Site and Reach Assessment
Dry Creek at US97

Garrett Jackson, Hydrologist
Jim Park Senior Hydrologist
WSDOT Environmental Services
Hydrology Program
January, 2012
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1.0. Introduction

United States Route 97 (US97) crosses Dry Creek several miles west of Ellensburg, at milepost 137.9 (Figure 1). At the highway, the stream flows through a double concrete box culvert, each opening being six feet high and nine feet wide. During the January, 2009, storm event, the stream jumped its banks and flowed into the ditch on the west side of Ellensburg. The ditch carried water and sediment into West Ellensburg, contributing to localized flooding. This flooding caused severe damage to infrastructure and private property. Prior to that storm event, there have been several other instances in which the culvert and highway have been affected. The Clarke Road bridge, upstream from the US97 culvert, regularly experiences damage and was replaced completely after the January 2009 event.

The Department of Transportation and the Kittitas County are both seeking to minimize the risk of flooding and flood damage from Dry Creek. This report provides background on the creek, the crossing, and potential solutions due the recurring problems in the stream corridor.

During the construction of US97 in this area, Dry Creek was straightened and channelized (see Figure 2). The channel was excavated into a trapezoid 70 feet wide at the top. The creek was realigned in a segment 1685 feet in length. The plans show a drainage easement. The easement still exists for this portion of the channel. An arch culvert 10’3” high was installed. The current stream crossing was built in 1970. This report analyzes site conditions, history, and reach geomorphology, and concludes that Dry Creek is highly unstable, and recommends that a betterment project be undertaken to reduce objective risks associated with the site and prevent future repetitive Emergency Project efforts and expenditures.
Figure 1. Project location map. Note: watershed boundary shown includes only the area upstream from US97.
2.0. Methods

This study included literature and data review as well as field reconnaissance. We also conducted synthesis of relevant aerial photos, ground photos taken at the site, topographic maps, geologic maps and reports, fish distribution data, and hydrologic data. Sources of information include:

- Ground photos obtained by environmental staff during site visits in 2010.
- GIS coverages of 24K USGS topographic maps, soils, geology, water quality, land use, zoning, and fish distribution for this area.
- Fish distribution information available from the Washington Lakes and Rivers Information System (WLRIS).
- Engineering records from WSDOT headquarters.
- Existing literature and data, as listed in the “References” section of this report.
3.0. Existing Environment

3.1 Watershed Conditions and Land Cover

Dry Creek drains an area of 66.8 square miles above SR97. The area is semi-arid, receiving about 12 inches of precipitation on average, annually. The upper part of the watershed is a little over 3900 feet in elevation at its highest, while the outlet of Dry Creek at the Yakima River is 1540 feet above mean sea level.

The watershed is mostly privately owned, with a very small portion being in the Wenatchee National Forest. Most of the land is used for cattle grazing (Figure 2). A significant portion of the watershed is irrigated for pasture for grazing. Otherwise there are no towns and few buildings. Within the floodplain of Dry Creek there is very low density rural development.

Land cover is predominately grassland and pasture, with a significant portion of scrub/shrub. A small amount of evergreen forest is present in the upper reaches of the watershed.

3.2 Geology and Soils

The Dry Creek watershed is part of the Wenatchee Mountains. It occupies an area in the lower foothills of the mountains that probably did not directly experience glaciation during the Pleistocene glaciations. Much of the watershed is, however, covered in sediment from various glacial deposits higher in the mountains.

Exposed in the highest portions of the Dry Creek watershed are igneous rocks of the Columbia River Basalt Group (CRBG). This section of the CRBG includes various basalt flows and volcaniclastic deposits. The CRBG corresponds roughly to the more rugged upper watershed (units Mv(c) and Mv, Figure 3). Within this portion of the watershed, a series of deep-seated landslides within the CRBG is present. This type of landslide is common at this elevation in the surrounding area of the Wenatchee Mountains. The relative level of activity of these landslides is not indicated on the geologic map. In the middle watershed, Pliocene glacial deposits (the Thorp Gravel; Waitt, 1979) form a semi-continuous surface that roughly represents the original deposition surface. This surface is dissected the first order tributaries of Dry Creek. The swales cut by these tributaries are up to 200 feet deep, exposing the underlying CRBG rocks in various places.

