City of Austin

Summary Report

Cumulative Impacts of Development on Water Quality and Endangered Species in the Bull and West Bull Creek Watersheds

Prepared by

City of Austin
Environmental and Conservation Services Department
Environmental Resources Management Division

Bull Creek Watershed Study

November, 1993

BULL CREEK WATERSHED STUDY

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BULL CREEK WATERSHED STUDY

I. INTRODUCTION

On July 8, 1993, the Austin City Council addressed the issue of development in the Bull Creek and West Bull Creek Watersheds, particularly as it impacts traffic conditions, water quality, and endangered species habitat. An ordinance was passed by the Council that day which:

1) Requested that the City Manager prepare within 120 days a regional development study of the area along RM 2222 and the area within the Bull Creek and West Bull Creek Watersheds, and
2) Established a development moratorium in the study watersheds until November 7, 1993, when the report was to be completed, and further action considered, based on the findings.

This document contains information assembled by the Environmental and Conservation Services Department (ECSD) to satisfy a request in the ordinance that the development study include an examination and evaluation of the relative impacts of cumulative land uses on water quality and endangered species.

The water quality of the Bull Creek watershed was assessed using three sources of water quality information. They are:

1) Available historical data from the COA/USGS cooperative monitoring program and Austin/Travis County Health Department monitoring from sites at or near the most downstream bridge of Loop 360 as it crosses Bull Creek.
2) An intensive water quality survey of Bull Creek watercourses conducted by ECSD staff during August and September, 1993;
3) A water quality survey of springs in the watershed conducted by ECSD staff during August and September, 1993.

Additionally, this report includes:

4) Pollutant loading estimates for existing and potential build-out scenarios,
5) A discussion of potential alternatives to mitigate water quality impacts to the study watersheds,
6) A description of public participation during the 120 day study period, and
7) A discussion of the impact of development in the Bull Creek watershed on endangered species.

The scope of the investigation of Bull Creek water quality was limited by the short length of the study. This report does not represent a fully detailed water quality investigation; therefore, results should be considered preliminary.

II. WATERSHED DESCRIPTION

A. General Geography

The watersheds of Bull and West Bull Creek are located in the northwest portion of the city of Austin and extend beyond the city limits into Travis county (Figure 1). The combined watershed covers 31.6 square miles. Upland elevations range from 1100 feet on the west side to 900 feet on the east and north sides. There is 530 feet of total elevation change from this point to Lake Austin, which ultimately receives the waters of Bull Creek. The main channel of Bull Creek is approximately 13 miles long, with a gradient of roughly 25 feet/mile. Typical relief from the uplands to the main channel of Bull Creek is about 200 feet in the upper creek reaches and greater in lower reaches. There are many areas of steeply sloping terrain in the watershed and many of the tributaries of Bull Creek run through small, steep canyons. Creek channels in the drainage basin are generally sinuous with some meandering near the mouth. Spicewood Springs Road parallels the main channel of Bull Creek through much of the upper watershed, and R.M. 2222 similarly runs along much of West Bull Creek.

B. Geological Setting

The Bull Creek watershed is located at the eastern edge of the Texas Hill Country and immediately west of the Balcones Fault Zone. The watershed is characterized by the flat Jollyville Plateau uplands dissected by numerous steep-sided canyons and tributaries, predominantly oriented to drain eastward.

The Edwards Limestone caps upland areas and is underlain by the Walnut Formation which forms the base of the Jollyville Plateau and uppermost slopes. The Glen Rose Formation underlies the Walnut and forms the canyon slopes and bottomlands. Quaternary sands and gravels occupy bottomlands adjacent to the main creek channel.

Numerous seeps and springs provide baseflow to Bull Creek, discharging from three discrete hydrogeologic systems - the Edwards-Walnut, the Glen Rose, and the Quaternary systems. There is no estimate of the relative contribution of each hydrogeologic system to the flow in Bull Creek. However, Edwards-Walnut springs are likely more critical to upper reaches, Glen Rose springs more important in middle and lower reaches, and Quaternary springs are only locally important. Flow in Bull Creek can be discontinuous following extended dry weather, particularly in upper reaches and tributaries.

The Edwards-Walnut systems characterize those springs discharging from massive limestone at the heads of creeks and tributaries. Recharge to these springs is generally only from direct infiltration of rain water on the upland plateau and the storm water runoff which infiltrates in the short swales and draws. Recharge and groundwater migration occur through karst features such as fractures, sinkholes, caves, and vuggy limestone - a recharge process which affords limited filtration of

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Creeks and Tributaries

Figure 1

Bull Creek Watersh

pollutants. Water quality of these springs is extremely sensitive to land use in their recharge areas because of the exceptionally high porosity of the underlying limestone in the area. Significant mixing of local groundwater with regional groundwater flow does not occur since the recharge areas are localized.

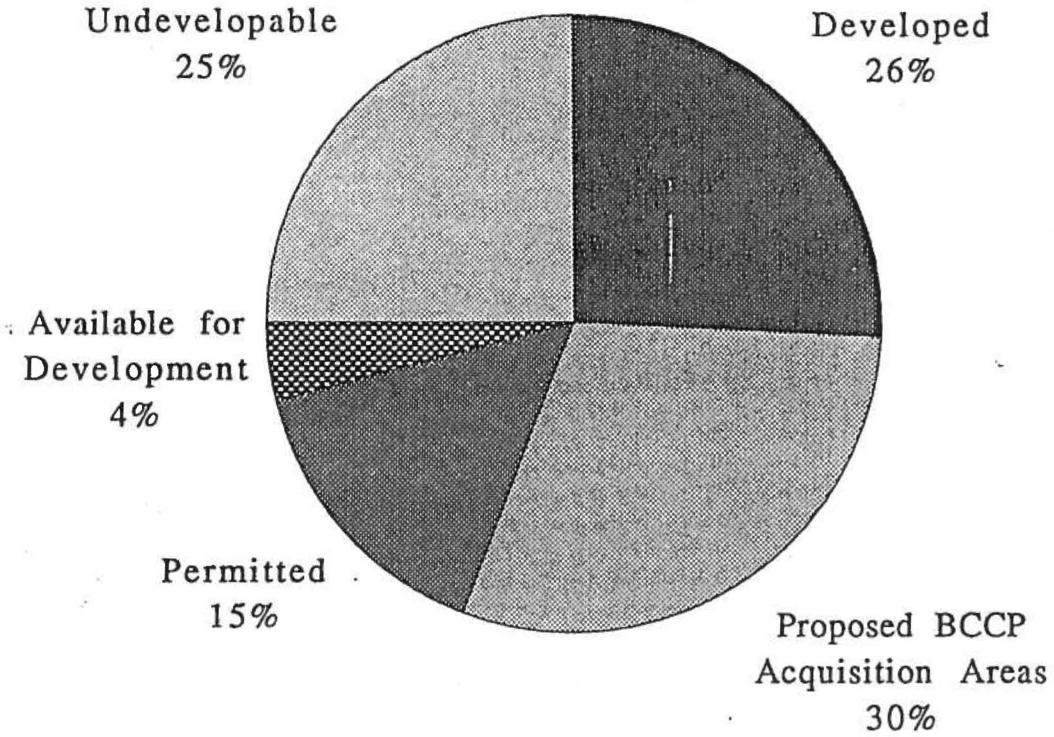
Glen Rose springs receive a combination of regional and local recharge; therefore, impacts of land use in the immediate vicinity on flow quality and quantity may be ameliorated to some degree. Recharge is thought to derive from the bordering Lake Travis and Buttercup Creek areas, from seepage from the overlying Edwards-Walnut system, and from direct infiltration. Soil depths are somewhat greater and infiltration capacity of the Glen Rose limestone is not as high as that in the Edwards limestone. The Glen Rose springs generally discharge along creek channels. Springs associated with the Quaternary hydrogeological system are emerging from shallow, perched aquifers in the alluvial and terrace deposits, usually adjacent to or near the mainstem of the creek.

C. Existing Development Conditions

Development of the Bull Creek watershed is a relatively recent phenomena. In 1970, less than 10% of the watershed had been developed or was under construction, less than half of present development levels. Figure 2 characterizes the entire Bull Creek watershed in terms of its current level of development. Assuming the successful implementation of the BCCP, fully 30% of the watershed will be preserved and unavailable for development. Twenty-six percent has already been developed and an additional fifteen percent more has already been permitted for future development. It is estimated that perhaps 25% of the watershed is undevelopable due to physical and environmental constraints such as steep slopes and floodplains. Therefore, only 4% of the watershed remains unpermitted and still available for development. Figure 3 is a breakdown of developable land categories only (that is, deleting the 26% currently developed and 25% undevelopable). This graphic shows clearly the significance of the proposed BCCP preserves relative to the future of water quality in Bull Creek.

Figure 2

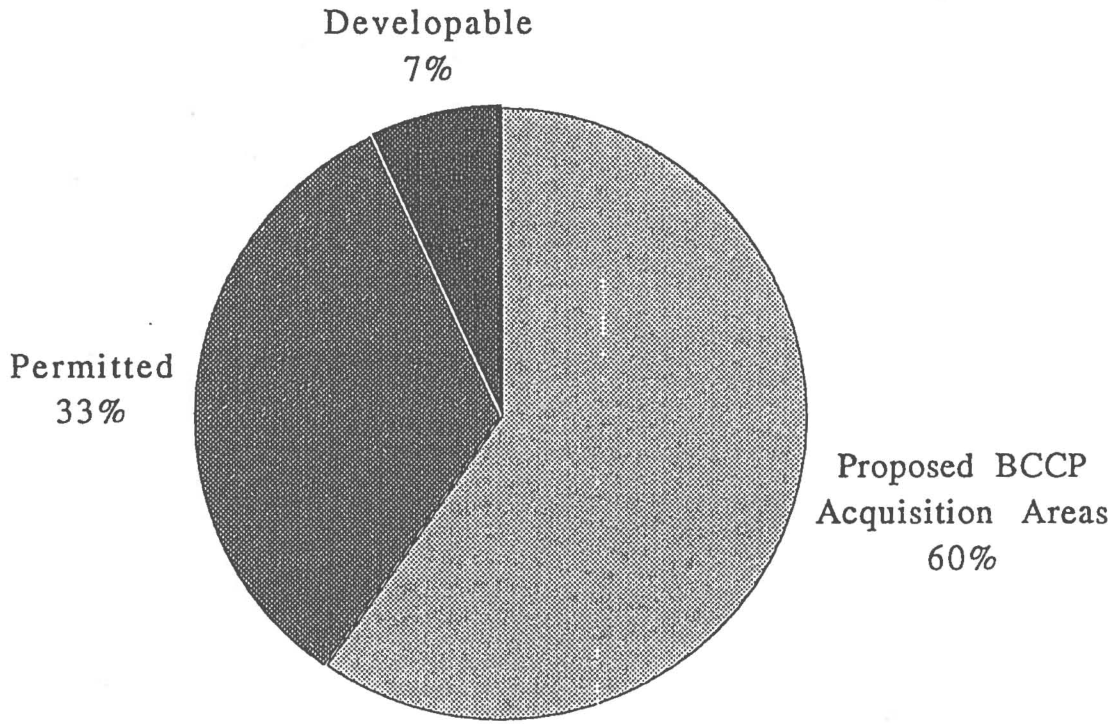
Development Categories within the Bull Creek Watershed



Derived from COA Planning Dept. data, 1993.

Figure 3

Developable Land Categories within the Bull Creek Watershed



Derived from COA, Planning Dept. data, 1993.

III. HISTORICAL USGS GAGE DATA TRENDS

A. Available Data Description

USGS maintains a flow and water quality gage on Bull Creek at Loop 360 located at the most downstream bridge and immediately upstream of Bull Creek Park. This station lies above the confluence with West Bull Creek and is therefore not representative of West Bull creek or the Lake Austin backwaters. This monitoring site is part of the City of Austin/USGS cooperative monitoring program and is partially funded by the City's Drainage Utility. The watershed area upstream of the gage is 13,209 acres. With existing development, the estimated impervious cover upstream of the gage is 15%. Baseflow and stormflow samples have been collected at this site since 1978.

Monitoring of this site includes continuous flow measurement along with periodic sampling of 25 water quality parameters including:

- Temperature
- dissolved oxygen (DO)
- total dissolved solids (TDS)
- ammonia
- total Kjeldahl nitrogen (TKN)
- total suspended solids (TSS)
- fecal streptococci
- hardness
- biochemical oxygen demand (BOD).
- total organic carbon (TOC)
- pH
- specific conductivity
- turbidity
- nitrate
- total phosphorus
- fecal coliform
- alkalinity
- lead
- zinc
- cadmium

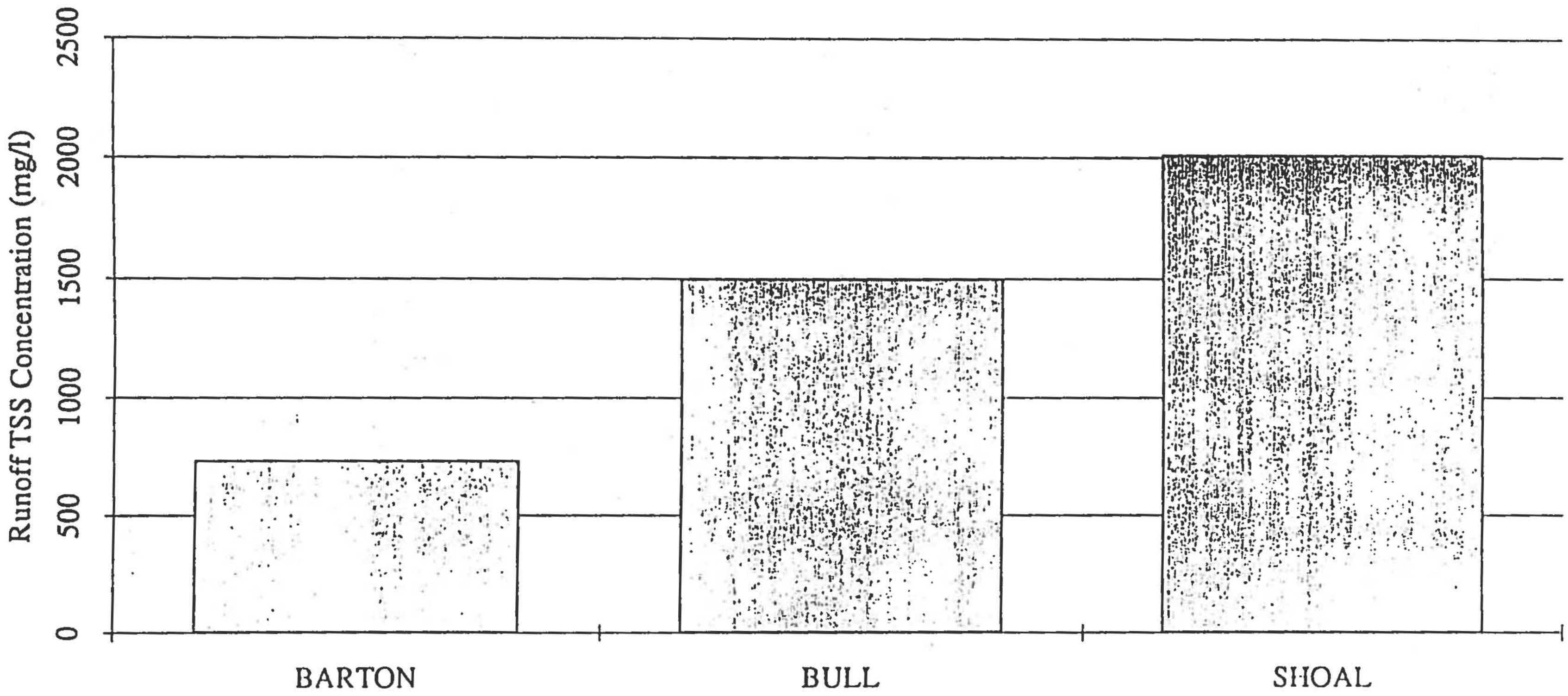
The cooperative sampling program with USGS was enhanced this year with funding from the Non-urban Watersheds Program. The enhancements affecting the Bull Creek station include more frequent baseflow and storm sampling along with an increase in the number of parameters analyzed; however, most of the new 1993 data was not available for use in this study.

B. Water Quality Trends in Historical USGS Data

General - No significant changes in quality over time can be detected for baseflow conditions in the data from the single USGS gage. This reflects the fact that despite localized heavy development, most of the Bull Creek watershed remains relatively undeveloped to date. There is not enough current data to evaluate transient changes in stormflow quality; however, using historical data for total suspended solids as an indicator, it appears that at least some aspects of stormflow quality for Bull Creek are generally not as good as Barton Creek but better than Shoal Creek (See Figure 4). Additionly, data from the last five years indicate that pollutant loads are increasing with the increased runoff from development.

Figure 4

Stormflow Total Suspended Solids for Selected Austin Area Creeks



Total Suspended Solids - TSS concentrations in the mainstem Bull Creek during storms are primarily related to channel erosion and are generally a function of flow rate. Since peak stormflow increases with impervious cover along with duration and frequency of high flows, TSS concentrations can significantly increase with development. Increased TSS concentrations, when combined with increased runoff volumes will result in a substantial increase in pollutant load of suspended solids, unless the peak flows are properly controlled using stormwater detention. Previous studies have found that instream nutrients also increase due to channel erosion.

Bacteria - The bacteriological data indicated that fecal coliform levels in baseflow were typically below 200 colonies per 100 ml; whereas, stormflow fecal coliform levels are over 200 colonies per 100 ml. Based on the observed ratios, the USGS data for fecal coliform and fecal streptococci generally indicate that the source of the bacteria is from animals and not from human wastewater.

Dissolved Solids - Generally the dissolved solids content for baseflow is within the range expected for Hill Country creeks. However, the average concentration of sulfates in Bull Creek under baseflow conditions slightly exceeds the State standard for sulfate in the Lake Austin segment of the Colorado River.

