REQUEST FOR PROPOSALS

Feasibility Study and Conceptual Plan with Alternatives for
Seeley's Rio Vista Street Drain Pipeline
County Project Number 7132

<u>Requested by:</u>

John A. Gay, PE
Director of Public Works

<u>Prepared By:</u>

Frank Fiorenza, PE
Resident Engineer II

Deadline for Submissions: <u>March 22, 2024 by 4:00 P.M</u>

Imperial County Department of Public Works
155 S. 11th Street
El Centro, CA 92243

RFP Issued on February 21, 2024
Questions due March 6, 2023

PROPOSALS MUST BE SUBMITTED ON THE SPECIFIED DATE AND TIME. THE COUNTY WILL NOT CONSIDER PROPOSALS RECEIVED AFTER THE DUE DATE. AN AMENDMENT IS CONSIDERED A NEW PROPOSAL AND WILL NOT BE ACCEPTED AFTER THE SPECIFIED DATE AND TIME.

Special Notice

Notification of Contractor Registration Requirements (where required)

Pursuant to the requirements of California Labor Code section 1771.1, all contractors and subcontractors that wish to engage in public work through a public works contract must be registered with the Department of Industrial Relations (DIR).

Beginning March 1, 2015, no contractor or subcontractor may be listed on a bid proposal for a public works project unless registered with DIR.

Beginning April 1, 2015, no contractor or subcontractor may be awarded a contract for public work on a public works project unless registered with the DIR, pursuant to Labor Code section 1725.5

All contractors, including subcontractors, listed in the proposal must be registered with **the DIR at the time proposals are due, and must submit proof of registration with the proposal. Any proposals received listing unregistered contractors and/or subcontractors will be deemed non-responsive.**

***NOTE:* DIR number is to be specified on the cover page of the consultant proposal. Proof of registration for consultant and sub consultant shall also be submitted as an exhibit of the proposal.**

Application and renewal are completed online with a non-refundable fee of $400. Read the Public Works Reforms (SB 854) Fact Sheet for requirements. Instructions for completing the form and additional information can be found on the DIR website.

This Project is subject to compliance monitoring and enforcement by the Department of Industrial Relations (DIR).

SOURCES OF INFORMATION

INFORMATION	WEBSITE
Department of Industrial Relations (Public Works)	http://www.dir.ca.gov/Public-Works/PublicWorks.html
SB 854 Fact Sheet	http://www.dir.ca.gov/Public-Works/PublicWorksSB854.html
Senate Bill 854 Compliance	http://www.dir.ca.gov/Public-Works/SB854.html
Public Works Contractor (PWC) Registration	https://www.dir.ca.gov/Public-Works/Contractor-Registration.html
Classifications and Minimum Labor Rates	http://www.dir.ca.gov/OPRL/Pwd/

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<u>EXHIBIT(S):</u>

A – Location Map and Topographic Survey Limits Map

B – Sample Proposal Evaluation Form

C – Sample Consultant Agreement and Insurance Requirements*
****No changes shall be made to consultant agreement or insurance requirements***

D – 2010 Seeley Area Drainage Master Plan

E – 2018 Imperial County Hydrology Report (Draft)

I. PURPOSE AND BACKGROUND

Imperial County Department of Public Works (County) is considering future storm drainage improvements within the community of Seeley. The County operates and maintains public roads within the Seeley community. Electric power is provided by the Imperial Irrigation District (IID) Energy Department, and irrigation water for agricultural use is provided by the IID Water Department, but in outlying areas primarily. Potable water and sewer services within the community are provided by Seeley County Water District, a special district serving the Seeley community.

In 2010 a Drainage Master Plan was prepared by Rick Engineering Company for the Seeley area. The master plan included recommendations for phased future capital improvements to address the drainage concerns. Although there were seven (7) phases in the master plan, the County would like to see Phase 1 (SD-01) of the master plan explored in more detail with alternatives to be prepared by a consultant as a first phase of this RFP. If one of the selected alternatives is selected, a second phase will be requested of the Consultant to prepare final design plans for the selected alternative. The original Phase 1 (SD-01) includes provision of underground storm drain along Rio Vista Street from Haskell Road to its discharge to an earthen, open channel that connects to the New River located north of the Seeley County Water District WWTP ponds.

II. SCOPE OF WORK:

The scope of work is to provide the necessary site reviews, research of existing utilities, right of way/easements, land ownerships, hydrologic & hydraulic engineering studies, discussion with County, and respective affected utility agencies, Federal, State and other local permitting agencies for the review, analysis and recommendations of alternative project scopes that reflect Phase 1 (SD-01) of the master plan. This is termed Phase One of this RFP. Phase Two of this RFP will be to prepare the stamped engineered design of the selected alternative. If the County decides to move forward with the selected alternative, a fee proposal will be requested from the consultant for the final design.

All work shall be in accordance with this Request for Proposal Scope of Work, civil engineering standard practice and the County's Engineering Design Guidelines Manual posted on the ICPW website address at https://publicworks.imperialcounty.org/forms-and-guidelines/. All work shall be performed under the direction of a Civil Engineer licensed by the State of California. All studies and engineering analysis shall meet current Imperial County Public Works requirements, including the County's Design Guidelines as appropriate.

Consultant shall consider the following tasks including but not limited to:

1. **Site visit & Meetings**. Consultant shall perform multiple site visits to the Seeley community, including upstream tributary drainage areas, include kick off meeting with Imperial County and to gain an appreciation of the concerns with respect to storm drainage/flooding in the community and impacts to the road and utility infrastructure. Meeting with Seeley County Water District and impacted utility agency representatives is to be considered as included in the utility coordination scope described herein. The Consultant shall assume two meetings in Seeley, one meeting at the County of Imperial Public Works Department and multiple zoom meetings with the County during project development, as needed.

2. **Review Existing Materials & Reports**. The Consultant shall review relevant existing County maps, hydrology studies, drainage master plans, reports, and any other available relevant information to prepare for the Consultant's final deliverables for Phase One.
3. **Coordination & Research with Utilities.** Consultant shall coordinate with Imperial County, IID, Seeley County Water District, and other utility agencies to determine specific areas of responsibility, location of key utilities specific to the areas where master plan SD-01 storm drain and street improvements will be required along Rio Vista Street (and portion of Haskell Road as appropriate) within the community of Seeley. Anticipation of potential large retention area for storm water attenuation before discharges to the earthen open channel north of the Seeley County WD, and/or the New River is one of the alternatives to be explored. The utility coordination must consider all utilities within the project site, between New River, along Rio Vista Street and including Haskell Road as indicated within the original master plan, SD-01. This may also be linked and associated with the topographic survey scope portion.
4. **Hydrologic/Hydraulic Analysis**. Consultant shall conduct a focused hydrology study with appropriate hydraulics to review drainage impacts on the Seeley community specific for the design of the underground storm drain along Rio Vista Street. Consideration of surface flows, and future underground storm drain connections from future phases of master plan phasing of Seeley shall be considered. Additionally, a narrative detailing the drainage scheme due to community generated storm water should be concise, and detailed to explain to laypersons what, where, how, and what can be done to reduce flooding risks in the community. Use of Imperial County's 2018 Hydrology Manual is desirable as it is in the process of being adopted for use within Imperial County soon. Hydrology and hydraulics shall include analysis of direct flow discharge from the drain pipeline to outlet to New River via the existing, earthen open channel as one alternative, and a tentative retention basin to be sited as indicated elsewhere in this RFP and/or during the Phase One work scope.
5. **Topographic Survey**. Consultant shall provide a topographic survey of the Seeley community, including storm drainage pathways considering the tributary areas that drain to Rio Vista Street. ***The survey shall be sufficient for detailed design of the Rio Vista Street storm drain, and street improvements (curb, gutter, and sidewalks) along Rio Vista Street to the future storm drain discharge to a future retention area (alternative) and/or to the earthen, open channel prior to New River***. Outside Rio Vista Street, upstream of this drain pipeline, the topographic survey can be less precise for conceptual level planning only. This would include consideration of future capital improvements such as curb, gutters and sidewalks and underground storm drain laterals which shall require spot elevations at key points along the Seeley community road centerlines, edge of pavements, drainage borrow pit, sidewalks (where exists), shoulder areas, etc. to assure sufficient topographic features and elevations will support future alternative CIP projects. County suggests these surface elevations be taken at cross sections at each road intersection and mid-block each street segment in the areas upstream of the Phase 1 drain pipeline along Rio Vista Street. Please refer to Exhibit A.
6. **Right of Way**. Consultant shall research existing monumentation, survey and determine the location of the right of way along Rio Vista from Haskell Road to New River Blvd and

New River Blvd from W. Evan Hewes Hwy to the westerly extension of El Centro Street. This work is to be completed by a licensed Land Surveyor in the State of California. The right of ways shall be shown on the topographic map. It is anticipated that sufficient monumentation exists. A Record of Survey (ROS) is not included in the scope of work. Should it be determined that a ROS is required, it will be considered additional work.

7. **Environmental Permitting**. Consultant shall coordinate with Federal, and/or State permitting agencies once the feasibility study and conceptual plan alternatives are determined. The coordination shall be only to the point of determining what type of permitting may be required by these agencies relative to the improvements proposed. The goal is to minimize impacts to direct discharges to the New River, and minimal environmental permitting. Alternative to direct discharge to New River and/or to earthen open channel will include a retention storage basin to be sited north of Rio Vista Street either on Seeley County Water District land or private land just east of New River Road. A summary of potential environmental permitting for each potential alternative will benefit the final recommendations.
8. **Feasibility Study and Conceptual Plan with Alternatives.** Phase One of this RFP is to provide a summary of the Consultants findings for addressing SD-01 (Phase 1 of original drainage master plan) storm drain pipeline along Rio Vista Street. It shall be documented in a Feasibility Study and Conceptual Plan with Alternatives. The two key alternatives include direct discharge of the Rio Vista drain pipeline to the existing earthen channel prior to New River, and discharge first to a retention basin, with discharge to the existing earthen channel mentioned.

   The results shall include a conceptual level set of plan and profile sheets only, no title or detail sheets for Rio Vista Street Drain Pipeline. The plan and profile sheets shall be a 40 scale at conceptual level (30% completion) which would be a base for future Phase Two of this RFP for design level plans. The sizing of the underground storm drain will include consideration of a 100-year frequency storm to be carried within a combination of the pipeline and within the surface of road right of way along Rio Vista Street with at least one dry lane (12’ for emergency access) along the street center. The Feasibility Study portion shall include a summary of all pertinent, related items such as high-level design and construction costs, environmental permitting, utility relocation, encroachment permits and/or right of way or easements required, along with land ownerships of impacted properties where improvements are suggested.
9. No Subconsultants shall be utilized without prior authorization by the County. Any authorized Subconsultants providing professional services to consultant shall be held to the same licensing, accreditation, and certification standards as consultant.

SCOPE OF WORK – Phase Two:

Phase Two shall include final design of plans and technical specifications of the selected alternative from the Consultant’s Feasibility Study and Conceptual Plan for the Rio Vista Street drain pipeline. Bid

Specifications will be prepared by the County with use of Consultant's technical specifications using Caltrans latest Standard Plans and Specifications.

Consultant shall submit a detailed cost proposal and general analysis of effort/methodology to prepare plans and develop scope of work, with complete engineering design plans, technical specifications, supporting calculations, engineer's cost estimate for County to bid with County prepared bid specifications. Typical plans will include a title sheet, plan and profile sheets, cross sections, details, traffic control plans and erosion control plans. It is the County's intent to use the results of Phase One to seek funding for Phase Two construction..

Phase Two scope and costs will be requested by County after review of Phase One work (when/if funding is available), and is not to be included in fee for response to this RFP for Phase One.

Consultant shall attend and participate in the project kick-off meeting with the County and review project goals, scope, workflow methodology, responsibilities of both Consultant and County, and will introduce key staff. During this project, all communications and coordination will be with the Engineer assigned to the project, who is the primary point of contact for the County.

Throughout the course of the project, the Consultant will maintain orderly project files. All tracings, plans, studies, calculations, exhibits, and maps prepared or obtained under the terms of the agreement with County shall be delivered to and become property of the County. Basic survey notes and sketches, charts, computations, and other data prepared or obtained under such agreement shall be made available upon request to the County without restriction or limitation on their use.

At the conclusion of the project, Consultant shall submit to the County an Engineering Report (Feasibility Study with Conceptual Plan) as mentioned above, and clearly labeled with the Project title.

Additionally, a copy of the record of the project is to be provided in Portable Document Format (PDF) on one (1) USB thumb drive. The required project file and all pertinent documents will need to be submitted before the final payment and retention will be released.

III. RESPONSIBILITIES OF COUNTY:

The County will direct the development of the project(s), provide management oversight, and conduct administrative arrangements only. The County will provide any other available plans and records to the consultant as required. The consultant will be responsible for all activities and meetings associated with the project including meeting minutes and record keeping.

The County will pay an agreed upon amount normally within 30 days after receipt of invoice(s). Invoice(s) shall be submitted with a detailed accounting of staff hours attributed to specific tasks. Separate invoices shall be submitted for specific project billings, with a clear notation of the County Project Number.

The County will not provide dedicated workplace facilities, but upon request will provide a conference room for meetings with the Department, Consultant and other appropriate agencies if needed.

The County reserves the right to perform any portion of the scope of work by County personnel or other consultants should the County determine that it would be in the best interest of the County to do so.

IV. PROPOSAL CONTENT AND INFORMATION:

At a minimum, proposals should include:

1. Letter of Interest: Provide a cover letter expressing your interest in the project. Include name, address, phone number, and email address of the primary contact; identifying the capacity of this person.

2. Statement of Qualifications: Describe the company's qualifications and experience related to multi-modal transportation planning.

3. Understanding of the project: Provide understanding of the project scope and commitment to address all requirements.

4. Relevant experience with similar project(s): Provide a list of at least three (3) or more similar projects that the firm and staff, proposed for assignment, have successfully completed.

5. References: Provide at least three (3) references, with contact information, for other similar work performed.

6. Legal entity: describe the legal entity with which the County would contract including the structure of the anticipated partnership agreement(s) and ownership interests in the project. Include length of time in business, and number of employees.

7. Project Management: Identify the members of the project team, including the project manager, key consultants, and sub-consultants; include their names and positions, their qualifications, list of similar projects in which they assumed substantial roles, and responsibilities related to the assignment. It is expected that individuals identified as the project team will be actively involved throughout the project.

8. Analysis of Effort/Methodology: Prospective consultants shall describe the overall approach to the project, specific techniques that will be used, and the specific administrative and operational management expertise that will be employed. A proposed schedule shall be included. The project schedule must be clearly stated with intermittent milestones.

9. Approach: Provide a narrative that explains your approach to realizing the specifications stated in the enclosed RFP. Include a description of the approach for the project, including, but not limited to:

    - Overall approach and recommendation for the comprehensive plan;
    - Detailed scope of work that incorporates the guidance provided in this RFP;
    - Schedule; Timeline

10. Capacity: a statement that the firm(s) has sufficient staff resources and capability to perform the work contained within this RFP within the specified timeframe.

11. Taxpayers Identification Number: Each consultant whether an individual, proprietor, partnership or a non-profit corporation or organization must obtain, complete and include, with the proposal submitted, an Internal Revenue Service Form W-9, "Request for Taxpayer Identification Number and Certification".

12. Cost Proposal/Worksheet Includes fee schedule for Phase One only, on a time (by personnel) and materials basis; cost by task; and total cost to complete the project. The cost proposal shall be fully inclusive of all services, overhead, and direct expenses. If applicable, include fee structure for additional work/services outside the scope of work. Cost proposal must include statement that offer is valid for at least a ninety (90) day period.

    - All costs/fees proposed must accompany proposal ***within a separate sealed envelope*** clearly labeled with the name of the firm submitting and the title of the RFP.

    As mentioned above, Phase Two scope and costs will be requested by County after receipt and review of Phase One deliverables, if and when the County has identified funding available to continue with this project.

V. RFP QUESTIONS, CONTACT PERSON, AND SCHEDULE:

Questions concerning this RFP will be responded to collectively, and made available for interested consultants via the ICDPW website http://www.co.imperial.ca.us/publicwork/default.htm under "Projects out to Bid" as an addendum. *All inquiries must be submitted in writing no later than close of business on Wednesday, March 6, 2024* to the contact person below. **No oral questions will be taken or responded to except for administrative clarifications.**

Contact Person: Janette Lewenthal, MPA, Administrative Analyst II
janettegovea@co.imperial.ca.us

EVENT	DATE
Issue Request for Proposal	**February 21, 2024**
Last Day for Request(s) for Clarification *must be submitted in writing*	**March 6, 2024**
Proposal Due	**March 22, 2024**
Consultant Selection	**March/ April 2024**
Agreement for Services	**April/ May 2024**

VI. PROPOSAL EVALUATION:

The County will utilize a one-step selection process. The County reserves the right to include an oral interview process component. If an oral interview is considered, selected firms will be notified. Sample evaluation criteria for proposals is attached for review as Exhibit B.

Proposals received shall be reviewed according to the criteria and weighting shown in Exhibit B. In addition to ICDPW Staff, the evaluation panel may include representatives from project stakeholders. A recommendation to award contract will be presented to the Imperial County Board of Supervisors for approval to enter into an agreement.

Please take note that the County reserves the right to select any consultant who is determined qualified and may not correlate to a number 1, number 2 or even number 3 ranked consultant. Additionally, the County reserves the right to reject any and all proposals submitted and/or request additional information for clarification.

Consultants are to submit one (1) original, three (3) copies, and one (1) electronic copy in Portable Document Format (PDF) on a USB thumb drive of the proposal as requested in Section VIII Proposal Submittal. Proposal must be clearly titled:

Feasibility Study and Conceptual Plan with Alternatives for
Seeley's Rio Vista Street Drain Pipeline
County Project Number 7132

VII. CONSULTING AGREEMENT:

A sample agreement is attached for review as Exhibit C.

Prior to the start of work, the selected consultant will be required to execute an Agreement for Services with the County. The consulting firm must review the attached sample consulting agreement and minimum insurance amounts. No modification requests to material terms of agreement will be made. The agreement shall not be in force until contracting is approved by the Imperial County Board of Supervisors and after written authorization to proceed has been provided.

Any contract resulting from this RFP will be financed with funds available to the County and/or other available funding.

VIII. PROPOSAL SUBMITTAL:

One (1) original, three (3) copies, and one (1) electronic copy in Portable Document Format (PDF) on a USB Thumb Drive or Compact Disc (CD) of the proposal must be received in person or by mail to Imperial

County Department of Public Works no later than close of business ***(4:00pm) on Friday, March 22, 2024***. Proposal must be clearly titled:

Feasibility Study and Conceptual Plan with Alternatives for Seeley's Rio Vista Street Drain Pipeline, County Project Number 7132
Proposals are to be delivered in a sealed envelope and addressed to:

Janette Lewenthal – MPA, Administrative Analyst II
Imperial County Department of Public Works
155 S. 11th Street
El Centro, California 92243

Email proposals concurrently to janettegovea@co.imperial.ca.us

Note: Late proposals will not be considered.

IX. CLOSING ITEMS:

A pre-proposal conference has not been scheduled for this project.

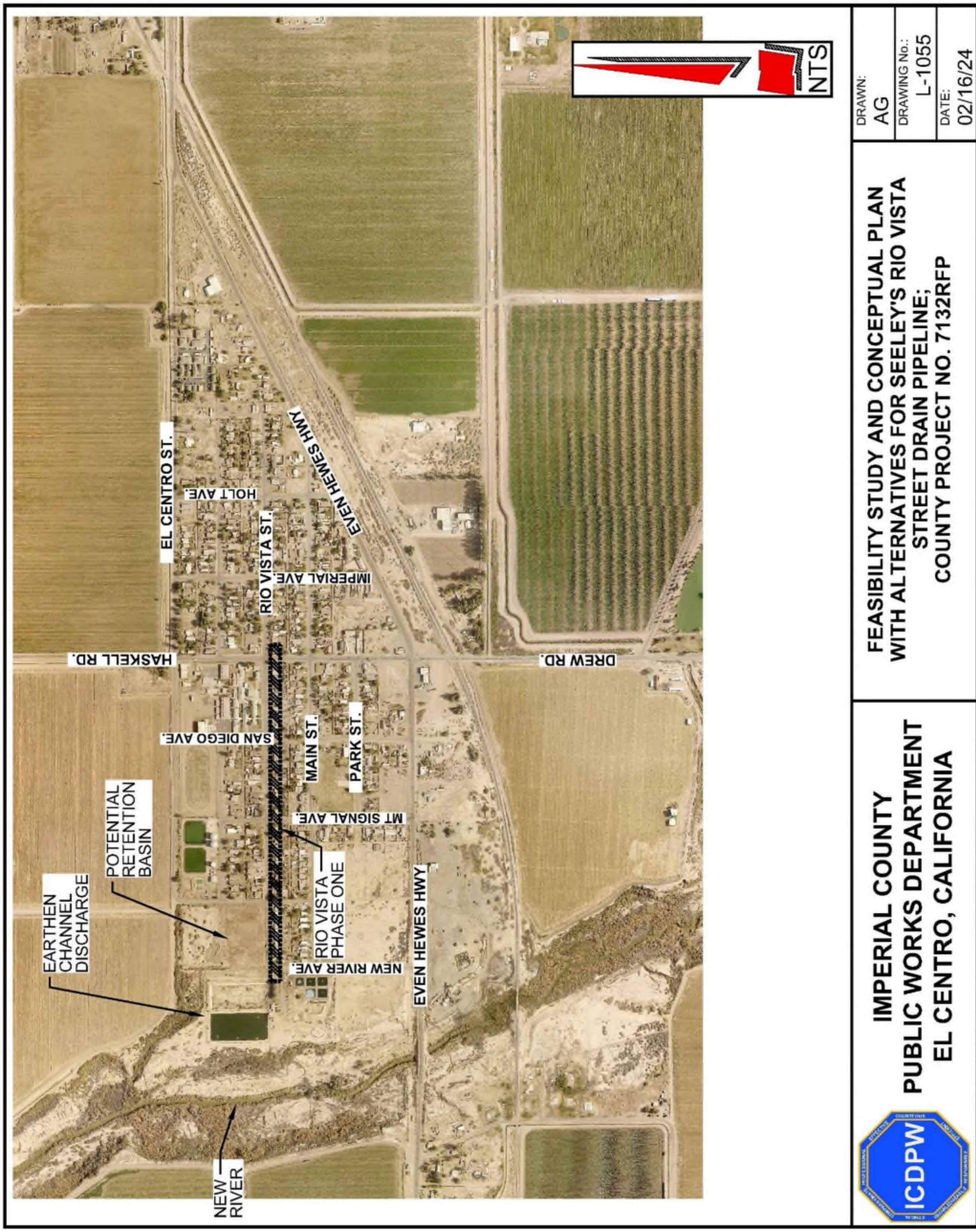
Any modifications to this solicitation will be issued by the County as a written addendum and posted to the Imperial County Department of Public Works website: http://www.co.imperial.ca.us/publicwork/default.htm under "Projects out to Bid"

The County will not consider proposals received after the specified date and time. An amendment is considered a new proposal and will not be accepted after the specified date and time.

This RFP does not commit the County of Imperial to award a contract or pay any costs associated with the preparation of a proposal. The County reserves the right to cancel, in part or in its entirety, this solicitation should this be in the best interest of the County.

EXHIBIT A

LOCATION MAP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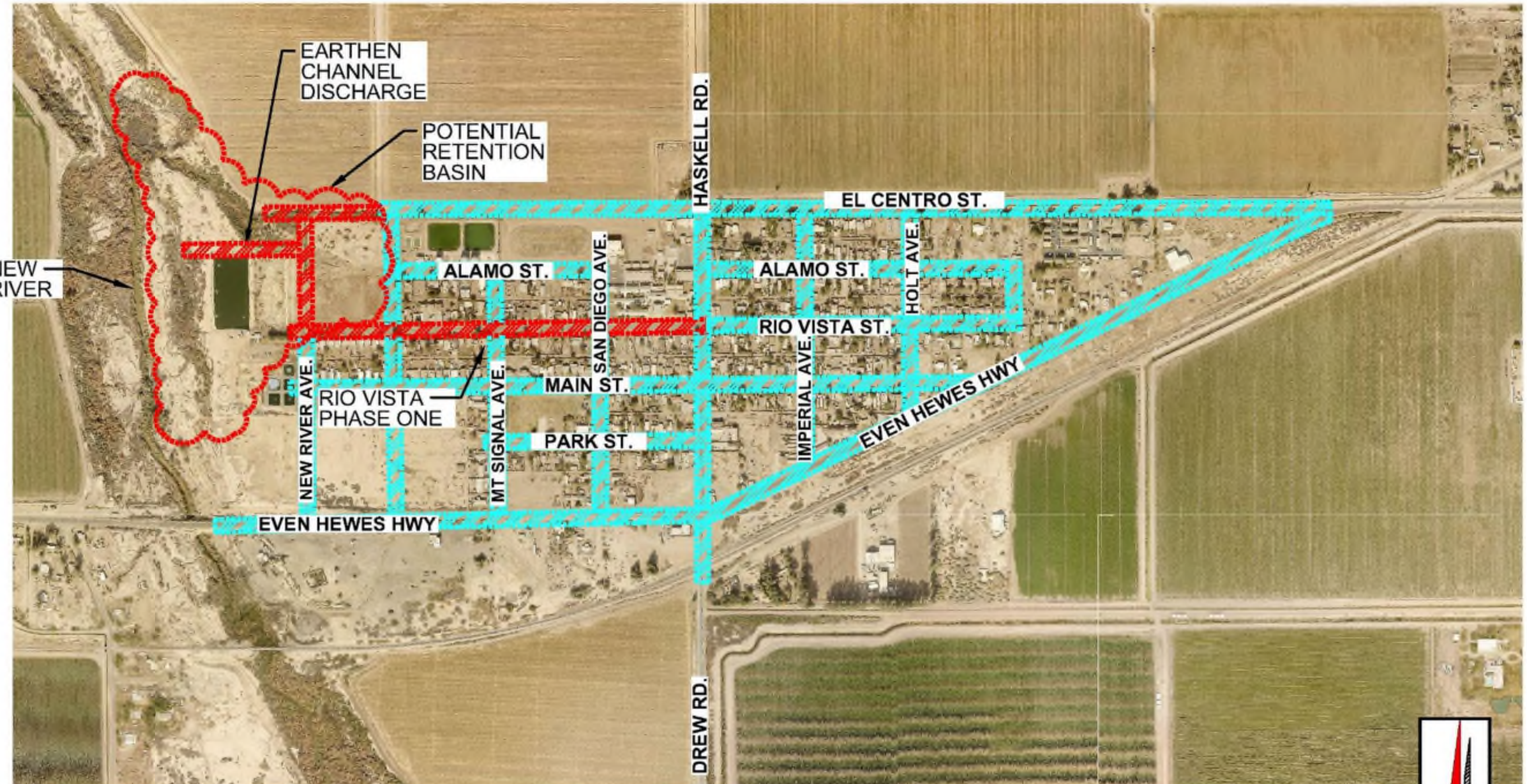
HOLT AVE.
RIO VISTA ST.
IMPERIAL AVE.
EVEN HEWES HWY
HASKELL RD.
DREW RD.
SAN DIEGO AVE.
MAIN ST.
PARK ST.
MT SIGNAL AVE.
POTENTIAL RETENTION BASIN
EARTHEN CHANNEL DISCHARGE
RIO VISTA PHASE ONE
NEW RIVER AVE.
EVEN HEWES HWY
NEW RIVER
NTS
ICDPW
IMPERIAL COUNTY
PUBLIC WORKS DEPARTMENT
EL CENTRO, CALIFORNIA
FEASIBILITY STUDY AND CONCEPTUAL PLAN
WITH ALTERNATIVES FOR SEELEY'S RIO VISTA
STREET DRAIN PIPELINE;
COUNTY PROJECT NO. 7132RFP
DRAWN:
AG
DRAWING No.:
L-1055
DATE:
02/16/24



LEGEND

TOPOGRAPHIC SURVEY, DONE BY DRONE SHOWING THE SPOT ELEVATIONS, INCLUDING PROJECTED FLOWLINE, EDGE OF PAVEMENT AND CENTERLINE.

DETAILED TOPOGRAPHIC SURVEY (IN AUTOCAD) OF THE RIO VISTA STREET SUFFICIENT FOR THE DESIGN OF STORM DRAIN, AND STREET IMPROVEMENTS (CURB, GUTTER, AND SIDEWALKS) TO THE FUTURE STORM DRAIN DISCHARGE, TO A FUTURE RETENTION AREA (ALTERNATIVE) AND/OR TO THE EARTHEN, OPEN CHANNEL PRIOR TO NEW RIVER.

ICDPW IMPERIAL COUNTY PUBLIC WORKS DEPARTMENT EL CENTRO, CALIFORNIA	FEASIBILITY STUDY AND CONCEPTUAL PLAN WITH ALTERNATIVES FOR SEELEY'S RIO VISTA STREET DRAIN PIPELINE; COUNTY PROJECT NO. 7132RFP	DRAWN: AG DRAWING No.: L-1055 DATE: 02/21/24

S:\PROGRAMS\ENGINEERING PROJECTS\7132 SEELEYS RIO VISTA DRAIN PIPELINE STUDY\DRAWINGS\L-1055_RIO VISA DRAIN STUDY.DWG
PLOT DATE: 2/21/2024

EXHIBIT B

SAMPLE PROPOSAL EVALUATION FORM

(for information only)

PROPOSAL EVALUATION FORM

FEASIBILITY STUDY AND CONCEPTUAL PLAN WITH ALTERNATIVES FOR SEELEY'S RIO VISTA STREET DRAIN PIPELINE
COUNTY PROJECT NO. 7132

RATING POINTS:

RESPONDENT: ______________________________ 5 = excellent
EVALLUATOR: ______________________________ 4 = good
DATE: ______________________________ 3 = above average
EVALUATOR SIGNATURE: ______________________________ 2 = average
1 = below average
0 = unsatisfactory

CRITERIA	WEIGHT FACTOR	X RATING	= WEIGHTED RATING
A. Relevant Experience	**(0.35)**		
• Responsiveness & understanding of work to be done, (i.e. scope of work).	(0.15)	_____	_____
• Storm Drainage & Hydrology relevant experience, key personnel, & staff	(0.10)	_____	_____
• Related experience with Drainage Infrastructure CIP, key personnel, & staff	(0.10)	_____	_____
B. Project Management	**(0.25)**		
• Consultants ability to provide respective services within budget and on schedule.	(0.15)	_____	_____
• Demonstrates organizational skills, and ability to meet client program requirements and goals.	(0.10)	_____	_____
C. References	**(0.05)**		
D. Understanding	**(0.20)**		
• Proposal specific to RFP scope of work. Any additional items suggested beyond scope can be included but referenced separately.	(0.20)	_____	_____
E. Problem Solving	**(0.15)**		
Demonstrate creative problem solving and solutions in dealing with difficult planning, programming, and evaluation analysis.	(0.15)	_____	_____
		Subtotal Score	_____
F. Previous Experience and performance working With County of Imperial Department of Public Works			_____ (0 to -5)
		Total Score	_____

Note: Positive previous experience and no previous experience will constitute a score of zero (0). Negative experience points will be deducted from the overall score.

Comments:

EXHBIT C

SAMPLE CONSULTANT AGREEMENT
AND
INSURANCE REQUIREMENTS

(For information only)

AGREEMENT FOR SERVICES

«Consultant_Business_Name»

THIS AGREEMENT FOR SERVICES ("Agreement"), made and entered into effective the ______ day of _____________, 2015, by and between the County of Imperial, a political subdivision of the State of California, by and through its Department of Public Works ("COUNTY") and **«Consultant_Business_Name»**, «Consultant_Business_Type» ("CONSULTANT") (individually, "Party;" collectively, "Parties").

RECITALS

WHEREAS, COUNTY desires to retain a qualified individual, firm or business entity to provide «Contract_Services» for «Project_Name»; «Project_Number» ("Project"); and

WHEREAS, CONSULTANT represents that it is qualified and experienced to perform the services; and

WHEREAS, COUNTY desires to engage CONSULTANT to provide services by reason of its qualifications and experience for performing such services, and CONSULTANT has offered to provide the required services for the Project on the terms and in the manner set forth herein.

NOW, THEREFORE, in consideration of their mutual covenants, COUNTY and CONSULTANT have and hereby agree to the following:

1. DEFINITIONS.

1.1. "Request for Proposal" or "RFP" shall mean that document that describes the Project and project requirements to prospective bidders entitled, "«Name_of_RFP»," dated «Date_of_RFP». The Request for Proposal is attached hereto as **Exhibit "A"** and incorporated herein by this reference.

1.2. "Proposal" shall mean CONSULTANT's document entitled, "«Name_of_Proposal»," dated «Date_of_Proposal» and submitted to COUNTY's Department of Public Works. The Proposal is attached hereto as **Exhibit "B"** and incorporated herein by reference.

2. CONTRACT COORDINATION.

2.1. The Director of Public Works or his/her designee shall be the representative of COUNTY for all purposes under this Agreement. The Director of Public Works or his/her designee is hereby designated as the Contract Manager for COUNTY. He/she shall supervise the progress and execution of this Agreement.

2.2. CONSULTANT shall assign a single Contract Manager to have overall responsibility for the progress and execution of this Agreement. Should circumstances or conditions subsequent to the execution of this Agreement require a substitute Contract Manager for any reason, the Contract Manager designee shall be subject to the prior written acceptance and approval of COUNTY's Contract Manager.

3. DESCRIPTION OF WORK.

CONSULTANT shall provide all materials and labor to perform this Agreement consistent with the RFP and the Proposal, as set forth in **Exhibits "A" and "B."** In the event of a conflict amongst this Agreement, the RFP, and the Proposal, the RFP shall take precedence over the Proposal and this Agreement shall take precedence over both.

4. WORK TO BE PERFORMED BY CONSULTANT.

4.1. CONSULTANT shall comply with all terms, conditions and requirements of the Proposal and this Agreement.

4.2. CONSULTANT shall perform such other tasks as necessary and proper for the full performance of the obligations assumed by CONSULTANT hereunder.

4.3. CONSULTANT shall:

4.3.1. Procure all permits and licenses, pay all charges and fees, and give all notices that may be necessary and incidental to the due and lawful prosecution of the services to be performed by CONSULTANT under this agreement;

4.3.2. Keep itself fully informed of all existing and proposed federal, state and local laws, ordinances, regulations, orders and decrees which may affect those engaged or employed under this Agreement;

4.3.3. At all times observe and comply with, and cause all of its employees to observe and comply with all of said laws, ordinances, regulations, orders and decrees mentioned above; and

4.3.4. Immediately report to COUNTY's Contract Manager in writing any discrepancy or inconsistency it discovers in said laws, ordinances, regulations, orders and decrees mentioned above in relation to any plans, drawings, specifications or provisions of this Agreement.

5. REPRESENTATIONS BY CONSULTANT.

5.1. CONSULTANT understands and agrees that COUNTY has limited knowledge in the multiple areas specified in the Proposal. CONSULTANT has represented itself to be an expert in these fields and understands that COUNTY is relying upon such representation.

5.2. CONSULTANT represents and warrants that it is a lawful entity possessing all required licenses and authorities to do business in the State of California and perform all aspects of this Agreement.

5.3. CONSULTANT shall not commence any work under this Agreement or provide any other services, or materials, in connection therewith until CONSULTANT has received written authorization from COUNTY's Contract manager to do so.

5.4. CONSULTANT represents and warrants that the people executing this Agreement on behalf of CONSULTANT have the authority of CONSULTANT to sign this Agreement and bind CONSULTANT to the performance of all duties and obligations assumed by CONSULTANT herein.

5.5. CONSULTANT represents and warrants that any employee, contractor and/or agent who will be performing any of the duties and obligations of CONSULTANT herein possess all required licenses and authorities, as well as the experience and training, to perform such tasks.

5.6. CONSULTANT represents and warrants that the allegations contained in the Proposal are true and correct.

5.7. CONSULTANT understands that COUNTY considers the representations made herein to be material and would not enter into this Agreement with CONSULTANT if such representations were not made.

5.8. CONSULTANT understands and agrees not to discuss this Agreement or work performed pursuant to this Agreement with anyone not a party to this Agreement without the prior permission of COUNTY. CONSULTANT further agrees to immediately advise COUNTY of any contacts or inquiries made by anyone not a party to this Agreement with respect to work performed pursuant to this Agreement.

5.9. Prior to accepting any work under this Agreement, CONSULTANT shall perform a due diligence review of its files and advise COUNTY of any conflict or potential conflict CONSULTANT may have with respect to the work requested.

5.10. CONSULTANT understands and agrees that in the course of performance of this Agreement CONSULTANT may be provided with information or data considered by the owner or the COUNTY to be confidential. COUNTY shall clearly identify such information and/or data as confidential. CONSULTANT shall take all necessary steps necessary to maintain such confidentiality including but not limited to restricting the dissemination of all material received to those required to have such data in order for CONSULTANT to perform under this Agreement.

5.11. CONSULTANT represents that the personnel dedicated to this project as identified in CONSULTANT's Proposal, will be the people to perform the tasks identified therein. CONSULTANT will not substitute other personnel or engage any contractors to work on any tasks identified herein without prior written notice to COUNTY.

6. <u>TERM OF AGREEMENT</u>.

This Agreement shall commence on the date first written above and shall remain in effect until the services provided as outlined in Paragraph 3, ("DESCRIPTION OF WORK"), have been completed, unless otherwise terminated as provided for in this Agreement.

7. <u>COMPENSATION</u>.

7.1. The total compensation payable under this Agreement shall not exceed **«Cost_of_Original_Contract»**, unless otherwise previously agreed to in writing by COUNTY.

7.2. The fee for any additional services required by COUNTY will be computed either on a negotiated lump sum basis or upon actual hours and expenses incurred by CONSULTANT and based on CONSULTANT's current standard rates as set forth in the Proposal. Additional services or costs will not be paid without a prior written agreement between the Parties.

7.3. Except as provided under paragraph 7.1 and 7.2, COUNTY shall not be responsible to pay CONSULTANT any compensation, out of pocket expenses, fees, reimbursement of expenses or other remuneration.

8. <u>PAYMENT</u>.

8.1. CONSULTANT shall bill COUNTY on a time and material basis as set forth in **Exhibit "A."** COUNTY shall pay CONSULTANT for completed and approved services upon presentation of its itemized billing.

8.2. COUNTY shall have the right to retain five percent (5%) of the total of amount of each invoice, not to exceed five percent (5%) of the total compensation amount of the completed project. "Completion of the Project" is when the work to be performed has been completed in accordance with this Agreement, as determined by COUNTY, and all subcontractors, if any, have been paid in full by CONSULTANT. Upon completion of the Project CONSULTANT shall bill COUNTY the retention for payment by COUNTY.

9. <u>METHOD OF PAYMENT</u>.

CONSULTANT shall at any time prior to the fifteenth (15^{th}) day of any month, submit to COUNTY a written claim for compensation for services performed. The claim shall be in a format approved by COUNTY. No payment shall be made by COUNTY prior to the claims being approved in writing by COUNTY's Contract Manager or his/her designee. CONSULTANT may expect to receive payment within a reasonable time thereafter and in any event in the normal course of business within thirty (30) days after the claim is submitted.

10. <u>TIME FOR COMPLETION OF THE WORK</u>.

The Parties agree that time is of the essence in the performance of this Agreement. Program scheduling shall be as described in Exhibits unless revisions are approved by both COUNTY's Contract Manager and CONSULTANT's Contract Manager. Time extensions may be allowed for delays caused by COUNTY, other governmental agencies or factors not directly brought about by the negligence or lack of due care on the part of CONSULTANT.

11. <u>MAINTENANCE AND ACCESS OF BOOKS AND RECORDS</u>.

CONSULTANT shall maintain books, records, documents, reports and other materials developed under this Agreement as follows:

11.1. CONSULTANT shall maintain all ledgers, books of accounts, invoices, vouchers, canceled checks, and other records relating to CONSULTANT's charges for services or expenditures and disbursements charged to COUNTY for a minimum period of three (3) years, or for any longer period required by law, from the date of final payment to CONSULTANT pursuant to this Agreement.

11.2. CONSULTANT shall maintain all reports, documents, and records, which demonstrate performance under this Agreement for a minimum period of five (5) years, or for any longer period required by law, from the date of termination or completion of this Agreement.

11.3. Any records or documents required to be maintained by CONSULTANT pursuant to this Agreement shall be made available to COUNTY for inspection or audit at any time during CONSULTANT's regular business hours provided that COUNTY provides CONSULTANT with seven (7) days advanced written or e-mail notice. Copies of such documents shall, at no cost to COUNTY, be provided to COUNTY for inspection at CONSULTANT's address indicated for receipt of notices under this Agreement.

12. SUSPENSION OF AGREEMENT.

COUNTY's Contract Manager shall have the authority to suspend this Agreement, in whole or in part, for such period as deemed necessary due to unfavorable conditions or to the failure on the part of CONSULTANT to perform any provision of this Agreement. CONSULTANT will be paid the compensation due and payable to the date of suspension.

13. TERMINATION.

COUNTY retains the right to terminate this Agreement for any reason by notifying CONSULTANT in writing twenty (20) days prior to termination and by paying the compensation due and payable to the date of termination; provided, however, if this Agreement is terminated for fault of CONSULTANT, COUNTY shall be obligated to compensate CONSULTANT only for that portion of CONSULTANT's services which are of benefit to COUNTY. Said compensation is to be arrived at by mutual agreement between COUNTY and CONSULTANT; should the parties fail to agree on said compensation, an independent arbitrator shall be appointed and the decision of the arbitrator shall be binding upon the parties.

14. INSPECTION.

CONSULTANT shall furnish COUNTY with every reasonable opportunity for COUNTY to ascertain that the services of CONSULTANT are being performed in accordance with the requirements and intentions of this Agreement. All work done and materials furnished, if any, shall be subject to COUNTY's Contract Manager's inspection and approval. The inspection of such work shall not relieve CONSULTANT of any of its obligations to fulfill its Agreement as prescribed.

15. OWNERSHIP OF MATERIALS.

All original drawings, videotapes, studies, sketches, computations, reports, information, data and other materials given to or prepared or assembled by or in the possession of CONSULTANT pursuant to this Agreement shall become the permanent property of COUNTY and shall be delivered to COUNTY upon demand, whether or not completed, and shall not be made available to any individual or organization without the prior written approval of COUNTY.

16. INTEREST OF CONSULTANT.

16.1. CONSULTANT covenants that it presently has no interest, and shall not acquire any interest, direct or indirect, financial or otherwise, which would conflict in any manner or degree with the performance of the services hereunder.

16.2. CONSULTANT covenants that, in the performance of this Agreement, no sub-contractor or person having such an interest shall be employed.

16.3. CONSULTANT certifies that no one who has or will have any financial interest under this Agreement is an officer or employee of COUNTY.

17. INDEMNIFICATION.

17.1. CONSULTANT agrees to the fullest extent permitted by law to indemnify, defend, protect and hold COUNTY and its representatives, officers, directors, designees, employees, successors and assigns harmless from any and all claims, expenses, liabilities, losses, causes of actions, demands, losses, penalties, attorneys' fees and costs, in law or equity, of every kind and nature whatsoever arising out of or in connection with CONSULTANT's negligent acts and omissions or willful misconduct under this Agreement ("Claims"), whether or not arising from the passive negligence of COUNTY, but does not include Claims that are the result of the negligence or willful misconduct of COUNTY.