The lower watershed is covered by Pleistocene glacial drift and outwash, and Holocene alluvium in the floodplains. The glacial drift is part of the Green Canyon alluvial fan. The Holocene alluvium is inset into the alluvial fan and in parts of the incised Thorp Gravels surface. The lowermost portions of the watershed, including the project area, are covered with Holocene and historic alluvium.

The headwaters of Dry Creek drain a series of landslide deposits. These landslides cover a 1.8 square mile area of the upper watershed (2.7 percent of the watershed above US97). These landslides may be providing considerable amounts of sediment to Dry Creek.

There is a fault upstream from the project that offsets the Thorp Gravels and pre-Fraser alpine glacial drift. The amount of offset is not known, but may have affected local stream geomorphology by steepening the stream gradient, since the upthrown block is on the downstream side of the fault.
Figure 2. Land use.

Source: Land cover: NOAA Ocean Services Center, 2006; Land use: Ecology, 2009
Figure 3. Generalized geology of project area.
Source: WA state Dept of Natural Resources GIS layer, 2011.
3.3 Geomorphology

The modern valley of Dry Creek is a product of a complex sequence of stream capture during the last 1 million years or so. Initially, Green Canyon had a tributary that reached much higher into the Wenatchee Mountains (Waitt, 1979). However, Swauk Creek, which is the next major drainage to the west, also had a tributary also reaching up in the same area, following a natural weakness caused by faulting (See Figure 3). This tributary “captured” the drainage of the tributary of Green Canyon Creek, leaving it with much less runoff, and likely very little snow melt. It is likely that de-glaciation during the end of the Pleistocene epoch contributed to the capture of Green Canyon’s upper watershed by First Creek, or at least accelerated it.

The Dry Creek watershed is composed of surfaces of several different ages. At the headwaters is highly dissected terrain that is underlain by landslides within the CRBG. Immediately below that, the finer tributaries emanating from the landslides flow into entrenched swales in Pliocene sediments of the Thorp Gravel (Cheney and Hayman, 2007). Much of the runoff in Dry Creek emanates from this portion of the watershed. Another significant amount of runoff comes from Green Canyon itself. A very small portion of the former upper watershed continues to drain into Green Canyon. Green Canyon Creek flows on the west side of a large alluvial fan that is underlain predominantly by Pleistocene glacial outwash gravels. A portion of this alluvial fan also has received sediment from the adjacent Reecer Creek. The fans from both creeks merged sometime during the Pleistocene. Much of this alluvial fan was likely formed during the Inset within the older alluvial fan are Holocene sediments, presumably deposited by Green Canyon Creek after losing the headwater drainage to First Creek. Finally, lowermost in the valley cross-section are recent alluvial deposits and the active channel of Dry Creek.

It can be seen from the photo comparison in Figure 4 that the channel, prior to European settlement, had a braided character. The photograph from 1942 highlights the multiple channels at the lower end of the valley. Braided streams have multiple, shallow, anabranching channels. This pattern is evident in Figure 4. Braided channels are typical of a “transport-limited” stream. This means that there is more and/or larger sediment than the stream can transport efficiently.

The majority of the flow appears to have been along the east side of the valley floor. From the photographs, it is apparent that Dry Creek was channelized to allow for a single siphon on the Kittitas Reclamation District Canal at Clarke Road. It was channelized for some distance below the road, and perhaps for much farther down the valley. The channel appears to have been re-routed through a minor channel. The construction of US97 used that location for a stream crossing. Between 1942 and 1966, a section of channel upstream from the highway culvert was straightened, cutting off about 900 feet of channel. The line of trees forming a gentle arc in the 2009 photo indicates the former channel alignment in this reach.

The floodplain of Dry Creek is wide and very flat. Two cross-sections typical of it are shown in Figure 5. The entire valley floor is about 1000 feet wide, while the channel is only about 5 feet deep. Seven cross-sections were surveyed in January of 2011. We selected locations for cross-sections that appeared to be least affected by human activity. The average bankfull width from cross-sections upstream and downstream of the highway crossing was 102 feet. The average bankfull depth was about 5 feet. Dry Creek has an average gradient of about 1.2%.

