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EXECUTIVE SUMMARY

This report was prepared for the Boardman River Dams Committee (BRDC) by the Environmental Consulting & Technology team (ECT team) of specialists. The report is a detailed analysis of six alternatives for the fate of the Boardman Dams that were developed after screening 81 possible combinations of alternatives for the four dams. The basis for the analysis was approximately 100 questions developed by the BRDC in four categories as follows:

- Environmental
- Societal
- Engineering
- Economic

The detailed analysis of alternatives was based on new and existing information collected in previous studies by the ECT team and other investigators who have studied the Boardman River and its impoundments. In particular, the U.S. Army Corps of Engineers has been studying the fate of the dams with funding provided through the Section 506 Great Lakes Fishery and Ecosystem Restoration Program. The U.S. Army Corps of Engineers provided a Hydrology and Hydraulic Model Report, preliminary engineering evaluation of the dams, sediment transport information and bathymetric data for Boardman Pond.

General Remarks

Several categories of effects or impacts were determined to not be significantly changed regardless of the alternative. The following categories of effects will not be significantly impacted:

- Historic status of dams and power houses
- Transportation and infrastructure
- Water supplies and on-site waste water treatment systems
- Property boundaries and rights
- Programs at the County's Natural Education Reserve

While the effect of altering a dam on the Boardman River is a complex question, the primary variable that drives the effects, if any, is the change in water level and the extent to which Great Lakes fish are allowed to enter the Boardman River. Most of the other effects can be traced to the change, if any, of the water level in the impoundment. The water level in the impoundments influences fish and wildlife populations; terrestrial, aquatic, and wetland habitat; sediment transport; floodplain boundaries, hydrology and hydraulics; recreational uses; property values; and many other aspects of the Boardman River environment.

Public Opinion Survey

The *Public Opinion Survey* developed and administered through this project was not designed as a referendum or a statistically valid sample of public opinion. Rather, the *Survey* and associated *Informational Booklet* were intended to inform and engage the general population while offering another opportunity for public participation. The *Surveys* were distributed as broadly as feasible given time and funding limitations between September 23 and October 10, 2008.

In total, 749 completed surveys were collected, including: 323 from the web, 233 from Record Eagle inserts and handouts, 124 from the mailings, and 69 from people at public meetings. We witnessed no obvious attempts to unduly influence the survey results in any systematic way (e.g., large quantities of duplicate surveys). Therefore, we believe that the survey results provide a reasonable reflection of the opinions held by people (mostly middle age or older) with an active interest in the future of the Boardman River and the Boardman River Dams.

About 82% of all survey respondents (612) were year round residents of Grand Traverse County. Approximately 15% of those who responded (109) said that they own property on the Boardman River. The vast majority of survey respondents were 45 years of age or older (78% or 588 respondents); though on-line respondents tended to be younger than those people responding using printed forms. Of the categories provided, respondents most often identified themselves as *nature enthusiast* (198 respondents) or *fisherman* (150 respondents).

Over 90% of the respondents believe that the Boardman River is an important resource for *recreation* and the *community*. Over 95% of those responding (703) said they had visited the Boardman River within the last year. Large majorities of respondents also reported having visited each dam. When asked what water-based recreation they engage in, about 92% said they *walk or hike* in nature areas. About 76% of all respondents *canoe or kayak*; and a little more than half of the respondents say they *fish*.

When asked which concerns or considerations are most important in deciding the future of the Boardman River Dams, 83% of all respondents identified *preserving habitat for wildlife*. The next most frequently cited criteria were *increase habitat for cold water fish, limit costs to taxpayers,* and *keep impoundments for waterfowl*; identified as important by 60% to 64% of all respondents. However, responses to this question also indicate a significant amount of disagreement over several criteria. For example, respondents were nearly split on the importance of *protecting the buildings and dam structures*, with large numbers taking each of the extreme positions (e.g., *Not at all Important* vs. *Very Important*). Similar splits in opinion occur over the criteria identified as *generate electric power* and *returning river to more natural state*.

TABLE 1. Survey Response: *How important are each of the following concerns or considerations in deciding whether to repair, modify, or remove each dam?*

	Levels of Importance							
Concern or Consideration	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Preserve Habitat for Wildlife	21 2.9%	53 7.4%	171 23.7%	476 66.0%	721 96.3%	28 3.7%	3.53	0.57
Keep size of impoundments	212 29.5%	144 20.1%	96 13.4%	266 37%	718 95.9%	31 4.1%	2.58	1.58
Open river to fish passage	232 32.5%	143 20.1%	138 19.4%	200 28.1%	713 95.2%	36 4.8%	2.43	1.46
Protect the buildings & dam structures	259 35.9%	118 16.4%	112 15.5%	232 32.2%	721 96.3%	28 3.7%	2.44	1.61
Keep impoundments for Waterfowl	117 16.1%	169 23.3%	161 22.2%	278 38.3%	725 96.8%	24 3.2%	2.83	1.23
Increase habitat for cold water fish	125 17.4%	133 18.5%	153 21.3%	308 42.8%	719 96.0%	30 4.0%	2.90	1.30
Prevent Great Lake fish from moving upstream	177 25.1%	169 24.0%	116 16.5%	243 34.5%	705 94.1%	44 5.9%	2.60	1.43
Return river to more natural state	205 28.8%	101 14.2%	114 16.0%	292 41%	712 95.1%	37 4.9%	2.69	1.61
Generate electric power	216 29.8%	101 13.9%	108 14.9%	300 41.4%	725 96.8%	24 3.2%	2.68	1.64
Improve conditions for canoeing & kayaking	135 19.0%	187 26.4%	221 31.2%	166 23.4%	709 94.7%	40 5.3%	2.59	1.09
Preserve warm water fisheries	243 34.7%	210 30.0%	140 20.0%	107 15.3%	700 93.5%	49 6.5%	2.16	1.14
Limit costs to taxpayers	80 11.1%	180 24.9%	214 29.6%	249 34.4%	723 96.5%	25 3.3%	2.87	1.02

The last section of the survey was designed to gather public opinions and suggestions concerning the alternatives for managing each of the Boardman River Dams. Response patterns suggest that the people who answered this survey are not in agreement on any single course of action for any single dam, with one notable exception. The vast majority of respondents appear to support the *Retain & Repair* alternative for the Union Street Dam. About 72% of respondents ranked this option as *important* or *very important*. No other alternative for any of the dams received such broad support.

The option of *Retain & Repair* of the Brown Bridge Dam received the second greatest amount of support, with about 57% identifying this option as important or very important. About 51% to 54% of respondents said that *modification of dams for electric power generation* was important or very important for each of the upstream dams (Sabin, Boardman, and Brown Bridge Dams). An even smaller majorities said that the *Retain & Repair* alternatives for the Sabin (~51%) and Boardman (~52%) Dams were important or very important.

The lack of agreement on particular alternatives for each dam is emphasized by the distribution of respondent opinions. The data suggest that most respondents held extreme views of many alternatives. For example, over 83% of the respondents selected one of two extremes (*Not at All Important* or *Very Important*) concerning the option of *Retain & Repair* for the Sabin Dam. This pattern of strong disagreement is repeated over the *Modify for Electric Power Generation* and *Remove the Entire Dam* alternatives with the Sabin Dam. In fact, the same pattern of strong disagreement over these three alternatives is also apparent with the Boardman and Brown Bridge Dams.

ALTERNATIVE 1: REPAIR AND RETAIN ALL DAMS

Alternative 1 would consist of repairing and retaining all of the dams. The repairs are listed in the report but the major repairs and cost items are as follows:

Union Street Dam:

- Construct a toe drain system on the downstream slope of the embankment near the downstream headwall and just upstream of the principal spillway outlet headwall.
- Repair or reline the discharge culverts.

Sabin Dam:

- Minor concrete spalling on some sections of spillway and powerhouse should be repaired.
- The roof has been known to leak, per the Traverse City Light and Power Company and a new roof should be installed.

Boardman Dam:

- Cracking of the deck supports and beams were observed.
- Roadway guard rails should be repaired or replaced.
- Structural cracking of Cass River Bridge supports should be repaired.
- Repair penstock bay (downstream side of road) cracks and spalling of concrete.
- Repair or replace the roof.

Brown Bridge Dam:

- Prepare an operational procedure plan for the monitoring and operation of Brown Bridge Dam and update the Emergency Action Plan
- Repair concrete in the spillway structure.
- Repair spalling and structural cracking of the concrete was observed at numerous locations in the downstream support piers for the tainter gates.
- Repair the safety railing on the downstream side of the power plant deck.
- Repair the portions of the downstream embankment of the dam that have unsafe slopes.

What is the cost?
The estimated cost of repairing and retaining the dams is between $1,070,000 and $2,630,000.

As a result of the drawdown of Boardman Pond and considering 1) the gain in wetland acreage with the conversion of open water areas and 2) the increase in species and structural diversity with the conversion of deep aquatic habitats to emergent and ultimately forested/scrub-shrub systems, Alternative 1 would improve the quality of and increase the quantity of wildlife habitat available along this stretch of the Boardman River. A portion of the deep-water habitats would be replaced by submerged aquatic, emergent, and forested/scrub-shrub wetland habitats with varying water depth and higher structural and floral and faunal species diversity.

TABLE 2: SUMMARY OF ALTERNATIVE 1

Category	Union St.	Sabin	Boardman	Brown Bridge	Total
Construction Cost (Avg. of estimates)	$540,000	$195,000	$245,000	$870,000	$1,850,000
Present Value (PV) of Construction Cost (Avg. of estimates)					$3,080,000
Impoundment size (acres)	339	40	103	192	674
New Upland habitat (acres)	0	0	0	0	0
New Wetland habitat (acres)	0	0	0	0	0
New River length (miles)	0	0	0	0	0
Wildlife	No Change	No Change	No Change	No Change	No Change
Fisheries	No Change	No Change	No Change	No Change	No Change
Floodplain	No Change	No Change	No Change	No Change	No Change
Recreational Uses	No Change	No Change	No Change	No Change	No Change
Property Values	No Change	No Change	No Change	No Change	No Change
Hydroelectricity	No Change	No Change	No Change	No Change	No Change

TABLE 2A: SUMMARY OF THE SURVEY RESULTS FOR ALTERNATIVE 1-RETAIN AND REPAIR ALL DAMS

	Levels of Importance							
Boardman Lake & Union Street Dam	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Retain & Repair existing dam structure	134 19.0%	60 8.5%	81 11.5%	430 61%	705 94.1%	44 5.9%	3.14	1.44
Sabin Dam & Sabin Pond	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Retain & Repair existing dam structure	279 41.6%	51 7.6%	61 9.1%	280 41.7%	671 89.6%	78 10.4%	2.51	1.92
Boardman Dam & Boardman Pond	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Retain & Repair existing dam structure	270 40.1%	56 8.3%	58 8.6%	290 43.0%	674 90.0%	75 10.0%	2.55	1.91
Brown Bridge Dam & Brown Bridge Pond	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Retain & Repair existing dam structure	251 37%	41 6.0%	58 8.6%	328 48.4%	678 90.5%	71 9.5%	2.68	1.93

ALTERNATIVE 25: REPAIR UNION ST. AND BROWN BRIDGE DAMS AND REMOVE SABIN AND BOARDMAN DAMS

Alternative 25 would consist of repairing and retaining Union Street and Brown Bridge dams and partially removing Sabin and Boardman dams. The repairs would consist of the following activities:

Union Street Dam:

- Construct a toe drain system on the downstream slope of the embankment near the downstream headwall and just upstream of the principal spillway outlet headwall.
- Repair or reline the discharge culverts.

Brown Bridge Dam:

- Prepare an operational procedure plan for the monitoring and operation of Brown Bridge Dam and update the Emergency Action Plan
- Repair concrete in the spillway structure.
- Repair spalling and structural cracking of the concrete was observed at numerous locations in the downstream support piers for the tainter gates.
- Repair the safety railing on the downstream side of the power plant deck.
- Repair the portions of the downstream embankment of the dam that have unsafe slopes.

Sabin Dam and Boardman Dam:
These dams would be either partially removed by breaching the dam and allowing the water in the impoundment to drain or completely removing the power houses, spillways and earthen embankments.

What is the cost?
The estimated cost of this alternative with partial removal of the dams would be between $3,070,000 and $5,723,000. The estimated cost of this alternative with complete removal of the dams, spillways and powerhouses would be between $8,040,000 and $14,523,000

TABLE 3: SUMMARY OF THE EFFECTS OF ALTERNATIVE 25

Category	Union St.	Sabin	Boardman	Brown Bridge	Total
Cost (Avg. of estimates, partial removal)	$540,000	$686,500	$2,300,000	$870,000	$4,396, 000
Cost (Avg. of estimates, Total Removal)	$540,000	$2,776,000	$7,095,000	$870,000	$11,281,000
Present Value (PV) of Cost (Avg. of estimates, partial removal)					$4,451,000
Present Value (PV) of Cost (Avg. of estimates, total removal)					$10,268,000
Recreation Benefit(PV)					$112,000
Tourism Benefit(PV)					$1,380,000
Property Values Benefit (PV)					$1,040,000
Impoundment size (acres)	339	0	0	192	531
New Upland habitat (acres)	0	7	25	0	32
New Wetland habitat (acres)	0	28	69	0	97
New River length (miles)	0	0.7	1.2	0	1.9
Wildlife	No Change	Increase	Increase	No Change	Increase
Fisheries	No Change	Increase	Increase	No Change	Increase
Floodplain	No Change	Decrease	Decrease	No Change	Decrease

Recreational Uses	No Change	Increase	Increase	No Change	Increase
Property Values	No Change	Increase	Increase	No Change	Increase
Hydroelectricity	Not Applicable	Decrease	Decrease	No Change	Decrease

TABLE 3A: SUMMARY OF THE SURVEY RESULTS FOR ALTERNATIVE 25-RETAIN AND REPAIR UNION ST. AND BROWN BRIDGE DAM AND REMOVE SABIN AND BOARDMAN DAM.

	Levels of Importance							
Boardman Lake & Union Street Dam	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Retain & Repair existing dam structure	134 19.0%	60 8.5%	81 11.5%	430 61%	705 94.1%	44 5.9%	3.14	1.44
Sabin Dam & Sabin Pond	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Partially remove dam to allow free-flow of river.	322 49.7%	93 14.4%	134 20.7%	99 15.3%	648 86.5%	100 13.4%	2.02	1.32
Remove the entire dam structure.	317 48.7%	47 7.2%	45 6.9%	242 37.2%	651 86.9%	98 13.1%	2.33	1.94
Boardman Dam & Boardman Pond	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Partially remove dam to allow free-flow of river.	325 50.5%	97 15.1%	131 20.3%	91 14.1%	644 86%	105 14.0%	1.98	1.27
Remove the entire dam structure.	318 48.7%	46 7.0%	40 6.1%	249 38.1%	653 87.2%	96 12.8%	2.34	1.96
Brown Bridge Dam & Brown Bridge Pond	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Retain & Repair existing dam structure	251 37%	41 6.0%	58 8.6%	328 48.4%	678 90.5%	71 9.5%	2.68	1.93

<u>What could change?</u>

If Alternative 25 were implemented, the following characteristics of the impoundments and Boardman River could change:

- Water levels and floodplains would decrease on Sabin and Boardman Pond
- Wetland and upland habitat would increase
- Wildlife populations, including threatened and endangered species, could increase for some and decrease for others
- Fish populations, including threatened and endangered species, could increase
- Recreational uses of the river, ponds, and trails could increase
- Private property values adjacent to Boardman Pond could increase
- Local jobs and economies could increase

ALTERNATIVE 41: MODIFY ALL THE DAMS

Alternative 41 would consist of modifying (See Section 4 of the report) all of the dams, but hydroelectricity would not be generated. The modifications would consist of:

- Fish passageways at all of the dams;
- Improved capacity at the emergency spillway for Boardman and Brown Bridge dams; and
- A bottom draw system at Brown Bridge Dam.

What is the cost?
The estimated cost of modifying the dams would be between $8,700,000 and $12,230,000.

TABLE 4: SUMMARY OF THE EFFECTS OF ALTERNATIVE 41 WITHOUT HYDROELECTRICITY

Category	Union St.	Sabin	Boardman	Brown Bridge	Total
Cost (Avg. of estimates)	$1,790,000	$1,945,000	$2,645,000	$3,770,000	$10,150,000
Present Value (PV) of Cost (Avg. of estimates)					$10,092,000
Recreation Benefits(PV)					$83,000
Tourism Benefits(PV)					$1,440,000
Property Values Benefits (PV)					0
Hydroelectricity	Not Applicable	No Change	No Change	No Change	0
Impoundment size (acres)	339	40	103	192	674
New Upland habitat (acres)	0	0	0	0	0
New Wetland habitat (acres)	0	0	0	0	0
New River length (miles)	0	0	0	0	0
Wildlife	No Change	No Change	No Change	No Change	No Change
Fisheries	No Change	Increase	Increase	Increase	Increase
Floodplain	No Change	No Change	No Change	No Change	No Change

TABLE 4A: SUMMARY OF THE SURVEY RESULTS FOR ALTERNATIVE 41-MODIFY ALL DAMS

	Levels of Importance							
Boardman Lake & Union Street Dam	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Modify dam to provide a fish passageway	220 33.5%	145 22.1%	143 21.8%	148 22.6%	656 87.6%	93 12.4%	2.33	1.35
Sabin Dam & Sabin Pond	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Modify dam to provide a fish passageway	280 43.7%	150 23.4%	123 19.2%	88 13.7%	641 85.6%	108 14.4%	2.03	1.18
Boardman Dam & Boardman Pond	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Modify dam to provide a fish passageway	280 45%	143 22.2%	119 18.5%	92 14.3%	644 86.0%	105 14%	2.02	1.21
Brown Bridge Dam & Brown Bridge Pond	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Modify dam to provide a fish passageway	300 46.4%	137 21.2%	129 20.0%	80 12.4%	646 86.2%	103 13.8%	1.98	1.16

What could change?

If Alternative 41 were implemented, the following characteristics of the impoundments and Boardman River could change:

- Certain species of wildlife, including threatened and endangered species, could be adversely impacted by contaminants in Great Lakes fish.
- Wildlife populations, including threatened and endangered species, could benefit from increased food supply
- Fish populations, including threatened and endangered species, could change due to availability of additional habitat
- Recreational uses of the river, ponds, and trails could change due to changed fish populations
- Local jobs and economies could change due to increased recreational activity and power generation

ALTERNATIVE 41A: MODIFY ALL THE DAMS AND GENERATE ELECTRICITY

Alternative 41 would consist of modifying all of the dams and electricity would be generated. The modifications that would be required would be negotiated with FERC as part of the licensing process. However, based on the fact that TCLP operated these dams under a FERC license and that improvements were anticipated prior to TCLP relinquishing their license, the following modifications are anticipated:

- Fish passageways at all of the dams;
- Improved capacity at the emergency spillway for Boardman and Brown Bridge dams; and
- A bottom draw system at Brown Bridge Dam.

The modifications to the spillway will be different in this alternative compared to Alternative 41 because the solution designed in Alternative 41 is not applicable if hydroelectricity is generated at the dams. In Alternative 41, the modification to provide emergency flood control that meets MDEQ guidelines depends on water passing freely through the penstocks without obstructions. When electricity is generated at the dam, FERC regulates the safety of the dams and determines requirements for emergency flood control. Since the penstocks would be obstructed by the turbines and power generating equipment during power generation, there is a need for an alternative approach to meeting the FERC flood control regulations.

What is the cost?

The estimated cost of modifying the dams to generate electricity would be between $9,690,000 and $17,180,000.

TABLE 5: SUMMARY OF THE EFFECTS OF ALTERNATIVE 41A WITH HYDROELECTRICITY

Category	Union St.	Sabin	Boardman	Brown Bridge	Total
Cost (Avg. of estimates)	$1,790,000	$2,320,000	$4,270,000	$5,505,000	$13,435,000
Present Value (PV) of Cost (Avg. of estimates)					$16,768,000
Recreation Benefit (PV)					$83,000
Tourism Benefit (PV)					$1,440,000
Property Values Benefit (PV)					0
Hydroelectricity Revenue(PV)					$9,100,000
Impoundment size (acres)	339	40	103	192	674
New Upland habitat (acres)	0	0	0	0	0
New Wetland habitat (acres)	0	0	0	0	0
New River length (miles)	0	0	0	0	0
Wildlife	No Change	No Change	No Change	No Change	No Change
Fisheries	No Change	Increase	Increase	Increase	Increase
Floodplain	No Change	No Change	No Change	No Change	No Change

TABLE 5A: SUMMARY OF THE SURVEY RESULTS FOR ALTERNATIVE 41A-MODIFY ALL DAMS FOR POWER GENERATION.

	Levels of Importance							
Boardman Lake & Union Street Dam	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Modify dam to provide a fish passageway	220 33.5%	145 22.1%	143 21.8%	148 22.6%	656 87.6%	93 12.4%	2.33	1.35
Sabin Dam & Sabin Pond	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Modify dam for electric power generation.	245 36.8%	78 11.7%	84 12.7%	257 38.7%	664 88.7%	85 11.3%	2.53	1.76
Boardman Dam & Boardman Pond	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Modify dam for electric power generation.	249 36.9%	75 11.1%	82 12.1%	269 39.9%	675 90.1%	74 9.9%	2.55	1.78
Brown Bridge Dam & Brown Bridge Pond	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Modify dam for electric power generation.	243 36.3%	66 9.9%	86 12.9%	274 41.0%	669 89.3%	80 10.7%	2.58	1.79

What could change?

If Alternative 41 were implemented, the following characteristics of the impoundments and Boardman River could change:

- Certain species of wildlife, including threatened and endangered species, could be adversely impacted by contaminants in Great Lakes fish.
- Wildlife populations, including threatened and endangered species, could benefit from increased food supply
- Fish populations, including threatened and endangered species, could change due to availability of additional habitat
- Recreational uses of the river, ponds, and trails could change due to changed fish populations
- Local jobs and economies could change due to increased recreational activity and electricity generation

ALTERNATIVE 43: REPAIR UNION ST., REMOVE SABIN DAM, AND MODIFY BOARDMAN AND BROWN BRIDGE DAMS

Alternative 43 would consist of repairing and retaining Union Street Dam, partial removal of Sabin Dam, and modifying Boardman and Brown Bridge dams. The repair would consist of the following activities:

Union Street Dam would be repaired as follows:

- Construct a toe drain system on the downstream slope of the embankment near the downstream headwall and just upstream of the principal spillway outlet headwall.
- Repair or reline the discharge culverts.

Sabin Pond would be removed by partially or completely removing the dam, spillway, and powerhouses.

The modifications to **Boardman Dam** and **Brown Bridge Dam** would address fish access and passage, emergency spillway capacity and mitigating the impact of warm water discharge at Brown Bridge Dam.

What is the cost?

The estimated cost of implementing Alternative 43 with partial removal of Sabin Dam would be between $6,400,000 and $10,283,000. The estimated cost of Alternative 43 with complete removal of the dam, spillway, and powerhouse would be $7,910,000 and $12,953,000.

TABLE 6: SUMMARY OF THE EFFECTS OF ALTERNATIVE 43

Category	Union St.	Sabin	Boardman	Brown Bridge	Total
Cost (Avg. of estimates, Partial Removal)	$540,000	$686,500	$2,645,000	$4,470,000	$8,341,000
Cost (Avg. of estimates, Total Removal)	$540,000	$2,776,000	$2,645,000	$4,470,000	$10,431,000
Present Value (PV) of Cost (Avg. of estimates, partial removal)					$7,784,000
Present Value (PV) of Cost (Avg. of estimates, total removal)					$9,550,000
Recreation Benefits(PV)					$133,000
Tourism Benefits(PV)					$1,500,000
Property Values Benefits(PV)					$700,000
Hydroelectricity (PV)					0
Impoundment size (acres)	339	0	103	192	634
New Upland habitat (acres)	0	7	0	0	7
New Wetland habitat (acres)	0	28	0	0	28
New River length (miles)	0	0.7	0	0	0.7
Wildlife	No Change	Increase	No Change	No Change	Increase
Fisheries	No Change	Increase	Increase	Increase	Increase
Floodplain	No Change	Decrease	No Change	No Change	Decrease

TABLE 6A: SUMMARY OF THE SURVEY RESULTS FOR ALTERNATIVE 43-RETAIN AND REPAIR UNION STREET, REMOVE SABIN DAM, AND MODIFY BROWN BRIDGE AND BOARDMAN DAMS.

	Levels of Importance							
Boardman Lake & Union Street Dam	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Retain & Repair existing dam structure	134 19.0%	60 8.5%	81 11.5%	430 61%	705 94.1%	44 5.9%	3.14	1.44
Sabin Dam & Sabin Pond	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Partially remove dam to allow free-flow of river.	322 49.7%	93 14.4%	134 20.7%	99 15.3%	648 86.5%	100 13.4%	2.02	1.32
Remove the entire dam structure.	317 48.7%	47 7.2%	45 6.9%	242 37.2%	651 86.9%	98 13.1%	2.33	1.94
Boardman Dam & Boardman Pond	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Modify dam to provide a fish passageway	280 45%	143 22.2%	119 18.5%	92 14.3%	644 86.0%	105 14%	2.02	1.21
Brown Bridge Dam & Brown Bridge Pond	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Modify dam to provide a fish passageway	300 46.4%	137 21.2%	129 20.0%	80 12.4%	646 86.2%	103 13.8%	1.98	1.16

<u>What could change?</u>

If Alternative 43 were implemented, the following characteristics of the impoundments and Boardman River could change:

- Water levels and floodplains would decrease on Sabin Pond
- Wetland and upland habitat would increase at Sabin Pond
- Wildlife populations, including threatened and endangered species, could increase at Sabin Pond
- Fish populations, including threatened and endangered species, could increase in the new river segment and downstream from Brown Bridge Pond
- Recreational uses could increase on the new river in Sabin Pond and trails along the new river
- Local jobs and economies could increase due to the new river segment and improved fishery below Brown Bridge Pond

ALTERNATIVE 79: REPAIR UNION ST. AND REMOVE SABIN, BOARDMAN, AND BROWN BRIDGE DAMS

Alternative 79 would consist of repairing and retaining Union Street dam and partially or completely removing Sabin, Boardman, and Brown Bridge dams. The repairs would consist of the following types of activities:

Union Street Dam:

- Construct a toe drain system on the downstream slope of the embankment near the downstream headwall and just upstream of the principal spillway outlet headwall.
- Repair or reline the discharge culverts.

Sabin Pond, Boardman Pond, and Brown Bridge Pond would be removed by partially or completely removing the dam, spillway, and powerhouses.

What is the cost?

The estimated cost of implementing this alternative with partial removal would be between $3,990,000 and $6,413,000. The estimated cost of this alternative with complete removal would be between $16,170,000 and $28,633,000.

TABLE 7: SUMMARY OF THE EFFECTS OF ALTERNATIVE 79

Category	Union St.	Sabin	Boardman	Brown Bridge	Total
Cost (Avg of estimates, partial removal)	$540,000	$686,000	$2,300,000	$1,675,000	$5,201,000
Cost (Avg. of estimates, total removal)	$540,000	$2,777,000	$7,095,000	$11,990,000	$22,402,000
Present Value (PV) of Cost (Avg. of estimates, partial removal)					$4,741,000
Present Value (PV) of Cost (Avg. of estimates, total removal)					$19,274,000
Recreation (PV)					$241,000
Tourism (PV)					$1,580,000
Property Values (PV)					$1,180,000
Hydroelectricity (PV)					0
Impoundment size (acres)	339	0	0	0	339
New Upland habitat (acres)	0	7	25	25	57
New Wetland habitat (acres)	0	28	69	156	253
New River length (miles)	0	0.7	1.2	1.5	3.4
Wildlife	No Change	Increase	Increase	Increase	Increase
Fisheries	No Change	Increase	Increase	Increase	Increase
Floodplain	No Change	Decrease	Decrease	Decrease	Decrease

TABLE 7A: SUMMARY OF THE SURVEY RESULTS FOR ALTERNATIVE 79-RETAIN AND REPAIR UNION STREET DAM, REMOVE ALL OTHERS.

Boardman Lake & Union Street Dam	Not at all Important 1	2	3	Very Important 4	Total Responses	No Response	Average Response	Response Variance
Retain & Repair existing dam structure	134 19.0%	60 8.5%	81 11.5%	430 61%	705 94.1%	44 5.9%	3.14	1.44
Sabin Dam & Sabin Pond	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Partially remove dam to allow free-flow of river.	322 49.7%	93 14.4%	134 20.7%	99 15.3%	648 86.5%	100 13.4%	2.02	1.32
Remove the entire dam structure.	317 48.7%	47 7.2%	45 6.9%	242 37.2%	651 86.9%	98 13.1%	2.33	1.94
Boardman Dam & Boardman Pond	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Partially remove dam to allow free-flow of river.	325 50.5%	97 15.1%	131 20.3%	91 14.1%	644 86%	105 14.0%	1.98	1.27
Remove the entire dam structure.	318 48.7%	46 7.0%	40 6.1%	249 38.1%	653 87.2%	96 12.8%	2.34	1.96
Brown Bridge Dam & Brown Bridge Pond	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Partially remove dam to allow free-flow of river.	349 53.9%	89 13.8%	123 19.0%	86 13.3%	647 86.4%	102 13.6%	1.92	1.26
Remove the entire dam structure.	344 52.9%	36 5.5%	37 5.7%	233 35.8%	650 86.8%	99 13.2%	2.24	1.96

What could change?

If Alternative 79 were implemented, the following characteristics of the impoundments and Boardman River could change:

- Water levels and floodplains would decrease on Sabin, Boardman Pond and Brown Bridge Pond
- Wetland and upland habitat would increase
- Wildlife populations, including threatened and endangered species, could increase for some species and decrease for others
- Fish populations, including threatened and endangered species, could increase for some species and decrease for others
- Recreational uses could increase on the new river, and trails
- Private property values could increase
- Local jobs and economies could increase

ALTERNATIVE 81: MODIFY UNION ST. AND REMOVE SABIN, BOARDMAN, AND BROWN BRIDGE DAMS

Alternative 81 consists of modifying Union Street Dam and partially removing Sabin, Boardman, and Brown Bridge dams. The modification would consist of the following types of activities:

Union Street Dam would be modified to allow Great Lakes fish species to pass over the dam. **Sabin Pond, Boardman Pond, and Brown Bridge Pond** would be removed by partially or completely removing the dam, spillway, and powerhouses.

What is the cost?

The estimated cost of implementing this alternative with partial removal would be between $4,990,000 and $7,913,000. The estimated cost of implementing this alternative with complete removal would be between $17,170,000 and $30,133,000.

TABLE 8: SUMMARY OF THE EFFECTS OF ALTERNATIVE 81

Category	Union St.	Sabin	Boardman	Brown Bridge	Total
Cost (Avg. of estimates, partial removal)	$1,790,000	$686,500	$2,300,000	$1,675,000	$6,452,000
Cost (Avg. of estimates, total removal)	$1,790,000	$2,776,000	$7,095,000	$11,990,000	$23,651,000
Present Value (PV) of Cost (Avg. of estimates, partial removal)					$5,798,000
Present Value (PV) of Cost (Avg. of estimates, total removal)					$20,329,000
Recreation (PV)					$241,000
Tourism (PV)					$1,500,000
Property Values (PV)					$1,180,000
Hydroelectricity (PV)					0
Impoundment size (acres)	339	0	0	0	339
New Upland habitat (acres)	0	7	25	25	57
New Wetland habitat (acres)	0	28	69	156	253
New River length (miles)	0	0.7	1.2	1.5	3.4
Wildlife	No Change	Increase	Increase	Increase	Increase
Fisheries	No Change	Increase	Increase	Increase	Increase
Floodplain	No Change	Decrease	Decrease	Decrease	Decrease

TABLE 8A: SUMMARY OF THE SURVEY RESULTS FOR ALTERNATIVE 81-MODIFY UNION STREET DAM AND REMOVE ALL OTHERS.

Boardman Lake & Union Street Dam	Not at all Important 1	2	3	Very Important 4	Total Responses	No Response	Average Response	Response Variance
Modify dam to provide a fish passageway	220 33.5%	145 22.1%	143 21.8%	148 22.6%	656 87.6%	93 12.4%	2.33	1.35
Sabin Dam & Sabin Pond	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Partially remove dam to allow free-flow of river.	322 49.7%	93 14.4%	134 20.7%	99 15.3%	648 86.5%	100 13.4%	2.02	1.32
Remove the entire dam structure.	317 48.7%	47 7.2%	45 6.9%	242 37.2%	651 86.9%	98 13.1%	2.33	1.94
Boardman Dam & Boardman Pond	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Partially remove dam to allow free-flow of river.	325 50.5%	97 15.1%	131 20.3%	91 14.1%	644 86%	105 14.0%	1.98	1.27
Remove the entire dam structure.	318 48.7%	46 7.0%	40 6.1%	249 38.1%	653 87.2%	96 12.8%	2.34	1.96
Brown Bridge Dam & Brown Bridge Pond	**Not at all Important 1**	**2**	**3**	**Very Important 4**	**Total Responses**	**No Response**	**Average Response**	**Response Variance**
Partially remove dam to allow free-flow of river.	349 53.9%	89 13.8%	123 19.0%	86 13.3%	647 86.4%	102 13.6%	1.92	1.26
Remove the entire dam structure.	344 52.9%	36 5.5%	37 5.7%	233 35.8%	650 86.8%	99 13.2%	2.24	1.96

What could change?

If Alternative 81 were implemented, the following characteristics of the impoundments and Boardman River could change:

- Water levels and floodplains would decrease on Sabin Pond, Boardman Pond and Brown Bridge Pond
- Wetland and upland habitat would increase
- Certain wildlife species, including threatened and endangered species, could be adversely impacted by contaminants in Great Lakes fish
- Wildlife populations, including threatened and endangered species, could increase for some and decrease for others
- Fish populations, including threatened and endangered species, could increase for some species and decrease for others
- Recreational uses could increase on the new river and trails
- Private property values could increase
- Local jobs and economies could increase

TABLE 9: SUMMARY OF DETAILED ANALYSIS OF BOARDMAN RIVER DAMS ALTERNATIVES

	ALTERNATIVE 1	ALTERNATIVE 25	ALTERNATIVE 41	ALTERNATIVE 41 w/Hydro	ALTERNATIVE 43	ALTERNATIVE 79	ALTERNATIVE 81
CATEGORY	Repair all dams	Remove Part of Sabin/Boardman; Repair Union/Brown Bridge	Modify all dams	Modify all dams for hydroelectricity	Repair Union; Remove Part of Sabin; Modify Boardman and Brown Bridge	Repair Union; Remove Part of all others	Modify Union; Remove Part of all others
Present Value (PV) of Cost (Avg. of estimates, partial removal)	$3,080,000	$4,451,000	$10,092,000	$16,768,000	$8,174,000	$4,741,000	$5,798,000
Recreation (PV)	$0	$112,000	$83,000	$83,000	$133,000	$241,000	$241,000
Tourism (PV)	$0	$1,380,000	$1,440,000	$1,440,000	$1,500,000	$1,580,000	$1,580,000
Property Values (PV)	$0	$1,040,000	$0	$0	$700,000	$1,180,000	$1,180,000
Hydroelectricity (PV)	$0	$0	$0	$9,100,000	$0	$0	$0
Impoundment size (acres)	674	531	674	674	634	339	339
New Upland habitat (acres)	0	32	0	0	7	57	57
New Wetland habitat (acres)	0	97	0	0	28	253	253
New River length (miles)	0	1.9	0	0	0.7	3.4	3.4
Ecosystem Output (From USACE)	17064		20208				28124
Wildlife	No Change	Increase	No Change	No Change	Increase	Increase	Increase
Fisheries	No Change	Increase	Increase	Increase	Increase	Increase	Increase
Floodplain	No Change	Decrease	No Change	No Change	Decrease	Decrease	Decrease

1.0 INTRODUCTION

The Boardman River is located in the northwestern portion of Michigan's Lower Peninsula and originates in central Kalkaska County, flows southwest into Grand Traverse County where it turns north and flows into West Grand Traverse Bay, Lake Michigan in Traverse City, Michigan. The Boardman River watershed drains a surface area of approximately 291 square miles and includes 179 lineal stream miles and 12 natural lakes. The Boardman River is designated a Natural River and is considered one of the top ten best trout streams in Michigan, containing nearly 36 lineal miles of Blue Ribbon Trout Stream. The project area is a 20-mile plus section of the Boardman River's main stem, located in Grand Traverse County, and contains four dams: Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam.

The upper three dams were constructed and operated for hydropower generation; however Traverse City Light and Power has relinquished its licenses to generate hydroelectric power at the Sabin, Boardman, and Brown Bridge dams. The owners of the dams, the City of Traverse City and Grand Traverse County are now responsible for the operation and maintenance of these facilities. The City of Traverse City and Grand Traverse County are in the process of determining the fate of the dams and are committed to involving the public to help determine the fate of these dams.

The Boardman River Dams Committee (BRDC) has been formed to facilitate an open and transparent public discussion of the fate of the dams and the BRDC has retained the services of a team of consulting firms headed by Environmental Consulting and Technology, Inc. (ECT) to conduct an engineering feasibility study of the Boardman River dams for the long term disposition of the four existing dams: Brown Bridge Dam, Boardman Dam, Sabin Dam and Union Street Dam on the basis of environmental, engineering, economic, and societal considerations. The City and County will use the information and recommendations gathered during this process to make a decision regarding the fate of the dams.

Also, at the request of the City and County, the U. S. Army Corps of Engineers (USACE) is conducting a Feasibility Study on the Boardman River Dams under the Great Lakes Fisheries and Ecosystem Restoration (GLFER) Program. The GLFER program enables the Corps to utilize its planning, design, and construction expertise for projects to restore the Great Lakes fishery and ecosystem. The USACE has provided valuable information of the bathymetry of Boardman Pond, the sediment transport in the Boardman River and the hydraulic model. The USACE study is a valuable supplement to the BRDC effort, but the BRDC effort is a broader study that incorporates more issues than the USACE study.

2.0 PURPOSE OF THIS REPORT

The purpose of this report is to summarize information gathered to date to evaluate six alternative scenarios for the dams. The analysis of the alternative scenarios is based on existing data and information collected during the review of existing information phase of the project. Following the review of existing information, the ECT team determined that certain data gaps existed that should be closed by performing addition investigations in the field. The following reports were prepared during the review of baseline information and the collection of information to fill data gaps:

Environmental Consulting & Technology, Inc. Boardman River Feasibility Study. A Summary of Terrestrial Habitats in the Boardman River Watershed. September 2007.

Environmental Consulting & Technology, Inc. Boardman River Feasibility Study. Wetland Determination Report. October 2007.

Environmental Consulting & Technology, Inc. Boardman River Feasibility Study. An Interim Report on Boardman River Wildlife Data. October 2007.

Environmental Consulting & Technology, Inc. Boardman River Feasibility Study. Preliminary Engineering Evaluation of Existing Structures. January 2008.

Environmental Consulting & Technology, Inc. Boardman River Feasibility Study. A Report on Boardman River Existing Sediment Chemistry Data. April 2008.

Environmental Consulting & Technology, Inc. Boardman River Feasibility Study. Boardman River Dam Alternative Study. August 2008.

Environmental Consulting & Technology, Inc. Boardman River Feasibility Study. A Report on the Boardman River Fisheries Habitat Survey and Data Collection. January 2008.

Environmental Consulting & Technology, Inc. Boardman River Feasibility Study. Boardman Dams Breach/Drawdown Study. August 2008.

Following the collection of information, the summary of existing conditions was used to prepare a detailed analysis of the changes that may occur as a result of repairing, modifying, and removing the dams.

3.0 DESCRIPTION OF THE DAMS

UNION STREET DAM

The Union Street Dam is located at River Mile 1.5, and is the first dam encountered moving upstream from the mouth of the Boardman River at Traverse Bay. The height of the structure, as measured from the principal spillway apron to the top of the embankment, is approximately 21 feet.

The existing Union Street Dam consists of approximately 250 lineal feet of earthen embankment, two spillways, and a fish ladder. The principal spillway consists of a concrete overflow section with five 10.5 foot wide bays. Each bay is connected to two-48 inch diameter corrugated metal pipe (CMP) outlet conduits that extend through the earthen embankment. Each pipe has an upstream control gate. The auxiliary spillway consists of a concrete inlet section and overflow structure with two eleven-foot wide stop log bays. Two 48-inch diameter CMPs extend through the embankment and outlet into a separate channel that connects to the Boardman River downstream of the dam. A six-foot wide concrete fish ladder connects to the inlet structure of the auxiliary spillway and outlets downstream to the left of the principal spillway. The fish ladder has several weir sections that step down from the lake elevation to the tail water elevation in the river (MDEQ 2000 Dam Safety Inspection Report).

Project History

The Union Street Dam was constructed in 1867 to supply power for a now defunct flourmill. It is owned by Traverse City and its current purpose is to maintain the water level in Boardman Lake. The dam's impoundment, Boardman Lake, is a natural lake that was originally 259 acres in size and increased to 339 acres after the Union Street Dam was constructed. The spillways were reconstructed in 1965.

Operation

The Union Street Dam is owned and operated by Traverse City. It is operated in a run of the river mode and to maintain a fixed water surface level of Boardman Lake.

Existing Spillway Capacity

The spillway capacity for Union St. Dam is noted as 2,000 cfs with approximately 1.0 foot of freeboard (2005 Inspection Report).

MDEQ Requirements

MDEQ has been the sole regulatory authority for the Union Street Dam. The dam is less than 40 feet in height, and thus is required to have a spillway capacity capable of passing the 200 year design flood or the flood of record, whichever is greater. The 200-year (0.5% chance) flood discharge is estimated to be 2,000 cfs (2005 Inspection), which exceeds the flood of record. As stated above, the spillway capacity is reported to be 2,000 cfs. Therefore, the existing dam does meet MDEQ spillway criteria.

