Glen
FILE
CPW-Library

# PRELIMINARY WHITES CREEK BASIN MANAGEMENT STUDY

## (SECOND DRAFT)

Prepared For:

WASHOE COUNTY

DEPARTMENT OF PUBLIC WORKS

By:

CELLA BARR ASSOCIATES
777 Campus Commons Road, Suite 200
Sacramento, California 95825

April 4, 1994
CBA File No. 530013-01

# PRELIMINARY WHITES CREEK BASIN MANAGEMENT STUDY

## (SECOND DRAFT)

Prepared For:

WASHOE COUNTY

DEPARTMENT OF PUBLIC WORKS

By:

CELLA BARR ASSOCIATES
777 Campus Commons Road, Suite 200
Sacramento, California 95825

April 4, 1994
CBA File No. 530013-01

PROFESSIONAL ENGINEER-STATE OF NEVADA
JAMES H. NELSON
CIVIL
No. 8810

4-4-94

# TABLE OF CONTENTS

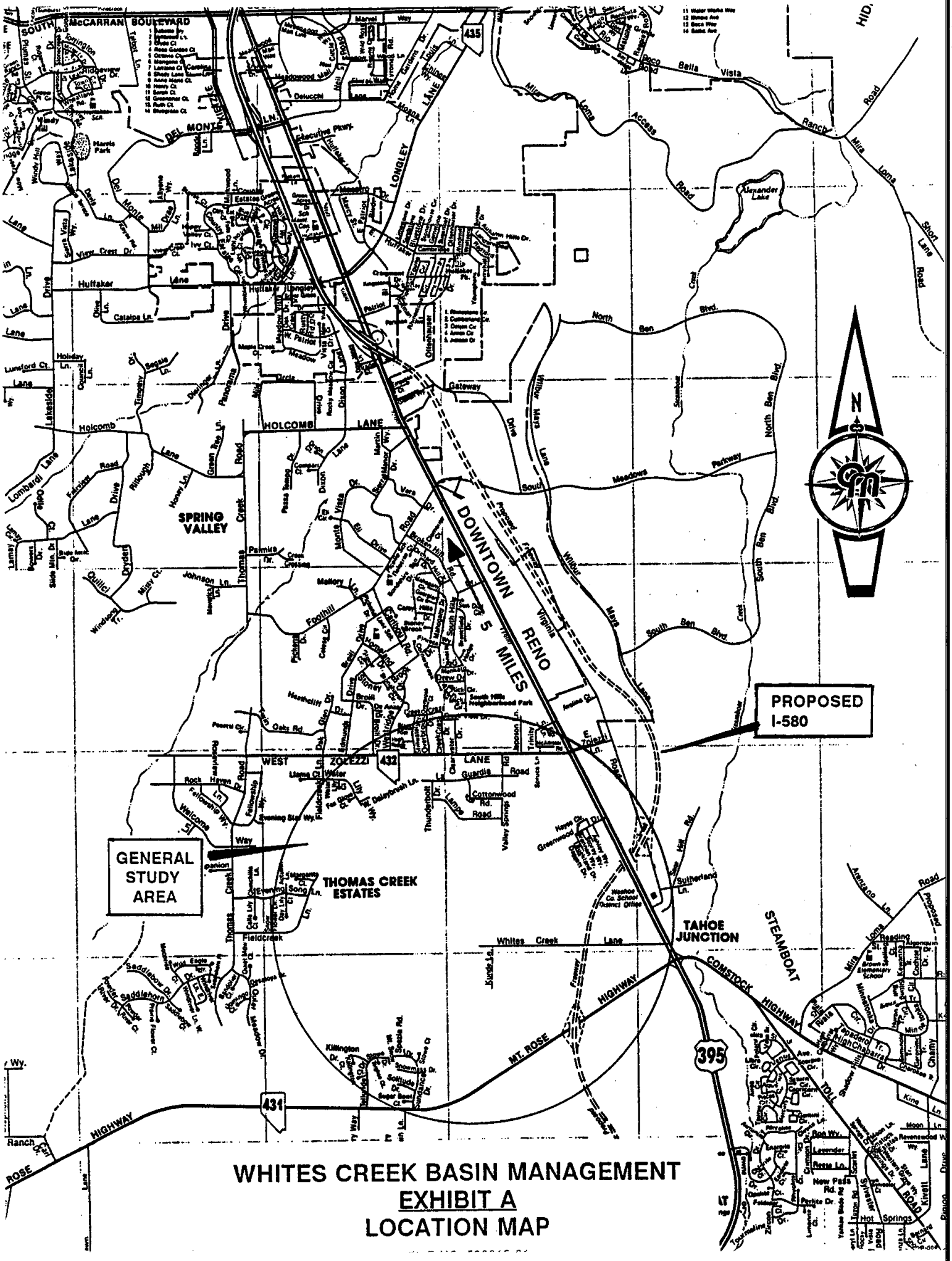
# LIST OF EXHIBITS

## INTRODUCTION

This document is the second draft of a Preliminary Basin Management Study performed for the lower Whites Creek watershed located approximately five (5) miles south of downtown Reno, Nevada (see Exhibit A, Location Map). This Preliminary Basin Management Study has been formulated in response to active new development and infrastructure construction occurring within the area and the existence of a unique set of flood hazards. Conclusions and recommendations provided herein have been based upon a review of available information, discussions with several key individuals, workshops, field reconnaissance and cursory calculations.

The purpose of this Preliminary Basin Management Study is to derive a unified set of conclusions with respect to existing flood hazards and develop interim policies for new development and infrastructure improvements within the watershed. Conceptual flood control measures are also recommended, as appropriate.

Much of the information presented herein is envisioned to be subsequently enhanced and supplemented by more detailed studies, which will undoubtedly serve to revise some of its conclusions and recommendations. Until such studies are performed or until other factors impact the information presented in this document, the interim policies shall be utilized for regulating the drainage design of new development and infrastructure projects, once this draft report becomes finalized.




# WHITES CREEK BASIN MANAGEMENT

## EXHIBIT A

## LOCATION MAP

# I. DATA COLLECTION AND RECONNAISSANCE

## A. Literature Review

In accordance with the Whites Creek Basin Management Scope of Work, the studies, reports and plans listed below were reviewed. Following each listing is a brief and general description of the pertinent information contained therein.

- **Regional Water Study: Concept Level Report - Washoe County Flood Control Master Plan, Volumes I and II; prepared by Kennedy/Jenks/Chilton in association with Kato & Warren, Inc. and FCS Group, Inc.; January, 1991.**
  - Conceptual level flood control master plan for Washoe County intended to provide an estimate of the overall program costs, establish the general level of long-term capital needed, and develop a recommended institutional structure and funding plan.

  - Existing hydrologic data were used to develop a regional relationship between watershed area, average stream slope, 100-year rainfall depth, and 100-year peak discharge, resulting in a 100-year peak discharge of 3100 cfs for the Whites Creek watershed. Flood control improvements identified include a detention site on Whites Creek at the location where Whites Creek divides into four (4) distinct channels, and replacement of existing structures with improved culverts at Thunderbolt Street, La Guardia Road, Zolezzi Lane, U.S. 395 and Old Virginia Road for a total cost of $345,000.

- **I-580 Concept Drainage Study prepared for the Nevada Department of Transportation (NDOT); Plans for I-580 north of Highway 341.**
  - CBA has had several discussions with the Hydraulics Division of NDOT regarding the status of drainage structure design for I-580 along the base of the Whites Creek watershed and has reviewed current Plans for I-580. At this time the drainage design has not been finalized; however, it is proposed that several structures will be provided beneath I-580 to pass the projected 100-year flows resulting from splitting the total 100-year flow amongst the four (4) branches of Whites Creek.

- **Feasibility Study for Huffaker Detention Facility near the City of Reno, Washoe County, Nevada; prepared for Washoe County Public Works in cooperation with City of Reno Engineering by Nimbus Engineers; February, 1990.**
  - Examination of the feasibility of constructing a detention dam at the Huffaker Narrows, upstream of the proposed Mira Loma crossing of Steamboat Creek. A study of alternatives, resulting in the proposed detention site, was originally undertaken to provide all-weather access to the Truckee Meadows area east of Reno, including the Hidden Valley area. The analysis included development of detailed hydrology for the

109-square-mile Steamboat Creek watershed, which includes Whites Creek. The study states that the majority of flow from Whites Creek occurs as sheet flow across meadow or pasture land, with velocities ranging from one (1) to three (3) feet per second.

- **Whites Creek Detention Facility Feasibility Study, Washoe County, Nevada; prepared for the Nevada Department of Transportation by Nimbus Engineers; revised June, 1993.**
  - Evaluation of the benefits of a detention basin on Whites Creek at the existing major flow split at Shadowridge Park, including detailed development of a 100-year peak discharge and runoff hydrograph using the Corps of Engineers' hydrologic computer model, HEC-1.

    The resulting 100-year peak discharge of 5100 cfs at the flow split was distributed amongst the four downstream branches of Whites Creek based on a ratio of available conveyance. This ratio, in turn, was based on cross-sectional channel geometries, slopes, and resulting water surface elevations derived from the Corps of Engineers water surface program, HEC-2. One-hundred year peak discharges divided among the four branches were estimated as follows:

    Channel #1: 700 cfs (14%)
    Channel #2: 1950 cfs (38%)
    Channel #3: 1100 cfs (22%)
    Channel #4: 1350 Cfs (26%)

- **Hydrologic Analysis of Thomas Creek, Dry Creek and Evans Creek, Washoe County, Nevada; prepared for the Federal Emergency Management Agency by Nimbus Engineers; August, 1990.**
  - Evaluation of existing hydrology studies and development of rainfall-runoff models for Thomas Creek, Dry Creek and Evans Creek. The discharges resulting from these models were recommended for use in a Flood Insurance Restudy for Thomas Creek, Dry Creek, and Evans Creek in Washoe County and the City of Reno, instead of discharges previously developed by FEMA and the Corps of Engineers.

- **Thomas Creek Detention Basin Study; prepared for the Technical Advisory Committee, Washoe County Regional Flood Control Master Plan by Kennedy/Jenks/Chilton; May, 1990.**
  - Development of specific hydrologic modeling for the Thomas Creek drainage basin and analysis of several stormwater detention/debris basin sites within the watershed for the Washoe County Regional Flood Control Master Plan. The purpose of this study was threefold: 1) to determine whether detention could be utilized in the watershed to reduce the sizes of planned drainage conveyance structures for U.S. 395 and I-580; 2) to analyze the potential for reclassifying the FEMA-based designation of the Thomas Creek Watershed as an alluvial fan; and 3) to prepare preliminary

design parameters for the detention dam/debris basin and channel improvements.

- **Flood Insurance Study for Washoe County, Nevada Unincorporated Areas; prepared by the Federal Emergency Management Agency (FEMA); revised April 16, 1990.**
  - This Flood Insurance Study (FIS) establishes peak discharges, water surface elevations, and floodplain and floodway limits for portions of the Truckee River, Steamboat Creek, Bailey Canyon Creek, Boynton Slough, North Truckee Drain, Dry Creek, and the four playas in Lemmon Valley. The FEMA alluvial fan methodology was used to study Galena Creek, Thomas Creek and Evans Creek. Approximate methods were utilized to study flooding caused by several creeks along the northern shore of Lake Tahoe and to study those areas having a low development potential or minimal flood hazards. The resulting Flood Insurance Rate Maps are used to set local flood insurance rates and to guide land development with respect to flood hazards. In this study, the peak discharge - frequency relationships for Steamboat Creek and tributaries were determined from regional analyses based on 18 moderate-sized, natural drainage basins in the Truckee River and Carson River basins.

- **Washoe County Flood Control Master Plan - Draft Final Report on Meteorological Analysis; prepared for Kennedy/Jenks Consultants by Henz Meteorological Services; September 29, 1993.**
  - A detailed meteorologic analysis whose purpose was to provide a 100-year precipitation event for Washoe County to use in HEC-1 rainfall-runoff modeling. A review of the study has been performed by HYDMET, Inc. and states that it actually provides the following: 1) Annual and seasonal depth-duration-frequency (DDF) precipitation maps and intensity-duration-frequency analyses; 2) Areal Reduction Factors for 100-year summer thunderstorm events; and 3) Orographic and temporal variations in rain/snow line and snowpack for 100-year winter rain-on-snow events. Values represented are higher than depicted on current NOAA atlases. The study has not been accepted by Washoe County at present.

- **Flood Plain Information - Southwest Foothills Streams (Evans, Thomas, and Whites Creeks & Skyline Wash), Reno, Nevada; prepared for the Regional Planning Commission of Reno, Sparks and Washoe County by the Department of the Army, Sacramento District Corps of Engineers; June, 1974.**
  - Information on past floods, and maps, profiles, and cross sections that indicate the approximate extent and depth of inundation of Evans, Dry, Thomas and Whites Creeks and Skyline Wash from the Intermediate Regional and Standard Project Floods.

  - Intermediate Regional Flood values (equivalent to the 100-year discharge) for Whites Creek, developed by the Corps of Engineers from available

streamflow and precipitation records and synthesized from records of other similar watersheds, are as follows:

| | |
|---|---|
| At Canyon Mouth: | 3,000 cfs |
| At Divide (mile 4.99): | 2,000 cfs |
| At Highway 395: | 2,300 cfs |

- **Water and Related Land Resources - Central Lahontan Basin, Truckee River Subbasin, Nevada...California: Flood Chronology, 1861-1976; based on a Cooperative Survey by the Nevada Department of Conservation and Natural Resources, the Resources Agency of California, and the United States Department of Agriculture; September, 1977.**
  - Presentation of a flood history of the Truckee River Subbasin of the Central Lahontan Basin, 1861-1976. This history is based on research of newspaper files and other historical archives and is concerned with three types of flood phenomena that have inflicted flooding and flood damage through the years of record: wet-mantle and rain-on-snow or frozen-ground events characteristic of late winter or early spring, and the dry-mantle event typical of localized summer thunderstorms.

- **Truckee River, California and Nevada - Hydrology; Office Report prepared by the Department of the Army, Sacramento District, Corps of Engineers; February, 1980.**
  - Presentation of basic hydrologic data and criteria for the Truckee River Basin for use in flood protection feasibility studies for the Truckee Meadows area near Reno, Nevada. The hydrologic characteristics of the basin are discussed, followed by analysis of flow frequencies and development of the Standard Project and Probable Maximum Floods resulting from winter type rain storms and summer-fall type cloudbursts. The peak flow for Whites Creek at Steamboat Ditch resulting from a Cloudburst Standard Project Flood, was estimated to be 8,700 cfs.

- **Flood Plain Information, Truckee River - Reno-Sparks-Truckee Meadows, Nevada; prepared for the Regional Planning Commission of Reno, Sparks, and Washoe County by the Department of the Army, Sacramento District, Corps of Engineers; October, 1970.**
  - Presentation of information on past floods, and maps, profiles and cross sections that indicate the depth and extent of flooding resulting from the Intermediate Regional and Standard Project Floods along the floodplains of the Truckee River; Steamboat Creek and its tributaries; Alum, Hunter, and Peavine Creeks; and the North Truckee Drain. The area covered extends northward from Huffaker Hills.

- **Flood Plain Information, Steamboat Creek and Tributaries, Steamboat & Pleasant Valleys, Nevada; prepared for the Regional Planning Commission of Reno, Sparks and Washoe County by the Department of the Army, Sacramento District Corps of Engineers; June, 1972.**
  - This report presents information on existing flood hazards along Steamboat Creek and tributary streams in Pleasant and Steamboat Valleys, including the portion of Steamboat Creek that drains Whites Creek and immediately downstream, and the Upper Truckee Meadows area of Washoe County, Nevada. The flood hazard maps produced are those resulting from the Intermediate Regional and Standard Project Floods.

- **Draft Development Standards and Design Guidelines; prepared for the Washoe County Department of Comprehensive Planning; July 6, 1993.**
  - Presentation of draft development standards and design guidelines for Washoe County, including Article 420, Storm Drainage Standards. This article provides general requirements regarding 10-year and 100-year storm runoff improvements; detention requirements; required drainage report contents for land development projects; and design requirements for different types of storm drainage systems. Emergency access roadway design requirements are contained in Article 408, Street Design Standards.