The stream sediment is composed predominantly of gravel, subdominantly with cobble, and with minor amounts of sand. The sediment is coarse probably because of the steep gradient and abundant sediment supply.
There are points along the channel upstream of the highway where photographs indicate the channel has jumped its banks (avulsed). Furthermore, when the topographic maps from the survey done for the current project are superimposed on the aerial photograph (Figure 6), it is evident that there are natural low points outside the current stream channel to which any floodwaters would flow. The overflow paths are highlighted with red lines in this figure. The flow path along the highway was flooded during the 2009 storm event.

The channelization of Dry Creek is a fundamental change from a multiple channel, branching stream to a single channel. Braided streams have floodplains that are sediment storage sites. The multiple channels shift frequently, as they drop out sediment. A single thread channel, cut in a straight line, is disconnected from the floodplain. Dry Creek is disconnected from the floodplain during all but the highest flows (greater than 100-year). The only place for sediment storage is in the channel. Given that there is likely a high sediment load and that the stream is transport limited, it can be expected that the stream will adjust over time by depositing sediment in the channel, increasing the tendency to avulse (abruptly change course) onto the adjacent floodplain. In its current configuration, the Dry Creek channel is highly unstable and poses a significant objective hazard to the highway and adjacent populated areas. The current alignment contributes to the risk of damage to the highway and flooding in West Ellensburg.

The cross-sections in Figure 5 show that there are old channels on the east side of the floodplain. These channels indicate potential flow paths should the stream overtop its banks (Figure 6). One of these flowpaths was activated during the January 2009 flood.
Figure 4. Comparison of aerial photographs of project area, showing the evidence for braided channels.
Figure 5. Cross-sections at Dry Creek floodplain. Upper: station 5306.7; Lower: station 5585.9.

Note: See Figure 6 for cross-section locations. View is looking downstream.
Figure 6. Cross-section locations (green lines), and potential overflow paths.

Note: Based on topography surveyed 2011.
3.4 Hydrology and Flow Conditions

Climate and runoff

The Dry Creek watershed is typical of drainages on the east slope of the Cascades Mountains. The climate is temperate but moderated somewhat by the proximity to the coast. Winters are cool and moist, while summers are hot and very dry. In this area, onshore flow across the Cascades from the west contributes to a high average wind speed. Runoff is dominated by a strong snowmelt peak in late spring. However, the watershed also experiences “rain-on-snow” events, such as the January 2009 storm. This type of flood, occurring when there is snowpack low in the watershed followed by warm, wet storms, may be the cause of the highest peak flows. In addition, ice in the channel may play a significant role in flooding. Not enough is known about the contribution of ice to make a definitive statement. However, observations by WSDOT maintenance staff indicate that Dry Creek was not affected by ice as much as other rivers during recent flooding in the area.

There are no gages on Dry Creek and therefore there is no flood data. However, several stream discharge measurements were made by the Department of Ecology in 1999/2000. They reported a minimum discharge of 1.5 cfs in early April, and a maximum discharge of 19 cfs in early summer (Evans and Larson, 2000). Dry Creek goes dry during the summer months, though there is no record when it typically goes dry.

Although the United States Geological Survey (USGS) gage at Naneum Creek had a similar drainage area (its use was discontinued in 1978), the elevation of the watershed was on average much higher than in the Dry Creek watershed. In addition, nearly all of the Naneum Creek watershed above the gage site is forested. Thus the Naneum gage did not serve as a reasonable representation of stream flow for Dry Creek.

The next best method for estimating peak flows is to use regressive regression equations. The equations developed by the USGS incorporate a number of variables into the equation, so that the peak flow can be estimated based on existing gage data and certain watershed parameters. The USGS website StreamStats provides a quick way of using these equations for any place in Washington State. This method was used for Dry Creek; the basin was delineated and the website generated peak flows for various return intervals. Table 1 shows the results of the analysis. The 100 year flow was estimated at 893 cfs, while the 2 year flood was estimated at 214 cfs.