17.2. CONSULTANT agrees to defend with counsel acceptable to COUNTY, indemnify and hold COUNTY harmless from all Claims, including but not limited to:

17.2.1. Personal injury, including but not limited to bodily injury, emotional injury, sickness or disease or death to persons including but not limited to COUNTY's representatives, officers, directors, designees, employees, agents, successors and assigns, subcontractors and other third parties and/or damage to property of anyone (including loss of use thereof) arising out of

CONSULTANT's negligent performance of, or willful misconduct surrounding, any of the terms contained in this Agreement, or anyone directly or indirectly employed by CONSULTANT or anyone for whose acts CONSULTANT may be liable;

17.2.2. Liability arising from injuries to CONSULTANT and/or any of CONSULTANT's employees or agents arising out of CONSULTANT's negligent performance of, or willful misconduct surrounding, any of the terms contained in this Agreement, or anyone directly or indirectly employed by CONSULTANT or anyone for whose acts CONSULTANT may be liable;

17.2.3. Penalties imposed upon account of the violation of any law, order, citation, rule, regulation, standard, ordinance or statute caused by the negligent action or inaction, or willful misconduct of CONSULTANT or anyone directly or indirectly employed by CONSULTANT or anyone for whose acts CONSULTANT may be liable;

17.2.4. Infringement of any patent rights which may be brought against COUNTY arising out of CONSULTANT's work;

17.2.5. Any violation or infraction by CONSULTANT of any law, order, citation, rule, regulation, standard, ordinance or statute in any way relating to the occupational health or safety of employees; and

17.2.6. Any breach by CONSULTANT of the terms, requirements or covenants of this Agreement.

17.3. These indemnification provisions shall extend to Claims occurring after this Agreement is terminated, as well as while it is in force.

18. <u>INDEPENDENT CONTRACTOR</u>.

In all situations and circumstances arising out of the terms and conditions of this Agreement, CONSULTANT is an independent contractor, and as an independent contractor, the following shall apply:

18.1. CONSULTANT is not an employee or agent of COUNTY and is only responsible for the requirements and results specified by this Agreement or any other agreement.

18.2. CONSULTANT shall be responsible to COUNTY only for the requirements and results specified by this Agreement and except as specifically provided in this Agreement, shall not be subject to COUNTY's control with respect to the physical actions or activities of CONSULTANT in fulfillment of the requirements of this Agreement.

18.3. CONSULTANT is not, and shall not be, entitled to receive from, or through, COUNTY, and COUNTY shall not provide, or be obligated to provide, CONSULTANT with Workers' Compensation coverage or any other type of employment or worker insurance or benefit coverage required or provided by any Federal, State or local law or regulation for, or normally afforded to, an employee of COUNTY.

18.4. CONSULTANT shall not be entitled to have COUNTY withhold or pay, and COUNTY shall not withhold or pay, on behalf of CONSULTANT, any tax or money relating to the Social Security Old Age Pension Program, Social Security Disability Program, or any other type of pension, annuity, or disability program required or provided by any Federal, State or local law or regulation.

18.5. CONSULTANT shall not be entitled to participate in, nor receive any benefit from, or make any claim against any COUNTY fringe program, including, but not limited to, COUNTY's pension plan, medical and health care plan, dental plan, life insurance plan, or any other type of benefit program, plan, or coverage designated for, provided to, or offered to COUNTY's employees.

18.6. COUNTY shall not withhold or pay, on behalf of CONSULTANT, any Federal, State, or local tax, including, but not limited to, any personal income tax, owed by CONSULTANT.

18.7. CONSULTANT is, and at all times during the term of this Agreement, shall represent and conduct itself as an independent contractor, not as an employee of COUNTY.

18.8. CONSULTANT shall not have the authority, express or implied, to act on behalf of, bind or obligate COUNTY in any way without the written consent of COUNTY.

19. <u>INSURANCE</u>.

19.1. CONSULTANT hereby agrees at its own cost and expense to procure and maintain, during the entire term of this Agreement and any extended term therefore, insurance in a sum acceptable to COUNTY and adequate to cover potential liabilities arising in connection with the performance of this Agreement and in any event not less than the minimum limit set forth in the "Minimum Insurance Amounts" attachment to the Plans and Specifications (**Exhibit A**) which are incorporated as if set forth fully herein.

19.2. Special Insurance Requirements. All insurance required shall:

19.2.1. Be procured from California admitted insurers (licensed to do business in California) with a current rating by Best's Key Rating Guide, acceptable to COUNTY. A rating of at least A-VII shall be acceptable to COUNTY; lesser ratings must be approved in writing by COUNTY.

19.2.2. Be primary coverage as respects COUNTY and any insurance or self-insurance maintained by COUNTY shall be in excess of CONSULTANT's insurance coverage and shall not contribute to it.

19.2.3. Name The Imperial County Department of Public Works and the County of Imperial and their officers, employees, and volunteers as additional insured on all policies, except Workers' Compensation insurance and Errors & Omissions insurance, and provide that COUNTY may recover for any loss suffered by COUNTY due to CONSULTANT's negligence.

19.2.4. State that it is primary insurance and regards COUNTY as an additional insured and contains a cross-liability or severability of interest clause.

19.2.5. Not be canceled, non-renewed or reduced in scope of coverage until after thirty (30) days written notice has been given to COUNTY. CONSULTANT may not terminate such coverage until it provides COUNTY with proof that equal or better insurance has been secured and is in place. Cancellation or change without prior written consent of COUNTY shall, at the option of COUNTY, be grounds for termination of this Agreement.

19.2.6. If this Agreement remains in effect more than one (1) year from the date of its original execution, COUNTY may, at its sole discretion, require an increase to liability insurance to the level then customary in similar COUNTY Agreements by giving sixty (60) days notice to CONSULTANT.

19.3. Additional Insurance Requirements.

19.3.1. COUNTY is to be notified immediately of all insurance claims. COUNTY is also to be notified if any aggregate insurance limit is exceeded.

19.3.2. The comprehensive or commercial general liability shall contain a provision of endorsements stating that such insurance:

a. Includes contractual liability;

b. Does not contain any exclusions as to loss or damage to property caused by explosion or resulting from collapse of buildings or structures or damage to property underground, commonly referred to by insurers as the "XCU Hazards;"

c. Does not contain a "pro rata" provision which looks to limit the insurer's liability to the total proportion that its policy limits bear to the total coverage available to the insured;

d. Does not contain an "excess only" clause which require the exhaustion of other insurance prior to providing coverage;

e. Does not contain an "escape clause" which extinguishes the insurer's liability if the loss is covered by other insurance;

f. Includes COUNTY as an additional insured.

g. States that it is primary insurance and regards COUNTY as an additional insured and contains a cross-liability or severability of interest clause.

19.4. Deposit of Insurance Policy. Promptly on issuance, reissuance, or renewal of any insurance policy required by this Agreement, CONSULTANT shall, if requested by COUNTY, provide COUNTY satisfactory evidence that insurance policy premiums have been paid together with a duplicate copy of the policy or a certificate evidencing the policy and executed by the insurance company issuing the policy or its authorized agent.

19.5. Certificates of Insurance.

CONSULTANT agrees to provide COUNTY with the following insurance documents on or before the effective date of this Agreement:

19.5.1. Complete copies of certificates of insurance for all required coverages including additional insured endorsements shall be attached hereto as **Exhibit "C"** and incorporated herein.

19.5.2. The documents enumerated in this Paragraph shall be sent to the following:

County of Imperial
Risk Management Department
940 Main Street, Suite 101
El Centro, CA 92243

County of Imperial
Department of Public Works
155 South 11th Street
El Centro, CA 92243

19.6. Additional Insurance. Nothing in this, or any other provision of this Agreement, shall be construed to preclude CONSULTANT from obtaining and maintaining any additional insurance policies in addition to those required pursuant to this Agreement.

20. PREVAILING WAGE.

20.1. CONSULTANT acknowledges that any work that qualifies as a "public work" within the meaning of California Labor Code section 1720 shall cause CONSULTANT, and its sub-consultants, to comply with the provisions of California Labor Code sections 1775 et seq.

20.2. When applicable, copies of the prevailing rate of per diem wages shall be on file at COUNTY's Department of Public Works and available to CONSULTANT and any other interested party upon request. CONSULTANT shall post copies of the prevailing wage rate of per diem wages at the Project site.

20.3. CONSULTANT hereby acknowledges and stipulates to the following:

20.3.1. CONSULTANT has reviewed and agrees to comply with the provisions of Labor Code section 1776 regarding retention and inspection of payroll records and noncompliance penalties; and

20.3.2. CONSULTANT has reviewed and agrees to comply with the provisions of Labor Code section 1777.5 regarding employment of registered apprentices; and

20.3.3. CONSULTANT has reviewed and agrees to comply with the provisions of Labor Code section 1810 regarding the legal day's work; and

20.3.4. CONSULTANT has reviewed and agrees to comply with the provisions of Labor Code section 1813 regarding forfeiture for violations of the maximum hours per day and per week provisions contained in the same chapter.

20.3.5 CONSULTANT has reviewed and agrees to comply with any applicable provisions for those Projects subject to Department of Industrial Relations (DIR) Monitoring and Enforcement of prevailing wages. COUNTY hereby notifies CONSULTANT that CONSULTANT is responsible for complying with the requirements of Senate Bill 854 (SB854) regarding certified payroll record reporting. Further information concerning the requirements of SB854 is available on the DIR website located at: http://www.dir.ca.gov/Public-Works/PublicWorksEnforcement.html.

21. <u>WORKERS' COMPENSATION CERTIFICATION</u>.

21.1. Prior to the commencement of work, CONSULTANT shall sign and file with COUNTY the following certification: "I am aware of the provisions of California Labor Code §§3700 et seq. which require every employer to be insured against liability for workers' compensation or to undertake self-insurance in accordance with the provisions of that code, and I will comply with such provisions before commencing the performance of the work of this contract."

21.2. This certification is included in this Agreement and signature of the Agreement shall constitute signing and filing of the certificate.

21.3. CONSULTANT understands and agrees that any and all employees, regardless of hire date, shall be covered by Workers' Compensation pursuant to statutory requirements prior to beginning work on the Project.

21.4. If CONSULTANT has no employees, initial here: __________.

22. <u>ASSIGNMENT</u>.

Neither this Agreement nor any duties or obligations hereunder shall be assignable by CONSULTANT without the prior written consent of COUNTY. CONSULTANT may employ other specialists to perform services as required with prior approval by COUNTY.

23. <u>NON-DISCRIMINATION</u>.

During the performance of this Agreement, CONSULTANT and its subcontractors shall not unlawfully discriminate, harass or allow harassment against any employee or applicant for employment because of sex, race, color, ancestry, religious creed, national origin, physical disability (including HIV and AIDS), mental disability, medical condition (cancer), age (over forty (40)), marital status and denial of family care leave. CONSULTANT and its subcontractors shall insure that the evaluation and treatment of their employees and applicants for employment are free from such discrimination and harassment. CONSULTANT and its subcontractors shall comply with the provisions of the Fair Employment and Housing Act (Gov. Code §12990 (a-f) et seq.) and the applicable regulations promulgated thereunder (California Code of Regulations, Title 2, §7285 et seq.). The applicable regulations of the Fair Employment and Housing Commission implementing Government Code §12990 (a-f), set forth in Chapter 5 of Division 4 of Title 2 of the California Code of Regulations, are incorporated into this Agreement by reference and made a part hereof as if set forth in full. The applicable regulations of §504 of the Rehabilitation Act of 1973 (29 U.S.C. §794 (a)) are incorporated into this Agreement by reference and made a part hereof as if set forth in full. CONSULTANT and its subconsultants shall give written notice of their obligations under this clause to labor organizations with which they have a collective bargaining or other agreement. CONSULTANT shall include the nondiscrimination and compliance provisions of this clause in all subcontracts to perform work under this Agreement.

24. NOTICES AND REPORTS.

24.1. Any notice and reports under this Agreement shall be in writing and may be given by personal delivery or by mailing by certified mail, addressed as follows:

COUNTY
Director of Public Works
155 South 11th Street
El Centro, CA 92243

County of Imperial
Clerk of the Board of Supervisors
940 W. Main Street, Suite 209
El Centro, CA 92243

CONSULTANT
«Consultant_Business_Name»
«Consultant_Street_Address»
«Consultant_City_State»

24.2. Notice shall be deemed to have been delivered only upon receipt by the Party, seventy-two (72) hours after deposit in the United States mail or twenty-four (24) hours after deposit with an overnight carrier.

24.3. The addressees and addresses for purposes of this paragraph may be changed to any other addressee and address by giving written notice of such change. Unless and until written notice of change of addressee and/or address is delivered in the manner provided in this paragraph, the addressee and address set forth in this Agreement shall continue in effect for all purposes hereunder.

25. ENTIRE AGREEMENT.

This Agreement contains the entire Agreement between COUNTY and CONSULTANT relating to the transactions contemplated hereby and supersedes all prior or contemporaneous agreements, understandings, provisions, negotiations, representations, or statements, either written or oral.

26. <u>MODIFICATION</u>.

No modification, waiver, amendment, discharge, or change of this Agreement shall be valid unless the same is in writing and signed by both Parties.

27. <u>CAPTIONS</u>.

Captions in this Agreement are inserted for convenience of reference only and do not define, describe or limit the scope or the intent of this Agreement or any of the terms thereof.

28. <u>PARTIAL INVALIDITY</u>.

If any provision in this Agreement is held by a court of competent jurisdiction to be invalid, void, or unenforceable, the remaining provisions will nevertheless continue in full force without being impaired or invalidated in any way.

29. <u>GENDER AND INTERPRETATION OF TERMS AND PROVISIONS</u>.

As used in this Agreement and whenever required by the context thereof, each number, both singular and plural, shall include all numbers, and each gender shall include a gender. CONSULTANT as used in this Agreement or in any other document referred to in or made a part of this Agreement shall likewise include the singular and the plural, a corporation, a partnership, individual, firm or person acting in any fiduciary capacity as executor, administrator, trustee or in any other representative capacity or any other entity. All covenants herein contained on the part of CONSULTANT shall be joint and several if more than one person, firm or entity executes the Agreement.

30. <u>WAIVER</u>.

No waiver of any breach or of any of the covenants or conditions of this Agreement shall be construed to be a waiver of any other breach or to be a consent to any further or succeeding breach of the same or any other covenant or condition.

31. <u>CHOICE OF LAW</u>.

This Agreement shall be governed by the laws of the State of California. This Agreement is made and entered into in Imperial County, California. Any action brought by either party with respect to this agreement shall be brought in a court of competent jurisdiction within said County.

32. AUTHORITY.

32.1. Each individual executing this Agreement on behalf of CONSULTANT represents and warrants that:

32.1.1. He/She is duly authorized to execute and deliver this Agreement on behalf of CONSULTANT;

32.1.2. Such execution and delivery is in accordance with the terms of the Articles of Incorporation or Partnership, any by-laws or Resolutions of CONSULTANT and;

32.1.3. This Agreement is binding upon CONSULTANT accordance with its terms.

32.2. CONSULTANT shall deliver to COUNTY evidence acceptable to COUNTY of the foregoing within thirty (30) days of execution of this Agreement.

33. COUNTERPARTS.

This Agreement (as well as any amendments hereto) may be executed in any number of counterparts, each of which when executed shall be an original, and all of which together shall constitute one and the same Agreement. No counterparts shall be effective until all Parties have executed a counterpart hereof.

34. REVIEW OF AGREEMENT TERMS.

34.1. Each Party has received independent legal advice from its attorneys with respect to the advisability of making the representations, warranties, covenants and agreements provided for herein, and with respect to the advisability of executing this Agreement.

34.2. Each Party represents and warrants to and covenants with the other Party that:

34.2.1. This Agreement in its reduction to final written form is a result of extensive good faith negotiations between the Parties and/or their respective legal counsel;

34.2.2. The Parties and their legal counsel have carefully reviewed and examined this Agreement for execution by said Parties; and

34.3. Any statute or rule of construction that ambiguities are to be resolved against the drafting party shall not be employed in the interpretation of this Agreement.

35. NON-APPROPRIATION.

This Agreement is based upon the availability of public funding. In the event that public funds are unavailable and not appropriated for the performance of the services set forth in this Agreement, the Agreement shall be terminated without penalty after written notice to CONSULTANT of the unavailability and/or non-appropriation of funds.

IN WITNESS WHEREOF, the Parties have executed this Agreement on the day and year first above written.

County of Imperial

By:________________________________
Ryan E. Kelley, Chairman
Imperial County Board of Supervisors

«Consultant_Business_Name»

By:________________________________
«Consultant_Name_for_Signature»

ATTEST:

____
Blanca Acosta, Clerk of the Board,
County of Imperial, State of California

APPROVED AS TO FORM:

Katherine Turner,
County Counsel

By:__________________________
«CC_Attorney»,
«CC_Attorney_Title»

MINIMUM INSURANCE AMOUNTS

Consultant contract (Agreement for Services) form and content is included.

Insurance Minimum Amounts *

Insurance	Minimum Limit *
Errors & Omissions/Professional Liability	$2 million per occurrence
Workers Compensation, Coverage A	Statutory
Employers Liability, Coverage B	$1 million
Commercial General Liability	
(Including Contractual Liability):	
Bodily Injury	$1 million per occurrence $2 million aggregate
Property Damage	$1 million per occurrence $2 million aggregate
Comprehensive Automobile Liability	
(Owned, hired & non-owned vehicles) Bodily Injury	$1 million per occurrence
Property Damage	$1 million per occurrence

An endorsement covering any explosion collapse and underground exposures, "XCU", in the Commercial General Liability policy is also required.

*Minimums subject to additional review after Consultant is selected.

EXHIBIT D

2010 SEELEY AREA DRAINAGE MASTER PLAN

SEELEY AREA
DRAINAGE MASTER PLAN

Job Number 16101
June 2010

SEELEY AREA
DRAINAGE MASTER PLAN

JUNE 2010

Prepared For:

Imperial County
Planning & Development Services
801 Main Street
El Centro, California 92243

Ms. Esperanza Malagon Colio
(760) 482-4986

Dennis C. Bowling, M.S.
R.C.E. #32838
Exp 06/12

Prepared by:

Rick Engineering Company
Water Resources Division
5620 Friars Road
San Diego, California 92110
(619) 291-0707
www.rickengineering.com

Job Number 16101
DCB:JM:vs:reports/.005

TABLE OF CONTENTS

1.0 INTRODUCTION

This document summarizes the findings of the Drainage Master Plan (DMP) prepared for the Community of Seeley, California, located within Imperial County. The California Housing and Community Development Department (HCD) through its Community Development Block Grant (CDBG) funded the development of this DMP.

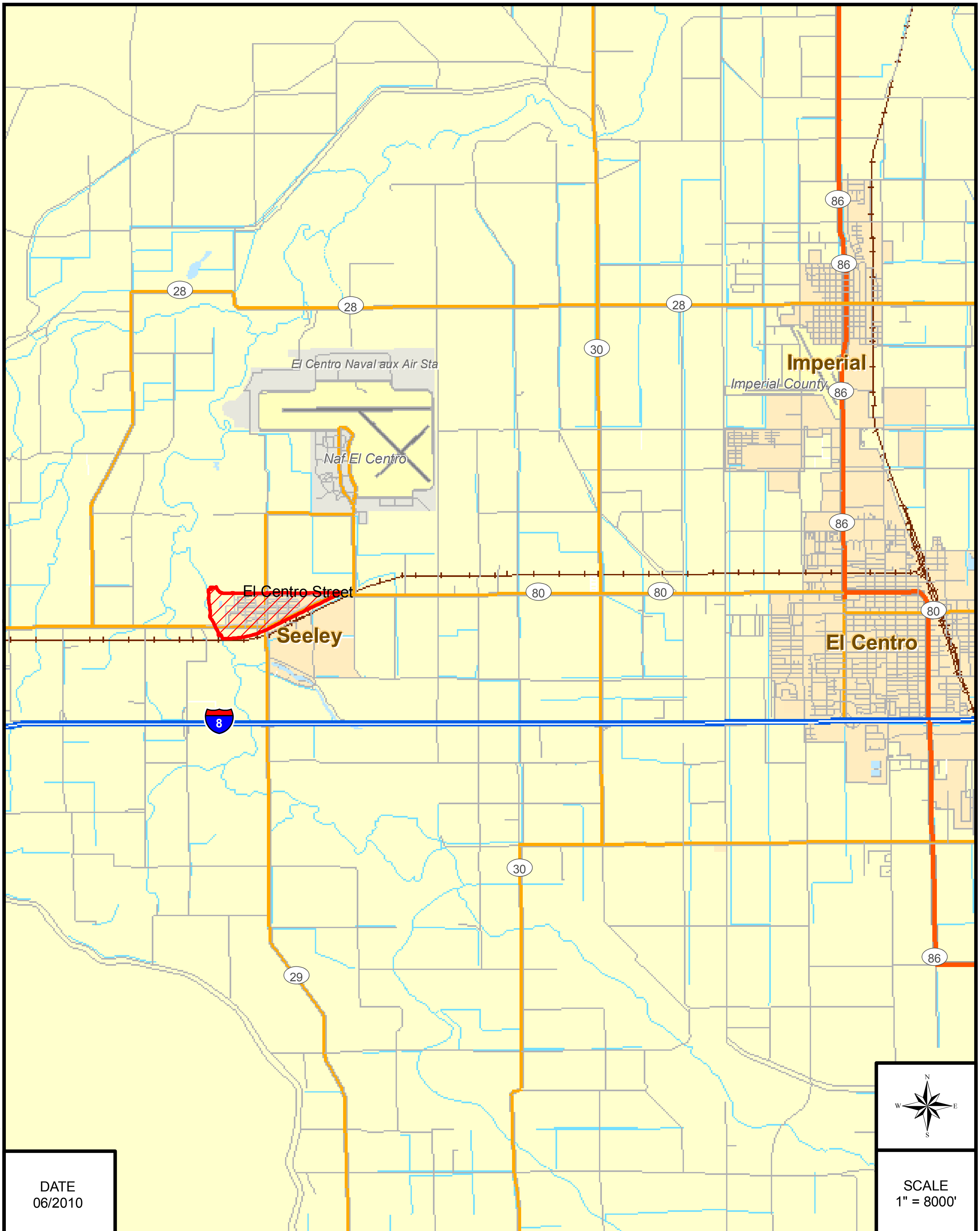
1.1 Purpose of DMP

The purpose of this DMP is to identify current drainage and flooding characteristics within the Community of Seeley, and determine recommended drainage improvements to reduce flood hazards and improve public safety. Drainage improvements recommended in this report will be based on the criteria outlined in the current Imperial County design standards.

The following information is provided within this DMP:

- Existing Condition topographic information for the Seeley Community, as of March 2009.
- Existing Condition 25-year and 100-year peak flow rates and drainage patterns
- Ultimate anticipated 25-year and 100-year peak flow rates and drainage patterns
- Recommended drainage improvements including storm drains, inlets, retention areas, and outlet locations.
- Opinion of probable construction costs for each recommended phase of the drainage improvements
- Prioritization of recommended drainage improvements for implementation

The results of the DMP calculations were used to develop a Capital Improvement Program Report that outlines the recommended drainage improvements for implementation, and is attached with this DMP as Appendix D.



W:\16101\GIS\16101_VicinityMap_9-3.mxd

DATE
06/2010

SCALE
1" = 8000'

IMPERIAL COUNTY CALIFORNIA 1907

Seeley Area Drainage Master Plan
Vicinity Map

RICK ENGINEERING COMPANY

5620 Friars Road
San Diego, CA 92110-2596
www.rickengineering.com

EXHIBIT
1.2

1.3 Computer Programs

The following computer programs were used for preparation of the Seeley Area DMP:

- AutoCAD 2002
- US Army Corps of Engineers, Hydrologic Engineering Center - Hydrologic Modeling System, HEC-HMS v. 3.3.
- ArcGIS, version 9
- Microsoft Excel

1.4 Limitations

The Seeley Area DMP is a comprehensive plan for future drainage needs within the Seeley Community. This report has been prepared for master planning purposes only, as a guide for engineers, planners, developers, and County staff. Detailed engineering calculations and investigations should be prepared for the implementation of any of the facilities outlined in this study.

2.0 PROJECT APPROACH

The Seeley Area DMP covers approximately 0.556 square miles (356 Acres) of the developed area within Seeley, California, known as the Seeley Townsite. The limits of the DMP are shown on the Vicinity map in Section 1.0. Seeley is located approximately 8 miles west of El Centro and 1.5 miles North of Interstate-8, within Imperial County California. Seeley is bordered on the west by the New River.

2.1 Previous Drainage Plan

A previous drainage master plan titled "Seeley Streets Overlay and Drainage Plan" was prepared circa 1975, for the Seeley Area (Reference 9). The previous plan recommended the use of drainage swales along major roadways as the method for conveying storm runoff to the New River. The improvements recommended in the previous study were constructed and as-built in 1979. However, this design approach did not take into consideration public safety factors related to the proximity to the local schools, etc. In addition, the terrain within the Community of Seeley is very flat, and therefore, a significant amount of ponding occurs within the streets and low-lying areas during and after rainfall events.

2.2 HEC-HMS Program

The hydrologic modeling was prepared using US Army Corps of Engineers, Hydrologic Engineering Center - Hydrologic Modeling System, HEC-HMS v. 3.3. HEC-HMS is public domain software designed for modeling the precipitation-runoff processes that occur in watershed systems. It is designed to be applicable in a wide range of geographic areas including for use in small urban or natural watershed runoff situations. Hydrographs produced by HEC-HMS can be used directly or in conjunction with other software for studies of urban drainage, future urbanization impact, reservoir design, flood damage reduction, floodplain regulation, drainage master planning.

2.3 GIS Data Processing

GIS tools were utilized to calculate spatial factors related to the development of the hydrologic modeling for the Seeley Area. Information including land use, hydrologic soil data, and terrain information were compared with existing drainage patterns and drainage areas to calculate factors such as runoff length, slope, time of concentration, drainage area, curve number, and percent impervious. Detailed discussion of the hydrologic parameters used in the preparation of this DMP is included in Section 3.0 of this report.

3.0 SUMMARY OF BASE INFORMATION

The following provides a summary of the base information used in the preparation of the Seeley Area DMP. Rick Engineering Company is not responsible for any future changes to the topographic information, land use information, drainage facilities, or any other base information used in the preparation of this DMP that may occur after the preparation of this report.

3.1 TOPOGRAPHY & ORTHO IMAGERY

The following summarizes the source information of the base topography generated for the preparation of the DMP:

Date of Survey:	March 24, 2009
Contour Interval:	1-Foot
Horizontal Datum:	NAD 83, CCS Zone 6, 2007.0 EPOCH
Vertical Datum:	NAVD 88

Date of Photography:	March 24, 2009
Approximate Photo Scale:	1”= 300’
Pizel Size:	0.25 feet

It should be noted that the elevations in the Seeley Community are below Sea Level. Therefore, 1,000 vertical feet were added to the elevations in Seeley. The adjusted elevations range from 899 feet to 967.5 feet.

3.1.1 DRAINAGE BASIN BOUNDARIES

Hydrologic modeling for the Seeley area was prepared utilizing the base topography obtained for this project. The limits of the overall drainage study, and corresponding drainage basin boundaries were confined to the surveyed topographic area and were determined based on the high points surrounding the Seeley area. The terrain within the Seeley Townsite identified that no significant drainage areas outside of the townsite limits flow into the community of Seeley due to the existing topography and the existence of Imperial Irrigation District canals along the northern limit of the community that prevent run-on from adjacent areas. The watershed tributary to the New River was not analyzed in this study.

3.2 PRECIPITATION DATA

2-year and 100-year precipitation values were obtained from the Imperial Irrigation District (IID) DRAFT Hydrology Manual (Reference 7), Figures B-1 through B-4. Table 3.2.1 summarizes the precipitation information obtained from the IID manual.

3.2.1 TABLE OF PRECIPITATION INFORMATION

Duration	Precipitation (Inches)	
	2-Year	100-Year
1-hour	0.38	1.35
24-Hour	0.96	2.80

3.2.2 INTENSITY-DURATION CALCULATIONS

The rainfall intensity at differing durations storms is required for modeling the 25-year and 100-year storm events reflected in this DMP. Therefore, the following formula was utilized to convert the above noted precipitation values into intensities at varying storm durations.

For storm durations less than 1-hour:

$$\mathbf{Yp = Y_2 + [\ (Y_{100} - Y_2) * Kp\ ] / 263}$$

where:

Kp = Constant associated w/ Return Period P

5-yr = 65 10-yr = 108
25-yr = 164 50-yr = 215

Y2 = Intensity associated with the 2-year return period

Y100 = Intensity associated with the 100-year return period

Yp = Intensity at Return Period P

The Kp value for the 25-year storm event was obtained from Appendix II and Figure D-4 in the DRAFT IID Hydrology Manual.

For storm durations between 1-hour and 24-hours logarithmic interpolation was utilized to determine intermediate values from the precipitation depths shown in Table 3.2.1. Additional guidance on the development of rainfall depths and intensities for varying storm events can be found in Section D of the Imperial Irrigation District DRAFT Hydrology Manual (Reference 7).

3.2.3 TABLE OF CALCULATED INTENSITY AND PRECIPITATION INFORMATION

	Intensity (Inches/Hour)			Precipitation (Inches)		
Duration	2-Year	25-Year	100-Year	2-Year	25-Year	100-Year
5-min	1.50	3.90	5.35	0.13	0.33	0.45
15-min	0.91	2.36	3.24	0.23	0.59	0.81
60-min	0.38	0.98	1.35	**0.38**	0.98	**1.35**
120-min	0.23	0.58	0.79	0.47	1.16	1.58
180-min	0.17	0.43	0.58	0.52	1.28	1.74
360-min	0.11	0.25	0.34	0.64	1.49	2.04
720-min	0.07	0.15	0.20	0.78	1.74	2.39
1440-min	0.04	0.09	0.12	**0.96**	2.11	**2.80**

The methodology used to calculate the intensities shown in Table 3.2.3 are described in section 3.2.2 of this report. Precipitation values for other than the 2-year and 100-year, 1-hour and 24-hour duration storms were calculated based on multiplying intensity (inches/hour) times duration (hours), to determine the precipitation in inches.

3.3 LAND USE

Hydrologic modeling for the Seeley area was prepared based on two land use scenarios, the current condition as of the authoring of this report and the ultimate planned development within the study area.

3.3.1 EXISTING CONDITION (ZONING)

Existing Condition Land Use data was provided by Imperial County, as shown on the land use zoning "Map 9A" dated May 11, 2006. The land use zoning was compared with the aerial imagery obtained March 2009, and currently vacant parcels of significant size were manually designated as "open space" for the existing condition land use. Exhibit 3.4.1 shows the Existing Land Use zoning designation used for the hydrologic modeling. Table 4.1.2 summarizes the curve number assigned to each land use category

3.3.2 ULTIMATE CONDITION (GENERAL PLAN)

Ultimate Condition (General Plan) Land Use data was provided by Imperial County, as shown on the exhibit titled "Seeley Urban Area Map" dated September 13, 2004. The general plan land use data was compared with the current condition land use zoning to identify areas of future development or redevelopment. The impacts of the future development were incorporated into the design of the recommended drainage improvements. Exhibit 3.4.2 shows the General Plan Land Use designation used for the hydrologic modeling. Table 4.1.2 summarizes the curve number assigned to each land use category

3.3.3 ASSESSOR'S PARCEL DATA

Assessor's parcel data for the Seeley Area was obtained from the Imperial County GIS division on October 8, 2009. The Assessor's parcel data was utilized to identify approximate existing road right of way, locations of publicly owned parcels, and limits of land use/zoning designations. The assessors parcel boundaries are shown for reference on the exhibits within this report.

3.4 HYDROLOGIC SOIL TYPE

The Seeley Area DMP was prepared taking into consideration the hydrologic soil type in the determination of the loss rates and curve numbers within the watershed. SSURGO 2008 Soil data was obtained from the Natural Resources Conservation Service (NRCS) Soil Data Mart (Reference 4), which includes a classification of soil types ranging from type A to type D. The soil types within the limits of the study area are primarily type C soils with some type D along the New River corridor.

The following summarizes the hydrologic characteristics of the differing soil groups:

Type A: Low Runoff Potential. Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep , well-drained sands or gravels. These soils have a high rate of water transmission.

Type B: Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well-drained sandy-loam soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

Type C: Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of silty-loam soils with a layer that impedes downward movement of water, or soils with moderately-fine to fine texture. These soils have a slow rate of water transmission.

Type D: High Runoff Potential. Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

DATE 06/2010

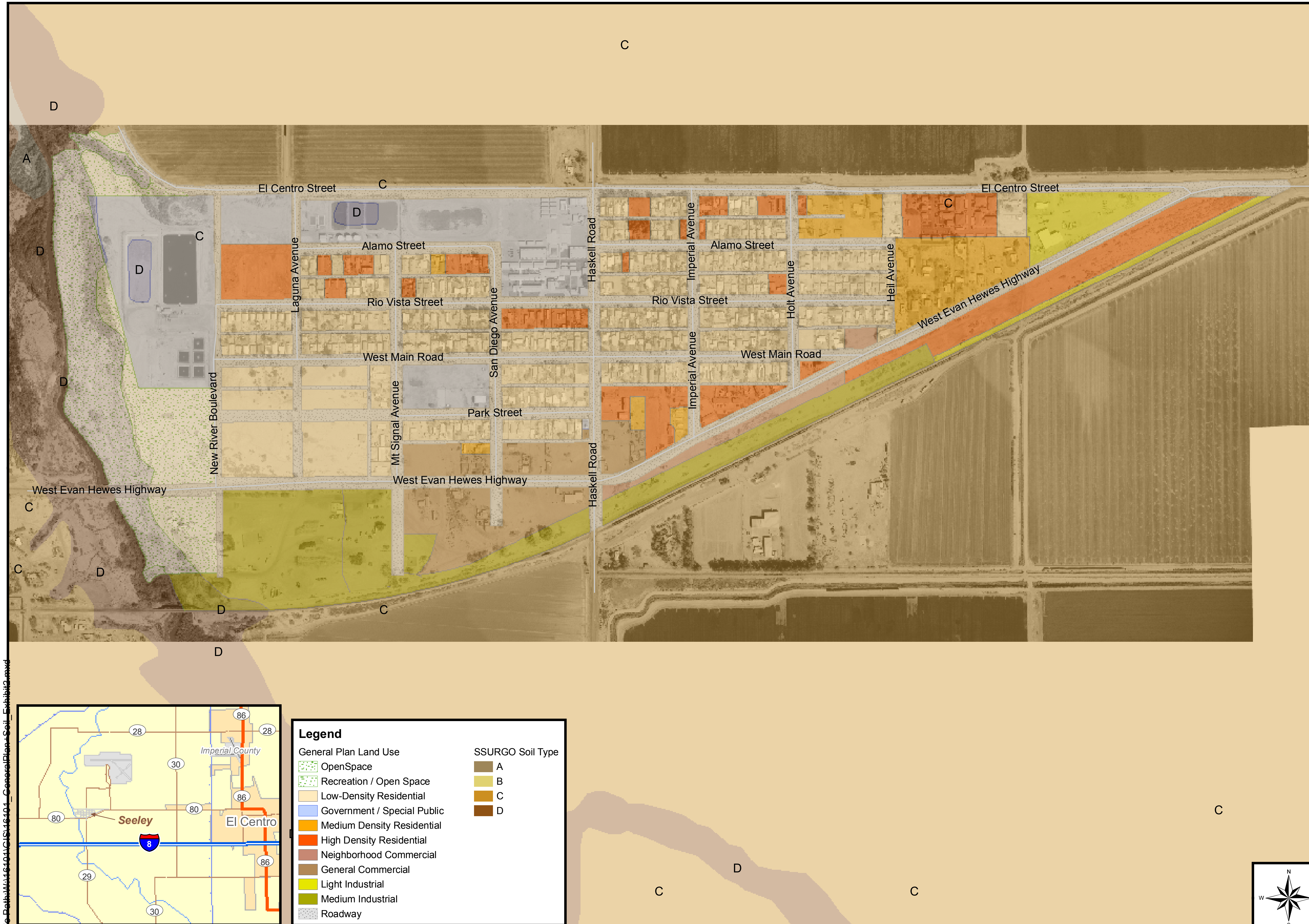
SCALE 1" = 600'

RICK ENGINEERING COMPANY
5620 Friars Road
San Diego, CA 92110-2596
www.rickengineering.com

Seeley Area Drainage Master Plan
Existing Land Use Zoning and Hydrologic Soil Data

EXHIBIT
3.4.1

File Path:W:\16101\GIS\16101_ExistingZoning+Soil_Exhibit1.mxd



File Path:W:\16101\GIS\16101_GeneralPlan+Soil_Exhibit2.mxd

DATE
06/2010

SCALE
1" = 600'

RICK ENGINEERING COMPANY
5620 Friars Road
San Diego, CA 92110-2596
www.rickengineering.com

Seeley Area Drainage Master Plan
General Plan Land Use Zoning
and Hydrologic Soil Data

EXHIBIT
3.4.2

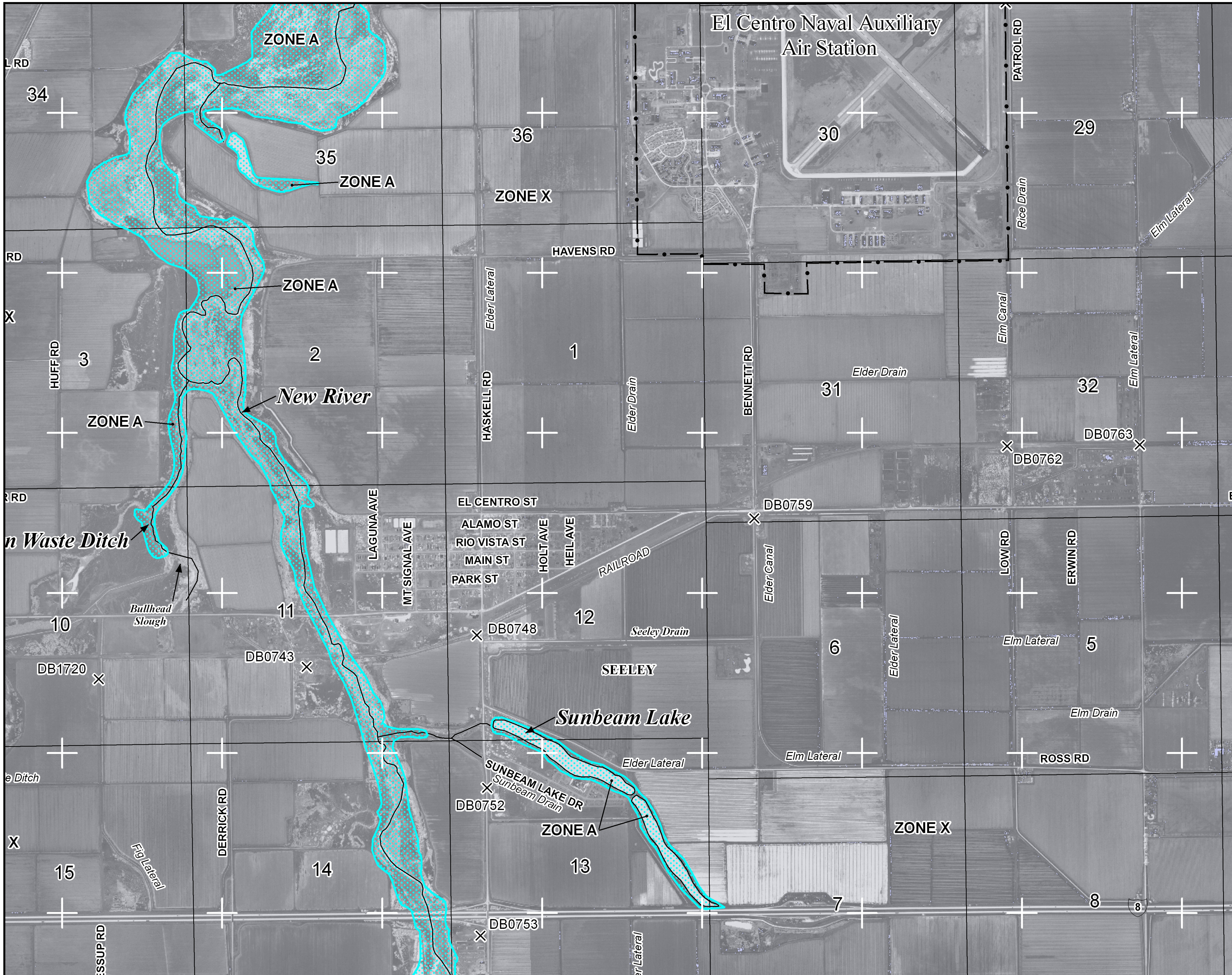
3.5 EXISTING DRAINAGE FACILITIES

A minimal number of engineered drainage structures currently exist within the Community of Seeley. Some recently constructed developments have included design and construction of on-site retention basins in accordance with Imperial County Criteria. In addition, there are a few isolated locations where drain inlets and storm drains have been constructed, however these systems function as retention facilities by storing runoff from the tributary areas as they have no identified discharge locations. The existing condition hydrologic analysis within this DMP considers the impact of the known retention facilities in developing the peak discharges for the study area. Currently there are no constructed or engineered drainage outlets into the New River. Runoff discharges to the New River via overland flow.

3.6 NATIONAL FLOOD INSURANCE PROGRAM

Imperial County is a participant in the National Flood Insurance Program (NFIP), which provides flood insurance and oversees floodplain management regulations to reduce the potential for flood damages. The Federal Emergency Management Agency (FEMA) manages the NFIP.

The FEMA Special Flood Hazard Area (SFHA) for Seeley is identified on Flood Insurance Rate Map (FIRM) panel No 06025C1700C, effective September 26, 2008, attached as Exhibit 3.6.1. The FIRM identifies portions of the New River as a Zone A floodplain, indicating areas subject to inundation by the 1-percent-annual-chance flood event generally determined using approximate methodologies. The FIRM also identifies the remaining areas of the FIRM as Zone X (unshaded), indicating areas of minimal flood hazard, which are the areas outside the SFHA and higher than the elevation of the 0.2-percent-annual-chance flood. Any future construction activities within the limits of the SFHA are required to comply with the requirements of FEMA and the NFIP.



MAP SCALE 1" = 2000'

0 2000 4000 FEET

METERS

NFIP

PANEL 1700C

NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

IMPERIAL COUNTY, CALIFORNIA

AND INCORPORATED AREAS

PANEL 1700 OF 2300

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
IMPERIAL COUNTY, UNINCORPORATED AREAS	060065	1700	C

Notice to User: The **Map Number** shown below should be used when placing map orders: the **Community Number** shown above should be used on insurance applications for the subject

MAP NUMBER
06025C1700C

EFFECTIVE DATE
SEPTEMBER 26, 2008

Federal Emergency Management Agency

Exhibit 3.6.1

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

4.0 HYDROLOGIC METHODOLOGY

Hydrologic Modeling for the Community of Seeley study area was prepared following the criteria outlined in the Imperial Irrigation District (IID) DRAFT Hydrology Manual (Reference 7). Rational method precipitation and intensity information was utilized to reflect peak runoff consistent with rational method calculations, however NRCS (SCS) modeling parameters were utilized to reflect the volume of runoff generated by the watershed and to incorporate the impacts of storage and attenuation on peak flows.

