STORMWATER MANAGEMENT MASTER PLAN (SWMMP)

FOR THE

CITY OF FRUITA

JUNE 1998

Prepared By:
Williams Engineering
1231 19 Road
Fruita, CO 81521
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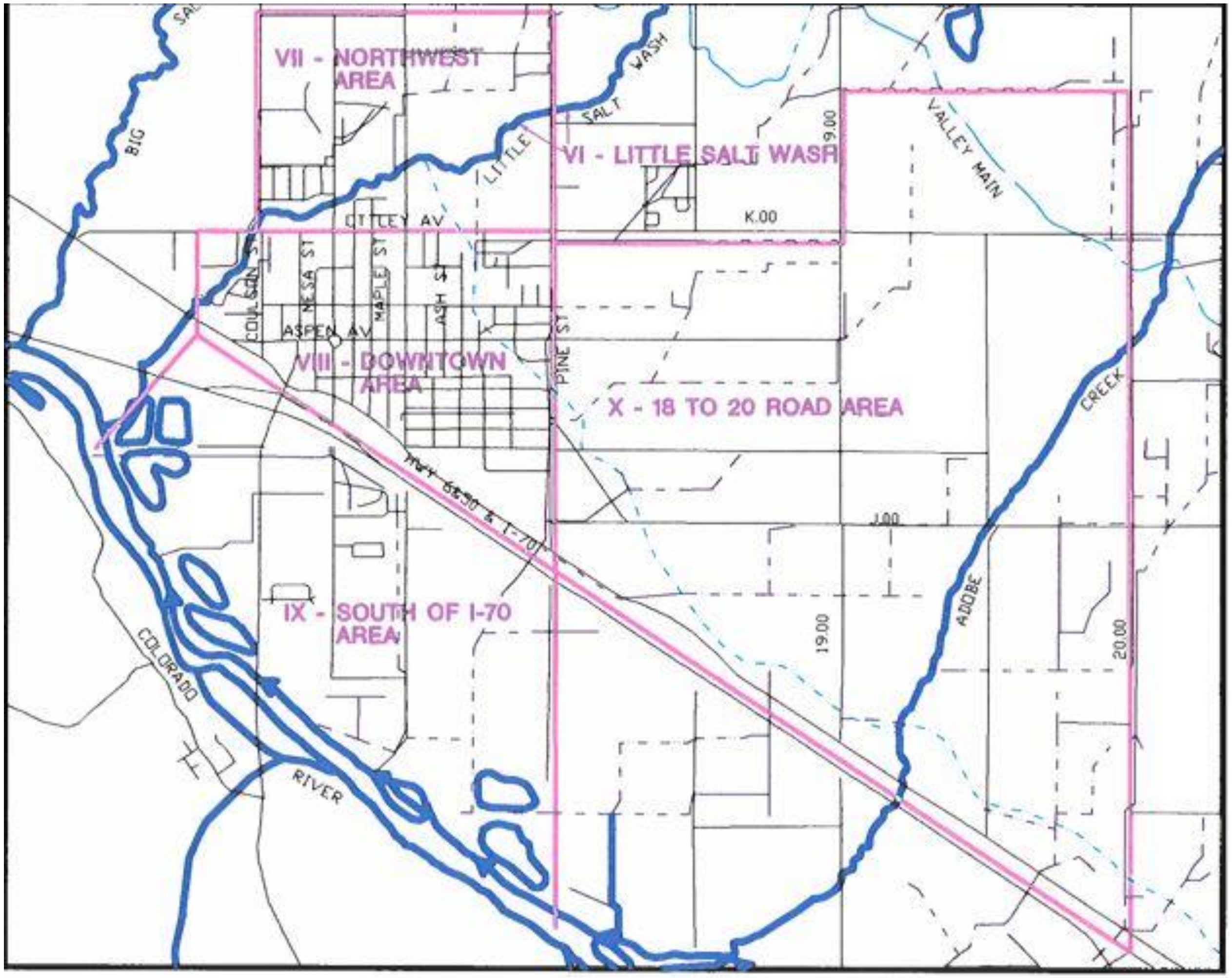
STUDY AREAS


VII - NORTHWEST AREA
VI - LITTLE SALT WASH
VIII - DOWNTOWN AREA
X - 18 TO 20 ROAD AREA
IX - SOUTH OF I-70 AREA
BIG
SALT
WASH
LITTLE
VALLEY MAIN
OTTLEY AV
ASPEN AV
COULSON ST
MESA ST
MAPLE ST
ASH ST
PINE ST
K.00
J.00
9.00
19.00
20.00
HWY 6&50 & I-70
ADOBE
CREEK
COLORADO
RIVER

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ACKNOWLEDGEMENTS

Base mapping used on this project was made available by the City of Fruita, City of Grand Junction, Mesa County, and the Grand Junction Drainage District.

Appreciation is extended to Wayne Costa, Jay Ingelhart, Bennett Boeschenstein, and John Ballagh for their part in providing valuable input with respect to needs, information regarding existing facilities, and review of exhibits and the report.

Finally, appreciation is extended to City of Fruita staff and officials who have patiently awaited the results and recommendations of this SWMMP.

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

This section provides an overall summary and compilation of recommendations for this Stormwater Management Masterplan or SWMMP (pronounced "swamp").

A. USE OF THIS REPORT

1. **Format** This SWMMP consists of narrative with 8 1/2" x 11" figures.and 11" x 17" exhibits.

   a. **Narrative** The narrative is organized as outlined below.

   - **Section** I - **Introduction** consists of policy discussion for consideration by elected officials, managers, and department heads. Topics covered include management of existing facilities, master planning and interdepartmental planning and cooperation, and EPA water quality regulations;
   - **Section** II **-Establishing the City of Fruita's SWMMP** defines the Scope of Work for this study;
   - **Section** III - **Previous Studies and Available Mapping and Data** identifies information available at the time the study was performed;
   - **Section IV and V** provide an overview of hydrology and hydraulics, respectively, as generally used for all area analyses as part of this study; and
   - **Section VI through X** focus on specific watershed areas. Detailed information regarding analyses, results, recommendations, and costs are provided therein. Watershed areas are numbered-consistent with these report sections. For example, watershed number 6 is discussed in Section VI of the SWMMP, and is also shown on Exhibits 6*.

   b. **Exhibits** The entire SWMMP should be read and studied by those involved in stormwater management, and this Executive Summary and Section I Introduction understood by all elected officials, managers, and department heads. However, we realize that the more frequent use of the SWMMP will be to quickly access information regarding proposed facilities and associated costs. We believe that such information is best presented in graphical format. Consequently, as much as practical, information is presented on 11' x 17" color exhibits. These are presented in the back of their respective sections behind the 8-1/2" x 11" narrative.

2. **General Recommendations** These recommendations pertain to overall drainage policy and stormwater management rather than to a single watershed area. These will be outlined in Subsection B of this Executive Summary.

3. Master Planning Recommendations As presented in Section I-D, this SWMMP provides recommendations which, if adopted, provide a regulatory framework and a tool or plan for guiding policy and decision making, budgeting, and administration of development and capital improvements and maintenance programs. This SWMMP and future SWMMPs should focus on and help allow implementation of practical and continuous systems of drainage improvements.

4. **Area Recommendations** Recommendations for facilities and stormwater management for specific watershed areas are provided for the respective areas in Sections VI through X of this SWMMP. Furthermore, a brief overall summary is provided in Subsection C of this Executive Summary.

B. GENERAL RECOMMENDATIONS

A number of recommendations pertain to overall policy and stormwater management. These are presented here.

1. **Formal Adoption of SWMM** In order to be able to manage and administrate stormwater activity and processes in the City of Fruita, stormwater management policy, criteria, and procedures must be adopted. The Mesa County Stormwater Management Manual, or SWMM (pronounced "swim"), contains such information, and has recently been informally adopted by the City of Fruita to regulate stormwater activity. We recommend formal adoption of the manual by the City of Fruita, as supplemented by this report and the modifications presented below.

   - **The drainage impact fee option** discussed in SWMM Subsection I-B-2 Table "I - 3" and Subsection VIII-B will be allowed by the City of Fruita, but only under the conditions presented therein and as approved by the City Engineer. Furthermore, the base coefficient used in calculating the fee shall be changed from "10,000" to "12,000" and this base value shall be subject to an annual adjustment by a percentage equal to the percentage change in the Consumer Price Index (all items), for the Denver, Colorado area, as published by the U.S. Department of Labor Statistics.
   - **Enforcement responsibility** shall be revised in SWMM paragraphs 11-A-4 and II-A-6 to refer to the City Engineer.
   - **Submittal requirements** for drainage to the City of Fruita shall be per Subsection II-D-2, the same as it is for Mesa County, except that not all portions may be applicable depending upon the project and selected method of addressing mitigation of drainage impacts. Subsection B-10 of this Executive Summary further discusses this issue.
   - **In case of conflict with the SWMM,** the SWMMP shall be considered more detailed and specific to the City of Fruita and shall govern.

2. **Formal Adoption of This SWMMP** The SWMM provides general policy and detailed criteria and procedures. Supplemental and more focused policy and planning recommendations are provided in this SWMMP. We recommend it's formal adoption. Because this SWMMP relates m<?re to overall policy, guidelines, and planning rather than criteria and procedures, this SWMMP need not be available for general distribution like the SWMM.

3. **Comprehensive Masterplanning** We reemphasize the need to approach stormwater management with comprehensive masterplanning and interdepartmental cooperation as explained in Subsections I-B, C, & D, with emphasis on multi-use and multi-function facilities.

4. **Trail Easements and/or ROW** As explained in Subsections VI-E-4 & 5, which sections are devoted to the Little Salt Wash pathway and dumping regulation and enforcement, maintenance access along the wash is vital. Periodic removal of bush, debris, lower tree branches, and other obstacles, along with greater public visibility to help reduce dumping, are all very important. The best way we know of to address these issues is to have a path or trail along the wash. We recommend that easements and/or ROW be obtained along the wash for a future path, with emergency and maintenance access points approximately every eight mile.

5. **Intergovernmental Agreement With the GJDD** The Grand Junction Drainage District
1,) (GJDD) owns and maintains several key components of the area drainage system. Many of these are open drains. The GJDD has a program of piping some of these drains and otherwise maintains them and upgrades culverts at roadway crossings. We recommend that the City enter an intergovernmental agreement with the GJDD to inform each other of all proposed development, capital improvement projects, or other efforts that could have an impact on each other. For example, a condition could be that the GJDD will notify the City 18 months in advance of construction of any planned piping project so that the City could have opportunity to review the plan, discuss upgrade or upsizing opportunities and/or possibilities, and budget to participate in any such upgrade or upsizing project as deemed desirable.

6. **Maintenance** We recommend that priority be given in the budget to adequately maintain existing facilities so that they function as designed (see Subsection I-A-1).

7. **Water Quality** Section IX and Appendix M of SWMM and Section I-E of this SWMMP discuss water quality, the latter of which also provides a number of recommendations. In general, while the City of Fruita may not be regulated in the near future by current or proposed EPA regulations, it seems inevitable that they will be, and likely in the next decade. We recommend avoiding additional compliance difficulties by adopting a policy now to have all new development and capital improvement projects

conform to EPA regulations where feasible and practical. Regulations are outlined in 40 CFR Parts 122 and 123, and are summarized in SWMM and this SWMMP as referenced above.

Recommendations made throughout this SWMMP consider water quality issues, and should be followed.

We note also that while the SWMM adequately addresses Best Management Practices (BMPs) for use during construction activities, additional guidance and construction details could be prepared for pennanent water quality control devices and ponds. We recommend that the City, perhaps in conjunction with other agencies in the Grand Valley, pursue preparation and adoption of additional water quality control device recommendations, including guidelines, design procedures, and typical construction details.

8. **Drainage Impact Fees and Facilities** We recommend implementing procedures to have development address, either with constructed facilities or by payment of funds therefore, any adverse impact that development may have on drainage.

a. **Drainage Impact Fees** These may be of two types if and when allowed for a specific project by the City Engineer.

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1) **System Specific Drainage Impact Fee** For many areas, this study and resultant SWMMP identify specific outfall drainage improvements that are recommended to address drainage issues that will arise as development occurs. Where these systems have been identified, there has also been a cost estimate provided that includes design, construction, and construction engineering. The estimates are in 1998 dollars and should be adjusted in future years in accordance with changes in the Consumer Price Index (all items) of the U.S. Department of Labor Statistics for the Denver, Colorado area. Alternatively, a new estimate may be prepared or approved by the City Engineer. Where costs for a system are established or identified and accepted by the City Engineer, then a fee for such facilities may be imposed upon development that, in the master plan, could and should use such facilities. For example, Acme Acres is a proposed 40 acre subdivision in an overall watershed basin having 120 acres. Allowed land uses are similar, so runoff generation will be fairly equivalent on a per acre basis. The recommended drainage outfall facility is estimated to cost $1,000,000. Since Acme Acres consists of 20 acres of the total 120 acres to be served by the outfall facility, the appropriate share of cost would be 1/6 of the $1,000,000. Another approach is to have a drainage report provided that identifies a development's proposed discharge rate, then the percent of pipe use and cost or cost of required pipe for that development's discharge could be charged to the developer. (Alternatively, as discussed in Subsection 2 hereafter, actual construction to the amount of a development's share of cost may also be allowed or advisable.) This procedure is very defensible, because developers would only pay based upon their percentage of cost for facilities specifically needed for their watershed area as opposed to using a more generic drainage impact fee.

2) **Generic Drainage Impact Fee** For areas where no specific drainage systems have been recommended or identified, or where a parcel of land cannot reasonable be drained to a recommended outfall system, it may be advisable to use the generic drainage impact fee equation in SWMM Subsection I-B-2 and VIII-Bas modified per Subsection B-1 of this Executive Summary; that is,

Drainage Fee ($) = B(CIOOd- CIOOh)A [7]

Where B = Base value of 12,000, to be adjusted annually per the Denver area Consumer Price Index (all items); from 1998

Ciao= 100 year Rational Method composite runoff coefficient, with subscripts "d" and "h" pertaining to the proposed developed and current existing or historic conditions, respectively (see SWMM Appendix "B"); and

A = Area to be developed in acres.

b. **Construction of Offsite Facilities** In addition to constructing onsite facilities, a developer may be required, or may be allowed to choose the option, of constructing offsite facilities as their share of drainage responsibility. For example, if there is no existing outfall facility, or it is inadequate and another facility with greater capacity is required, the developer may construct an outfall line per this SWMMP or other master plan that would be adequate and necessary for proper drainage in the area. The constructed outfall facility may be used for a time by only one development before other areas connect in or the outfall facility is extended. Because it would have at least some immediate use, this would be a "wet" line. Alternatively, there may be an adequate outfall, but only to the extent of serving existing and the proposed development, and not future development that would exceed the capacity of the outfall; or, perhaps there is no outfall and it would be impractical at the time to construct one, and so full retention or permissible detention is allowed until such time as an outfall is available. In either case, an offsite outfall would not be constructed with the development to serve the development. However, it may be that a "dry" drainage facility could be constructed alongside the development as part of required offsite improvements, to be extended downstream and upstream at a later date. The facility would be constructed, however, while offsite improvements were being made, and the developer would thus pay for the proportionate share of the overall drainage facility.

What if the required outfall facility would cost more than is justifiable for one developer alone? What about timing? Who would pay fqr improvements and when they would be done are difficult questions. Development occurs in quilt patchwork fashion and is not always conducive to the construction of drainage facilities. A few possibilities and considerations are described below.

1) **Design** Although the construction may be phased, the design should not be piecemeal. Each storm drain line should be designed for the entire length to ensure consistency and a comprehensive design. The cost of the design could be recouped through drainage impact fees imposed upon development. Considering project timing, it may be necessary to have the design done in advance of or at least simultaneously with the next development in an area, with the City reimbursed by future development for design costs.

2) **Construction** Once the design is completed, the storm drain may be constructed all at once by the City or piecemeal in conjunction with development, roadway developments, or other projects such as the piping of drains. This way, a developer could construct the drain per plans along their property as part of their offsite improvements. It may be that there is a "dry line" segment for a while, but eventually the line will be complete without up front cost to the City and without unnecessary removal and replacement of improvements.

c. **Summary of Handling Drainage Impacts** The above discussion hopefully illustrates the fact that having a rigid requirement for handling drainage impacts is impractical. There must be guidelines established, and a basis identified for those guidelines, and then the program administered on a case by case basis.

The foundational principle is stormwater law as discussed in the SWMM: one is not entitled, through the course of property development, to adversely impact another with increased runoff, change of runoff form or location, or with decreased runoff water quality. While an absolute position on the above would be administratively difficult and perhaps unnecessary, protection should be provided where reasonable and possible. We have presented in this SWMMP and referenced the SWMM regarding several methods of providing immediate or eventual protection against adverse affects of development on stormwater. To summarize, these alternative methods are:

- Pay a watershed specific drainage impact fee as a fair cost share of a required outfall facility;

- Pay a generic drainage impact fee to an estimated fair cost share of eventual drainage improvement costs when a specific drainage system is not identified or other conditions merit this approach;
- Construct offsite downstream or adjacent "wet" outfall facilities for immediate use;
- Construct offsite adjacent "dry" outfall facilities for future use; or
- Provide retention or detention facilities that meet the conditions of no adverse impact and other guidelines relating to water quality and major outfall facility limitations, such as allowing localized peaks to pass through a major conveyance system before peaks from higher up in the watershed arrive.

If these five methods are adopted by the City of Fruita as generally acceptable for handling drainage impact issues, with the stipulation that the City Engineer, after review of circumstances and conditions involved, may identify which options of the five may be allowed for a specific project, then the City would have established procedures broad enough for the variety of conditions that arise, sufficient control or authority to eliminate undesirable options when necessary, and a basis of justification for any unallowed options.

It may be well to note here that while this SWMMP and the options discussed herein allows some latitude in how drainage is handled in an area, it must be understood that as options one selected by earlier development, the course of action or overall drainage system scheme begins to be more defined, and subsequent developers as a result must follow suit, and thereby will of necessity have fewer options. They must carry out or continue on with the system already commenced. Consequently, the "first come first serve" principle will apply. Thus it is very important that the City Engineer, is allowing or disallowing options, keep in mind what limiting impacts an option allowed and selected at the time may have on future development.

Furthermore, there may be situations where, under existing conditions, flooding downstream of a proposed development is undesirable. These conditions can and should be considered by the City Engineer, which may result in the elimination of options allowed so that the bigger picture of drainage needs are realized and addressed. In summary, the City Engineer must have the authority to allow or disallow options for development in order to address master planning issues.

9. **Financing Stormwater Facilities** There are many methods of financing stormwater management projects. The means used to finance required projects to improve conditions in areas of existing infrastructure may be quite different than those used for facilities required by new development. A combination of funding methods may be useful for some projects. A few possibilities are outlined below with brief descriptions.

a. **Developer Assistance** The drainage impact fee, both specific and generic, and also developer installed offsite facilities, have been discussed in the previous subsection. Oftentimes, however, a facility upsize or extension may be required that may not be the developer's responsibility, and yet the City is lacking revenue to pay the difference. Options include most of the funding methods described hereafter, but additional developer assistance is possible. Perhaps the developer is willing to construct the upgrade or extension in exchange for a reduction of other development fees or required offsite improvements. This would not require more of the developer, but would allow necessary improvements to be constructed, and inter or intra departmental adjustments can be made later by the City. Another possibility, which is not so acceptable to developers because of the initial cost and risk of returns, is to agree to a buy-in fee. For example, if a developer constructs facilities beyond their responsibility, and that line will service future development, then when future development occurs, the developer who constructed the facility would be reimbursed the proportionate share of cost based upon usage.

b. **Connection Fees** An equitable connection fee system could be established that would require developers to pay a fee when they connect into an existing drainage facility. This would be similar to a tap, hook-up, connection fee, or plant investment fee commonly charged for municipal water and sewer systems. Justification for having such a fee is,the fact that the new development would not only benefit from a previously paid for drainage conveyance facility, but eventually, some means of water quality facility will be required before stormwater is discharged to "waters of the U.S.". The fee would allow the City compensation for the developer's share of use and benefit.

The connection fee could be paid for lump sum by the developer, or by the property owner as part of obtaining a building permit.

c. **Capital Improvement Projects** Projects could be constructed or paid for out of the general fund for capital improvement projects.

d. **Grand Junction Drainage District (GJDD)** The GJDD owns and maintains many drainage facilities in the Fruita area, with purpose primarily for groundwater and irrigation tailwater usage. However, stormwater can be an element of facility function, and cooperative efforts in funding, construction, and/or seeking grants or loans a viable solution. An example is the project of piping a portion on the Denton Drain along 17-1/2 Road, where the GJDD, City of Fruita, and a developer cooperated in constructing an upsized pipeline to address not only irrigation tailwater and ground water, but also stormwater runoff.

e. **Bonds** Bonds may be sold to generate revenue which would be retired by other means of funding.

f. **Improvement Districts** Improvement districts may be initiated by a coalition of neighbors who wish to upgrade or provide additional facilities or by a municipality which recognizes a specific need in an area. An Improvement District may then be established by a governmental agency, within the limits and per guidelines established by Colorado Revised Statutes, if an acceptable majority of the property owners affected by the proposed project are in favor of the District. These Districts are formed for a specific purpose, and when accomplished, are absolved. Generally, the governmental agency funds the project and then levies special assessments to participating property owners over a given period of years to pay for the project.

g. **GOCO Funds, Parks, and Paths/Trails** Recreational facility funding can be of benefit for stormwater management projects as well. Multi-use facilities such as parks and water quality and/or detention facilities; paths and trails and drainage conveyance, drainage system access, or embankment stability improvements, can be integrated into a single win-win project. Funding sources for parks, trails, and recreation are more available now than for stormwater or flood control projects, and may be a significant source of funding for projects and land that indirectly assist with needed stormwater projects. (Examples of this are provided in Section 1-B.)

h. **State Grants and Loans** Funding is sometimes available through state agencies such as the Colorado Water Conservation Board (303-866-3441), Division of Local Governments, or other agencies.

Another source of funding pertains to non-point source water quality projects. The Water Pollution Control Revolving Fund (WPCRF) is a loan program authorized under the 1987 Amendments to the federal Clean Water Act, and by Senate Bill 50, passed by the Colorado General Assembly in 1988. The loan program is jointly managed by the Colorado Water Resources and Power Development Authority (CWR&PDA), the Water Quality Control Division (WQCD) and the Division of Local Government (DLG). The U.S. Environmental Protection Agency (EPA) oversees the administration of these loan programs.

Under Colorado's WPCR program, local governments (counties municipalities and special districts) can apply to borrow less than $1 million at an annual interest rate of 4.5%. Applicants who are approved to borrow more than $1 million through the program pay an annual interest rate equal to 80% of the market rate when bonds as sold by the CWR&PDA.

In Colorado, for projects to be eligible for funding, they must be listed on the

WPCRF "eligibility list" which is revised every summer and approved by the Colorado Water Quality Control Commission (WQCC) every fall. This list is in tum adopted by the General Assembly through a joint resolution every year.

As of spring 1998, the eligibility list can be accessed over the Internet at www.state.co.us/gov_dir/loc_affairs_dir/wpcrflst.htm. To have a project listed on the WPCRF eligibility list, contact either the DLG (303-866-2352) or WQCD (303-692-3553).

i. **<u>Stormwater Utility Fee or Service Charges</u>** Municipal water and sewer systems have an extensive collection or distribution system, a treatment facility, and operation and maintenance expenses. Capital and on-going costs are paid for by monthly utility bills or service charges. Many municipalities have recognized that stormwater systems are also very costly, provide the whole community with a benefit, and could be handled much like other utilities. These communities have set up a stormwater utility, with monthly service charges the same as for water and sewer, though much lower.

The primary reasons to utilize a service charge concept are as follows:

- **<u>Fairness</u>**
  ..properties are measured and evaluated based on contribution to the drainage system
  ..the greater the impervious area development on a parcel, the greater the service provided to that customer
  ..courts have held this action to equitable
- **<u>Dependable</u>**
  ..revenues provide a reliable source of support for surface water operations which is predictable and uniform
  ..the consistency and reliability of this revenue flow enables the development of revenue sources beyond service charges
  ..consistency allows accurate forecasting of revenues which enables better planning for physical improvements to the surface water control system
- **<u>Dedicated</u>**
  ..by law, revenues raised through the service charge concept must be expended on maintenance, operation and/or capital improvements to the system and may not be allocated to other general funds.
- **<u>Legally Defensible</u>**
  ..state supreme courts have held that municipalities and counties do have the authority to establish charges based on a contribution to run-off methodology AND charges based on impervious surface measurement are not considered arbitrary

- **Clear**
  ..the service charge is usually very straightforward as it is based on the amount of impervious surface or runoff contribution

While there are many positive aspects to a stormwater utility, public familiarity and acceptance may be the biggest drawback. The City council and involved staff should be aware of and consider stormwater utility possibilities, if not for now, then perhaps to slowly migrate that direction so that there will be a reliable source of revenue to fund necessary future projects, particularly those mandated by the EPA for water quality. The City of Fruita's day of reckoning will arrive with that issue, and adequate planning and preparing is important.

10. **Development Drainage Report Requirements** Drainage Reports shall follow the format outlined for Mesa County in Subsection II-D-2 of SWMM as noted previously. However, not all projects under all drainage mitigation methods will require a full report as presented. The extent required should be identified in a pre-application conference. In general, the following should be considered:

- Onsite drainage and inflow from offsite should always be addressed; and

- Outflow or discharge from a site may require a simple paragraph or extensive report, depending upon the mitigation method selected. General requirements are presented in Table 1-3 and Table VIII-I in SWMM.

11. **Software Use** Recommendations for hydrological and hydraulic software are provided in Sections IV-Band V-B, respectively. These recommendations were made primarily for City use, but under certain circumstances, such as for large development that would require a reanalysis of the overall drainage system, the principles and procedures and software discussed in the referenced sections should be considered for model integration and compatibility, and perhaps required by the City of the developer.