Irrigation

The flow patterns in Dry Creek, particularly during the spring snowmelt, are affected by water diversion. Since the late 1800s, area property owners on both sides of US 97 in the project area have diverted irrigation water from Dry Creek via series of trenches for flood irrigation practices (via water right claims). According to Kirsch (1996), water from First Creek is diverted into the Dry Creek drainage at Green Canyon. A total of 3.9 cfs and 435 acre-feet is granted for seasonal irrigation and stock watering. This irrigation uses up to five diversion points on Dry Creek upstream and downstream of US 97, all located within the project area. It is assumed that some of the water rights supply water to adjacent lands owned by Hand and Clarke [Claim 00692 and Claim 01767, respectively].

Below the Clarke Road bridge, flows in Dry Creek are assumed to be a combination of both natural flows (although intermittent and sometimes nonexistent) and return flows from Kittitas
Reclamation District (KRD), a junior water right holder. WSDOT does not know if the property owners also divert and use any KRD water from Dry Creek (or other source), nor the quantity used, if any. Review of the Yakima Adjudication Superior Court records shows diversion methods (flood irrigation) and features, including pond storage areas, as well as irrigated lands in the project area. These methods and practices continue today. However, based on review of the court records and aerial photos, it appears the amount of land that is flood irrigated has increased.

A network of diversion ditches stems from the creek in the project area (Figure 7). This type of irrigation is for pasture. The low slope channels deliver water by sheet flow, or a wide, very shallow flow across a broad area. The extensive wetlands present in the Dry Creek valley east and south of Dry Creek are likely a result of this irrigation. Some of the diversions have been moved due to the straightening of the Dry Creek channel over time.
Figure 7. Map showing irrigation ditches and diversion points in the project reach.

Note: Channel mapped by the USGS in 1958. Some diversion points are still mapped along this reach. The channel has been straightened since the USGS topographic map was produced.
<table>
<thead>
<tr>
<th>Return Interval (yr)</th>
<th>Discharge (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>214</td>
</tr>
<tr>
<td>10</td>
<td>468</td>
</tr>
<tr>
<td>25</td>
<td>624</td>
</tr>
<tr>
<td>50</td>
<td>753</td>
</tr>
<tr>
<td>100</td>
<td>893</td>
</tr>
</tbody>
</table>

Table 1. Calculated peak flows for Dry Creek at US97. *Source: USGS StreamStats website, 2011.*

### 3.5 Riparian Conditions and Large Woody Debris

Most of the watershed is covered by grass and brush. Only a few trees are present in the uppermost reaches. Within the project reach, there are a few scattered cottonwoods and willows, but no significant riparian canopy. Almost no wood was observed in the active channel during a January 2011 site visit. However, willow thickets present along portions of the channel downstream of the highway culvert provide some canopy. Figure 8 shows a photograph of a typical portion of channel at this location.

### 3.7 Fish Utilization and Habitat Availability

There are no salmonids known to be actively using this reach of Dry Creek. However, neither the culvert at SR97 or at SR10 are listed as fish passage barriers, and Spring Chinook and summer steelhead are indicated by SSHIAP (2010) as using the reach below SR10 for rearing. According to the Washington Department of Fish and Wildlife’s GIS database, there are no known occurrences of Bull Trout in the Dry Creek watershed. Eastern Brook Trout and Rainbow Trout are known resident fish, however.

Figure 8. Riparian zone of Dry Creek, upstream from US97.
4.0. Alternatives considered

This section describes a variety of Alternatives that could be implemented to address flooding and sedimentation in the Dry Creek Valley. Figure 9 shows the basic components of the five alternatives. Table 2 includes brief descriptions of each alternative and its major elements.

4.1 No Action (Alternative 1)

Under this alternative, there would be no new construction at the Dry Creek stream crossing. The levee and channel would be left in place. Any sediment accumulated within the culvert, its inlet, or outlet, would be removed according to standard maintenance schedules.

Damages to the road and the culvert caused by flooding would be treated under emergency circumstances and would be repaired. Mitigation for stream buffer and wetland impacts during emergency repair could be required.

4.2 80-foot Bridge and Minor Channel re-alignment (Alternative 2)

This alternative includes construction of a new bridge immediately south of the existing culvert. The bridge would be 80 feet in length, consisting of a single span with a skew of about 70 degrees. The existing culvert would remain in place to serve as an overflow structure. To align with the new bridge, a section of stream about 80 feet upstream of the culvert would be excavated. Approximately 200 feet of channel re-alignment would be needed on the downstream side to connect with the existing channel. The new channel would have a top width of 80 feet. In addition, the levee on the left bank would be re-created on the new channel segment.

