CITY OF MONTROSE
STORM DRAIN MASTER PLAN

December 2009

MONTROSE

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i. EXECUTIVE SUMMARY

The City of Montrose Comprehensive Plan stated "handling of storm water drainage will be one of the greater challenges to Montrose" and noted the need for a Storm Drain Master Plan. A Storm Drain Master Plan provides guidance for infrastructure sizing, conveyance corridors and outfall locations on a large scale. A Master Plan is important for continuity between development projects and to ensure piecemeal construction will provide for comprehensive needs. The Plan also develops design criteria and methodology that can be adopted as policy so future designs will be consistent.

The purpose of a storm drain system is to provide conveyance of rainfall and snowmelt from developed urban areas to outfall points. Residents, property owners and businesses receive the benefit of this system by the reduction of flooding which reduces property damage and increases public safety. Drainage system improvements proposed in the Master Plan are planned to provide a certain level of service to the community.

Preparation of a Master Plan also allows the City to prepare long term financial and infrastructure forecasts for planning purposes, although it should be recognized that the Master Plan is a guidance document only and updates and revisions may be appropriate.

The main features of the plan are as follows:

Background Data: Background data collected for the Master Plan included soils mapping, existing landuse, future landuse, topography, existing drainage infrastructure, existing problem areas, natural drainage features and major irrigation structures.

Criteria and Modeling: Study criteria including the design storms, precipitation, rainfall distribution, hydrologic model and model parameters were developed and are outlined in the plan. The EPA SWMM model was selected for the Plan.

Major Drainage Basins: Six major drainage basins were delineated based on natural drainage features in the study area: Happy Canyon, Dry Cedar Creek, Cedar Creek, Montrose Arroyo, Uncompahgre River and Selig Canal. Each major basin was then broken into sub-basins, based on conveyance corridors and outfall locations, to allow for detailed hydrologic and hydraulic modeling of existing and proposed conditions.

Recommended Improvements: Recommendations for infrastructure improvements to supplement, extend and replace existing infrastructure were developed to provide drainage service to existing and future within the City growth boundary. These included recommendations for conveyance corridors, conveyance sizing, detention and outfalls.

Costs and Prioritization: A prioritization of improvements is provided based on existing problems and deficiencies, along with Master Planning costs for construction (in 2009 dollars). A discussion regarding potential funding of improvements is also provided.

CITY OF MONTROSE
STORM DRAIN MASTER PLAN

A. INTRODUCTION AND STUDY AREA

1. INTRODUCTION

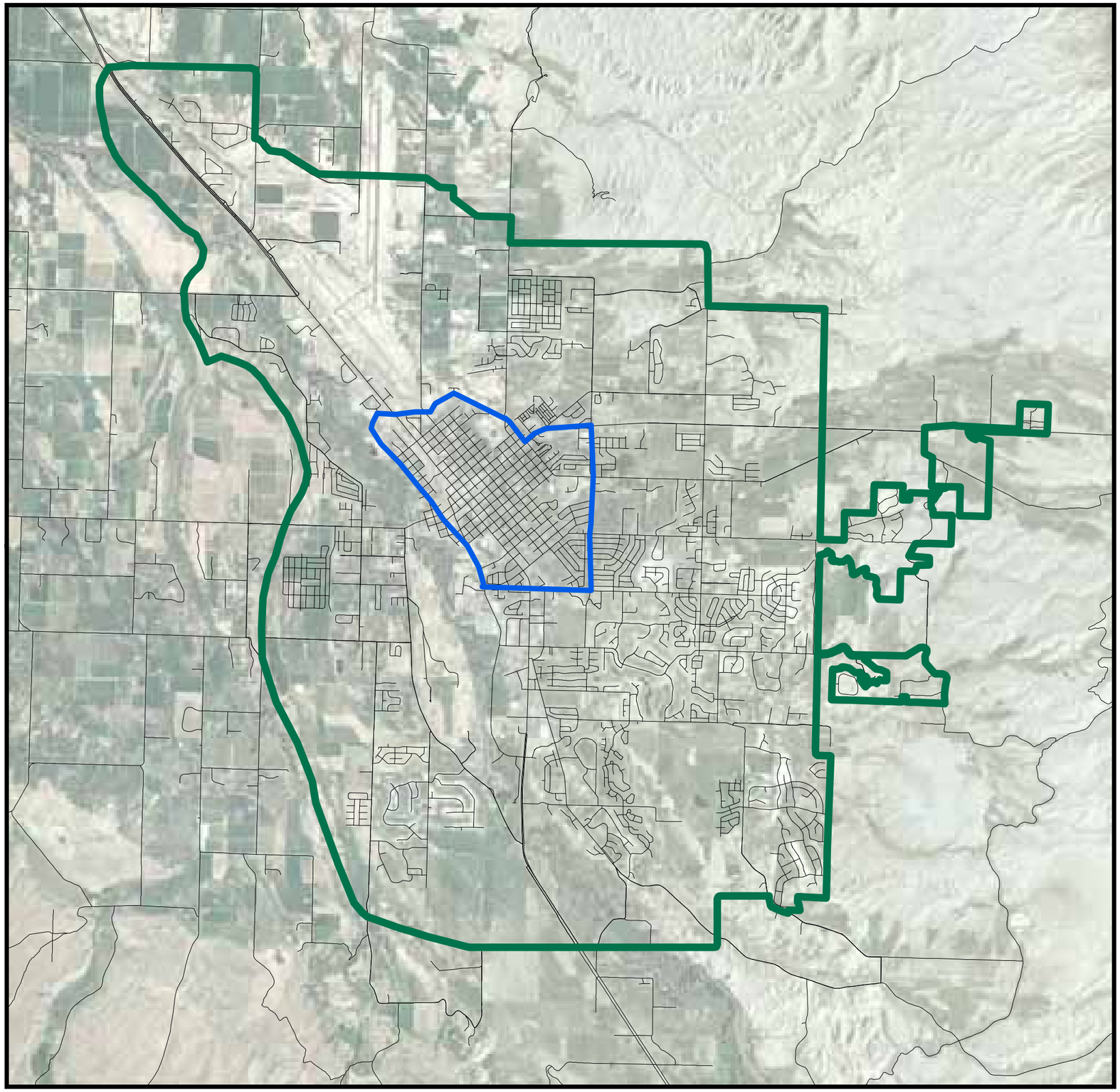
The City of Montrose Comprehensive Plan states that the City of Montrose has grown at a high rate of approximately 4-percent per year. As development expands into historically rural areas and natural stream corridors, and as in-fill occurs in the urbanized areas, management of storm water becomes an important issue. Existing infrastructure is sometimes discontinuous and sporadic and often inadequate for the growth that is occurring. Areas outside the urbanized development often have no access to storm drainage infrastructure. Conflict between urban runoff and agricultural ditches and canals occurs when storm water impairs the capacity and quality of irrigation facilities. This impact may become a bigger problem as development occurs. Similar storm water impacts from development can also occur on natural streams and creeks.

The Comprehensive Plan also notes that the "handling of storm water drainage will be one of the greater challenges to Montrose" and notes the need for a Storm Drain Master Plan. The Storm Drain Master Plan will provide a tool to allow the City to understand the storm drainage network and characteristics, identify needs, and plan capital improvements. The Plan will allow the City to identify and prioritize required improvements and to outline requirements for future development.

The City of Montrose is included in the Phase II regulations of the Colorado Stormwater Program propagated from the NPDES (National Pollutant Discharge Elimination System) part of the Clean Water Act. Municipalities included in the Phase II regulations are tasked with minimum controls to reduce impacts of urban storm water on receiving streams. While these minimum controls target water quality of storm water runoff, storm water management may be achieved through master planned improvements which may also afford opportunities to improve water quality.

2. STUDY AREA

The study area was defined as the Urban Growth Boundary as delineated by the City of Montrose and as shown on Figure 1. This includes the incorporated areas of the City of Montrose and a surrounding "area of influence" in the unincorporated County, as discussed in the Comprehensive Plan. The area of influence is land contiguous to the City limits that may potentially be annexed into the City as urban development occurs.



CITY OF MONTROSE STORM DRAIN MASTER PLAN

2008-317

LEGEND

- Detailed Plan Study Area
- Growth Boundary & Study Area
- Streets

N

0 5,000 10,000

Feet

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FIGURE 1

The study area includes a wide range of land use from natural areas and agricultural fields to residential and commercial land use. The major natural drainage features in the study area are the Uncompahgre River and associated tributaries. There is a significant irrigation distribution system throughout the study area that is owned by the Bureau of Reclamation (BOR) and operated by the Uncompahgre Valley Water Users Association (UVWUA). This system includes major irrigation canals, laterals, drain ditches and associated private feed ditches and waste ditches. In the urbanized area of the City, the ownership of several of the drain ditches has been transferred from the BOR to the City with the intent that these ditches can be used for storm drainage conveyance although there is often a continued base flow from irrigation waste and/or groundwater.

There are three state highways within the study area, Highway 90, Highway 50 and Highway 550, with associated drainage systems, managed by the Colorado Department of Transportation (CDOT). Public roadways and associated drainage structures outside the City limits are owned and operated by Montrose County.

A “detailed” study area was also defined, as shown on Figure 1, and is generally the more densely developed urban area of the City consisting of the downtown central business area, the highway corridors, and associated higher density residential. The detailed study for this area includes mapping of all existing drainage structures and hydraulic modeling of the piped drainage system to determine deficiencies, with specific recommendations for improvements that go beyond a master plan approach. The limits of the detailed study area are Niagara Road on the south, the San Juan bypass on the north, Rio Grande Avenue on the west and Hillcrest Drive on the east.

3. MAJOR DRAINAGE BASINS

Six major drainage basins as shown on Figure 2 were delineated for the City of Montrose Storm Drain Master Plan:

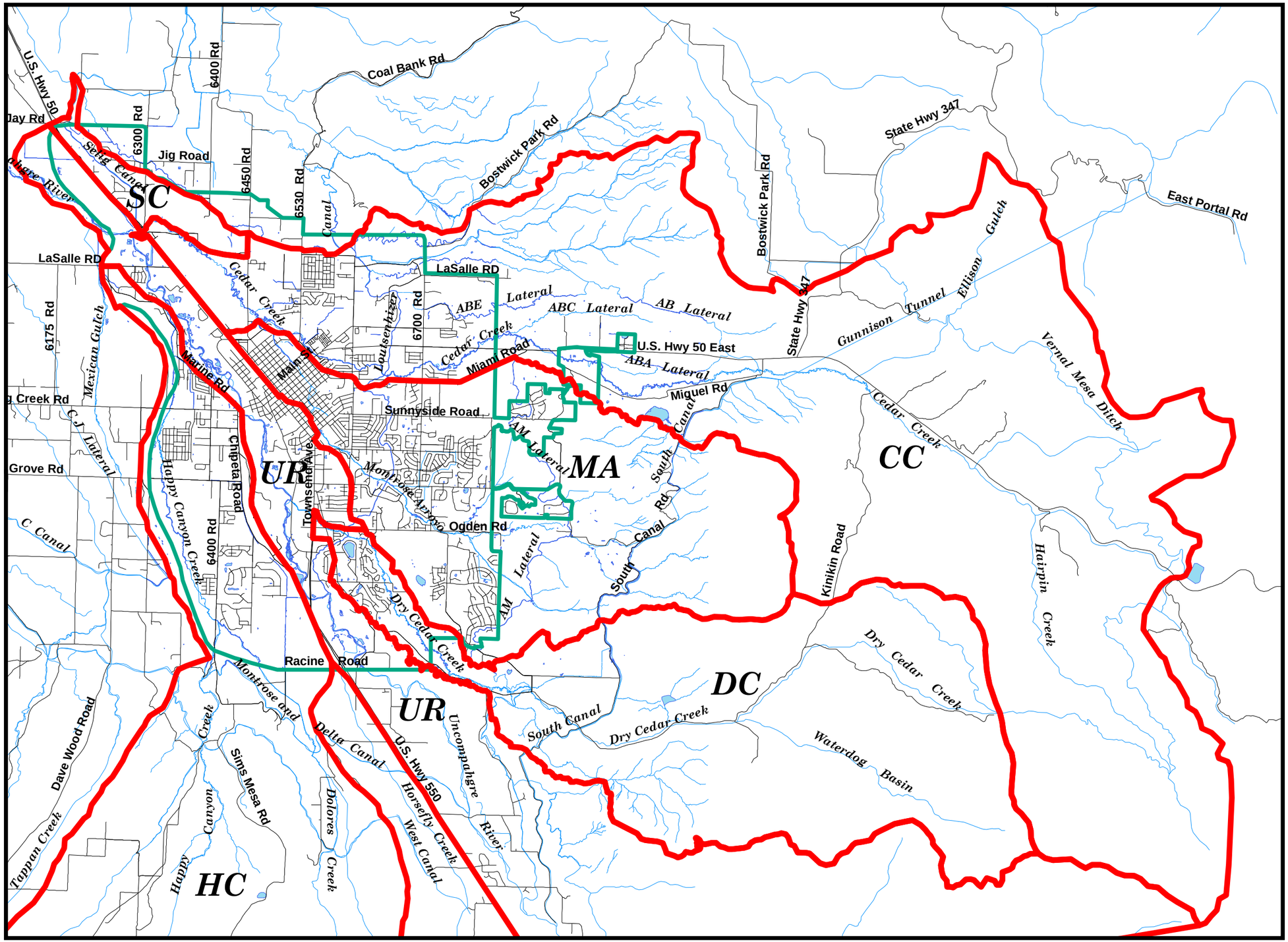
- Happy Canyon Creek
- Dry Cedar Creek
- Montrose Arroyo
- Cedar Creek
- Uncompahgre River
- Selig Canal

The watersheds for these drainages extend outside of the study area and base mapping prepared from City aerial mapping was supplemented with USGS quadrangle mapping to include the outer reaches of these watersheds.

A short description of each major basin is provided below.

CITY OF MONTROSE STORM DRAIN MASTER PLAN

2008-317



MAJOR BASIN ABBREVIATIONS

CC = Cedar Creek Basin
DC = Dry Cedar Creek Basin
HC = Happy Canyon Creek Basin
MA = Montrose Arroyo Basin
SC = Selig Canal Basin
UR = Uncompahgre River Basin

BASIN LEGEND

GROWTH BOUNDARY & STUDY AREA
MAJOR BASINS

N

0 5,000 10,000
Feet

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FIGURE 2

a. Cedar Creek

Cedar Creek enters the study area from the east and flows west to the Uncompahgre River north of La Salle Road. Cedar Creek drainage basin extends beyond the study area to the east and southeast. The total drainage area consists of 58 square miles, with 7.3 square miles within the study area.

The portion of the drainage basin in the study area ranges in elevation from 5650 to 7650 feet with a length of 12.4 miles and an average slope of 3 percent. The Cedar Creek active channel is sparsely to moderately vegetated with steep eroded side banks and evidence of piping. During storm events and spring runoff, the creek can carry a high sediment load due to the erodible nature of the banks and surrounding land.

Historic land use in the lower part of this basin is agricultural, irrigated fields and rangeland with single family and multifamily residential areas. The drainage basin also contains the Montrose Regional Airport. The upper reaches of the basin, east of the south canal and the AB lateral, are undeveloped and unsuitable for agriculture or urban development due to restrictive soils and the shallow depth to bedrock.

The existing developed land-use in the study area portion of this drainage basin is primarily medium to low density residential with commercial development along North Townsend Avenue and Main Street. The existing land use also includes irrigated fields, native fields, rangeland and barren hills. The Montrose Comprehensive Plan shows this area to be planned for mixed residential use of low to medium density with commercial use along Main Street and North Townsend Avenue.

b. Dry Cedar Creek

Dry Cedar Creek enters the study area from the southeast and flows northwest to the Uncompahgre River toward the south end of Rio Grande. Dry Cedar Creek drainage basin extends to the southeast beyond the study area by approximately 9 miles to Waterdog Peak, with a total drainage area of 24 square miles. Approximately 2.2 square miles is considered potential for urbanization with 1.6 square miles within the study area. The southern boundary of the potential urbanization is Kinikin Road and Sunshine Road.

The portion of the drainage basin in the study area ranges in elevation from 5840 to 6000 feet with a length of 3 miles and average slope of 1 percent. The Dry Cedar Creek active channel has areas of heavy grass vegetation and areas with sparse vegetation where there are steep eroded side banks and evidence of piping. During storm events, the creek has been observed to carry a high sediment load due to the erodible nature of the banks and surrounding land.

Historic land use in the lower part of this basin is agricultural with irrigated fields and rangeland. The upper reaches of the basin, above the South Canal, are undeveloped and unsuitable for agriculture or urban development due to restrictive soils. Existing developed land-use in the study area portion of this drainage basin is primarily medium to low density residential with some commercial development along Woodgate Road and the Highway 550 corridor. The Montrose Comprehensive Plan shows this area to be planned for mixed residential use of low to medium density.

c. Happy Canyon Creek

This basin enters the study area from the southwest and flows north to terminate at the Uncompahgre River toward the north end of Marine Road. Happy Canyon Creek drainage basin extends to the south beyond the study area with a total drainage area of approximately 69 square miles. Approximately 7 square miles is within the study area.

The lower area of the drainage basin, within the study area, ranges in elevation from 5700 at the Uncompahgre River to 5960 feet at Racine Road with a total length of close to 6 miles and average slope of just under 1 percent. The Happy Canyon Creek active channel is vegetated with grass and low shrubs with some areas having steep eroded side banks.

Historic land use in the lower part of this basin, within the study area, is agricultural with irrigated fields, pastures and orchards with associated rural residential development. The upper reaches of the basin are on the northeast flank of Horsefly Peak and include a substantial portion of public land. Existing developed land-use in the study area portion of this drainage basin is primarily medium to low density residential with some commercial development along the Highway 90 corridor. Recent development has been medium density residential with some recent commercial along the highway. A large portion of this area is outside current City limits; however with the West Montrose Sanitation District serving most of this area, County development will potentially be medium density residential as growth occurs. The Montrose Comprehensive Plan shows this area to be planned for mixed residential use of medium density with smaller areas of low density toward the south end of the study area.

d. Montrose Arroyo

The Montrose Arroyo enters the study area from the east-southeast and flows northwest to Cedar Creek; the confluence with Cedar Creek is just north of San Juan Avenue. The drainage basin extends southeast of Montrose, comprising of a drainage area of 20.5 square miles with 8.7 square miles within the study area. This basin includes the greater part of the developed area of the City of Montrose. The natural basin is truncated by two large irrigation canals in the upper reaches, the South Canal and the AM Lateral. The Loutsenhizer Canal runs south to north through the lower reaches of the basin and also intercepts storm flows impacting natural runoff patterns.

The drainage basin ranges in elevation from 5750 to 7574 feet at the top of Lujane Peak with a total length of 9.3 miles and average slope of 3.7 percent. Within the City of Montrose, the Montrose Arroyo active channel is vegetated with grasses and shrubs and has segments that have been channelized or piped due to development. North and south of town, the Montrose Arroyo is sparsely vegetated with steep eroded side banks and evidence of piping.

Historic land use in this basin is agricultural (irrigated fields and rangeland), with single family residential, multifamily residential and commercial areas in downtown Montrose. Existing developed land-use in the study area portion of this drainage basin ranges from medium and low density residential to offices, commercial and industrial businesses and schools. The commercial and industrial corridors are mainly in the downtown business district and along Highway 50. The Montrose Comprehensive Plan shows this area as mixed residential with low to medium density, downtown mixed density, highway commercial and central business districts and some commercial/industrial areas to the southwest.

e. Selig Canal

The Selig Canal flows north from the Uncompahgre River at La Salle Road out of the study area continuing northwest. This 1.5 square mile basin is on the north fringe of the study area and is not a true basin but delineates an area of the study with no defined outfall.

The basin is sparsely to moderately vegetated with native grasses and shrubs with an average slope of 0.85 percent. The roadside ditches along Highway 50 and the Frontage Road to Highway 50 convey the majority of runoff within the basin.

Historic land use in this basin is agricultural with irrigated fields and rangeland. There are also steep, eroded hills in the northeast area. Existing land-use is primarily commercial along Highway 50 with some irrigated fields and rangeland and a small amount of low density residential housing. The Montrose Comprehensive Plan shows this area to be planned for low density residential housing with a commercial center around Highway 50.

f. Uncompahgre River

The Uncompahgre River enters the study area from the south and flows northerly along the west fringe of the urbanized area of the City. The Uncompahgre River drainage basin extends to the southeast well beyond the study area with its headwaters in the San Juan Mountains above Ouray, Colorado. The basin within the study area consists of 6.9 square miles with an average slope of 0.74 percent.

The Uncompahgre River active channel is moderately to densely vegetated with shallow side banks and fairly well defined overbank areas. The vegetation consists of trees, shrubs and grasses. River flows are manipulated by Ridgway Reservoir to the south, which is an irrigation storage facility. During spring runoff the river may contain high sediment loads from side tributaries below the reservoir.

Historic land use in this basin includes the original township for the City and surrounding agricultural fields and rangeland. Residential and commercial growth has expanded in this basin over recent years, primarily on the east side of the river, with existing land use now including a mixture of commercial, industrial, and high to medium density residential. The Montrose Comprehensive Plan shows land use to remain in much the same configuration although some in-fill is anticipated with a potential for slightly higher density of development and a potential for new development on the west side of the river.

B. STUDY CRITERIA

1. MAPPING

a. Base mapping:

Base mapping for each major basin and associated sub-basins was prepared showing basin delineation, natural drainage features, significant irrigation structures, zoning, soils and topography. This base mapping was completed from existing databases and was submitted to the City under separate cover in January 2009 and is available in GIS format.

b. Existing storm drainage problem areas:

Known problem areas were added to the maps based on discussions with the City of Montrose, Montrose County, CDOT and UVWUA. These are areas that require ongoing maintenance and response during storm events due to surface flooding impacting property and roadways.

c. Mapping of Detailed Study Area:

Further mapping of the detailed study area was performed using aerial photographs as a background with existing storm system infrastructure superimposed. The storm system data was field verified and revised based on field observation and research of available record plans. There were areas of the detailed mapping where there were no record drawings and the system is obscured in the field so the maps are approximate only, based on best available data. Maps at a scale of 1”=200’ were prepared on 11”x17” sheets for easy use in the field and were submitted to the City of Montrose for review and comment based on their personnel input.

2. STORM WATER MODELING CRITERIA

A recommendation for the storm water model used in the study, and the associated modeling criteria was presented to City of Montrose in October 2008. A summary of the recommendations is as follows:

a. Background Information:

Mean precipitation for Montrose County is 9.07 inches annually (NOAA Climatology report 1951-1980). The highest rainfall period is generally July through September when the area experiences short duration intense rainstorms, locally called “monsoon season”. Based on local observations, the summer monsoon rainfall caused by convection storms produce the most frequent flooding events and can often be attributed to storms of less than 3-hours duration. The three most important factors to be determined in the development of a peak runoff estimate are infiltration losses, time component and total rainfall. Storm modeling criteria were developed from review of the 5-2-1 Stormwater Management Manual for Mesa County area and the Urban Drainage and Flood Control District (UDFCD) Drainage Criteria Manual for the Denver area along with past and regional experience and training.

b. Model and method selection to be used for Master Plan:

The EPA SWMM Model was selected for the Master Plan. This model has been accepted practice with Municipalities over the past 10 years and remains in use today. It is a public domain model. Both the 5-2-1 Manual and the UDFCD Manual include this model in their runoff analysis tools. This model allows for different methods to be used for rainfall, runoff and routing parameters. It has been used recently for large road projects for the City of Montrose and the integration of that data will be easier by continuing to use SWMM. This model is appropriate for larger projects but will not be applicable for small urban site development and the City will need to consider alternatives for their Drainage Manual for developers as they proceed with that document.

c. Design Storms:

Using the criteria established in the UDFCD Manual, design storms selected were the 2, 10 and 100-year storm events. As the total study area is approximately 40 square miles and the major drainage basins are anticipated to be less than 10 square miles, the UDFCD manual

recommends using minimum storm duration of 2-hours with no areal adjustment. The 3-hour storm was selected for the study, consistent with the 5-2-1 Manual, with no areal adjustment.

d. Rainfall Data:

Rainfall data was taken from the NOAA Atlas 2 Maps, similar to the 5-2-1 and UDFCD manuals. Rainfall tables 1, 2 and 3 were presented to the City for use in the study. The NOAA maps show 90-percent of rainfall in the first hour of the storm. It should be noted that the design rainfall for the 10-year 3-hour event per the table below is a total of 1.088 inches and the past flood study for the City of Montrose (*Hydro-Triad 1979*) indicates major storms of record were often late summer to early fall events with total rainfall of 1 to 1.5 inches.

RAINFALL TABLE 1 – DATA FROM NOAA MAPS		
Return Period	**6 Hour Value (in)**	**24 Hour Value (inch)**
2-Year	0.8	1.0
10-Year	1.2	1.6
100-Year	1.8	2.4

RAINFALL TABLE 2 – CALCULATED INCHES OF RAIN (CUMULATIVE)							
RETURN PERIOD	**INTERVAL (MINUTES)**						
	5	**10**	**15**	**30**	**60**	**120**	**180**
2-Year	0.172	0.266	0.337	0.468	0.592	0.663	0.710
10-Year	0.273	0.423	0.536	0.743	0.940	1.029	1.088
100-Year	0.439	0.681	0.863	1.195	1.513	1.611	1.676

RAINFALL TABLE 3 – CALCULATED RAIN INTENSITY (INCHES PER HOUR)							
RETURN PERIOD	**INTERVAL (MINUTES)**						
	5	**10**	**15**	**30**	**60**	**120**	**180**
2-Year	2.060	1.598	1.349	0.935	0.592	0.331	0.237
10-Year	3.271	2.538	2.143	1.485	0.940	0.514	0.363
100-Year	5.266	4.086	3.450	2.391	1.513	0.806	0.559

e. Runoff Factors:

The SCS Curve Number method was selected to estimate runoff for the Master Plan. The SCS Curve Number is based on underlying soils, vegetation and land use. Curve numbers have been developed for urbanized, agricultural and undeveloped land use. The SCS Curve Number is widely accepted and easily defendable and reproducible whereas some of the alternatives require more detailed knowledge of the soil structure and are not as easily applied to urban/suburban land use.

f. Time Component:

The SWMM Model uses the width factor and the basin characteristics to develop the time component of the hydrograph. The width factor is the hardest factor to accurately develop. Particularly in large irregular shaped basins several approaches were reviewed to determine this width factor and each sub-basin was checked for sensitivity to this factor before completing the model.

g. Sensitivity Analysis:

Once the model and criteria selection was complete, a baseline model was developed and the input parameters were checked for sensitivity. A summary of the sensitivity analysis, along with modeling recommendations, was submitted to the City in January 2009 which allowed us to proceed with selection of input criteria for each sub-basin.

3. MODEL OF EXISTING CONDITIONS

Sub-basins within each major basin were modeled in the SWMM program for the 2-year, 10-year and 100-year storm events (3-hour storm). Sub-basin flows were routed downstream to "junction points" and ultimately to the "outlets". The large upstream sub-basins on each major basin that are outside the study area were also estimated to allow for estimation of total flow at junction points and outlets (with the exception of the Uncompahgre River and Happy Canyon). A summary of the input parameters and resulting flow estimates is as follows and as shown on the attached figures.

