II. BASIN CHARACTERISTICS

2.1 General Information

The Town of Windsor is located in northwest Weld County approximately 60 miles north of the Denver metropolitan area. The Town is contained within a watershed that can generally be defined by Weld County Road 100 (WCR 100) on the north, Weld County Road 25 (WCR 25) on the east, U.S. Highway 34 on the south and Interstate 25 on the west. The watershed encompasses approximately 120 square miles. The primary land use is agricultural, ranching, and open space that comprises less than 67,000 acres or approximately 87% of the watershed. Less than 10% of the watershed is currently developed and of the area that is developed, the land use ranges from very low density to mixed-use residential housing and light to medium commercial/industrial development.

Several jurisdictional entities are responsible for regulating growth and development within the watershed. These entities include:

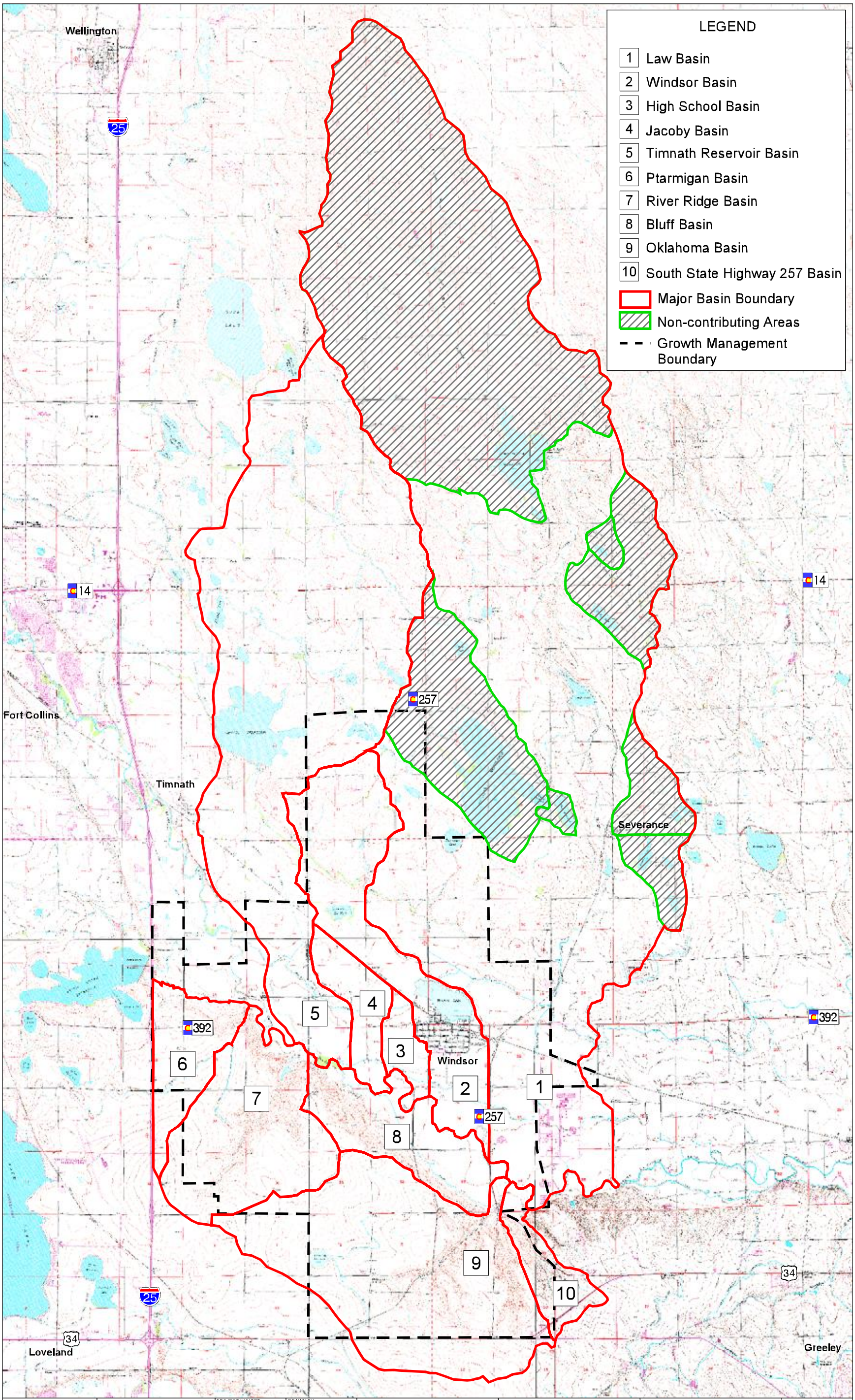
- Town of Windsor (~9,500 acres or 12.5%),
- Weld County (~53,200 acres or 70.0%),
- Larimer County (~11,400 acres or 15.0%),
- Town of Severance (~1,200 acres or 1.5%),
- City of Loveland (~700 acres or 0.9%), and
- City of Greeley (~90 acres or 0.1%).