- **Flooding in Douglas County - Making Tough Choices (A Guide for Public Policy Dialogue); prepared by the Citizens Task Force on Flood Control.**
  - A publication written to serve as an educational guide for residents of Douglas County. Its purpose is to educate citizens about hazards from alluvial fan and riverine flooding; to pose alternative policy directions for citizens to consider and debate; and to serve as a basis for gathering public input and setting future County direction.

- **Pertinent Letters and Memoranda from Washoe County Files:**
  - 4/11/93 Memorandum and attachments from Craig V. McConnell, Public Works Director, to the Washoe County Commissioners and County Manager regarding actions taken concerning public discussion of the Whites Creek Detention Basin project at the location of the four-branch flow split. Attachments include the April, 1993 Agenda for the Southwest Truckee Meadows Citizens Advisory Board (CAB); the Presentation Agenda to the Southwest Truckee Meadows CAB regarding the detention basin; notification letter to local property owners regarding discussions held concerning the detention basin and schedule of subsequent meetings; and a description of key factors to consider regarding feasibility of the basin.

  - 4/23/93 Letter from the Southwest Truckee Meadows CAB to the Washoe County Commissioners informing them of the Board's unanimous denial of the Whites Creek Detention Basin project.

- 4/28/93 Letter from Craig McConnell to Garth Dull, Director of the Nevada Department of Transportation (NDOT), stating the County Commissioners' vote to not proceed with a joint County-NDOT detention basin on Whites Creek.

- 5/11/93 Letter from the Office of the Washoe County Clerk to Craig McConnell stating the Washoe County Commissioners' discussion and negative vote on the Whites Creek Detention Basin project.

- 5/11/93 Letter from Ronald W. Hill, Deputy Director of NDOT, to Mr. Brian Walters regarding factors considered in proposing the Whites Creek Detention Basin project.

- 7/26/93 Agenda for the 7/26/93 meeting of the Regional Water Planning and Advisory Board of Washoe County. Agenda Item No. 5 is a "Discussion on the Need for Whites Creek Drainage Basin Study".

- 7/29/93 Letter from David R. Roundtree, Regional Water Manager, to Mr. Keith Kellison, Chairman of the Southwest Truckee Meadows CAB regarding involvement of the CAB in development of a Whites Creek Basin Management Program.

- 8/17/93 List of private and public property owners within the Whites Creek Basin.

- 8/20/93 Sample Request for Proposals and schedule to consultants for the following items: (1) Formulation of an approach to stormwater management planning of the Whites Creek basin and its connection to Steamboat Creek; and (2) Development of interim policies for managing the basin.

• **Report on the February 1986 Flood in Western Nevada; prepared by Michael W. Ekern, National Weather Service Forecast Office; March 21, 1986.**
  - Summary of the meteorological conditions leading up to the mid-February, 1986 flooding along the Carson and Truckee Rivers, including precipitation records, and a description of the impacts of the flooding, including National Weather Service bulletins.

• **Current Plan Development Report, Truckee Meadows (Reno-Sparks-Metropolitan Area) Nevada; prepared by the Army Corps of Engineers, Sacramento District; July, 1990.**
  - Description of the "Current Plan" being developed by the Corps of Engineers for the Truckee River and tributaries from Reno downstream through Sparks and the Truckee Meadows area in Washoe County north of Huffaker Hills. The Plan includes the Huffaker Hills Dam, a

downstream high-flow channel, levees, floodwalls, excavation, and bridge replacements.

- **Refinement Study, Truckee Meadows (Reno-Sparks Metropolitan Area), Nevada; prepared by the Army Corps of Engineers, Sacramento District; February 1, 1989.**
  - A discussion of potential refinements to the Truckee Meadows project to be studied during the Preconstruction Engineering and Design phase of the project. The project refinements considered include: assessment of the consideration given the Brown Plan; incorporation of the UNAES detention basin into the project; possible reduction of levee freeboard; elimination of Standard Project Flood structural features; and location of marsh enhancement features. Discussion is also provided regarding the Corps' responsibilities in fulfilling requirements of the National Historic Preservation Act of 1966, an assessment of the downtown Reno floodwalls, and local cost share credit requests.

- **Hydrology Office Report Update for the Truckee Meadows, Nevada General Design Memorandum - Spanish Springs and Huffaker Hills Detention Facilities Site Evaluations; prepared by the Army Corps of Engineers, Sacramento District; January, 1989.**
  - A memorandum presenting the results of the revised hydrology for Spanish Springs Valley, including evaluation of two reservoir sites in Spanish Springs Valley and one at the Huffaker Hills Narrows.

- **Office Report for the Truckee Meadows, Nevada General Design Memorandum - Hydrology Review and Update; prepared by the Army Corps of Engineers, Sacramento District; May, 1989.**
  - Results of the hydrology review and update for the Truckee Meadows area and for Spanish Springs Valley, evaluation of the two reservoir sites in Spanish Springs Valley, and a project-level evaluation of the Huffaker Hills Dam site on Steamboat Creek.

- **Office Report: Truckee Meadows (Reno-Sparks Metropolitan Area), Nevada Project; prepared by the Army Corps of Engineers, Sacramento District; May, 1992.**
  - Update to prior reports dealing with proposed flood control and recreation improvements. New evaluations indicated that the project was economically unfeasible with a benefit-to-cost ratio (BCR) of 0.42 to 1. The project was correspondingly reclassified from an active to a deferred category.

- **Major Drainageways Plan, City of Reno**
  - This Plan identifies critical drainage areas in the City of Reno and surrounding area and presents strategies for their treatment and maintenance. The focus of the Plan is to address the visual appearance and uses of specific major drainageways. Of particular concern are those

drainageways that are important to public health, safety and welfare and those that retain additional public values. The document includes a resource analysis, policy analysis, implementation strategies and recommendations designed to preserve and improve these public resource areas.

- **"Draft" Preliminary Feasibility Analysis, Whites and Thomas Creeks Flood Control Detention Basins; prepared by Nimbus Engineers; March, 1994.**
  - Preliminary feasibility study for the construction of regional detention basins near the base of Mt. Rose at Timberline Road to attenuate flood discharges experienced in downstream reaches of Whites Creek and Thomas Creek.

## B. Contacted Parties

The following individuals have been contacted on one or more occasions to discuss existing information and present preliminary findings and approaches:

- Craig McConnell, Washoe County Public Works
- David Price, Washoe County Public Works
- Leonard Crowe, Washoe County Comprehensive Planning
- Kirk Nichols, Washoe County Public Works
- David Roundtree, Regional Water Management Agency
- Peggy Bowker, Nimbus Engineers
- Mark Forest, Kennedy/Jenks Consultants
- Amir Soltani, NDOT
- Chris Miller, NDOT
- Paul Frost, NDOT
- Robert Sader, Attorney
- Alex Fittinghoff, CFA
- Samuel Chacon, CFA
- Participants of two (2) Initial Workshops

Several meetings have been held with the staff of Washoe County cited above, and a First Draft of the Preliminary Whites Creek Basin Management Study was prepared and submitted to Washoe County on December 7, 1993. It is anticipated that several additional interested parties will be brought into the review and evaluation process as a part of refining and finalizing this current draft of the Preliminary Whites Creek Basin Management Study.

## C. Hydrologic and Hydraulic Reports for Development Projects

Numerous hydrologic and hydraulic reports prepared for existing and proposed development projects within the lower Whites Creek watershed have been reviewed, and information provided in said documents has been incorporated into the evaluation of existing conditions and formulation of interim policies.

## D. Base Map

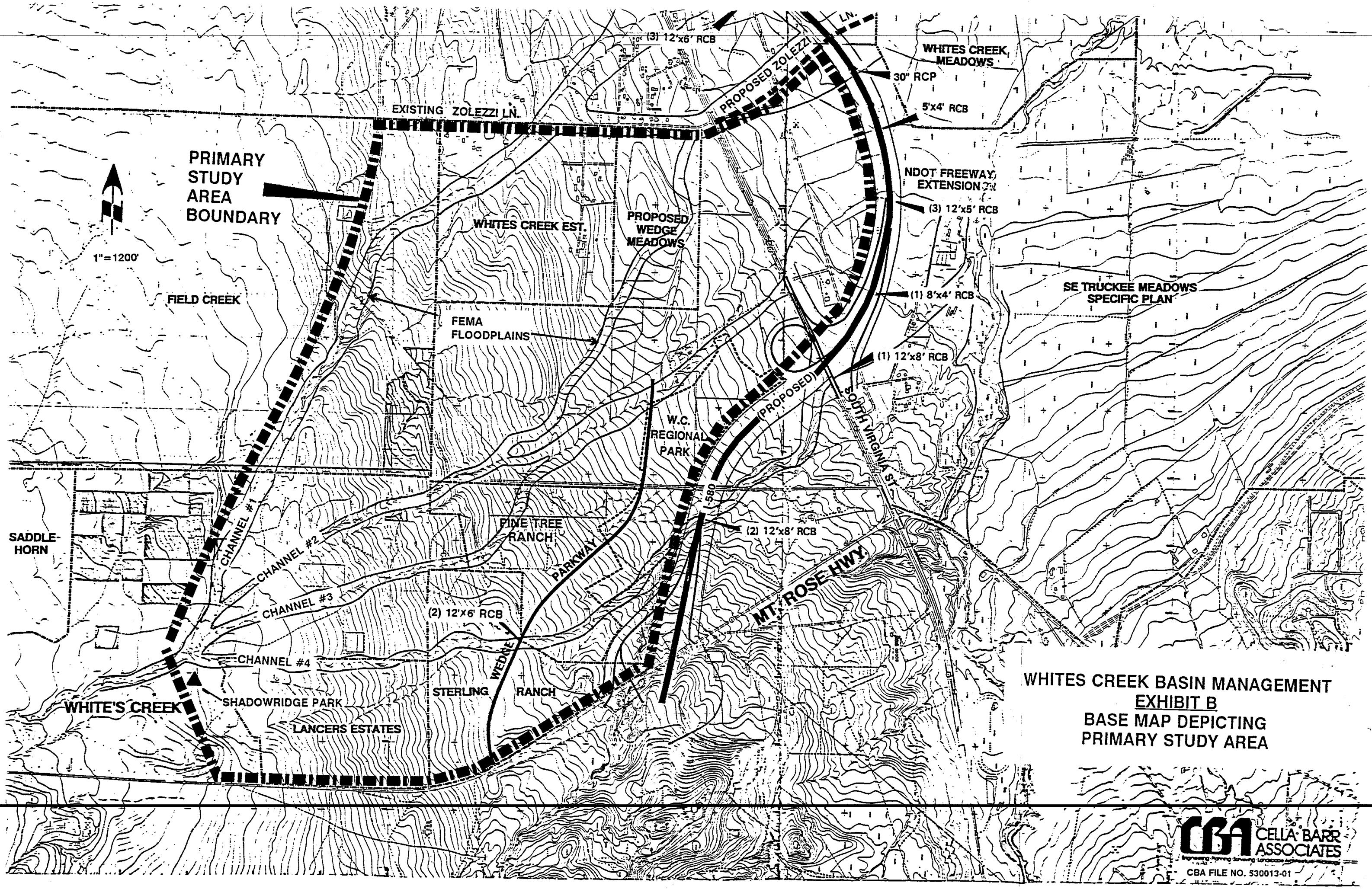
A base map has been prepared that assimilates the location of existing and proposed development projects, highway improvements, drainage structures, FEMA floodplain boundaries and other significant features within the primary study area comprising the lower Whites Creek watershed. The underlying information on the map consists of five foot (5') contour interval topography developed in 1966 by NDOT. Though the topography has been altered locally by improvements related to land development since 1966, much of the topographic features have essentially remained unchanged since that time, and the general overall topography of the lower watershed is substantially correct on the base map. This base map and pertinent information is represented as Exhibit B.

## E. Geologic Mapping

The Nevada Bureau of Mines and Geology was contacted to determine the nature and extent of geologic mapping that has been performed in the lower Whites Creek watershed. In response, CBA acquired Map 4BG, the Mt. Rose NE Quadrangle Geologic Map prepared in 1983 by H.F. Bonham, Jr. and David K. Rogers. This map includes most of the Whites Creek watershed north of Mount Rose Highway and west of U.S. 395. Geologic units delineated on the map in the study area consist primarily of the Upper Pleistocene (greater than 10,000 years old) Tahoe Outwash-Mount Rose Fan Complex and Donner Lake Outwash-Mount Rose Fan Complex adjacent to the flow split near Shadowridge Park and covering large areas downslope, and younger Alluvial Bajada deposits of the Holocene age (less than 10,000 years old) along two of the four primary channels (Channels #2 and #4, Exhibit B) and adjacent to U.S. 395. Exhibit C depicts generalized surface geologic characteristics derived from soils information.

## F. Field Investigations

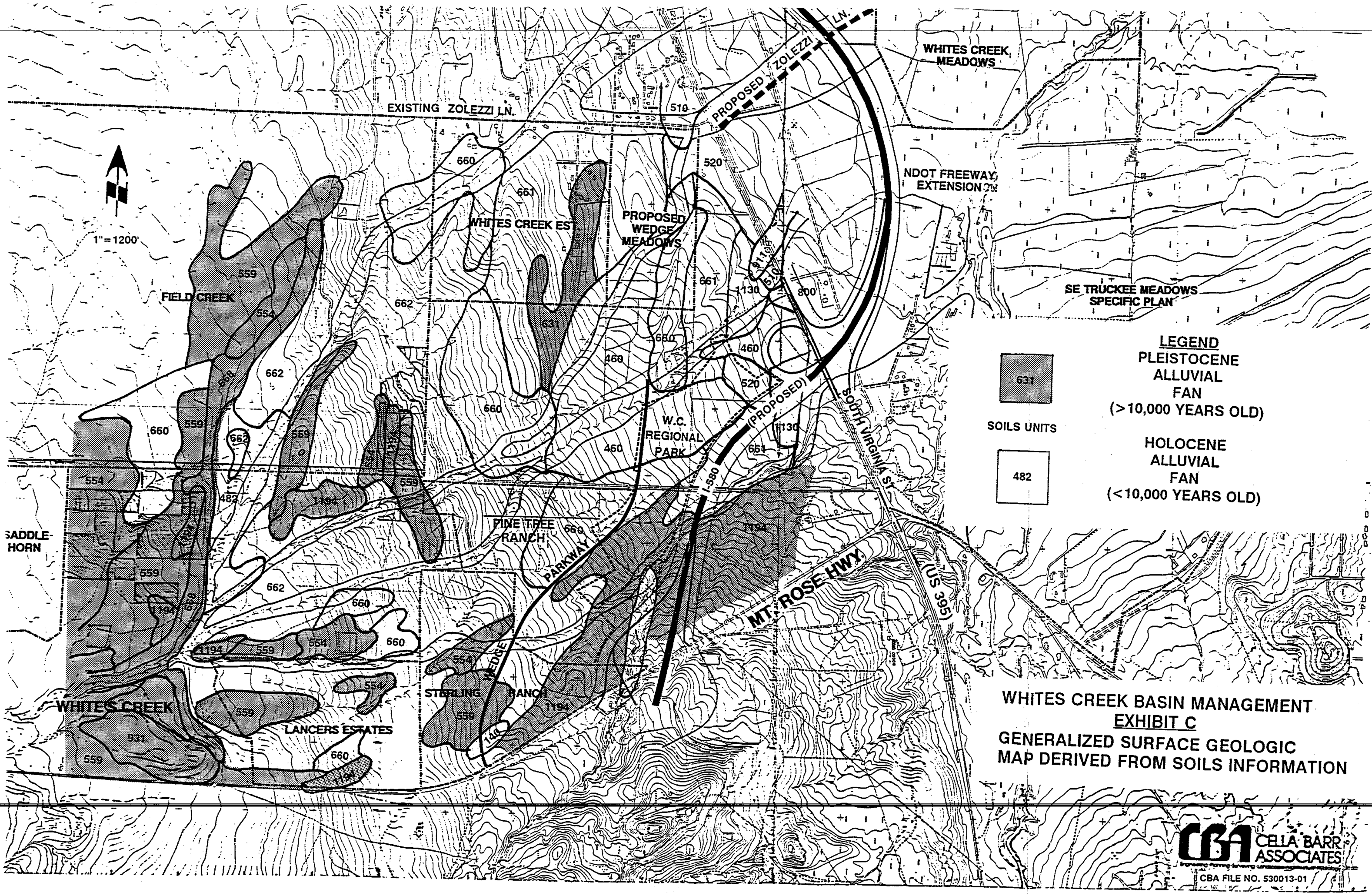
Several field investigations have been performed within various portions of the Whites Creek watershed, with particular emphasis on the primary study area of the lower Whites Creek watershed. Information derived from these field investigations, as well as from the data collection effort and discussions with Washoe County staff and other key individuals, have facilitated the formulation of conclusions presented in this Preliminary Basin Management Study.




