GRAND COUNTY

STORM DRAINAGE DESIGN AND TECHNICAL CRITERIA MANUAL

OFFICIALLY ADOPTED: August 1st, 2006

TABLE OF CONTENTS

CHAPTER 1: GENERAL PROVISIONS

1.1 SHORT TITLE

These regulations, as well as future amendments and revisions shall be known as the "Grand County Storm Drainage Design and Technical Criteria" (hereafter called CRITERIA) as referenced from time to time in the Grand County Subdivision Regulations, Zoning Regulations, Outright Exemption Regulations, Minor Subdivision Regulations, Rural Land Use Regulations and Planned Unit Development (hereafter collectively called REGULATIONS).

1.2 JURISDICTION

The requirements of these CRITERIA shall apply to all development permits, as that term is defined under C.R.S. §§ 29-20-103 and 13-51.5-102, and further upon all subdividers, building permit applicants, applicants, developers, or other landowners, and their employees, agents and contractors, designing and constructing any public or private improvement, street, road, driveway, or vehicular access of any kind or duration, as such are subject to review and approval by Grand County, pursuant to Grand County land use regulations and requirements. The Land Use Regulations shall include the applicable sections of the Grand County Subdivision Regulations, Zoning Regulations, Outright Exemption Regulations, Minor Subdivision Regulations, Rural Land Use Regulations and Planned Unit Development Regulations and Building Code.

1.3 PURPOSE

Presented in these CRITERIA are the minimum design and technical criteria for the analysis and design of storm drainage facilities. All subdivisions, resubdivisions, planned development, or other proposed construction, public or private shall be submitted for approval under the provisions of the REGULATIONS and may include adequate storm drainage system analysis and appropriate drainage system design. These CRITERIA provide the minimum standards and specifications required by the County. The applicant may suggest options to the provisions of these CRITERIA. The applicant shall have the burden of showing that the options are equal or better. Policies and technical criteria not specifically addressed in these CRITERIA shall follow the provisions of the most current edition of the Urban Drainage and Flood Control District (hereafter called UD&FCD) "Urban Storm Drainage Criteria Manual" (hereafter called MANUAL). Additionally, there may be other requirements set forth by local, state and/or federal agencies that may need to be met in conjunction with these CRITERIA.

1.4 ENFORCEMENT

It will be the duty of the Board of County Commissioners (BOCC), acting through the Planning and Zoning Department, to enforcement of the provisions of these CRITERIA.

1.5 REVIEW AND APPROVAL

The County Engineer will review all drainage submittals for general compliance with these CRITERIA. An approval by the County Engineer does not relieve the owner, developer or engineer from the responsibilities of ensuring that the calculations, plans, specifications, construction and as-built information are correct and in compliance these CRITEIRA, and accepted engineering practices.

1.6 INTERPRETATION

In the interpretation and application of the provisions of the CRITERIA, the following will govern:

1) In its interpretation and application, the provisions shall be regarded as the minimum requirements for the protection of the public health, safety, comfort, morals, convenience, prosperity, and welfare of the residents of the County.

2) Whenever a provision of these CRITERIA and any other provision of the REGULATIONS or any provision on any law, ordinance, resolution, rule, or regulation of any kind, contain any restriction covering any of the same subject matter, whichever restrictions are more restrictive or impose higher standards of requirements will govern.

1.7 RELATIONSHIP TO OTHER STANDARDS

These CRITERIA are consistent with generally accepted engineering practices and the MANUAL. If a special district imposes more stringent criteria than that in these Standards, this difference is not considered a conflict. If the State or Federal Government impose a stricter criteria, standards, or requirements, these shall be incorporated into the County's requirements after due process and public hearings needed to modify the County's regulations and standards.

1.8 VARIANCES

Variances from these CRITERIA may be requested by the applicant and will be considered on a case-by-case basis. For further information on variances, see the Grand County Road and Bridge Standards, Section 9.1.

1.9 ABBREVIATIONS

BMPs	Best Management Practices
CDOT	Colorado Department of Transportation
CRS	Colorado Revised Statute
CMP	Corrugated Metal Pipe
CUHP	Colorado Urban Hydrograph Procedure
FEMA	Federal Emergency Management Agency

HDPE	High Density Polyethylene Pipe
NRCS	National Resource Conservation Service
NOAA	National Oceanic and Atmospheric Administration
RCP	Reinforced Concrete Pipe
ROW	Right Of Way

CHAPTER 2: DRAINAGE SUBMITTAL REQUIREMENTS

2.1 REVIEW PROCESS

All drainage reports and plans, construction drawings, specifications and as-built information shall be submitted, reviewed and approved as required by the REGULATIONS. All submitted information shall be in a clear, concise and legible form. Drainage reports shall contain a declaration of the level of report being submitted (i.e. Phase I, Phase II or Phase III). Incomplete or absent information may result in the report being rejected.

2.2 PHASE I DRAINAGE REPORT

The purpose of a Phase I drainage report shall be to review the feasibility and design characteristics of the proposed development, at a conceptual level. The Phase I drainage report shall address the entire subdivision, not just one phase. The Phase I drainage report shall include a statement by the professional engineer that prepared the report and shall state:

> "This report was prepared by me, or under my direct supervision, in accordance with the Grand County Strom Drainage Design and Technical Criteria and was designed to comply with the provisions thereof. I understand that Grand County does not and will not assume liability for drainage facilities designed by others."
>
> _____
> Licensed Professional Engineer
> State of Colorado No. _____
> (Affix Seal)

The Phase I drainage report shall include the following:

I. General Location and Description of Site
   - A. Location (include vicinity map in report)
     1. Section, Township and Range.
     2. General location in relation to towns and roads.
     3. Names of surrounding developments.
   - B. Description of Site
     1. Area in acres.
     2. Soil classifications.
     3. Existing vegetation and approximate density.
     4. Minor and major drainageways.
     5. All existing irrigation facilities.
     6. Existing and proposed land uses.

II. Drainage Basins and Sub-basins
   - A. Major Basin Description

1. Discuss any and all major drainage basins associated with the site.
2. Discuss any and all previous drainage studies associated with the site.
3. Discuss the flood potential of the site and how this may effect or be effected by the proposed development.

B. Sub-basin Description
1. Discuss historic drainage patterns associated with the site.
2. Discuss off-site drainage flow patterns and the impact on the development under existing and developed conditions.

III. Drainage Facility Design

A. General Concept
1. Discuss conceptual and typical drainage patterns.
2. Discuss minor and major recurrence interval rainfall.
3. Discuss historic and developed discharge points and effects of concentrating flows on downstream properties.
4. Discuss any proposed phasing of development and how drainage infrastructure construction will be effected.
5. Discuss any assumptions that have been, or are anticipated to be made, during the preparation of the report.
6. Anticipated methodology and reasons why it is appropriate.
7. Discuss maps, tables, charts and/or nomographs presented in report.

B. Specific Details (Optional Information)
1. Discussion of the maintenance aspects of the design.
2. Discussion of detention storage and outlet design.
3. Discussion of hydrologic and/or hydraulic calculations.

2.2.1 PHASE I DRAWING REQUIREMENTS

I. General Drainage Map:

All drawings shall be 24” x 36” in size. A map shall be provided in sufficient detail to identify drainage tributary to the site as well as the general drainage patterns of the tributary run-off. The map should be at a scale of 1” = 200’ to 1” = 2000’ (Quad Maps at 1” = 2000’ will suffice for a Phase I map) The map shall provide the following:

A. Approximate flooding limits, where available.
B. Significant on and off-site features, including all drainage facilities.
C. Major basin and sub-basin delineation.
D. Conceptual proposed drainage facilities including detention basins, and flow arrows.
E. Legend and title block
F. Approximate drainage path of tributary run-off.
G. Approximate drainage path of on site flows to the Major Drainage(s)

II. Floodplain Information:
A copy of any applicable floodplain mapping shall be included with the report. If no flood plain maps are available a statement stating what sources were researched shall be provided.

2.3 PHASE II DRAINAGE REPORT

The purpose of the Phase II Drainage Report is to identify and/or refine conceptual solutions to the problems, which may occur on-site and off-site, as a result of the development and provide calculations that support the proposed solutions. All reports must be on 8½" x 11" paper and bound. The drawings, figures, exhibits, tables and other reference information utilized in the report shall be bound with the report or included in a pocket attached. The report shall include a statement by the professional engineer that prepared the report and shall state:

> "This report was prepared by me, or under my direct supervision, in accordance with the Grand County Strom Drainage Design and Technical Criteria and was designed to comply with the provisions thereof. I understand that Grand County does not and will not assume liability for drainage facilities designed by others."
>
> _____
> Licensed Professional Engineer
> State of Colorado No. _____
> (Affix Seal)

The Phase II drainage report shall include the following:

I. General Location and Description of Site
   A. Location
      1. Vicinity map.
      2. Section, township and range.
      3. General location in relation to towns and roads.
      4. Names of surrounding developments.
   B. Description of Site
      1. Area in acres.
      2. Soil classification.
      3. Existing vegetation and approximate density.
      4. Minor and major drainageways.
      5. Existing irrigation facilities.
      6. Existing and proposed land uses.
      7. General project description.

II. Drainage Basins and Sub-basins
   A. Major Basin Description
      1. Discuss any and all major drainage basins associated with the site.

2. Discuss any and all previous drainage studies associated with the site.
3. Discuss the flood potential of the site and how this may effect or be effected by the proposed development.
4. Discuss major basin characteristics, existing and planned land uses.
5. Discuss of all irrigation facilities, if any, within the basin that will influence or be influenced by the local drainage.

B. Sub-basin Description
1. Discuss historic drainage patterns of the property in question.
2. Discuss off-site drainage flow patterns and impact on development under existing and fully developed basin conditions.

