Conceptual Storm Water Management And Floodplain Mitigation Report

For

Hogan-Pancost Property

5399 Kewanee Drive &
5697 South Boulder Road
Boulder County, Colorado

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Prepared for:

BCC, LLC
1526 Spruce Street, Suite 260
Boulder, CO 80302
(303)949-1322
Contact: Michael Boyers

Prepared by:

Drexel, Barrell & Co.
1800 38th Street
Boulder, Colorado 80301
(303) 442-4338
Contact: James Brzostowicz, P.E.

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REPORT SUMMARY

This report provides a conceptual overview of the proposed storm water management and mitigation of the impacts of the South Boulder Creek floodplain on the development of the Hogan-Pancost property. The objective of this report was to determine if this site can support suitable drainage and flood mitigation facilities for development. The findings of this report demonstrate that the necessary drainage and flood mitigation facilities for proposed development can be easily accommodated on the site and that the proposed development will not adversely affect, and in some cases may improve, conditions on the surrounding properties, irrigation facilities, existing storm drainage system, and South Boulder Creek.

An integrated design approach was used to generate the concept Land Use diagram. Through the collaborative efforts of the project team, we identified critical design constraints and opportunities for the site. The storm water management and flood mitigation design strategies presented in this report were developed collaboratively with the groundwater, wetland design and planning professionals. An overview of the storm water management design and floodplain mitigation is presented in the following report.

Offsite Runoff

The property intercepts storm water discharge from a 42.9-acre off-site drainage basin. The portion of the off-site basin located within unincorporated Boulder County is generally comprised of large parcels with single-family homes. Within the City of Boulder limits, the off-site basin is fully developed with detached single-family residential, multi-family residential and commercial businesses. These offsite developments provide little or no detention or water quality treatment of their storm water discharge prior to release to downstream properties or public right-of-way.

Dry Creek Ditch No. 2 Improvements

The existing drainage basin is traversed by Dry Creek Ditch No. 2 and several irrigation laterals. Much of the off-site flow is intercepted by Dry Creek Ditch No. 2 along the west property line and results in flooding at the east end of Kewaunee Drive. Dry Creek Ditch No. 2 will be piped. Under normal operation, the Dry Creek Ditch No. 2 pipe will have excess pipe capacity that intercepts off-site storm flows, which will reduce surface flows and flooding at the end of Kewanee Drive.

The Dry Creek Ditch No. 2 pipe operational conditions may vary, but even with the operational extremes, the pipe does not adversely affect the existing downstream hydrologic conditions.

Proposed Stormwater Infrastructure

The proposed storm water management infrastructure is designed to intercept the entire off-site flow at the southwest corner of the property and the flood flows diverted from South Boulder Creek entering the site along the south property line. The proposed storm water management design does not rely upon any excess capacity of Dry Creek Ditch No. 2.

The facilities will include a constructed wetland channel bioswale and two integrated storm water detention basins to imitate the natural hydrologic response of the undeveloped property. These improvements will also provide water quality enhancements for both the onsite and a significant portion of the offsite flows.

The facilities are sized to manage 100-year developed storm flows, off site flows, and the diverted South Boulder Creek flood flows with 1-foot of freeboard. The facilities have been designed to accommodate the variations in the amount of off-site flow intercepted by the Dry Creek Ditch No. 2 pipe and, in all scenarios, decrease storm water runoff rates at the end of Kewanee Drive and at the historical release point at the northwest corner of the Hogan-Pancost Property.

Floodplain Mitigation

Floodplain mitigation of South Boulder Creek flood flows is feasible for the Hogan-Pancost Property. The design presented in this report reflects the most recent South Boulder Creek Flood Mapping Study results dated December 2008. The proposed Land Use diagram and supporting storm water infrastructure design will eliminate the 100-year floodplain and associated High Hazard Zone along the Dry Creek Ditch No. 2 corridor from the south property line to Kewanee Drive. Flood waters will be routed through the bioswale and sequential detention ponds and will be released again at the northwest corner of the property where the floodwater confluence currently occurs.

The Property's storm water infrastructure safely routes the flood waters through the project without adversely affecting the downstream hydrology and discharges at a rate that is equal to the existing conditions, 100-year local storm event plus flood flows, without relying on the capacity of Dry Creek Ditch No. 2.

If the excess capacity of Dry Creek Ditch No. 2 is considered, the proposed storm water infrastructure will discharge the 100-year local storm plus flood flows at a rate that is less than the existing 100-year local storm event without flood flows.

All proposed residential structures will be constructed in accordance with the requirements prescribed by the City of Boulder Floodplain Regulations (Chapter 9, B.R.C. 1981). All proposed residential structures will be flood proofed by raising the finished floor elevations of each of the homes a minimum of 2.0-ft above the base flood elevation.

The proposed land use diagram presented in this report for the Hogan-Pancost Property can easily accommodate the necessary drainage facilities. When constructed in accordance with the recommendations presented in this report, the proposed development will not adversely affect the surrounding properties or existing downstream drainage systems. The development of the property will maintain the existing drainage patterns on the site in an environmentally sensitive manner using the bioswale in lieu of standard detention facility and will improve existing drainage and flood conditions along the western property line and at the eastern end of Kewanee Drive.

1.0 INTRODUCTION

The following report is prepared in accordance with the City of Boulder's "Design and Construction Standards" [1] and is submitted as part of the Hogan-Pancost Property "Concept Plan Submittal Part A: Engineering and Environmental Development Feasibility Study" for the City of Boulder Land Use Review – Concept Plan application. This report provides a conceptual overview of the storm water management of the drainage from the proposed development and mitigation of the impacts of the South Boulder Creek floodplain on the development. The objectives of this report are to demonstrate that the necessary drainage facilities for the proposed development can be accommodated on the site and that the proposed development will not adversely affect the surrounding properties or existing storm drainage system.

The proposed Hogan-Pancost Property project is located just south of the East Boulder Recreation Center on 55th Street in unincorporated Boulder County. 55th Street crosses the property at the southeast corner: 19.44-acres are located west of 55th Street and the remaining 2.73-acres are located east. The property is bounded on the north by the City of Boulder East Boulder Recreation Center, on the east by Boulder County Open Space, on the south by two estate lots in unincorporated Boulder County, and on the west by the Keewaydin Meadows subdivision. A vicinity map is provided on the following page.

The property is currently undeveloped agricultural land located in unincorporated Boulder County. The applicant is seeking to annex the property into the City of Boulder. Under current County zoning, the property is zoned SR-Suburban Residential [2] and is identified as Area IIA, area for annexation for new urban development, by the Boulder Valley Comprehensive Plan [3].

The legal description for the 22.17-acre property is:

> PARCEL 1 (5697 South Boulder Road)
>
> A PORTION OF THE SOUTHEAST 1/4 OF SECTION 4, TOWNSHIP 1 SOUTH, RANGE 70 WEST OF THE 6TH P.M., DESCRIBED AS FOLLOWS:
>
> BEGINNING AT THE SOUTHWEST CORNER OF THE SOUTHEAST 1/4 OF THE SOUTHEAST 1/4 OF SECTION 4, TOWNSHIP 1 SOUTH, RANGE 70 WEST OF THE 6TH P.M.; THENCE NORTH 0°35' WEST, 1592.00 FEET TO THE TRUE POINT OF BEGINNING, CORNER NO. 1; THENCE NORTH 88°22' EAST, 1296.93 FEET TO CORNER NO. 2; THENCE NORTH 60°11' WEST, 1503.50 FEET TO CORNER NO. 3; THENCE SOUTH 0°35' EAST, 784.80 FEET TO THE TRUE POINT OF BEGINNING, COUNTY OF BOULDER, STATE OF COLORADO.
>
> PARCEL 2 (5399 Kewanee Drive)
>
> BEGINNING AT THE SW CORNER OF THE SE 1/4 OF THE SE 1/4 OF SECTION 4, TOWNSHIP 1 SOUTH, RANGE 70 WEST OF THE 6TH P.M.; THENCE N 0°35' W 1259.00 FEET TO THE TRUE POINT OF BEGINNING, CORNER NO. 1; THENCE N 88°22' E 1728.15 FEET TO CORNER NO. 2; THENCE N 0°29' E 71.48 FEET TO CORNER N0.3; THENCE N 60°1 I' W 501.20 FEET TO CORNER NO. 4; THENCE S 88°22' W 1296.93 FEET TO CORNER NO. 5; THENCE S 0°35' E 333.00 FEET TO THE POINT OF BEGINNING, EXCEPT THAT PORTION REFERENCED IN RULE AND ORDER RECORDED NOVEMBER 10;1993 AT RECEPTION NO. 1360066; AND DESCRIBED IN AGREEMENT RECORDED NOVEMBER 15,1993 AT RECEPTION NO. 1361390, COUNTY OF BOULDER, STATE OF COLORADO.

BOULDER CREEK COMMONS

DTJ DESIGN

May 5, 2010

Contextual Site Diagram
Existing Conditions

NORTH

0 100 200 400 600

The site is currently accessed by an existing drive way on 55th Street. Kewanee Drive is extended to the property at the northwest corner. With the proposed development, Kewanee Drive may or may not be extended through the property to 55th Street. For the purpose of this report, Kewanee Drive is assumed to be extended to 55th Street.

The property is undeveloped agricultural land that was used as a pasture for livestock. The land is now fallow. The site is sparsely vegetated and slopes from south to north at approximately 1.0%. Dry Creek Ditch No. 2 irrigation ditch flows from south to north along the western property line. A lateral that serves the Bodam property to the south flows from east to west along the south property line and returns flow to Dry Creek Ditch No. 2 at the southwest corner of the property. The Howard-Superphostical lateral flows from southeast to northwest generally along the north property line of the site. The southeast and extreme northwest portions of this lateral are on the subject property. The remainder of the Howard-Superphostical lateral is on the East Boulder Community Park land to the north. With the exception of a portion of the Howard-Superphostical that is piped, the irrigation ditches are open channels. For the purpose of this report, Dry Creek Ditch No. 2 is assumed to be piped prior to the development of this project.

A portion of the property is located within a designated FEMA floodplain, Zone AE (Base Flood Elevations Determined) for South Boulder Creek as shown on the Flood Insurance Rate Map Number 08013C0555 G [4]. The affected portion of the property is east of 55th Street, which is not part of the proposed residential development. The Figure 1 below is a portion of the FEMA regulatory floodplain for the City of Boulder GIS mapping system prior to the current South Boulder Creek floodplain remapping study.