Results of the Dam Safety Inspection (Coughlin, 2005)

Overall, the dam was said to be in good condition, attributable to good maintenance practices. The report made several recommendations, and listed the following actions to be taken as soon as possible:

- Repair and realign trash racks in Bay #2 of the principal spillway
- Continue weekly maintenance inspections and good maintenance practices.
- Lubricate and exercise all principal spillway gate operator stems on an annual basis.

- The Emergency Action Plan (EAP) should be reviewed and updated on an annual basis. A copy of the updated EAP should be provided to the MDEQ Dam Safety Program when significant changes to the EAP occur.
- Consider constructing a toe drain system on the downstream slope of the embankment near the downstream headwall.

<u>Onsite Observations During 2007 Joint Inspection (ECT, 2008)</u>
General observations of the condition of the dam observed on the 7 September 2007 inspection are noted below.

- Seepage noted at downstream toe of the earthen embankment, near sidewalk, as observed during the 2005 Dam Safety Inspection.
- Trees/ stumps present on the downstream slope of the earthen embankment.
- A large diameter city water main is located above ground and crosses the dam.
- A city storm sewer is shown downstream of the auxiliary spillway on the 1965 construction drawings.
- Half of the discharge culverts were observed to have turbulent flow discharge while the others were observed to have laminar discharge. Turbulent flow may indicate deterioration of the culverts.
- The trash racks in Bay#2 were observed to have been repaired since the 2005 Dam Safety Inspection.

<u>2008 Safety Inspection of Union Street Dam (STS, 2008)</u>
In September, 2008 STS issues a report on the safety of Union Street Dam (STS, 2008).
The report contained the following key findings and recommendations.

- Union Street dam is well-maintained and in generally good condition.
- Construct a toe drain just upstream of the principal spillway outlet headwall.
- Trees and woody vegetation on the embankments of the dam should be removed.
- Evaluate the project spillway capacity for the 200-year design inflow.
- Update the Operations and Maintenance Plan.
- Install a staff gage to monitor reservoir elevation.
- The principal spillway CMP outlet pipes should be replaced or relined. An alternative to this would be to replace the pipes with a passive spillway system.
- Consider relocating the water main at the dam.

SABIN DAM
The Sabin Dam is the second dam moving upstream from the Grand Traverse Bay, at River Mile 5.3. The existing Sabin Dam is an earthen dam consisting of a left earth embankment, powerhouse, intermediate earth embankment, stop log spillway section, tainter gate spillway section, and a right earth embankment. The <u>left earth embankment</u> extends approximately 60 feet from the powerhouse and was constructed of sand fill. The top of the embankment serves as an access road to the powerhouse. The crest elevation of the left embankment is 618.5 feet NGVD. The <u>powerhouse</u> consists of a concrete substructure with a brick superstructure, and contains two vertical shafts; the left one is equipped with a turbine for power generation, while the right one provides for water control. The <u>intermediate embankment</u> extends approximately 52 feet between the powerhouse and the spillway and was constructed with sand fill and a core wall which ties into the spillway and powerhouse structures. The <u>stop log spillway section</u> is approximately 32 feet wide. The Probable Failure Mode Analysis (PFMA) report states that there are two

foot high timber stop logs above the crest and three low flow outlets with wood lift gates that are not being used. These are not shown on the 1930s construction drawings. The tainter gate spillway section is 18 feet in length and consists of a 5.5 foot high steel tainter gate. The gate is operated with an electric cable hoist. The tainter gate is equipped with an aerator to prevent upstream ice buildup. The right embankment extends 330 feet from the spillway structure and was constructed of sand fill.

Project History

The original Sabin Dam structure was constructed in 1906 for the Boardman River Light and Power Company and was completely reconstructed in 1930. Various owners operated the dam until 1969 when the turbines and generators were removed from the powerhouse and Consumers Power Company sold the powerhouse to Grand Traverse County. In 1983, the powerhouse was renovated for hydroelectric power generation. Power generation re-commenced by Traverse City Light and Power in 1985, and continued until 2006.

Operation

In 2006, the dam was de-commissioned and Traverse City Light and Power terminated power generation operations. The power generation equipment is still in place, but it is our understanding that it would be removed at an unknown date in the future. Traverse City Light and Power Company operated, monitored and maintained Sabin Dam while the dam was used for power generation. Below is a description of the procedures that were followed during power generation and what is done now that power is no longer generated. While generating power the dam was operated in a run-of-river mode and the primary course for the water was to pass through the vertical shaft turbine and outlet from the powerhouse, discharging directly into the Boardman River. The right vertical shaft was used for water control. When required, additional flow capacity was provided by the tainter gate spillway.

Existing Spillway Capacity

The existing spillway capacity for the Sabin Dam has been reported as 3650 cfs (PFMA 2005). Prior to decommissioning in November 2006, the Sabin Dam was regulated by FERC requirements. The IDF for Sabin Dam was established as 2,000 cfs (Mead & Hunt IDF study). At 2,000 cfs a failure of Sabin Dam would not be expected to present a hazard to human life nor cause significant damage. As stated above the spillway capacity for the Sabin Dam has been reported as 3650 cfs. The existing spillway capacity does meet FERC criteria.

As of the decommissioning in November, 2006, MDEQ assumed fully regulatory authority for dam safety. Sabin Dam is less than 40 feet in height, thus the required spillway capacity shall be capable of passing the 200 year design flood or the flood of record, whichever is greater. MDEQ has determined the 200 year flood flow to be 2000 cfs, which exceeds the flood of record. As stated above, the spillway capacity of Sabin Dam is 3650 cfs. Therefore, the existing spillway capacity meets MDEQ requirements.

Results of Most Recent FERC Operation Report (2006)

The most recent FERC inspection was conducted on 26 September 2006, and summarized in a report dated 8 February 2007 (FERC, 2007). The report stated that the project structures were in satisfactory condition, with no action needed at the time. The following are some noteworthy observations presented in the 2006 FERC Operation Report:

- Cloudy standing water downstream of right embankment at location of original spillway. No change in condition from previous years, recommended frequent monitoring.

- Minor cracks noted in brick superstructure and the concrete divider between the two bays of the tailrace. Continued monitoring recommended.
- Minor concrete spalling on some sections of spillway.

2007 Site Inspection

General observations of the condition of the dam observed on the 5 September 2007 (ECT, 2008) the downstream slope of the intermediate embankment.

- At the upstream side of the right end of the right embankment an area of change in vegetation was noted. It is speculated that this area had experienced erosion or a localized failure in the past and since has vegetated and stabilized.
- Concrete deterioration and spalling were noted on the downstream side of the powerhouse, as reported in the 2006 FERC Operation Report. It should be noted here that such spalling, would continue to increase with each winter season.
- The roof has been known to leak, per the Traverse City Light and Power Company. Leaking was evidenced by retrofitted gutters on the inside of the building near the downspouts.
- Deterioration of brick mortar joints and window lintels noted in many locations of the superstructure, along with minor cracks as reported in the 2006 FERC Operation Report.
- Corrosion noted on angle brackets at door and window framing.
- Cloudy standing water downstream of the right embankment at the location of the original spillway was observed, as reported in the 2006 FERC Operation Report.

BOARDMAN POND DAM

The Boardman (Pond) Dam is located at River Mile 6.1. The project consists of a detached embankment to the left of the dam, an emergency spillway in the left bank, a concrete spillway structure and the penstock intake, and a short right embankment. A short middle embankment is located between the spillway chute and the powerhouse. An excavated power canal feeds the reservoir to the intake structure. The description of project features in this section is taken from the 2006 FERC Operation Report for Boardman Dam. The detached embankment is 650 feet long and 43 feet high, and was constructed in the original river channel with compacted sand fill. A concrete head wall, which extends from the ground surface into the clay layer and into the river banks with steel sheet piling. The headwall provides upstream erosion protection and was constructed about 24 feet upstream from the crest center line. The emergency spillway structure is located between the detached embankment and the dam/ bridge structure. A sheet pile control section is provided. The crest of the emergency spillway section is 2.1 feet lower than the crest of the detached dike. The emergency spillway directs flow from the power canal into the area between the detached embankment and Cass Road embankment passing through an abandoned penstock and highway culvert. The concrete (or principal) spillway is equipped with one split-leaf, 18-foot wide by 13 foot high steel roller gate operated with a fixed electric cable hoist. The gate was replaced during the 2000 construction season. The middle earth embankment of the project is located between the spillway structure and the powerhouse. The powerhouse has a reinforced concrete substructure and brick superstructure, and is located approximately 73 feet downstream of the intake structure. Two 10 foot diameter steel penstocks convey the flow to the powerhouse. The right penstock serves as a bypass spillway, and the left penstock is connected to the turbine. The powerhouse intake has a bubbler/ agitator system to prevent ice-buildup in winter.

Project History
The original Boardman Dam structure was constructed in 1894 for the Boardman River Light and Power Company. In 1930 the dam was reconstructed. Power was generated at the Boardman dam until 1969, at which time, the turbines and generators were removed and the dam was sold to the County. In 1983 the Boardman Dam was then redeveloped for power generation. Power generation recommenced in 1985 and continued until 2007.

Operation
In 2007, Traverse City Light and Power Company ceased operations of the dam for the generation of hydroelectric power. The power generation equipment was purchased by a third party. It has been reported that other associated equipment may be removed as well, such as the agitator/ bubbler system. While Traverse City Light and Power Company used the dam for hydroelectric power, they operated, monitored and maintained the Boardman Dam. Water used for power generation traveled through the penstock to the turbine located on the left hand side of the powerhouse. Additional water discharge capacity was provided by the second penstock and the concrete spillway to the left of the penstock intake structure.

Hydropower is no longer in use, and dam is being operated as a run of the river dam. All flow at time of inspection was being discharged through the right penstock (bypass spillway). The spillway was dry (excluding minor seepage). It should be noted that there is control available at the slide gates that prevents water from entering the turbine. Upon the surrender of the operation of the Boardman Dam by the Federal Energy Regulatory Commission (FERC), the Michigan Department of Environmental Quality (MDEQ) assumed regulatory responsibility of the dam, at which time the MDEQ evaluated the dam for hazard and spillway capacity. Based on this evaluation, the MDEQ determined that the spillway capacity of the dam did not meet the MDEQ requirements for the high hazard potential rating that it had been given.

Consequently, in January of 2007, the MDEQ entered into a consent agreement with Grand Traverse County, the owner of the dam, for the required actions to be taken at the Boardman Dam. This consent agreement indicates the following:

- The MDEQ rated the Boardman Dam as a “high hazard potential dam”.
- The Boardman Dam spillway capacity does not meet the state requirements of Part 315.
- The County shall address the inadequate spillway conditions of the dam according to the following schedule
  - Draw down the water behind the dam by August 31, 2007.
  - Complete a feasibility study for options by September 30, 2008.
  - Complete design of spillway modification or removal by June 30, 2009.
  - Complete work on dam for spillway modification by December 31, 2010.
  - Complete work on dam for removal by December 31, 2012.
- The County must provide annual reports on the progress of this project.

Based on this consent agreement, during the summer of 2007 the water level behind the dam was lowered. It had been previously determined that the distance between the normal water level and the lowest outlet (invert of penstocks) is approximately 17 feet. The drawdown, however, resulted in approximately 16 feet water level decrease.

During a site visit in September, 2007 by the ECT team, the water level behind the dam was at this drawn down elevation. It is planned that this water level would be maintained at this level until dam removal or modification to achieve compliance with the regulations is completed.

Existing Spillway Capacity

A spillway capacity of 9,070 cfs was reported in the 2005 PFMA Study (Mead & Hunt, 2005). However, this capacity included a flow through the emergency spillway. The PFMA stated that the emergency spillway would fail by undercutting or erosion during use, due to the highly erodible soil. Therefore, the reported spillway capacity is problematic, as discussed below. The concrete spillway and both penstocks have a flow capacity of 4,550 cfs, corresponds to a reservoir elevation of 656.4 ft, National Geodetic Vertical Datum (NVGD). This elevation corresponds to the low point in the embankment at the emergency spillway.

Prior to decommissioning in January 2007, the Boardman Dam was regulated by FERC requirements. The established IDF for the Boardman Dam is equal to the full PMF, or 11,600 cfs (2006 FERC Operation Report). Therefore, the spillway capacity at Boardman Dam does not meet FERC criteria. Traverse City Light and Power has indicated that FERC had not directed modifications at the Boardman Dam, but expected FERC to do so after modifications were completed at Brown Bridge Dam, which is located directly upstream from Boardman Dam.

Upon the surrender of the operation of the Boardman Dam by the FERC, the Michigan Department of Environmental Quality (MDEQ) assumed regulatory responsibility of the dam. The Boardman Dam is greater than 40-feet in height, therefore, the statute requires the spillway be able to pass a design flood equal to the ½ PMF, which MDEQ has established to be 6100 cfs. In their analysis, the MDEQ did not consider the flow capacity of the emergency spillway because of the likelihood that the emergency spillway would fail by undercutting or erosion under any significant flow, due to the highly erodible soils. Under these assumptions, the total spillway capacity at Boardman Dam is 4,550 cfs, which is less than the capacity required by statute. Therefore, the current spillway capacity does not meet MDEQ criteria.

MDEQ also routed the design flood through the facility assuming that the water surface was reduced to the maximum practical level. Considering only the flow capacity of the concrete spillway and the penstocks, MDEQ determined that the resulting water surface would approximate the top of the embankment, with no freeboard. Thus the directed lowering of the water level is considered to be only a temporary, emergency measure and not a permanent solution.

Results of Most Recent FERC Operation Report (2006)

The most recent FERC inspection was conducted on 26 September 2006, and summarized in a report dated 6 February 2007. The report stated that the project does not meet the Commission's engineering dam safety standards and criteria due to insufficient spillway capacity. The following noteworthy observations were reported:

- Stated that remedial measures were taken in 1996 & 1997 to address seepage in the right abutment. Area was dry at time of inspection.
- Steel roller gate placed in 2000 was in excellent condition.
- Stated that repairs were made to the Cass River Road Bridge in 1997, and the supporting beams were in good condition.

- Seepage was reported in 2000 at the middle earth embankment (between the spillway structure and powerhouse). A gravity relief drainage system was installed in 2004, and was reported as draining approximately 60 gpm. In 2005, two more observation wells were added. At the time of this inspection, the area was reported to be dry and firm.
- Powerhouse noted in good condition, with a few cracks in grout noted on the downstream brick substructure of the powerhouse.
- Vertical offset and seepage were noted at the first joint from the left in the powerhouse gallery.
- Horizontal offset was noted at the second joint in the powerhouse gallery. Noted that a crack monitor installed in 1997, with no unusual trends noted.
- Noted that a drainage system was installed at the right abutment in the late 1990's, with the discharge pipe located to the right of the wing wall. It was reported that the pipe was discharging a small amount of water at the time of this inspection.
- Discussed void discovered beneath the right tailrace wing wall in July 2003. Void was approximately 1' x 1' x 1.5', with flow passing beneath it. Sandbags were placed to prevent additional scour.

Onsite Observations from the 2007 Inspection

General observations of the condition of the dam observed on the September 6th & 7th 2007 inspection are noted below. Items observed that may affect the alternatives being considered for this dam include:

- Dam is currently drawn down approximately 16 feet, as temporary risk mitigation action.
- Emergency spillway is very close to Cass River Road, and unlined. Soils are highly erodible.
- Cracking of the deck supports and beams were observed. There was also significant spalling and exposed rebar underneath parking deck.
- Roadway guard rails are in disrepair
- Structural cracking of Cass River Bridge supports.
- Posted load limitations for Cass River Road of 10-20 tons (depending on no. of axles)
- Downstream "chute" at spillway, seepage is visible at bottom of channel. 1930s construction plans show 4" drain tile located underneath slab. Could be a break in the pipe.
- Holes drilled through access deck for drainage are allowing water to erode material below deck.
- Penstock bay (downstream side of road) cracks and spalling
- Penstock bay- soil material observed in penstock bay are coming from road drain
- Corrosion of window and door frames
- Roof may need repair or replacement
- Seepage coming from left end of detached embankment and through monitoring weir
- Rodent hole noted on downstream slope of detached embankment

BROWN BRIDGE DAM

The Brown Bridge dam is the furthest inland of the four dams, at River Mile 18.5. The existing Brown Bridge Dam consists of a left earth embankment, powerhouse/ spillway structure, log chute with a slide gate, and a right earth embankment. Additionally, there exists an abandoned fish ladder which intersects the right earth embankment near the powerhouse/ spillway structure. The left earth embankment extends approximately 400 feet from the powerhouse. The lower portion of the embankment is a hydraulic fill and the upper portion is a compacted fill. There is a concrete wall along the upstream side of the embankment that is believed to serve only for wave protection and not as seepage cutoff. The top of the embankment serves as an access road to the powerhouse. The powerhouse consists of a concrete substructure with a brick superstructure. The powerhouse currently contains two vertical shafts containing turbines. There are a total of four tainter gates, two upper and two lower. The lower gates allow for the water to bypass the turbines. Adjacent to the powerhouse is a log chute which contains a slide gate. The right embankment extends 1200 feet from the powerhouse/ spillway structure. The lower portion of the embankment is a hydraulic fill and the upper portion is a compacted fill. There is a concrete wall along the upstream side of the embankment that is believed to serve only as wave protection and not seepage cutoff.

The original Brown Bridge Dam structure was constructed in 1921 for the Traverse City Light and Power Company. Power had been generated at the Brown Bridge dam since its construction until the time of its decommissioning in 2006. In April 2003, the existing spillway at the Brown Bridge Dam was determined to be incapable of passing the Probable Maximum Flood without overtopping the embankments, therefore not complying with the FERC regulatory requirements. An auxiliary spillway was then proposed. The auxiliary spillway was never constructed, but the construction plans are available.

Operation

While Traverse City Light and Power Company used the dam for hydroelectric power, they operated, monitored and maintained the Brown Bridge Dam. Below is a description of the procedures that were followed during power generation and what is done now that power is no longer generated. Traverse City Light and Power has indicated that there are no plans to remove the power generation equipment from Brown Bridge Dam. While generating power the dam was operated in a run-of-river mode, the primary course for the water was to pass through the vertical shaft turbines and outlet from the powerhouse, discharging directly into the Boardman River. If additional discharge capacity was required, the slide gate was operated and the spillway and log chute was used. The headwater is allowed to fluctuate +/- 1.7 ft during operation. The impoundment was lowered 0.5 feet prior to spring runoff and anticipated major storm events. This was done to minimize effect on Boardman Pond. The Brown Bridge Dam was operated to discharge a continuous minimum flow of 100 cfs or the inflow to the reservoir, whichever is less, to protect fishery, wildlife and recreational resources in the Boardman River. Historically, since its construction, Brown Bridge has continuously generated power up to the decommissioning in November, 2006.

Existing Spillway Capacity

The July 1991 Addendum No. 1 Spillway Flood Studies for the Brown Bridge, Boardman, and Sabin Projects indicated that the Brown Bridge Dam spillway capacity is equal to 5,670 cfs (Mead & Hunt, 1991). However, the two lower gates are currently inoperable. The spillway capacity without the two lower gates is equal to 2,900 cfs, per communications with FERC.

Prior to decommissioning in November 2006, the Brown Bridge Dam was regulated by FERC requirements. The established IDF for the Brown Bridge Dam is equal to the full PMF, or 8,100 cfs (*Mead and Hunt, 2001).* As indicated above, the Brown Bridge spillway capacity is reported to be 2,900 cfs. Therefore, the existing spillway capacity does not meet current FERC criteria. In April 2003, an auxiliary spillway was then proposed. This spillway was never constructed, but the construction plans are available.

Now that the dam is not being used for hydroelectric power generation, the Michigan Department of Environmental Quality has assumed full regulatory authority. Brown Bridge Dam is more than 40-feet in height and as such is required to have a spillway capacity capable of safely passing half the probable maximum flood or 4,050 cfs (STS, 2008). As stated above, the Brown Bridge spillway capacity is reported to be 2,900 cfs. Therefore, the existing spillway capacity does not meet MDEQ criteria.

Results of most recent FERC Operation Report (2006)

The most recent FERC inspection was conducted on 26 September 2006, and summarized in a report dated 8 February 2007. The report stated that the project does not meet the Commission's engineering dam safety standards and criteria due to insufficient spillway capacity. The following noteworthy observations were reported:

- The left embankment was noted as in good condition.
- Lower two gates at the project were reported as inoperable.
- Minor spalling on concrete surface of ogee spillway.
- Powerhouse intake noted as in generally good condition, but noted several tight cracks with efflorescence.
- Seepage noted from right embankment. Flow was noted as clear (containing no visible fines). Area was noted as relatively dry.

Onsite Observations from the 2007 Inspection

General observations of the condition of the dam observed on September 7, 2007 inspection are noted below.

- Seepage and moist areas were observed near the toe of the downstream right embankment slope and downstream of the left and right embankment slopes.
- The drainage pipes located on the downstream slope of the right embankment showed evidence of fines being carried through the pipes. Several moist areas were noted on the right embankment. It should be noted that this appears to be a changed condition since the 2006 FERC Operation Report, in which seepage was reported at the right embankment, but the flow was noted as clear.
- Wetlands are present downstream of the right embankment. The wetlands seem to be fed from streams created from discharge of the drainage pipes. A series of weir boxes are present along the stream.
- Observations made onsite during the site visit raised serious concerns regarding the structural integrity of the concrete support piers for the slide gate of the log chute. Significant structural cracks were noted on the piers. It was recommended to the city to remove or alleviate the load on this gate until repairs to the concrete support piers could be made.
- Spalling and structural cracking of the concrete was observed at numerous locations in the downstream support piers for the tainter gates. These cracks were noted to be in the vicinity of the tainter gate trunnion pins or supports.
- The welds on the safety railing on the downstream side of the power plant deck were observed to be inadequate and in poor condition. It is recommended that no one lean on the railings, and warning signs should be posted until the rail posts are adequately attached to the deck.
- It was recommended that a thorough structural evaluation be conducted which includes testing of the existing concrete.
- Remnants of an old fish passage were visible on the right abutment.
- The City stated that old riverbed thought to be present along right abutment.
- Increased potential for scour immediately downstream of dam as a result of current water control operations consisting of release of water from the right spillway and log chute.

2008 Safety Inspection of Brown Bridge Dam

In September, 2008 STS issues a report on the safety of Brown Bridge Dam (STS, 2008). The report contained the following key findings and recommendations.

- Brown Bridge is considered a high hazard dam and the spillway capacity is inadequate.
- Active seeps and wet spongy conditions were observed over most of the downstream toe of the right embankment.
- The pool at Brown Bridge should be drawn down approximately four feet.
- A formal operation, monitoring, and maintenance plan should be prepared.
- Perform an evaluation of the spillway capacity and flood routing in order to provide recommendations for modifying the spillway to meet MDEQ requirements.
- Stabilize the slopes on the right and left embankments.
- Perform concrete repairs tot eh powerhouse/spillway structure.
- Update the Emergency Action Plan.

Below is a compilation of references that were made available to the USACE/ ECT team during the course of the Preliminary Engineering Evaluation of Existing Structures study (ECT, 2007).

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4.0 DESCRIPTION OF THE ALTERNATIVES

INTRODUCTION

The process by which these alternatives were selected for detailed analysis was open and consistent with other decisions made by the BRDC. A list of all combinations of retain and repair, modify and remove each of the dams was prepared. The list of 81 possibilities was reviewed by the BRDC and comments were received regarding which of the 81 possibilities warranted detailed study. From that list a short list for detailed analysis was prepared that consisted of seven alternatives and these alternatives were the basis for the initial detailed analysis. After an initial review of the information regarding each alternative, the ECT team recommended to the BRDC that the removal of Union Street Dam not be an alternative that warranted detailed study. The BRDC approved that modification of the original list and a letter was forwarded to the City of Traverse City requesting approval of eliminating the removal of Union Street Dam from detailed analysis. The City of Traverse City approved removing the option that involves removal of Union Street from detailed analysis.

While the analysis of six alternatives is the focus of this report, it is important to stress that all of the options and variations of the options identified by the BRDC are viable. The list of alternatives selected for detailed analysis is as follows:

- **Alternative 1.** Retain/ repair all dams
- **Alternative 25.** Retain/ repair Union Street, remove Sabin and Boardman, and retain/repair Brown Bridge
- **Alternative 41.** Modify all dams with or without hydroelectricity
- **Alternative 43.** Retain/ repair Union Street, remove Sabin, modify Boardman and Brown Bridge
- **Alternative 79.** Retain/ repair Union Street, remove all others
- **Alternative 81.** Modify Union Street dam, remove all others

The terms retain and repair, modify and remove mean different things to different people. For purposes of this report, **retain and repair** means that the dams, power houses and spillways would remain in place and that the size and elevation of the lake or pond behind the dam would not change. Repairs would be made to the dam consistent with accepted operation and maintenance of dams, power houses and spillways, but major modifications would not be implemented. **Modify** means that the dam would be modified for passage of Great Lakes fish, flood protection in compliance with MDEQ or FERC requirements, and, in the case of Brown Bridge Dam, bottom draw to mitigate the impact of warm water discharge from the impoundment. For purposes of this report, fish passage means that a fish passageway would be built and that all species of Great Lakes fish could pass upstream using the fish passageway. **Remove** means that the dam would be partially or completely removed and the impoundment would be completely removed, thus creating a river where a lake or impoundment once existed. Partial removal means that a section of the earthen embankment would be removed in order to drain the impoundment and allow the river to pass through the earthen embankment. Under partial removal, the spillway, powerhouse and remaining portions of the embankment would remain. Total removal means that the entire earthen embankment, spillway, powerhouse and associated structures would be removed.

The following is a brief synopsis of each of the alternatives considered for detailed analysis.

Alternative 1. Retain/ repair all dams

This option would consist of retaining all of the dams as they currently exist. Water levels and impoundment size would not be changed. Repairs would be made to the dams and associated structures, but the spillway at Boardman Pond would not be modified, therefore the lowered water level would remain. The dams would not be modified to allow increased fish passage. The Brown Bridge Dam would not be modified to reduce adverse impact of warm water discharge. The fish ladder at Union Street would be maintained and the fish weir operated by the MDNR would be maintained.

Alternative 25. Retain/ repair Union Street, remove Sabin and Boardman, and retain/repair Brown Bridge

This alternative would consist of retaining Union Street Dam, along with the existing fish ladder and DNR weir operation. In addition, Brown Bridge Dam would be repaired and retained. The fish ladder at Union Street would be operated to allow native species of Great Lakes fish and salmon and trout to pass around the dam, but invasive aquatic species would be blocked at Union Street. Sabin Dam would be partially or completely removed to allow a free flowing river to be restored from the upstream end of Boardman Lake to the upstream end of Boardman Pond. Boardman Dam would be partially or completely removed and Boardman Pond would be replaced with a river. The Brown Bridge Dam would be repaired and retained without any action to mitigate the impact of warm water discharge on downstream coldwater habitat.

Alternative 41. Modify all dams with or without hydroelectricity

This option would consist of modifying all of the dams by adding fish passageways at all of the dams, improving the spillway at Boardman Dam and Brown Bridge Dam, and constructing a bottom draw structure at Brown Bridge Dam. The DNR weir operation on the Boardman River would be maintained. The fish ladder at Union Street would be replaced with a passage way that would maintain the current Boardman Lake level, but would allow the passage of fish from the Great Lakes into the Boardman River and vice versa. Sabin Dam would be maintained, but a fish passageway would be installed to allow fish passage at the dam. Boardman Dam and Brown Bridge Dam would be modified to meet the emergency flood control requirements of the MDEQ. A fish passage structure would be installed to allow fish to pass at the dam. The Brown Bridge Dam would be modified to allow fish passage at the dam and a bottom draw system would be installed to potentially mitigate the impact of warm water discharge from the impoundment on downstream coldwater habitat.

The modification to provide flood protection at Boardman Dam and Brown Bridge dam depends on whether power is generated at the dams. If the dams are not modified to produce power, then MDEQ regulates the flood protection requirement. If power is not generated, then the emergency flood capacity can be provided by passing water through the penstocks and concrete spillway. In order for this option to be feasible, the concrete spillway would need to be modified slightly to accommodate the additional flow.

If the dams are used to generate power, the capacity to pass flood water is reduced and a new reinforced spillway is required. The details of the new reinforced spillway are provided in Section 6.0, Alternative 41A.

Alternative 43. Retain/repair Union Street, remove Sabin, modify Boardman and Brown Bridge

This option would consist of retaining Union Street Dam, along with the existing fish ladder and DNR weir operation. The fish ladder would be operated to allow salmonids to pass the dam, but invasive aquatic species would be blocked at the weir and Union Street. Sabin Dam would be partially or completely removed to allow a free flowing river to be restored from Boardman Pond Dam to Boardman Lake.

Boardman Dam and Brown Bridge Dam would be modified to meet MDEQ requirements for emergency spillways. The dams at Boardman Pond and Brown Bridge Pond would be modified to allow passage of Great Lakes fish, including salmon and trout. The Brown Bridge Dam would be modified to allow for cold water at the bottom of the impoundment to be discharged, which may mitigate the impact of warm water discharge into the Boardman River.

Alternative 79. Retain/ repair Union Street, remove all others

This option would consist of retaining Union Street Dam, along with the existing fish ladder and DNR weir operation. The fish ladder would be operated to prevent fish from passing around the dam. Sabin Dam would be partially or completely removed to allow a free flowing river to be restored from Boardman Pond Dam to Boardman Lake. Boardman Dam would be partially or completely removed and a river would replace the impoundment known as Boardman Pond. The Brown Bridge Dam would be partially or completely removed and a river would replace the impoundment known as Brown Bridge Pond.

Alternative 81. Modify Union Street dam, remove all others

This option would consist of retaining Union Street Dam and modifying the fish ladder to allow Great Lakes fish to migrate around the dam. The fish passageway would be operated to allow fish, including Great Lakes fishes to pass around the dam, but invasive species of fish would be blocked at Union Street. Sabin Dam, Boardman Dam, and Brown Bridge Dam would be partially or completely removed to allow a free flowing river to be restored where impoundments currently exist.

5.0 SUMMARY OF EXISTING CONDITIONS

During the course of this study a number of studies were conducted to summarize the existing conditions in the study area, identify information needs, and collect new information on the key areas of interest. Accordingly, the following studies were performed:

- Engineering
- Fish populations
- Wildlife populations
- Threatened and endangered species
- Wetlands
- Terrestrial habitat
- Historic status of the dams
- Hydrology and hydraulics
- Bathymetry
- Sediment quality

These studies contain information that was used to perform the detailed analysis. A summary of the information that is important in evaluating the effects of various alternatives is presented below.

Terrestrial Habitats

The terrestrial habitats upstream of the **Union Street Dam** occur in the glacial context of flat lakeplain physiography with undulating drumlin fields. The soils surrounding Boardman Lake consist mainly of somewhat excessively drained sandy loam and excessively drained sand soils. The northern portion of the reservoir is surrounded by urban development associated with the City of Traverse City and dominated by ruderal vegetation, including eastern cottonwood (*Populus deltoides*), black locust (*Robinia pseudoacacia*), staghorn sumac (*Rhus typhina*), and tall goldenrod (*Solidago altissima*). The southern half is less developed with adjacent deciduous, evergreen, and mixed forested lands, dominated by sugar maple (*Acer saccharum*), eastern white pine (*Pinus strobus*), northern red oak (*Quercus rubra*), eastern cottonwood, trembling aspen (*Populus tremuloides*), and bracken fern (*Pteridium aquilinum*).

The terrestrial habitats upstream of the **Sabin Dam** are set in the glacial context of flat lakeplain and morainal ridges with coarse-textured till. The soils surrounding Sabin Pond consist mainly of moderately well drained loamy sand, somewhat excessively drained loamy sand, and very poorly drained muck. Sabin Pond is surrounded mostly by agricultural, grassland/pasture, and forested terrestrial habitats, with some urban/residential development. Upland forested areas include deciduous, evergreen, and mixed vegetation and are dominated by sugar maple (*Acer saccharum*), eastern white pine (*Pinus strobus*), white oak (*Quercus alba*), white ash (*Fraxinus americana*), and bracken fern (*Pteridium aquilinum*). Significant areas of wooded wetland occur east and southwest of the pond.

The terrestrial habitats upstream of the **Boardman Dam** are set in the glacial context of flat lakeplain and morainal ridges with coarse-textured till. The soils surrounding Boardman Pond consist mainly of well drained gravelly sand and gravelly sandy loam, somewhat poorly drained gravelly sandy loam, somewhat excessively drained loamy sand, well drained loamy sand, poorly drained sandy loam, poorly drained loam, and very poorly drained muck. Boardman Pond is surrounded mostly by open shrub/grassland, agriculture, and mixed pine-hardwood forest, with some residential development. Upland forested areas include mixed deciduous and evergreen vegetation and are dominated by sugar maple (*Acer saccharum*), black cherry (*Prunus serotina*), eastern white pine (*Pinus strobus*), northern red oak (*Quercus rubra*), white oak (*Quercus alba*), northern pin oak (*Quercus ellipsoidalis*), red maple (*Acer rubrum*), paper birch (*Betula papyrifera*), basswood (*Tilia americana*), trembling aspen (*Populus tremuloides*), bigtooth aspen (*Populus grandidentata*), and bracken fern (*Pteridium aquilinum*).

The terrestrial habitats upstream of the Brown Bridge Dam are set in the glacial context of a narrow outwash channel with sand and gravel parent material. The soils adjacent to Brown Bridge Pond consist mainly of excessively drained sand, poorly drained sand, very poorly drained muck, moderately well drained loamy sand, somewhat poorly drained sands, and very poorly drained muck over sand. Brown Bridge Pond is primarily surrounded by evergreen and mixed forest vegetation with expansive areas of forested wetland on its east and south sides. Upland forests are dominated by sugar maple (*Acer saccharum*), eastern white pine (*Pinus strobus*), red pine (*Pinus resinosa*), witch-hazel (*Hamamelis virginiana*), Canada mayflower (*Maianthemum canadense*), and bracken fern (*Pteridium aquilinum*).

Wetland Habitats

The study of the distribution of wetlands in and around the impoundments was completed in 2007 (ECT, 2007).

The impoundment behind the Union Street Dam is currently 339 acres. Approximately 140 acres of aquatic wetland occur within the impoundment, dominated by submerged and floating vegetation. The plant community within this type of wetland is characterized by relatively low species diversity and is dominated by floating and sago pondweeds (*Potamogeton natans* and *P. pectinatus*) and stonewort (*Chara* spp.). Approximately 5 acres of wetland occur near or adjacent to the Boardman Lake impoundment, consisting of 2.4 acres of palustrine scrub-shrub and 2.8 acres of palustrine emergent/palustrine scrub-shrub wetlands. These wetlands occur on very poorly drained sapric muck. Dominant shrub and emergent vegetation species include ninebark (*Physocarpus opulifolius*), black willow (*Salix nigra*), silky dogwood (*Cornus amomum*), common cattail (*Typha latifolia*), and purple loosestrife (*Lythrum salicaria*).

The impoundment behind the Sabin Dam is currently 40 acres. Approximately 15 acres of aquatic wetland occur within the impoundment, dominated by submerged, floating, and emergent vegetation. The plant community within this type of wetland is characterized by relatively low species diversity and is dominated by floating and sago pondweeds (*Potamogeton natans* and *P. pectinatus*), stonewort (*Chara* spp.), yellow pond-lily (*Nuphar advena*), and hardstem bulrush (*Schoenoplectus acutus*). Approximately 17 acres of diverse wetland habitat occur near or adjacent to the Sabin Pond impoundment, consisting of 0.6 acres of palustrine emergent, 0.2 acres of palustrine emergent/palustrine scrub-shrub, 9.4 acres of palustrine forested, 0.3 acres of palustrine forested/palustrine scrub-shrub, and 6.9 acres of palustrine forested/palustrine scrub-shrub/palustrine emergent/open water wetlands. Although some of these wetlands are influenced by inundation from the impoundment, most of these wetlands are primarily fed by groundwater seepage. They occur on very poorly drained sapric muck. Dominant forest, shrub, and emergent wetland vegetation species include northern white-cedar (*Thuja occidentalis*), red maple (*Acer rubrum*), common elder (*Sambucus canadensis*), common and narrow-leaved cattail (*Typha latifolia* and *T. angustifolia*), spotted joe pye weed (*Eupatorium maculatum*), hardstem bulrush, marsh shield fern (*Thelypteris palustris*), and jewelweed (*Impatiens capensis*).

The impoundment behind the Boardman Dam was originally 103 acres. Following an emergency drawdown in 2007 during which the water level in the impoundment was dropped approximately 16 feet, approximately 25 acres of newly formed emergent wetland have replaced open water and submerged and floating wetland vegetation within the impoundment. The previous aquatic plant community was characterized by relatively low species diversity and was dominated by floating and sago pondweeds (*Potamogeton natans* and *P. pectinatus*) and stonewort (*Chara* spp.). The new emergent plant community developing within the impoundment is characterized by higher species diversity and is dominated by blue vervain (*Verbena hastata*), nodding bur-marigold (*Bidens cernnuus*), nodding smartweed (*Polygonum lapathifolium*), rice-cut grass (*Leersia oryzoides*), hardstem bulrush (*Schoenoplectus acutus*), three-square (*Schoenoplectus pungens*), and sedges (*Carex* spp.). Approximately 15 acres of diverse wetland habitat occur near or adjacent to the Boardman Pond impoundment, consisting of 1.2 acres of palustrine emergent, 11.3 acres of palustrine emergent/palustrine scrub-shrub, 0.6 acres of palustrine scrub-shrub, and 1.6 acres of palustrine forested/palustrine scrub-shrub. Although some of these wetlands are influenced by inundation from the impoundment, most of these wetlands occur upstream of the wide upstream end of the impoundment and are primarily fed by groundwater seepage. They occur on poorly and very poorly drained mucky sand. Dominant forest, shrub, and emergent wetland vegetation species include northern white-cedar (*Thuja occidentalis*), black ash (*Fraxinus nigra*), tag alder (*Alnus rugosa*), ninebark (*Physocarpus opulifolius*), common cattail (*Typha latifolia*), rice-cut grass, nodding bur-marigold, blue vervain, spotted joe pye weed (*Eupatorium maculatum*), common boneset (*Eupatorium perfoliatum*), hardstem bulrush, and sensitive fern (*Onoclea sensibilis*).

The impoundment behind the Brown Bridge Pond Dam is currently 192 acres. Approximately 77 acres of wetland occur within the impoundment, dominated by submerged, floating, emergent, and scrub-shrub vegetation. The plant communities within these lacustrine wetlands are characterized by moderately low species diversity and are dominated by floating and long-leaf pondweeds (*Potamogeton natans* and *P. nodosus*), stonewort (*Chara* spp.), rice cut grass (*Leersia oryzoides*), common beggar-ticks (*Bidens frondosus*), red-osier dogwood (*Cornus sericea*), hardstem bulrush (*Schoenoplectus acutus*), common cattail (*Typha latifolia*), and wild celery (*Vallisneria americana*). Approximately 144 acres of diverse wetland habitat occur near or adjacent to the Brown Bridge impoundment, consisting of 59.7 acres of palustrine forested and 84.3 acres of palustrine forested/lacustrine and palustrine emergent wetlands. Although some of these wetlands are influenced by inundation from the impoundment, most of these wetlands are primarily fed by groundwater seepage. They occur on very poorly drained sapric muck. Dominant forest, shrub, and emergent wetland vegetation species include northern white-cedar (*Thuja occidentalis*), red maple (*Acer rubrum*), balsam fir (*Abies balsamea*), tag alder (*Alnus rugosa*), sedges (*Carex* spp.), common and narrow-leaved cattail (*Typha latifolia* and *T. angustifolia*), cinnamon fern (*Osmunda cinnamomea*), reedcanary grass (*Phalaris arundinacea*), and fowl manna grass (*Glyceria striata*).

Wildlife Populations

The following is a summary of the wildlife survey completed during the baseline survey conducted in 2007 (ECT, 2007).

Frogs and Toads

Amphibian species recorded during the Boardman River survey included the northern spring peeper, western chorus frog, wood frog, the gray tree frog, green frog, northern leopard frog, and eastern American toad. Many observers have been concerned with the increasing rarity and apparent population decline of several of these species. The northern leopard frog has been one of these species, experiencing a serious decline in the upper Midwest including Michigan. It is a species of wet meadows and its breeding habitat is usually wetlands or ponds with more permanent, year round water conditions. Only two of the ten survey sites had leopard frogs, the emergent cattail/bulrush marsh on the south shore of Brown Bridge impoundment east of the boat launch and a roadside pond. The site at Brown Bridge Pond had a healthy population of this rare frog, recording the highest call index value of 3.

Salamanders

Salamander species believed to occur within the river corridor are the redback salamander, the spotted salamander, blue-spotted salamander, and the red-spotted newt. The larger species breed in ponds with semi-permanent water but live most of the year in upland terrestrial habitats with thicker leaf cover or heavy ground cover such as downed woody debris. The small red-spotted newt is an aquatic salamander that spends most of its adult life in ponds or flooded wetlands. These four species are most abundant in and near aquatic habitats that have no or only limited game fish populations. The mudpuppy, another aquatic salamander and the largest salamander in Michigan, has been found in the Boardman Pond.