4.1 NRCS (SCS) METHODOLOGY

The Natural Resources Conservation Service (NRCS), formerly known as the Soil Conservation Service (SCS) developed an approach to calculate runoff from a tributary watershed as a function of the drainage area, precipitation, initial abstraction, soil storage potential, and runoff curve number.

4.1.1 CURVE NUMBER

Curve Number for each watershed was calculated as a function of the land use within each area and the hydrologic soil type. Runoff Curve Numbers are an indication of runoff potential for a given area. The higher the Curve Number for a given watershed, the higher the runoff potential. Runoff Curve Numbers were determined based on from Figure C-2 of DRAFT IID Hydrology Manual and Table 2-2a in TR-55 (Reference 8). A detailed description of the runoff curve number values assigned to each land use designation is included in Table 4.1.2.

4.1.2 TABLE OF CALCULATED CURVE NUMBERS BASED ON LAND USE

Existing Condition Land Use Designation	Category	General Plan Land Use	Description	Estimated % Impervious *	Curve Number (AMC II)**	
					Type C Soil	Type D Soil
Openspace – Annual Grasses	OS	Open Space	Poor cover	0%	86	89
Low Density Residential (LDR)	R1	Low-Density Residential	1 DU/Parcel (max density 5 du/acre)	50%	90	92
Medium Density Residential (MDR)	R2	Medium Density Residential	1 – 2 DU/Parcel – duplexes (max density 10 du/acre)	70%	94	95
Medium-High Density Residential	R3	- -	2+ Du/Parcel (max density 29 du/acre)	75%	95	96
High Density Residential and Mobile Homes	R4	High Density Residential	Mobile home parks	85%	96	97
Light Commercial	C1	Neighborhood Commercial	In residential areas	85%	96	97
General Commercial	C2	General Commercial	Along highways, shopping centers	90%	97	98
Government/Special	GS-S	Government/Special	School	70%	94	95
	GS	Government/Special	Other G/S lands	80%-95%	96-98	97-98
Light Industrial	M1	Light Industrial	Storage & manufacturing	90%	97	98
Medium Industrial	M2	Medium Industrial	- -	95%	98	98
Roadway/Paved	ROAD	Roadway	Roadway Paved	98%	98	98

** Estimated % Impervious obtained from Figure C-3 of DRAFT IID Manual*
*** Curve Number obtained from Figure C-2 of DRAFT IID Manual and Table 2-2a in TR-55 (Reference 8)*

4.1.3 TIME OF CONCENTRATION

To generate a hydrograph for small watersheds, less than one square mile, Lag times utilized in SCS methodology are frequently calculated as a function of Time of Concentration (Tc). Time of Concentration (Tc) for each watershed was calculated based on the Time of Concentration Nomograph for the Rational method, using the following formula:

$$\mathbf{Tc = K\,(L^3/H)^{0.2}}$$

Where:

Tc = Time of Concentration (minutes)

K = is a function of % impervious for the basin

L = is the length of the longest flowpath within the basin

H = the elevation change (ΔE) along the longest flowpath.

The K value for each percent impervious was obtained from Appendix II and Figure D-1 in the DRAFT IID Hydrology Manual, and is summarized below.

% Impervious	K
90	0.304
80	0.324
75	0.336
65	0.360
60	0.374
50	0.389
40	0.412
30	0.438
20	0.469
15	0.483
10	0.487
0 (Poor Cover)	0.525
0 (Fair Cover)	0.706
0 (Good Cover)	0.935

4.1.4 LAG

Lag was then computed from the following formula:

Lag = 0.8 Tc / 60

Where:

Lag = is the basin Lag time (hours)

Tc = Time of Concentration (minutes)

The Time of Concentration and Lag calculations were performed in accordance with the Imperial Irrigation District DRAFT Hydrology Manual.

4.2 HEC-HMS PARAMETERS

BASIN MODEL:

Loss Methodology:	SCS Curve Number, with AMC II
Transform:	Standard SCS Unit Hydrograph (Lag)
Channel Routing:	Muskingum-Cunge

METEOROLOGICAL MODEL:

Intensity Position:	2/3 of hydrograph (67%) – equating to approximately hour 16 of a 24-hour storm.
Storms Modeled:	25-year, 24-hr – Precipitation = 2.11 inches 100-year, 24-hr – Precipitation = 2.80 inches “Frequency Storm”

5.0 EXISTING CONDITION HYDROLOGIC MODELING

The existing basin routing for the previously constructed "Seeley Streets Overlay and Drainage Plan" (Reference 9) was compared to the current terrain and watershed delineations. In general, the existing terrain and basin routing corresponded with the previous drainage plan. However, based on the topographic information, the existing routing was slightly different in the following areas:

- Laguna Avenue, between Alamo St. and Rio Vista St.
- Signal Avenue, between Park St. and Main St.
- Haskell Road, between Park St. and Rio Vista St., and between Alamo St. and El Centro St.
- Imperial Avenue between Rio Vista St. and Alamo St
- Evan Hewes Highway between Mt. Signal Avenue and San Diego Avenue, and between Haskell Road and Holt Avenue.

The results of the Existing Condition Hydrologic Modeling, including flowrates and flow paths, are shown on the Existing Condition Hydrologic Exhibit included as Appendix B of this Report and summarize 25-year and 100-year peak flow rates within the townsite.

5.1 EXISTING RETENTION AREAS

The locations of existing retention areas were determined through the use of the existing topography, and survey points of existing structures. The volumes of the above ground retention facilities were calculated from the existing topography, while the volumes of the underground facilities were calculated based on the surveyed pipe size and length between the survey points. The routing in the model was set up so that the runoff tributary to these areas would not contribute to the downstream routing, until the retention volume was full, at which time the flowrate of the runoff exiting the retention area would equal the flow rate of runoff entering the retention area. The existing retention areas have been identified on the Existing Condition Hydrologic Exhibit in Appendix B.

5.2 SURFACE STORAGE

Based on the existing topography within the Seeley townsite area, it was evident that there are localized sump areas where surface storage will occur. In the areas where more significant storage occurs, typically streets and low-lying areas, the volumes were calculated based on the existing topography. The impact of surface storage was incorporated into the hydrologic modeling by allowing these areas to pond and store runoff before contributing the tributary runoff to the downstream routing. The existing surface storage areas have been identified on the Existing Condition Hydrologic Exhibit in Appendix B.

6.0 ULTIMATE CONDITION HYDROLOGIC MODELING

Ultimate Condition hydrologic modeling was prepared to reflect the ultimate planned land uses within the watersheds, as identified in the Imperial County General plan for the Seeley area, including:

- Future roadway improvements reflecting construction of curb and gutter throughout the community,
- Development of currently vacant land, consistent with the general plan land uses in the study area,
- Construction of private retention facilities assumed to be constructed in conjunction with new multiple lot residential developments and on all new commercial and industrial developments areas
- Construction of drainage infrastructure to convey the 25-year storm discharges.

The results of the Ultimate Condition Hydrologic Modeling are shown on the Ultimate Condition Hydrologic Exhibit included as Appendix C of this Report and summarize 25-year and 100-year peak flow rates within the townsite. This exhibit also includes the locations and sizes of the recommended drainage improvements and anticipated retention areas within the study.

6.1 ROADWAY IMPROVEMENTS

Currently minimal curb-and-gutter exists within the study area, and flow is conveyed in roadway swales along the edges of the pavement sections. The ultimate condition hydrologic modeling reflects the construction of curb-and-gutter throughout the Community of Seeley.

The majority of the roadways within the Seeley study area are classified as a "Local Road", with only a few major roadways classified as "Major Collector" and "Prime Arterial." Major Collector roadways include Rio Vista Street, and Haskell Road. Drainage Improvements were recommended in locations where the roadway capacity would likely be exceeded in a 25-year storm event.

Hydrologic routing for the ultimate condition hydrologic modeling reflects roadway geometries based on the roadway classifications identified in the Imperial County Engineering Design Guidelines Manual (Reference 3), which are summarized in Table 6.1.1.

6.1.1 TABLE SHOWING PLANNED ROAD CLASSIFICATIONS

Road Classification	Width* (feet)	Curb Height (Inches)
Local Road	40	6
Major Collector	64	6
Prime Arterial	106	6

*Width (ft) represents width of paved road (curb to curb), and does not include right of way.

6.2 RETENTION CRITERIA FOR FUTURE DEVELOPMENTS

Imperial County currently has retention criteria in place for new development projects as cited in Section III-A of the Imperial County Engineering Design Guidelines Manual. For the purposes of this drainage master plan, retention was assumed to be implemented for all new multiple lot residential developments, commercial developments, and industrial developments. However, retention was not assumed on individual residential lots that may currently be vacant but are zoned for use as single-family residential.

Future retention systems are not included in the construction cost estimates, as they are anticipated to remain private systems and not constructed or maintained by Imperial County, but were included in the Ultimate Condition Hydrologic Modeling. Drainage areas where future retention has been accounted for are identified on the Ultimate Condition Hydrologic Exhibit included in Appendix C.

6.3 DRAINAGE INFRASTRUCTURE

Recommended drainage improvements have been identified within the Community of Seeley, with the goal of providing 25-year flood protection for portions of the community where the flow cannot be contained within the road right-of-way, or in areas of public safety concern.

6.3.1 STORM DRAIN DESIGN CRITERIA

The following Criteria were considered when determining the location and sizes of the recommended drainage improvements:

- Minimum Pipe Slopes shall be 0.001 (0.1%) per Imperial County Standards
- Slopes of recommended pipes designed at 0.0015 (0.15%)
- Cleanout Spacing:
  - 300 feet maximum spacing pipes < 48-inches in diameter
  - 500 feet maximum spacing for pipes ≥ 48-inches in diameter
- 30-inches minimum cover depth is required
- Manning's Roughness Coefficient, n = 0.013

6.3.2 STORM DRAIN SIZING

The following table relates the pipe sizes specified for the recommended storm drain facilities along with their respective capacities at their proposed slope of 0.15%.

Pipe Diameter (inches)	Slope (%)	Capacity (cfs)*
24	0.15	7.9
36	0.15	23.2
48	0.15	50.1
60	0.15	90.8
72	0.15	147.6
84	0.15	222.6
96	0.15	317.8

*Capacity based on Manning's Equation with friction slope adjusted to 90% of pipe slope, to reflect assumed hydraulic losses of 10%.

6.3.3 INLET SIZING

The following criteria were considered when determining the minimum number of inlets recommended for each phase of drainage improvements:

- Curb Inlets at a sump condition should be designed for two (2) cfs per lineal foot of opening when headwater may rise to top of curb.
- Curb inlets on a continuous grade should be designed based on the following equation:

$$\mathbf{Q = 0.7L(A+Y)^{3/2}}$$

Where:

Y= depth of flow in approach gutter in feet

A = depth of depression of flow line at inlet in feet

L = length of clear opening in feet (maximum 30 feet)

Q = flow in CFS

Detailed Inlet Sizing calculations were not performed for the recommended facilities; however, a minimum number of inlets were assumed associated with the construction of each storm drain segment to intercept the 25-year storm flows. Detailed calculations will be required during final design of any drainage improvements to identify the need for additional storm drain inlets within the drainage system to maintain required flow depth and dry lane requirements within the roadways.

7.0 RECOMMENDED DRAINAGE IMPROVEMENTS

The following summarizes the recommended drainage improvements identified within the Seeley Area Drainage Master Plan study area. Recommended drainage improvements were sized to convey the 25-Year Storm Event. Appendix D of this document serves as a detailed summary of each improvement, including cost estimates and an exhibit showing the limits of the improvement. The location, limits, and costs associated with each phase of the recommended drainage improvement are based on preliminary drainage master plan information. Detailed investigations into potential utility conflicts, right-of-way needs, constructability, and or environmental impacts should be investigated prior to the construction of each project, and may impact the design and/or cost of each project.

7.1 PRIORITIZATION OF IMPROVEMENTS

This DMP anticipates construction of the recommends drainage improvements will occur as a phased approach to improving drainage within the Seeley area. The recommended drainage improvements have been identified as 7 specific phases of construction, or drainage improvement projects. The phase limits are based on providing flood protection benefits with each phase, as well as identifying logical locations for the limits of improvement. The following items were considered when prioritizing the recommended drainage improvements:

- Public Safety,
- Need for downstream improvements prior to implementation,
- Tributary drainage area,
- Property that would be protected by the drainage improvement, and whether it is currently developed or undeveloped.

7.2 CONSTRUCTION COST ESTIMATES

Preliminary opinions of the probable construction costs were prepared for each identified improvement project. The facility quantities and costs presented are preliminary and should only be used for planning purposes. A summary of the assumptions associated with the development of the probable construction costs are included in the Capital Improvement Program Report attached as Appendix D of this DMP.

7.3 TABLE OF RECOMMENDED DRAINAGE IMPROVEMENTS

Project ID	Location	Maximum Q_{25}	Maximum Q_{100}	Pipe Sizes	Total Length	Number of Inlets	Number of Cleanouts	Estimated Cost
SD-01	Rio Vista Street, Haskell Road, San Diego Avenue	220 cfs	319 cfs	36”-84”	4,512 ft	12	15	$7,828,700
SD-02	Rio Vista Street, Imperial Avenue	116 cfs	146 cfs	24”-72”	1,853 ft	8	9	$2,096,700
SD-03	San Diego Avenue, Park Street	54 cfs	77 cfs	36”-48”	1,547 ft	9	6	$1,110,700
SD-04	Rio Vista Street, Holt Avenue, West Main Road, Evan Hewes Highway	72 cfs	106 cfs	36”-60”	1,769 ft	5	8	$1,619,900
SD-05	Holt Avenue, El Centro Street	46 cfs	70 cfs	36”-48”	2,228 ft	8	9	$1,619,500
SD-06	Laguna Avenue	19 cfs	29 cfs	36”	804 ft	4	4	$555,700
SD-07	Evan Hewes Highway	39 cfs	55 cfs	36”-48”	3,477 ft	5	11	$3,210,400

The Projects in this table are listed in the recommended order of priority.
Detailed Descriptions of the Project limits, location, and cost estimates are included in the CIP Report as Appendix D of this report..

8.0 SUMMARY

This report presents a summary of the existing condition and ultimate condition 25-year and 100-year peak discharges within the Community of Seeley, in Imperial County, California. This report also identifies recommended drainage improvements with the goal of providing 25-year storm drain infrastructure within the study area, and alleviating current flooding concerns within the community. Hydrologic calculations were prepared using HEC-HMS, and runoff calculations were performed based on the criteria outlined in the Imperial Irrigation District DRAFT Hydrology Manual.

The recommended drainage improvements identified in this report were prioritized in an order of recommended construction from SD-01 (the first recommended phase) to SD-07 (the final recommended phase). The drainage improvements were prioritized based on the necessity to construct downstream facilities first, and on the public safety issue of reducing flooding first in the areas historically subject to the most flooding and that convey the most water, such as Rio Vista Street.

The results of this Drainage Master Plan report were used to prepare a Capital Improvement Program report, which is attached as Appendix D, summarizing each recommended drainage improvement project, the associated construction cost, and the recommended order of construction.

This report has been prepared for master planning purposes only, as a guide for engineers, planners, developers, and County staff. The recommendations outlined in this report are preliminary and the recommended locations, facility sizes, alignments, and costs should be re-evaluated during final design of each improvement phase.

9.0 REFERENCES

1. *Hydrologic Modeling System HEC-HMS User Manual (CPD-74A),* prepared by The U.S. Army Corps of Engineers, Hydrologic Engineering Center, Version 3.3, September 2008.

2. *Flood Insurance Study for Imperial County, California, and Incorporated Areas,* prepared by the Federal Emergency Management Agency (FEMA), September 26, 2008.

3. *Engineering Design Guidelines Manual for the Preparation and Checking of Street Improvement, Drainage and Grading Plans Within Imperial County,* County of Imperial Department of Public Works, September 15, 2008.

4. *Soil Survey Geographic (SSURGO) database for Imperial County, California, Imperial Valley Area (CA683),* prepared by the U.S. Department of Agriculture, Natural Resources Conservation Service, January 2008, URL:<http://SoilDataMart.nrcs.usda.gov/>

5. *Imperial County Land Use Zoning, Townsite of Seeley, Map 9A,* prepared by Imperial County Planning Department, revised May 11, 2006.

6. *Imperial County General Plan, Seeley Urban Area Map, Figure 1,* prepared by Imperial County Planning Department, revised September 13, 2004.

7. *Imperial Irrigation District, DRAFT Preliminary Drainage Master Plan, Hydrology Manual*, prepared by Black & Veatch, November 1994.

8. *TR-55: Urban Hydrology for Small Watersheds*, prepared by the U.S. Department of Agriculture, Soil Conservation Service, June 1986.

9. *Seeley Streets Overlay and Drainage Plan (M-572),* prepared by the Imperial County Department of Public Works, As-Built May 9, 1979.

APPENDIX A

CD CONTAINING DIGITAL HEC-RAS, GIS, AND CAD FILES.

APPENDIX B

EXISTING CONDITION HYDROLOGIC EXHIBIT

RICK ENGINEERING COMPANY
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IMPERIAL COUNTY CALIFORNIA

Existing Condition Hydrologic Exhibit

W:\16101\Hydro\Seeley_Basins_Map.mxd
Exhibit Date: March 2010
REC JN: 16101

200 100 0 200 400
Feet
NORTH

APPENDIX C

ULTIMATE CONDITION HYDROLOGIC EXHIBIT

RICK
ENGINEERING COMPANY
5620 Friars Road
San Diego, CA 92110
619.291.0707
www.rickengineering.com

IMPERIAL COUNTY CALIFORNIA

Ultimate Condition Hydrologic Exhibit

W:\16101\Hydro\Seeley_Basins_Map_ultimate.mxd
Exhibit Date: March 2010
REC JN: 16101

200 100 0 200 400
Feet
NORTH

APPENDIX E

TOPOGRAPHIC MAP


SEELEY
0 100 200 300
GRAPHIC SCALE. 1"=150'
N
COMPILED BY PHOTOGRAMMETRIC METHODS
JOB NUMBER: 16101
DATE OF SURVEY: 03/24/2009
DATE OF PHOTOGRAPHY: 03/24/2009 TYPE: B/W
CONTOUR INTERVAL: 1 FT. APPROX. PHOTO SCALE: 1"=300'
BASIS OF COORDS: NGS MON. "F 612"
BASIS OF ELEV: NGS BM "M 59"
HORIZONTAL DATUM: NAD83, CCS ZONE 6, 2007.0 EPOCH
VERTICAL DATUM: NAVD88 PLUS 1000 FEET
EXCEPT CONTROL VALUES
MAP BOUNDARY
RETAINING WALL
MASONRY WALL
FENCE GENERAL
ASPHALT EDGE
CONCRETE EDGE
DIRT ROAD
CURB
BRIDGE
RAILROAD SINGLE
MARINA DOCKS
TANK
MISC UTILITIES
HEADWALL
WATER LINE
ASPHALT DRAIN
CONCRETE CHANNEL
BUILDING
POOL/SPA
PATIO/SHELTER
TRAILER
CONVEYOR
TREE LINE
BRUSH LINE
TREE LINE CIRCLE
PILE
INDEX CONTOUR
INTERM CONTOUR
DASH INDEX CONT
DASH INTERM CONT
DEP INDEX CONT
DEP INTERM CONT
DASH DEP IND CON
DASH DEP INTERM
HARD BREAK
DASH TREE CON
NORTH ARROW
Undefined
HORIZ/VERT CONTR
GRIDTICK
STREET LIGHT
TRAFFIC SIGNAL
RAIL ROAD SWITCH
POWER POLE
X SPOT ELEVATION
E 6,739,000
E 6,739,500

SEELEY AREA DRAINAGE MASTER PLAN

APPENDIX D

CAPITAL IMPROVEMENT PROGRAM REPORT

Job Number 16101
June 2010

RICK ENGINEERING COMPANY
ENGINEERING COMPANY
RICK ENGINEERING CO

SEELEY AREA DRAINAGE MASTER PLAN

APPENDIX D

CAPITAL IMPROVEMENT PROGRAM REPORT

JUNE 2010

Prepared For:

Imperial County
Planning & Development Services
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Dennis C. Bowling, M.S.
R.C.E. #32838
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Job Number 16101
DCB:JM:vs:report/.006

INTRODUCTION

The following projects, included in this Capital Improvement Program Report, are designed to improve flooding conditions in the Seeley area during runoff producing rainfall events, and in doing so, improve public safety. Each project includes a description along with a detailed cost estimate and exhibit showing the approximate location of each phase of recommended improvements. The following page includes a summary of the recommended drainage improvement projects, including an opinion of probable cost for the construction of all recommended improvements included in the Seeley Area Drainage Master Plan (DMP).

The recommended drainage improvements identified in this Capital Improvement Program report were prioritized in an order of recommended construction from SD-01 (the first recommended phase) to SD-07 (the final recommended phase). The drainage improvements were prioritized based on the requirement to construct downstream facilities first, public safety concerns, tributary drainage area, and the goal of reducing flooding in the areas historically subject to the most flooding.

Information regarding the location of existing water mains and sewer mains were provided as CAD files from the Imperial County Engineering Department. Assessors parcel lines were provided as GIS shapefiles by the Imperial County GIS department.

This report has been prepared for master planning purposes only, as a guide for engineers, planners, developers, and County staff. The recommendations outlined in this report are preliminary and the recommended locations, facility sizes, alignments, and costs should be re-evaluated during final design of each improvement phase.

TABLE OF RECOMMENDED DRAINAGE IMPROVEMENTS

Project ID	Priority	Page	Location	Maximum Q_{25}	Maximum Q_{100}	Pipe Sizes	Total Length	Number of Inlets	Number of Cleanouts	Estimated Cost
SD-01	Short Term (5-Years)	3	Rio Vista Street, Haskell Road, San Diego Avenue	220 cfs	319 cfs	36”-84”	4,512 ft	12	15	$7,828,700
SD-02		6	Rio Vista Street, Imperial Avenue	116 cfs	146 cfs	24”-72”	1,853 ft	8	9	$2,096,700
SD-03	Medium Term (10-Years)	9	San Diego Avenue, Park Street	54 cfs	77 cfs	36”-48”	1,547 ft	9	6	$1,110,700
SD-04		12	Rio Vista Street, Holt Avenue, West Main Road, Evan Hewes Highway	72 cfs	106 cfs	36”-60”	1,769 ft	5	8	$1,619,900
SD-05	Long Term (20-Years)	15	Holt Avenue, El Centro Street	46 cfs	70 cfs	36”-48”	2,228 ft	8	9	$1,619,500
SD-06		18	Laguna Avenue	19 cfs	29 cfs	36”	804 ft	4	4	$555,700
SD-07		21	Evan Hewes Highway	39 cfs	55 cfs	36”-48”	3,477 ft	5	11	$3,210,400

The sizes, quantities, and costs shown in this table are preliminary and should be verified during final design and plan preparation for each improvement project.

PROJECT ID: SD-01

Description:
This project addresses improvements along Rio Vista Street, Haskell Road, and San Diego Avenue. These improvements include:

- The construction of approximately 4,500 linear feet of storm drain pipe ranging from 36 inches to 84 inches in diameter, twelve inlets, and fifteen cleanouts, extending along Rio Vista Street from Haskell Road (north of Rio Vista Street) and outletting into a drainage swale located north of the wastewater treatment plant, eventually discharging to the New River.

- The construction of an outlet structure into an existing channel and a corresponding riprap pad / energy dissipater.

- The construction of street improvements (classified as a Major Collector), including curb and gutter for:
  - Rio Vista Street between New River Road and Haskell Road. This will include widening of Rio Vista Street to its ultimate width of 64 feet.
  - Haskell Road from Rio Vista Street to Alamo Road. This will include widening of Alamo Road to its ultimate width of 64 feet.

- The construction of street improvements (classified as a Local Road), including curb and gutter for San Diego Avenue from the Rio Vista Street intersection to the end of San Diego Avenue north of Rio Vista Street. This will include widening of San Diego Avenue to its ultimate width of 40 feet.

- Environmental permitting and processing.

This project will require associated utility relocations and modifications to accommodate the storm drain and road improvements.

Right of way /easement requirements:
The majority of storm drain improvements are proposed within the street right of ways. The most downstream portion will require acquisition of approximately 730 liner feet of a 20-foot wide drainage easement within APNs 051-430-008 and 051-130-018. Final alignment and limits of the easement should be determined during final design of the drainage improvements. Costs associated with Right-of-way acquisition are not included in the estimate construction cost.

Opinion of Probable Construction Cost:
The estimated construction cost of this project is **$7,828,700.00**

Implementation Priority:
Short Term – within 5 years

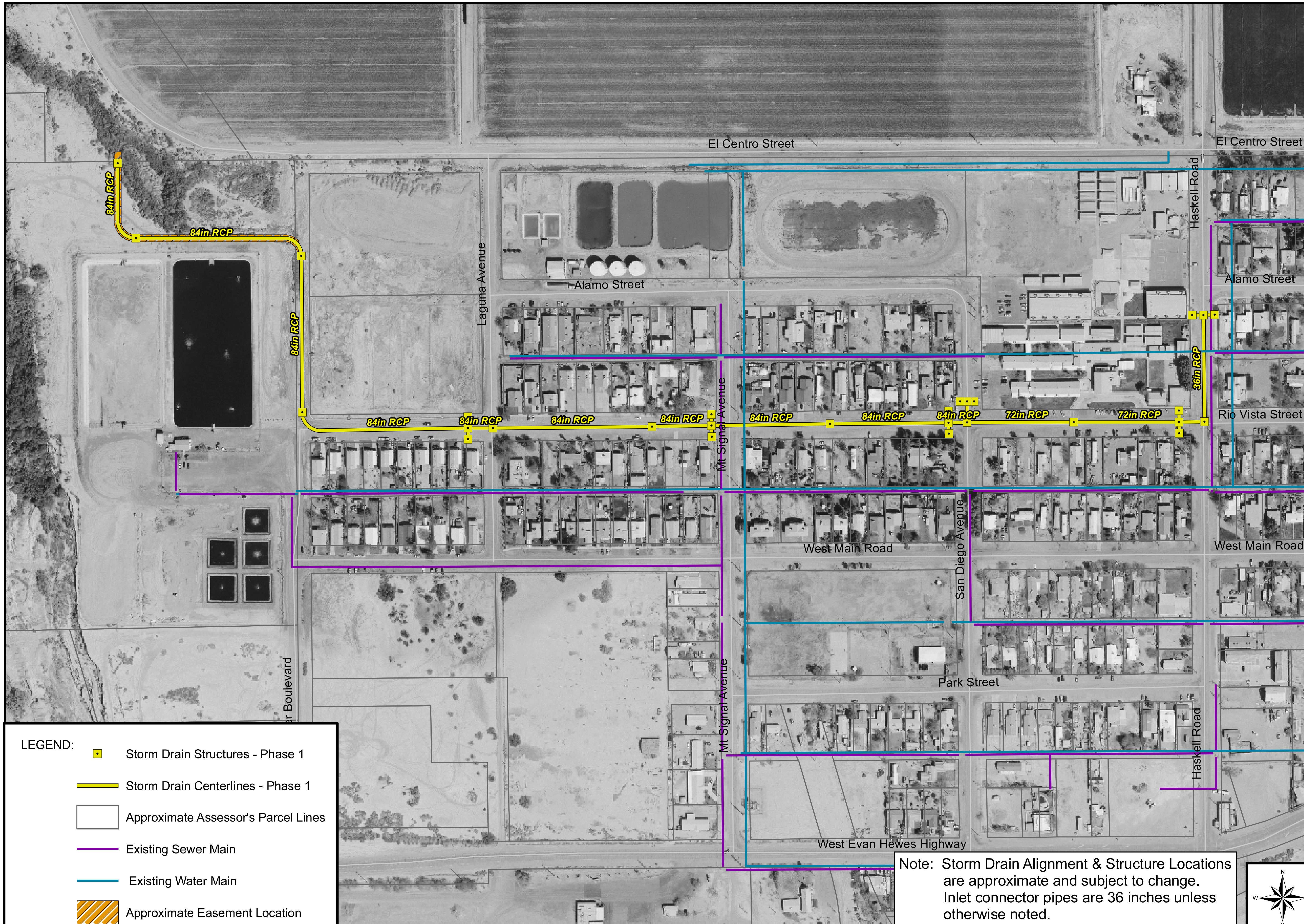
RICK ENGINEERING COMPANY

Seeley Area Drainage Master Plan
Engineers Opinion of Probable Cost - Phase 1 (SD-01)

ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL PRICE
Mobilization	1	LS	$ 328,400.40	$ 328,410.00
Clearing and Grubbing	1	LS	$ 54,733.40	$ 54,740.00
Asphalt Concrete Removal	11,285	SY	$ 4.00	$ 45,140.00
Aggregate Base, Class 2	10,857	CY	$ 30.00	$ 325,710.00
Asphalt Concrete, Type B	4,837	TON	$ 105.00	$ 507,890.00
Curb & Gutter	5,590	LF	$ 25.00	$ 139,750.00
Sidewalk	26,995	SF	$ 6.00	$ 161,970.00
Driveway	54	EA	$ 1,800.00	$ 97,200.00
Commercial Driveway	5	EA	$ 2,500.00	$ 12,500.00
Curb Ramps	16	EA	$ 2,000.00	$ 32,000.00
A4 Clenaout	1	EA	$ 4,000.00	$ 4,000.00
A5 Clenaout	2	EA	$ 4,500.00	$ 9,000.00
A6 Clenaout		EA	$ 5,000.00	$ -
A7 Clenaout	3	EA	$ 5,500.00	$ 16,500.00
A8 Clenaout	10	EA	$ 6,000.00	$ 60,000.00
Curb Inlet (Type B-2)	14	EA	$ 8,000.00	$ 112,000.00
Catch Basin(Type G-1)		EA	$ 4,000.00	$ -
Headwall Structure	1	EA	$ 7,000.00	$ 7,000.00
84" RCP SD	3,089	LF	$ 1,000.00	$ 3,089,000.00
72" RCP SD	672	LF	$ 800.00	$ 537,600.00
60" RCP SD		LF	$ 400.00	$ -
48" RCP SD		LF	$ 200.00	$ -
36" RCP SD	751	LF	$ 175.00	$ 131,430.00
24" RCP SD		LF	$ 160.00	$ -
Rock Slope Protection	49	CY	$ 225.00	$ 11,030.00
Utility Crosssing (Water)	2	EA	$ 10,000.00	$ 20,000.00
Excavation / Embankment	3,619	CY	$ 9.00	$ 32,580.00
Alley Connection	1	EA	$ 1,700.00	$ 1,700.00
Access Road	1,290	LF	$ 37.00	$ 47,730.00
Erosion Control	30,325	SY	$ 1.50	$ 45,490.00
Traffic Striping	12,230	LF	$ 0.50	$ 6,120.00
Transition areas	10	EA	$ 2,000.00	$ 20,000.00
Traffic Control and Detour Signing	1	LS	$ 273,667.00	$ 273,670.00
Environmental Permits	1	LS	$ 130,000.00	$ 130,000.00
Engineering (10%)	1	LS	$ 547,334.00	$ 547,334.00

SUBTOTAL	$ 6,807,500.00
CONTINGENCY (15%)	$ 1,021,200.00
TOTAL	**$ 7,828,700.00**

1. Mobilization assumed to be 6%
2. Clearing and grubbing assumed to be 1%
3. Assumed 24' wide roadways for AC removal for existing corridors
4. Even Hewes Hwy, Rio Vista St and Haskill Rd are classified as a Major Collector (STD 432)
5. All other roads classified as Local roads (STD 430)
6. 12' Driveways and 30' Commercial Driveways
7. For the outlet structures assume critical depth, and thus the critical velocity for rock slope protection
8. Assumed rerouting of water lines to avoid strom drain conflicts
9. Sewer crossings excluded from this estimate based on limited information. Note the potential sewer conflicts could cause complete sewer system replacement in some areas.
11. Assumed 6" excavation/embankment per SF of proposed AC
12. Alley concrete assumed to be 20'x10' with 5.5" thick concrete
13. Access road assumed to be 15' wide with 8" DG material
14. Proposed RW assumed to be erosion control limits
15. Striping assumes lane deliniation with no shape markers and no reflectors
16. Transition areas include work required to tie proposed work to existing conditions
17. Traffic contol assumed to be 5%
18. Engineering cost assumed to be 10%
19. Contingency of 15%
20. All asphalt quantities assume no reuse for base material (however this can be evaluated the design stage)
21. Unit costs were taken from Imperial County 2008 and San Diego County 2007 bid histories
22. Costs rounded up to the nearest $100.00



DATE 06/2010

SCALE 1" = 250'

RICK ENGINEERING COMPANY
5620 Friars Road
San Diego, CA 92110-2596
www.rickengineering.com

Seeley Area Drainage Master Plan
Appendix D: Exhibit Showing Proposed Storm Drain Alignment (SD-01)

IMPERIAL COUNTY CALIFORNIA

EXHIBIT
SD-01

PROJECT ID: SD-02

Description:
This project addresses improvements along Rio Vista Street, and Imperial Avenue. These improvements include:

- The construction of approximately 1,850 linear feet of storm drain pipe ranging from 24 inches to 72 inches in diameter, eight inlets, and nine cleanouts, extending from Haskell Road to Imperial Avenue along Rio Vista Street, and from West Main Road to El Centro Street along Imperial Avenue.

- The construction of street improvements (classified as a Major Collector), including curb and gutter for Rio Vista Street from Haskell Road to Imperial Avenue. This will include widening of Rio Vista Street to its ultimate width of 64 feet.

- The construction of street improvements (classified as a Local Road), including curb and gutter for Imperial Avenue from West Main Road to El Cento Street. This will include widening of Imperial Avenue to its ultimate width of 40 feet.

This project will require associated utility relocations and modifications to accommodate the storm drain and road improvements.

Right of way /easement requirements:
The storm drain improvements are proposed within the street right of ways, and are not expected to require any additional drainage easements.

Opinion of Probable Construction Cost:
The estimated construction cost of this project is **$2,096,700.00**

Implementation Priority:
Short Term – within 5 years

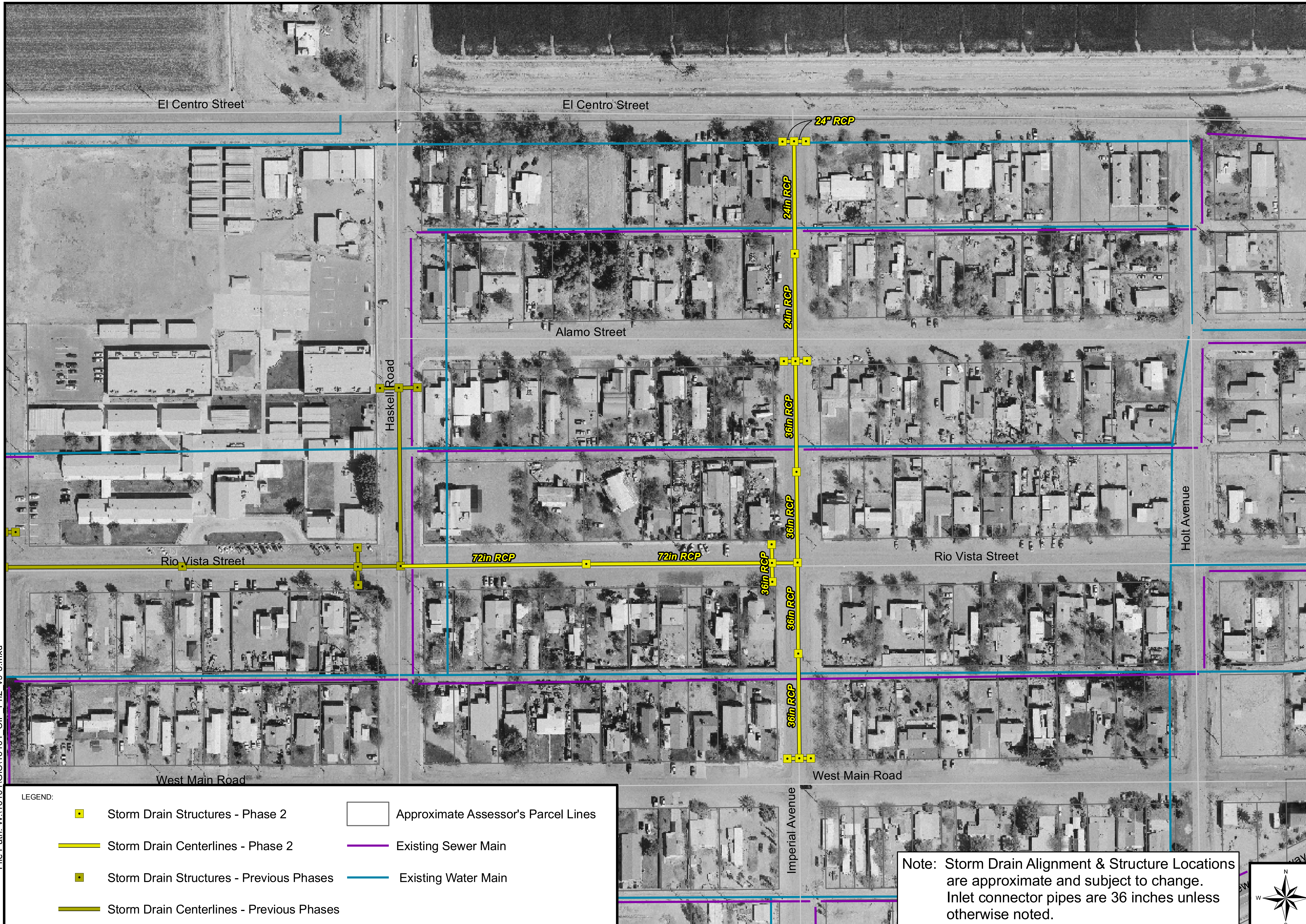
RICK ENGINEERING COMPANY

Seeley Area Drainage Master Plan
Engineers Opinion of Probable Cost - Phase 2 (SD-02)

ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL PRICE
Mobilization	1	LS	$ 89,663.40	$ 89,670.00
Clearing and Grubbing	1	LS	$ 14,943.90	$ 14,950.00
Asphalt Concrete Removal	4,621	SY	$ 4.00	$ 18,490.00
Aggregate Base, Class 2	4,225	CY	$ 30.00	$ 126,750.00
Asphalt Concrete, Type B	1,871	TON	$ 105.00	$ 196,460.00
Curb & Gutter	3,259	LF	$ 25.00	$ 81,480.00
Sidewalk	15,710	SF	$ 6.00	$ 94,260.00
Driveway	23	EA	$ 1,800.00	$ 41,400.00
Commercial Driveway		EA	$ 2,500.00	$ -
Curb Ramps	10	EA	$ 2,000.00	$ 20,000.00
A4 Clenaout	6	EA	$ 4,000.00	$ 24,000.00
A5 Clenaout		EA	$ 4,500.00	$ -
A6 Clenaout		EA	$ 5,000.00	$ -
A7 Clenaout	3	EA	$ 5,500.00	$ 16,500.00
A8 Clenaout		EA	$ 6,000.00	$ -
Curb Inlet (Type B-2)	8	EA	$ 8,000.00	$ 64,000.00
Catch Basin(Type G-1)		EA	$ 4,000.00	$ -
Headwall Structure		EA	$ 7,000.00	$ -
84" RCP SD		LF	$ 1,000.00	$ -
72" RCP SD	628	LF	$ 800.00	$ 502,400.00
60" RCP SD	40	LF	$ 400.00	$ 16,000.00
48" RCP SD		LF	$ 200.00	$ -
36" RCP SD	784	LF	$ 175.00	$ 137,200.00
24" RCP SD	401	LF	$ 160.00	$ 64,160.00
Rock Slope Protection		CY	$ 225.00	$ -
Utility Crosssing (Water)	5	EA	$ 10,000.00	$ 50,000.00
Excavation / Embankment	461	CY	$ 9.00	$ 4,150.00
Alley Connection	3	EA	$ 1,700.00	$ 5,100.00
Access Road		LF	$ 37.00	$ -
Erosion Control	13,367	SY	$ 1.50	$ 20,060.00
Traffic Striping	3,941	LF	$ 0.50	$ 1,980.00
Transition areas	5	EA	$ 2,000.00	$ 10,000.00
Traffic Control and Detour Signing	1	LS	$ 74,719.50	$ 74,720.00
Environmental Permits		LS	$ 130,000.00	$ -
Engineering (10%)	1	LS	$ 149,439.00	$ 149,439.00

SUBTOTAL	$ 1,823,200.00
CONTINGENCY (15%)	$ 273,500.00
TOTAL	**$ 2,096,700.00**

1. Mobilization assumed to be 6%
2. Clearing and grubbing assumed to be 1%
3. Assumed 24' wide roadways for AC removal for existing corridors
4. Even Hewes Hwy, Rio Vista St and Haskill Rd are classified as a Major Collector (STD 432)
5. All other roads classified as Local roads (STD 430)
6. 12' Driveways and 30' Commercial Driveways
7. For the outlet structures assume critical depth, and thus the critical velocity for rock slope protection
8. Assumed rerouting of water lines to avoid strom drain conflicts
9. Sewer crossings excluded from this estimate based on limited information. Note the potential sewer conflicts could cause complete sewer system replacement in some areas.
10. All dry utilites (including above and below ground) relocation will be performed by others
11. Assumed 6" excavation/embankment per SF of proposed AC
12. Alley concrete assumed to be 20'x10' with 5.5" thick concrete
13. Access road assumed to be 15' wide with 8" DG material
14. Proposed RW assumed to be erosion control limits
15. Striping assumes lane deliniation with no shape markers and no reflectors
16. Transition areas include work required to tie proposed work to existing conditions
17. Traffic contol assumed to be 5%
18. Engineering cost assumed to be 10%
19. Contingency of 15%
20. All asphalt quantities assume no reuse for base material (however this can be evaluated the design stage)
21. Unit costs were taken from Imperial County 2008 and San Diego County 2007 bid histories
22. Costs rounded up to the nearest $100.00



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LEGEND:

- Storm Drain Structures - Phase 2
- Storm Drain Centerlines - Phase 2
- Storm Drain Structures - Previous Phases
- Storm Drain Centerlines - Previous Phases
- Approximate Assessor's Parcel Lines
- Existing Sewer Main
- Existing Water Main

Note: Storm Drain Alignment & Structure Locations are approximate and subject to change. Inlet connector pipes are 36 inches unless otherwise noted.

DATE 06/2010

SCALE 1" = 600'

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www.rickengineering.com

Seeley Area Drainage Master Plan
Appendix D: Exhibit Showing Proposed Storm Drain Alignment (SD-02)

IMPERIAL COUNTY CALIFORNIA

EXHIBIT SD-02

PROJECT ID: SD-03

Description:
This project addresses improvements along San Diego Avenue, and Park Street. These improvements include:

- The construction of approximately 1,550 linear feet of storm drain pipe ranging from 36 inches to 48 inches in diameter, nine inlets, and six cleanouts, extending from Rio Vista Street to Park Street along San Diego Avenue, and from San Diego Avenue to Haskell Road along Park Street.

- The construction of street improvements (classified as a Local Road), including curb and gutter for:
    - San Diego Avenue from Rio Vista Street to Park Street. This will include widening of San Diego Avenue to its ultimate width of 40 feet.

    - Park Street from San Diego Avenue to Haskell Road. This will include widening of Park Street to its ultimate width of 40 feet.

This project will require associated utility relocations and modifications to accommodate the storm drain and road improvements.