Figure 2.1 provides a vicinity map illustrating the watershed boundary along with the Growth Management Boundary for the Town of Windsor.

2.2 Summary of Major Drainage Features

For the purposes of this master planning effort, the watershed was divided into ten major drainage basins. The major drainage basin boundaries are delineated on the vicinity map on Figure 2.1 and identified below:

> Law Basin	> Ptarmigan Basin
> Windsor Basin	> River Ridge Basin
> High School Basin	> Bluff Basin
> Jacoby Basin	> Oklahoma Basin
> Timnath Reservoir Basin	> South State Highway 257 Basin



REVISIONS:	N Contour Interval 10 feet 2000 0 2000 4000 Feet	PROJECT NUMBER: COTOW08	DRAWN BY: RJN	Anderson Consulting Engineers, Inc.	TOWN OF WINDSOR Master Drainage Plan	VICINITY MAP	FIGURE 2.1
		FILENAME: Windsor-masterplan.apr Vicinity Map 11x17	DESIGNED BY: CJP				
		DATE: 10/02/2003	CHECKED BY: BAA				

The Cache la Poudre River, which defines the southern boundary of the Law, Windsor, High School, Jacoby, and Timnath Basins and the northern boundary of the River Ridge, Bluff, Oklahoma, and South State Highway 257 Basins, represents the most notable drainage feature in the watershed. Fossil Creek represents the northern boundary and receiving watercourse for the Ptarmigan Basin. All stormwater runoff generated within the watershed is ultimately conveyed to the Cache la Poudre River. The 100-year floodplain associated with the Cache la Poudre River encompasses less than 5 percent (950 acres) of the total drainage area within the watershed.

Several irrigation facilities also traverse the ten major basins including:

- Greeley No. 2 Canal
- Lake Canal
- Law Ditch
- Whitney Ditch
- Timnath Reservoir Outlet
- Windsor Reservoir Outlet
- Louden Ditch
- Eaton Ditch

These ditches convey irrigation flows within the basin but generally offer limited value as drainage features that will convey stormwater runoff out of the basin. Due to the limited capacity of the ditch systems, coupled with the magnitude of the stormwater flows, these irrigation ditches do not appear to represent major drainage boundaries within the watershed.

The remainder of this chapter provides information related to the major drainage features within each of the ten basins. This information is generally limited to a description of the main flow paths including major crossings.

2.2.1 Law Basin

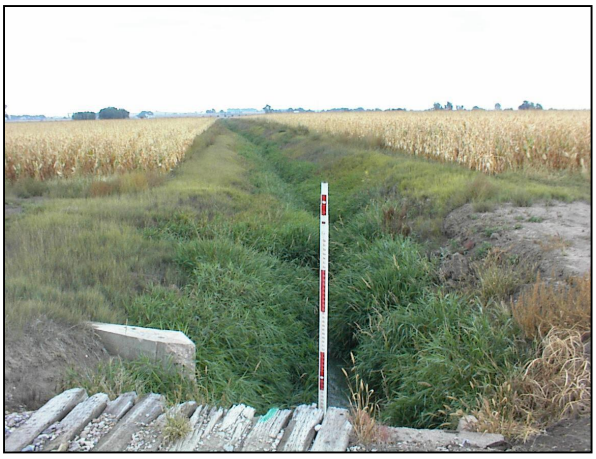
The Law Basin consists of a predominantly rural watershed with a well-defined major drainage channel. The major drainageway, referred to as the Law Ditch, (also known as The Slough above Law Reservoir, and The Consolidated Law Ditch below the Greeley No. 2 Canal) is the most predominant drainage feature and traverses the central portion of the basin in a southerly direction. A secondary drainageway associated with the Law Ditch, hereafter referred to as the West Tributary, collects stormwater runoff from the western portion of the basin and confluences with the main flow path immediately north of State Highway 392. Below the confluence with the West Tributary, the Law Ditch flows due south to its confluence with the Cache la Poudre River.

