UPPER TURTLE RIVER DAM 9 (Larimore)

Appendix D-5: Economics Analysis

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USDA United States Department of Agriculture

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The reader will note the use of acronyms throughout this report; they are identified in the table below.

Acronyms

BEA	Bureau of Economic Analysis
BU	Bushel
CCI	Construction Cost Index
CDF	Crop Damage Factors
CDL-E	Crop Data Layer enhanced by machine learning
CWT	Hundredweight
DRV	Depreciated Replacement Value
EAD	Expected Annual Damages
ERS	Economic Research Service
FWOFI	Future without Federal Investment
FY	Fiscal Year
GDP	Gross Domestic Product
LDRA	Larimore Dam Recreation Area
NAA	No Action Alternative
NASS	National Agricultural Statistics Service
NFIP	National Flood Insurance Program
NRCS	Natural Resources Conservation Service
P&G	Principles and Guidelines
PPPI	Producer Prices Paid Index
PR&G	Principles, Requirements, and Guidelines
UDV	Unit Day Value
USACE	U.S. Army Corps of Engineers

I. Introduction

This economic analysis summarizes the methodology used to estimate the project benefits under the three alternatives and provides the results of the cost-benefit analysis. The analysis follows the guidance provided by the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G), the subsequent *Principles, Requirements, and Guidelines* (PR&G), the *National Watershed Program Manual* as revised in 2024, the *National Watershed Program Handbook*, and the *National Resource Economics Handbook Part 611 – Water Resource Handbook for Economics*.

Throughout the report, the data is provided in 2024 values unless stated otherwise. The analysis was conducted using the fiscal year (FY) 2026 federal discount rate for water resources projects of 3.25% (Natural Resources Conservation Service [NRCS], 2026).

This appendix evaluates the three alternatives carried forward in the Watershed Plan.

Alternative 1 is considered as the Future without Federal Investment (FWOFI). In this alternative, the Sponsor would likely initiate a constructed breach of the dam to forestall the risk of loss of life under a more damaging event. As the dam and reservoir would no longer exist, this alternative can be considered as modeling the without-dam condition. This event would significantly alter the recreation activities currently enjoyed at Larimore. As noted in the Watershed Plan:

> neither the state dam safety authority (ND Department of Water Resources) nor the Sponsor sees the No Action alternative as a reasonable assumed FWOFI. The Sponsor indicated that what they would do, if a structural rehabilitation were not undertaken on the dam with federal assistance, would be to remove their liability for public safety and property damages by taking a “least cost” approach to decommissioning the dam embankment to the point it no longer posed downstream risk.

Alternative 2 involves a structural rehabilitation of the dam to remedy all existing structural deficiencies. This rehabilitation would enable the existing recreational activity at Larimore to continue for the next 100 years. This is the Preferred Alternative.

Alternative 3 is the No Action Alternative (NAA). Per the National Instruction 390-303 to clarify the NAA:

> For watershed rehabilitation projects, the no-action alternative is the condition of the existing dam remaining in place without any action that would improve the dam from its original design or correct safety deficiencies beyond maintenance or replacements performed in accordance with its operation and maintenance plan. The dam is assumed to fail and not be subsequently rebuilt or rehabilitated. […] The no-action alternative documents baseline conditions against which all other alternatives are analyzed. (NRCS, 2022b)

A dam breach is modeled to occur during an 1,844-year flood event (0.00054 exceedance probability). Consistent with the National Instruction, the dam and associated recreational opportunities are assumed to continue to operate in the absence of any remediation activities until a breach occurs. We modeled the expected annual damages (expected annual value, in the case of recreation), on the basis of the probability of dam failure, consistent with our understanding of the National Instruction and verified in conversation with the NWMC Economist (Goode, 2026).

II. Study Area Inventory

The study area for this analysis is set by the modeled inundation of the 500-year floodplain under the currently existing conditions. This area is contained within Grand Forks and Walsh Counties, North Dakota.

Damages – and the benefits from damage reductions – accrue primarily in four categories: structures and vehicles, agricultural land, roadway infrastructure, and recreational activity. The remainder of Part II will introduce each category to the set the stage for the estimation, in Part III, of the expected damages to each category under the different alternatives – the economic analysis.

In common terminology, flood events are commonly referred to by interval: a 2-year or 100-year flood event, for example. More precise terminology identifies flood events by the annual exceedance probability (0.5, or 0.01 event probability). This analysis aims to use them together for clarity but does treat the terms as interchangeable.

A. Structures and Vehicles

This section reviews the structures present in the watershed and the associated contents and vehicle valuations, as well as the data collection methods.

The Natural Resources Conservation Service (NRCS) utilized aerial photographs and the National Structure Inventory data from the U.S. Army Corps of Engineers (USACE) to develop a database of structures within the study area.[1] Structure type was verified through aerial imagery; the results are summarized in Table 1.

Of the 485 structures, 331 experience flooding depths greater than 0" during the 500-year flood event; the remaining 154 structures are within one foot of flooding. For this analysis, we considered flood damage for contents to begin within one foot of the structure elevation.

Table 1- Summary of Structure Inventory

Structure Type	Within Study Area	Within Flood-Impacted Area (500 yr)
Agricultural	364	261
Residential	332	203
Commercial	18	12
Government	8	5
Industrial	6	4
SUM	728	485

[1] The number of structures within the flood extents are evaluated for the FWOFI condition.

[2] No additional structures come into the flood extents between the 500 and the 1844 flood events, but the dollar value of the damages increases.

The structures and contents values provided in Table 2 rely on data from the *Hazus Inventory Technical Manual* from the Federal Emergency Management Agency (FEMA) (FEMA, 2025; 2022a; 2022b). Depreciated replacement values (DRV) and contents values were calculated based on the initial structural values. This was the source for all building types except for the two types of grain storage facilities.

The area of each structure was estimated using Geographic Information System (GIS) data, and then structure value utilized Hazus methodology. Values for grain storage facilities and contents were initially determined as part of a similar project proposal in the same region of the state using state-level data and local interviews (Gannett Fleming, 2022). The structure values for grain storage bins is a function of their diameter; the contents damages are a function of both bin diameter and flood depth. Silo values were updated to 2024 values using the Engineering Construction Cost Index (CCI) for structures and a composite index from the Economic Research Service (ERS) national normalized prices for the contents (NRCS, 2025; Economic Research Service [ERS], 2025).[2]

[1] The National Structure Inventory data is current as of March 2023. More details on the structure shapefile and the River Analysis System (RAS) models are included in the Hydrology and Hydraulics (H&H) report.

[2] The contents were updated using an average of the price change, 2018 to 2024, for the four crops that would potentially be stored in the silo: corn, dry beans, soybeans, and wheat. The contents values increased by 12.40%; the structure values by 22.69%.

Table 2- Structure and Contents Values

	Structure Type	Structure Value	Structure - DRV	Contents Value	Notes
Agricultural	Ag Outbuilding – Equipment Storage	$141.35	106.01	141.35	content calculated as 100% of structure value
	Ag Outbuilding – Grain Bin	Bin diameters ranged from 15’ to 56’, with associated structure DRVs ranging from $10,396 to $52,062.		Contents value for bins is a function of diameter, with estimated values ranging from $24,000 to $475,918	
	Ag Outbuilding – Silo	63,633	47,725	41,924	content values updated as noted in the text
	Ag Outbuilding – Livestock	141.35	106.01	141.35	content calculated as 100% of structure value
	Ag Outbuilding – No Machinery Storage	141.35	106.01	141.35	content calculated as 100% of structure value
Residential	Single Family Residential	147.10	110.32	73.55	content calculated as 50% of structure value
	Mobile Home	61.71	46.28	30.85	content calculated as 50% of structure value
	Multi-Family Housing 2 - 4 Units	140.41	105.31	70.23	content calculated as 50% of structure value
	Residential – Detached Garage	147.10	110.32	73.55	content calculated as 50% of structure value
Commercial	Retail	139.41	104.55	139.41	content calculated as 100% of structure value
	Wholesale	141.35	106.01	141.35	content calculated as 100% of structure value
	Personal and Repair Services	169.63	127.22	169.63	content calculated as 100% of structure value
	Professional or Technical Services	213.30	159.97	213.30	content calculated as 100% of structure value
Industrial	Heavy Industrial or Factory	169.71	127.28	254.56	content calculated as 150% of structure value
	High Technology	240.43	180.32	360.64	content calculated as 150% of structure value
Government or Public	Government Services	181.92	136.44	181.91	content calculated as 100% of structure value
	Emergency Services	296.80	222.60	$445.20	content calculated as 150% of structure value

[3] *DRV is 75% of the Structure Value.*

[4] *Hazus 6.1 structure values were initially provided in $2022; they were indexed to 2024 values using the CCI.*

[5] *Content was calculated as a percentage of the non-depreciated structure value.*

Vehicle damages from flooding were added to the model on the basis of the Federal Emergency Management HAZUS-MH MRC Technical Manual methodology, which estimates the vehicle average values based on the local market (FEMA, 2018). Vehicle valuation and assignment by structure type are summarized in Table 3.

The type of vehicle and the number of vehicles lost to flooding varied depending on the structure type. Agricultural equipment (harvesters, tractors, attachments, etc.) values were factored into the contents value based on the operator interviews conducted as part of a previous project in the same region (Gannett Fleming, 2022). The vehicle values were updated to 2024 using the Consumer Price Index (NRCS, 2025).[3]

Table 3- Vehicle Valuation Summary

Structure Type	Number of Vehicles	Total Vehicle Value
Agricultural Machinery Storage	4	$70,315
Grain Bin	0	0
Silo	0	0
Agriculture Livestock	0	0
Agriculture Non-Machinery	0	0
Retail	0	0
Wholesale	0	0
Personal and Repair Services	3	52,736
Professional or Technical Services	3	52,736
Government Services	1	17,579
Emergency Response Services	4	70,315
Heavy Industrial / Factory	2	35,157
High Technology	0	0
Single Family Residential Structure	3	52,736
Mobile Home	0	0
Multi-Family Housing 2-4 Units	0	0
Detached Garage	3	$52,736

B. Agricultural Land

Corn, soybeans, wheat, dry beans, potatoes, sugar beets, and sunflowers are grown within the study area, comprised primarily of land in Grand Forks County, ND.[4] North Dakota NRCS Engineers utilized the 2020 Crop Data Layer (CDL) to determine the acres of each crop affected by flooding. 2020 was a representative spring planting with typically seen flooding extents, such that farming decisions were not altered based on abnormal weather within the area of interest.

The CDL was enhanced through a machine-learning algorithm to purge erratic and erroneous raster cells to conform to the predominant crop type for each farmed tract. This enhanced CDL will be referred to as CDL-E through the remainder of the document.

According to the 1983 P&G 2.3.2(b): “Basic crops […] are crops that are grown throughout the United States in quantities such that no water resources project would affect the price and thus cause transfers of crop production from one area to another.” Basic crops are distinguished from non-basic crops by the fact that their production is “limited primarily by the availability of suitable land”. Production of crops other than basic crops is more typically limited by other factors, such that any increased production of these crops in the study area would lead to an offsetting decrease in production somewhere else (NRCS, 1983).

[3] The index value to update vehicle values was 1.07.

[4] Corn was measured as corn grain, wheat as spring wheat, and sunflowers as oil sunflowers, based on the crop proportions detailed in the National Agricultural Statistics Service (NASS) ND Agricultural Statistics bulletins.

Table 4 summarizes the acres of the seven crops that were planted in North Dakota during the period 2019 – 2023 (NASS, 2025).[5]

Table 4- Crop Acres Planted in North Dakota, Summary Statistics

Crop	5-year Average	Low Value	High Value	Range (high - low)
Corn	3,310,000	1,950,000	4,100,000	2,150,000
Soybeans	6,100,000	5,600,000	7,250,000	1,650,000
Wheat	5,750,000	5,300,000	6,700,000	1,400,000
Dry Beans	640,000	530,000	820,000	290,000
Potatoes	74,200	72,000	76,000	4,000
Sugar Beets	227,760	212,000	251,000	39,000
Sunflowers	546,000	460,000	660,000	200,000

The 5-year average values from Table 4 contribute to the next step in the discussion of basic crops: exploring the potential impact of the proposed project on these crops to establish whether any of these crops should not be considered as basic crops. The affected acres value is the number of acres modeled to be inundated for at least one day from a flood event with an exceedance probability of 0.5 or less (a 2-year or more severe flood event). Table 5 reports the total affected acres of each crop, and the change in affected acres of each crop, as a share of the total acres of that crop planted in North Dakota.

Table 5- Affected Crop Acres in the Watershed as a Share of Acres Planted in ND

Crop	ND Planted Acres (average 2019-2023)	Total Affected Acres under Baseline (NAA) Condition	Total Affected Acres as Share of ND Planted Acres	Total Affected Acres under Preferred Alternative	Decrease in Affected Acres under Preferred Alternative	Decrease as Share of ND Planted Acres
Corn	3,310,000	7,705	0.23%	7,006	699	0.02%
Soybeans	6,100,000	12,091	0.20%	11,402	689	0.01%
Wheat	5,750,000	14,386	0.25%	13,750	636	0.01%
Dry Beans	640,000	10,885	1.70%	10,126	758	0.12%
Potatoes	74,200	28	0.04%	26	2	0.00%
Sugar Beets	227,760	7,516	3.30%	7,419	97	0.04%
Sunflowers	546,000	2,971	0.54%	2,720	251	0.05%

For example, during the period 2019 – 2023, an average of 3,310,000 acres were planted to corn in North Dakota each year. Over the same period, planted acres ranged from 1,950,000 to 4,100,000 acres. Within the study area, there were 7,705 acres of corn (using the 2020 CDL-E) projected to be inundated for at least one day from a 2-year or more significant flood event.

Those 7,705 acres constitute 0.23% of the average corn acres planted in North Dakota. Should the rehabilitation be completed, the corn acres vulnerable to inundation per the 2020 CDL-E are modeled to decrease from 7,705 to 7,006: a decrease of 699 acres. Those acres that are no longer vulnerable to inundation as a result of the project represent 0.02% of the average corn acres planted annually in our state.

[5] This period (2019 – 2023) matches the 5-year period used by the ERS in the 2025 report on normalized prices. Rounding may lead to small differences in the values presented compared to by-hand calculations as you work through the report.

For each of the crops considered in this report, the decrease in acres affected by flooding as a share of acres planted in North Dakota is less than 1%.

Corn, soybeans, and wheat are all identified within the 1983 P&G as examples of basic crops.