Right of way /easement requirements:
The storm drain improvements are proposed within the street right of ways, and are not expected to require any additional drainage easements.

Opinion of Probable Construction Cost:
The estimated construction cost of this project is **$1,110,700.00**

Implementation Priority:
Medium Term – within 10 years

RICK ENGINEERING COMPANY

Seeley Area Drainage Master Plan
Engineers Opinion of Probable Cost - Phase 3 (SD-03)

ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL PRICE
Mobilization	1	LS	$ 47,493.00	$ 47,500.00
Clearing and Grubbing	1	LS	$ 7,915.50	$ 7,920.00
Asphalt Concrete Removal	3,877	SY	$ 4.00	$ 15,510.00
Aggregate Base, Class 2	2,299	CY	$ 30.00	$ 68,970.00
Asphalt Concrete, Type B	998	TON	$ 105.00	$ 104,790.00
Curb & Gutter	2,510	LF	$ 25.00	$ 62,750.00
Sidewalk	12,255	SF	$ 6.00	$ 73,530.00
Driveway	24	EA	$ 1,800.00	$ 43,200.00
Commercial Driveway		EA	$ 2,500.00	$ -
Curb Ramps	5	EA	$ 2,000.00	$ 10,000.00
A4 Clenaout	2	EA	$ 4,000.00	$ 8,000.00
A5 Clenaout	2	EA	$ 4,500.00	$ 9,000.00
A6 Clenaout		EA	$ 5,000.00	$ -
A7 Clenaout		EA	$ 5,500.00	$ -
A8 Clenaout		EA	$ 6,000.00	$ -
Curb Inlet (Type B-2)	6	EA	$ 8,000.00	$ 48,000.00
Catch Basin(Type G-1)	1	EA	$ 4,000.00	$ 4,000.00
Headwall Structure		EA	$ 7,000.00	$ -
84" RCP SD		LF	$ 1,000.00	$ -
72" RCP SD		LF	$ 800.00	$ -
60" RCP SD		LF	$ 400.00	$ -
48" RCP SD	705	LF	$ 200.00	$ 141,040.00
36" RCP SD	842	LF	$ 175.00	$ 147,350.00
24" RCP SD		LF	$ 160.00	$ -
Rock Slope Protection		CY	$ 225.00	$ -
Utility Crosssing (Water)	2	EA	$ 10,000.00	$ 20,000.00
Excavation / Embankment	985	CY	$ 9.00	$ 8,870.00
Alley Connection	2	EA	$ 1,700.00	$ 3,400.00
Access Road		LF	$ 37.00	$ -
Erosion Control	9,693	SY	$ 1.50	$ 14,540.00
Traffic Striping	1,186	LF	$ 0.50	$ 600.00
Transition areas	4	EA	$ 2,000.00	$ 8,000.00
Traffic Control and Detour Signing	1	LS	$ 39,577.50	$ 39,580.00
Environmental Permits		LS	$ 130,000.00	$ -
Engineering (10%)	1	LS	$ 79,155.00	$ 79,155.00

SUBTOTAL	$ 965,800.00
CONTINGENCY (15%)	$ 144,900.00
TOTAL	**$ 1,110,700.00**

1. Mobilization assumed to be 6%
2. Clearing and grubbing assumed to be 1%
3. Assumed 24' wide roadways for AC removal for existing corridors
4. Even Hewes Hwy, Rio Vista St and Haskill Rd are classified as a Major Collector (STD 432)
5. All other roads classified as Local roads (STD 430)
6. 12' Driveways and 30' Commercial Driveways
7. For the outlet structures assume critical depth, and thus the critical velocity for rock slope protection
8. Assumed rerouting of water lines to avoid strom drain conflicts
9. Sewer crossings excluded from this estimate based on limited information. Note the potential sewer conflicts could cause complete sewer system replacement in some areas.
10. All dry utilites (including above and below ground) relocation will be performed by others
11. Assumed 6" excavation/embankment per SF of proposed AC
12. Alley concrete assumed to be 20'x10' with 5.5" thick concrete
13. Access road assumed to be 15' wide with 8" DG material
14. Proposed RW assumed to be erosion control limits
15. Striping assumes lane deliniation with no shape markers and no reflectors
16. Transition areas include work required to tie proposed work to existing conditions
17. Traffic contol assumed to be 5%
18. Engineering cost assumed to be 10%
19. Contingency of 15%
20. All asphalt quantities assume no reuse for base material (however this can be evaluated the design stage)
21. Unit costs were taken from Imperial County 2008 and San Diego County 2007 bid histories
22. Costs rounded up to the nearest $100.00

LEGEND:

- Storm Drain Structures - Phase 3
- Storm Drain Centerlines - Phase 3
- Storm Drain Structures - Previous Phases
- Storm Drain Centerlines - Previous Phases
- Approximate Assessor's Parcel Lines
- Existing Sewer Main
- Existing Water Main

Note: Storm Drain Alignment & Structure Locations are approximate and subject to change. Inlet connector pipes are 36 inches unless otherwise noted.

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DATE 06/2010

SCALE 1" = 600'

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Seeley Area Drainage Master Plan
Appendix D: Exhibit Showing Proposed Storm Drain Alignment (SD-03)

Imperial County California

EXHIBIT
SD-03

PROJECT ID: SD-04

Description:
This project addresses improvements along Rio Vista Street, Holt Avenue, West Main Road, and Evan Hewes Highway. These improvements include:

- The construction of approximately 1,770 linear feet of storm drain pipe ranging from 36 inches to 60 inches in diameter, five inlets, and eight cleanouts, extending from Imperial Avenue to Holt Avenue along Rio Vista Street, from Rio Vista Road to West Main Road along Holt Avenue, from Holt Avenue to Evan Hewes Highway along West Main Road, and for several hundred feet north of West Main Road along Even Hewes Highway.

- The construction of street improvements (classified as a Major Collector), including curb and gutter for Rio Vista Street from Imperial Avenue to Holt Avenue. This will include widening of Rio Vista Street to its ultimate width of 64 feet.

- The construction of street improvements (classified as a Local Road), including curb and gutter for:

  - Holt Avenue from Rio Vista Street to West Main Road. This will include widening of Holt Avenue to its ultimate width of 40 feet.

  - West Main Road from Holt Avenue to Evan Hewes Road. This will include widening of West Main Road to its ultimate width of 40 feet.

- The construction of street improvements (classified as a Prime Arterial), including curb and gutter for Evan Hewes Highway from West Main Road to approximately 300 feet east of West Main Road. This will include widening of Evan Hewes Highway to its ultimate width of 106 feet.

This project will require associated utility relocations and modifications to accommodate the storm drain and road improvements.

Right of way /easement requirements:
The storm drain improvements are proposed within the street right of ways, and are not expected to require any additional drainage easements.

Opinion of Probable Construction Cost:
The estimated construction cost of this project is **$1,619,900.00**

Implementation Priority:
Medium Term – within 10 years

RICK ENGINEERING COMPANY

Seeley Area Drainage Master Plan
Engineers Opinion of Probable Cost - Phase 4 (SD-04)

ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL PRICE
Mobilization	1	LS	$ 69,271.80	$ 69,280.00
Clearing and Grubbing	1	LS	$ 11,545.30	$ 11,550.00
Asphalt Concrete Removal	4,789	SY	$ 4.00	$ 19,160.00
Aggregate Base, Class 2	4,198	CY	$ 30.00	$ 125,940.00
Asphalt Concrete, Type B	1,863	TON	$ 105.00	$ 195,620.00
Curb & Gutter	2,935	LF	$ 25.00	$ 73,380.00
Sidewalk	14,370	SF	$ 6.00	$ 86,220.00
Driveway	23	EA	$ 1,800.00	$ 41,400.00
Commercial Driveway		EA	$ 2,500.00	$ -
Curb Ramps	5	EA	$ 2,000.00	$ 10,000.00
A4 Clenaout	5	EA	$ 4,000.00	$ 20,000.00
A5 Clenaout		EA	$ 4,500.00	$ -
A6 Clenaout	3	EA	$ 5,000.00	$ 15,000.00
A7 Clenaout		EA	$ 5,500.00	$ -
A8 Clenaout		EA	$ 6,000.00	$ -
Curb Inlet (Type B-2)	5	EA	$ 8,000.00	$ 40,000.00
Catch Basin(Type G-1)		EA	$ 4,000.00	$ -
Headwall Structure		EA	$ 7,000.00	$ -
84" RCP SD		LF	$ 1,000.00	$ -
72" RCP SD		LF	$ 800.00	$ -
60" RCP SD	672	LF	$ 400.00	$ 268,800.00
48" RCP SD		LF	$ 200.00	$ -
36" RCP SD	1,097	LF	$ 175.00	$ 191,980.00
24" RCP SD		LF	$ 160.00	$ -
Rock Slope Protection		CY	$ 225.00	$ -
Utility Crosssing (Water)	3	EA	$ 10,000.00	$ 30,000.00
Excavation / Embankment	460	CY	$ 9.00	$ 4,140.00
Alley Connection	2	EA	$ 1,700.00	$ 3,400.00
Access Road		LF	$ 37.00	$ -
Erosion Control	13,797	SY	$ 1.50	$ 20,700.00
Traffic Striping	1,566	LF	$ 0.50	$ 790.00
Transition areas	4	EA	$ 2,000.00	$ 8,000.00
Traffic Control and Detour Signing	1	LS	$ 57,726.50	$ 57,730.00
Environmental Permits		LS	$ 130,000.00	$ -
Engineering (10%)	1	LS	$ 115,453.00	$ 115,453.00

SUBTOTAL	$ 1,408,600.00
CONTINGENCY (15%)	$ 211,300.00
TOTAL	**$ 1,619,900.00**

1. Mobilization assumed to be 6%
2. Clearing and grubbing assumed to be 1%
3. Assumed 24' wide roadways for AC removal for existing corridors
4. Even Hewes Hwy, Rio Vista St and Haskill Rd are classified as a Major Collector (STD 432)
5. All other roads classified as Local roads (STD 430)
6. 12' Driveways and 30' Commercial Driveways
7. For the outlet structures assume critical depth, and thus the critical velocity for rock slope protection
8. Assumed rerouting of water lines to avoid strom drain conflicts
9. Sewer crossings excluded from this estimate based on limited information. Note the potential sewer conflicts could cause complete sewer system replacement in some areas.
10. All dry utilites (including above and below ground) relocation will be performed by others
11. Assumed 6" excavation/embankment per SF of proposed AC
12. Alley concrete assumed to be 20'x10' with 5.5" thick concrete
13. Access road assumed to be 15' wide with 8" DG material
14. Proposed RW assumed to be erosion control limits
15. Striping assumes lane deliniation with no shape markers and no reflectors
16. Transition areas include work required to tie proposed work to existing conditions
17. Traffic contol assumed to be 5%
18. Engineering cost assumed to be 10%
19. Contingency of 15%
20. All asphalt quantities assume no reuse for base material (however this can be evaluated the design stage)
21. Unit costs were taken from Imperial County 2008 and San Diego County 2007 bid histories
22. Costs rounded up to the nearest $100.00

DATE
06/2010

SCALE
1" = 600'

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Seeley Area Drainage Master Plan
Appendix D: Exhibit Showing Proposed Storm Drain Alignment (SD-04)

EXHIBIT
SD-04

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PROJECT ID: SD-05

Description: This project addresses improvements along Holt Avenue, and El Centro Street. These improvements include:

- The construction of approximately 2,230 linear feet of storm drain pipe ranging from 36 inches to 48 inches in diameter, eights inlets, and nine cleanouts, extending from Rio Vista Street to El Centro Street along Holt Avenue, and from Holt Avenue to approximately 1400 feet east of the Holt Avenue intersection along El Centro Street.

- The construction of street improvements (classified as a Local Road), including curb and gutter for:

    - Holt Avenue from Rio Vista Street to El Centro Street. This will include widening of Holt Avenue to its ultimate width of 40 feet.

    - El Centro Street from Holt Avenue to approximately 1400 feet east of Holt Avenue. This will include widening of El Centro Street to its ultimate width of 40 feet.

This project will require associated utility relocations and modifications to accommodate the storm drain and road improvements.

Right of way /easement requirements:
The storm drain improvements are proposed within the street right of ways, and are not expected to require any additional drainage easements.

Opinion of Probable Construction Cost:
The estimated construction cost of this project is **$1,619,500.00**

Implementation Priority:
Long Term – within 20 years

RICK ENGINEERING COMPANY

Seeley Area Drainage Master Plan
Engineers Opinion of Probable Cost - Phase 5 (SD-05)

ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL PRICE
Mobilization	1	LS	$ 69,252.00	$ 69,260.00
Clearing and Grubbing	1	LS	$ 11,542.00	$ 11,550.00
Asphalt Concrete Removal	5,757	SY	$ 4.00	$ 23,030.00
Aggregate Base, Class 2	3,640	CY	$ 30.00	$ 109,200.00
Asphalt Concrete, Type B	1,580	TON	$ 105.00	$ 165,900.00
Curb & Gutter	4,041	LF	$ 25.00	$ 101,030.00
Sidewalk	19,915	SF	$ 6.00	$ 119,490.00
Driveway	20	EA	$ 1,800.00	$ 36,000.00
Commercial Driveway	2	EA	$ 2,500.00	$ 5,000.00
Curb Ramps	5	EA	$ 2,000.00	$ 10,000.00
A4 Clenaout	7	EA	$ 4,000.00	$ 28,000.00
A5 Clenaout	2	EA	$ 4,500.00	$ 9,000.00
A6 Clenaout		EA	$ 5,000.00	$ -
A7 Clenaout		EA	$ 5,500.00	$ -
A8 Clenaout		EA	$ 6,000.00	$ -
Curb Inlet (Type B-2)	8	EA	$ 8,000.00	$ 64,000.00
Catch Basin(Type G-1)		EA	$ 4,000.00	$ -
Headwall Structure		EA	$ 7,000.00	$ -
84" RCP SD		LF	$ 1,000.00	$ -
72" RCP SD		LF	$ 800.00	$ -
60" RCP SD		LF	$ 400.00	$ -
48" RCP SD	422	LF	$ 200.00	$ 84,400.00
36" RCP SD	1,806	LF	$ 175.00	$ 316,050.00
24" RCP SD		LF	$ 160.00	$ -
Rock Slope Protection		CY	$ 225.00	$ -
Utility Crosssing (Water)	3	EA	$ 10,000.00	$ 30,000.00
Excavation / Embankment	1,560	CY	$ 9.00	$ 14,040.00
Alley Connection	4	EA	$ 1,700.00	$ 6,800.00
Access Road		LF	$ 37.00	$ -
Erosion Control	14,393	SY	$ 1.50	$ 21,590.00
Traffic Striping	5,335	LF	$ 0.50	$ 2,670.00
Transition areas	4	EA	$ 2,000.00	$ 8,000.00
Traffic Control and Detour Signing	1	LS	$ 57,710.00	$ 57,710.00
Environmental Permits		LS	$ 130,000.00	$ -
Engineering (10%)	1	LS	$ 115,420.00	$ 115,420.00

SUBTOTAL	$ 1,408,200.00
CONTINGENCY (15%)	$ 211,300.00
TOTAL	**$ 1,619,500.00**

1. Mobilization assumed to be 6%
2. Clearing and grubbing assumed to be 1%
3. Assumed 24' wide roadways for AC removal for existing corridors
4. Even Hewes Hwy, Rio Vista St and Haskill Rd are classified as a Major Collector (STD 432)
5. All other roads classified as Local roads (STD 430)
6. 12' Driveways and 30' Commercial Driveways
7. For the outlet structures assume critical depth, and thus the critical velocity for rock slope protection
8. Assumed rerouting of water lines to avoid strom drain conflicts
9. Sewer crossings excluded from this estimate based on limited information. Note the potential sewer conflicts could cause complete sewer system replacement in some areas.
10. All dry utilites (including above and below ground) relocation will be performed by others
11. Assumed 6" excavation/embankment per SF of proposed AC
12. Alley concrete assumed to be 20'x10' with 5.5" thick concrete
13. Access road assumed to be 15' wide with 8" DG material
14. Proposed RW assumed to be erosion control limits
15. Striping assumes lane deliniation with no shape markers and no reflectors
16. Transition areas include work required to tie proposed work to existing conditions
17. Traffic contol assumed to be 5%
18. Engineering cost assumed to be 10%
19. Contingency of 15%
20. All asphalt quantities assume no reuse for base material (however this can be evaluated the design stage)
21. Unit costs were taken from Imperial County 2008 and San Diego County 2007 bid histories
22. Costs rounded up to the nearest $100.00

Note: Storm Drain Alignment & Structure Locations are approximate and subject to change. Inlet connector pipes are 36 inches unless otherwise noted.

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LEGEND:

- Storm Drain Structures - Phase 5
- Storm Drain Structures - Previous Phases
- Existing Sewer Main
- Approximate Assessor's Parcel Lines
- Storm Drain Centerlines - Phase 5
- Storm Drain Centerlines - Previous Phases
- Existing Water Main

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SCALE 1" = 600'

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Seeley Area Drainage Master Plan
Appendix D: Exhibit Showing Proposed Storm Drain Alignment (SD-03)

IMPERIAL COUNTY CALIFORNIA

EXHIBIT
SD-05

PROJECT ID: SD-06

Description: This project addresses improvements along Laguna Avenue. These improvements include:

- The construction of approximately 800 linear feet of storm drain pipe 36 inches in diameter, four inlets, and four cleanouts, extending from Rio Vista Street to El Centro Street along Laguna Avenue.
- The construction of street improvements (classified as a Local Road), including curb and gutter for Laguna Avenue from Rio Vista Street to El Centro Street. This will include widening of Laguna Avenue to its ultimate width of 40 feet.

This project will require associated utility relocations and modifications to accommodate the storm drain and road improvements.

Right of way /easement requirements:
The storm drain improvements are proposed within the street right of ways, and are not expected to require any additional drainage easements.

Opinion of Probable Construction Cost:
The estimated construction cost of this project is **$555,700.00**

Implementation Priority:
Long Term – within 20 years

RICK ENGINEERING COMPANY

Seeley Area Drainage Master Plan
Engineers Opinion of Probable Cost - Phase 6 (SD-06)

ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL PRICE
Mobilization	1	LS	$ 23,759.40	$ 23,760.00
Clearing and Grubbing	1	LS	$ 3,959.90	$ 3,960.00
Asphalt Concrete Removal	1,941	SY	$ 4.00	$ 7,770.00
Aggregate Base, Class 2	1,338	CY	$ 30.00	$ 40,140.00
Asphalt Concrete, Type B	581	TON	$ 105.00	$ 61,010.00
Curb & Gutter	1,397	LF	$ 25.00	$ 34,930.00
Sidewalk	6,535	SF	$ 6.00	$ 39,210.00
Driveway	1	EA	$ 1,800.00	$ 1,800.00
Commercial Driveway		EA	$ 2,500.00	$ -
Curb Ramps	2	EA	$ 2,000.00	$ 4,000.00
A4 Clenaout	4	EA	$ 4,000.00	$ 16,000.00
A5 Clenaout		EA	$ 4,500.00	$ -
A6 Clenaout		EA	$ 5,000.00	$ -
A7 Clenaout		EA	$ 5,500.00	$ -
A8 Clenaout		EA	$ 6,000.00	$ -
Curb Inlet (Type B-2)	4	EA	$ 8,000.00	$ 32,000.00
Catch Basin(Type G-1)		EA	$ 4,000.00	$ -
Headwall Structure		EA	$ 7,000.00	$ -
84" RCP SD		LF	$ 1,000.00	$ -
72" RCP SD		LF	$ 800.00	$ -
60" RCP SD		LF	$ 400.00	$ -
48" RCP SD		LF	$ 200.00	$ -
36" RCP SD	804	LF	$ 175.00	$ 140,700.00
24" RCP SD		LF	$ 160.00	$ -
Rock Slope Protection		CY	$ 225.00	$ -
Utility Crosssing (Water)		EA	$ 10,000.00	$ -
Excavation / Embankment	573	CY	$ 9.00	$ 5,160.00
Alley Connection	1	EA	$ 1,700.00	$ 1,700.00
Access Road		LF	$ 37.00	$ -
Erosion Control	4,853	SY	$ 1.50	$ 7,280.00
Traffic Striping	578	LF	$ 0.50	$ 290.00
Transition areas	2	EA	$ 2,000.00	$ 4,000.00
Traffic Control and Detour Signing	1	LS	$ 19,799.50	$ 19,800.00
Environmental Permits		LS	$ 130,000.00	$ -
Engineering (10%)	1	LS	$ 39,599.00	$ 39,599.00
			SUBTOTAL	$ 483,200.00
			CONTINGENCY (15%)	$ 72,500.00
			TOTAL	**$ 555,700.00**

1. Mobilization assumed to be 6%
2. Clearing and grubbing assumed to be 1%
3. Assumed 24' wide roadways for AC removal for existing corridors
4. Even Hewes Hwy, Rio Vista St and Haskill Rd are classified as a Major Collector (STD 432)
5. All other roads classified as Local roads (STD 430)
6. 12' Driveways and 30' Commercial Driveways
7. For the outlet structures assume critical depth, and thus the critical velocity for rock slope protection
8. Assumed rerouting of water lines to avoid strom drain conflicts
9. Sewer crossings excluded from this estimate based on limited information. Note the potential sewer conflicts could cause complete sewer system replacement in some areas.
10. All dry utilites (including above and below ground) relocation will be performed by others
11. Assumed 6" excavation/embankment per SF of proposed AC
12. Alley concrete assumed to be 20'x10' with 5.5" thick concrete
13. Access road assumed to be 15' wide with 8" DG material
14. Proposed RW assumed to be erosion control limits
15. Striping assumes lane deliniation with no shape markers and no reflectors
16. Transition areas include work required to tie proposed work to existing conditions
17. Traffic contol assumed to be 5%
18. Engineering cost assumed to be 10%
19. Contingency of 15%
20. All asphalt quantities assume no reuse for base material (however this can be evaluated the design stage)
21. Unit costs were taken from Imperial County 2008 and San Diego County 2007 bid histories
22. Costs rounded up to the nearest $100.00

LEGEND:

- Storm Drain Structures - Phase 6
- Storm Drain Centerlines - Phase 6
- Storm Drain Structures - Previous Phases
- Storm Drain Centerlines - Previous Phases
- Approximate Assessor's Parcel Lines
- Existing Sewer Main
- Existing Water Main

Note: Storm Drain Alignment & Structure Locations are approximate and subject to change. Inlet connector pipes are 36 inches unless otherwise noted.

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Seeley Area Drainage Master Plan
Appendix D: Exhibit Showing Proposed Storm Drain Alignment (SD-06)

IMPERIAL COUNTY CALIFORNIA

EXHIBIT
SD-06

PROJECT ID: SD-07

Description: This project addresses improvements along Evan Hewes. These improvements include:

- The construction of approximately 3,480 linear feet of storm drain pipe ranging from 36 inches to 48 inches in diameter, five inlets, and eleven cleanouts, extending from the New River to approximately 100 feet west of the intersection with Drew Road, along Evan Hewes Highway.
- The construction of street improvements (classified as a Prime Arterial), including curb and gutter for Evan Hewes Highway from the New River Crossing to approximately 100 feet east of the intersection with Drew Road. This will include widening of Evan Hewes to its ultimate width of 106 feet.
- Environmental permitting and processing.

This project will require associated utility relocations and modifications to accommodate the storm drain and road improvements.

Right of way /easement requirements:
The storm drain improvements are proposed within the street right of ways, and are not expected to require any additional drainage easements.
Opinion of Probable Construction Cost:
The estimated construction cost of this project is **$3,210,400.00**

Implementation Priority:
Long Term – within 20 years

RICK ENGINEERING COMPANY

Seeley Area Drainage Master Plan
Engineers Opinion of Probable Cost - Phase 7 (SD-07)

ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL PRICE
Mobilization	1	LS	$ 130,895.40	$ 130,900.00
Clearing and Grubbing	1	LS	$ 21,815.90	$ 21,820.00
Asphalt Concrete Removal	11,826	SY	$ 4.00	$ 47,310.00
Aggregate Base, Class 2	11,920	CY	$ 30.00	$ 357,600.00
Asphalt Concrete, Type B	5,310	TON	$ 105.00	$ 557,550.00
Curb & Gutter	6,531	LF	$ 25.00	$ 163,280.00
Sidewalk	32,140	SF	$ 6.00	$ 192,840.00
Driveway	7	EA	$ 1,800.00	$ 12,600.00
Commercial Driveway	3	EA	$ 2,500.00	$ 7,500.00
Curb Ramps		EA	$ 2,000.00	$ -
A4 Clenaout	9	EA	$ 4,000.00	$ 36,000.00
A5 Clenaout	2	EA	$ 4,500.00	$ 9,000.00
A6 Clenaout		EA	$ 5,000.00	$ -
A7 Clenaout		EA	$ 5,500.00	$ -
A8 Clenaout		EA	$ 6,000.00	$ -
Curb Inlet (Type B-2)	5	EA	$ 8,000.00	$ 40,000.00
Catch Basin(Type G-1)		EA	$ 4,000.00	$ -
Headwall Structure	1	EA	$ 7,000.00	$ 7,000.00
84" RCP SD		LF	$ 1,000.00	$ -
72" RCP SD		LF	$ 800.00	$ -
60" RCP SD		LF	$ 400.00	$ -
48" RCP SD	685	LF	$ 200.00	$ 137,000.00
36" RCP SD	2,792	LF	$ 175.00	$ 488,600.00
24" RCP SD		LF	$ 160.00	$ -
Rock Slope Protection	7	CY	$ 225.00	$ 1,580.00
Utility Crosssing (Water)	2	EA	$ 10,000.00	$ 20,000.00
Excavation / Embankment	3,973	CY	$ 9.00	$ 35,760.00
Alley Connection		EA	$ 1,700.00	$ -
Access Road		LF	$ 37.00	$ -
Erosion Control	31,043	SY	$ 1.50	$ 46,570.00
Traffic Striping	14,790	LF	$ 0.50	$ 7,400.00
Transition areas	7	EA	$ 2,000.00	$ 14,000.00
Traffic Control and Detour Signing	1	LS	$ 109,079.50	$ 109,080.00
Environmental Permits	1	LS	$ 130,000.00	$ 130,000.00
Engineering (10%)	1	LS	$ 218,159.00	$ 218,159.00
			SUBTOTAL	$ 2,791,600.00
			CONTINGENCY (15%)	$ 418,800.00
			TOTAL	**$ 3,210,400.00**

1. Mobilization assumed to be 6%
2. Clearing and grubbing assumed to be 1%
3. Assumed 24' wide roadways for AC removal for existing corridors
4. Even Hewes Hwy, Rio Vista St and Haskill Rd are classified as a Major Collector (STD 432)
5. All other roads classified as Local roads (STD 430)
6. 12' Driveways and 30' Commercial Driveways
7. For the outlet structures assume critical depth, and thus the critical velocity for rock slope protection
8. Assumed rerouting of water lines to avoid strom drain conflicts
9. Sewer crossings excluded from this estimate based on limited information. Note the potential sewer conflicts could cause complete sewer system replacement in some areas.
10. All dry utilites (including above and below ground) relocation will be performed by others
11. Assumed 6" excavation/embankment per SF of proposed AC
12. Alley concrete assumed to be 20'x10' with 5.5" thick concrete
13. Access road assumed to be 15' wide with 8" DG material
14. Proposed RW assumed to be erosion control limits
15. Striping assumes lane deliniation with no shape markers and no reflectors
16. Transition areas include work required to tie proposed work to existing conditions
17. Traffic contol assumed to be 5%
18. Engineering cost assumed to be 10%
19. Contingency of 15%
20. All asphalt quantities assume no reuse for base material (however this can be evaluated the design stage)
21. Unit costs were taken from Imperial County 2008 and San Diego County 2007 bid histories
22. Costs rounded up to the nearest $100.00

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Seeley Area Drainage Master Plan
Appendix D: Exhibit Showing Proposed Storm Drain Alignment (SD-07)

EXHIBIT
SD-07

EXHIBIT E

2018 IMPERIAL COUNTY HYDROLOGY REPORT

DRAFT

Imperial County
Hydrology Manual

OCTOBER 2018

Image source: California Environmental Protection Agency
Air Resources Board

IMPERIAL COUNTY
1907
CALIFORNIA

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Imperial County

Hydrology Manual

October 2018

Prepared for:

Imperial County
Department of Public Works
155 South 11th Street
El Centro, CA 92243

Prepared by:

WEST Consultants, Inc.
11440 W. Bernardo Court, Suite 360
San Diego, CA 92127

Table of Contents

List of Tables

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Abbreviations

A ..... drainage area
ac ..... acre(s)
ARC ..... antecedent runoff condition
C ..... runoff coefficient
CN ..... runoff curve number
CN_C ..... composite runoff curve number
CN_P ..... pervious runoff curve number
C_p ..... pervious runoff coefficient
cfs ..... cubic feet per second
D ..... period (duration) of excess rainfall
DARF ..... depth-area-reduction factor
DEM ..... digital elevation model
DU/A ..... dwelling units per acre
FAA ..... Federal Aviation Administration
FHWA ..... Federal Highway Administration
ft ..... foot, feet
GIS ..... geographic information system
HEC ..... Hydrologic Engineering Center
HMS ..... Hydrologic Modeling System
hr ..... hour(s)
I ..... rainfall intensity
IDF ..... intensity-depth-frequency
IID ..... Imperial Irrigation District
in ..... inch(es)
k ..... intercept coefficient
L ..... flow length
L_C ..... length along watercourse to location nearest to centroid
L_M ..... maximum overland sheet flow length
m ..... empirical coefficient
mi ..... mile(s)
MRM ..... Modified Rational Method
n ..... Manning's roughness coefficient
$\bar{n}$ ..... mean basin Manning's roughness coefficient
NEH ..... National Engineering Handbook
NOAA ..... National Oceanic and Atmospheric Administration
NRCS ..... Natural Resources Conservation Service
P ..... total rainfall
P_{imp} ..... percent imperviousness
PFDS ..... Precipitation Frequency Data Server
Q ..... discharge
Q_p ..... peak discharge
RM ..... Rational Method
R ..... hydraulic radius
R ..... ratio of unconnected impervious area
R_{nD} ..... depth-area adjusted rainfall amount for duration (n x D)
S ..... slope
sec ..... second(s)
T_c ..... time of concentration

T_i .... initial time of concentration
T_l .... Corps lag time
T_N .... NRCS lag time
T_p .... time to peak
T_t .... travel time
USACE .... United States Army Corps of Engineers
USDA .... United States Department of Agriculture
V .... velocity

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1 Introduction

1.1 About This Manual

The goal of Imperial County, California, is to provide flood protection for all habitable structures and other non-floodproofed structures, consistent with Imperial County ordinances and design criteria. This manual is intended to provide guidance and recommendations on computational techniques and criteria for the estimation of runoff, discharges, and volumes for use in hydrology study submittals to the County. It is not a substitute for sound engineering judgment. This document is not intended to provide guidelines for the design of drainage structures, but rather the estimated flows to be used in the design of such structures. For guidance with sizing and designing hydraulic structures (e.g., detention basins, storm drains, curb and gutter), consult Imperial County Department of Public Works for the latest design criteria.

The County's Engineering Design Guidelines Manual provides specific recommendations for retention/detention basin sizing including the minimum precipitation depth to consider for the 100-year storm and requirements for drain time. If any proposed development drains to an Imperial Irrigation District (IID) facility, the design will need to meet IID standards and is subject to IID review/approval.

It is not the intent nor purpose of this manual to inhibit sound innovative design or the use of new techniques. Therefore, where special conditions or needs exist, other methods and procedures may be used *with prior approval.*

1.2 Manual Organization

In general, each main section is laid out following a similar format:

- General Description: This segment provides a brief overview of the topics covered in the section.

- Subsection(s): Each section contains sub-sections of main concepts relevant to the larger section. The sub-sections explain the techniques or concepts necessary to perform the desired task or use a certain hydrologic method.

- Instructions: When applicable, procedures to perform detailed calculations are provided.

- Online Resources: Online data resources have website links. In addition, a description including the website owner and data type is provided in case the web page should be moved by the owner.

- Tables and Figures: Related tables and figures are generally located immediately adjacent to the text to which the Table or Figure refers.

- Examples: Example problems demonstrating the use of methods described in a section are located at the end of the section.

- Equations: Equations utilized in a section are numbered according to the section number and order of appearance of the equation in the section.

- Related Equations: Previously defined equations related to a topic of discussion are referenced by the equation number.

1.3 Hydrologic Procedure Guidance

The choice of hydrologic method should be dictated by the intended use of the result. The Rational Method was originally developed to estimate runoff from small areas and assumes a uniform distribution of precipitation over the study area. This is a major reason the Rational Method is applicable only when areas are less than or equal to 640 acres (1.0 square mile). The Rational Method should not be used in circumstances where there is a junction of independent drainage systems. In these instances, the Modified Rational Method should be used to analyze the junction(s) of the independent drainage systems. The Natural Resources Conservation Service (NRCS) Hydrologic Method should be used for watersheds greater than approximately 640 acres (1.0 square mile) in size.

1.4 Acknowledgments

This hydrology manual was prepared by WEST Consultants, Inc. (WEST) on behalf of the Imperial County Department of Public Works. As part of the WEST team, Hromadka and Associates, Inc. provided quality control reviews and content recommendations. Review comments were incorporated based on input from the Imperial County Department of Public Works and the local engineering community.

2 Precipitation Analysis

2.1 General Description

Imperial County is within the Sonoran and Colorado Desert region with high temperatures and an average annual rainfall of 3 inches (U.S. Climate Data, 2016). Storms in Imperial County can be classified as general storms and local storms (Caltrans, 2007).

General storms are usually frontal or convergence storms that typically move in from the Pacific Ocean and produce light rain over relatively large areas. These storms normally occur between October and May, with most occurring in January and February. Although not as common, general storms that occur in the summer are often tropical storms. Typically, the mountain areas receive more precipitation than the lower desert areas.

While general storms bring a large volume of water over time, local storms are small and intense, producing higher peak rainfall amounts. Local thunderstorms can occur in Imperial County at any time of the year but are most common and most intense during the summer months (June to September). They develop as warm, moist tropical air drifts northward and northwestward from Mexico and the Gulf of California, and are sometimes enhanced by moisture and atmospheric circulation drifting northward from tropical storms off the west coast of Baja California. These local thunderstorms can produce very heavy rain for short periods of time over small areas, causing very rapid runoff from small drainages. The result may be flash floods, which can lead to loss of life and substantial property damage. A significant percentage of the largest runoff is likely caused by summer thunderstorms over small basins with drainage areas generally less than 20 square miles.

Because both general storms and local thunderstorms may cause significant runoff in Imperial County, both the 6-hour design storm and the 24-hour design storm should be analyzed when applying the NRCS method (Chapter 4). The design storm that produces the largest peak discharge (or volume, when appropriate) should be selected for use in the runoff calculation.

When applying the Rational Method, the storm duration for the rainfall intensity parameter will be equal to the time of concentration (T_c) (Chapter 3).

This chapter provides guidance for estimating the rainfall intensity for use with the Rational Method when the watershed is less than 640 acres (1.0 square mile) and the NRCS Method when the watershed is larger than 640 acres (1.0 square mile).

2.2 Rainfall Depth and Intensity

Rainfall depth and intensity at a point can be obtained using the National Oceanic and Atmospheric Administration (NOAA) online Precipitation Frequency Data Server (PFDS): http://hdsc.nws.noaa.gov/hdsc/pfds/. NOAA Atlas 14, Volume 6, encompasses Imperial County and was updated in 2011. The NOAA Atlas 14 online tool uses an interactive map or user provided latitude/longitude, once the state has been selected. The required return interval will be dictated by the project.

An assumption of the Rational Method is equal intensity rainfall over the entire drainage basin. For this reason, when using NOAA Atlas 14 for the Rational Method, multiple points within the watershed should be evaluated and the highest value used.

The NRCS Method, for larger areas, requires an average rainfall over the entire watershed. The recommended method to obtain the average precipitation over the watershed is to use GIS software. The PFDS (link above) provides gridded rainfall estimates under the “Supplementary information” tab. Once the recurrence interval and duration are selected, the gridded data can be downloaded. The data will cover the Southwestern United States, which includes Imperial County. Average rainfall can be determined using a georeferenced shapefile of the watershed.

2.3 Depth-Area Reduction Factors

Convective storms are not uniformly distributed in space, typically having a higher rainfall intensity at the storm center and decreasing intensity toward the storm edge. Similarly, general storms tend to have rainfall depths that vary through the spatial extent of the storm.

Rainfall values are selected from point depth duration frequency curves in standard resources like NOAA Atlas 14 as described in Section 2.2. This is the expected rainfall depth at one location in a watershed for the specified duration and frequency. Because storms are not uniformly distributed in space, point rainfall is typically higher than aerially-averaged rainfall depths. Depth Area Reduction Factors (DARFs) are used to convert point precipitation values of a given recurrence interval to an area average precipitation value of the same recurrence.

DARFs are represented by a set of curves relating the DARF to watershed area and return interval. The DARF curves for Imperial County are presented in Figure 2-1 and Figure 2-2 (NOAA, 1973). DARF values range from 0 to 1.0 (shown as 0 to 100 percent on the figures) and reduce the point value to an average areal estimate. After watershed rainfall depth has been determined for the appropriate return interval, the rainfall depth should be reduced using the DARF value from Figure 2-1, Figure 2-2 or Table 2-1 corresponding to the watershed size and rainfall duration. If the watershed size is not represented in Table 2-1, select the next size smaller watershed, interpolate or use Figure 2-1 or Figure 2-2. For watersheds smaller than 5 square miles, use a DARF equal to 1.0. If the watershed is larger than 400 square miles, use the value for 400 square miles. In the case of durations less than 30 minutes, use the 30-minute DARF value. For durations greater than 24 hours, use a DARF equal to 1.0.

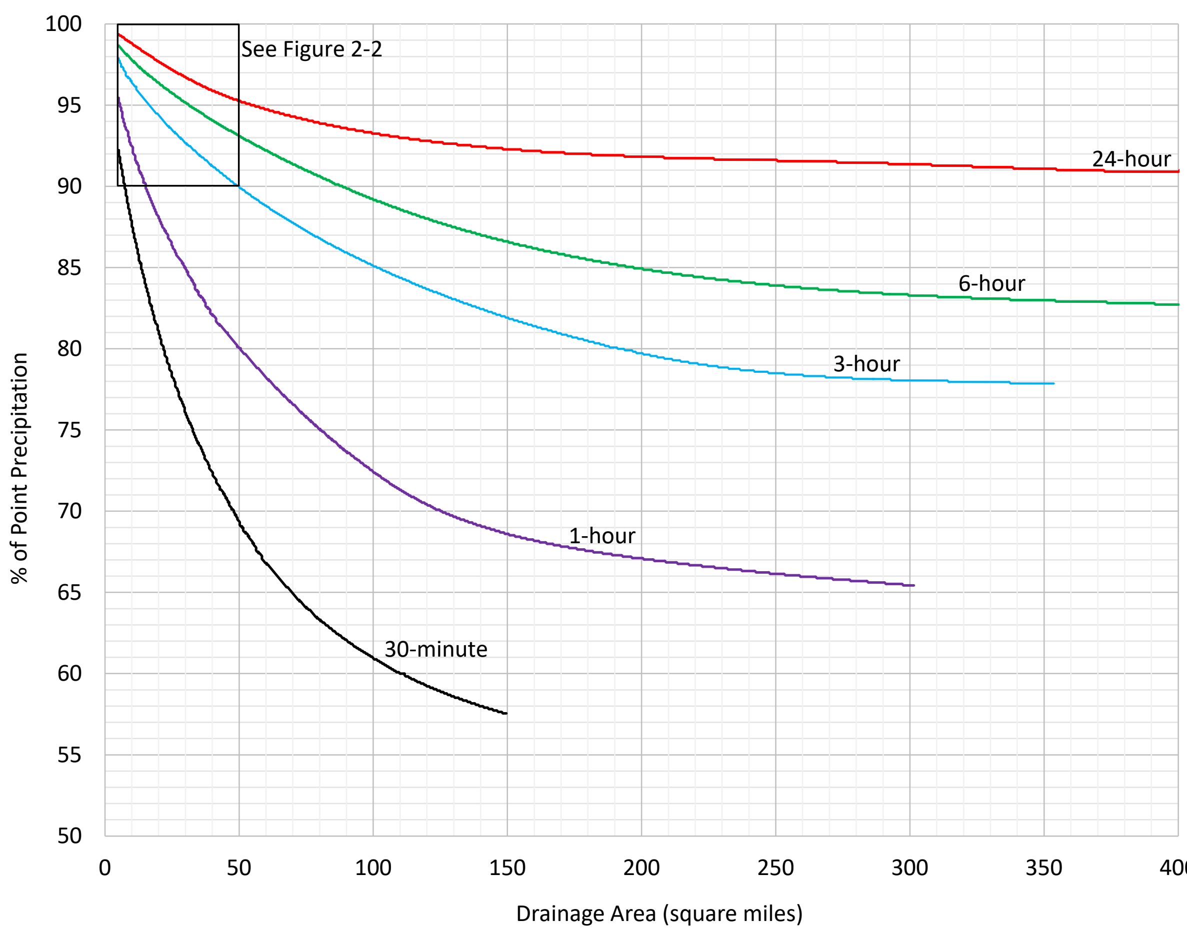


Figure 2-1. Depth-Area Reduction Factor Curves for Imperial County

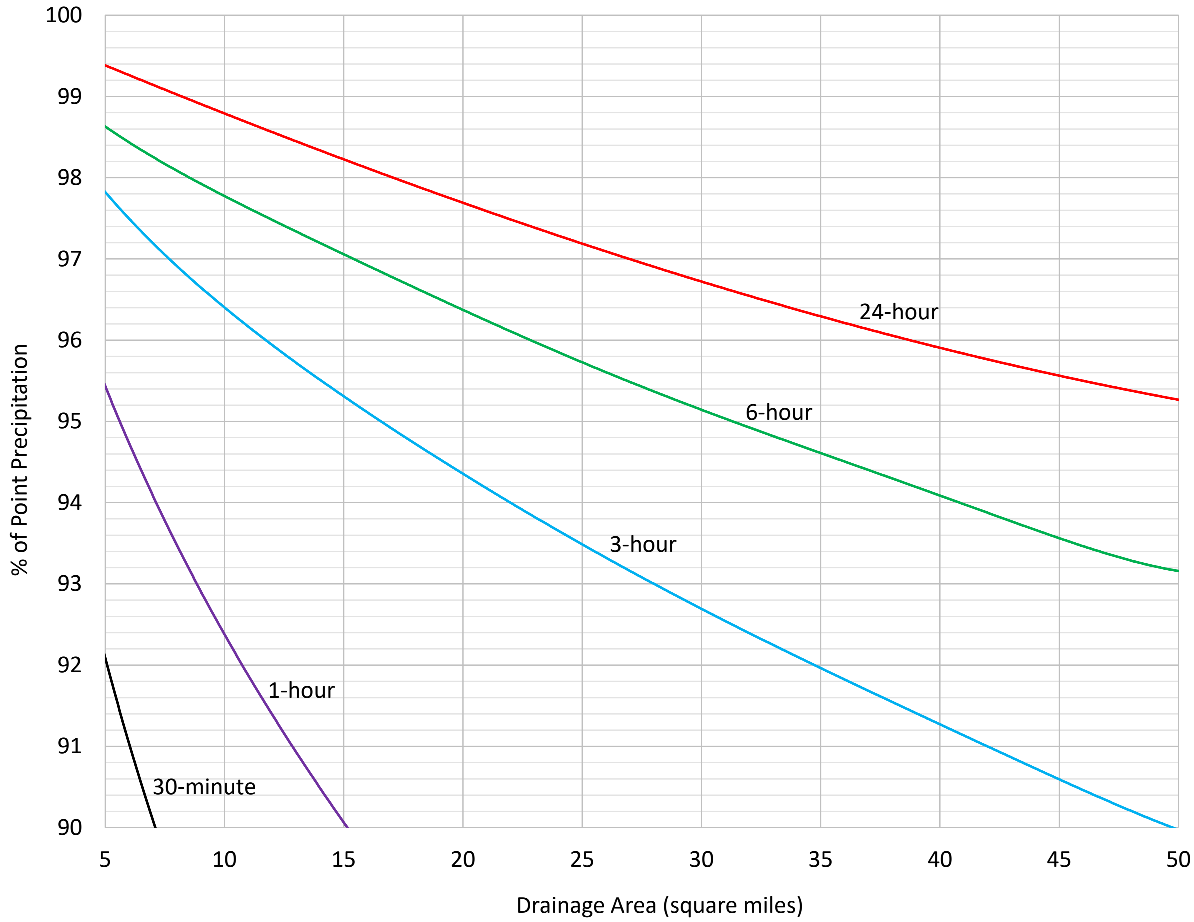


Figure 2-2. Depth-Area Reduction Factor Curves for Imperial County (5 to 50 square miles)

Table 2-1. Depth-Area Reduction Factors for Imperial County

Watershed Area (mi^2)	Duration				
	30-min	1-hr	3-hr	6-hr	24-hr
0	1.000	1.000	1.000	1.000	1.000
5	0.942	0.970	0.980	0.985	0.990
10	0.900	0.947	0.970	0.980	0.985
20	0.834	0.900	0.952	0.963	0.975
30	0.768	0.858	0.932	0.950	0.964
40	0.730	0.830	0.915	0.940	0.958
50	0.692	0.800	0.900	0.928	0.952
60	0.663	0.778	0.883	0.920	0.948
70	0.645	0.760	0.872	0.912	0.945
80	0.630	0.746	0.862	0.904	0.942
90	0.620	0.735	0.853	0.896	0.938
100	0.610	0.722	0.845	0.890	0.935
125	0.588	0.700	0.830	0.878	0.930
150	0.572	0.685	0.818	0.865	0.925

Watershed Area (mi^2)	Duration 30-min	1-hr	3-hr	6-hr	24-hr
175	0.572	0.672	0.808	0.858	0.922
200	0.572	0.666	0.798	0.851	0.918
225	0.572	0.660	0.790	0.845	0.915
250	0.572	0.655	0.787	0.842	0.914
300	0.572	0.652	0.782	0.838	0.912
350	0.572	0.652	0.780	0.830	0.910
400	0.572	0.652	0.780	0.828	0.908

2.4 Temporal Distribution

When the Rational Method is used, equal distribution of rainfall is assumed and only the peak discharge resulting from the rainfall is estimated. When the NRCS Method is used, there is no assumption of evenly distributed rainfall and the method may be used to estimate a runoff hydrograph (discharge varies with time). Because rainfall may vary over the runoff time period, the temporal distribution of the rainfall event becomes important. The temporal distribution of the rainfall is *when* the rainfall occurs throughout the storm event. The time distribution of rainfall during a storm can be represented graphically as a hyetograph, a chart showing increments of average rainfall during successive units of time during a storm.

