exceeded. It is not understood why these and other metals concentrations occur so high at the canyon mouth, although speculation about possible mine tailings effect deserves additional sampling attention.

2) STORMWATER RUNOFF

Figures 11 and 12 recount the occurrence of increased pollutant concentrations during storm flows and Figure 13 shows cumulative runoff for Big and Little Cottonwood. Although the increases for various parameters are dramatic, they are generally characteristic. Little Cottonwood Creek at the Canyon mouth for example, posts the following percentage increases during storms for the parameters selected:

Total Suspended Sediment:	400%
Total Dissolved Solids:	400%
Coliform - Total:	1000%
BOD_5:	-20%
Phosphorus:	140%
Lead:	100%

r ~yc ~d solid wast products. Local sewer treatment entities may now sell sludg ompost tha previously landfilled. 'Hercules Powder Company spent $750,000 to red ants it was dumping into the Mississippi River - now it saves well a quarter of a million dollars a year in lost materials and water costs." The conclusion to claims of market constraint . that significant pollution prevention pays - it does not cost.

C. RESOURCE SCARCITY: THE RENEWAL OF ECONOMIC EFFICIENCY

Conservation is usually thought of as relating to natural ame s or processes. But conservation of goods purchased applies as wel Neglect in new automobile maintenance cuts short the effective life of the car; playing the stereo o loud produces earlier cost for speaker replacement; polluting water pre ludes fishing; allocating water use for only culinary or industrial use precludes boati , f ing, or other recreation. Because water is such a scarce commodity in the est, its use must be optimized by spreading it among competing uses. Because oil is becoming a nationally scarce commodity, conservation may prove to be the only solution to optimizing its use. The good life depends on it. The same is true for water:

> Efficiency.....is the dominant new value of the marketplace - making the most of everything we have, capturing and using what used to be considered "waste," quality pushing aside the old standard of planned obsolescence, high-efficiency design replacing the old standard of gross size. [38]

Water policy in Utah has heretofore emphasized culinary, industrial, and agricultural consumptic as "beneficial use." It has placed recreat on and wildlife as lc pric ities mostly incident to "unused" streamflow. Yet State water pollution regu tions expressly protect water for recreation wildlife use. Instream flows provide benefits only to those willing to pa for them, or to those who are "first in time - first in right." This issue is with in the most cost-efficient manner possible.

The conclusion of this inquiry is that such cost-efficient management is more nearly attainable when coordinated and integrated with Federal, State, and local clean water goals. Many legal and institutional avenues exist which make such integration not only possible, but - in context of federal laws and regulation - also probable. The management problems faced by people living within the local creek environments are not unlike those of others throughout the country, but with one exception: scarcity of water resources in the West demand equitable and wise use policies. We all demand and use water for many purposes, and our public policy serves everyone best if purposes are balanced.

The structure of this study consists of an inventory of creek characteristics: length, flow, land use, water quality, habitat and wildlife quality, pollution sources, diversions, flow gains and losses, and riparian vegetation.

A discussion on the impairment of protected beneficial use considers State classification, pollution standards, known pollution conditions, use attainability analysis, and further research needs.

Section IV provides a review of economic factors which illustrate how water resource use is factored into total economic policy: The role of environmental economics, the progress and profit dimensions of environmental protection, water resource scarcity as the basis for achieving economic efficiency, measuring economic recreation variables as related to water quality, instream flow needs and preservation strategies, and the need for balance in water resource policy.

Section V applies the recreational economic framework to existing and projected valley tributary demand. Recreation facilities, preferences, market, use patterns and trends are examined. Projected use for different recreational activities, together with accompanying benefits, is estimated.

Finally, Section VI presents alternative conservation strategies available for the attainment of these uses and benefits. Authority and programs at the Federal, State, and local level are reviewed.

The conclusion of the inquiry is that the public can do much to stimulate economic balance and growth in the way it manages local water resources, and recommends the development of integrated stream environment zone policies to assist in such management.

II CREEK CHARACTERISTICS

The valley tributary segments display many similarities as well as differences. They all have similar overstory vegetative communities but are widely divergent in bank elevation, flow, and extent of channelization. In order to evaluate the creeks for multiple use potential, it is necessary to outline these similarities and differences. Existing conditions in or adjacent to the creeks may prohibit certain future use opportunities. This section is intended to outline basic existing conditions so that potential can be estimated.

Inventory of existing conditions is divided into three main sections: Land Use/Pollution Sources, Riparian Vegetation/Habitat, and Hydrology Quantity and Quality. Each main inventory section is further subdivided into detailed components. Each valley creek segment is individually discussed in terms of this inventory, as opposed to discussing all creeks collectively. Data is too detailed to allow a comprehensive description, but Table 1 summarizes some basic characteristics. Criteria that have been developed or measurements used to describe conditions are defined prior to individual creek definition. Figures 1, 2, and 15 are map series of each creek reach which describe these conditions. They are grouped together behind descriptive narrative.

TABLE 1

SUMMARY OF EXISTING CONDITIONS

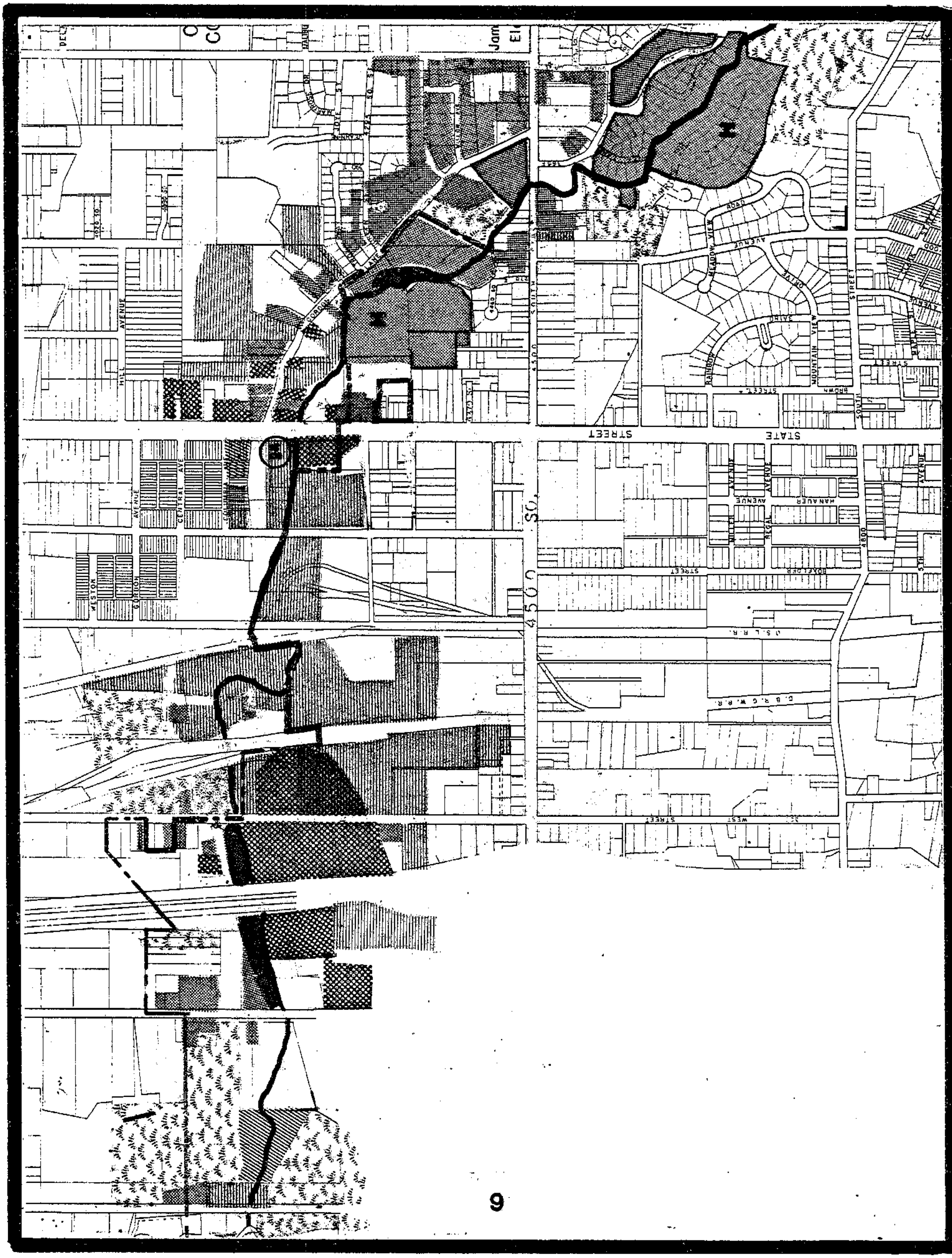
	Big Cottonwood	Little Cottonwood	Mill Creek
Valley Segment Length (Miles)	9.5	10.7	7.9
Channelized:Concrete Flume (%/Miles)	2%/1	4%/ 1	10%/.76
Average Annual Flow (CFS)	61	53.2	16.8
a Jordan River	61.2	44.5	23.8
a Canyon Mouth	61.0	61.9	9.9
Adjacent Land Use(%/Miles)	90%/8.4	80%/8.4	87%/6.7
Residential	48%/4.5	32%/3.4	60%/4.7
Commercial	10%/.95	4%/.38	5%/5.8
Industrial	12%/1.14	5%/.57	10%/.76
Park/Open Space	6%/.57	16%/1.70	7%/.57
Agricultural	6%/.57	23%/2.4	5%/.38
Sand and Gravel	8%/.76	-0-	-0-
Seasonally Dewatered (%/Miles)	32%/3.0	18%/1.9	-0-
Annually Dredged (%/Miles)	38%/3.6	46%/4.92	12%/.95
Riparian Overstory Vegetation (%/Miles)	89%/8.4	80%/8.5	78%/6.2
Fishery Suitability (%/Miles)	54%/5.1	35%/3.7	38%/3.0
Fishery Classification	Upper: VI (dewatered seasonally) Lower: IV	Upper: VI (dewatered seasonally) Lower: IV	Upper: III Lower: IV
Water Quality Conditions			
Classification	2B,3A,Agriculture	2B,3A,Agriculture	2B,3A,Agriculture
Impaired Uses	Recreation, Aesthetics,Aquatic Wildlife	Recreation Aesthetics,Aquatic Wildlife	Recreation, AestheticsAquatic Wildlife
Problem Parameters	TSS,TDS,Coliform, Heavy Metals, Nitrates,Phosphates Oil and Grease	TSS,Coliform,BOD, Heavy Metals, Nitrates,phosphates Oil and Grease	TSS,Coliform, BOD,Heavy Metals,Nitrate Phosphates, Oil and Grease
Causes/Sources: Point Discharges	Storm conduits/ drains, canal spills, treatment plant dewatering	Storm conduits/ drains, canal treatment plant and power plant dewatering,canal spills	Storm conduits/ drains, canal spills, industrial discharge municipal treatment plant
Non-Point Discharges	Bank and bed scour, construction runoff, urban runoff agriculture, residential impacts.	Construction runoff, bank and bed scour, agriculture, urban runoff, residential impacts.	Bank and bed scour, urban-runoff,residential impacts construction runoff.

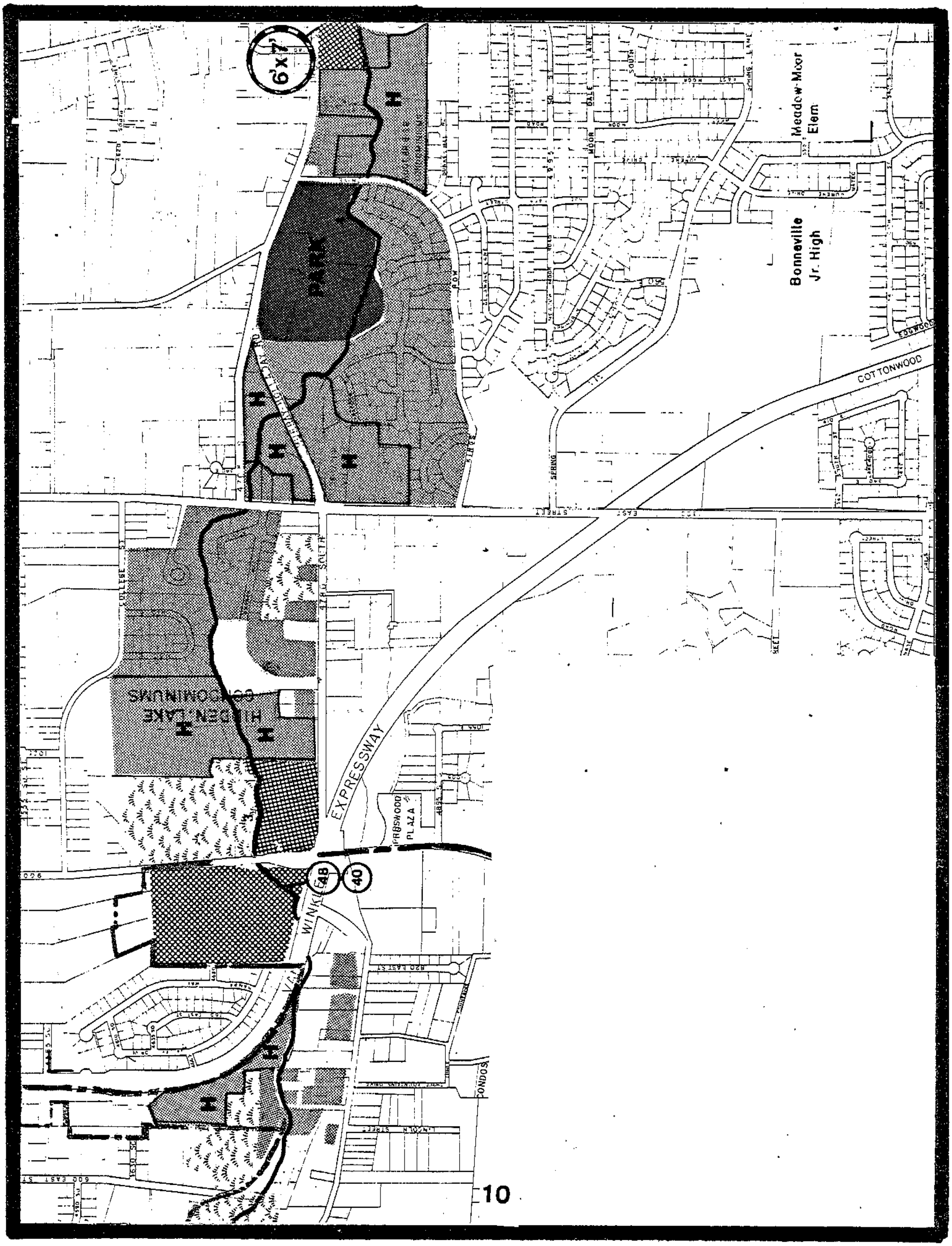
FIGURE 1

LEGEND

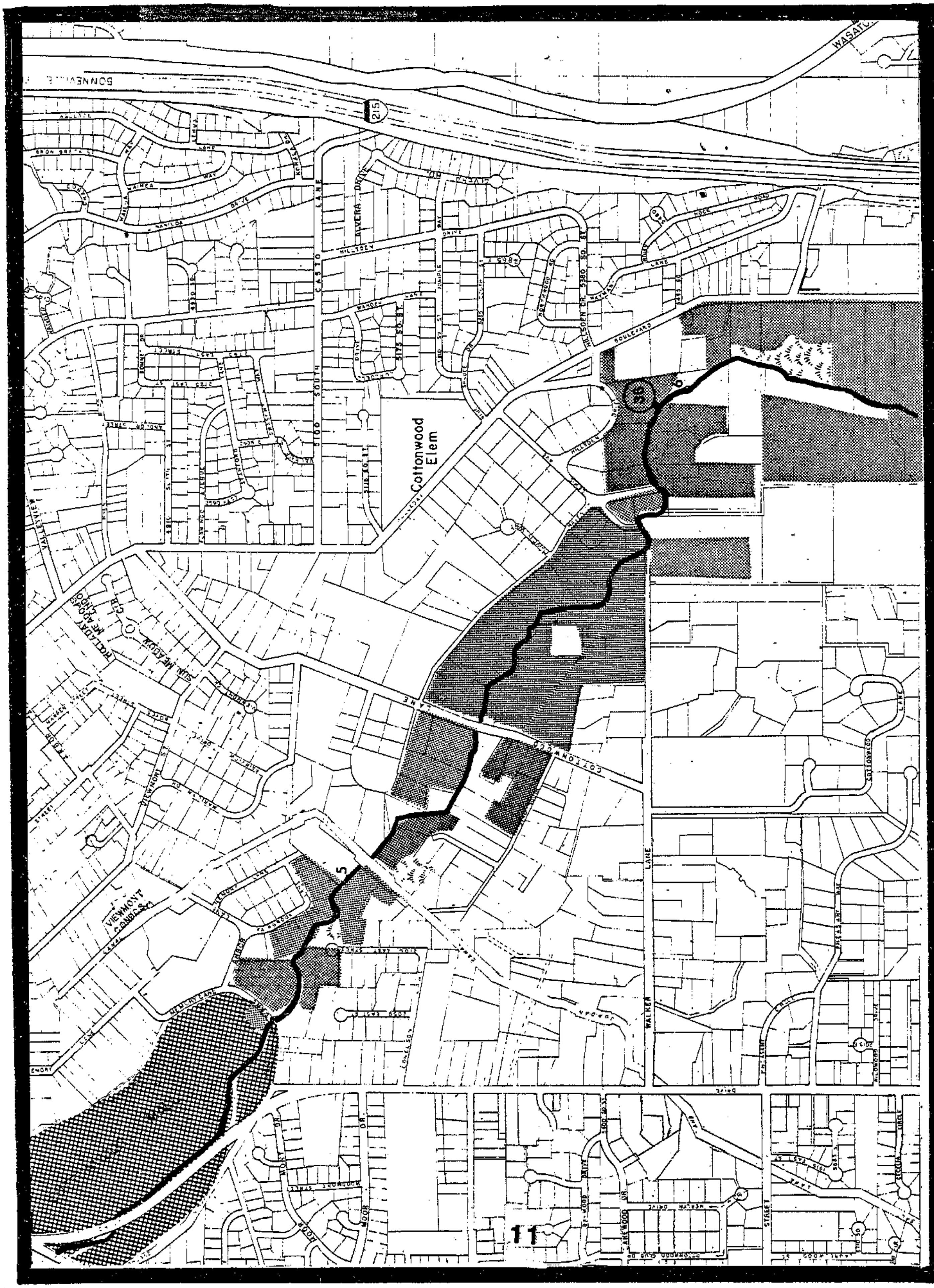
LAND USE/POLLUTION SOURCES

RESIDENTIAL: LOW DENSITY	
RESIDENTIAL: HIGH DENSITY	H
COMMERCIAL:	
INDUSTRIAL:	
PARK/OPEN SPACE:	PARK
AGRICULTURAL:	
SAND & GRAVEL EXCAVATION:	
POTENTIAL NON-POINT POLLUTION SOURCE	NPS
MAJOR POINT SOURCE DISCHARGES BY PIPE DIAMETER SIZE (INCHES UNLESS NOTED OTHERWISE)	24

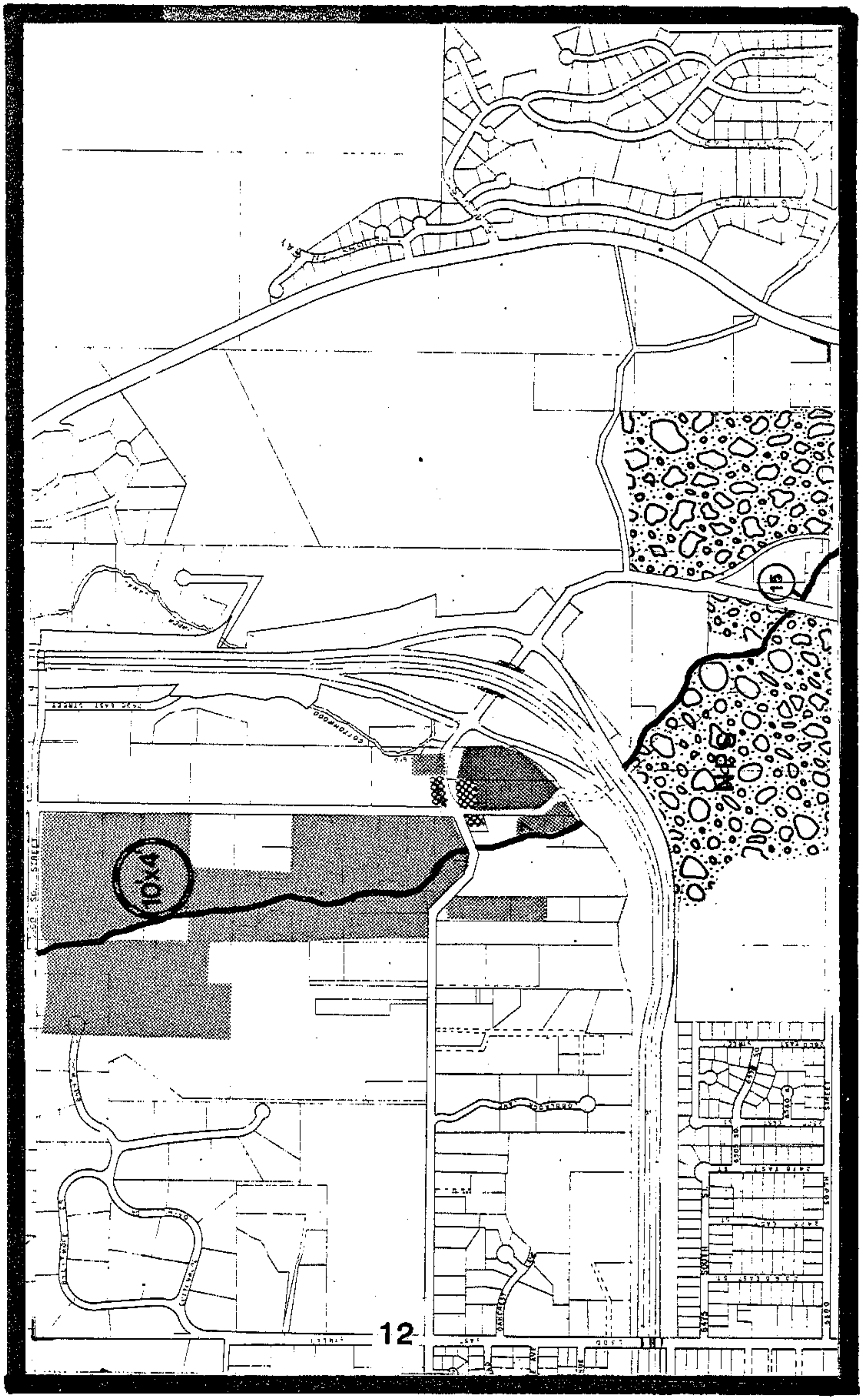

STATE
STREET
450 SO.
CENTRAL AVE
AVENUE
WESTON
GORDON
HANAUER
REGAL
MOUNTAIN VIEW
RAINBOW
DRIVE
BROWN
WEST
O.S.L. R.R.
D. & R. G. W. R.R.

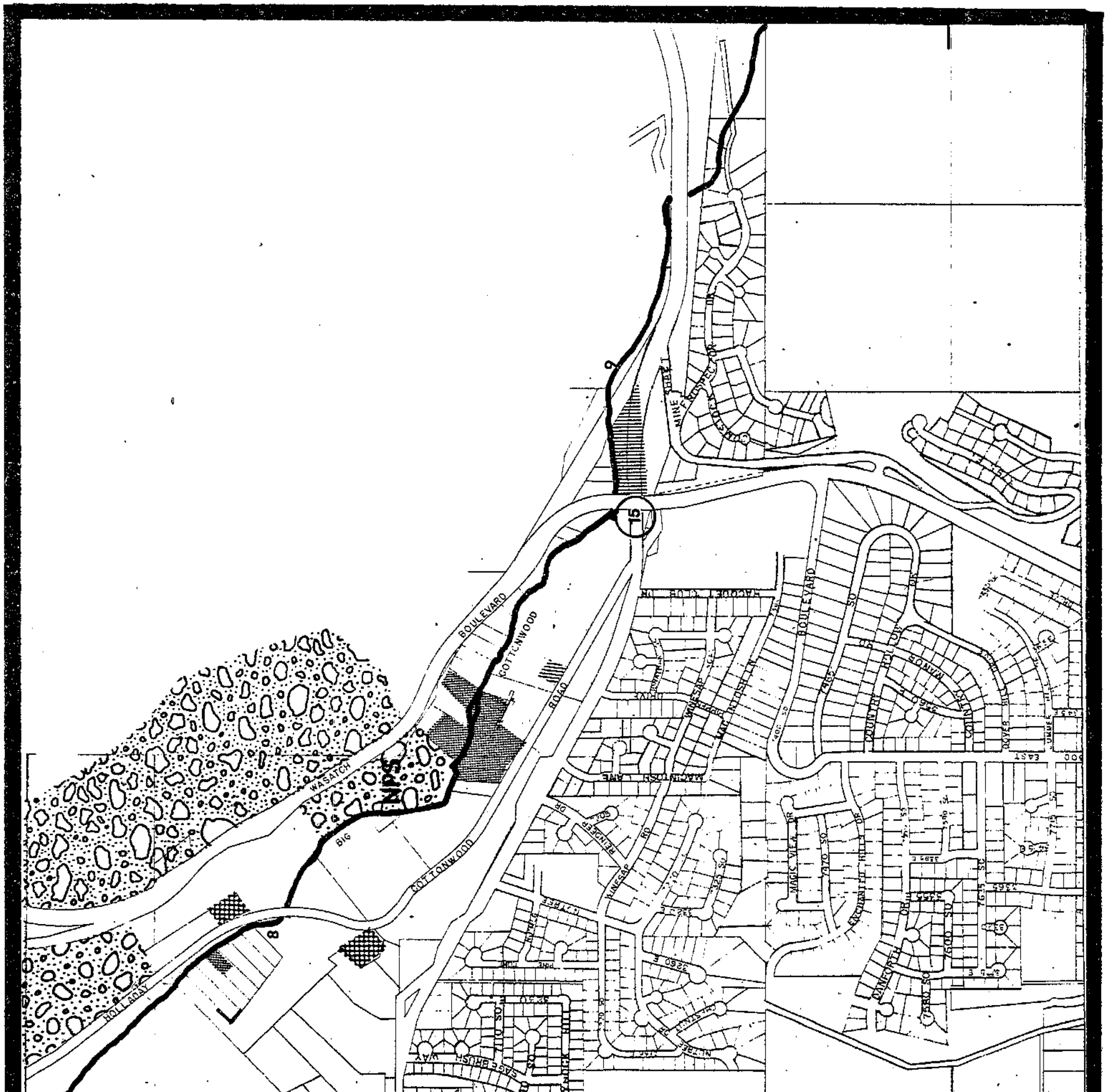


PARK
Bonneville
Jr. High
Meadow-Moor
Elem
COTTONWOOD
EXPRESSWAY
HIDDEN LAKE
CONDOMINIUMS
6'x7'
48
40
CONDOS

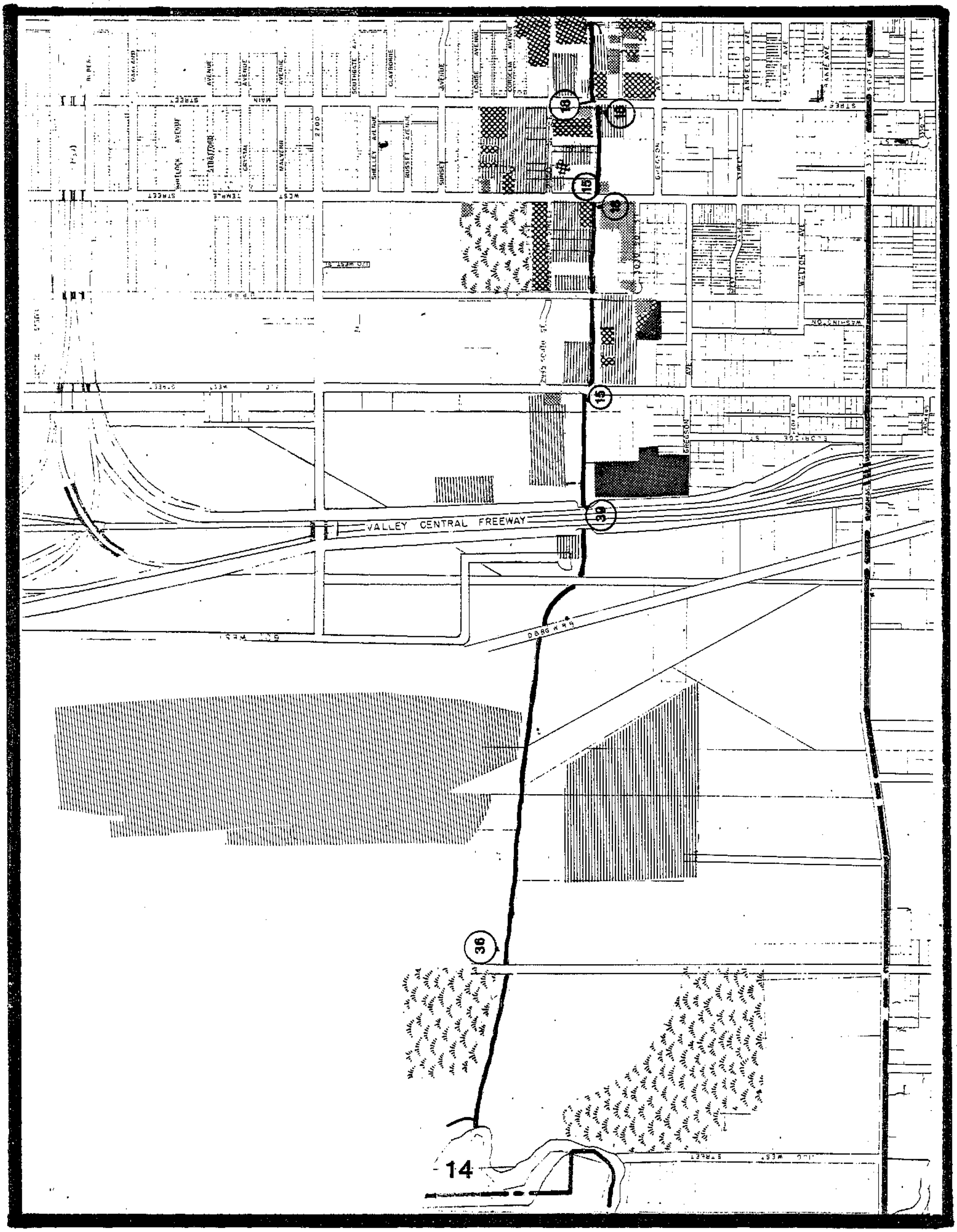


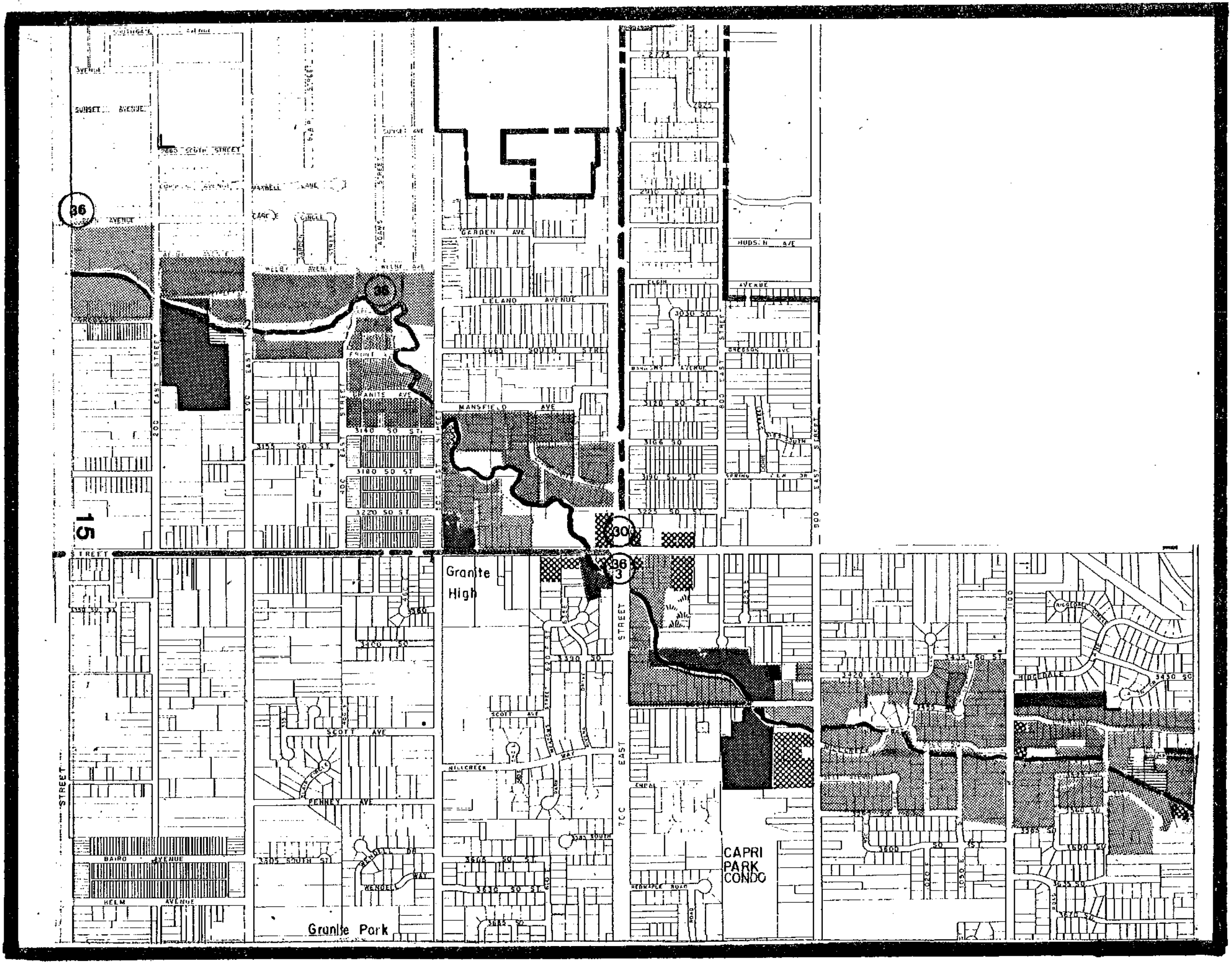
215
Cottonwood Elem
VIEWMONT CONDOS
36
5
6
11

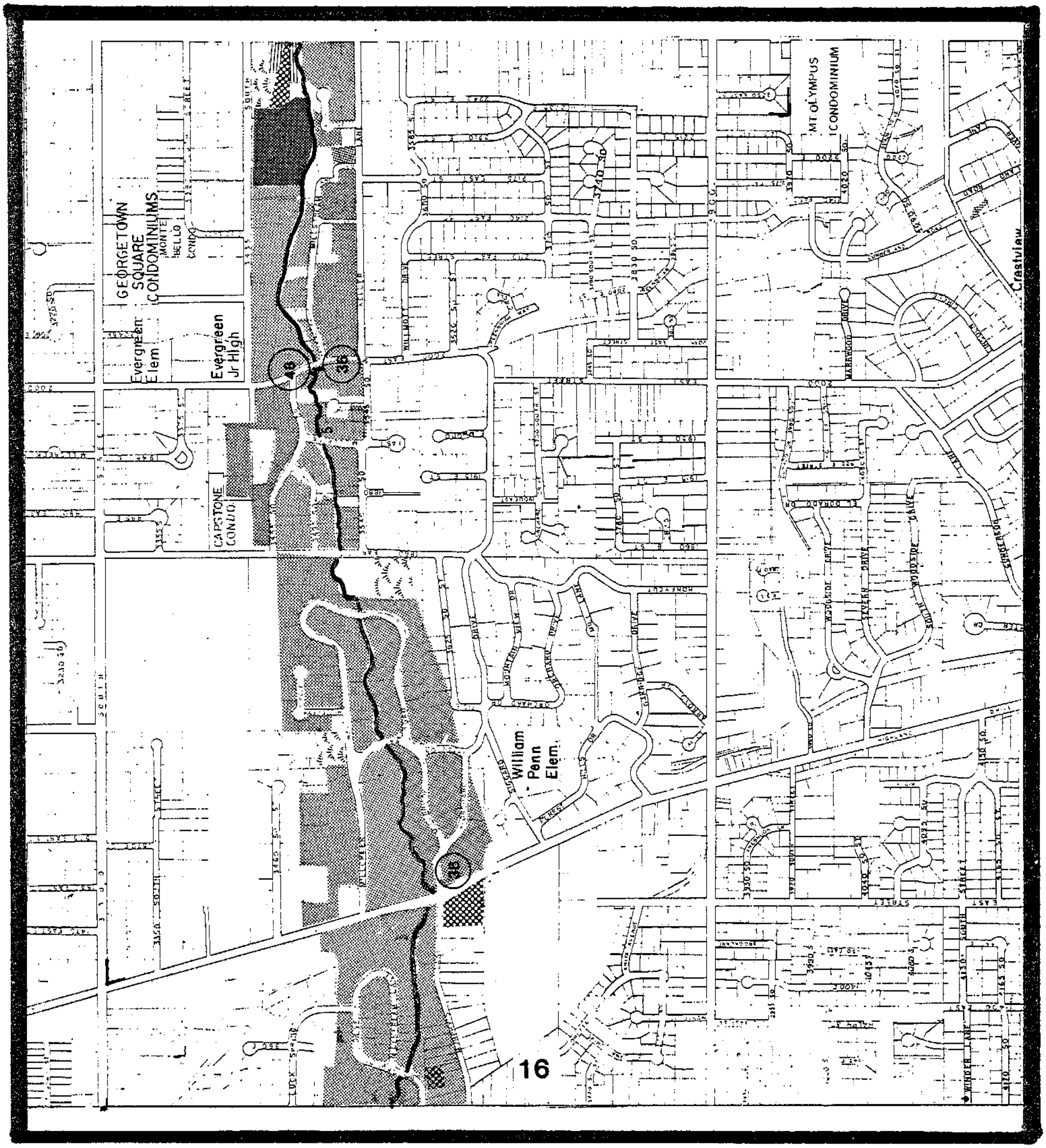

10x4
15

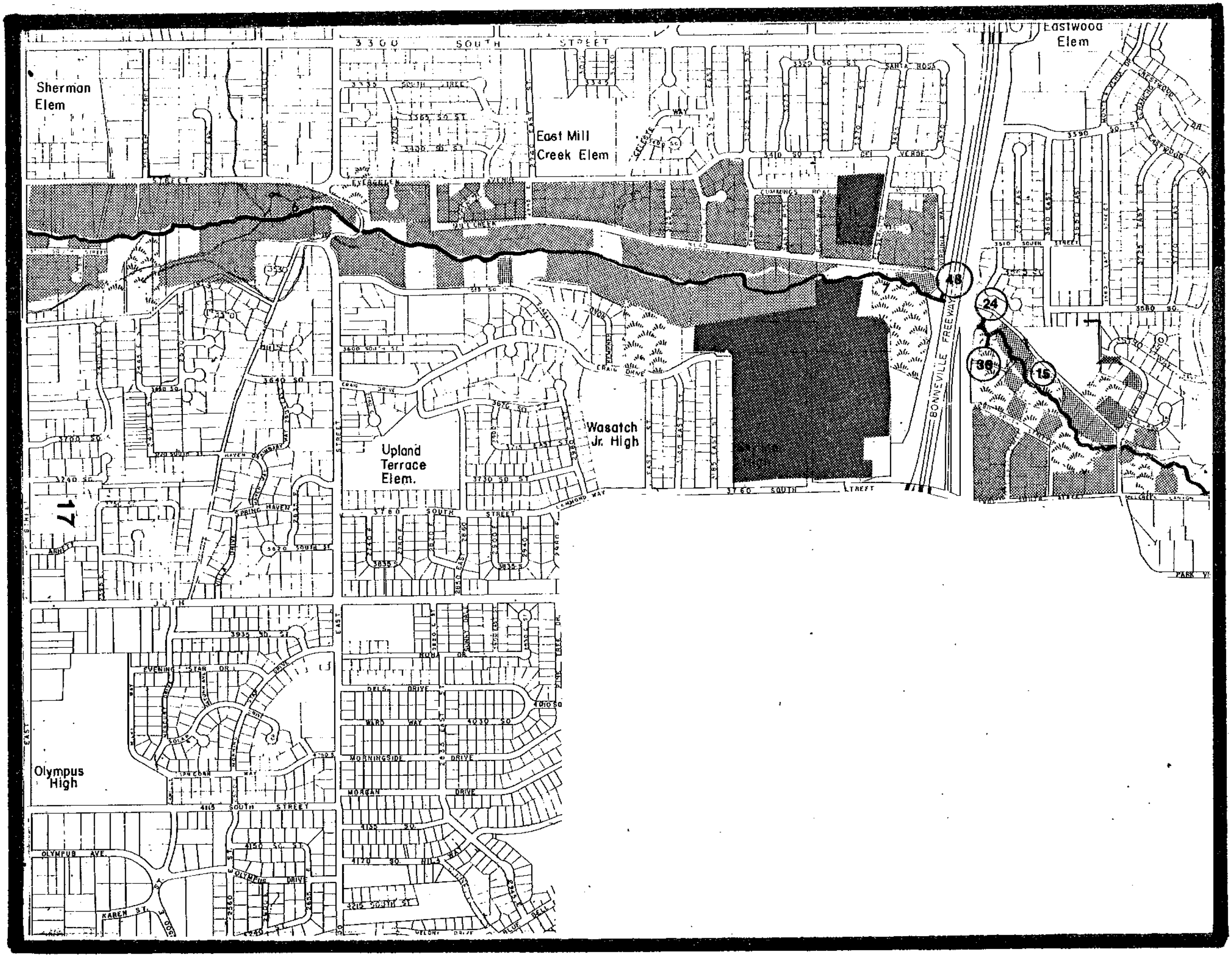


WASATCH
BOULEVARD
BIG
COTTONWOOD
ROAD
NPS
15
8
9
HOLLADAY
MACINTOSH LANE
MAGIC VIEW DR
SAGEBRUSH
WAY
13

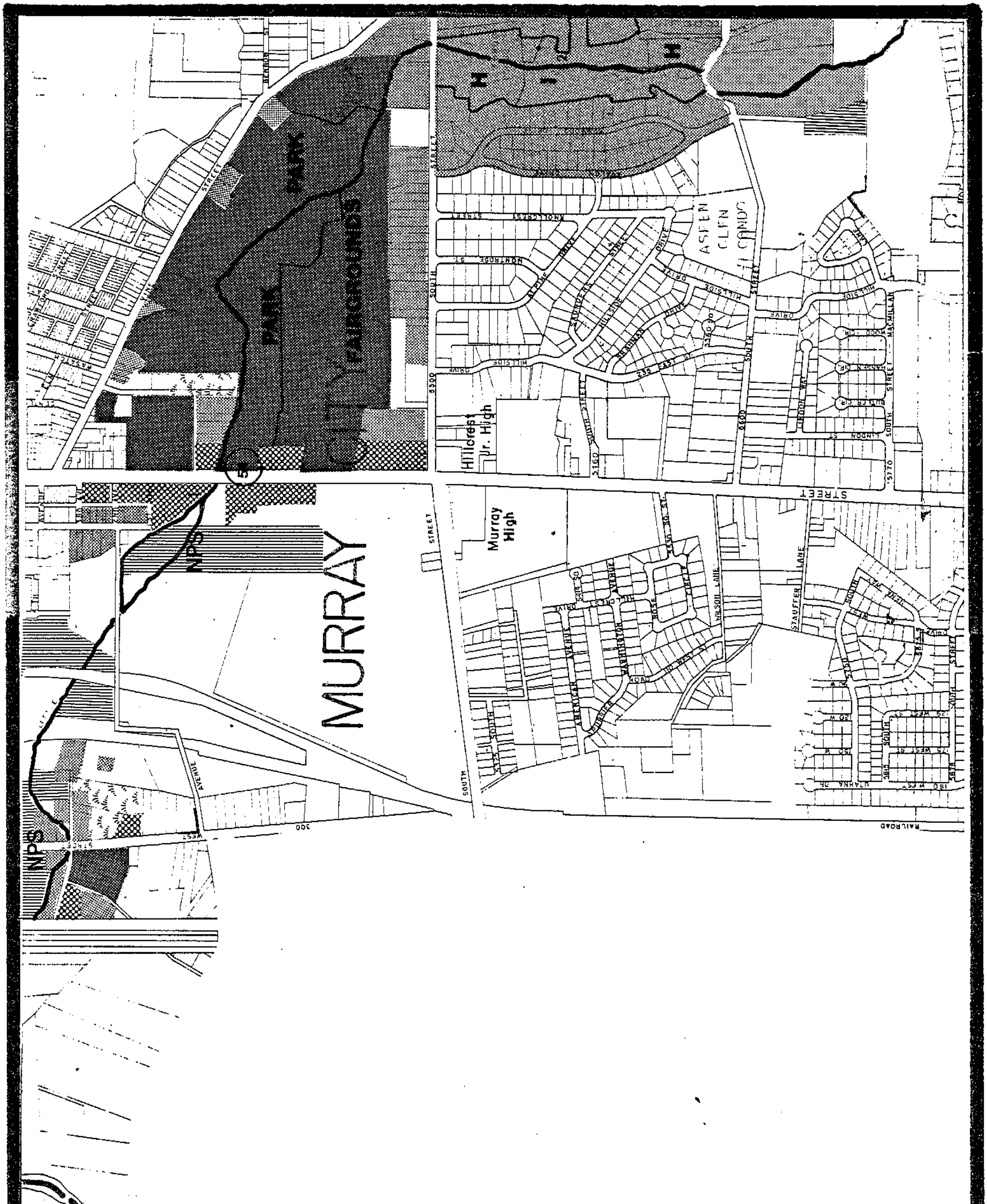

VALLEY CENTRAL FREEWAY
GREGSON AVE
WASHINGTON
WALTON AVE
ANGELO AVE
MILLER AVE
CLAYBORNE
SOUTHGATE
SHELLEY AVENUE
RUSSET AVENUE
SUNSET
LOUISE AVENUE
CORDELIA AVENUE
MALVERN
CRYSTAL
MAIN
WHITLOCK AVENUE
OAKLAND
WEST TEMPLE STREET
2700
D&RG W RR
15
16
18
30
36
14

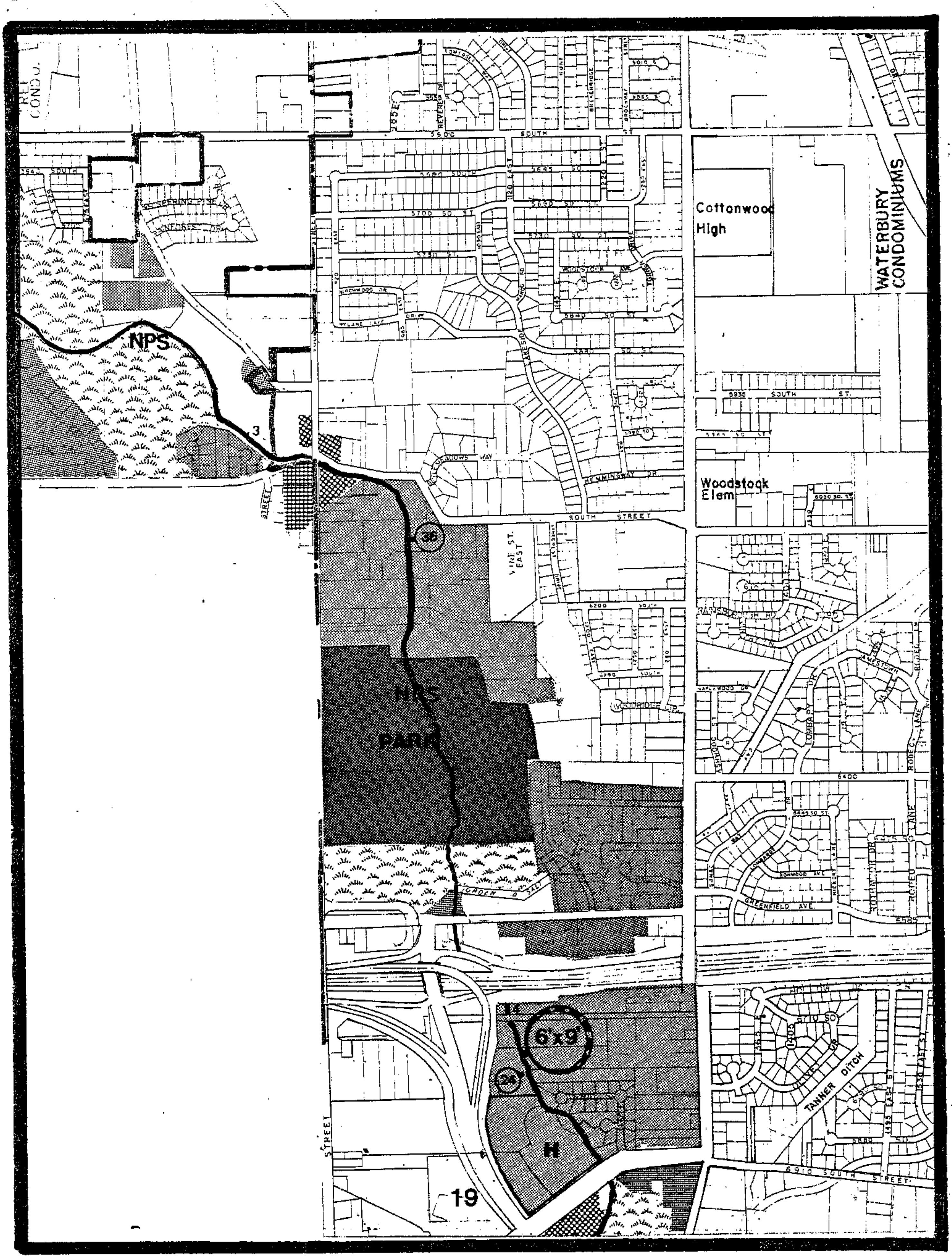

15
Granite High
CAPRI PARK CONDO
Granite Park
MANSFIELD AVE
LELAND AVENUE
GARDEN AVE
SCOTT AVE
PENNEY AVE
BAIRD AVENUE
HELM AVENUE
HILLCREEK
HUDSON AVE
SUNSET AVENUE
2865 SOUTH STREET
MAXBELL LANE
GRANITE AVE
3140 SO ST
3180 SO ST
3220 SO ST
3155 SO ST
3305 SOUTH ST
3120 SO ST
3166 SO
700 EAST STREET
200 EAST STREET
300 EAST
500 EAST STREET
RIDGEDALE
3450 SO
3600
1100
36
30
3

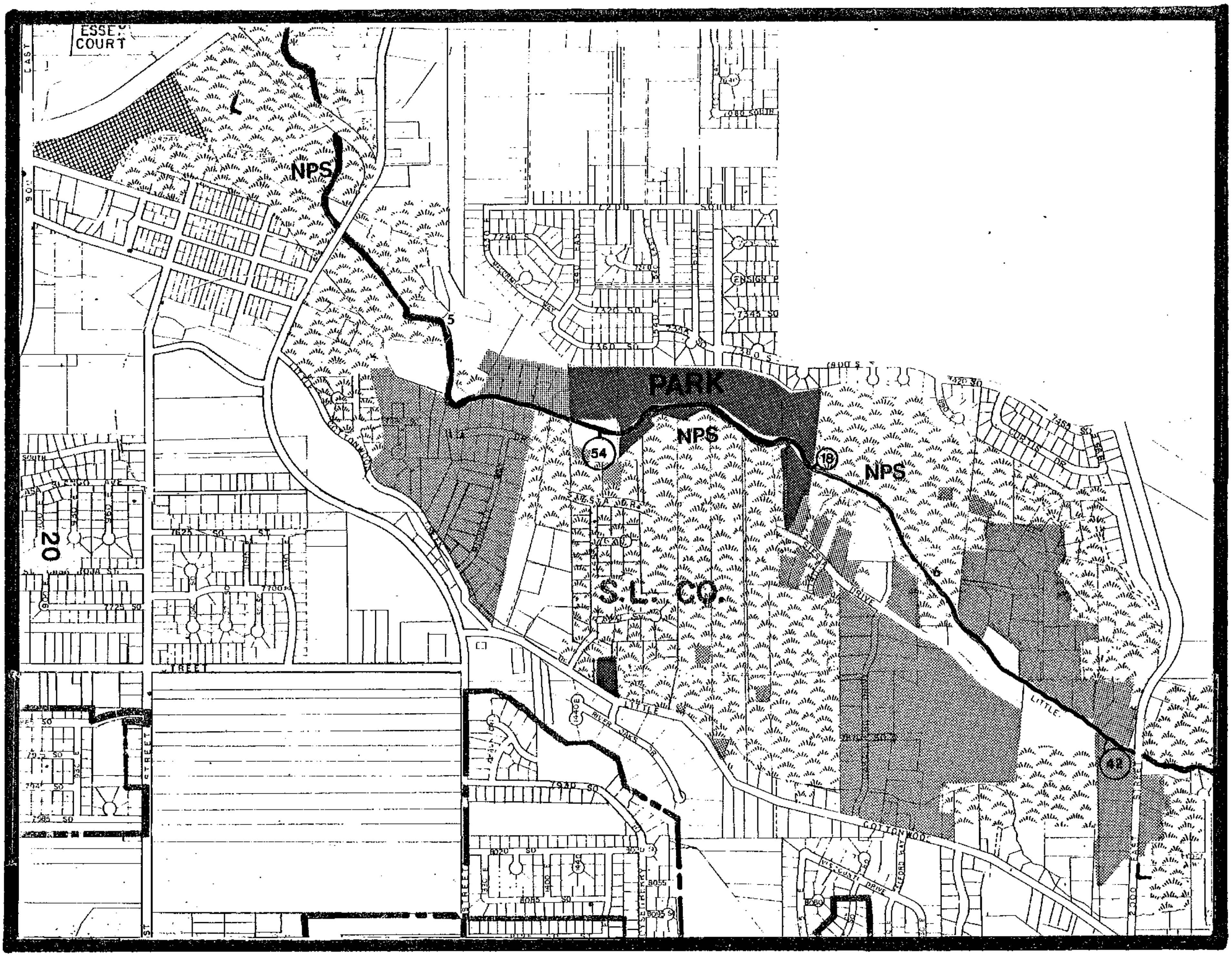

GEORGETOWN SQUARE CONDOMINIUMS
MONTE BELLO CONDO
Evergreen Elem
Evergreen Jr High
CAPSTONE CONDO
William Penn Elem
MT OLYMPUS CONDOMINIUM
Crestview
48
36
38



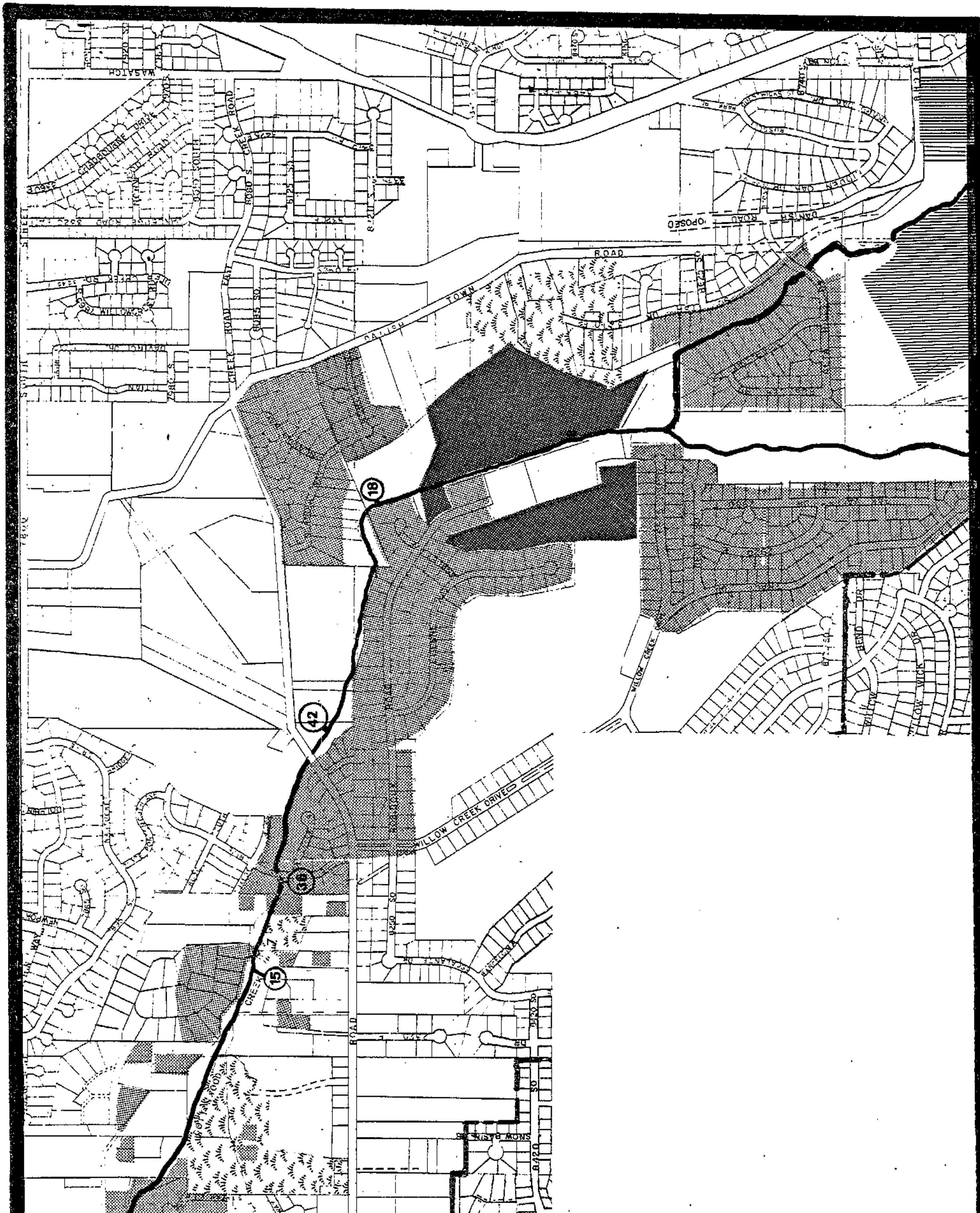
3300 SOUTH STREET
Sherman Elem
East Mill Creek Elem
Eastwood Elem
EVERGREEN AVENUE
CUMMINGS ROAD
SANTA ROSA
BONNEVILLE FREEWAY
48
24
36
15
Wasatch Jr. High
Upland Terrace Elem.
3760 SOUTH STREET
CRAIG DRIVE
SPRING HAVEN
3640 SO.
3700 SO.
3600 SOUTH ST.
3730 SO. ST.
LEMMOND WAY
3835 S
EVENING STAR DR.
DELS DRIVE
WARD WAY
4030 SO.
4010 SO.
MORNINGSIDE DRIVE
MORGAN DRIVE
4115 SOUTH STREET
4135 SO.
4170 SO.
4150 SO. ST.
4215 SOUTH ST.
OLYMPUS AVE.
OLYMPUS DRIVE
KAREN ST.
Olympus High
3390 SO. ST.
3580 SO.
3610 EAST
3510 SOUTH
PARK VI

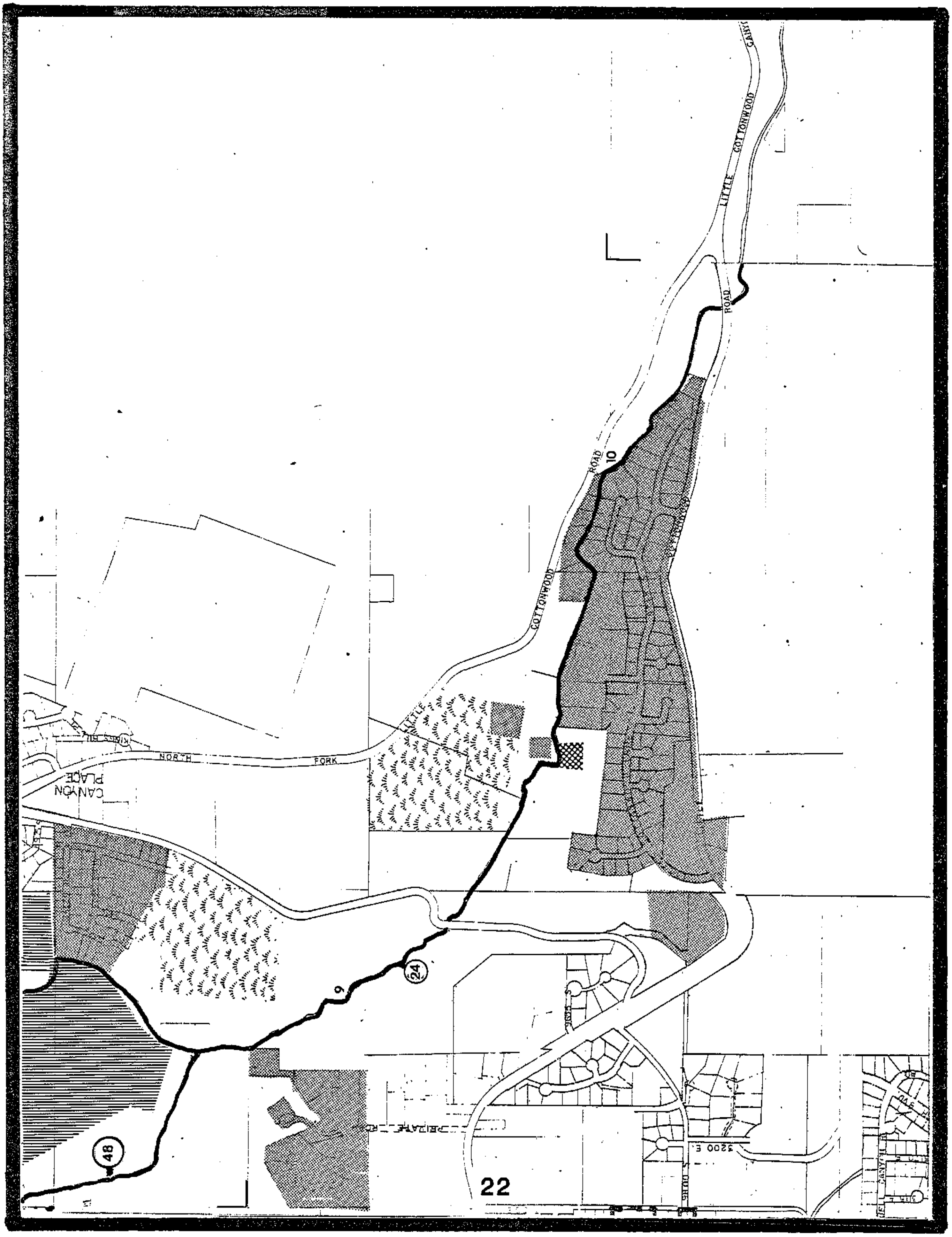

PARK
PARK
FAIRGROUNDS
MURRAY
NPS
NPS
Murray High
Hillcrest Jr. High
ASPEN GLEN CONDOS


Cottonwood High
WATERBURY CONDOMINIUMS
NPS
Woodstock Elem
SOUTH STREET
HRS PARK
6'x9'
TANNER DITCH
6910 SOUTH STREET
H
36
24
3
19



ESSEX COURT
NPS
PARK
NPS
NPS
S.L. CO.
LITTLE
COTTONWOOD
20


WASATCH
ROAD
WILLOW CREEK DRIVE
WILLOW CREEK
18
42
36
15


LITTLE COTTONWOOD ROAD
LITTLE COTTONWOOD ROAD
LITTLE COTTONWOOD CANY
NORTH FORK
CANYON PLACE
3200 E
10
9
24
48
22

DEFINITION OF ANALYTICAL FACTORS

Each main section is divided here into sub-categories and defined. The source and method of obtaining these definitions provides a basis for weighting creek reaches or smaller segments so that collectively all constraints and opportunities can be evaluated.

LAND USE/POLLUTION SOURCES: The following land use categories were identified and mapped using land use mapping produced by the Salt Lake County Planning Commission. [1] It is not known the extent to which the maps have been updated. Residential use patterns are displayed for each creek in Figure one.

RESIDENTIAL-LOW DENSITY

Single family residential use is low density development ranging from one to four units per acre. Low density residential produces higher rates of water runoff due to more ratios of impermeable to permeable surface. [2] This type of development is characterized by high use of fertilizer application and concentrations of oil and grease which drip from automobiles. Daily automobile trips in low density residential are higher than other types of dwelling use, and airborne particulate and fallout from exhaust systems is high. [3] High concentrations of individually owned homes adjacent to waterways produce other unique management problems such as uncontrolled trashing and littering, and inhibition of access to the waterway for flood control maintenance or recreation activities.

RESIDENTIAL-HIGH DENSITY

High density is normally considered as exceeding ten units per acre. For purposes of this study, large apartment or condominium complexes were outlined as high density development. This land use category typically produces lower runoff rates than low density because the impermeable to permeable coverage ratio is smaller. This occurs from clustering or grouping units which leaves a greater portion of the site in common open space.[4] Potential for nutrient-related pollution from fertilizer is possibly increased, but oil, grease, and exhaust effects are decreased. High density development along creeks does not present the complexity of waterway management problems as does low density, because the stream frontage is held under common ownership, usually left open, and relatively accessible. Greater opportunity for recreation activity exists, and higher social density increases local demand for such activities.[5]

COMMERCIAL USE

Commercial use presents another set of unique problems when located adjacent or in close proximity to waterways. Automobile trip frequency is high, and potential for oil, crease, and exhaust-related pollutants is increased.[6] Runoff rates are high with larger ratios of impermeable to permeable cover. The runoff factor can be reduced if commercial development occurs in planned shopping centers as opposed to uncoordinated individual businesses, and the management factors for flood control and recreation are likewise increased under planned conditions. However, most commercial centers - planned or otherwise - lack sufficient runoff management to reduce pollutant loads originating from large paved areas. Specific types of commercial use, such as service stations or repair shops, pose greater pollution potential or hazard than others.

INDUSTRIAL USE

The conditions described for commercial development apply to industrial use, with the exception that potential pollution in industial areas can include hazardous and toxic waste materials either deliberately or indiscriminately discharged to local waterways or drainage conveyances. Based on inventories conducted by volunteer water quality personnel, evidence of such discharge practices exist. [7]

PARK/OPEN SPACE USE

A number of publicly owned lands and facilities are intersected by valley creeks. These are mostly parks or recreation areas, but often include schools or special district easements for government facilities. These areas are of critical importance from a multiple use standpoint. They provide central staging areas for creek-related recreation, links between water sport recreation centers, and management opportunities through easements or dedicated rights-of-way. The viability of specific creek reaches or stream segments as recreation resources depends to a great extent on both existing and proposed public recreation facilities on or near them. [8] Put-and-take fishing programs centered in public parks, for example, are not optimized by environmental degradation up or downstream. Pollution or channelization will reduce the level to which park facilities are used; public expenditures for park maintenance are wastefully increased; visitor frequency and quality is decreased. Increased use resulting from higher flow or quality may also increase trashing, littering, and erosion from site wear, thus decreasing environmental quality and increasing costs. The relationship between central park recreation demand and supply versus dispersed stream recreation demand and supply becomes critical to any public policy addressing stream resource use. [9]

AGRICULTURAL USE

Agriculture is defined as raising crops, feed, seed or animals for consumption. It includes irrigated and non-irrigated crop production, pasturing, feedlots, and barnyards. Most agriculture adjacent to valley creeks consists of horse pasture and is oriented to recreation rather than food production, although some cattle, sheep and goats are grazed for limited family use or marketing. The vast majority of agricultural acreage on the valley east bench has given way to residential use. Agriculture produces the lowest runoff rate and has the lowest ratio of impermeable surface. The greatest pollution potential is from feedlots or watering areas located directly on the stream. Management of waterways bounded by agriculture is inhibited mostly by lack of access. Because of access limitation, habitat and aesthetic values are well preserved, while recreation values may be diminished.

SAND AND GRAVEL EXCAVATION

Benchlands are characterized by stream alluvium or Lake Bonneville deposits which are extracted and processed for sand and gravel. Several sand and gravel operations are located within creek drainages, and may discharge runoff to streams without benefit of detention facilities to reduce sediment loads. Where creeks intersect these unique resource areas, severe bank-cutting and sloughing has been observed.[10] More detailed assessment of these sites should be made to determine the nature and extent of their impact, but it is possible that extraction-impacted stream segments could be the principle source of sediment entrained and carried miles downstream by storm flows.

POTENTIAL NON-POINT SOURCE POLLUTION

Non-point sources are differentiated from point sources by the lack of a definite or discrete conveyance, such as a pipe or ditch.[11] Some geographic areas have been shown as potential non-point source pollution generators. This is based on general rather than specific knowledge about current practices. As a technical matter, all low-density residential development poses non-point source potential, but as a practical matter the quantification of impact and solution is difficult. Single uses in large acreage lend advantage to pollution cleanup, while hundreds of small lots and fragmented drainages complicate cleanup efforts.

MAJOR AND MINOR POINT SOURCE DISCHARGES

Volunteer Water Quality personnel identified almost 100 point source discharges (pipe or other conveyances) along Big Cottonwood Creek between State Street and 6200 South.[12] Most of these are considered "minor" discharges, (under 12" in diameter) while "major" discharges are those storm drainage pipes identified by Flood Control personnel - usually larger than twelve inches.

Water Quality data gathered since 1977 show dramatically high concentrations of coliform bacteria (including streptococus), Biochemical Oxygen Demand (BOD), suspended sediment, nitrogen/nitrates, phosphorus/phosphates, and heavy metals. The effect of these "shock loads" of pollution to stream biota has not yet been fully assessed. Sediment loads contribute to channel-capacity reduction thus encouraging and increasing heavy equipment maintenance within the streams[13].

OWNERSHIP PATTERNS

The majority of ownership adjacent to streams is private. Salt Lake County, Murray and South Salt Lake City own very small parcels for public use along the creeks, and Flood Control access and easements are limited by existing development patterns. As a result, heavy equipment operations in natural stream segments are extensive. Machines must move through high habitat value segments to get at extreme sediment deposits and obstructions, and in progress remove values which marginally increase flood protection but severely damage multiple use.

HYDROLOGY: QUANTITY AND QUALITY

A. WATER QUANTITY AND SEASONAL FLOWS

Water flowing in the valley tributaries originates from four major sources: 1) Inflow from the Canyons (mostly snowmelt and groundwater seepage), 2) Irrigation return flows and exchanges originating from three major east-side canals (Jordan and Salt Lake, East Jordan, and Upper Canals), 3) Groundwater inflow, and 4) Stormwater discharges. All sources are drastically affected by seasonal changes and diversion shifts.

United States Geological Survey (USGS) - gauges located at the mouth of each canyon and at confluence points with the Jordan River provide accurate measurements of year-round flow. USGS also has gauges on Little Cottonwood Creek at 2000th East and Big Cottonwood Creek at Cottonwood Lane (about 2300 East). Period-of-record for gauged flows extends back to 1899 for Mill Creek (84 years), 1899 for Big Cottonwood Creek, and 1910 for Little Cottonwood Creek (73 years).

The Salt Lake County Area-Wide Water Study generated both average annual and seasonal flow-duration values for each creek at the canyon mouths.[14] These values were based on the 1964-68 and 1980 period-of-record. Flow data presented here reflect monthly means over the longer period of record which correspond to the 25% flow-duration values in the Area-Wide Study.

1) CANYON INFLOW

The valley segments of Millcreek, Big and Little Cottonwood Creeks are "fed" by a perennial flow from the canyons. The volume and rate fluctuates seasonally with flows highest during late spring to early summer, and lowest during late autumn and winter. Water treatment plant and power plant diversions also add to these seasonal fluctuations, with an annual average of 60% diverted for culinary use.

Snowmelt runoff produces the greatest percentage of total surface discharge with groundwater inflow yielding a lesser ratio. Refer to Figure 2 for seasonal flow estimates at the mouth of each canyon.

2) IRRIGATION INFLOW

Several irrigation flows contribute to the valley tributary hydrologic regime. Irrigation affects streams both in terms of diversions out and return/exchange flows in.

DIVERSIONS

Structures to divert water exist along the full length of all valley creeks, but the majority of diversions are located close to canyon mouths, and are the oldest. Numerous ditch and irrigation companies hold appropriations - many of which may have lapsed. Urbanization has closed many drainages which once served old diversions. The result in many cases is increased flow in the creeks, until the State Engineer (responsible for water allocation in Utah) adjudicates and reappropriates the water for other uses. No detailed investigation of active diversions along the creeks has been made, and it is suspected that many are inactive. Figure 3 summarizes diversions on each creek, and Figure 2 identifies their approximate location. 15

IRRIGATION RETURN FLOWS

Diversions which are still active deliver water primarily to small residential garden plots. Return flow from the gardens and ditch system discharges into canals, storm drains, and creeks. No specific investigation of return flow discharge points has been made, since it was deemed outside the general scope and objectives of this study. Pollution abatement programs would require a more detailed inventory of diversion trails and discharges.