We can consider the reduction in affected acres against the range in planted acres statewide to gain additional perspective on the magnitude of potential impact. Over the 5-year period 2019 – 2023, dry bean planted acres in North Dakota varied from a low of 530,000 to a high of 820,000 acres: a range of 290,000 acres. The 758 acres of dry beans potentially removed from risk of inundation constitute less than 1% of the range in variation.

When we consider only the acreage impacted by a 2-year flood event (0.5 annual exceedance probability), we can see that the existing acres vulnerable to inundation do not exceed one-quarter of one percent of the average planted acres for any of the crops in the study area.

Table 6- Affected Acres from a 2-year Flood Event as a Share of ND Planted Acres

Crop	ND Planted Acres (average 2019-2023)	Affected Acres, 2 yr Flood Event, Baseline (NAA)	Affected Acres as Share of ND Planted Acres
Corn	3,310,000	735	0.02%
Soybeans	6,100,000	757	0.01%
Wheat	5,750,000	421	0.01%
Dry Beans	640,000	925	0.14%
Potatoes	74,200	4	0.00%
Sugar Beets	227,760	147	0.06%
Sunflowers	546,000	317	0.06%

The acreage impact to dry bean and sunflower production is minimal; the modeled impact of the project shows a reduction in affected acres from the proposed project as less than 1% of the total planted North Dakota acres for each crop. Potato and sugar beet production within the study area are constrained by contract systems. The market for potatoes is structured by contracts with potato processors. Sugar beet production is organized and controlled through producer cooperatives. No net change to contracted potato or sugar beet acreage would be realized since contracts dictate acreage planted.

All of the crops in this analysis are treated as basic crops. This proposed rehabilitation project at Larimore within the Upper Turtle River watershed is not expected to result in any change to crop prices or to crop patterns. Agricultural benefits will be measured as the reduction in expected annual damages modeled to result from the Preferred Alternative (NRCS, 1983).

C. Roadway Infrastructure

For this analysis, roadways were divided into two categories: paved or gravel. Both paved and gravel roads require repair if damaged, but the repair process and expense is significantly greater for paved roads. Both are also vulnerable to embankment loss from flooding, though at different rates. The road network was overlaid on existing and proposed flooding extents to derive impacted distances.

Table 7- Overtopped Roadways in the Study Area, NAA

Flood Event	Length Overtopped (miles)	
	Paved	Unpaved/Gravel
100-year Flood Event	3.0	19.0
1,844-year Flood Event	9.8	45.6

There are several bridges and culverts downstream within the watershed. Impacts to these structures are not expected to be significant. Any damages that would occur due to flooding are anticipated to be covered within the overtopping damages applied to flooded roadways. The rates for the overtopping damages were developed based on historical repair costs. While there are railroads within the watershed, none are modeled to experience meaningful damage from the expected flooding.

D. Recreational Activity

The 72-acre pool at the Larimore Dam Recreation Area (LDRA) offers a number of recreational activities to visitors: a swimming beach, boating (limited to non-motorized boats), three covered picnic areas for reunions, weddings, and other celebrations, fishing – including ice fishing in the winter, and myriad other activities such as softball, horseshoes, volleyball, frisbee golf, playgrounds and hiking (Grand Forks County). The camping facilities at the LRDA offer 125 seasonal sites, 7 monthly sites, and 12 overnight camp sites; the facilities include water and electric hookups as well as comfort stations. While most of the LRDA is open year-round, the camping facilities are available May 1 through October 1 (Bornsen, 2025).

In 2024, 2,779 day passes and 274 annual passes were sold. During the same year, the LDRA welcomed campers for seasonal, monthly, and nightly camping in their 144 total sites.[6]

Table 8- LDRA Access and Campground Use Data, 2024

Reservation Type	# Sites	Booking %						Turnover
		May	June	July	August	September	Average	
Seasonal	125	100%	100%	100%	100%	100%	100%	1
Monthly	7	50%	100%	100%	100%	50%	80%	5
Nightly	12	30%	30%	30%	30%	30%	30%	153

[6] *Turnover represents the number of times that type of site can be rented during the 5-month season - the total number of rental opportunities per site.*

III. Flood Damage Reduction Benefits

Benefits are measured as the reduction in expected annual damages from flooding that results from the Preferred Alternative, compared to the baseline condition. For this analysis, the baseline condition is modeled as Alternative 3, the No Action Alternative (NAA).

The modeled impacts of the various alternatives rely on different amounts of acreage that would be flooded by various rainfall events. The NAA, as it evaluates the existing dam, utilizes the same flooded acreage as the Preferred Alternative for the 2-year through 500-year flood events. The difference between the two alternatives comes in the modeling for the 1844-year flood event, with the Preferred Alternative modeled with the rehabilitated dam holding and the NAA modeled to breach. These differences are summarized in Table 9. The FWOFI condition is modeled as the without-dam condition.

[6] The recreation use data was provided by the Manager of Larimore Dam.

The 1,844 return interval on the South Branch Turtle River results in the breach of Larimore Dam; a coincidental frequency of 500-year flood is applied for the greater Upper Turtle River watershed.

Table 9- Affected Acreage Comparison by Alternative

Flood Event	No Action Alternative acreage	Preferred Alternative acreage	Future without Federal Investment acreage
2-year through 500-year	Preferred	Preferred	FWOFI
1,844-year	NAA/breach	Preferred	FWOFI

For the first three considered damage categories (structures and vehicles, agricultural land, and roadway infrastructure), the expected annual flood damages are calculated under the NAA and then separately under the Preferred and FWOFI alternatives. The reduction in expected annual damages between the NAA and the Preferred Alternative represents the benefit of the proposed rehabilitation. Recreation value is maintained under the Preferred Alternative and reduced (to different degrees) under the NAA or FWOFI outcomes. For this category, the expected annual value of recreation is calculated for each alternative; the forestalled loss under the Preferred Alternative, compared to the NAA, represents a benefit of the proposed rehabilitation.

The economic analysis for each category will first introduce the data necessary for the calculations, then calculate the expected annual damages under each of the three alternatives, and finally summarize the differences to report the impact of the proposed project in terms of reduction of expected annual flood damages.

A. Structures and Vehicles

We utilized the Hydraulic Engineering Center's Flood Impact Analysis (FIA) software (version 3.3) to estimate flood damages to structures and vehicles. The FIA software calculates the damage elevation at each structure location, such that inundation above that level would result in structural damage. The damage elevation incorporates both terrain elevation and foundation heights.

In feet, the foundation heights for structures were set to be:

Table 10- Foundation Height Settings for Structures

Residential Structures	1.0
Grain Storage	0.0
Remaining Structure Types	0.5

FIA incorporates gridded flood depth, duration, and arrival time rasters to estimate flood damages. The estimate of flood damages relies on the following structure variables: type, DRV, content and vehicle value, and foundation height.

1. No Action Alternative (NAA)

The NAA assumes that the existing dam will continue to operate as it has been in the absence of any remediation activities until a breach occurs. Given this working assumption, damages from flood events up to a 500-year event are modeled the same as in the Preferred Alternative. The difference comes with analysis of the breach-level rainfall event.

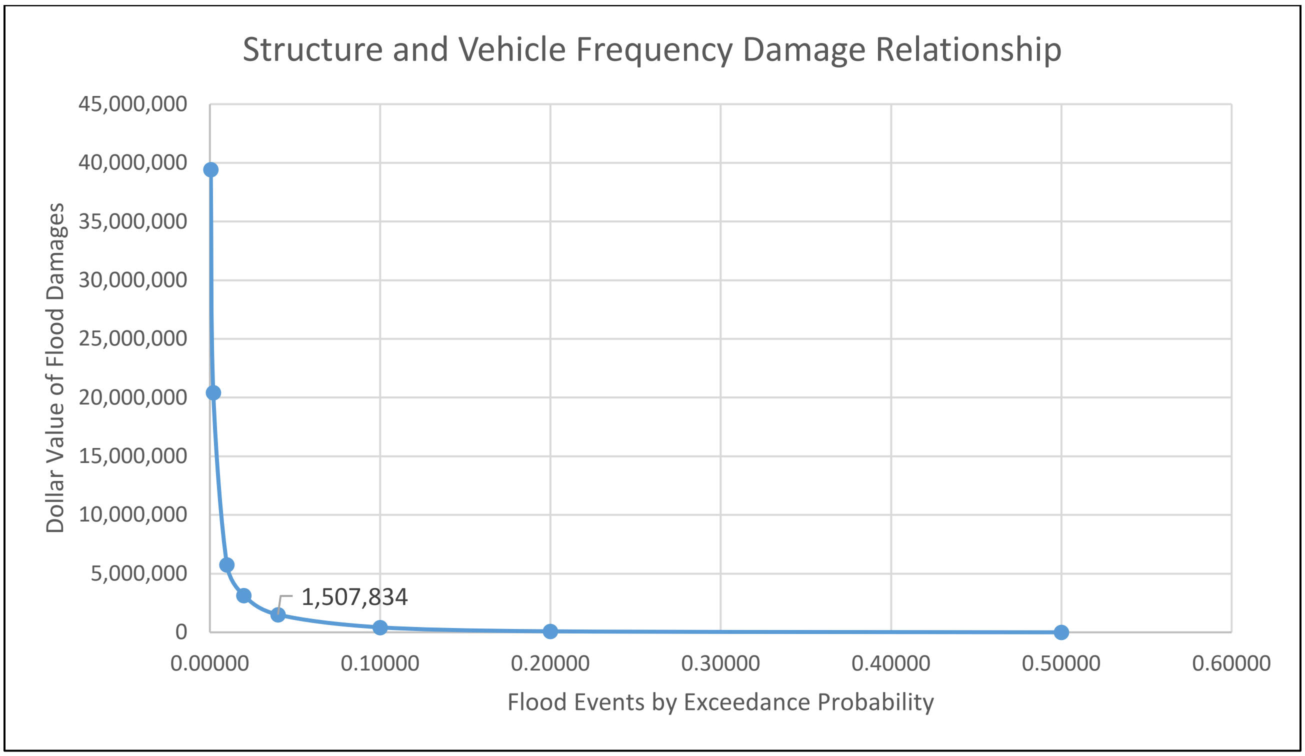
The NAA is the baseline against which the Preferred Alternative will be compared. Table 11 summarizes the modeled damages resulting from each flood event by sub-category: structures, contents, and vehicles.

Table 11- Summary of Estimated Damages to Structures and Vehicles, NAA

Flood Event	Exceedance Probability	Number of Structures Affected	Total Damage by Category			Total Damage
			Structures	Contents	Vehicles	
2 yr	0.50000	0	$0	0	0	0
5 yr	0.20000	6	11,910	74,546	0	86,456
10 yr	0.10000	14	72,888	340,682	9,317	422,887
25 yr	0.04000	48	268,886	1,184,650	54,299	1,507,834
50 yr	0.02000	94	660,669	2,358,027	122,842	3,141,538
100 yr	0.01000	148	1,224,335	4,275,632	264,695	5,764,661
500 yr	0.00200	377	4,475,702	14,763,930	1,193,127	20,432,759
1844 yr	0.00054	424	9,150,965	26,793,161	3,482,905	$39,427,031

Figure 1 illustrates the total modeled damages to structures and vehicles for each event probability under the NAA.

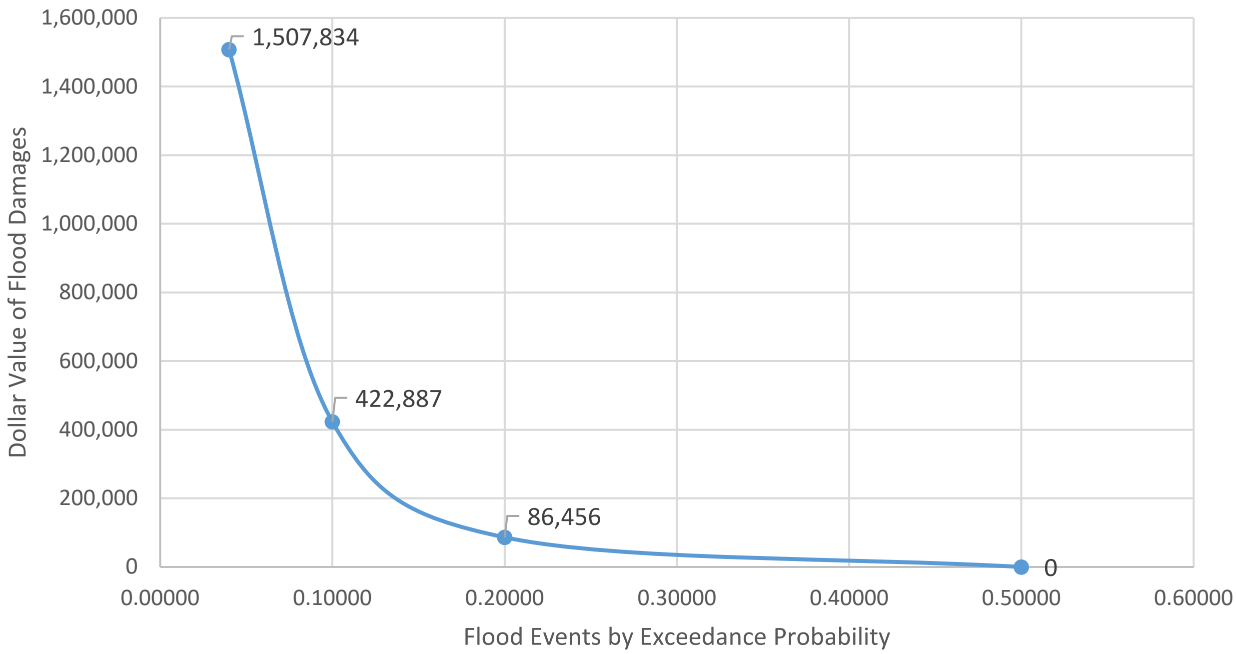
Figure 1- Frequency Damage Curve for Structures and Vehicles, NAA



The relatively high value of damages occurring from the 500-year and 1,844-year flood events masks the variation of the higher-probability flood events. Figure 2 shows only the damages, under the NAA, for flood events with an exceedance probability of at least 0.04 (a 25-year or more frequent event).

The data points in Figures 1 and 2 correspond to the specific damage values in Tables 11 and 12. For example, the dollar value of expected flood damages for a 5-year event (0.2 probability) is $86,456, which is marked in Figure 2 and identified as the damage value for a 5-year flood in both tables.

Figure 2- Frequency Damage Curve for Structures and Vehicles, close-up, NAA



The damage calculations in Table 12 value the area under the damage curve. The process detailed here is followed in the subsequent sections.

The expected damage for a given event is the exceedance probability multiplied by the damage if it occurs. The expected annual damage (EAD) calculations use the mid-point method to account for a complete range of probabilities of occurrence and damage. This can be visually thought of as the area under the frequency damage curve (see Figures 1 and 2). Table 12 provides the calculations and values for the EAD to structures and vehicles under the baseline condition.

