REPORT

100 PERCENT BASIS OF DESIGN REPORT
WDFW CULVERT IMPROVEMENT PROJECT

Prepared for

U.S. Bureau of Reclamation

1150 N. Curtis Road, Suite 100

Boise, Idaho 83706

Prepared by

Anchor QEA, LLC

1605 Cornwall Avenue

Bellingham, Washington 98225

March 2013

100 PERCENT BASIS OF DESIGN REPORT WDFW CULVERT IMPROVEMENT PROJECT

Prepared for

U.S. Bureau of Reclamation
1150 N. Curtis Road, Suite 100
Boise, Idaho 83706

Prepared by

Anchor QEA, LLC
1605 Cornwall Avenue
Bellingham, Washington 98225

March 2013

TABLE OF CONTENTS

List of Accompanying Documents

Construction Drawings (11 sheets)

Construction Technical Specifications

Opinion of Probable Construction Costs

Guardrail Lengths of Need Calculations

LIST OF ACRONYMS AND ABBREVIATIONS

%	percent
AER	Alternative Evaluations Report
AASHTO	American Association of State Highway and Transportation Officials
cfs	cubic feet per second
CPAA	Conceptual Project Alternatives Assessment
ESA	Endangered Species Act
H:V	horizontal to vertical
LiDAR	Light Detection and Ranging
MSRF	Methow Salmon Recovery Foundation
MVID	Methow Valley Irrigation District
Reclamation	U.S. Bureau of Reclamation
RM	river mile
RTT	Regional Technical Team
WDFW	Washington Department of Fish and Wildlife
WSDOT	Washington Department of Transportation

1 PROJECT DESCRIPTION

Anchor QEA, LLC, was retained by the U.S. Bureau of Reclamation (Reclamation) to complete a 100 percent design for the Washington Department of Fish and Wildlife (WDFW) Culvert Improvement Project. This project is proposed to be constructed in the summer 2013. The purpose of the project is to increase and improve the presence and quality of juvenile salmonid (off-channel) habitat to benefit the abundance and productivity of Endangered Species Act- (ESA-) listed salmonids in the Methow River. The project site is located within the western (right bank) floodplain of the Methow River north of the Town of Twisp in Okanogan County, Washington, on land owned by WDFW and two private landowners, between approximately river miles (RM) 46 and 45.5.

The 100 percent design includes two bottomless culverts and approximately 930 linear feet of enhanced floodplain channels, referred to herein as channels. The channels are identified as Alcove Channel A and Channel B, downstream to upstream, respectively. Activation of these channels, in combination with the culvert installations, will create approximately 1,800 feet of off-channel habitat within the floodplain and improve the hydraulic connection to an existing wetland that is currently isolated from the river and floodplain by the Old Twisp Highway, which contains only a perched, undersized, and deteriorating culvert. Riparian re-vegetation, maintenance, and monitoring will occur under a separate contract and is not included as part of this report.

This basis of design report includes a description of each design element and the relevant assumptions and analyses completed as part of the 30, 60, 90, and 100% engineering design processes. Additional relevant studies that have been completed include:

- *The Methow Subbasin Geomorphic Assessment* (Reclamation 2008)
- *The Middle Methow Reach Assessment* (Reclamation 2010)
- *Conceptual Project Alternatives Assessment* (CPAA) (Anchor QEA 2010)
- *30 Percent Design Report Upper Middle Methow Reach WDFW Floodplain* (Anchor QEA 2011a)
- *Alternatives Evaluation Report* (AER) (Anchor QEA 2011b)
- Groundwater Assessment of WDFW Floodplain – Memo (Anchor QEA 2011c)

- *Draft 60 Percent Basis of Design Report WDFW Culverts and Alcove Channel Project* (Anchor QEA 2012a)
- *Final 90 Percent Basis of Design Report WDFW Culverts Improvement Project* (Anchor QEA 2012b)

As a part of the CPAA, AER, and 30% design efforts, an extensive groundwater channel and wetland complex was proposed and evaluated. This channel network would have begun in the right bank floodplain opposite the Methow Valley Irrigation District (MVID) East intake in the main channel Methow River and traversed the floodplain to a location 200 feet north of the current head of Channel B. This channel would have collected groundwater and conveyed flow under the Old Twisp Highway to Plummer Pond and ultimately maintain a year-round connection between Channel A and the main channel. In addition, an extensive wetland complex within the floodplain was considered for enhancement and integration to the groundwater channel network. Anchor QEA conducted a preliminary groundwater availability analysis and developed a technical memorandum suggesting that a groundwater channel could be designed to meet biological objectives and provide a year-round surface water connection between Plummer Pond and the Methow River main channel.