FIGURE TWO

HYDROLOGY: QUANTITY & QUALITY

AVERAGE SEASONAL & MONTHLY FLOW - c.f.s. - SEE FLOW "CLOCK"

AVERAGE POLLUTION CONDITIONS:

TSS-Total Suspended Solids-mg/l	0-11	20-80	80-140	150-600+
TDS-Total Dissolved Solids-mg/l	0-300	300-400	400-800	800-900
Coli-Total Coliform Bacteria-MPN/100 ml	0-93	100-1500	1500-5000	5000-33000
BOD_5-Biochemical Oxygen Demand-5 day mg/l	0-<1	1.0-3.0	3.0-5.0	5.5-16.0
CD-Cadmium-Dissolved ug/l	0-<1	<1-1.0	1.1-1.7	2.0-6.0
HG/Mercury-Total ug/l	0-<1	.05-1.0	.10-.13	.13-.20

WATER QUALITY EXCEEDING STANDARDS

STREAM SEGMENT EXCEEDING STANDARD FOR:

Nitrates:
Coliform:
Phosphates:
BOD_5
Oil & Grease

MAJOR DIVERSIONS — SUMMER — WINTER

MAJOR INFLOWS WITH c.f.s. ESTIMATE AND IDENTIFIED AS TO SOURCE — 5

GROUNDWATER INFLOW GAIN ESTIMATE IN c.f.s. (cumulative) — 2

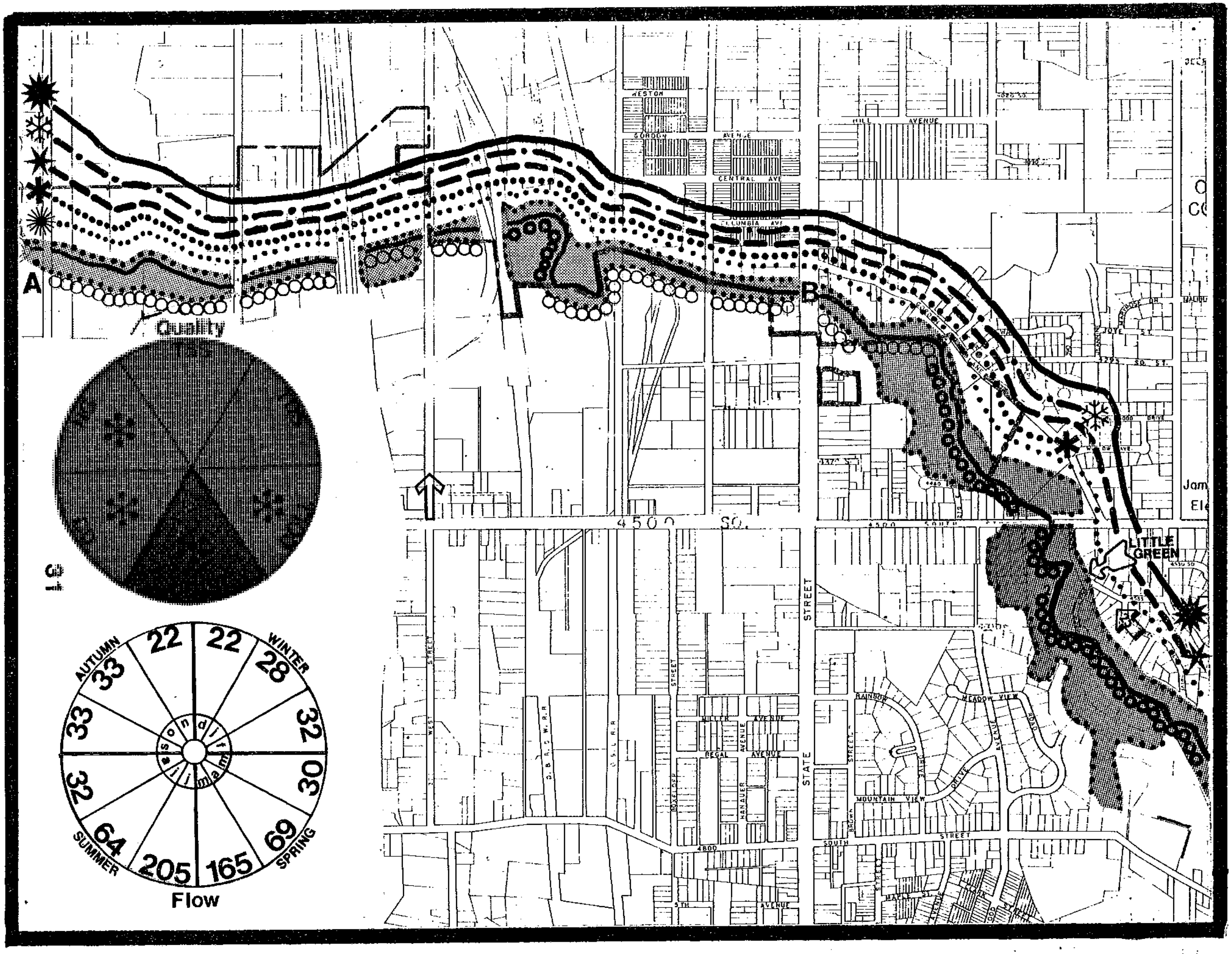
FLOOD CONTROL MAINTENANCE SEGMENT: ANNUAL

FLOOD CONTROL MAINTENANCE SEGMENT: 5-YEAR

FLOOD CONTROL EXPENDITURE SEGMENT: A thru F

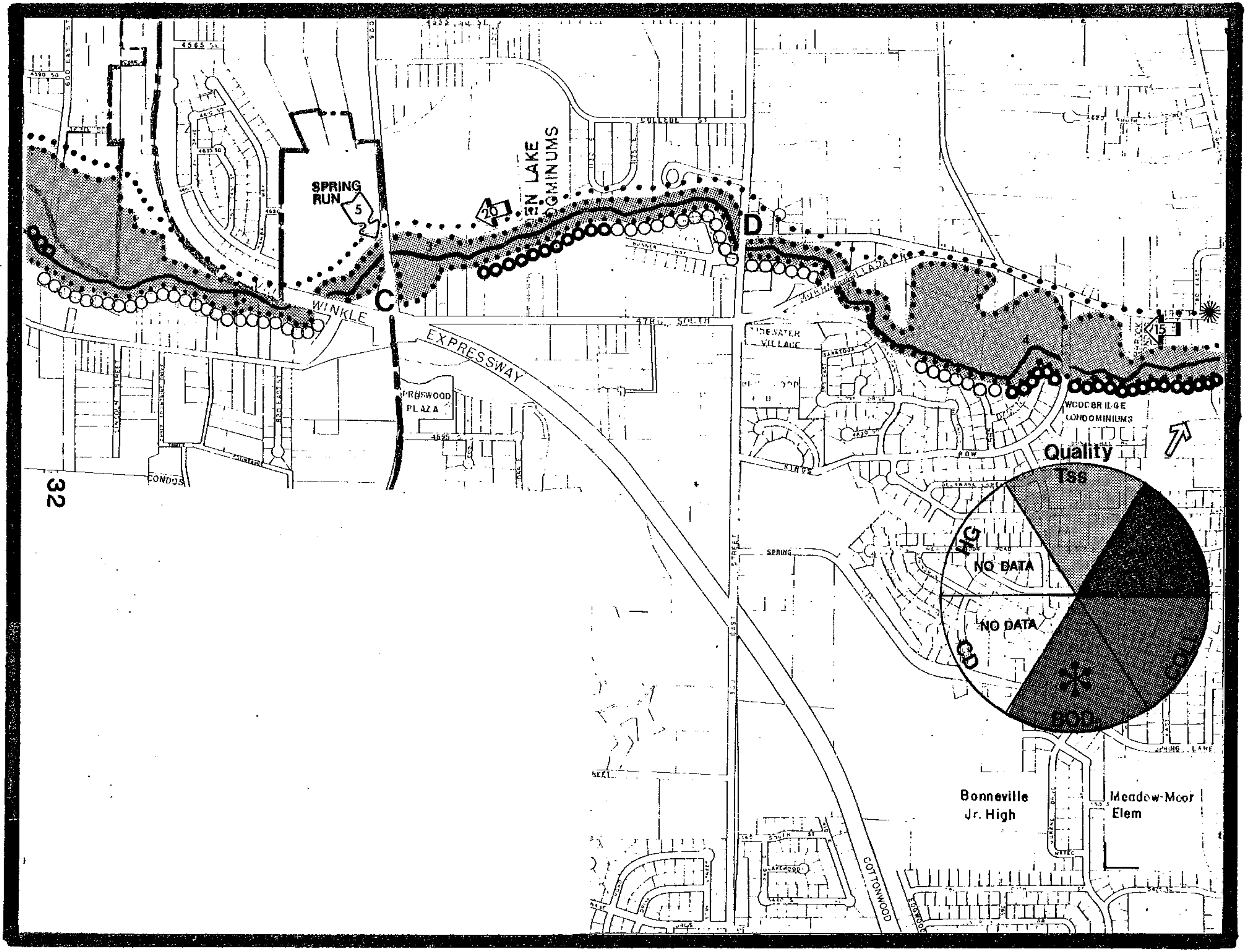
DEWATERED STREAM SEGMENT

FLOODPLAIN LIMITS (100 Year, Zone "A")

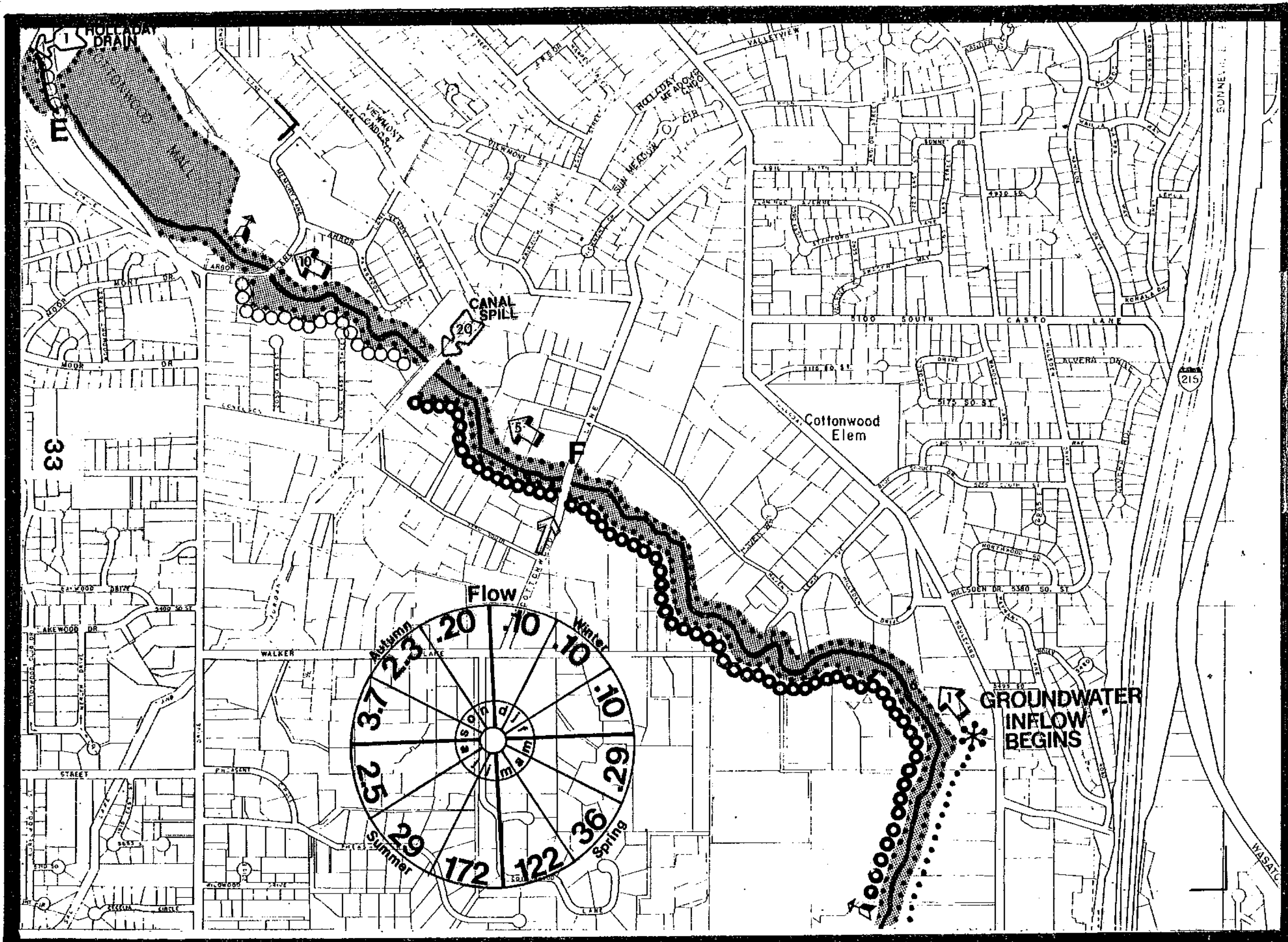


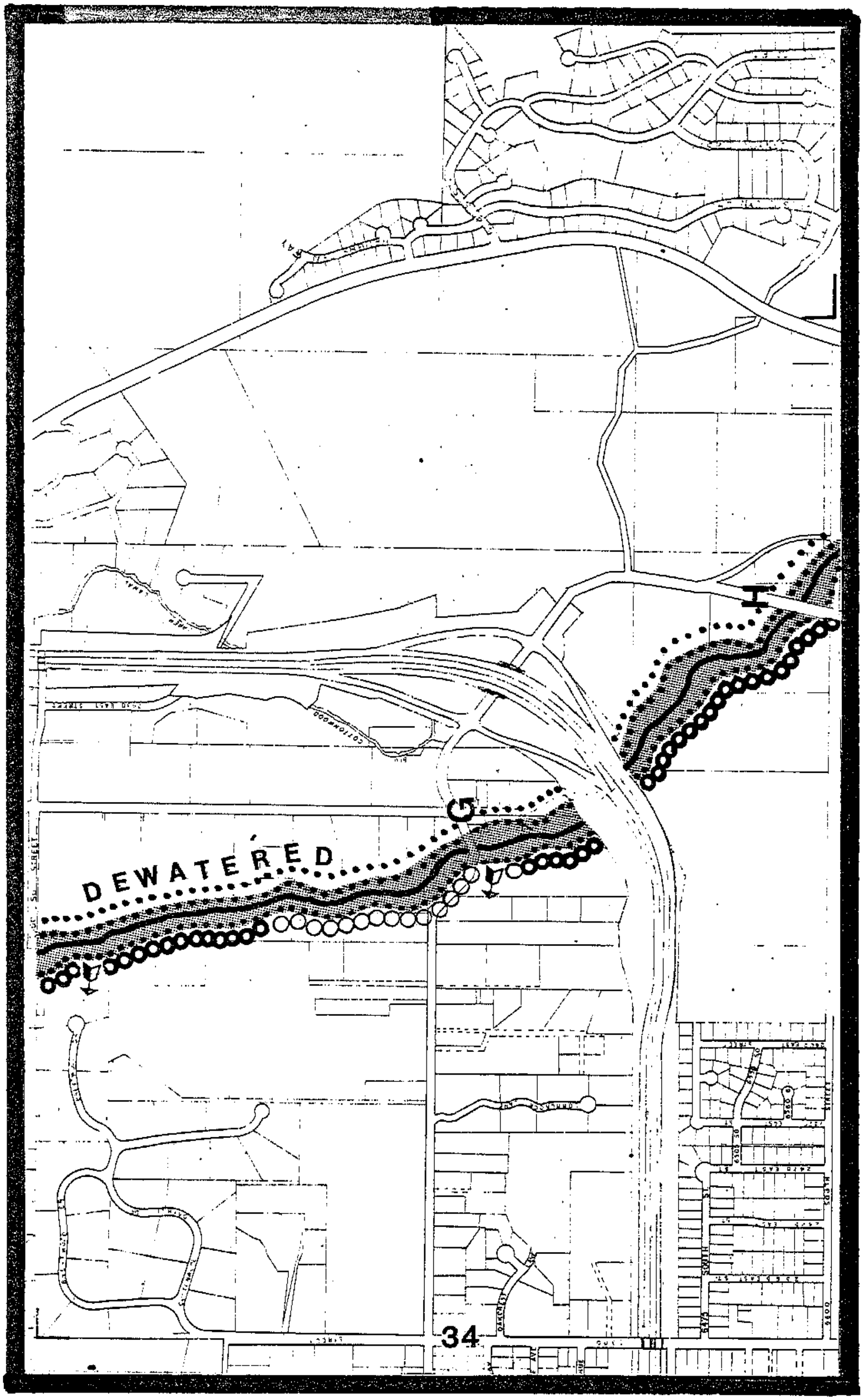
A
B
LITTLE GREEN
Quality
Flow
WINTER
SPRING
SUMMER
AUTUMN
22
22
28
32
30
69
165
205
64
32
33
33
4500 SO.
STATE STREET
WEST STREET
HILL AVENUE
CENTRAL AVE
COLUMBIA AVE
GORDON AVENUE
WESTON
MOUNTAIN VIEW
MEADOW VIEW
RAINBOW
REGAL AVENUE
MILLER AVENUE
HANAUER
BOXELDER
D.&R.G.W.R.R
U.S.L.R.R
4800 SOUTH STREET

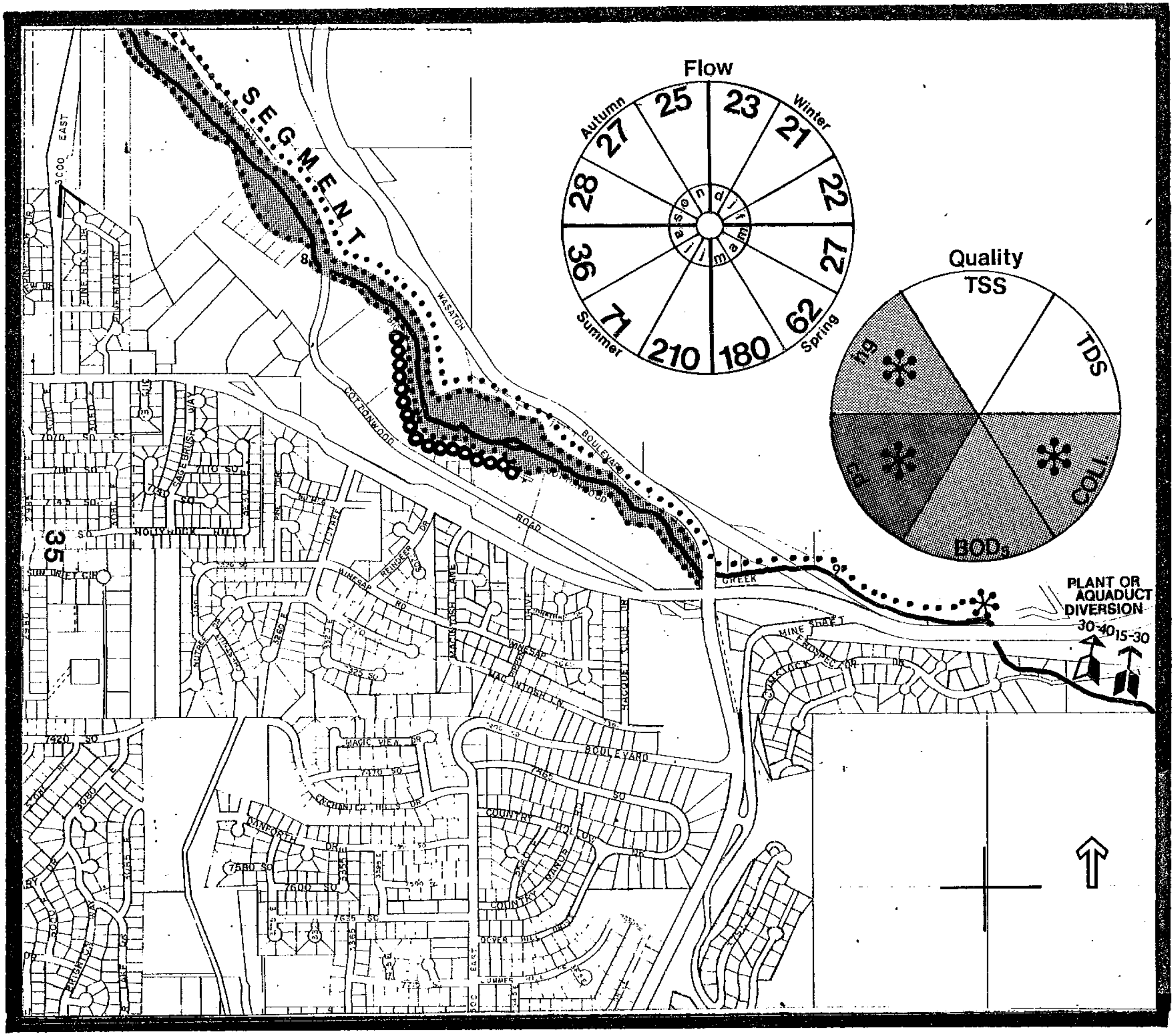
31



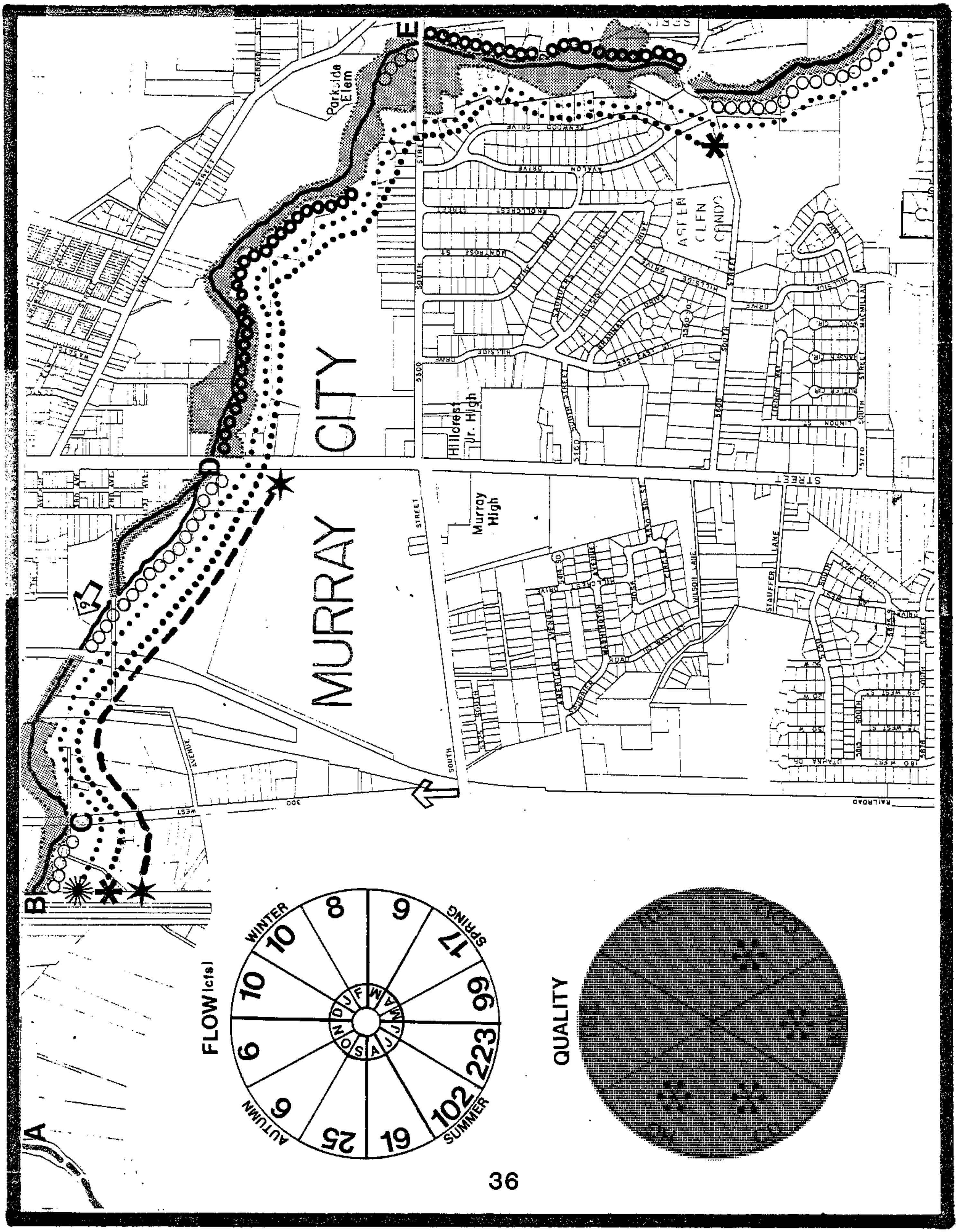
SPRING RUN
5
20
N LAKE
OMINUMS
D
C
WINKLE
47TH SOUTH
EXPRESSWAY
TIDEWATER VILLAGE
PR?SWOOD PLAZA
WOODBRIDGE CONDOMINIUMS
15
Quality
TSS
HG
NO DATA
NO DATA
CD
BOD
COLI
SPRING
STREET
EAST
COTTONWOOD
CONDOS
Bonneville Jr. High
Meadow-Moor Elem


HOLLADAY DRAIN
1
E
COTTONWOOD MALL
10
CANAL SPILL
20
5
F
Cottonwood Elem
5100 SOUTH CASTO LANE
VIEWMONT CONDOS
HOLLADAY MEADOWS CONDO
SUN MEADOW CIR
WALKER LANE
215
GROUNDWATER INFLOW BEGINS
1
Flow
Winter
Spring
Summer
Autumn
.20
.10
.10
.10
.29
36
122
172
29
2.5
3.7
2.3

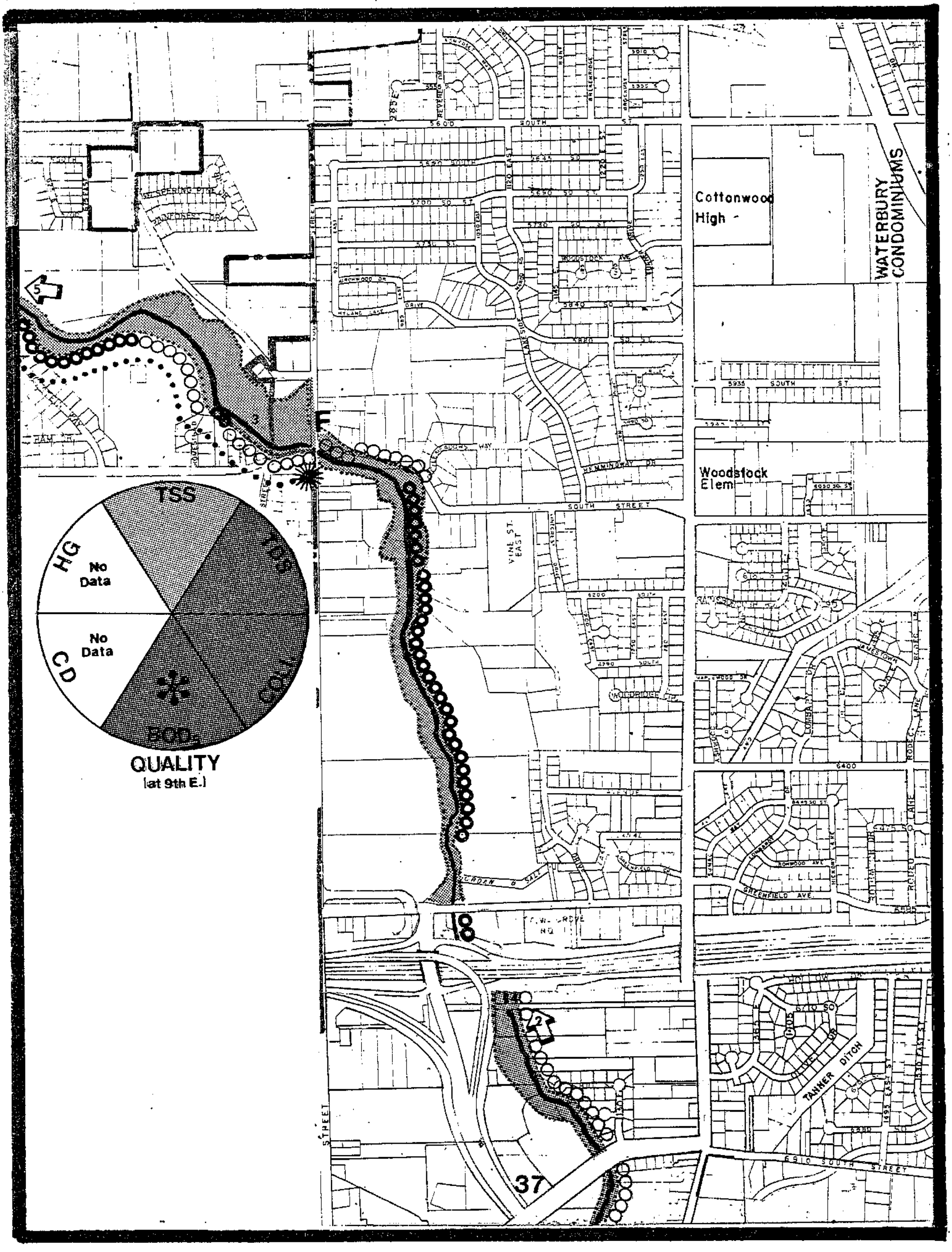

DEWATERED
G
H



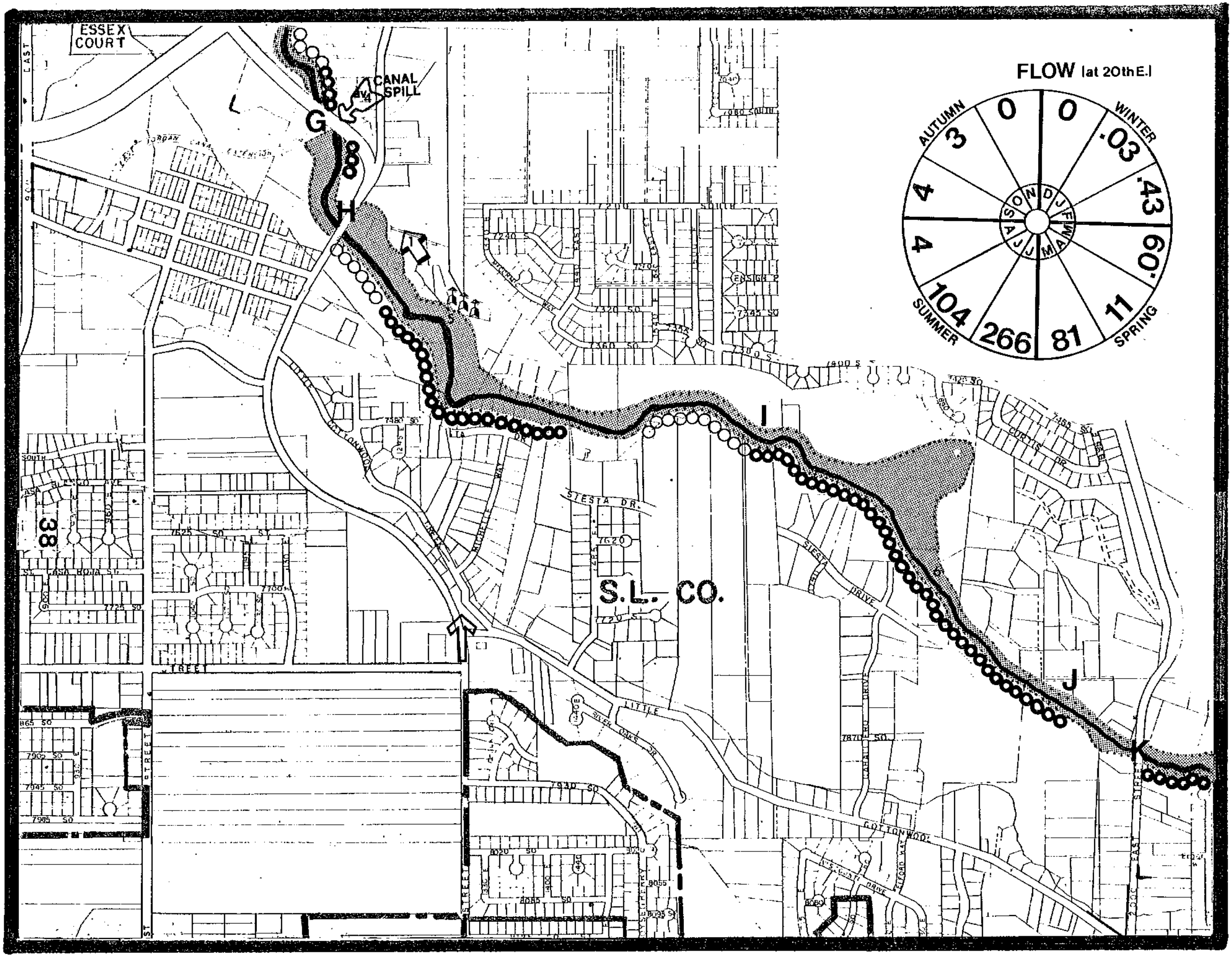
SEGMENT
Flow
Autumn
Winter
Summer
Spring
25
23
21
22
27
62
180
210
71
36
28
27
Quality
TSS
TDS
COLI
BOD5
cd
hg
PLANT OR AQUADUCT DIVERSION
30-40
15-30
WASATCH
BOULEVARD
COTTONWOOD
ROAD
CREEK
MINE SHAFT
35

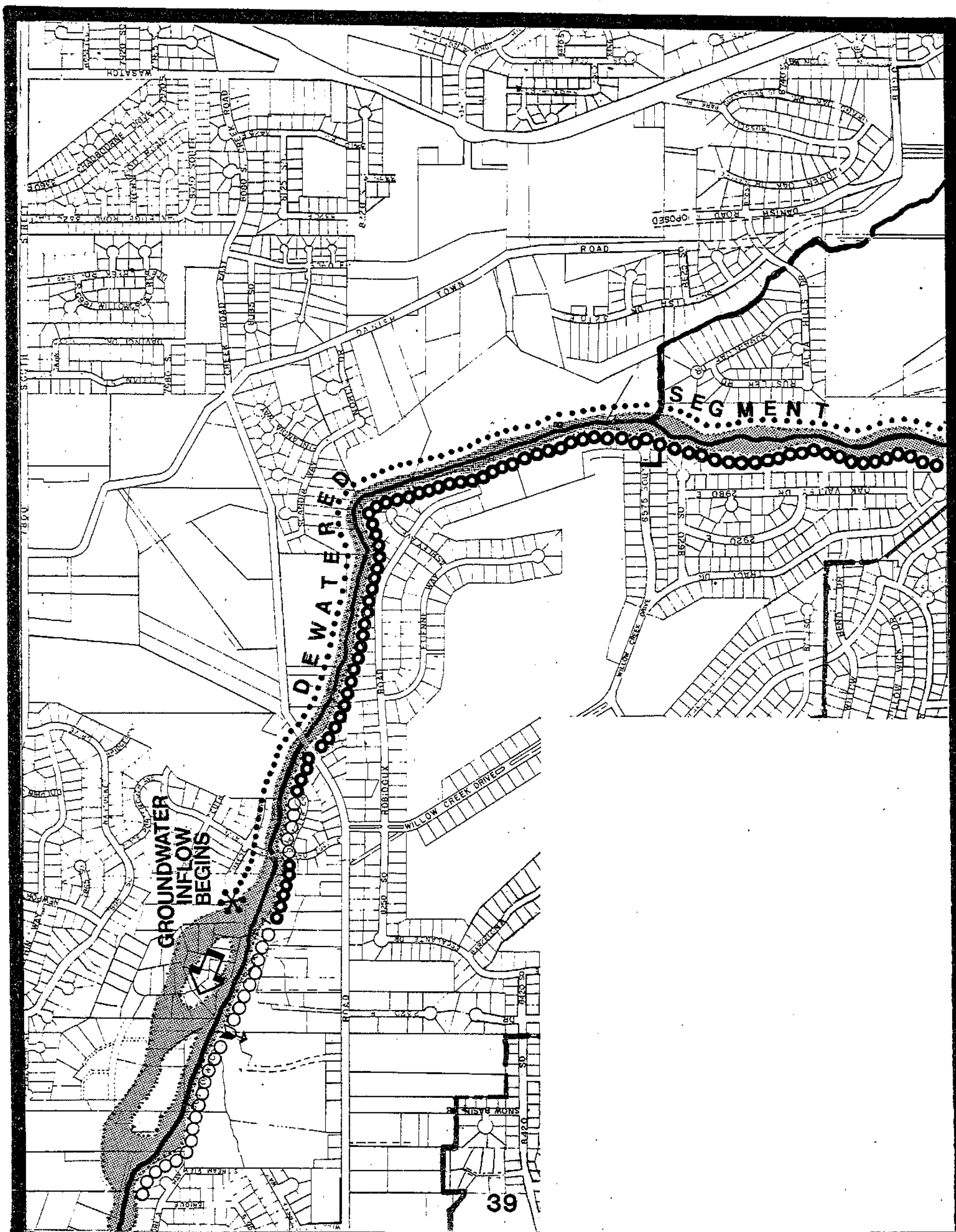


MURRAY CITY
Parkside Elem
Hillcrest Jr. High
Murray High
ASPEN GLEN CONDO'S
FLOW (cfs)
WINTER
SPRING
SUMMER
AUTUMN
QUALITY

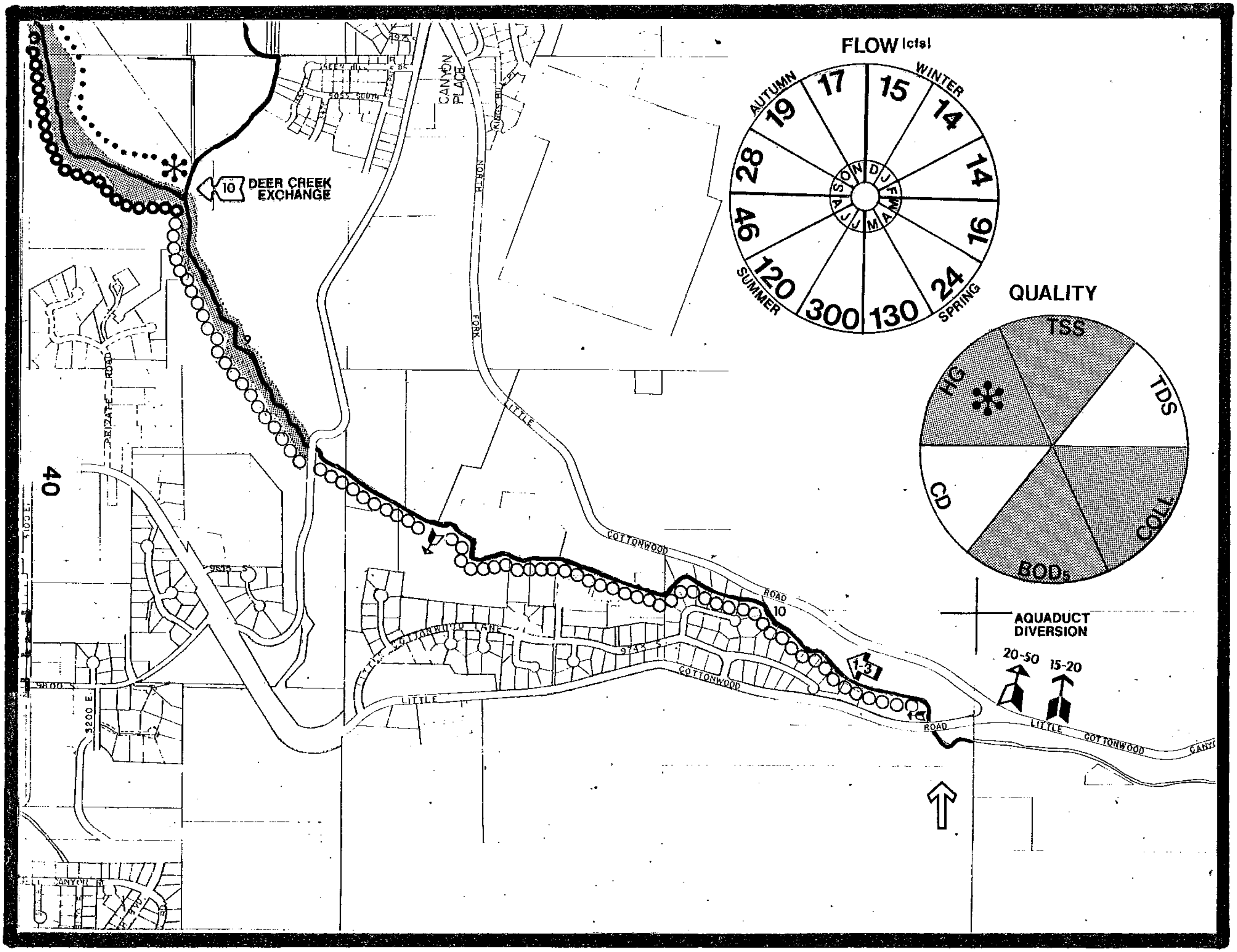


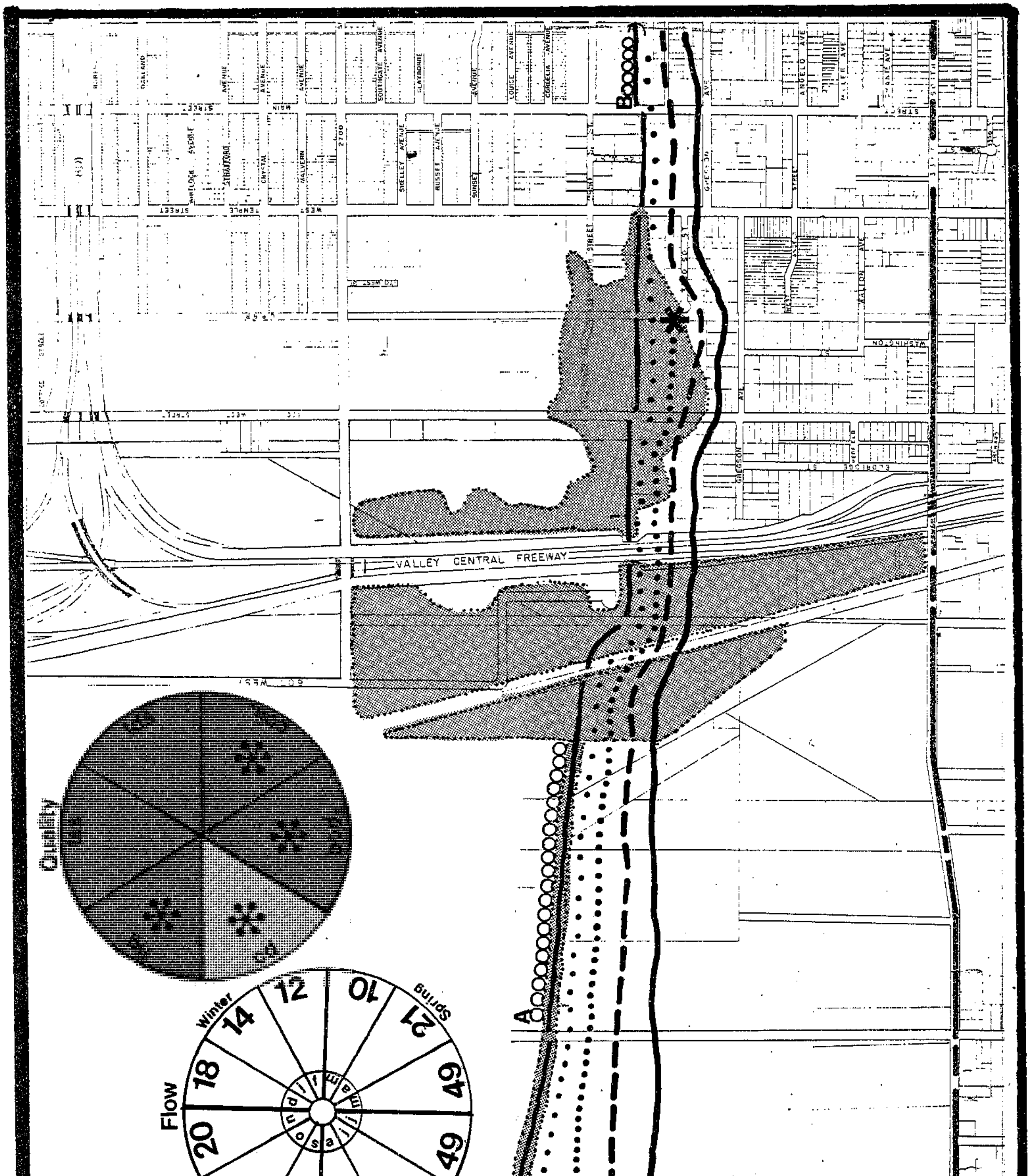
Cottonwood High
WATERBURY CONDOMINIUMS
Woodstock Elem
5600 SOUTH ST.
SOUTH STREET
HEMMINGWAY DR
VINE ST. EAST
GREENFIELD AVE.
6910 SOUTH STREET
TANNER DITCH
5
3
F
2
37
TSS
TDS
COLI
BOD5
CD
No Data
HG
No Data
QUALITY
(at 9th E.)

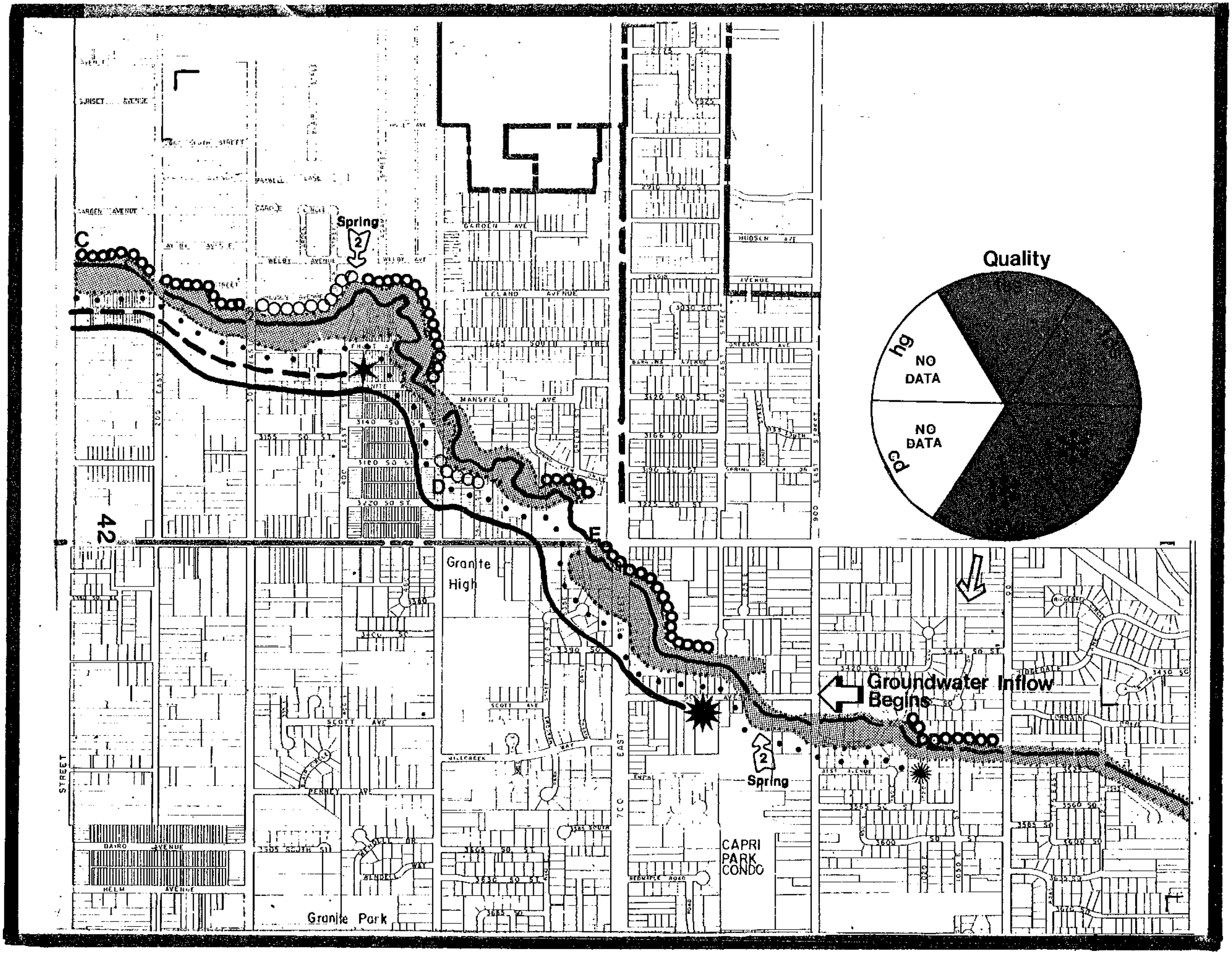

FLOW (at 20th E.)
WINTER
SPRING
SUMMER
AUTUMN
0
.03
.43
.09
11
81
266
104
4
4
3
0
J F M A M J J A S O N D
ESSEX COURT
CANAL SPILL
G
H
I
J
K
L
S.L. CO.
SIESTA DR.
COTTONWOOD
LITTLE
38

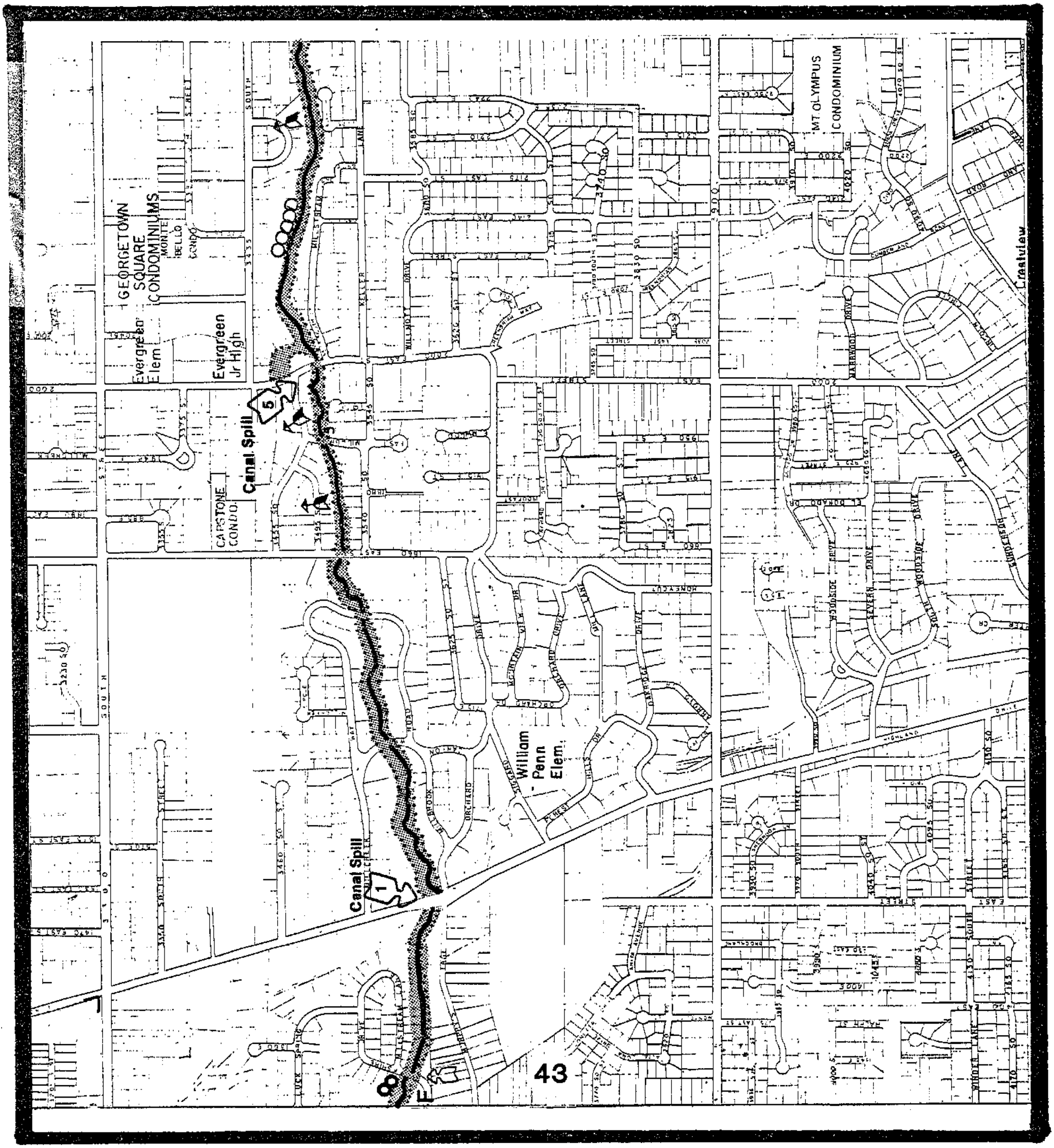


GROUNDWATER INFLOW BEGINS
DEWATERED SEGMENT
DANISH TOWN ROAD
WILLOW CREEK DRIVE
ROBIDOUX ROAD
WASATCH

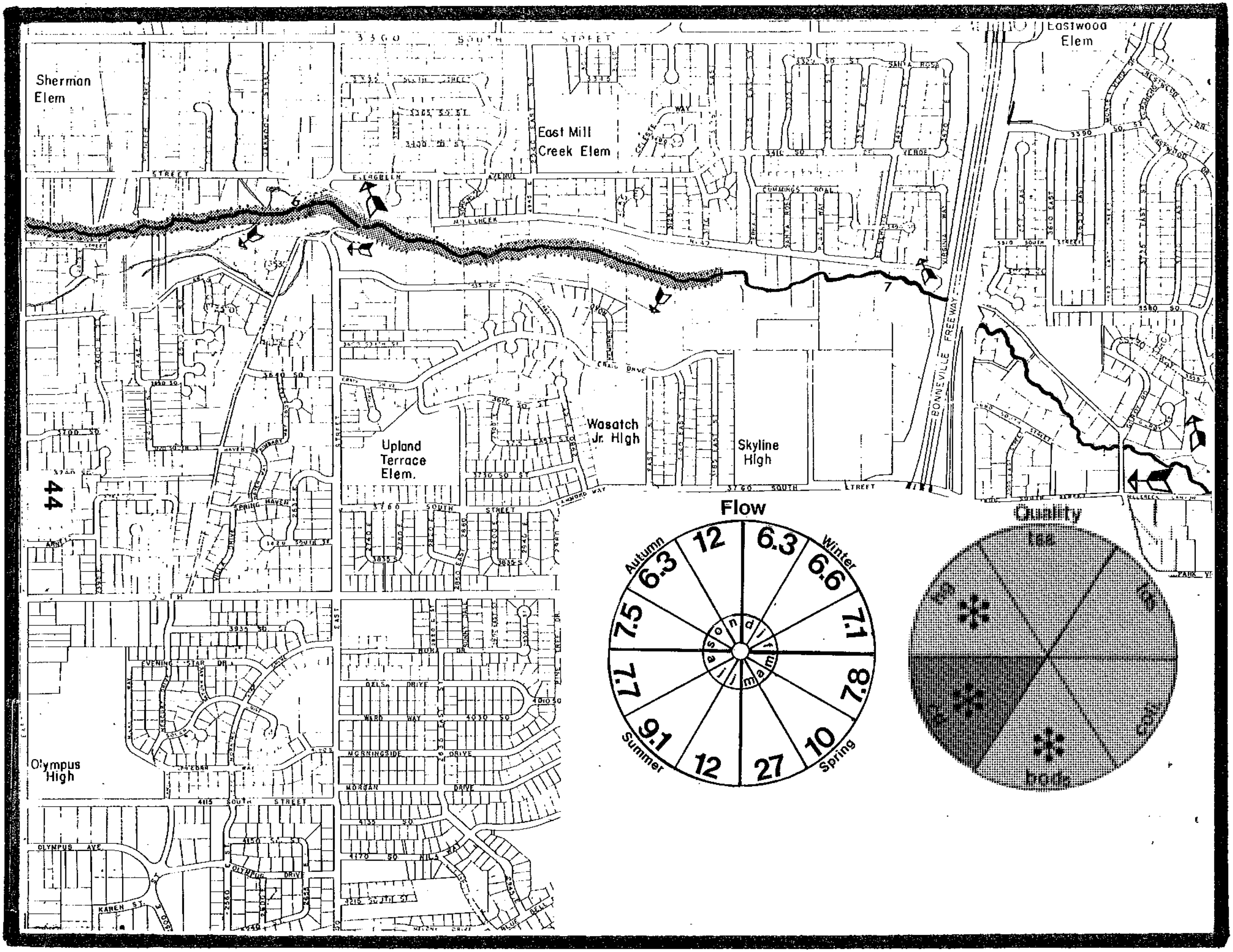

FLOW (cfs)
WINTER
SPRING
SUMMER
AUTUMN
15
14
14
16
24
130
300
120
46
28
19
17
D
J
F
M
A
M
J
J
A
S
O
N
QUALITY
TSS
TDS
COLI
BOD5
CD
HG
DEER CREEK EXCHANGE
10
AQUADUCT DIVERSION
20-50
15-20
1-3
LITTLE COTTONWOOD ROAD
LITTLE COTTONWOOD CANYON
NORTH FORK
CANYON PLACE
PRIVATE ROAD
3200 E.
9800 S.
9743 S.
9535 S.


VALLEY CENTRAL FREEWAY
Quality
Flow
Winter
Spring
Summer
Autumn
14
12
10
21
49
49
27
21
21
24
20
18
A
B
41


Quality
hg
NO DATA
NO DATA
cd
Groundwater Inflow Begins
Spring
2
Spring
2
C
D
E
Granite High
CAPRI PARK CONDO
Granite Park
MANSFIELD AVE
LELAND AVENUE
GARDEN AVE
HUDSON AVE
SCOTT AVE
HELM AVENUE
DAIRO AVENUE
700 EAST
STREET



GEORGETOWN
SQUARE
CONDOMINIUMS
MONTE BELLO CONDO
Evergreen Elem
Evergreen Jr High
CAPSTONE CONDO.
Canal Spill
5
Canal Spill
1
William Penn Elem.
MT. OLYMPUS CONDOMINIUM
Crestview
43


Sherman Elem
East Mill Creek Elem
Eastwood Elem
Upland Terrace Elem.
Wasatch Jr. High
Skyline High
Olympus High
3300 South Street
3760 South Street
4115 South Street
Bonneville Freeway
Flow
Autumn
Winter
Spring
Summer
12
6.3
6.6
7.1
7.8
10
27
12
9.1
7.7
7.5
6.3
Quality

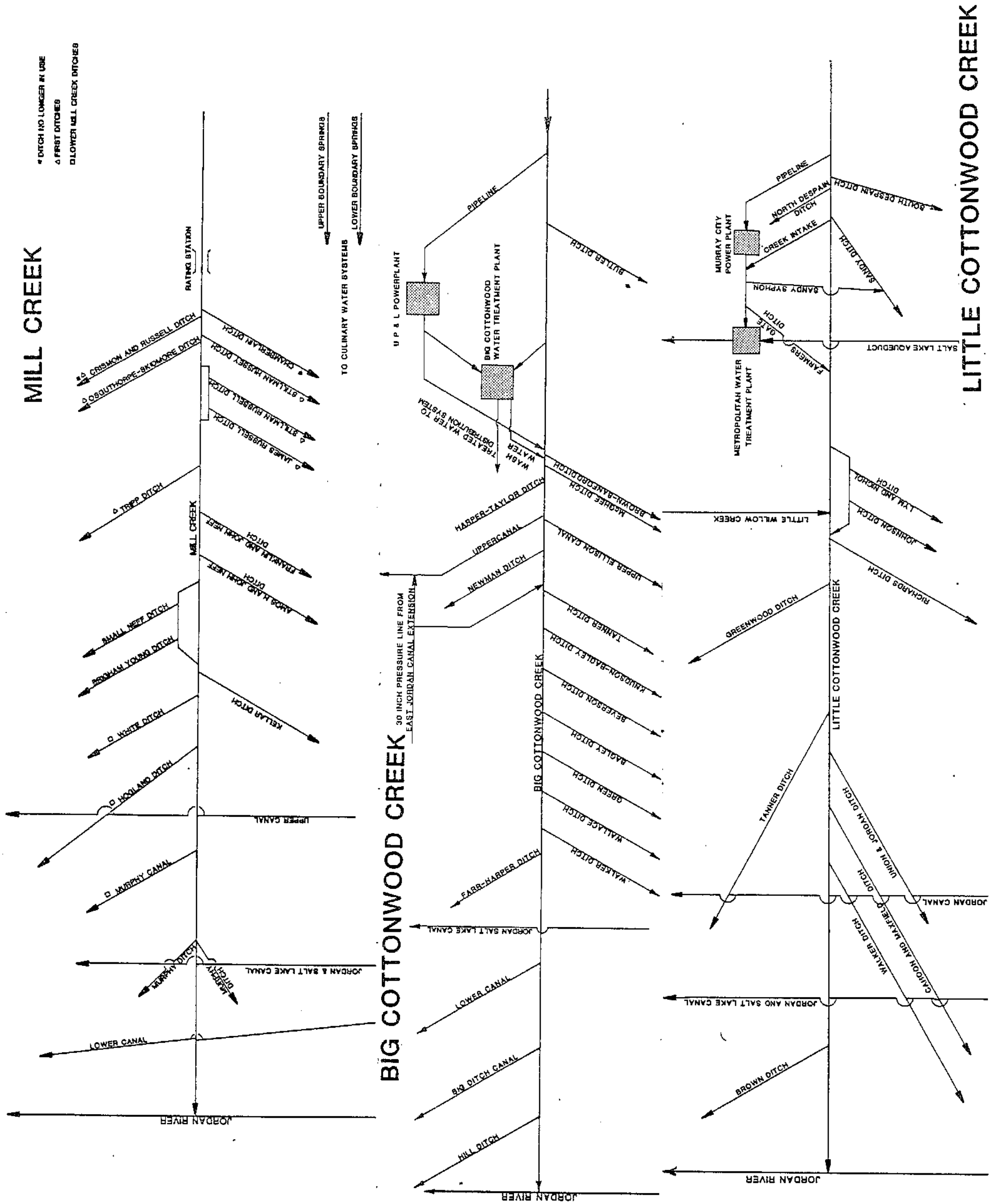


Figure 3 SUMMARY OF CREEK DIVERSIONS

Because of present practices involving chemical weed control, tree root control, trashing, littering, and hazardous waste disposal into these drainages, such follow-up studies could greatly increase quality and potential use.

IRRIGATION EXCHANGES

In return for culinary water diversion of rights at the canyon entries, water supply agencies have negotiated exchanges with canal and irrigation companies to maintain necessary downstream flows. These exchange agreements result in spills from canals at their junctures with natural streams that deliver flow downstream. In many cases, these spills are substantial. For example, an exchange on Big Cottonwood Creek during irrigation season (April-October) averages about 12-14 c.f.s. [16] In other words, high quality water flowing downstream is diverted to treatment plants in exchange for low quality water. More detailed discussion of quality appears later in this section. Exchange points are located and average flow/volume estimated on Figure 2.

3) GROUNDWATER INFLOW

GROUNDWATER LOSS

Based on total valley tributary inflow estimates by USGS, annual channel loss from groundwater recharge is 16% for Millcreek (1580 acre-feet), 9% for Big Cottonwood (4700 acre-feet), and 10% for Little Cottonwood Creek (4780 acre-feet). Table 2 summarizes mean monthly channel loss for each creek, and Figure 4 shows these losses graphed for each creek. The great majority of recharge loss occurs in Big and Little Cottonwood Creeks during peak runoff months. The losses occur from approximately 2000th East upstream on both creeks, and late autumn through winter normally finds these segments totally dewatered. The dewatered segments lie in the principle groundwater recharge

Table 2 —Summary of mean monthly channel losses, in acre-feet, in six Wasatch streams in eastern Jordan Valley, 1964-68 water years

Stream	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
Little Cottonwood Creek	210	160	160	90	70	90	470	910	990	890	520	220	4,780
Big Cottonwood Creek	160	40	20	10	50	110	540	1,150	1,370	700	310	240	4,700
Mill Creek	130	140	120	130	130	130	120	130	170	140	130	110	1,580
Subtotal	500	340	300	230	250	330	1,130	2,190	2,530	1,730	960	570	11,060
Parleys Creek	110	110	90	90	80	220	110	300	350	400	120	130	2,110
Emigration Creek	50	40	40	40	50	60	140	200	110	120	100	70	1,020
Red Butte Creek	10	10	20	30	40	60	90	140	70	50	10	10	540
Total	670	500	450	390	420	670	1,470	2,830	3,060	2,300	1,190	780	14,730

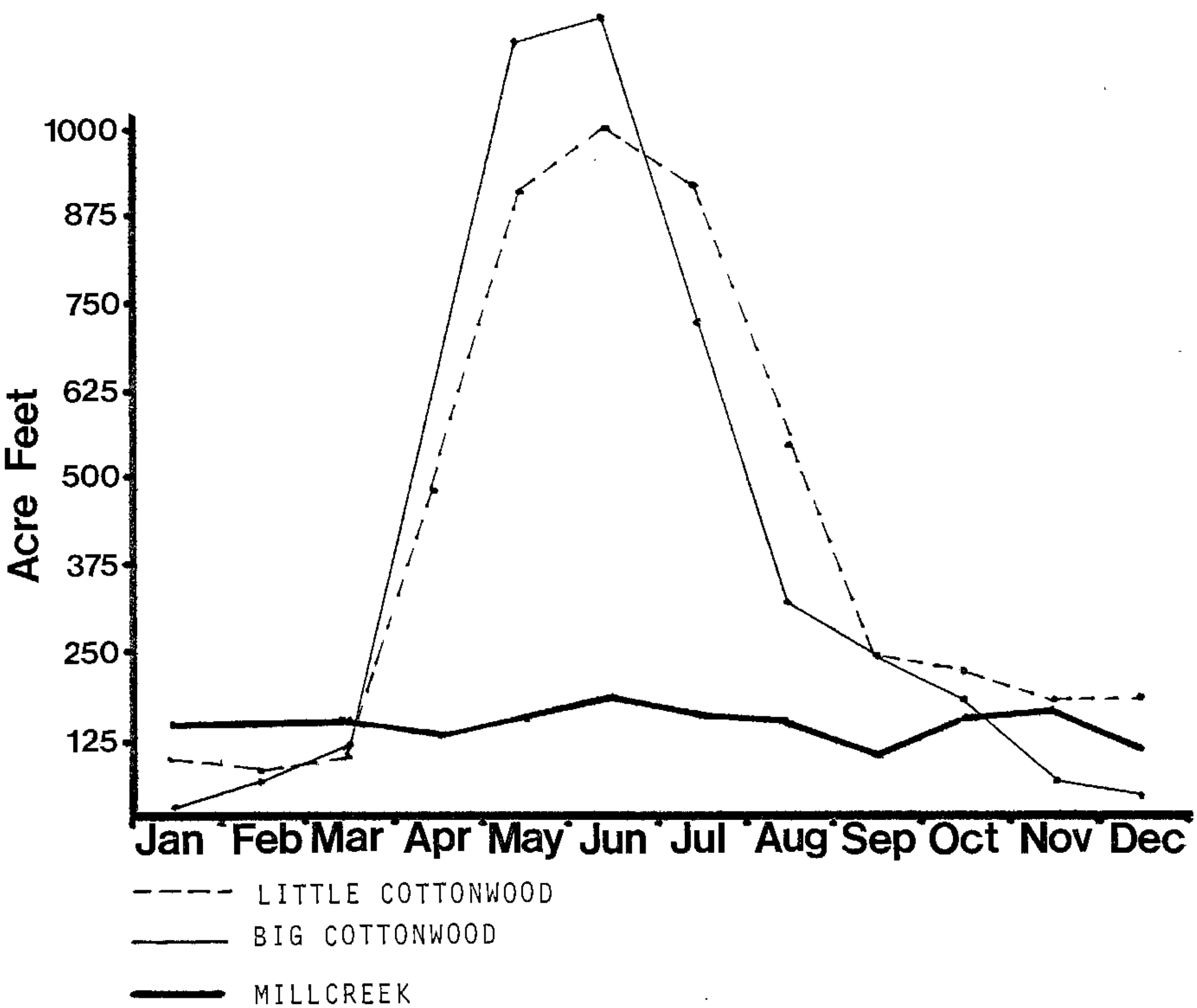


Figure 4. Graph showing mean monthly channel loss

zone consisting of very permeable alluvium and ancient lake-shore deposits.

This recharge loss, coupled with culinary diversions at the canyon mouths, constitute a serious constraint to multiple use of about eight stream miles - four miles each for Big and Little Cottonwood Creek. Only those creek segments which gain groundwater can presently be considered for multiple use analysis.

GROUNDWATER GAIN

As valley streams proceed down-gradient to the Jordan River, they intercept seeps and springs which indicate "zones" of groundwater discharge. Figures 5 and 6 indicate location where groundwater inflow begins, and Figure 7 reflects estimated gains to Big Cottonwood Creek from shallow or perched aquifers. Based on the pattern observed for Big Cottonwood, extrapolated estimates of groundwater gain between 1500-2000 acre-feet per year can be made for each stream between the Jordan River and upstream groundwater inflow zones. Figure 2 illustrates groundwater flow in relation to stream loss and gain.

4) STORMWATER DISCHARGE

In 1978 Salt Lake County was awarded a grant under the Nationwide Urban Runoff Program to conduct a basin-wide assessment on the nature and extent of stormwater quality. This large assessment proceeded two smaller sub-basin assessments conducted in 1975 and 1977.

The results of this research indicate that very high pollutant loads accompany very high increases in flow due to stormwater discharge. Such finds are consistent with observations in other basins made by the U.S. Geological Survey.

The duration of high storm flows is dependent on a number of factors, including basin size, stream length and stability, land use, channelization,

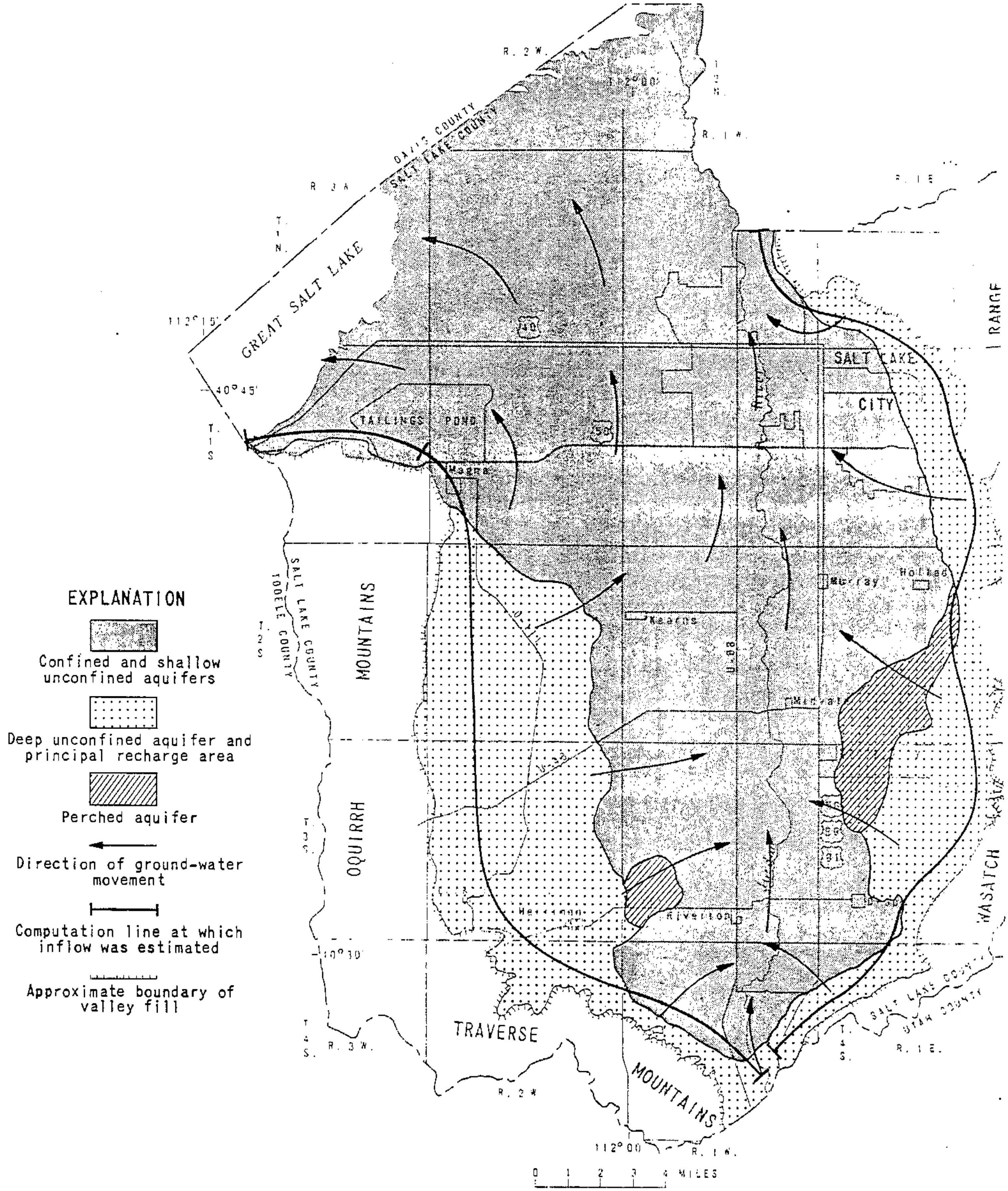


Figure 5.—Approximate areas in which ground water occurs in confined, shallow unconfined, deep unconfined, and perched aquifers in Jordan Valley.

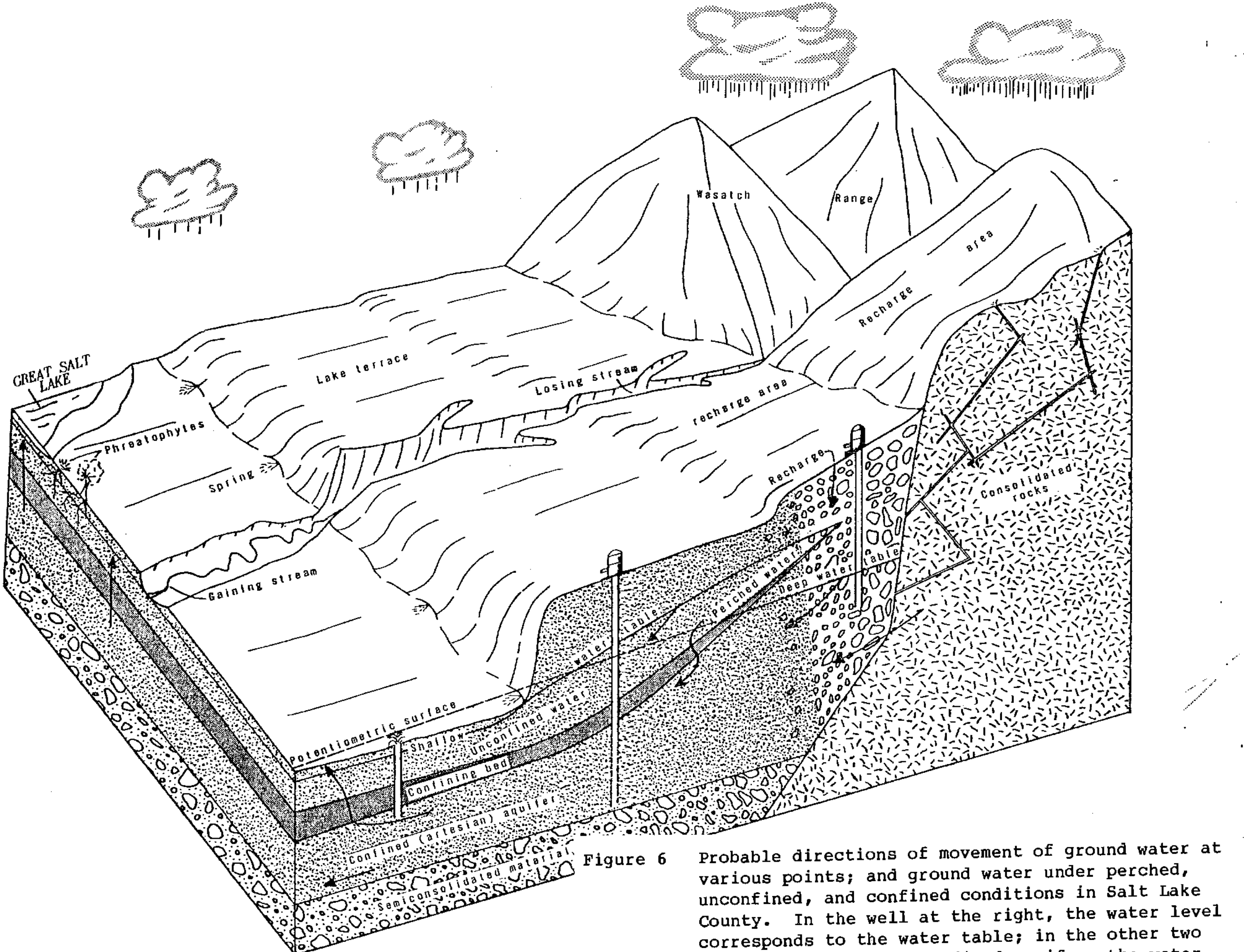


Figure 6 Probable directions of movement of ground water at various points; and ground water under perched, unconfined, and confined conditions in Salt Lake County. In the well at the right, the water level corresponds to the water table; in the other two wells, which tap the confined aquifer, the water rises above the confining layer to the potentiometric surface.

