TROUT UNLIMITED Chapter 010
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Via email: NISP.EIS@usace.army.mil

Subject: Northern Integrated Supply Project, Supplementary Draft Environmental Impact Statement, Comments by Trout Unlimited

Dear Mr. Urbanic,

On behalf of Trout Unlimited, Colorado Trout Unlimited and Trout Unlimited's Rocky Mountain Flycasters chapter (collectively, "TU""), we earnestly offer these comments on the Supplemental Draft Environmental Impact Statement (SDEIS) published by the Army Corps of Engineers (the "Corps"), and relating to the Northern Integrated Supply Project (NISP) proposed by Northern Colorado Water Conservancy District (Northern).

TU is a non-profit conservation organization with approximately 150,000 members nationwide, more than 10,000 members in Colorado, and more than 800 members in the Rocky Mountain Flycasters chapter in Larimer and Weld Counties, Colorado. Those two counties encompass the entire watershed of the Cache la Poudre River (the Poudre). For more than three decades TU members have been advocates for and physically committed to conserving, protecting, restoring and sustaining the Poudre and its watershed. Paramount to the mission of TU is ensuring that the high quality waters of the Poudre are not jeopardized through adverse impacts brought about by unintended consequences. To that end it is vital that all current and relevant scientific modeling be consistently utilized to identify and minimize to the greatest extent possible the impacts brought about by any water development project.

In past years, positive actions by other Federal agencies have protected segments of the Poudre, most notably as a Wild and Scenic River in its mountain headwaters. Segments of the Poudre downstream of that protection are where the Poudre would be directly impacted by NISP. TU looks to the Corps to protect the Poudre and its historic legacy in those segments.

Beneficial usage of the Poudre's water has been developed for agricultural, municipal, and industrial uses to an amazingly productive extent. But those accomplishments, by and for humans, have also resulted in some sacrifices of the Poudre's ability to sustain all of its natural functions including aquatic habitats and populations of coldwater and warmwater fish. The challenge that NISP presents to these precious aquatic assets is whether, and how, use of Grey Mountain water rights can be attained with minimal environmental damage.

TU's Perspective of NISP

In comments on the NISP DEIS that TU filed with the Corps in 2008, TU noted that environmental impacts were so inadequately addressed in the DEIS that a Supplemental DEIS would be necessary. TU is pleased there now is opportunity for comment following release of the SDEIS. However, TU is disappointed that there continue to be serious shortcomings in the technical analyses contained in the SDEIS. Widely accepted multi-dimensional environmental models and analytic techniques have not been appropriately used in the SDEIS. In our opinion, and as supported by noted academics, this failure to properly employ these models and techniques has led to a substandard and inadequate evaluation of the impacts NISP will have on the aquatic and riparian environments. We describe more fully what we believe are the technical and modeling shortcomings used in the SDEIS analysis of impacts elsewhere in this document.

These deficiencies need to be remedied in a Final EIS.

TU's usual focus is on coldwater resources. With NISP, the focus also includes a water-temperature transition zone in which trout are regularly found to inhabit the river, but in limited quantities. Therefore, the Poudre River Study Segments A and B, as defined in the SDEIS, are of particular interest to TU. In geographic terms, this is from the Poudre Valley Canal diversion at the canyon mouth downstream to the Mulberry Street bridge in Fort Collins. Thus, TU's focus includes a segment classified by the Colorado Water Quality Control Commission (CWQCC) as "Aquatic Life Cold" and a segment classified as "Aquatic Life Warm", but where moderate populations of trout exist at least on a seasonal basis. The line of demarcation between the CWQCC's classifications is the Shields Street bridge.

TU neither favors nor opposes NISP, per se. The environmental impacts of each of the four alternatives in the SDEIS are not described in sufficient detail to make informed comparisons of their relative environmental impacts. Consequently, TU is neutral at this time as to which of the proposed alternatives would qualify as the preferred alternative by virtue of being "the least environmentally damaging practicable alternative".

On a time-scale, TU's interest in NISP extends at least to the NISP target year of 2050. In a near-term perspective, TU is concerned about adverse environmental impacts during both the construction and initial operating phases of whichever NISP alternative is selected by the Corps to be permitted. These concerns are explicitly identified below. It will be imperative that firm, clearly defined and achievable mitigation measures are included in the Final EIS (FEIS) and the Record of Decision (ROD).

Given that the operating period is expected to extend many decades into the future, the environmental impacts forecasted today are almost certain to be erroneous to some extent in their realization. Thus, the ensuing FEIS and ROD must include a mechanism for adaptive management with continuing adjustments of operations of and mitigation for NISP as circumstances change.

One model of such a mechanism is the "Learning by Doing" effort associated with permitting for the Moffat and Windy Gap Firming Projects. In that initiative, all the several parties having stakes in the project's water supply operations, on the one hand, and on the other hand, those parties (including TU and Grand County) having stakes in the quality of the environmental resources, including the coldwater fishery in the Colorado River, negotiated a mutually acceptable set of Mitigation and Environmental Commitments. Actual implementation of those commitments – using operational flexibility and applying water and financial resources to the environmental needs of the watershed – will take place through a cooperative effort informed by ongoing monitoring of river and watershed conditions. We believe this model could be adapted to the Poudre watershed and applied for use with NISP (and potentially other projects such as Halligan and Seaman enlargements).

In a longer term perspective, none of NISP alternatives 2, 3, or 4 provide sufficient water supply to fully satisfy the long term anticipated Municipal and Industrial consumptive needs of the northern Colorado communities that are participants in NISP. TU understands this larger issue may not be the responsibility of the Corps to solve. But the Corps, in selecting "the least environmentally damaging practicable alternative", might define the applicable "environment" as being all of northern Colorado, and then consider the environmental impacts of a long term balance between water supply and demand, and the resultant analysis of environmental impacts would then be incorporated in the Final EIS.

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We offer the following specific comments on the environmental impact analysis for Alternative 2. To assist us in reviewing the SDEIS and its technical backbone, TU commissioned Colorado State University PhD. candidate Ryan McShane to prepare a technical memorandum reviewing key elements of the document. While our comments touch on the same major topics, we also ask that Mr. McShane's technical memorandum be incorporated into our comments; it is attached with this letter as Appendix A.

The SDEIS presentation of surface water impacts is flawed and should be improved before a final EIS is issued.

An accurate and informative presentation of surface water impacts is critical, as it is a foundational piece of the SDEIS – the specific analysis of other environmental impacts for flow-dependent resources is built from the modeled impacts on surface water hydrology. Any errors in the modeled results, or a failure to model streamflows of particular importance, may in turn produce errors in the modeled impacts for riparian and aquatic resources.

We commend the Corps for working to create a Common Technical Platform (CTP) for use in analyzing impacts not only for NISP but for other projects (eg Halligan – Seaman) in the basin. It is appropriate to use common hydrologic data for understanding different projects operating within the same watershed. Unfortunately, as outlined in Mr. McShane's technical memorandum, the presentation of CTP information in the SDEIS is flawed in several ways that tend to obscure understanding of impacts:

- Presentation of monthly streamflow data fails to demonstrate key impacts. A significant criticism of the DEIS, including in TU's comment letter of September 12, 2008, was its use of monthly averages in streamflow modeling. The SDEIS, in response to this criticism, disaggregated streamflow to a daily timestep for use in analyzing flow-related impacts – yet much of the data on impacts in the SDEIS and technical reports is still presented in terms of monthly streamflow.

- Presentation in terms of mean and median streamflows is not particularly informative. Showing impacts of alternatives on mean or median streamflow – whether on a monthly or daily basis – reflects only an average condition, whereas the greatest impacts on habitat and aquatic life are likely to occur at the extremes (ie, changes in the *minimum* and *maximum* daily streamflows). The more presentation of data is averaged, the more critical changes in the patterns of streamflow variability may be obscured. Such changes in the minimum and maximum can be critical for flow-dependent species and presenting *median* flow data and showing limited change from historic *median* conditions does <u>not</u> support a conclusion of no significant impact.
- Where the most meaningful information is presented with maximum, mean, median and minimum streamflows (e.g. WRTR Figure 6.11; Appendix A Figure A3), the y-axis is presented on an arithmetic scale rather than a logarithmic scale – making it difficult to discern impacts on the minimum daily streamflow (where particularly important impacts on fish and other aquatic life, as well as stream temperature, are most likely to occur). Moreover, figures should be presented to compare these measures for alternatives against the current conditions rather than on separate graphs. The Corps should add to its presentation of surface water impacts the changes in minimum and maximum daily streamflows relative to current conditions – i.e., graphed as a percentage change from current conditions.
- Figures for streamflow duration curves (e.g. WRTR Figure 6.21; Appendix A Figure A4) also do not have a y-axis graphed on a logarithmic scale, as is the scientific norm – making it difficult to distinguish the effects of alternatives of streamflow at the highest and lowest exceedance probabilities. Again, impacts on these extremes may be highly significant for aquatic resources – but the current presentation tends to obscure the impacts of the alternatives on the extremes.
- Tables presenting changes in median monthly streamflow (e.g. WRTR Table 6.1; Appendix A Table A5) have the same shortcomings described for the figures described above. However, for reasons unknown, the data is presented to show streamflow increases as negative numbers and decreases as positive numbers – the opposite of how they should be logically presented. Percentage change is also shown as an absolute value, rather than using negative or positive numbers to indicate whether the change reflects an increase or decrease in streamflow.

Finally, in order to provide a basis for evaluating how well the CTP hydrology model performed in characterizing streamflow, some performance metrics should be presented (e.g, Nash-Sutcliffe efficiency, percent bias or root mean square error). Given that hydrologic analysis is the foundation for analyzing alternative impacts on other resources, it is difficult to have confidence in the SDEIS analysis of impacts on those flow-related resources without seeing how well the CTP hydrology model performed.

Impacts on surface water quality (temperature) have only been qualitatively assessed; the planned quantitative evaluation is needed and should be made available for public review and comment.

The SDEIS notes that its analysis is only the first phase of necessary water quality analysis and that further quantitative analyses will be completed and presented in the FEIS:

> *The results presented in the SDEIS reflect the first of two phases of water quality analysis. The first phase includes a qualitative assessment of likely*

> *changes in water quality for multiple locations under each of the alternatives. The intent of the first phase of analysis was to determine which water quality constituents and locations are most likely to be affected by hydrologic changes. Results of this first phase of analysis will then be used to determine which parameters can be quantitatively modeled at those locations most likely to be sensitive to hydrologic changes. Phase II water quality modeling will be conducted for the FEIS in coordination with the WQCD and the EPA using WQCD protocols to satisfy 401 certification requirements. Results of Phase II water quality modeling will be presented in the FEIS.* (SDEIS p. S-40)

We are dismayed that, despite seven years having elapsed since the DEIS was released, that more advanced stream temperature modeling still remains unfinished. It is also unclear whether or how the Corps intends to allow for public scrutiny and comment on its methodology for quantitative stream temperature modeling and the results. In the interest of transparency, when this information is assembled we ask that the Corps provide an additional opportunity for public comment on its proposed quantitative model for stream temperature.

The Poudre already experiences temperature exceedances and a thorough analysis of potential further impacts associated with NISP is needed.

As previously noted, the reaches of the Poudre on which TU has focused extend to the Mulberry Street bridge in Fort Collins – including portions of Segment 10 and Segment 11, designated for coldwater aquatic life (10) and warmwater aquatic life (11) respectively by the Colorado Water Quality Control Division. Despite the warmwater designation on Segment 11, the reach does harbor brown trout – indeed some may be found even further downstream than the Mulberry Street bridge.

In light of our segments of interest, the gage data presented in the 2015 Stream Temperature and Dissolved Oxygen Analysis (STDOA) on which we focus will be for the gages at the mouth of the Poudre River canyon, above the Hansen Supply Canal (the outlet from Horsetooth Reservoir), and below the confluence with Boxelder Creek – which bracket the area of TU's concern for the resident brown trout fishery.

As described in Mr. McShane's technical memorandum, summer temperature exceedances are already occurring in many years in July through September in Segment 10, and in July and August in Segment 11 (STDOA Table 4; Appendix B Table B1). Exceedances in Segment 10 are concentrated between the canyon mouth and the Hansen Supply Canal because the canal delivers cold water in summer from the depths of Horsetooth Reservoir, cooling temperatures in the Poudre River. However, that cooling dissipates by Segment 11, as temperatures at the Boxelder gage are warmer by 5-6°C than those at the Hansen gage. Winter exceedances have also been observed in Segment 10. Impacts of the alternatives on stream temperature will involve exacerbation of these existing exceedances of water quality standards for temperature.

In particular, we note that Segment 10 temperatures have exceeded both the acute (Daily Maximum) and the chronic (Maximum Weekly Average) summer standards for coldwater aquatic life. Further stream depletions during the summer months when these exceedances already occur will likely exacerbate the existing problem. A thorough quantitative analysis of these impacts is needed, and mitigation should be proposed to address them.

Brown trout in Segment 11 face an even greater challenge, as the segment has reported exceedances even of the higher warmwater summer daily maximum standard. Further increases in stream temperature may render the segment unsuitable for brown trout adults even seasonally.

The SDEIS also includes a statement that the Poudre River is a gaining river (p. 3-53), with the river recharged by shallow groundwater that is 5-10°C cooler than surface water. It is presumed that shallow groundwater recharge will moderate some effects of the alternatives on stream temperature because even though surface water will be reduced, increasing its temperature, a greater proportion of water in the river will be gained from cooler groundwater relative to warmer surface water. This supposition is not substantiated. Since shallow groundwater is recharged from surface water, if surface water is reduced and warmed so too will groundwater be reduced and warmed. If this claim is to be used in projecting impacts (or lack thereof), more substantial analysis and documentation on surface water-groundwater interactions must be provided.

The analysis of impacts on fish is flawed and fails to appropriately consider factors beyond modeled physical habitat availability.

A significant criticism of the DEIS was that impacts on fish were not understood adequately using streamflow modeled at a monthly timestep. The SDEIS addresses this shortcoming through more extensive physical habitat modeling using streamflow disaggregated to a daily timestep, but fails to address other imperative ecological information on fish, such as population abundance, reproductive success, survival probability or food availability. It is disappointing that in the seven years since the DEIS was issued, that progress was not made on data collection and model development to provide more comprehensive ecological information than merely physical habitat.

Beyond the failure to model ecological factors beyond physical habitat, the SDEIS analysis and presentation of fish habitat impacts is flawed in several ways as outlined in Mr. McShane's technical memorandum.

- Use of "WUA years" rather than streamflow years. The 2015 Aquatic Biological Resources Effects Technical Report (ABRETR), prepared by GEI Consultants, provides the analysis of impacts on fish. The evaluation relies solely on the modeling of physical habitat, which is modeled as weighted usable area (WUA). Data show WUA in median, 20th and 80th percentile *WUA years* (e.g. ABRETR Figure 3-4; Appendix C Figure C1). To inform analysis of alternatives, the SDEIS should be presenting WUA in median, 20th and 80th percentile *streamflow years*, because otherwise effects of the alternatives on streamflow in any given year, and in turn effects on WUA for any species or life stage of fish, are incomprehensible. For example, to understand effects of the alternatives on fish in a dry (e.g. 20th percentile streamflow) year, the figures need to compare WUA of all species and life stages of fish for that dry year.

- Failure to analyze impacts at minimum and maximum conditions, and at times of greatest flow modification. As noted previously, an understanding of the impacts of alternatives in more extreme periods is vital. Looking at WUA in median years would have limited value. Although an alternative may not substantially change

WUA in the median year, WUA in the minimum and maximum years can be changed quite considerably. Even looking at the 20th percentile streamflow year may fail to account for important limiting conditions in the most extreme period – considering the 5th percentile streamflow year would be more useful in understanding possible impacts at the minimum end of streamflow variability. Most useful would be to look at the types of years when the alternatives will have the greatest percent impact on streamflow, and to model changes in WUA for those years.