III. Drainage Design Criteria
A. Regulations: Discuss any deviations from the CRITERIA, if any, and its justification.
B. Development of Basic Data and Constraints
1. Discuss any previous studies associated with the site.
2. Discuss impacts to adjacent developments and town.
3. Discuss constraints such as streets, utilities, etc.
C. Hydrological Criteria
1. Identify design rainfall.
2. Identify runoff calculation method.
3. Identify detention discharge and storage calculation method
4. Identify storm recurrence interval.
5. Intensity/duration frequency curves (with rational method).
D. Hydraulic Criteria
1. Identify capacity references used.
E. Stormwater Quality Criteria
1. Identify permanent and temporary water quality measures implemented on the site.
F. Variances from Criteria
1. Identify provisions by section number for which a variance is being requested.
2. Provide justification why each variance is being requested.

IV. Drainage Facility Design
A. General Concept
1. Discuss rationale and methodology used to analyze and design the drainage facilities and infrastructure on-site as well as off-site.
2. Typical drainage patterns.
B. Specific Details
1. Discuss each Sub-basin delineated.

a. Area.
b. Runoff coefficients / estimated imperviousness.
c. Time of concentration / time to peak.
d. Runoff quantity.
e. Conveyance.

2. Discuss each design point delineated.
   a. Conveyance routing and infrastructure requirements, connection to major drainageway.
   b. Maintenance requirements including delineated easements, tracks and/or outlots for drainage facilities.
3. Discuss each Detention Facility
   a. Allowable release rates.
   b. Storage required and provided.
   c. Water surface elevations.
   d. Downstream conveyance, major drainageway.
   e. Comparison of historic and developed discharge at critical design points around the periphery of the site.
   f. Maintenance requirements including delineated easements, tracks and/or outlots for drainage facilities.

IV. Conclusions
   A. Compliance with CRITERIA and MANUAL.
   B. Effectiveness of drainage design to control design storm run-off.

V. References
   A. Cite all criteria, technical information and references used.

VI. Appendices
   A. Hydrologic Calculations
      1. Assumed Land uses, both on and off site.
      2. Historic coefficients, imperviousness, Tc or Tp, Q minor and major.
      3. Developed coefficients, imperviousness, Tc or Tp, Q minor and major.
      4. Detention and water quality volumes along with allowable release rates.
   B. Hydraulic Calculations
      1. Street design with typical street sections
      2. Gutter capacity where applicable.
      3. Roadside ditch and/or culvert design.
      4. Storm sewer and/or inlet design.
      5. Open channel design.

2.3.1 PHASE II DRAWING REQUIREMENTS

I. Existing Drainage Map:

The map shall be 24" x 36" and should be at a scale of 1"=20'to 1"=200'.
The map shall provide the following information:

A. Title block, north arrow and scale
B. Existing topography at a 2-foot contour interval. Contours shall extend a minimum of 100' beyond the project limits.
C. Manner and amount of offsite drainage entering the site and the manner and amount of drainage leaving the site.
D. Existing flooding limits, where available.
E. Any existing improvements, including drainage facilities.
F. Existing property lines, easements and rights of way.
G. Significant offsite features.
H. Existing major basins and sub-basins delineation including area, major storm coefficient, and minor storm coefficient.

II. Proposed Drainage Map:

The map shall be 24" x 36" and should be at a scale of 1"=20'to 1"=200'.
The map shall provide the following information:

A. Title block, north arrow and scale.
B. Existing and proposed topography at a 2-foot contour interval. Existing contours shall extend a minimum of 100' beyond the project limits.
C. Manner and amount of offsite drainage entering the site and the manner and amount of drainage leaving the site.
D. Proposed structures and their finished floor elevations.
E. Proposed improvements relative to and including all drainage facilities.
F. Proposed property lines, easements and rights of way.
G. Significant offsite features.
H. Proposed major basins and sub-basins delineation including area, major storm coefficient, and minor storm coefficient.
I. Detention Pond information, including grading, required volumes provided volumes and water surface elevations.
J. Proposed outfall point(s) for the proposed development.
K. Summary runoff table, including design point(s), contributing area, minor and major runoff volumes.

2.3.2 COST ESTIMATE REQUIREMENT

Provide an engineer's opinion of probable construction costs of both onsite and offsite drainage infrastructure that is required. The engineer's opinion of probable construction cost shall be signed and stamped by a Colorado registered engineer.

2.4 PHASE III DRAINAGE REPORT

The purpose of the Phase III Drainage Report is to finalize all on-site and off-site drainage improvements that are require as a result of the proposed development. The Phase III drainage report shall provide all calculations, specifications and details to support the proposed drainage infrastructure as well as the proposed detention pond outlet structure. Pertinent information on the outlet structure should be added to the "Proposed Drainage Map". The Phase III drainage report shall include all the requirements set forth in section 2.3, above as well as the "General Drainage Map" called for in section 2.2.1, above. The report shall include a statement by the professional engineer that prepared the report and shall state:

> "This report was prepared by me, or under my direct supervision, in accordance with the Grand County Strom Drainage Design and Technical Criteria and was designed to comply with the provisions thereof. I understand that Grand County does not and will not assume liability for drainage facilities designed by others."
>
> _____
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In addition to the requirements set forth in section 2.30 of these CRITERIA, the Phase III Drainage Report shall contain a signed developer certification section as follows:

> "I *(Developer)* hereby certify that the drainage facilities for *(Name of Development)* shall be constructed according to the design presented in this report. I understand that Grand County does not and will not assume liability for drainage facilities designed or reviewed by my engineer. I also understand that Grand County relies on the representations of others to establish that drainage facilities are designed and built in compliance with applicable guidelines, standards and specifications. Review by Grand County can therefore in no way limit or diminish any liability which I or any other party may have with respect to the design or construction of such facilities."
>
> _____
> Name of Developer

CHAPTER 3: DRAINAGE POLICY

3.1 INTRODUCTION

The provisions for adequate drainage in urban areas are necessary to preserve and promote the general health, welfare and economic wellbeing of the County. As land use changes from agricultural and rural to urban in character the need for adequate drainage facilities become increasingly significant. Watersheds and corresponding watercourses know no jurisdictional boundaries and therefore affect all governmental jurisdictions and all parcels of land. This characteristic of drainage makes it necessary to formulate a program that balances both public and private involvement.

When planning drainage facilities, certain underlying principles provide direction for the effort. These principles are made operational through this set of policy statements. The application of the policy is in turn facilitated by technical criteria and data.

3.2 GENERAL PRINCIPLES

3.2.1 DRAINAGE SUB-SYSTEM

Planning of drainage facilities must be included in the development process. Incorporating drainage design into an overall development plan in the early stages is essential to eliminate possible conflicts and competition concerning land allocation or other necessary infrastructure improvements.

THE POLICY OF THE COUNTY SHALL BE TO CONSIDER STORM DRAINAGE A SUB-SYSTEM OF AN OVERALL DEVELOPMENT SYSTEM AND REQUIRE STORM DRAINAGE PLANNING FOR ALL DEVELOPMENT TO INCLUDE THE ADEQUATE ALLOCATION OF LAND FOR DRAINAGE FACILITIES.

3.2.2 MULTI-PURPOSE RESOURCE

Stormwater runoff and associated facilities can be considered a liability, however they have the potential for beneficial use. The drainage sub-system should be a multi-purpose system that helps satisfy the increasing demand placed on water within the environment. This system however must be compatible with adjacent land use and Colorado Water Law. Examples of beneficial uses of drainage facilities are recreation facilities, parking lots and use in landscape features. Innovative stormwater facility design is encouraged to maximize this multi-purpose resource.

THE POLICY OF THE COUNTY SHALL BE TO CONSIDER STORMWATER RUNOFF AND ASSOCIATED FACILITIES AS A

MULTI-PURPOSE RESOURCE AND TO ENCOURAGE MULTI-PURPOSE USE.

3.2.3 WATER RIGHTS

Drainageways and storage facilities often interrelate with existing water rights. Drainage improvements may alter the quantity or quality available for existing water rights. When the drainage sub-system interferes with existing water rights, the value and use of the water rights are affected. Planning and design of drainage facilities must account for existing water rights.

THE POLICY OF THE COUNTY SHALL BE TO REQUIRE THAT ANALYSIS OF IMPACTS ON WATER RIGHTS BE INCLUDED IN THE PLANNING AND DESIGN OF PROPOSED DRAINAGE FACILITIES.

3.2.4 MAJOR DRAINAGEWAYS

A definition of a major drainageway is necessary for clarification and implementation of these CRITERIA.

THE POLICY OF THE COUNTY SHALL BE TO DEFINE A MAJOR DRAINAGEWAY AS ANY FLOWPATH WITH A TRIBUTARY AREA IN EXCESS OF 400 ACRES.

3.3 REGIONAL AND LOCAL PLANNING

3.3.1 POST DEVELOPMENT FLOW CONDITIONS

The development process has the potential to significantly alter predevelopment (historic) drainage conditions. During the development process, if water is allowed to flow into the development in its historic quantity and manner, and is discharged in the historic quantity and manner, the alterations are generally acceptable. When development impedes the historic flow into the development it violates the rule of Colorado law that property is subject to the historic drainage from upper lands. In addition, if the development does not return the drainage to historic conditions, then the rule that drainage water cannot be sent down to do more harm than was formerly done to lower lands, is violated. Development proposals that are in violation of either of these principles will not be approved, unless the developer can obtain approval from the affected owner(s).

THE POLICY OF THE COUNTY SHALL BE FOR POST DEVELOPMENT FLOW CONDITIONS TO BE IN A MANNER AND QUANTITY (FLOW RATE) AS TO NOT DO ALTER THE PREDEVELOPMENT (HISTORIC) FLOWS, UNLESS THE

DEVELOPER CAN OBTAIN APPROVAL FROM THE AFFECTED OWNER(S).

3.3.2 DRAINAGE MASTER PLANNING

Pursuant to section 3.2.1, drainage design and planning is required for all development. The County encourages Drainage Master Planning for larger, or multi-phased developments. The County, at its discretion may require a Master Drainage Plan during the planning stages of larger developments, or those developments that substantially increase imperviousness.

THE POLICY OF THE COUNTY SHALL BE TO ENCOURAGE DRAINAGE MASTER PLANNING FOR LARGER OR MULIT-PHASED DEVELOPMENTS.