WHITES CREEK BASIN MANAGEMENT
EXHIBIT B
BASE MAP DEPICTING
PRIMARY STUDY AREA

CELLA BARR ASSOCIATES
Engineering Planning Surveying Landscape Architecture Hydrology

CBA FILE NO. 530013-01




WHITES CREEK BASIN MANAGEMENT
EXHIBIT C
GENERALIZED SURFACE GEOLOGIC MAP DERIVED FROM SOILS INFORMATION

CELLA BARR ASSOCIATES

CBA FILE NO. 530013-01

## II. OPINIONS, ACCEPTANCE AND CONCURRENCE PERTINENT TO EXISTING STUDIES

Based upon a review of existing studies and reports, field reconnaissance and discussions with Washoe County staff and other key individuals, the following fundamental conclusions have been drawn with regard to the lower Whites Creek watershed.

**A.** **Magnitude of the 100-Year Discharge for Whites Creek** - CBA reviewed the hydrologic analyses and various calculated values for the 100-year discharge for Whites Creek as presented in the background materials provided by Washoe County in an effort to establish a value that would be most appropriate for use in basin management planning activities. After completion of our review, we have concluded that the 100-year discharge magnitude of **5100 cfs** for Whites Creek at Shadowridge Park should be utilized for the current basin management planning activities, at least until such time that a detailed and comprehensive hydrologic analysis is performed. Our rationale for this recommendation is as follows:

1. The HEC-1 analysis presented in the Whites Creek Detention Feasibility Study for NDOT appears to be reasonable.

2. Although technically outside of CBA's Scope of Work for this Preliminary Basin Management Study, CBA modified selected parameters in the HEC-1 analysis cited above to determine their impact upon the calculated discharge for Whites Creek at Shadowridge Park. These modifications included the use of normal depth calculations with varying roughness values along routing reaches, adjustments to impervious cover and adjustments to lag time calculations. The result of these various modifications was that the calculated 100-year discharge for Whites Creek at Shadowridge Park was lowered by as much as 1000 cfs under certain sets of assumptions and elevated by as much as 1000 cfs under other sets of assumptions. Within this range of impacts it appears that the 5100 cfs value is reasonable.

3. Downstream drainage structures along I-580 are being sized in consideration of an upstream discharge of 5100 cfs at Shadowridge Park, thus providing support to this value in terms of system compatibility.

4. In the absence of detailed analyses that would be pertinent to the preparation of the actual Basin Management Plan or a specific and comprehensive hydrologic investigation, it is more prudent to utilize conservative base assumptions in the development of interim basin management policies. The 5100 cfs value appears to be reasonable, yet conservative, and it is the highest of the values calculated from the prior studies reviewed by CBA.

Updated meteorological analyses are currently being performed as a part of the Washoe County Flood Control Master Plan. Upon completion of the updated meteorological analyses and their acceptance by Washoe County, it may be advantageous to revisit the adopted 5100 cfs value to determine if a revision is warranted.

**B.** **<u>Distribution</u> of the 100-Year Discharge for Whites Creek Downstream of Shadowridge Park** - Whites Creek at Shadowridge Park represents the location where flows are initially distributed across the lower Whites Creek watershed area under investigation. Flow is distributed into one or more of essentially four (4) channels that traverse the lower Whites Creek watershed, ultimately delivering proportionate runoff to the Steamboat Creek area east of U.S. 395. The flow distribution in the Shadowridge Park vicinity is impacted by the following:

1. The magnitude of the discharge collected at said location.

2. The extent to which existing vegetation within the channel becomes denuded by flood flows.

3. The existence of debris flow during a characteristic flood event.

4. The topographic definition of flow paths that exists immediately downstream prior to and during a given flood event.

During a 100-year flood event, it is CBA's opinion that, under existing conditions, it is not possible to accurately predict the distribution of the total discharge that will be allocated to each of the channels forming downstream of the Shadowridge Park area. Perhaps the most significant variable that limits the predictability of the distribution is the potential occurrence of <u>debris flow</u> within Whites Creek. Evidence of prior debris flows is readily identifiable in the field and is characterized by numerous residual large boulders that have been transported from the defined channel upstream of Shadowridge Park to various locations along channels and other areas downstream within the lower Whites Creek watershed. The occurrence of a debris flow will result in a slug of concentrated boulders, sediment and vegetation moving down the defined channel to be distributed at varying locations downstream of the defined channel as flow depth and velocities are diminished through expansion of the flow width.

The potential for debris flow can significantly impact the initial flow distribution originating at Shadowridge Park by effectively diverting flows in a random manner from one downstream channel to another and blocking some of the available flow areas during a given flooding event. For this reason, it is most appropriate to examine the flow distribution in terms of preferential values of proportional discharges to be applied to each downstream channel, from a future planning perspective for new development and infrastructure improvements. The flow distribution presented in the Whites Creek Detention Feasibility Study for NDOT would appear to be reasonable in this regard, as proportional discharges

are somewhat equitably allocated to each of the four (4) downstream flow paths and as these distributions have been applied to the design of downstream drainage structures at I-580.

The distribution recommended for adoption by CBA for each of the four primary channels is represented below:

| Channel | Allocated Discharge |
|---|---|
| #1 | 700 cfs |
| #2 | 1950 cfs |
| #3 | 1100 cfs |
| #4 | 1350 cfs |
| Total | 5100 cfs |

These values may be applied to each channel as a future design capacity goal, but are not representative of actual existing conditions due to the dynamic unpredictability of the flow distribution and potential for debris flow. For floodplain management purposes, a probabilistic approach must also be applied to facilitate the selection of a 100-year discharge rate that may enter each of the four (4) channels downstream of Shadowridge Park under existing conditions.

Based on an assessment of probability, CBA has concluded that a flow of approximately 3000 cfs has a one percent (1%) chance of being delivered to any of the four (4) available flow paths in any given year (i.e., a 100-year event). This conclusion was derived as follows:

- 5100 cfs has a 1 in 100 chance of occurring at Shadowridge Park (100-year event).
- Conservatively, there is a 1 in 4 chance of the entire flow at Shadowridge Park being delivered to any of the four (4) downstream flow paths.
- 3000 cfs has a 1 in 25 chance of occurring at Shadowridge Park (25-year event).
- The product of the probabilities of the 1 in 4 chance (flow paths) and the 1 in 25 chance (25-year discharge at Shadowridge Park) is a 1 in 100 chance for 3000 cfs to be delivered to any of the four (4) flow paths, or a 100-year event.

CBA derived the 3000 cfs value for the 25-year discharge at Shadowridge Park by applying 25-year precipitation values represented on available NOAA atlases

to the HEC-1 model presented in the Whites Creek Detention Feasibility Study for NDOT. Since the standard for floodplain management in Washoe County and per FEMA is the 100-year event, floodplain conditions along each of the four (4) flow paths downstream of Shadowridge Park need to be established under the assumption that 3000 cfs is initially delivered to them. Until such time as structural measures are implemented that will serve to establish the flow distribution desired for 5100 cfs at Shadowridge Park, a flow of 3000 cfs being delivered to each flow path must be considered in the design of development projects within the lower Whites Creek watershed.

C. **Existing Problem Areas** - As a part of the field investigations performed by CBA staff and the review of available information, several problem areas or potential problem areas were identified within the lower Whites Creek watershed in terms of flooding potential associated with development projects and existing infrastructure improvements. The following listing represents a preliminary identification of potential problem locations that may merit further investigation as a part of future studies. It must be noted that CBA's conclusions are not substantiated by detailed calculations, but have been based upon engineering judgement; hence, the following listing may not be complete and/or some of the listed locations may be determined to not have problems from a flood hazard or capacity perspective upon closer, more detailed examination.

1. **Existing Culverts Along U.S. 395** - All of the existing drainage structures that drain Whites Creek flows are substantially inadequate to convey distributed discharges underneath the roadway during a 100-year flood event. The existing highway will cause upstream ponding of stormwater runoff and, when ponded flood waters reach sufficient levels, sheet flooding across the highway will occur.

2. **Old Virginia Street Culverts** - Inadequate drainage structures exist across Old Virginia Street, and similar conditions will prevail as described for U.S. 395.

3. **Zolezzi Lane Drainage Structures** - The drainage structure crossing of Zolezzi Lane that serves Channel #1 is of substantially insufficient capacity to pass the proportioned 100-year discharge. The existing roadway will divert some of the flow east along the south side of Zolezzi Lane and some of the flow will spill northerly across the roadway. At the intersection of Zolezzi Lane and U.S. 395, there is virtually no provision for accommodating runoff originating from Channel #2 (with some spillover flow from Channel #3), and flooding of this intersection will occur during a 100-year event.

4. **Existing Residential Structures Immediately Downstream of the Defined Channel at Shadowridge Park** - Several existing residential structures at this location are subject to a high flood and debris flow hazard during a 100-year flood event.

5. **Whites Creek Estates** - Some of the existing residential structures adjacent to Channel #1 have a potential for flooding during a 100-year event as induced by spillover from the channel at subdivision street crossings or by limitations in channel capacity.

6. **Lancers Estate** - Some of the residential lots backing up adjacent to the south of Channel #4 have a potential for flooding during a 100-year event.

7. **Existing Residential Structures South of Whites Creek Lane, West of the Proposed Pine Tree Ranch Subdivision** - Several of these structures have a potential for flooding from Channels #2 and #3 during a 100-year flooding event.

8. **Wedge Parkway** - Wedge Parkway is elevated from one to several feet above existing grade and crosses the lower Whites Creek watershed somewhat transversely to the direction of drainage flow. The newly constructed segment of Wedge Parkway between the Mt. Rose Highway and Whites Creek Lane will have a tendency to impound runoff in excess of the proportioned discharge of 1350 cfs for Channel #4 on the upstream side of the roadway and divert flow northeasterly along the west side of the roadway toward Whites Creek Lane. The existing drainage structure under construction across Channel #4 appears to have adequate capacity for the proportioned discharge for this flow path, provided the flow is delivered to the drainage structure itself. Currently, it is proposed that the proportioned flow within Channel #4 be channelized and delivered to the drainage structure as a part of the future development of Sterling Ranch.

**It should be reiterated that the above observations and conclusions of system capacity problems are based upon preliminary investigations, only, and will require further substantiation as additional more detailed studies are performed.**

## III. QUALITATIVE EVALUATIONS OF FLOODING CONDITIONS

To date, floodplain administration within the lower Whites Creek watershed has been based primarily upon floodplain information presented on the FEMA Flood Insurance Rate Maps for Washoe County, Panel Numbers 1501 (Effective date: August 1, 1984) and 1463 (Effective date: April 16, 1990). The floodprone areas depicted for the lower Whites Creek watershed are represented as "Zone A" which indicates that they were originally studied using approximate methods only. Based upon CBA's experience as a Flood Insurance Study Contractor with FEMA, the degree of detail that would have been inherent to these approximate Zone A designations was undoubtedly minimal and, per FEMA guidelines, would have been limited to a cursory review of USGS quad sheets, aerial photographs, and primary low flow paths. It is CBA's professional opinion that the extent of the floodplains represented on these FEMA Flood Insurance Rate Maps for the lower Whites Creek watershed is significantly understated.

In order to accurately delineate the extent and characteristics of flood hazard areas within the lower Whites Creek watershed, a detailed hydrologic and hydraulic analysis will be needed, which is outside the scope of the current study. Such an analysis will need to include the following:

1. Refinement of the total 100-year discharge value of 5100 cfs for Whites Creek at Shadowridge Park, if appropriate.

2. Acquisition of current topographic mapping of the lower Whites Creek watershed with a minimum contour interval of two feet (2').

3. Hydraulic evaluations of flow characteristics across the lower Whites Creek watershed utilizing a combination of HEC-2 evaluations, normal depth calculations, weir flow calculations and culvert capacity calculations.

The detailed floodplain analysis should be performed at the earliest possible date in order to supplement the information contained in the current study; to more accurately define floodplain limits and characteristics; and to provide better information to be utilized in the design of new development and infrastructure projects. The analysis should consider both of the following assumptions pertinent to the flow distribution originating at Shadowridge Park:

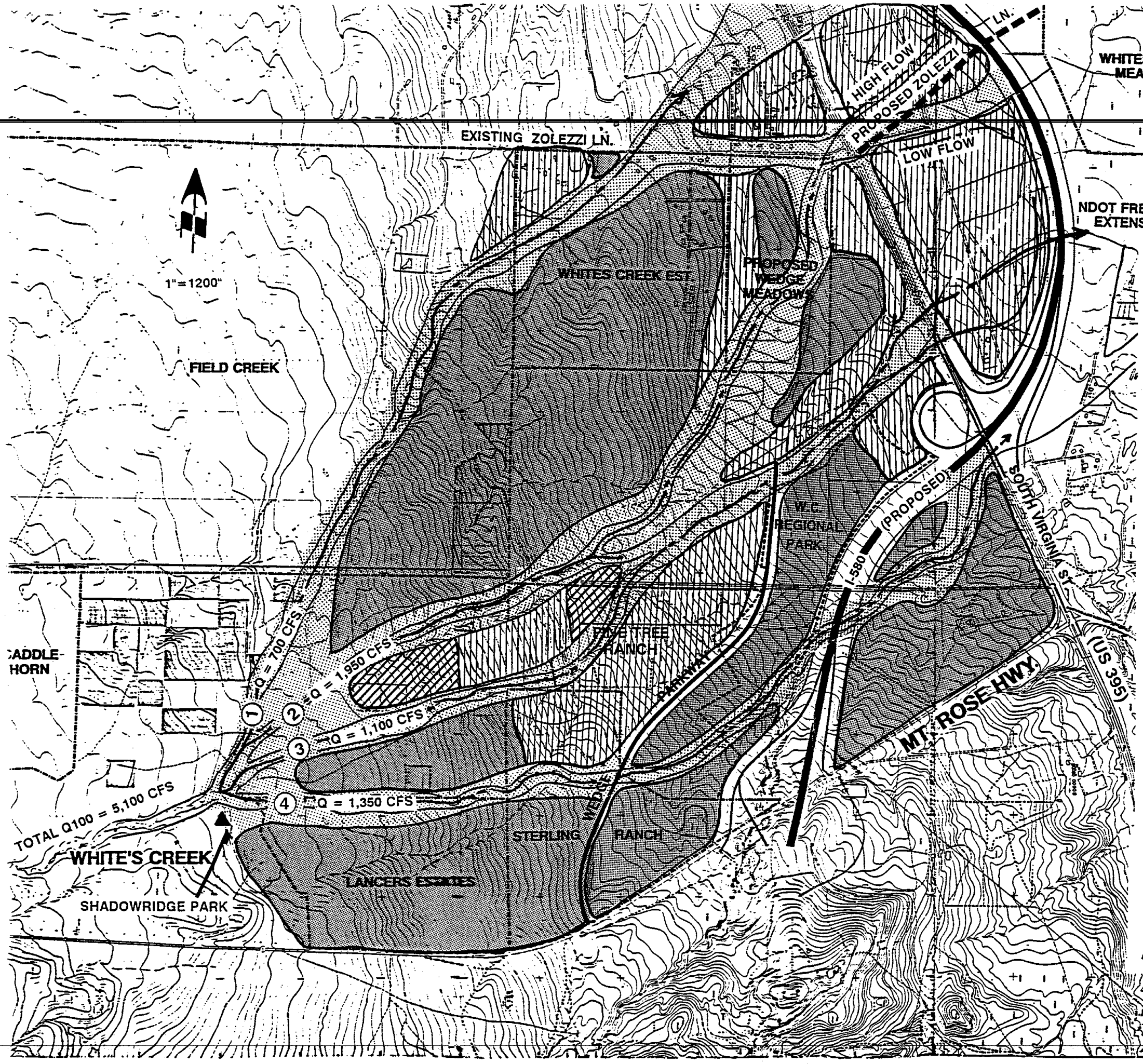
- The existing conditions which create a potential for the total discharge of 3000 cfs (or a revised number, if applicable) being delivered to any of the four (4) downstream channels (see Section II.B.).