C. AREARECOMMENDATIONS

Recommendations for proposed improvements and policy pertaining to specific watershed areas are presented in corresponding sections of this report and need not be presented here. The Table of Contents indicates where each Recommendations subsection is located in Sections VI through X.

1. **Basis of Prioritization** All recommendations for which a cost is estimated are prioritized. The following describes the basis of prioritization.

- **First Priority; Land Acquisition and Easements** Even though land may be used for a low priority project, purchase or otherwise securing land is critical to keep a project viable. Many opportunities have been lost because the best alternative is no longer possible because of the unavailability of land. More often than not, the land is needed for detention and/or water quality ponds.

- **Second Priority:** **Major Outfall Releases** Facilities that would allow for the continued conveyance of runoff and mitigate serious backup ponding are very important. This generally occurs at the railroad or roadway that acts as a dam, such as at Highway 6 & 50. Corrective measures generally include bores under the railroad or highway that can act as a culvert until a storm drain system can be constructed to and through it.
- **Third Priority:** **Major Outfall Storm Drain Systems** A major storm drain trunkline or mainline that would serve an area currently without any drainage facilities and/or that would have significant impact on the overall drainage system.
- **Fourth Priority: Minor Storm Drain Systems** Minor collection and conveyance systems with less significant drainage would have lower priority.
- **Fifth Priority:** **Minor Storm Drain Upgrade Systems** Minor collection and conveyance system upgrades or piping of adequate open channel drains.

2. **Basis of Costs** Facility costs estimated are based upon 1998 local costs for construction. Recommended facilities are schematic only, and therefore estimates do no include all miscellaneous work usually involved in a construction project. Nonetheless, we have attempted to account for this and other factors by using the following pricing scheme.

COST SCHEME

Description	**Cost (%)**
Construction Subtotal (Estimated cost of itemized facilities)	100%
Contingency (Mobilization, Insurances, bonds): 5.0% Construction Surveying: 3.5% Traffic Control: 1.5% Miscellaneous Work:25.0% 35.0%	35%
Construction Total	135%
Engineering Design	8% of 135%
Construction Engineering	7% of 135%
Total Cost	115% of 135%

3. **Recommended Facility Cost Summary** A summary of area facility costs is provided below. Bear in mind that much of the costs for facilities in areas outside of the

The downtown area would be developer financed.

Area No.	Area Description	Approx. Cost
6	Little Salt Wash - Trails	Not Estimated
7	Northwest Fruita - Trunklines	$2,350,000
8	Downtown – Trunklines & Outfalls	$2,525,000
9	Southwest Fruita – Trunklines & Water Quality Basins	$1,850,000
10	East of 18 Road to 20 Road - Various	Not Estimated

I INTRODUCTION

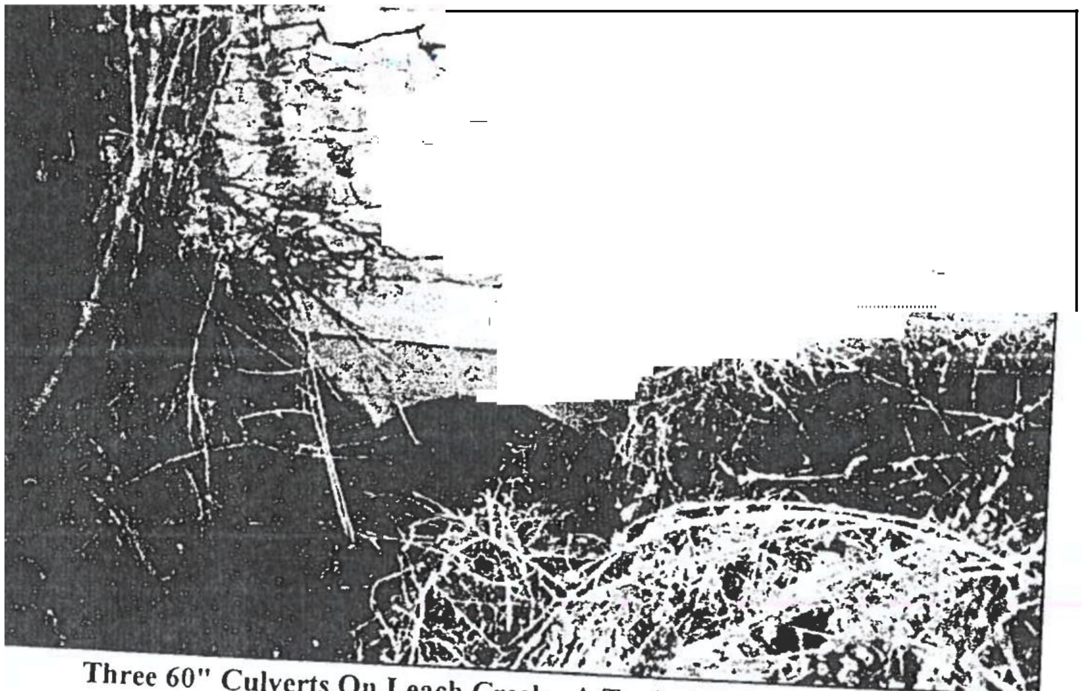
Typically, a drainage or stormwater management masterplan report begins with discussion- of the study area and existing problems and needs, which in turn substantiates the study, and then the scope of work is defined. Thereafter, the full focus is on hydrology, hydraulics, water quality, and costs of proposed systems. Certainly these are major components involved in any stormwater management masterplan, but we would be remiss if we did not first direct attention to two other important issues. With increased costs and demands on limited financial and natural resources, there should be a shift towards:

- Better management and use of existing facilities, and
- Better management and coordination between departments and agencies to obtain, where possible, multi-use facilities or benefits (comprehensive masterplanning and management).

A. BETTER MANAGEMENT OF EXISTING FACILITIES

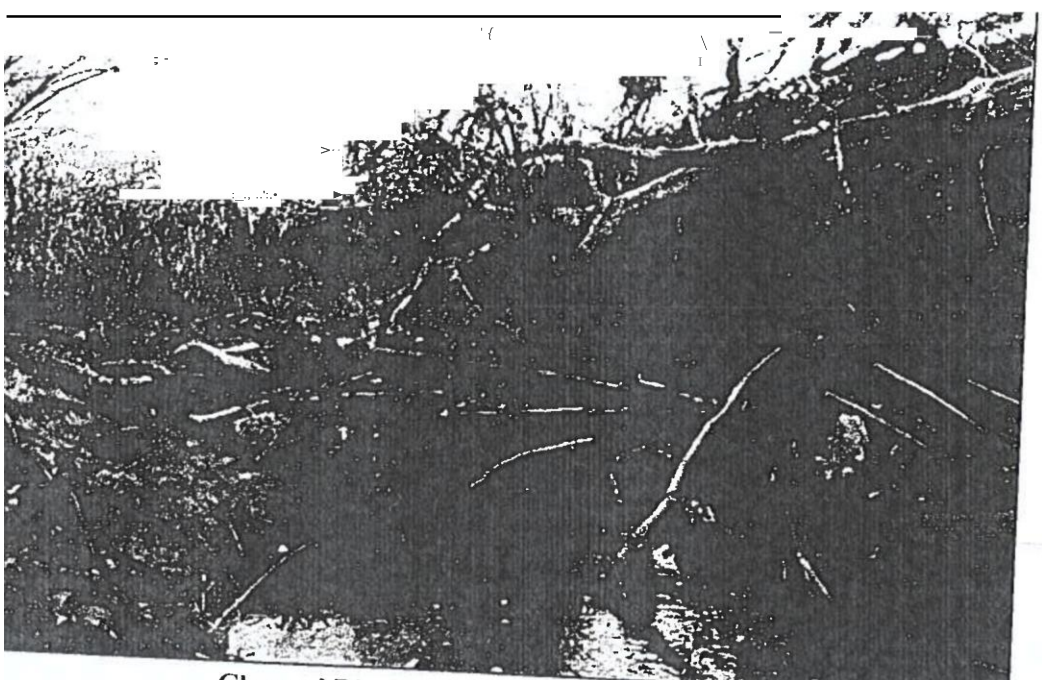
1. **Maintenance** The focus of this study is not on maintenance of existing facilities, and yet it is appropriate to note that this is an important issue. Many agencies have little or no provisions for culvert, storm drain, inlet, and trash rack cleaning. Maintenance may be limited to response to complaints about failing systems. As we walk facilities, we generally note a number of instances where maintenance is poor or next to non-existent. Figure "IA" shows examples of facilities that could use more frequent maintenance for better facility functionality, less liability, and better accountability to the public. Agencies are typically burdened with heavy demand and needs and limited funding with which to work. Funding generally goes to the more visible or obvious needs, or to address hotter political issues, and drainage issues are often given lower priority. While this may be understandable, continued practice eventually results in serious system malfunction.

2. **Multi-Use Facilities** Sometimes there are infrastructure facilities that are currently serving a single function, or even a dual function in a less than efficient or desirable way. Improved cooperation between departments and/or agencies can sometimes result in significant cost savings. In general, agencies do well on this point, but usually there is room for improvement. An example of cooperation relating to stormwater is Saint Mary's Park. Saint Mary's Hospital is a large complex of roof and asphalt that generates large quantities of runoff having poor water quality. A small steep park was adjacent to the hospital. Capacity of the multi-use Buthorn Drain in the area was limited, so it was decided to use a part of the park as a detention facility. This would be a retrofit situation, which usually results in less than optimum conditions. Nonetheless, the detention basin was constructed. Space was limited, but the small area effectively reduced peak runoff released to the Buthorn Drain from the hospital site to pre-developed conditions between the two year and approximately 60-year storm runoff event. The detention basin reduced flooding problems downstream on the Buthorn, and helped water quality as well. The



Three 60" Culverts On Leach Creek - A Typical Culvert Problem

Three 60" Culverts on Leach Creek - A Typical Culvert Problem



Channel Blockage On Little Salt Wash

Channel Blockage On Little Salt Wash

FIGURE- IA MAINTINANCE PROBLEMS

park still functions as a park. In retrospect, a redesign rather than a simple replacement of the irrigation system would have been helpful in order to adequately water the slopes but not over water the bottom (a point to remember for the future). Even so, overall the facility functions well as a multi-use facility (see Figure "1B").

B. COMPREHENSIVE MASTERPLANNING

We place emphasis on the word "comprehensive". Definitions include "all-inclusive", "broadly inclusive", and "including much". While these terms can and should be applied to masterplanning of sub-systems of the total urban infrastructure, it is important here to stress its application to management and masterplanning the entire infrastructure as a whole. In other words, if various departments (or even agencies) masterplan their facilities and concerns without regard to other public facilities and concerns, then masterplanning is not comprehensive, and agencies are acting irresponsibly to the taxpayers. This principle is often overlooked and yet so important. That it may be better understood, and given more attention in the future, we offer a single local example of where departmental masterplanning and otherwise good efforts in the absence of overall comprehensive masterplanning has resulted in an unfortunate lost opportunity.

Unfortunate Example Leach Creek is a significant drainageway in the northwest area of Grand Junction. Floodplain mapping shows significant overtopping of the main Leach Creek channel between 1-70 and G Road. Also along G Road west of 24-1/2 Road, there is substantial split flow, which is where flow overtops the bank, leaves the channel, and travels overland in another direction. What many call the North Leach Creek Tributary joins with the main Leach Creek at 24 Road south of G Road, and then the channel heads south across Patterson Road, highway access ramps, Highway 6 & 50, the railroad, and River Road on its way to the Colorado River. Channel capacity along the 24 Road alignment is limited, resulting in extensive split flow flooding. Inevitable future widening of 24 Road will only aggravate the problem. Upgrading conveyance to reduce flooding along Leach Creek would be very expensive, and 24 Road widening under current conditions extremely costly.

The City of Grand Junction's Parks and Recreation Department has studied recreational needs, and in recent years has purchased several regional park sites. The Sacamano Park property is located on high ground at the top of a drainage divide, which disallows its use as a highly functional multi-use facility for parks and drainage. Had the Sacamano Park property been purchased slightly north of where it is along Leach Creek, 3 miles of floodplain could have been significantly reduced. Fortunately, further west the Canyon View Park property was purchased in a ideal location for a multi-use facility. Corcoran Wash passed through the property from the east and joins North Leach Creek. North Leach Creek is located on the east side of 24 Road along the entire west edge of the park site. It is just south of the park where North Leach Creek joins the main Leach Creek channel (see Figure "1C"). At little or no extra cost, Canyon View Park, with all its currently planned facilities, would not only have functioned as a park as planned, but could also have functioned under

Saint Mary's Park: View North

FIGURE-1C CANYON VIEW PARK

very infrequent storm events as a detention facility. As such, it would have detained Corcoran Wash and North Leach Creek runoff just long enough to offset the peak runoff from that flowing down the main Leach Creek channel, thus eliminating substantial flooding and significantly reducing future 24 Road widening costs and difficulty. Use of the park would not have been impaired. After all, in a storm event that happens once every 25 or 50 or 100 years, people usually are not out playing ball, nor are fields ready for such activity within a few days anyway. A few additional hours delay on an infrequent basis would seem acceptable.

The City of Grand Junction Public Works and Parks and Recreation departments try to keep abreast with needs and concerns, and work with departmental masterplans. This result of a lack of comprehensive masterplaning and management across departments, however, is extremely unfortunate.

This example is not provided to criticize nor direct blame. It any be an issue of departments being too focused on their area of responsibility. It may be an issue of upper management, with all the "hats" they must wear, not realizing the importance of coordinating objectives and goals of various subsets of the whole. Whatever the reason, greater responsibility to the public served will be achieved when comprehensive masterplanning and management is implemented. This is particularly true for possible multi-use facilities such as parks, greenbelts, creekside trail systems, and detention facilities.

Positive Example Rather than end on a negative note, we offer a positive example involving a creekside project in Moab, Utah. One interest desired a reduction of floodplain along Mill Creek which passes through the downtown area. Flooding of residences and businesses, along with the undesirable costly flood insurance, was something adjacent property owners wanted mitigated. Flooding problems was due partly to fill encroachment into the creek, but mostly due to Russian Olive growth and undersized or reduced capacity bridges. Lack of access to trim lower tree branches, and lack of funds to increase bridge conveyance capacity, prevented any foreseeable solution. Meanwhile, another faction of people wanted a bike and pedestrian trail system for pleasure and safety. Having stream crossings off the main traffic ways and a system for students to get to and from schools without crossing major traffic ways was desired. Funding for trails was available, so paths were planned in such a way that they would be a multi-use facility. Where needed, trails are recessed to widen the flood conveyance capacity. Generally, additional creek cross-sectional area was not needed, but a 10 foot wide path with 3 foot wide shoulders on both sides offers a 16 foot wide clear conveyance area for flow. Furthermore, the path was designed per AASHTO requirements to accommodate emergency access vehicles, and thereby could also be used by maintenance vehicles to trim lower tree branches and remove sediment from under bridges. Moreover, additional bridge capacity was also planned. The streambed under one bridge had aggraded five feet since construction. In order to get proper headroom, the channel had to be lowered back down. Hard surfacing to protect the path would also reduce future aggradation and maintenance problems. At another bridge, lack of capacity resulted in a major portion of flow leaving the main channel and flowing through town. The bridge was on a major collector street, so to protect school children crossing-back and forth, an underpass was proposed which, once properly located, would occasionally function to pass high runoff flows without any overtopping of the creek bank. At another bridge, a state agency was requiring erosion protection against streambed degradation. A proposed path under that bridge would resolve the erosion problems and an irrigation intake problem. The above are win-win situations for several departments, agencies, and of course, the public. In this case, funding was mostly available from only one source, but even so all benefited, and perhaps on future projects, reciprocation may occur.

C. STORMWATER MASTERPLANNING: A SUBSET OF THE WHOLE

A stormwater management masterplan will address issues primarily dealing with drainage, floodplain, and water quality. However, a look at planned street reconstruction, utility extensions or replacements, parks, greenbelts, and creekside trailways are among other issues that should be considered when preparing a stormwater management masterplan.

Understanding the role of drainage and flood control systems in the total infrastructure is also important. In general, a drainage system serves several vital community functions:

- It removes stormwater from streets and permits the continued use of roads during bad weather for emergency vehicles and others, and when functioning properly, allows much faster and safer travel without hydroplaning;
- The drainage system conveys runoff from the street, thus helping promote longer pavement life;
- The drainage system conveys runoff to natural or manmade major drainageways to prevent flooding and damage to private property;
- Major drainageway systems can be improved or preserved in capacity and function to further prevent significant inconvenience, property damage, or even loss of life;
- The system can be designed to control or mitigate the affects of pollutants; and
- Major open drainageways and detention facilities offer opportunities for multiple use such as recreation, parks, water quality ponds, irrigation storage reservoirs, and wildlife preserves.

D. THE STORMWATER MASTERPLANNING PROCESS

The masterplanning process for stormwater is essentially the same as for other facilities. There must be an identified need, a regulatory framework, an analytical tool as a guide, and funding to implement the plan.

1. **An Identified Need** Actions are generally in response to a need; therefore, the need, if any, must per identified. System, maintenance, management, and/or funding deficiencies should be noted with respect to an acceptable level of service, and any other problems noted.

2. **A Regulatory Framework** A stormwater management masterplan, to be useful, must be an idea supported by the administration in general. Furthermore, the agency must have an idea what they want. Preliminary goals and objectives, once defined, establish the framework of the masterplan. A realistic set of regulations, policy, and criteria must either be in place or established. This includes regulation of land use and development, both for new development and floodplain issues. There must also be a commitment of funding and resources to mitigate stormwater impacts, such as flooding, soil erosion, sedimentation, and water quality. The masterplan must also be tempered with the fact that one's land is a basic freedom that should be protected.

3. **An Analytical Tool** The regulatory framework is the backbone of developing a good stormwater drainage system. A stormwater management masterplan, or SWMMP, (pronounced "swamp"), provides the balance of skeletal support. It provides a community or agency with a road map of how to develop this vital part of its infrastructure. Such a plan addresses system needs and design in a coherent manner, rather than in a piecemeal fashion. A masterplan helps assure that each subsystem is consistent with the total drainage system. Knowing the overall plan, each proposed project, whether directly or indirectly related to drainage, may be in harmony with or complement the overall system.

   The **SWMMP** consists of hydrological and hydraulic analyses, which may include both stormwater and floodwater, for both existing and proposed or built-out conditions, along with cost estimates of proposed systems. Financing alternatives may also be included.

4. **A Practical Financing Program** An Aesop fable tells of a group of mice meeting to discuss how they might protect themselves from the resident cat. A number of ideas were suggested, but none that seemed to be adequate. Then a young mouse stepped forward and suggested that they put a bell around the cat's neck, then they would always hear the cat in time to scamper to safety before the cat arrived. The mice all cheered and welcomed the idea with great enthusiasm. Finally an old sage stood and asked, "But who will bell the cat?" After long silence, they all realized that the solution was not really a solution after all, because it was not feasible. A SWMMP should focus on cost-effective, reasonable, and politically acceptable solutions. An otherwise good masterplan is of no value if there are insufficient funds and support to implement the plan.

E. EPA WATER QUALITY REGULATIONS

The EPA's Phase I stormwater discharge program has been in effect for many years, which involves municipalities and counties with unincorporated populations greater than 100,000. Regulations were imposed quickly with relatively little time allowed for municipalities and agencies to prepare. Strict criteria was costly to comply with. Fortunately, the Phase II program is more realistic, and more time allowed for municipalities to get prepared. Even so, the time allowed should be used or compliance with Phase II will also be difficult to achieve.

1. **Overview of EPA's Phase II Program** Within Colorado, the EPA's stormwater discharge program is administered by the Colorado Department of Public Health and Environment (CDPHE). They are given some latitude in both regulation and enforcement. Additional or updated information may be obtained by calling 303-692-3596, or by writing to the CDPHE, Water Quality Control Division, Stormwater Discharges Department, 4300 Cherry Creek Drive South, Denver, Colorado, 80246-1530. Although final regulation will not be available before March 1, 1999, draft copies are available and a summary is provided below.

   a. **Who Must Comply** Owners or operators of small Municipal Separate Storm Sewer Systems (MS4s) located in any incorporated place, county, or place under the jurisdiction of a governmental entity within a Census-designated "urbanized area" will be required to develop a local storm water program. Owners or operators of small MS4s located outside of an "urbanized area" may be designated if they have existing or potential significant water quality impacts, as determined by criteria set by the permitting authority.

      Urbanized Area The Census Bureau delineates urbanized areas as comprising one or more places ("central place") and the adjacent densely settled surrounding territory ("urban fringe") that together have a minimum of 50,000 persons. The urban fringe generally consists of contiguous territory having a density of at least 1,000 persons per square mile. The urban fringe also includes outlying territory of such density if it was connected to the core of the contiguous area by road and is within 1-1/2 road miles of that core, or within 5 road miles of the core but separated by water or other undevelopable territory. Other territory with a population density of fewer than 1,000 people per square mile is included in the urban fringe if it eliminates an enclave or closes an indentation in the boundary of the urbanized area. The population density is determined by (1) outside of a place, one or more contiguous census blocks with a population density of a least 1,000 persons per square mile or (2) inclusion of a place containing census blocks that have at least 50 percent of the population of the place and a density of at least 1,000 persons per square mile. There are additional criteria, the above is only a summary.

      Based upon the above criteria and the 1990 census, the Colorado Demography Information Service maps Grand Junction , Orchard Mesa, Fruitvale, Clifton, and the Redlands as an urbanized area. Fruita, Loma, Mack, Appleton, East Orchard Mesa, and Palisade were not. The 2000 Census, continued growth, and recent designation as a metropolitan area may affect the non-urbanized area status, however.

      The City of Fruita could come under requirements due to involvement in the metropolitan planning organization (MPO), changes in urbanization and development or policy, etc. While not currently under the proposed Phase II jurisdiction, Fruita possibly will be after the 2000 Census.

Non-Urbanized Area Proposed regulation allows CDPHE to require compliance for MS4s even if they are not within an urbanized area. Generally, if an MS4 has a population between 10,000 and 50,000, CDPHE will be required by the EPA to determine whether they must comply or not. If an MS4 has less than 10,000 in population, CDPHE will have the right to determine if the MS4 must comply or not. However, CDPHE has indicated to us that is unlikely that they will require compliance for populations less than 10,000, simply due to administrative limitations.

b. Important Dates Milestone dates currently set forth are as follows:

4/1/98 - Final date for public review comments;

3/1/99 - Notice of Final Rulemaking [Law is in effect, regulated MS4s have 3 years and 90 days to "comply".]

5/31/02 - Regulated MS4s must have applied for coverage under a nationwide permit [i.e., regulated MS4s must have, as a minimum, prepared a Stormwater Management Plan if not also started implementing the Best Management Practices (BMPs), and have applied for coverage];

The permit, when received, will be good for 5 years. However, progress reports regarding plan implementation (program compliance, the appropriateness of identified BMPs and progress towards achievement of identified measurable goals) must be submitted annually. The EPA will require a report in at least year 2 and 4 in subsequent 5 year permit terms, but CDPHE has indicated that they will likely continue with the annual report requirement. Accepted implementation of the Stormwater Management Plan constitutes "compliance".

?/?/15 - EPA will release a report of their comprehensive evaluation of the NPDES municipal stormwater programs.

c. Requirements A regulated small MS4 must develop, implement, and enforce a storm water management program designed to reduce the discharge of pollutants from the MS4 to the maximum extent practicable (MEP) and attain water quality standards.

A regulated small MS4 must submit to the permitting authority, either in the Notice of Intent or individual permit, the BMPs to be implemented and the measurable goals for each of the following minimum control measures:

- Public Education and Outreach on Storm Water Impacts
- Public Involvement/Participation
- Illicit Connection and Discharge Detection and Elimination
- Construction Site Storm Water Runoff Control
- Post-Construction Storm Water Management in Development/ Redevelopment
- Pollution Prevention/Good Housekeeping of Municipal Operations

d. <u>Of Special Note</u> Currently, construction activity that disturbs, with all phases included, more than 5 acres, must be covered by CDPHE's version of an NPDES permit. This will change to 1 acre. Also, governmental agencies have been allowed certain exemptions under the Intermodal Surface Transportation Efficiency Act of 1991. These exemptions will expire in August 7, 2001.

2. <u>Water Quality Control Criteria</u> Neither the EPA nor CDPHE have stipulated design criteria for water quality control. They have taken a more qualitative approach, with emphasis on reducing pollutants discharged into the waters of the U.S. by implementing Best Management Practices (BMPs). The idea is to address the "first flush", or frequent storm event that flushes streets and urbanized areas of hydrocarbons, blown sediment, and other pollutants. In other words, water quality control practices pertain to smaller and more frequent rainfall events rather than infrequent high intensity storms that are used in designing detention ponds for reducing peak runoff rates. Some agencies, such as the Colorado Department of Transportation, use 0.5 inches of rainfall to calculate required WQCVs. Other agencies, such as the Utah Department of Transportation and Urban Drainage & Flood Control District (Denver), use 0.5 inches of rainfall runoff (flow <u>after</u> initial abstraction of interception, evaporation, and percolation into the soil). Other agencies, such as Maricopa County in Arizona (Phenix metropolitan area), and many others back east, use 1.0 inches of rainfall runoff. In order to account for variations in land use, we recommend determining WQCVs based upon the theoretical 2 year storm event. For the Grand Valley, this is 0.70 inches of rainfall, which results in runoff volumes similar to those obtained using procedures required by other agencies.

3. <u>Water Quality Control Facilities</u> Water quality must be protected for both the construction and permanent phases of a project. Section IX of SWMM discusses Stormwater Quality for both conditions. (Note, however, that Subsection B discusses conditions of EPA's Phase I program (over 100,000 in population), so where conflicting information is presented, use this SWMMP. Also, Appendix Min SWMM discusses BMP's which are more particularly for the construction phase, but in some cases may also be used under permanent conditions. Moreover, premanufactured water quality facilities are available for small sites, and larger site can be served by a more permanent version of a sedimentation basin, called a water quality control volume basin or pond, As recommended in subsection (2) above, this would essentially be a 2 year retention facility with very slow bleed off (24-48 hours).

