Morningside Drainage Basin Design Plan

Prepared for:

City of Rapid City Engineering Division

April 1998
April 17, 1998

Ms. Mely Rahn, PE
Project Manager
Rapid City Engineering Division
300 Sixth Street
Rapid City, SD  57701

Re: Morningside Drainage Basin Design Plan

Dear Mely:

We are pleased to submit this final Report for the Morningside Drainage Basin Design Plan. This report summarizes our hydrologic study of the Basin, and provides the City and other users guidelines for the future development of this area. This submittal includes the Design Plan Report, copies of the 1"=200' Drainage Orthophotos, and computer input and output files for the hydrologic and hydraulic modeling.

We have enjoyed working with the City Staff in the preparation of this document, and look forward to working with you on other projects in the future. If you have questions, or need additional information, please feel free to contact us.

Sincerely,

FERBER ENGINEERING COMPANY

[Signatures]

Encl.
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INTRODUCTION

BACKGROUND

This Drainage Basin Design Plan has been prepared for the City of Rapid City by Ferber Engineering Company. Basin Design Plans quantify the amount of runoff which would occur during a 10-year initial storm event and a 100-year major storm event. The plan also identifies major drainage facilities required to convey the runoff from the most remote reaches of the basin to the outlet with Rapid Creek.

The City of Rapid City has recognized the need to provide long range plans for major drainage improvements in each drainage basin. This design plan is one of a series being developed under the direction of the City Engineering Department. These design plans will be implemented to promote orderly growth and to protect vital drainage routes.

The basin design plan identifies major routes to be protected as development occurs. The design plan also sizes the facilities necessary to convey flows for the purpose of modeling. Any structure installed within the scope of the basin design plan must be designed using accepted engineering practices. Consideration must be given to changes in proposed land use and upstream detention storage.

Morningside Drainage Basin has many unique features. The basin is divided east from west by I-190. On the west side of I-190, most of the basin remains undeveloped due to steep and unstable slopes. The eastern portion of the basin is fully developed with residential housing in the north and the Civic Center complex, Journey Museum, and Central High School in the south. The most southern end of the basin is largely flood plain and, therefore, will not be developed. The existing development creates many challenges in the conveyance of storm flows.

OBJECTIVES

The objectives of the Basin Design Plan are:

- To determine storm flows within the basin for the initial and major storm.
- Use the predicted storm flows to identify potential problem locations.
- Prepare conceptual designs for storm drainage improvements.

This plan is intended to be a guide for the City of Rapid City, Pennington County, and the State of South Dakota to use in the design and construction of major drainage facilities within the basin. Any improvements must safely, economically, and aesthetically convey the major storm event to Rapid Creek.
DESIGN PLAN LIMITATIONS

This design plan provides a conceptual outline of the major drainage improvements required to convey the major storm runoff to Rapid Creek. This plan contains the necessary data to begin design of specific drainage improvements. The improvements, when completed will form an efficient -- planned storm water management system.

It is unlikely that all improvements will follow the outline of this plan exactly. As facilities are constructed and modifications to the plan are made, it is essential to adjust the computer models to accurately reflect changes. Users of the plan are advised to contact the City Engineering Department to verify the accuracy of the design model.

This plan includes only the major drainage improvements. In undeveloped areas, the plan assumes local drainage improvements will be designed and constructed as part of development activity and will safely convey the flows to the major drainage facilities. In developed areas, certain conveyances will be required to meet the requirements of the Rapid City Drainage Criteria Manual.
BASIN DESCRIPTION

GENERAL

The Morningside Drainage Basin is located in north central Rapid City. The basin includes approximately 1078 acres, portions of which are located in and out of the Rapid City Corporate Limits. The basin lies entirely within Pennington County. The basin is bounded on the north and west by the natural ridgeline of the Dakota Hogback Ridge, on the south by Rapid Creek, and on the east by the Haines Avenue Drainage Basin.

The basin discharges at several locations along Rapid Creek from the base of Cowboy Hill to the Railroad Bridge known as Pressler Junction.

The basin is divided into two distinct and differing parts by the West Boulevard/I-190 Access. The eastern portion of the basin is fully developed with primarily single family residential housing, Central High School, the Civic Center, Boys Club, and Journey Museum. The western portion is partially developed with primarily single family residential housing and a meat packing plant. The undeveloped portion of the basin is comprised of steep slopes ranging from 15 to 60 percent. A ridge known (geologically) as the Dakota Hogback bound the undeveloped area. The area is considered undevelopable due to the steep slopes and limited access. Any development that occurs is typically limited to the ridge lines, knolls, and occasional areas of lesser slope.

Figure 1 is a portion of the USGS 7.5 minute Rapid City East Quadrangle showing the basin boundaries.

SUB-BASIN INFORMATION

The subdivision of the basin into smaller, more homogeneous sub-basins enables the engineer to more accurately predict runoff from the basin. Runoff hydrographs are created for each sub-basin using a computer model of the basin. Each sub-basin hydrograph is then routed to the ultimate basin outlet through a drainage network (another computer model). This method of calculating and routing runoff through a basin provides a more accurate prediction than calculating the entire basin as a single entity.

The Morningside Basin was divided into nineteen sub-basins as shown on Figure 2. The sub-basin boundaries were determined using topography, man-made barriers, and location of conveyance elements.
LAND USE AND ZONING

The objective of the Basin Design Plan is to identify the drainage improvements required in a fully developed basin. Meeting this objective requires the Engineer to make assumptions regarding the ultimate land use in the basin. The Morningside Drainage Basin lies within the Rapid City Planning Department jurisdiction and is covered in the Rapid City 2000 Comprehensive Plan. The projected land use for the basin is illustrated in Figure 3.

Land use and zoning in the basin falls into seven categories:

- Floodway and Floodplain
- Park Forest
- Residential: Low, Medium, and High Density
- Interstate (Highway right of way)
- Civic Center District
- Public
- Heavy Industry

FEMA has designated an area associated with Rapid Creek at the south end of the basin as floodway and floodplain. This area has been developed as a greenway for general public use. Some uses within the floodplain include: a golf course, parking, a bike path, and a public park.

Interstate I-190, running north and south, divides the basin into two distinct areas.

The west half of the basin is largely undeveloped. Steep slopes prevent the development of higher density uses. The undeveloped area is primarily zoned park forest. Some development has occurred on ridge lines and near the bases of the hills where the slopes are not as severe. Development will most likely continue in accordance with park forest zoning guidelines. Areas near I-190 have developed as low, medium, and high density residential areas. These areas are typically 1-2 blocks wide. Development in the area has been steady through several decades and continues today. On the banks of Rapid Creek is an area zoned heavy industry including a meat packing plant.

The east half of the basin is divided into the Civic Center District, residential districts, and a small portion of public use lands. The Civic Center District is located adjacent to the floodplain near Rapid Creek and is home to Central High School, the Rushmore Plaza Civic Center, the Rapid City Boy’s Club, and the Journey Museum. The residential areas are zoned low and medium density residential and were developed in the 1950’s and 1960’s. The public use lands within the east half of the basin include the Horace Mann Elementary School and Horace Mann Park.
LEGEND

- MEDIUM DENSITY RESIDENTIAL
- LOW DENSITY RESIDENTIAL
- HIGH DENSITY RESIDENTIAL
- HEAVY INDUSTRIAL
- CIVIC CENTER DISTRICT
- HOTEL/MOTEL
- PUBLIC
- INTERSTATE ROW
- PARK FOREST
- FLOOD

Figure 3 MORNINGSIDE LAND USE MAP
STREET CLASSIFICATION

The Rapid City Drainage Criteria Manual allows different levels of inundation and
different criteria for traffic access during storms for collector and arterial streets. The
Rapid City Major Street Plan, dated January 15, 1996, was reviewed to determine the
applicability of these provisions. Figure 4 shows the major street plan for the basin. The
basin contains four types of streets: interstate, principal arterial, collector, and local.
Local streets and alleys are not included in the major street plan.

