STATE OF MICHIGAN
DEPARTMENT OF NATURAL RESOURCES
LANSING

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August 23, 2012

Mr. James Sallee
Michigan Department of Environmental Quality
Water Resources Division
Jackson District Office
301 E. Louis Glick Highway
Jackson, Michigan 49201-1535

Re: Fisheries comments concerning DEQ file no. 12-81-0027-P

Dear Mr. Sallee:

The Michigan Department of Natural Resources (DNR), Fisheries Division is providing comment on the Michigan Department of Environmental Quality (DEQ) permit application titled "MichCon Broadway Street MGP Whitewater and Habitat Improvements" (DEQ file no. 12-81-0077-P). The DNR met on two separate occasions with representatives from DEQ, City of Ann Arbor, TRC and Recreational Engineering and Planning (REP) to discuss the proposed project.

At those meetings, DNR expressed issues of concern relative to the two channel-spanning whitewater structures proposed to be constructed in the main channel of the Huron River downstream of the Argo Dam. Specifically, that the proposed structures were in fact dams created with a U drop that creates a hydraulic roller and allows for kayak passage. The DNR provided the Dams and Barriers Policy 01.02.002 to the participants (Attachment 1). The policy clearly states that, "Because of the significant environmental effects of dams, Fish Division does not support new dam construction." The policy outlines and provides citations of the effects that dam have on riverine ecosystems.

Much discussion at the meetings focused on DNR's position that any structures proposed must allow for unimpeded fish passage for all species, at all times of the year, for all life stages relative to what exists with current conditions. During the initial meeting with the applicant, DNR expressed the need to incorporate unimpeded fish passage into any proposed structure. Discussion ensued why fish passage would be necessary since Argo Dam was located upstream of the proposed project. In Michigan, and around the county, dam removals are becoming more prevalent due to aging infrastructure requiring costly repairs. If the dam still serves an economic purpose, private investments would be made to maintain and repair them. A decision to "leave the dams alone" is a decision to promote deterioration and invite uncontrolled consequences to both human and natural communities.

The American Society of Civil Engineers considers dams to have an engineered life span of 50 years. In most cases, state and federal funding have been used to address water- quality issues associated with dam failures and restoration because dam owners do not have the funding necessary to either maintain or remove the dams. Any new structures constructed in a river system should allow for fish passage and natural sediment transport so as not to repeat the history that we are currently funding and living. Dams are not permanent structures and in this case the location of Argo Dam in relation to the proposed structures should not allow for further degradation of the Huron River. Planning should provide for a naturally functioning system below Argo Dam as history has made clear that, at some point in time, the Argo Dam will be modified or removed. Impediments should not be constructed in the river that the public will again be asked to address.

Additionally, discussion focused on the need for natural stream function and that sediment transport should remain unchanged with the construction of any structure. Sediment transport is necessary to maintain the stability of the stream so that it maintains its dimension, pattern and profile and neither aggrades nor degrades, thereby maintaining current habitat in the stream. This is true for any river, but specifically it is important for this site so as not to compromise the remediation conducted on the adjacent contaminated MichCon site.

Following the meeting, DNR sent an e-mail from Chris Freiburger to REP on March 7, 2012 which is included as Appendix 7 in the permit application (Attachment 2). The e-mail was provided at the request of Mr. Gary Lacy, REP, to provide clarity and reiterate many of the issues discussed at the previous meetings and offered additional information sources that may assist in design modifications.

In the "Alternatives" section the applicant offered modifications to the initial design in an attempt to enhance fish passage and sediment transport by reducing slope between the crest and pool structures, the addition of roughness and a vertical-slot fish way. The applicant offered these design modifications as alternatives and suggests that any other changes to reduce slope will degrade the whitewater features to a point that their benefit as recreational features would be minimal.

DNR does not view modifications to the initial design as alternatives to the proposed project, but as a necessity to maintain current conditions without degradation. Also we do not support the applicant's position that further changes to the structure would provide minimal recreational benefit. Our experience here in Michigan has been that the development of natural channel-design structures that provide for unimpeded fish passage and sediment transports have also provide many recreational opportunities including kayaking, canoeing, tubing, angling, boating, swimming and viewing.

The State of Minnesota has had similar experiences with whitewater enthusiasts utilizing natural channel design structures and often incorporates rounded rock into their designs as not to damage watercraft with sharp rocks and reduce injury to recreationalists. Aadland (2010) has found that emulating natural channel geomorphology and materials has several advantages. First, fish react to complex current and bathymetry cues, and channels similar to natural channels are less likely to cause disorientation than channels that are not. Second, natural channel design allows fish ways to provide important habitat as well as passage. A greater number of alternative spawning areas are also likely to provide greater reproductive success and resilience. Third, use of natural substrates, rather than concrete or other smooth materials, provides roughness and interstitial spaces that allow small fishes and benthic invertebrates to pass and, in many cases, colonize.

The March 7 e-mail clarifies that the applicant should follow the Natural Channel Design (NCD) checklist provided by DEQ as a guidance document. This information must be collected to fully evaluate the proposed stream project. Specifically, the e-mail responds to the applicant's question of what sediment model should be utilized to determine if the proposed structures will have any effect on sediment transport that differs from that which currently exists. The DNR e-mail responds that, "As it relates to sediment model selection the NCD checklist recommends the applicant select a model and discuss its appropriateness with the regulatory and resource agencies." Unfortunately, there was no follow up by the applicant to discuss with DNR appropriate models to use for sediment transport.

Additionally the e-mail states, "I also wanted to note that, as the NCD checklist addresses, when additional geomorphic information is collected (i.e. longitudinal profile) it is necessary to collect bank full measurements on all cross sections and the longitudinal profile in order for DNR to evaluate. My understanding is that to date no longitudinal profile or bank full measurements have been taken on any of the data which has been collected. Further reference reach information may need to be collected to determine stable conditions in order to determine appropriate design if the subject reach is deemed to be unstable based on geomorphic data collected."

Unfortunately, detailed geomorphic information was not collected in the stream reach as requested both by DNR and DEQ staff in the meetings or in the follow up e-mail from DNR. Although numerous cross sections were provided, by the applicant, presumably for HEC-RAS model runs, they do not provide the level of detail for a geomorphic survey or describe what facets the cross sections traverse (i.e. riffle, run, pool, and glide). Further, based on review of the application, it does not appear that a detailed longitudinal profile in the thalweg was surveyed which is needed to determine reach, facet, bank full, bed slope and other geomorphic data.

Neither the cross sections nor longitudinal profile identify bank full elevation which is paramount to understanding what effect structures will have on a stream. This is unfortunate since it was clearly articulated that bank full measurements are necessary. The NCD checklist also indicates that pebble counts should be conducted at cross sections, along the longitudinal profile and point bars.

The only indication in the application that refers to sediment characterization, which we were able to locate, was found in Table 4 of the Hydraulic Report and Model in Attachment 8 in the permit application. The information provided indicates that TRC Environmental conducted a grain size analysis at site T-4-3 and the D_{90} was 250 millimeter (mm). No additional information was provided on the location or method of sample collection. Pebble count information is necessary for classification purposes, discharge, and sediment transport calculations (competence and capacity).

As a result of not having sufficient detailed geomorphic data, as discussed and requested, it is difficult for the applicant and the DNR to fully evaluate the effects of the proposed project on natural stream function and aquatic organism passage on the this stretch of the Huron River. In order to evaluate, staff from DNR and DEQ dedicated substantial time collecting and analyzing geomorphic data to determine stream impacts and validate model input parameters from tables and assumed values relative to actual geomorphic data collected.

Please find DNR comments below to specific sections of the permit application. For organization and efficiency of review, page numbers and excerpts contained within the application are copied below in standard formatting. The DNR response follows in italics.

Fill/Excavation Summary

Attachment 5, Fill/Excavation Summary, states that, "The project has proposed to excavate a total of 728 cubic yards of sediment in the Huron River in an area of 9,776 square feet (ft). In addition, the project proposed to place a total of 1,783 cubic yards of fill overt a 23,263-square-foot-area. The net effect of the excavation and fill is a 1,055 cubic yards gain in material (less floodplain storage). This loss in floodplain storage will be offset by the gain on 1,555 cubic yards in storage to be made by the concurrent proposed remediation of the Former Broadway

MGP site on the southern bank of the Huron River (File No. 11-81-0066-P). When considering both projects, a small net gain in floodplain storage will be achieved."

Based on information provided by the applicant a small increase in floodplain storage will be recognized immediately in the proposed project area while 1,554 cubic yards of fill are being placed below the ordinary high water mark and bank full elevation. The increase in storage capacity is important as it relates to water surface elevations. However, a large quantity of fill is being placed in the bank full channel inducing immediate changes in bank full cross sectional area, slopes, depths and roughness.

Comments below are specific to the document titled; "Summary Hydraulic Report and Final Design for the In-River Whitewater Structures-Huron River, Ann Arbor, Michigan" dated April 19, 2012 and is included as Attachment 8 in the application.

Model Parameters

Page 7. REP created the proposed conditions model using the existing conditions model as a base while inserting proposed geometry at specific locations to mimic the proposed modifications. Using the existing conditions model as a base allows for direct comparison between the existing conditions and the proposed conditions. This is referred to as "apples-to-apples" comparisons within this report.