3.3.3 PUBLIC IMPROVEMENTS

Public improvements associated with drainage may include improvements to both the local drainage system and the major drainage system. The local drainage system consists of curb and gutter, inlets, storm sewers, culverts, bridges, swales, ditches, channels, detention/retention areas, and other drainage facilities required to convey the minor and major storm runoff to the major drainageway. The major drainageway system consists of channels, storm sewers, bridges, detention/retention areas, and other facilities serving more than the development or property in question that may be impacted by the development.

THE POLICY OF THE COUNTY SHALL BE THAT ALL DEVELOPMENT IS REQUIRED TO CONSTRUCT THE IMPROVEMENTS TO THE LOCAL AND MAJOR DRAINAGEWAY AS DEFINED BY THE APPROVED PHASE III DRAINAGE REPORT AND PLANS.

3.3.4 BASIN TRANSFER

Colorado drainage law recognizes the inequity in transferring the burden on managing storm drainage from one location or property to another. Liability questions also arise when the historic drainage continuum is altered. The diversion of storm runoff from one basin to another should be avoided unless specific and prudent reasons justify and dictate such a transfer. Prior to selecting a solution, alternatives should be reviewed. Planning and design of stormwater drainage systems should not be based on the premise that problems can be transferred from one location to another.

THE POLICY OF THE COUNTY SHALL BE TO DISCOURAGE THE INTER-BASIN TRASFER OF STORM DRAINAGE RUNOFF AND TO MAINTAIN THE HISTORIC DRAINAGE PATH WITHIN

THE DRAINAGE BASIN. THE TRANSFER OF DRAINAGE FROM BASIN TO BASIN IS A VIABLE ALTERNATIVE IN CERTAIN INSTANCES AND WILL BE REVIEWED ON A CASE-BY-CASE BASIS. WHEN BASIN TRANSFER IS PERMITTED, THE PLAN MUST ACHIEVE HISTORIC FLOW CONDITIONS AT THE CONFLUENCE OF THE BASIN AND MEET THE REQUIREMENTS OF POST DEVELOPMENT CONDITIONS.

3.3.5 FLOODPLAIN MANAGEMENT

Naturally occurring floodplains and associated floodways are vital for continued conveyance and storage of runoff. Urban land use can often compete with areas that historically have served this conveyance and storage function. In general, floodplains should be left in historic condition whenever possible.

THE POLICY OF THE COUNTY SHALL BE TO LEAVE FLOODPLAINS IN A NATURAL STATE WHENEVER POSSIBLE.

3.3.6 STORMWATER DETENTION

The value of storm runoff detention has been explored by many individuals, agencies and professional societies. Detention is considered a viable method to reduce urban drainage costs. Temporarily detaining storm runoff associated with the increase in impervious areas caused by urban development can sufficiently reduce downstream hazards as well as infrastructure requirements. Storage also provides for sediment and debris collection, which helps to keep streams and rivers cleaner thus helping to protect the natural resources of the County.

THE POLICY OF THE COUNTY SHALL BE TO REQUIRE ON-SITE DETENTION FACILITIES FOR ALL DEVELOPMENT, EXPANSIONS AND REDEVELOPMENT, UNLESS A VARIANCE IS GRANTED, AS NOTED IN THE VARIANCE PROCEDURE BELOW. THE REQUIRED MINIMUM VOLUME AND MAXIMIMUM RELAESE RATES FOR THE 10-YEAR AND 100-YEAR STORM EVENTS WILL BE DETERMINED IN ACCORDANCE WITH THESE CRITERIA.

Individual requests to waive this detention requirement will be considered if it is determined by Planning and Zoning that there are no cumulative effects from previous variances in the development proximity and the applicant demonstrates one of the following:

1) The development will not cause a significant increase in flow, both in the immediate downstream local drainage system (Less than or equal to one cubic foot per second for the 10-year storm) and within the major drainage basin.

2) Impervious area, including structures, streets/roads/driveways/parking areas (paved or unpaved) will not total more than 10,000 square feet. If this limit to the impervious area is used in granting a variance, the development proposal shall restrict the allowable impervious area at the time of building permit issuance so that the maximum impervious area established in the variance request is not exceeded.

3) The project consists of 35-acre tracts of land with a small percent of imperviousness. (1%-3% - according to table RO-3 of the MANUAL)

In order for the variance request to be approved, the applicant must display that water quality issues have been addressed in accordance with Section 3.3.7, below.

3.3.7 STORMWATER QUALITY

Land development and human activities affect both the quantity and the quality of stormwater discharge to receiving waters. Development increases the volume of stormwater and the pollutants leaving the project property. To remove pollutants, the collection and conveyance infrastructure must be supplemented with collection and infiltration best management practices. Refer to the MANUAL, Volume 3, for BMP's and design specifications.

THE POLICY OF THE COUNTY SHALL BE TO REQUIRE USE OF BMP'S TO REDUCE STORMWATER QUALITY POLLUTION CAUSED BY DEVELOPMENT AND THE UTILIZATION OF WATER QUALITY POND.

Planning and Zoning will consider a variance of the Stormwater Quality requirement if the applicant can demonstrate one of the following:

1) The project disturbs less than one half acre of ground and is not part of a larger common plan or master plan.

2) Regional water quality facilities have been used in satisfying the BMP requirements and it can be demonstrated that the facility provides the required water quality capture volume.

3) The project consists of 35-acre tracts of land with minimal site disturbance.

3.3.8 OPERATIONS AND MAINTENANCE

To ensure storm drainage facilities function as they are designed to, continued maintenance is required. Maintenance of drainage facilities may include clearing debris from inlets, culverts, channels, ditches, or detention facilities.

Responsibility for maintenance of drainage improvements lies with the property owner. Maintenance responsibility shall be delineated on all Final Plats.

THE POLICY OF THE COUNTY SHALL BE TO REQUIRE THAT THE PROPERTY OWNER SHALL BE RESPONSIBLE FOR THE MAINTENANCE OF ALL DRAINAGE FACILITIES, INCLUDING INLETS, PIPES, CULVERTS CHANNELS, DITCHES, HYDRAULIC STRUCTURES, AND DETENTION BASINS LOCATED ON THEIR LAND; AND THAT THIS RESPONSIBILITY SHALL BE NOTED ON THE FINAL PLAT. SHOULD THE OWNER FAIL TO ADEQUATELY MAINTAIN SAID FACILITIES, THE COUNTY SHALL HAVE THE RIGHT TO ENTER SAID LAND FOR THE PURPOSE OF OPERATIONS AND MAINTENANCE. ALL SUCH COSTS WILL BE ASSESSED TO THE PROPERTY OWNER.

3.3.9 DRAINAGE EASEMENT REQUIREMENTS

The easement requirements are indicated on the following table:

DRAINAGE FACILITY	EASMENT WIDTH
Storm Sewer (a.) Less than 36" dia. (b.) Equal to or greater than 36" dia.	 20' width of pipe plus twice the pipe invert depth with sewer placed in the middle third of the easement.(min. 20')
Swales / Open Channels (a.) Q-100 less than, or equal to 20 cfs (b.) Q-100 greater than 20 cfs	 15' minimum 15' minimum (Must accommodate Q100 plus one-foot freeboard)
Detention Pond	Use engineering discretion – as required to contain storage, plus one foot of freeboard, and associated facilities as well as access around the perimeter of the pond.
Along side lot lines for single family residential subdivisions	The easement will be a minimum of 5' centered on the lot line.

Additionally, access easements shall be required for all drainage facilities and they must be adequate for the required maintenance. All required easements must be show on the Final Plat.

THE POLICY OF THE COUNTY SHALL BE TO REQUIRE DRAINAGE EASEMENTS FOR ALL ONSITE DRAINAGE FACILITIES. ALL DRAINAGE EASEMENTS SHALL BE DEDICATED TO GRAND COUNTY IN A FORM ACCEPTABLE TO THE COUNTY ATTORNEY AND MUST BE SHOWN ON THE

FINAL PLAT. THE COUNTY HAS THE RIGHT TO ACCESS DRAINAGE EASEMENTS, AND THE RIGHT, BUT NOT THE OBLIGATION, OF CONSTRUCTION AND/OR MAINTENANCE WITHIN DRAINAGE EASEMENTS.

3.4 PLANNING AND DESIGN

3.4.1 MINOR AND MAJOR DRAINAGE SYSTEM

Every urban area has two separate and distinct drainage systems, whether or not they are actually planned or designed. One is the Minor Drainage System and the other is the Major Drainage System, which are combined to make the Total Drainage System.

THE POLICY OF THE COUNTY SHALL BE TO REQUIRE THAT ALL DEVELOPMENT INCLUDE THE PLANNING, DESIGNING, AND IMPLEMENTATION FOR BOTH THE MINOR AND MAJOR DRAINAGE SYSTEMS.

3.4.1.1 MINOR DRAINAGE SYSTEM

The Minor Drainage System shall be designed to transport the run-off from the 10-year (5-year in developments with curb and gutter) recurrence interval storm with minimal disruption to the urban environment. The Minor Drainage System may consist of any combination of curb and gutter, roadside ditches and culverts, storm sewers and inlets, swales and channels, or other drainage facilities proposed by the design engineer. For roadways Classified as Type 'C' crossing major drainageways, the minor storm event shall be the 50-year recurrence interval storm.

THE POLICY OF THE COUNTY SHALL BE TO REQUIRE THAT ALL MINOR STORM DRAINAGE FACILITIES BE DESIGNED AND SIZED WITHOUT ACCOUNTING FOR PEAK FLOW REDUCTIONS CAUSED BY ON-SITE DETENTION.

3.4.1.2 MAJOR DRAINAGE SYSTEM

The design objective of the Major Drainage System is to minimize life and health hazards, damage to structures or improvements, and interruption of emergency vehicular traffic and services. The Major Drainage System may consist of any combination of curb and gutter, roadside ditches and culverts, storm sewers and inlets, swales and channels, or other drainage facilities proposed by the design engineer.

