REQUEST FOR QUALIFICATIONS
FOR CONSULTING SERVICES TO DEVELOP A
COMPREHENSIVE STORMWATER MASTER PLAN
FOR THE TOWN OF JOHNSTOWN, COLORADO

January 3, 2024

Town of Johnstown – Public Works Department
450 S. Parish Avenue
Johnstown, CO 80534
Phone: (970) 587-4664

The Town of Johnstown ("Town") is seeking professional services from a qualified firm with experience in stormwater management, flood resiliency, community outreach and master planning for the purpose of developing a Stormwater Master Plan ("SWMP"). This plan is to involve the public, Town Officials and Town staff and evaluate the existing stormwater system in order to develop strategies and a prioritized phased improvement program with projected costs to address current and future stormwater infrastructure needs. The Town is requesting proposals for professional services to prepare a comprehensive Stormwater Master Plan which will include: surveying, field assessment of storm drain systems, hydrologic analysis of flow quantities, hydraulic capacity analysis and modeling of streets and piped systems and stormwater system design and capital improvement planning for the Town.

Anticipated Schedule of Activities:

The following activities and dates are a tentative outline of the process that will be used to solicit Consultant responses and to evaluate each Consultant response:

January 3, 2024	Issue Request for Qualifications
January 12, 2024	Deadline for Submitting Questions
January 17, 2024	Questions Responses Posted
February 16, 2024	RFQ Submittal Deadline
February 26, 2024	Consultant Interviews (if deemed necessary)
March 13, 2024	Contract Awarded

Submission Deadline:

Proposals are due no later than 2:00 p.m. MST, on Friday, February 16, 2024. Submissions received after the published date and time set shall be considered non-responsive and will not be accepted by the Town.

Submission Format:

Consultants/Firms responding to this RFQ are required to submit **One Electronic Copy in PDF format** via email to: Jason Elkins jelkins@johnstownco.gov. Submittals may be transferred via a link to a file sharing service (such as Dropbox, Google docs, etc.) as long as the invitation email is received by the submittal deadline.

General Terms and Conditions:

Consultants shall make all investigations necessary to thoroughly inform themselves regarding the items affected by the conditions of this solicitation. No plea of ignorance by the Consultant of conditions that exist or that may hereafter exist as a result of failure to fulfill the requirements of the Contract Documents will be accepted as the basis for varying the requirements of the Town or the compensation to the Consultant. The accuracy of the Offer is the sole responsibility of the Consultant.

Any ambiguity, conflict, discrepancy, omissions or other errors discovered in the solicitation must be reported immediately in writing to the Town and a request be made for modifications or clarifications. Any such change(s) will be posted as an amendment or addenda.

Any information submitted with the Proposal will become public information, subject to release, under the Colorado Open Records Act. The Town shall be held harmless for any claims arising from the potential release of information with any submission. It is the responsibility of the proposing firm to ensure that no confidential or proprietary information is included in the submission that is not desired to be released.

Content Formatting:

Proposal page count and required format:

- Proposals shall be no more than **twenty-five (25)** type written pages. General size of pages shall be typical letter size.
- Minimum font size 10-point, single spaced.
- A maximum of three (3) 11” x 17” pages will be acceptable for exhibits that may benefit from the larger size, these pages will be counted toward the page maximum as a single page, unless part of the “Work Sample” section (see below).
- The cover letter will be counted toward the page maximum.
- The RFQ digital submittal form (RFQ Attachment A) will not be counted toward the page maximum.
- Cover page, divider pages, resumes, and the maximum 10-page Work Sample section will not count toward the page limit, but we request that each individual’s resume be reduced to a single page.
- Resumes of key personnel shall be provided in an Appendix to the RFQ response.
- Samples of similar work shall be provided as Appendix to the RFQ response—note that no more than ten (10) pages of sample work will be accepted.

Cover Letter:

Submittal responses must contain a signed cover letter (electronic signature) of the authorized agent of the Consultant, summarizing the Consultant's statement of interest, and providing contact information for the primary point of contact. The Town requests that consultants identify a contact person within the submittal that will be available to answer questions regarding the proposal and/or possibly attend an informal interview after the Town appointed selection committees' evaluation of the written proposals.

Inquiries:

No pre-proposal conference will be held; however, questions may be emailed directly to Jason Elkins, P.E., Public Works Director as noted previously regarding the proposal for this project. Questions must be submitted prior to the published deadline of **January 12, 2024**.

Responses to questions submitted will be posted on the Rocky Mountain E-Purchasing System (BidNet) website on or before **January 17, 2024.** Submitting Consultants are responsible for obtaining any such published clarifications/addenda via the BidNet website. Consultants shall acknowledge all addenda within their submittals, failure to acknowledge the addenda may deem the Consultant non-responsive.

Eligibility

To be eligible to respond to this RFQ, the proposing firm or principals must demonstrate that they, or the principals assigned to the project, have successfully provided services similar magnitude to those specified in the Scope of Services section of this RFQ to at least one Town or City similar in size and complexity to the Town of Johnstown or can demonstrate they have the experience with large scale private sector clients and the managerial and financial ability to successfully perform the services.

The proposing firm shall also demonstrate and by responding to this RFQ agrees to the following:

- The Consultant has no conflict of interest with regard to any other work performed by the Consultant for the Town of Johnstown or on active private land development projects in the Town of Johnstown and will not engage in the review or submittal of private land development related projects within the Town of Johnstown for the duration of the contract.
- The Consultant has not been involved with the application for the grant award or in the preparation of this RFQ.
- The Consultant and any sub-consultants included in this response shall provide a Unique Entity Identifier and DUNS number, and shall provide this information as part of the contract negotiation process.
- Regular submittal of invoices meeting the standards as required by the State of Colorado's Department of Homeland Security for federally funded projects.

Minority Participation:

Disadvantaged Business Enterprises(DBE) participation. Consultants are advised that the Town promotes equal employment opportunity (EEO) and encourages the participation of minority and women business enterprises (M/WBE) as well as small business enterprises (SBE) in all aspects of contracting. Joint venturing at the prime and sub-consultant levels is encouraged where the joint venture results in a more qualified and/or more diverse consulting team.

Fee Proposal:

This is a qualifications-based selection; however, a separate fee proposal must be included. This fee proposal shall be included in a **separate digital folder labeled "FEE PROPOSAL"**. The Fee Proposal will not be distributed to the RFQ selection committee, and will be opened by Town staff only after a selection recommendation is made and will be used by the Town in the contract negotiation process. Failure to submit the Fee Proposal in a separate digital folder, labeled as noted above will result in disqualification.

Rejection of Submissions:

The Town at its sole and absolute discretion, may reject Submittals or deem a Consultant nonresponsive based on the following:

- Reject any and all, or parts of any or all, submittals by prospective Consultants if not in the best interests of the Town.
- Waive any irregularities in the Submittals received.
- Consultant misstates or conceals any material fact in its Submission.
- Submission does not include all documentation required.
- A conflict of interest is determined.

Special Terms & Conditions:

The Town reserves the right, before making a selection or awarding a contract, to require a consultant to submit supplemental information such as evidence of its financial, technical, or other qualifications and ability to perform the work as necessary and may consider any evidence available to it in making the award in the best interests of the Town. Such information may include but not necessarily be limited to: financial statements, contracts cancelled, prior or pending lawsuits against the firm or its principals.

Consultant shall furnish all information and data for this purpose as the Town requests. The Town reserves the right to reject any proposal if evidence submitted, or investigation, of such consultant fails to satisfy the Town that such consultant is properly qualified to meet the obligations of the project.

Consultants shall identify any and all subconsultants or subcontractors that will be used in the performance of the contract resulting from this solicitation. The primary consultant shall also identify the capabilities and experience of the work to be performed by such subconsultants. The competency of the subconsultants with respect to skill, responsibility, and business standing may be considered by the Town when making the award.

Proposal Content & Evaluation:

Proposals will be evaluated based on the following information:

Qualifications of Firm and of the Project Team: (30 Pts)

Briefly discuss firm capability and project team qualifications that are being included in the Stormwater Master Plan. Include examples of current or past projects of a regional nature for stormwater master plans in existing developed urban areas as applicable. Identify project references that may be contacted in regard to the Consultant's performance on past projects. Include samples of previously completed master plans, with a focus on how information developed was conveyed in exhibits, etc.

Project Approach: (30 Pts)

Describe your team's proposed course of action to accomplish the work identified. Identify critical issues to accomplishing the work. Submitters shall review the Scope in this RFQ and from that sample, prepare a detailed scope of services outlining the work required to complete the Stormwater Master Plan as presented in this RFQ. Describe any innovative ideas, critical issues, and/or alternative approaches that may benefit the study, including multi-use, LID and other innovative ideas that could be implemented to reduce runoff in developed areas.

Schedule of Services: (10 Pts)

Provide a detailed schedule that is well coordinated with the developed scope of services and identify milestones you believe are critical for the project. Allow two weeks for Town of Johnstown review at each submittal milestone (30/60/90). Discuss the approach your project team will take in order to maintain the project schedule, and discuss any obstacles that could impact the schedule.

Project Management and Cost Controls: (10 Pts)

Discuss methods/concepts that your team uses for schedule, scope and budget management and how these methods will be employed during field investigation and analysis phases.

Availability to Perform Work: (10 Pts)

Describe the team members' current and projected workloads and anticipated time dedicated to the work during the course of the study.

Other: (10 Pts)

Other considerations that could benefit the evaluation may include but not be limited to the following:

- Extent to which the consulting team involves the use of minority-owned business enterprises.
- Prior experience with the Town of Johnstown.

Potential Interviews:

The Town will make an effort to notify of intent to conduct a limited number of consultant interviews and discuss project issues within **fifteen (15) working days** after the RFQ submittal deadline.

In the event your firm is asked to attend an interview, consultants shall be prepared to discuss the information in your proposal including the following:

- Project Approach
- Project Communications
- Understanding of the Scope of Work
- Design Tools
- Resources and Availability
- Schedule
- Project Concerns

Award of Contract:

After the Town has selected the highest ranked submitting Consultant, the Town and the selected Consultant will negotiate fees for the requested services. If a negotiated fee cannot be reached with the highest ranked Consultant, the Town will then proceed to negotiate with the second, third, and so forth until accepted. The Town has the right to reject any and all proposals if the Town does not negotiate an acceptable fee.

The Town anticipates selecting a consultant, negotiating study fees and giving a Notice to Proceed by March 15, 2024**.** The Consultant selected should be prepared to initiate work within **ten (10) working days** from the Notice to Proceed date.

A draft copy of the Town's standard professional services agreement (PSA) is included as Attachment B to this RFQ. Submitters shall note any exceptions and potential agreeable remedies to the PSA within the RFQ response.

BACKGROUND

Johnstown is a 13.84 square mile home rule municipality incorporated in 1907. The watershed boundaries impacting the Town of Johnstown include approximately 23 square miles (not including the watershed areas associated with the Big Thompson River and Little Thompson River). This project is funded by the Federal Emergency Management Agency (FEMA), under the Hazard Mitigation Assistance Program and all requirements of the grant agreement and federal policy for grant awards must be followed.

The Town of Johnstown has an existing Stormwater Master Plan that was prepared in 2001 (included as RFQ ATTACHMENT C). This plan identifies major watersheds within the Town of Johnstown, and has been used to guide development and management of stormwater runoff since it's completion in 2001. This may be utilized as a rough guide, but it is expected that the new Stormwater Master Plan prepared under this award will provide improved data, improved mapping and exhibits, and a more extensive analysis of the existing and future system than contained in the 2001 Stormwater Master Plan.

With the growth the Town has experienced in the last 23 years, the updated Stormwater Master Plan is needed to identify flow patterns, quantify current and future stormwater runoff, identify specific areas of concern, locate existing local and "regional" drainage facilities (public or private), inventory and assess existing stormdrain systems including catchbasins, open channels (including irrigation ditches as several are no longer allowing stormwater conveyance) and other stormdrain facilities that ultimately deliver stormwater discharge to the Big Thompson and Little Thompson Rivers. Riverine flooding limits should be incorporated, through utilization of the most recent scientific data available from FEMA, and the impacts to local facility outfall(s) should be discussed.

The anticipated deliverables will be used as a tool for the Town to determine placement of new public infrastructure, and maintenance needs on existing infrastructure. The updated Stormwater Master Plan will identify areas where stormwater mitigation projects are needed based on current and projected growth patterns, future roadway alignments, etc. and will determine where privately held facility's impact the public right-of-way or downstream areas. A GIS dashboard that captures all pertinent information on location, size, and condition of the existing system is to be included. The Stormwater Master Plan will also develop a strategy to fund/construct needed updates (via the preparation of a 10-year Capital Improvement Plan) for identified drainage facility needs. The completed Stormwater Master Plan will also be utilized as a tool to help manage future growth and as a guide for future development to assure compliance with established regional and local standards as new development occurs.

SCOPE OF SERVICES

The following is the draft Scope of Services, based on the conceptual scope of services that accompanies the grant award for the Town of Johnstown's Stormwater Master Plan. Be advised that because this project is 90% funded with federal grant dollars, it is anticipated that all items or a close approximation will be produced as part of the expected deliverable. If the Consultant can identify a more effective means to produce a specific deliverable, or if additional scope is needed to produce a comprehensive Stormwater Master Plan you are encouraged to include modify Scope of Services in the RFQ response based on your proposed project approach, so long as the modifications are clearly noted as such.

This Scope of Work may be revised during contract negotiations and is meant to serve as guidance in the preparation of Consultant responses to the RFQ.

1) PROJECT COORDINATION AND DATA GATHERING

a) Kick-Off Meeting
    i) CONSULTING TEAM shall prepare an agenda, organize and prepare minutes for the Kick-Off Meeting.
    ii) The Public Engagement process shall be discussed at the Kick-Off meeting and integrated into the Project.

b) 30% Progress Meeting
    i) CONSULTING TEAM shall conduct a conceptual content level progress meeting with the Town's Project Manager at the 30% project milestone interval and shall provide progress sets of work completed for Town review at this intervals.

c) Community Engagement Workshops
    i) CONSULTING TEAM shall coordinate public engagement workshop style meetings (3 minimum)

d) Coordination with Stakeholders
    i) CONSULTING TEAM shall coordinate with adjacent agencies and other stakeholders to determine the potential for mutually beneficial projects, and to assure adjacent agency stormwater improvements, whether existing or planned are memorialized in the Town of Johnstown's Stormwater Master Plan if they are determined to have any impact on the Town's current jurisdictional boundary or future growth area.

e) Progress Meetings
    i) CONSULTING TEAM shall conduct a page-flip style progress meeting with Town's Project Manager at the 30% milestone interval and shall provide progress sets of work completed for Town review.
    ii) CONSULTING TEAM shall conduct a page-flip style progress meeting with Town's Project Manager at the 60% milestone interval and shall provide progress sets of work completed for Town review.
    iii) CONSULTING TEAM shall conduct a final product progress meeting with Town's Project Manager at the 90% project milestone interval and shall provide progress sets of work completed for Town reviews. (Concurrently a Public Engagement Workshop shall be held)
    iv) CONSULTING TEAM shall conduct a 60% and 100% complete presentation of Storm Drainage Master Plan and CIP to Town Board
    v) CONSULTING TEAM shall prepare agendas, organize and prepare minutes for monthly progress meetings with the Town's Project Manager and key stakeholders.

f) Information Gathering
    i) CONSULTING TEAM shall research existing plans, reports and studies in detail and utilize this information as much as possible for preparation the Stormwater and Drainage Master Plan. This will include review of all Drainage Master Plans, and documents provided by Town staff including plats, as-builts, existing CCTV runs etc. In order to complete these Tasks, information will be needed from the Town's staff.
    ii) The CONSULTING TEAM shall review the information on the Town of Johnstown's website, and review the prepared list of documents herein to determine if additional historic information is available to facilitate preparation of this project. Where data and/or information is not readily available the Consultant will need to independently prepare data and field verification of historic data may be needed.
    iii) The list of needed items to be provided by the Town and reviewed by the Consultant may include:
        (1) Digital/paper copies of all storm drain as-builts for review and inclusion to the interactive GIS database.
        (2) Digital copy of models, including input and output files from the previously prepared studies (hydrologic and hydraulic)
        (3) Historic drainage reports for large development projects
        (4) Locations of existing storm drain facilities, including lift stations, siphons, catchbasins, channels, detention/retention ponds, pipes (material and year installed)—FIELD VERIFICATION MAY BE NEEDED
        (5) Locations of all corrugated metal pipe culverts in the public right-of-way FIELD VERIFICATION MAY BE NEEDED
        (6) Operations and Maintenance Manuals for stormdrain lift stations, siphons, and detention ponds
        (7) Location of existing Town owned parks and critical facilities (developed and primitive), both existing and planned

    (8) *If available the Town will also provide GIS shape files for:*
        (a) *existing land use (zoning map)*
        (b) *future land use (zoning map)*
        (c) *parcels (available from Weld and Larimer County GIS)*
        (d) *water, wastewater and stormwater systems (data available is not fully up to date)*
        (e) *jurisdictional boundary*

iv) The CONSULTING TEAM shall confer with Town staff, to determine:
    (1) maintenance issues/know problem areas
    (2) private property flooding localized flooding
    (3) presence of hydrophobic soils
    (4) sediment deposition issues
    (5) debris accumulation issues
    (6) outlet erosion issues
    (7) side-slope issues on open channels
    (8) head cutting locations

g) Conditions Assessment

i) The CONSULTING TEAM shall gather historic plans, report, as-builts, and any available CCTV data from Town staff and other jurisdictional agencies, and conduct a cursory review of existing CCTV data discovered and make a recommendation to Town staff regarding the need for additional CCTV data.

ii) Existing CCTV data shall be augmented with new runs of any CMP storm drains in the publicly held right-of-way in order to verify conditions in these facilities and for use in the conditions analysis and CIP. Note that camera runs of existing RCP and HDPE storm drains will not need to be conducted due to anticipated longevity of these materials.
    (1) Include in the RFQ response a line item allowance of **$25,000 for CCTV** data collection and review.
    (2) The CONSULTING TEAM shall produce a system condition assessment for inclusion into the Stormwater Master Plan and Capital Improvement Plan.

iii) Where conveyances are passed under public-right-of-way in box culverts or bridges, the conditions assessment shall include observation of the condition of these crossings, and where possible incorporate a summary from the most recent bridge inspection.

iv) The CONSULTING TEAM shall review collected data and determine where gaps are present and determine locations where a field survey is needed to fill data gaps. Where needed to augment GIS information, scientific modeling, to determine horizontal and vertical location, to verify material type, and in order to conduct accurate street and catch basin capacity computations or other built environment conditions, field survey work will be conducted by the CONSULTING TEAM. Flow directions on storm drain lines shall be verified using available or field surveyed topographic information to ensure the data is suitable for the use in scientific modeling.

v) The CONSULTING TEAM will also be expected to gather data for use in the hydrologic and hydraulic analysis, such as existing and future land use patterns, by conducting verification of drainage areas through field inspection and by assessment of vegetative and other conditions that impact facility hydraulics.

h) Field Verifications

i) The CONSULTING TEAM shall conduct a field verification of drainage patterns and facilities as represented in historic reports.

ii) Include in the RFQ response a line item **allowance of $50,000** for field survey work which may include horizontally and vertically locating existing stormwater facilities.

2) GIS DATA REVIEW and GIS DASHBOARD DEVELOPMENT

a) The CONSULTING TEAM shall have the expertise needed to review the Town of Johnstown's existing GIS data and schema and evaluate this data for completeness. Where gaps are discovered or additional GIS information needed, the CONSULTIMG TEAM shall provide updates in the format preferred by the Town's staff.

   i) Where new layers are required, the CONSULTIMG TEAM shall develop GIS shapefiles using the most current ESRI data models. The CONSULTING TEAM shall research and develop data to for use in modeling environments where the direction of flow is associated to the lines and all assure features are topologically correct so that features are connected to the appropriate lines to properly represent spatial relationships.

   ii) Unique IDs will be required for all the features in the system for the association of any CCTV information and other available data, such as material type, age, inverts, etc.

   iii) Information gathered from field surveys is to be used to update the existing GIS data. This will include all elevation information for points, lines and surface structures along with key features and locations such as detention areas.

   iv) The best available information shall be used to develop the GIS data which may include data from additional sources. Data from the modeling and system assessments will be input into the GIS layers for conditions, criticality, modeled information and overall assessments. Any as-builts or plans used in the data development will be attached to the features in the GIS. The data will be developed in a manner that provides a straightforward methodology to update the information as conditions in the system change or features are replaced or repaired. Documentation is to be developed by the CONSULTING TEAM for the GIS data related to the ongoing maintenance needs, related table associations, and data development methodologies.

b) The CONSULTING TEAM shall conduct GIS updates to include existing facilities. The CONSULTING TEAM shall develop additional application data specific to the storm system information. This will have the layers for the assets, soils, drainage areas, etc. This will have specific information related to the system assets, drainage areas, and soils etc. The application will have preconfigured filters for things like pipe types, date built, and ownership. It will also provide the ability to create custom filters. The application developed shall include a set of standard tools.

c) The CONSULTING TEAM shall incorporate new stormwater capital projects identified as part of the Capital Improvement Plan preparation into a comprehensive GIS platform for integration to the Town's system.

3) STORMWATER MASTER PLAN PREPARATION

a) The CONSULTING TEAM will prepare a detailed and comprehensive Stormwater Master Plan for the Town of Johnstown which incorporates and summarizes all information derived from information gathering and coordination tasks. Using this information, the CONSULTING TEAM shall develop a detailed analysis of the Town's stormwater conveyance system. Information will be presented in a clear and concise format, containing all historic and future hydrologic and hydraulic models and exhibits, inlet and street capacity calculations and pond sizing of both existing and future improvements. The Consultant shall familiarize themselves with the methodology that has been implemented to guide growth in the current Stormwater Master Plan and make recommendations on retaining this methodology or by developing a more accurate alternative. This will include as a minimum:

   i) Regional watershed delineation and quantification of runoff in historic and future developed conditions.

ii) Local watershed delineation and quantification of runoff in historic and future developed conditions.
iii) Location and capacity of existing drainage facilities (public and metro-district owned).
iv) Location of major conveyances and regulatory floodplain.
v) Use of the 5-year storm (minor) and 100-year storm (major) for resultant flows at critical points.
vi) Development of a stormwater model for analysis of system capacity needs for existing and future development and expansion for the next 10 years. The model shall consist of a comprehensive basin by basin analysis of the existing and proposed stormwater systems. The Town-wide stormwater hydraulic/hydrological model must be developed from publicly available platforms (i.e. USACOE software) and the rights to the model provided to the Town to ensure that the model may be used for permitting of stormwater projects or for future Town use and modifications.
vii) Use of Mile High Flood District Methodology.
viii) Use of the Town's Draft Stormdrain Design Standards (will be provided to selected consultant).
ix) Identification of system deficiencies and improvement alternatives including new regional detention ponds, conveyance replacements, conveyance improvements, etc.
x) Identification of a major watershed specific guideline to manage future growth where downstream conveyance is under or undeveloped and cannot accommodate historic or future stormwater flow.
xi) Special consideration shall be given to identification of new projects that promote regional partnerships and those that involve low maintenance and low impact techniques.
xii) Clear and concise graphics and exhibits.
xiii) The CONSULTING TEAM staff will utilize the information from any available historic studies, and combined with the field work and research conducted to prepare an existing conditions and future conditions hydrologic and hydraulic analysis for each major Town of Johnstown watershed. This will include reviewing and modifying existing basin subareas, existing conveyance facilities and all appurtenant structures, such as catchbasins, sidewalk drains, laterals, etc. and presenting findings in the form of a comprehensive narrative along with gathering public input as needed to fully conceptualize alternatives as part of the 30% complete project review. It is expected that at the 30% level:
    (1) 30% complete draft of narrative outline will be presented for review
    (2) 30% complete draft of anticipated exhibit content and style for narrative will be presented for review
    (3) Results of stakeholder and public input in the form of a draft project prioritization matrix will be presented for review
    (4) Concepts for data gap correction, data integration, and GIS dashboard will be presented for review
xiv) The CONSULTING TEAM shall analyze the findings and develop recommendations for new stormwater conveyance and storage facilities as needed for the Town of Johnstown. These recommendations will be presented to the public and to the Town's staff for comment and concurrence and will be incorporated into revised scientific models to determine downstream impacts, sizing, placement, planning level costs, etc. at both the 60% and 90% complete project progress submittals. It is expected that:
    (1) 60% and 90% complete Stormwater Master Plan narrative will be presented for review
    (2) 60% complete draft and 90% finalized submittal of related exhibits, scientific model input and output data, street and inlet capacity calculations, and results of system condition assessment will be presented at 60% for utilization in developing recommendations for the Capital Improvement Plan.

            (3) 60% complete data gap correction, data integration, and GIS dashboard will be presented for review and 90% complete GIS dashboard presentation to staff and stakeholders

4) 10-YEAR CAPITAL IMPROVEMENT PLAN

a) CONSULTING TEAM shall summarize identified system deficiencies, prepare detailed planning level cost estimates for each identified deficiency upgrade, prepare a prioritization matrix based on project ranking scorecards, and spread costs over a 10-year period.
    i) Provide recommendations for new and upgraded stormwater infrastructure throughout the City.
    ii) Provide recommendations to improve the resiliency of existing and future stormwater infrastructure and facilities.
    iii) Provide recommendations to address water quality and environmental issues in accordance with the requirements of the Clean Water Act, National Pollution Discharge Elimination System Permits, CDPHE and other State of Colorado regulations, Mile High Flood District (MHFD) and any additional applicable regulatory requirements.
    iv) Identify Capital Improvement Projects (CIP) needs based on a ten (10) year time frame and recommend projects based on two (2) year increments.
    v) Include planning level cost estimates for engineering, construction, contingency, operation and annual maintenance costs.
    vi) Prioritized list of CIP projects shall provide justification for the areas of highest concern and be ranked using a comprehensive ranking matrix based on cost benefit analysis and its impact on Level of Service, risk of flooding, resiliency enhancements, water quality and public support. Identified projects shall have a one page "Project Scorecard" which describes the project in detail and includes the ranking number from the matrix. It is anticipated that the "Project Scorecard" will be included in the GIS Dashboard developed by the Consultant for future capital improvement projects.
    vii) Recommendations for changes or modifications should be developed for consideration for stormwater projects and programs over the next ten (10) years and include sustainable design standards/ approach where feasible.
    viii) Evaluate and provide recommendation of alternative funding options including grants, loans, and/or public-private partnerships to fund future CIP projects. This information shall be summarized and shall include a summary of each including funding agency, partnering potential, grant and/or loan cycles, match funding requirements and a summary of what type of projects are preferred/eligible.

5) RATE STUDY

a) CONSULTING TEAM shall prepare a Financial Analysis for the stormwater improvements, using the projected Stormwater Capital Improvement Plan expenditures developed during the master planning process. The financial plan shall feature financial projections of revenue sources, operations and maintenance expenditures adjusted for anticipated inflation, cash reserve balances and debt service coverage expenditures. The CONSULTING team shall consider alternative rate structures and provide an optimal capital financing strategy that features the most appropriate combination of projected rate revenue increases, new external debt financing and cash funded CIP expenditures.

6) DELIVERABLES:

a) A comprehensive Stormwater Master Plan per the outlined scope of services herein which must include:
    i) Existing stormwater infrastructure assessment as a stand-alone document
        (1) 30%, 60%, 90% and 100% phase Town-wide growth area Stormwater Master Plan.