Turtles

Turtle species observed during field work or believed to occur along the natural shoreline of the Boardman River include the wood turtle and the eastern painted turtle, both of which could be found in the slower moving stretches of the river. Species believed to be common or occur in the four impoundments include the common snapping turtle, the eastern painted turtle, the map turtle, and the Blanding's turtle, a species of "special concern." Blanding's turtle juveniles would use tag alder and willow wetland habitat adjacent to slow moving streams the first couple years of their lives (Harding, pers. comm.) so they could be found in some sections of the river above the four impoundments.

Snakes

The northern water snake, the eastern garter snake, northern ribbon snake, blue racer, northern brown snake, eastern hog-nosed snake, red-bellied snake, and the smooth green snake are the species believed to be found in the river corridor and the impoundment habitats. The northern water snake is found in riparian habitats, including wetlands. The other species listed above are most common in upland terrestrial areas. Snakes are attracted to habitats with a good habitat structure like downed logs and tree tops and brush which provide safe cover, but also because of the abundant insect life and small mammals that are attracted to these habitats.

Lizards

One lizard, the five-lined skink, has been recorded as occurring in the river corridor near MDNR Sheck's State Forest Campground, which is just north of Brown Bridge impoundment (NMC, Bill Scharf). This species is rare in northern Michigan and like many snakes, when found, is often in areas with local habitat structure such as logs and downed wood or rock piles along habitat edges.

Waterfowl

The distribution and abundance of ducks, geese and swans on the Boardman river system and its impoundments is not well documented in existing data. Since northwest Lower Michigan does not have a large population of breeding waterfowl, the majority of waterfowl using the region are believed to be migrants. This is particularly true for diving ducks such as redheads and scaup. To determine the importance of the Boardman River and its lower impoundments to migrating waterfowl, we designed surveys to count waterfowl during the 2007 spring and fall migration periods. Funding limited the surveys to weekly counts on the four impoundments during peak migration this spring.

Spot checks at road crossings, river access sites, and on reconnaissance canoe trips this spring suggested waterfowl use of the natural, free-flowing portions of the river was limited to resident ducks such as mallards, wood ducks, and hooded mergansers.

Five waterfowl surveys were conducted on the four impoundments over a six week period in April and May 2007. A total of 2167 waterfowl were counted during all surveys; seventy-two percent were recorded on Boardman Lake, fifteen percent on Brown Bridge, ten percent on Sabin and three percent on Boardman Pond. We believe that the majority of the ducks were migrating ducks since diving ducks made up 83 per cent of the survey count. Diving ducks included redheads (the most abundant species) and buffleheads, lesser and greater scaup, golden-eyes, and American mergansers. Only a few dabbling ducks, including mallards, black ducks, pintails, blue-winged and green-winged teal, wood ducks and northern shovelers, were mixed in these multi-species flocks.

Brown Bridge was the other impoundment that had high waterfowl use, also mostly migratory diving ducks. As with Boardman Lake, waterfowl were concentrated in open water almost exclusively in the upper end an eighth mile or so off shore from the inlet. Buffleheads were the most abundant species at Brown Bridge, making up 237 of the 326 (73%) of waterfowl counted there, with small groups of ring-necked ducks and golden-eyes mixed in among the flocks of buffleheads. These diving ducks were observed actively feeding during the surveys. Mated pairs of wood ducks and mallards were observed along the delta and its associated marsh habitat.

Common loons were observed on Boardman Lake, Boardman Pond and Brown Bridge pond. Boardman Pond and Brown Bridge pond had active nesting loons, both pairs hatched young. Nesting mute swans were observed on all impoundments except Brown Bridge. A pair of trumpeter swans, a reintroduced species, was observed throughout the survey period on Brown Bridge pond.

Based on this one year's data on waterfowl use during spring migration, Boardman Lake and Brown Bridge impoundments appear to be important stopover and refueling areas for migrating waterfowl. Only 13% of waterfowl counted during the spring surveys were observed on Sabin and Boardman ponds (10% and 3%, respectively), with buffleheads being the primary duck species on these two impoundments. Sabin Pond had the highest use by Canada geese of the four impoundments, accounting for 61% of the Canada geese recorded in the spring surveys.

<u>Songbirds</u>

It is common knowledge among forest ecologists that forested riparian and riverine systems such as those found along the Boardman River have a higher diversity of plants and animals than most other forest habitat types. The biological richness of riparian habitats creates a wide diversity of niches and homes for a wide variety of wildlife, particularly songbirds. To survey birds living along the Boardman River corridor, birds were surveyed using a proven census technique called "point counts". This is similar to the method used for the USGS Breeding Bird Survey with surveys being conducted during the breeding season and individual species identified by male territorial songs, or visually. Thirteen survey sites were sampled in a variety of habitats along the river corridor. The species recorded during this survey totaled 77.

<u>Water Birds</u>

Water birds such as herons, gulls, terns, and shorebirds were recorded during the spring waterfowl surveys and other visits to the project area. Green herons were observed leaving the same woodlot area in the Sabin Pond delta area on several surveys, and a small nesting colony may occur there. Caspian terns were observed loafing and feeding in the delta area on Brown Bridge pond in mid-summer. Ring-billed gulls and herring gulls were commonly observed on Boardman Lake. Spotted sandpipers and killdeers were observed feeding at the newly exposed Boardman Pond bottomlands and riverbanks, and at the Brown Bridge delta. One great blue heron rookery was recorded by MNFI to be within the Boardman River watershed but the location is out of the project area in Kalkaska County.

Birds of Prey

The birds of prey observed during 2007 wildlife surveys within the project area included the Cooper's hawk, goshawk and broad-winged hawk, bald eagle and turkey vulture. An active broad-winged hawk nest was observed near the Brown Bridge impoundment when doing the small mammal trapping in mid-July 2007. MNFI data indicated occurrence records for the red-shouldered hawk just south of the river corridor in the central portions of the project area. Other hawk species that are known to occur as breeding birds in this region are the sharp-shinned hawk, red-tailed hawk, northern harrier, American kestrel, and merlin. Owl species believed to be breeding birds in the river corridor include the great horned, barred, sawhet and screech owl.

Mammals

The following mammals were reported as be present or likely to be present in the Boardman River Valley in the report by ECT (2007)

Short-tailed shrew
Coyote
Beaver
13- lined ground squirrel
Red-backed vole
Star-nosed mole
Opossum
Big brown bat
Southern flying squirrel
Bobcat
Red bat
Hoary bat
Woodchuck
Pine marten
Striped skunk
Meadow vole
Little brown bat
Mink
Long-tailed weasel
River otter
White-tailed deer
Muskrat
White-footed mouse

Raccoon
Eastern mole
Eastern gray squirrel
Meadow jumping mouse
Water shrew
Masked shrew
Cottontail
Eastern chipmunk
Red squirrel
Gray fox
Black bear
Red fox
Fox squirrel

To supplement this information, live trapping of mammals occurred in areas near or adjacent to the impoundments and included upland oak-pine-aspen forests and riparian habitats including mixed conifer-deciduous forest types, alder-willow shrub swamp, grassy-herbaceous habitats on riverbanks, and deltas. Four different habitat types were sampled at Brown Bridge, three at Boardman Pond, and three at the upper Sabin Pond delta and marsh. The emergency drawdown on Boardman Pond and its revegetated bottomlands provided an opportunity to study how wildlife and small mammal populations respond to newly created habitat. This area was one of the small mammal survey sites.

The results of this live trapping revealed that white-footed mice (*Peromyscous leucopus*) occur in most of the woodland upland forest types we sampled in the river corridor and even a few in the wetland habitat types. Meadow jumping mice appeared, from our live trapping data, to be restricted to habitat close to running water, and usually within sedge or grassy habitat. Meadow voles were limited mostly to grass-sedge-cattail habitats often where there were freshly sprouted forbs. Meadow voles were found in good numbers in the newly created lush herbaceous habitat on the recently exposed bottomlands at Boardman Pond, indicating their quick response and adaptability to these habitat changes caused by the emergency drawdown. Short-tailed shrew habitat preferences were less predictable than mice and voles. They appeared to be most common in areas with moist, thick ground vegetation where they had a suitable prey base for their insect and small mammal diets.

Fisheries

The MDNR operates a fish harvesting weir in Segment 1 (See Figure 1), downstream of Union Street Dam. Operation of the weir blocks salmon from migrating upstream during their fall spawning run. Some salmon may still migrate upstream before and after the weir is in operation, but most are blocked and harvested. The MDNR has stated that it intends to continue operation of the weir regardless of the fate of the Boardman dams. However, the harvest weir is not a fixed structure and requires operation to block migrating salmon. Therefore, there is always the potential for salmon to migrate upstream if the weir became inoperable, if operational funding is reduced or eliminated, or if management goals change. The analysis of fishery impacts under each alternative is based on the assumption that the weir does not exist because it is a management tool rather than a permanent impediment to migration. This approach inherently considers the full potential of the Boardman River to naturally produce salmon in addition to steelhead. If an alternative is determined to result in increased salmon productivity, that productivity would not be realized if the MDNR continues to operate the harvest weir according to the status quo.

The MDNR currently stocks Chinook salmon, coho salmon, and steelhead in the Boardman River and Kids Creek. Stocking maintains the salmon and steelhead fishery in the West Arm Grand Traverse Bay and the Boardman River. There are two options for evaluating the alternatives with the potential to increase natural reproduction. First, natural reproduction is added to stocking numbers. Second, natural reproduction replaces stocking. Stocking is done at a considerable cost: approximately $100,000 annually. Providing that natural reproduction was sufficient to generate current West Arm Grand Traverse Bay population levels, stocking could be discontinued or reduced, saving the State of Michigan thousands of dollars. If the MDNR chooses to continue stocking, then natural reproduction would increase salmon and steelhead abundance in the Boardman River and West Arm Grant Traverse Bay. Consequently, the overall value of the fishery to the local and regional economies increases. The alternatives analysis evaluates each alternative with the assumption that the MDNR would continue stocking. Again, this approach considers the full potential of the Boardman River at current stocking levels.

Sea lamprey control is a major factor that largely influences the type of fish passage that can be used at the Union Street Dam. For all alternatives that involve modifications to Union Street Dam, or any of the other three dams, the assumed goal is to provide passage for sturgeon and other desirable cool water species in addition to salmon and steelhead, as feasible. Fish passage structures that can pass sturgeon and other desirable cool water species such as walleye and smallmouth bass would also allow sea lamprey to migrate upstream, requiring new sea lamprey control strategies and increased control costs to maintain the existing level of sea lamprey control in the Boardman River. The cost of lampricide applications and its impacts on the environment are often stated as limiting principles in decision making regarding sea lamprey control. However, there is also an indirect cost to blocking desirable fish species from accessing rivers. The inherent unintended consequence of blocking sea lamprey migrations is the negative effect on natural reproductive potential for desirable fish species. For example, the MDNR spends approximately $100,000 annually to stock steelhead and salmon to support the West Arm Grand Traverse Bay fishery. In contrast, the USFWS spends approximately $75,000 every five years to treat Segment 1 of the Boardman River and Kids Creek with lampricide. Clearly, the current cost of stocking to offset the negative effect of blocking lamprey is greater than lampricide treatments. While the costs of treating many more miles of the Boardman River with lampricide could certainly be greater than the current cost of stocking, there are trade-offs in terms of cost that should be considered. Furthermore, the potential added value of the local fisheries could at least partially offset the additional cost of lampricide treatments. These cost-balancing issues are difficult to quantify, but should be considered during the decision making process.

Salmon and steelhead competition with resident trout is also an important management consideration. Several Lake Michigan tributaries currently contain resident trout and anadromous salmon and steelhead populations. There is speculation that competition between the resident and anadromous salmonids affect resident trout in the Pere Marquette River where brown trout young-of-year abundance has been low over the last two to three decades. However, brown trout are abundant in the Little Manistee River. Research conducted by the MDNR at the Hunt Creek Research Station showed that adding steelhead to Hunt Creek decreased brown trout abundance. However, Hunt Creek has very high brown trout densities compared to the Pere Marquette, Little Manistee, and Boardman rivers. In cases where brown trout densities are high, a reduction in brown trout abundance is possible. Unfortunately, there is little evidence or data to support the conclusion that the addition of or increase in abundance of anadromous salmon and steelhead to a river would negatively affect resident trout populations in natural uncontrolled systems. In fact, some data suggest that good brown trout and steelhead fisheries can co-exist. The Little Manistee River is one example. In any respect, it is impossible to quantifiably say that existing resident trout populations in the Boardman River would be negatively impacted by the passage of salmon and steelhead upstream beyond Sabin Dam. It is just as possible that the resident trout populations could benefit from the increased productivity resulting from transport of nutrients from West Arm Grand Traverse Bay upstream into the Boardman River.

The analysis of alternatives with respect to fisheries of the Boardman River is supported by baseline data and documentation obtained and prepared in 2007 and 2008 for the Boardman River Dams Committee. The two baseline reports that are used throughout the fisheries portion of the alternatives analysis were produced by Environmental Consulting & Technology, Inc. in August of 2007 and January of 2008. The two reports document existing fisheries data and new habitat data that were collected during August and September of 2007. References to existing habitat conditions and characterizations of existing fisheries in the following discussion are based on the following baseline reports.

- ECT, Boardman River Feasibility Study – A Report on the Boardman River Fisheries Existing Data, August 2007; and
- ECT, Boardman River Feasibility Study – A Report on the Boardman River Fisheries Habitat & Survey Data Collection, January 2007

Readers of this alternatives analysis are encouraged to seek further details and review information in those reports.

Economic modeling conducted for the Boardman River Dams alternatives analysis involves the valuation of recreational salmon and steelhead fisheries. The economic model uses catch rates to estimate the value of a recreational fishery to the local and state economy. In order to estimate the potential increase in salmon and steelhead catch rates associated with each alternative, Little Manistee River fish count data were obtained from the MDNR Fisheries Division for the egg-take weir on the Little Manistee River located approximately 5 miles upstream of Manistee Lake. The Little Manistee River and Boardman River are similar in many respects. Both rivers drain similar glacial geologies, have a predominance of cold ground water flow, and have abundant salmonid spawning habitat. Consequently, it is reasonable to assume that the salmon and steelhead productivity or potential of the Boardman River is similar to that of the Little Manistee River. The Little Manistee River provides the best available data that can be used to estimate adult salmon and steelhead spawning runs that is at least comparable to the Boardman River.

MDNR blocks steelhead in the spring and salmon in the fall at a weir. Steelhead and salmon are blocked at the weir, attracted into the egg-take facility; and then processed in the egg-take facility. Only fish that are actually captured and processed at the weir are counted. The weir is typically operated from mid-August to mid-November (82 days average 2000-2007) and mid-March to mid-April (32 days average 2000-2008). Once the MDNR has met its quota, the weir is removed and fish are no longer counted. Therefore, the count data only represent the number of adult salmon and steelhead processed at the facility. Many more fish migrate past the facility prior to installation of the weir, after the egg-take quota is met, and after removal of the weir and/or weir grates. The actual number of fish that migrate past the weir is not known. The MDNR fish counts are an under estimate of the actual number. In terms of their utility to the Boardman River alternatives analysis, the data provide a conservative estimate that would not over state the potential benefits of removing or modifying the dams relative to anadromous salmonid reproduction.

The annual average number of Chinook and coho salmon counted at the MDNR egg-take facility located on the Little Manistee River between 2000 and 2007 is 14,440 and 801 respectively. The counts for coho are not influenced by stocking, as coho stocking was discontinued in the Little Manistee River after 1993. The Chinook salmon counts are influenced by stocking, as the MDNR continues to stock approximately 500,000 salmon in the Little Manistee River annually. Following discontinuation of coho stocking in 1993, coho counts at the egg-take facility decreased from a mean of 25,155 annual to 907 annually (1994 to 2007). Coho and Chinook counts at the weir were similar while both were being stocked. Therefore, it is reasonable to assume that the numbers should be similar if Chinook were no longer being stocked. Applying this assumption results in an annual average count of the free flowing mainstem of the Little Manistee River is 55 miles in length, resulting in a productivity estimate of 19 Chinook and 16 adult coho per mile. This productivity estimate is applied to the Boardman River to estimate the potential increase in the abundance of adult salmon and steelhead under each alternative, based on the length of accessible river.

Steelhead have been counted at the Little Manistee River egg-take facility in the spring and fall. However, only limited counts of steelhead have been made at the Boardman River salmon harvesting weir during the fall only. Comparatively, the number of steelhead counted at the Boardman River salmon harvesting weir in the fall is much lower than the number counted at the Little Manistee River egg-take facility in the fall; the annual average for the Little Manistee River is 875 for the fall run (2000 to 2007), versus 15 for the Boardman River fall run (2000 through 2007). On the Little Manistee River, the spring steelhead run is seven times greater than the fall run on average. It is possible, therefore, that the existing Boardman River spring steelhead run could be at least 100 adult fish. The run could be higher, but better estimates are not available.

Threatened and endangered species

The Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam and their impoundments provide valuable habitats for state-listed threatened, endangered or special concern and rare species occurring in the impoundments. These include the Blanding's turtle (*Emys blandingii*) (all impoundments), wood turtle (*Glyptemys insculpta*), common loon (*Gavia immer*) (Boardman Pond, Brown Bridge pond), bald eagle (*Haliaeetus leucocephalus*) (Brown Bridge pond), trumpeter swan (Brown Bridge pond), red-shouldered hawk (*Buteo lineatus*), ebony boghaunter (*Williamsonia fletcheri*), and king rail (*Rallus elegans*). In addition, during the wildlife survey a population of leopard frogs was recorded at Brown Bridge Pond and one other location along the Boardman River. While the leopard frog is not a State listed species, there is concern that the leopard frog population is declining.

The only element occurrence of a threatened or endangered species recorded within the Michigan Natural Features Inventory (MNFI) database for the Boardman Lake area is that of the king rail (*Rallus elegans*), an endangered shorebird of permanent marsh habitats last sighted in the area in 1970. The threatened common loon (*Gavia immer*) has also been observed on Boardman Lake, but no nesting sites have been recorded.

The only element occurrence of a threatened or endangered species recorded within the Michigan Natural Features Inventory (MNFI) database for the Sabin Pond area is that of the wood turtle (*Glyptemys insculpta*), a reptile of special concern known to inhabit various wetland types, especially forested river floodplain wetlands adjacent to upland habitats with sandy soils. This species is not legally protected by state law but may become listed in the future with continued population decline. It was very recently recorded near Sabin Pond in 2005 and in two other sections further east along the Boardman River.

Blanding's turtle (*Emys blandingii*) is another special concern species believed to be present near the impoundments along the Boardman River. It's presence at Sabin Pond has not been confirmed.

While no threatened and endangered element occurrences are recorded for the Boardman Pond area within the Michigan Natural Features Inventory (MNFI) database, the Common loon (*Gavia immer*) has been reported on the pond, including a nesting site, for many years. This threatened species prefers to nest in lakes, rivers, and ponds isolated from extensive human disturbance. It has been recorded by MNFI in seven additional sections within the watershed as recently as 2003, especially in the Forest Lakes area north of the Boardman River. Although not known to nest near any of the four impoundments, the threatened red-shouldered hawk (*Buteo lineatus*) is known to occur in the forested region between Boardman and Brown Bridge Ponds. The wood turtle (*Glyptemys insculpta*), a reptile of special concern that inhabits various wetland types including forested river floodplain wetlands adjacent to upland habitats with sandy soils, is known to occur in the free-flowing sections of the Boardman River between Boardman and Brown Bridge Ponds. Blanding's turtle (*Emys blandingii*) is another special concern species believed to be present near the impoundments along the Boardman River. It's presence at Boardman Pond has not been confirmed.

Brown Bridge Dam is recognized as habitat for common loon, bald eagle, red-shouldered hawk, trumpeter swan, wood turtle, and Blanding's turtle habitat. One of seven occurrences recorded in the Michigan Natural Features Inventory (MNFI) database for the Boardman River Watershed, the common loon (*Gavia immer*) has been reported for the western end of Brown Bridge Pond as recently as 1998. The U.S. Army Corps of Engineers also reported the occurrence of a bald eagle (*Haliaeetus leucocephalus*) nest near Brown Bridge Pond. This state threatened raptor nests in large trees near open water areas such as ponds, rivers, streams, and lakes isolated from extensive human disturbance. MNFI reports its occurrence in two sections east of Brown Bridge Pond along the river and north of the river in the Forest Lakes area. Although not known to nest near any of the four impoundments, the threatened red-shouldered hawk (*Buteo lineatus*) is known to occur in the forested region between Boardman and Brown Bridge Ponds. A reintroduced pair of threatened trumpeter swans (*Cygnus buccinators*) has been observed within the Brown Bridge impoundment. The special concern wood turtle (*Glyptemys insculpta*), is known to occur in the free-flowing sections of the Boardman River between Boardman and Brown Bridge Ponds. Blanding's turtle (*Emys blandingii*) is another special concern species believed to be present near the impoundments along the Boardman River. It's presence at Brown Bridge Pond has not been confirmed since the 1970's.

<u>Sediment</u>

Any alternative that involves the removal of one or more dams would require consideration of how sediment stored in the associated impoundment(s) would be managed. Sediment management is predicated on four factors: quantity of sediment, quality of sediment (physical and chemical), method of removal, and transportation and disposal. Costs are greater with more quantity or if the sediment quality necessitates strict disposal requirements. Costs are also greater the further the disposal site is located from the source due to transportation related costs.

Sediment quality and physical characteristics are summarized and discussed in the following baseline report:

- ECT, Boardman River Feasibility Study – A Report on Boardman River Existing Sediment Chemistry Data, April 2008

Available sediment data generally show that arsenic, selenium, and/or barium are present in Sabin, Boardman, and Brown Bridge ponds at concentrations exceeding one or more sediment quality criteria used for evaluation. The following excerpt from the sediment baseline report provides more details for each impoundment

- Sabin Pond - Barium exceeded the USEPA Ecological Screening Level in one sample and selenium exceeded the Apparent Effects Threshold in another sample.

- Boardman Pond - Arsenic, barium, and selenium were present at concentrations exceeding the USEPA Ecological Screening Levels in some or all of the six core samples. Arsenic also exceeded the statewide default background level and MDEQ Residential Direct Contact Criterion in all six samples.

- Brown Bridge Pond - Arsenic, barium, lead, selenium, and zinc exceeded the USEPA Ecological Screening Levels in some or all of the core samples.

Sediment quality influences disposal options and consequently transportation costs. The least costly disposal option is to place dredged sediment in uplands as close to the point of removal as possible. It is probable that the sediment could be disposed on uplands adjacent to or within the impoundments, but such disposal may require some restrictions depending on the results of additional testing conducted at the time of removal and could carry negative social perceptions. Given that the sediment that would actually be removed would consist primarily of sands, the sediment may actually be shown to be inert and free of contaminants once removed. It is also important to recognize that the contaminants found in the three impoundments are commonly found in aquatic sediments and cannot be traced to a specific point source.

The total volume of sediment also affects costs, regardless of quality. Sediment coring data is not available for estimating the depth and quantity of sediment in the three impoundments. Furthermore, good bathymetric data is only available for Boardman Pond. The Boardman Pond bathymetric data provides the best information for estimating stored sediment quantity and can be used to make inferences about Sabin Pond and Brown Bridge Pond. Based on the bathymetric data, sediment samples, field observations, and aerial photograph interpretation, it appears that most of the stored sediment in Brown Bridge Pond and Boardman Pond is stored in the delta at the head of the impoundments. A discernible delta has not been observed in Sabin Pond. Therefore, either the stored sediment volume is low or the stored sediment is more evenly distributed throughout the impoundment. Sabin impoundment is approximately 1/3 the length of Boardman and Brown Bridge ponds, so sediment could be distributed over a larger portion of Sabin Pond compared to the other two.

Using the Boardman Pond bathymetric data, ECT determined that the former valley floor elevation was at an elevation of approximately 640.0 feet AMSL. The top elevation of the sediment delta is approximately 650.0 feet AMSL, or ten (10) feet higher than the former valley floor. The estimated area of the Boardman Pond sediment delta is 936,063 square feet upstream to the point of impoundment influence. The volume of the delta can be calculated as that of a wedge (H*L*D/2). The resulting stored sediment volume estimate for Boardman Pond is 170,000 cubic yards. The actual volume of sediment that could be transported depends on the size of the stream channel and can be estimated in the same manner. The estimated length of the stream channel that would form, or the distance over which sediments are stored on the former river bed and floodplain and would be eroded and transported is 4,200 feet. The estimated width of the channel is 60 feet. The maximum depth is ten (10) feet. The resulting transported sediment volume estimate that could be transported is 45,000 cubic yards, or roughly 25% of the total stored volume.

Bathymetric data is not available for Brown Bridge Pond. However, the surface area of the delta can be estimated from aerial interpretation and field observations, while the delta thickness can be estimated from what is known about Boardman Dam and Boardman Pond. Assuming the underlying valley floors of the two impoundments are of similar slope as USGS Topographic maps suggest, the thickness of the sediment delta in Brown Bridge Pond and Boardman Pond would be roughly proportional to the heights of the their respective dams, providing they are of similar age. The height of the Boardman Dam is 61.1 feet, while Brown Bridge Dam is 46.5 feet. The dam height ratio is 0.70; meaning the Brown Bridge Dam height is equal to 70% of the Boardman Dam height. Therefore, the Brown Bridge Pond sediment delta thickness should be 70% of the Boardman Pond sediment delta thickness. The resulting estimate of the Brown Bridge Pond sediment delta thickness is seven (7) feet (10 x 0.7 = 7). The estimated area of the Brown Bridge Pond sediment delta is 1,375,279 square feet. The resulting stored sediment volume is 180,000 cubic yards. The estimated channel width is 45 feet. The estimated channel length is 4,000 feet. The resulting estimate of potential transport of sediment is 25,000 cubic yards, or roughly 14% of the total stored volume.

Bathymetric data is not available for Sabin Pond either. Estimating the stored volume is more problematic for Sabin Pond because it lies immediately downstream of Boardman Pond, which traps sediment that would otherwise be transported downstream into Sabin Pond. Furthermore, the channel length and watershed area between Boardman Dam and Sabin Pond are both small, reducing the overall sediment supply to its impoundment. Due to the lack of data on Sabin and low sediment load, it is necessary to use inference based on what is known about Boardman Pond to estimate the stored sediment quantity in the delta of Sabin Pond. Given that sediment load is largely a function of the contributing drainage area in a relatively undisturbed watershed, the relative drainage areas of Sabin and Boardman dams can be used to scale the stored sediment estimate for Boardman Pond to that of Sabin Pond. The drainage area of Sabin, Boardman, and Brown Bridge dams are 211, 209, and 121 square miles respectively. Because Brown Bridge Dam traps sediment that would otherwise be transported downstream to Boardman Pond, its drainage area should be subtracted from that of Boardman Dam, resulting in a drainage area of 88 square miles for Boardman Dam. The drainage area of Sabin Dam should be reduced by that of the Boardman Dam, resulting in a drainage area of just 2 square miles for Sabin Dam from which sediment is supplied to its impoundment, or just 2% of the Boardman Dam drainage Area. Applying this drainage area ratio results in a stored delta sediment volume estimate for Sabin Pond of just 3,500 cubic yards. At the most, approximately 25% of that volume could be expected to be transported during a dam breach/removal, or 875 cubic yards.

There are three basic options for managing sediment stored in the impoundments during dam breaching or removal as outlined below.

- Option 1: Allow stored sediment to be mobilized and transported downstream of the dam without capture and removal
- Option 2: Excavate or dredge stored sediment from the impoundments prior to dam removal
- Option 3: Allow stored sediment to be mobilized and transported with downstream capture and removal at the dam

Each option is discussed in more detail below.

Option 1: Allow stored sediment to be mobilized and transported downstream of the dam without capture and removal

Allowing stored sediment to be mobilized and transported downstream of the dam is the least costly of the options because it requires no action during dam removal. However, releasing stored sediment downstream would have a range of negative effects on aquatic habitat and geomorphology of the stream channel downstream of the dams. Releasing sediment downstream, particularly sands, can decrease pool habitat and depth, cover spawning gravel, cover large woody debris, cause stream bank erosion and channel widening, and alter streambed slope. The degree of impacts depends on the rate and quantity of sediment released. It also depends to some extent on the nature of the channel and habitat downstream. For example, Segment 3 of the Boardman (Figure 1) is sediment starved and the channel morphology is dominated by pool and run habitat. While these characteristics provide good habitat for some fish species and especially adult brown trout, it is poor habitat for reproduction. Releasing sediment downstream of Boardman and Sabin dams into Segment 3 would decrease average depth and pool habitat, but may increase spawning habitat. Some of the released sediment would also be transported into the head of Boardman Lake, with the potential to increase wetland habitat in that area. In contrast, releasing sediment downstream of Brown Bridge into Segment 6 (Figure 1) could have negative effects on the fisheries due to a decrease in pool habitat which is already lower in abundance and smothering of gravels that provides spawning habitat and food for fishes. The effects of released sediment downstream of a dam, particularly morphological changes, can be permanent or persist for decades.

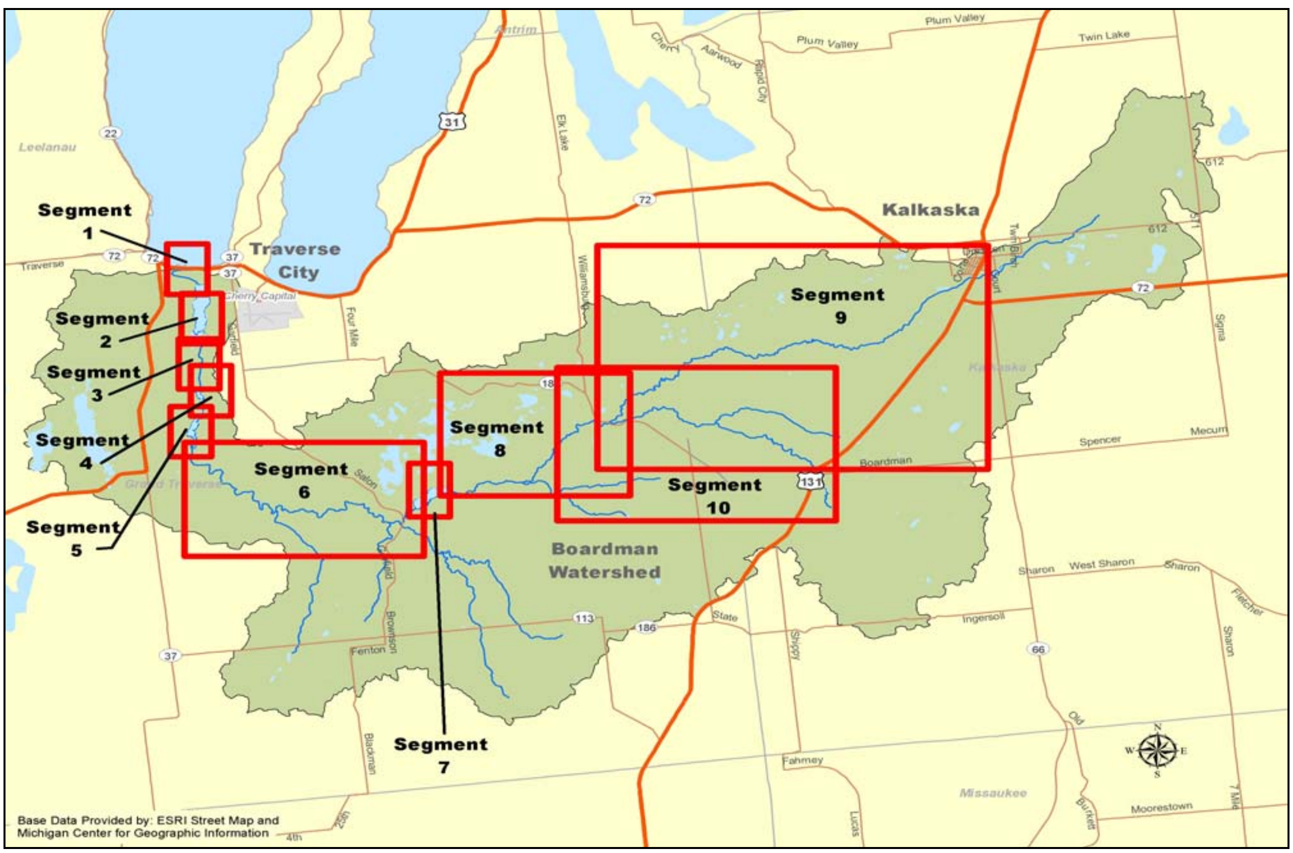

Figure 1. Location of Segments 1–10 Along the Boardman River

Division of the Boardman into distinct segments is required for modeling and facilitates identification of appropriate input data.

Option 2: Excavate or dredge stored sediment from the impoundments prior to dam removal

Given that most of the stored sediment in the impoundment is located in deltas at the head of the impoundments, sediment could be removed from that general location prior to dam breaching or removal. Because it is difficult to predict the location and migration of the new stream channel that would form within the delta following dam removal, this option requires removal of the entire volume of sediment stored in the deltas. In reality, only a portion of the delta sediments would be mobilized during dam removal, depending on where the new channel forms. Attempting to predict where the channel would form and removing sediments only from that location within the delta could result in costly sediment removal with no net gain. Therefore, Option 2 is more costly than Option 3 because a much greater volume of stored sediment would require removal. Based on stored volume estimates versus estimates of transported sediment for Brown Bridge and Boardman ponds, the amount of sediment removed under Option 2 could be 75% to 90% greater than that of Option 3.

Option 3: Allow stored sediment to be mobilized and transported with downstream capture and removal at the dam

During breaching or drawdown, a natural channel would reform through the stored sediment delta. Flowing water in the newly formed channel would transport sediment from within the channel, while sediments stored in the delta outside of the new channel would remain in place. Therefore, the actual transported volume is much less than the total volume stored in the delta. Predicting where the channel would occur is difficult. Instead, the sediment can be allowed to transport downstream to a designed capture and removal point near the dam. Channel formation and sediment transport would happen rapidly. Therefore, more than 80% of the sediment that gets transported out of the delta could potentially be captured and removed during dam breaching and removal. This option reduces the overall volume of sediment that needs to be removed and facilitates the removal process. Consequently the cost of removal is much lower than Option 2, and is more protective of the Boardman River ecology downstream of the dams. This option is more desirable from an ecological perspective for Brown Bridge Pond than Boardman and Sabin ponds due to the greater potential impact on Segment 6 versus Segment 3 and Boardman Lake. Sediment capture and removal efforts could be focused more so on Brown Bridge Dam than Boardman and Sabin dams to further reduce overall sediment management costs for alternatives involving the removal of all three of those dams. Option 3 is the most cost effective sediment management option. Therefore, it is used when estimating the costs associated with sediment management for each alternative.

Property Boundaries

The issue of the property boundaries around Sabin Pond and Boardman Pond was addressed by a study in 2007 by the law firm of Varnum Riddering Schmidt and Howlett (see Appendix A). The report was based on a review of title abstracts for Boardman Pond and Sabin Pond. The report found that when Boardman Pond and Sabin Pond were constructed the electric company

> "acquired rights to the flooded land either by:
> (i) accruing the fee title to the property;
> (ii) acquiring flowage rights; or
> (iii) by a prescriptive use of flowage over the upstream property for a period of 15 years or longer."

In 1930, the Michigan Public Service Company acquired title to the Emerson's bottomland and the upland portion of the property was retained by the Emerson's. The bottomland property has been conveyed over the years to various properties and the report concluded that Grand Traverse County is the current owner of the fee title interest of the impoundment bottomlands at Sabin and Boardman Pond.

Historic status of dams and power houses

A study of the historical status and character of the dams was performed in 2007 (Commonwealth Cultural Resources Group, 2007). The study found that the dams, powerhouses, and associated structures would not qualify as historic structures. During discussion with the State Historic Preservation Officer (SHPO), there was agreement that the structures would not qualify as historic structures, but there continues to be a concern about cultural resources that may exist on the bottomlands beneath the waters of the impoundments. The SHPO has requested that a survey be conducted of the bottomlands in the event that the decision is made to remove one or more of the impoundments.

Grand Traverse County's Natural Education Reserve

The Grand Traverse County Natural Education Reserve was established by the Grand Traverse County Board of Commissioners in part in order to protect the public trust which should be preserved and protected for future generations. The reserve is over 500 acres in size and includes the land along the Boardman River between Cass and Boardman Roads. The education programs at the reserve concentrate on natural education and include programs for teachers and the public. A popular activity at the reserve is discovery hikes and the following hikes are listed in their brochure:

- A Nocturnal Adventure
- Reptiles and Amphibians
- This Hike is for the Birds
- Stuff in the Sky
- Traverse City Rocks!
- Michigan Mammals
- Creepy Crawlies
- The Wonder of Ponds
- Nature Scavenger Hunt
- Wings and Things
- Ecology of Hickory Meadows
- What Can You Eat in the Woods
- Sugaring for Moths

Economic Conditions

Veritas Economic Consulting (Veritas) was retained to assist in the socioeconomic component of the evaluation of alternatives. The report evaluated Information for conducting a socioeconomic assessment of Boardman River dam management options. The report evaluated information for conducting a socioeconomic assessment of dam management options and suggested directions.

The Veritas study (Bingham, et al., 2008) found that the linkages between the options and the welfare of the citizens of Grand Traverse and Kalkaska counties are complex. The report considered available information and how it could be used to develop the socioeconomic impact model. The modeling approach considered in the report was a structurally calibrated transfer approach. This approach uses established theory to link the dam-management options to human welfare and available data to empirically specify the linkages. For example, changes in recreation activity on the river may be estimated based on findings in other places, transferred to this setting, and calibrated to the specific socioeconomic conditions of the community. This approach can produce useful insights and estimates of the socioeconomic impacts of the options without requiring the substantial resources needed for a de novo analysis. Critical to this approach, however, is the need to ensure the internal consistency of the model.

The envisioned socioeconomic modeling framework requires characterizing area residents in terms of their recreation activities, property ownership, income sources, tax payments, and expenditures. Data are available from governmental and private sources to develop those characterizations for population subgroups of interest.

At the front end of the model are the physical effects of the dam-management options. These effects include the impact of the options on the impoundments and river morphology, on water flow and quality, and on the proximate ecosystems. Each option is mapped into a unique set of physical effects. The literature supports the development of the linkages between these physical effects and the socioeconomic welfare of area residents. For example, there is at least one professionally performed study of the impact of dam removal on property values that can be used to inform this analysis.

The report estimated that a policy simulation model based on the calibrated transfer approach and existing data could be implemented at a reasonable cost. This would include developing the underlying simulation model, using the model to evaluate selected options, and authoring a report that describes the model and its findings. Extensions to this effort would include developing the model to support additional uses or extending it to a state-of-the-art analysis. For example, with appropriate development, potentially including web-enablement, the model could be transferred to the project team or BRDC. In this fashion it can serve multiple roles such as providing an information repository, supporting learning and communication, functioning as an analytical decision-support tool, and informing project data collection activities.

The report divided the river into the segments (Figure 1) described below in order to assess the socioeconomic status of the river.

TABLE 10: BOARDMAN RIVER SEGMENTS

Segment Number	Location	Length (ft)
1	From mouth of Boardman River to Union Street Dam	7,920
2	Boardman Lake	8,448
3	From inlet of Boardman Lake to Sabin Dam	10,560
4	Sabin Pond	3,828
5	Boardman Pond	6,000
6	From inlet of Boardman Pond to Brown Bridge Dam	32,000
7	Brown Bridge Pond	6,336
8	From inlet of Brown Bridge Pond to Forks	
9	North Branch of the Boardman River	
10	South Branch of the Boardman River	

Background on current economic conditions

The Boardman River Valley provides an attractive destination for outdoor recreation. Fishing, canoeing, hiking, and camping account for much of the land use in the valley (Michigan Department of Natural Resources [MDNR] 2007). The Boardman River system offers a variety of fishing experiences. The segment closest to Lake Michigan is stocked with rainbow trout, Chinook salmon, and Coho salmon but also supports warmwater species (ECT 2007). Boardman Lake, because it is proximate to Traverse City, is a popular spot for warmwater fishing. The smaller impoundments are less popular, due in part to more limited fish habitats. Further upstream, portions of the river support self-sustaining populations of brown and brook trout. Currently, upstream portions of the Boardman River are rated as top-quality trout streams by the MDNR. Based on a recent creel study conducted by the Michigan Department of Natural Resources (2005), we estimate that the Boardman River currently supports approximately 21,000 to 33,000 fishing days per season (Bingham et al. 2008). Approximately 80 percent of these days are attributed to residents of Grand Traverse and Kalkaska Counties, while the remainder is attributed to visitors from outside these two counties.

The Boardman River offers both canoeing and kayaking (hereafter, paddling) opportunities to recreators. According to Trails.com (2007), the Boardman is "[a] spirited, attractive stream that flows past conifer forests and north-country cottages before emptying into Grand Traverse Bay. The Boardman ranks as one of the Lower Peninsula's finest rivers for paddling. Possessed of a moderate current and a winding river corridor that passes through a broad valley of cedar, pine, and assorted hardwoods, it also features one of Lower Michigan's rare bursts of light whitewater." Our assessment (Bingham et al. 2008) reveals that recreators spend approximately 5,500 to 17,000 paddling days on the Boardman River in its current condition. Residents of the Grand Traverse and Kalkaska Counties account for approximately 60 percent of these trips while the remainder is attributed to visitors.

The Boardman River enhances the recreation experience for a variety of trail activities, including hiking, walking, biking, and horseback riding. Several segments of the Boardman River support designated trails, particularly around the impoundments. For example, a 2-mile trail surrounds Boardman Lake. Around Sabin and Boardman Ponds, there are many trails, which are part of the Natural Education Reserve managed by the Grand Traverse Conservation District (GTCD 2008). Several of these trails are in the vicinity of the recently opened Boardman River Nature Center. In the river segments farther upstream, portions of the Michigan Shore-to-Shore Riding Trail and the North Country Trail follow the Boardman. We estimate that campers spend approximately 4,000 to 6,500 nights in more than 100 designated campsites along the Boardman River in its current condition, half of which are attributed to residents. Our assessment indicates that trail users spend approximately 90,000 to 177,000 activity days on trails near and along the Boardman River. Residents account for at least 80 percent of the trail activity days (Bingham et al. 2008).