DNR concurs that inserting proposed geometry at specific locations to mimic the proposed modifications at the physical location of the structures is acceptable to have an "apples to apples comparison". However many parameters in the model run need to be modified for hydraulic evaluation since geometry of the cross section will change including roughness, cross sectional area, depth and slope.

Page 8. The Manning's "n" value used for the proposed conditions channel varied from 0.02 to 0.03 depending on location. Values of 0.02 were used at the crest and exit of proposed drop structures to reflect the roughness of smoothed concrete drops (Chow, 1959, Barnes, 1987) and values of 0.03 were used at locations with no change from the existing conditions model. Overbank values were unchanged from the existing conditions model and ranged from 0.04 to 0.1.

The applicant uses a Manning's n value of 0.02 as the roughness coefficient at the crest and exit of the proposed drop structures. It is not clear from the application what type of channel and description the applicant used from Chow's table (1959), however DNR does not concur with the roughness coefficient used by the applicant. Chow (1959) shows Manning's n values for Lined or Channel, neat cement (5, a, 1) ranging from 0.010 to 0.013 with a normal 0.011 while mortar (5, a, 2) has a range of values from 0.011 to 0.015 with a normal of 0.013 (Attachment 3).

Further, the Huron River Watershed Council collected flow data at structure number six in the Argo headrace. Flow measurements were taken mid-way through the structure. This location was chosen so measurements were not influenced by backwater created at the crest or turbulence at the exit of the structure. Based on the discharge data collected Manning's n was back-calculated having a value 0.01 which is consistent with Chow's values described above. The decrease in Manning's n values and roughness will result in increases in mean velocity predictions.

Page 9. The upstream boundary condition of normal depth was also used and multiple thalweg elevations were used to determine the appropriate slopes. The slope was found to be relatively inelastic and all values were set to a slope of 0.0015.

Staff from DNR and DEQ conducted a detailed longitudinal profile which included the project reach which extended from the riffle immediately downstream of Argo Dam to the first riffle downstream of the proposed project. The longitudinal profile begins and ends on a riffle since they are the same facet features and serve as hydraulic controls in the river dependent on flows. Riffle to riffle bed slope through this area was measured at 0.0033 ft/ft or 0.33% (Attachment 4).

Page 9. The model was run under subcritical flow conditions for existing conditions and proposed conditions to reflect the existing hydraulic conditions within the modeled reach. Cross sections within the drop structures, and the associated hydraulic jump, are not effectively modeled by HEC-RAS. Because of this, "errors, warnings, and notes" in these areas were disregarded.

Not surprisingly, error messages would be expected when conducting modeling runs with HEC-RAS within the drop structures since they are not effectively modeled by running sub-critical flow conditions in HEC-RAS. The errors and warnings provided by the model should not be disregarded as they are provided to the user to indicate it is outside of the bounds of model. HEC-RAS is a one dimensional model that was not developed to handle complex hydraulics as experienced at these structures. HEC-RAS does allow the user to run a mixed flow scenario, however from the indications in the narrative this feature was not utilized. Even with the use of the mixed flow model run HEC-RAS is a one dimensional model that does not predict velocity distributions through a complex structure.

Fish Passage

Page 15. To model and design the fish passages, REP took the HEC-RAS model explained above and isolated the areas designed for fish migration. While the one-dimensional model has specific limits and capabilities, it provides quantifiable hydraulic calculations that can be used when assessing mean velocities in areas designed for fish migration. HEC-RAS is the industry standard for water surface, and associated depth, hydraulic calculations.

DNR concurs with the applicant that the one dimensional model, HEC-RAS, has specific limitations and capabilities and it does provide quantifiable hydraulic calculations used to assess mean column velocity. HEC-RAS may be used to provide "rough" estimates of velocity however it should not be used to calculate velocities for final fish passage design purposes. Further, mean water column velocities are an inappropriate parameter to utilize to predict fish passage. The actual velocities and velocity distribution are useful to assist in determining fish passage. Aadland (2010) stated, "This limits the usefulness of hydraulic models in predicting fish passage. While more sophisticated two- and three-dimensional models are available, like all models, they are only as accurate as the data input into them. Accurate depictions of bed velocity require detailed surveys of the streambed."

HEC-RAS does not account for this distribution. We recognize that FEMA and many state regulatory agencies utilize HEC-RAS to predict water surface elevations; however it is not the accepted standard for fisheries sciences as it relates to aquatic organism passage.

In July of 2012 the Huron River Watershed Council measured water depth and velocities at 20%, 40%, 60%, 80% and full depth at structure 2 in the Argo Headrace. Data results can be *seen below. Measured velocities at structure 2 varied through the water column particularly near the water surface. Velocities ranged from 2.92 ft per second (fps) to 6.03 fps through the water column.*

Depth profile at Chute 2 (first one past the chute 1/bridge/weir)					
	Depth	Velocity (ft/s)	Mean velocity	5.136	fps
20%	0.2	2.92	80/20 velocity	4.42	fps
40%	0.4	5.12	60 velocity	5.69	fps
60%	0.7	5.69			
80%	0.9	5.92			
100% (full depth)	1.1	6.03			

Page 17. To model the preferred design, REP staff installed approximately 0.6 foot high by 0.6 foot wide obstructions within the fish passages. The obstructions were put at varying elevations, thicknesses and locations as shown in Appendix 6. The obstructions were designed to effectively model the protruding boulders that will be placed within the roughened fish passages. In addition, the Manning's n-value was raised to 0.06 to accurately reflect the roughness that is estimated within these passages. For reference, USGS Water Supply Paper 1849 contains a visual reference (See Figure 6) for the aforementioned Manning's n-value.

As the applicant has explained HEC-RAS has the capability of calculating one-dimensional mean column velocities (among other statistics) for up to 43 vertical subsections (slices) of the conveyance area, and associated depths. These statistics provide valuable information that can be used during design and the associated optimization.

As discussed above HEC-RAS is a not able to predict velocity distribution and therefore is not an appropriate tool for determining fish passage. Further, we would contend that just because a model has the capability to provide up to 43 vertical subdivisions does not indicate that they should be used or more importantly that the model outputs are accurate.

Obstructions 0.6 ft wide and high were incorporated into the three-foot wide vertical slot fish way to simulate protruding boulders proposed to be grouted into the fish way. As depicted in Appendix 6 of the application, the three-foot vertical slot fish way was subdivided into approximately 0.5 foot sections to simulate the effect of obstructions on mean water column velocities. Modeling these subdivisions implies that there are discrete rigid boundary conditions that begin and end at the edge of each of these obstructions and continue through the water column.

Clearly, discrete boundary conditions do no exists as the model predicts. Flow over and through the U drop and vertical slot fish way is not entirely laminar due to the substantial reduction in bank full cross- sectional area resulting in increased head, flow convergence and turbulence. The model runs used to predict mean column velocities depict a discrete boundary between the U drop and the vertical slot in the vertical slot fish way which does not exists. As the applicant clarifies the model does not account for the effects of turbulence, velocity vector orientation and vertical turbulence. So although the model may allow the user to subdivide the cross section it must be used appropriately and results interpreted cautiously.

Not unlike the Manning's n-value that was chosen by the applicant for the U drop of the structure, DNR does not concur with a Manning's n-value of 0.06 to reflect the roughness of the fish passageway. The applicant cites the use of Water Supply Paper 1849 in determining the appropriate n value. The Water Supply Paper 1849 is titled, "Roughness Characteristics of Natural Channels." It provides a tool to assist practitioners in selecting the appropriate Manning's n-values. In the introduction it states that, "Familiarity with the geometry, appearance, and roughness characteristics of these channels will improve the engineer's ability to select roughness coefficients for other channels."

According to Chow (1959) which DNR and the applicant referenced, the fish way channel may best be described in Chow's table as Lined or Constructed Channel, random stone in mortar (5,d,2) with a range of Manning's n-values of 0.017 to 0.024 with a normal of 0.02. Even for channels described as Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages, bottom, gravels, cobbles and few boulders (2,a) has a range of 0.03 to 0.05 with a normal of 0.040. This last description would more accurately reflect the existing Huron River channel prior to the proposed modification.

In fact, Manning's n was solved for at the bank full stage at the surveyed riffle cross section then using friction factor and relative roughness the Manning's n roughness coefficient was calculated at 0.033 with a discharge of 1504.23 cfs. The discharge depicted on the USGS stage rating table has a discharge related to bank full stage of 1521 cfs. There was very good agreement between the two methods. Further, the Manning's n value for the Rosgen F4 stream type (Rosgen 2009) has a Manning's n value of 0.33.

Further, the vertical-slot fish way with the roughened channel is not accurately represented by this paper as the fish way is not a natural channel in geometry or material. The roughened bottom consist of cobble, small boulders and grout which make up the bed at this location both of which may substantially lower the Manning's n-value below 0.06.

The vertical slot fish way as proposed will have cobble veneer with small hand placed boulders protruding up to 0.6 ft above the grouted surface to induce roughness. The increased roughness relative to smooth concrete may reduce velocities at some level however it should be recognized that spaces between the cobble and small boulders will be smooth grout with much lower Manning's n-values. There will be little to no overlap of cobble or boulders and the bed will be homogenous with gaps composed of grout.