4.3 120-foot Bridge and Major Channel realignment with setback levee (Alternative 3)

This alternative would include construction of approximately 3600 feet of new stream channel. The slope of the new channel would be about 1.2%, slightly lower than the existing channel. A new bridge 120’ in length would span the 100-year flood event and include three feet of freeboard. The bridge length is based on the bankfull width of the channel plus 20 feet for additional floodplain terrace. This would be a 2-span bridge with a skew of about 80 degrees. The bridge would be located approximately 1200 feet south of the existing culverts. The existing twin culverts and channel would remain. No additional right-of-way acquisition is planned. A porous “plug” would be installed at the upstream end of the existing channel, minimizing flow into the old channel in all but the highest flows.

The rest of the old channel would be kept open for use in diversion for irrigation. Diversion points affected by the channel alignment would be re-established at appropriate elevations and locations.

The new channel alignment closely follows old channels within the Dry Creek floodplain. The only exception is lower in the valley the alignment is shifted to the west to minimize impacts to potentially high quality wetlands.

The project includes raising the elevation of Lower Green Canyon Road and Green Spur Road. This would, in effect, replace the non-standard levee that currently exists immediately adjacent to the creek on the left bank, upstream of the existing US97 culvert, with a levee that meets federal standards for infrastructure protection. In addition, two 60” culverts would be installed under SR97, as a safeguard against potential channel avulsion and over bank flooding. These culverts would allow water to drain under the highway and back toward Dry Creek. These “relief” cul-
verts are recommended because the sediment load of Dry Creek is unknown. Although the channel capacity would be designed to accommodate the 100-year flood, that capacity could change if sediment storage develops in the reach upstream of the highway. The culverts will provide another way of draining the floodplain upslope from Lower Green Canyon Road, should a major flood occur and change the channel cross-section. One considerable drawback with this alternative is that the affected landowners have expressed concern about the effects of this alternative on their agricultural use of their land which includes flood irrigation and cattle grazing.

4.4 120-foot Bridge and Minor channel realignment with four relief cross culverts and smaller setback levee. (Alternative 4)

In the event that acquisition of right-of-way for the preferred alternative is not feasible, a hybrid alternative that includes selected elements from Alternatives 2 and 3 may offer the best compromise between long-term risk and maintenance reduction and project feasibility. Under this alternative, a 120 foot bridge would be constructed at the site of the existing culvert. A small amount of channel re-alignment would be needed to center the channel on the new bridge. The levees upstream and downstream of the highway on the stream’s left bank would need to be modified to match the new width of the crossing. These elements are similar to those found in Alternative 2, except that the bridge length is the same is in Alternative 3.

Alternative 4 also includes an important element from Alternative 3. This element consists of raising the elevation of Lower Greek Canyon Road and Green Spur Road to form a setback levee and avulsion prevention structure. This in effect replaces the levee that currently exists immediately adjacent to the creek on the left bank, upstream of the existing US97 culvert. However, the new setback levee in Alternative 4 would be shorter than under Alternative 3. The levee would only extend from the junction of Lower Greek Canyon Road and US97 to junction with Green Spur Road. The levee can be shorter under this alternative since the stream channel is not being relocated.

The last element in Alternative 4 consists of relief culverts that would be installed under SR97, as a safeguard against potential channel avulsion and over bank flooding. These culverts would allow water to drain under the highway and back toward Dry Creek. Relief culverts are recommended because the existing and future sediment load of Dry Creek is unknown. Although the channel capacity would be designed to accommodate the 100-year flood, that capacity could change if sediment storage develops in the reach upstream of the highway. The culverts will provide another way of draining the floodplain upslope from Lower Greek Canyon Road, should a major flood occur and change the channel cross-section. Culverts would be a minimum of 60 inches in diameter. The recommended culvert locations are shown in Figure 9.

Note that there would be no major channel re-alignment under this alternative, and construction would be almost entirely within the existing right-of-way.