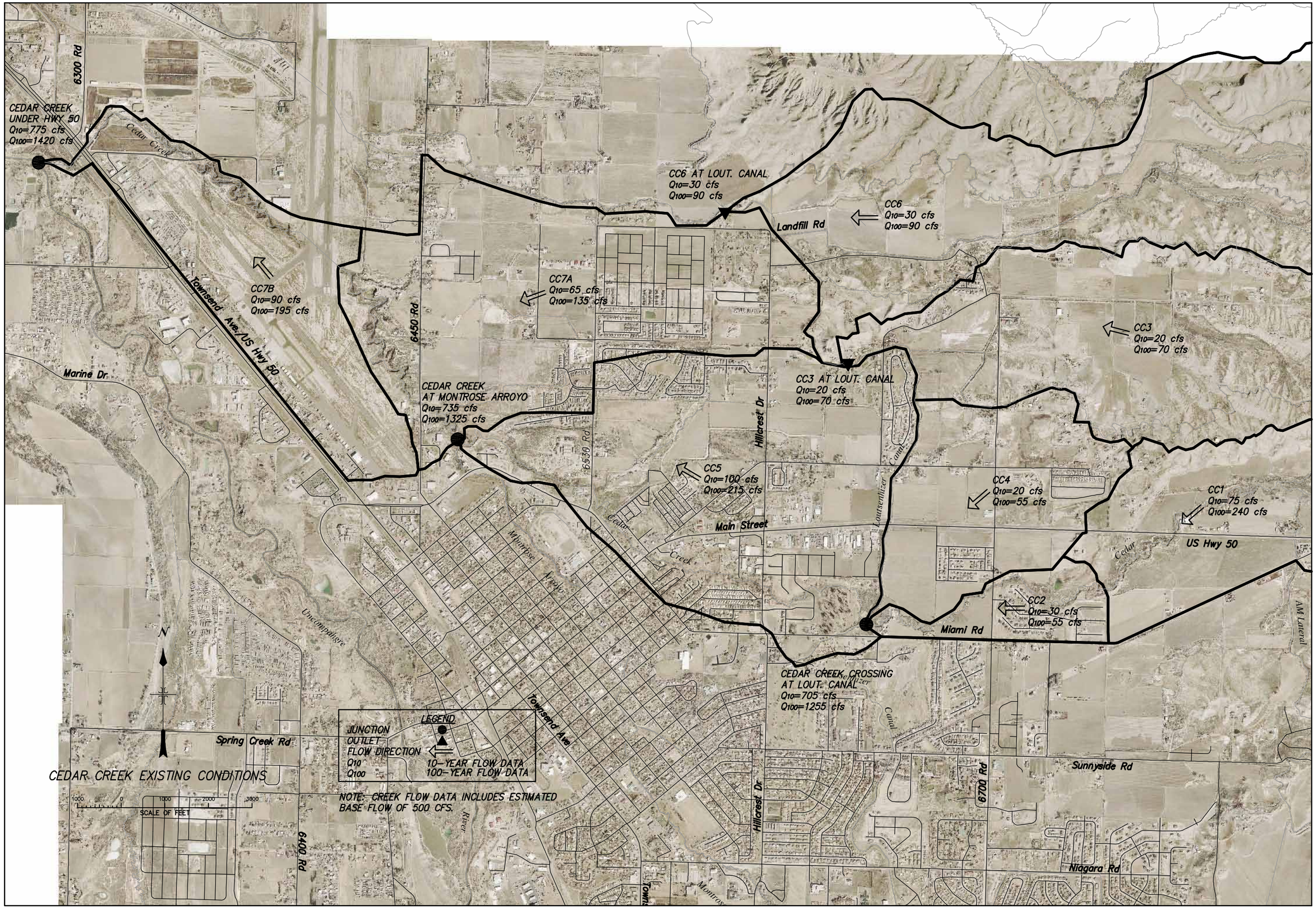
The Hydro-Triad, Ltd. Report *"Floodplain Information and Urban Drainage Report, Cedar Creek, Montrose Arroyo, Dry Cedar Creek*", 1979, was reviewed for comparison of discharge estimates. This report generally focused on the flood potential for area creeks and included an estimate of snowmelt for base flows of the creeks. The study used the SCS procedure for the large undeveloped basin areas and rational formula for runoff from urban areas. Resultant estimates for peak flood discharge for Cedar Creek, Montrose Arroyo and Dry Cedar Creek are discussed under each major basin for the 10-year and 100 year events. Note that the 1979 estimates included all basins, whereas this study excludes basins that currently discharge to canals. Also, there has been significant development in some of the sub-basins since the 1979 study. There is no gage data for these creeks to corroborate peak flow estimates.

a. Cedar Creek

Existing development in the Cedar Creek basin is generally in sub-basins 2, 4, 5, and 7A, with Montrose County Airport development located in basin 7B. The basins outside of the current development have undeveloped land, mostly in the form of agricultural or range land, with very low density residential use. The upstream sub-basin is outside of the study area; however, it was included in the models to establish Cedar Creek peak flows at key design points.

CEDAR CREEK EXISTING RUNOFF ESTIMATES							
Sub-Basin	**Area (ac)**	**Land Use**	**% Impervious**	**HSC/RCN**	**Q 2yr**	**Q 10yr**	**Q 100yr**
CC1	6432	Undeveloped/Ag	0	D/88	15	75	250
CC2	145	Med Density Res/Ag	30	C/81	15	30	55
CC3	1060	Undeveloped/Ag	0	C/85	4	20	70
CC4	453	Ag/Residential /Commercial	15	C/85	7	16	55
CC5	1079	Ag/Residential /Commercial	35	C/84	50	100	225
CC6	3809	Undeveloped	0	D/88	5	30	100
CC7A	986	Low-Med Density Res/Ag	30	C/81	35	65	150
CC7B	560	Airport	70	C/86	45	90	200
In-stream Peak Flows due to runoff							
At Confluence of Montrose Arroyo					550	750	1350

For comparison, the Hydro-Triad, Ltd. report "*Floodplain Information and Urban Drainage Report, Cedar Creek, Montrose Arroyo, Dry Cedar Creek*", 1979, was reviewed. This report focused on flood potential for area creeks and included estimates of snowmelt for base flows. The study used the SCS procedure for the large undeveloped basin areas and the rational formula for runoff from urban areas. Resultant estimated peak flood discharge for Cedar Creek at the confluence with the Montrose Arroyo was shown as 660 cfs for the 10-year event and 1250 cfs for the 100-year event. The Hydro-Triad estimates are within 15 percent of the estimates provided in the table above. There is no gage data for Cedar Creek to corroborate peak flow estimations.



CEDAR CREEK EXISTING CONDITIONS

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REVISIONS	DATE

CITY OF MONTROSE, COLORADO
MONTROSE STORM WATER STUDY
CEDAR CREEK EXISTING CONDITIONS

DESIGNED	J.K.
DRAWN	BMB
DATE	MAY 2009
PROJ. NO.	08-317
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OF <-> DWGS.	

b. Dry Cedar Creek

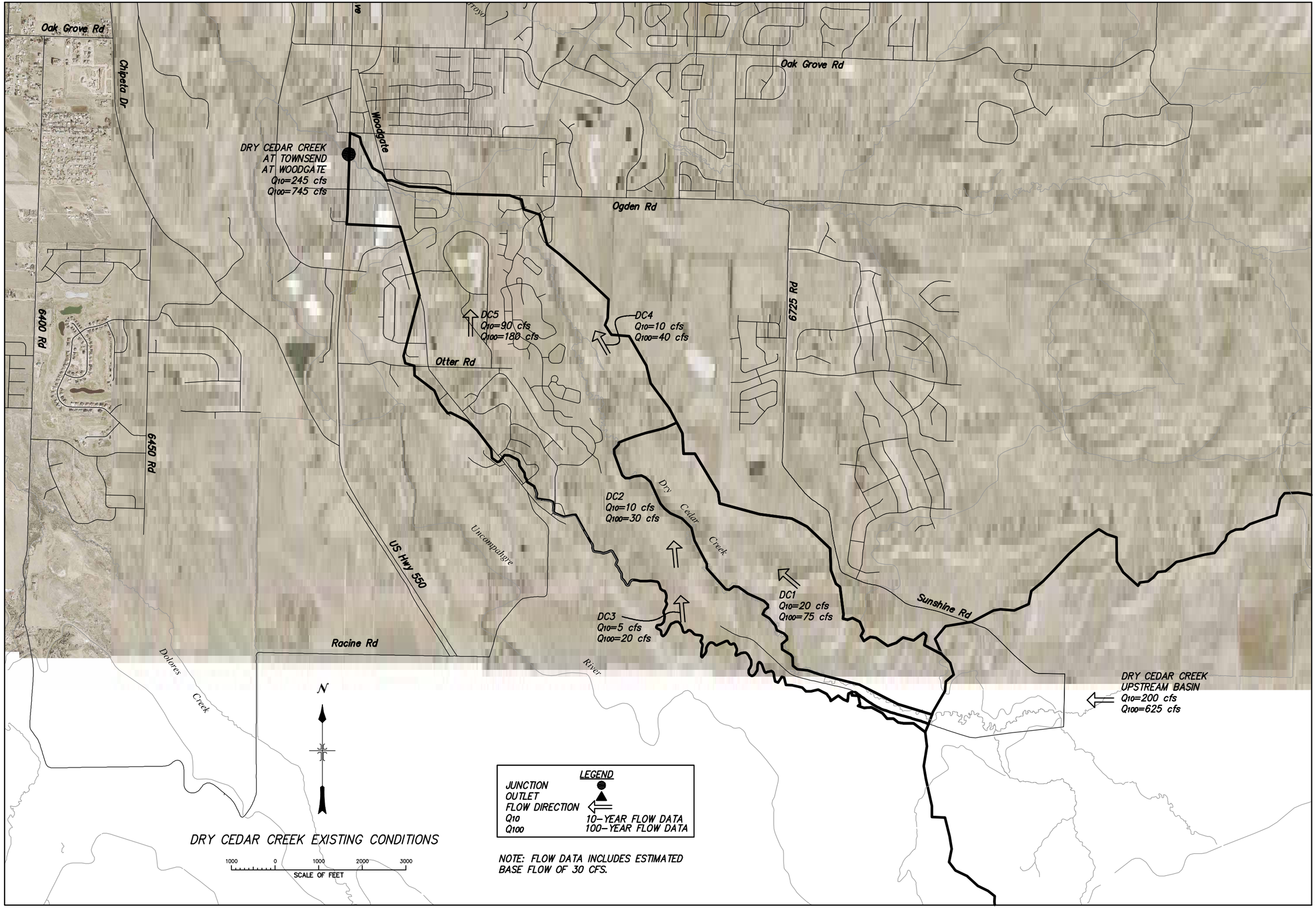
Existing development in the Dry Cedar Creek basin is generally limited to sub-basin 5 and is low to medium density residential with a small amount of commercial use between Woodgate Road and Highway 550. There are some areas of low density residential in sub-basins 1, 2 and 3. The large upstream basin includes undeveloped land, agricultural use and very low density residential use. The upstream sub-basin is outside the study area but was included in estimates to establish the in-stream peak flows at key design points.

DRY CEDAR CREEK EXISTING RUNOFF ESTIMATES							
Sub-Basin	**Area (ac)**	**Land Use**	**% Impervious**	**HSC/RCN**	**Q 2yr**	**Q 10yr**	**Q 100yr**
Upstream	14685	Undeveloped/Ag	0	D/88	40	200	625
DC1	322	Ag/Low density Res	2	C/85	4	20	75
DC2	164	Ag/Low Density Res	2	C/85	2	10	30
DC3	79	Low Density Res./Ag	2	C/81	1	5	20
DC4	160	Ag/Low Density Res	2	C/85	2	10	40
DC5	490	Low-Med Density Res/Comm	40	C/81	50	90	180
In-stream Peak Flows due to runoff							
At Townsend Ave					80	250	750

For comparison, the Hydro-Triad, Ltd. report "*Floodplain Information and Urban Drainage Report, Cedar Creek, Montrose Arroyo, Dry Cedar Creek*", 1979, was reviewed. This report focused on flood potential for area creeks and included estimates of snowmelt for base flows. The study used the SCS procedure for the large undeveloped basin areas and the rational formula for runoff from urban areas. Resultant estimated peak flood discharge for Dry Cedar Creek at the confluence with the Uncompahgre River was shown as 370 cfs for the 10-year event and 1550 cfs for the 100-year event. The Hydro-Triad estimates are 50 to 100 percent higher than the estimates provided in the table above. This discrepancy may be a result of the following:

- Different methods used to develop runoff hydrographs
- Different design storm durations
- Inclusion of snowmelt in Hydro-Triad numbers
- Use of directly connected impervious for Buckhorn estimate (lower than total impervious)

There is no gage data for Dry Cedar Creek to corroborate peak flow estimations.



DRY CEDAR CREEK EXISTING CONDITIONS

NOTE: FLOW DATA INCLUDES ESTIMATED BASE FLOW OF 30 CFS.

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MONTROSE STORM WATER STUDY
DRY CEDAR CREEK EXISTING CONDITIONS

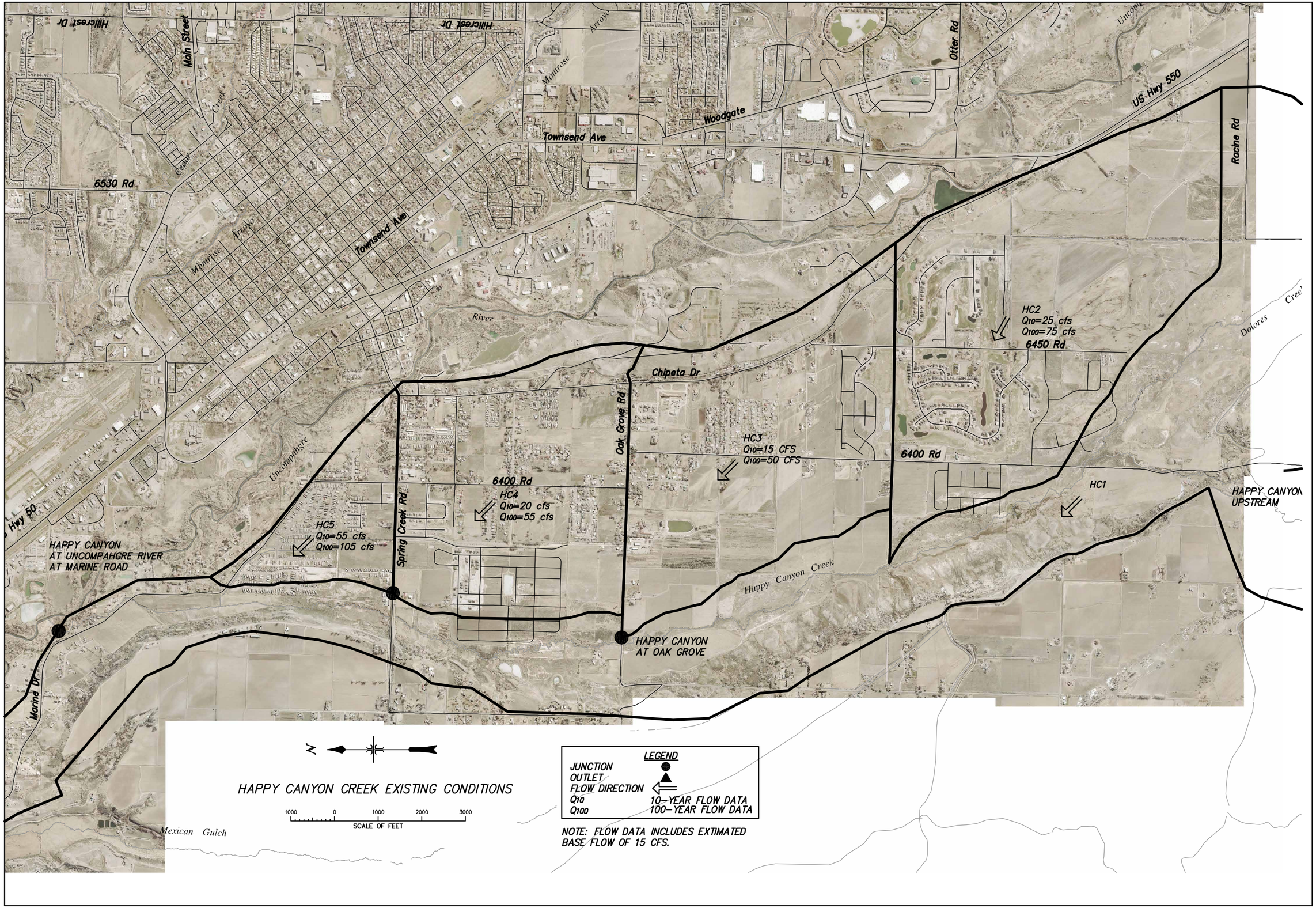
DESIGNED	J.K.
DRAWN	BMB
DATE	MAY 2009
PROJ. NO.	08-317

DRAWING NUMBER
DC-EX
OF <-> DWGS.

c. Happy Canyon Creek

Happy Canyon sub-basins 2 through 5 have the most potential for future growth and runoff estimates were completed for these sub-basins. Since Sub-basin 1 includes the west side of Happy Canyon Creek, which is generally hilly, and the river corridor, the sub-basin has very low development potential and estimates for this basin were considered not applicable. The upstream basin, which is outside the study area, is a large complex basin with numerous tributaries and irrigation interfaces. Runoff estimates from this upper sub-basin were outside the scope of the study. The Montrose County Flood Study shows estimates for the whole Happy Canyon Creek drainage of 1300-cfs for the 10-year event and 2125 cfs for the 100-year event.

HAPPY CANYON CREEK EXISTING RUNOFF ESTIMATES							
Sub-Basin	**Area (ac)**	**Land Use**	**% Impervious**	**RCN**	**Q 2yr**	**Q 10yr**	**Q 100yr**
HC1	2140	Undeveloped/Ag	2	81	N/A	N/A	N/A
HC2	1071	Ag/Low-med density Res/Golf	10	87	6	23	70
HC3	806	Ag/Low Density Res	5	83	2	13	45
HC4	694	Ag/Low-Med Density Res /Comm.	15	84	10	20	54
HC5	215	Low-high Density Res/Comm.	35	81	28	54	103



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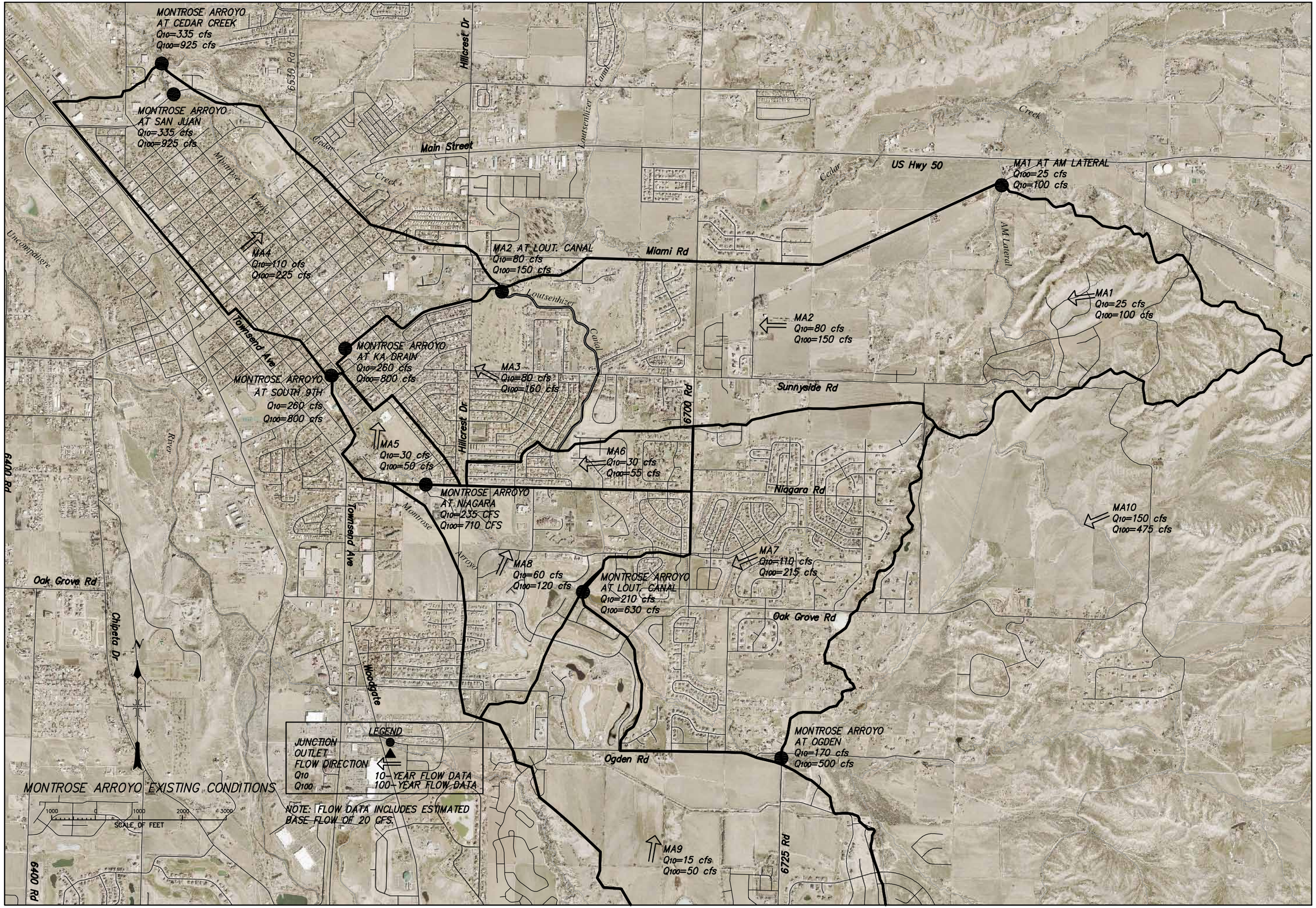
d. Montrose Arroyo

The Montrose Arroyo basin includes the greater part of the developed area of the City of Montrose. The natural channel has been piped, channelized and altered through the downtown City area (Niagara Road to North 1st Street) as development has occurred, which limits the capacity. All sub-basins have potential for in-fill/redevelopment or new development with the exception of the upper sub-basin MA10.

MONTROSE ARROYO EXISTING RUNOFF ESTIMATES							
Sub-Basin	**Area (ac)**	**Land Use**	**% Impervious**	**HSG/ RCN**	**Q 2yr**	**Q 10yr**	**Q 100yr**
MA1 Discharge to S. Canal	434	Undeveloped/Ag	0	D/87	6	25	100
MA2 Discharge to L. Canal	931	Ag/Low Density Res	10	C/80	41	80	150
MA3	371	Low-Med Density Res /Golf Course	40	C/80	41	80	160
MA4	668	High Density Res/Comm./Bus.	60	C/84	54	110	225
MA5	87	High Density Res/Comm./Bus	50	C/82	14	30	50
MA6	122	Low-Med Density Res /Golf Course	40	C/80	14	30	55
MA7	910	Low –Med Density Res Ag/Undev.	30	C/80	27	110	215
MA9 south	1243	Ag/Undev.	8	C/80	2	15	50
MA10 east	7960	Undeveloped/Ag	0	D/88	32	150	475
In-stream Peak Flows due to runoff							
At Ogden/6725 Road					52	170	500
At Loutsenhizer Canal					80	210	630
At Niagara Road					102	235	710
At KA Drain S. 8th Street					135	260	800
At San Juan Bypass and Cedar Creek					172	335	925

For comparison, the Hydro-Triad, Ltd. report *"Floodplain Information and Urban Drainage Report, Cedar Creek, Montrose Arroyo, Dry Cedar Creek*", 1979, was reviewed. This report focused on flood potential for area creeks and included an estimate of snowmelt for base flows. The study used the SCS procedure for the large undeveloped basin areas and rational formula for runoff from urban areas. Resultant estimated peak flood discharge for Montrose Arroyo at the confluence with Cedar Creek was shown as 300 cfs for the 10-year event and 1100 cfs for the 100-year event which are within approximately 10% of the estimates shown above. Note that the 1979 estimates included all basins, whereas we have excluded basins that currently discharge to canals. Also, there has been significant development in some of the sub-basins since the 1979 study. There is no gage data for the Montrose Arroyo to corroborate peak flow estimations.



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MONTROSE ARROYO EXISTING CONDITIONS

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e. Selig Canal

The Selig Canal basin was not divided into sub-basins due to the small area of the basin. This basin currently has commercial and industrial development along Highway 50 and native grasses and agricultural development outside of the highway corridor. This basin is expected to infill with re-development or new development of commercial/light industrial nature.

SELIG CANAL BASIN EXISTING RUNOFF ESTIMATES							
Sub-Basin	**Area (ac)**	**Land Use**	**% Impervious**	**HSG/ RCN**	**Q 2yr**	**Q 10yr**	**Q 100yr**
SC1	236	Mixed business/ commercial	39	C/84	55	110	225

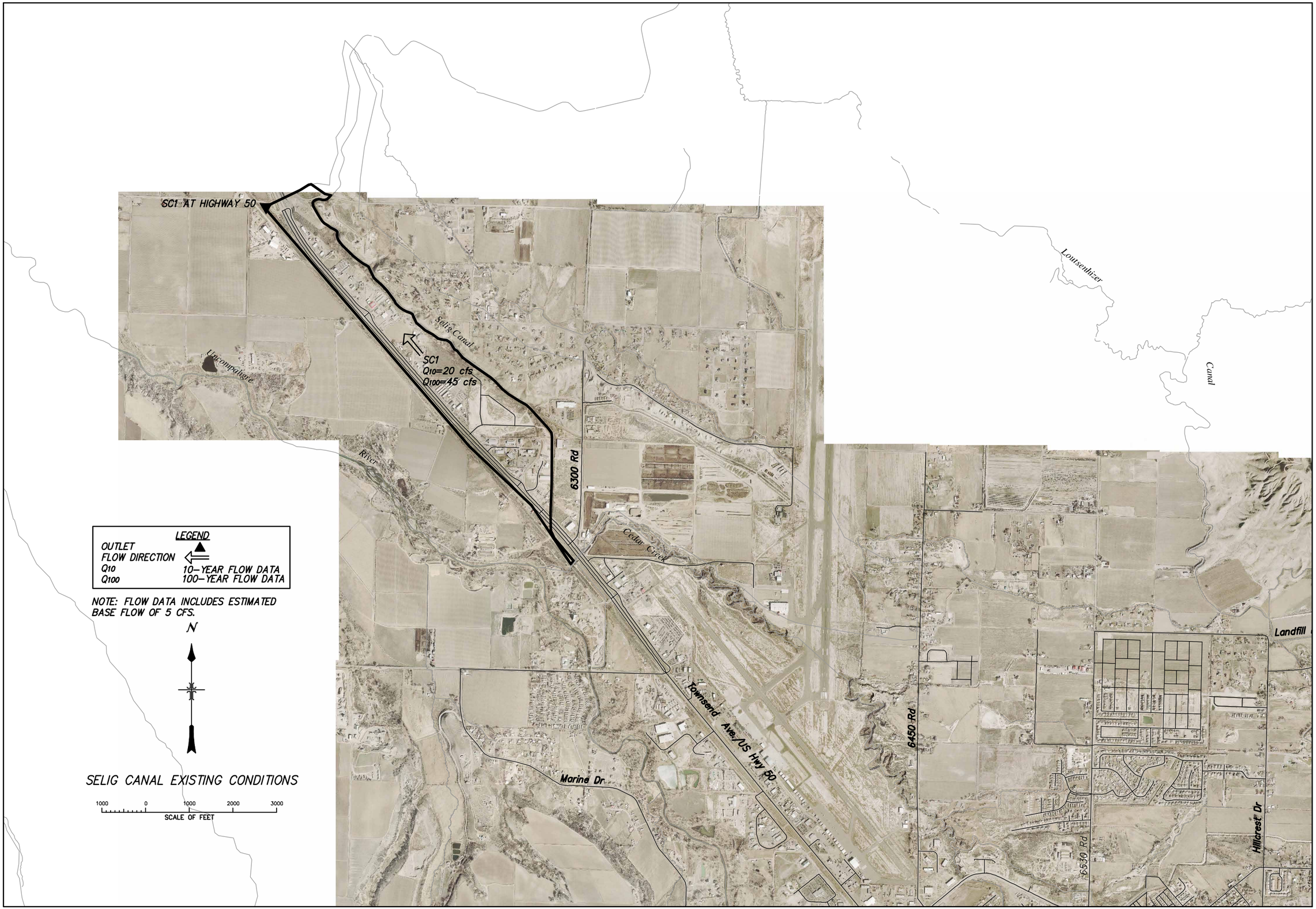
f. Uncompahgre River Basin

The Uncompahgre River basin within the City of Montrose was divided into 3 major sub-basins based on land use.

- The southern basin runs from Ogden Road north to Main Street and includes the commercial and light industrial use associated with Highway 550 and Rio Grande, along with residential neighborhoods.
- The middle basin is from Main Street north to the San Juan bypass and includes central business district and commercial use associated with the downtown area, the Highway 50 corridor and the railroad.
- The north basin runs from the San Juan bypass north to the City limits and includes the light industrial use associated with Highway 50 and the Airport.