During the evaluation process, concerns were raised with respect to the likelihood of success, persistence through time, and benefits to target species. It was determined that conducting the studies necessary to document an acceptable certainty of success would cost more money than building the project and would require a timeline extending beyond the planning and design timeline for the project. Therefore, additional analysis was not conducted. It was agreed that persistence over time would be highly dependent on future hydrologic conditions, which are somewhat uncertain. The benefits to target species were strongly questioned by the Regional Technical Team (RTT). While the design team did not necessarily agree with the position of the RTT, the full groundwater channel was removed from the design after the 30% submittal.

Wetland enhancement and integration with the groundwater channel was removed from the project because of landowner concerns about creating a mosquito breeding area and the RTT's position that wetland enhancement will not provide a benefit to target species.

Based on discussions with landowners and Methow Salmon Recovery Foundation (MSRF), further design of Channel C was abandoned after the 60% submittal. This was because of uncertain benefits associated with its implementation, as well as WDFW's stated preference for connecting a groundwater channel through this location in the future as opposed to routing a groundwater channel through the Channel B location.

Additional revisions were made to the design based upon the results of Reclamation's 2-D hydraulic model. The model results clarified changes to floodplain connectivity associated with the removal of the upstream levee adjacent to the MVID diversion, as well as natural flow paths under existing conditions once river discharge reaches a 10-year return period event and above. Based on these results, and the stated preference of WDFW described above, it was determined that the north culvert should focus on collecting changes in floodwaters during frequent flood events (2- and 5-year return period discharge events) and routing these floodwaters beneath the Old Twisp Highway. In addition, it was decided that the location for routing floodwaters should be more consistent with natural flow paths during the 10-year and greater return period discharge events. Specific modifications to the design, from the 60% design, as a result of these decisions are detailed in Section 4.

In addition, MSRF has requested that Anchor QEA develop guardrail designs for each of the culvert locations that would follow the standard Washington State Department of Transportation (WSDOT) specifications for guardrails on roadways with similar design speeds. This request was made to satisfy the road and guardrail design requirements of Okanogan County. Designing the road and guardrails to Okanogan County and WSDOT standards requires a small fill of adjacent wetlands (0.01 acres). In the interest of limiting this fill while maintaining the existing pavement width, the road and guardrail design reflects the variance grated by the County to allow 2 feet of paved width on either side of the road to be considered shoulder width (OCPW 2013). The guardrails in the 100% design package represent this request and standards variance from the County. See Section 4.2 for additional details.

2 ASSUMPTIONS AND CONSIDERATIONS

Assumptions and design considerations relevant to the functionality and performance of the project design elements include the following:

- **Subgrade soils:** Geotechnical borings or other means of subgrade characterization have not been completed within the Old Twisp Highway road prism or within the adjacent soils. Observed floodplain soils in the vicinity of the project site include alluvial sands and gravels (Anchor QEA 2011c). Subgrade soils are assumed to be adequate for the specifications of the proposed channels and for culvert placement. Specifications have been developed should unsuitable soils be encountered during construction.
- **Depth-to-bedrock:** Subsurface exploration along the channel alignments has not been completed. Excavation of Alcove Channel A along the toe of the bedrock valley wall may encounter bedrock; modification of the alignment may be required if bedrock is encountered upon excavation. The likelihood of this occurrence is expected to be low based on visual observation along the proposed alignment.
- **Extreme (low recurrence interval) discharge events:** 2-D hydraulic modeling results provided by Reclamation indicate surface flow over the floodplain at an approximately 5-year return period event, and overtopping of the Old Twisp Highway at the 10-year return period event (Reclamation 2010). Although the culverts will convey floodplain flow, they are not designed to minimize the impacts of flooding to existing infrastructure during discharge events equal to or greater than the 10-year return period discharge event.
- **Downstream surface water connection:** The water surface elevation at the downstream end of Alcove Channel A was predicted using a 1-D hydraulic model as described in Appendix A of the WDFW Floodplain 30 Percent Design Report (Anchor QEA 2011a). The results of this model indicate that a surface water connection is maintained between the existing side channel and main river channel throughout the year. Because the alcove channel is hydraulically connected to the river via the existing side channel, deviations from the modeled results, channel migration, sedimentation, and other processes may affect the surface water connection to the alcove channel.