THE POLICY OF THE COUNTY SHALL BE TO REQUIRE THAT ALL MAJOR STORM DRAINAGE FACILITIES BE DESIGNED

AND SIZED TO MINIMIZE LIFE AND HEALTH HAZARDS, DAMAGE TO STRUCTURES OR IMPROVEMENTS AND INTERRUPTION OF EMERGENCY VEHICULAR TRAFFIC AND SERVICES.

3.4.2 FLOODPROOFING EXISTING STRUCTURES

Floodproofing can be described as measures that reduce the potential for flood damages to existing property and/or structures within a floodplain. The floodproofing measures can range from the elevating of structures to intentional flooding of noncritical building spaces to minimize structural damages. Floodproofing measures are only a small part of good floodplain management, which encourages wise floodplain development to minimize the adverse effects of floods.

3.4.3 STORM RUNOFF

THE POLICY OF THE COUNTY SHALL BE TO ALLOW STORM RUNOFF TO BE DETERMINED BY EITHER THE RATIONAL METHOD OR THE URBAN HYDROGRAPH PROCEDURE (CUHP), WITHIN THE LIMITATIONS SET FORTH BY THESE CRITERIA, UNLESS A VARIANCE IS GRANTED AS NOTED IN THE VARIANCE PROCEDURE BELOW. FOR BASINS LARGER THAN 160 ACRES, THE PEAK FLOWS AND VOLUMES SHALL BE DETERMINED BY CUHP.

Planning and Zoning will consider a variance of the Storm Runoff requirement if the applicant can demonstrate and substantiate that a different methodology is more appropriate than the one required.

3.5 IRRIGATION FACILITIES

3.5.1 INTRODUCTION

There are many irrigation ditches and reservoirs in the County. As land use in the County changes from agricultural and rural to increasingly urban, irrigation facilities such as ditches and reservoirs should not be used as a means of developed drainage conveyance or outfall. When delineating developed drainage basins, irrigation ditches should not be utilized as basin boundaries due to the limiting flow capacity of the ditch. During periods of high runoff, the existing irrigation facilities will most likely be at, or near, brink full capacity, therefore runoff from an upper developed basin would flow across the ditch and contribute to downstream basins.

THE POLICY OF THE COUNTY SHALL BE TO GENERALLY PROHIBIT THE USE OF IRRIGATION FACILITIES AS PART OF THE DEVELOPED DRAINAGE SYSTEM.

3.5.2 IRRIGATION DITCHES

The physical limitations of irrigation ditches including relatively flat longitudinal gradients and limited conveyance capacity, generally prohibits their use in developed drainage systems. Under certain circumstances, however, irrigation ditches may be utilized for conveyance or outfall for developed stormwater runoff, provided thorough hydraulic and hydrologic analysis justifies capacity and written consent from the ditch owner is provided upon submission of a Phase III drainage report.

THE POLICY OF THE COUNTY SHALL BE WHEN IRRIGATION DITCHES AND MAJOR DRAINAGEWAYS CROSS, THE DEVELOPER SHALL BE REQUIRED TO DESIGN AND CONSTRUCT APPROPRIATE STRUCTURES TO SEPARATE THE FACILITIES.

See section 9.9 of these CRITERIA for additional information.

CHAPTER 4: RAINFALL

4.1 INTRODUCTION

Presented in this chapter are the design rainfall data to be used with the CUHP and the Rational Method. All hydrological analysis within the jurisdiction of Grand County shall use one of these two procedures, unless a variance is granted pursuant to section 3.4.3. Should a different methodology be used for determining rainfall data and distribution, special care should be taken to assure that the information accurately depicts rainfall data for the appropriate region.

Two distinct rainfall events shall be analyzed, in accordance with section 3.4.1 of these CRITERIA. The minor storm shall be considered the 5-yer recurrence interval for developments with curb and gutter, and the 10-year recurrence interval for developments without curb and gutter. The major event shall be considered the 100-year recurrence interval in all cases.

For the purposes of these CRITERIA, the "NOAA Atlas 2, Precipitation-Frequency Atlas of the Western United States, Volume III - Colorado", published by the US Department of Commerce, National Oceanic and Atmosphere Administration, 1973 (hereafter NOAA Atlas) shall be utilized for determining rainfall values. For further information or to obtain a copy, visit NOAA's website at www.nws.noaa.gov.

4.2 COLORADO URBAN HYDROGRAPH PROCEDURE DESIGN STORMS

For drainage basins less than five square miles, a two-hour storm distribution without area adjustment of the point rainfall values shall be used for the CUHP. For drainage basins between five and ten square miles, a two-hour storm distribution is used but the incremental rainfall values are adjusted for the larger basin area in accordance with suggested procedures in the NOAA Atlas. For drainage basins between ten and twenty square miles, a three-hour storm duration with adjustment for area shall be used. The incremental rainfall distribution for all basin areas up to twenty square miles is presented in table 402.

4.3 TIME – INTENSITY – FREQUENCY CURVES

The Time-Intensity-Frequency (TIF) curves for various parts of the County were developed by distributing the one-hour point rainfall values, listed in Table 401, using the factors obtained from the NOAA Atlas, listed in Table 400, and applying them to equations provided in the NOAA Atlas for Region 2. These point rainfall values are translated to intensities and plotted on Figures 410 – 413, for convenient use of these CRITERIA. For information in the Winter Park area, refer to the Town of Winter Park Drainage Standards.

Table 400
ADJUSTMENT FACTORS TO OBTAIN N-MINUTE ESTIMATES FROM ONE-HOUR VALUES

Duration (minutes)	5	10	15	30
Ratio to 1-Hr Depth	0.29	0.45	0.57	0.79

From NOAA Atlas 2 Vol. III Table 12

Table 401
ONE-HOUR DESIGN POINT RAINFALL VALUES
FOR VARIOUS PARTS OF GRAND COUNTY

	5-YR	10-YR	100-YR
FRASER	0.88	1.01	1.64
GRAND LAKE	0.88	0.99	1.47
GRANBY	0.80	0.95	1.43
KREMMLING	0.78	0.90	1.43

From NOAA Atlas 2 Vol. III Table 11

Engineering discretion should be used when performing analysis outside these areas. All pertinent information concerning the NOAA Atlas should be referenced and applied as site location dictates.

TABLE 402

Design Storm Distributions of 1-Hour NOAA Atlas Depths

Time	Percent of 1-Hour NOAA Rainfall Atlas Depth				
Minutes	2-Year	5-Year	10-Year	50-Year	100-Year
5	3.5	3.0	2.0	1.7	1.5
10	7.2	6.8	5.0	4.5	4.0
15	11.1	11.4	8.3	7.9	7.4
20	14.7	14.7	11.8	11.5	11.0
25	18.0	18.0	15.3	15.1	14.9
30	14.9	13.0	18.0	18.0	18.0
35	11.2	11.7	14.3	14.6	14.7
40	7.8	8.4	10.3	10.8	11.1
45	4.2	5.1	6.3	6.9	7.5
50	2.6	2.8	3.1	3.6	3.9
55	1.8	2.0	2.2	2.4	2.5
60	1.7	1.9	1.8	1.9	1.9
65	1.6	1.8	1.6	1.6	1.6
70	1.5	1.7	1.5	1.5	1.5
75	1.4	1.5	1.4	1.4	1.4
80	1.3	1.2	1.3	1.3	1.3
85	1.2	1.1	1.2	1.2	1.2
90	1.1	1.0	1.1	1.1	1.1
95	1.0	.9	1.0	1.0	1.0
100	.9	.8	.9	.8	.9
105	.8	.7	.8	.7	.8
110	.6	.6	.7	.6	.7
115	.5	.5	.6	.5	.6
120	.4	.4	.5	.4	.5
TOTALS	**111.0**	**111.0**	**111.0**	**111.0**	**111.0**