- Annual accumulation of WUA may mask impacts. Tables presented on average and minimum WUA (e.g. ABRETR Table 3-9; Appendix C Table C2) lack meaningful information because WUA only has meaning as a time series of daily values over any given year, not as a single annual value. Presenting WUA as an annual accumulated value discounts the importance of short-term or seasonal impacts that may be critical; if WUA is increased slightly for eleven months but reduced to zero for the remaining one month of the year – the overall implications for fish life are likely to be dire. Yet the cumulative WUA presented could be unchanged or even appear positive. Presenting data in this fashion gives an unsupported impression of limited impact.

- Habitat suitability curves fail to consider changes in fish habitat usage at higher flows. The 2013 Aquatic Biological Resources Baseline Report (ABRBR) provides information on the methodology for developing the habitat suitability curves used in modeling available habitat for different species and life stages of fish. However, the habitat suitability curves themselves are not presented for review or critique. The curves were developed using data collected on habitat use in July through October (ABRBR Appendix E). This time of year represents lower streamflows on the river, so the depths and velocities that fish use during this time are not representative of those that are available during higher streamflows. In modeling WUA from these curves, it is assumed that fish use depths and velocities similarly during low or high streamflows – but this assumption lacks sufficient support in the scientific literature on the ecology of fish in rivers with streamflows that vary throughout the year (such as the Poudre). Fish in these rivers are known to use habitat differently at different times of the year depending on specifics of their life history and the habitat available at different times.

- Improper assumption that reduced runoff flows produces habitat benefit. The report suggests that habitat availability for most species and life stages of fish will increase because the alternatives will reduce high streamflows during spring runoff. This claim is unfounded, and suggests a misunderstanding of fish ecology in rivers with snowmelt-driven streamflow regimes. The importance of high streamflows during spring runoff is not for habitat use by fish but principally for maintaining the stream channel and resulting habitat that is available to fish at lower streamflows during summer through winter baseflows. Moreover, projecting habitat suitability curves into times of high streamflows, beyond the range of depths and velocities observed in creating the curves, is scientifically and statistically suspect. Because observations are lacking during spring runoff, any predictions of habitat availability during higher flows will be extremely uncertain and cannot be supported by the physical habitat modeling.

- Qualitative basis for conclusion of “minor” impact is lacking. The interpretation that the alternatives will have at worst minor adverse impacts on fish (e.g. ABRETR Table 3-174; Appendix C Table C3) lacks adequate support from just the physical habitat modeling. No explanation is provided in the SDEIS or technical reports for how this modeling was used (alone or in concert with other unspecified data) to define alternative impacts on fish as negligible, minor, moderate or major. It seems that no quantitative thresholds of reduction in WUA by the alternatives were used to categorize impacts.

In short, the analysis of impacts on aquatic life is flawed in its use of habitat availability modeling, fails to account for other critical ecological factors for aquatic life, and seems to rely heavily on unquantified “professional judgment” being offered without backup from appropriate scientific evaluation. These shortcomings must be remedied before a Final EIS can be completed. A good place to start would be coordination with the group of scientists who developed an Ecological Response Model for predicting ecosystem condition of the Poudre River at varied streamflows (SDEIS Appendix F p. 13).

Analysis of flushing flows overestimates the flows needed to accomplish sediment flushing and understates impacts of the alternatives.

The SDEIS analysis of sediment transport and flushing flows concludes that extremely high flows are required to accomplish flushing, and thus are minimally impacted by the proposed project. Unfortunately, these conclusions are contravened by analysis prepared by one of the top experts in this field, Dr. Brian Bledsoe. We have reviewed his Technical Memorandum (submitted to the City of Ft. Collins comments for its comments on this SDEIS, and attached with these comments) and support his concerns. Dr. Bledsoe writes:

> *All the standard methods for estimating shear stress I examined result in significantly greater sediment flushing and mobilization potential compared to values reported in the SDEIS. This one source of bias in shear stress estimates produces errors averaging 52% with some errors exceeding 80% at the SDEIS “representative” cross-sections selected in the Fort Collins reach. These errors in shear stress, in turn, propagate through the hydraulic analysis of what flows are required to estimate sediment flushing. Many of the errors in flushing flow estimates are two- to fivefold in magnitude.* (Bledsoe Technical Memorandum, p. 3)

These substantial errors result in a significant over-estimation of what flows are needed to accomplish flushing, and thus obscure the impacts of reducing flows at more moderate high flow levels where flushing also takes place – but is not acknowledged in the SDEIS. The flaws in this analysis must be corrected to accurately project impacts of project operations on sediment transport, and in turn to develop appropriate operating requirements or mitigation measures to address those impacts.

Climate change impacts must be considered and addressed in mitigation.

The SDEIS presents a Climate Change Hydrologic Impacts Analysis (CCHIA), which in turn relies on prior studies on climate change in the Poudre basin. The analysis notes that there is not agreement on whether precipitation will increase or decrease, but there is agreement that temperature will increase both annually and (to a greater extent) in summer (CCHIA p. 15). It is also states that runoff and baseflow conditions will likely shift by possibly a month earlier (CCHIA p.6). The combination of these factors likely will, when looked at cumulatively with the alternatives, significantly exacerbate the existing temperature exceedances in July and August and potentially (with the earlier runoff) extend these problems into June as well. Yet these likely changes are not reflected in any proposed mitigation activities. A final mitigation plan for any approved alternative should address such temperature impacts as exacerbated by anticipated climate change.

Comments on Proposed Mitigation.

We have previously voiced concern that mitigation measures often remain undefined, and are not open to public scrutiny, until late in the NEPA process after the standard public comment opportunities have passed. We commend Northern for developing an extensive set of proposed mitigation measures – importantly, including a program of adaptive management – and making it available for public review as part of the SDEIS release. These measures are helpful and appreciated; below we offer comments and questions including ideas on how they may be supplemented or modified to better address likely project impacts.

Poudre Valley Canal Diversion Structure
Adding fish passage to the proposed new diversion structure would be a greatly needed improvement that would allow brown trout to move upstream into the canyon. The design of the new diversion structure is not yet defined. We recommend that Northern coordinate closely with Colorado Parks and Wildlife and with the Fish Passage program staff of the US Fish and Wildlife Service to ensure that their design is effective in allowing fish passage.

Glade Reservoir Release Structure
Northern proposes including aeration with the release structures from Glade Reservoir. This is a helpful mitigation measure that will help ensure adequate oxygenation in the Poudre River to support its brown trout fishery. We understand that Colorado Parks and Wildlife has also suggested the possibility of creating a tailrace fishery below the Glade release structure; we strongly encourage exploring this possibility as it would create an added project benefit for the community and could partly offset impacts to recreational fishing elsewhere.

Avoid Munroe Canal Diversions
Northern proposes to use the Poudre Valley Canal at the canyon mouth for project diversions, rather than the Munroe Canal. We raised questions about Munroe Canal diversions in our 2008 comment letter and appreciate this proposed mitigation measure to avoid impacts on brown trout fisheries in the Poudre canyon and reduce the total number of river miles impacted by water diversions.

Curtail Diversions for Non-Consumptive Water Rights
Northern proposes curtailing water diversions to Glade Reservoir in order to satisfy several instream flow rights, even though they are junior to the Grey Mountain water right. We appreciate this proposal to avoid flow depletions under low flow conditions for the instream flow reaches, though information in the SDEIS and technical reports is not

sufficient to determine how often this would be triggered and how much of an effect the proposed mitigation would have.

Summer and Winter Diversion Curtailments
Northern proposes curtailment of diversions to Glade Reservoir when needed to maintain minimum flows in the Poudre River of 25 cfs in winter and 50 cfs in summer. If effective, this action would mitigate significant project impacts on brown trout throughout their range in the Poudre River during summer and winter baseflow periods. More information is needed to demonstrate how foregone diversion water would be maintained instream (past other diversions) through the reaches to be mitigated – or if the water is expected to be diverted elsewhere, to clearly define the reaches that would still benefit.

Low Streamflow Augmentation Release
Northern proposes releases from Glade Reservoir to augment current low streamflow conditions by maintaining 10 cfs in November through April and in September. We appreciate this step to enhance current conditions; the SDEIS notes that a minimum streamflow of 10 cfs could as much as double current minimum streamflows, and increase habitat availability for fish (SDEIS p. 4-314). We encourage Northern to explore options – through joint operations with other facilities or diversions – to look at a possibly greater streamflow augmentation program. The scientists who developed an Ecological Response Model for the Poudre River (SDEIS Appendix F p. 13) concluded that a minimum streamflow of 35 cfs in winter was necessary for strong recruitment of brown trout, and that recruitment was poor at less than 20 cfs. As data for recruitment at streamflows between 20 and 35 cfs was lacking, an acceptable threshold might be within this range. An important component, as well, is to ensure stable streamflows from the time of brown trout spawning (fall) through incubation (winter) and emergence (early spring) – so that trout spawning beds are not used and then subsequently dewatered by dropping streamflows.

This proposal is noted as a possible mitigation measure for impacts on stream temperature. While it may help to avoid or reduce temperature excursions in April and September, it would have no effect in July and August, when temperature excursions would have the most significant impacts on fish, especially brown trout.

Poudre River Streamflow Augmentation Protection
It is proposed that the proposed streamflow augmentation would be legally protected. This will be a critical element in ensuring that the releases are shepherded through the reaches to be mitigated.

Multi-Level Outlet Tower for Glade Reservoir Releases
Northern proposes an outlet works for Glade Reservoir with selective depth withdrawals, allowing for releases of varying temperature to help meet targeted stream temperatures in the Poudre River downstream. This should help cooling water for brown trout on reaches downstream from Glade Reservoir – and as noted previously, could provide an opportunity to establish a new tailrace fishery. Because the SDEIS lacks quantitative information on stream temperature impacts, it is not yet possible to define exactly how this mitigation measure can be used to address those impacts.

Ramp Hansen Supply Canal releases
Ramping rates on releases from Horsetooth Reservoir through the Hansen Supply Canal are proposed. Making gradual increases and decreases in releases will help avoid the impacts

that rapid streamflow fluctuations can cause for brown trout in the Poudre River downstream from the release and diversion structures.

Stream Channel and Habitat Improvement Plan
Northern proposes a partnership to develop a comprehensive plan for improving the stream channel throughout the Poudre River, and to provide $1 million toward the planning effort. We believe this type of collaborative planning effort, involving all key local stakeholders (e.g., City of Ft Collins, Colorado Parks and Wildlife, TU, etc.), is a valuable measure and promotes the type of cooperative efforts that can help address challenges facing the Poudre.

Channel and Habitat Improvements
Northern proposes to improve the Poudre River stream channel in two reaches of the Poudre River – approximately 1.2 miles (within a 2.1 mile reach) between the Poudre Valley Canal and the Hansen Canal, and another 1.2 miles near Watson Lake. Other than noting that the Poudre Valley to Hansen reach would be used in part to help address temperature concerns it is unclear how these reaches were selected or what the channel improvements might be; further detail should be developed on this concept.

We concur that well-designed channel modifications may be able to help address some impacts such as temperature (narrower, deeper channel should reduce warming) as well as sediment transport (channel design to facilitate flushing of sediment at a lower flow) and improved fishery habitat and fish passage. Plans for improvements should be closely coordinated with Colorado Parks and Wildlife and other interested stakeholder.

Multi-Objective Diversion Structure Retrofits
Northern proposes retrofitting several existing diversion structures at strategic points on the Poudre River to include fish passage. Such an effort is very welcome and would help reconnect currently disconnected sections of the Poudre, allowing brown trout to move upstream during summer through winter baseflows. Fish passage design should be developed with significant input from Colorado Parks and Wildlife and the Fish Passage program of the US Fish and Wildlife Service, to maximize the likelihood of success. To ensure the intended results, it will also be vital to connect these efforts with streamflow management and stream channel improvements on the intervening reaches, to ensure that habitat in the reaches between these structures is also conducive to fish passage. Such factors should be incorporated in the Stream Channel and Habitat Improvement Plan described previously.

Riparian Vegetation Enhancements
Riparian vegetation enhancement is also proposed for four 10- to 50-acre sites on the Poudre River, including at the two reaches of proposed stream channel and habitat improvements. The plan should more clearly define standards for measuring success of these riparian improvements (eg, successful reestablishment of cottonwoods at a defined level, or other similar measures).

Poudre River Adaptive Management Program
Some impacts (and opportunities) associated with the proposed project may be difficult to accurately predict, and so we were pleased that the mitigation plan included a conceptual adaptive management program. Northern has proposed funding the program with $5 million for implementation plus $50 thousand per year for 20 years for maintenance. The

effort would be guided through a steering committee of key stakeholders – a good approach that engages key publics and also may open up opportunities to leverage resources. The plan suggests that the program would continue for 20 years or until the $5 million is exhausted (whichever comes first). However project impacts will not cease to exist after 20 years, nor will opportunities for leveraging of resources or considering operational adjustments that may help reduce or offset project impacts. We suggest that an adaptive management program be maintained as a permanent feature to help monitor conditions and guide efforts to address impacts that may not have been anticipated and that may emerge in the future. As mentioned previously, there are models for collaborative adaptive management from the western slope that could be adapted to the Poudre basin.

Glade Reservoir Water Quality Enlargement
Northern suggests that to mitigate impacts on stream temperature in July and August, Glade Reservoir might be enlarged from 170,000 to 192,500 acre-feet. Water diversions would be curtailed in August and September, with more water being diverted in April through July. While the proposed enlargement might mitigate temperature excursions in August, it conversely could worsen them in July. Furthermore, an enlarged reservoir and increased seasonal water diversions would change environmental impacts of the preferred alternative as disclosed in this SDEIS and would therefore require revisiting impact analyses to reflect the enlarged reservoir footprint and increased seasonal water withdrawals. We are not certain that this concept is viable as a mitigation measure, but if proposed it certainly requires significant further analysis.

Water Quality – Coalition for the Poudre River Watershed
Northern proposes addressing water quality measures in part through collaborations with the Coalition for the Poudre River Watershed (CPRW):

> *Activities conducted by the Coalition for the Poudre River Watershed could decrease sediment load in the Poudre River, reduce point and non-point source pollution, and improve channel and conveyance conditions in the Poudre River. These types of activities may decrease conveyance of sediment to lower portions of the Poudre River, improve ambient water quality concentrations including temperature in reaches upstream of those affected by NISP thereby improving downstream reaches, and improve the quality of water stored in Glade Reservoir.* (Appendix F, p. 95).

We appreciate this commitment to cooperative efforts on improving watershed health and water quality. As with the stream channel and habitat improvement plan, it is vital that such efforts be planned and undertaken with collaboration and involvement from all key local stakeholders (e.g., City of Ft Collins, City of Greeley, Colorado Parks and Wildlife, CPRW, TU, etc.) in coordination with Northern.

Mitigation for Impacts on High Flows
The mitigation plan includes measures to address and enhance baseflows, but lacks measures to address impacts of high streamflows during spring runoff. These high streamflows are critical for maintaining the stream channel and rejuvenating fish habitat. The scientists who developed the Ecosystem Response Model do not propose a specific high streamflow that is essential, but an appropriate recommendation can be surmised from their analyses. To flush fines and mobilize the bed, an effective discharge, at minimum, would be a high streamflow of at least 3350 cfs, for at least 3 days, and at least every 3 years. A high streamflow of greater magnitude but of perhaps shorter duration and lower

frequency would be necessary for more consequential bed mobilization. Northern and the Corps should examine what types of high flows need to be provided to address stream health, and with what frequency and duration (or in what types of water years) they should be provided.