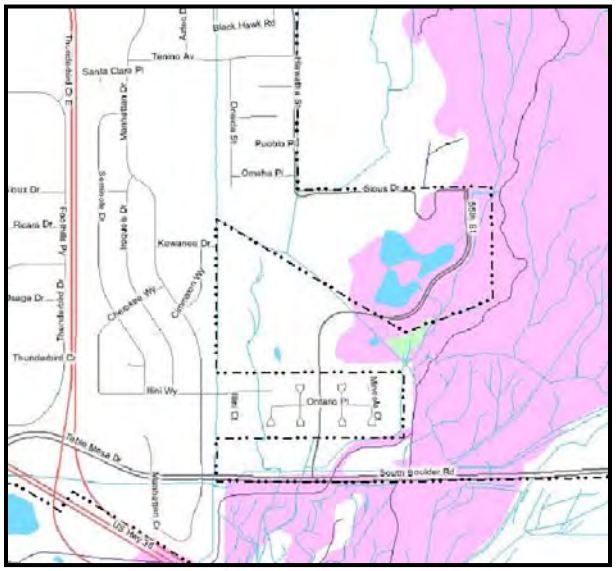

Figure 1: Existing FEMA Regulatory Floodplain (purple=100-year floodplain)

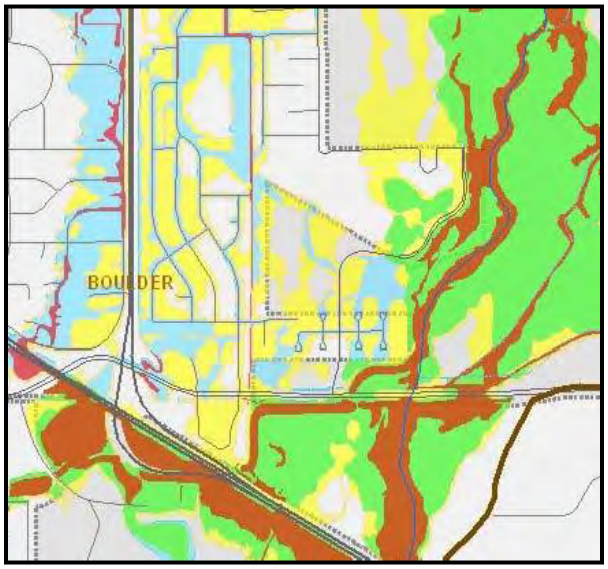

Figure 2: New South Boulder Creek Floodplain (blue=100-year floodplain)

Figure 2 shows the current floodplain map from the South Boulder Creek remapping study. The area east of 55th Street remains largely unchanged. The area west of 55th Street will be impacted by two small areas of 100-year flooding and these areas are denoted in blue. This site is located well outside of the South Boulder Creek High Hazard

Zone (denoted in brown) and Conveyance Zone (denoted in green). The yellow areas shown on Figure 2 represent areas of 500-year flooding. Mitigation of the 100-year floodplain is discussed in detail in Section 6.0 of this report.

The City of Boulder Datum is the vertical datum for the topographic information presented in the report. City of Boulder Benchmark V3-5 was the referenced benchmark for establishing grades on-site and is located at the northwest corner of Mohawk and Baseline Road. The conversions for the various vertical datum references are as follows:

For NGVD 1929 Datum add 0.4-ft to the elevations presented within the report.
For NGVD 1988 Datum add 3.43-ft to the elevations presented within the report.

Previous FEMA mapping presented in the Report is on NGVD 1929. The new South Boulder Creek Flood Study is on the NGVD 1988 Datum.

The local groundwater table is relatively shallow and ranges in depth across the site. Telesto Solutions, Inc. has prepared a ground water evaluation report which specifically addresses groundwater conditions and is provided as part of Hogan-Pancost Property Land Use Review – Concept Review Phase 1 application.

Western Ecological Resource, Inc. has identified and delineated limited wetland areas on the subject property. Refer to "Groundwater Hydrology Monitoring & Wetland Delineation Report" prepared by Western Ecological Resource, Inc. for a detailed discussion of the wetlands. This report is provided as part of Hogan-Pancost Property Land Use Review – Concept Review Phase 1 application.

2.0 PROPOSED DEVELOPMENT

The development proposal for the site will be a mix of detached single-family residential and multi-family senior affordable housing. The residential development of the project will occur on the area west of 55th Street with only environmental site enhancements proposed east of 55th Street. A conceptual land use diagram of the proposed project is provided on the following page.

The conceptual land use diagram was developed with storm water management as an integral part of the site. A bioswale begins at the southeast corner of the site to convey off-site storm water flows through the property and generally bisects the western parcel. The upper reach of the bioswale is integrated with an area of the site designated for wetland mitigation. Where the bioswale turns north and away from the southern property line, the bioswale begins to accept on-site developed flows and is designed with a Urban Drainage Flood Control District [UDFCD] Constructed Wetland Channel [CWC] within the low flow channel. The CWC provides continuous storm water quality treatment of both on-site and a significant portion of off-site flows along the length of the bioswale. A pedestrian path is provided above the low flow channel on a bench that is wide enough to provide maintenance access to the bioswale. At-grade pedestrian crossings are provided at each road crossing which double as maintenance access points into the bioswale. The low flow channel is sized to convey the 10-year storm event without over topping the bench. The bioswale also conveys the local 100-year storm event with 1-foot of freeboard.

An embankment with an outlet structure is provided at the downstream terminus of the bioswale to control storm water rates discharged from the property. On-site developed flows will be detained within the bioswale and released at or below existing discharge. Detailed discussions of the developed storm water hydrology, water quality and detention facilities are provided in later sections of this report.

BOULDER CREEK COMMONS

DTJ DESIGN

May 5, 2010

Neighborhood Diagram & Conceptual Land Use Diagram

NORTH

0 50 100 200 300

3.0 HYDROLOGY

The existing and proposed conditions hydrology was determined using the Rational Method as outlined in Section 7.05 Hydrology of the City of Boulder "Design and Construction Standards". Per Table 7-1 "Design Storm Frequencies", the 10-year minor and 100-year major design storms were used to size the proposed on-site storm water conveyances and detention facilities. Run-off coefficients are per Table 7-2: "Runoff Coefficients for the Rational Method" and are based on existing and proposed land uses. Due to the extremely low density residential development of the properties located in unincorporated Boulder County, for the purpose of this study, these properties are considered undeveloped areas with "Historic Flow Analysis" runoff coefficients applied.

3.1 EXISTING HYDROLOGIC CONDITIONS

The Hogan-Pancost Property intercepts storm water discharge from a 42.9-acre off-site tributary drainage basin. South Boulder Road forms the southerly limits of the off-site basin which generally extends west from the northeast corner of the Foothills Parkway interchange east along South Boulder Road to the Flatirons Baptist Church. The off-site basin includes the Westwood Condominiums, Seasons Condominiums, Days Inn, Manhattan Plaza, and portions of the Greenbelt Meadows Subdivision, Greenbelt Meadows South Subdivision and Keewaydin Meadows Subdivision. Each of these developments is located within the limits of the City of Boulder. The off-site basin also includes areas of unincorporated Boulder County and includes the Rose property, the Vencel Property, Flatirons Baptist Church, the Bodam Property and the Kent Property.

The off-site tributary basin was delineated using aerial photos, topographic information at 1-ft contour intervals and storm sewer mapping provided by the City of Boulder. The delineations were field verified by visual inspection. The off-site basin delineations are mapped on the "Existing Conditions Drainage Exhibit" Sheets DR-1 and DR-2 provided in the back pocket of this report. Drainage reports for the existing developments were requested from the City of Boulder, but were not available for review. The existing conditions drainage analysis of the adjacent development were based on field findings and may differ from the design intent presented in the record drainage reports. For reasons discussed in the following section, the affects of the off-site detention facilities are discounted. Therefore, the flows reported in this study may be higher and more conservative than those reported in the record drainage reports.

3.1.1 Off-Site Drainage Basin

The portion of the off-site basin located within unincorporated Boulder County is generally comprised of large parcels with a single-family home. In contrast, within the City of Boulder limits the off-site basin is fully developed with detached single-family residential, multi-family residential and commercial businesses.

Keewaydin Meadows Subdivision is a single-family residential subdivision that was constructed at a time when storm water detention and water quality facilities were not required. Within the portion of Keewaydin Meadows Subdivision tributary to the Hogan-

Pancost Property, there are no underground storm sewer facilities and developed storm water flows are conveyed through the subdivision within the roadways.

The Westwood and Seasons Condominium developments were constructed with storm water detention facilities, but with minimal storm water quality treatment. Concrete pans direct flows through the developments to three concrete weir outfall structures. The weirs are designated A, B and C on the "Existing Conditions Drainage Exhibit" and are shown below in Photos 1-3.

Each of these weirs appear to functionally control the minor storm event. However, due to the limited ponding area and the steep terrain upstream of Weir C, it is assumed that this weir does not adequately control the 100-year storm and that Basin OS-1B releases fully undetained. Weirs A and B appear to be two stage weirs that were designed to control release rates for both the minor and major storm events. However, the grading around each of these weirs does not provide ponding integrity at the second stage. For the purpose of this report, we have assumed that neither weir controls the 100-year storm event and that Basin OS-1A and OS-1C release fully undetained. Field measurements of each of the weirs were taken at the time of visual inspection. These measurements are provided in Appendix A of this report.

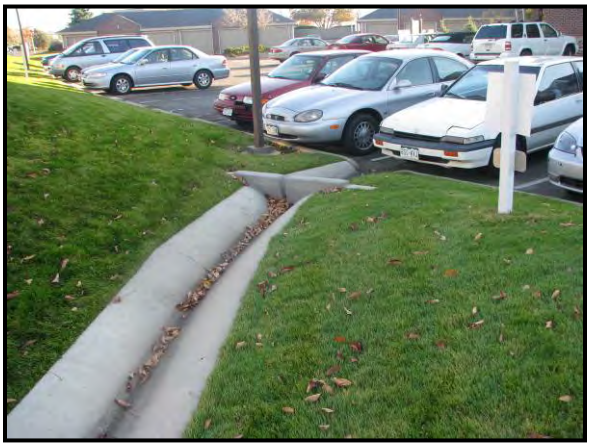

Photo 1: Westwood Condominium Weir C

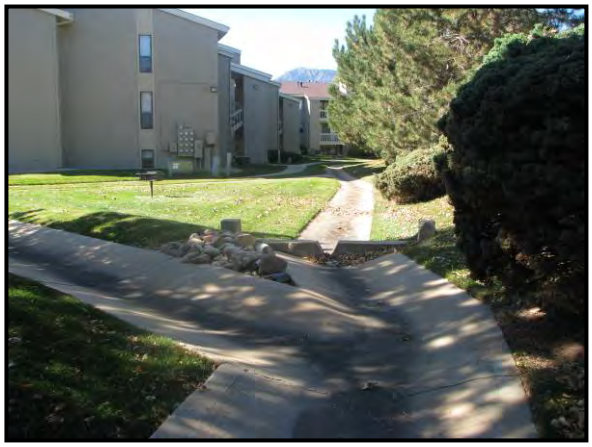

Photo 2: Seasons Condominiums Weir B

Photo 3: Seasons Condominiums Weir C

The Westwood and Seasons Condominium complexes discharge to the west flowline of Manhattan Drive as shown in Photo 4 on the following page. Manhattan Plaza discharges to the west flowline of Manhattan Drive through a sidewalk chase drain (Photo 5). Based on visual observations, it appears that Manhattan Plaza may have been developed with a storm water detention facility. However, as shown in Photo 5 this facility does not appear to have the capacity to control a major storm event. Days Inn, also, appears to

Photo 4: Condominium Outfall

Photo 5: Manhattan Plaza Outfall

have no storm water detention facilities. For the purpose of this report, discharges from both Manhattan Plaza and Days Inn are considered to be fully developed flow and undetained for both the 10-year and 100-year storm events.