The rainfall distribution adopted for this manual is a nested storm pattern, based on the United States Army Corps of Engineers (USACE), Hydrologic Engineering Center (HEC) Training Document Number 15 (HEC TD-15), *Hydrologic Analysis of Ungaged Watersheds Using HEC-1* (USACE, 1982). A 24-hour nested storm shall be used for flood flow computations. The peak of the nested storm will occur at hour 16 of the 24- hour storm. The nested storm will be distributed about hour 16 of the 24-hour storm using a (2/3, 1/3) distribution. The nested storm pattern with 2/3, 1/3 distribution is presented in Figure 2-3.

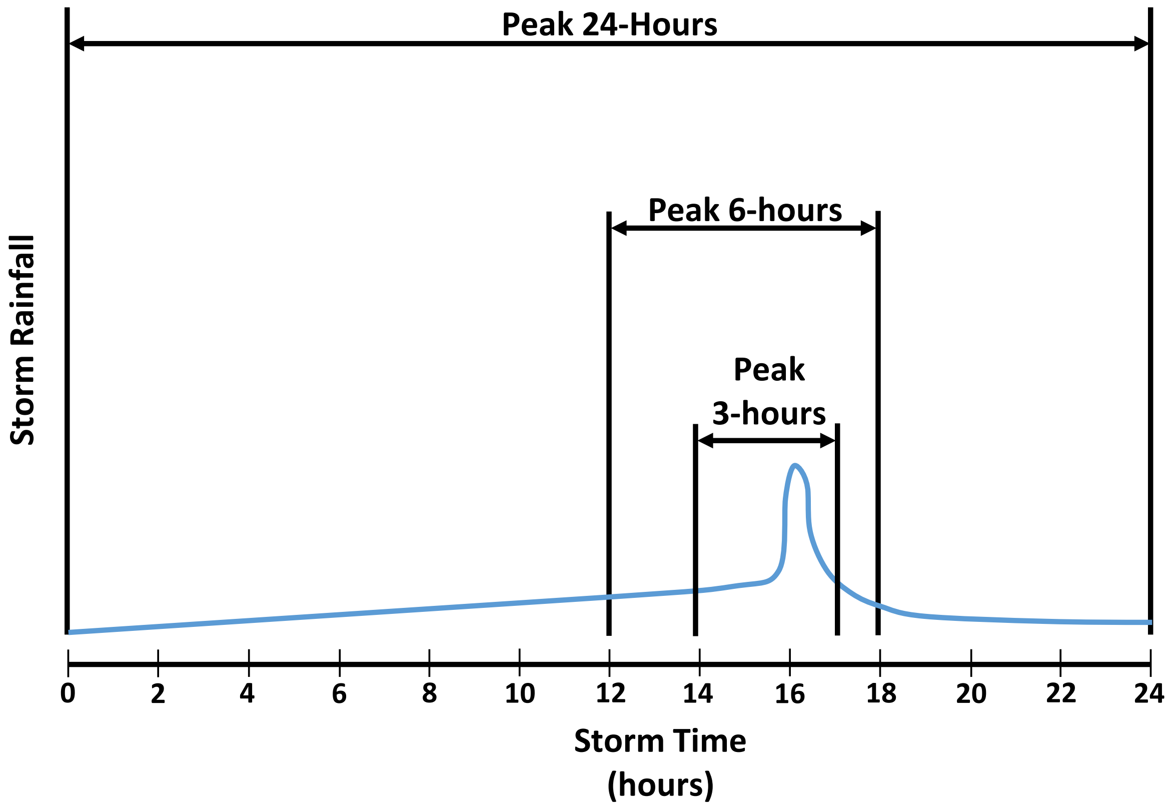


Figure 2-3. Nested Storm Pattern with 2/3, 1/3 Distribution

Creation of the 24-hour nested storm rainfall distribution requires rainfall depths for increments of storm duration from the selected computation interval through 24 hours (e.g., to create the nested storm using a 15-minute computation interval, rainfall depths are required for durations equal to 15 minutes, 30 minutes, 45 minutes, 1 hour, 1.25 hours, and so on through 24 hours). The computation interval is the period of excess rainfall (D) and should be less than or equal to twenty percent of the time to peak ($0.2T_p$). Excess rainfall is the volume of precipitation that falls at any intensity exceeding that which can infiltrate and T_p is the time to peak runoff in the watershed, which is discussed in Section 4.2.5.

Total rainfall amounts for the appropriate 6-hour design duration and/or 24-hour design duration shall be obtained from the NOAA Atlas 14 PFDS as described in Section 2.2. For durations not available from the NOAA Atlas 14 PFDS, log-log interpolation with the nearest duration values may be used to estimate the rainfall for the duration. If the watershed area is greater than 10 square miles, the rainfall depth for each duration must be adjusted using the appropriate depth-area adjustment values based on the watershed area from Table 2-1. For durations less than 30 minutes, the 30-minute depth area adjustment value is used. For durations greater than 30 minutes and not equal to durations with data available in Table 2-1, depth area adjustment is interpolated by linear interpolation between the surrounding data points.

Ordinates of the design storm hyetograph are created using the depth-area adjusted rainfall amounts. The first ordinate R_D is the depth-area adjusted total rainfall amount for the first time increment. The second ordinate R_{2D} - R_D is the depth-area adjusted total rainfall amount for the second time increment minus the depth-area adjusted total rainfall amount for the first time increment. The third ordinate R_{3D} - R_{2D} is the depth-area adjusted total rainfall amount for the third time increment minus depth-area adjusted total rainfall amount for the second time increment, and so on. Note: the sum of the ordinates of the hyetograph should be equal to the depth-area adjusted total rainfall amount for the design duration (6 hours or 24 hours). A worked example of this procedure is presented in the following section of this manual. This procedure is also available within the Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) software (the frequency storm hyetograph option with 67 percent weighting).

To obtain the 2/3, 1/3 temporal distribution, sort the ordinates of the hyetograph into the 2/3, 1/3 order of distribution. The first ordinate is the peak rainfall ordinate. This peak rainfall ordinate occurs at hour 16.0 of the 24-hour storm. The second rainfall ordinate occurs at 16.0 hours - 1D, the third rainfall ordinate occurs at 16.0 hours - 2D, and the fourth rainfall ordinate occurs at 16.0 hours + 1D. The sequence continues alternating two ordinates to the left and one ordinate to the right as presented in Figure 2-4. Creation of such a design storm is required for use of the NRCS Method to determine runoff from watersheds larger than 640 acres (1.0 square mile.) A method using HEC-HMS to perform the calculations is described in Section 4.4.

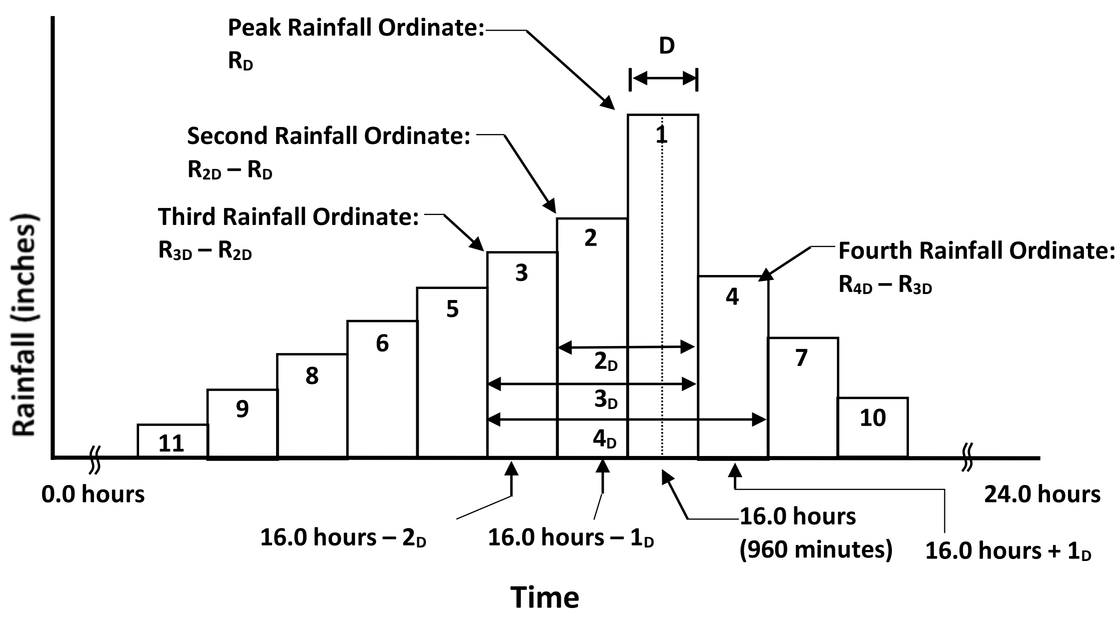


Figure 2-4. Design Storm Hyetograph Construction

2.5 Worked Example

Create a 100-year, 24-hour storm hyetograph. Assume the watershed area is 7,400 acres and the T_p is 5 hours. The center of the watershed is located at approximately 33.1130°N, 115.8755°W.

Because T_p is 5 hours, the duration D is 1 hour ($D = 0.2T_p$). The gridded point precipitation data for the 100-year, 24-hour storm are downloaded from NOAA Atlas 14 as described in Section 2.2. The duration, D, is 1 hour, so required point precipitation frequency estimates are all durations from 1 hour to 24 hours. Available durations are: 60 minute, 2 hour, 3 hour, 6 hour, 12 hour and 24 hour.

Using GIS software, the watershed boundary is delineated and an average point precipitation in the watershed is estimated for each duration using the gridded point precipitation data. Average point precipitation for this example is presented in Table 2-2.

Table 2-2. Hyetograph Example Average Precipitation

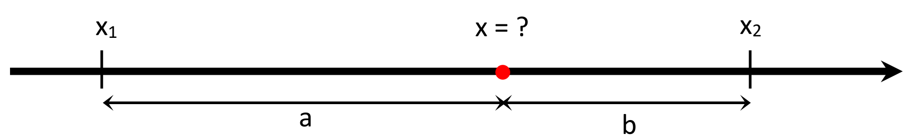
Duration	**60 min**	**2 hr**	**3 hr**	**6 hr**	**12 hr**	**24 hr**
Average Watershed Precipitation (in)	1.58	1.98	2.23	2.67	3.13	4.00

To create the hyetograph, rainfall depths for each multiple of the Duration D not provided by NOAA Atlas 14 are estimated using log interpolation. This is accomplished as follows:

Precipitation values for hours 1, 2 and 3 were obtained directly from NOAA Atlas 14. The 4th and 5th hour precipitation amounts must be estimated using log interpolation between hour 3 and 6, however. This is accomplished using the formula

$$x = x_2^{\left(\frac{a}{a+b}\right)} x_1^{\left(1-\frac{a}{a+b}\right)} \tag{2-1}$$

having variables defined as,



The 4th hour precipitation is then estimated as

$x_1 = 2.23 \qquad x_2 = 2.67$

$a = (4-3) = 1 \qquad b = (6-4) = 2$

$$x = 2.67^{\left(\frac{1}{1+2}\right)}\ 2.23^{\left(1 - \frac{1}{1+2}\right)}$$

So, 4th hour precipitation, x = 2.37 inches

Similarly, the 5th hour precipitation is then estimated as

$$x_1 = 2.23 \qquad x_2 = 2.67$$

$$a = (5\text{-}3) = 2 \qquad b = (6\text{-}5) = 1$$

$$x = 2.67^{\left(\frac{2}{1+2}\right)}\ 2.23^{\left(1 - \frac{2}{1+2}\right)}$$

So, 5th hour precipitation, x = 2.51 inches

This is repeated until point precipitation values for all hours not available from NOAA Atlas 14 have been estimated. The watershed area is greater than 10 square miles (7,400 acres = 11.6 square miles), so a depth-area reduction will be applied by multiplying the DARF value and the point precipitation for that time period yielding the depth area adjusted precipitation for that time period. The hyetograph ordinate for each time period may then be determined as the difference between the hourly depth-area adjusted precipitation values. Results are summarized in Table 2-3.

Table 2-3. Summarized Values Hyetograph Example

Duration (hr)	Point Precipitation for Duration (in)*	DARF	Depth-Area Adjusted Precipitation (in)	Hyetograph Ordinate (R_{nD}) (in)
1	**1.58**	0.94	1.48	1.48
2	**1.98**	0.95	1.89	0.40
3	**2.23**	0.97	2.16	0.27
4	2.37	0.97	2.30	0.14
5	2.51	0.97	2.45	0.15
6	**2.67**	0.98	2.61	0.16
7	2.74	0.98	2.68	0.07
8	2.82	0.98	2.75	0.07
9	2.89	0.98	2.83	0.07
10	2.97	0.98	2.91	0.08
11	3.05	0.98	2.98	0.08
12	**3.13**	0.98	3.07	0.08
13	3.19	0.98	3.13	0.06
14	3.26	0.98	3.20	0.07
15	3.33	0.98	3.26	0.07

Duration (hr)	Point Precipitation for Duration (in)*	DARF	Depth-Area Adjusted Precipitation (in)	Hyetograph Ordinate (R_{nD}) (in)
16	3.40	0.98	3.33	0.07
17	3.47	0.98	3.40	0.07
18	3.54	0.98	3.47	0.07
19	3.61	0.98	3.55	0.07
20	3.69	0.98	3.62	0.07
21	3.76	0.98	3.70	0.08
22	3.84	0.98	3.77	0.08
23	3.92	0.98	3.85	0.08
24	**4.00**	0.98	3.93	0.08
				Σ = 3.93

*Bold values are directly from data, others are interpolated

Duration rainfall amounts are the hyetograph ordinates in Table 2-3 arranged in descending order in a 2/3, 1/3 fashion centered on hour 16, i.e., hour 16 = 1.48 inches, hour 15 = 0.41 inches, hour 14 = 0.27 inches, hour 17 = 0.14 inches, hour 13 = 0.15 inches, etc. The resulting, completed hyetograph is presented in Figure 2-5.

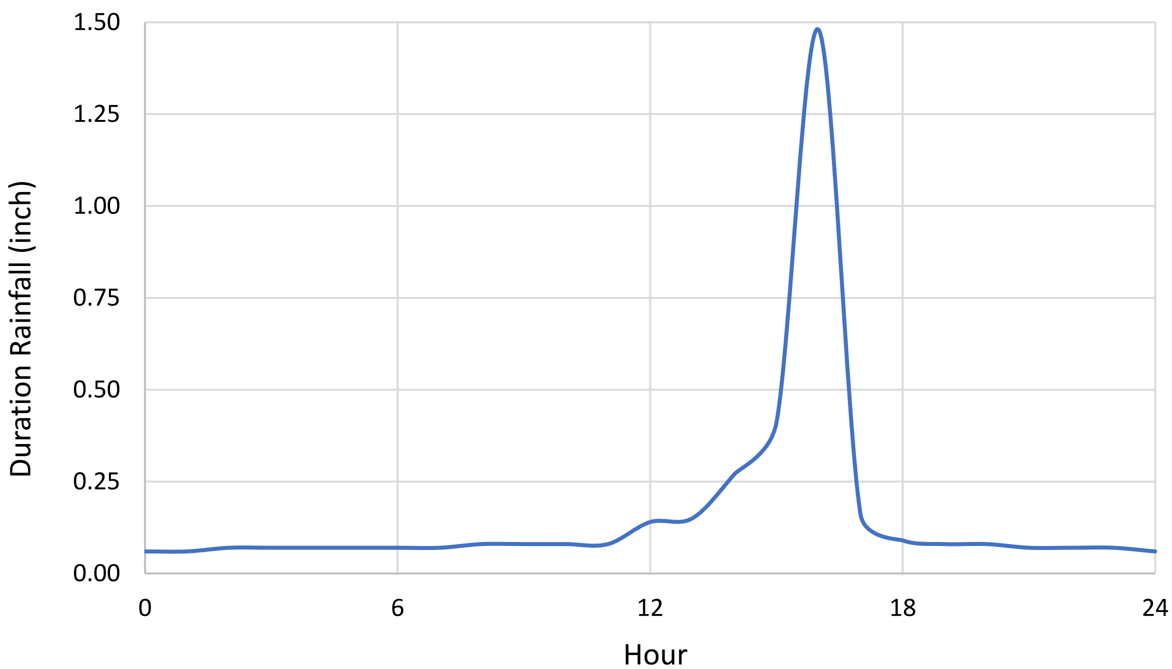


Figure 2-5. Completed Design Storm Hyetograph Example

3 Small Area Hydrologic Procedure – Rational Method

3.1 General Description

The Rational Method (RM) is a mathematical formula used to determine the maximum runoff rate from a given rainfall. It has particular application in urban storm drainage, where it is used to estimate peak runoff rates from small urban and rural watersheds for the design of storm drains and small drainage structures. The RM is recommended for analyzing the runoff response from drainage areas up to approximately 640 acres (1.0 square mile) in size. When independent drainage systems are present within the watershed being analyzed using the RM, the Modified Rational Method (MRM) should be used in order to combine the flows of the independent systems at junctions (see Section 3.4). When the watershed size exceeds 640 acres the Natural Resources Conservation Service (NRCS) Hydrologic Method should be used (see Section 4).

The RM can be applied using any design storm return interval (e.g., 100-year, 50-year, 10-year, etc.). Precipitation estimates are based on National Oceanic and Atmospheric Administration (NOAA) Atlas 14. Precipitation frequency estimates for the required storm frequency and duration can be attained via the NOAA Atlas 14 online Precipitation Frequency Data Server (PFDS) as described in Section 2.2.

3.1.1 Rational Method Formula

The RM formula estimates the peak rate of runoff at any location in a watershed as a function of the drainage area (A), runoff coefficient (C), and rainfall intensity (I). The intensity is a function of the rainfall duration and is determined for a duration set equal to the time of concentration (T_c), which is the time required for water to flow from the most hydraulically remote point of the basin to the location being analyzed. The RM formula is expressed as follows:

$$Q_p = C \cdot I \cdot A \tag{3-1}$$

Where: Q_p = peak discharge, in cubic feet per second (cfs)

C = runoff coefficient, proportion of the rainfall that runs off the surface (no units)

I = average rainfall intensity for a duration equal to the T_c for the area, in inches per hour (Note: If the computed T_c is less than 5 minutes, use 5 minutes for computing the peak discharge, Q_p)

A = drainage area contributing to the design location, in acres

Combining the units for the expression CIA yields:

$$\left(\frac{\text{acres}\cdot\text{inches}}{\text{hour}}\right)\left(\frac{43{,}560\text{ square feet}}{\text{acres}}\right)\left(\frac{1\text{ foot}}{12\text{ inches}}\right)\left(\frac{1\text{ hour}}{3{,}600\text{ seconds}}\right)=1.008\text{ cfs} \qquad (3\text{-}2)$$

For practical purposes the unit conversion coefficient difference of 0.8% can be ignored.

The RM formula is based on the assumption that for constant rainfall intensity, the peak discharge rate at a point will occur when the raindrop that falls at the most hydraulically remote point in the tributary drainage basin arrives at the point of interest. The most hydraulically remote point is the location from which drainage will take the longest to arrive at the point of interest. Figure 3-1 demonstrates this concept.

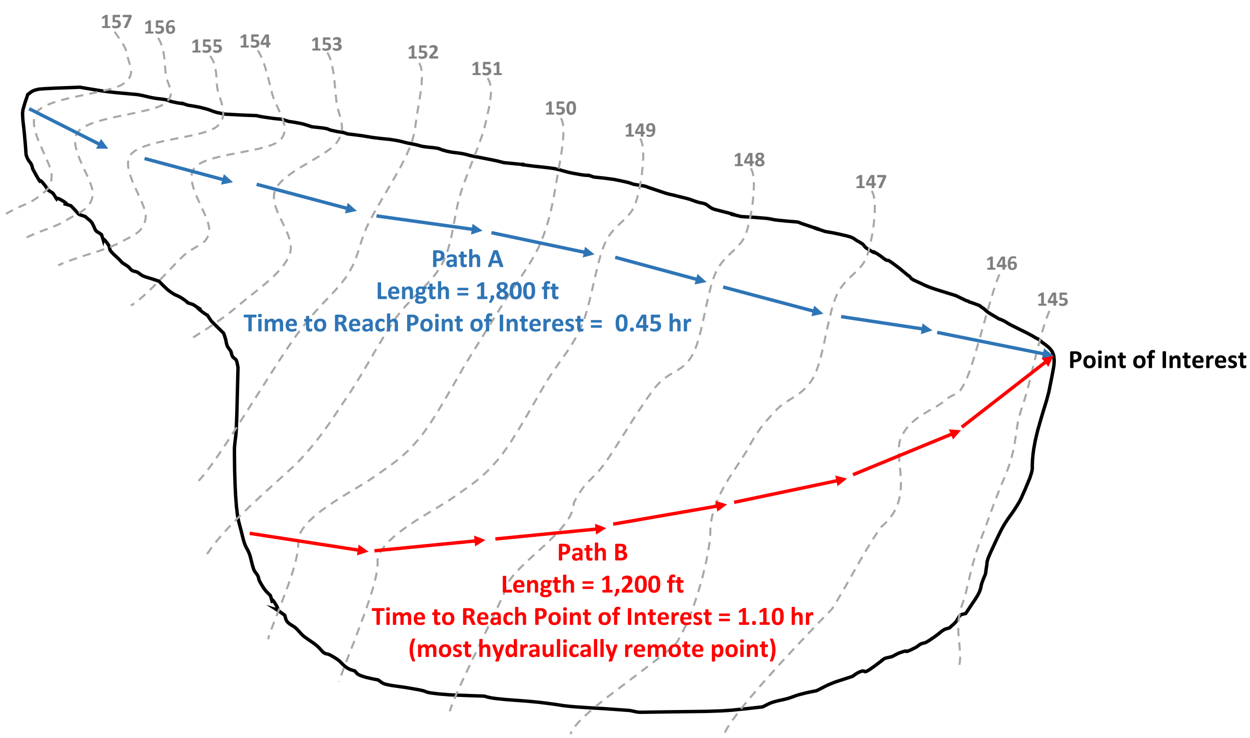


Figure 3-1. Most Hydraulically Remote Point

Unlike the Modified Rational Method (MRM) (discussed in Section 3.4) or the NRCS hydrologic method (discussed in Section 4), the RM does not create hydrographs and therefore does not add separate subarea hydrographs at collection points.

As discussed above, the characteristics of the RM are summarized as follows:

1) Peak flow occurs when the entire watershed is contributing to the flow.

2) Rainfall intensity is the same over the entire drainage area.

3) Rainfall intensity is uniform over a time duration equal to T_c.

4) The storm frequency of peak discharges is the same as that of I for the given T_c.

5) The fraction of rainfall that becomes runoff (or the runoff coefficient, C) is dependent on the return period.

6) The peak rate of runoff is the only information produced by using the RM.

3.1.2 Runoff Coefficient

The runoff coefficient (C) corresponds to the percentage of rainfall that becomes runoff. An estimated value for C may be determined from Table 3-2 or Table 3-3. Table 3-2 provides ranges of runoff coefficient values based on land use. Table 3-3 provides urban runoff coefficients based on land use and soil type.

Soil type determination should be done using a method approved by the County prior to work being done. If the County has no preferred method at the site, two possible methods are soil testing at the site or using the USDA NRCS Web Soil Survey online tool available here: http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx. An appropriate runoff coefficient (C) for each type of land use in the subarea should be selected from Table 3-3 and multiplied by the percentage of the total area (A) included in that class. The sum of the products for all land uses is the weighted runoff coefficient $\sum(C \cdot A)$. Good engineering judgment should be used when applying the values presented in Table 3-3, as adjustments to these values may be appropriate based on site-specific characteristics.

Table 3-2 and Table 3-3 provide approximate runoff coefficient values for various development types. In urban areas the runoff coefficient can also be estimated based on the percent of impervious area and the percent of open space based on the following formula:

$$C = 0.90 \times (\%\ \text{Impervious}) + C_p \times (1 - \%\ \text{Impervious}) \qquad (3\text{-}3)$$

Where: C_p = Pervious Coefficient Runoff Value for the soil type (shown in Table 3-3 as Undisturbed Natural Terrain/Permanent Open Space, 0% Impervious). Soil type can be determined as previously described.

The values in Table 3-3 are typical for most urban areas. However, if the basin contains rural or agricultural land use, parks, golf courses, or other types of nonurban land use that are expected to be permanent, the appropriate value should be selected based upon the soil and cover and approved by the County.

The determined runoff coefficient (C) is for storm return periods up to 10 years. Less frequent, higher intensity storms tend to generate more runoff requiring a modification to the runoff coefficient. For these storms, the adjusted C value is obtained by multiplying C by the appropriate value in Table 3-1. *The final runoff coefficient may never exceed 1.0.* (If the modified runoff coefficient exceeds 1.0, use the value 1.0.)

Table 3-1. 'C' Modification Value Based on Return Period

Return Period (years)	'C' Modification Value
25	1.1
50	1.2
100	1.25

after Caltrans Highway Design Manual, July 1, 2015. pp. 810-18

Table 3-2. Runoff Coefficient Values

Land Use	'C' Coefficient Range		Soil Type	'C' Coefficient Range
Business			**Lawns, slope**	
downtown areas	0.70 – 0.95		sandy soil, flat, 2%	0.05 – 0.10
neighborhood areas	0.50 – 0.70		sandy soil, avg., 2 – 7%	0.10 – 0.15
Residential			sandy soil, steep, 7%	0.15 – 0.20
single family areas	0.30 – 0.50		heavy soil, flat, 2%	0.13 – 0.17
multi units, detached	0.40 – 0.60		heavy soil, avg., 2 – 7%	0.18 – 0.22
multi units, attached	0.60 – 0.75		heavy soil, steep, 7%	0.25 – 0.35
suburban	0.25 – 0.40		**Agricultural land**	
Industrial			*bare packed soil*	
light areas	0.50 – 0.80		smooth	0.30 – 0.60
heavy areas	0.60 – 0.90		rough	0.20 – 0.50
Parks and Cemeteries	0.60 – 0.90		*cultivated rows*	
Playgrounds	0.60 – 0.90		heavy soil, no crop	0.30 – 0.60
Railroad yard areas	0.60 – 0.90		heavy soil, with crop	0.20 – 0.50
			sandy soil, no crop	0.20 – 0.40
			sandy soil, with crop	0.10 – 0.25
			pasture	
			heavy soil	0.15 – 0.45
			sandy soil	0.05 – 0.25
			woodlands	0.05 – 0.25

Table 3-3. Runoff Coefficients for Urban Areas

Land Use		Runoff Coefficient "C"				
			Soil Type			
NRCS Elements	Structure(s) Utilization	% IMPER	A	B	C	D
Undisturbed Natural Terrain (Natural)	Permanent Open Space	0*	0.20	0.25	0.30	0.35
Low Density Residential (LDR)	Residential, 1.0 DU/A or less	10	0.27	0.32	0.36	0.41
Low Density Residential (LDR)	Residential, 2.0 DU/A or less	20	0.34	0.38	0.42	0.46
Low Density Residential (LDR)	Residential, 2.9 DU/A or less	25	0.38	0.41	0.45	0.49
Medium Density Residential (MDR)	Residential, 4.3 DU/A or less	30	0.41	0.45	0.48	0.52
Medium Density Residential (MDR)	Residential, 7.3 DU/A or less	40	0.48	0.51	0.54	0.57
Medium Density Residential (MDR)	Residential, 10.9 DU/A or less	45	0.52	0.54	0.57	0.60
Medium Density Residential (MDR)	Residential, 14.5 DU/A or less	50	0.55	0.58	0.60	0.63
High Density Residential (HDR)	Residential, 24.0 DU/A or less	65	0.66	0.67	0.69	0.71
High Density Residential (HDR)	Residential, 43.0 DU/A or less	80	0.76	0.77	0.78	0.79
Commercial/Industrial (N. Com)	Neighborhood Commercial	80	0.76	0.77	0.78	0.79
Commercial/Industrial (G. Com)	General Commercial	85	0.80	0.8	0.81	0.82
Commercial/Industrial (O.P. Com)	Office Professional/Commercial	90	0.83	0.84	0.84	0.85
Commercial/Industrial (Limited I.)	Limited Industrial	90	0.83	0.84	0.84	0.85
Commercial/Industrial (General I.)	General Industrial	95	0.87	0.87	0.87	0.87

*The values associated with 0% impervious may be used for direct calculation of the runoff coefficient as described in Section 3.12 (representing the pervious runoff coefficient, C_p, for the soil type), or for areas that will remain undisturbed in perpetuity. Justification must be given that the area will remain natural forever (e.g., the area is located in Cleveland National Forest).

DU/A = dwelling units per acre

3.1.3 Rainfall Intensity

The rainfall intensity (I, inches/hour) is the rainfall rate for a duration equal to the time of concentration (T_c) for a selected storm frequency. Once a particular storm frequency has been selected for design and a T_c calculated for the drainage area, the rainfall intensity can be determined from the NOAA Atlas 14 Point Precipitation Frequency Estimates as described in Section 2.2. Interpolation will likely be necessary to obtain the rainfall intensity corresponding to T_c.

3.1.4 Time of Concentration

The time of concentration (T_c) is the time required for runoff to flow from the most hydraulically remote part of the drainage area to the point of interest. The T_c is composed of two components: initial time of concentration (T_i) and travel time (T_t). Methods of computation for T_i and T_t are discussed below. The T_i is the time required for runoff to travel as sheet flow across the surface of the most remote subarea in the study, or "initial subarea." Guidelines for designating the initial subarea are provided within the discussion of computation of T_i in the following section. The T_t is the time required for the runoff to flow in a watercourse (e.g., swale, channel, gutter, and pipe) or series of watercourses from the initial subarea to the point of interest. For the RM, the T_c at any point within the drainage area is given by:

$$T_c = T_i + T_t \qquad (3\text{-}4)$$

Methods of calculation differ for natural watersheds (non-urbanized) and for urban drainage systems, however, if T_C is estimated to be less than 5 minutes, use 5 minutes in natural or urban watersheds. When analyzing storm drain systems, the designer must consider the possibility that an existing natural watershed may become urbanized during the useful life of the storm drain system. Future land uses must be used for T_c and runoff calculations, and can be determined by consulting with the County.

3.1.4.1 Initial Time of Concentration

The initial time of concentration (T_i) is typically based on sheet flow at the upstream end of a drainage basin. Sheet flow is the shallow mass of runoff on a planar surface with a uniform depth across the sloping surface. This usually occurs at the headwater of streams over relatively short distances, rarely more than about 400 feet, and possibly less than 80 feet. Maximum overland sheet flow lengths based on land use and slope are provided in Table 3-4. Suggested initial T_i values based on average C values are also provided in the table. Alternatively, the initial time of concentration (T_i) may be estimated using Equation (3-5) developed by the Federal Aviation Administration (FAA) (still observing maximum overland sheet flow length).

$$T_i = \frac{1.8(1.1\text{-}C)\sqrt{L}}{S^{1/3}} \qquad (3\text{-}5)$$

Where: T_i = sheet flow travel time, minutes

C = runoff coefficient (use Table 3-3 or Equation (3-3) and modify using Table 3-1 according to the return period)

L = flow length, feet (subject to Table 3-4)

S = surface slope, %

The sheet flow that is predicted by the FAA equation is limited to conditions that are similar to runway topography. Some considerations that limit the extent to which the FAA equation applies are identified below:

Urban Areas - This “runway type” runoff includes:

1) Flat roofs, sloping at 1%.

2) Parking lots at the extreme upstream drainage basin boundary (at the “ridge” of a catchment area). Even a parking lot is limited in the amounts of sheet flow it can produce. Parked or moving vehicles “break-up” the sheet flow, concentrating runoff into streams that are not characteristic of sheet flow.

3) Driveways are constructed at the upstream end of catchment areas in some developments. However, if flow from a roof is directed to a driveway through a downspout or other conveyance mechanism, flow is concentrated.

4) Flat slopes are prone to meandering flow that tends to be disrupted by minor irregularities and obstructions. Maximum Overland Flow lengths are shorter for flatter slopes (see Table 3-4).

Rural or Natural Areas - The FAA equation is applicable to these conditions since (0.5% to 10%) slopes that are uniform in width of flow (e.g. flow depth and velocity are not being greatly affected by widely varying lateral boundaries) have slow velocities consistent with the equation. Irregularities in terrain limit the length of application.

1) Most hills and ridge lines have a relatively flat area near the drainage divide. However, with flat slopes of 0.5%, minor irregularities cause flow to concentrate into streams.

2) Parks, lawns and other vegetated areas have slow velocities that are consistent with the FAA Equation.

Table 3-4. Maximum Overland Sheet Flow Length (L_M) in feet and Corresponding T_i Estimate in minutes

Land Use*	DU/ acre	.5%		1%		2%		3%		5%		10%	
		L_M	T_i	L_M	T_i	L_M	T_i	L_M	T_i	L_M	T_i	L_M	T_i
Natural		50	13.2	70	12.5	85	10.9	100	10.3	100	8.7	100	6.9
LDR	1	50	12.2	70	11.5	85	10.0	100	9.5	100	8.0	100	6.4
LDR	2	50	11.3	70	10.5	85	9.2	100	8.8	100	7.4	100	5.8
LDR	2.9	50	10.7	70	10.0	85	8.8	95	8.1	100	7.0	100	5.6
MDR	4.3	50	10.2	70	9.6	80	8.1	95	7.8	100	6.7	100	5.3
MDR	7.3	50	9.2	65	8.4	80	7.4	95	7.0	100	6.0	100	4.8
MDR	10.9	50	8.7	65	7.9	80	6.9	90	6.4	100	5.7	100	4.5
MDR	14.5	50	8.2	65	7.4	80	6.5	90	6.0	100	5.4	100	4.3
HDR	24	50	6.7	65	6.1	75	5.1	90	4.9	95	4.3	100	3.5
HDR	43	50	5.3	65	4.7	75	4.0	85	3.8	95	3.4	100	2.7
N. Com		50	5.3	60	4.5	75	4.0	85	3.8	95	3.4	100	2.7
G. Com		50	4.7	60	4.1	75	3.6	85	3.4	90	2.9	100	2.4
O.P. Com		50	4.2	60	3.7	70	3.1	80	2.9	90	2.6	100	2.2
Limited I.		50	4.2	60	3.7	70	3.1	80	2.9	90	2.6	100	2.2
General I.		50	3.7	60	3.2	70	2.7	80	2.6	90	2.3	100	1.9

*Source: Hill, 2002. See Table 3-3 for land use abbreviations.

Because the rainfall intensity, (I), depends on T_C and T_C is not initially known, the computation of T_C is an iterative process. An initial estimate of T_C is assumed to be T_i, computed from Equation (3-5). The *initial estimate* of T_C is then used to obtain I from the Intensity-Depth-Frequency (IDF) curve for the locality. A more complete T_C is then computed from Equation (3-5) by incorporating travel time (Section 3.1.4.2). The T_C which incorporates T_i and T_t is then used to select a new rainfall intensity and T_C is calculated again. If the first and second calculated T_C are not the same, a new rainfall intensity is determined and Equation (3-5) is used to calculate T_C again. The process is repeated until two successive T_C estimates are the same.

3.1.4.2 Travel Time

Sheet flow is the first type of flow to occur when a rain drop falls on the most hydraulically remote point of the basin. This is typically followed by shallow concentrated flow and eventually open channel or pipe flow. The shallow concentrated flow time and open channel or pipe flow travel time together comprise the total travel time (T_t). Both of these are determined by calculating the velocity of flow and dividing by the travel length. Per Equation (3-4) when added to the initial sheet flow time, one obtains the time of concentration T_c.

Because the velocity normally changes with change in flow rate or slope, such as at an inlet or grade break, the total T_t must be computed as the sum of the T_t's for each section of the flow path. Figure 3-2 is a typical street gutter cross section and shows two possible flow depths: (1) all flow is contained in the concrete section adjacent to the curb and (2) flow fills the concrete portion of the gutter and extends out onto the asphalt. For street gutter geometries sufficiently similar to Figure 3-2, use Figure 3-3 to estimate shallow concentrated flow velocity. To estimate shallow concentrated flow velocity for other land covers, use Equation (3-6). To estimate average velocities in channels or pipes (or street gutter geometries not sufficiently similar to Figure 3-2), use Equation (3-7) (Manning's equation).

When flow is through a closed conduit where no additional flow can enter the system during travel, length, velocity and T_t are determined using the peak flow in the conduit. In cases where the conduit is not closed and additional flow from a contributing subarea is added to the total flow during travel (e.g., street flow in a gutter), calculation of velocity and T_t is performed using an assumed average flow based on the total area (including upstream subareas) contributing to the point of interest. The Manning equation is typically used to determine velocity. A reasonable initial estimate of average discharge for small watersheds is 2 to 3 cfs per acre, dependent on land use, drainage area, slope, and rainfall intensity.

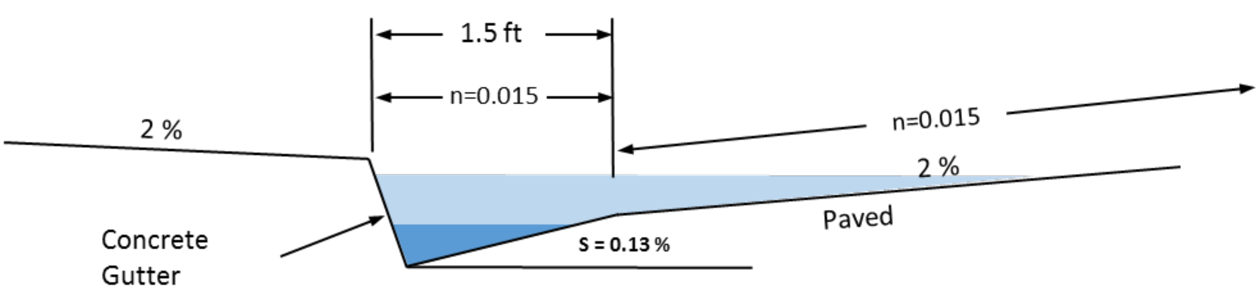
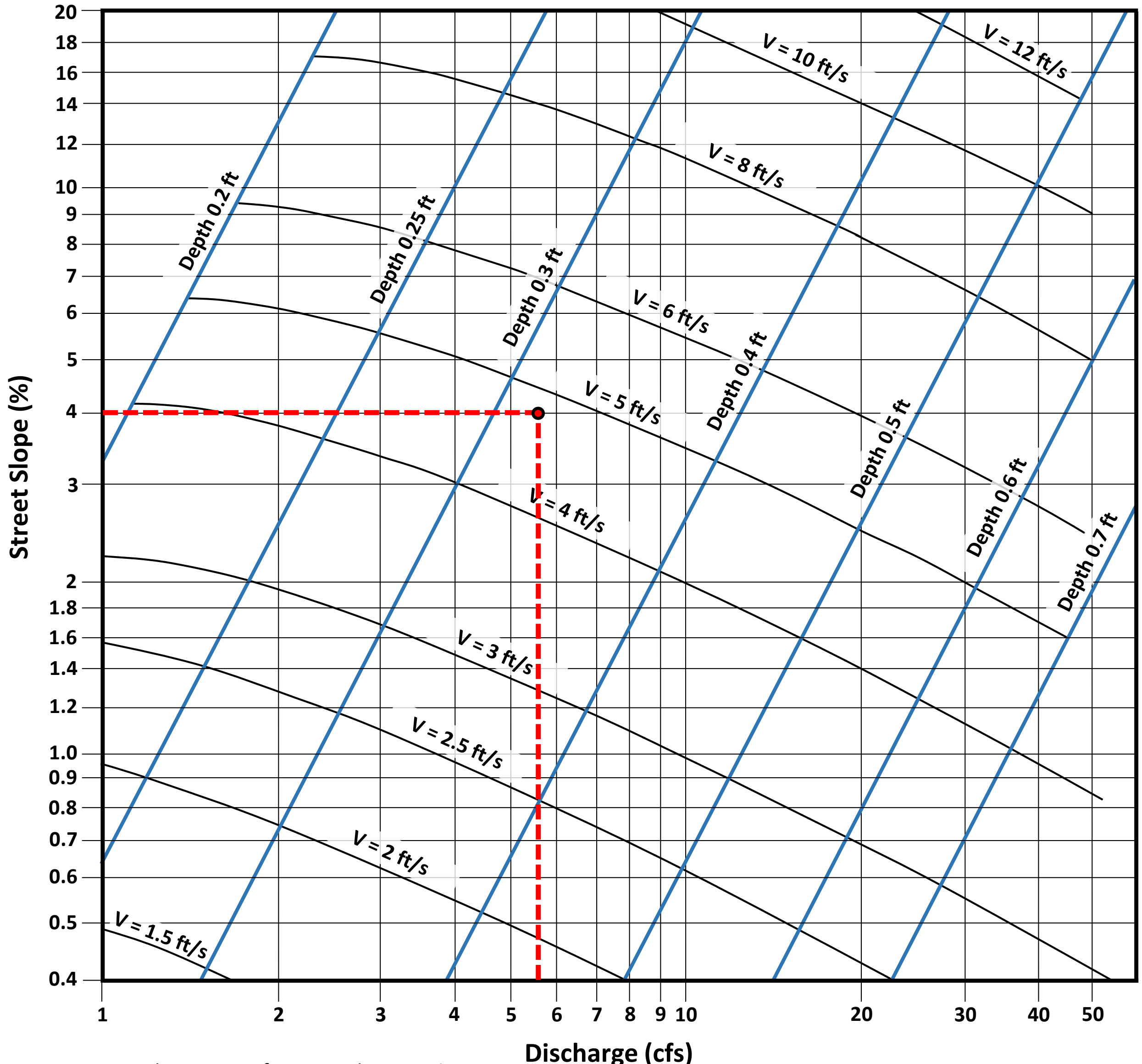


Figure 3-2. Street Gutter Geometry



Example: Q = 5.5 cfs, Street Slope = 4%
Then, Flow Depth = 0.32 ft and V = 4.8 ft/s.