This is unlike a heterogeneous bed, which currently exists in the Huron River, with a mixture of silt, sand, gravel, cobble and boulders which overlap inducing rough boundary conditions. This differs from the proposed vertical slot fish way with grout, cobble and small boulders. Heterogeneous mixtures provide for a roughened channel bottom and allow fish and other aquatic organisms to move upstream along the stream bottom.

Aadland (2010) offered, "That most fish have burst speeds that approximate ten body lengths per second but they cannot maintain this speed for more than a fraction of a second to a few seconds. Small fishes have proportionately slower burst speeds but have the advantage of moving closer to or within the substrates where velocities are slower. Some small riffle oriented species like the rainbow darter (Etheostoma caeruleum) shown, prefer habitats where mean column velocities are greater than their burst speed capability. The use of interstitial space as a velocity refuge is not restricted to small fishes. . . Bed velocities are lower above large substrates due to the resistance they create. Velocity distributions near large substrates are also very complex resulting in small eddies that provide resting areas. The distribution of velocity is far more important than are mean column velocities. . . Concrete is smooth resulting *in less resistance and high bed velocities. It also lacks interstitial space important to the passage of small-bodied species."*

Page 18. The invert of the fish passage was designed to be 0.7 ft lower than the low flow portion of the structure on the upstream side. This design geometry ensures the fish passage is "wet" and contains water down to the lowest discharge during drought conditions. The fish passage will operate even when there is no in-stream recreational value in the structure and no water flowing over the low flow portion of the structure. Multiple parameters were set to facilitate fish migration. The slope of the fish passage was set at 30:1 to create hydraulic conditions that further reduce velocity. The 30:1 slope was chosen based on engineering experience, prior modeling results, existing modeling results, and associated studies (Kubitschek, et. al. 1997 and Kubitschek et. al. 2001). In addition, multiple cobbles and small boulders were placed to create off-setting sills (Kubitschek, et. al. 1997, Kubitschek et. al. 2001, Price Stubb Fish Passage Final Environmental Assessment. 2004). The sills create valuable velocity refuge zones and micro-eddies within the turbulent boundary layer (Schlicting, H. 1979) that has been shown to facilitate fish migration. Concrete and boulders placed within the passages are designed to maximize irregularities and increase the Manning's n-value to as high as 0.08-0.1. This ensures maximum friction within the fish passages, eddy features, velocity purposes, these areas are assumed to have a conservative aggregate Manning's n-value of 0.06. All of these design parameters facilitate fish migration.

At the initial meetings DNR provided comment and later provided e-mail and additional information on the best available information on fish passage, specifically on hydraulic head, step height and slope. The applicant states that they have modified the original structure design to enhance fish passage and sediment transport by reducing slopes between the crest and pool structures. A three-foot wide vertical-slot fish way was incorporated into the design that is 0.7 ft lower than the U drop portion of the structure on the upstream side and overall has a slope of 30:1 in the fish way. DNR appreciates the efforts to improve fish passage and incorporating a vertical-slot fish way with low slopes.

However, DNR does not concur that a three-foot vertical slot fish way with a roughness element and a 30:1 slope will have similar fish passage capabilities as existing conditions. Bank full cross sectional area will be reduced by 78% at structure 1 and 72% at structure 2. The intent of the structures are to pass flows from sub-critical to super-critical to create a hydraulic jump for kayakers. This is done by raising bed elevation (creating a dam and impounding water), reducing cross sectional area which results in convergence of flow thereby increasing water velocity, and shear stress over existing conditions.

Even with the modifications of the structures to enhance fish passage and sediment transport, the structures continue to have a substantial hydraulic head that dictates the hydraulics of the structure. Therefore the effects that the proposed modifications have on the structure will be minimal.

Information provided to the applicant from Verry (2011) and Aadland (personnel communication 2012) and addressed in our March 7 e-mail indicated that head loss should not be greater than 0.7 ft for effective fish passage. The proposed structures are approximately 19 ft in length, in an upstream and downstream direction at the U drop with a 1 foot drop in elevation from the crest to the exit of the structure with a slope greater than 5.0%

In July, Flow depths and water velocity data were collected by the Huron River Watershed Council at structures 2 thru 5 in the Argo Headrace. Data are depicted in the table below. Velocities were lower near the upstream end or crest of the structure and then increase *dramatically as the water travels through U drop and through the outlet of the structure. Huron River Watershed Council took depth and velocity readings approximately 1.5 ft upstream of the exit of the structure. Council staff had intended to take measurements at the downstream end of the structure although velocities were too high to safely stand at this location (Steen 2012, personal communication).*

Water velocity through chutes

	Depth (feet)			Water Velocity fps (@ 60% depth)		
	Top	Mid	Bottom	Top	Mid	Bottom
Structure 2	1.1	1.25	1.25	5.69	5.74	7.45
Structure 3	1.35	1	0.9	3.33	8.14	9.86
Structure 4	1.2	0.75	1.5	2.8	8.61	7.51
Structure 5	1.3	1.25	1	3.41	5.29	9.35

Most fish species inhabiting Michigan waters are not strong swimmers and are not able to sustain swim speeds of over three feet per second (fps) for any extended period of time. Typically, in low gradient Michigan streams, velocities of three fps are found during bank full events when many fish are found to move. Based on our experience in high slope streams of two percent or more flow velocities typically are near five fps at bank full flow. As can be seen from the values above, only one data point falls below the three fps even though flows are well below bank full. Based on the data and the information available on fish swim speeds, these existing structures appear to serve as barriers as the velocities are greater than burst and sustained swim speeds for the majority of fish species inhabiting the Huron River.

Based on the science produced by leading fish passage experts in the country and data collected at the existing structures of the Argo Headrace there is no expectation that the proposed structures, even with the modifications, will be any more effective at fish passage than those currently occupying the headrace. In fact, due to the proposed cross channel structures being designed for moderate and advance users, instead of novices as they are in the Argo Headrace, there is an expectation that conditions for fish passage would be reduced.

Page 19. Depth is a key parameter associated with fish habitat (McGrath, 2003). The proposed conditions will create two significant pools downstream of the structures. The pools are designed to not only dissipate energy associated with the drop structures, but also to create valuable holding areas for fish and deep over-winter habitat that protects aquatic habitat from predation. Specifically, the pools will be approximately 4 ft deep (at lower flows) just downstream of structures. REP staff has performed multiple snorkel surveys downstream of structures resulting in qualitative observations showing these areas are common feeding zones and holding areas.

The applicant is correct in that pools provide critical habitat for fish. This is true not only in the winter but during all seasons of the year. However, the Huron River from the upstream extent of the Barton Impoundment to Ypsilanti Dam is not limited by pool habitat. This stretch of river is approximately 14.7 miles in length with impoundments comprising 13 miles and free flowing river just 1.7 miles or approximately 11%. The proposed structures would substantially reduce the free flowing portion of the river by 2%. Riffle, glide, and run habitat are the limiting habitat *type in this stretch of the Huron River and every effort should be made to protect and restore these habitats not allowing reductions causing further habitat degradation.*

A detailed longitudinal profile 1,036 ft in length was surveyed from the Argo Dam to the outfall of the Argo Headrace. Riffle to riffle bed slope in this reach was 0.33% with a bank full slope of 0.25%. Measured riffle to riffle bed slope from the Argo Headrace outfall to the USGS Wall Street Gage (No.04174500), a distance of 3,061 ft had a slope of 0.053% or six times less than the comparative reach. Relative to other Michigan streams, and the Huron River itself, this stretch of river is regarded as high quality habitat not only because it is high gradient riffle/pool habitat but also it is not impounded has quality gravel substrate and considerable large woody habitat.

Work conducted by aquatic researcher Matt Kondratieff (personal communication 2012), Colorado Parks and Wildlife, specifically studied densities of brown trout in sections of a river system that had whitewater park structures installed vs. natural river channel. Based on electro-fishing results Kondratieff found brown trout densities (expressed a number per pool) in the scour pools below whitewater structures to be 53% of densities in the natural channel in the lower section of the river, 32% of densities in the natural channel in the middle reach and 9.3% of densities in the natural channel in the upper section.

Ongoing research is being conducted to understand why pools created by the U drop structures have lower densities than natural pools. There may be many reasons; however potentially it may be that that the environment is too extreme and the fish may have to expend too much energy to stay within the pool. This concept may be supported by the fact that the application calls for boulders in the pool bed below the structures to be grouted to hold them in place. The need to grout boulders together in the pool indicates tremendous shear stress and high velocities. If boulders and grout are needed to maintain the substrate in place, it speaks to the energy in the system and indicates that constructed pools do not act similarly to pools in streams where fish prefer to inhabit.