Major streets are defined by the Rapid City Street Design Criteria Manual as:

- Arterial: A street serving the highest volume corridors and major centers of
  activity.

- Collector: a street which collects traffic from other minor streets and channels
  it into the arterial street system.

Interstate 90 passes through the northern portion of the basin in an East-West direction.
A portion of the Exit 56 Interchange is within the basin. Exit 56 serves I-190 running
from the interstate to Rapid Creek in a North-South direction. I-190 is a four lane major
access to Rapid City and ends at Omaha Street on the south side of Rapid Creek where it
transitions to West Boulevard. I-190 has one exit that serves Silver Street.

The only street classified as a Principal Arterial within the basin is 5th Street (Haines
Avenue). Fifth Street passes through the eastern portion of the basin in a north-south
direction. There are numerous designated collector streets within the basin. Running
east-west are Anamosa Street and North Street. Running north-south are Silver Street,
and West Boulevard North. There are two proposed collector streets within the basin.
The first proposed collector is the extension of Anamosa Street west over the Dakota
Hogback to intersect with Deadwood Avenue. The second proposed collector would
parallel I-90 on the north side of the Interstate.

Numerous street crossings are in existence or will be required to convey storm flows
through the basin to Rapid Creek. Major crossings include Interstate 90, Silver Street,
and I-190 (West Boulevard).
Figure 4 MORNINGSIDE STREET PLAN
TOPOGRAPHY

The most significant topographic feature in the Morningside Drainage Basin is the Dakota Hogback ridge. Sharply dipped sedimentary rocks that create a fairly continuous ridgeline form the hogback ridge. The ridgeline is the western boundary of the basin. The topography adjacent to the ridgeline constitutes the west half of the drainage basin. The west half of the drainage basin is characterized by steep slopes and short, deeply entrenched drainage ways. The area is sparsely covered with short evergreen trees and grasses typically associated with a woodland wildlife habitat.

The boundary where the steep slopes from the Dakota Hogback meet the undulating plains of Western South Dakota forms the major drainage way within the basin and divides the basin in half along a north-south line.

The eastern portion of the basin slopes moderately to the southeast in a manner typically associated with prairies in western South Dakota. Ground cover in the eastern portion includes cover associated with urban development such as maintained lawns and parking lots.

The Rapid Creek Flood Plain with very mild slopes and minor topographic definition characterizes the southern portion of the basin.

The basin generally slopes from northwest to southeast with elevations ranging from 3849 to 3206 feet above sea level. The basin discharges at several locations along Rapid Creek from the base of Cowboy Hill to Pressler Junction.

Natural drainage channels remains in existence for most of the western half of the basin. In the hogback area, drainage ways are generally small well defined gullies with steep, unstable side slopes. The small gullies become steeper and more unstable as they progress downstream until they discharge into constructed, grass lined swales.

The eastern half of the basin is fully developed. Natural drainage ways have been largely eliminated through land development activities. Shallow gutter flow in the streets, and storm sewers in the lower reaches of the basin have replaced the natural channels.
SOIL CLASSIFICATION

The hogback area of the basin is characterized by well drained, gently sloping to very steep, loamy soils formed from weathered material originating from limestone, sandstone, and shale, interspersed with rock outcrops of the same rocks.

The eastern portion of the basin is characterized by well drained, moderately sloping to very steep, clayey soils.

The flood plain area is characterized by well drained, very mildly sloping alluvium associated with Rapid Creek.

The U.S. Department of Agriculture, Natural Resources Conservation Service, classifies soils into four Hydrological Groups based on runoff and infiltration potential.

Figure 5 shows the Hydrologic Soil Groups within the basin.

The specific soil types and their Soil Groups are listed in Appendix E.

Group A soils have higher infiltration rates and lower runoff potential. Conversely, Group D soils have lower infiltration rates and higher runoff potential. The soils within the basin are Group B and D soils.
LEGEND

B  HYDROLOGIC SOIL GROUP B
D  HYDROLOGIC SOIL GROUP D
W  WATER

Figure 5 MORNINGSIDE HYDROLOGIC SOIL CLASSIFICATION
SPECIAL FEATURES AND PROBLEM AREAS

General

The major drainage outfall channel for the Morningside Drainage Basin begins at I-90 just west of the I-190 interchange. The channel follows I-190 on the west side until residential development causes the channel to end. At this point, the water must enter a storm sewer outfall north of Van Buren Street through a grated sump. The underground storm sewer outfall is the major limitation to the existing system. To prevent flooding of the residential area north and west of the I-190/Silver Street intersection, flows upstream must be limited to the capacity of the outfall pipe. The inlet must also be improved to utilize the maximum capacity of the pipe.

Business I-190 also divides the basin east from west and acts as a man-made barrier to the natural flow of water. This artificial barrier requires that two sub-basins must use the roadside facilities and the interstate roadway itself as their drainage way. The flows from these roadside basins and sub-basins L and M combine under the Silver Street Exit. These flows must be accommodated in the outfall storm sewer.

The eastern portion of the basin is fully developed. Consequently, drainage facility plans for this area address local drainage issues and not major drainage concerns.
Existing I-190 Storm Sewer Analysis

The storm sewer in I-190 is a series of inlets and pipes conveying water to the main channel west of I-190 or to the inlet structure below the Silver Street Bridge.

The first series of inlets is immediately north of the Anamosa Street Bridge. The capacity of the inlets matches the capacity of the outlet pipe, 47 cfs. The system includes six drop inlets; four in the median and two on the curb. The system also is the main discharge for Sub-Basin P. The inlet system is incapable of conveying the anticipated 10- and 100-year storm flows. The developed storm flows from Sub-Basin P are: 10-year = 77 cfs, 100-year = 154 cfs. Any storm water bypassing the inlets proceeds down I-190 to the second series of inlets.

The second series of inlets is immediately south of the Anamosa Street Bridge. Twelve inlets are connected together with 12", 15", and 18" pipes. The capacity of the 18" outlet pipe is 26 cfs. Six of the inlets are located below the median barrier and four of the inlets are curb inlets on I-190. Each has an estimated capacity of 8 cfs. The other inlets are located on the east branch of West Boulevard North. These two inlets operate in a sump condition and ponding is frequently observed after small storms. Any storm water overflowing the second series of inlets proceeds downstream to Silver Street.

The third reach of inlets on I-190 is a set of 5 inlets. The inlets are standard Type “B” drop inlets with grates. The inlets are capable of receiving more water than can be conveyed by the connecting pipes. The capacity of the outlet pipe is 26 cfs. Each inlet in this area has a capacity between 6 and 8 cfs. Any excess flow and the flow from the outlet pipe travels overland to the inlet below the Silver Street Bridge.

To support the requirements of the Rapid City Drainage Criteria Manual the entire system of inlets along I-190 must be reexamined and reconstructed or a borrow ditch constructed to convey the anticipated storm flows. Since I-190 is a major obstacle to surface flow it is recommended that an effective borrow ditch be created between I-190 and West Boulevard North to convey flows from Sub-Basins P and O. The creation of a borrow ditch would alleviate the need to reconstruction the storm sewer system associated with I-190.
RAPID CREEK FLOOD PLAIN

The Morningside Drainage Basin includes areas identified as flood prone in the "Flood Insurance Study for City of Rapid City" by the Federal Emergency Management Agency (FEMA) as revised February 16, 1996. The southern end of the drainage basin is bounded by Rapid Creek and its the associated Floodway and Floodplain. Figure 6 shows the Rapid Creek Floodway and Floodplain within the basin. Rapid Creek flows from west to east along the basin.
LEGEND

FLOOD PLAIN

FLOOD WAY

Figure 6 RAPID CITY FLOOD PLAIN AND FLOOD WAY
Design Plan
DESIGN PLAN

GENERAL

The process of developing the basin design plan included computer simulation of runoff from each of the Sub-Basins. Sub-Basin flows are then routed through a network of conveyance elements.