As indicated on Figure 2.1, the Law Ditch enters the Growth Management Boundary near the intersection of WCR 21 and the Greeley No. 2 Canal. As this location, the Law Ditch has limited capacity to convey the peak discharge associated with large flood events; consequently,

much of the flood flows will be conveyed in overbank areas. The stormwater conveyed along the Law Ditch will enter and overtop the Greeley Number 2 Canal and WCR 21 from the north and east. These flood flows will continue south and west utilizing the culvert crossing at State Highway 392 (4'H x 6'W arched CMP) and overtopping State Highway 392 at the Great Western Railroad crossing.

Flood flows associated with the West Tributary are conveyed along the alignment of the Windsor Reservoir Outlet (a.k.a. the Spring Ditch). Initially, the stormwater runoff captured by the Springer Ditch is conveyed through the crossings of both WCR 74 (8'H x 10'W bridge) and WCR 72 (7'H x 11.5'W arch CMP). South of the WCR 72 crossing, the West Tributary follows the alignment of the Springer Ditch adjacent to WCR 17 and ultimately to its confluence with the Greeley No. 2 Canal directly north of Windsor Lake (a.k.a. Kern Reservoir). At this location, the flows conveyed along the Springer Ditch overtop the Greeley No. 2 Canal and ultimately flow across WCR 10 and the Great Western Railroad embankment to State Highway 392. At State Highway 392, the Western Tributary confluences with the main flow path of the Law Ditch.

South of State Highway 392, flood flows are generally conveyed along the alignment of the Law Ditch to the crossing of the Colorado and Southern Railroad (4'H x 8'W RCBC). Stormwater flows conveyed through this crossing continue south and overtop the crossing of Eastman Park Drive (3'H x 5'W arch CMP). South of Eastman Park Drive, flood flows are conveyed through the Kodak property, ultimately overtopping the Whitney Ditch and terminating at the Cache la Poudre River.



Consolidated Law Ditch
Upstream of C&S Railroad

Within the Law Basin, several irrigation reservoirs and inadvertent storage areas exist which provide for a reduction in stormwater runoff. To significantly reduce or attenuate the peak discharge for major storm events, these reservoirs or storage areas must have substantial storage volumes available for detention of the stormwater runoff. Several storage facilities within the Law Basin were determined to have sufficient available capacity to fully retain the runoff from the major storm events. In general, these facilities were associated with irrigation reservoirs located outside the Growth Management Boundary and are more fully discussed with respect to their impact on the reduction on flood flows in Chapter 4. Two additional reservoirs (Loop Lake and Law Reservoir) also provide for significant reduction of the 100-year peak discharge within the Law Basin. These reservoirs are also discussed in more detail in Chapter 4.

Little erosion of the Law Basin channel is evident. In general, active erosion of the channel bed and banks is not prevalent throughout the basin. The Law Basin channel and floodplain are not heavily encroached with vegetation. The vegetation species vary from rangeland grasses and shrubs to farm crops in the overbank areas. The low flow channel is typically lined with dense stands of wetland grasses and shrubs.

2.2.2 Windsor Basin

The majority of the historic urbanization has occurred within the Windsor Basin and continues to occur through the construction of new residential developments. The Windsor Basin consists of an upper and lower basin that are separated by the Kern Reservoir (also known as Windsor Lake). The upper portion of the basin exhibits a more rural land use. The lower basin reflects a high level of development that consists of limited commercial and industrial facilities along with residential housing.

With the exception of a small residential development, stormwater in the upper portion of the basin is generated from agricultural lands, collected in a series of swales and conveyed in a southerly direction toward the Lake Canal in a well-defined drainage channel. Given the limited capacity of the Lake Canal in comparison to the peak discharge associated with the major storm events, stormwater runoff will likely be captured, spilled and conveyed to an existing irrigation reservoir, Lake Canal Reservoir No. 1, in a less defined swale. Based on a review of the operating criteria and available storage in Lake Canal Reservoir No. 1, minimal attenuation of the peak discharge associated with the stormwater runoff will occur. Stormwater spilled from the irrigation reservoir or conveyed in swales around this facility, will continue in a southeasterly direction toward WCR 15. It should be noted that the Colorado and Southern Railroad embankment represents a drainage boundary to direct the stormwater to the southeast within this basin.