- Future conditions that would prevail if the flow distribution becomes fixed at Shadowridge Park through the implementation of structural measures or if the overall flow in Whites Creek is attenuated through implementation of other upstream structural measures.

As a part of this study, CBA performed a very preliminary analysis to estimate the extent and magnitude of flooding that currently has a potential of occurring within the lower Whites Creek watershed during a 100-year storm event. This analysis utilized USGS quad sheets, current aerial photographs, field investigations, the 1966 topographic mapping acquired from NDOT and rough normal-depth calculations performed across hypothetical flat cross sections of varying widths and slopes. Based on evaluations of the above, it is CBA's opinion that, under existing conditions, much of the lower Whites Creek watershed would be subject to "shallow sheet flooding" during a 100-year event. Approximate flood zones and average 100-year flooding depths have been delineated and are represented on Exhibit D. The flood zone designations that have been utilized in the approximate floodprone area mapping represented on Exhibit D are:

- Minimal Flooding Potential, Average Depth Less Than 0.5 feet
- Sheet flow, Average Depth = 0.5 feet
- Sheet flow, Average Depth = 1 foot
- Sheet flow, Average Depth Greater Than 1 foot

The approximate floodprone areas have attempted to account for the impacts of the construction of Wedge Parkway and I-580. In determining the shallow flooding zones, CBA assumed that a discharge of 3000 cfs may be directed to any of the four (4) primary channels originating downstream of Shadowridge Park. At such time as structural measures are implemented to attenuate the total flow or define the flow distribution for the downstream flow paths originating near Shadowridge Park, the extent and severity of flooding for the downstream areas within the lower watershed will be appreciably reduced.




LEGEND

| | |
|---|---|
| ① | DRAINAGE CORRIDOR/ CORRIDOR NUMBER |
| 700 CFS | CORRIDOR DISCHARGE VALUE |
| | > 1 FOOT |
| | 1 FOOT |
| | 0.5 FEET |
| | MINIMAL (LESS THAN 0.5 FEET) |

AVERAGE DEPTHS OF SHALLOW FLOODING *

NOTE: FOR FINISHED FLOOR ELEVATION REQUIREMENTS FOR STRUCTURES IN EACH FLOOD ZONE, SEE SECTION VII.3. OF TEXT.

*100-YEAR, EXISTING CONDITIONS, ASSUMING TOTAL DISCHARGE OF 3,000 CFS ORIGINATING ALONG EACH DRAINAGE CORRIDOR DOWNSTREAM OF SHADOWRIDGE PARK (SEE SECTION II.B. OF TEXT)

# WHITES CREEK BASIN MANAGEMENT

## EXHIBIT D

## MAP SHOWING PROPOSED DRAINAGE CORRIDORS AND APPROXIMATE FLOOD HAZARD INFORMATION

CELLA BARR ASSOCIATES

CBA FILE NO. 530013-01

## IV. QUALITATIVE GEOMORPHOLOGY

CBA has performed a qualitative assessment of the types of fluvial processes that occur within the lower Whites Creek watershed downstream of the flow split at Shadowridge Park, in order to assist in the development of design requirements and policies for continued land development activities and infrastructure improvements proposed within the area. This assessment is based on field reconnaissance; the Soil Survey of Washoe County, Nevada, South Part prepared by the United States Department of Agriculture, Soil Conservation Service (August, 1983); geologic mapping of the Mt. Rose NE Quadrangle prepared by H.F. Bonham, Jr. and David K. Rogers (1983) and published by the Nevada Bureau of Mines and Geology; aerial photographs; and 1966 topography obtained from the Nevada Department of Transportation. In addition, two papers have been consulted extensively: "Alluvial Fan: Proposed New Process-Oriented Definitions for Arid Southwest" by Richard H. French, Jonathan E. Fuller, and Steve Waters (Journal of Water Resources Planning and Management, Vol.119, No. 5, September/October, 1993); and "Geologic Insights into Flood Hazards in Piedmont Areas of Arizona" by Philip A. Pearthree (Arizona Geology, Vol. 21, No. 4, Winter 1991, Arizona Geological Survey).

Alluvial fans are complex landforms. They are typically cone-shaped features containing boulders, gravel, sand and fine sediments that have been eroded from mountain watersheds and deposited on the adjacent piedmont or valley floor. In general, alluvial fans in the Southwest can be classified as active alluvial fans, distributary flow areas, and inactive alluvial fans (French, et al, 1993). A brief description of each type of fan is provided below to aid in understanding the geomorphic characteristics of the lower Whites Creek watershed.

Processes associated with **active alluvial fans** include rapid channel migration, debris flows, hyper-concentrated sediment transport, channel bank erosion, local bed scour and flash flooding. These fans are characterized by the following:

- Drastic changes in channel pattern and frequent channel movement;
- Bifurcating channel patterns that radiate outward in the downstream direction and that may be discontinuous;
- Low channel capacities with channel flow changing to sheetflow in the downstream direction;
- Recent and relatively uniform deposition of sediment across the fan surface;
- Debris flow levees;
- Weak soil development;
- Immature vegetative communities;
- Limited topographic relief; and,
- Lack of bedrock exposure.

In contrast, **inactive alluvial fans** are subject to sheet flooding, local deposition and scour within a stable channel pattern, extensive sediment transport, and flash flooding. Landforms associated with inactive alluvial fans include:

- Tributary drainage networks;
- Channel and/or overbank capacities adequate for significant flood events, and that increase in capacity in the downstream direction;
- Lack of recent deposition of sediment on the fan surface;
- No recent debris flow activity;
- Extensive soil profile development;
- Mature vegetative communities;
- Significant topographic relief; and,
- Bedrock outcropping within or between channels.

**Distributary flow areas** exhibit a channel pattern similar to active alluvial fans, but experience hydraulic processes more like those of inactive alluvial fans. Processes that occur in distributary flow areas include local scour and fill, divergent flow, stream capture, flash flooding, hyper-concentrated sediment transport, and shifting of runoff among existing channels. These areas can be identified according to the following characteristics:

- Bifurcating channels that radiate outward;
- Lack of channel capacity for significant flood events;
- Channels that are poorly defined and that may be discontinuous downstream;
- Sheet flooding;
- No debris flow activity below the fan apex;
- Broad floodplain with no apparent stream terraces;
- Low to variable topographic relief;
- Variable soil development;
- Immature and mature vegetation;
- Stable, although not completely predictable, flow paths.

Whites Creek originates on the eastern flank of Mount Rose (elevation 10,778 feet), from which it delivered to the base of the mountain front, at an elevation of approximately 6000 feet. From this location flow expands for a distance of approximately 3500 feet downstream from the mountain front, then becomes re-confined into a channel that is entrenched into an old alluvial fan surface. This alluvial fan surface is probably of Pleistocene age (greater than 10,000 years old), as upper piedmont areas near mountain ranges throughout the Southwest are often dominated by abandoned alluvial fans of this age. The entrenched Whites Creek channel continues in the downstream direction until it reaches a concrete, low flow splitter structure at Shadowridge Park. At this location flow exits the defined channel onto the lower Whites Creek basin, which is characterized by a radial, distributary flow network dominated by four channels. These channels are characterized by low, but variable flow capacity, resulting in generally unconfined distributary flow and alluvial-fan activity downstream of the concrete flow splitter.

Using the classification scheme outlined briefly above, the Whites Creek basin, below the flow split at Shadowridge Park, exhibits characteristics of both an active alluvial fan and a distributary flow system. Based on field reconnaissance, the lower Whites Creek basin displays the following characteristics:

- Radiating channel pattern from the apex (Shadowridge Park area) to the toe of the fan;
- Relatively stable channel pattern; we did not see any evidence of recently abandoned channels indicative of channel migration or avulsion (sudden changes in the course of a channel);
- Generally low channel capacities with no definite trend towards increases in channel capacity in the downstream direction; confinement of flow varies greatly, depending upon fan topography and Quaternary geologic faulting.
- Recent debris flow activity, as evidenced by debris flow deposits at the apex and downstream. One boulder train at the apex, between Channels #1 and #3, is located on a geologically young (Holocene) surface;
- Sheetflooding, increasing in the downstream direction and particularly adjacent to U.S. 395, resulting from poor channel definition and detention of flow created by U.S. 395 and adjacent development;
- Variable topographic relief across the fan;
- Relatively weak soil development throughout most of the fan.

Soil profile development provides a tool to use in determining how old an alluvial surface is, as such factors as silt, clay and calcium carbonate content tend to increase with age. Soils can be used, therefore, to determine approximate ages of surfaces and, therefore, which surfaces have been subject to recent flooding, erosion and deposition. The Soil Survey maps produced by the Soil Conservation Service depict much of the Whites Creek basin below the fan apex at Shadowridge Park as being occupied by Oest soils, described primarily as bouldery or sandy loams. Additional soil units adjacent to and immediately west of U.S. 395, the Surprise sandy loam and the Dithod sandy loam, are described mainly as coarse sandy loams that are subject to flooding. Based on the soil descriptions, the Oest, Surprise and Dithod units can be interpreted as being young soils of Holocene age (less than 10,000 years old) and younger (see Exhibit C).

The Whites Creek fan also contains remnants of Leviathan and Spasprey stony sandy loams, which make up the higher alluvial fan surface into which Whites Creek has entrenched its channel upstream of Shadowridge Park and which also exist on topographically high areas of the lower Whites Creek basin. These latter soil units can be interpreted as being of Pleistocene age (greater than 10,000 years) or older, and therefore, have not been subject to any significant flooding for at least 10,000 years (see Exhibit C). This corroborates well with the approximate floodplain information presented on Exhibit D.

With the exception of the Pleistocene-age alluvial deposits upstream of and adjacent to the fan apex, and the relatively high Pleistocene-aged remnants on the lower fan, it is our opinion that most of the lower Whites Creek basin has been and is currently subject to flooding, erosion and sediment deposition. This is in distinct contrast to the geologic mapping of the Whites Creek watershed published by the Nevada Bureau of Mines and Geology. As previously stated, this mapping shows most of the lower basin to be covered by Pleistocene-age Tahoe Outwash - Mount Rose Fan Complex and Donner Lake - Mount Rose Fan Complex alluvial deposits, with Holocene deposits located primarily along the toe of the fan adjacent to U.S. 395. It is our professional opinion, based on field reconnaissance, that the Soil Survey more accurately reflects current geomorphic processes within the lower basin than the geologic map.

In summary, the lower Whites Creek basin displays some characteristics typical of active alluvial fans and some characteristics typical of distributary flow areas. It is subject primarily to relatively unconfined flooding and sheetflow, and debris flow activity that will be most prevalent in the vicinity of the fan apex and immediately downstream. In our opinion, during significant flow events large quantities of sediment varying in size from small particles to boulders and other debris are likely to be carried by Whites Creek onto the alluvial surface downstream of the concrete flow splitter. Where this sediment and debris are deposited will impact where flooding occurs. It is likely that flow will spread out across the upper fan area immediately downstream of the concrete flow splitter, distributing itself initially among the three channels immediately below the fan apex (Channels #1, #3 and #4) and areas in between. (Channel #2 begins as a divergence from Channel #1 a short distance downstream from the apex.) Within a short distance downfan, topographic relief increases and likely constrains the extent of flooding until the toe of the fan is reached. Because the existing channel pattern appears to be fairly stable, in comparison to a classic, active alluvial fan, rapid channel migrations or avulsion are not anticipated. Shallow sheetflooding will dominate the lowermost part of the basin adjacent to U.S. 395 because of the lack of topographic relief in this area and because of the current detention effect produced by the roadway.

## V. DOWNSTREAM CONDITIONS

CBA examined downstream channel, floodplain and riparian conditions along Steamboat Creek, including field review. This qualitative assessment was necessitated by the fact that different approaches to resolving flooding concerns within the Whites Creek watershed may impact downstream conditions along Steamboat Creek.

Steamboat Creek is the largest tributary to the Truckee River in the south Reno area. It originates from Washoe Lake, about 15 miles south of Reno, and drains the southern and eastern part of Truckee Meadows, entering the Truckee River near Vista about six (6) miles downstream from Huffaker Hills. The valley floor area is mostly improved meadowlands used for pasture, hay production, and other agricultural purposes. Rural residences are scattered throughout the area, primarily in the vicinity of U.S. 395 and at the higher elevations along the east side of Truckee Meadows. Existing commercial development is very limited.

Per the Washoe County Flood Control Master Plan, Volume I, Steamboat Creek is well defined until it reaches Highway 341. Downstream of this point flow becomes much shallower and wider. The portion of the Truckee Meadows area traversed by Steamboat Creek is subject to severe flooding during periods of high runoff.

Steamboat Creek appears to contain some level of runoff on a perennial basis, which has resulted in the development of wetlands adjacent to the stream channel and within portions of the Truckee Meadows. Approaches to controlling flows within the Whites Creek watershed will have to be examined closely from a water quantity and quality perspective, in order to have as little impact as possible on the existing wetlands and the larger Truckee Meadows area and in order to avoid increasing downstream flooding of existing roadways and structures.

There are two (2) large scale development proposals that cover properties east of I-580 downstream of the primary study area, including Steamboat Creek north to Huffaker Hills. These proposed development projects are named Damonte Ranch and Double Diamond Ranch. The drainage designs for these development projects, as they relate to the Whites Creek basin, will be facilitated by the concentration of runoff at known locations along proposed I-580 and will not be appreciably impacted by variable sheet flooding conditions that currently prevail upstream of proposed I-580.

## VI. CONCEPTUAL APPROACHES TO FLOOD CONTROL

Based upon the review of available information and evaluations of existing conditions, it is CBA's recommendation that implementation of all or a combination of the following flood control measures will most effectively simplify continued development and infrastructure improvements within the lower watershed with a reasonable probability of local and community acceptance:

### Flow Distribution Structure

Under existing conditions, the distribution of the 100-year discharge to channels downstream of Shadowridge Park is highly unpredictable. This condition produces a greater potential for flooding along and adjacent to each of the downstream channels within the lower Whites Creek watershed. Channels #1 and #4 are currently reasonably well defined or will become well defined with development and infrastructure improvement projects proposed in the near future downstream of Shadowridge Park. Significant co-mingling of flows between Channels #2 and #3 occurs downstream of the initial flow distribution at Shadowridge Park, and this condition is not foreseen to be corrected in the near future.

The establishment of a predictable flow distribution just downstream of Shadowridge Park to allocate applicable percentages of the total 100-year discharge of 5100 cfs to each of the four (4) primary downstream channels will serve to appreciably reduce the flood potential within the entire lower Whites Creek watershed. The greatest immediate benefit in flood hazard reduction will be realized along Channels #1 and #4 and adjacent areas. Channels #2 and #3 will also experience a significant reduction in flood hazard, initially, with further benefits being gained in the future as the co-mingling of flows between these two primary flow paths becomes eliminated as continued development occurs within the lower watershed.

It is recommended that a **flow distribution structure** be considered at the approximate location depicted on Exhibit E1 as soon as such a structure may be designed and funded, in order to proportionately distribute the total discharge for Whites Creek to each of the downstream channels at rates consistent with the values represented on Exhibit D and per the Whites Creek Detention Facility Feasibility Study prepared for NDOT. This flow distribution structure is recommended to consist of a reinforced ring levee with incremental openings at each of the four (4) primary channel areas. A typical schematic cross section of this ring levee is depicted on Exhibit E2.

Although the design cross section and height of the ring levee will need to be determined as a part of a detailed design process, it is our opinion that the required height and proposed slope reinforcement will be relatively visually unobtrusive once constructed. The slope treatment of soil cement depicted on Exhibit E2 is capable of having an earth-colored finish and natural appearance while providing a monolithic barrier that provides significant stabilization against erosion and impact by large boulders and other debris. This concept will also serve to maintain the integrity of the existing perennial nature of Channels #1 and #3, as all four (4) channels would be allowed to pass through the ring

EXISTING ZOLEZZI LN.

PROPOSED ZOLEZZI LN.

WHITES CREEK MEADOWS

NDOT FREEWAY EXTENSION

1"=1200'

FIELD CREEK

WHITES CREEK EST.