Hydrologic computer modeling was developed based on observed rainfall-runoff relationships. Rapid City has adopted a combination of the Colorado Urban Hydrograph Procedure (CUHP) and the Storm Water Management Model (SWMM) as a standard for design. Regionalized parameters were developed for the Rapid City area and are detailed in the Rapid City Drainage Criteria Manual.

Peak flows from basins are based on several parameters including; area, length, length to centroid, percent impervious area, slope, depression storage, and infiltration. Flows are predicted using the CUHP program. CUHP provides an output file which is capable of being read by the SWMM program. The file contains time and flow values for each sub-basin.

Conveyance elements are modeled to reflect either natural channels or constructed channels. To properly model the elements, several iterations are required to first determine the magnitude of the flows and then define the conveyance elements. Elements must convey the flows safely, aesthetically, economically, and within the constraints of the Drainage Criteria Manual.

The existing natural channels that are modeled in the design plan are infinitely variable. For modeling the existing conditions, a cross section was selected that is uniformly representative of the existing cross section.

The final step in developing the design plan is the inclusion of detention cells. The initial phases included only the detention created by the Interstate. Five potential detention cell locations were identified and a reconnaissance was conducted to determine the constructability of the cells. Of the initial five cell locations, we determined four cell locations were feasible. Through further investigation we determined three of the cells could impact downstream flow significantly enough to include in the plan.

Through an iterative process the effective size (storage) and discharge parameters for each detention cell and the detention cells in combination were determined to effectively control downstream flows.
Figure 7 is a Design Plan Hydrologic Schematic. The schematic indicates all of the design plan elements and their relationship in a graphic manner. The information from this schematic is shown more precisely on the 1” = 200' orthophotos in the back pockets of this document.

The numbering conventions used in this design plan are:

- **A - S**: Sub-Basin Label
- **10 -31**: Conveyance Elements - West of main channel
- **50-63**: Conveyance Elements - Main channel
- **64**: Conveyance Element - I-190
- **70-71**: Conveyance Elements - 8th Street
- **100**: Detention Cell (Existing)
- **110 - 120**: Detention Cells (Proposed)
- **200 - 211**: Direct Flow Elements

This design plan only concerns itself with those elements needed to convey the design storm runoff from the sub-basins to the outlets with Rapid Creek. Additional drainage improvements will be required to collect the runoff from individual parcels and development areas; and transport the runoff to the major drainage system.

This design plan model does not include specific crossing information for minor street crossings.
Figure 7 MORNSIDES HYDROLOGIC SCHEMATIC
FLOOD PLAIN DRAINAGE

A large portion of the basin lies within the boundaries of the Rapid Creek Flood Plain. Drainage issues within the Flood Plain are not specifically addressed within this Design Plan. The predicted runoff from the sub-basins containing the flood plain have been calculated and conveyed through direct flow elements for modeling purposes. Any storm drainage design within the Flood Plain must be analyzed according to the Rapid City flood Plain Ordinance.

For the purpose of this design plan, flows were conveyed through proposed elements across the Flood Plain to Rapid Creek. The elements conveying flows within the Flood Plain are 10, 30, 50 and 70. Elements 10 and 30 were modeled as wide swales to represent overland flows. Elements 50 and 70 were modeled as the underground pipes currently in place with overflow channels representing in-street or overland flow.

The Flood Plain is located primarily in Sub-Basins J, Q, and S.
MULTIPLE USE OPPORTUNITIES

The largest area available for multiple use opportunities in the basin is the flood plain. Development within the flood plain is governed by the Rapid City Flood Plain Ordinance. The main use of the flood plain is the Rapid City Greenway. The uses within the greenway are:

- Hike/bike path
- Municipal golf course
- Parking
- Memorials
- Formal gardens
- Bandshell
- Fishing
- Memorial Pond

The Rapid City Recreational Facilities Map identifies a Proposed Hike/Bike Route connecting the existing bike path to Horace Mann School on Anamosa Street. The proposed route follows existing streets west of I-190. The proposed path could be contained within the easement for the drainage channel and remove hikers and bikers from the streets.

Detention Cells can, with proper planning, provide multiple uses opportunities. Detention Cell 110 identified in the design plan is of adequate size to provide alternate uses. The area required for the cell is approximately 5.5 Acres. The cell could provide an area for a sports field, picnic area, BMX bicycles, or skateboarding. It must be noted while detention cells provide ideal areas for multiple uses they can also become unusable during and for a short time after storm events.

Detention Cell 120 could be developed into a neighborhood park with playground equipment or smaller scale sports facilities.

The hike/bike path could connect to both detention cells to provide easy access to the sports facilities for all ages.
HYDROLOGY

Methodology

The primary method used to determine storm runoff in Rapid City is the Colorado Urban Hydrograph Procedure (CUHP). CUHP was developed by the Urban Drainage and Flood Control District after extensive studies of the rainfall-runoff relationship in the Denver Metropolitan Area. Since the CUHP method yields reasonable results for the Rapid City area, the parameters and methodology remain as described in the Denver Drainage Criteria Manual.

It is recommended that the design storm runoff be analyzed by deriving synthetic unit hydrographs for basins larger than 90 acres. Basins smaller than 90 acres may be analyzed if the engineer makes provisions in the model to compensate for the smaller basins.

The first step in any hydrologic analysis is to identify the contributing area. To complete this step, orthophoto mapping of the area at a 1" = 200' scale was provided. Typically 2' contours are needed to delineate the basin, however, in some areas the ground is too steep and 10' contours are used.

Once the basin boundary has been determined the engineer uses his judgment to divide the basin into smaller, homogeneous sub-basins. Sub-basins are determined using natural topography, desired design points, man-made barriers, and existing storm sewer facilities. Desired design points may be locations identified as potential road crossings, potential detention facilities, existing or potential storm sewer facilities, or the confluence of drainage ways.

Modeling Parameters

Each sub-basin is analyzed in detail to determine runoff parameters. Parameters required to run the CUHP computer model are:

- Length
- Length to centroid
- Area
- Percent impervious area
- Initial infiltration rate
- Infiltration decay rate
- Final infiltration rate
- Weighted basin slope
- Impervious area depression storage
- Pervious area depression storage
- Time of concentration (for basins smaller than 90 acres)
Parameters are determined using maps of the area representing the contours and soil types within the basin.

The hydrologic study of the basin included the 10-year initial storm and 100-year major storm. Rainfall input for the initial storm was 1.86 inches per hour. Rainfall input for the major storm was 2.95 inches per hour. These intensities are established by the Rapid City Drainage Criteria Manual. A five minute unit hydrograph duration was used for all hydrologic modeling. Figure 8 is a summary of the sub-basin input parameters.

**Figure 8**

**Morningside Drainage Basin**

*Parameter Summary*

<table>
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<th>Basin</th>
<th>Area (Acre)</th>
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**SUM** 1077.89 1.682

*CUHP Limits the maximum slope to 6%.*
Resultant Sub-Basin Flows

The CUHP program results are sub-basin runoff hydrographs and detailed hydrologic information relating to peak runoff values and hydrograph characterization information. Figure 9 is a summary of sub-basin peak runoff values. Several of the basins had no change in flows from the existing to future conditions. These basins have achieved their full development potential.