IV. FIELD WATER QUALITY INVESTIGATIONS

A. Surface Water Survey Description - Summer 1993

The intensive survey was conducted by collecting water quality samples during periods of baseflow and stormflow. Field stations were located on both developed and undeveloped tributaries of Bull Creek as well as from the mainstem channel. The baseflow survey was performed at 17 sites in Bull Creek and West Bull Creek on August 17, 1993 (See Figure 5 for individual locations). Eight sites on the mainstem of Bull Creek were selected to correspond with sites previously sampled by the Texas Department of Water Resources (now the Texas Natural Resources Conservation Commission) during a Spring 1982 intensive survey. Conditions in August of 1993 were very dry after 51 days without rain. Four sites surveyed in West Bull Creek had no flow.

Seventeen water quality sample parameters were analyzed for this survey and included the following:

Field Measurements -

- temperature
- dissolved oxygen(DO)
- total dissolved solid(TDS)
- pH
- specific conductivity
- turbidity

Lab Analyses -

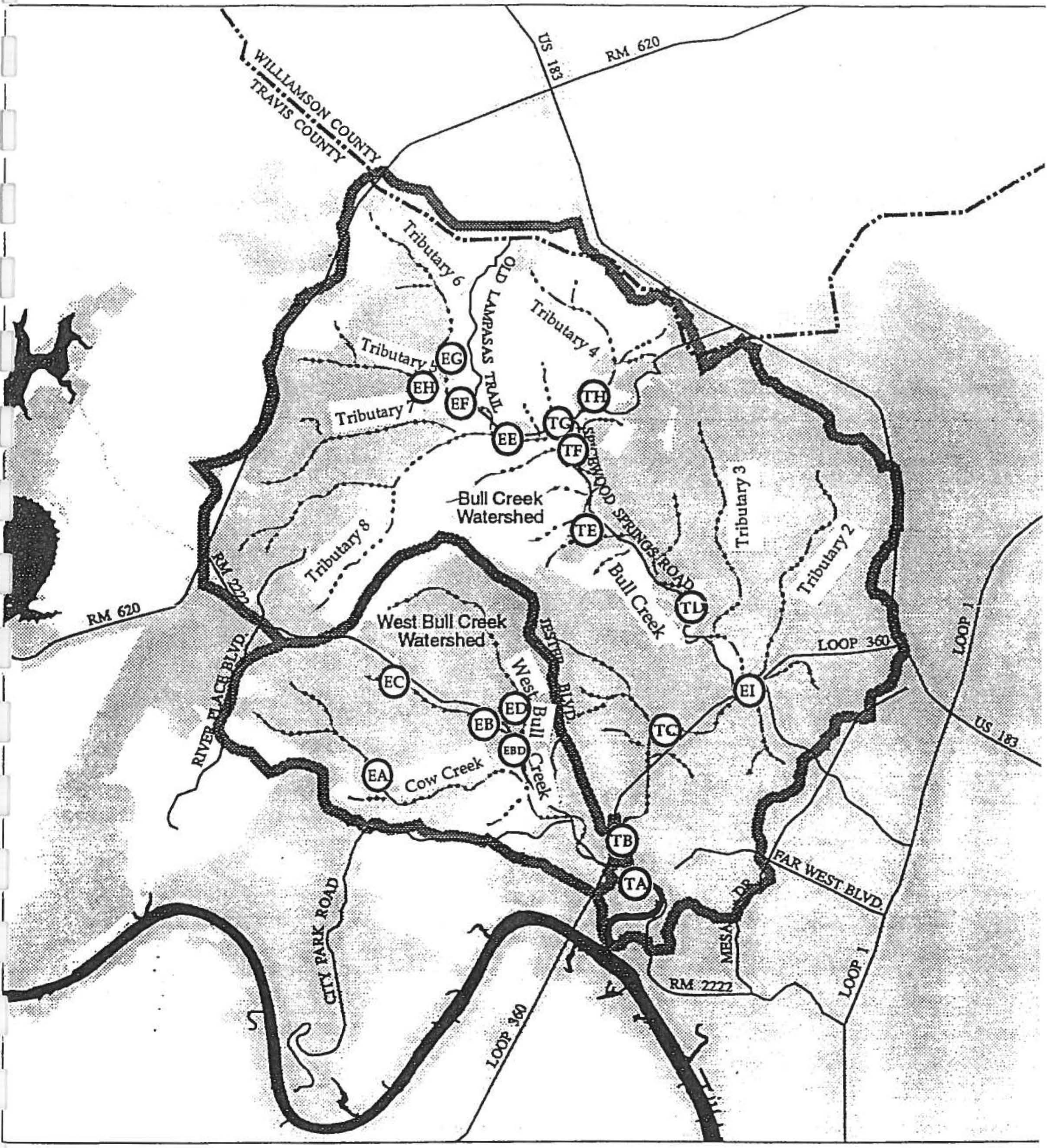
- ammonia
- total Kjeldahl nitrogen (TKN)
- total phosphorus
- volatile suspended solids
- chemical oxygen demand(COD)
- total organic carbon (TOC)
- nitrate
- orthophosphorus
- total suspended solids(TSS)
- alkalinity
- fecal coliform
- fecal streptococci

Additional analyses performed for the survey included:

1) sampling at the site (TH) just downstream of a wastewater lift station overflow on August 18 (one day after the baseflow survey), and
2) stormflow sampling at 5 sites (TB, EF, EG, EH, EJ) on September 3, 1993 after 0.31 inches of rain. Although single stormflow samples are typically of limited value in storm event monitoring, the data collected was used for comparative purposes.

B. Surface Water Survey Results

Overall Results- In general, the baseflow quality observed during the intensive survey was good. The baseflow results were similar to the State's 1982 intensive survey and the long-term monitoring data taken at the USGS Loop 360 gage. Generally, the baseflow quality of Bull Creek is also comparable to Barton Creek baseflow quality. This same relationship can also be seen in Figure 6, which shows



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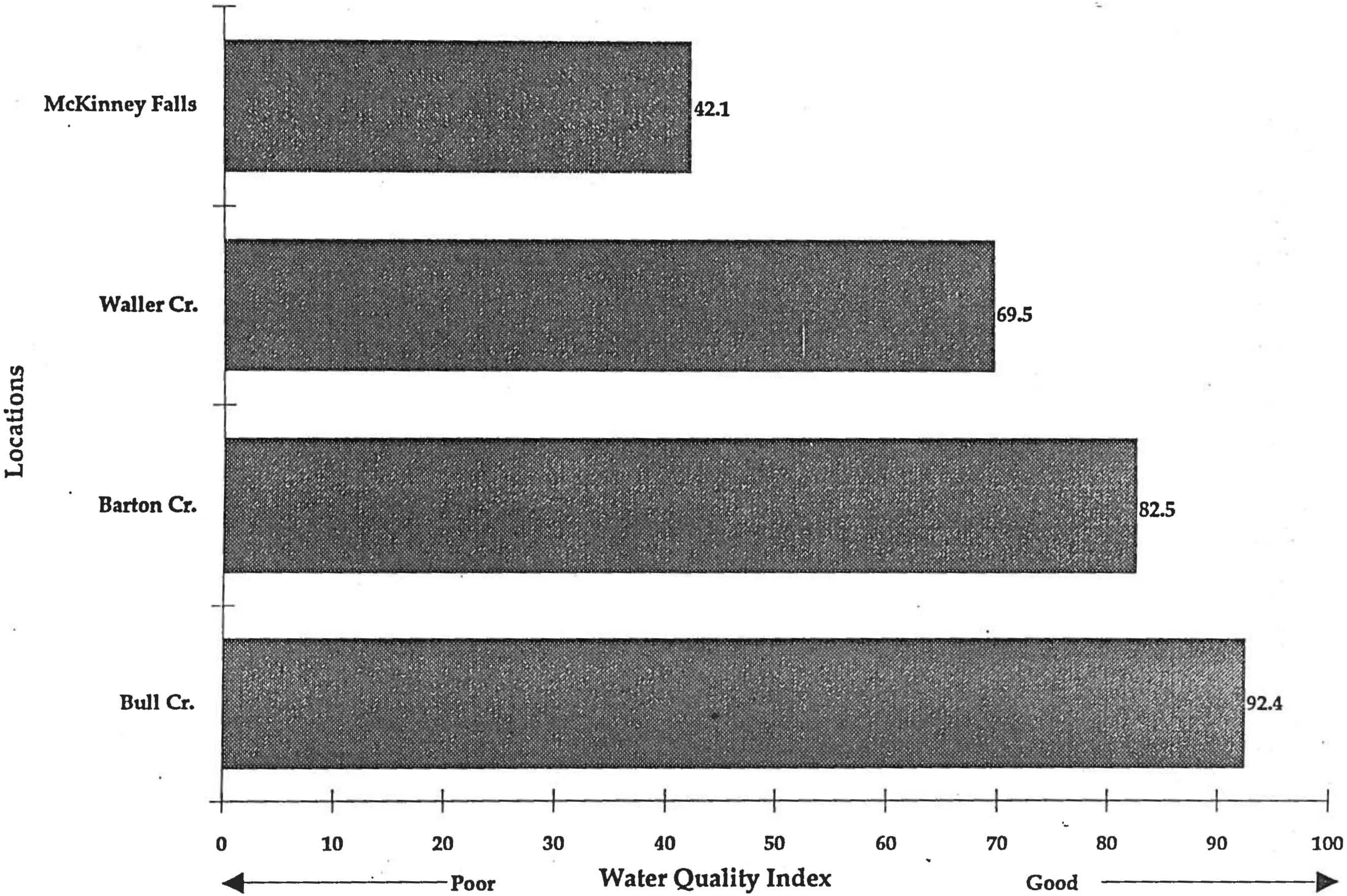
EA Sampling Site

Figure 5

Surface Water Sampling Sites

Figure 6

Water Quality Index - Bull Creek vs. Other Creeks



Source: ECSD water quality monitoring data, 1981-1993.

a Water Quality Index which can be used to give a generalized picture of relative water quality. This index was used as part of the Town Lake Study by ECSD, and is also used by the City's Citizen Monitoring Program. The index compares the levels of several pollutants and converts these data to a scale of 1 to 100, achieving an overall picture of observed water quality. Although there are some technical limitations to the accuracy of the Water Quality Index numbers shown in the graph, it generally shows that the baseflow quality is as good or better than Barton Creek, better than urban creeks (as represented by Waller Creek), and significantly better than Onion Creek at McKinney Falls. ECSD is in the process of refining the Water Quality Index, adding biological indicators to make it more useful for future long term water quality monitoring.

Developed vs Undeveloped Tributaries - The data appear to confirm results from other local and national studies that pollutant concentration from developed areas is higher than undeveloped areas. The survey results from side-by-side tributaries in the upper Bull Creek watershed (developed site EG and undeveloped site EH) indicate:

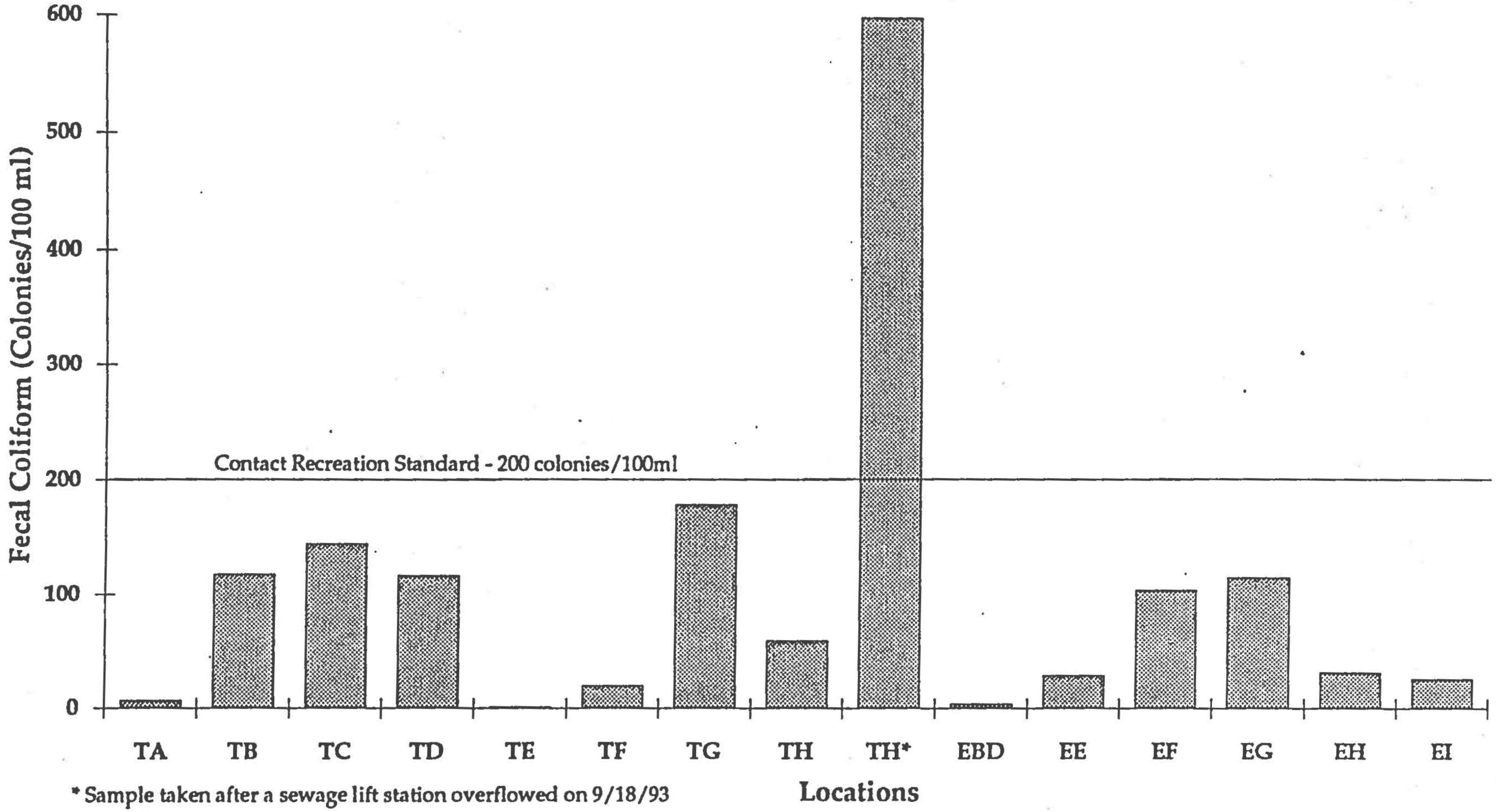
- Higher ambient concentrations in baseflow at the developed site for TDS, total nitrogen, total phosphorus, TSS, and bacteria; and
- Higher concentrations in flow after storms at the developed site for total nitrogen, total phosphorus and bacteria.

Bacteria Data - All but one of the baseflow samples had fecal coliform levels below 200 colonies per 100 ml, which is the State standard for the maximum allowable level for contact recreation (See Figure 7). The only baseflow sample that exceeded the State bacteriological standard was the sample taken downstream of the wastewater lift station overflow on August 18th (shown as TH* in Figure 5). For stormflow, the developed tributary had much higher fecal coliform levels than the undeveloped tributary (See Figure 8). In this case, the single data points for storm runoff can be compared since these are adjacent tributaries and since they were sampled for the same storm. Based on the fecal coliform to fecal streptococci ratio, the bacteria in the stormwater appears to be from animal sources. Although the intensive survey did not find a problem with respect to bacteria level, the fecal coliform data collected by Austin/Travis County Health Department did indicate a possible problem in 1992 (See Figure 9). This may have been a result of the very high rainfall that occurred that year; however, additional localized sampling is being planned to try to investigate the source or sources.

Nutrients - Nutrient concentrations along the mainstem of Bull Creek were fairly low, similar to the 1982 intensive survey levels and the USGS long-term monitoring data. However, the tributary sites had somewhat higher nutrient concentrations. The side-by-side comparison for undeveloped vs developed tributaries showed higher total Nitrogen concentration for both baseflow and stormflow in the developed tributary (See Figure 10). Due to the time constraints of this study, a detailed biological survey was not attempted; however, field observations during the survey noted that algae and/or rooted aquatic plants were

Figure 7

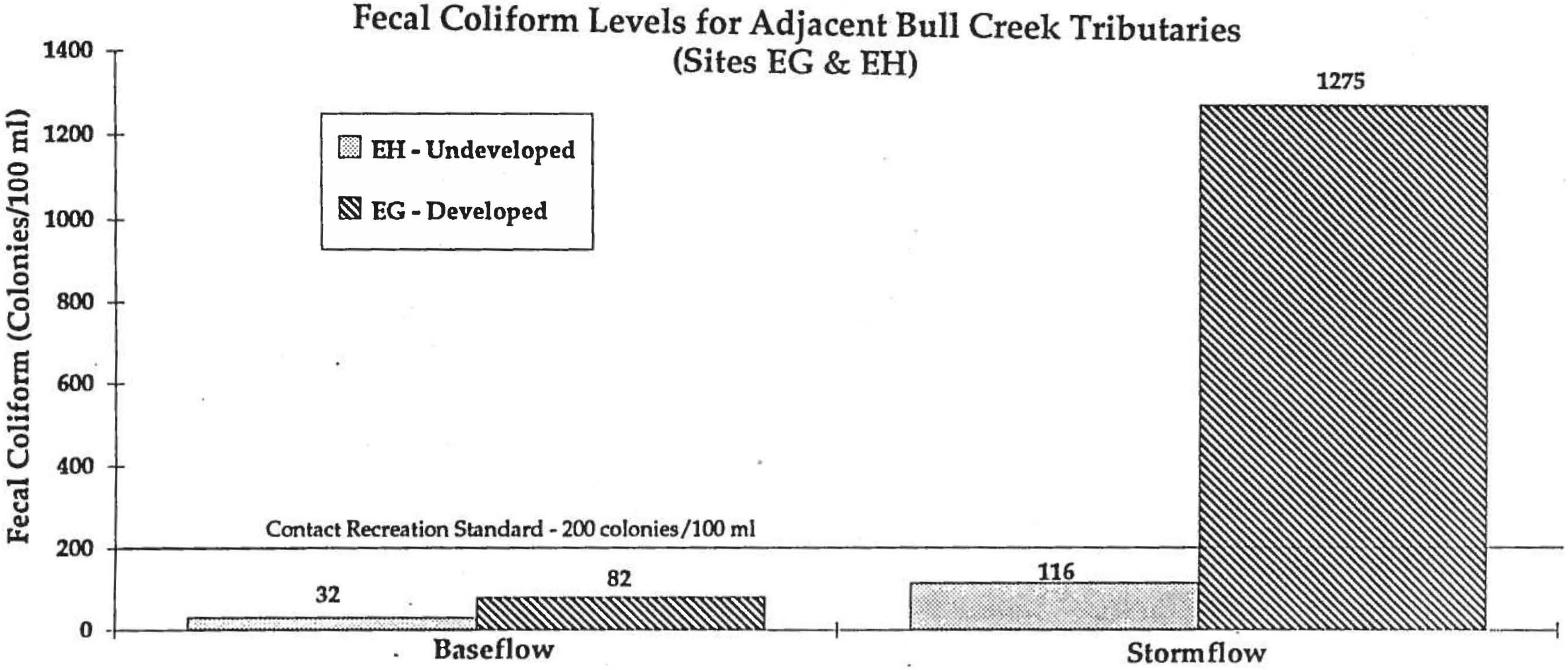
Fecal Coliform Levels in Bull Creek During Baseflow