For each level of flood event (identified by common terminology in column 1 and exceedance probability in column 2), column 3 reports the difference in probability between that flood event and the next. Column 4 reports the estimated damages; for a 5-year event, this value is $86,456, consistent with the data in Table 11 and Figure 2. Column 5 reports the average damages, calculated as the average of the damages between each pair of events. The EAD in column 6 is the product of the difference in probabilities and the average damage value (columns 3 and 5).

(1) 0.2 – 0.1 = 0.1 *difference in probability between consecutive flood events (column 3)*
(2) (86,456 + 422,887) / 2 = $254,671 *average of damages between each pair of events (column 5)*
(3) 0.1 * $254,671 = $25,467 *expected annual damage of a 5-year flood event, NAA*

Table 12- Expected Annual Damages to Structures and Vehicles, NAA

Expected Annual Damages: No Action Alternative (full breach)						
(1) Flood Event	(2) Probability	(3) Difference	(4) Damages	(5) Average Damages	(6) EAD[7]	(7) Cumulative EAD
2 yr	0.50000		$0		12,968	12,968
		0.30000		43,228		
5 yr	0.20000		86,456		25,467	38,435
		0.10000		254,671		
10 yr	0.10000		422,887		57,922	96,357
		0.06000		965,360		
25 yr	0.04000		1,507,834		46,494	142,851
		0.02000		2,324,686		
50 yr	0.02000		3,141,538		44,531	187,382
		0.01000		4,453,100		
100 yr	0.01000		5,764,661		104,790	292,171
		0.00800		13,098,710		
500 yr	0.00200		20,432,759		43,629	335,800
		0.00146		29,929,895		
1844 yr	0.00054		39,427,031		21,381	$357,182
SUM					$357,182	

The total EAD under the NAA is $357,182.

2. Preferred Alternative

A rehabilitation plan was developed to address structural deficiencies in the existing dam. The project benefits are based on the reduction of expected annual flood damages modeled to occur under this preferred alternative relative to the baseline outcome.

[7] Reported values may differ from by-hand calculations due to rounding. For example, 0.00146 * 29,929,895 = 43,698. However, the fuller probability 0.0014577007 * 29,929,895 = 43,629.

Table 13- Summary of Estimated Damages to Structures and Vehicles, Preferred Alternative

Flood Event	Exceedance Probability	Number of Structures Affected	Total Damage by Category			Total Damage
			Structures	Contents	Vehicles	
2 yr	0.50000	0	$0	0	0	0
5 yr	0.20000	6	11,910	74,546	0	86,456
10 yr	0.10000	14	72,888	340,682	9,317	422,887
25 yr	0.04000	48	268,886	1,184,650	54,299	1,507,834
50 yr	0.02000	94	660,669	2,358,027	122,842	3,141,538
100 yr	0.01000	148	1,224,335	4,275,632	264,695	5,764,661
500 yr	0.00200	377	4,475,702	14,763,930	1,193,127	20,432,759
1844 yr	0.00054	377	5,011,251	16,541,777	1,389,143	$22,942,170

A comparison of Tables 11 and 13 illustrates the shared acreage between the NAA and Preferred outcomes from the 2-year through the 500-year events.

Table 14- Expected Annual Damages to Structures and Vehicles, Preferred Alternative

Expected Annual Damages: Preferred Alternative (structural rehabilitation)						
Flood Event	Probability	Difference	Damages	Average Damages	EAD	Cumulative EAD
2 yr	0.50000		$0		12,968	12,968
		0.30000		43,228		
5 yr	0.20000		86,456		25,467	38,435
		0.10000		254,671		
10 yr	0.10000		422,887		57,922	96,357
		0.06000		965,360		
25 yr	0.04000		1,507,834		46,494	142,851
		0.02000		2,324,686		
50 yr	0.02000		3,141,538		44,531	187,382
		0.01000		4,453,100		
100 yr	0.01000		5,764,661		104,790	292,171
		0.00800		13,098,710		
500 yr	0.00200		20,432,759		31,614	323,785
		0.00146		21,687,464		
1844 yr	0.00054		22,942,170		12,442	$336,227
SUM					$336,227	

The total EAD under the Preferred Alternative is estimated at $336,227. The difference between the total expected annual damages under the NAA and Preferred Alternative is the annual benefit (from structures and vehicles), measured as a reduction in EAD, of the proposed rehabilitation.

3. Future without Federal Investment (FWOFI)

The FWOFI condition represents the Sponsor's indicated actions in place of the NAA outcome. Tables 15 and 16 replicate the analysis from the earlier scenarios, but this time under the assumption of a no-dam condition.

Table 15- Summary of Estimated Damages to Structures and Vehicles, FWOFI

Flood Event	Exceedance Probability	Number of Structures Affected	Total Damage by Category			Total Damage
			Structures	Contents	Vehicles	
2 yr	0.50000	0	$0	0	0	0
5 yr	0.20000	6	24,163	132,408	1,222	157,793
10 yr	0.10000	19	98,477	467,880	19,985	586,343
25 yr	0.04000	59	374,720	1,445,421	66,856	1,886,997
50 yr	0.02000	110	832,422	2,854,447	157,945	3,844,815
100 yr	0.01000	171	1,385,576	4,871,580	306,697	6,563,853
500 yr	0.00200	410	5,199,509	17,515,177	1,489,866	24,204,551
1844 yr	0.00054	412	5,901,833	19,712,694	1,752,383	$27,366,910

[7] The structure numbers in column 3 are the structures that incur damage, based on their damage curves, which include damages for negative flood depths (within 1'). For example, in a 100-year flood event, this includes 171 structures. The Watershed Plan (section 5) utilizes a more narrow classification, where flood damages are associated with depths greater than 0". In the same case of the 100-year flood event, 114 of those 171 structures are included.

The total EAD to structures and vehicles under the FWOFI alternative from the range of flood events is estimated at $419,940.

Table 16- Expected Annual Damages to Structures and Vehicles, FWOFI

Expected Annual Damages: Future without Federal Investment (no dam)						
Flood Event	Probability	Difference	Damages	Average Damages	EAD	Cumulative EAD
2 yr	0.50000		$0		23,669	23,669
		0.30000		78,897		
5 yr	0.20000		157,793		37,207	60,876
		0.10000		372,068		
10 yr	0.10000		586,343		74,200	135,076
		0.06000		1,236,670		
25 yr	0.04000		1,886,997		57,318	192,394
		0.02000		2,865,906		
50 yr	0.02000		3,844,815		52,043	244,437
		0.01000		5,204,334		
100 yr	0.01000		6,563,853		123,074	367,511
		0.00800		15,384,202		
500 yr	0.00200		24,204,551		37,588	405,099
		0.00146		25,785,731		
1844 yr	0.00054		27,366,910		14,841	$419,940
SUM					$419,940	

4. Relative EAD Values

All of the damages from the 2-year through the 500-year event in no-dam (FWOFI) outcome incorporate the damages modeled to occur from the same flood event under the NAA and Preferred scenarios.

For example, the $86,456 in total damages modeled from a 5-year flood event under a with-dam condition (Preferred and NAA) is the flood damage from that event when the protective barrier of the dam is in place. The guidance from 390-303-NI instructs that "the no-action alternative is the condition of the existing dam remaining in place without any action that would improve the dam from its original design […]" (NRCS, 2022b). The damages from the same flood event, without the protection of the dam ($157,793) are greater – as we should expect.

The result is that for all of the flood events where the dam is expected to hold, the damages under the FWOFI outcome (without the protection of the dam) will exceed those of the damages under the with-dam conditions. For Larimore, that applies for all analyzed flood events up through and including the 500-year flood event. The impact of the NAA shows up in the breach-level recurrence interval; an 1,844-year flood event.

Table 17 pulls data from Tables 11, 13, and 15 to illustrate the difference:

Table 17- EAD Illustration

Flood Event	Total Estimated Damages to Structures and Vehicles		
	NAA	Preferred	FWOFI
500-year	$20,432,759	20,432,759	24,204,551
1,844-year	39,427,031	22,942,170	$27,366,910

The pattern from the 2-year through the 500-year events is broken by the breach-level event: the flood wave from the dam breach under the NAA substantially increases the modeled damages beyond those that would accrue when the dam holds (separating the NAA and Preferred values). While the FWOFI is not affected by this flood wave, it is no longer providing flood attenuation for the entire storm frequencies analyzed in this report.

In this case, the significantly higher damages from the 1,844-year event are reduced by the relatively low probability of the event occurring (0.00054 exceedance probability). This leads to the outcome, evident in Table 18 (below), that the total EAD from the FWOFI is greater than the total EAD from the baseline (NAA) condition.

Pulling data from Table 18, the expected benefit to the Preferred Alternative is calculated in equation (1):

(1) $357,182 - $336,227 = $20,955 — $EAD_{(NAA)} - EAD_{(Preferred)}$ = *benefit of the Preferred Alternative*

(2) $357,182 - $419,940 = ($62,758) — $EAD_{(NAA)} - EAD_{(FWOFI)}$ = *benefit of the FWOFI Alternative*

In equation (2), the monetized benefit of the FWOFI alternative is negative – expected annual damages increase, relative to the baseline condition. This pattern holds for Larimore for damages to Agricultural Lands and to Roadway Infrastructure. A similar pattern is evident in recreation benefits: that the Preferred Alternative forestalls losses relative to the baseline, while the FWOFI outcome incurs greater losses than baseline (NAA) condition.

The monetized benefits of the FWOFI alternative are actually negative (as opposed to merely less than the costs), compared to the baseline, and the FWOFI condition requires non-zero construction costs.

5. Summary

Table 18 provides a summary of the EAD under each of the three alternatives: the baseline (which is the No Action Alternative), the Preferred Alternative (structural rehabilitation), and the Future without Federal Investment (modeled as the without-dam condition).

Table 18- Summary of Expected Annual Damages to Structures and Vehicles

Flood Event	Exceedance Probability	NAA		Preferred		FWOFI	
		Damages	Contribution to EAD	Damages	Contribution to EAD	Damages	Contribution to EAD
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2 yr	0.50000	$0	12,968	0	12,968	0	23,669
5 yr	0.20000	86,456	25,467	86,456	25,467	157,793	37,207
10 yr	0.10000	422,887	57,922	422,887	57,922	586,343	74,200
25 yr	0.04000	1,507,834	46,494	1,507,834	46,494	1,886,997	57,318
50 yr	0.02000	3,141,538	44,531	3,141,538	44,531	3,844,815	52,043
100 yr	0.01000	5,764,661	104,790	5,764,661	104,790	6,563,853	123,074
500 yr	0.00200	20,432,759	43,629	20,432,759	31,614	24,204,551	37,588
1844 yr	0.00054	39,427,031	21,381	22,942,170	12,442	27,366,910	14,841
SUM			357,182		336,227		$419,940

Columns 1 and 2 in Table 18 identify each flood event by common terminology and exceedance probability. Columns 3 – 8 summarize the damages and the EAD for each alternative: this table brings together the data from each of the three alternatives discussed previously. With respect to structures and vehicles, the proposed rehabilitation is modeled to reduce expected annual flood damages by $20,955 relative to the NAA baseline. This value is the difference between columns 4 and 6. Expected annual damages under the FWOFI outcome are $62,758 higher than they are under the NAA. The EAD under the Preferred Alternative is $83,713 less than the EAD under the FWOFI outcome (the difference between column 8 and column 6).

As noted in equation (2) in the previous section, the monetized benefits of the FWOFI outcome are negative, relative to the NAA baseline.

B. Agricultural Land

There are four categories of flood damage that accrue on agricultural land: land rehabilitation costs, costs due to late planting, damage to planted crops after the planting window has closed, and damage to planted crops within the replant window. The necessary information to estimate flood damage on agricultural land (prices, data on yield and yield impact, planting and replant cost data, and the historical monthly flood pattern) is detailed below.

Price and Yield

This analysis was conducted using the state-level normalized prices from the ERS (ERS, 2025; U.S. Department of Agriculture [USDA], 2017; NRCS, 1998). The ERS reports normalized prices as 5-year lagged averages. The 2025 report utilizes the data from 2019 – 2023 to develop the 2024 normalized prices (ERS, 2025). Average yield for each of the study area crops was calculated over the same period; this information is provided in Tables 19 and 20 (NRCS, 1998).

Table 19- Crop Yield and Price Values

	Corn	Soybeans	Wheat	Dry Beans	Potatoes	Sugar Beets	Sunflowers
Units	bu	bu	bu	cwt	cwt	ton	cwt
Yield (units per acre)	140.36	33.28	53.62	16.88	325.00	27.02	19.07
Price per unit	$4.76	$11.38	$7.18	$34.26	$12.25	$65.51	$23.78
Revenue per acre	$668.11	$378.73	$384.99	$578.14	$3,981.25	$1,770.08	$453.41

[8] *Revenue per acre is calculated as the product of the price and yield values for each crop.*

[9] *The state-level ERS normalized prices do not include sunflowers. This price is the 5-year average, 2019 - 2023, of the marketing year average price for oil sunflowers from the 2025 ND Agricultural Statistics Bulletin (NASS, 2025; NRCS, 1998).*

The ND statewide yield data is an average from 2019 – 2023, as reported in the 2025 North Dakota Agricultural Statistics Bulletin. The county-level yield data is based on data from Grand Forks County, averaged over the same 5-year period. The county-level yields were used where the data was available; state-level yields were used for potatoes and sugar beets. Table 20, below, compares the county-level and statewide yield values.

Table 20- Statewide and County-level Yield Comparison

Crop (units)	ND statewide yield	County-level yield
Corn (bu)	129.60	140.36
Soybeans (bu)	32.30	33.28
Wheat (bu)	46.00	53.62
Dry Beans (cwt)	15.20	16.88
Potatoes (cwt)	325.00	NA
Sugar Beets (ton)	27.02	NA
Sunflowers (cwt)	17.68	19.07

[10] *County-level data were not available for dry beans and sunflowers in 2019; sunflower data was also not available for 2023.*

[11] *Sources: (NASS, 2021, 2022b, 2023, 2024, 2025)*

Crop Damage Factors

The crop damage factors (CDF) in Table 20 identify, by crop and by month, the percentage reduction in yield in response to specific inundation durations (Soil Conservation Service [SCS], 1981).[8] Crops are anticipated to only incur yield reductions in response to inundation during the months of the growing season identified in Table 21; the damage factor is presumed zero for the months outside of this period.