    (2) Each phase submittal (30/60/90/100) shall include an electronic progress copy of the Stormwater Master Plan.
    (3) Ten (10) hard copies professionally bound of the Stormwater Master Plan at 100% phase.
    (4) Hydrologic and Hydraulic Models with digital copies of input and output files, analyzing existing and proposed improvements and stormwater systems.

b) A comprehensive Stormwater Capital Improvement Plan per the outlined scope of services herein which must include:
   i) Recommendations for new and upgraded stormwater infrastructure, inclusive of planning level cost estimates as well as conceptual alignment for planning/ budgeting purposes.
   ii) Prioritization of capital improvements project based on level of service, risk of flooding, resiliency, water quality/quantity and public support, summarized and presented using a comprehensive matrix with project scorecards included. The CIP shall be presented as a stand-alone document.

c) A complete GIS compatible dashboard of existing and future system, with components alpha-numerically identified in a comprehensive manner for incorporation into the Town's existing GIS system.

d) A 10-year financial planning model based on the financial analysis/rate study per the outlined scope of services herein.

ATTACHMENT A-RFQ SUBMISSION FORM FOR ELECTRONIC SUBMISSION

(Include this form as a PDF with your electronic submission)

Does your offer comply with all the terms and conditions? (YES / NO)
If no, indicate where exceptions can be found in the proposal.

Does your offer meet or exceed all specifications? (YES / NO)
If no, indicate where exceptions can be found in the proposal.

Does your offer intend to comply with the Town's Professional Service Agreement? (YES / NO)
If no, indicate what exceptions you may have to the Agreement template.

Have All Addendums Been Acknowledged? (YES/NO)

(Please Note Addendums by Number/Date)

Has a Duly Authorized Agent of the Consultant Signed the Cover Letter? (YES / NO)

Has your UEI been included in your Cover Letter? (YES / NO)

Has a W-9 Form Been Included With the Proposal? (YES / NO)

Does Consultant agree to execute contract documents electronically if the Town so requests?

(YES / NO)

Person authorized to execute contract documents:

Printed Name: ____________________________

Title: ____________________________________

Email Address: ____________________________

Date: ____________________________________

ATTACHMENT B- Town of Johnstown Professional Services Agreement

TOWN OF JOHNSTOWN
PROFESSIONAL SERVICES AGREEMENT

THIS PROFESSIONAL SERVICES AGREEMENT (the "Agreement") is made and entered into this ____ day of ________ 2023 (the "Effective Date") by and between the Town of Johnstown, Colorado, a Colorado home-rule municipal corporation (the "Town") and _____________________________________, a ______ ("Contractor") (collectively, the "Parties").

RECITALS

WHEREAS, the Town desires to engage the services of Contractor and Contractor desires to provide those services more fully described on Exhibit A, attached hereto and incorporated herein by reference ("Services"), to the Town; and

WHEREAS, the Parties wish to memorialize their contractual relationship.

AGREEMENT

NOW, THEREFORE, incorporating the foregoing Recitals herein and in consideration of the mutual promises, agreements, undertakings and covenants set forth herein and for other good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, the Parties hereby mutually agree as follows:

SECTION 1: PARTIES

1.01 Town. The Town is a home-rule municipal corporation located in Johnstown, Colorado.

1.02 Contractor. Contractor is a private, independent business entity who will exercise discretion and judgment of an independent contractor in the performance and exercise of its rights and obligations under this Agreement.

SECTION 2: SERVICES, COMPENSATION AND TERM

2.01 Services. Contractor agrees to perform the Services for the Town.

2.02 Compensation. In consideration of Contractor's performance of the Services contemplated herein, the Town agrees to pay Contractor the compensation set forth on Exhibit A. Contractor shall submit detailed invoices reflecting the portion of the Services completed to the date of the invoice. The Town shall provide payment for Services to Contractor within thirty (30) days of receipt of the invoice. In its discretion, the Town may withhold payment for disputed portions of invoices on the condition that the Town provides written notice to Contractor of the dispute. Upon delivery of notice, the Town and Contractor shall promptly endeavor to resolve such dispute.

2.03 Expenses: Contractor shall not incur any expense or debt on behalf of the Town without the Town's prior written authorization.

2.04 Term. Unless otherwise terminated in accordance with Section 5, the term of this Agreement shall be from the Effective Date through ____, and shall not extend beyond that date absent the written approval of the Town.

SECTION 3: OPERATIONS

3.01 Contractor Status. Contractor avers that it has the background, expertise and education to provide the Services. Contractor shall be responsible for the proper performance of the Services in accordance with the terms hereof. Contractor shall obtain the necessary permits, if any, and maintain all required licenses, including but not limited to a Town business license.

3.02 Schedule. Unless otherwise set forth in Exhibit A, Contractor shall provide the Services in accordance with the timeline requested by the Town

SECTION 4: INSURANCE AND INDEMNITY PROVISIONS

4.01 Insurance.

A. Contractor understands and agrees that Contractor shall have no right of coverage under any existing or future Town comprehensive or personal injury liability insurance policies. As a material term of this Agreement, Contractor agrees to maintain and keep in force during the term of this Agreement one or more policies of insurance written by one or more responsible insurance carrier(s) authorized to do business in the State of Colorado in the following amounts:

1. Workers' compensation insurance as required by law;

2. Commercial general or business liability insurance with minimum combined single limits of ONE MILLION DOLLARS ($1,000,000.00) each occurrence and TWO MILLION DOLLARS ($2,000,000.00) general aggregate;

3. Automobile liability insurance with minimum combined single limits for bodily injury and property damage of not less than ONE MILLION DOLLARS ($1,000,000) for any one occurrence, with respect to each of Contractor's owned, hired or non-owned vehicles assigned to or used in performance of the Services. In the event that Contractor's insurance does not cover non-owned automobiles, the requirements of this paragraph shall be met by each employee of Contractor who utilizes an automobile in providing services to Town under this Agreement; and

4. Professional liability insurance with minimum limits of ONE MILLION DOLLARS ($1,000,000.00) each claim and TWO MILLION DOLLARS ($2,000,000.00) general aggregate.

B. Contractor shall procure and maintain the minimum insurance coverages listed herein. All coverages shall be continuously maintained to cover all liability, claims, demands and other obligations assumed by Contractor pursuant to this Agreement. In the case of any claims-made policy, the necessary retroactive dates and extended reporting periods shall be procured to maintain such continuous coverage. The Town shall have the right to request and receive a certified copy of any policy and any endorsement thereto. Except for workers compensation insurance, the Town shall be listed as an additional insured party on Contractor's insurance policies.

C. A certificate of insurance shall be completed by Contractor's insurance agent(s) as evidence that policies providing the required coverages, conditions and minimum limits are in full force and effect, and, upon request by the Town, shall be subject to review and approval by the Town. The certificate shall identify this Agreement and shall provide that the coverages afforded under the policies shall not be canceled, terminated or materially changed until at least thirty (30) days prior written notice has been given to Town. If the words "endeavor to" appear in the portion of the certificate addressing cancellation, those words shall be stricken from the certificate by the agent(s) completing the certificate. The completed certificate of insurance shall be provided to the Town.

4.02 Damage and Indemnity. Contractor assumes full responsibility for any and all damages caused by Contractor's exercise of its activities, or failures to act, under this Agreement. Contractor agrees that it will at all times protect, defend, indemnify and hold harmless the Town, its elected officials, employees, agents, and their successors and assigns, from and against all liabilities, losses, claims, demands, actions and costs (including reasonable attorneys' fees), arising from or related to loss or damage to property or injury to or death to any persons arising from or resulting in any manner from the actions or failures to act of Contractor or any invitees, guests, agents, employees or subcontractors of Contractor, whether brought by any of such persons or any other person.

SECTION 5: TERMINATION

5.01 Termination. The Town may terminate this Agreement, with or without cause, by providing thirty (30) days prior written notice to Contractor. Notwithstanding the foregoing, if the Town terminates this Agreement for cause and determines that a notice period is not in the best interests of the Town, the Town may terminate this Agreement by providing written notice to Contractor effective immediately.

SECTION 6: INDEPENDENT CONTRACTOR

6.01 Independent Contractor. Contractor understands and agrees that Contractor is an independent contractor and not an employee of the Town. The Town shall not provide benefits of any kind to Contractor. The Town shall not be responsible for withholding any portion of Contractor's compensation for the payment of Federal Insurance Contributions Act (FICA) tax, workers' compensation, or other taxes or benefits. CONTRACTOR IS NOT ENTITLED TO UNEMPLOYMENT COMPENSATION COVERAGE FROM THE TOWN. CONTRACTOR IS OBLIGATED TO PAY FEDERAL AND STATE INCOME TAX ON MONEYS PAID

PURSUANT TO THIS AGREEMENT. As long as there is not a conflict of interest with the Town, Contractor may engage in any other lawful business activities during the term of this Agreement.

SECTION 7: NOTICE

7.01 Notices. All notices required under this Agreement shall be in writing and shall be: 1) hand-delivered; 2) sent by registered or certified mail, return receipt requested, postage prepaid, to the addresses of the Parties herein set forth; or 3) sent by electronic mail ("email") return receipt or written acknowledgment requested and received. All notices by hand-delivery shall be effective upon receipt. All notices by mail shall be considered effective seventy-two (72) hours after deposit in the United States mail with the proper address as set forth below. All notices by email shall be effective upon acknowledgment of receipt by the intended recipient. Either party, by notice to be given, may change the address to which future notices shall be sent.

TO THE TOWN:
Town of Johnstown
Attn: Jason Elkins, Public Works Director
450 S. Parish Avenue
P.O. Box 609
Johnstown, CO 80534
Email: jelkins@johnstownco.gov

TO CONTRACTOR:
[Contractor Name]
[Contractor Address]
[Contractor Phone]
[Contractor Email]

SECTION 8: MISCELLANEOUS

8.01 Time. Time is of the essence of this Agreement and of each covenant hereof.

8.02 Non-Appropriation of Funds. Pursuant to Section 29-1-110, C.R.S., as amended, financial obligations of the Town payable as set forth herein, after the current fiscal year, are contingent upon funds for that purpose being budgeted, appropriated and otherwise made available. This Agreement shall be terminated effective January 1 of the first fiscal year for which funds are not budgeted and appropriated.

8.03 Laws and Regulations. In the conduct of the Services, Contractor shall comply with all applicable laws, rules and regulations, and the directives or instructions issued by the Town or its designated representatives.

8.04 Assignment; Third Party Rights. Contractor may not assign, delegate or subcontract any part of its rights, duties or obligations under this Agreement. The Parties do not intend to confer any benefit hereunder on any person or entity other than the Parties hereto.

8.05 Amendment. This Agreement may not be amended or modified except by a subsequent written instrument signed by the Parties. Course of performance, no matter how long, shall not constitute an amendment to this Agreement.

8.06 Severability. If any part, term or provision of this Agreement is declared unlawful or unenforceable, the remainder of this Agreement shall remain in full force and effect, except that, in the event any state or federal governmental agency or court determines that the relationship between the Town and Contractor is one of employment rather than independent contractor, this Agreement shall become null and void in its entirety.

8.07 Waiver. No consent or waiver, express or implied, by the Town to or of any breach or default by Contractor in the performance by Contractor of its obligations hereunder shall be deemed or construed to be a consent or waiver to or of any other breach or default by the Town. Failure on the part of the Town to complain of any act or failure to act or to declare Contractor in default, irrespective of how long such failure continues, shall not constitute a waiver by the Town of its rights hereunder.

8.08 Governmental Immunity. The Parties agree that the Town is relying on, and does not waive or intend to waive by any provision of the Agreement, the monetary limitations or any other rights, immunities, and protections provided by the Colorado Governmental Immunity Act, §§ 24-10-101 *et seq.*, C.R.S., as amended from time, or otherwise available to the Town, its elected officials, employees or agents.

8.09 Applicable Law and Venue. This Agreement shall be construed according to the laws of the State of Colorado. Venue for any claim, proceeding or action arising out of this Agreement shall be in Weld County, State of Colorado.

8.10 Mediation. In the event of any dispute arising under this Agreement, except in the case of an action for injunctive relief, the Parties shall submit the matter to mediation prior to commencing legal action and shall share equally in the cost of the mediation.

8.11 Costs and Attorney's Fees. If any judicial proceedings may hereafter be brought to enforce any of the provisions of this Agreement, the Town, if the prevailing party, shall be entitled to recover the costs of such proceedings, including reasonable attorney's fees and reasonable expert witness fees.

8.12 Entire Agreement. The provisions of this Agreement represent the entire and integrated agreement between the Town and Contractor and supersede all prior negotiations, representations and agreements, whether written or oral.

8.13 Public Official Personal Liability. Nothing herein shall be construed as creating any personal liability on the part of any elected official, employee or agent of the Town.

8.14 No Presumption. Each Party acknowledges that it has carefully read and reviewed the terms of this Agreement. Each Party acknowledges that the entry into and execution of this Agreement is of its own free and voluntary act and deed, without compulsion. Each Party acknowledges that it has obtained, or has had the opportunity to obtain, the advice of legal counsel of its own choosing in connection with the negotiation and execution of this Agreement and with respect to all matters set forth herein. The Parties agree that this Agreement reflects the joint drafting efforts of all Parties and in the event of any dispute, disagreement or controversy arising from this agreement, the Parties shall be considered joint authors and no provision shall be interpreted against any Party because of authorship.

8.15 Controlling Document. In the event of a conflict between the provisions in this Agreement and Exhibit A, the provisions in this Agreement shall control.

8.16 Headings. The headings in this Agreement are inserted only for the purpose of convenient reference and in no way define, limit or prescribe the scope or intent of this Agreement or any part thereof.

8.17 Counterparts. This Agreement may be executed in counterparts, each of which shall be an original, but all of which, together, shall constitute one and the same instrument.

8.18 Data Security. If Contractor has access to personal identifying information during the term of this Agreement, Contractor shall, pursuant to Section 24-73-101, *et seq.*, C.R.S., destroy all paper and electronic documents containing such personal identifying information within six months of termination of this Agreement, unless otherwise required by law. During the term of this Agreement, Contractor shall implement and maintain reasonable security procedures that are appropriate to the nature of the personal identifying information disclosed or maintained and that are reasonably designed to help protect the information from unauthorized access, use, modification, disclosure or destruction. If Contractor discovers or is informed of a security breach, Contractor shall give the Town notice in the most expedient time and without unreasonable delay, no later than ten (10) calendar days after it is determined a security breach occurred. Contractor shall cooperate with the Town in the event of a security breach that compromises computerized data, if misuse of personal information about a Colorado resident occurred or is likely to occur. Cooperation includes sharing with the Town information relevant to the security breach.

8.19 Right to Injunction. The Parties hereto acknowledge that the Services to be rendered by Contractor and the rights and privileges granted to the Town under the Agreement are of a special, unique, unusual and extraordinary character which gives them a peculiar value, the loss of which may not be reasonably or adequately compensated by damages in any action at law, and the breach by Contractor of any of the provisions of this Agreement may cause the Town irreparable injury and damage. Contractor agrees that the Town, in addition to other relief at law, shall be entitled to injunctive and other equitable relief in the event of, or to prevent, a breach of any provision of this Agreement by Contractor.

[Remainder of page intentionally left blank.]

IN WITNESS WHEREOF, the parties have executed this Agreement on the date first written above.

TOWN OF JOHNSTOWN, COLORADO

ATTEST:

By:______________________________ By:____________________________________
Hannah Hill, Town Clerk Matt LeCerf, Town Manager

By:___[Contractor Signature Line]__________
Name:
Title:

STATE OF COLORADO)
) ss
COUNTY OF __________)

SUBSCRIBED AND SWORN to before me this __________day of ___________, 20______, by __________________________ as the ________________ of __________________________.

WITNESS my hand and official seal.

My commission expires:______________________________

____
Notary Public

EXHIBIT A
SERVICES

ATTACHMENT C- Town of Johnstown's 2001 Stormwater Master Plan

STORM WATER
MASTER PLAN

FOR THE

TOWN OF JOHNSTOWN

APRIL 2001

March 30, 2001
File No: 00-047

Town of Johnstown
101 West Charlotte
P.O. Box 609
Johnstown, CO Zip Code

ATTN: Roy Lauricello

RE: Drainage Master Plan

Dear Roy:

Please accept our "Storm Water Master Plan for the Town of Johnstown," for distribution to your Board.

This report includes a detailed list of recommendations for both storm drainage policy, and infrastructure improvements. Included are coceptual cost estimates for these improvements.

We would like to thank you and your staff for your cooperation and help during the course of this study. It has been a pleasure to work on this project, and we trust that our report will provide the necessary information to help you in implementation of drainage improvements in Johnstown.

Sincerely,

Doug Paull, P.E.	J. Brian Zick, P.E.
Project Engineer	Principal In Charge
The **Engineering** Co.	

Enclosures:

ai

STORM WATER
MASTER PLAN

FOR THE

TOWN OF JOHNSTOWN

APRIL 2, 2001

Prepared by

THE **ENGINEERING** COMPANY
2310 East Prospect Road
Fort Collins, CO 80525
970-484-7477

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I. INTRODUCTION

I. INTRODUCTION

Two significant features complicate drainage in and around Johnstown: The Great Western Railroad, which has several tracks running through the Town, and the Hillsborough Ditch. The various railroad embankments act as very low levees that tend to dam up water. The Hillsborough Ditch, as documented in previous studies, does not have the capacity required to act as a storm water conveyance for the Town. Much of the runoff from the older part of town enters the ditch, and various study efforts have shown that overtopping of the ditch banks is likely to occur from any significant storm.

Prior to the 1990s, Johnstown had grown very slowly (about 1% per year). However, by the mid-1990s the robust economic climate in Colorado was driving growth in Johnstown at a much higher rate. According to the U.S. Census Bureau, the population of Johnstown increased over 70% between 1990 and 1998. The vast majority of this growth has been in the form of new subdivisions adjoining the older part of town to the north, south and west. For the most part these new subdivisions lie along the Highway 60 corridor, taking advantage of its access to I-25. Much of this newly developed land is also upslope from the Hillsborough Ditch and the railroad embankments.

The various engineering firms designing these new subdivisions were required to perform drainage studies to determine the effects these developments would have on the drainage of each particular site. Unfortunately, Johnstown did not have a defined drainage policy, or a drainage criteria manual (the latter will be provided as part of this project) when they were designed. The engineers working for the developers therefore employed drainage standards from other jurisdictions and agencies, primarily the Urban Drainage and Flood Control District (UDFDC) of Denver. Fortunately, the drainage criteria of many cities and towns along the Front Range have been derived from the UDFDC criteria, and this fact is reflected in the consistency of the reports we have examined.

Five major goals are addressed in this study. They are:

- To identify existing drainage problems, and propose solutions for the existing conditions.
- To establish a plan to mitigate drainage from proposed or future development.
- To establish drainage design criteria for future developers and engineers to follow.
- Prioritize Town-funded improvements, and generate cost estimates for these improvements.
- Allocate proposed improvements by major drainage basin for incorporation into the Tischler plan for funding of improvements.

This master plan is intended to provide a flexible framework within which drainage policy can be conceived and implemented by the Town Council. Its scope is intentionally broad so as to cover the numerous issues relating to drainage. While this approach may appear to omit some details, we feel that such details were adequately addressed in other studies. The intent of this document is to provide guidance to both the developer and the policy maker.

II. EXISTING DRAINAGE SYSTEM

II. EXISTING DRAINAGE SYSTEM

A. Geography

Geographically, the portion of Johnstown to the west of the Hillsborough Ditch is located on a hill or promontory. Between one and two miles to the north is the Big Thompson River, and a lesser distance to the south lays the Little Thompson River. The confluence of these two rivers is roughly three miles to the east, near Milliken. The Hillsborough Ditch skirts around the base of Johnstown Hill, approaching from the northwest, and leaving to the southwest. Consequently, any storm runoff generated above (to the west of) the Hillsborough Ditch must either enter the ditch or cross it to reach either river. In the event of significant rainfall, storm water entering the ditch causes it to overflow, and it then finds its way to one of the rivers.

The portion of Johnstown below the ditch, including the downtown area, lies in the bottomlands. Though outside of the river floodplains, these areas are characterized by the flat slopes of the river terraces. Without adequate storm drains, the areas below the ditch are prone to flooding. The railroad embankments exacerbate the flooding problems by impeding the runoff of storm water.

The Great Western Railroad operates a junction within Johnstown, serving lines that run to the east, west, north and south. These lines act as barriers not only to storm water on the surface, but also to the construction of storm drain lines.

The scope of growth occurring in and around Johnstown has necessitated examining a larger area than covered in a previous study by M&I. In general, the Little Thompson and Big Thompson Rivers and their confluence bound the study area to the north, south and east. To the west the study area is extended to include Gateway Center and all the subdivisions proposed or being built along SH 60, along with all areas these developments might drain to. In addition, a basin has been defined that includes Stroh Farm, located south of and draining to the Little Thompson River. The total land area covered by the study is 15,163 acres, or 23.7 square miles. The individual basins are described in greater detail later in this report.

An area annexed by the Town and located between US 34 and the Big Thompson River, was excluded from this study. This area is the subject of a detailed utility study (including drainage) to be completed and implemented through a metropolitan district working with the Town. The study is expected to include the Chapman Reservoir drainage.

B. Other Studies

In 1975, M&I performed a storm drainage study for the town, which it presented in January of 1976. M&I determined flows within the older part of town using UDFCD criteria, and estimated flows for

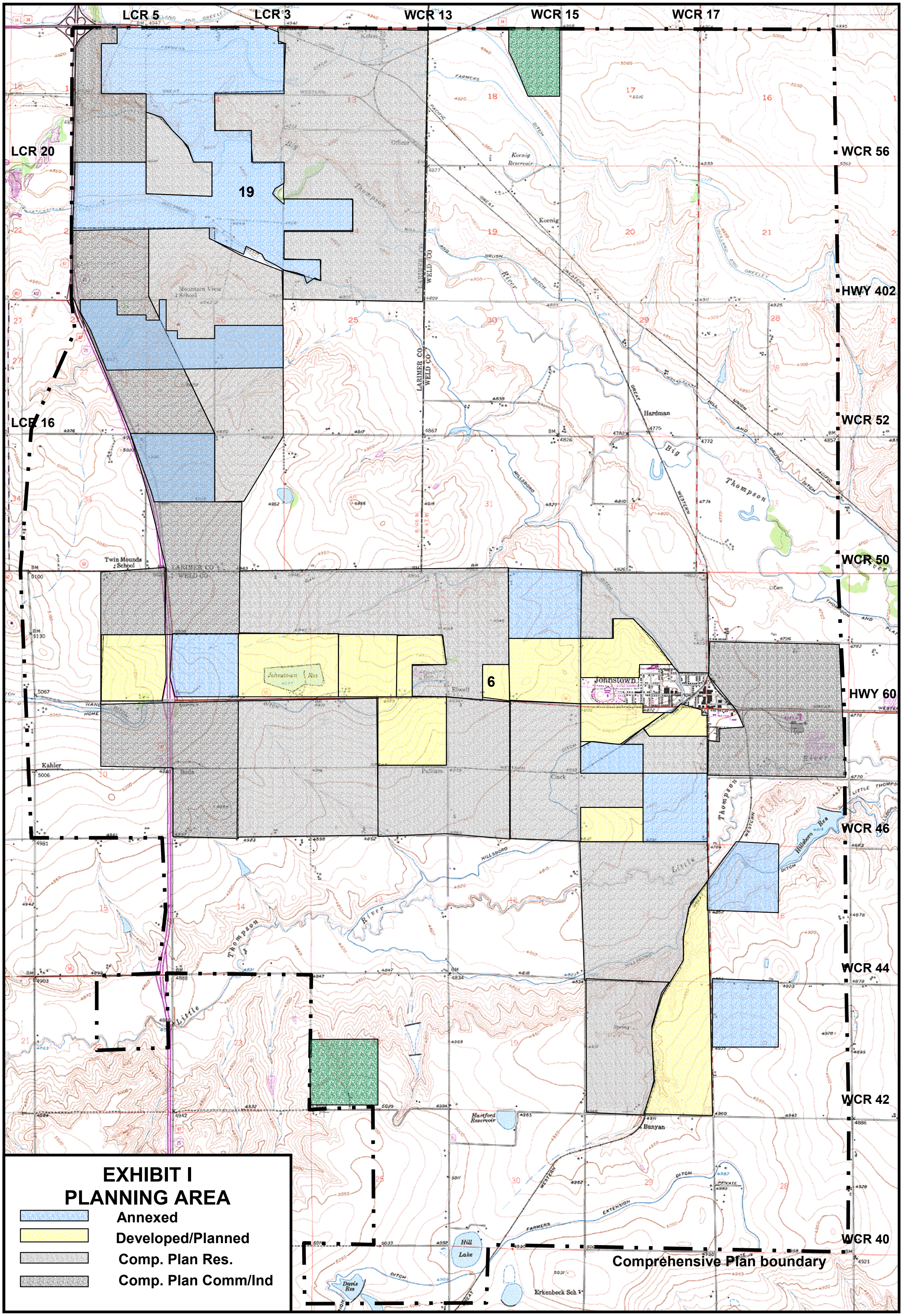


EXHIBIT I
PLANNING AREA

basins outside of town using Soil Conservation Service techniques. M&I inventoried the Town's drainage facilities, calculated major storm flows at key points, and made recommendations for capital improvements and drainage criteria. It does not appear that any of the capital improvements projects recommended by M&I were ever constructed. Their specific recommendations are discussed in greater detail later in this report.

In 1997, Weld County commissioned a study, "Analysis of Inflows to the Hillsborough Ditch" (Chang Engineering, Inc.). This report examined the effects that proposed improvements to culverts on Weld County Roads 42 and 50 would have on the ditch. The culverts that were replaced were undersized in relation to the flows that would occur during any significant storm. Apparently the Hillsborough Ditch Company believed that water impounded behind the roadway embankment during a storm would mitigate flows into the ditch, in effect acting as storm water detention ponds with controlled releases. The results of the Chang report indicate that in only very minor storms did these old culverts have any mitigating effect on flows to the ditch. The study showed that the volume of water detained was a small percentage of the total storm volume, assuming that the roadway didn't breach in the larger storms.

In 1997, a group of students from CSU performed a study to determine causes and solutions of flooding of the Hillsborough Ditch. As part of their work efforts, they performed a detailed survey of the ditch and an analysis of its capacity. The students surveyed over 100 ditch cross-sections and performed their analysis using state-of-the-art software. Using a program called HEC-RAS, they determined the bank-full capacity of the ditch to be between 160 and 195 cfs. Irrigation base flow in the ditch is about 60 cfs. This means that under the conditions of a typical summer thunderstorm, the ditch would be running and would therefore would be able to take only 100 to 135 cfs of storm water before overflowing its banks. Standard procedure during a storm is for all ditch gates to be opened, spilling water from the ditch to increase the amount of storm water it can take. However, these gates must all be opened manually, and each can convey only a modest amount of water. In a major storm the amount of water entering the ditch would be so great that opening the gates would have little effect. In general, the amount of water that can enter a relatively small irrigation ditch (such as the Hillsborough Ditch) during a storm is so great, relative to its capacity, that standard practice in flood modeling is to assume that the ditch is full. The students developed a solution to alleviate flooding in Johnstown that involved constructing large spillway structures to empty the ditch immediately upstream and downstream of the Town. This approach has merit, assuming the structures are located close enough to the Town.

Peter Swift and Ted Combs for the City of Loveland completed the "Technical Memorandum for East Loveland Storm Drainage Master Plan" in early 2000. This study modeled several basins east of Loveland, and geographically overlaps this study to a considerable extent. All basin outputs from the Loveland study were calibrated to 1.0 to 1.2 cfs/acre. This was based on long-term data collected in the Denver metropolitan area.

C. Existing Drainage Patterns

There are, by various counts, 17 or more places in Johnstown where surface runoff enters the Hillsborough Ditch. The Consolidated Hillsborough Ditch Company maintains five "overflow" structures along the 34-mile length of the main ditch. During a rainstorm, the ditch rider opens the gates on these structures to allow excess water to spill from the ditch in a controlled manner into sloughs or other watercourses, including the Little Thompson River. The capacity of the nearest overflow structure upstream of the Town was reported in the M&I report to be 34 cfs. The ditch company also requires its members to leave open their diversion gates during storms to further relieve the ditch. According to Gary Bauer, Ditch Superintendent, it is possible to maintain the ditch well within its banks upstream of Johnstown using these measures. Once the ditch enters the town, however, the volume of storm water it receives can rapidly fill the ditch and exceed its capacity. Water will spill over any section of the east (downhill) bank that is depressed. This has happened on more than one occasion at a point south of South First Street, where the ditch has overflowed its bank into the backyard of a house on Avara Street. The danger to life and property of such uncontrolled releases cannot be overstated.