* Sample taken after a sewage lift station overflowed on 9/18/93

Source: ECSD water quality monitoring data, 1993

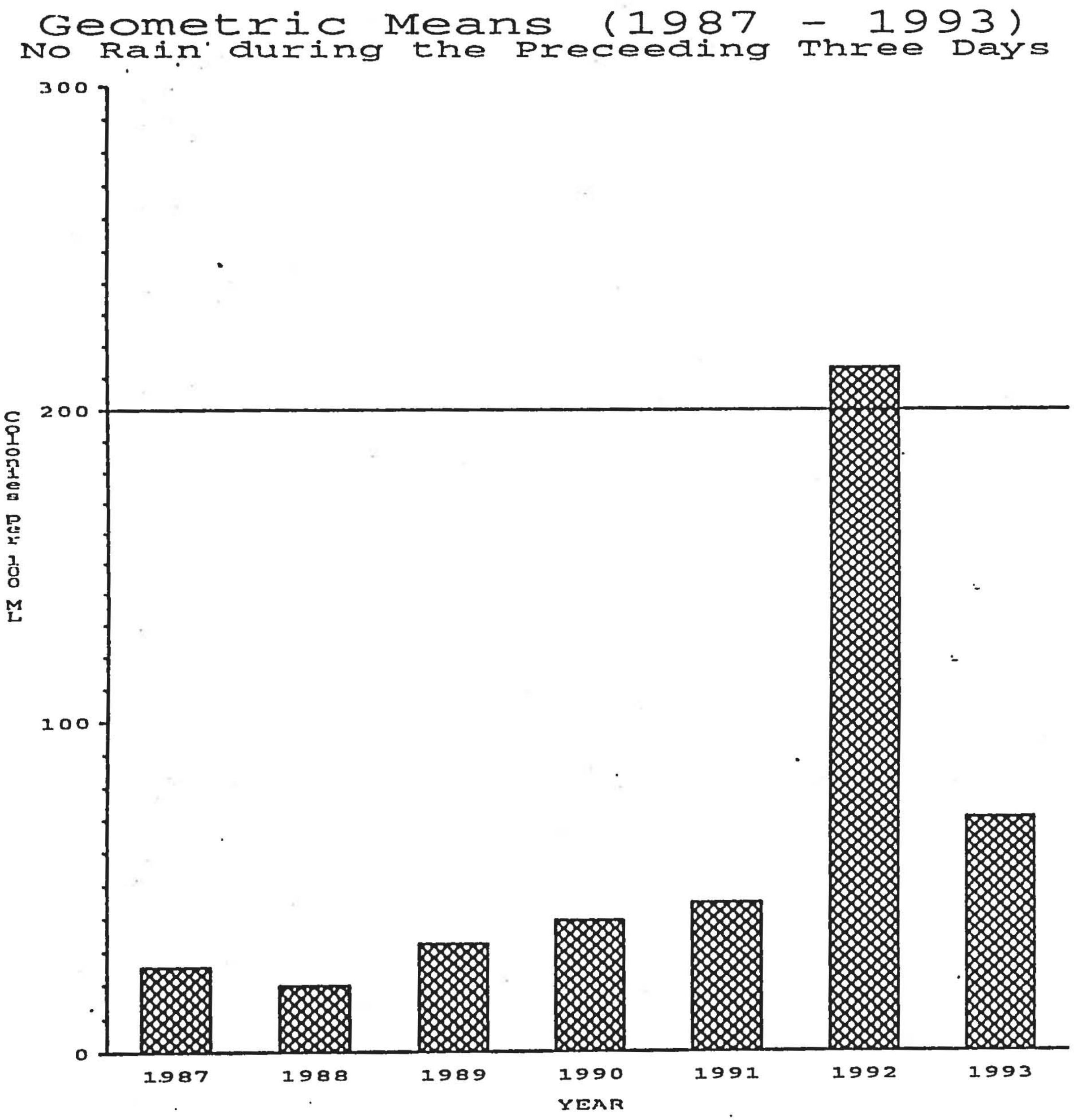
Figure 8



Source: ECSD water quality monitoring data,1993.

Figure 9

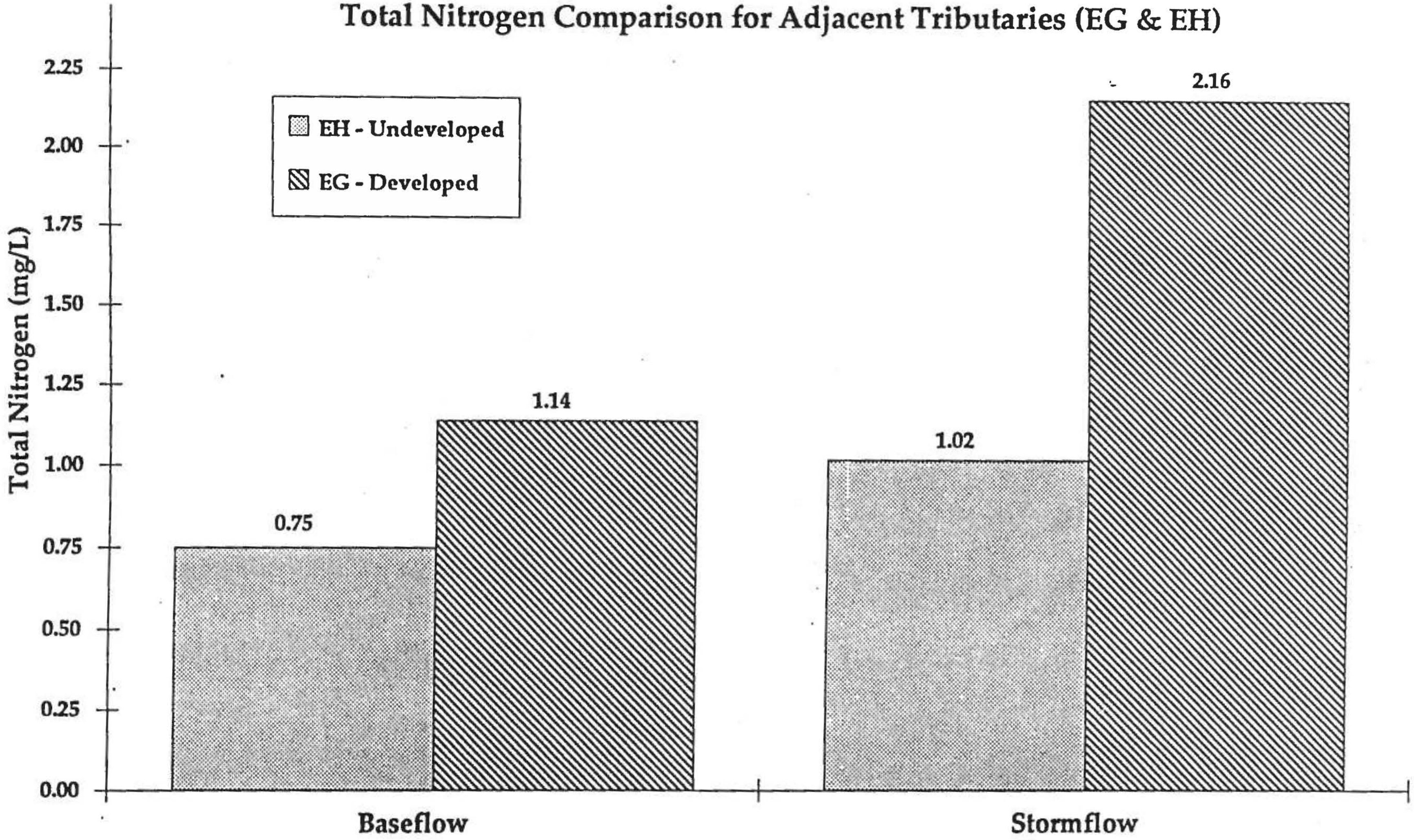
Historical Fecal Coliform Levels at Bull Creek Park



Source: ECSD water quality monitoring data,1993.

Figure 10

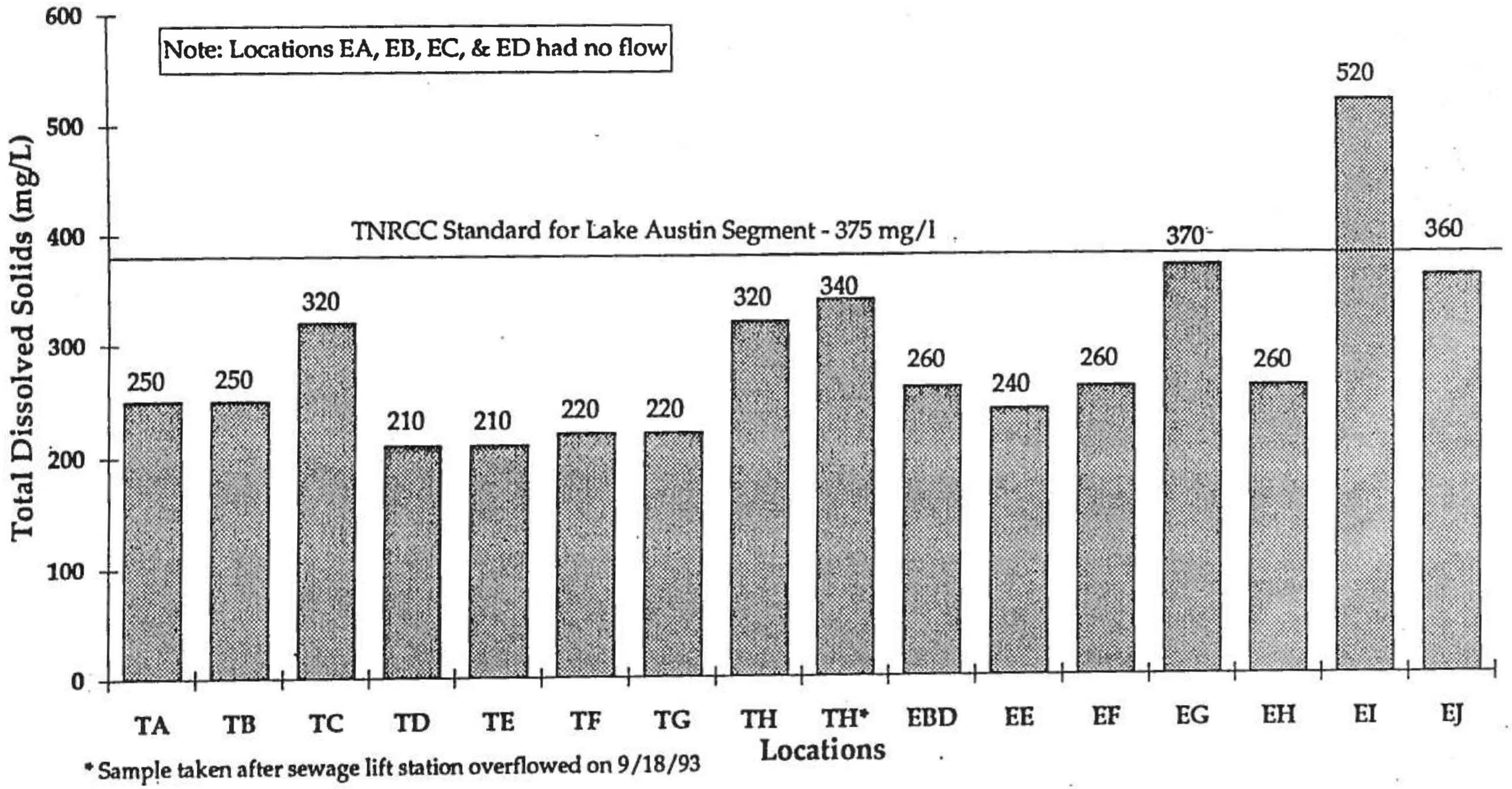
Total Nitrogen Comparison for Adjacent Tributaries (EG & EH)



Source: ECSD water quality monitoring data,1993.

Figure 11

Total Dissolved Solids in Bull Creek During Baseflow



Source: ECSD water quality monitoring data,1993.

present at most of the sample sites. In particular, the tributary where the lift station spill occurred had 100% coverage of the algae, *Cladophora*, before the spill. Also, the two tributaries with the highest total nitrogen values have golf courses located upstream of the sample sites. The site with the highest total nitrogen values (site EI) is downstream of the Great Hills golf course and this site had a significant growth of the algae, *Spirogyra*.

Total Dissolved Solids(TDS) - Most of the sites had baseflow TDS concentrations of 260 mg/L or below. This is the same as the median TDS concentrations for undeveloped springs sampled in the groundwater survey and below the Lake Austin TDS standard of 375 mg/L (See Figure 11). However, two sites were above or near this standard, sites EI and EG, respectively. Both of these tributaries have golf courses located upstream of the sample sites. Site EI had the highest TDS concentration with 520 mg/L. This site lies downstream of the Great Hills golf course which is irrigated with groundwater from the Trinity aquifer that is typically very high in TDS. The high TDS concentrations along with the high nitrogen levels and observations of algae indicate that seepage from the golf course irrigation is an existing problem.

Chemical Oxygen Demand(COD) - Highest values of COD were detected near the mouth of Bull Creek for both baseflow and stormflow conditions. Since COD is a good indicator of washoff of petroleum products from roads and highway, the data appears to indicate a problem with road runoff from Loop 360 and Ranch Road 2222.

V. RESULTS OF SPRINGFLOW SURVEY

A. Springs Survey Description

Historical springflow data from the Bull Creek watershed were reviewed, including long-term spring monitoring data from the COA/USGS cooperative monitoring program and data collected by the groundwater portion of the City's Non-urban Watersheds Program. Statistical tests revealed a number of significantly different results for springs in the Bull Creek watershed. In general, springs in developed areas have significantly different water chemistries than those in undeveloped areas. More specifically, concentrations of major dissolved ions (Mg, Na, K, SO4, Chl), nitrate-nitrogen (NO3-N), nickel, and total organic carbon (TOC) are higher in the developed areas than in undeveloped areas. Parameters related to the dissolved mineral content (hardness, specific conductivity, and alkalinity) also reflect this trend.

To augment this data and to gain a better understanding of the cumulative impact of development on springflow water quality, ECSD conducted a survey of springs in the Bull Creek watershed in August of 1993. Nineteen springs - primarily originating from Edwards Limestone strata located in canyonheads of tributaries to Bull Creek - were assessed for potential sampling during the springflow quality survey. Of these 19 assessed sites, 6 sites were not sampled because of the very low flow associated with the dry conditions in August. Of the thirteen springs that were sampled, seven were located in areas that are primarily developed and six were in undeveloped areas. Sampling occurred over a three-day period ofAugust 16 - 18, 1993. Figure 12 shows the location of the 13 spring sites that were sampled.

Water quality parameters analyzed for this survey included:

Field Measurements
- Temperature
- total dissolved solid(TDS)
- pH

Lab Analyses
- ammonia
- nitrate
- orthophosphorus
- total suspended solids (TSS)
- total organic carbon (TOC)
- total petroleum hydrocarbons
- sulfate
- sodium
- calcium.
- organophosphorus pesticides
- total Kjeldahl nitrogen (TKN)
- total phosphorus
- alkalinity
- oil & grease
- chloride
- fluoride
- magnesium

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(G8) Sampling Site

Figure 12

Springflow Sampling Sites

B. Springflow Survey Results

Overall - The recent survey showed that there is a major difference in water quality between springs in developed areas and undeveloped areas. Specifically, the springs in developed areas have significantly higher TDS, alkalinity, chloride, sulfate, calcium, and total nitrogen (nitrate plus TKN concentrations).

Total Dissolved Solids - The TDS concentrations were 60% higher in developed areas than undeveloped areas. Average concentrations from developed area springs exceeded the State TDS standard of 375 mg/L for the Lake Austin segment of the Colorado River (See Figure 13). Chloride and sulfate concentration were also higher for springs in developed areas with some of the concentrations exceeding the state standards for Lake Austin (See Figure 14).

Nitrogen - Both TKN and nitrates were significantly higher in springflow from developed areas. Springs in developed areas had total nitrogen concentrations that averaged 3 times higher than springs in undeveloped areas (See Figure 15). The higher nitrogen concentrations of groundwater from developed areas may explain the higher nitrogen concentrations found in baseflow from developed tributaries. For comparative purposes, the total nitrogen concentrations of groundwater in developed areas of Bull Creek are more than double the concentrations in Barton Springs outflows.

Other Parameters - Total organic carbon (TOC) and magnesium concentrations were also higher for developed springs in long-term USGS monitoring programs. Total petroleum hydrocarbon and organophosphorus pesticides were not detected in any samples. Very little difference was detected between the undeveloped and developed condition concentrations of total phosphorus.