The purpose for a whitewater feature is to develop an extreme environment which creates a hydraulic jump, increased velocities, vertical drops with high slopes and the resulting localized high shear stresses for recreation. Further, based on Colorado's observations and ours to date at the Argo Headrace, there is typically not a natural gradation of bed material along the margin of the channel to pool maximum depth as often observed in naturally occurring pools. Observations indicate that eddies circle back upstream along the downstream face of the structure and then intersect with the U drop. This eddy is lower velocity and induces deposition of fine material along the margin of the stream. The deposition of fines then extends to the grout and boulders in the pool. This results in limited transition from the fine sediment to the larger boulders leaving little transition to sand, gravel, or cobble that are important habitat for fish and aquatic invertebrates.

Model Results Associated with the Fish Passages

Page 19. To provide quantified estimates of the velocities and depths within the fish passages, REP performed a micro-analysis within the existing floodplain model. The analysis included creation of representative roughness and obstructions to determine velocity and depth within different areas of the passages. While the limits of one-dimensional modeling are documented (Toombes, et. al., 2011), we feel they provide a quantifiable comparison of existing conditions versus proposed conditions, especially when the two are directly compared, as opposed to absolute comparisons to published data. The model was run with the addition of flow conveyance distributions within the fish passage. Up to 43 vertical divisions were included at each cross section. The divisions showed average velocity over the vertical profile. It is important to note the calculations occurred over one-dimension and do not include estimates of turbulence, velocity vector orientation, and vertical turbulence. The results are shown in Appendix 6 and include screenshots for discharges of 200 cfs and 450 cfs for both existing and proposed.

To provide more valuable information on fish passages, REP compared the proposed conditions with existing conditions. As noted above in the hydraulic report, the proposed conditions model was created using the existing calibrated model as a base. Therefore, locations where no changes to the channel will occur are the same between the two models. It allows designers to directly compare model statistics between existing and proposed conditions in an "apples-to-apples" situation. We feel this type of comparison is as valuable, if not more, than setting specific criteria and comparing model results to those criteria. Regardless, we have analyzed the proposed design for both documented conditions and "apples-to-apples" criteria. Directly comparing the figures suggests the margins of the existing channel contain zones of similar velocity and depth as the proposed conditions fish passages. Because of this, REP anticipates similar fish passage capabilities between existing and proposed conditions.

DNR has already addressed what we believe are the limitations of the HEC-RAS model and its usefulness for fish passage. However, the model for cross sections at the crest and exit of structures 1 and 2 were run at 200 and 450 cfs and had predicted velocities of 4.5 cubic feet per second (cfs). The Huron River Watershed Council measured velocities at the structures in the Argo Headrace as presented in the table above. Measured velocities at the crest of the existing structures were greater than what HEC-RAS predicted for the proposed structures and measured velocities in the mid chute and exit are approximately two times of that predicted and shown graphically in the HEC-RAS model runs. Inquiries were made to DEQ to determine if model runs had been conducted for the structures in the Argo Headrace to determine how well HEC-RAS performed to the as-built conditions, however, no modeling of velocities were provided as part of the permit.

As noted by the applicant in the "Alternatives Section" the proposed whitewater features have been designed for use by moderate to advanced kayakers. It is our understanding from meeting with Gary Lacy, REP, that the structures constructed in the headrace were designed for beginning kayakers and the new proposed structures would be more aggressive. Therefore, velocities may be greater in the proposed structures than those in the Argo Headrace.

The concern with high velocities is further supported by velocity measurements taken by the United States Fish and Wildlife Service (USFWS) and DNR at cross channel structures on the Bear River in Petoskey, Michigan which were designed by REP. Velocity measurements were taken with an Acoustic Doppler Profiler and checked with a Marsh-McBirney flow meter. Velocities greater than 10 fps and up to 13 fps were measured just below the crest of these structures in spring of 2012. Velocity measurements were taken while water surface elevation was approximately one foot below bank full elevation. Since the cross channel structures considerably reduce bank full cross sectional area it would be expected that velocities potentially would increase as flows reach bank full elevation and would continue to increase until the structures flood.

Interestingly, work conducted by Colorado Division of Parks and Wildlife has measured similar velocities at cross channel whitewater structures at several locations through Colorado and the USFWS and Nevada Fish and Game have measured similar velocities at structures on the Truckee River in Nevada. Due to the high velocities and resulting lack of fish passage the United States Army Corps of Engineers is requiring modifications to be made to structures at *the Rockpark Whitewater Park on the Truckee River in Nevada to meet permit conditions requiring fish passage.*

The applicant speaks to the physical aspects of fish passage in the application; however the behavioral aspects were not addressed. There are a number of behavioral concerns associated with the proposed vertical-slot fish way. The first relates to the location of the vertical-slot fish way within the structure and the river itself. The fish way is located with in the center third of the channel. This is problematic relative to fish behavior as the applicant pointed out fish typically travel up the margins of the stream in the outer thirds of the channel where velocities are reduced due to increased roughness.

Behaviorally, the entrance of the fish way is not located in an area of the stream most often used for upstream movements thereby limiting its effectiveness. The fish way is constructed at an angle within the structure where the crest is nearer the center of the stream and the exit angles toward the outer bank. If it were accepted that velocities were low enough that allowed for fish passage at the exit (downstream at the exit) and through the fish way the fish would have to exit the structure (upstream at the crest) where cross sectional area is greatly reduced and flows become more laminar as it is directed through the U drop structure. Fish passage effectiveness is again compromised as laminar flow is not conducive to fish passage. As discussed earlier fish rely on hydraulic diversity for effective upstream passage.

Also, the cross currents created, by design are problematic for upstream fish passage from a behavioral perspective. As water passes over the structure, back eddies are created and re-circulated along the margins of the stream, along the face of the structure until intersecting with the flow through the U drop. These cross currents are troublesome for fish since they have evolved over thousands of years swimming into the current. While downstream and outside of the influence of the structure, fish will typically be travelling upstream in the outer margins of the stream swimming against the current. However, once they encounter the reverse flow of the back eddies they will need to rotate their bodies 180° degrees so that their heads are oriented downstream. In essence, they need to swim backwards to go upstream. Once the face of the structure is encountered the fish need to determine the location of the three-foot vertical-slot fish way, which is less than 3% of the current bank full width. They will have to reorient their bodies 90° to again face the current as they travel across the face of the structure to travel to the vertical-slot fish way. Upon reaching the opening, fish will then have to reorient their bodies 90° to turn upstream where the water is passing through the structure. The orientation of the fish prior to turning into flow will be broadside to the high velocities through the structure and at or near location of the hydraulic jump (Aadland personnel communication 2012).

Based on measurements taken by DNR, Huron River Watershed Council, and the USFWS at existing U drop structures in the Argo Headrace and at the Bear River in Petoskey, the high velocities will likely result in the fish being swept downstream. Even if the fish are able to orient themselves in an upstream direction the water velocities are greater than the burst speeds of almost all fish species inhabiting the Huron River.

This is based both on fish behavior and measured exit, through and entrance velocities from similar cross channel structures in Michigan and measured by the Colorado Department of Parks and Wildlife in Colorado, the USFWS and Nevada Department of Fish and Game. Cross channel U drop dam structures were constructed on the Bear River and a condition of the permit is that fish passage is a required. Based on velocity data collected by the USFWS and DNR fish passage is questionable at many of these structures. Additional work is planned to further evaluate.

Based on the information collected, and the observations and experiences from multiple agencies, ***DNR does not believe fish passage will be similar to existing conditions or be effective for unimpeded fish passage for all species, at all times of the year for all life stages.***

Sediment Transport

Page 20. "REP completed a sediment transport analysis for the project. The analysis was particularly important because of multiple factors: 1) Structure #1 is located above the invert of the channel and could potentially create backwater conditions conducive to sediment deposition and habitat degradation, 2) the material placed upstream of Structure #1 should be relatively stable and maintain sediment transport competence. Because of these two factors, the analysis focused on determining the particle entrainment threshold and associated particle sizing. Once the sizing was determined, REP completed design and quantification of the material that would be placed, and the approximate particle size that could be effectively transported in a dynamic equilibrium upstream of Structure #1.

Particle-entrainment calculations usually focus on thresholds associated with the dominant discharge (a.k.a. channel forming discharge). This discharge has been defined in a number of ways (Leopold, 1964) but is commonly known to be somewhere near the 1.5- to- 2-year recurrence interval flood. Because the 50% (or 2-year) flood for the project site was provided by the DEQ, REP chose this value as an approximation to the actual dominant discharge. The calculations provided a range of values suggesting variability in the accuracy."

"REP used the dominant discharge to estimate particle entrainment thresholds for five different methods. Those methods were: 1) Meyer-Peter Muller, 2) Competent Bottom Velocity Method, 3) Lane's Tractive Force Theory 4) Shield's Diagram, 5) and the Urban Drainage and Flood Control District method. ...Multiple methods were used to provide a range of values and ultimately, better engineering decisions."

"The results suggest the particle entrainment threshold within the project reach occurs for material sized between 114mm (4.5 in.) and 29 mm (1.1in.). Specifically, the majority of sediment transport within the project reach occurs near the dominant discharge of 2,900 cfs and particles smaller than 114 mm to 29 mm are effectively transported through two methods."

As indicated earlier in the written comments, determination of bank full while conducting the geomorphic survey is paramount in order to understand and evaluate how the river system currently is functioning and predict how perturbations to the system may effect it. Without this information we largely are just guessing what "may" happen.