FIGURE 410

T.I.F. CURVE - FRASER, COLORADO

LATITUDE: 39°57' N
LONGITUDE: 105°49' W
DATA FROM NOAA ATLAS 2, VOL III

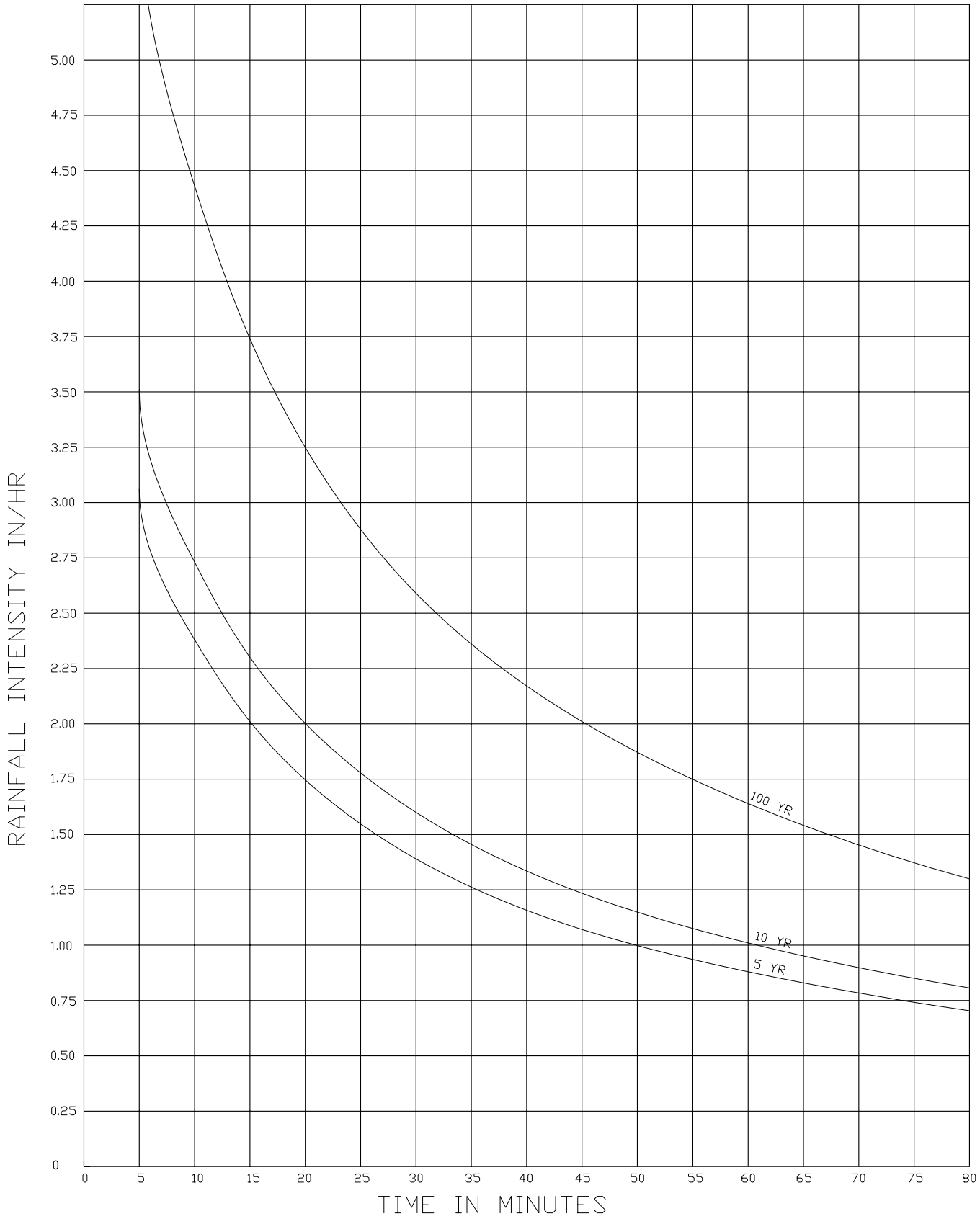


FIGURE 411

T.I.F. CURVE - GRANBY, COLORADO

LATITUDE: 40°05' N
LONGITUDE: 105°56' W
DATA FROM NOAA ATLAS 2, VOL III

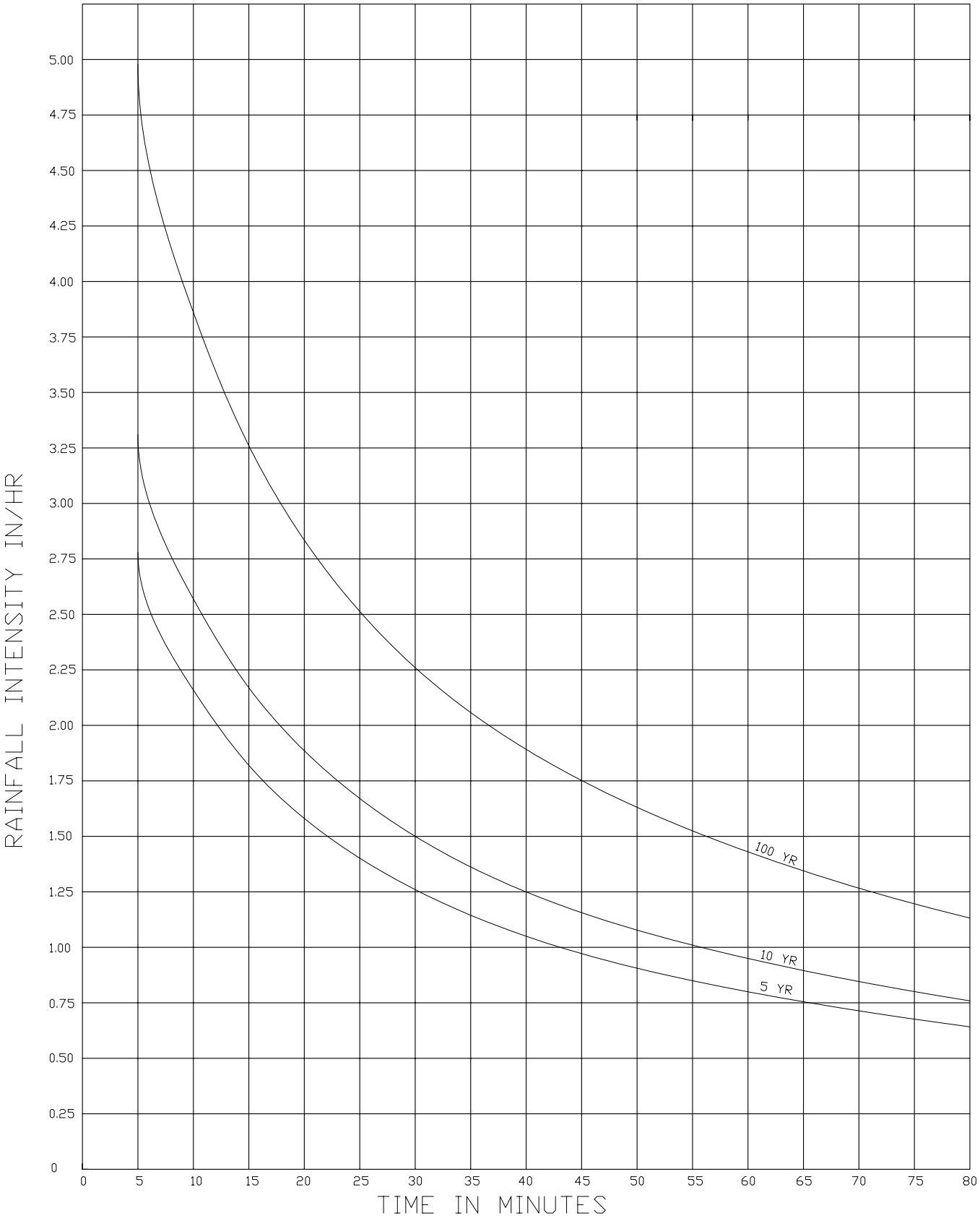


FIGURE 412

T.I.F. CURVE - GRAND LAKE, COLORADO

LATITUDE: 40° 15' N
LONGITUDE: 105° 50' W
DATA FROM NOAA ATLAS 2, VOL III

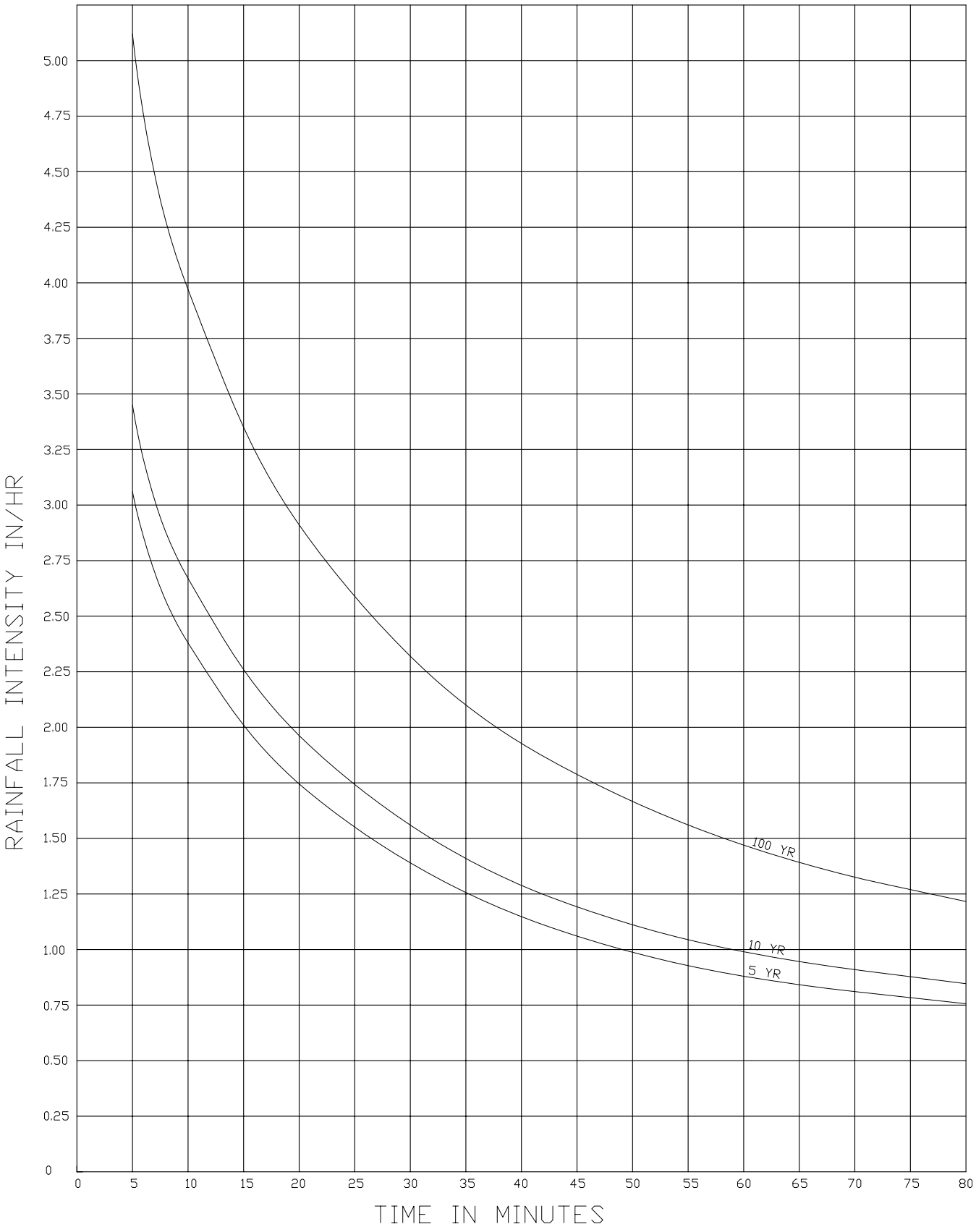
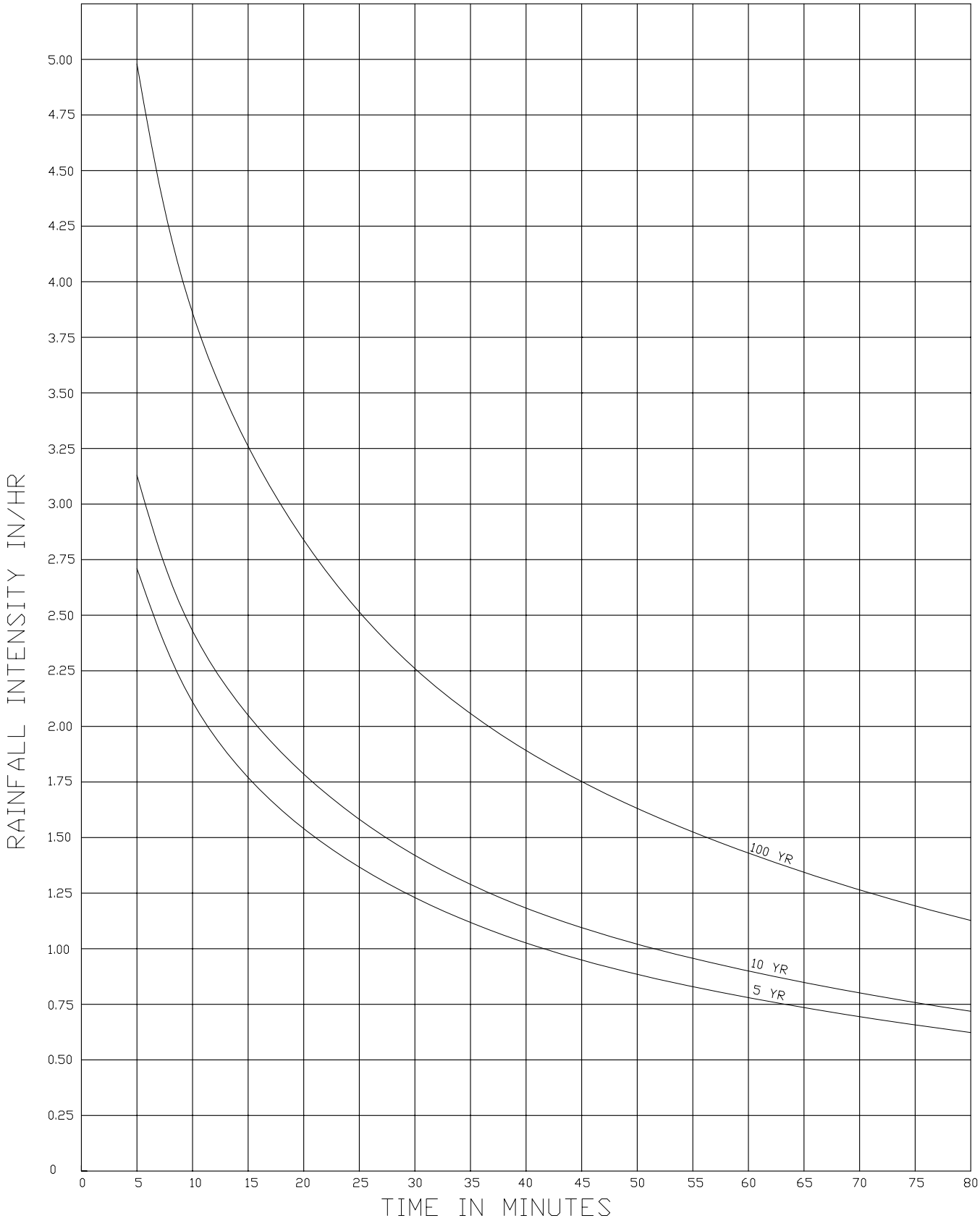