C. Potential Causes of Increased Concentration in Developed Areas

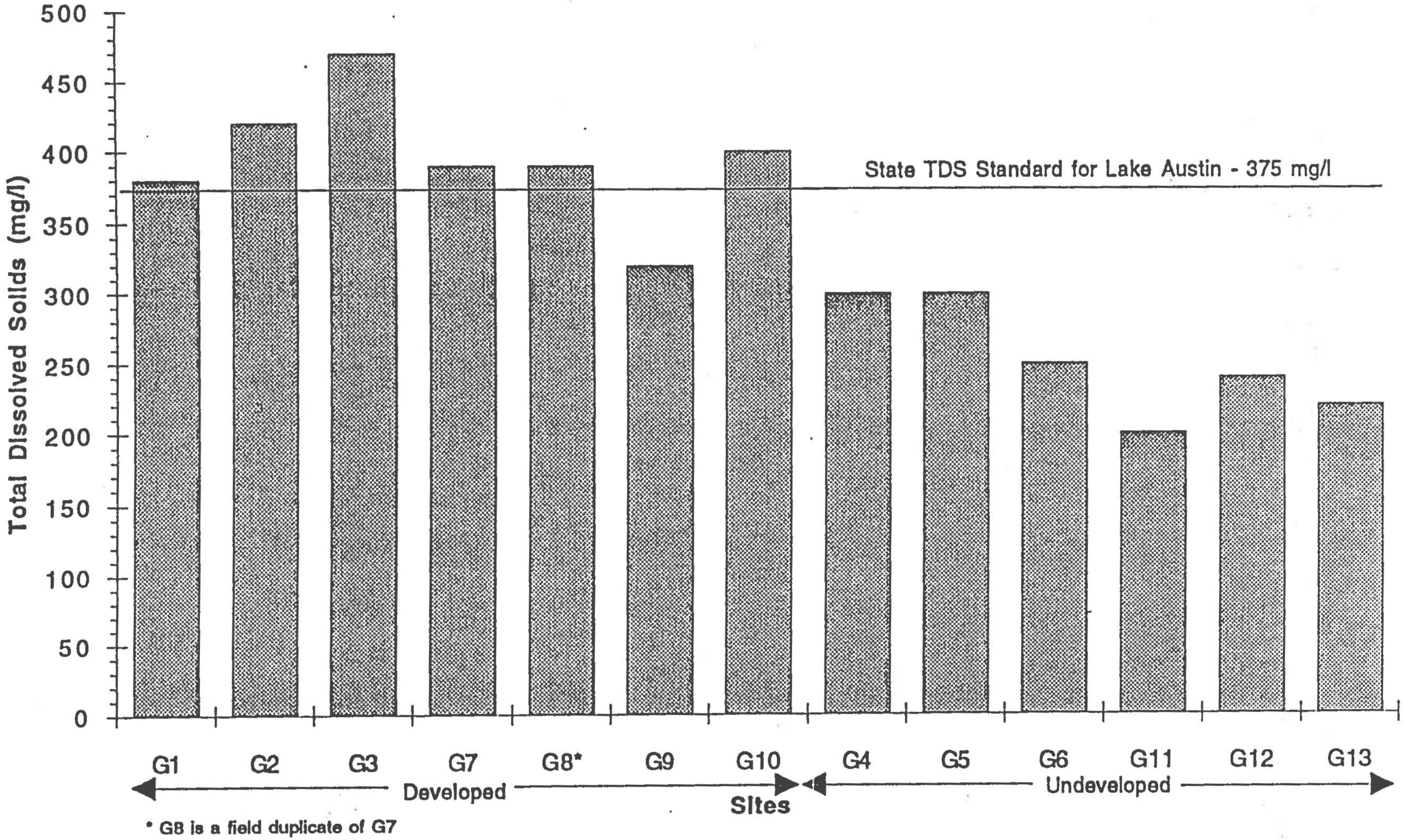
There are several potential causes for the increased concentrations of dissolved solids and nitrogen of groundwater in developed areas. These include:

- Reduced infiltration and discharge resulting from impervious cover;
- Occasional and/or chronic leakage from sewer systems and/or septic tanks; and,
- Turf fertilization and watering.

The limited duration of this study did not allow for the follow-up investigations that would be needed to accurately determine the source or sources of the observed higher concentrations.

Figure 13

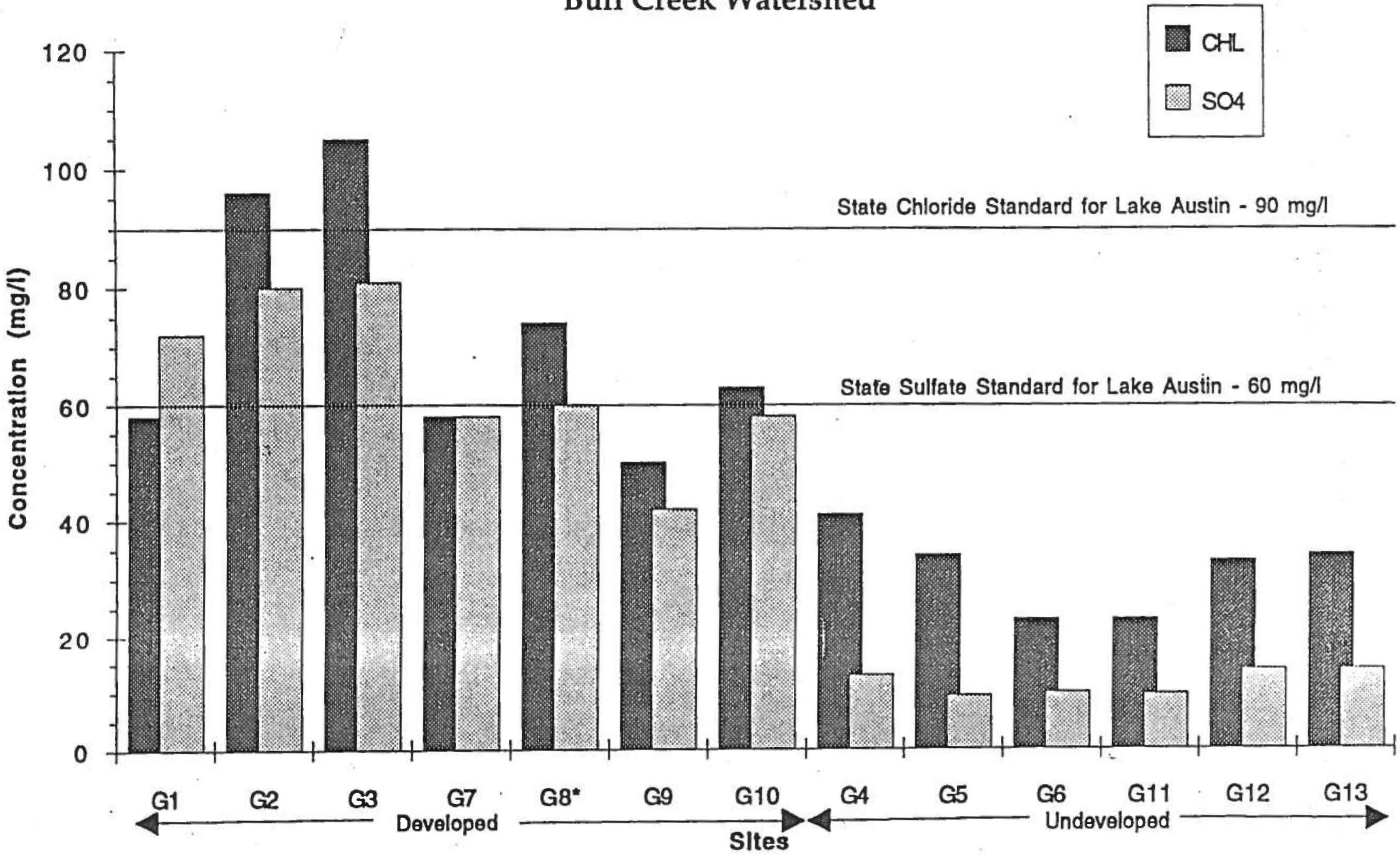
Total Dissolved Solids Levels in Selected Springs
Bull Creek Watershed



Source: ECSD spring quality monitoring data,1993.

Figure 14

Chloride and Sulfate Levels in Selected Springs
Bull Creek Watershed

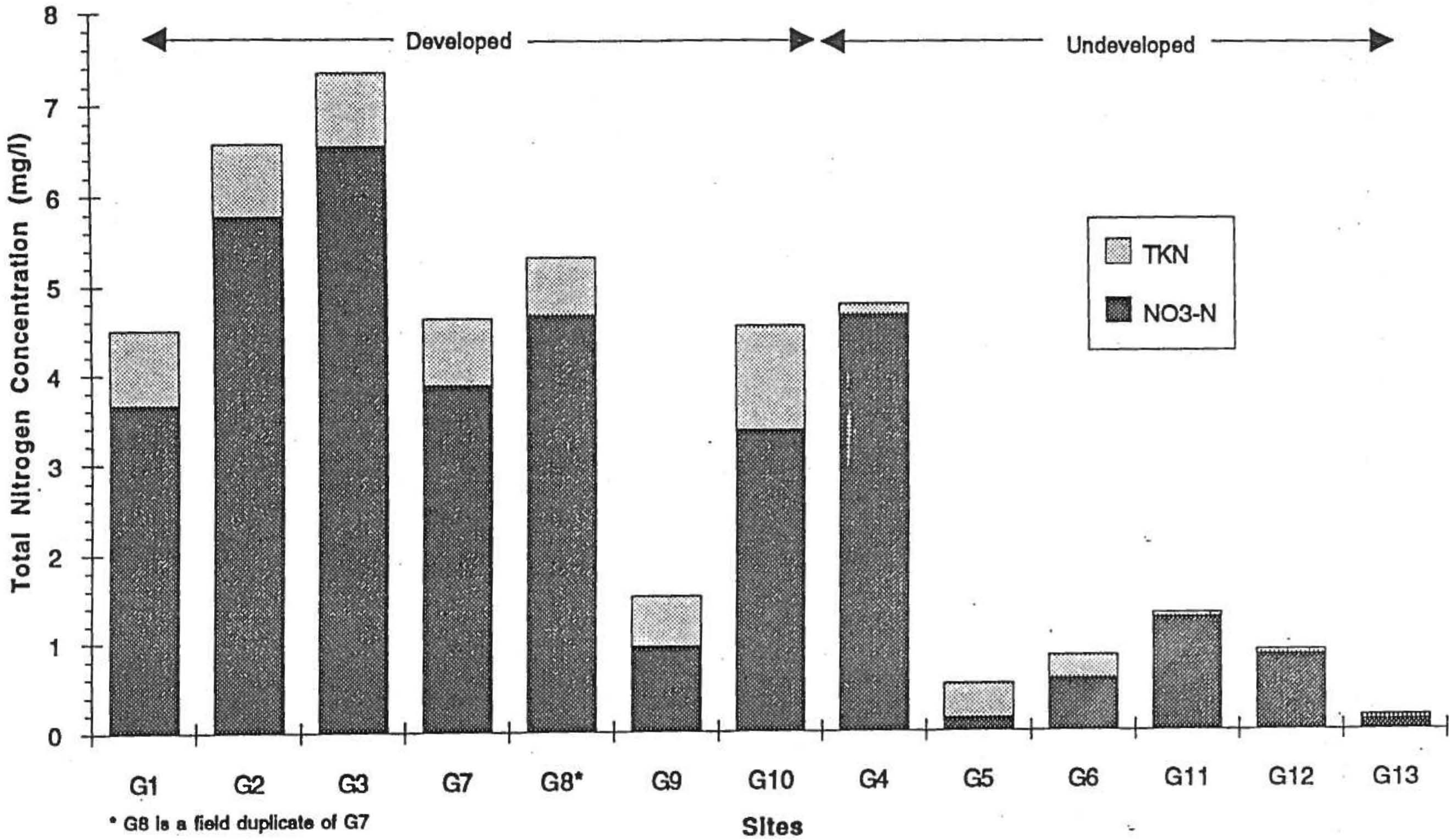


* G8 is a field duplicate of G7

Source: ECSD spring quality monitoring data,1993.

Figure 15

Nitrogen Levels in Selected Springs
Bull Creek Watershed



Source: ECSD spring quality monitoring data,1993.

VI. ENVIRONMENTAL IMPACT ASSESSMENT: HYDROLOGY

A. Methodology

The 15-minute flow records for the USGS gage on Bull Creek were analyzed to provide some indication of the hydrologic impacts of urbanization and the associated increases in impervious cover. The amounts of surface runoff and baseflow were estimated using a graphical flow separation method. The flow estimates were compared to preliminary model results from ECSD's Bull Creek computer model (using EPA's Stormwater Management Model - SWMM). A preliminary model calibration was performed using the actual flows recorded by USGS. The model was then used to estimate future effects of development on peak flows, runoff volumes and baseflow volumes compared to actual historical flow measurements.

B. Peak Flood Flow Estimates

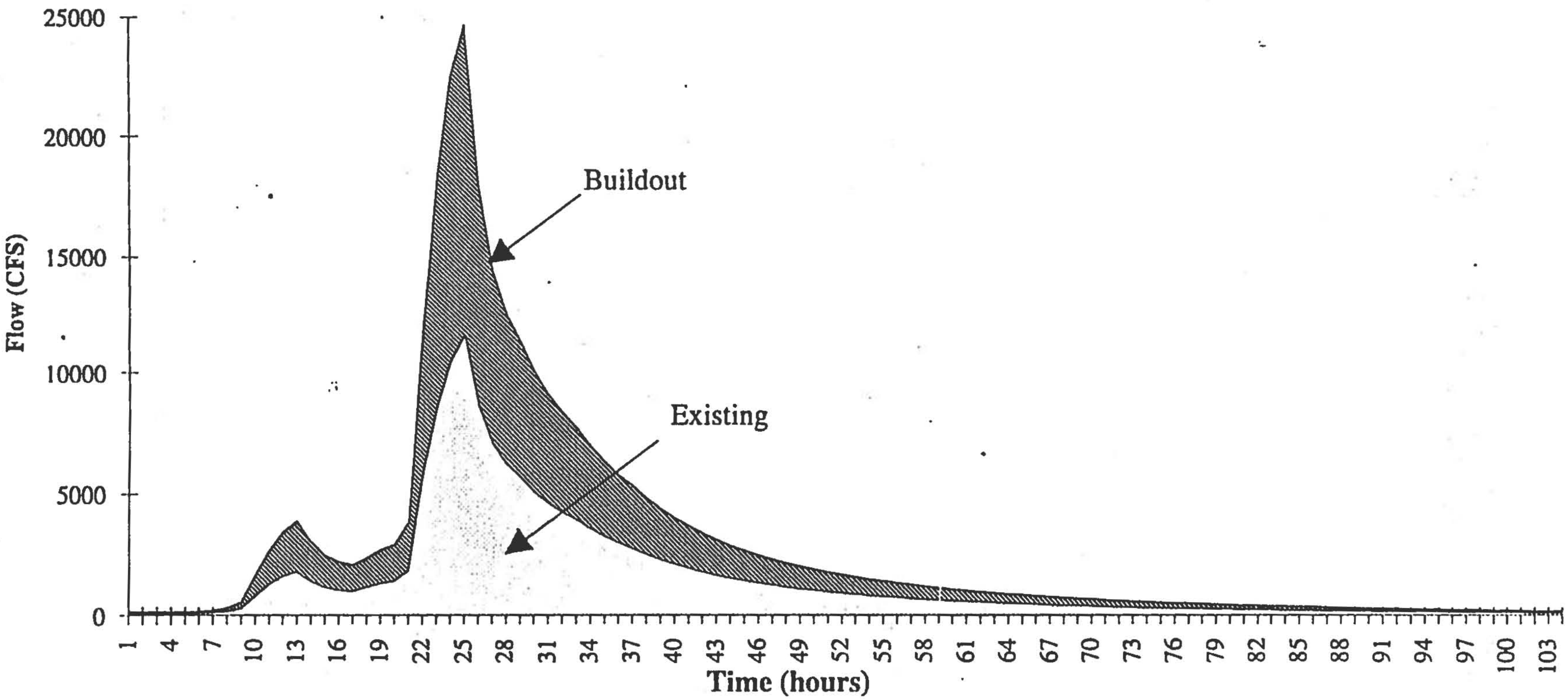
Based on preliminary modeling results, peak flows could double with projected development and the frequency of storms exceeding the previous normal peak flows will also increase. Figure 16 illustrates the peak flow of the "Memorial Day Flood" in May 1981 for existing and build out conditions. Although this flood was significantly larger, even in the Bull Creek area, than would be expected in an a year of more average rainfall, significant increases are also projected in the 2, 5 and 10 year storms. In some cases, flows are projected to increase by 1000 cfs. The increases in the 2-year storm peak flows projected by the model results is noteworthy because 2-year storm peak flows are the most damaging to the creekbank and riparian habitat. If adequate stormwater detention is not provided, then heightened peak flow could seriously increase channel erosion which would effect the quality of both Bull Creek and Lake Austin. A more detailed analysis is required to ensure that channel erosion does not increase with new development, however, it appears that on-site detention to limit the peak of the 2-year storm is generally desirable for water quality protection.

C. Baseflow Decreases

Previous local and national studies have shown that watershed baseflow decreases as impervious cover increases. Preliminary modeling results indicate increasing impervious cover results in significant decreases in baseflow volume as well as a decrease in the baseflow as a percent of total flow (See Figure 17). Currently the baseflow makes up approximately 64% of the total flow in Bull Creek; however, with a projected 13% drop in baseflow quantity under build-out conditions, this percentage of total flow would drop to below 60%. There would be a corresponding increase in storm runoff volume; therefore, the overall quality of water in Bull Creek would reflect the lower quality seen in the stormwater runoff. Also, based on the gage records, Bull Creek exhibited zero flow for only 3% of the time. The amount of time with zero flow will increase as baseflow volumes decrease.