PROPOSED WEDGE MEADOWS

FUTURE STORMWATER DETENTION FACILITY

W.C. REGIONAL PARK

(PROPOSED)

SOUTH VIRGINIA ST.

I-580

SADDLE-HORN

PINE TREE RANCH

PARKWAY

(US 395)

MT. ROSE HWY.

WEDGE

STERLING RANCH

WHITE'S CREEK

LANCERS ESTATES

FUTURE FLOW DISTRIBUTION STRUCTURE

ADDITIONAL POSSIBLE DOWNSTREAM SITES FOR STORMWATER DETENTION FACILITIES

# WHITES CREEK BASIN MANAGEMENT

## EXHIBIT E1

## LOCATION MAP FOR FUTURE FLOW DISTRIBUTION STRUCTURE AND LOCAL, SUB-REGIONAL STORMWATER DETENTION FACILITIES

CELLA BARR ASSOCIATES

CBA FILE NO. 530013-01

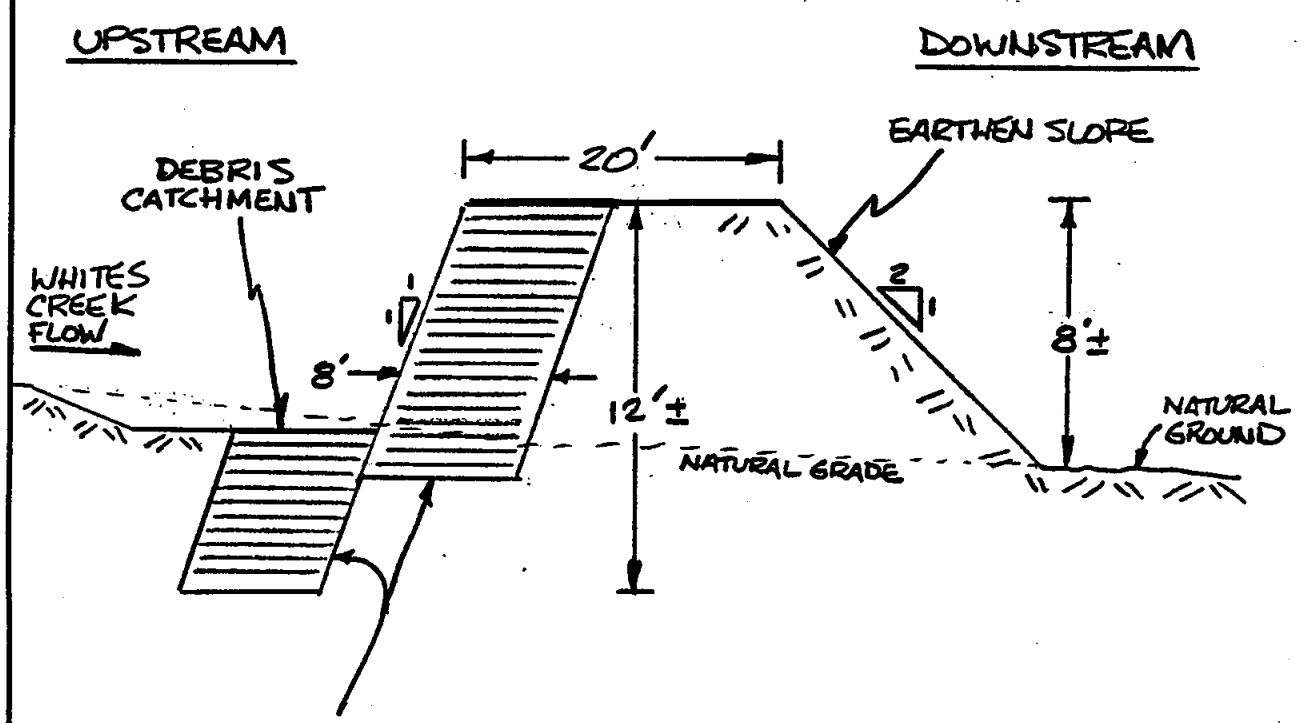
DESIGN NOTES AND COMPUTATIONS

SUBJECT:

EXHIBIT E2

530013-01·0930
JOB NO.:

CROSS-SECTION OF RING LEVEE COMPRISING FLOW DISTRIBUTION STRUCTURE




PREPARED BY: [signature] DATE: 12-6-93 CHECKED BY: SHEET NO.: 1 OF 1

CBA
CELLA BARR ASSOCIATES
777 CAMPUS COMMONS RD STE 200
SACRAMENTO, CA 95825
[916]649-3137
FAX[916]649-8797

levee individually via designated openings. By avoiding structural obliteration of riparian zones inherent to Channels #1 and #3, construction of the ring levee will not fall under the jurisdiction of Section 404 of the Clean Water Act and essentially will allow for the preservation of this existing riparian feature and habitat.

It is envisioned that construction of a ring levee system to serve as a flow distribution structure will allow for an effective desired distribution of flows to occur, if stormwater runoff is designed to pass through the designated openings in the levee system as an equalized and distributed weir flow. In order for this to be accomplished, the alignment of the ring levee will need to be parallel with the existing contours downstream of Shadowridge Park as approximately located on Exhibit E1. Use of a flow distribution structure as described will provide appreciable flood relief for downstream properties at a cost that is significantly less than previous proposals, including the Whites Creek Detention Facility Feasibility Study proposal applicable to this location. It will also be much less visually obtrusive than the detention basin option and will not require the obliteration of existing riparian areas. Actual construction costs, right-of-way/easement requirements and design parameters associated with the flow distribution structure will be developed as a part of subsequent design activities if this approach to flood control is deemed acceptable; however, the total cost is expected to be less than $1,000,000.

**Local, Sub-Regional Stormwater Detention Basins**

As continued development occurs within the lower Whites Creek watershed, the introduction of impervious surfaces and improved flow conveyance mechanisms (such as streets and excavated channels) will cause increases in rates of runoff experienced downstream of the lower Whites Creek watershed. The quality of runoff, particularly "first flush" runoff, will also diminish as pollutants inherent to land development (such as petroleum products, heavy metals, etc.) will also increase. These increases may have an adverse impact upon flooding and upon existing wetland areas present downstream along Steamboat Creek.

The majority of new development that is expected to occur within the lower Whites Creek watershed will ultimately drain toward primary Channels #2 and/or #3, with little new development draining toward Channels #1 and #4. One approach to addressing the impacts of continued development upon runoff rates and water quality is to require on-site detention of stormwater runoff with each new development project. However, until such time as the flow distribution at the Shadowridge Park area becomes structurally defined and downstream flow paths become predictable, the potential exists for flooding (drowning out) and breaching of local on-site detention facilities during a major storm event that causes overflow of primary channels to occur, and this will tend to have a potential of exacerbating downstream flooding problems. Further, the construction of local on-site detention facilities with new development does not guarantee that the combined timing of regulated flows released from said facilities will provide a reduction in downstream discharges, and thus, the local on-site detention approach as a requirement for new development projects is not an ideal solution.

Instead, it is CBA's recommendation that **local, sub-regional stormwater detention basins** be considered at the approximate locations shown on Exhibit E1 as a more effective means of compensating for increases in runoff rates and for water quality issues associated with new development within upstream portions of the lower Whites Creek watershed. Hence, with the construction of such facilities, development within the lower Whites Creek watershed may occur without consideration of any on-site detention facilities, with the need for such detention being provided by local, sub-regional facilities that serve all of the contributing projects.

The cost, sizing, design requirements and permitting requirements for these local, sub-regional stormwater detention facilities will need to be established as a part of a subsequent detailed design process.

**Upstream Regional Detention Basins**

Another conceptual approach to providing flood control for the lower Whites Creek watershed is the construction of **upstream regional stormwater detention facilities.** An option under this approach is presented in the "Draft" Preliminary Feasibility Analysis, Whites and Thomas Creeks Flood Control Detention Basins report prepared by Nimbus Engineers (March, 1994). The "Draft" report examines a location that would capture flows from both Whites Creek and Thomas Creek on a 120 acre site near the base of Mt. Rose at Timberline Drive (see Exhibit E3 Location Maps).

The overall concept presented by Nimbus Engineers is to capture and attenuate the peak flows for Whites Creek and Thomas Creek and release them into the existing downstream channels at more manageable rates. The concept also includes a multi-use approach that incorporates passive recreation features, wetlands creation and a waterfowl and wildlife refuge into the flood control design. Groundwater recharge and fisheries enhancements are also being investigated.

Nimbus Engineers has made contact with a number of regulatory agencies and interested parties. All of the agencies contacted have given a positive response to the concept of the project. The agencies contacted to date are:

- U.S. Army Corps of Engineers (COE)
- Nevada State Historic Preservation Office
- Nevada Department of Wildlife
- Nevada Department of Environmental Protection
- Nevada Division of Water Resources
- Washoe County Public Works
- Washoe County Department of Comprehensive Planning
- Regional Water Board

Further input from these agencies and others will be sought as the concept continues to be refined by Nimbus Engineers. The project concept will also be presented to the Southwest Area Citizens Advisory Board (CAB) and the Regional Water Board Technical Advisory Committee (RWBTAC) for their review and comment. A Section 404 Permit

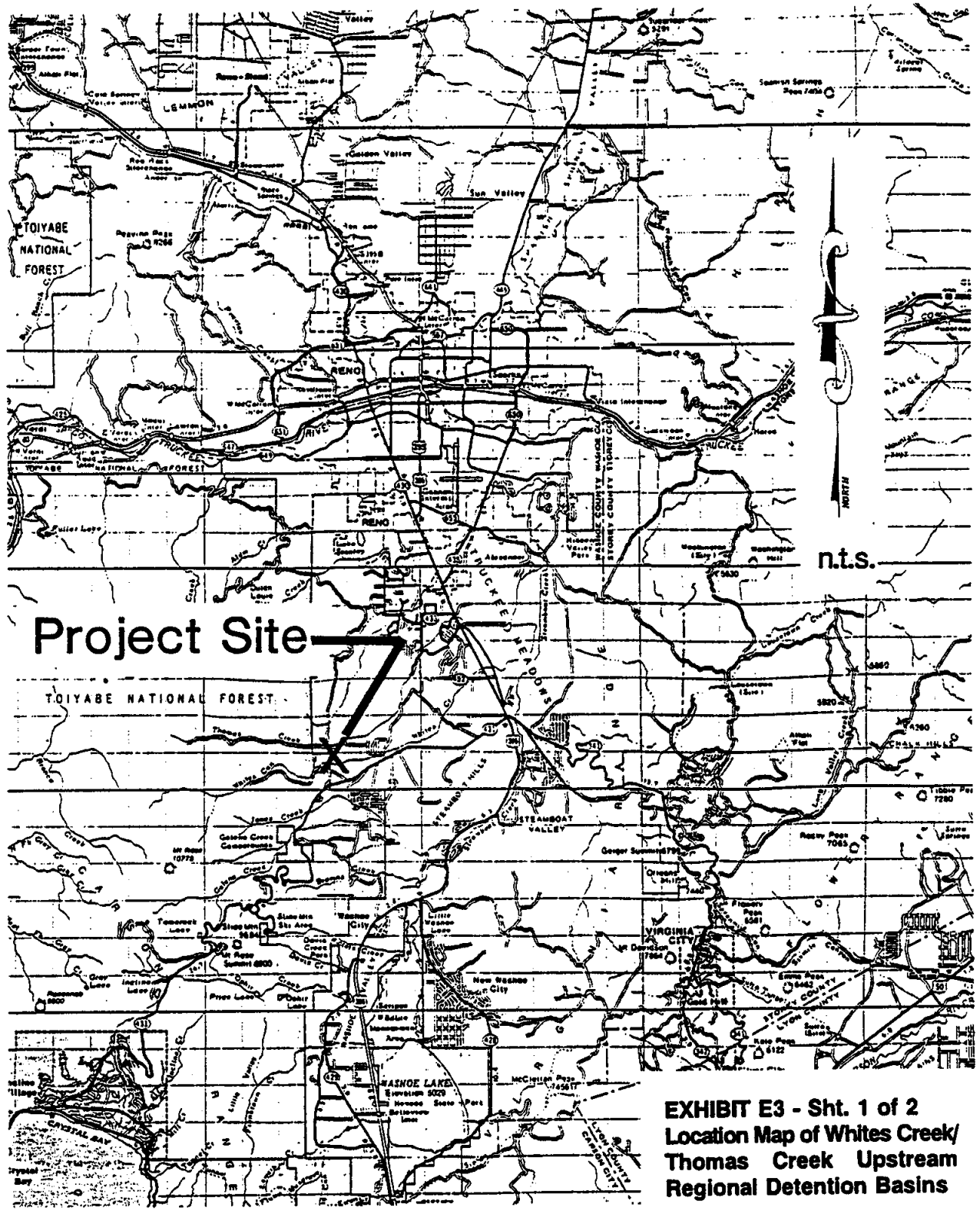



**EXHIBIT E3 - Sht. 1 of 2**
**Location Map of Whites Creek/ Thomas Creek Upstream Regional Detention Basins**

Nimbus Engineers
3710 Grant Dr., Suite D, Reno, NV 89509
Mail : P.O. Box 10220, Reno, NV 89510
(702) 689-8630

# Location Map

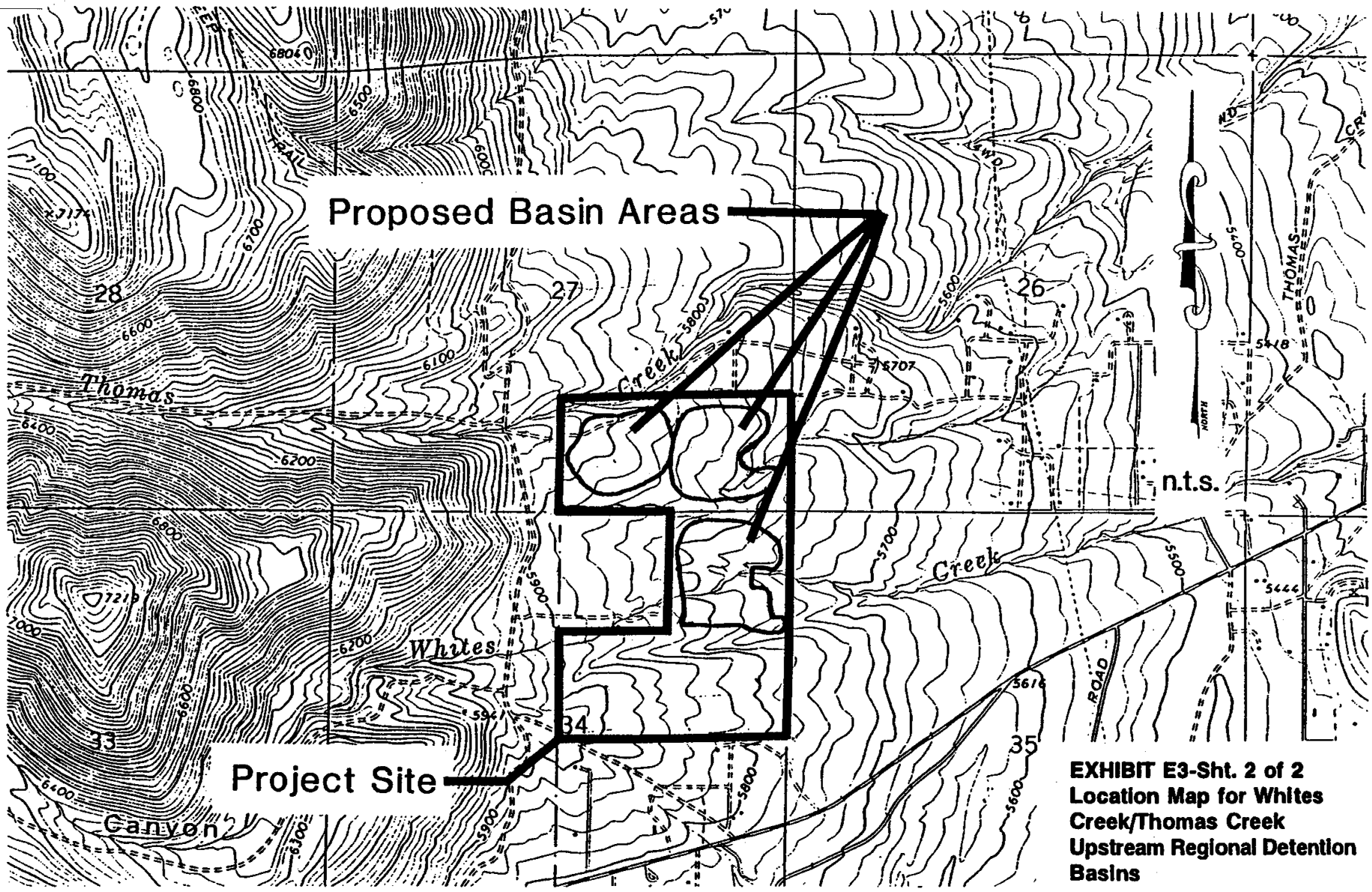



**EXHIBIT E3-Sht. 2 of 2**
**Location Map for Whites Creek/Thomas Creek Upstream Regional Detention Basins**

Nimbus Engineers

# Figure 1
## Project Site

preapplication meeting is scheduled with the COE for April or early May to discuss the project.