The Greenbelt Meadows and Greenbelt Meadows South Subdivisions are single-family residential developments that like the Westwood and Seasons Condominium developments were constructed with storm water detention facilities, but with minimal storm water quality treatment. Portions of these subdivisions (Basin OS-9) discharge to Dry Creek Ditch No. 2 at the Illini Way irrigation ditch crossing.

Photo 6: Illini Way Curb Chase (South)

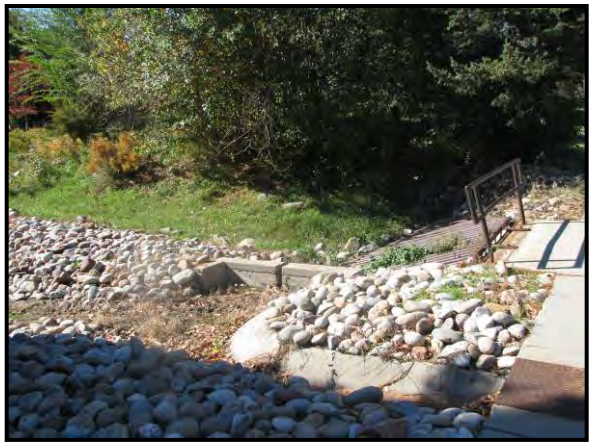

Photo 7: Outfall to Dry Creek Ditch No. 2 (South)

The north and south flowlines of Illini Way direct storm water runoff to sidewalk chases (Photos 6 and 8). The developed storm water flows are released directly to Dry Creek Ditch No. 2 via two concrete weir structures (Photo 7 and 9). The area upstream of each of the weirs appears to function as shallow detention ponds. The weirs were field measured and are each 12-inches high with a 2.75-inch wide opening. Sketches of the wiers and the field measurements are provided in Appendix A of this report. However, the aerial survey did not provide enough topographic relief to accurately model each of the

detention facilities. For the purpose of this report discharges from the area tributary to these weirs are considered to be fully developed flow and undetained for the 10-year and 100-year storm events.

Photo 8: Outfall to Dry Creek Ditch No. 2 (North)

Photo 9: Illini Way Curb Chase (North)

The storm drainage from remaining portions of Greenbelt Meadows South and Greenbelt Meadows Subdivisions are collected by storm sewer inlets and directed to the east away from the Hogan-Pancost Property by storm sewer and concrete channels (Photos 10-13). The storm sewer infrastructure appears to be oversized to capture and convey the 100-year developed storm water flows. As allowed by the City of Boulder "Design and Construction Standards", the fully developed storm water flows from these subdivisions discharge directly to the overbank area of South Boulder Creek without attenuation to historic rates by a storm water detention facility. These subdivisions were constructed prior to current water quality regulations and the developed storm water flows receive minimal storm water quality treatment prior to release to South Boulder Creek.

Photo 10: Greenbelt Meadows South Inlet (East)

Photo 11: Greenbelt Meadows Grated Inlet

Photo 12: Greenbelt Meadows 55th Street Inlet (West)

Photo 13: Greenbelt Meadows 55th Street Inlet (East)

Future increases in runoff rates within the existing off-site drainage basin are not anticipated. As discussed previously, the portion of the existing off-site drainage basin within the City limits is fully developed. It is anticipated that within the existing off-site drainage basin additional development may occur on the properties within unincorporated Boulder County. The Boulder Valley Comprehensive Plan Land Use Map designates all of these properties as "Low Density Residential". Upon annexation, any proposed development will be required to meet or exceed the storm water management requirements of the City of Boulder. Therefore, it is not anticipated that the storm water run-off rates will increase within the off-site basin.

3.1.2 Existing Off-Site Drainage Patterns

The off-site drainage basin is divided into eleven sub-basins designated OS-1 through OS-11. The drainage area, 10-year and 100-year runoff coefficients and contributing 10-year and 100-year flows are presented for each of the sub-basins on the "Existing Conditions Drainage Exhibit". An Existing Conditions Storm Drainage Schematic is provided on Sheet DR-2 of the "Existing Conditions Drainage Exhibit" which graphically presents the existing drainage patterns both off-site and on-site.

Sub-basins OS-1, OS-2, OS-3 and OS-8 drain to Manhattan Drive. The confluence of the flows from these basins is at the intersection of Manhattan Drive and Illini Way (Design Point 2). During both the 10-year and 100-year storm events, the gutter capacity is exceeded and storm water overtops the crown of the road. Hydraulic calculations of the existing roadway capacities are provided in Appendix A for reference. At Design Point 2, the storm water flows split. It is assumed that fifty percent of the flows will divert to Illini Way (Design Point 4) and the remaining flows will continue north along Manhattan Drive (Design Point 3).

Flows from sub-basins OS-4 and OS-7 drain to Manhattan Drive and confluence with the flows from the south at the intersection of Manhattan Drive and Cimmaron Way (Design Point 5). As with the previous intersection, the gutter capacity is exceeded and the storm water overtops the crown of the road. At Design Point 5, the storm water flows split again. It is assumed that fifty percent of the flows will divert to the east along Cimmaron

Way (Design Point 7) and the remaining flows will continue northeast along Manhattan Drive (Design Point 6). The diverted storm flows in Cimmaron Way combine with drainage from sub-basin OS-5. The storm water turns east and flows along Kewanee Drive to the eastern end of Kewanee Drive at the west property line of the Hogan-Pancost Property at Design Point 8 (Photo 14).

Photo 14: Eastern end of Kewanee Drive looking west from Hogan-Pancost Property

Photo 15: Southwest corner of Hogan-Pancost Property looking south along Dry Creek Ditch No. 2 Corridor

The Illini Way split flows (Design Point 4) combine with the storm flows from sub-basin OS-9 at Illini Way and Dry Creek Ditch No. 2 culvert crossing (Design Point 9). Developed storm flows enter the Dry Creek Ditch No. 2 corridor through two sidewalk chases (shown previously in Photos 6 and 8). The storm flows are routed through two weir structures prior to entering Dry Creek Ditch No. 2. The storm water flows north along the Dry Creek Ditch No. 2 corridor to the southwest corner of the Hogan-Pancost Property where it confluences with flows from sub-basin OS-10 at Design Point 10 (Photo 15).

Sub-basin OS-6 borders the Hogan-Pancost Property on the west. Storm drainage sheet flows onto the Hogan-Pancost Property along the western property line from the southwest corner of the property to Kewanee Drive.

Sub-basin OS-11 borders the Hogan-Pancost Property East Parcel on the south. Storm drainage sheet flows onto the Hogan-Pancost Property along the southern property line from the southwest corner of the property at 55th Street to the eastern boundary.

3.1.3 Existing On-Site Drainage Patterns

The Hogan-Pancost Property is former agricultural land used primarily for livestock grazing. The existing on-site development is minimal and consists of structures and fencing in support of the agricultural use. The land is now fallow and is sparsely vegetated. The site generally slopes from south to north at approximately 1.0%. The property has been flood irrigated in the past and several irrigation laterals cross the site creating a fairly uneven topography. 55th Street divides the Hogan-Pancost Property into two parcels. The

proposed development of the property will occur on the 19.44-acre West Parcel. The 2.73-acre area east of 55th Street (East Parcel) will remain undeveloped.

The Hogan-Pancost Property is divided into five drainage sub-basins: H1 through H5. The delineations of the on-site existing basins are shown on Sheet DR-1 of the "Existing Conditions Drainage Exhibit". The drainage area, 10-year and 100-year runoff coefficients and contributing 10-year and 100-year flows are presented for each of the sub-basins. The Existing Conditions Storm Drainage Schematic is provided on Sheet DR-2 and graphically presents the existing drainage patterns both the off-site and on-site drainage basins.

Photo 16: Hogan-Pancost Property West Parcel looking west from southeast corner along south property line.

Photo 17: Hogan-Pancost Property West Parcel looking at the northwest property corner from southeast corner at 55th Street.

Photo 18: Hogan-Pancost Property West Parcel looking north to the East Boulder Community Park from southeast property corner at 55th Street.

Sub-basins H-1 and **H-2** are the westerly 16.85-acres of the West Parcel. Run-off generally flows south to northwest. Storm drainage from Sub-basin H-2 sheet flows north onto the East Boulder Community Park property. The Howard-Superphositcal Lateral is located just beyond the north property line. The East Boulder Community Park property is elevated above this irrigation lateral creating topography that diverts storm flows west along the Howard-Superphostical Lateral. Existing topography is presented on Sheet DR-3 of the Proposed Conditions Drainage Exhibit. When the lateral is flowing, storm flows that discharge off-site from H-2 are conveyed back on to the Hogan-Pancost Property at the northwest corner where the Howard-Superphostical Lateral enters the property and crosses Dry-Creek Ditch No. 2. Just east of the crossing, the Howard-Superphostical Lateral is piped underground. Flows entering the lateral pipe are controlled by a head gate and excess flows (irrigation or storm) spill from the Howard-Superphostical Lateral into Dry Creek Ditch No. 2. Sub-basin H-1 and H-2 are shown to confluence at the northwest property corner (Design Point 12).

Photo 19: Howard-Superphostical Lateral elevated crossing at Dry Creek Ditch No.2 looking west. Barbed wire fencing is approximately on the Hogan-Pancost west property line.

Photo 20: Howard-Superphostical Lateral intake and head gate. Note that the lateral is spilling to the north into Dry Creek Ditch No. 2.

Sub-basin H-1 intercepts off-site flow from three locations: the Dry Creek Ditch No. 2 corridor at the southwest property corner (Design Point 10), the eastern end of Kewanee Drive (Design Point 8) and the sheet flow from sub-basin OS-6 along the west property line. The off-site flows are generally intercepted by the Dry Creek Ditch No. 2 channel and conveyed to the northwest corner of the Hogan-Pancost Property. Storm flows in excess of the irrigation ditch capacity spill east onto the Hogan-Pancost Property and flow north adjacent to the Dry Creek Ditch No. 2 channel. The off-site flows confluence at Design Point 11 which is located just east of the end of Kewanee Drive. The off-site flows combine with the on-site flows at Design Point H-1 prior to discharging onto the adjacent East Boulder Community Park property.

Sub-basins H-3 and **H-4** are the remaining areas of the West Parcel and are located north of 55th Street and east of H-1 and H-2. H-3 is located southwest of the Howard-Superphostical Lateral and is included in the development of the West Parcel. H-4 is located northeast of the lateral and will remain undeveloped. Runoff from these sub-basins generally sheet flows northwest onto the East Boulder Community Park property. These sub-basins confluence at the point where the Howard-Superphostical Lateral is piped underground (Design Point H-2). The East Boulder Community Park property is elevated above this irrigation lateral creating topography that diverts storm flows west along the Howard-Superphostical Lateral. Based on the site topography it appears that when the irrigation lateral is flowing, storm water conveyed along the lateral will exceed the capacity of the intake structure and will be impounded until it spills northeast towards the existing pond south of the East Boulder Recreation Center.