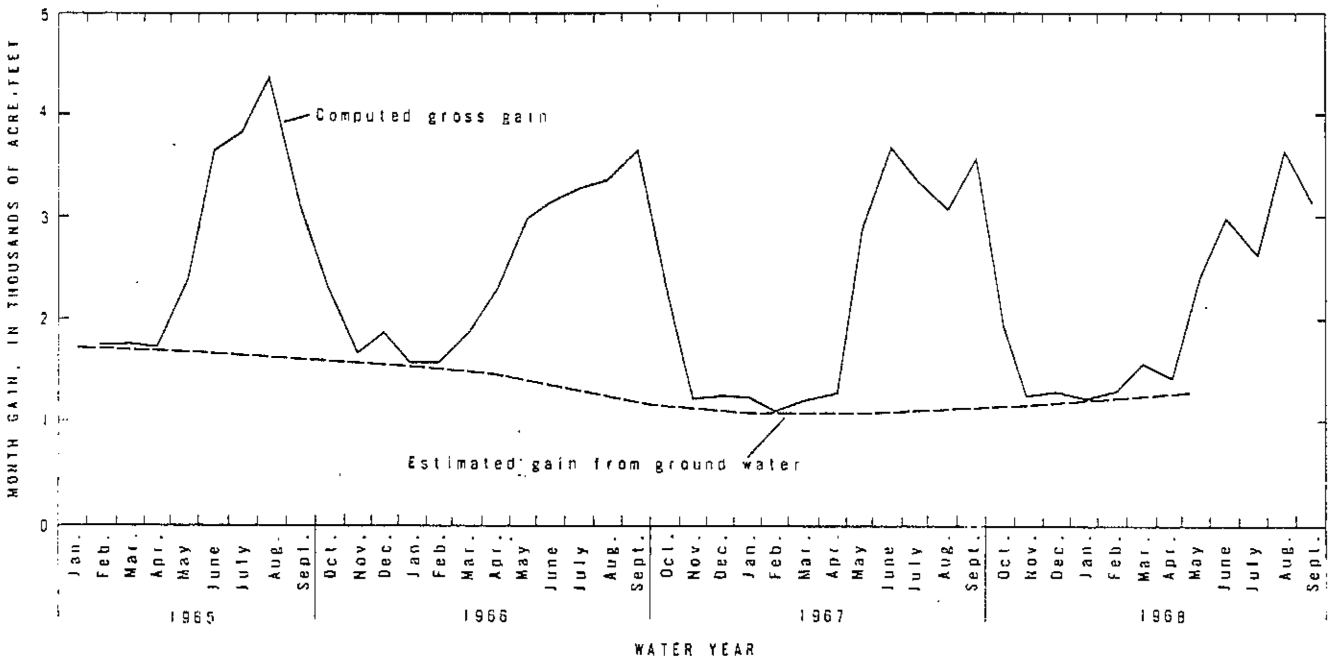


Figure 7 —Monthly gains in Big Cottonwood Creek between Cottonwood Lane and 300 West, 1965-68 water years.

amount of rainfall and intensity/duration, groundwater regime, and others. Water quality of storm flows is dependent on many of the same factors. A particular variable which influences valley tributary stormwater flow and quality is canal exchanges into the creeks.

No specific conclusions have yet been formulated about stormwater quality impacts on aquatic biota or health, but much is known about stormwater impacts and flood control management programs.

FLOODPLAINS

Figure 2 shows the "Zone A" floodplains identified from detailed consultant studies for the Corps of Engineers. Floodplain data have been revised recently, and divided into zones of inundation as well as into frequency/probability flood boundaries. "A Zones" are inundations produced by the "100 year" frequency flood in excess of six inches. "B Zones" are characterized as sheet flood flows under six inches in depth. Zone A floodplains require property owners to maintain flood insurance and to "mitigate" flood impacts by deleting basements, raising surface elevations for foundations, constructing tow-level or split-level dwellings, or preventing fill from invading the floodway boundary. These provisions provide important constraints and opportunities for effective stream management, where stream segments which have not been channelized or "built-up" can be preserved in conjunction with riparian vegetation. [17]

The U.S. Corps of Engineers has identified several central locations along major valley streams where detention facilities for flood control could be built. [18] The purpose of these facilities would be to control peak flood flows from damaging low-lying downstream segments. Cost-benefit ratios for such single purpose facilities are improved through multiple recreation use. The Corps has also proposed numerous channel improvements discussed in the following section.

FLOOD MAINTENANCE

About one-half of the total valley length of Big/Little Cottonwood and Mill Creeks are dredged annually for flood control maintenance. This dredging activity involves heavy machinery placed within the stream channel primarily for the removal of sediment. Logs, trees, and other obstructions are removed during the process, resulting in flat channel morphology with little variation. In many cases riparian vegetation is removed as potential channel obstruction, without regard to stabilization functions.

Table 3 summarizes expenditure data for flood control maintenance on all three valley tributaries, together with maintained segments for annual and five-year frequency, and costs (total as well as per stream mile). Table 4 estimates the amount of material removed for the same period-of-record, with supporting data in Appendix I. Figure 2 indicates the locations of stream segments maintained on an annual and five-year frequency basis.

Heavy equipment is employed to remove sediment which reduces channel capacity and encourages meandering and flooding from high seasonal or thunderstorm flows. Sediment is removed on a selective basis mostly along flatter gradients where sand and silt deposits accumulate. Because gradient varies greatly in short distances, heavy machinery will enter streams at restricted access points and travel the full length of the segments removing sand bars as they occur. This practice results in destruction of fishery habitat, stream fauna, aquatic flora, pool/riffle ratios, bank cover, bank shading, and species density and diversity. It also results - in many cases - in the stabilization of eroding banks partly responsible for sediment entrainment. This stabilization is achieved through the "Gabion" program.

Stream bank stabilization, however, occurs on a cooperative needs basis

	MAINTENANCE EXPENDITURES			STREAM-MILES MAINTAINED				AVERAGE ANNUAL MAINT.COST/STREAM MILE		
	SPRING 82*	SEPT.82**	TOTAL	ANNUAL	5-YR.	TOTAL	%	MILES	ANNUAL COST	82 COST/MI
BIG COTTONWOOD	45,000	83,576	128,576	4.1	3.09	7.19	76%	4.1	128,576	31,360
LITTLE COTTONWOOD	50,014	186,421	236,435	5.49	4.48	9.97	93%	5.5	236,435	42,988
MILL CREEK	25,010	24,245	49,255	.87	.83	1.70	22%	.87	49,255	56,615
TOTALS	120,024	294,242	414,266	10.46	8.40	18.86	-	10.46	414,266	39,604

* Total County Exp. = $570,000 Valley Tributary Maintenance comprised 21%

Total County Exp. = $346,000 Valley Tributary Maintenance comprised 85%

TABLE 3. FLOOD MAINTENANCE
EXPENDITURES FOR VALLEY TRIBUTARIES: 1982

	SEDIMENT (TONS) SPRING MAINTENANCE	SEDIMENT (TONS) FALL MAINTENANCE (POST-FLOOD)	TOTAL 1982 SEDIMENT (TONS)
BIG COTTONWOOD	8,206	15,057	23,263
LITTLE COTTONWOOD	9,797	29,497	39,294
MILL CREEK	3,660	4,085	7,745
TOTAL	21,663	48,639	69,802

ESTIMATED AVERAGE TONS
TABLE 4. SEDIMENT REMOVED FROM
VALLEY TRIBUTARIES: 1982

where capital for materials is privately provided. Therefore, priority erosion segments are often left to continue eroding, while those landowners who can afford bank stabilizing materials insure that their property is protected. A systematic program for bank stabilization has been proposed by the Corps of Engineers for specific stream reaches, but the program concentrates on lower segments where stream velocities are less eroding. The objective of the Corps program is primarily efficient flow transport with bank stability secondary. See Figure 8 for extent of proposed Corps projects.

Two objectives of future resource management on valley creeks are evident regarding flood control: 1) Flood water does need to be safely transported through previously channelized segments with limited capacity, and 2) Flood channel capacity limitations should be reduced to the optimum level. These objectives can best be accomplished through insuring that maximum benefits to the public are achieved with the cost. This means that prevention of sediment entrainment into channels and enhancement of resource improvements for recreation should be employed as a federal or local project component.

Detailed studies on sediment source are necessary to insure that bank stabilization/channelization projects are in themselves cost-effective. Field inventories of maintenance segments preliminarily indicate that bank scour is the primary sediment source, with outside non-point sources (construction runoff) second.[19] Sediment import from canyons is believed to be minimal, and erosion-sediment controls have begun to be implemented in Salt Lake County in order to reduce loads from construction runoff, but the extent to which the control program will be successful hinges a great deal on the sediment budget derived from a source inventory. From a fishery or wider economic benefit standpoint, present heavy equipment use along entire segments

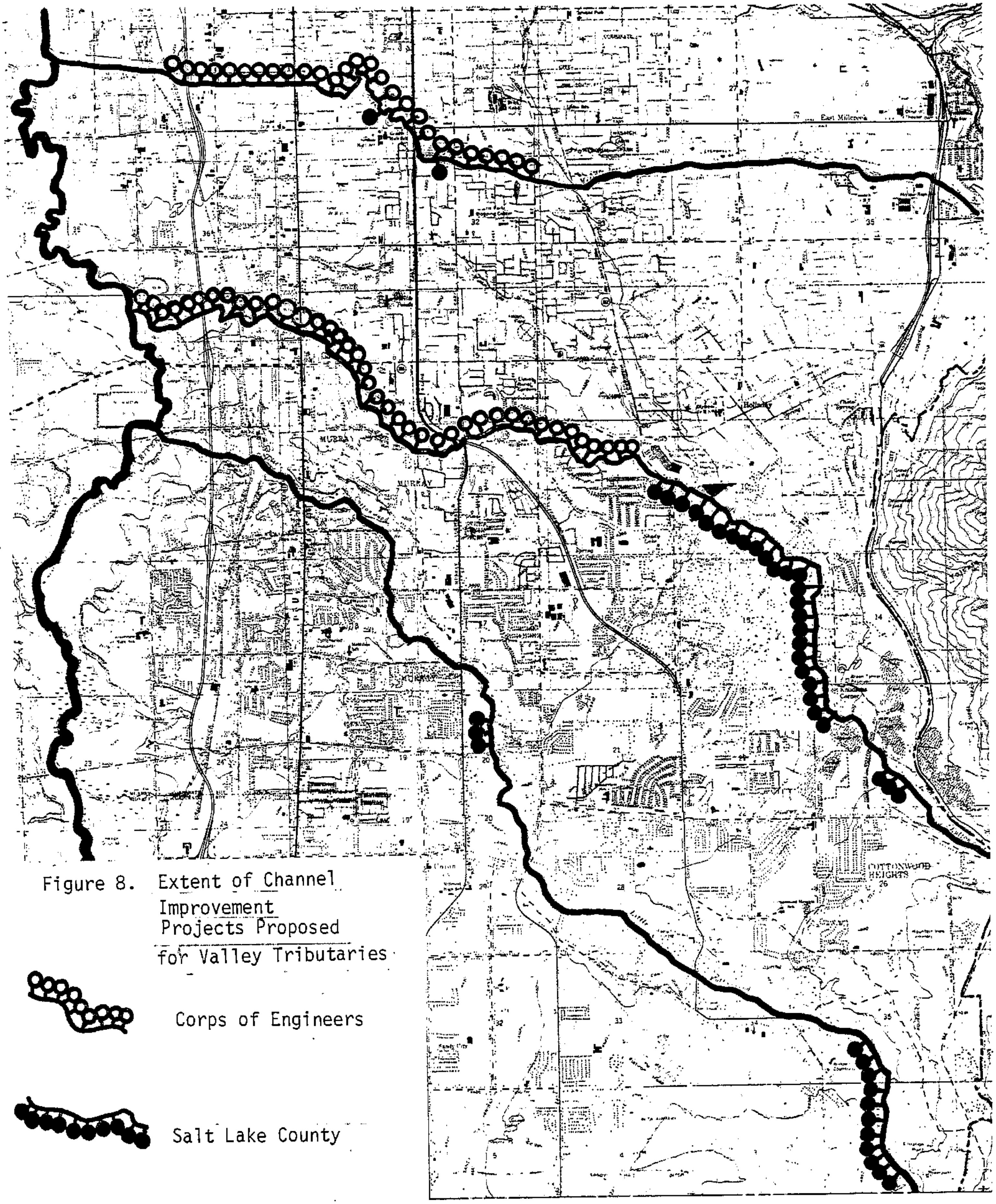


Figure 8. Extent of Channel Improvement Projects Proposed for Valley Tributaries

may be better substituted with bank stabilization, non-point (construction) controls, habitat improvement, and removal of sediment at centrally restricted locations. Completion of detailed studies will enable refinement and evaluation of such a preventive program. Fishery restoration efforts, described later, testify to the recreation benefits possible under preventive multiple use approaches.

Flood-flow conveyance needs on the lower stream reaches should also be satisfied within the context of multiple use enhancement. The construction of bank stabilization improvements should enhance aesthetic streamside values, restore fishery habitat, and maintain groundwater inflow to the creeks. Linear parkways have been components of Salt Lake County recreation master plans along these streams since 1974,[20] and public expenditures should accomplish widest economic return to the community where possible. All improvement programs should seek to enlarge rather than constrict beneficial use.

B. WATER QUALITY

The quality of water flowing from the Wasatch Canyons is relatively high. Quality gradually degrades in all streams as it flows through Salt Lake Valley toward confluence with the Jordan River (See USGS Figure 9 chemical Quality). Several factors influence this gradual degradation, among the major causes: 1) Seasonal flows which affect pollutant concentrations; 2) Stormwater Runoff; 3) Irrigation exchange water and return flows from various canals; 4) Groundwater inflow. Each pollution source should be considered in view of Utah State Numerical Standards for Protection of Beneficial Uses of Water (Table 5) and the beneficial use classification of valley streams (Table 6.)

1) BACKGROUND QUALITY: SEASONAL CANYON FLOW

Canyon water quality is typically very high during the year. Larger loads of pollution produced by spring snowmelt are mitigated by larger flows. Table 7 displays the relative quality of canyon water compared to other sources in the basin, [21] while Figure 10 illustrates seasonal variability of coliform bacteria in Big Cottonwood Canyon. The Nationwide Urban Runoff Program (NURP) carried out jointly by Salt Lake County and USGS since 1979 include baseline conditions (usually represented by the low values) and peak storm/runoff conditions (represented by the high values) and are displayed in Table 8, statistical means/extremes. It is noted that the two standards for the most toxic metals, mercury and cadmium, are often exceeded. It is not understood why these and other metals concentrations occur so high at the canyon mouth, although speculation about possible mine tailings effect deserves additional sampling attention.

2) STORMWATER RUNOFF

Figures 11 and 12 recount the occurrence of increased pollutant concentrations during storm flows and Figure 13 shows cumulative runoff for Big and Little Cottonwood. Although the increases for various parameters are dramatic, they are generally characteristic. Little Cottonwood Creek at the Canyon mouth for example, posts the following percentage increases during storms for the parameters selected:

Total Suspended Sediment:	400%
Total Dissolved Solids:	400%
Coliform - Total:	1800%
BOD_5:	-20%
Phosphorus:	140%
Lead:	100%

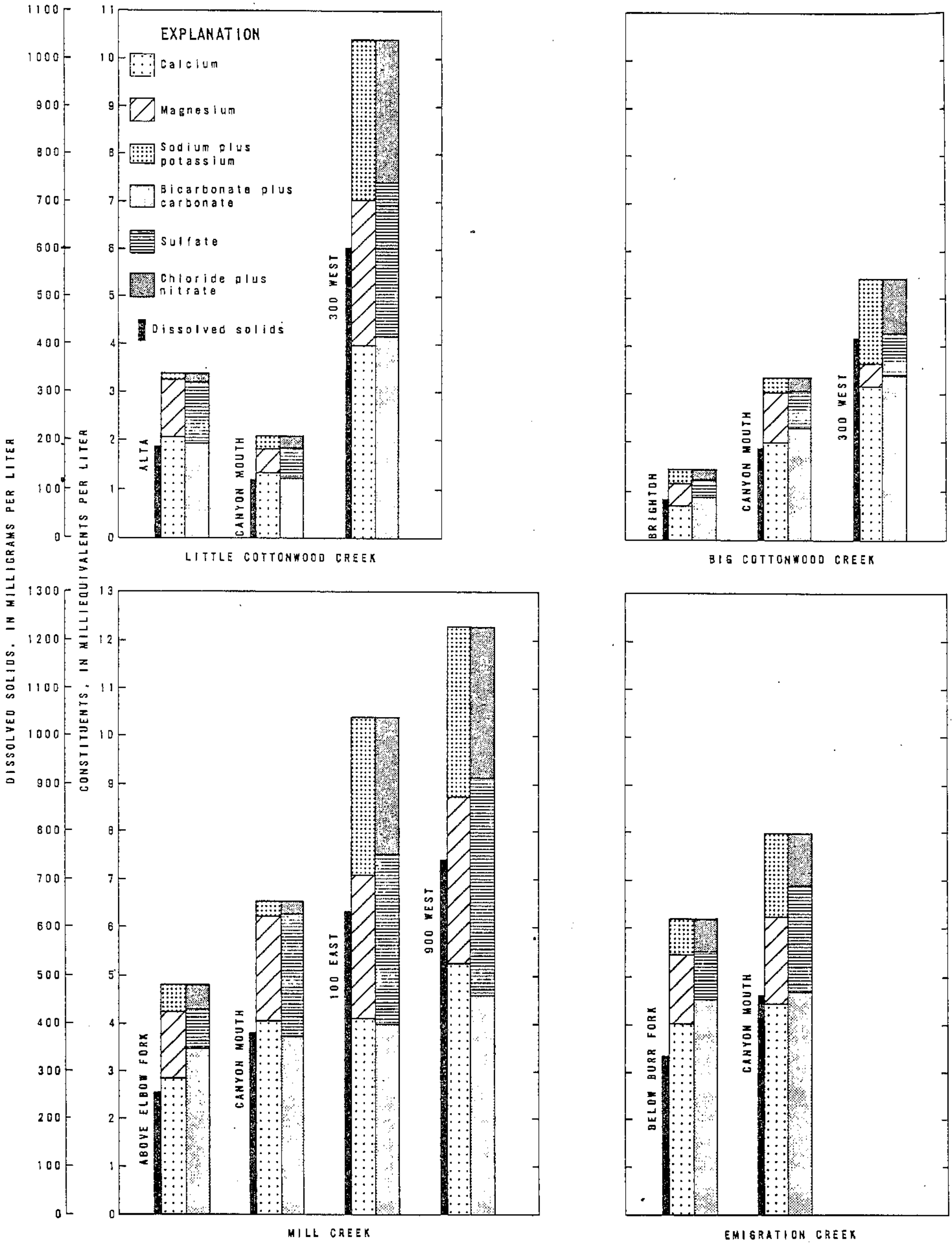


Figure 9 Downstream Changes in the Chemical Composition of Water in Four Wasatch Streams

TABLE 5

Numerical Standards for Protection of Beneficial Uses for Water

CONSTITUENT	CLASSES											
	DOMESTIC SOURCE			RECREATION & AESTHETICS		AQUATIC WILDLIFE				AGRI-CULTURE	INDUSTRY	SPECIAL
	1A	1B	1C	2A	2B	3A	3B	3C	3D	4	5	6
											STANDARDS WILL BE DETERMINED ON A CASE BY CASE BASIS	STANDARDS WILL BE DETERMINED ON A CASE BY CASE BASIS
Bacteriological (No./100 ml)												
(30-day Geometric Mean)												
Maximum Total Coliforms	1	50	5,000	1,000	5,000	*	*		*	*		
Maximum Fecal Coliforms	*	*	2,000	200	2,000	*	*		*	*		
Physical												
Total Dissolved Gasses	*	*	*	*	*	(b)	(b)		*	*		
Minimum DO (mg/l) (a)	*	*	5.5	5.5	5.5	6.0	5.5	5	5.5	*		
Maximum Temperature	*	*	*	*	*	20°C	27°C	27°C	*	*		
Maximum Temp. Change	*	*	*	*	*	2°C	4°C	4°C	*	*		
pH	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0		
Turbidity Increase (c)	*	*	*	10 NTU	10 NTU	10 NTU	10 NTU	15 NTU	15 NTU	*		
Chemical (Maximum mg/l)												
Arsenic, dissolved	.05	.05	.05	*	*	*	*		*	.1		
Barium, dissolved	1	1	1	*	*	*	*		*	*		
Cadmium, dissolved	.010	.010	.010	*	*	.0004 (d)	.004 (d)	.004	*	.01		
Copper, dissolved	*	*	*	*	*	.10	.10	.10	.10	.10		
Cyanide	*	*	*	*	*	.005	.005	.005	*	*		
Iron, dissolved	*	*	*	*	*	1.0	1.0	1.0	1.0	*		
Lead, Dissolved	.05	.05	.05	*	*	.05	.05	.05	*	.1		
Mecury, total	.002	.002	.002	*	*	.00005	.00005	.0005	.00005	*		
Phenol	*	*	*	*	*	.01	.01	.01	*	*		
Selenium, dissolved	.01	.01	.01	*	*	.05	.05	.05	*	.05		
Silver, dissolved	.05	.05	.05	*	*	.01	.01	.01	*	*		
Zinc, dissolved	*	*	*	*	*	.05	.05	.05	*	*		
NH_3 as N (un-ionized)	*	*	*	*	*	.02	.02		*	*		
Chlorine	*	*	*	*	*	.002	.01	.2	*	*		
Floride, dissolved (e)	1.4-2.4	1.4-2.4	1.4-2.4	*	*	*	*		*	*		
NO_3 as N	10	10	10									
Boron, dissolved	*	*	*	*	*	*	*		*	.75		
H_2S	*	*	*	*	*	.002	.002	.02	*	*		
TDS (f)	*	*	*	*	*	*	*		*	1200		
Radiological (Maximum pCi/l)												
Gross Alpha	15	15	15	*	*	15 (g)	15 (g)	15 (g)	15 (g)	15 (g)		
Radium 226, 228 combined	5	5	5	*	*	*	*		*	*		
Strontium 90	8	8	8	*	*	*	*		*	*		
Tritium	20,000	20,000	20,000									
Pesticides (Maximum ug/l)												
Endrin	.2	.2	.2	*	*	.004	.004	.004	.004	*		
Lindane	4	4	4	*	*	.01	.01	.01	.01	*		
Methoxychlor	100	100	100	*	*	.03	.03	.03	.03	*		
Toxaphene	5	5	5	*	*	.005	.005	.005	.005	*		
2, 4-D	100	100	100	*	*	*	*		*	*		
2, 4, 5-TP	10	10	10	*	*	*	*		*	*		
Pollution Indicators (g)												
Gross Beta (pCi/l)	50	50	50	*	*	50	50		50	50		
BOD (mg/l)	*	*	5	5	5	5	5	5	5	5		
NO_3 as N (mg/l)				4	4	4	4	4	*	*		
PO_4 as P (mg/l) (h)	*	*	*	.05	.05	.05	.05		*	*		

* Insufficient evidence to warrant the establishment of numerical standard. Limits assigned on case-by-case basis.

(a) These limits are not applicable to lower water levels in deep impoundments.

(b) Not to exceed 110% of saturation.

(c) For Classes 2A, 2B, 3A and 3B at background levels of 100 NTUs or greater, a 10% increase limit will be used instead of the numeric values listed. For Class 3C at background levels of 150 NTUs or greater, a 10% increase limit will be used instead of the numeric value listed. Short term variances may be considered on a case-by-case basis.

(d) Limit shall be increased threefold if $CaCO_3$ hardness in water exceeds 150 mg/l.

(e) Maximum concentration varies according to the daily maximum mean air temperature.

Temperature °C	mg/l
12.0 and below	2.4
12.1 to 14.6	2.2
14.7 to 17.6	2.0
17.7 to 21.4	1.8
21.5 to 26.2	1.6
26.3 to 32.5	1.4

(f) Total dissolved solids (TDS) limit may be adjusted on a case-by-case basis.

(g) Investigations should be conducted to develop more information where these pollution indicator levels are exceeded.

(h) PO_4 as P(mg/l) limit for lakes and reservoirs shall be .025

CLASSIFICATION OF WATERS OF THE STATE	USE CLASSES: DOMESTIC SOURCE	RECREATION AND ESTHETICS		AQUATIC WILDLIFE				AGRICULTURE
	1C	2A	2B	3A	3B	3C	3D	1
JORDAN RIVER DRAINAGE								
Jordan River from Farmington Bay to North Temple Street, Salt Lake City			X			X	X	X
Jordan River from North Temple in Salt Lake City to confluence with Little Cottonwood Creek			X		X			X
Jordan River from confluence with Little Cottonwood Creek to Narrows Diversion			X	X				X
Jordan River, from Narrows Diversion to Utah Lake			X		X			X
City Creek, from Memory Park in Salt Lake City to City Creek Water Treatment Plant			X	X				
City Creek, from City Creek Water Treatment Plant to to Headwaters	X			X				
Parley's Creek and tributaries, from 1300 East in Salt Lake City to Mountain Dell Reservoir			X			X		
Parley's Creek and tributaries, from Mountain Dell Reservoir to Headwaters	X		X					
Emigration Creek and tributaries from Foothill Boulevard in Salt Lake City to Headwaters				X				
Red Butte Creek and tributaries, from Red Butte Reservoir to Headwaters	X			X				
Mill Creek and tributaries, from confluence with Jordan River to Headwaters				X				X
Big Cottonwood Creek and tributaries from confluence with Jordan River to Big Cottonwood Water Treatment Plant			X	X				X
Big Cottonwood Creek and tributaries, from Big Cottonwood Water Treatment Plant to Headwaters	X			X				
Little Cottonwood Creek and tributaries, from confluence with Jordan River to Metropolitan Water Treatment Plant				X				X
Little Cottonwood Creek and tributaries, from Metropolitan Water Treatment Plant to Headwaters	X			X				
Bell Canyon Creek and tributaries, from lower Bell's Canyon reservoir to Headwaters	X			X				
Little Willow Creek and tributaries, from Draper Irrigation Company diversion to Headwaters	X			X				
South Fork of Dry Creek and tributaries, from Draper Irrigation Company diversion to Headwaters	X			X				
All permanent streams on east slope of Oquirrh Mountains (Coon, Barney's, Bingham and Butterfield Creeks)				X				X
ALL IRRIGATION CANALS AND DITCHES STATEWIDE, EXCEPT AS OTHERWISE DESIGNATED								X
ALL DRAINAGE CANALS AND DITCHES STATEWIDE, EXCEPT AS OTHERWISE DESIGNATED (CLASS 6)								X
Farmington Bay Waterfowl Management Area, Davis and Salt Lake Counties						X	X	

TABLE 6 . Classification of Waters in Salt Lake County
Source: State Waste Disposal Regulations

TABLE 7

TYPICAL WATER QUALITY OF WATER SOURCES

	MPN Coliforms no./100ml	Suspended Solids mg/l	Total Dissolved Solids mg/l	Biochemical Oxygen Demand mg/l	Dissolved Chloride mg/l
Little Cottonwood[1]	266	71	130	1.1	23
Big Cottonwood[1]	135	50	180	2.3	12
Mill Creek[1]	250	17	340	1.8	13
Parleys Creek[1]	25		400	3	
Emigration Creek[1]	3,000	5	470	2.6	45
Red Butte Creek[1]	36		390	2	13
City Creek[1]	25		280	2	18
Provo River -Deer Creek Res.	41		240	2	12
Jordan River -Jordan Narrows	2,000	10	950	4	222
-Cudahy Lane	17,000	67	855	6	172
Groundwater -Holladay Area			100-500		5-20
-Draper Area			500-1000		50-300
-Magna Area			1000-2000		100-400

[1]Data for Wasatch Front streams near canyon mouths.

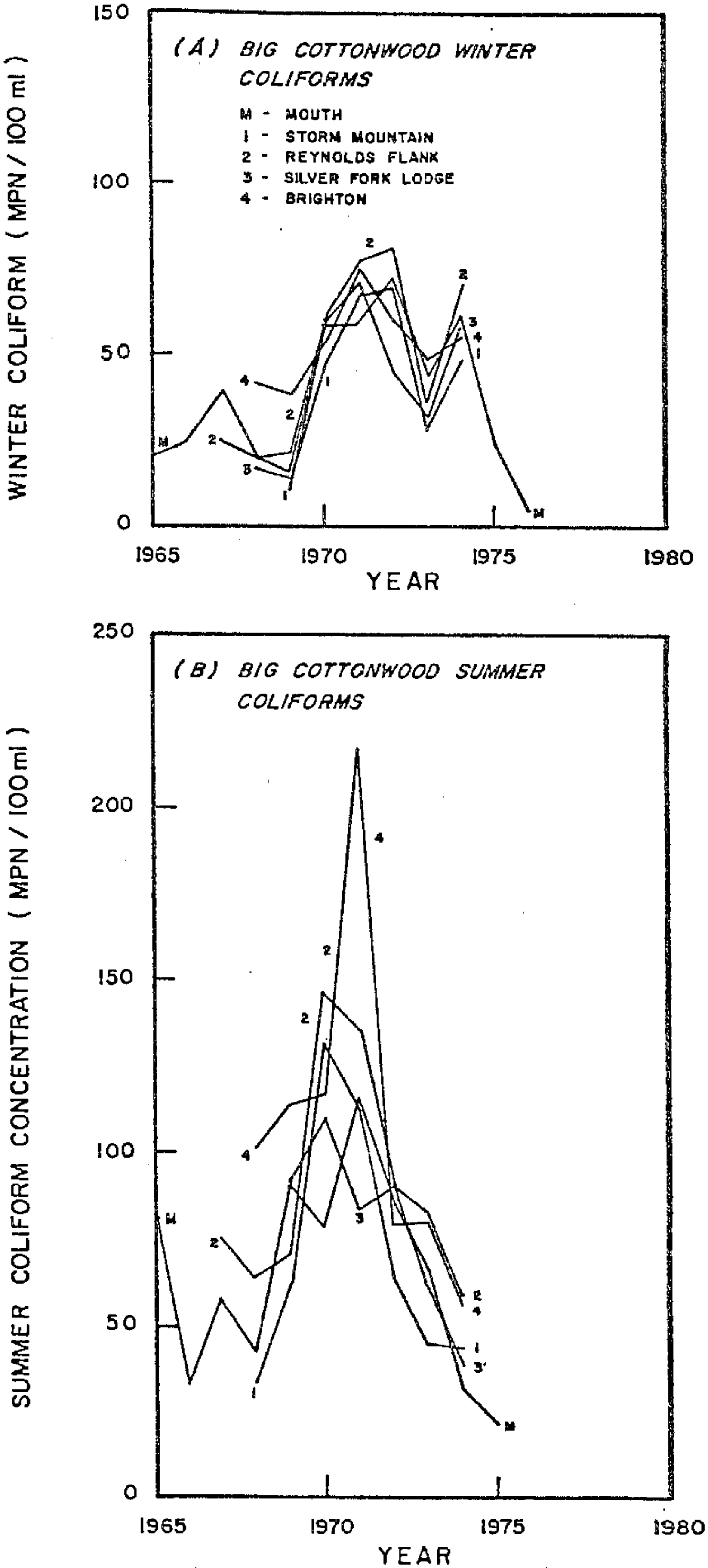


Figure 10 Summer and Winter Coliforms at 5 Stations along Big Cottonwood Creek

TABLE 8 2/9/83

STATION 2 VALLEY TRIBUTARY ASSESSMENT

STATISTICAL MEANS - EXTREMES

CANYON:	BIG COTTONWOOD			LITTLE COTTONWOOD			MILLCREEK		
	LOW	MEAN	HIGH	LOW	MEAN	HIGH	LOW	MEAN	HIGH
BOD_5	.40	1.10	2.0	1.40	2.20	4.00	<1.0	1.43	5.5
COLIFORM	15	732	7900	9	758	33000*	30	727	2300
TDS	104	162	231	88	192	359	336	369	400
TSS	3	11	33	2	23	150	0	27	140
MERCURY	0	.05	.20	<1	.10	.10	0	.08	.10
CADMIUM	≤1	1.14	2.0	<1	≤1	1.	≤1	1.71	6.0
COPPER	0	7.86	27.	<10	<8.0	9.0	2	6.40	8.0
ZINC	3.0	14.	30.	13.	41.	77.	<3	10.	28.
LEAD	<10	10.4	29.	0	5.4	14.	2.	12.	33.
JORDAN RIVER:									
BOD_5	<1.0	7.35	16.0	1.1	3.7	9.2	<1.0	3.6	10.0
COLIFORM	93	4093	12000	93	2686	14000*	230	3866	21000*
TDS	257	584	799	331	643	900	327	654	834
TSS	5	101	676	2	81	299	4	88	328
MERCURY	0	.11	.20	10	.13	.20	.10	1.77	.20
CADMIUM	≤1	1.11	2.0	0	1.44	5.0	≤1	1.06	2.0
COPPER	2.0	8.44	26.0	2.0	9.06	16.0	2.0	7.69	15.0
ZINC	8	20.2	160.	7.0	24.9	72.0	≤3	18.1	43.0
LEAD	0	5.09	11.0	0	8.5	16.0	3.0	8.8	16.0
MIDPOINT									
BOD_5	<1	3.09	5.1	.60	3.4	7.6	2.0	6.1	9.9
COLIFORM	43	2425	4300	92	2398	4300	1500	7314	24000
TDS	710	802	916	630	739	890	670	861	986
TSS	40	78	125	11	62	140	100	167	452

* Exceeds Standards

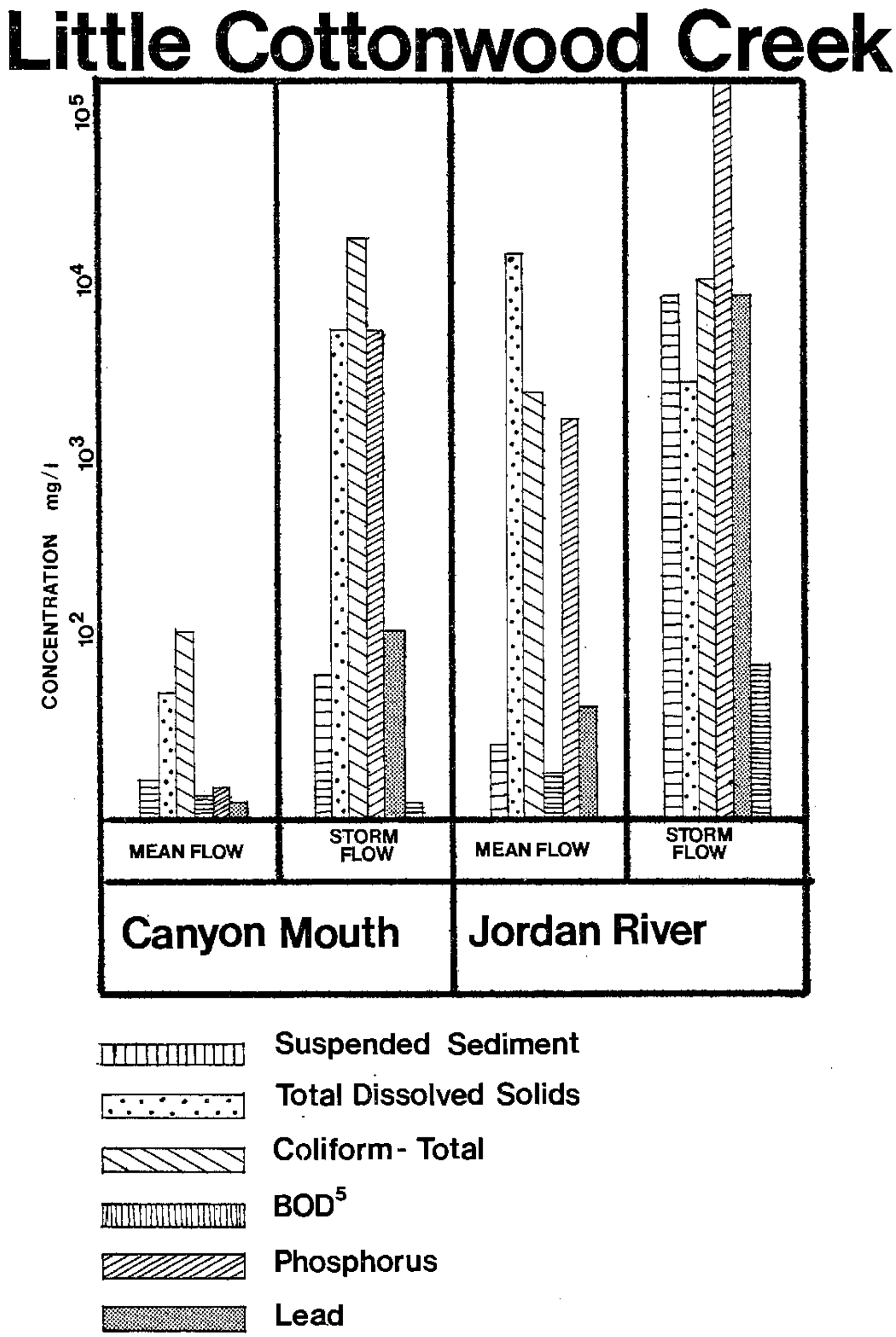


Figure 11 Increased Pollutant Concentrations due to Stormwater Runoff - Little Cottonwood Creek

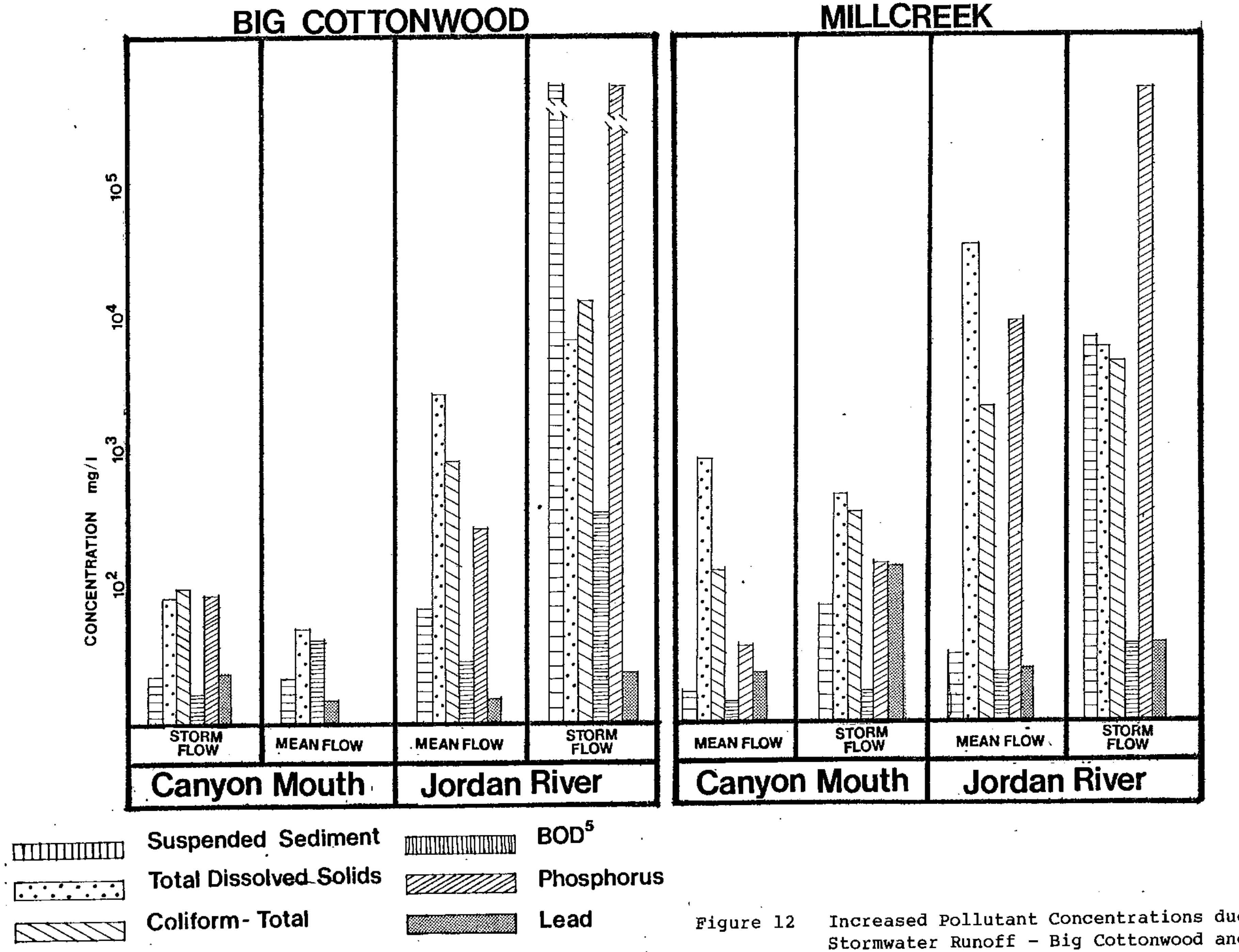


Figure 12 Increased Pollutant Concentrations due to Stormwater Runoff - Big Cottonwood and Mill Creek

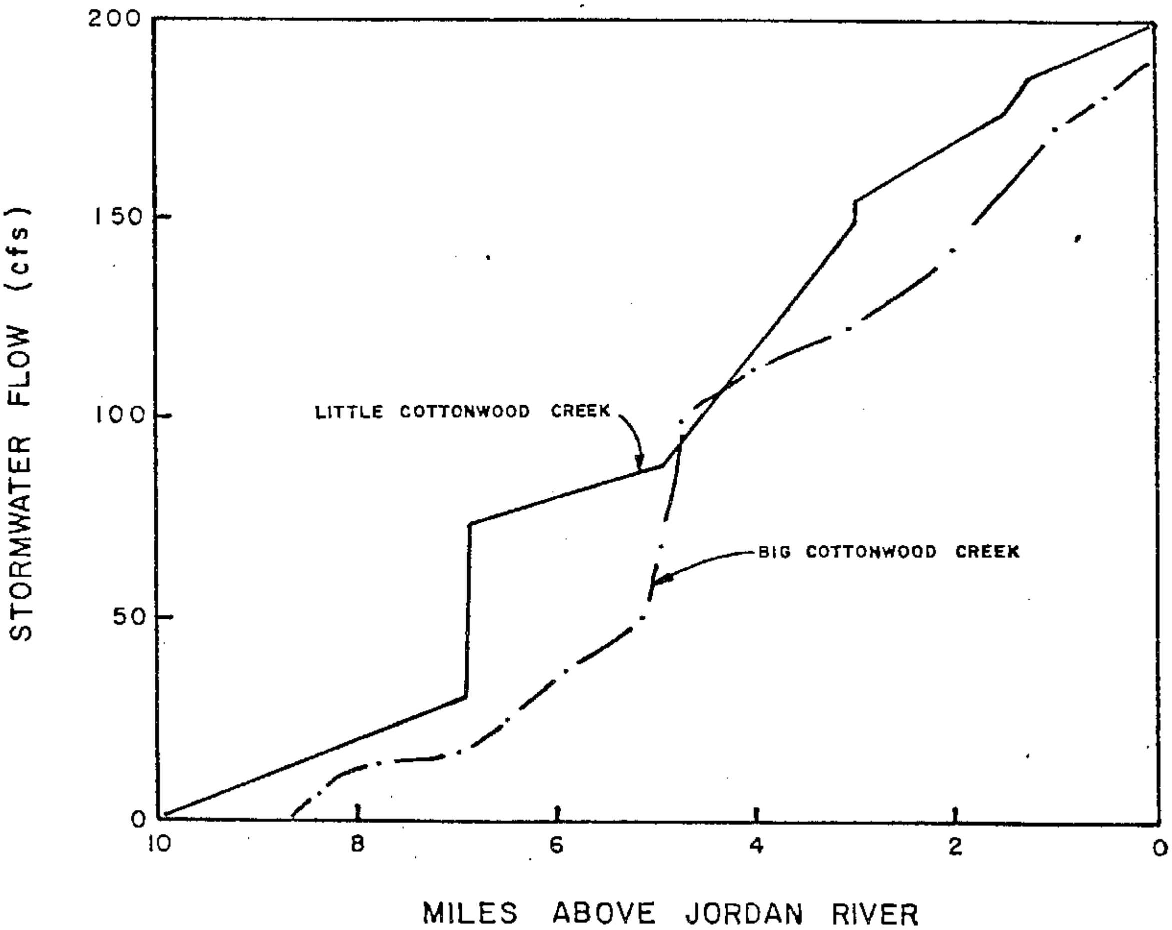


Figure 13 Cumulative Stormwater Runoff Big and Little Cottonwood Creeks

RIPARIAN VEGETATION AND HABITAT

Streamside vegetation plays a key role in the productivity and enjoyment of valley tributary resources. Both understory (low-growing plants, grasses and shrubs) and overstory (high-growing shrubs and trees) provide essential elements for propagation of aquatic and terrestrial animals. The enjoyment derived from streams is mostly credited to the natural vegetative setting. Sights, sounds, temperature, and vegetative diversity all contribute to recreational enjoyment of creek environs.

FUNCTIONS OF RIPARIAN VEGETATION

Creekside vegetation performs many functions of immediate and secondary benefit to people. Bank stability, evapotranspiration, shading, nutrient uptake, flood storage, prevention of overland erosion, all play important roles in protecting people from natural forces and enabling enjoyment of stream zones. Wildlife habitat - both terrestrial and aquatic - are fully dependent on the conservation of riparian vegetation.

- BANK STABILITY: During spring runoff or flood stages, bank stability is needed to avert bank scouring which produces property damage and flooding. Bank erosion nessitates extensive channel cleaning to remove accumulations of sediment which constrict channel capacity. This removal process in turn degrades fishery density and diversity.
- EVAPOTRANSPIRATION: Groundwater discharge into creeks and stored seepage from the creeks produce density and diversity of water-loving or hydrophytic plant species. These plants help maintain hydrologic balance by taking up water through roots and evaporating it through leaves. The lack of riparian plants could increase water available for basement flooding or other physical imbalance incurred by higher water tables.

Many questions have been raised as to the implications for public health, safety, and welfare in view of consistently high stormwater pollutant concentrations. Coliform bacteria concentrations are excessive and often accompanied by high concentrations of fecal streptococcus. Body contact with stormwater flows could pose immediate health hazard, as could minor flooding. Thorough disinfection of a flooded residence is very difficult. High concentrations of sediment are deposited within channels thereby reducing channel capacity and increasing future flood hazard. Salt Lake County expended about $300,000 in the three valley creeks to clean up and remove sediment produced from a single storm event (September 26, 1982).[22] The implications surrounding excessive total and dissolved metals concentration on aquatic biota (and man at the end of the food chain) deserve further scientific inquiry. A more complete discussion is presented under "Impairment of Beneficial Use."

3) IRRIGATION EXCHANGE AND RETURN FLOWS

Water is diverted from the Jordan Narrows as it flows directly out of Utah Lake into a system of irrigation canals. Three canals, the Jordan and Salt Lake, Upper Canal, and East Jordan Canal, flow northward along the East Bench. Exchange agreements (discussed earlier) allow for the spilling of canal flows into the creeks. Irrigation return flows also find their way into numerous drainages and creek discharge avenues. Little sampling of irrigation return flows in the urban area has been done, but canal water quality has been well documented.

Table 9 lists and average annual creek exchange flow and numerical values of typical canal water quality parameters.[23]

4) GROUNDWATER INFLOW

Shallow and perched aquifer inflow supply gradual gain to valley creeks.

TABLE 9. AVERAGE ANNUAL CANAL EXCHANGE FLOW AND QUALITY ON THREE VALLEY TRIBUTARIES

	ESTIMATED ANNUAL AVERAGE IRRIGATION DISCHARGE TO: (cfs)			AVERAGE WATER QUALITY					
				MPN/100ml	mg/l	mg/l	mg/l	ug/l	ug/l
	MILL CREEK	LITTLE COTTONWOOD	BIG COTTONWOOD	Coli	BOD	TDS	TSS	Cd	Hg
UPPER CANAL	EST. 5.0	NONE	NONE	12,800	5.2	576	98	1.0	.00
JORDAN & S.L. CANAL	1.63	3.2	14.3	15,000	3.8	654	93	1.0	ND
EAST JORDAN CANAL	NONE	21.4	NONE	ND	ND	837	118	1.5	ND

Principal perched aquifer discharge is returned to Big and Little Cottonwood Creeks. The U.S. Geological Survey reports the volume, rate and quality of aquifer discharge to be generally poor.[24]

Chemical quality of shallow unconfined aquifer is represented mostly in terms of the total dissolved solids parameter. More parameters are being investigated under a valley-wide groundwater quality assessment presently underway. Table 10 gives TDS measures for the shallow unconfined aquifer.

Water in the shallow aquifer is heavier in TDS than the principal or deep aquifer. Upward mineral migration through the confining bed, irrigation seepage, road salt contamination are all potential causes of higher TDS. Leachate from landfills or mine tailings could contribute as well.[25]

Table 10–Dissolved-solids content of water from the shallow unconfined aquifer in Jordan Valley

Well, trench, or spring number	Sampling depth (feet)	Dissolved solids (mg/l)	Well, trench, or spring number	Sampling depth (feet)	Dissolved solids (mg/l)
(B-1-1)23bdd-1	30	12,000	(C-3-1)6cac-1	90	928
23bdd-2	30	8,960	18abc-S1	---	24,300
(C-1-1)32bbb [1]	13	1,700	27aaa-1	12	2,330
(C-1-2)21dad-10	60	1,410	(C-4-1)10bdd-1	50	1,320
22bdd-4	35	967	(C-2-1)6dbb-12	85	270
22dcc-3	99	1,340	8ccd-8	86	458
28aaa-3	60	1,610	9dbd [1]	8	658
32aab-1	52	1,330	14bcc-1	17	809
35ada-2	64	1,140	17bcc-7	99	515
(C-2-1)12ada-1	82	342	20add [1]	14	1,330
14caa-1	63	1,430	(D-3-1)7ccd-1	62	2,050
34acb [1]	12	1,510	12adc-1	71	140
34dda-2	65	1,400	30dcb-1	10	2,030
(C-3-1)2cab-1	10	1,680	(D-4-1)6bdd-1	28	659

[1] Open trench.

- SHADING: The cool local environment of stream zones is due in great part to shading which maintains temperature balance along creek corridors.
- NUTRIENT UPTAKE: Pollutants like nitrogen and phosphorus are absorbed by hydrophytic plants through root microbial activity. This process helps maintain healthy nutrient balance in streams and averts eutrophic (or overgrown algae) conditions which deplete oxygen. Large oxygen concentrations are necessary for good cold water fisheries.
- FLOOD STORAGE: Low-lying reaches of riparian vegetation provide natural zones for flood inundation that would otherwise incur damages if developed. These areas provide natural "breathing" space for flood swollen streams which otherwise could increase physical property loss.
- PREVENTION OF OVERLAND EROSION: Rooted vegetation constricts overland drainage that could carry away valuable topsoil and nuisance sediment which eventually are discharged into streams.
- WILDLIFE HABITAT: Terrestrial (land) and aquatic animals are dependent on stream flow and vegetation. Plants and water form the basic food chain components for all organisms.

VEGETATIVE (FLORAL) COMMUNITIES

The composition and percentage of vegetative cover was taken from soil conservation service mapping units. Individual soil mapping units are further grouped into general "rangesites" which are characterized by certain plant species. Plants are divided into four categories; trees, shrubs, grasses, and forbs. Cover percentage is estimated, and species variation is broad. Ornamental species have replaced much native streamside species, particularly where creeks are heavily channelized by residential land use.

Figure 14 indicates the limits of different soil and rangesite boundaries, and Table 10 enumerates those soil categories occurring on lower, middle, and upper stream reaches, and indicates which rangesite and

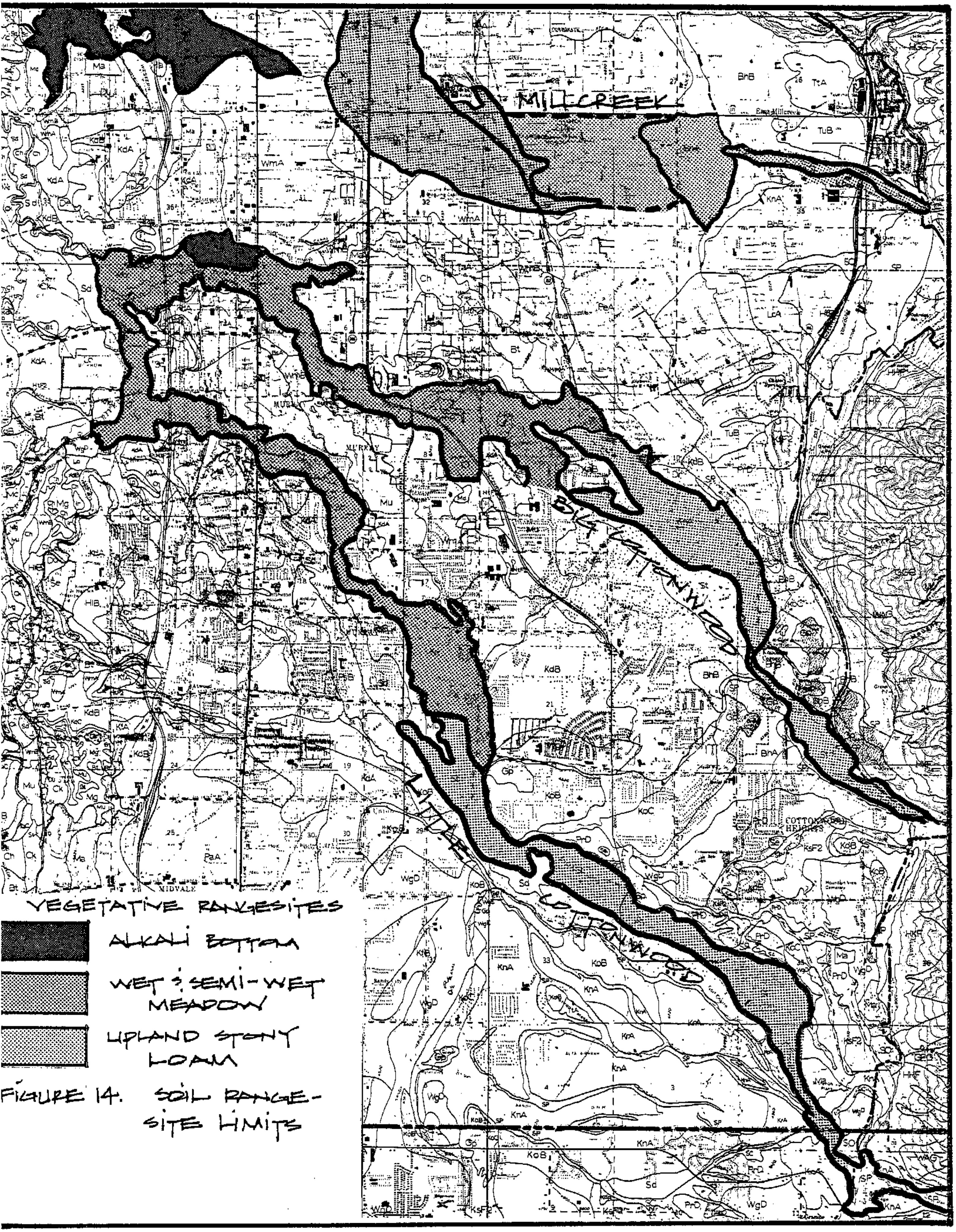


FIGURE 14. SOIL RANGE-SITE LIMITS

TABLE 10 CREEK SOIL MAPPING UNITS GROUPED BY REACH AND RANGESITE VEGETATIVE COMMUNITIES

VEGETATIVE RANGESITE	LOWER			MIDDLE			UPPER		
	M C	B C	L C	M C	B C	L C	M C	B C	L C
ALKALI BOTTOMS Trees (5%) Cottonwood, Russian Olive. Shrubs (20%) Nuttal Saltbush, Four-wing Saltbush, Bud Sagebrush, Gardner Saltbush, Winterfat, Greasewood, Rubber Rabbitbrush, Iodinebush, Big Sagebrush. Grasses (80%) Alkali Bluegrass, Alkali Cordgrass, Alkali Sacaton, Great Basin Wildrye, Creeping Wildrye, Native Bluegrass, Needle & Thread, Saltgrass, Foxtail, Squirreltail, Sedges, Rushes, Cattails, Cheatgrass,. Forbs (5%) Native Clover, Globemallow, Bassia, Pickleweed, Annual Kochia.	Ch Ck								
WET MEADOW Trees (5%) Willow, Hawthorn, River Birch, Cottonwood. Shrubs (5%) Willows, Wild Rose, Dogwood, Hawthorn. Grasses (85%) Rushes, Sedges, Saltgrass, Rubber Rabbitbrush, Slender Wheatgrass, Tall Native Bluegrass, Tufted Hairgrass, Redtop, Alkali Sacton, Foxtail, Wiregrass, Squirreltail, Western Wheatgrass, Great Basin Wildrye, Cattail, Arrowgrass, Horsetail. Forbs (5%) Yarrow, Dandelion, Plantain, Black Medic, Cinquefoil, Curly Dock, Native Clover.	Mc Ir								
SEMI-WET MEADOW Trees (5%) Willow, Hawthorn, Cottonwood, River Birch, Box Elder, Russian Olive. Shrubs (5%) Wild Rose, Willows, Hawthorn. Grasses (85%) Tufted Hairgrass, Native Bluegrasses, Alkali Sacaton, Redtop, Slender Wheatgrass, Timothy, Saltgrass, Kentucky Bluegrass, Squirreltail, Sandberg Bluegrass, Sedges, Baltic Rush, Western Wheatgrass and Great Basin Wildrye. Forbs (5%) Aster, False Solomon's Seal, Native Clover, Dandelion, Curly Dock, Dutch Clover, Yarrow, Canada Thistle, Bullthistle.		Mu	Mu			Sd			
UPLAND LOAM Trees (5%) Cottonwood, River Birch, Box Elder, Hawthorn Shrubs (25%) Serviceberry, Snowberry, Bitterbrush, Big Sagebrush, Shrubby Buckwheat, Yellowbrush, Spinelss Horsebrush, Snakeweed. Grasses (60%) Bluebunch wheatgrass, Muttongrass, Nevada Bluegrass, Prairie Junegrass, Slender Wheatgrass, Indian Ricegrass, Needle & Thread, Dryland Sedge, Kentucky Bluegrass, Letterman Needlegrass, Squirreltail, Western Wheatgrass, Great Basin Wildrye, Sandberg Bluegrass. Forbs (15%) Hawksbeard, Globemallow, Balsam Root, Aster, Buckwheat, Herbaceous Sage, Lupine.				TaB PeA					
UPLAND STONY LOAM Trees (5%) Cottonwood, River Birch, Box Elder, Hawthorn Shrubs (30%) Bitterbrush, Snowberry, Serviceberry, Big Sagebrush, Shrubby Buckwheat, Yellowbrush, Spineless, Horsebrush, Oregon Grape, Squawbush, Oakbrush. Grasses (55%) Tall Native Bluegrass, Prairie Junegrass, Oniongrass, Slender wheatgrass, bluebunch wheatgrass, Indian Ricegrass, Needle & Thread, Sand Dropseed, Dryland Sedge, Letterman Needlegrass, Squirreltail, Sandberg Bluegrass, Kentucky Bluegrass, Great Basin Wildrye, Western Wheatgrass. Forbs (15%) Hawksbeard, Globemallow, Balsamroot, Herbaceous Sage, Buckwheat, Lupine, Segolily, Phlox, Peavine, Locoweed. Rock Golden Rod.				BhA SP	KhA St	St	St.	St	SP

SOILS KEY:

- Ch - Chipman Silty Clay Loam
- Ck - Chipman Silty Clay Loam (Saline Alkali)
- Mc - Magna Silty Clay
- Ir - Ironton Loam
- Mu - Mixed Alluvial Land
- Sd - Sandy Alluvial Land
- SP - Stony Terrace Escarpments
- TaB - Taylorsville Silty Clay Loam
- PeA - Parleys Silt Loam
- BhA - Bingham Gravelly Loam
- KnA - Knutsen Coarse Sandy Loam
- St - Stony Alluvial Land

vegetative community is dominant. Figure 15 also identifies primary aquatic plants inventoried by the Utah State Division of Wildlife Resources.

TERRESTRIAL AND AQUATIC (FAUNAL) COMMUNITIES

The various species of birds, reptiles, amphibians, and mammals are identified by major ecosystem and communities within the ecosystems.[26] Figure 16 shows the boundaries of the major wildlife ecosystems while Appendix 2 lists the species known to occur within the ecosystem communities.

Brief explanation is necessary on the ecosystem/community framework. Site-specific assessment of the three valley tributary segments found instances where vegetation density and diversity were locally representative of ecosystems normally located at higher altitudes. For example, upper reaches of Millcreek, Big Cottonwood, and Little Cottonwood appear to be extensions of the Lower Montane Ecosystem. Upper Millcreek (Highland Drive to Canyon Entry), Mid to Upper Big Cottonwood (Highland Drive to Canyon Entry) and Upper Little Cottonwood (Wasatch Boulevard to Canyon Entry) reaches display characteristics of the streamside woods/thickets community, more so than those of the grass-sagebrush community or ecosystem.

It should be noted that the influence of the Great Salt Lake Desert Ecosystem 2, displayed by marsh community wildlife habitants ends between 700 East and 1300 East. It is likely that more mobile wildlife forms - mainly birds - inhabit this broad community extension within the riparian vegetation boundaries. Lower creek reaches may provide greater opportunities for enjoyment of more diversified bird species.

- FISHERIES:

In view of the flow stabilities for 75% of all creek reaches, and the quality of those flows, surprisingly little is known about present fish species density and diversity. The Utah Division of Wildlife Resources (DWR)

FIGURE FIFTEEN

LEGEND

RIPARIAN VEGETATION & HABITAT

LIMITS OF OVERSTORY RIPARIAN VEGETATION ZONE:

LIMITS (ESTIMATED) OF STREAM SEGMENT SUITABLE FOR OR PRODUCING FISHERY:

HABITAT RESTORATION SEGMENT:

RIPARIAN VEGETATION & HABITAT:
Jordan River to W. Temple

BOTTOM TYPE:

		Boulders	%
Rubble	25 %	Gravel	12 %
Sand	4 %	Silt	59 %

BANK COVER COMPOSITION: Russian Olive, Willows, Whitetop, Cheatgrass

% BANK STABILIZATION: LB=80% RB=60%

% STREAM SHADED: LB=58% RB=18%

HABITAT CONSTRAINTS: Silt & nutrient pollution in moderate amounts. Litter degrades aesthetics.

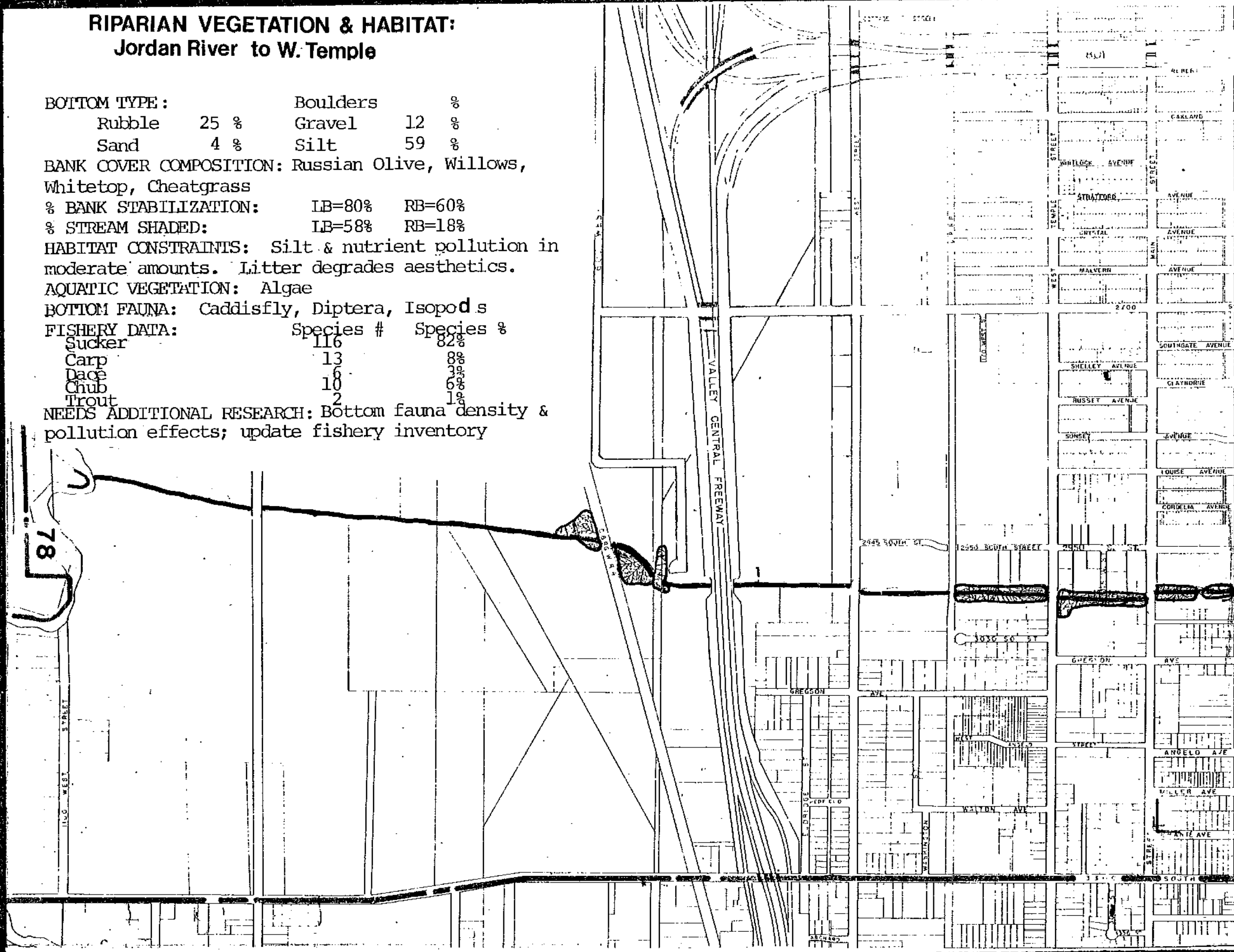
AQUATIC VEGETATION: Algae

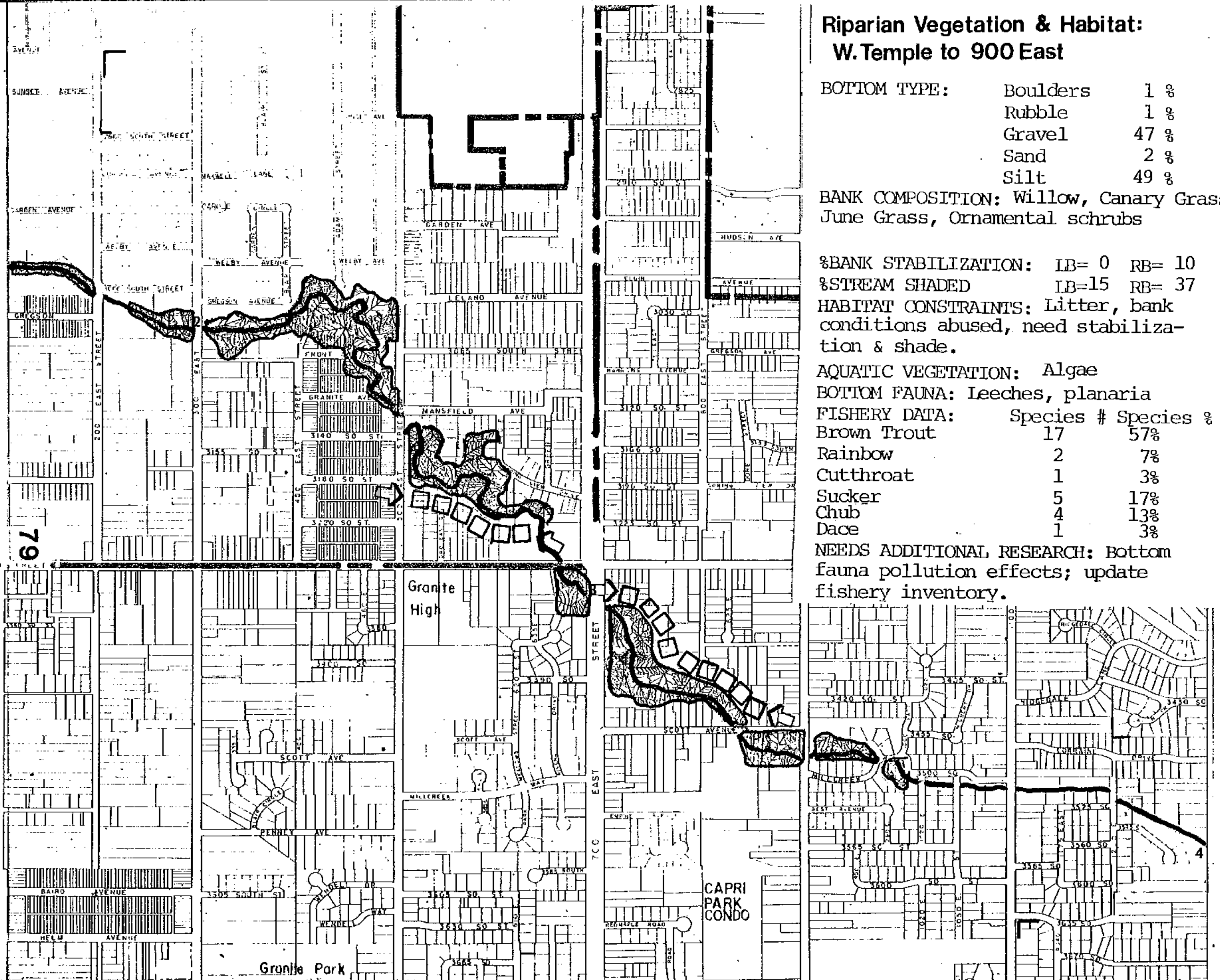
BOTTOM FAUNA: Caddisfly, Diptera, Isopods

FISHERY DATA:

	Species #	Species %
Sucker	116	82%
Carp	13	8%
Dace	6	3%
Chub	10	6%
Trout	2	1%

NEEDS ADDITIONAL RESEARCH: Bottom fauna density & pollution effects; update fishery inventory





Riparian Vegetation & Habitat: W. Temple to 900 East

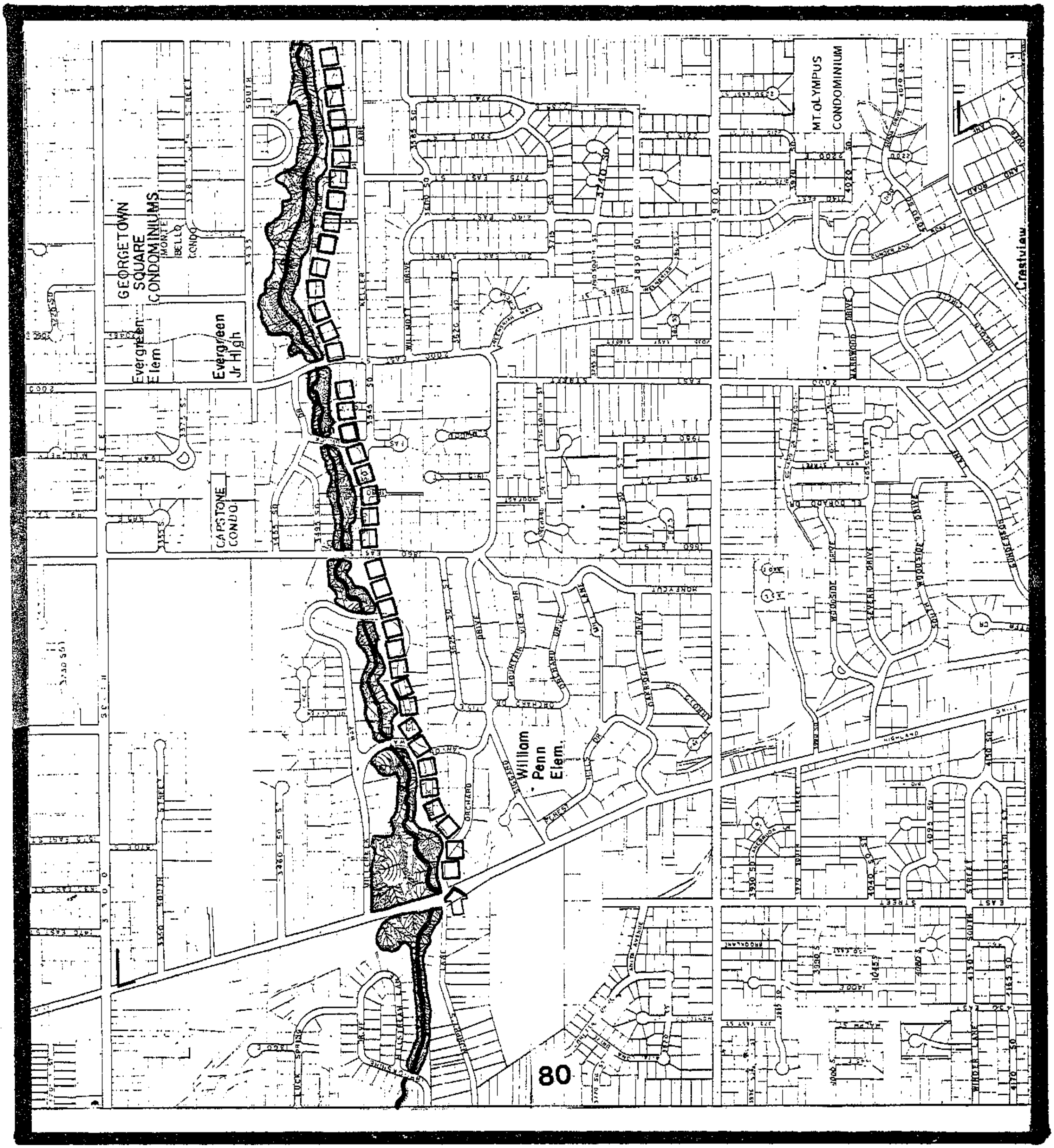
BOTTOM TYPE:	Boulders	1 %
	Rubble	1 %
	Gravel	47 %
	Sand	2 %
	Silt	49 %

BANK COMPOSITION: Willow, Canary Grass June Grass, Ornamental schrubs

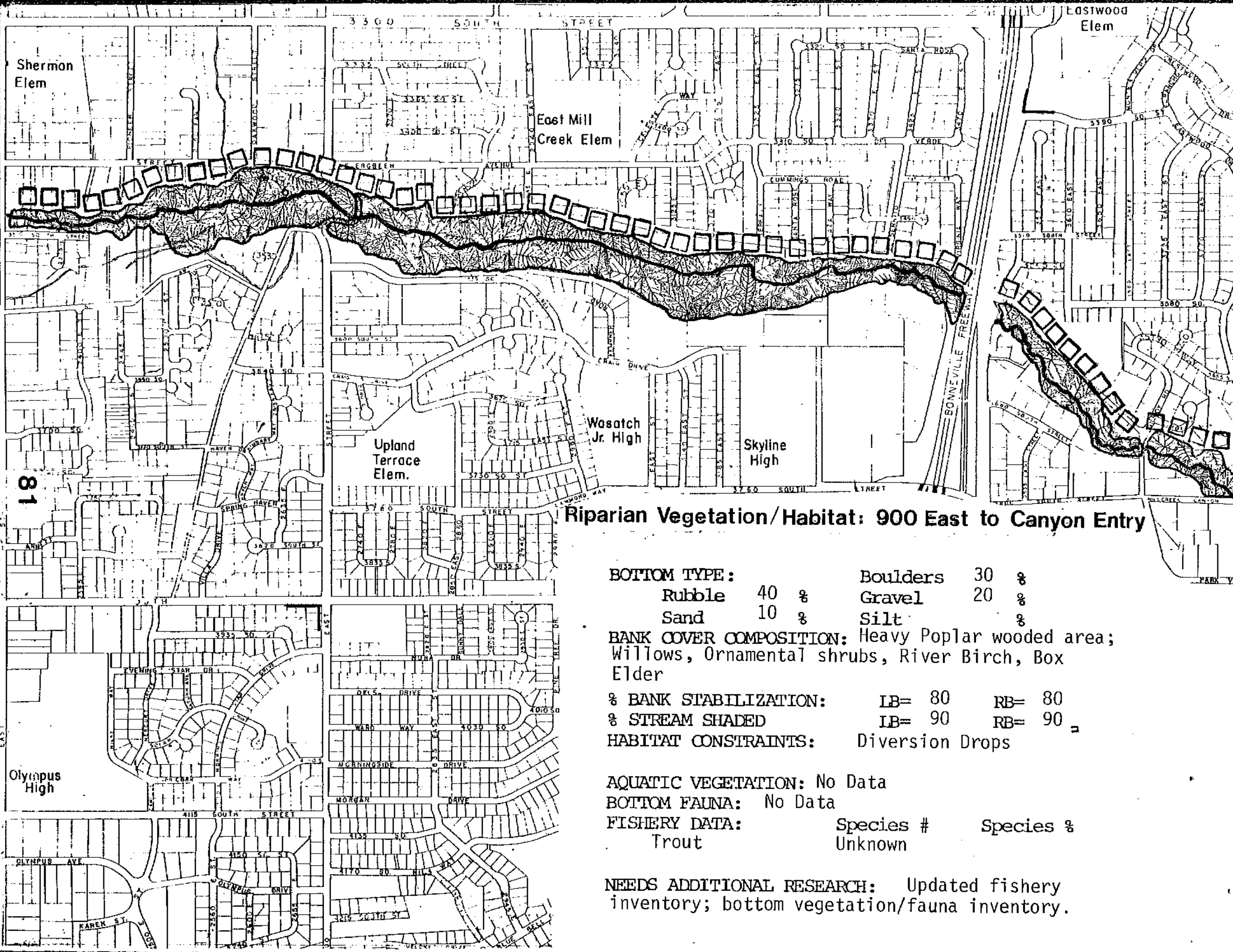
%BANK STABILIZATION: LB= 0 RB= 10
%STREAM SHADED LB=15 RB= 37
HABITAT CONSTRAINTS: Litter, bank conditions abused, need stabilization & shade.
AQUATIC VEGETATION: Algae
BOTTOM FAUNA: Leeches, planaria

FISHERY DATA:	Species #	Species %
Brown Trout	17	57%
Rainbow	2	7%
Cutthroat	1	3%
Sucker	5	17%
Chub	4	13%
Dace	1	3%

NEEDS ADDITIONAL RESEARCH: Bottom fauna pollution effects; update fishery inventory.