4. **Water Quality Control Volume (WQCV) Ponds Combined With Deten ion Facilities** Most are familiar with detention ponds, their design and function. They receive storm runoffs, passing a design release rate through and storing excess flow for later release. The higher the during-storm release rate, the less storage volume required. Detention ponds are generally designed for the 100 year storm event. WQCV ponds, on the other hand, are essentially "retention" ponds that capture the entire runoff volume from a 2 year storm event. The release rate is negligible during the storm event, and is ignored in hydrological analyses. There may be instances where it would be desirable to have a combined WQCV and detention pond. The design would allow for full storage of the 2 year runoff volume with no release, followed with typical release rates allowed by conditions for the 100 year event. Issues relating to a combined WQCV and detention pond include:

   - Functionality for both purposes is easily obtained with proper design and construction;
   - A combined WQCV and detention basin would not have the additive required separate volumes, because much of the WQCV is part of the 100 year detention volume. The combined total volume would be the 100 year detention volume plus the volume of runoff that cannot be released during the time that the 2 year WQCV is being accumulated in the basin;
   - Based upon the preceding concept, it may be further stated that for every increase in volume required due to combining detention with WQCV in an upstream basin, there will be a greater corresponding reduction in a separate WQCV basin downstream;
   - There may be areas where available land and volume does not allow for WQCV in addition to a detention facility;
   - There may be areas where the only opportunity for WQCV is at a detention facility;
   - WQCV ponds should be publicly owned and maintained, and would therefore more reasonably be larger and few in number, typically located just prior to discharge into "waters of the U.S.", and therefore it may be normally undesirable to combine them with detention facilities; and
   - Reserving flexibility to combine or not combine WQCV and detention ponds, considering all of the above issues, is recommended.

5. **Recommendations** Although the City of Fruita may not be regulated as part of Phase II initially, it is likely that it will be sometime between year 2000 and 2015. Rather than be caught with major infrastructure to retrofit, new development and projects should henceforth conform with BMPs and water quality considerations where feasible and practical, both on public and private projects.

   This SWMMP identifies work to be done and reasonable approaches. It is not sufficient alone in making application for coverage under a permit, however. The management plan for CDPHE will undoubtably include other requirements, one of which will be a plan for measurable progress, such as what specifically will be accomplished each year, as is done in preparing short and long range budgets and capital improvement programs.

We recommend that water quality considerations be based upon the 2 year storm event.

We recommend that sites provide water quality control or drain to a system that has water quality control facilities. This can be accomplished through proper site design, use of BMPs and WQCVs. We note that our regional systems recommended in areas 6 through IO generally provide for water quality control just prior to release into major drainageways (washes, creeks, and rivers).

We do not recommend combined WQCV and detention ponds for currently developed areas in Fruita, because undelayed discharge at the lower end of drainageways before peaks from upper watersheds arrive is important. There may be some instances, east of 18 Road for example, where combined ponds may be of benefit to reduce the cost of outfall lines to a major drainageway.

II ESTABLISHING THE CITY OF FRUITA'S SWMMP

A. PHYSICAL PARAMETERS

1. **Selected Study Area** The study area selected by the City is bounded by the Colorado River to the South, the divide between the Little and Big Salt Washes to the west and north (although not past M Road), and 20 Road to the east. This area was initially subdivided into four sub-basins for study purposes:

   - The Little Salt Wash drainage area for channel capacity;
   - The downtown area;
   - The urbanized area south ofl-70; and
   - The mostly non-urbanized area between 18 and 20 Roads.
   - Although not a part of the original scope of work, the consultant has added the northwest area of Fruita north of the Little Salt Wash to provide at least a limited level of investigation for the entire Fruita area.

   The study areas are shown on Exhibit "2A". In order to analyze runoff conditions on and through this study area, watersheds upstream from this area must also be analyzed. Consequently, hydrological analyses have been performed for the Little Salt Wash and Adobe Creek from the top.

2. **Key Drainage Components** Major drainage features within the study area include the Little Salt Wash and Adobe Creek. There are also several Grand Junction Drainage District (GJDD) drains which empty into Little Salt Wash and the Colorado River. GJDD open channel drains are generally fairly deep and have significant conveyance capacity. However, culvert crossings and downstream pipelines which go under Highway 6 & 50, the railroad, and 1-70 are all small, sized primarily for groundwater and irrigation tailwater drainage. The City also has several piped drainage systems. These storm sewers are primarily located in Ottley, Pabor, Aspen, and Highway 6 & 50. Reference is made to Exhibits "2A", "2B", "2C", and "2D".

B. EXISTING CONDITION DEFICIENCIES

1. **Little Salt Wash System** In general, Little Salt Wash has good capacity. However, there is a problem with dumping into the wash of trees, batteries, furniture, lawn and tree clippings, and nearly every other type of trash. Dumping reduces water quality and conveyance capacity, and can cause severe creek blockage if jammed together during high flows, such as at a bridge (see Figure 2A). In-growth of Russian Olive trees is also a problem. They are a bushy tree, with low branches that impede flow. Steep embankments and erosion are another concern with the wash (see Figure 2B). Embankment instability is foremost a safety issue in populated areas, and when

embankments slough or collapse, conveyance is further reduced for a short duration, and often the flow sinuosity is affected, which results in further embankment erosion.

Most of the drainage systems that drain to Little Salt Wash appear to be functioning well except for the Starr School Drain, which is addressed in subsection 5 below.

2. **The Downtown Area** Drainage systems south of Ottley are undersized, and accumulated surface runoff at Highway 6 & 50 presents the most significant problem in the downtown area. The highway acts as a dam or levee, and surface inflow to the area greatly exceeds storm drain capacity in more intense storms, resulting in damaging flood depths before adequate surface outfalls are available. There is an undersized detention facility east of the overpass, but its size renders it useless except for in very minor storms. Furthermore, considerable flooding may occur before runoff would even reach the detention basin. A much larger outfall facility is needed. This and other more minor problems discussed hereafter are shown on Exhibit "2B".

   The Peach Street and Aspen Avenue v-pan is a nuisance, and the Maple and Aspen v-pan not much better. Both provide "traffic calming" and slow traffic down, but overall they have not been desirable to many. Providing inlets at the northeast corners would allow elimination of the v-pans.

   In Laura Avenue there is a low point east of Ranchman's Ditch that has an 8 inch drain pipe draining north to Ottley. The system is severely undersized, and does not function well, even with the "bubble-up" outfall inlet that has been provided west of Ranchman's Ditch.

   Cedar Street collects runoff from East Laura Avenue, and conveys it to Aspen where it is then taken by roadside channel back north again to an alley, and then west to an irrigation ditch, and from there to the aforementioned inadequate Laura Avenue drain system. This system functions poorly and adversely affects pedestrian and other travel ways in the area.

   The GJDD has a small groundwater drain in Harrison that is in poor condition that discharges to a sanitary sewer line in Maple Street (17-1/2 Road). If not too deep, the line should drain to a storm drain.

   At Cedar Way along Ranchman's Ditch, there is a low point that outfalls to an 8" pipe that protrudes through the curb face and drains east toward Pine Street (18 Road).·The drain functions poorly and is mostly plugged.

3. **The Urbanized Area South of 1-70** Inlets have been provided at most of the low points in streets, but they may discharge to inadequate systems. For example, the inlet receiving runoff from Peter Drive and Bonnie Vista outlets to a small sanitary sewer line

because there are not other facilities available. Concorde Drive and Heritage Court drain to small Grand Junction Drainage District (GJDD) lines. The Redcliff Mobile Home Park surface drains south to an open field. All of the systems function marginally well, but a better outfall system is desirable, and even necessary when future development occurs. Reference to made to Exhibit "2D" and Figure 2C.

4. **Between 18 and 20 Roads** The Starr School Drain services a large area, and is open until it reaches Holly Park, where it is reduced to a 24 inch diameter pipe. Holly Park also drains to the pipe, and at the south end of Holly Park Drive, a single inlet and 18 inch outlet pipe to the 24 inch Starr School Drain pipe is a severely inadequate system. Reference is made to Exhibit "2D".

   Most of the area between 18 and 20 Roads drain directly to Adobe Wash or to the Murray Drain System. The Murray Drain also comprises of the Compton and North Compton Drain, Kettles Drain, and Palmer Drain which empty into the Murray Drain. These drains, where open, have significant conveyance capacity, but culverts are small, and the system outfall is a 42" pipe under Highway 6&50. This is hardly adequate to handle runoff from 1700 acres. Either an upgrade in outfall is necessary or significant detention to reduce peak flows.

   The 18 Road or Pine Street drainage system consists of an 18 inch GJDD pipeline. This is inadequate to function as both a tailwater/groundwater drain and a stormwater drain. For proper drainage of areas to the east and west of 18 Road, a better system is needed.

5. **North of Little Salt Wash** We are not aware of significant drainage problems in this area, but note that as more development occurs, there will be increased need for outfall lines extending north from Little Salt Wash in the quarter mile roads.

C. POTENTIAL DEFICIENCIES

The percentage of growth in the study area has been significant in the last few years, with no apparent decrease in sight. As urbanization take place, irrigation runoff is reduced, but storm runoff peaks and volumes are increased. Water quality is also an issue, although the imbalance or trade-off is complex. Nitrates and other crop fertilizer and pesticide residues are reduced in exchange for an increase in hydrocarbons. Potential or actual impacts due to development should be mitigated, which expense should be borne by the developer. But what should be done and how? What jurisdiction or authority would a single developer have to implement a drainage scheme that goes beyond the limits of the developer's property? How well would individual developers, whose project timetables are not the same, be able to coordinate a practical and cost-effective drainage solution? These questions help underscore the need for community wide policy, planning, and management.

D. FRUITA'S SWMMP

1. **The Need for a SWMMP** There is an old adage which states that "when you fail to plan, you plan to fail". Fortunately, responsible agencies are realizing that even though drainage systems may be utilized on a less frequent basis than other public facilities, they are nonetheless important, should be masterplanned and coordinated, and given more priority. Preparation of a SWMMP will provide the City of Fruita with the drainage system "road map" referred to earlier, and a solution to both existing and potential deficiencies.

2. **Outline of Goals and Objectives** In general, the City of Fruita desires to maintain or improve the quality of life had by its residents, and recognizes that a good drainage system is a part of the infrastructure involved in accomplishing that. More specifically, however, the City would like to:

   - Reduce the impacts of storm runoff on private property;
   - Have a good management plan for use in regulating new development and land use with respect to drainage issues;
   - Determine Little Salt Wash capacity under current and possible future conditions;
   - Estimate how much adjacent urbanization can or should be sent to Little Salt Wash undetained;
   - Investigate the concept of a drainage fee in lieu of detention;
   - Update the drainage capital improvement program;
   - Promote use of regional stormwater detention/park/open space areas; and
   - Focus on natural or "soft engineering" solutions to problems where practical.

3. **Scope of Work**

   Several watershed basins will be analyzed as part of the study. The level of detail and service provided will vary from basin to basin, as explained below.

   a. Little Salt Wash A primary stormwater conveyance facility in the City is Little Salt Wash. Encroachment and vegetative growth in more recent years has reduced and choked conveyance capacity at the same time that new development has increased stormwater runoff. Agricultural irrigation runoff is reduced as urbanization takes place. Knowing how much stormwater can reasonably be allowed in the wash and under what conditions is of primary concern. It is proposed to provide a detailed level of floodplain analyses on the wash within the City to analyze adequacy for build-out conditions, and determine if improvements are necessary for conveyance. These investigations will result in floodplain analyses and mapping that could be used, if desired, in a subsequent submittal to FEMA for a Letter of Map Revision (LOMR) or Conditional Letter of Map Revision (CLOMR), although that report and submittal process is not a part of this scope of work. Analyses will also include investigations regarding additional or future inflows

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into the wash.

b. Downtown Area For the purpose of this scope of work, the downtown area is considered to be bounded on the west and north by the Little Salt Wash drainage basin, the south by Highway 6 & 50 and/or Interstate 70, and by 18 Road on the east. Intermediately detailed observations, analyses, investigations, and solutions would be provided in this area to determine level of problems, alternative and recommended solutions, and costs with prioritization. Schematic mapping would show proposed solutions.

c. Urbanized Area South of 1-70 This area includes that area located south of 1-70 and north of the Colorado River and east to 18 Road. Level of study detail and product provided would be similar to that performed for the Downtown Area.

d. 18 Road to 20 Road Only a generalized investigation of this area is proposed, with overall recommendations made regarding development and masterplanning.

The report would provide a summary of all findings in the basin studies discussed above. Additional issues and recommendations resulting from the study will also be presented in the report, such as:

- Proposed drainage routes, needed easements and/or rights-of-way, and requirements of development;
- Drainage impact fees (in lieu of stormwater detention/retention);
- Detention and retention basins; and
- Use of GJDD facilities and recommended intergovernmental agreement (formal or informal).

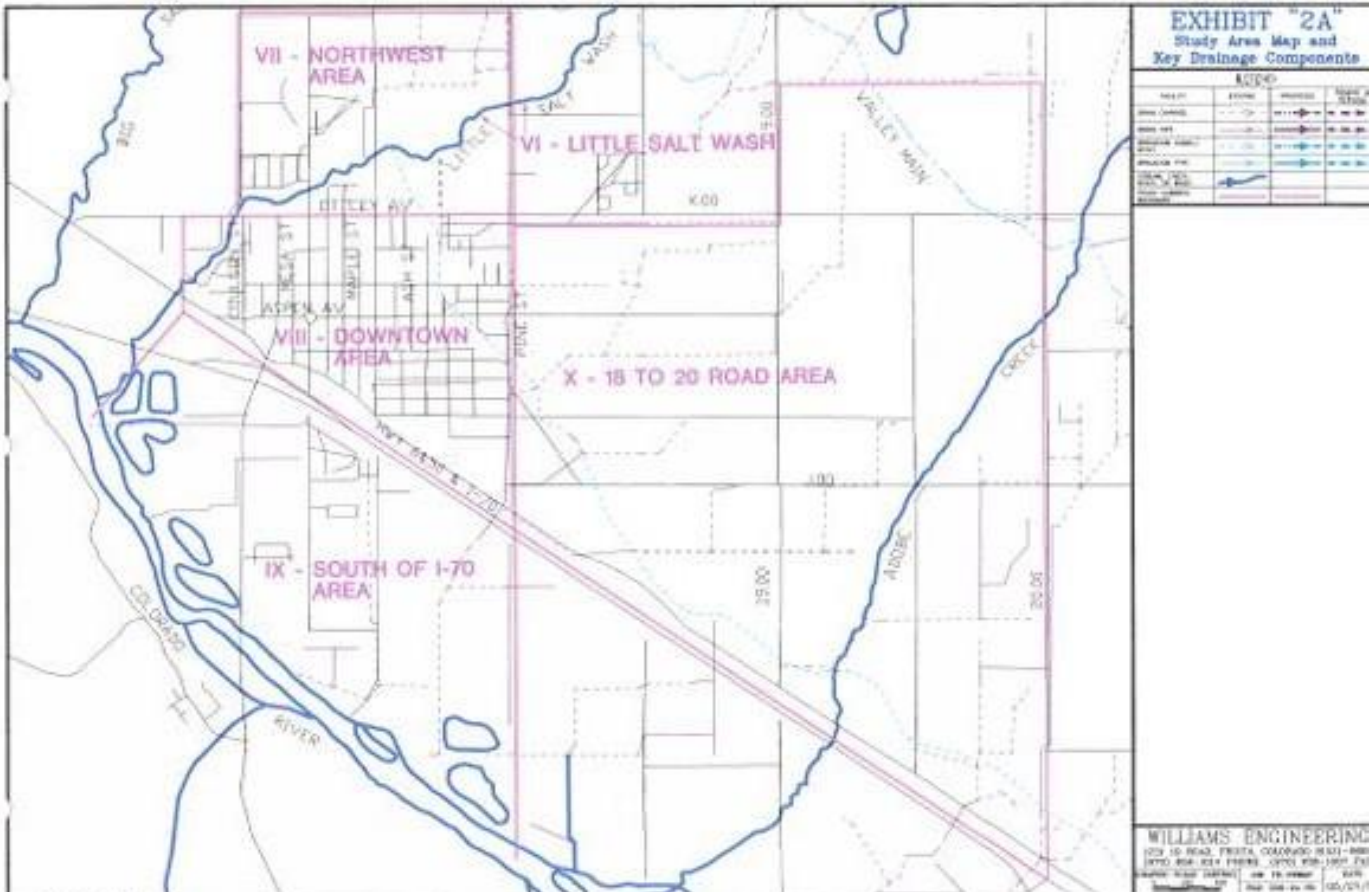


EXHIBIT "2A"
Study Area Map and
Key Drainage Components
VII - NORTHWEST AREA
VI - LITTLE SALT WASH
VIII - DOWNTOWN AREA
X - 18 TO 20 ROAD AREA
IX - SOUTH OF I-70 AREA
LITTLE SALT WASH
VALLEY WASH
ADOBE CREEK
COLORADO RIVER
ASPEN AV
PINE ST
K.00
J.00
20.00
WILLIAMS ENGINEERING

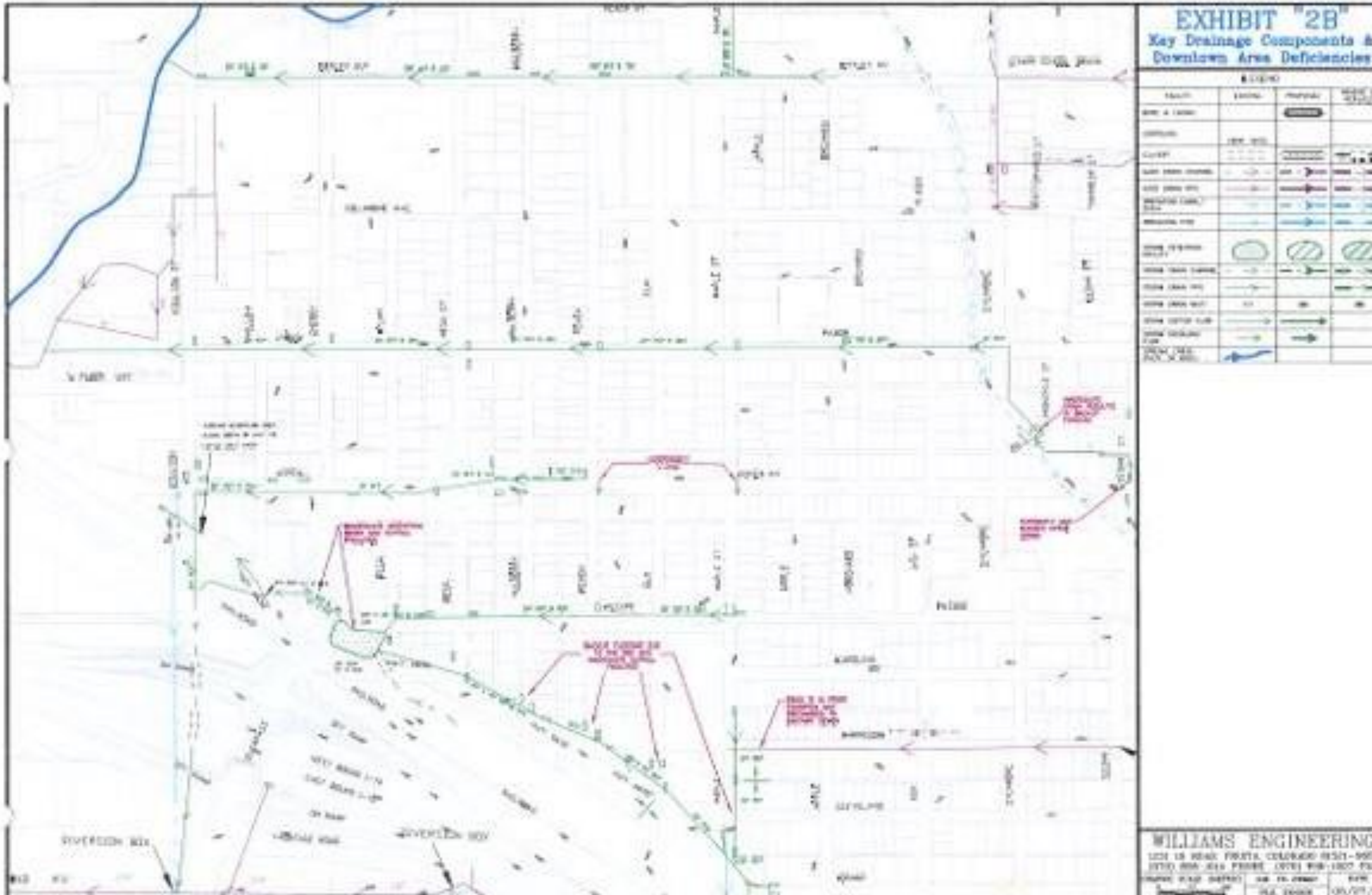
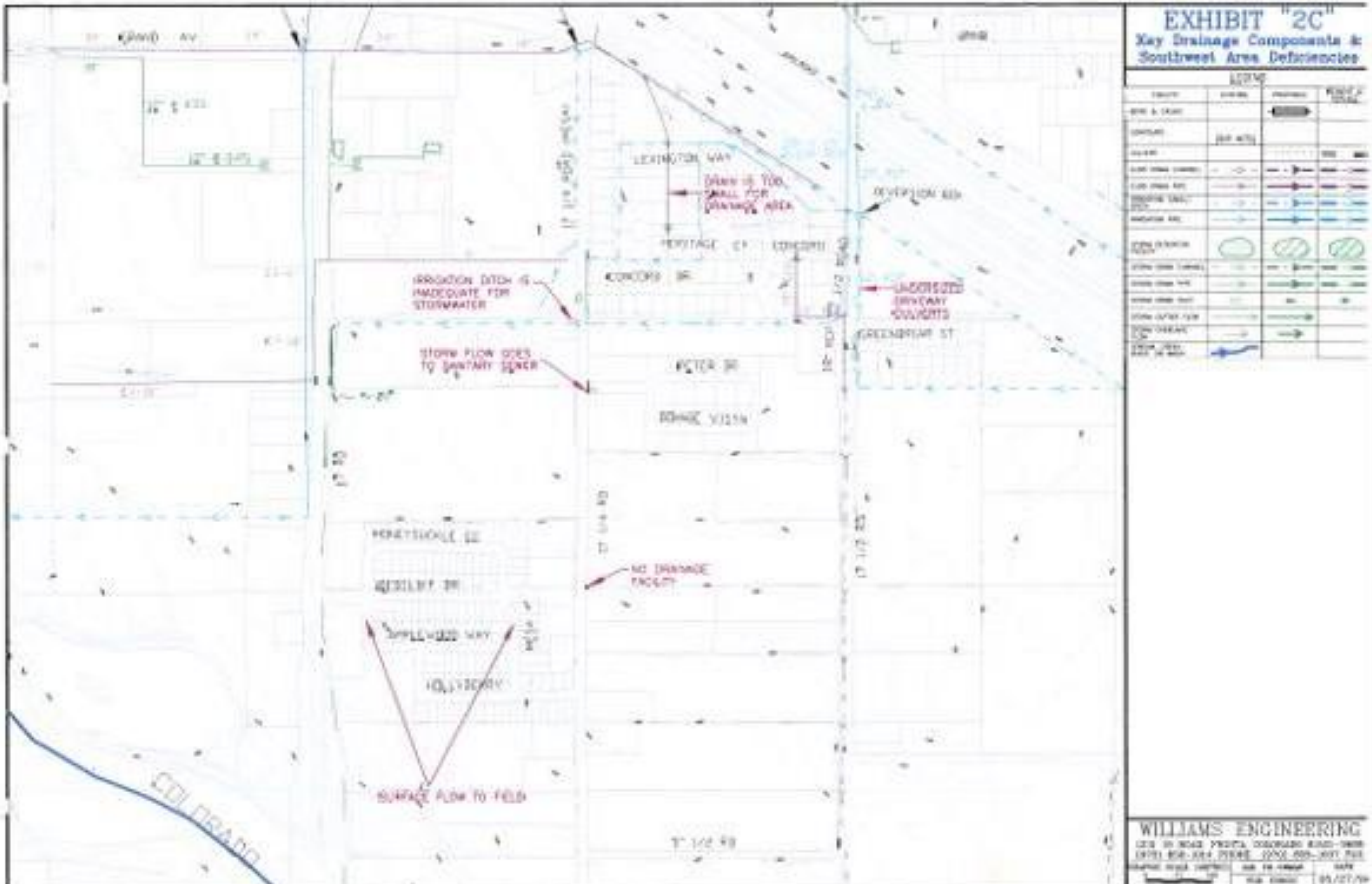


EXHIBIT "2B"
Key Drainage Components & Downtown Area Deficiencies
WILLIAMS ENGINEERING

EXHIBIT "2C"
Key Drainage Components & Southwest Area Deficiencies



WILLIAMS ENGINEERING

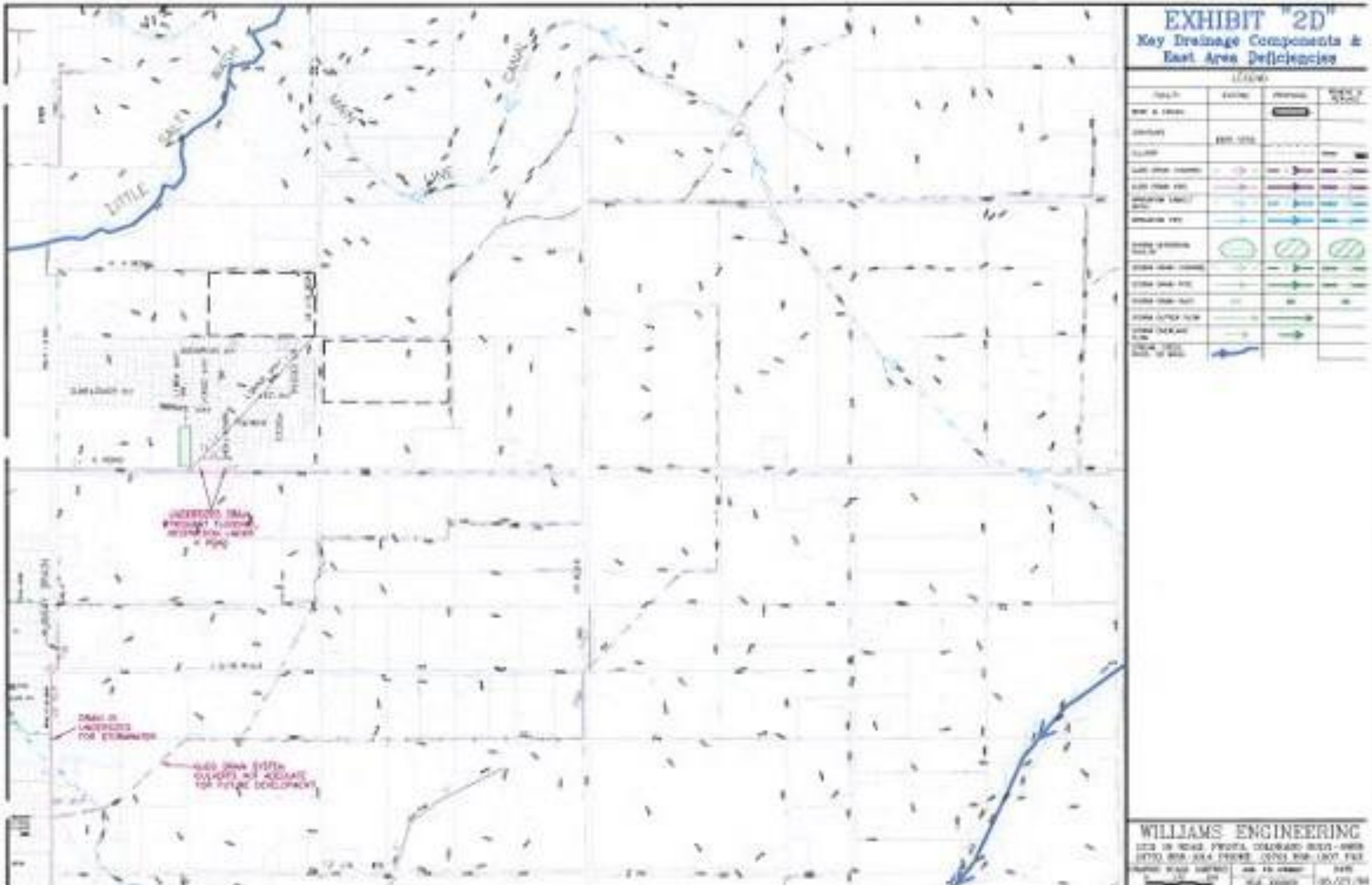


EXHIBIT "2D"
Key Drainage Components & East Area Deficiencies
LITTLE
SALT
WASH
CANAL
WILLIAMS ENGINEERING

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III PREVIOUS STUDIES AND AVAILABLE MAPPING AND DATA

A. URBAN STORMWATER STUDIES

In 1982, the City of Fruita reconstructed many of their streets and improved drainage facilities. Surface drainage and valley gutters were the primary means of conveyance, but there were also storm drains installed. The design was done by Arix Engineers, which company long ago closed their local office, and has since been acquired by another firm. However, we have spoken with an engineer involved in the design of the project, and he indicated that it is his recollection that drainage calculations were performed as part of the design, but never formally prepared or presented. The City of Fruita is also unaware of any drainage report.