These basins have large areas that are fully developed with minimal storm water detention and include large areas of impervious pavement due to the commercial/business nature of land use. Drainage from east to west is impeded by the highway and by the railroad. There are pockets of agricultural land and vacant land remaining in the basins and areas of undeveloped land along the Uncompahgre River itself due to flood plain and wetland restrictions. All sub-basins have potential for in-fill/redevelopment or new development. For existing conditions the Uncompahgre River Basin within the study limits was modeled as one basin.

UNCOMPAHGRE RIVER BASIN EXISTING RUNOFF ESTIMATES							
Sub-Basin	**Area (ac)**	**Land Use**	**% Impervious**	**HSG/ RCN**	**Q 2yr**	**Q 10yr**	**Q 100yr**
UR All	4439	Mixed business/ commercial/mid to high residential/ parks	48	C/85	175	360	780



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MONTROSE STORM WATER STUDY

SELIG CANAL EXISTING CONDITIONS

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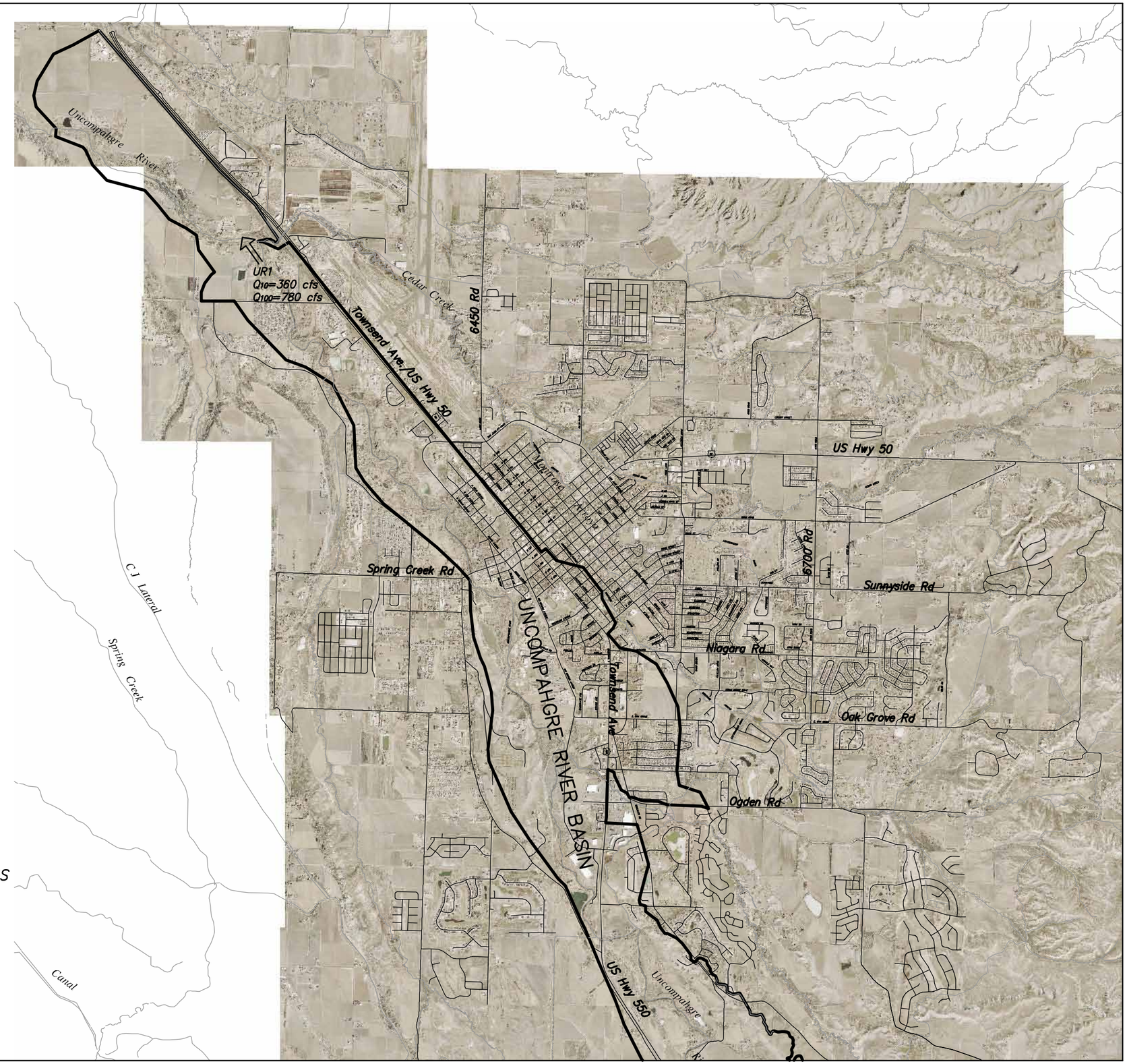

LEGEND

JUNCTION	●
OUTLET	▲
FLOW DIRECTION	⇐
Q10	10-YEAR FLOW DATA
Q100	100-YEAR FLOW DATA

NOTE: FLOW DATA DOES NOT INCLUDE BASE FLOWS

N

UNCOMPAHGRE RIVER BASIN EXISTING CONDITIONS

2000 0 2000 4000 6000
SCALE OF FEET

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C. MAJOR DRAINAGE BASINS DESCRIPTIONS

a. Cedar Creek

Cedar Creek Channel
East of San Juan

Cedar Creek Channel
East of N. Townsend

Typical Highway Drainage
within Town Limits
Curb and Gutter with
Sidewalk Inlets

Typical Residential Rural Road
within Drainage Basin

GENERAL

Cedar Creek enters the study area from the east and flows west to the Uncompahgre River north of La Salle Road. Cedar Creek drainage basin extends to the east and southeast, beyond the study area by nearly 15 miles to a ridge 2.4 miles southeast of Waterdog Peak. Cedar Creek basin comprises of a total drainage area of 58 square miles. The area modeled contains nine sub-basins (see attached figure) consisting of 23 square miles total. Of the 58 square mile total drainage area, 7.3 square miles is within the study area.

The drainage basin ranges in elevation from 5650 at the Uncompahgre River to 9394 at the top of Waterdog Peak with a total length of 20.4 miles and average slope of 3.5 percent. The portion of the drainage basin in the study area ranges in elevation from 5650 to 7650 feet msl with a length of 12.4 miles and an average slope of 3 percent.

The Cedar Creek active channel is sparsely to moderately vegetated with steep eroded side banks and evidence of piping. During storm events and spring runoff, the creek may carry a high sediment load due to the erodible nature of the banks and surrounding land.

LAND USE

Existing land use in the lower part of this basin is agricultural, irrigated fields and rangeland with single family residential areas. The lower part of the drainage basin also contains the Montrose Regional Airport. The upper reaches of the basin, east of the south canal and the AB lateral, are undeveloped and unsuitable for agriculture or urban development due to restrictive soils and the shallow depth to bedrock.

There are two large irrigation canals crossing Cedar Creek: the South Canal near Highway 347; and the Loutsenhizer Canal crossing east of Hillcrest Road. Two laterals also drain into Cedar Creek: the Aba Lateral, west of 6900 Road; and the Am Lateral, west of Miami Road. The Montrose Arroyo flows into Cedar Creek north of San Juan Ave. There are numerous irrigation feed ditches and waste ditches throughout the basin.

The existing developed land-use in the study area portion of this drainage basin is primarily medium to low density residential with commercial development along North Townsend Avenue and Main Street. The existing land use also includes irrigated fields, undeveloped land, rangeland and barren hills.

The existing zoning map and the Montrose Comprehensive Plan show this area to be planned for mixed residential use (low to medium density) and commercial use along Highway 50 including both Main Street and North Townsend Avenue.

SOILS AND VEGETATION

The General Soils Map for the Delta-Montrose Area (SCS 1967) shows soils in the stream beds and flood plains to be Billings-Christianburg association with Chipeta-Persayo association in the rest of the areas. The Billings-Christianburg soils are noted to be deep, fine textured and moderately fine textured soils occurring on gently sloping to moderately level topography. The Chipeta-Persayo soils are fine to moderately fine textured, shallow soils derived from shale located on nearly level to hilly ground.

The detailed mapping in the 1967 report indicates soils within the study area to be primarily Billings silty clay loam and Badland soil. The Billings silty clay loam occurs throughout the majority of the basin and has moderate percolation rates, poor surface drainage and is susceptible to erosion and piping. Within the study area, these soils have been used for agriculture and range land, vegetation consists of agricultural fields and range land areas with dry land grasses and shrubs where native vegetation exists. Areas that have been converted to residential and commercial use have typical landscaping.

The Badland soils in the hilly parts of the basin, outside of the study area, have a shallow bedrock depth and a nearly impermeable surface giving high rates of runoff and a high susceptibility to erosion. The area does not readily support native or agricultural vegetation.

The updated soils study that is dated 7/10/2006 by the NRCS renames the primary soils in this basin as the Montrose-Delta Complex (map unit 701) the Montrose-Persayo Complex (map unit 900) on the west end of the basin, and the Typic-Torriorthents-Badland Complex (map unit 801) in sub-basins CC1 and CC6. The Montrose-Delta Complex soils consist of silts, clays and loams with a hydrologic soil classification of C. The Montrose- Persayo Complex soils consist of shallow silty clays and loams and also have a hydrologic soil classification of C. The Typic-Torriorthents-Badland Complex soils consist of clayey silts and have a hydrologic soil classification of D.

MAJOR DRAINAGE STRUCTURES

East of the City of Montrose, Cedar Creek crosses under Highway 50 four times. North of San Juan Avenue, Cedar Creek provides one of the few major drainage crossings in the City of Montrose to pass drainage under Highway 50 (North Townsend) west to the Uncompahgre River.

Typical Road Drainage
at North Townsend

Bridge Structure for Cedar Creek
0.4 miles East of Miami Road

Cedar Creek Culvert
Crossing under North Townsend

Cedar Creek feeds several laterals and also crosses the Loutsenhizer Canal. Cedar Creek flows under major road crossings such as Highway 50 east of Montrose, 6700 Road, Hillcrest, Main Street, 6530 Road, 6450 Road, under the airport, and Highway 50 north of Montrose. Existing drainage systems within the basin are limited to fragmented drainage systems related to road improvements and property development which often overlap with irrigation ditches. Estimated capacity of drainage structures at the major crossings are shown in the table below.

Cedar Creek Capacities at Major Drainage Structures

Location	Description	Approx Capacity at Full Structure (cfs)	Approx Capacity with 3' Freeboard (cfs)
At Hwy 50 W of Miami	82' wide x 12' high bridge	1900	6800
At 6700 Road (existing)	16' x 12' box	1800	[N/A]
At 6700 Road (proposed)	16' x 8' box	1000	1100
At Hillcrest	10' CMP	800	[N/A]
At Main Street E of San Juan	52' x 6' Bridge	2000	[N/A]
At 6530 Road	15' high x 25' wide bridge	3300	[N/A]
At 6450 Road	60' x 60' bridge	>25000	[N/A]
Under Airport	12' Ø	1050	[N/A]
At Hwy 50 S of 6300 Road	12' CMP	1200	2150

MODELING

For the purposes of modeling, the Cedar Creek Basin was divided into 9 sub-basins as shown on the attached map.

Sub-basins:

CC1 is located east of the City of Montrose along Highway 50. Future development potential is limited by the soils and the topography within the sub-basin. Most of the sub-basin is located outside of the growth boundary; therefore we are anticipating minimal development.

CC2 contains the area from Miami Road north including the Cedar Creek flood plain and from the Loutsenhizer Canal east to 6750 Road. Part of this sub-basin is developed with a medium density residential neighborhood. It is expected that the rest of the basin will develop into a residential area as well.

CC3 is northeast of the City of Montrose, north of Highway 50. About half of the sub-basin is within the growth boundary. CC3 is sparsely developed and has a limited development potential due to the soils and the topography. The sub-basin is bordered on the west by the Loutsenhizer canal, and on the south, north and east by the adobe hills. CC3 does not drain into Cedar Creek, but into the Loutsenhizer Canal. Drainage from future development will not be directed into the canal, but conveyed downstream via 6700 Road or 6650 Road to Cedar Creek.

CC4 is bordered by the Loutsenhizer Canal on the west, Cedar Creek on the south, and the ABE Lateral on the north. Currently, the sub-basin has a residential neighborhood, a school and open grassland within its boundary. The future plan calls for the sub-basin to be developed into commercial areas around Highway 50 and residential areas elsewhere.

CC5 is located directly northeast of downtown Montrose. It is bordered on the east by the Loutsenhizer Canal and on the south by the Cedar Creek flood plain. CC5 contains a number of high density and medium density residential developments as well as commercial businesses. The entire sub-basin is expected to develop into residential and commercial subdivisions. This sub-basin contains three major drainage problems which have been identified by City staff, and which can be found on the drainage problem maps:

- Flooding at the end of Rose Lane. City installed a second outlet pipe to correct problem, but needs a heavy rain to verify.
- Flooding at southeast corner of Main Street and Rose Lane. City installed valley pans and it seems to have alleviated the problem, but now the trailer park floods.
- Inlet overflowing and park flooding.

CC6 is the northern-most sub-basin within the Cedar Creek Basin. It is bordered along the west side by the Loutsenhizer Canal and only a small portion of the sub-basin is within the growth boundary. The rest of the sub-basin contains soils and topography which limit the growth potential. CC6 does not drain into Cedar Creek, but into the Loutsenhizer Canal. Drainage from future development will not be directed into the canal, but into detention areas and then the storm water will be conveyed downstream through roadside ditches to Cedar Creek. One drainage problem has been identified by the City of Montrose for this sub-basin: during stormwater events, the roadside ditch along Landfill Road floods.

CC7A is directly north of downtown Montrose. It is bordered on the east by the Loutsenhizer Canal. There is one medium density residential neighborhood within the sub-basin. The rest of the sub-basin is expected to develop with low and medium density residential neighborhoods.

CC7B contains the airport and the businesses along the east side of Highway 50. This sub-basin is already well developed and is expected to fill in with more businesses along Highway 50. One problem area which has been identified by the City of Montrose staff includes the roadside ditch along Highway 50. This ditch often floods, particularly at the driveway CMPs.

CCUPSTREAM contains the rest of the basin outside of the growth boundary. This area is not expected to develop, due to the topography and soils in the area.

See Table of Existing Input/Output Data for sub-basin modeling parameters, below.

b. Dry Cedar Creek

Dry Cedar Creek Basin at Kinikin Road Looking North

Kinikin Road Bridge over Dry Cedar Creek

Dry Cedar Creek at 6700 Road

Woodgate Road 10' CMP with Bend

Landscape and Vegetation Typical of DC3 (distance) and DC2 (foreground)

GENERAL

Dry Cedar Creek enters the study area from the southeast and flows northwest to the Uncompahgre River toward the south end of Rio Grande. Dry Cedar Creek drainage basin extends to the southeast, beyond the study area by approximately 9 miles to Waterdog Peak, with a total drainage area of 24 square miles. Of the 24 square mile drainage area, approximately 2.2 square miles is considered potential for urbanization with 1.6 square miles within the study area. The southern boundary of the potential urbanization is Racine Road.

The drainage basin ranges in elevation from 5890 at the Uncompahgre River to 9394 at the top of Waterdog Peak with a total length of 12.7 miles and an average slope of 5 percent. The portion of the drainage basin in the study area ranges in elevation from 5840 to 6000 feet msl with a length of 3 miles and average slope of 1 percent.

The Dry Cedar Creek active channel has areas of heavy grass vegetation and areas with sparse vegetation with steep eroded side banks and evidence of piping. During storm events, the creek has been observed to carry a high sediment load due to the erodible nature of the banks and surrounding land.

LAND USE

Existing land use in the lower part of this basin is agricultural with irrigated fields and rangeland. The upper reaches of the basin, above the South Canal, are undeveloped and unsuitable for agriculture or urban development due to restrictive soils. There are three large irrigation canals crossing Dry Cedar Creek: the South Canal near the upper end of the basin; the AM lateral crossing at Sunshine Road; and the Loutsenhizer Canal crossing near Ogden Road. There are numerous minor irrigation feed ditches and waste ditches throughout the basin.

Existing developed land-use in the study area portion of this drainage basin is primarily medium to low density residential with some commercial development along Woodgate Road and the Highway 550 corridor. There are plans in place to widen Woodgate Road from Highway 550, south, to Otter Road. The existing zoning map and the Montrose Comprehensive Plan show this area to be planned for mixed residential use of low to medium density. The sub-basins on the north side are planned to be a mix of low density residential and medium density residential. The three sub-basins in the south are all shown to be medium density residential.

SOILS AND VEGETATION

The General Soils Map for the Delta-Montrose Area (SCS 1967) shows soils in the southwest part of the study area, the Dry Cedar Creek basin, to be Billings-Christianburg association and Chipeta-Persayo association. Both associations are noted to be fine textured and moderately fine textured soils with the latter noted as derived from shale.

The detailed mapping in the 1967 report indicates soils within the study area to be primarily Billings silty clay loam and Persayo silty clay loam. These soils have slow percolation rates, poor surface drainage and are susceptible to erosion and piping. Within the study area of these soils have been used for agricultural plantings and range land so vegetation consists of agricultural and range land plantings with dry land grasses and shrubs where native vegetation exists. Areas that have been converted to residential and commercial use have typical landscaping. The updated soils study that is in progress by the NRCS renames the primary soils in this basin as the Montrose-Delta Complex (map unit 701) which are silts, clays and loams with a hydrologic soil classification of C.

Soils outside the study area are similar silty clay loams with soils above the South Canal noted as Badland and rough broken land with shale in various stages of weathering. These areas support minimal vegetation and have high rates of runoff and erosion.

MAJOR DRAINAGE STRUCTURES

Dry Cedar Creek provides one of the few major drainage crossings in the City of Montrose to pass drainage under Highway 550 west to the Uncompahgre River. Dry Cedar Creek flows under major roads such as Woodgate Road, Otter Road and 6700 Road. It also crosses the Loutsenhizer Canal. Existing drainage systems within the basin are limited to fragmented drainage systems related to road improvements and property development which often overlap with irrigation ditches. The South Canal in the upper end of the basin carries approximately 1000 cfs and may impact flows in this basin if it breaches its banks during a major storm event, the Loutsenhizer Canal crosses Dry Cedar Creek near Woodgate Road. Estimated capacity of drainage structures at major crossings are shown in the table below.

Dry Cedar Creek Capacities at Major Drainage Structures

Location	Description	Approx Capacity at Full Structure (cfs)	Approx Capacity with 3' Freeboard (cfs)
At 6700 Road	7.5' high x 13' wide CMP	600	1100
At Otter Road	(2) 8' Ø CMP	800	2300
At Loutsenhizer Canal	9' Ø CMP	600	1200
At Woodgate (Existing)	10' Ø CMP	800	1300
At Woodgate (Proposed)	(2) 8' Ø CMP	900	1950
At Hwy 550	64' x 24.3' Bridge	13500	[N/A]

Typical Rural Road for
DC1, DC2 and DC3

Typical Road for
DC4 and DC5

Dry Cedar Creek Basin Looking
From Upstream to Downstream

Typical Medium Density Road

MODELING

For the purposes of modeling, the Dry Cedar Creek Drainage Basin was divided into 6 sub-basins as shown on the attached map.

Sub-basins:

DC1 is located on the southeast corner of the City of Montrose growth boundary. About half of the sub-basin is within the growth boundary. The southwestern boundary of the sub-basin is Dry Cedar Creek. The current development consists of a few roads with ranch land. Future development is expected to be medium density residential.

DC2 is bordered by Dry Cedar Creek and Kinikin Road on the southeastern corner of the growth boundary. The south half of the sub-basin is outside of the growth boundary. Currently the development consists of a few roads with ranch land. Future development will be mostly medium density residential.

DC3 contains the area uphill from Kinikin Road. About half of the sub-basin is within the growth boundary. There are very few houses currently built in this sub-basin. It is expected that the future development will consist of medium density residential neighborhoods.

DC4 is found east of Dry Cedar Creek. The Loutsenhizer Canal runs through the sub-basin. Currently there is limited development of businesses along Townsend Avenue and a few medium density residential developments along the creek. Future development will consist of mostly medium density residential infill with businesses remaining along the Townsend corridor.

DC5 is west of Dry Cedar Creek and for the most part east of Woodgate Road. The basin includes a business area between Woodgate and Townsend and several medium density residential developments. It is expected that the rest of the basin will develop with medium density residential developments.

DCUPSTREAM is located upstream of the growth boundary. This area is not expected to develop, due to the soils and topography.

See Table of Existing Input/Output Data for sub-basin modeling parameters, below.

c. Happy Canyon Creek

Happy Canyon at West Oak Grove Road

Happy Canyon at 6400 Road

Happy Canyon at Highway 90

GENERAL

Happy Canyon Creek enters the study area from the southwest and flows north to converge with the Uncompahgre River east of Marine Road. Happy Canyon Creek drainage basin extends to the south, beyond the study area and includes Dolores Creek and numerous other tributaries with total drainage area of approximately 69 square miles. Of the 69 square mile drainage area, approximately 7 square miles are within the study area with a southerly boundary at approximately Racine Road.

The lower area of the drainage basin, within the study area, ranges in elevation from 5700 at the Uncompahgre River to 5960 at Racine Road with a total length of close to 6 miles and average slope of just under 1 percent.

The Happy Canyon Cedar Creek active channel is vegetated with grass and low shrubs with some areas having steep eroded side banks. During storm events the creek has been observed to carry a high sediment load due to the erodible nature of soils in the upper basin. The FEMA flood plain maps indicate the creek leaving its banks upstream of West Oak Grove and Highway 90, Montrose County noted that both bridges back up water during significant events but do not overtop.

LAND USE

Existing land use in the lower part of this basin, within the study area, is agricultural with irrigated fields, pastures and orchards with associated rural residential development. The upper reaches of the basin are on the northeast flank of Horsefly Peak and include a substantial portion of public land. Mostly unsuitable for agriculture or urban development due to restrictive soils these upper areas are rangeland, rural residential and undeveloped lands. There are two large irrigation canals crossing Happy Canyon Creek south of the study area, the Montrose and Delta Canal near Racine Road and the West Canal south of Racine Road. There are numerous minor irrigation feed ditches and waste ditches throughout the basin.

Existing developed land-use in the study area portion of this drainage basin is primarily medium to low density residential with some commercial development along the Highway 90 corridor. Recent development has been medium density residential with some recent commercial along the highway. A large portion of this area is outside of current City limits, however with the West Montrose Sanitation District serving most of this area, even County development will potentially be medium density

residential as growth occurs. The Montrose Comprehensive Plan shows this area to be planned for mixed residential use of medium density with smaller areas of low density toward the south end of the study area.

SOILS AND VEGETATION

The General Soils Map for the Delta-Montrose Area (SCS 1967) generally shows soils in the north part of the basin to be Mesa-Orchard association which are deep, nearly level, moderately fine textured soils. Toward the south of the study area the soils are noted as Colona-Salt Lake association fine textured soils. Soils in the corridor along the creek are shown as Genola-Fruitland associations which are also fine-textured soils.

The detailed mapping in the 1967 report indicates soils within the study area to be primarily Vernal clay loam and Genola clay loam. These soils have moderate percolation rates depending on degree of compaction and drainage and are only slightly susceptible to erosion. Within the study area these soils have been used for agricultural plantings so vegetation consists of crop plantings, native vegetation is noted as grasses and sage in the soils study. Areas that have been converted to residential and commercial use have typical landscaping. The updated soils study that is in progress by the NRCS renames the primary soils in this basin as Lizzydea and Mesa soils (map units 726 and 904) which are clay loam overlying sandy and gravelly clay loam with hydrologic soil classification of B for Lizzydea and C for Mesa Soils. Gravels, cobbles and sand are noted below 2-feet. Soils in the south part of the study basin (Happy Canyon 2) change to primarily Cynfeske and Saltlick (map units 791 and 792) with hydrologic soil classification of C and D respectively. These soils in the south part of the basin are clays and are noted to have potential for high groundwater during summer months.

MAJOR DRAINAGE STRUCTURES

Happy Canyon Creek flows north through the west side of the City of Montrose at the base of Spring Creek Mesa. Happy Canyon Creek flows through major road crossings including two locations at 6400 Road, Oak Grove Road, Highway 90 and Marine Road. Existing drainage systems within the basin are limited to fragmented drainage systems related to road improvements and property development which often overlap with irrigation ditches. The Delta Canal crosses through the southern part of the basin. Estimated capacity of drainage structures at the major crossings are shown in the table below.

Happy Canyon Capacities at Major Drainage Structures

Location	Description	Approx Capacity at Full Structure (cfs)
At 6400 Road (southern)	10' x 10' bridge	750
At 6400 Road (northern)	20' x 4' bridge	130
At Oak Grove	20' x 4' bridge	120
At Highway 90	(2) 6' Ø CMP	400
At Marine Road	(2) 4' Ø CMP (Had 3.5' tailwater)	150

Normandy Road
(gravel - no formal drainage)

6400 Road
(road side swales mix with irrigation ditches)

Oak Grove Road
(note irrigation ditch left side of road)

MODELING

For the purposes of modeling, the Happy Canyon Basin was divided into 5 sub-basins as shown on the attached map.

Sub-basins:

HC1 contains the flood plain around Happy Canyon Creek. There is little to no development within this area and it is expected that little development will transpire in the future. One problem area was defined in this area: Happy Canyon Creek has risen to the top of the bridge at Oak Grove Road.

HC2 is located between Chipeta Road and Happy Canyon. Currently, there is a medium density residential neighborhood with a golf course and a medium density residential neighborhood developed in the sub-basin. In the future, the basin will contain commercial businesses along Highway 550 with medium density residential neighborhoods in the rest of the sub-basin.

HC3 is bordered on the east side by Sunset Mesa, on the north by Oak Grove Road and on the west by the Happy Canyon Creek flood plain. Currently, there are a few small medium density subdivisions in the sub-basin. The sub-basin is expected to develop into all low and medium density neighborhoods.

HC4 is positioned between Spring Creek Road to the north and Oak Grove Road to the south, with Sunset Mesa to the east. There are several low and medium density neighborhoods existing in the sub-basin. There are also several businesses along the Spring Creek Road Corridor. In the future, it is expected that the sub-basin will contain mostly low and medium residential neighborhoods with businesses along Spring Creek Road.

HC5 encompasses the area from the Happy Canyon Creek flood plain east past Marine Road and south to Spring Creek Road. The area currently contains a medium density subdivision and many commercial businesses along Spring Creek Road. It is expected that in the future, more medium density residential neighborhoods will develop, while the business corridor remains the same.

See Table of Existing Input/Output Data for sub-basin modeling parameters, below.

d. Montrose Arroyo

Montrose Arroyo
North End of Montrose

Typical Downtown Montrose
Residential Street

Typical Downtown Montrose
Mixed Density

Highway 550 at Niagara Road
Typical Arterial Road Drainage
Curb and Gutter with Inlets

GENERAL

The Montrose Arroyo enters the study area from the southeast and flows northwest to Cedar Creek; the confluence with Cedar Creek is just north of San Juan Avenue. The drainage basin extends southeast of Montrose to Lujane Peak, comprising of a drainage area of 20.5 square miles. Of the 20.5 square mile drainage area, 8.7 square miles is within the study area and covers a greater part of the developed area of the City of Montrose. The natural basin is truncated by two large irrigation canals in the upper reaches, the South Canal and the AM Lateral. The Loutsenhizer Canal runs south to north through the lower reaches of the basin and also intercepts storm flows impacting natural runoff patterns.

The drainage basin ranges in elevation from 5750 at the confluence with Cedar Creek to 7574 at the top of Lujane Peak with a total length of 9.3 miles and average slope of 3.7 percent.

The study area is divided into ten sub-basins. See attached figure for locations and sub-basin names. The sub-basins have slopes ranging from 0.7% to 7.0%.

Within the City of Montrose, the Montrose Arroyo active channel is vegetated with grasses and shrubs. North and south of town, the Montrose Arroyo is sparsely vegetated with steep eroded side banks and evidence of piping.

LAND USE

Existing land use in this basin is agricultural (irrigated fields and rangeland), with single family residential, multifamily residential and commercial areas in downtown Montrose. The upper reaches of the basin, east of the South Canal, are undeveloped and unsuitable for agriculture or urban development due to restrictive soils and the shallow depth to bedrock. There are three large irrigation canals crossing south to north in the Montrose Arroyo basin: the South Canal crosses in the area of the Montrose Arroyo headwaters; the AM Lateral crosses at the approximately the base of the eastern foothills and the Loutsenhizer Canal crosses the lower developed reaches of the basin. The Montrose Arroyo runs through residential development in the south and east areas of the City and through the downtown business district. Just north of San Juan Ave, the Montrose Arroyo flows into Cedar Creek. There are numerous irrigation supply ditches, waste ditches and drain ditches throughout the basin.