The older portion of Johnstown was built prior to the advent of modern urban drainage design practices. Though some storm drains were installed, the analytical tools did not exist then to adequately determine what their capacity should be. The existing storm drains and catch basins were identified in the M&I report, and are described below:

- Inlets at the intersections of South First Street with Lippitt Street and Estes Avenue, which connect to drains that carry water to the south side of South First Street.
- Inlets at North First Street and Greeley Avenue, which connect to a drain that discharges in an alley some 135 feet north.
- Inlets connected to irrigation lines exist at the intersections of South First Street with Rutherford and Parish Avenues, and Parish Avenue with North First Street.

The remaining elements of the Town's storm drain system in the older part of town consist primarily of swales and in-street capacity.

The effect of urban development is to increase the impervious area in a basin. That is to say, portions of the land will not absorb any significant moisture from a storm. Impervious areas, such as pavement, driveways and sidewalks, not only increase the amount of storm water runoff, but they tend to cause runoff to occur more rapidly. Because water will flow more quickly over smooth pavement, and in gutters, runoff reaches the basin outfall more quickly. The result of all this is that urban basins will produce more runoff than undeveloped land in all types of storms. It also means that the short, intense thunderstorms that are characteristic of the summer season will in urban basins develop very rapid flooding if there is not an adequate storm water collection system. Basin lag, the time when the rain starts falling and when the runoff begins, is less in an urban basin. The graphs below illustrate this concept. The "Q" on the left of the graph is the rate of runoff, and the "t" is the time since the storm began. As the basin becomes more developed, the peak runoff rate increases, and the peak occurs sooner. The total volume of runoff also increases.

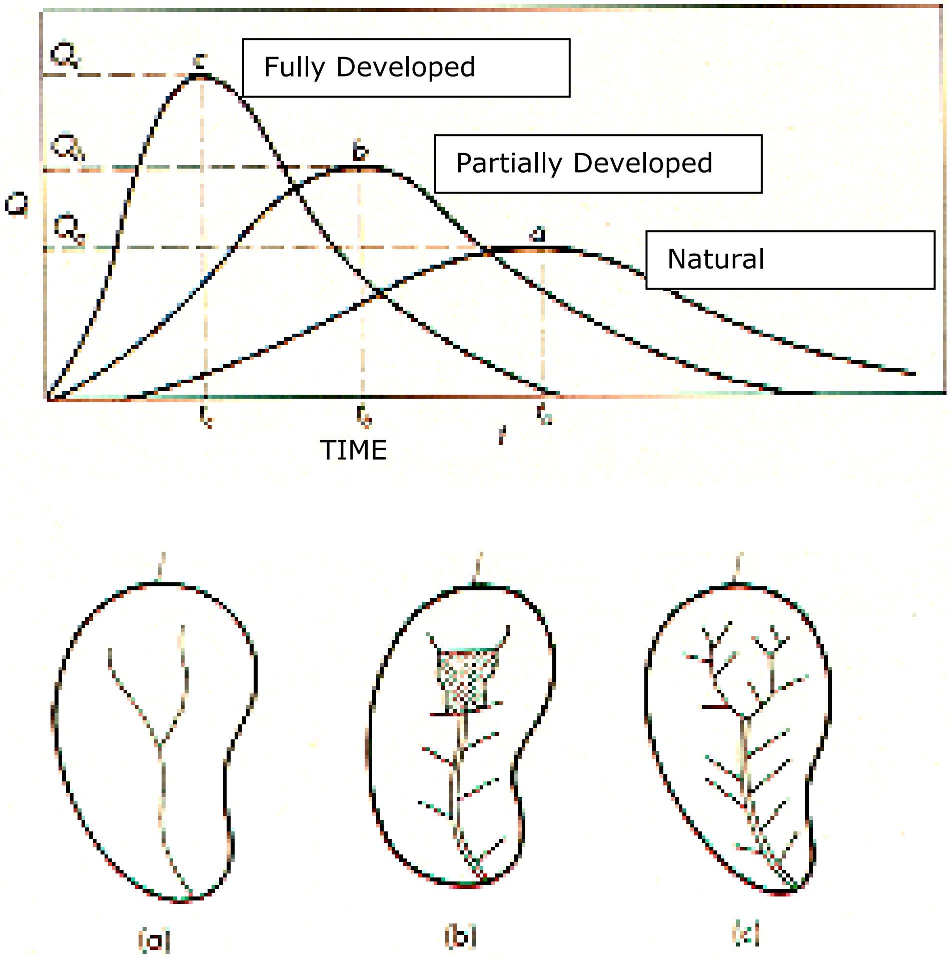


Figure 1 – Basin Runoff vs. Development Condition

Modern urban drainage policies typically require some form of storm water detention whenever property is developed. The general concept is that detention basins detain a portion of the runoff to mitigate the impact development has on the basin. Detention basins typically have restricted outlets, which release storm water at a controlled rate. The amount of storm water to be detained in a given basin depends on the particular policies of the storm water authority. Some jurisdictions require that detention basins store the difference between that amount of runoff that would have occurred before development, and the amount of runoff generated by the developed property. This is common practice in the Denver area, where the major basin drainage ways have been mapped and improved to handle this volume of water.

Many other cities along the Front Range of Colorado are more restrictive. Most jurisdictions also require that at least a portion of the storm water be detained for an extended period for water quality reasons. Typically urban runoff carries sediment and various pollutants. Extended detention allows particles in the storm water to settle out, and vegetation in the basins helps remove some pollutants.

For the most part, the new subdivisions in Johnstown have included detention ponds in some form. One unique case is Sunrise Ridge and the Knolls. The eastern portion of the subdivision drains to one culvert that discharges undetained into the Hillsborough Ditch. According to the original drainage report for Sunrise Ridge, the detention/retention pond located in the western portion of Sunrise Ridge was intended to store storm runoff until after a storm, at which time the Hillsborough Ditch Company could open a valve and release the water into the ditch. A concept described in the Sunrise Ridge Drainage Report (CDS Engineering) is that the Town would construct a pump station adjacent to the ditch to transfer flows to the retention pond. Though the pump station was never constructed, the pond exists as a regional detention/retention facility. Due to the lack of design standards that are specific to Johnstown, engineers have utilized various other methods for calculating storm water detention. The table below summarizes the detention provided by each subdivision, based on drainage reports obtained during this study:

	Volume			**Vol.**	**Release Rates (cfs)**				
Subdivision	**5-yr**	**10-yr**	**100-yr**	**(ac-ft)**	**2-yr**	**5-yr**	**10-yr**	**100-yr**	**Notes**
Carlson Farms - Prelim.		4.34	7.75	2.16		18.6	32.8	112.6	One pond; UDFCD method
Phase 1 Stroh Farm	4.12		7.37	0		31.6		111.9	UDFCD method
Podtburg Village			4.0					7.0	Some release to Hwy 60 (< historic); rest to detention in Rolling Hills; temporary detention onsite
Country Acres, 8th filing			1.75	1.75					8.3 cfs undetained disch. to WCR 15
The Knolls - 1st filing			0	0	13.05	27.0	37.3		
Rocksbury Ridge			8.61					135	Preliminary rept. - lacks details
Johnstown Center 3rd Add.			5.09				16.5		
Phase 1 Clearview PUD		5.29	9.49			26.55	46.86	156.2	
church property		0.38	0.65			0.99	1.75	5.85	Discharges to Home Supply Ditch
offsite						36.3	48.5	94.9	
total				2.71		**64**	**97**	**257**	
Carlson Farms - Final		3.96	9.13	0					

Table II-1 – Existing Area Detention Volumes and Release Rates

In some cases it is not clear if water quality requirements for detention ponds were imposed. Common practice is to design detention facilities so that some initial volume of water is detained for an extended period of time, typically between 40 and 72 hours. It is our understanding that the Hillsborough Ditch Company would like to see water quality measures enforced, since so much of the new development ultimately discharges to the ditch. In recent years the United States Environmental Protection Agency (EPA) has promulgated storm water regulations for municipalities. The regulatory program seeks to require municipalities to account for, and improve the quality of, their storm water. At this time the EPA regulations do not apply to municipalities under 10,000 in population. However, it may be wise for

Johnstown to require storm water BMPs (best management practices) in the future in case the EPA regulations become applicable, or the State or county governments require them.

As Johnstown makes the transition from farm community to urban community, inevitably there will be cases where residential developments are built downstream of agricultural operations such as feedlots. Feedlots and other similar operations are regulated by the Environmental Protection Agency, but conflicts may occur.

D. Major Drainage Basins

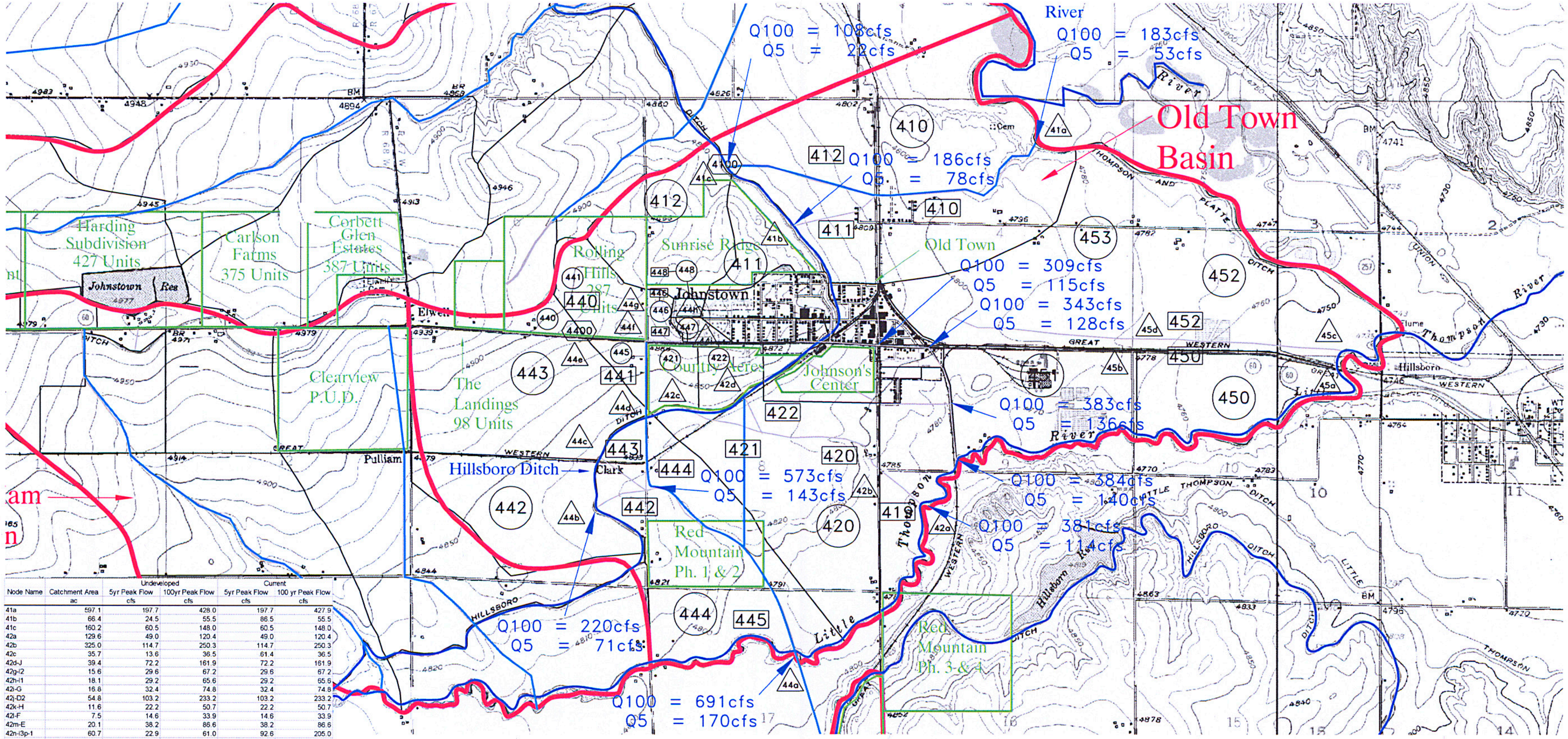
The study area has been divided into six major drainage basins. Each basin has in turn been divided up into a number of sub-basins. Many of these sub-basins were defined based on drainage reports submitted to the Town by developers. Typically existing geographic features define drainage basins. Where the sub-basins in the drainage reports were based on geography, we incorporated them into the study to allow comparison of results.

Within each major basin, one or more major drainage ways have been defined. The major drainage ways are intended to be corridors into which new development will discharge storm water from their respective detention ponds or other approved facilities. Each drainage way defined in this master plan has associated with it allowable flows, based on the 5-year and 100-year storms. When a parcel of land containing a portion of one of these drainage ways is developed, the developer will be required to set aside an appropriate corridor of right-of-way or easement for the drainage way. In all cases, the major basins are defined based on existing natural topography. In most cases, the drainage ways defined herein are based on existing drainage patterns. Some exceptions have been made where, for example, land planning operations by farmers have obscured natural drainage channels. In such cases, the ultimate alignment of the drainage way may depend in part on land uses proposed by the respective developers. Wherever possible the drainage ways have been aligned on existing sloughs, streambeds, or channels. In those cases where developers wish to redirect flow from one basin to another by grading of the property, they should be required to mitigate the flows to the release rates given in this master plan.

1. ***Old Town Basin***

Of the six major basins, this is the only one that had significant development prior to 1990. Unlike the other basins, the Baseline Model (see Section III, Drainage Model) for this basin is a mix of pre- and post-development conditions. Old Town Basin is 3,509 acres (5.5 square miles) in area. It drains to both the Little and Big Thompson Rivers, and therefore could have been split into two major basins. However, this would have meant splitting the town in two. It is more relevant that the majority of the basin drains first into the Hillsborough Ditch. Most of the recommendations made in this report regarding this basin address how to pass water across the ditch prior to any discharge to a river.

OLD TOWN BASIN



	Undeveloped		Current	
Node Name	Catchment Area ac	5yr Peak Flow cfs	100yr Peak Flow cfs	5yr Peak Flow cfs	100 yr Peak Flow cfs

Node Name	Catchment Area ac	Undeveloped 5yr Peak Flow cfs	Undeveloped 100yr Peak Flow cfs	Current 5yr Peak Flow cfs	Current 100 yr Peak Flow cfs
41a	597.1	197.7	428.0	197.7	427.9
41b	66.4	24.5	55.5	86.5	55.5
41c	160.2	60.5	148.0	60.5	148.0
42a	129.6	49.0	120.4	49.0	120.4
42b	325.0	114.7	250.3	114.7	250.3
42c	35.7	13.6	36.5	61.4	36.5
42d-J	39.4	72.2	161.9	72.2	161.9
42g-I2	15.6	29.6	67.2	29.6	67.2
42h-I1	18.1	29.2	65.6	29.2	65.6
42i-G	16.8	32.4	74.8	32.4	74.8
42j-D2	54.8	103.2	233.2	103.2	233.2
42k-H	11.6	22.2	50.7	22.2	50.7
42l-F	7.5	14.6	33.9	14.6	33.9
42m-E	20.1	38.2	86.6	38.2	86.6
42n-I3p-1	60.7	22.9	61.0	92.6	205.0
42n-I3p-2	10.1	17.0	31.2	26.9	64.3
42o	13.3	5.1	25.4	17.0	36.8
44a	336.7	113.2	245.0	113.2	245.0
44b	188.1	75.2	224.9	75.2	224.9
44c	271.1	99.7	225.1	99.7	225.1
44d	22.3	8.4	20.2	8.4	20.2
44e	36.7	14.1	49.0	14.1	49.0
44f	69.4	26.5	70.6	119.1	70.6
44g-AB	14.7	26.0	57.9	26.0	57.9
44h-D1	6.1	8.5	19.6	8.5	19.6
44i-C	10.2	20.5	50.1	20.5	50.1
45a	161.0	59.1	111.8	59.1	111.8
45b	196.7	67.5	146.2	67.5	146.2
45c	320.2	112.7	245.9	106.8	245.9
45d	294.4	106.8	237.4	106.8	237.4

Exhibit 2

Legend

🟥 – Basin Boundary	(310) – Subcatchment
🟩 – Subdivisions	310 – Subcatchment Channel
– Drainageways	(3100) – Detention Element
– Waterways	△ – Concentration Point
☐ – Johnstown Stormwater Basins	

N

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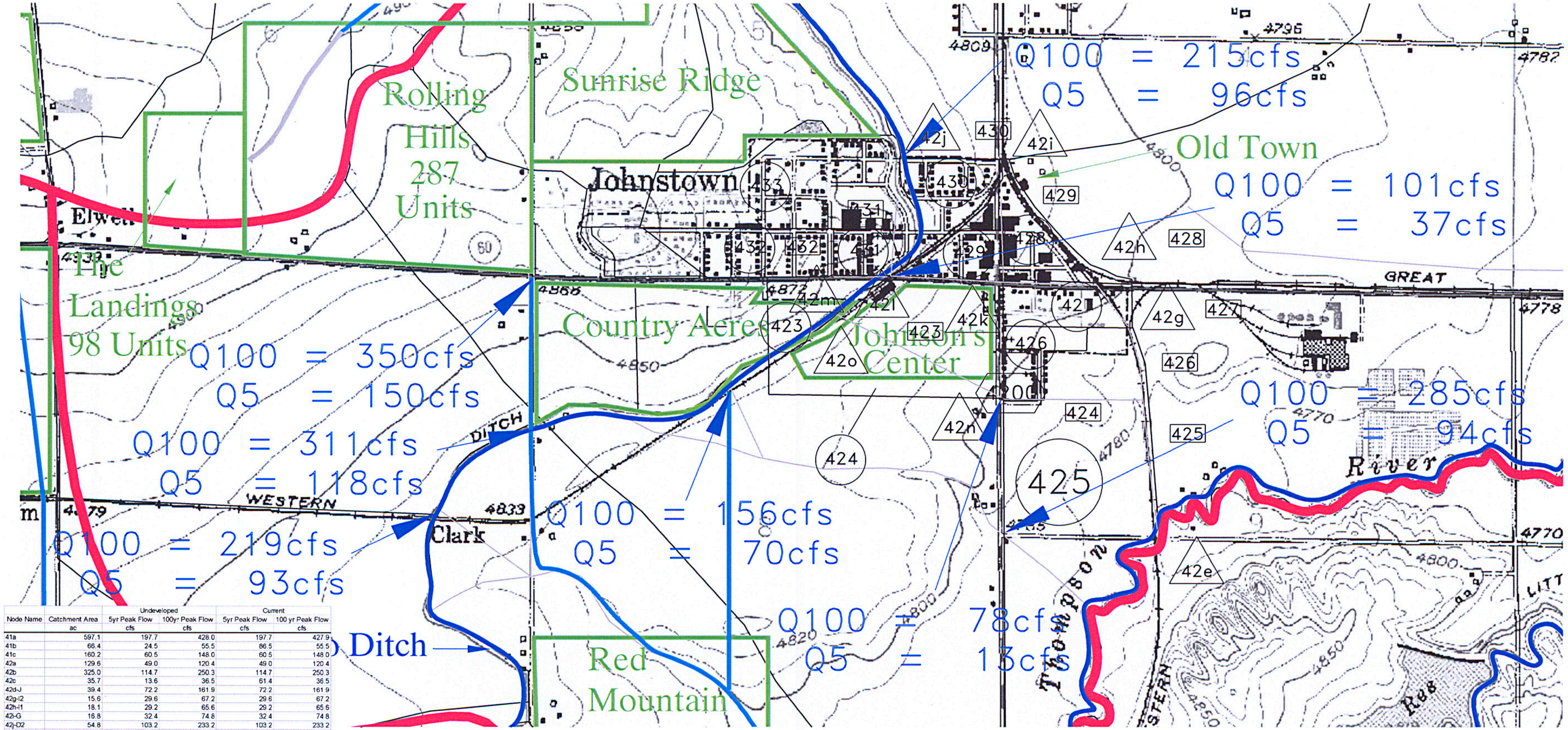
OLD TOWN BASIN DETAIL



		Undeveloped		Current	
Node Name	Catchment Area ac	5yr Peak Flow cfs	100yr Peak Flow cfs	5yr Peak Flow cfs	100 yr Peak Flow cfs
41a	597.1	197.7	428.0	197.7	427.9
41b	66.4	24.5	55.5	86.5	55.5
41c	160.2	60.5	148.0	60.5	148.0
42a	129.6	49.0	120.4	49.0	120.4
42b	325.0	114.7	250.3	114.7	250.3
42c	35.7	13.6	36.5	61.4	36.5
42d-J	39.4	72.2	161.9	72.2	161.9
42g-I2	15.6	29.6	67.2	29.6	67.2
42h-I1	18.1	29.2	65.6	29.2	65.6
42i-G	16.8	32.4	74.8	32.4	74.8
42j-D2	54.8	103.2	233.2	103.2	233.2
42k-H	11.6	22.2	50.7	22.2	50.7
42l-F	7.5	14.6	33.9	14.6	33.9
42m-E	20.1	38.2	86.6	38.2	86.6
42n-I3p-1	60.7	22.9	61.0	92.6	205.0
42n-I3p-2	10.1	17.0	31.2	26.9	64.3
42o	13.3	5.1	25.4	17.0	36.8
44a	336.7	113.2	245.0	113.2	245.0
44b	188.1	75.2	224.9	75.2	224.9
44c	271.1	99.7	225.1	99.7	225.1
44d	22.3	8.4	20.2	8.4	20.2
44e	36.7	14.1	49.0	14.1	49.0
44f	69.4	26.5	70.6	119.1	70.6
44g-AB	14.7	26.0	57.9	26.0	57.9
44h-D1	6.1	8.5	19.6	8.5	19.6
44i-C	10.2	20.5	50.1	20.5	50.1
45a	161.0	59.1	111.8	59.1	111.8
45b	196.7	67.5	146.2	67.5	146.2
45c	320.2	112.7	245.9	106.8	245.9
45d	294.4	106.8	237.4	106.8	237.4

E:\00047\Old Town Detail.dwg

Exhibit 3

Legend

- 🟥 – Basin Boundary
- 🟩 – Subdivisions
- ▬ – Drainageways
- ▬ – Waterways
- ☐ – Johnstown Stormwater Basins
- (310) – Subcatchment
- [310] – Subcatchment Channel
- (3100) – Detention Element
- △ – Concentration Point

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The M&I report predated the Rolling Hills and Sunrise Ridge subdivisions. It separated its study area into one set of basins (A-J) containing urbanized (developed) basins, and another set of basins (1-9) describing the undeveloped basins tributary to the town or adjacent areas. We have preserved the basin layout, for the most part, of basins A through J. This is partly because the drainage patterns haven't changed for most of the town, and also to provide some basis for comparison of results.

Old Town Basin includes all of Sunrise Ridge, The Knolls, Redstone, Country Acres, Johnstown Center, and most of Rolling Hills. Sub-basin 411 discharges undetained into the Hillsborough Ditch. A detention pond has been constructed in Basin 412, and reportedly contains more volume than is needed for the area tributary to it. This practice is typically referred to as "over-detention," in which sufficient compensatory detention volume is provided for the sum of the two basins (411 and 412).

Basin 411 discharges directly to the Hillsborough Ditch via a 24-inch reinforced concrete pipe (RCP). Undetained flows like this can cause the ditch to rapidly rise through town and, in heavier storms, overflow. Upstream of the town, the water levels in the ditch can be controlled using overflow structures and by opening headgates. Once the ditch enters the town, however, there is currently no way to spill the ditch in a controlled manner. Consequently, the ditch will overflow at any point where the bank is locally depressed.

Significant flows from town enter the ditch from Charlotte and South First Streets (Hwy 60). In major storms, flows from the north-south-running streets to the east of Idaho Avenue will spill across South First Street. Some of this storm water concentrates and enters the ditch near Denver Avenue and South First Street. Other flows enter first into Country Acres before reaching the ditch. Other than a small retention pond in Country Acres, and another in Johnstown Center, none of these flows are detained. According to the drainage report for Country Acres, the detention pond will eventually be abandoned once facilities to relieve the Hillsborough Ditch are constructed.

Three major drainage ways are proposed for the Old Town Basin. The first of these would extend from a point along the Hillsborough Ditch, where it bounds Sub-Basin 411. The drainage way would extend to the Big Thompson River. Except for where it nears the river, this drainage way is not well defined. Its exact location would depend on factors such as proposed land uses, and the availability of drainage easements or rights-of-way. The second drainage way could extend south along WCR 15 from its intersection with Highway 60, to a point south of the Great Western Railroad tracks, where an existing slough extends southeast to the Little Thompson River. This slough crosses the Lebsack property. The owners of this property have expressed a desire to develop their land, and a willingness to cooperate in passing drainage across their property. The third proposed drainage way would extend south from South First Street, beginning at a point between Kuner Avenue and the railroad embankment. The drainage way would parallel the railroad tracks south to the Little Thompson River. This last major drainage way would be constructed as part of a storm drain system serving Old Johnstown, and is discussed in greater detail in the Recommendations section of this report.

Another channel will be required to connect a spillway proposed for the Hillsborough Ditch in the vicinity of Country Acres (see Recommendations section). The alignment of this channel should be determined in conjunction with the major drainage way on the south side of Old Johnstown. At least one development is proposed in this area (Red Mountain). Proper coordination with the developers of Red Mountain, and those of any other properties in this area, is essential to ensure that the required easements are dedicated to the Town. If developers are made aware of the overall plan for drainage in this part of the basin, they can in turn accommodate drainage in a way that works with adjacent properties.