No other urban drainage study has been completed as far as the current City Engineer and Public Works Director are aware.

B. FLOODPLAIN STUDIES

A study was performed in 1976 by the Army Corps of Engineers (COE) entitled "Flood Hazard Information, Colorado River and Tributaries, Fruita, Colorado". The study documents hydrological procedures used to determine 100 and 500 year estimated runoff rates for the Little Salt Wash. An S-graph developed for Rifle Creek at Rifle, Colorado, was used to generate a unit hydrograph. Resultant 100 year and 500 year estimated runoff rates were 4,340 cubic feet per second (CFS) and 8,100 CFS, respectively, at the Highway 6 & 50 bridge.

The 1976 100 year and 500 year COE runoff rates were used by MSM Consultants, Inc., to obtain floodplain information. This was done in 1979. A restudy was done in 1990 by J.F. Sato & Associates, who again used the COE runoff rates, and performed hydraulic modeling using the COE Water Surface Profiles computer program HEC-2. The 1990 study was more refined than the 1979 study, and resulted in new floodplain mapping as part of the July 15, 1992 FIS. Even so, only one runoff rate was used throughout the entire study reach, and cross-sections averaged 1000 feet apart. Lower cross-sections were obtained from the COE report, and upper cross-sections were taken from the 1975 USBR 2 foot contours on a map at 1"=400'. Hydraulic analyses were based upon unobstructed flow; that is, all culverts and bridges were assumed to be clear of obstruction and sedimentation. All elevation data was based upon the 1929NGVD.

MAPPING

Several forms of mapping are available as noted below. Many were in the same coordinate system, but were schematics that did not align properly. Prior to use, rotation, translation, and rubbersheeting was required. The contour mapping provided by Williams Engineering was based upon the most control points, and is likely the most correct horizontally, but rubbersheeting to contours would be very difficult. We followed Mesa County's practice of honoring the aerial orthophotography, translating the contours slightly to the aerials, and rubbersheeting parcels to the aerials. Other mapping provided general information, but could not be used directly because of conflict with the higher accuracy mapping.

1. **Aerials** Aerials were flown in 1994 at a photo scale of 1"= 1667'. Provided electronically by the City of Grand Junction and Mesa County, the coordinate system is NAD-83(92), UTM-12, and NAVD-88 in metric scale.

2. **Drainage District** An AutoCAD drawing was provided by the Grand Junction Drainage District. This drawing shows schematic locations of drains, those sections that are piped, and also the centerline of roads. The Drainage District developed this drawing by digitizing drains onto a county drawing that has centerline of roads.

3. **FEMA Flood Study** The FIS flood study was performed by J.F. Sato and Associates in 1990. Resultant FEMA maps for the area are dated July 15, 1992 and can be obtained by contacting Baker Engineering at (703) 960-8800.

4. **USGS Quadrangle Maps** Contour maps with 20 foot intervals show streams, roads and other main features.

5. **Parcel Maps** Mesa County has parcel maps that were scanned and are available electronically.

6. **Contour Mapping** The 1975 Bureau of Reclamation's contour maps were converted to electronic format in 1997 by Williams Engineering from Palisade west to 15 Road and north to M Road.

C. DATA

1. **USGS Digital Elevation Model** X,Y,Z points from 20' contour quadrangle maps are available. The coordinate system is based on NAD-27, UTM-12, NGVD-29 in metric scale.

2. **Digital Orthophotography Points** XYZ points were generated in producing orthophotos from the 1994 valley wide aerial photography. These points are sufficient to produce 1O' contours and are on NAD-83(92), UTM-12, NAVD-88. The coordinate system is in

metric scale.

3. **Digital Elevation Model** Two foot interval contour maps produced by the Bureau of Reclamation were converted to electronic format by Williams Engineering in 1997. These maps were provided to the City of Grand Junction in both AutoCAD contour and ASCII XYZ point formats. The coordinate system was an adjusted NAD-27, NGVD-29, in feet. The City then graphically converted the contour mapping horizontally to NAD-83(92), UTM-12, metric scale, but the contour interval and elevations are still in feet on NGVD-29. The XYZ points have not been converted.

4. **Stormwater Management Manual** The combined City of Grand Junction/Mesa County Stormwater Management Manual (SWMM) provides precipitation values, management practices, and other guidelines for stormwater studies as informally adopted by the City of Fruita.

5. **JF Sato HEC-2 Files** We obtained from JF Sato the original HEC-2 files. Some bridge and culvert information was taken from the files.

D. GEOGRAPHICAL INFORMATION SYSTEM (GIS)

1. **GIS information** Many GIS coverage are provided by Mesa County. They are in the NAD- 83(92), UTM-12, NAVD-88 coordinate system in metric scale.

2. **Land Use** Mesa County provided a land use shape file named fruita.shp.

3. **Soil Type** Shape files show the-location of soil types in the Mesa County. The file used was soilsply.shp.

4. **Roads** Shape files show the centerline of roads and highways in the area. These are useful when locating features in a digital environment and when presenting the information. The file used was cntrd.shp.

5. **Streams** Shape files show the location of streams and other waterways. However, they could not be used with the USGS digital elevation models because they are on a different coordinate system. Files used were water.shp and water_ad.shp.

IV HYDROLOGICAL OVERVIEW

Most of the hydrological concepts, criteria, procedures, and software used are the same for the entire study area. These are discussed in this section. Specific issues relating to a single subbasin will be presented in the section devoted to that watershed or subbasin.

A. GENERAL CONCEPTS

There is insufficient data available to allow direct computation of stormwater runoff from various storm events. Consequently, estimation methods must be used. There are a number of methods and models used to estimate storm runoff, but subbasin sizes, interest in both estimated runoff volume and peak flows, and limited hydrological data precludes the appropriate use of many procedures. It was our intent to use procedures that were not only appropriate for the range of expected conditions, but for which there was also available an industry standard modeling program, or an enhanced program based upon or which incorporated use of an industry standard program.

B. SOFTWARE SELECTION

A decade ago, there were only a handful of commonly used hydrological programs, and these were all developed by the federal government. They were powerful, generally bug free, had been in long use and had proven themselves, were commonly known, fairly commonly used, and availability of software and training was good. However, as we have entered the 1990's, computing power has increased and with it has come a flood of hydrological programs. Many of the programs incorporate the Army Corps of Engineer's (COE) HEC-1 program, others the Natural Resources Conservation Service (formerly SCS, and hereinafter referred to as SCS) TR-20 program, the EPA's **SWMM** program, and a host of programs that compute runoff estimates based upon simplified procedures such as non-TR20 procedures presented in the SCS TR-55 manual and the rational method.

1. **Selection Criteria** It is important to select a stormwater modeling program that is powerful and yet flexible enough to properly model current and future basin conditions in a watershed basin. Hydrological methods and procedures should be applicable to the conditions being modeled, and since these often vary within a watershed, particularly when there is a mix of land uses, topography, and urbanization, it is important to select a modeling program that is flexible enough to address such variableness. The modeling program should be sound, and one that is common enough that others may use, build upon, and update the model in future years without having to start over. Software which requires excessive simplification of conditions should be avoided, as well as software that uses methods that are not really applicable to the watershed basin being modeled. Software selection criteria and considerations may be summarized as follows:

- Quality and overall soundness of the software program and procedures used;
- Program flexibility, applicability , and capability to handle current and potential future modeling conditions;
- Current public and private knowledge of how to use the software.so that the model can readily and easily be kept current;
- The learning curve required for those unfamiliar with it;
- Capability to include water quality analysis;
- The ability of the software to be integrated with other engineering tools such as CADD, digital terrain models (DTMs) and triangular irregular networks (TINs), digital aerial photography, and geographical information systems (GIS);
- Product cost; and
- Product support.

2. **Initial Survey** Williams Engineering has long had a special interest or focus on stormwater hydrology and hydraulics, and has tried to keep abreast of various methods, procedures, and software programs. Thus, we had a fairly good idea of available software capabilities and limitations. Nonetheless, in 1993 we researched previously performed studies (Lewis, 1991), and conducted a survey of our own. We sent out a tabular questionnaire to twenty-six entities for them to fill out and identify their software capabilities with respect to 95 features. Based upon the survey, we then requested additional information on nearly a dozen software programs, and further reviewed capabilities, refining the selection process.

3. **Software Demonstration Evaluation** We then selected about a half dozen programs for further evaluation, and went through the product demonstration on a computer. This, along with a review of product literature, allowed us to narrow our evaluation to three programs: Eagle Point's Watershed Modeling and Storm Sewers; XP Software's SP-SWMM; and Boss' Geo-HEC-1 (now called Watershed Modeling System, or WMS).

4. **Full Software Package Review** We were then able to obtain full operating programs for review. We did not spend the time necessary to master any of these programs, but did use each one sufficiently enough to arrive at a conclusion.

   Eagle Point Watershed Modeling had some HEC-1 capabilities at the time, but not enough. There was also no dynamic link with Eagle Point's Storm Sewer Module. Storm Sewers would perform runoff estimates, but only using the rational method which, for most stormwater management master plans, is too limited of a method.

   XP-SWMM is based upon the EPA's Stormwater Management Model (SWMM), and was a powerful tool that seamlessly integrated hydrology, hydraulics, and water quality. Modeling capabilities were good, and graphics impressive, but the learning curve and lack of general familiarity of the program was a drawback. Furthermore, there seemed to be too few methods available for use. It was a unique procedure, and would not readily allow for model use with other programs or models prepared by others, such as models provided in conjunction with land development. In other words, it was basically an all or nothing type of modeling program.

GeoHEC-1 was impressive. It used the COE's HEC-1 program in a graphical environment. However, the complexity of model building and modifying in a graphical environment was not yet adequately addressed.

We concluded (this was in the summer of 1994) that none of the programs were far enough along in their development to have adequately made it to the next generation of software. We felt that the old tried and true COE HEC-1 non-graphical modeling program was still the superior software.

5. **Initial Selection** In late summer of 1995, one year after our previous software evaluation was concluded, we were informed that Eagle Point's Watershed Modeling program now fully incorporated COE's HEC-1. Furthermore, we were told that the Storm Sewers module could then import runoff data from other sources, such as Watershed Modeling. We further questioned Eagle Point regarding these issues, and it appeared that Eagle Point had finally made the break through to the next generation of stormwater software. Due to our concurrent interest in obtaining a full engineering design software package that worked inside of AutoCAD, we bought the entire Eagle Point engineering package.

   It was not until spring of 1996 that we had opportunity to test the newer modules. We learned, to our disappointment, that Watershed Modeling did not incorporate all HEC-1 features, and was missing several that we felt were very desirable. Furthermore, it could not read nor write HEC-1 files for use by others. Additionally, Storm Sewers could not import a flood hydrograph, only a static peak flow at any given point in the storm sewer model. These were considered to be serious deficiencies. We then attended a 3-day hydrology and hydraulics workshop put on by Eagle Point and discovered more fully how cumbersome model building was in Watershed Modeling. At that time (spring 1996), we decided that the Eagle Point product was not a software modelling program that we could recommend for governmental agencies as a basis for large scale stormwater management master planning.

6. **Final Selection** Once we decided not to use Eagle Point for hydrological modeling, we quickly surveyed available software again. We discovered a few new packages, but like most programs in early stages, they were not as far along in their development and complete in what they could do as other software previously investigated. At that point, our attention was turned first to XP-SWMM, then Boss Stormshed and Boss WMS.

   XP-SWMM is a comprehensive and integrated hydrological, hydraulic, and water quality program. There is no other program that we are aware of that has seamless integration of all three components. Because of this, and also because of current and future stormwater quality regulations, we felt that XP-SWMM had distinct advantages worth looking at.

We discovered that XP-SWMM began allowing use of a more common hydrological method, that being the SCS unit hydrograph procedure. Reportedly, XP-SWMM could import data from GIS, AutoCAD, spreadsheets, and other databases. However, we discovered that while XP-SWMM had many nice features, its ability to import and export GIS data was very limited, often requiring extra programming by XP-Software. We also got the feeling in talking with XP-SWMM representatives that they were not real committed at that time to aggressively pursuing "front-end" and "back-end" capabilities. We refer to front-end capabilities as getting GIS and other database information directly into XP-SWMM (reading Arclnfo coverage or shape files, USGS DEMs or other forms of TINs or even be able to use TINs, or directly import information graphically). We refer to back-end capabilities as those allowing generated data from XP-SWMM to be exported to CADD packages such as AutoCAD or Microstation easily and correctly. The only method of graphical output besides printing was creating a DXF file, and we have seen enough data/drawing loss in DXF conversion processes to be leery.

Finding several disappointments with XP-SWMM, we moved on to Boss Stormshed.

Boss Stormshed During a conversation with an individual from a large consulting firm in the Denver Area, we learned that they had and frequently used both Boss Stormshed and XP-SWMM. XP-SWMM is what they learned first, and they would use it whenever water quality was a significant part of the scope of work. Otherwise, they would prefer not to use it because (this is interesting, because they were already well past the learning curve stages) XP-SWMM was-very cumbersome to use. Instead they would use Boss Stormshed, which is really just a newer version of Anginas Systems with which we were already familiar. Previously, we had gone through evaluation of literature and demonstration programs of Anginas Systems, and had long visits with the developer. The program has progressed in capability, was simpler to use than many models (mostly because of reduced capability), but still it does not allow automation of a number of tasks. We did not spend a lot of time with Boss Stormshed, but concluded that it was not the "next generation" software that we were looking for. If one was very adept at the COE's HEC-1, they could do essentially the same thing.

Boss WMS We looked lastly at Boss Watershed Modeling System, or "WMS". It appeared that it had made the quantum leap between hydrological computer modelling and GIS to graphical usage. There were some missing capabilities, but the software appeared to be adequately close, and there seemed to be developer ambition to close the gap. Having exhausted resources that we could devote to our software search, we settled on Boss WMS.

7. **Conclusion** Hindsight is a wonderful thing -- only it comes to late. In the jump from a

fairly bug-free GEO-HECl to WMS, the software became buried in bugs and problems. Supposedly WMS was in a marketable state when we purchased it, but we spent nearly 8 months working constantly with the developer to overcome problems, discovering the software to be more at the "alpha" stage when we started. We helped them (we were at the forefront of their software development) finally reach what we would call a "beta" stage. At that point, we could no longer afford to be a "full time beta tester" for WMS, and we essentially shelved it and went back to the COE's HEC-1 except for a few preliminary data entry conversion tasks which we still did in WMS. When version 5 of WMS was released, with most of the problems and deficiencies reportedly resolved, we were provided a free upgrade and tried it on a new project, only to discover a few additional problems. In all likelihood, by now (1998), the WMS software is probably fairly clean of bugs and fairly usable, and we will revisit it again sometime in the future.

In retrospect, we know that use of the tried and true COE's HEC-1 program would have saved us an immense amount of time and effort over WMS, and XP-SWMM likely would have too. We have found the same to be true with river hydraulic programs -- for all the bells and whistles of the "next generation" software, most of it does not save a lot of time over the "old stuff' if one knew the old programs. For new learners, certainly the newer software packages are easier to learn. We conclude that if a governmental agency does not have an experienced hydrologist in-house and will not be frequently performing analyses, the work should be hired out. If the agency will be doing lots of hydrological analyses with personnel inexperienced with the old programs, learning on the newer software may be the best bet. However, for occasional use by someone experienced with the older software, our advise is to stick with it. The old software is free to download (it is all government domain), and they are rock-solid. Frustrations are limited to learning curve, not program bugs.

C. CRITERIA

For the most part, criteria used are presented in the Mesa County Stormwater Management Manual (Williams, 1996). However, often the criteria allows use of more than one method or procedure, so the specific procedures used need to be identified. Moreover, for the convenience of working within WMS, which we initially used in building our models, there were a few other criteria used, all of which are presented in this section.

1. **Dynamic Analyses and Unit Hydrographs** In the previous section, we discussed software selection, and why it was important to use software that had capabilities appropriate for use on larger watersheds in analyzing for both peak runoffs and volumes. For stormwater management master plans, it is important to have a dynamic model of the watershed; that is, one where generated flows can be routed and added together in an appropriate time sequence or lag, so that offset peaks from various subbasin areas can be properly modelled. There are several methods available for use that allow for a dynamic analysis, but we have selected the SCS unit hydrograph.

2. **Storm Duration and Intensity** SCS unit hydrographs are available for different storm durations and intensities. We have selected the 24 hour storm with type II distribution. The advantage of this storm duration/precipitation curve is that the storm duration is long enough to adequately model for lar er runoff volumes, and yet the precipitation distribution curve also allows modelling as well for the short duration high intensity storms that generally produce the highest runoff peak . This is because the SCS 24 hour storm unit hydrograph incorporates the shorter duration peak precipitations within the 24 hour distribution curve. For example, the peak half hour storm precipitation is set to occur between 11-1/2 and 12 hours after the start of the storm. The next highest peak half hour storm precipitation is set to start at 12 hours into the storm, resulting in the peak 1 hour precipitation occurring between 11-1/2 and 12-1/2 hours after storm commencement. The third highest half hour peak is set to begin at 11 hours, the fourth highest half hour peak at 12-1/2 hours, and so forth, so that each storm duration peak precipitation (in half hour increments) is built into the 24 hour SCS type II precipitation distribution. Again, the benefit of using this type of distribution is that it yields realistic results for both peak runoff volumes and peak runoff rates.

3. **Precipitation** Annual precipitation in Fruita is approximately 9 inches. Per the 1990 Flood Insurance Study, approximately one-half of the annual precipitation comes in the form of convection-type cloudburst storms, generally over an area of small extent during the months of August through October (Sato, 1992).

   Henz Meteorological Services investigated local rainfall for Mesa County in 1992. The results of their study was presented in two technical memorandums (Henz, 1992). Use of a previously prepared depth-duration-frequency (D-D-F) table for Mesa County was verified as appropriate, but a new D-D-F table and intensity-duration-frequency (1-D-F) table was prepared and recommended by Henz for the Grand Valley area for storm frequencies having statistical return periods of 2, 5, 10, 25, 50, and 100 years. Values presented in the Henz report have been adopted by Mesa County, and are presented in the current Mesa County Stormwater Management Manual, or "SWMM".

   In accordance with the SWMM, storm analyses were based upon the 2 year and 100 year event, unless the analyses were for investigating creek or wash floodplains, in which case the 100 year and 500 year events were used. The 500 year precipitation value was not determined by Henz, so the more general and higher value for the region per NOAA Atlas II was used.

4. **Abstraction** There are many methods of estimating abstraction, or rainfall losses due to evaporation, evapotranspiration, interception, surface storage, and infiltration. A commonly used method is the SCS curve number, which is generally but not necessarily used with the SCS unit hydrograph procedure. The SCS curve number relates land use and surface type to rainfall abstraction. Pros and cons of this method of estimating abstraction is presented in the SWMM. The author of this report is familiar with the SCS

curve number method, having used it extensively in the past, performed calibration analyses, and written papers on its use that have been published (Williams, 1988 & 1991). In general, the method is fairly good if separate analyses are used for storms having significantly different intensities. For example, a 2 year storm should be modelled separately from a 100 year storm using a different curve number. Furthermore, when using the SCS curve number method, knowing the analysis objective is also important. A CN value that will likely yield good runoff volume results in a low intensity storm will likely yield too high of a runoff volume estimate in a high intensity storm (ASAE, 1973), and a CN value that will likely yield good runoff peak results in a low intensity storm will likely yield too low of a peak runoff in a high intensity storm (Williams, 1990). Moreover, if a high enough CN value is used to model peak runoffs in developed areas, the estimated runoff volumes will be particularly high from undeveloped land. For a singular basin, multiple modelling can easily be done to address these peculiarities, but for a larger stormwater management master plan, multiple models are cumbersome, confusing, and lead to discrepancies between models, one potentially being updated and the other not.

The Green & Ampt method of modeling abstraction is more physically based, not difficult to use, and seems to be more stable or provide reasonable results across a wide range of conditions. This method was not initially supported by WMS, so we decided to use the SCS curve number to model abstraction in all of our hydrological models. Meanwhile, we requested inclusion of the Green & Ampt procedure in the WMS program, and it was eventually added. Most of our watershed basin models were then remodeled using the Green & Ampt method. Exceptions are the large watersheds pertaining to washes and creeks, where the curve number method gave what appeared to be realistic results.

Soil types were taken from the most current complete soil survey by the SCS, which was published in 1963 (SCS, 1963).

5. **Lag Time** Several methods of calculating watershed and subbasin lag times are presented in the SWMM, many of which were not supported by WMS. We are most comfortable with results obtained using the TR-55 method of calculating time of concentration (Tc), and setting the lag time (TL) at 60% of Tc. This is particularly true for smaller and more complex watersheds, such as in urbanized areas. Consequently, we used the TR-55 manually on several watersheds and runoff conditions to establish "calibration" times of concentration, and then compared results from various procedures provided in WMS. We determined that the Kirpich procedure gave results most similar to the TR-55 procedure, so we used that procedure in our models. Later, when we refined models, we manually calculated Tc values using TR-55 procedures for all downtown subbasins.

6. **Hydrologic Routing and Diversions** Inlet interception and pipeline capacities per SWMM were used in hydrologic modelling as diversions from surface flow. Also, surface flow routing was performed using the Muskingum method.

Detention and retention basins were modelled using criteria presented in the SWMM. However, proposed basin parameters were only approximated in terms of depth-storage-release values. During the basin design process, refined parameters will need to be used which provide similar inflow/outflow characteristics.

D. PROCEDURES

Modelling procedures were in accordance with the SWMM, Appendix P, Sections A, B, & C.

1. **Base Mapping** We gathered available information that we were aware of, compiled, sorted, translated, rubbersheeted, and discarded as deemed appropriate (much of the data was conceptual and conflicted with more accurate information), and prepared base mapping.

2. **Basin Delineation** Watershed and subbasin areas were initially delineated by WMS using contours and triangular irregular networks (TINs) that are used to define a land surface model. However, manual adjustments were made to connect and improve subbasin delineation in flat urban areas, and also to conform with guidelines presented in the SWMM for subbasin delineation.

3. **Land Uses** Land use and zoning mapping was correlated with land use surface treatments and percent impervious cover, and used in determining abstraction parameters. Information relating to land use was obtained from the County.

4. **Abstraction Values** SCS curve numbers were retained for models of the creek and wash watersheds, but for the Downtown and Murray Drain areas where smaller and more developed subbasins were involved, models were refined using Green & Ampt abstraction procedures.