- **Backwater effects:** Currently, high seasonal flows in the main channel backwater low areas of the floodplain near the existing culvert location at the downstream (south) end of the project site. Similar backwater effects are anticipated within the proposed Alcove Channel A.
- **Culvert design:** The two bottomless culverts are neither hydraulically designed nor designed in accordance with fish passage criteria and, therefore, no hydraulic calculations were developed in the design process. It is important to note that the culverts will be constructed based on parameters and criteria indicated on the drawings and described in the specifications and amended, as necessary, depending on the contractor-selected material and construction method for the culvert installations. The geometry of the north culvert is proposed primarily to allow floodplain flow to pass beneath the roadway. The south culvert design is based on allowing the passage of amphibians, small mammals, deer, and other animals beneath the roadway, in addition to channel flow.
- **Irrigation Ditch**: The Fulton irrigation ditch is located up-valley of the project area and overflow from the ditch traverses the right bank floodplain and contributes water to the existing wetlands. The ditch contains flowing water seasonally from around May 15 until the end of September.

3 EXISTING FISH USE

Target species are generally not using the main channel habitats. The species present have been shown to prefer to use the off-channel habitats, which are limited throughout this reach during the low-flow rearing periods. If this preference is true, existing conditions should result in a juvenile population that is carrying-capacity limited, and opening up new habitat that supports juveniles would support additional use for this life stage. This project is designed to provide additional habitat that supports juveniles during these critical low-flow rearing periods.

3.1 Spring Chinook

Spring Chinook emerge in the late winter and early spring from approximately February to April. The spring Chinook fry prefer shallow, slow-moving water with dense cover and they extensively use off-channel and side channel habitat in May and June, especially bushy cover. As the fry grow and become larger, they move to deeper water with higher velocities. Spring Chinook will tend to move out with early peaks of the spring flows, which occur from April 15 to May 30.

3.2 Steelhead

Steelhead emerge in the late spring to early summer from approximately June to early July. The steelhead fry tend to stay along the shallow channel margins and, as they grow, they move into deeper accessible habitat. In the fall (early October to early November), as the river water rises, they move to rearing habitat.

3.3 Plummer Pond

Little documentation exists on Plummer Pond fish use. Fish have access to the pond only during extremely high water, when water backs up from the river. Fish monitoring in the pond began in 2011. Fish were observed during summer 2011. In 2012, main channel water levels did not reach a sufficient elevation to provide fish access to the pond. The pond was not surveyed for the presence/absence of fish in 2012, but there was no obvious indication of a fish kill in 2012.

4 DESIGN COMPONENTS AND ANALYSIS

The proposed design includes installing two bottomless culverts and excavating approximately 930 feet of floodplain channel. The design components should be completed as described in the plans and specifications, Sheets 01 through 11. The following sections describe the design components and relevant design criteria or rationale.

4.1 Channels

The proposed design is expected to maintain a hydraulic connection between the downstream end of Alcove Channel A and the existing side channel of the Methow River during snowmelt and the time period when the Fulton irrigation ditch is in service. The discharge and flow depth within the channels will be primarily dictated by outflow from the irrigation ditch, which currently discharges into the project area between May 15 and the end of September. The exception would be during snowmelt months when groundwater elevations are high and the channel is backwatered from the main channel.