Table 21- Crop Damage Factors for ND (% decrease in yield by number of days inundated)[9]

Corn (bu)	April	May	June	July	August	September
1 day inundation	13.0%	13.0	18.0	11.0	5.0	5.0
2 days inundation	31.0	31.0	45.0	19.0	13.0	19.0
3 days inundation	66.0	66.0	72.0	46.0	19.0	36.0
4 days inundation	70.0	70.0	78.0	57.0	33.0	44.0
5 days inundation	100.0	100.0	100.0	72.0	44.0	51.0
6 days inundation	100.0	100.0	100.0	76.0	68.0	65.0
7+ days inundation	100.0	100.0	100.0	100.0	71.0	77.0%
Soybeans (bu)[10]	April	May	June	July	August	September
1 day inundation	NA	7.0%	13.0	4.0	4.0	10.0
2 days inundation	NA	8.0	16.0	17.0	16.0	62.0
3 days inundation	NA	16.0	32.0	34.0	30.0	83.0
4 days inundation	NA	29.0	58.0	56.0	50.0	83.0
5 days inundation	NA	36.0	71.0	81.0	69.0	83.0
6 days inundation	NA	40.0	79.0	81.0	83.0	83.0
7+ days inundation	NA	40.0	79.0	81.0	83.0	83.0%
Wheat (bu)	April	May	June	July	August	September
1 day inundation	14.0%	14.0	17.0	20.0	30.0	30.0
2 days inundation	29.0	29.0	34.0	43.0	65.0	65.0
3 days inundation	44.0	44.0	54.0	65.0	75.0	75.0
4 days inundation	60.0	60.0	75.0	90.0	80.0	80.0
5 days inundation	80.0	80.0	100.0	100.0	90.0	90.0
6 days inundation	100.0	100.0	100.0	100.0	100.0	100.0
7+ days inundation	100.0	100.0	100.0	100.0	100.0	100.0%

Table 21 is continued on the next page.

[8] Resource and interpretation assistance from (Nichols, 2023, 2024).
[9] Original data from Soil Conservation Service (SCS, 1981). Per Gannett Fleming (2022, pg 10): "Damage factors for April are not in the original SCS tables; May factors are used. Original SCS did not have May factors for soybeans; May factors used are half of June factors, per consultation with L. Mairs (2017). SCS did not provide damage factors for drybeans; drybean damage factors are midway between those of potatoes and soybeans, per consultation with S. Lahman (2018)."
[10] Per the 2025 ND Agricultural Statistics Bulletin, planting for soybeans, dry beans, and sunflowers did not occur until May. Therefore, the CDF values for those crops for April is listed as NA.

Dry Beans (cwt)	April	May	June	July	August	September
1 day inundation	NA	11.0%	28.5	24.5	26.0	24.5
2 days inundation	NA	14.5	48.5	49.5	49.5	57.5
3 days inundation	NA	21.5	66.0	67.0	65.0	71.0
4 days inundation	NA	31.5	79.0	78.0	75.0	72.0
5 days inundation	NA	37.0	85.5	90.5	79.5	72.0
6 days inundation	NA	40.5	89.5	90.5	91.5	72.0
7+ days inundation	NA	40.5	89.5	90.5	91.5	72.0%
Potatoes (cwt)	April	May	June	July	August	September
1 day inundation	15.0%	15.0	44.0	45.0	48.0	39.0
2 days inundation	21.0	21.0	81.0	82.0	83.0	53.0
3 days inundation	27.0	27.0	100.0	100.0	100.0	59.0
4 days inundation	33.0	33.0	100.0	100.0	100.0	61.0
5 days inundation	38.0	38.0	100.0	100.0	100.0	61.0
6 days inundation	38.0	38.0	100.0	100.0	100.0	61.0
7+ days inundation	38.0	38.0	100.0	100.0	100.0	61.0%
Sugar Beets (ton)	April	May	June	July	August	September
1 day inundation	15.0%	15.0	15.0	20.0	15.0	15.0
2 days inundation	25.0	25.0	30.0	40.0	25.0	25.0
3 days inundation	40.0	40.0	65.0	70.0	40.0	45.0
4 days inundation	60.0	60.0	100.0	100.0	55.0	60.0
5 days inundation	80.0	80.0	100.0	100.0	70.0	70.0
6 days inundation	100.0	100.0	100.0	100.0	85.0	80.0
7+ days inundation	100.0	100.0	100.0	100.0	100.0	85.0%
Sunflowers (cwt)	April	May	June	July	August	September
1 day inundation	NA	17.0%	11.0	13.0	20.0	19.0
2 days inundation	NA	34.0	23.0	27.0	38.0	36.0
3 days inundation	NA	54.0	38.0	42.0	55.0	51.0
4 days inundation	NA	76.0	55.0	58.0	71.0	65.0
5 days inundation	NA	100.0	74.0	77.0	85.0	77.0
6 days inundation	NA	100.0	100.0	100.0	100.0	89.0
7+ days inundation	NA	100.0	100.0	100.0	100.0	100.0%

[12] *Sunflower data were not provided in the original SCS documentation. Values set per consultation with A. Wittenberg (2024).*

Late Plant Yield Loss

Table 22 summarizes crop progress, yield losses, and replant decisions. In the table, percent planted is a measure of crop planting progress, and the late plant yield loss is the percentage yield loss that results from planting late. The replant threshold is the damage value that, when exceeded, would indicate that producers should replant the crop, and the expected replant crop is provided in the following row. In North Dakota the planting season is generally considered over, for these crops, by the end of June.

Table 22- Crop Progress, Yield Losses, and Late Plant Thresholds[11]

Corn	April	May	June
Percent Planted	0.50%	25.50%	96.00%
Late Plant Yield Loss	20.00%	30.00%	NA
Replant when damage exceeds	30.00%	30.00%	75.00%
Replant with	Corn	Corn	Soybeans
Soybeans	April	May	June
Percent Planted	0.00%	16.50%	91.33%
Late Plant Yield Loss	NA[12]	10.00%	30.00%
Replant when damage exceeds	NA	30.00%	65.00%
Replant with	NA	Soybeans	Soybeans
Wheat	April	May	June
Percent Planted	4.00%	43.50%	97.67%
Late Plant Yield Loss	10.00%	20.00%	NA
Replant when damage exceeds	40.00%	30.00%	65.00%
Replant with	Wheat	Wheat	Soybeans
Dry Beans	April	May	June
Percent Planted	0.00%	9.00%	90.33%
Late Plant Yield Loss	NA	10.00%	30.00%
Replant when damage exceeds	NA	25.00%	65.00%
Replant with	NA	Dry Beans	Dry Beans
Potatoes[13]	April	May	June
Percent Planted	0.50%	35.00%	95.33%
Late Plant Yield Loss	NA	50.00%	NA
Replant when damage exceeds	NA	NA	NA
Replant with	NA	NA	NA
Sugar Beets	April	May	June
Percent Planted	1.50%	62.00%	100.00%
Late Plant Yield Loss	1.00%	15.00%	NA
Replant when damage exceeds	25.00%	75.00%	90.00%
Replant with	Sugar Beets	Sugar Beets	Soybeans

Table 22 is continued on the next page.

[11] Most of the data in this table is from (Gannett Fleming, 2022, pg 11), and cites "Personal communication with Chris Nelson, NRCS (2017), and Loren Mairs, Mairs Agricultural Consulting (2017), Samantha Lahman, Pembina County Extension (2018), Muhamed Khan, NDSU Extension (2019)."

[12] When 0% of the crop is planted in April, the following variables (late plant yield loss, replant threshold, and replant crop) are not applicable (NA).

[13] Per discussion with State Agronomist, potato crops are distinctive and would not offer the same replant opportunities as other crops (Wittenberg, 2024).

Sunflowers	April	May	June
Percent Planted	0.00%	5.00%	80.67%
Late Plant Yield Loss	NA	10.00%	30.00%
Replant when damage exceeds	NA	25.00%	65.00%
Replant with	NA	Sunflowers	Sunflowers

[13] The sunflower data in this table is from consultation with ND NRCS State Agronomist (Wittenberg, 2024).

[14] The percent planted is calculated as the average of the middle two or middle 3 weeks percent planted value, 5-year average (2019 - 2023), from the 2025 Agricultural Statistics Bulletin, per consultation with ND NRCS State Agronomist.

Unit Costs

Table 23 reports cost factors that will impact the final flood damage estimations. Seed and planting costs are estimated per acre, as planting costs are incurred at that level. Harvest costs are also measured per acre. Hauling, drying, and additional post-harvest costs that the producer may incur, such as cleaning and storage, are measured per unit (Gannett Fleming, 2022).

Table 23- Cost Factors

Category	Replant Costs ($/acre)			Avoided Cost Factors		
Crop	Seed[14]	Planting[15]	Sum	Hauling[16] ($/unit)	Additional[17] ($/unit)	Harvest[18] ($/acre)
Corn (bu)	$94.50	28.83	123.33	0.22	0.20	43.87
Soybeans (bu)	65.80	28.83	94.63	0.22	0.00	36.02
Wheat (bu)	28.00	23.25	51.25	0.26	0.00	36.49
Dry Beans (cwt)	86.63	29.25	115.88	0.81	0.00	43.40
Potatoes (cwt)	NA	NA	NA	0.40	1.21	127.92
Sugar Beets (ton)	281.43	24.96	306.39	7.20	0.00	79.95
Sunflowers (cwt)	41.04	28.83	69.87	1.22	0.40	$37.08

[15] Based on consultations (Buland, 2024) and (Wittenberg, 2024).

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[14] Seed costs for all crops except sugar beets are from the 2025 NDSU Projected Crop Budget for the North Valley region on North Dakota (Haugen, 2025). The seed cost for sugar beets in an indexed update of the price in the 2022 Gannett Fleming report. It was indexed using the Producer Prices Paid Index (PPPI) from the Water Resource Planning Discount Rates, 2024 annual value (Gannett Fleming, 2022; NRCS, 2025).

[15] Planting costs for replant for corn, soybeans, wheat, dry beans, and sunflowers are from the 2024 ND Custom Rates Early Season report (North Dakota State University [NDSU], 2024a). The values are the average cost for regular drilling or planting with fertilizer. This report does not include a value for sugar beets; that planting cost is an indexed update of the price in the 2022 Gannett Fleming report. It was updated using the PPPI from the Water Resource Planning Discount Rates, 2024 annual value.

[16] The per-unit hauling costs for corn, wheat, and sunflowers are from the 2024 ND Custom Rates Late Season report (NDSU, 2024b). The hauling cost for sugar beets is from the same source but is only most recently available for 2020; that cost has been updated to $2024 using the PPPI (NDSU, 2020). The hauling costs for soybeans, dry beans, and potatoes are from the 2022 Gannett Fleming report; they have been updated to $2024 using the PPPI.

[17] Additional costs include both drying (corn and sunflowers) and other post-harvest costs (potatoes). The drying costs for corn and sunflowers are from the 2025 Projected Crop Budgets from NDSU. The additional costs for potatoes are from the 2022 Gannett Fleming report, updated to $2024 using the PPPI.

[18] Harvest costs are provided per-acre. The costs for potatoes and sugar beets are updated from the values in the 2022 Gannett Fleming report to $2024, using the PPPI. The harvest costs for the remaining crops are from the 2024 ND Custom Rates Late Season report; they are the average cost for straight combining (NDSU, 2024b).

In addition to the costs identified in Table 23, all cropland inundated from flooding will incur additional costs as the land is rehabilitated after the water subsides. Land rehabilitation efforts may involve subsequent clean-up efforts such as removing silt, or actions to prepare the soil for a return to cropping activities. The cost is estimated at $20 per acre during the growing season and half that rate ($10 per acre) during the remaining months (Gannett Fleming, 2022, 2024).

Seasonal Flood Distribution

Agricultural damages due to flooding will vary over the months of the year; in this analysis, the damages are weighted by the historical frequency of flood events to account for this variation. The National Oceanic and Atmospheric Administration (NOAA) maintains records of four-day rain events. These records, dating back to 1966, were used to identify the historical pattern of counted rainfall events by month; the data is outlined in Table 24.

Table 24- Historical Flood Event Distribution by Month

	April	May	June	July	August	September	Other Months	**SUM**
Number	6	18	32	32	24	20	9	141
Percent	4.26%	12.77%	22.70%	22.70%	17.02%	14.18%	6.38%	100.00%

[16] *(National Oceanic and Atmospheric Administration)*

The percentages from Table 24 were used to weight the damage values, so that the final damage estimates reflect the historical pattern of flood events in the region of the watershed.

The enhanced CDL, overlaid on the range of flood intervals, allowed NRCS Engineers to develop a dataset of affected acres for each flood event in each of the 3 scenarios.

1. No Action Alternative

Table 25 and Figure 3 report the total acres modeled to be inundated for at least one day under the NAA.