Figure 3-3. Street Gutter Flow Velocity (San Diego County, 2003)

Shallow concentrated flow begins when sheet flow ends, without a well-defined channel, and with flow depths of 0.1 to 0.5 feet. Shallow concentrated flow continues until justification can be made for defining it as an open channel or pipe flow. Engineering judgment may be called for in deciding where shallow concentrated flow ends and open channel flow begins. Equation (3-6) can be used to estimate shallow concentrated flow velocity (FHWA, 2013):

$$V = 3.28 \cdot k \cdot \sqrt{S} \qquad (3\text{-}6)$$

Where: V = velocity, feet/second

k = intercept coefficient (see Table 3-5)

S = slope, %

Table 3-5. Shallow Concentrated Flow Intercept Coefficients (k) (FHWA, 2013)

Land Cover	k
Forest with heavy ground litter; hay meadow	0.076
Trash fallow or minimum tillage cultivation; contour or strip cropped; woodland	0.152
Short grass pasture	0.213
Cultivated straight row	0.274
Nearly bare and untilled; alluvial fans in western mountain regions	0.305
Grassed waterway	0.457
Unpaved	0.491
Paved area; small upland gullies	0.619

$$V = \frac{1.49}{n} \cdot R^{2/3} \cdot S^{1/2} \qquad (3\text{-}7)$$

Where: V = velocity, feet/second

n = roughness coefficient (see Table 3-6)

R = hydraulic radius (cross sectional flow area divided by wetted perimeter), feet

S = slope, foot/foot

Table 3-6. Typical Manning's Coefficient (*n*) Ranges for Channels and Pipes (FHWA, 2013)

Material	Manning's *n**
Closed Conduits	
Concrete pipe	0.010 - 0.015
Corrugated Metal Pipe (CMP)	0.011 - 0.037
Plastic pipe (smooth)	0.009 - 0.015
Plastic pipe (corrugated)	0.018 - 0.025
Pavement/gutter sections	0.012 - 0.016
Small Open Channels	
Concrete	0.011 - 0.015
Rubble or riprap	0.020 - 0.035

Material	Manning's *n**
Vegetation	0.020 - 0.150
Bare Soil	0.016 - 0.025
Rock Cut	0.025 - 0.045
Natural channels (minor streams, top width at flood stage < 30 m (100 ft))	
Fairly regular section	0.025 - 0.050
Irregular section with pools	0.040 - 0.150

*Lower values are usually for well-constructed and maintained (smoother) pipes and channels

A common mistake in urbanized areas is to assume travel velocities that are too slow. Another common error is to not check the runoff peak resulting from only part of the catchment. Sometimes a lower portion of the catchment or a highly impervious area produces a larger peak than that computed for the whole catchment. This error is most often encountered when the catchment is long or the upper portion contains grassy open land and the lower portion is more developed.

3.2 Input Data Development for the Rational Method

This section describes the development of the necessary data to perform Rational Method (RM) calculations. Section 3.3 describes the RM calculation process. Input data for calculating peak flows and T_c's with the RM should be developed as follows:

1) On a digital elevation map (DEM) or topographic base map create a drainage map of existing conditions:

    a) Delineate the drainage area boundary, and

    b) Mark drains, including drains adjacent to the delineated drainage area and overland flow paths. (Mark existing and proposed drains if evaluating existing and proposed conditions, otherwise mark existing drains for an existing conditions study and proposed drains for a proposed conditions study.)

2) Visit the site to verify the accuracy of the drainage map.

3) Divide the drainage area into subareas by locating significant points of interest. These divisions should be based on topography, soil type, and land use. Ensure that an appropriate first subarea is delineated. The first subarea is the area that is most hydraulically distant and whose runoff will

take the longest to reach the outlet. For natural areas, the first subarea flow path length should be less than or equal to 4,000 feet plus the overland flow length (see Table 3-4 for maximum allowable overland sheet flow lengths). For developed areas, the initial subarea flow path length should be consistent with Table 3-4. The topography and slope within the initial subarea should be generally uniform.

4) Working from upstream to downstream, label subareas and subarea drainage outlet locations.

5) Determine the areal coverage in acres (A) of each subarea in the drainage area.

6) Determine the length and effective slope(s) of the flow path in each subarea.

7) Identify the soil type for each subarea.

8) Determine the runoff coefficient (C) for each subarea based on Table 3-3 or Equation (3-3). If the subarea contains more than one type of development classification, determine a weighted average for C in the subarea. In determining C, use future land use taken from the applicable community plan, Multiple Species Conservation Plan, National Forest land use plan, etc.

9) Calculate the $(C \cdot A)$ value for the subarea.

10) Calculate the $(C \cdot A)$ value(s) for the subareas upstream of the point(s) of interest. Determine C for each subarea based on guidance in Section 3.1.2

3.3 Performing Rational Method Calculations

Using the developed input data, calculation of peak flows and T_c's should be performed as follows:

1) Determine T_i for the first subarea. An example is presented as Subarea A_1 in Figure 3-4. Use Table 3-4 or Equation (3-5) as discussed in Section 3.1.4.1. Additional travel time (T_t) to the downstream end of the first subarea should be added to T_i to obtain the T_c if the flow path in the first subarea is longer than the maximum length for sheet flow. Refer to Section 3.1.4.2.

2) Determine I for the subarea using NOAA Atlas 14. If T_i is less than 5 minutes, use the 5 minute time to determine intensity for calculating the flow.

3) Calculate the peak discharge flow rate for the subarea, where

$$Q_p = (C_1 \cdot A_1) I \qquad (3\text{-}8)$$

4) In case the downstream flow rate is less than the upstream flow rate, due to lower I resulting from the long travel time that is not offset by the additional subarea runoff, use the upstream peak flow for design purposes until downstream flows increase again.

5) Estimate the T_t to the next point of interest.

6) Add the T_t to the previous T_c to obtain a new T_c.

7) Continue with step 2, above, summing subareas and corresponding C values, until the final point of interest is reached.

$$Q_p = \sum_{n=1}^{\#\text{ of subareas}} (C_n \cdot A_n) I \qquad (3\text{-}9)$$

Note: The MRM should be used to calculate the peak discharge when there is a junction incorporating flows from independent subareas into the drainage system.

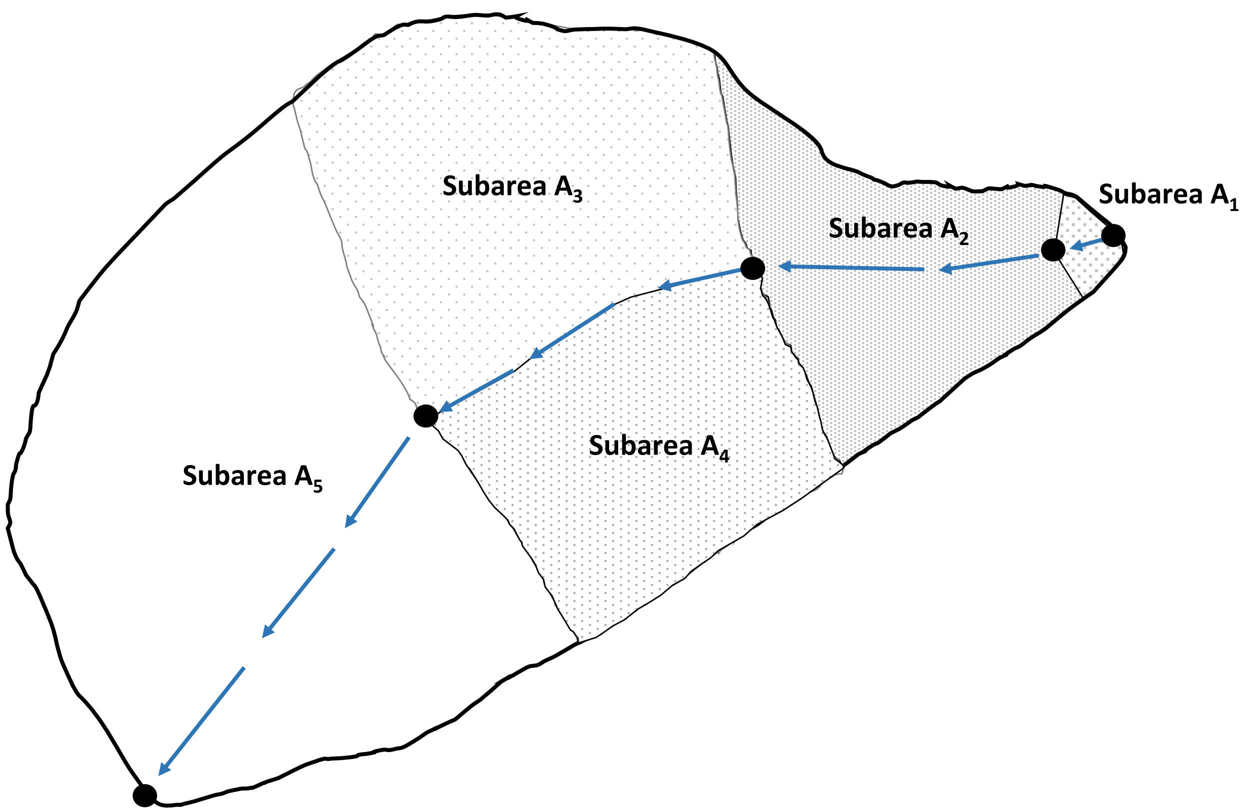


Figure 3-4. Rational Method Calculation Subareas

The flow path having the longest time of concentration to the point of interest in the storm drainage system will usually define the duration used in selecting the intensity value in the Rational Method. Exceptions to the general application of the Rational Equation exist. For example, a small relatively impervious area within a larger drainage area may have an independent discharge higher than that of the total area. This anomaly may occur because of the high runoff coefficient (C value) and high intensity resulting from a short time of concentration. If an exception does exist, it can generally be classified as one of two exception scenarios.

The first scenario occurs when a highly impervious section exists at the most downstream area of a watershed and the total upstream area flows through the lower impervious area. When this situation occurs, two separate calculations should be made.

1) Calculate the runoff from the total drainage area with its weighted C value and the intensity associated with the longest time of concentration.

2) Calculate the runoff using only the smaller less pervious area. The typical procedure would be followed using the C value for the small less pervious area and the intensity associated with the shorter time of concentration.

The results of these two calculations should be compared and the largest value of discharge should be used for design.

The second scenario exists when a smaller less pervious area is tributary to the larger primary watershed. When this scenario occurs, two sets of calculations should also be made.

1) Calculate the runoff from the total drainage area with its weighted C value and the intensity associated with the longest time of concentration.

2) Calculate the runoff to consider how much discharge from the larger primary area is contributing at the same time the peak from the smaller less pervious tributary area is occurring. When the small area is discharging, some discharge from the larger primary area is also contributing to the total discharge. In this calculation, the intensity associated with the time of concentration from the small less pervious area is used. The C coefficients for the larger and smaller areas should be determined independently of each other; the larger primary area C coefficient should *not include* the smaller, less pervious tributary area. The portion of the larger primary area to be considered is determined by the following equation:

$$A_C = A \cdot \left(\frac{T_{C1}}{T_{C2}}\right) \qquad (3\text{-}10)$$

Where: A_C = most downstream part of the larger primary area that will contribute to the discharge during the time of concentration associated with the smaller, less pervious area,

A = area of the larger primary area,

T_{C1} = time of concentration of the smaller, less pervious, tributary area,

T_{C2} = Time of concentration associated with the larger primary area as is used in the first calculation

3.4 Modified Rational Method (for Junction Analysis)

The purpose of this section is to describe the steps necessary to develop an analysis for a small watershed using the Modified Rational Method (MRM). It is necessary to use the MRM if the watershed contains junctions of independent drainage systems. The general process description for using this method, including an example of the application of this method, is described below. (Another option is to use available software acceptable to the County that performs these calculations.)

The engineer should only use the MRM for total drainage areas up to approximately 640 acres (1.0 mi^2) in size. If the overall watershed will significantly exceed 640 acres, then the NRCS method described in Section 4 should be used. The engineer may choose to use either the RM or the MRM for calculations for up to an approximately 640 acres area and then transition the study to the NRCS method for additional downstream areas that exceed approximately 640 acres. The transition process is described in Section 4.

The general process for the MRM differs from the RM only when a junction of independent drainage systems is reached. The peak Q, T_c, and I for each of the independent drainage systems at the point of the junction are calculated using the RM. The independent drainage systems are then combined using the MRM procedure described below. The peak Q, T_c, and I for each of the independent drainage systems at the point of the junction must be calculated using the RM prior to using the MRM procedure to combine the independent drainage systems. After the independent drainage systems have been combined, RM calculations are continued to the next point of interest.

3.4.1 Procedure for Combining Independent Drainage Systems at a Junction

Calculate the peak Q, T_c, and I for each of the independent drainage systems using the RM at the point of the junction. These values will be used for the MRM calculations.

At the junction of two or more independent drainage systems, the respective peak flows are combined to obtain the maximum flow out of the junction at T_c. Based on the approximation that total runoff increases directly in proportion to time, a general equation may be written to determine the maximum Q and its corresponding T_c using the peak Q, T_c, and I for each of the independent drainage systems at the junction. The general equation requires that contributing Q's be numbered in order of increasing T_c.

Let Q_1, T_1, and I_1 correspond to the tributary area with the shortest T_c. Likewise, let Q_2, T_2, and I_2 correspond to the tributary area with the next longer T_c. Continuing ranking Q's, T_c's, and I's according to increasing T_c, until all contributing drainage areas to the junction are ranked. If only two independent drainage systems are combined, only Q_1, T_1, I_1, Q_2, T_2, and I_2 will be in the equation. Combine the independent drainage systems using the Junction Equations (3-11):

$$
\begin{aligned}
Q_{T1} &= Q_1 + \frac{T_1}{T_2} Q_2 + \frac{T_1}{T_3} Q_3 + \cdots + \frac{T_1}{T_n} Q_n \\
Q_{T2} &= Q_2 + \frac{I_2}{I_1} Q_1 + \frac{T_2}{T_3} Q_3 + \cdots + \frac{T_2}{T_n} Q_n \\
Q_{T3} &= Q_3 + \frac{I_3}{I_1} Q_1 + \frac{I_3}{I_2} Q_2 + \cdots + \frac{T_3}{T_n} Q_n \\
&\vdots \\
Q_{Tn} &= Q_n + \frac{I_n}{I_1} Q_1 + \frac{I_n}{I_2} Q_2 + \cdots + \frac{I_n}{I_{n-1}} Q_{n-1}
\end{aligned}
\tag{3-11}
$$

Calculate Q_{T1}, Q_{T2}, Q_{T3}, up to Q_{Tn}. Select the largest Q and use the T_c associated with that Q for further calculations (see Note #1 and Note #2 below for options). If the largest calculated Q's are equal (e.g., $Q_{T1} = Q_{T2} > Q_{Tn}$), use the shorter of the T_c's associated with that Q.

This equation may be expanded for a junction of more independent drainage systems using the same procedure. In general, when the Q from a selected subarea (e.g., Q_2) is combined with Q from another subarea with a shorter T_c (e.g., Q_1), the Q from the subarea with the shorter T_c is reduced by the ratio of the rainfall intensities (I_2/I_1); and when the Q from a selected subarea (e.g., Q_2) is combined with the Q from another subarea with a longer T_c (e.g., Q_3), the Q from the subarea with the longer T_c is reduced by the ratio of the T_c's (T_2/T_3).

Note #1: At a junction of two independent drainage systems that have the same T_c, the tributary flows may be added to obtain the Q_p: $Q_p = Q_1 + Q_2$; when $T_1 = T_2$; and $T_c = T_1 = T_2$. This can be verified by using the junction equation above. Let Q_3, T_3, and $I_3 = 0$. When T_1 and T_2 are the same, I_1 and I_2 are also the same, and T_1/T_2 and $I_2/I_1 = 1$. T_1/T_2 and I_2/I_1 are cancelled from the equations. At this point, $Q_{T1} = Q_{T2} = Q_1 + Q_2$.

Note #2: In the upstream part of a watershed, a conservative computation is acceptable. When the times of concentration (T_c's) are relatively close in magnitude (within 10%), use the shorter T_c for the intensity and the equation $Q_p = \sum_{n=1}^{\#\text{ of subareas}} (C_n \cdot A_n) I$.

3.5 Example of Rational Method

A developer is sizing a storm inlet for a site that is to be developed. Plans are to develop the site with single family residential homes on ½ acre lots. For this example, a 50-year return period will be used.

From topographic data and a field survey, the area of the drainage basin upstream of the culvert is found to be 41.9 acres. In addition the following data were measured or determined from proposed plans:

Length of overland flow = 570 feet

Slope of overland flow = 3.5%

Length of gutter flow = 1,500 feet

Slope of gutter = 2.2%

Figure 3-5 is a sketch of the site with key Rational Method calculation points defined in Table 3-7.

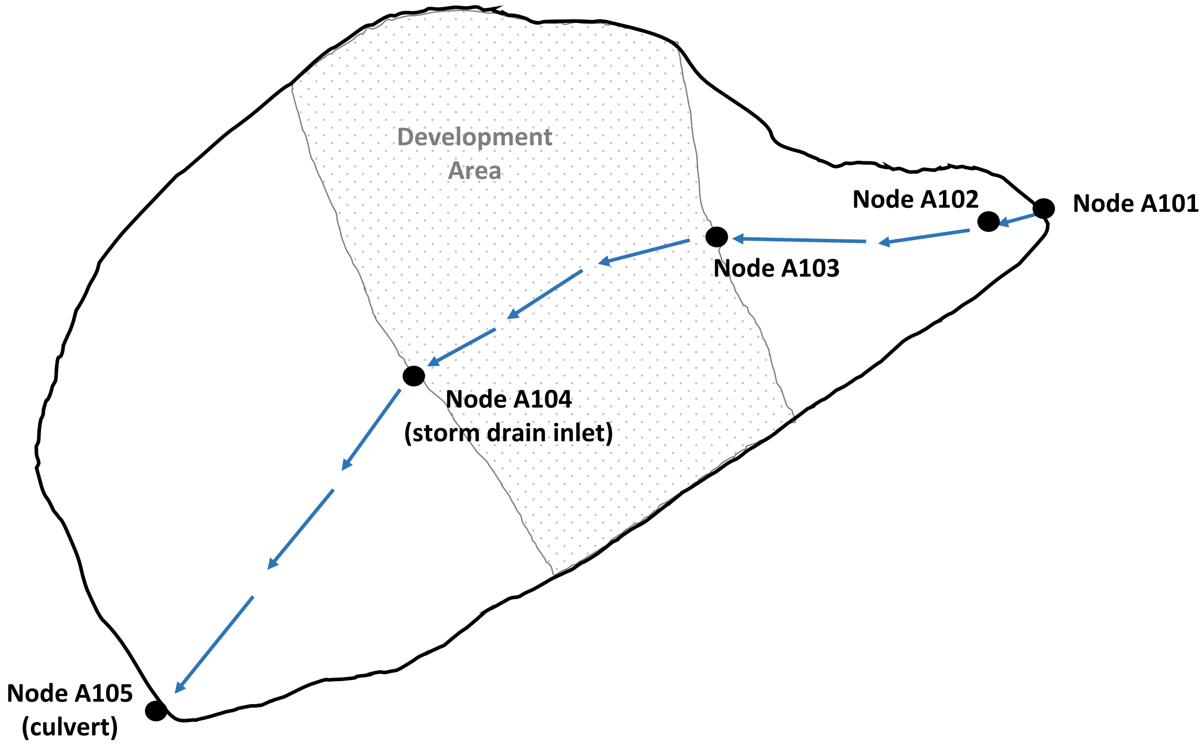


Figure 3-5. Rational Method Example Site

Table 3-7. Rational Method Example Node Descriptions

Location	Description
Node A101	most remote hydraulic point location
Node A102	beginning of shallow overland flow
Node A103	beginning of gutter flow
Node A104	storm drain inlet

After a review of topography and site development plans, key data is summarized in Table 3-8.

Table 3-8. Rational Method Example – Key Data

Watercourse	Description	Length (ft)	Slope (%)	Contributing Drainage Area (ac)	Land Use	Hydrologic Soil Group
Node A101 to A102	sheet flow	100	3.5	0.4	natural	B
Node A102 to A103	shallow overland flow	470	3.5	11.5	natural	B
Node A103 to A104	gutter flow	1,500	2.2	30.0	Residential (low density, 2 DU/A)	B

To use the Rational Method, the initial time of concentration must first be determined. From development plans, the most hydraulically remote point is "Natural" land use and the slope is 3.5%. From Table 3-4 and a slope of 3.5%, it is determined the maximum length of sheet flow is 100 feet. The drainage area for the initial sheet flow runoff is determined from the plans to be 0.4 acre. From Table 3-3 the runoff coefficient is determined to be C = 0.25. Because the return period is 50 years, the runoff coefficient is modified using Table 3-1 The sheet flow runoff coefficient is C = 0.25 x 1.2 = 0.30. To estimate T_i, Equation (3-5) is used. Evaluating Equation (3-5):

$$T_i = \frac{1.8(1.1\text{-}0.30)\sqrt{100}}{3.5^{1/3}} = 9.5 \text{ minutes}$$

The length of overland flow was determined to be 570 feet. The first 100 feet is sheet flow and the remaining 470 feet is shallow overland flow. The travel time (T_t) for this portion is determined using Equation (3-6). The natural area is nearly bare so an intercept coefficient (k) of 0.31 is assigned. The slope is 3.5%.

$$V = (3.28)\cdot(0.31)\cdot\sqrt{3.5} = 1.9 \text{ feet/second}$$

The shallow overland flow travel time is,

$$T_t = {470 \text{ feet}} \Big/ {1.9 \ \frac{\text{feet}}{\text{second}}} = 247 \text{ sec} = 4.1 \text{ minutes.}$$

Rainfall intensity determination is an iterative process based on the total T_c. The sheet flow and shallow overland flow travel time is 13.6 minutes (9.5 minutes + 4.1 minutes). Rainfall intensity is determined using NOAA Atlas 14. Using the latitude and longitude of the site, NOAA Atlas 14, the 50-year rainfall value for 10 minutes is 0.573 inches and 15 minutes is 0.693 inches. After interpolating to obtain an intensity value for 13.6 minutes, I = 2.96 inches/hour.

Travel time in the gutter is a function of discharge and slope and can be determined using Figure 3-3. Discharge in the gutter is from the area along the length of gutter flow in addition to the sheet flow and shallow overland flow contributing areas. The area contributing to sheet flow was determined to be 0.4 acre. The area contributing to shallow overland flow is determined to be 11.5 acres. Since soil type and land use are the same, the runoff coefficient for the shallow concentrated flow is determined to be the same as for sheet flow. Use Equation (3-9) to estimate discharge at the upstream end of the gutter:

$$Q_p = \Sigma(C \cdot A) I = [(CA_{A101\text{-}A102}) + (CA_{A102\text{-}A103})]\ I$$

$$Q_p = \Sigma(C \cdot A) I = [(0.3 \times 0.4) + (0.3 \times 11.5)]\ (2.96) = 10.6 \text{ cfs}$$

The area contributing flow directly to the 1,500 feet of gutter is determined to be 30 acres (denoted as $A_{A103\text{-}A104}$). The gutter is not a closed conduit and velocity in the gutter depends on discharge. For this reason, travel time in the gutter must be determined in an iterative fashion. To find velocity, assume an average Q over the gutter length (discharges for small watersheds typically range from 2 to 3 cfs per acre, depending on land use, drainage area, slope, and rainfall intensity), and proceed as follows:

1) Assume the average discharge in the gutter is the upstream discharge plus the average inflow into the gutter along the watercourse

$$Q_{AVG} = Q_{A103} + (\text{average Q per ac}) \frac{(A_{A103\text{-}A104})}{2}$$

$$Q_{AVG} = 10.57 \text{ cfs} + \left(2.5\ \frac{\text{cfs}}{\text{acre}}\right) \frac{(30 \text{ acre})}{2} = 48.2 \text{ cfs}$$

2) Using the gutter discharge, slope (2.2%) and Figure 3-3)

$$V = 5.6\ \frac{\text{feet}}{\text{second}}$$

3) Calculate travel time in the gutter, $T_{t\text{-gutter}}$

$$T_{t\text{-gutter}} = \frac{1{,}500 \text{ feet}}{5.6\ \frac{\text{feet}}{\text{second}}} = 267.9 \text{ seconds} = 4.5 \text{ minutes}$$

4) Calculate time of concentration, T_c from sheet flow, shallow concentrated flow and gutter flow times

$$T_C = 9.5 \text{ minutes} + 4.1 \text{ minutes} + 4.5 \text{ minutes} = 18.1 \text{ minutes}$$

5) Re-determine rainfall intensity using NOAA Atlas 14 and a time of 18.1 minutes. After interpolation, I = 2.59 inches/hour.

6) Check the Q_{AVG} assumption of 48.2 cfs,

$$Q_p = \Sigma(C \cdot A) I \rightarrow Q_{A104} = (CA_{A101} + CA_{A102} + CA_{A103})\ I$$

$$Q_{A104} = [(0.3\times0.4)+(0.3\times11.5)+(0.3\times30)]\ (2.59) = 32.6\ \text{cfs}$$

$$32.6 \neq 48.2\ \text{cfs}$$

7) Since the assumption of average runoff of 2.5 cfs was incorrect, make a different assumption and re-calculate.

8) Re-calculate Q_p at the upstream end of the gutter,

$$Q_p = \Sigma(C\cdot A)I = [(0.3\times0.4)+(0.3\times11.5)]\ (2.59) = 9.3\ \text{cfs}$$

9) Assume a different average discharge per acre (1.55 cfs/acre, this time)

$$Q_{AVG} = 9.3\ \text{cfs} + \left(1.55\ \frac{\text{cfs}}{\text{acre}}\right)\frac{(30\ \text{acre})}{2} = 32.3\ \text{cfs}$$

10) Using the new gutter discharge, slope and Figure 3-3

$$V = 5.1\ \frac{\text{feet}}{\text{second}}$$

11) Re-calculate travel time in the gutter, $T_{t\text{-gutter}}$

$$T_{t\text{-gutter}} = \frac{1{,}500\ \text{feet}}{5.1\ \frac{\text{feet}}{\text{second}}} = 294.1\ \text{second} = 4.9\ \text{minutes}$$

12) Re-calculate time of concentration, T_c from sheet flow, shallow concentrated flow and gutter flow times

$$T_C = 9.5\ \text{minutes} + 4.1\ \text{minutes} + 4.9\ \text{minutes} = 18.5\ \text{minutes}$$

13) Re-determine rainfall intensity using NOAA Atlas 14 and a time of 18.5 minutes. After interpolation, I = 2.57 inches/hour.

14) Check the Q_{AVG} assumption of 32.3 cfs,

$$Q_{A104} = [(0.3\times0.4)+(0.3\times11.5)+(0.3\times30)]\ (2.57) = 32.3\ \text{cfs}$$

$$32.3 = 32.3\ \text{cfs}$$

15) Check that conditions relating to exceptions to applying the Rational Method do not exist:

a) There is not a highly impervious section at the most downstream area of the watershed with the total upstream area flowing through a lower impervious area.

b) There is not a smaller, less pervious area tributary to the larger primary watershed.

Therefore, the estimated 50-year return period peak discharge at the inlet is 32.3 cfs.

3.6 Example - Modified Rational Method

A developer is sizing a storm inlet at the junction between a new site under development and two existing, independent drainage systems. The site under development is the small urban watershed of the previous example where the RM was applied. The small urban watershed is to be connected to an existing drainage system comprised by two additional independent watersheds. The total peak flow at the junction resulting from the contributions of the small urban watershed under development and the two independent drainage watersheds will be computed using the MRM.

Figure 3-6 is a sketch of the watershed considered for the Modified Rational Method. The watershed is composed of three independent drainage systems labelled A, B and C. System A is the small watershed under development considered in the previous example. System B and C are the two additional independent drainage systems. The three drainage systems have storm runoff that drains to the junction node labelled D101. The description of the nodes is reported in Table 3-9 and the key data for each system are defined in Table 3-10. Subareas have been defined based on land use, topography, and drainage structures, and node numbers have been placed at points of interest. The procedure for calculating flow at the junction using the MRM is described in the text below.

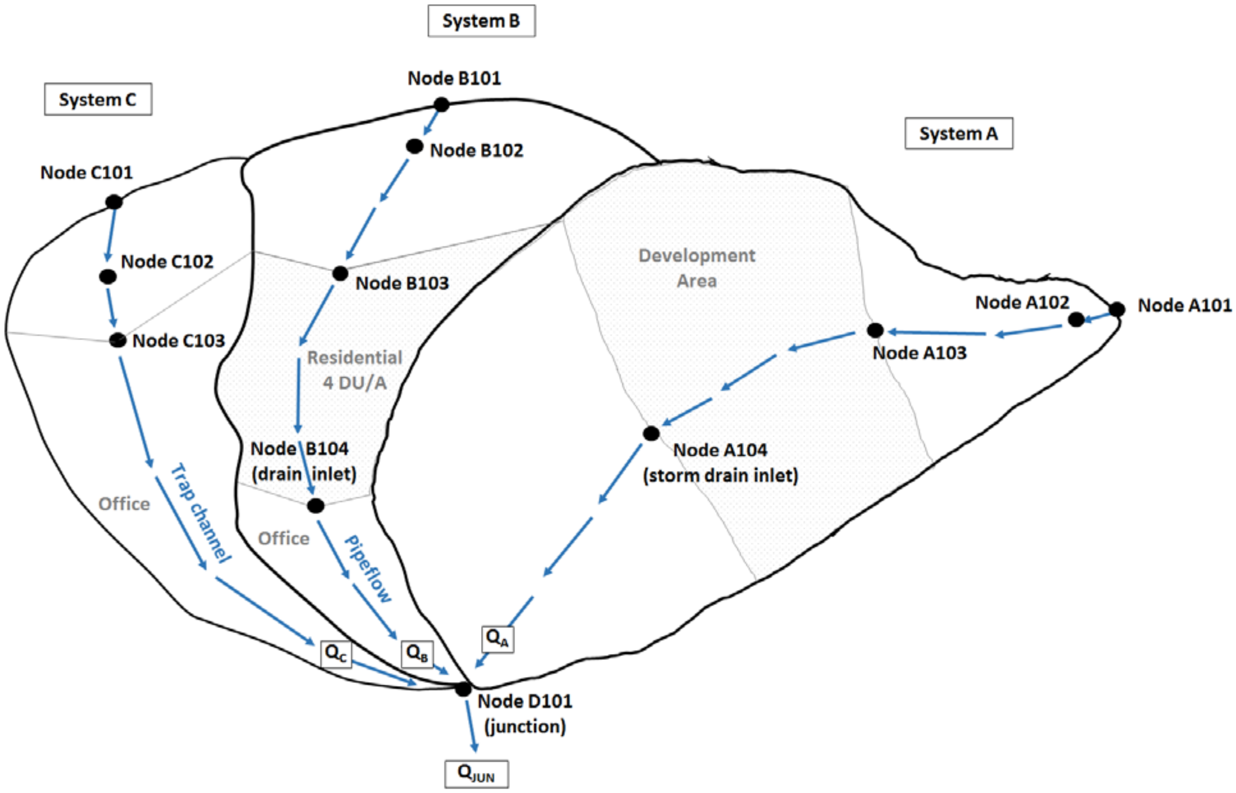


Figure 3-6. Modified Rational Method Example Site

Table 3-9. Modified Rational Method Example – Node Descriptions

Independent drainage system	Location	Description
A	Node A101	most remote hydraulic point location
	Node A102	beginning of shallow overland flow
	Node A103	beginning of gutter flow
B	Node B101	most remote hydraulic point location
	Node B102	beginning of shallow overland flow
	Node B103	beginning of gutter flow
	Node B104	storm drain inlet, beginning of pipe flow
C	Node C101	most remote hydraulic point location
	Node C102	beginning of shallow overland flow
	Node C103	beginning of trap channel

Table 3-10. Modified Rational Method Example – key data

System	Watercourse	Description	Length (ft)	Slope (%)	Drainage Area (ac)	Land Use	Hydrologic Soil Group
A	**Node A101 to A102**	sheet flow	100	3.5	0.4	natural	B
	Node A102 to A103	shallow overland flow	470	3.5	11.5	natural	B
	Node A103 to A104	gutter flow	1,500	2.2	30.0	Residential (low density, 2 DU/A)	B
B	**Node B101 to B102**	sheet flow	85	2.0	0.6	natural	B
	Node B102 to B103	shallow overland flow	515	2.0	7.8	natural	B
	Node B103 to B104	gutter flow	1,000	1.8	25	Residential (medium density, 4 DU/A)	B
	Node B104 to D101	pipe flow	850	1.4	15	office commercial	B
C	**Node C101 to C102**	sheet flow	70	2.5	1	natural	D
	Node C102 to C103	shallow overland flow	130	2.5	9	natural	D
	Node C103 to D101	trapezoidal channel	2,500	1.2	35	office commercial	D

The flow from System A was computed in the previous example and is equal to 32.3 cfs with a time of concentration of 18.5 minutes, a rainfall intensity of 2.57 inches/hour and a drainage area of 41.9 acres. The flow from System B was computed to be 41.7 cfs with a time of concentration of 22.0 minutes, a rainfall intensity of 2.39 inches/hour and a drainage area of 48.4 acres. The flow from System C was computed to be 89.9 cfs with a time of concentration of 18.0 minutes, a rainfall intensity of 2.60 inches/hour and a drainage area of 45.0 acres. The computation for each independent system can be performed with the RM as shown in the previous example. Table 3-11 presents a summary of the results.

Table 3-11. Modified Rational Method Example – Summary of discharges

System	Time of concentration (min)	Rainfall intensity (in/hr)	Drainage area (ac)	Peak discharge (cfs)	Symbols
A	18.5	2.57	41.9	32.3	T_A, I_A, Q_A
B	22.0	2.39	48.4	41.7	T_B, I_B, Q_B
C	18.0	2.60	45.0	88.3	T_C, I_C, Q_C

Once the T_c, I and peak Q are known for each independent drainage system, they need to be sorted based on increasing time of concentration. This step is required in order to establish the time at which the flows from each independent drainage system reach the junction point. Once the time of concentrations, intensities and discharges are sorted, Equations (3-11) are applied to combine them and compute the junction peak flow. The MRM procedure is as follows:

1) Sort the peak Q based on T_c

$$T_1 < T_2 < T_3$$

$$T_C < T_A < T_B$$

$$\begin{cases} T_1 = T_C = 18.0 \\ T_2 = T_A = 18.5 \\ T_3 = T_B = 22.0 \end{cases} \quad \begin{cases} I_1 = I_C = 2.60 \\ I_2 = I_A = 2.57 \\ I_3 = I_B = 2.39 \end{cases} \quad \begin{cases} Q_1 = Q_C = 88.3 \\ Q_2 = Q_A = 32.3 \\ Q_3 = Q_B = 41.7 \end{cases}$$

2) Apply equations (3-11) for each time of concentrations

$$Q_{T1} = Q_1 + \frac{T_1}{T_2} Q_2 + \frac{T_1}{T_3} Q_3$$

$$Q_{T1} = Q_C + \frac{T_C}{T_A} Q_A + \frac{T_C}{T_B} Q_B$$

$$Q_{T1} = 88.3 + \frac{18.0}{18.5} 32.3 + \frac{18.0}{22.0} 41.7 = 153.8 \text{ cfs}$$

$$Q_{T2} = Q_2 + \frac{I_2}{I_1} Q_1 + \frac{T_2}{T_3} Q_3$$

$$Q_{T2} = Q_A + \frac{I_A}{I_C} Q_C + \frac{T_A}{T_B} Q_B$$

$$Q_{T2} = 32.3 + \frac{2.57}{2.60} 88.3 + \frac{18.5}{22.0} 41.7 = 154.6 \text{ cfs}$$

$$Q_{T3} = Q_3 + \frac{I_3}{I_1} Q_1 + \frac{I_3}{I_2} Q_2$$

$$Q_{T3} = Q_B + \frac{I_B}{I_C} Q_C + \frac{I_B}{I_A} Q_A$$

$$Q_{T2} = 41.7 + \frac{2.39}{2.60} 88.3 + \frac{2.39}{2.57} 32.3 = 152.9 \text{ cfs}$$

3) Identify the largest Q and use the T_c associated with that Q and select it for the junction peak flow. Note that if the largest calculated Q's are equal (e.g., $Q_{T1} = Q_{T2} > Q_{T3}$), use the shorter of the T_c's associated with that Q.

$$Q_{JUN} = \max(Q_{T1}, Q_{T2}, Q_{T3}) = Q_{T2} = 154.6$$

$$T_{JUN} = T_2 = 18.5$$

Therefore, the estimated peak discharge and time of concentration at the junction are 154.6 cfs and 18.5 min, respectively. These estimates could be used to route the peak downstream to a new point of interest using the RM.

4 Large Area Hydrologic Procedure – NRCS Hydrologic Method

The Natural Resources Conservation Service (NRCS) hydrologic method requires basic data similar to the RM: drainage area, a "runoff curve number" (CN) describing the proportion of rainfall that becomes runoff, time to peak (T_p, the elapsed time from the beginning of unit effective rainfall to the peak flow at the point of concentration), and total rainfall (P). The NRCS approach is more sophisticated than the RM in that it considers the time distribution of rainfall, initial rainfall losses to interception and depression storage, and an infiltration rate that decreases during the course of a storm. Rainfall losses and resulting runoff should be estimated using the NRCS hydrologic method for study areas approximately 1 square mile and greater in size. The NRCS hydrograph is calculated using the synthetic unit hydrograph S-graph technique. Details of the methodology can be found in the NRCS National Engineering Handbook (NEH), Part 630 Hydrology (NEH-630) (USDA, 2010).

The NRCS hydrologic method may be used for the entire study area, or the RM or MRM may be used for approximately 1 square mile of the study area and then transitioned to the NRCS hydrologic method using the procedure described in Section 4.5. The recommended approach for applying the NRCS hydrologic method is to develop required input parameters for the method and use HEC-HMS software to perform the calculations.

4.1 General Description

The NRCS hydrologic method differs from the Rational Method in two fundamental ways: (1) the NRCS hydrologic method provides a method to estimate the amount of rainfall that is initially intercepted and *does not* contribute to runoff (precipitation losses) and an infiltration rate that decreases during a storm event while the Rational Method C factor determines what proportion of rainfall becomes runoff, and (2) the NRCS hydrologic method considers the time distribution of rainfall thus enabling the creation of a runoff hydrograph which estimates runoff discharge over a period of time whereas the Rational Method estimates only the peak discharge.

The recommended approach to precipitation losses is the NRCS Curve Number approach. Because there is little observed data for the rainfall-runoff hydrograph relationship in Imperial County, the recommended hydrograph approach is the synthetic unit hydrograph S-graph technique using calibrated s-graphs available from nearby, similar regions. A necessary component to utilizing the S-graph is watershed lag which should be calculated using the U.S. Army Corps of Engineers (Corps) method (1976). The large area hydrologic method includes the following steps:

1) Determination of rainfall losses and runoff,

2) S-graph selection, and

3) Hydrograph calculation using HEC-HMS.

4.2 NRCS Precipitation Losses and Runoff

The storm runoff hydrograph from a drainage area is based in part on the physical characteristics of the watershed. The principal physical watershed characteristics affecting the relationship between rainfall and runoff are land use, land treatment, soil types, and land slope. The NRCS method uses a combination of soil conditions, land uses (ground cover) and land treatment (generally agricultural practices) to assign a runoff factor to an area. These runoff factors, called runoff curve numbers (CNs), indicate the runoff potential of an area. The higher the CN, the higher the runoff potential. The CN does not account for land slope. However, in the NRCS hydrologic method, land slope is accounted for in the determination of watershed lag time (see Section 4.2.5). The steps for estimating rainfall runoff are:

1) Delineate the watershed on a map and determine watershed physical characteristics including location of centroid, total length of longest watercourse, length along the watercourse to location nearest the centroid, soil type, and land use/land treatment,

2) Determine a composite curve number (CN) for the watershed, which will represent the combination of land use and soil type within the drainage area and describe the proportion of rainfall that runs off,

3) Determine frequency of the design storm, total rainfall amount for the design storm and *Antecedent Runoff Condition* (ARC) for the watershed location,

4) Adjust CN based on the Antecedent Runoff Condition (ARC),

5) Prepare the incremental rainfall distribution,

6) Determine the excess rainfall amounts using the composite CN for the watershed and the depth-area adjusted incremental rainfall distribution.

7) Select an appropriate S-graph,

8) Use the HEC-HMS software to compute a runoff hydrograph.

The CN values in Table 4-1, Table 4-2 and Table 4-3 are suitable for preparing hydrographs in accordance with the methods shown in Chapters 10 and 16 of NEH-630 and described in Section 4.2 of this manual. The CN values are based on hydrologic soil group and land use/land treatment. When a drainage area has more than one land use, hydrologic soil group or hydrologic condition, a composite CN should be calculated and used in the analysis. It should be noted that when composite CNs are used, the analysis does not take into account the location of the specific land uses but treats the drainage area as a uniform land use represented by the composite CN.

4.2.1 Watershed Delineation

Once the accumulation point has been determined, watershed delineation may be accomplished by hand or using GIS methods. Depending on the size and distribution of soil types, vegetative cover, land uses and other factors affecting rainfall runoff, it may be necessary to subdivide the watershed into smaller sub-basins. Ideally, sub-basins would have similar hydrologic characteristics. Each sub-basin will be analyzed separately, creating runoff hydrographs for each which are subsequently combined creating the runoff hydrograph for the entire watershed.