4.5 80-foot Bridge with five relief culverts and smaller setback levee (Alternative 5)

This alternative would include the replacement of the existing culvert, with an 80-foot bridge in its place. The bridge’s north abutment would be in approximately the same location as the existing culvert’s north wall (or right wall when viewed looking downstream). In addition, this alternative would include the installation of 5 relief culverts. These culverts would be either concrete box or bottomless arch types, and would be 20 feet wide. The relief culverts would be placed at existing topographically low points along the US97 right-of-way. Lower Green Canyon Road
would be reconstructed in place to serve as a setback levee. This would elevate the surface of the road.

This alternative avoids any acquisition of land off the right-of-way, while providing a large amount of capacity for sediment and water transport under the highway, should Dry Creek overtop its banks. The total cross-sectional area of the culverts is about the same as the area of Dry Creek at bankfull depth. Notably, because there would be no channel re-alignment, or guiding of overbank flows to the relief culverts, it is unknown how these flows would be distributed amongst the relief culverts. The culverts are placed to take advantage of existing lows, but during a flood, avulsion and sedimentation could rapidly change the course of overbank flows. The locations of the culverts are shown in Figure 9.
Figure 9. Schematic of potential treatment alternatives.
### Table 2. Comparison of Alternatives

<table>
<thead>
<tr>
<th>US97 Dry Creek Alternative Comparison</th>
<th>Major elements of alternatives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alternative</strong></td>
<td><strong>Channel relocation</strong></td>
</tr>
<tr>
<td>Alt 1</td>
<td>No Action</td>
</tr>
</tbody>
</table>
| Alt 2 | Install bridge next to culvert  
- With existing culvert to remain as overflow structure | None | 80 feet | None | None | May require levee maintenance easement revision |
| Alt 3 | Re-locate main channel to low terrace  
- With flow splitter/plug at old channel  
- Existing culverts and channel to remain | 3600 feet of new channel | 120 feet | Two 60 inch | Along Lower Green Canyon Road & Green Spur Road | Two parcels on east side of SR97 |
| Alt 4 | Replace culvert with larger bridge and add relief culverts | None | 120 feet | Four 60 inch | Along Lower Green Canyon Road only | May require levee maintenance easement revision |
| Alt 5 | Replace culvert with smaller bridge and large capacity relief culverts | None | 80 feet | Five 20-foot (box or arch) | Along Lower Green Canyon Road only | May require levee maintenance easement revision |
5.0 Environmental Effects of Alternatives

This section describes potential floodplain environmental effects of the alternatives.

5.1 Flood hazard & channel stability

Under the no action alternative, during extreme flooding, Dry Creek could flood into one or both of the identified overflow channels, possibly contributing to flooding to West Ellensburg. The highway could be damaged as well, with the potential damage to the culvert, the road embankment and pavement. US97 would continue to experience closures during flood emergencies that result in road damage and subsequent repairs.

Various peak flows were modeled with HEC-RAS, using topography recently obtained from ground surveys. Steady flow was assumed. Figure 10 shows two cross-sections, and how the old side channels can be activated. In this model run, the levee was not specifically designated as blocking flow to the floodplain, simulating a levee breach. This gives an idea of the potential effect of channel avulsion. Initial results of the model indicate containment of the 100-year flood within the existing channel. Since it is documented that the stream avulsed out of its channel, there may have been ice blocking the culvert, or a combination of ice and coarse sediment. Additional modeling is being conducted to both address this potential issue and to aid in development of the conceptual design.

Under Alternative 2, the capacity of the stream channel for water and sediment would be increased. The wider bridge would allow for more water and sediment (and ice) to pass through. However, the channel capacity upstream would remain the same. The long term sediment buildup in the channel would eventually re-create the risk of avulsion present now. Not enough is known about the sediment transport to predict when Dry Creek would avulse again. However, we can speculate that building a bridge would diminish the risk avulsion for at least 10 years. The effects of channel avulsion could be similar to that experienced during the 2009 flood. The highway embankment could be eroded, resulting in lane closures. Flooding could happen downstream in West Ellensburg.