Existing developed land-use in the study area portion of this drainage basin ranges from medium and low density residential to offices, commercial and industrial businesses. The commercial and industrial corridors are mainly in downtown business district and along Highway 50.

The Montrose Comprehensive Plan shows this area as mixed residential use of low to medium density, downtown mixed density, highway commercial and central business districts and some commercial/industrial areas to the southwest. The areas outside the study area in sub-basin MA10 will continue to have native vegetation and existing agricultural fields.

SOILS AND VEGETATION

The General Soils Map for the Delta-Montrose Area (SCS 1967) shows soils in the low lying areas to be Billings-Christianburg association with Chipeta-Persayo association in the rest of the areas. The Billings-Christianburg soils are noted to be deep, fine textured and moderately fine textured soils occurring on gently sloping to moderately level topography. The Chipeta-Persayo soils are fine to moderately fine textured shallow soils derived from shale located on nearly level to hilly ground.

The detailed mapping in the 1967 report indicates soils within the study area to be primarily Billings silty clay loam and Badland soil. The Billings silty clay loam occurs throughout the majority of the site, except in the steeper hilly areas on the east side of the basin. The Billings soils have moderate percolation rates, poor surface drainage and are susceptible to erosion and piping. Within the undeveloped portions of the study area, vegetation consists of agricultural and range land plantings with dry land grasses and shrubs. Areas that have been converted to residential and commercial use have typical landscaping.

The Badland soils are located in the hilly parts of the basin, generally outside of the study area to the south and southeast and above the South canal. These soils are highly susceptible to erosion and have high rates of surface runoff due to the shallow bedrock surface and a nearly impermeable surface. The area does not readily support native or agricultural vegetation.

The updated soils study that is dated 7/10/2006 by the NRCS renames the primary soils in this basin as the Montrose-Delta Complex (map unit 701); the Typic Torriorthents, with (map unit 800) or without (map unit 801) Badland soil; and the Montrose-Persayo Complex (map unit 900) on the west end of the basin. The Montrose-Delta Complex soils consist of silts, clays and loams with a hydrologic soil classification of C. The Montrose-Persayo Complex soils consist of shallow silts clays and loams and have a hydrologic soil classification of C. The Typic Torriorthents soils contain a higher percentage of silts and have a hydrologic soil classification of D. The Typic Torriorthents soils are found mainly in sub-basins MA1 and MA10.

MAJOR DRAINAGE STRUCTURES

The Montrose Arroyo passes under bridges and through culverts as it flows through the study area. For the most part, roads within the downtown area for the City of Montrose drain into the Montrose Arroyo. The Montrose Arroyo feeds several laterals and flows past the AM Lateral and the Loutsenhizer Canal before discharging into Cedar Creek. It flows under major road crossings such as Ogden Road, 6750 Road, Pavillion Drive, Hillcrest, Niagara, Main Street, San Juan Ave and many other smaller downtown roads.

Montrose Arroyo in Downtown Montrose

Existing drainage systems within the basin are limited to drainage systems related to road improvements and property development which often overlap irrigation ditches. The lower part of the basin has been extensively developed. Estimated capacity of drainage structures at the major crossings are shown in the table below.

Montrose Arroyo Capacities at Major Drainage Structures

Location	Description	Approx Capacity at Full Structure (cfs)	Approx Capacity with 3' Freeboard (cfs)
At Ogden Road	4' CMP	76	[N/A]
At 6750 Road (existing)	4' CMP	76	170
At 6750 Road (proposed)	16' x 8' box	1000	1100
At Pavillion Drive	(2) 4.5' Ø Culverts	180	[N/A]
At Hillcrest Service Road	(3) 3' Ø ADS	110	230
At Hillcrest	50' wide x 10' high bridge	1250	[N/A]
At Niagara	5.5' Ø culvert (approx)	170	[N/A]
At S 12th St	8' x 3.25' Reinforced Conc Box Culvert	130	[N/A]
At S 9th St	5.5' Ø CMP	170	170
At S Park Ave/S 8th St	15.75' x 7.5' Structural Plate Pipe Arch	700	750
At S 7th St	5.5' Ø CMP	170	[N/A]
At S Mesa Ave/S 6th St	7' Ø CMP	315	[N/A]
At S Nevada Ave/S 5th St	6' Ø CMP	200	[N/A]
At S 4th St to S 2nd St	5.0'Ø Culvert	70	[N/A]
At S 1st St to N 1st St	72"Ø CIP	210	[N/A]
At N 7th St	12' X 4' Concrete Box Culvert	265	850
At San Juan	10' Ø Culvert	800	[N/A]

MODELING

For the purposes of modeling, the Montrose Arroyo Drainage Basin was divided into 10 sub-basins as shown on the attached map.

Sub-basins:

MA1 is near the northern part of the study area, north of Sunnyside Road and all drainage for this sub-basin is currently intercepted by the AM Lateral. Future development potential is limited by soils and topography and although this area is planned as medium density residential we anticipate minimal development. Urban drainage as a result of development can not be directed to the canal and will need to conveyed downstream in the Sunnyside Road and Miami Road corridors.

MA2 is located adjacent to and between Sunnyside and Miami Roads with the AM Lateral at the upper boundary and the Loutsenhizer Canal at the lower boundary. Existing development and future planned use is low density residential. Currently almost all storm runoff is directed to the Loutsenhizer Canal with some of the recent development using infiltration areas adjacent to the canal and on-site detention. Urban drainage should not be directed to the canal and will need to be conveyed downstream in the Sunnyside Road corridors possibly with the exception of small areas currently discharging to the canal. The H Drain provides a significant conveyance of storm drainage through this basin and discharges to the canal. This should be addressed as more development occurs in this drainage. Alternatives include:

- Pipe flows along Sunnyside Road to lower basin MA3
- Utilize canal and provide overflow at Cedar Creek
- Install drainage conveyance parallel to canal to Cedar Creek
- Route flows through the Black Canyon golf course to Hillcrest Drive
- Provide regionalized detention with one of the above alternatives

MA3 includes the English Gardens subdivision, the Black Canyon Golf Course and surrounding low to medium density residential development in the Sunnyside Road corridor. This sub-basin drains to a remnant drain ditch at the south end of Nevada Avenue with ultimate discharge to the Montrose Arroyo at Mesa Ave and S. 8th Street. Significant irrigation flows were observed in the conveyance system for this sub-basin and the open channel conveyance is restricted with irrigation structures. No detention exists in this sub-basin. This sub-basin contains 4 major drainage problems identified by City staff:

No. 10: Inlet flooding on Hillcrest Drive at Devon/Cambridge
No. 11: Flooding at S. 8th Street (confluence with Arroyo)
No. 12: Flooding at S. 10th Street
No. 13: Flooding at Ridge and Highland

MA4 includes the downtown area of the city, east of Townsend Avenue and surrounding residential, commercial and mixed use. Drainage is primarily directed to streets and to the Arroyo with no detention and little formalized conveyance other than curbs. The only major problem noted is at N. 5th and Uncompahgre where the inlets flood. However, due to lack of formal drainage and nearly flat grades, many of the road intersections exhibit some gutter flooding during major storm events.

MA5 is a small sub-basin along the arroyo banks between Niagara Road and S. Ninth Street. This sub-basin includes Columbine Middle School and playing fields, and mixed business and residential use. The flood plain mapping shows that the Montrose Arroyo breaches 12th Street and overland flooding continues to the north. Field observations during irrigation season noted

only 0.5-feet free opening at this culvert during dry conditions, due to irrigation flows. The City did not note any major drainage problems in this sub-basin.

MA6 is on the north side of Niagara Road between 6700 Road and Hillcrest Road. The natural westerly drainage from the upper part of this basin is interrupted by the Loutsenhizer Canal and retained on the uphill side of the canal in infiltration areas. The lower part of the sub-basin drains to Niagara Road and is conveyed primarily by road swale and curb and gutter to the Montrose Arroyo with some piped conveyance closer to the Arroyo. The City noted a problem area at Kent and James Streets where inlets often flood. Roadside ponding and flooding has also been observed along Niagara Road for high intensity storm events.

MA7 is the sub-basin contributing to the Montrose Arroyo at the Loutsenhizer Canal (west boundary) with the easterly boundary being the ridge line above Cattail Creek. There are two large irrigation tailwater drains in this basin, the A drain and the A19 drain which join at the intersection of Oak Grove Road and 6700 Road and continue west to the Montrose Arroyo as the A drain. The City has ownership of these two drains. Approximately 75% of this basin is developed as low to medium density residential. The storm drainage flows from detention areas to the A drain and the A19 drain. The City has not noted any current drainage problems in this basin although short term road and gutter flooding has been observed during intense storm events. This is primarily due to long travel paths with no formal drainage system. There are groundwater and irrigation flows contributing to drainage in this basin. As Oak Grove Road and 6700 Road are widened and infill development occurs, a more formal drainage system will be required to handle flows.

MA8 is directly below MA7 with the Loutsenhizer Canal forming the upper (east) boundary and Niagara road forming the lower west boundary. The B drain and the D1.60 drain run north through this basin to the Arroyo. A small section of the basin, 58 acres, is located above the Loutsenhizer and flows to Niagara Road. This sub-basin is close to fully developed as mixed residential and business use and includes a portion of the Bridges Golf Course. Groundwater and irrigation flows contribute to drainage in this basin.

MA9 is generally the sub-basin contributing to the C drain with the bulk of the area on the south side of Ogden Road and a smaller area north of Ogden, with discharge to the Arroyo just below the Loutsenhizer crossing. The sub-basin is approximately 20 percent developed primarily as low density residential with drainage detention provided. Undeveloped areas are agricultural with future planning showing mixed residential use. The C Drain is currently administered by the UVWUA and has not been transferred to the City due to water quality concerns in the upper reaches.

MA10 is primarily the upper undeveloped areas of the drainage outside the study area but does includes a small area of low density residential development discharging to the F9 drain and Cattail Creek. A portion of storm runoff from this upper basin is intercepted by the MA lateral.

See Table of Existing Input/Output Data for sub-basin modeling parameters, below.

e. Selig Canal

Typical Roadside Ditches Between Highway 50 And Frontage Road

Typical Roadside Ditch Culvert

GENERAL

The Selig Canal flows from the Uncompahgre River at La Salle Road, north, out of the study area. The drainage for the area flows northwest toward the Uncompahgre River. The southern boundary of the drainage basin is Cedar Creek and the eastern boundary is 63.00 Road, see the attached map. The Selig Canal Drainage Basin is comprised of 1.6 square miles with 1.5 square miles within the study area. The entire study area is considered to have a potential for urbanization.

The drainage basin ranges in elevation from 5664 at 64.50 Road to 5586 at the Uncompahgre River with a total length of 3.7 miles and average slope of 0.85 percent.

The Selig Canal drainage basin drains into the Uncompahgre River north of the study area. Stormwater runoff above the canal runs into the canal and out of the study area. The basin is sparsely to moderately vegetated with native grasses and shrubs. The roadside ditches along Highway 50 and the Frontage Road to Highway 50 carry the majority of the water within the basin.

LAND USE

Existing land use in this basin is agricultural with irrigated fields and rangeland. Existing developed land-use in the study area portion of this drainage basin is primarily commercial with some irrigated field and rangeland and a small amount of low density residential housing. The commercial area is located around the Highway 50 corridor.

The existing zoning map and the Montrose Comprehensive Plan show this area to be planned for low density residential housing with a commercial center around Highway 50.

SOILS AND VEGETATION

The General Soils Map for the Delta-Montrose Area (SCS 1967) shows the soils in the drainage basin to be mostly Billings-Christianburg association. The Billings-Christianburg association is noted to be fine textured and moderately fine textured occurring on gently sloping to moderately level topography.

The detailed mapping in the 1967 report indicates soils within the study area to be primarily Billings silty clay loam and Menoken-Chacra clay loam. The Billings soils have slow percolation rates, poor surface drainage and are susceptible to erosion and piping. The Menoken-Chacra soils have moderate percolation rates and are moderately susceptible to erosion. Within the study area vegetation consists of agricultural and range land plantings with dry land grasses and shrubs where native vegetation exists. Areas that have been converted to residential and commercial use have typical landscaping.

The updated soils study is dated 7/10/2006 by the NRCS renames the primary soils in this basin as the Montrose-Delta Complex (map unit 701) which consists silts, clays and loams with a hydrologic soil classification of C.

MAJOR DRAINAGE STRUCTURES

The water from the area below the Selig Canal flows under Highway 50 north of the study area. This is one of the few major drainage crossings in the City of Montrose to pass drainage under Highway 50 west to the Uncompahgre River. Existing drainage systems within the basin are limited to roadside ditches with culverts at driveways. The Selig Canal may impact flows in this basin if it breaches its banks during a major storm event. The table below shows the estimated capacities of the major drainage structure within the basin.

Selig Canal Capacities at Major Drainage Structures

Location	Description	Approx Capacity at Full Structure (cfs)	Approx Capacity with 3' Freeboard (cfs)
At Highway 50	3' CMP	22	30

MODELING

The Selig Canal basin location is shown on the attached figure.

SC1 is located north of the City of Montrose east of Highway 50. Existing development consists of industrial and commercial businesses. It is expected that the business development will expand and fill up the majority of the basin.

See Table of Existing Input/Output Data for sub-basin modeling parameters, below.

f. Uncompahgre River

The Uncompahgre River Basin at Southern Part of Study Area

Typical Rural Road Drainage With Roadside Ditches

Typical Medium Density Road Drainage with Curb and Gutter

The Uncompahgre River at La Salle Road

GENERAL

The Uncompahgre River enters the study area from the southeast and flows northwest. When the Uncompahgre River enters the area, it is on the east side of South Townsend (Highway 550); it crosses under South Townsend just south of town and remains on the west side for the remainder of the study area. The Uncompahgre River drainage basin extends to the southeast, beyond the study area. The basin within the study area consists of 6.9 square miles. The entire area is considered to have potential for urbanization. The southern boundary of the potential urbanization is parallel, in the east-west direction, with Racine Road.

The drainage basin ranges in elevation from 5970 where the Uncompahgre River enters the study area to 5570 where the Uncompahgre River exits the study area. The length of the basin over that distance is 10.2 miles with an average slope of 0.74 percent.

The Uncompahgre River active channel is moderately to densely vegetated with shallow side banks. The vegetation consists of trees, shrubs and grasses. During the spring runoff, the river carries a high sediment load due to the erodible nature of the banks of the tributary creeks.

LAND USE

Existing land use in the lower part of this basin was agricultural with irrigated fields and rangeland, consisted of the downtown area of Montrose, and contained the vegetated river basin. The river basin is continually being developed; with a majority of the development, in recent years, bring in the upper part of the basin, south of Niagara Road. The Uncompahgre River feeds several large irrigation ditches including the South Canal, Loutsenhizer Canal and Selig Canal.

Existing developed land-use in the study area portion of this drainage basin is a mixture of commercial, industrial, medium and low density residential, irrigated crops and the vegetated river basin. The Montrose Comprehensive Plan shows the basin to remain in much the same configuration, except the irrigated crop land will be developed into medium density housing.

SOILS AND VEGETATION

The General Soils Map for the Delta-Montrose Area (SCS 1967) shows soils in the study area to be primarily the Uncompahgre association with some Billings-Christianburg association. The Uncompahgre association is moderately coarse to moderately fine textured alluvium formed from many different kinds of rock occurring in the river bed on moderately level topography. The Billings-Christianburg association is noted to be fine textured and moderately fine textured soils derived from shale occurring on gently sloping to moderately level slopes.

The detailed mapping in the 1967 report indicates soils within the study area to be dry and wet loams and clay loams with alluvial and wet alluvial areas next to the Uncompahgre River. These soils have slow percolation rates and are not susceptible to erosion or piping due to the medium particle size. Within the study area, these soils have been used for agricultural plantings and range land so vegetation consists of agricultural and range land plantings. Along the river, there is a dense cover of grass, willow trees and cottonwood trees. Where native vegetation exists away from the river dry land grasses and shrubs are prevalent. Areas that have been converted to residential, industrial and commercial use have typical landscaping.

The updated soils study that is dated 7/10/2006 by the NRCS renames the primary soils in this basin as the Montrose-Persayo Complex (map unit 900) and the Fluvaquents (map unit 806). The Montrose-Persayo Complex consists of shallow silts clays and loams and has a hydrologic soil classification of C. The Fluvaquents soils are made up of alluvial material and are poorly drained, giving a hydrologic soil classification of D.

In order to model this basin, a hydrologic soil classification of C was used, since the Montrose-Persayo soil was in the majority of the area of the basin and the Fluvaquents occur mostly in the river basin area.

MAJOR DRAINAGE STRUCTURES

The Uncompahgre River crosses under many bridges in the City of Montrose. These bridges include the ones at South Townsend (Highway 50), Main Street and La Salle Road.

MODELING

The Uncompahgre River drainage basin was not divided into sub-basins, but was modeled as just one basin. See Table of Existing Input/Output Data for sub-basin modeling parameters, below.

TABLE OF EXISTING INPUT / OUTPUT DATA FOR SWMM

BASIN Sub-basin	Area (acres)	Width (feet)	High Elev	Low Elev	Avg Slope (%)	HSG	Existing % Routed (Imperv to Perv)	Existing % Impervious	Acres Impervious	Existing Runoff CN	2 Yr Exist Runoff (cfs)	10 Yr Exist Runoff (cfs)	100 Yr Exist Runoff (cfs)	Base Flow (cfs)	2-Year (cfs - with Base Flow added)	10-Year	100-Year
CEDAR CREEK																	
CC3	1060	2500	6200	5890	1.9	C	100	0	0	85	3.5	19.4	66.0 [2]				
Water released into Lout Canal CC3											3.5	19.4	66.0		3.5	19.4	66.0
CC6	3809	1500	7000	5850	3.9	D	100	0	0	88	5.3	26.6	90.7 [2]				
Water released into Lout Canal CC6											5.3	26.6	90.7		5.3	26.6	90.7
CC UPSTREAM	22531	10000	9394	6550	3.0	D	100	0	0	88	31.4	156.2	532.9				
CC1	6432	4000	7650	5980	4.3	D	100	0	0	88	14.8	71.9	237.5				
CC2	145	1000	5980	5900	1.4	C	50	30	43	81	14.1	27.2	53.5				
CC4	453	1400	6030	5890	1.9	C	85	15	68	85	6.8	15.7	55.0				
Cedar Creek crossing at Lout. canal											30.6	205.4	751.1	500	530.6	705.4	1251.1
CC5	1079	3000	5880	5740	1.2	C	62	35	378	84	50.1	100.4	213.5				
CC at Montrose Arroyo											54.9	233.3	825.1	500	554.9	733.3	1325.1
CC7A	986	2500	5900	5690	1.2	C	70	30	296	81	32.2	63.4	135.3				
CC7B	560	1500	5758	5646	0.7	C	45	70	392	86	42.3	88.7	193.1				
DRY CEDAR CREEK																	
DC UPSTREAM	14685	10000	9394	6090	5.0	D	100	0	0	88	39.5	190.8	621.2				
DC3	79	1000	6060	6010	4.2	C	100	2	2	81	0.8	4.4	19.5				
DC1	322	2500	6130	6000	4.0	C	100	2	6	85	4.3	18.2	74.4				
DC2	164	1300	6090	5950	1.1	C	100	2	3	85	1.4	7.3	26.1				
DC4	160	1400	6010	5920	2.8	C	100	2	3	85	2.0	8.6	35.5				
DC5	490	2500	6030	5890	1.5	C	50	40	196	81	46.8	87.0	175.6				
Crossing at Townsend											46.8	212.6	711.8	30	76.8	242.6	741.8
Crossing at Woodgate											46.8	212.6	711.8	30	76.8	242.6	741.8
HAPPY CANYON																	
HC2	1071	2400	5980	5854	0.9	D	90	10	107	87	5.9	22.7	70.4				
HC3	806	2600	5889	5810	0.8	C	94	5	40	83	2.4	13.1	45.2				
HC4	694	2200	5820	5773	0.6	C	81	15	104	84	9.6	19.6	54.7				
HC5	215	3120	5780	5739	0.7	C	50	35	75	81	28.4	53.5	103.4				
HC UPSTREAM	39234	7000	9600	6000	2.0	C	100	2	785	81	5.6	47.6	205.1				
HC1	2140	10000	5970	5665	0.9	C	100	2	43	81	5.1	36.5	133.9				
MONTROSE ARROYO																	
MA1	434	2700	6290	6080	3.8	D	100	0	0	87	6.0	23.8	92.8 [2]				
Drain into AM lateral											6.0	23.8	92.8		6.0	23.8	92.8
MA2	931	3200	6080	5900	1.8	C	50	10	93	80	41.1	75.3	141.4 [2]				
Drain into Loutsenheizer Canal											41.1	75.3	141.4		41.1	75.3	141.4
MA10	7961	7000	7574	5960	7.0	D	100	0	0	88	32.0	149.1	471.4				
MA at Ogden											32.0	149.1	471.4	20	52.0	169.1	491.4
MA7	910	2300	6080	5900	2.0	C	50	30	273	80	57.2	107.7	212.9 [1]				
MA9	1243	2400	6120	5900	1.2	C	100	8	99	80	1.8	13.0	48.9				
MA at Loutsenhizer Canal											57.2	189.2	605.7	20	77.2	209.2	625.7
MA6	122	800	5960	5860	1.9	C	50	40	49	80	13.9	27.3	54.3 [1]				
MA8	393	1600	5900	5850	0.8	C	50	45	177	81	29.5	57.9	118.5				
MA at Niagara											82.3	213.1	688.7	20	102.3	233.1	708.7
MA3	371	3000	5900	5830	1.1	C	50	40	148	80	40.5	79.7	159.4				
Montrose Arroyo at KA drain											114.7	237.2	773.3	20	134.7	257.2	793.3
MA5	87	700	5860	5830	0.7	C	30	50	44	82	13.6	25.4	49.2				
MA at South 9th											114.8	237.2	773.3	20	134.8	257.2	793.3
MA4	668	1300	5890	5750	1.0	C	30	60	401	84	54.1	107.8	220.3				
MA at San Juan											152.1	311.4	900.4	20	172.1	331.4	920.4
MA at confluence of Cedar Creek											152.1	311.4	900.4	20	172.1	331.4	920.4
MA at Cedar Creek with all flows routed											173.3	350.8	931.4	20	193.3	370.8	951.4
SELIG CANAL																	
SC1	236	800	5664	5586	0.6	C	67	39	92	84	8.9	18.4	42.5				
Crossing under Highway 50											8.9	18.4	42.5	5	13.9	23.4	47.5
UNCOMPAHGRE RIVER																	
UR1	4439	6200	5970	5570	0.7	C	50	48	2131	85	174.1	361.3	777.9		174.1	361.3	777.9

Notes:
SWMM recommends no continutiy errors to be larger than 10%

[1] Significant detention has been excluded from the model
[2] Subbasin is not routed to any other subbasin, drains to irrigation canal

D. FUTURE IMPROVEMENTS PLAN

1. CRITERIA FOR FUTURE IMPROVEMENTS PLAN

a. Protect Natural Drainage Features:

An important part of the storm water management plan for the City of Montrose will be protection of the natural water courses and associated overbank areas to protect natural conveyance capacity for normal storm and flood events. Natural drainages should also be protected from degradation due to sedimentation and erosion to prevent loss of capacity. Piping and channelization of natural drainages should be avoided. Such protection should be provided at all piped discharge to the natural drainage and may include use of energy dissipation structures, sediment basins, or similar Best Management Practices. The protection of the natural drainage corridors and their overbank areas, which can handle large storm events, will provide natural attenuance of peak flows due to the retardance factor of the natural channel and will help will minimize needs for larger infrastructure. Future bridge and culvert crossings for roadways should be designed to pass the 100-year flood flows with limited encroachment into the overbank areas.

b. Reserve Conveyance Corridors:

As development occurs, the City must reserve storm water drainage corridors to natural drainages to ensure later development has access to outfall points, just as they currently reserve transportation corridors. We have identified major corridors in the Capital Improvement Plan; minor corridors will also need to be considered as development occurs. Often storm drainage conveyance corridors can follow road alignments, however, in some areas the natural low areas for the basin need to be considered and additional corridors may need to be preserved.

c. Canals and Irrigation:

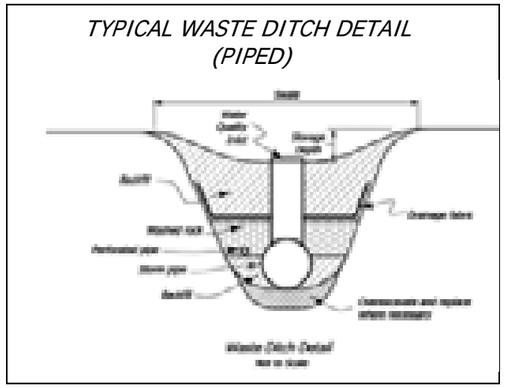
No discharge of urban runoff should be allowed into canals or irrigation ditches due to potential for flooding, urban pollutants, legal issues and future changes in irrigation structures or conveyance that may preclude storm water. Existing discharges to canals and irrigation ditches

should be discontinued as adjacent development occurs and infrastructure is constructed. As development occurs, the City should mandate that irrigation systems within the development are designed and upgraded to ensure they will not impact capacity of storm water facilities.

d. Waste Ditches:

Waste ditches are prevalent drainage features in historically agricultural areas of Montrose. As the urbanized area has spread, waste ditches have been incorporated into the drainage system in varying ways. The City has acquired ownership of waste ditches in the past to allow continued use as drainage conveyance; in other areas the developer has sought permission from the Bureau of Reclamation (BOR) for discharge to a waste ditch. Through discussions with the Uncompahgre Valley Water Users Association (UVWUA), who administers the ditches for the BOR, it is apparent that no new discharge will be allowed to BOR waste ditches and their preference is for the City to take ownership of these ditches. These ditches are generally deep with steep side slopes and are utilized for waste conveyance and for groundwater interception. We would recommend these corridors be maintained as open space. If the ditch is to remain open, side slopes should be graded appropriately for safety and maintenance. If the waste ditch is to be piped, a groundwater collection component should be included and the ditch should be backfilled with a surface swale. The surface swale is to be used as a linear storm water detention/water quality facility.

TYPICAL WASTE DITCH DETAIL (PIPED)



e. Storm Water Detention and Quality:

As development occurs, the City will continue to require on-site detention to detain storm flows to pre-developed levels for the entire development including public roadways. It is important to set design standards that will ensure the detention areas function for most storms so that even small storm events are detained to prevent increased peak flows and associated degradation at natural drainages. Recent research indicates a 2-year design storm should be used to determine lower end outfall parameters for detention. The detention area design should incorporate water quality features such as a stilling area for sedimentation, vegetated channels for bio-filtration, an outfall at the opposite end to the inflow and similar Best Management Practices. Existing basins could be retrofitted for detention of smaller storms and for water quality enhancement as opportunity arises.

The following excerpt from the Urban Storm Drainage Criteria Manual Vol. III – 1999 Edition (Includes Later Revisions) discusses the "first flush" concept regarding water quality design for detention areas, supporting design of detention for smaller storm events: *"A phenomenon termed first flush has been discussed for a number of years resulting in mixed conclusions. The first flush represents the higher levels of initial concentrations of constituents that are washed off from a surface at the very beginning of a rainfall event. Some reports include a first flush because of atmospheric fallout that accumulates before a storm occurs. Other reports conclude that there is no first flush, or an insignificant first flush of pollutants in separate, namely, not combined sewer stormwater runoff. However, by designing facilities to capture in total and treat the majority of runoff events, whether a first flush exists or not becomes irrelevant. At the same*

time, if it does exist for larger runoff events, such designs will then also capture their 'first flush' of runoff."

f. Infiltration areas

Infiltration of excess runoff can be a common component of a storm water management plan. Infiltration areas need to be sited on good percolating soils without influence of seasonally high groundwater. Soils in the Montrose area are not generally conducive to infiltration as a long term solution to storm water management due to slow percolation rates which require large infiltration areas and due to seasonal high groundwater during irrigation season. There may be pockets of suitable soils for infiltration within the major drainage basins with the Happy Canyon basin having the most potential for suitable soils. Infiltration should not be allowed for permanent storm water management except in areas with adequate percolation rates as deemed by the City Engineer and as shown by site specific soils investigations.

g. Conveyance Sizing:

Conveyance for master plans improvements are shown as piped improvements sized to gravity flow, with no surcharge, for the estimated future 10-year peak flow. Pipe slopes used to determine sizing were based on surface topography and will need to be verified at design stage. The pipe sizing selected to convey the 10-year storm was then modeled for the estimated 100-year peak flows to check that surcharge was acceptable and generally less that 6-feet over pipe (assumed to be minor surface flooding) for less than 4 hours. See next two pages for Modeled Future Input Data for SWMM. A minimum pipe diameter of 18-inches was used. The sketches of proposed improvements (found in section *2. Recommended Improvements by Drainage Basin*) show the estimated peak flow for the 10-year and 100-year events. In some instances these flows are similar due to surcharge during the 100-year event causing storage in the pipes and flow lost at surcharged junctions (surface flow).