Figure 9
Morningside Drainage Basin
Sub-Basin Flow Summary

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*CUHP uses a peaking parameter related to the percent impervious area in the determination of the unit hydrograph. This modeling anomaly can create a decrease in peak flows with small increases of percent impervious area. The affected basin's impervious area increased from 2% for existing conditions to 5% for fully developed conditions. The minor flow differences from the existing conditions to fully developed conditions are within the tolerance of any hydrologic model.
HYDRAULICS

Methodology

The hydraulic modeling of the conveyance elements used in this report was completed using the SWMM computer program. Following the definition of the sub-basin runoff hydrographs, these flows are routed through a series of conveyance elements to determine peak flows at any point along the drainage network. The existing channel conditions were determined from aerial photographs and field observation.

SWMM runs were completed for the existing conditions and the fully developed conditions. Detention ponds were added, in varying scenarios, to limit downstream flows to the capacity of the existing outfall under I-190. The network selected provides detention and limits flows to the existing system capacity where possible. The optimal network is identified as the Basin Design Plan.

This program uses some hydraulic characteristics of the individual conveyance elements to create time delayed routing of the flows through the conveyance model. Users of this report are cautioned that while flow depths are calculated for each conveyance element, these depths are based upon simplified hydraulic properties. Each element must be designed using accepted hydraulic engineering practices.

Modeling Parameters

The input parameters used in this report to represent the hydraulic characteristics of elements were primarily obtained from the Rapid City Drainage Criteria Manual. In certain instances, parameters were used which more closely represented the actual hydraulic characteristics of the element. These parameters were obtained from the Handbook of Hydraulics by Brater and King or Hydrology and Hydraulic Systems by Ram S. Gupta.

Channel Parameters
Input parameters for the conveyance elements include size and shape of the channels, longitudinal slope, length, and roughness coefficient. Manning’s roughness coefficients were increased by 25% as per the SWMM users manual. The majority of the input parameters define the shape of the element cross-section, length, and slope. The roughness coefficient for the proposed improved channels reflect a maintained man-made grass lined trapezoidal channel. The recommended coefficient for the channel is 0.030 - 0.040 and with a 25% increase is 0.0375 - 0.050. The roughness coefficient was set at 0.045 to reflect a conservative estimate.

Additional analysis was performed on the open channel elements using the Haestad Method Flowmaster software to determine flow depth and velocity using Manning’s
Equation. Appendix D contains the Flowmaster printouts for each conveyance element. All improved channel segments were selected to provide freeboard equal to 1 foot plus \( V^2/2g \). In addition, proposed channels should maintain laminar flow and have Froude numbers less than 0.95.

Pipe Parameters
Input parameters for pipes are fundamentally the same as open channels except instead of width and side slope, diameter is used. Where possible, pipes were modeled as they exist with overflow channels representing the existing path the water would take if the pipe could not handle the flow. Manning's roughness coefficient for concrete pipes is 0.013 modeled with a 25% increase as 0.016.

Overflow channels are typically either roadways or the floodplain. The widths of overflow channels was modeled to represent the roadway or flood plain for each element. Side slopes were set at 20:1 to represent a very wide channel or sheet flow across the flood plain. Overflow channels on pipes enable the model user to more accurately predict flows in pipes without storage or headwater.

Typical culvert sizes were determined for each open channel element based on the design flow. The typical culverts were determined using a pipe flowing full at a 1% slope. The typical sizes were not modeled in each element but were used for estimation of channel improvements.

Detention Ponds
SWMM runs were completed for the existing drainage situation with detention north of the Interstate. The capacity of the existing basin outfall pipe was determined and used as the flow limitation to which detention must occur. Proposed detention ponds were sized using the existing topography and assuming a maximum pond depth of 10 feet and side slopes of 4H:1V. The available area was determined using aerial photographs with 2 foot contours. The available area for the ponds was reduced by 20% to allow for design variations and embankment positioning.

Outlets from the detention ponds were assumed to be 100 feet long and at a 1% slope. Ponds were added individually and in combination and then analyzed to determine the resultant decrease in downstream flows. During the analysis we determined that the detention presently occurring north of and caused by the Interstate should continue. Furthermore, two locations were identified as possible detention areas. Both detention ponds are required to reduce flows in the outfall pipe. The outfall pipe entering Rapid Creek has a capacity of 616 CFS and the combination of the two ponds reduces the peak 100-Year flow to 571 CFS. Additional detention, provided no further significant reduction in flows.
CONVEYANCE ELEMENTS

To model future conveyance element conditions effectively several assumptions were made based on the construction of other channels and hydraulic limitations. The assumptions include:

- Grade control structures would be placed along the channel at key locations to limit flow velocities. The structures could include in-channel drop structures and drop inlets to major road crossing conveyances.
- It was assumed inlets to crossings and conveyance elements do not control the flow capacity of pipes.

Figure 10 is a summary of the conveyance element peak flows. Shown are the peak flows for fully developed conditions within the basin and a set of potential detention and conveyance scenarios.

The first scenario shows the peak flows as if all the facilities identified in the design plan have been constructed and is labeled “With Proposed Detention”.

The second scenario shows the peak flows as if the conveyance elements within the plan have been constructed and the detention facilities were not constructed. The existing detention north of the Interstate is assumed to remain in place in all scenarios. The respective flows are labeled “Without Proposed Detention”.

The third scenario shows the peak flows with the existing facilities conveying the developed flows from the basin. The flows are labeled “With Existing Facilities”.

CAUTION STATEMENT: The user is advised to use caution when using open channel peak flows and hydrographs given in this report. The UDSWM2-PC model assumes that all adjacent sub-basin flows enter the channel element at a design point, typically the downstream end of the element. The open channel element is simply routing the upstream incoming flow and ignoring the possibility that addition flow may enter from the adjacent sub-basin. Due to this modeling limitation, flow used for channel design may need to be increased appropriately using engineering judgment to reflect incoming sub-basin flows.
**Figure 10**  
**Summary Of Conveyance Element Peak Flows**  
*Fully Developed Conditions*  
*All flows are in Cubic Feet per Second (CFS)*

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<th>Without Proposed Detention</th>
<th>With Existing Facilities</th>
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</table>

*See narrative

**Flows are combined in the design plan at a different location than is presently occurring. The combination of flows at a point higher in the basin provides more developable land and requires the construction of less channel.*
**Element 10**

Conveyance element 10 is a *proposed* grass lined channel.

**Design plan flows:**
- 10 year – 23 cfs
- 100 year – 65 cfs

**Location:** Element 10 begins approximately 200 feet north of the intersection of East Philadelphia and West Streets. The element runs parallel to East Philadelphia Street for approximately 400 feet flowing East and joins the proposed channel for Element 31.

**Modeled element:**
- Trapezoidal channel
- 20’ Bottom
- Length = 400’
- Slope = 0.010 ft/ft

- 3:1 Side slopes
- Manning’s n = 0.045 (Design n = 0.035)
- Q100 depth of Flow = 0.8’

**Required Improvements:** Construct grass lined channel.
- Trapezoidal channel
- 20’ Bottom

- 4:1 Side slopes
- Slope = 0.010 ft/ft

---

**FLOW HYDROGRAPH - CONVEYANCE ELEMENT 10**

![Flow Hydrograph](image)

- 10 YEAR
- 100 YEAR

---

Morningside Drainage Basin Design Plan

04/14/98
Element 30

Conveyance element 30 is a proposed channel with a culvert.

Design plan flows:
- 10 year – 99 cfs
- 100 year – 286 cfs

Location: Element 30 begins at Rapid Creek approximately 200 feet west of the existing I-190 bridge. The channel crosses the Executive Golf Course passing under East Philadelphia Street through three 36-inch Arch RCP culverts. Element 30 ends at the confluence of elements 10 and 31 approximately 200 feet north and 400 feet east of the intersection of East Philadelphia St. and West Street.

Existing culvert capacity: The capacity of the three RCP arch culverts is estimated as 60 cfs each.