4.1.1 Alcove Channel A

Alcove Channel A is approximately 450 linear feet between the existing wetland pond (Plummer Pond) and the existing perennial side channel. Construction of the channel will require approximately 400 linear feet of excavation at a slope of no greater than 0.008 feet/feet. The channel cross-section has a 2-foot bottom width and 1 horizontal to 1 vertical (1H:1V) side slopes. The elevation of the upstream end of Alcove Channel A is designed to maintain approximately 1 to 2 feet of ponded water depth on the west side of the Old Twisp Highway at an elevation of 1,650 feet. Where the channel passes beneath the roadway, a bottomless culvert (identified as the south culvert) will convey the channel beneath the roadway, as described in Section 4.2.2. The alignment is located through an area of the floodplain that is dominated by shrubs and immature trees. The position of the alignment was chosen to minimize disturbance to existing vegetation. Because the elevation of the proposed south culvert opening is 4.3 feet (invert elevation) lower than the existing culvert, backwater will access the west side of the Old Twisp Highway at a greater frequency than under existing conditions.

The downstream end of Alcove Channel A is designed to tie into the existing perennial side channel at approximately Station 1+88 and an elevation of 1,646.5 (Station 0+00 is at the centerline of the Methow River main channel). 1-D modeling results indicate that main channel water surface elevation at the seasonal flow event (700 cubic feet per second [cfs]) is approximately 1,646.1. Recognizing that this analysis is not precise, model results suggest that backwatering of the alcove channel begins at approximately 910 cfs in the main channel. On average, this will occur approximately 110 days per year (based on the mean daily flow annual hydrograph [Anchor QEA 2011a]), from approximately April 7 to July 25. This period overlaps with the juvenile rearing and migration for both steelhead and spring Chinook, which are looking for these habitats from April to June. Therefore, juveniles will likely be able to access the side channel near the beginning of April (or earlier if some flow exists within Channel A) once the flows begin to backwater into the channel and pond.

As the result of uncertainties in landowner agreements and property sales, Alcove Channel A is shown as an optional bid item on the Bid Set Drawings. If a land use agreement or a property sale is not in place in time for construction, Alcove Channel A will not be completed. Installation of the south culvert is not dependent on the landowner agreement or property sale. In the event that Alcove Channel A is not constructed, the outlet area of the south culvert will be graded back to existing grade at a slope no steeper than 2H:1V and vegetated. Without the excavation of Alcove Channel A, discharge from the south culvert will spread out over the existing area between the road and the river. Topography generated from 2006 aerial Light Detection and Ranging (LiDAR) data suggests that the flow path may initially be to the east before splitting and going to the north and south as the discharge and water level increase. However, the differences in the flow path direction elevations are well within the uncertainty of the LiDAR-generated topography, especially considering obstructions such as logs that may have fallen and moved since 2006. Ultimately, the discharge pattern from the south culvert without Alcove Channel A will not present a significant variation in the local flooding risks compared to existing conditions.

Other than Alcove Channel A becoming an optional bid item, no significant modifications to Alcove Channel A were made during the 100% design process.

4.1.2 Channel B

The alignment of Channel B is approximately 480 linear feet and located between the northwest edge of the existing wetland and the upstream side of the north culvert. The channel slope is approximately 0.002 feet/feet between Stations 20+23 and 15+30. Upstream and downstream of the north culvert, the channel cross-section has a fixed top width of 20 feet (to minimize disturbance to existing vegetation) and a variable bottom width. Upstream of Station 18+00, the channel cross-section has 4H:1V side slopes transitioning to 2H:1V side slopes by Station 17+48 and continuing with 2H:1V side slopes down to Station 15+30. The upstream end of Channel B ties into the existing floodplain surface elevation east of the Old Twisp Highway. A low profile side cast berm is located on the right bank of the channel at Station 20+50. This small berm will direct flow coming down the floodplain into the channel up to the 5-year event. For discharges greater than the 5-year event the channel is anticipated to continue to direct a portion of floodplain flows towards the north culvert, however, flow will also continue directly to the south as it does in existing conditions. The downstream end of the channel cut ties into the ground surface elevation of the existing wetland to minimize disturbance within the wetland area.

No significant modifications to Channel B were made during the 100% design process.