The applicant references that the bank full or dominant discharge is near the 1.5- to 2- year event. As the applicant explains they chose the 2-year return interval with a discharge of 2,900 cfs. DNR concurs with the applicant that dominant discharge (aka. bank full discharge) is important as it relates to particle entrainment calculations. Hence, it is therefore necessary to conduct the appropriate survey and gage analysis to determine the dominant or bank full discharge

The Michigan Stream Team developed regional curves by conducting surveys that included cross-sections, longitudinal profiles and pebble counts at USGS Gage stations throughout Michigan (Rachol and Boley-Morse 2009) and found that bank full discharges in Michigan recur *more frequently than every two- years. Rosgen (1996) has documented the bank full event to range from one to two years.*

DNR and DEQ staff conducted a detailed geomorphic survey of the Huron River from Argo Dam to the Wall Street USGS Gage using protocol detailed by (Rachol and Boley-Morse 2009). The survey extended to the USGS Gage in order to validate the bank full indicators identified and relate it to a known datum for stage, discharge and reoccurrence interval.

Bank full discharge, cross sectional area, depth, and width relative to drainage area were compared to that determined for the regional curves developed by the Michigan Stream Team for southern Michigan. The regional curves for southern Michigan only extend to drainage areas of approximately 400 square miles while the drainage area of the Wall Street USGS Gage is 729 square miles. Even though the drainage area for the Wall Street Gage is outside the regression developed for the above parameters measured values were input into the regression to determine if they would fall within the confidence intervals and provide additional confidence in bank full verification. The analysis determines that the above parameters fall within the confidence limits.

Using the geomorphic survey and protocol referenced above the reoccurrence interval of the Huron River at the Wall Street USGS Gage was determined to be 1.32 years. The stage discharge relationship correlated a flow of 1521 cfs associated with the bank full elevation. The importance of conducting the appropriate survey becomes obvious as the dominant discharge or bank full discharge is nearly half of what was utilized by the applicant to calculate incipient point of motion for sediment transport. The difference in discharge will have substantial effect on predicted sediment competence.

A bar sample was collected in the Huron River within the proposed project area as described by Rosgen (2008). The purpose of the bar sample is to measure the largest mobile particle size in the stream. To maintain stream stability the stream must be competent to transport the largest size of sediment available and the capacity to transport the load on an annual basis. The largest particle collected and measured on the bar was a 75 mm particle.

The interpretation of the bar sample analysis indicates that the Huron River currently has sufficient shear stress to move the 75 mm particle. Based on the data collected during the detailed geomorphic survey of the riffle cross section the calculated depth required to move the 75 mm particle is 2.76 ft while the actual bank full depth is 3.15 ft. The Colorado Curve predicted the largest moveable particle size of 90.15 mm at a bank full shear stress of 0.491. The Colorado Curve developed by Rosgen most closely represented the actual measured particle size moved relative to the methods chosen by the applicant however the Colorado Curve over predicted measured values by 15 mm. The available bank full shear stress is greater than that required to move the D_{100} so excess bed scour would be anticipated. Using competence alone the prediction would lead to degradation of the channel.

The applicant used five separate sediment transport equations with an associated discharge of 2,900 cfs to determine entrainment or incipient point of motion. The predicted incipient point of motion ranged from 29 mm to 114 mm. However no justification is provided by the applicant for which of the methods are most appropriate for predictive purposes. The consultant states that, "Multiple methods were used to provide a range of values and ultimately, better engineering decisions." DNR does concur with this statement as rigorous data collection and analysis are necessary to determine actual particle entrainment.

Based on the applicants analysis they offer that particles smaller than 114 mm to 29 mm are effectively transported through the system. DNR has a number of concerns with the analysis. The first being the discharge used to determine sediment transport, the second is that the calculations used generally under predict the size of material transported as the equations were developed largely in homogenous materials not in heterogeneous materials which occur in the Huron River. This is the importance of collecting a bar sample in order to verify competence. Lastly, unless field analysis is conducted the equations predict different incipient point of motion therefore; differing results will occur depending on the method chosen however it is not known what is correct.

It is not clear to us based on the information provided if the shear stress is great enough to move material only up to 29 mm or 114 mm in size? This distinction in size of material that can be transported is necessary in order to determine if material supplied into the system can be transported. Lastly, it is our understanding that the analysis was conducted for the current slope of the existing stream. We were not able to locate any information on the incipient point of motion for materials upstream of each of the structures with the associated change in slope.

The development of the two proposed structures may not change the overall slope of the river in this reach however there will be a flattening of water surface slope above the structures and the majority of the change in elevation will occur as drops over the two structures. DNR conducted analysis based on the reduction in slope from 0.25% to 0.15% above structure 1 and the largest particle predicted to move was 78.24 mm using the Colorado Curve. This was a reduction of 12 mm from the higher slope associated with existing conditions. The required bank full mean depth, required to move the largest bar particle, is 4.6 ft and the calculated existing bank full mean depth is 4.33 ft. Decreases in slope affect stream unit power and the ability to transport sediment; thereby leading to aggradation over time and an increase in fines.

Based on DNR data collection and competence analysis the stream is capable of moving the D_{100} *particle size and predicts that the stream is degrading (down cutting). However to determine stream stability competence and capacity must be considered. Based on competence alone sand particles 2 mm in size or less in diameter could easily move through the system. However pebble count data collected at the riffle, pool, reach and bar depict a bimodal grain size distribution (Attachment 5).*

The bimodal distributions indicate that although the river has the competence to transport 2 mm particles, that supply is high and does not have the capacity to move all of the sand out of the river; therefore the stream bed is infiltrated with sand under existing conditions. Flattening of water surface slope above the channel spanning structures will reduce velocities and shear stress upstream, reducing transport of sand and smaller particles inducing deposition of fines thereby reducing bed slope and covering existing quality bed material which is currently comprised largely of gravel and small cobble.

The prediction model FLOWSED/POWERSED was used in order to evaluate and predict if changes in channel dimension, profile, slope and velocity of the proposed structures will affect the capacity of the river channel to transport sediment (Rosgen 2006). A description of the model can be found in Watershed Assessment of River Stability and Sediment Supply (Rosgen 2009).

To run the model suspended or bed load data need to be collected for model inputs. Since no data were collected by the applicant DEQ staff obtained discharge and suspended sediment data from seven USGS gauging stations within the same hydrophsyiographic region in southeast Michigan as the Huron River. The assumption was made that each of these gage *stations had the same bank full return interval of the Huron River at 1.32 years as measured at the USGS Wall Street Gage.*

Regression relationships were developed from discharge (cfs) to suspended sediment concentrations (mg/l) for each of the gage sites. A return interval of 1.32 years was used to determine the corresponding bank full discharge and associated suspended sediment concentration. The bank full suspended sediment concentration for each plot was then used to develop a regression for the seven gage sites in southeast Michigan. The regression equation $y=0.0477x+0.0439$ ($r^2$0.81) was used with the bank full flow of 1521 cfs determined for the USGS Wall Street Gage location. The suspended sediment concentration was calculated at 72.99 mg/l.

No bed load sampling was conducted so estimates were needed to determine bed load transported through the project reach. To develop an estimate of bed load, data collected by the USGS was utilized (Emmett and Leopold 1980). Bed load data was collected from a belt sampler on East Fork River near Pinedale, Wyoming. The East Fork is comparable to the Huron in that it is a gravel bed stream, C4 stream type within a valley type 8 (terraced alluvial valley) with at slope of 0.004. Based on the detailed geomorphic data collected the Huron River below the project reach is a C4 stream and the stable state of the project reach is a C stream type but the dam and the location of berms has resulted in a class change to an F4. At bank full (1760 cfs) the East Fork has a measured bed load of 1188 tons/day. Suspended sediment was 210 mg/l or 998 tons/day for bank full with total load at 2,186 tons/day, thus bed load was 54% of the total load.

Because the Argo Dam and its associated impoundment are located upstream of the proposed structures bed load would be expected to be reduced from what was measured on the East Fork. Based on bar sampling, pebble count and Pfankuch rating on the proposed reach bed load continues to move through the system. Bed load supply may derive from the banks or be transported through the Argo Dam because it has bottom draw gates. For the model run the assumption was made that 15% of the total load (tons/day) consisted of bed load.

Suspended sediment concentration was developed from regression equations, bed load concentration was estimated by using data from a river that has the same valley and stream type and an estimate was made in the percent reduction of bed load due to the upstream dam. In order to determine capacity and the ability of the river to continue to move sediment efforts were made to utilize suspended and bed load data collected by the USGS to best predict transport in the project reach.

Powersed uses sediment rating and flow-duration curves to determine annual sediment yields and is able to predict changes in degradation and/or aggradation within the cross section. In this particular case a detailed riffle cross was surveyed upstream of structure 1 and located near the applicant's cross section 2354.5. The model was run for existing conditions at the riffle cross section with a bank full flow of 1521 cfs and the model predicted that 10,540 tons/year of sediment are transported with 6,924 tons being suspended sediment. The model was then run with the structure 1 in place using HEC-RAS data provided by the applicant. The predicted water surface elevation at bank full for the riffle cross section was 764.29 The Powersed model was run with structure 1in place and predicted total sediment was 3,991 tons/year with 3,149 being suspended sediment (Attachment 6).