Corrugated Metal Pipes (CMP) will not be allowed as drainage facilities. Stormwater conveyance pipes shall be RCP unless the City approves the use of HDPE materials. Open channels may be used in place of pipes if appropriate for proposed development. Disadvantages of open channels include loss of land use and the increase of maintenance; several potential advantages over piped conveyance include:

- over bank capacity above design flow
- water quality enhancement
- easy inspection for maintenance
- can be constructed to match terrain

h. Storm inlets:

Storm inlets (or catch basins) are an integral part of the stormwater collection system for urban development. For urban street drainage to be efficient, the design/operation must include:

- appropriate location of inlets
- appropriate grate type for location
- sufficient number of inlets
- sufficient inlet capacity at each location
- sufficient maintenance of inlets
- allowance for carry-over of excess runoff

Roadway geometrics may dictate inlet location due to low points, changes in direction, intersections and outfall location. The spacing of inlets between these points should be such that in a minor storm event the gutter flow does not impede the traffic lane. The calculation of

this spacing is based on type of inlet, grate, curb, road width and cross slope, longitudinal slope and allowed street flooding (spread of flow into street) and therefore can be extremely variable. Typically, single grates will capture 1 to 1.4 cfs on a sloped curb.

We would recommend a 2-year 1-hour storm event with 0.6-inches of rainfall and allowed flooding into the roadway of 7-feet be used for calculating inlet adequacy for road design. This storm will replicate intense summer thunderstorms which sporadically cause road flooding in the urbanized areas.

The City of Montrose has two types of inlets for street curbs: one for a drive-over type curb and one for a vertical type curb. Both are a combination of grate and curb opening providing higher capacity and less clogging than non-combination inlets, with the vertical curb being higher capacity due to the larger unimpeded curb opening. The City is considering CDOT Type R inlets due to ease of maintenance. Several grate styles are allowed by the City and they should be selected based on site specific design. The Type L grate allowed is the most efficient grate for sloped curbs as it has directional vanes which provide better interception of water and is bicycle safe. ***Use of the Type L grate should be required on sloped inlet installation***.

As noted above, there are many variables to consider in inlet spacing. Increasing water capture by using double grates may allow for further spacing, as will steeper longitudinal slopes, less pavement width, sump conditions where inlets are at low spots, and other considerations. Inadequate inlet capacity on a system is a common cause of street flooding. Design should create sump conditions for inlet placing wherever possible.

i. Cost Estimates:

Cost estimates for Master Plan improvements have been prepared for pipe costs only; anticipating detention will be provided by future development (unless noted otherwise). Unit prices for piped improvements are as follows and are shown as estimates for 2009 construction:

MASTER PLANNING COSTS FOR PIPED IMPROVEMENTS						
Pipe Dia.	**Pipe Cost Installed/ LF**	**Catch Basins/LF of Pipe**	**Manholes /LF of Pipe**	**20% other / LF Pipe [1]**	**Final Master Plan Cost No Asphalt [2]**	**Asphalt Repair/LF Pipe For retrofit [3]**
18"	$65	$7	$3	$14	**$89**	$30
24"	$85	$7	$3	$16	**$111**	$30
30"	$95	$7	$4	$20	**$126**	$30
36"	$105	$7	$4	$22	**$138**	$40
48"	$150	$7	$4	$32	**$193**	$40
60"	$190	$7	$5	$40	**$242**	$50

[1] "20% other" includes contingency for utility conflicts, permits, traffic, survey and materials testing and other miscellaneous costs.
[2] No asphalt is included for Master Plan improvements outside roadways or for improvements for future roads where asphalt will be part of the road cost.
[3] Asphalt is added to costs for Master Plan improvements proposed in existing roadways.

Cost estimates for each improvement are prioritized in Section 3 below.

TABLE OF MODELED FUTURE INPUT DATA FOR SWMM

BASIN Sub-basin	Sheet Number	Area (acres)	Width (l.f.)	Avg Slope (%)	Future % Routed (Imperv to Perv)	% Impervious	Curve number	Future Conditions
DRY CEDAR CREEK								
A	DCC1	474.9	2400	1.2	39	49	80	Residential: Low/Med
B	DCC1	322.1	2500	4.0	40	50	81	Med Dens Residential
C	DCC1	214.5	1200	2.0	40	50	81	Med Dens Residential
D	DCC1	28.4	1100	3.5	40	50	81	Med Dens Residential
E	DCC1	591.9	2400	1.2	39	49	80	Residential: Low/Med
F	DCC1	160.3	1400	2.8	39	520	81	Residential
G	DCC1	172.8	2500	1.5	38	48	81	Existing Residential
H	DCC1	12.1	350	2.5	20	50	90	Residential Impervious Areas/ Med Dens
I	DCC1	4.0	50	0.5	0	50	98	Residential Impervious Areas
J	DCC1	257.1	2500	1.5	38	48	81	Existing Residential
K	DCC1	14.9	150	2.1	20	50	90	Residential Impervious Areas/Med Dens
L	DCC1	30.1	700	0.6	40	50	81	Med Dens Residential
M	DCC1	83.7	1200	1.1	33	75	86	Commercial
N	DCC1	28.7	1100	1.5	33	75	86	Commercial
UPSTREAM BASIN (NOT SHOWN)	DCC1	14685.2	10000	5.0	100	0	88	Upstream Basin
HAPPY CANYON								
A	HC1	2,140.0	10000	0.88	63	29	81	River/ Medium Density
B	HC1	1,071.0	2400	0.9	37	47	85	Medium Density Residential
C	HC1	806.0	2600	0.78	39	49	81	Medium Density Residential
D	HC1	694.0	2200	0.6	40	50	81	Medium Density Residential
E	HC1	215.0	3120	0.7	40	50	81	Medium Density Residential
CEDAR CREEK								
Locust Rd. Improvements								
AA	CC3	82.5	1200	2.7	40	50	81	Medium Density
AB	CC3	18.8	400	4.2	40	50	81	Medium Density
AC	CC3	9.7	450	3.2	36	55	81	Mixed Density
AD	CC3	43.4	1200	1.6	40	50	81	Medium Density
AE	CC3	36.6	900	2	40	50	81	Medium Density
Miami Rd. Improvements								
BA	CC3	13.0	1300	5.0	40	50	81	Medium Density
BC	CC3	21.0	900	4.1	40	50	81	Medium Density
BD	CC3	4.0	150	1.1	0	50	98	Residential Impervious Areas
BE	CC3	13.0	300	1.6	36	55	82	Downtown Mixed Density
BF	CC3	12.0	400	1.6	36	55	82	Downtown Mixed Density
BG	CC3	23	600	1.6	36	55	82	Downtown Mixed Density
BH	CC3	7.0	300	1	36	55	82	Downtown Mixed Density
BI	CC3	9.0	700	1.4	36	55	82	Downtown Mixed Density
BJ	CC3	7.0	500	1.5	36	55	82	Downtown Mixed Density
Main Street Improvements								
CA	CC3	4.1	150	0.7	0	50	98	Residential Impervious Areas
CB	CC3	58.7	950	3.3	40	50	81	Mixed Density Medium
CC	CC3	28.3	1000	2.6	40	50	81	Mixed Density Medium
CD	CC3	36.6	850	4.9	40	50	81	Mixed Density Medium
CE	CC3	11.1	625	2.2	40	50	81	Mixed Density Medium
CF	CC3	53.2	900	2.1	40	50	81	Mixed Density Medium
CG	CC3	19.7	350	1.5	0	90	95	Highway Commercial
CH	CC3	17.4	800	1.6	0	90	95	Highway Commercial
CI	CC3	12.9	875	1.5	0	90	95	Highway Commercial
CJ	CC3	25.9	650	1.1	0	90	95	Highway Commercial
CK	CC3	6.3	550	2.0	0	90	95	Highway Commercial
CL	CC3	0.5	100	1.2	0	50	98	Residential Impervious Areas
CM	CC3	13.4	1000	1.9	0	90	95	Highway Commercial
Western Improvements								
EA	CC1	3436.5	1500	3.9	100	0	88	Badlands
EB	CC1	254.7	1200	1.5	38	48	81	1/2 Medium, 1/2 Low Density
EC	CC1	27.9	300	1.8	40	50	81	Medium Density
ED	CC1	33.2	600	1.3	40	50	81	Medium Density
EE	CC1	73.9	800	1.1	40	50	81	Medium Density Residential
EF	CC1	124.7	1700	1.1	40	50	81	Medium Density Residential
EG	CC1	43.8	1500	1.4	40	50	81	Medium Density Residential
FA	CC1	64.6	900	3.5	35	45	80	Low Density Residential
FB	CC1	51.4	1200	4.8	35	45	80	Low Density Residential
FC	CC1	7.8	500	1.1	35	45	80	Low Density Residential
FD	CC1	47.0	1800	3.9	35	45	80	Low Density Residential
FE	CC1	78.2	1800	1.3	40	50	81	Medium Density
FF	CC1	128.8	2000	1.3	40	50	81	Medium Density
FG	CC1	24.7	300	1.3	40	50	81	Medium Density
FH	CC1	32.6	1000	1.1	40	50	81	Medium Density Residential
FI	CC1	3.9	600	1.1	40	50	81	Medium Density Residential
FJ	CC1	163.8	1700	1.0	35	45	80	Low Density Residential
GA	CC1	95.7	1000	1.4	40	50	81	Medium Density
GB	CC1	74.1	1700	2.5	40	50	81	Medium Density
Interior Improvements								
A	CC2	511.4	1500	3.5	100	0	88	Badlands
B	CC2	315.4	1500	3.4	40	50	81	Medium Density Residential
C	CC2	39.0	900	4.5	40	50	81	Medium Density Residential
D	CC2	44.4	1000	4.5	40	50	81	Medium Density Residential
E	CC2	28.3	2000	5.0	35	45	80	Low Density Residential
F	CC2	100.5	1700	1.4	40	50	81	Medium Density Residential
G	CC2	24.6	1000	5.0	35	45	80	Low Density Residential
H	CC2	43.2	2200	1.7	35	45	80	Low Density Residential
I	CC2	41.8	1400	2.0	40	50	81	Medium Density Residential
J	CC2	106.3	1400	1.8	38	48	81	1/2 Medium Res, 1/2 Low Res
K	CC2	49.9	700	1.2	40	50	81	Medium Density Residential
L	CC2	53.4	1500	2.4	40	50	81	Medium Density Residential
M	CC3	22.5	700	1.8	40	50	81	Medium Density Residential

TABLE OF MODELED FUTURE INPUT DATA FOR SWMM - CONTINUED

BASIN Sub-basin	Sheet Number	Area (acres)	Width (l.f.)	Avg Slope (%)	Future % Routed (Imperv to Perv)	% Impervious	Curve number	Future Conditions
UNCOMPAHGRE RIVER								
South Improvements								
AA	UR3	17.5	500	1.1	38	80	86	Industrial
AB	UR3	68.5	900	0.9	40	50	81	Medium Density
AC	UR3	5.7	200	0.9	0	90	95	Business
AD	UR3	33.6	600	0.8	40	50	81	Medium Density
AE	UR3	66.1	1000	0.8	20	70	88	Business/ Med. Dens (50/50)
BA	UR3	9.6	300	1.2	69	41	80	Indust./ Irr. Landsc. (50/50)
BB	UR3	34.1	600	1.1	69	41	80	Indust./ Irr. Landsc. (50/50)
BC	UR3	42.7	900	1.1	38	80	86	Industrial
BD	UR3	67.5	1100	1.0	20	70	88	Business Com./ Med Dens.
CA	UR3	53.0	900	1.1	38	80	86	Industrial
CB	UR3	6.3	300	1.0	33	75	86	Commercial Area
CC	UR3	35.5	1400	0.9	40	50	81	Medium Density
CD	UR3	36.0	500	0.9	40	50	81	Medium Density
CE	UR3	44.0	1100	0.8	40	50	81	Medium Density
DA	UR2	41.0	700	1.3	36	55	82	Downtown Mixed Density
DB	UR2	1.3	100	0.9	50	26	84	Imp. Area/ Natural (50/50)
DC	UR2	3.5	200	1.1	0	90	95	Highway Commercial
DD	UR2	10.8	400	1.1	0	90	95	Highway Commercial
DF	UR2	1.1	50	0.8	0	50	98	Impervious Area
DF	UR2	14.4	500	1.0	36	55	82	Downtown Mixed Density
DG	UR2	24.9	600	1.1	36	55	82	Downtown Mixed Density
DH	UR2	38.5	700	1.0	100	2	74	Irrigated Landscaping
DI	UR2	15.0	300	1.0	67	39	80	Com./ Irrig. Land (50/50)
DJ	UR2	61.6	1000	0.9	36	55	82	Downtown Mixed Density
Middle Improvements								
AA	UR2	6.7	200	1.5	33	75	86	Commercial
AB	UR2	18.1	500	1.1	33	75	86	Commercial
AC	UR2	24.7	400	1.3	33	75	86	Commercial
AD	UR2	19.2	500	1.4	33	75	86	Commercial
BA	UR2	29.6	500	1.2	33	75	86	Commercial
BB	UR2	22.9	500	1.1	33	75	86	Commercial
CA	UR2	13.9	400	1.4	33	75	86	Commercial
CB	UR2	18.8	500	1.1	33	75	86	Commercial
CC	UR2	15.9	500	1.5	0	90	95	Central Business
North Improvements								
A	UR1	19.9	800	0.6	38	80	86	Emplymnt Cntr (Ind./ Airport)
B	UR1	21.1	500	0.9	38	80	86	Emplymnt Cntr (Ind./ Airport)
C	UR1	10.0	500	1.3	38	80	86	Emplymnt Cntr (Ind./ Airport)
D	UR1	35.4	500	0.9	38	80	86	Emplymnt Cntr (Ind./ Airport)
E	UR1	20.3	500	0.9	38	80	86	Emplymnt Cntr (Ind./ Airport)
F	UR1	27.7	700	0.9	38	80	86	Emplymnt Cntr (Ind./ Airport)
G	UR1	18.7	800	1.0	38	80	86	Emplymnt Cntr (Ind./ Airport)
H	UR1	14.7	500	1.4	38	80	86	Emplymnt Cntr (Ind./ Airport)
I	UR1	39.3	800	1.1	38	80	86	Emplymnt Cntr (Ind./ Airport)
J	UR1	66.2	1000	1.0	38	80	86	Emplymnt Cntr (Ind./ Airport)
K	UR1	10.7	300	1.3	38	80	86	Emplymnt Cntr (Ind./ Airport)
MONTROSE ARROYO								
Sunnyside Improvements								
AA	MA1	908.0	3200	1.8	38	49	81	Mostly Medium Density
AB	MA1	97.7	1500	1.7	70	26	78	Golf Course/ Med Density
AC	MA1	21.5	900	1.5	40	50	81	Medium Density Residential
AD	MA1	51.4	700	1.4	40	50	81	Medium Density
AE	MA1	59.0	700	1.2	40	50	81	Med. Dens./ Small Park
AF	MA1	98.3	700	1.1	40	50	81	Medium Density
AG	MA1	14.7	1000	6.0	36	55	82	Downtown Mixed Density
AH	MA1	6.6	400	2.2	36	55	82	Downtown Mixed Density
AI	MA1	32.1	1100	2.3	36	55	82	Downtown Mixed Density
AJ	MA1	15.5	700	1.4	36	55	82	Downtown Mixed Density
AK	MA1	12.2	1500	1.6	36	55	82	Downtown Mixed Density
AL	MA1	17.1	700	1.4	36	55	82	Downtown Mixed Density
AM	MA1	14.6	1500	1.6	36	55	82	Downtown Mixed Density
AN	MA1	10.4	700	0.9	36	55	82	Downtown Mixed Density
Niagara Rd. Improvements								
BA	MA1	8.6	125	2.4	0	50	98	Residential Imp. Area
BB	MA1	24.0	1000	1.8	40	50	81	Medium Density Residential
BC	MA1	47.3	1200	1.4	33	75	86	Commercial Area
BD	MA1	64.6	1200	2.4	40	50	81	Medium Density Residential
BE	MA1	5.6	230	1.4	40	50	81	Medium Density Residential
BF	MA1	12.2	500	0.6	40	50	81	Medium Density Residential
Oak Grove Road Improvements								
CA	MA3	243.0	2000	2.0	40	40	80	Residential
CB	MA3	107.0	1000	2.0	40	40	80	Residential
CC	MA3	220.0	400	2.0	40	40	80	Residential
Misc. Mont. Arroyo Impvmnts								
DA	MA3	88.0	3200	1.8	38	49	81	Mostly Medium Density
DB	MA3	182.0	1000	2.0	70	26	78	Medium Density / Golf Course

2. RECOMMENDED IMPROVEMENTS BY DRAINAGE BASIN:

a. Cedar Creek (CC):

Areas of the Cedar Creek drainage basin near the business district are currently developed with limited opportunity for detention. Outlying areas are less developed, affording opportunity to implement storm water detention as development occurs, which will minimize impact to the creek and reduce infrastructure requirements. Estimates of aggregate detention required in each sub-basin to restrict runoff to pre-developed flows are shown on sheets C-1 through C-3. The Cedar Creek channel is primarily intact although adjacent land use has degraded the side slopes and channel in some areas and restoration maybe required as adjacent development occurs, particularly benching and stabilization of slopes.

The Cedar Creek basin was divided into western, northern and southern drainage basin areas with proposed improvements as follows:

Cedar Creek Western (CCW):
This drainage basin is largely undeveloped with some residential subdivision between 6530 Road and 6600 Road; no existing problems were noted. Existing drainage generally follows waste ditches; the City will need to acquire ownership of or an adjacent easement to the I-Drain to service part this basin (see waste drain discussion under "1. *CRITERIA FOR FUTURE IMPROVEMENTS PLAN, paragraph d* "). Proposed improvements may be piped or flow in open channels in the future road corridors for Lilac Road and Lincoln Road, conveying flows west to 64.50 Road, with discharge to the H Drain and D6.40 Lateral. The southern area on 65.30 Road will utilize the I Drain corridor with discharge to Cedar Creek.

Cedar Creek Northern (CCN):
This drainage basin is primarily undeveloped with some scattered residential subdivisions and no existing problems were noted. Existing drainage generally follows the J-Drain, which is the low area for the basin. The City will need to acquire ownership of or an easement adjacent to the J-Drain in order to service this basin (see waste drain discussion under "1. *CRITERIA FOR FUTURE IMPROVEMENTS PLAN, paragraph d* "). Proposed improvements may be piped or open channel conveyance generally following the J Drain with discharge to Cedar Creek just upstream of 6530 Road.

Cedar Creek Southern (CCS):
The southern area includes the Highway 50, Miami Road and Locust Road corridors, east of San Juan Avenue. Problem areas noted in this basin include:

- Drainage from Highway 50, east of Hillcrest Drive, drains to an irrigation ditch near Rose Lane and causes private property flooding periodically
- the Miami Road drainage, east of the Loutsenhizer Canal, drains into the canal which is not acceptable for future development
- The Hillcrest Drive/Miami Road intersection drains into an irrigation ditch with minimal excess capacity
- Drainage from Pennsylvania Avenue is not functional
- The Miami Road/San Juan Avenue drainage is not functional

Improvements proposed include:

- Areas adjacent to the Creek can be drained directly to the creek with appropriate detention and water quality facilities.

- **CCS-1: Locust Road Corridor**: As development occurs, drainage from the Locust Road corridor can be piped west to Mesa Vista Drive and north to the proposed Cedar Creek North Improvements (see CCN).

- **CCS 2: Miami Road from Hillcrest Drive west:** The Miami Road corridor from Hillcrest Drive west is proposed to be piped west to San Juan Avenue, then northerly along San Juan Avenue to Cedar Creek at approximately North 3rd Street. By continuing this piped system to North 3rd flows are discharged past the channelized reach of Cedar Creek which occurs just north of Highway 50, and there is opportunity for water quality enhancement at the outfall location. As San Juan Avenue was recently improved, an alternative would be to route this improvement along Stough Avenue instead of San Juan Avenue to combine the storm drain construction with road improvements. This improvement has the added advantage of intercepting flows that go west to the Montrose Arroyo and contribute to flooding in that basin.

- **CCS-3: Highway 50:** The Highway 50 corridor is proposed to be conveyed west to Rose Lane and south to the creek in a dedicated storm drain line, separate from existing irrigation. Storm inlets behind the Red Arrow Lodge are suspected to discharge to the sanitary sewer and can be redirected to this storm drain. Highway development east of Hillcrest Drive may allow conveyance using open channels instead of piped improvements. An alternative would be to route this improvement south on Hillcrest Drive instead of Rose Lane should this coincide with planned road improvements. This alternative would require a smaller improvement at Rose Lane.

- **CCS 4: Miami Road east of Hillcrest Drive:** Runoff from Miami Road east of Hillcrest Drive and associated areas can be discharged to Cedar Creek at several locations, as shown on the attached exhibit, as development occurs. Appropriate detention and water quality controls should be employed.

b. Dry Cedar Creek (DCC):

The majority of the Dry Cedar Creek drainage basin is undeveloped affording opportunity to implement storm water detention as development occurs, which will minimize impact to the creek and reduce infrastructure requirements. Estimates of aggregate detention required in each sub-basin to restrict runoff to pre-developed flows are shown on sheets DCC-1 and DCC-2. The Dry Cedar Creek channel is primarily intact although adjacent land use has degraded the side slopes and channel in some areas and restoration will be required as adjacent development occurs, particularly benching and stabilization of slopes. There were no existing problem areas identified in this basin although two specific improvements proposed are designed to mitigate problems in adjacent basins as follows:

- **DCC 1- 6725 Road/Ogden Road:** Divert storm water from Montrose Arroyo Basin 9 (MA9) to Dry Cedar Creek to reduce flooding and infrastructure needs in the downstream Montrose Arroyo basins. MA9 is south of Ogden Road and generally between 6725 Road and a ridge east of Dry Cedar Creek. Drainage from this basin runs

north to Ogden Road and into the C-drain with discharge to the Montrose Arroyo near Oak Grove Road, at the Bridges Golf Course. The C-Drain will continue to deliver irrigation water to the Bridges Golf Course with storm water infrastructure intended to direct runoff south to Dry Cedar Creek, near the intersection of Ogden and Odelle Roads, where the natural ridge line dividing these basins is minimal. The Dry Cedar Creek crossings at the Loutsenhizer canal, at Woodgate Road and at Highway 550 have excess capacity to accommodate these flows. The "*Flood Control and Drainage Plan"* by Gingery and Associates, 1981, and the "*Floodplain Information and Urban Drainage Report"* by Hydro-Triad Ltd. 1979, both discussed potential diversion of flows from the Montrose Arroyo as a means to mitigate flooding through the downtown area.

- **DCC 2 - Odelle Road / Highway 550**: Divert storm water from a portion of the Uncompahgre River basin drainage, at the Highway 550/ Woodgate corridor, south to Dry Cedar Creek to reduce downstream flooding at the intersection of Oak Grove Road and Highway 550. This drainage area has existing commercial land use with no existing detention. The Dry Creek crossing at Highway 550 has excess capacity to accommodate these flows. Piped conveyance would be extended from Kellie Drive on Woodgate Road, and on Odelle Road, to the highway corridor and directed south to Dry Cedar Creek.

The other recommended master plan improvements, as described below, primarily pertain to the development of the Woodgate Road corridor and the road itself. For development to the east of and below Woodgate Road, the City should ensure conveyance corridors are set aside to allow access to the Creek.

- **DCC 3 – Woodgate from Dry Cedar Creek at Ogden Road, south to Otter Road**: Option A extends an 18-inch pipe south to collect road drainage and the small contributory areas adjacent to the road with discharge to Dry Cedar Creek. Option B would extend this pipe further south as noted below (DCC 4); no upsizing is required for the extension in Option B. Minimal opportunities for storm water detention/water quality areas exist in this corridor due to existing development and topography; however we have shown two potential locations, one immediately upstream of the piped discharge to the creek (east side of road) and a second immediately upstream of the Loutsenhizer crossing. There is also an opportunity to add a water quality area at the Ogden and Woodgate intersection, when it is improved.

- **DCC 4: Woodgate Road from Otter Road south to Pioneer Road:** Option A extends an 18-inch pipe south on Woodgate Road from Otter Road to collect road drainage and the small contributory areas adjacent to the road, with discharge to a proposed pipe in Otter Road, running east to Dry Cedar Creek. Option B would discharge to a pipe continuing north on Woodgate instead of using Otter Road, connecting to DCC 3 above, with ultimate discharge to Dry Cedar Creek at Woodgate/Ogden Road.

- **DCC 5: Kinikin Road to Dry Cedar Creek:** There is a low point on Kinikin Road that collects road drainage and the small contributory areas above the road. Currently this has informal discharge to road side drainage with ultimate discharge to Dry Cedar Creek. As the area develops a conveyance easement from this low spot needs to be reserved and potentially a piped discharge will ultimately be required as shown as an 18-inch pipe on the attached exhibit.

- **DCC 6: Otter Road from Woodgate Road east to Dry Cedar Creek**: Otter Road and adjacent drainage basins are proposed to be piped along Otter Road to Dry Cedar Creek with a detention/water quality area immediately prior to discharge. Option A includes drainage from Woodgate Road; Option B is Otter road drainage only.

c. Happy Canyon

The majority of the Happy Canyon Cedar Creek drainage basin is undeveloped affording opportunity to implement storm water detention as development occurs, which will minimize impact to the creek and reduce infrastructure requirements. Currently the majority of this basin is outside City limits. Estimates of aggregate detention required in each sub-basin to restrict runoff to pre-developed flows are shown on the attached exhibit.

Montrose County noted the structure at Oak Grove Road causes backwater and overbank flooding during large storm events and that the channel below Oak Grove Road also exhibits overbank flooding. No improvement was proposed for this flooding as it was not noted as it can be accommodated with future development and provides flood storage. No other existing problem areas were identified in this basin. There is substantial open irrigation in this basin that potentially could conflict with storm drainage.

Recommended improvements are shown on sheet HC-1 and are primarily to reserve conveyance corridors and to construct dedicated storm drainage conveyance as development occurs. The conveyance corridors shown include Marine Road, Spring Creek Road, Oak Grove Road, and the future Orange Road alignment. Some areas in the basin may lend themselves to infiltration of storm water runoff and that option can be assessed on a case by case basis as development occurs.

d. Montrose Arroyo

The Montrose Arroyo Basin, north of Niagara Road, is very developed with limited opportunity for detention. Between Niagara Road and Main Street the Arroyo has been channelized and piped in segments and is also impacted by irrigation flows and structures, limiting the channel capacity. Existing drainage infrastructure in this basin is minimal, has a lack of inlet capacity, and often overlaps with irrigation infrastructure. Many of the problem areas identified by the City are within the Montrose Arroyo basin and are surface and channel flooding. General improvements for this basin are:

- Improve channelized sections
- Separate irrigation flows from storm flows
- Provide more inlet capacity on drainage systems
- Add detention where possible
- Minimize future channelization and piping
- Negotiate for "off-channel" structures for irrigation

The potential to divert storm water flows from development south of Ogden Road to Dry Cedar Creek, alleviating impact to Montrose Arroyo, are discussed under improvement DCC-1. The remainder of the proposed Master Plan improvements for Montrose Arroyo are shown on sheets MA-1 to MA-3 the sketches for the northern and southern basins and described as follows.