In our comments, we have noted numerous areas where the SDEIS analysis needs to be revised or extended and where there may be opportunities to refine and improve the mitigation proposals. This includes at least one topic where the Corps has already indicated its intent to do additional analysis (quantitative temperature analysis). These shortcomings must be addressed before a Final EIS can be completed, and given the significance of the issues we ask that the Corps provide some additional opportunity for public review and comment on new or revised analysis and the associated EIS revisions that are made to address it.

Thank you for the opportunity to comment.

Sincerely,

Wil Huett
President, Rocky Mountain Flycasters

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Appendix A
NISP SDEIS Technical Review

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Preparer's Qualifications
I am a doctoral candidate in Ecology at Colorado State University. My doctoral dissertation is concentrated on the impacts of climate change on watershed hydrology, and integrating water resources management with river hydraulics to manage the distribution of native and non-native riverine species in the western United States. I have a bachelor's degree in Natural Resources from University of Michigan, and a master's degree in Fishery and Wildlife Sciences from New Mexico State University. My master's thesis focused on the impacts of non-native fishes on the native fish and invertebrate communities of intermittent streams in the Chihuahuan Desert. I also worked for a number of years as a fishery biologist for the US Geological Survey at the Reno Field Station. I was a researcher on a number of projects on the ecology of threatened and endangered aquatic species in the Sierra Nevada and the Great Basin–Mojave Deserts. These projects involved the impacts of altered hydrologic and thermal regimes, introduced non-native fishes, and modified watershed land use and geomorphic processes. As a scientist, I have training and am experienced with modeling hydrology and hydraulics in rivers, and physical (including thermal) habitat of fish.

NISP SDEIS Technical Review

In this review, I will focus on five elements in the SDEIS. First, I will discuss deficiencies in the modeling of impacts on surface water. Second, I will discuss some initial findings from the analysis of impacts on surface water quality, specifically temperature. Third, I will discuss deficiencies in the modeling of impacts on aquatic biological resources, specifically fish. Fourth, I will discuss some limited inferences from the analysis on impacts of climate change. Last, I will discuss the pros and cons of several of the proposed mitigation activities, and some possibilities for their improvement. The first three sections in this review correspond to quantitative and qualitative analyses in the SDEIS of direct and indirect effects on surface water, surface water quality, and aquatic biological resources. The fourth section, on climate change, corresponds to qualitative analyses in the SDEIS of cumulative effects of climate change and the alternatives on the three aforementioned resources. The fifth section corresponds to the "Proposed Conceptual Mitigation Plan" included as Appendix F of the SDEIS.

Surface Water

Environmental impacts of the alternatives on surface water are only presented rather generally in the SDEIS. It is stated that more specific impacts on surface water were analyzed only as effects on flow-related resources:

> "Surface water hydrology is the foundational resource for the evaluation of the effects to other flow-related resources. The time series data output from the Common Technical Platform (CTP) hydrologic modeling were provided to other resource specialists for use as inputs for their models and other analytical tools used for assessing potential NISP effects. [...] The objective of this section is to summarize modeled diversions and to illustrate the modeled changes in streamflow—as compared to modeled Current Conditions hydrology—at multiple locations that are of importance to proposed NISP operations. [...] This section does not include evaluation of impact intensity, but rather sets the stage for such designations in the context of the flow-related resource effects analyses that follow. The reader is encouraged to review the full technical reports to gain a more complete understanding of project operations and modeled changes in Poudre River and South Platte River streamflows associated with the NISP alternatives." (SDEIS pp. 4-11–4-12)

These statements suggest that significant environmental impacts of the alternatives on surface water may have been missed if resource effects at streamflows of particular importance were not modeled. For example, a consultant may have failed to model effects on a flow-related resource at the minimum extreme of the statistical distribution of streamflows. This circumstance will be discussed in more detail in the section on aquatic biological resources.

As it is quite possible that modeling of resource effects may have neglected important attributes of the streamflow regime, it is troubling that impacts of the alternatives on surface water in the Poudre River were treated only superficially in the SDEIS and technical reports. Important impacts on, for example, riparian and aquatic biological resources can be apparent just from analyzing hydrologic alteration from an alternative, without even rendering streamflows through models analyzing effects on flow-related resources. However, the detail needed to infer hydrologic alteration from the alternatives is lacking in the SDEIS and technical reports.

A significant criticism of the DEIS was that modeling streamflow at a monthly timestep provided no applicable information for evaluating environmental impacts of the alternatives on numerous resources, including streamflow, stream temperature, stream morphology, sediment transport, riparian vegetation and fish habitat. In the SDEIS, in response to this criticism, monthly streamflow was disaggregated to a daily timestep to facilitate analyses of effects on flow-related resources, but many of the data for impacts on surface water in the SDEIS and technical reports are still presented as monthly streamflow. Although monthly streamflow may provide information appropriate for managing water resources, it is uninformative for assessing environmental impacts.

The 2014 Water Resources Technical Report (WRTR), prepared by CDM Smith, provides the analysis of impacts on surface water. It presents a number of figures and tables that show impacts of the alternatives at ten streamflow gages and diversion structures on the Poudre and South Platte Rivers. Only some data for impacts on surface water are presented as daily streamflow in the SDEIS or technical reports. However, those data are presented so poorly in the figures and tables that it is impossible to properly interpret impacts of the alternatives on streamflow. I will discuss several flaws of these figures and tables that diminish or obscure impacts on streamflow. [Figures and tables from the WRTR that I reference are also included in Appendix A attached to this review.]

The figures of statistical distributions (i.e. minimum, maximum, mean and quartiles) of the *mean monthly* streamflow for the 1950-2005 current conditions (e.g. WRTR Figure 6.31; Appendix A Figure A1) do not provide any information appropriate for understanding environmental impacts because the data just show effects on an increasingly averaged streamflow condition (i.e. because monthly streamflow is already an average of streamflow for all days of the month, the data show the mean of a mean). It is uninformative to show effects of the alternatives on the *mean* or *median* streamflow, whether at a monthly or daily timestep. The data need to show effects on the *minimum* and *maximum daily* streamflows, where fish habitat and stream temperature will be most impacted by the alternatives.

The figures of time series of the median daily streamflow (e.g. WRTR Figure 6.1; Appendix A Figure A2) are more informative, but are still unsatisfactory because, even though presented at a daily timestep, they still just show effects on an averaged streamflow condition. Moreover, it is not justifiable to infer, as implied by these figures, that impacts of an alternative are not significant if the median daily streamflow for an alternative is within the 90% confidence interval of the historical median. Although an alternative may not substantially change the median daily streamflow, the minimum and maximum daily streamflows can be changed quite considerably.

The figures of time series of the maximum, mean, median and minimum daily streamflows (e.g. WRTR Figure 6.11; Appendix A Figure A3) are most informative, but unfortunately they have a y-axis graphed on an arithmetic scale (i.e. the scale is too constricted toward zero), instead of graphed more reasonably on a logarithmic scale. Therefore, effects of the alternatives on the minimum daily streamflow are indiscernible, and some flow-related resources, such as fish habitat and stream temperature, will be most impacted at this minimum extreme. Moreover, these figures need to compare the minimum and maximum daily streamflows for the alternatives *against* the current conditions hydrology. It is impossible to compare streamflow for an alternative against streamflow for the current conditions hydrology if they are shown on separate graphs, instead of more rationally on a single graph. However, to most appropriately interpret effects of the alternatives, the figures need to show the change in the minimum and maximum daily streamflows for the alternatives *relative* to the current conditions hydrology (i.e. the data need to be graphed as a percentage change from the current conditions hydrology to the streamflow for an alternative).

The figures of duration curves for daily streamflow (e.g. WRTR Figure 6.21; Appendix A Figure A4) also do not have a y-axis graphed on a logarithmic scale, as is the scientific norm. Therefore, effects of the alternatives on daily streamflow at the highest and lowest exceedance probabilities cannot be distinguished, and impacts on flow-related resources, like fish habitat, will be greatest at these extreme maxima and minima. However, important information on the annual sequence of high and low streamflows is also lost by ranking streamflows as exceedance probabilities in flow duration curves.

The tables of change in the median monthly streamflow (e.g. WRTR Table 6.1; Appendix A Table A5) lack meaningful information for the same reason as the figures that present these data. However, more problematic w is how the data are presented in these tables. They misleadingly show streamflow increases for the alternatives as negative numbers, and streamflow decreases as positive numbers, which is opposite of how the *effect* of an alternative would be shown logically. This mode of presentation gives the false impression that the alternatives have a minor effect because just a few relatively small numbers are negative, whereas the many large numbers are positive, when really those large *positive* numbers represent a major *negative* change in streamflow. Furthermore, with no reason given, the percentage change is shown as an absolute value, which obfuscates whether the effect of an alternative is an increase or a decrease in streamflow because all values are positive.

Lastly, and perhaps most importantly, no performance metrics are provided in the SDEIS or technical reports as evidence of how well the CTP hydrology model performed. Any water resources analysis needs to demonstrate how well a hydrologic model simulates the observed streamflow by computing performance metrics, such as Nash-Sutcliffe efficiency, percent bias or root mean square error. It is difficult to have confidence in any of the flow-related resource effects analyses in the SDEIS without knowing how well the CTP hydrology model even performed.

Surface Water Quality (Temperature)

Environmental impacts of the alternatives on surface water quality have only been qualitatively assessed in the SDEIS. It is stated that more thorough quantitative evaluation of stream temperature will not be completed until the FEIS, which indicates that this updated modeling by the consultants may not be made available for public comment:

> "The results presented in the SDEIS reflect the first of two phases of water quality analysis. The first phase includes a qualitative assessment of likely changes in water quality for multiple locations under each of the alternatives. The intent of the first phase of analysis was to determine which water quality constituents and locations are most likely to be affected by hydrologic changes. Results of this first phase of analysis will then be used to determine which parameters can be quantitatively modeled at those locations most likely to be sensitive to hydrologic changes. Phase II water quality modeling will be conducted for the FEIS in coordination with the WQCD and the EPA using WQCD protocols to satisfy 401 certification requirements. Results of Phase II water quality modeling will be presented in the FEIS." (SDEIS p. S-40)

These statements suggest that the methodology used to model stream temperature is not a matter of enough importance to merit further scrutiny by the public. An important criticism of the DEIS was that stream temperature was not modeled in a sophisticated enough manner, especially because one of the most significant environmental impacts of increased water diversions from the alternatives would be increased stream temperatures. As seven years have elapsed since the DEIS was released, it is worrisome that this more advanced modeling was not finished before releasing the SDEIS. No explanation is offered in the SDEIS for why it has not been completed yet and made available for public review. No information is provided in the SDEIS on how this more complex model will be developed, parameterized or tested.

The 2015 Stream Temperature and Dissolved Oxygen Analysis (STDOA), prepared by Hydros Consulting, provides the analysis of impacts on surface water quality (i.e. temperature). It presents a number of figures that show data for the years 2002-2013 at nineteen temperature gages on the Poudre River and three on the South Platte River, although only some gages have data for all twelve years. Less than ten of these gages are discussed in any detail in the technical report, and I will discuss just four of them on the Poudre River. However, impacts of the alternatives are discussed in just one table in the technical report, and merely as "qualitative anticipated effects"; no quantitative information is provided whatsoever. [Figures and tables from the STDOA that I reference are also included in Appendix B attached to this review.]

The four temperature gages of interest are those at the mouth of the Poudre River canyon, above the Hansen Supply Canal (the outlet from Horsetooth Reservoir), below the confluence with Boxelder Creek, and below the outlet from Fossil Creek Reservoir. These gages represent the upstream–downstream range of brown trout in the Poudre River, although only brown trout adults are found seasonally downstream of the confluence with Boxelder Creek. The first two gages are found in Segment 10, and the third and fourth, respectively, in lower Segment 11 and upper Segment 12, with the first segment designated coldwater by the Colorado Water Quality Control Division and the other two warmwater. The regulatory standards for stream temperature are the daily maximum (DM) and the maximum weekly average temperature (MWAT), which are used to determine whether the Poudre River exceeds temperature thresholds that are acutely or chronically detrimental to aquatic life.

Temperature exceedances are already occurring in many years in March and in July through September in Segment 10, and in July and August in Segment 11 (STDOA Table 4; Appendix B Table B1). Exceedances are worse in Segment 10 because it is designated coldwater and has colder regulatory standards. Exceedances in Segment 10 are concentrated between the canyon mouth and the Hansen Supply Canal because the canal delivers cold water in summer from the depths of Horsetooth Reservoir, cooling temperatures in the Poudre River. However, that cooling dissipates by Segment 11, as temperatures at the Boxelder gage are warmer by 5-6°C than those at the Hansen gage. In addition, although Segment 12 has not exceeded the summer regulatory standards (STDOA Table 4; Appendix B Table B1), temperatures have been almost equal to them in some years in July and August. Impacts of the alternatives on stream temperature will involve exacerbation of existing exceedances in mid-summer and late winter in Segment 10 and in mid-summer in Segment 11, and will most likely involve new exceedances in mid-summer in Segment 12.

Coldwater Segment 10 has exceeded the summer DM standard of 23.9°C in July and August in at least five years at the Canyon gage (STDOA Appendix A Figure 1; Appendix B Figure B2), and in at least one year (and very nearly in three other years) at the Hansen gage (STDOA Appendix A Figure 3; Appendix B Figure B3). The winter DM standard of 13°C has also been exceeded in March in at least four years at the Canyon gage, and in at least two years at the Hansen gage. These exceedances have been on as many as ten consecutive days and by as much as 5°C. Coldwater Segment 10 has also exceeded the summer MWAT standard of 18.3°C in July and August in at least six years at the Canyon gage (STDOA Appendix A Figure 2; Appendix B Figure B2), and in at least four years at the Hansen gage (STDOA Appendix A Figure 4; Appendix B Figure B3). The winter MWAT standard of 9°C has also been exceeded in March in at least three years at the Canyon gage, but in no years at the Hansen gage. These exceedances have been on as many as 50 (perhaps even more) consecutive days and by as much as 5°C. Exceedances at the Hansen gage would likely have been more similar to those at the Canyon gage, but data for just years 2007-2013 were available for the Hansen gage compared to 2002-2013 for the Canyon gage.

Warmwater Segment 11 has exceeded the summer DM standard of 29°C in July and August in at least five years (and very nearly two other years) at the Boxelder gage (STDOA Appendix A Figure 19; Appendix B Figure B4), and Segment 12 very nearly in one year (and within 1°C in another year) at the Fossil gage (STDOA Appendix A Figure 23; Appendix B Figure B5). These exceedances have been on as many as five consecutive days and by as much as 1°C. The winter DM standard of 14.5°C has not been closely approached in any years at the Boxelder gage or the Fossil gage. Warmwater Segment 11 has also exceeded the summer MWAT standard of 24.2°C in July and August in one year (and within 1°C in at least seven other years) at the Boxelder gage (STDOA Appendix A Figure 20; Appendix B Figure B4), and Segment 12 in very nearly one year (and within 0.5°C in three other years) at the Fossil gage (STDOA Appendix A Figure 24; Appendix B Figure B5). The winter MWAT standard of 12.1°C has not been closely approached in any years at the Boxelder gage or the Fossil gage. These exceedances have been on as many as 10 consecutive days and by as much as 1°C. Because data just for years 2004-2013 were available for the Fossil gage compared to 2002-2013 for the Boxelder gage, exceedances at Fossil gage would likely have been more similar to those at the Boxelder gage.