FIGURE 413

T.I.F. CURVE - KREMMLING, COLORADO

LATITUDE:
LONGITUDE:
DATA FROM NOAA ATLAS 2, VOL III



CHAPTER 5: RUNOFF

5.1 INTRODUCTION

The information presented in this chapter shall be used for the determination of stormwater runoff design peaks and volumes to be used in the County in the preparation of storm drainage studies, plans, and facility design. The engineer is referred to the MANUAL for details of the rainfall/runoff models. The purpose of this chapter is to define acceptable methods to be used within the County.

5.2 RATIONAL METHOD

The rational method, as described in the MANUAL, shall be followed in the preparation of drainage reports and drainage facility design in the County. The limit of application of the Rational Method is approximately 160 acres. When the urban drainage basin exceeds 160 acres, the CUHP method represents better practice and shall be used.

Standard forms and spreadsheets are available in the MANUAL and on the CD version of the MANUAL. They are also available on the Urban Drainage and Flood Control District's website, www.udfcd.org,

5.3 COLORADO URBAN HYDROGRAPH PROCEDURE

The CUHP, as described in the MANUAL, may be utilized for hydrological analysis for basins as small as five acres. However, the CUHP is required for watershed areas larger than 160 acres.

5.4 STORM FLOW ANALYSIS

When determining the design storm flows, the engineer shall follow particular criteria and guidelines to assure that minimum design standards and uniformity of drainage solutions are maintained in the County. The information presented herein shall be used by the engineer in the development of design storm runoff.

5.4.1 ONSITE FLOW ANALYSIS

When analyzing the flood peaks and volumes, the engineer shall use the proposed fully developed land use plan to determine runoff coefficients. In addition, the engineer shall take into consideration the changes in flow patterns (from the undeveloped site conditions) caused by the proposed development. When evaluating surface flow times, the proposed lot grading shall be used to calculate the time of concentration or the CUHP parameters.

5.4.2 OFFSITE FLOW ANALYSIS

The analysis of offsite runoff is dependent on the development status and whether the tributary offsite area lies within a major drainage basin as defined in section 3.2.4. In all cases, the minor drainage system is designed for the fully developed minor storm runoff per section 3.4.1 (a), without the benefits of onsite detention.

5.4.2.1 TRIBUTARY AREA WITHIN A MAJOR DRAINAGEWAY

(a) Where the offsite area is undeveloped, the storm runoff shall be calculated assuming the basin is fully developed as defined by the County zoning map. The runoff shall be calculated using the coefficients defined in Table RO-3 and Table RO-5 of Section 3.6, "Runoff", Volume I, of the MANUAL. No credit will be given for detention in the offsite area for any design frequency.
(b) Where the offsite area is fully or partially developed, the storm runoff shall be based upon the existing platted land uses and topographic features. No credit will be given for detention in the offsite area for any design frequency.

5.4.2.2 TRIBUTARY AREA NOT WITHIN A MAJOR DRAINAGEWAY

(a) Where the offsite area is undeveloped, the minor storm runoff shall be calculated assuming the basin is fully developed as defined by the County zoning map. The runoff shall be calculated using the coefficients defined in Table RO-3 and Table RO-5 of Section 3.6, "Runoff", Volume I, of the MANUAL. The major storm runoff may be calculated assuming the historic runoff rates computed in accordance with the procedures described in these CRITERIA.
(b) Where the offsite area is fully or partially developed, the storm runoff shall be based upon the existing platted land uses and topographic features, unless detention has been constructed and verified. However, no credit will be given for detention in the offsite area for the minor storm runoff, unless otherwise approved by Planning and Zoning.

CHAPTER 6: STREETS

6.1 INTRODUCTION

Streets are an integral part of the urban total drainage system, transporting runoff from the minor and major recurrence intervals. However, the primary function of streets is for traffic movement and, therefore, the drainage function is subservient and must not interfere with the traffic function of the street.

The purpose of this chapter is to define the limits to which the engineer may use streets for conveyance of stormwater runoff generated in the minor and major recurrence intervals. The review of all submittals will be based on the criteria herein and the MANUAL. Additionally, on the CD version of the MANUAL, a series of design spreadsheets and software is provided.

6.2 DRAINAGE FUNCTION OF STREETS

The curb and gutter of an urban street or the roadside ditch of a rural street will be used as part of the minor drainage system. Stormwater discharge associated with the minor storm may be conveyed up to the design limitations as set forth in these CRITERIA. When the street capacity begins to exceed the allowed parameters some other form of conveyance, such as a storm sewer system or an open channel, must be used in conjunction to adequately convey these nuisance flows. Streets are also utilized as a part of the major drainage system when they carry floods in excess of the minor storm and are also subject to certain limitations.

6.3 ALLOWABLE USE OF STREETS AS A DRAINAGE SYSTEM

For efficient and convenient use of these CRITERIA, the streets in the County are classified on the following table, according to the average daily traffic (ADT) limits, as defined by the Grand County Road and Bridge Standards. The larger the ADT, the more restrictive the allowable drainage encroachment into drive lanes. The limits of storm runoff encroachment for each classification are shown on tables 601 & 602.

Table 600
STREET CLASSIFICATION

TRAFFIC CLASSIFICATION	DRAINAGE CLASSIFICATION
Local	**A**
Minor Collector	**B**
Major Collector	**C**
Arterial	**C**

Table 601

ALLOWABLE USE OF STREETS FOR STORM RUNOFF

CLASSIFICATION	MINOR STORM	MAJOR STORM
A	No curb overtopping. Flow may spread to back of walk for attached sidewalk. Depth of water at flowline shall not exceed 6".	Flow may spread to edge of ROW. Depth of water at flowline shall not exceed 12".
B	Flow must leave one 10' drive lane free of inundation w/ no curb overtopping.	Flow may spread to edge of ROW. Depth of water at flowline shall not exceed 12".
C	Flow must leave two 10' drive lanes free of inundation w/ no curb overtopping.	Flow may spread to edge of ROW. Depth of water at shall not exceed 12" at flowline, or 6" at the crown, whichever is more restrictive.

Table 602
ALLOWABLE CROSS STREET FLOW

CLASSIFICATION	MINOR STORM	MAJOR STORM
A	6" depth in cross-pan or gutter flowline.	12" depth at gutter flowline or edge of asphalt if no gutter.
B	NONE	12" depth at gutter flowline or edge of asphalt if no gutter.
C	NONE	NONE

Table 602 identifies the maximum allowable cross street flow of stormwater within the street section. Cross street flow occurs under three conditions, when runoff spreads across the crown to the opposite gutter, when cross-pans are used, or when culverts are overtopped.