GEORGETOWN SQUARE CONDOMINIUMS
MONTE BELLO CONDO
Evergreen Elem
Evergreen Jr High
CAPSTONE CONDO
William Penn Elem.
MT. OLYMPUS CONDOMINIUM
Crestview



Riparian Vegetation/Habitat: 900 East to Canyon Entry

BOTTOM TYPE:		Boulders	30 %
Rubble	40 %	Gravel	20 %
Sand	10 %	Silt	%

BANK COVER COMPOSITION: Heavy Poplar wooded area; Willows, Ornamental shrubs, River Birch, Box Elder

% BANK STABILIZATION:	LB= 80	RB= 80
% STREAM SHADED	LB= 90	RB= 90

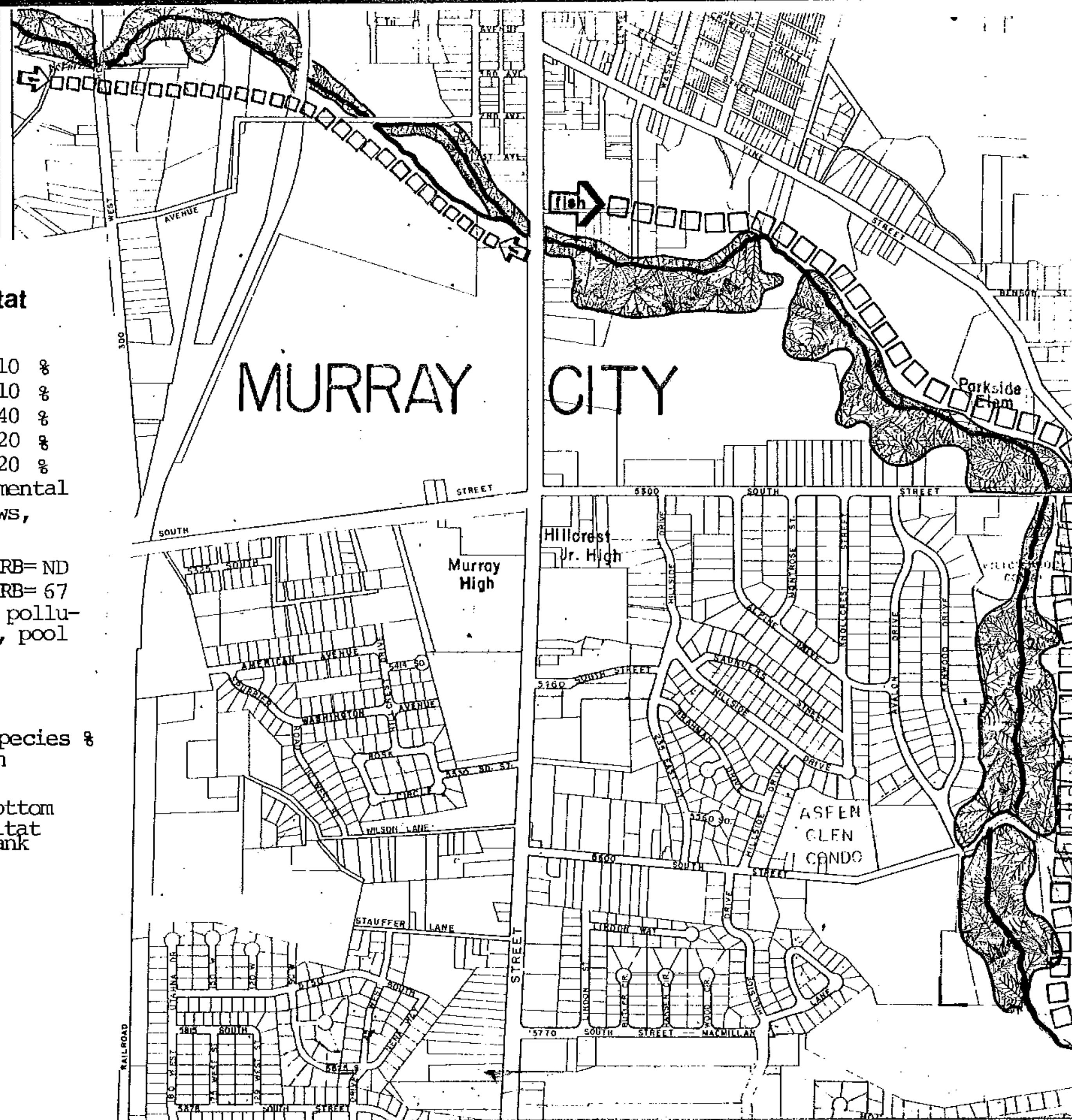
HABITAT CONSTRAINTS: Diversion Drops

AQUATIC VEGETATION: No Data

BOTTOM FAUNA: No Data

FISHERY DATA:	Species #	Species %
Trout	Unknown	

NEEDS ADDITIONAL RESEARCH: Updated fishery inventory; bottom vegetation/fauna inventory.



Riparian Vegetation & Habitat Jordan River to 900 East

BOTTOM TYPE:	Boulders	10 %
	Rubble	10 %
	Gravel	40 %
	Sand	20 %
	Silt	20 %

BANK COMPOSITION: Mostly ornamental shrubs, Russian Olive, Willows, Poplar, Native Grass

%BANK STABILIZATION: LB= ND RB= ND

%STREAM SHADED LB= 61 RB= 67

HABITAT CONSTRAINTS: Possible pollution effects on bottom fauna, pool & riffle ratio imbalance.

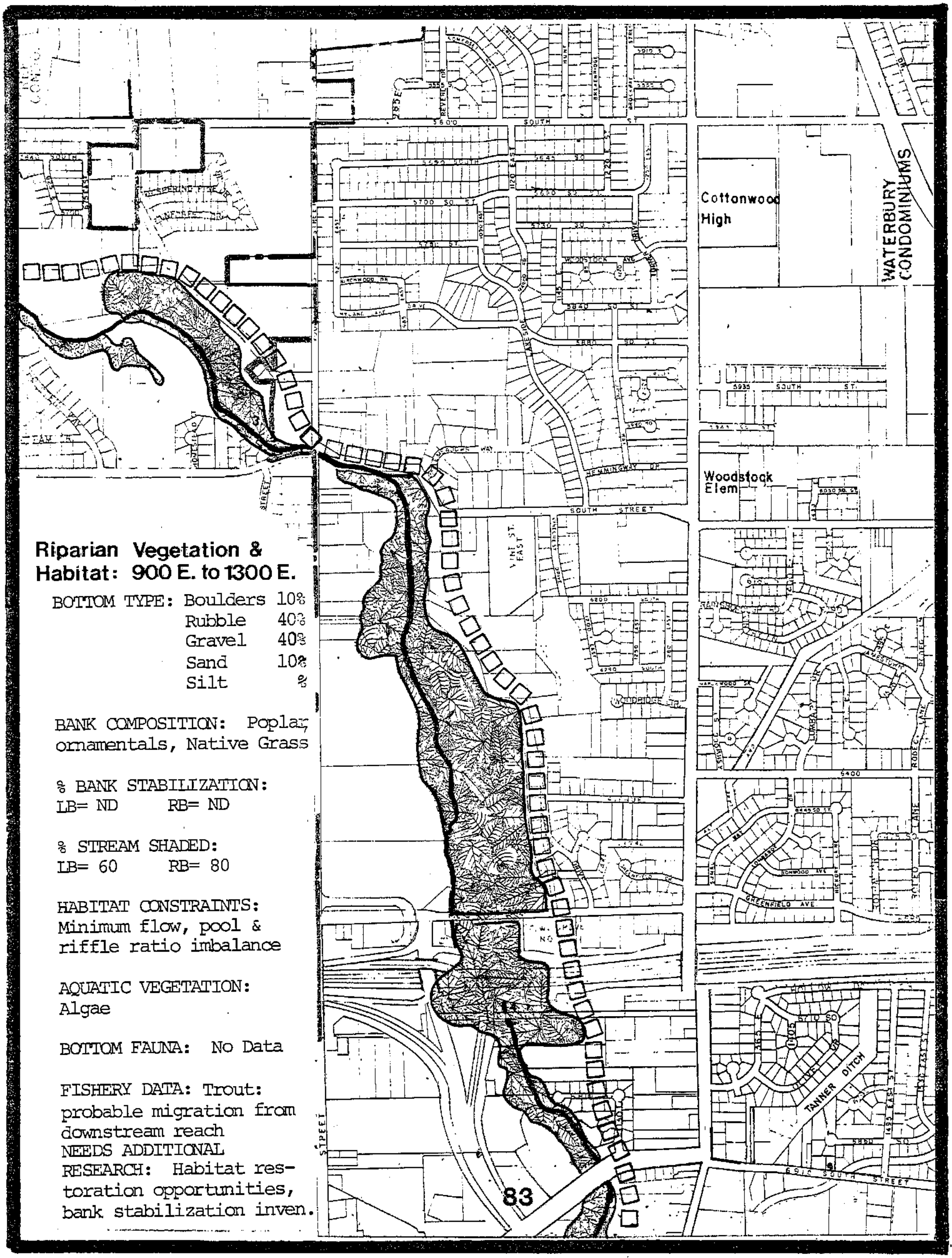
AQUATIC VEGETATION: Algae

BOTTOM FAUNA: No data

FISHERY DATA: Species # Species %

Trout: Stocked annually with rainbow at 5000 South.

NEEDS ADDITIONAL RESEARCH: Bottom fauna pollution effects; habitat restoration opportunities; bank stabilization inventory.



Riparian Vegetation & Habitat: 900 E. to 1300 E.

BOTTOM TYPE: Boulders 10%
Rubble 40%
Gravel 40%
Sand 10%
Silt %

BANK COMPOSITION: Poplar, ornamentals, Native Grass

% BANK STABILIZATION:
LB= ND RB= ND

% STREAM SHADED:
LB= 60 RB= 80

HABITAT CONSTRAINTS:
Minimum flow, pool & riffle ratio imbalance

AQUATIC VEGETATION:
Algae

BOTTOM FAUNA: No Data

FISHERY DATA: Trout: probable migration from downstream reach

NEEDS ADDITIONAL RESEARCH: Habitat restoration opportunities, bank stabilization inven.

Riparian Vegetation & Habitat
1300 E. to Creek Road:

BOTTOM TYPE: Boulders 10 %
Rubble 60 % Gravel 20 %
Sand 10 % Silt %

BANK COVER COMPOSITION: Poplar & Native Grasses

% BANK STABILIZATION: LB= ND RB= ND
% STREAM SHADED LB= 80% RB= 80%

HABITAT CONSTRAINTS: Minimum flows, pool & riffle ratio imbalance, flood control maint.

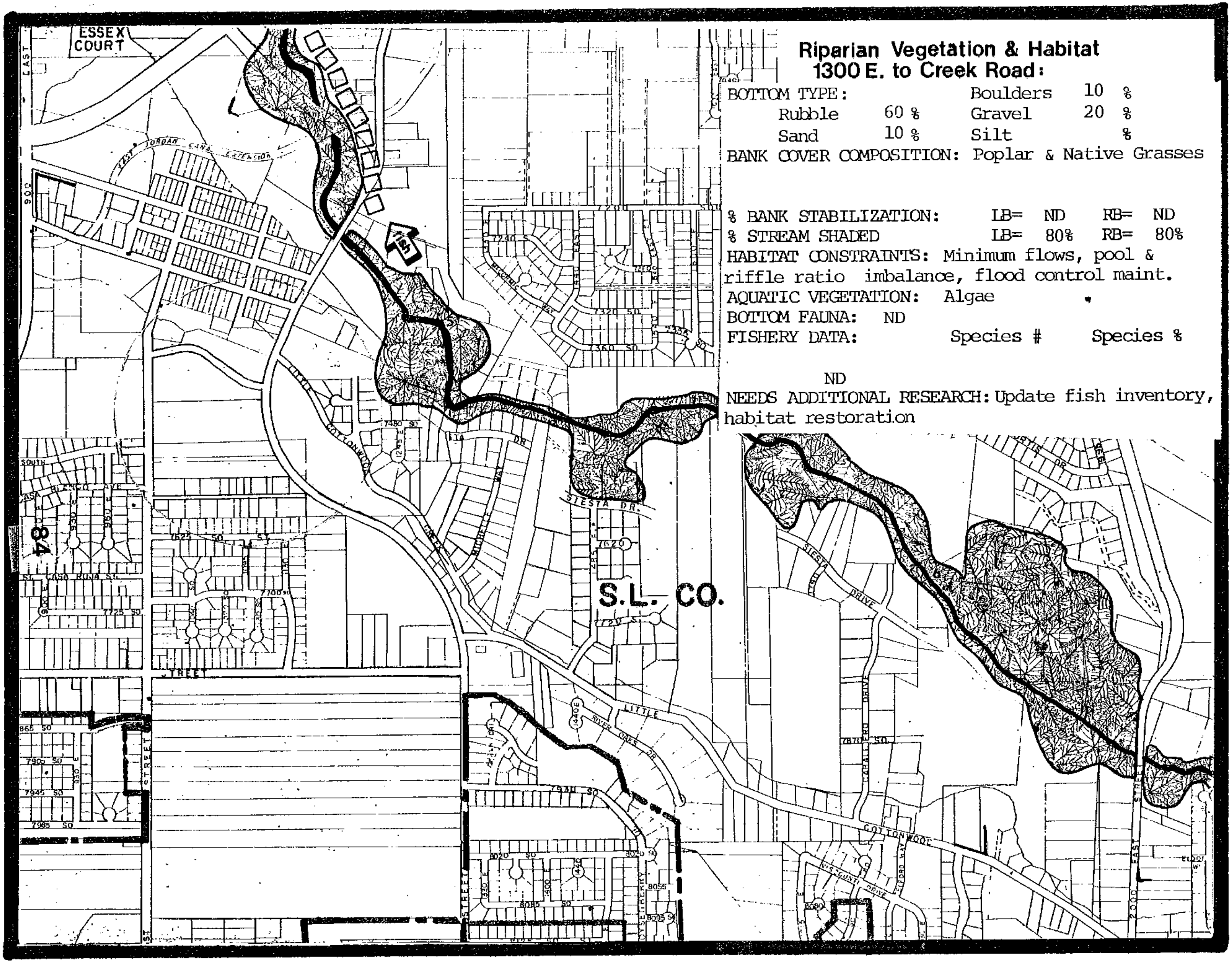
AQUATIC VEGETATION: Algae

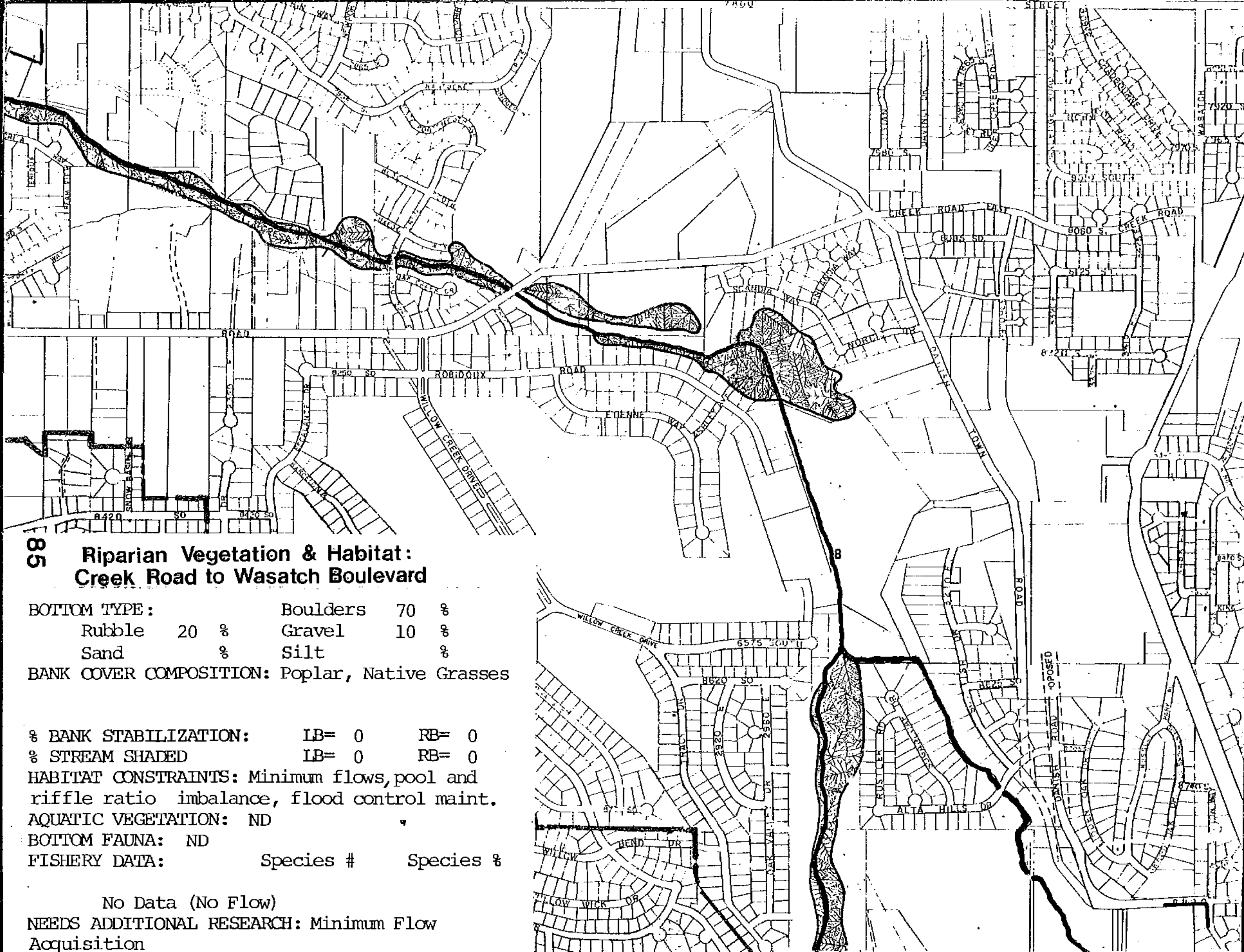
BOTTOM FAUNA: ND

FISHERY DATA: Species # Species %

ND

NEEDS ADDITIONAL RESEARCH: Update fish inventory, habitat restoration





85

Riparian Vegetation & Habitat: Creek Road to Wasatch Boulevard

BOTTOM TYPE: Boulders 70 %
Rubble 20 % Gravel 10 %
Sand % Silt %
BANK COVER COMPOSITION: Poplar, Native Grasses

% BANK STABILIZATION: LB= 0 RB= 0
% STREAM SHADED LB= 0 RB= 0
HABITAT CONSTRAINTS: Minimum flows, pool and riffle ratio imbalance, flood control maint.
AQUATIC VEGETATION: ND
BOTTOM FAUNA: ND
FISHERY DATA: Species # Species %

No Data (No Flow)

NEEDS ADDITIONAL RESEARCH: Minimum Flow Acquisition

Riparian Vegetation & Habitat: Wasatch Boulevard to Canyon Entry

BOTTOM TYPE:

Rubble	49	%	Boulders		%
Sand		%	Gravel	9	%
			Silt		%

BANK COVER COMPOSITION: Birch, Cottonwood, Dogwood, Native Grass

% BANK STABILIZATION:	LB= 40	RB= 60
% STREAM SHADED	LB= 76	RB= 84

HABITAT CONSTRAINTS: Minimum Flows

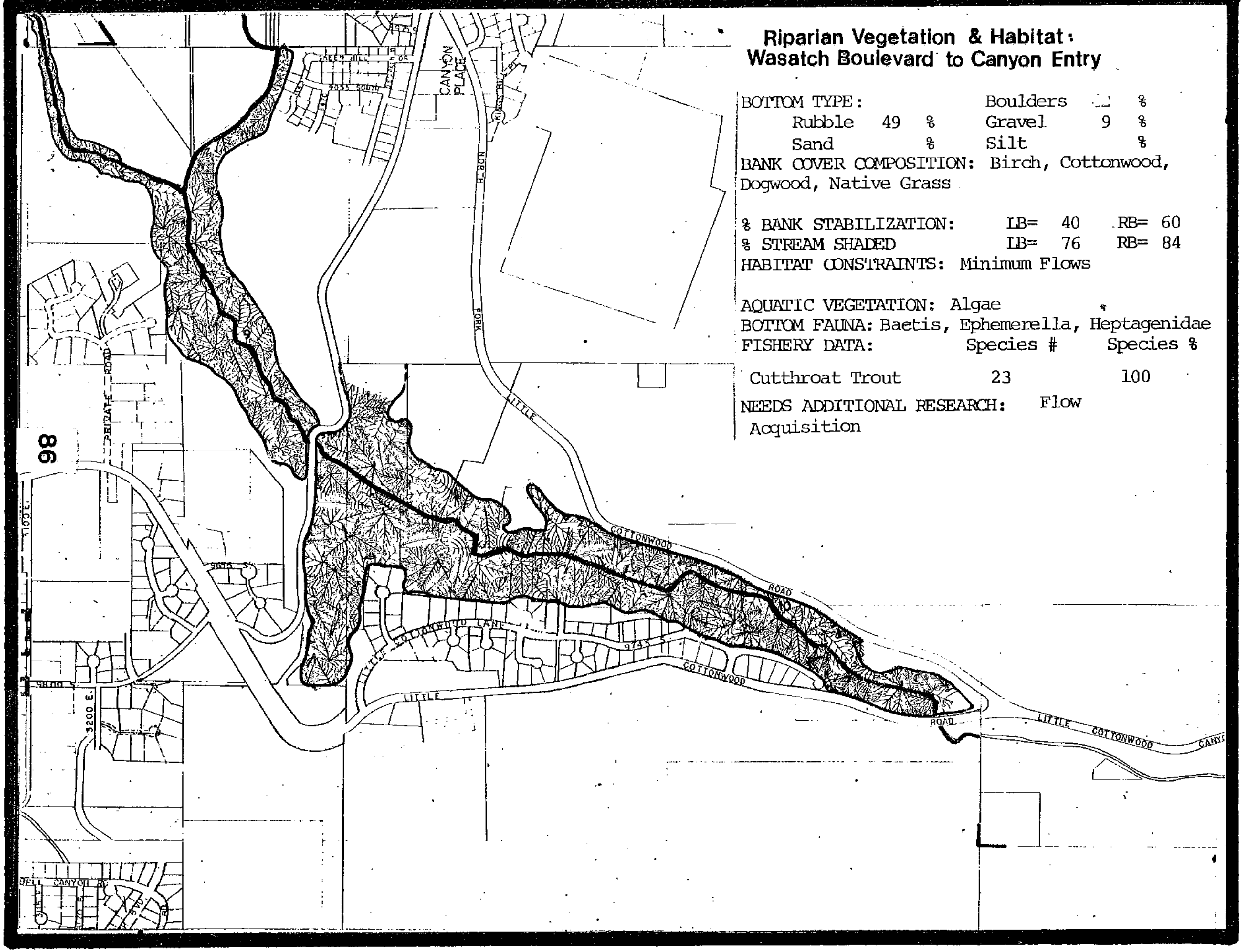
AQUATIC VEGETATION: Algae

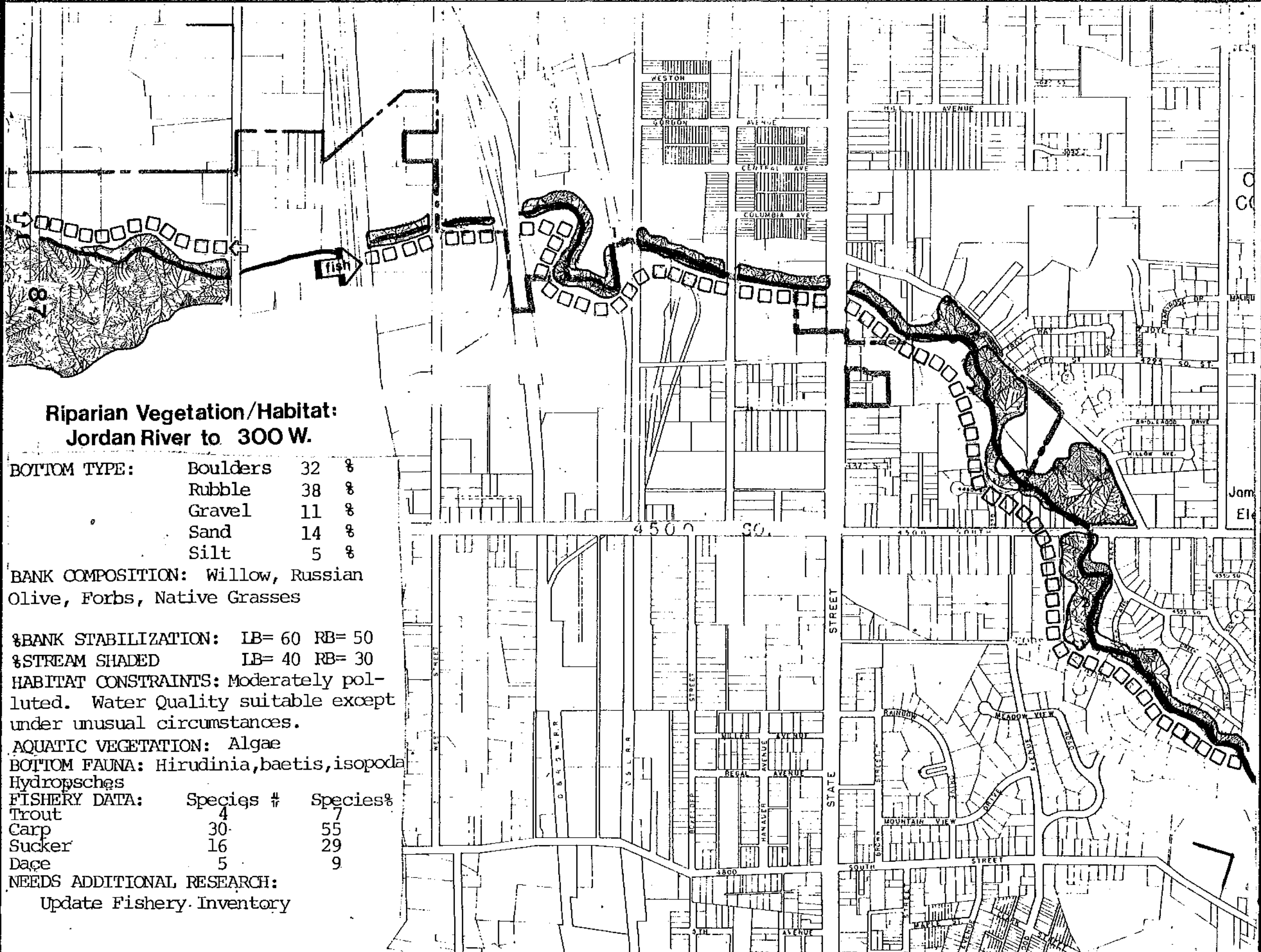
BOTTOM FAUNA: Baetis, Ephemerella, Heptagenidae

FISHERY DATA:

	Species #	Species %
Cutthroat Trout	23	100

NEEDS ADDITIONAL RESEARCH: Flow Acquisition





Riparian Vegetation/Habitat: Jordan River to 300 W.

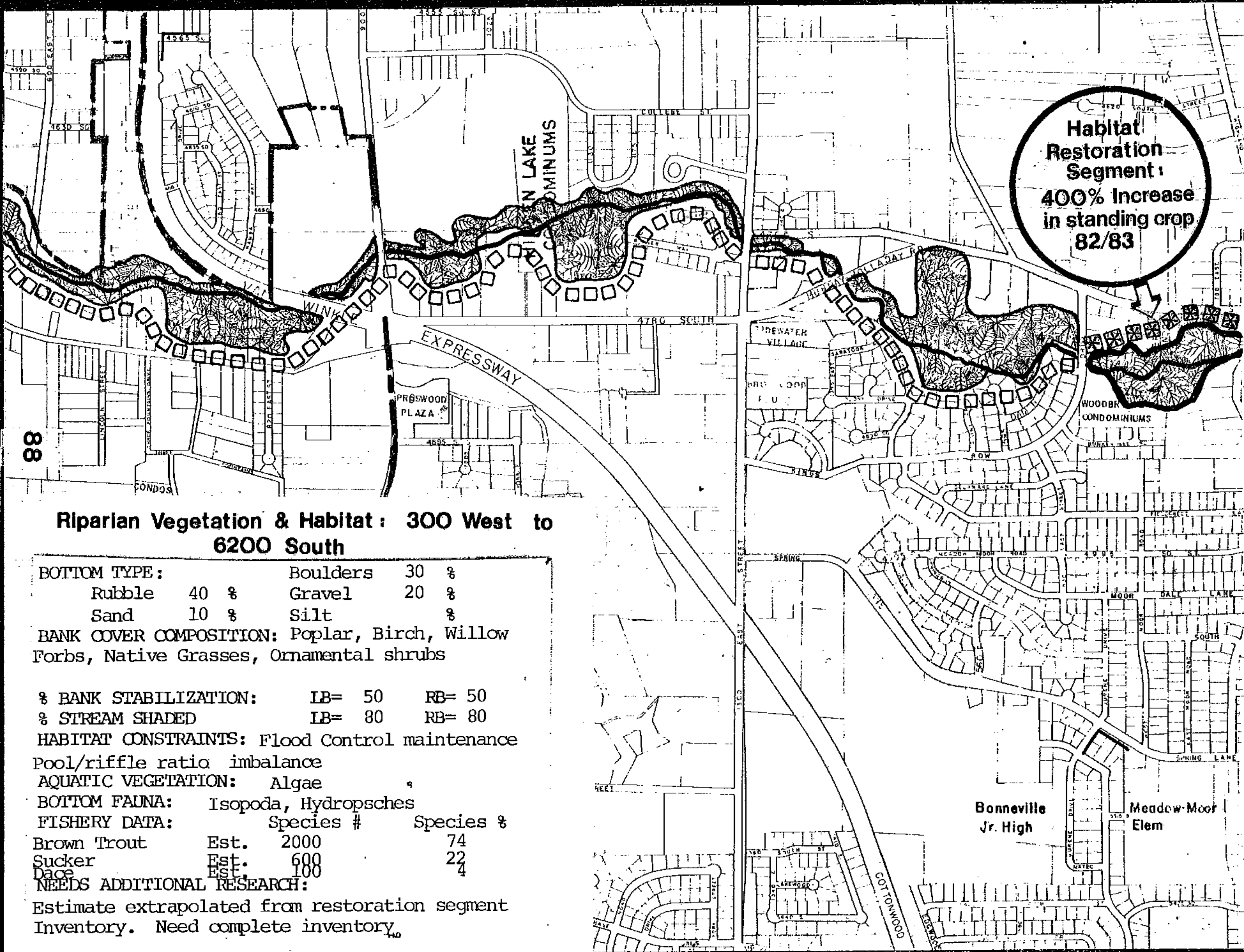
BOTTOM TYPE:	Boulders	32	%
	Rubble	38	%
	Gravel	11	%
	Sand	14	%
	Silt	5	%

BANK COMPOSITION: Willow, Russian Olive, Forbs, Native Grasses

%BANK STABILIZATION: LB= 60 RB= 50
%STREAM SHADED LB= 40 RB= 30
HABITAT CONSTRAINTS: Moderately polluted. Water Quality suitable except under unusual circumstances.
AQUATIC VEGETATION: Algae
BOTTOM FAUNA: Hirudinia, baetis, isopoda
Hydropsches

FISHERY DATA:	Species #	Species%
Trout	4	7
Carp	30	55
Sucker	16	29
Dace	5	9

NEEDS ADDITIONAL RESEARCH:
Update Fishery Inventory



Riparian Vegetation & Habitat: 300 West to 6200 South

BOTTOM TYPE:			Boulders	30 %
Rubble	40 %		Gravel	20 %
Sand	10 %		Silt	%

BANK COVER COMPOSITION: Poplar, Birch, Willow Forbs, Native Grasses, Ornamental shrubs

% BANK STABILIZATION:	LB= 50	RB= 50
% STREAM SHADED	LB= 80	RB= 80

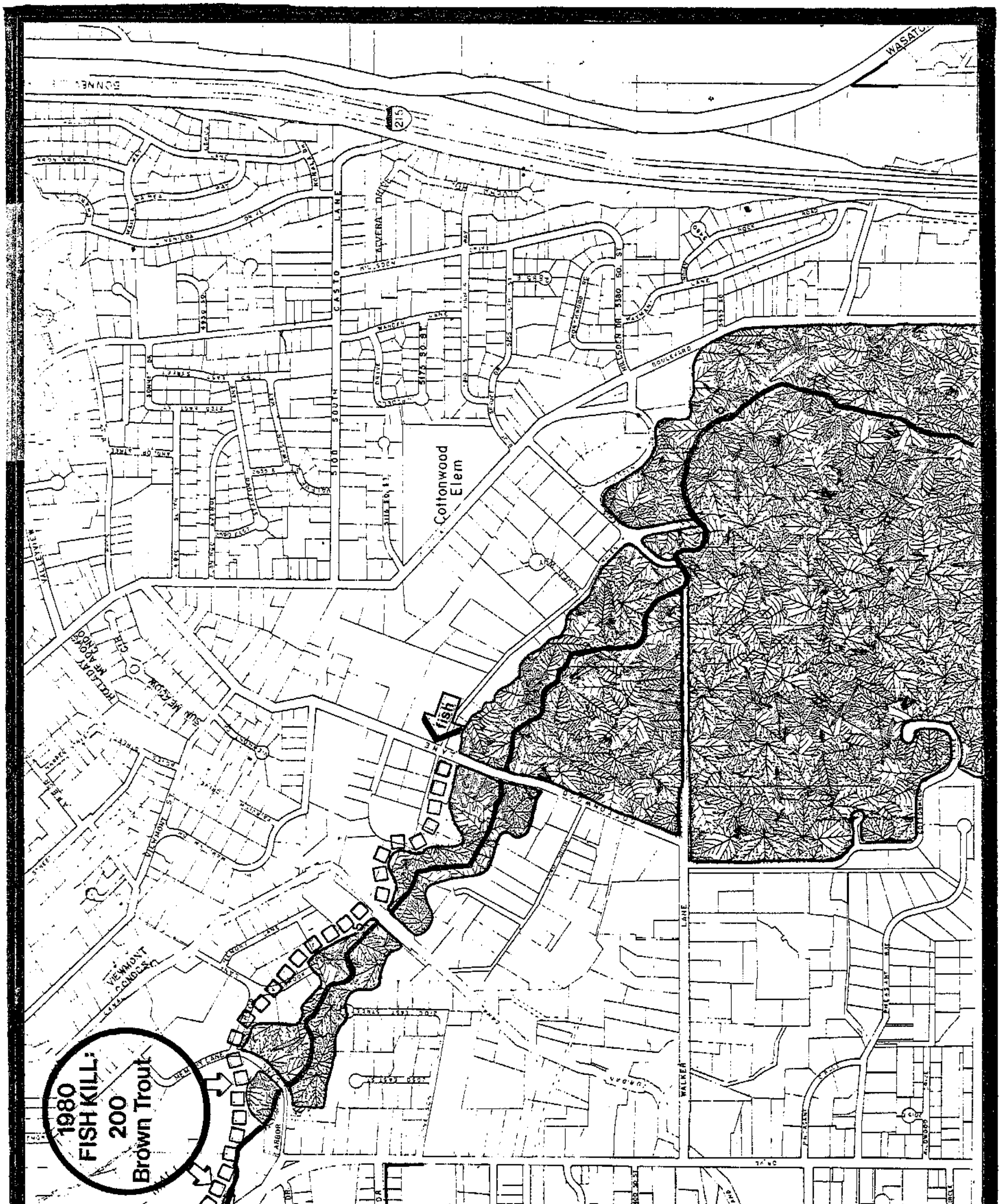
HABITAT CONSTRAINTS: Flood Control maintenance Pool/riffle ratio imbalance

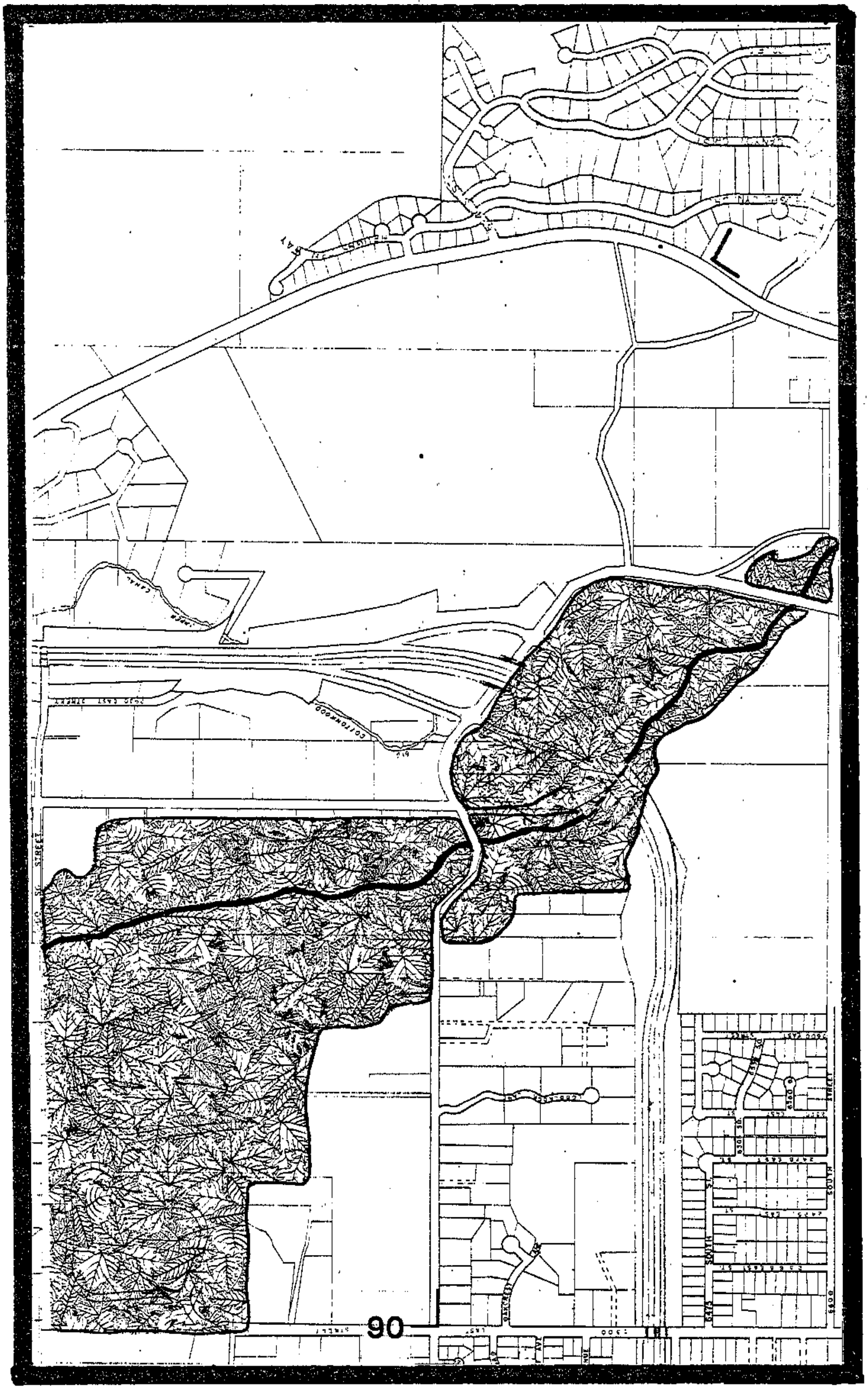
AQUATIC VEGETATION: Algae

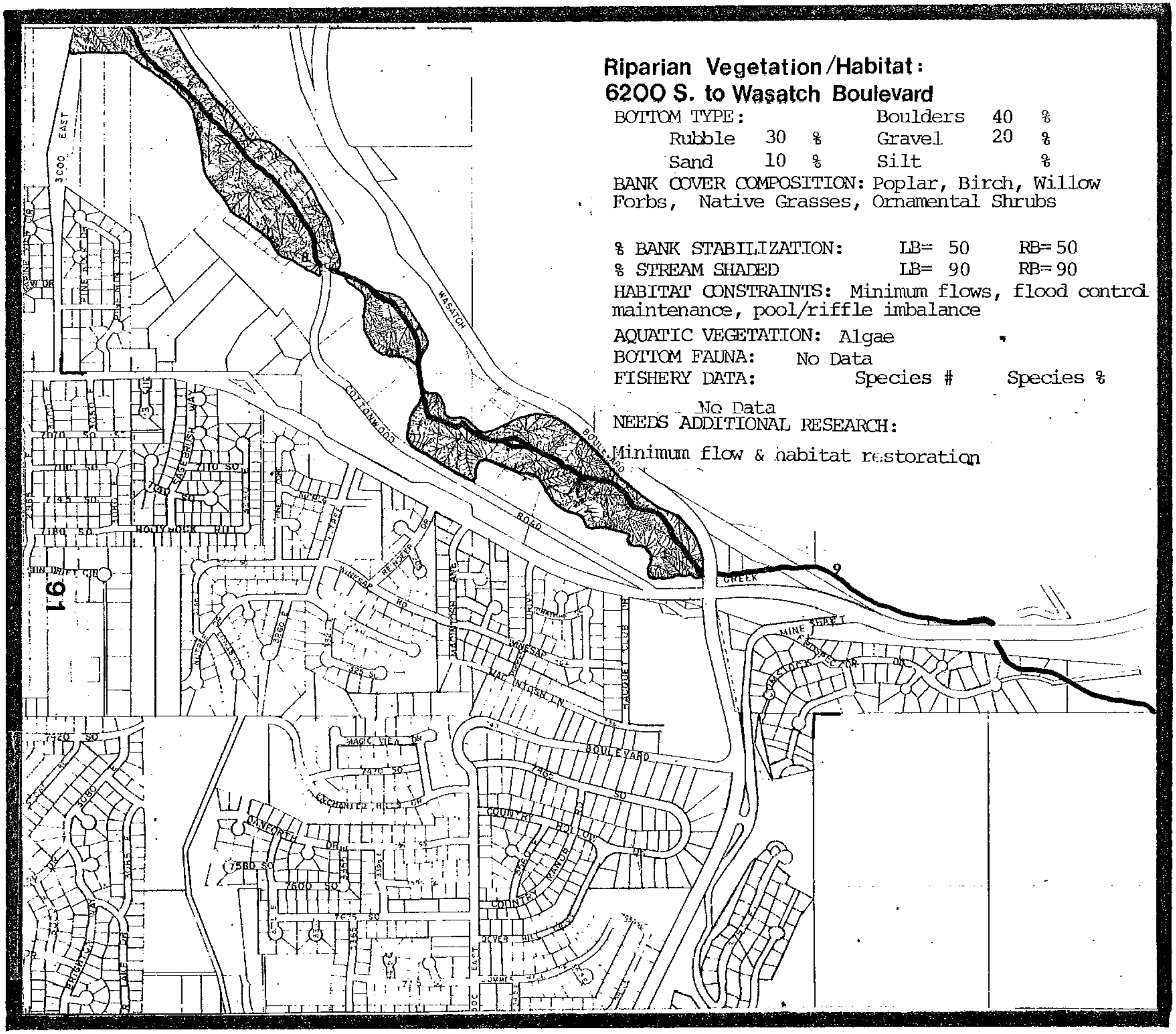
BOTTOM FAUNA: Isopoda, Hydropsches

FISHERY DATA:		Species #	Species %
Brown Trout	Est.	2000	74
Sucker	Est.	600	22
Dace	Est.	100	4

NEEDS ADDITIONAL RESEARCH:
Estimate extrapolated from restoration segment Inventory. Need complete inventory.


1980 FISH KILL: 200 Brown Trout
fish
Cottonwood Elem
COTTONWOOD
CASTO LANE
5100 SOUTH
WALKER LANE
215





Riparian Vegetation/Habitat:
6200 S. to Wasatch Boulevard

BOTTOM TYPE:			Boulders	40	%
Rubble	30	%	Gravel	20	%
Sand	10	%	Silt		%

BANK COVER COMPOSITION: Poplar, Birch, Willow Forbs, Native Grasses, Ornamental Shrubs

% BANK STABILIZATION:	LB= 50	RB= 50
% STREAM SHADED	LB= 90	RB= 90

HABITAT CONSTRAINTS: Minimum flows, flood control maintenance, pool/riffle imbalance

AQUATIC VEGETATION: Algae

BOTTOM FAUNA: No Data

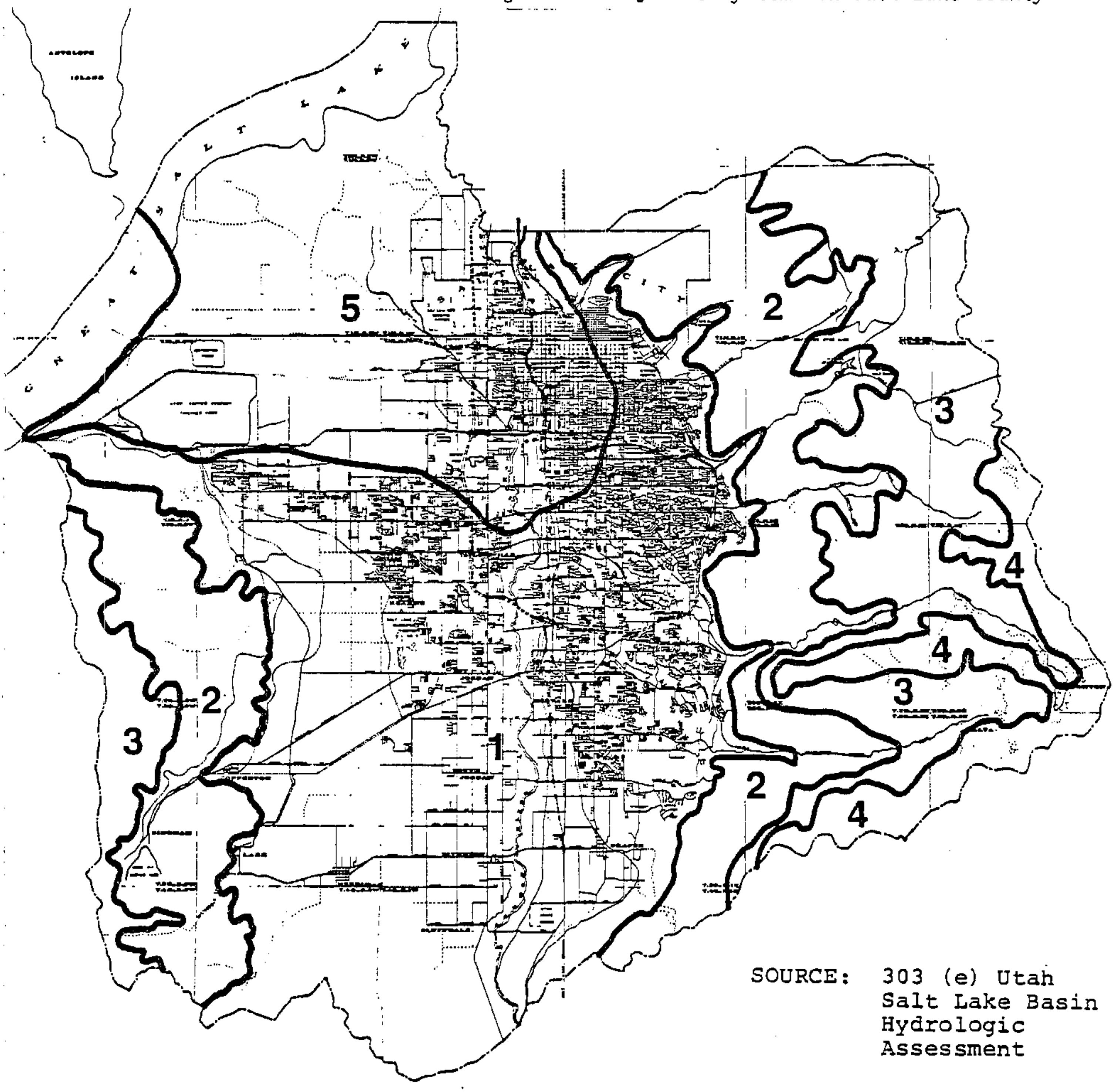
FISHERY DATA: Species # Species %

No Data

NEEDS ADDITIONAL RESEARCH:

Minimum flow & habitat restoration

Figure 16. Major Ecosystems in Salt Lake County



SOURCE: 303 (e) Utah Salt Lake Basin Hydrologic Assessment

1 Valley - Grass, Sagebrush
2 Lower Montane - Mountain Brush
3 Upper Montane - Aspen, Conifer
4 Subalpine & Alpine - Krumholz & Alpine Herb
5 Salt Desert - Saline Meadow

conducted limited stream surveys between 1974 and 1979, but concentrated only on 500 foot segment samples.[27] A comprehensive inventory has never been conducted by DWR. Volunteer creek investigators for Salt Lake County Flood Control/Water Quality inventoried and photographed Millcreek and Big Cottonwood in 1982 but did not sample stream aquatic vegetation, benthos, or species.[28] Further work in this area is needed, and may provide future cooperative project opportunities.

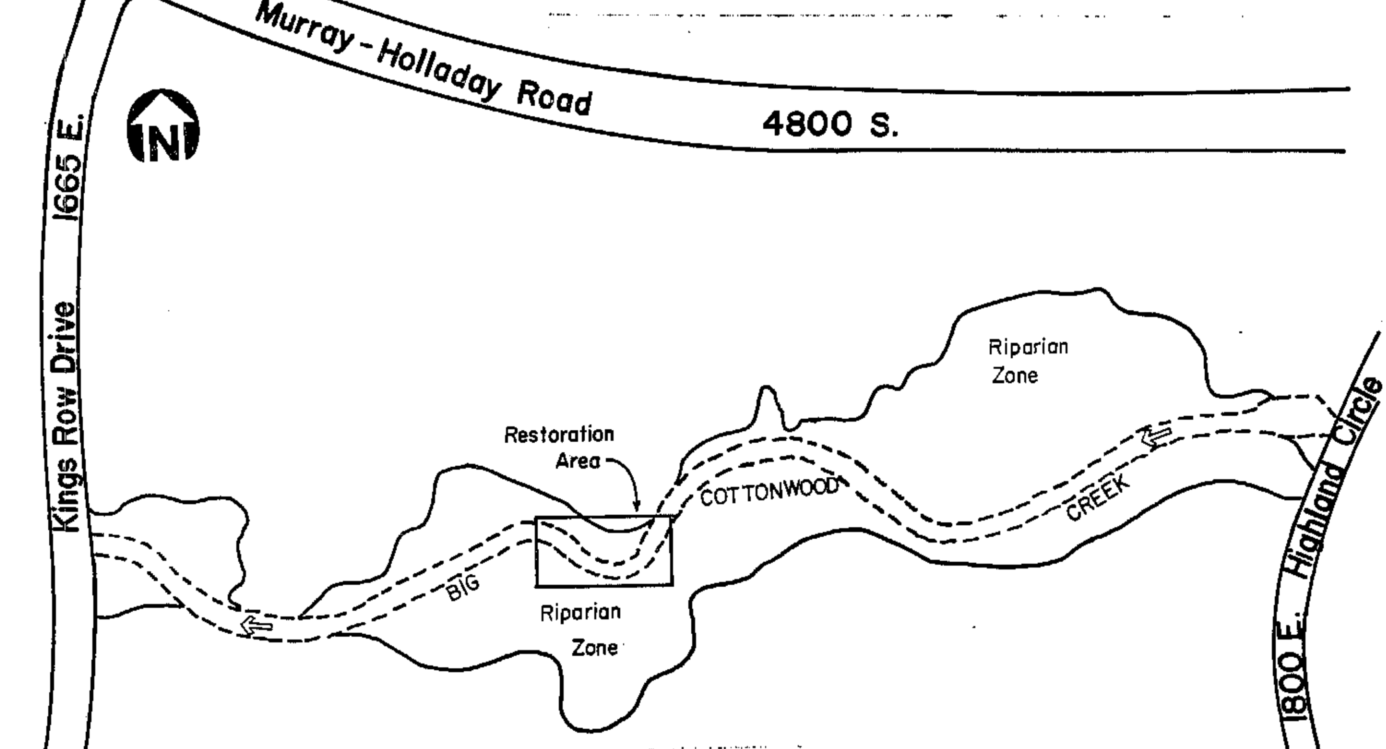
The data generated by both DWR and Salt Lake County is summarized in Figure 15. Examples of data sheets and stream inventory program - Habitat Restoration Components appear in Appendix 3.

A stream restoration reach was identified and implemented on Big Cottonwood Creek in 1982. Following dredging by Flood Control crews, the segment (approximately 1500 feet length) was electrically shocked by DWR and County personnel and species data recorded. The reach was then modified from a flat-bottom to habitable bottom with use of pools and boulder stream deflectors. After one season the reach was reshocked and reinventoried. Figure 17 shows the before-and-after results of the habitat restoration project. Based on standing crop yields within the project time period (one year), fish-count estimates were derived for the entire reach. The estimates documented in Figure 17 apply to the entire reach between 300 West and 6200 South.

In addition measuring standing fish crop, elevations and creek profiles were taken on the sections where deflectors were installed. Figure 18 represents before-and-after physical changes resulting within the one season period. Sediment accumulations were also measured.

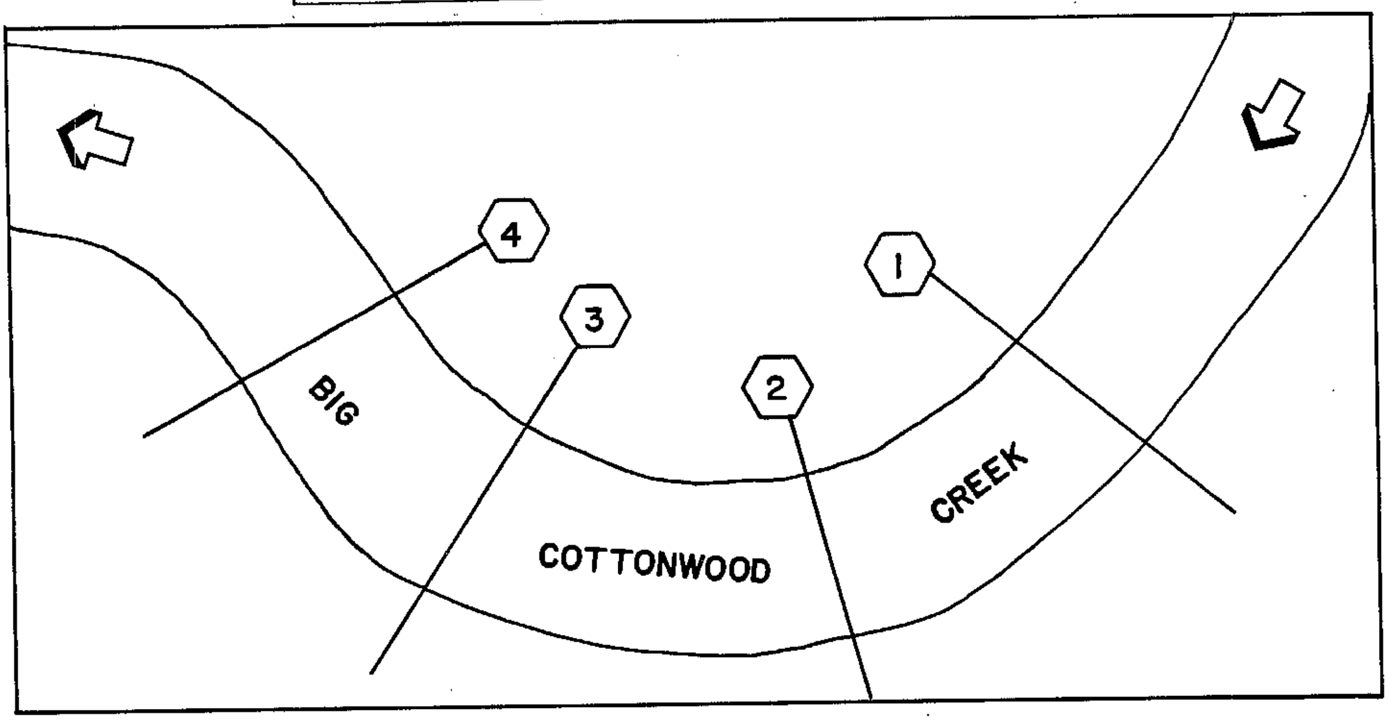
The results of the habitat restoration project have many implications to present stream management for County flood control. These are discussed

FIGURE 17. HABITAT RESTORATION EXPERIMENTAL SEGMENT AND MEASURED RESULTS



BIG COTTONWOOD CREEK HABITAT RESTORATION SEGMENT: STREAM INVENTORY 1983/84
(Post- Dredging conditions 82/Dredging Suspended 83)

1982 / 1983	Adult 8"-16"	Juvenile 4"- 8"	Fingerling 4"	Total
BROWN TROUT (Salmo Trutta)	6 / 17	/ 18	6 / 11	12 / 46
LONGNOSE DACE (Rhinichthys Sp.)		2 /		2 /
ROCKY MOUNTAIN SUCKER (Catostomus Platyrhynchus)		4 / 16	/ 7	4 / 23
CARP (Cyprinus Carpio)	/ 1			
TOTAL	6 / 18	6 / 34	6 / 18	18 / 70



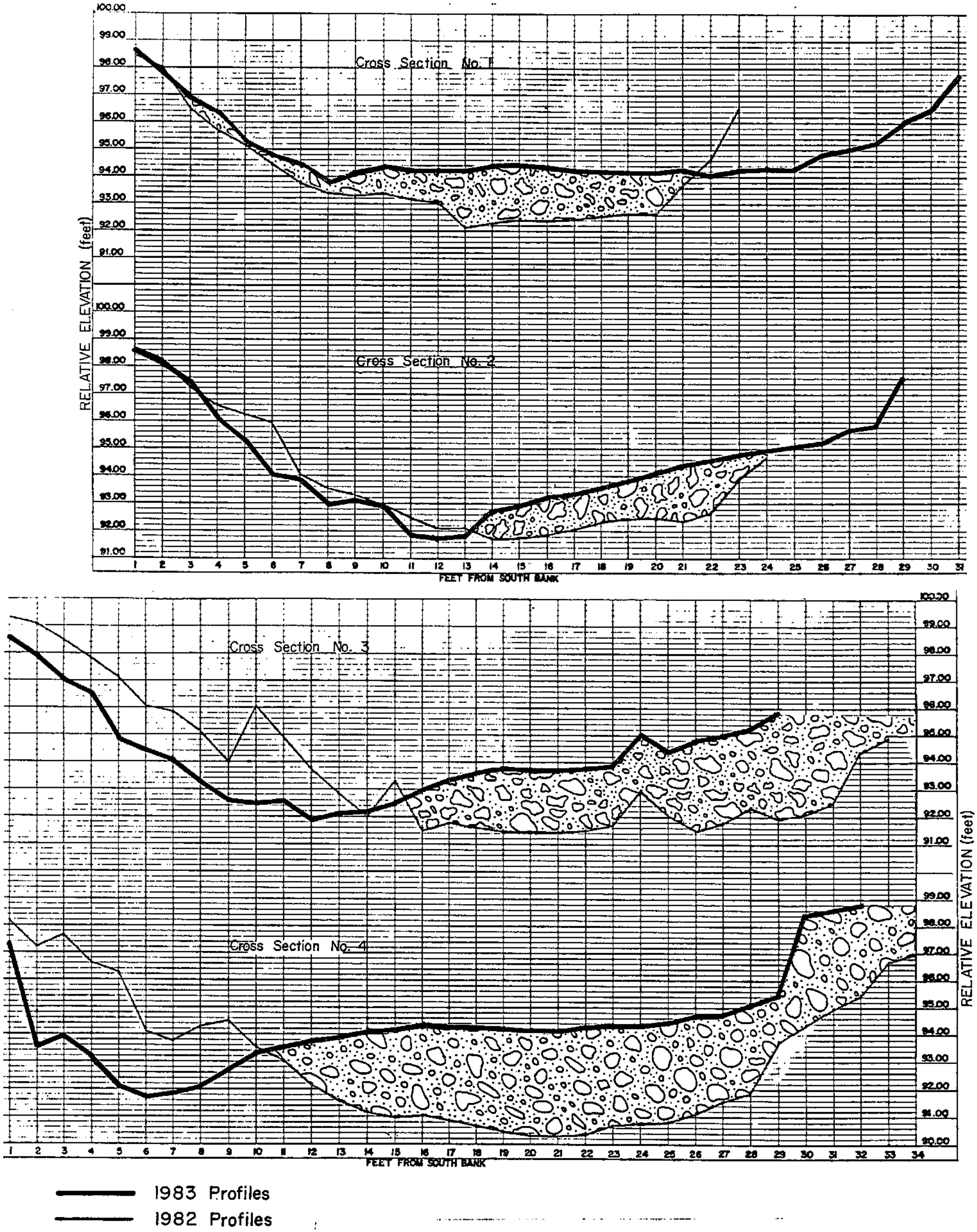


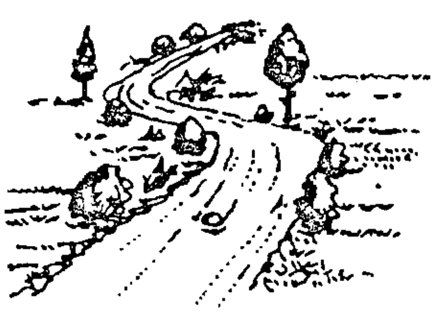
FIGURE 18. HABITAT RESTORATION SEGMENT: CHANGES IN STREAM PROFILES, 82/83

further in the Section dealing with Use Impairment. It is clear, however, that fishery values are exponentially enhanced with "selective" dredging practices that incorporate small habitat improvement measures. Figure 19 shows advantages of natural vs. man-made channels. Enforcement by game management officials can also help avoid unfortunate illegal activities such as the fish kill of 1980.

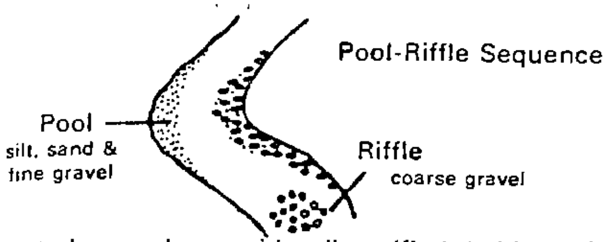
Stream reaches suitable for or presently possessing fishery values are shown in Figure 15 together with notation of the habitat restoration segment.

Figure 19 Some Adverse Impacts of Channelization

NATURAL CHANNEL



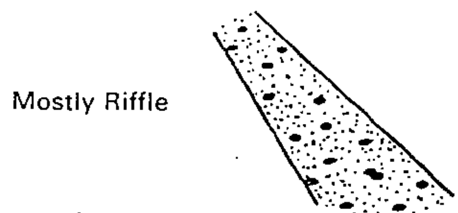
Suitable Water Temperatures:
Adequate shading; good cover for fish life; minimal variation in temperatures; abundant leaf material input.



sorted gravels provide diversified habitats for many stream organisms.

MANMADE CHANNEL

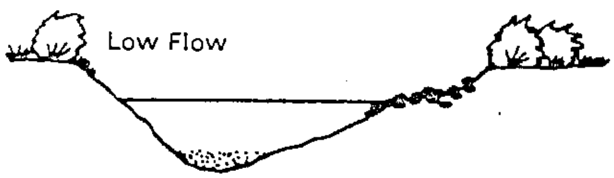
Increased Water Temperatures:
No shading; no cover for fish life; rapid daily and seasonal fluctuations in temperatures; reduced leaf material input.



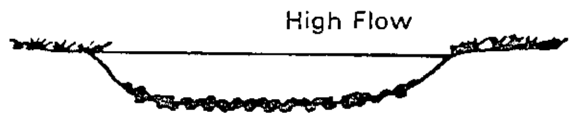
Unsorted gravels: reduction in habitats; few organisms.

POOL ENVIRONMENT

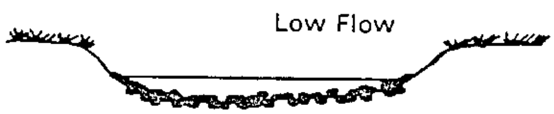
Diversity of Water Velocities:
High in pools, lower in riffles. Resting areas abundant beneath undercut banks or behind large rocks, etc.



sufficient water depth to support fish and other aquatic life during dry season.



May have stream velocity higher than some aquatic life can withstand. Few or no resting places.



Insufficient depth of flow during dry seasons to support diversity of fish and aquatic life. Few if any pools (all riffle).

III. IMPAIRMENT OF BENEFICIAL USE

This section is divided into two main sub-sections. The first deals with the way beneficial use and impairment are defined and measured; the second discusses how present valley creeks apply to these definitions and measures. Conclusions and recommendations for specific parameters and conditions follow the two-part structural analysis.

An important word of caution for the reader: The science of stream ecology is difficult to describe in absolute terms. Streams are dynamic systems continually struggling toward equilibrium. Change is a constant variable in the study of streams at any signal point in time. In the case of the subject creeks, our realm of knowledge is narrower. Much of what can be said about use impairment is actually subjective judgement qualified at best, and decisions are often made on the basis of incomplete data. Where data is grossly incomplete, recommendations for filling those gaps will be made and solutions pursued. But some conclusions can be made on the basis of existing data, although they can always be refined with more time.

A. DEFINITIONS: USE AND IMPAIRMENT

1) STATE REGULATIONS

Two documents provide the framework for defining the beneficial use of water, State Wastewater Disposal Regulations and State Water Quality Assessments which prioritize and identify impaired stream segments.

The State Standards define use classifications in 6 components: Table 11 summarizes classification and use designations of Salt Lake County streams.

DEFINITIONS [27]

A. Classifications

1A Domestic drinking water without treatment

TABLE 11 CLASSIFICATION OF WATERS AND PROTECTED USES OF SALT LAKE COUNTY TRIBUTARIES STATE WASTE DISPOSAL REGULATIONS

	1C	2A	2B	3A	3B	3C	3D	1
Mill Creek and tributaries, from confluence Jordan River to Headwaters				X				X
Big Cottonwood Creek and tributaries from confluence with Jordan River to Big Cottonwood Water Treatment Plant			X	X				X
Little Cottonwood Creek and tributaries, confluence with Jordan River to Metropolitan Water Treament Plant				X				X
ALL IRRIGATION CANALS AND DITCHES STATEWIDE, EXCEPT AS OTHERWISE DESIGNATED								X
ALL DRAINAGE CANALS AND DITCHES STATEWIDE,						X	X	

1B Domestic drinking water with disinfection

1C Domestic drinking water with complete treatment

2A Recreational bathing (swimming)

2B Boating and water skiing

3A Cold water game fish and aquatic life

3B Warm water game fish and aquatic life

3C Non-game fish and aquatic life

3D Water fowl, shorebirds and other water oriented wildlife

4 Agricultural purposes

5 Industrial reuses

6 Special

B. DIVISION OF WILDLIFE RESOURCES FISHERY CLASSIFICATION

1. THE METHODS OF CLASSIFICATION

Each stream (or section of stream), reservoir, lake, and pond is rated numerically for aesthetics, availability, and productivity ranging from 1 to 5. This value is then multiplied by a factor of 1 for aesthetics, 2 for availability, and 4 for productivity. The subtotals are then added to obtain a composite reading, which is used to assign a water to a class. Classes range from Class I, the best fishing waters, to Class VI, the poorest.

2. Class I

These are the top quality fishing waters of the State. They should be protected or improved for fishery and other recreational uses. No water developments should be allowed which might destroy any of the creational values. These waters are judged on their aesthetics, availability and productivity as described.

The aesthetics of the stream or body of water are generally outstanding in natural beauty and of a unique type.

Availability is satisfactory for modern car to suitable points. Larger waters are floatable with launching facilities such that boats can be launched and taken out. Posting is not a serious problem. Camping or lodging is available within a reasonable distance. Aquatic vegetation is not a major problem to the angler.

Productivity is such that it supports a high fish population in good condition of one or more species of the more desirable game fish. Natural reproduction, or stocking of small fish, maintain an excellent sport fishery.

3. Class II

These waters are of great importance to the fishery program. Fishing and other recreational uses should be one of the primary uses. The developments on these waters should not decrease any fishery or other recreational value. They are judged by their aesthetics, availability, and productivity as in Class II, however, for the following reasons these waters rate lower.

Aesthetics. - They are comparable to Class I, except there may be developments such as roads, farms, or commercial establishments along or near them. Climatic or biological factors, such as excessive rainfall, extreme cold, or insect pests may be the difference.

Availability. - Vehicular access is relatively good (road may be alongside stream). The shoreline and aquatic vegetation is not unduly restrictive to fishermen. Posting is not extensive. Larger streams are not readily floatable. Some camping or lodging facilities are generally available.

Productivity. - Supports a moderate to high population of one or more game fish. Natural reproduction and fry and fingerling plants maintain a good to excellent sport fishery. Water fluctuation may be the difference between Class I and II. Waters may be moderate in size.

4. Class III

The majority of Utah waters are in this class, making them very important to the fishery program. Fishing and other recreational uses should be one of the primary uses. These should be protected and improved. Should water developments be necessary, they should be planned to minimize any fishery losses. In some cases these streams could be improved as a fishery with little expense if more water is available.

Aesthetics. - These are waters of considerable natural beauty but of a more common type than those in Classes I or II. They are usually clean and clear.

Availability. - Access is relatively good, and posting is not considered an important restrictive problem, but may exist. Waters you have to walk, ride a horse, or take a jeep into, are usually in this class. Also, areas where bank cover or aquatic vegetation restricts fishing may be included here.

Productivity. - There are all sizes of water in this class. Generally in the smaller waters productivity is fairly good, and in the larger waters it is low. Artificial stocking may be required to maintain the fishery program. Catchables, fingerling, or fry may be stocked. The management situation determines the size of fish that are planted.

5. Class IV

This class is of minor importance to the fishery resource of Utah. Some of the factors that adversely affect the fishery values are dewatering, diversions, dams, heavy or complete drawdown on reservoirs, or natural drought. Whenever it is possible and economical, these waters should be improved for fisheries.

Aesthetics. - Waters are of fair scenic value but lack unusual or outstanding scenic qualities.

Availability. - Access is often difficult or posting is so extensive as to seriously restrict fishermen access.

Productivity. - Waters are generally small. There is a short growing season and excessive drawdown or dewatering may occur. Catchables are required to maintain a sport fishery. Summer or winter mortality problems may occur. The various habitat factors are not suitable for the survival and growth of game fish in numbers necessary to provide a reasonable fishery.

6. Class V

These waters are of little or no value to the present fishery program, due to the natural environment of the area or the effect of human developments. Some waters could be of some importance if habitat were improved or other factors were altered.

Aesthetics. - Waters are low in quality. The water is often turbid, from noxious domestic and industrial wastes or natural erosion; water may fluctuate excessively or be dewatered every year. Also, stream flows may be naturally too low to support fish populations. The adjacent area may be of little or mediocre appeal and of common occurrence.

Availability. - Access is inadequate as natural or manmade restrictions cause fisherman utilization to be almost impossible.

Productivity. - Supports few or no game fish. Waters may be large or small, but a long-term fishery cannot be carried out by either natural or artificial means. Some waters could be very valuable if a sustained downstream flow were available for streams or a conservation pool provides for reservoirs.

7. Class VI

These waters are dewatered and it is impossible at the present to carry on a long-term fishery by either natural reproduction or stocking.