The limited discussion in the SDEIS and technical reports of these temperature exceedances, and their likely increase from the alternatives, indicates a rather dismissive treatment of their significance to aquatic life (STDOA Table 7; Appendix B Table B6). As brown trout are physiologically stressed at temperatures greater than 23°C, an increase in temperatures in warmwater Segment 11 and Segment 12 of just 1-2°C in summer suggests that the warmwater segments may be rendered unsuitable to brown trout adults even seasonally. Furthermore, brown trout in coldwater Segment 10 may also be significantly impacted by an increase of only 1-2°C, as temperatures in summer would be approaching, although not likely exceeding, their threshold for physiological stress.

Lastly, it is stated that the Poudre River is a gaining river (SDEIS p. 3-53), with the river recharged by shallow groundwater that is 5-10°C cooler than surface water, but no information is referenced in the SDEIS or technical reports that shows how much water is gained from groundwater relative to that delivered by surface water. It is presumed that shallow groundwater recharge will moderate some effects of the alternatives on stream temperature because even though surface water will be reduced, increasing its temperature, a greater proportion of water in the river will be gained from cooler groundwater relative to warmer surface water. However, this supposition is not substantiated whatsoever, and it suggests a misunderstanding of surface water–groundwater interactions. Shallow groundwater is recharged from surface water, so if surface water has been reduced, groundwater will be reduced, and because surface water has been warmed, groundwater will be warmed as well. In addition, no explanation is offered in the SDEIS or technical reports for how surface water-groundwater interactions will factor in the more quantitative model that will supposedly be completed for the FEIS.

Aquatic Biological Resources (Fish)

Environmental impacts of the alternatives on aquatic biological resources have been quantitatively assessed in the SDEIS only for fish, and only for their available habitat. It is stated that “professional judgment” was principally relied on to qualitatively evaluate impacts on aquatic life:

> “Final impacts were determined on a segment-by-segment basis for each alternative. Impacts were determined by taking into account the effects to all separate components of the aquatic community evaluated in each segment. The overall impact was categorized as negligible, minor, moderate, or major according to professional judgment by taking into account the individual impacts to the components of the aquatic environment based on the magnitude of the changes, the risk of crossing an ecological threshold, the changes in habitat availability for other species and life stages in that segment, and the predicted changes to other relevant aspects such as water quality, temperature, channel geomorphology, sedimentation, and riparian vegetation.” (SDIES pp. 4-311–4-312)

These statements suggest that the modeling of physical habitat alone was not sufficient for understanding effects of the alternatives on fish. A significant criticism of the DEIS was that impacts on fish were not understood adequately using streamflow modeled at a monthly timestep. However, it is a surprise that so much effort was expended on providing excessive physical habitat modeling using streamflow disaggregated to a daily timestep at the expense of more imperative ecological information on fish, such as population abundance, reproductive success, survival probability or food availability. As the DEIS was released seven years ago, more than enough time has elapsed for data collection and model development that would provide more comprehensive ecological information than merely physical habitat.

The 2015 Aquatic Biological Resources Effects Technical Report (ABRETR), prepared by GEI Consultants, provides the analysis of impacts on aquatic biological resources (i.e. fish). It presents a number of figures and tables that show impacts of the alternatives on several species and life stages of fish, including brown trout adults, juveniles and fry, in seven segments on the Poudre and South Platte Rivers. I will discuss a number of faults with these figures and tables that render impacts on fish difficult to interpret. [Figures and tables from the ABRETR that I reference are also included in Appendix C attached to this review.]

The three segments of interest are Segment A from Poudre Valley Canal to Larimer-Weld Canal, Segment B from Larimer-Weld Canal to Spring Creek, and Segment C from Spring Creek to New Cache La Poudre Ditch. These segments represent the upstream–downstream range of brown trout in the Poudre River, although only brown trout adults are found seasonally downstream of the confluence with Spring Creek. These segments align somewhat with coldwater Segment 10 and warmwater Segment 11 and Segment 12 that were discussed in some detail in the section on surface water quality. However, I will not discuss specific information on impacts of the alternatives on each life stage of brown trout in each segment, but rather will focus on brown trout adults in Segment A strictly as an example of the flaws involved in the modeling used for the assessment of impacts on fish.

The evaluation of impacts on fish relied solely on the modeling of physical habitat, which is modeled as weighted usable area (WUA; i.e. square meters of available habitat per linear meter of river). Although modeling WUA is standard industry practice for trying to estimate impacts of hydrologic alteration on fish, the figures that show WUA in the technical report cannot be sensibly interpreted. Data show WUA in median, 20th and 80th percentile *WUA years* (e.g. ABRETR Figure 3-4; Appendix C Figure C1). These WUA years are synthetic and idiosyncratic, meaning that data are specific to each species and life stage of fish, and are not comparable each other in any given year. The figures need to present data that show WUA in median, 20th and 80th percentile *streamflow years*, because otherwise effects of the alternatives on streamflow in any given year, and in turn effects on WUA for any species or life stage of fish, are incomprehensible. For example, to understand effects of the alternatives on fish in a dry (e.g. 20th percentile streamflow) year, the figures need to compare WUA of all species and life stages of fish for that dry year.

Although the figures need to present data that show WUA in real streamflow years instead of artificial WUA years, data showing WUA in *median* streamflow years would be as uninformative as showing effects of the alternatives on the median streamflow, which was discussed in some detail in the section on surface water. The data need to show effects on WUA in the *minimum* streamflow year, when fish habitat will likely be most impacted by the alternatives. The figures in the technical report present data on WUA in the 20th percentile WUA year, but the 5th percentile streamflow year would be more appropriate for understanding impacts of the alternatives on fish habitat toward the minimum extreme of the statistical distribution of streamflows. However, probably most judiciously, effects of the alternatives on fish habitat need to be analyzed for the percentile streamflow year(s) where streamflows are most impacted by the alternatives. Furthermore, it is not defensible to infer, as intended with these figures, that impacts of an alternative are not significant if WUA in the median year for an alternative is within the 95% confidence interval of the historical median. Although an alternative may not substantially change WUA in the median year, WUA in the minimum and maximum years can be changed quite considerably.

The tables on average and minimum WUA (e.g. ABRETR Table 3-9; Appendix C Table C2) lack meaningful information because WUA only has meaning as a time series of daily values over any given year, not as a single annual value. For example, an alternative might increase maximum WUA by 1000% on one day while decreasing minimum WUA by 100% (to zero WUA) on ten consecutive days. Average WUA for the year would not be changed by the alternative, and the alternative would not have changed minimum WUA for the year if one day of the year already had zero WUA. The ten consecutive days of zero WUA from the alternative would obviously be more detrimental to fish, but would not be represented with a single annual value of minimum WUA. The data presented in these tables give a false impression of limited impact by the alternatives.

The 2013 Aquatic Biological Resources Baseline Report (ABRBR), prepared by GEI Consultants, provides information on the methodology for developing the habitat suitability curves for the different species and life stages of fish in the Poudre River whose physical habitat was modeled. However, the habitat suitability curves, which need to be critiqued, are not presented. These curves were developed using data collected on habitat use (principally depth and velocity) by fish in July through October (ABRBR Appendix E). This time of year represents lower streamflows on the river, so the depths and velocities that fish use during this time are not representative of the depths and velocities that are available during higher streamflows. It is assumed that fish use depths and velocities similarly during low or high streamflows, but this assumption lacks sufficient support in the scientific literature on the ecology of fish in rivers with streamflows that vary throughout the year, like the Poudre River. Fish in these rivers are known to use habitat differently at different times of the year depending on specifics of their life history and on the habitat available at the time.

The interpretation that habitat availability for most species and life stages of fish will increase because the alternatives will reduce high streamflows during spring runoff is unfounded, and it suggests a misunderstanding of fish ecology in rivers with streamflow regimes dominated by snowmelt, like the Poudre River. The importance of high streamflows during spring runoff is not for habitat use by fish but principally for maintaining the stream channel and resulting habitat that is available to fish at lower streamflows during summer through winter baseflows. In addition, it may be standard industry practice to project habitat suitability curves into times of high streamflows, but taking them beyond the range of depths and velocities observed during times of low streamflows is scientifically and statistically suspect. Because observations are lacking during spring runoff, any predictions of habitat availability will be extremely uncertain beyond summer through winter baseflows, and cannot be supported by the physical habitat modeling. Therefore, the physical habitat modeling cannot be solely used for interpreting effects of the alternatives on fish.

Lastly, the interpretation that the alternatives will have at worst minor adverse impacts on fish (e.g. ABRETR Table 3-174; Appendix C Table C3) lacks adequate support from just the physical habitat modeling. No explanation is provided in the SDEIS or technical reports for how this modeling was used to assess impacts of the alternative on fish as negligible, minor, moderate or major. It seems that no quantitative thresholds of reduction in WUA by the alternatives were used to categorize impacts. It is curious then why quantitative modeling was even performed if evaluating impacts was based principally on "professional judgment", which is just qualitative.

Climate Change

It is recognized in the SDEIS that climate change may have a significant environmental impact, but discussion is rather limited on the cumulative effects of climate change on surface water, surface water quality or aquatic biological resources. The 2014 Climate Change Hydrologic Impacts Analysis (CCHIA), prepared by CDM Smith, provides the analysis of impacts of climate change on surface water. Because several studies on climate change in the Poudre River basin were already available, it was determined that additional modeling was not necessary. Conclusions in the CCHIA relied on these previous studies, particularly the Water Research Foundation's 2012 Joint Front Range Climate Change Vulnerability Study and the Colorado Water Conservation Board's 2008 Climate Change in Colorado Report.

It is stated that climate change models do not agree that precipitation will increase or decrease in the Poudre River basin, but that models do agree that temperature will increase by 1.4-3.1°C annually (relative to current conditions of 1950-2005), and by 1.7-3.9°C in summer (CCHIA p. 15). This increase will undoubtedly have a significant cumulative effect with all of the alternatives, but it is not acknowledged in any of the proposed mitigation activities. It is stated that all of the alternatives will cause additional temperature excursions in July and August in coldwater Segment 10 and warmwater Segment 11 and Segment 12, with just the historical climate in effect (STDOA pp. 91-92). However, with climate change also in force, these temperature excursions will only be further exacerbated. It would seem then any proposed mitigation activity for temperature excursions needs to recognize the probable temperature increases with climate change.

In addition, it is stated that climate change will likely shift runoff in spring and baseflow in summer by possibly a month earlier in 2050 future conditions (CCHIA p. 6). This earlier shift in runoff and baseflow will also likely have an important cumulative effect with all of the alternatives. If baseflow in summer begins in June instead of July, temperature excursions will be more likely in June and will also need recognition in any proposed mitigation activity.

Proposed Mitigation

Poudre Valley Canal Diversion Structure

It is proposed that the existing diversion structure would be revamped for the increased water diversions through the Poudre Valley Canal to Glade Reservoir, and that the new diversion structure would also include fish passage. This activity would be a greatly needed improvement that would allow brown trout to move upstream into the canyon. The design of the new diversion structure is not decided in the proposed mitigation, but for it to be successful, it needs to have an instream ramp, not an off-channel bypass, which have constantly proven ineffective. However, it is unknown whether this activity would mitigate impacts on brown trout in the Poudre River downstream of the diversion structure during summer through winter baseflows.

Glade Reservoir Release Structure

It is proposed that the release structures from Glade Reservoir would include water aeration. This activity would be a much needed requirement that would ensure the Poudre River remains well oxygenated for brown trout downstream from Glade Reservoir. The design of the release structures is not decided in the proposed mitigation, but if they are similar to the Hansen Supply Canal release structure, then they would probably function satisfactorily. This activity would probably mitigate any impacts on brown trout in the Poudre River downstream of the release structure from depressed dissolved oxygen concentrations in water from Glade Reservoir.

Avoid Munroe Canal Diversions

It is proposed that water would not be diverted to Glade Reservoir through the Munroe Canal upstream of the confluence with the North Fork, but rather through the Poudre Valley Canal at the canyon mouth. This action would mitigate significant impacts on brown trout in the canyon from reduced streamflows, and would reduce the number of river miles impacted by water diversions. However, perhaps it would be possible to divert water even farther downstream than the Poudre Valley Canal, pumping it to Glade Reservoir, and even further reducing the number of river miles impacted.

Curtail Diversions for Non-Consumptive Water Rights

It is proposed that water diversions to Glade Reservoir would be curtailed to satisfy several instream flow rights, even though they are junior to the Grey Mountain water right. This action might mitigate some significant impacts on brown trout from reduced streamflows in some reaches for an unknown number of river miles. However, it is unknown whether this activity would mitigate impacts because even though it was supposedly included in the CTP hydrologic modeling for the preferred alternative, none of the information in the SDEIS or technical reports can be used to determine whether this proposed mitigation would have much, if any, effect.

Summer and Winter Diversion Curtailments
It is proposed that water diversions to Glade Reservoir would be curtailed to maintain minimum flows in the Poudre River of 25 cfs in winter and 50 cfs in summer. This action would mitigate significant impacts on brown trout throughout their range in the Poudre River during summer through winter baseflows. However, it seems very unlikely that it would be accomplished because of the need for potentially multiple agreements with owners of junior water rights.

Low Streamflow Augmentation Release
It is proposed that to mitigate impacts on fish that releases from Glade Reservoir would augment low streamflows by maintaining 10 cfs in November through April and in September. However, no explanation is provided in the SDEIS or technical reports for why this action would be beneficial to fish. It is stated that a minimum streamflow of 10 cfs would as much as double current minimum streamflows, and increase habitat availability for fish (SDEIS p. 4-314), but any possible benefit is merely inferred from WUA. In contrast, a group of scientists developed an Ecological Response Model (SDEIS Appendix F p. 13) for predicting ecosystem condition of the Poudre River at varied streamflows. They concluded that a minimum streamflow of 35 cfs in winter was necessary for strong recruitment of brown trout, and that recruitment was poor at less than 20 cfs. However, data for recruitment at streamflows between 20 and 35 cfs was lacking, so an acceptable threshold might be within this range. Therefore, this action, which already does not mitigate impacts on brown trout in summer, would be unlikely to mitigate impacts of low winter baseflow on brown trout unless greater than 20 cfs. These scientists also concluded that a minimum streamflow of 20 cfs was necessary to sustain brown trout during summer baseflow.

It is also proposed that this action would mitigate impacts on stream temperature. However, although this action might mitigate temperature excursions in April and September, it would have no effect in July and August, when temperature excursions would have the most significant impacts on fish, especially brown trout. The only possible way to mitigate these excursions would be to preclude water diversions in July and August.

Finally, although this action is proposed to mitigate impacts on low streamflows during winter baseflow, it does nothing to mitigate impacts on high streamflows during spring runoff. Mitigation needs to be proposed that would permit high streamflows in the Poudre River for maintaining the stream channel and rejuvenating fish habitat. The scientists who developed the Ecosystem Response Model do not propose a specific high streamflow that is essential, but an appropriate recommendation can be surmised. To flush fines and mobilize the bed, an effective discharge, at minimum, would be a high streamflow of at least 3350 cfs, for at least 3 days, and at least every 3 years. However, a high streamflow of greater magnitude but of perhaps shorter duration and of lower frequency would be necessary for more consequential bed mobilization.

Poudre River Streamflow Augmentation Protection
It is proposed that the proposed streamflow augmentation would be legally protected. This action would seemingly be mandatory to ensure that the proponents cannot rescind their commitment to

release augmentation flows from Glade Reservoir or their commitment to curtail water diversions to satisfy instream flow rights and to maintain minimum flows in the Poudre River.