Figure 16

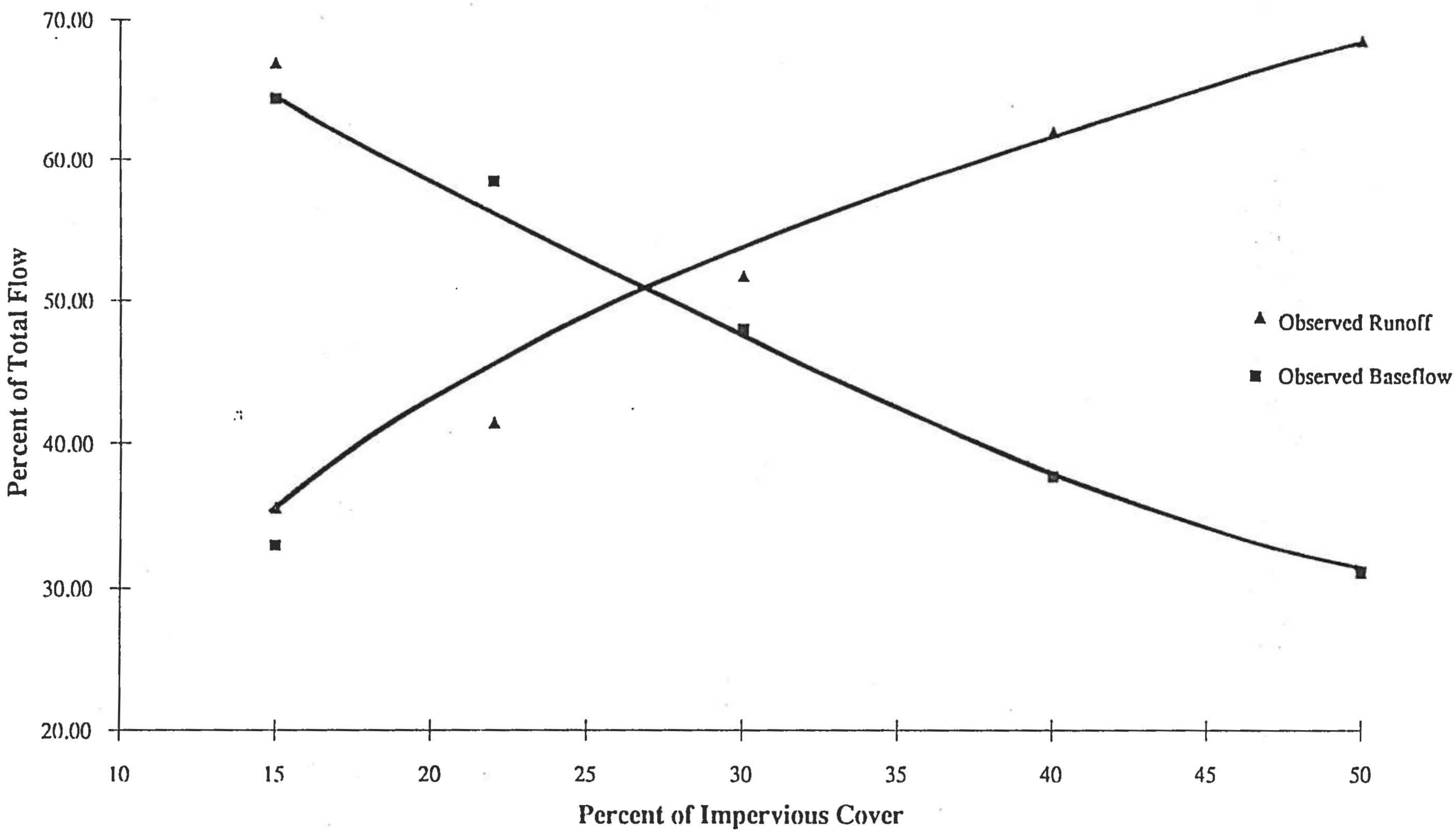
Hydrographs of Existing and Buildout Conditions (with BCCP) for the Bull Creek Watershed Model at Loop 360



… model based on NWS data from May 24 to May 26 of 1981.

Figure 17

Baseflow and Runoff Percentage of Total Flow for Bull Creek at Loop 360



D. Overall Flow Analysis Results

The general conclusion of the analysis of the USGS flow records and the preliminary model results is that it is important to maintain the natural flow regime of Bull Creek in order to maintain the current water quality. This includes preventing significant increases in peak flows and maintaining baseflow quantity.

VII. ENVIRONMENTAL IMPACT ASSESSMENT: WATER QUALITY

A. Model Methodology

Scenario Assumptions

In an effort to predict the impact of development on the total load of selected pollutants, ECSD made three different model iterations of the Simple Pollution Loading Model developed by the Metropolitan Washington Council of Governments and adapted by ECSD for local conditions and data. Although some specific adaptations to the Bull Creek watershed were made, the set up of the model is based on the Town Lake Study completed by ECSD last year. The first run of the model was used to reflect existing conditions, the second to show those projects that already have received some level of permitting, and a third to illustrate conditions of maximum practical build out within the watershed. Additionally a fourth set of assumptions was generated to illustrate the impact that the proposed BCCP land acquisition has on water quality in Bull and West Bull Creek.

To develop the existing land use map, ECSD first divided the Bull and West Bull Creek watersheds into 12 sub-watersheds based on the 1991 Public Works Stormwater study maps. Next, the amount of 1990 acreage for each land use category in each sub-watershed was calculated by using digitized 1990 land use acreages, provided by the Department of Planning and Development. This data was updated to yield existing land use by adjusting the land use acreage in each sub-watershed to reflect the building permit data 1990-93 also supplied by the Planning Department.

The land use assumptions of the final Build-out Scenario were also derived with the assistance of the Planning Department. The Comprehensive Planning Section provided a digitized map coverage of acreage which was currently undeveloped, but which lacked any major development constraint, such as steep slopes or planned acquisition for the BCCP. The build-out land use patterns were extrapolations of past growth patterns and land use mixes, but at density levels allowable under the CWO. These estimates were refined by sub-watershed in instances where new development patterns would likely be different than existing patterns. (For example, in a sub-watershed whose existing development was primarily single family, but whose remaining developable acres were all immediately adjacent to a major arterial, a higher percentage of commercial land uses was assumed in any future development).

The intermediate, or Potential Development Scenario, reflects those developments which have received some level of approval, but which have not been fully constructed. Because it can be many years before an approved project is built, this was not readily accessible information. Although the Planning Department is now determining the status of the various development projects in the Bull and West Bull Creek watersheds, this information was not available early enough in this study's timetable to assist ECSD analysis. Based on more general development information previously supplied by the Planning Department and estimates made as part of the BCCP, ECSD estimated the percentage of the potentially developable land which has already been platted or has received some kind of preliminary approval. Since this estimate was more general than those of the other scenarios, it was not calculated on the sub-watershed level, but for the entire Bull/West Bull Creek watershed.

Although the primary underlying study assumption presupposes the successful implementation of the BCCP, ECSD ran one iteration of the simple pollution loading model without that assumption. Many factors would interact to determine the actual development patterns that would occur in the Bull Creek watershed without a BCCP agreement, and this study does not attempt to predict what the result of that interaction would be. But for illustrative purposes, in the "No-BCCP" model run it was assumed that 50% of those lands now designated for protection under the BCCP would instead be built out in compliance with the 1986 CWO in densities similar to the already developed areas of the watershed.

Note: This fourth model iteration is not an attempt to suggest what actions the City or the U.S. Fish and Wildlife Service would or should take in absence of a BCCP agreement. It serves only to illustrate the magnitude of the impact of the proposed acquisition areas of BCCP on water quality in Bull and West Bull creeks.

<u>Data Limitations</u>
Every effort was made to ensure that the figures used for all land use scenarios were as accurate as possible. However, given the time allowed and the lack of complete data, some generalizations and estimations were made. The permitted development and build-out scenarios may underestimate the amount of land which could be developed and the amount of pollutant load in the runoff from these sites. The slope map used to determine steep slopes was originally generated as part of the Austinplan in 1986, and was designed to show general areas of steeply sloping ground, not site specific topography. Within the general areas considered by these calculations to be too steep for development, there may be smaller areas which are sufficiently level and large enough to permit some development. Furthermore, although it was assumed that all future developments will comply with the pollutant control requirements of the CWO, some yet to be built subdivisions may have received their initial approval under one of the less stringent Lake Austin ordinances. Offsetting this, recent actions by the City Council have shortened the time a developer may wait between site plan approval and construction. This may result in many of the pending developments being forced to reapply for approval, under current stricter regulations.

<u>Modeled Pollutant Parameters</u>.
Observed runoff concentrations of four target pollutants were selected for the pollutant loading calculations performed for this study. These four constituents are total suspended solids (TSS), total phosphorus (TP), total nitrogen (TN), and total organic carbon (TOC). Although other runoff parameters are important to water quality, the target pollutants: 1) can be used as indicators of a variety of different types of urban pollutants; 2) have fairly good databases both nationally and locally; and 3) are common parameters used in water quality studies. Total suspended

solids is a commonly measured pollutant quality parameter that is also used in sedimentation rate analysis. It also is a useful parameter because it is an easily removed pollutant that typically has other pollutants associated with it, such as heavy metals. Total phosphorus is typically considered the limiting nutrient in local lake eutrophication. Total phosphorus can also be an indicator of more intensive landscaping activities in the watershed, and as a surrogate for higher pesticide usage. Total nitrogen, another primary nutrient responsible for lake eutrophication, measures a variety of aqueous nitrogen species. Total nitrogen has a higher dissolved and bio-available fraction than phosphorus. Nitrogen also appears to increase with traffic-related activities in highly urbanized areas. Total organic carbon is even a better indicator of pollution, including certain toxics, from high traffic areas based on the local data and the highway runoff data.

B. Conclusions of the Pollutant Load Modeling

Land Use Levels

Undeveloped and park lands predominate in the existing land use and in all the predictive scenarios. Even in the build out scenario, there is more undeveloped and park land then there is actual development. Only in the "No-BCCP" alternative is more of the watershed developed than undeveloped. This relative lack of development is the largest single factor affecting the water quality of the area creeks.

Pollutant Loads

The total pollutant loads for the four modeled parameters are summarized in Table 1. This table shows the relative land use acreage under each scenario and total pollutant load for each of the modeled parameters. The total loads are displayed by land use for each of the three scenarios. Total pollutant loads for the "no-BCCP" scenario are shown for comparative purposes only.

Table 2 summarizes the modeled results of an aggressive program to reduce pollutant loading by retrofitting existing land uses. Due to siting constraints it may not be possible to retrofit all of the existing developments in a given area. ECSD assumed that suitable sites could be found to provide water quality controls for 50% of the existing development to provide treatment levels equivalent to those required by the 1986 CWO. These data show that incremental reductions in load in the 5 - 20% range can be achieved through a retrofit program for existing development.

Figure 18 illustrates the increase of total suspended solid load as development increases. Due to the effectiveness of the provisions of the CWO at controlling sediment in site runoff, as demonstrated at previously monitored study sites, the increase in TSS from existing to build out conditions is only 1%. As shown in Table 2, a successful retrofit of 50% of the existing development could actually reduce the amount of TSS in storm runoff by 21%, even as build out occurs. More precise estimates of the effects of retrofitting will require the development of a water quality retrofit master plan for this watershed.

Table 1

Bull Creek Pollutant Loading Model Results

Development Level

Land Use	Existing	Permitted		Build Out		No BCCP	
	Acres	Acres	% Increase	Acres	% Increase	Acres	% Increase
Undeveloped/Park	15,038	11,947	-21%	11,174	-26%	7,944	-47%
Residential	4,530	7,101	57%	7,744	71%	10,044	122%
Office/Commercial	383	856	124%	974	155%	1,774	364%
Industrial/Transport	122	163	34%	174	42%	234	92%
Utility/Civic	130	136	4%	137	6%	207	59%
Total Development	5,165	8,256	60%	9,029	75%	12,259	137%

Total Suspended Solids

Land Use	Existing	Permitted		Build Out		No BCCP	
	lbs/yr	lbs/yr	% Increase	lbs/yr	% Increase	lbs/yr	% Increase
Undeveloped/Park	561,099	464,291	-17%	440,089	-22%	339,039	-40%
Residential	744,300	801,903	8%	816,304	10%	874,209	17%
Office/Commercial	116,092	157,825	36%	168,259	45%	239,541	106%
Industrial/Transport	109,518	114,452	5%	115,686	6%	136,870	25%
Utility/Civic	33,515	35,142	5%	35,549	6%	53,642	60%
TOTAL LOAD	1,564,524	1,573,614	1%	1,575,887	1%	1,643,301	5%

Total Phosphorus

Land Use	Existing	Permitted		Build Out		No BCCP	
	lbs/yr	lbs/yr	% Increase	lbs/yr	% Increase	lbs/yr	% Increase
Undeveloped/Park	281	232	-17%	220	-22%	170	-40%
Residential	2,044	2,496	22%	2,610	28%	3,038	49%
Office/Commercial	210	320	53%	347	66%	535	155%
Industrial/Transport	98	109	11%	112	14%	137	39%
Utility/Civic	69	72	4%	73	5%	107	54%
TOTAL LOAD	2,702	3,230	20%	3,362	24%	3,986	48%

Total Nitrogen

Land Use	Existing	Permitted		Build Out		No BCCP	
	lbs/yr	lbs/yr	% Increase	lbs/yr	% Increase	lbs/yr	% Increase
Undeveloped/Park	4,349	3,598	-17%	3,411	-22%	2,628	-40%
Residential	10,512	14,092	34%	14,987	43%	18,512	76%
Office/Commercial	2,622	4,257	62%	4,666	78%	7,459	184%
Industrial/Transport	1,620	1,796	11%	1,840	14%	2,264	40%
Utility/Civic	432	453	5%	458	6%	691	60%
TOTAL LOAD	19,535	24,196	24%	25,361	30%	31,553	62%

Total Organic Carbon

Land Use	Existing	Permitted		Build Out		No BCCP	
	lbs/yr	lbs/yr	% Increase	lbs/yr	% Increase	lbs/yr	% Increase
Undeveloped/Park	49,096	40,625	-17%	38,508	-22%	29,666	-40%
Residential	49,540	59,902	21%	62,492	26%	72,290	46%
Office/Commercial	26,667	37,003	39%	39,587	48%	57,241	115%
Industrial/Transport	15,809	17,235	9%	17,591	11%	20,939	32%
Utility/Civic	4,294	4,524	5%	4,581	7%	7,023	64%
TOTAL LOAD	145,405	159,288	10%	162,759	12%	187,159	29%

Based on ECSD modeling data, 1993.

Table 2

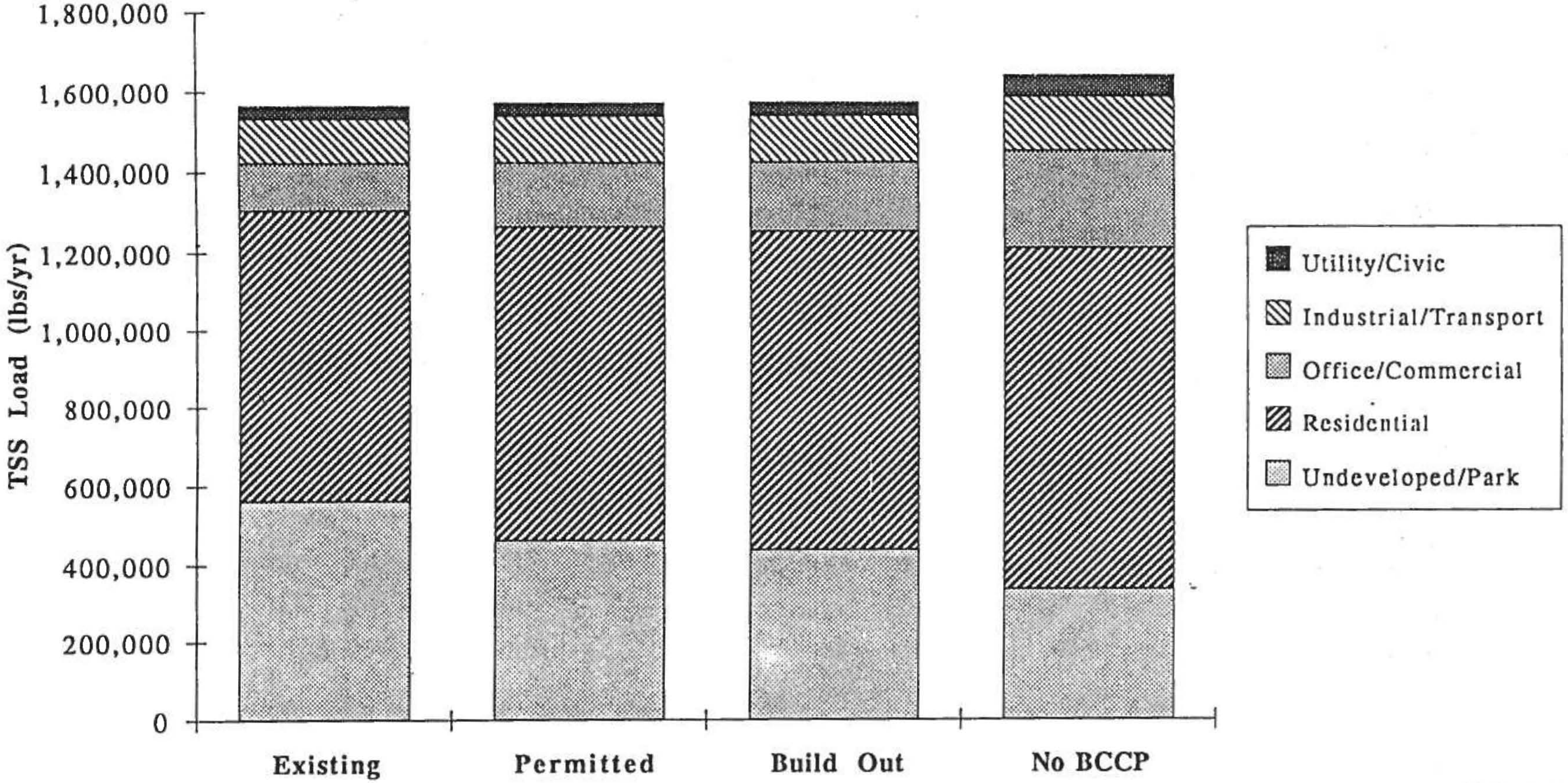
Estimated Pollutant Load Reductions through Retrofitting*

Scenario	TSS load (lb/yr)	TSS % reduction	TP load (lb/yr)	TP % reduction	TN load (lb/yr)	TN % reduction	TOC load (lb/yr)	TOC % reduction
Current Existing	1,564,524	-	2,702	-	19,535	-	145,405	-
50% CWO Retrofit	1,226,227	22%	2,145	21%	18,237	7%	126,480	13%
Proposed	1,573,614	-	3,230	-	24,196	-	159,288	-
50% CWO Retrofit	1,235,317	21%	2,673	17%	22,898	5%	140,363	12%
Build Out	1,575,887	-	3,362	-	25,361	-	162,759	-
50% CWO Retrofit	1,237,590	21%	2,805	17%	24,063	5%	143,834	12%
"No-BCCP"	1,643,301	-	3,986	-	31,553	-	187,159	-
50% CWO Retrofit	1,305,004	21%	3,429	14%	30,255	4%	168,234	10%

*Assumes 50% of Existing Brought up to CWO Standards

Based on ECSD modeling data, 1993.