6.4 HYDRAULIC EVALUATION

6.4.1 ALLOWABLE GUTTER CAPACITY

The allowable gutter capacity shall be calculated using Manning's formula. For convenience the following modified Manning's formula can be used when the stormwater runoff is contained entirely in the street section, otherwise a composite section shall be used in accordance with the MANUAL.

$Q = R\ (0.56(Z/n)\ S^{1/2}\ d^{8/3})$

Where Q = discharge in cfs

$Z = 1/S_x$, where S_x is the street traverse slope (ft/ft)

d = depth of water at face of curb

S = street longitudinal slope (ft/ft)

N = Manning's coefficient

R = reduction factor

The reduction factor shall be determined using Figure ST-2 "Reduction Factor for Gutter Flow" from the MANUAL.

A Manning's value of 0.016 shall be used for the calculations at all street slopes.

The allowable gutter capacity is computed by multiplying the theoretical street capacity by the appropriate reduction factor. Street capacity calculation shall be submitted to the County at critical locations of the street section(s). The allowable street capacity will need to be reduced for non-symmetrical streets.

6.4.2 STREETS WITH ROADSIDE DITCHES

Some streets are characterized by roadside ditches rather than curb and gutters. The capacity of the roadside ditch is limited by the depth of the ditch and the maximum flow velocity. Refer to Chapter 9 for the design and capacity of roadside ditches.

CHAPTER 7: STORM SEWERS

7.1 INTRODUCTION

Storm sewers serve as part of the Minor Drainage System. The use of storm sewers is necessary when other facilities designed to convey stormwater associated with the minor storm are approaching, or at capacity. Except as modified herein, design of storm sewers shall be in accordance with the MANUAL.

7.2 CONSTRUCTION MATERIALS

All storm sewer construction with in County Right Of Way shall be either Reinforced Concrete Pipe (RCP) or High Density Polyethylene (HDPE), in accordance with the manufacturer's specifications. Corrugated Metal Pipe (CMP) and Corrugated Steel Pipe (CSP), in accordance with manufacturer's specifications, are not recommended and are only permitted in privately owned and maintained installations.

7.3 PIPE SIZE

Minimum pipe size to be used in storm sewers is dictated by hydraulic efficiency, however in no case shall be less than 15 inches in diameter.

7.4 VERTICAL ALIGNMENT

Storm sewers shall be designed to withstand AASHTO HS-25 loading on the pipe. Minimum cover constraints are dictated by pipe size, type, class as well as bedding material and thickness, however in no case shall be less than 18 inches. Minimum vertical separation from water lines shall be 18 inches.

7.5 HORIZONTAL ALIGNMENT

Storm sewer alignment may be curvilinear for pipe diameters of 48 inches or greater, but only when approved in writing by Planning and Zoning. The applicant must demonstrate the need for a curvilinear alignment as well as define the limitations on the radius and joint pull as well as provide manufacturer's specifications.

7.6 MANHOLES

Manholes shall be required for maintenance access to the storm sewer whenever there is a change in size, direction, elevation, grade or where there is a junction of two or more pipes. Maximum spacing for manholes shall be 400' for storm sewer runs less than 48" in diameter, and 500' for runs greater than 48" diameter.

Table 700
MINIMUM MANHOLES SIZES

SEWER DIAMETER	MANHOLE DIAMETER
15” – 18”	4’
21” – 42”	5’
48” – 54”	6’
60” and larger	Special Design

Larger diameter manholes may be required if horizontal alignment is not straight through, or more than one sewer goes through the manhole. Engineering discretion should be used when designing large or complex storm sewer networks.

7.7 INLETS

Storm sewer inlets can be classified by the operating condition, being continuous grade or sump. The type of inlets permitted for use within the County along with appropriate reduction factors are described as follows:

Table 701
INLETS

CONDITION	INLET TYPE	PERCENT OF THEORETICAL CAPACITY PERMITTED
	Type R	
Sump or Continuous Grade	5’ (single)	88
	10’ (double)	92
	15’ (triple)	95
Sump or Continuous Grade	Grated Type 13	50
Continuous Grade	Combination Type 13	66
Sump	Combination Type 13	65
Sump	Grated Type C	50

Theoretical inlet capacity shall be designed in accordance with the MANUAL along with the design limitations as set forth in these CRITERIA. Adequate provisions shall be designed for inlets located in sumps pertaining to potential clogging or larger than expected storms in the form of emergency overflow conveyance.

CHAPTER 8: CULVERTS

8.1 INTRODUCTION

A culvert is defined as a conduit under an embankment such as a roadway, railroad, or a canal that allows the passage of surface waters. Except as modified herein, design of culverts shall be in accordance with the MANUAL. The design engineer should refer to the MANUAL or other references cited for basic design concepts or technicalities.

8.2 CONSTRUCTION MATERIALS

Permitted materials for construction of culverts within the County shall be reinforced concrete pipe (RCP), corrugated metal pipe (CMP), as well as high-density polyethylene pipe (HDPE).

8.3 PIPE SIZE

Minimum culvert size in the County right-of-way shall be dictated by hydraulic efficiency, however in no case shall be less than 15". The County recommends minimum size be 18", however under certain circumstances 15" will be allowed. For shapes other than round, the minimum cross sectional area shall be equivalent to that of a minimum round culvert. Driveway culverts shall be designed to convey stormwater associated with the Minor storm with no overtopping. Minimum diameter for a driveway culvert shall be 15".

8.4 MINIMUM COVER

All culverts shall be designed for HS-25 loadings. Minimum cover over the pipe shall not be less than 18" for roadways and 12" for driveways, measured from the crown of the pipe to the top of the pavement sub-grade.

8.5 HEADWATER CONSIDERATIONS

The maximum design headwater depth shall be 1.5 times the diameter, or 1.5 times the rise for shapes other than round. When culverts are used for road crossings, the maximum cross-street flow discussed in Chapter 6 of these CRITERIA may dictate allowable headwater depths.

8.6 VELOCITY CONSIDERATIONS

A minimum velocity of 2 fps should be maintained at the outlet of the culvert, to serve as a cleansing velocity. Maximum velocity through a culvert should be less than 7 fps to limit the effects of erosion. Adequate erosion control measures shall be taken at the inlet and outlet of all culverts. Energy dissipaters may be necessary on steep slopes when velocities exceed acceptable parameters.

CHAPTER 9: OPEN CHANNELS

9.1 INTRODUCTION:

Open channels are defined as any watercourse, natural or artificial in nature, where runoff is concentrated along a defined path. Except as modified herein, design of open channels shall be in accordance with the MANUAL.

9.2 NATURAL CHANNELS

Natural channels can be defined as drainageways carved or shaped by nature before urbanization occurs. They often have mild slopes and are reasonably stable. As the natural channel's tributary watersheds become developed the runoff peaks and volumes are increased causing erosions and degradation to the natural channel. Detailed hydraulic analysis will be necessary to ensure the stability of the natural channel. The designer must prepare cross sections of the channel, water surface profiles for the minor and major events and bed and bank stability calculations to assure that degradation will not occur as a result of development. Some in-stream modifications may be necessary to insure a stabilized condition. If however, calculations by the design engineer conclude that degradation of a natural channel will not occur under developed conditions then, the channel can be left in a natural state.

9.3 ARTIFICIAL CHANNELS

For the purposes of these CRITERIA, three types of artificial channels will be permitted for conveyance of stormwater associated with urban development. Grass lined channels are most desirable whenever feasible. Rock lined channels will be permitted, however their use should be restricted. Concrete lined channels will only be allowed in instances where other options have been exhausted.

9.4 GRASS LINED CHANNELS

This channel type is the most desirable of the artificial channels. Grasses generally slow runoff facilitating both infiltration and biological uptake. A properly designed vegetated channel will effectively eliminate the potential for erosion by stabilizing the soil. Velocities shall be limited to 5 fps and Froude numbers restricted to 0.5 for erosive soils. Velocities up to 7 ft/sec and Froude numbers up to 0.8 are acceptable when soils stabilization techniques are implemented. Side slopes of 4:1 or greater flatter are encouraged. 3:1 side slopes will be accepted, if topographical constraints can be demonstrated. A minimum freeboard of 1.0 foot shall be maintained.

9.5 ROCK LINED CHANNELS

A riprap lined channel will be permitted when design parameters cannot be met for the construction of a grass lined channel. Rock channels can effectively decrease the velocity and energy of a watercourse to within acceptable levels. Rock lined channels

can also be used in areas where there is high potential for erosion due to soil properties and gradient, proper sizing and bedding parameters are essential. Velocities shall be limited to 12 fps and Froude numbers restricted to 0.8. Maximum side slopes of 2.5:1 shall be maintained throughout the reach. A minimum freeboard of 2.0 feet shall be maintained.

9.6 CONCRETE CHANNELS

A concrete lined channel will only be allowed when no other channel type's design parameters can be met and other options are not feasible. Detailed structural analysis will be required addressing heaving and undermining in addition to hydraulic design. The designer in referred to the MANUAL in cases where concrete channels are to be designed.

9.7 ROADSIDE DITCHES

Roadside ditches shall be designed to adequately convey stormwater associated with the minor storm within allowable parameters as defined in these CRITERIA. Particular attention must be given to prevent the adverse effects of erosion.

9.8 DITCH CROSSINGS

Development of land that contains irrigation ditches requires that the developer and all future land owners respect the rights of the ditch owner(s) to access and maintain the ditch without any increased burden of maintenance or liability due to the development of the land. Minor Subdivision plats shall minimize ditch crossings. If crossings are necessary, at a minimum, the following rules shall apply:

(1) Approval from the ditch owner or ditch company to cross the ditch easement shall be required prior to any disturbance of the ditch. The developer shall be required to provide the ditch easement owner with design drawings and hydraulic analysis of the proposed crossing. The developer or owner is responsible for all costs associated with any review of plats or specifications for ditch crossings by the ditch company.

(2) Crossings shall be at roads or driveways whenever possible. The crossing shall be sized so as not to interfere with the ditch operation or alter the existing flow characteristics. (i.e. width, depth, slope, velocity or pattern)

(3) Provide access to the ditch on both sides from all roads that allow vehicles and maintenance equipment access to the ditch, on both sides.