Modeled element: The modeled channel matches the existing channel south of East Philadelphia Street.
- Trapezoidal channel
- 20' Bottom
- Length = 1600'
- Slope = 0.010 ft/ft
- 3:1 Side slopes
- Manning's n = 0.045 (Design n = 0.035)
- Q100 depth of flow = 2.2'

Required improvements: Construct improved channel north of East Philadelphia Street. Add capacity to the existing crossing under East Philadelphia Street by the addition of two additional 36-inch RCP arch culverts.
- Trapezoidal channel
- 20' Bottom width
- 4:1 Side slopes
- Slope = 0.010 ft/ft

FLOW HYDROGRAPH - CONVEYANCE ELEMENT 30

Morningside Drainage Basin Design Plan

04/14/98

33
**Element 31**

Conveyance element 31 is a **proposed** channel.

**Design plan flows:**
- 10 year – 55 cfs
- 100 year – 161 cfs

**Location:** Element 31 begins at the upper end of element 30 approximately 400 feet east and 200 feet north of the intersection of East Philadelphia St. and West St.. The element follows the natural drainage channel northwest to the confluence of Sub-Basins D and E, approximately 1400 feet north of the intersection of East Philadelphia St. and West St..

**Modeled element:** The modeled element is a proposed channel.

- Trapezoidal channel
- 20’ Bottom
- Length = 900’
- Slope = 0.010 ft/ft

- 3:1 Side slopes
- Manning’s n = 0.045 (Design n = 0.035)
- Q100 depth of flow = 1.6’

**Required improvements:** Construct uniform channel including grade control structures and channel shaping.

- Trapezoidal Channel
- 20’ Bottom width

- 4:1 Side slopes
- Slope = 0.010 ft/ft

---

**FLOW HYDROGRAPH - CONVEYANCE ELEMENT 31**

![Flow Hydrograph Graph](image-url)

- 10 YEAR
- 100 YEAR

---

Mominside Drainage Basin Design Plan

04/14/98
**Element 50**

Conveyance element 50 is an existing 72" RCP arch storm sewer.

**Design plan flows:**
- 10 year – 279 cfs
- 100 year – 581 cfs

**Location:** Element 50 begins under the I-190 bridge at Rapid Creek and extends to the median inlets in I-190 near East Philadelphia St.. Element 50 connects to Element 51 under the median of I-190 with a 60" RCP to 72" RCP arch transition.

**Existing capacity:** The capacity of the existing storm sewer is 616 cfs. The modeled flow has a depth of 6.2 feet, indicating a surcharge condition. A more detailed analysis of the storm sewer using Haestad Flowmaster® resulted in a full flow capacity of 616 cfs (Manning’s n = 0.013). If Manning’s n is increased to 0.016, as in the SWMM model, the capacity of the storm sewer is reduced to 501 cfs. This reduced capacity is reflected in the SWMM model as a surcharge condition.

**Modeled element:** The modeled element is the existing storm sewer.
- 72” Arch RCP Pipe with overflow.
- Overflow = Channel 300’ wide, Length = 850’, 20:1 side slopes
- Length = 850’
- Slope = 0.010 ft/ft
- Manning’s n = 0.012
- Q100 depth of flow = 6.2’

**Required improvements:** No improvements are needed.

![FLOW HYDROGRAPH - CONVEYANCE ELEMENT 50](image-url)
Element 51

Conveyance element 51 is a proposed storm sewer.

Design plan flows:
- 10 year – 280 cfs
- 100 year – 592 cfs

Location: Element 51 begins at the upstream end of Element 50 and extends to the Silver Street bridge. The element follows the alignment of the median of I-190.

Existing capacity: The capacity of the existing 60” RCP pipe is 336 cfs. The inlet to the element serves as a collection point for two sub-basins and two conveyance elements. Conveyance Element 52 is an underground storm sewer entering from the west. Conveyance Element 64 is an open channel along I-190 entering from the north.

Modeled element:
- 60” RCP Pipe with overflow
- Overflow = Channel 100’ wide, Length = 400’, 20:1 side slopes
- Length = 400’
- Slope = 0.010 ft/ft
- Manning’s n = 0.012
- Q100 depth of flow = 5.6’ (pipe surcharged)

Required improvements: The pipe size must be increased to allow the design plan flows to be conveyed to element 50. Furthermore, the inlet at the junction of Elements 51 and 52 must have the capacity to accommodate the flows from Conveyance Element 64, Sub-Basin L, and Sub-Basin O. The combined overland flow to the junction of Elements 51 and 52 is 311 cfs in the 100-year storm.
Element 52

Conveyance element 52 is the existing 60” RCP pipe.

Design plan flows:
- 10 year – 180 cfs
- 100 year – 360 cfs

Location: Element 52 begins at a junction box under the Silver Street Bridge and follows Silver Street northwest to an inlet north of the Silver Street off-ramp. The pipe then parallels the Silver Street off-ramp northeast to Gold Street leading to Boegel Street. The element ends directly north of Boegel Street in the existing drainage channel. Element 52 connects to Element 53.

Existing capacity: The capacity of the 60” RCP pipe is 369 cfs using Haestad Flowmaster®. Using the Federal Highway Administration Hydraulic Design of Highway Culverts Report the inlet capacity is 180 cfs.

Modeled element:
- 60” RCP Pipe with overflow
- Overflow = Channel 100’ wide, Length = 1000’, 20:1 side slopes
- Length = 1000’
- Slope = 0.010 ft/ft
- Manning’s n = 0.012
- Q100 depth = 5.4’(pipe surcharged)

Required Improvements: Improve inlet to allow the required flow to enter the pipe.

FLOW HYDROGRAPH - CONVEYANCE ELEMENT 52

Morningside Drainage Basin Design Plan 04/17/98
Element 53

Conveyance element 53 is an existing channel and street crossing.

Design plan flows:
- 10 year – 147 cfs
- 100 year – 258 cfs

The flows do not included flows from Sub-Basin P, which is located on the east side of I-190. Sub-Basin P flows remain on the east side of I-190 until they reach the Silver Street bridge.

Location: Begins at the end of Element 52 directly north of Boegel Street and parallels West Boulevard North to the north side of Anamosa Street.

Existing Capacity: The capacity of the existing 48" and 36" RCP culverts under Anamosa Street is approximately 250 cfs. The channel has adequate capacity to convey the flows, however, the existing grade allows water to travel at speeds which may cause channel scour.

Modeled element:
- Triangular channel
- Length = 1400'
- Slope = 0.010 ft/ft
- 3:1 Side Slopes
- Manning’s n = 0.045
- Q100 depth of flow = 4.1'

Required improvements: Channel shaping is required to provide grade control and slow the water to acceptable levels. Inlet improvements to the existing combination of culverts could provide the adequate capacity for the water to pass under Anamosa Street. A detailed study of the Anamosa Street crossing is beyond the scope of this study.
- Triangular channel
- Slope = 0.010 ft/ft
- 4:1 Side Slopes

FLOW HYDROGRAPH - CONVEYANCE ELEMENT 53

Morningside Drainage Basin Design Plan
Element 55

Conveyance element 55 is an existing channel.

Design plan flows:
- 10 year – 76 cfs
- 100 year – 129 cfs

Location: Begins directly north of Anamosa Street and ends at the two 27” culverts from the I-190 borrow ditch approximately 50 feet south of Oriole Drive.

Existing capacity: The existing channel has the capacity to convey the design flows.

Modeled element:
- Trapezoidal channel
- Length = 600’
- 10’ bottom
- Slope = 0.010 ft/ft
- 3:1 Side Slopes
- Manning’s n = 0.045
- Q100 depth of flow = 2.0’

Required improvements: Minor improvements are required to the channel to provide grade control and slow the water to acceptable levels and prevent erosion.
- Trapezoidal channel
- 10’ bottom
- Slope = 0.010 ft/ft
- 4:1 Side Slopes

FLOW HYDROGRAPH - CONVEYANCE ELEMENT 55
Element 56

Conveyance element 56 is an existing pair of 27" RCP arch culverts.