Stormwater runoff conveyed to WCR 15 overtops the roadway since no crossing presently exists. Downstream of WCR 15, stormwater continues to flow to the southeast toward the Greeley No. 2 Canal and Osterhaut Lake. At this location, stormwater captured by the Greeley No. 2 Canal will either be spilled into Osterhaut Lake or conveyed by the canal. Stormwater conveyed to Osterhaut Lake will ultimately overtop the State Highway 257 crossing (24-inch circular pipe) and flow into Kern Reservoir. Stormwater captured by the Greeley No. 2 Canal will pass through the bridge crossing (bridge width of 35 feet) of State Highway 257 and is diverted into Kern Reservoir immediately east of State Highway 257. Assuming delivery of the maximum irrigation diversions, the Greeley No. 2 Canal provides limited capacity to convey stormwater.

In general, Kern Reservoir provides detention benefits for the stormwater conveyed to the reservoir. However, stormwater in excess of the principal outlet pipe will be conveyed over the existing emergency spillway (approximately 100 feet in length) located at the southeast corner of the reservoir and into the lower basin. Downstream of the Kern Reservoir, stormwater will be collected, combined with local runoff and conveyed within the existing network of streets and storm sewers through portions of the heavily urbanized areas of the Town. Specifically, stormwater runoff released from Kern Reservoir will overtop State Highway 392, pass under the Colorado and South Railroad, (bridge width of 26 feet) and be conveyed to a crossing structure (36-inch diameter pipe) at Walnut Street. Stormwater collected in the urbanized area will ultimately overtop the four existing culvert crossings of Eastman Park Drive (42"x 66" arch RCP, 54-inch RCP storm drain, 36-inch RCP, and twin 48"H x 72"W arch CMPs) and flow through the Water Valley residential development via the drainage channel constructed as part of the development. This drainage channel conveys stormwater over the Whitney Ditch to Rock Bridge Lake and subsequently, the Cache la Poudre River. Given the magnitude of the flows and the limited capacity of the existing facilities (storm sewers, streets, and culvert crossings), localized flooding is likely to occur throughout the lower portion of the basin.

Kern Reservoir in the Windsor Basin

Minimal to no erosion of the major drainageway is evident in this basin. Furthermore, the major drainageway and floodplain are not generally encroached with heavy, dense vegetation. The vegetation species vary from rangeland grasses and shrubs to farm crops in the upper basin. The major drainageway in the lower basin typically consists of grass-lined swales and channels as well as the local street and storm sewer system.

2.2.3 High School Basin

The High School Basin is largely encroached by urbanization; consequently, the majority of the stormwater generated in the basin is conveyed through the existing network of streets and storm sewer systems. Near the upper portion of the basin, the Greeley No. 2 Canal intercepts stormwater from a small residential development (approximately 35 acres) and conveys the stormwater, within the capacity of the ditch, into the Windsor Basin through a bridge crossing

(width of 54 feet) of the Colorado and Southern Railroad. Stormwater that exceeds the capacity of the ditch continues to the south, combines with the runoff generated high school facilities, and is conveyed to State Highway 392. At State Highway 392, the stormwater overflows the street and is conveyed in the existing streets, primarily 10th, 11th, and 12th Streets. Near Palisade Mountain Drive, a stormwater channel (bottom width of 2 feet and depth of 5 feet) conveys water collected and conveyed in 10th Street to a crossing at Stone Mountain Drive (three 30-inch CMPs) and into the Poudre Park Detention Pond. A minor storm sewer system located beneath 10th Street also conveys stormwater to the channel near Palisade Mountain Drive. Releases from the Poudre Park Detention Pond are siphoned (twin 30-inch diameter pipes) under the Whitney Ditch and ultimately reach the Cache la Poudre River.

10th Street Channel Upstream of Stone Mountain Drive

Stormwater conveyed within 11th Street continues to the south and is intercepted by the Whitney Ditch. That portion of the stormwater not captured by the ditch continues to the river.

Along the western portion of the basin, stormwater is conveyed primarily within 12th Street to an existing detention pond south of Walnut Street. Releases from the detention pond are directed toward the Whitney Ditch and ultimately to the river.