V HYDRAULIC OVERVIEW

Most of the hydraulic concepts, criteria, procedures, and software used are the same for the entire study area. These are discussed in this section. Specific issues relating to a single subbasin will be presented in the section devoted to that watershed or subbasin.

A. GENERAL CONCEPTS

There are several types of hydraulic calculations involved in the study. On a larger scale, we have creek or wash or large drain hydraulics, and on a smaller scale, storm drain inlet, pipe, and culvert hydraulics. Trash, debris, sediment, and clogging can have a significant impact on the actual capacities of all of these types of facilities, and therefore have been considered in analyses. The criteria, procedures, and principles involved in hydraulic analyses performed with this study are for the most part in conformance with the Mesa County Stormwater Management Manual. In some cases, a less refined analysis was provided because of the limited scope of work.

B. SOFTWARE USED

As was discussed earlier relating to hydrological modelling software, it is important to use an industry standard program or modelling procedure that is generally accepted, widely known, and comprehensive. This is particularly true for any models that will be used again in the future, such as for floodplain mapping or significant basin hydraulic analyses. Software is discussed in this section as it pertains to the specific type of hydraulic modelling involved.

1. **Channel and Bridge/Culvert Hydraulics** Our tax dollars have been used by several departments of federal government to produce their own version of hydraulic modelling program. For one-dimensional flow, which is generally used except in more extreme alluvial fan conditions, the Army Corp of Engineers (COE) has developed "HEC-2", the US Geological Survey (USGS) has developed for the Federal Highway Department the older "E43 l/J635" and newer "WSPRO" or "HY-7"; and the Soil Conservation Service (SCS) the "WSP2" program. More recently, the COE has introduced HEC-RAS, their "new generation" HEC-2. Two-dimensional modelling programs are also available, although not commonly used. As computing power and the use of TINs increase, these will likely gain favor.

   For decades, HEC-2 has been the industry standard for modelling streams and open channels for capacity and floodplain/floodway determination. HEC-2 is still the most widely used, and any program that may supersede it will necessarily be able to read in HEC-2 data because of the large amount of HEC-2 models that have already been prepared and are available for updates. Consequently, use of HEC-2 for channel and bridge/culvert hydraulic modelling is appropriate.

We were very familiar with HEC-2, having used it many times in the past, and having attended and taught workshops and seminars regarding its use. However, being on the verge of "new generation" software, we thought we would investigate what was available.

Initially, we decided to try Eagle Point's Water Surface Profiles (WSP) program, because we had already purchased it as part of a total engineering software package. WSP uses HEC-2 methodology and incorporates the HEC-2 kernel. WSP runs inside AutoCAD in a graphical environment, creates a HEC-2 file, and then HEC-2 runs the file. WSP makes excellent use of the graphical environment to automate all tasks that could be done from graphical information and a land surface model or TIN. Unfortunately, we found the program to be full of bugs, and we received little response from technical support to resolve the problems.

We looked at COE's new HEC-RAS, which is free to download. We found it to be far inferior to Eagle Point in terms of being "next generation" software--it provided a schematic graphical view, but really was not "next generation". It will be the new base program that replaces HEC-2, but an private enhanced version of it may be the best way to go--once fully developed.

We then investigated HEC-2 for AutoCAD, or AHEC2 by Boss International. It uses the COE HEC-2 kernel, with nearly all the same capabilities. AHEC2 works inside of AutoCAD in a graphical environment, and therefore enhances and/or automates a number of the routine tasks where human error is more possible or probable. It does not take advantage of the graphical environment for automating as many tasks as Eagle Point's Water Surface Profile does, but we found it to work, unlike the Eagle Point product. It also has limited split flow capability, allowing only a single percentage of return flow for all locations rather than individual percentage of return for each cross section or reach. This limitation had no effect on this project, however. The program has been available for some time and is fairly sound. (Before our evaluation of AHEC2 was complete, Boss introduced their latest version called RMS for river modelling system, in which HEC-2 and HEC-RAS modules may be run. We opted to purchase the older AHEC-2, knowing that it had been around a while, and having used it, that it worked and was fairly bug free. By now (1998), the RMS may be fairly clean of bugs.)

We used BOSS' AHEC2 for riverine hydraulic modelling performed for this study.

If an agency desired to perform riverine hydraulic modelling on their own, we would recommend to continue using HEC-2 if they have personnel that knows it. If not, HEC-RAS may be the model to learn and use, because it will be around, supported, sound, and it is free. The cost of the other programs like WSP (once properly developed) and AHEC2 or RMS may not be cost effective for the casual user. Even our usage has been infrequent enough that thus far the cost has not been justified.

2. **Pipe Hydraulics** There are many software programs available for analyzing storm sewer systems. Most are not fully integrated with hydrological modelling, such as THYSIS and HYDRAIN that have been around a long while. Many programs have been produced that combine hydrology and hydraulics, but the hydrology is the Rational Method, which is a fairly limited modelling procedure. The only program that we are aware of that seamlessly integrates a powerful hydrological modelling program with powerful hydraulic routines is SWMM or XP-SWMM, although Boss Stormshed is also very capable. Eagle Points' Storm Sewers allows for Rational Method hydrological calculations in hydraulic modelling, or one can input static peak flows generated elsewhere into the model. To obtain a "dynamic" analysis using Eagle Point's Storm Sewers, one must perform hydrological analyses in other software using unit and flood hydrographs having each point of interest in the hydraulic system as a concentration point in the hydrological model, enter the peak flow values into Storm Sewers, and thus have routed peak flows used in the hydraulic model. With our selection of HEC-1 (or WMS and HEC-1) for our hydrological model, use of Eagle Point's Storm Sewers is an acceptable approach, when the scope of work and available data justified the additional detail in analyses. If not, a reliable and quick solution is to simply use a hydraulic wheel "calculator".

Given the scope of work for this study, we used of the hydraulic wheel calculator for determining pipe capacity and for sizing proposed pipes.

3. **Inlet Hydraulics** The industry standard method for calculating inlet capacities is outlined in the Federal Highway's HEC-12 (FHWY 1994), which is the method outlined for use in the Mesa County Stormwater Management Manual (SWMM). This procedure is also used by Eagle Point's Storm Sewers, but where a hydraulic model was not generated by Storm Sewers, we simply used the inlet capacity data generated by HEC-12 procedures that are provided in the SWMM.

C. CRITERIA and PROCEDURES USED

For this study, we established specific criteria beyond SWMM that we felt was appropriate for the study objective. We also selected a specific procedure to help ensure quality results.

1. Channel Hydraulics

a. Cross Section Frequency The J.F. Sato hydraulic analysis was broadbrush, with cross sections taken at approximately 1500 feet intervals except for at bridges. We provided cross sections at 200 foot intervals, plus the additional cross sections in the vicinity of bridges.

b. Cross Section Geometry We used 2 foot contour mapping, with cross sections defined automatically by AHEC2. Modifications were made as necessary from our field measurements, and also at bridges where data was used from the J.F. Sato study.

c. Manning "n" Values Mannings friction or flow resistance "n" values were selected and adjusted per Table "F-4" of the SWMM, with the more detailed approach of using "n" value changes by horizontal location along the cross section. Based upon a walk of the entire study reach of the wash, a review of photos taken during the walk (approximately one per hundred feet), consideration of debris source and clogging potential, and aerial photos, we determined that "n" value selection for three conditions in five segments would be most appropriate: the more clear main channel with a "n" value of 0.046; the brushy terraced channel with a "n" value of 0.161; and the overland shallow floodplain area with an "n" value of 0.040. The bank width of each of these areas was scaled from the aerial photos. Under bridges, a channel "n" value of 0.040 was used except at 18 Road, where the channel was essentially unchanged due to the bridge, so an "n" value of 0.046 was used there.

d. Coefficients of Contraction and Expansion Along the channel, the contraction and expansion coefficients used were, respectively, 0.1 and 0.3. At bridges, the respective values used were 0.3 and 0.5.

e. Non-Effective Flow Areas (NEFA). Non-effective flow areas are used to identify areas not useful in the flow conveyance of water. These areas may include pool areas, areas at bridge encroachments that are inside the channel geometry but outside of bridge abutments, and areas below roadways at crossings. The NEFA allows adjustment of cross-section areas obtained from contours or TINs to model dead pool or eddy areas without imposing a fictitious hard boundary and wetted perimeter. NEFAs were used in our models.

2. **Bridges and Culverts** Bridge modelling data was taken from the J.F. Sato model because, per the FIS Report, their data was based upon field survey. We then merged their data into our contour data to make a seamless model. The special bridge method was used except at 17-1/4 Road and 18 Road bridges, where the normal bridge method was used. The culvert at 18-1/2 Road was field measured and analyzed per the HEC-2 Special Culvert procedure, which is really the Federal Highway procedure (FHWA HDS-5).

   Culverts not associated with Little Salt Wash were also analyzed using FHWA's HDS-5 per SWMM.

3. **Pipes and Inlets** Storm drain pipes were analyzed using a Manning "n" value of 0.013 as calculated with a Manning wheel pipe flow calculator. Inlets were analyzed using the SWMM, although under sump conditions, a higher clogging factor was used.

VI LITTLE SALT WASH

General hydrological and hydraulic concepts, criteria, and procedures used for all watershed basins have been discussed in Sections IV and V. Only additional, unique, or variances from those procedures will be presented herein as they pertain to Little Salt Wash, along with results and recommendations.

A. ADDITIONAL DATA OBTAINED

Section III lists information that was available for use for all watershed areas. Additional information was obtained by field walk, measurements, and photographs as described in Section V-D Criteria and Procedures.

B. HYDROLOGY

1. **Model Assumptions and Limitations** Little Salt Wash was divided into two separate models: one above M Road; and the other below M Road. Two models were made because of the available topographic data. Two-foot contour data was available as far north as M Road. Beyond that, only XYZ points from a USGS digital elevation model (DEM) was available. The two DEMs could not be easily combined for a single analysis because they are in different coordinate systems.

2. **Procedures** The upper watershed above M Road was analyzed first, and the resultant flood hydrograph imported into the model of the lower watershed. This was done for both the 100 year and 500 year storm events. Precipitation for the basin was adjusted for the basin size per SWMM Figure "A-2".

3. **Exceptions** Base flow from groundwater seepage and irrigation tailwater were considered negligible compared to the 100 and 500 year storm runoff rates, and were not added.

4. **Alternatives Explored** We were particularly concerned about the possible need for a detention facility along Little Salt Wash to reduce flooding at bridges through town. Consequently, we analyzed the upper basin under various time of concentration procedures to see if under any method the upper basin runoff arrived soon enough to result in an overlap in peaks. With no time of concentration method did an overlap in peaks occur, even though the local and upper area hydrological peaks were close. Both peaks were nearly the same, and essentially maximize the capacity of the channel at bridges, but overall the system appears to work fairly well.

5. **Results** Hydrological results are shown on Exhibits "6A", Upper Little Salt Wash, and "6B", Lower Little Salt Wash.

C. CHANNEL HYDRAULICS

Model assumption and limitations, procedures, channel geometry, Mannings "n" values, expansion and contraction coefficients, non-effective flow areas, and bridge and culverts were all analyzed as discussed in Section V, Hydraulic Overview. There were no exceptions to those procedures.

1. **Alternatives Explored** It was our initial assumption that with in-growth of vegetation, dumping, encroachment, and limited capacity bridges, that there would likely be a flooding problem along the more developed portion of Little Salt Wash, more specifically at Ottley and Highway 6 & 50. The basis for that assumption was the flooding in that area due to backup behind bridges as shown on the 1992 Flood Insurance Rate Maps. Furthermore, we know that continued dumping and vegetatal in-growth has occurred which would worsen conditions. Consequently, we were of the opinion that it might be well to have a detention facility along Little Salt Wash above the main downtown area that would attenuate or dampen the peaks by providing storage capacity. These types of facilities also make excellent parks and water amenities as well, so we looked for a logical site and found only one. It was 23 acres of land along the wash bordered by 18 Road on the east.

   Inasmuch as a large detention facility, in order to be maintained, must function normally as a park, we discussed the location with the City as to the site's suitability. They City was of the opinion that the location and setting was ideally suited for a park, so we proceeded with our hydraulic analyses of the wash, observing the effect of various capacities of proposed storage in the area.

2. **Results** Analyses results indicate that the detention volume that is realistically available at the proposed park site was insufficient to be of help in the 500 year storm event, and was, for the most part, unnecessary in the 100 year event. Reference is made to Exhibits "6C" and "6D" for graphical results of our 100 year and 500 year floodplain analyses.

   While some out-of-bank flooding does occur between Ottley and Highway 6 & 50, the 100 year flood remains within the currently defined channel, and the 500 year results in minimal flooding along the Downer Subdivision. The City was of the opinion that the estimated flooding did not appear to be to detrimental, and that major bridge or channel improvements were necessary.

D. WATER QUALITY

The water quality of Little Salt Wash should be protected. Pollutants are primarily from three sources: irrigation tailwater; dumping; and stormwater discharge. Irrigation tailwater is usually high in sediment, and also contains traces of fertilizer and pesticides. Mitigation of pollution from farming practices is a big issue, one that even the EPA has done little to address or target.

The City has more control over the other two sources of water pollution, however. There can be improved regulation and/or enforcement of regulation regarding dumping. We have seen couches, large appliances, cars, car batteries and tires, Christmas trees, lawn clippings, and a host of other "landfill" uses for the wash that are unacceptable. Increased public education, such as newspaper articles and presentations at the schools may help, but either enforcement of penalties or a pathway along the creek that makes dumping publicly visible will also be necessary.

Stormwater runoff is generally high in sediment, and also contains hydrocarbons from developed areas. One of the best ways to deal with both of those issues is to require new development to provide water quality treatment, such as in water quality basins, for the two year event. This way, during the more frequent and common storm events, hydrocarbons are flushed from the surface, along with silt and sediment, and water quality is improved. These water quality basins essentially retain stormwater runoff from development with a very gradual bleed-off, and would not present a problem for the wash channel hydraulics. This is because the release rate is slow, and the wash would not be at or near capacity from a two year storm event. During greater storms, the basins would directly overflow to the wash without detention or a delayed release, allowing more local runoff to pass through the wash before the peak runoff from the upper watershed arrives. Watersheds that drain to Little Salt Wash should not have detention for large storm events, but should have capacity for direct discharge to the wash.

E. RECOMMENDATIONS

For the Little Salt Wash system, recommendations are enumerated below.

1. **Major Structural and Channel Improvements** Based upon our floodplain analyses and floodplain limits as shown on Exhibits "6C" and "6D", it does not appear that major structural and channel improvements are a high priority from a hydraulic standpoint. Thus, improvements of this kind are not recommended.

2. **Major Detention Facility** A large detention facility on Little Salt Wash does not appear to be needed. There are two separate and nearly equal peaks in flood hydrographs, one due to local runoff, and one due to upper watershed runoff. Flood discharge reduction in Little Salt Wash would thus require two detention basins, one upland and one near the crossing with Ottley. However, we do not believe that a reduction in flood discharge is necessary nor cost effective, and thus do not recommend any. Furthermore, detention at the 23 acre site bordered by 18 Road on the east would be more detrimental than good -- it would capture, delay, and then release upper local runoff simultaneously with upper watershed basin runoff, and actually increase flood flows through the wash during greater storm events.

3. **Floodplain Mapping Changes** The current flood insurance floodplain mapping is based upon a broadbrush hydraulic analysis. Such analyses are necessarily conservative to ensure being adequate in the absence of a more detailed and refined analysis. Little Salt

Wash, however, is mostly a well defined channel with adequate capacity, and our refined analysis did not yield significantly different results. Compared with the FIS Study , we show a wider floodplain along Downer Subdivision between Ottley and Highway 6 & 50, no flooding along the north side of Ottley west of Little Salt Wash as the FIS Study does (this is due in part to infill of a drain that diverted water), and a slightly wider floodplain east of 18 Road and South of L Road. Overall, the difference is not significant. Furthermore, the only reduction in floodplain is removal of the 500 year floodplain north of Ottley west of the wash. Insurance is not required by lenders for 500 year flood zones, only the I00 year flood zone. Consequently, if revised mapping were approved, it would not change what people are required to pay, it would only eliminate property owner's opportunity to purchase flood insurance if they so desire. Overall, a change of mapping would provide minimal benefit and would be costly, and we do not recommend pursuing it unless significant changes and/or improvements are made. It may be appropriate to notify FEMA of the new study, but not necessarily pursue a map revision.

4. **Pathway Along the Wash** The greatest concern is that measures are taken to preserve current channel conveyance capacity, and perhaps to make a few improvements as well. One of the best ways we know of to accomplish this is to provide a pathway along the wash. With a path along the wash, access is available for debris and brush removal, and also for trimming of lower tree branches. Moreover, public visibility discourages dumping and encroachment. Furthermore, a path can improve flood conveyance capacity when in the terraced channel, because it provides a cleared swath that is open for flow conveyance. Pathways at bridges can also be used to improve bridge flow capacity by lowering areas filled with sediment, keeping bridge entrances clear, and1 when necessary, even a separate pedestrian underpass can be provided which greatly increases bridge capacity. In other words, the win-win situation described in Section 1-B under "Positive Example" need not be unique -- funding is fairly available these days for trails and pathways, and such projects can be a means of maintaining and/or improving flood conveyance as well.

We recommend that a pathway be planned for along the wash. The pathway design should not only address aesthetic and pathway design issues, but flood conveyance, channel maintenance, and slope stability issues as well. We also recommend that a pathway/access easement or tract be obtained from all adjacent development, and a pathway eventually constructed. Furthermore, we also recommend obtaining an access to the pathway easement or tract from public roads approximately every eighth mile for emergency and maintenance vehicles.

5. **Dumping Regulation & Enforcement** We recommend that a public education program be implemented to increase awareness of the problems associated with dumping and penalties that will be imposed for infractions. The pathway recommended above will also help reduce dumping.

6. **Water Quality Basins** Stormwater from new development should provide water quality treatment for storm runoff for up to a 2 year storm event. The volume required would be the full 2 year storm runoff as would be designed for a retention basin, except that a very slow release is incorporated per the SWMM.

7. **Direct Discharge of Runoff From Storms Exceeding the 2 year Event** The water quality basins should be designed for adequate overflow for storms exceeding the 2 year storm event. Adequate facilities should be available (pipes, streets, channels, etc) to convey the full 100 year storm runoff to Little Salt Wash.

F. COST OF FACILITIES

A pathway along the wash would have considerable cost, both for land and construction. We have not attempted to quantify it, because of the many variables involved. Land may be obtained through the development process in some areas, but purchase would be required in others. We have also not attempted to estimate the cost of dumping enforcement and a public education program. Water quality basins would be required as part of development at no cost to the City, and direct discharge facilities, where required, are covered in the next section.

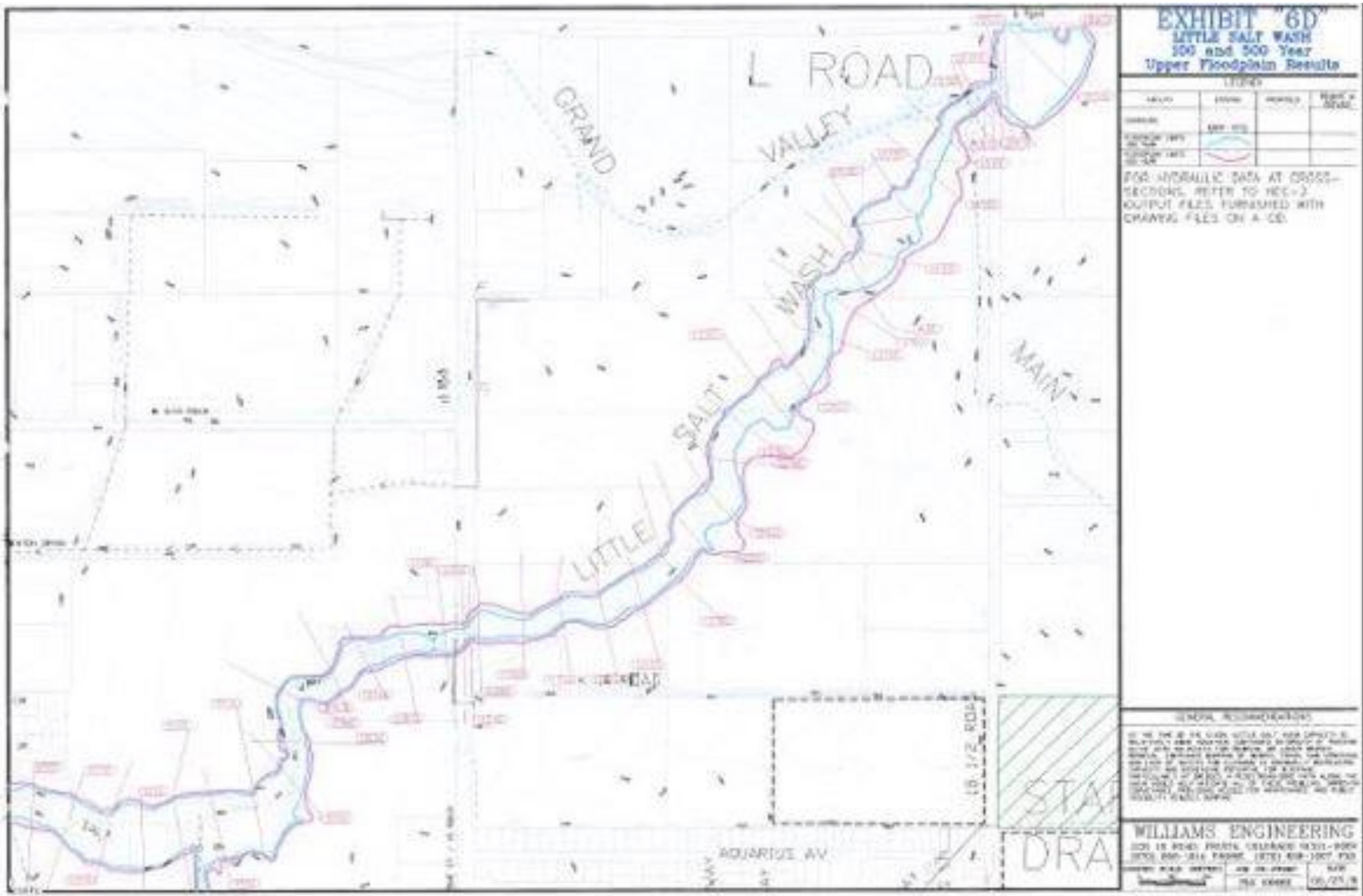
EXHIBIT "6D"
LITTLE SALT WASH
100 and 500 Year
Upper Floodplain Results
FOR HYDRAULIC DATA AT CROSS-SECTIONS, REFER TO HEC-2 OUTPUT FILES FURNISHED WITH DRAWING FILES ON A CD.
WILLIAMS ENGINEERING
L ROAD
GRAND VALLEY
LITTLE SALT WASH
MAIN
AQUARIUS AV
18 1/2 ROAD

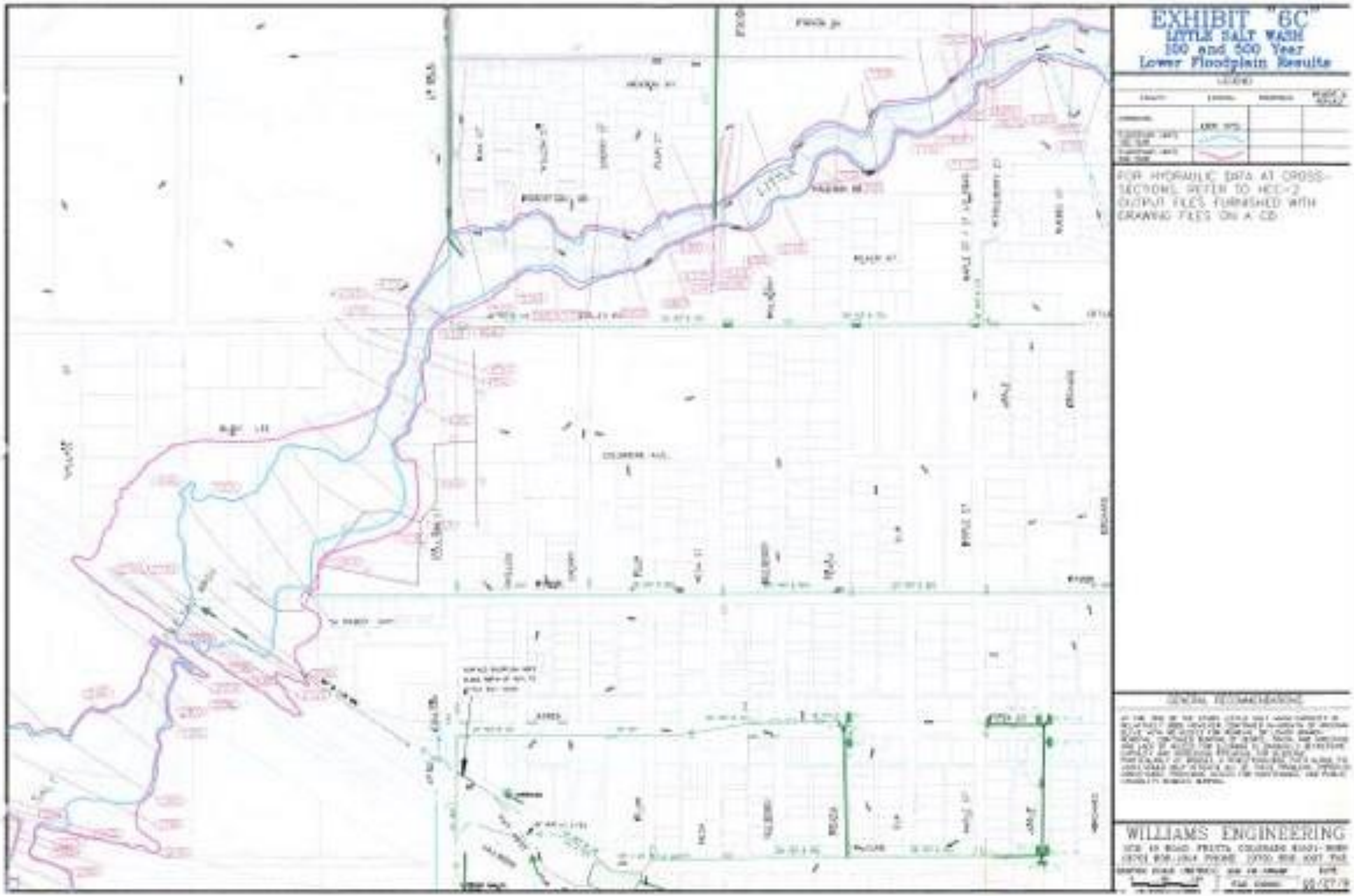
EXHIBIT "6C"
LITTLE SALT WASH
100 and 500 Year
Lower Floodplain Results
FOR HYDRAULIC DATA AT CROSS-
SECTIONS, REFER TO HEC-2
OUTPUT FILES FURNISHED WITH
DRAWING FILES ON A CD
GENERAL RECOMMENDATIONS
WILLIAMS ENGINEERING