Sub-basin H-5 is the 2.73-acre East Parcel. Sub-basin H-5 intercepts off-site storm flows from OS-11 along the south property and at the existing pond (Design Point 19). Storm flows sheet across the property northeasterly towards a low-point at 55th Street (Design Point H-3). The Howard-Superphostical Lateral flows across the East Parcel from the southeast to the northwest. The topography on the property allows storm water to flow across the lateral when it is in operation. The low-point on the property is lower than the existing roadway and lacks an outfall. Storm drainage will pond at the low-point until it spills east towards the City of Boulder open space. Development is not proposed for the East Parcel and this drainage pattern will remain unaltered with the development proposal.

3.1.4 Influences of Irrigation Ditches

The existing drainage basin system is intersected by Dry Creek Ditch No. 2 and several irrigation laterals. Each of these irrigation ditches are labeled on the Existing Conditions Drainage Exhibit. As described in the preceding sections, due to the topography of the existing drainage basin, these irrigation ditches play an integral part of the existing storm drainage system. Dry Creek Ditch No. 2, in particular, forms the backbone of the existing drainage system tributary to Design Point H-1. The standards presented in Section 7.01 (H) "Irrigation Ditches" of the City of Boulder "Design and Construction Standards" states:

> No storm runoff shall be conveyed into an irrigation ditch or lateral without written approval and permission from the affected irrigation ditch company or lateral owner.

Based on discussions with the Dry Creek Ditch No. 2 regarding the proposed development, it is unlikely that formal written permission was granted to the existing subdivisions to directly discharge storm water into their ditch. However, given the size of the channel the ditch physically intercepts storm water flows and does influence the existing drainage patterns. The Boulder County "Ditch & Reservoir Map Directory" documents Dry Creek Ditch No. 2 as having a decreed flow of 71.0-cfs. A copy of a portion of this directory is provided in Appendix A. During normal operation, the ditch company only conveys 25.0-cfs. Existing channel cross-sections were measured at various locations within the Hogan-Pancost Property to verify the existing ditch capacity. These sections are presented in Appendix A. The existing Dry Creek Ditch No. 2 channel is irregular and the channel capacity varies greatly through the property. At the

upstream end of the channel, the maximum capacity is only 21.6-cfs. Approximately, 232 feet north of this section, the channel capacity increases to 124.7-cfs. Generally, the existing channel capacity is about 60.0-cfs. Note that these capacities are maximum full-flow capacities without any freeboard. Typically, irrigation ditches are designed with at least 1-foot of freeboard. The existing concrete diversion structure at the northwest corner of the property has a 47.6-cfs capacity within the structure. The upstream entrance to the diversion structure was modeled as a culvert and found to have a 27.9-cfs maximum capacity. The existing channel configuration and diversion structure appear to be sized for the normal operational flow of 25-cfs.

Photo 21: Dry Creek Ditch No. 2 channel along west property line looking north.

Photo 22: Dry Creek Ditch No. 2 channel at the end of Kewanee Drive along west property line looking north.

For the purpose of this study, it is assumed that the existing storm water flows entering Dry Creek Ditch No. 2 are conveyed within the corridor created by the topography and that the ditch is flowing at normal operational capacity of 25-cfs. Irrigation and storm flows that spill from the ditch at the southwest corner of the Hogan-Pancost property flow adjacent to the existing channel and spill back into the existing channel prior to exiting the property at the northwest corner.

The standards presented in Section 7.01 (H) "Irrigation Ditches" of the City of Boulder "Design and Construction Standards" states:

> The irrigation ditch or lateral shall not be used [as] basin boundaries to eliminate the contribution of the upper basin area in the evaluation of runoff conditions. Irrigation ditches shall not be assumed to intercept storm water runoff.

The hydrology analysis presented in this study assumes that all irrigation laterals are flowing full and that the irrigation lateral structures are sized to only accept the irrigation flows. The interplay of storm flows and irrigation flows with the Howard-Superphostical Lateral are discussed in the previous sections, and the hydrology analysis adheres to the City standard quoted above.

However, due to the physical characteristics of the Dry Creek Ditch No. 2 – Bodam Lateral along the south property line, this lateral cannot be treated in the manner

presented in the City standard. This lateral is used solely by the Bodam Property for irrigation and eventually returns flow to Dry Creek Ditch No. 2 at the southwest corner of the Hogan-Pancost Property. The lateral straddles the southern property line common with the Bodam Property. At the east end, the lateral is partially on the Hogan-Pancost Property. When the lateral reaches the confluence of Dry Creek Ditch No. 2 it is fully on the Hogan-Pancost Property (Photos 23 and 24, below).

Photo 23: Dry Creek Ditch No. 2-Bodam Lateral looking west from the southeast corner of the West Parcel.

Photo 24: Dry Creek Ditch No. 2-Bodam Lateral looking east from the southwest corner of the West Parcel.

The lateral is approximately 2 to 3-ft deep and is blocked periodically at its western end to impound water for irrigation pumping. The northern embankment of the lateral is bermed higher than its southern bank, effectively blocking excess storm flows from spilling onto the Hogan-Pancost Property. Even when blocked, this lateral has sufficient freeboard to accept storm flows from sub-basin OS-10. The hydrology analysis presented in this study assumes that the Dry Creek Ditch No. 2- Bodam Lateral conveys storm flows even when flowing full and that it forms the northern drainage boundary of sub-basin OS-10. The Hogan-Pancost Property still intercepts the storm flows at the southwest corner of the property which meets the intent of the City standard.

The proposed Land Use diagram and supporting storm water management design addresses the potential for changes in operation of the adjacent irrigation ditch and laterals. Refer to Section 3.3.2 for a detailed discussion.

3.1.5 Existing Storm Water Runoff

The existing runoff rates for the 10-year minor and 100-year major storm events at each design point are summarized in the "Existing Conditions Runoff Summary: Dry Creek Ditch No. 2 Open Channel" Table on Sheet DR-2 of the Existing Conditions Drainage Exhibit. Key design points are presented on the following page in Table 3.1 for ease of reference. The supporting hydrologic models are presented in Appendix A as the "10-Year Ex. Conditions Hydrology Model" and the "100-Year Ex. Conditions Hydrology Model".

The storm water flows presented are storm flows exclusively and do not include any irrigation flows, decreed or otherwise.

Table 3.1: Existing Hydrology Summary

(Key Design Points)

	Runoff Rates [CFS]	
Design Point	**10-Year**	**100-Year**
DP 8	17.33	34.67
DP 10	38.90	78.93
DP 11	49.48	95.55
DP H-1	52.25	103.58
DP H-2	1.84	5.21
DP H-3	2.91	8.09

Based on existing conditions hydrology, the maximum allowable release rates for the development of the Hogan-Pancost Property are defined at Design Points H-1, H-2 and H-3 as presented above in Table 3.1.

3.1.6 Dry Creek Ditch No. 2 Piping

It is anticipated that prior to the annexation of the Hogan-Pancost Property into the City, Dry Creek Ditch No. 2 will be piped. The Dry Creek Ditch No. 2 Ditch Company ["Ditch Company"] has agreed to allow the ditch to be piped from the southwest corner of the Hogan-Pancost Property north to the existing dual culverts north of the Hogan-Pancost Property on the East Boulder Community Park property. Construction plans for the piping project have been prepared and are currently in review by the ditch company for formal approval. These construction plans are provided in Appendix D of this report.

As required by the Ditch Company, the new piping is sized to convey the maximum decreed irrigation flow of 71-cfs. Flows in excess of this capacity will spill east onto the Hogan-Pancost Property through a weir in the pipe headwall. A head gate at the entry of the pipe is not provided per the Ditch Company's direction. When the ditch is at normal operation (25-cfs), the Dry Creek Ditch No. 2 pipe has an excess capacity of 46-cfs. Additional existing conditions hydrologic models were prepared to isolate the impacts of the Dry Creek Ditch No. 2 pipe and the affects of its additional excess capacity on the existing storm drainage system. It is worth noting that only off-site flows from the adjacent neighborhoods already flowing along the Dry Creek Ditch No. 2 corridor can be intercepted by the pipe. No runoff from the Hogan-Pancost Property can be intercepted by the Dry Creek Ditch No. 2 pipe either undeveloped or with the proposed Land Use diagram.

The resulting runoff rates for the 10-year minor and 100-year major storm events at each design point are summarized in the "Existing Conditions Runoff Summary: Dry Creek Ditch No. 2 Piped" Table on Sheet DR-2 of the Existing Conditions Drainage Exhibit. Key design points are presented on the following page in Table 3.2 for ease of reference. The supporting hydrologic models are presented in Appendix A as the "10-Year Ex. Conditions

Hydrology Model with Dry Creek Ditch No. 2 Pipe" and the "100-Year Ex. Conditions Hydrology Model with Dry Creek Ditch No. 2 Pipe".

Design Points 13 and 14 were added to the existing conditions model to represent the storm water diversion Dry Creek Ditch No. 2 pipe entrance. Design Point 13 represents the off-site storm flow intercepted by the Dry Creek Ditch No. 2 pipe at the southwest corner of the Hogan-Pancost Property (Design Point 10). Design Point 14 is the remaining off-site flow that spills into the Hogan-Pancost Property. Design Point 10 is the sum of Design Points 13 and 14. Design Point H-1 represents both the storm flows in the Dry Creek Ditch No. 2 pipe and the storm flows at the surface. In the hydrologic models, Design Point P represents the piped storm flows that are included at Design Point H-1.

Table 3.2: Existing Hydrology Summary
With Dry Creek Ditch No. 2 Piped
(Excess Pipe Capacity = 46-cfs)

(Key Design Points)

	Runoff Rates [CFS]			
Design Point	**10-Year**	**Δ[1]**	**100-Year**	**Δ[1]**
DP 8	17.33	0.00	34.67	0.00
DP 10	38.90	0.00	78.93	0.00
DP 11	19.45	-30.03	48.65	-46.90
DP 13[2]	38.90	-	46.00	-
DP 14[3]	0.00	-	32.93	-
DP H-1	53.06	+0.81	102.44	-1.14

[1] Change in storm water runoff rate as compared to rates presented in Table 3.1 "Existing Hydrology Summary"
[2] Off-site storm flow intercepted by Dry Creek Ditch No. 2 Pipe
[3] Off-site storm flow continuing on to Hogan-Pancost Property

The resulting peak flow at Design Point H-1, which includes the piped flow as well as the surface flow, vary only slightly from the existing hydrologic conditions. The Dry Creek Ditch No. 2 pipe will generally be constructed along its current open channel alignment. The new pipe will be constructed as a shallower slope than the existing open channel. The change in slope offsets the improved conveyance of the pipe due to a reduction in the Manning's "n" such that the hydrograph routing times are not significantly altered by the new pipe. As a result, when the storm flows intercepted by the pipe daylight again north of the existing dual culverts, the downstream existing hydrology is not adversely affected.