A small portion of the basin in the vicinity of Elm Street and Eighth Street is serviced by a minor storm sewer system. The minor storm sewer system conveys stormwater to the storm sewer system beneath 10th Street and ultimately to the stormwater channel near Palisade Mountain Drive.

Minimal to no erosion is evident in the stormwater facilities located within this basin. The majority of the main flow paths are paved streets or minor storm sewer systems. The main conveyance channel located south of 10th Street and Palisade Mountain Drive, is presently lined with concrete (lower 2 feet) and vegetation (upper 3 feet) and no erosion of the channel is apparent.

2.2.4 Jacoby Basin

The Jacoby Basin continues to experience changes in land use as predominantly agricultural land transitions to residential and commercial development. In general, the upper

portion of the Jacoby Basin north of State Highway 392 consists of agricultural land with residential development representing approximately 20% of the land use. South of State Highway 392, commercial and residential development represents the majority of the land use along with the regulatory floodway associated with the Cache la Poudre River.

Similar to the High School Basin, a single well-defined drainageway does not exist in the Jacoby Basin. Stormwater generally moves from the north to the south within the basin. Where commercial and residential development is encountered, stormwater is conveyed through the development in the network of streets and minor storm sewers.

The Greeley No. 2 Canal bisects the Jacoby Basin approximately one-quarter mile north of State Highway 392. While the canal does not represent a drainage boundary, a portion of the stormwater is captured and conveyed by the canal to the extent that capacity is available. That portion of the stormwater not captured by the canal, overtops the canal banks and is conveyed to the south toward State Highway 392. Near the intersection of State Highway 392 and WCR 15, the Town of Windsor recently installed the West Side Storm Sewer (72-inch RCP) to convey stormwater within the basin. The West Side Storm Sewer collects stormwater at this intersection, conveys the runoff approximately one-quarter mile to the west along the south side of State Highway 392, and continues south for almost three-quarters of a mile before discharging into the Cache la Poudre River. Near the outfall from the storm sewer system, an inverted siphon conveys the stormwater runoff under the Whitney Ditch. Less frequent releases associated with minor storm events are routed into a constructed wetland/water quality pond prior to release into the river.

West Side Storm Sewer Outlet Channel

Given the lack of a well-defined drainageway coupled with the structural nature of the street and storm sewer systems, minimal to no erosion of the existing stormwater conveyance systems is evident in this basin.

2.2.5 Timnath Reservoir Basin

The Timnath Reservoir Basin is characterized by its lack of development and largely agricultural land use. Timnath Reservoir represents the basin's dominant drainage feature and is

centrally located within the basin. The majority of the watershed tributary to Timnath Reservoir lies outside the Growth Management Boundary; less than 15% of the total watershed is located within the Growth Management Boundary.

The stormwater generated in the upper portion of the watershed is captured, attenuated and released by Timnath Reservoir. Irrigation releases from Timnath Reservoir are conveyed to the Greeley No. 2 Canal in a well-defined drainageway called the Timnath Reservoir Outlet (bottom width of 15 feet, depth of 12 feet). Given its location within the watershed, the Timnath Reservoir Outlet also collects and conveys all stormwater generated below Timnath Reservoir as well as stormwater captured and released from Timnath Reservoir.

The Timnath Reservoir Outlet approaches the Growth Management Boundary near the intersection of LCR 36 and the Colorado and Southern Railroad. At this location, the Timnath Reservoir Outlet conveys stormwater and irrigation releases under a bridge crossing (width of 15 feet) of LCR 36 as well as the bridge crossing of the Colorado and Southern Railroad (width of 13.5 feet). Unlike the Windsor Basin, the embankment associated with the Colorado and Southern Railroad does not represent a drainage boundary in the Timnath Reservoir Basin.

Timnath Reservoir Outlet
Downstream of C&S Railroad

The outlet ditch continues south until it joins the Greeley No. 2 Canal. Stormwater, captured during a major storm event, will overtop a low area along the southern bank of the Greeley Number 2 Canal and continue south into the floodplain of the Cache la Poudre River. Within the floodplain, the runoff will be conveyed through a series of abandoned gravel pits and agricultural fields prior to joining the river.