If water were available, many of these could provide a productive fishery, and even be rated with the best in the State.

C.

a. Cont - continuously flowing stream

b. Int - intermittent stream

D. Problem parameters

Parameters to be considered are those listed in Table Five - Numerical Standards for Protection of Beneficial Uses of Water, of the State water quality standards, sediment, salinity (particularly in the Colorado River drainage), and any of the other relevent parameter covered by the Narrative Standards.

USE DESIGNATIONS

The Committee and Board, as required by 73-14-6 and 63-46--1 through 13, Utah Code Annotated 1953, as amended, shall group the waters of the state into classes so as to protect against controllable pollution the beneficial uses designated within each class as set forth below. Waters of the state are hereby classified as shown in (Table 11.)

2.6.1 Class 1 -- protected for use as a raw water source for domestic water systems.

a. Class 1A -- protected for domestic purposes without treatment.
b. Class 1B -- protected for domestic purposes with prior disinfection.
c. Class 1C -- protected for domestic purposes with prior treatment by standard complete treatment processes as required by the Utah State Division of Health.

2.6.2 Class 2 -- protected for in-stream recreational use and aesthetics.

a. Class 2A -- protected for recreational bathing (swimming).
b. Class 2B -- protected for boating, water skiing, and similar uses, excluding recreational bathing (swimming).

2.6.3 Class 3 -- protected for in-stream use by beneficial aquatic wildlife.

a. Class 3A -- protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain.

b. Class 3B -- protected for warm water species of game fish and other warm water aquatic life, including the necessary aquatic organisms in their food chain.

c. Class 3C -- protected for non-game fish and other aquatic life, including the necessary aquatic organisms in their food chain. Standards for this class will be determined on a case-by-case basis. (See Appendix D).

d. Class 3D -- protected for waterfowl, shorebirds and other water-oriented wildlife not included in Classes 3A, 3B, or 3C, including the necessary aquatic organisms in their food chain.

2.6.4 Class 4 -- protected for agricultural uses including irrigation of crops and stockwatering.

2.6.5 Class 5 -- protected for industrial uses including cooling, boiler make-up, and others with potential for human contact or exposure. Standards for this class will be determined on a case-by-case basis.

Table 12 summarizes the Water Quality Assessment which prioritizes polluted stream segments and provides data on existing conditions affecting quality.

2.6.6 Class 6 -- protected for uses of waters not generally suitable for the uses identified in Section 2.6.1 through 2.6.5, above. Standards for this class will be determined on a case-by-case basis.

TABLE 12
WATER QUALITY ASSESSMENT SUMMARY 1982

RIVER BASIN: Utah Lake - Jordan River

SEGMENT	Code	W.Q. CLASS	WQL - EL	FISH CLASS (1)	7 DAY-10YR.L.F.	PROB. PAR.	IMPAIRED USES	CAUSES/ SOURCES	SEG. L. (Miles)	DATA BASE	COMMENTS
Mill Creek from Jordan River confluence to headwaters	MC-1	2B,3A,4	EL	IV[2]JR to 880 E. VI[2]880 E to 2300 E III[2]2300E waters	?	Bacteria BOD TDS TSS NH^3 PG4	1A,1B,1C, 2A 3A 4	1A,R,C, URO,HM, HD,UP	3.4 2.6 12.4	A	Good quality from Canyon mouth to headwaters (anti-degradation
Big Cottonwood Creek from Jordan River Confluence to WTP	BC-2	2B,3A,4	EL	IV[3]JR to Knudsen's Corner IV[4]Knudsen's Corner to WTP	?	Bacteria BOD TSS TDS NH_3 PO4	1A,1B,1C 2A,2B 3A	HM,URO, C,R,1A UP	7.0 4.0	A	Low quality some portions dewatered UROproblems
Little Cottonwood Cr. from Jordan River Confluence to WTP	LC-2	2B,3A,4	EL	IV[3]	?	Bacteria BOD TSS TDS NH_3 PO 4	1A,1B,1C, 2A,2B 3A 4	HM,URO,C R,1A,UP	15.1	A	Low quality UROproblems dewatered some portions
Irrigation Canals and Ditches (Countywide)	PR-1 UL-1 US-1 SJ-1 NJ-1 EJ-1 VS-1 DI-1	4	EL	VI[3]	?	Bacteria BOD,DO IDS,TSS NH_3PO_4 Others	1A,1B,1C 2A,2B,3A 3B,3C,3D	N,UP,MPS IPS,F,1A C,URO,HM	-	M	
Drainage Canals and Ditches Countywide)	JR-4 SC-1 KC-1	6	WQL	VI[3]	?	Bacteria BOD,DO TSS,TDS NH,PO Others	1A,1B,1C 2A,2B,3A 3B,3C,3D, 4,5	N,IPS,1A C,URO,HM	-	M	-

2). FEDERAL REGULATIONS

The regulations adopted by EPA to govern water quality standards in the nation are presently being revised. The intent of the regulations and their proposed changes are reviewed here in order to understand the framework in which states must work to identify impaired streams and improve or restore quality.

Under the new proposed regulations, much emphasis is placed on whether or not protected uses can ever be attained. Use Attainability Analysis is the process by which these answers are derived. Such an analysis is now underway on the lower sections of the Jordan River to determine the level of protection afforded by the present ammonia standard.

WATER QUALITY STANDARDS REGULATIONS[28]

An interesting corrollary to the following abstract of proposed regulations is that one of the major goals of the broad-based county-wide citizens advisory committee during the initial "208" planning process was the desire for fishing in the Jordan River and its tributaries. From the standpoint of solid goal definition, citizens made clear the goal of continuing to provide urban fishing activities through maintenance of clean water.

The Introduction to Proposed New Standard Regulations stresses goals and standard attainability as a continuous process:

> A water quality standard defines the water quality goals of a water body, or portion thereof, by designating the use or uses to be made of the water and by setting criteria necessary to protect the uses. States adopt water quality standards to protect public health or welfare, enhance the quality of water and serve the purposes of the Clean Water Act (the Act). "Serve the purposes of the Act" (as defined in Sections 101(a)(2) and 303(c) of the Act) means that water quality standards should, "wherever attainable," provide water quality for the protection and propagation of fish, shellfish and wildlife and for recreation in and on the water and take into consideration their use and value for public water supplies, propagation of fish and wildlife, recreation, agricultural and industrial purposes and navigation.

Water quality standards are the foundation of a State's water quality management process. The State water quality management process varies from State to Stae but the phrase is used here to describe the general mechanism States use to integrate the various activities under the Act into a coherent management framework. Section 106, 205(g), 205(j), 208, 303 and 305 of the Act set out the planning and management activities to be undertaken by States and local governments to establish their water quality goals and standards and to improve their decision-making process. State water quality agencies should work with other State, Federal, areawide and local planning agencies and the private sector to assist in assembling the data and in performing the analyses. Since the review of standards will be a continuous process, EPA and the States should cooperatively develop a list of priority water quality limited segments which will be reviewed in the coming year. Such annual plans will enable EPA to assist States more effectively in revising their standards.

USE ATTAINABILITY ANALYSIS

Existing Provision: Under Sections 35.1550(b) and (c) of the existing regulation:

The water quality standards of the State shall:

1) Protect the public health of welfare, enhance the quality of water and serve the purposes of the Act;

2) Specify appropriate water uses to be achieved and protected, taking into consideration the use and value of water for public water supplies, propagation of fish, shellfish, and wildlife, recreation purposes, and agricultural, industrial, and other purposes, and also taking into consideration their use and value for navigation..."

"In reviewing and revising its water quality standards, the State shall adhere to the following principles:

1) The State shall establish water quality standards which will result in the achievement of the national water quality goal specified in section 101(a)(2) of the Act, wherever attainable. In determining whether such standards are attainable for any particular segment, the State should take into consideration environmental, technological, social, economic, and institutional factors.

2) The State shall maintain those water uses which are currently being attained. Where existing water quality standards specify designated water uses less than those which are presently being achieved, the State shall upgrade its standards to reflect the uses actually being attained.

3) At a minimum, the State shall maintain those water uses which are currently designated in water quality standards, effective as of the date of these regulations or as subsequently modified.... The State may establish less restrictive uses than those contained in existing water quality standards, however, only where the State can demonstrate that:

i) The existing designated use is not attainable because of natural background;

ii) The existing designated use is not attainable because of irretrievable man-induced conditions;

iii) Application of effluent limitations for existing sources more stringent than those required pursuant to section 301(b)(2)(A) and (B) of the Act in order to attain the existing designed use would result in substantial and widespread economic impact.

4) The State shall take into consideration the water quality standards of downstream waters and shall assure that its water quality standards provide for the attainment of the water quality standards of downstream waters."

Proposed Change: Since passage of the Water Quality Act of 1965 (Public Law 89-234) water quality standards were set to provide for the protection and propagation of fish, shellfish and wildlife, and recreation in and on the water, often without adequate analysis as to whether these uses were attainable. Agricultural or industrial purposes or navigation, which may have been more appropriate as the principal use, were usually rejected as not meeting the requirements of the Act. As a result, some standards reflecting unreasonable stream uses were adopted which either forced overly stringent and costly treatment controls or were simply ignored in the implementation of water pollution control programs.

Because legitimate factors may effectively prevent a use from being met, EPA recommends that States justify changes in the use designations by analyzing the attainability of uses (see proposed section 40 CFR 131.11(a) and (b)). These particular analyses are optional. However, some type of adequate analysis must be submitted to support revisions to standards. EPA believes that the information generated by the suggested analyses, and the involvement of the public in providing data for the analyses, will enable States to improve their decision-making process.

Analyzing the attainability of uses is a multi-step, but not necessarily complex, process for determining whether impaired uses are attainable and for determining other appropriate uses of a particular water body.

Much debate could be had over the suggestion that this process is not complex. Table 13 is a summary of factors analyzed for use attainability. Very little research at this level-of-detail has been undertaken locally due to time and funding constraints. The present Jordan River inquiry is the only one in a five State region, and deals only with ammonia.

The following abstract describes in more detail the objectives and goals of such analysis:

(a) USE ATTAINABILITY ANALYSIS (environmental and physical factors)

The term "use attainability analysis" refers to a scientific analysis of factors which determine the suitability of the water body for a particular use. These factors include the physical, chemical, and biological characteristics of the water body, its geographic setting, scenic qualities, and current uses.

TABLE 13

SUMMARY OF TYPICAL USE ATTAINABILITY ANALYSIS

PHYSICAL EVALUATIONS	CHEMICAL EVALUATIONS	BIOLOGICAL EVALUATIONS
Instream Characteristics	dissolved oxygen	Biological Inventory (Existing Use Analysis)
size (mean width/depth)		
flow/velocity	toxicants	fish
total volume		macroinvertebrates
reaeration rates	nutrients	macroinvertebrates
gradient/pools/riffles	nitrogen	phytoplankton
temperature	phosphorus	macrophytes
suspended solids		
sedimentation Analysis	sediment oxygen demand	Biological Condition/Health
channel modifications		Diversity Indices
channel stability	salinity	HSI Models
		Tissue Analyses
Substrate composition and characteristics	hardness	Recovery Index
		Intolerant Species Analysis
	alkalinity	Omnivore-Carivore Analysis
Channel debris		
	pH	Biological Potential Analysis
Sludge deposits		Reference Reach Comparison
	dissolved solids	
Riparian characteristics		

With the completion of effluent guidelines and the application of technology-based controls, EPA is now emphasizing the implementaion of the water quality based approach to pollution control. The water quality based approach will allow States to focus on their priority water bodies and, when necessary, to provide adequate water quality protection beyond what will be achieved through technology-based control. In implementing a water quality approach, the use attainability analysis is a key analysis.

The proposed regulation (Sec. 131.10(d) and (i)(2) and (3)) prohibits States from modifying or reclassifying designated uses if they can be attained by implementing technology-based controls and cost-effective and reasonable best management practices (BMP's) for the control of non-point sources.

If adequate data are available to conduct a use attainability analysis, intensive surveys may be precluded. Lack of "adequate" data of course require a survey to determine present uses, uses impaired, and the reasons the uses are impaired. The analysis must answer the following questions:

1. What is the use to be protected? How is it characterized in physical, chemical and biological terms, and in terms of its social or economic value? Present and future?

2. To what extent does pollution contribute to the impairment of the use? Which pollutant is significant in terms of impairing the use? To what extent does water quality affect the use relative to other non-water quality factors such as flow, and the physical habitat? What level of in-stream water quality must be maintained to provide adequate protection for the use given the characteristics of the use?

3. What is the level of point source pollution control necessary to restore or enhance the use? What are the pollutants of significance that are present in the point source discharges? What is the contribution of point-source discharges relative to background levels (pollutants in the stream from upstream sources) and relative to non-point sources generated in the water body. What is the allowable pollution load from point-sources under specified in-stream flow conditions in the water body and how does that translate to permit requirements? What is the plan?

4. What is the level of non-pont source pollution control necessary to restore or enhance the use? What are the non-point source pollutants of significance that are present? What is the contribution of non-point sources relative to background levels and point sources? Does the occurrence of non-point sources contribute to the impairment of the use? Is it significant? What is the "feasible" level of control of non-point sources? What is the plan?

Experience indicates that defining the problem is neither an easy process nor, in all cases, a simple scientific exercise. Rather, problem definition requires debate and consensus building among all interested and affected organizations and individuals.

BENEFIT-COST ANALYSIS:

Although there are no universally accepted methods of quantifying or placing a dollar value on direct and indirect benefits or costs, the water quality standards decision-making process by its very nature includes an assessment of the benefits and costs of meeting the standard. Water quality management plans, peer review of the scientific analyses of the attainability of uses or the appropriateness of criteria, and pubic debate of the decisions provide the responsible State rulemaking body with the information it needs to weigh and balance the tangible and intangible benefits and costs of its standards decisions.

This proposed regulation advocates a structured exercise to identify and evaluate the incremental impact of the standards decision. It is difficult to generalize on the level of precision and detail appropriate for a site-specific, benefit-cost assessment. However, the more costly and controversial the potential impacts of a standards decision, the more comprehensive the analyses of the benefits and costs will need to be. The analysis should be sufficiently detailed to identify and display significant impacts, the sensitivity of key assumptions, variables, and risk and uncertainty of attaining a designated use, to serve as a basis for the rulemaking body to determine that there is (or is not) a reaonable relationship between the costs and resulting benefits.

States are allowed to reclassify protected uses that cannot be attained under the following conditions:

- naturally occurring pollutant concentrations prevent the attainment of the use:

- natural, ephemeral, intermittent or low flow conditions or water levels prevent the propagation or survival of fish and other aquatic life. These natural conditions may be compensated for by the discharge of sufficient volume of effluent discharges to enable uses to be met;

- human caused conditions or sources of pollution exist which cannot be remedied or would cause more environmental damage to correct than to leave in place;

- dams, or other types of hydrologic modifications interfere with the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that will maintain the use; (Existing and future?)

- physical conditions unrelated to water quality preclude attainment of the use; or

- benefits of attaining the use do not bear a reasonable relationship to the costs. (Intangibles are not reasonable in $ terms)

States may not modify or reclassify designated uses if (see Section 131.10(i)):

- they are existing uses unless uses requiring more stringent criteria are added;
- uses will be attained by implementing the effluent limits required under Section 301(b)(1) and (2) of the Act (including modifications under Section 301(c) of the Act);
- uses will be attained by implementing cost-effective and reasonable best management practices for non-point source controls; or
- the revision is based on anticipated growth; or
- the revision would result directly or indirectly in impairment of downstream uses.

It is rather apparent that more extensive research and funding will be necessary in order to define protected uses and those which are impaired. The employment of best available data may not be adequate for decisions to remove protection of coldwater fisheries or other beneficial uses. Under present Utah water law, the State Engineer does not maintain fishing or water-based recreation as a beneficial use. These issues must be settled prior to further pollution control and research efforts.

B. USE AND IMPAIRMENT: THE VALLEY TRIBUTARIES

The criteria in The Table 13 summary of typical use attainability analyses are useful as a tool to evaluate present conditions in the valley tributaries. The criteria outlined in Table 13 are enumerated on Table 14 which summarizes the extent to which valley streams meet attainability characteristics.

1) PHYSICAL EVALUATIONS

For each streamreach - lower, middle, and upper - average condition are estimated based on available data and a composite of field staff observations.

INSTREAM CHARACTERISTICS

Size: Variable based on extent of channelization. General pattern is wider and deeper on lower reaches; narrower with variable depth on upper reaches.

Flow/Velocity: Refer to flow"clock" charts for each stream reach, since flows are seasonally variable.

TABLE 14
VALLEY TRIBUTARY ATTAINABILITY INDEX

PHYSICAL EVALUATION	(JR-700E)			700E - 1700E			1700E - CANYON)		
	LOWER			MIDDLE			UPPER		
	MC	BC	LC	MC	BC	LC	MC	BC	LC
Instream Characteristics	48	47	48	73	97	96	101	86	76
size (mean width/depth									
flow/velocity	H	H	H	H	H	M	M	L	L
total volume									
reaeration rates	P	P	P	G	E	E	E	G	G
gradient/pools riffles *	P	P	P	G	G	G	G	G	G
temperature	G	G	G	G	G	G	G	G	G
suspended solids	M	H	M	H	L	L	L	L	L
sedimentation*	H	H	H	H	H	H	H	H	H
channel modification*	M	M	M	H	M	M	L	M	M
channel stability*	F	F	F	F	F	F	G	F	F
Substrate composition and characteristics	F	F	F	G	G	G	G	G	G
Channel debris	M	M	M	M	M	M	H	L	L
Sludge deposits	L	L	L	L	L	L	L	L	L
Riparian characteristics	F	F	F	G	E	E	E	E	G
Downstrm characteristics	G	G	G	G	G	G	G	G	G
BIOLOGICAL EVALUATIONS	25	25	26	26	27	23	22	20	21
Biological Inventory(Existing Use Analysis)									
fish *	H	H	H	H	H	H	H	H	H
macroinvertebrates*	H	H	H	H	H	H	H	H	H
microinvertebrates*	M	M	M	M	M	M	M	M	M
phytoplankton*	H	H	H	H	H	H	H	H	H
macrophytes*	NO AVAILABLE DATA								
Biological Condition/Health Analysis									
Diversity Indices*	H	H	H	H	H	H	M	M	M
HSI Models*	M	M	H	M	H	M	M	M	H
Tissue Analyses*	NO AVAILABLE DATA								
Recovery Index*	H	H	H	H	H	H	H	L	L
Intolerant species Anal.*	H	H	H	L	L	L	L	H	H
Omnivore-Carnivore Anal.*	NO DATA			H	H	NO DATA			
Biological Potential Analysis									
Refer.Reach Comparison*	H	H	H	H	H	H	H	L	L
CHEMICAL EVALUATIONS	15	15	17	15	17	17	21	22	23
dissolved oxygen	H	H	H	H	H	H	H	H	H
toxicants* (cadmium & mercury)	H*	H*	H*	H	H	H	H*	H*	M
nutrients									
nitrogen	M	L	L	L	L	L	L	L	L
phosphorus*	H*	H*	H*	H*	H*	L	L	L	L
coliform*	H*	H*	M*	H*	M	M	L	L*	L*
hardness	H	H	H	H	H	H	H	H	H
BOD*$_5$	M*	H*	M*	H*	M*	M*	L	L	L
dissolved solids	M	M	M	M	M	M	M	L	L

* NEEDS FURTHER INVESTIGATION   * HAS VIOLATED STANDARDS

Because upper-most reaches of Big and Little Cotttonwood are seasonally dewatered (except for Little Cottonwood above Wasatch Boulevard) most criteria ratings are lowered.

Seasonally variable.

REAREATION RATES: A function of high riffle/pool ratios; reflects dissolved oxygen conditions. Expressed as Excellent, Good, Fair, Poor.

GRADIENTS/POOLS/RIFFLES: Steeper stream gradients are characterized by short pools and long riffle runs. As gradients are reduced, riffles become shorter, pools longer. Riffles act as oxygenation producers for pool-dwelling fish. Expressed as Excellent, Good, Fair, Poor.

TEMPERATURE: Adequate coldwater fishery temperatures are generally found along all three stream segments.

SUSPENDED SOLIDS: This criteria actually should be considered as a water quality rather than physical parameter. Expressed as High, Medium, or Low concentrations, this measures the amount of sediment suspended in the stream flow during average conditions. During storm flows, suspended sediment concentrations increase four to five times, and these are mainly responsible for sedimentation Refer to Table 8 for mean/extreme concentrations.

SEDIMENTATION: This is the occurrence of sediment accumulation within a stream reach where stream velocities decrease and allow for settling. This occurs mainly in the sides and bottom of low-gradient reaches, and on inside curves or bends on high-gradient reaches. Flood control maintenance is presently confined to physically removing these accumulatons with heavy equipment as opposed to preventing them. High rates of sedimentation occur during storm flows and spring runoff - due mainly to bank scouring and stream-bed abrasion. Construction runoff also contributes to both suspended sediment and sedimentation.

CHANNEL MODIFICATIONS: This applies to channelization structures such as flumes, walls, rip-rap, gabion baskets, or earthen berms and dikes, as well as diversion headworks. Expressed as High, Medium or Low occurrence, most creeks are partially modified for limited reaches. Examples:

- Millcreek is flumed extensively within its middle reach, and diverted extensively in its upper reach.
- Little Cottonwood Creek is gabion-lined and flumed partially in its middle and upper reach, and
- Big Cottonwood Creek is channelized from land use intrusion for most of its lower and middle reach.

Channelization has gradually taken place - in one form or another - for the majority of all stream segments. However, habitat variation does occur within the existing channel widths and in many cases pool/riffle ratios and depths are more stable than would exist with wider channels.

CHANNEL STABILITY: Figure 15, Riparian Vegetation/Habitat, generalizes the condition of bank stability within larger reaches. In many locations, full overstory and understory cover combines with rip-rap or other naturally occurring materials to provide good stabilization. However, many areas erode heavily. These are the subject of further sediment source identification. Most stabilization along the segments is in fair to good condition. Badly eroding segments require further stabilization.

SUBSTRATE COMPOSITION AND CHARACTERISTICS: The composition of stream bottoms is summarized in Figure 15 Riparian Vegetation/Habitat. Most conditions are fair to good, with lower reaches reflecting greater siltation, and upper reaches characterized by erosion.

CHANNEL DEBRIS: Measured occurrences in High, Medium, or Low, most middle/lower stream reaches suffer from man-induced littering, where upper reaches have greater natural debris potential from fallen trees, shrubs, etc. Channel debris is often a secondary effect of bank instability, with vegetation being under-cut and falling into the stream.

SLUDGE DEPOSITS: These are animal waste solids originating from waste-treatment settlement facilities. Based on existing data. These are largely absent in valley creeks.

RIPARIAN CHARACTERISTICS: Figure 15 documents these values, and is most noted by presence of native overstory and understory vegetation. A measure of passive recreation and aesthetic values, they are expressed as Excellent, Good, Fair, and Poor.

DOWNSTREAM CHARACTERISTICS: All downstream conditions were judged "good."

2) BIOLOGICAL EVALUATIONS

For each lower, middle, and upper stream reach, typical biological conditions are estimated. The main source of data is Division of Wildlife Resource (DWR) stream inventories which are 5-10 years old and represent only one or two 500 foot sections in any stream reach. Generally, comprehensive inventories of all biological conditions within broader representative reaches are necessary and strongly recommended for further study.

BIOLOGICAL INVENTORY

FISH: The occurrence of fish is rated High, Medium, and Low, based on the assumption that existing DWR data is representative. All streams display fairly good populations of both game and non-game species. Non-game species inhabit primarily lower-gradient reaches and tend to be dominant. Game species inhabit middle to upper reaches of higher-gradients and outnumber non-game fish four to one. Each stream has unusual fishery traits:

MILLCREEK: Displays greatest game species diversity: Rainbow, brown and cutthroat trout.

BIG COTTONWOOD: Inhabited by a unique and extraordinarily healthy reproducing brown trout population.

LITTLE COTTONWOOD: Stocked with rainbow in lower reaches, houses a unique native Utah cutthroat trout fishery above Wasatch boulevard.

MACROINVERTEBRATES: Benthic (bottom fauna) organisms which supply fish with half of their diet or nutritional needs. Figure 15 itemizes those species most often found within short inventory reaches by DWR. Detailed inventory along more representative reaches is necessary to better define this factor. Because of good fish population, good populations of both macro and microinvertebrates are assumed rather than quantified.

MICROINVERTEBRATES: Bacteria, flagellates, and other microscopic organisms have not been adequately identified. Detailed inventory along more representative reaches is necessary.

PHYTOPLANKTON: Single-celled plants which - together with macrophytes comprise the other half of fishery nutrition. Algae is the most common aquatic vegetation sampled in lower reaches, and high nutrient loads promote healthy - occasionally excessive - algae growth. Excessive growth of blue-green algae is possible in certain stream reaches where copper and sulphate residuals are high. Further analysis of existing data is advisable to anticipate potential blue-green algae growth reaches since die-off of this species produces toxic as well as anoxic stream conditions. Photosynthetic reversal during evening hours often produce oxygen deficits in lower stream reaches where re-aereation does not occur at sufficient rate. Non-game fish species requiring lower dissolved oxygen usually occur in these reaches, because they can tolerate night-time oxygen deficits.

MACROPHYTES: Multiple-celled plants have not been sufficiently sampled to allow description of even general conditions. Detailed inventory along representative stream reaches is necessary.

BIOLOGICAL CONDITION/HEALTH ANALYSIS

DIVERSITY INDICES: Based on DWR stream inventories, wide diversity of species is evident for all three streams. Different species of suckers, dace, chubs, carp, trout and even walleye appear in electro-shocking samples. Lower reaches accommodate larger proportions of non-game species, while middle-upper reaches harbor greater ratios of game species. High, Medium and Low values are assigned.

HABITAT SUITABILITY INDEX (HSI): Based on 500 foot reach samples, DWR assesses fishery habitat suitability (Appendix 3).

TISSUE ANALYSIS: This is conducted to determine presence of heavy metals on biota. Work completed by Clubb (University of Utah, 1974) on Cadmium Toxicity to Stoneflies implies a need for further work in this area - particularly in view of high local metals concentrations. No tissue analysis data is available on local tributary biota.

RECOVERY INDEX: Based on observations along the Big Cottonwood Creek Habitat Restoration segment, instream ecosystem recovery to steady-state conditions is believed to occur at a high rate for middle-reach gradients. Non-game species recovery is high for lower-reach gradients. Upper reaches are often constrained due to flow (See Figure 2, Dewatered Segments).

OMNIVORE - CARNIVORE ANALYSIS: Karr (1980) found that as a reach declines in quality, proportion of omnivores increases. Detailed information must be generated for all three creeks in order to accurately determine local proportions. High concentrations of carnivorous brown trout in middle Big Cottonwood reaches is indicative of a relatively healthy, diverse aquatic community.

BIOLOGICAL POTENTIAL ANALYSIS: Defining major faunal (fishery) reaches, selecting control sites, sampling fish populations, and establishing community characteristics for the reference reaches are all involved in biological potential analysis. The next section on local recreation opportunities described what could potentially exist as valuable fishery resources on all valley tributaries. The model employed to make "standing crop" projections assumes that adequate faunal/floral data are available - which for all stream reaches are not. But the population increase observed within the Habitat Restoration reach on Big Cottonwood Creek does provide corroboration that necessary biotic health exists to maintain a reproducing fishery.

3) CHEMICAL EVALUATIONS

Water quality parameters were analyzed for all three creeks and summarized in Table 8. Other indicator parameters, such as dissolved oxygen, nutrients, and hardness were not displayed (mainly for graphic reasons) but are summarized here. Based on water quality analysis, it is apparent that certain stream reaches are limited only by annual flood control dredging activities, and lack of habitat improvements which provide aeration, resting, feeding, and breeding zones. Both these externalities are to a great extent manageable - they can be optimized and their effects lessened. Average annual water quality conditions do not appear - by themselves - to limit the attainability of the "fishable" water goal.

DISSOLVED OXYGEN

Table 15 represents dissolved oxygen concentrations at lower, middle, and upper reaches of all three creeks. All are well saturated with oxygen, but night-time limiting concentrations are not represented. Photosynthesis ceases in the evening, and plants reverse their oxygen-producing role by respirating. Nutrient concentrations likely point to stream reaches where potential evening oxygen deficits may occur, but daytime dissolved oxygen is more than sufficient for both cold and warmwater fisheries. Better D.O. measures are needed during early morning hours when concentrations hit "rock-bottom".

TABLE 15 MEAN/EXTREME CONCENTRATIONS DISSOLVED OXYGEN (mg/l) FOR VALLEY TRIBUTARIES

CANYON:	CANYON MOUTH			MIDWAY			JORDAN RIVER		
	LOW	MEAN	HIGH	LOW	MEAN	HIGH	LOW	MEAN	HIGH
MILLCREEK	7.0	7.0	8.8	6.8	7.7	8.1	7.1	7.8	8.8
BIG COTTONWOOD	7.0	7.8	9.1	7.5	7.8	9.1	6.5	7.2	8.2
LITTLE COTTONWOOD	6.9	7.7	8.6	7.2	7.6	8.0	6.4	7.5	8.2

TOXICANTS:

Occasional gasoline spillages in valley creeks have been documented and resulted in fish kills (July, 1981 - Big Cottonwood Creek Bridge Construction at Highland Circle), but these events are not comparable to metals concentrations observed in Nationwide Urban Runoff Program (N.U.R.P.) data. A number of metals, including lead, zinc, copper, mercury, and cadmium, occur in concentrations which exceed present state water quality standards. Table 8 reiterates mean/extreme concentrations for selected metals. Cadmium and mercury have been evaluated because of their documented effects on both fish and humans. [29]

MERCURY:

The standard for total mercury is .00005 mg/l or .05 ug/l. Data gathered over a three-year term (1979-81) indicate high background concentrations increasing downstream toward the Jordan River. Standards violations appear fairly common. Consultation with State Water Pollution, Wildlife Resource, and U.S. Geological personnel indicate some limitations to serious concern about this. Hardness and "ph" of water influences the composition of mercury compounds available to the biota. Most local dissolved mercury concentrations are found to be bound up with sulphides and oxides. Such compounds are not in an available form to benthic organisms - except those that are "filter feeders" such as the caddisfly nymph. [30] Also, the detection limits for total mercury is so high that observed concentrations may not bear any realistic relationship to benthic availability, inhibition of reproduction or other biological impacts. [31] Bottom "filter feeders" such as suckers, dace, or carp, may uptake mercury,as could the caddisfly. No local data exists to document contamination or extreme inhibition of fishery density, diversity, or productivity. Further study of this potential problem is strongly recommended.

CADMIUM:

This toxic metal holds more potential as a serious problem even though its standards are slightly lower (.0004 mg/1 or .40 ug/1). Detection limits are slightly lower and data suggest higher relative concentrations than that of mercury. The data also show high background concentrations entering the valley (Table 8). Local study of cadmium uptake by stoneflies has occurred but only under laboratory conditions. No field application of results has taken place, and further study of this potentially serious problem is strongly recommended. Both mercury and cadmium toxicity and bio-uptake studies should occur as part of an overall benthos inventory. The apparent success of trout recovery in the Habitat Restoration section could be due to flood-water migration, but the diversity of fingerling, juvenile, and adult population implies that the influence of toxicants may be minimal.

NUTRIENTS:

Dissolved nitrate (as NO_3) and dissolved nitrate (as PO_4) are phytoplankton nutrients which help to supply much of the instream food cycle. They also increase consumption of oxygen during plant respiration at night by stimulating plant growth. Review of dissolved nitrate (NO_3 as N) data do not demonstrate serious potential impairment, but dissolved phosphorus (PO_4 as P) clearly indicate potential problems relative to oxygen depletion. Table 16 summarizes mean/extreme data for valley tributaries, for both nitrogen and phosphorus parameters. All three creeks have exceeded standards at Midway and Jordan River stations. During the three-year data period-of-record, both Millcreek and Little Cottonwood Creek show evidence of nutrient uptake before reaching the Jordan, while Big Cottonwood PO_4 steadily increases. Oxygen deficit potential exists for all three lower creek reaches. "Investigations should be conducted to develop more information where these pollution indicator levels are exceeded."[32]

TABLE 16

MEAN/EXTREME CONCENTRATIONS
DISSOLVED NITRATE AS "N" AND
PHOSPHORUS AS "P" (mg/l)
(STANDARD: $NO_3 - N$ = 4 mg/l; $PO_4 - P$ = .05mgll)

CANYON:	CANYON MOUTH						MIDWAY						JORDAN RIVER					
	NO_3-N			PO_4-P			NO_3-N			PO_4-P			NO_3-N			PO_4-P		
	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H
MILLCREEK	.04	.16	.33	.01	.03	.06	.15	.24	.33	.10	.25	.51	.07	1.68	3.0	.00	.04	.09
BIG COTTONWOOD	.00	.15	.30	.00	.02	.04	.04	.41	.94	.04	.17	.35	.12	.77	1.4	.01	.94	4.0
LITTLE COTTONWOOD	.10	.46	.79	.00	.03	.05	.17	.23	.30	.28	.32	.39	.00	.56	1.20	.00	.06	.11

COLIFORM BACTERIA:

As stated in the State Waste Disposal Code:

"Bacteria of the coliform group are considered the primary indicators of fecal contamination and are some of the most frequently applied indicators of water quality." State water quality standards for waters protected for recreation and aesthetics is 1000 N/100ml for body contact, and 5000 N/100 ml for non-body contact (however, wading and water skiing are not considered "body contact"). Total coliform bacteria are displayed in Table 8. Because fecal coliform bacteria are part of total measured coliform and potential problem with human pathogens may exist, particularly where streptococcus indicators occur. Streptococcus was sampled during the "N.U.R.P." three-year term, but not counted as part of the coliform mean data set. No serious impairment to biota is indicated. Because of high coliform present over storm hydrographs, further isolation of other pathogens such as salmonella is adviseable.

HARDNESS:

Hardness generally increases in each stream as it flows toward the Jordan River. For example: Mean hardness for Little Cottonwood Creek over period-of-record was 145 mg/l. Mean hardness at the confluence with the Jordan River was 250 mg/l. This trend is characteristic of other creeks.

BIOCHEMICAL OXYGEN DEMAND - BOD5:

Organisms in the water such as bacteria demand oxygen. When organisms die, the deterioration process demands oxygen. This oxygen demanding biomass is typically measured in mg/l over a five-day period to determine the rate and time at which the biomass depletes oxygen to other biota. Like phosphorus and nitrogen, BOD is an indicator parameter, and violations of the State standard (5 mg/l) are documented in all three tributaries - particularly from midpoint stations downstream to the Jordan River (Table 8). "Investigations should be conducted to develop more information where these pollution indicator levels are exceeded.[33]

TOTAL DISSOLVED SOLIDS (TDS):

Solids occur in freshwater as both total and dissolved, the former usually measured in total suspensed and bedload solids, the latter in solution. The TDS of the valley creeks is normally very low until irrigation canals spill Utah Lake water to satisfy exchange agreements. Table 8 displays TDS, which reflects the influence of the Utah Lake spills.

There are many implications to pollution loads and stream impairment resulting from these exchanges. The TDS standard for irrigation is 1200 mg/l, and many TDS measurements approach 1000 mg/l. Algae is usually bound up and suspended with the solids, giving the exchange water a murky green appearance, and the water possesses a characteristic - and rather objectionable - odor. Aesthetic considerations are not well satisfied with irrigation exchange water of this quality. The canals also collect numerous loads of nitrogen-enriched irrigation tailwater, insecticides, herbicides, litter, trash, disposed oil and grease, as well as urban stormwater, which is high in coliform bacteria and potential pathogens.

4) CONCLUSIONS:

From the discussion which followed the use attainability and impairment format, it appears that further investigation is appropriate for a number of factors in each evaluation category. At least three factors require quantification under physical evaluations; data for virtually all factors under Biological Evaluations should be updated and in most cases generated; several important indicator parameters - including two metaltoxicants - should be further investigated for chemical evaluations.

PHYSICAL EVALUATIONS:

The following factors require further quantification:

POOL/RIFFLE RATIOS: These can be optimized or improved with physical modifications. Stream reaches where such modifications are appropriate should be prioritized and implemented in coordination with County and Corps of Engineer Bank Stabilization programs.

SEDIMENTATION:

The cost to taxpayers for sediment removal is extremely high. Tax savings can be realized by developing a sediment-source budget for each stream reach, and taking action to reduce sedimentation through bank stabilization and non-point source controls on construction runoff. Benefits to fishery potential would be exponential, as shown in the habitat restoration test section.

CHANNEL MODIFICATIONS:

Creek reaches that have been channelized with in-fill will continue to erode and hamper flood control efforts. These areas would be addressed as part of a channel stabilization program which would offer habitat improvement opportunities through reduced sedimentation.

CHANNEL STABILITY:

There are many stream reaches which are bounded by eroding alluvial formations as high as 50-60 feet. Such areas should be identified, erosion rates/loads calculated, and prioritized for stabilization.

BIOLOGICAL EVALUATIONS:

Some work has been done by State Wildlife Resources, but much more remains if the water resources in Salt Lake County are to be protected and optimized:

- FISH - Fishery inventories should be updated for several more representative valley stream reaches.
- MICRO/MACROINVERTEBRATES - Collection of species in all three creeks should be undertaken to improve this data base. Field studies of probable metal toxicity should be conducted for human health safeguard.
- PHYTOPLANKTON/MACROPHYTES - Density, diversity, and productivity of all available species is needed.
- DIVERSITY INDICIES - Can be constructed with newly obtained above data.
- HSI MODELS - Can be calibrated and made more valuable with newly obtained data.
- TISSUE ANALYSIS - Should be conducted as part of a heavy metal toxicity investigation.
- RECOVERY INDEX - Based on Habitat Restoration reach result, it can be generalized that recovery rates are high, but segment/reach comparability analysis cannot presently be quantified.
- INTOLERANT SPECIES/OMINVORE-CARNIVORE ANALYSIS - Should be an objective of detailed fishery inventories.
- REFERENCE REACH COMPARISON - Can be developed from composite of all new biological data.
- CHEMICAL EVALUATIONS

Based on old fishery inventories and recent habitat restoration, it can generally be concluded that water pollution has not totally destroyed opportunities for multiple use of the valley creeks. Pollution is, however, a major constraint to improving opportunities, together with factors described under physical evaluations (i.e. pool/riffle ratios, sedimentation, channel modificaton, channel stability).

PHOSPHORUS, COLIFORM, AND BOD - All require intensive sampling in order to:

1. Determine human pathogen risk levels and periods.
2. Determine critical oxygen depletion reaches.
3. Construct a non-point control program to reduce the level of observed concentrations.
4. Determine cost-benefit assessment of such a program.

METALS TOXICITY - Although cadmium and mercury have been discussed in detail, other heavy metals appear in sufficient quantities to merit further inquiry. Both cadmium and mercury should be objectives in a bioassay assessment of macroinvertebrates and fish, with emphasis on filter-feeding species. The goal of such an assessment is protection of human health in determining acceptable intake levels of these metals through consumption of fish.

Based on numerical values assigned to high, medium, low, excellent, good, fair, and poor weights shown in Table 14, each creek reach was added to obtain a very cursory estimate of composite value. The results are shown in Table 17.

The shortcomings of these values are evident from the previous narration on data needs. Quantificaton resulting from better data could significantly modify reach values of Table 17 but existing data show that the greatest multiple use opportunities are likely on mid to lower reaches. Instream flow stabilization would reverse this trend, making mid to upper reaches more valuable.

Streambank stabilization and non-point source pollution control programs will make significant gains in greater use of precious valley stream resources.

TABLE 17

CURSORY ESTIMATED COMPOSITE
STREAM VALUES

	LOWER			MIDDLE			UPPER		
	MC	BC	LC	MC	BC	LC	MC	BC*	LC*
PHYSICAL EVALUATION	48	47	48	73	97	96	101	86	76
BIOLOGICAL EVALUATION	25	25	26	26	27	23	22	20	21
CHEMICAL EVALUATION	15	15	17	15	17	17	21	22	23
TOTAL	88	87	91	117	141	136	144	128	120

* BC and LC DEWATERED 4-6 MONTHS ANNUALLY
REDUCE TOTAL VALUES BY AVERAGE 40% FOR THESE
REACHES, BC = 77; LC = 72

IV RECREATION ECONOMICS

Water resources are put to many beneficial uses. Many of the uses are easy to value, others less so. The cost of a water-unit for culinary or irrigation consumption is easy to determine compared to assessing water-unit cost for fishing, boating, or recreation. Yet those values do exist, although economists have difficulty quantifying them. Optimizing resource use is more important now than ever before because resources - particularly water - are scarce in the west. This analysis describes: How economic benefits occur from wise multiple-use in the context that resources are not exploited beyond environmental limits; local multiple resource benefits and opportunities; the issue of instream flow maintenance for use optimization; and the overall philosophy of Balance vs. Imbalance in structuring economic development.

A. THE ROLE OF ENVIRONMENTAL ECONOMICS

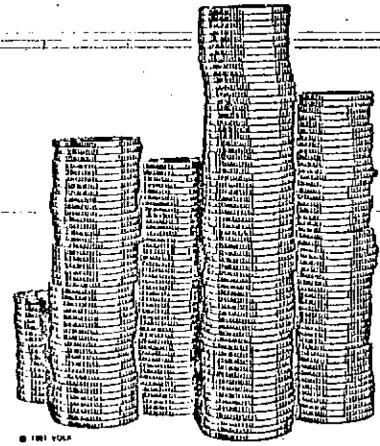
In the free-market process of supplying needs or demands, certain outside factors have a tendency to affect the efficiency in the way those demands are satisfied. These factors are called externalities. The economic inefficiencies they produce are external diseconomies. The role of environmental economics is to minimize externalities, first by recognizing that they exist, and second by quiding policy decisions which avoid or lesson environmental effects.[34]

Environmental regulations have been called unnecessary hinderances to free-market economies because of the additional costs associated with their attainment. This is a short-sighted view. It is inconsistent with long-term resource use. A typical example is the floodplain: Owners adjacent to streams desire maximum return on their investment, so floodplains are filled and structures built. But the filling has precluded natural flood storage volume that previously existed; it reduces evaporation and groundwater recharge and discharge functions; it generates polluted stormwater runoff volumes that did not exist; it incrementally constricts the channel and produces accelerated bank/bed erosion, sedimentation, and high flood control costs; it robs us of wildlife habitat which is scarce in urban areas and forces further travel distances and higher energy expenditures to enjoy it. Meanwhile, the stream flooding incidences increase due to channel constriction, higher storm runoff volumes, and lowered maintenance efficiencies, and the public picks up the tab in flood damages. In many areas throughout the country authorities are finding it cheaper to buy out development they have allowed rather than continue to subsidize it through damage/maintenance expenditures. In other words, it makes economic sense to disallow construction in floodplains. Yet when such policies are attempted, they are termed hindrances to the "free" market. However, the "free" market is not really free in the literal sense, because laws determine the extent to which markets exploit people and resources. Environmental laws have been passed to minimize private exploitation at public expense.[35]

B. ENVIRONMENTAL PROTECTION: PROGRESS AND PROFIT COEXIST

The autumn issue of County News (Figure 19) points out that industry receives a payoff from environmental requlation compliance: "increased profit through efficiency, growth through development of new products, and a much-improved relationship with government and consumer."[36] The article stresses that costs of environmental protection are not just costs, they represent expenditures in goods and services that improve employment and individual production. Expenditures for upgrading local sewer treatment plants will stimulate a number of jobs in the construction, service, and government sectors.[37] Increased profits have been documented by many industries that previously dumped waste into streams and landfills, and since

Economy and environment: Progress and profits coexist



By Lee Epstein

The corporate executive clears his throat, introduces himself and thanks the chairman for the opportunity to present his views at today's hearing. A handful of congressmen shuffle and settle down into their seats to listen. The testimony begins, and the executive explains at great length why the proposed environmental health legislation will adversely affect the economics of his business and of the nation as a whole.

While such a reaction is understandable, evidence is accumulating that such a judgment may well be too hasty. Environmental protection and substantial economic progress and profits can go hand in hand. In fact, hundreds of businesses, large and small (and thus their host counties), have benefited economically from the environmental protection measures of the past decade.

The costs of environmental protection, placed in the billions of dollars yearly, are not just costs. They represent big dollars for those in the environmental control business—dollars and jobs provided in engineering, manufacturing and construction, dollars and jobs that help to drive and not stall the national economy.

For example, Apollo Chemical started in the air pollution business in the mid 1960s. It now employs more than 100 people and has subsidiaries worldwide. The three largest solid and hazardous waste management firms in this country turned in recent record profits nearing a billion dollars combined. Direct employment engendered by all aspects of environmental protection in the U.S. was estimated in 1977 to be 2 million jobs, and environmentally induced economic activity at 2 percent of the nation's gross national product. One recent study determined that environmental quality expenditures would reduce the unemployment rate by four-tenths of 1 percent in 1980-81: a yield of some 400,000 jobs.

INCREASED PROFITS

And there is another good business result that has come out of complying with pollution standards. It's called increased profits. Where's the proof? Surprisingly, it abounds, and it's making "environmentalists" of some of this country's most hardened businessmen. Here are just a few examples:

- Westvaco Corporation used to "dump" hundreds of thousands of tons of mill wastes as byproducts of its processes. Instead of thinking of these products as wastes, the company began thinking of them as resources. Westvaco created a chemical subsidiary with four processing plants and a research center to convert the byproducts into saleable chemicals. Since 1975, Westvaco's chemical sales have doubled to $45 million—all from former wastes.
- Chlorine and hydrogen used to disappear into the atmosphere in Dow Corning's silicone process. By recovering the pollution, the company has reduced operating costs by $900,000 yearly. Its $2.7 million capital investment is producing a 33 percent annual return.
- Union Camp's mill wastes were formerly sold for 8 cents a pound. Not too long ago it began converting them into flavors and fragrances that it now sells for over a dollar a pound, boosting its chemical sales to $100 million a year.
- Goldkist Corporation took a long, hard look at its process streams and efficiencies in conjunction with an effort to reduce pollutant production. The result: a 32 percent drop in water usage, a 66 percent reduction in overall waste production, and a net annual gain of $2.33 for every $1 expended.
- Minnesota Mining and Manufacturing—the 3M Company—has since 1976 substantially expanded international production. At the same time, it has significantly reduced its annual pollutant load: liquid effluent has gone from 47 tons to 2.6 tons, gaseous effluents from 3,000 tons to 2,400 tons, and solid waste from 6,000 tons to 1,800 tons. Annual cost savings: $2.4 million. In fact, by 1977, after only nine months of promoting its intensive "Pollution Prevention Pays" program worldwide, 70,000 tons of air pollution and 500 million gallons of waste water were eliminated. By 1979, the company had saved $20 million.
- The Hercules Powder Company spent $750,000 to reduce the pollutants it was dumping into the Mississippi River. It now saves well over a quarter of a million dollars a year in lost materials and water costs.

THE COUNTY CONNECTION

For hard-nosed business people, as for county government officials, the bottom line is cost-efficiency: making a good, competitive product or providing an adequate service for the least cost. Rather than holding big sticks over local industry, counties can maintain and expand their economic bases by helping businesses understand how particular environmental regulations can help them. Good housekeeping is often the simple answer—changes in process flows that eliminate or reduce waste and pollutants or turn them into resources and products. As the companies mentioned above have realized, the economic way to abate pollution was not to add on costly equipment but to analyze their product flows for waste, and for material, energy and water imbalances. Then they could take conserving actions and convert pollutants to saleable materials and deal with the remaining residues in a cooperative spirit with state and local government.

The payoff for industry, as Michael Royston explained in a *Harvard Business Review* article in 1980, is increased profit through efficiency, growth through development of new products, and a much-improved relationship with government and consumer. The payoff for counties' encouraging and assisting in these endeavors, is the robust good health of their tax and employment bases. And that ain't hay.

recycled solid waste products. Local sewer treatment entities may now sell sludge compost that was previously landfilled. "Hercules Powder Company spent $750,000 to reduce pollutants it was dumping into the Mississippi River - now it saves well over a quarter of a million dollars a year in lost materials and water costs." The conclusion to claims of market constraint is that significant pollution prevention pays - it does not cost.

C. RESOURCE SCARCITY: THE RENEWAL OF ECONOMIC EFFICIENCY

Conservation is usually thought of as relating to natural amenities or processes. But conservation of goods purchased applies as well. Neglect in new automobile maintenance cuts short the effective life of the car; playing the stereo too loud produces earlier cost for speaker replacement; polluting water precludes fishing; allocating water use for only culinary or industrial use precludes boating, floating, or other recreation. Because water is such a scarce commodity in the West, its use must be optimized by spreading it among competing uses. Because oil is becoming a nationally scarce commodity, conservation may prove to be the only solution to optimizing its use. The good life depends on it. The same is true for water:

> Efficiency.....is the dominant new value of the marketplace - making the most of everything we have, capturing and using what used to be considered "waste," quality pushing aside the old standard of planned obsolescence, high-efficiency design replacing the old standard of gross size.[38]

Water policy in Utah has heretofore emphasized culinary, industrial, and agricultural consumption as "beneficial use." It has placed recreation and wildlife as lower priorities - mostly incident to "unused" streamflow. Yet State water pollution regulations expressly protect water for recreation and wildlife use. Instream flows provide benefits only to those willing to pay for them, or to those who are "first in time - first in right." This issue is dealt with in detail later, but the fact remains that economic efficiency is being lost by imbalance in multiple use opportunities. To capitalize a stream resource for one use and thereby deny others incidental use raises many questions related not just to legal or ethical philosophy, but to dollars lost to the local economy from precluding or constraining those uses.

D. MEASUREMENT OF RECREATION VARIABLES

Efficient use of water resources must always include recreation (and wildlife as an indirect recreation function), although drought periods will out of necessity reorder and reduce this function. But while the stream flows it can be expected that many recreation hours will be spent, and the value of those hours may continue to go unmeasured. Local water-related recreation is in high demand. It is constricted by available flow and pollution primarily, and secondarily by land use and access.

The purpose here is to describe how local recreation demand for water-related activities can be supplied through valley tributary resources, and demonstrate that such activities are demanded but at the same time supplies constricted by present management strategies. Attitudes and behavior toward water-related activities are highly preferred, and the benefits from improved water quality and creek habitat can be substantial.

RECREATION NEEDS

Local needs assessment will be more fully discussed in later paragraphs, but some comments are appropriate to the subject of typical recreation needs assessment.

Too often, government and the market place concentrate on providing recreation facilities without feedback on whether those facilities provide an enriching experience. Crompton (1977) addresses this problem in formulating an updated recreation system model that emphasizes providing solutions to needs as opposed to producing recreation programs. Typical recreation programs have not been framed in response terms of personal experience:

> Rather, they have operated either without clear objectives or objectives which were concerned only with Output or Promotion. This type of management is facility - rather than consumer-oriented, placing more value on the physical and administrative tools of the field than on the quality of the user's experience. The product which is being sought by the participant is a quality recreation experience; facilities, management, and other aspects are simply means to an end, distribution channels through which this experience is marketed to the consumer. The system model is not intended to underestimate the importance of technical problems, but rather to illustrate that production is only one facet in the managerial environment, and that the personal experience of the consumer is of greater relevance.[39]

Needs for recreation are only partially met by the typical approach of providing public facilities. Individuals tend to substitute private space for public space wherever possible, as Cordell (1976) demonstrated.[40] Key findings of his work are that public and private recreational space are substitutes. Thus, the "change in supply or price of one directly affects the demand for the other." The traditional reliance on space standards as a "stand-in" for good demand data is suspect, because open space planning must consider existing neighborhood space if "social welfare per tax dollar spent is to be maximized."

> Another important finding is that privately supplied space seems to be preferred to publicly supplied space. Middle-income and upper-income neighborhoods expressed less demand for public space because they could afford to substitute the more preferred private space. Demand for public space in densely populated, lower-income neighborhoods was greater because they could not afford the private space alternative.
>
> Income level and existing supply of private recreational space emerge as essential considerations in urban open space planning. In addition, these are important considerations for many other public policy decisions

> land-use zoning, transportation planning, urban renewal, and taxing policies.[41]

The implications to recreation on valley tributaries are: 1) Upstream reaches flanked by residential land use generate numerous potential recreation opportunities that are uncounted in recreation supply because of substitution, and 2) Downstream reaches that are flanked by lower income and commercial - industrial uses afford greater opportunities for public facilities because substitution is restricted.

Study of stream recreation patterns and preferences is needed to accurately assess anticipated stream-use patrons for future planning. Such a needs assessment would determine whether certain activities relating to water, such as floating, boating, or fishing occur in sufficient numbers and consistency to project future use. Attitude surveys are commonly employed as a typical assessment tool:

> Attitude studies (primarily cross-sectional surveys), if done carefully, can play an important role in answering major questions about recreation and recreationists. They are particularly useful in explaining why certain events are observed. They also give the most systematic information about what people say they prefer (although experiments may give a wider range of choice and tell more about what people actually prefer in certain settings). Attitude studies, however, seem to be done to the exclusion of both observational studies and experiments. Such a strong reliance on these techniques limits the ability to increase our knowledge about a variety of recreational phenomena.[42]

There is no substitute for site-specific observational studies, but in view of the lack of these, attitude surveys remain most available. Nationwide surveys of attitude and behavior toward water-based recreation are consistent with responses of local residents studied previously by Hunt (1977).

WATER RECREATION ATTITUDES AND BEHAVIOR

Several inquiries of user preferences have been conducted over the past years. Veissman and Stork as early as 1974 critiqued weaknesses in user-oriented research design; subsequent studies have yielded important information relevant to user preferences.

The Journal of Leisure Sciences has documented several studies dealing with attitudes toward water-based recreation, which have important implications to local recreation planning and needs assessment. Cheek and Field (1977) report that aquatic environments provided the resource base for 38% of all recreation participation events. Table 18 summarizes the results of their findings.[44]

Table 18 Number of Different Recreational Activities (Grouped) Associated With a Specific Base

Activity Type	Resource Base River	Lake	Ocean	Swamp/ Marsh	Forest/ Mountain	Range/ Farm	Town City
Water Activity N = 12	12	11	12	3	7	5	9
Nature Study, Food Gathering N = 6	6	6	6	5	6	6	6
Hiking, Camping, Picnicking N = 10	8	9	8	4	9	7	6
Rec. Vehicle Driving N = 8	6	5	6	3	8	6	7
Sports, Games, other N = 12	8	11	11	2	11	12	12
Total No. of Different Activities	40	42	43	17	41	36	40
Percent water activities of total num.	30%	26%	28%	18%	17%	14%	23%

Proportion of Participation Events Associated With a Specified Resource Base

	Resource Base Water	Forest/ Mountain	Range/Farm	Town/City	Not Reported
Number of Activity Events N = 31,649	12,220	3787	3571	9383	2688
Percent	38.4	12.0	11.0	29.6	8.5

Cheek and Field conclude that these results are useful "state-demand" patterns that can be projected into the future, and available water-resource bases in the public sector must be acquired where they are presently insufficient to meet demand. In the past, such land and water acquisitions were simple in absence of competing use. However,

> today, diverting resources from one use to an alternative use at a reasonable cost is not an easy task. Once relatively unlimited resources have become scarce as the number of potential uses for them have increased. Ocean beaches in the State of Washington are a case in point. Acquisition of ocean beaches for potential recreation is declining due to cost and scarcity of available resources. We, therefore, need to examine resource use systematically to assess the activity options which this use provides, so that less scarce resources capable of providing the same or similar recreation opportunities may be acquired. By looking both at activity types associated with resources and at frequency of occurrence, we can gain insight into the relationship of resources, activities, and participation rates.

McCool (1978) evaluated recreation activity "packages" at water-based resources by Utah residents, and found that water-based facilities provide an entire range of activities for which the area might not have been designed. Fishing, boating, etc., were found to provide staging activities for other recreation which occurred as a consequence. The activity of fishing may also involve "appreciative-symbol" functions such as sightseeing, hiking, exploring, photography, and nature study. It is fair to judge that time-in-demand or financial cost accounting for a fishing day may involve numerous "activity clusters" which are water-based.[45]

Such recreational responses and use patterns are more frequently asociated with natural areas close to cities, and "non-designated" recreation spaces within urban areas. More and Payne (1978) measured important mood elevation responses among visitors to local Audubon nature centers. The psychological effect of local natural areas was found to be beneficial in mood positively in all cases.[46] Johnson (1978) developed four hypotheses to an inquiry of attitudes about local "non-designated" open spaces as opposed to designated spaces (i.e., Public Park Facilities):

> 1) Nondesignated open space receives much use because of choice as well as location; 2) the amount of recreation use of an area is dependent upon the proximity of the area to the user's home; 3) nondesignated open space has intrinsic value for recreation because of its unstructured character, as compared to more traditional recreation areas; and 4) the use pattern depends upon the age of the user.

Non-designated spaces are chosen as choice locations because of physical qualities, association with friends, and close location. "When given a free choice of play areas, non-designated areas, which offer alternate forms of play activity and recreational setting, are often chosen over the more traditional playground."[47]

The implications here for natural, riparian corridors in urban settings are wide-ranging. Passive, unstructured activity near water rates high among respondents to improved attitude surveys. This pattern is consistent with local use preferences and will be discussed further in a later section.

ECONOMIC CONSIDERATIONS RELATIVE TO RECREATION USE AND WATER QUALITY

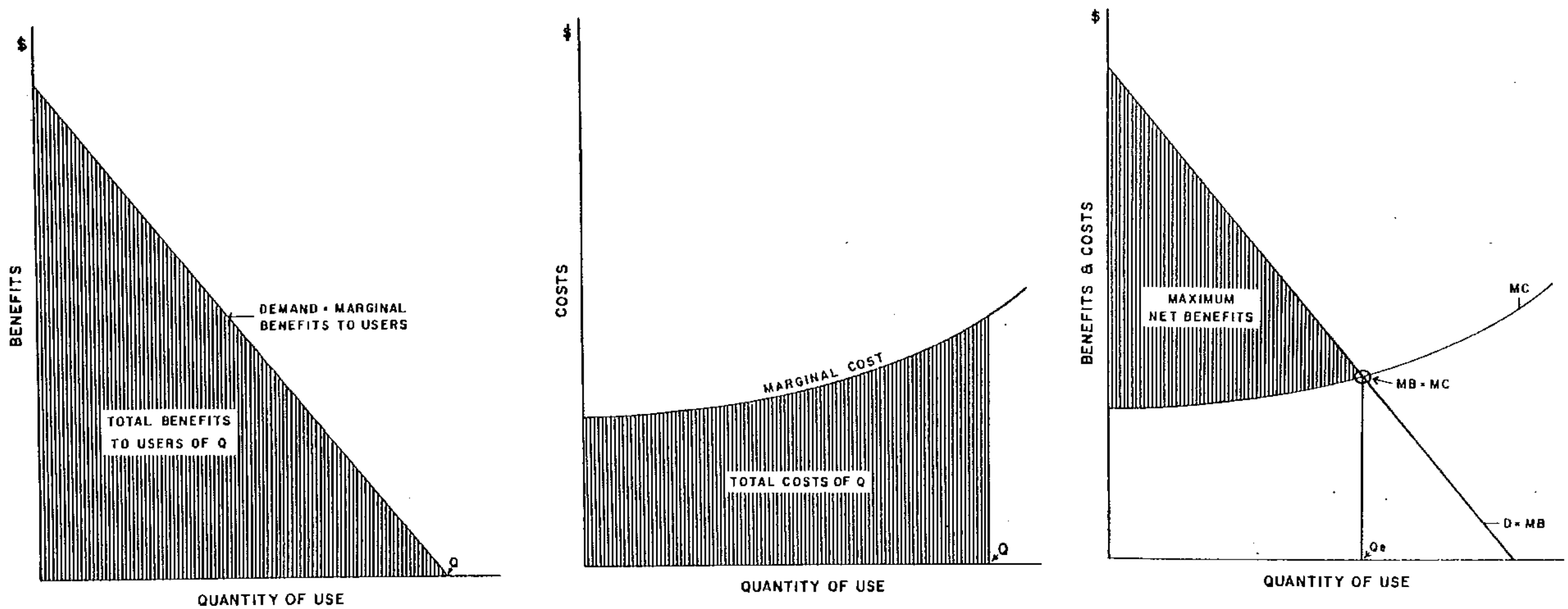
"Economic Evaluation of Alternative Uses of Rivers" has become a process of increasing importance in the West. The scarcity of the resource demands greater efficiency through conservation and optimization of use. King (1977) described benefit-cost analysis, the concept of opportunity cost, measurement of recreation benefits, and data needs for refinement of alternative use evaluation.[48] These concepts are summarized here because they are important to understanding both existing and future potential valley tributary use.

BENEFIT - COST ANALYSIS

Benefit-Cost analysis is far from perfect mainly due to inability to all actual benefits and costs. Incomplete cost accounting also occurs due to bias, but bias probably exists to a greater extent with political decisions, which is the alternative to avoiding benefit-cost measurement. Measuring benefits that are not typically captured in the benefit-cost formula is perhaps the greatest challenge to stream management. Data must be acquired through costly and time-consuming site-specific analysis, and the importance of stream management decisions will dictate whether the expense is justified. Federal, State, and local goals, manifest through laws, regulations, or goal statements often form the basis of importance.

The benefits of resource allocation for a project or policy will be maximized at the point where marginal benefits are equivalent to marginal cost. Various amounts of use or demand for a resource form the incremental basis for marginal benefits derived. Demand for various quantities of use produce the total benefit. Figure 20 summarizes the demand function of water resources. Costs also fluctuate with different use levels, and the point at which marginal benefits equal marginal cost is the point of optimization or maximization between benefits and costs.

The opportunity cost of implementing a certain policy or project is what is given up from the implementation. Market goods are easily assigned costs, but non-market goods, such as a primitive river floating experience, are more difficult to estimate in deciding whether or not to build a dam. Yet these costs and benefits are lost or traded for the dam decision. New economic concepts have arisen to begin estimating these "intangible" costs and benefits. Commodity values and amenity values are examples. Commodity values are benefits from use of natural environments for mineral, livestock, timber, energy, etc. Amenity values are produced from the direct use of natural areas by final consumers. User and option values are two types of amenity values:



Demand function for use of a public natural environment.

Marginal cost function for provision of use of a public environment.

Level of use that maximizes net benefits.

Figure 20 BENEFITS, COSTS, AND OPTIMIZING NET BENEFITS FOR STREAM MANAGEMENT ALTERNATIVES.

1) USER VALUES. Users of natural environments obtain these through on-site activity. An example of such a value is the travel-cost model. Travel-cost is used as a price proxy for estimating demand, and is often used as a partial measure of a person's willingness-to-pay for a particular activity. Income is a typical constraint to measuring value in this way because users are considered buyers rather than sellers. If users are considered sellers, higher values are estimated because income is no longer a constraint. Other constraints are relative to significance in the cost formula. Local resource use by those living in close proximity is typically demonstrative of very new travel cost factors. But value is increased for the resource because it is in close proximity, thus reducing income as a constraint. For those users who are not fortunate enough to be sellers or providers, Moncur (1973) has shown that small expenditures of travel and time can be captured within traditional travel-cost methods. His work studied beach visits by local Hawaiian residents, and he concluded that short time/travel cost benefits are significant.[49] Table 19 summarizes these estimated values.

TABLE 19

SUMMARY OF ESTIMATED VALUES

SURVEY GROUP ESTIMATES

Recreation	"Willingness to Pay" ($12 wks.)	Number of Househld Visits	Value Per household-Visit ($)	Number of Visitor-Occasions Per Household Visit	Value Per Visitor-Occ. ($)	Total Value Oahu Population ($12 wks)
1. Ala Moana	687	687	.84	2.40	0.35	86,473
2. Waikiki to Hawaii Kai	1,688	592	2.84	2.39	1.19	211,839
3. Hanauma Bay	4,983	280	-	2.29	-	-
4. Sandy & Makapuu	567	361	-	2.37	-	-
5. Waimanalo & Bellows	445	352	1.26	3.22	0.39	56,012
6. Kailua	1,917	477	4.03	2.94	1.37	241,671
7. Kaneohe to Laie	1,218	327	3.72	3.68	1.01	153,310
8. Pupukea to Mokuleia	1,126	372	3.03	3.99	0.76	141,730
9. Yokohama Bay to Nanakuli	1,057	370	2.86	4.30	0.66	133,045
10. Barber's Point to Sand Island	1,168	339	3.45	2.94	1.17	147,016
11. Keaiwa Heiau (Aiea Hts.)	93	93	1.00	2.67	0.37	11,706

An important facet of user values is that natural environments are fixed in supply. Growing scarcity of amenity values will increase demand overtime, which projections of resource use must recognize. Carrying capacity constraints will necessitate high user fees commensurate with resource scarcity.

2) OPTION VALUES. So far these remain immeasurable in economic terms. Such values apply to being able or having opportunity to visit areas of scarcity in the future. The opportunity cost of time-in-demand for estimating on-market resources has been addressed by Keith and Workman (1975). No empirical test of time costs had been attempted prior to this work. More impressive is that the cost occurred in Utah for local fishing trips. The concept of optional time allocations possessing a value and thus contributing to total willingness-to-pay calculations is both new and significant. "Willingness-to-pay analyses which ignore the time cost of recreation seriously underestimate the dollar value of recreation to participants." The opportunity cost was 5-10 times the magnitude of travel and on-site user costs.[50]

Site-specific or small area data are necessary to determine both user and option values as elements of valley tributary amenity value. Based on present income, preference, and user data, these values and projections are possible to a limited extent.

WATER QUALITY LIMITATIONS AND RECREATION DEMAND

The literature exhaustively covers the potential for incurring high opportunity costs due to pollution. A few of the more significant studies are reviewed here, and reflect evolution of water quality economic impact measurement efforts over the past twelve years.

1) ECONOMIC CONSIDERATIONS RELATIVE TO WATER QUALITY [51]

Whipple (1969) initiated the first of many discussions about economic consideratons to water quality. Emphasized at the very beginning of his analysis was the concept of "multiple objective functions" water pollution clean-up should serve, including:

1) National economic efficiency. The objective of increasing national income and product.

2) Preserving and improving the natural environment for man's use and enjoyment, referred to as conservation.

3) Regional development. Refers to preferential favoring of a geographic locality or region.

Alternative plans addressing these objectives should be drafted for water quality and use management, some alternatives stressing economic efficiency and some stressing environmental quality. "Those making the final decision will be able to see from the comparison how much will be lost in national income to obtain specified environmental advantages." But Whipple concedes that evaluation of multiple benefits must be tempered with what constitutes economic efficiency, and stresses conservation as a means to allocate these benefits.

The decision, for example, to stimulate central growth along the Wasatch Front requires assumptions that central growth is more efficient than dispersed or decentralized growth. Centralization offers numerous advantages toward provision of services at lower costs, but losses in lifestyle diversity and quality scales may result, as well as Constraining values of self-sufficiency. Threshholds for density of population and social quality are viewed differently by urban dwellers than rural dwellers, so planning at regional scales must recognize eventual populaton re-distribution. Therefore, do we plan to restore or maintain environmental quality in already heavily populated regions, or do we plan to capture opportunity costs and option values in areas to be developed in the future? Which region should be favored for what purpose? Do national economic efficiency and conservation benefit better from increasing services and population along the Wasatch Front, or distributing them statewide? Should growth and development be specialized or balanced?

Either growth scenario requires maintenance of man's home, working and recreational environment, and threshold pollution levels that influence attitudes toward adjacent waters are important to determine. Evaluations of water-based home, work and recreation environments must consider:

1) The size of population accessible to the attraction.
2) The capacity and relative attractiveness of the facilities provided.
3) Presence of competing attractions.
4) Effective demand for water-based recreation.

These considerations will directly influence regional growth scenarios close to recreational amenities of national significance. National Park, recreation or primitive areas all affect populations greater than local home and working populations. Higher levels of maintenance may be required of water resources where these conditions exist, evidenced by watershed anti-degradation, policies administered by State and local authorities.

2) EVALUATION OF RECREATIONAL DAMAGE COST FUNCTIONS [52]

Recreation benefit costs have been determined an important aspect in evaluating water resources project strategies. Whipple's assertion that values for water-based recreation and values for adjacent land near water resources are measureable and significant are consistent with the assumptions made by Bundgaard-Nielson and Himmelblau (1974) who described a quantitative formulation for recreation in which water quality coefficients were evaluated:

> The recreation term in the objective function must be expressed in terms of the major quality variables that can be measured in practice. If data is collected interms of other variables, then these must be related to the usual variables of:
> 1. Biochemical oxygen demand (BOD).
> 2. Chemical oxygen demand (COD).
> 3. Nutrient materials other than carbon, such as phosphate and nitrate.
> 4. Dissolved oxygen (DO).
> 5. Temperature.
>
> In addition, it is also possible to measure suspended solids, organic materials, pesticides, mercury. p^H, and other variables that may under special circumstances be important. Factors such as odor, algae growth, turbidity, and so forth are hard to quantify and in general are related to the factors listed above by one means or another.

Difficulties in relating dollar values to these variables include:

1. Outdoor recreation factors involving personal subjective responses are not amenable to a common measure of value.
2. valid dollar measures of non-market commodities - user, amenity, and option values - is a difficult task.
3. Surrogate values may be irrelevant-attitude surveys, (Aukerman, 1971) supply/demand water quality functions (Chichetti et al. 1972) and imitation studies by Brown and Marr (1968) all provide methods of solving these difficulties. Brown and Marr attacked the problem from the standpoint of identifying critical thresholds rather than marginal damage.

They classified the benefits accruing from water quality as follows:

> 1. Water based activities that require a certain minimum water quality, but increasing the water quality further does not increase the benefits. Typical examples in this group would include fishing, boating, and swimming.
> 2. Water related activities whose beneficial value increases linearly with water quality, such as the supply of water for municipal purposes.

> 3. Water related activities that are independent of water quality, such as the use of the river system for waste disposal. By summing these functions, a total benefit function of water quality can be obtained as shown in Figure 21A.

An important emphasis to Bundgaard-Neilsen and Himmelblau's conclusion is that below a particular dissolved oxygen content in water a particular recreational activity cannot take place. However, decreasing water quality even further does not imply increased damage to the activity; the activity just stops. On the other hand, above a certain dissolved oxygen content the activity can be sustained completely, and increasing water quality further does not imply increased benefits. They assert that Families of activity dependent benefit-cost functions are affected by particular parameter limitations, not just single benefits, Figure 21B.

DeBettencourt and Peterson (1977) produced a format for developing standards and criteria for environmental quality for streams which included threshold rather than marginal water quality limits, and also included degree of development, crowding-use, trash-litter, and skill-levels necessary to allow or preclude stream enjoyment:[53]

> The hypotheses are (1) recreational decisions and satisfactions are strongly sensitive to the environmental attributes of alternative sites, (2) an individual can recognize and differentiate between acceptable and unacceptable sites for an activity when those sites are described in terms of their environmental characteristics, (3) the boundary between acceptable and unacceptable sites for an individual can be described by means of a mathematical function of environmental variables, using suitable experimental and statistical methods, (4) the boundary will be probabilistically distributed for a group of individuals, and the tendency for a site to be acceptable to the group can be described in terms of probabilities, and (5) criteria and standards of perceived recreational quality can be developed on individual acceptance thresholds and/or group acceptance probabilities.

Figure 22 displays the hypothetical threshold function together with an example distribution of thresholds for an homogeneous population.

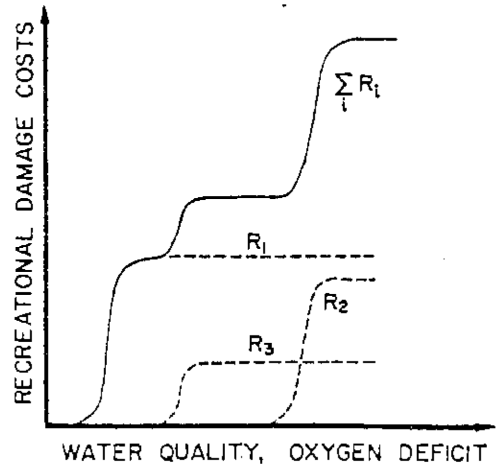


FIGURE 21b

Recreational damage cost functions for three different recreational activities

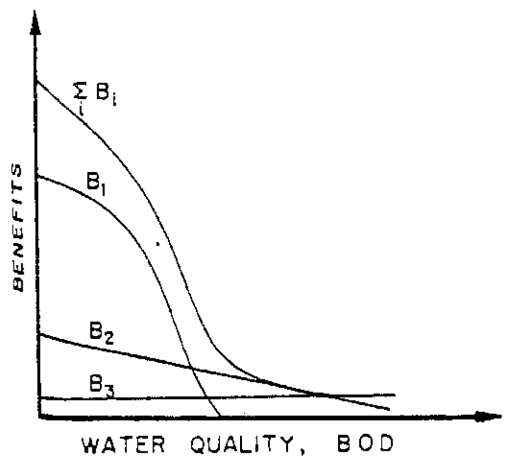
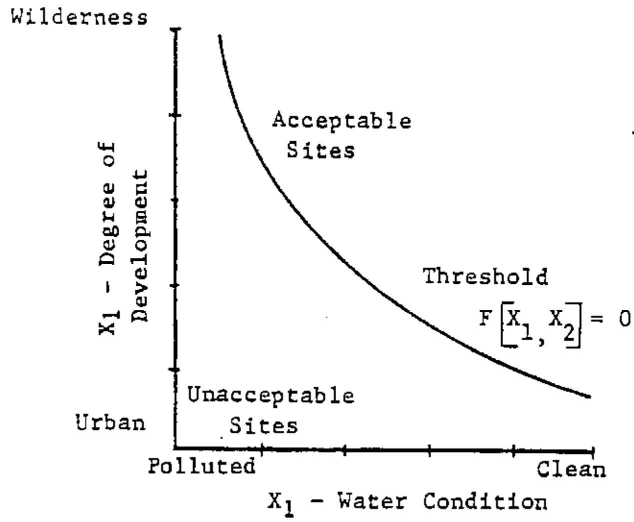


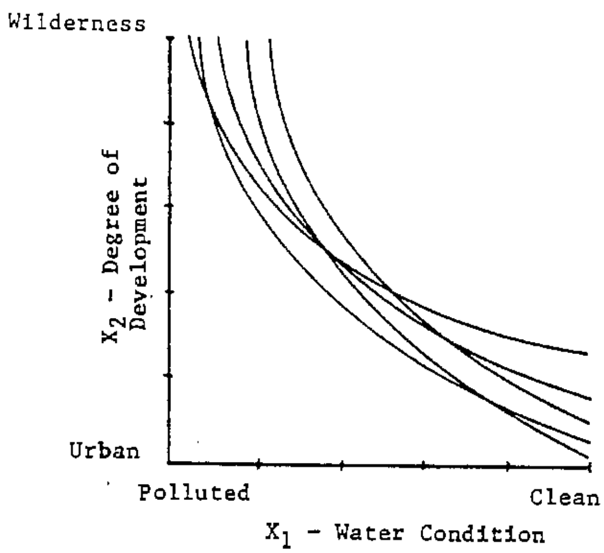
FIGURE 21a

Variation of benefits (B_i) with water quality according to Brown and Mar



.--*Hypothetical threshold function.*

FIGURE 22



--*Hypothetical distribution of thresholds for a homogeneous population.*

3. APPLIED CASE-STUDIES OF RECREATION DOLLAR BENEFITS

Nemerow and Faro (1970) developed and applied systematic procedures to estimate total dollar benefits of water pollution control at a water-recreaton site in New York. [54] Blomquist and Fishelson (1980) [55] and Hwang and Rudzitis (1980) [56] applied systematic recreation benefit models in Illinois, the former applied to Park use, the latter the Chicago Rivers.