Table 25- Affected Acres by Crop and Flood Event, NAA

Flood Event (probability)	Affected Acres: No Action Alternative (full breach)							
	2 yr (0.50000)	5 yr (0.20000)	10 yr (0.10000)	25 yr (0.04000)	50 yr (0.02000)	100 yr (0.01000)	500 yr (0.00200)	1844 yr (0.00054)
Corn	735	1,081	1,450	2,283	2,757	3,218	4,612	7,705
Soybeans	757	1,350	2,136	3,366	4,682	5,901	9,240	12,091
Wheat	421	888	1,661	3,177	4,893	6,551	11,138	14,386
Dry Beans	925	1,592	2,247	3,327	4,215	5,116	7,359	10,885
Potatoes	4	6	7	10	12	13	16	28
Sugar Beets	147	432	951	1,981	2,963	4,052	6,037	7,516
Sunflowers	317	453	631	914	997	1,199	1,928	2,971
SUM	3,305	5,801	9,085	15,058	20,518	26,050	40,330	55,580

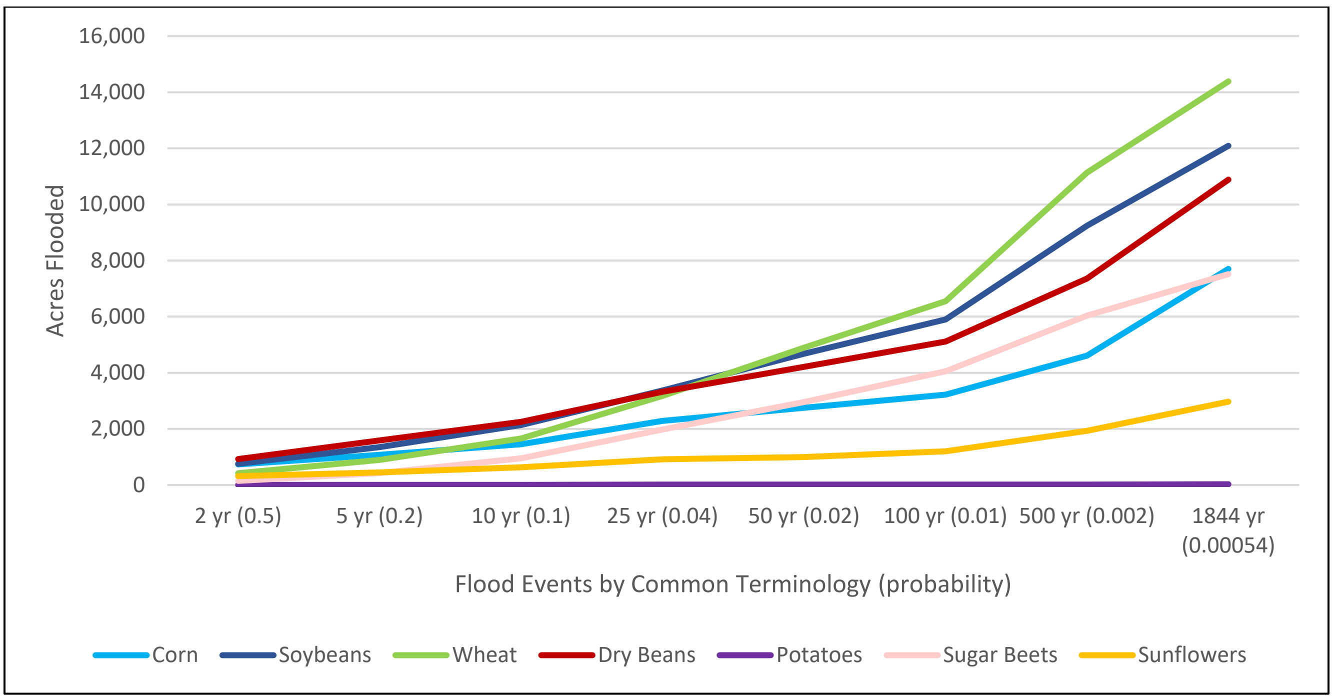
We can see in Table 25 that a 100-year flood event (0.01 annual exceedance probability) is modeled to inundate a total of 3,218 acres of corn. Table 26 breaks down those 3,218 acres to show the variation by inundation captured by the detailed modeling. 539 acres were inundated for 1 day and 1,204 acres for at least 7 days.

Table 26- Affected Acres by Flood Event, Corn, NAA

Inundation Duration	Flood Event							
	2 yr (0.50000)	5 yr (0.20000)	10 yr (0.10000)	25 yr (0.04000)	50 yr (0.02000)	100 yr (0.01000)	500 yr (0.00200)	1844 yr (0.00054)
1 day	163	249	320	365	449	539	787	1,336
2 days	129	153	207	280	392	497	773	1,069
3 days	61	117	169	248	259	304	511	636
4 days	29	80	112	196	212	209	326	548
5 days	18	53	91	137	208	243	215	431
6 days	48	31	64	163	161	223	242	415
7+ days	287	400	488	894	1,075	1,204	1,757	3,269
SUM	735	1,081	1,450	2,283	2,757	3,218	4,612	7,705

Figure 3 is a visual representation of the total acres of each crop affected by each flood event.

Figure 3- Affected Acres by Crop and Flood Event, NAA



Sample Damage Calculations[19]

There are four types of costs that may result from flooding on agricultural land; examples of the calculations are provided below.

[19] Assistance in developing and organizing calculations provided by (Nichols, 2023, 2024) and (Wittenberg, 2024).

Land Rehabilitation Costs

Land rehabilitation costs, set at a flat rate per acre, cover the cost to return the flooded acres to a productive state. This cost is estimated at $20 per acre during the growing season, and $10 per acre outside of that season.

For a corn crop, a 2-year flood in May is modeled to leave 163 acres inundated for one day. Because it occurs during the growing season, the rehabilitation cost is $20 per acre. The resultant land rehabilitation cost is:

(1) 163 * $20.00 = $3,260

Late Plant Costs

This category captures crop damages from late plant yield losses for crops not yet planted. This damage category only returns non-zero values for the months in the planting season (April – June). Broadly, these damages are measured as the affected acres multiplied by the percent yet to plant; this captures the acres that are vulnerable to delayed planting from flooding. This value is multiplied by the full yield, the late plant yield loss, and the price, reduced by the avoided per-unit costs of hauling and drying.

For a corn crop that experienced a 2-year flood event in May, leaving 163 acres inundated for one day, these calculations look like:

(1) 163 * 75% (percent yet to plant) = 122.25	*acres vulnerable to delayed plant*
(2) 122.25 * 140.36 (yield) * 30% (late plant yield loss) = 5,148	*bushels lost*
(3) 5,148 * $4.34[20] (price) = $22,342	*dollar value of the bushels lost*

Planted, outside of the Replant Window

This category captures the damages to planted crops when a flood occurs outside of the replant window; $0 damages will be returned for months when replant is possible. These damage calculations begin with the flooded (affected) acres multiplied by the percent planted; this captures the acres vulnerable to damages. This value is then multiplied by the full yield and the crop damage factor (CDF) to calculate the bushels lost. Finally, this is multiplied by the price (reduced by avoided per-unit costs), with the harvest cost deducted if the CDF is equal to 1 (such that the entire crop is lost).

Continuing the example of a corn crop that has experienced a 2-year flood, with 163 acres inundated for one day, but this time in July:

(1) 163 * 100% (percent planted) = 163	*acres vulnerable to damages*
(2) 163 * 140.36 * 11% (CDF) = 2,517	*bushels lost*
(3) 2,517 * $4.34 = $10,924	*dollar value of the bushels lost*

At this point, the crop damage factor is less than 1, and so the producer will still incur harvest costs.

[20] The $4.34/bu value is the $4.76 price, minus the per-unit hauling and drying costs (as these costs would not be paid for the bushels that are lost). $4.34 reflects the income available to producers from each unit produced. In the case of lost production, the producer loses the revenue from each unit ($4.76), but then has costs reduced as the producer does not have to pay per-unit costs (such as hauling and drying) for those lost units of production. Mathematically, ((5,148*4.76) – (5,148 * (0.20+0.22)) = 22,342.32 = (5,148 * (4.76 – 0.42)).

Planted, within the Replant Window

The final category captures damages from floods that occur during the months when it is possible to replant. These damages are calculated in three steps: 1) the initial loss, 2) the offsetting revenue impacts from subsequent replanting, and 3) calculation of total damages from the flood event.

Both the initial loss and the offsetting revenue impacts from subsequent replanting are calculated on a per-acre basis; the final step incorporates acreage to calculate the total damages.

The initial losses from a 2-year flood event, inundating 163 acres of corn for one day in May, are dependent on whether the CDF is less than the replant threshold (RT). If the CDF is less than the RT, the loss per acre is the full yield * CDF * price; otherwise, the loss per acre is the full yield * price.

In this example, the CDF = 13% and the RT = 30%. This means that the crop will not be replanted.

(1) 140.36 * 13% * $4.34 = $79.21 — *initial loss per acre*

Because the RT was not exceeded, the crop will not be replanted; there is no offsetting revenue.

The final calculation in this example will take the difference between the initial loss and any offsetting revenue (in this case, there was none), multiplied by the inundated acres and the percent planted.

(2) ($79.21 – $0) * 163 * 26% (percent planted) = $3,357 — *total estimated damages*

If we consider the same event, but for acres inundated for 3 days, the acreage value will drop to 61 and the CDF increases to 66% (which exceeds the RT of 30%), and so there now will be offsetting revenue from a subsequent replant to consider in the calculations.

The initial loss calculations are now the full yield * price, minus the harvest cost (as that will be avoided)[21]:

(3) 140.36 * $4.34 = $609.16 - $43.87 (harvest cost per acre) = $565.29 — *initial loss per acre*

The offsetting revenue is calculated as the yield, reduced by the late plant yield loss factor of 30%, multiplied by the price. That value will be reduced by the sum of the replant costs (replanting and seed costs) and the harvest cost per acre. This value is different in construct than others in this section because it is calculated as revenue coming in, where other values are calculated as losses.

(4) 140.36 * (1 – 0.3) = 98.25 — *reduced yield per acre, given late plant*
(5) 98.25 * $4.34 = $426.41 — *dollar value of replant crop*
(6) $426.41 – $123.33 (replant cost) = $303.08
(7) $303.08 - $43.87 (harvest cost) = $259.21 — *offsetting revenue per acre*

The final calculation here, as in the preceding example, will take the difference between the initial loss and the offsetting subsequent revenue per acre, multiplied by the affected acres and the percent planted.

(8) ($565.29 - $259.21) * 61 * 26% = $4,854 — *total estimated damages*

In some cases, though, it may be not feasible to replant a crop when it would otherwise be an appropriate step, given the relative values of the crop damage factor and the replant threshold: where it is not an easy or

[21] The initial loss per acre is reduced by the harvest cost. The initial loss value of $609.16/acre would be an overstatement in that does not account for the cost of harvesting the grown crop. A more correct loss value is $609.16 - $43.87 (harvest cost) = $565.29. Harvest cost is accounted for in equation (8) because now it does get paid and so would not count toward any offsetting revenue from the replant crop.

a distinct section of the field, for example.[22] The difficulty facing the producer is magnified by time pressure, particularly as the crop is inundated for an extended period. In these cases, when the CDF exceeds the RT, and acres have been inundated for 4 or more days, the producer is assumed able to only replant 80% of the acres eligible for replant, with costs as described above.[23] The remaining 20% incurs losses per the CDF and would still be harvested.

Estimated Damages

Estimated damages are calculated in several steps. For each crop, and each alternative, damages are calculated from four sources (as illustrated in the previous Sample Damage Calculations section). A sample of those results, for corn under the NAA, is provided in Table 27.

Table 27- Summary of Estimated Damages to Corn, NAA

Flood Event	Exceedance Probability	Land Rehabilitation	Late Plant	Planted, No Replant	Planted, Replant Possible	**SUM**
2 yr	0.50000	$14,233	17,310	114,114	63,295	208,952
5 yr	0.20000	20,926	25,450	164,410	93,401	304,187
10 yr	0.10000	28,083	34,155	218,586	126,284	407,108
25 yr	0.04000	44,207	53,765	386,261	213,118	697,351
50 yr	0.02000	53,384	64,926	459,808	254,705	832,823
100 yr	0.01000	62,325	75,799	528,124	294,616	960,864
500 yr	0.00200	89,310	108,618	738,776	417,263	1,353,967
1844 yr	0.00054	149,197	181,453	1,303,359	707,062	$2,341,071

After making these calculations for each crop, the total estimated damages to crops under the NAA are summarized in Table 28.

Table 28- Summary of Estimated Damages to All Crops by Damage Category, NAA

Flood Event	Exceedance Probability	Land Rehabilitation	Late Plant	Planted, No Replant	Planted, Replant Possible	**SUM**
2 yr	0.50000	$64,000	40,299	544,058	209,390	857,747
5 yr	0.20000	112,346	67,664	1,057,581	418,415	1,656,006
10 yr	0.10000	175,932	102,083	1,754,309	706,208	2,738,532
25 yr	0.04000	291,598	167,657	3,129,844	1,278,523	4,867,622
50 yr	0.02000	397,337	221,896	4,245,661	1,739,864	6,604,758
100 yr	0.01000	504,469	277,404	5,488,876	2,276,114	8,546,863
500 yr	0.00200	780,984	420,339	8,621,062	3,536,449	13,358,834
1844 yr	0.00054	1,076,302	601,998	11,947,605	4,847,609	$18,473,514

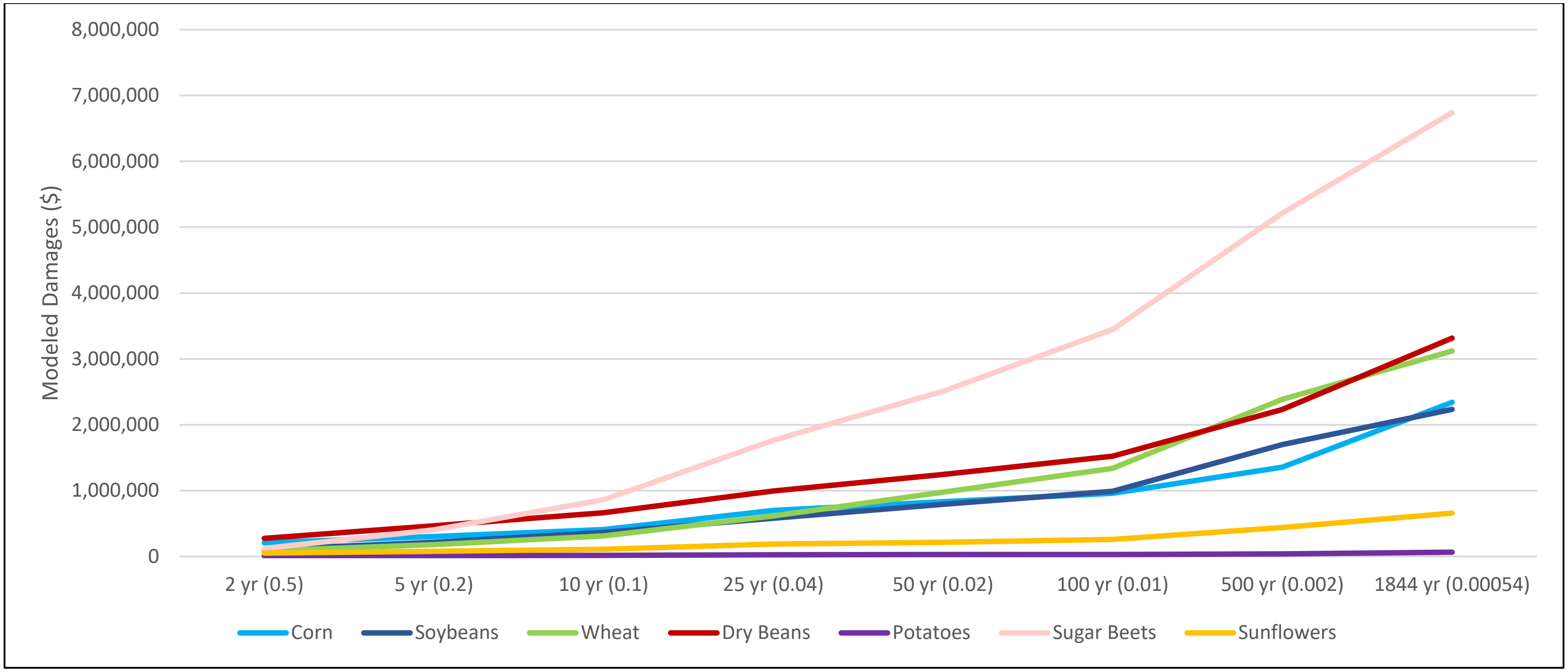
This information can be recategorized to provide total estimated damages by crop and by flood event.