Design plan flows:
- 10 year – 76 cfs
- 100 year – 123 cfs

Location: The culverts convey water from the I-190 borrow ditch to the main channel west of West Boulevard North. The crossing is located approximately 50 feet south of Oriole Drive.

Existing capacity: The capacity of the two culverts is approximately 130 cfs. The ditch block in the borrow ditch provides appropriate head to convey the design plan flows.

Modeled element:
- 48" diameter RCP Pipe with overflow
- Overflow = Channel 100' wide, Length = 80', 20:1 side slopes
- Length = 80'
- Slope = 0.015 ft/ft
- Manning’s n = 0.012
- Q100 depth of flow = 2.7'

Required improvements: None
Element 57

Conveyance element 57 is the *existing* I-190 borrow ditch.

**Design plan flows:**
- 10 year – 76 cfs
- 100 year – 123 cfs

**Location:** Element 57 begins at the two 27" culverts across West Boulevard North from Oriole Drive. Element 57 is the I-190 borrow ditch. The element ends where two 36" culverts convey water from west of West Boulevard North and north of Blue Jay Drive to the borrow ditch.

**Existing capacity:** The existing channel has the capacity to convey the design flows.

**Modeled element:**
- Triangular channel
- Length = 1000’
- Slope = 0.010 ft/ft
- 3:1 Side Slopes
- Manning’s n = 0.045
- Q100 depth of flow = 3.1

**Required improvements:** Minor improvements in the channel are required to prevent channel erosion.
- Triangular channel
- Slope = 0.010 ft/ft
- 4:1 Side Slopes

---

FLOW HYDROGRAPH - CONVEYANCE ELEMENT 57

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Morningside Drainage Basin Design Plan

04/14/98
Element 58

Conveyance element 58 is an existing pair of 36" Reinforced Concrete Pipe culverts.

Design plan flows:
- 10 year – 76 cfs
- 100 year – 123 cfs

Location: Element 58 is immediately north of Blue Jay Drive and crosses West Boulevard North to the I-190 borrow ditch.

Existing capacity: The capacity of these pipes is approximately 120 cfs. The entrance conditions to the pipes require the entrance be in a sump condition to optimize the flow. The pipes were modeled in conjunction with direct flow element 209. The model simulated the pipes conveying the water and any overflow passing over the road and entering element 59.

Modeled element:
- 51" diameter (Equivalent flow area to 2-36") RCP Pipe
- Length = 100'
- Slope = 0.007 ft/ft
- Manning’s n = 0.012
- Q100 depth of flow = 3.9'

Required improvements: Erosion protection at the inlet and outlet to prevent scour.

FLOW HYDROGRAPH - CONVEYANCE ELEMENT 58

Morningside Drainage Basin Design Plan 04/14/98
Element 59

Conveyance element 59 is an existing channel.

Design plan flows:

- 10 year – 0 cfs (76 cfs – preferred design flow)
- 100 year – 6 cfs (129 cfs – preferred design flow)

The preferred design plan flows represent the storm flow if Element 58 becomes plugged or changes in the interchange eliminate Elements 56, 57, or 58.

Location: Element 59 begins approximately 50 feet south of Oriole Drive where the two 27" RCP culverts pass from the I-190 borrow ditch to the channel west of West Boulevard North.

Existing capacity: The channel has the capacity to convey the preferred Q100 design flow, 129 cfs. The existing road crossing culverts do not have the capacity to convey the preferred design flows.

Modeled element:

- Triangular channel
- Length = 1800'
- Slope = 0.010 ft/ft
- 10:1 Side Slopes
- Manning’s n = 0.045
- Q100 depth of flow = 0.6’ (6 cfs)

The model was constructed so the travel time from direct flow Element 209 to Direct Flow Element 208 is the same whether water is conveyed by Elements 58, 57, and 56 or Element 59.

Required Improvements: Road crossings should convey the preferred design flow.

FLOW HYDROGRAPH - CONVEYANCE ELEMENT 59
(Read narrative pertaining to use of design flows associated with Element 59)
Element 61

Conveyance element 61 is an existing channel with proposed improvements.

Design plan flows:
- 10 year – 86 cfs
- 100 year – 223 cfs

Location: Element 61 is the inlet channel to the proposed Detention Cell 110. The detention cell is located north of Blue Jay Drive and south of Harmony Heights Drive on property currently owned by the Dove Christian Center. The element includes the road crossing on Harmony Heights Drive.

Existing capacity: The existing channel has the capacity to convey the design flows, however, improvements must be made to allow for maintenance prevent scour. The existing culvert under Harmony Heights Drive has an estimated capacity of 120 cfs.

Modeled element:
- Trapezoidal channel
- Length = 520'
- 65' Bottom
- Slope = 0.010 ft/ft

- 3:1 Side Slopes
- Manning’s n = 0.045
- Q100 depth of flow = 1.0'

Required improvements: Improvements to the channel include shaping and the installation of a properly sized crossing at Harmony Heights Drive.
- Trapezoidal channel
- 65' Bottom

- Slope = 0.010 ft/ft
- 4:1 Side Slope
Element 62

Element 62 is an existing channel with proposed improvements.

Design plan flows:
- 10 year – 71 cfs
- 100 year – 177 cfs

Location: Element 62 begins north of Harmony Heights Drive and parallels Interstate 90 to a 36” culvert passing under I-90. The 36” culvert serves as the outlet from Detention Pond 100.

Existing capacity: The channel has the capacity to convey the design flows.

Modeled element:
- Trapezoidal channel
- Length = 860’
- 15’ Bottom
- Slope = 0.010 ft/ft
- 3:1 Side Slopes
- Manning’s n = 0.045
- Q100 depth of flow = 2.0’

Required improvements: Improvements to the channel include culvert outlet protection, channel shaping and grading.
- Trapezoidal channel
- 15’ Bottom
- Slope = 0.010 ft/ft
- 4:1 Side Slopes

FLOW HYDROGRAPH - CONVEYANCE ELEMENT 62

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</table>

TIME (Minutes)
Element 63

Conveyance element 63 is a proposed channel.

Design plan flows:

- 10 year – 41 cfs
- 100 year – 71 cfs

Location: Element 63 is a branch from the main channel to serve Detention Cell 120. The channel is located north of Anamosa Street. The channel runs from the approximate location of the existing pond northwest of Anamosa Street to the existing channel adjacent to West Boulevard North.

Existing capacity: None. The channel does not exist.

Modeled element:

- Trapezoidal channel
- Length = 300'
- 20' Bottom
- Slope = 0.007 ft/ft
- 3:1 Side Slopes
- Manning’s n = 0.045
- Q100 depth of flow = 1.1'

Required improvements: The channel must be constructed.

- Trapezoidal channel
- 20' Bottom
- Slope = 0.007 ft/ft
- 4:1 Side Slopes

FLOW HYDROGRAPH - CONVEYANCE ELEMENT 63
Element 64

Conveyance element 64 is a proposed storm sewer.

Design plan flows:
- 10 year – 68 cfs
- 100 year – 145 cfs

Location: Element 64 begins at the storm sewer junction box located under the Silver Street Bridge. The element primarily serves the east half of I-190 and the adjoining slopes. The storm sewer intercepts water from the small basin east of I-190 and West Boulevard North. The element ends at Anamosa Street.

Existing capacity: None. Element must be constructed.

Modeled element:
- Trapezoidal channel
- Length = 2400’
- 20’ Bottom
- Slope = 0.010 ft/ft

Modeled as an open channel since actual pipe sizes will depend upon inlet placement.