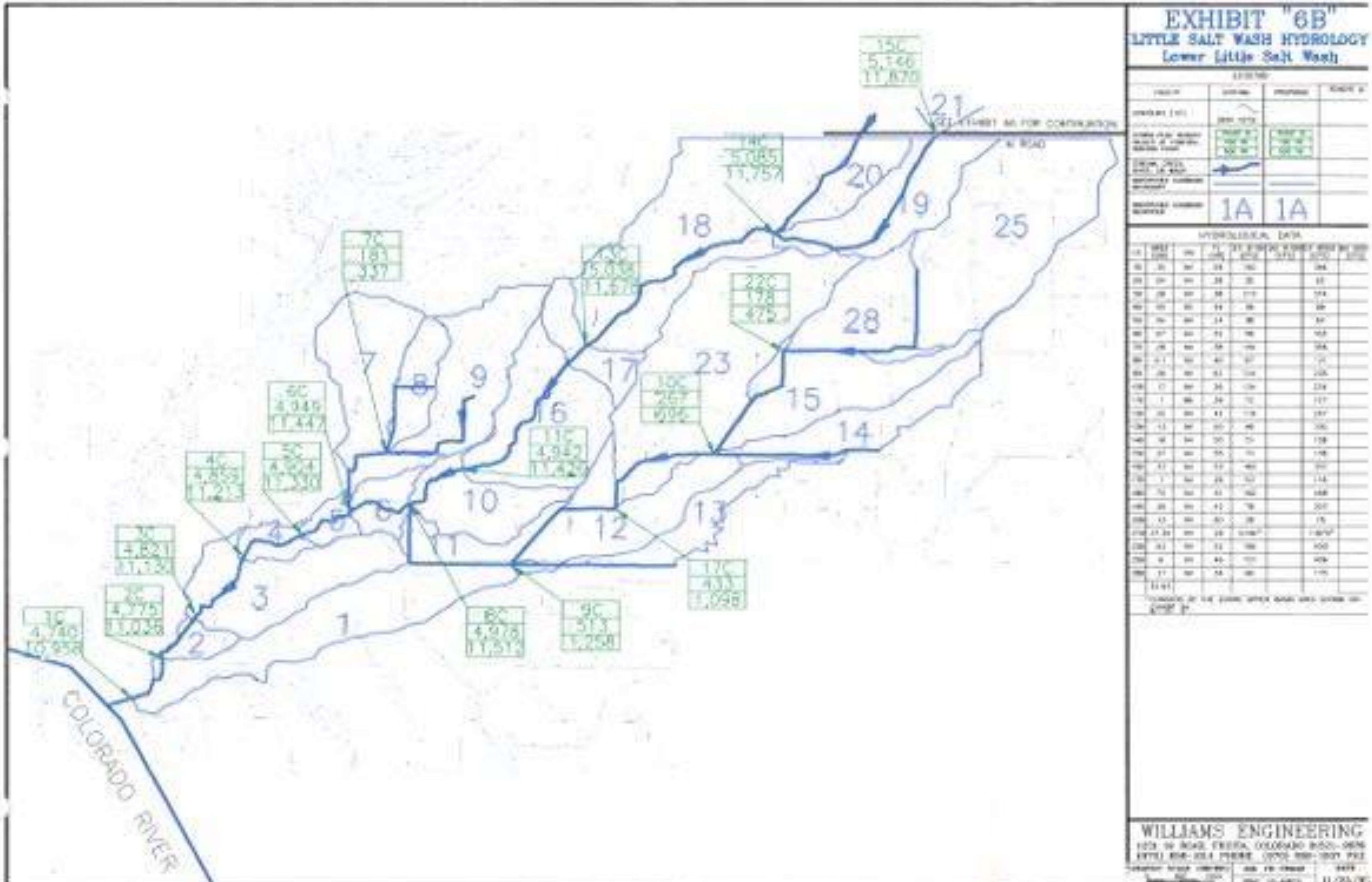
EXHIBIT "6B"
LITTLE SALT WASH HYDROLOGY
Lower Little Salt Wash
1A
1A
HYDROLOGICAL DATA
WILLIAMS ENGINEERING
COLORADO RIVER
15C
5,146
11,870
7C
181
337
6C
4,946
11,447
5C
4,904
11,330
4C
4,852
11,213
3C
4,821
11,130
2C
4,775
11,028
1C
4,740
10,958
8C
4,978
11,512
9C
513
1,258
11C
4,942
11,429
10C
257
696
17C
433
1,098
22C
178
475
5,085
11,757
1
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EXHIBIT "6A"

LITTLE SALT WASH HYDROLOGY

Upper Little Salt Wash

LEGEND

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			
[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	
[illegible]	1A	1A	

HYDROLOGICAL DATA

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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2	[illegible]	[illegible]	[illegible]				
3	[illegible]	[illegible]	[illegible]				
4	[illegible]	[illegible]	[illegible]				
5	[illegible]	[illegible]	[illegible]				
6	[illegible]	[illegible]	[illegible]				
7	[illegible]	[illegible]	[illegible]				
8	[illegible]	[illegible]	[illegible]				
9	[illegible]	[illegible]	[illegible]				
10	[illegible]	[illegible]	[illegible]				
11	[illegible]	[illegible]	[illegible]				
	[illegible]						

WILLIAMS ENGINEERING

[illegible] FRUITA, COLORADO [illegible]

[illegible]

VII NORTHWEST AREA

The northwest area was not a part of the original scope of work. However, runoff from the area, which is shown on Exhibit "7A", drains to the Little Salt Wash. Section VI of this report addresses Little Salt Wash itself, and general recommendations were given regarding local runoff to it. We have added this section to provide a little more focus on drainage issues related to development in this area.

A. HYDROLOGY

Given the scope of work and the lack of existing facilities that would have capacity analyzed, a hydrological computer model was not made for this area. However, we did provide simplified hydrological calculations in order to determine what proposed facilities would be desirable.

We noted that there are north-south streets in the area that all drain south to Little Salt Wash. These are spaced at 1/4 mile intervals from 17 Road to 17-1/2 Road. These corridors of right-of- way allow for storm drain trunklines, each suited for draining the area immediately adjacent to and 1/4 mile uphill towards the east. Each proposed drain, then, would service a 1/4 mile wide strip. This allowed us to perform generic calculations using the Rational Method, for a 20, 40, 60, and 80 acre watershed area. Using a rational coefficient of 0.45 and estimating Tc values per SWMM (TR-55 procedures), we obtained rough runoff estimates for the 100 year event. The entire area has positive slope to the wash, and excessive ponding and flooding should not occur.
Where a pipeline would also double as an irrigation tailwater or groundwater drain, we added an additional 5 cubic feet per second (cfs) flow.

B. RECOMMENDATIONS

1. **Water Quality Ponds** As was discussed in Section VI, runoff from this area should pass through water quality ponds capable of retaining the 2 year storm runoff with water quality rate bleed off. However, there should be facilities (pipes, streets, channels, etc) for direct stormwater conveyance and discharge for storms between the 2 year and 100 year event. Tributary areas south of the wash are mostly adjacent to the wash, so conveyance to the wash is not really a problem. On the north side of the wash, distances are further, and most development that will occur is not adjacent to the wash. Runoff above the 2 year event from these areas must be taken directly to the wash without delay. There are some drains in place, but only the Denton Drain is of adequate size to be of much benefit.

2. **Denton Drain Diversion** We recommend that the Denton Drain east of the 17-5/8 Road alignment be diverted directly to Little Salt Wash. This allows greater use of the 36" drain in 17-1/2 Road for more localized storm runoff.

North-South Trunklines We recommend that there be a trunkline storm sewer north from the wash in 17 Road, 17-1/4 Road, and 17-1/2 Road. Each line would serve adjacent property, primarily as a discharge line for land located within 1/4 mile east of the line, and for a distance of 3/4 mile north of the wash. Ground surface slopes towards the wash. are generally quite good, and although they vary, pipes would generally be sized as follows:

- Lower 1/4 mile - 48" pipe
- Middle 1/4 mile - 42" pipe
- Upper 1/4 mile - 36" pipe to the collection point

If the streets were lowered and reconstructed with curb and gutter to provide conveyance capacity, then pipe sizes could be one size smaller. However, the increase in cost for a size larger pipe is minimal compared with lowering a street, even if reconstruction was being done anyway. The impact to utilities and the haul-off of material and reconstruction of a road base alone would more than offset the cost of upsizing a storm drain as shown above.

There is already a 36" drain in 17-1/2 Road as part of the Denton Drain. We would not recommend enlarging or providing parallel line. Instead, we recommend extending the 36" line north, and the shortage of pipe capacity would be made up by surface flow.

Proposed improvements are shown on Exhibit "7A".

) **C. COST OF FACILITIES**

The estimated total cost of facilities is shown on Exhibit "7A". Costs may be lower if done in conjunction with a street project or if located outside of existing paved areas, which would be advisable.

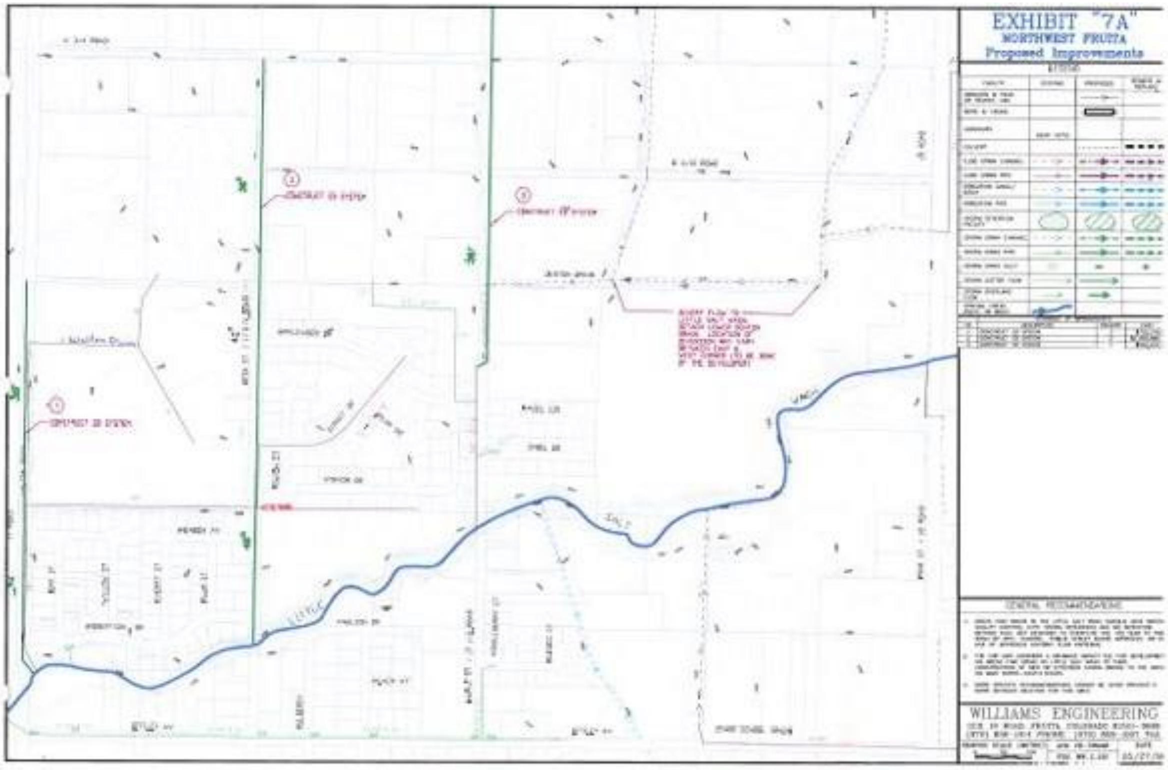
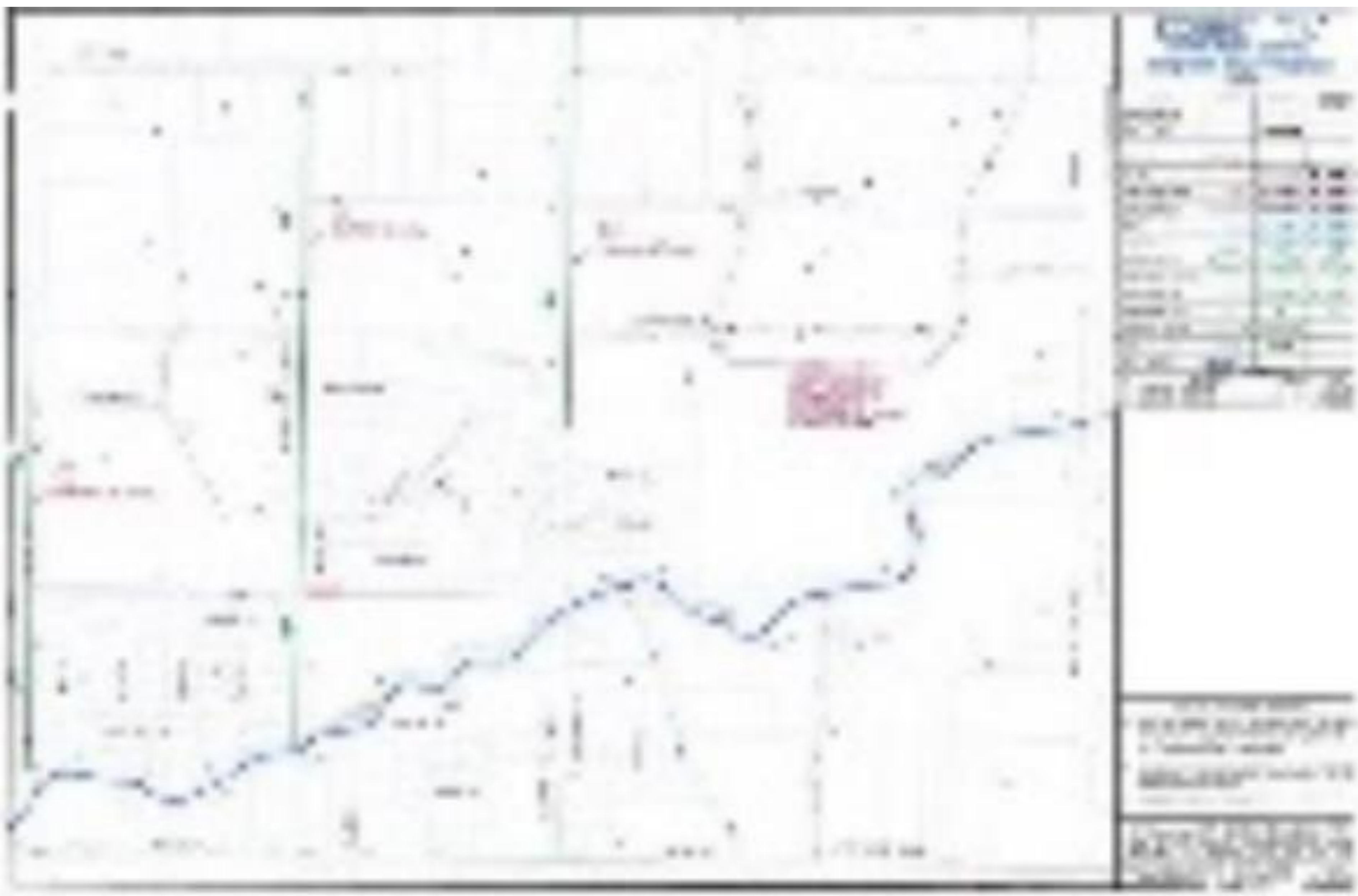


EXHIBIT "7A"
NORTHWEST FRUITA
Proposed Improvements
WILLIAMS ENGINEERING



VIII DOWNTOWN AREA

General hydrological and hydraulic concepts, criteria, and procedures used for all watershed basins have been discussed in section IV and V. Only additional, unique, or variances from those procedures will be presented herein as they pertain to the "Downtown Area", along with results and recommendations.

A. ADDITIONAL DATA OBTAINED

Section III lists information that was available for use on all watershed areas. Additional information used for the Downtown area was as follows:

- A schematic AutoCAD drawing of the downtown area was provided by the Public Works Department which showed existing storm drains and the direction of street gutter flow;

- A 1982-83 "Irrigation System Improvements" plan for irrigation and some storm drain lines as prepared by Arix Engineering was provided; and

- Williams Engineering performed a field reconnaissance of all catch basin inlets, noting location and size (length, width, and curb opening height). Many other field conditions were also investigated.

B. HYDROLOGY

1. **<u>Model Assumptions and Limitations</u>** The existing storm drain system was considered to be generally adequate for the 2 year event, and therefore watershed subbasins, flow routing, and modelling was set up based upon storm drain interception of runoff. Reference is made to Exhibit "8A". For the 100 year event, the Ottley storm drain was found to be essentially adequate, and therefore complete interception modelled. Elsewhere, however, the storm drain system is not capable of intercepting and conveying the 100 year storm runoff. Consequently, subbasin layout, flow routing, and modelling was set up to follow the lay of the land, with diversions as appropriate to represent storm drain interception. Reference is made to Exhibit "8B".

2. **<u>Procedures</u>** Minor storms have not been as critical as major storms, where overflow past storm drain systems eventually ends up along the north side of Highway 6 & 50, with significant flooding potential before overflow to the west would occur. Knowing that a number of alternative solutions would be investigated, we subdivided watershed basins to facilitate such investigations.

3. **<u>Alternative Explored</u>** We explored a number of alternatives to address the flooding

problem along the north side of the highway. From a cost standpoint, the most desirable was boring under the highway at Maple (17-1/2 Road), and providing detention in highway and railroad ROW, with adequate bleedoff available through an existing 30" irrigation line that drains south under the railroad and I-70, and eventually discharges into a GJDD drain. We met with staff from both the railroad and highway department, and learned that this option would not be allowed. We also explored detention possibilities in Reed Park, but the size was not adequate and the location as favorable as it could be. Overall, using Reed Park for detention was helpful only in less intense storms during which there is less flooding anyway. During storms greater than a 5 year event, the detention would not provide any benefit. It did not seem appropriate to cause so much disruption of the park for so little benefit, so that option was dropped. We also looked at other land available in the area and explored options.

The alternative discussed above pertains to the middle portion of the downtown area. We also investigated options for the west side, which included a new storm drain line both south and west of the overpass, increased detention in COOT and railroad right-of-ways (which they did not approve), detention on property west of the overpass and north of the highway, bores under the overpass bridge approach, an open drainage channel between the highway and railroad to Little Salt Wash (which was not approved -- they would require piping), and also a pipe along the north side of the highway to Little Salt Wash. We met with COOT, the railroad, and City staff regarding options and costs.

COOT and railroad policy, along with consideration of the high cost of boring long distances under highways, railroads, 1-70, and highway frontage roads, led to a final solution of addressing both the middle and west downtown areas with a single storm drain system. Our final hydrological model is based upon this solution, and is shown on Exhibit **"8B".**

C. CHANNEL HYDRAULICS AND STORM SEWER SYSTEM

Options that involved an open channel were not allowed, so hydraulic conveyance for proposed facilities in the downtown area are limited to storm drains and culverts.

1. **West Downtown Area Alternatives Explored** Various options were looked at to adequately intercept and convey runoff in order to prevent significant flooding along Highway 50. A minor collection in Apple Street, which is to be repaved, was preferable to digging up Maple Street, so a line was planned for Apple up to Aspen where excessive street inundation at Maple occurs. Interception runoff at Apple could be taken west in a new parallel drain constructed in McCune, which could also pick up additional runoff that converges at Peach and Aspen. Unfortunately, there would still be enough runoff from east of Maple Street, and also south of McCune, to result in flooding north of the highway beyond what the existing highway drain could handle. Thus another drain would be required along the highway, or at least a branch off the proposed McCune storm drain to

service the Elm, Maple, and Grand Avenue areas. This approach would require two proposed lines, or, if the branch off line from McCune was used, a longer line. Neither of these solutions would be cost effective. Not only would a shorter larger line be cheaper than two slightly smaller lines (or a longer one), but the required road reconstruction associated with a large storm drain line in roads is also very expensive.

Alternatively, if the Apple Street storm drain had less interception capacity, the existing McCune storm drain would be adequate in moderate storms, and overflows would go to the north side of Highway 50 as it currently does. Then, only one additional large capacity storm drain would be required, located along the north side of the highway parallel to an existing undersized storm drain. This appeared to be the most cost effective use of street conveyance capacities, the existing storm drain system, and new storm drain. The length is shortest, only one new line in the area would be required, and it would be out of road pavement. Furthermore, the line would be located where it is most needed, with inlets placed directly above the pipe in most cases. This is the alternative settled upon, and is depicted in Exhibit "8C" -- West System Proposed Improvements.

The final discharge for the west Downtown area, as discussed previously under hydrological alternatives explored, is along the north side of the highway towards Little Salt Wash. This would require a box culvert under the overpass, and open channel or pipe west to the park, park channel excavation, and a large culvert west to the wash.

2. **East Downtown Area Alternatives Explored** The drainage deficiency at Cedar Drive has recently been addressed by a developer. This leaves three main drainage deficiencies in the East Downtown area: Laura Avenue; Cedar Way; and Pine Street (18 Road).

The Laura Avenue area either drains to an inadequate 8 inch storm drain system along Ranchman's Ditch or to the intersection of Cedar and Aspen Avenue where it is taken through an interesting but poor surface drainage system back to the same inadequate 8 inch storm drain system. Cedar Way has an 8 inch outfall line out of the face of a street curb. Neither system works well, and yet both areas receive considerable runoff backup behind Ranchman's Ditch. The only sensible solution we could see was to intercept runoff going to both places and take it to 18 Road where another storm drain line is needed anyway.

A large parallel storm drain line in Pine Street (18 Road) would be desirable in addition to the GJDD 18"to 24" line. Unfortunately, the outfall is restricted at the highway/railroad/I-70 crossing with a 42" pipe. The cost of boring to increase capacity would be very expensive and not recommended, but the conveyance system to the 42" culvert may as well match the culvert capacity. Therefore, we looked at the alternative of providing a new parallel 36" storm drain along 18 Road. Existing and proposed facilities are shown on Exhibit "8D" -- East System Proposed Improvements.

3. **Results** The resulting storm drain system layout and pipe size is shown on Exhibits "8C" and "8D". The drain system as shown should address more significant local drainage needs, plus protect properties along the north side of the highway from major flooding up to the 100 year storm event.

D. WATERQUALITY

1. **West Downtown Area** The existing outfall system for the west area is a 24" storm drain line just west of the overpass that drains south to Grand Avenue and then west to the Colorado River. This drain would remain in place. Furthermore, the new outfall system should tie into this line with a junction that causes initial flows to be diverted through the 24" line, with only flows exceeding the 24" drain capacity continuing west in the large proposed line (see Exhibit "8C"). The 24" line would become the "water quality" line, and its discharge point would be redirected to an existing pond that is proposed to become a water quality pond. Although the capacity of the 24" line is not great, it will be able to convey the frequent "flush" storms that contain most of the urbanized dust, sediment, and hydrocarbons, and would thus function well as a water quality drain.

2. **East Downtown Area** The east downtown area drains down Pine Street (18 Road), and outfalls in the Murrary Drain. A water quality basin is proposed, but this would be south ofl-70, and is shown on Exhibit "9A".

E. RECOMMENDATIONS & COSTS

Recommended facilities, their priority, and also estimated costs are shown on Exhibits "8C" and "8D".