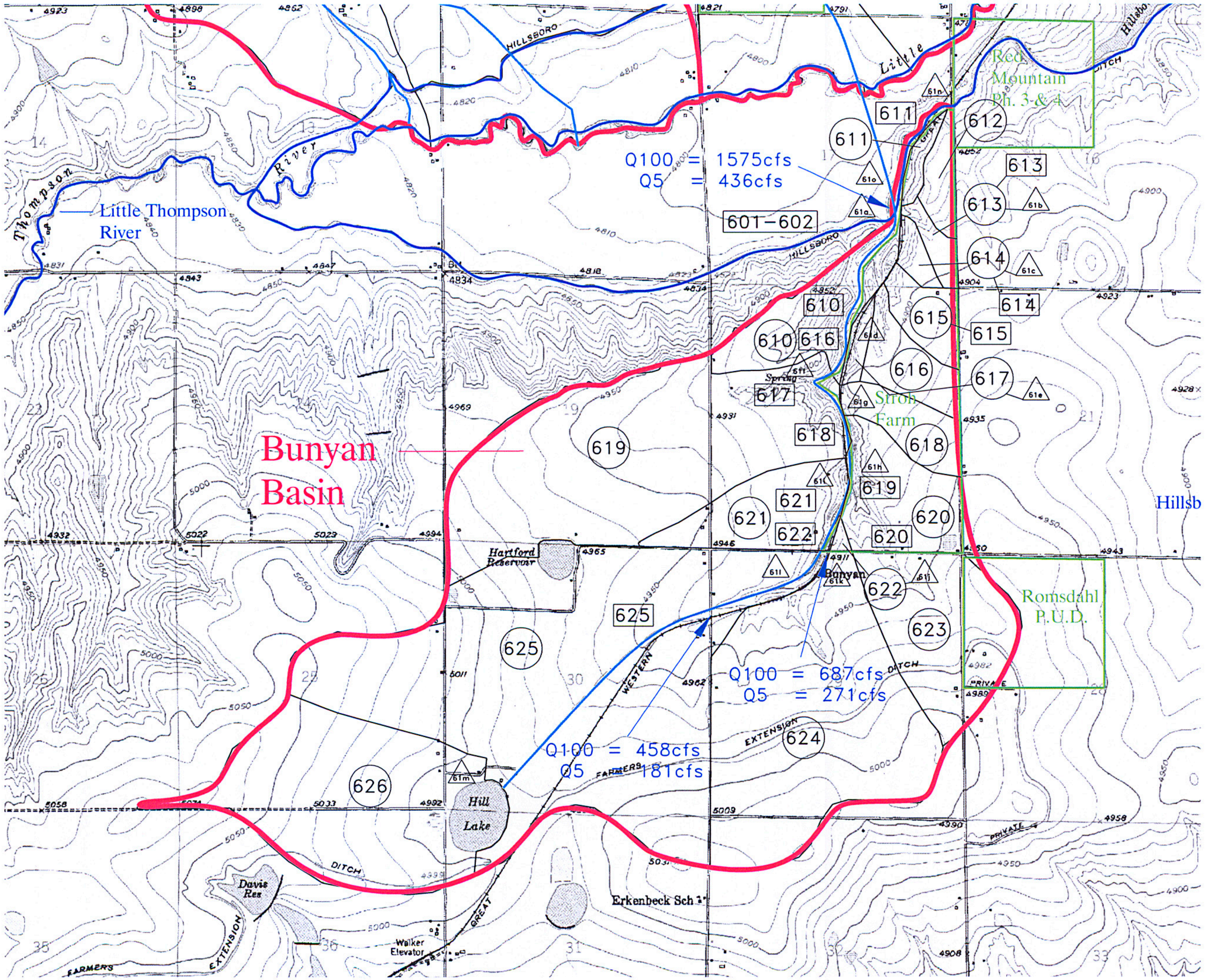
It is important to note that what we have discussed for major drainage ways are potential alignments. Actual development plans and proposed land uses will affect the final alignments of these drainage ways. The overriding principle is that stormwater must be safely conveyed through the basin to a point of outfall, either into the Big Thompson or Little Thompson Rivers.

2. Bunyan Basin

Bunyan Basin is the only basin that does not lie adjacent to any of the other basins. Included within its boundaries is the Stroh Farm subdivision, the first filing of which is currently under construction. This basin is 2,829 acres (4.4 square miles) in area, and has the steepest topography of any of the basins, dropping some 250 feet from its high point to its outfall. This basin was included in Chang Engineering's study for Weld County. Their report examined the flows tributary to the Hillsborough Ditch, and the effect that an undersized culvert at WCR 42 had on the magnitude of flows. The Chang study determined that only in very minor storms did ponding behind the culvert and road embankment have any effect on flows to the ditch. Subsequent to this report, the old culvert was replaced by a new bridge with a much larger (~12' in diameter) culvert.

The single drainage way identified for this basin is, in the lower half of the basin, a very well-defined gully. The gully eventually discharges to the Hillsborough Ditch. Due to the considerable amount of storm water flows this basin can generate, the ditch has overflowed several times at the point where the gully enters the ditch. Stroh Farm subdivision was designed with three separate detention ponds. The release rates from the ponds in the 100-year storm are close to what would be required under the standards proposed in this master plan. However, because of the size of the upstream basin, discharges to the ditch are still likely to cause it to overflow. We propose that the drainage way be extended from the point where the gully enters the ditch, north in a constructed swale to the Little Thompson River. Drainage impact fees collected in this basin could be used to acquire easement for the drainage way, and to construct a spillway and riprap blanket on the downstream bank of the ditch at the point where the gully meets the ditch. Given the substantial 100-year flow at the point where the existing channel enters the ditch (about 1,575 cfs), it is not practical to construct a reservoir to dam up this flow and control it. The total storm runoff at this point would be approximately 58 acre-feet in the 5-year storm, and 243 acre-feet in the 100-year storm.

BUNYAN BASIN



		Undeveloped	
Node Name	Catchment Area ac	5yr Peak Flow cfs	100yr Peak Flow cfs
61a	123.99	47.52	167.883
61b	18.16	6.66	16.006
61c	14.5	5.57	24.602
61d-1	54.01	42.58	131.682
61d-2	40.72	-	-
61e	10.47	9.22	40.721
61f	480	125.10	309.63
61g	44.83	18.37	49.676
61h	113.25	52.04	162.004
61i	106.02	42.17	111.05
61j	171.44	65.25	166.572
61k	4.43	4.48	19.991
61l-1	811.54	412.96	934.43
61l-2	438.7	-	-
61m	357.8	105.22	238.17
61n	25.73	9.87	37.036
61o	13.45	5.17	42.081

Legend

🟥 – Basin Boundary	(610) – Subcatchment
🟩 – Subdivisions	[610] – Subcatchment Channel
▬ – Drainageways	⟨XXXX⟩ – Detention Element
▬ – Waterways	△ – Concentration Point
☐ – Johnstown Stormwater Basins	

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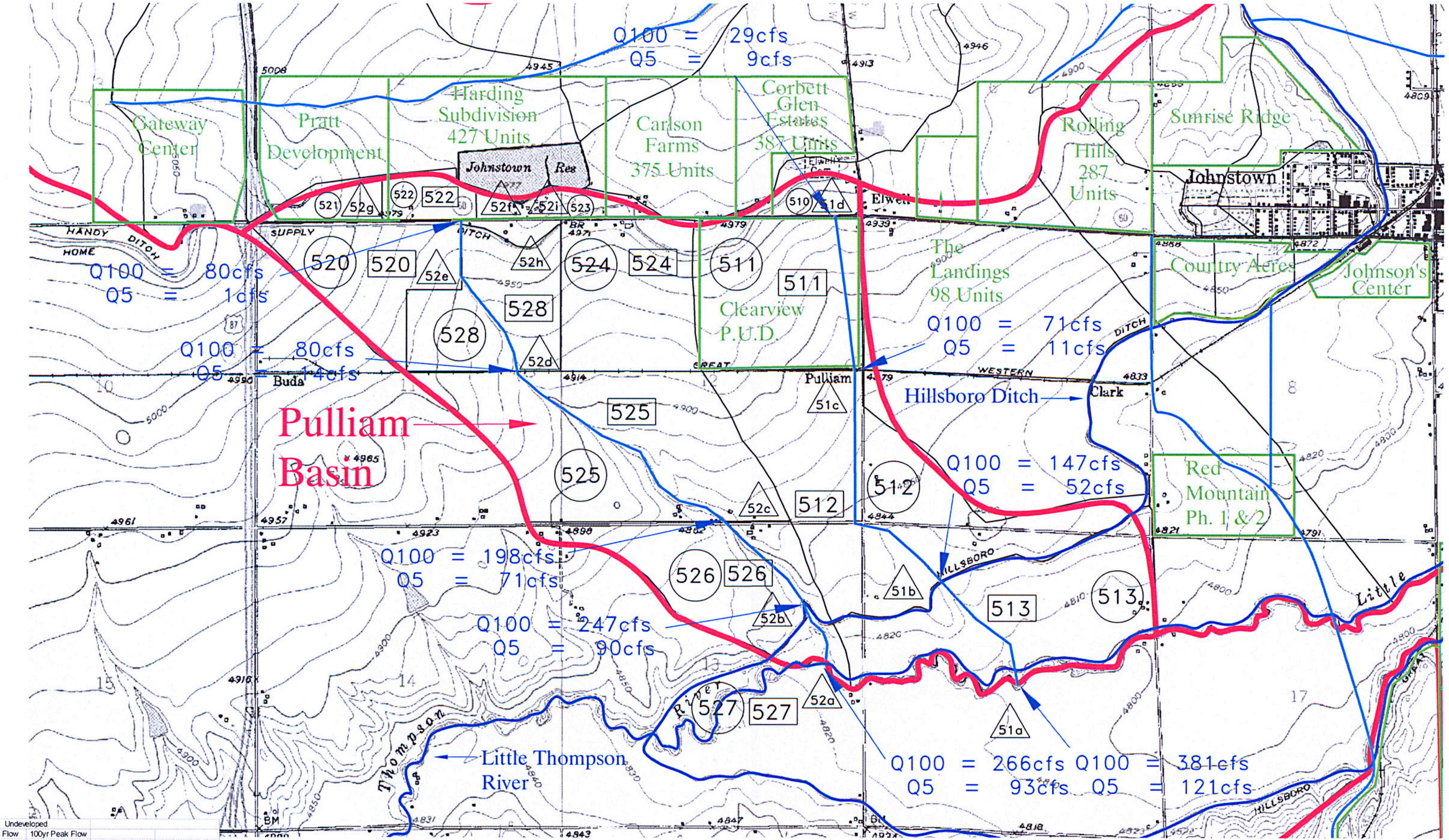
Exhibit 4

PULLIAM BASIN



		Undeveloped			
Node Name	Catchment Area ac	5yr Peak Flow cfs	100yr Peak Flow cfs		
51a	224.9	94.6	263.3		
51b	318.8	94.1	212.8		
51c	180.0	64.6	150.1		
51d	36.2	13.8	44.1		
52a	19.2	7.3	23.0		
52b	146.6	51.8	101.8		
52c	425.1	129.1	290.9		
52d	126.2	45.9	108.3		
52e	116.8	42.8	102.2		
52f	30.4	11.3	27.9		
52g	28.8	10.5	25.2		
52h	11.6	4.5	20.4		
52i	30.2	11.5	39.2		

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Exhibit 5

Legend

- 🟥 – Basin Boundary
- 🟩 – Subdivisions
- – Drainageways
- – Waterways
- ☐ – Johnstown Stormwater Basins
- (510) – Subcatchment
- 510 – Subcatchment Channel
- 5100 – Detention Element
- △ – Concentration Point

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2. Pulliam Basin

Pulliam Basin lies mostly south of Highway 60, and drains southeasterly to the Little Thompson River. It is 1,695 acres (2.6 square miles) in area. Two drainage ways are proposed for this basin. The first would extend from a point along Highway 60 near the west end of Johnstown Reservoir, southeast in an existing slough to the Little Thompson River. The slough becomes very well defined south of the railroad embankment, crossing WCR 46 via a bridge. The slough crosses the Hillsborough Ditch near the river. The ditch has an existing overflow structure very near to this crossing, and therefore an additional structure would likely not be necessary.

The other major drainage way proposed for this basin would closely parallel WCR 15 on the west side. Existing storm water flows appear to run southeast from the intersection of WCRs 15 and 46, but there is not a defined slough. Therefore it may make more sense to follow WCR 15 all the way to the Little Thompson River. Regardless, establishment of a major drainage way will result in drainage reaching the ditch at a point of concentration, where in the past it has likely entered the ditch as a distributed flow. At the point where this major drainage way crosses the ditch, the downstream bank of the ditch should be protected at minimum with a riprap blanket.

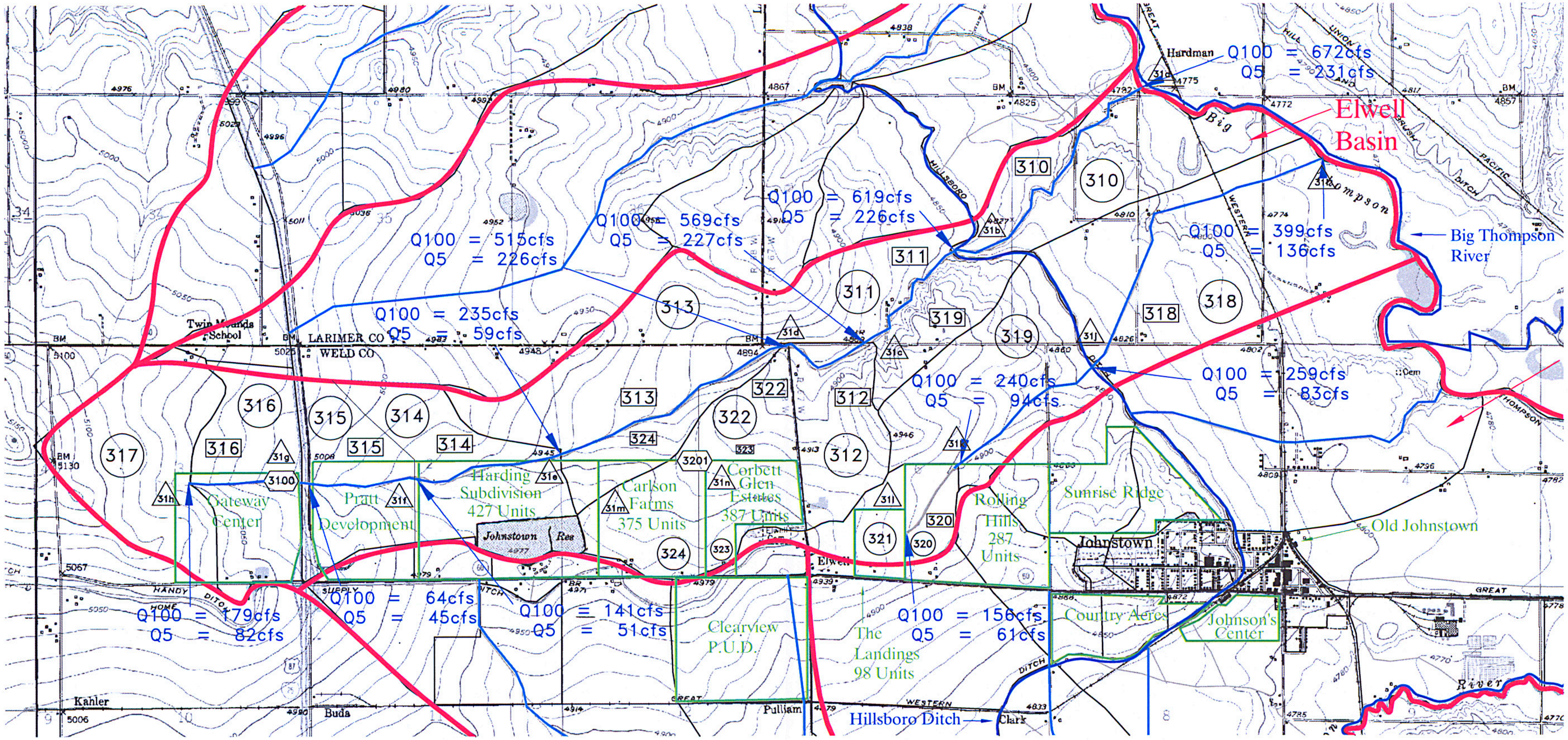
4. Elwell Basin

Elwell Basin begins approximately one mile west of I-25, and extends east and then northeast to the Big Thompson River. It includes many of the existing and proposed developments along the north side of Highway 60. It is 3,140 acres (4.9 acres) in size.

Several detention facilities have been designed for the various subdivisions proposed in this basin. Gateway Center, Carlson Farms, and Potburg Village all contain detention ponds. The pond in Potburg Village appears to outfall to the Rolling Hills subdivision. Rolling Hills has not yet constructed any storm water detention at this time for the portion of the development tributary to this basin (Several small ponds have been constructed for the portion tributary to Old Town Basin). Runoff currently discharges off the end of Rolling Hills Parkway into the adjacent field. Drainage discharged to this field ultimately makes its way to the Big Thompson River, after having crossed the Hillsborough Ditch. There is not a well-defined slough leaving the Rolling Hills property to the north. However, storm water detention should be required for the remainder of Rolling Hills, as it should for all properties lying above the Hillsborough Ditch. For Rolling Hills plans are to construct a basin prior to discharge off-site to the north.

The detention pond in Carlson Farms outfalls into a swale that has been constructed to an existing slough (Thornton Draw), approximately 900 feet north of the property. The slough crosses the Hillsborough Ditch before reaching the Big Thompson River. This slough is the major drainage way for Elwell Basin. The discharge during the 100-year storm from the detention pond in Carlson Farms is well in excess of the capacity of the Hillsborough Ditch. Though the Ditch Company has an turnout structure just

ELWELL BASIN



		Undeveloped		Current	
Node Name	Catchment Area	5yr Peak Flow	100yr Peak Flow	5yr Peak Flow	100 yr Peak Flow
	ac	cfs	cfs	cfs	cfs
31a	279.9	76.02	174.59	76.0	174.6
31b	250.1	73.5	166.4	73.5	166.4
31c	146.97	52.9	123.3	52.9	123.3
31d-1	390.23	134.2	308.4	134.2	308.4
31d-2	84.01	-	-		
31e	234.62	82.6	189.2	82.6	189.2
31f	173.45	63.0	148.5	63.0	148.5
31g	209.06	74.6	172.4	130.2	292.3
31h	261.78	93.0	214.2	93.0	214.2
31i	524.04	126.4	297.7	126.4	297.7
31j	276.05	86.4	194.2	86.4	194.2
31k	49.64	18.2	43.4	61.7	146.2
31l	58.38	22.1	60.1	92.2	207.8
31m	111.44	40.7	97.2	138.3	327.8
31n	90.32	33.8	86.5	33.8	86.5

Exhibit 6

Legend

🟥 – Basin Boundary	(310) – Subcatchment
🟩 – Subdivisions	▭310 – Subcatchment Channel
– Drainageways	(3100) – Detention Element
– Waterways	△31a – Concentration Point
☐ – Johnstown Stormwater Basins	

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downstream of where the slough crosses the ditch, its capacity is only about 34 cfs. The existing slough can, in the major storm, see a considerable flow of storm water. Weld County has recently constructed two new bridges across this slough, one on WCR 13, and one on WCR 50. The original culvert under WCR 50, and the flows tributary to it, was one of the subjects of the study by Chang and Associates for Weld County. The Chang study calculated a 100-year flow of 1,483 cfs at WCR 50. This is a significantly higher figure than the 534 cfs given in our model. This is due to the application of significantly different methodologies, as well as different goals. Chang used HEC-1 and TR-55, which are programs developed by the U.S. Government to determine maximum flows for the purpose of designing dams and other flood control structures. The Chang study also used a storm duration of 24 hours, with a total storm depth of 5 inches, whereas we have based our analysis on a storm duration of 2 hours, which is the standard for urban drainage design, and a total storm depth of 3.01 inches. Finally, in the method used by Chang the peak rainfall doesn't occur until several hours into the storm, after the ground is saturated. In the two-hour storm typically used in urban drainage design, the peak rainfall occurs early in the storm, when the ground still has significant potential for absorbing water.

5. __Twin Mounds Basin__

Twin Mounds Basin is almost completely undeveloped at this time. The basin is 1,853 acres (2.9 square miles) in area, and lies almost entirely to the north of WCR 50. The basin extends from a point about one-half mile west of I-25, and drains to the Big Thompson River.

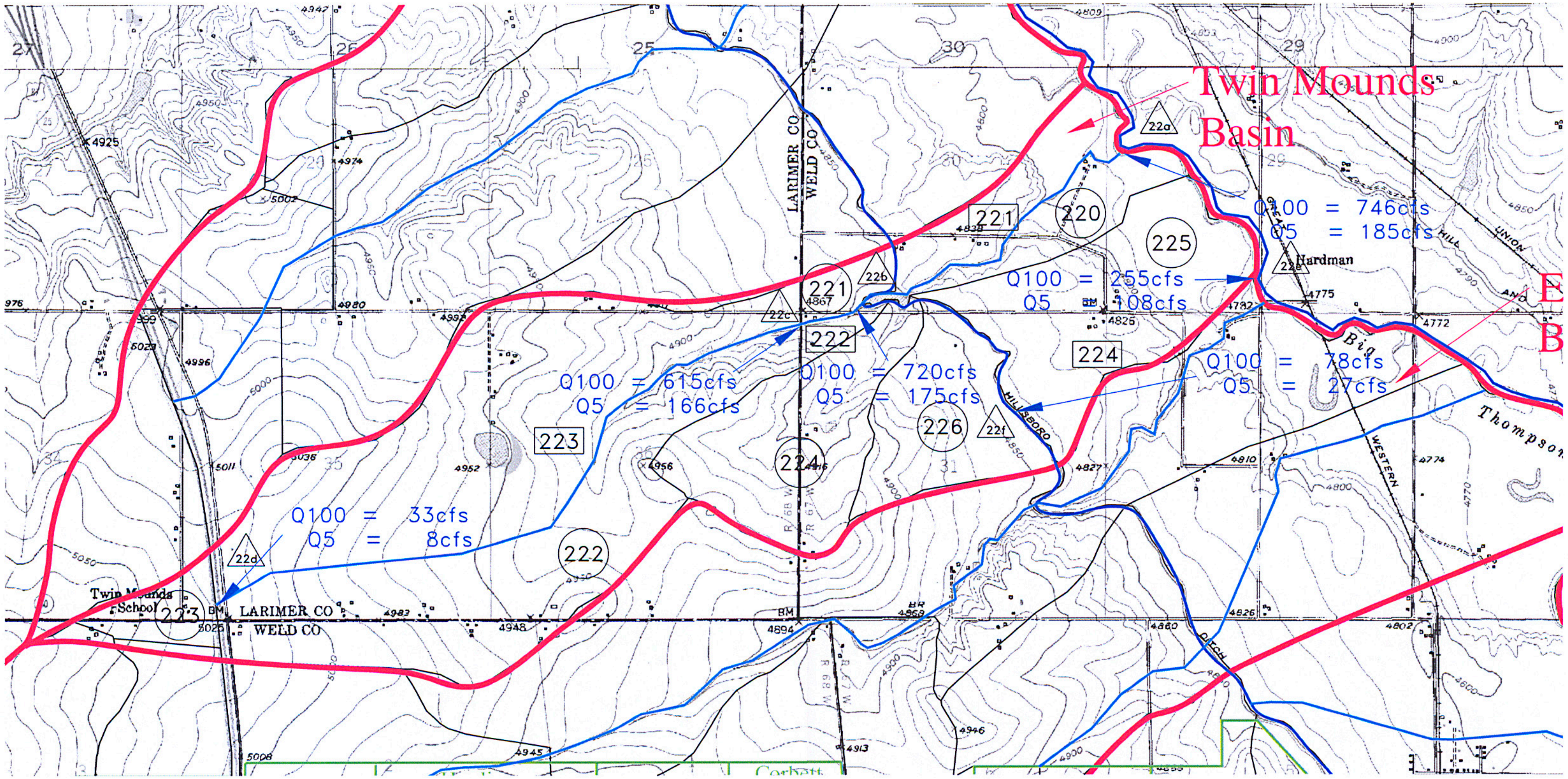
One major drainage way has been defined for this basin. An existing slough becomes well-defined west of WCR 13, and crosses that road and WCR 52 via 48-inch culverts. Just downstream of the point where the slough crosses WCR 52, it crosses the Hillsborough Ditch. There is believed to be a ditch overflow structure near this point. According to the USGS map, there is a pond located near this location on the slough.

6. __Johnson's Corner Basin__

Johnson's Corner Basin is 2,137 acres (3.3 square miles) in area, and in its upper reach extends nearly one mile southwest of Johnson's Corner, or about one-half mile west of I-25. Like Twin Mounds Basin, this basin is largely undeveloped, and also drains to the Big Thompson River.

One major drainage way has been defined for this basin. Beginning with a 36"x48" culvert under I-25, an existing slough extends northeast to the Big Thompson River. The slough crosses the Hillsborough Ditch at a point just west of WCR 13, and just south of SH 402. The ditch has an overflow structure at this point, which discharges into the slough.

TWIN MOUNDS BASIN



		Undeveloped			
Node Name	Catchment Area ac	5yr Peak Flow cfs	100yr Peak Flow cfs		
22a	164.77	66.18	129.8		
22b-1	46.63	91.627	212.315		
22b-2	219.53	-	-		
22c	916.85	330.665	824.095		
22d	49.53	19.63	51.768		
22e	278.17	90.82	203.85		
22f	158	55.317	126.247		

Exhibit 7

Legend

- 🟥 – Basin Boundary
- 🟩 – Subdivisions
- – Drainageways
- – Waterways
- ☐ – Johnstown Stormwater Basins
- (220) – Subcatchment
- 220 – Subcatchment Channel
- xxxx – Detention Element
- △22a – Concentration Point

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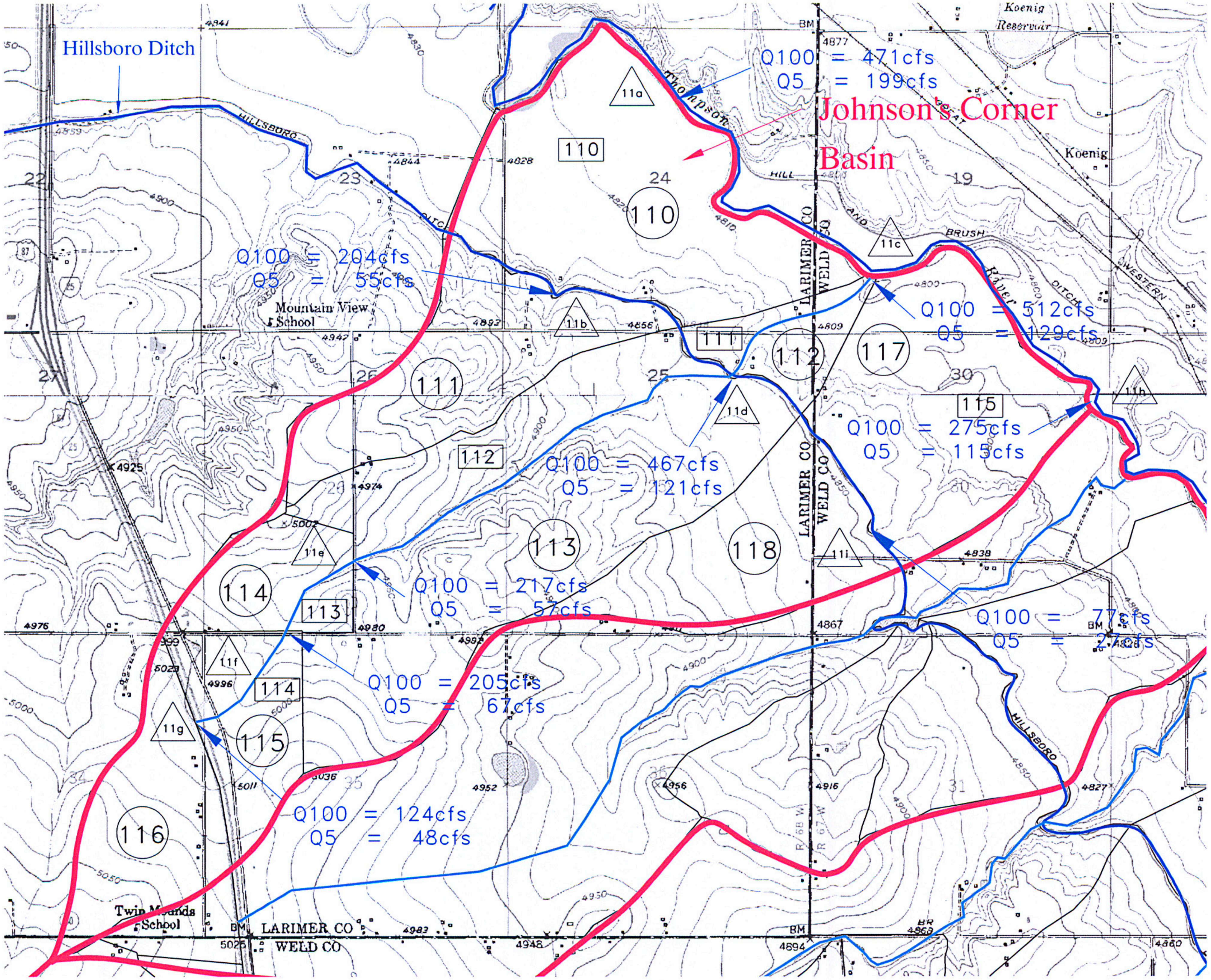
JOHNSON'S CORNER BASIN



		Undeveloped	
Node Name	Catchment Area ac	5yr Peak Flow cfs	100yr Peak Flow cfs
11a	446.3	154.1	349.3
11b	258.9	97.6	258.3
11c	84.9	31.0	74.0
11d	720.4	237.0	532.2
11e	118.4	40.9	92.8
11f	146.1	51.0	116.3
11g	196.6	62.4	152.2
11h	363.9	108.9	245.9
11i	247.8	65.7	151.7

Legend

- ▭ – Basin Boundary
- ▭ – Subdivisions
- ▬ – Drainageways
- ▬ – Waterways
- ▭ – Johnstown Stormwater Basins
- (610) – Subcatchment
- [610] – Subcatchment Channel
- (XXXX) – Detention Element
- △ – Concentration Point

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Exhibit 8

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III. DRAINAGE MODEL

III. DRAINAGE MODEL

During the 25 years since M&I performed the original drainage study for Johnstown, the advent of the personal computer has allowed the development of highly sophisticated software for use in modeling drainage. Many of the computer programs available are based on some version of the EPA's SWMM (Storm Water Management Model). SWMM was originally developed in 1970, and has been updated several times since then. SWMM can calculate the amount of runoff from a basin for a given storm. SWMM can also route the runoff through the drainage network. This is a capability that the Soil Conservation Service methods used by M&I did not have.