Required improvements: This storm sewer must be constructed. Inlets and some of the required pipes may be in place depending on the design and reconstruction of the Silver Street Bridge and I-190. The improvements may be a combination of channel and storm sewers.
- Trapezoidal channel
  - 20’ Bottom

OR
- Reinforced Concrete Pipe

FLOW HYDROGRAPH - CONVEYANCE ELEMENT 64

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Morningside Drainage Basin Design Plan
04/14/98

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Element 70

Conveyance element 70 is the existing 48" storm sewer with a proposed parallel storm sewer.

Location: Element 70 parallels 8th Street (Mount Rushmore Road) from Rapid Creek to a point approximately 500' south of the intersection of 8th and North Streets. The storm sewer serves 8th Street and the Central High School parking lot. The existing storm sewer is located almost exclusively in the Rapid Creek Flood Plain.

Design plan flows:
- 10 year - 122 cfs
- 100 year - 260 cfs

Existing capacity: The capacity of the existing pipe is 122 cfs. Gutter flow spread in the 100-year storm exceeds the limitations outlined in the RCDCM.

Modeled element:
- 48" RCP Pipe with overflow to flood plain
- Overflow = Channel 100' wide, Length = 850', 20:1 side slopes
- Length = 850'
- Slope = 0.010 ft/ft
- Manning's n = 0.012
- Q100 depth of flow = 4.4'

The modeled system represents an underground 48" pipe with the overflow passing to the creek in 8th Street. This pipe is in the flood plain.

Required improvements: System improvements include either the installation of additional pipes to handle the excess flow or the replacement of the current system with larger capacity storm sewer.

FLOW HYDROGRAPH - CONVEYANCE ELEMENT 70

![Flow Hydrograph](image-url)
Element 71

Conveyance element 71 is an existing 42" storm sewer and a proposed parallel storm sewer.

Design plan flows:
- 10 year – 126 cfs
- 100 year – 267 cfs

Location: Element 71 begins approximately 500 feet south of the intersection of 8th and North Street and ends at the intersection of 8th and North Streets. The element is the main conveyance serving the residential area immediately north of North Street.

Existing capacity: The capacity of the pipe is 196 cfs. Predicted flows exceed the gutter flow spread limitations outlined in the RCDCM.

Modeled element:
- 42" RCP Pipe
- Length = 500'
- Slope = 0.010 ft/ft

Manning’s n = 0.012  
Q100 depth of flow = 3.9'

The modeled system allows the pipe to reach capacity and the excess flow to pass down 8th Street to the flood plain.

Required improvements: System improvements include either the installation of additional pipes to handle the excess flow or up-sizing the current system. This area of the basin would require a detailed flow analysis prior to the design of any additional improvement. Additional storm sewer installation is required to drain the low area on the northeast corner of the intersection of 8th and North Streets. The minor storage provided by the small depression is not significant in either the 10 or 100 year storm.

FLOW HYDROGRAPH - CONVEYANCE ELEMENT 71
DETENTION CELLS

Detention of water is the storage of runoff for a short period of time with a controlled release to the natural water course. Detention of storm water is very effective at reducing peak downstream flows. Detention cells are most effective when placed at the upper reaches of basins. As the water is collected and flows to the lower reaches of a basin, much larger cells are required to effect an equivalent reduction in downstream flows.

The design plan for the Morningside Drainage Basin includes three detention cells. The first detention cell exists and is formed by the Interstate. The second pond is located directly south of the Interstate in the low lying area currently utilized as a horse pasture. The third detention pond is located north of the west end of Anamosa Street where a small pond currently exists.

All detention cells should be designed with an emergency spillway capable of discharging the maximum inflow. This will protect the embankment in case of the Probable Maximum Precipitation event or in the event the outlet structure becomes plugged.
Detention Cell 100

Detention Cell 100 is an existing detention cell.

**Design plan parameters:**
- 10 year flows:
  - Inflow – 73 cfs
  - Discharge – 73 cfs
- 100 year flows:
  - Inflow – 213 cfs
  - Discharge – 178 cfs
- Storage
  - 10 Year – 0.3 acre-feet
  - 100 Year – 2.2 acre-feet
- Discharge Structure (Existing) – 36” RCP
- Required Area – 1 Acre

**Location:** The detention cell is immediately north of I-90. The embankment for the detention cell is the Interstate fill area.

**Existing capacity:** The cell will detain 2.2 acre-feet of water with a maximum depth of 16 feet. Two-thirds of the required acre is within the right-of-way for I-90. The outlet to the cell is the existing 36” RCP culvert passing under the Interstate to the south.

**Required improvements:** Clearing of the existing vegetation is required. Placement of a ditch block in the I-90 borrow ditch is required to prevent water from entering the Haines Avenue Basin. The ditch block could also serve as the emergency spillway. The spillway would allow water to flow along the Interstate and ultimately enter the Haines Avenue Basin.
Detention Cell 110

Detention Cell 110 is a proposed facility.

Design plan:

- 10 year flows
  - Inflow – 124 cfs
  - Discharge – 76 cfs
- 100 year flows
  - Inflow – 321 cfs
  - Discharge – 131 cfs
- Storage
  - 10 Year – 3.2 acre-feet
  - 100 Year – 15.8 acre-feet
- Discharge structure – 30" RCP
- Required Area – 5.5 Acres

Location: The cell is located in the low area south and west of Harmony Heights Drive and north of Morningside Drive.

Required improvements: Construction of the cell includes the excavation and shaping of the cell and the construction of an embankment. The proposed embankment is approximately 10 feet high and the discharge pipe is a 100 foot long 30" RCP at a 1% slope.

Critical Element. Detention cell 110 is critical to the reduction of downstream flows. Many of the downstream structures are adequate based on the detention provided by this cell. The critical factors include the volume of detention, the rate of discharge, and the time of discharge.

![Diagram of Detention Cell 110 Stage/Storage/Discharge]
Detention Cell 120

Detention Cell 120 is a *proposed* detention cell.

**Design plan parameters:**
- 10 year
  - Inflow – 67 cfs
  - Discharge – 41 cfs
- 100 year
  - Inflow – 188 cfs
  - Discharge – 71 cfs
- Storage
  - 10 Year – 1.4 acre-feet
  - 100 Year – 7.6 acre-feet
- Discharge Structure – 24” RCP
- Required Area – 3 Acres

**Location:** The proposed cell is located north of the western terminus of Anamosa Street.

**Required improvements:** The existing pond in the proposed location would be removed and a detention cell capable of detaining 7.6 acre-feet would be constructed. The required area for the cell is approximately 3 acres. The proposed cell would have a 10’ embankment with a 24” diameter culvert as a discharge.

**DETENTION CELL 120**

*Stage/Storage/Discharge*

![Graph showing stage, storage, and discharge for Detention Cell 120.](image)
DIRECT FLOW ELEMENTS

Direct flow elements are used to model the confluence of flows. Direct flow elements combine storm hydrographs with timing and flow parameters from elements and/or sub-basins. The resultant hydrograph is used as the input hydrograph for the next downstream element. Direct flow elements as terminus elements to predict flows entering the creek.

Direct Flow Element 200

Direct Flow Element 200 sums flows entering Rapid Creek from Sub-Basin A.

Design plan flows:
- 10 year – 38 cfs
- 100 year – 113 cfs

Location: Direct Flow Element 200 is located at the east base of Cowboy Hill on Rapid Creek.
Direct Flow Element 201

Direct Flow Element 201 sums flows entering Rapid Creek from Sub-Basin B.

Design plan flows:
- 10 year – 33 cfs
- 100 year – 83 cfs

Location: Direct Flow Element 201 is located on Rapid Creek at the Southeast corner of the Black Hills Packing Plant.