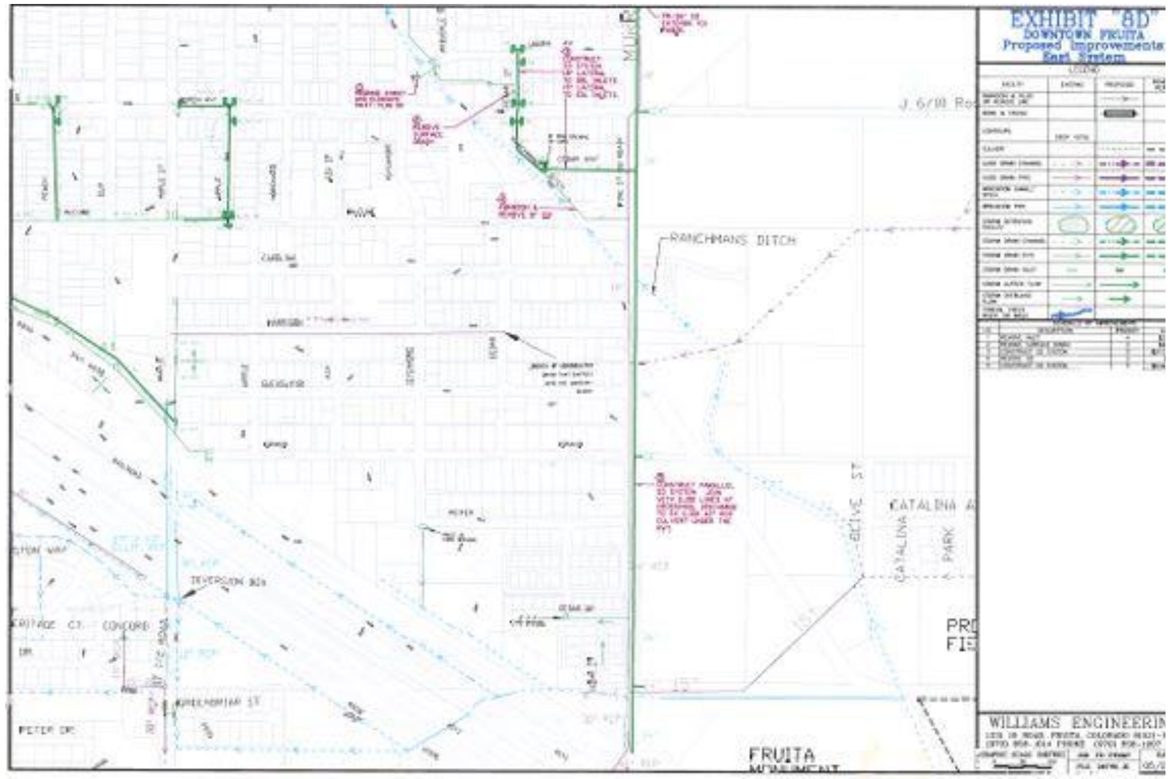


EXHIBIT "8D"
DOWNTOWN FRUITA
Proposed Improvements
East System
J 6/10 Ro
RANCHMANS DITCH
DIVERSION BOX
CATALINA A
CATALINA
PARK
PETER DR.
FRUITA
MONUMENT
PRO
FIE
WILLIAMS ENGINEERIN

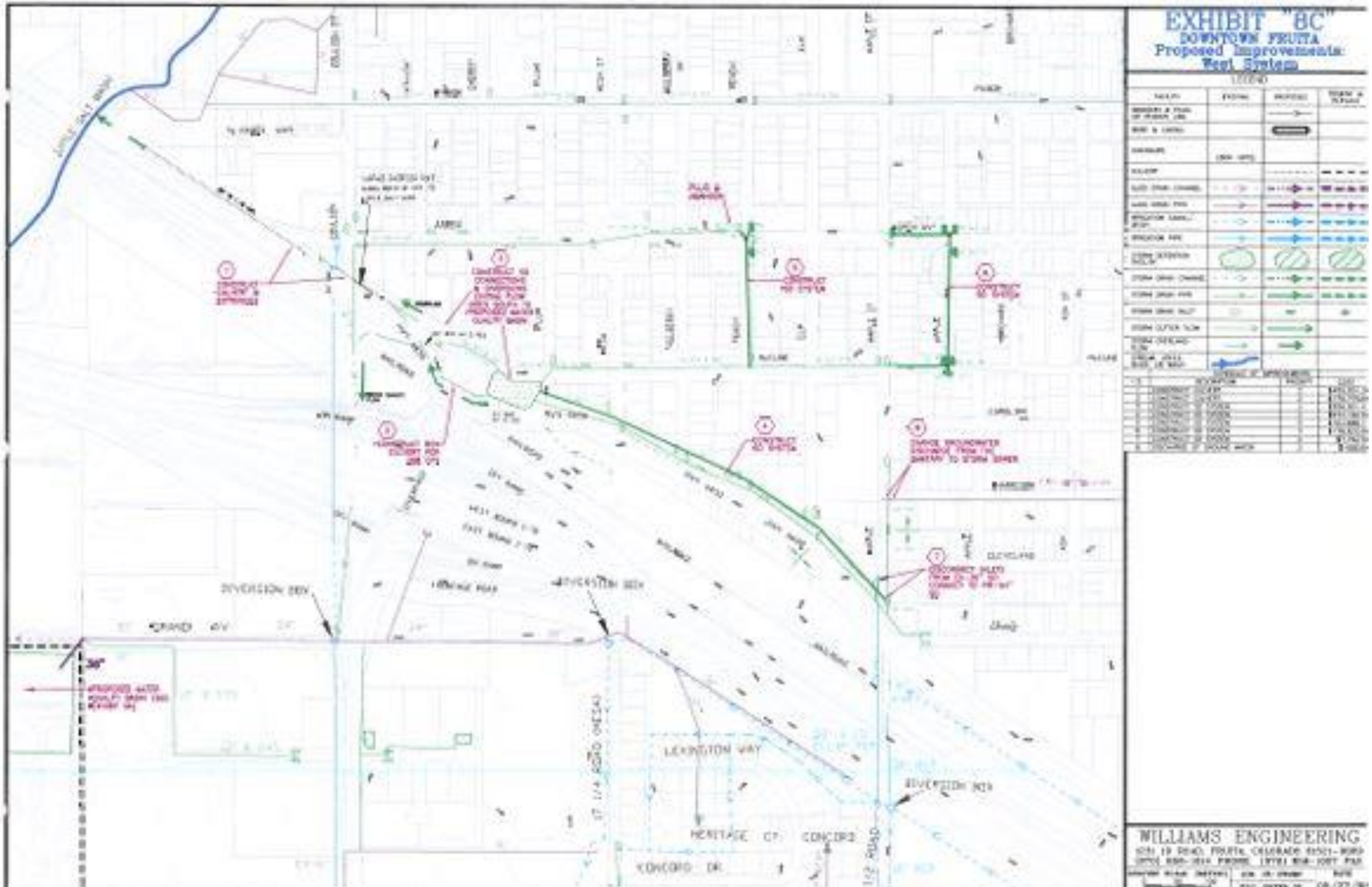


EXHIBIT "8C"
DOWNTOWN FRUITA
Proposed Improvements:
West System
LEGEND
WILLIAMS ENGINEERING
DIVERSION BOX
DIVERSION BOX
DIVERSION BOX
LEXINGTON WAY
HERITAGE CT.
CONCORD
CONCORD DR.
17 1/4 ROAD
17 1/2 ROAD

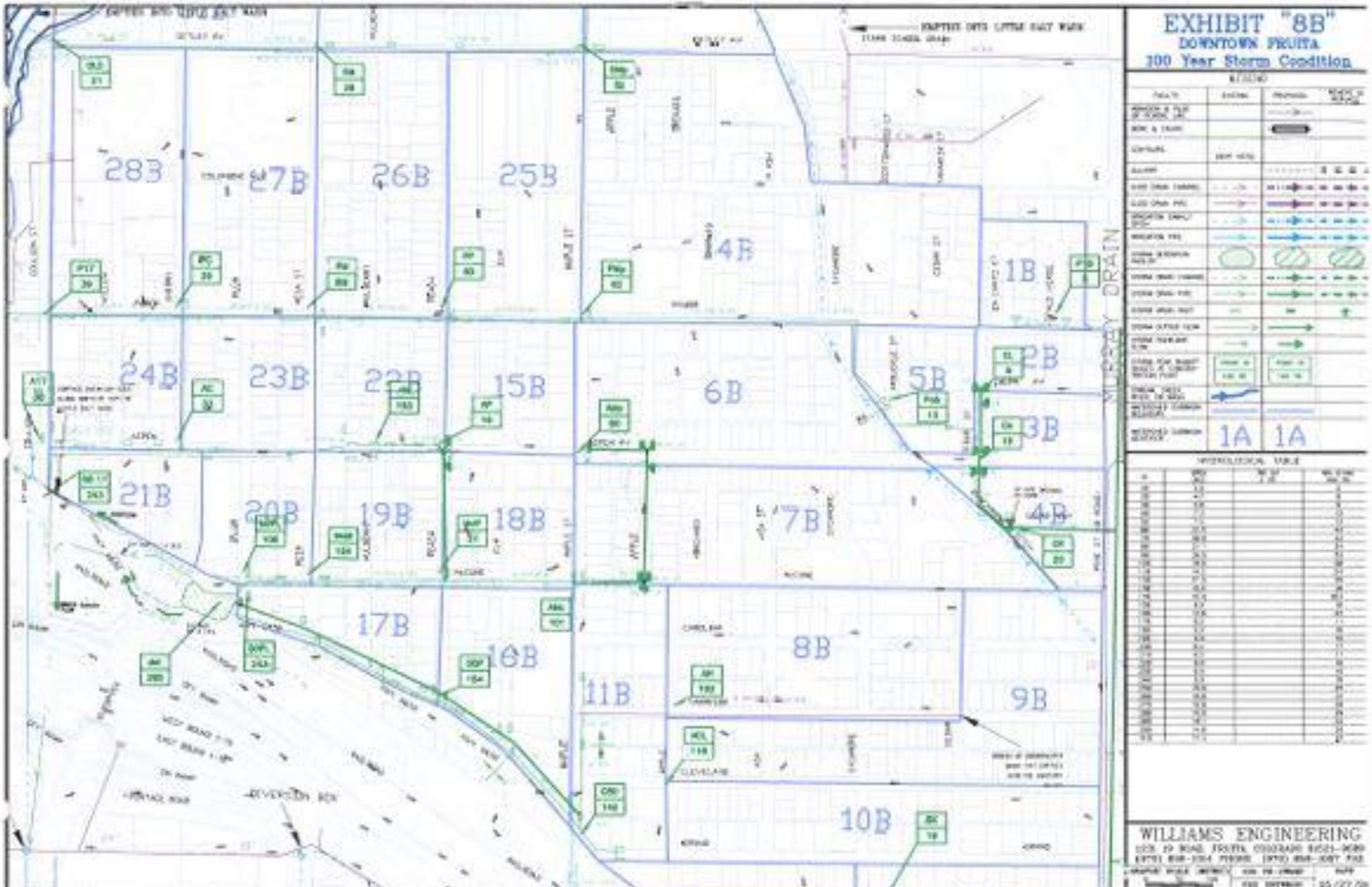


EXHIBIT "8B"
DOWNTOWN FRUITA
100 Year Storm Condition
28B
27B
26B
25B
14B
1B
24B
23B
22B
15B
6B
5B
2B
3B
21B
20B
19B
18B
7B
4B
17B
16B
8B
11B
9B
10B
DRAIN
1A
1A
WILLIAMS ENGINEERING

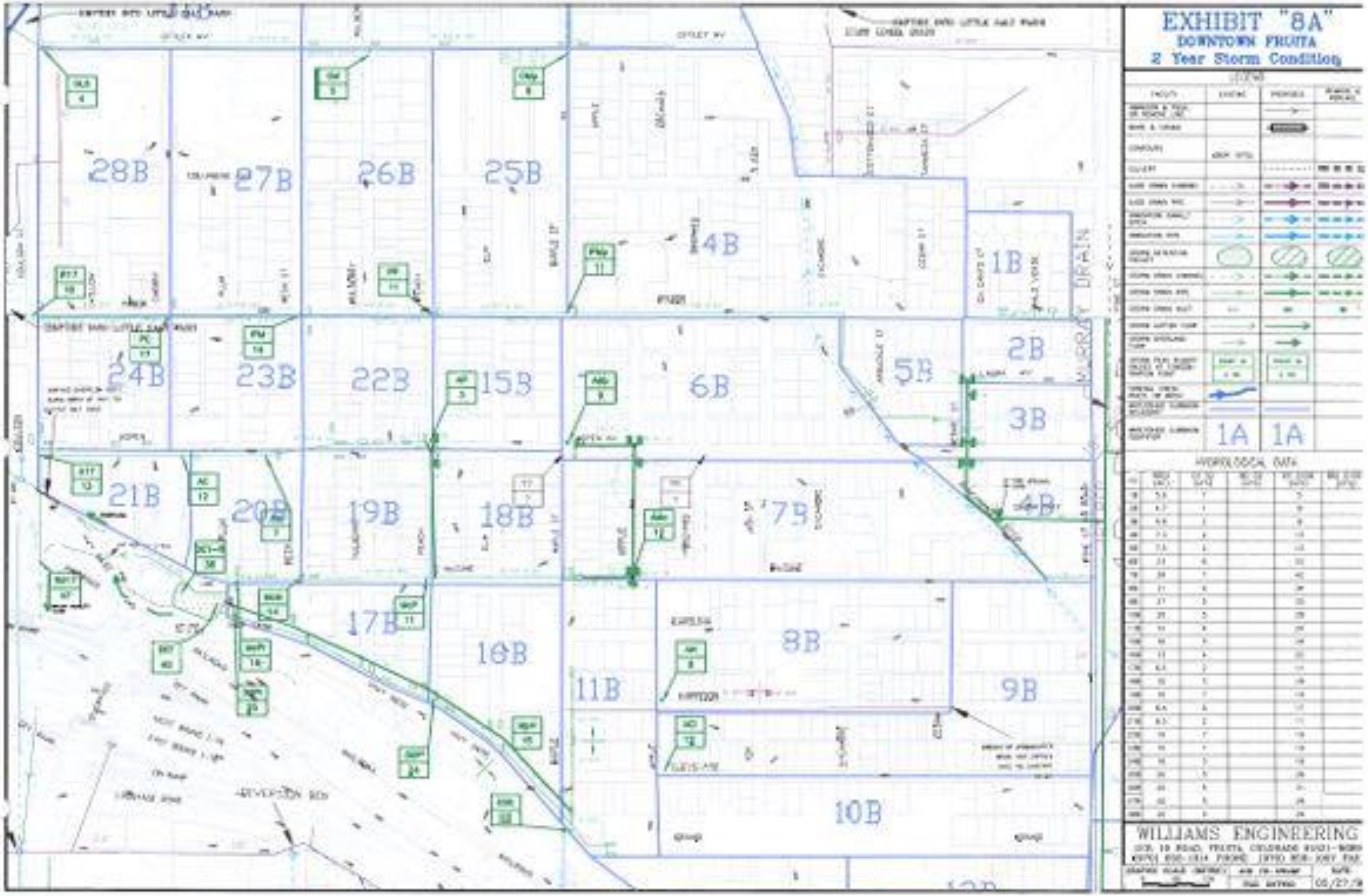


EXHIBIT "8A"
DOWNTOWN FRUITA
2 Year Storm Condition
HYDROLOGICAL DATA
WILLIAMS ENGINEERING
28B
27B
26B
25B
14B
1B
24B
23B
22B
15B
6B
5B
2B
3B
21B
20B
19B
18B
7B
4B
17B
16B
11B
8B
9B
10B
1A
1A

IX URBANIZED AREA SOUTH OF I-70

A. ADDITIONAL DATA OBTAINED

Several field trips were made to observe conditions, plus meetings were held with the Public Works Director and GJDD to learn more about facilities and their function. Base mapping for the area is provided on Exhibit "9A".

B. HYDROLOGY

Given the scope of work and the lack of existing facilities that would have capacity analyzed, a hydrological computer model was not made for this area. However, we did provide simplified hydrological calculations in order to determine what proposed facilities would be desirable.

We noted that there are north - south streets in the area that all drain south to the Colorado River. These are spaced at 1/4 mile intervals from 17 Road to 18 Road, except at the 17-3/4 Road alignment where the Murray Drain is located. These corridors of right-of-way allow for storm drain trunklines, each suited for draining the area immediately adjacent to and 1/4 mile uphill towards the east. Each proposed drain, then, would service a 1/4 mile wide strip. This allowed us to perform generic calculations using the Rational Method, for a 20, 40, 60, and 80 acre watershed area. Using a rational coefficient of 0.45 and estimating Tc values per SWMM (TR-55 procedures), we obtained rough runoff estimates for the 2 year event. The 100 year event was not important to us for this area, because there is no barrier to prevent floodwaters from flowing towards the Colorado River. The entire area has positive slope to the river, and excessive ponding and flooding should not occur. Where a pipeline would also double as an irrigation tailwater or groundwater drain, we added an additional 5 cubic feet per second (cfs) flow.

C. STORM DRAIN RECOMMENDATIONS AND COST

Storm drains sizes were determined using the flow rates discussed above at pipe slopes and hydraulic grade lines assumed to be equal to the ground surface slope. The resultant recommended storm drain systems, layout, and pipe sizes are shown on Exhibit "9A", along with priorities and costs.

D. WATERQUALITY

The north end of the 17 Road system would drain to an existing pond which would function as a water quality pond. The balance of the 17 Road to 18 Road area should eventually have a water quality basin, which could be separate basins or a single combined basin. Land currently is not available along the river for a water quality pond, it all being a part of the Arcubi farm. However, with the need for a water quality pond there known now, preparations f r acquisition can be acted upon when the opportunity arises.

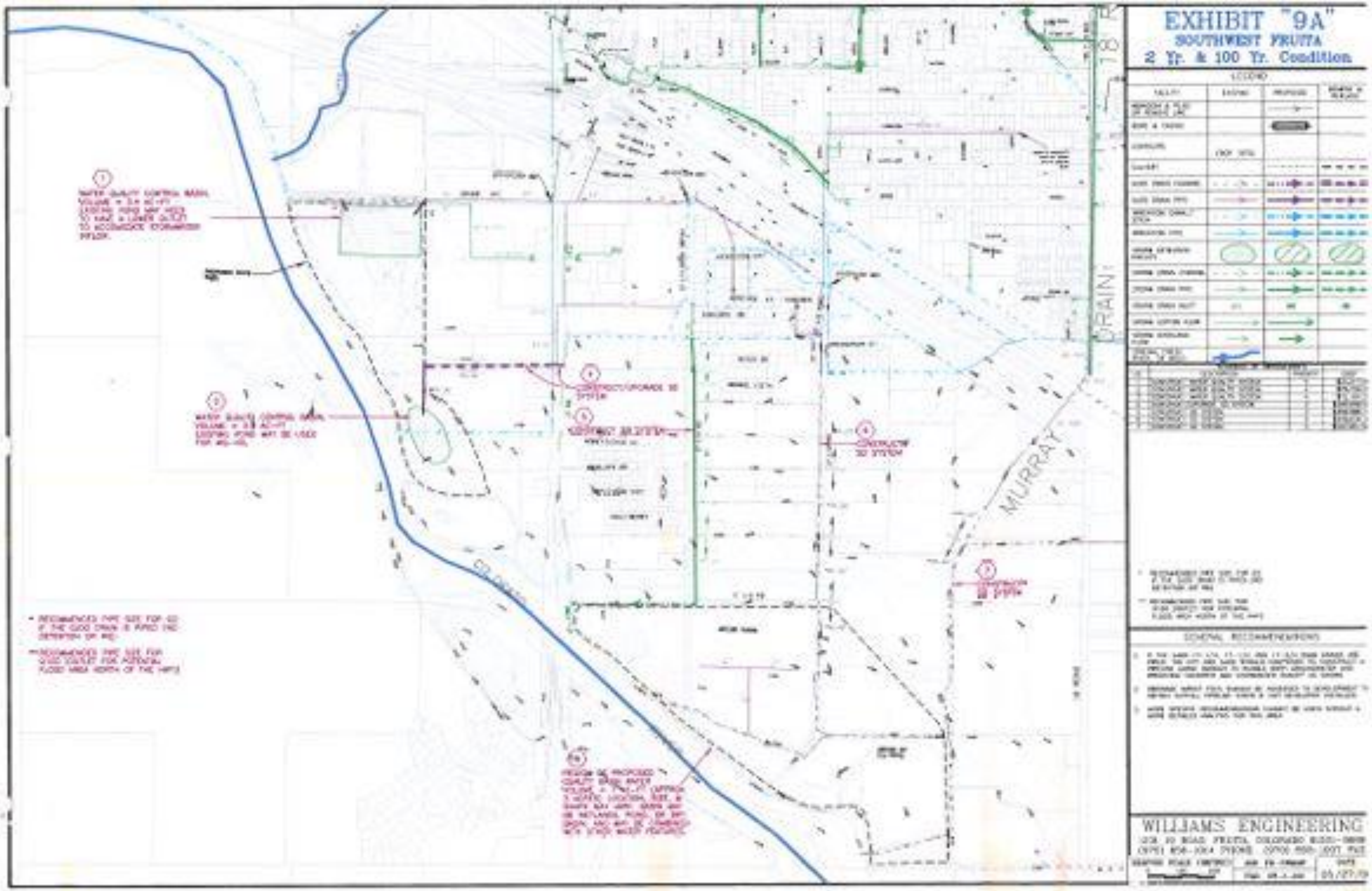


EXHIBIT "9A"
SOUTHWEST FRUITA
2 Yr. & 100 Yr. Condition
LEGEND
GENERAL RECOMMENDATIONS
WILLIAMS ENGINEERING
MURRAY
DRAIN
18

X 18 ROAD TO 20 ROAD

The scope of work for this area was to give a cursory look at problems and needs, and to make general recommendations regarding stormwater management planning. As we looked at the area, we found it easiest to approach investigations by focusing on:

- The GJDD Murray Drain System, which includes the Palmer, Kettles, and Compton's Drains;
- The Adobe Creek watershed area;
- The northeast area in general, but more particularly the Starr School Drain and problems at Holly Park; and
- The southeast area.

A. HYDROLOGY

Hydrological modelling and procedures were followed as outlined in Section IV for the GJDD Murray Drain System and Adobe Creek (see Exhibit "IOA" and "I0B" respectively). Hydrological calculations were not performed for other areas. For those areas modelled, base flows from groundwater seepage and irrigation tailwater were ignored as insignificant. Only existing conditions were analyzed, because we knew in advance that outfall facilities under the highway, railroad, and 1-70 were insufficient even for the existing condition (except for Adobe Creek), and therefore all new development must not result in a increase in runoff.

B. HYDRAULICS

The GJDD drains were not analyzed for capacity, but the 100 year runoff values obviously exceed culvert and outfall capacities. Adobe Wash was not analyzed for conveyance capacity nor floodplain limits, but its conveyance and outfall discharge capacity under the highway and I-70 is far greater than for the Murray Drain.

C. RECOMMENDATIONS AND COST

1. **GJDD Murray Drain System** Recommendations are only general in nature, and are presented below.

   The GJDD drain culverts and outfall across the highways and railroad are not adequate to convey runoff from design storm events. Development in the Murray Drain System area cannot increase runoff due to development.

   Drainage impact fees should be used to fund construction of a regional park/detention facility on the Murray Drain System just north of the highway. A facility in conjunction with the high school or separately would be acceptable.

Adobe Creek is a long narrow watershed, and the localized runoff could be passed through in advance of the full basin contributing. Therefore it would be advisable to direct as much flow from the Murray Drain as possible to Adobe Creek.

More specific recommendations cannot be given without a more detailed analysis for this area.

Cost of facilities for improvements in this area are not provided.

2. **<u>Adobe Creek</u>** Recommendations are only general in nature, and are presented below.

Before development encroaches upon Adobe Wash, policy should be adopted that would protect its flood flow capacity. If tracts or easements were obtained for maintenance and ingress/egress, which works best with a path/trail system, then the creek can be properly maintained as a adequate major stormwater conveyance system.

A floodplain analysis should be performed to delineate floodplains and floodways at least up to 20 Road for proper floodplain administration. This would also allow analyses of where and how much diversion from the Murray Drain System could be allowed.

More specific recommendations cannot be given without a more detailed analysis for this area.

Costs of facilities for improvements in this area are not provided.

3. **<u>Northeast Area</u>** The Starr School Drain services a large watershed area. The drain has been piped under Holly Park with a 24" pipe, which is inadequate even.for Holly Park alone, and very inadequate for stormwater that would enter the Starr School Drain. Adding to the problem is a restriction or blockage in the line as it crosses under K Road that should be corrected. We recommend that the Starr School Drain either be separated at the northeast corner of Holly Park or that a park/detention facility be used to reduce peak flows from the upper watershed area and slowly released into the existing 24" pipe. Both alternatives have similar cost, but the detention alternative would also provide a community amenity. Reference is made to Exhibit "10C".

Other recommendations are only general in nature, and are presented below.

Regional park/detention facilities are not only municipal amenities, but provide cost-effective stormwater control ahead of development. Parcels should be purchased along GJDD drainage ways at flatter locations.

The City should have an agreement from GJDD to have opportunity to review and participate in all drain piping and culvert replacement projects so that appropriate upgrades can be made.

More specific recommendations cannot be given without a more detailed analysis for this area.

Costs are only provided for the specific recommendations made, and are shown on Exhibit "l 0C" along with prioritization.

4. **Southeast Area** Where possible, flows in the Murray Drain system that has only a 42" culvert outfall should be redirected to the Adobe Creek that has highway and railroad bridges over the creek, and outflow capacity is much greater. Furthermore, local flows would pass through to the Colorado River before the greater upland peak arrives in Adobe Creek, and consequently such diversions would not result in greater peak flows in the creek. Reference is made to Exhibit "1OD".

Even with diversions, the Murray Drain watershed area is large compared to the 42" outfall culvert capacity. Either a larger outfall is required at nearly $1000 bore and pipe cost per lineal foot under the highway, railroad, and interstate, or detention is tiered just upstream of the highway. Both solutions are costly, but the detention solution is likely less costly and provides a community amenity as well. Furthermore, detention upstream of the highway allows use of smaller conveyance facilities from the highway to the Colorado River. Consequently, detention is the alternative that we recommend. The high school expansion may allow an opportunity for detaining flows from the Palmer Drain tributary, but additional detention on the main Murray Drain would also be required.

Other recommendations are only general in nature, and are presented below.

Regional parks/detention facilities are not only municipal amenities, but provide cost-effective stormwater control ahead of development. Parcels should be purchased along GJDD drainage ways at flatter locations.

The City should have an agreement from GJDD to have opportunity to review and participate in all drain piping and culvert replacement projects so that appropriate upgrades can be made.

More specific recommendations cannot be given without a more detailed analysis for this area.

Only the cost of specific recommendations has been estimated, which is provided on Exhibit "1OD" along with prioritization.

D. WATERQUALITY

Drainage that empties into Adobe Creek should be regulated the same as for local drainage to Little Salt Wash: provide water quality for the 2 year storm event; and directly discharge runoff from greater storms undetained. Drainage that empties into the Murray Drain system should eventually have water quality addressed prior to discharging to the Colorado River. This was discussed in Section IX for the area south of 1-70.