Required watershed (or sub-basin) attributes for the NRCS method are: basin area, basin centroid, length (miles) of the longest watercourse from the accumulation point to the basin boundary, length (miles) along the longest watercourse from the accumulation point to a point opposite the basin centroid, average slope (feet per mile) of the longest watercourse, soil hydrologic classification (NEH-630, Chapter 7) and vegetative cover and condition.

4.2.2 Curve Number Determination

Once the watershed and sub-basins have been delineated, hydrologic soil types determined, and vegetative cover and condition estimated, the Curve Number (CN) can be estimated. The combination of soil type and vegetative cover and condition is the hydrologic soil-cover complex. If a sub-basin contains more than one complex, a composite CN for the sub-basin must be determined using a weighted area approach. A more detailed description of hydrologic soil-cover complexes and Curve Number is available in NEH-630, Chapter 9 and Chapter 10 (USDA, 2004).

Table 4-1 through Table 4-3 are from NEH-630 (USDA, 2004) and provide guidance in selecting CN based on hydrologic complex. The CNs in the table assume the initial abstraction (I_a) is equal to 20% of the total runoff retention capacity of the watershed ($I_a = 0.2S$), which is the standard assumption put forth in NEH-630 (USDA, 2004). Any assumption other than $I_a = 0.2S$ would require determination of different CNs for the hydrologic soil complexes. When impervious areas are part of the basin, it must be determined if they are connected or unconnected to the drainage system and treated accordingly. Treatment of connected and unconnected impervious areas is discussed following Table 4-1. Also note that the CN for some urban cover types assumes a certain percent imperviousness and these areas should not be double-counted.

Table 4-1. Runoff Curve Numbers for Urban Areas[1]

Cover Description			**Curve Number by Hydrologic Soil Group**			
Cover Type	**Hydrologic Condition**	**Average % Impervious Area[2]**	**A**	**B**	**C**	**D**
Fully developed urban areas (vegetation established):						
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]	Poor (grass cover < 50%)		68	79	86	89
	Fair (grass cover 50 to 75%)		49	69	79	84
	Good (grass cover > 75%)		39	61	74	80
Impervious areas:						
Paved parking lots, roofs, driveways, etc. (excluding un-improved right-of-way)			98	98	98	98
Streets and roads:						
Paved; curbs and storm sewers (excluding un-improved right-of-way)			98	98	98	98
Paved; open ditches (including right-of-way)			83	89	92	93
Gravel (including right-of-way)			76	85	89	91
Dirt (including right-of-way)			72	82	87	89
Western desert urban areas:						
Natural desert landscaping (pervious areas only)[4]			63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-			96	96	96	96

Cover Description			Curve Number by Hydrologic Soil Group			
Cover Type	Hydrologic Condition	Average % Impervious Area[2]	A	B	C	D
inch sand or gravel mulch and basin borders)						
Urban districts:						
Commercial and business		85	89	92	94	95
Industrial		72	81	88	91	93
Residential districts by average lot size:						
1/8 acre or less (town houses)		65	77	85	90	92
1/4 acre		38	61	75	83	87
1/3 acre		30	57	72	81	86
1/2 acre		25	54	70	80	85
1 acre		20	51	68	79	84
2 acres		12	46	65	77	82
Developing urban areas:						
Newly graded areas (pervious areas only, no vegetation)			77	86	91	94

[1] Average runoff condition and $I_a = 0.2S$.

[2] The average percent impervious area shown was used to develop composite CNs. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition.

[3] CNs shown are equivalent to those of pasture. Composite CNs may be computed for other combinations of open space type.

[4] Composite CNs for natural desert landscaping should be computed using Figure 4-1 or Figure 4-2 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CNs are assumed equivalent to desert shrub in poor hydrologic condition.

Impervious areas can be connected or unconnected to the drainage system and the distinction can affect the composite CN. From USDA (2010), an impervious area is considered connected if runoff from it flows directly into the drainage system. It is also considered connected if runoff from it occurs as shallow concentrated flow running over a pervious area and into a drainage system. If all impervious area is directly connected to the drainage system, but the impervious area percentages in Table 4-1 or the pervious land use assumptions are not applicable, use Equation (4-1) or Figure 4-1 to compute a composite CN.

$$CN_C = CN_P + \left(\frac{P_{imp}}{100}\right)(98 - CN_P) \qquad (4\text{-}1)$$

Where: CN_C = composite runoff curve number,

CN_P = pervious runoff curve number,

P_{imp} = percent imperviousness.

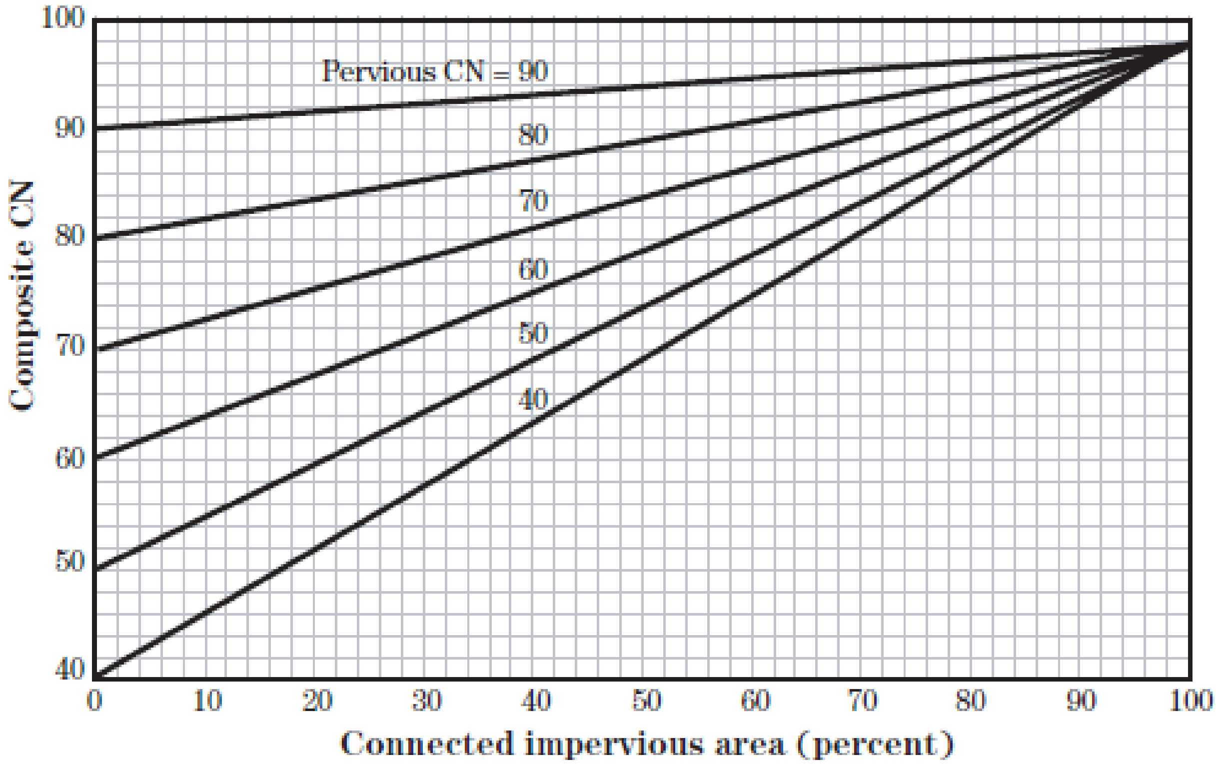


Figure 4-1. Composite CN with Connected Impervious Area (USDA, 2010)

If runoff from impervious areas flows over a pervious area as sheet flow prior to entering the drainage system, the impervious area is unconnected. To determine CN when all or part of the impervious area is not directly connected to the drainage system, use Equation (4-2) or Figure 4-2 (USDA, 2010) if the total impervious area is less than 30 percent of the total area or use Equation (4-1) or Figure 4-1 if the total impervious area is equal to or greater than 30 percent of the total area (as the absorptive capacity of the remaining pervious areas will not significantly affect runoff).

$$CN_C = CN_P + \left(\frac{P_{imp}}{100}\right)(98 - CN_P)(1 - 0.05R) \qquad (4\text{-}2)$$

Where: R = ratio of unconnected impervious area,

and other variables are as defined in Equation (4-1).

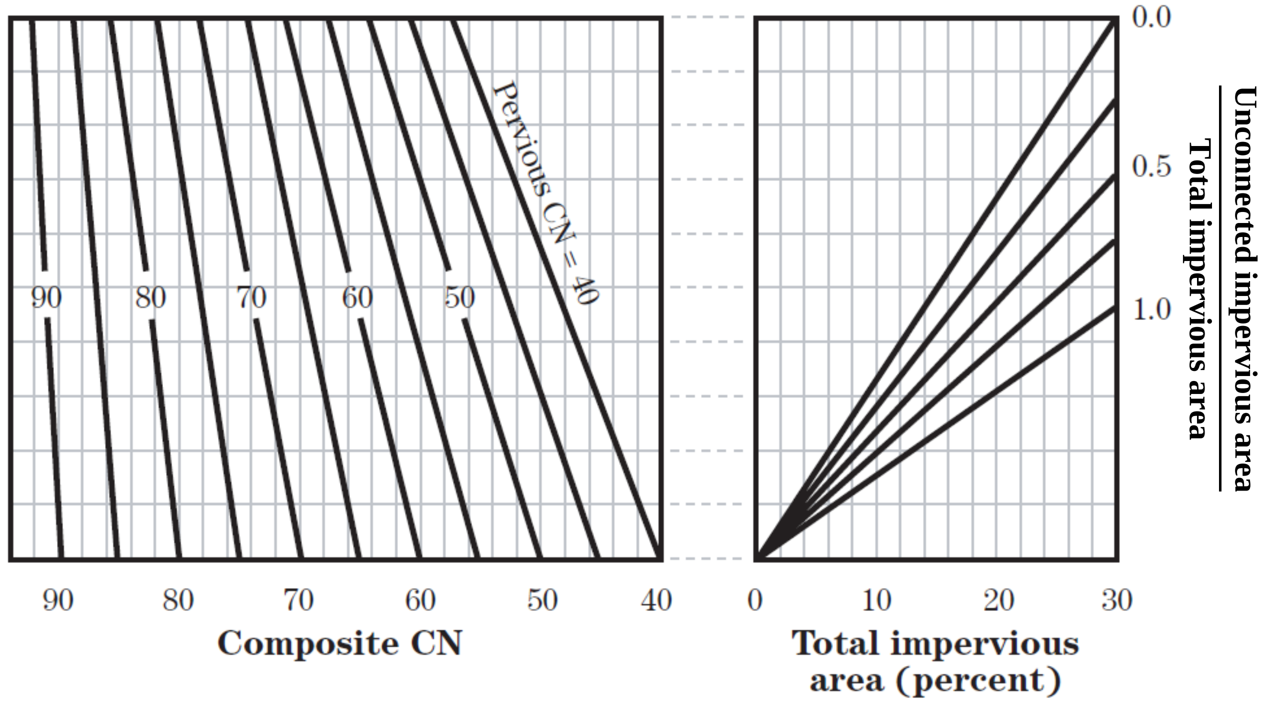


Figure 4-2. Composite CN: Unconnected Impervious Areas, Total Impervious Area < 30%

When impervious area is less than 30%, obtain the composite CN by entering the right half of Figure 4-2 with the percentage of total impervious area and the ratio of total unconnected impervious area to total impervious area. Then move horizontally to the left to the appropriate pervious CN and read down to find the composite CN.

Table 4-2. Runoff Curve Numbers for Arid and Semiarid Rangelands[1]

Cover Description		Curve Number by Hydrologic Soil Group			
Cover Type	Hydrologic Condition[2]	A[3]	B	C	D
Herbaceous – mixture of grass, weeds and low-growing brush, with brush the minor element	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen – mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper – pinyon, juniper, or both: grass understory	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sage-grass – sage with an understory of grass	Poor		67	80	85
	Fair		51	63	70

Cover Description		Curve Number by Hydrologic Soil Group			
Cover Type	Hydrologic Condition[2]	A[3]	B	C	D
	Good		35	47	55
Desert shrub – major plans include saltbush, greasewood, creosotebush, blackbrush, bursage, paloverde, mesquite, and cactus	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

[1] Average runoff condition and $I_a = 0.2S$. For range in humid regions, use Table 4-3.

[2] Poor: < 30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: > 70% ground cover.

[3] CNs shown are equivalent to those of pasture. Composite CNs may be computed for other combinations of open space type.

Table 4-3. Runoff Curve Numbers for Agricultural Lands[1]

Cover Description			Curve Number by Hydrologic Soil Group			
Cover Type	Treatment[2]	Hydrologic Condition[3]	A	B	C	D
Fallow	Bare soil	---	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured and terraced (C & T)	Poor	66	74	80	82
		Good	62	71	78	81
	C & T + CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85

Cover Description			Curve Number by Hydrologic Soil Group			
Cover Type	**Treatment[2]**	**Hydrologic Condition[3]**	**A**	**B**	**C**	**D**
		Good	61	73	81	84
Small grain	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C & T	Poor	61	72	79	82
		Good	59	70	78	81
	C & T + CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C & T	Poor	63	73	80	83
		Good	51	67	76	80
Pasture, grassland, or range-continuous forage for grazing[4]		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
Meadow-continuous grass, protected from grazing and generally mowed for hay		Good	30	58	71	78
Brush-brush-forbs-grass mixture with brush the major element[5]		Poor	48	67	77	83
		Fair	35	56	70	77
		Good	30[6]	48	65	73
Woods-grass combination (orchard or tree farm)[7]		Poor	57	73	82	86
		Fair	43	65	76	82
		Good	32	58	72	79
Woods[8]		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	30	55	70	77
Farmstead – buildings, lanes, driveways, and surrounding lots		---	59	74	82	86

Cover Description			Curve Number by Hydrologic Soil Group			
Cover Type	**Treatment[2]**	**Hydrologic Condition[3]**	**A**	**B**	**C**	**D**
Roads (including right-of-way):						
Dirt		---	72	82	87	89
Gravel		---	76	85	89	91

[1] Average runoff condition and I_a = 0.2S.

[2] Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.

[3] Hydrologic condition is based on combinations of factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good $\geq$ 20%), and (e) degree of surface toughness.
Poor: Factors impair infiltration and tend to increase runoff.
Good: Factors average and better than average infiltration and tend to decrease runoff.30 to 70% ground cover.
For conservation tillage poor hydrologic condition, 5 to 20% of the surface is covered with residue (< 750 pounds per acre for row crops or 300 pounds per acre for small grain.)
For conservation tillage good hydrologic condition, more than 20% of the surface is covered with residue (> 750 pounds per acre for row crops or 300 pounds per acre for small grain.)

[4] Poor: < 50% ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.

[5] Poor: < 50% ground cover.
Fair: 50 to 75% ground cover.
Good: > 75% ground cover.

[6] If actual CN is less than 30, use CN = 30 for runoff computation.

[7] CNs shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CNs for woods and pastures.

[8] Poor: Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed, but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

4.2.3 Rainfall and the Antecedent Runoff Condition (ARC)

Determination of design storm frequency is based on County and project requirements. Once the design storm frequency has been determined, rainfall amounts can be obtained by following the procedure in Section 2.2.

Basin conditions at the onset and during a storm can affect the quantity of runoff. Factors including rainfall intensity and duration, total rainfall, soil moisture conditions, cover density, stage of growth and temperature can all contribute to variability in the amount of rainfall that becomes runoff. Collectively these factors are called the Antecedent Runoff Condition (ARC). ARC is divided into three classes: II for average conditions, I for dryer than normal conditions, and III for wetter than normal conditions. Provided adequate justification can be made and acceptable conservatism demonstrated, an ARC adjustment to CNs may be valid. In general a design ARC Class II should be used.

4.2.4 Antecedent Runoff Condition adjustment values

CN values presented in Table 4-1 through Table 4-3 assume an ARC II condition. ARC II CN values and the corresponding ARC I and ARC III values are presented in Table 4-4.

Table 4-4. Antecedent Runoff Condition (ARC) CN Values

Curve Number by ARC										
ARC II	**ARC I**	**ARC III**		**ARC II**	**ARC I**	**ARC III**		**ARC II**	**ARC I**	**ARC III**
100	100	100		**74**	55	88		**48**	29	68
99	97	100		**73**	54	87		**47**	28	67
98	94	99		**72**	53	86		**46**	27	66
97	91	99		**71**	52	86		**45**	26	65
96	89	99		**70**	51	85		**44**	25	64
95	87	98		**69**	50	84		**43**	25	63
94	85	98		**68**	48	84		**42**	24	62
93	83	98		**67**	47	83		**41**	23	61
92	81	97		**66**	46	82		**40**	22	60
91	80	97		**65**	45	82		**39**	21	59
90	78	96		**64**	44	81		**38**	21	58
89	76	96		**63**	43	80		**37**	20	57
88	75	95		**62**	42	79		**36**	19	56
87	73	95		**61**	41	78		**35**	18	55
86	72	94		**60**	40	78		**34**	18	54
85	70	94		**59**	39	77		**33**	17	53
84	68	93		**58**	38	76		**32**	16	52
83	67	93		**57**	37	75		**31**	16	51
82	66	92		**56**	36	75		**30**	15	50
81	64	92		**55**	35	74		**25**	12	43
80	63	91		**54**	34	73		**20**	9	37
79	62	91		**53**	33	72		**15**	6	30
78	60	90		**52**	32	71		**10**	4	22
77	59	89		**51**	31	70		**5**	2	13
76	58	89		**50**	31	70		**0**	0	0
75	57	88		**49**	30	69				

Once basin CN estimates have been finalized, a storm hyetograph is prepared.

4.2.5 Preparation of incremental rainfall distribution

The variation in rainfall intensity that occurs from the beginning of the storm through the storm peak and to the end of the storm is represented in the time distribution of rainfall. The time distribution of rainfall during a storm should be tabulated and can be represented graphically as a hyetograph, a chart showing increments of average rainfall during successive units of time during a storm. As discussed in Section 2.4, the rainfall distribution pattern adopted by Imperial County is a nested storm pattern with 2/3, 1/3 distribution. The time to peak (T_p) necessary for determining duration D of the hyetograph should be determined using the Corps lag method (USACE, 1976). Corps lag (T_l) in hours is expressed by the empirical formula,

$$T_l = 24\,\bar{n}\left(\frac{LL_C}{\sqrt{S}}\right)^m \qquad (4\text{-}3)$$

and time to peak, T_p, is

$$T_p = 0.862\,T_l \qquad (4\text{-}4)$$

Where: $\bar{n}$ = the visually estimated mean of all Manning's *n* values for watercourses in the basin,

L = length of the longest watercourse in miles,

L_C = length along the longest watercourse measured from the outlet to a point opposite the basin centroid, in miles,

m = 0.38 (empirically determined coefficient estimated for Southern California),

S = slope of the longest watercourse between the outlet and the headwaters in feet per mile,

Descriptive aids for estimating the basin $\bar{n}$ factor, based on Plate 21 from USACE (1976) are:

$\bar{n}$ = 0.015, drainage area has fairly uniform, gentle slopes with most watercourses either improved or along paved streets. Ground cover consists of some grasses with appreciable areas developed to the extent that a large percentage of the area is impervious. Main watercourse is improved channel or conduit.

$\bar{n}$ = 0.020, drainage area has some graded and non-uniform, gentle slopes with over half of area watercourses either improved or along paved streets. Ground cover consists of equal amount grasses and impervious area. Main watercourse is partly improved channel or conduit and partly greenbelt (unimproved).

$\bar{n}$ = 0.025, drainage area is generally rolling with gentle slopes and some drainage improvements in the area such as streets and canals. Ground cover consists mostly of scattered brush and grass with a low % impervious area. Main watercourse is straight channel with turf or stony bed and weeds on earthen bank.

$\bar{n}$ = 0.030, drainage area is generally rolling, with rounded ridges and moderate side slopes and no drainage improvements in the area. Ground cover includes scattered brush and grasses. Watercourses meander in fairly straight, unimproved channels with some boulders and lodged debris.

$\bar{n}$ = 0.040, drainage area is steep upper canyons with moderate slopes in lower canyons and no drainage improvements in the area. Ground cover is mixed brush and trees with grasses in lower canyons. Watercourses have moderate bends and are moderately impeded by boulders and debris with meandering courses.

$\bar{n}$ = 0.050, drainage area is quite rugged, with sharp ridges and narrow, steep canyons and no drainage improvements in the area. The ground cover, excluding small areas of rock outcrops, includes many trees and considerable underbrush. Watercourses meander around sharp bends, over large boulders and considerable debris obstruction.

$\bar{n}$ = 0.100, the drainage area has extensive vegetation, including grass, or is farmed with contoured plowing, and streams that contain a large amount of brush, grass or other vegetation that slows water velocity.

$\bar{n}$ = 0.200, the drainage area has comparatively uniform slopes with no drainage improvements. Groundcover consists of cultivated crops or substantial growths of grass and fairly dense small shrubs, cacti or similar vegetation. Surface characteristics are such that channelization dies not occur

In addition, the *Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Floodplains* (USGS Water Supply paper 2339) and *Open Channel Hydraulics* by Ven Te Chow may provide supplementary guidance.

Once Corps basin lag time is determined, NRCS lag time (T_N) may be determined using (San Diego County, 2003):

$$T_N = 0.862\ T_l - \frac{D}{2} \qquad (4\text{-}5)$$

A hyetograph creation example is provided in Section 2.5. As discussed in Section 2.4, if warranted, the depth-area rainfall reduction should be applied prior to arranging the incremental rainfall amounts in the 2/3, 1/3 distribution. Tabulated and/or graphical hyetograph representations should be converted to units of inches per hour if not already determined as such.

4.2.6 Determination of excess rainfall amounts

Excess rainfall is the precipitation that becomes runoff. To estimate excess rainfall, obtain the partial duration rainfall values as described in Section 2.2, apply a depth-area reduction factor as described in Section 2.4 (if appropriate) and use HEC-HMS software, along with CN, percent impervious, NRCS lag (T_N) and the appropriate S-graph to determine the excess rainfall runoff hydrograph. The process is described in detail in Section 4.4.

4.3 S-graph selection

As previously discussed, long term rainfall and streamgage data is sparse in the County. For this reason, the S-graph method has been chosen as the preferred hydrograph calculation approach. From Caltrans (2007), because no two drainage areas have identical hydrologic characteristics, the runoff patterns from these areas are generally dissimilar and the time distribution of runoff may differ considerably. Therefore, direct transposition of the characteristic time distribution of runoff from drainage areas for which rainfall-runoff data are available to nearby areas for which data are not available is usually not advisable. The S-graph method uses a basic time-runoff relationship for a watershed type in a form suitable for application to ungaged basins.

The Desert and Foothill S-graphs of other, local Southern California regions best approximate the watershed response most likely to be present in Imperial County. The Desert and Foothill S-graphs are presented in **Error! Reference source not found.** and tabulated in Appendix A. The Foothill S-graph is for watersheds characterized by natural channels incised in canyon bottoms with overbank flows confined near the main channel. The Desert S-graph is for use in undeveloped desert areas. The recommended approach for hydrograph calculation with the S-graphs is using HEC-HMS (HMS) (USACE, 2016) software. The process is described in Section 4.4.

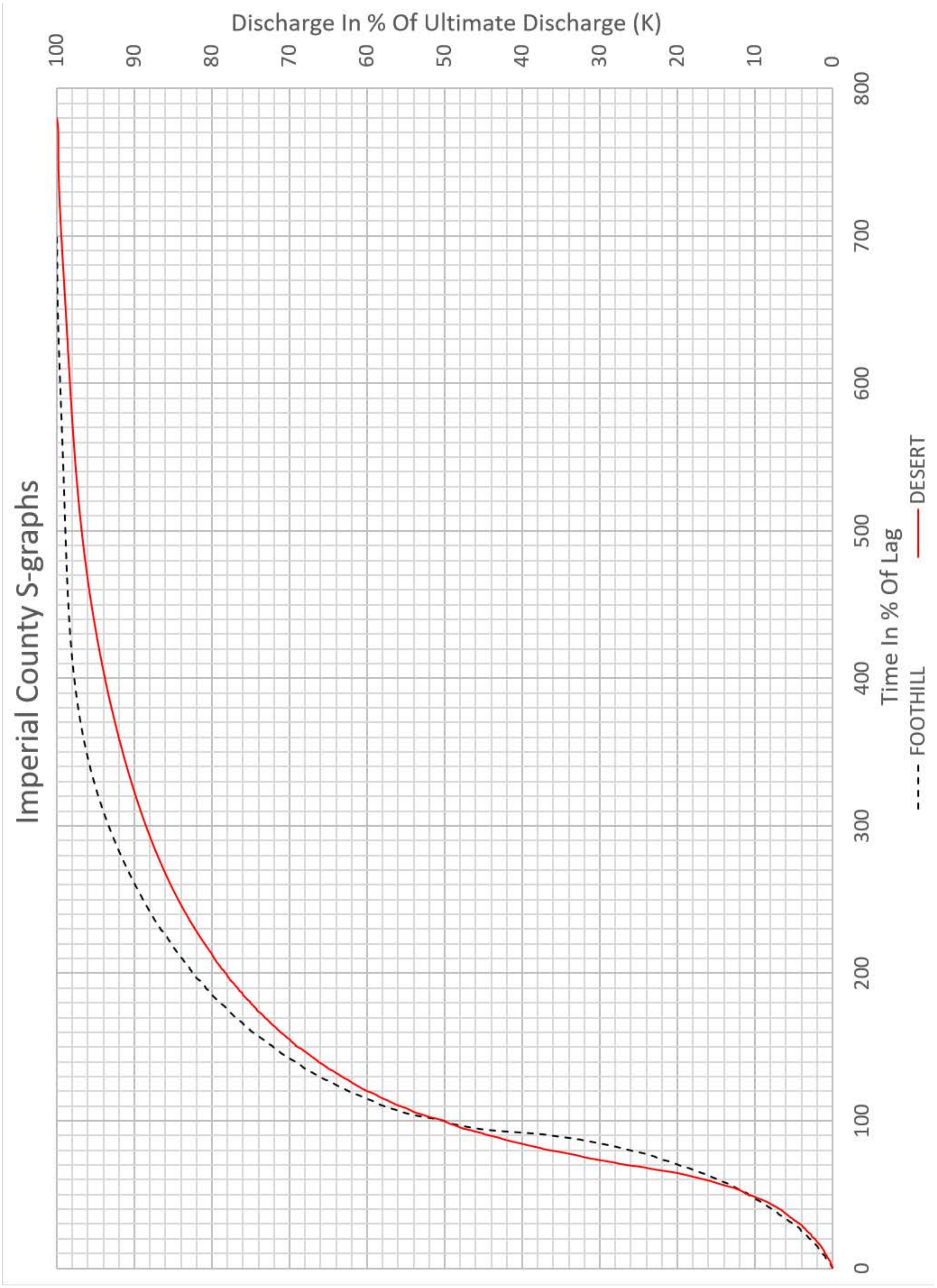


Figure 4-3. Imperial County S-graphs

4.4 Hydrograph calculation

Once an HMS project is opened, a basin hydrograph may be estimated using the following steps:

Step 1. HMS paired data creation. Use the "Components" → "Paired Data Manager" to create a "Data Type: Percentage Curves" named after the S-graph being used, as presented in Figure 4-4.

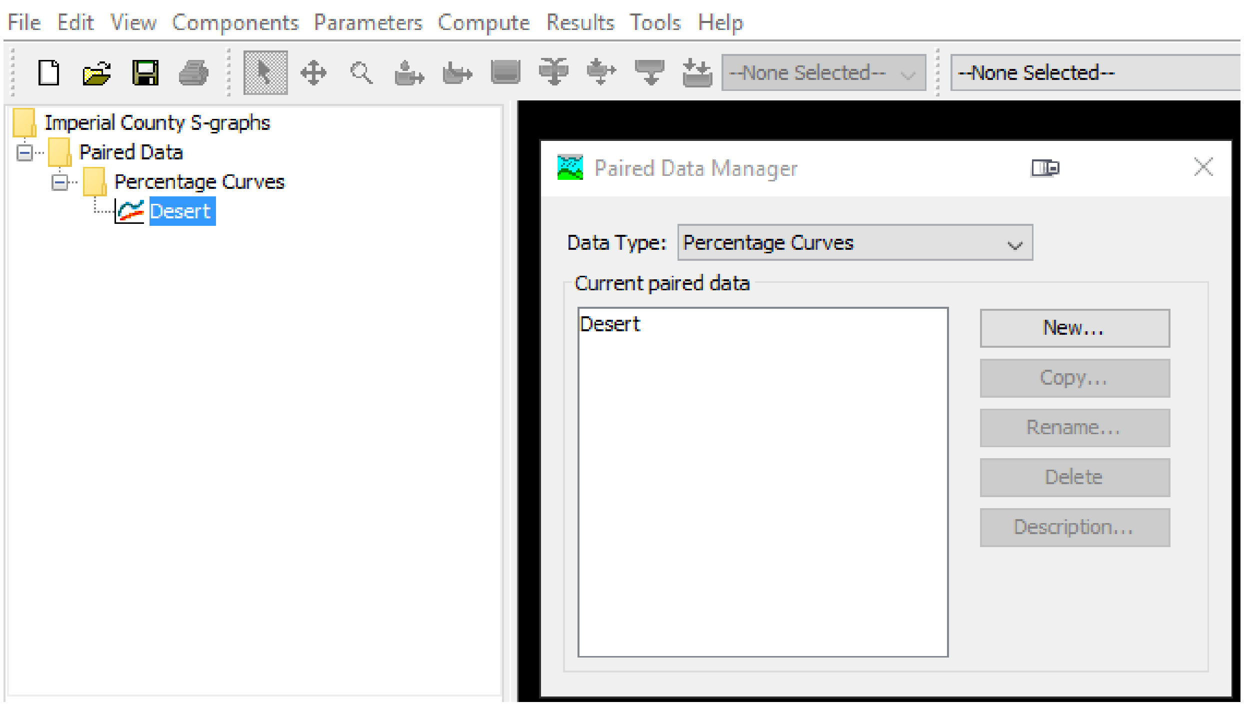


Figure 4-4. HEC-HMS paired data creation

Step 2. S-graph data entry. Select the newly created paired data type, select the "Table" data entry method and copy the proper S-graph values from Appendix A of this manual ensuring values are copied in ascending order, as presented in Figure 4-5.

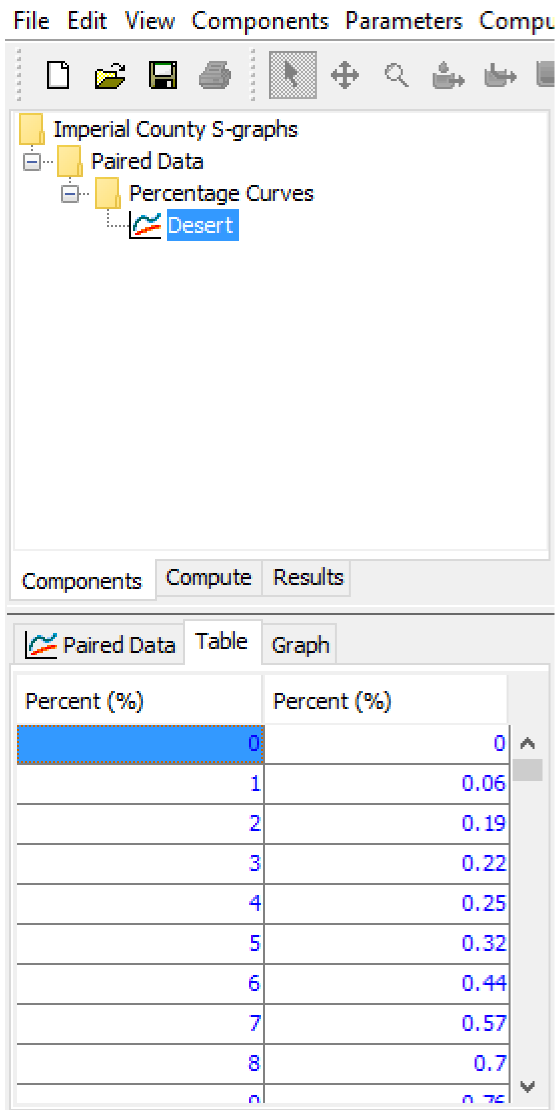


Figure 4-5. HEC-HMS S-graph data entry

Step 3. Use the "Components" → "Basin Model Manager" to create and name a basin model for the area where the hydrograph is desired. The default basin model settings as presented in Figure 4-6 are acceptable for basic hydrograph calculation.

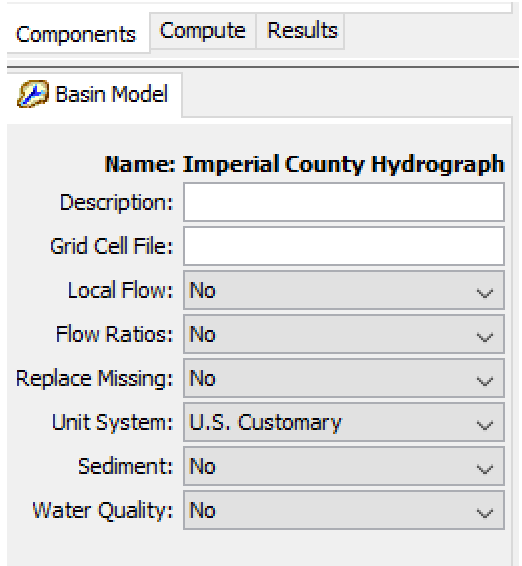


Figure 4-6. HEC-HMS basin default settings

Step 4. Using the “Subbasin Creation Tool”, create and name a subbasin, enter the subbasin area, select “Loss Method” as SCS Curve Number, “Transform Method” as User-Specified S-Graph and “Baseflow Method” as –None-- as presented in Figure 4-7 and Figure 4-8.

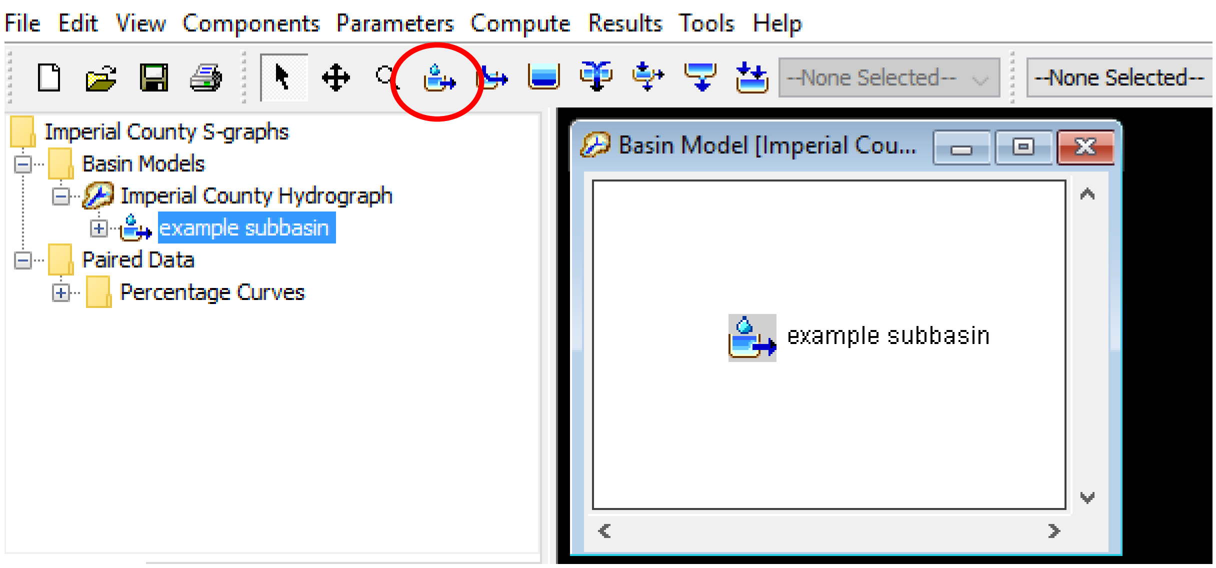


Figure 4-7. HMS subbasin creation tool

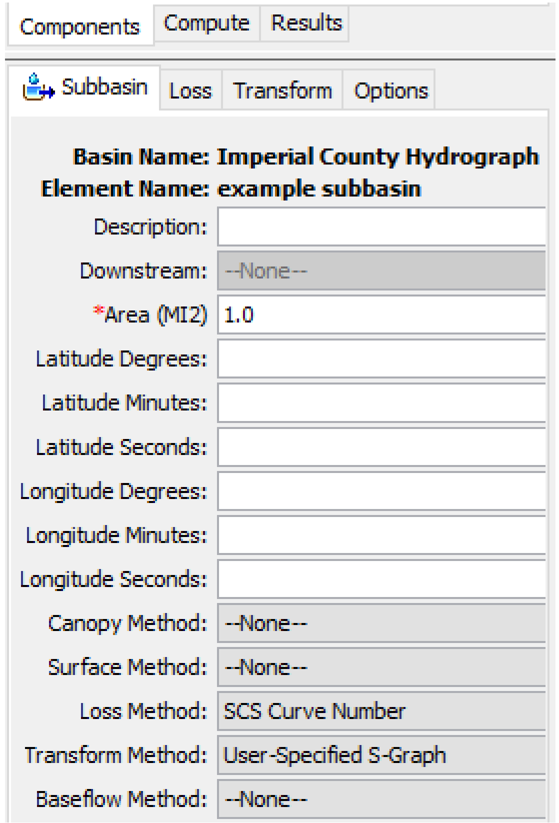


Figure 4-8. HMS subbasin area settings

Step 5. Set subbasin loss and transform parameters. As presented in Figure 4-9, select the “Loss” tab and enter a Curve Number and Impervious % as determined using the methods described in Section 4.2.2. Do not enter an Initial Abstraction (IN) value. As presented in Figure 4-10, select the “Transform” tab, select the S-graph created in Step 1 and Step 2 and enter the NRCS Lag Time determined using the Corps lag method described in Section 4.2.5.

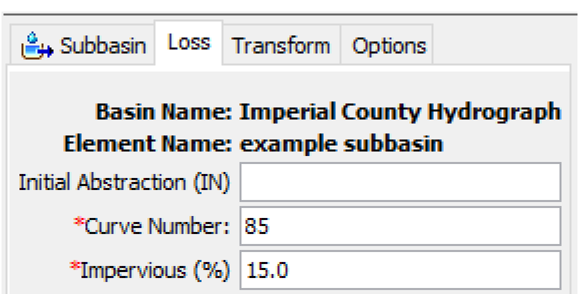


Figure 4-9. HMS S-graph loss settings

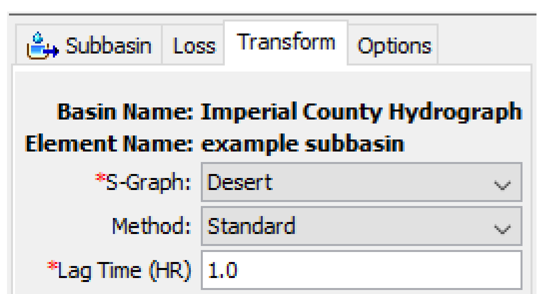


Figure 4-10. HMS S-graph transform settings

Step 6. Meteorologic Model creation. Use the “Components” → “Meteorologic Model Manager” to create and name a meteorologic model for the area where the hydrograph is desired as presented in Figure 4-11. Settings should be as presented in Figure 4-12. On the “Basins” tab, set “Include Subbasins” to “Yes” as presented in Figure 4-13.

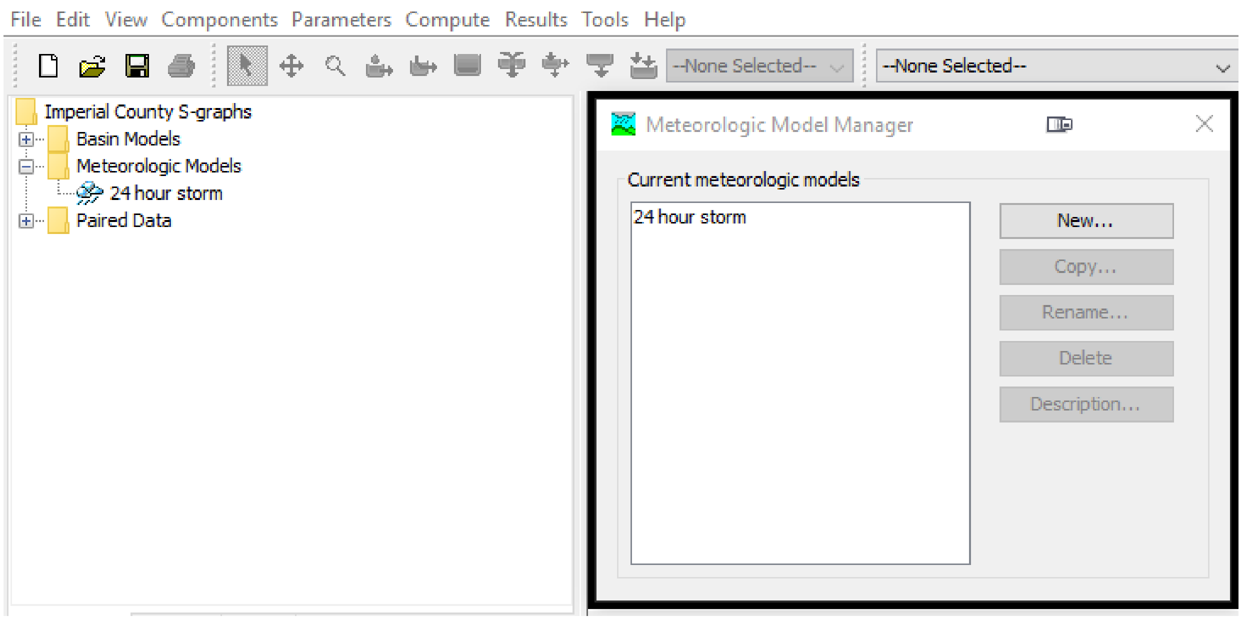


Figure 4-11. HMS Meteorologic Model creation

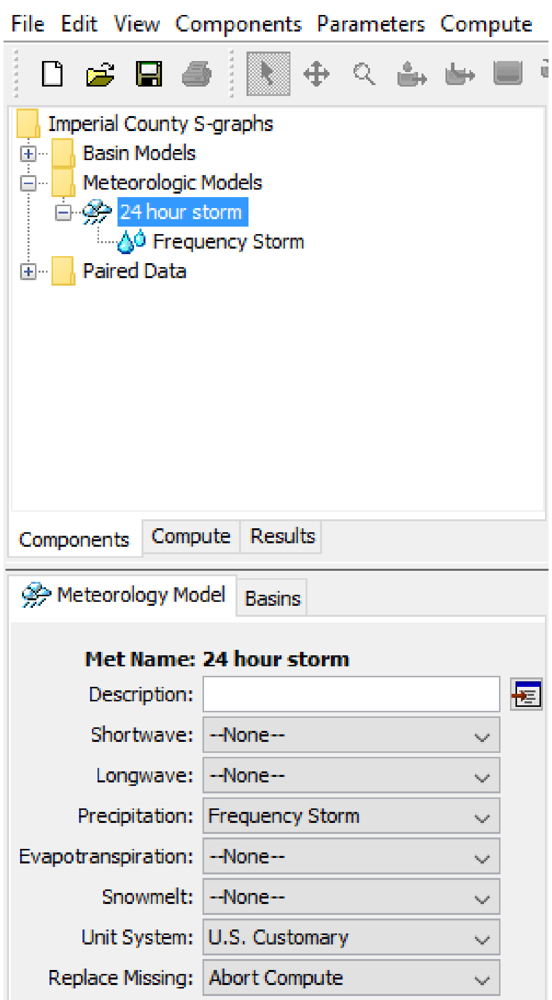


Figure 4-12. HMS Meteorologic Model settings

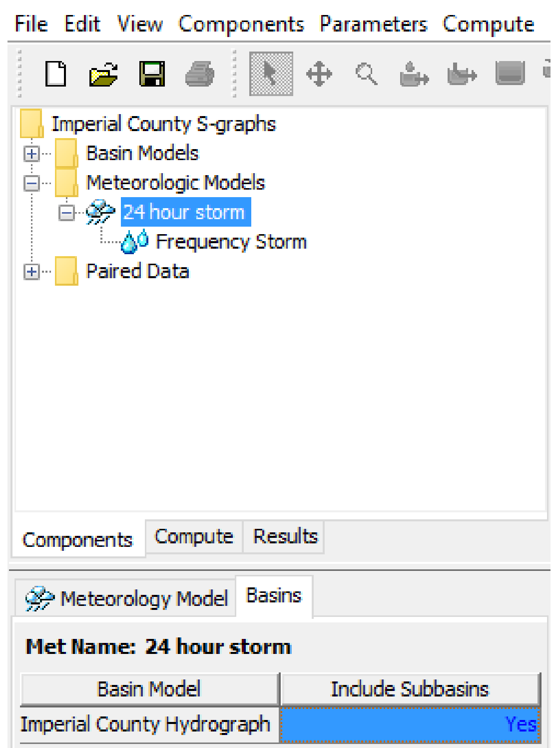


Figure 4-13. HMS Meteorologic Model subbasins

Step 7. Create the 1/3, 2/3 balanced hyetograph for the storm. Select “Frequency Storm” under the “Meteorologic Model” created in Step 6. Set “Storm Duration” to the design storm duration (24 hours in this example), “Intensity Position” to 67 Percent and “Storm Area (MI2)” to 1 (regardless of the watershed area.) *It is important to set “Storm Area (MI2)” to 1, otherwise the HEC-HMS default depth-area-reduction factor will be applied in addition to the area reduction already applied using the methodology in Section 2.3*. Under “Partial-Duration Depth (IN)”, enter the appropriate rainfall depths for the site as determined using the methods in Section 2.2 and Section 2.3 – these values should include any appropriate depth-area-reduction. Settings should be as presented in Figure 4-14, with the exception of the Partial-Duration Depth values, which will be site and storm duration specific.