[22] This may result from the distribution of the inundated acres across a larger field, or from areas of shorter flooding durations that are closely mixed (Gannett Fleming, 2022).
[23] Based on (Gannett Fleming, 2022) and further consultation with (Wittenberg, 2024).

Table 29- Summary of Estimated Damages to Agricultural Land, NAA

Crop	2 yr (0.50000)	5 yr (0.20000)	10 yr (0.10000)	25 yr (0.04000)	50 yr (0.02000)	100 yr (0.01000)	500 yr (0.00200)	1844 yr (0.00054)
Corn	$208,952	304,187	407,108	697,351	832,823	960,864	1,353,967	2,341,071
Soybeans	107,272	216,296	366,641	581,972	793,403	991,695	1,697,495	2,233,881
Wheat	84,711	178,235	313,728	616,110	975,253	1,337,097	2,388,090	3,120,029
Dry Beans	274,882	463,798	664,643	994,304	1,246,747	1,521,056	2,230,410	3,315,810
Potatoes	8,834	12,373	15,656	24,456	28,576	31,387	38,050	64,911
Sugar Beets	121,815	402,157	862,275	1,763,165	2,511,055	3,445,905	5,211,785	6,739,860
Sunflowers	51,281	78,960	108,481	190,264	216,901	258,859	439,037	657,952
SUM	857,747	1,656,006	2,738,532	4,867,622	6,604,758	8,546,863	13,358,834	$18,473,514

Figure 4- Estimated Damages to Agricultural Land, NAA



Under the NAA, the agricultural damages from the modeled breach event were estimated at $18,473,514, leading to a total EAD for the NAA of $1,136,298 (table not shown). There would be further crop impacts from erosion and flooding; additional clean-up costs would add approximately $12,600,000 in the year of the breach.[24] This would increase the total damages from the 1,844-year event to $31,073,514.

Table 30- Expected Annual Damages to Agricultural Land, NAA

Expected Annual Damages: No Action Alternative (full breach)						
Flood Event	Probability	Difference	Damages	Average Damages	EAD	Cumulative EAD
2	0.50000		857,747		377,063	377,063
		0.30000		1,256,877		
5	0.20000		1,656,006		219,727	596,790
		0.10000		2,197,269		
10	0.10000		2,738,532		228,185	824,974
		0.06000		3,803,077		
25	0.04000		4,867,622		114,724	939,698
		0.02000		5,736,190		
50	0.02000		6,604,758		75,758	1,015,456
		0.01000		7,575,811		
100	0.01000		8,546,863		87,623	1,103,079
		0.00800		10,952,849		
500	0.00200		13,358,834		32,385	1,135,464
		0.00146		22,216,174		
1844	0.00054		31,073,514		16,851	1,152,315
SUM					$1,152,315	

[24] This value is taken from the Environmental Assessment (Supplemental Watershed Plan No. 1 – Environmental Assessment for the Rehabilitation of Upper Turtle River Watershed Dam No. 9 (Larimore Dam).

2. Preferred Alternative

Table 31 and Figure 5 report the total acres modeled to be inundated for at least one day under the Preferred Alternative.

Table 31- Affected Acres by Crop and Flood Event, Preferred Alternative

Flood Event (probability)	Affected Acres: Preferred Alternative (structural rehabilitation)							
	2 yr (0.50000)	5 yr (0.20000)	10 yr (0.10000)	25 yr (0.04000)	50 yr (0.02000)	100 yr (0.01000)	500 yr (0.00200)	1844 yr (0.00054)
Corn	735	1,081	1,450	2,283	2,757	3,218	4,612	7,006
Soybeans	757	1,350	2,136	3,366	4,682	5,901	9,240	11,402
Wheat	421	888	1,661	3,177	4,893	6,551	11,138	13,750
Dry Beans	925	1,592	2,247	3,327	4,215	5,116	7,359	10,126
Potatoes	4	6	7	10	12	13	16	26
Sugar Beets	147	432	951	1,981	2,963	4,052	6,037	7,419
Sunflowers	317	453	631	914	997	1,199	1,928	2,720
SUM	3,305	5,801	9,085	15,058	20,518	26,050	40,330	52,448

Figure 5- Affected Acres by Crop and Flood Event, Preferred Alternative

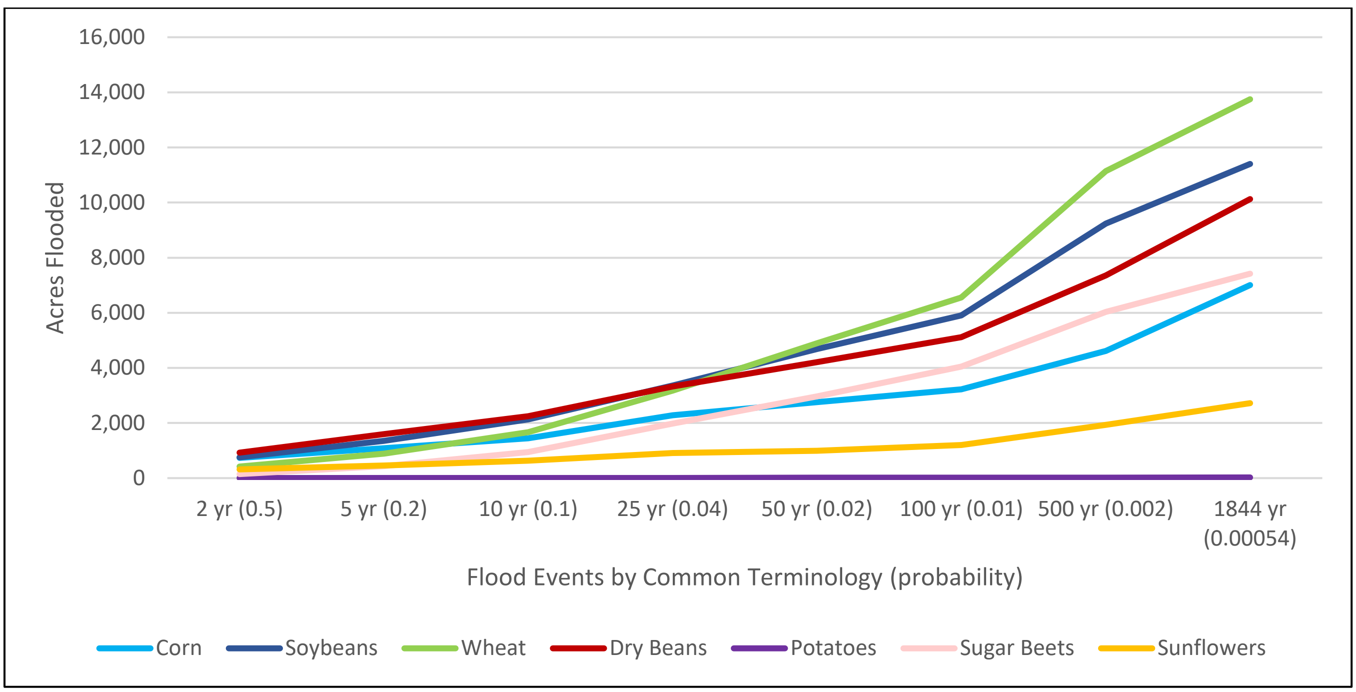
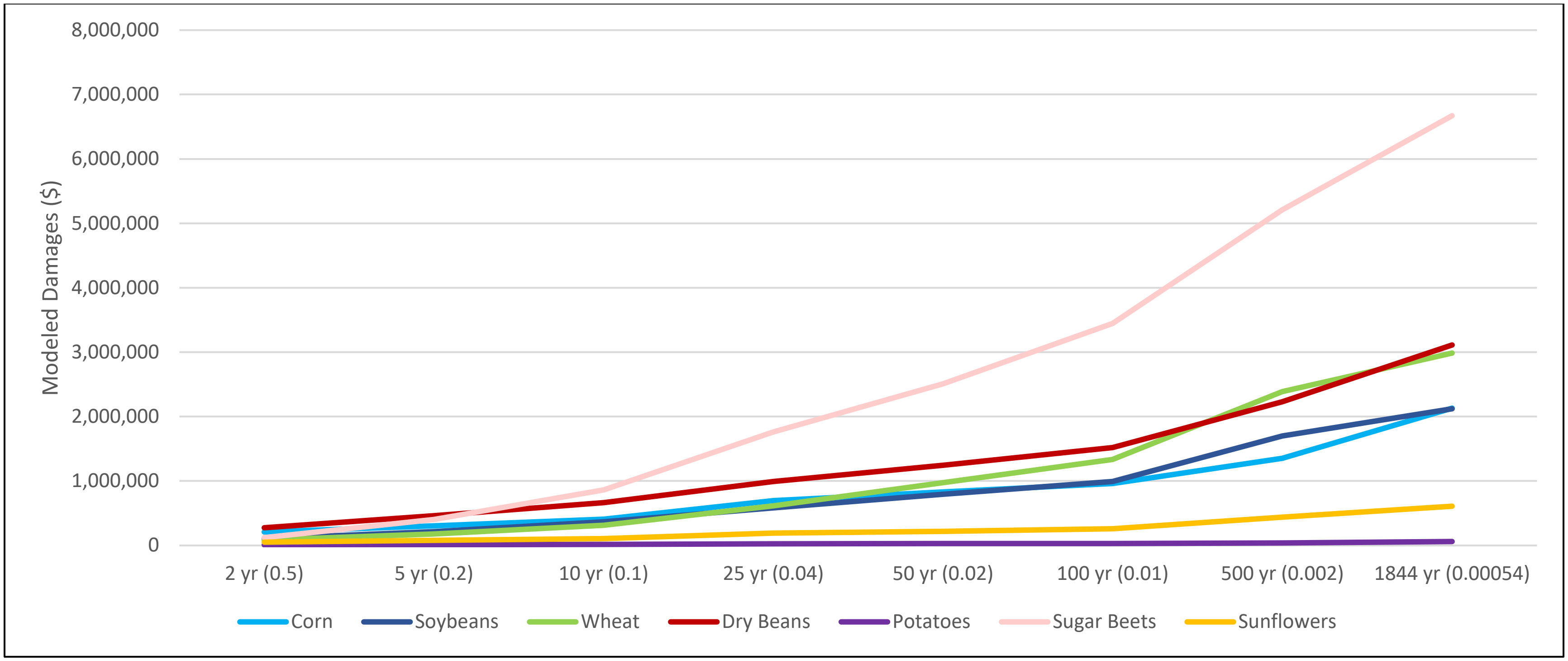


Table 32 summarizes the damages to each crop by flood event under the Preferred Alternative.

Table 32- Summary of Estimated Damages to Agricultural Land, Preferred Alternative

Crop	2 yr (0.50000)	5 yr (0.20000)	10 yr (0.10000)	25 yr (0.04000)	50 yr (0.02000)	100 yr (0.01000)	500 yr (0.00200)	1844 yr (0.00054)
Corn	$208,952	304,187	407,108	697,351	832,823	960,864	1,353,967	2,131,023
Soybeans	107,272	216,296	366,641	581,972	793,403	991,695	1,697,495	2,121,662
Wheat	84,711	178,235	313,728	616,110	975,253	1,337,097	2,388,090	2,986,725
Dry Beans	274,882	463,798	664,643	994,304	1,246,747	1,521,056	2,230,410	3,112,062
Potatoes	8,834	12,373	15,656	24,456	28,576	31,387	38,050	60,919
Sugar Beets	121,815	402,157	862,275	1,763,165	2,511,055	3,445,905	5,211,785	6,671,474
Sunflowers	51,281	78,960	108,481	190,264	216,901	258,859	439,037	609,013
SUM	857,747	1,656,006	2,738,532	4,867,622	6,604,758	8,546,863	13,358,834	$17,692,878

Figure 6- Estimated Damages to Agricultural Land, Preferred Alternative



The EAD calculations below follow those in previous sections.

Table 33- Expected Annual Damages to Agricultural Land, Preferred Alternative

Expected Annual Damages: Preferred Alternative (structural rehabilitation)						
Flood Event	Probability	Difference	Damages	Average Damages	EAD	Cumulative EAD
2 yr	0.50000		$857,747		377,063	377,063
		0.30000		1,256,877		
5 yr	0.20000		1,656,006		219,727	596,790
		0.10000		2,197,269		
10 yr	0.10000		2,738,532		228,185	824,974
		0.06000		3,803,077		
25 yr	0.04000		4,867,622		114,724	939,698
		0.02000		5,736,190		
50 yr	0.02000		6,604,758		75,758	1,015,456
		0.01000		7,575,811		
100 yr	0.01000		8,546,863		87,623	1,103,079
		0.00800		10,952,849		
500 yr	0.00200		13,358,834		22,632	1,125,711
		0.00146		15,525,856		
1844 yr	0.00054		17,692,878		9,595	$1,135,306
SUM					$1,135,306	

3. Future without Federal Investment

Table 34 and Figure 7 report the total acres modeled to be inundated for at least one day under the FWOFI outcome.

Table 34- Affected Acres by Crop and Flood Event, FWOFI

Flood Event (probability)	Affected Acres: Future without Federal Investment (no dam)							
	2 yr (0.50000)	5 yr (0.20000)	10 yr (0.10000)	25 yr (0.04000)	50 yr (0.02000)	100 yr (0.01000)	500 yr (0.00200)	1844 yr (0.00054)
Corn	797	1,191	1,545	2,410	2,877	2,930	4,776	7,257
Soybeans	813	1,520	2,218	3,544	4,899	5,824	9,451	11,706
Wheat	489	996	1,760	3,373	5,177	6,484	11,510	14,229
Dry Beans	1,026	1,752	2,337	3,465	4,388	5,025	7,552	10,382
Potatoes	5	6	7	10	12	13	16	26
Sugar Beets	164	450	966	2,088	3,083	4,051	6,216	7,658
Sunflowers	323	483	675	926	1,011	1,123	1,997	2,815
SUM	3,618	6,397	9,508	15,816	21,445	25,450	41,519	54,073

Figure 7 is a visual representation of the total acres of each crop affected by each flood event.