MA-1 Niagara Road from 6700 Road to Hillcrest: The Niagara Road drainage, west of 6700 Road, is proposed to be piped to the Montrose Arroyo at Hillcrest Drive with appropriate inlets. Discharge is to an existing detention/settling structure at the southwest corner of

Hillcrest Drive and Niagara Road that is currently underutilized, with outlet to the Montrose Arroyo. This improvement will convey street drainage past the Loutsenhizer Canal, eliminating the current discharge to the canal, and will alleviate roadside flooding that currently occurs in the lower reach of this corridor. This system will separate Niagara Road drainage from Hillcrest Drive drainage, alleviating surcharge of the drainage manhole at Hillcrest Drive and Altrusa Park. Additional inlet capacity should be added at James and Kent Streets to resolve street flooding. Opportunities for detention and water quality enhancement occur at the City open space / park parcels on the north and south side of Niagara Road, east of Pavilion Drive.

MA-2 Sunnyside Road from 6700 Road, west to Bristol Drive, north to North 2nd Street: The Sunnyside Road corridor, east of the Loutsenhizer Canal, has seen recent development with opportunity for further development. Plans are being developed for extension and widening of 6700 Road which will impact this corridor. Currently developed drainage is directed to the H drain and discharged to the canal; this is not favored due to policy and the lack of capacity in the canal, and will become more problematic as additional development occurs. West of the canal, drainage is directed to the KA Drain at South 11th Street and Nevada Avenue, and is intermixed with irrigation supply and waste flows, causing flooding during storm events.

The proposed improvements are a dedicated storm water system on Sunnyside Road, including appropriate inlets, from 6700 Road west to Bristol Drive. A connection to the south at Hillcrest Drive will pick up a low area that floods due to irrigation conflicts, improvement of inlet capacity will be required. At Bristol Drive the existing two 36-inch pipes that service both the existing irrigation system and drainage system (with cross-connection for balancing of flows), will convey flows north to the KA Drain at 11th Street. A diversion is proposed at 11th Street to allow 50-cfs to continue into the KA Drain with discharge to the arroyo, with the excess flows piped north on Nevada Avenue to North 2nd Street, bypassing the constricted reaches of the Montrose Arroyo. Drainage in the Nevada Avenue corridor will be intercepted by this new system. An alternative to improve restricted areas was not considered due to physical constraints and the risk of moving the problem elsewhere.

Option B: Due to the pipe sizes required to provide a bypass for this large basin to North 2nd Street, alternatives to continue this flow west with ultimate discharge to the Uncompahgre River were developed. These alternatives are "Option B" and are shown on the Uncompahgre River improvements. Using Option B allows for the interceptor pipe on Nevada Avenue to begin further north, at South 9th Street, and continue north to North 2nd Street, again intercepting adjacent road drainage and bypassing the constructed segment of the Montrose Arroyo. Similar bypass proposals to divert a portion of the Arroyo flows to the Uncompahgre River were presented in the past studies; "*Flood Control and Drainage Plan*" by Gingery and Associates, 1981, and the "*Floodplain Information and Urban Drainage Report"* by Hydro-Triad Ltd. 1979. These two past studies had different corridors identified for the bypass and looked at 100-year flood flows rather than the 10-year design storm we have considered.

Preferred Alternative: After review of pipe routing, sizing, and potential costs for Options A and B, it was determined that Option A was the preferred alternative. However; based on review of the past two studies that recommend a 100-year bypass option to the Uncompahgre River, the bypass proposed in Option B, using the Cascade Avenue and Colorado Avenue alignment, could be included in proposed improvements to alleviate 100-year flooding on the Montrose Arroyo.

MA-3 East Oak Grove and 6700 Road: MA-3 addresses the area between Ogden Road and Niagara Road, east of the Montrose Arroyo. There are several large residential developments in this area and there are plans to widen 6700 Road in this corridor. Proposed improvements will connect piecemeal improvements installed in the individual developments and provide infrastructure for future development, with a corridor for outfall to the Montrose Arroyo. Improvements and outfall corridor follow the A Drain, we understand the City owns a portion of the A Drain and will need to pursue ownership of the entire drain.

The existing 36-inch pipe at Niagara Road low point, east of 6700 Road, is proposed to be piped south in the waste ditch alignment (see general typical waste ditch detail) to the existing detention at Meadows Parkway with controlled release to a 36-inch drain in 6700 Road (also in the A-drain alignment). Allowance should be made for groundwater and irrigation waste flows to bypass the detention. The intersection of Meadows Parkway should be improved with inlets and piped to the detention area.

East Oak Grove and a portion of 6750 Road south of East Oak Grove will be drained west to the intersection of East Oak Grove and 6700 Road, connecting with the proposed 36-inch line in 6700 Road, and discharged to detention at this intersection. Existing detention at Monte Vista and Fox Park Subdivisions should be retrofitted to accept adjacent road drainage and to provide water quality enhancement. There is an existing detention area in place at 6700 Road and East Oak Grove, that may be utilized or may need to be reconstructed due to road improvements. Allowance should be made for low flow bypass of detention to meet downstream irrigation needs. The detention area will discharge to a piped or open channel conveyance, following the alignment of the A Drain, to the west, with ultimate discharge to the Montrose Arroyo. We recommend the discharge be similar to the general typical waste ditch detail shown under "1. *CRITERIA FOR FUTURE IMPROVEMENTS PLAN, paragraph d.",* this should be compatible with the downstream golf course development.

MA-4 Montrose Arroyo at 12th Street: The existing structure on the Montrose Arroyo at the 12th Street crossing is an 8-foot wide by 3.25-foot high box culvert. The profile of this culvert and the channel at this location causes backwater conditions even during small storm events and limits capacity, restricting flows. A detailed channel survey and hydraulic analysis should be conducted to determine what size and shape structure should be installed with associated channel regarding. This survey and analysis should extend downstream to ensure the restriction is fully mitigated and not just moved downstream to the next structure. The reach of the arroyo above this location is in open space providing opportunity to create larger overbank areas for storage of flood flows.

MA-5 Oak Grove - Eastern: MA-5 addresses the road drainage in the vicinity of 6800 Road and Oak Grove Road. Conveyance pipes 18" in diameter are proposed on westbound Oak Grove Road, eastbound Oak Grove Road and southbound 6800 Road. All three of these pipes will flow into the natural drainage corridor and then into the Montrose Arroyo.

MA-6 6700 Road south to Montrose Arroyo: MA-6 addresses the future and existing development north of the Montrose Arroyo and east of 6700 Road. A proposed 18" pipe will convey the water from the high point in 6700 Road to the Montrose Arroyo.

e. Selig Canal

No improvements are proposed.

f. Uncompahgre River

The Uncompahgre River Basin, east of the river channel, is very developed with high percent of impervious area and limited opportunity for detention. The City is in the process of developing a river buffer requirement to preserve the natural channel and overbanks of the river, with future plans for a River Corridor Master Plan.

Existing drainage infrastructure in this basin is intermittent, has a lack of inlet capacity, and often overlaps with irrigation infrastructure. Conveyance of drainage from east to west is impeded by the railroad and by the state highway with limited existing drainage crossings of these two corridors. Several of the major problem areas identified by the City are within the Uncompahgre River basin and are surface and channel flooding. General improvements for this basin are:

- Separate irrigation flows from storm flows
- Provide more inlet capacity on drainage systems
- Add detention where possible
- Protect the river and overbank capacity
- Reduce impervious area
- Negotiate for improved conveyance or elimination of irrigation flow

The proposed Master Plan improvements for Uncompahgre River basin are shown on sheets UR-1 to UR-3 for the north, middle and south basins and described as follows.

UR North - Highway 50 corridor from San Juan Bypass north to Cedar Creek: This drainage basin is developed and has a high percentage of impervious area due the industrial/commercial use associated with the highway corridor. The current drainage for this corridor is roadside open channel with culverts at driveways; there is no curb on the highway. This functions well on the west side of the highway due to the small drainage area, limited driveway crossings, and well maintained vegetated channel which can accommodate short term ponding. On the east side of the highway, the numerous driveway crossings restrict flows and culverts are often partially blocked due to sediment, debris and damage. Also on the east side, due to the commercial nature of the businesses along this corridor, the roadside drainage channel is gravel and has been restricted to a small frontage area, causing high velocities and associated erosion and sediment problems and deterioration of the channel. A major problem occurs on the east side of the highway at the north end of the Parish Oil property where the open channel enters a piped system. The entrance to the piped system has insufficient capacity for the storm drainage and causes significant ponding on a regular basis.

Proposed improvements for the east side of the highway, shown on the attached sketch, are piped conveyance starting at the existing piped system at the San Juan bypass and continuing north to the Cedar Creek crossing under Highway 50. This system shall include appropriate inlet capacity. An open channel could be considered, however due to the nature of the drainage this would be a large structure and would need armoring possibly creating a hazard. An alternative, as shown on the attached sketch, uses the La Salle Road corridor to divert flows west to the Uncompahgre River instead of continuing north to Cedar Creek. This alternative would require a bore under the highway and under the railroad and associated permitting.

Any redevelopment of properties in this corridor should require on-site detention of storm water and reduction of impervious area to reduce runoff.

UR Middle – Rio Grande and Townsend Avenue corridors from Colorado Avenue north to the San Juan Bypass: This drainage basin is developed with mixed business/commercial and high density residential use. The current drainage for this corridor is a mix of piped conveyance and roadside open channels often mixed with irrigation flows. Conveyance of drainage from east to west is impeded by the railroad with limited existing drainage crossings of this structure. Existing problems identified in this drainage basin are surface flooding due to insufficient inlet capacity, localized grading problems, maintenance issues, and irrigation conflicts.

Proposed improvements are a dedicated piped storm drainage system along the Rio Grande and Grand Avenue corridor with discharge west to the Uncompahgre River at Main Street, North 5th Street, North 9th Street and near the north end of Grand Avenue. All identified outfall points currently exist but need to be upgraded with appropriately sizing and can be open channel where appropriate. This system shall include addition of appropriate inlet capacity and connection to lateral drainage from streets east of Rio Grande and Grand Avenue. Water quality structures should be developed, where possible, at outfall points to the river.

An existing problem area was noted at North 5th Street and the railroad, with noted surface flooding to the south of this location. There is an existing piped drainage system in place that should service this area that apparently is not functioning. Inlets on this system should be located and cleaned and a concrete apron installed around the grate to improve function, additional inlets should be installed at any localized low areas. The pipes on this system should be cleaned and checked by camera for maintenance issues, any pipes under 15-inches in diameter should be upgraded to a minimum size of 18-inches in diameter.

UR South – Rio Grande and Townsend Avenue corridor from Odelle Road north to Colorado Avenue: This drainage basin is developed with mixed business/commercial and mid to high density residential use. The current drainage for this corridor is a mix of piped conveyance and roadside open channels often mixed with irrigation flows. North of Oak Grove Road, conveyance of drainage from east to west is impeded by the railroad with limited existing drainage crossings of this structure. Existing problems identified in this drainage basin are primarily due to lack of storm water infrastructure, causing surface and open channel flooding.

Proposed improvements are a dedicated storm drainage conveyance system and appropriate inlet capacity with 3 outfall points as follows:

Outfall at west end of Oak Grove Road: This outfall will service storm drainage from Woodgate Road, Highway 50, and East Oak Grove Road as shown on sheet UR-3. This system will require a new 36-inch diameter piped crossing of the highway at the East Oak Grove intersection to provide capacity for drainage from the east. This system will also replace the current gravel conveyance ditch along the south side of Oak Grove Road, west of the highway, that is problematic due to volume of runoff and associated erosive velocities. Outfall is to the existing drainage channel on the west side of the City bike path with ultimate discharge to the Uncompahgre River to the southwest. Water quality enhancement should be developed at the outfall.

Outfall at Recreation District pond at McNeil Fields: This outfall will service storm drainage from Rio Grande Avenue, Highway 50 and adjacent drainage areas, between Oak Grove Road to the south, and Niagara Road to the north, as shown on the attached sketch. Existing problems occur due to insufficient storm drainage infrastructure and conflict with irrigation flows. The proposed system will provide dedicated storm water conveyance with appropriate inlet capacity and will require a new 36-inch diameter piped crossing of railroad at the Recreation District Road, to provide capacity for drainage from the east. A detention/water quality facility is proposed at the former railroad turn out to the west of Montrose Drive, the City will need to obtain an easement if this property is still under railroad ownership. Sizing of the system, as shown on the attached sketch, shows two alternatives; service for the basin described above, and an alternative that includes flows bypassed from the Montrose Arroyo basin (Montrose Arroyo 2: Option B). The piped conveyance and associated inlets along the Recreation District Road will mitigate on-going flooding due to storm water discharge to the irrigation ditch along this road. Outfall to the pond will need to be negotiated with the Recreation District and shall include an overflow to the Uncompahgre River to the southwest.

Outfall to existing bermed low area at west end of Colorado Avenue (behind bus barn): There is a low area/impoundment at this location, caused by berming for sewer line construction, that can provide storm water detention and water quality enhancement, with overflow to the west to the Uncompahgre River. This outfall will service drainage from a segment of Rio Grande Avenue, Colorado Avenue, Townsend Avenue and adjacent drainage areas as shown on the attached sketch. The proposed system will provide dedicated storm water conveyance with appropriate inlet capacity and will require a new 36-inch diameter piped crossing of railroad at Colorado Avenue to provide capacity for drainage from the east. Sizing of the system, as shown on sheet UR-3, shows two alternatives; service for the basin described above including flows bypassed from the Montrose Arroyo basin (Montrose Arroyo 2: Option B), and sizing without the bypassed flows. The piped conveyance and associated inlets along the Rio Grande and the collection of flows from the Colorado Avenue will mitigate on-going road side flooding due to storm water discharge to the irrigation ditches. The outfall design will need to consider a stilling basin to dissipate energy and appropriate overflow structure to prevent erosion of the bermed sewer construction.

LEGEND

12"	EXISTING STORM SYSTEM (PIPE SIZE AS NOTED)
IR	EXISTING IRRIGATION LINE
36"	PROPOSED STORM SYSTEM IMPROVEMENTS (PIPE SIZE AS NOTED)
36"	ALTERNATIVE STORM SYSTEM IMPROVEMENT (PIPE SIZE AS NOTED)
	SUB-BASIN BOUNDARY
	SURFACE DRAINAGE ARROW
	POSSIBLE DETENTION/WATER QUALITY LOCATION. SIZE NOT DETERMINED
5	AGGREGATE DETENTION REQUIRED TO DETAIN TO 100-YEAR HISTORIC FLOWS (AC-FT AS NOTED ON PLAN) – LOCATION DETERMINED ONLY BY BASIN
	WATERCOURSE (STREAM, CANAL, RIVER, DITCHES, ETC.)
$Q_{10} = 10$	10 YEAR DEVELOPED FLOW DATA (CFS)
$Q_{100} = 20$	100 YEAR DEVELOPED FLOW DATA (CFS)
$Q_{FULL} = 10$	FLOW RATE WITH FULL PIPE (CFS)
$Q_{SUR} = 20$	FLOW RATE WITH SURCHARGED PIPE (CFS)
$Q_{IRR} = 10$	FLOW RATE OF IRRIGATION (CFS)
	PRIORITY ONE IMPROVEMENTS
	PRIORITY TWO IMPROVEMENTS
	PRIORITY THREE IMPROVEMENTS

NOTES

1. THE CITY OF MONTROSE SHALL TO SECURE AN EASEMENT WITH THE DITCH COMPANY FOR PIPES THAT FOLLOW EXISTING DITCHES.
2. FOR PIPES THAT FLOW ACROSS OPEN FIELDS THE CITY OF MONTROSE WILL SHALL TO SECURE RIGHT-OF-WAY OR EASEMENTS FROM PROPERTY OWNERS.
3. SOILS ARE HSG CLASS D FOR THE ADOBE HILLS. MOST OF THE AREA WITHIN THE GROWTH BOUNDARY IS NOT WITHIN THE ADOBE HILLS. ALL BASINS WITHIN THE GROWTH BOUNDARY ARE ASSUMED TO BE HSG CLASS C.

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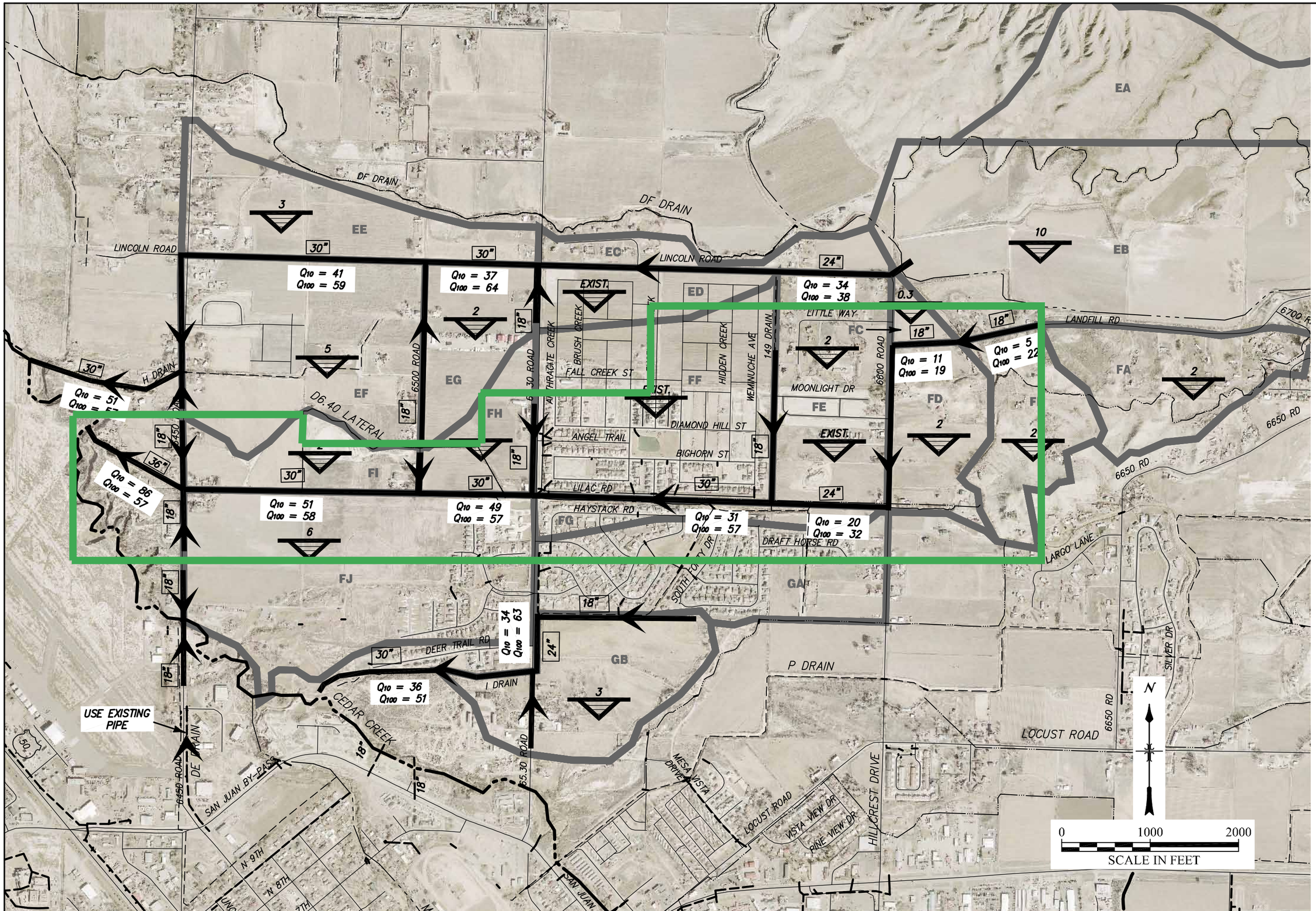
REVISIONS	DATE

CITY OF MONTROSE
STORM DRAIN MASTER PLAN IMPROVEMENTS
NOTES AND LEGEND

DESIGNED	JK
DRAWN	DDC
DATE	9-30-09
PROJ. NO.	08-317

DRAWING NUMBER
GEN-1



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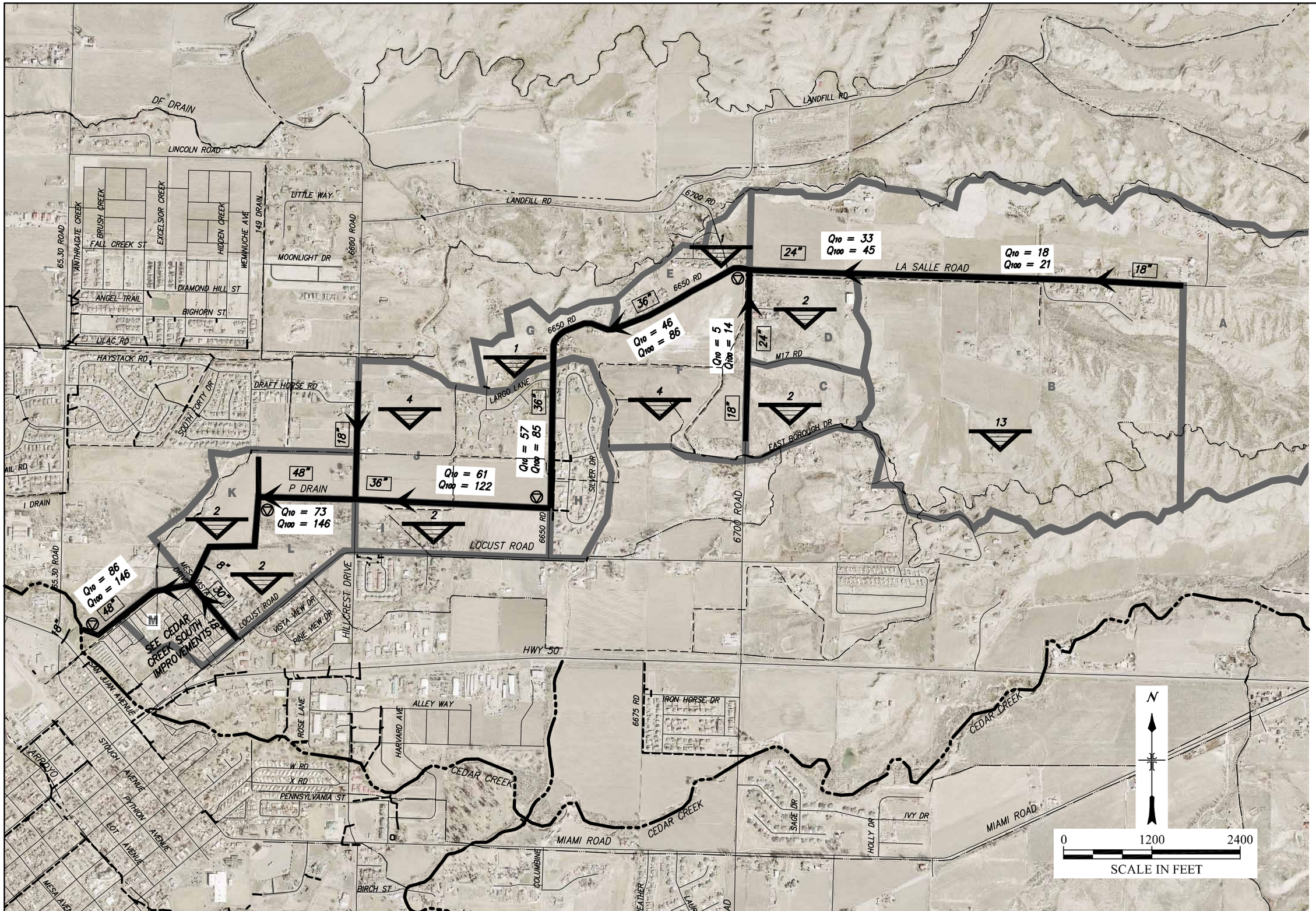
REVISIONS	DATE

CITY OF MONTROSE
STORM DRAIN MASTER PLAN IMPROVEMENTS
WESTERN CEDAR CREEK DRAINAGE BASIN

DESIGNED	JK
DRAWN	DDC
DATE	9-30-09
PROJ. NO.	08-317

DRAWING NUMBER
CC-1



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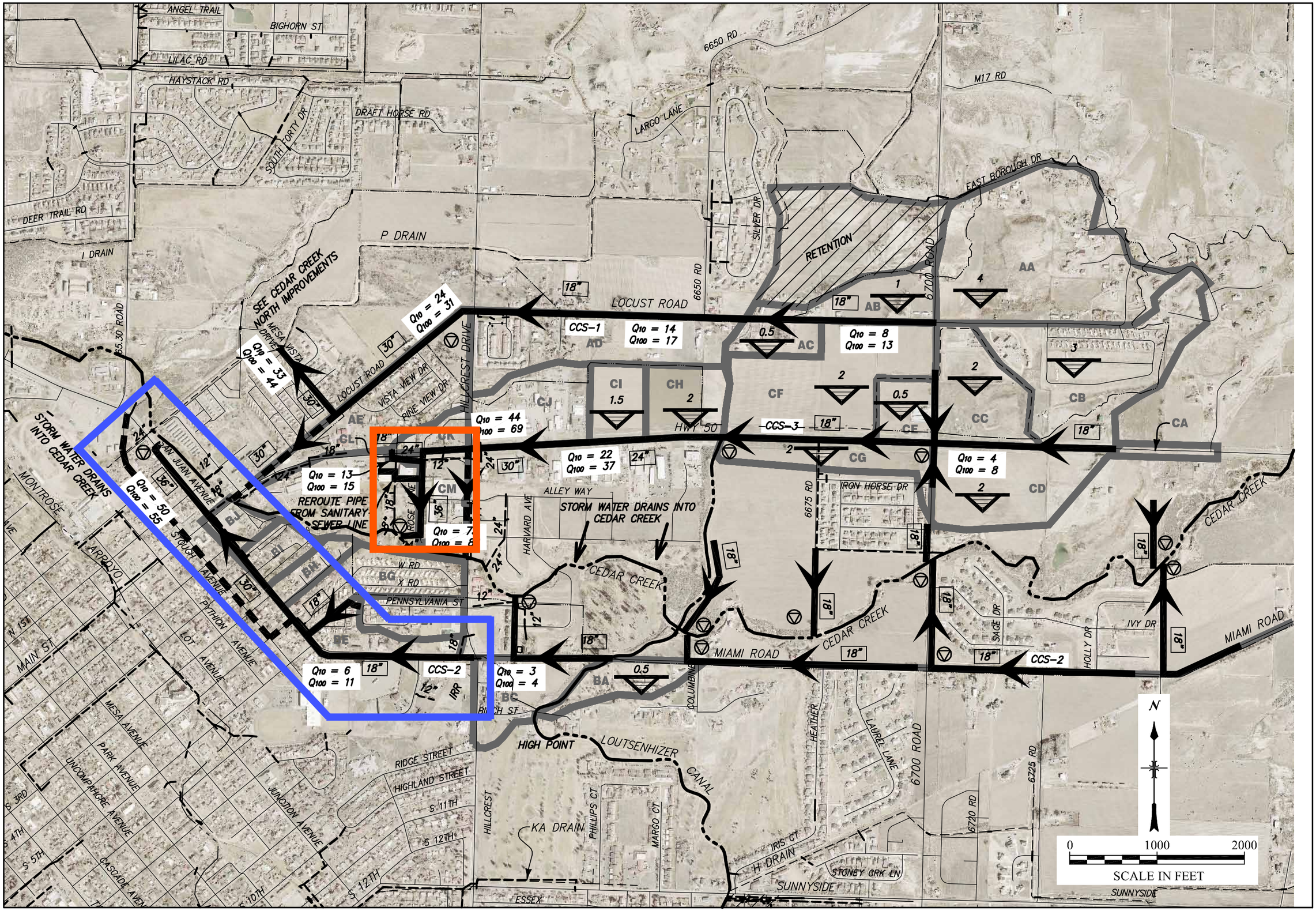
REVISIONS | DATE