FLOW HYDROGRAPH - DIRECT FLOW ELEMENT 201

Note: During the modeling process it was determined that Direct Flow Element added no detail to the plan and was eliminated in the final revision of the Design Plan. Direct Flow Element measured flows from Sub-Basin C.
Direct Flow Element 203

Direct Flow Element 203 sums flows entering Rapid Creek from Element 30 and Sub-Basin J. Flows entering Rapid Creek at Direct Flow Element 203 include flows from Sub-Basins C, D, E, J, and K.

Design plan flows:
- 10 year – 145 cfs
- 100 year – 394 cfs

Location: Direct Flow Element 203 is located where the existing channel crossing the Executive Golf Course meets Rapid Creek.

FLOW HYDROGRAPH - DIRECT FLOW ELEMENT 203
Direct Flow Element 204

Direct Flow Element 204 sums flows entering Rapid Creek from Element 50. Flows entering Rapid Creek at Element 204 include flows from Sub-Basins F, G, H, I, L, M, and N. Element 204 is the primary discharge point for the basin.

Design plan flows:
- 10 year – 279 cfs
- 100 year – 581 cfs

Location: Direct Flow Element 204 is located under the Rapid Creek Bridge on I-190.
Direct Flow Element 205

Direct Flow Element 205 sums flows entering Rapid Creek from Element 70 and Sub-Basin Q. Flows entering Rapid Creek at Element 205 include flows from Sub-Basins Q and R.

Design plan flows:
- 10 year – 572 cfs
- 100 year – 1024 cfs

Location: Direct Flow Element is located at the Rapid Creek Bridge on 8th Street.

FLOW HYDROGRAPH - DIRECT FLOW ELEMENT 205

| TIME (Minutes) | 0 | 20 | 35 | 50 | 65 | 80 | 95 | 110 | 125 | 140 | 155 | 170 |
|---------------|--|--|--|--|--|--|--|--|--|--|--|--|--|
Direct Flow Element 206

Direct Flow Element 206 sums flows entering Rapid Creek from Sub-Basin S.

Design plan flows:
- 10 year – 247 cfs
- 100 year – 465 cfs

Location: Direct Flow Element 206 is located on Rapid Creek near the railroad bridge on the eastern boundary.
Direct Flow Element 207

Direct Flow Element 207 combines flows from Elements 52 and 64 with flows from Sub-Basins D and L. Element 207 discharges to Element 51.

Design plan flows:
- 10 year – 280 cfs
- 100 year – 588 cfs

Location: Direct Flow Element 207 is located under the Silver Street Bridge on I-190.
**Direct Flow Element 208**

Direct Flow Element 208 combines flows from Elements 55 and 63 with flows from Sub-Basin N. Element 208 discharges to Element 53.

**Design plan flows:**
- 10 year – 148 cfs
- 100 year – 258 cfs

**Location:** Direct Flow Element 208 is located immediately north of Anamosa Street on the main channel.

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FLOW HYDROGRAPH - DIRECT FLOW ELEMENT 208

![FLOW HYDROGRAPH - DIRECT FLOW ELEMENT 208](image-url)
Direct Flow Element 209

Direct Flow Element 209 conveys flows from Detention Pond 110 to Elements 58 and 59. When the capacity of Element 58 is reached during a storm event the remaining flows are discharged to Element 59.

Design plan flows:
- 10 year – 76 cfs
- 100 year – 131 cfs

Location: Direct Flow Element 209 is located north of Blue Jay Drive and west of West Boulevard North.
Direct Flow Element 210

Direct Flow Element 210 combines flows from Element 61 and Sub-Basin G. Element 210 is the inlet to Detention Pond 110.

Design plan flows:
- 10 year – 124 cfs
- 100 year – 321 cfs

Location: Direct Flow Element 210 is located immediately south of Harmony Heights Drive on the main channel.

FLOW HYDROGRAPH - DIRECT FLOW ELEMENT 210
Direct Flow Element 211

Direct Flow Element 211 combines flows from Sub-Basins D and E.

Design plan flows:
- 10 year – 57 cfs
- 100 year – 162 cfs

Location: Direct Flow Element 211 is located at the confluence of Sub-Basins D and E. The confluence of Sub-Basins D and E is generally described as the point where two minor drainages combine approximately 1400 feet north of the intersection of East Philadelphia and West Streets and 1400 feet west of the intersection of Silver and Boegel Streets.
COST ANALYSIS

Cost Estimate

The engineer's estimate of probable construction cost for this design plan is $2,013,506. This estimate includes the improvement of existing facilities, the construction of new detention cells and channels. Figure 11 details the estimated cost for each element within the plan.

The costs included in the summary are commensurate with the level of engineering detail completed for this report. The accuracy of the costs are affected by the accuracy and scale and the aerial photographs on which the plans are based.

The costs were computed on a linear foot basis using recent bids received by the county for major drainage channels in Rapid Valley. The Racetrack Draw Channel was bid at $52/foot. The County Heights Channel was bid at $34/foot. Channel construction in this report was estimated at $45/foot. Storm sewer installation was estimated at $200/foot.

Detention cell construction costs were based on estimated construction cost of similar detention cells in Rapid Valley. The detention cells in the Morningside Basin were estimated at $150,000 for Cell 110 and $120,000 for Cell 120.

Easement and property acquisition costs were based on 100% of the full and true property values established by the County Director of Equalization.

The details required to properly estimate construction costs of drainage improvements are not part of a basin design plan. The cost estimate is provided for preliminary planning purposes only. The cost estimate includes 5% contingency and 25% engineering and administration fees. These preliminary costs are still only an estimate based on channel and pipe lengths, not engineered facilities.
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Prioritization

Construction priorities have been established based on which elements provide the greatest downstream benefit and protection.

Immediate attention should be given to the acquisition of easements, rights-of-way, and property for the future construction of detention cells and conveyances.

The first priority for construction is to the detention cells.

The second priority is the improvement of inlets and construction of channel protection measures for existing structures.

The third priority is the construction of storm sewers to alleviate flooding in the lower areas of the basin.

The remaining elements should be constructed as development occurs in the affected sub-basins.

Based on the above criteria the priority of construction should be:

1. Detention Cell 110 15.8 Acre-feet detention cell
2. Detention Cell 120 7.6 Acre-feet detention cell
3. Element 51 72” RCP Arch storm sewer
4. Element 52 Inlet improvements on existing storm sewer
5. Element 53 Improve channel, street crossing
6. Element 64 I-190 storm sewer
7. Element 55 Improve existing channel
8. Element 57 Improve existing channel
9. Element 58 Improve inlet, outlet protection
10. Element 61 Improve channel
11. Element 62 Improve channel
12. Element 63 Construct channel
13. Element 70 Add additional storm sewer capacity
14. Element 71 Add additional storm sewer capacity
15. Detention Cell 100 Improve existing detention cell
16. Element 30 Construct channel
17. Element 10 Construct channel
18. Element 31 Construct channel

This priority assessment is subject to change. Development within the basin should be closely monitored for potential drainage impacts. Collateral construction, I-90 interchange reconstruction, Silver Street exit reconstruction, etc., may provide the opportunity to construct portions of the required facilities at lower costs.
REFERENCES


Rapid City 2000 Comprehensive Plan.

National Flood Insurance Program, FIRM (Flood Insurance Rate Map); City of Rapid City, South Dakota, Pennington County; Community-Panel Number 465420 0004F; Map Revised February 16, 1996; Federal Emergency Management Agency.

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Soil Conservation Service National Engineering Handbook, Section 4 -- Hydrology.


United States Department of the Interior Geologic Survey, Rapid City East Quadrangle Map sheet, South Dakota -- Pennington County, 7.5 Minute Series (Topographic), (44103-A2-TF-024), 1953, Photorevised 1978.