Previously developed hydrologic studies of Whites Creek and Thomas Creek were utilized to develop a preliminary size of facilities. The studies used were the Thomas Creek Flood Insurance Study developed for FEMA and the Whites Creek Detention Facility Feasibility Study prepared for NDOT. The hydrologic models for these studies were slightly modified to determine the volume of runoff which would impact the Timberline Road area during a 100-year event.

A preliminary facility size and configuration was developed using the entire volume of flow at Timberline Road and considering the physical constraints of the available site. An initial configuration of three basins, one for Whites Creek and two in series for Thomas Creek was used as a basis for a further analysis and for developing quantities and costs.

The hydraulic characteristics of the regional detention facilities determined from the Nimbus Engineers analysis are as follows:

| | Whites Creek | Thomas Creek |
|---|---|---|
| Maximum Stage | 17.3 ft. | 13.8 ft. |
| Maximum Volume | 317 Ac-ft. | 308 Ac-ft. |
| Maximum Outlet Discharge | 301 cfs | 256 cfs |

The estimated 100-year peak flows experienced downstream for the with and without regional detention conditions are given below:

| | Without Detention | With Detention |
|---|---|---|
| Thomas Creek at Virginia Street | 2544 cfs | 880 cfs |
| Whites Creek at Shadowridge Park | 5115 cfs | 589 cfs |

The investigated regional detention basins will require a maximum excavation of 3.9 million cubic yards of material and an estimated construction cost of roughly $12,500,000. Indications are that the excavation quantities could be significantly reduced (and consequently the costs) with several iterations of cost/benefit analyses and better topographic information.

Additional information regarding this conceptual approach to flood control is provided in the Nimbus Engineers' report.

**Drainage Crossings of Existing Roadways**

Several existing drainage crossings of roadways should be enlarged or have drainage structures provided, in response to development activities and/or reducing current flood hazards in selected locations. The primary locations requiring drainage structure enlargement or new structure installation include:

- Zolezzi Lane crossing of Channel #1.
- U.S. 395 crossing of Channel #1.
- Zolezzi Lane and U.S. 395 Intersection; Drainage structure and outfall channel needed to accommodate flows from Channel #2.
- U.S. 395 crossing of Channel #3.

## VII. INTERIM POLICIES FOR MANAGING THE BASIN

As a result of the reviews, discussions, evaluations and investigations performed as a part of this Preliminary Basin Management Study, several proposed interim policies have been formulated relating to new development and infrastructure improvement projects within the lower Whites Creek watershed. It is proposed that these interim policies be utilized until such time as more detailed basin management planning activities or structural improvements are completed at a later date.

### 1. Drainage Corridors

Open space will be established and retained along each of the four (4) drainage corridors represented on Exhibit D. The purpose of establishing these drainage corridors shall be twofold:

A. To provide a continuous means of conveyance of the proportional discharge for each of the primary channels originating from the flow split at Shadowridge Park downstream to I-580 or the limit of the primary study area.

B. To provide open space linkages and opportunities for passive recreation within the primary study area.

At locations where channel definition and/or capacity is insufficient to convey the desired proportionalized flow, a combination of excavation and adjacent filling will be needed to create a defined channel or conveyance area.

There are several issues associated with the establishment of drainage corridors that require resolution. They are:

- Who will retain ownership of drainage corridors?
- Will they be retained as easements or fee title right-of-way?
- What mechanism will be utilized to convey drainage corridors or easements to an appropriate authority?
- Who is responsible for maintenance?
- Should drainage corridors be natural to the extent feasible or modified by excavation and grading?
- What stabilization measures are deemed appropriate when needed?
- Should establishment of drainage corridors occur on a piecemeal basis in conjunction with new development or should an overall drainage improvement district be established?

2. **Discharges**

The following discharges shall be applied as the required design capacities, or incremental discharges, for each drainage corridor:

| Drainage Corridor | Design Capacity |
|---|---|
| #1 | 700 cfs |
| #2 | 1950 cfs |
| #3 | 1100 cfs |
| #4 | 1350 cfs |

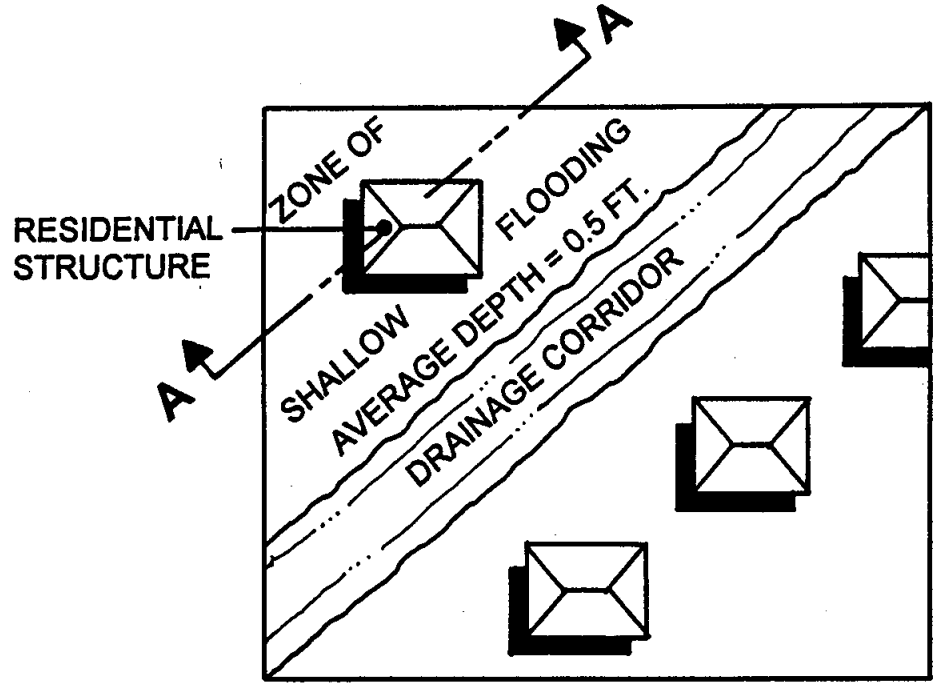
**The value of the total 100-year discharge for Whites Creek at Shadowridge Park is 5100 cfs.**

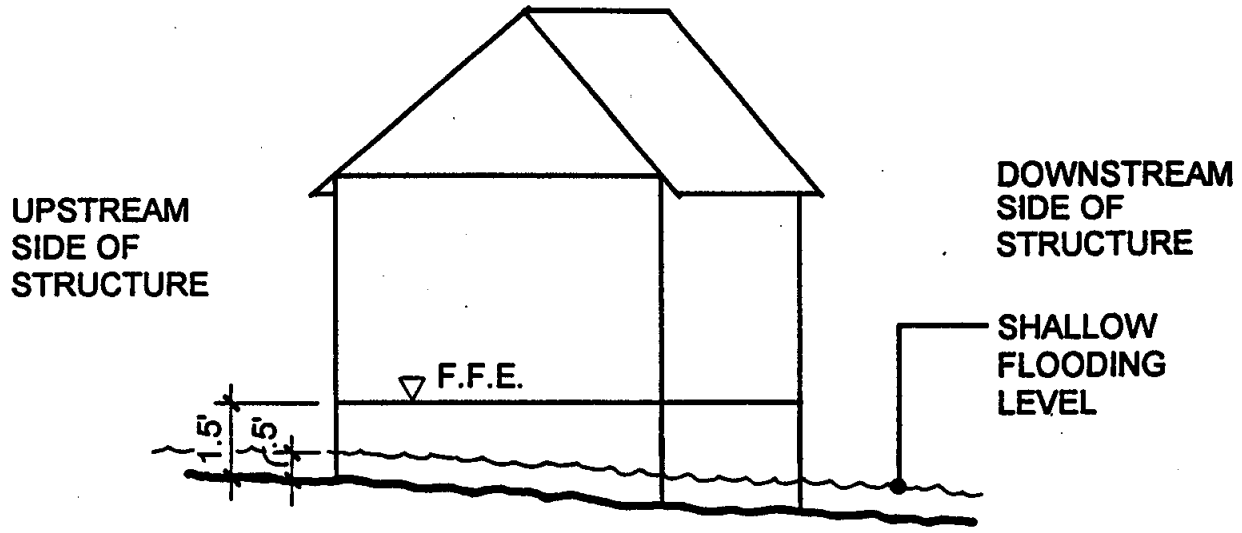
Until such time as flows are predictably distributed downstream of Shadowridge Park through the construction of a structural flow distribution facility or until upstream attenuation is provided, the design for downstream development projects and the elevating of building finished floors must consider the possibility of **3000 cfs** entering any one of the four (4) drainage corridors (see Section II.B.). After construction of a flow distribution structure, the incremental discharges for individual drainage corridors will be applied. However, in certain instances, i.e., drainage corridors #2 and #3, the effect of co-mingling of flows will need to be considered for applicable downstream areas until such time as continuity exists along the applicable drainage corridors to a location downstream of a given point of interest.

3. **Finished Floor Elevations**

Finished floor elevations of new individual structures where mass grading has not occurred shall be established based upon the average flood depths represented on Exhibit D, until such time as more detailed floodplain mapping is performed for the lower Whites Creek watershed. The flood depths represented on Exhibit D may also be revised at any given location if substantiated by an acceptable site-specific engineering analysis. Average flooding depths represented on Exhibit D have been established under the assumption that **3000 cfs** may enter any of the four (4) drainage corridors downstream of Shadowridge Park, causing flooding of the corridor itself and adjacent areas. Finished floor elevations of individual structures where no mass grading has occurred shall be set a minimum of one foot (1′) above the estimated shallow flooding depths represented on Exhibit D for areas within, between or adjacent to drainage corridors. The one foot (1′) criteria applies to the upstream side of a given structure (see Exhibit F1).

# WHITES CREEK BASIN MANAGEMENT




SECTION A - A

**EXHIBIT F 1**

EXAMPLE OF FINISHED FLOOR ELEVATION
REQUIREMENTS IN SHALLOW FLOODING ZONES
**(INDIVIDUAL BUILDING SITES - NO MASS GRADING)**

For structures that are integrated into development projects where mass grading is proposed or has occurred, finished floors will be elevated a minimum of one foot (1′) above the applicable water surface elevations calculated via a site specific engineering analysis. In such instances, spillover from drainage corridors will need to be conveyed in streets and/or drainage easements around and adjacent to structures. Provisions must be made to accept spillover runoff, convey it safely, and release it downstream in essentially the same manner as for existing conditions. The one foot (1′) criteria applies to the upstream side of each structure. These concepts are graphically represented on Exhibit F2.

In areas of "minimal" flooding depicted per Exhibit D, finished floor elevations for structures shall be set a minimum of one foot (1′) above the highest adjacent natural grade (individual building sites) or the adjacent top of curb (mass graded condition). These requirements may be waived if a site specific engineering analysis demonstrates that no flood hazard exists. Requirements for the elevating of structures in areas of "minimal" flooding are represented on Exhibit F3.

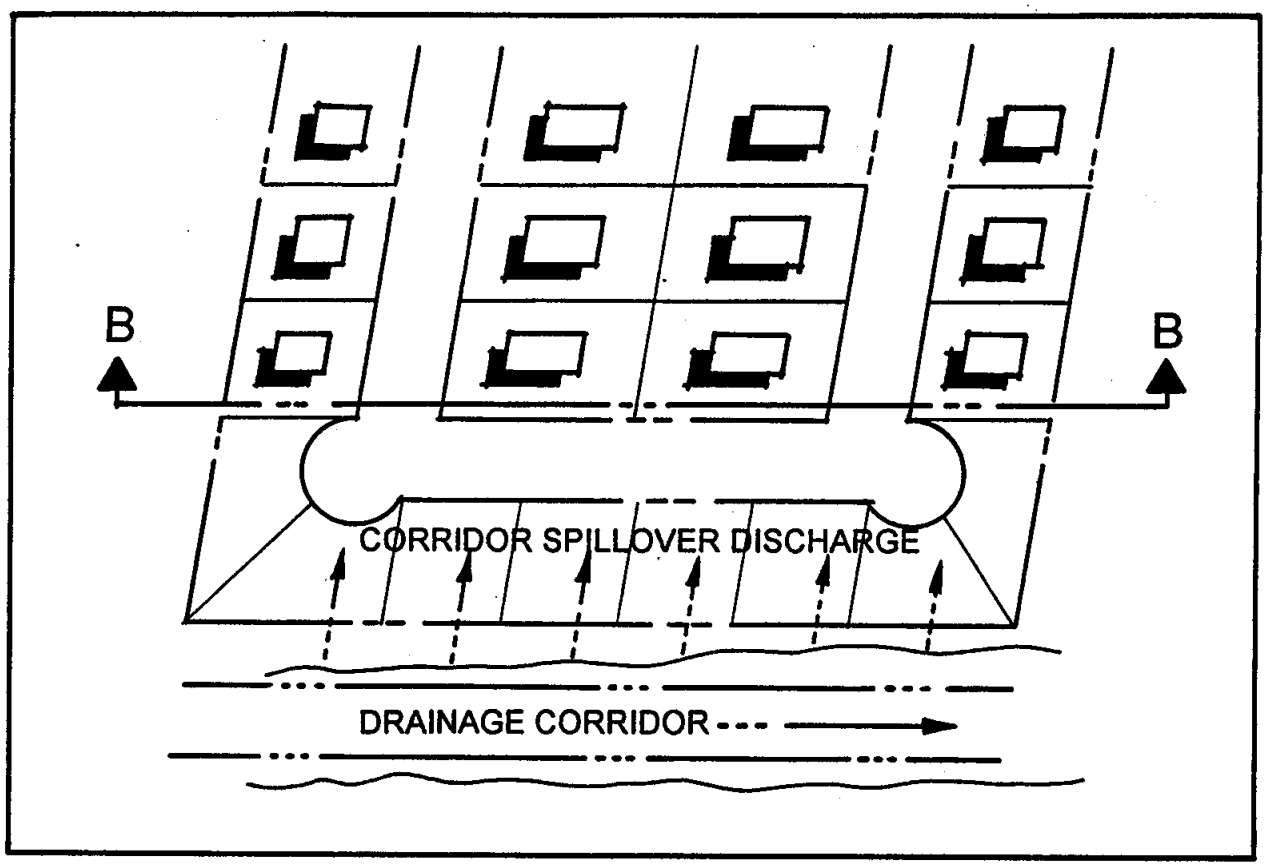
4. **Street Alignments**

In areas of "minimal" flooding, no special requirements apply pertinent to street alignments. In areas having flood depth designations on Exhibit D, an appropriate amount of streets will be aligned with the direction of existing grades to provide conveyance for shallow flooding (see Exhibit G), at least until such time as incremental discharges for individual drainage corridors become established through upstream structural measures. Appropriate means for inflow and outflow to and from the internal street conveyance systems for development projects shall be provided and applicable shallow flooding in excess of the corridor discharge must enter and exit developed properties in essentially the same manner as under existing conditions. Where possible, the outfall for runoff generated on-site within a development project should be the nearest drainage corridor.