CITY OF MONTROSE
STORM DRAIN MASTER PLAN IMPROVEMENTS
NORTHERN CEDAR CREEK DRAINAGE BASIN

DESIGNED	JK
DRAWN	DDC
DATE	9-30-09
PROJ. NO.	08-317

DRAWING NUMBER

CC-2



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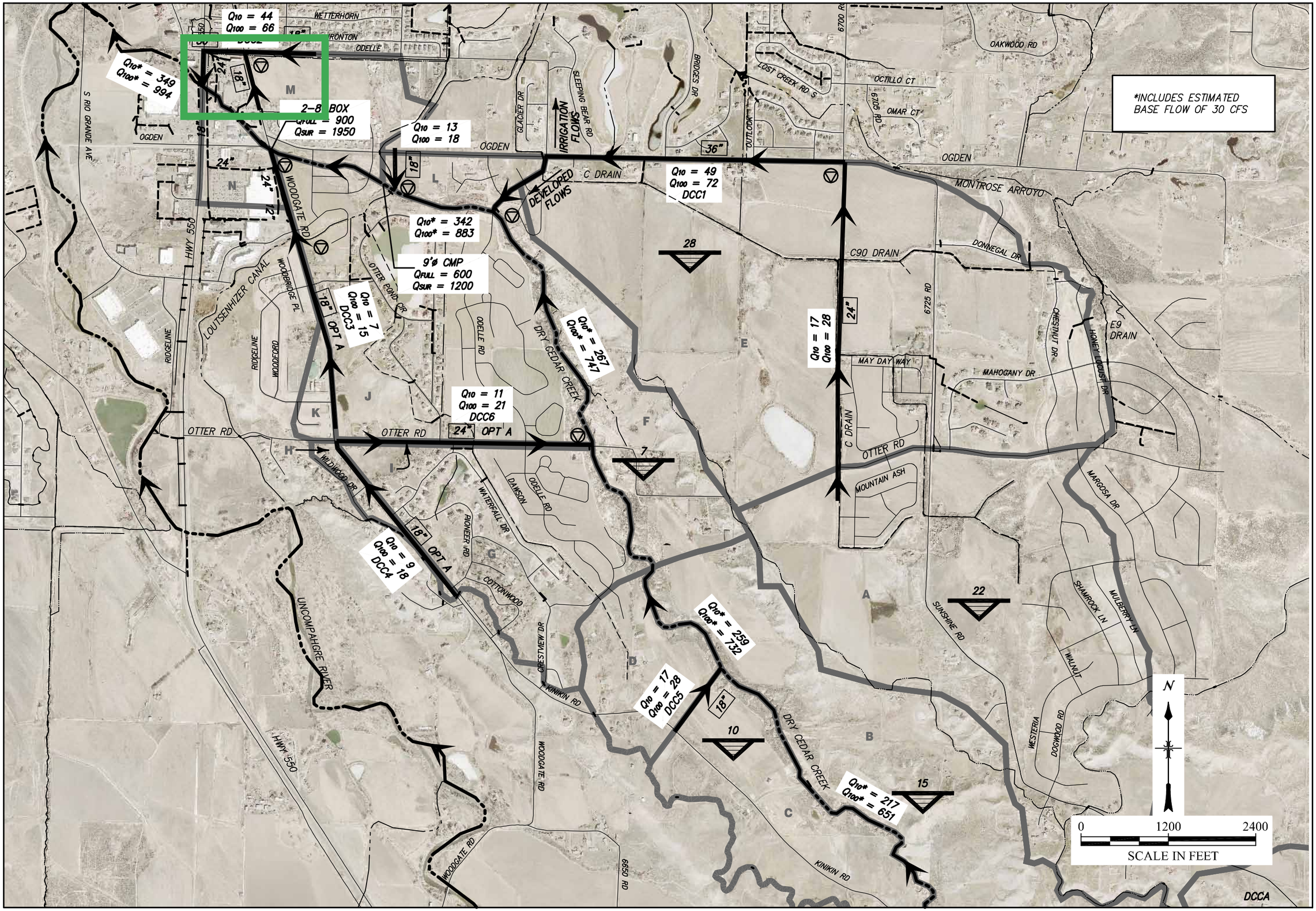
REVISIONS | DATE

CITY OF MONTROSE
STORM DRAIN MASTER PLAN IMPROVEMENTS
SOUTHERN CEDAR CREEK DRAINAGE BASIN

DESIGNED	JK
DRAWN	DDC
DATE	9-30-09
PROJ. NO.	08-317

DRAWING NUMBER
CC-3



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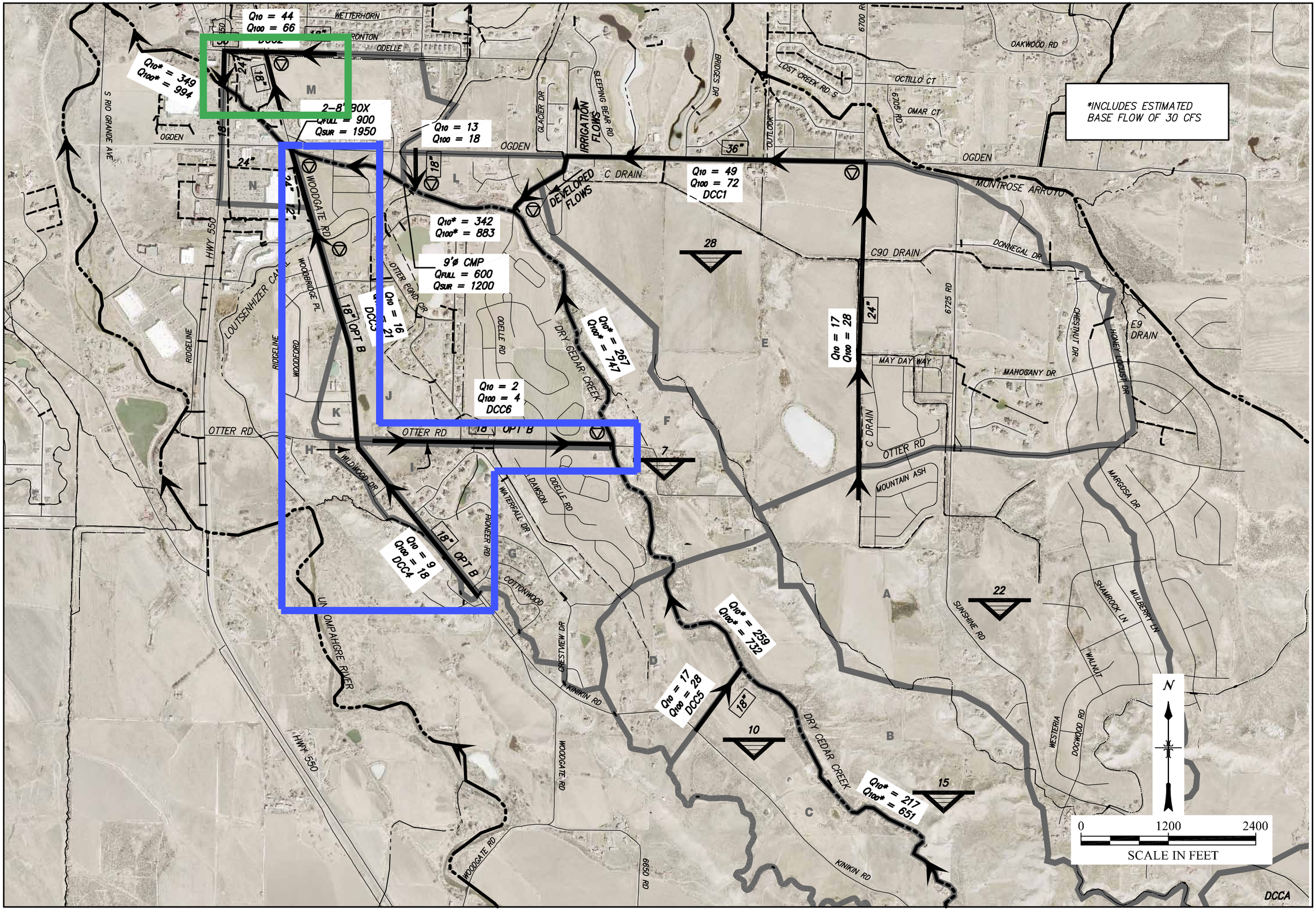
REVISIONS	DATE

CITY OF MONTROSE
STORM DRAIN MASTER PLAN IMPROVEMENTS
DRY CEDAR CREEK DRAINAGE BASIN OPTION A

DESIGNED	JK
DRAWN	DDC
DATE	9-30-09
PROJ. NO.	08-317

DRAWING NUMBER
DCC-1



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REVISIONS	DATE

CITY OF MONTROSE
STORM DRAIN MASTER PLAN IMPROVEMENTS
DRY CEDAR CREEK DRAINAGE BASIN OPTION B

DESIGNED	JK
DRAWN	DDC
DATE	9–30–09
PROJ. NO.	08–317

DRAWING NUMBER
DCC–2

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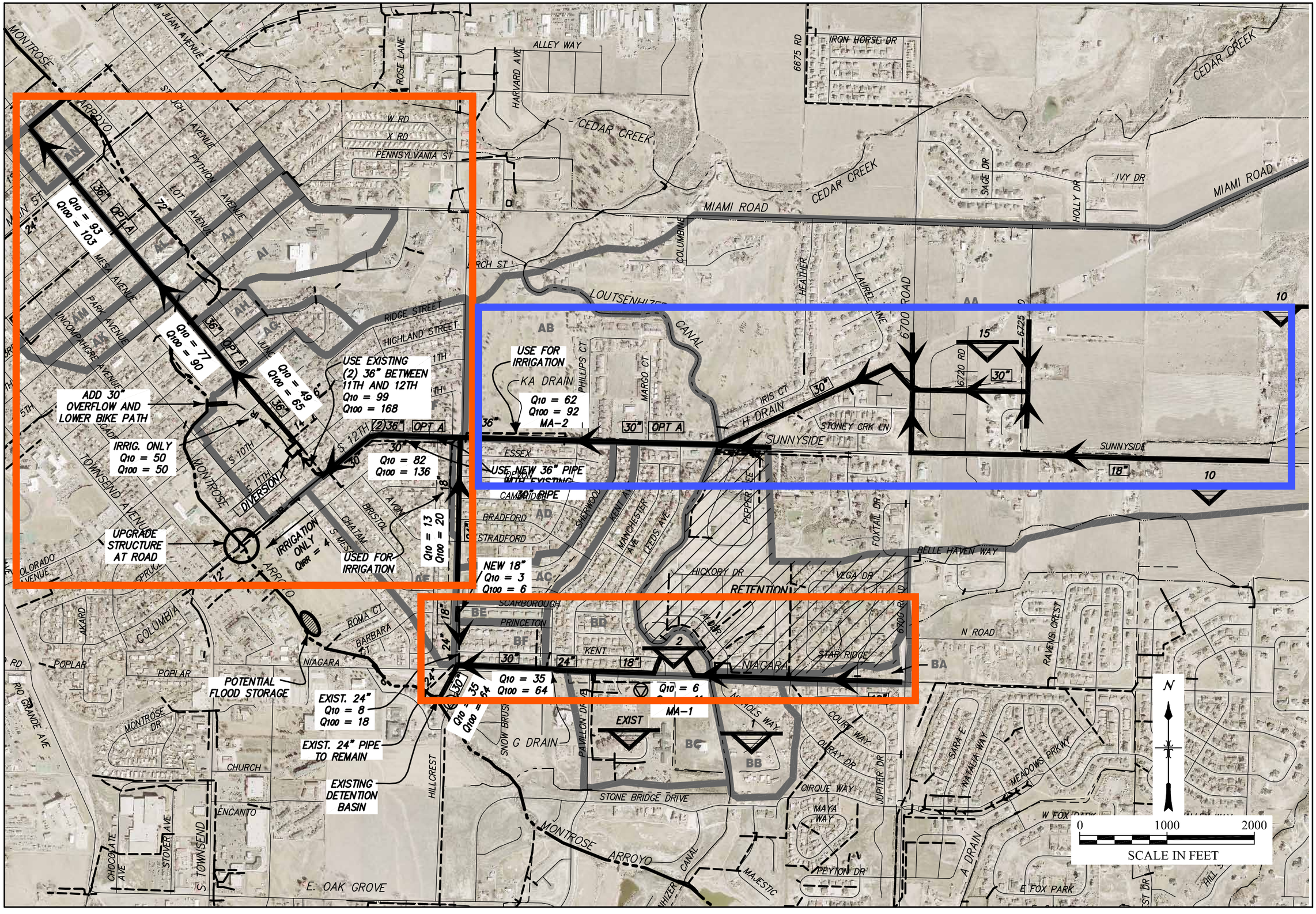
REVISIONS	DATE

CITY OF MONTROSE
STORM DRAIN MASTER PLAN IMPROVEMENTS
HAPPY CANYON DRAINAGE BASIN

DESIGNED	JK
DRAWN	DDC
DATE	9-30-09
PROJ. NO.	08-317

DRAWING NUMBER
HC-1



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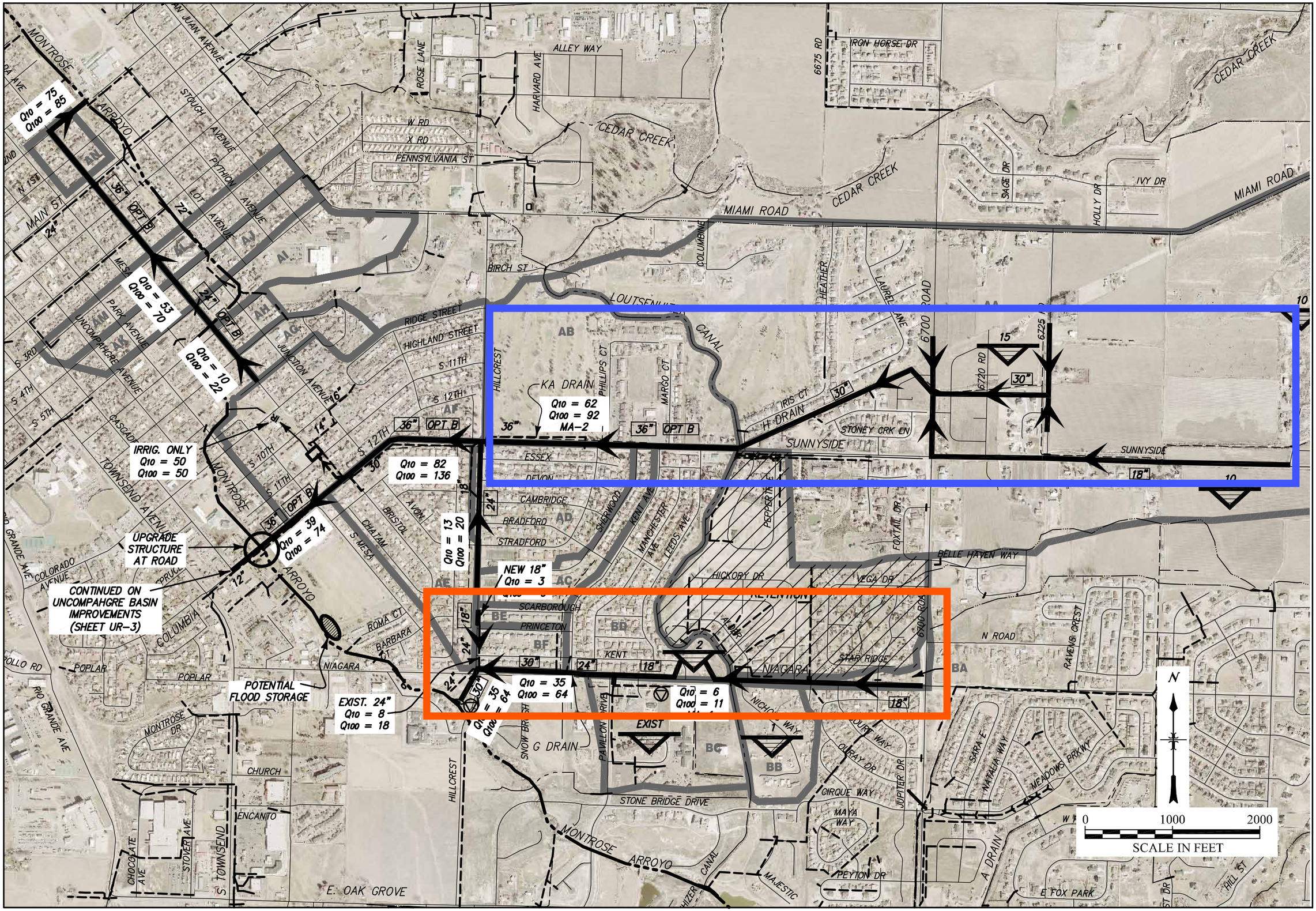
REVISIONS	DATE

CITY OF MONTROSE
STORM DRAIN MASTER PLAN IMPROVEMENTS
MONTROSE ARROYO DRAINAGE BASIN OPTION A

DESIGNED	JK
DRAWN	DDC
DATE	9-30-09
PROJ. NO.	08-317

DRAWING NUMBER

MA-1



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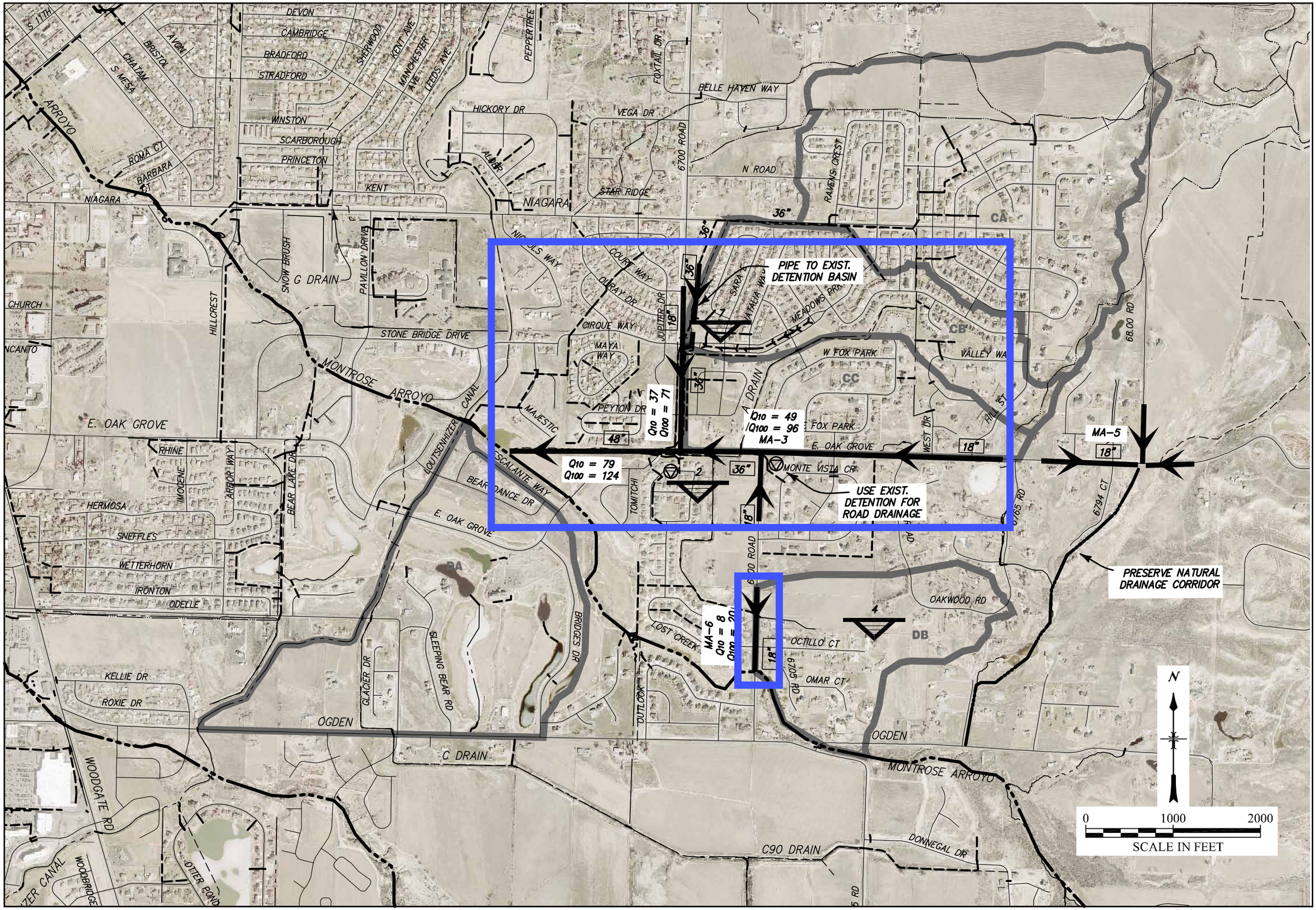
REVISIONS	DATE

CITY OF MONTROSE
STORM DRAIN MASTER PLAN IMPROVEMENTS
MONTROSE ARROYO DRAINAGE BASIN OPTION B

DESIGNED	JK
DRAWN	DDC
DATE	9-30-09
PROJ. NO.	08-317

DRAWING NUMBER
MA-2



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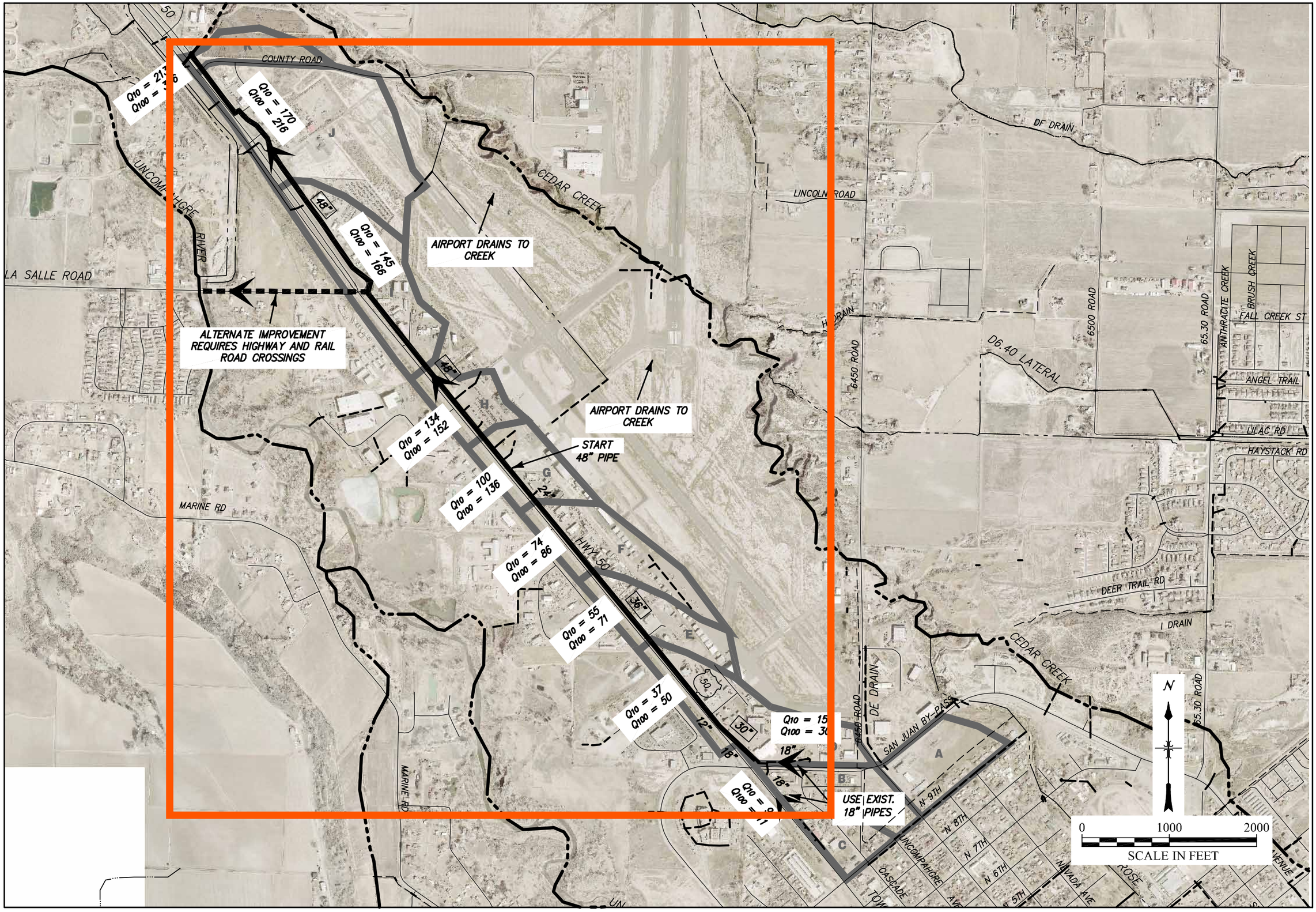
REVISIONS | DATE

CITY OF MONTROSE
STORM DRAIN MASTER PLAN IMPROVEMENTS
SOUTHERN MONTROSE ARROYO DRAINAGE BASIN

DESIGNED	JK
DRAWN	DDC
DATE	9-30-09
PROJ. NO.	08-317

DRAWING NUMBER
MA-3



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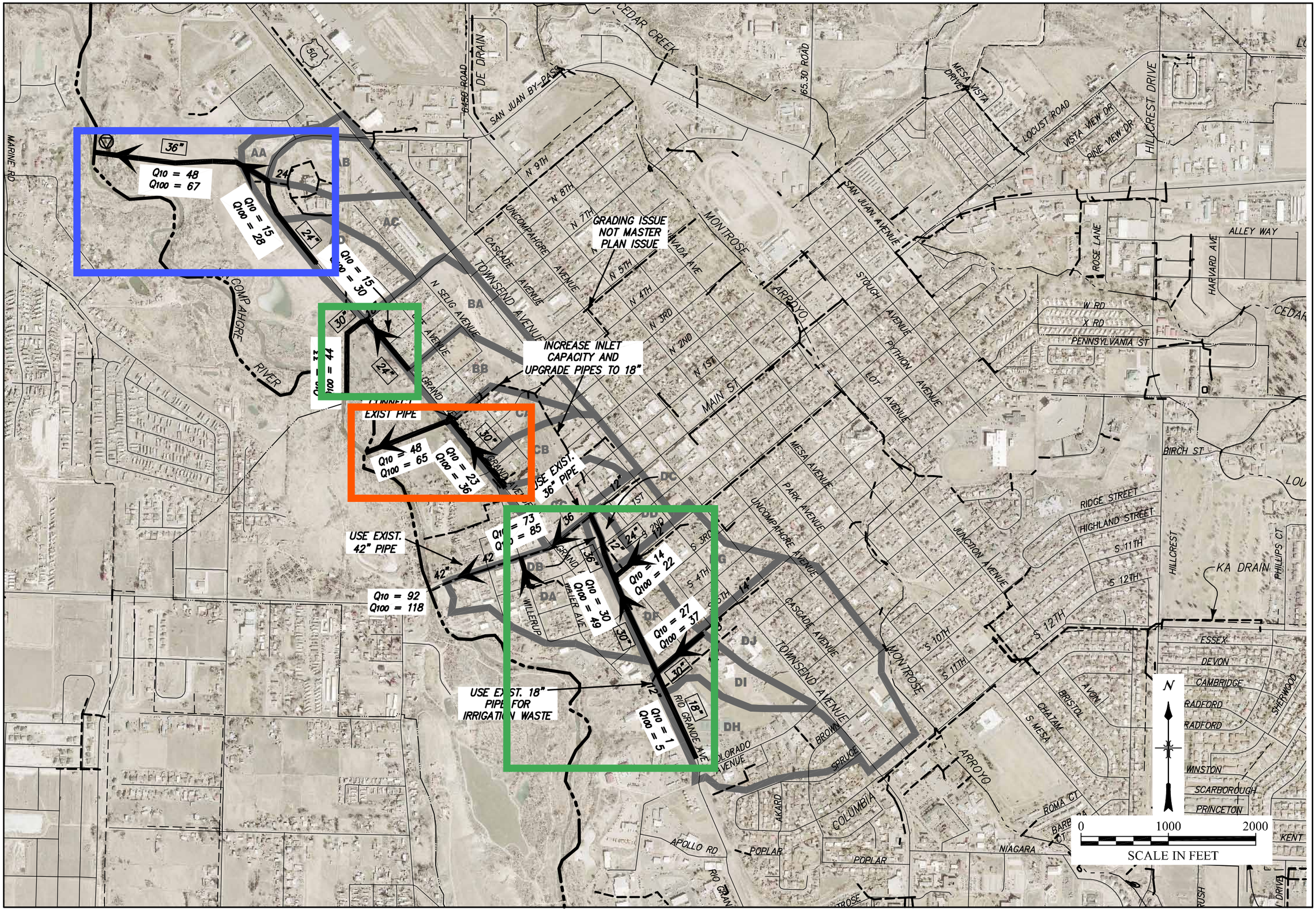
REVISIONS	DATE