Even though bank full shear stress was greater than that required to move the D_{100} and using competence alone degradation of the channel was predicted. Capacity and supply need to be considered in sediment transport. The Flowsed/Powersed model predicted that sediment *transport would be reduced by over 7,000 tons per year in the proposed channel, thereby causing channel aggradation. The predicted amount of aggradation converts to 5,885 cubic yards. To place into context, if suspended and bed load was spread evenly over the Huron River channel from Argo Dam to the structure 1 a distance of approximately 1090 ft and a measured bank full width of 102 ft sediment would be over 1.3 ft deep over what currently exist. An argument could be made that model results should be carefully applied as a "true" quantity because model parameters were calculated and bed load estimated because sediment data were not collected. However efforts were made to use data collected by the USGS to predict the accurate model inputs. Most importantly the modeling efforts predict that once the structure 1 is constructed sediment deposition will occur upstream of the structure.*

The concern of sediment deposition behind these structures is not unfounded this concern is also shared by the USFWS. Below is an excerpt provided as part of August 7, 2008 USFWS Biological Opinion (2008) on Rockpark Whitewater Park located on the Truckee River in Reno, Nevada. The USFWS developed their opinion based on their experiences with sediment deposition within Wingfield Whitewater Park on the Truckee River. Information on the Wingfield and Rockpark Whitewater Park can be found on REP's website at "http://www.boaterparks.com/projects_new_list.html".

"Sediment/ Debris Transport

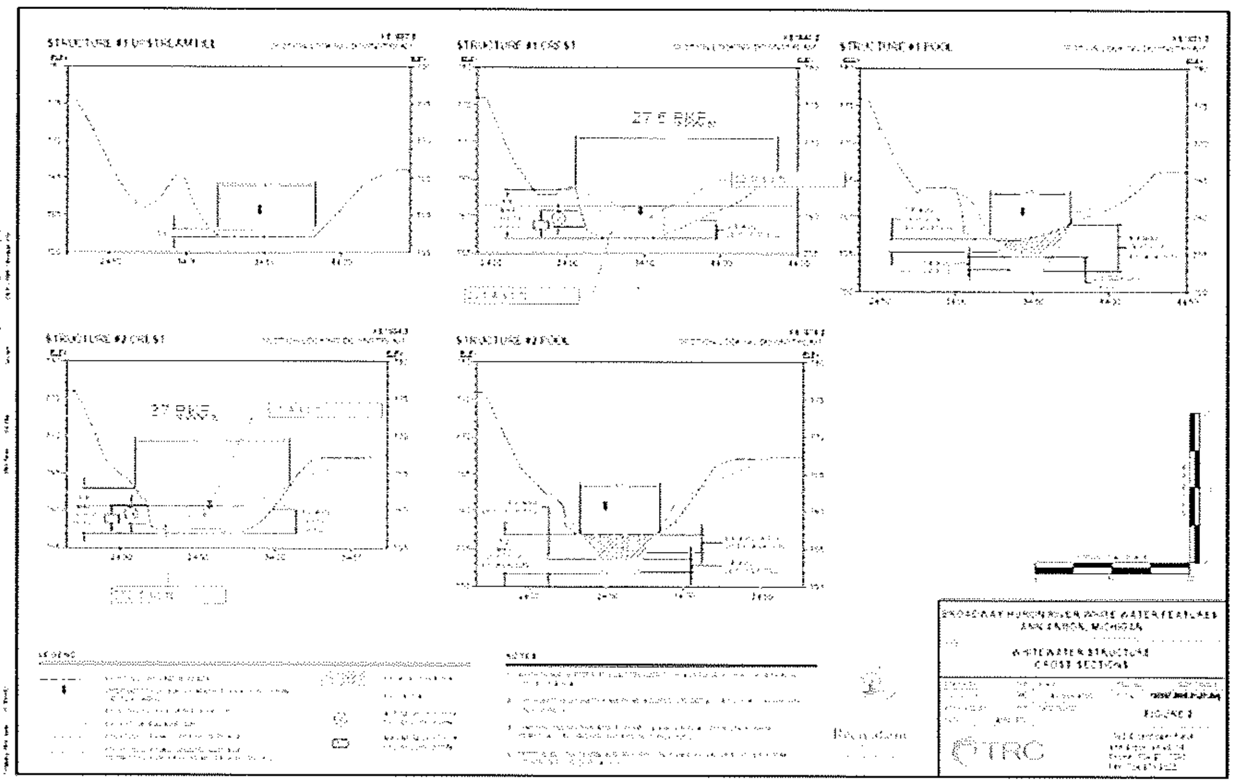
Past efforts to control the Truckee River have contributed to understanding the geomorphological processes that demonstrate rivers as being dynamic and often not responding well to efforts to contain or direct them. The proposed project site is relatively stable with little erosion and adequate sediment transport capabilities.

Due to structural design similarities with the whitewater facility at Wingfield Park upstream in Reno, Nevada, resource agencies are concerned about adverse impacts of the proposed project on sediment/debris transport. The 2005-2006 flood event resulted in substantial sediment/debris deposition at the Wingfield Park facility associated with the hardened structures in the river. As a result of the significant deposition of materials, it became necessary to dewater the river to allow excavation equipment to enter the river channel and restore the whitewater park features. This activity took place at a time when instream construction activities are normally prohibited and further impacted spawning success of brown trout and mountain whitefish. Additionally, the extensive amount of sediment that was released downstream of the excavation activities settled into the gravels, which likely resulted in suffocation of fish eggs deposited downstream of the affected area. Not only does sediment suffocate eggs, it limits invertebrate production which is the primary source of food for the river fishes. The full extent to which these activities negatively impacted the fishery can only be speculated, but it serves as an example of how the proposed project can have an ongoing negative impact on the river and associated aquatic species. Given that these natural high water events tend to occur on the Truckee River every 10 years or so, resource agencies anticipate the repeated implementation of significant maintenance measures which are highly destructive to aquatic habitats and communities in the years to come.

Given these concerns, proposed structures shall not disrupt or curtail sediment or debris transport by decreasing water velocities upstream of the structures and allowing new silt depositional areas to form upstream, within, or downstream of the structures. Any damming effect can eliminate preferred fish habitat through sedimentation and interfere with the necessary downstream drifting of aquatic invertebrates. It will also increase facility maintenance requirements."

Woody debris or other blockages in a stream may be desirable for both physical and biological channel functions, however, when the magnitude and frequency of debris is such that the stream aggrades, loses sediment transport capacity and provides fish migration barriers, then the debris is likely adding to sediment supply and instability. Debris-driven supply increases can often result in avulsions, lateral migration or stream bank or side-slope rejuvenation, which often accelerate mass failures. These blockages also include check dams, diversion structures or similar structures (Rosgen 2008). The structures proposed in the Huron River are similar to check dams or often called U drop dams and both the magnitude and frequency of the channel blockages may likely result in instability issues.

Based on personal experience Verry (personal communication 2012) has observed that once blockages exceed twenty percent or greater of the bank full cross sectional area that the channel will often seek adjustment to regain the cross sectional area. From information provided by the applicant the bank full cross sectional area at the location of structure 1 would be reduced from 291.4 ft^2 to 63.9 ft^2 or 78% while at structure 2 bank full cross sectional area would be reduced from 252.6 ft^2 to 71.4 ft^2 or 72%. Bank full width at the location of structure 1 would be reduced from approximately 90 ft to 27.5 ft and the location of structure 2 bank full width would be reduced from approximately 88 ft to 37 ft.



The structures proposed have been observed to have many of the same effects as check dams. Using the Rosgen Classification this reach of the Huron River is classified as an F4 channel. F channels with medium stage check dams have been found to cause increased stream aggradation, accelerated bank erosion, slope rejuvenation and floodplain encroachment (Rosgen 1996).

General Comments on the Application

Water Quality/Quantity Issues
A Concept Design prepared for the City of Ann Arbor (Lacy 2008) shows water quality issues related to E. coli and human contact were considered in the design by bypassing Allen Creek flow downstream of the proposed project. This excerpt is taken from the November 2008 Concept Design Report "The whitewater features will be separated from Allen Creek by a flow separator island. This will allow pollutants from Allen Creek to be separate from the whitewater project that will have full-body contact." As the design currently exists in this application, there is nothing indicating flows from Allen Creek will be separated from the Huron River as stated above.

DNR's letter dated April 24, 2012 (Attachment 7) to the City of Ann Arbor addresses water quality data collected by the Huron River Watershed Council that indicates that the Huron River below Argo Dam is designated by DEQ as not meeting full body contact standards due to high levels of E. coli. DNR has concern about increasing full body contact use in this stretch of the river with the poor water quality as it relates to resource and human health issues. The Huron River Watershed Council report indicates that the Huron River between Argo Dam and Geddes Dam continues to remain on the state's list of impaired waters due to bacterial contamination and that monitoring efforts indicate that efforts to reduce bacterial contamination have not been successful (Lawson 2011).