Nemerow and Faro inventoried total cost to pay for several water use benefit groups and water use benefits for a primary multiple-use center (Onondaga Lake) were calculated, (Table 20).

Table 20. Beneficial Use Value at Polluted and Unpolluted Levels.

Beneficial Use (1)	Value at existing water quality (PI = 5), in dollars (2)	Value at unpolluted water quality (PL = 1), in dollars (3)
Recreation use	1,479,416	5,194,856
Withdrawal water use	300,000	1,095,000
Wastewater disposal use	2,584,104	0
Bordering land use	595,291	1,266,952
Instream water use	80,931	0
Total annual benefit	3,087,298	7,556,808

The conclusions drawn from this study are:

1. The total dollar benefit of a lake or stream at a given water quality may be estimated by determining all uses which both affect and are affected by water quality, by valuing each use independently, and summing the resultant values.
2. The beneficial water uses which are measurable and affected by or affect water quality are recreation uses, withdrawal water uses, wastewater disposal uses, bordering land uses and in-stream water uses.
3. The value of each beneficial use may be estimated by a willingness to pay criteria or an evaluation of benefits derived from avoiding payment.
4. Application of the suggested benefit measurement

techniques to Onondaga Lake at Syracuse, New York gives total annual user benefits of $3,100,000 at existing water quality and $7,5000,000 at an unpolluted water quality. Therefore, a net social benefit of $4,400,000 per year may be realized by users of Onondaga Lake withthe removal of existing pollution.

5. Recreation proves to be the most important beneficial use for Onondaga Lake at improved water quality and its value comprises close to half of the total positive net annual benefits of decreased pollution. This may also be true for other urban lakes located near centers of population.
6. Measurement of the total dollar benefits of water pollution control should be the aim of local, state and federal pollution control agencies before requiring the installation of advanced forms of sewage and industrial waste treatment. These decisions are more of an economic nature than a public health nature, and therefore may be more equitably carried out by a river basin firm, composed of members representing all major groups in the water-using society.

Blomquist and Fishelsons study of park use affected by water quality concluded that, again, cleaner water increases attendance. "The level of its significance is approximately 90%." Because of lacking accurate visitor-day patterns (accounting also for length of stay), good water quality data, and measuring off-season use, the water quality effects may be biased downward.

Hwang and Rudzitis avoided valuing each use individually and estimated recreational benefits via changes in demand. This allows determining a magnitude of benefits rather than exact dollar amounts:

> The major obstacle we faced was the lack of detailed data. In order to estimate total recreational benefits in the Chicago rivers in the absence of data, we estimated a set of average number of days per person engaged in a particular activity by using per person outdoor activity days data in North Central States and the assumed percentage of river-related activity days to total outdoor activity days in Chicago SMSA. Multiplying average number of activity days per person by total population gives total day's usage per year in a particular activity.
>
> Following Davidson, Adams, Seneca, a set of arbitrary(call it x dollars per activity day) are then chosen for converting units of calendar days into units of benefits (4). The Chicago SMSA population wasto be

Table 21 Sensitivity Analysis for River-Related Recreational Activity in Chicago SMSA

(a) Assumed average number of days per person in All Chicago rivers engaged in the listed activities[a]:

	I	II	III	IV
Boating	0.502	0.401	0.301	0.201
Fishing	0.692	0.550	0.420	0.280
Swimming	0.180	0.180	0.180	0.180

(b) Day's Usage Per Year (1970):

	I	II	III	IV
Boating	3,776,550	3,016,723	2,264,420	1,512,120
Fishing	5,205,920	4,137,650	3,159,166	2,106,440
Swimming	1,354,140	1,354,140	1,354,140	1,354,140

(c) Gross Recreational Benefit Schedules:

		I	II	III	IV
	(x = $1	3,776,550	3,016,723	2,264,420	1,512,120
Boating	(x = $2	7,553,100	6,033,446	4,528,840	3,024,240
	(x = $3	11,329,650	9,050,169	6,793,260	4,536,360
	(x = $1	5,205,920	4,137,650	3,159,660	2,106,440
Fishing	(x = $2	10,411,840	8,275,300	6,319,320	4,212,880
	(x = $3	15,617,760	12,412,950	9,478,980	6,319,320
	(x = $1	1,354,140	1,354,140	1,354,140	1,354,140
Swimming	(x = $2	2,708,280	2,708,280	2,708,280	2,708,280
	(x = $3	4,062,420	4,062,420	4,062,420	4,062,420

[a] The assumed percentages of river-related activities to respective total outdoor recreation activities are as follows: (I) Boating, 50%; Fishing, 50%; Swimming, 5%; (II) Boating, 40%; Fishing, 40%; Swimming, 5%; (III) Boating, 30%; Fishing, 30%; Swimming, 5%; (IV) Boating, 20%; Fishing, 20%; Swimming, 5%.

7,523,000 (as of 1970). The results of this sensitivity analysis for three recreational activities (boating, fishing, and swimming) are summarized in Table 21. To interpret the table, let's suppose that before cleaning up (average DO level 3ppm, for example) average number of activity days per person per year were boating 0.301, fishing 0.280, and zero swimming. Now, when dissolved oxygen level increases to 5ppm in all rivers as a whole, assume that average activity days are boating 0.401, fishing 0.420, and swimming 0.180. At x = $1, the marginal recreational benefit is calculated as follows:

Boating = (3,016,723 - 2,264,420) = 752,303
Fishing = (3,159,660 - 2,106,440) = 1,053,220
Swimming = (1,354,140 - 0) = 1,354,140

Therefore, the marginal recreational benefit due to water quality improvement is estimated as $3,159,663 while the absolute benefits is $7,530,523 for all three activities. These values are illustrative and give an indication of the magnitude of the benefits.

Based on the concept of magnitude, "one of the most important benefits of pollution abatement in heavily populated areas is the increase in the recreational use of improved water." However, more accurate water quality data and indexes of recreational activity days on streams need to be provided for detailed cost-benefit accounting.

E. INSTREAM FLOW MAINTENANCE

The attainability of wider diversity in beneficial use of valley tributaries depends to a great extent on the conservation of stream ecologies in some state of equilibrium. Instream use withdrawals are becoming more often based on this conservation ethic. Upper reaches of Big and Little Cottonwood Creek testify to past traditional philosophies of substituting primary culinary use for that of secondary recreational use. As a result, the traditional philosophy faces a new era of competing use. Applications for withdrawal and appropriation of scarce water for dams and energy are beginning to conserve minimum flows for instream uses.

This section reviews progress on evolving "new" water rights philosophy described by Tarlock (1978), summarizes existing options for securing minimum stream flows explained by Nelson, Horak, and Lewis (1978), and presents instream flow criteria developed by the Cooperative Instream Flow Group (1978).

APPROPRIATION FOR INSTREAM FLOW MAINTENANCE

Tarlock's (Utah Law Review, 1978) survey [57] of Western State laws and procedures which recognize and protect instream flow rights, proposed the thesis that "instream uses are entitled to equal footing with traditional consumptive beneficial uses, but that these new uses should be recognized and protected only as public rights." It also called for strict legislative standards for state-created appropriation systems to recognize, preserve and protect instream uses.

(I) PHILOSOPHY OF INSTREAM PRESERVATION

Tarlock argues that instream values are not fundamental constitutional or natural rights, but discretionary state exercises of its police power. Opportunity costs of alternative withdrawal scenarios must always be considered, and those activities which threaten equally weighted environmental values must assume a high burden of justification by those exercising discretion. Emphasized here is the notion that environmental values have equal weight with non-environmental values, but this does not necessarily imply that instream flows have primacy over culinary appropriations.

The proposal that instream flow "rights" have no constitutional basis is supported by an interesting assertion: "Environmental degradation is not a case where a powerful majority is attempting to deny a powerless minority access to the political process to claim its share of public benefits." This is a sweeping proposition which may have little basis in fact. Several Local examples can be cited that demonstrate where poweful majorities have done that in the context of the Utah State political structure. One example case can be made that whole groups of individuals comprising industrial (recreation industry) interests have been excluded access to the political process to claim their share of instream flows.

(II) INSTREAM FLOW PRESERVATION STANDARDS

The requirement for strict legislative standards in determining instream flow needs has been substantially influenced by the 1975 cooperative Instream Flow Group established by the U.S. Fish and Wildlife Service. Flow requirements vary in different States where water quality enhancement and recreation are given weight. Most flow provisions are designed to maintain fisheries, and critical stream reaches (where fishery values are greatest) are necessary to identify in order to prescribe exacting and politically resilient instream flow provisions.

(III) ELIMINATION OF BARRIERS TO FLOW PRESERVATION APPROPRIATIONS

The requirement for an actual diversion has to date been a barrier to instream flow allocation. However:

> Most western water experts agree that the actual diversion requirement serves no function that cannot be served by other water law doctrines and statutory procedures. Thus, the real issue is whether these uses are beneficial. In light of the modern and widespread appreciation of instream use values, it can no longer be argued that insteam uses are per se grossly inefficient and thus should be denied in favor of other claimants such as energy developers. Because water is scarce in the West and must be shared among diverse users, the states have always asserted the right to determine who can use how much. Private rights are subordinate to collective allocation decisions which reflect a societal consensus about the optimum use of a state's water resources. So long as vested rights remain unimpaired, a state may exercise its police power to decide among whom water should be allocated. A state may choose between public and private allocations and between instream and traditional consumptive uses. Thus a state can withdraw the water from appropriation and reserve it for instream uses; it can appropriate the water itself or it can choose to rely upon private initiative operating within state designated ground rules. For

these reasons, instream uses should be valid without the requirement of an actual diversion, and these uses should be presumed beneficial. The amount of water needed to support a use is always subject to judicial review or to administrative evaluation when other users claim that the use is non-beneficial.

This analysis sets the stage for state filings for instream use. Such filings are considered the highest beneficial use of the water under circumstances which clearly meet objectives of public support and demand. Demand can be demonstrated through accounting of all costs associated with use on a particular stream. (Section IV).

FLOW PRESERVATION STRATEGIES

The following abstract of Instream Flow Strategies for Utah summarizes the approaches available for securing minimum flows. Because definitions of the public trust and concepts of beneficial use are expanding, "new interpretations of the scope of the public trust have mandated greater attention to alternative uses of water including instream uses."

Although Utah streams are fully appropriated during periods of peak demand, many options are available to secure instream uses for priority streams and rivers.

ABSTRACT: INSTREAM FLOW STRATEGIES FOR UTAH [58]

The U.S. Fish and Wildlife Service produced an analysis of instream flow strategies specific to Utah in May 1978. The analysis provides an information matrix which identifies a general description and application of different strategies, together with an evaluation matrix that weighs both elements of cost and effectiveness (See Figure 22).

While the analysis is a valuable tool for determining optimum strategies, some aspects of a general policy nature are absent, such as the influence of water conservation through voluntary or conjunctive use programs, and values

FIGURE 22

EVALUATION MATRIX Strategies for Reserving Instream Flows in ____________

yes = Advantage ●
no = Disadvantage ○
blank - Inapplicable (in this State)

	ELEMENTS OF EFFECTIVENESS																					ELEMENTS OF COST					
	Overall		Political			Legal					Administrative						Resource					Institutional			Monetary		
	Demonstrated past utility in this State?	Optimism over future effectiveness in this State?	Predominantly involves fish & wildlife interests?	Can be implemented by fish and wildlife interests?	Attracts support from public interest groups?	Clearly established statutory basis?	Avoids legislative or judicial action?	Recognized without legal challenge?	Legally recognizes fish & wildlife values?	Creates legal right to flow reservation?	Available independent of other strategies?	Fits into a funded agency program?	Involves established administrative procedure?	Uses available fish & wildlife agency expertise?	Uses quantified instream flow needs?	Influences early planning & design decisions?	Directly results in flow reservation?	Results in storage for flow augmentation?	Useful during extended low flows?	Useful for overappropriated streams?	Useful with small streams?	Avoids costly legal process?	Avoids costly bargaining process?	Avoids costly planning & design?	Avoids costly reservoir development?	Avoids costly water rights acquisition?	Avoids costly forfeiture of water revenue?
Appropriative Water Rights																											
State Condemnation/Reallocation of Water Rights																											
State Appropriation of Instream Flow																											
State Moratoria on New Appropriations																											
State Discretionary Water Permit Authority																											
Legislative/Administrative Controls																											
Federal Reauthorization of Projects																											
State-Federal Wild & Scenic River Systems																											
State Definition of Navigable Waters																											
State-Federal Interagency Consultation																											
Federal License & Permit Stipulations																											
State Allocation of Reservoir Space																											
State Purchase & Lease of Water Rights																											
Water Resource Planning																											
Federal WRC Planning Programs																											
Federal Aid Funding to Purchase Storage																											
Federal Reservoir Construction/Enlargement																											
Water Resource Management																											
State Water Rights Records Analyzed																											
State-Federal Flow Requests Made Early																											
State-Federal Flow Requests Made Specific																											
State-Federal Combined Storage/Flow Requests																											
Engineering Alternatives																											
Coordinated Multireservoir Operations																											
Reservoir Sediment Storage Releases																											
Stream Channels to Convey Stored Water																											

to the State presently ignored by traditional definitions of consumptive use.

Until overall State water policy adopts revised definitions of consumptive use for recreation, and conjunctive use for conservation, many strategies and opportunities for instream flow protection will be foregone.

This abstract lists the fourteen (14) most probable strategies believed likely to succeed in obtaining instream flow components to water resource management proposals. It also compares identification comments from the information matrix with those recommended here. The strategies discussed, in order of priority, include:

1. State Moratoria on New Appropriations.
2. State Discretionary Water Permit Authority.
3. State Water Rights Records Analyzed.
4. State-Federal Interagency Consultation.
5. State Appropriation of Instream Flow.
6. State Purchase and Lease of Water Rights.
7. Federal License and Permit Stipulations.
8. State-Federal Requests Made Specific.
9. Reservoir Sediment Storage Releases.
10. State-Federal Wild and Scenic Rivers System.
11. Federal Reauthorization of Projects.
12. State Definition of Navigable Waters.
13. Federal Water Resources Council Planning Programs.
14. Stream Channels to Convey Stored Water.

For each stream segment identified as a priority preservation segment, one or more of these strategies can be employed to provide mitigation of a specific water resource development proposal. The evaluation matrix should be carefully filled out for each stream, thus indicating weights for each strategy. The strategy can then be pursued through conventional or unconventional political processes. Figure 22A records an hypothetical application

1. STATE MORATORIA ON NEW APPROPRIATIONS - Such a moratoria is in according to Jerry Olds, State Division of Water Resources, for the State of Utah (Intermountain Water Alliance Conference, April 17, 1982). Thus,

FIGURE 22A

EVALUATION MATRIX Strategies for Reserving Instream Flows in Utah

yes = Advantage ●
no = Disadvantage ○
blank - Inapplicable (in this State)

	ELEMENTS OF EFFECTIVENESS																					ELEMENTS OF COST					
	Overall		Political			Legal					Administrative						Resource					Institutional			Monetary		
	Demonstrated past utility in this State?	Optimism over future effectiveness in this State?	Predominantly involves fish & wildlife interests?	Can be implemented by fish and wildlife interests?	Attracts support from public interest groups?	Clearly established statutory basis?	Avoids legislative or judicial action?	Recognized without legal challenge?	Legally recognizes fish & wildlife values?	Creates legal right to flow reservation?	Available independent of other strategies?	Fits into a funded agency program?	Involves established administrative procedure?	Uses available fish & wildlife agency expertise?	Uses quantified instream flow needs?	Influences early planning & design decisions?	Directly results in flow reservation?	Results in storage for flow augmentation?	Useful during extended low flows?	Useful for overappropriated streams?	Useful with small streams?	Avoids costly legal process?	Avoids costly bargaining process?	Avoids costly planning & design?	Avoids costly reservoir development?	Avoids costly water rights acquisition?	Avoids costly forfeiture of water revenue?
Appropriative Water Rights																											
State Condemnation/Reallocation of Water Rights																											
State Appropriation of Instream Flow																											
State Moratoria on New Appropriations	○	○	○	○	●	●	○	●	○	○	○	●	●	●	●	●	○	○	○	○	●	●	○	○	●	●	○
State Discretionary Water Permit Authority	○	○	●	○	●	○	●	○	○	○	●	○	●	●	●	○	○	○	○	○	●	○	○	●	●	●	○
Legislative/Administrative Controls																											
Federal Reauthorization of Projects	○	○	●	○	●	●	○	●	●	●	●	○	○	●	●	○	●	●	●	●	○	○	○	○	●	●	○
State-Federal Wild & Scenic River Systems	○	●	○	○	●	●	○	●	●	●	●	●	●	●	○	○	●	○	●	○	●	○	○	○	●	●	●
State Definition of Navigable Waters																											
State-Federal Interagency Consultation	○	●	●	●	●	●	●	●	●	○	○	●	●	●	○	●	○	○	○	○	○	●	○	●	●	●	●
Federal License & Permit Stipulations	○	●	○	○	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	○	○	●	●	○
State Allocation of Reservoir Space																											
State Purchase & Lease of Water Rights	●	●	●	●	●	●	●	○	○	●	●	●	●	●	●	○	●	●	●	●	●	●	●	●	●	○	●
Water Resource Planning																											
Federal WRC Planning Programs	●	○	○	○	○	●	●	●	○	○	●	●	●	●	●	●	○	○	○	○	○	●	○	○	●	●	●
Federal Aid Funding to Purchase Storage	●	●	●	●	○	●	●	○	●	●	●	●	●	●	●	○	●	●	●	●	●	●	●	●	●	○	●
Federal Reservoir Construction/Enlargement	○	●	●	○	●	●	○	●	○	○	●	●	●	○	●	●	●	●	●	●	○	●	○	○	○	●	●
Water Resource Management																											
State Water Rights Records Analyzed	○	●	●	●	○	●	●	●	○	○	○	○	○	○	●	●	○	○	○	●	●	●	●	●	●	●	●
State-Federal Flow Requests Made Early	●	●	●	○	○	●	●	●	○	○	●	●	●	●	●	●	●	○	●	●	○	●	○	○	●	●	●
State-Federal Flow Requests Made Specific	○	○	●	○	○	●	●	●	○	○	●	●	●	●	●	●	●	○	●	●	●	●	○	○	●	●	●
State-Federal Combined Storage/Flow Requests	●	●	●	○	○	●	●	●	○	○	●	●	●	○	●	●	●	●	●	●	○	●	○	○	●	●	○
Engineering Alternatives																											
Coordinated Multireservoir Operations	○	●	●	○	●	○	●	●	○	○	●	○	○	○	●	○	●	○	●	●	○	●	○	○	●	●	○
Reservoir Sediment Storage Releases	○	○	●	○	●	○	○	●	○	○	●	○	○	○	●	○	○	●	●	●	○	●	○	●	●	●	○
Stream Channels to Convey Stored Water	○	●	●	○	○	○	●	●	○	○	○	○	○	○	●	●	●	○	●	●	●	●	○	○	●	●	●

Answers are strictly judgmental, based on written and verbal opinion reported to the Enviro Control study team through December 1977; subject to modification by selected reviewers (empty matrix furnished for reviewers on the following page).

identification of streams lacking impoundments and large diversions, and those possessing wild/scenic rivers values, should be evaluated for instream flow appropriation Those free-flowing streams with either quantified/unquantified recreation values (fishing, boating, canoeing, wilderness, solitude) should head an instream priority list. "A moratorium provides an opportunity to formulate a plan for optimal utilization of water resources for achieving environmental and developmental interests, and establishment of priorities for the allocation of available water resources among these competing interests."

2. STATE DISCRETIONARY WATER PERMIT AUTHORITY - This strategy is probably the most effective interim approach. Establishment of a prioritized stream program and data base, together with development of positive organizational relationships with the State Engineer will go far in demonstrating the utility of this approach in Utah. Low bargaining cost.

3. STATE WATER RIGHTS RECORDS ANALYZED - This approach is expensive because it incurs substantial personnel cost. However, present trends toward volunteerism offer a great potential cost savings. This strategy is promising in areas where rapid growth has occurred (i.e., Wasatch Front) and rights have lapsed and require adjudication. The availability of volunteers in rapid growth areas is good, and where a substantial public benefit could accrue from records analysis, the likelihood of initiating such a program for a specific basin is high. This strategy holds great promise in exchanging water for instream flows, and should be pursued in prioritized basins where rights have lapsed.

4. STATE-FEDERAL INTERAGENCY CONSULTATION - The Fish and Wildlife Coordination Act (FWCA) institutes formalized procedures between the Corps of U.S. Fish and Wildlife Service, State Wildlife Resources, and other agencies to coordinate implementation for wildlife habitat as part of a mitigation

plan. Any projects undertaken by Federal agencies (particularly the Bureau of Reclamation) or those requiring permits (as with the BLM) provide an opportunity to address instream flow needs. The amount of Federal ownership and public expenditure in Utah makes this strategy preferred in a majority of situations.

5. STATE APPROPRIATION OF INSTREAM FLOW - Although no mention exists in State statutes regarding appropriation for instream use, several bills to be proposed by local Representatives to the Utah Legislature will request such appropriations on Blacksmith's Fork and other priority streams for fishing. This approach, if successful, may be effective for the river-running industry as well. Ultimately, the State should formalize this process as an exercize of its police power.

6. STATE PURCHASE/LEASE OF WATER RIGHTS - Streams requiring only a few cfs can be augmented through direct purchase or lease. In many instances, the State Wildlife Resource Division could earmark budget funds for selective acquisition of critical habitat, or the Legislature could authorize funds via a resolution or bill.

7. FEDERAL LICENSE AND PERMIT STIPULATIONS - This strategy also applies within context of Federal coordination on dam/reservoir projects, but has particular importance in evaluating Federal Energy Regulatory Commission (FERC) proposals or licenses for power generation from low-head hydro units.

8. STATE-FEDERAL FLOW REQUESTS MADE SPECIFIC - A detailed study of planned dam/reservoir releases in meeting habitat requirements allows specific reservation of flows along stream reaches below planned Federal projects. Gaging installation/maintenance, and study cost will be incurred where data is available.

9. RESERVOIR SEDIMENT STORAGE RELEASES - Quantity of available yield

from sediment reserve may be released for fish/wildlife benefit. Requires minor modifications for project operation at existing Federal dams and reservoirs.

10. STATE-FEDERAL WILD AND SCENIC RIVERS SYSTEM - Stream segments 25 miles or longer and bordered by landscape of high visual quality can be petitioned for study by the Federal government. Process is similar to that for wilderness designation. This strategy is a strong one where collective suport for a segment is very strong and "non-consumptive" type recreation economics demonstrate obvious instream flow values. Both the Green and Colorado meet these criteria and were recommended for inclusion in 1979. Fish and wildlife values are critical keys to justifying designation.

11. FEDERAL REAUTHORIZATION OF WATER PROJECTS - This approach is effective but costly. It should be employed only where Federal project money has been spent and where hard economic data can justify a strong argument in Congress. It also requires extensive analytical data handling, information dissemination, transportation, equipment, and personnel cost to oversee and carry out basic lobby activities.

12. STATE DEFINITION OF NAVIGABLE WATERS - The analysis of U.S. Fish and Wildlife Service indicates "this strategy is not applicable in this State." A review of recent legal decisions and application of Federal Clean Water Act provisions in Utah through Sections 201, 208 and 404 (1977) indicate this position to be arguable in a court of law. Legal research and fees will be incurred with this strategy. The U.S. Corps of Engineeers has asserted Federal authority over navigable waters in Utah, and to date have successfully resisted legal challenge.

13. FEDERAL WATER RESOURCES COUNCIL PLANNING PROGRAMS - Such programs are administered for river basin planning or energy develoment. Requires

lobbying to include instream flows in assessment/study phase.

14. STREAM CHANNELS TO CONVEY STORED WATER - Conveyance systems are typically designed to minimize water treatment cost, evaporation and seepage loss. These diseconomies in water deliveries may be reversed by regained benefits from fish and wildlife recreation. Redesign of the conveyance system may be merited after a more exhaustive economic analysis.

INSTREAM FLOW CRITERIA

Figures 23, 24, 25, 26, and 27 summarize flow depth/velocity requirements for recreational activities most applicable to valley tributaries.

These criteria, estimated by the U.S. Fish and Wildlife Insream Flow Group, may vary for different reaches depending on physiographic characteristics of the stream. They are intended as guidelines rather than absolutes.

WATER RESOURCES DEVELOPMENT: BALANCED VS. UNBALANCED GROWTH

As local economies at a regional scale become more service oriented, the demands for water change. McCuen (1974) maintains that "water policies and associated economic research should reflect the change in the orientation of our economy:

> "Furthermore, the service sector is more labor intensive than the secondary sector and thus may involve the creation of more jobs per doallar of investment than similar investment in the secondary sector. This would reduce the out-migration of the young, which in general are better educated than the older inhabitants. The availability of a more educated labor force will then attract additional industry. To reflect the above policy. Investment in water development might place less emphasis on power, irrigation, and pollution abatement and emphasize those aspects of water development that are conducive to development in the service sector. The service sector requires increased waste treatment facilities for homes and office buildings and water-based recreational facilities for the labor force. [59]

The orientation of newly-developing regions toward primary sector growth (i.e., capital-intensive industrial/agricultural) implies less demand for water-based recreation activities. However, some geographic resources which exhibit natural resources of value greater than local concern - or national in scale - may be an exception.

All consumptive uses of water should be recognized in balanced policy. Changing needs for water should guide what constitutes balance within a region. A highly populated region places greater scarcity value on natural resources and demands those resources at a more intensive rate. Local water resources management policy must recognize such demand in order to achieve efficiency in multiple resource use. In any case, outstanding resources of national merit require stable policies.

Water resources in Salt Lake County are demanded for use by a dominant service-oriented population. Needs for multiple use - recreation and wildlife - are greater in the Salt Lake Valley and Wasatch Front, and local officials have an obligation to satisfy these needs consistent with local water quality goals.

FIGURE 23 WATER CONTACT WADING

CRITERIA

	PHYSICAL	SAFETY	OPTIMUM
DEPTH			0.75-2.5 ft
minimum	0.25 ft	0.5 ft	
maximum	4.0 ft	3.0 ft	
VELOCITY			0.25-2.0 fps
minimum	0 fps	0 fps	
maximum	3.0 fps	2.5 fps	

COMMENTS: Depth in feet multiplied by velocity in fps should equal 10 or less. Saftey depends upon height and weight of individual as well as substrate type.

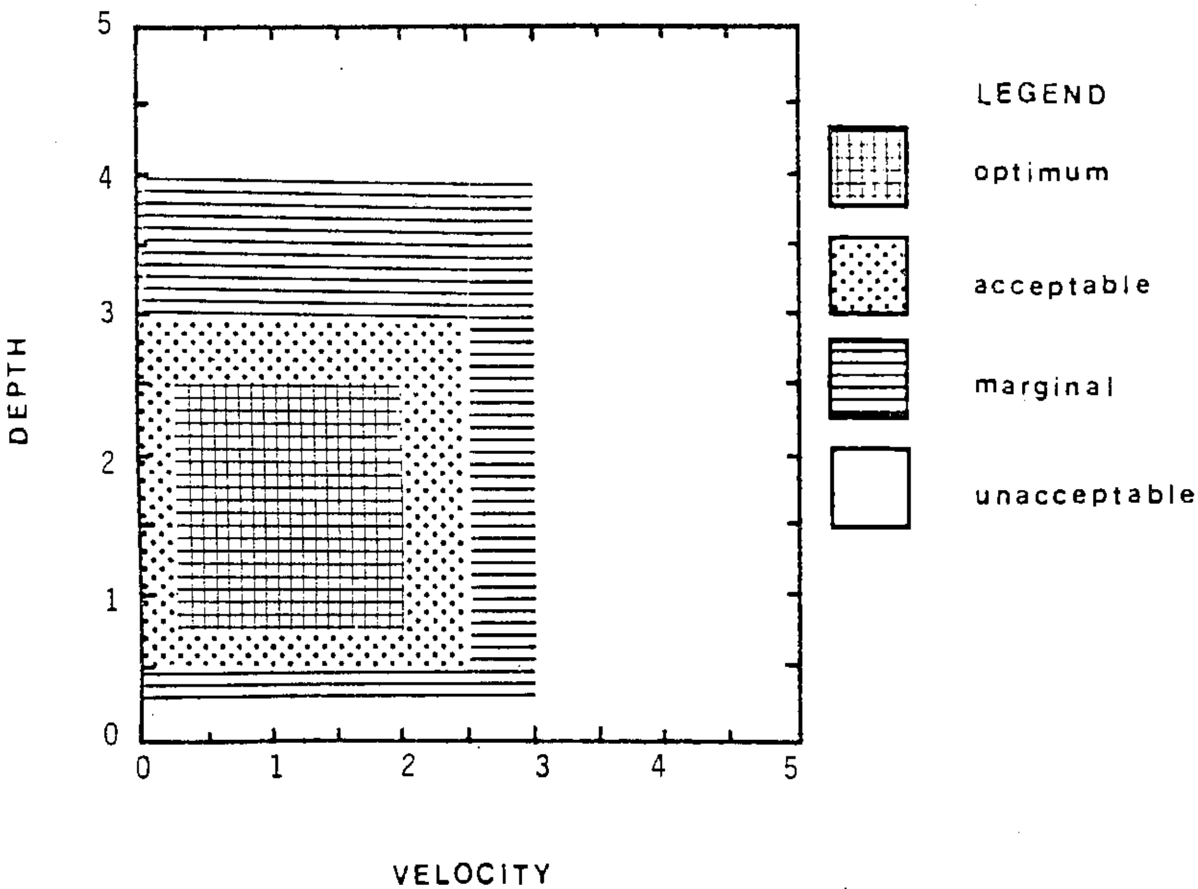


FIGURE 24 BOATING TUBING-FLOATING

CRITERIA

	PHYSICAL	SAFETY	OPTIMUM
DEPTH			2.0 ft +
minimum	1.0 ft	1.5 ft	
maximum	NA	NA	
VELOCITY			1.0-5.0 fps
minimum	0 fps	0 fps	
maximum	8.0 fps	7.0 fps	

COMMENTS: Higher velocities safe only under certain conditions.

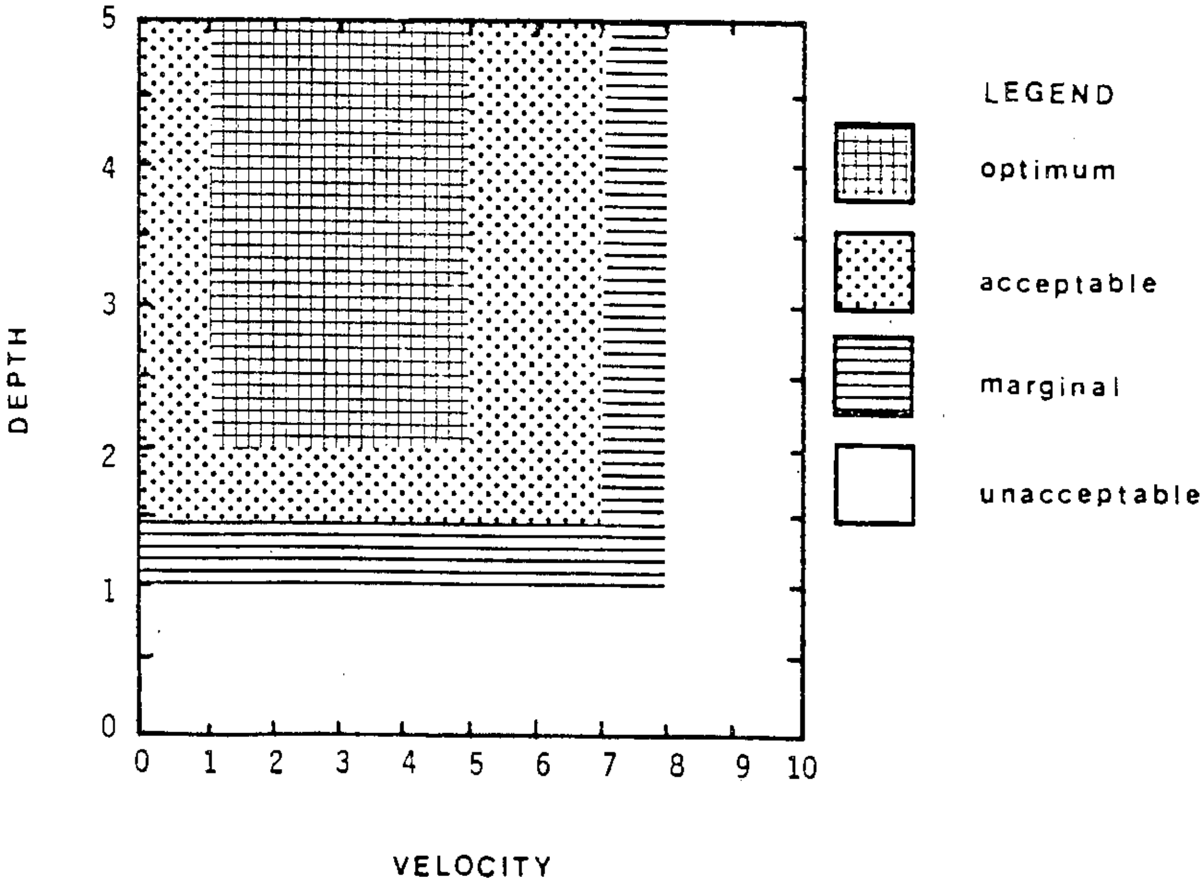


FIGURE 25 FISHING WADING

CRITERIA

	PHYSICAL	SAFETY	OPTIMUM
DEPTH			1.0-2.5 ft
minimum	0.5 ft	0.75 ft	
maximum	4.0 ft	3.50 ft	
VELOCITY			0.25-2.0 fps
minimum	0.0 fps	0.0 fps	
maximum	3.0 fps	2.5 fps	

COMMENTS: Depth in ft multiplied by velocity in fps should equal 10 or less. Safety depends upon height and weight of individual as well as substrate type.

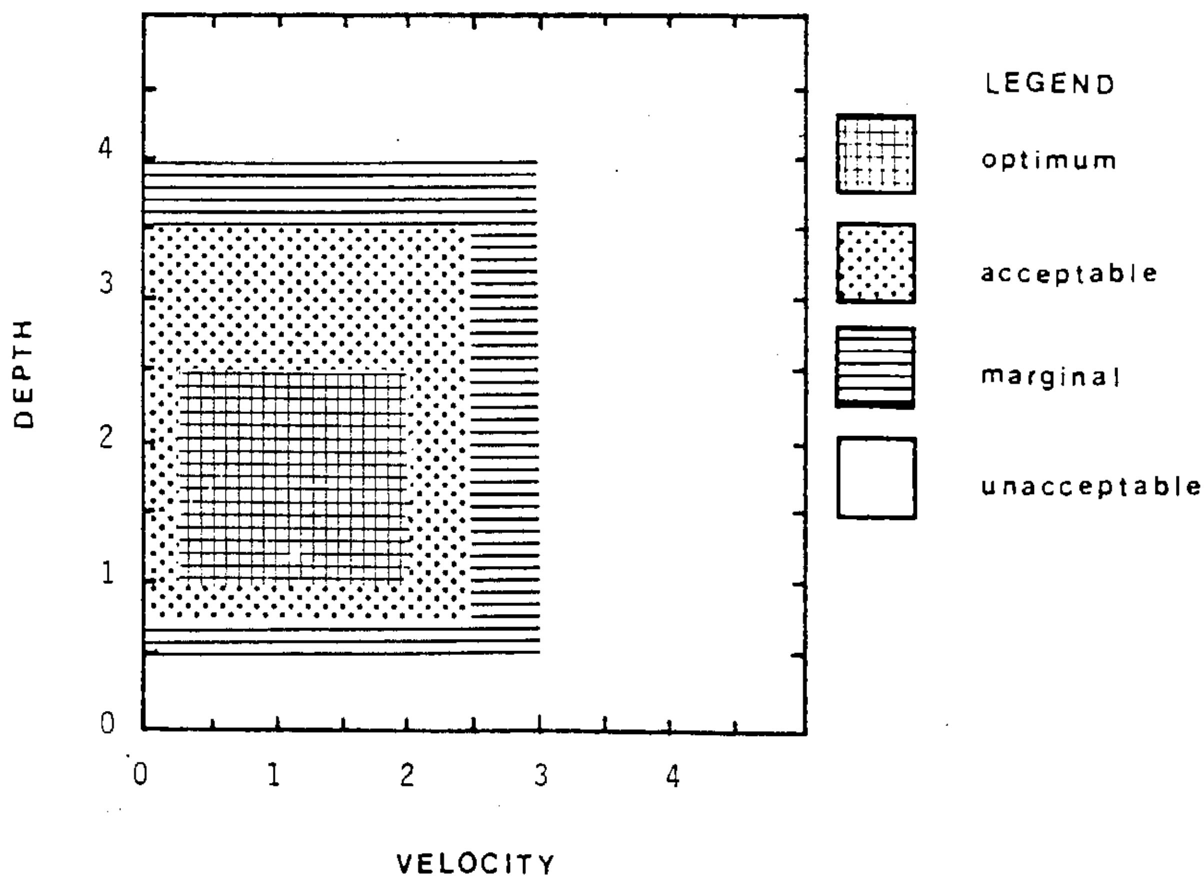


FIGURE 26 BOATING ROWING-RAFTING-DRIFTING

CRITERIA

	PHYSICAL	SAFETY	OPTIMUM
DEPTH			3.0 ft +
minimum	1.0 ft	2.0 ft	
maximum	NA	NA	
VELOCITY			1.0-10.0 fps
minimum	0 fps	0 fps	
maximum	14.0 fps	12.0 fps	

COMMENTS: Higher velocities require boats/rafts of a type specifically designed for white water. Higher velocities safe only under certain conditions.

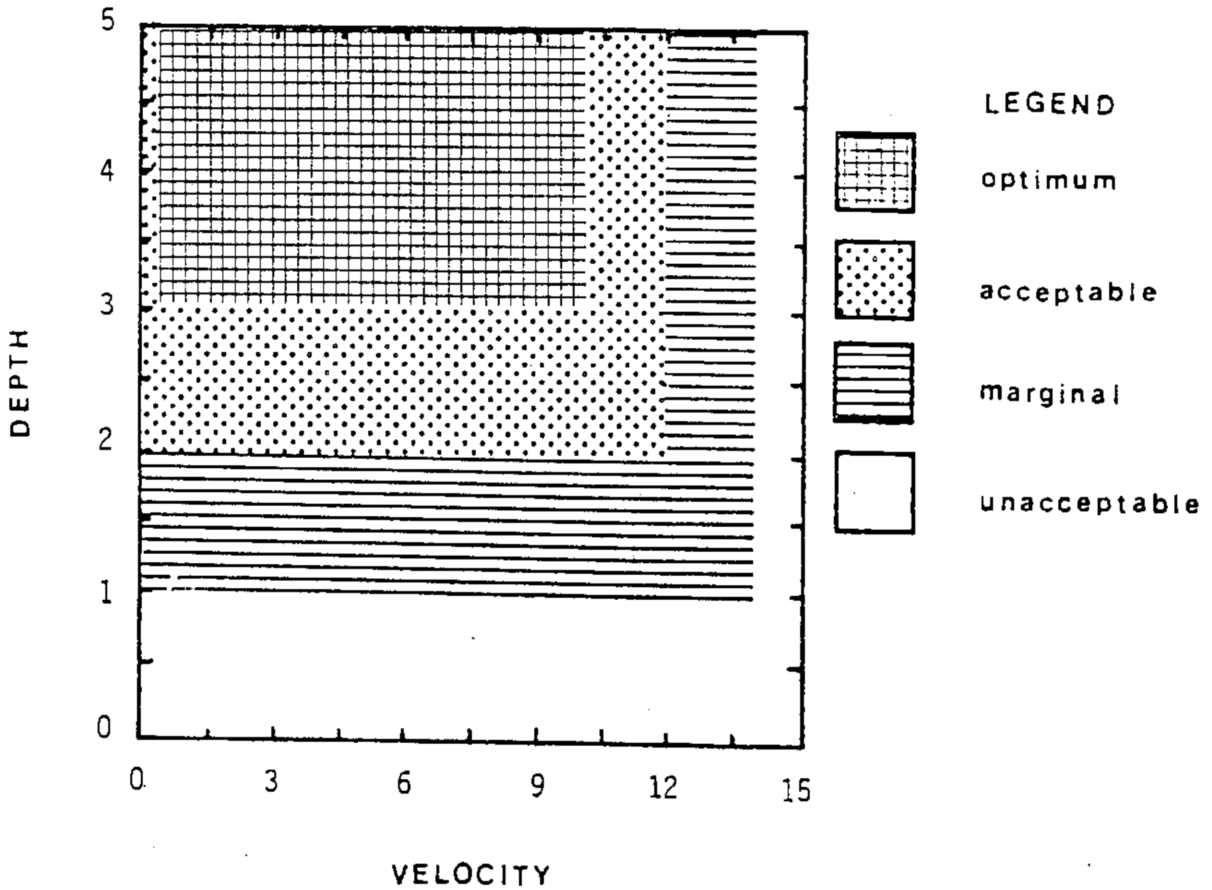
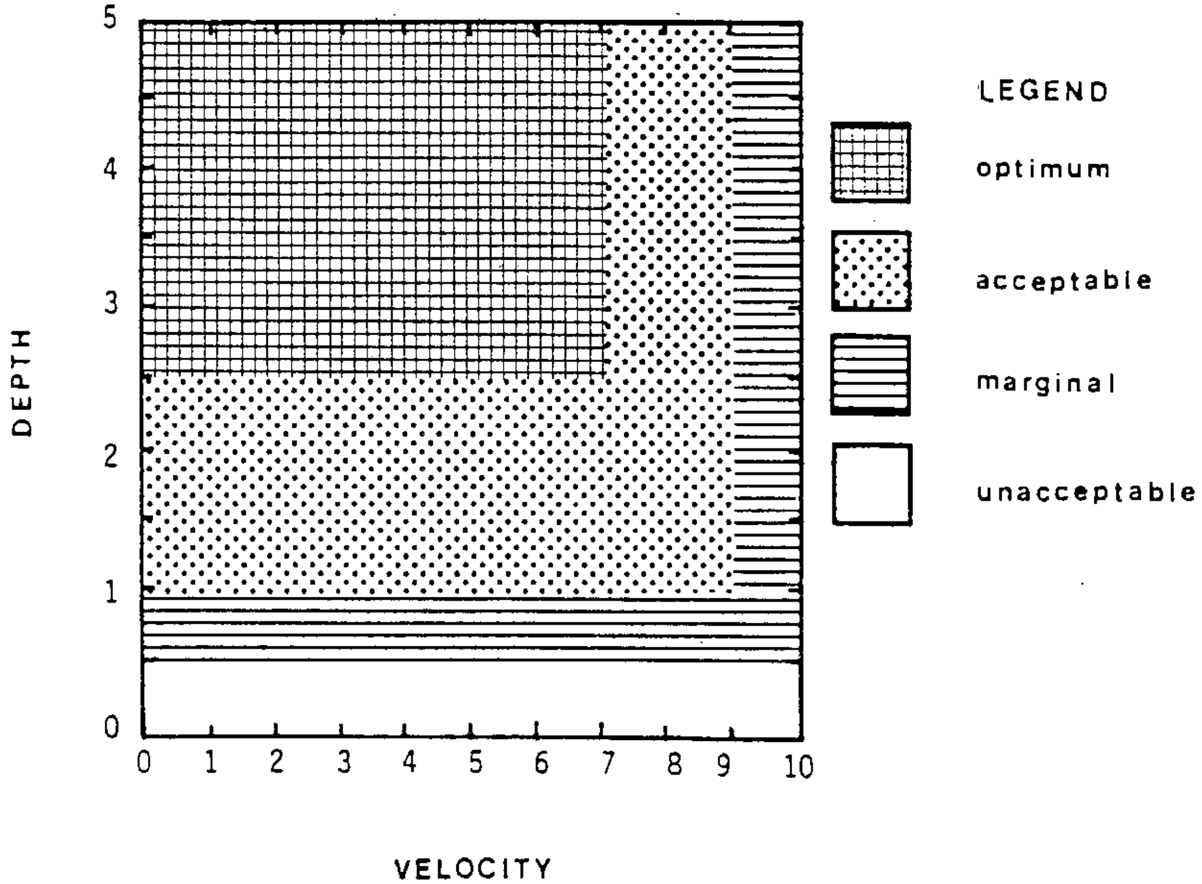


FIGURE 27 BOATING CANOEING-KAYAKING

CRITERIA

	PHYSICAL	SAFETY	OPTIMUM
DEPTH			2.5 ft +
minimum	0.5 ft	1.0 ft	
maximum	NA	NA	
VELOCITY			0.5-7.0 fps
minimum	0 fps	0 fps	
maximum	10.0 fps	9.0 fps	

COMMENTS: Higher velocities exclude open canoes. Higher velocities safe only under certain conditions.



V. SALT LAKE VALLEY TRIBUTARIES: ECONOMIC OPPORTUNITIES FOR INCREASED BENEFICIAL USE

Section II described numerous characteristics of Salt Lake Valley tributaries necessary to enable analysis of existing and future use; Section III discussed the extent to which present uses are impaired, and made recommendations for improving the data base for estimating existing and future conditions; Section IV presented an argument that recreation use is a valid beneficial industry to local economies, and that instream flow preservation leads to a more balanced regional economy. Also, several recreation criteria applicable to Salt Lake Valley tributaries were outlined.

This discussion applies concepts presented in Section IV and estimates local recreation demand as a measure of potential beneficial use. It also incorporates analytical elements and conclusions from Sections II and III to the extent possible. Local recreation preferences, facilities, and user patterns are presented, followed by a discussion of beneficial use potential protected under Recreation/Aesthetics Chapters of State Pollution Regulations. Finally, a fishery model developed by State Wildlife Resources is applied to appropriate stream segments and results evaluated.

A. LOCAL RECREATION: PREFERENCES, FACILITIES, PATTERNS

Statewide recreation inventory and analysis began in 1972 with basic data gathering on recreation desires, location and frequency of use by residents in multi-county planning districts. County-wide breakouts were derived from the multi-county data base. Hunt, Nielson, Duering, and Dalton at Utah State University published extensive county and statewide data between 1976-1978 under a grant from the Bureau of Outdoor Recreation, U.S. Department of Interior, under provisions of the Land and Water Conservation Fund Act.[60] No update of the data base has been performed on a county basis. Since the

70's were a period of dynamic growth for the Wasatch Front, the need for detailed update entailing the past five year's growth is desirable.

As discussed in Section IV, good local user data is important to generating accurate water-based recreation patterns. Fishery-recreation patterns have been locally improved, but "non-contact" water recreation and aesthetics activities need additional inventory. There are many implications to transfering water-related use and preferences from present data to available stream reaches in view of the lack of detailed studies, but budgetary limitations preclude such studies.

RECREATION PREFERENCES

Nielson and Hunt (1978)[61] describe local resident recreational preferences based on stratified samples. Lack of time and money, crowding and insufficient facilities, and recreation areas being too far away were cited by local residents as reason for not participating in their most preferred activities. The authors emphasize that coordinated planning for new recreation opportunities can lessen the impact of distance and crowding limitations. Table 22 notes percentages of recreation constraints. Fishing is the most favorite outdoor recreation activity by Utah residents, and the potential for coordinated planning of local fishing resources and facilities on valley tributaries is consistent with this preference.

Neighborhood recreation needs are shown in Tables 23 and 24. Walking-distance, information improvement, and public access to streams are three important variables which imply support for enhanced creek-related recreation. Present crowdedness at existing urban facilities make local creeks attractive, but the closure of public access makes total exploitation of creek reaches impossible. Optimization of access points and public ownership or dedication and easements could make available reaches less

TABLE 22

WHAT KEEPS YOU FROM DOING YOUR VERY FAVORITE ACTIVITY MORE?
(SALT LAKE COUNTY)

	# Respondents	%[a]
a. Lack of time	71	55.5
b. Too far away	29	22.7
c. Too crowded	49	38.3
d. Lack of money	29	22.7
e. Areas not properly administered	13	10.2
f. Lack of information	8	6.3
g. Lack of transportation	14	10.9
h. Lack of equipment	11	8.6
i. Lack of facilities	27	21.1
j. Poor physical condition or health	4	3.1
k. Public access closed	15	11.7
l. Presence of drug use or threat of crime	5	3.9
m. Hazardous nature of the facility of equipment	1	0.8
n. Other	6	4.7

[n] Adds to more than 100 percent because of multiple responses.

TABLE 23

HOW MUCH ARE THE FOLLOWING RECREATION OPPORTUNITIES NEEDED IN YOUR NEIGHBORHOOD?
(SALT LAKE COUNTY)

	Frequency	%
● More neighborhood recreation areas within walking distance from your home.		
Very much needed	17	37.8
Slightly needed	13	28.9
No opinion	8	17.8
Probably not needed	5	11.1
Not needed at all	2	4.4
● More information concerning local recreation programs.		
Very much needed	20	44.4
Slightly needed	13	28.9
No opinion	6	13.2
Probably not needed	4	8.9
Not needed at all	2	4.4
● Development of more public access to rivers and streams.		
Very much needed	17	37.8
Slightly needed	6	13.8
No opinion	7	15.6
Probably not needed	8	17.8
Not needed at all	7	15.6

TABLE 24

HOW MUCH ARE THE FOLLOWING RECREATION OPPORTUNITIES NEEDED IN YOUR NEIGHBORHOOD? (STATEWIDE)

	Frequency	%
MORE NEIGHBORHOOD RECREATION AREAS WITHIN WALKING DISTANCE OF YOUR HOME.		
Very much needed	125	33.2
Slightly needed	61	16.2
No opinion	111	29.4
Probably not needed	38	10.1
Not needed at all	42	11.1
MORE INFORMATION CONCERNING LOCAL RECREATION PROGRAMS.		
Very much needed	108	28.6
Slightly needed	87	23.1
No opinion	123	32.6
Probably not needed	38	10.1
Not needed at all	21	5.6
DEVELOPMENT OF MORE PUBLIC ACCESS TO RIVERS AND STREAMS.		
Very much needed	123	32.6
Slightly needed	48	12.7
No opinion	108	28.6
Probably not needed	44	11.7
Not needed at all	54	14.3

to access.

RECREATION FACILITIES

The U. S. Corps of Engineers (1981)[62] reported a preliminary recreation evaluation of use and facilities along Salt Lake Valley tributaries while Dalton and Hunt (1976)[63] inventoried supply of facilities county-wide. The Corps also addressed recreation needs in creek-related facilities, and Salt Lake County [64] has produced numerous community-level master plans which indicate reservation of linear parks or trails along valley tributaries. The extent to which these systems can be or have been implemented is discussed in the next section.

The Corps of Engineers has concentrated their analysis of existing recreation on parks as opposed to instream uses. The lack of substantive data on instream use has limited discussion/description by the Corps, and the need for good data on user patterns for instream use is crucial to identifying balanced - and realistic - recreation supply. Limitations of present park use data are also noted:

> Although use records are not available for most activities (records are kept for only those activities where a fee is charged, such as swimming), informal contact with the Salt Lake County Recreation Department indicated that the parks are heavily used, particularly on summer weekends, with severe overcrowding on holidays.

Facilities are listed that are adjacent to the valley creeks. These areas are identified in Figure 1, Land Use Characteristics.

a. MILL CREEK.
   1. Evergreen Park. - Mill Creek and 2300 East Street. County operated.
   2. Willow Park. - Mill Creek and 500 East Street. County operated.

b. BIG COTTONWOOD CREEK.
   1. Big Cottonwood Regional Park. - Big Cottonwood Creek and 1500 East Street. County operated.
   2. 10-acre undeveloped park. - 6700 South Street and 3000 East Street. County operated.

c. LITTLE COTTONWOOD CREEK.
   1. Murray Park. - Little Cottonwood Creek and State Street. Operated by the City of Murray.

2. Bayou Country Club. - Little Cottonwood Creek and 2000 East Street Private golf course.
3. Willow Creek Country Club. - Little Cottonwood Creek and Willow Creek Road. Private golf course.
4. Wheeler Farm. - 6351 South 900 East Street. County operated.
5. Unnamed park at 1300 East Street and 7200 South Street. County operated (Salt Lake County is currently planning to sell this parcel).
6. Crestwood Park. - 1800 East Street and 7600 South Street County operated.

Updated preferences for local recreation have been previously described. Data reported by the Corps (1971 and 1973) have since been reevaluated by Dalton and Hunt (1978), but the Corps points out important constants:

> Increases in available time, income, mobility, and population are rapidly expanding outdoor recreation demand and need for facilities. Planning District 3 (Salt Lake and Tooele Counties) with 45.3 percent of the total State population, has the least outdoor recreation site acreage available per person." With regard to urban hiking trails, the SCORP says "there are few existing urban trails in the State. Most existing trails are in parks. Urban hiking trails are appropriate in, but not limited to, the following areas: 1) flood plains, 2) connective corridors between outdoor recreation areas (parks, mountains and valley areas, etc.), 3) within parks, 4) in or near concentrated housing areas and 5) along easements, canals, etc." For Planning District 3, a total of 105 miles are needed by 1985. A total of 594 miles of bicycle trail is needed in Planning District 3 by 1985. (A summary of acreages needed for outdoor recreation in Planning District 3 for 1985 is presented in Table 25.)

The market areas identified in the Corps assessment were designated "Salt Lake County." No "cross-over" trend data is available to determine imported or exported recreation attractions, and the limitations of origin-destination patterns make determinations of market broad and generalized. However, some refinement of potential market and use patterns is possible through use of sub-basin drainage population data.[65] It is assumed that given an acceptable level of recreation attraction - such as a local fishery - the primary beneficiaries and market zone is located within the drainage basin. Access and ownership limit highest exploitation of creek resources for recreation, but adjacent market can still be isolated.

Figure 28 outlines the primary market zone for each tributary, while Table 26 lists population within each zone together with ten and twenty year projections.

The ability and willingness-to-pay for recreation influences the density

TABLE 25

1985 OUTDOOR RECREATION ACTIVITY ACREAGE NEEDS BY ACTIVITY IN PLANNING DISTRICT 3

PRIMARY OUTDOOR: RECREATION ACTIVITIES		ACREAGE NEEDS
1.	GENERAL WINTER ACTIVITIES: TOTAL ACRES NEEDED (EXISTING NOT INVENTORIED)	8,868
2.	GOLFING: GOLF COURSES, @ 95 ACRES FOR 9-HOLE UNIT	1,805
3.	PLAYGROUND ACTIVITIES: ACRES OF PLAYGROUND AND SUPPORT FACILITIES	782
4.	WILDLAND TRAIL HIKING: TRAIL, @ 0.5 ACRES PER MILE	488
5.	PICNICKING: AVERAGE OF 8 UNITS PER ACRE OR 0.13 ACRES PER UNIT (TABLE)	397
6.	CAMPING: CAMPING AREA, AVERAGE OF 5 UNITS PER ACRE OF 0.2 ACRES PER UNIT	272
7.	BICYCLING: IMPROVED PATHS, @ 1.2 ACRES PER MILE (OFF STREET)	205
8.	TENNIS: COURTS, @2 ACRES PER COURT FOR COURT & SUPPORT FACILITIES	134
9.	HORSEBACK RIDING (URBAN): URBAN TRAILS, @ 1.21 ACRES PER MILE OF TRAIL	98
10.	ARCHERY: FIELD COURSE & TARGET RANGE, @ 20 ACRES PER FACILITY	80
11.	BOATING (AND ASSOCIATED ACTIVITIES): LOAD-LAUNCH AREAS, @ 1.5 ACRES/LANE	54
12.	BALL GAMES: PLAYFIELDS, @ 0.4 ACRES PER ACTIVITY UNIT AVERAGE (CT. & BALL FIELD)	44
13.	HIKING: URBAN TRAILS, @ 1 ACRE PER MILE	30
14.	SNOWMOBILING: ACRES OF STAGING AREA NEEDED	27
15.	SWIMMING: POOLS @ 2 ACRES PER 4,500 SQ. FT. POOL UNIT	22
	SUB TOTALS: (& DISTRICT'S % OF TOTAL)	40% 4,438
	WILDLIFE & GENERAL WINTER ACTIVITIES: WINTER RANGE, WATERFOWL AREAS, ETC.	16,202
	TOTALS (& DISTRICT'S % OF TOTAL)	3% 20,640
	TRAIL BIKING: TRAILS, @ 1.21 ACRES PER MILE OF TRAIL	UNDETERMINED
	FIREARMS SHOOTING: RANGE FOR RIFLE, SKEET, PISTOL, ETC. @ 40 ACRES/FACILITY	UNDETERMINED

SOURCE: Corps of Engineers
Preliminary Recreation Evaluation

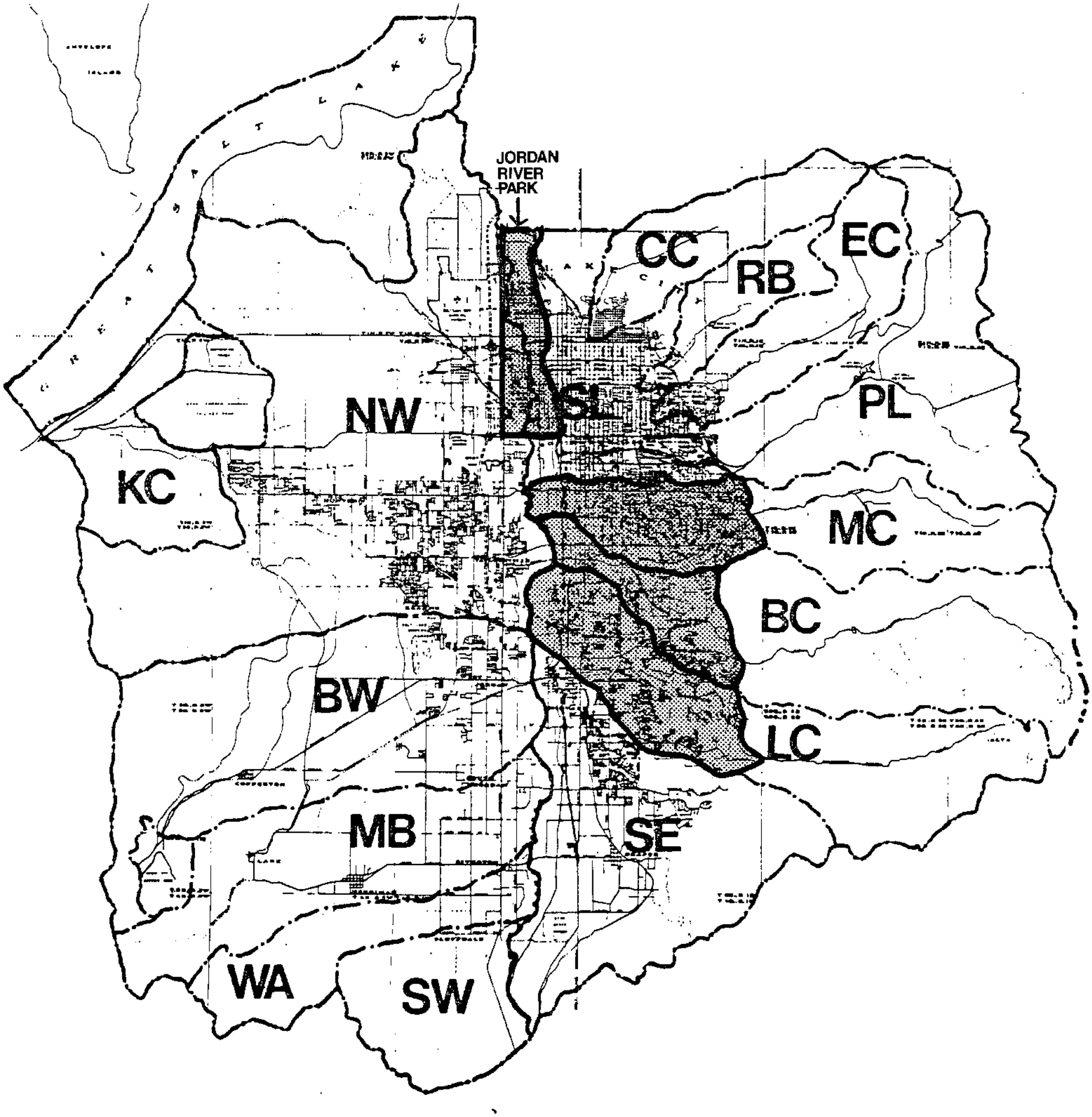


Figure 28

Sub-Basin Drainages in Salt Lake County
Comprising Primary Recreational Market Zones

TABLE 26 POPULATION BY SUB-BASIN DRAINAGE AND STREAM REACH MARKET ZONE

	TOTAL			LOWER			MIDDLE			UPPER		
	1980	1990	2000	1980	1990	2000	1980	1990	2000	1980	1990	2000
MILLCREEK	57,679	60,019	63,123	16,463	17,662	18,925	19,244	20,493	21,865	21,972	21,968	22,229
LITTLE COTTONWOOD	88,592	109,908	124,784	34,824	41,517	47,616	28,620	35,694	39,475	25,148	32,697	37,693
BIG COTTONWOOD	38,471	43,522	48,243	9,233	11,117	12,542	8,488	8,880	9,396	20,760	23,525	26,305

diversity of recreation within a given market area. Census data divide the three tributary market zones into communities where household and family income differ substantially. Income may indicate levels of demand within market zones, particularly where access restricts optimum use. Figure 29 and Table 27 respectively shows community and income divisions intersecting valley streams.

USE PATTERNS

Hunt et at (1978) reported outdoor recreation participation for Salt Lake and Tooele County combined for 1976-77. The possibility for error in assigning activity occasions to County levels from multi-County bases is increased substantially, but trends for activity occasions, total hours, average hours per activity occasions and percentage of activity occasions which occur in Salt Lake and Tooele Counties are significant. Because Salt Lake population over Tooele population ration is marked (21:1), it can safely be assumed that 95% of total activity occasions for the two combined Counties (reported as Multi-County Planning District 3) fall into Salt Lake. Hunt maintains that:

> although we would be the first to recognize the weaknesses of this study, in the final analysis we believe its results are very adequate for purposes of state and district planning, feasibility studies, and most any other purpose for which outdoor recreation participation data may be necessary.

The data utilized in Hunt's work represent a total sample of over 12,000 individuals and 4400 households. Salt Lake County contributed the largest share of outdoor recreation participation in the State, and although fishing is the most highly preferred recreation statewide, it is eighth in terms of participation.

Most water-related recreation activities - with exception of waterskiing,

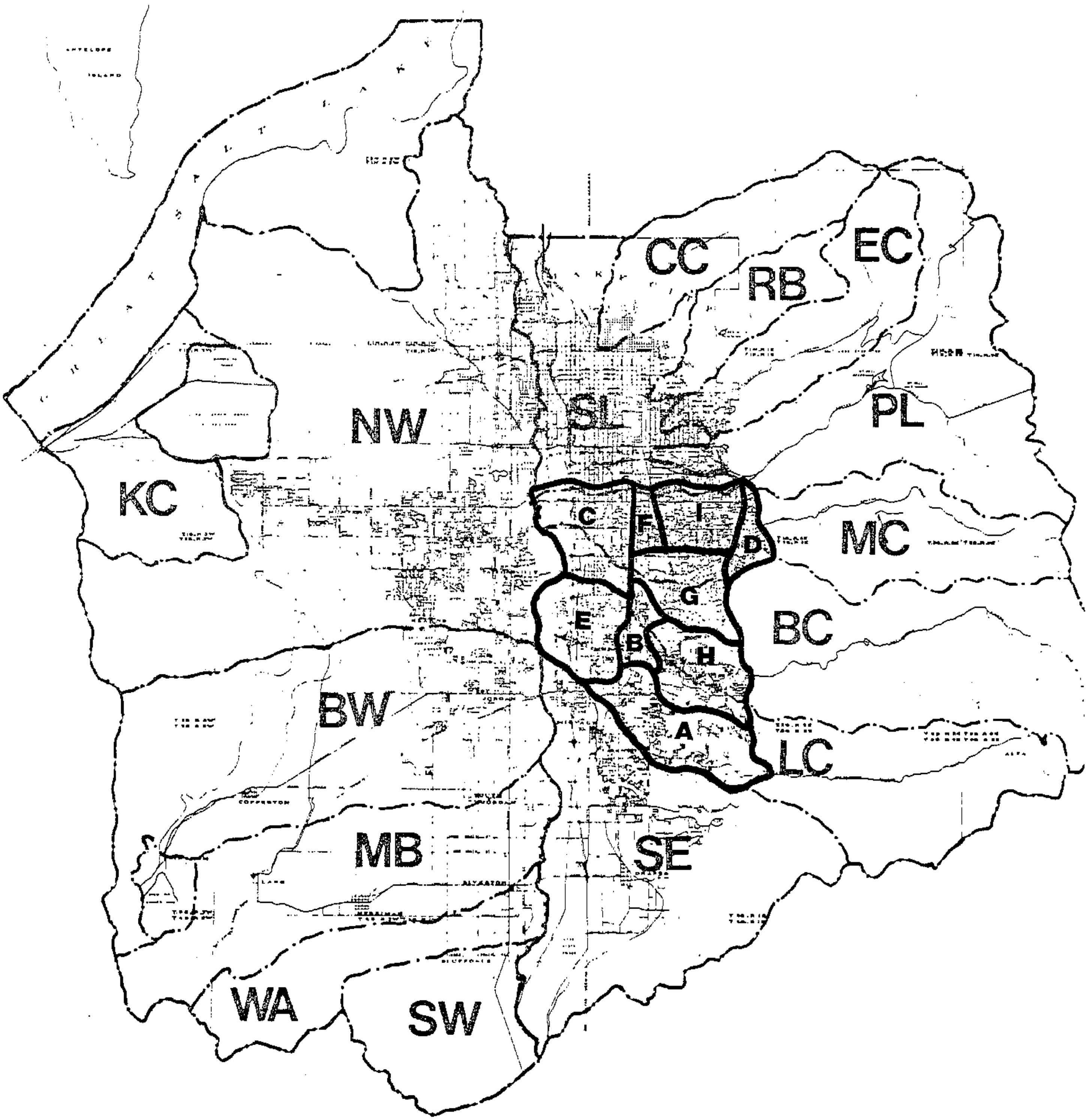


Figure 29

Sub-Basin Drainages in Salt Lake County Divided Into Local Community Boundaries

TABLE 27 COMMUNITY POPULATION AND INCOME
WITHIN VALLEY TRIBUTARY REACHES

CITY/COMMUNITY	POPULATION	INCOME: HOUSEHOLDS MEDIAN	INCOME: HOUSEHOLDS MEAN	INCOME: FAMILIES MEDIAN	INCOME: FAMILIES MEAN
A SANDY	25,640	23,837	25,544	24,306	26,191
B SOUTH COTTONWOOD	11,727	23,326	27,376	26,747	30,578
C SOUTH SALT LAKE	59	11,894	14,116	14,313	16,535
D MT. OLYMPUS	8,275	41,353	51,091	42,501	52,696
E MURRAY	26,992	18,391	20,798	21,062	23,341
F GRANITE PARK	15,838	14,741	16,450	15,938	17,723
G HOLLADAY	20,569	21,806	27,007	24,557	29,992
H COTTONWOOD HEIGHTS	28,714	26,609	28,270	27,357	29,062
I EAST MILLCREEK	46,700	22,202	26,623	24,934	29,644

power-boating, and sailing - are in the top fifteen recreational categories in Salt Lake County. Table 28 summarizes the ranking of activities and occasion hours.

Important indicators are seen in Table 28 relative to some recreation activities: 95% of all bicycling, walking/sightseeing, jogging/running occurs within the County. The majority of all picnicking (60%) takes place locally. But only 15% of all fishing occasions occur within the County. Salt Lake County residents still contribute 36% of all statewide fishing hours, yet only a small 6% of all fishing hours by County resident are spent locally. The potential market for capturing a greater proportion of economic benefit from fishing is discussed later. However, those benefits are at least very impressive. The State Division of Wildlife Resources estimated that for a 2.5 mile segment dewatered by Murray Power Plant Facilities on Little Cottonwood Creek, the long-term opportunity cost foregone to local fishermen approaches $400,000.

Because adequate fishing data, user patterns, and methodology exists to estimate fishery values, emphasis is placed on non-fishing recreation - so as to accurately quantify (within limits of best available data) values attendant wider beneficial use of valley tributaries.

JORDAN RIVER PARKWAY FACILITY USE: INDICATIONS FOR LOCAL DEMAND.

The State of Utah designated a reach of the Jordan River as a State Parkway Reserve in 1980. This four mile reach contains a primary market population of over 32,000 individuals, and 11,500 households. Parkway visitation patterns for certain recreation activities are assumed to be transferable to appropriate valley tributary stream reaches based on demand for both local recreation and specific activity types.

TABLE 28 OUTDOOR RECREATION PARTICIPATION IN UTAH BY RESIDENTS OF MULTI-COUNTY PLANNING DISTRICT THREE - 1976-1977

ACTIVITY	ACTIVITY OCCASIOINS	TOTAL HOURS	AVE.HRS/ ACT.OCC.	% ACT.OCC. IN MC 3
Bicycling*	3,212,100	3,530,100	1.1	95
Driving for Pleasure	2,664,400	7,985,400	3.0	55
Camping	1,820,600	25,977,400	14.3	15
Tennis	1,796,200	3,834,000	2.1	85
Swimming	1,696,000	3,802,000	2.2	90
Walking*	2,538,700	1,248,500	0.8	95+
Golf	1,377,000	4,560,600	3.3	75
Fishing*	1,329,400	8,417,200	6.3	15
Picnicking*	1,323,400	4,691,200	3.5	60
Basketball	1,178,300	2,331,400	2.0	95+
Hiking/Backpacking	1,144,100	3,348,100	2.9	55
Jogging/Running*	1,122,100	792,900	0.7	95
Baseball	1,048,100	2,361.700	2.2	95+
Unstructured Play	1,034,800	3,391,900	3.3	95+
Playground Activities	988,500	1,285,300	1.3	95+
Spectator Sports	914,300	2,232,800	2.4	95+
Exercise/Gym Activities	886,500	1,367,600	1.5	95+
Big Game Hunting	804,700	6,347,700	8.0	15
Motorcycle Activities	605,200	1,453,800	2.4	85
Skiing, Downhill	560,900	3,038,100	5.4	95+
Hunting, Other	538,400	3,799,800	7.1	35
Football	510,500	855,200	1.7	95+
Skateboarding	489,900	847,100	1.7	95+
Outdoor Games	477,800	842,600	1.8	80
Photography/Painting, etc.	441,500	696,300	1.6	50
Power Boating	371,800	1,486,400	4.0	5-
Target Shooting	360,900	955,900	2.6	95+
Horseback Riding*	347,000	890,600	2.6	70
Fairs/Amusement Parks	321,200	1,728,400	5.4	75
Visiting Museums & Hiustoric Places	306,300	558,900	1.8	65
Fourwheeling	270,700	815,700	3.0	40
Waterskiing	257,600	1,124,100	4.4	5-
Sailing	254,000	2,053,800	8.1	15
Dog Training	246,600	218,700	0.9	95
Volleyball	235,900	299,300	1.3	95+

* Indicates Activities Applicable to Stream/Creek Corridor Recreation Potential

JORDAN RIVER STATE PARK

Based on direct-count observation data compiled by the Utah State Division of Parks and Recreation, bicycling, jogging/running, picnicking, walking/sightseeing, fishing, canoeing, canoeing/kayaking and horseback riding all rank high among local participants using the Jordan River State Park. Neither canoeing nor canoeing/kayaking were identified as activities by Hunt's questionnaire, and it is assumed that this occurs since the Jordan River Parkway proceeded Hunt's work. Table 29 summarizes 1982 vistor-use patterns, while Figure 30 outlines the percentages of specific uses within the months they occur. These data indicate variability of seasonal demand for some uses over others, i.e., increase of sightseeing/picnicking during summer and decreasing in winter; increase of jogging/bicycling during fall, winter, and spring decreasing in summer months.

The data shown for the Parkway can be considered not only typical but conservative. Park Rangers estimate only a fraction of the recorded data represent total visitation due to shortage of Park personnel and numerous Parkway access points. It is important to note that trends for visitation at the local Parkway are dramatic. Comparable water-related recreation attractions within 120 miles of Salt Lake have shown steady decline over the last three years, while both Jordan River Parkway and Saltair have logged steady and very substantial increases, noted in Figure 31. Saltair and Jordan River have shown 33% and 129% average increases in visitation over three years, while comparable water attractions show average declines ranging from 2% to 24% in the same period.

Park personnel estimate that mostly residents in the primary market zone utilize Parkway facilities (95%) but that the canoe rental program tends to draw County-wide. The great increase in 1981 and 1982 visitation is believed

TABLE 29

JORDAN RIVER PARKWAY
VISITOR-USE PATTERNS: 1982

	Canoe/Kayak	Jogging	Bicycling	Sightseeing	Picnicking	Fishing	Horseback Riding	TOTAL
JANUARY		85	39	47	46			217
FEBRUARY	18	545	320	311	311			1505
MARCH	16	424	171	126	125			862
APRIL	218	839	842	3116	3115			8130
MAY	743	986	1031	5105	5105			12970
JUNE	857	910	679	5261	5261		88	13056
JULY	1393	777	670	4070	4069		105	11084
AUGUST	1622	490	225	2803	2803		64	8007
SEPTEMBER	734	656	385	553*	552*		118	2998
OCTOBER	409	229	224	212	120		55	1249
NOVEMBER**	52	79	46	48	47			272**
DECEMBER		20	17	20		12	8	77
TOTAL	6062	6040	4649	21671	21554	12	438	60427
%	10%	10%	8%	36%	35%	<1%	1%	100%

* Telephone Data From Ann Wilkerson, Park Ranger - 4/4/83
Extrapolate 1/2 of total "other" into sightseeing and fishing, as with Form PR-67

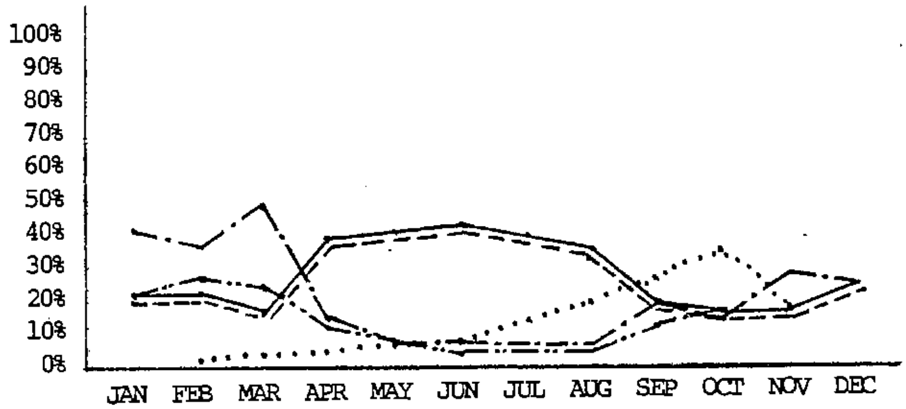
** Constructed based on other 11 months %.