Figure 18
Source of Total Suspended Solids Load Under Various Land Use Scenarios



It should be noted that the pollutant loads listed here represent the loads in runoff from the site only, and do not reflect the full impact on the creek. In particular, total suspended solids will tend to be much higher as impervious cover increases than predictive runoff values alone indicate. Increased development heightens peak flow in the creek, increasing the erosion of the creek bank, and consequently, the amount of sediment carried in the creek water.

Total phosphorus increases 28% over existing levels in the build out scenario (Figure 19). This load could be reduced 17% by retrofitting half of the existing development, as shown in Table 2.

Total nitrogen loads are most affected by increases in watershed development. As build out occurs, total nitrogen increases by 30% over existing levels (Figure 20). Retrofits similar to the structural controls called for by the CWO would be only marginally effective in addressing this load, reducing the build out load by 5% (Table 2).

Total organic carbon would be increased 12% by a full build out of the watershed. However, a 50% retrofit to CWO standards would decrease this load by 22%, reducing it to levels below existing conditions (Figure 21, Table 2).

For all key parameters, the load increase as development occurs is much more striking in the no BCCP exercise. More than any other single factor, the set aside of the BCCP acquisition areas will help to preserve water quality in Bull and West Bull Creek. Based on the current CWO impervious cover limits, and the proposed BCCP land acquisition areas, the impervious cover estimates for full build-out will be 19% for the entire Bull Creek watershed.

Figure 19

Source of Total Phosphorus Load Under Various Land Use Scenario:

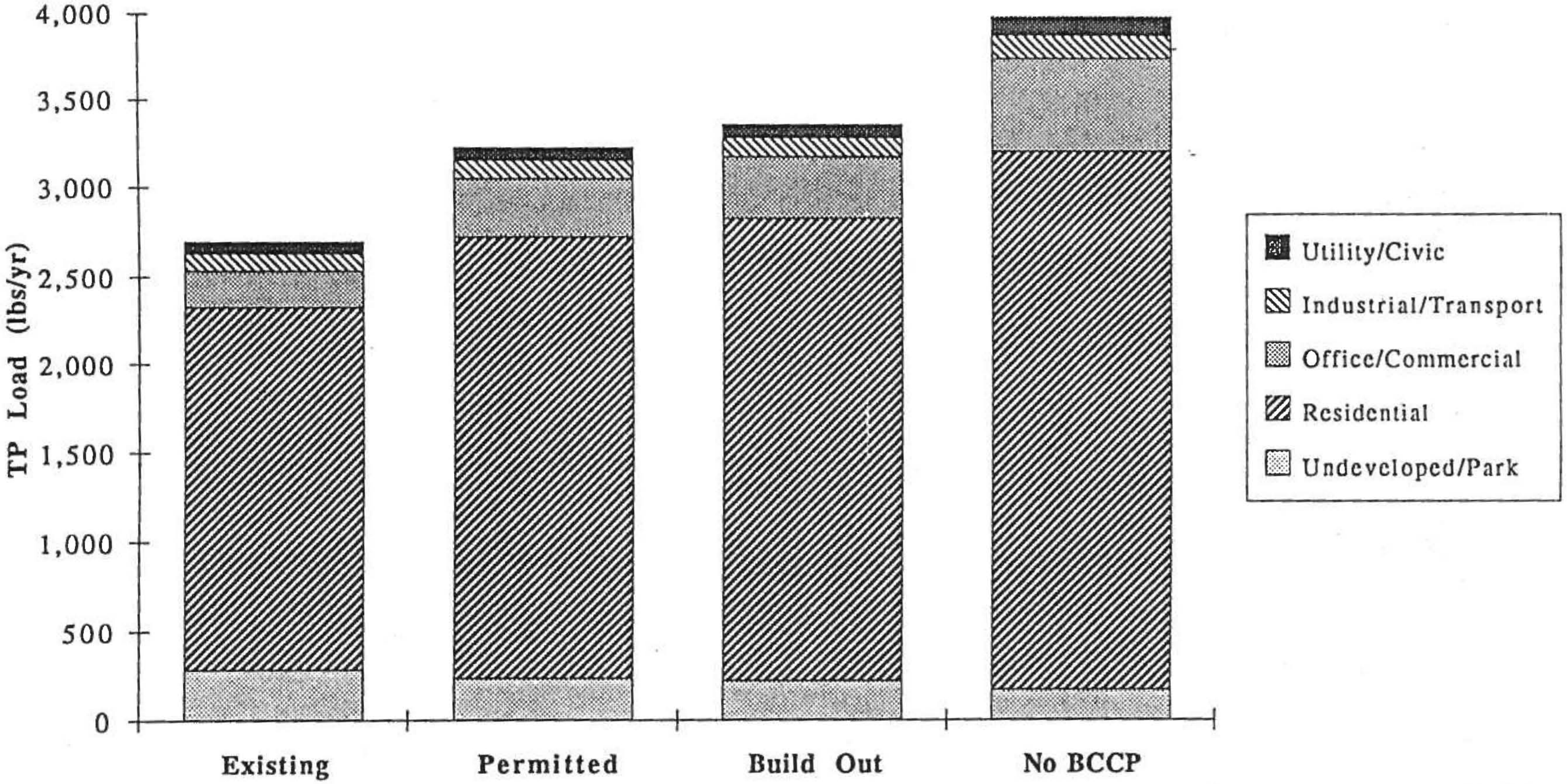


Figure 20

Source of Total Nitrogen Load Under Various Land Use Scenarios

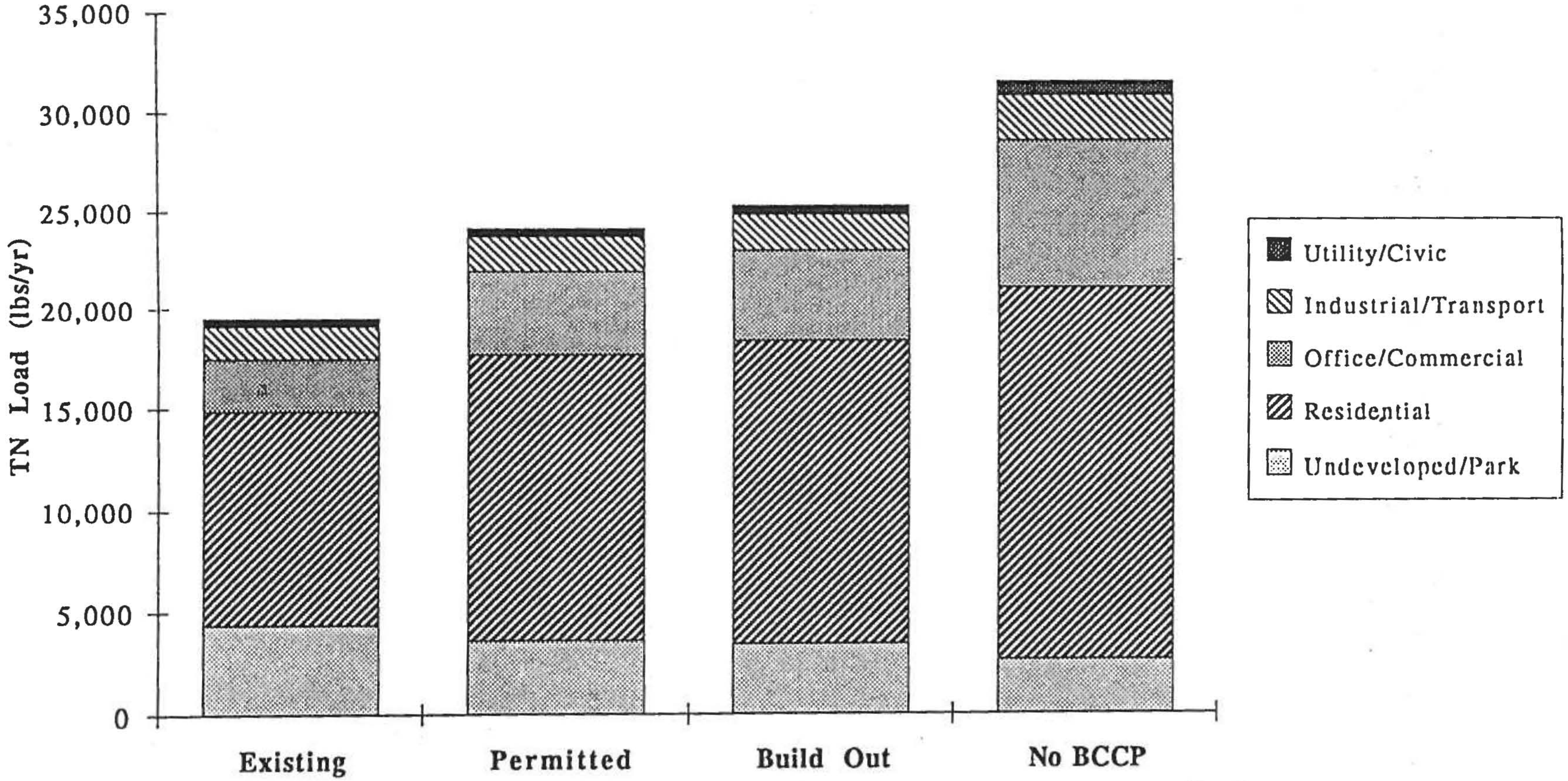
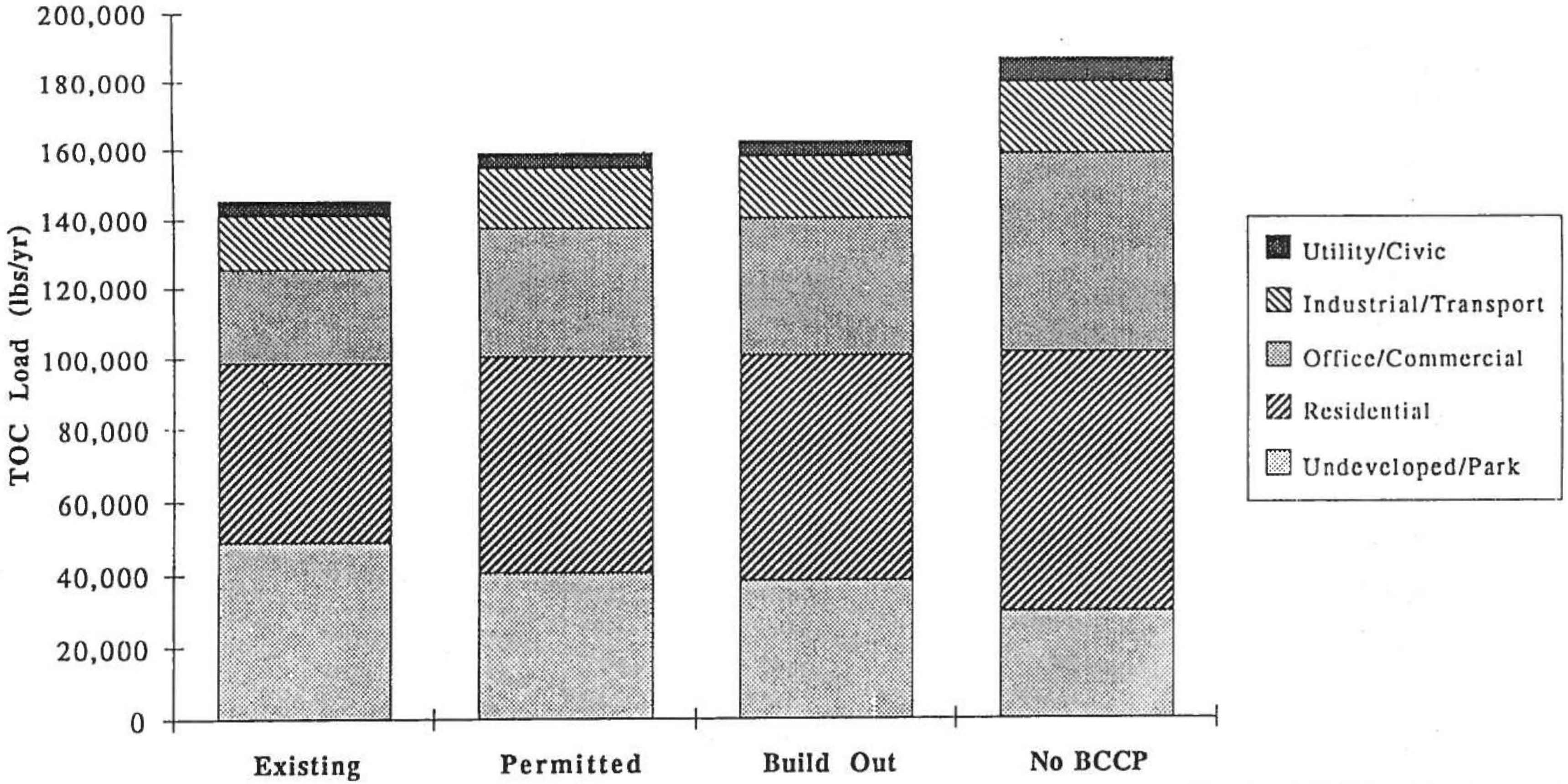


Figure 21

Source of Total Organic Carbon Load Under Various Land Use Scenarios



Results of Pollutant Load Modeling.

VIII. ALTERNATIVES FOR WATER QUALITY IMPACT MITIGATION

Based on ECSD's water quality review and evaluation, the protection from development afforded by the BCCP land acquisition appears to be the most significant water quality protection measure available in the Bull Creek Watershed. This will result in an overall impervious cover percentage for the entire watershed of 19%.

The following alternatives are additional measures to mitigate existing water quality impacts as well as those predicted by the future loading estimates developed for this report. They are primarily applicable to the first three acreage categories - developed, permitted, or available for development - which comprise 45% of the watershed.

A. Mitigation of Water Quality Impacts from Previously Developed Areas

The ability of the City of Austin to mitigate the water quality impacts of older developments in the Bull Creek Watershed which were built with little or limited water quality controls or failing septic systems is constrained because many of these problem areas are outside the City limits. This situation could be amended by the following alternatives, some of which may be dependent upon mutual agreements between the City of Austin and the affected areas:

1) Extension of the Drainage Utility Service Area Through the formation of the Drainage Utility, the City of Austin created a Non-urban Watershed program to pay for water quality retrofit projects for developments built before stringent water quality controls were required along with other pollution prevention programs. Although possibly allowable, it would be unlikely that the City would elect to expend funds in areas in the Bull Creek Watershed which are not contributing to the fund through the Utility. The Drainage Utility Cost of Service Study will be making recommendations for extension of service within the ETJ.

   Extending the Drainage Utility Service Area to include the entire Bull Creek Watershed would increase the potential to solve specific water quality problems through the retrofit and pollution prevention programs. It would also help to fund the maintenance of some of the water quality ponds which were built as a result of City requirements but have no associated source of funds for routine maintenance. Additional research by the Department of Public Works and Transportation is needed to determine if poorly maintained water quality ponds are a significant problem in the watershed and whether the City currently is adequately fulfilling any maintenance responsibilities it has in the watershed.

2) Extension of the Water and Wastewater Utility Service Area There are several residential areas within the Bull Creek Watershed which are on septic systems which may be large contributors to the pollutant load in Bull Creek (such as Northview Hills and Balcones Village). If a mutual

agreement were reached between the City and the affected developments to extend the Water and Wastewater Utility Service Area to include those areas, the City could potentially switch areas currently served by septic systems to the central wastewater system. More study will be necessary to determine whether the advantage of switching to a central system outweighs the negative impacts associated with the construction of the infrastructure that such a conversion would require. (In particular, if wastewater service is increased, it may necessitate the construction of the 30" Main Bull Creek Interceptor adjacent to the creek.)

3) Annexation The annexation of all or part of the Bull Creek Watershed would result in the automatic extension of both the Water and Wastewater Utility Service Area and the Drainage Utility Area. However, the responsibility for roads and other infrastructure would also fall upon the City under this scenario.

4) Water Quality Retrofits An aggressive program of water quality retrofits in previously developed areas could improve water quality in the Bull Creek Watershed. The construction or expansion of stormwater detention measures and other retrofits could help many areas that were built under guidelines less strict than the Comprehensive Watershed Ordinance achieve levels of pollutant removal closer to those called for by the CWO. Siting limitations and other constraints would limit the feasibility of retrofitting all such developments. Table 2 illustrates the effectiveness of a retrofit of 50% of the previously developed areas on four significant pollutants.

Additional work by ECSD, W&WW Department, DPWT and the Planning Department will be necessary to determine whether any of these alternatives have merit from water quality, economic and policy standpoints. Furthermore, some of these scenarios are dependent on mutual agreement between the City of Austin and the affected areas.

The three actions described above, would facilitate City efforts to reduce some of the existing pollution sources in the Bull Creek watershed. Full implementation of a retrofitting program would be possible as well as a variety of nonstructural control options that could help mitigate existing water quality impacts. These include increased inspection of construction sites and permitted businesses, and citizen education programs targeting potentially polluting landscape practices.

B. Alternatives for Water Quality Control in Areas Previously Permitted

Approximately fifteen percent of the Bull Creek Watershed is permitted under a variety of historical ordinances which may require very little in the way of water quality controls, or may be permitted for development under no ordinances at all. Depending on the type of development permit and its date of issuance, the City may have the authority to impose increased pollution control requirements on such projects.

C. Alternatives for Water Quality Control on Developable Land

Significant improvements in water quality control in the watershed could be achieved by amending the ordinance under which the currently unpermitted areas must eventually fall - the Comprehensive Watershed Ordinance. Recommended amendments to the ordinance include:

1) Requirements for on-site stormwater detention ponds to prevent increases in the 2 year peak flows. These flows are primarily responsible for the channel erosion which typically results from increased impervious cover. This is an existing flood control requirement (City of Austin Drainage Criteria Manual, 1.2.2.C). However, currently, this requirement for on site detention may be waived through participation in a regional detention program, provided there are no adverse flooding impacts of the waiver. The recommended amendment would add environmental criteria to Public Works existing drainage review process, and would allow participation in a regional detention program in lieu of on-site detention only if this would produce no adverse water quality impacts from the increased in-stream peak flow and resulting streambank erosion. Additionally, participation in a regional detention program in lieu of on-site detention would be permitted if the review determines that on site detention would result in unacceptable environmental damage to the site.