In the same letter, DNR addresses issues with erratic flow issues that have been measured and documented at the USGS Wall Street Gage which is located downstream of the Argo Dam and the proposed structures. DNR has been working with the City of Ann Arbor and the Federal Energy Regulatory Commission (FERC) to identify and address the erratic and inconsistent flows (i.e. large fluctuations and saw tooth hydrograph) that are recorded at the gauging station. The origination of the source or sources of the erratic flows is important as stage may increase well over a foot with a resulting change in discharge of hundreds or thousands of cfs in a matter of minutes (Attachment 8).

These rapid shifts in the hydrograph are unnatural and may be having detrimental impacts on aquatic biota and stream geomorphology. Further, these rapid flow fluctuations may be a serious public safety concern for users in the Huron River. DNR will continue to work with the City of Ann Arbor, FERC and other stakeholders to address these issues.

Most recently, water flow issues surrounding the Huron River received considerable public scrutiny as a result of low water levels between the Argo Dam and the outlet of the headrace. DNR sent a letter dated July 31, 2012 (Attachment 9) to the City of Ann Arbor concerning the flow issue after receiving a number of complaints about the dewatered condition of this stretch of river.

Specifically, the letter outlined concerns which included the un-natural flow hydrograph as recorded at the USGS Wall Street Gage and a recommendation for minimum flows. The City of Ann Arbor responded later in the week that they would not adopt the DNR's minimum flow recommendation and planned to continue to operate as they have. The fact that no operational plan was ever developed has resulted in controversy and potential resource damages to the state's public trust resources.

The diversion of flow from the Huron River to the Argo Headrace has not been resolved by the resource and regulatory agencies, City of Ann Arbor, and other stakeholders for the existing structures to date, nor does the current permit application address flow management for the proposed structures. The Huron River through Argo has had well- documented flow issues through Ann Arbor for twenty years that have largely remained unresolved. Additional complications to the system with the existing structures and newly proposed structures will not improve the situation. The question should certainly be asked that if the proposed structures are constructed, is there adequate flow in the Huron River during the low flow summer months, in most years, to facilitate operation of the structures as designed for both the Huron River and the Argo Headrace? Based on the period of record for the USGS Gage, average daily flows in July and August may potentially not be high enough to facilitate operation of structures in both the river channel and headrace. The question above speaks to kayak recreation, however, the same question must be asked of the effects on resource impacts.

Channel Changes
As detailed above, modifications to the existing channel are significant immediately due to construction. The applicant states, based on the sediment transport analysis and proposed channel fill above structure 1 that the slope remains constant and the reach should maintain a dynamic equilibrium. DNR does not concur with this statement in that 231 cubic yards of fill are proposed to be placed in the existing bed upstream of structure 1 encompassing an area 63 ft wide, 110 ft long and a depth of 0.9 ft. The proposed fill increases existing bed elevation, eliminates the thalweg, and reduces bed slope through this section. Changes in the existing bed material to that proposed will modify channel roughness impact flows and sediment transport.

According to the plans provided by the applicant, the maximum fill in elevation at structure 1 is 6.6 ft and 5.9 ft at structure 2 and raises the invert of the bed elevation. These constitute major changes to bedform, slope, roughness and cross-sectional area and the stream will adjust. These changes will not allow the stream to remain dynamically stable thereby maintaining its current dimension, pattern and profile and continue to transport stream flows and sediment without aggrading or degrading.

The U drop portion of the structure reduces bank full cross sectional area at structure 1 and 2 by 78 and 72 percent, respectively. The invert elevation of the U drop is elevated over two ft in height relative to the existing thalweg at structure 1 and over a foot at structure 2. The crests adjacent to the U drop are approximately 2.5 ft higher than the invert of the U drop. This rise in bed elevation changes slope of the stream considerably. Bed slope upstream of structure 1 is reduced from 0.33% to 0.019% (Attachment 10).

The Huron River between Argo Dam and the outlet of the headwater currently is not impounded, is relatively high gradient with valuable riffle, glide, and run habitat, and has considerable in-stream woody habitat particularly on the river left (north side). This is high-quality habitat in any river system, but particularly in an urban setting. As mentioned previously, un-impounded water in the Huron River through and near the City of Ann Arbor is limited. From Huron River Drive, upstream of Barton Impoundment, to Belleville Dam, there is approximately 29.2 miles of river of which only 11% is not impounded.

Pebble count data collected documents that the bed substrate is quality habitat which consist of heterogeneous material comprised largely of gravel, cobble habitat and occasional boulders. Development of cross channel structures reduces slope of the existing reaches upstream of the structures creating impounded areas thereby reducing limited bedforms and habitat.

Clearly, based on the information provided by the applicant and analysis conducted by DNR, the proposed structures will change the character of the stream from a riffle/pool sequence stream to that of a step/pool system. The proposal modifies the existing stream into a channel type that is not stable based on the natural slope of the valley. Although overall slope of the channel may remain the same as it is currently, facet to facet slope changes, thereby inducing channel changes in flow, bedform and planform.

Water surface slope flattens as a result of these structures thereby reducing velocity and shear stress between structures inducing sediment deposition and the accumulation of fines behind the structures. As the applicant clearly states, drop structures will be constructed with grout to hold the structures together. This speaks to the fact that these structures are not stable in the existing system and cause instability.

Any instability in the river geomorphology should be seriously considered since it is physically tied into the remediation work permitted at the MichCon site. As referenced in the Sediment Transport section above, F channels with medium stage check dams have been found to cause increased stream aggradation, accelerated bank erosion, slope rejuvenation, and floodplain encroachment.

Biological Issues

Biological assessments of fish and aquatic invertebrates were not conducted by the applicant as requested by DEQ and supported by DNR staff during the initial meeting. However, historical and recent surveys of fish and other aquatic organisms in the portion of the Huron River downstream of the Argo Dam have found several State endangered, threatened, and/or special concern mussels and fish species to be present in the area. The most recent survey work conducted in July of 2012 by University of Michigan mussel expert, Renee Sherman Mulcrone, found live individuals of the State threatened Wavy-rayed lampmussel (*Lampsilis fasciola*) and evidence of the state special concern species Elktoe (*Alasmidonta marginata*) and Kidneyshell (*Ptychobranchus fasciolaris*) in the immediate area of the proposed structures. Other historical surveys (as recorded in the Michigan Natural Features Inventory database) have found the state threatened Purple wartyback (*Cyclonaias tuberculata*) and Slippershell (*Alasmidonta viridis*), and special concern Paper pondshell (*Utterbackia imbecillis*) and Rainbow (*Villosa iris*) mussels. The state endangered northern madtom (*Noturus stigmosus)* and southern redbelly dace (*Phoxinus erythrogaster)* have also been reported downstream of the Argo Dam.

Changes to the river flow and habitat characteristics in the vicinity of the proposed structures could significantly effect the populations of these protected species in this portion of the Huron River. Fish passage problems could affect mussel distribution and survival as mussels have an obligatory parasitic stage on fish. In fact, certain mussels have become functionally extinct because of the restricted movement of host fish. Water velocities through the proposed structures would impede fish passage in this portion of the river with potential effects on both current and future fish communities.

User Conflict

The current issue related to flow through Argo Dam and the headrace highlights the conflict between and among user groups. Currently the City of Ann Arbor operation plan is to provide 60 cfs through the headrace while the Huron River immediately below Argo Dam may be receiving less flow during low-flow periods such as has been experienced in July and August 2012. There is considerable concern from the DNR and public, as addressed in the July 31 letter, and flow management has caused conflict between users of the existing structures and long-term recreationalists who have established uses below the Argo Dam and the headwater outlet.

This conflict is not surprising; for years there has been conflict in Michigan among canoers and anglers in several rivers for competing uses. Kondratieff (2012) cites a study conducted in 1996 by the State of Wyoming, Fish and Game to determine why anglers fished. The top reasons are listed below:

1. Opportunity to be outdoors
2. Relax
3. Get away from people
4. Fish in pleasant surroundings
5. Catch good tasting fish
6. Hook/land large fish

Similarly a survey was undertaken in 2008 by the Colorado Division of Wildlife, preferences at to why people fish in Colorado were:

1. Relax
2. Be close to Nature
3. Be with family
4. Get away from others
5. To catch and eat fish
6. "Trophy" fish

The work conducted by Kondratieff addresses that there are potential compatibility issues between whitewater park users and anglers. The information collected during the creel survey from anglers also inquired about preferences and problems. Anglers responded that aesthetics are highly valued, stream anglers prefer to fish in a natural setting and "pleasant surroundings" and prefer to fish without crowds and "get away from people." Colorado believes that angler use has been reduced in natural rivers where whitewater park structures are constructed due to the compatibility issues discussed above as well as reduced fish biomass.

In a July 29, 2008, column written in the Pagosa Daily Post, Bill Hudson interviewed Bill Whittington, whose family owns the Springs Resort which is located on the on the banks of the San Juan River next to a whitewater structure in Pagosa Springs, Colorado. Whittington told Hudson that there is no conflict between fishermen and boaters when the boaters are floating through the w-weir structure (natural channel design structure), but when a stoppage in the river like the Davey Wave (whitewater structure) was constructed, problems began between boaters and fishermen (Attachment 11).