Because the excess pipe capacity of the Dry Creek Ditch No. 2 Pipe intercepts off-site storm flows, the new pipe will reduce the storm flows entering the Hogan-Pancost Property at the southwest corner which results in a corresponding reduction of surface flows at the end of Kewanee Drive (Design Point 11). The reduction is storm flows at Kewanee Drive in combination with the new swale on the Hogan-Pancost Property to be constructed as part of the Dry Creek Ditch No. 2 pipe construction project will help to reduce localized flooding that frequently occurs at the end of Kewanee Drive.

The proposed Land Use diagram and supporting storm water management design addresses the potential for changes in operation of the adjacent irrigation ditch and laterals including the Dry Creek Ditch No. 2 pipe. With the development of the Hogan-Pancost Property, the improved drainage conditions for Kewanee Drive discussed previously are incorporated into the storm water management design and will not be dependent on the operation of Dry Creek Ditch No. 2 pipe. Refer to Section 3.3.2 for a detailed discussion.

3.2 PROPOSED HYDROLOGIC CONDITIONS

The proposed development of the Hogan-Pancost Property will occur on the West Parcel. The East Parcel and the area northeast of the Howard-Superphostical Lateral with the West Parcel will remain undeveloped. The proposed development is a mix of single-family residential detached homes and senior multi-family attached housing as shown on the proposed Land Use diagram is presented on page 5 of this report. For this hydrologic analysis, the 19.44-acre West Parcel is assumed to be 12.37-acres of single-family residential, 3.07-acre multi-family, 3.72-acres of landscaped/open space areas and 0.28-acres undeveloped northeast of the Howard-Superphostical Lateral.

Conceptual grading and storm sewer infrastructure designs were prepared in support of the proposed Land Use diagram and are shown on Sheet DR-3 "Proposed Conditions Grading Exhibit" provided in the back pocket of this report. The proposed on-site drainage sub-basins are delineated based on the conceptual grading design. These delineations are presented on Sheet DR-3. With the proposed development, the Hogan-Pancost Property will be divided into five (5) sub-basins: A, B, C, H-4 and H-5. The drainage area, 10-year and 100-year runoff coefficients and contributing 10-year and 100-year flows are presented for each of the sub-basins. The Developed Conditions Routing Schematic is provided on Sheet DR-3 and graphically presents the on-site drainage basins and the contributing off-site drainage design points.

3.2.1 Proposed Conditions On-site Drainage Patterns

The proposed development maintains the historic storm water release locations at the northwest corner of the property (Design Point H-1), the intake of the Howard-Superphostical Lateral (Design Point H-2). Development does not occur on the East Parcel. The existing drainage patterns, storm water runoff rates and discharge location (Design Point H-3) for the East Parcel remain unchanged.

Sub-basin A is 2.35-acres that abuts the Keewaydin Meadows along the western property line. The sub-basin is 24.7% impervious and includes the 30-foot Dry Creek Ditch No. 2 pipe easement, limited portions of single-family residential development and a small section of the Kewanee Drive Extension. For the purpose of this study, Kewanee Drive is assumed to be extended from the Keewaydin Subdivision. If Kewanee Drive is not extended, the drainage patterns presented will remain unchanged, but the storm water runoff rates for Sub-basin A will be reduced with the reduction in impervious area. Sub-basin A extends from the southwest corner of the Hogan-Pancost Property to the northwest corner and intercepts the off-site flows from Keewaydin Meadows. Storm water discharge from off-site sub-basin OS-6 will continue to sheet flow onto the Hogan-

Pancost Property as it does now. The off-site runoff will be collected in a grass swale and conveyed north to Kewanee Drive. Sub-basin A will also collect existing off-site flows discharged from Keewaydin Meadows at Kewanee Drive (Design Point 8). These off-site flows will confluence with the flows from Sub-basin A at Kewanee Drive (Design Point 11). The storm water runoff will continue north in a grass swale to the northwest corner of the subdivision where it is released off-site to the East Boulder Community Park Property (Design Point H-1).

The majority of the proposed development is included in **Sub-basin B** which is 16.61-acres and 39.1% impervious. This basin intercepts off-site storm flows at the southwest corner of the property (Design Point 10) with a bioswale that conveys the off-site runoff through the Hogan-Pancost Property and through two detention facilities. At the southwest corner of the property, the upper reach of the bioswale is integrated with a designated wetland mitigation area. Refer to the "Groundwater Hydrology Monitoring & Wetland Delineation Report" prepared by Western Ecological Resource, Inc. for a detailed discussion of the wetlands.

The bioswale will begin to intercept on-site developed flows once the bioswale turns north and away from the southern property line. An Urban Drainage Flood Control District [UDFCD] Constructed Wetland Channel [CWC] is designed within the low flow channel. The CWC provides continuous storm water quality treatment of <u>both</u> on-site and off-site flows along the length of the bioswale through the Hogan-Pancost Property. A pedestrian path is provided above the low flow channel on a bench that is wide enough to provide maintenance access to the bioswale. At-grade pedestrian crossings are provided at each road crossing which double as maintenance access points into the bioswale. The low flow channel is sized to convey the 10-year storm event without over topping the bench. The bioswale has the capacity to convey the full local 100-year storm event plus diverted South Boulder Creek flood flows with 1-foot of freeboard. Refer to **Section 6.0 Floodplain Mitigation** for a detailed discussion of the bioswale's role in flood flow conveyance and mitigation. Information on the UDFCD Constructed Wetlands Channel and the bioswale hydraulic worksheets are provided in Appendix D for reference.

Sub-basin C is a 0.20-acre area that extends along the north property line and sheet flows into the East Boulder Community Park Property. This sub-basin is only 14.0% impervious and mimics the behavior of the existing on-site Sub-basin H-2. Like H-2, storm drainage from Sub-basin C sheet flows north where, due to the topography, it is directed west along the Howard-Superphostical Lateral and back into the Hogan-Pancost Property (Design Point 12).

Sub-basins H-4 and H-5 which are located northeast of the Howard-Superphostical Lateral and on the East Parcel remain undeveloped. The existing storm water patterns and discharge rates remain unchanged.

The proposed development maintains the historic storm water release locations at the northwest corner of the property (Design Point H-1), the intake of the Howard-Superphostical Lateral (Design Point H-2). Development does not occur on the East Parcel. The existing drainage patterns and storm water runoff rates for the East Parcel remain unchanged (Design Point H-3).

3.2.2 Influences of Irrigation Ditches

Irrigation ditches surround the Hogan-Pancost Property. The Land Use diagram and supporting concept grading design recognizes and addresses the potential impacts that operational changes in these irrigation ditches may have on the drainage design. The bioswale is sized to intercept and convey the entire off-site storm water volume that enters the Hogan-Pancost Property at the southwest corner and does not rely on the excess capacity within the Dry Creek Ditch No. 2 pipe. The proposed detention facilities are designed so that the downstream existing run-off rates at Design Point H-1 are not exceeded even when the Dry Creek Ditch No. 2 pipe has excess capacity that intercepts storm flows. Multiple developed hydrology scenarios are presented in the following section that elaborates on the influences of the Dry Creek Ditch No. 2 pipe on the detention facility design.

The detention pond outlet at the northwest corner of the site is designed to release above the existing Dry Creek Ditch No. 2 channel banks well within the Hogan-Pancost Property and does not rely on the irrigation ditch channel or future piping as an outfall. The outlet will be designed with an energy dissipator to spread out the flows released from the detention pond to mimic the sheet flow conditions that currently existing today.

The proposed development areas are offset from the south property line. The bioswale and a smaller grass swale within this region prevent developed runoff from the Hogan-Pancost Property from entering the Dry Creek Ditch No. 2-Bodam Lateral. Conversely, should this lateral ever be modified to allow offsite flows from OS-10 to enter the Hogan-Pancost Property along the south property line rather than concentrated at the southwest corner, the drainage facilities are positioned to collect and sized to convey these off-site flows without modification to the Land Use diagram.

The property owner met with the ditch company Board for Dry Creek Ditch No. 2 and with the owner of the Bodam Lateral on numerous occasions. The Board provided input on the piping design and reviewed the construction documents dated 22 October 2008 (included in the report) and supporting hydraulic calculations. Easements or outlot dedication will be provided for each ditch and associated ditch access. The Dry Creek Ditch No. 2 easement/outlot will be 30' feet wide and parallel to the west property line. The Bodam Lateral easement width has not been determined. Each of these easements will be dedicated to the ditch owner and the City of Boulder. The geometry for each easement dedication will be shown during subsequent City Land Use Reviews. The actual dedications will be provided as part of the City's Technical Document Review application.

Written permission from each ditch owner will be collected prior to any physical work or modifications to the ditches.

The proposed Hogan-Pancost development does not rely in any way on the existing irrigation ditches to convey storm water and will not be seeking permission from the ditch owners to do so. The report identifies and documents that this is currently happening along the Dry Creek Ditch No. 2 alignment. The proposed improvements include measures to separate storm water from Dry Creek Ditch No. 2 and release the water at-grade (still separate from the ditch flows). Open channels are proposed immediately

north of the Bodam Lateral to collect storm water should the lateral be breached or removed.

3.2.3 Developed Conditions Storm Water Runoff

The developed conditions runoff rates for the 10-year minor and 100-year major storm events at each design point are summarized in the "Developed Conditions Runoff Summary" Table on Sheet DR-2 of the Existing Conditions Drainage Exhibit. The Dry Creek Ditch No. 2 Ditch is assumed to piped and to be at a normal operational flow of 25.0-cfs. Key design points are presented in Table 3.3 for ease of reference. The supporting hydrologic models are presented in Appendix B as the "10-Year Dev. Conditions Hydrology Model" and the "100-Year Dev. Conditions Hydrology Model".

The capacity of the Dry Creek Ditch No. 2 pipe can range from 71-cfs when the irrigation ditch is not operating to 0-cfs if the ditch running at full decreed flow or if a head gate is installed that restricts flow to the pipe. While it is recognized that the ditch company is unlikely to accept these storm flows, the pipe physically has capacity to accept off-site storm flows at Design Point 10. The large range in physically available pipe capacity does affect the local storm drainage system. The runoff from the Hogan-Pancost Property does not enter the Dry Creek Ditch No. 2 pipe either undeveloped or with the proposed Land Use diagram. Only off-site flows from the adjacent neighborhoods already flowing along the Dry Creek Ditch No. 2 corridor can be intercepted by the pipe.

The storm water flows presented are storm flows exclusively and do not include any irrigation flows, decreed or otherwise.