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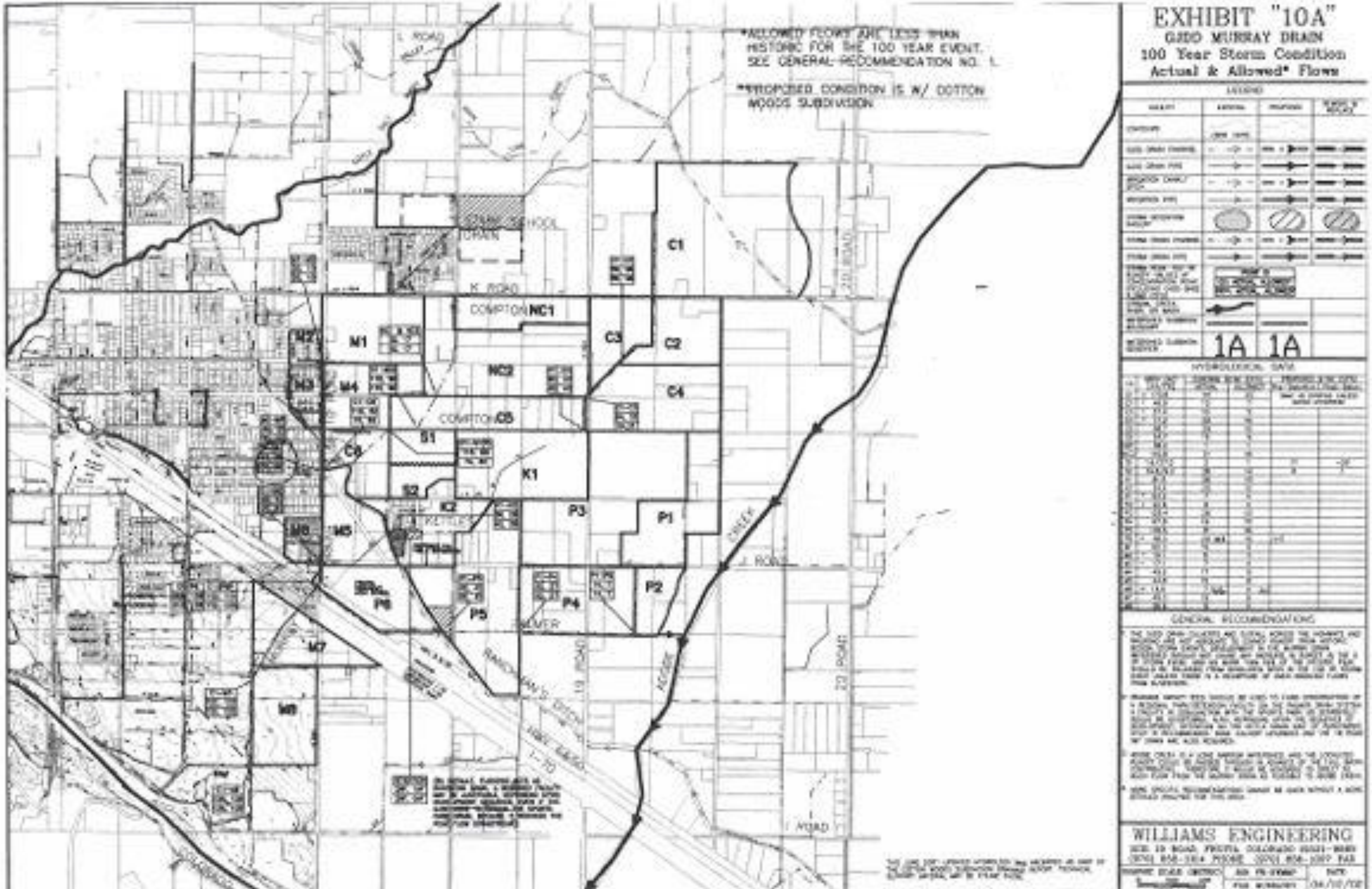
EXHIBIT "10A"
GJDD MURRAY DRAIN
100 Year Storm Condition
Actual & Allowed* Flows
*ALLOWED FLOWS ARE LESS THAN HISTORIC FOR THE 100 YEAR EVENT. SEE GENERAL RECOMMENDATION NO. 1.
**PROPOSED CONDITION IS W/ COTTON WOODS SUBDIVISION.
LEGEND
HYDROLOGICAL DATA
GENERAL RECOMMENDATIONS
WILLIAMS ENGINEERING
L ROAD
K ROAD
J ROAD
I ROAD
19 ROAD
20 ROAD
COMPTON
SCHOOL
DRAIN
CREEK
I-70
C1
C2
C3
C4
C5
C6
NC1
NC2
M1
M2
M3
M4
M5
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M8
S1
S2
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P1
P2
P3
P4
P5
P6
1A

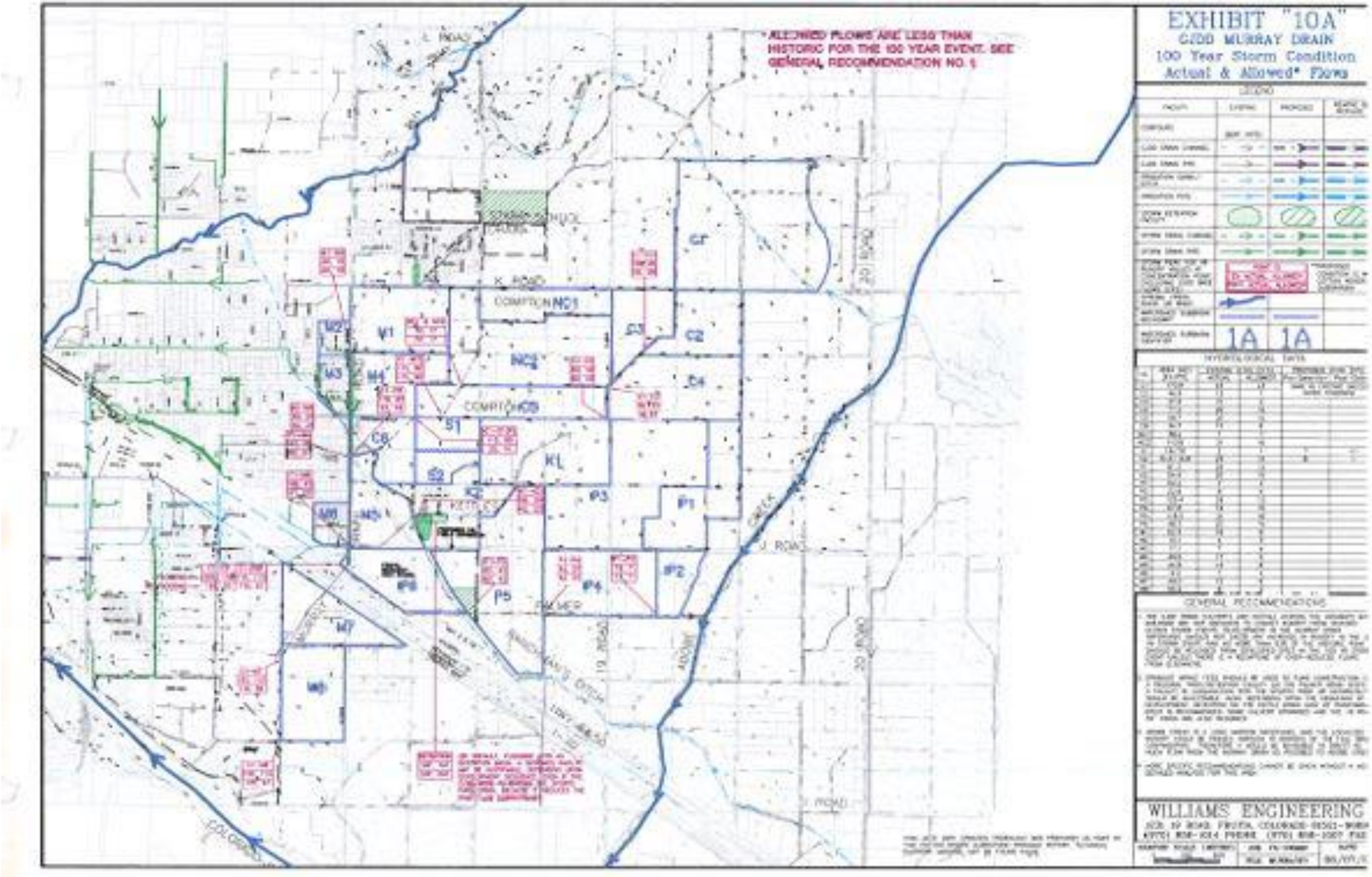

EXHIBIT "10A"
GJDD MURRAY DRAIN
100 Year Storm Condition
Actual & Allowed* Flows
*ALLOWED FLOWS ARE LESS THAN HISTORIC FOR THE 100 YEAR EVENT. SEE GENERAL RECOMMENDATION NO. 1
LEGEND
HYDROLOGICAL DATA
GENERAL RECOMMENDATIONS
WILLIAMS ENGINEERING
K ROAD
J ROAD
COMPTON
C1
C2
C3
C4
NC1
NC2
V1
M2
M3
M4
M6
M7
S1
S2
K1
K2
P1
P2
P3
P4
P5
PALMER
1A

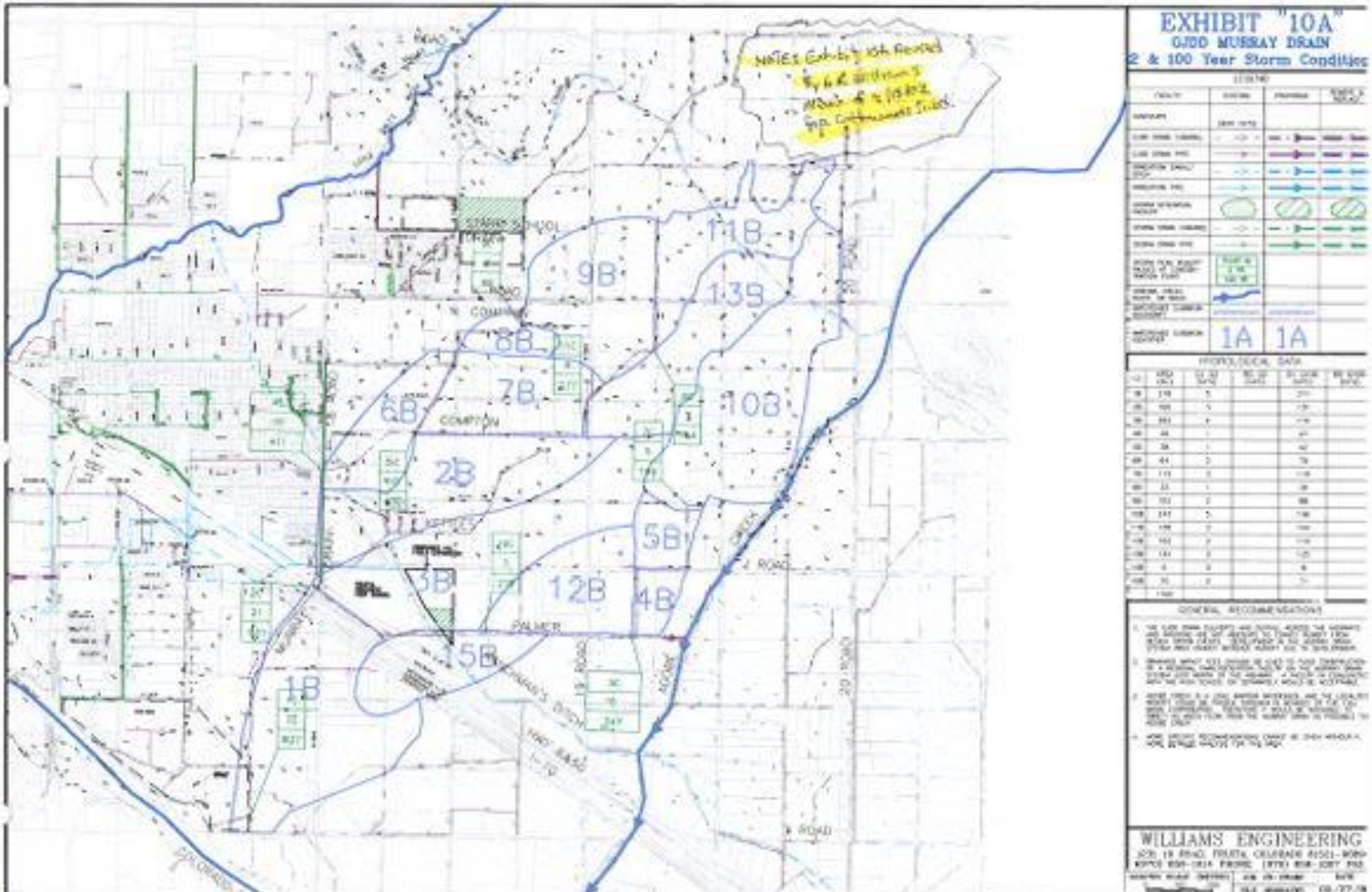

EXHIBIT "10A"
GJDD MURRAY DRAIN
2 & 100 Year Storm Conditio
LEGEND
HYDROLOGICAL DATA
GENERAL RECOMMENDATIONS
WILLIAMS ENGINEERING
11B
9B
13B
8B
7B
6B
10B
2B
5B
3B
12B
4B
15B
1B
COMPTON
PALMER
J ROAD
20 ROAD
1A

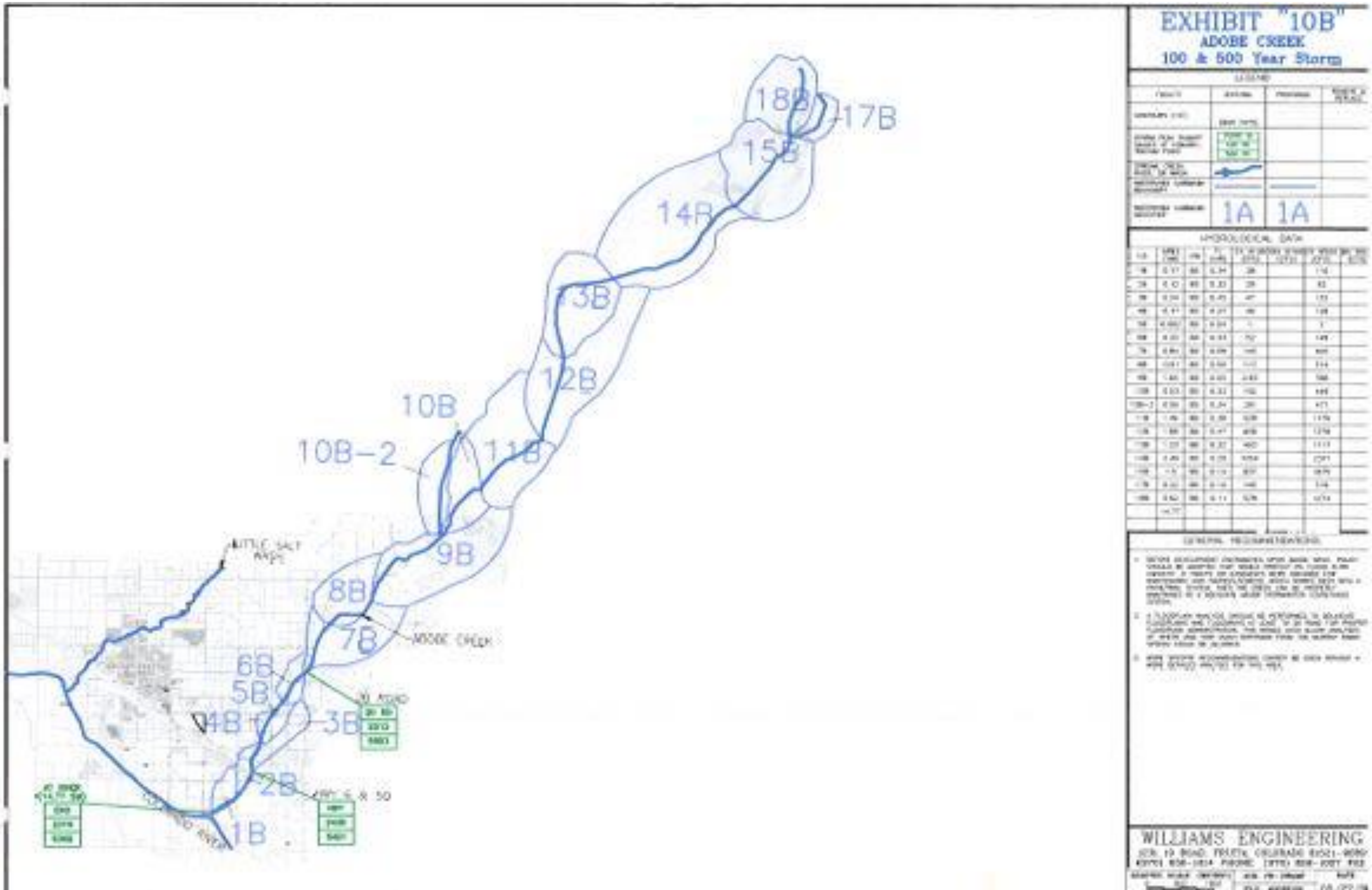
EXHIBIT "10B"
ADOBE CREEK
100 & 500 Year Storm
1A
1A
HYDROLOGICAL DATA
WILLIAMS ENGINEERING
18B
17B
15B
14B
13B
12B
10B
10B-2
11B
9B
8B
7B
ADOBE CREEK
6B
5B
4B
3B
2B
1B
LITTLE SALT WASH

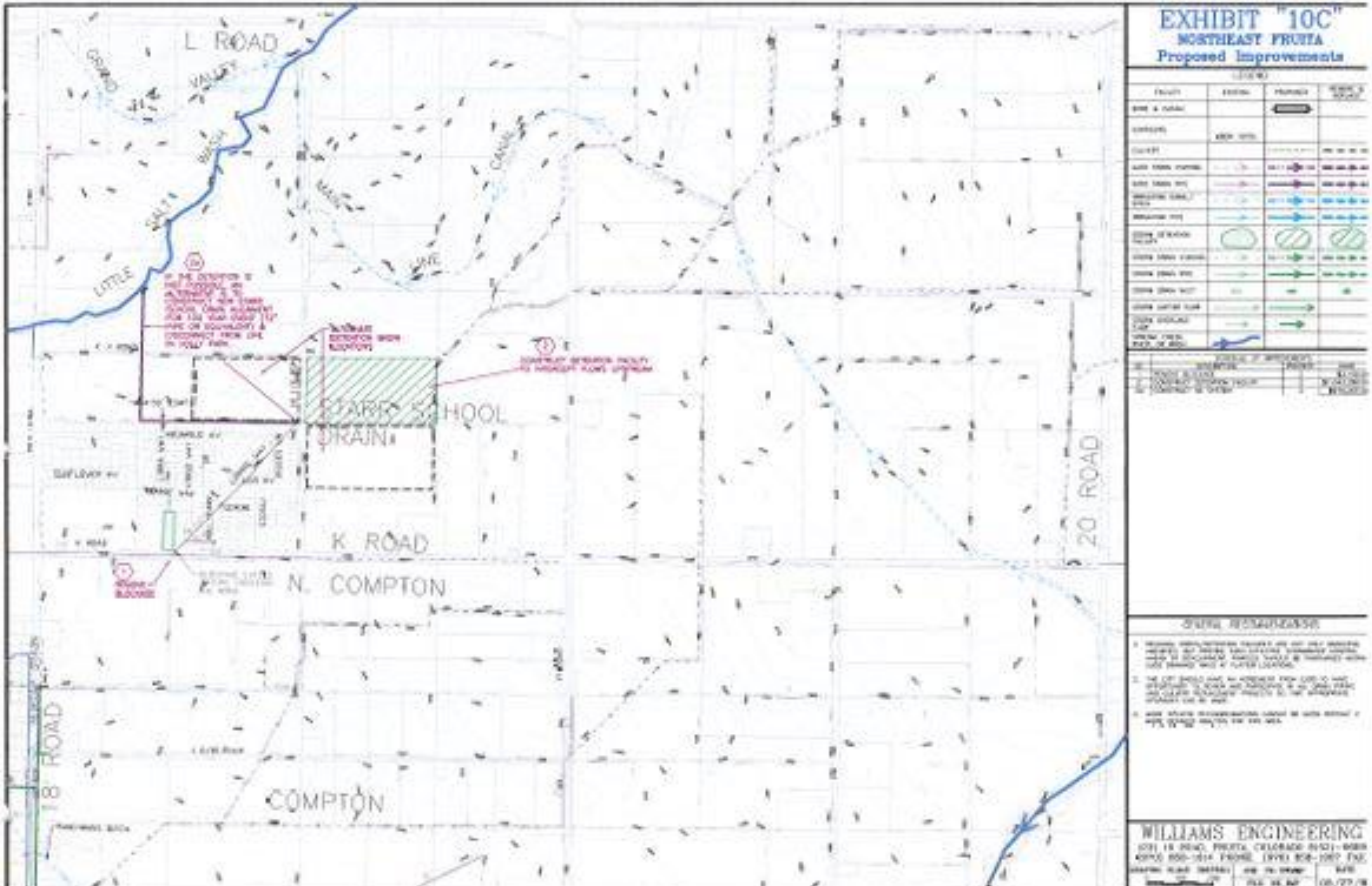

EXHIBIT "10C"
NORTHEAST FRUITA
Proposed Improvements
L ROAD
K ROAD
20 ROAD
18 ROAD
STARR SCHOOL DRAIN
N. COMPTON
COMPTON
LITTLE SALT WASH
GRAND VALLEY
CANAL
WILLIAMS ENGINEERING

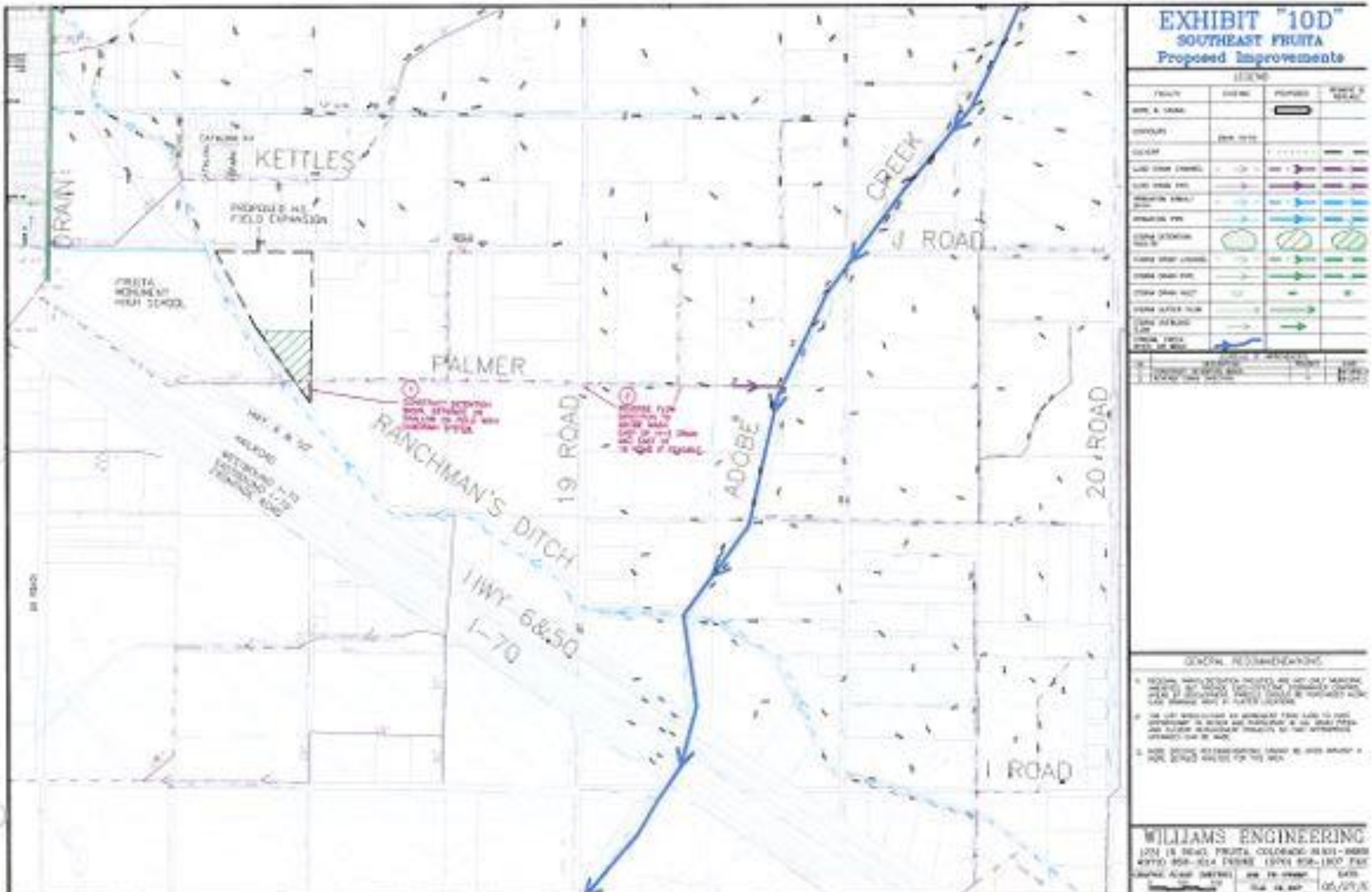
EXHIBIT "10D"
SOUTHEAST FRUITA
Proposed Improvements
KETTLES
DRAIN
PROPOSED H.S. FIELD EXPANSION
FRUITA MONUMENT HIGH SCHOOL
PALMER
J ROAD
CREEK
ADOBE
19 ROAD
20 ROAD
RANCHMAN'S DITCH
HWY 6&50
I-70
I ROAD
GENERAL RECOMMENDATIONS
WILLIAMS ENGINEERING

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