Simply stated, routing means that the model not only looks at how much runoff is generated, it also determines when that runoff reaches any given point in the system. For example, runoff originating high in the basin will take longer to reach the outfall than runoff originating low in the basin. In fact, the runoff from the distant basin may not reach the outfall until after it stops raining. The peak runoff experienced in Johnstown is, therefore, less than a sum of the peak runoff from all basins tributary to it. It is a case of the whole being less than the sum of the parts. SWMM can describe what is happening in each basin from the beginning of rainfall to well after the storm ends.

Many of the drainage modeling programs currently on the market are simply SWMM, with a user interface to make data entry easier. Even the UDFCD UD-SWMM and CUHP programs are based on EPA's SWMM. For this project, we have employed XP-SWMM by XP Software to model Johnstown's drainage system. XP-SWMM is based on version 4.4 of EPA's SWMM, the latest version available.

The goals of the drainage model are:

- To determine baseline (pre-development) conditions. The release of storm water from future developments would be limited to the baseline discharges shown in the model.
- To determine the magnitude of flows to be handled by proposed storm drainage facilities.
- To identify and analyze existing drainage problems.

A. Basin Layout

Six major basins were defined for this study (see back pocket for map). Five of the basins are grouped together, and bounded by the Little Thompson and Big Thompson Rivers. The sixth, Bunyan Basin, includes Stroh Farm and those areas that drain to it. The basins and their respective areas are listed in the table below:

Bunyan Basin	2,829	acres
Elwell Basin	3,140	acres
Johnson's Corner Basin	2,137	acres
Old Town Basin	3,509	acres
Pulliam Basin	1,695	acres
Twin Mounds Basin	1,853	acres
Total	15,163	acres (23.7 sq. miles)

Table III-1 – Major Basin Areas

The Old Town Basin incorporates the original basin layout described in the M&I report (Basins A-J), but has been expanded to include the area bounded by the two rivers to the north, south and east, and County Road 13 to the west. For the Baseline Model, only the development in and around Old Johnstown that existed prior to 1990 is included. For the rest of the study area, pre-development conditions are assumed.

B. Rainfall Analysis

No two rainstorms are the same. Nevertheless, it is necessary to establish a conceptual "design storm" for which drainage plans and facilities are designed. In Colorado, the type of storm that produces heavy runoff is typically short in duration, with intense rainfall early in the storm. Common practice along the Front Range of Colorado is to use a design storm that is two hours in duration, with the assumed rainfall depth based on a "return period." The return period of a storm refers to the probability that a storm of that magnitude might occur in a given year. For example, a storm with a return period of two years (a 2-year storm) has a probability of 1 in 2 of occurring in any given year. The 100-year storm has a 1 in 100 chance of occurring in any given year. This does not guarantee that two 100-year storms couldn't occur in the same summer. Nature is unpredictable. But the odds are 100 to 1 against it happening in any given year.

The expected rainfall depths for various design storms are based on measurements of actual storms, and statistical analysis of those measurements. This work has been performed by NOAA (National Oceanic and Atmospheric Administration), and compiled in their "Precipitation-Frequency Atlas of the Western U.S., Atlas 2, Vol. 3 – Colorado." The Atlas estimates rainfall depths for storms of six and 24 hours in duration. The Atlas also has formulas for extrapolating rainfall depths for storms of shorter duration. The table below gives the rainfall depths given in the Atlas for the study area, along with the calculated values storms of two hours in duration.

Period (yrs)	Length (hrs)	Depth (in)
2	6	1.5
2	24	2.0
5	6	2.0
5	24	2.7
10	6	2.3
10	24	3.2
25	6	2.8
25	24	3.9
50	6	3.1
50	24	4.4
100	6	3.6
100	24	5.0
2	1	1.02 *
2	2	1.18 *
100	1	2.65 *
100	2	2.98 *

* calculated from NOAA formulas

Table III-2 – Storm Depths from NOAA Atlas

Combs and Swift used a rainfall depth of 3.01 inches for their study for the City of Loveland. This is only 0.03 inches greater than what we derived from the NOAA maps, and well within the accuracy of such techniques. We therefore chose to use the same rainfall depth and distribution for our study to allow comparison of results.

C. Modeling Parameters

For every inch of rain that falls, less than an inch runs off. Some is absorbed into the ground (infiltration), some is retained as surface storage, some evaporates, and some is lost to plant activity (transpiration). The portion of the total rainfall depth that runs off is termed the "effective rainfall." The total infiltration was calculated in the model using the Horton Equation, a common technique for estimating the infiltration rate. Four different sets of Horton parameters were used, relating to the four hydrologic soil groups defined by the Soil Conservation Service. These are:

Group A – soils having a high infiltration rate
Group B – soils having a moderate infiltration rate
Group C – soils having a slow infiltration rate
Group D – soils having a very slow infiltration rate

Group B soils were predominant throughout the study area, though all types were found. Horton parameters describe the initial and final (or long-term) infiltration rate, and the decay rate. The table below gives the Horton parameters used for each soil group, along with the other hydrologic parameters used in the model.

Soil Type	Initial Infiltration Rate (in/hr)	Final Infiltration Rate (in/hr)	Decay Rate (1/sec)
A	7.5	0.38	0.00115
B	4.5	0.23	0.00115
C	2	0.1	0.00115
D	2	0.025	0.00115

Table III-3 – Horton Infiltration Parameters

Basin slopes were calculated from USGS topographical maps, as were basin areas and channel lengths. Physical surveys were not conducted as part of this study.

D. Model Calibration

One of the primary purposes of the Baseline Model is to determine allowable release rates from detention ponds constructed in new housing and commercial developments. To ensure that the results generated by the model are reasonable and accurate, some kind of calibration is required. Calibration is, essentially, the practice of comparing model results with some expected results, and adjusting the model accordingly. Our expectation for the Johnstown area is that runoff rates would be low, compared to most urban systems along the Front Range. There are two reasons for this. The first is that the Soil Conservation Service classifies most soil types in the Johnstown area as Group B. As discussed above, Group B soils readily infiltrate, or absorb, water. Soils closer to the foothills typically have a higher clay content, and therefore they generate more runoff.

The other reason for expecting relatively low runoff rates relates to our definition of the historic condition. Virtually all the undeveloped land in the study area is ground that is currently being farmed, or has been farmed in the recent past. Cultivated ground is conditioned by the plow to absorb as much of the natural rainfall as possible. The top few inches of cultivated soil will have much lower compaction than undisturbed grassland. Low compaction results in much greater void space in the soil in which water can be absorbed and stored.

The model has incorporated within it the characteristics of cultivated farmland, in an effort to produce a physically-based model of each basin. These characteristics include infiltration, surface storage, overland flow characteristics, percent impervious, and numerous other criteria. To calibrate the model, several approaches were considered. We compared our results to the results of the study by Combs and Swift. However, they calibrated their model to a discharge of 1.0 to 1.2 cfs per acre, numbers derived from the UDFCD, and we did not feel that such numbers were representative of the Johnstown area for the reasons discussed above. After inputting the same surface detention (0.3") and percent impervious (40) for Old

Johnstown, our results for that portion of the study area were nearly identical with those in the M&I report. We finally applied the Rational Method to the catchments in the Twin Mounds basin, and compared our results. The Rational Method incorporates soil parameters, runoff slopes, and other basin characteristics, just as SWMM does, but using completely different sets of calculations. It thus represents a method of generating results completely independent of SWMM. Good correlation was found between the two methods. Twin Mounds basin contains soil types A, B and C in the approximate proportions found throughout the study area. We felt it to be the most representative basin, and therefore the entire model was calibrated based on the calibration of the Twin Mounds Basin model to the Rational Method results.

E. Historic Runoff

The calculated historic runoff for the six major basins are given in the exhibits in Section II of this report, for each sub-basin. The peak runoff rates are for "pre-development" conditions as discussed above, except for Old Town where we have assumed an interim condition dating to approximately the same time as the M&I study. Peak runoff rates are for the 5-year and the 100-year storms. The tables printed on the exhibits also show the 5-year and 100-year runoff rates for current conditions.

The Baseline Drainage Model is a tool to establish allowable release rates from previously undeveloped properties. However, the Town has approved several residential and commercial developments within Johnstown in recent years. To gage the effect of these new developments, another version of the drainage model was constructed to analyze the "as is" condition. The purpose was to any identify current drainage problems, and to generate potential solutions. Town staff had identified some existing problems, and this information was compiled and used to verify model output. It was necessary to determine the conditions that exist now (or in the very near future) in order to identify what the most urgent needs are for the Town.

F. Modeling Assumptions

As discussed previously, a variety of methods were applied by various developers' engineers in determining detention storage, release rates, and other design elements for each new subdivision. It would be extremely difficult, if not impossible, to duplicate all these individual analyses in one model. Therefore, we have assumed that residential developments will increase the impervious area from 7.5% (used for undeveloped land) to 40%. Detention ponds known to exist, or that are under construction, have been added to the developed models. The models were then run with the developed conditions, and resultant flows at critical points generated for the 5-year and 100-year storms.

IV. DRAINAGE POLICY

IV. DRAINAGE POLICY

Prior to any discussion of specific recommendations, it is prudent to discuss drainage policy. The policies enacted by Johnstown with regard to drainage will form the basis for specific design criteria. Drainage policy will also drive the formation of a storm water utility, and codify how drainage improvements are to be funded. The choices made by the Town will directly affect the size and cost of improvements. They will also directly affect the level of protection afforded to Johnstown residents from property damage or loss of life due to major storms.

Regarding drainage improvements, the formula followed by other municipalities along the Front Range is one that we recommend for Johnstown. Typically, development pays for the drainage facilities required to mitigate the impact of their activities, both on-site and downstream of the new development. The argument may be made that if a new development detains the excess runoff caused by the development, and releases at the historic rate, then no downstream improvements should be required.

The fact is that even if historic runoff rates are maintained, the character of the runoff is changed by development. The land-planning effects of decades of farming have generally led to distributed runoff patterns. Development of a parcel of land will route the runoff to one or two discharge points. Thus, though the peak rate of runoff is held to historic limits, that runoff is channelized by development. One way to state the proposed policy is to say that after development, those downstream of the development should see no change in the volume or “character” of the storm runoff. If prior to development water sheet-flowed off the upstream parcel, and development concentrates the runoff to a single discharge point, the new development cannot simply discharge the channelized flow onto the adjacent property. The new development should be required to convey their storm water downstream to the nearest established drainage way or channel.

A good example of this is the swale that was constructed from the detention pond on Carlson Farms, approximately 1,500 downstream to an established channel (which we have proposed as a major drainage way). Historically most of the storm water runoff would have reached the drainage way by flowing over the ground, and across the property to the north.

If a piece of property under development is adjacent to an existing channel, the developer might not need to do anything more than design his/her drainage system to outfall to the channel. In many cases, however, the development will be located some distance away from a major drainage way. The developer should then be required to construct whatever improvements are needed to convey drainage downstream to an established channel. In addition, if the drainage patterns post-development concentrate storm water flows at the point where they cross the Hillsborough Ditch, the developer should be required to mitigate the impact on the ditch. In many cases this would mean that the ditch banks should be protected so that they will not be washed out in the major storm. Riprap or a concrete apron on the downstream ditch bank could provide this kind of protection, and would allow low flows to still enter the ditch. Siphons and overchutes could also be used. However, they would be considerably more expensive to construct, and they would have to be somehow designed to allow low flows to enter the ditch. In general the principle to follow should be to mitigate the impacts of development only, and not to try and protect the ditch from all acts of nature.

The standard to which downstream improvements should be held would be dependent on whether they lay within the corporate limits of Johnstown, outside the corporate limits but within the urban growth boundary, or within Larimer or Weld County jurisdiction. Within the corporate limits, drainage is typically conveyed by the combination of storm drains, and curb and gutter. Development occurring within the corporate limits might be required to construct off-site road improvements, or at least participate in their cost, to convey drainage. This is likewise true of areas proposed for annexation. Where drainage ways cross roads under county jurisdiction, development need not upgrade the crossing to Johnstown street standards. As long as the county were to maintain the culvert or bridge, their standards would apply. However, in those cases where the road would eventually be transferred to Johnstown's jurisdiction, then Johnstown's street standards would apply.

As we have stated above, development should pay its own way. In the worst case scenario, this policy may require a developer to acquire drainage easements for two or three miles downstream of his/her property, and to improve the ditch bank at the point where drainage crosses the ditch. It is almost certain that the drainage easements will be along a proposed major drainage way, and downstream property owners should be willing to grant easements. They would be motivated to do so if they plan to develop their property in the future. In any case, if it is an existing drainage slough, then it is an existing path of flow. Under this master plan the downstream property owners would know that eventually the easements would be requested. If the developer is unable to get all the required easements, then the Town may wish to become involved in negotiating easements.

Some drainage improvements are proposed in this report to correct existing problems. The Town would construct these capital projects. Nearly all of them are located in the Old Town Basin. Certain other projects may place a disproportionate burden on developers, such as where the required drainage improvements would ultimately serve multiple developments. In this case the Town may choose to participate in the cost of such improvements, with the intention of gaining reimbursements from future developers. Johnstown will need to be flexible in how it approaches raising and spending revenues of its proposed storm water utility. It should also be recognized that even for those developments that have constructed adequate storm water management systems, the Town will be responsible for ongoing operation and maintenance of those systems. Property assessments by the storm water utility must cover the costs not only of capital projects, but operation and maintenance for the entire system.

A. Design Storms

During this study we made a choice to use the 5-year storm as the “minor” storm, and the 100-year storm as the “major” storm. The 100-year storm is the regional standard for urban drainage design. The 100-

year storm represents an event that is unlikely in any given year, but within the realm of possibility. At any given location, the likelihood that the 100-year storm will occur during a 40-year period is one in three.

The definition of the minor storm is not as universal along the Front Range of Colorado. Depending on the jurisdiction, the minor storm may be the 2-, 5- or 10-year storm. Some jurisdictions require the storm water collection system to be designed for the 2-year storm, and storm water detention ponds to be designed for the 10-year storm. UDFCD uses the 2-year storm for residential areas, and the 5-year storm for high-value commercial areas and public buildings.

The major and minor storms relate to the initial and major drainage systems. The initial drainage system is intended to collect storm water from the minor storm. It includes all curbs and gutters, swales, and any storm drains. The initial drainage system should be able to collect and convey storm water, without allowing excessive depth of water in streets, and without causing any property damage. The allowable depth of water in streets during the minor storm may depend on the street. During the 100-year storm, major thoroughfares must still be able to pass traffic each way, whereas local residential streets may need only to allow access to emergency vehicles. During the major storm, all storm drains are likely to be running full or even surcharged, and the major drainage system will need to carry the rest of the storm water. This would likely require greater depth of flow in all streets, but flowing water should still be contained within street rights-of-way. Overflow channels or other conveyances may be needed to route storm water away from private property.

We propose to use the 5-year storm as the minor storm in Johnstown's drainage criteria. This will afford a higher degree of protection than would be provided by using the 2-year storm, with a moderate impact on costs. Most such costs will be borne by developers in the form of slightly larger pipe sizes in on-site storm drain systems, and/or more storm drain piping. For the Town, it will impact certain capital improvement projects slightly. For example, a storm drain serving the downtown area might be six inches larger in diameter than what would be required for a 2-year storm. However, commercial areas are typically designed for the 5-year storm in most jurisdictions.

B. Detention Ponds and Release Rates

In modeling the six major drainage basins, historic release rates were calculated for each basin, sub-basin and catchment, for the entire study area (see appendices). This data was then used to generate a weighted average historic release rate per acre for each basin. For the Old Town Basin, only the undeveloped portions of the basin were used to generate the allowable release rate per acre for that basin. Release rates are by soil type, similar to table 3-2 of the Urban Drainage and Flood Control District Design Criteria Manual. In some basins, not all soil types were found in significant extent. In such cases a weighted average from the other basins with that soil type was used. Developers should be required to provide detention volume sufficient to contain the difference between the storm runoff prior to development, and the developed runoff. The rate of release from all detention ponds should not be allowed to exceed the values given in the table below, either during or immediately after the storm event.

	Soil Group			
Control Frequency	**A**	**B**	**C**	**D**
5-year				
Bunyan	0.31	0.33	0.34	0.35
Elwell	0.30	0.31	0.32	0.35
Johnson’s Corner	0.31	0.33	0.33	0.35
Old Town	0.37	0.37	0.40	0.42
Pulliam	0.35	0.35	0.37	0.42
Twin Mounds	0.36	0.36	0.36	0.37
100-year				
Bunyan	0.7	0.81	0.93	0.97
Elwell	0.7	0.72	0.93	1.00
Johnson’s Corner	0.7	0.76	0.77	1.00
Old Town	0.69	0.81	1.20	1.00
Pulliam	0.69	0.79	0.93	1.17
Twin Mounds	0.7	0.77	0.91	1.00

Table IV-1 – Allowable Release Rates, cfs/acre

We recommend that the Town adopt a variable detention policy. Such a policy is based on the principle that if a property is on a major drainage way and close to a major waterway (the Little or Big Thompson Rivers), peak flows in the major drainage way may actually be reduced by allowing discharge of storm water without detention. This is because runoff from catchments high up in the basin may not reach the outfall until long after the peak of the storm. If catchments near the bottom of the basin are allowed to discharge immediately, they will be done discharging before the runoff from the upper basins reaches the outfall. No developments above the Hillsborough Ditch would be qualified for any reduction in required detention.

In general, any development whose storm water discharge enters the Hillsborough Ditch (or any other ditch, for that matter) should be required to detain storm water. An exception could be made if the developer constructs a siphon or overchute to cross the ditch. The developer would then also need to make improvements to the downstream channel to ensure that it could carry the undetained flows, accounting for all other discharges to that channel. Any requests for variances from the Town's storm water detention policy should be considered on a case-by-case basis to ensure that downstream property owners would not be adversely affected, and to ensure adherence to good engineering practice.

All drainage systems and detention ponds should allow for the maintenance of low flows, which are essential to sustain wetlands. Some developers may propose combination detention/retention ponds. In addition to detaining storm water flows, these structures maintain permanent pools. Such facilities may impact downstream water rights. Prior to approval by the Town of any facility that may impound water, the developer should be required to get approval of the facility from the State Engineer's Office.

C. Water Quality

As previously discussed, we recommend that the Town enforce some kind of water quality requirements for storm water runoff from urbanized basins. A variety of methods exist, called BMPs (best management practices), and developers can be given the option to choose among them. Typically the most practical method, especially for smaller (less than 160 acres) developments, is to oversize detention ponds slightly so that they provide extended detention for the "first washoff" of storm water. Outlet structures are designed so that the runoff generated by the average afternoon thunderstorm drains very slowly from the detention pond, allowing pollutants to settle out prior to discharge to the receiving waterway. This practice would also provide an additional buffer to mitigate flooding of the Hillsborough Ditch during the minor storm. Other BMPs include constructed wetlands, which can double as an amenity. We recommend that the Town adopt Volume 3 of the Urban Drainage and Flood Control District Drainage Criteria Manual, which includes detailed descriptions and design procedures for water quality BMPs.

D. Major Drainage Ways

Drainage ways were defined earlier in this report for each Major Basin. Regardless of the policies adopted by the Town, during a major storm the water will flow into existing channels, just as it has always done. By identifying these drainage ways in this master plan, and requiring new developments to incorporate them into their land use plans, the Town ensures that the water will always have a place to go.

The drainage ways also provide the opportunity for development of natural corridors. We propose that the width of these drainage ways be 100 feet at a minimum, and greater if warranted by existing topography, expected storm water flows, or other considerations. They can incorporate trail systems and other amenities, act as wildlife corridors, and in general add to the quality of life in Johnstown. When a parcel of land containing a portion of a drainage way applies for annexation and proposes development, the developer should be required to dedicate the drainage way as permanent easement to the Town.

Developers will likely appreciate this arrangement. The amenity provided by a natural corridor would be a good selling point. Existing Federal law would require any existing wetlands to be preserved in any case. Potential developers would also have more guidance as to where they can discharge drainage.

The proposed major drainage ways in the Bunyan, Johnson's Corner and Twin Mounds basins incorporate existing well-defined channels. Only at the very bottom of each basin, just before the channels reach the Little Thompson River in the case of the Bunyan Basin, and the Big Thompson River for the other two basins, do the established channels lose definition. This is due to farming practices, the effect of the ditch in intercepting low flows, and the natural topography of the river terraces. We have already recommended within this report that a spill structure should be built in Bunyan Basin on the downstream bank of the ditch where the existing channel crosses the ditch. In conjunction with this work, a channel should be established to carry water to the Little Thompson River. Alignment of this channel should be coordinated with the property owner that will be affected, so as not to interfere unduly with agricultural operations. Likewise, as development occurs in the Johnson's Corner and Twin Mounds basins, the developers should be required to construct similar facilities in those basins.

Elwell Basin has two proposed major drainage ways, one of which is an existing channel. The existing channel extends roughly four miles, from Gateway Center down to the Big Thompson River. It is into this channel that we propose to divert flow via a spillway structure. This structure (discussed further in the Recommendations Section) would be located just west of Weld County Road 15, and north of Weld County Road 50. The other major drainage way proposed for this basin is well-defined above the ditch, but not at all defined below the ditch. Without an existing path of flow to the Big Thompson River, could easily be made to follow roadway alignments. The northernmost drainage way for Old Town Basin is also lacking an existing channel, and it would be possible to route the flows from the two drainage ways to a shared channel.

The proposed major drainage way in the northeastern portion of Old Town would primarily serve Sunrise Ridge (including the Knolls), and the eastern two-thirds of Rolling Hills. Given the existing detention pond within Sunrise Ridge, and the proposed ditch spillway structure upstream of this point, a major drainage way may not be required west of Weld County Road 17. East of WCR 17 there appears to be an existing path of flow, but until this land is developed there may not be any need to dedicated a major drainage way.

As discussed previously, of the two major drainage ways proposed for Pulliam Basin, the eastern one is not based on a defined channel, and could therefore be aligned along county roads to minimize impacts on existing land uses.

E. Roadways and Streets

Streets and roadways are an essential element of the storm water collection system. Johnstown currently uses the City of Greeley streets standards for new construction. We recommend that the Town formally adopt these standards for all new construction.

V. RECOMMENDATIONS

V. RECOMMENDATIONS

This section describes our recommendations for drainage improvements in and around Johnstown. These have been broken down into two categories, structural improvements and policy recommendations. The recommended structural improvements are projects that would mitigate existing drainage problems. They are, for the most part, located in and around Old Johnstown, and would be built by the Town. The policy recommendations we have made throughout this report are again stated in this section. The intent is to provide a plan for development of drainage facilities within the six major basins as they develop. We believe that the guiding principle should be that development pays its own way.

M&I made several recommendations in the 1976 report. Those that remain valid have been adapted to current conditions, and incorporated into our own recommendations. Cost estimates are provided for the structural improvements to be built by the Town, broken down into separate components of design, construction, easement acquisition, etc. Project costs have not been allocated by basin because, except for Bunyan Basin, the rest of the study area could have been considered as one basin. The reasons for dividing it up have more to do with the technical aspects of the drainage model than with actual geographic divisions.

Open channels were recommended for all of the major drainage ways, as well as for conduits serving the proposed side-channel spillways and the proposed backbone storm drain. These channels all represent critical storm water conveyances, and as such should not be piped. The major drainage ways are the primary path of flow for a storm of any size. By attempting to pipe the flow, the capacity of the drainage way would be restricted, and eventually a storm of sufficient magnitude would occur to exceed the capacity of the pipe. In that event the storm water would find its natural path, and any structures or properties blocking that path would be endangered. By preserving the drainage ways as channels, particularly where channels already exist, flood waters from any storm will have a place to drain without endangering life or property. In the case of the side-channel spillways, it may be possible to pipe the overflow that would be generated. However, on the south side of the Town this might require up to a mile of large-diameter storm drain pipe. The cost of this pipe would be prohibitive, considerably greater than the benefit, and would draw money away from other needed projects. Open channels represent a cost-effective means of conveying storm water, and an efficient one.

A. Policy Recommendations

Our recommendations regarding storm drainage policy are based on the assumption that the Town will form a storm water utility to implement policies and standards. Funding of a storm water utility was addressed in the “Drainage Financing Alternatives” study performed for the Town by Tischler & Associates. The first group of recommendations given below are general policies that apply to all major drainage basins, and would govern how developers are to design on-site drainage facilities, as well as convey drainage from their properties to the ultimate receiving waters.

*1. **General Policies***

- Johnstown should adopt a zero impact policy, whereby developers would be required to mitigate all impacts on the drainage system resulting from their activities.
- Johnstown should establish a storm water utility for the purpose of funding capital improvements, implementing drainage design standards, and maintaining drainage facilities.
- Johnstown should designate major drainage ways, based on this master plan. These drainage ways should identified in the Town's Comprehensive Plan. When a parcel that contains a portion of a drainage way is developed, dedication of the drainage way to the Town, in the form of an easement, should be made a condition of development.
- Major drainage ways should wherever possible be open channels.
- Criteria governing drainage and detention pond design should include BMPs (best management practices) for protection of water quality.
- Drainage design undertaken for development of a parcel of land should account for both on-site drainage, and any off-site drainage that historically or currently enters the site from upstream.
- Drainage design undertaken for development of a parcel of land should also account the downstream condition until it reaches a receiving water, or established drainage channel. For property owners downstream, the rate of flow, quality, and intensity of storm water runoff should not be adversely affected by upstream development.
- In areas down-gradient from the Hillsborough Ditch, and near a receiving water, it may be in the Town's best interests to waive in part or whole the detention requirement. In such cases the water quality requirements should still be enforced.
- No waiver of detention should be granted to any property upslope from the Hillsborough Ditch, or any other irrigation ditch that might intercept drainage from the subject property.

*2. **Specific Basin Policies***

Bunyan Basin

- Establish one major drainage way, based on the existing channel. The major drainage way should extend from Hill Lake, downstream to the Little Thompson River. The width of the major drainage way should be adequate to carry the 100-year flow, plus freeboard, but in no case less than 100 feet wide.
- Between the Hillsborough Ditch and the Little Thompson River, the major drainage way should, to the extent possible, be aligned so that it interferes as little as possible with existing land uses.
- Approval was granted and construction was begun on a development in this basin upstream of the Hillsborough Ditch prior to completion of this master plan. Therefore, the Town

should construct protection of the ditch bank at the point where the existing channel crosses the ditch.