Table 3.3: Proposed Conditions Hydrology Summary
Dry Creek Ditch No. 2 at Normal Operation
(Excess Pipe Capacity = 46-cfs)

(Key Design Points)

	Runoff Rates [CFS]			
Design Point	**10-Year**	**Δ[1]**	**100-Year**	**Δ[1]**
DP 8	17.33	0.00	34.67	0.00
DP 10	38.90	0.00	78.93	0.00
DP 11	21.86	+2.41	44.12	-4.53
DP 13	38.90	0.00	46.00	0.00
DP 14	0.00	0.00	32.93	0.00
DP H-1	43.33	-9.73	81.60	-20.84
DP H-2[2]	0.30	-1.54	0.86	-4.35
DP H-3[2]	2.91	0.00	8.11	+0.02

[1] Change in storm water runoff rate as compared to rates presented in Table 3.2 "Existing Hydrology Summary with Dry Creek Ditch No. 2 Piped"
[2] DP H-2 and DP H-3 are not influenced by Dry Creek Ditch No. 2 Pipe. Change in storm water runoff rate as compare to rates presented in Table 3.1 "Existing Hydrology Summary"

Design Points 13 and 14 represent the storm water diversion at the Dry Creek Ditch No. 2 pipe entrance. Design Point 13 represents the off-site storm flow intercepted by the Dry Creek Ditch No. 2 pipe at the southwest corner of the Hogan-Pancost Property (Design Point 10). Design Point 14 is the remaining off-site flow that spills into the Hogan-Pancost Property. Design Point 10 is the sum of Design Points 13 and 14. Design Point H-1 represents both the storm flows in the Dry Creek Ditch No. 2 pipe and the storm flows at the surface. In the hydrologic models, Design Point P represents the piped storm flows that are included at Design Point H-1.

To verify that existing flow rates at Design Point H-1 are maintained, the two extreme scenarios were tested. The first modeling scenario verifies that there are no adverse impacts on downstream hydrology when the Dry Creek Ditch No. 2 pipe is not in operation. In this scenario, the maximum capacity of 71.0-cfs is available to intercept storm flows. This alternative scenario is modeled only for the 100-year design storm. When the pipe is not in operation, the entire 10-year developed off-site flow is intercepted by the pipe. Key design points are presented in Table 3.4 for ease of reference. The supporting hydrologic model is presented in Appendix B as the "100-Year Dev. Conditions Hydrology Model: No Irrigation Flow".

The storm water flows presented are storm flows exclusively and do not include any irrigation flows, decreed or otherwise.

The second modeling scenario extreme verifies that there are no adverse impacts on downstream hydrology when the Dry Creek Ditch No. 2 pipe is either flowing at full decreed flow or is restricted by a head gate. Either case results in no available pipe capacity to intercept storm flows. Again, this alternative scenario is run only for the 100-year design storm. Key design points are presented on the below in Table 3.5 for ease of reference. The supporting hydrologic model is presented in Appendix B as the "100-Year Dev. Conditions Hydrology Model: Full Decreed Flow".

As shown in the following tables, the storm water management design for the proposed Land Use diagram is able to accommodate the variations in the amount of off-site flow intercepted by Dry Creek Ditch No. 2 pipe and, in all scenarios, decreases storm water runoff rates at the end of Kewanee Drive within the Hogan-Pancost Property (Design Point 11) and at the historical release point at the northwest corner of the Hogan-Pancost Property (Design Point H-1).

Table 3.4: Proposed Conditions Hydrology Summary
Dry Creek Ditch No. 2 Not in Operation
(Excess Pipe Capacity = 71-cfs)

(Key Design Points)

	Runoff Rates [CFS]		
Design Point	**100-Year**	Δ^1	Δ^2
DP 8	34.67	0.00	0.00
DP 10	78.93	0.00	0.00
DP 11	44.12	-4.53	-51.43
DP 13	71.00	+46.00	-
DP 14	7.93	-25.00	-

DP H-1	81.56	-20.88	-22.02

[1] Change in storm water runoff rate as compared to rates presented in Table 3.2 "Existing Hydrology Summary with Dry Creek Ditch No. 2 Piped"

[2] Change in storm water runoff rate as compared to rates presented in Table 3.1 "Existing Hydrology Summary" without Dry Creek Ditch No. 2 pipe. DP 13 and 14 not included.

Table 3.5: Proposed Conditions Hydrology Summary
Dry Creek Ditch No. 2 Pipe at Full Decreed Flow
(Excess Pipe Capacity = 0-cfs)

(Key Design Points)

	Runoff Rates [CFS]		
Design Point	**100-Year**	Δ^1	Δ^2
DP 8	34.67	0.00	0.00
DP 10	78.93	0.00	0.00
DP 11	44.12	-4.53	-4.53
DP 13	0	-25.00	-
DP 14	78.93	+71.00	-
DP H-1	98.35	-4.09	-5.23

[1] Change in storm water runoff rate as compared to rates presented in Table 3.2 "Existing Hydrology Summary with Dry Creek Ditch No. 2 Piped"

[2] Change in storm water runoff rate as compared to rates presented in Table 3.1 "Existing Hydrology Summary" without Dry Creek Ditch No. 2 pipe. DP 13 and 14 not included.

4.0 STORM W[illegible]

The proposed Land Use diagram and supporting storm water management design for the Hogan-Pancost Property are designed to intercept the entire off-site flow at the southwest corner of the property and the diverted South Boulder Creek flood flows along the south property line. The proposed storm water management design does not depend upon any excess capacity of the Dry Creek Ditch No. 2 pipe. However, the proposed design does acknowledge and addresses the physical implications of the excess pipe capacity on the downstream hydrology.

The bioswale with two integrated storm water detention facilities are designed to imitate the natural hydrologic response of the undeveloped property. Each detention facility is designed to impound storm water in excess of the design release rates behind an embankment within the bioswale. The storm water detention facilities are designed in sequence. The primary detention facility, designated Detention Pond 1 on Sheet DR-3 "Proposed Conditions Drainage Exhibit", is located at the northwest corner of the property is created by an embankment at the downstream end of the bioswale. Detention Pond 1 fully controls the release of storm flows up to the 10-year design storm. The secondary detention facility, designated Detention Pond 2 on Sheet DR-3 "Proposed Conditions Drainage Exhibit", is located at the mid-point of the bioswale, just upstream of the future road connection, and is created by a drop structure that crosses the bioswale. Detention Pond 2 becomes an active part of the storm water system only when storm water flows are in excess of the 10-year design storm.

4.1 DETENTION FACILITY PHYSICAL CHARACTERISTICS

Detention Pond 1 is designed with a bottom elevation of 5312.0 at the outlet structure, which is above the existing Dry Creek Ditch No. 2 channel banks, and does not rely on the existing irrigation ditch channel or future piping as an outfall. The detention pond outlet structure is located well within the Hogan-Pancost Property to provide room for energy dissipation of the storm flow discharge and to allow the flows to spread out to mimic the existing sheet flow conditions of the storm flows at the northwest corner of the property.

Detention Pond 1 will have a two stage outlet structure to control the release of the 10-year and 100-year developed design storms. (As with the proposed conditions hydrology, multiple design scenarios for the 100-year storm flows will be presented later in this section.) The first stage of the outlet structure is a 15.50-inch orifice with an invert of 5312.00. The first stage of the outlet structure releases the 10-year design storm without overtopping the second stage weir. The second stage weir controls the 100-year developed design storms and has a crest elevation of 5314.30 that is set at the maximum ponding elevation for the 10-year design storm. In addition to the two-stage outlet structure, Detention Pond 1 is designed with a broad crested weir set into the embankment at elevation 5315.60 to provide a controlled overflow route for flows in excess of the developed design storms. The top bank of Detention Pond 1 is at elevation 5316.50 and provides over 1.0-ft of freeboard for the 100-year developed design storms.

Detention Pond 2 is designed with a bottom elevation of 5316.0 at the outlet structure which is incorporated into a drop structure within the bioswale. Detention Pond 2 will have a two stage outlet structure to manage the release of the 10-year and 100-year developed design storms. The first stage of the outlet structure is are two 18-inch pipes with an invert of 5316.00 that allow storm flows less than the 10-year design storm to pass through to the downstream detention facility. The second stage weir controls the 100-year developed design storms and has a crest elevation of 5319.50. This weir is only 12.00 feet long and is part of the drop structure. The remain length of the drop structure is set at an elevation 5320.50 to provide a controlled overflow release of storms in excess of the 100-year developed design storms. The top bank of Detention Pond 2 is at elevation 5321.50 and provides over 1.0-ft of freeboard for the 100-year developed design storms.

4.2 DETENTION FACILITY ROUTING MODELS

The detention pond volumes were determined by using a simplified hydrograph routing method as required by Section 7.12C(1) of the City of Boulder "Design and Construction Standards". As with the developed hydrology presented in Section 3.2.3, the detention facilities were modeled under multiple design scenarios that include the various operational conditions of the Dry Creek Ditch No. 2 pipe.

As shown on the Developed Conditions Routing Schematic presented on Sheet DR-3, Design Point 15 represents the inflow hydrograph for Detention Pond 2, while Design Point is 16 represents the discharge hydrograph for the pond. Similarly, Design Point 17 represents the inflow hydrograph for Detention Pond 1, while Design Point is 18 represents the discharge hydrograph for the pond.

Initially, the Dry Creek Ditch No. 2 pipe is assumed to be operating under normal conditions (25.0-cfs) and has an excess capacity of 46-cfs that intercepts off-site flows at the southwest corner of the Hogan-Pancost Property. The responses of the storm water detention facilities are modeled for both the 10-year and 100-year design storms under with the Hogan-Pancost Property fully developed. The supporting hydrologic models are presented in Appendix B as the "10-Year Dev. Conditions Hydrology Model (DCD Normal Operation)" and the "100-Year Dev. Conditions Hydrology Model (DCD Normal Operation)". The responses of the detention facilities are summarized in Table 4.1.

As discussed previously, the capacity of the Dry Creek Ditch No. 2 pipe can range from 71-cfs when the irrigation ditch is not operating to 0-cfs if the ditch running at full decreed flow or if a head gate is installed that restricts flow to the pipe. While it is recognized that the ditch company is unlikely to accept these storm flows, the pipe physically has capacity to accept off-site storm flows. The large range in physically available pipe capacity does affect the local storm drainage system. The responses of the storm water detention facilities are also modeled for the 100-year design storms in each operational extreme of the Dry Creek Ditch No. 2 pipe.

The next modeling scenario is with Dry Creek Ditch No. 2 pipe not in operation and with the full 71.0-cfs capacity of the pipe intercepting off-site storm flows. The responses of the detention facilities to this scenario are summarized in Table 4.2. The supporting hydrologic model is presented in Appendix B as the "100-Year Dev. Conditions Hydrology Model (DCD No Irrigation Flow)".

The storm water flows presented are storm flows exclusively and do not include any irrigation flows, decreed or otherwise.