Visitors who recreate on or along the Boardman River contribute nearly $2 million to the local economy through direct expenditures on food, lodging and other trip expenses. Additionally, the spending by recreation visitors accounts for 37 jobs in the two counties and results in a total economic impact of almost $2 million.

The assessment also considers residential properties on or near the Boardman River that may be affected by various dam management scenarios. Based on recent data received from the Grand Traverse County Assessor's Office, there are nearly 4,000 parcels within ½ mile of the Boardman River, which total nearly 7,500 acres. The current assessed value of these parcels exceeds $331 million.

Three of the Boardman River dams have been used for electricity production. All three dams were operational until Consumers Power removed the electric power generation equipment from the Sabin and Boardman dams in 1969. In 1980, TCL&P began operating and maintaining the dams under a leasing arrangement. Between 1987 and 2003 TCL&P generated $4,655,221 of power.

Engineering

During the review of existing conditions, the ECT team evaluated the condition of the dams. As a result of that study, the City of Traverse City hired STS Consultants to conduct a more detailed analysis of the condition of Union St. Dam and Brown Bridge Dam. In addition, Prein and Newhof of the ECT team conducted separate studies of modifications of the Boardman Dam that would bring the dam into compliance with MDEQ regulations. Prein and Newhof also studied the engineering of breaching the dams, including a cost estimate. The results of those studies have been presented to the BRDC and are summarized in the detailed analysis of each alternative (Section 6.0 Alternative 41 and 41A).

6.0 DETAILED ANALYSIS OF THE ALTERNATIVES

INTRODUCTION

The detailed analysis of the alternatives follows the general categories described in the purpose of this report. The key to understanding the impact of any alternative is to understand the hydrology and whether Great Lakes fish are allowed access to the Boardman River. The details of the effects can be traced to changes in the fish population or the hydrology of the impoundments.

While many types of effects vary with each alternative, several categories of effects or impacts were determined to not be significantly changed regardless of the alternative. The following categories of effects will not be significantly impacted:

- Historic status of dams and power houses
- Transportation and infrastructure
- Water supplies and on-site waste water treatment systems
- Property boundaries and rights
- Programs at the County's Natural Education Reserve

ALTERNATIVE 1: RETAIN AND REPAIR THE DAMS

DESCRIPTION OF THE REPAIRS

The dams are inspected on a regular basis and the following repairs have been recommended as a result of those inspections.

Union Street Dam:

- Repair and realign trash racks in Bay #2 of the principal spillway
- Lubricate and exercise all principal spillway gate operator stems.
- Construct a toe drain system on the downstream slope of the embankment near the downstream headwall.
- Construct a toe drain just upstream of the principal spillway outlet headwall.
- Remove trees/ stumps present on the downstream slope of the earthen embankment.
- Repair or reline the discharge culverts.

Sabin Dam:

- Minor concrete spalling on some sections of spillway should be repaired.
- Rodent holes at the downstream slope of the intermediate embankment should be filled.
- Concrete deterioration and spalling were noted on the downstream side of the powerhouse, as reported in the 2006 FERC Operation Report. Spalling at this location should be repaired.
- The roof has been known to leak, per the Traverse City Light and Power Company and a new roof should be installed.
- Deterioration of brick mortar joints and window lintels noted in many locations of the superstructure, along with minor cracks as reported in the 2006 FERC Operation Report should be repaired.
- Corrosion noted on angle brackets at door and window framing should be corrected.

Boardman Dam:

- Cracking of the deck supports and beams were observed. There was also significant spalling and exposed rebar underneath parking deck.
- Roadway guard rails should be repaired or replaced.
- Structural cracking of Cass River Bridge supports should be repaired.
- Downstream "chute" at spillway, seepage is visible at bottom of channel. Investigate and repair, if necessary, the drain pipe beneath the slab.
- Correct erosion of material below the access deck caused by holes drilled through access deck for drainage.
- Repair penstock bay (downstream side of road) cracks and spalling of concrete.
- Correct corrosion of window and door frames
- Repair or replace the roof.
- Correct rodent holes noted on downstream slope of detached embankment

Brown Bridge Dam:

- Prepare an operational procedure plan for the monitoring and operation of Brown Bridge Dam.
- Update the Emergency Action Plan

- Monitor embankment monitoring wells, weirs, reservoir and tailwater levels and precipitation monthly.
- Repair concrete in the spillway structure.
- Remove the concrete support for the log sluice gate hoist. Design a new steel hoist support frame.
- Repair spalling and structural cracking of the concrete was observed at numerous locations in the downstream support piers for the tainter gates.
- Repair the safety railing on the downstream side of the power plant deck.
- Repair the portions of the downstream embankment of the dam that have unsafe slopes.

In 2007, Boardman Pond was lowered in order for the dam to comply with the MDEQ Dam Safety regulations. The dam was lowered as a result of a consent agreement between Grand Traverse County and the MDEQ which specified a number of actions the County was to undertake in order to provide for the safety of the dam and specifically, the safety of the spillway. The water level in the impoundment, which was lowered approximately 16 feet, cannot be raised until the County demonstrates that the dam and spillway are sufficient to meet the MDEQ criteria. The actions described in the repair section would not correct the deficiencies in the spillway as cited by the MDEQ; therefore, repairing the dam would not raise the water level.

ENVIRONMENTAL EFFECTS OF THE REPAIRS

Effects on Terrestrial Habitats and Wetlands

Retaining and repairing the Union Street Dam would not change the water level in the impoundment. Therefore, no change in the acreage of either terrestrial or wetland habitat is anticipated. No new terrestrial habitat and no new wetlands are likely to form as a result of this alternative. The less urbanized uplands surrounding the southern half of Boardman Lake would remain dominated by deciduous, evergreen, and mixed forests. Wetlands within the impoundment would remain dominated by submerged and floating aquatic vegetation. Wetlands near or adjacent to the impoundment would remain dominated by scrub-shrub and emergent vegetation. By keeping the Union Street Dam in place, upstream reaches of the Boardman River and its associated habitats would be protected by inhibiting the upstream migration of sea lamprey and other Great Lakes invasive species. No changes to the quantity or quality of potential king rail or common loon habitat are anticipated.

Implementing Alternative 1 at Sabin Dam would not change the water level in the impoundment. Therefore, no change in the acreage of either terrestrial or wetland habitat is anticipated. No new terrestrial habitat and no new wetlands are likely to form as a result of this alternative. The uplands surrounding Sabin Pond would remain dominated by deciduous, evergreen, and mixed forests. Wetlands within the impoundment would remain dominated by submerged and floating aquatic and emergent vegetation. Wetlands near or adjacent to the impoundment would remain dominated by forested, scrub-shrub, and emergent vegetation.

Implementing Alternative 1 at Boardman Dam would not change the water level in the impoundment from its current elevation, 16 feet below the original impoundment level. It is anticipated that the existing terrestrial habitats surrounding Boardman Pond would remain unchanged and that approximately 21 acres of new upland habitat would form. These additional 21 acres of upland are anticipated to develop 1) along the western and eastern edges of the impoundment, approximately 100 feet from the original impoundment's edge of water and 2) along the northern edge of the impoundment, approximately 75 feet from the original impoundment's edge of water. The upland slope along the western edge of the impoundment is very steep, and uplands along the north and east sides of the pond also have moderately sloping topography. Thus, new uplands are likely to form where open water and submerged and floating aquatic habitats once covered the toe of slope.

Initially, these new upland areas would be seeded by pioneer herbaceous and woody species from adjacent mixed forests. Dominant species might initially include black cherry, red maple, bigtooth and trembling aspen, paper birch, gray dogwood (*Cornus foemina),* staghorn sumac (*Rhus typhina*), autumn olive (*Elaeagnus umbellata*), honeysuckle (*Lonicera* spp.), tall goldenrod (*Solidago altissima*), wild carrot (*Daucus carota)*, and bracken fern. Over time, these upland areas are anticipated to succeed to a mixed northern hardwoods-conifer forest dominated by sugar maple, red maple, eastern white pine, American beech (*Fagus grandifolia*), northern pin oak, northern red oak, and white oak. Depending upon the spread of the emerald ash borer and intensity of white-tailed deer browsing, white ash (*Fraxinus americana*) and eastern hemlock (*Tsuga canadensis*) may also become established at lower densities in the long term.

Since the repairs to Boardman Dam would not address the deficiency in the spillway, the analysis of the impact of repairing the dam is based on the change from the historic water level to the current water level in the Boardman Pond impoundment. Overall, approximately 31 acres of wetland could form in the long term if the water level is maintained at the 2008 water level. As described above, approximately 25 of these 31 acres are new emergent wetlands forming in the northeast corner, east central side, and southern end of the original impoundment. The new emergent wetlands are dominated by blue vervain, nodding bur-marigold, nodding smartweed, rice-cut grass, hardstem bulrush, three-square, and sedges. Over time, it is anticipated that these new emergent wetlands would succeed to forested/scrub-shrub wetlands with dominants such as northern white-cedar, black ash, red maple, tag alder, ninebark, sensitive fern, and marsh shield fern (*Thelypteris palustris*). An additional 6 acres of submerged and floating aquatic wetland are anticipated to form along the west central side of the impoundment, currently occupied by shallow open water. Approximately 11 acres of small forested/scrub-shrub/emergent wetlands directly adjacent to the upstream end of the impoundment may also be impacted by the drawdown. Due to the presence of groundwater seepage as a source of hydrology, it is unlikely that these small wetlands would convert to uplands. Although surface water influences have been reduced as the water elevation was lowered, these wetlands remain connected to the floodplain of the Boardman River and would likely continue to receive surface water inputs from spring flooding. It is likely that these wetlands would shift from emergent/scrub-shrub to a slightly drier species composition with dominance by wetland trees and shrubs.

Considering 1) the gain in wetland acreage with the conversion of open water areas and 2) the increase in species and structural diversity with the conversion of deep aquatic habitats to emergent and ultimately forested/scrub-shrub systems, Alternative 1 would improve the quality of and increase the quantity of wildlife habitat available along this stretch of the Boardman River. A portion of the deep-water habitats would be replaced by submerged aquatic, emergent, and forested/scrub-shrub wetland habitats with varying water depth and higher structural and floral and faunal species diversity.

Alternative 1 (retain and repair the Brown Bridge Dam) would not change the water level in the impoundment. Therefore, no change in the acreage of either terrestrial or wetland habitat is anticipated. No new terrestrial habitat and no new wetlands are likely to form as a result of this alternative. The uplands surrounding Brown Bridge Pond would remain dominated by evergreen and mixed forests. Wetlands within the impoundment would remain dominated by submerged and floating aquatic and emergent vegetation.

Wetlands near or adjacent to the impoundment would remain dominated by forested, scrub-shrub, and emergent vegetation.

Effects on Wildlife Populations

The wildlife populations in the Boardman River impoundments were studied as part of the review of existing and baseline conditions (ECT, 2007).

Repairing and retaining the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on wildlife populations on the Boardman River or the impoundments behind the dams. Stream-carried sediment would continue to collect in the upstream areas and inlets of the impoundments. This would be most noted in upper Brown Bridge and Boardman Pond. Over time, the sediment accumulation would reduce water depths, increase sandbar and shallow water habitats including emergent vegetation habitats dominated by sedges, spike rushes and other aquatic plants. The scrub-shrub habitats in these inlet areas, that currently include willows, tag alder and ninebark, would expand downstream. Wading bird and shorebird use would increase in shallow water and sandbar areas, songbird, small mammal and amphibian use would increase with the expanded emergent vegetation habitat

Repairing and retaining the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on migrant and resident ducks, geese and swans that utilize the submerged wetlands in upper Boardman Lake and the Brown Bridge impoundment. These impoundments provide valuable food resources and sanctuary. The presence of waterfowl in these impoundments provides important recreational and educational opportunities such as waterfowl hunting and wildlife viewing. Repairing the dams would not have a significant impact on these activities.

Sediment accumulation and aging of the dam structures would increase the potential for significant losses to downstream fish and wildlife habitats and populations, if a dam would fail and release the accumulated sediment into downstream habitats.

Retaining the dams -- lost opportunities for river restoration

By retaining the dams, the positive impacts from dam removal would be lost by not restoring and reconnecting riparian and wetland habitats along the river. The restoration of riparian and wetland habitats is a positive impact because these habitats are two of the most valuable habitat types found in the northern Michigan because of the large number of plants and animals they support. Many songbird species such as the black and white warbler, northern water thrush, cardinal, catbird, and many small mammals including the meadow vole, meadow jumping mouse and short-tailed shrew are more abundant in the moist, diverse habitats similar to those that would be created following dam removal.

Removing the dams would restore the historic, contiguous riparian habitats along the river corridor, benefiting species like the wood turtle (a state threatened species), river otter, mink, bobcat, bear, the white-tailed deer, pine marten, ruffed grouse and red-shouldered hawk (a state threatened species)

Retaining the dams – reducing the threat of chemical contamination and introducing invasive species and pathogens.

The dams on the Boardman restrict fish passage and protect the watershed above Sabin Pond from the introduction of chemical contaminants found in fish from Lake Michigan and Boardman Lake.

Chemical contaminants found in some Great Lakes fish species that could present a threat to certain wildlife species include PCB, DDT metabolites and other chlorinated hydrocarbons. Wildlife species vulnerable to chemical contaminants that could be impacted by chemical contaminants in Great Lakes fish include, but are not limited to, mink, otters, gulls, bald eagles, and snapping turtles.

The dams limit access by non-native species such as the European crayfish, round gobies, ruff, sea lamprey, steelhead trout, and salmon.

Effects on Fisheries

Alternative 1 would not change any of the existing fisheries or fisheries habitat in the Boardman River. The dams have various negative impacts on the Boardman River and West Arm Grand Traverse Bay fisheries. Therefore, retaining the dams maintains the reduced overall productivity of the Boardman River and does not realize the potential for increased natural reproduction of steelhead, salmon, and other Great Lakes diadromous fish species (e.g., lake sturgeon). The existing fish ladder at Union Street Dam connects Segment 1 to Segment 3 (Figure 2) for steelhead, Chinook salmon, and coho salmon. Warm and cool water fish cannot pass the Union Street Dam via the existing fish ladder. Most Chinook and coho salmon are blocked at the MDNR harvest weir during the fall run. Some salmon that run before and after the weir is in operation are able to pass Union Street Dam and access Segment 3 up to Sabin Dam. All steelhead are allowed to run up river during the winter and spring spawning runs. Spawning habitat is limited in Segment 3, but some natural reproduction of salmon and steelhead may be occurring. Overall, the limited natural reproduction of steelhead and salmon that may be occurring in Segment 3 probably does not contribute to the sport fishery in the Boardman River or West Arm of Grand Traverse Bay. Those anadromous salmonid sport fisheries are entirely supported by current fish stocking and would be maintained at their current levels as long as stocking continues. During 2005 MDNR creel surveys, shore anglers caught 339 Chinook salmon (0.02/hour), 94 coho salmon (0.01/hour), and 2,302 steelhead (0.15/hour, reported as 'rainbow trout') between Sabin Dam and the West Arm Grand Traverse Bay, including harvest and catch-and-release statistics.

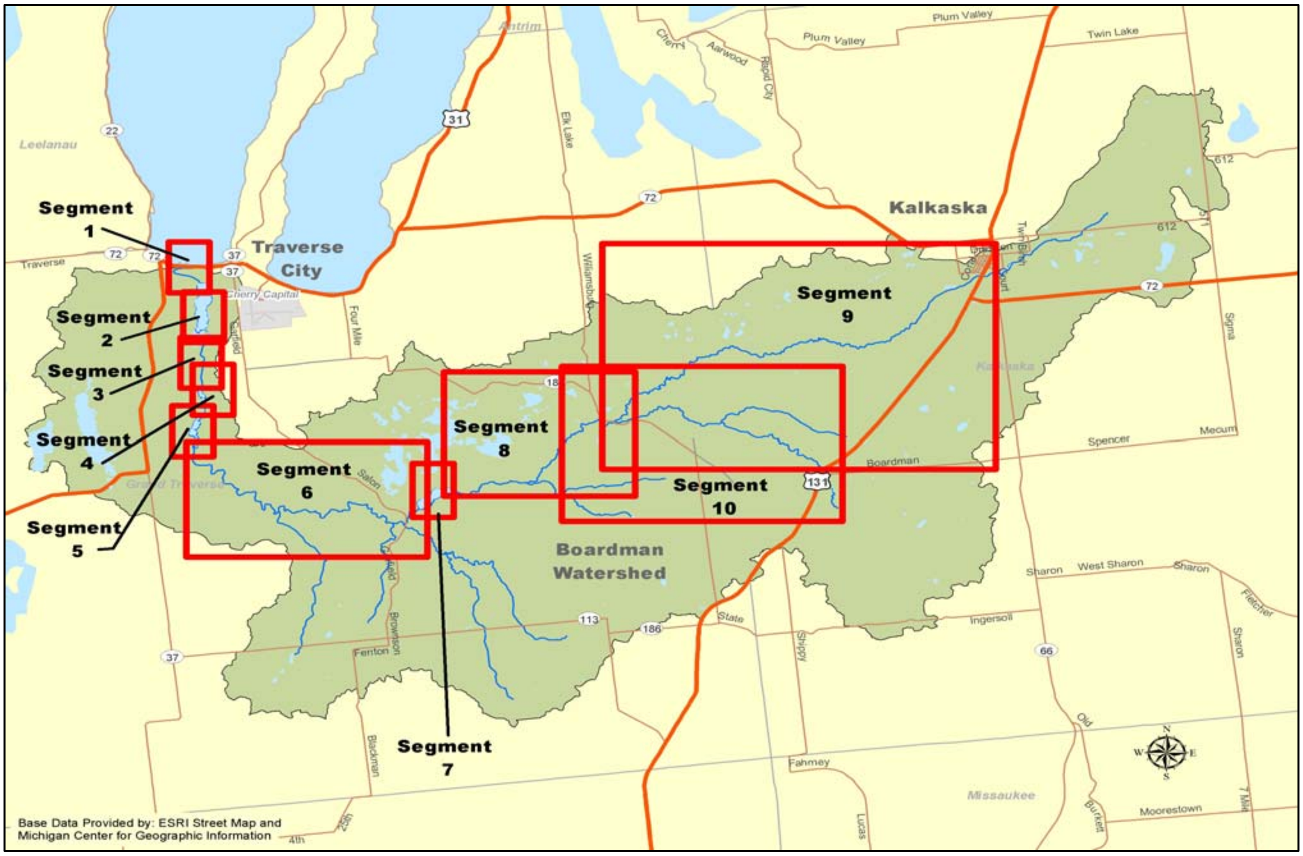

Figure 2. Location of Segments 1–10 Along the Boardman River

Segment 1 – Union Street Dam to West Arm Grand Traverse Bay

The existing second quality cold water and mixed warm/cool water fisheries in Segment 1 would not change. Both of these fisheries are limited by physical habitat alteration, warm-water discharge from Union Street Dam, and low natural reproduction. Existing sea lamprey management would not be impacted.

Segment 2 – Boardman Lake

While salmon and steelhead are able to pass the Union Street Dam and enter Boardman Lake, they do not appear to be targeted by fishermen fishing from boats on Boardman Lake. Creel data collected by the MDNR in 2005 indicate that all salmon and steelhead caught between Sabin Dam and the West Arm Grand Traverse Bay are caught by shore anglers. This fishery condition would not change under Alternative 1.

Segment 3 – Sabin Dam to Boardman Lake

The numbers of salmon and steelhead present in Segment 3 is limited to adult fish during spawning runs and juveniles from limited natural reproduction. The numbers of salmon and steelhead are dependent upon the number of salmon and steelhead passing the Union Street Dam indirectly and MDNR fish stocking directly. The anadromous salmonid sport fishery in Segment 3 is entirely supported by fish stocking and would be maintained at the current level as long as stocking continues in Segment 1.

Segments 4 Through 10 – Sabin Pond (Sabin Dam) to Headwaters

Anadromous salmonids would not be able to pass Sabin Dam under Alternative 1. Therefore, the fisheries upstream of Sabin Dam would not change. The existing impoundments, warm water fisheries, and cold water fisheries would be maintained in their current condition.

Sediment

Retaining and repairing all of the dams would have no impact on existing sediment stored in the impoundments of Sabin, Boardman, and Brown Bridge dams. The existing stored sediments in the impoundments contain levels of some contaminants above applicable state and federal criteria. These contaminated sediments would remain in the impoundments and not be mobilized unless a dam were to fail. In the case of a dam failure, there would be a catastrophic release of sediment stored in the impoundment downstream. The dams currently disrupt natural sediment transport throughout the Boardman River mainstem. Sediment starvation influences fisheries habitat and channel geomorphology downstream of the dams. Dam repairs do not mitigate the altered sediment transport regime.

Stream channel morphology

The repairs to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on stream channel morphology.

Threatened and endangered species

The repairs to the Union Street Dam would not have a significant impact on threatened or endangered species. No changes to the quantity or quality of potential wood turtle or Blanding's turtle habitat at Sabin Pond are anticipated if Sabin Dam is repaired. Alternative 1 will not have an adverse impact on the common loon, the threatened red-shouldered hawk, the wood turtle, Blanding's turtle, and bald eagle . The drawdown of Boardman Pond could increase the habitat for these species resulting in an increase in the population. Repairing Brown Bridge Dam would not change the quantity or quality of common loon, bald eagle, red-shouldered hawk, trumpeter swan, wood turtle, or Blanding's turtle habitat.

Water quality

The repairs to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on water quality. The adverse impact to the Boardman River caused by warm water discharge from Brown Bridge Pond would continue.

Ground water

The repairs to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on ground water resources.

ENGINEERING IMPACTS

Transportation and infrastructure

The repairs to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on transportation and infrastructure. There are utilities located at the Union Street Dam, but the repairs would not impact the utilities.

Hydrology and hydraulics

The repairs to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on hydrology and hydraulics of the Boardman River in the vicinity of the dams.

Flood plain changes
The repairs to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on flood plains on the impoundments and lakes because the repairs would not change the water levels in the impoundments or lakes.

Stream bank stabilization
The repairs to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on stream banks and would not require additional stream bank stabilization efforts because the repairs would not change the water level in the lakes or flow patterns in the river.
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Water supplies and on-site waste water treatment systems
The repairs to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on water supplies and on-site wastewater treatment systems
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SOCIETAL IMPACTS
Recreational uses
The repairs to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on recreation uses of Boardman Lake or Boardman River.

Property boundaries and rights
The repairs to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on property boundaries or property rights.

Risks to property owners
The repairs to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on risks to property owners and may alleviate some risks as a result of the repairs made to the dams.

Historic status of dams and power houses
The repairs to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on historic or cultural resources in the vicinity of the dams.

Impact of changing fishery
The repairs to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on the fishery of the Boardman River.

Impact on County's Natural Education Reserve
The repairs to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on the County's Natural Education Reserve.

ECONOMIC IMPACTS
Property values
The repairs to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on property values within ½ mile of the dam.

Cost of the repairs
The annual maintenance of the dams is estimated to be as follows:

Union Street = $30,000-50,000
Sabin Dam = $30,000-60,000
Boardman Dam = $30,000-60,000
Brown Bridge Dam = $30,000-60,000
The estimate to maintain the dams was obtained from County employees who currently maintain the dams.

The estimated cost of repairing the dams is shown in Table 9.

TABLE 11: PROBABLE CONSTRUCTION COST ESTIMATES FOR REPAIRING THE DAMS.

Dam	Low Cost Estimate	High Cost Estimate
Union Street Repairs	$430,000	$650,000
Sabin Dam Repairs	$130,000	$260,000
Boardman Dam Repairs	$130,000	$360,000
Brown Bridge Dam Repairs	$380,000	$1,360,000
Alt.1 Total repair	$1,070,000	$2,630,000

These estimates were developed by STS in their study of Union Street and Brown Bridge Dam (STS, 2008) and by the ECT team for Sabin and Boardman Dam as part of the detailed analysis of alternatives for the dams. A detailed summary of the cost estimates in provided in Appendix D.

Property tax implications

The repairs to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam could have an impact on property taxes if that is the source of funds used to implement the repairs. However, there are numerous options for funding the repairs and a decision as to the source of funding has not been made at this time.

Jobs

The repairs would create local construction jobs.

Hydroelectricity

The repairs to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not be sufficient to allow electricity to be generated at the dams. There are additional actions and modifications that would need to be made to generate electricity at the dams. Alternative 41 describes the actions and modifications that are anticipated in order to allow electricity to be generated at the dams.

ALTERNATIVE 25: RETAIN AND REPAIR UNION STREET AND BROWN BRIDGE AND REMOVE SABIN AND BOARDMAN DAMS

DESCRIPTION OF THE ALTERNATIVE

The dams are inspected on a regular basis and the following repairs have been recommended as a result of those inspections.

Union Street Dam:

- Repair and realign trash racks in Bay #2 of the principal spillway
- Lubricate and exercise all principal spillway gate operator stems.
- Construct a toe drain system on the downstream slope of the embankment near the downstream headwall.
- Construct a toe drain just upstream of the principal spillway outlet headwall.
- Remove trees/ stumps present on the downstream slope of the earthen embankment.
- Repair or reline the discharge culverts.

Brown Bridge Dam:

- Prepare an operational procedure plan for the monitoring and operation of Brown Bridge Dam.
- Update the Emergency Action Plan
- Monitor embankment monitoring wells, weirs, reservoir and tailwater levels and precipitation monthly.
- Repair concrete in the spillway structure.
- Remove the concrete support for the log sluice gate hoist. Design a new steel hoist support frame.
- Repair spalling and structural cracking of the concrete was observed at numerous locations in the downstream support piers for the tainter gates.
- Repair the safety railing on the downstream side of the power plant deck.
- Repair the portions of the downstream embankment of the dam that have unsafe slopes.

Sabin Dam and Boardman Dam would be removed by removing the dam under different scenarios. The first scenario is a partial removal of the dam by breaching the dam and allowing the water in the impoundment to drop to a point where only the Boardman River exists and the impoundment has been removed. The second scenario would breach the dam and the power houses, spillway and earthen embankment would be completely removed after the impoundment has been drained.

ENVIRONMENTAL EFFECTS OF ALTERNATIVE 25

Effects on Terrestrial Habitats and Wetlands

Retaining and repairing the Union Street Dam would not change the water level in the impoundment. Therefore, no change in the acreage of either terrestrial or wetland habitat is anticipated. No new terrestrial habitat and no new wetlands are likely to form as a result of this alternative. The less urbanized uplands surrounding the southern half of Boardman Lake would remain dominated by deciduous, evergreen, and mixed forests. Wetlands within the impoundment would remain dominated by submerged and floating aquatic vegetation. Wetlands near or adjacent to the impoundment would remain dominated by scrub-shrub and emergent vegetation. By keeping the Union Street Dam in place, upstream reaches of the Boardman River and its associated habitats would be protected by inhibiting the upstream migration of sea lamprey and other Great Lakes invasive species. No changes to the quantity or quality of potential king rail or common loon habitat are anticipated.

Alternative 25 (retain and repair the Brown Bridge Dam) would not change the water level in the impoundment. Therefore, no change in the acreage of either terrestrial or wetland habitat is anticipated. No new terrestrial habitat and no new wetlands are likely to form as a result of this alternative. The uplands surrounding Brown Bridge Pond would remain dominated by evergreen and mixed forests. Wetlands within the impoundment would remain dominated by submerged and floating aquatic and emergent vegetation. Wetlands near or adjacent to the impoundment would remain dominated by forested, scrub-shrub, and emergent vegetation.

Removing Sabin Pond would decrease water levels in the pond and both wetland acreage and type would change within the former Sabin Pond impoundment. Overall, approximately 28 acres of wetland are anticipated to form following drawdown of the impoundment. As described above, less than half of the submerged/floating/emergent wetlands located within the impoundment over the toe of slope are likely to form uplands. However, over half of these low diversity submerged/floating/emergent wetlands are anticipated to succeed to emergent wetlands initially. New emergent wetlands would likely be dominated by a more diverse set of wetland species, including blue vervain (*Verbena hastata*), swamp milkweed (*Asclepias incarnata*), common cattail (*Typha spp.*), black bulrush (*Scirpus atrovirens*), hardstem bulrush, spotted joe pye weed, jewelweed, common boneset (*Eupatorium perfoliatum*), sensitive fern (*Onoclea sensibilis*), and beggar-ticks (*Bidens* spp.). Over time, it is anticipated that these new emergent wetlands would succeed to approximately 5 acres of forested/scrub-shrub wetlands with dominants such as northern white-cedar, red maple, common elder, and marsh shield fern. Several small forested/scrub-shrub/emergent wetlands directly adjacent to the west side of the impoundment may also be impacted by the drawdown. Due to the presence of groundwater seepage as a source of hydrology, it is unlikely that these small wetlands would convert to uplands following drawdown. When surface water influences are removed as the water elevation is lowered, it is more likely that these wetlands would shift from emergent/scrub-shrub to a slightly drier species composition with dominance by wetland trees and shrubs.

Throughout the central portion of the impoundment directly adjacent to the newly formed river channel, it is anticipated that approximately 23 acres of open water would be converted to and remain emergent/scrub-shrub wetland. These permanently emergent/scrub-shrub portions would be similar in structure and composition to areas found elsewhere along the Boardman River and likely be dominated by common elder, silky dogwood (*Cornus amomum*), red-osier dogwood (*Cornus sericea*), sandbar willow (*Salix exigua*), tag alder (*Alnus rugosa*), blue vervain, swamp milkweed, spotted joe pye weed, common boneset, common cattail, black bulrush, sedges (*Carex* spp.), hardstem bulrush, and burreed (*Sparganium* spp.).

Considering 1) the gain in wetland acreage with the conversion of open water areas and 2) the increase in species and structural diversity with the conversion of deep aquatic habitats to emergent and ultimately forested/scrub-shrub systems, partial or total removal of Sabin Dam would improve the quality of and increase the quantity of wildlife habitat available along this stretch of the Boardman River. Deep-water habitats would be replaced by flowing riparian habitats with varying water depth and higher structural and floral and faunal species diversity.

As a result of the decrease in water elevation, it is anticipated that both wetland acreage and type would change within the Boardman Pond impoundment. Overall, approximately 69 acres of wetland are anticipated to form in the long term. Approximately 25 of these 69 acres are new emergent wetlands that would form in the northeast corner, east central side, and southern end of the original impoundment. Approximately 11 acres of additional emergent wetland is also expected to form along the west and east central sides of the impoundment currently covered in shallow open water. The new emergent wetlands would be dominated by blue vervain, nodding bur-marigold, nodding smartweed, rice-cut grass, hardstem bulrush, three-square, and sedges. Over time and as the water level in the impoundment is completely lowered, it is anticipated that these new emergent wetlands would succeed to forested/scrub-shrub wetlands with dominants such as northern white-cedar, black ash, red maple, tag alder, ninebark, sensitive fern, and marsh shield fern (*Thelypteris palustris*). Approximately 11 acres of small forested/scrub-shrub/emergent wetlands directly adjacent to the upstream end of the impoundment may also be impacted by the drawdown. Due to the presence of groundwater seepage as a source of hydrology, it is unlikely that these small wetlands would convert to uplands following drawdown. Although surface water influences would be reduced as the water elevation is lowered, these wetlands would likely remain connected to the floodplain of the Boardman River and would likely continue to receive surface water inputs from spring flooding. It is likely that these wetlands would shift from emergent/scrub-shrub to a slightly drier species composition with dominance by wetland trees and shrubs.

Throughout the central portion of the existing impoundment directly adjacent to the newly formed river channel, it is anticipated that approximately 33 acres of open water would be converted to and remain emergent/scrub-shrub wetland. These permanently emergent/scrub-shrub portions would be similar in structure and composition to areas found elsewhere along the Boardman River and likely be dominated by tag alder (*Alnus rugosa*), common elder (*Sambucus canadensis*), silky dogwood (*Cornus amomum*), red-osier dogwood (*Cornus sericea*), sandbar willow (*Salix exigua*), ninebark, blue vervain, nodding bur-marigold, rice-cut grass, swamp milkweed (*Asclepias incarnata*), spotted joe pye weed, common boneset, common cattail, black bulrush (*Scirpus atrovirens*), sedges (*Carex* spp.), hardstem bulrush, and burreed (*Sparganium* spp.).

Considering 1) the gain in wetland acreage with the conversion of open water areas and 2) the increase in species and structural diversity with the conversion of deep aquatic habitats to emergent and ultimately forested/scrub-shrub systems, a partial or total removal of the dam would improve the quality of and increase the quantity of wildlife habitat available along this stretch of the Boardman River. Deep-water habitats would be replaced by flowing, riparian habitats with varying water depth and higher structural and floral and faunal species diversity.

Effects of Repairing and Retaining the Dams on Wildlife

The wildlife populations in the Boardman River impoundments were studied as part of the review of existing and baseline conditions (ECT, 2007).

Repairing and retaining the Union Street Dam and Brown Bridge Dam would not have a significant impact on wildlife populations on the Boardman River or the impoundments behind the dams. Stream-carried sediment would continue to collect in the upstream areas and inlets of the impoundments. This would be most noted in upper Brown Bridge Pond. Over time, the sediment accumulation would reduce water depths, increase sandbar and shallow water habitats including emergent vegetation habitats dominated by sedges, spike rushes and other aquatic plants. The scrub-shrub habitats in these inlet areas, that currently include willows, tag alder and ninebark, would expand downstream. Wading bird and shorebird use would increase in shallow water and sandbar areas, songbird, small mammal and amphibian use would increase with the expanded emergent vegetation habitat

Repairing and retaining the Union Street Dam and Brown Bridge Dam would not have a significant impact on migrant and resident ducks, geese and swans that utilize the submerged wetlands in upper Boardman Lake and the Brown Bridge impoundment. These impoundments provide valuable food resources and sanctuary. The presence of waterfowl in these impoundments provides important recreational and educational opportunities such as waterfowl hunting and wildlife viewing. Repairing the dams would not have a significant impact on these activities.

Retaining/repairing the Union Street Dam and Brown Bridge Dam would help conserve, and may expand the floating and submergent wetland habitats along shorelines and shallow water areas. These habitats tend to be rich in aquatic plant life and provide important habitat to aquatic insects and other invertebrates which in turn nurture fish, turtles, toads and frogs, waterfowl and wading birds within the impoundments, as well as songbirds that use adjacent uplands.

Sediment accumulation and aging of the dam structures would increase the potential for significant losses to downstream fish and wildlife habitats and populations, if a dam would fail and release the accumulated sediment into downstream habitats.

Retaining the dams -- lost opportunities for river restoration

By retaining the dams, the positive impacts from dam removal would be lost by not restoring and reconnecting riparian and wetland habitats along the river. The restoration of riparian and wetland habitats is a positive impact because these habitats are two of the most valuable habitat types found in the northern Michigan because of the large number of plants and animals they support. Many songbird species such as the black and white warbler, northern water thrush, cardinal, catbird, and many small mammals including the meadow vole, meadow jumping mouse and short-tailed shrew are more abundant in the moist, diverse habitats similar to those that would be created following dam removal.

Retaining the dams – reducing the threat of chemical contamination and introducing invasive species and pathogens.

The dams on the Boardman restrict fish passage and protect the watershed above Sabin Pond from the introduction of chemical contaminants found in fish from Lake Michigan and Boardman Lake.

Chemical contaminants found in some Great Lakes fish species that could present a threat to certain wildlife species include PCB, DDT metabolites and other chlorinated hydrocarbons. Wildlife species vulnerable to chemical contaminants that could be impacted by chemical contaminants in Great Lakes fish include, but are not limited to, mink, otters, gulls, bald eagles, and snapping turtles.

The dams limit access by non-native species such as the European crayfish, round gobies, ruff, sea lamprey, steelhead trout, and salmon.

Partial or total removal of Sabin Dam and Boardman Pond Dam would have a variety of effects on the existing wildlife populations in the Sabin Pond, Boardman Pond, and Brown Bridge Dam as summarized in Table 10.

TABLE 12: EFFECTS OF ALTERNATIVE 25 ON WILDLIFE POPULATIONS

Wildlife Species or Group	Change	Location
Leopard Frog*	Potential for increase in population	Sabin Pond and Boardman Pond
Green Frog	Potential for increase in population	Sabin Pond and Boardman Pond
Spring Peeper	Potential for increase in population	Sabin Pond and Boardman Pond
American Toad	Potential for increase in population	Sabin Pond and Boardman Pond
Salamanders	Potential for increase in population	Sabin Pond and Boardman Pond
Blanding's Turtle	Potential for increase in population	Sabin Pond and Boardman Pond
Wood Turtle	Potential for increase in population	Sabin Pond and Boardman Pond
Snapping Turtle	Potential for decrease in population due to contaminants in Great Lakes fish	Sabin Pond and Boardman Pond
Painted Turtle	Potential for decrease in population due to loss of habitat	Sabin Pond and Boardman Pond
Trumpeter Swan	Breeding pair may remain in Brown Bridge Pond.	Brown Bridge Pond
Bald Eagle	Breeding pair unlikely to abandon their territory	Brown Bridge Pond
Common Loon	Breeding pairs would abandon Boardman Pond due to loss of habitat and may relocate to a different site	Boardman Pond
Bald eagle, common loon, merganser, great blue heron, kingfisher, terns, and gulls	Contaminant levels of PCB and DDT in some Great Lakes fish are above the "no effect" level for wildlife. If toxic contaminants don't have adverse effects, then populations could be expected to increase.	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Waterfowl migrations	Waterfowl would be displaced due to loss of habitat	Sabin Pond and Boardman Pond
Ruffed Grouse & woodcock	Potential for increase in population	Sabin Pond and Boardman Pond
Song birds	Potential for increase in population of many species due to increase in habitat and important conservation species would gain such as Golden-winged warbler and others	Sabin Pond and Boardman Pond
Mink , marten & otter	Contaminant levels of PCB and DDT in some Great Lakes fish are above the "no effect" level for wildlife. If toxic contaminants don't have adverse effects, then populations could be expected to increase.	Sabin Pond and Boardman Pond
Beaver	Potential for increase in population	Sabin Pond and Boardman Pond
Muskrat	Potential for increase in population	Sabin Pond and Boardman Pond
White-tailed Deer	Potential for increase in population	Sabin Pond and Boardman Pond
Bobcat, fox, and coyote	Potential for increase in population	Sabin Pond and Boardman Pond
Short-tailed Shrew	Potential for increase in population	Sabin Pond and Boardman Pond
Meadow Jumping mouse	Potential for increase in population	Sabin Pond and Boardman Pond
Water shrew	Contaminant levels of PCB and DDT in some Great Lakes fish are above the "no effect" level for wildlife. If toxic contaminants don't have adverse effects, then populations could be expected to increase.	Sabin Pond and Boardman Pond
White-footed Mouse	Potential for increase in population	Sabin Pond and Boardman Pond

One change would be to increase habitat diversity and, hence, wildlife species diversity in the new habitat created after the drawdown. In addition, the removal, whether partial or total, would reconnect riverine habitats fragmented by the Sabin impoundment and Boardman Pond benefiting species such as the wood turtle, mink, river otter, bobcat, bear, and white-tailed deer and many others.

In the study of newly exposed habitat on Boardman Pond, ECT (2007) determined that numerous species of wildlife were using the newly exposed bottomlands. Their study reported that meadow voles were found in good numbers in the newly created lush herbaceous habitat on the recently exposed bottomlands at Boardman Pond, indicating their quick response and adaptability to these habitat changes caused by the emergency drawdown. Based on these data it is likely that the exposed bottomlands would be used as new habitat by 39 species of mammals, 77 species of songbirds, wading birds, amphibians, snakes, lizards and waterfowl.

The drawdown of Sabin Pond would replace a 40 acre impoundment and the drawdown of Boardman Pond would replace a 103 acre impoundment of still-water habitat conditions with a river, thus reducing loafing and foraging habitat for migrating and resident waterfowl. Boardman Lake and many other areas are suitable alternative loafing sites, but the waterfowl that currently use Sabin Pond and Boardman Pond would relocate to other areas. Habitat for painted and snapping turtles would be replaced with habitat for other reptiles, amphibians, small mammals and song birds.

Effects on Fisheries

Under the existing conditions, the longest free flowing river segment is 13.8 miles (Segment 6). The remainder of the river is fragmented into smaller segments by the dams and their impoundments. The removal of Sabin and Boardman dams would create 17.9 miles of free flowing river upstream of Boardman Lake, including 1.9 miles of new stream channel in their former impoundments. Alternative 25 directly alters the existing habitat and fisheries in Segments 4 and 5. The impoundment habitats and warm water fisheries of Sabin (Segment 4) and Boardman (Segment 5) (Figure 3) ponds would be replaced with riverine habitat and cold water fisheries. Indirectly, Alternative 25 also has a positive effect on the existing top quality cold water fisheries in Segments 1 and 6 due to reconnection of fragmented river habitat, elimination of dam and impoundment impacts, and an increase in overall productivity. The existing fish ladder at Union Street Dam would allow salmon and steelhead to gain access to all 17.9 miles of free flowing stream channel upstream of Boardman Lake to Brown Bridge Dam, versus only 2.2 miles under existing conditions (Segment 3). Anadromous salmonids would not be able to pass Brown Bridge Dam. Therefore, the habitat and top quality cold water fishery upstream of Brown Bridge Pond would not change. The existing warm water fishery of Brown Bridge Pond would also be maintained along with its effects on the river. Sea lamprey would not be able to p[ass the Union Street Dam. Therefore, current sea lamprey control strategies and costs would not be affected. However, sturgeon and other desirable cool water species would not be able to access spawning habitat upstream of Boardman Lake.