Multi-Level Outlet Tower for Glade Reservoir Releases

It is proposed that the outlet tower for Glade Reservoir would include selective depth withdrawals. This activity would be a much needed requirement that would ensure the Poudre River becomes partially cooled for brown trout downstream from Glade Reservoir. The design of the outlet tower is not decided in the proposed mitigation, but if it is similar to the Carter Lake outlet tower, then it would probably operate acceptably. This activity might mitigate some significant impacts on brown trout from increased stream temperatures for an unknown number of river miles downstream from Glade Reservoir. However, it is unknown whether this activity would mitigate impacts because no quantitative stream temperature model was included in the SDEIS, and stream temperature was only discussed qualitatively in the technical report. None of the information in the SDEIS or technical reports can be used to determine whether this proposed mitigation would have much, if any, effect.

Ramp Hansen Supply Canal releases

It is proposed that releases from Horsetooth Reservoir through the Hansen Supply Canal would be ramped. This action would be a greatly needed improvement that would reduce the rapid streamflow fluctuations that brown trout experience in the Poudre River downstream from release and diversion structures. However, it seems very unlikely that it would be accomplished because of the need to install new automated headgates at all diversion structures and to develop potentially complex hydrologic and hydraulic models that would ensure the proper timing of releases and diversions for multiple owners of water rights.

Stream Channel and Habitat Improvement Plan

It is proposed that a comprehensive plan would be developed for improving the stream channel throughout the Poudre River, and that it would be funded with $1 million. This action reads well on paper. However, it seems very unlikely that it would be accomplished because of the need to coordinate multiple parties that would have diverse desires that would likely be in conflict. In addition, this action would only vaguely mitigate any anticipated impact.

Channel and Habitat Improvements

It is proposed that the stream channel would be improved in two one-mile reaches of the Poudre River. This activity is not at all detailed enough for how the stream channel would be improved in these reaches, and it is unknown why improving these sites would mitigate environmental impacts on fish habitat, stream temperature or stream morphology. It is also unknown how the mitigation would be judged effective.

Multi-Objective Diversion Structure Retrofits

It is proposed that several existing diversion structures that cause drying up of the Poudre River would be revamped to include fish passage. This activity would be a greatly needed improvement that would allow brown trout to move upstream during summer through winter baseflows. The design of the new diversion structures is not decided in the proposed mitigation, but for them to be effective, they need to have an instream ramp, not an off-channel bypass, which have repeatedly proven unsuccessful. However, it is unknown whether this activity would mitigate impacts because streamflows, even if augmented with releases from Glade Reservoir as proposed, might still be too negligible for the stream channel to remain watered enough for brown trout to move upstream.

Riparian Vegetation Enhancements

It is proposed that riparian vegetation would be enhanced at four 10- to 50-acre sites on the Poudre River, including at the two reaches of proposed stream channel and habitat improvements. This activity is detailed enough for how riparian vegetation would be enhanced at those sites, but it is unknown why enhancing these sites would mitigate environmental impacts on riparian vegetation or stream temperature. It is also unknown how the mitigation would be deemed successful.

Poudre River Adaptive Management Program

It is proposed that an intensive program would be developed for adaptively managing the stream channel throughout the Poudre River, and that it would be funded with $5 million for implementation and $50 thousand per year for 20 years for maintenance. This action also reads well on paper. However, it seems very unlikely that this funding would be even remotely enough to effect any enduring improvements in stream temperature, stream morphology, sediment transport, riparian vegetation or fish habitat. In addition, the preferred alternative would not cease having environmental impacts after 20 years, and environmental impacts would not be mitigated after 20 years.

Glade Reservoir Water Quality Enlargement

It is proposed that to mitigate impacts on stream temperature in July and August, Glade Reservoir might be enlarged from 170,000 to 192,500 acre-feet. Water diversions would be curtailed in August and September, with more water being diverted in April through July. However, although the proposed enlargement might mitigate temperature excursions in August, it would only exacerbate them in July. This enlargement does not even seem plausible because it would just shift some environmental impacts of the preferred alternative from summer to spring, besides that it would require increased water withdrawals from the river. The enlarged reservoir and increased water diversions would change environmental impacts of the preferred alternative, and none of the flow-related resource effects analyses were performed with this enlargement in mind. Therefore, the SDEIS would need to be revised to analyze the new, additional impacts from the enlarged reservoir and increased water withdrawals. Because this revision seems very unlikely, it is unknown how the impacts of the alternatives on temperature excursions in July and August would be mitigated.

NISP SDEIS Technical Review

Appendix A

Example figures and tables from the 2014 Water Resources Technical Report, prepared by CDM Smith.

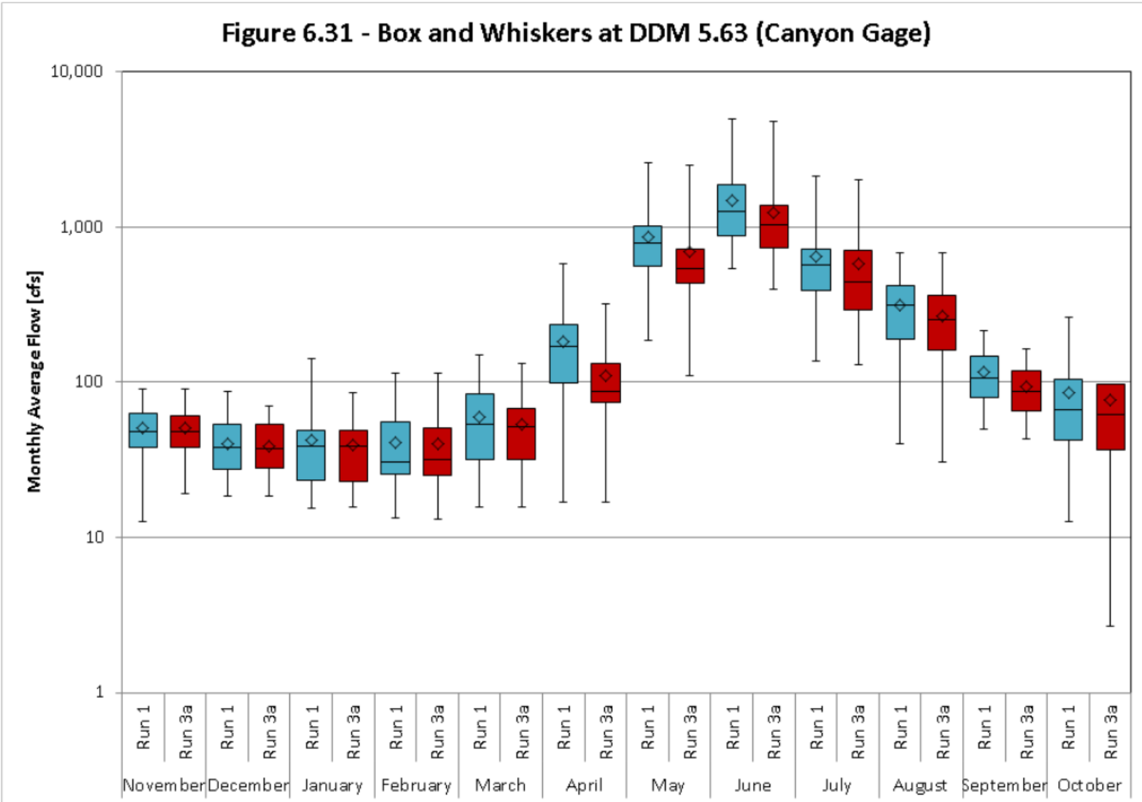

Figure A1. Example figure of box and whiskers of monthly average streamflow.

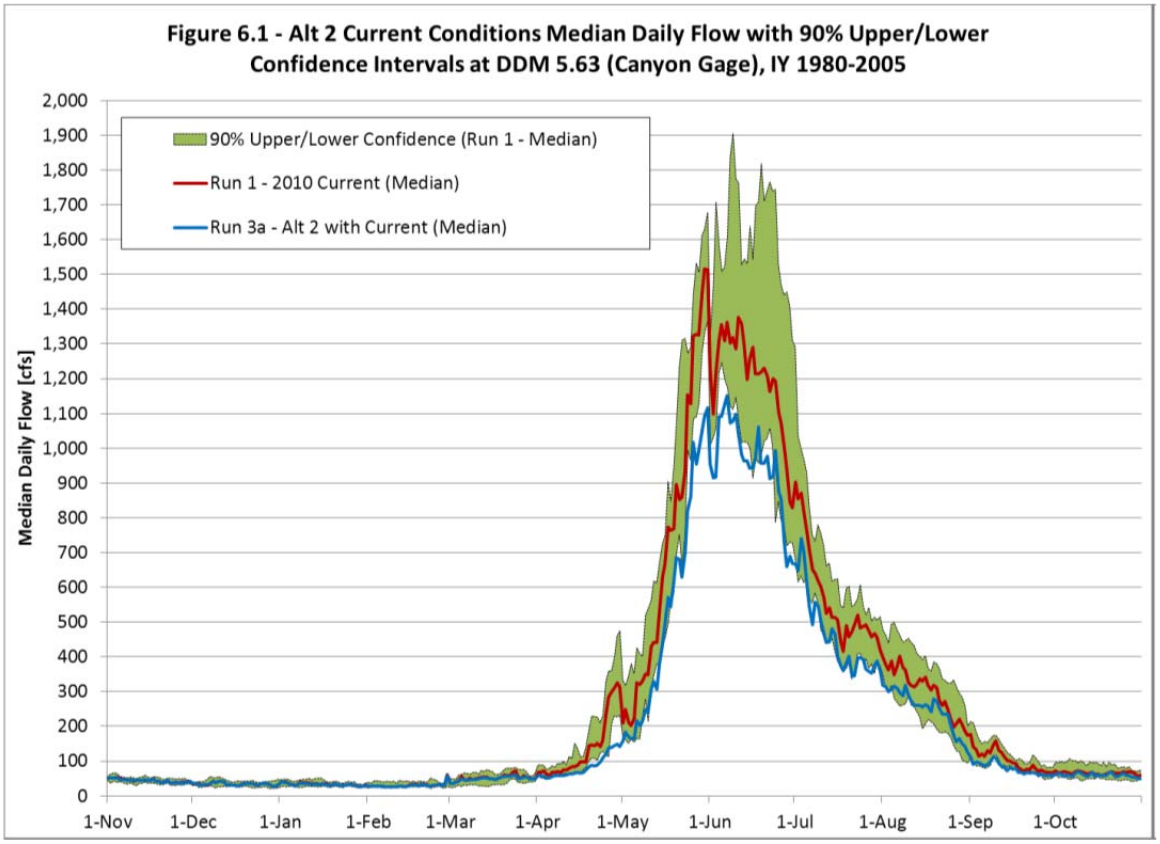

Figure A2. Example figure of median daily streamflow.

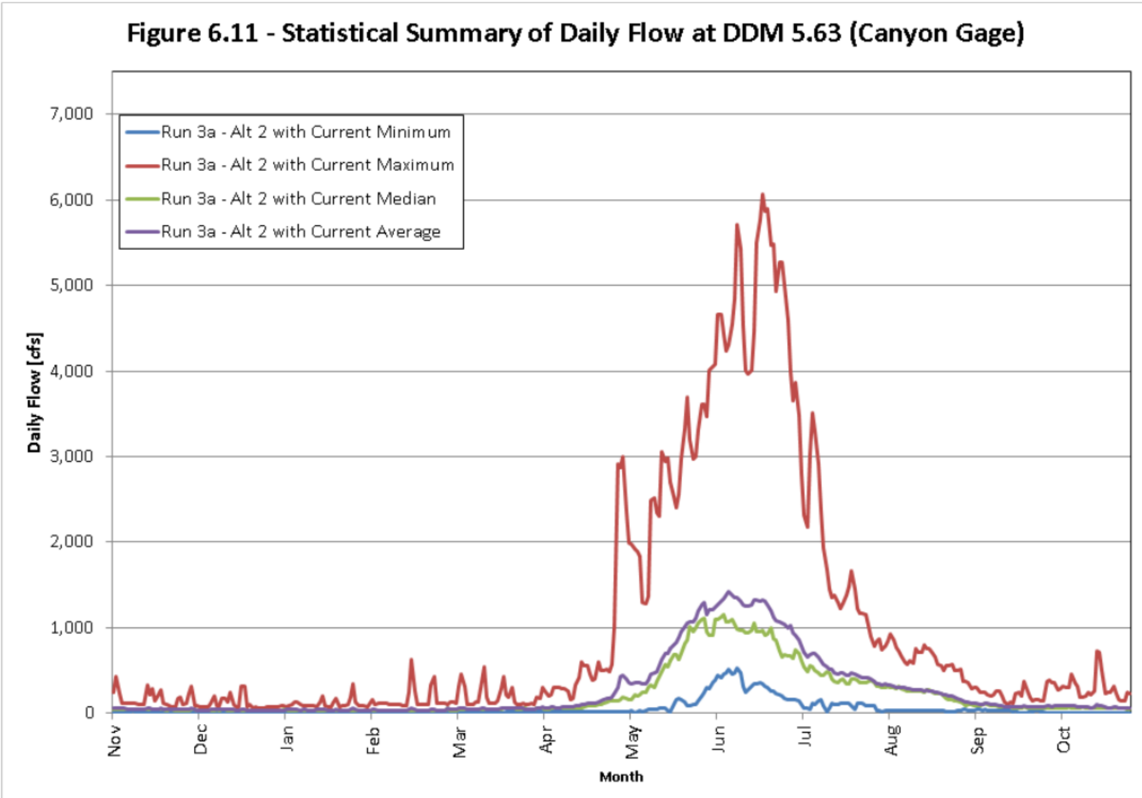

Figure A3. Example figure of statistical summary of daily streamflow.

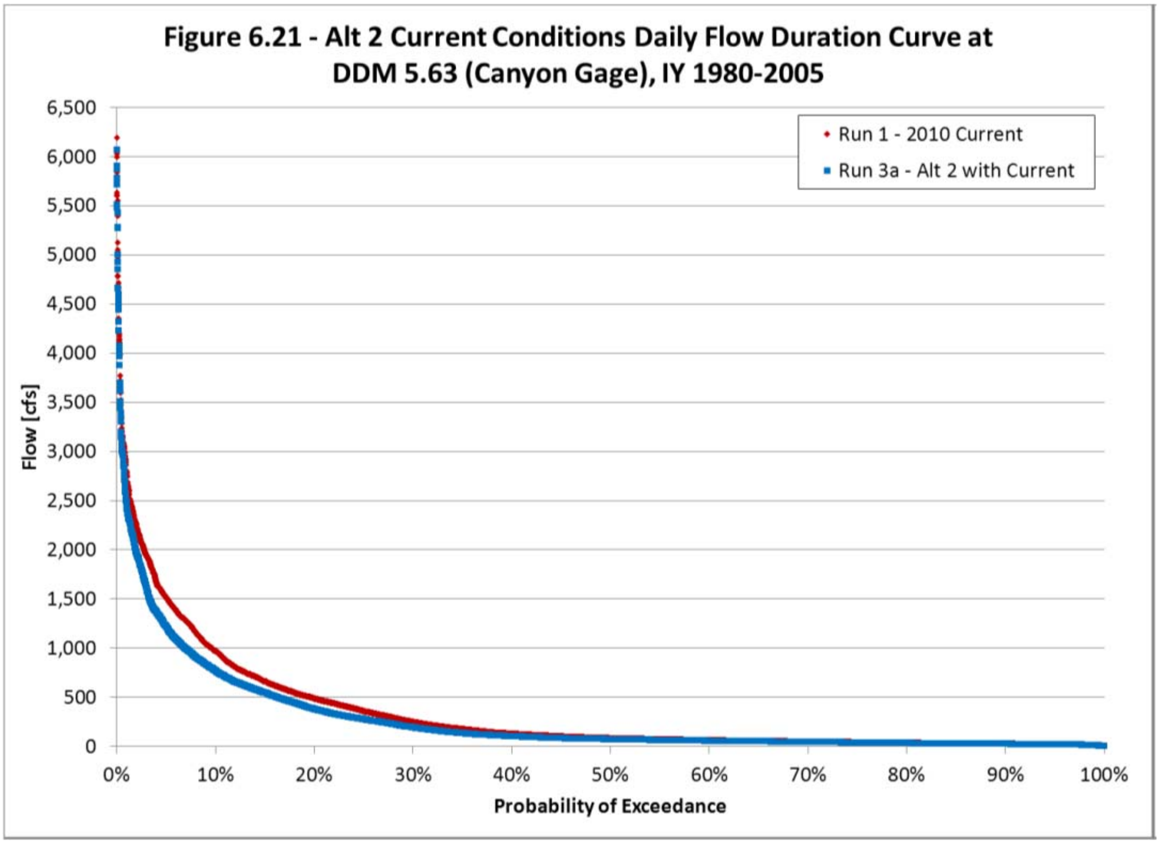

Figure A4. Example figure of daily streamflow duration curve.