FIGURE 30

JORDAN RIVER PARKWAY

USE PATTERNS: % BY ACTIVITY

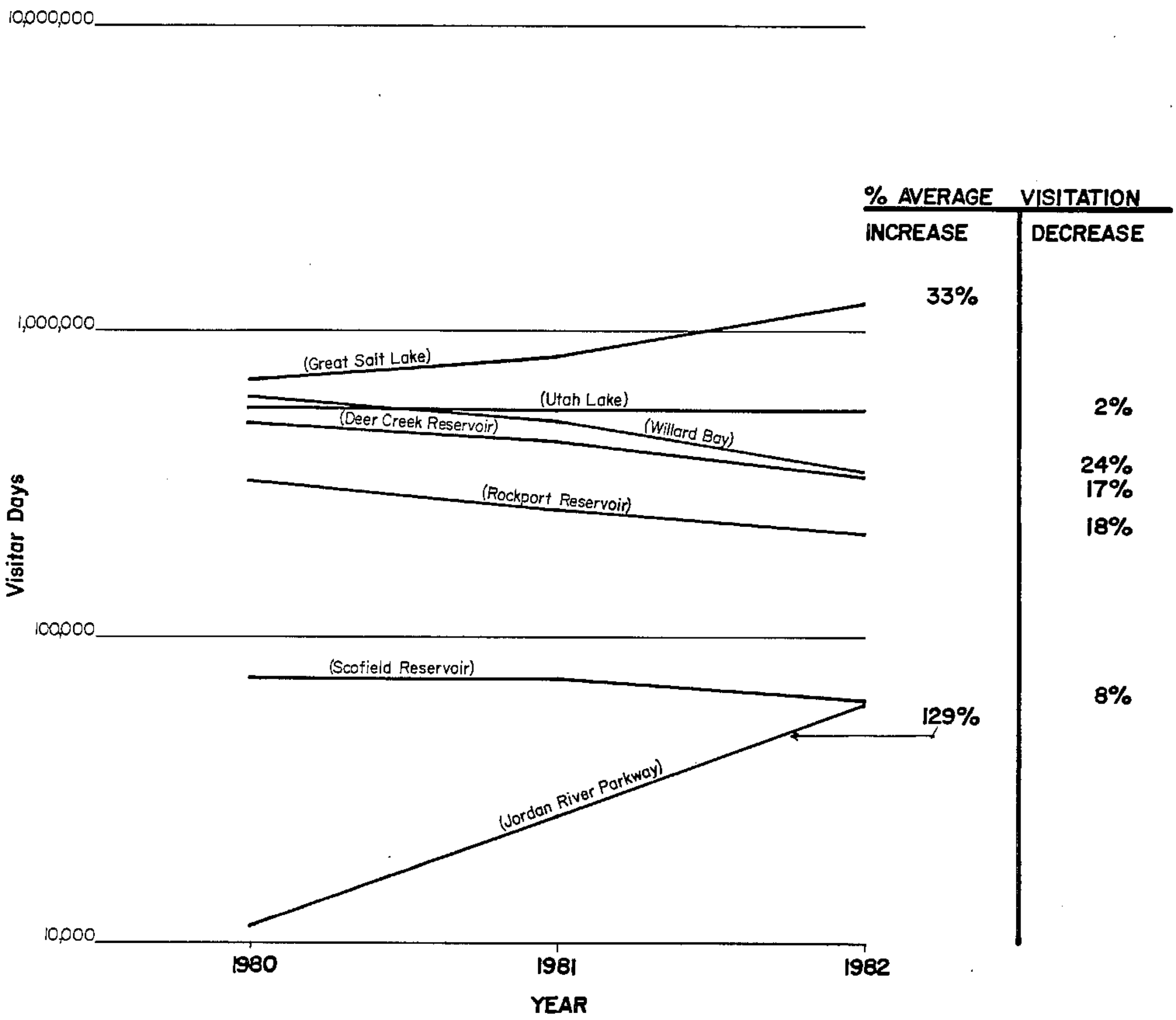
	J	F	M	A	M	J	J	A	S	O	N	D
SIGHTSEEING	21	21	15	38	39	40	37	35	18	17	18	26
PICNICKING	21	21	15	38	39	40	37	35	18	10	17	–
BOATING		1	2	3	6	7	13	17	24	33	19	–
JOGGING	40	36	48	11	8	7	6	6	21	18	29	26
BICYCLING	18	21	20	10	8	5	6	6	13	18	17	22
FISHING	–	–	–	–	–	–	–	–	–	–	–	16
HORSEBACK	–	–	–	–	–	1	1	1	6	4	–	10



SIGHTSEEING ————
PICNICKING – – – –
BOATING ·········
JOGGING —·—·—
BICYCLING —··—··
FISHING ————
HORSEBACK — — —

TREND:	AVERAGE %
High Summer	38%
Low Spring/Fall	18%
High Summer/Fall	19%
Low Spring/Winter	3%
High Winter/Spring/Fall	29%
Low Summer	7%
High Winter/Spring/Fall	17%
Low Summer	6%

FIGURE 31 Visitor Increase and Decrease for Selected Recreational Sites



SOURCE: State Division of Parks and Recreation due mainly to more frequent visitation by the resident population. Households formerly visiting three to four times per year now frequent the Parkway once per week during peak (summer) months. Based on this trend, one average household (consisting of 2.8 persons) will produce about 34 visitor-days annually during peak summer months (May, June and July). Table 30 estimates projected visitations for the Parkway assuming household size stabilizes at an average of 2.8 persons per household, and projecting average visits per person and per household at the present rates of 1.82 and 5.08 respectively. Given the large increase in visitation over two years, such static visitation rates produce very conservative total visit projections.

Table 30 JORDAN RIVER STATE PARK PROJECTIONS:

	1982	1990	2000
Population	33,068	36,729	41,119
Households	11,809	13,118	14,685
Visits	60,046	66,847	74,837
Average Annual Visits/Person	1.82	1.82	1.82
Average Annual Visits/Household	5.08	5.08	5.08

Total visitations can be subdivided into activity components based on observed percentages of activity. Table 31 enumerates projected visitation by activity on the Parkway through use of multipliers derived from household and person visitation rates, shown in Table 32.

TABLE 31 JORDAN RIVER STATE PARK PROJECTIONS BY ACTIVITY

	1982	1990	2000
Activity Total (100%)	60,046	66,847	74,837
Sightseeing (36%)	21,671	24,065	26,941
Picnicking (35%)	21,554	23,396	26,193
Jogging (10%)	6,040	6,685	7,484
Boating (10%)	6,062	6,685	7,484
Bicycling (8%)	4,649	5,348	5,987
Horseback Riding (1%)	438	668	748

TABLE 32 ACTIVITY MULTIPLIERS PER PERSON/HOUSEHOLD

ACTIVITY PARTICIPATION/PERSON:			ACTIVITY PARTICIPATION/HOUSEHOLD
Sightseeing	.66	(@ 36%)	1.83
Picnicking	.63	(@ 35%)	1.77
Jogging	.18	(@ 10%)	.51
Boating	.18	(@ 10%)	.51
Bicycling	.15	(@ 8%)	.41
Horseback	.02	(@ 1%)	.05
	1.82	(@100%)	5.08

VALLEY TRIBUTARY ESTIMATED RECREATION DEMAND

It is important to understand the application of activity multipliers in terms of both present and future potential use. Activity is not maximized on valley creeks because of restricted access which effectively closes them to many types of use. Some uses carry on despite land use enclosures because of inability or apathy of property owners to effectively restrict the use, and because many creekside dwellers and their friends may desire certain reaches to be unobstructed. In fact, Flood Control statutes and ordinances bar such stream obstructions. Therefore, some use can be anticipated despite limited access. Present use estimations are made assuming that a limited range of users may access stream reaches, where future estimates presuppose that creek easements will effectively open creek reaches to wider use. The Corps of Engineers refer to the latter assumption as the "Parkway Alternative" and say that cost-benefit ratios for creekside flood control improvements are most favorable when combined with recreation.[66]

1) PRESENT USE LEVELS

Table 33 summarizes expected stream-related use for sightseeing, picnicking, and boating/floating activities. Most streamside use occurs within the "substitution market" described in Section IV, i,e., private residences which allow between four to eight persons access to participate in creekside activities.

Table 33 ESTIMATED PRESENT USE LEVELS FOR WATER-RELATED RECREATION

	JR-700 East LOWER			700 E 2000 E MIDDLE			2000 E Wasatch UPPER		
	MC	BC	LC	MC	BC	LC	MC	BC	LC
Private Households									
A. Adjacent to Creek	75	280	190	230	600	90	66	120	137
B. Av.Persons/Household	2.3	2.8	2.8	2.9	3.0	3.4	2.9	3.4	4.0
C. Multiplier/Household	4.0	8.0	4.0	4.0	8.0	4.0	4.0	4.0	4.0
D. Adjacent Market Population	173	784	532	667	1800	396	191	408	548
TOTAL ANNUAL VISITS	1014	9219	3127	3920	21168	3174	1126	2399	3222
Sightseeing (.66xD)	455	4140	1404	1760	9504	1425	505	1077	1447
Picnicking (.63xD)	435	3950	1340	1680	9072	1360	483	1028	1380
Boating/Floating (.18xD)	124	1129	383	480	2592	389	138	294	395
E. Av.Annual Visits Per/ Person (TOTAL)	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47

This multiplier is higher for stream segments characterized by high density residential land use patterns, where streamside access lies within open spaces, thereby inducing greater use. Total visits are derived by applying this multiplier to existing residential units and multiplying by average persons per household. Multipliers for specific activities are computed to enable summation of all estimated activity-days. Average annual visits (1.47) are close to those observed for similar activities on the Jordan River (1.82).

a. BOATING/FLOATING

Boating/floating activity is likely underestimated based on the growing popularity of tubing on local streams. Hammitt, McDonald and Cordell (1983)[67] estimate that this water-based activity has few barriers to participation and thus occurs on most types of stream resources. Characteristics of tube-floaters in their study of Southeast recreationists match those living in local valley creek market zones:

> They are mainly teenagers and middle-aged adults, slightly more males than females, well educated, and those employed tend to be in professional, technical, or administrative occupations. Use tends to be local, although an attraction, for example, a national park, associated with a river can draw floaters from some distance. Because innertube floating requires little equipment or skill and because most users live within 50 miles of the rivers, little advance trip planning is done by floaters. Also, the majority of floaters are newcomers to the activity. The floaters prefer to begin their float trips at noon or before, and average from two and one-half to three and one-half hours floating the streams. Innertube floating is a group-oriented activity (6-12 people), where sharing an experience with friends is a major participation motive.

b. SIGHTSEEING/PICNICKING

Both these activities occur along linear stream corridors where stream access or common open space is provided. Based on Jordan River Parkway data, these activities tend to be trail related, except in public parks. Substitution of private for public activity would account for the largest use share because linear stream corridors are mostly enclosed by private ownership. Established trail systems would increase greater public visitation and thus the political acceptability of this option may be diminished. Stream bank stabilization programs may provide effective "informal" access for leisure sightseeing, picnicking, and fishing despite possible unpopularity of "formal" access or trail routes. Table 34 indicates the popularity of activities where trail opportunities are present:

> planning District 3 (Salt Lake and Tooele Counties, with + 45% of the State population): Walking and bicycling are the highest trail-related activities (52% and 50% respectively, of the total participation in the State for these activities), followed by jogging/running at 43%, picnicking at 29%, hiking at 29%, and horseback riding at

15% of total State participation for these activities.

TABLE 34 TRAIL RLATED ACTIVITIES 1976-1977

Ranking[1] by Tot.Hrs.of Partici-pation	Activity	Activity Occasions	Total Hours	Avg.Hrs.per Activity Occassion
29	Jogging/Running	2.52 million	2.04 million	0.8 hours
22	Walking	2.92 million	2.66 million	0.9 hours
16	Horseback Riding	1.56 million	4.89 million	3.1 hours
11	Hiking/Backpacking	2.28 million	7.28 million	3.2 hours
10	Bicycling	6.14 million	7.55 million	1.2 hours
5	Picnicking	2.76 million	9.76 million	3.5 hours

[1]USU Institute of Outdoor Recreation and Tourism, Utah Resident Outdoor Recreation Participation, January, 1978, USU Rankings are relative to all 72 activities identified by USU.

c. FISHING

Local models have previously been developed for estimation of potential fish habitat productivity, recreation use, and economic benefit. Appendix FOUR outlines methodology employed to generate such estimates for valley tributaries. Binns & Eisermann published "Quantification of Fluvial Trout Habitat in Wyoming" (Transactions of the American Fisheries Society, May 1979)[74] which produced a Habitat Quality Index. This index was programmed and applied to Wasatch Front streams in Utah by Geer (1981) for the State Division of Wildlife Resources. The resultant model has been applied to several instream flow applications involving power plant diversions, including "An Assessment of Trout Fishery Conditions in Little Cottonwood Creek, Salt Lake County" (June, 1981).[75]

Estimates of habitat conditions in valley tributaries were made using point sample stream profiles which are judged typical of a specific reach. Further quantification is necessary to refine predicted standing crop estimates. Projections of existing estimates are based upon percentage increases in habitat resulting from improved flood control and instream flow management over the next twenty years. Table 34A summarizes the results of the fishery habitat indix for valley creeks, and predicted existing use levels.

TABLE 34A

Predicted Standing Crop, Use, and Value of

Existing Valley Tributary Fishery Habitat

	STANDING CROP LBS/YEAR	ANGLER DAYS/YEAR	ANNUAL NET PRESENT WORTH
LITTLE COTTONWOOD	3,403	7,681	$ 94,707
BIG COTTONWOOD	2,606	5,882	$ 72,525
MILL CREEK	1,686	3,806	$ 46,928
TOTALS	7,695	17,369	$214,160

Existing use levels predict usage only by adjacent residents. They participate in fishing only about 15% of their recreation time. Improvement of stream management (reducing dredging through bank stabilization) and development of improved access to streams which may result from stabilization, may increase both standing crop and rate of fishing participation.

2) PROJECTED USE LEVELS

In the absence of site-specific user data, comparable use levels adjacent to valley creeks have been estimated based on patterns observed along the Jordan River. Future improvement to the valley creeks for purposes of flood control and water quality is anticipated in the future, and both additional urban parks and linear parkways may result from these improvements. The Corps of Engineers proposal, if supported by needs assessments described in the State Comprehensive Outdoor Recreation Plan (SCORP) 1980, provides the basis for projecting recreation use levels within valley tributary drainage basins. Utah State Parks and Recreation guidance (SCPR (1980) suggests that urban trail needs for Salt Lake County are substantial. Table 35 below indicates present need for 343 miles of bicycle and 65 miles of urban hiking trails to meet standard recreation needs.

TABLE 35 PROJECTION URBAN TRAIL NEEDS: 1980, 1985, 1990[1] (By County-Trails in Miles)

	Standard/Population	1980	1985	1990
Salt Lake County	Population	548,995	600,512	652,540
Bicycle	1 mi./1,600	343	375	408
Hiking	1 mi./8,500	65	71	77
Equestrian	30 mi./150,000	110	120	131

Based on hiking trail standards, local valley tributary sub-basin drainages would presently require the following trail-mile provisions:

TABLE 35A POTENTIAL HIKING SUPPLY AND COSTS FOR VALLEY TRIBUTARIES

	MILLCREEK	BIG COTTONWOOD	LITTLE COTTONWOOD
POPULATION	57,679	338,471	88,592
HIKING STANDARD @ 1MI/8500' STREAM	6 MI	4.5	10.4
MILES/SUB BASIN	7.9 MI	9.5	10.7
ESTIMATED COST/MI 68 @ $12,321 AV.PERSONS	$83,660	$55,814	$128,13
PER HOUSEHOLD AV.COST	3.46	2.93	3.54
PER HOUSEHOLD	$5.02	$4.25	$5.12

a. CORPS OF ENGINEERS: ESTIMATED RECREATION POTENTIAL

The following narrative is taken from the Corps Upper Jordan River Investigation: Preliminary Recreation Evaluation:

> Recreation potential - The project would have potential for recreation and fish and wildlife enhancement, depending upon the alternative(s) selected and amount and type of right-of-way acquired. The potential for recreation and open space features along the creeks and the Jordan River, Little Cottonwood Creek, and the detention basins are described. The actual implementation of any enhancement would be constrained by whatever non-Federal interests are willing to sponsor as required by Public Law 89-72. The overall concept of the recreation development would be designed to complement the existing and proposed systems of local bicycle trails, hiking trails, and local and regional parks. A listing of the project alternatives and their recreation potential is provided in Table 36 and Table 37 summarizes the project components for selected alternatives, together with recreation days estimated.

TABLE 36

UPPER JORDAN RIVER, UTAH

RECREATION POTENTIAL OF THE ALTERNATIVES

	Recreation Potential
1. Non-structural	
a. Floodproofing	NO
b. Flood walls	NO
c. Acquisition of flood plain	YES
2. Channel improvements	
a. Re-excavate stream channels	YES*
b. Rock-lined side slopes	MAYBE*
c. Reconstruct or modify road crossings	YES*
3. Detention basin and channel improvements	
a. Re-excavate stream channels	YES*
b. Detention basins	YES*
c. Levees	YES*
d. Reconstruct or modify road crossings	YES*
e. Rock-lined side slopes	YES*
4. Environmental Alternative	
a. Re-excavate stream channel	YES*
b. Set-back levees	YES
c. Desilting pond	YES
d. Replant riparian vegetation	YES
e. Reconstruct or modify road crossings	YES*

* If adequate right-of-way is obtained.

TABLE 37

SUMMARY OF CORPS OF ENGINEERS

FLOOD CONTROL PROJECTS

FACILITY	ACREAGE	PARKING	PICNIC SITES	FIELD SPORTS	SUPPORT FACILITIES	OTHER FACILITIES	AVERAGE ANNUAL RECREATION DAYS
LITTLE COTTONWOOD CRÈEK TRAIL	.97 (1.3Mi)	NA	NA	NA	None	Bicycling Jogging Sightseeing Fishing	137,000
WHEELER FARM DETENTION BASIN	20	150 Cars	50	Baseball Football Soccer	Water Restrooms Waste Disp.	Ice Skating Children's Play	320,000
SCOTT AVENUE DETENTION BASIN	9.5	75 Cars	25	Baseball Football Soccer	Water Restrooms		160,000
900 EAST DETENTION BASIN	30	200 Cars	75	Baseball Football Soccer	Water Restrooms Waste Disp.	Ice Skating	425,000

Not included in this analysis are current plans for combined detention basin facilities and creek improvement for Millcreek below 700 East. The proposed 550 East Detention Basin could feasibly generate an additional 160,000 annual recreation days.

b. "PARKWAY" OR STREAM TRAIL POTENTIAL

The addition of set-back levees, dikes, or other trail improvements adjacent to valley creeks would enable greater access by sub-basin residents. Riparian vegetation removed for construction of such improvements must be replaced to enable ecological equilibrium and maintain productivity. Although Corps of Engineers note cost-benefit ratios for combined floodcontrol/recreation projects are more favorable, recreation continues to be discounted because of higher costs associated with acquisition of easements and rights-of-way.

Recreation visits estimated for each sub-basin market area are shown in Table 38. Activity ratios of users at a comparable local stream-zone recreation area (Jordan River Parkway) are used to estimate specific activity visits. Due to limited data which defines long-term trends for visits per person, the average factor of 1.8 visits per person annually are applied for the twenty-year planning period.

B. RECREATION BENEFITS

Existing benefits to the community from creek-relatred recreation are constrained by private ownership patterns, land use, water quality, and water quantity. Based on local creekside market, investment to the community is limited. If creekside environment zones are preserved and maintained for public access - with minimum safeguards for stream flow and quality - local water resource use may be optimized. Estimates of economic benefit from recreation have been generated by the Corps of Engineers and Utah State

TABLE 38

PROJECTED ANNUAL RECREATIONAL VISITS PER TRIBUTARY MARKET AREA, BASED ON TYPICAL JORDAN RIVER PARKWAY ACTIVITY PATTERNS

ACTIVITY	MILL CREEK			BIG COTTONWOOD			LITTLE COTTONWOOD		
	1980*	1990	2000	1980*	1990	2000	1980*	1990	2000
SIGHTSEEING OR WALKING	38,068	39,681	41,593	25,390	28,725	31,840	58,470	72,539	82,357
PICNICKING	36,338	37,877	39,702	24,237	27,419	30,393	55,813	69,242	78,614
JOGGING	10,382	10,822	11,343	6,925	7,834	8,684	15,947	19,783	22,461
BOATING/FLOATING	10,382	10,822	11,343	6,925	7,834	15,947	15,947	19,783	22,461
BICYCLING	8,652	9,018	9,453	5,770	6,528	7,236	13,288	16,486	18,718
FISHING**	3,806	4,862	4,923	5,882	16,087	17,457	7,681	14,525	15,092
TOTAL	107,628	113,082	118,357	75,129	94,427	111,557	167,146	212,358	239,703

* Represents Trips Foregone

** Fishing visits reported as potential angler days per year, with growth in 1990 and 2000 standing crop resulting from appropriate bank stabilization and habitat restoration

University for local visitation (Salt Lake County). Both sources estimate approximately $4.00 per group visit, and Utah State University estimates an individual cost of $1.71 per visit.

These unit costs are not based on willingness-to-pay data but on real usage divided by total expenditures for local recreation. Time-in-demand and short travel cost has not been factored but can be estimated based on local income and travel distances within individual sub-basins. Opportunity costs are reflected in the 1980 column of Table 38 projected benefits. The difference between present use column benefits in Table 38 and potential benefits in Table 38 represent one aspect of opportunity cost component. Reduced land value appreciation has not been determined as an element of opportunity cost. Projected fishery visits assume 10% and 20% increases in future standing crops for 1990 and 2000 respectively.

EXISTING ESTIMATED BENEFITS

Table 39 reflects estimated real benefits from existing recreation use opportunities. Individual expenditure factors outlined by Dalton (1982) are applied to derive benefits. Fishing expenditures and net worth are generated from local user patterns and shown in Table 39A. The expenditure average for in-community recreation is estimated now at $1.71 per visit (per person) and $4.00 per visit per household. For those non-fishing activities possible under existing access and limitations, all creeks combined contribute only about $214,160 annually to the local economy.

POTENTIAL ESTIMATED BENEFITS

The Corps of Engineers estimates that over $4.2 million in annual benefits would accrue to the community with development of detention basins. This is based on annual average expenditures per household of $4.10. Table 40 shows benefits for each proposed facility.

TABLE 39

POTENTIAL
DOLLAR BENEFITS ESTIMATED FROM
EXISTING RECREATION OPPORTUNITIES AT PRIMARY MARKET AREA

ACTIVITY	MILL CREEK			BIG COTTONWOOD			LITTLE COTTONWOOD			TOTAL
	LOWER	MIDDLE	UPPER	LOWER	MIDDLE	UPPER	LOWER	MIDDLE	UPPER	
SIGHTSEEING OR WALKING	778	3,010	864	7,079	16,252	1,842	2,400	2,437	2,474	37,136
PICNICKING	744	2,873	826	6,755	15,513	1,758	2,291	2,326	2,360	35,446
BOATING/FLOATING	382	10,822	11,343	6,925	7,834	15,947	15,947	19,783	22,461	111,444
TOTAL	1,904	16,705	13,033	10,759	39,599	19,547	20,638	25,546	27,295	195.026
FISHING-SUB BASIN		46,928		72,525					94,707	214,160
TOTAL SUB-BASIN		78,570		152,430					168,186	399,186

TABLE 39A

The 1982 mean angler expenditures, net worth and gross worth for 1 angler-day on the impacted reaches of Little Cottonwood Creek under three scenarios of LCGS operation.
SOURCE: State Division of Wildlife Resources.

Scenario	Expenditures (1982 Weighted Mean Basis)	Initial Mean Daily Net Worth	Initial Mean Daily Gross Worth
Present	$31.26	$11.10	$42.36
Proposed	$31.26	$11.10	$42.36
Minimum Flow	$31.26	$12.33	$43.59

NOTE: The weighted mean expenditure is based upon an extrapolated number recorded from 1975. It also includes non-resident as well as resident license expenditures. The extent to which non-resident fishing could occur in valley tributaries is unknown, but the weighted mean daily angler expenditure is only 36% higher than resident costs. Recent inflated license costs (1983) raise trout fishing for residents close to the mean.

TABLE 40 ESTIMATED ANNUAL BENEFITS FROM CORPS OF ENGINEERS IMPROVEMENT PROGRAM

Project Feature	Annual Recreation Benefit ($) :Jordan River-Little :Cottonwood Creek Trail
Trail System	$344,400
Little Cottonwood Creek Area	217,300
TOTAL	$561,700

Detention Basin	Annual Recreation Benefit ($)
Wheeler Farm	$1,312,000
Scott Avenue	656,000
900 East Street (offstream)	1,742,500
TOTAL	$4,272,200

If the "Parkway" alternative for valley tributaries were constructed, or if adequate easements and rights-of-way were acquired for stream environment zones on each creek segment, potential expenditures and benefit to the local economy are substantially increased. Dalton's expenditure rate of $1.71 per visit is adjusted by an annual average rate of 5% for inflation to determine expenditures for 10 and 20 year projections. These unit expenditures increase to $2.78 per visit by 1990, and $4.55 per visit by 2000, and should be considered conservative since unit cost data is based on expenditures without travel-cost, time-in-demand, or other additive factors, (Table 41).

Total opportunity costs foregone by the community around Mill Creek are estimated at about $273,000 annually. Big Cottonwood residents will forego spending over $267,000 per year, and people living within the Little Cottonwood Creek Sub-Basin will be prevented from contributing over $466,000 annually to the local economy without stream environment zone enhancement. Fishing opportunities can be greatly enhanced with reduced flood control maintenance occurring from sediment and creek-bank stabilization, and conservation of instream flows. Present opportunity costs foregone by residents from impaired fishing totals $96,000 for Mill Creek, $148,000 for Big Cottonwood Creek, and $193,000 for Little Cottonwood Creek.

Total initial annual benefits for improvement and conservation of all valley tributary environment zones in 1980 dollars is $1 million; 1990 - $1.78 million: 2000 - $3.1 million. Increased real estate appreciation, increased transportation and time-in-demand costs have not been estimated. Assuming that local fishing will substitute a greater supply of total fishing demand, daily expenditures for fishing may decrease as much as 50%. A multiplier factor of 4.0 for local investment in support services for recreational activities produces the following real investment benefits to the local

TABLE 41

PROJECTED ANNUAL RECREATION DOLLAR BENEFITS PER SUB-BASIN MARKET AREA,
BASED ON INFLATION-ADJUSTED COSTS PER VISIT

ACTIVITY	MILL CREEK			BIG COTTONWOOD			LITTLE COTTONWOOD		
	1980*	1990	2000	1980*	1990	2000	1980*	1990	2000
SIGHTSEEING OR WALKING	65,096	110,313	189,248	43,417	79,856	144,872	99,984	201,658	374,724
PICNICKING	62,138	105,298	180,644	41,445	76,225	138,288	95,440	192,493	359,694
JOGGING	17,753	30,085	51,611	11,842	21,779	39,512	27,269	54,997	102,198
BOATING/FLOATING	17,753	30,085	51,611	11,842	21,779	39,512	27,269	54,997	102,198
BICYCLING	14,795	25,070	43,011	9,867	18,148	32,924	22,722	45,831	85,167
FISHING	95,855	97726	161228	148,163	323349	571717	193,453	291953	494263
TOTAL	273,390	398,577	677,353	266,576	541,136	966,825	466,137	841,929	1,518,244

* Represents Opportunity Costs Foregone

economy every year:

TABLE 42 MULTIPLIED INITIAL EXPENDITURES FOR VALLEY TRIBUTARY REACREATION VALUE

	1980 $	1990 $	2000 $
Initial Expenditure	1,006,103	1,781,642	3,162,422
Service Multiplier at 4.0 = Total Potential Investment Benefit	4,024,412	7,126,568	12,649,688

The Salt area will demand greater types and opportunities for local recreation as it grows. Valley tributaries may provide a significant supply of diverse recreation activities if the public identifies the creek environs as public goods. Implementation options for various stream environment zone conservation programs are examined in Section VI.

VI ALTERNATIVE CONSERVATION STRATEGIES

Local valley tributary resources are not presently used to full potential. Water pollution, land use policies, and flood control maintenance restrict use, and enhancement of upper reaches require provision of minimum instream flows. Demand for local water-based recreation will increase as transportation costs and population increase. Salt Lake County has some options available to respond to this demand, reduce pollution and increase fishery production, reduce flood maintenance and increase available revenues for other programs, reduce land use channelization and negotiate instream flows.

Options for procurement or management of stream environment zones exist at all levels of government as well as with private entities. Federal mandates by Congress to conserve navigable waterways are evident in the Clean Water Act and Rivers and Harbors Act. State initiatives are possible based on litigation (specific to Utah) that expands State authority within and adjacent to streams. Cities and Counties also have opportunities under Flood Control and Land Use Planning Authority. Together these legal and institutional tools afford the public a framework by which greater beneficial use and enjoyment of local stream resources can be attained.

A. FEDERAL AUTHORITY AND PROGRAMS

Numerous programs exist under federal authority for preservation of stream and river resources, but the primary roles rest with the U.S. Corps of Engineers and Environmental Protection Agency. Bureau of Land Management, Bureau of Reclamation, Forest Service, and Park Service organizations share administrative responsibilities where such ownership or control exists, but these agency roles do not always apply in Salt Lake Valley. Congress authorizes programs under agency headings and oversees the promulgation of federal regulations which define scope, objectives, authority, and limitations of agency operation. These factors are further clarified by the courts system through litigation.

CORPS OF ENGINEERS

The Rivers and Harbors Act of 1896 authorized the Corps of Engineers to manage and maintain navigable waterways for protection of interstate commerce and public health, safety, and welfare. The concepts of navigability and interstate commerce have undergone extensive legal interpretation and testing, and today the Corps assumes control over all "waters of the United States" that exceed a minimum of five cubic feet per second.

The Corps of Engineers provides for the control of flooding on waters of the United States by conducting technical evaluations of streams, flooding patterns, and improvements needed to control floods, such as levying, diking, and channelization. Improvements are built in cooperation with State and local agencies on a cost-share basis.

Recently, the Corps has completed the "Upper Jordan River Investigation" for the Salt Lake Valley. The waterways evaluated include Mill Creek, Big Cottonwood and Little Cottonwood Creeks, in addition to the Jordan River. The objective of the investigation is to determine improvements on the valley tributaries that will enable the creeks to pass design storm and spring runoff flows with a minimum of flood damage. Several structural, non-structural, and parkway alternatives were considered. Structural alternatives have been confined to various channel stabilization schemes, such as rip-rap, gabions, and rock channels. Non-structural alternatives include detention/retention basins on or off stream. The Parkway options foresaw acquisition of easements for permanent maintenance access and trails. Local agencies are reviewing the alternatives and providing detailed studies for refinement. All Corps of

Engineers alternatives have the potential for providing stream access corridors to some extent. The Parkway alternatives maximize the access corridor concept, but are also most costly. However, other alternatives, such as structural channelization, are not cost-effective unless coupled with recreation. Certain structures, such as gabions, can provide enhanced stream access in addition to stabilization. Other structures, such as flumes or rock-lined channels, may provide less recreation benefits. None of the alternatives incorporate structural measures for fishery habitat enhancement. Detention facilities are proposed in conjunction with public parks, but these facilities are not accessible via stream corridor.

A combination of detention parks inter-connected by stream access or trails, with banks structurally stabilized on a selective basis, may provide extensive recreational benefits at minimized cost if improvements are fully designed and coordinated. Local fishing stamps have been used in other urban areas to provide revenues necessary for construction and maintenance of habitat restoration measures, and the quality and flow of valley creeks may make this option economically approachable. Materials for structural stabilization should also be selected for multiple - rather than singular-use benefits. Large boulder rip-rap, for example, provides excellent fishery habitat if properly placed, and may outlive the useful life of gabion baskets which may rust and fail, within ten years.

The combination of improvements finally selected must weigh a number of economic and social factors to determine optimum benefits. Local goals for common stream access and recreation must be balanced against private property and safety considerations. The final outcome of stream improvements lies within the limits of negotiation between affected property owners and local agency discretion. If the local agency determines trailways and access to be most desirable, appropriate acquisitions can be made.

ENVIRONMENTAL PROTECTION AGENCY (EPA) - 404 PROGRAM

In conjunction with authority vested with the Corps of Engineers, the Federal Clean Water Act provides the EPA with responsibility for conservation of wetland riparian environs. Wetlands are communities of hydrophytic plants located adjacent to waters of the United States which exceed the flow of five cubic feet per second.

Permits to fill or destroy wetlands are required by the Clean Water Act through the Corps of Engineers. This process introduces weighting of public values or functions performed by the wetland relative to wildlife habitat (reproduction and recreation values), natural flood storage, and water quality. Landowners are prevented from destroying these areas where the Corps finds - with local public participation - that they perform these functions for the public good. Floodplains located in conjunction with wetlands are given high public good weighting. Prime agricultural areas that serve as buffer zones in conjunction with wetlands provide additional weight, and EPA requires identification of these "environmentally significant" lands as conditions to receiving wastewater treatment facility conservation funds.

Recent provisions in EPA and Corps regulations provide for filling selected wetlands so long as the developer replaces them elsewhere in-kind. These "mitigation" plans allow opportunities for reservation of riparian zones adjacent to streams with full access for water quality, flood, or wildlife habitat management. Local wetland resources and mitigation plans were mapped and developed by Salt Lake County. Lower stream reaches on valley creeks near the Jordan River are candidates for wetland conservation, and some mid-valley reaches of exceptionally high quality are possibilities for inclusion in riparian zone implementation.

POINT SOURCE POLLUTION MANAGEMENT: NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)

The National Pollutant Discharge Elimination System (N.P.D.E.S.) provides the legal mechanism for controlling the quality of discharge into the nation's waterways. Polluters are required to submit data to EPA on the nature and extent of discharge to receiving streams, and effluent limits are prescribed. It then becomes the responsibility of the discharger to meet quality criteria and not exceed pollution limits.

This mechanism has great potential in Salt Lake County for not only managing discharges, but for providing means for removing discharge pollutants. Since Salt Lake County Flood Control has area-wide responsibility for managing receiving streams and storm conduits, an "area" permit for discharge into these streams is required by EPA for point source stormwater pollution.[69] This permit mechanism affords the County an opportunity to require best management practices within a drainage basin to conserve water quality.

Best management practices typically mean erosion and sediment controls, and detention or desilting basins fall within this general category. Such basins, when placed streamside or between the conduit discharge and the terminus of the drainage sub-basin, will provide three main functions:

1) Temporary (but often critical) detention time for stormwater discharge which rapidly elevates creeks to flood stage.

2) Desilting of sediment-laden runoff which in the long-run increases flood channel capacity in the creek. Use of wetland plants in the ponds also removes nutrients and heavy metals which may impair the use of the creek during low flow periods. Since metals and nutrients (as well as sediment) are limiting factors to stream use,

wetland detention facilities may provide a valuable role.

3) Neighborhood Recreation Centers.

Possible locations for such facilities should be reviewed by both County and municipal agencies for long-term flood control and water quality management. Control of pollutants in wetland-detention facilities may prove more effective than other "best" management practices, and in view of stormwater discharge requirements under N.P.D.E.S., more timely if coordinated with Corps of Engineer flood control activities. Both linear and nodal detention concepts would provide open space corridors or "nodes" along valley tributary reaches.

NON-POINT SOURCE MANAGEMENT: CONSERVATION OF STREAM ENVIRONMENT

EPA supervises, in cooperation with States, the impementation of non-point pollution source management programs. Where N.P.D.E.S., can provide incentive for streamside detention facilities, the non-point best management practices call for control of pollution at its source. Stream environment zones have been identified as priority areas for implementation of non-point source management practices. Erosion and sediment controls, such as temporary diversions, straw bales, rip-rap, jute or other soil netting, and revegetation, can be reduced during construction at streamside development if set-backs are required. The conservation of existing riparian overstory and understory vegetation removes necessity of incurring additional project costs that nature provides free-of-charge.

Where substantial reparian values exist, local planning agencies may secure streamside conditions by delineating conservation zones, easements, or open spaces, not to be disturbed during the construction phase. Where riparian values are absent, local residents, civic groups, or developers can reduce creek damage and enhance aesthetic, recreation and wildlife values by replacing native plants and introducing certain species of trees and shrubbery to assist in long-term stream-bank stabilization.

LOCAL WATER QUALITY MANAGEMENT PLANNING

The implementation of water pollution controls is carried out by States in coordination with local agencies. These local agencies evaluate regional sub-basin drainages for compliance with provisions of the Federal Clean Water Act. EPA enforces these provisions, while State and local water quality programs identify and prioritize areas where enforcement is needed.

Planning for such clean water strategies lies with local water quality planning entities, who are also charged with updating Water Quality Management Plan provisions and coordinating local implementation with management agencies. The Area-wide Water Quality Management Plan becomes an important tool for decision makers in optimizing the use of stream resources. Since legal and institutional analysis of management agency roles is part of the water quality plan, realistic strategies for implementation can be evaluated and modified within local financial capability.

FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA) FLOODPLAIN MANAGEMENT

FEMA has published floodplain maps, mitigation guidelines, and flood insurance information to assist local management agencies in the administration of floodplain policy. In Salt Lake Valley, new floodplain and floodway maps have been published which identify "Zone A" and "Zone B" flood regimes along the valley tributaries. These maps are used to require setbacks and restrictions for development, and are useful in planning streamside zone management corridors. For areas yet to be developed, FEMA floodplain management guidelines can help local agencies determine where appropriate open space corridors are located for purposes of flood maintenance access, flood prevention setbacks, slope and bank stabilization, recreation and habitat enhancement.

If local agencies do not employ set-back requirements or prevention of floodplain in-fill, grades are raised above the flood level. This process continues the channelization of narrower floodways and increases erosion and sedimentation within stream channels. This process in-turn restricts channel capacity and necessitates continued high public expenditures for expensive dredging and channel clearing, and frustrates the less expensive process of flood channel set-back acquisition and bank stabilization.

FEMA data provide adequate basis for the identification and legislation of restrictive floodplain zoning, and local Flood Control management agencies would economize tax dollars by gradually phasing out dredging and clearing and replacing with bank stabilization and easement acquisition.

In conjunction with EPA construction Grant conditions that new regional wastewater treatment plants refrain from granting sewer connections in existing floodplains, the FEMA guidelines and 404 permit requirements form the basis for cooperative efforts between federal, state, and local agencies to prevent further elimination of floodplain storage. The public should also be made aware of the cumulative costs to subsidize development within floodplains, as compared with initial acquisition and maintenance cost by local government to manage them.

B. STATE AUTHORITY AND PROGRAMS

The ownership of water surface and access to stream resources lies primarily with the State of Utah. Recent litigation involving ownership of lakes as public domain has resulted in invitations by the Utah Supreme Court to litigate the same issue applying to streams. Utah, in concert with previous decisions in Idaho, maintains that streams fall within the public domain and that public access to cite all streams up to the historic mean water mark are allowed. In essence, the State of Utah owns all streams up to the historic "mean" water mark at the banks.

This position is somewhat in conflict with authority purported by the federal government as outlined in the Clean Water Act. There, the Corps of Engineers asserts authority over all waters of the United States flowing in excess of five c.f.s. The authority appears confined to the process of dredging, placing fill, and constricting flood channel capacity. Originally, the Corps authority extended only to "navigable" waters used for purposes of interstate commerce, as described in the Rivers and Harbors Act. However, for the past 70-80 years, extensive litigation and court interpretation of congressional intent has expanded the jurisdiction to all waters of the United States.

In summary, ownership and control of creeks, streams and rivers in the State of Utah fall within the purview of the public domain, with the State asserting ownership to mean historic watermark, and the Federal Government asserting management.

DELEGATION OF FLOOD CONTROL MANAGEMENT

The Utah Code delegates the State function for flood prevention and control to Counties, which in turn generate mill levy revenues for construction and maintenance of flood channel capacity.[70] Such improvements, or activities by Counties are regulated by the Corps of Engineers under general permits provided under Section 404 of the Clean Water Act. Activities carried on by the Counties are discussed at length under flood control planning.

STATE PARKWAY PROGRAMS

The local Jordan River Parkway Authority recently organized a land acquisition program under auspices of a private foundation which solicits land donations and procures property for open space greenways adjacent to the Jordan River. The Jordan River Parkway Authority, a division of the State Department of Natural Resources, administers lands procured by the Foundation and implements capital improvements and maintenance for Parkway facilities.

Similar arrangements can be made through legislative action for local valley tributary resources. The Mill Creek Parkway Authority or Big Cottonwood Parkway Authority could be incorporated either as a subdivision of a State or County Department. Acquisition of streamside property could be carried out via fee simple purchase, trade, dedication, easement, or lease with option to purchase. Recreation bonding or Flood Control mill levies are primary financial arrangements, but private foundation donation/acquisition may prove more politically acceptable.

C. LOCAL AUTHORITY AND PROGRAMS

At the County level, two major implementation approaches show great promise for stream-zone conservation. Land use planning policies at the County or municipal level, coordinated with flood control and water quality planning policies, provide a combined effort that works well within the scope of Federal and State authority.

LAND USE POLICIES

The authority delegated by the State to pursue land use planning at County and City levels offers many tools in procuring effective riparian open space conservation in undeveloped areas. These include the exercize of police power through zoning of floodplains, riparian communities, and recreational open space areas with local options for conditional use performance zoning or clustering. Dedication and restrictive covenants also offer many advantages by providing effective easements.

FLOODPLAIN/RIPARIAN ZONING

Salt Lake County has authority delegated by the State of Utah to exercize police power in zoning land for protection of public health, safety, and welfare. Although, reasonable use of land by private owners cannot be precluded by zoning, such activities related to agriculture clearly provide for reasonable use while protecting public revenues incurred for flood control and subsidization, and protecting private landowners from increased annual damage resulting from extreme channelization. The real estate ethic for defining the "highest and best" use of land does not encompass the value of floodplain/riparian areas in the total economic equation that includes "public goods." The recognition that government controls and maintains the use of floodplains and flood channels is manifest in many local zoning ordinances around the country.

In 1978, EPA and the U.S. Forest Service undertook a study on stream environment zones on State and private forest lands for information on local laws governing streamside management.[71] Although, not comprehensive, the study provided a national sample in order to determine zoning effectiveness in reaching water quality management goals. State laws from all 50 States were examined, including three Counties and Cities per State. Several recommendations for local legislation evolved from the study:

A. Additional knowledge is needed to formulate more effective legislation.

   1. Pollution production coefficients should be obtained related to:

      a. Specific land uses in a given range of physical environments.

      b. Intensity of specific uses.

      c. Management practices within a specific use.

      d. Multiple use relationships.

      e. Physical environmental features functioning both independently and as an interactive part of a total hydrological response unit. (Hydrological response unit - Unit of land that responds more or less uniformly to a given climate.)

B. Legislation could be made more effective by including the following features:

1. Include a variable streamside zone responsive to physical and vegetative conditions in relation to specific land uses or a combination of land uses.
2. Include specific authority and responsibility for administration and enforcement.
3. Be definitive as to type of pollutants and allowable levels of pollutants.
4. Land use restrictions should be defined in relation to different conditions within a hydrological response unit.
5. Monitoring should be specified, with explicit guidelines as to methods, frequency, and responsibilities.
6. Legislation should provide for the preparation of a management plan.
7. Provide for flexibility and a mechanism for up-dating.
8. Include bonding, penalties, taxing, or other mechanisms to restore hydrologic conditions.

C. Provide adequate funding and personnel to administer the legislation.

1. Minimum funding and personnel should be specified in the law.
2. Funding mechanism should be identified.

D. Legislation should be coordinated with upstream and downstream laws and regulations to provide continuity within a hydrologic system, such as within a river basin or municipal watershed.

E. Determinations should be made as to the relative effectiveness of voluntary actions, information programs, and other alternatives to enforcement.

F. More information relating to sample clauses and criteria are found in Appendix 4.

Several trends were observed as a result of the joint study, most dealt with State and local laws that affect water quality:

1. Institutional approaches to water quality laws (direct or indirect) differ drastically by geographic areas of the United States. These differences are much more evident when comparing the West with the rest of the country.
2. Pollutant levels from non-point sources have not been adequately quantified in such a way as to become standards for inclusion in legislation.
3. In defining streamside zones, there are trade-offs between ease of administration and water quality enhancement. Most zones defined do not vary with slope, soil types, vegetation, type of land use, or other parameters having a direct effect on water quality. However, some of the western timber harvesting ordinances did provide for on-the-ground adjustment of the width of streamside zones.
4. Primary purpose water quality laws, ordinances, or regulations by and large have not been initiated by legislative authorities.

   Pollution production coefficients have been produced by Glenne, Eckhoff, and Paschal for stream buffer zones in local canyon watershed, and many factors are transferable to valley riparian zones.

No laws, ordinances, or regulations at State/local level dealt primarily with just water quality, but simply added water quality to primary purpose ordinances. This has been the case in Salt Lake County, where water quality planning provisions have been integrated into general purpose flood control planning. Such a basin-wide hydrologic unit response is rational and consistent with regulatory goals of the Clean Water Act.

CLUSTER DEVELOPMENT AND PERFORMANCE ZONING

The Salt Lake County Planning Commission coordinates review and approval of creekside projects with the Flood Control, Recreation, and Engineering Divisions. Conditional Use permits are most often the vehicle by which such projects are approved. The Planned Unit Development Ordinance administered by the County offers many advantages for flood plain and water quality protection through incentives for cluster development. Performance Zoning, similar in effect to cluster or planned unit develoment, is also an available local option. The Southeast Michigan Council of Governments has published technical bulletins for both approaches: [73] Local Government techniques for open space resource conservation are summarized in Table 43.

A. WHAT IS CLUSTER DEVELOPMENT?

When development is clustered, housing units are grouped together, rather than spread uniformly over the entire site. This process allows for higher density (units/acre) in certain areas of the site, while preserving open space and natural areas on other portions of the site. Cluster development does not result in increased overall densities of housing units on the site unless the local government wishes to provide an extra incentive to the developer.

Specific standards and requirements for cluster developments are usually incorporated in the local government zoning ordinance. Single-family housing, multiple-family housing, or mixed uses may be

TABLE 43
LOCAL GOVERNMENT TECHNIQUES FOR OPEN SPACE AND RESOURCE CONSERVATION

TECHNIQUE	LEGAL FRAMEWORK	MAJOR ADVANTAGES	MAJOR DISADVANTAGES
Cluster Development Option (in zoning ordinance)	Amendments to zoning ordinance to allow cluster development as an option	For an individual site plan, reduces impervious surfaces and increases open space areas; the process encourages creative site plans that take natural resources into account	In rural communities, cluster development incentives (increased densities on part of the site) may not be attractive to developers
Performance Zoning	Amendments to zoning ordinance adding performance standards	Leads to an objective review of the impacts of a proposed development; encourages innovative site plans which reduce negative impacts	It may be difficult to develop quantified, objective standards; it may be difficult to convince some local officials to use objective technical standards in the site plan review process
Transfer of Development Rights	Amendments to zoning ordinance establishing transfer districts (amendments to enabling legislation may be needed)	Compensates owners of environmentally sensitive lands with public values without necessitating public purchase; allows for preservation of large tracts.	In order for development rights to be marketable, development pressure and limited availability of land are needed; this situation may not be present in all communities
Regulation of Fragile Lands (Such as Wetlands and Floodplains)	Special districts included in zoning ordinances or special-purpose ordinances	During development reviews, allows for special consideration of the resource in question; low-cost to the community	When parcels are predominantly wetlands or floodplains, it may not be possible to comply with regulations and still make reasonable use of the parcel
Conservation Easements	Legal agreement (easement) between the landowner and the organization receiving the easement	Can provide significant property and federal income tax benefits to the landowner; provides scenic natural areas without land purchase	Requires voluntary consent of the landowner; may have piecemeal effects — difficult to implement open space or conservation plan
Capital improvements programming	Planning enabling acts and other laws	Roads, sewers, and water mains are essential for intensive urban development; the control of types and locations of facilities can protect resources without the necessity of land purchase or regulation	Control of certain types of capital improvements (such as county roads and drains) is not within local government powers; financing of major public improvements may be difficult as well
Purchase of parklands	Local government home rule authority	Provides the potential for complete control of the site purchased	Acquisition and long-term maintenance of parkland can be costly

permitted, depending on the local government ordinance. In other cluster developments, mixed townhouses and single-family units on smaller lots have been built. As compared with conventional development, lot sizes and building setbacks are usually reduced in order to preserve more open space lands on the site.

Cluster development saves costs for the community as a whole, the developer, and the resident. In Southeast Michigan, an increasing number of local governments are including cluster development options (or planned unit development options) in their zoning ordinances. In addition to saving costs, cluster development results in the preservation of natural areas such as wetlands and flood plains which in turn reduce sedimentation and pollution of surface and groundwaters. Significant benefits from cluster develoment are illustrated on Figure 32.

1. WATER QUALITY BENEFITS FROM CLUSTER DEVELOPMENT

By grouping housing units and other buildings together on one portion of the site, natural areas such as flood plains, wetlands, stands of trees, and steep slopes can be left undeveloped. Preservation of natural resources on the site provides the following water quality benefits:

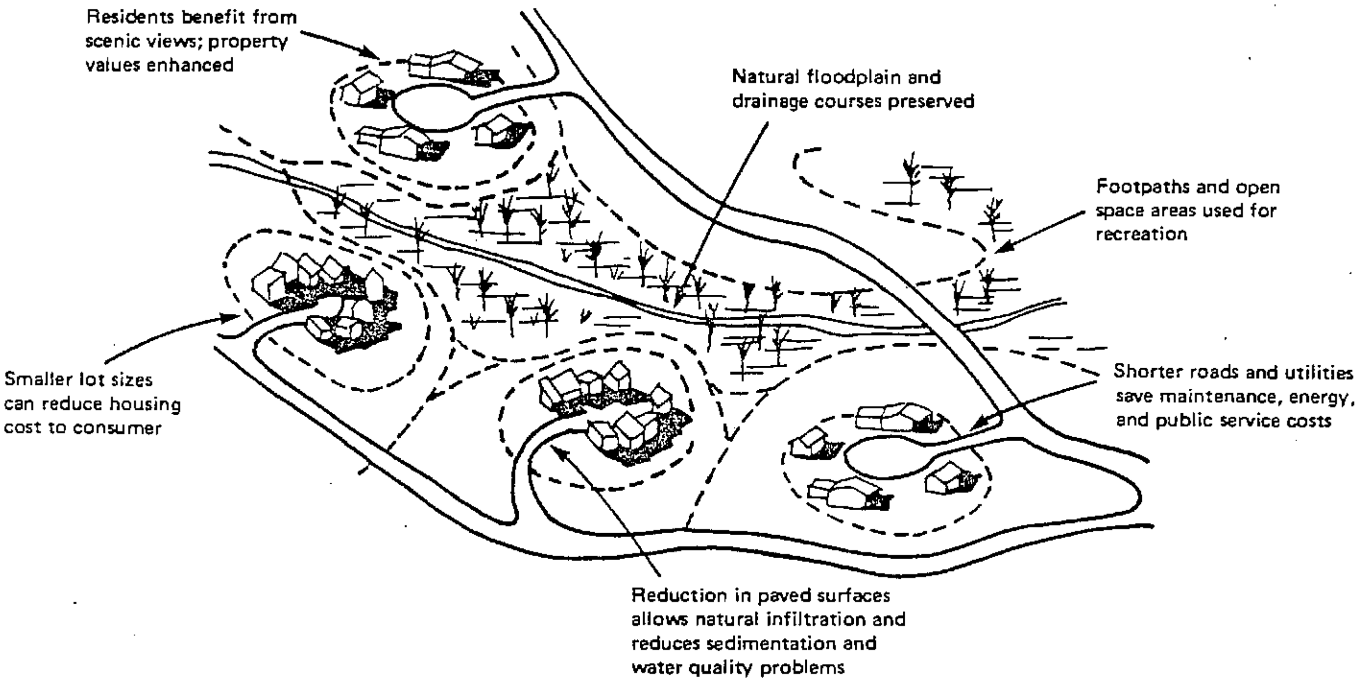
Wetlands, lowlands, and grassed areas hold stormwater runoff, allowing sediment and certain pollutants to settle out from the runoff before reaching surface and ground waters.

When development activity on the site is concentrated on only a portion of the site, mass grading and related erosion problems can be avoided. Fewer land surfaces are disturbed, less soil erosion occurs, and less sediment reaches rivers and streams.

Paved surfaces are reduced, hence reducing the volume and rate of stormwater runoff. Stormwater runoff carries sediment, oils, and toxic

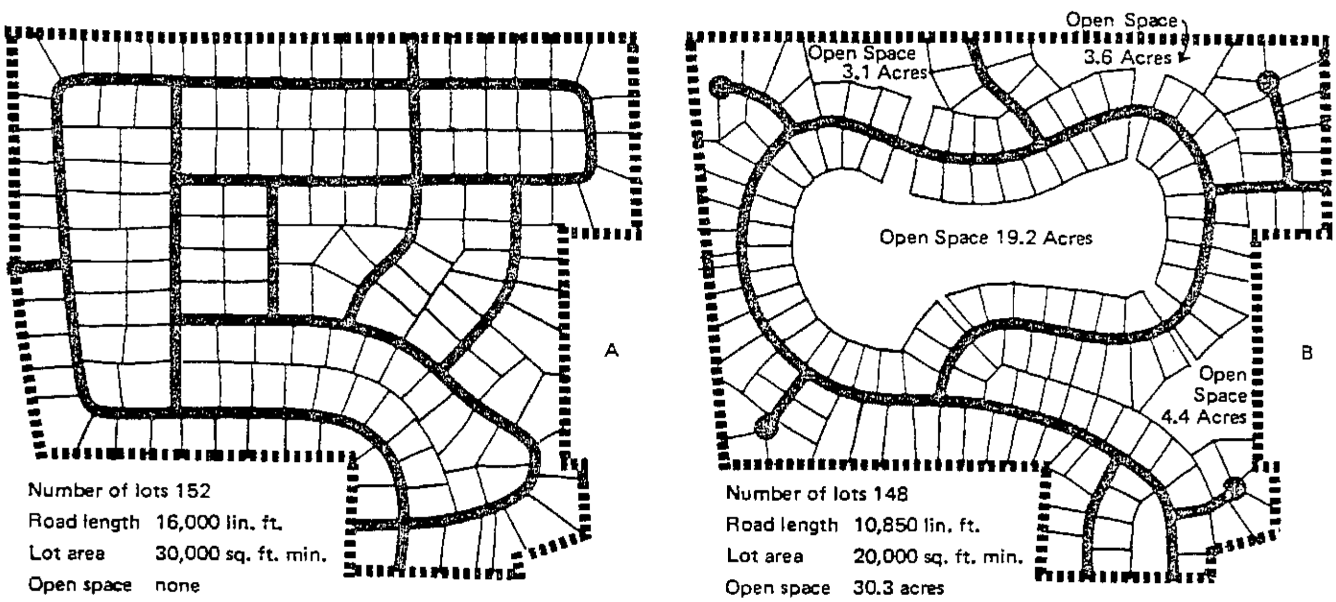
FIGURE 32

CLUSTER DEVELOPMENT: SCHEMATIC VIEW



Source: Based upon dragram in City of Grand Rapids "Planned Unit Development" brochure.

A COMPARISON OF CONVENTIONAL (A) AND CLUSTER (B) SUBDIVISIONS



Source: Welford Sanders, *The Cluster Subdivision: A Cost-Effective Approach,* Planning Advisory Service Report No. 356, December, 1980.

materials found on roadways.

When large open space areas are provided on the site, it is often possible to integrate stormwater facilities (such as retention basins and ponds) into the design of the development. When open space lands are available, stormwater retention and recreational uses can be combined.

A unique advantage to locating such facilities within common open space is that cost to build and maintain is borne by a private homeowners association, thus releasing government from incurring additional cost. Table 44 compares conventional and cluster development characteristics.

Table 44

CONVENTIONAL AND CLUSTER DEVELOPMENT COMPARED

	CONVENTIONAL DEVELOPMENT		CLUSTER DEVELOPMENT
1.	Even distribution of housing units over the development sites.	1.	Important natural areas on the using loop roads and cul-de-sacs.
2.	No provision for common open space lands within the development.	2.	Important natural areas on the site remain undivided and protected.
3.	Standard lot sizes and setbacks for housing units.	3.	Reduction in lot size and setback requirements.
4.	No savings on road maintenance or community services.	4.	Shorter length of roads and utilities, resulting in cost reductions for maintenance and certain public services
5.	Parklands and open space areas to serve new residential developments must be acquired and maintained by government agencies.	5.	Homeowners' Association maintains common open space area at no cost to the local government.
6.	No encouragement of design innovation.	6.	Innovative and attractive site design encouraged.
7.	The type of land use (single-family residential; multiple-residential; commercial; or industrial) is specified in the zoning ordinance.	7.	The type of land use (single-family residential; multiple-residential; commercial; or industrial) is specified in the zoning ordinance.
8.	Impervious surfaces increase the volume and rate of runoff carrying pollutants.	8.	Fewer paved surfaces and increased open spaces helps protect water quality.

2. PRESERVING OPEN SPACES: THE SITE PLAN DEVELOPMENT PROCESS

Cluster development plans are typically developed through a series of careful steps including (1) site analysis; (2) schematic plan preparation; and (3) final plan preparation.

The design process begins with an analysis of the natural assets and liabilities of the site. Characteristics and features such as forrested areas, drainage patterns, wetlands, topography, and scenic views are identified. Natural areas which benefit water quality, wildlife, flood control, and receation are noted as preservation and open space areas.

After the site analysis has been completed, the schematic site plan is prepared, illustrating the general locations of various site uses. The configuration of the roads and the location of the development reflect the natural site characteristics. Sensitive resource areas are avoided whenever possible.

The third step is the preparation of the final plan, showing individual dwelling units and the final configuration of roads and other site plan features.

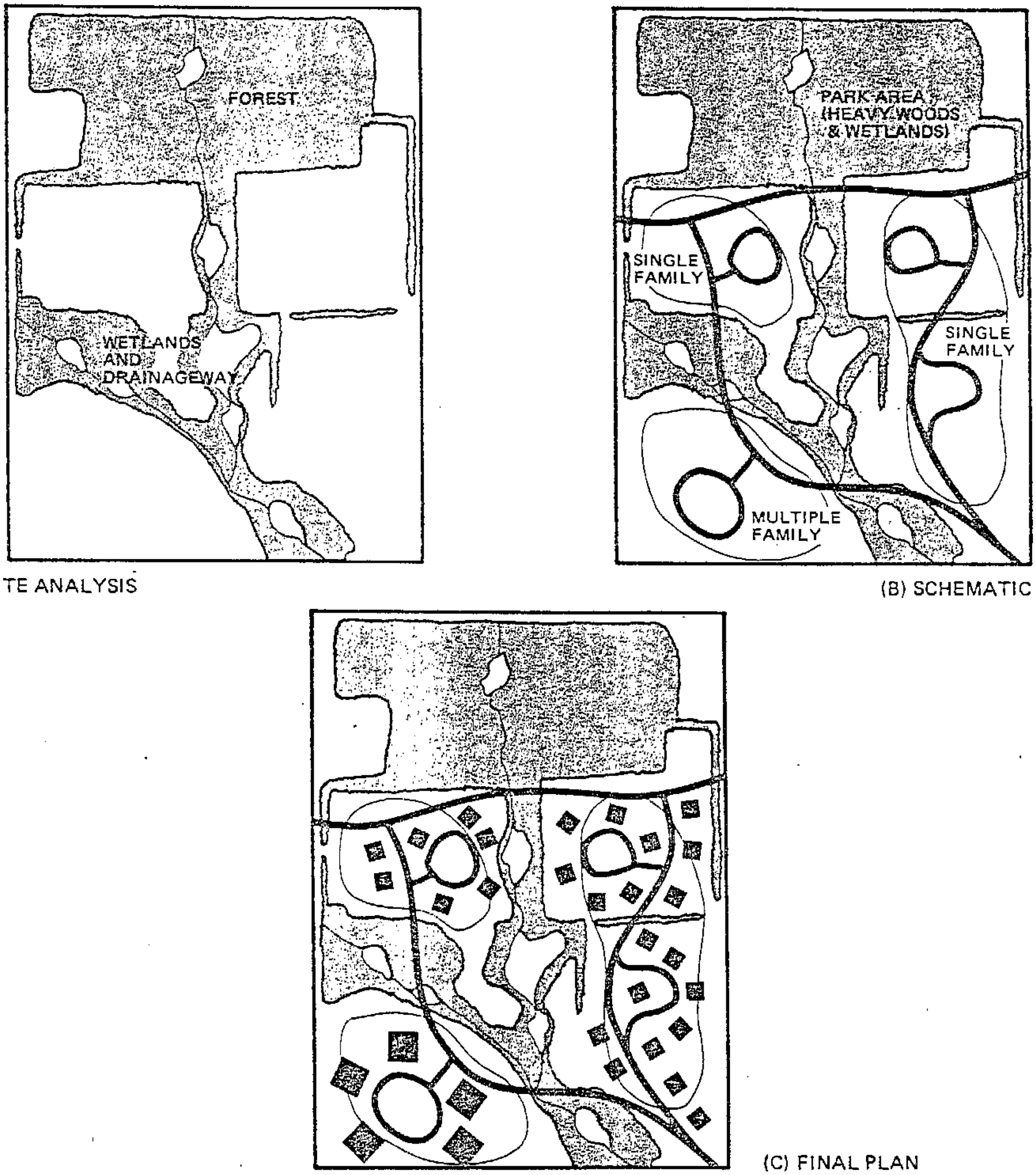
The drawings on Figure 33 illustrate the site analysis and plan development process for a cluster development proposed for Southwest Oakland County. The site has a number of attractive natural features which will provide amenities to residents and which will help market the homes after construction has been completed. Thirty-one acres of the 84 acre site (37 percent of the total area) are forrested, with large oak, beech and ash trees. One cottonwood on the site is over 100 feet high. A series of depressions, ponds, and an old agricultural drainageway provide a wetland habitat for small birds and mammals and help retain stormwater runoff on the site.

The proposed site plan protects nearly the entire forrested and wetland area as a natural park. Several pathways cross through the forest, so further improvements are not planned. The stand of trees will form a screen and buffer for the property to the north of the development site. A manmade stormwater detention basin will be added in the southern area of the property to supplement the natural drainage features and prevent off-site flood hazards.

The proposed plan is to include multiple-family and single family housing units in the development. Some of the single-family units will be attached

FIGURE 33

PREPARING THE SITE PLAN:
A CLUSTER DEVELOPMENT IN OAKLAND COUNTY



(A) SITE ANALYSIS

(B) SCHEMATIC PLAN

(C) FINAL PLAN

together (zero lot lines) so that housing prices can be affordable to middle income families.

By using a cluster development concept, the developer has provided an attractive layout of structures and a blending of the urban development with the natural features of the site. By protecting the natural drainageway and forrested lands, water quality in the area will also be protected. The alternative to the cluster design would have been cookie-cutter homes on individual lots - an alternate which would have destroyed the forest and wetlands and would probably not be marketable.

3. DENSITY BONUSES: FINANCIAL INCENTIVES FOR THE DEVELOPER

Cluster development is typically a land development option available to the property owner - not a requirement. To encourage the use of cluster development options, local governments sometimes allow more housing units per acre than would be allowed if conventional zoning requirements were followed. The cities of Novi and Farmington Hills, Michigan for example, have adopted cluster development regulations which provide density bonuses.

Cluster development saves developers certain costs related to road and utility construciton since the length of roadways is decreased. It is often forgotten, however, that certain costs for the developer are increased with cluster developments. Increased cost factors include:

LAND COSTS PER UNIT:

Sometimes as much as 40 percent of the development site is devoted to open space preservation. The open space dedication reduces the land area available for home construction purposes.

PLAN APPROVAL COSTS:

Cluster development plans are subject to a series of public reviews. In addition to higher design costs, the developer typically must allow more time for approval of plans.

MARKETING RISKS:

Cluster developments may be new to a particular community, and the market for the new units may not be tested. Marketing risks may compel a developer not to attempt a cluster development. Density bonuses can be used to offset the additional costs of cluster development experienced by the developer.

Density bonuses may not be needed to make cluster development attractive to developers. In West Bloomfield Township (Oakland County), Michigan, for example, numerous cluster developments have been built without density bonuses. In West Bloomfield, cluster developments have strong market acceptance and do not need special incentives to be feasible.

PROTECTION OF NATURAL STORMWATER RETENTION AREAS:

Cluster development encourages the preservation of wetlands, lowlands, and natural drainageways which help slow and detain stormwater as it flows over the land. Natural retention of stormwater on the site enhances grondwater quality, improves water quality in lakes and streams, and reduces flooding problems downstream. The protection of natural retention areas helps to avoid costly remedial public works projects. In addition to these cost saving features, cluster development often creates a positive "image" which enhances and supports property values in the community.

Comparisons of both costs and revenues resulting from a cluster development and a conventional development on the same tract of land usually dramatically demonstrate community cost savings.

Table 45 reports cost savings from cluster development as calculated for the Pine Hills development in the City of Grand Rapids.

Cluster development in the City of Grand Rapids is allowed as a "Planned Unit Development" option, similar to Salt Lake County.

Overall density requirements are actually more stringent (fewer units/acre are allowed) than for conventional development proposals. Homes are closer together in the cluster development, however, as a result of flexible lot size requirements.

TABLE 45

COST SAVINGS FROM CLUSTER DEVELOPMENT

PINE HILLS DEVELOPMENT, CITY OF GRAND RAPIDS

	Conventional	Cluster
Housing Units	2,350	2,350
Housing Types	Single-Family	Single-and Multi-Family
Tax Revenue	$1,750,000	$1,800,000
Road Maintenance	$60,000	$20,000
Other Services	$334,000	$248,000
TOTAL COSTS	$1,712,000	$876,000
Surplus Revenue	$38,000	$924,000

SOURCE: "Planned Unit Development", public information brochure prepared by the City of Grand Rapids.

4. COMMUNITY COST SAVINGS THROUGH CLUSTER DEVELOPMENT

Cluster development offers the following financial advantages to local governments:

SAVINGS IN PARK LAND ACQUISITION AND MAINTENANCE COSTS:

Cluster developments, by definition, provide open space areas for the use of residents. Property owners associations are typically established to maintain common open space areas. Cluster developments reduce the need of the local government to acquire and maintain public parklands.

REDUCTION IN PUBLIC ROADWAY MAINTENANCE COSTS:

Local governments often pay for repair and maintenance of certain streets within the cluster development. Because the streets are shorter in length than a conventional develoment, certain costs are saved. In cluster developments, the length of roadways (and related sewer and water lines) may be shorter by 20 percent or more.

REDUCTION IN PUBLIC SERVICE COSTS:

In urbanizing areas, local governments sometimes provide services such as street sweeping, garbage pickup, and snow plowing. Direct costs for providing these types of services can be reduced through cluster develoment. Costs for police patroling may also be reduced, since there are fewer road miles to patrol. Many of these cost savings are also energy savings.

B. PERFORMANCE ZONING

Seeking to protect public health, safety and welfare, zoning ordinances divide land into distinct zoning districts. Most zoning districts segregate land uses by type and density. One district is for single-family residential development, a second for multi-family, a third for intensive commercial develoment, etc. Each district,, in turn, has a number of standards or specifications which must be met before development may take place.

In most traditional zoning ordinances, the proposed land use and the proposed site plan and layout provide the basic factors for the approval of a development. When zoning ordinances incorporate performance standards (hence the term "performance zoning"), attention is placed upon the effect of a development on the comunity. Performance standards should be quantifiable and capable of being measured.

The use of performance standards is not new to many local governments. Industrial use standards related to noise and odors, for example, are sometimes written as performance standards with measurable criteria. The application of performance standards to many different types of land uses and the effort to make "effects" the major basis for development decisions by local officials, however, are new directions for land use regulations.

Performance standards and regulations may be applied in two ways:

1. As a supplement or "overlay" to traditional land use districts and zones; or

2. As a substitute for land use districts.

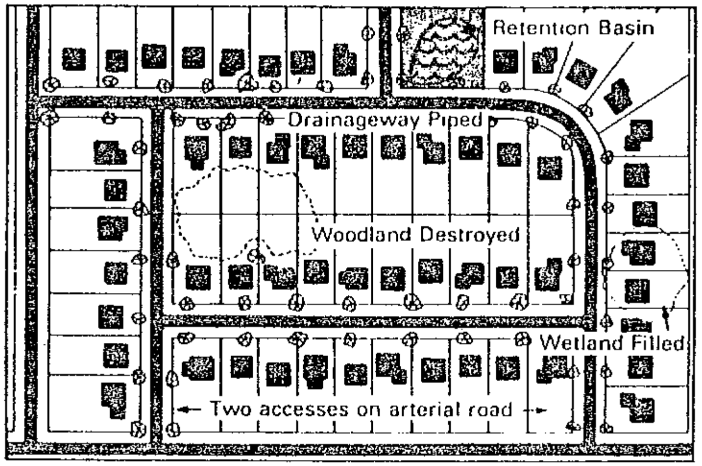
Under the first approach, zoning districts remain the same but performance standards are added to the requirements for development within each district. Performance standards may be mixed with other types of specifications and requirements.

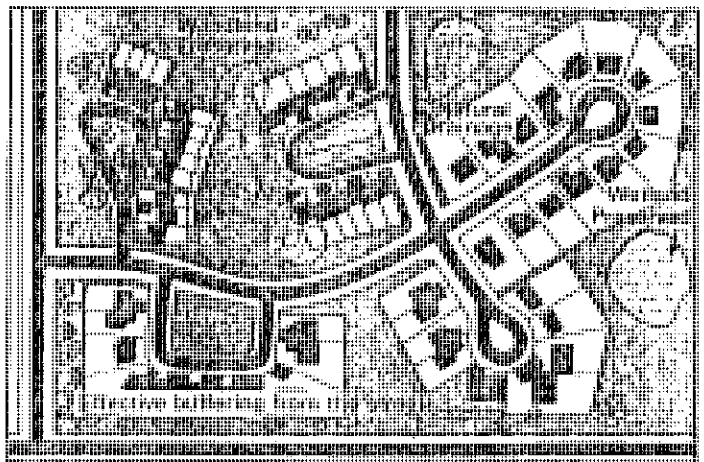
Under the second approach, districts are conceptualized and designated on the basis of impact. Rather than single family residential, commercial, and industrial districts, for example, districts are titled "urban core district," "heavy industrial district," "neighborhood conservation district" or "rural district." Within most districts, all uses are allowed by right, provided that they meet the performance standards included in the zoning ordinance.

When performance standards reflect the physical carrying capacity of the site and natural resources, landowners are directed to a site analysis process which starts with the resource base. Figure 34 compares a conventional zoning layout with a performance zoning layout for the same site. Performance zoning directs the developer to work with the costraints of the site and to buffer adjoining uses and roads. The developer is free to develop a site design to meet the performance standards. The effect of performance zoning on site design is similar in many ways to cluster developments or planned unit developments.

FIGURE 34

PERFORMANCE AND CONVENTIONAL ZONING COMPARED





Conventional Zoning

Conventional zoning (focusing on road design specifications, building setbacks, lot sizes, etc.) sometimes leads to poor design because of its rigidity. The standards set become the lowest common denominator with mediocrity in design a predictable result. As illustrated here, a cookie-cutter design can result which involves destruction of natural resources, increased surface runoff and increased water pollution.

Performance Zoning

Good design is predicated on freedom, flexibility, and creativity. Performance zoning was developed to permit the designer to implement these values. The increased flexibility of performance zoning enables the landowner to work with the constraints of the site and to buffer adjoining uses and roads. Water quality can be protected by using natural drainage systems, by protecting wetlands and open spaces, and by minimizing paved surfaces.

The "art" of performance zoning is to develop performance standards which are objective, measurable when compared with proposed developments, and reasonable in terms of public health, safety and welfare protection.

Two types of regulations which are sometimes confused with performance standards are: 1) subjective standards; and 2 specification standards.

Subjective standards are more like policy statements than quantifiable standards. A subjective standard is not specific enough to be administered without making discretionary judgments. For example, a subjective standard referenced in the Michigan Township Rural Zoning Act (Act 184, P.A. of 1943, as amended) is that special land uses, planned unit developments, and other discretionary decisions (such as many site plan reviews) must "insure that the land use or activity authorized shall be compatible with adjacent uses of land, the natural environment, and the capacities of public services and facilities affected by the land use" (Section 16d). The application of this standard requires study and judgment - different factors might be considered by different persons. although it is a useful policy statement, it is not a performance standard.

Specification standards may also be confused with performance standards. Since specifications are usually numerical, measurable standards, they are easier to administer and enforce than subjective standards. However, since they do nt deal directly with the effect or impact of a particular activity, they are not performance standards. Setback requirements, density restrictions, and other design requirements which can be stated in measurable unit are examples of specification standards. In contrast, performance standards are applied to effects rather than to structural or design features. Specifications sometimes dictate use and design and preclude creative use of natural features of the site.

DEDICATION AND RESTRICTIVE COVENANTS

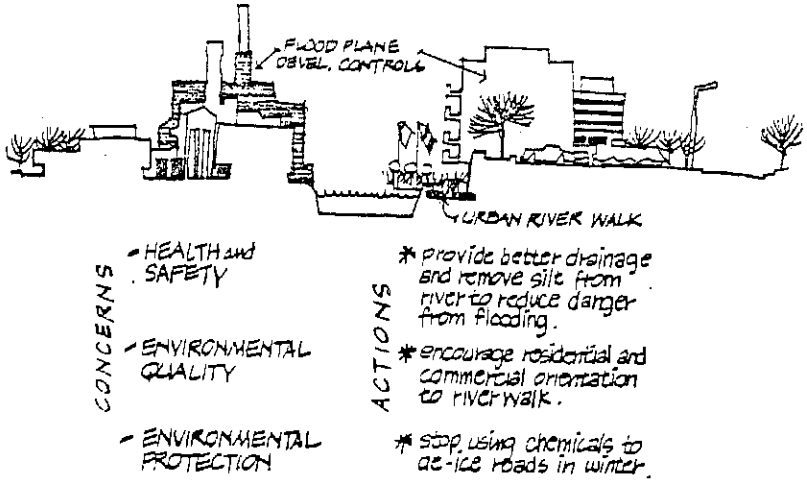
Conditional use permits and subdivision plats are usually approved with stipulations that property adjacent to or within public use rights-of-way be dedicated to the City or Couty for development and maintenance by such a public entity. Street widening or dedication is a typical example, but can be legally extended to streamside corridors where Federal, State, and County authority requires regulations, access, maintenance or other public management. Fifty to sixty foot rights-of-way are typically dedicated for street construction, while seven to twenty foot dedications are acquired for widening. Average width of valley tributary dedication corridors would probably include fifteen to twenty five to forty feet. Figures 35,36,37,38 and 39 display alternatives strategies possible through dedication or open space conservation processes. Restrictive covenants have been used locally as a tool to obtain such open space or stream buffer requirements. The Glacio Park Subdivision incorporated a 50 foot buffer for riparian and water quality maintenance.