(4) An executed agreement binding the property owner and all successor property owners to accept all liability for damage caused by any improvements installed within the ditch or ditch easement.

(5) An executed agreement that requires current and successor property

owners to maintain the ditch crossing and to keep it and the ditch access easement safe and clean at all times. Maintenance shall include but not be limited to trash removal, as well as repair or replacement of the crossing when necessary. Ditch owners or easement owners shall be notified in writing by certified mail prior to any disturbance within the ditch easement.

(6) The Board of County Commissioners, through the Planning and Zoning Department, may require specific improvements to the ditch crossings in order to limit the liability of ditch owners or ditch easement owners caused by any approved ditch crossings or improvements. These improvements may be required in order to minimize the possibility of flooding or to protect downstream water rights. The cost of these improvements shall be paid by the developer.

(7) All utilities crossing the ditch must be cased at as near a right angle as feasible and installed at a minimum of five (5) feet from the bottom of the ditch to the top of the casing. This is to allow for future cleaning and ditch maintenance.

(8) Any approved ditch crossing by any utility company shall be cased so future maintenance of the carrier pipe will not interfere with the operation of the ditch. Additionally, the location of any crossing shall be clearly marked on each side of the irrigation ditch.

(9) All open cuts across any irrigation ditch are only allowed during the off season while the ditch is dry and shall be replaced with a four (4) inch thick impermeable soil barrier placed on the ditch bottom and banks. The barrier walls shall meet soil classification CL or ML-CL and shall be compacted to ninety-five percent (95%) of the standard proctor density.

(10) Utilities installed during the irrigation season while the ditch is in operation must be bored as to not interrupt the operation of the ditch.

CHAPTER 10: DETENTION

10.1 INTRODUCTION

Stormwater detention facilities within the County shall be designed in accordance with the procedures and data as set forth in these CRITERIA. Detention facilities will be required for all urban development, as stated in Section 3.3.6 of these CRITERIA. Temporarily detaining excess storm water as a result of urban development can decrease flood potential in downstream conveyances. As landuse changes from agricultural and rural to urban in character, historic imperviousness is generally increased. The construction of roads, sidewalks, driveways, parking lots and structures generally prohibit the stormwater infiltration processes and leads to higher rates of runoff as compared to historic conditions.

The purpose of this chapter is to address these issues and provide solutions and procedures for calculating required stormwater detention volumes as well as allowable release rates to be utilized within the County. For catchments larger that 90 acres, and for use of the CUHP, the use of hydrograph routing procedures are recommend.

10.2 DETENTION VOLUME

Detention pond facilities within the County shall be designed to adequately detain excess runoff associated with both the minor and major recurrence intervals. For detention purposes the minor storm event shall be the 10-year recurrence interval, and the major storm event shall be the 100-year recurrence interval.

10.2.1 RATIONAL PROCEDURE

For basins in which the Rational Method is utilized to estimate runoff, typically basins less than 160-Acres, the detention volume may be calculated by determining the difference in runoff between historic and developed conditions. This equation does not take into consideration release volumes or timing elements associated with larger basins where significantly more time and accuracy is needed considering the complexity and cost of the drainage facilities design. Detention volumes can be calculated as follows:

$$V_{required} = V_d - V_h$$

Where:

V_d = Developed Volume

V_h = Historic Volume

$$V_{10} = (C_{10})\,(P_{10})(A)$$

Where:

V_{10} = Volume from the Minor Storm (Ac-ft)

C_{10} = 10 -Year Runoff Coefficient

P_{10} = 10 -Year 24-Hour Precipitation (ft)

A = Area of Developed Basin (Ac)

$$V_{100} = (C_{100})\ (P_{100})(A)$$

Where:

V_{100} = Volume from the Major Storm (Ac-ft)

C_{100} = 100 -Year Runoff Coefficient

P_{100}= 100 -Year 24-Hour Precipitation (ft)

A = Area of Developed Basin (Ac)

These equations will provide reasonable attenuation of flood peaks. The volume calculated for both the Minor and Major recurrence interval shall be considered the minimum required detention volume. For calculating the water surface elevations for a given area and corresponding volume, the Prismoidial Formula may be used, expressed as follows:

$$V = (H/3)*(A_1 + (A_1*A_2)^{.5} + A_2)$$

10.2.2 RATIONAL FORMULA-BASED MODIFIED FAA PROCEDURE

As an alternative to the rational procedure, the modified FAA procedure may be used in accordance with the procedures outline in the MANUAL.

10.3 RELEASE RATES

Maximum allowable release from a developed basin shall not be greater than the historic basin discharge for both the Minor and Major recurrence interval. Allowable discharge rates shall be calculated and compared as set forth in the procedures contained in Chapter 5 of these CRITERIA for both design storms. Offsite discharge accepted by a detention basin will be allowed to flow through the pond at historic rates. These discharge values can be considered additional flows to be incorporated into the design and analysis of the outlet works. The outlet works shall be designed to discharge both the minor and major recurrence interval at less than historic rates.

10.4 ORIFICE EQUATION

Regulating the discharge from a detention basin through the use of an orifice may be calculated with the following equation:

Orifice:

$$Q = C_d*A*\sqrt{2gh}$$

Where:

C_d = Orifice Coefficient (0.40-0.60)

A = Area (ft^2)

G = Gravitational Constant = 32.2 ft/s^2

H = Head Measured From Centroid of the opening (ft)

10.5 WEIR EQUATION

Regulating the discharge from a detention basin through the use of a weir may be calculated with the following equation:

Broad Crested Weir:

$$Q = CLH^{3/2}$$

Where:

C = Weir Coefficient = 3.0 (or as specifically designed)

L = Length (ft)

H = Head (ft)

10.6 DETENTION FACILITIES DESIGN

The design and implementation of detention facilities can enhance the urban environment. Detention basins can serve as a buffer to environmentally sensitive areas, the water storage function can provide for consumptive and conjunctive uses, and the upper areas of a large basin can be utilized for passive recreation activities.

10.6.1 PERMITTED FACILITIES

A grass lined earthen basin is the most desirable method for detaining stormwater runoff within the County and is the focus of this Chapter. Other methods of detaining stormwater runoff as a result of urban development, including but not limited to underground or parking lot facilities will be permitted, however engineering discretion shall be used. Rooftop detention facilities shall be prohibited within the County.

10.6.2 GRADING REQUIREMENTS

Storage facilities with a surface area, volume or dam height as specified in Colorado Revised Statutes 37-87-105 as amended shall require approval of the plans by the State Engineer's Office. All detention storage facilities shall be designed and constructed in accordance with these CRITERIA. Those facilities subject to state statues shall be designed and constructed in accordance with the criteria of the state.

10.6.3 FREEBOARD REQUIREMENTS

A minimum of 1.0 feet of freeboard shall be required, measured from the calculated 100-year water surface elevation.

10.6.4 EMERGENCY SPILLWAY REQUIREMENTS

To protect from catastrophic failure of the detention basin as a result of a larger magnitude storm or failed outlet works, an emergency spillway must be provided.

Incorporating a weir into the embankment is the most desirable method. The sizing of the spillway should be based on the risk and consequences of a facility failure. At a minimum the spillway shall be total peak 100-year storm discharge, including all off-site areas.

10.6.5 MAINTENANCE ACCESS

Maintenance access shall be provided to all detention facilities in accordance with section 3.3.9 of these CRITERIA.

10.6.6 PERFORMANCE REQUIREMENTS

To assure that the detention facility has been constructed according to the approved plans, an as-built survey, signed and sealed by a Colorado Professional Licensed Surveyor, shall be required. This pond certification shall be submitted to the County, signed and sealed by a Licensed Professional Engineer. The certification shall attest to the fact that the pond was built in substantial compliance with the design, including but not limited to the volume available, freeboard, outlet works and emergency spillway.

CHAPTER 11: WATER QUALITY

11.1 INTRODUCTION

The County recognizes the necessity to address stormwater quality issues that may arise as a result of urban development. Non-point source pollution continues to be one of the major contributors affecting the aesthetic values of receiving waterways, ecological benefits for fish and wildlife populations. Stormwater runoff across lawns, roofs, and impervious roadways facilitates the transport of sediment laden with fertilizers, nutrients, oil, grease and other contaminants. The most desirable method for treating this sediment-laden runoff within the County is to effectively slow and control the release of this stormwater to facilitate deposition prior to discharge into the receiving downstream conveyance. The County shall require a water quality pond to be built with each development.

In recognition that stormwater hydrology is regional in nature, these CRITERIA are written to be in substantial compliance with the Northwest Colorado Council of Governments – Water Quality Protection Standards. The design engineer should be familiar with the intent of those Standards, as well as Local, State and Federal Regulations concerning the treatment of stormwater runoff. Please see chapter 8 of the Grand County Road & Bridge Standards for further information on the State requirements for a Stormwater Management Plan (SWMP), as well as other valuable references.

The purpose of this Chapter is to identify the County requirement of a water quality pond for any development that is subject to these CRITERIA. As the predominate portion of the proposed developments will require a detention pond, the following section describe the procedures to provide an Extended Detention Basin (EDB) – Sedimentation Facility. Please see Volume III of the MANUAL, Structural Best Management Practices, Section 6 for further details.

11.2 WATER QUALITY CAPTURE VOLUME

When there is a detention pond is proposed in the design of a development, the County encourages the design of water quality control ponds to be calculated as an extended detention basin sedimentation facility (EDB).

11.2.1 WQCV

The water quality capture volume is determined based on developed watershed imperviousness and is expressed as watershed inches. The Water Quality Capture Volume (WQCV-watershed inches) can be calculated as follows:

$$WQCV = a*(0.91i^3 - 1.19i^2 + 0.78i)$$

Where a = 1.0 for a 40 hour drain time.

11.2.2 DESIGN VOLUME

The design volume is described as a storage volume equal to 120 percent of the WQCV based on watershed area and can be calculated as follows:

$$V_{design} = (WQCV/12)*Area*1.2$$