Table A1. Example table of median monthly streamflow.

Table 6.1 Median Monthly Flow at DDM 5.63 (Canyon Gage)

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Annual
2010 Current Conditions Hydrology - Run 1 (cfs)													
Wet Years, IY 1980-2005	59	44	48	42	80	251	1,194	2,192	968	468	162	102	**140**
Avg Years, IY 1980-2005	43	36	33	28	45	177	757	1,266	542	313	98	71	**87**
Dry Years, IY 1980-2005	42	28	33	29	52	96	552	830	242	170	77	47	**63**
All Years, IY 1950-2005	-	-	-	-	-	-	-	-	-	-	-	-	**-**
All Years, IY 1980-2005	48	38	39	31	53	169	792	1,266	571	313	107	67	**90**
NISP Alternative 2 with Current Conditions Hydrology - Run 3a (cfs)													
Wet Years, IY 1980-2005	59	42	48	41	68	133	882	1,864	963	390	119	102	**111**
Avg Years, IY 1980-2005	43	35	28	27	45	97	528	1,034	401	264	75	56	**72**
Dry Years, IY 1980-2005	42	28	34	29	52	76	466	668	272	159	65	46	**59**
All Years, IY 1950-2005	-	-	-	-	-	-	-	-	-	-	-	-	**-**
All Years, IY 1980-2005	48	38	39	31	51	88	543	1,034	442	253	87	62	**75**
Change in Flow (CTP Run 1 – CTP Run 3a) (cfs)													
Wet Years, IY 1980-2005	0	2	0	0	12	117	312	328	5	78	43	0	**29**
Avg Years, IY 1980-2005	0	2	5	1	0	80	229	232	142	49	23	15	**15**
Dry Years, IY 1980-2005	0	0	-2	0	0	19	87	162	-30	11	12	1	**4**
All Years, IY 1950-2005	-	-	-	-	-	-	-	-	-	-	-	-	**-**
All Years, IY 1980-2005	0	0	0	-1	2	81	249	232	129	60	20	5	**15**
Percent Difference													
Wet Years, IY 1980-2005	0%	4%	0%	0%	15%	47%	26%	15%	0%	17%	27%	0%	**21%**
Avg Years, IY 1980-2005	1%	4%	14%	5%	0%	45%	30%	18%	26%	16%	23%	20%	**17%**
Dry Years, IY 1980-2005	0%	1%	5%	0%	0%	20%	16%	20%	12%	6%	15%	2%	**7%**
All Years, IY 1950-2005	-	-	-	-	-	-	-	-	-	-	-	-	**-**
All Years, IY 1980-2005	0%	1%	0%	2%	3%	48%	31%	18%	23%	19%	19%	8%	**17%**

*Negative change in flow values indicate an increase in flow in NISP Run 3a compared to CTP Run 1.

Appendix B

Example tables and figures from the 2015 Stream Temperature and Dissolved Oxygen Analysis, prepared by Hydros Consulting.

Table B1. Table of summary of temperature excursions in the Poudre River.

Table 4. Summary of DM and MWAT Excursion Occurrences in the Poudre River

Poudre River Segment	DM Excursions?	MWAT Excursions?	Typical Months with Excursions*	Notes
10	Yes	Yes	March, July-September	Primarily upstream of Hansen Supply Canal; likely also near Shields St.
11	Yes	Yes	July and August	Primarily just upstream of Boxelder Creek; Greater DM excursions, as compared to MWATs
12	No	No	n/a	Summer MWAT values can approach standard value in some years.

*This does not indicate a frequency of occurrence within a month or from year to year. At most locations with excursions, excursions are not observed in all years of record.

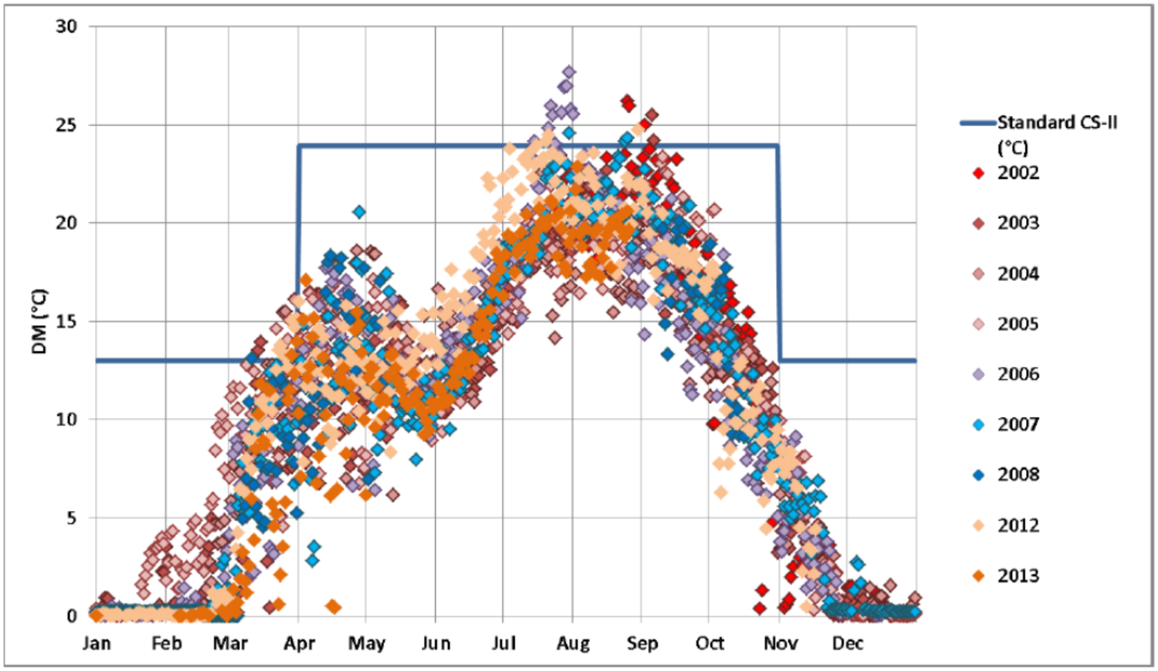

Figure 1. DM Values Calculated from CLAFTCCO (PR-55.2) Observed Water Temperature Data

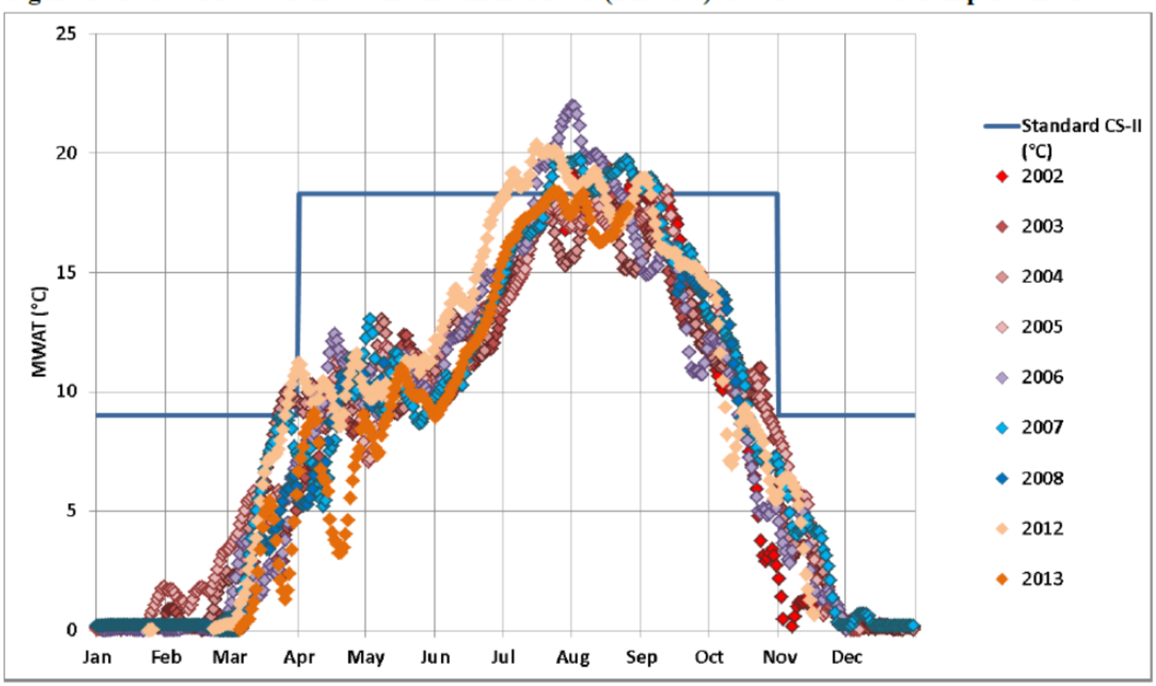

Figure 2. MWAT Values Calculated from CLAFTCCO (PR-55.2) Observed Water Temperature Data

Figure B2. Figures of DM (top) and MWAT (bottom) temperature excursions at the canyon mouth gage in coldwater Segment 10.

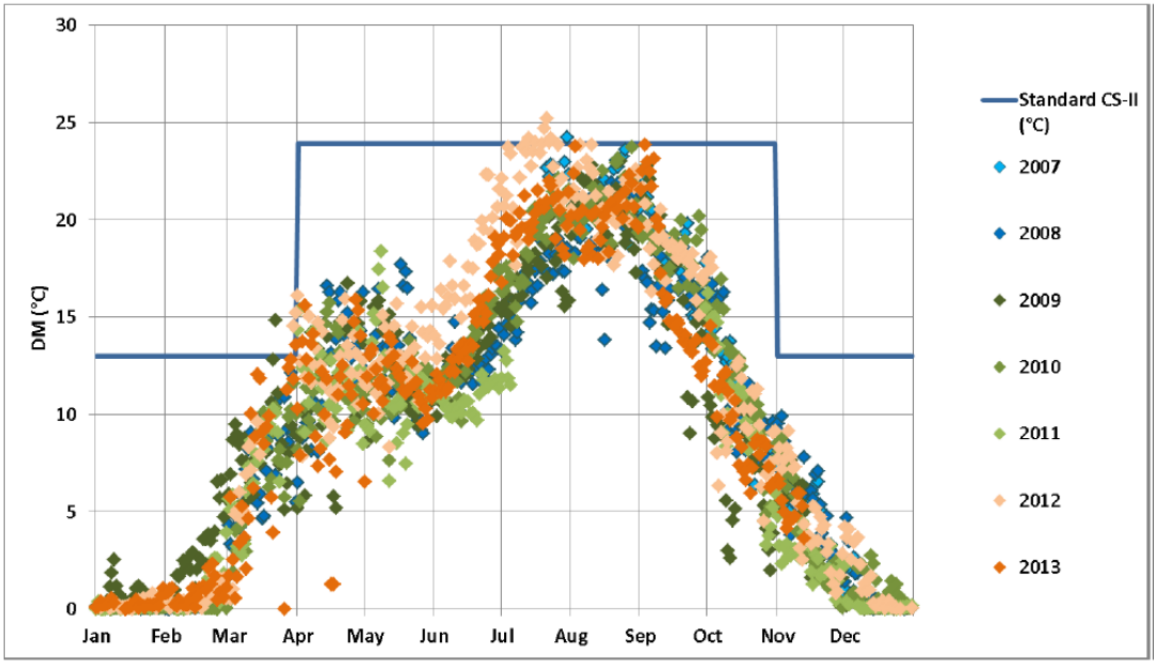

Figure 3. DM Values Calculated from HSC-PRU (PR-54.2) Observed Water Temperature Data

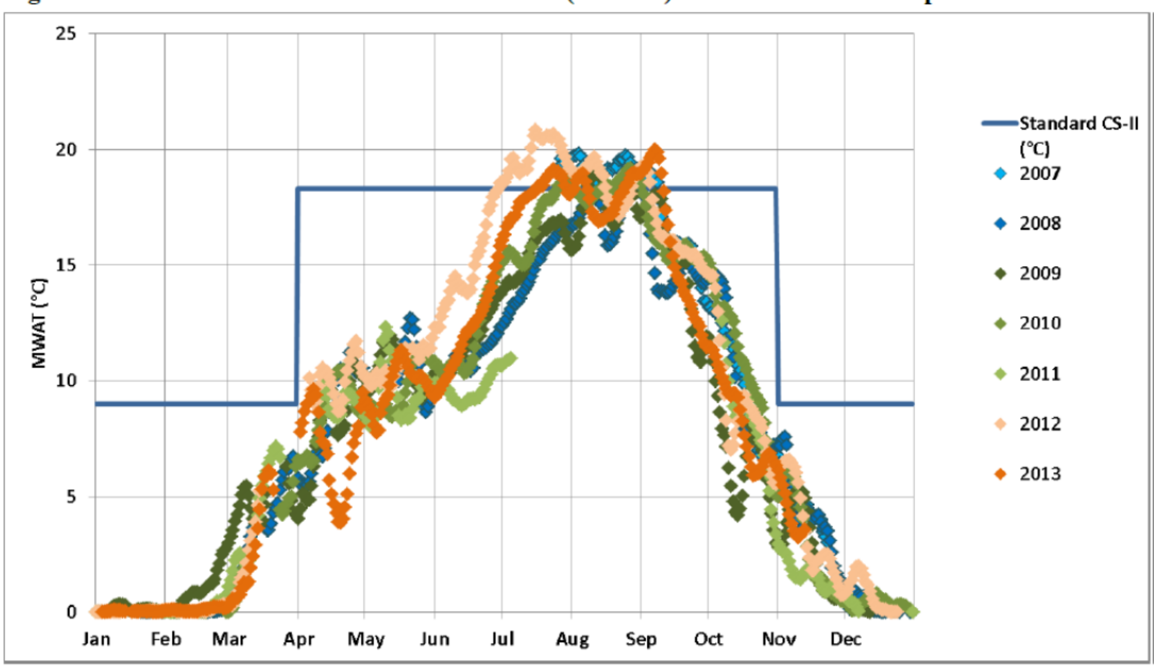

Figure 4. MWAT Values Calculated from HSC-PRU (PR-54.2) Observed Water Temperature Data

Figure B3. Figures of DM (top) and MWAT (bottom) temperature excursions at the gage upstream of Hansen Supply Canal in coldwater Segment 10.