Elwell Basin

- Establish a major drainage way, based on the existing channel extending from Gateway Center (west of I-25), to the Big Thompson River. The width of the major drainage way should be adequate to carry the 100-year flow, plus freeboard, but in no case less than 100 feet wide.
- A spillway and bank protection should be constructed at the point the major drainage way crosses the Hillsborough Ditch. Design and construction is the responsibility of the developer or developers in this basin, with review and approval performed by the Town.
- Establish a second major drainage way, extending from the north boundary of Rolling Hills, to the Big Thompson River. The width of the major drainage way should be adequate to carry the 100-year flow, plus freeboard, but in no case less than 100 feet wide.
- Alignment of the second major drainage way should be based on the existing channel or path of flow between Rolling Hills and the Hillsborough Ditch. Below the ditch the major drainage way should to the extent possible be aligned so that it interferes as little as possible with existing land uses.
- Relatively extensive development has occurred in this basin upstream of the Hillsborough Ditch, prior to completion of this master plan. Therefore, if other proposed improvements designed to mitigate overflow of the ditch are not sufficient in this area, the Town should construct protection of the ditch bank at the point where the existing channel crosses the ditch.

Johnson's Corner Basin

- Establish a major drainage way, based on the existing channel extending from I-25, to the Big Thompson River. The width of the major drainage way should be adequate to carry the 100-year flow, plus freeboard, but in no case less than 100 feet wide.
- A spillway and bank protection should be constructed at the point the major drainage way crosses the Hillsborough Ditch. Design and construction is the responsibility of the developer or developers in this basin, with review and approval performed by the Town.

Old Town Basin

- Establish a major drainage way, extending from the intersection of Highway 60 and Weld County Road 15, to the Little Thompson River. The width of the major drainage way should be adequate to carry the 100-year flow, plus freeboard, but in no case less than 100 feet wide. The alignment should if possible make use of an existing slough that runs southeast across the

OLD TOWN BASIN

Proposed Drainage Improvements

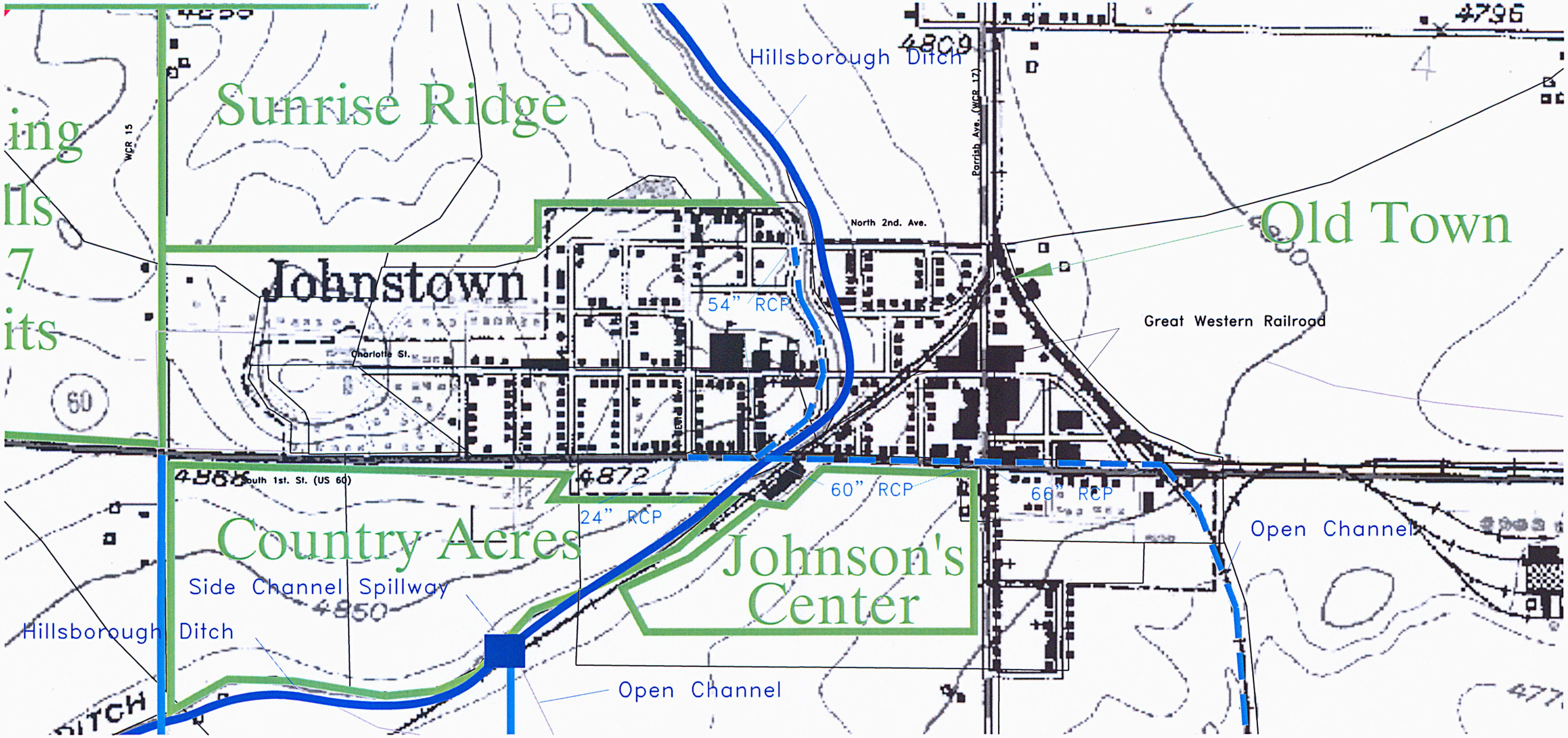

Exhibit 9

Legend

- ▭ – Basin Boundary
- ▭ – Subdivisions
- ▬ – Drainageways
- ▬ – Waterways
- ▭ – Johnstown Stormwater Basins
- (310) – Subcatchment
- [310] – Subcatchment Channel
- (3100) – Detention Element
- △ – Concentration Point

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E:\00047\Old Town Improvements.dwg

southwest quarter of Section 8. It should also be coordinated with the alignment of a channel to serve the Town's proposed side-channel spillway.

- A spillway and bank protection should be constructed at the point the major drainage way crosses the Hillsborough Ditch. Design and construction is the responsibility of the developer or developers in this basin, with review and approval performed by the Town.
- Establish a second major drainage way, extending from the Hillsborough Ditch where it borders the Sunrise Ridge development, to the Big Thompson River. The width of the major drainage way should be adequate to carry the 100-year flow, plus freeboard, but in no case less than 100 feet wide.
- A spillway and bank protection should be constructed at the point the major drainage way leaves from the Hillsborough Ditch. Design and construction is the responsibility of the developer or developers in this basin, with review and approval performed by the Town.

Pulliam Basin

- Establish a major drainage way, based on the existing channel extending from Highway 60 at the west end of Johnstown Reservoir, to the Little Thompson River. The width of the major drainage way should be adequate to carry the 100-year flow, plus freeboard, but in no case less than 100 feet wide.
- Establish a second major drainage way, extending from Highway 60 and Weld County Road 13, to the Little Thompson River. Alignment of the major drainage way should coordinated among the proposed developers, and should interfere as little as possible with existing land uses.
- A spillway and bank protection should be constructed at the point the second major drainage way crosses the Hillsborough Ditch. Design and construction is the responsibility of the developer or developers in this basin, with review and approval performed by the Town.

Twin Mounds Basin

- Establish a major drainage way, based on the existing channel extending from I-25, to the Big Thompson River. The width of the major drainage way should be adequate to carry the 100-year flow, plus freeboard, but in no case less than 100 feet wide.
- A spillway and bank protection should be constructed at the point the major drainage way crosses the Hillsborough Ditch. Design and construction is the responsibility of the developer or developers in this basin, with review and approval performed by the Town.

B. Structural Improvements

Most of the structural improvements described below are intended to mitigate existing drainage problems. In one case (Bunyan Basin), the proposed improvement is intended to bring that basin into conformance with the standards set forth in this master plan for major drainage ways. The developers of Stroh Farm have constructed detention ponds and paid drainage impact fees. It is the expectation that these fees could be used to construct the proposed improvements in that basin.

The following projects were prioritized by first placing those improvements which could most reasonably be constructed in the next twelve months, thereby giving the Town some immediate results. Construction of the two side-channel spillways prior to any other projects would also allow their effectiveness to be judged. This information would be very useful for sizing the proposed storm drains.

1. A spillway structure should be constructed on the downhill bank of the Hillsborough Ditch, on the south side of town. This will provide a controlled release from the ditch to prevent flooding from undetained storm water flows entering the ditch from town.
   A. In conjunction with the spillway structure, a downstream channel must be constructed to receive these flows and carry them to the Little Thompson River. This might best be accomplished by establishing the major drainage way along WCR 15, as identified earlier in this report.
2. A second spillway structure upstream of the Town, at the site of the existing 34 cfs overflow gate. This second spillway will allow the ditch to be emptied prior to its entrance into Johnstown.
   A. Construct a channel to convey flows from the second spillway structure to the nearby major drainage way in Elwell Basin.
3. Construct a large “backbone” storm drain along South First Street, from Estes Avenue east to Kuner Avenue. The drain should be sized to carry the 5-year storm flows from those areas bounded by Idaho Avenue on the west, North Second Avenue on the north, the Hillsborough Ditch on the east, and South First Street. In addition, this drain should pick up flows from downtown Johnstown, north of South First Street. This will greatly mitigate flooding in the neighborhoods south of this street, and east of Parish Avenue.
   A. The backbone drain should outfall into an open channel between Kuner Avenue and the railroad, as recommended by M&I.
4. Construct an overflow spillway at the point where the major drainage way in Bunyan Basin crosses the Hillsborough Ditch.
   A. Construct a channel from the proposed spillway in Bunyan Basin to the Little Thompson River to complete the major drainage way in that basin.
5. To collect flows from the areas west of the Hillsborough Ditch, storm drains should be constructed in the north-south streets such as Estes Avenue, and Columbine Avenue. Inlets at the intersections will intercept flows that now go into the ditch, and carry them south to the backbone drain in South First Street.

The proposed backbone storm drain should ideally be sized to carry the minor storm flows, i.e. the 5-year storm, leaving the excess flows during the major storm to be collected and routed by the streets system. However, other issues will affect sizing of the drain. The first is the side-channel spillways that will be constructed first. They will increase the amount of storm runoff that can be safely intercepted by the Hillsborough Ditch. The other issues regard the various engineering constraints that will be encountered during the design of the drain. The proposed drain will have to pass under the ditch, and it will have to fit around the other utilities that are in Highway 60. East of the downtown area the grade of the drain may be so flat that even a large pipe might not have as much capacity as would be ideal.

The costs given below are for the major capital improvements projects identified above. Construction of the improvements identified in this report will substantially improve the storm drain system of Johnstown, providing a higher level of service to its citizens. All costs include engineering, survey, construction administration, and a 20% contingency. Easement acquisition costs have not been included. Portions of these projects will be constructed in existing rights-of-way, and thus no easement may be required. Easements will be needed for the channels, but some of these may be dedicated to the Town by developers, at no cost to the Town. Costs have not been included for a channel between the Hillsborough Ditch and the Little Thompson River, in Bunyan basin. The need for and alignment of this channel will have to be negotiated with the property owner. Costs have also not been included for the additional storm drains in Old Town. Construction of the backbone storm drain and the side-channel spillways will significantly improved drainage in the Town. The magnitude of the improvement will not be fully known until these projects are completed. Additional drains would then be built based on need, available funding, and in coordination with street replacement projects.

VI. OPINION OF COST

VI. OPINION OF COST

See opinion of cost on the following pages.

	Description	Qty.	Unit	Unit Price	Item Price
	Project 1 - South Side Channel Spillway				
1	**Structure**				
	Excavation/Backfill	150	CY	$35	$5,250
	Spillway structure	75	CY	$550	$41,250
	Type 3 baffeld outlet	45	CY	$550	$24,750
2	**Riprap**				
	Downstream Spillway	24	CY	$200	$4,800
	Bedding Material	45	CY	$50	$2,250
3	**Concrete Pipe (Class 2, mastic joint)**				
	Downstream Spillway - d=5 ft	50	LF	$105	$5,250
	Pipe Installation - Downstream	50	LF	$75	$1,378
4	**Metals**				
	Slide Gate	1	Ea	$2,500	$2,500
	Hand Rail	120	LF	$92	$11,040
			Subtotal		**$98,468.00**
			Contingencies		$19,693.60
			Engineering		$8,960.59
			Survey		$4,500.00
			Engineering Const		$10,831.48
			Total Construction		**$131,622.19**
	Project 1 A - Discharge Channel from SouthSide Channel Spillway				
1	**Channel**				
	Excavation	28000	CY	$18	$504,000
	Road Crossing 60" RCP	100	LF	$200	$20,000
	Road Crossing Transitions	2	EA	$15,000	$30,000
2	**Riprap**				
	Channel Bends	450	CY	$150	$67,500
	Channel Discharge to Little Thompson	35	CY	$100	$3,500
	Bedding Material	500	CY	$75	$37,500
3	**Restoration**				
	Temporary Erosion Control	1	LS	$5,000	$5,000
	Sedding	10	Acres	$1,000	$10,000
3	**Utility Relocation**				
	Water and Sewer	1	LS	$15,000	$15,000
	Other Utilities	1	LS	$12,000	$12,000
			Subtotal		**$704,500.00**
			Contingencies		$140,900.00
			Engineering Design		$64,109.50
			Survey		$8,000.00
			Engineering Const		$77,495.00
			Total Construction		**$917,509.50**

	Description	Qty.	Unit	Unit Price	Item Price
	Project 2 - North Side Channel Spillway				
1	**Structure**				
	Excavation	250	CY	$30	$7,500
	Spillway structure	125	CY	$550	$68,750
	Type 3 baffeled outlet	68	CY	$550	$37,400
2	**Riprap**				
	Downstream Spillway	45	CY	$200	$9,000
	Bedding Material	55	CY	$50	$2,750
3	**Concrete Pipe (Class 2, mastic joint)**				
	Downstream Spillway - d=6 ft	50	LF	$150	$7,500
	Pipe Installation - Downstream	50	LF	$90	$4,500
4	**Metals**				
	Slide Gate	1	EA	$3,500	$3,500
	Hand Rail	120	LF	$92	$11,040
			Subtotal		**$151,940.00**
			Contingencies		$30,388.00
			Engineering		$15,194.00
			Survey		$4,500.00
			Engineering Const		$16,713.40
			Total Construction		**$202,022.00**
	Project 2 A - Discharge Channel from North Side Channel Spillway				
1	**Channel**				
	Excavation	1500	CY	$25	$37,500
2	**Riprap**				
	Channel Bends	50	CY	$150	$7,500
	Channel Discharge to Thornton Drain	35	CY	$150	$5,250
	Bedding Material	100	CY	$23	$2,300
3	**Restoration**				
	Temporary Erosion Control	1	LS	$5,000	$5,000
	Sedding	2	Acres	$1,000	$2,000
			Subtotal		**$59,550.00**
			Contingencies		$11,910.00
			Engineering		$6,610.05
			Survey		$8,000.00
			Engineering Const		$6,550.50
			Total Construction		**$86,070.05**

	Description	Qty.	Unit	Unit Price	Item Price
	Project 3 - Highway Storm Sewer				
1	**Storm Sewer Pipelines**				
	66" Class 3 Reinforced Concrete Pipe	1,000	LF	$108.00	$108,000
	60" Class 3 Reinforced Concrete Pipe	1,175	LF	$94.00	$110,450
	54" Class 3 Reinforced Concrete Pipe	1,200	LF	$79.00	$94,800
	24" Class 3 Reinforced Concrete Pipe	630	LF	$18.75	$11,813
	Manholes	14	EA	$5,000	$70,000
	Inlets and Laterals	40	Ea	$3,500	$140,000
2	**Installation**				
	Trenching/Backfiling	15,000	CY	$20.00	$300,000
	Hauling	6,000	CY	$6.20	$37,200
	Bore under Ditch	40	LF	$1,000.00	$40,000
	Bore under Railroad	130	LF	$1,000.00	$130,000
3	**Open channel**				
	Channel from Storm Sewer outlet to Big Thompson River, 2950 LF -				
	Excavation	5,245	CY	$25.00	$131,125
	Hauling - Spoil	5,245	CY	$6.20	$32,519
	Grade Control Structure	11	EA	$1,500.00	$16,500
3	**Pavement Replacement**	1	LS	$377,000	$377,000
4	**Traffic Control**	1	LS	$35,200	$35,200
			Subtotal		**$1,634,606.50**
			Contingencies		$326,921.30
			Engineering		$122,595.49
			Survey		$4,500.00
			Engineering Const		$179,806.72
			Total Construction		**$2,268,430.00**

	Description	Qty.	Unit	Unit Price	Item Price
	Project 4 - Stroh Channel Spillway				
1	**Structure**				
	Excavation	250	CY	$30	$7,500
	Spillway Crest structure (150' long)	50	CY	$550	$27,500
2	**Riprap**				
	Downstream Spillway	800	CY	$200	$160,000
	Bedding Material	400	CY	$50	$20,000
	Upstream Spillway	500	CY	$200	$100,000
	Bedding Material	250	CY	$50	$12,500
			Subtotal		**$327,500.00**
			Contingencies		$65,500.00
			Engineering		$39,300.00
			Survey		$4,500.00
			Engineering Const		$36,025.00
			Total Construction		**$436,800.00**

The following implementation plan assumes that all of the improvements described above are constructed over a 5-year span. This may not be feasible, depending on the available funding, but the plan still serves to prioritize the required improvements so that they may be constructed as funding becomes available.

Year 1

South Side-Channel Spillway and Open Channel	$1,049,132
Design of First Street Drain and Open Channel	$85,571
Total Year 1	**$1,134,703**

Year 2

North Side-Channel Spillway and Open Channel	$288,092
Phase I Construction of First Street Drain	$727,620
Total Year 2	**$1,015,712**

Year 3

Phase II Construction of First Street Drain	**$727,620**

Year 4

Phase III Construction of First Street Drain	**$727,620**

Year 5	
Construction of Bunyan Basin Spillway	**$436,800**
Total Five-Year Cost	**$4,042,455**

We have weighted spending in the five-year plan towards the beginning of the period. There are two reasons for this. First is the need to get projects underway as soon as possible, and complete them as quickly as is practical to provide protection to the community from flooding. The second reason is that we anticipate that within five years the Town's storm water utility will have engaged in a cycle of annual review of project needs. Four of five years from now the utility may very well have identified projects that they consider as necessary as the Bunyan Basin Spillway.

APPENDICES

I. BASIN DESIGNATIONS AND DIMENSIONS

Johnstown Basin Study

SUBBASIN	BASINNAME	BASIN	AREA	ACRES	OVERLAND FLOW LENGTH	BASIN WIDTH
110	Johnsons Corner	100	19,441,271.71	446.31		3400 *
111	Johnsons Corner	100	11,279,557.73	258.94		10900 *
112	Johnsons Corner	100	3,698,308.18	84.90		6200 *
113	Johnsons Corner	100	31,379,121.23	720.37		12600 *
114	Johnsons Corner	100	5,158,619.68	118.43		2200 *
115	Johnsons Corner	100	6,363,694.63	146.09		3300 *
116	Johnsons Corner	100	8,562,297.98	196.56	1400	6100
117	Johnsons Corner	100	15,852,915.22	363.93		9100 *
118	Johnsons Corner	100	10,792,747.81	247.77		17500 *
220	Twin Mounds	200	8,048,497.18	184.77	1000	8000
221	Twin Mounds	200	2,031,297.23	46.63		1600 *
222	Twin Mounds	200	39,937,753.39	916.85	2600	20200 *
223	Twin Mounds	200	2,157,377.96	49.53	800	2700
224	Twin Mounds	200	9,562,789.09	219.53	1700	5600
225	Twin Mounds	200	12,117,167.39	278.17		8650 *
226	Twin Mounds	200	6,882,660.45	158.00	1300	5300
310	Elwell	300	12,192,266.99	279.90	1300	9400
311	Elwell	300	10,894,485.09	250.10	2500	4400
312	Elwell	300	6,402,106.00	146.97	3200	2000
313	Elwell	300	16,998,445.12	390.23	3200	8100 *
314	Elwell	300	10,220,231.09	234.62	3200	3200
315	Elwell	300	7,555,536.94	173.45	3200	2400
316	Elwell	300	9,106,446.62	209.06	2700	3400
317	Elwell	300	11,403,327.51	261.78	3400	3400
318	Elwell	300	22,827,327.34	524.04	2500	1100 *
319	Elwell	300	12,024,532.52	276.05	3250	5800 *
320	Elwell	300	2,162,221.13	49.64	1000	2200
321	Elwell	300	2,543,190.35	58.38	1700	1500
322	Elwell	300	3,659,417.20	84.01	900	4100
323	Elwell	300	3,934,190.28	90.32	1100	3600
324	Elwell	300	4,854,418.08	111.44	2600	1900
410	Old Town	400	26,010,615.21	597.12		8200 *
411	Old Town	400	2,892,834.03	66.41	2350	1200
412	Old Town	400	6,979,360.81	160.22	1500	4700
420	Old Town	400	14,154,644.83	324.95		5900 *
421	Old Town	400	1,553,278.28	35.66		1200 *
422	Old Town	400	1,715,244.17	39.38		1800 *
423	Old Town	400	579,332.98	13.30		1500 *
424	Old Town	400	2,645,525.68	60.73	1200	2200
425	Old Town	400	5,643,432.32	129.56	1000	5600
426	Old Town	400	438,961.66	10.08	800	500
427	Old Town	400	679,755.24	15.61	1300	500
428	Old Town	400	786,748.34	18.06	1250	600
429	Old Town	400	506,656.11	11.63	500	1000
430	Old Town	400	729,427.40	16.75	250	2900
431	Old Town	400	328,371.55	7.54	500	700
432	Old Town	400	876,026.26	20.11	700	1300
433	Old Town	400	2,387,074.20	54.80	600	4000
440	Old Town	400	1,597,225.37	36.67		3700 *
441	Old Town	400	3,022,251.79	69.38	700	4300

Johnstown Basin Study

SUBBASIN	BASINNAME	BASIN	AREA	ACRES	OVERLAND FLOW LENGTH	BASIN WIDTH
442	Old Town	400	8,195,513.10	188.14	1300	6300
443	Old Town	400	11,810,082.09	271.12	2200	5400
444	Old Town	400	14,666,974.80	336.71	2650	5500
445	Old Town	400	969,742.47	22.26	1300	700
446	Old Town	400	638,922.21	14.67	750	900
447	Old Town	400	445,820.74	10.24		1000 *
448	Old Town	400	263,740.41	6.06	250	1100
450	Old Town	400	7,013,484.06	161.01		5300 *
451	Old Town	400	8,566,252.15	196.65		3800 *
452	Old Town	400	13,946,923.61	320.18	1900	7300
453	Old Town	400	12,825,898.58	294.44	1500	8600
510	Pulliam	500	1,575,953.27	36.18	600	2600
511	Pulliam	500	7,840,861.01	180.00		3000 *
512	Pulliam	500	13,888,678.07	318.84	1700	8200
513	Pulliam	500	9,797,887.77	224.93		5400 *
520	Pulliam	500	5,088,406.53	116.81		#
521	Pulliam	500	1,254,857.14	28.81		#
522	Pulliam	500	1,325,433.69	30.43		#
523	Pulliam	500	1,313,384.59	30.15	1600	800
524	Pulliam	500	505,877.64	11.61		#
525	Pulliam	500	18,518,303.59	425.12		7000 *
526	Pulliam	500	6,385,076.73	146.58		2600 *
527	Pulliam	500	837,068.79	19.22	800	1000
528	Pulliam	500	5,496,390.87	126.18	3750	3600 #
610	Bunyan	600	5,400,963.63	123.99	3600	5300 *
611	Bunyan	600	585,918.75	13.45	400	1500
612	Bunyan	600	1,120,790.57	25.73	300	3700
613	Bunyan	600	791,002.32	18.16	200	4000
614	Bunyan	600	631,496.95	14.50	300	2100
615	Bunyan	600	1,773,833.47	40.72	1300	1400
616	Bunyan	600	2,352,585.22	54.01	1200	2000
617	Bunyan	600	456,167.40	10.47	150	3000
618	Bunyan	600	1,952,684.00	44.83	800	2400
619	Bunyan	600	20,903,994.76	479.89	1600	13100
620	Bunyan	600	4,933,062.91	113.25	2500	4700 *
621	Bunyan	600	4,618,132.85	106.02	1700	2700
622	Bunyan	600	193,004.66	4.43	250	800
623	Bunyan	600	7,467,900.59	171.44	2600	2900
624	Bunyan	600	19,109,892.76	438.70	2200	8700
625	Bunyan	600	35,350,508.00	811.54	5000	10700 *
626	Bunyan	600	15,585,570.29	357.80	3200	4900

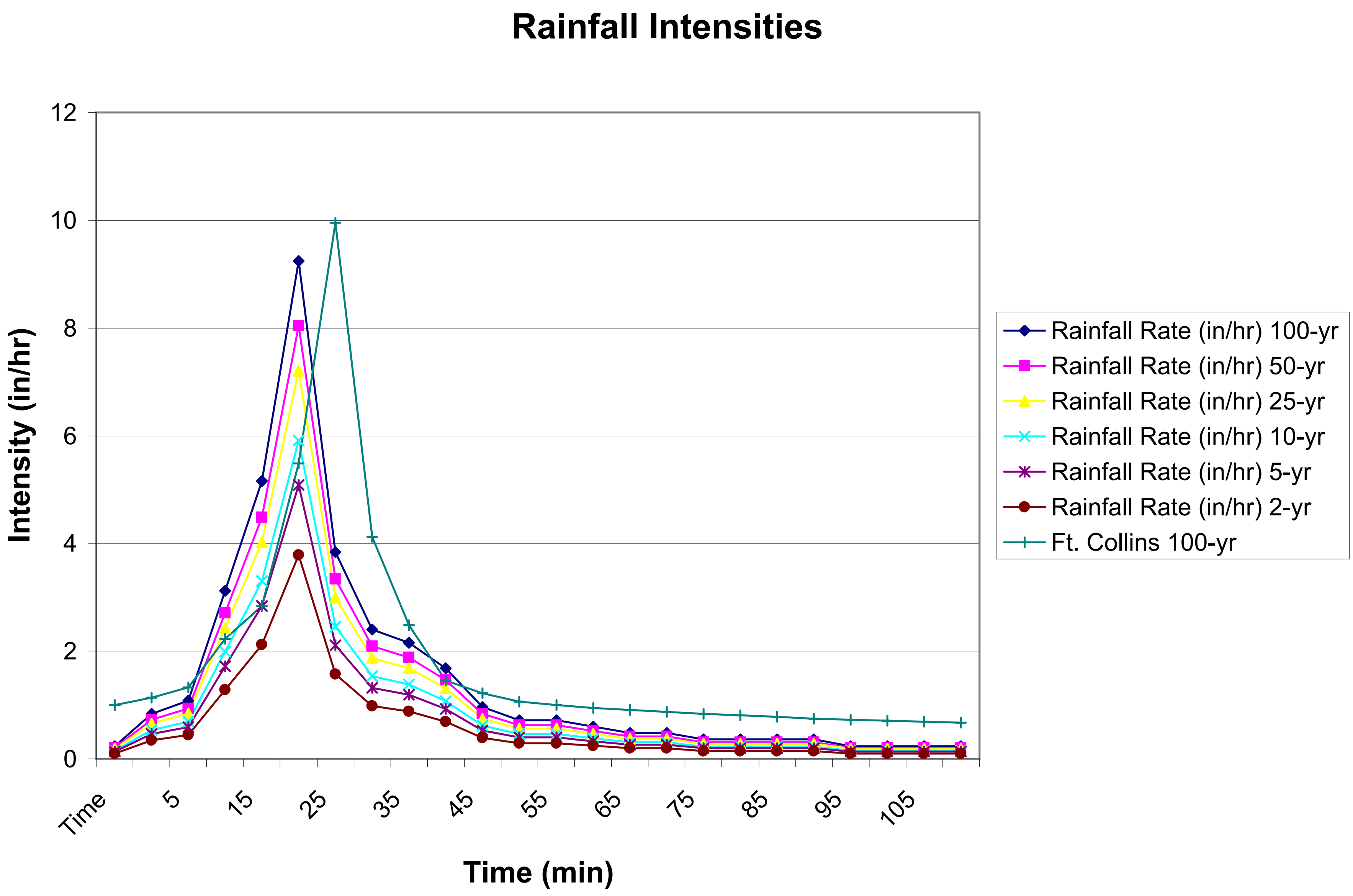
13,670,965.86 313.84

- Sum of 520, 521, 522, 524, 528

II. JOHNSTOWN RAINFALL INTENSITIES

JOHNSTOWN RAINFALL INTENSITIES

Time	**Rainfall Rate (in/hr)**					
(min)	**100-yr**	**50-yr**	**25-yr**	**10-yr**	**5-yr**	**2-yr**
5	0.24	0.21	0.19	0.15	0.13	0.10
10	0.84	0.73	0.66	0.54	0.46	0.34
15	1.08	0.94	0.84	0.69	0.59	0.44
20	3.12	2.71	2.43	2.00	1.72	1.28
25	5.16	4.49	4.02	3.30	2.84	2.12
30	9.24	8.04	7.21	5.91	5.08	3.79
35	3.84	3.34	3.00	2.46	2.11	1.57
40	2.4	2.09	1.87	1.54	1.32	0.98
45	2.16	1.88	1.68	1.38	1.19	0.89
50	1.68	1.46	1.31	1.08	0.92	0.69
55	0.96	0.84	0.75	0.61	0.53	0.39
60	0.72	0.63	0.56	0.46	0.40	0.30
65	0.72	0.63	0.56	0.46	0.40	0.30
70	0.6	0.52	0.47	0.38	0.33	0.25
75	0.48	0.42	0.37	0.31	0.26	0.20
80	0.48	0.42	0.37	0.31	0.26	0.20
85	0.36	0.31	0.28	0.23	0.20	0.15
90	0.36	0.31	0.28	0.23	0.20	0.15
95	0.36	0.31	0.28	0.23	0.20	0.15
100	0.36	0.31	0.28	0.23	0.20	0.15
105	0.24	0.21	0.19	0.15	0.13	0.10
110	0.24	0.21	0.19	0.15	0.13	0.10
115	0.24	0.21	0.19	0.15	0.13	0.10
120	0.24	0.21	0.19	0.15	0.13	0.10
Total Depth	**3.01**	**2.62**	**2.35**	**1.93**	**1.66**	**1.23**