Overall, removal of the Sabin and Boardman dams would benefit resident brown and brook trout below Brown Bridge Dam. Brown Bridge Dam would still have negative effects on one to two miles of stream downstream due to elevated water temperature. Resident trout abundance should increase throughout the free flowing river above Boardman Lake upstream to Brown Bridge Dam to levels similar to that of Segment 6 with a decrease in overall fish diversity minus the influence of the impoundments. Although there is the potential for some level of competitive interaction between anadromous salmonids and resident trout, competition is not expected to decrease existing resident trout abundance.

Due to a significant increase in the length of river accessible to salmon and steelhead, natural salmon and steelhead reproduction would increase in the Boardman River. Natural reproduction in the 17.9 miles of free flowing river upstream of Boardman Lake to Brown Bridge Dam could produce 350 adult Chinook salmon, 300 adult coho salmon, and 1,300 adult steelhead in addition to existing runs. Adult salmon and steelhead would be distributed throughout the Boardman River during spawning runs up to Brown Bridge

Dam, creating a new shore fishery during fall and spring runs upstream of Sabin Dam. The anadromous salmonid fisheries, particularly salmon, would result in dead fish carcasses and increased fishing pressure that have associated negative social perceptions among the general public, riparian landowners, and outdoor enthusiasts. Salmon and steelhead abundance would decrease moving upstream due to attrition from fish passage efficiencies less than 100% at Union Street Dam and through Boardman Lake, natural mortality, harvest, and spawning habitat distribution.

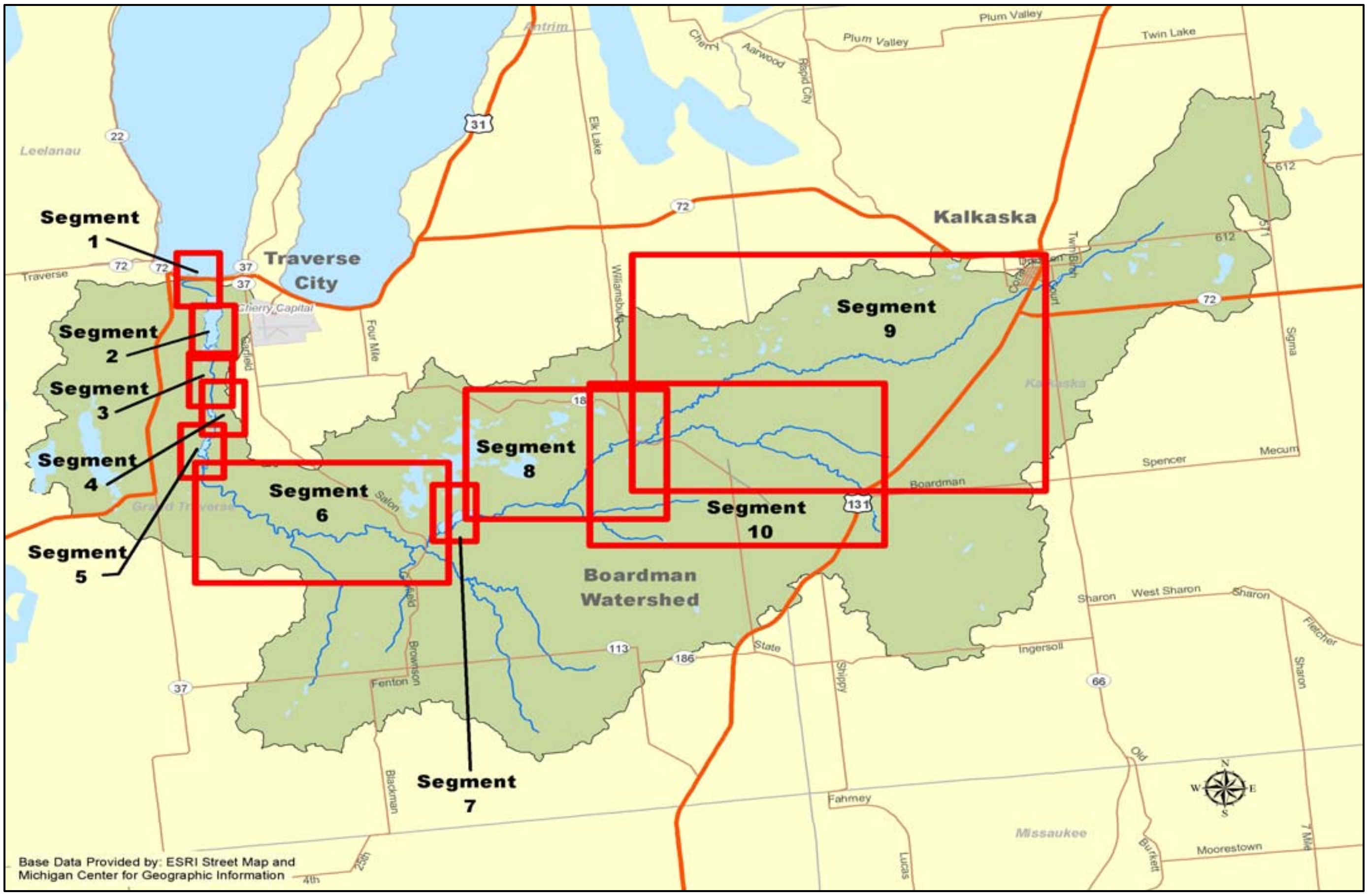

Figure 3. Location of Segments 1–10 Along the Boardman River

Changes specific to certain river segments are discussed in detail below.

<u>Segment 1 – Union Street Dam to West Arm Grand Traverse Bay</u>

The physical channel conditions and fish habitat in Segment 1 would not change. Segment 1 would be connected to 17.9 miles of free flowing river upstream of Boardman Lake to Brown Bridge Dam via the existing fish ladder. The existing salmon and steelhead fisheries would benefit from increased natural reproduction, resulting in higher abundance of adult fish during spawning migrations and higher angler catch rates. Otherwise, the existing second quality cold water and mixed warm/cool water fisheries in Segment 1 would not change. Both of these fisheries are limited by physical habitat alteration, warm-water discharge from Union Street Dam, and low natural reproduction within Segment 1. Existing sea lamprey management would not be impacted.

Segment 2 – Boardman Lake

While the number of salmon and steelhead passing the Union Street Dam and entering Boardman Lake would increase, it is not likely that a significant boat fishery would result. Creel data collected by the MDNR in 2005 indicate that all salmon and steelhead caught between Sabin Dam and the West Arm Grand Traverse Bay are currently caught by shore anglers. This fishery condition is not expected to change under Alternative 25.

Segment 3 – Sabin Dam to Boardman Lake

Under Alternative 25, Segment 3 would be connected to 15.7 miles of free flowing river upstream to Brown Bridge Dam. Due to upstream dam removal and associated transport of sediment downstream, the habitat in Segment 3 would change over time, with an expected decrease in average depth, decrease in pool habitat, and increase in riffle and run bed forms. Brown trout are currently present in low numbers, but are larger and of older age than Segments 6 and 8. Good adult habitat is present, but spawning habitat is limited. With connection to 15.7 miles of free flowing river upstream and changes in habitat, the abundance of earlier age classes of brown trout would likely increase. The resident trout abundance and age structure would become more similar to high quality sites in Segment 6. The existing salmon and steelhead fisheries would benefit from increased natural reproduction, resulting in higher abundance of adult fish during spawning migrations and higher angler catch rates. Sea lamprey would not be able to reach Segment 3.

Segment 4 – Sabin Pond (Sabin Dam)

The existing impoundment would be replaced with 0.7 miles of new stream channel. Segment 4 would be connected to 2.2 miles of free flowing river downstream (Segment 3) and 15.0 miles of free flowing river upstream (Segments 5 and 6) to Brown Bridge Dam. The existing warm water fishery would be replaced with a top quality cold water fishery with trout densities similar to that of Segment 6. The poor survival of older age classes of brown and brook trout present in Segment 6 may be replicated in Segment 4. The presence of salmon and steelhead would create a new anadromous shore fishery. The anadromous salmonid fisheries, particularly salmon, would result in dead fish carcasses and increased fishing pressure that have associated negative social perceptions among the general public, riparian landowners, and outdoor enthusiasts. Sea lamprey would not be able to reach Segment 4.

Segment 5 – Boardman Pond (Boardman Dam)

The existing impoundment would be replaced by 1.2 miles of new stream channel. Segment 5 would be connected to 2.9 miles of free flowing river downstream (Segments 3 and 4) and 13.8 miles of free flowing river upstream (Segment 6) to Brown Bridge Dam. The existing warm water fishery would be replaced with a top quality cold water fishery with trout densities similar to that of Segment 6. The poor survival of older age classes of brown and brook trout present in Segment 6 may be replicated in Segment 5. The presence of salmon and steelhead would create a new anadromous salmonid shore fishery. The anadromous salmonid fisheries, particularly salmon, would result in dead fish carcasses and increased fishing pressure that have associated negative social perceptions among the general public, riparian landowners, and outdoor enthusiasts. Sea lamprey would not be able to reach Segment 5.

Segment 6 – Brown Bridge Dam to Boardman Pond (Boardman Dam)

Segment 6 would be connected to 4.1 miles of free flowing river downstream (Segments 3, 4, and 5). The existing top quality cold water fishery would benefit from overall increased productivity of the larger free flowing river segment. Resident trout abundance may increase. The presence of salmon and steelhead would create a new anadromous salmonid shore fishery. The anadromous salmonid fisheries, particularly salmon, would result in dead fish carcasses and increased fishing pressure that have associated negative social perceptions among the general public, riparian landowners, and outdoor enthusiasts. Sea lamprey would not be able to reach Segment 6.

Segments 7 Through 10 – Brown Bridge Dam to Headwaters

Anadromous salmonids would not be able to pass Brown Bridge Dam. Therefore, the existing warm water fishery in Brown Bridge Pond (Segment 7) and top quality cold water fisheries in Segments 8, 9, and 10, would be maintained in their current state.

Sediment

The repairs to the Union Street Dam and Brown Bridge Dam would not have a significant impact on sediment quality or transport. Sediment would continue to accumulate in the impoundments reducing deep water habitat and creating shallow water and wetland habitat.

The stored sediment volume in Sabin Pond is relatively low, so Option 3 (collection and removal of sediment) could be implemented and a controlled sediment management program could be implemented. The initial sediment chemistry data indicates that the sediment is contaminated with heavy metals. However, there are reasons to consider Option 1 (release of sediment from the impoundment) and to explore the nature and extent of sediment contamination in the impoundment. Prior to implementing Option 1 sediment chemistry would need to be submitted to the MDEQ and approval given that the sediment does not pose a threat to the aquatic environment.

Removing Sabin and Boardman dams would result in transport of sediments from their respective deltas or depositional areas. For this alternative, Options 1 and 3 could be acceptable methods of managing transported sediment. If Option 1 is chosen, then sequenced breaching/removal is recommended starting with Boardman. Breaching or removing Boardman Dam first would allow sediment in Boardman Pond to be stored in Sabin Pond (Option 1). This sequencing and sediment management approach would reduce the overall quantity of sediment that needs to be managed between Boardman and Sabin dams. Sediment capture and removal could then be performed during breaching/removal of Sabin Dam only (Option 3). There is no unaffected river between Boardman Dam and Sabin Pond that would be negatively affected by release of sediment from Boardman Pond. Restoring a natural sediment transport regime would benefit the ecology of the Boardman River downstream of Boardman Pond. The altered sediment transport regimes downstream of Brown Bridge Dam would not be addressed.

Stream channel morphology

The repairs to the Union Street Dam and Brown Bridge Dam would not have a significant impact on stream channel morphology. The removal of Sabin and Brown Bridge dams would create approximately 0.7 miles and 1.2 miles of new stream channel, respectively.

Threatened and endangered species

The repairs to the Union Street Dam would not have a significant impact on threatened or endangered species. Repairing Brown Bridge Dam would not change the quantity or quality of common loon, bald eagle, red-shouldered hawk, trumpeter swan, wood turtle, or Blanding's turtle habitat. The partial removal or total removal of the Sabin Dam could have a positive impact on populations of threatened or endangered species. The only element occurrence of a threatened or endangered species recorded within the Michigan Natural Features Inventory (MNFI) database for the Sabin Pond area is that of the wood turtle (*Glyptemys insculpta*), a reptile of special concern known to inhabit various wetland types, especially forested river floodplain wetlands adjacent to upland habitats with sandy soils. It was very recently recorded near Sabin Pond in 2005 and in two other sections further east along the Boardman River. Blanding's turtle (*Emys blandingii*) is another special concern species believed to be present near the impoundments along the Boardman River.

Given increases in emergent, scrub-shrub, and forested wetlands adjacent to sandy upland habitat, it is likely that partial or total removal of Sabin Dam would increase the quantity and quality of wood turtle habitat available. Although submerged and floating aquatic vegetation habitat of the Blanding's turtle would transition to emergent, scrub-shrub, and forested wetlands, the turtle is known to utilize a variety of wetland habitats including swamp, emergent marsh, fen, wet meadow, inundated shrub swamp, and floodplain forest. Blanding's turtle juveniles would use tag alder and willow wetland habitat adjacent to slow moving streams the first couple years of their lives (Harding, pers. comm.) so this species could be found in some sections of the new river after the drawdown is complete.

Other rare species known to occur within the watershed that may benefit from this improved habitat diversity include the red-shouldered hawk (*Buteo lineatus*), bald eagle (*Haliaeetus leucocephalus*), and ebony boghaunter (*Williamsonia fletcheri*). With the lowering of the impoundment, the potential also exists for rare natural communities like northern fen and rich conifer swamp to develop along the numerous groundwater seeps occurring at the southern end of Sabin Pond.

The common loon (*Gavia immer*), which has been reported on Boardman Pond for many years, would move from Boardman Pond and relocate to another breeding site. Given increases in aquatic, emergent, scrub-shrub, and forested wetlands adjacent to sandy upland habitat, it is likely that Alternative 25 would increase the quantity and quality of habitat available for rare species known to occur within the watershed, such as wood turtle, Blanding's turtle, bald eagle (*Haliaeetus leucocephalus*), red-shouldered hawk, and ebony boghaunter (*Williamsonia fletcheri*). Habitat for the common loon would be lost, but this species is likely to relocate to other habitat in the surrounding area.

Water quality

The repairs to the Union Street Dam and Brown Bridge Dam and removal of Sabin and Boardman dams would not have a significant impact on water quality. The adverse impact to the Boardman River caused by warm water discharge from Brown Bridge Pond would continue.

Ground water

The repairs to the Union Street Dam and Brown Bridge Dam and removal of Sabin and Boardman dams would not have a significant impact on ground water resources.

ENGINEERING IMPACTS

Transportation and infrastructure

The repairs to the Union Street Dam and Brown Bridge Dam would not have a significant impact on transportation and infrastructure. There are utilities located at the Union Street Dam, but the repairs would not impact the utilities. Removing the dams would not have an impact on transportation because a new Cass Road bridge would be constructed over the removed power house and spillway at Boardman Pond.

Hydrology and hydraulics

The repairs to the Union Street Dam and Brown Bridge Dam and removal of Sabin and Boardman dams would not have a significant impact on hydrology and hydraulics of the Boardman River in the vicinity of the dams.

Floodplain changes

The repairs to the Union Street Dam and Brown Bridge Dam would not have a significant impact on flood plains on the impoundments and lakes because the repairs would not change the water levels in the impoundments or lakes. Removing Sabin Pond and Boardman Lake would lower the floodplain elevation that once existed on these water bodies. The floodplain condition without the impoundments is provided in Appendix C.

Stream bank stabilization

The repairs to the Union Street Dam and Brown Bridge Dam would not have a significant impact on stream banks, but removing the impoundments would require stream bank stabilization in certain locations to avoid detrimental sedimentation and loss of habitat.

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Water supplies and on-site waste water treatment systems

The repairs to the Union Street Dam and Brown Bridge Dam and removal of Sabin and Boardman dams would not have a significant impact on water supplies and on-site wastewater treatment systems

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SOCIETAL IMPACTS

Property boundaries and rights

The repairs to the Union Street Dam and Brown Bridge Dam and removal of Sabin and Boardman dams would not have a significant impact on property boundaries or property rights.

Risks to property owners

The repairs to the Union Street Dam and Brown Bridge Dam and removal of Sabin and Boardman dams would not have a significant impact on risks to property owners and may alleviate some risks as a result of the repairs made to the dams.

Historic status of dams and power houses

The repairs to the Union Street Dam and Brown Bridge Dam and removal of Sabin and Boardman dams would not have a significant impact on historic or cultural resources in the vicinity of the dams.

Impact on County's Natural Education Reserve

The repairs to the Union Street Dam and Brown Bridge Dam and removal of Sabin and Boardman dams would not have a significant impact on the County's Natural Education Reserve.

ECONOMIC IMPACTS

Recreation and Tourism

With the removal of Sabin and Boardman dams, we anticipate that the corresponding changes in stream hydrology and fish habitats will change the recreation opportunities associated with the Boardman River. Under Alternative 25, the impoundments associated with these dams will become free-flowing river segments. The removal of the dams will change the nature of the fishery for several segments. Specifically, anadromous species are predicted to become available as far upstream as the Brown Bridge Dam. In addition, catch rates for anadromous fish species in western Grand Traverse Bay are predicted to improve somewhat. Boardman Lake, however, will continue to offer warm water fishing experiences. Moreover, some segments will offer more “whitewater” under this alternative than current conditions do, consequently changing recreational paddling opportunities. The former impoundments are predicted to become more scenic, as well.

Bingham et al. (2008) provide a description of the process used to quantify the economic impacts associated with a change in one or more dams. That same process is used here to evaluate Alternative 25, as well as the subsequent alternatives. Relative to current conditions, implementing Alternative 25 will increase the recreation value of residents by approximately $112,000. This increase represents the present value over 30 years. In addition, we expect tourism spending to increase. The present value estimate of the increase in tourism spending over 30 years is $1.38 million. Finally, once the fishery improvements have realized their maximum potential, we expect that the tourism-based jobs will increase by 4 jobs.

Property Values

The repairs to the Union Street Dam and Brown Bridge Dam would not have a significant impact on property values within ½ mile of the dam.

In addition to the recreation and tourism changes described above, Alternative 25 will result in likely changes in residential property values in parcels near Sabin Pond and Boardman Pond. The methodology for this assessment has been previously described in Bingham et al. (2008). Based on that methodology, Bingham,et al., (2008) found that the value of an individual residential parcel in the vicinity of Sabin Pond and Boardman Pond could fall, on average, by as much as 6 percent following removal of the dams, if all other influences on property values are held constant. About two years after the removal, the affected properties are predicted to begin to increase in value. Twenty years after removal, the properties, on average, could increase in value by as much as 18 percent, or approximately one percent per year, relative to current conditions.

Table 11 shows how the total assessed value of residential parcels within a ½ mile of the Boardman River would change if Alternative 25 were implemented. Initially, the aggregate assessed value of the properties could fall by as much as $0.6 million. Over time, the aggregate assessed value may increase by as much as $1.7 million. The present value of the stream of property value impacts is $1.04 million. When considering the results in Table 11, it is important to keep in mind that calculated changes in value represent the expected change associated only with dam removal. Changes in market values are likely to occur over time for reasons unrelated to dam removal but are not represented in the table. For example, Table 11 does not account for the general appreciation of property values that may occur over the next 20 years. None of those other future influences is reflected in Table 11.

In terms of the property value impacts, it is important to understand several aspects. First, the impacts will not be equally distributed across residents of Grand Traverse County. Initially, individual property owners may experience a decline in the value of their individual properties that is proportionally greater than the overall impact. Over time, those same owners may experience a gain in value that is proportionally greater than the overall impact. Second, the statistical model applied for this assessment represents the average impact. Not all affected properties will experience the average impact. Some individual parcels may increase or decrease in value in amounts greater to, or less than, the predicted average impact.

TABLE 13: ESTIMATED CHANGES IN ASSESSED VALUE OF RESIDENTIAL PARCELS UNDER ALTERNATIVE 25
($ Millions)

Number of Years Since Removal	Value with Current Conditions	Value with Alternative 25	Estimated Change in Assessed Value	Percent Change
1	$331.3	$330.8	$(0.6)	–0.2%
2	$331.3	$330.8	$(0.6)	–0.2%
3	$331.3	$331.4	$0.1	0.0%
4	$331.3	$331.5	$0.2	0.1%
5	$331.3	$331.6	$0.3	0.1%
6	$331.3	$331.7	$0.4	0.1%
7	$331.3	$331.8	$0.5	0.1%
8	$331.3	$331.9	$0.6	0.2%
9	$331.3	$332.0	$0.6	0.2%
10	$331.3	$332.1	$0.7	0.2%
11	$331.3	$332.2	$0.8	0.3%
12	$331.3	$332.3	$0.9	0.3%
13	$331.3	$332.3	$1.0	0.3%
14	$331.3	$332.4	$1.1	0.3%
15	$331.3	$332.5	$1.2	0.4%
16	$331.3	$332.6	$1.3	0.4%
17	$331.3	$332.7	$1.4	0.4%
18	$331.3	$332.8	$1.5	0.4%
19	$331.3	$332.9	$1.6	0.5%
20	$331.3	$333.0	$1.7	0.5%

Note: Future values noted here do not reflect any influences on property values except those uniquely associated with dam removal. General appreciation of values over time is not reflected in this table.

Finally, any given property owner does not have identical preferences for the attributes of a property that determine the property's value, when compared to another owner. For example, for one property owner, having a fireplace may be a high priority, such that he is willing to pay more for a property with that amenity. For another owner, she may be indifferent to whether her home has a fireplace, or may actually prefer to not have a fireplace. That second owner is not likely to be willing to pay more for a property with a fireplace. Similarly, some individuals may not value living near a free-flowing river, when compared to living near an impoundment. If the current property owners near Sabin and Boardman Ponds chose their properties specifically because they are near an impoundment, then the change to a free-flowing river will not make these individuals better off over the long run. For these individuals, their properties may be worth less to them personally relative to the current condition because they have lost an important feature. Even if the market values of the property value rise over time, the current owners' individual satisfaction with their properties may not increase over time, and could even decrease.

Cost of the repairs

The annual maintenance of the dams is estimated to be as follows:
Union Street = $30,000-50,000
Brown Bridge Dam = $30,000-60,000
The estimate to maintain the dams was obtained from County employees who maintain Boardman and Sabin dams the dams and extrapolated to Union Street and Brown Bridge dams .

The estimated cost of this alternative is shown in Table 12

TABLE 14: PROBABLE CONSTRUCTION COST ESTIMATES FOR ALTERNATIVE 25.

Dam	Low Cost Estimate	High Cost Estimate
Union Street Repairs	$430,000	$650,000
Sabin Dam Partial Removal	$360,000	$1,013,000
Sabin Dam Total Removal	$1,870,000	$3,683,000
Boardman Dam Partial Removal	$1,900,000	$2,700,000
Boardman Dam Total Removal	$5,360,000	$8,830,000
Brown Bridge Dam Repair	$380,000	$1,360,000
Alt.25 Total with Partial Removal	$3,070,000	$5,723,000
Alt. 25 Total with Total Removal	$8,040,000	$14,523,000

The cost estimates for Union Street and Brown Bridge Dam were developed by STS in their study of the dams (STS, 2008) and for Sabin and Boardman Dam by ECT and Prein and Newhof as part of the detailed analysis of alternatives for the dams. A detailed summary of the cost estimates in provided in Appendix D.

Property tax implications

The repairs to the Union Street Dam and Brown Bridge Dam and removal of Sabin and Boardman dams could have an impact on property taxes if that is the source of funds used to implement the repairs. However, there are numerous options for funding the repairs and a decision as to the source of funding has not been made at this time.

Jobs

The repairs to the Union Street Dam and Brown Bridge Dam and removal of Sabin and Boardman dams would create local construction, recreation, and tourism jobs.

Hydroelectricity

The repairs to the Union Street Dam and Brown Bridge Dam would not be sufficient to allow electricity to be generated at the dams. There are additional actions and modifications that would need to be made to generate electricity at the dams. Removing Sabin Dam and Boardman Dam would prevent hydroelectricity to be generated using traditional methods of hydroelectric generation. Alternative 41 describes the actions and modifications that are anticipated in order to allow electricity to be generated at the dams.

ALTERNATIVE 41: MODIFY ALL OF THE DAMS

DESCRIPTION OF THE MODIFICATIONS

The modifications described in this alternative were developed in conjunction with the BRDC. The modifications are intended to address fish access and passage, emergency spillway capacity and mitigating the impact of warm water discharge at Brown Bridge Dam. The following is a summary of the modifications at each dam that were studied during a detailed analysis of Alternative 41.

Union Street Dam:

Union Street Dam would be modified to allow Great Lakes fish species to pass over the dam and gain access to Boardman Lake and its tributaries. During discussions on various fish passage options at a BRDC meeting, the consensus seemed to be that the fish ladder could be replaced with a fish passageway. Fish passageways have recently been used as replacements for fish ladders for a number of reasons. In the case of Union Street Dam, the primary benefit is that a fish passageway could allow all Great Lakes fish to pass over the dam. Currently, only fish species capable of jumping from pool to pool in the ladder can pass over the dam. The fish passageway could be constructed by placing a ramp made of stone and soil in the river below the dam that could replace the dam with a new river channel that has a more gradual slope. The gradually sloped fish passageway could allow Great Lakes fish species to access Boardman Lake.

Sabin Dam:

Sabin Dam could be modified to allow Great Lakes fish species to pass over the dam and gain access to Boardman Lake and its tributaries. During discussions on various fish passage options at a BRDC meeting, the consensus seemed to be that fish passageways were preferable to fish ladders. Fish passageways have recently been used as replacements for fish ladders for a number of reasons. In the case of Sabin Dam, the primary benefit is that a fish passageway could allow all Great Lakes fish to pass over the dam. Currently, fish species are not able to pass over the dam. The fish passageway could be constructed by placing a ramp made of stone and soil in the river below the dam that could replace the dam with a new river channel that has a more gradual slope. The gradually sloped fish passageway could allow Great Lakes fish species to access the impoundment at Sabin Dam.

Boardman Dam:

Boardman Dam could be modified in two ways. First, a fish passageway would be built to allow Great Lakes fish species to pass over the dam and gain access to Boardman Pond and its tributaries. During discussions on various fish passage options at a BRDC meeting, the consensus seemed to be that fish passageways were preferable to fish ladders. Fish passageways have recently been used as replacements for fish ladders for a number of reasons. In the case of Boardman Dam, the primary benefit is that a fish passageway could allow all Great Lakes fish to pass over the dam. Currently, fish species are not able to pass over the dam. The fish passageway could be constructed by placing a ramp made of stone and soil along the downstream side of the dam. The gradually sloped fish passageway could allow Great Lakes fish species to access the impoundment at Boardman Pond.

In 2007, Boardman Pond was lowered in order for the dam to comply with the MDEQ Dam Safety regulations. The dam was lowered as a result of a consent agreement between Grand Traverse County and the MDEQ which specified a number of actions the County was to undertake in order to provide for the safety of the dam and specifically, the safety of the spillway. The water level in the impoundment, which was lowered approximately 16 feet, could be raised if the modification described above is acceptable to the MDEQ.

Brown Bridge Dam:

Brown Bridge Dam would be modified in two ways. First, a fish passageway could be built to allow Great Lakes fish species to pass over the dam and gain access to Brown Bridge Pond and its tributaries. During discussions on various fish passage options at a BRDC meeting, the consensus seemed to be that fish passageways were preferable to fish ladders. Fish passageways have recently been used as replacements for fish ladders for a number of reasons. In the case of Brown Bridge Dam, the primary benefit is that a fish passageway could allow all Great Lakes fish to pass over the dam. Currently, fish species are not able to pass over the dam. The fish passageway could be constructed by placing a ramp made of stone and soil along the downstream side of the dam. The gradually sloped fish passageway could allow Great Lakes fish species to access the impoundment at Brown Bridge Pond.

The second modification could be to address the warm water discharge from Brown Bridge Dam. Several years ago, a study determined that the warmer surface waters of Brown Bridge Pond were impacting the Boardman River downstream of the dam and having an adverse impact on the cold water fish species that should be prevalent in the river. One common modification used to address the impact of warm water discharges from dams is to construct a bottom draw at the dam. A bottom draw is a pipe that is installed below the surface of the impoundment at a depth where the pipe collects and discharges cold water at the bottom of the impoundment, thus mitigating the impact of warmer surface water that use discharge into the river. While this technique has been successfully implemented at some locations, it is not clear that the volume of cold water beneath the surface at Brown Bridge Pond is sufficient to mitigate the potential impact of warm water discharges for an entire growing season.

The status of the flood control spillway at the dam is a complex issue. If electricity is generated at the dam, then an emergency spillway may be required to meet FERC regulations. In 2004, when Travers City Light and Power (TCLP) operated the dams, an improved spillway that met FERC requirements was designed. TCLP decided to discontinue operations at the dams, so the spillway was not constructed. If electric power generation is restored at the dam, then, there is a potential for FERC to require a new and improved spillway be constructed.

DESCRIPTION OF FISH PASSAGE

During discussions at the BRDC the idea of fish passage at the dams has been discussed and this modification has been included in the study. The following information provides some background information on the current state of fish passage and the costs associated with constructing fish passageways. Fish passage is studied in this report as a voluntary management technique whose purpose would be to restore access to the Boardman River for Great Lakes fish species. During the FERC relicensing process, there is a possibility that fish passage will be required as a condition of the license to generate hydroelectricity. Currently only the Union Street Dam is equipped with a fish passage structure.

The best available information regarding the cost of providing fish passage in Michigan is nearly 20 years old. The table below shows the locations, original costs, and estimated 2008 construction costs of several fish passage structures similar to what may be required at the Boardman River dams. The Construction Cost Index used to estimate current costs is taken from the US Army Corps of Engineers' cost index for dams.

Fish Ladder Location	River	Built	Original Cost	Construction Cost Index When Constructed[21]	Estimated 2008 Construction Cost[21] CCI=685.12
Berrien Springs	St. Joseph	1975	$692,500	189.20*	$2,507,640
Niles	St. Joseph	1991	$2,500,000	400.37	$4,278,042
Buchanan	St. Joseph	1990	$3,000,000	393.91	$5,217,841
South Bend	St. Joseph	1988	$1,100,000	371.82	$2,026,873
Mishawaka	St. Joseph	1991	$1,400,000	400.37	$2,395,570
Grand Rapids	Grand	1980	$1,100,000	268.61	$2,805,673
Lyons	Grand	1981	$1,000,000	291.27	$2,352,181

* Extrapolated

The Grand River fish passage structures each rise less than 10 ft, while the St. Joseph River structures are similar in height to the Boardman Dams. Other types of fish passage are available, including the construction of engineered rock ramps. Rock ramps are easier to construct on low-head dams because the required slopes for velocity control do not require long reaches of stream coupled with fewer actual rock structures.

One such recent project was constructed on the Green River near Mancelona for a total cost of $200,000 for a very small stream with less about 8 ft of head differential.

A similar rock fish passage structure studied for a dam project with about 8 ft of head differential in Frankenmuth was estimated to cost $1,600,000 to $1,800,000.[23]

The City of Chesaning currently is in the design phase of a reported $1,300,000 to $1,600,000 rock ramp project proposed to replace an aging, 9-ft-high dam on the Shiawassee River.

A rock ramp for any of the Boardman Dams would be quite expensive, if even practical, due to the height differential between the impoundments and the downstream river bottom. A series of costly rock ramps would be required over a lengthy stretch of river bottom.

Based upon the above discussion, it is estimated that fish passage structures at any of the Boardman River dams would cost at least $2,000,000, and possibly much more.

DESCRIPTION OF THE FERC RELICENSING PROCESS

If a decision is made to restore electric generation at any of the dams, a new Federal Energy and Regulatory Commission (FERC) license must be obtained. In the application process, FERC requires an applicant to explain how a project affects things such as land use, recreation, water supply, wildlife and fish habitat, endangered species, and historic and cultural values. It often takes over five years of extensive planning, professional and environmental studies, agency consultation and review, and public involvement before a license to operate a hydropower facility is granted. The review process often leads to extended conflict between environmental and power interests. The FERC licensing process is frequently a very costly process, but if the applicant is successful, the licenses and the requirements that accompany that license are typically issued for 30 to 50 years.

Each FERC re-licensing effort has its own unique set of issues and concerns that need to be addressed, therefore, the cost of a permit application varies from project to project. There are three recent hydropower project re-licensing applications in Michigan that demonstrate the magnitude of costs associated with a FERC application.

The City of Hart in Oceana County operates a municipal power system. The Hart Dam is owned by the city and is equipped to produce hydropower. Its recent FERC re-licensing effort cost over $800,000 as of January 2008, and it is expected to top $1,000,000 when all the re-licensing requirements, including recreational improvements, have been met.[18]

Similarly, the City of Marshall in Calhoun County operates a municipal power system. The Marshall Dam on the Kalamazoo River is owned by the city and produces hydropower. Its 2005 FERC re-licensing effort took six years and cost the city $389,000.[19]

Consumers Energy's Calkins Bridge Dam in Kalamazoo County is currently in the FERC re-licensing process. It is estimated by Consumers to cost approximately $250,000. [20]

In addition when Consumers Energy re-licensed dams on the Muskegon, Au Sable and Manistee Rivers in the 1990s, it established the Michigan Habitat Improvement Fund as a condition of licensure. The fund currently provides $400,000 each year in grants within the three watersheds until 2014. Originally, it granted over $800,000 per year. This obligation is over and above the costs incurred to renew FERC licenses.

Based upon the above discussion, it would be reasonable to assume that it will cost at least $250,000 and potentially over $1,000,000 to re-license the Boardman River dams for hydropower generation. This is in addition to any "structural" costs such as constructing a new emergency spillway at the Boardman Dam, which will certainly be a condition for re-licensing. Other costs, such as recreational improvements, would be in addition to the engineering costs.

MODIFICATION OF BOARDMAN DAM EMERGENCY OVERFLOW WITH HYRDOELECTRICITY

The Boardman Dam currently does not comply with the emergency spillway requirements of MDEQ and FERC. While the dam can be modified to meet MDEQ requirements, if electricity is generated at the dam, that modification would not comply with FERC requirements. Accordingly Prein & Newhof studied the modifications to the hydraulic structures that would be required such that power generation could resume.

Currently, the emergency spillway cannot safely carry significant flow without the risk of failure. The basic concept is to build a gated intake structure on the west side of the existing intake channel, and route emergency flow through a pipe or a series of pipes under Cass Road to the downstream river channel, as shown in Figure 1. The results of the hydraulic sizing analysis are as follows:

Max Allowable WSEL=558'
½ PMF=6,100 cfs
Rated Generator Discharge (existing) = 332 cfs each (2)
Existing Auxiliary Spillway Overflow Capacity @ WSEL 558 = 3,586 cfs
Emergency Overflow Discharge Capacity Needed = 1,850 cfs

Rectangular Opening:

Height	Width	#	Invert
8	8	2	641.0
10	10	2	647.7
10	15	1	643.5
15	10	1	641.0
10	20	1	647.8

Round Opening:

Diameter	#	Invert
8'	2	640.2
12'	1	641.0

The calculations indicate that orifice flow occurs in each case. For simplicity, we would recommend one 144-in.-diameter outlet pipe, with intake invert at 641.0 to be built under Cass Road, with a gated, concrete headwall/intake structure upstream and a concrete discharge structure downstream. The estimated total project cost, as shown below, is $1,760,000.

Cost Estimate for New Emergency Overflow

Item	Quantity	Unit	Unit Cost	Total Cost
Concrete Headwalls	2	ea	$125,000	$ 250,000
Energy Dissipators	1	ea	$60,000	$ 60,000
114-in.-Diameter Pipe	250	ft	$1,500	$375,000
Steel Sheet Piles	3400	sft	$30	$ 100,000
Roller or Sluice Gate	1	ea	$350,000	$ 350,000
Restoration	1	ls	$25,000	$25,000
Gate Frame	1	Ls	$50,000	$50,000
Gate Operator	1	ea	$50,000	$50,000
Engineering, Administration, Contingencies (40%)				$500,000
Total Budget				$1,760,000

ENVIRONMENTAL IMPACTS OF THE MODIFICATIONS

Effects on Terrestrial Habitats and Wetlands

Modifying the **Union Street Dam** would not change the water level in the impoundment. Therefore, no change in the acreage of either terrestrial or wetland habitat is anticipated. No new terrestrial habitat and no new wetlands are likely to form as a result of this alternative. The less urbanized uplands surrounding the southern half of Boardman Lake would remain dominated by deciduous, evergreen, and mixed forests. Wetlands within the impoundment would remain dominated by submerged and floating aquatic vegetation. Wetlands near or adjacent to the impoundment would remain dominated by scrub-shrub and emergent vegetation. No changes to the quantity or quality of potential king rail or common loon habitat are anticipated.

Implementing Alternative 41 at **Sabin Dam** would not change the water level in the impoundment. Therefore, no change in the acreage of either terrestrial or wetland habitat is anticipated. No new terrestrial habitat and no new wetlands are likely to form as a result of this alternative. The uplands surrounding

Sabin Pond would remain dominated by deciduous, evergreen, and mixed forests. Wetlands within the impoundment would remain dominated by submerged and floating aquatic and emergent vegetation. Wetlands near or adjacent to the impoundment would remain dominated by forested, scrub-shrub, and emergent vegetation.

Implementing Alternative 41 at Boardman Dam would return the water level in the impoundment to its original design elevation prior to the 2007 emergency drawdown. It is anticipated that the existing terrestrial habitats surrounding Boardman Pond would remain unchanged and that approximately 21 acres of newly forming upland habitat would be flooded. These additional 21 acres of upland anticipated to be lost occur:

1) along the western and eastern edges of the impoundment, approximately 100 feet from the original impoundment's edge of water; and

2) along the northern edge of the impoundment, approximately 75 feet from the original impoundment's edge of water.

Open water and minimal submerged and floating aquatic habitats with relatively low species diversity are expected to cover the previous upland areas once more. Given the steep grade of these slopes, water depth is anticipated to be too deep to support most wetland plants. It is likely that relatively few species tolerant of deep water, such as floating and sago pondweeds and stonewort, would revegetate the fringe of the impoundment where steep slopes occur underwater.

As a result of the water level in the impoundment returning to its original design elevation prior to the 16-foot emergency drawdown, it is anticipated that approximately 25 acres of newly formed emergent wetland would be converted back to open water habitat along the northeast corner, east central side, and southern end of the original impoundment. Approximately 11 acres of small forested/scrub-shrub/emergent wetlands directly adjacent to the upstream end of the impoundment are likely not to be impacted by the raising of the impoundment's water level.

Considering 1) the loss in wetland acreage with the conversion of newly formed emergent wetland to open water areas and 2) the resulting decrease in species and structural diversity with the conversion of emergent habitats to deep-water habitats, Alternative 41 would likely decrease the quality and the quantity of wildlife habitat available along the shores of Boardman Pond. Given decreases in aquatic and emergent wetlands adjacent to sandy upland habitat, it is likely that Alternative 41 would either 1) not change or 2) decrease the quantity and quality of habitat available for rare species known to occur within the watershed, such as common loon, wood turtle, Blanding's turtle, bald eagle (*Haliaeetus leucocephalus*), red-shouldered hawk, and ebony boghaunter (*Williamsonia fletcheri*).

Alternative 41 (modify the Brown Bridge Dam) would not change the water level in the impoundment. Therefore, no change in the acreage of either terrestrial or wetland habitat is anticipated. No new terrestrial habitat and no new wetlands are likely to form as a result of this alternative. The uplands surrounding Brown Bridge Pond would remain dominated by evergreen and mixed forests. Wetlands within the impoundment would remain dominated by submerged and floating aquatic and emergent vegetation. Wetlands near or adjacent to the impoundment would remain dominated by forested, scrub-shrub, and emergent vegetation.

<u>Effects on Wildlife Populations</u>

The wildlife populations in the Boardman River impoundments were studied as part of the review of existing and baseline conditions (ECT, 2007).

Modifying the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on wildlife habitat, but could have an impact on wildlife populations due to contaminants in Great Lakes fish. Stream-carried sediment would continue to collect in the upstream areas and inlets of the impoundments. This would be most noted in upper Brown Bridge and Boardman Pond. Over time, the sediment accumulation would reduce water depths, increase sandbar and shallow water habitats including emergent vegetation habitats dominated by sedges, spike rushes and other aquatic plants. The scrub-shrub habitats in these inlet areas, that currently include willows, tag alder and ninebark, would expand downstream. Wading bird and shorebird use would increase in shallow water and sandbar areas, songbird, small mammal and amphibian use would increase with the expanded emergent vegetation habitat

Modifying the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on migrant and resident ducks, geese and swan habitat in Boardman Lake and the impoundments. These impoundments provide valuable food resources and sanctuary. The presence of waterfowl in these impoundments provides important recreational and educational opportunities such as waterfowl hunting and wildlife viewing. Modifying the dams would not have a significant impact on these activities.

Modifying the dams would help conserve, and may expand the floating and submergent wetland habitats along shorelines and shallow water areas of Boardman Lake, Sabin Pond, and Brown Bridge Pond. These habitats tend to be rich in aquatic plant life and provide important habitat to aquatic insects and other invertebrates which in turn nurture fish, turtles, toads and frogs, waterfowl and wading birds within the impoundments, as well as songbirds that use adjacent uplands. However, approximately 21 acres of newly formed wetlands at Boardman Pond will be flooded by returning the water level to its historic level.