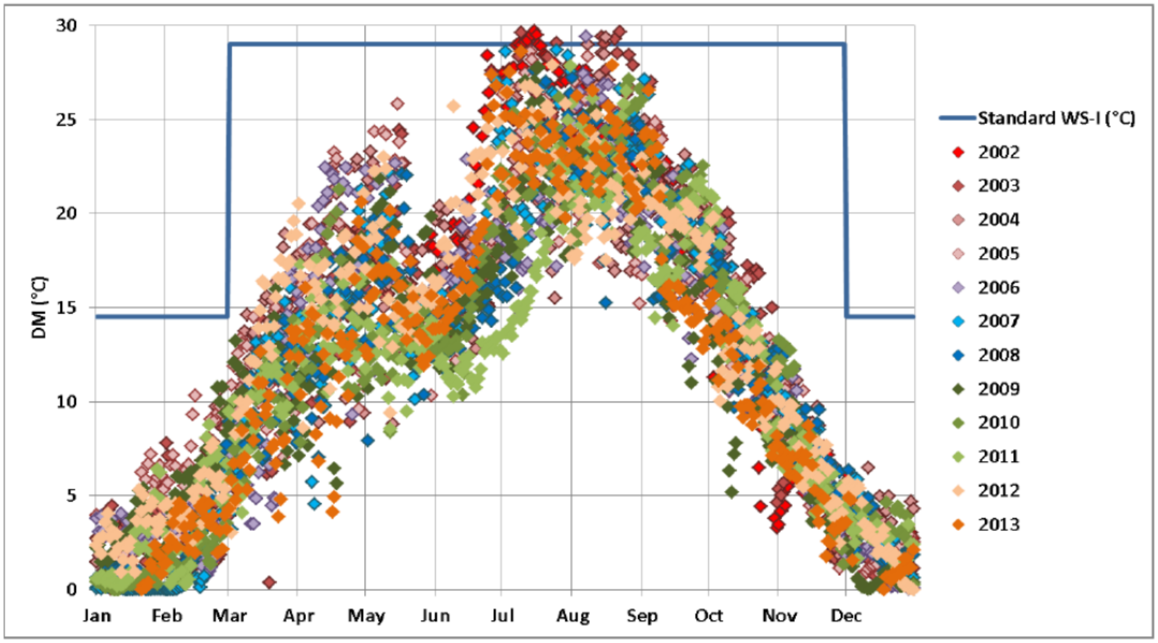

Figure 19. DM Values Calculated from CLABOXCO (PR-39.3) Observed Water Temperature Data

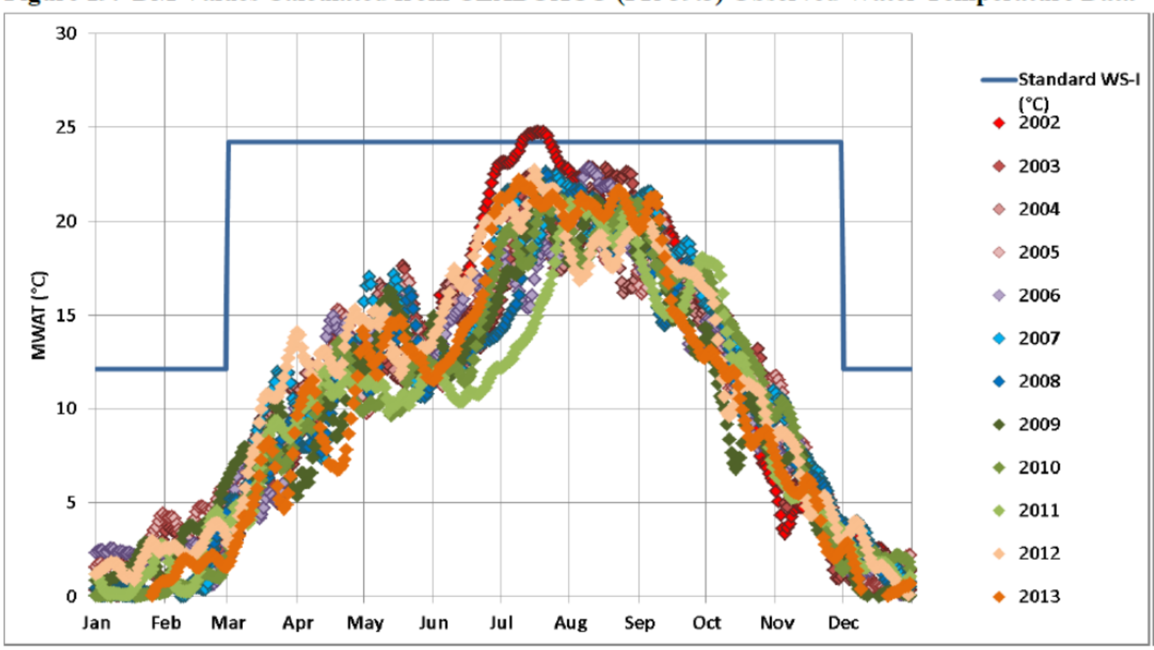

Figure 20. MWAT Values Calculated from CLABOXCO (PR-39.3) Observed Water Temperature Data

Figure B4. Figures of DM (top) and MWAT (bottom) temperature excursions at the gage downstream of Boxelder Creek in warmwater Segment 11.

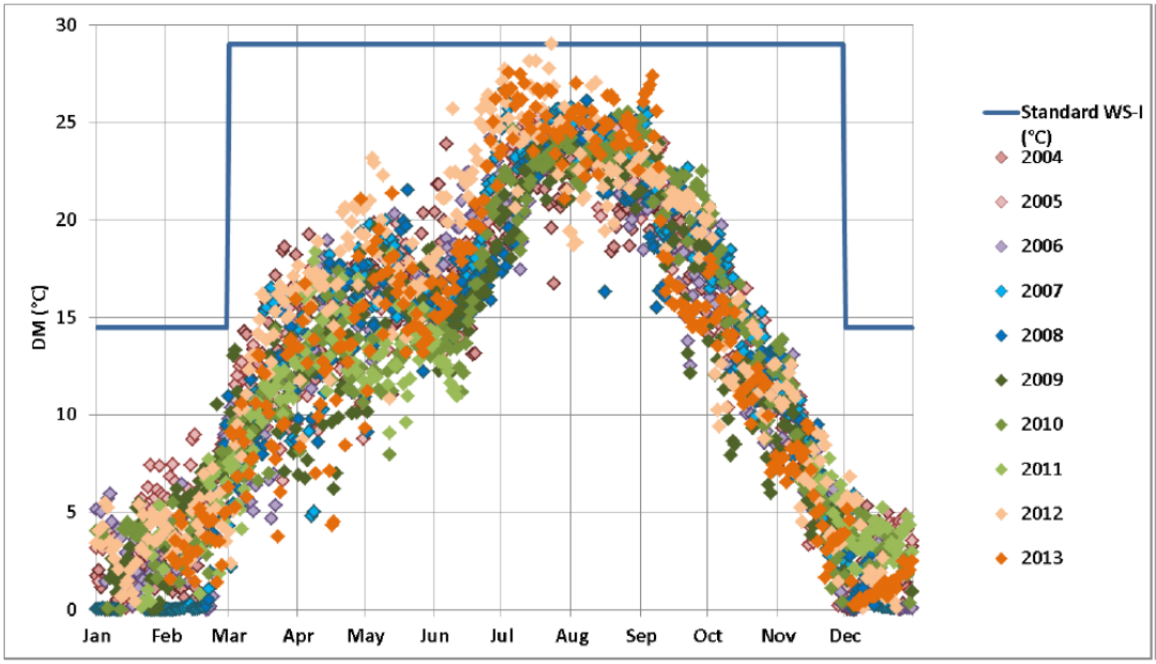

Figure 23. DM Values Calculated from CLARIVCO (PR-31.9) Observed Water Temperature Data

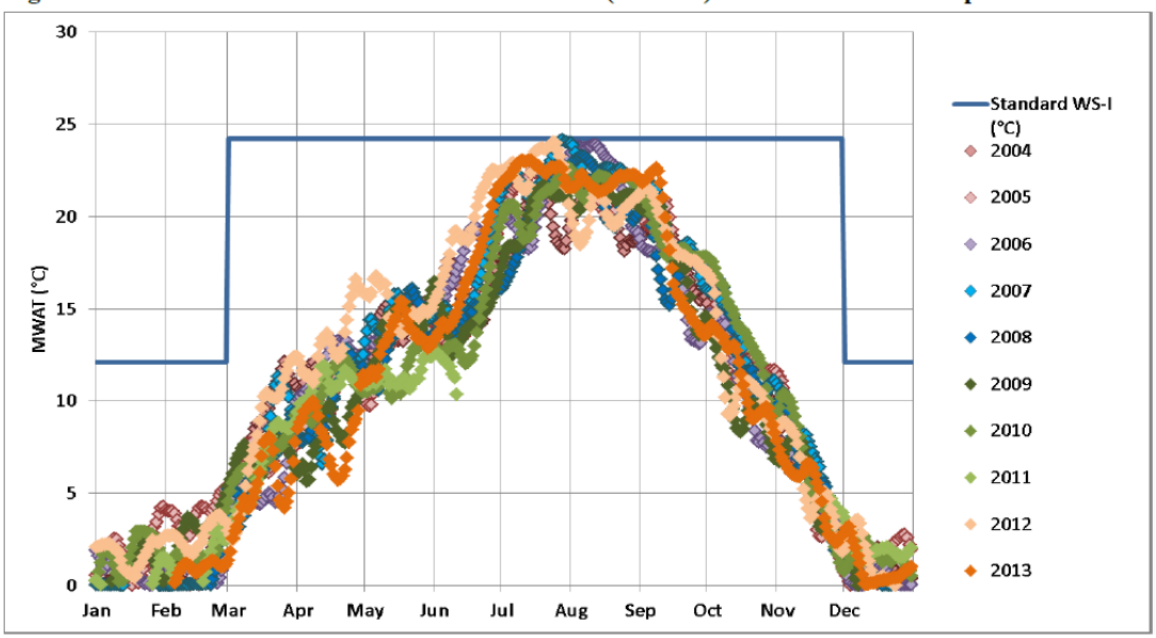

Figure 24. MWAT Values Calculated from CLARIVCO (PR-31.9) Observed Water Temperature Data

Figure B5. Figures of DM (top) and MWAT (bottom) temperature excursions at the gage downstream of Fossil Creek in warmwater Segment 12.

Table B6. Table of summary of potential impacts on stream temperatures in the Poudre River.

Table 7. Sensitive Locations and Summary of Potential Factors that Could Affect Irrigation-Season Stream Temperatures

	Poudre River Segment 10	Poudre River Segment 11	Poudre River Segment 12	South Platte River
Most Sensitive Portions of Reach	• Canyon Gage to Hansen Supply Canal • From Larimer and Weld Canal to Shields St. • Months of key concern: March shoulder season and July through early September	• Reach between Fossil Creek Inlet and Boxelder Creek • Month of key concern: July and August	• Entire reach not currently very sensitive (can approach standards June through September) • Sensitivity subject to change with major changes to relative contribution of groundwater inflow	Exceeds DM standards (esp. June through August), but not highly sensitive to effects of Poudre River based on flow rates.
Alt 1	Reduced flow from Poudre Valley Canal (PVC) to Larimer and Weld Canal	Inflow of warmer water from upstream	Likely reduction in relative contribution of cooling groundwater inflows (though no change in river flow rates anticipated)	Inflow of possibly warmer water from the Poudre River
Alt 2	• Reduced flow from the PVC to end of Segment 10 (May-Aug.) • Reduced flow from the PVC to 0.4 miles downstream of HSC (Mar., Apr., Sept.) • Streamflow Augmentation: Increased cooler flow from ~1 mile downstream of HSC to end of Segment (Mar., Apr., Sept.)	• Inflow of warmer water from upstream • Reduced flow -all of Segment 11 (May-Aug.) • Streamflow Augmentation: Increased cooler flow from top of Segment 11 to Timnath Inlet (Mar., Apr., Sept.)	• Reduced flow from top of Segment 12 to New Cache • Reduced flow from New Cache to South Platte (limited primarily to June)	Substantial warming effect not anticipated
Alt 3	• Reduced flow rates from the PVC to Shields St. (greater reduction than Alt 2; includes July and August)	• Inflow of warmer water from upstream • Reduced flow -all of Segment 11 (greater reduction than Alt2; includes May-August)	• Reduced flow from top of Segment 12 to New Cache (greater reduction than Alt2; includes May-August) • Reduced flow from New Cache to South Platte (limited primarily to June)	Substantial warming effect not anticipated
Alt 4	• Reduced flow rates from the PVC to Shields St. (lesser reduction than Alt 2 and Alt 3; includes July and August)	• Inflow of warmer water from upstream • Reduced flow -all of Segment 11 (lesser reduction than Alt2 and Alt3; includes May-August)	• Reduced flow from top of Segment 12 to New Cache (lesser flow reduction than Alt2 and Alt3) • Reduced flow from New Cache to South Platte (limited primarily to June)	Substantial warming effect not anticipated

Appendix C

Example tables and figures from the 2015 Aquatic Biological Resource Effects Technical Report, prepared by GEI Consultants.

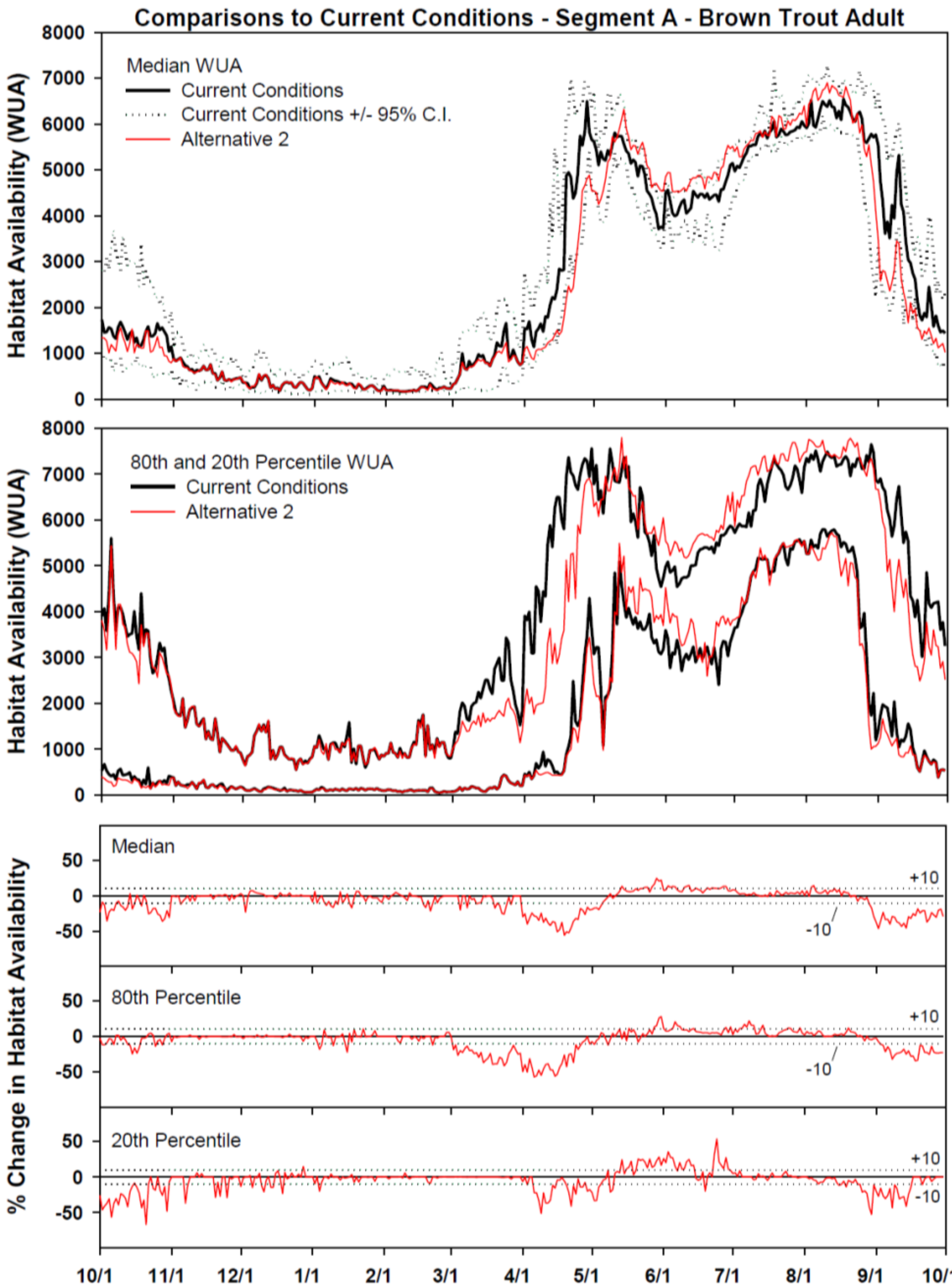

Figure 3-4: Comparison of Habitat Availability Time Series for Median, 20th Percentile, and 80th Percentile WUA for Brown Trout Adults in Segment A for Alternative 2. Lower graphs show differences in median, 20th percentile, and 80th percentile year WUA.