Rainfall Intensities
Intensity (in/hr)
12
10
8
6
4
2
0
Time
5
15
25
35
45
55
65
75
85
95
105
Time (min)
Rainfall Rate (in/hr) 100-yr
Rainfall Rate (in/hr) 50-yr
Rainfall Rate (in/hr) 25-yr
Rainfall Rate (in/hr) 10-yr
Rainfall Rate (in/hr) 5-yr
Rainfall Rate (in/hr) 2-yr
Ft. Collins 100-yr

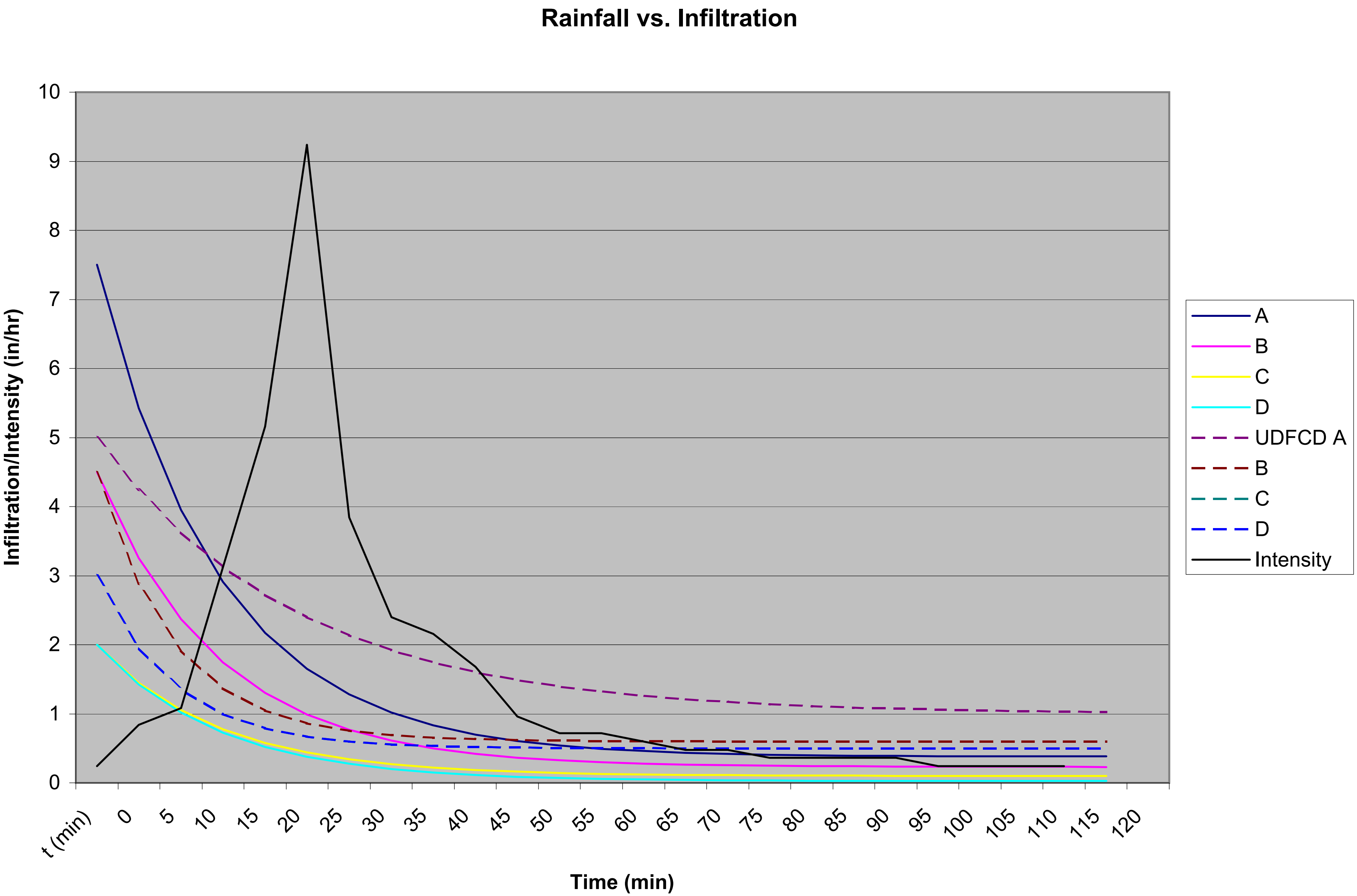
III. JOHNSTOWN INFILTRATION RATES

JOHNSTOWN INFILTRATION TABLE

$$f = f_o + (f_i - f_o)e^{-at}$$

	Johnstown			
	A	B	C	D
f_i =	7.5	4.5	2	2
f_o =	0.38	0.23	0.1	0.025
a =	0.00115	0.00115	0.00115	0.00115

	Johnstown				UDFCD					
t (min)	A	B	C	D	A	B	C	D	Intensity	FC
0	7.5	4.5	2	2	5	4.5	3	3	0.24	1
5	5.422529	3.254101	1.445619	1.423735	4.242337	2.872718	1.956871	1.956871	0.84	1.14
10	3.951222	2.37173	1.052995	1.015613	3.628187	1.924423	1.348989	1.348989	1.08	1.33
15	2.909212	1.746817	0.77493	0.726572	3.130367	1.371805	0.994747	0.994747	3.12	2.23
20	2.171239	1.30424	0.577999	0.521868	2.726842	1.049768	0.788313	0.788313	5.16	2.84
25	1.648592	0.990799	0.438529	0.376892	2.399751	0.862101	0.668014	0.668014	9.24	5.49
30	1.278443	0.768813	0.339753	0.274217	2.134616	0.752739	0.59791	0.59791	3.84	9.95
35	1.016295	0.611599	0.269798	0.2015	1.919702	0.689008	0.557057	0.557057	2.4	4.12
40	0.830637	0.500256	0.220254	0.150001	1.745496	0.65187	0.53325	0.53325	2.16	2.48
45	0.699151	0.421401	0.185167	0.113528	1.604287	0.630227	0.519376	0.519376	1.68	1.46
50	0.606029	0.365554	0.160317	0.087698	1.489826	0.617615	0.511291	0.511291	0.96	1.22
55	0.540078	0.326002	0.142718	0.069404	1.397045	0.610265	0.50658	0.50658	0.72	1.06
60	0.493371	0.297991	0.130253	0.056448	1.321838	0.605982	0.503835	0.503835	0.72	1
65	0.460291	0.278152	0.121426	0.047272	1.260877	0.603486	0.502235	0.502235	0.6	0.95
70	0.436864	0.264102	0.115174	0.040773	1.211463	0.602031	0.501302	0.501302	0.48	0.91
75	0.420272	0.254152	0.110747	0.036171	1.171409	0.601184	0.500759	0.500759	0.48	0.87
80	0.408522	0.247105	0.107611	0.032912	1.138941	0.60069	0.500442	0.500442	0.36	0.84
85	0.4002	0.242114	0.10539	0.030603	1.112623	0.600402	0.500258	0.500258	0.36	0.81
90	0.394306	0.238579	0.103818	0.028968	1.091291	0.600234	0.50015	0.50015	0.36	0.78
95	0.390132	0.236076	0.102704	0.02781	1.073999	0.600137	0.500088	0.500088	0.36	0.75
100	0.387175	0.234303	0.101915	0.02699	1.059982	0.60008	0.500051	0.500051	0.24	0.73
105	0.385082	0.233048	0.101356	0.02641	1.048621	0.600046	0.50003	0.50003	0.24	0.71
110	0.383599	0.232158	0.10096	0.025998	1.039411	0.600027	0.500017	0.500017	0.24	0.69
115	0.382549	0.231529	0.10068	0.025707	1.031946	0.600016	0.50001	0.50001	0.24	0.67
120	0.381805	0.231083	0.100482	0.025501	1.025895	0.600009	0.500006	0.500006		
									3.01	3.67


Rainfall vs. Infiltration
Infiltration/Intensity (in/hr)
10
9
8
7
6
5
4
3
2
1
0
t (min)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
115
120
Time (min)
A
B
C
D
UDFCD A
B
C
D
Intensity

2/20/2004

IV. MODEL CALIBRATION

CALIBRATION
OLD TOWN

	Area		Basin Runoff		cfs/acre			
Basin	M&I	TEC	M&I	TEC	M&I	TEC	% error	Notes
A	5		37		7.4			
B	3	15	24	62	8	4.1	-46%	TEC combines basins A & B
C	10	10	55	52	5.5	5.2	-5%	
D	64	61	183	267	2.9	4.4	53%	
E	17	20	60	91	3.5	4.6	29%	
F	6	8	26	36	4.3	4.5	4%	
G	17	17	63	86	3.7	5.1	37%	
H	12	12	43	53	3.6	4.4	23%	
I	42	34	147	141	3.5	4.1	18%	TEC splits into 2 basins
J	36	39	147	171	4.1	4.4	7%	
Total	**212**	**216**	**785**	**959**	**3.7**	**4.4**	**20%**	

CALIBRATION
TWIN MOUNDS

Rational Calcs for Twin Mounds Basin

C_5 values for soil classes

A	0.01
B	0.05
C	0.1
D	0.15

															XP-SWMM TwinMounds								
Basin	**C_5**	**Lo**	**So**	**Ti**	**Lc**	**Sc**	**Vc**	**Tt**	**Tc**	**I**	**C_{100}**	**A**	**Q_{100}**	**cfs/ac**	**Q_{100}**	**cfs/ac**	**Var.**	**Var_{UDFDC}**	**Q_{100}**	**cfs/ac**	**Var_R**	**Var_X**	**Var_{UDFDC}**
220	0.01	500	1.9	35	5710	1.1	1.6	59	**95**	1.9	0.2	185	70	0.38	51	0.28	73%	55%	51	0.28	73%	100%	55%
221	0.05	500	6	23	1160	1.2	1.7	11	**35**	3.8	0.3	47	54	1.14	39	0.83	73%	98%	39	0.83	73%	100%	98%
222	0.1	500	2.3	30	12000	1.4	1.9	105	**136**	1.3	0.4	917	477	0.52	688	0.75	144%	75%	678	0.74	142%	99%	74%
223	0.1	330	0.3	49	1900	1.6	2	16	**65**	2.5	0.4	50	50	1	48	0.96	96%	96%	48	0.96	96%	100%	96%
224	0.05	500	2.25	32	4400	2.3	1	73	**106**	1.7	0.3	220	112	0.51	106	0.48	94%	57%	106	0.48	94%	100%	57%
225	0.05	500	0.3	63	4950	1.3	1.8	46	**109**	1.7	0.3	278	142	0.51	125	0.45	88%	53%	125	0.45	88%	100%	53%
226	0.05	500	2.5	31	2900	2.6	1	48	**79**	2.1	0.3	158	100	0.63	85	0.54	85%	63%	85	0.54	85%	100%	63%
												1855	**1004**	**0.54**	**1142**	**0.62**	**114%**		**1132**	**0.61**	**113%**		

Twin Mounds vs. UDFCD Release Rates

Soil Type	XP	UD
A	0.276	0.5
B	0.44	0.85
C	0.761	1
D		

CALIBRATION
JOHNSONS CORNER

Basin	Soil	Area	Q_{100}	cfs/ac	cfs/ac - UD	Var_{UDFDC}		
a	B	446	230	0.52	0.85	61%	262	114%
b	B	259	226	0.87	0.85	103%	261	115%
c	B	85	56	0.66	0.85	78%	65	116%
d	B	720	328	0.46	0.85	54%	369	113%
e	B	118	61	0.52	0.85	61%	70	115%
f	B	146	78	0.53	0.85	63%	89	114%
g	C	197	117	0.59	1	59%	127	109%
h	B	364	141	0.39	0.85	46%	157	111%
l	B	248	83	0.33	0.85	39%	91	110%
			1320				1491	113%
			avg (B) =	0.50	cfs/ac			

V. HYDROLOGICAL RESULTS – UNDEVELOPED AND DEVELOPED 5-YEAR AND 100-YEAR RUNOFF

XP-UDD Hydrology Data&Result - 100-Year Undeveloped

Node Name US Node	Sub area data Infiltration method	Contributing area ac	Impervious % %	Slope %	Width ft	Nodal Results Total rainfall in	Peak infiltration in	Total surface runoff depth in	Peak Runoff cfs	cfs/ac
61a	HortonB	123.99	7.5	2.3%	8400	3.01	1.951	1.197	167.883	1.35
61b	HortonB	18.16	7.5	3.2%	300	3.01	2.153	0.945	16.006	0.88
61c	HortonB	14.5	7.5	5.5%	1000	3.01	1.887	1.257	24.602	1.70
61d-1	HortonD	54.01	7.5	2.7%	2000	3.01	0.619	1.816	131.682	1.39
61d-2	HortonD	40.72	7.5	3.4%	500	-	-	-	-	
61e	HortonD	10.47	7.5	1.8%	2000	3.01	0.618	2.174	40.721	3.89
61f	HortonD	480	7.5	1.8%	2200	3.01	0.618	1.176	309.63	0.65
61g	HortonD	44.83	7.5	2.8%	700	3.01	0.619	1.866	49.676	1.11
61h	HortonD	113.25	7.5	1.8%	3900	3.01	0.619	2.016	162.004	1.43
61i	HortonD	106.02	7.5	1.6%	1900	3.01	0.619	1.816	111.05	1.05
61j	HortonD	171.44	7.5	2.3%	2100	3.01	0.619	1.738	166.572	0.97
61k	HortonD	4.43	7.5	6.0%	600	3.01	0.618	2.184	19.991	4.51
61l-1	HortonB	811.54	7.5	1.0%	14500	3.01	2.153	0.675	934.43	0.75
61l-2	HortonB	438.7	7.5	1.8%	3350	-	-	-	-	
61m	HortonB	357.8	7.5	2.1%	2300	3.01	2.153	0.651	238.17	0.67
61n	HortonB	25.73	7.5	2.8%	1800	3.01	1.931	1.216	37.036	1.44
61o	HortonB	13.45	7.5	8.0%	2200	3.01	1.8	1.337	42.081	3.13
	Area Type B	1803.9		Total cfs/acre Type B		0.81		Total Peak cfs Type B	1460.2	
	Area Type D	1025.2		Total cfs/acre Type D		0.97		Total Peak cfs Type D	991.3	
	Total Area	2829.0		Total cfs/acre		0.87		Total Peak cfs	2451.5	

XP-UDD Hydrology Data&Result - 5-Year Undeveloped

Node Name		Sub area data				Nodal Results				
US Node	Infiltration method	Contributing area ac	Impervious % %	Slope %	Width ft	Total rainfall in	Peak infiltration in	Total surface runoff depth in	Peak Runoff cfs	cfs/ac
61a	HortonB	123.99	7.5	2.3%	8400	1.656	1.655	0.116	47.52	0.38
61b	HortonB	18.16	7.5	3.2%	300	1.656	1.655	0.116	6.66	0.37
61c	HortonB	14.5	7.5	5.5%	1000	1.656	1.655	0.116	5.57	0.38
61d-1	HortonD	54.01	7.5	2.7%	2000	1.656	0.618	0.59	42.58	0.45
61d-2	HortonD	40.72	7.5	3.4%	500		0.618			
61e	HortonD	10.47	7.5	1.8%	2000	1.656	0.618	0.826	9.22	0.88
61f	HortonD	480	7.5	1.8%	2200	1.656	0.618	0.341	125.10	0.26
61g	HortonD	44.83	7.5	2.8%	700	1.656	0.618	0.616	18.37	0.41
61h	HortonD	113.25	7.5	1.8%	3900	1.656	0.618	0.704	52.04	0.46
61i	HortonD	106.02	7.5	1.6%	1900	1.656	0.618	0.59	42.17	0.40
61j	HortonD	171.44	7.5	2.3%	2100	1.656	0.618	0.552	65.25	0.38
61k	HortonD	4.43	7.5	6.0%	600	1.656	0.618	0.835	4.48	1.01
61l-1	HortonB	811.54	7.5	1.0%	14500	1.656	1.655	0.115	412.96	0.33
61l-2	HortonB	438.7	7.5	1.8%	3350					
61m	HortonB	357.8	7.5	2.1%	2300	1.656	1.655	0.115	105.22	0.29
61n	HortonB	25.73	7.5	2.8%	1800	1.656	1.655	0.116	9.87	0.38
61o	HortonB	13.45	7.5	8.0%	2200	1.656	1.655	0.116	5.17	0.38

Area Type B	1803.9	Total cfs/acre Type B	0.33	Total Peak cfs Type B	593.0
Area Type D	1025.2	Total cfs/acre Type D	0.35	Total Peak cfs Type D	359.2
Total Area	2829.0	Total cfs/acre	0.34	Total Peak cfs	952.2

Bunyan

XP-UDD Hydrology Data&Result - 100-Year Developed

Node Name		Sub area data					Nodal Results		
US Node	Infiltration method	Contributing area ac	Impervious % %	Slope %	Width ft	Total rainfall in	Total surface runoff depth in	Peak Runoff cfs	cfs/ac
61a	HortonB	123.99	7.5	0.023	8400	3.01	1.20	167.9	1.35
61b	HortonB	18.16	40	0.032	300	3.01	1.69	54.3	2.99
61c	HortonB	14.5	40	0.055	1000	3.01	1.86	66.8	4.61
61d-1	HortonD	54.01	40	0.027	2000	3.01	2.28	347.3	6.43
61d-2	HortonD	40.72	40	0.034	500				
61e	HortonD	10.47	40	0.018	2000	3.01	2.44	67.7	6.47
61f	HortonD	480	7.5	0.018	2200	3.01	1.18	309.6	0.65
61g	HortonD	44.83	40	0.028	700	3.01	2.30	138.6	3.09
61h	HortonD	113.25	40	0.018	3900	3.01	2.37	439.3	3.88
61i	HortonD	106.02	7.5	0.016	1900	3.01	1.82	111.1	1.05
61j	HortonD	171.44	7.5	0.023	2100	3.01	1.74	166.6	0.97
61k	HortonD	4.43	40	0.06	600	3.01	2.44	30.7	6.92
61l-1	HortonB	811.54	7.5	0.01	14500	3.01	0.68	934.4	1.15
61l-2	HortonB	438.7	7.5	0.018	3350	3.01			
61m	HortonB	357.8	7.5	0.021	2300	3.01	0.65	238.2	0.67
61n	HortonB	25.73	40	0.028	1800	3.01	1.84	110.8	4.31
61o	HortonB	13.45	40	0.08	2200	3.01	1.90	79.0	5.87
	Gross Area =	2829.0		Gross cfs/ac =		1.15	Gross Peak Runoff =	3262.2	
	Undev. Area =	2489.5		Undev. cfs/ac =		0.77	Undev. Runoff =	1927.7	
	Dev. Area =	339.6		Dev. cfs/ac =		3.93	Dev. Runoff =	1334.4	

XP-UDD Hydrology Data&Result - 5-Year Developed

Node Name US Node	Sub area data Infiltration method	Contributing area ac	Impervious % %	Slope %	Width ft	Nodal Results Total rainfall in	Total surface runoff depth in	Peak Runoff cfs	cfs/ac
61a	HortonB	123.99	7.5	0.023	8400	1.6555	0.1162	47.5	0.38
61b	HortonB	18.16	40	0.032	300	1.6555	0.6130	23.0	1.27
61c	HortonB	14.5	40	0.055	1000	1.6555	0.6178	28.4	1.96
61d-1	HortonD	54.01	40	0.027	2000	1.6555	0.9671	142.3	2.63
61d-2	HortonD	40.72	40	0.034	500	1.6555	0.9671		
61e	HortonD	10.47	40	0.018	2000	1.6555	1.0877	25.5	2.43
61f	HortonD	480	7.5	0.018	2200	1.6555	0.3415	125.1	0.26
61g	HortonD	44.83	40	0.028	700	1.6555	0.9819	55.4	1.24
61h	HortonD	113.25	40	0.018	3900	1.6555	1.0277	182.5	1.61
61i	HortonD	106.02	7.5	0.016	1900	1.6555	0.5899	42.2	0.40
61j	HortonD	171.44	7.5	0.023	2100	1.6555	0.5518	65.3	0.38
61k	HortonD	4.43	40	0.06	600	1.6555	1.0922	11.3	2.55
61l-1	HortonB	811.54	7.5	0.01	14500	1.6555	0.1154	413.0	0.51
61l-2	HortonB	438.7	7.5	0.018	3350	1.655	0.1154		
61m	HortonB	357.8	7.5	0.021	2300	1.6555	0.1153	105.2	0.29
61n	HortonB	25.73	40	0.028	1800	1.6555	0.6172	48.8	1.90
61o	HortonB	13.45	40	0.08	2200	1.6555	0.6193	27.4	2.04

Gross Area =	2829.0	Gross cfs/ac =	0.47	Gross Peak Runoff =	1342.9
Undev. Area =	2489.5	Undev. cfs/ac =	0.32	Undev. Runoff =	798.2
Dev. Area =	339.6	Dev. cfs/ac =	1.60	Dev. Runoff =	544.7

XP-UDD Hydrology Data&Result - 100-Year Undeveloped

Node Name		Sub area data				Nodal Results				
US Node	Infiltration method	Contributing area ac	Impervious % %	Slope %	Width ft	Total rainfall in	Peak infiltration in	Total surface runoff depth in	Peak Runoff cfs	cfs/ac
31a	HortonB	279.9	7.5	1.1%	2000	3.01	2.153	0.598	174.59	0.62
31b	HortonB	250.1	7.5	0.6%	3000	3.01	2.153	0.651	166.4	0.67
31c	HortonB	146.97	7.5	1.4%	3000	3.01	2.153	0.895	123.3	0.84
31d-1	HortonB	390.23	7.5	0.9%	3000	3.01	2.153	0.841	308.4	0.65
31d-2	HortonB	84.01	7.5	1.2%	1500	-	-	-		
31e	HortonB	234.62	7.5	1.3%	4200	3.01	2.153	0.852	189.2	0.81
31f	HortonB	173.45	7.5	1.3%	4000	3.01	2.153	0.916	148.5	0.86
31g	HortonB	209.06	7.5	1.7%	3600	3.01	2.153	0.876	172.4	0.82
31h	HortonB	261.78	7.5	2.8%	3400	3.01	2.153	0.868	214.2	0.82
31i	HortonB	524.04	7.5	1.0%	3000	3.01	2.153	0.537	297.7	
31j	HortonB	276.05	7.5	1.6%	2500	3.01	2.153	0.703	194.2	0.70
31k	HortonB	49.64	7.5	0.5%	2000	3.01	2.153	0.936	43.4	0.87
31l	HortonB	58.38	7.5	2.2%	2000	3.01	2.09	1.069	60.1	1.03
31m	HortonB	111.44	7.5	1.6%	2500	3.01	2.153	0.935	97.2	0.87
31n	HortonB	90.32	7.5	3.3%	2000	3.01	2.145	1.018	86.5	0.96
	Total Area/Area Type B	3139.99		Total cfs/acre		0.72		Total Peak cfs Type B	2276.0	

XP-UDD Hydrology Data&Result - 5-Year Undeveloped

Node Name		Sub area data				Nodal Results				
US Node	Infiltration method	Contributing area ac	Impervious % %	Slope %	Width ft	Total rainfall in	Peak infiltration in	Total surface runoff depth in	Peak Runoff cfs	cfs/ac
31a	HortonB	279.9	7.5	1.1%	2000	1.656	1.655	0.115	76.02	0.27
31b	HortonB	250.1	7.5	0.6%	3000	1.656	1.655	0.115	73.5	0.29
31c	HortonB	146.97	7.5	1.4%	3000	1.656	1.655	0.116	52.9	0.36
31d-1	HortonB	390.23	7.5	0.9%	3000	1.656	1.655	0.116	134.2	0.28
31d-2	HortonB	84.01	7.5	1.2%	1500	-	-	-		
31e	HortonB	234.62	7.5	1.3%	4200	1.656	1.655	0.116	82.6	0.35
31f	HortonB	173.45	7.5	1.3%	4000	1.656	1.655	0.116	63.0	0.36
31g	HortonB	209.06	7.5	1.7%	3600	1.656	1.655	0.116	74.6	0.36
31h	HortonB	261.78	7.5	2.8%	3400	1.656	1.655	0.116	93.0	0.36
31i	HortonB	524.04	7.5	1.0%	3000	1.656	1.655	0.115	126.4	
31j	HortonB	276.05	7.5	1.6%	2500	1.656	1.655	0.115	86.4	0.31
31k	HortonB	49.64	7.5	0.5%	2000	1.656	1.655	0.116	18.2	0.37
31l	HortonB	58.38	7.5	2.2%	2000	1.656	1.655	0.116	22.1	0.38
31m	HortonB	111.44	7.5	1.6%	2500	1.656	1.655	0.116	40.7	0.37
31n	HortonB	90.32	7.5	3.3%	2000	1.656	1.655	0.116	33.8	0.37
		3139.99		Total cfs/acre		0.31		Total Peak cfs Type B	977.4	