As evidenced by the flow issues, conflict has already begun. The question currently is, during low-flow conditions, are flows provided to operate the new structures in the headrace for the designed 60 cfs or to provide flows to the Huron River for established recreational uses and biological needs below the dam? This topic is important to address not only because there is an established use, but because DNR and its partners have been working to introduce and improve urban fishing opportunities and experiences. If flow and compatibility issues are not adequately addressed, opportunities for urban fishing may be further reduced.

Cross Channel Structures Relevance to Stream Crossings
DNR's policy (No. 02.01.007) on Stream Crossings reads (Attachment 12), "The most important objective when considering a new, replacement, or temporary stream crossing is to maintain a free-flowing, natural stream channel. Fisheries, hydrology, recreation, water quality, and aesthetics can all be significantly degraded by poorly designed, constructed, or maintained stream crossing."

Cross channel structures dependent on flow conditions may act similarly to concrete culverts. This occurs when flows pass through the U drop and is not flowing over the wings. Physically, the U drop will be 19 ft long dropping one foot in elevation from the crest to the exit having a slope of approximately 5%. In fall of 2011, DEQ adopted rules for General and Minor Permit Categories addressing installation of culverts to allow for natural stream processes and aquatic organism passage. In order to allow for these conditions culverts are to be buried 1/6th of bank full depth, span the bank full channel, be aligned with the stream, and be placed on the same slope of the stream.

Certainly, an argument can be made that the U drop portion of these structures act similarly to concrete culverts placed at a slope that is high relative to riffle to riffle slope in the stream and are perched above the streambed on both the upstream and downstream end. The effects of these structures are in many ways similar to an improperly installed culvert as it relates to sediment transport, localized scour and aquatic organism passage.

Michigan Stream Team

Staff from state and federal agencies formed the Michigan's Stream Team in 2002. The Stream Team consists of governmental agencies in Michigan which are involved in various aspects of stream geomorphology including studying stream function, channel stabilization, and rehabilitation. An important component of the Michigan Stream Team as outlined in their mission is to:

- Train agency and stakeholders on stream morphology
- Serve as a technical resource to advance stream morphology science to Michigan agencies and interest groups

The Michigan Stream Team developed the document titled, "Michigan Stream Team White Paper Whitewater Parks" dated May 2012 (Attachment 13). The Michigan Stream Team suggest that whitewater park structures, like all man-made, in-stream structures, have the potential to negatively impact stream hydrology and hydraulics, sediment transport, channel morphology, and ecology, which collectively are known as stream function.

The white paper continues that, "The primary goal of any stream construction project should be to maintain or restore stream function. Stream function is defined in the Clean Water Act as the physical, chemical and biological processes that occur in ecosystems. Stream function concerns specific to whitewater parks include:

- Accommodation of the stream's seasonally variable hydrology without triggering geomorphic instability in the channel or interfering with other stream functions such as organism passage.
- Conveyance of the stream's sediment, organic material, and woody debris loads.
- Connectivity for fish, macroinvertebrates and other aquatic organisms.
- Loss of interstitial habitats for fish and macroinvertebrates.
- Maintenance of hyporheic exchanges.
- Disruption of riparian habitat.
- Degradation of water quality.
- River dynamics."

Many of the stream function concerns were addressed previously in our comment letter; however, the white paper is comprehensive and expands on the above topics. DNR concurs with the comments developed by the Michigan Stream Team and contained within the whitepaper as it relates to channel-spanning structures.

American Whitewater, an organization focused on protecting and restoring rivers, developed a Whitewater Parks Policy Statement Developed May 2007 (Attachment 14). American

Whitewater has a direct interest in whitewater parks that will either significantly impact a river or that will restore significant ecological or social values to an impaired river. It is American Whitewater's policy that natural un-modified river channels should not be modified for the creation of whitewater parks. Bulleted points below address issues American Whitewater believes need to be considered in any proposed whitewater park design and construction process.

- Instream flows- diversion of water to off-channel or features that result in a loss of stream flow.
- Riverbed condition -alteration of a natural unmodified riverbed to a less natural state.
- Fish passage - changes to the streambed reduce or eliminate upstream and/or downstream passage of fish and other aquatic species.
- Pre-existing and potential recreation values - recreational uses such as whitewater boating, calm-water boating, angling, swimming, or sightseeing are impacted or limited through park or feature construction.

American Whitewater staffer Kevin Colburn (2012) authored the document titled, Integrating Recreational Boating Considerations Into Stream Channel Modification & Channel Design Projects. The document states the mission of American Whitewater is "to protect and restore our nation's whitewater resources and to enhance opportunities to enjoy them safely. Our members are predominantly conservation-oriented whitewater kayakers, canoeists, and rafters. Our river stewardship program focuses on restoring rivers impacted by hydropower dams, protecting free flowing rivers from environmental harm, and ensuring that river management supports sustainable river recreation."

- All in-stream channel work should protect natural structure (bedrock, boulders, and native riparian vegetation) in the existing or new streambed area.
- Rivers are inherently dynamic systems and every structure placed in a stream will one day be disassembled and moved by the stream. This process should be a fundamental component of the design. Structures should be viewed as temporary, and be designed to accelerate or guide natural processes which will eventually take over.
- Regardless of any special designation, rivers belong to all citizens and should be managed accordingly. Channel design elements that appear artificial can have detrimental aesthetic impacts that can last for a generation or more.
- Generally, channel designs that mimic natural streams will benefit the ecology of the stream – and they will be consistent with natural geomorphology. For example, if the design reach is in the middle of a popular Class II whitewater river, it would be appropriate to design Class II rather than Class V rapids in the reach.

These excerpts were taken from the American Whitewater publication. DNR concurs with American Whitewater's mission statement and agrees with the bulleted points listed by American Whitewater above. DNR does not believe the current cross channel structures meet any of the bulleted items above as proposed by American Whitewater.

Natural substrate is not being protected in the existing reach as data collected clearly shows that the stream will aggrade, covering current bed material with finer particles, and much of the existing instream and riparian habitat will be removed to armor the banks with boulders.

As discussed previously in detail, the current design does not allow for natural river processes and stream function as DNR outlined at the initial meeting. The proposed structures change the bedform of the river from a riffle/pool stream to a step/pool system. Structure 1 is at the location of the only naturally occurring pool in the proposed project reach and rock is proposed to fill this pool in an upstream direction through its length. Riffles, runs, pools, and glides are naturally created and maintained in river systems to allow for the dissipation and transfer of energy thereby maintaining dynamic equilibrium. It is not sound science or engineering to disregard the existing bedform as these perturbations cause instability in the system. Rivers have a central tendency to adjust their dimension, pattern and profile to maintain and again reach stability if perturbed. The necessity to grout boulders and structures in place speaks to the fact that stream geomorphology principles for a stable stream are being violated.

Although the structures may consist of boulders which are natural material, the structures are not natural acting or looking in the Huron River. The structures consists primarily of congregated large to very large boulders (diameters of 1024 -2048 mm) grouted together. The D_{50} of this reach of stream is 26.22 mm which is classified as coarse gravel. Information was provided to the applicant on natural channel design structures; however, consultants for the applicant said they had no interest in these structures.

Lastly American Whitewater recognizes that modifying designs that mimic natural streams will benefit the ecology of the stream – and they will be consistent with natural geomorphology and offer that if the design reach is in the middle of a popular Class II whitewater river, it would be appropriate to design Class II rather than Class V rapids in the reach. Clearly, modifying this stretch of the Huron River from a riffle/pool sequence to step/pool system appears counter to what they support and is not conducive to natural stream function

Other Potential Alternatives
DNR does not concur with the applicant that modifications to the initial design serve as an alternative to the proposed project. However other options are presented as potential alternatives to the project.

- Construct an off-channel whitewater park allowing for kayaking and tubing while minimizing resource impacts and recreational conflict among users of the pubic trust resource.
- Removal or modification of the Argo Dam would allow for considerable whitewater opportunity and true rehabilitation of the Huron River up to Barton Dam.
- Address and resolve water quality in Allen Creek to address full body contact issues.
- Modify gates as necessary at Ann Arbor-owned and operated dams to allow for run of river operation which simulates a natural flow hydrograph.
- Improve operating, monitoring and data collection equipment as necessary for improved operation of dams and flow releases to the Argo Dam and headrace.
- Enhance fish passage at existing whitewater structures in the Argo Headrace. Fish passage in these structures appears limited based on velocity measurements taken at the structures.
- Explore use of natural channel design structures to address stream stability, natural stream function, habitat and recreational opportunities.

Based on our review of the data provided by the applicant for the MichCon Broadway Street MGP Whitewater and Habitat Improvement Project, specifically DEQ permit application No. 12-81-0077, and data collected by ourselves and other entities, **Fisheries Division of the DNR is strongly opposed to permitting the proposed project.** Although the project is titled as a habitat improvement project, evaluation of the information available indicates this project has substantial negative habitat and resource impacts. As the Michigan Stream Team outlines in their white paper, cross channel whitewater structures may provide other benefits, but they do not fully address stream function and are not designed and installed with documented bank full characteristics of width, depth, cross sectional area and slope.

Please feel free to contact Chris Freiburger, Elizabeth Hay-Chmielewski, or myself if there are any questions or if further information is needed.

Sincerely,

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Attachments

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