Figure 7- Affected Acres by Crop and Flood Event, FWOFI

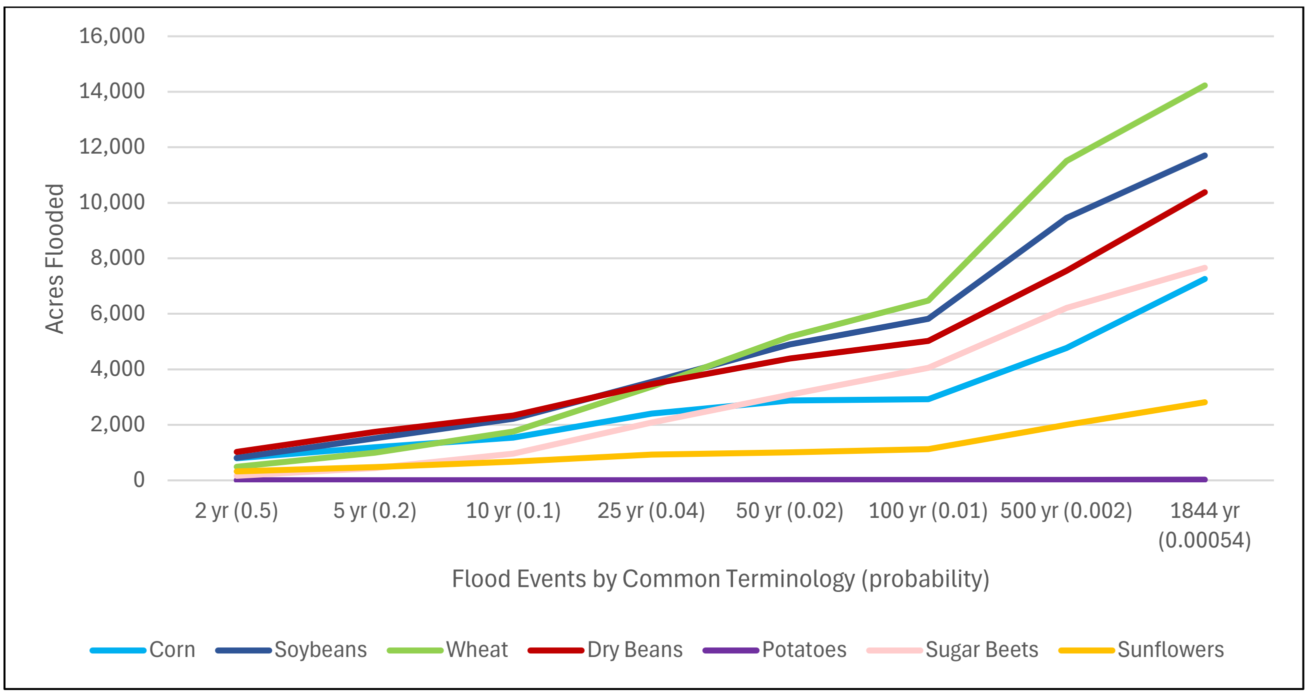


Table 35 summarizes the damages to each crop by flood event under the FWOFI outcome.

Table 35- Summary of Estimated Damages to Agricultural Land, FWOFI

Crop	2 yr (0.50000)	5 yr (0.20000)	10 yr (0.10000)	25 yr (0.04000)	50 yr (0.02000)	100 yr (0.01000)	500 yr (0.00200)	1844 yr (0.00054)
Corn Grain	$219,827	330,598	434,500	716,445	848,406	961,549	1,366,374	2,138,660
Soybeans	115,248	248,180	390,355	615,392	827,314	964,619	1,716,507	2,139,112
Wheat	98,880	198,354	335,527	661,195	1,035,953	1,301,188	2,443,660	3,053,142
Dry Beans	300,389	514,826	693,933	1,025,344	1,293,375	1,481,737	2,267,531	3,156,851
Potatoes	10,923	13,243	15,740	24,943	28,572	30,779	38,869	62,216
Sugar Beets	138,705	426,383	879,446	1,888,610	2,613,422	3,223,377	5,291,050	6,780,787
Sunflowers	54,911	86,051	118,940	194,007	218,777	244,390	445,876	616,002
SUM	938,883	1,817,635	2,868,441	5,125,936	6,865,819	8,207,639	13,569,867	$17,946,770

Figure 8- Estimated Damages to Agricultural Land, FWOFI

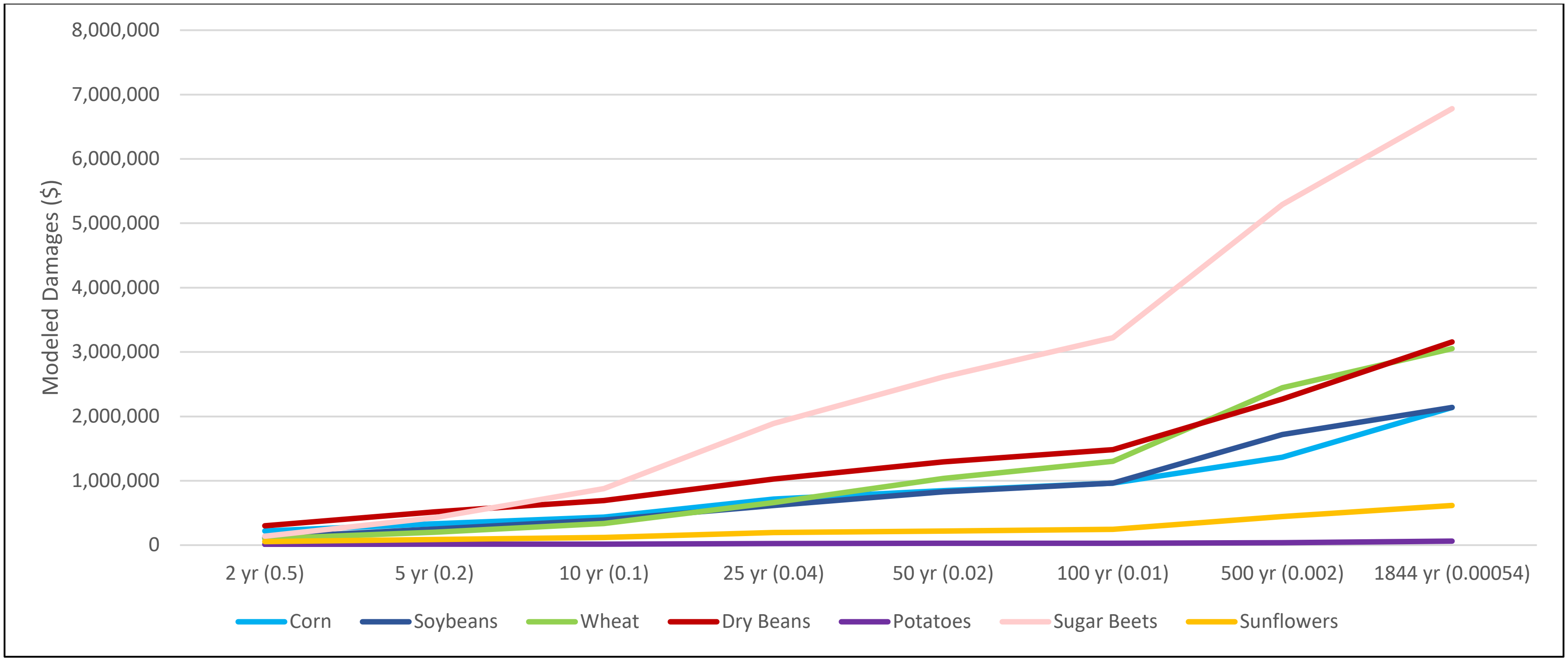


Table 36 reports the EAD for agricultural lands under the FWOFI condition. The EAD calculations below follow those in previous sections.

Table 36- Expected Annual Damages to Agricultural Land, FWOFI

Expected Annual Damages: Future without Federal Investment (no dam)						
Flood Event	Probability	Difference	Damages	Average Damages	EAD	Cumulative EAD
2 yr	0.50000		$938,883		413,478	413,478
		0.30000		1,378,259		
5 yr	0.20000		1,817,635		234,304	647,782
		0.10000		2,343,038		
10 yr	0.10000		2,868,441		239,831	887,613
		0.06000		3,997,189		
25 yr	0.04000		5,125,936		119,918	1,007,530
		0.02000		5,995,878		
50 yr	0.02000		6,865,819		75,367	1,082,898
		0.01000		7,536,729		
100 yr	0.01000		8,207,639		87,110	1,170,008
		0.00800		10,888,753		
500 yr	0.00200		13,569,867		22,971	1,192,979
		0.00146		15,758,319		
1844 yr	0.00054		17,946,770		9,733	$1,202,711
SUM					$1,202,711	

4. Summary

Table 37 summarizes the reduction in EAD for agricultural land. The preferred structural rehabilitation is modeled to reduce the expected annual damage to agricultural land by $17,009 relative to the NAA. Expected annual damages under the FWOFI outcome are $50,396 higher than they are under the NAA. The Preferred Alternative would reduce the EAD, relative to the FWOFI outcome, by $67,405.

Table 37- Summary of Expected Annual Damages to Agricultural Land

Flood Event	Exceedance Probability	NAA		Preferred		FWOFI	
		Damages	Contribution to EAD	Damages	Contribution to EAD	Damages	Contribution to EAD
2 yr	0.50000	$857,747	377,063	857,747	377,063	938,883	413,478
5 yr	0.20000	1,656,006	219,727	1,656,006	219,727	1,817,635	234,304
10 yr	0.10000	2,738,532	228,185	2,738,532	228,185	2,868,441	239,831
25 yr	0.04000	4,867,622	114,724	4,867,622	114,724	5,125,936	119,918
50 yr	0.02000	6,604,758	75,758	6,604,758	75,758	6,865,819	75,367
100 yr	0.01000	8,546,863	87,623	8,546,863	87,623	8,207,639	87,110
500 yr	0.00200	13,358,834	32,385	13,358,834	22,632	13,569,867	22,971
1844 yr	0.00054	31,073,514	16,851	17,692,878	9,595	17,946,770	9,733
SUM			1,152,315		1,135,306		$1,202,711

C. Roadway Infrastructure

Roadways were measured and categorized as either paved or unpaved / gravel, to account for the differences in planning, materials, and repair time. The greater requirements for paved roads are evident in the repair costs: the cost to repair a paved road is estimated at $137.14 per linear foot (LF); the repair cost for a gravel road is $55.34 per linear foot. Flooding may also damage the roadway embankment; repair costs for embankment loss are estimated at $160 per linear foot. The embankment losses include breaching near bridges or culverts, as typical for this area per local highway engineers (West, 2023).

Table 38- Damage Percentages and Repair Costs for Watershed Roadways

Roadway Type	Damage (%)	Repair Cost ($/LF)	Wash Out (%)	Wash Out Repair Cost ($/LF)	Total Embankment Cost
Paved	10%	$137.14	1%	$160.00	$297.14
Unpaved / Gravel	20%	$55.34	2%	$160.00	$215.34

[17] *Embankment damages include the cost of embankment reconstruction and the full cost of surface type (embankment + surface repair).*

[18] *Source: (Gannett Fleming, 2022), referencing their earlier 2019 work. 2019 values were updated to 2024 values using the Construction Cost Index (NRCS, 2025).*

Table 38, above, includes the percentages used in the damage estimates. For paved roads, 10% of the length of the road overtopped by flooding is estimated to incur damage; for gravel roads, damage is estimated at 20%. Of the damaged road lengths, 1% of the paved and 2% of the gravel roads are modeled to experience embankment loss.

1. No Action Alternative

Table 39 reports the length of damages, in linear feet, to paved and gravel roads within the study area by flood event. The damage estimates here rely on the information from Table 38. The majority of the roads within the study area are unpaved; these incur more damage from a flood event than paved roads. Paved roads, though, have a higher per-LF repair cost.

Table 39- Length of Roadway Damages in Linear Feet (LF), NAA

Flood Event	Exceedance Probability	Paved			Unpaved / Gravel		
		Overtop Length	Damaged Length	Embankment Lost	Overtop Length	Damaged Length	Embankment Lost
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2 yr	0.50000	793	79	1	5,710	1,142	23
5 yr	0.20000	2,475	248	2	15,957	3,191	64
10 yr	0.10000	4,066	407	4	33,915	6,783	136
25 yr	0.04000	9,102	910	9	59,933	11,987	240
50 yr	0.02000	12,026	1,203	12	77,764	15,553	311
100 yr	0.01000	16,002	1,600	16	100,307	20,061	401
500 yr	0.00200	25,810	2,581	26	164,724	32,945	659
1844 yr	0.00054	51,516	5,152	52	241,008	48,202	964

The first step in estimating the damage from each type of flood event is to record the length of each type of roadway (paved or gravel) that was overtopped by the flood event.

For example, using the information from Table 39, a 100-year flood event is modeled to overtop 16,002 linear feet of paved roads (column 3). We know from Table 38 that roughly 10% of paved roads will incur damages from overtopping: this leads to the estimate of 1,600 LF of paved roads incurring damage from the 100-year event (column 4). One percent of this damaged length is modeled to incur embankment loss: 16 linear feet (column 5). These damage lengths are multiplied by the appropriate repair cost as noted in Table 38; damages for roadway infrastructure (including both paved and gravel roads) are reported in Table 40.

Table 40- Summary of Estimated Damages to Roadway Infrastructure, NAA

Flood Event	Exceedance Probability	Overtopping Damages	Embankment Damages	Total Damages
2 yr	0.50000	$74,066	5,154	79,220
5 yr	0.20000	210,542	14,479	225,021
10 yr	0.10000	431,118	30,420	461,538
25 yr	0.04000	788,134	54,327	842,462
50 yr	0.02000	1,025,571	70,554	1,096,125
100 yr	0.01000	1,329,591	91,152	1,420,744
500 yr	0.00200	2,177,026	149,551	2,326,577
1844 yr	0.00054	3,373,824	222,895	$3,596,719

Table 41 reports the EAD to roadway infrastructure under the NAA.

Table 41- Expected Annual Damages to Roadway Infrastructure, NAA

Expected Annual Damages: No Action Alternative (full breach)						
Flood Event	Probability	Difference	Damages	Average Damages	EAD	Cumulative EAD
2 yr	0.50000		$79,220		45,636	45,636
		0.30000		152,120		
5 yr	0.20000		225,021		34,328	79,964
		0.10000		343,280		
10 yr	0.10000		461,538		39,120	119,084
		0.06000		652,000		
25 yr	0.04000		842,462		19,386	138,470
		0.02000		969,293		
50 yr	0.02000		1,096,125		12,584	151,054
		0.01000		1,258,435		
100 yr	0.01000		1,420,744		14,989	166,044
		0.00800		1,873,660		
500 yr	0.00200		2,326,577		4,317	170,361
		0.00146		2,961,648		
1844 yr	0.00054		3,596,719		1,950	$172,311
SUM					$172,311	

2. Preferred Alternative

Damages to paved and unpaved roadways were modeled for the Preferred Alternative; the calculations rely on the same process described for the NAA.