4.2 Proposed Culverts

The plans and specifications present three culvert construction methods/materials with final selection determined by the bid-awarded contractor. The proposed culverts are bottomless and the three methods/materials are: ribbed aluminum box culverts, pre-cast concrete culverts, or cast-in-place concrete culverts. See the plan sheets and specifications for details of each.

The design constraints of the proposed culverts include the rights-of-way, existing road elevation, and the proposed alignments and invert elevations of Channel B and Alcove Channel A for the north and south culverts, respectively. Given these constraints, the clear height (rise) inside the proposed culverts may vary, depending on the culvert material and construction method. It is anticipated that the clear height inside the proposed culverts may

range between 2 feet and 3 feet for the north culvert and between 6 feet and 7 feet for the south culvert.

4.2.1 North Culvert

The north culvert is located within the Old Twisp Highway road prism at approximately Station 17+20 of the Channel B alignment. The proposed culvert is bottomless with a 19-foot span and 4-foot rise from the footing top elevation. However, the contractor is allowed to provide shop drawings for an alternative culvert or bridge that meets the design criteria provided in the Drawings and Specifications. The proposed culvert design will provide a minimum open area of 20 square feet. The footings will be placed on suitable subgrade as described in the specifications. Substrate material for the channel bed within the culvert will be suitable excavation spoils or native subgrade (suitable for habitat) as described in the specifications. Through the culvert, the channel width is approximately 17 feet with no side slopes.

Design of the culvert was based on the dimensions and geometry of Channel B, geometry of Old Twisp Highway South (Reclamation 2012), and criteria from the *Okanogan County Road and Street Standards and Guidelines for Developments* (OCPW 2007). The culvert structural design is based on the requirements of the WSDOT Bridge Design Manual M23-50.12 (WSDOT 2012) using the American Association of State Highway and Transportation Officials (AASHTO) HL-93 loadings and the geotechnical design parameters listed in the drawings. Floodplain flow during 2-year return period (and greater) discharge events will pass through the culvert opening, although road overtopping is expected to continue to occur during 10-year return period discharge events. The culvert design is expected to collect flood waters associated with the proposed upstream levee removal (Anchor QEA 2011a) for instream flow conditions within the range of the 2- and 5-year return period discharge events. The culvert design is not expected to mitigate for flood conditions during a 10-year return period (or greater) discharge event.

The road surface restoration will match existing extents and will follow the applicable Okanogan County and other state or local standards. Okanogan County has maintained this Class II road with a pavement width closer to that of a Class III road (16 versus 20 feet

respectively; OCPW 2007). The slightly wider paved width will be continued over the new culvert. For the purposes of guardrail design, the additional pavement width will be considered to be road shoulder (OCPW 2013). This consideration allows the design to closely match the existing geometry of the road prism and limit the need for additional fill material at the culvert. For reference the guardrail lengths of need calculations accompany this document. At this time, a utility locate has not been performed at the culvert placement site. Any modification to existing utilities requires prior approval by the Contracting Officer and shall be performed in accordance with applicable standards and in coordination with utility owners.

Modifications to the north culvert during the 100% design process include:

- The paved width over the new culvert was increased to 20 feet.

4.2.2 South Culvert

The south culvert is located within the Old Twisp Highway road prism at approximately Station 5+70 of the Alcove Channel A alignment. The existing culvert that is located approximately 200 feet north of the south culvert site will remain in place with no proposed modifications. The proposed culvert is bottomless with a 14-foot span and 7-foot rise from the alcove channel bottom elevation. However, the contractor is allowed to provide shop drawings for an alternative culvert or bridge that meets the design criteria provided in the Drawings and Specifications. The proposed culvert design will provide a minimum open area of 20 square feet. The footings will be placed on suitable subgrade as described in the specifications. Substrate material for the channel bed within the culvert will be suitable excavation spoils or native subgrade (suitable for habitat) as described in the specifications.

The culvert design was based on the dimensions and geometry of Alcove Channel A, geometry of Old Twisp Highway South (Reclamation 2012), and criteria from the *Okanogan County Road and Street Standards and Guidelines for Developments* (OCPW 2007), as well as the requirements of the WSDOT Bridge Design Manual M23-50.12 (WSDOT 2012) using the AASHTO HL 93 loadings and the geotechnical design parameters listed in the drawings. The culvert opening was maximized to allow wildlife to pass beneath with road while

minimizing cost as much as practicable. The culvert design is not expected to adversely affect, nor mitigate for, existing flooding or roadway overtopping in the project area.