XP-UDD Hydrology Data&Result - 100-Year Developed

Node Name		Sub area data				Nodal Results				
US Node	Infiltration method	Contributing area ac	Impervious % %	Slope %	Width ft	Total rainfall in	Peak infiltration in	Total surface runoff depth in	Peak Runoff cfs	cfs/ac
31a	HortonB	279.9	7.5	1.1%	2000	3.01	2.153	0.598	174.6	0.62
31b	HortonB	250.1	7.5	0.6%	3000	3.01	2.153	0.651	166.4	0.67
31c	HortonB	146.97	7.5	1.4%	3000	3.01	2.153	0.895	123.3	0.84
31d-1	HortonB	390.23	7.5	0.9%	3000	3.01	2.153	0.841	308.4	0.79
31d-2	HortonB	84.01	7.5	1.2%	1500	-	-			
31e	HortonB	234.62	7.5	1.3%	4200	3.01	2.153	0.852	189.2	0.81
31f	HortonB	173.45	7.5	1.3%	4000	3.01	2.153	0.916	148.5	0.86
31g	HortonB	209.06	15	1.7%	3600	3.01	2.153	1.059	292.3	1.40
31h	HortonB	261.78	7.5	2.8%	3400	3.01	2.153	0.868	214.2	0.82
31i	HortonB	524.04	7.5	1.0%	3000	3.01	2.153	0.537	297.7	0.57
31j	HortonB	276.05	7.5	1.6%	2500	3.01	2.153	0.703	194.2	0.70
31k	HortonB	49.64	40	0.5%	2000	3.01	2.153	1.686	146.2	2.95
31l	HortonB	58.38	40	2.2%	2000	3.01	2.09	1.763	207.8	3.56
31m	HortonB	111.44	40	1.6%	2500	3.01	2.153	1.686	327.8	2.94
31n	HortonB	90.32	7.5	3.3%	2000	3.01	2.145	1.018	86.5	0.96
	Total Area/Area Type B	3139.99		Total cfs/acre		0.92		Total Peak cfs Type B	2877.1	

XP-UDD Hydrology Data&Result - 5-Year Developed

Node Name		Sub area data				Nodal Results				
US Node	Infiltration method	Contributing area ac	Impervious % %	Slope %	Width ft	Total rainfall in	Peak infiltration in	Total surface runoff depth in	Peak Runoff cfs	cfs/ac
31a	HortonB	279.9		1.1%	2000	1.656	1.655	1.6555	76.0	0.27
31b	HortonB	250.1		0.6%	3000	1.656	1.655	1.6555	73.5	0.29
31c	HortonB	146.97		1.4%	3000	1.656	1.655	1.6555	52.9	0.36
31d-1	HortonB	390.23		0.9%	3000	1.656	1.655	1.6555	134.2	0.34
31d-2	HortonB	84.01		1.2%	1500	-	-			0.00
31e	HortonB	234.62		1.3%	4200	1.656	1.655	1.6555	82.6	0.35
31f	HortonB	173.45		1.3%	4000	1.656	1.655	1.6555	63.0	0.36
31g	HortonB	209.06		1.7%	3600	1.656	1.655	1.6555	130.2	0.62
31h	HortonB	261.78		2.8%	3400	1.656	1.655	1.6555	93.0	0.36
31i	HortonB	524.04		1.0%	3000	1.656	1.655	1.6555	126.4	0.24
31j	HortonB	276.05		1.6%	2500	1.656	1.655	1.6555	86.4	0.31
31k	HortonB	49.64		0.5%	2000	1.656	1.655	1.6555	61.7	1.24
31l	HortonB	58.38		2.2%	2000	1.656	1.655	1.6555	92.2	1.58
31m	HortonB	111.44		1.6%	2500	1.656	1.655	1.6555	138.3	1.24
31n	HortonB	90.32		3.3%	2000	1.656	1.655	1.6555	33.8	0.37

XP-UDD Hydrology Data&Result - 100-Year Undeveloped

Node Name	Sub area data					Nodal Results				
US Node	Infiltration method	Contributing area	Impervious %	Slope %	Width	Total rainfall	Peak infiltration	tal surface runoff dep	Peak Runoff	
		ac	%		ft	in	in	in	cfs	cfs/ac
11a	HortonB	446.3	7.5	1.0%	8000	3.01	2.153	0.8187	349.3	0.78
11b	HortonB	258.9	7.5	2.4%	7700	3.01	2.112	1.048	258.3	1.00
11c	HortonB	84.9	7.5	1.6%	1900	3.01	2.153	0.935	74.0	0.87
11d	HortonB	720.4	7.5	1.2%	9200	3.01	2.153	0.755	532.2	0.74
11e	HortonB	118.4	7.5	1.4%	1800	3.01	2.153	0.82	92.8	0.78
11f	HortonB	146.1	7.5	1.5%	2300	3.01	2.153	0.838	116.3	0.80
11g	HortonC	196.6	7.5	1.5%	1600	3.01	0.965	1.286	152.2	0.77
11h	HortonB	363.9	7.5	0.8%	4000	3.01	2.153	0.665	245.9	0.68
11i	HortonB	247.8	7.5	0.3%	3200	3.01	2.153	0.585	151.7	0.61
	Area Type B	1940.4	Total cfs/acre Type B			0.76	Total Peak cfs Type B		1471.1	
	Area Type C	196.6	Total cfs/acre Type C			0.77	Total Peak cfs Type C		152.2	
	Total Area	2137.0	Total cfs/acre			0.76	Total Peak cfs		1623.3	

XP-UDD Hydrology Data&Result - 5-Year Undeveloped

Node Name	Sub area data					Nodal Results				
US Node	Infiltration method	Contributing area	Impervious %	Slope %	Width	Total rainfall	Peak infiltration	tal surface runoff dep	Peak Runoff	
		ac	%		ft	in	in	in	cfs	cfs/ac
11a	HortonB	446.3	7.5	1.0%	8000	1.656	1.655	0.116	154.1	0.35
11b	HortonB	258.9	7.5	2.4%	7700	1.656	1.655	0.116	97.6	0.38
11c	HortonB	84.9	7.5	1.6%	1900	1.656	1.655	0.116	31.0	0.37
11d	HortonB	720.4	7.5	1.2%	9200	1.656	1.655	0.116	237.0	0.33
11e	HortonB	118.4	7.5	1.4%	1800	1.656	1.655	0.116	40.9	0.35
11f	HortonB	146.1	7.5	1.5%	2300	1.656	1.655	0.116	51.0	0.35
11g	HortonC	196.6	7.5	1.5%	1600	1.656	0.96	0.327	62.4	0.32
11h	HortonB	363.9	7.5	0.8%	4000	1.656	1.655	0.115	108.9	0.30
11i	HortonB	247.8	7.5	0.3%	3200	1.656	1.655	0.115	65.7	0.27
	Area Type B	1940.4	Total cfs/acre Type B			0.33	Total Peak cfs Type B		632.2	
	Area Type C	196.6	Total cfs/acre Type C			0.32	Total Peak cfs Type C		62.4	
	Total Area	2137.0	Total cfs/acre			0.33	Total Peak cfs		694.6	

XP-UDD Hydrology Data&Result - 100-Year Undeveloped

Node Name	Sub area data					Nodal Results				
US Node	Infiltration method	Contributing area ac	Impervious % %	Slope %	Width ft	Total rainfall in	Peak infiltration in	Total surface runoff depth in	Peak Runoff cfs	Peak Runoff cfs/ac
41a	HortonB	597.1	7.5	1.1%	8200	3.01	2.153	0.694	428.0	0.72
41b	HortonB	66.4	7.5	3.0%	1200	3.01	2.153	0.878	55.5	0.84
41c	HortonB	160.2	7.5	2.7%	4700	3.01	2.153	0.972	148.0	0.92
42a	HortonB	129.6	7.5	1.3%	5600	3.01	2.153	0.977	120.4	0.93
42b	HortonB	325.0	7.5	1.3%	5900	3.01	2.153	0.781	250.3	0.77
42c	HortonB	35.7	7.5	4.2%	1200	3.01	2.12	1.041	36.5	1.02
42d-J	HortonB.1	39.4	40	4.2%	1800	3.01	1.901	1.824	161.9	4.11
42g-I2	HortonB.1	15.6	40	1.7%	1400	3.01	1.874	1.841	67.2	4.31
42h-I1	HortonB.1	18.1	40	0.5%	1400	3.01	1.985	1.772	65.6	3.63
42i-G	HortonB.1	16.8	40	1.9%	1700	3.01	1.855	1.853	74.8	4.47
42j-D2	HortonB.1	54.8	40	2.3%	4000	3.01	1.88	1.837	233.2	4.26
42k-H	HortonB.1	11.6	40	2.1%	1000	3.01	1.867	1.845	50.7	4.36
42l-F	HortonB.1	7.5	40	2.4%	700	3.01	1.852	1.854	33.9	4.49
42m-E	HortonB.1	20.1	40	3.3%	1300	3.01	1.873	1.841	86.6	4.31
42n-I3p-1	HortonB	60.7	7.5	1.6%	2200	3.01	2.059	1.728	61.0	0.86
42n-I3p-2	HortonB	10.1	40	1.6%	500	3.01	2.059	1.728	31.2	1.33
42o	HortonB	13.3	7.5	6.0%	1500	3.01	1.933	1.214	25.4	1.91
44a	HortonB	336.7	7.5	0.9%	5500	3.01	2.153	0.712	245.0	0.73
44b	HortonC	188.1	7.5	1.3%	6300	3.01	0.966	1.684	224.9	1.20
44c	HortonB	271.1	7.5	2.3%	5400	3.01	2.153	0.87	225.1	0.83
44d	HortonB	22.3	7.5	2.0%	700	3.01	2.153	0.955	20.2	0.91
44e	HortonB	36.7	7.5	1.9%	3700	3.01	2.005	1.148	49.0	1.34
44f	HortonB	69.4	7.5	1.2%	4300	3.01	2.123	1.038	70.6	1.02
44g-AB	HortonB.1	14.7	40	1.6%	900	3.01	1.928	1.808	57.9	3.95
44h-D1	HortonB.1	6.1	40	5.0%	100	3.01	2.065	1.723	19.6	3.23
44i-C	HortonB.1	10.2	40	4.0%	1100	3.01	1.819	1.875	50.1	4.90
45a	HortonA	161.0	7.5	0.8%	5300	3.01	2.931	0.29	111.8	0.69
45b	HortonB	196.7	7.5	0.8%	3800	3.01	2.153	0.738	146.2	0.74
45c	HortonB	320.2	7.5	0.8%	7300	3.01	2.153	0.778	245.9	0.77
45d	HortonB	294.4	7.5	0.8%	8600	3.01	2.153	0.836	237.4	0.81

Gross Area =	3509.4	Gross cfs/ac =	1.04	Gross Peak Runoff =	3633.7
Dev. Area =	224.9	Dev. cfs/ac =	4.15	Dev. Runoff =	932.7
Undev. Area Type A =	161.0	Undev. cfs/ac Type A =	0.69	Undev. Runoff Type A =	111.8
Undev. Area Type B =	2935.4	Undev. cfs/ac Type B =	0.81	Undev. Runoff Type B =	2364.4
Undev. Area Type C =	188.1	Undev. cfs/ac Type C =	1.20	Undev. Runoff Type C =	224.9
Total Undev. Area =	3284.5	Total Undev. cfs/ac =	0.82	Total Undev. Runoff =	2701.0

XP-UDD Hydrology Data&Result - 5-Year Undeveloped

Node Name	Sub area data					Nodal Results				
US Node	Infiltration method	Contributing area	Impervious %	Slope %	Width	Total rainfall	Peak infiltration	Total surface runoff depth	Peak Runoff	
		ac	%		ft	in	in	in	cfs	cfs/ac
41a	HortonB	597.1	7.5	1.1%	8200	1.656	1.656	0.116	197.7	0.33
41b	HortonB	66.4	7.5	3.0%	1200	1.656	1.656	0.116	24.5	0.37
41c	HortonB	160.2	7.5	2.7%	4700	1.656	1.656	0.116	60.5	0.38
42a	HortonB	129.6	7.5	1.3%	5600	1.656	1.656	0.116	49.0	0.38
42b	HortonB	325.0	7.5	1.3%	5900	1.656	1.656	0.116	114.7	0.35
42c	HortonB	35.7	7.5	4.2%	1200	1.656	1.656	0.116	13.6	0.38
42d-J	HortonB.1	39.4	40	4.2%	1800	1.656	1.655	0.617	72.2	1.83
42g-I2	HortonB.1	15.6	40	1.7%	1400	1.656	1.655	0.617	29.6	1.90
42h-I1	HortonB.1	18.1	40	0.5%	1400	1.656	1.655	0.615	29.2	1.62
42i-G	HortonB.1	16.8	40	1.9%	1700	1.656	1.655	0.618	32.4	1.94
42j-D2	HortonB.1	54.8	40	2.3%	4000	1.656	1.655	0.617	103.2	1.88
42k-H	HortonB.1	11.6	40	2.1%	1000	1.656	1.655	0.617	22.2	1.91
42l-F	HortonB.1	7.5	40	2.4%	700	1.656	1.655	0.618	14.6	1.94
42m-E	HortonB.1	20.1	40	3.3%	1300	1.656	1.655	0.617	38.2	1.90
42n-I3p-1	HortonB	60.7	7.5	1.6%	2200	1.656	1.656	0.616	22.9	0.32
42n-I3p-2	HortonB	10.1	40	1.6%	500	1.656 -	-		17.0	0.72
42o	HortonB	13.3	7.5	6.0%	1500	1.656	1.656	0.116	5.1	0.38
44a	HortonB	336.7	7.5	0.9%	5500	1.656	1.656	0.116	113.2	0.34
44b	HortonC	188.1	7.5	1.3%	6300	1.656	0.96	0.437	75.2	0.40
44c	HortonB	271.1	7.5	2.3%	5400	1.656	1.656	0.116	99.7	0.37
44d	HortonB	22.3	7.5	2.0%	700	1.656	1.656	0.116	8.4	0.38
44e	HortonB	36.7	7.5	1.9%	3700	1.656	1.656	0.116	14.1	0.38
44f	HortonB	69.4	7.5	1.2%	4300	1.656	1.656	0.116	26.5	0.38
44g-AB	HortonB.1	14.7	40	1.6%	900	1.656	1.655	0.616	26.0	1.77
44h-D1	HortonB.1	6.1	40	5.0%	100	1.656	1.655	0.614	8.5	1.40
44i-C	HortonB.1	10.2	40	4.0%	1100	1.656	1.655	0.618	20.5	2.00
45a	HortonA	161.0	7.5	0.8%	5300	1.656	1.656	0.116	59.1	0.37
45b	HortonB	196.7	7.5	0.8%	3800	1.656	1.656	0.116	67.5	0.34
45c	HortonB	320.2	7.5	0.8%	7300	1.656	1.656	0.116	112.7	0.35
45d	HortonB	294.4	7.5	0.8%	8600	1.656	1.656	0.116	106.8	0.36

Gross Area =	3509.4	Gross cfs/ac =	0.45	Gross Peak Runoff =	1584.5
Dev. Area =	224.9	Dev. cfs/ac =	1.84	Dev. Runoff =	413.5
Undev. Area Type A =	161.0	Undev. cfs/ac Type A =	0.37	Undev. Runoff Type A =	59.1
Undev. Area Type B =	2935.4	Undev. cfs/ac Type B =	0.35	Undev. Runoff Type B =	1036.7
Undev. Area Type C =	188.1	Undev. cfs/ac Type C =	0.40	Undev. Runoff Type C =	75.2
Total Undev. Area =	3284.5	Total Undev. cfs/ac =	0.36	Total Undev. Runoff =	1171.0

XP-UDD Hydrology Data&Result - 100-Year Developed

Node Name		Sub area data				Nodal Results		
US Node	Infiltration method	Contributing area	Impervious %	Slope %	Width	Total rainfall	Peak Runoff	
		ac	%		ft	in	cfs	cfs/ac
41a	HortonB	597.12	7.5	0.011	8200	3.01	427.9	0.72
41b	HortonB	66.41	7.5	0.03	1200	3.01	55.5	0.84
41c	HortonB	160.22	7.5	0.027	4700	3.01	148.0	0.92
42a	HortonB	129.56	7.5	0.013	5600	3.01	120.4	0.93
42b	HortonB	324.95	7.5	0.013	5900	3.01	250.3	0.77
42c	HortonB	35.66	7.5	0.042	1200	3.01	36.5	1.02
42d-J	HortonB.1	39.38	40	0.042	1800	3.01	161.9	4.11
42e	-	-	-	-	-	-	-	
42g-I2	HortonB.1	15.6	40	0.017	1400	3.01	67.2	4.31
42h-I1	HortonB.1	18.06	40	0.005	1400	3.01	65.6	3.63
42i-G	HortonB.1	16.75	40	0.019	1700	3.01	74.8	4.47
42j-D2	HortonB.1	54.8	40	0.023	4000	3.01	233.2	4.26
42k-H	HortonB.1	11.63	40	0.021	1000	3.01	50.7	4.36
42l-F	HortonB.1	7.54	40	0.024	700	3.01	33.9	4.49
42m-E	HortonB.1	20.11	40	0.033	1300	3.01	86.6	4.31
42n	HortonB	60.73	40	0.016	2200	3.01	205.0	3.38
42o	HortonB	13.3	40	0.06	1500	3.01	64.3	4.84
42p-I3	HortonB	10.08	40	0.016	500	3.01	36.8	3.65
44a	HortonB	336.71	7.5	0.009	5500	3.01	245.0	0.73
44b	HortonC	188.14	7.5	0.013	6300	3.01	224.9	1.20
44c	HortonB	271.12	7.5	0.023	5400	3.01	225.1	0.83
44d	HortonB	22.26	7.5	0.02	700	3.01	20.2	0.91
44e	HortonB	36.67	7.5	0.019	3700	3.01	49.0	1.34
44f	HortonB	69.38	7.5	0.012	4300	3.01	70.6	1.02
44g-AB	HortonB.1	14.67	40	0.016	900	3.01	57.9	3.95
44h-D1	HortonB.1	6.06	40	0.05	100	3.01	19.6	3.23
44i-C	HortonB.1	10.24	40	0.04	1100	3.01	50.1	4.90
45a	HortonA	161.01	7.5	0.008	5300	3.01	111.8	0.69
45b	HortonB	196.65	7.5	0.008	3800	3.01	146.2	0.74
45c	HortonB	320.18	7.5	0.008	7300	3.01	245.9	0.77
45d	HortonB	294.44	7.5	0.008	8600	3.01	237.4	0.81

XP-UDD Hydrology Data&Result - 5-Year Developed

Node Name US Node	Sub area data Infiltration method	Contributing area ac	Impervious % %	Slope %	Width ft	Nodal Results Total rainfall in	Peak Runoff cfs	cfs/ac
41a	HortonB	597.12	7.5	0.011	8200	1.656	197.708	0.33
41b	HortonB	66.41	40	0.03	1200	1.656	86.477	1.30
41c	HortonB	160.22	7.5	0.027	4700	1.656	60.507	0.38
42a	HortonB	129.56	7.5	0.013	5600	1.656	48.969	0.38
42b	HortonB	324.95	7.5	0.013	5900	1.656	114.656	0.35
42c	HortonB	35.66	40	0.042	1200	1.656	61.438	1.72
42d-J	HortonB.1	39.38	40	0.042	1800	1.656	72.249	1.83
42e	-	-	-	-	-	-	-	
42g-I2	HortonB.1	15.6	40	0.017	1400	1.656	29.585	1.90
42h-I1	HortonB.1	18.06	40	0.005	1400	1.656	29.225	1.62
42i-G	HortonB.1	16.75	40	0.019	1700	1.656	32.42	1.94
42j-D2	HortonB.1	54.8	40	0.023	4000	1.656	103.161	1.88
42k-H	HortonB.1	11.63	40	0.021	1000	1.656	22.228	1.91
42l-F	HortonB.1	7.54	40	0.024	700	1.656	14.634	1.94
42m-E	HortonB.1	20.11	40	0.033	1300	1.656	38.156	1.90
42n	HortonB	60.73	40	0.016	2200	1.656	92.625	1.53
42o	HortonB	13.3	40	0.06	1500	1.656	26.857	2.02
42p-I3	HortonB	10.08	40	0.016	500	1.656	16.954	1.68
44a	HortonB	336.71	7.5	0.009	5500	1.656	113.185	0.34
44b	HortonC	188.14	7.5	0.013	6300	1.656	75.228	0.40
44c	HortonB	271.12	7.5	0.023	5400	1.656	99.661	0.37
44d	HortonB	22.26	7.5	0.02	700	1.656	8.379	0.38
44e	HortonB	36.67	7.5	0.019	3700	1.656	14.072	0.38
44f	HortonB	69.38	40	0.012	4300	1.656	119.077	1.72
44g-AB	HortonB.1	14.67	40	0.016	900	1.656	25.962	1.77
44h-D1	HortonB.1	6.06	40	0.05	100	1.656	8.495	1.40
44i-C	HortonB.1	10.24	40	0.04	1100	1.656	20.46	2.00
45a	HortonA	161.01	7.5	0.008	5300	1.656	59.1	0.37
45b	HortonB	196.65	7.5	0.008	3800	1.656	67.46	0.34
45d	HortonB	294.44	7.5	0.008	8600	1.656	106.811	0.36
45d	HortonB	294.44	7.5	0.008	8600	1.656	106.811	0.36

XP-UDD Hydrology Data&Result - 100-Year Undeveloped

Node Name US Node	Sub area data Infiltration method	Contributing area ac	Impervious % %	Slope %	Width ft	Nodal Results Total rainfall in	Peak infiltration in	Total surface runoff depth in	Peak Runoff cfs	cfs/ac
51a	HortonD	224.9	7.5	1.8%	5000	3.01	0.619	1.91	263.3	1.17
51b	HortonB	318.8	7.5	1.0%	3000	3.01	2.153	0.654	212.8	0.67
51c	HortonB	180.0	7.5	2.0%	3000	3.01	2.153	0.889	150.1	0.83
51d	HortonB	36.2	7.5	3.8%	1500	3.01	1.993	1.158	44.1	1.22
52a	HortonB	19.2	7.5	2.2%	1000	3.01	2.002	1.15	23.0	1.20
52b	HortonA	146.6	7.5	1.5%	2500	3.01	2.91	0.31	101.8	0.69
52c	HortonB	425.1	7.5	1.2%	4000	3.01	2.153	0.677	290.9	0.68
52d	HortonB	126.2	7.5	1.8%	2500	3.01	2.153	0.919	108.3	0.86
52e	HortonB	116.8	7.5	1.8%	2500	3.01	2.153	0.938	102.2	0.88
52f	HortonB	30.4	7.5	1.1%	1000	3.01	2.153	0.982	27.9	0.92
52g	HortonB	28.8	7.5	2.7%	500	3.01	2.153	0.936	25.2	0.87
52h	HortonB	11.6	7.5	1.0%	2000	3.01	1.879	1.264	20.4	1.76
52i	HortonB	30.2	7.5	2.0%	2000	3.01	1.967	1.183	39.2	1.30

Area Type A	146.6	Total cfs/acre Type A	0.69	Total Peak cfs Type A	101.8
Area Type B	1323.3	Total cfs/acre Type B	0.79	Total Peak cfs Type B	1044.2
Area Type D	224.9	Total cfs/acre Type D	1.17	Total Peak cfs Type D	263.3
Total Area	1694.9	Total cfs/acre	0.83	Total Peak cfs	1409.4

XP-UDD Hydrology Data&Result - 5-Year Undeveloped

Node Name US Node	Sub area data Infiltration method	Contributing area ac	Impervious % %	Slope %	Width ft	Nodal Results Total rainfall in	Peak infiltration in	Total surface runoff depth in	Peak Runoff cfs	cfs/ac
51a	HortonD	224.9	7.5	1.8%	5000	1.656	0.618	0.639	94.6	0.42
51b	HortonB	318.8	7.5	1.0%	3000	1.656	1.655	0.115	94.1	0.30
51c	HortonB	180.0	7.5	2.0%	3000	1.656	1.655	0.116	64.6	0.36
51d	HortonB	36.2	7.5	3.8%	1500	1.656	1.655	0.116	13.8	0.38
52a	HortonB	19.2	7.5	2.2%	1000	1.656	1.655	0.116	7.3	0.38
52b	HortonA	146.6	7.5	1.5%	2500	1.656	1.656	0.116	51.8	0.35
52c	HortonB	425.1	7.5	1.2%	4000	1.656	1.655	0.115	129.1	0.30
52d	HortonB	126.2	7.5	1.8%	2500	1.656	1.655	0.116	45.9	0.36
52e	HortonB	116.8	7.5	1.8%	2500	1.656	1.655	0.116	42.8	0.37
52f	HortonB	30.4	7.5	1.1%	1000	1.656	1.655	0.116	11.3	0.37
52g	HortonB	28.8	7.5	2.7%	500	1.656	1.655	0.116	10.5	0.37
52h	HortonB	11.6	7.5	1.0%	2000	1.656	1.655	0.116	4.5	0.38
52i	HortonB	30.2	7.5	2.0%	2000	1.656	1.655	0.116	11.5	0.38

Area Type A	146.6	Total cfs/acre Type A	0.35	Total Peak cfs Type A	51.8
Area Type B	1323.3	Total cfs/acre Type B	0.33	Total Peak cfs Type B	435.4
Area Type D	224.9	Total cfs/acre Type D	0.42	Total Peak cfs Type D	94.6
Total Area	1694.9	Total cfs/acre	0.34	Total Peak cfs	581.8

XP-UDD Hydrology Data&Result - 100-Year Undeveloped

Node Name	Sub area data					Nodal Results				
US Node	Infiltration method	Contributing area ac	Impervious % %	Slope %	Width ft	Total rainfall in	Peak infiltration in	Total surface runoff depth in	Peak Runoff cfs	cfs/ac
22a	HortonA	184.77	7.5	0.01	4300	3.01	2.9	0.318	129.8	0.70
22b-1	HortonB	46.63	7.5	0.012	1800	3.01	2.153	0.787	212.315	4.55
22b-2	HortonB	219.53	7.5	0.021	2400	3.01 -	-	-		
22c	HortonC	916.85	7.5	0.014	11800	3.01	0.965	1.476	824.095	0.90
22d	HortonC	49.53	7.5	0.016	900	3.01	0.965	1.632	51.768	0.16
22e	HortonB	278.17	7.5	0.013	3300	3.01	2.153	0.746	203.85	0.73
22f	HortonB	158	7.5	0.024	2000	3.01	2.153	0.842	126.247	0.80

Area Type A	184.77	Total cfs/acre Type A	0.70	Total Peak cfs Type A	129.8
Area Type B	702.33	Total cfs/acre Type B	0.77	Total Peak cfs Type B	542.412
Area Type C	966.38	Total cfs/acre Type C	0.91	Total Peak cfs Type C	875.863
Total Area	1853.48	Total cfs/acre	0.84	Total Peak cfs	1548.075

XP-UDD Hydrology Data&Result - 5-Year Undeveloped

Node Name	Sub area data					Nodal Results				
US Node	Infiltration method	Contributing area ac	Impervious % %	Slope %	Width ft	Total rainfall in	Peak infiltration in	Total surface runoff depth in	Peak Runoff cfs	cfs/ac
22a	HortonA	184.77	7.5	0.01	4300	1.656	1.656	0.116	66.18	0.36
22b-1	HortonB	46.63	7.5	0.012	1800	1.656	1.655	0.116	91.627	1.96
22b-2	HortonB	219.53	7.5	0.021	2400 -	-	-	-		
22c	HortonC	916.85	7.5	0.014	11800	1.656	0.96	0.387	330.665	0.36
22d	HortonC	49.53	7.5	0.016	900	1.656	0.96	0.446	19.63	0.06
22e	HortonB	278.17	7.5	0.013	3300	1.656	1.656	0.116	90.82	0.33
22f	HortonB	158	7.5	0.024	2000	1.656	1.655	0.116	55.317	0.35

Area Type A	184.77	Total cfs/acre Type A	0.36	Total Peak cfs Type A	66.18
Area Type B	702.33	Total cfs/acre Type B	0.34	Total Peak cfs Type B	237.764
Area Type C	966.38	Total cfs/acre Type C	0.36	Total Peak cfs Type C	350.295
Total Area	1853.48	Total cfs/acre	0.35	Total Peak cfs	654.239