Given the duration and magnitude of the irrigation releases from Timnath Reservoir, some erosion of the Timnath Reservoir Outlet channel is evident. During a major storm event, erosion of the channel will likely be exacerbated. The Timnath Reservoir Outlet channel and floodplain are not heavily encroached with vegetation. The vegetation species vary from rangeland grasses and shrubs to farm crops in the overbank areas. The low flow channel is typically lined with dense stands of wetland grasses and shrubs. Where historic erosion is evident, the channel has been lined with concrete debris.

2.2.6 Ptarmigan Basin

In contrast to the major basins north of the Cache la Poudre River, the basins located south of the river have a more defined drainage system. The only exception is the Ptarmigan Basin, which has four minor drainage paths, all of which terminate in Fossil Creek.

Much of the lower and middle portions of the Ptarmigan Basin are developed. The recent development south of State Highway 392 incorporated stormwater runoff facilities consisting of a series of channels, detention ponds, and storm sewers. In general, these facilities convey runoff from the development to existing culvert crossings of State Highway 392. In this area, the stormwater facilities were designed to limit the release associated with development to the capacity of the existing culvert crossings. North of State Highway 392, the stormwater runoff is conveyed via a series of stormwater channels ultimately reaching Fossil Creek.

Culvert Crossing of State Highway 392 and Downstream Channel in Ptarmigan Basin

The upper portion of the Ptarmigan Basin south of LCR 30 is located outside the Growth Management Boundary and is presently undeveloped. The stormwater from this area is conveyed across LCR 30 and into the development located along the I-25 frontage road. The Louden Ditch located north of LCR 30 captures and conveys stormwater runoff to a limited extent based on its existing capacity. Runoff not captured by the Louden Ditch spills to the north and into the existing residential housing developments. The area between the Louden Ditch and LCR 30 continues to experience development pressure and several residential housing developments are presently planned for this area.

As stated previously, the existing drainage network in the area south of State Highway 392 consists primarily of channels, detention ponds and storm sewers. Minimal erosion of the conveyance facilities is evident. In those areas where development does not exist, the runoff is conveyed in existing swales with no noticeable erosion. With respect to the stormwater runoff north of State Highway 392, the existing drainage channels in the developed portion of this area are stabilized with man-made structures and minimal erosion is noted. Where development is not present, the drainage channels are experiencing minor to moderate erosion.

2.2.7 River Ridge Basin

The River Ridge Basin consists of primarily agricultural land. In recent years, however, the basin has experienced a transition from agricultural land to residential development in approximately 20% of the watershed.

Unlike the basins north of the Cache la Poudre River, the River Ridge Basin is characterized by a well-defined drainage system. A major drainageway traverses the central portion of the basin in a northeasterly direction. Several minor tributaries exist within the watershed to collect and convey stormwater runoff into the major drainageway and ultimately to the Cache la Poudre River. Near the lower portion of the watershed, runoff conveyed in the major drainageway flows into a small irrigation reservoir, also known as Joe Dee Reservoir. Runoff captured by the irrigation reservoir is released through an outlet pipe (36-inch RCP) or an emergency spillway. The stormwater passing through the reservoir is conveyed by the major drainageway through the River West residential development. Within the development, the major drainageway crosses both River West Drive and River Edge Road (crossing structures consisting of five 7-foot RCPs) prior to its confluence with the Cache la Poudre River.

River Edge Road Culverts

The existing network of natural channels has historically experienced moderate to severe channel erosion as indicated by the magnitude of the incised channel sections throughout the watershed. Minor to moderate erosion of the existing channels continues to occur.

2.2.8 Bluff Basin

The Bluff Basin is located immediately south of the Cache la Poudre River between WCR 13 and State Highway 257. Limited development has occurred within or adjacent to the basin. Development planning has been initiated in the portion of the basin located immediately west of WCR 17. The Bluff Basin also incorporates a large portion of the Cache la Poudre River floodplain between WCR 13 and State Highway 257.

Given the topographic relief within the basin, no major drainageway exists. Runoff generated within the upper portion of the watershed concentrates along the bluff and results in

the formation of gullies that convey the stormwater runoff to the lower portion of the watershed. At the base of the bluff, the drainage system transitions from the gullies to a less concentrated system of drainage swales. At this location, the Eaton Ditch, generally located along the base of the bluffs, intercepts stormwater generated within the watershed. Given the limited capacity of the Eaton Ditch, minimal stormwater will be conveyed out of the basin. That portion of the stormwater not captured and conveyed within the Eaton Ditch will overtop the ditch banks and spill onto the floodplain of the Cache la Poudre River.