2) Requirements to increase pond volumes with increasing levels of impervious cover. Current requirements are based on the volume required to capture the first one half inch of runoff, but remains constant for impervious cover levels over 20%. Sizing requirements could be increased for projects with an impervious cover percentage of over 20% at the rate of 1/10" of additional capture volume for every 10% of additional impervious cover.

3) Elimination of legal lot exemptions. In the Bull Creek Watershed, many of the projects which are now in the development process are not required to observe the CWO's standard setbacks from the creek because they are exempt due to their status as legal lots. There does not appear to be any technical reason to continue these exemptions.

Although these amendments could be made as Bull Creek amendments to the CWO, the justifications for the amendments are not specific to Bull Creek, and in fact are valid wherever the CWO is applied. In the Urban Watersheds, the second and third amendments are also appropriate. The first may also be applied in urban watersheds; however additional provisions must be allowable for payments in lieu of on-site detention due to severe space constraints in the urban area.

D. Alternatives for Flood Control

Another area which the City must review is the current stormwater management plan developed by the Department of Public Works and Transportation in 1991. The plan called for the construction of three regional detention ponds to be located within the channels of headwater tributaries to Bull Creek and allowed developers to pay into a fund for their construction as a substitute for the construction of on-site ponds. The ponds are proposed in areas either acquired or proposed for acquisition by the BCCP, adjacent to woodlands suitable for golden cheeked warbler habitat, or in tributaries in which the Jollyville Salamander (a category 2 species for federal listing) is now known to be present.

ECSD has recommended against the siting of ponds in defined stream channels in other sensitive watersheds due to the disruption of natural vegetated buffers and their water quality functions, the disruption of stream corridors for their habitat value, and the potential for accumulation of contaminated sediments in the ponds and their subsequent resuspension and dispersal into downstream areas during flood events. For these reasons, the regional plan should be re-examined before further implementation.

E. Potential Future Water Quality Investigations

Future investigations could be conducted to further define the threats to water quality in Bull Creek and to help design the most appropriate response strategy.

Based on the results of the preliminary investigation of Bull Creek water quality, some follow-up investigations may be warranted. Depending on Council priorities, staff availability and funding, investigations that will be considered include:

- Investigation of existing water quality degradation, possibly including:
  - biological assessments;
  - additional undeveloped vs developed tributary monitoring; and,
  - periodic high fecal coliform levels at Bull Creek Park.
- Pollutant source identification for:
  - the high TDS and nitrogen concentrations in Tributaries 2 & 6;
  - the high COD levels near the mouth of Bull Creek; and,
  - the high nitrogen and TDS concentrations of groundwater in developed areas.
- Evaluation of additional pollution control and prevention measures including:
  - maintenance procedures and leak detection in areas with high nitrogen (Note: Current State requirements for the Edwards Aquifer do not cover the Bull Creek portion of the Edwards Aquifer);
  - enhancement of public education efforts to minimize nitrogen application and to promote xeriscape and small lawn areas; and
  - water quality and stormwater controls that maintain baseflow quality, possibly including those allowing infiltration as a control measure.

IX. PUBLIC PARTICIPATION

A. Forums for Public Participation

Throughout the study period, the residents of the Bull Creek watershed provided valuable comments, critiques and suggestions about the Bull Creek/RM 2222 report. Citizens provided input through a variety of venues, including regularly scheduled "focus group" meetings, letters and phone calls, as well as personal visits and meetings with city staff. Some residents supplemented city monitoring data with observations and information on water quality that they had gathered themselves, or took city staff to sites along the creek to point out areas of particular concern.

Four focus group meetings were held during the study period, providing an opportunity for anyone interested to receive updates on the direction, progress and draft results of the study. Representatives of the City Council, the Planning Department and ECSD were present at each meeting to answer citizen questions and respond to comments and suggestions.

B. Major Citizen Comments, Questions, and Input

During the period of the study, citizens raised many questions about the environmental portions of the report, and made several major comments about its scope and assumptions.

From the beginning of the study, one of the assumptions has been the successful implementation of the Balcones Canyonlands Conservation Plan. The pollutant load and other land use dependent variables all assume that the BCCP will be enacted and that major areas of the Bull and West Bull Creek watersheds will be set aside for habitat preserve. Many citizens wanted to know the impact on the watershed if the BCCP were not fully implemented. Staff explained that although the defeat of the county bonds for BCCP acquisition might alter the study's assumptions, the actual outcome would be very hard to predict. The city has already purchased many preserve areas, and could purchase more, independent of a formal BCCP. With no regional BCCP, the U.S. Fish and Wildlife Service would require 10a permits from every development, and this could result in even more restrictions on development than would exist under the BCCP. It would add significantly to the expense of any project and cause a slowing of the development process, if not abandonment of potential developments. However, the variety of biological, political and economic factors that would come to bear and the limited time allotted for this study did not allow for a full examination of the many possible outcomes of BCCP.

ECSD did perform one iteration of the Simple Pollution Loading Model in which 50% of the lands currently proposed as acquisition areas for the BCCP were assumed to be available for development. This was not an attempt to predict nor suggest what decisions would be made by the City of Austin, the U.S. Fish and Wildlife Service nor any other entity in the wake of a failure of the county bond election for

BCCP purchases. The only purpose of this exercise was to demonstrate the importance of land acquisition on water quality in Bull and West Bull creeks.

Long time residents noted that significant changes in the creek have already resulted from the development which has occurred in the past ten or fifteen years. They wanted the study to address the impact of existing development as well as potential new development. ECSD has addressed this request by including the contribution of existing land uses in the report analyses. Additionally, the list of alternatives in the conclusion of this section includes options designed to help control runoff from already built developments. As sampling data became available which illustrated the impact of existing development on the creek, many citizens reemphasized their desire that retrofits of existing land uses seriously be considered in any implementation plan.

Many citizens were concerned that much of the needed infrastructure expansions, such as road widening and the extension of water and wastewater lines, can degrade water quality in the creek. Although on-site pollution controls are required in any construction project, residents cited the large amount of sediment fouling of Bull Creek near the widening of RM 2222 as evidence that these controls are inadequate. Although the expansion of RM 2222 is a State project and exempt from City ordinances, the point is still valid.

One common concern was that money not be spent on retrofits in areas where money to pay for those retrofits is not being collected. Many were tired of City taxes going to benefit areas outside the city. The extension of City services and associated City revenue collections to the entire Bull creek watershed is one of the alternatives presented in the final portion of this section of the report.

Neighbors commented that they have witnessed developments that received their initial approval many years ago, make only the legal minimum of progress necessary to avoid revocation of their approval. They expressed frustration that these developments are allowed to sit, with effectively no activity, for far too long before their permit expires. City council has taken action recently to address some of these concerns, and additional opportunities for action remain.

Another major area of concern was the perception that many approved projects in various stages of development violate the spirit, if not the letter of the Lake Austin Ordinances and the Comprehensive Watershed Ordinance. Many of the local area residents feel that the CWO, as currently interpreted and enacted, has fallen far short of adequately protecting Bull Creek. Some of their frustration stems from a lack of full understanding of exactly what the Lake Austin ordinances and CWO can and can't do. Considering the complexity of watershed regulation in Austin, this confusion is very understandable. Although much of the evidence given was anecdotal, the general feeling is that the water quality in Bull Creek and West Bull Creek is definitely declining. Furthermore, citizens generally believe that whether due to grandfathering or loopholes, variances and exemptions, existing regulation is not adequately protecting the creek.

C. Citizen Suggestions and Recommendations

The five major environmental recommendations developed by citizens for consideration by city staff and Council include:

1) City should act decisively and quickly to protect what is still relatively high water quality in Bull and West Bull creeks before further degradation can occur;
2) The city should get a clearer picture of the already approved developments, and understand the impact of everything in the "approval pipeline" before approving any more development;
3) The development review and inspection procedures should be tightened to make sure all new development follows as strictly as possible the existing CWO;
4) Existing developments should contribute equitably to the cost of clean-up;
5) A masterplan is needed for the watershed, comprehensively addressing the all issues of development and development impacts.

D. Groups/Organizations Represented during Public Participation Events

The following groups participated in scheduled events during the preparation of this study:

2222 Coalition of Neighborhood Associations
Bull Creek Homeowners' Association
Cat Mountain Homeowners' Association
Colorado Riverwatch
Courtyard Homeowners' Association
Glenlake Homeowners' Association
Jester Homeowners' Association
Las Canteras Development
Lakewood Club Neighborhood Association
Long Canyon Homeowners' Association
Meadows of Cat Mountain Neighborhood Association
North Cat Mountain Neighborhood Association
North Oaks Neighborhood Association
Northwest Hills Neighbors
Real Estate Council
Richardson Verdoorn
Riverplace Residence Community Association
Stoneledge Condominiums Neighborhood Association
Texas Commerce Bank- Austin
Upper Bull Creek Neighborhood Association
WHM Transportation Engineers

X. IMPACTS OF DEVELOPMENT ON ENDANGERED SPECIES HABITAT

A. Overview of Endangered Species and Impacts of Urbanization

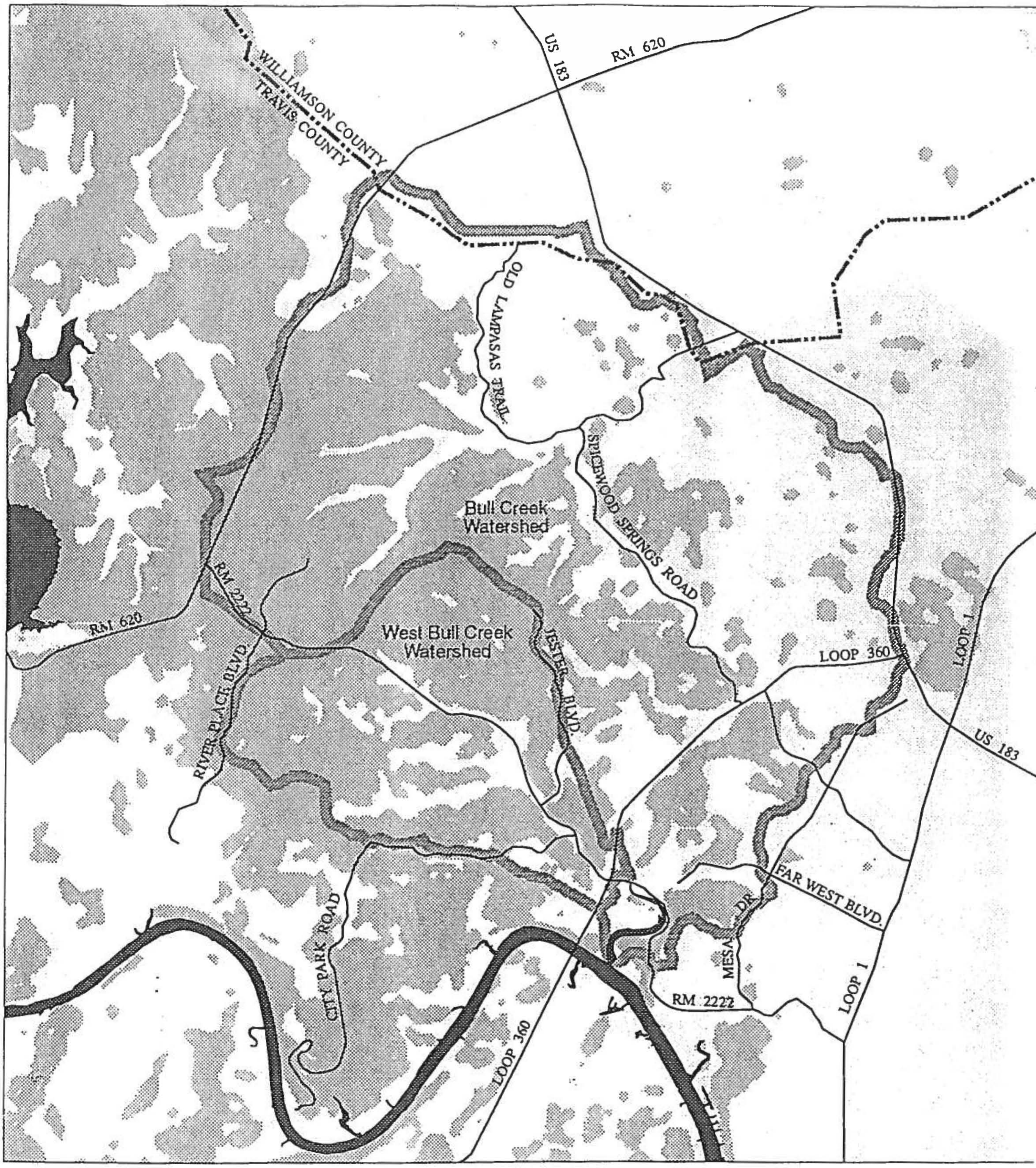
Endangered and rare species in the Bull Creek and West Bull Creek watersheds

The Bull Creek and West Bull Creek watersheds contain suitable habitat for a variety of endangered and rare plant and animal species. The following federally-listed endangered species, two neotropical migrant songbirds and six karst invertebrates, are known to occur within this region: golden-cheeked warbler (*Dendroica chrysoparia*), black-capped vireo (*Vireo atricapillus*), Tooth Cave spider (*Neoleptoneta myopica*), Tooth Cave pseudoscorpion (*Tartarocreagris texana*), Bee Creek Cave harvestman (*Texella reddelli*), Bone Cave harvestman (*Texella reddelli*), Tooth Cave ground beetle (*Rhadine persephone*), and Kretschmarr Cave mold beetle (*Texamaurops reddelli*). Figure 22 illustrates the known and potential habitat of the golden-cheeked warbler and the black-capped vireo in the Bull Creek watershed. In addition, the following federally-listed Category 2 species are also found in the region: bracted twistflower (*Streptanthus bracteatus*), canyon mock-orange (*Philadelphus ernestii*), and the Jollyville salamander (*Eurycea* sp.). Category 2 species are species which are currently under consideration by the U.S. Fish and Wildlife Service to be added to the Federal Endangered Species list.

The Bull Creek/West Bull Creek region is characterized by a very diverse flora, including an inordinate number of uncommon and local species which are at the edge of their range. In addition to the bracted twistflower and the canyon mock-orange, there is a single record in the Bull Creek drainage of *Tetraclea viscida,* a small wildflower known from fewer than six records in Travis and Uvalde counties. Other plants of concern in the region include low loostrife (*Lythrum ovalifolium*), the Texas leatherflower, (*Clematis texensis*), crossvine (*Bignonia capreolata*), woods bedstraw (*Galium circaezans*), and Ozark savory (*Satureja arkansana*). Heller's marbleseed (*Onosmodium helleri*) has been previously considered very rare but recent work indicates that it is fairly common locally along Bull Creek, its tributaries, and other drainages in this region.

Golden-cheeked warblers are obligately dependent on large blocks of mature juniper-oak woodlands for nesting habitat. Such woodlands usually have a canopy cover of 60 to 100 percent and these are usually 15 to 40 feet tall. Large blocks of warbler habitat may still be found in the West Bull Creek basin along FM 2222.

The black-capped vireo is a species in serious decline in Travis County. At present, one of the largest populations of vireos known in the world occurs in the Four Points area. The black-capped vireo requires blocks of second-growth brushy habitat on ridges and flatter slopes.



City Limits
(Full and Limited Purpose)

Known and Potential
Golden-Cheeked Warbler and
Black-Capped Vireo Habitat

Figure 22

Known and Potential
Golden-Cheeked Warbler and
Black-Capped Vireo Habitat

Habitat loss and fragmentation: golden-cheeked warbler & black-capped vireo
A large body of scientific literature exists which documents the negative effects of habitat loss and fragmentation on indigenous plants and animals, including the golden-cheeked warbler and black-capped vireo (Whitcomb et al. 1981; Marshall, et al. 1985; Wilcove 1985; 1988; Wilcove, et al. 1986; Soulé, et al. 1988; Robbins, et al. 1989; Sexton 1989; Shaw et al. 1989; Wahl et al. 1989; Terborgh 1989; Engels & Sexton in press). Land-clearing and forest fragmentation is primarily responsible for the recent population declines for these two species in Travis County (Biological Advisory Team 1990). Limiting further habitat loss and fragmentation in the Bull Creek and West Bull Creek watersheds will be especially critical for the protection of the golden-cheeked warbler, because this region contains the largest contiguous block of habitat for this species in its entire breeding range (Wahl et al. 1989; Shaw et al. 1989).

A substantial amount of habitat conversion has already occurred in the Bull Creek and West Bull Creek watersheds due to urban development. As a result, less than one-third of the region still exists as actual or potential habitat for the species listed above. Major urban developments which have contributed to habitat loss and fragmentation in these watersheds include those in Jester Estates, Long Canyon, Great Hills, Northwest Hills, and Anderson Mill Estates areas. The construction of numerous roadways, especially RM 2222, has also fragmented the habitat for these species.

Other impacts to the warbler & vireo
In addition to habitat loss and fragmentation, there are other impacts to endangered species which are associated with human activity in these two watersheds. For example, the vegetation in certain open space areas has been adversely affected by off-road vehicle and mountain bike usage. Such activity usually results in soil erosion problems, as has occurred on the Forest Ridge tract (north of Jester Estates and adjacent to Loop 360) which was recently purchased by the City of Austin.

The harmful effects of livestock grazing and browsing on neotropical migrating songbirds such as the golden-cheeked warbler and black-capped vireo is widely known and well documented (for a review, see Brittingham & Temple 1983; Terborgh 1989). Among other impacts, cattle and other livestock species are associated with elevated densities of brown-headed cowbirds, which are brood parasites for both the warbler and vireo. In addition, grazing and browsing by domestic livestock can cause both substantial vegetation damage and water degradation.

Traffic noise along RM 2222, Loop 360, and RM 620 is also believed to be negatively affecting both the warbler and vireo in nearby nesting habitat (D.L. Steed, pers. comm.). Unfortunately, very little scientific data exists yet to document this potential impact. Nevertheless, expansion of existing roadways should be very carefully considered.