Sediment accumulation and aging of the dam structures would increase the potential for significant losses to downstream fish and wildlife habitats and populations, if a dam would fail and release the accumulated sediment into downstream habitats.

Modifying the dams -- lost opportunities for river restoration

By modifying the dams, the positive impacts from dam removal would be lost by not restoring and reconnecting riparian and wetland habitats along the river. The restoration of riparian and wetland habitats is a positive impact because these habitats are two of the most valuable habitat types found in the northern Michigan because of the large number of plants and animals they support. Many songbird species such as the black and white warbler, northern water thrush, cardinal, catbird, and many small mammals including the meadow vole, meadow jumping mouse and short-tailed shrew are more abundant in the moist, diverse habitats similar to those that would be created following dam removal.

Removing the dams would restore the historic, contiguous riparian habitats along the river corridor, benefiting species like the wood turtle (a state threatened species), river otter, mink, bobcat, bear, the white-tailed deer, pine marten, ruffed grouse and red-shouldered hawk (a state threatened species)

Modifying the dams – increasing the threat of chemical contamination and introducing invasive species and pathogens.

The dams on the Boardman restrict fish passage and protect the watershed above Sabin Pond from the introduction of chemical contaminants found in fish from Lake Michigan and Boardman Lake.

Chemical contaminants found in some Great Lakes fish species that could present a threat to certain wildlife species include PCB, DDT metabolites and other chlorinated hydrocarbons. Wildlife species vulnerable to chemical contaminants that could be impacted by chemical contaminants in Great Lakes fish include, but are not limited to, mink, otters, gulls, bald eagles, and snapping turtles.
Modifying the dams to allow Great Lakes fish to access Boardman Lake and the impoundments upstream of the dams could increase the exposure of wildlife populations to contaminants contained in Great Lakes fish.

The dams limit access by non-native species such as the European crayfish, round gobies, ruff, sea lamprey, steelhead trout, and salmon. Alternative 41 would include a plan to control undesirable species, such as sea lamprey, from accessing the Boardman River and the impoundments upstream from the dams.

Effects on Fisheries

Under the existing conditions, the longest free flowing river segment is 13.8 miles (Segment 6). The remainder of the river is fragmented into smaller segments by the dams and their impoundments. Retaining the dams with modifications does not create new stream channel or increase the length of free flowing river. Alternative 41 maintains the warm water fisheries of Sabin Pond, Boardman Pond, and Brown Bridge Pond. Modifications at Sabin, Boardman, and Brown Bridge dams would include fish passage, which connects 22.0 miles of unimpounded river between the dams/impoundments upstream of Boardman Lake (Segments 3, 6, and 8). The existing fish ladder at Union Street Dam currently allows salmon and steelhead to gain access to all 22.0 miles of unimpounded river upstream of Boardman Lake to the forks versus just 2.2 miles (Segment 3) under existing conditions. Dam modifications may include reduced downstream water temperatures, which further decreases affects of the dams. Alternative 41 does not eliminate all of the negative effects that the dams currently have on the Boardman River and West Arm Grand Traverse Bay fisheries. Although improved fish passage would benefit the fisheries, the overall productivity of the Boardman River would still be suppressed by negative effects of the dams. It is not likely that fish passage would allow all species to freely migrate between unimpounded segments of the river with high efficiency. Furthermore, modifications would not address the altered state of transportation and storage of sediment, organic matter, and large woody debris. Modification of the Union Street Dam would provide upstream passage for sturgeon and other cool water species (e.g., walleye, suckers, and smallmouth bass) in addition to salmon and steelhead. Passing sturgeon and other cool water species would support efforts to restore lake sturgeon populations and improve the cool water fisheries of the Boardman River, Boardman Lake, and West Arm Grand Traverse Bay. However, a fish passage structure that allows sturgeon and other cool water species to migrate upstream would also allow sea lamprey to migrate upstream, altering current sea lamprey control strategies, activities, and costs.

The top quality cold water fisheries upstream of Sabin Dam would be maintained in their current state. Although there is the potential for some level of competitive interaction between anadromous salmonids and resident trout, competition is not expected to decrease existing resident trout abundance. Because the affects the dams have on the ecology of the Boardman River would not be removed or fully mediated for, resident trout populations would not benefit from Alternative 41.

Due to a significant increase in the length of river accessible to salmon and steelhead, natural salmon and steelhead reproduction would increase in the Boardman River. Natural reproduction in the 22.0 miles of connected unimpounded river segments (Segments 3, 6, and 8) upstream of Boardman Lake to the forks could produce 400 adult Chinook salmon, 350 adult coho salmon, and 1,200 adult steelhead in addition to existing runs. Adult salmon and steelhead would be distributed throughout the Boardman River during spawning runs up to the headwaters, creating a new shore fishery during fall and spring runs upstream of Sabin Dam. Salmon and steelhead abundance would decrease moving upstream due to attrition from fish passage efficiencies less than 100% at the dams and through the impoundments, natural mortality, harvest, and spawning habitat distribution. The anadromous salmonid fisheries, particularly salmon, would result in dead fish carcasses and increased fishing pressure that have associated negative social perceptions among the general public, riparian landowners, and outdoor enthusiasts.

Changes specific to certain river segments are discussed in detail below.

Segment 1 – Union Street Dam to West Arm Grand Traverse Bay
The physical channel conditions and fish habitat in Segment 1 would not change. Segment 1 would be connected to 22.0 miles of unimpounded river upstream (Segments 3, 6, and 8) to the forks due to the installation of fish passage at all three upstream dams. The existing second quality cold water and mixed warm/cool water fisheries in Segment 1 would not change. Modification of the Union Street Dam to decrease downstream water temperature would benefit cold water fish species in Segment 1, but would not be sufficient to change the fishery status from second quality cold water to top quality cold water. The existing salmon and steelhead fisheries would benefit from increased natural reproduction, resulting in higher abundance of adult fish during spawning migrations and higher angler catch rates.

Segment 2 – Boardman Lake
While the number of salmon and steelhead passing the Union Street Dam and entering Boardman Lake would increase, it is not likely that a significant boat fishery would result. Creel data collected by the MDNR in 2005 indicate that all salmon and steelhead caught between Sabin Dam and the West Arm Grand Traverse Bay are currently caught by shore anglers. This fishery condition is not expected to change under Alternative 41.

Segment 3 – Sabin Dam to Boardman Lake
Under Alternative 41, Segment 3 would be connected to 19.8 miles of unimpounded river upstream (Segments 6 and 8) to the forks due to installation of fish passage at all three upstream dams. The existing second quality cold water fishery would be maintained. Existing resident trout abundance and age structure would not change. The existing salmon and steelhead fisheries would benefit from increased natural reproduction, resulting in higher abundance of adult fish during spawning migrations and higher angler catch rates. Sea lamprey would be able to reach Segment 3, requiring new control strategies and increased control costs.

Segment 4 – Sabin Pond (Sabin Dam)
While the number of salmon and steelhead passing the Union Street Dam would increase and salmon and steelhead would be able to pass the Sabin Dam, it is not likely that a significant boat fishery would result in Sabin Pond. Creel data collected by the MDNR in 2005 indicate that all salmon and steelhead caught between Sabin Dam and the West Arm Grand Traverse Bay are currently caught by shore anglers. The existing warm water fishery in Sabin Pond would be maintained.

Segment 5 – Boardman Pond (Boardman Dam)
While the number of salmon and steelhead passing the Union Street Dam would increase and salmon and steelhead would be able to pass the Sabin and Boardman dams, it is not likely that a significant boat fishery would result in Boardman Pond. Creel data collected by the MDNR in 2005 indicate that all salmon and

steelhead caught between Sabin Dam and the West Arm Grand Traverse Bay are currently caught by shore anglers. The existing warm water fishery in Boardman Pond would be maintained.

Segment 6 – Brown Bridge Dam to Boardman Pond (Boardman Dam)
Under Alternative 41, Segment 6 would be connected to 3.4 miles of unimpounded river downstream (Segments 1 and 3) due to installation of fish passage at Sabin and Boardman dams. Segment 6 would also be connected to 6.0 miles of unimpounded river upstream to the forks (Segment 8) due to installation of fish passage at Brown Bridge Dam. The existing top quality cold water fishery would be maintained, and would benefit from reduction of water temperature discharging from Brown Bridge Dam. The abundance of existing resident trout in the first one to two miles downstream of Brown Bridge Dam is expected to increase due to lower water temperature. Otherwise, the existing top quality cold water fishery would not change. The presence of salmon and steelhead would create a new anadromous salmonid shore fishery. The anadromous salmonid fisheries, particularly salmon, would result in dead fish carcasses and increased fishing pressure that have associated negative social perceptions among the general public, riparian landowners, and outdoor enthusiasts. Sea lamprey would be able to reach Segment 6, requiring new control strategies and increased control costs.

Segment 7 – Brown Bridge Pond (Brown Bridge Dam)
The existing warm water fishery in Brown Bridge Pond would be maintained. While the number of salmon and steelhead passing the Union Street Dam would increase and salmon and steelhead would be able to pass the Sabin, Boardman, and Brown Bridge dams, it is not likely that a significant boat fishery would result in Brown Bridge Pond. Creel data collected by the MDNR in 2005 indicate that all salmon and steelhead caught between Sabin Dam and the West Arm Grand Traverse Bay are currently caught by shore anglers.

Segments 8, 9, and 10 – Brown Bridge Pond to Headwaters
Under Alternative 41, the Boardman River upstream of Brown Bridge Pond and the South and North Branches would be connected to 17.2 miles of unimpounded river downstream (Segments 1, 3, and 6) due to installation of fish passage at Sabin, Boardman, and Brown Bridge dams. The existing top quality cold water fishery would be maintained. The presence of salmon and steelhead would create a new anadromous salmonid shore fishery. The anadromous salmonid fisheries, particularly salmon, would result in dead fish carcasses and increased fishing pressure that have associated negative social perceptions among the general public, riparian landowners, and outdoor enthusiasts. Sea lamprey would be able to reach Segments 8, 9, and 10 requiring new control strategies and increased control costs.

Sediment
The modifications to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on sediment quality or transport. Retaining all of the dams with modifications would have no impact on existing sediment stored in the impoundments of Sabin, Boardman, and Brown Bridge dams. The existing sediments in the impoundments contain some contaminants at concentrations that exceed applicable state and federal criteria. These contaminated sediments would remain in the impoundments and not be mobilized unless a dam were to fail. In the case of a dam failure, there would be a catastrophic release of sediment stored in the impoundment downstream. The dams currently disrupt natural sediment transport throughout the Boardman River mainstem. Sediment starvation influences fisheries habitat and channel geomorphology downstream of the dams. Dam modifications do not address the altered sediment transport regime.

Stream channel morphology

The modifications to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on stream channel morphology.

Threatened and endangered species

The modifications to the Union Street Dam would not have a significant impact on habitat used by threatened or endangered species. No changes to the quantity or quality of potential wood turtle or Blanding's turtle habitat at Sabin Pond are anticipated if Sabin Dam is modified. The common loon (*Gavia immer*) has been reported on the pond and modifying the dam would not impact this species. Given that Alternative 41 could decrease the area of newly formed aquatic and emergent wetlands, there could be a decrease in habitat available for rare species known to occur within the watershed, such as wood turtle, Blanding's turtle, bald eagle (*Haliaeetus leucocephalus*), red-shouldered hawk, and ebony boghaunter (*Williamsonia fletcheri*). The open water habitat for the common loon would be restored to its historic level and this species could benefit from the restored water level in Boardman Pond. Modifying Brown Bridge Dam would not change the quantity or quality of common loon, bald eagle, red-shouldered hawk, trumpeter swan, wood turtle, or Blanding's turtle habitat.

Water quality

The modifications to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam could have a significant impact on water quality. The adverse impact to the Boardman River caused by warm water discharge from Brown Bridge Pond could be mitigated by implementing the bottom draw system that discharges cold water at the bottom of the impoundment instead of the warm water on the surface of the impoundment.

Ground water

The modifications to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on ground water resources.

ENGINEERING IMPACTS

Transportation and infrastructure

The modifications to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on transportation and infrastructure. There are utilities located at the Union Street Dam and the modifications included in Alternative 41 would include rerouting the water main that currently exists at that location.

Hydrology and hydraulics

The modifications to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on hydrology and hydraulics of the Boardman River in the vicinity of the dams.

Flood plain changes

The modifications to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on flood plains on the impoundments and lakes because the modifications would not change the water levels in the impoundments or lakes.

Stream bank stabilization

The modifications to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on stream banks and would not require additional stream bank stabilization efforts because the modifications would not change the water level in the lakes or flow patterns in the river.

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Water supplies and on-site waste water treatment systems

The modifications to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on water supplies and on-site wastewater treatment systems

SOCIETAL IMPACTS

Recreational uses

The modifications to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam could have an effect on the fishing activity in the impoundments and Boardman River due to the presence of Great Lakes fish in these waterbodies.

Property boundaries and rights

The modifications to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on property boundaries or property rights.

Risks to property owners

The modifications to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on risks to property owners and may alleviate some risks as a result of the modifications made to the dams.

Historic status of dams and power houses

The modifications to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on historic or cultural resources in the vicinity of the dams.

Impact of changing fishery

The modifications to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam could have a significant impact on the fishery of the impoundments and the Boardman River if Great Lakes fish are allowed access to the Boardman River and its impoundments.

Impact on County's Natural Education Reserve

The modifications to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on the County's Natural Education Reserve.

ECONOMIC IMPACTS

Recreation and Tourism

With fish passage modifications on all four dams, we anticipate that recreation opportunities will improve in some of the Boardman River segments. Specifically, these modifications will improve fishing somewhat in the river segments downstream of Brown Bridge Pond. In addition, catch rates for anadromous fish species in western Grand Traverse Bay are predicted to improve somewhat. The dam modifications will permit the passage of anadromous fish species as far upstream as the north and south branches. The existing impoundments will continue to support only warm water fisheries. None of the modifications will result in improvements to the existing whitewater features or scenic quality of the segments. Additionally, we do not anticipate any changes in property values associated with the dam modifications.

Relative to current conditions, implementing Alternative 41 will increase the recreation value of residents by approximately $83,000. This increase represents the present value over 30 years. In addition, we expect tourism spending to increase. The present value estimate of the increase in tourism spending over 30 years is $1.44 million. Finally, once the fishery improvements have realized their maximum potential, we expect that the tourism-based jobs will increase by 4 jobs per year.

<u>Property values</u>
The modifications to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam would not have a significant impact on property values within ½ mile of the dam.

<u>Cost of the modifications</u>
The annual maintenance of the dams is estimated to be as follows:
Union Street = $30,000-50,000
Sabin Dam = $30,000-60,000
Boardman Dam = $30,000-60,000
Brown Bridge Dam = $30,000-60,000
The estimate to maintain the dams was obtained from County employees who currently maintain two of the dams. The maintenance cost would not be changed significantly if the dams are modified, however, if the dams are used for power generation we have assumed there would be an additional operation and maintenance annual cost of $100,000 to $200,000 per dam.

TABLE 15: PROBABLE CONSTRUCTION COST OF REPAIRS AND MODIFICATIONS WITHOUT HYDROELECTRICITY

Dam	Low Cost Estimate	High Cost Estimate
Union Street Repairs and Modifications	$1,430,000	$2,150,000
Sabin Dam Repairs and Modifications	$1,630,000	$2,260,000
Boardman Dam Repairs and Modifications	$2,230,000	$3,060,000
Brown Bridge Repairs and Modifications	$2,780,000	$4,760,000
Alt.41 Total	$8,070,000	$12,230,000

TABLE 16: PROBABLE CONSTRUCTION COSTS OF REPAIRS AND MODIFICATIONS WITH HYDROELECTRICITY

Dam	Low Cost Estimate	High Cost Estimate
Union Street Repairs and Modifications	$1,430,000	$2,150,000
Sabin Dam Repairs and Modifications	$1,930,000	$2,710,000
Boardman Repairs and Modifications	$3,430,000	$5,110,000
Brown Bridge Repairs and Modifications	$2,900,000	$7,210,000
Alt.41 Total with Hydroelectricity	$9,690,000	$17,180,000

These estimates include the recommended repairs to the dams as well as modifications. The estimates for repairing Union Street and Brown Bridge dams were developed by STS in their study of Union Street and Brown Bridge Dam (STS, 2008) and for Sabin and Boardman Dam by ECT and Prein and Newhof as part of the detailed analysis of alternatives for the dams. The cost estimate for modifying the dams to allow fish passage, updated emergency spillways, and a cold water discharge at Brown Bridge Dam was prepared by ECT and Prein and Newhof as part of this study. A detailed summary of the cost estimates is provided in Appendix D.

Property tax implications

The modifications to the Union Street Dam, Sabin Dam, Boardman Dam, and Brown Bridge Dam could have an impact on property taxes if that is the source of funds used to implement the modifications. However, there are numerous options for funding the modifications and a decision as to the source of funding has not been made at this time.

Jobs

The modifications would create some local construction jobs and jobs associated with increased recreational use of the Boardman River and its impoundments.

Hydroelectricity

If electricity is generated at Sabin Dam, Boardman Dam, and Brown Bridge Dam then additional modifications would be required. The modification to Boardman Dam and Brown Bridge Dam to comply with DEQ and FERC regulations would need to modify the spillway. The modification that meets DEQ regulations without electricity generation assumes that flood water would pass through the penstocks unimpeded by a turbine. If the dams are used for electricity, the turbine impedes the flow of water and other modifications need to be made to the spillway in order to comply with state and federal statutes.

Electricity quantities are identified using a combination of river flow and dam-specific information, including head and turbine efficiency as identified in Bingham et al (2008). At the expected level of hourly generation and historical hourly prices annual revenues are estimated at $452,000. Michigan's "21st Century Electric Energy Plan" (Lark 2007) recommends a portfolio standard that requires load-serving entities to provide 10 percent of their energy sales from renewable energy options by the end of 2015. Load-serving entities can meet the standard in several ways including buying qualifying renewable energy credits. Revenue from renewable energy credits is estimated at $15 per megawatt hour beginning in 2015. With this value and electricity prices that increase at 3% the estimated net present value over 30 years for re-powering the dams is $9,100,000.

ALTERNATIVE 43: REPAIR UNION STREET DAM, REMOVE SABIN DAM, AND MODIFY BOARDMAN AND BROWN BRIDGE DAMS

DESCRIPTION OF THE ALTERNATIVE

This alternative was developed in conjunction with the BRDC and the alternative consists of a variety of actions. Alternative 43 consists of repairing Union Street Dam, removing Sabin Pond (either totally or partially), and modifying Boardman and Brown Bridge dams.

Union Street Dam would be **repaired** as follows:

- Repair and realign trash racks in Bay #2 of the principal spillway
- Lubricate and exercise all principal spillway gate operator stems.
- Construct a toe drain system on the downstream slope of the embankment near the downstream headwall.
- Construct a toe drain just upstream of the principal spillway outlet headwall.
- Remove trees/ stumps present on the downstream slope of the earthen embankment.
- Repair or reline the discharge culverts.

Sabin Pond would be **removed** by removing the dam under different scenarios. The first scenario is a partial removal of the dam by breaching the dam and allowing the water in the impoundment to drop to a point where only the Boardman River exists and the impoundment has been removed. The second scenario would breach the dam and after the impoundment has been drained the power houses, spillway and earthen embankment would be completely removed.

The **modifications** to Boardman Dam and Brown Bridge Dam are intended to address fish access and passage, emergency spillway capacity and mitigating the impact of warm water discharge at Brown Bridge Dam. The following is a summary of the modifications that would be included in this alternative.

Boardman Dam:

Boardman Dam could be modified in two ways. First, a fish passageway would be built to allow Great Lakes fish species to pass over the dam and gain access to Boardman Pond and its tributaries. During discussions on various fish passage options at a BRDC meeting, the consensus seemed to be that fish passageways were preferable to fish ladders. Fish passageways have recently been used as replacements for fish ladders for a number of reasons. In the case of Boardman Dam, the primary benefit is that a fish passageway could allow all Great Lakes fish to pass over the dam. Currently, fish species are not able to pass over the dam. The fish passageway could be constructed by placing a ramp made of stone and soil along the downstream side of the dam. The gradually sloped fish passageway could allow Great Lakes fish species to access the impoundment at Boardman Pond.

In 2007, Boardman Pond was lowered in order for the dam to comply with the MDEQ Dam Safety regulations. The dam was lowered as a result of a consent agreement between Grand Traverse County and the MDEQ which specified a number of actions the County was to undertake in order to provide for the safety of the dam and specifically, the safety of the spillway. The water level in the impoundment, which was lowered approximately 16 feet, could be raised if the modification described above is acceptable to the MDEQ.

Brown Bridge Dam:

Brown Bridge Dam would be modified in two ways. First, a fish passageway could be built to allow Great Lakes fish species to pass over the dam and gain access to Brown Bridge Pond and its tributaries. During discussions on various fish passage options at a BRDC meeting, the consensus seemed to be that fish passageways were preferable to fish ladders. Fish passageways have recently been used as replacements for fish ladders for a number of reasons. In the case of Brown Bridge Dam, the primary benefit is that a fish passageway could allow all Great Lakes fish to pass over the dam. Currently, fish species are not able to pass over the dam. The fish passageway could be constructed by placing a ramp made of stone and soil along the downstream side of the dam. The gradually sloped fish passageway could allow Great Lakes fish species to access the impoundment at Brown Bridge Pond.

The second modification could be to address the warm water discharge from Brown Bridge Dam. Several years ago, a study determined that the warmer surface waters of Brown Bridge Pond were impacting the Boardman River downstream of the dam and having an adverse impact on the cold water fish species that should be prevalent in the river. One common modification used to address the impact of warm water discharges from dams is to construct a bottom draw at the dam. A bottom draw is a pipe that is installed below the surface of the impoundment at a depth where the pipe collects and discharges cold water at the bottom of the impoundment, thus mitigating the impact of warmer surface water that use discharge into the river. While this technique has been successfully implemented at some locations, it is not clear that the volume of cold water beneath the surface at Brown Bridge Pond is sufficient to mitigate the potential impact of warm water discharges for an entire growing season.

The status of the flood control spillway at the dam is a complex issue. If electricity is generated at the dam, then an emergency spillway may be required to meet FERC regulations. In 2004, when Travers City Light and Power (TCLP) operated the dams, an improved spillway that met FERC requirements was designed. TCLP decided to discontinue operations at the dams, so the spillway was not constructed. If electric power generation is restored at the dam, then, there is a potential for FERC to require a new and improved spillway be constructed.

ENVIRONMENTAL IMPACTS OF THE REPAIR, REMOVAL, AND MODIFICATIONS

Effects on Terrestrial Habitats and Wetlands

Repairing the Union Street Dam would not change the water level in the impoundment. Therefore, no change in the acreage of either terrestrial or wetland habitat is anticipated. No new terrestrial habitat and no new wetlands are likely to form as a result of this alternative. The less urbanized uplands surrounding the southern half of Boardman Lake would remain dominated by deciduous, evergreen, and mixed forests. Wetlands within the impoundment would remain dominated by submerged and floating aquatic vegetation. Wetlands near or adjacent to the impoundment would remain dominated by scrub-shrub and emergent vegetation. No changes to the quantity or quality of potential king rail or common loon habitat are anticipated.

Proposing to remove or partially remove the Sabin Dam would lower the impoundment's water level approximately 1-20 feet depending on the location in Sabin Pond. As a result of this decrease in water elevation, it is anticipated that the existing terrestrial habitats surrounding Sabin Pond would remain unchanged and that approximately 13 acres of new upland habitat would form. These additional 13 acres of upland are anticipated to develop 1) along the entire western edge of the impoundment, approximately 100 feet from the current edge of water and 2) along north and central portions of the eastern edge of the impoundment, approximately 100 feet from the current edge of water. The upland slope along the western edge of the impoundment is very steep, and uplands along the north- and mid-eastern side of the pond also have moderately sloping topography. Thus, new uplands are likely to form where open water and submerged and floating aquatic habitats currently cover the toe of slope.

Initially, these new upland areas would be seeded by pioneer herbaceous and woody species from adjacent deciduous, evergreen, and mixed forests. Dominant species might initially include white ash, red maple, eastern cottonwood (*Populus deltoides*), trembling aspen (*Populus tremuloides*), autumn olive (*Elaeagnus umbellata*), honeysuckle (*Lonicera* spp.), tall goldenrod (*Solidago altissima*), and bracken fern. Over time, these upland areas are anticipated to succeed to a mixed northern hardwoods-conifer forest dominated by sugar maple, red maple, eastern white pine, American beech (*Fagus grandifolia*), and white oak. Depending upon the spread of the emerald ash borer and intensity of white-tailed deer browsing, white ash and eastern hemlock (*Tsuga canadensis*) may also become established at lower densities in the long term.

Effects on Wetlands

As a result of this decrease in water elevation, it is anticipated that both wetland acreage and type would change within the Sabin Pond impoundment. Overall, approximately 28 acres of wetland are anticipated to form following drawdown of the impoundment. As described above, less than half of the submerged/floating/emergent wetlands located within the impoundment over the toe of slope are likely to form uplands. However, over half of these low diversity submerged/floating/emergent wetlands are anticipated to succeed to emergent wetlands initially. New emergent wetlands would likely be dominated by a more diverse set of wetland species, including blue vervain (*Verbena hastata*), swamp milkweed (*Asclepias incarnata*), common cattail (*Typha spp.*), black bulrush (*Scirpus atrovirens*), hardstem bulrush, spotted joe pye weed, jewelweed, common boneset (*Eupatorium perfoliatum*), sensitive fern (*Onoclea sensibilis*), and beggar-ticks (*Bidens* spp.). Over time, it is anticipated that these new emergent wetlands would succeed to approximately 5 acres of forested/scrub-shrub wetlands with dominants such as northern white-cedar, red maple, common elder, and marsh shield fern. Several small forested/scrub-shrub/emergent wetlands directly adjacent to the west side of the impoundment may also be impacted by the drawdown. Due to the presence of groundwater seepage as a source of hydrology, it is unlikely that these small wetlands would convert to uplands following drawdown. When surface water influences are removed as the water elevation is lowered, it is more likely that these wetlands would shift from emergent/scrub-shrub to a slightly drier species composition with dominance by wetland trees and shrubs.

Throughout the central portion of the impoundment directly adjacent to the newly formed river channel, it is anticipated that approximately 23 acres of open water would be converted to and remain emergent/scrub-shrub wetland. These permanently emergent/scrub-shrub portions would be similar in structure and composition to areas found elsewhere along the Boardman River and likely be dominated by common elder, silky dogwood (*Cornus amomum*), red-osier dogwood (*Cornus sericea*), sandbar willow (*Salix exigua*), tag alder (*Alnus rugosa*), blue vervain, swamp milkweed, spotted joe pye weed, common boneset, common cattail, black bulrush, sedges (*Carex* spp.), hardstem bulrush, and burreed (*Sparganium* spp.).

Considering 1) the gain in wetland acreage with the conversion of open water areas and 2) the increase in species and structural diversity with the conversion of deep aquatic habitats to emergent and ultimately forested/scrub-shrub systems, partial or total removal of Sabin Dam would improve the quality of and increase the quantity of wildlife habitat available along this stretch of the Boardman River. Deep-water habitats would be replaced by flowing riparian habitats with varying water depth and higher structural and floral and faunal species diversity.

Implementing Alternative 43 at Boardman Dam would return the water level in the impoundment to its original design elevation prior to the 2007 emergency drawdown. It is anticipated that the existing terrestrial habitats surrounding Boardman Pond would remain unchanged and that approximately 21 acres of newly forming upland habitat would be flooded. These additional 21 acres of upland anticipated to be lost occur 1) along the western and eastern edges of the impoundment, approximately 100 feet from the original impoundment's edge of water and 2) along the northern edge of the impoundment, approximately 75 feet from the original impoundment's edge of water. Open water and minimal submerged and floating aquatic habitats with relatively low species diversity are expected to cover the toe of slope in these areas once more. Given the steep grade of these slopes, water depth is anticipated to be too deep to support most wetland plants. It is likely that relatively few species tolerant of deep water, such as floating and sago pondweeds and stonewort, would revegetate the fringe of the impoundment where steep slopes occur underwater.

As a result of the water level in the impoundment returning to its original design elevation prior to the 16-foot emergency drawdown, it is anticipated that approximately 25 acres of newly formed emergent wetland would be converted back to open water habitat along the northeast corner, east central side, and southern end of the original impoundment. Approximately 11 acres of small forested/scrub-shrub/emergent wetlands directly adjacent to the upstream end of the impoundment are likely not to be impacted by the raising of the impoundment's water level.

Considering 1) the loss in wetland acreage with the conversion of newly formed emergent wetland to open water areas and 2) the resulting decrease in species and structural diversity with the conversion of emergent habitats to deep-water habitats, Alternative 43 would likely decrease the quality and the quantity of wildlife habitat available along the shores of Boardman Pond. Given decreases in aquatic and emergent wetlands adjacent to sandy upland habitat, it is likely that Alternative 43 would either 1) not change or 2) decrease the quantity and quality of habitat available for rare species known to occur within the watershed, such as common loon, wood turtle, Blanding's turtle, bald eagle (*Haliaeetus leucocephalus*), red-shouldered hawk, and ebony boghaunter (*Williamsonia fletcheri*).

Alternative 43 (modify the Brown Bridge Dam) would not change the water level in the impoundment. Therefore, no change in the acreage of either terrestrial or wetland habitat is anticipated. No new terrestrial habitat and no new wetlands are likely to form as a result of this alternative. The uplands surrounding Brown Bridge Pond would remain dominated by evergreen and mixed forests. Wetlands within the impoundment would remain dominated by submerged and floating aquatic and emergent vegetation. Wetlands near or adjacent to the impoundment would remain dominated by forested, scrub-shrub, and emergent vegetation.

<u>Effects on Wildlife</u>

The wildlife populations in the Boardman River impoundments were studied as part of the review of existing and baseline conditions (ECT, 2007).

Repairing Union Street Dam, and modifying Boardman Dam and Brown Bridge Dam would not have a significant impact on wildlife habitat, but could have an impact on wildlife populations due to contaminants in Great Lakes fish. Stream-carried sediment would continue to collect in the upstream areas and inlets of the impoundments. This would be most noted in upper Brown Bridge and Boardman Pond. Over time, the sediment accumulation would reduce water depths, increase sandbar and shallow water habitats including emergent vegetation habitats dominated by sedges, spike rushes and other aquatic plants. The scrub-shrub habitats in these inlet areas, that currently include willows, tag alder and ninebark, would expand downstream. Wading bird and shorebird use would increase in shallow water and sandbar areas, songbird, small mammal and amphibian use would increase with the expanded emergent vegetation habitat

Repairing Union Street Dam, and modifying Boardman Dam and Brown Bridge Dam would not have a significant impact on migrant and resident ducks, geese and swan habitat in Boardman Lake and the impoundments. These impoundments provide valuable food resources and sanctuary. The presence of waterfowl in these impoundments provides important recreational and educational opportunities such as waterfowl hunting and wildlife viewing. Modifying the dams would not have a significant impact on these activities.

Repairing Union Street Dam, and modifying Boardman Dam and Brown Bridge Dam would help conserve, and may expand the floating and submergent wetland habitats along shorelines and shallow water areas in Boardman Lake and Brown Bridge Pond. These habitats tend to be rich in aquatic plant life and provide important habitat to aquatic insects and other invertebrates which in turn nurture fish, turtles, toads and frogs, waterfowl and wading birds within the impoundments, as well as songbirds that use adjacent uplands. Approximately 21 acres of wetlands in Boardman Pond would be flooded by modifying Boardman Pond and restoring the historic water level.

Sediment accumulation and aging of the dam structures would increase the potential for significant losses to downstream fish and wildlife habitats and populations, if a dam would fail and release the accumulated sediment into downstream habitats.

Modifying the dams -- lost opportunities for river restoration

By modifying the dams, the positive impacts from dam removal would be lost by not restoring and reconnecting riparian and wetland habitats along the river. The restoration of riparian and wetland habitats is a positive impact because these habitats are two of the most valuable habitat types found in the northern Michigan because of the large number of plants and animals they support. Many songbird species such as the black and white warbler, northern water thrush, cardinal, catbird, and many small mammals including the meadow vole, meadow jumping mouse and short-tailed shrew are more abundant in the moist, diverse habitats similar to those that would be created following dam removal.

Removing the dams would restore the historic, contiguous riparian habitats along the river corridor, benefiting species like the wood turtle (a state threatened species), river otter, mink, bobcat, bear, the white-tailed deer, pine marten, ruffed grouse and red-shouldered hawk (a state threatened species)

Modifying the dams – potential increase in the threat of chemical contamination and introducing invasive species and pathogens.

The dam at Union Street would be maintained at Union Street, restricting fish passage to salmon and steelhead. There is a potential for contaminants, such as PCB and DDT, that are in the tissue of Great Lakes fish to be introduced into the Boardman River upstream from Sabin Dam.

Effects on Wildlife of Removing Sabin Dam

Partial or total removal of Sabin Dam would have a variety of effects on the existing wildlife populations in the Sabin Pond. One change would be to increase habitat diversity and, hence, wildlife species diversity in the new habitat created after the drawdown. In addition, the removal, whether partial or total, would reconnect riverine habitats fragmented by the Sabin impoundment benefiting species such as the wood turtle, mink, river otter, bobcat, bear, and white-tailed deer and many others. The drawdown of Sabin Pond would replace a 40 acre impoundment of still-water habitat conditions with a river, thus reducing loafing and foraging habitat for migrating and resident waterfowl. Boardman Lake and many other areas are suitable alternative loafing sites, but the waterfowl that currently use Sabin Pond would relocate to other areas. Habitat for painted and snapping turtles would be replaced with habitat for other reptiles, amphibians, small mammals and song birds.

In the study of newly exposed habitat on Boardman Pond, ECT (2007) determined that numerous species of wildlife were using the newly exposed bottomlands. Their study reported that meadow voles were found in good numbers in the newly created lush herbaceous habitat on the recently exposed bottomlands at Boardman Pond, indicating their quick response and adaptability to these habitat changes caused by the emergency drawdown. Based on these data it is likely that the exposed bottomlands would be used as new habitat by 39 species of mammals, 77 species of songbirds, wading birds, amphibians, snakes, lizards and waterfowl.

Partial or complete dam removal would allow migrating Great Lakes fish which are contaminated with PCBs and other chemicals to enter the Boardman River above Sabin dam, and increase the potential threat of contamination of food webs in the upper watershed. The introduction of contaminants through migrating Great Lakes fish into the Boardman River could result in declines in species sensitive to contaminants, such as mink, river otters, wood and snapping turtles, herons, bald eagles, and loons. These wildlife populations are currently exposed to contaminants from a number of sources, but the concern is the effect contaminants in Great Lakes fish could have on sensitive wildlife populations.

Effects on Fisheries

Under the existing conditions, the longest free flowing river segment is 13.8 miles (Segment 6). The remainder of the river is fragmented into smaller segments by the dams and their impoundments. Removing Sabin Dam would create 0.7 miles of new stream channel in its former impoundment. The existing warm water fishery in Sabin Pond would be replaced with a second quality cold water fishery connected to 2.2 miles in Segment 3. Alternative 43 maintains the warm water fisheries of Boardman Pond, and Brown Bridge Pond. Modifications at Sabin, Boardman, and Brown Bridge dams would include fish passage, which connects 22.7 miles of unimpounded river upstream of Boardman Lake to the forks, including 0.7 miles of new stream channel in the former impoundment. The existing fish ladder at Union Street Dam would allow salmon and steelhead to gain access to all 22.0 miles. Modification of Boardman and Brown Bridge dams to reduce downstream water temperature would increase resident trout abundance and increase natural reproduction in the first one to two miles downstream of the dams. Alternative 43 does not eliminate all of the negative effects that the dams currently have on the Boardman River and West Arm Grand Traverse Bay fisheries. Although removal of Sabin and fish passage at Boardman and Brown Bridge dams would benefit the fisheries, the overall productivity of the Boardman River would still be suppressed by negative effects of the Boardman and Brown Bridge dams. It is not likely that fish passage would allow all species to freely migrate between unimpounded segments of the river with high efficiency. Furthermore, modifications would not address the altered state of transportation and storage of sediment, organic matter, and large woody debris. The existing top quality cold water fisheries upstream of Boardman Pond would be maintained in their current state. The Union Street Dam fish ladder would not be modified. Therefore, sea lamprey control would not be affected. However, sturgeon and other desirable cool water species would not be able to access spawning habitat upstream of Boardman Lake.

Natural reproduction in the 22.0 miles of free flowing river upstream of Boardman Lake to the forks could produce 400 adult Chinook salmon, 350 adult coho salmon, and 1,200 adult steelhead in addition to existing runs. Salmon and steelhead would be distributed throughout the Boardman River up to the headwaters, creating a new shore fishery during fall and spring runs upstream of Sabin Dam. Salmon and steelhead abundance would decrease moving upstream due to attrition from fish passage efficiencies less than 100% at Union Street Dam, natural mortality, harvest, and spawning habitat distribution. The anadromous salmonid fisheries, particularly salmon, would result in dead fish carcasses and increased fishing pressure that have associated negative social perceptions among the general public, riparian landowners, and outdoor enthusiasts.

Changes specific to certain river segments are discussed in detail below.

Segment 1 – Union Street Dam to West Arm Grand Traverse Bay

The physical channel conditions and fish habitat in Segment 1 would not change. Segment 1 would be connected to 22.7 miles of unimpounded river between the dams/impoundments upstream to the forks due to the removal of Sabin Dam and installation of fish passage at Boardman Dam and Brown Bridge Dam. The existing second quality cold water and mixed warm/cool water fisheries in Segment 1 would not change. Both of these fisheries are limited by physical habitat alteration, warm-water discharge from Union Street Dam, and low natural reproduction. Sea lamprey management would not be impacted. The existing salmon and steelhead fisheries would benefit from increased natural reproduction, resulting in higher abundance of adult fish during spawning migrations and higher catch rates.

Segment 2 – Boardman Lake

While the number of salmon and steelhead passing the Union Street Dam and entering Boardman Lake would increase, it is not likely that a significant boat fishery would result. Creel data collected by the MDNR in 2005 indicate that all salmon and steelhead caught between Sabin Dam and the West Arm Grand Traverse Bay are currently caught by shore anglers. This fishery condition is not expected to change under Alternative 43.

Segment 3 – Sabin Dam to Boardman Lake

Segment 3 would be connected to 0.7 miles of unimpounded river upstream in the former Sabin Pond. Due to dam removal and transport of sediment downstream, the habitat in Segment 3 would change over time, with an expected decrease in depth and increase in riffle and run bed forms. Brown trout are currently present in low numbers, but are larger and of older age than Segments 6 and 8. Good adult habitat is present, but spawning habitat is limited. With connection to new stream channel in the former Sabin Pond, spawning habitat in Segment 3 would increase, but only slightly due to the relatively short length of new river channel. The abundance of younger age classes would increase. The existing salmon and steelhead fisheries would benefit from increased natural reproduction, resulting in higher abundance of adult fish during spawning migrations and higher angler catch rates.

Segment 4 – Sabin Pond (Sabin Dam)

The existing impoundment would be replaced with 0.7 miles of new stream channel. Segment 4 would be connected to 2.2 miles of unimpounded river downstream (Segment 3) and 19.8 miles of unimpounded river upstream (Segments 6 and 8) to the forks. The existing warm water fishery would be replaced with a top quality cold water fishery with trout densities similar to those of Segment 6. The poor survival of older age classes present in Segment 6 may be replicated in Segment 4. The presence of salmon and steelhead would create a new anadromous salmonid shore fishery. The anadromous salmonid fisheries, particularly salmon, would result in dead fish carcasses and increased fishing pressure that have associated negative social perceptions among the general public, riparian landowners, and outdoor enthusiasts.

Segment 5 – Boardman Pond (Boardman Dam)

While the number of salmon and steelhead passing the Union Street Dam would increase and salmon and steelhead would be able to pass Boardman Dam, it is not likely that a significant boat fishery would result in Boardman Pond. Creel data collected by the MDNR in 2005 indicate that all salmon and steelhead caught between Sabin Dam and the West Arm Grand Traverse Bay are currently caught by shore anglers. The existing warm water fishery in Boardman Pond would be maintained.

Segment 6 – Brown Bridge Dam to Boardman Pond (Boardman Dam)

Under Alternative 43, Segment 6 would be connected to 4.1 miles of unimpounded river downstream (Segments 1, 3, and 4) due to installation of fish passage at Boardman Dam. Segment 6 would also be connected to 6.0 miles of free flowing river upstream (Segment 8) to the forks due to installation of fish passage at Brown Bridge Dam. The existing second quality cold water fishery would be maintained, and would benefit from reduction of water temperature discharging from Brown Bridge Dam. The abundance of existing resident trout in the first one to two miles downstream of Brown Bridge Dam is expected to increase due to lower water temperature. The presence of salmon and steelhead would create a new anadromous salmonid shore fishery. The anadromous salmonid fisheries, particularly salmon, would result in dead fish carcasses and increased fishing pressure that have associated negative social perceptions among the general public, riparian landowners, and outdoor enthusiasts.

Segment 7 – Brown Bridge Pond (Brown Bridge Dam)

While the number of salmon and steelhead passing the Union Street, Boardman, and Brown Bridge dams would increase and salmon and steelhead would be able to access Brown Bridge Pond, it is not likely that a significant boat fishery would result in Brown Bridge Pond. Creel data collected by the MDNR in 2005 indicate that all salmon and steelhead caught between Sabin Dam and the West Arm Grand Traverse Bay are currently caught by shore anglers. The existing warm water fishery in Brown Bridge Pond would be maintained.