FLOOD CONTROL AND WATER QUALITY POLICIES

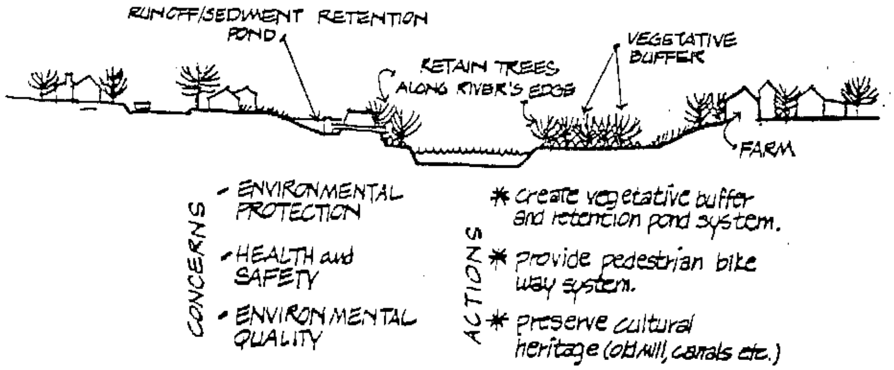
Consolidation of local water quality management planning under the Clean Water Act with local flood control planning and capital improvements offer unique tools for acquisition and management of public streamzone environment. The ordinance recently implemented by the Board of County Commissioners in Salt Lake gives the Flood Control Division primary responsibility for maintaining flood control and water quality integrity for each valley tributary.

Under terms of the ordinance, the County requires control and treatment of stormwater discharge through provision of detention basins, bank stabilization, erosion-sediment controls, or other management practices. This

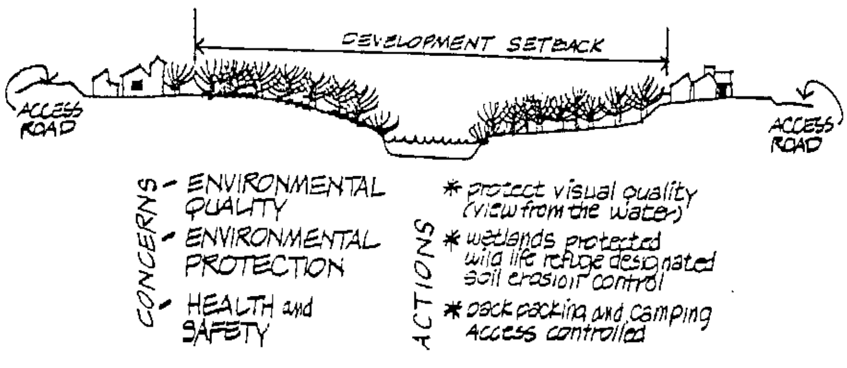
FIGURE 35



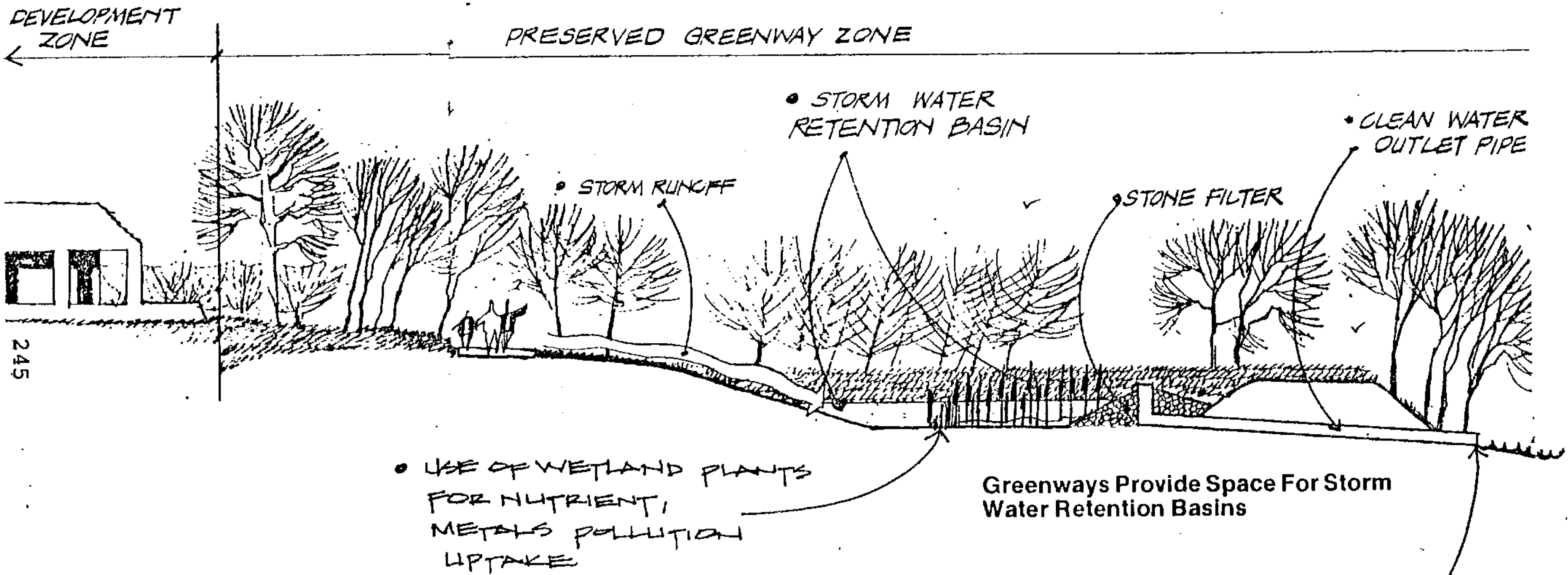
A. Urban Zone Strategy



B. Suburban Zone Strategy

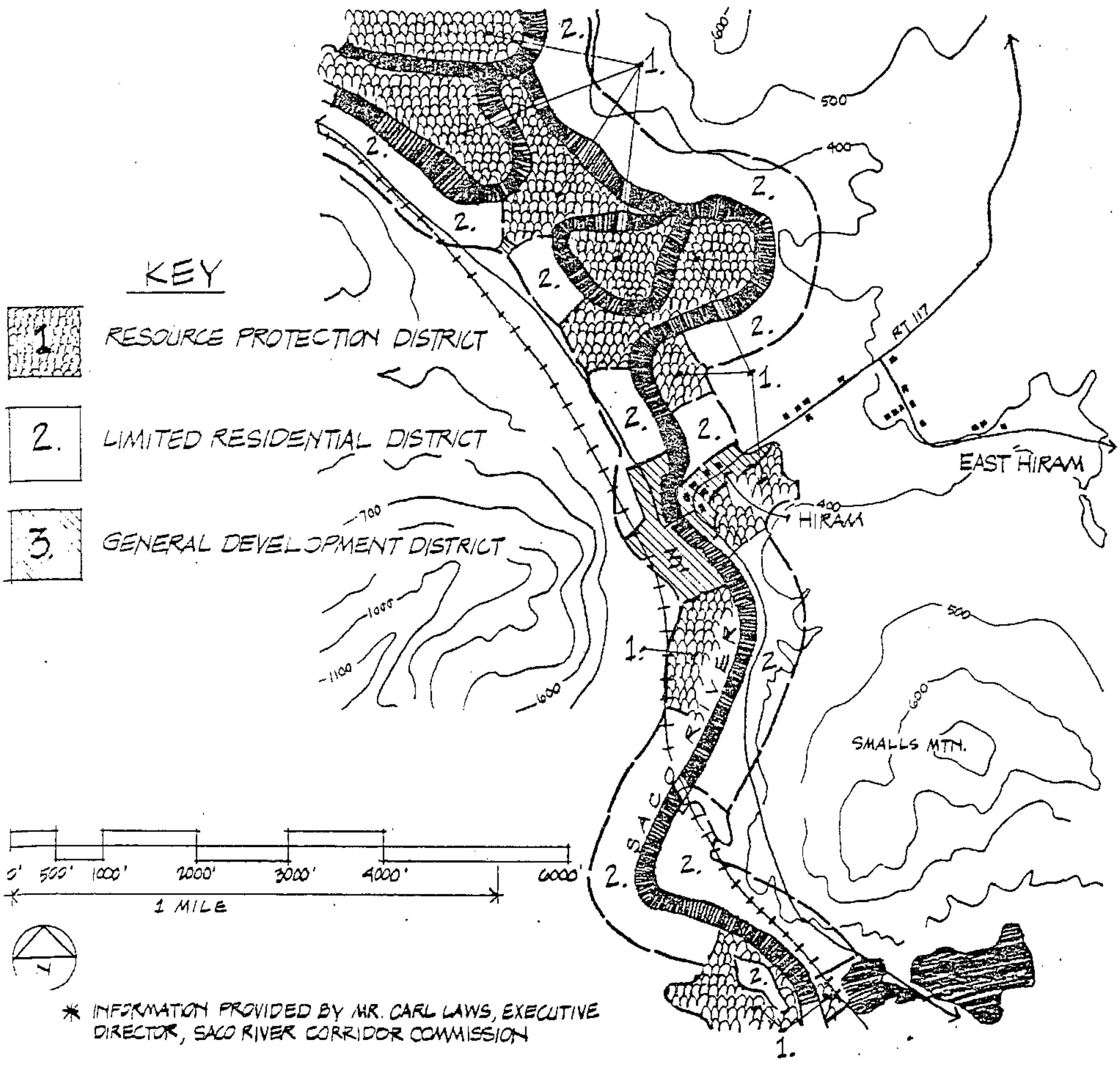


C. Natural Zone Strategy



Greenways Provide Space For Storm Water Retention Basins

FIGURE 36



**A Sample District Classification
Saco River Corridor**

FIGURE 37

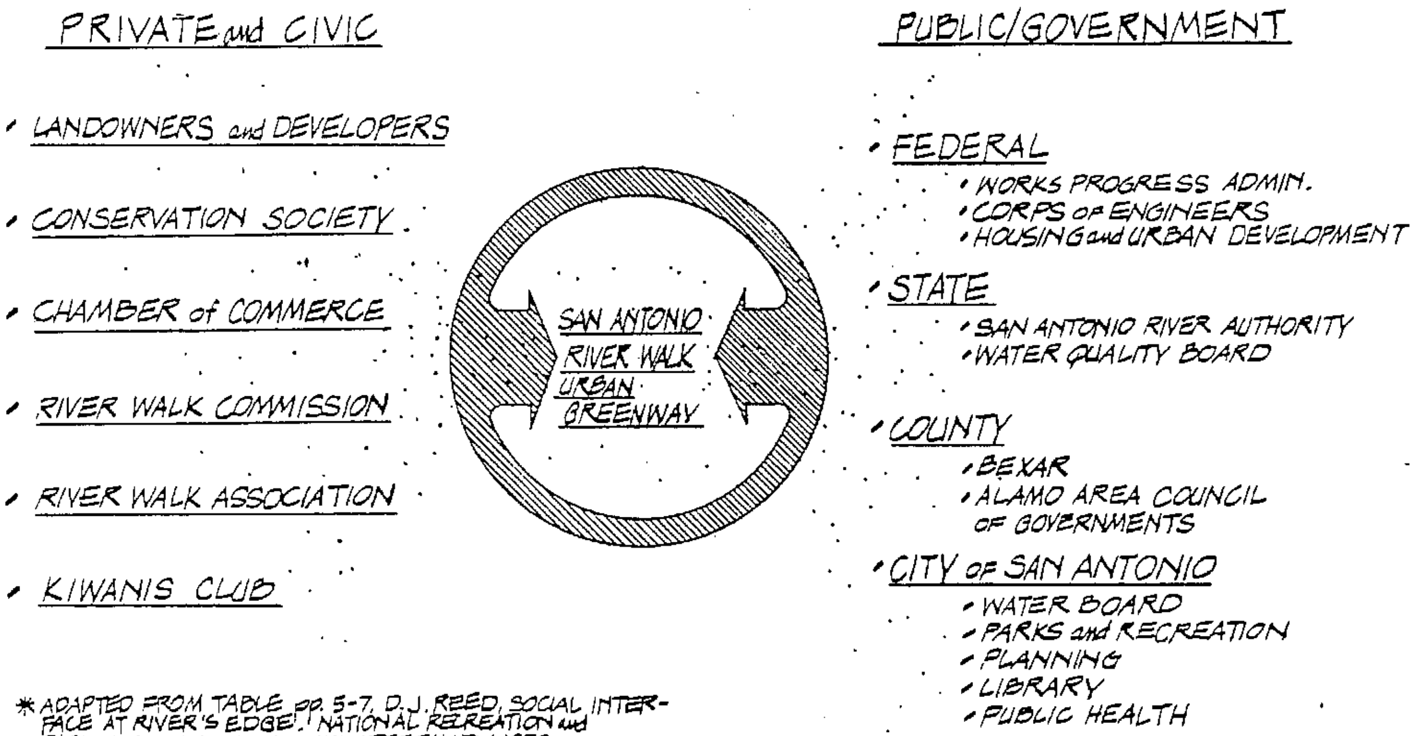
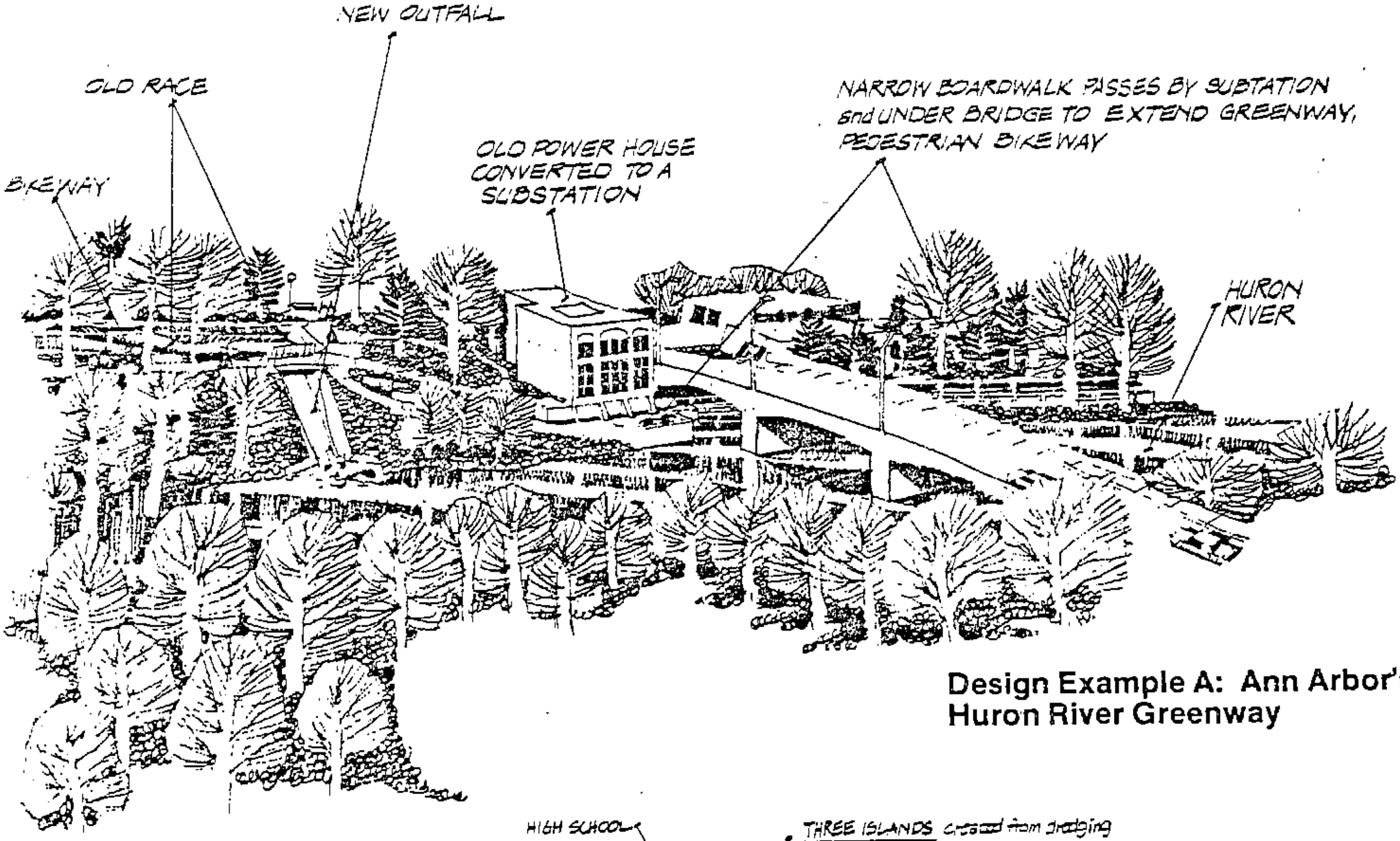
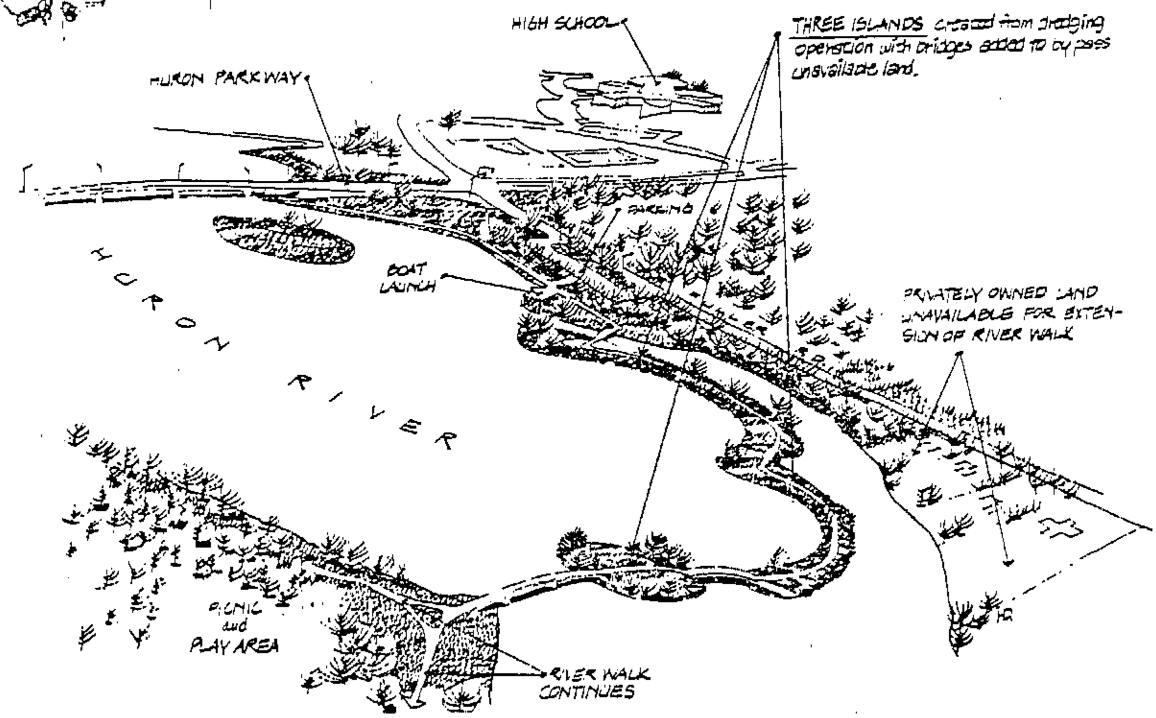


FIGURE 38 Participants in River Walk Development



Design Example A: Ann Arbor's Huron River Greenway



Design Example B: Ann Arbor's Huron River Greenway

FIGURE 39

requirement is consistent with Federl regulations governing discharge permits for stormwater conveyances to classified stream segments. The County, due to its role articulated in the ordinance, may assume the role of procuring, holding, and enforcing N.P.D.E.S. general permits in the Salt Lake basin.

In addition to institutional requirements of the flood control ordinance, several options allow for reservation of stream-zone corridors. These include condemnation, fee-simple acquisition, land exchange or trade, and public leasing. The County has recently begun a bank stabilization program which offers both creation of easement and creation of effective open space corridors.

CONDEMNATION

Salt Lake County may condemn - for public acquisition - lands which have a direct impact on health, safety, and welfare, where flood control and protection dictates need for continuous ownership and access. The difference between fee-simple acquisition and condemnation is a judgment by a public agency that land procurement is mandatory rather than optional, for protection of health, safety, and welfare owners are then required to negotiate fair market value with the agency, and land is purchased within time-frames consistent with a prescribed level or schedule of protection.

Condemnation has been used to a limited extent in Salt Lake County. Examples are on the Jordan River, detention basins, and stormwater conduits.

FEE-SIMPLE ACQUISITION

This method is used primarily where properties have been developed and the overriding need to obtain access is justified. The owner is offered fair market value for only access corridors, usually ten to twenty feet on either side of the stream. Such acquisition occurs in problem areas where owners suffer annual damage and are desirous of insuring protection with permanent access by the flood control agency, or where the owner considers such a corridor marginal to the total value of the property.

EXCHANGE/TRADE

Public entities such as school or special improvement districts are often candidates for flood control land exchange or trade. This approach has been employed for acquisition of detention basin sites, some adjacent to or directly on streams. Perhaps the most cost-effective method of open space acquisition, its application is restricted to locations of other public holdings, which most often are not streamside.

LEASING

Private property owners adjacent to valley tributaries may find the concept of lease income attractive where the flood control agency has access difficulty. The public agency may likewise find leasing over a short-term period attractive for stream segments soon to be stabilized. Cost for leasing would likely be less than that for fee-simple purchase and the effect of interim access would achieve the same goal as acquisition. The limitation of the lease option is the timetable and resources entailed through incremental bank stabilization programs. Assuming that annual dredging maintenance will be reduced with segment bank stabilization, the scheduling of specific segments improvements may dictate the desirability of leasing access versus acquisition.

STREAMBANK STABILIZATION PROGRAMS

Salt Lake County Flood Control provides a streambank stabilization program for property owners willing to purchase bank stabilization materials. County crews install the materials and maintain their effectiveness. The installation of such materials in most cases enhances stream accessibility and leisure opportunity. Large angular rip-rap, rock-filled wire baskets, and bank re-grading with revegetation are most often employed in the program.

The effect of these improvements is to provide linear accessways or paths adjacent to the stream. Fishing trails or other leisure pathways are created by such improvements.

There are two major disadvantages to the present program. First, the priority problem areas on the stream are not addressed. Eroding areas are stabilized where property owners can afford to purchase the materials, and other seriously eroding areas are left to annual dredging. Second, stabilization is most often carried out lacking important habitat or recreation use enhancement details, such as step-downs, vegetation, and stream deflectors. Total bank stability typically does not afford opportunities for other beneficial uses, but experience has been locally gained in measuring design criteria. For example, the Habitat Restoration project on Big Cottonwood Creek recorded substantial habitat improvement from rip-rap material adjacent to gabion baskets, while the basket reach provided little or none. The conclusion is that a system of mixed bank stabilization must be employed in order to improve management of streams for fisheries, wildlife habitat, recreation, and aesthetic values.

In the short-run the effective access created by the bank stabilization program offers many solutions to problems of obtaining access and open space for attainment of greater beneficial use, particularly in areas where existing development prohibits open space conservation.

RECOMMENDED BEST MANAGEMENT PRACTICES OF THE AMERICAN FISHERIES SOCIETY

The Western Division of the American Fisheries Society, in 1982, made recommendations for specific Best Management Practices for the Management and Protecton of Western Riparian Stream Exosystems. The document was prepared by an interdisciplinary team of the Riparian Habitat Committee of that organization and is intended as future guidance for public agencies, landowners, and individuals. (See Appendix 5)

The guidelines cover four critical areas pertinent to the present discussion:

1) Structural/Non-structural Flood Control Practices

2) Road Construction

3) Urbanization/Land Use Planning

4) General Erosion Control

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APPENDIX I

METHOD FOR ESTIMATING SEDIMENT REMOVED FROM VALLEY TRIBUTARIES-1982 MAINTENANCE SEASON

The annual stream maintenance program did not make provisions for reporting loads of material removed from creeks during routine maintenance. Starting in 1982, records began to be compliled by Flood Control project foremen and supervisors which provided some basic data.

A stream segment on Big Cottonwood Creek (1500 East to Highland Drive) was recorded in January, 1982, detailing equipment, labor, and materials cost, together with total tons material removed and cost of removal per ton. The segment was approximately one-mile long.

Unit tons for total material removed within the "typical" one-mile segment were applied to total recorded maintenance costs, while unit cost per ton was applied to the same maintenance dollars. The result was a range of tons produced by the total maintenance expenditure, which was then averaged to produce the tonnage estimate.

TYPICAL MAINTENANCE COST

Big Cottonwood - Highland Drive to 1500 East
(Approx. One Stream Mile)

Date	Equipment	Labor	Material	Total
1/25/82	$410.65	$627.69	$9.22	$1,047.56
1/26/82	342.65	268.88	-0-	611.53
1/28/82	325.40	411.90	-0-	737.30
1/29/82	312.20	452.51	-0-	935.48
2/1/82	545.40	390.08	-0-	935.48

Equipment Cost	$1,936.30	Total	$5,344.19
Labor Cost	$2,151.06	Total Tons Mat.	1320
Overhead & Benefit 58%	$1,247.61	Project Cost Per Ton	$4.05
Material	9.22		

Estimated tons material for each creek using "BC Typical" project cost/ton at $4.05:

	Pre-Flood '82 Cost		Cost/Ton		Estimated Tons	Post-Flood '82 Cost
Big Cotton.	45,000	÷	4.05	=	11,111	84,000÷4.05=20,741
L. Cotton.	50,000	÷	4.05	=	12,346	186,000÷4.05=45,926
Mill Creek	25,000	÷	4.05		6,173	24,000÷4.05= 5,926

Estimated tons material for each creek using "BC Typical" Tons Removed Per Mile at 1320:

	Miles(Annual) Maintained		Tons/ Mile		Est. Tons	Miles Maintained (5 yr. Maint Freq*)
Big Cotton.	4.1	X	1320	=	5412	7.1X1320=9372
L. Cotton.	5.49	X	1320	=	7247	9.9X1320=13068
Mill Creek	.87	X	1320	=	1148	1.7X1320=2244

*Glen Marcus reports 5 yr. maintenance frequency for flood cleanup, autumn '82.

Estimated tons using Average of Combined Cost/Ton & Cost/Mile

	SPRING '82	AUTUMN '82	TOTAL '82
Big Cotton.	8206 tons	15057	23263
L. Cotton.	9797 tons	29497	39294
Mill Creek	3660 tons	4085	7745
TOTAL	21663	48639	70302

Appendix 2

Identified Ecosystem Habitat Types and Inventoried Faunal Components As per Utah Division of Wildlife Resources.

ECOSYSTEM	Great Salt Lake Desert	Grass - Sagebrush			Lower Montane
FAUNAL COMPONENT (Common Name) / COMMUNITY	**Marsh**	**Grass-Sagebrush**	**Jordan River**	**Meadow**	**Streamside Woods-Thickets**
Birds					
Bohemian Waxwing	X				X
Cedar Waxwing	X				X
Northern Shrike	X	X			
Loggerhead Shrike	X	X			
Dipper			X		
Long-billed Marsh Wren	X				
Mockingbird		X			X
Sage Thrasher		X			
Robin	X				
Mountain Bluebird	X				X
Barn Swallow	X	X			
Cliff Swallow	X				
Purple Martin	X				
Black-billed Magpie	X				X
Common Raven	X	X			
Common Crow	X				X
Western Kingbird	X				
Say's Phoebe	X				X
Trail's Flycatcher	X		X		
Horned Lark	X				
Violet-green Swallow	X		X		
Tree Swallow	X				
Bank Swallow	X				
Roughwinged Swallow	X				
Long-eared Owl	X				X
Short-eared Owl	X	X		X	
Poor-will		X			
Common Nighthawk	X	X			X
Broadtailed Hummingbird	X				X
Rufous Hummingbird	X				X

ECOSYSTEM	Great Salt Lake Desert	Grass - Sagebrush			Lower Montane
FAUNAL COMPONENT (Common Name) / COMMUNITY	Marsh	Grass-Sagebrush	Jordan River	Meadow	Streamside Woods-Thickets
Belted Kingfisher	X	X	X		
Red-Shafted Flicker	X				X
Northern Phalarope	X			X	
California Gull	X			X	
Ring-billed Gull	X			X	
Franklin's Gull	X			X	
Forester's Tern	X				
Caspian Tern	X				
Ruby-crowned Kinglet					X
Starling	X				X
Solitary Vireo					X
Warbling Vireo					X
Orange-crowned Warbler				X	X
Virginia's Warbler				X	X
Yellow Warbler					X
Audubon Warbler					X
MacGillivray's Warbler					X
Yellowthroat Warbler					X
Yellow-breasted Ghat					X
Brown Creeper					X
House Wren					X
Catbird					X
Swainson's Thrush					X
Veery					X
Townsend's Solitaire					X
Blue-gray Gnatcatcher					X
Steller's Jay					X
Scrub Jay					X
Black-capped Chickadee					X
Mountain Chickadee					X
Plain Titmouse					X
Downy Woodpecker					X
Eastern Kingbird					X
Hammonds Flycatcher					X

FAUNAL COMPONENT (Common Name)	ECOSYSTEM: Great Salt Lake Desert	ECOSYSTEM: Grass - Sagebrush			ECOSYSTEM: Lower Montane
COMMUNITY	Marsh	Grass-Sagebrush	Jordan River	Meadow	Streamside-Woods-Thickets
Gray Flycatcher					X
Western Flycatcher					X
Olive-sided Flycatcher					X
Saw-whet Owl					X
Black-chinned Hummingbird					X
Callione Hummingbird					X
Lewis' Woodpecker					X
Yellow-bellied Sapsucker					X
Hairy Woodpecker					X
Yellow-billed Cuckoo					X
Barn Owl					X
Schreech Owl					X
Flammulated Owl					X
Pygmy Owl					X
Cattle Egret				X	
Snowy Egret	X		X		
Pine Siskin					X
Lesser Goldfinch					X
Red Crossbill					X
Green-tailed Towhee					X
Junco					X
Sandhill Crane				X	
American Golden Plover				X	
Wilson's Warbler					X
American Redstart					X
Black Tern	X				
Mourning Dove	X	X			X
Great Horned Owl	X		X		X
Burrowing Owl	X	X			
Long Billed Curlew	X			X	
Spotted Sandpiper	X			X	
Solitary Sandpiper	X				
Willet	X			X	

FAUNAL COMPONENT (Common Name)	Great Salt Lake Desert	Grass - Sagebrush			Lower Montane
ECOSYSTEM	Great Salt Lake Desert	Grass - Sagebrush			Lower Montane
COMMUNITY	Marsh	Grass-Sagebrush	Jordan River	Meadow	Streamside Woods-Thickets
Greater Yellowlegs	X			X	
Lesser Yellowlegs	X			X	
Pactoral Sandpiper	X				
Baird's Sandpiper	X				
Least Sandpiper	X				
Long-billed Dowitcher	X			X	
Western Sandpiper	X				
Marbled Godwit	X			X	
White-fronted Goose	X			X	
Snow Goose	X				
Mallard	X			X	
Gadwall	X				
Pintail	X			X	
Green-winged Teal	X				
Blue-winged Teal	X				
Cinnamon Teal	X			X	
Shoveler	X				
Redhead	X				
Ring-necked Duck	X				
Canvasback	X				
Greater Scaup	X				
Lesser Scaup	X				
Common Goldeneye	X		X		
Bufflehead	X				
Common Loon	X				
Horned Grebe	X				
Eared Grebe	X				
Western Grebe	X		X		
Pied-billed Grebe	X		X		
White Pelican	X		X		
Double-crested Cormorant	X		X		

FAUNAL COMPONENT (Common Name)	Great Salt Lake Desert	Grass - Sagebrush			Lower Montane
	Marsh	Grass-Sagebrush	Jordan River	Meadow	Streamside Woods-Thickets
Great Blue Heron	X		X		X
Green Heron	X			X	
Common Egret	X			X	
Black-crowned Night Heron	X		X		
American Bittern	X			X	
White-faced Ibis	X				
Whistling Swan	X				
Canada Goose	X				
Gray-crowned Rosy Rinch	X	X			
Black Rosy Finch		X			
American Goldfinch	X	X			X
Rufous-sided Towhee		X		X	
Savannah Sparrow	X	X			
Vesper Sparrow	X	X			
Lark Sparrow	X				
Black-throated Sparrow		X			
Sage Sparrow		X			X
Tree Sparrow	X	X			X
Chipping Sparrow	X				
Ruddy Duck	X	X			
Common Merganser	X		X		
Red-breasted Merganser	X		X		
Turkey Vulture	X	X			X
Ring-necked Pheasant	X		X	X	X
Virginia	X				
Sora	X			X	
Common Gallinule	X				
American Coot	X				
Snowy Plover	X				
Killdeer	X			X	

FAUNAL COMPONENT (Common Name)	Great Salt Lake Desert: Marsh	Grass - Sagebrush: Grass-Sagebrush	Grass - Sagebrush: Jordan River	Grass - Sagebrush: Meadow	Lower Montane: Streamside Woods-Thickets
Black-bellied Plover	X			X	
Common Snipe	X				
House Sparrow	X				
Bobolink	X			X	
Western Meadowlark	X	X		X	
Yellow-headed Blackbird	X				
Redwinged Blackbird	X				
Bullock's Oriole	X				X
Brewer's Blackbird	X			X	X
Brown-headed Cowbird	X				X
Lazuli Bunting	X				X
House Finch	X				X
Lapland Longspur		X			
Chestnut-collared Longspur			X		
Snow Bunting		X			
Baldpate	X				
Burrow's Goldeneye	X				
Oldsquaw	X				
White-winged Scoter	X				
Surf Scoter	X				
Hooded Merganser	X		X		
Slate-colored Junco	X				
Western Tanager					X
Black-headed Grosbeak					X
Evening Grosbeak					X
Cassins Finch					X
White-crowned Sparrow				X	X
Fox Sparrow					X
Lincoln's Sparrow				X	X
Song Sparrow					X
Swainson's Hawk	X	X	X		

FAUNAL COMPONENT (Common Name)	ECOSYSTEM: Great Salt Lake Desert	ECOSYSTEM: Grass - Sagebrush			ECOSYSTEM: Lower Montane
COMMUNITY	Marsh	Grass-Sagebrush	Jordan River	Meadow	Streamside Woods-Thickets
Ferruginous Hawk	X	X	X		X
Golden Eagle	X	X	X		X
Bald Eagle	X	X	X		X
Marsh Hawk	X	X	X		X
Prarie Falcon	X	X	X		X
Peregrine Falcon	X	X	X		X
Sparrow Hawk	X	X	X		X
Ross' Goose	X				
Black Duck	X				
Song Sparrow	X				X
<u>Snakes</u>					
Wandering Garter Snake	X	X	X	X	X
Red-sided Garter Snake		X	X	X	
Regal Ring-necked Snake		X	X	X	
Western Racer	X	X	X	X	X
Great Basin Gopher Snake	X	X	X	X	X
Utah Milk Snake		X	X	X	X
Utah Ringed Snake		X	X	X	X
Desert Night Snake	X	X	X	X	
Great Basin Rattlesnake	X	X	X	X	X
Rocky Mountain Rubber Boa					X
Western Smooth Green Snake					X
<u>Amphibians</u>					
Clouded Tiger Salamander	X	X	X	X	X
Boreal Toad		X	X	X	X
Woodhouse's Toad	X	X	X	X	
Western Chorus Frog	X	X	X	X	X

ECOSYSTEM	Great Salt Lake Desert	Grass - Sagebrush			Lower Montane
FAUNAL COMPONENT (Common Name) / COMMUNITY	Marsh	Grass-Sagebrush	Jordan River	Meadow	Streamside Woods-Thickets
Bullfrog		X	X	X	
Western Leopard Frog	X	X	X	X	X
Western Spotted Frog		X	X	X	
<u>Reptiles</u>					
Leopard Lizard		X	X	X	
Sagebrush Lizard		X	X	X	X
Northern Side-blotched Lizard		X	X	X	
Mountain Short-horned Lizard	X	X	X	X	
Great Basin Horned Lizard	X	X	X	X	
Tessellated Race Runner	X	X	X	X	
Great Basin Skink		X	X	X	X
<u>Mammals</u>					
Great Basin Pocket Mouse		X			
Ord's Kangaroo Rat		X			
Western Harvest Mouse		X			
Deer Mouse		X		X	X
Desert Wood Rat		X			
Sagebrush Vole	X	X			
Nuttall's Cottontail		X			
Desert Cottontail		X			
White-tailed Jack Rabbit		X			
Red Fox		X			X
Kit Fox		X			
Long-tailed Weasel		X			X
Badger		X			X
Spotted Skunk		X			X
Striped Skunk		X			

ECOSYSTEM	Great Salt Lake Desert	Grass - Sagebrush			Lower Montane
FAUNAL COMPONENT (Common Name) / COMMUNITY	Marsh	Grass-Sagebrush	Jordan River	Meadow	Streamside Woods-Thickets
Bobcat		X			X
Least Chipmunk		X			X
Yellow-bellied Marmot		X			X
White-tailed Antelope Squirrel		X			
Uinta Ground Squirrel		X		X	X
Rock Squirrel		X			X
Golden-Mantled Ground Squirrel		X			
Elk					X
Mule Deer					X
Northern Flying Squirrel					X
Southern Pocket Gopher				X	X
Northern Pocket Gopher		X	X		X
Beaver					X
Meadow Vole			X		
Water Vole				X	X
Muskrat			X		
Vagrant Shrew				X	X
Water Shrew					X
Hoary Rat				X	
Jumping Mouse				X	
Porcupine					X
Coyote		X			X
Black Bear					X
Ermine		X			X
Mountain Lion					X

						COMMUNITY	ECOSYSTEM
						Marsh	Great Salt Lake Desert
						Grass-Sagebrush	Grass - Sagebrush
						Jordan River	
						Meadow	
						Streamside Woods-Thickets	Lower Montane

Appendix 3.

Data Sheets Utilized in Stream Inventory

DATE____________ STATION________________ STREAM____________

LOCATION____________________________ ELEVATION________

WEATHER CONDITIONS________ VOLUME (cfs)_______ VELOCITY (fps)_______

INVESTIGATED BY:____________________________

	WIDTH		BOTTOM TYPE						STABILITY & SHADE				POOLS			
No.	Ch	W	B	R	G	Sa	Si.	O	RB	LB	RB	LB	No.	W	L	Rating
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																

Bank Cover Composition____________________

Aquatic Vegetation____________________

Bottom Fauna____________________

Pollution/Sources____________________

Observed Wildlife/Habitat____________________

____

1 2 3 4 5

Esthetics____________________

Availability____________________

Productivity____________________

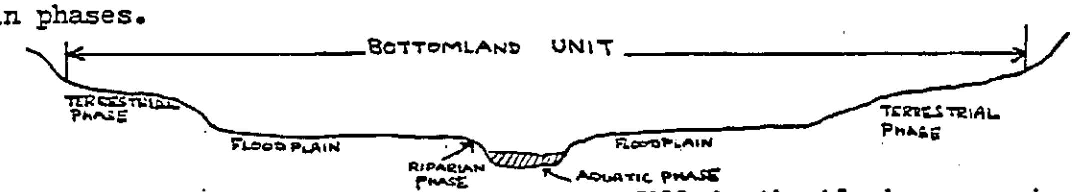
WASATCH NATIONAL FOREST BOTTOMLAND INVENTORY

Major Drainage__________ Ranger District__________ Date__________

Observer(s)__________ Stream Name__________ Reach Number__________

Elevation range_____ to_____ feet P.W.I. Watershed #__________

A valley bottomland is that total area of land which includes the stream channel, the adjacent floodplain, benches or terraces, and other gentle terrain, and normally those valley toe slopes which may directly affect or be affected by the stream. Valley bottomlands may be stratified into aquatic, riparian, terrestrial, and floodplain phases.



DIRECTIONS: Circle the appropriate response or fill in the blank as required.

Valley Shape:

Valley Width: narrow (<100') moderately wide (100'-325') wide (>325')

Sideslope Gradient: low (<30%) moderately steep (30-60%) steep (>60%)

Valley Gradient: low (<4%) moderately steep (4-8%) steep (>8%)

Channel Gradient: very low (<2%) low (2-3%) moderately steep (3-6%) steep (>6%)

Channel Size: width_____ft. Average depth_____ft. Flow pattern__________

Geologic materials in bottom:__________

Landform/Type__________

	RIPARIAN PHASE	FLOODPLAIN	TERRESTRIAL PHASE
vegetative type:	__________	__________	__________
	__________	__________	__________
vegetative cover density	__________	__________	__________
type of debris:	__________	__________	__________
sediment buffer potential:	__________	__________	__________

Number of debris jams &/or fish blocks/mile______. Upstream watershed impacts (Types)__________

____

Size Composition of Bottom Materials (Total to 100%)

1. Exposed bedrock..........____%
2. Large boulders, 3' + Dia..____%
3. Small boulders, 1-3'......____%
4. Large rubble, 6"-12"......____%
5. Small rubble, 3"-6"......____%
6. Coarse gravel, 1"-3"......____%
7. Fine gravel, 0.1"-1"......____%
8. Sand, silt, clay, muck...____%

____

____

____

____

____

____

R-1 STREAM CHANNEL STABILITY FIELD EVALUATION FORM

Item Rated	Stability Indicators by Classes							
	EXCELLENT		GOOD		FAIR		POOR	
UPPER BANKS								
Landform Slope	Bank slope gradient <30%	(2)	Bank slope gradient 30-40%	(4)	Bank slope gradient 40-60%	(6)	Bank slope gradient 60% +	(8)
Mass Wasting (Existing or Potential)	No evidence of past or potential for future mass wasting into channels.	(3)	Infrequent and/or very small. Mostly healed over. Low future potential.	(6)	Moderate frequency & size, with some raw spots eroded by water during high flows.	(9)	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	(12)
Debris Jam Potential (Floatable Objects)	Essentially absent from immediate channel area.	(2)	Present but mostly small twigs and limbs.	(4)	Present, volume and size are both increasing.	(6)	Moderate to heavy amounts, predominantly larger sizes.	(8)
Bank Protection from Vegetation	90% + plant density. Vigor and variety suggests a deep, dense root mass.	(3)	70-90% density. Fewer plant species or lower vigor suggests a less dense or deep root mass.	(6)	50-70% density. Lower vigor and still fewer species form a somewhat shallow and discontinuous root mass.	(9)	<50% density plus fewer species & less vigor indicate poor, discontinuous, and shallow root mass.	(12)
LOWER BANKS								
Channel Capacity	Ample for present plus some increases. Peak flows contained. W/D ratio <7.	(1)	Adequate. Overbank flows rare. Width to Depth (W/D) ratio 8-15.	(2)	Barely contains present peaks. Occasional overbank floods. W/D ratio 15-25.	(3)	Inadequate. Overbank flows common. W/D ratio >25.	(4)
Bank Rock Content	65% + with large, angular boulders 12" + numerous.	(2)	40 to 65%, mostly small boulders to cobble 6-12".	(4)	20 to 40% , with most in the 3-6" diameter class.	(6)	<20% rock fragments of gravel sizes, 1-3" or less.	(8)
Obstructions Flow Deflectors Sediment Traps	Rocks, old logs firmly embedded. Flow pattern of pool & riffles stable without cutting or deposition.	(2)	Some present, causing erosive cross currents and minor pool filling. Obstructions and deflectors newer and less firm.	(4)	Moderately frequent, moderately unstable obstructions & deflectors move with high water causing bank cutting and filling of pools.	(6)	Frequent obstructions and deflectors cause bank erosion yearlong. Sed. traps full, channel migration occuring.	(8)
Cutting	Little or none evident. Infrequent raw banks less than 6" high generally.	(4)	Some, intermittently at outcurves & constrictions. Raw banks may be up to 12".	(8)	Significant. Cuts 12"-24" high. Root mat overhangs and sloughing evident.	(12)	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	(16)
Deposition	Little or no enlargement of channel or point bars.	(4)	Some new increase in bar formation, most from coarse gravels.	(8)	Moderate deposition of new gravel & coarse sand on old and some new bars.	(12)	Extensive deposits of predominately fine particles. Accelerated bar development.	(16)
BOTTOM								
Rock Angularity	Sharp edges and corners, plane surfaces roughened.	(1)	Rounded corners & edges, surfaces smooth & flat.	(2)	Corners & edges well rounded in two dimensions.	(3)	Well rounded in all dimensions, surfaces smooth.	(4)
Brightness	Surfaces dull, darkened, or stained. Gen. not "bright".	(1)	Mostly dull but may have up to 35% bright surfaces.	(2)	Mixture, 50-50% dull and bright, ± 15%, ie 35-65%.	(3)	Predominately bright, 65% +, exposed or scoured surfaces.	(4)
Consolidation or Particle Packing	Assorted sizes tightly packed and/or overlapping.	(2)	Moderately packed with some overlapping.	(4)	Mostly a loose assortment with no apparent overlap.	(6)	No packing evident. Loose assortment, easily moved.	(8)
Bottom Size Distribution & Percent Stable Materials	No change in sizes evident. Stable materials 80-100%.	(4)	Distribution shift slight. Stable materials 50-80%.	(8)	Moderate change in sizes. Stable materials 20-50%.	(12)	Marked distribution change. Stable materials 0-20%.	(16)
Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition.	(6)	5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	(12)	30-50% affected. Deposits & scour at obstructions, constrictions, and bends. Some filling of pools.	(18)	More than 50% of the bottom in a state of flux or change nearly yearlong.	(24)
Clinging Aquatic Vegetation (Moss & Algae)	Abundant. Growth largely moss like, dark green, perennial. In swift water too.	(1)	Common. Algal forms in low velocity & pool areas. Moss here too and swifter waters.	(2)	Present but spotty, mostly in backwater areas. Seasonal blooms make rocks slick.	(3)	Perennial types scarce or absent. Yellow-green, short term bloom may be present.	(4)
COLUMN TOTALS →								

Add the values in each column for a total reach score here. (E.____+ G.____+ F.____+ P.____= ____).

Reach score of: <38=Excellent, 39-76=Good, 77-114= Fair, 115+=Poor.

R1-2500-5 (6/73)

OVER

APPENDIX 4

ASSESSMENT OF TROUT FISHERY CONDITIONS IN THE

VALLEY TRIBUTARY SEGMENTS

Objectives of a cursory assessment on valley tributary segments were:

1. To develop typical stream conditions along each creek reach using typical segment profiles.

2. After Binns & Eiserman, (1979) compute existing standing crop in total pounds for each valley creek segment.

3. After Geer (1981) compute predicted initial angler use potential under existing and projected conditions and,

4. Compute mean annual present worth for each valley creek segment.

5. Project present worth, standing crop, and angler use over a twenty-year planning period.

I. STANDING CROP/ANGLER DAY CALCULATIONS

Based on field inspection of four to five representative reaches on each valley tributary segment, creek attributes were estimated. Attributes include: flow (late summer % of average daily flow), annual stream flow variation, maximum summer stream temperature, nitrate-nitrogen, cover, eroding banks, substrate, water velocity, and stream width. Table Series BCC-1-5, LCC 1-5, and MC 1-4 describe values and ratings estimated for each attribute.

Table A-5-1 summarizes computations of Binns & Eiserman values, Table A-5-2 summarizes existing predicted Habitat Units and total standing crop in poundsfor each valley tributary segment.

TABLE A-5-32

Habitat Units and Total Standing Crop

for Valley Tributaries

	HABITAT UNITS	STANDING CROP (lbs)
LITTLE COTTONWOOD	3,673	3,403
BIG COTTONWOOD	2,803	2,606
MILL CREEK	1,822	1,686
TOTAL	8,298	7,695

Values for standing crop in pounds are converted to predicted initial angler use using the following computation:

(X lb/yr)(fish/0.33 lb)(2hr/fish)(AD/2.6 hr)(0.76) = Y AD/yr

in which:

Xlb/yr	=	The total biomass of native or hatchery trout stocked or residing in the subject reach each year;
0.33 lb/fish	=	the mean weight of a native or hatchery trout at the time of capture;
2 hr/fish	=	The mean catch rate in 1982;
2.6 hr/AD	=	the mean length of 1 angler-day;
0.76	=	the proportion of the annual stocking quota harvested by anglers the same year; and
Y AD/yr	=	the predicted initial angler use for native hatchery trout.

Table A-5-3 summarizes angler days per year for each creek segment.

The values for mean weight of creeled trout, proportion of the annual standing crop captured per year, mean catch rate, and mean angler-day length are well established from recent angler surveys in the Wasatch Front conducted by UDWR. Angler days per year are multiplied by mean daily expenditures and net worth to determine mean annual gross present worth of existig predicted standing crop per creek, displayed in Table A-5-4.

Using mean length of angler day (4.5 hours) computed after Hunt (6.33) and Geer (2.6), total angler days per year available are shown in Table A-5-5. Revised present worth (subtracting expenditures) using only net daily values are shown in Table A-5-6.

TABLE A-5-3

Predicted Angler Days Per Year

for Valley Tributaries

	lb/yr.	x.331b/fish	x2hr/fish	x2.6hr/ad	x.76	AD/yr
LITTLE COTTONWOOD	3,403	1,122.99	2,245.9	5,839.5	4,438	4,438
BIG COTTONWOOD	2,606	859.9	1,719.9	4,471.9	3,399	3,399
MILL CREEK	1,686	556.3	2,225.5	5,766.3	2,199	2,199

TABLE A-5-4

Predicted Mean Annual Present

Worth of Trout Fisheries For Valley Tributaries

	MEAN DAILY		MEAN ANNUAL
	EXPENDITURES @	NET WORTH A	TOTAL
	$ 31.26	$12.33	$43.59
LITTLE COTTONWOOD	$138,732	$ 54,721	$193,453
BIG COTTONWOOD	$106,253	$ 41,910	$148,163
MILL CREEK	$ 68,741	$ 27,114	$ 95,855.
TOTALS	$313,726	$123,745	$437,471

TABLE A-5-5

Revised Predicted Angler Days Per Year

Based on Mean Length/Day After Geer & Hunt

	lbs/yr	.331b/fish	2hr/fish	4.5hr/AD	.76	AD/yr
LITTLE COTTONWOOD	3,403	1,122.9	2,245.9	10,106.9		7,681
BIG COTTONWOOD	2,606	859.9	1,719.9	7,739.8		5,882
MILL CREEK	1,686	556.3	1,112.7	5,007.4		3,806

TABLE A-5-6

Revised Predicted Present Worth

(Using Revised Angler Days x Net Worth)

	AD/YR	Net Worth/Day	Present Worth Mean Annual Worth
LITTLE COTTONWOOD	7,681	$ 12.33	$ 94,707
BIG COTTONWOOD	5,882	$ 12.33	$ 72,525
MILL CREEK	3,806	$ 12.33	$ 46,928
TOTAL	17,369	$ 12.33	$214,160

Projected standing crop, which may result in future flood control improvements to valley creeks, were made through assuming increases in cover, decreases in eroding banks, and increases in substrate (sub-aquatic vegetation). For Big and Little Cottonwood Creek upper reaches, assumptions were made for maintenance of minimum instream flows. Binns & Eisermann Model results in standing crop are shown in Table A-5-7.

Angler days per year are projected in Table A-5-8. Mean length per fishing day (4.5 hours) was used in place of Geer's assumption of 2.6 hours.

Projected Mean Annual Present Worth is displayed in Table A-5-9. Estimated net worth (1980 dollars) of $12.33 per day is increased at the rate of 50% annually to arrive at 1990 and 2000 net worth values.

Present worth (net worth) does not include investment multipliers.

TABLE A-5-7

Standing Crop Projections After

Binns & Eiserman: 1990 and 2000

	STANDING CROP (lbs/YR)	
	1990	2000
LITTLE COTTONWOOD	6,435	6,686
BIG COTTONWOOD	7,127	7,734
MILL CREEK	2,154	2,181
TOTALS	15,716	16,601

TABLE A-5-8

Projected Angler Days Per Year Based on

Mean Length/Day After Geer & Hunt

	LBS/YR		ANGLER DAYS/YR	
	1990	2000	1990	2000
LITTLE COTTONWOOD	6,435	6,686	14,525	15,092
BIG COTTONWOOD	7,127	7,734	16,087	17,457
MILL CREEK	2,154	2,181	4,862	4,923
TOTALS	15,716	16,601	35,474	37,472

TABLE A-5-9

Predicted Present Worth: 1990/2000

Using Revised Angler Days x Net Worth

(Adjusted 5% Annual Inflation)

	AD/YR		NET WORTH $12.33 x .05%		PROJECTED MEAN Annual Present Worth	
	1990	2000	1990	2000	1990	2000
LITTLE COTTONWOOD	14,525	15,092	20.10	32.75	$291,953	$ 494,263
BIG COTTONWOOD	16,087	17,457	20.10	32.75	$323,349	$ 571,717
MILL CREEK	4,862	4,923	20.10	32.75	$ 97,726	$ 161,228
TOTAL	35,474	37,472	20.10	32.75	$713,028	$1,227,208

II. ADJUSTED FISHERY BENEFIT CALCULATIONS

Fishing Benefit calculations are based on two sources, Hunt et al, and Geer, (UDWR). Only adjacent population to valley creeks are used for projection purposes, which will yield grossly conservative participation rates. Jordan River Parkway data indicate market expansion for certain activities outside of adjacent market boundaries.

Local fishing participation is generated by dividing activity occasions estimated by Hunt by total population. Result is occasions per persons. Time spent in occasions are derived from total hours divided by total populations (A,B,C,D).

Activity occasions for local sub-basin population adjacent to each creek (primary market) are adjusted by a rate of .15 and multiplied by average activity occasions per person, and average hours per occasion. This product is the likely total activity hours likely in each sub-basin comprising the primary market (E).

The ratio of activity occasions to angler days possible is the probable percentage of existing use (F).

I. Local Participation

A. Fishing Participation:[1] MCD 3 (S.L. & Tooele)

1. Activity occasions - 1,329,400
2. Total hours - 8,417,200
3. Av.hours/occasion - 6.3
4. % Act occasions in MC3 - 15%

B. Population:[2] MCD 3

1. S.L. 1980: - 585,000
2. Tooele 1980: - 27,700
3. Total - 612,700

C. 1. $\frac{A1}{B3}$ = 2.17 occasions per person

2. $\frac{A2}{B3}$ = 13.74 hours per person

$\frac{2}{1}$ = 6.33 HRS/occasion

D. Population:[3] Tributary Sub-Basins

		Total valley sub-basin:	Adjacent to creek:
1.	MILL CREEK	- a. 57,679	b. 1,031
2.	BIG COTTONWOOD	- a. 38,471	b. 2,992
3.	LITTLE COTTONWOOD	- a. 88,592	b. 1,386

[1] Hunt, USU

[2] State Planning, Utah 2000

[3] Econ/Demo Futures

E. Activity occasions

Population Adjacent to creek:

MC - 1031 x .15*	= 156	Adjusted Act. occ.
BC - 2992 x .15	= 449	
LC - 1386 x .15	= 208	
MC - x 2.17**	= 339	Total activity occasions
BC - x 2.17	= 974	
LC - x 2.17	= 451	
MC - x 4.5***	= 1526	Total activity hours/days Likely in 3 sub-basins
BC - x 4.5	= 4383	
LC - x 4.5	= 2030	

* % Activity occasions in MC3 - Fishing[1]

** Average fishing occasions per person[1]

*** Mean hours per activity occasion [1]

(Geer = 2.6; Hunt j= 6.3; mean = 4.5)

This factor constitutes total activity days

F. Total angler days available

Based on present stream conditions:

Rate of productivity:		% Utilized:
LC - 4438	4438 / 7681	58%
BC - 3399 (3400)	3400 / 5882	58%
MC - 2199 (2200)	2200 / 3806	58%

Based on ratios of expected streamside participation (Angler Days Available) to Predicted Angler Days Per Year (Based on Present Productivity), 58% of stream productivity will be utilized by local activity.

Appendix 5.
Best Management Practices
Adopted by the American Fisheries Society

FLOOD CONTROL (NONSTRUCTURAL)

Basic non-structural floodplain management strategies for preventing loss of natural floodplain values and reducing the need for costly structural flood control measures are: Avoid and/or minimize actions that affect adversely the floodplain, restoration of previously degraded floodplains to serve their natural function, and preservation of those floodplains whose natural functions are relatively undisturbed (Water Resource Council, 1979).

Floodplain Regulations

By providing direction to growth and change, regulations are particularly well suited to preventing unwise floodplain occupancy.

a. Regulations must be equitably applied and should permit reasonable use of the land.

b. Non-conforming uses can be handled by recognition in an ordinance, by amortization provisions that lead to removal over a predetermined period, or by purchase.

Land Treatment Measures

Land treatment measures modify floods by temporarily storing runoff and gradually releasing it at a rate that downstream channels can accommodate. These measures include vegetative cover, runoff interceptors, diversions, small detention and erosion control structures, terraces, and street-side swales.

a. These measures are effective in headwater areas and can help ameliorate flooding in larger watersheds.

b. These measures are very important in the control of non-point sources of water pollutions.

Floodproofing

Floodproofing involves structural modifications of existing floodplain structures to reduce flood damages and the need for flood control structures (as dams, levees, dikes).

a. Structural modifications can include elevating buildings, reinforcing foundations, installing small protective dikes and bulkheads, and anchoring building to resist flotation and lateral.

b. Floodproofing may, however, undercut attempts to preserve natural floodplain values and can encourage a false sense of technological protection by floodplain owners (New England River Basin Commission, 1976).

Acquisition and Relocation of Structures

Acquisition and purchase of land rights and open space easements lessen the potential for flood losses and their consequences.

a. Land can be purchased directly, or land control can be purchased through easement or development rights in order to preclude future uses incompatible with floodplain management programs and to provide open space.

b. Disaster assistance, urban redevelopment, as well as flood insurance programs should also be used to encourage relocation of structures and facilities away from floodplain areas.

FLOOD CONTROL (STRUCTURAL)

Structural means of flood control (dams, dikes, levees, floodwalls, channel alterations and high flow diversions) should be a last resort and used only when it is clearly demonstrated in the public interest to protect human life, health, safety, or welfare. In addition, streams should not be modified to provide for farming of lands that are subject to frequent flooding.

The following guidelines help reduce impacts to aquatic and riparian habitats resulting from structural flood control projects. (Recognize that any alteration of the stream channel or water regime has traumatic consequences upon floodplain ecosystems.)

High Flow Floodways

Where structural means of flood control is the only alternative, first consideration should be given to the following:

a. Implementation of high-flow floodways, through non-riparian vegetation, that would bypass only the highest floodflows.

b. Floodway entrances should be designed to maintain normal and minimum flows in the natural channel.

Levees

The following structures, if properly planned, can preserve natural floodplain values and provide flood protection at the same time.

a. Levees should be placed beyond the outer perimeter of the riparian zone and constructed in a manner not to impede ingress and egress of water to wetlands.

b. Flushing flows should also be provided to obviate channel aggradition and encroachment of vegetation into the low flow channel and also to help maintain a diverse riparian plant community throughout the floodplain.

Clearing and Snagging

This practice is one of the least damaging techniques for restoring original stream flow capacity. The Federal Fish and Wildlife Service, Soil Conservation Service, and various state agencies have stablished management guidlines to mitigate impacts to acquatic and riparian habitats due to stream alternation. These guidelines include:

a. Selective removal of log jams.

b. Removal of hazardous trees (trees leaning over the channel at angle greater than 30 degrees).

c. Removal of major debris accumulations that are obstructing flows to a degree that results in significant ponding or sediment deposition.

d. Removal of stream blockages, first consideration should be given to the use of hand operated equipment.

e. Water-based equipment should also be used if appropriate.

f. In all cases, use the smallest feasible equipment that minimizes disturbances to floodplain vegetation(McConnell, 1980).

Channel Alteration

Stream alteration should be limited to restoration of original stream flow capacity, in a manner which preserves the existing channel alignment.

a. Stream alteration should be restricted to channel deepening, but not to widening or straightening. Maintaining the original alignment and width helps to sustain the self-cleaning action of the stream, while at the same time preserving important habitat for fish and wildlife.

b. Access routes for equipment should be selected to minimize disturbance to riparian vegetation and should be limited to one side of the stream.

c. Excavated materials should be removed from the floodplain..

d. Spoil should be placed on the highest practical elevation and no material should be placed in wetlands if floodplain disposal is the only feasible alternative.

e. Spoil piles should not exceed 50 feet in length or width and a gap of equal or greater length should be left between adjacent spoil piles.

f. The placement of soil around the bases of mature trees should also be avoided.

g. All disturbed areas should be reseeded or replanted with plant species which will stabilize soils and benefit wildlife.

Dams and Reservoirs

Reservoir storage of floodwater or waters for agricultural, industrial, and municipal use can have a broad range of effects on riparian and aquatic ecosystems. In addition to the large areas of land they inundate, reservoirs also modify downstream behavior and habitat. In most cases, dams seriously change streamflow regime by reducing the depth and duration of downstream flooding. Overbank flooding with sediment and nutrient deposition are essential for establishment, maintenance, and regeneration of riparian plant species (WDAFS, 1980). Instream flows also may be reduced below those required to maintain riparian and aquatic habitats. Sediment-free water released from these structures is highly erosive and can cause bank erosion and channel degradation (downcutting) as it acquires a new load of sediment. This, plus impedance of groundwater flows by dam foundations, can result in lowering of the water table and may lead to the replacement of riparian plant species by terrestrial species (McNatt, 1980).

a. Stage or incremental filling is a management option which can be used when the immediate need for impounded water is less than available storage or initial demands. This practice delays the ultimate loss of stream and riparian habitat, resulting in extended public and wildlife use.

1. The reservoir sport fishery production will be sustained at a high level over a greater period of time with a gradual inundation of vegetation and nutrients.

b. The purpose of multi-level intakes is to permit selection of discharge water from various reservoir strata.

1. Multi-level intakes aid in the control of downstream water quality such as temperature, dissolved gases, and dissolved solids.

2. Multi-level intakes also can be designed to release sediment and nutrient-enriched water for the preservation and enhancement of downstream riparian and wetland habitats. This, however, should be done with extreme care in order to prevent damage to downstream fishery due to siltation of gravel beds and high stream turbidition.

c. Reregulating dams, where they are feasible, allow upstream hydroelectric dams to achieve full power production while downstream riparian and aquatic habitats benefit from stabilized flows. The cost of these structures can be a limiting factor as can the location of sites that will not impact important fish and wildlife habitat.

d. Stilling basins are in accepted feature for dissipating high energy forces of water released from dams. When properly designed stilling basins:

1. Are an effective means of preventing downstream scouring and erosion, thereby reducing turbidity and silting of spawning gravel.

2. Reduce scouring thus preventing channel degradation and consequent dewatering of downstream water tables that maintain riparian

vegetation.

Instream Flow Regulation

Instream flow regulation is probably the most important prerequisite for the maintenance and preservation of aquatic and riparian habitats. Maintenance flows are designed to maintain a satisfactory combination of spawning, resting, and food-production areas for fish. A number of methods have been developed to determine instream flow requirements for fish and wildlife. For the most up-to-date information on instream flow methodologies contact the Fish and Wildlife Service, Western Energy and Land Use Team, Cooperative Instream Flow Service Group, Fort Collins, Colorado. Other agencies such as the USDA Forest Service Intermountain and Rocky Mountain Regions, and the United States Department of the Interior, Bureau of Reclamation have adopted specific methodologies to evaluate instream flow conditions to aquatic habitat and hydrological parameters. Although frequently receiving less emphasis, instream flows have a significant effect on groundwater recharge and the riparian plant comunity.

Western States water laws and administratie regulations frequently place severe limitations on water allocations for acquatic and wildlife resouces. In many states, instream flow reservations for maintenance of fish and wildlife values cannot be appropriated or reserved. Another major constraint on reserving instream flows for aquatic and riparian preservation is the resulting loss of reservoir storage capacity and yield for irrigation, power production, and water supply. An excellent summary of strategies for achieving minimum instream flows has been developed by the Instream Flow Group (U.S. Fish & Wildlife).

ROAD CONSTRUCTION

Roads constructed in or adjacent to riparian zones have high potential for altering the stream channel and disturbing the vegetative complex resulting in long-term negative effects on fish and wildlife populations. The detrimental effects of roads and road costruction area; removal of riparian vegetation, increased sediment load to streams and alteration of the physical stream channel.

Destruction of riparian vegetation eliminates one of the most diverse and productive wildliffe habitats known. Vegetation loss on streambanks often results in bank erosion and subsequent channel widening, reduces stream shading which in turn increases stream temperatures, and reduces insect and leaf litter drop, the primary food base for aquatic life.

Sediment load will depress stream productivity by eliminating micro-habitat for fish and aquatic invertebrates, preventing spawning of adult fish by covering and embedding stream gravels, and smothering developing eggs and juveniles.

The alternation of the natural stream channel canals results in the loss of pools, meanders, undercut banks and ripples that provide food, cover, and shelter for fish and other aquatic life.

Roads and road construction impacts on riparian areas can be avoided through careful preconstruction planning, special precautions practiced during road costruction, and an adhered-to road maintenance program.

The folowing is a list of BMP's designed to proted the riparian zone values during; road planning, construction, and maintenance. BMP's have been extracted from a variety of technical reports listed in the reference section.

Road Planning and Design

The key to reducing negative environmental effects on the riparian zone from road construction activities is long-range planning on the total watershed by an interdisciplinary team of engineers, fish and wildlife biologists, hydroloffists, geologists, and soil scientists. Well designed road plans can also reduce total road mileage and costruction costs. Where possible, locate roads on natural benches, ridges, flat slopes near ridge or valley bottoms, and away from stream channels.

Stream crossing approaches should avoid steep pitches and grades in order to prevent sedimentation of stream habitat.

Stream crossing sites should be selected with particular care, ensuring that bridge structures will have as little influence as possible on the natural stream flow. In streams inhabited by fish, all structures need to provide for fish passage. In addition, structure containing natural stream bottoms are preferred over culverts.

Culverts and other drainage structures should accommodate at least a 25-year flood frequency, and preferably, a 50-year flood frequency for large structures.

Downspouts on drainage structures should have appropriate sized energy dssipators, and road fills adjacent to streams should have sufficient fill protection (rip-rap, retaining walls, etc.) to prevent stream undercutting.

Reduce road dimensions to that which will adequately fulfill anticipated needs and avoid large road cuts and fills.

Roads should be outsloped and designed with rolling grades to reduce surface water velocities and culvert requirements.

Roads constructed in valley bottoms should maintain a natural vegetation buffer or filter strip between road and stream.

Permanent roads should be paved or rocked; temporary roads following completed use or prior to wet weather should be cross-drained, crossings pulled, and natural drains reestablished and revegetated.

Avoid channel changes or disturbance of stream channels and minimize impacts to riparian vegetation.

Road Construction

Road construction should be planned so sediment will not reach streams.

Waste material should be end-hauled and compacted into a stable fill at predesignated locations and not sidecasted in areas where they may enter a stream.

Minimize excavation with a balanced earth work design; the area of cut slopes should be minimized in order to reduce erosion and slop instability.

Construction should take place only during the dry season.

Large cut and fill slopes should be stabilized and revegetated before the next wet season.

Exposed slopes should be protected with rip-rap, paving or vegetation to reduce erosion and stream turbidity.

Sediment basins should be constructed to remove silt from run-off before it reaches aquatic areas.

Drainage ditches should be of adequate depth and size to carry heavy runoff in order to prevent road sloughing.

Bridges and culverts should be installed in a way that prevents stream sedimentation and channel changes.

Culverts need to be properly installed to minimize downstream impacts and provide for fish migration (where a viable fishery exists). The following general considerations for culvert installation were taken from Yee and Roelofs (1980):

a. A single large culvert is better than several small ones because it is less likely to become plugged and carries water at much lower velocity.

b. The diameter of culverts should be adequate to pass maximum flows. Washing out of culverts and their earth fills may result in road damage and subsequent downstream sedimentation.

c. Where a stream fishery exists, the entire culvert length should be placed slightly below the normal stream grade to reduce fish passage problems and prevent a lowered streambed. Installation gradient should be at or near zero percent.

d. In areas where fish passage might be difficult, install open-arch culverts or bridges instead of round culverts.

e. Avoid creating a culvert outfall barrier where the outlet of a culvert is so far above the tailwater that fish cannot enter the pipe. It may be necessary to provide one or a series of low-head dams, by using gabions or logs, to provide access to the culverts.

f. Culverts used for drainage down steep slopes should be extended completely down the slope with the exit portal adjacent to and at the same level as the receiving stream. Exit portals placed above the stream may result in bank erosion and instability and subsequent sediment recruitment (BLM 1980).

Precautions should be taken to prevent chemical toxicants (gasoline, lubricants, heating oils, and pesticides) from entering aquatic areas during construction operations.

Unless no other source is available, gravel should not be taken from streambeds. At no time should gravel washing operations be conducted in or adjacent to aquatic areas.

In excavating bridge footings and abuttments, limit machine work as much as possible to avoid disturbing the stream.

Stream crossings approaches should be as near a right angle to the stream as possible to minimize bank disturbance.

Road Maintenance

Road maintenance is an essential prerequisite for safeguarding aquatic and riparian areas from excessive siltation due to road failures and drainage problems.

Prior to wet weather, roads should be graded so they will drain properly and not become waterways.

Provide frequernt cross-drains on all temporary roads at the end of the use season to prevent erosion of road and fill.

After the first rain in the fall, check roads to see where drainage problems have developed and take corrective action.

During heavy run-off periods, road surfaces should be checked to see that drainage systems are functioning.

Roads should be bladed and ditched before or after the first rain so that there is no interruption to drainage from the center of road to the ditches.

Debris accumulations at culvert inlets should be cleaned out annually or as necessary.

Oil or other dust abatement additives should be dispensed in such a manner that they do not enter streams.

Culverts should be inspected annually to assure that they are functioning satisfactorily for fish passage.

SOURCE CONTROL OF SOIL EROSION

a. The emphasis on soil erosion control should focus on prevention of problems at the source.

b. Special attention should be given to restoration of formerly productive eroded lands, especially riparian areas. The following soil conservation practices are from the U.S. Soil Conservation Service (USSCS 1979). These practices are all essentially the same ide (planting or maintaining riparian vegetaion) approached from different solution viewpoints.

1. Vegetative Stream/Lake Buffer Strip

Establish new or use existing adapted grasses, legumes, shrubs, and trees on areas adjacent to streams or lakes, managing these species for adequate vegetative cover. The purpose of the buffer strip is to remove suspended solids carried by water flowing overland toward the stream or lake, improve water quality, provide streambank stabilization, provide wildlife habitat, protect riparian vegetation, and improve natural; beauty.

These practices are applicable to irrigated lands adjacent to natural or artificial waterwys. Benefits to fishery resources include temperature regulation, sediment filtration, and allochthonous energy input.

2. Streambank Protection

Establish adapted trees and shrubs along streambanks, lakes and excavated channels to protect them against scour and erosion. The purpse of steambank protection is to: 1) prevent erosion loss of land, or damage to utilities, roads, buildings, or other facilities adjacenty to the eroding area, 2) maintain the capacity of a channel,

3) control channel meander which would adversely affect downstream facilities, 4) reduce sediment loads causing damages and pollution, or to improve areas for recreational use or as a habitat for fish and wildlife.

This practice emphasizes the ability of the root structures of riparian vegetation to maintain streambank stability, as a remedy to streambank erosion problems.

3. Tree Planting

Establish adapted trees by planting seedlings or cuttings on riparian areas without trees or on land with a partial stand of trees. The purpose of tree planting is to conserve soil and moisture, beautify an area, protect a watershed, maintain water quality or produce wood crops.

4. Critical Area Planting

Establish vegetation such a trees, shrubs, vines, grasses, or legumes on severely eroding areas. The purpose of critical area planting is to stabilize the soil, reduce damage from sediment and runoff to downstream areas, improve wildlife habitat, and enhance natural beauty (USSCS 1979).

URBANIZATION

The rapid loss of riparian habitats to urban growth demonstrates an urgent need for better consideration of this resource in urban planning. The following are several approaches which could be used as BMP's to protect and enhance riparian habitat. A united effort by concerned citizens, developers, and enlightened leadership of elected officials will be necessary to implement these approaches.

Land Use Plannig

a. Establish land use planning at the City, County, and State levels to encourage land uses that are compatible with the preservation of riparian aras for the best interest of the general public, i.e., natural floodways, recreation, open space esements, and wildlife sanctuaries.

Nonstructural Flood Control

a. Encourage local, State, and Federl agencies to utilize or advocate the use of nonstructural instead of structural alternatives of flood control.

b. Adopt subdivision drainage standards that would require developers to implement controls to reduce storm water runoff to a level no greater than the preconstruction rate, thereby eliminating the need for costly flood control projects at a later date and preventing the destruction of valuable riparian habitat.

Watershed Protection

a. Preserve and protect natural water courses and associated riparian vegetation, thereby ensuring the preservation of natural resource values they provide, i.e., flood control, pollution control, recreation, fish and wildlife habitat.

Building Encroachment

a. Prevent encroachment of buildings and landfills into the 100-year flood plain.

b. Encourage voluntary relocation of structures out of the 10-year flood plain.

Erosion Control

a. Implement measures to control erosion and sedimentation from construction sites and exposed areas. The following list is a summary of practices recommended by the U.S. Department of Agriculture, Soil Conservation Service:

1. Disturb only the areas needed for construction.
2. Remove only trees, shrubs, and grasses that must be removed for construction.
3. The development plan should be designed to conform to the topography and soils so as to minimize erosion hazards.
4. Prior to construction, install sediment basins and diversion dikes to trap and prevent sediment from entering area streams.
5. During costruction, temporarily stabilize disturbed areas and sediment-control devices by seeding and mulching. As construction is completed, permanently stabilize disturbed areas with vegetation and, if necessary, install structural measures.
6. After construction, install permanent detention reservoirs so that peak runoff from the development is no greater than that before the development was established.

<u>Performance Standards</u>

a. Implement land use performance standards to protect important riparian and natural resources from unwise development.

<u>Tax Relief</u>

a. Change tax laws to relieve riparian landowners from heavy tax burdens, thereby providing financial incentives to protect these important resources. Any tax relief law should have features to recover back taxes from landowners who develop their lands. The rollback period should be at least 10 years, preferably the entire period during which tax savings were enjoyed.

Conservation Easements

a. Purchase conservation easements frm riparian landowners to assure a tract of land remains in its natural state. Ths mechanism would still allow the landowner to use land for prescribed purposes such as grazing, woodcutting, and agriculture.

Enrollment in Federal Programs

a. Encourage private landowners to participate in the Water Bank Program administered by the USDA Agricultural Stabilization and Conservation Service. This program authorizes the Department of Agriculture to enter into a 10-year lease agreement with landowners to preserve wetland habitat. Recently, the program has been expanded to include riparian and coastal wetlands that provide flood, sediment and pollution control, groundwater rechange, and important wildlife habitat.

Conservation Ethics

a. A conscientious conservation effort by developers can help to retain much of an area's natural values, as well as making the areas a more desirable place to live.

b. Elements that could be incorporated into the design of such environmentally-oriented new subdivision are open space corridors, restriction of development in flood plains, and control of runoff by retention ponds.

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