B. Water quality degradation: Threats to the Jollyville Plateau Salamander and Karst Invertebrates

Potential threats to water quality in this region include pollutants introduced from urban runoff, construction site erosion into creeks, improperly managed package treatment plants and on-site wastewater treatment systems, illegal dumping, animal wastes, and nutrients from landscaped areas washing off into streams. Existing greenbelts and vegetative corridors along creeks, use of water quality buffer zones and overland flow (rather than concentrating drainage in storm sewers), and control of erosion at construction sites help mitigate the effects of urban runoff and lower the pollutant load in area creeks and drainages.

Because the Jollyville Plateau salamander is closely associated with spring discharge, changes in groundwater recharge and discharge and water quality may adversely affect populations. Among the constituents which may affect the health of a salamander population are oil and grease, heavy metals, organochlorine and organophosphorus pesticides and herbicides, and bacteria (Kirkpatrick and Mahler 1992). Although no data are available regarding the effects of specific pollutants on a salamander species such as this, it is likely that any substantial degradation of water quality could be detrimental to the survival of populations of these amphibians (Chippindale et al. 1993).

Little is known about the habitat requirements of the karst invertebrates which are found in the Bull Creek/West Bull Creek watersheds. However, a recent U.S. Fish & Wildlife Service (1993) report indicates that:

> Because karst is highly susceptible to groundwater contamination, urbanization (including industrial, residential, road, and commercial development) may result in the contamination of karst ecosystems. Types of contaminants associated with urbanization may include chemical, sewage, and oil pollution. These pollutants are derived from general urban runoff (non-point source pollution); broadcasting, spraying, and fogging pesticides and fertilizers; transportation and pipeline spills; storage tank leaks; power transformer accidents; industrial accidents; leakage from septic systems, landfills, and sewer lines; and other sources.
>
> The same report also states that "[b]ecause karst ecosystems depend on air-filled voids with some water infiltration, diverting water away from a cave could lead to the direct mortality of many karst faüna. Increasing water infiltration could also lead to flooding and loss of air-breathing species. Altering the quantity of water inflow would result in changes in the nutrient input."

Development in recharge zones introduces impervious cover, thereby altering drainage patterns and potentially diminishing spring flow or causing physical damage of small springs. Runoff from construction sites can carry silt into the karst openings and springs and may plug or fill such areas. Therefore, existing scientific information suggests that urban development in the vicinity of karst features will significantly harm its occupying fauna.

The numerous separate localities occupied by the Jollyville Plateau salamander may offer some buffering against local extinction events simply by their number. However, these springs are frequently supported by highly localized recharge zones with limited contributing drainages. Much of the recharge supporting the Jollyville Plateau springs is on highly developable (and developing) plateau tops. The spring locations themselves often occur in very close proximity (a few feet to a few hundred feet) to rapidly urbanizing areas. Physical damage to these small localized Jollyville Plateau springs has occurred in the past and potentially may occur in the future as urbanization proceeds close to them. The close proximity of urban sources of potentially detrimental water quality inputs offers extremely limited distances and times for attenuation or amelioration by the local karst systems.

C. <u>The BCCP in the Bull Creek and West Bull Creek watersheds</u>

The Balcones Canyonlands Conservation Plan (BCCP) proposes to acquire several thousand acres of land in the Bull Creek and West Bull Creek watersheds for the protection of endangered and rare species in the region. These two watersheds comprise all of the BCCP's "Bull Creek macrosite" and the northern part of the "North Lake Austin macrosite". Most of the Bull Creek/West Bull Creek watershed area is contained within the BCCP's Bull Creek macrosite.

The Bull Creek macrosite is delineated by RM 2222 and RM 620 on the south and west, U.S. Hwy. 183 on the north, and Loop 360 and Mesa Drive on the east. Most of the undeveloped land in this macrosite supports good golden-cheeked warbler habitat as well as botanically rich communities and numerous springs, seeps, and associated hydric habitats (wetlands). The Bull Creek macrosite has a total area of approximately 17,744 acres. It is centrally located within the preserve system, and contains significant populations of most of the species listed above. The entire macrosite contains approximately 9,502 acres of karst-forming strata, 3,093 acres of potential habitat for the rare plants, 4,880 acres of potential vireo management areas, and 5,591 acres of potential warbler habitat.

The recommended preserve area includes approximately 5,995 acres. This would encompass an estimated 3,090 acres containing karst-forming limestone, 3,423 acres of potential black-capped vireo management areas, and 2,976 acres of potential golden-cheeked warbler habitat. Golden-cheeked warbler habitat within the Bull Creek macrosite that is not included for acquisition is generally highly fragmented or impacted by existing development. The potential preserve area includes approximately 1,673 acres which are identified as potential habitat for both bird species. Additional research will be required to determine the actual amount of existing and potentially manageable habitat that occurs for the vireo and warbler within the proposed preserve unit.

This area is also important for the Jollyville Plateau salamander which, in the Bull Creek macrosite, occurs in Stillhouse Hollow Springs, Bull Creek Spring, Schlumberger Spring, Bull Creek Tributary Spring, Barrow Hollow Spring, Horse Thief Hollow, and Canyon Vista Springs. Of these locations, only Canyon Vista Spring is not included within the Bull Creek preserve unit. Additional research is necessary to determine the actual distribution of this species and appropriate protection measures.

A large population of canyon mock-orange occurs in the vicinity of Jester Estates. Bracted twistflower is known from localities in the vicinity of North Cat Mountain and Cat Mountain (McNeal, 1989).

The long-term viability of the Bull Creek preserve area is high for the several species of concern occurring in the macrosite, assuming that properties are secured to form a contiguous preserve without significant developed in-holdings. Approximately 638 acres of public/institutional lands within this macrosite are potentially available for preserve management, including portions of City of Austin parks and preserves, other city-owned lands, and the 3M Company St. Edwards tract (title to which is now held by The Nature Conservancy).

The Jester Estates subdivision represents an existing intrusion into any possible preserve design in this macrosite, and poses a significant challenge to management for the species of concern in the area, particularly for the golden-cheeked warbler and a large population of canyon mock-orange. Aside from property acquisition, landowner cooperation will be necessary to restrict activities which could jeopardize the species of concern in parts of this proposed preserve, particularly in the vicinity of the plant localities.

<u>Minimum Specifications of the BCCP Bull Creek Macrosite</u>.
The Bull Creek preserve unit is considered essential to the BCCP and is recommended to include a minimum of 5,200 acres. The outer boundaries of this preserve should be no more than 0.5 mile from the North Lake Austin preserve unit and 0.75 miles from the Cypress Creek preserve unit. The central core of the Bull Creek preserve unit would be configured to have a minimum width of 5,500 ft and a maximum of 20% of the total area occurring within 330 ft of the boundary.

<u>Preserve management; recreational uses</u>
The primary goal of the BCCP preserve management is to protect viable populations of the species of concern. All other uses of the BCCP preserves, including human uses, are secondary. The prioritization of management goals and activities will be based upon regular population assessments of the target species, and will consider all current and historical scientific research in order to fulfill the primary goal. The highest priority will be given to management policies designed to arrest the decline in populations of the species of concern.

The BCCP preserves will consist of a number of seperate preserve units. These preserve units will be owned by a variety of government, non-profit entity and private landowners. The management of the preserve lands may fall into three classifications:

1. Lands owned by member institutions of the BCCP Coordinating Committee and managed to BCCP standards by the member.

2. Lands purchased by or donated to BCCP members and then owned and managed by Texas Parks and Wildlife Department as the lead management entity for the BCCP.

3. Lands owned and managed by entities other than the BCCP members which have entered into an agreement to manage preserves in compliance with BCCP standards using guidelines developed by Texas Parks and Wildlife Department.

All BCCP preserves in the Bull Creek and West Bull Creek watersheds will be managed in accordance with Texas Parks and Wildlife Department's BCCP Management Standards and Guidelines. This document also outlines the recreational uses which will be permitted within these preserves. All management plans for BCCP preserves will be reviewed and approved by TPWD before they are implemented.

Timing of preserve acquisition
The BCCP proposes to complete all preserve acquisition in the Bull Creek and West Bull Creek watersheds within three years after permit issuance by the U.S. Fish and Wildlife Service. Issuance of the permit is anticipated in May 1994.

Utility corridors
Infrastructure Corridors are located within BCCP preserves to provide for the essential and continuing public needs for utilities and roadways. New facilities will be routed outside of the habitat preserves, except as provided for by the plan. Changing conditions over the life of this permit may require the addition or realignment of corridors.

The BCCP identifies two types of corridors which currently exist in the preserve area: primary corridors and secondary corridors. The plan also addresses all corridors which are planned in the future.

Primary corridors are existing corridors that already have utility or roadway structures within them and that should receive the major share of new structure development and service activity in the future. There are two sub-types of primary corridors:

1. Those corridors of critical importance into which considerable new activity will be channeled. These corridors may be widened up to the maximum width specified, but the anticipated loss of preserve due to this future expansion shall be balanced by increasing the size of the acquired preserves to compensate at a 1

acre to 1 acre ratio if the corridor runs along a preserve boundary, or at the prevailing rate if it is interior to the preserve.

2. Major corridors of high importance, which may need at some time in the future to be widened in whole or in part. No widening shall take place, however, until the preserve acreage to be lost is replaced at the prevailing ratio for mitigation. This mitigation land must be contiguous to an existing preserve, and should preferably be added to the macrosite from which acreage is taken.

Secondary corridors are existing corridors which already have utility or roadway structures within them and for which no widening is to occur. There are two sub-types of secondary corridors.

1. Corridors that should not receive additional development that would contribute to loss of habitat outside of the corridor.

2. Corridors that should be phased out if and when possible.

Planned corridors are corridors in which facilities have not yet been constructed. Any anticipated future loss of habitat shall be balanced by increasing the size of the acquired preserves to compensate at a 1 acre to 1 acre ratio if the corridor runs along a preserve boundary, or at the prevailing rate if it is interior to the preserve. The newly acquired land should preferably be added to the macrosite from which acreage is taken.

<u>Existing Facilities</u> - An inventory of existing facilities reveals that several already cross or intrude in the Bull Creek area which is designated for purchase and/or dedication of habitat preserve. These are illustrated in a general way in a map entitled "BCCP Existing Facilities" which is available for review at the City of Austin's Environmental & Conservation Services Department. However, not all existing facilities are shown on the map, since some providers did not participate and not all records were located. Furthermore, at the time these guidelines were formulated, the precise boundaries of the habitat preserves were unknown.

Unless otherwise designated, all existing easements, rights-of-way and sites of all existing facilities shall be designated as Secondary A type infrastructure corridors, whether or not they are located or shown on maps prior to BCCP approval. However, existing service lines (feeds) to individual structures shall be designated as Secondary B type corridors. The Preserve Management Authority shall recognize the rights that accompany the existing easements, rights-of-way (ROW) and sites, subject to the new construction and operation and maintenance (O&M) guidelines in this section.

For the purposes of the BCCP application documents, no attempt has been made to document the precise locations or characteristics of existing facilities and their corridors. This will be done in the Preserve Management Plans.

As individual properties are acquired and/or dedicated for habitat, the existing infrastructure easements, ROW and sites shall be precisely located (previous survey documents may be adequate). As the Preserve Management Plans are created for each preserve unit, these plans shall document the existing easements, ROW and sites, and show each of them as infrastructure corridors.

Opportunities will be sought in the future to eliminate the existing corridors that are no longer needed. However, the corridor designation of existing easements, ROW and sites can be removed only with the consent of all service providers owning an interest in the easement, ROW or facilities.

Replacement facilities and new facilities may be placed in existing corridors in accordance with the guidelines for new construction and O&M, and in compliance with the restrictions associated with the type of corridor. Any utility provider may negotiate an agreement with the owner of the easement or ROW to share the use of such easement or ROW, subject to the new construction and O&M guidelines in this section.

<u>Roadway Corridors -</u> The previously mentioned map entitled "BCCP Existing Facilities" shows the public roadways that cross or border the designated preserve areas.

<u>Electric Corridors</u> - Electric <u>transmission</u> corridors contain higher voltage electrical lines, the purpose of which is to transport electricity around the system to various substation locations. Transformers at the substation locations "step down" the voltage to a distribution voltage level. <u>Distribution</u> lines are routed to the individual commercial and residential customers to provide service. Electric <u>distribution</u> corridors do not contain transmission lines.

Transmission lines have wider easement requirements and clearances from the ground and other objects due to the higher voltages and design code requirements. These lines can be built with steel mono-pole structures, steel lattice towers, or wood poles. These lines are typically accessed for purposes of routine maintenance or emergency situations such as storm-related outages.

Distribution lines are typically seen as the smaller wood structures built parallel to roadways, and which also have telephone and cable service lines attached. Distribution lines are sometimes laid underground.

Electric transmission lines shall be designated as Primary B type corridors. Distribution lines will be designated as Secondary A type corridors, unless located within roadways of higher designation or transmission line corridors.

<u>Planned Corridors -</u> The need for a limited number of new corridors is anticipated. Planned corridors should be restricted to the absolute minimum required to insure public safety and essential service. The general locations of these corridors are illustrated in a map entitled "BCCP Planned Corridors and Special Use Tracts"

which is available for review at the City of Austin's Environmental & Conservation Services Department. Every effort will be made by the service providers to design these new corridors so that the impact on habitat will be minimized. The preserve landowner shall allow for the acquisition of easements for approved corridors. The planning and implementation of the new corridors shall be negotiated between the preserve landowner, the service provider or designated entity seeking the easements, the Preserve Management Authority, and the Coordinating Committee.

D. Individual Section 7 Consultations & Section 10(a) Applications

There are several Section 7 consultations and Section 10(a) applications which have either been completed or are pending in the Bull Creek and West Bull Creek watersheds. These are all summarized in Tables 3 and 4.

Completed consultations and approved permits have allowed a substantial amount of urban development to occur in these watersheds and have somewhat compromised the quality of habitat for species of concern in the region. Therefore, the economic benefit of further development in these watersheds must be very carefully considered against the harm to its biodiversity.

Table 3

Section 7 Consultations in the Bull Creek & West Bull Creek Watersheds

October 20, 1993

Development Name	Applicant	Acres	Species	Date Initiated	Status
Jester Point 2 (I)	Jester Estates	425	warbler cave invertebrates	June 1990	completed
RM 2222 (Loop 360 to 0.2 mile W of Jester Blvd.)	Texas Dept. of Transportation		warbler	June 1990	completed
3M Austin Center	3M Austin Center	ca. 100	warbler	July 1990	completed
RM 620 (Debba Lane to RM 2222)	Texas Dept. of Transportation		warbler vireo cave invertebrates	March 1991	completed
Jester Point 2 (II)	Jester Estates	425	warbler cave invertebrates	August 1991	completed
River Place	Sierra Development	1453	warbler vireo	September 1992	completed
Canyon Creek	FAMCO Services, Inc.	1327	warbler cave invertebrates Jollyville salamander potential vireo	March 1993	pending

Table 4

Section 10(a) Applications in the Bull Creek & West Bull Creek Watersheds

October 20, 1993

Development Name	Applicant	Acres	Species	Date Submitted	Status
LakeLine Mall	H. Co., Simon LakeLine Mall Partnership	116	cave invertebrates	November 1991	completed
Canyon Ridge	Beard Family trust	198	warbler mock-orange	October 1992	completed
Spicewood at Bull Creek	Richland Bull Creek Associates	182	warbler	March 1993	pending
Great Hills Reserve	Crown Oaks, Inc.	280	warbler	May 1993	pending
Overlook at Cat Mtn.	Overlook, Inc.	213	warber vireo		application in prep.

E. Recommendations

Assuming that the BCCP permit is issued by the U.S. Fish and Wildlife Service in 1994, endangered and rare species in the Bull Creek/West Bull Creek watersheds, including the Jollyville Plateau salamander and karst invertebrate species, will be adequately protected from the impacts of future urban development in the area.

Since much still needs to be known regarding the effects of water quality degradation on the Jollyville Plateau salamander and the karst invertebrates, however, further biological and hydrogeological studies would augment the BCCP's protection strategy. Potential avenues for funding of these studies include the BCCP, mitigation requirements of other individual Section 10(a) permits and Section 7 consultations, and federal funding as authorized under Section 6 of the Endangered Species Act.

Texas Parks and Widlife Department has recently assembled a Biological Advisory Team to examine the effects of urban development on rare aquatic species, including the Jollyville Plateau salamander, in Travis County. It is anticipated that this team of experts will issue a report in early 1994 containing specific recommendations concerning future studies needed for adequate protection of this species. These recommendations will be incorporated into phase IV of the BCCP Section 10(a) permit application.

Studies which may potentially enhance the protection of the Jollyville Plateau salamander and the karst invertebrates include the following:

- Continued biogeographic survey of potential salamander habitat areas
- Research to identify water quality threats to the Jollyville Plateau salamander
- Study of nutrient input to karst features
- Continued biogeographic survey of karst areas
- Geologic and hydrogeologic studies of karst areas identified for protection
- Continued baseline karst ecology studies to describe the microclimate, organic input and biotic components of, and seasonal variation in cave systems supporting endangered cave invertebrates

The time and cost allocation which will be needed to complete these studies is unknown at this time.

XI. CONCLUSIONS

Some of the results of this study should be considered preliminary because of the relatively short time-frame in which it was performed; however, the results have provided some immediate information that can be used to protect the water quality of Bull Creek. In particular, the importance of the BCCP land acquisition to the long-term protection of Bull Creek water quality protection was demonstrated. The need for some basic improvements to the City's water quality regulations also became apparent. If the improvements are enacted, then a higher level of water quality protection will be provided not just for Bull Creek , but for most of the City of Austin.

The report and investigations also provide some direction for City planning and future water quality protection. Annexation and/or Drainage Utility service area expansion has been shown to be an important consideration with respect to implementing retrofitting and other pollution prevention measures in the Bull Creek watershed. The results of the field investigations and data evaluations have provided significant findings relative to specific pollution problems and sources in the Bull Creek watershed and have added to the technical base for implementing pollution control and prevention throughout the City. With the staff and funding provided through the Non-urban Watersheds Program of the Drainage Utility, specific follow-up studies on Bull Creek and similar intensive studies of other non-urban creeks can be performed in the future.

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