Alternative 3 addresses the long term risk associated with channel avulsion, and thus would provide the most assurance for minimized flood hazard. With a wider bridge than alternative 2, and with more channel capacity, the space available for water and sediment transport would be greatly increased. In addition, the new channel alignment would allow for re-connection of the channel with the floodplain. There would be potential for temporary storage of sediment within the floodplain. While the channel would initially be a single thread, it is expected that some braiding within the channel would occur. With the channel’s expanded capacity, the ability to interact with the floodplain and store sediment, the conveyance would be better maintained over the long term compared to the alternatives. The risk of avulsion and its consequences would be minimal for several decades under this alternative. In addition, should water leave the re-aligned channel, the setback levee incorporated into Lower Green Canyon Road/Green Spur Road would prevent water from flowing down US97 and into West Ellensburg.

The set of relief culverts would allow flood waters to drain back to Dry Creek and its mapped floodplain, preventing damage to Lower Green Canyon Road, Green Spur Road, and adjacent and downstream properties that are not designated floodplains. We anticipate that these culverts would have no deleterious effects. Most of the time there would be no flow in them. Under extreme flood conditions, there would be flow, but likely it would be quiescent, as it would be
shallow and spread across the floodplain. Flow on the downstream side would follow natural low points in the floodplain.

Alternative 4 presents a compromise between effectiveness and feasibility. Placing a wider bridge than Alternative 2 increases both the effectiveness and periodicity of resistance to sedimentation problems, with more space available for sediment and water passage. The setback levee would prevent avulsions or overflows from entraining against the road prism and damaging the highway. The set of relief culverts would allow flood waters to drain back to Dry Creek, preventing damage to Lower Green Canyon Road, Green Spur Road, and downstream properties. We anticipate that these culverts would have no deleterious effects. Most of the time there would be no flow in them. Under extreme flood conditions, there would be flow, but would likely be quiescent, as it would be shallow and spread across the floodplain. Flow on the downstream side would follow natural low points in the floodplain. Because there is much less channel re-alignment work involved in Alternative 4 than Alternative 3, the excavation and right-of-way costs of the project will be considerably reduced while still protecting the highway and delivering flood control and damage reduction benefits. Like Alt 2, diminish risk avulsion for 10 years or so or??

Alternative 5 would greatly increase the water and sediment transport capacity and also provide a large amount of capacity should Dry Creek overtop its banks upstream from the highway. Like Alternative 4, this alternative avoids property acquisition. There would be more relief culverts, and they would be larger, but still no deleterious effects would be anticipated.

5.2 Debris
Because there is very little riparian forest upstream of the bridge site, there is a low amount of wood debris loading. While no detailed riparian survey was conducted for this study, it can be seen from historical and recent aerial photographs that large wood debris (LWD) supply, recruitment, and transport is not an issue on this stream. Therefore all three alternatives are similar with respect to LWD, having little or no effect.

5.3 Irrigation diversion
Under Alternative 4 the minor re-alignment of the channel would have little effect on the current irrigation diversion. New diversion points would likely be needed to allow continued irrigation for pasture. Some length of new diversion ditches would also be needed. Under Alternative 3, more diversions would likely be affected, and more new ditches would be required to maintain irrigation, than under Alternative 4 or Alternative 2. There is also a new diversion (with fish screen) downstream from the existing Dry Creek crossing that would need to be moved. Under Alternative 5, no irrigation diversions or conveyance ditches would be affected.

5.4 Aquatic habitat effects
Under the no action alternative, there would be no change in the aquatic habitat on site.

Under Alternative 2, the small amount of channel re-alignment would take water away from the existing habitat in that reach. However, the habitat lost in the old channel would be replaced by that of the new channel.

Alternative 3 would create more aquatic and riparian habitat. The re-aligned channel would be somewhat longer than the current channel, and would be re-vegetated. Its cross-sectional area would be greater than the current channel.
Under Alternative 4, the smaller amount of channel re-alignment would shift the watercourse only slightly in relation to the existing habitat in that reach. However, the habitat lost in the old channel would be replaced by that of the new channel. The channel would be wider, so alternative 4 provides slightly more aquatic habitat than Alternative 2.

A small amount aquatic habitat would be disturbed under Alternative 5, near the existing culvert. This would be temporary, during bridge construction.