CITY OF MONTROSE
STORM DRAIN MASTER PLAN IMPROVEMENTS
UNCOMPAHGRE RIVER DRAINAGE BASIN – NORTH

DESIGNED	JK
DRAWN	DDC
DATE	9-30-09
PROJ. NO.	08-317

DRAWING NUMBER

UR-1



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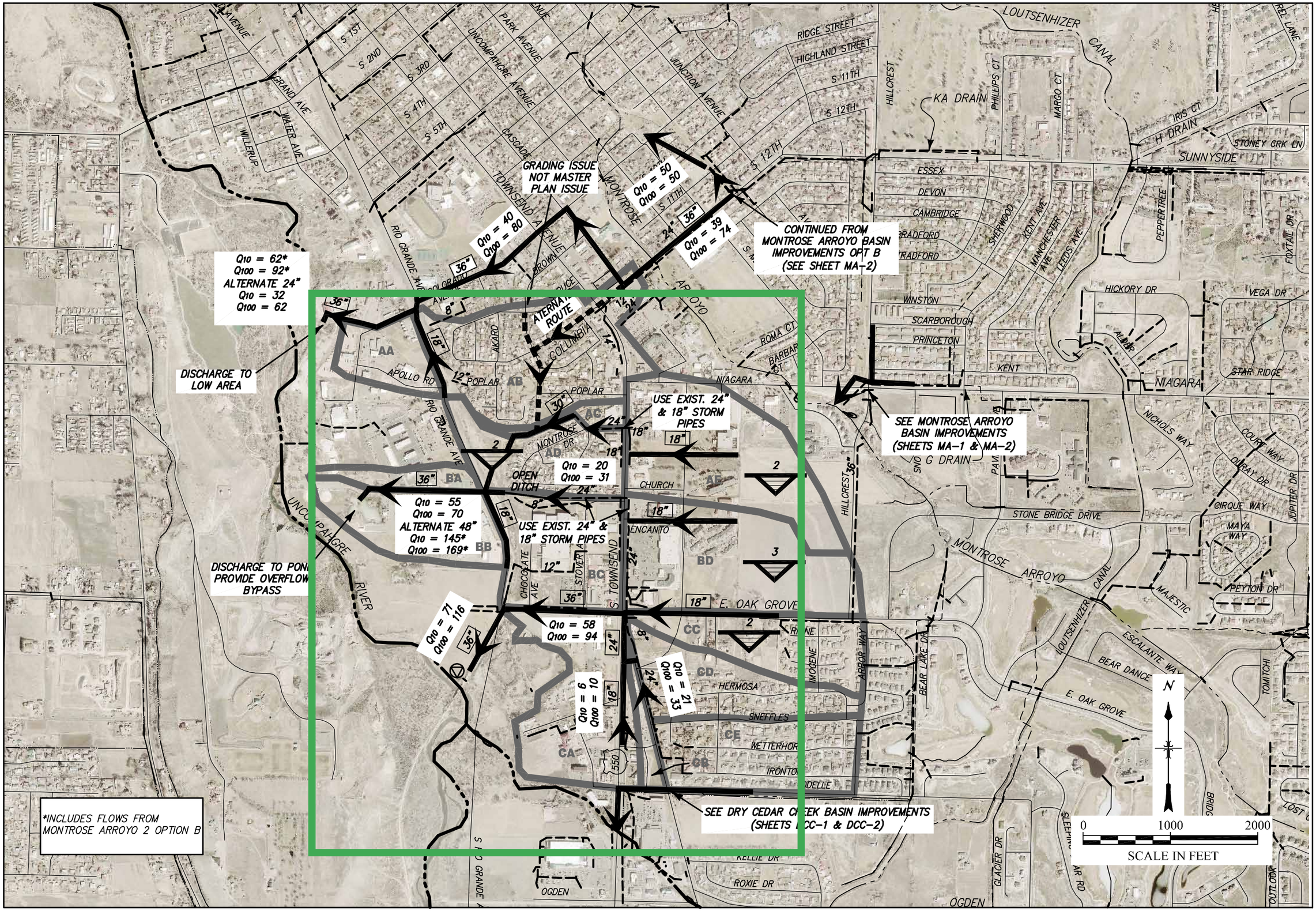
REVISIONS | DATE

CITY OF MONTROSE
STORM DRAIN MASTER PLAN IMPROVEMENTS
UNCOMPAHGRE RIVER DRAINAGE BASIN – MIDDLE

DESIGNED	JK
DRAWN	DDC
DATE	9–30–09
PROJ. NO.	08–317

DRAWING NUMBER
UR–2



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CITY OF MONTROSE
STORM DRAIN MASTER PLAN IMPROVEMENTS
UNCOMPAHGRE RIVER DRAINAGE BASIN - SOUTH

DESIGNED	JK
DRAWN	DDC
DATE	9-30-09
PROJ. NO.	08-317

DRAWING NUMBER
UR-3

3. PRIORITIZED DRAINAGE BASIN IMPROVEMENTS

Individual drainage basin improvements were prioritized according to three criteria:

- Existing problem areas with reoccurring flooding as described by City staff
- Deficiencies of storm drainage in developed areas
- Projected needs for future expansion of system

Each drainage basin improvement was placed into a priority group, as follows, with the highest priority group listed first. Improvements have been separated into different priorities, and may be constructed separately, provided that the downstream segments are completed first. Prioritization is a guideline only and the City of Montrose may choose to construct improvements in a different sequence to meet other infrastructure needs. Note: Cost Estimates only include the costs for the pipe, pipe burial, and reconstruction of existing road (if necessary) and do not include engineering, survey or testing costs. Cost estimates are in 2009 dollars and a complete breakdown of costs can be found in Appendix A.

a. Priority One Improvements

Improvements listed in the Priority One Group include areas with existing major drainage problems. Priority One improvements are shown in orange on the drainage basin improvement maps.

PRIORITY ONE PROPOSED IMPROVEMENTS		
Associated Basin	**Proposed Pipes / Road Repair**	**Cost Estimate**
CCS-3 (a)	700 lf 18" Pipe	$62,300
	300 lf 24" Pipe	$33,300
	610 lf 30" Pipe	$76,860
	1120 lf 36" Pipe	$154,560
	18" Pipe Asphalt Repair	$4,500
	24" Pipe Asphalt Repair	$9,000
	30" Pipe Asphalt Repair	$18,300
	36" Pipe Asphalt Repair	$44,800
	IMPROVEMENT TOTAL	$403,620
MA-1	4185 lf 18" Pipe	$372,465
	250 lf 24" Pipe	$27,750
	1420 lf 30" Pipe	$178,920
	18" Pipe Asphalt Repair	$125,550
	24" Pipe Asphalt Repair	$7,500
	30" Pipe Asphalt Repair	$42,600
	IMPROVEMENT TOTAL	$754,785
MA-2 (a) Option A (Preferred Alternative)	1700 lf 24" Pipe	$188,700
	230 lf 30" Pipe	$28,980
	9740 lf 36" Pipe	$1,344,120
	24" Pipe Asphalt Repair	$51,000
	36" Pipe Asphalt Repair	$389,600
	IMPROVEMENT TOTAL	$2,002,400

UR North	1965 lf 30" Pipe	$247,590
	2065 lf 36" Pipe	$284,970
	6630 lf 48" Pipe	$1,279,590
	30" Pipe Asphalt Repair	$58,950
	36" Pipe Asphalt Repair	$82,600
	48" Pipe Asphalt Repair	$265,200
	IMPROVEMENT TOTAL	$2,218,900
UR Middle (a)	2050 lf 30" Pipe	$258,300
	30" Pipe Asphalt Repair	$30,000
	IMPROVEMENT TOTAL	$288,300

Priority 1 Total: $5.7 Million

b. Priority Two Improvements

Improvements listed in Priority Two include areas with existing drainage problems. Priority Two improvements are shown in green on the drainage basin improvement maps.

PRIORITY TWO PROPOSED IMPROVEMENTS		
Associated Basin	**Proposed Pipes / Road Repair**	**Cost Estimate**
CCW – Lilac Road	6440 lf 18" Pipe	$573,160
	3160 lf 24" Pipe	$350,760
	6660 lf 30" Pipe	$839,160
	1320 lf 36" Pipe	$182,160
	18" Pipe Asphalt Repair	$193,200
	24" Pipe Asphalt Repair	$94,800
	36" Pipe Asphalt Repair	$119,700
	IMPROVEMENT TOTAL	$2,352,940
DDC 2	1810 lf 18" Pipe	$161,090
	1050 lf 36" Pipe	$114,900
	18" Pipe Asphalt Repair	$54,300
	36" Pipe Asphalt Repair	$42,000
	IMPROVEMENT TOTAL	$402,290
UR Middle – (b)	1485 lf 18" Pipe	$132,165
	1040 lf 24" Pipe	$115,440
	2890 lf 30" Pipe	$364,140
	780 lf 36" Pipe	$107,640
	18" Pipe Asphalt Repair	$44,550
	24" Pipe Asphalt Repair	$31,200
	30" Pipe Asphalt Repair	$56,700
	36" Pipe Asphalt Repair	$31,200
	IMPROVEMENT TOTAL	$883,035
UR South *without* MA2 Option B (Preferred Alternative)	6060 lf 18" Pipe	$539,340
	710 lf 24" Pipe	$78,810
	1545 lf 30" Pipe	$194,670
	3745 lf 36" Pipe	$516,810
	18" Pipe Asphalt Repair	$148,200
	24" Pipe Asphalt Repair	$21,300
	36" Pipe Asphalt Repair	$56,200
	IMPROVEMENT TOTAL	$1,555,330

Priority 2 Total: $5.2 Million

c. Priority Three Improvements

Improvements listed in Priority Three include existing developed areas with storm drain deficiencies. Priority Three improvements are shown in blue on the drainage basin improvement maps.

PRIORITY THREE PROPOSED IMPROVEMENTS		
Associated Basin	**Proposed Pipes / Road Repair**	**Cost Estimate**
CCS-4	2785 lf 18" Pipe	$247,865
	420 lf 24" Pipe	$46,620
	1350 lf 30" Pipe	$170,100
	1050 lf 36" Pipe	$144,900
	18" Pipe Asphalt Repair	$83,550
	24" Pipe Asphalt Repair	$12,600
	30" Pipe Asphalt Repair	$40,500
	36" Pipe Asphalt Repair	$42,000
	IMPROVEMENT TOTAL	$788,135
DCC 3/4/6 Option B (Preferred Alternative)	10345 lf 18" Pipe	$920,705
	18" Pipe Asphalt Repair	$310,350
	IMPROVEMENT TOTAL	$1,231,055
MA2 (b)	6065 lf 18" Pipe	$539,785
	7690 lf 30" Pipe	$968,940
	18" Pipe Asphalt Repair	$181,950
	30" Pipe Asphalt Repair	$160,650
	IMPROVEMENT TOTAL	$1,851,325
MA3	4240 lf 18" Pipe	$377,360
	3055 lf 36" Pipe	$421,590
	1960 lf 48" Pipe	$378,280
	18" Pipe Asphalt Repair	$127,200
	36" Pipe Asphalt Repair	$95,400
	IMPROVEMENT TOTAL	$1,399,830
MA6	970 lf 18" Pipe	$89,330
	18" Pipe Asphalt Repair	$29,100
	IMPROVEMENT TOTAL	$115,430
UR Middle (c)	1150 lf 24" Pipe	$127,650
	1713 lf 36" Pipe	$236,394
	24" Pipe Asphalt Repair	$34,500
	IMPROVEMENT TOTAL	$398,544
	Priority 3 Total:	**$5.8 Million**

d. Priority Four Improvements

Improvements listed in Priority Four include the remainder of the proposed improvements. These are the lowest priority improvements and are anticipated to be deferred until required by development. As these may be implemented 15 years or more in the future, cost estimates have not been prepared.

E. FUNDING OPPORTUNITIES

1. Purpose

Future drainage system improvements, as outlined in this master plan, are required to provide a level of service to residents and businesses within the City of Montrose. The City is looking to fund the design, construction, operation and maintenance of existing and future system improvements. The City has requested an evaluation of potential funding mechanisms to cover these costs.

2. Benefits and Beneficiaries

The construction and operation of a storm drain system provides conveyance of rainfall and snowmelt from developed urban areas to receiving waters. Residents, property owners and businesses receive the benefit of this system by the reduction of flood damage, an increase in public safety and increased property values. Additional benefits are gained if water quality features are designed and built into the system.

3. Costs

The City storm drain system consists of detention ponds, catch basins, piped and open channel conveyances, and outfalls. It requires one-time funding for capital improvements (design and construction), and ongoing funding for operation and maintenance. Through this master plan, the following costs have been identified:

Capital Improvements (infrastructure):	Costs to mitigate existing problems with system
	Costs to construct system for future
Operation and Maintenance:	Costs to operate and maintain existing system
	Capital expenditure for equipment
	Costs to operate and maintain future system

Infrastructure Costs: Priority determination and cost estimates of capital improvements for infrastructure needs are shown in Section D: Future Improvements Plan. Anticipated implementation and annual costs (2009 dollars) for the 20-year projected needs are as follows:

Priority 1:	$5.7 M	Anticipate 0-5 years implementation $1.1M/year
Priority 2:	$5.2 M	Anticipate 5-10 years implementation $1.0M/year
Priority 3:	$5.8 M	Anticipate 10-20 years implementation $0.6M/year

Operation and Maintenance Costs: The City currently has an annual expenditure of approximately $350,000 under the Street Cleaning account for storm drainage maintenance. With increased infrastructure it is anticipated this budget will grow over a 20-year period. We would recommend the City plan for an annual increase in this budget on the order of 5 to 10 percent.

Stormwater Quality: Costs for implementation of stormwater quality best management practices or treatment related to other regulatory programs (e.g. TMDL) will not be identified at this time.

4. Funding Mechanisms

Three broad categories of funding mechanisms have been identified for the purposes of covering costs for stormwater capital improvements and operation and maintenance: 1) taxes, 2) fees, and 3) grants.

The basic difference between the first two funding sources is that taxes are collected from taxable entities (property owners, businesses, sales, etc.) in the form of property or sales tax. Fees are collected from users or beneficiaries of the service (generators of stormwater runoff). In general, government, schools, churches, other non-profits do not pay taxes and do not directly fund costs for stormwater drainage from their facilities. Therefore, those costs must be made up by the public-at-large through increased taxes.

Grants are available through various governmental entities but are usually one-time monies and cannot be counted on to provide operation and maintenance funding.

The strengths and weaknesses of these funding mechanisms are discussed below.

a. Tax – City General Fund

a. Sales tax
b. Sales tax on water & sewer fees

Strengths
- Costs born by tax payers (can be applied to entire population or specific subset)
- Can be used for any capital or maintenance cost
- Can be used to leverage bonds for capital improvements

Weaknesses
- Compete with other City services for funds
- Tax-exempt entities (schools, churches, government) do not contribute
- Political implications from raising current taxing levels or creating new taxes

b. Tax – Specific Fund

a. Drainage sales tax

Strengths
- Drainage tax levied money is only spent on drainage
- Does not directly compete with other City service for funds
- Can be used for any capital or maintenance cost
- Can be used to leverage bonds

Weaknesses
- Tax-exempt entities (schools, churches, government) do not contribute
- Taxing rate may be lowered to compensate for increase taxes to General Fund resulting in less funding designated for drainage

c. Fee – Stormwater/Drainage Utility

a. Monthly fee assessed to property owners for use of the system, usually based on amount of impervious land cover.

Strengths
- Fees are equitably distributed among users
- Fund capital projects and provides ongoing revenue
- Can be used to leverage bonds
- Uniform rates or “rate classes” for typical residential properties
- Non-residential properties can be based on impervious area
- Fee applies to all users (including tax-exempt entities)

Weaknesses
- Fees may not cover all costs as they are generally proportional and related to service
- Fees are typically not set high enough, due to public opposition
- Funding is required to set up a collection system.

d. Fee – Stormwater Impact

a. Impact fees are assessed to new development for proportional drainage system costs.

Strengths
- Fees are equitable, new development pays for new systems

Weaknesses
- Must meet State Impact Fee legislation
- Only applied to new development
- Can only be used for capital costs (design and construction costs)
- Once fee is collected, money must be spent in basins where collected and generally within a time frame (6 years)

e. Drainage Special Service District

a. Special district is created for assessment purposes

Strengths
- Created by vote of property owners
- City determines costs of improvements to be assessed
- Various methods for assessing property (property valuation)
- Fund capital projects and provides ongoing revenue

Weaknesses
- Collection may be difficult

f. Grants

a. Available from time to time – must submit application each time

Strengths
- Provides funding when other sources not available
- May be "free" funds (not repaid)

Weaknesses
- One time money (usually)
- Cannot be relied upon for operation and maintenance

5. Comparison with Other Cities

West and South-Slope municipalities primarily use the general fund option to fund drainage capital and maintenance costs. Information regarding funding sources was obtained from the engineering departments in twelve (12) municipalities, and is presented in the table below. It should be noted that many of these cities/towns expressed interest in forming utilities because of the creation of a dedicated funding source.

Drainage Funding Sources Table

City/Town	2000 Population	Drainage Funding
Cortez	7,977	Dedicated drainage fund from City sales tax
Craig	9,189	
Delta	6,400	Capital Improvements from City Sales tax General fund for maintenance costs
Durango	13,922	General fund from taxes
Fruita	6,478	General drainage fund from taxes; Impact fees for new development
Glenwood Springs	7,736	
Grand Junction	41,896	General fund from taxes; Impact fees for new development
Gunnison	5,409	
Montrose	12,344	General fund from taxes
Rifle	6,784	General fund from taxes
Salida	5,504	
Steamboat Springs	9,815	General drainage fund from taxes

6. Stormwater Utilities in Colorado

In 2007, Gary Haynes was retained by the City of Fountain, CO to conduct a study of existing stormwater utilities in Colorado in order to compare methods used for charging monthly user fees for stormwater management. The report states that in 2007, at least 24 cities in Colorado have adopted a stormwater utility enterprise to generate revenue for the management of stormwater facilities and address the EPA clean water mandate. The report suggests that typical monthly fees for stormwater utility enterprises in Colorado range from $2.00 to $14.26, with an

average of $4.43 for a residential single-family property. (http://www.fountaincolorado.org/egov/docs/1187981534_125823.pdf).

7. Funding CDPS General Permit COR-090061

Funding options for the implementation of the Stormwater Management Plan required by permit COR-090061 consist of taxes and fees. Grants may be available for perhaps demonstration projects or innovation but for the most part grant funds cannot be use for permit compliance funding. An indirect source of funding for some activities required to meet permit conditions is cost-sharing program elements with other permittees. Public education programs where multiple permittees cost-share commercial air time is an example of this source. A group who does this in Colorado is the Colorado Stormwater Council (CSC). They have a website which describes their function (http://www.coloradostormwatercouncil.org).

8. Recommendations

After cost estimates for remedying existing problems with the drainage system and estimates for implementing the proposed Capital Improvement Plan are developed, it is recommended that the City:

- Determine how much revenue can be generated by taxes and fees
- Determine which funding scenario would be acceptable to the citizens of Montrose
- Pursue grant monies as they become available
- Investigate joining the Colorado Stormwater Council for cost-sharing stormwater quality discharge permit compliance costs

A most promising scenario for funding would be the creation of a stormwater utility for generating capital and O&M funds and imposing impact fees on new development to fund expansion of the system to handle such development.

Appendix A

COST ESTIMATE IMPROVEMENTS

- Cost Estimates are for the main alternative
- Cost Estimates are in 2009 dollars

CEDAR CREEK

CEDAR CREEK WESTERN

Improvement / Pipe Size	*Linear Feet*	*Cost per LF*	*Line Item Cost*	*Improvement Cost*
Lincoln Road				$2,046,115
18"	3125	$89	$278,125	
24"	4280	$111	$475,080	
30"	7210	$126	$908,460	
18" Asphalt Repair	3125	$30	$93,750	
24" Asphalt Repair	4280	$30	$128,400	
30" Asphalt Repair	5410	$30	$162,300	
Lilac Road				$2,352,940
18"	6440	$89	$573,160	
24"	3160	$111	$350,760	
30"	6660	$126	$839,160	
36"	1320	$138	$182,160	
18" Asphalt Repair	6440	$30	$193,200	
24" Asphalt Repair	3160	$30	$94,800	
30" Asphalt Repair	3990	$30	$119,700	
6450 Road				$154,700
18"	1300	$89	$115,700	
18" Asphalt Repair	1300	$30	$39,000	
I Drain				$678,090
18"	2670	$89	$237,630	
24"	650	$111	$72,150	
30"	2560	$126	$322,560	
18" Asphalt Repair	875	$30	$26,250	
24" Asphalt Repair	650	$30	$19,500	

CEDAR CREEK NORTHERN

Northern				$3,896,295
18"	7605	$89	$676,845	
24"	5440	$111	$603,840	
36"	7880	$138	$1,087,440	
48"	4890	$193	$943,770	
18" Asphalt Repair	7060	$30	$211,800	
24" Asphalt Repair	5440	$30	$163,200	
36" Asphalt Repair	5235	$40	$209,400	

CEDAR CREEK SOUTHERN

Improvement / Pipe Size	*Linear Feet*	*Cost per LF*	*Line Item Cost*	*Improvement Cost*
CCS-1 Locust Road				$1,100,590
18"	5270	$89	$469,030	
30"	3035	$126	$382,410	
18" Asphalt Repair	5270	$30	$158,100	
30" Asphalt Repair	3035	$30	$91,050	
CCS-2 Miami Road - From Hillcrest Drive East				$1,423,130
18"	13570	$89	$1,207,730	
18" Asphalt Repair	7180	$30	$215,400	
CCS-3 Highway 50				$1,516,755
18"	6535	$89	$581,615	
24"	3270	$111	$362,970	
30"	610	$126	$76,860	
36"	1120	$138	$154,560	
18" Asphalt Repair	5985	$30	$179,550	
24" Asphalt Repair	3270	$30	$98,100	
30" Asphalt Repair	610	$30	$18,300	
36" Asphalt Repair	1120	$40	$44,800	
CC-4 Miami Road - West of Hillcrest Drive				$788,135
18"	2785	$89	$247,865	
24"	420	$111	$46,620	
30"	1350	$126	$170,100	
36"	1050	$138	$144,900	
18" Asphalt Repair	2785	$30	$83,550	
24" Asphalt Repair	420	$30	$12,600	
30" Asphalt Repair	1350	$30	$40,500	
36" Asphalt Repair	1050	$40	$42,000	

DRY CEDAR CREEK

Improvement / Pipe Size	*Linear Feet*	*Cost per LF*	*Line Item Cost*	*Improvement Cost*
DCC 1 - 6725 Road and Ogden Road				$1,718,700
18"	560	$89	$49,840	
24"	6680	$111	$741,480	
36"	5210	$138	$718,980	
36" Asphalt Repair	5210	$40	$208,400	
DCC 2 - Odelle Road and Highway 550				$402,290
18"	1810	$89	$161,090	
36"	1050	$138	$144,900	
18" Asphalt Repair	1810	$30	$54,300	
36" Asphalt Repair	1050	$40	$42,000	
DCC 3/4/6 - Woodgate and Otter Roads - Option A				$1,308,385
18"	6830	$89	$607,870	
24"	3515	$111	$390,165	
18" Asphalt Repair	6830	$30	$204,900	
24" Asphalt Repair	3515	$30	$105,450	
DCC 3/4/6 - Woodgate and Otter Roads - Option B				$1,231,055
18"	10345	$89	$920,705	
18" Asphalt Repair	10345	$30	$310,350	
DCC 5 - Kinikin Road to Dry Cedar Creek				$97,010
18"	1090	$89	$97,010	

HAPPY CANYON

Improvement / Pipe Size	*Linear Feet*	*Cost per LF*	*Line Item Cost*	*Improvement Cost*
Marine Road				$708,000
30"	4600	$126	$579,600	
30" Asphalt Repair	4280	$30	$128,400	
Spring Creek Road				$1,217,920
18"	4070	$89	$362,230	
24"	1990	$111	$220,890	
30"	3075	$126	$387,450	
18" Asphalt Repair	3180	$30	$95,400	
24" Asphalt Repair	1990	$30	$59,700	
30" Asphalt Repair	3075	$30	$92,250	
Oak Grove Road				$1,390,660
18"	12440	$89	$1,107,160	
18" Asphalt Repair	9450	$30	$283,500	
Orange Road				$0
18"	2715	$89	$241,635	
24"	6760	$111	$750,360	
18" Asphalt Repair	2715	$30	$81,450	
24" Asphalt Repair	760	$30	$22,800	

MONTROSE ARROYO

Improvement / Pipe Size	*Linear Feet*	*Cost per LF*	*Line Item Cost*	*Improvement Cost*
MA-1 Niagara Road from 6700 Road to Hillcrest				$754,785
18"	4185	$89	$372,465	
24"	250	$111	$27,750	
30"	1420	$126	$178,920	
18" Asphalt Repair	4185	$30	$125,550	
24" Asphalt Repair	250	$30	$7,500	
30" Asphalt Repair	1420	$30	$42,600	
MA2 - Option A				$3,853,725
18"	6065	$89	$539,785	
24"	1700	$111	$188,700	
30"	7920	$126	$997,920	
36"	9740	$138	$1,344,120	
18" Asphalt Repair	6065	$30	$181,950	
24" Asphalt Repair	1700	$30	$51,000	
30" Asphalt Repair	5355	$30	$160,650	
36" Asphalt Repair	9740	$40	$389,600	
MA2 - Option B				$4,156,530
18"	6065	$89	$539,785	
24"	3235	$111	$359,085	
30"	7690	$126	$968,940	
36"	10415	$138	$1,437,270	
18" Asphalt Repair	6065	$30	$181,950	
24" Asphalt Repair	3235	$30	$97,050	
30" Asphalt Repair	5355	$30	$160,650	
36" Asphalt Repair	10295	$40	$411,800	
MA3 - Oak Grove and 6700 Road				$1,399,830
18"	4240	$89	$377,360	
36"	3055	$138	$421,590	
48"	1960	$193	$378,280	
18" Asphalt Repair	4240	$30	$127,200	
36" Asphalt Repair	2385	$40	$95,400	
MA4 - Montrose Arroyo at 12th Street				
No cost estimate: to be determined by channel analysis				
MA5 - Oak Grove - Eastern Improvements				$280,245
18"	2355	$89	$209,595	
18" Asphalt Repair	2355	$30	$70,650	
MA6 - 6700 Road South to Montrose Arroyo				$115,430
18"	970	$89	$86,330	
18" Asphalt Repair	970	$30	$29,100	

UNCOMPAHGRE RIVER

Improvement / Pipe Size	*Linear Feet*	*Cost per LF*	*Line Item Cost*	*Improvement Cost*
UR North				$2,218,900
30"	1965	$126	$247,590	
36"	2065	$138	$284,970	
48"	6630	$193	$1,279,590	
30" Asphalt Repair	1965	$30	$58,950	
36" Asphalt Repair	2065	$40	$82,600	
48" Asphalt Repair	6630	$40	$265,200	
UR Middle				$1,569,879
18"	1485	$89	$132,165	
24"	2190	$111	$243,090	
30"	4940	$126	$622,440	
36"	2493	$138	$344,034	
18" Asphalt Repair	1485	$30	$44,550	
24" Asphalt Repair	2190	$30	$65,700	
30" Asphalt Repair	2890	$30	$86,700	
36" Asphalt Repair	780	$40	$31,200	
UR South ***with*** *MA-Option B*				$1,671,810
18"	4940	$89	$439,660	
24"	710	$111	$78,810	
30"	1545	$126	$194,670	
36"	3745	$138	$516,810	
48"	1120	$193	$216,160	
18" Asphalt Repair	4940	$30	$148,200	
24" Asphalt Repair	710	$30	$21,300	
36" Asphalt Repair	1405	$40	$56,200	
UR South ***without*** *MA-Option B*				$1,555,330
18"	6060	$89	$539,340	
24"	710	$111	$78,810	
30"	1545	$126	$194,670	
36"	3745	$138	$516,810	
18" Asphalt Repair	4940	$30	$148,200	
24" Asphalt Repair	710	$30	$21,300	
36" Asphalt Repair	1405	$40	$56,200	