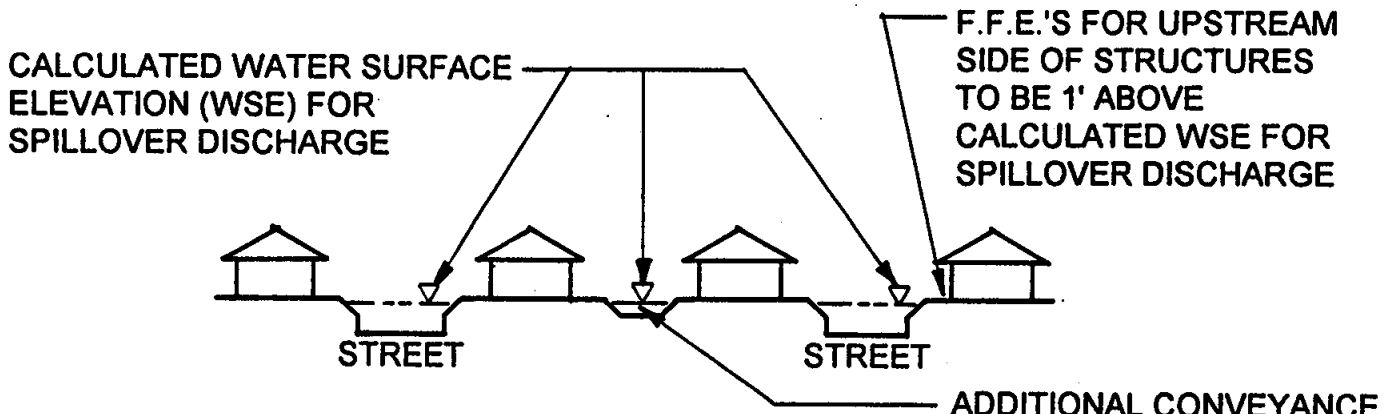
5. **Depth of Flow in Streets**

Streets utilized for overflow conveyance from drainage corridors shall have a maximum allowable depth of one foot (1′) and must consider the flooding conditions that would be present assuming that 3000 cfs has entered the drainage corridor downstream of Shadowridge Park, until such time as the distribution of flows becomes fixed or attenuation occurs through upstream structural measures. Once upstream structural measures are implemented to distribute the flow, the incremental corridor discharges will govern, the potential for shallow flooding in streets will be appreciably reduced or eliminated, and this requirement will be waived, if appropriate.

# WHITES CREEK BASIN MANAGEMENT




* APPLICABLE TO ALL EXHIBIT D FLOOD PRONE AREAS, EXCEPT AREAS WITH "MINIMAL" DEPTH DESIGNATION.




SECTION B - B

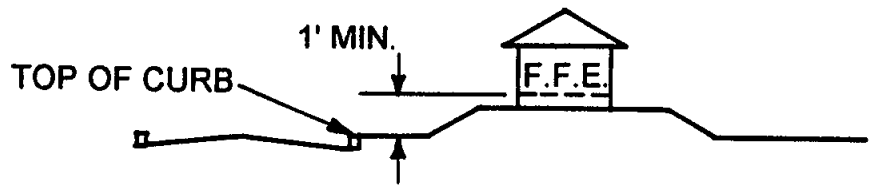
## EXHIBIT F2

EXAMPLE OF FINISHED FLOOR ELEVATION REQUIREMENTS IN SHALLOW FLOODING ZONES * (MASS GRADED DEVELOPMENT PROJECTS)

# WHITES CREEK BASIN MANAGEMENT

IN AREAS OF "MINIMAL" FLOODING PER EXHIBIT D, F.F.E.'S FOR STRUCTURES SHALL BE SET 1' OR MORE ABOVE THE HIGHEST ADJACENT NATURAL GRADE (INDIVIDUAL BUILDING SITES) OR 1' OR MORE ABOVE ADJACENT TOP OF CURB (MASS GRADED CONDITION).


INDIVIDUAL BUILDING SITE



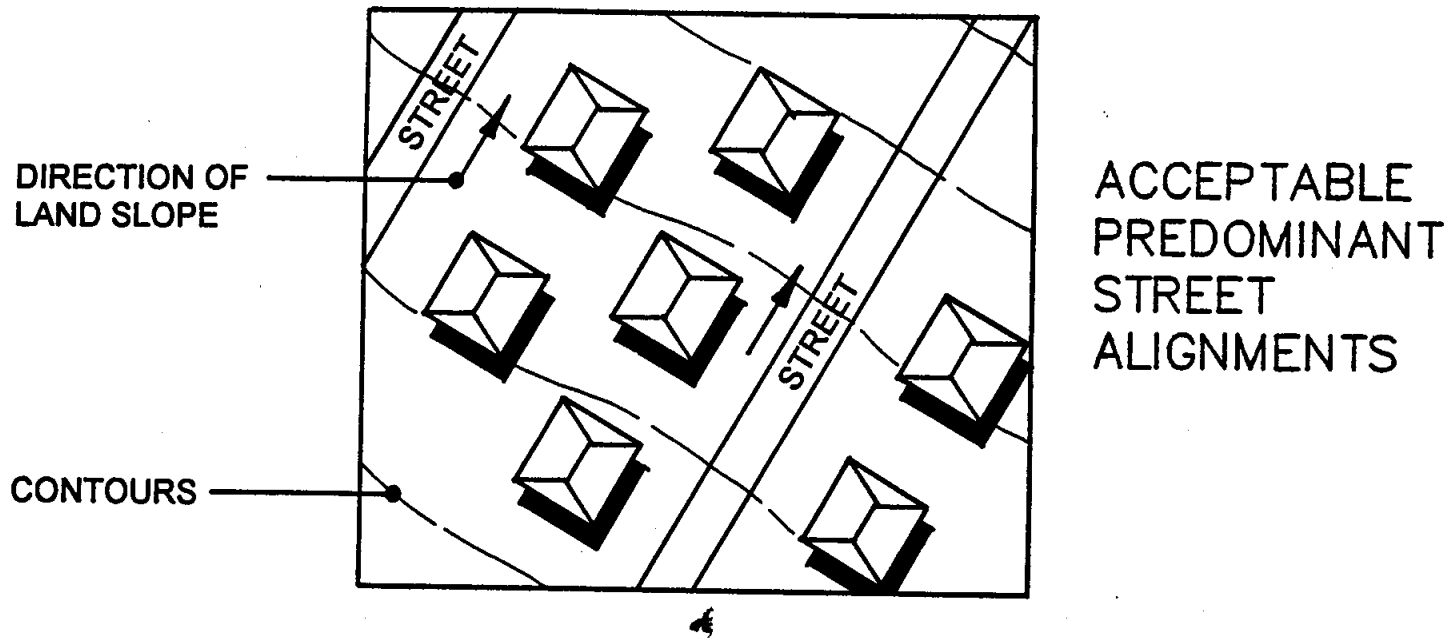

MASS GRADED CONDITION

THE ABOVE SPECIAL REQUIREMENTS MAY BE WAIVED IF A SITE SPECIFIC ENGINEERING STUDY DEMONSTRATES THAT NO FLOOD HAZARD EXISTS.

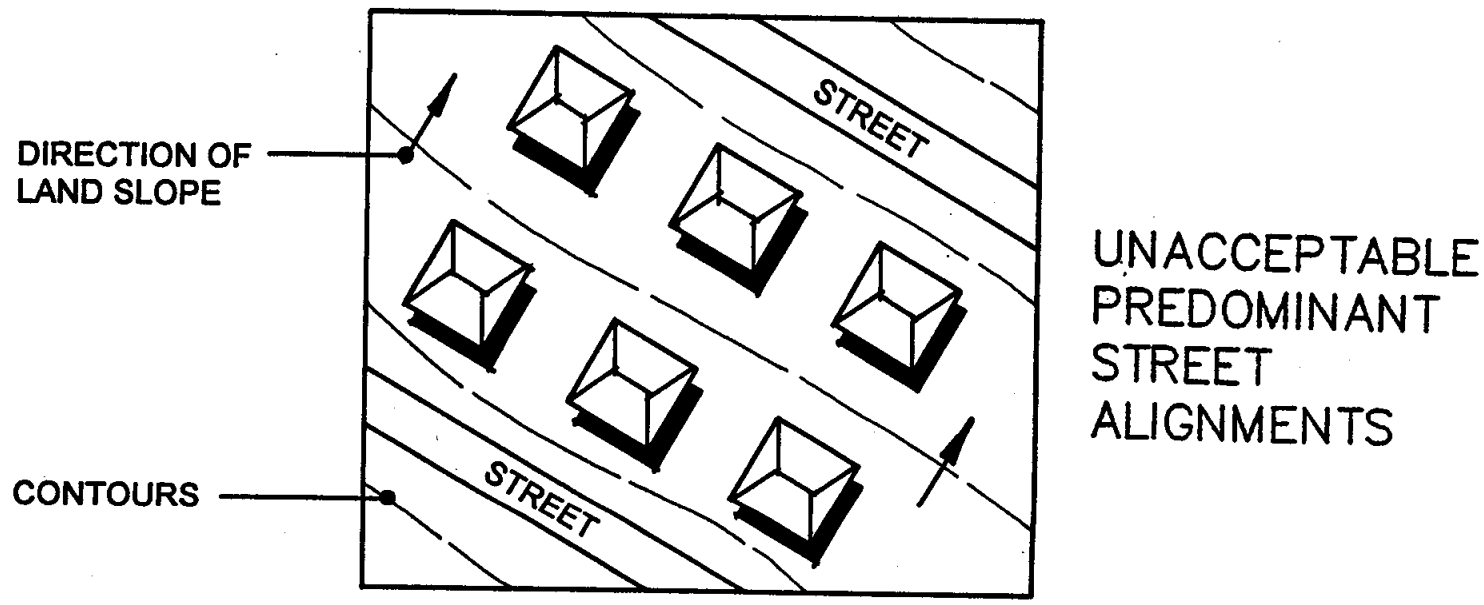
## EXHIBIT F3

FINISHED FLOOR ELEVATION REQUIREMENTS IN ZONES OF "MINIMAL" FLOODING.

# WHITES CREEK BASIN MANAGEMENT




ACCEPTABLE PREDOMINANT STREET ALIGNMENTS




UNACCEPTABLE PREDOMINANT STREET ALIGNMENTS

**EXHIBIT G**

STREET ALIGNMENTS IN SUBDIVISIONS LOCATED WITHIN SHALLOW FLOODING ZONES

CBA

6. **Drainage Structures**

Drainage structures for new roadways crossing drainage corridors will be sized to accommodate the applicable incremental corridor discharge. Where possible, a depressed section shall be provided within the roadway over the structure. Reinforcement of the adjacent fill slopes will also be required to minimize damage to the structure in the event that the roadway is overtopped, until such time as corridor discharges become predictably established through upstream structural measures.

7. **Transverse Roadway Grades**

Elevated roadways that extend perpendicular to flow directions are discouraged and will require prior approval of Washoe County, with consideration being given to any potential for obstructing, retarding or diverting said drainage flows when compared with existing conditions.

8. **Grading**

Lowering of existing grades for new development projects between or adjacent to drainage corridors will only be allowed if it can be demonstrated that additional flows are not diverted into the development project during a 100-year event as a result of site grading.

9. **Detention**

Based upon the evaluations and opinions discussed in Section VI of this Preliminary Basin Management Study, it has been concluded that attenuation of increased runoff produced by new development is needed to preclude the potential of significant increases in flooding and a deterioration in water quality experienced downstream within Steamboat Creek. It is also recommended that a preferred approach to providing attenuation of runoff and water quality storage is the construction of local sub-regional stormwater detention facilities, as opposed to requiring local on-site detention with each new development project.

Local, sub-regional detention facilities offer preferred benefits in terms of consolidated flood control and water quality treatment and the removal of requirements for setting aside lands within individual development projects to provide local on-site detention facilities. Also, until such time as incremental flows are successfully assigned to drainage corridors via upstream structural measures, the local on-site detention concept may serve to increase flood hazards due to a potential for overflow and breaching of said facilities during a major storm event. Hence, it is recommended that new development projects not include provisions for local on-site stormwater detention.

Until such time as local sub-regional detention facilities are built, the following options may be considered as an interim means of accounting for adverse impacts associated with the construction of development projects in the lower Whites Creek watershed:

- Impact fees
- Phased basin excavation/construction
- Temporary on-site detention facilities that do not have a potential for overflowing induced by drainage corridor spillovers
- Hold harmless agreements with downstream property owners

The approximate locations for local, sub-regional stormwater detention facilities are represented on Exhibit E1. Further evaluations will be necessary to design, size and prepare a cost estimate for these facilities.

Funding mechanisms to be considered for construction of these facilities may include:

- Drainage improvement district
- Impact fees for new development
- Property taxes
- Drainage utility
- Other alternatives presented in the Washoe County Flood Control Master Plan

## 10. Site-Specific Engineering Analyses

There are a number of circumstances where a site-specific engineering analysis will be required to supplement or amend the information contained in this study prior to commencing with a given development or infrastructure improvement project. The following situations will require such an analysis:

- A development project that includes mass grading in a portion of the watershed having a flood hazard designation other than "minimal" on Exhibit D.
- A development project that includes basements. Basements will not be allowed in flood hazard areas.

- Any design proposal to amend or that would otherwise alter the flood hazard information represented on Exhibit D.

- Any design proposal to waive the finished floor elevation requirements set forth for areas of "minimal" flooding per Exhibit F3.

- Any project that proposes modification to, constriction to, or realignment of a drainage corridor.

- Any roadway design project that impacts existing drainage patterns.

- Any other applicable set of circumstances where such an analysis is deemed appropriate by Washoe County.

# PRELIMINARY FEASIBILITY ANALYSIS
## Whites and Thomas Creeks
## Flood Control Detention Basins

### INTRODUCTION

The lower basin areas of Whites Creek and Thomas Creek in Washoe County and the City of Reno are currently experiencing rapid growth. Proposals from numerous developers have been submitted to the planning and public works departments for review and approval. Scattered developments have already been built within both basins and the U.S. Government has sold much of its holdings in small acreage parcels which have not undergone the review process.

In order to provide a unified approach to development within the Whites Creek Basin, Washoe County has hired Cella Barr Associates (CBA) to prepare interim development policies. These policies are proposed to guide developers in planning projects and to regulate the design and construction of the infrastructure to serve those projects. Due to budgetary constraints, only conceptual long term solutions will be presented in the CBA effort. The investigation which is documented in the following sections of this report is proposed to provide an alternative long term solution to the flooding problems on both Whites and Thomas Creeks. The sponsors of this proposal have requested that this project be included in the CBA study and Washoe County has concurred.

Both Thomas and Whites Creeks originate high in the Carson Range of the Southern Truckee Meadows. The upper channels are steep and well incised. As the streams leave the mountain front just west of Timberline Road, some capacity is lost in the channel and flow will break out to some extent, but then return to the channel as it continues in an easterly direction. Further downstream, both stream channels lose capacity and sheet flooding occurs over several stream miles. It is this upstream area, where little development has taken place, that is proposed for detention facilities for both creeks. The property that has been identified as available for the project is shown on Figure 1.

The flood control concept is a simple detention design which will reduce the peak

flood flows and release them at a more manageable rate. The overall concept will incorporate the flood control facilities into a multi-use facility to include passive recreation features, some wetlands creation and a waterfowl and wildlife refuge. Recreational features contemplated are trails with observation points for wildlife viewing and picnic areas.

## APPEARANCE

The construction of the project will cause a great deal of recontouring of the site. An extensive revegetation program with native species is anticipated. The steeper cut slopes will be planted with conifers and aspen and be in appearance similar to the western side of Timberline Road. The more gentle slopes will be planted with grasses and shrubs. No extensive berming or filling, which would alter the overall slope of the land is anticipated. Designs will be produced with a purpose of minimizing any disturbance to the views in the area.

## TECHNICAL ANALYSIS

At this concept stage, no new technical data was developed. Previously developed hydrologic studies of the two catchments were utilized to develop a preliminary size of facilities. The studies used were the Thomas Creek Flood Insurance Study developed for FEMA dated November 1990 and the Whites Creek Detention Basin Feasibility Study for the Nevada Department of Transportation dated March 1993.

The hydrologic models for these studies were slightly modified to determine the volume of runoff which would impact the Timberline Road area during a 100 year event. That volume was removed from the model to determine the effect upon the peak flows of the streams as they reached critical points. On Whites Creek, the critical area is the diffluence point where the channel splits near Shadowridge Park and on Thomas Creek the area selected was just upstream of Virginia Street and Holcomb Lane. Both streams demonstrated a dramatic reduction in peak flow after the removal of the upper watersheds; this result was an assurance that the proposal would have a beneficial impact.