Figure C1. Example figure of habitat availability time series for the preferred alternative for adult brown trout in Segment A.

Table C2. Example table of habitat availability for the preferred alternative for adult brown trout in Segment A.

Table 3-9: Comparison of Habitat Availability for Alternative 2 and Current Conditions for Adult Brown Trout at the Canyon Gage in Segment A. Changes in WUA (ft^2/1,000ft) and 95% confidence intervals for minima shown in parentheses.

Habitat Availability	Current Conditions		Alternative 2		
	Value (95% CI)	Date	Value	% Change	Date
Median Year					
Minimum WUA	168 (109-577)	2/9	167	<-1%	2/11
Average WUA	2,627	n/a	2,497	-5%	n/a
80^{th} Percentile Year					
Minimum WUA	548 (437-1,137)	12/24	542	-1%	12/24
Average WUA	3,875	n/a	3,669	-5%	n/a
20^{th} Percentile Year					
Minimum WUA	49 (12-168)	2/24	48	-2%	2/24
Average WUA	1,656	n/a	1,640	-1%	n/a

Table C3. Example table of summary of effects for the alternatives.

Table 3-174: Summary of Aquatic Biological Resources Effects Determinations by River Segment and Reservoir Compared to Current Conditions.

Segment/ Reservoir	Alternative 2 Reclamation Action Option	Alternative 2 No Reclamation Action Option	Alternative 3	Alternative 4
Mainstem Cache la Poudre River				
Segment A	Minor Adverse	Minor Adverse	Minor Adverse	Minor Adverse
Segment B	Moderate Beneficial	Moderate Beneficial	Minor/Moderate Adverse	Negligible
Segment C	Minor Adverse	Minor Adverse	Minor Adverse	Negligible
Segment D	Minor Adverse	Minor Adverse	Minor Adverse	Minor Adverse
Segment E	Minor Adverse	Minor Adverse	Minor Adverse	Minor Adverse
Segment F	Minor Adverse	Minor Adverse	Minor Adverse	Minor Adverse
South Platte River				
Segment 1	Negligible	Negligible	Negligible	Negligible
Reservoirs				
Glade	Major Beneficial	Major Beneficial	N/A	N/A
Cactus Hill	N/A	N/A	Major Beneficial	Major Beneficial
Galeton	Minor Beneficial	Minor Beneficial	Minor Beneficial	Minor Beneficial
Horsetooth	Minor Beneficial	Negligible	Negligible	Negligible
Carter	Negligible	Negligible	Negligible	Negligible

Technical Memorandum

To: John Stokes, City of Fort Collins, Natural Areas

From: Brian Bledsoe, Ph.D., P.E.
Department of Civil and Environmental Engineering, Colorado State University

Date: 9/2/2015

Re: Northern Integrated Supply Project - Supplemental Draft EIS Flushing Flow Analysis

This technical memorandum provides additional information on hydraulic modeling and flushing flow analyses I performed as part of my review of all the Stream Morphology and Sediment Transport documentation provided in the Northern Integrated Supply Project (NISP) Supplemental Draft Environmental Impact Statement (SDEIS) report and appendices. Given that substantial discrepancies were identified between the results of my flushing flow analysis and the results presented in the SDEIS, I was asked by City staff to provide additional technical documentation. Accordingly, this memorandum is intended to supplement the comments I previously submitted to the City of Fort Collins by providing further details on methodology and key findings.

Methods

I used the same HEC-RAS hydraulic model that was used to perform flushing flow analyses for the SDEIS. The HEC-RAS model was provided to City staff by Anderson Consulting Engineers. No inputs, parameters, boundary conditions or any other aspect of the model were changed. I ran the "Incremental Flow" steady flow analysis for 100 increments of discharge from 10-10,000 cfs to generate shear stresses and other hydraulic characteristics at each flow and cross-section. Given that several results reported in the SDEIS are focused on six "representative" cross-sections in Fort Collins, I also focused on these same cross-sections. I extracted several HEC-RAS model outputs for these sections including main channel shear, hydraulic depth of the main channel, slope of the energy grade line (E.G. slope; estimated at a point using Manning's equation), and friction slope (averaged over two cross-sections). These outputs were used to calculate multiple estimates of shear stress using hydraulic radius vs. hydraulic depth of the main channel and E.G. slope vs. friction slope. Specifically, the estimates included:

- Shear stress of the main channel directly output from HEC-RAS;
- Product of specific weight of water, hydraulic depth of the main channel, and friction slope; and
- Grain shear based on Strickler approximation following a standard approach detailed by Wilcock et al. (2009).

In an attempt to recreate the flushing flow results reported in the SDEIS I also applied the Ackers and White (1973) relationship used in the SDEIS (p.6-10 of Stream Morphology and Sediment Transport Baseline Report) to calculate shear stresses. I evaluated the applicability of this relationship for this type of analysis by reviewing the scientific literature since 1973 and examining the range of conditions for which it is calibrated and intended. To estimate the flow required for flushing sediment and maintaining physical habitat in the Poudre, I calculated dimensionless shear stress values for each increment of flow from 1500-10,000 cfs at each "representative" cross-section using the median grain diameter reported in the SDEIS for that cross-section (see Tables 3.7 and 3.9 of Volume II of the "Effects" report for grain sizes and river cross-section stations).

Dimensionless shear stress (τ_*) is a fundamental hydraulic parameter representing a ratio of erosive forces to resisting forces. It is commonly used in river mechanics to characterize the mobility of various sizes of sediment particles on the river bed. Dimensionless shear stress is defined as:

$$\tau_* = \frac{\tau}{\gamma(G-1)d}$$

where *R* is hydraulic radius, *S* is slope, γ is the specific weight of the fluid mixture (estimated at 9810 N/m^3), *G* is specific gravity of sediment (estimated at 2.65), and *d* represents grain diameter. Calculating τ_* for each flow and cross-section allowed me to compare the discharges required for river bed flushing as reported in SDEIS against the discharges calculated using main channel shear stress from HEC-RAS. To perform this analysis, I used the same median grain diameters used in the SDEIS analysis and the same dimensionless shear stress criteria for fine sediment flushing and coarse substrate mobilization used in the SDEIS, namely 0.02 and 0.03, respectively. Finally, I compared the SDEIS grain sizes that were used in the flushing flow analysis with grain sizes measured in the field by CSU engineers using intensive sampling methods.

Results and Discussion

The equation from Ackers and White (1973; p.6-10 of Stream Morphology and Sediment Transport Baseline Report) is not appropriate for the conditions for the Poudre River. Specifically, the data set used to develop the Ackers and White sediment transport relationship included gravel up to 7 mm in diameter. The American Society of Civil Engineers Manual of Practice 110 on Sedimentation Engineering states that "In point of fact very little of the data used to develop this relation was in the range of gravel-bed rivers" (Parker, 2008). Further, this relationship was calibrated to estimate bedload rates through interaction with the other Ackers and White (1973) bedload equations in sand bed rivers. This relation was not intended for this application nor calibrated for the prevailing grain size and roughness characteristics found in the Poudre River in Fort Collins. Nevertheless, it was apparently used to adjust shear stress output from HEC-RAS modeling because I could only reproduce some semblance of the SDEIS shear stress results by applying this equation. This erroneous application of shear stress "partitioning" biases the results such as to give an impression that there is little sediment flushing occurring under baseline conditions, and ultimately masks the net reduction in sediment flushing that occurs under NISP Alt. 2 (Table 1). In fact, the application of shear stress "partitioning" using the Ackers and White (1973) or any other method is not appropriate for the analysis of how NISP Alt.2 affects flushing flows that produce a τ_* of 0.02. This approach was developed by Dr. Robert Milhous at the USGS (Milhous 2000, 2003) and intended to be assessed using total shear stresses, not partitioned shear stresses (Dr. Robert Milhous retired USGS, email communication, July 29, 2015).

All the standard methods for estimating shear stress I examined result in significantly greater sediment flushing and mobilization potential compared to values reported in the SDEIS. This one source of bias in shear stress estimates produces errors averaging 52% with some errors exceeding 80% at the SDEIS “representative” cross-sections selected in the Fort Collins reach. These errors in shear stress, in turn, propagate through the hydraulic analysis of what flows are required to estimate sediment flushing. Many of the errors in flushing flow estimates are two- to fivefold in magnitude (Table 1).

Reach ID	Station	SDEIS grain size (mm)	SDEIS Table 3.7 flow required for flushing at τ_* of 0.02 (cfs)	CSU analysis of flow required for flushing at τ_* of 0.02 based on SDEIS grain size and and main channel shear from SDEIS HEC-RAS model (cfs)	SDEIS Table 3.9 flow required for flushing at τ_* of 0.03 (cfs)	CSU analysis of flow required for flushing at τ_* of 0.03 based on SDEIS grain size and and main channel shear from SDEIS HEC-RAS model (cfs)
Fort Collins 1	244249	88	9,260	1,850	>10,000	3,000
Fort Collins 2	238538	99	3,971	2,200-2,400	5,815	3,600-3,800
Fort Collins 3	231351	69	1,115	< 1,500	2,208	< 1,500
Fort Collins 4	228361	80	7,387	1,850-1,900	>10,000	6,800-7,000
Fort Collins 5	219576	51	2,239	< 1,500	>10,000	< 1,500
Fort Collins 6	215717	86	5,084	2,400-2,600	9,071	4,200-4,400

Table 1. Comparison of river flows estimated by SDEIS to provide sediment flushing versus flows estimated using standard methods with same SDEIS model and grain size data. These discrepancies arise, at least in part, due to an erroneous application of shear stress partitioning using an obscure equation from Ackers and White (1973). Tables 3.7 and 3.9 are in the SDEIS Stream Morphology and Sediment Transport Effects report Volume II.

Another concern with the SDEIS analysis is the selection of grain sizes used in the flushing flow analysis. Colorado State University engineers led by Dr. Dan Baker conducted river substrate sampling in Fort Collins in 2012. These data were collected using highly intensive methods (>300 diameter observations per reach) following the point grid methodology of Bunte and Abt, and are summarized in Table 2. Although these data were provided to the SDEIS consultants and subsequently mentioned in the SDEIS, they were not utilized in the SDEIS flushing flow analysis. CSU’s aggregated median grain size for Shields St and Lee Martinez sampling sites is between 55-60 mm with fine sediments less than 2mm removed. These grain size estimates are substantially smaller than the median grain sizes used in the SDEIS analysis (third column of Table 1 above).

Inspection of the dimensionless shear stress equation presented above indicates that a reduction in the grain size used in the denominator results in a linear increase in τ_* and flushing potential in proportion to grain diameter. That is, if the grain size used in this type of dimensionless shear stress analysis is decreased from 90 mm to 60 mm, τ_* would increase by 50% . The difference in the discharge required to produce that shear stress would be even greater since shear stress scales with discharge with a power exponent less than unity. The sensitivity of flushing flow results to grain size underscores the importance of robust field sampling methods, and careful selection of the data used in the analysis. The SDEIS does not provide a rationale for selecting grain sizes that are generally on the coarser end of the available data (see Figure 3.8 of Stream Morphology and Sediment Transport Baseline report) and collected using less spatially intensive methods.

		Shields Street (SS)			9/19/2012	Lee Martinez Park (LM)		9/21/2012
Grain Size Bins (mm)		**SS_X2**	**SS_X1**	**SS_X3**	**SS_ TOTAL**	**LM_X2**	**LM_X1**	**LM_ TOTAL**
Min	**Max**	**Riffle 2**	**Run**	**Riffle 1**	**TOTAL**	**Run 2**	**Run 1**	**TOTAL**
0	**2**	26	37	8	71	17	17	34
2	**2.8**	6	1	0	7	1	0	1
2.8	**4**	3	2	1	6	9	0	9
4	**5.6**	0	2	2	4	5	0	5
5.6	**8**	0	5	3	8	7	0	7
8	**11**	1	2	3	6	7	6	13
11	**16**	0	2	1	3	5	3	8
16	**22.6**	3	4	4	11	10	8	18
22.6	**32**	1	7	6	14	15	16	31
32	**45**	6	5	6	17	23	37	60
45	**64**	12	8	17	37	30	24	54
64	**90**	15	8	21	44	33	23	56
90	**128**	13	12	22	47	18	23	41
128	**180**	9	6	6	21	3	16	19
180	**256**	3	5	0	8	1	5	6
256	**362**	0	0	0	0	2	0	2
362	**512**	0	0	0	0	0	0	0
512	**1024**	0	0	0	0	0	0	0
1024	**2048**	0	0	0	0	0	0	0
2048	**bedrock**	0	0	0	0	0	0	0
	# counted	98	106	100	304	186	178	364
	% Fines (<2mm)	27%	35%	8%	23%	9%	10%	9%
(a)	**d_{50}**	49.1	19.0	62.7	47.2	41.2	46.3	44.0
(b)	**d_{50} (no fines)**	70.1	54.9	67.2	65.8	46.3	52.5	49.0
(c)	**d_{50} (no fines or bedrock)**	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 2. Grain size data from intensive sampling of the Poudre River substrate in Fort Collins performed by CSU. These results indicate substantially smaller median grain sizes and higher flushing potential under current conditions compared to the SDEIS.

Conclusion

Bias in the SDEIS analysis significantly underestimates changes to the frequency of flushing because it incorrectly asserts that the flows required for flushing are extremely high and therefore minimally affected by NISP. It is fundamentally important to recognize that the proposed SDEIS Alt. 2 most impacts flows in the range that provides fine sediment flushing. Although I was not able to find a flow duration curve that allowed accurate estimation of the reduction in the frequency of flushing flows in the range of 1500-2500 cfs, inspection of Table 3.2 in the SDEIS Stream Morphology and Sediment Transport Effects report Volume II documents the substantial nature of these effects under average conditions using coarse hydrology data. Finer resolution hydrologic data would further accentuate these impacts.

In the absence of flushing flows, existing physical habitat will be negatively affected in the future as the Poudre River channel and its substrate characteristics (e.g., extent of interstices clogged with fine sediment, amount of algae) evolve with ongoing changes in water management. A large body of scientific literature supports this assertion (e.g. see review by Waters (1995)). River habitat would degrade irrespective of instream flows and 10 cfs mitigation flows because such low flows are incapable of rejuvenating the river bed to maintain habitats required for trout reproduction and aquatic insects. This underscores that inclusion of flushing flows, and not just extreme low flows, is an essential component of any plan to mitigate the effects of NISP.

To resolve the issues described in this memorandum, the SDEIS analysis will need to be performed with total main channel shear stresses or shear stresses based on the product of specific weight of water, main channel hydraulic depth, and friction slope from the existing HEC-RAS model without applying shear stress partitioning. The resulting shear stress estimates will need to be combined with more defensible and representative grain sizes for the Fort Collins reaches to evaluate impacts to flushing flows and river health.

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