Channel erosion associated with the drainage system is evident given the topographic relief associated with the basin and the magnitude of the existing gullies. The gullies continue to actively erode and produce sediment that is accumulated along the base of the bluff.

2.2.9 Oklahoma Basin

The Oklahoma Basin represents the largest of the drainage basins located south of the Cache la Poudre River. This basin is also characterized by its lack of development and largely agricultural land use. Limited development has occurred along WCR 15 adjacent to the Bluff Basin and along U.S. Highway 34, which traverses the upper portion of the basin.

Similar to the River Ridge Basin, a well-defined drainage network including the existence of the major drainageway conveys runoff generated within the basin. The channel associated with the major drainageway becomes evident west of the intersection of WCR 17 and WCR 60. From this point, stormwater captured by the main channel and its tributary channels flows in a northeasterly direction to the Cache la Poudre River. The main channel varies in bottom width from 5 feet to 10 feet and is moderately to deeply incised within the contributing watershed.

As stormwater runoff is collected by the main channel in the upper watershed, it is conveyed under WCR 17 in a reinforced concrete box culvert (8.5'H x 5.5'W). At this location, the road embankment associated with WCR 17 creates an inadvertent detention area within the deeply incised channel. Runoff released through the box culvert is conveyed in the main drainage channel located adjacent to the alignment of the Great Western Railroad. Approximately one mile downstream of the WCR 17 crossing, the main channel crosses the

Weld County Road 17 Culvert

Great Western Railroad tracks in an arched corrugated metal pipe (9'H x 12'W). East of the railroad crossing, the stormwater conveyed in the main channel is combined with runoff collected by a major tributary located along the east portion of the basin. Directly northeast of this location, storm flows are conveyed under the bridge crossing (width of 60 feet) of State Highway 257 before reaching the confluence of the Cache la Poudre River.

The main channel and tributaries are deeply incised within the watershed. Wetland grasses and shrubs dominate the vegetative cover along the bottom of the channel. Similar to the River Ridge Basin, the existing network of natural channels has historically experienced moderate to severe channel erosion as indicated by the magnitude of the incised channel sections throughout the watershed. Minor to moderate erosion of the existing channels continues to occur.

2.2.10 South State Highway 257 Basin

The watershed associated with the South State Highway 257 Basin is noted by its wide range of topographic relief and relatively small drainage area. In the upper portion of the basin, a relatively shallow slope is reflected by the largely agricultural land use. The shallow slope of the agricultural land quickly transitions to the middle portion of the basin that is characterized by moderate to steep terrain with numerous incised tributary channels and gulleys. The lower portion of the watershed, north of State Highway 257 reflects a landform typical of the floodplain area associated with the Cache la Poudre River. In general, land use within the South State Highway 257 Basin is largely agricultural with development encroaching along that portion of the upper basin located adjacent to the U.S. Highway 34 corridor.

Given the basin characteristics, stormwater runoff efficiently travels through the watershed from the southeast to the northwest. The main drainage channel is well defined, either as a channel or swale, which generally parallels State Highway 257 until it crosses under the highway and confluences with the Cache la Poudre River. At the crossing of State Highway 257, two reinforced concrete box culverts (two 6'H x 10'W) have been installed to convey storm flows within the channel.

State Highway 257 Culverts

Similar to the Oklahoma Basin, vegetation along the bottom of the channel

consists of wetland grass and shrubs. The overbank area is vegetated with dry rangeland grasses and shrubs. Consistent with the majority of the basins located south of the Cache la Poudre River, the existing channels have historically experienced moderate to severe channel erosion as indicated by the magnitude of the incised channel sections throughout the watershed. Minor to moderate erosion of the existing channels continues to occur.

The drainage features along with the limits of the 100-year floodplain associated with the Cache la Poudre River and the Law Ditch Drainageway are presented on the existing drainage facilities map provided on Sheets 1A and 1B.

Sheet 1A and 1B presents a map illustrating the major drainageways and major crossing structures within the basins along with the location of the major tributaries to the drainageways. A detailed description of the existing detention facilities/reservoirs, conveyance facilities and major road crossings, is provided in Chapter 3.