Segments 8, 9, & 10 – Headwaters to Brown Bridge Pond

Under Alternative 43, the Boardman River upstream of Brown Bridge Pond (Segment 8) and the South and North Branches (Segments 9 & 10) would be connected to 17.9 miles of unimpounded river downstream (Segments 1, 3, 4, and 6) due to removal of Sabin dam and installation of fish passage at Boardman and Brown Bridge dams. The existing top quality cold water fishery would be maintained. The presence of salmon and steelhead would create a new anadromous salmonid shore fishery. The anadromous salmonid fisheries, particularly salmon, would result in dead fish carcasses and increased fishing pressure that have associated negative social perceptions among the general public, riparian landowners, and outdoor enthusiasts.

Sediment

The repair to Union Street Dam and modifications to the Boardman Dam and Brown Bridge Dam would not have a significant impact on sediment quality or transport.

The stored sediment volume in Sabin Pond is relatively low, so Option 3 could be implemented and a controlled sediment management program could be implemented. The initial sediment chemistry data indicates that the sediment is contaminated with heavy metals. However, there are reasons to consider

Option 1 and to explore the nature and extent of sediment contamination in the impoundment. Prior to implementing Option 1 sediment chemistry would need to be submitted to the MDEQ and approval given that the sediment does not pose a threat to the aquatic environment.

The study of existing conditions in the Boardman River indicates that Segment 3 downstream of Sabin Dam has been affected by sediment starvation. Given this condition, it may be acceptable to release sediment from Sabin Dam, assuming the sediment does not pose a risk to the environment, during a controlled drawdown and breach/removal (Option 1). A controlled drawdown of water elevation allows sediment transported at the head of the impoundment to be redeposited further downstream in the impoundment, thereby reducing the overall volume of sediment that would be transported downstream into Segment 3. The habitat characteristics of Segment 3 would change, with a reduction in pool habitat and pool depth, but increase in run and riffle bedforms. This approach would reduce sediment management costs. Option 3 would increase costs, but would avoid the expected changes to Segment 3. Segment 3 currently supports a brown trout population with large size but low abundance. Habitat changes in Segment 3 resulting from Option 1 sediment management may alter the brown trout fishery, possibly decreasing abundance of large brown trout and increasing the abundance of younger age classes. Restoring a natural sediment transport regime would benefit the ecology of the Boardman River in Segment 3. The altered sediment transport regimes downstream of Boardman and Brown Bridge dams would not be addressed.

Stream channel morphology

The repair to the Union Street Dam and modifications to Boardman Dam and Brown Bridge Dam would not have a significant impact on stream channel morphology. Approximately 0.7 miles of new river channel would develop in the area currently occupied by Sabin Pond.

Threatened and endangered species

The repair to the Union Street Dam would not have a significant impact on habitat used by threatened or endangered species. Habitat quantity and quality for wood turtle and Blanding's turtle at Sabin Pond could increase if Sabin Dam is removed. Given that modifying Boardman Dam could decrease the area of newly formed aquatic and emergent wetlands, there could be a decrease in habitat available for rare species known to occur within the watershed, such as wood turtle, Blanding's turtle, bald eagle (*Haliaeetus leucocephalus*), red-shouldered hawk, and ebony boghaunter (*Williamsonia fletcheri*). The open water habitat for the common loon would be restored to its historic level and this species could benefit from the restored water level in Boardman Pond. Modifying Brown Bridge Dam would not change the quantity or quality of common loon, bald eagle, red-shouldered hawk, trumpeter swan, wood turtle, or Blanding's turtle habitat.

Water quality

The repair to the Union Street Dam, removal of Sabin Dam and modifications to Boardman Dam and Brown Bridge Dam could have a significant impact on water quality. The adverse impact to the Boardman River caused by warm water discharge from Brown Bridge Pond could be mitigated by implementing the bottom draw system that discharges cold water at the bottom of the impoundment instead of the warm water on the surface of the impoundment.

Ground water

The repair to the Union Street Dam, removal of Sabin Dam and modifications to Boardman Dam and Brown Bridge Dam would not have a significant impact on ground water resources.

ENGINEERING IMPACTS

Transportation and infrastructure

The repair to the Union Street Dam, removal of Sabin Dam and modifications to Boardman Dam and Brown Bridge Dam would not have a significant impact on transportation and infrastructure. There are utilities located at the Union Street Dam and the modifications included in Alternative 43 would not include rerouting the water main that currently exists at Union Street.

Hydrology and hydraulics

The repair to the Union Street Dam, removal of Sabin Dam and modifications to Boardman Dam and Brown Bridge Dam would not have a significant impact on hydrology and hydraulics of the Boardman River in the vicinity of the dams.

Flood plain changes

The repair to the Union Street Dam and modifications to Boardman Dam and Brown Bridge Dam would not have a significant impact on flood plains on the impoundments and lakes because the modifications would not change the water levels in the impoundments or lakes. The floodplain at Sabin Pond would lower as a result of removing the impoundment. The new floodplain elevation is shown in Appendix C.

Stream bank stabilization

The repair to the Union Street Dam and modifications to Boardman Dam and Brown Bridge Dam would not have a significant impact on stream banks and would not require additional stream bank stabilization efforts because the modifications would not change the water level in the lakes or flow patterns in the river. Some portions of the stream bank of the new river channel could require stabilization to avoid excessive sedimentation and loss of terrestrial and wetland habitat.

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Water supplies and on-site waste water treatment systems

The repair to the Union Street Dam, removal of Sabin Dam and modifications to Boardman Dam and Brown Bridge Dam would not have a significant impact on water supplies and on-site wastewater treatment systems

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SOCIETAL IMPACTS

Property boundaries and rights

The repair to the Union Street Dam, removal of Sabin Dam and modifications to Boardman Dam and Brown Bridge Dam would not have a significant impact on property boundaries or property rights.

Risks to property owners

The repair to the Union Street Dam, removal of Sabin Dam and modifications to Boardman Dam and Brown Bridge Dam would not have a significant impact on risks to property owners and may alleviate some risks as a result of the modifications made to the dams.

Historic status of dams and power houses

The repair to the Union Street Dam, removal of Sabin Dam and modifications to Boardman Dam and Brown Bridge Dam would not have a significant impact on historic or cultural resources in the vicinity of the dams.

Impact on County's Natural Education Reserve

The repair to the Union Street Dam and modifications to Boardman Dam and Brown Bridge Dam would not have a significant impact on the County's Natural Education Reserve. Removal of Sabin Dam would mean that the hike called "The Wonder of Ponds" would need to be replaced with a walk on wetland restoration, river ecology, channel geomorphology or similar walk.

ECONOMIC IMPACTS

Recreation and Tourism

With the removal of Sabin dam and modifications of Boardman and Brown Bridge Dams, we anticipate that changes in stream hydrology and fish habitats will alter recreation opportunities associated with the Boardman River. Under this alternative, Sabin Pond will become a free-flowing river segment. The removal of Sabin Dam will change the nature of the fishery for this segment. In addition, the dam modifications will permit the passage of anadromous species as far upstream as the north and south branches. In addition, catch rates for anadromous fish species in western Grand Traverse Bay are predicted to improve. Moreover, some segments will offer more "whitewater" under this alternative than current conditions do, consequently changing recreational paddling opportunities. The former impoundment is predicted to become more scenic, as well. The existing warm water fisheries for Boardman Lake, Boardman Pond, and Brown Bridge Pond will not be materially affected.

Relative to current conditions, implementing Alternative 43 will increase the recreation of residents value by approximately $133,000. This increase represents the present value over 30 years. In addition, we expect tourism spending to increase. The present value estimate of the increase in tourism spending over 30 years is $1.50 million. Finally, once the fishery improvements have realized their maximum potential, we expect that the tourism-based jobs will increase by 4 jobs.

Property values

The repair to the Union Street Dam, removal of Sabin Dam and modifications to Boardman Dam and Brown Bridge Dam would not have a significant impact on property values within ½ mile of the dam.

In addition to impacts on recreation values and tourism expenditures, the removal of Sabin Dam will likely affect the property values of residential parcels near the existing impoundment. The discussion related to Alternative 25 provides the context and caveats associated with estimated changes in property values. Table 15 shows how the total assessed value of residential parcels within a ½ mile of the Boardman River would change if Alternative 43 were implemented. Initially, the aggregate assessed value of the properties could fall by as much as $0.2 million. Over time, the aggregate assessed value may increase by as much as $0.7 million. The present value of this change is $0.43 million.

TABLE 17: ESTIMATED CHANGES IN ASSESSED VALUE OF RESIDENTIAL PARCELS UNDER ALTERNATIVE 43
($ Millions)

Number of Years Since Removal	Value with Current Conditions	Value with Alternative 43	Estimated Change in Assessed Value	Percent Change
1	$331.3	$331.1	$(0.2)	–0.1%
2	$331.3	$331.1	$(0.2)	–0.1%
3	$331.3	$331.4	$0.0	0.0%
4	$331.3	$331.4	$0.1	0.0%
5	$331.3	$331.4	$0.1	0.0%
6	$331.3	$331.5	$0.2	0.0%

7	$331.3	$331.5	$0.2	0.1%
8	$331.3	$331.6	$0.2	0.1%
9	$331.3	$331.6	$0.3	0.1%
10	$331.3	$331.6	$0.3	0.1%
11	$331.3	$331.7	$0.3	0.1%
12	$331.3	$331.7	$0.4	0.1%
13	$331.3	$331.8	$0.4	0.1%
14	$331.3	$331.8	$0.5	0.1%
15	$331.3	$331.8	$0.5	0.2%
16	$331.3	$331.9	$0.5	0.2%
17	$331.3	$331.9	$0.6	0.2%
18	$331.3	$331.9	$0.6	0.2%
19	$331.3	$332.0	$0.7	0.2%
20	$331.3	$332.0	$0.7	0.2%

Note: Future values noted here do not reflect any influences on property values except those uniquely associated with dam removal. General appreciation of values over time is not reflected in this table.

Cost of the modifications
The annual maintenance of the dams is estimated to be as follows:
Union Street = $30,000-50,000
Boardman Dam = $30,000-60,000
Brown Bridge Dam = $30,000-60,000
The estimate to maintain the dams was obtained from County employees who currently maintain two of the dams. The maintenance cost would not be changed significantly if the dams are modified.

TABLE 18: PROBABLE CONSTRUCTION COST OF ALTERNATIVE 43.

Dam	Low Cost Estimate	High Cost Estimate
Union Street Repairs	$430,000	$650,000
Sabin Dam Partial Removal	$360,000	$1,013,000
Sabin Dam Total Removal	$1,870,000	$3,683,000
Boardman Dam Repairs and Modifications	$2,230,000	$3,060,000
Brown Bridge Repairs and Modifications	$3,380,000	$5,560,000
Alt.43 Total with Partial Removal	$6,400,000	$10,283,000
Alt. 43 Total with Total Removal	$7,910,000	$12,953,000

These estimates include the recommended repairs to the dams as well as modifications. The estimates for repairing Union Street and Brown Bridge dams were developed by STS in their study of Union Street and Brown Bridge Dam (STS, 2008) and for Sabin and Boardman Dam by ECT and Prein and Newhof as part of the detailed analysis of alternatives for the dams. The cost estimate for modifying the dams to allow fish passage, updated emergency spillways, and a cold water discharge at Brown Bridge Dam was prepared by ECT and Prein and Newhof as part of this study. A detailed summary of the cost estimates is provided in Appendix D.

Property tax implications

The repair to the Union Street Dam, removal of Sabin Dam and modifications to Boardman Dam and Brown Bridge Dam could have an impact on property taxes if that is the source of funds used to implement the modifications. However, there are numerous options for funding the modifications and a decision as to the source of funding has not been made at this time.

Jobs

The modifications would create some local construction jobs and jobs associated with increased recreational use of the Boardman River and its impoundments.

Hydroelectricity

If electricity is generated at Boardman Dam and Brown Bridge Dam then additional modifications would be required. The modification to Boardman Dam and Brown Bridge Dam to comply with DEQ and FERC regulations would need to modify the spillway. The modification that meets DEQ regulations without electricity generation assumes that flood water would pass through the penstocks unimpeded by a turbine. If the dams are used for electricity, the turbine impedes the flow of water and other modifications need to be made to the spillway in order to comply with state and federal statutes.

ALTERNATIVE 79: RETAIN AND REPAIR UNION STREET, REMOVE SABIN, BOARDMAN, AND BROWN BRIDGE DAMS

DESCRIPTION OF THE ALTERNATIVE

The dams are inspected on a regular basis and the following repairs have been recommended as a result of those inspections.

Union Street Dam:

- Repair and realign trash racks in Bay #2 of the principal spillway
- Lubricate and exercise all principal spillway gate operator stems.
- Construct a toe drain system on the downstream slope of the embankment near the downstream headwall.
- Construct a toe drain just upstream of the principal spillway outlet headwall.
- Remove trees/ stumps present on the downstream slope of the earthen embankment.
- Repair or reline the discharge culverts.

Sabin Dam, Boardman Dam, and Brown Bridge Dam would be removed by removing the dams under different scenarios. The first scenario is a partial removal of the dam by breaching the dam and allowing the water in the impoundment to drop to a point where only the Boardman River exists and the impoundment has been removed. The second scenario would breach the dams and after the impoundment has been drained the power houses, spillways and earthen embankments would be completely removed.

ENVIRONMENTAL IMPACTS OF THE ALTERNATIVE

Effects on Terrestrial Habitats and Wetlands

Retaining and repairing the Union Street Dam would not change the water level in the impoundment. Therefore, no change in the acreage of either terrestrial or wetland habitat is anticipated. No new terrestrial habitat and no new wetlands are likely to form as a result of this alternative. The less urbanized uplands surrounding the southern half of Boardman Lake would remain dominated by deciduous, evergreen, and mixed forests. Wetlands within the impoundment would remain dominated by submerged and floating aquatic vegetation. Wetlands near or adjacent to the impoundment would remain dominated by scrub-shrub and emergent vegetation. By keeping the Union Street Dam in place, upstream reaches of the Boardman River and its associated habitats would be protected by inhibiting the upstream migration of sea lamprey and other Great Lakes invasive species. No changes to the quantity or quality of potential king rail or common loon habitat are anticipated.

Alternative 79 retain and repair the Union Street Dam would not change the water level in the impoundment. Therefore, no change in the acreage of either terrestrial or wetland habitat is anticipated. No new terrestrial habitat and no new wetlands are likely to form as a result of this alternative. The uplands surrounding Boardman Lake would remain dominated by evergreen and mixed forests. Wetlands within the impoundment would remain dominated by submerged and floating aquatic and emergent vegetation. Wetlands near or adjacent to the impoundment would remain dominated by forested, scrub-shrub, and emergent vegetation.

Removing Sabin Pond would decrease water levels in the pond and both wetland acreage and type would change within the former Sabin Pond impoundment. Overall, approximately 28 acres of wetland are anticipated to form following drawdown of the impoundment. As described above, less than half of the submerged/floating/emergent wetlands located within the impoundment over the toe of slope are likely to form uplands. However, over half of these low diversity submerged/floating/emergent wetlands are anticipated to succeed to emergent wetlands initially. New emergent wetlands would likely be dominated by a more diverse set of wetland species, including blue vervain (*Verbena hastata*), swamp milkweed (*Asclepias incarnata*), common cattail (*Typha spp.*), black bulrush (*Scirpus atrovirens*), hardstem bulrush, spotted joe pye weed, jewelweed, common boneset (*Eupatorium perfoliatum*), sensitive fern (*Onoclea sensibilis*), and beggar-ticks (*Bidens* spp.). Over time, it is anticipated that these new emergent wetlands would succeed to approximately 5 acres of forested/scrub-shrub wetlands with dominants such as northern white-cedar, red maple, common elder, and marsh shield fern. Several small forested/scrub-shrub/emergent wetlands directly adjacent to the west side of the impoundment may also be impacted by the drawdown. Due to the presence of groundwater seepage as a source of hydrology, it is unlikely that these small wetlands would convert to uplands following drawdown. When surface water influences are removed as the water elevation is lowered, it is more likely that these wetlands would shift from emergent/scrub-shrub to a slightly drier species composition with dominance by wetland trees and shrubs.

Throughout the central portion of the impoundment directly adjacent to the newly formed river channel, it is anticipated that approximately 23 acres of open water would be converted to and remain emergent/scrub-shrub wetland. These permanently emergent/scrub-shrub portions would be similar in structure and composition to areas found elsewhere along the Boardman River and likely be dominated by common elder, silky dogwood (*Cornus amomum*), red-osier dogwood (*Cornus sericea*), sandbar willow (*Salix exigua*), tag alder (*Alnus rugosa*), blue vervain, swamp milkweed, spotted joe pye weed, common boneset, common cattail, black bulrush, sedges (*Carex* spp.), hardstem bulrush, and burreed (*Sparganium* spp.).

Considering 1) the gain in wetland acreage with the conversion of open water areas and 2) the increase in species and structural diversity with the conversion of deep aquatic habitats to emergent and ultimately forested/scrub-shrub systems, partial or total removal of Sabin Dam would improve the quality of and increase the quantity of wildlife habitat available along this stretch of the Boardman River. Deep-water habitats would be replaced by flowing riparian habitats with varying water depth and higher structural and floral and faunal species diversity.

Removing the impoundment at Boardman Pond would change the wetland acreage and type within the Boardman Pond impoundment. Overall, approximately 69 acres of wetland are anticipated to form in the long term. As described above, approximately 25 of these 69 acres are new emergent wetlands forming in the northeast corner, east central side, and southern end of the original impoundment. Approximately 11 acres of additional emergent wetland is also expected to form along the west and east central sides of the impoundment currently covered in shallow open water. The new emergent wetlands are/would be dominated by blue vervain, nodding bur-marigold, nodding smartweed, rice-cut grass, hardstem bulrush, three-square, and sedges. Over time and as the water level in the impoundment is completely lowered, it is anticipated that these new emergent wetlands would succeed to forested/scrub-shrub wetlands with dominants such as northern white-cedar, black ash, red maple, tag alder, ninebark, sensitive fern, and marsh shield fern (*Thelypteris palustris*). Approximately 11 acres of small forested/scrub-shrub/emergent wetlands directly adjacent to the upstream end of the impoundment may also be impacted by the drawdown. Due to the presence of groundwater seepage as a source of hydrology, it is unlikely that these small wetlands would convert to uplands following drawdown. Although surface water influences would be reduced as the water elevation is lowered, these wetlands would likely remain connected to the floodplain of the Boardman River and would likely continue to receive surface water inputs from spring flooding. It is likely that these wetlands would shift from emergent/scrub-shrub to a slightly drier species composition with dominance by wetland trees and shrubs.

Throughout the central portion of the impoundment directly adjacent to the newly formed river channel, it is anticipated that approximately 33 acres of open water would be converted to and remain emergent/scrub-shrub wetland. These permanently emergent/scrub-shrub portions would be similar in structure and composition to areas found elsewhere along the Boardman River and likely be dominated by tag alder (*Alnus rugosa*), common elder (*Sambucus canadensis*), silky dogwood (*Cornus amomum*), red-osier dogwood (*Cornus sericea*), sandbar willow (*Salix exigua*), ninebark, blue vervain, nodding bur-marigold, rice-cut grass, swamp milkweed (*Asclepias incarnata*), spotted joe pye weed, common boneset, common cattail, black bulrush (*Scirpus atrovirens*), sedges (*Carex* spp.), hardstem bulrush, and burreed (*Sparganium* spp.).

Considering 1) the gain in wetland acreage with the conversion of open water areas and 2) the increase in species and structural diversity with the conversion of deep aquatic habitats to emergent and ultimately forested/scrub-shrub systems, a partial or total removal of the dam would improve the quality of and increase the quantity of wildlife habitat available along this stretch of the Boardman River. Deep-water habitats would be replaced by flowing, riparian habitats with varying water depth and higher structural and floral and faunal species diversity.

As a result of this decrease in water elevation, it is anticipated that both wetland acreage and type would change within the Brown Bridge impoundment. Overall, approximately 156 acres of wetland are anticipated to form following drawdown of the impoundment. As described above, the submerged and floating aquatic wetlands located within the northern border of impoundment over the toe of slope are likely to form uplands. However, these low diversity wetlands are anticipated to initially succeed to emergent wetlands along the southern border. New emergent wetlands would likely be dominated by a more diverse set of wetland species, including blue vervain (*Verbena hastata*), swamp milkweed (*Asclepias incarnata*), rice cut grass, common cattail, black bulrush (*Scirpus atrovirens*), hardstem bulrush, spotted joe pye weed (*Eupatorium maculatum*), jewelweed (*Impatiens capensis*), common boneset (*Eupatorium perfoliatum*), sensitive fern (*Onoclea sensibilis*), monkey flower (*Mimulus ringens*), and common beggar-ticks (*Bidens frondosus*). Over time, it is anticipated that these new emergent wetlands would succeed to approximately 156 acres of forested/scrub-shrub wetlands with dominants such as northern white-cedar, red maple, common elder, marsh shield fern (*Thelypteris palustris*), balsam fir, tag alder, sedges, common and narrow-leaved cattail, cinnamon fern, and fowl manna grass. The scrub-shrub/emergent portions of the forested wetlands directly adjacent to the east and south sides of the impoundment may also be impacted by the drawdown. Due to the presence of groundwater seepage as a source of hydrology and continuity with forested wetland systems, it is unlikely that these scrub-shrub/emergent systems would convert to uplands following drawdown. When surface water influences are removed as the water elevation is lowered, it is more likely that these wetlands would shift from emergent/scrub-shrub to a slightly drier species composition with dominance by wetland trees and shrubs. Small emergent/scrub-shrub zones may form directly adjacent to the newly formed river channel. However, it is anticipated that the majority of the Brown Bridge impoundment would eventually convert to forested/scrub-shrub wetland, especially considering that this area is shown as mixed deciduous and coniferous swamp in presettlement times circa 1800.

Considering 1) the gain in wetland acreage with the conversion of open water areas and 2) the increase in species and structural diversity with the conversion of deep aquatic habitats to emergent and ultimately forested/scrub-shrub systems, a partial or total removal would improve the quality of and increase the quantity of wildlife habitat available along this stretch of the Boardman River. Deep-water habitats would be replaced by flowing riparian habitats with varying water depth and higher structural and floral and faunal species diversity.

Effects on Wildlife Populations

The wildlife populations in the Boardman River impoundments were studied as part of the review of existing and baseline conditions (ECT, 2007).

Repairing and retaining the Union Street Dam would not have a significant impact on wildlife populations on the Boardman River or the impoundment behind the dam. Stream-carried sediment would continue to collect in the upstream areas and inlets of Boardman Lake. Over time, the sediment accumulation would reduce water depths, increase sandbar and shallow water habitats including emergent vegetation habitats dominated by sedges, spike rushes and other aquatic plants. The scrub-shrub habitats in these inlet areas, that currently include willows, tag alder and ninebark, would expand downstream. Wading bird and shorebird use would increase in shallow water and sandbar areas, songbird, small mammal and amphibian use would increase with the expanded emergent vegetation habitat

Repairing and retaining the Union Street Dam would not have a significant impact on migrant and resident ducks, geese and swans that utilize the submerged wetlands in upper Boardman Lake. These impoundments provide valuable food resources and sanctuary. The presence of waterfowl in this impoundment provides important recreational and educational opportunities such as waterfowl hunting and wildlife viewing. Repairing the dam would not have a significant impact on these activities.

Retaining/repairing the Union Street Dam would help conserve, and may expand the floating and submergent wetland habitats along shorelines and shallow water areas. These habitats tend to be rich in aquatic plant life and provide important habitat to aquatic insects and other invertebrates which in turn nurture fish, turtles, toads and frogs, waterfowl and wading birds within the impoundments, as well as songbirds that use adjacent uplands.

Retaining the dams – reducing the threat of chemical contamination and introducing invasive species and pathogens.

The dams on the Boardman restrict fish passage and protect the watershed above Sabin Pond from the introduction of chemical contaminants found in fish from Lake Michigan and Boardman Lake.

Chemical contaminants found in some Great Lakes fish species that could present a threat to certain wildlife species include PCB, DDT metabolites and other chlorinated hydrocarbons. Wildlife species vulnerable to chemical contaminants that could be impacted by chemical contaminants in Great Lakes fish include, but are not limited to, mink, otters, gulls, bald eagles, and snapping turtles.

The dams limit access by non-native species such as the European crayfish, round gobies, ruff, sea lamprey, steelhead trout, and salmon.

Effects on Wildlife

Partial or total removal of Sabin Dam, Boardman Pond Dam, and Brown Bridge Dam would have a variety of effects on the existing wildlife populations in the Sabin Pond, Boardman Pond, and Brown Bridge Dam.

TABLE 19: EFFECTS OF ALTERNATIVE 79 ON WILDLIFE POPULATIONS

Wildlife Species or Group	Change	Location
Leopard Frog*	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Green Frog	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Spring Peeper	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
American Toad	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Salamanders	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Blanding's Turtle	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Wood Turtle	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Snapping Turtle	Potential for decrease in population due to contaminants in Great Lakes fish	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Painted Turtle	Potential for decrease in population due to loss of habitat	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Trumpeter Swan	Breeding pair would abandon Brown Bridge Pond.	Brown Bridge Pond
Bald Eagle	Breeding pair unlikely to abandon their territory	Brown Bridge Pond
Common Loon	Breeding pairs would abandon Brown Bridge and Boardman Pond due to loss of habitat and may relocate to a different site	Brown Bridge Pond and Boardman Pond
Bald eagle, common loon, merganser, great blue heron, kingfisher, terns, and gulls	Contaminant levels of PCB and DDT in some Great Lakes fish are above the "no effect" level for wildlife. If toxic contaminants don't have adverse effects, then populations could be expected to increase.	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Waterfowl migrations	Waterfowl would be displaced due to loss of habitat	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Ruffed Grouse & woodcock	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Song birds	Potential for increase in population of many species due to increase in habitat and important conservation species would gain such as Golden-winged warbler and others	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Mink , marten & otter	Contaminant levels of PCB and DDT in some Great Lakes fish are above the "no effect" level for wildlife. If toxic contaminants don't have adverse effects, then populations could be expected to increase.	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Beaver	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Muskrat	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
White-tailed Deer	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Bobcat, fox, and coyote	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Short-tailed Shrew	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Meadow Jumping mouse	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Water shrew	Contaminant levels of PCB and DDT in some Great Lakes fish are above the "no effect" level for wildlife. If toxic contaminants don't have adverse effects, then populations could be expected to increase.	Sabin Pond, Boardman Pond, and Brown Bridge Pond
White-footed Mouse	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond

One change would be to increase habitat diversity and, hence, wildlife species diversity in the new habitat created after the drawdown. In addition, the removal, whether partial or total, would reconnect riverine habitats fragmented by the Sabin impoundment and Boardman Pond benefiting species such as the wood turtle, mink, river otter, bobcat, bear, and white-tailed deer and many others.

In the study of newly exposed habitat on Boardman Pond, ECT (2007) determined that numerous species of wildlife were using the newly exposed bottomlands. Their study reported that meadow voles were found in good numbers in the newly created lush herbaceous habitat on the recently exposed bottomlands at Boardman Pond, indicating their quick response and adaptability to these habitat changes caused by the emergency drawdown. Based on these data it is likely that the exposed bottomlands would be used as new habitat by 39 species of mammals, 77 species of songbirds, wading birds, amphibians, snakes, lizards and waterfowl.

The drawdown of Sabin Pond would replace a 40 acre impoundment and the drawdown of Boardman Pond would replace a 103 acre impoundment of still-water habitat conditions with a river, thus reducing loafing and foraging habitat for migrating and resident waterfowl. Boardman Lake and many other areas are suitable alternative loafing sites, but the waterfowl that currently use Sabin Pond and Boardman Pond would relocate to other areas. Habitat for painted and snapping turtles would be replaced with habitat for other reptiles, amphibians, small mammals and song birds.

Partial or complete dam removal could allow migrating Great Lakes fish which are contaminated with PCBs and other chemicals to enter the Boardman River above Sabin and Boardman dams, and increase the potential threat of contamination of food webs in the upper watershed. The introduction of contaminants through migrating Great Lakes fish into the Boardman River could result in declines in species sensitive to contaminants, such as mink, river otters, wood and snapping turtles, herons, bald eagles, and loons. These wildlife populations are currently exposed to contaminants from a number of sources, but the concern is the effect contaminants in Great Lakes fish could have on sensitive wildlife populations.

Effects on Fisheries

Under the existing conditions, the longest free flowing river segment is 13.8 miles (Segment 6). The remainder of the river is fragmented into smaller segments by the dams and their impoundments. Removing Sabin, Boardman, and Brown Bridge dams would create 25.4 miles of continuous free flowing river from Boardman Lake upstream to the forks, including 3.4 miles of new river channel created in the former impoundments. An additional 33.5 miles of free flowing river in the north and south branches of the Boardman River would also be connected to the free flowing mainbranch. The existing fish ladder at Union Street Dam would allow salmon and steelhead to gain access to all 25.4 miles of free flowing stream channel, versus only 2.2 miles under existing conditions (Segment 3). Sturgeon and other cool water species (e.g., walleye, suckers, and smallmouth bass) would not be able to migrate upstream beyond Union Street Dam. Sea lamprey would still be blocked at Union Street Dam as well. Therefore, existing sea lamprey management in the Boardman River would not be affected by Alternative 79. However, sturgeon and other desirable cool water species would not be able to access spawning habitat upstream of Boardman Lake.

Overall, removal of Sabin, Boardman, and Brown Bridge dams would benefit resident brown and brook trout due to the greater length of free flowing river due to better genetic diversity, increased habitat access, and higher overall productivity. Resident trout abundance should increase throughout the free flowing river above Boardman Lake to densities similar to the highest densities in Segment 8 with a decrease in overall fish diversity minus the influence of the impoundments. Although there is the potential for some level of competitive interaction between anadromous salmonids and resident trout, competition is not expected to decrease existing resident trout abundance.

Due to a significant increase in the length of river accessible to salmon and steelhead, natural salmon and steelhead reproduction would increase in the Boardman River. Natural reproduction in the 25.4 miles of free flowing river upstream of Boardman Lake could produce 500 adult Chinook salmon, 400 adult coho salmon, and 1,000 adult steelhead in addition to existing runs. Adult salmon and steelhead would be distributed throughout the Boardman River during spawning runs up to Brown Bridge Dam, creating a new shore fishery during fall and spring runs upstream of Sabin Dam. The anadromous salmonid fisheries, particularly salmon, would result in dead fish carcasses and increased fishing pressure that have associated negative social perceptions among the general public, riparian landowners, and outdoor enthusiasts. Salmon and steelhead abundance would decrease moving upstream due to attrition from fish passage efficiencies less than 100% at Union Street Dam and through Boardman Lake, natural mortality, harvest, and spawning habitat distribution.

Changes specific to certain river segments are discussed in detail below.

<u>Segment 1 – Union Street Dam to West Arm Grand Traverse Bay</u>
The physical channel conditions and fish habitat in Segment 1 would not change. Segment 1 would be connected to 25.4 miles of free flowing river upstream of Boardman Lake to the forks due to the removal of Sabin, Boardman, and Brown Bridge dams. The existing salmon and steelhead fisheries would benefit from increased natural reproduction, resulting in higher abundance of adult fish during spawning migrations and higher angler catch rates. Sea lamprey management would not be impacted. Otherwise, the existing second quality cold water and mixed warm/cool water fisheries in Segment 1 would not change. Both of these fisheries are limited by physical habitat alteration, warm-water discharge from Union Street Dam, and low natural reproduction.

<u>Segment 2 – Boardman Lake</u>
While the number of salmon and steelhead passing the Union Street Dam and entering Boardman Lake would increase, it is not likely that a significant boat fishery would result. Creel data collected by the MDNR in 2005 indicate that all salmon and steelhead caught between Sabin Dam and the West Arm Grand Traverse Bay are currently caught by shore anglers. This fishery condition is not expected to change under Alternative 79.

<u>Segment 3 – Sabin Dam to Boardman Lake</u>
Under Alternative 79, Segment 3 would be connected to 23.2 miles of free flowing river upstream (Segments 4, 5, 6, 7 and 8) to the forks. Due to upstream dam removal and associated transport of sediment downstream, the habitat in Segment 3 would change over time, with an expected decrease in depth and increase in riffle and run bed forms. Brown trout are currently present in low numbers, but are larger and of older age than Segments 6 and 8. Good adult habitat is present, but spawning habitat is limited. With connection to 23.2 miles of free flowing river upstream, the abundance of earlier age classes of brown trout would likely increase. The resident trout abundance and age structure would become more similar to that of Segment 8. The existing salmon and steelhead fisheries would benefit from increased natural reproduction, resulting in higher abundance of adult fish during spawning migrations and higher angler catch rates.

<u>Segment 4 – Sabin Pond (Sabin Dam)</u>
The existing impoundment would be replaced with 0.7 miles of new stream channel. Segment 4 would be connected to 2.2 miles of free flowing river downstream (Segment 3) and 22.5 miles of free flowing river upstream (Segments 5, 6, 7, and 8) upstream to the forks. The existing warm water fishery would be

replaced with a top quality cold water fishery similar to that of Segment 8. The poor survival of older age classes present in Segment 8 may be replicated in Segment 4. The presence of salmon and steelhead would create a new anadromous salmonid shore fishery. The anadromous salmonid fisheries, particularly salmon, would result in dead fish carcasses and increased fishing pressure that have associated negative social perceptions among the general public, riparian landowners, and outdoor enthusiasts.

Segment 5 – Boardman Pond (Boardman Dam)

The existing impoundment would be replaced by 1.2 miles of new stream channel. Segment 5 would be connected to 2.9 miles of free flowing river downstream (Segments 3 and 4) and 21.3 miles of free flowing river upstream (Segments 6, 7, and 8) to the forks. The existing warm water fishery would be replaced with a top quality cold water fishery similar to that of Segment 8. The poor survival of older age classes present in Segment 8 may be replicated in Segment 5. The presence of salmon and steelhead would create a new anadromous shore fishery. The anadromous salmonid fisheries, particularly salmon, would result in dead fish carcasses and increased fishing pressure that have associated negative social perceptions among the general public, riparian landowners, and outdoor enthusiasts.

Segment 6 – Brown Bridge Dam to Boardman Pond (Boardman Dam)

Segment 6 would be connected to 4.1 miles of free flowing river downstream (Segments 3, 4, and 5) and 7.5 miles of free flowing river upstream (Segments 7 and 8) to the forks. The existing top quality cold water fishery would benefit from overall increased productivity of the larger free flowing river segment. Resident trout abundance is expected to increase, becoming more similar to that of Segment 8. The presence of salmon and steelhead would create a new anadromous shore fishery upstream to Brown Bridge Dam. The anadromous salmonid fisheries, particularly salmon, would result in dead fish carcasses and increased fishing pressure that have associated negative social perceptions among the general public, riparian landowners, and outdoor enthusiasts.

Segment 7 – Brown Bridge Pond (Brown Bridge Dam)

The existing impoundment would be replaced by 1.5 miles of new stream channel. Segment 7 would be connected to 17.9 miles of free flowing river downstream (Segments 3, 4, 5, and 6) and 6.0 miles of free flowing river upstream (Segment 8) to the forks. The existing warm water fishery would be replaced with a top quality cold water fishery similar to that of Segment 8. The poor survival of older age classes present in Segment 8 may be replicated in Segment 7. The presence of salmon and steelhead would create a new anadromous shore fishery upstream to Brown Bridge Dam. The anadromous salmonid fisheries, particularly salmon, would result in dead fish carcasses and increased fishing pressure that have associated negative social perceptions among the general public, riparian landowners, and outdoor enthusiasts.

Segment 8 – Forks to Brown Bridge Pond

Segment 8 would be connected to 19.4 miles of free flowing river downstream (Segments 3, 4, 5, 6, and 7) and is already connected to 35.5 miles of free flowing river upstream in the north and south branches. The existing top quality cold water fishery would be maintained and would benefit from the greater length of free flowing river due to better genetic diversity, increased habitat access, and higher overall productivity. The presence of salmon and steelhead would create a new anadromous shore fishery upstream to Brown Bridge Dam. The anadromous salmonid fisheries, particularly salmon, would result in dead fish carcasses and increased fishing pressure that have associated negative social perceptions among the general public, riparian landowners, and outdoor enthusiasts.

Segments 9 & 10 – North and South Branch

Segments 9 and 10 would be connected to 25.4 miles of free flowing river upstream of Boardman Lake. The existing top quality cold water fishery would be maintained and would benefit from the greater length of free flowing river due to better genetic diversity, increased habitat access, and higher overall productivity. The existing top quality cold water fishery would be maintained and would benefit from the greater length of free flowing river due to better genetic diversity, increased habitat access, and higher overall productivity. The presence of salmon and steelhead would create a new anadromous shore fishery. The anadromous salmonid fisheries, particularly salmon, would result in dead fish carcasses and increased fishing pressure that have associated negative social perceptions among the general public, riparian landowners, and outdoor enthusiasts.

Sediment

The repairs to the Union Street Dam would not have a significant impact on sediment quality or transport. Sediment would continue to accumulate in Boardman Lake reducing deep water habitat and creating shallow water and wetland habitat.

Removal of Brown Bridge Dam would require sediment management. Option 3 is the most cost effective and would be the preferred method. Designed sediment capture and removal near the dam during dam breaching/removal would protect the existing habitat quality and top quality cold water fishery in Segment 6. Restoring a natural sediment transport regime through dam breaching/removal would benefit the ecology of the Boardman River downstream of Brown Bridge Dam. Sediment management at Sabin and Boardman dams could be achieved the same as Alternative 25: breach/remove Boardman first using Option 1, and then manage sediment during breaching/removal of Sabin using Option 3. This approach would be the most cost effective approach to sediment management at Sabin and Boardman dams.

Stream channel morphology

The repairs to the Union Street Dam would not have a significant impact on stream channel morphology.

Threatened and endangered species

The repairs to the Union Street Dam would not have a significant impact on threatened or endangered species. The partial removal or total removal of the Sabin Dam could have a positive impact on populations of threatened or endangered species. The only element occurrence of a threatened or endangered species recorded within the Michigan Natural Features Inventory (MNFI) database for the Sabin Pond area is that of the wood turtle (*Glyptemys insculpta*), a reptile of special concern known to inhabit various wetland types, especially forested river floodplain wetlands adjacent to upland habitats with sandy soils.

Given increases in emergent, scrub-shrub, and forested wetlands adjacent to sandy upland habitat, it is likely that partial or total removal of Sabin Dam would increase the quantity and quality of wood turtle habitat available. Although submerged and floating aquatic vegetation habitat of the Blanding's turtle would transition to emergent, scrub-shrub, and forested wetlands, the turtle is known to utilize a variety of wetland habitats including swamp, emergent marsh, fen, wet meadow, inundated shrub swamp, and floodplain forest. Blanding's turtle juveniles would use tag alder and willow wetland habitat adjacent to slow moving streams the first couple years of their lives (Harding, pers. comm.) so they could be found in some sections of the river above the four impoundments.

Other rare species known to occur within the watershed that may benefit from this improved habitat diversity include the red-shouldered hawk (*Buteo lineatus*), bald eagle (*Haliaeetus leucocephalus*), and ebony boghaunter (*Williamsonia fletcheri*). With the lowering of the impoundment, the potential also exists for rare natural communities like northern fen and rich conifer swamp to develop along the numerous groundwater seeps occurring at the southern end of Sabin Pond.

Given increases in emergent, scrub-shrub, and forested wetlands adjacent to sandy upland habitat, it is likely that a partial or total removal would increase the quantity and quality of habitat available for rare species known to occur within the watershed, such as wood turtle, Blanding's turtle, bald eagle (*Haliaeetus leucocephalus*), red-shouldered hawk, and ebony boghaunter (*Williamsonia fletcheri*). Although the open-water habitat of the common loon would be lost, nearby lakes to the east with relatively undeveloped shorelines would likely provide suitable alternative habitats for nesting.

Although the open-water habitat of the common loon and trumpeter swan would be lost, nearby lakes to the north and east with relatively undeveloped shorelines would likely provide suitable habitats for nesting. Since their territory includes other nearby open-water habitats and the bald eagle uses a variety of habitats for feeding, the loss of the Brown Bridge impoundment would not impact the bald eagle population. Given increases in emergent, scrub-shrub, and especially forested wetlands adjacent to sandy upland habitat, it is likely that partial or total removal would increase the quantity and quality of habitat available for other rare species known to occur within the watershed, including wood turtle, Blanding's turtle, red-shouldered hawk, and ebony boghaunter (*Williamsonia fletcheri*).

Water quality

The repairs to the Union Street Dam would not have a significant impact on water quality. The removal of Brown Bridge Dam would mitigate the adverse impact to the Boardman River caused by warm water discharge from Brown Bridge Pond.

Ground water

The repairs to the Union Street Dam and removal of the other dams would not have a significant impact on ground water resources.

ENGINEERING IMPACTS

Transportation and infrastructure

The repairs to the Union Street Dam and removal of the other dams would not have a significant impact on transportation and infrastructure. There are utilities located at the Union Street Dam, but the repairs would not impact the utilities.

Hydrology and hydraulics

The repairs to the Union Street Dam and removal of the other dams would have a significant impact on hydrology and hydraulics of the Boardman River in the vicinity of the dams.

Flood plain changes

The repairs to the Union Street Dam would not have a significant impact on flood plains on Boardman Lake. Lowering the impoundments at Sabin, Boardman and Brown Bridge ponds will lower the floodplain adjacent to those impoundments. The revised floodplain is shown in Appendix C

Stream bank stabilization

The repairs to the Union Street Dam would not have a significant impact on stream banks and would not require additional stream bank stabilization efforts because the repairs would not change the water level in Boardman Lake. Stream bank stabilization could be required in certain sections of the restored river channel to protect against excessive sedimentation and loss of habitat.