A preliminary facility size and configuration was developed using the entire volume of flow at Timberline Road and considering the physical constraints of the available site. An initial configuration of three basins, one for Whites Creek and two in series for Thomas Creek was used as a basis for a further analysis and for developing quantities and costs.

**Results**

The inflow and outflow hydrographs for the proposed detention facilities on Whites and Thomas Creeks are shown in Figures 2 and 3, respectively. The estimated maximum conditions for both detention are given below.

| | Whites Creek | Thomas Creek |
|---|---|---|
| Maximum Stage | 17.3 ft | 13.8 ft |
| Maximum Volume | 317 Ac-ft | 308 Ac-ft |
| Maximum Outlet Discharge | 301 cfs | 256 cfs |

The estimated peak flows at these locations with and without detention are given below.

| | Without Detention | With Detention |
|---|---|---|
| Thomas Creek at Virginia St. | 2544 cfs | 880 cfs |
| Whites Creek at Split | 5115 cfs | 589 cfs |

## FINDINGS AND RECOMMENDATIONS

Nimbus Engineers believes, with the information developed to date, that this flood control facility can be an effective means for reducing the flows in both Thomas and Whites Creeks. Two of the largest and most apparent benefits from construction of the project are the flood protection and the recreational opportunities. The creation of wetlands and habitat are also significant benefits. The initial alternative investigated will require a maximum excavation of 3.9 million cubic yards of material. Indications are that the excavation quantities could be significantly reduced (and consequently the costs) with several iterations of cost/benefit analyses and better

topographic information.

Further investigations should incorporate hydraulic analyses of the downstream channels to determine a range of acceptable outflow values from the basins.

**DESCRIPTION**

**DRAINAGE APPURTENANCES**

The proposed detention basins for Whites Creek and Thomas Creek, to be located on approximately 120 acres between the two streams may require the following structures in addition to the basins excavations. These concepts were developed to estimate an overall cost figure. Agency input and further design may cause significant modifications of the structures.

1. A diversion structure on each of the creek channels which will divert the major flows allowing approximately 50 cfs to continue to flow through at all times. This structure must then divert any excess flow into the basins including the calculated 100 yr. storm peak flows. Based on the preliminary calculations the flows in each of the natural channels under peak flow conditions will likely be supercritical. This hydraulic condition will require additional height and width to handle the likely hydraulic jump and the sharp angle diversion into the basin inflow channel.

2. Each diversion structure will require a basin inflow channel. The channel on Thomas Creek, just south of Timberline Road, will have to cut through a small ridge in order to discharge into the upper basin as shown on the preliminary basin layout plan. The maximum cut will be approximately 35 feet and the channel will have to have at least a 60 bottom width. The channel will have high velocities under peak conditions and may require both bank and bottom protection, similar to rock gabions or grouted rock rip-rap. The upper slopes of the channel above estimated water surface will either be flatter slopes or be

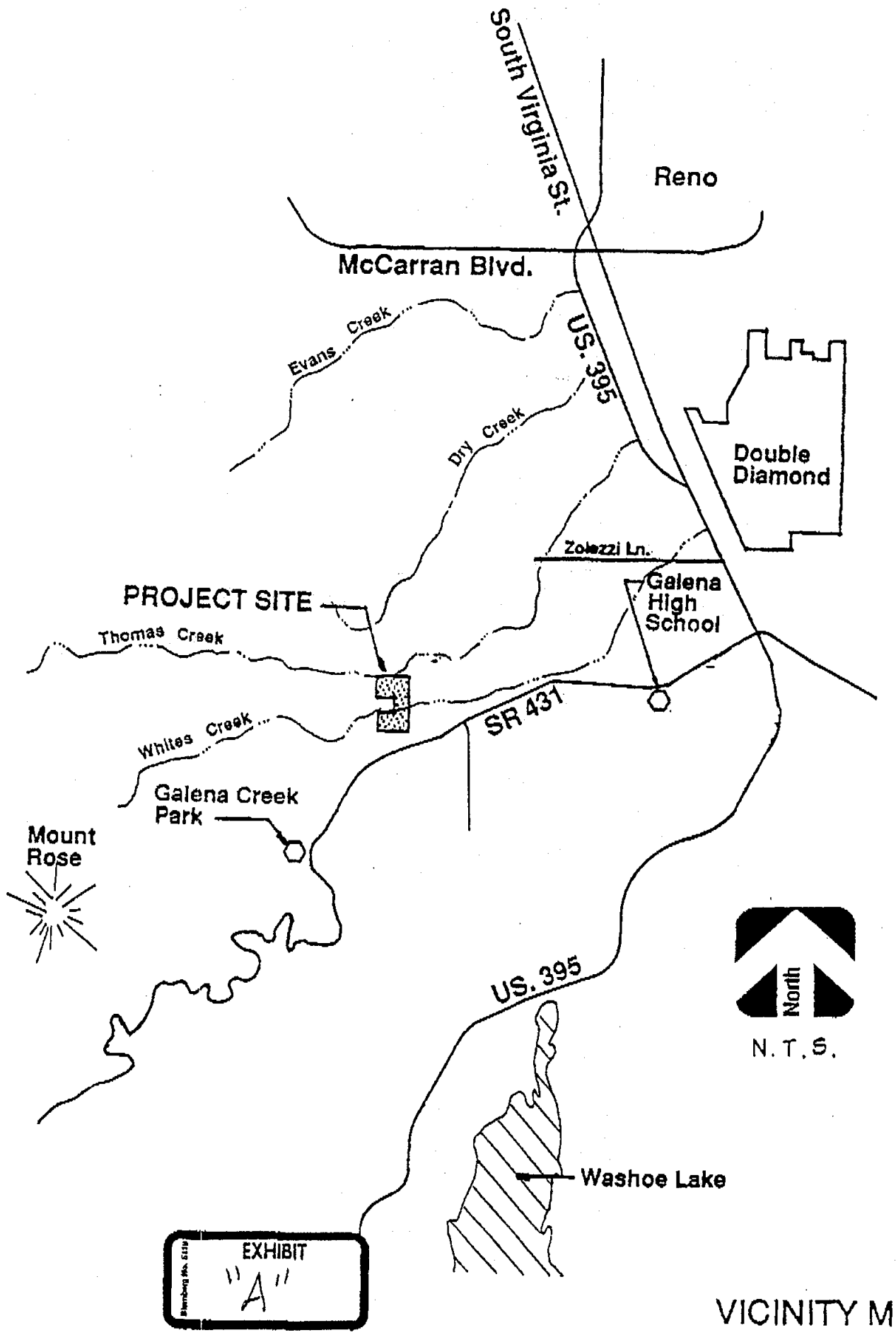
protected against erosion unless the material demonstrates a stability at steeper inclines and a resistance to face erosion.

3. The third set of structures which will be required are the facilities at the outlets of each of the inflow channels. These structures have to be wide enough and stable enough to handle the peak flow of the 100 year storm which will generate velocities down the cut slope of the basins of over 20 feet per second. Again protection like rock gabions, soil cement or rock rip-rap will be required down the slope as well as a large stilling basin at the bottom of the slope spillway. The length of the stilling basins will likely exceed 60 feet depending on the final design.

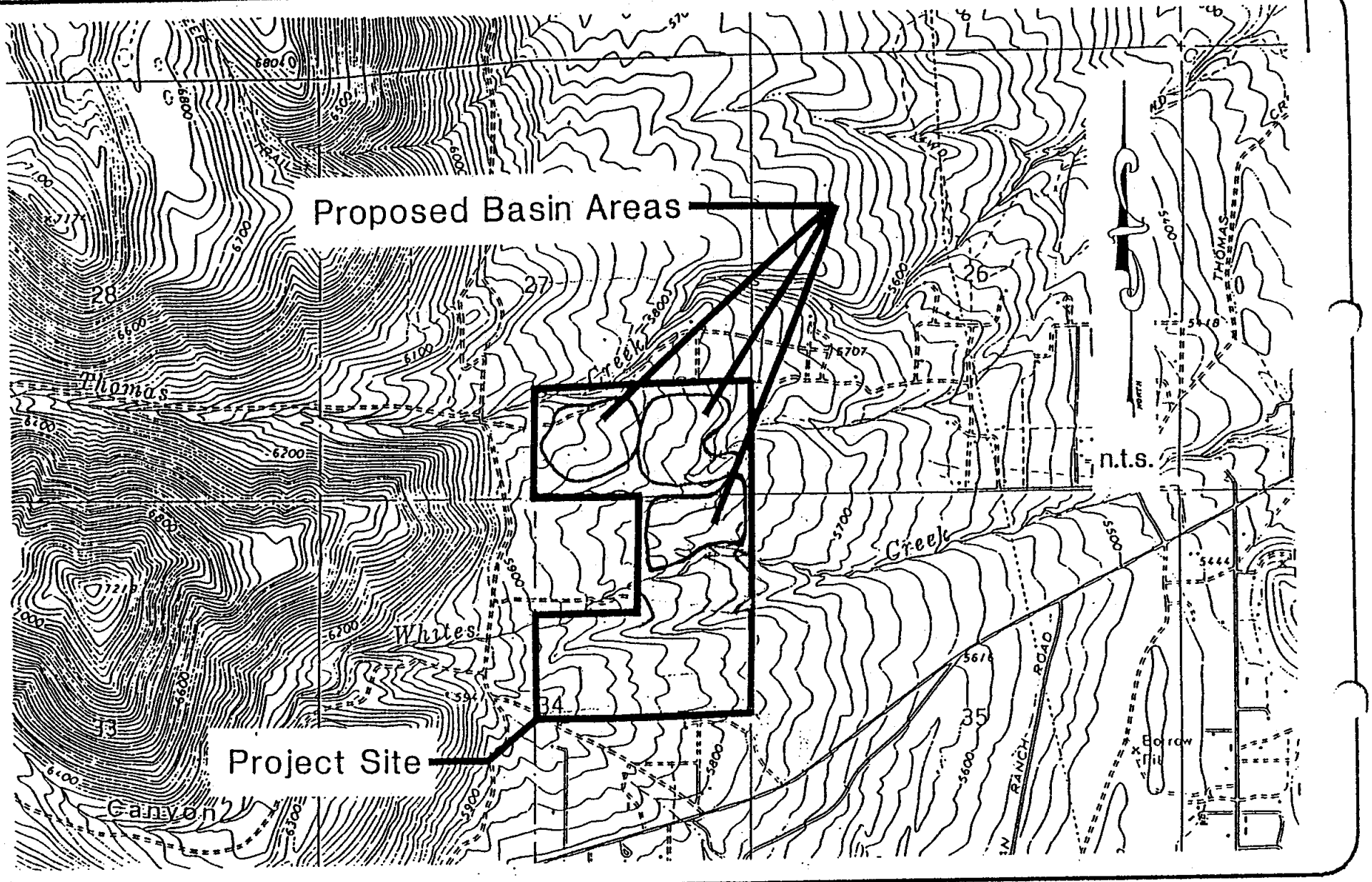
4. The upper Thomas Creek basin will require two additional facilities. The first an emergency spillway into the lower Thomas Creek basin and the second is a discharge structure that will empty the upper basin within a 24 hour period. The emergency spillway will either be gabions concrete or soil cement. This must protect the slope of the lower basin and will have to have an energy dissipator or stilling basin at the foot of the slope. The discharge pipe or channel will need to convey approximately 100 cfs with a concrete headworks at the inlet to facilitate the final flow as the basin empties. This flow will be discharged directly back into Thomas Creek from the southeast corner of the lower basin.

5. Discharges structures will be required for the two large basins. Whites Creek will need the capacity of approximately 300 cfs which would include a concrete headworks inlet structure, a reinforced concrete pipe or pipes, excavation, bedding and backfill. The discharge pipe for the Whites Creek basin will need to extend back into the existing natural Whites Creek channel. The lower Thomas Creek basin discharge structure will necessarily have to be piped underground because it will cross adjacent property in order to get back into Thomas Creek. The size will have to convey approximately 250 cfs in order to

drain completely within 24 hours. Both the discharge points back into the main channels will require energy dissipators. These structures should be constructed outside the existing raparian areas of the creeks.

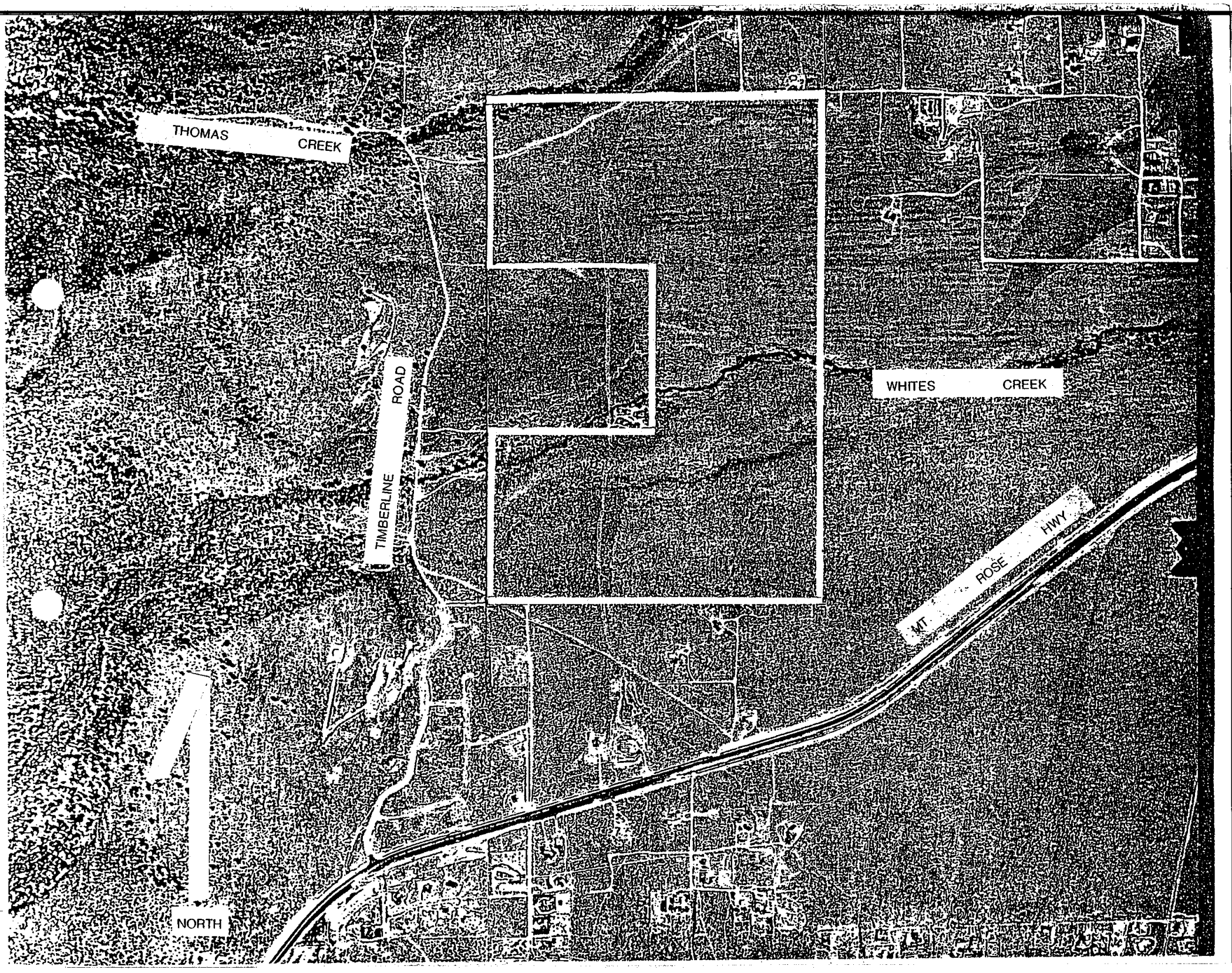



VICINITY MAP




Nimbus Engineers

# Figure 1
## Project Site


THOMAS
CREEK
ROAD
TIMBERLINE
WHITES
CREEK
MT
ROSE
HWY
NORTH