Table 4.1: Detention Facility Summary
Dry Creek Ditch No. 2 Pipe at Normal Operation
(Excess Pipe Capacity = 46-cfs)

	Detention Pond 1	Detention Pond 2
10-Year Volume Detained [cf][1]	32,061	0.00
10-Year Release Rate [cfs] [1]	8.13	0.00
10-Year Water Surface Elevation[1]	5314.30	-
10-Year Ponding Depth [ft][1]	2.30	0.00
100-Year Volume Detained [cf] [2]	53,502	8,960
100-Year Release Rate [cfs] [2]	40.20	20.38
100-Year Water Surface Elevation[2]	5315.02	5318.29
100-Year Ponding Depth [ft][2]	3.02	2.29

[1] "10-Year Dev. Conditions Hydrology Model (DCD Normal Operation)"
[2] "100-Year Dev. Conditions Hydrology Model (DCD Normal Operation)"

Table 4.2: Detention Facility Summary
Dry Creek Ditch No. 2 Pipe at Not in Operation
(Excess Pipe Capacity = 71-cfs)

	Detention Pond 1	Detention Pond 2
100-Year Volume Detained [cf] [1]	47,601	2,030
100-Year Release Rate [cfs] [1]	28.46	0.79
100-Year Water Surface Elevation[1]	5314.83	5317.25
100-Year Ponding Depth [ft] [1]	2.83	1.25

[1] "100-Year Dev. Conditions Hydrology Model (DCD No Irrigation Flow)"

Table 4.3: Detention Facility Summary
Dry Creek Ditch No. 2 Pipe at Not in Operation
(Excess Pipe Capacity = 0-cfs)

	Detention Pond 1	Detention Pond 2
100-Year Volume Detained [cf] [1]	69,613	48,042
100-Year Release Rate [cfs] [1]	70.62	50.65
100-Year Water Surface Elevation[1]	5315.43	5320.12
100-Year Ponding Depth [ft] [1]	3.43	4.12

[1] "100-Year Dev. Conditions Hydrology Model (DCD Full Decreed Flow)"

The next modeling scenario is with Dry Creek Ditch No. 2 pipe operating its full decreed flow of 71.0-cfs and no off-site storm flows intercepted by the pipe. The responses of the detention facilities to this scenario are summarized in Table 4.3. The supporting hydrologic model is presented in Appendix B as the "100-Year Dev. Conditions Hydrology Model (DCD Full Decreed Flow)".

4.3 DETENTION FACILITIES AND FLOOD FLOW CONVEYANCE

The bioswale and the storm water detention facilities are sized to safely convey the diverted South Boulder Creek flood flows through the Hogan-Pancost Property. Without relying on the Dry Creek Ditch No. 2 pipe capacity, the detention facilities are sized to manage 100-year developed storm flows plus the diverted South Boulder Creek flood flows. A detailed discussion of the flood flows are provided in **Section 6.0 "Floodplain Mitigation"** later in this report.

Two additional modeling scenarios were prepared to ensure that the proposed storm water detention facilities will operate as intended with the additional flood flows diverted from South Boulder Creek. The detention facilities are designed to allow the flood waters to pass through the site without breaching the pond embankments and without adversely affect the downstream hydrology. The first modeling scenario is with the Dry Creek Ditch No. 2 pipe operating at normal capacity of 25-cfs and with excess pipe capacity of 46-cfs. The second modeling scenario is with the Dry Creek Ditch No. 2 pipe operating at its full decreed flow of 71.0-cfs and no off-site storm flows intercepted by the

pipe. The responses of the detention facilities to each of these scenarios are summarized in Tables 4.4 and 4.5, respectively. The supporting routing models are presented in Appendix B as the "100-Year Dev. Conditions Hydrology Model (DCD Normal Operation +Flood)" and the "100-Year Dev. Conditions Hydrology Model (DCD Full Decreed Flow+ Flood)".

Other modeling permutations with flood flows fall within the range of the routing models presented in this report and are all less extreme than the scenario presented in Table 4.5. The proposed storm water detention facilities will safely convey the diverted flood flows from South Boulder Creek while detaining the local 100-year design storm at its peak without reliance any reliance on the Dry Creek Ditch No. 2 pipe capacity.

Table 4.4: Detention Facility Summary
Dry Creek Ditch No. 2 Pipe at Normal Operation PLUS Flood Flows
(Excess Pipe Capacity = 46-cfs)

	Detention Pond 1	Detention Pond 2
100-Year Volume Detained [cf] [1]	59,180	22,723
100-Year Release Rate [cfs] [1]	50.16	26.46
100-Year Water Surface Elevation [1]	5315.16	5319.25
100-Year Ponding Depth [ft] [1]	3.16	3.25

[1] "100-Year Dev. Conditions Hydrology Model (DCD Normal Operation + Flood)"

Table 4.5: Detention Facility Summary
Dry Creek Ditch No. 2 Pipe at Full Decreed Flow PLUS Flood Flows
(Excess Pipe Capacity = 0-cfs)

	Detention Pond 1	Detention Pond 2
100-Year Volume Detained [cf] [1]	77,111	59,574
100-Year Release Rate [cfs] [1]	86.41	70.20
100-Year Water Surface Elevation[1]	5315.62	5320.46
100-Year Ponding Depth [ft] [1]	3.62	4.46

[1] "100-Year Dev. Conditions Hydrology Model (DCD Full Decreed Flow + Flood)"

The ponding depths presented above in Table 4.5 are the maximum design depths of the detention facilities. Freeboard capacity is provided in each of the detention ponds above the maximum depth.

5.0 STORM WATER QUALITY AND EROSION CONTROL

The proposed Land Use diagram and supporting storm drainage design are prepared to make storm water quality an integral part of the development of the Hogan-Pancost Property.

The primary water quality control feature of the project includes a constructed wetland channel (CWC) bioswale bisecting the site. This feature will provide water quality enhancements to nearly all of the developed site and a significant portion of the off-site flows. The channel, which will be designed and constructed to Urban Drainage and Flood Control District (UDFCD) standards, will take advantage of dense natural vegetation (rushes, willows, cattails, and reeds) to slow down runoff and allow time for settling out sediment and promote biological uptake. The conceptual design of the channel features a very flat bottom, set at an elevation to interface with the groundwater levels sufficient to ensure survival of the wetland plantings. Final design of this channel will be closely coordinated with the wetland and groundwater specialists on the project team.

The Hogan-Pancost Property development will be constructed with erosion and sediment control Best Management Practices (BMPs) in accordance with Section 7.01 of the City of Boulder "Design and Construction Standards" and UDFCD Vol. 3. After the installation, these BMPs will be inspected and maintained during the construction of the proposed improvements. At a minimum, the construction BMPs will include perimeter silt fencing, inlet protection, dust mitigation, revegetation (temporary and permanent), and installation of a temporary construction sediment basin.

6.0 FLOODPLAIN MITIGATION

Floodplain mitigation for this development is feasible and the Hogan-Pancost Property land use diagram is designed such that flood mitigation is an integral part of the design. The proposed Land Use diagram and supporting storm water infrastructure design will eliminate the 100-year floodplain and associated High Hazard Zone along the Dry Creek Ditch No. 2 corridor from the south property line to Kewanee Drive. Flood waters will be routed through the development's bioswales and sequential detention ponds as discussed in **Section 4.3** and released again at the northwest corner of the property where the floodwater confluence currently.

6.1 SOUTH BOULDER CREEK FLOOD MAPPING STUDY

As stated previously in this report, a portion of the property is located within a designated FEMA floodplain, Zone AE (Base Flood Elevations Determined) for South Boulder Creek as shown on the Flood Insurance Rate Map Number 08013C0555 G [4]. The affected portion of the property is east of 55th Street, which is not part of the proposed residential development.

The City of Boulder initiated the South Boulder Creek Flood Mapping Study to "more accurately more accurately identify the floodplain and assess the flood hazard in east Boulder" [6] and is still in progress. According to the City's "South Boulder Creek Flood Mapping Study" web page, on March 25, 2009, FEMA notified the City of Boulder that it intends to officially adopt (effective January 2010) the revised floodplain mapping that resulted from the South Boulder Creek flood mapping study. The new floodplain mapping will be used as the basis for the Flood Insurance Rate Map (FIRM) that establishes minimum regulatory floodplain boundaries under the National Flood Insurance Program (NFIP) and federal mandatory flood insurance purchase requirements.

The Hogan-Pancost Property proposed land use diagram and supporting storm water management facilities are designed to accommodate diverted flood flow from South Boulder Creek. The design presented in this report reflects the most recent South Boulder Creek Flood Mapping Study results dated December 2008. The updated South Boulder Creek Flood Study Maps are provided in Appendix D for ease of reference.

The new South Boulder Creek 100-year floodplain delineation minimally impacts the development of the property. As shown in the figure below, the ZONE AE (Blue) 100-year floodplain with elevations determined is isolated to the Dry Creek Ditch No. 2 corridor within the Hogan-Pancost Property. The ZONE X (Yellow) is either areas of 100-year flooding where average depths are less than 1-foot or the 500-year flood plain. For the purpose of this report, it is conservatively assumed that the Zone X areas within the Hogan-Pancost Property are also a part of the 100-year floodplain. The full "South Boulder Creek Floodplains" Map dated December 2008 with zone definitions is provided in Appendix D.

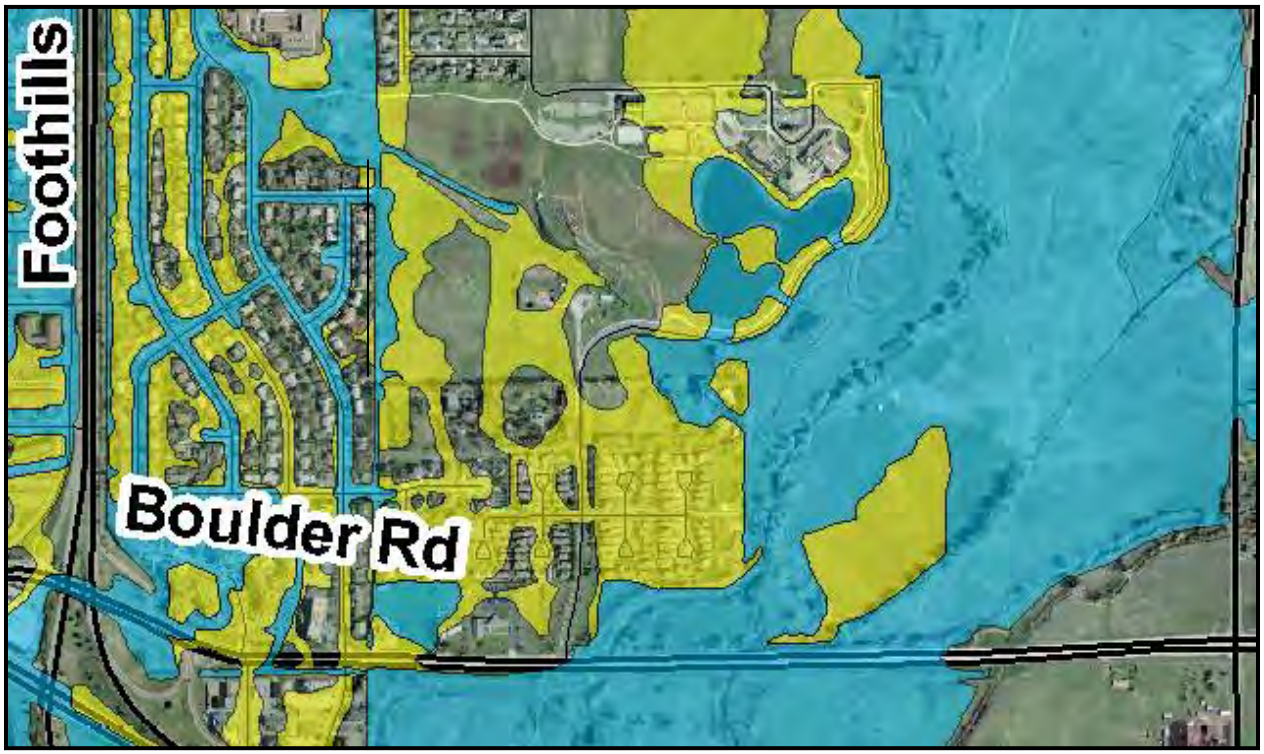

Figure 6.1: revised "South Boulder Creek Floodplains", December 2008

The property is not in the South Boulder Creek Conveyance Zone which carries the majority of the flood waters. By definition [5], the Conveyance Zone:

> ...means those portions of the floodplain required for the passage or conveyance of the one hundred-year flood based on equal encroachment (measured in volume of water) of the floodplain from the edges of the flood channel to a point where the one hundred-year flood profile will be raised by six inches or more, after considering a reasonable expectation of blockage at bridges and other obstructions by flood borne debris.