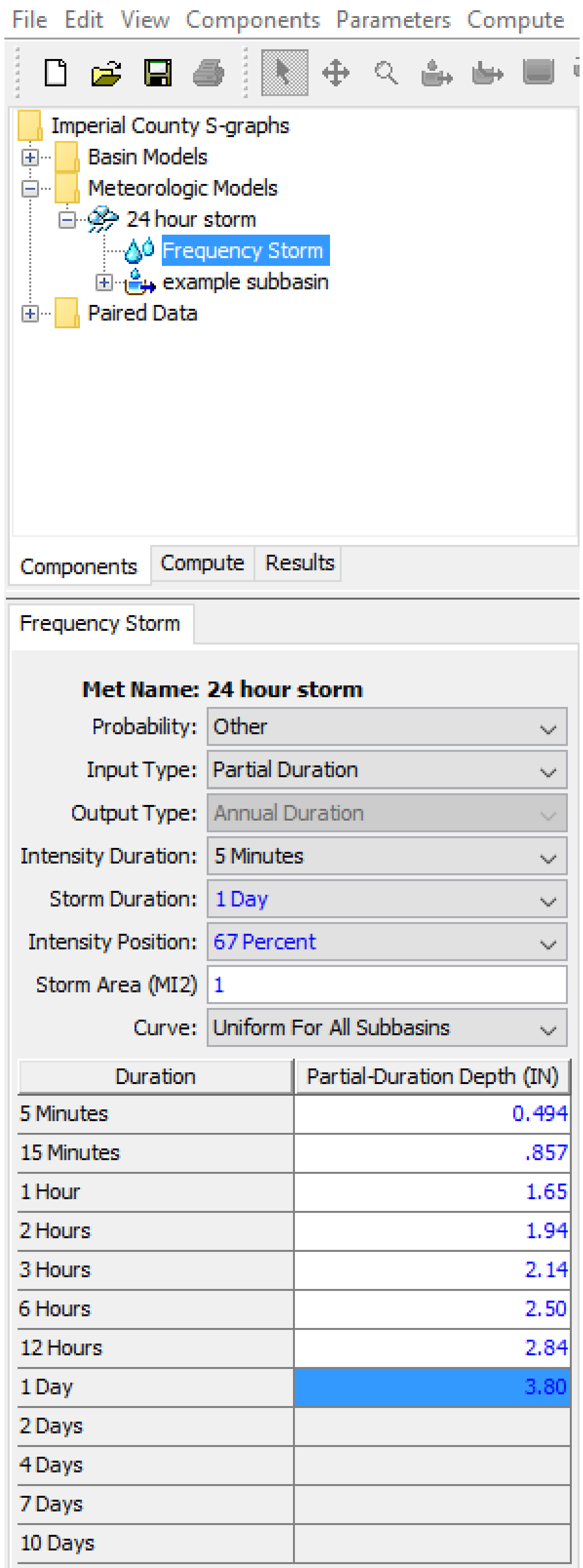


Figure 4-14. HMS 1/3, 2/3 balanced storm setup

Step 8. Control specification creation. Use the "Components" → "Control Specification Manager" to create a simulation time window for the hydrograph creation as presented in Figure 4-15.

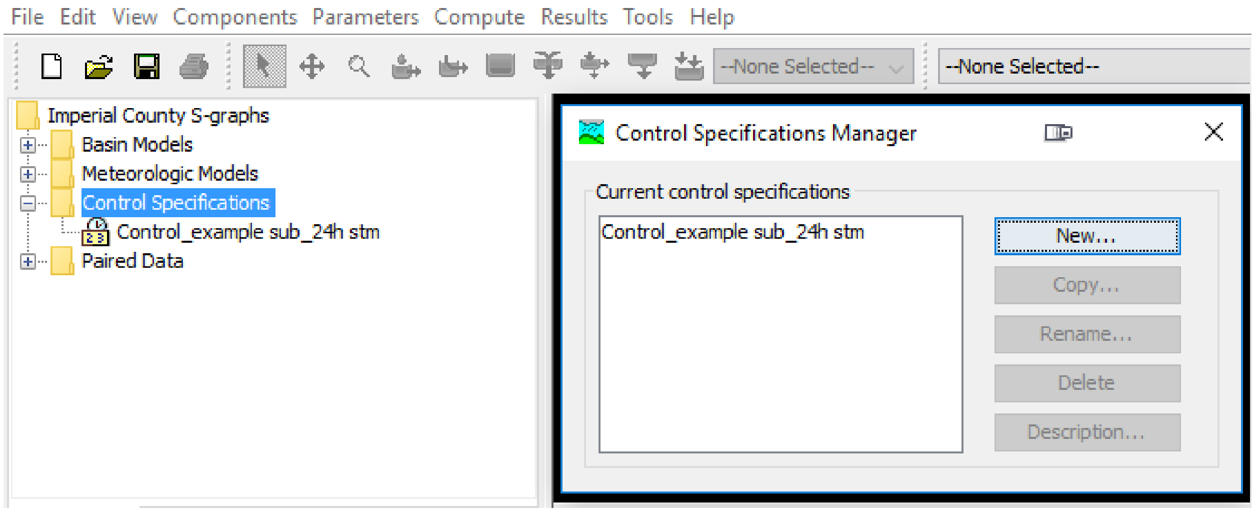


Figure 4-15. HMS Control Specifications creation

Step 9. Control Specifications settings. The start and end dates and times should be selected to provide enough time to capture the entire hydrograph. The "Time Interval" setting of the Control Specifications should be set no greater than the "Intensity-Duration" in Step 7 (5 minutes in this example.). In the example shown, a time interval of 5 minutes is selected. When peak discharge is of primary importance, a short time interval should be utilized. Settings should be as presented in Figure 4-16. .

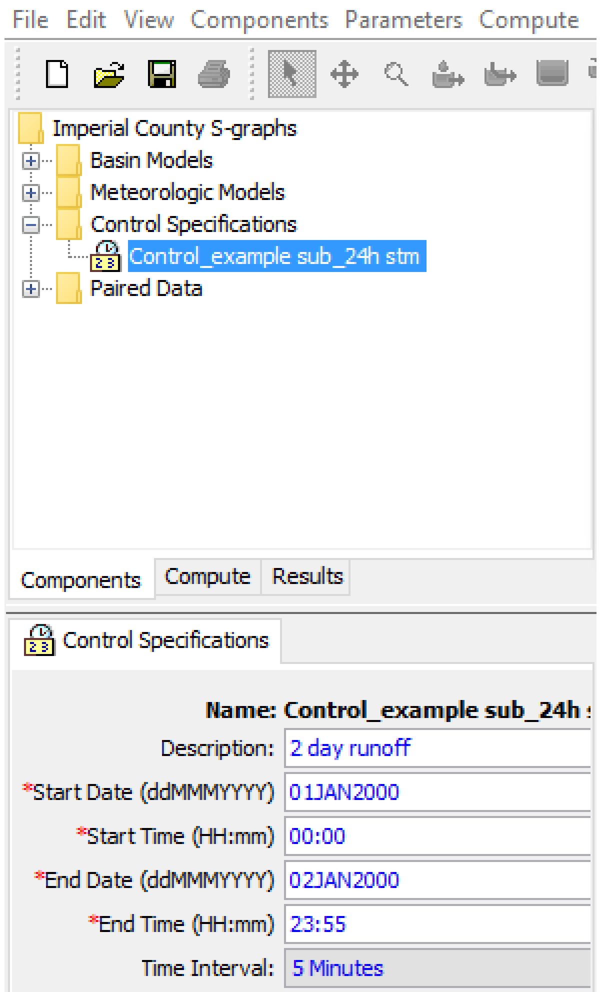


Figure 4-16. Control Specifications settings

Step 10. Create a Simulation Run. Use the “Compute” → “Create Compute” → “Simulation Run …” to prepare a model run. Follow the prompts to name the model run, select the basin model created in Step 3, Meteorologic Model created in Step 6 and the Control Specifications created in Step 9.

Step 11. Calculate the hydrograph. Select the “Compute” tab, select Simulation Runs and right click the simulation run created in Step 10. Click compute as presented in Figure 4-17.

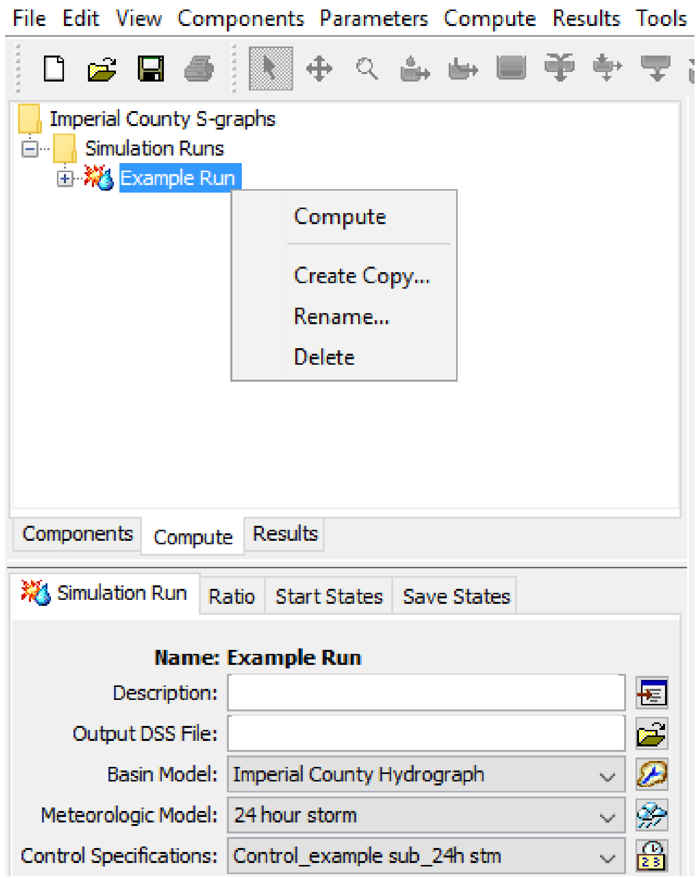


Figure 4-17. HMS hydrograph calculation

Step 12. View the results. The resulting hydrograph may be viewed by selecting the “Results” tab, clicking “Simulation Runs”, clicking the simulation run created in Step 10, clicking the subbasin created in Step 4 and selecting “Graph” as presented in Figure 4-18.

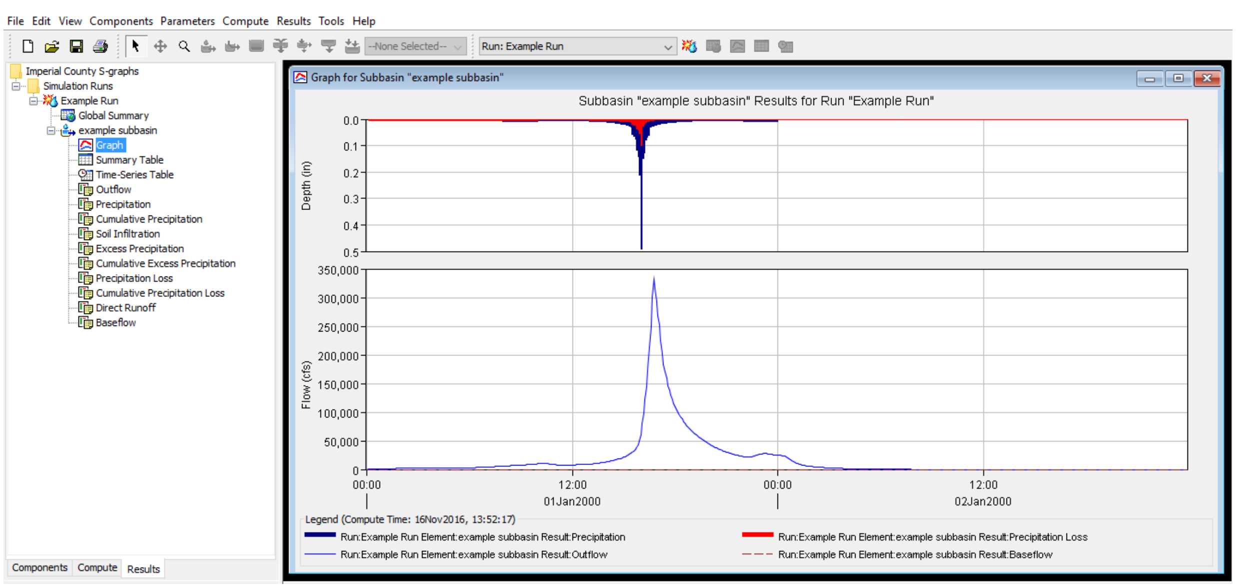


Figure 4-18. Viewing hydrograph results

By visual inspection, it may be concluded the time window chosen for simulation is sufficient to capture the rising and falling hydrograph limbs. (In fact, the time could be shortened by returning to Step 9, changing the end time and re-running the model.) Results such as peak discharge, time of peak discharge, runoff volume, etc. are available by clicking "Summary Table" below the "Graph" icon previously selected. An example Summary Results window is presented as Figure 4-19. Detailed output for each time step is also available by selecting "Time-Series Table" below "Summary Table" in the hierarchical list. An example of more detailed output is presented in Figure 4-20.

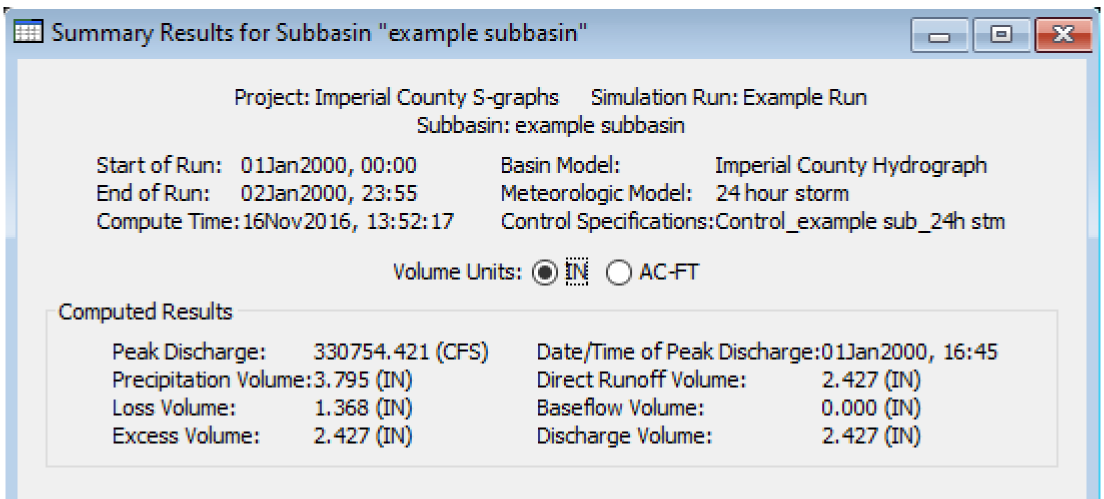


Figure 4-19. Hydrograph summary results

Time-Series Results for Subbasin "example subbasin"

Project: Imperial County S-graphs   Simulation Run: Example Run
Subbasin: example subbasin

Start of Run: 01Jan2000, 00:00   Basin Model: Imperial County Hydrograph
End of Run: 02Jan2000, 23:55   Meteorologic Model: 24 hour storm
Compute Time: 16Nov2016, 13:52:17   Control Specifications: Control_example sub_24h stm

Date	Time	Precip (IN)	Loss (IN)	Excess (IN)	Direct Flow (CFS)	Baseflow (CFS)	Total Flow (CFS)
01Jan2000	00:00				0.000	0.000	0.000
01Jan2000	00:05	0.006	0.005	0.001	15.386	0.000	15.386
01Jan2000	00:10	0.006	0.005	0.001	36.984	0.000	36.984
01Jan2000	00:15	0.006	0.005	0.001	68.883	0.000	68.883
01Jan2000	00:20	0.006	0.005	0.001	108.993	0.000	108.993
01Jan2000	00:25	0.006	0.005	0.001	155.429	0.000	155.429
01Jan2000	00:30	0.006	0.005	0.001	231.184	0.000	231.184
01Jan2000	00:35	0.006	0.005	0.001	325.905	0.000	325.905
01Jan2000	00:40	0.006	0.005	0.001	480.074	0.000	480.074
01Jan2000	00:45	0.006	0.005	0.001	679.697	0.000	679.697
01Jan2000	00:50	0.006	0.005	0.001	842.895	0.000	842.895
01Jan2000	00:55	0.006	0.005	0.001	975.639	0.000	975.639
01Jan2000	01:00	0.006	0.005	0.001	1082.621	0.000	1082.621
01Jan2000	01:05	0.006	0.005	0.001	1187.521	0.000	1187.521
01Jan2000	01:10	0.006	0.005	0.001	1269.334	0.000	1269.334
01Jan2000	01:15	0.006	0.005	0.001	1339.196	0.000	1339.196
01Jan2000	01:20	0.006	0.005	0.001	1397.524	0.000	1397.524
01Jan2000	01:25	0.006	0.005	0.001	1452.061	0.000	1452.061
01Jan2000	01:30	0.006	0.005	0.001	1503.888	0.000	1503.888
01Jan2000	01:35	0.006	0.005	0.001	1546.057	0.000	1546.057
01Jan2000	01:40	0.006	0.005	0.001	1587.484	0.000	1587.484
01Jan2000	01:45	0.006	0.005	0.001	1628.105	0.000	1628.105
01Jan2000	01:50	0.006	0.005	0.001	1661.687	0.000	1661.687
01Jan2000	01:55	0.006	0.005	0.001	1694.440	0.000	1694.440
01Jan2000	02:00	0.006	0.005	0.001	1723.902	0.000	1723.902
01Jan2000	02:05	0.006	0.005	0.001	1755.620	0.000	1755.620
01Jan2000	02:10	0.006	0.005	0.001	1780.838	0.000	1780.838
01Jan2000	02:15	0.006	0.005	0.001	1807.912	0.000	1807.912
01Jan2000	02:20	0.006	0.005	0.001	1833.191	0.000	1833.191
01Jan2000	02:25	0.006	0.005	0.001	1857.018	0.000	1857.018
01Jan2000	02:30	0.006	0.005	0.001	1879.635	0.000	1879.635
01Jan2000	02:35	0.006	0.005	0.001	1900.934	0.000	1900.934

Figure 4-20. Hydrograph detailed output

Of course, the simulation results from the example are for the 1 square mile watershed used to apply the proper depth-area-reduction. Final results are obtained by multiplying simulation results by the actual square mile area of the watershed. The abscissa and ordinate values of the hydrograph are available in the detailed output. The procedure described for determining a runoff hydrograph is applicable to a single basin. Analysis of more complicated watersheds requiring subbasins should follow a similar overall approach and may require the use of junctions, routing reaches, reservoirs, etc. Refer to the HEC-HMS User’s Manual for further information regarding the use of multiple subbasins.

4.5 Transition from Rational Method to NRCS Hydrologic Method

As discussed in Section 3.1, the engineer should only use the RM or MRM for drainage areas up to approximately 1 square mile. The NRCS hydrologic method should be used for study areas approximately 1 square mile and greater in size. For study areas greater than approximately 1 square mile, the NRCS hydrologic method may be used for the entire study area, or the RM or MRM may be used for approximately 1 square mile of the study area with results then transitioned to the NRCS hydrologic method solutions using the procedure described below:

1) Stop RM calculations at approximately 1 square mile;

2) Freeze RM peak discharge, Q_p, at approximately 1 square mile;

3) Begin NRCS hydrograph calculations at the next point of interest. Estimate the travel time, T_t, from the MRM calculations along the reach to the point of interest, and increase the T_c from the MRM calculations by T_t. Determine T_p based on T_c using McCuen (1982):

$$T_P = 0.67\ T_C \qquad (4\text{-}6)$$

   Perform NRCS calculations as described in Section 4.4 and the total watershed area to the point of interest.

If $Q_{MRM} > Q_{NRCS}$ then use Q_{MRM}.

If $Q_{MRM} < Q_{NRCS}$ then use Q_{NRCS}.

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Appendix

Imperial County S-graph Coordinates

Table A-1. Foothill S-graph values

% Lag	% Peak q	% Lag	% Peak q	% Lag	% Peak q	% Lag	% Peak q
0	0.00	40	7.74	80	25.92	120	62.26
1	0.03	41	8.00	81	26.63	121	62.65
2	0.16	42	8.32	82	27.41	122	63.03
3	0.22	43	8.58	83	28.25	123	63.42
4	0.42	44	8.90	84	29.15	124	63.81
5	0.61	45	9.16	85	30.12	125	64.16
6	0.80	46	9.48	86	31.09	126	64.45
7	0.86	47	9.87	87	32.12	127	64.84
8	0.93	48	10.13	88	33.09	128	65.35
9	1.06	49	10.45	89	34.57	129	65.74
10	1.31	50	10.83	90	35.99	130	66.06
11	1.38	51	10.96	91	37.28	131	66.38
12	1.57	52	11.35	92	39.48	132	66.77
13	1.70	53	11.73	93	42.13	133	67.09
14	1.83	54	12.19	94	44.39	134	67.54
15	1.95	55	12.51	95	45.87	135	67.87
16	2.13	56	12.83	96	46.97	136	68.12
17	2.34	57	13.22	97	47.92	137	68.38
18	2.53	58	13.67	98	48.91	138	68.57
19	2.60	59	14.18	99	49.64	139	68.89
20	2.89	60	14.51	100	50.00	140	69.22
21	3.11	61	15.02	101	50.69	141	69.47
22	3.24	62	15.54	102	51.74	142	69.86
23	3.50	63	15.92	103	52.87	143	70.05
24	3.82	64	16.38	104	53.88	144	70.31
25	4.01	65	16.96	105	54.71	145	70.76
26	4.08	66	17.47	106	55.36	146	71.08
27	4.20	67	17.99	107	55.94	147	71.28
28	4.40	68	18.44	108	56.52	148	71.53
29	4.65	69	19.08	109	57.17	149	71.79
30	4.91	70	19.73	110	57.75	150	72.05
31	5.23	71	20.18	111	58.26	151	72.24
32	5.56	72	20.70	112	58.71	152	72.56
33	5.81	73	21.28	113	59.04	153	72.89
34	6.13	74	22.12	114	59.42	154	73.01
35	6.39	75	22.57	115	59.98	155	73.30
36	6.65	76	22.95	116	60.33	156	73.59
37	6.97	77	23.60	117	60.84	157	73.85
38	7.10	78	24.24	118	61.29	158	74.04
39	7.42	79	25.08	119	61.87	159	74.30

% Lag	% Peak q	% Lag	% Peak q	% Lag	% Peak q	% Lag	% Peak q
160	74.69	201	82.59	242	88.01	283	91.99
161	74.94	202	82.65	243	88.12	284	92.07
162	75.14	203	82.85	244	88.23	285	92.15
163	75.33	204	82.91	245	88.34	286	92.23
164	75.52	205	83.08	246	88.44	287	92.31
165	75.85	206	83.30	247	88.55	288	92.39
166	75.97	207	83.36	248	88.66	289	92.47
167	76.17	208	83.55	249	88.76	290	92.55
168	76.42	209	83.68	250	88.87	291	92.63
169	76.62	210	83.81	251	88.97	292	92.71
170	76.87	211	84.00	252	89.08	293	92.79
171	77.13	212	84.07	253	89.18	294	92.87
172	77.32	213	84.19	254	89.28	295	92.94
173	77.52	214	84.39	255	89.39	296	93.02
174	77.71	215	84.58	256	89.49	297	93.09
175	77.94	216	84.71	257	89.59	298	93.17
176	78.03	217	84.84	258	89.69	299	93.24
177	78.22	218	85.03	259	89.79	300	93.31
178	78.42	219	85.09	260	89.89	301	93.38
179	78.67	220	85.22	261	89.99	302	93.46
180	78.93	221	85.35	262	90.08	303	93.53
181	79.06	222	85.48	263	90.18	304	93.60
182	79.32	223	85.60	264	90.28	305	93.67
183	79.51	224	85.73	265	90.37	306	93.74
184	79.70	225	85.79	266	90.47	307	93.80
185	79.92	226	85.99	267	90.56	308	93.87
186	79.96	227	86.18	268	90.66	309	93.94
187	80.13	228	86.24	269	90.75	310	94.00
188	80.41	229	86.44	270	90.84	311	94.07
189	80.54	230	86.63	271	90.93	312	94.14
190	80.79	231	86.69	272	91.03	313	94.20
191	80.86	232	86.89	273	91.12	314	94.26
192	81.05	233	86.95	274	91.21	315	94.33
193	81.24	234	87.11	275	91.30	316	94.39
194	81.37	235	87.23	276	91.38	317	94.45
195	81.50	236	87.34	277	91.47	318	94.51
196	81.76	237	87.45	278	91.56	319	94.57
197	82.01	238	87.57	279	91.65	320	94.64
198	82.08	239	87.68	280	91.73	321	94.69
199	82.14	240	87.79	281	91.82	322	94.75
200	82.27	241	87.90	282	91.90	323	94.81

% Lag	% Peak q		% Lag	% Peak q		% Lag	% Peak q		% Lag	% Peak q
324	94.87		365	96.76		406	97.88		447	98.49
325	94.93		366	96.80		407	97.90		448	98.50
326	94.98		367	96.83		408	97.92		449	98.51
327	95.04		368	96.87		409	97.94		450	98.52
328	95.10		369	96.90		410	97.96		451	98.53
329	95.15		370	96.94		411	97.98		452	98.54
330	95.20		371	96.97		412	98.00		453	98.55
331	95.26		372	97.00		413	98.01		454	98.56
332	95.31		373	97.03		414	98.03		455	98.57
333	95.36		374	97.07		415	98.05		456	98.58
334	95.42		375	97.10		416	98.07		457	98.59
335	95.47		376	97.13		417	98.08		458	98.60
336	95.52		377	97.16		418	98.10		460	98.61
337	95.57		378	97.19		419	98.12		461	98.62
338	95.62		379	97.22		420	98.13		462	98.63
339	95.67		380	97.25		421	98.15		463	98.64
340	95.72		381	97.28		422	98.16		464	98.65
341	95.76		382	97.31		423	98.18		465	98.66
342	95.81		383	97.33		424	98.20		467	98.67
343	95.86		384	97.36		425	98.21		468	98.68
344	95.91		385	97.39		426	98.23		469	98.69
345	95.95		386	97.42		427	98.24		470	98.70
346	96.00		387	97.44		428	98.25		472	98.71
347	96.04		388	97.47		429	98.27		473	98.72
348	96.09		389	97.50		430	98.28		474	98.73
349	96.13		390	97.52		431	98.30		476	98.74
350	96.17		391	97.55		432	98.31		477	98.75
351	96.22		392	97.57		433	98.32		478	98.76
352	96.26		393	97.60		434	98.34		480	98.77
353	96.30		394	97.62		435	98.35		481	98.78
354	96.34		395	97.64		436	98.36		482	98.79
355	96.38		396	97.67		437	98.37		484	98.80
356	96.42		397	97.69		438	98.39		485	98.81
357	96.46		398	97.71		439	98.40		487	98.82
358	96.50		399	97.73		440	98.41		488	98.83
359	96.54		400	97.76		441	98.42		490	98.84
360	96.58		401	97.78		442	98.43		491	98.85
361	96.62		402	97.80		443	98.44		493	98.86
362	96.65		403	97.82		444	98.46		494	98.87
363	96.69		404	97.84		445	98.47		496	98.88
364	96.73		405	97.86		446	98.48		498	98.89

% Lag	% Peak q		% Lag	% Peak q		% Lag	% Peak q		% Lag	% Peak q
499	98.90		544	99.18		595	99.54		624	99.74
501	98.91		546	99.19		597	99.55		625	99.75
502	98.92		547	99.20		598	99.56		627	99.76
504	98.93		549	99.21		599	99.57		628	99.77
506	98.94		550	99.22		601	99.58		630	99.78
507	98.95		552	99.23		602	99.59		632	99.79
509	98.96		553	99.24		603	99.60		633	99.80
511	98.97		555	99.25		605	99.61		635	99.81
512	98.98		556	99.26		606	99.62		637	99.82
514	98.99		558	99.27		608	99.63		638	99.83
515	99.00		559	99.28		609	99.64		640	99.84
517	99.01		561	99.29		610	99.65		642	99.85
519	99.02		562	99.30		612	99.66		644	99.86
520	99.03		575	99.39		613	99.67		646	99.87
522	99.04		576	99.40		615	99.68		648	99.88
524	99.05		577	99.41		616	99.69		651	99.89
525	99.06		579	99.42		618	99.70		653	99.90
527	99.07		580	99.43		619	99.71		655	99.91
528	99.08		582	99.44		563	99.31		658	99.92
530	99.09		583	99.45		565	99.32		661	99.93
532	99.10		584	99.46		566	99.33		667	99.94
533	99.11		586	99.47		568	99.34		674	99.95
535	99.12		587	99.48		569	99.35		683	99.96
536	99.13		588	99.49		570	99.36		687	99.97
538	99.14		590	99.50		572	99.37		692	99.98
540	99.15		591	99.51		573	99.38		697	99.99
541	99.16		592	99.52		621	99.72		700	100.00
543	99.17		594	99.53		622	99.73			

Table A-2. Desert S-graph values

% Lag	% Peak q	% Lag	% Peak q	% Lag	% Peak q	% Lag	% Peak q
0	0.00	40	6.66	80	36.20	120	59.83
1	0.06	41	7.02	81	37.17	121	60.25
2	0.19	42	7.31	82	37.81	122	60.63
3	0.22	43	7.69	83	38.72	123	60.95
4	0.25	44	8.01	84	39.56	124	61.28
5	0.32	45	8.34	85	40.33	125	61.60
6	0.44	46	8.79	86	41.17	126	61.92
7	0.57	47	9.24	87	41.94	127	62.18
8	0.70	48	9.75	88	42.59	128	62.50
9	0.76	49	10.14	89	43.17	129	62.88
10	0.96	50	10.72	90	44.01	130	63.21
11	1.02	51	11.23	91	44.78	131	63.46
12	1.08	52	11.49	92	45.30	132	63.78
13	1.21	53	11.88	93	46.07	133	64.11
14	1.34	54	12.33	94	46.78	134	64.36
15	1.46	55	12.84	95	47.62	135	64.81
16	1.59	56	13.60	96	48.13	136	65.07
17	1.79	57	14.26	97	48.58	137	65.33
18	1.98	58	14.91	98	49.22	138	65.58
19	2.11	59	15.49	99	49.64	139	65.91
20	2.23	60	16.18	100	50.00	140	66.23
21	2.49	61	16.97	101	50.59	141	66.42
22	2.68	62	17.75	102	51.31	142	66.68
23	2.75	63	18.52	103	52.13	143	66.93
24	2.94	64	19.29	104	52.65	144	67.19
25	3.20	65	20.20	105	53.23	145	67.45
26	3.39	66	21.40	106	53.87	146	67.71
27	3.52	67	22.65	107	54.26	147	67.96
28	3.77	68	23.68	108	54.64	148	68.22
29	3.90	69	24.65	109	55.09	149	68.48
30	4.07	70	26.20	110	55.67	150	68.86
31	4.41	71	27.36	111	56.19	151	69.16
32	4.67	72	28.20	112	56.58	152	69.31
33	4.99	73	29.36	113	56.96	153	69.51
34	5.19	74	30.46	114	57.35	154	69.76
35	5.51	75	31.49	115	57.80	155	69.89
36	5.70	76	32.33	116	58.25	156	70.15
37	5.96	77	33.10	117	58.57	157	70.40
38	6.21	78	34.07	118	58.89	158	70.60
39	6.41	79	35.04	119	59.28	159	70.85

% Lag	% Peak q	% Lag	% Peak q	% Lag	% Peak q	% Lag	% Peak q
160	71.11	201	78.35	242	83.51	283	87.25
161	71.30	202	78.48	243	83.62	284	87.33
162	71.50	203	78.67	244	83.72	285	87.40
163	71.69	204	78.87	245	83.83	286	87.48
164	71.88	205	78.93	246	83.93	287	87.56
165	72.14	206	79.12	247	84.03	288	87.63
166	72.33	207	79.25	248	84.14	289	87.71
167	72.52	208	79.44	249	84.24	290	87.78
168	72.71	209	79.51	250	84.34	291	87.85
169	72.89	210	79.70	251	84.44	292	87.93
170	73.16	211	79.76	252	84.54	293	88.00
171	73.29	212	79.89	253	84.63	294	88.07
172	73.48	213	79.97	254	84.73	295	88.15
173	73.68	214	80.11	255	84.83	296	88.22
174	73.93	215	80.24	256	84.92	297	88.29
175	74.19	216	80.38	257	85.02	298	88.36
176	74.25	217	80.51	258	85.11	299	88.43
177	74.45	218	80.65	259	85.21	300	88.50
178	74.64	219	80.78	260	85.30	301	88.57
179	74.83	220	80.91	261	85.39	302	88.64
180	75.02	221	81.04	262	85.48	303	88.71
181	75.09	222	81.17	263	85.57	304	88.77
182	75.34	223	81.30	264	85.66	305	88.84
183	75.54	224	81.42	265	85.75	306	88.91
184	75.71	225	81.55	266	85.84	307	88.97
185	75.92	226	81.67	267	85.93	308	89.04
186	76.05	227	81.79	268	86.02	309	89.11
187	76.11	228	81.91	269	86.10	310	89.17
188	76.37	229	82.04	270	86.19	311	89.24
189	76.56	230	82.15	271	86.27	312	89.30
190	76.63	231	82.27	272	86.36	313	89.37
191	76.82	232	82.39	273	86.44	314	89.43
192	77.01	233	82.51	274	86.52	315	89.49
193	77.14	234	82.62	275	86.61	316	89.56
194	77.33	235	82.74	276	86.69	317	89.62
195	77.52	236	82.85	277	86.77	318	89.68
196	77.71	237	82.96	278	86.85	319	89.74
197	77.78	238	83.07	279	86.93	320	89.81
198	77.97	239	83.18	280	87.01	321	89.87
199	78.03	240	83.29	281	87.09	322	89.93
200	78.16	241	83.40	282	87.17	323	89.99

% Lag	% Peak q	% Lag	% Peak q	% Lag	% Peak q	% Lag	% Peak q
324	90.05	365	92.25	406	94.02	447	95.44
325	90.11	366	92.30	407	94.06	448	95.47
326	90.17	367	92.35	408	94.10	449	95.50
327	90.23	368	92.39	409	94.14	450	95.53
328	90.29	369	92.44	410	94.18	451	95.56
329	90.34	370	92.49	411	94.22	452	95.59
330	90.40	371	92.54	412	94.25	453	95.62
331	90.46	372	92.58	413	94.29	454	95.65
332	90.52	373	92.63	414	94.33	455	95.67
333	90.58	374	92.67	415	94.36	456	95.70
334	90.63	375	92.72	416	94.40	457	95.73
335	90.69	376	92.77	417	94.44	458	95.76
336	90.74	377	92.81	418	94.47	459	95.79
337	90.80	378	92.86	419	94.51	460	95.82
338	90.86	379	92.90	420	94.55	461	95.84
339	90.91	380	92.95	421	94.58	462	95.87
340	90.97	381	92.99	422	94.62	463	95.90
341	91.02	382	93.03	423	94.65	464	95.93
342	91.08	383	93.08	424	94.69	465	95.95
343	91.13	384	93.12	425	94.72	466	95.98
344	91.18	385	93.16	426	94.76	467	96.01
345	91.24	386	93.21	427	94.79	468	96.03
346	91.29	387	93.25	428	94.83	469	96.06
347	91.34	388	93.29	429	94.86	470	96.09
348	91.40	389	93.34	430	94.89	471	96.11
349	91.45	390	93.38	431	94.93	472	96.14
350	91.50	391	93.42	432	94.96	473	96.16
351	91.55	392	93.46	433	94.99	474	96.19
352	91.60	393	93.50	434	95.03	475	96.22
353	91.66	394	93.55	435	95.06	476	96.24
354	91.71	395	93.59	436	95.09	477	96.27
355	91.76	396	93.63	437	95.12	478	96.29
356	91.81	397	93.67	438	95.16	479	96.31
357	91.86	398	93.71	439	95.19	480	96.34
358	91.91	399	93.75	440	95.22	481	96.36
359	91.96	400	93.79	441	95.25	482	96.39
360	92.01	401	93.83	442	95.28	483	96.41
361	92.06	402	93.87	443	95.31	484	96.44
362	92.11	403	93.91	444	95.35	485	96.46
363	92.15	404	93.95	445	95.38	486	96.48
364	92.20	405	93.99	446	95.41	487	96.51

% Lag	% Peak q	% Lag	% Peak q	% Lag	% Peak q	% Lag	% Peak q
488	96.53	529	97.34	570	97.94	611	98.43
489	96.55	530	97.36	571	97.96	612	98.44
490	96.57	531	97.37	572	97.97	613	98.45
491	96.60	532	97.39	573	97.98	614	98.46
492	96.62	533	97.41	574	97.99	615	98.47
493	96.64	534	97.42	575	98.01	616	98.48
494	96.66	535	97.44	576	98.02	617	98.49
495	96.69	536	97.46	577	98.03	618	98.50
496	96.71	537	97.47	578	98.04	619	98.52
497	96.73	538	97.49	579	98.06	620	98.53
498	96.75	539	97.50	580	98.07	621	98.54
499	96.77	540	97.52	581	98.08	622	98.55
500	96.79	541	97.53	582	98.09	623	98.56
501	96.81	542	97.55	583	98.10	624	98.57
502	96.83	543	97.57	584	98.12	625	98.58
503	96.85	544	97.58	585	98.13	626	98.59
504	96.88	545	97.60	586	98.14	627	98.60
505	96.90	546	97.61	587	98.15	628	98.61
506	96.92	547	97.63	588	98.16	629	98.63
507	96.94	548	97.64	589	98.18	630	98.64
508	96.96	549	97.66	590	98.19	631	98.65
509	96.98	550	97.67	591	98.20	632	98.66
510	96.99	551	97.68	592	98.21	633	98.67
511	97.01	552	97.70	593	98.22	634	98.68
512	97.03	553	97.71	594	98.23	635	98.69
513	97.05	554	97.73	595	98.25	636	98.70
514	97.07	555	97.74	596	98.26	637	98.71
515	97.09	556	97.76	597	98.27	638	98.72
516	97.11	557	97.77	598	98.28	639	98.74
517	97.13	558	97.78	599	98.29	640	98.75
518	97.15	559	97.80	600	98.30	641	98.76
519	97.16	560	97.81	601	98.31	642	98.77
520	97.18	561	97.82	602	98.33	643	98.78
521	97.20	562	97.84	603	98.34	644	98.79
522	97.22	563	97.85	604	98.35	645	98.80
523	97.24	564	97.86	605	98.36	646	98.81
524	97.25	565	97.88	606	98.37	647	98.82
525	97.27	566	97.89	607	98.38	648	98.83
526	97.29	567	97.90	608	98.39	649	98.85
527	97.31	568	97.92	609	98.40	650	98.86
528	97.32	569	97.93	610	98.42	651	98.87

% Lag	% Peak q	% Lag	% Peak q	% Lag	% Peak q	% Lag	% Peak q
652	98.88	679	99.18	706	99.48	733	99.76
653	98.89	680	99.19	707	99.49	734	99.77
654	98.90	681	99.20	708	99.50	735	99.78
655	98.91	682	99.22	709	99.51	736	99.79
656	98.92	683	99.23	710	99.52	737	99.80
657	98.94	684	99.24	711	99.53	738	99.81
658	98.95	685	99.25	712	99.54	739	99.82
659	98.96	686	99.26	713	99.55	740	99.83
660	98.97	687	99.27	714	99.56	741	99.84
661	98.98	688	99.28	715	99.57	742	99.85
662	98.99	689	99.29	716	99.59	743	99.86
663	99.00	690	99.30	717	99.60	744	99.87
664	99.01	691	99.32	718	99.61	745	99.88
665	99.02	692	99.33	719	99.62	746	99.89
666	99.04	693	99.34	720	99.63	747	99.90
667	99.05	694	99.35	721	99.64	748	99.91
668	99.06	695	99.36	722	99.65	749	99.92
669	99.07	696	99.37	723	99.66	750	99.93
670	99.08	697	99.38	724	99.67	751	99.94
671	99.09	698	99.39	725	99.68	755	99.95
672	99.10	699	99.40	726	99.69	760	99.96
673	99.11	700	99.41	727	99.70	765	99.97
674	99.13	701	99.42	728	99.71	770	99.98
675	99.14	702	99.43	729	99.72	775	99.99
676	99.15	703	99.45	730	99.73	780	100.00
677	99.16	704	99.46	731	99.74		
678	99.17	705	99.47	732	99.75		