Figure 10. Comparison of estimated water surface elevation at cross-sections 5585.8 (upper) and 5306.7 (lower). Note that the old side channels are activated.
5.4 Wetland effects

During the documentation and analysis of the initial betterment proposal in August 2010, WSDOT delineated wetlands immediately up and downstream of the existing culverts. WSDOT plans to delineate areas associated with the proposed project in March/April 2011. However, until we are able to complete delineation for the proposed project, WSDOT conducted preliminary analysis based on the previous delineation to estimate potential wetland impacts. WSDOT used both digital and field data that have been compiled, including adjacent vegetation patterns. The current (and past) land use and farming practices also factored into the analysis to determine which wetlands were jurisdictional. WSDOT reviewed aerials, topographic info and irrigation practices and preliminarily concludes that some parts of the irrigated pastureland would not be jurisdictional.

Some amount of wetlands would be disturbed under each of the four action alternatives. Wetland mitigation is normally achieved through negotiated mitigation ratios.
6.0 Regulatory Environment

6.1 Consistency with existing watershed and floodplain

A new bridge (under Alternatives 2, 3, and 4) would be in the floodplain roughly at the site of the existing culvert. The opening underneath may vary, subject to further design. The bridge and re-aligned channel (under Alternative 3) are consistent with existing uses of the floodplain. The highway already crosses the entire width of the valley, and there are several other existing bridges located not far upstream. The valley is used for pasture and there are no other uses or structures that would be affected. Lower Green Canyon Road and the Green Spur would be raised, but otherwise not substantially modified. Lower Green Canyon Road would be repaved. The Dry Creek Valley is rural and zoned for low density. As such, the proposed project is consistent with current watershed activity and conditions. However, Alternative 4 is more compatible with the property owners’ current ranching practices than the other alternatives.

6.2 Permits required

Kittitas County has regulatory authority for issuing flood hazard permits for the construction of any fill or structure within the 100-year floodplain and floodway associated with Dry Creek. The Kittitas County Code requires demonstration that such a project will not raise the base flood elevations, and compensatory mitigation for filling the 100-year floodplain if complete avoidance cannot be achieved.

The permits identified that would be necessary for the recommended alternative include the following:

**Kittitas County**

- Floodplain Development. (Kittitas County Code, Title 14.08 and Title 17A)
- Kittitas County Critical Area Ordinances (Kittitas County Code, Title 17A) for regulated wetlands and Dry Creek (DNR Type 2/Type F Stream) (compliance and consistency with a permit or just approval and review).

**Washington State**

- Hydraulic Project Approval (Washington Department of Fish and Wildlife).

**Federal**

- Section 404, Clean Water Act, Individual Permit (U.S. Army Corps of Engineers and U.S. Environmental Protection Agency).
- Section 7, Endangered Species Act, consultation (Chinook salmon) (U.S. Fish and Wildlife Service; National Marine Fisheries Service).
7.0 Recommendations

To minimize the risk to the highway, Kittitas County roads, private property, and West Ellensburg, and to minimize future maintenance costs, a new bridge and channel must be designed that reflects, as much as possible, the natural water and sediment transport capacity and continuity.

Alternative 3, of the alternatives considered, most closely recreates the sediment transport capacity prior to highway construction. The preliminary channel design includes the full bankfull width and depth, plus a small amount of floodplain terrace. The channel would be able to contain all but the highest peak flows (greater than 100-year), including sediment load. The proposed channel alignment also reduces risk of avulsion by virtue of its location – in the naturally occurring old channels of Dry Creek, which are lower in elevation than the existing channel. This alternative would provide a long-term solution to highway maintenance and flooding.

However, given potential constraints of property acquisition and rights-of-way, Alternative 5 is recommended. This alternative would provide a reasonable level of highway protection, through providing water and sediment transport capacity, and by providing contingency infrastructure (relief culverts and a setback levee), to address extreme flood events and near-term (20 years) changes in channel capacity due to aggradation. These relief culverts, in comparison to Alternative 4, provide a great deal of sediment and water transport capacity, in the event of channel avulsion upstream of the highway. In addition, this alternative will protect the highway at a lower cost than Alternative 3.
8.0. References.


Washington State Department of Fish and Wildlife. Salmon and Steelhead Habitat Inventory and Assessment Project (SSHIAP). http://wdfw.wa.gov/hab/sshiap/.

Washington State Department of Transportation. Bridge Engineering Information System (BEIST).