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Water supplies and on-site waste water treatment systems

The repairs to the Union Street Dam and removal of the other dams would not have a significant impact on water supplies and on-site wastewater treatment systems

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SOCIETAL IMPACTS

Property boundaries and rights

The repairs to the Union Street Dam and removal of the other dams would not have a significant impact on property boundaries or property rights.

Risks to property owners

The repairs to the Union Street Dam and removal of the other dams would not have a significant impact on risks to property owners and may alleviate some risks associated with dams.

Historic status of dams and power houses

The repairs to the Union Street Dam and removal of the other dams would not have a significant impact on historic or cultural resources in the vicinity of the dams.

Impact on County's Natural Education Reserve

The repairs to the Union Street Dam and removal of the other dams would not have a significant impact on the County's Natural Education Reserve. The discovery hike called "The Wonder of Ponds" would need to be replaced with hikes describing restored wetland and cold water streams.

ECONOMIC IMPACTS

Recreation and Tourism

With the removal of Sabin, Boardman, and Brown Bridge Dams, we anticipate that the corresponding changes in stream hydrology and fish habitats will result in changes in recreation opportunities associated with the Boardman River. Under this alternative, Sabin Pond, Boardman Pond, and Brown Bridge Pond will become free-flowing river segments. The removal of these dams will change the nature of the fishery not only for the existing impoundments, but for other segments as well. Specifically, anadromous fish species are predicted to become available as far upstream as the north and south branches. In addition, catch rates for anadromous fish species in western Grand Traverse Bay are predicted to improve. Boardman Lake, however, will continue to offer warm water fishing experiences. Moreover, some segments will offer more “whitewater” under this alternative than current conditions do, consequently changing recreational paddling opportunities. The former impoundments are predicted to become more scenic, as well.

Relative to current conditions, implementing Alternative 79 will increase the recreation value of residents by approximately $241,000. This increase represents the present value over 30 years. In addition, we expect tourism spending to increase. The present value estimate of the increase in tourism spending over 30 years is $1.58 million. Finally, once the fishery improvements have realized their maximum potential, we expect that the tourism-based jobs will increase by 5 jobs.

Property values

The repairs to the **Union Street Dam** would not have a significant impact on property values within ½ mile of the dam. A study of the property values adjacent to impoundments that have been removed reported that property values within ½ mile of the impoundment tend to increase over time (Provencher, et al., 2006). Property values near the current impoundments will likely be affected by the dam removals. The discussion related to Alternative 25 provides the context and caveats associated with estimated changes in property values that result from the implementation of Alternative 79. Table 18 shows how the total assessed value of residential parcels within a ½ mile of the Boardman River would change if Alternative 79 were implemented. Initially, the aggregate assessed value of the properties could fall by as much as $0.6 million. Over time, the aggregate assessed value may increase by as much as $1.9 million. The associated present value is $1.18 million.

TABLE 20: ESTIMATED CHANGES IN ASSESSED VALUE OF RESIDENTIAL PARCELS UNDER ALTERNATIVE 79 ($ MILLIONS)

Number of Years Since Removal	Value with Current Conditions	Value with Alternative 79	Estimated Change in Assessed Value	Percent Change
1	$331.3	$330.7	$(0.6)	–0.2%
2	$331.3	$330.7	$(0.6)	–0.2%
3	$331.3	$331.4	$0.1	0.0%
4	$331.3	$331.5	$0.2	0.1%
5	$331.3	$331.6	$0.3	0.1%
6	$331.3	$331.7	$0.4	0.1%
7	$331.3	$331.9	$0.5	0.2%
8	$331.3	$332.0	$0.6	0.2%
9	$331.3	$332.1	$0.7	0.2%
10	$331.3	$332.2	$0.8	0.3%
11	$331.3	$332.3	$0.9	0.3%
12	$331.3	$332.4	$1.0	0.3%
13	$331.3	$332.5	$1.2	0.3%
14	$331.3	$332.6	$1.3	0.4%
15	$331.3	$332.7	$1.4	0.4%
16	$331.3	$332.8	$1.5	0.4%
17	$331.3	$332.9	$1.6	0.5%
18	$331.3	$333.0	$1.7	0.5%
19	$331.3	$333.1	$1.8	0.5%
20	$331.3	$333.2	$1.9	0.6%

Note: Future values noted here do not reflect any influences on property values except those uniquely associated with dam removal. General appreciation of values over time is not reflected in this table.

Cost of the repairs

The annual maintenance of the dams is estimated to be as follows:
Union Street = $30,000-50,000
The estimate to maintain the dams was obtained from County employees who currently maintain the dams.

The estimated cost of repairing the dams is shown in Table 19.

TABLE 21: PROBABLE CONSTRUCTION COST ESTIMATES FOR ALTERNATIVE 79.

Dam	Low Cost Estimate	High Cost Estimate
Union Street Repairs	$430,000	$650,000
Sabin Dam Partial Removal	$360,000	$1,013,000
Sabin Dam Total Removal	$1,870,000	$3,683,000
Boardman Dam Partial Removal	$1,900,000	$2,700,000
Boardman Dam Total Removal	$5,360,000	$8,830,000
Brown Bridge Dam Partial Removal	$1,300,000	$2,050,000
Brown Bridge Total Removal	$8,510,000	$15,470,000
Alt.79 Total with Partial Removal	$3,990,000	$6,413,000
Alt. 79 Total with Total Removal	$16,170,000	$28,633,000

These estimates were developed by STS in their study of Union Street and Brown Bridge Dam (STS, 2008) and for Sabin and Boardman Dam by ECT and Prein and Newhof as part of the detailed analysis of alternatives for the dams. A detailed analysis of the cost estimates in provided in Appendix D.

Property tax implications

The repairs to the Union Street Dam and removal of the other dams could have an impact on property taxes if that is the source of funds used to implement the repairs. However, there are numerous options for funding the repairs and a decision as to the source of funding has not been made at this time.

Jobs

This alternative would create some local construction jobs and jobs associated with increased recreation and tourism.

Hydroelectricity

The repairs to the Union Street Dam and removal of the other dams would not allow electricity to be generated at the dams. Alternative 41 describes the actions and modifications that are anticipated in order to allow electricity to be generated at the dams.

ALTERNATIVE 81: MODIFY UNION STREET, REMOVE SABIN, BOARDMAN, AND BROWN BRIDGE DAMS

DESCRIPTION OF THE ALTERNATIVE

Union Street Dam would be **modified** to allow Great Lakes fish species to pass over the dam and gain access to Boardman Lake and its tributaries. During discussions on various fish passage options at a BRDC meeting, the consensus seemed to be that the fish ladder could be replaced with a fish passageway (See appendix B for fish passageway details). Fish passageways have recently been used as replacements for fish ladders for a number of reasons. In the case of Union Street Dam, the primary benefit is that a fish passageway could allow all Great Lakes fish to pass over the dam. Currently, only fish species capable of jumping from pool to pool in the ladder can pass over the dam. The fish passageway could be constructed by placing a ramp made of stone and soil in the river below the dam that could replace the dam with a new river channel that has a more gradual slope. The gradually sloped fish passageway could allow Great Lakes fish species to access Boardman Lake.

Sabin Dam, Boardman Dam, and Brown Bridge Dam would be **removed** by removing the dams under different scenarios. The first scenario is a partial removal of the dam by breaching the dam and allowing the water in the impoundment to drop to a point where only the Boardman River exists and the impoundment has been removed. The second scenario would breach the dams and after the impoundment has been drained the power houses, spillways and earthen embankments would be completely removed.

ENVIRONMENTAL IMPACTS OF THE ALTERNATIVE

Effects on Terrestrial Habitats and Wetlands

Modifying the **Union Street Dam** would not change the water level in the impoundment. Therefore, no change in the acreage of either terrestrial or wetland habitat is anticipated. No new terrestrial habitat and no new wetlands are likely to form as a result of this alternative. The less urbanized uplands surrounding the southern half of Boardman Lake would remain dominated by deciduous, evergreen, and mixed forests. Wetlands within the impoundment would remain dominated by submerged and floating aquatic vegetation. Wetlands near or adjacent to the impoundment would remain dominated by scrub-shrub and emergent vegetation. By keeping the Union Street Dam in place, upstream reaches of the Boardman River and its associated habitats would be protected by inhibiting the upstream migration of sea lamprey and other Great Lakes invasive species. No changes to the quantity or quality of potential king rail or common loon habitat are anticipated.

Removing **Sabin Pond** would decrease water levels in the pond and both wetland acreage and type would change within the former Sabin Pond impoundment. Overall, approximately 28 acres of wetland are anticipated to form following drawdown of the impoundment. As described above, less than half of the submerged/floating/emergent wetlands located within the impoundment over the toe of slope are likely to form uplands. However, over half of these low diversity submerged/floating/emergent wetlands are anticipated to succeed to emergent wetlands initially. New emergent wetlands would likely be dominated by a more diverse set of wetland species, including blue vervain (*Verbena hastata*), swamp milkweed (*Asclepias incarnata*), common cattail (*Typha spp.*), black bulrush (*Scirpus atrovirens*), hardstem bulrush, spotted joe pye weed, jewelweed, common boneset (*Eupatorium perfoliatum*), sensitive fern (*Onoclea sensibilis*), and beggar-ticks (*Bidens* spp.). Over time, it is anticipated that these new emergent wetlands would succeed to approximately 5 acres of forested/scrub-shrub wetlands with dominants such as northern white-cedar, red maple, common elder, and marsh shield fern. Several small forested/scrub-shrub/emergent wetlands directly adjacent to the west side of the impoundment may also be impacted by the drawdown. Due to the presence of groundwater seepage as a source of hydrology, it is unlikely that these small wetlands would convert to uplands following drawdown. When surface water influences are removed as the water elevation is lowered, it is more likely that these wetlands would shift from emergent/scrub-shrub to a slightly drier species composition with dominance by wetland trees and shrubs.

Throughout the central portion of the impoundment directly adjacent to the newly formed river channel, it is anticipated that approximately 23 acres of open water would be converted to and remain emergent/scrub-shrub wetland. These permanently emergent/scrub-shrub portions would be similar in structure and composition to areas found elsewhere along the Boardman River and likely be dominated by common elder, silky dogwood (*Cornus amomum*), red-osier dogwood (*Cornus sericea*), sandbar willow (*Salix exigua*), tag alder (*Alnus rugosa*), blue vervain, swamp milkweed, spotted joe pye weed, common boneset, common cattail, black bulrush, sedges (*Carex* spp.), hardstem bulrush, and burreed (*Sparganium* spp.).

Considering 1) the gain in wetland acreage with the conversion of open water areas and 2) the increase in species and structural diversity with the conversion of deep aquatic habitats to emergent and ultimately forested/scrub-shrub systems, partial or total removal of Sabin Dam would improve the quality of and increase the quantity of wildlife habitat available along this stretch of the Boardman River. Deep-water habitats would be replaced by flowing riparian habitats with varying water depth and higher structural and floral and faunal species diversity.

Removing the impoundment at Boardman Pond would change the wetland acreage and type within the Boardman Pond impoundment. Overall, approximately 69 acres of wetland are anticipated to form in the long term. As described above, approximately 25 of these 69 acres are new emergent wetlands forming in the northeast corner, east central side, and southern end of the original impoundment. Approximately 11 acres of additional emergent wetland is also expected to form along the west and east central sides of the impoundment currently covered in shallow open water. The new emergent wetlands are/would be dominated by blue vervain, nodding bur-marigold, nodding smartweed, rice-cut grass, hardstem bulrush, three-square, and sedges. Over time and as the water level in the impoundment is completely lowered, it is anticipated that these new emergent wetlands would succeed to forested/scrub-shrub wetlands with dominants such as northern white-cedar, black ash, red maple, tag alder, ninebark, sensitive fern, and marsh shield fern (*Thelypteris palustris*). Approximately 11 acres of small forested/scrub-shrub/emergent wetlands directly adjacent to the upstream end of the impoundment may also be impacted by the drawdown. Due to the presence of groundwater seepage as a source of hydrology, it is unlikely that these small wetlands would convert to uplands following drawdown. Although surface water influences would be reduced as the water elevation is lowered, these wetlands would likely remain connected to the floodplain of the Boardman River and would likely continue to receive surface water inputs from spring flooding. It is likely that these wetlands would shift from emergent/scrub-shrub to a slightly drier species composition with dominance by wetland trees and shrubs.

Throughout the central portion of the impoundment directly adjacent to the newly formed river channel, it is anticipated that approximately 33 acres of open water would be converted to and remain emergent/scrub-shrub wetland. These permanently emergent/scrub-shrub portions would be similar in structure and composition to areas found elsewhere along the Boardman River and likely be dominated by tag alder (*Alnus rugosa*), common elder (*Sambucus canadensis*), silky dogwood (*Cornus amomum*), red-osier dogwood (*Cornus sericea*), sandbar willow (*Salix exigua*), ninebark, blue vervain, nodding bur-marigold, rice-cut grass, swamp milkweed (*Asclepias incarnata*), spotted joe pye weed, common boneset, common cattail, black bulrush (*Scirpus atrovirens*), sedges (*Carex* spp.), hardstem bulrush, and burreed (*Sparganium* spp.).

Considering 1) the gain in wetland acreage with the conversion of open water areas and 2) the increase in species and structural diversity with the conversion of deep aquatic habitats to emergent and ultimately forested/scrub-shrub systems, a partial or total removal of the dam would improve the quality of and increase the quantity of wildlife habitat available along this stretch of the Boardman River. Deep-water habitats would be replaced by flowing, riparian habitats with varying water depth and higher structural and floral and faunal species diversity.

As a result of this decrease in water elevation, it is anticipated that both wetland acreage and type would change within the Brown Bridge impoundment. Overall, approximately 156 acres of wetland are anticipated to form following drawdown of the impoundment. As described above, the submerged and floating aquatic wetlands located within the northern border of impoundment over the toe of slope are likely to form uplands. However, these low diversity wetlands are anticipated to initially succeed to emergent wetlands along the southern border. New emergent wetlands would likely be dominated by a more diverse set of wetland species, including blue vervain (*Verbena hastata*), swamp milkweed (*Asclepias incarnata*), rice cut grass, common cattail, black bulrush (*Scirpus atrovirens*), hardstem bulrush, spotted joe pye weed (*Eupatorium maculatum*), jewelweed (*Impatiens capensis*), common boneset (*Eupatorium perfoliatum*), sensitive fern (*Onoclea sensibilis*), monkey flower (*Mimulus ringens*), and common beggar-ticks (*Bidens frondosus*). Over time, it is anticipated that these new emergent wetlands would succeed to approximately 156 acres of forested/scrub-shrub wetlands with dominants such as northern white-cedar, red maple, common elder, marsh shield fern (*Thelypteris palustris*), balsam fir, tag alder, sedges, common and narrow-leaved cattail, cinnamon fern, and fowl manna grass. The scrub-shrub/emergent portions of the forested wetlands directly adjacent to the east and south sides of the impoundment may also be impacted by the drawdown. Due to the presence of groundwater seepage as a source of hydrology and continuity with forested wetland systems, it is unlikely that these scrub-shrub/emergent systems would convert to uplands following drawdown. When surface water influences are removed as the water elevation is lowered, it is more likely that these wetlands would shift from emergent/scrub-shrub to a slightly drier species composition with dominance by wetland trees and shrubs. Small emergent/scrub-shrub zones may form directly adjacent to the newly formed river channel. However, it is anticipated that the majority of the Brown Bridge impoundment would eventually convert to forested/scrub-shrub wetland, especially considering that this area is shown as mixed deciduous and coniferous swamp in presettlement times circa 1800.

Considering 1) the gain in wetland acreage with the conversion of open water areas and 2) the increase in species and structural diversity with the conversion of deep aquatic habitats to emergent and ultimately forested/scrub-shrub systems, a partial or total removal would improve the quality of and increase the quantity of wildlife habitat available along this stretch of the Boardman River. Deep-water habitats would be replaced by flowing riparian habitats with varying water depth and higher structural and floral and faunal species diversity.

<u>Effects on Wildlife Populations</u>
The wildlife populations in the Boardman River impoundments were studied as part of the review of existing and baseline conditions (ECT, 2007).

Modifying the Union Street Dam would not have a significant impact on wildlife populations on the Boardman River or the impoundments behind the dams. Stream-carried sediment would continue to collect in the upstream areas and inlets of Boardman Lake. Over time, the sediment accumulation would reduce water depths, increase sandbar and shallow water habitats including emergent vegetation habitats dominated by sedges, spike rushes and other aquatic plants. The scrub-shrub habitats in these inlet areas, that currently include willows, tag alder and ninebark, would expand downstream. Wading bird and shorebird use would increase in shallow water and sandbar areas, songbird, small mammal and amphibian use would increase with the expanded emergent vegetation habitat

Modifying the Union Street Dam would not have a significant impact on migrant and resident ducks, geese and swans that utilize the submerged wetlands in upper Boardman Lake. The impoundment provides valuable food resources and sanctuary. The presence of waterfowl in the impoundment provides important recreational and educational opportunities such as waterfowl hunting and wildlife viewing. Modifying the dam would not have a significant impact on these activities.

Modifying the Union Street Dam would help conserve, and may expand the floating and submergent wetland habitats along shorelines and shallow water areas. These habitats tend to be rich in aquatic plant life and provide important habitat to aquatic insects and other invertebrates which in turn nurture fish, turtles, toads and frogs, waterfowl and wading birds within the impoundments, as well as songbirds that use adjacent uplands.

<u>Retaining the dams – reducing the threat of chemical contamination and introducing invasive species and pathogens</u>.
The dams on the Boardman restrict fish passage and protect the watershed above Boardman Lake from the introduction of chemical contaminants found in fish from Lake Michigan and Boardman Lake.

Chemical contaminants found in some Great Lakes fish species that could present a threat to certain wildlife species include PCB, DDT metabolites and other chlorinated hydrocarbons. Wildlife species vulnerable to chemical contaminants that could be impacted by chemical contaminants in Great Lakes fish include, but are not limited to, mink, otters, gulls, bald eagles, and snapping turtles.

The dams limit access by non-native species such as the European crayfish, round gobies, ruff, sea lamprey, steelhead trout, and salmon.

<u>Effects of Removing Dams on Wildlife</u>
Partial or total removal of Sabin Dam, Boardman Pond Dam, and Brown Bridge Dam would have a variety of effects on the existing wildlife populations in the Sabin Pond, Boardman Pond, and Brown Bridge Dam.

TABLE 22: EFFECTS OF ALTERNATIVE 81 ON WILDLIFE POPULATIONS

Wildlife Species or Group	Change	Location
Leopard Frog*	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Green Frog	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Spring Peeper	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
American Toad	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Salamanders	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Blanding's Turtle	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Wood Turtle	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Snapping Turtle	Potential for decrease in population due to contaminants in Great Lakes fish	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Painted Turtle	Potential for decrease in population due to loss of habitat	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Trumpeter Swan	Breeding pair would abandon Brown Bridge Pond.	Brown Bridge Pond
Bald Eagle	Breeding pair unlikely to abandon their territory	Brown Bridge Pond
Common Loon	Breeding pairs would abandon Brown Bridge and Boardman Pond due to loss of habitat and may relocate to a different site	Brown Bridge Pond and Boardman Pond
Bald eagle, common loon, merganser, great blue heron, kingfisher, terns, and gulls	Contaminant levels of PCB and DDT in some Great Lakes fish are above the "no effect" level for wildlife. If toxic contaminants don't have adverse effects, then populations could be expected to increase.	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Waterfowl migrations	Waterfowl would be displaced due to loss of habitat	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Ruffed Grouse & woodcock	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Song birds	Potential for increase in population of many species due to increase in habitat and important conservation species would gain such as Golden-winged warbler and others	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Mink , marten & otter	Contaminant levels of PCB and DDT in some Great Lakes fish are above the "no effect" level for wildlife. If toxic contaminants don't have adverse effects, then populations could be expected to increase.	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Beaver	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Muskrat	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
White-tailed Deer	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Bobcat, fox, and coyote	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Short-tailed Shrew	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Meadow Jumping mouse	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond
Water shrew	Contaminant levels of PCB and DDT in some Great Lakes fish are above the "no effect" level for wildlife. If toxic contaminants don't have adverse effects, then populations could be expected to increase.	Sabin Pond, Boardman Pond, and Brown Bridge Pond
White-footed Mouse	Potential for increase in population	Sabin Pond, Boardman Pond, and Brown Bridge Pond

One change would be to increase habitat diversity and, hence, wildlife species diversity in the new habitat created after the drawdown. In addition, the removal, whether partial or total, would reconnect riverine habitats fragmented by the Sabin impoundment and Boardman Pond benefiting species such as the wood turtle, mink, river otter, bobcat, bear, and white-tailed deer and many others.

In the study of newly exposed habitat on Boardman Pond, ECT (2007) determined that numerous species of wildlife were using the newly exposed bottomlands. Their study reported that meadow voles were found in good numbers in the newly created lush herbaceous habitat on the recently exposed bottomlands at Boardman Pond, indicating their quick response and adaptability to these habitat changes caused by the emergency drawdown. Based on these data it is likely that the exposed bottomlands would be used as new habitat by 39 species of mammals, 77 species of songbirds, wading birds, amphibians, snakes, lizards and waterfowl.

The drawdown of Sabin Pond would replace a 40 acre impoundment and the drawdown of Boardman Pond would replace a 103 acre impoundment of still-water habitat conditions with a river, thus reducing loafing and foraging habitat for migrating and resident waterfowl. Boardman Lake and many other areas are suitable alternative loafing sites, but the waterfowl that currently use Sabin Pond and Boardman Pond would relocate to other areas. Habitat for painted and snapping turtles would be replaced with habitat for other reptiles, amphibians, small mammals and song birds.

<u>Effects on Fisheries</u>
Under the existing conditions, the longest free flowing river segment is 13.8 miles (Segment 6). The remainder of the river is fragmented into smaller segments by the dams and their impoundments. Removing Sabin, Boardman, and Brown Bridge dams would create 25.4 miles of continuous free flowing river from Boardman Lake upstream to the forks, including 3.4 miles of new river channel created in the former impoundments. An additional 33.5 miles of free flowing river in the north and south branches of the Boardman River would also be connected to the free flowing mainbranch. The existing fish ladder at Union Street Dam currently allows salmon and steelhead to gain access to all 25.4 miles of free flowing river upstream of Boardman Lake to the forks versus just 2.2 miles (Segment 3) under existing conditions. Modification of the Union Street Dam would provide upstream passage for sturgeon and other cool water species (e.g., walleye, suckers, and smallmouth bass) in addition to salmon and steelhead. Passing sturgeon and other cool water species would support efforts to restore lake sturgeon populations and improve the cool water fisheries of the Boardman River, Boardman Lake, and West Arm Grand Traverse Bay. However, a fish passage structure that allows sturgeon and other cool water species to migrate upstream would also allow sea lamprey to migrate upstream, altering current sea lamprey control strategies, activities, and costs. Resident brown and brook trout populations would not be impacted, but may benefit from increased productivity.

Overall, removal of Sabin, Boardman, and Brown Bridge dams would benefit resident brown and brook trout due to the greater length of free flowing river due to better genetic diversity, increased habitat access, and higher overall productivity. Resident trout abundance should increase throughout the free flowing river above Boardman Lake to densities similar to the highest densities in Segment 8 with a decrease in overall fish diversity minus the influence of the impoundments. Although there is the potential for some level of competitive interaction between anadromous salmonids and resident trout, competition is not expected to decrease existing resident trout abundance.

Due to a significant increase in the length of river accessible to salmon and steelhead, natural salmon and steelhead reproduction would increase in the Boardman River. Natural reproduction in the 25.4 miles of free flowing river upstream of Boardman Lake could produce 500 adult Chinook salmon, 400 adult coho salmon, and 1,000 adult steelhead in addition to existing runs. Adult salmon and steelhead would be distributed throughout the Boardman River during spawning runs up to Brown Bridge Dam, creating a new shore fishery during fall and spring runs upstream of Sabin Dam. The anadromous salmonid fisheries, particularly salmon, would result in dead fish carcasses and increased fishing pressure that have associated negative social perceptions among the general public, riparian landowners, and outdoor enthusiasts. Salmon and steelhead abundance would decrease moving upstream due to attrition from fish passage efficiencies less than 100% at Union Street Dam and through Boardman Lake, natural mortality, harvest, and spawning habitat distribution.

Changes specific to certain river segments are discussed in detail below.

Segment 1 – Union Street Dam to West Arm Grand Traverse Bay

The physical channel conditions and fish habitat in Segment 1 would not change. Segment 1 would be connected to 25.4 miles of free flowing river upstream of Boardman Lake to the forks due to the removal of Sabin, Boardman, and Brown Bridge dams. The existing salmon and steelhead fisheries would benefit from increased natural reproduction, resulting in higher abundance of adult fish during spawning migrations and higher angler catch rates. Sea lamprey would be able to pass Union Street Dam, requiring new control strategies and increased costs. The existing second quality cold water and mixed warm/cool water fisheries in Segment 1 would not change. Both of these fisheries are limited by physical habitat alteration, warm-water discharge from Union Street Dam, and low natural reproduction.

Segment 2 – Boardman Lake

While the number of salmon and steelhead passing the Union Street Dam and entering Boardman Lake would increase, it is not likely that a significant boat fishery would result. Creel data collected by the MDNR in 2005 indicate that all salmon and steelhead caught between Sabin Dam and the West Arm Grand Traverse Bay are currently caught by shore anglers. This fishery condition is not expected to change under Alternative 81.

Segment 3 – Sabin Dam to Boardman Lake

Under Alternative 81, Segment 3 would be connected to 23.2 miles of free flowing river upstream (Segments 4, 5, 6, 7 and 8) to the forks. Due to upstream dam removal and associated transport of sediment downstream, the habitat in Segment 3 would change over time, with an expected decrease in depth and increase in riffle and run bed forms. Brown trout are currently present in low numbers, but are larger and of older age than Segments 6 and 8. Good adult habitat is present, but spawning habitat is limited. With connection to 23.2 miles of free flowing river upstream, the abundance of earlier age classes of brown trout would likely increase. The resident trout abundance and age structure would become more similar to that of Segment 8. The existing salmon and steelhead fisheries would benefit from increased natural reproduction, resulting in higher abundance of adult fish during spawning migrations and higher angler catch rates. Sea lamprey would be able to reach Segment 3, requiring new control strategies and increased control costs.

Segment 4 – Sabin Pond (Sabin Dam)

The existing impoundment would be replaced with 0.7 miles of new stream channel. Segment 4 would be connected to 2.2 miles of free flowing river downstream (Segment 3) and 22.5 miles of free flowing river upstream (Segments 5, 6, 7, and 8) upstream to the forks. The existing warm water fishery would be replaced with a top quality cold water fishery similar to that of Segment 8. The poor survival of older age classes present in Segment 8 may be replicated in Segment 4. The presence of salmon and steelhead would create a new anadromous salmonid shore fishery. The anadromous salmonid fisheries, particularly salmon, would result in dead fish carcasses and increased fishing pressure that have associated negative social perceptions among the general public, riparian landowners, and outdoor enthusiasts. Sea lamprey would be able to reach Segment 4, requiring new control strategies and increased control costs.

Segment 5 – Boardman Pond (Boardman Dam)

The existing impoundment would be replaced by 1.2 miles of new stream channel. Segment 5 would be connected to 2.9 miles of free flowing river downstream (Segments 3 and 4) and 21.3 miles of free flowing river upstream (Segments 6, 7, and 8) to the forks. The existing warm water fishery would be replaced with a top quality cold water fishery similar to that of Segment 8. The poor survival of older age classes present in Segment 8 may be replicated in Segment 5. The presence of salmon and steelhead would create a new anadromous shore fishery. The anadromous salmonid fisheries, particularly salmon, would result in dead fish carcasses and increased fishing pressure that have associated negative social perceptions among the general public, riparian landowners, and outdoor enthusiasts. Sea lamprey would be able to reach Segment 5, requiring new control strategies and increased control costs.

Segment 6 – Brown Bridge Dam to Boardman Pond (Boardman Dam)

Segment 6 would be connected to 4.1 miles of free flowing river downstream (Segments 3, 4, and 5) and 7.5 miles of free flowing river upstream (Segments 7 and 8) to the forks. The existing top quality cold water fishery would benefit from overall increased productivity of the larger free flowing river segment. Resident trout abundance is expected to increase, becoming more similar to that of Segment 8. The presence of salmon and steelhead would create a new anadromous shore fishery upstream to Brown Bridge Dam. The anadromous salmonid fisheries, particularly salmon, would result in dead fish carcasses and increased fishing pressure that have associated negative social perceptions among the general public, riparian landowners, and outdoor enthusiasts.

Segment 7 – Brown Bridge Pond (Brown Bridge Dam)

The existing impoundment would be replaced by 1.5 miles of new stream channel. Segment 7 would be connected to 17.9 miles of free flowing river downstream (Segments 3, 4, 5, and 6) and 6.0 miles of free flowing river upstream (Segment 8) to the forks. The existing warm water fishery would be replaced with a top quality cold water fishery similar to that of Segment 8. The poor survival of older age classes present in Segment 8 may be replicated in Segment 7. The presence of salmon and steelhead would create a new anadromous shore fishery upstream to Brown Bridge Dam. The anadromous salmonid fisheries, particularly salmon, would result in dead fish carcasses and increased fishing pressure that have associated negative social perceptions among the general public, riparian landowners, and outdoor enthusiasts. Sea lamprey would be able to reach Segment 7, requiring new control strategies and increased control costs.

Segment 8 – Forks to Brown Bridge Pond

Segment 8 would be connected to 19.4 miles of free flowing river downstream (Segments 3, 4, 5, 6, and 7) and is already connected to 35.5 miles of free flowing river upstream in the north and south branches. The existing top quality cold water fishery would be maintained and would benefit from the greater length of free flowing river due to better genetic diversity, increased habitat access, and higher overall productivity. The presence of salmon and steelhead would create a new anadromous shore fishery upstream to Brown Bridge Dam. The anadromous salmonid fisheries, particularly salmon, would result in dead fish carcasses and increased fishing pressure that have associated negative social perceptions among the general public, riparian landowners, and outdoor enthusiasts. Sea lamprey would be able to reach Segment 8, requiring new control strategies and increased control costs.

Segments 9 & 10 – North and South Branch

Segments 9 and 10 would be connected to 25.4 miles of free flowing river upstream of Boardman Lake. The existing top quality cold water fishery would be maintained and would benefit from the greater length of free flowing river due to better genetic diversity, increased habitat access, and higher overall productivity. The existing top quality cold water fishery would be maintained and would benefit from the greater length of free flowing river due to better genetic diversity, increased habitat access, and higher overall productivity. The presence of salmon and steelhead would create a new anadromous shore fishery. The anadromous salmonid fisheries, particularly salmon, would result in dead fish carcasses and increased fishing pressure that have associated negative social perceptions among the general public, riparian landowners, and outdoor enthusiasts. Sea lamprey would be able to reach Segments 9 and 10, requiring new control strategies and increased control costs.

Sediment

The modifications to the Union Street Dam would not have a significant impact on sediment quality or transport. Sediment would continue to accumulate in the impoundments reducing deep water habitat and creating shallow water and wetland habitat.

Removal of Brown Bridge Dam would require sediment management. Option 3 is the most cost effective and would be the preferred method. Designed sediment capture and removal near the dam during dam breaching/removal would protect the existing habitat quality and top quality cold water fishery in Segment 6. Restoring a natural sediment transport regime through dam breaching/removal would benefit the ecology of the Boardman River downstream of Brown Bridge Dam. Sediment management at Sabin and Boardman dams could be achieved the same as Alternative 25: breach/remove Boardman first using Option 1, and then manage sediment during breaching/removal of Sabin using Option 3. This approach would be the most cost effective approach to sediment management at Sabin and Boardman dams.

Stream channel morphology

The modifications to the Union Street Dam would not have a significant impact on stream channel morphology.

Threatened and endangered species

The modifications to the Union Street Dam would not have a significant impact on threatened or endangered species. The partial removal or total removal of the Sabin Dam could have a positive impact on populations of threatened or endangered species. Given increases in emergent, scrub-shrub, and forested wetlands adjacent to sandy upland habitat, it is likely that partial or total removal of Sabin Dam would increase the quantity and quality of wood turtle habitat available. Although submerged and floating aquatic vegetation habitat of the Blanding's turtle would transition to emergent, scrub-shrub, and forested wetlands, the turtle is known to utilize a variety of wetland habitats including swamp, emergent marsh, fen, wet meadow, inundated shrub swamp, and floodplain forest. Blanding's turtle juveniles would use tag alder and willow wetland habitat adjacent to slow moving streams the first couple years of their lives (Harding, pers. comm.) so they could be found in some sections of the river above the four impoundments.

Other rare species known to occur within the watershed that may benefit from this improved habitat diversity include the red-shouldered hawk (*Buteo lineatus*), bald eagle (*Haliaeetus leucocephalus*), and ebony boghaunter (*Williamsonia fletcheri*). With the lowering of the impoundment, the potential also exists for rare natural communities like northern fen and rich conifer swamp to develop along the numerous groundwater seeps occurring at the southern end of Sabin Pond.

Given increases in emergent, scrub-shrub, and forested wetlands adjacent to sandy upland habitat, it is likely that a partial or total removal would increase the quantity and quality of habitat available for rare species known to occur within the watershed, such as wood turtle, Blanding's turtle, bald eagle (*Haliaeetus leucocephalus*), red-shouldered hawk, and ebony boghaunter (*Williamsonia fletcheri*). Although the open-water habitat of the common loon would be lost, nearby lakes to the east with relatively undeveloped shorelines would likely provide suitable alternative habitats for nesting.

Although the open-water habitat of the common loon and trumpeter swan would be lost, nearby lakes to the north and east with relatively undeveloped shorelines would likely provide suitable habitats for nesting. Since their territory includes other nearby open-water habitats and the bald eagle uses a variety of habitats for feeding, the loss of the Brown Bridge impoundment would not impact the bald eagle population. Given increases in emergent, scrub-shrub, and especially forested wetlands adjacent to sandy upland habitat, it is likely that partial or total removal would increase the quantity and quality of habitat available for other rare species known to occur within the watershed, including wood turtle, Blanding's turtle, red-shouldered hawk, and ebony boghaunter (*Williamsonia fletcheri*).

<u>Water quality</u>
The modifications to the Union Street Dam would not have a significant impact on water quality. The removal of Brown Bridge Dam would mitigate the adverse impact to the Boardman River caused by warm water discharge from Brown Bridge Pond.

<u>Ground water</u>
The modifications to the Union Street Dam and removal of the other dams would not have a significant impact on ground water resources.

ENGINEERING IMPACTS

<u>Transportation and infrastructure</u>
The modifications to the Union Street Dam and removal of the other dams would not have a significant impact on transportation and infrastructure. There are utilities located at the Union Street Dam, but the modifications would not impact the utilities.

<u>Hydrology and hydraulics</u>
The modifications to the Union Street Dam and removal of the other dams would have a significant impact on hydrology and hydraulics of the Boardman River in the vicinity of the dams.

<u>Flood plain changes</u>
The modifications to the Union Street Dam would not have a significant impact on flood plains on Boardman Lake. The floodplain elevation of Sabin Pond, Boardman Pond, and Brown Bridge Pond would be lower with this alternative. The revised floodplain elevation is shown in Appendix C

<u>Stream bank stabilization</u>
The modifications to the Union Street Dam would not have a significant impact on stream banks and would not require additional stream bank stabilization efforts because the modifications would not change

the water level in Boardman Lake. There could be a need for stream bank stabilization along certain segments of the new river channel to avoid sedimentation and protect new habitat.

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Water supplies and on-site waste water treatment systems

The modifications to the Union Street Dam and removal of the other dams would not have a significant impact on water supplies and on-site wastewater treatment systems

SOCIETAL IMPACTS

Property boundaries and rights

The modifications to the Union Street Dam and removal of the other dams would not have a significant impact on property boundaries or property rights.

Risks to property owners

The modifications to the Union Street Dam and removal of the other dams would not have a significant impact on risks to property owners and may alleviate some risks associated with the dams.

Historic status of dams and power houses

The modifications to the Union Street Dam and removal of the other dams would not have a significant impact on historic or cultural resources in the vicinity of the dams.

Impact on County's Natural Education Reserve

The modifications to the Union Street Dam and removal of the other dams would not have a significant impact on the County's Natural Education Reserve. The discovery hike called "The Wonder of Ponds" would need to be replaced with hikes describing restored wetland and cold water streams.

ECONOMIC IMPACTS

Recreation and Tourism

With the removal of Sabin, Boardman, and Brown Bridge Dams, we anticipate that the corresponding changes in stream hydrology and fish habitats will result in changes in recreation opportunities associated with the Boardman River. Under this alternative, Sabin Pond, Boardman Pond, and Brown Bridge Pond will become free-flowing river segments. The removal of these dams will change the nature of the fishery not only for the existing impoundments, but for other segments as well. Specifically, anadromous fish species are predicted to become available as far upstream as the north and south branches. In addition, catch rates for anadromous fish species in western Grand Traverse Bay are predicted to improve. Boardman Lake, however, will continue to offer warm water fishing experiences. Moreover, some segments will offer more “whitewater” under this alternative than current conditions do, consequently changing recreational paddling opportunities. The former impoundments are predicted to become more scenic, as well.

Relative to current conditions, implementing Alternative 81 will increase the recreation value of residents by approximately $241,000. This increase represents the present value over 30 years. In addition, we expect tourism spending to increase. The present value estimate of the increase in tourism spending over 30 years is $1.58 million. Finally, once the fishery improvements have realized their maximum potential, we expect that the tourism-based jobs will increase by 5 jobs.

Property values

The repairs to the Union Street Dam would not have a significant impact on property values within ½ mile of the dam. A study of the property values adjacent to impoundments that have been removed reported that property values within ½ mile of the impoundment tend to increase over time (Provencher, et al., 2006).

Finally, property values near the current impoundments will likely be affected by the dam removals. The discussion related to Alternative 25 provides the context and caveats associated with estimated changes in property values that result from the implementation of Alternative 81. Table 21 shows how the total assessed value of residential parcels within a ½ mile of the Boardman River would change if Alternative 79 were implemented. Initially, the aggregate assessed value of the properties could fall by as much as $0.6 million. Over time, the aggregate assessed value may increase by as much as $1.9 million. The associated present value is $1.18 million.

TABLE 23: ESTIMATED CHANGES IN ASSESSED VALUE OF RESIDENTIAL PARCELS UNDER ALTERNATIVE 81
($ Millions)

Number of Years Since Removal	Value with Current Conditions	Value with Alternative 81	Estimated Change in Assessed Value	Percent Change
1	$331.3	$330.7	$(0.6)	–0.2%
2	$331.3	$330.7	$(0.6)	–0.2%
3	$331.3	$331.4	$0.1	0.0%
4	$331.3	$331.5	$0.2	0.1%
5	$331.3	$331.6	$0.3	0.1%
6	$331.3	$331.7	$0.4	0.1%
7	$331.3	$331.9	$0.5	0.2%
8	$331.3	$332.0	$0.6	0.2%
9	$331.3	$332.1	$0.7	0.2%
10	$331.3	$332.2	$0.8	0.3%
11	$331.3	$332.3	$0.9	0.3%
12	$331.3	$332.4	$1.0	0.3%
13	$331.3	$332.5	$1.2	0.3%
14	$331.3	$332.6	$1.3	0.4%
15	$331.3	$332.7	$1.4	0.4%
16	$331.3	$332.8	$1.5	0.4%
17	$331.3	$332.9	$1.6	0.5%
18	$331.3	$333.0	$1.7	0.5%
19	$331.3	$333.1	$1.8	0.5%
20	$331.3	$333.2	$1.9	0.6%

Note: Future values noted here do not reflect any influences on property values except those uniquely associated with dam removal. General appreciation of values over time is not reflected in this table.

<u>Cost of the modifications</u>
The annual maintenance of the dams is estimated to be as follows:
Union Street = $30,000-50,000

The estimate to maintain the dams was obtained from County employees who currently maintain the dams.

TABLE 24: PROBABLE CONSTRUCTION COST ESTIMATES FOR ALTERNATIVE 81.

Dam	Low Cost Estimate	High Cost Estimate
Union Street Modifications	$1,430,000	$2,150,000
Sabin Dam Partial Removal	$360,000	$1,013,000
Sabin Dam Total Removal	$1,870,000	$3,683,000
Boardman Dam Partial Removal	$1,900,000	$2,700,000
Boardman Dam Total Removal	$5,360,000	$8,830,000
Brown Bridge Dam Partial Removal	$1,300,000	$2,050,000
Brown Bridge Total Removal	$8,510,000	$15,470,000
Alt. 81 Total with Partial Removal	$4,990,000	$7,913,000
Alt. 81 Total with Total Removal	$17,170,000	$30,133,000

These estimates were developed by STS in their study of Union Street and Brown Bridge Dam (STS, 2008) and for Sabin and Boardman Dam by ECT and Prein and Newhof as part of the detailed analysis of alternatives for the dams. A detailed summary of the cost estimates in provided in Appendix D.

Property tax implications

The modifications to the Union Street Dam and removal of the other dams could have an impact on property taxes if that is the source of funds used to implement the modifications. However, there are numerous options for funding the modifications and a decision as to the source of funding has not been made at this time.

Jobs

The modifications would create some local construction jobs and recreation and tourism jobs.

Hydroelectricity

The modifications to the Union Street Dam and removal of the other dams would not allow electricity to be generated at the dams. Alternative 41 describes the actions and modifications that are anticipated in order to allow electricity to be generated at the dams.

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