The road surface restoration will match existing extents and will follow the applicable Okanogan County and other state or local standards. Okanogan County has maintained this Class II road with a pavement width closer to that of a Class III road (16 versus 20 feet respectively; OCPW 2007). The slightly wider paved width will be continued over the new culvert. For the purposes of guardrail design, the additional pavement width will be considered to be road shoulder (OCPW 2013). This consideration allows the design to closely match the existing geometry of the road prism limiting the wetland area impacted and the need for additional fill material at the culvert. For reference the guardrail lengths of need calculations accompany this document. At this time, a utility locate has not been performed at the culvert placement site. Any modification to existing utilities requires prior approval by the Contracting Officer and shall be performed in accordance with applicable standards and in coordination with utility owners.

Modifications to the south culvert during the 100% design process include:

- The paved width over the new culvert was increased to 20 feet.

5 LIMITATIONS

This report was prepared for Reclamation for use in documenting design analyses for the 100% design phase of the WDFW Culvert Improvement Project. Conditions within the project site may change both spatially and with time, and additional scientific data may become available. Significant changes in site conditions or the available information may require re-evaluation. Within the limitations of scope, schedule, and budget, our services have been executed in accordance with generally accepted scientific and engineering practices in the area at the time this report was prepared.

6 REFERENCES

Anchor QEA, 2010. *Conceptual Projects Alternatives Assessment: M2 Reach Project Concept Formulation.* Prepared for U.S. Bureau of Reclamation Pacific Northwest Region (Boise, Idaho). November 2010.

Anchor QEA, 2011a. *30 Percent Design Report, Upper Middle Methow Reach, WDFW Floodplain*. Prepared for U.S. Bureau of Reclamation Pacific Northwest Region (Boise, Idaho). December 2011.

Anchor QEA, 2011b. *Alternatives Evaluation Report: Upper Middle Methow Reach*. Prepared for U.S. Bureau of Reclamation Pacific Northwest Region (Boise, Idaho). September 2011.

Anchor QEA, 2011c. Draft Groundwater Assessment of WDFW Floodplain Memorandum. Prepared for Rob Richardson, U.S. Bureau of Reclamation Pacific Northwest Region (Boise, Idaho). December 9, 2011.

Anchor QEA, 2012a. *Draft 60 Percent Basis of Design Report WDFW Culverts and Alcove Channels Project*. Prepared for U.S. Bureau of Reclamation Pacific Northwest Region (Boise, Idaho). January 2012.

Anchor QEA, 2012b. *Final 90 Percent Basis of Design Report WDFW Culverts Improvement Project*. Prepared for U.S. Bureau of Reclamation Pacific Northwest Region (Boise, Idaho). August 2012.

Okanogan County Department of Public Works (OCPW), 2007. *Okanogan County Road and Street Standards and Guidelines for Developments*. Adopted: November 17, 1992; Revised (latest): April 10, 2007.

OCPW, 2013. *Email communications between Verlene Hughes of OCPW and Chris Johnson of MSRF.* Dated March 6, 2013.

Reclamation, 2008. *Methow Subbasin Geomorphic Assessment, Okanogan County, Washington*. U.S. Bureau of Reclamation Technical Service Center. Denver, Colorado. February 2008

Reclamation, 2010. *Middle Methow Reach Assessment, Methow River, Okanogan County, Washington*. U.S. Department of the Interior. U.S. Bureau of Reclamation Pacific Northwest Region. Boise, Idaho. August 2010.

Reclamation, 2012. *Topographic Survey of Road Features*. Ron Gross, Cartographic Technician, U.S. Bureau of Reclamation.

WSDOT, 2012. *Bridge Design Manual LRFD. Version M 23 -50.12*. Washington State Department of Transportation. August 2012.

ACCOMPANYING DOCUMENTS

- Construction Drawings (11 Sheets)
- Construction Technical Specifications
- Opinion of Probable Construction Costs
- Guardrail Lengths of Need Calculations