The "South Boulder Creek Conveyance Zone" Map dated December 2008 is provided in Appendix D.

A small portion of the Dry Creek Ditch No. 2 corridor is designated a High Hazard Zone. By definition [5], the High Hazard Zone:

> ...means those portions of the floodplain where an unacceptably high hazard to human safety exists defined as those areas where the product number of flow velocity (measured in ft./sec.) times flow depth (measured in feet) equals or exceeds four, or where flow depths equal or exceed four feet.

The "South Boulder Creek High Hazard Zone" Map dated December 2008 is provided in Appendix D.

The City of Boulder "Land Use Review Results and Comments" dated 14 May 2007 stated that the subject property is not suited for providing regional mitigation for the South

Boulder Creek floodplain due to the small flood volume impacting the property and the fact that the site is not located along the main South Boulder Creek flood channel. Furthermore, diverting additional flood flows from South Boulder Creek to the west across 55th Street and onto the Hogan-Pancost property is not practical as the property is at a higher elevation than the 100-year floodplain elevation of South Boulder Creek.

The South Boulder Creek flood flows entering the Hogan Pancost Property are estimated to be 16-cfs at the southwest property corner and 7-cfs at the south east property corner. The flood volume diverted from South Boulder Creek and entering the property is approximately 3.75 acre-feet and represents less than 0.25% of the total South Boulder Creek flood volume. Excerpts of the City of Boulder staff comments regarding the South Boulder Creek floodplain are provided in Appendix D for ease of reference.

To put the significance of flood flows into perspective, the total estimated diverted 100-year flood flow from South Boulder Creek entering the Hogan Pancost Property is only 23-cfs. This is similar in magnitude to the 10-year local storm discharged at the end of Kewanee Drive (17-cfs) and much less than the 38.9-cfs peak flow entering the Hogan-Pancost Property at the southwest corner during a 10-year local storm event. Additionally, the flood flow is significantly less than the 100-year local flows entering the Hogan-Pancost Property along the Dry Creek Ditch No. 2 corridor which are 78.9-cfs at its peak.

On a local level, there is opportunity to provide flood storage volume on the Hogan-Pancost property. As proposed, the Bioswale provides 4.0 acre-feet of total storage without freeboard. The flood flow routing models conservatively analyzed flood storage by assuming that the 100-year local storm event peaked at the same time the peak flood flows entered the site. The Bioswale provides 1.3 acre-feet of flood storage above and beyond the 2.7 acre-feet detention storage required for the local 100-year storm event. The Bioswale provides storage for 35% of the total flood volume entering the property and completely attenuates the peak flow of 23-cfs.

6.2 FLOOD FLOW ROUTING MODELS

As with the developed hydrology presented in Section 3.2.3, the proposed storm water facilities were modeled under two design scenarios that include both the diverted flood flows from South Boulder Creek and two operational conditions of the Dry Creek Ditch No. 2 pipe. In each case, the downstream hydrology was not adversely impacted by the development of the Hogan-Pancost Property. As a basis of design for the Hogan Pancost Property storm water infrastructure, it is assumed that the South Boulder Creek 100-year flood flows will peak at 23-cfs at the same moment as the local 100-year developed storm event. This is an extremely conservative assumption used solely for the purpose of evaluating a “worst-case” scenario, and is unlikely to actually occur due to the disparity of watershed sizes between the project site and South Boulder Creek.

Initially, the Dry Creek Ditch No. 2 pipe is assumed to be operating under normal conditions (25.0-cfs) and has an excess capacity of 46-cfs that intercepts off-site flows at

the southwest corner of the Hogan-Pancost Property. The responses of the storm water detention facilities are modeled for both the 10-year and 100-year design storms with the Hogan-Pancost Property fully developed. The supporting routing model is presented in Appendix B as the "100-Year Dev. Conditions Hydrology Model (DCD Normal Operation +Flood)".

Table 6.1: Proposed Conditions Flood Flow Hydrology Summary
Dry Creek Ditch No. 2 at Normal Operation PLUS Flood Flow
(Excess Pipe Capacity = 46-cfs)

(Key Design Points)

	Runoff Rates [CFS]			Notes
Design Point	**100-Year**	Δ^1	Δ^2	
DP 8	34.67	0.00	0.00	
DP 10	101.92	+23.00	+23.00	(flood flows input to model)
DP 11	44.12	-4.53	-51.43	
DP 13	46.00	0.00	-	
DP 14	55.92	+23.00	-	
DP H-1	103.22	+0.78	-0.36	

[1] Change in storm water runoff rate with flood flow as compared to rates presented in Table 3.2 "Existing Hydrology Summary with Dry Creek Ditch No. 2 Piped"

[2] Change in storm water runoff rate with flood flow as compared to rates presented in Table 3.1 "Existing Hydrology Summary" without Dry Creek Ditch No. 2 piped. DP 13 and 14 not included.

Note that under this scenario, the flow at DP 11 (the east end of Kewaunee Drive) is significantly less than under existing conditions. Compared to existing conditions, there is only a minor increase at DP H-1 (north end of the Dry Creek Ditch) despite the additional 23 cfs of South Boulder Creek flood flows. In essence, the proposed improvements "absorb" the flood flows, providing flood mitigation benefits for the entire area.

Table 6.2: Proposed Conditions Flood Flow Hydrology Summary
Dry Creek Ditch No. 2 at Full Decreed Flow PLUS Flood Flow
(Excess Pipe Capacity = 0-cfs)

(Key Design Points)

	Runoff Rates [CFS]			Notes
Design Point	**100-Year**	Δ^1	Δ^2	
DP 8	34.67	0.00	0.00	
DP 10	101.92	+23.00	+23.00	(flood flows input to model)
DP 11	44.12	0.00	-51.43	
DP 13	0.00	0.00	-	
DP 14	101.92	+23.00	-	
DP H-1	125.66	+27.31	+22.08	

[1] Change in storm water runoff rate with flood flow as compared to rates presented in Table 3.4 "Proposed Conditions Hydrology Summary with Dry Creek Ditch No. 2 at Full Decreed Flow (Excess Pipe Capacity=0-cfs)"

[2] Change in storm water runoff rate with flood flow as compared to rates presented in Table 3.1 "Existing Hydrology Summary" without Dry Creek Ditch No. 2 piped. DP 13 and 14 not included.

The flow at DP 11 (the east end of Kewaunee Drive) is also significantly less than under existing conditions. There is an increase at DP H-1 22 cfs, reflecting the additional 23 cfs of South Boulder Creek flood flows. This scenario demonstrates that even during the unlikely convergence of three extreme events (100-year local storm, 100-year Boulder Creek flood, and full flow in the Dry Creek Ditch), the proposed improvements will not increase the peak discharge to adjacent properties.

6.3 FLOOD MITIGATION

The City of Boulder "Land Use Review Results and Comments" dated 14 May 2007 stated that the subject property is not suited for providing regional mitigation for the South Boulder Creek floodplain due to the small flood volume impacting the property. As shown above, when Dry Creek Ditch No. 2 pipe is at its normal operational capacity of 25-cfs, the Hogan Pancost Property mitigates the entire 100-year flood flows such that the discharge at the northwest corner of the property is the same as the existing 100-year local storm event without flood flows. When the Dry Creek Ditch No. 2 pipe is flowing without excess capacity for storm flows, the Hogan Pancost Property's stormwater infrastructure safely routes the flood waters through the project without adversely affecting the downstream hydrology.

The proposed residential structures will be constructed in accordance with the requirements prescribed by the City of Boulder Floodplain Regulations (Chapter 9, B.R.C. 1981) [5]. Additional measures that will be taken to reduce damage to proposed improvements during the event of a flood include, but not limited to:

- Flood proofing all proposed residential structures by raising the finished floor elevations of each of the homes a minimum of 2.0-ft above the base flood elevation which in this case is assumed to be the maximum water surface of the detention facilities.
- Limiting floodwater depths within the subdivision's roadways to allow for emergency access during the event of a flood.
- Restricting basement construction.

7.0 CONCLUSION

This report provides a conceptual overview of the storm water management of the drainage flows from the proposed development and mitigation of the impacts of the South Boulder Creek floodplain on the development. The development of the property will maintain the existing drainage patterns on the site and will improve drainage conditions by removing existing flows to the north onto the East Boulder Recreation Center property and to the east end of Kewaunee Drive. Total runoff from the site will be less than existing conditions for the 10-and 100-year storm events. Water quality enhancements will be provided for both the on-site developed areas and a significant portion of the offsite flows. Erosion control BMP's will be implemented during construction in an effort to prevent adverse impacts on downstream properties and drainage facilities. The proposed development will not adversely affect the surrounding properties or existing storm drainage system.

8.0 REFERENCES

[1] "Design and Construction Standards" prepared by the City of Boulder, effective 16 November 2000.

[2] "Boulder County Zoning District Map" prepared by Boulder County, effective 20 September 2002.

[3] "Boulder Valley Comprehensive Plan" prepared by the City of Boulder effective 2002.

[4] Federal Emergency Management Agency, Flood Insurance Rate Map, Boulder County, Colorado and Incorporated Areas, Map Number 08013CO555 G, effective 04 October 2002.

[5] "Boulder Revised Code" (B.R.C.) 1981.

[6] City of Boulder South Boulder Creek Flood Mapping Study Web Page: http://www.bouldercolorado.gov/index.php?option=com_content&task=view&id=6527&Itemid=1189