Table 42- Length of Roadway Damages in Linear Feet (LF), Preferred Alternative

Flood Event	Exceedance Probability	Paved			Unpaved / Gravel		
		Overtop Length	Damaged Length	Embankment Lost	Overtop Length	Damaged Length	Embankment Lost
2 yr	0.50000	793	79	1	5,710	1,142	23
5 yr	0.20000	2,475	248	2	15,957	3,191	64
10 yr	0.10000	4,066	407	4	33,915	6,783	136
25 yr	0.04000	9,102	910	9	59,933	11,987	240
50 yr	0.02000	12,026	1,203	12	77,764	15,553	311
100 yr	0.01000	16,002	1,600	16	100,307	20,061	401
500 yr	0.00200	25,810	2,581	26	164,724	32,945	659
1844 yr	0.00054	34,130	3,413	34	207,174	41,435	829

Table 43 records the total modeled damages, by flood event, under the proposed structural rehabilitation.

Table 43- Summary of Estimated Damages to Roadway Infrastructure, Preferred Alternative

Flood Event	Exceedance Probability	Overtopping Damages	Embankment Damages	Total Damages
2 yr	0.50000	$74,066	5,154	79,220
5 yr	0.20000	210,542	14,479	225,021
10 yr	0.10000	431,118	30,420	461,538
25 yr	0.04000	788,134	54,327	842,462
50 yr	0.02000	1,025,571	70,554	1,096,125
100 yr	0.01000	1,329,591	91,152	1,420,744
500 yr	0.00200	2,177,026	149,551	2,326,577
1844 yr	0.00054	2,760,935	188,587	$2,949,522

The total damage values from Table 43 are used in Table 44 to calculate the EAD for roadway infrastructure under the Preferred Alternative: $171,489.

Table 44- Expected Annual Damages to Roadway Infrastructure, Preferred Alternative

Expected Annual Damages: Preferred Alternative (structural rehabilitation)						
Flood Event	Probability	Difference	Damages	Average Damages	EAD	Cumulative EAD
2 yr	0.50000		$79,220		45,636	45,636
		0.30000		152,120		
5 yr	0.20000		225,021		34,328	79,964
		0.10000		343,280		
10 yr	0.10000		461,538		39,120	119,084
		0.06000		652,000		
25 yr	0.04000		842,462		19,386	138,470
		0.02000		969,293		
50 yr	0.02000		1,096,125		12,584	151,054
		0.01000		1,258,435		
100 yr	0.01000		1,420,744		14,989	166,044
		0.00800		1,873,660		
500 yr	0.00200		2,326,577		3,845	169,889
		0.00146		2,638,050		
1844 yr	0.00054		2,949,522		1,600	$171,489
SUM					$171,489	

3. Future without Federal Investment

The last set of tables in this section provide the estimates for the FWOFI outcome.

Table 45- Length of Roadway Damages in Linear Feet (LF), FWOFI

Flood Event	Exceedance Probability	Paved			Unpaved / Gravel		
		Overtop Length	Damaged Length	Embankment Lost	Overtop Length	Damaged Length	Embankment Lost
2 yr	0.50000	566	57	1	6,365	1,273	25
5 yr	0.20000	2,970	297	3	22,153	4,431	89
10 yr	0.10000	4,790	479	5	39,848	7,970	159
25 yr	0.04000	10,084	1,008	10	65,373	13,075	261
50 yr	0.02000	13,209	1,321	13	84,605	16,921	338
100 yr	0.01000	16,354	1,635	16	101,112	20,222	404
500 yr	0.00200	28,337	2,834	28	174,682	34,936	699
1844 yr	0.00054	37,346	3,735	37	222,726	44,545	891

Table 46- Summary of Estimated Damages to Roadway Infrastructure, FWOFI

Flood Event	Exceedance Probability	Overtopping Damages	Embankment Damages	Total Damages
2 yr	0.50000	$78,213	5,651	83,863
5 yr	0.20000	285,916	19,964	305,880
10 yr	0.10000	506,706	35,746	542,452
25 yr	0.04000	861,796	59,304	921,100
50 yr	0.02000	1,117,504	76,798	1,194,302
100 yr	0.01000	1,343,329	91,951	1,435,280
500 yr	0.00200	2,321,894	158,879	2,480,774
1844 yr	0.00054	2,977,158	202,938	$3,180,096

Table 47 reports the EAD to roadway infrastructure under the FWOFI condition.

Table 47- Expected Annual Damages to Roadway Infrastructure, FWOFI

Expected Annual Damages: Future without Federal Investment (no dam)						
Flood Event	Probability	Difference	Damages	Average Damages	EAD	Cumulative EAD
2 yr	0.50000		$83,863		58,461	58,461
		0.30000		194,872		
5 yr	0.20000		305,880		42,417	100,878
		0.10000		424,166		
10 yr	0.10000		542,452		43,907	144,785
		0.06000		731,776		
25 yr	0.04000		921,100		21,154	165,939
		0.02000		1,057,701		
50 yr	0.02000		1,194,302		13,148	179,087
		0.01000		1,314,791		
100 yr	0.01000		1,435,280		15,664	194,751
		0.00800		1,958,027		
500 yr	0.00200		2,480,774		4,126	198,877
		0.00146		2,830,435		
1844 yr	0.00054		3,180,096		1,725	$200,601
SUM					$200,601	

4. Summary

Table 48 compares the expected annual damage to roadway infrastructure under the three conditions.

Table 48- Summary of Expected Annual Damages to Roadway Infrastructure

Flood Event	Exceedance Probability	NAA		Preferred		FWOFI	
		Damages	Contribution to EAD	Damages	Contribution to EAD	Damages	Contribution to EAD
2 yr	0.50000	$79,220	45,636	79,220	45,636	83,863	58,461
5 yr	0.20000	225,021	34,328	225,021	34,328	305,880	42,417
10 yr	0.10000	461,538	39,120	461,538	39,120	542,452	43,907
25 yr	0.04000	842,462	19,386	842,462	19,386	921,100	21,154
50 yr	0.02000	1,096,125	12,584	1,096,125	12,584	1,194,302	13,148
100 yr	0.01000	1,420,744	14,989	1,420,744	14,989	1,435,280	15,664
500 yr	0.00200	2,326,577	4,317	2,326,577	3,845	2,480,774	4,126
1844 yr	0.00054	3,596,719	1,950	2,949,522	1,600	3,180,096	1,725
SUM			172,311		171,489		$200,601

As modeled, the Preferred Alternative would lead to a reduction in EAD to roadways, relative to the NAA, of $822. Expected annual damages under the FWOFI outcome are $28,290 greater than the EAD under the NAA. The Preferred Alternative would reduce EAD to roadways, relative to the FWOFI outcome, by $29,112.

D. Recreation

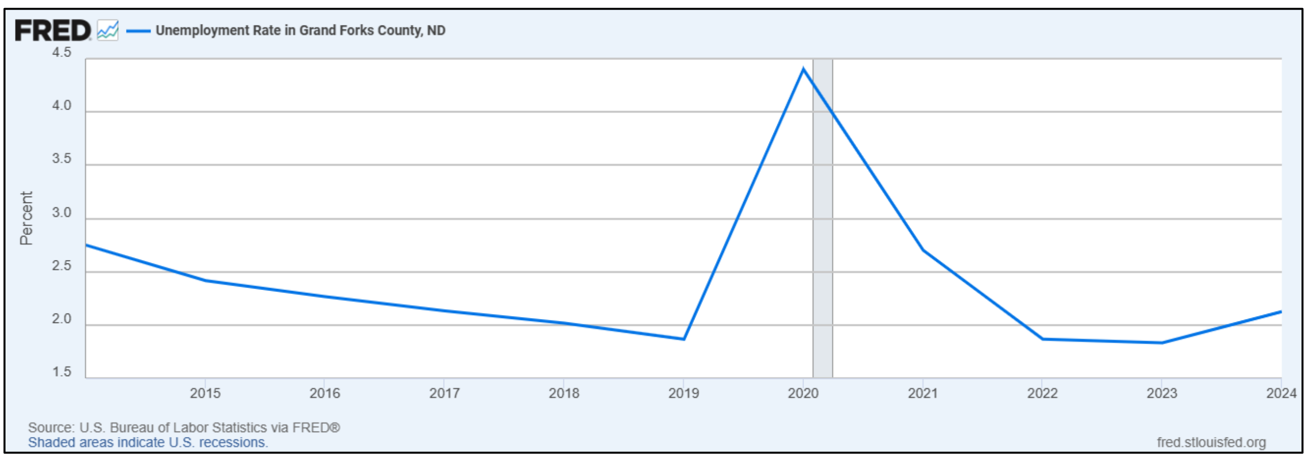
This section begins with an overview of the demographics of Grand Forks County. The following sections will describe the recreational activities within the region, and then address the value of recreation, and the extent to which the structural rehabilitation would protect recreational activities at the Larimore Dam Recreation Area.

1. Demographics

The LDRA is located on the western side of Grand Forks County. Annual Census data report the 2025 county population as approximately 74,500 (U.S. Census Bureau [Census], 2026c). The 5-year estimate of the county population was approximately 73,000 for the period ending in 2024.[25] This value has increased from approximately 67,000 in 2010 (Census, 2026b). This county population accounts for roughly 9% of our statewide population (Census, 2024b).

From 2015 through 2024, median household income in the county increased from approximately $52,000 to approximately $71,000 in 2024 (Census, 2026a). Median income represents the income level such that half of households in the county have incomes above that value and half have incomes below that value. Per-capita, or average, income in the county was $66,422 in 2024 (Bureau of Economic Analysis [BEA], 2026c). This value is slightly below the statewide average of $70,966 and the national value: $73,232 (North Dakota Legislative Council [NDLC], 2025; BEA, 2026b). Figure 9 reports the unemployment rate for Grand Forks County: 2.1% in 2024 (Bureau of Labor Statistics [BLS], 2026b). The unemployment rates shown below are notably below the U.S. average: national unemployment was 5.7% in January of 2015, peaked north of 14% in early 2020, and hovered near 4% through 2024 (BLS, 2026a).

Figure 9- Grand Forks County Unemployment Rate



[19] *(BLS, 2026b)*

761,755 acres of Grand Forks County is in farms; the 2022 Census of Agriculture reports that the county is home to 956 farms. The United States Census describes the county has having 1,436.2 square miles of land; the county covers approximately 919,168 acres, roughly 83% of which is farmland (NASS, 2022a; Census, 2024a).

The agriculture industry is a significant contributor to the ND economy. An economic analysis from North Dakota State University found that “Across all key economic metrics, the agriculture industry represented 20

[25] Per the Census Bureau description on FRED: “Multiyear estimates from the American Community Survey (ACS) are “period’ estimates derived from a data sample collected over a period of time, as opposed to “point-in-time estimates […] The date of the data is the end of the 5-year period” (Census, 2026b).

percent to 25 percent of the North Dakota economy." Crop production accounts for roughly half of that contribution (Bangsund & Hodur, 2025).

2. Regional Recreation Activities

Highlights of the Larimore Dam Recreation Area include camping, picnicking, and water-based recreation (Grand Forks County). The LDRA offers a swimming beach, non-motorized boating activities, and year-round fishing. The LDRA is a popular regional recreation resource, as detailed in the activity summary in Table 49.

Table 49- Access Passes and Camping Reservations at the LDRA, 2024

Access Passes	# Sold	Camping Type	# Sites	Turnover	Average % Booked
Daily	2,779	Nightly	12	153	30%
Annual	274	Monthly	7	5	80%
		Seasonal	125	1	100%

[20] *Turnover indicates how many distinct reservations can be made for each type of site during the camping season. The season runs from May through September; each monthly site could be reserved a maximum of 5 times.*
[21] *In 2024, daily passes sold for $5 and annual passes for $25. Nightly camping reservations cost $35, monthly: $450, and seasonal: $1,400. The LDRA Manager provided sales numbers for daily and annual passes and camping reservation information for 2024 (Bornsen, 2025).*

Unlike the previous three damage categories, the recreation benefit does not vary across the range of flood events, but only by alternative:

- Consistent with the previous sections, the NAA estimation for recreation maintains the assumption that the dam and LDRA will continue to operate in the absence of any remediation activities until a breach occurs.
- The Preferred Alternative restores the structural integrity of the dam; it does not enhance recreational facilities at the LDRA. Following construction, activities would resume at their previous volume and continue for the life of the dam.
- The constructed breach of the FWOFI is estimated to occur in what would be the 2nd year of construction under the structural rehabilitation. Water-based recreational activities would be eliminated, significantly reducing recreation use volume. The campground would be closed. Some portion of recreation users would relocate activities within the region; remaining recreation activity would be lost.

The LDRA is an important recreational facility within the region. Other facilities within the region either do not offer the same combination of activities to outdoor enthusiasts or do not have sufficient capacity to absorb the volume of activity currently enjoyed at the LDRA. A benefit of the Preferred Alternative is that it forestalls the loss of recreation value.

The region offers some capacity to absorb activity from Larimore should the LDRA face the FWOFI scenario. That capacity varies by activity: daily access and nightly camping may have a higher absorption rate through either Matejcek or Turtle River. Seasonal camping represents an investment and lifestyle distinct from shorter camping periods, one that enthusiasts might be more committed to transfer. However, opportunities to do so within the region are limited.

Figure 10- Map of Select Regional Recreation Facilities

[22] *(Google, 2026)*

Fordville and Matejcek Dams are each approximately 30 miles from the LDRA. While Fordville Dam is the most likely site to absorb recreational demand from Larimore, due to its similar array of offerings, it may also be unable to do so given its own concurrent pursuit of rehabilitation (Grand Forks County). Matejcek offers swimming, non-motorized boating, and is stocked for fishing (Walsh County). Outside of the immediate area, Devils Lake and Grahams Island State Park offer another fishing and boating substitute; this is located an hour further away from the LDRA and so may be less viable for some. Turtle River State Park offers fly-fishing opportunities but does not provide water-based recreation activities to match those at Larimore (the LDRA Manager identified the swim beach as “probably the most used day activity”) (Bornsen, 2025). Both state parks offer hiking and picnicking activities, a playground, and group shelters (North Dakota Parks and Recreation).

The monthly and seasonal camping at Larimore are less easily absorbed within the region. Fordville offers seasonal camping, but the Fordville Manager confirmed that their seasonal sites are 100% booked with a waiting list; they do have a single site for shorter camping periods that is booked about 25% of the time (Bellah, 2026).

Turtle River State Park is within 10 miles of the LDRA and offers overnight camping but does not offer monthly or seasonal camping (North Dakota Parks and Recreation). The 2021 State Parks report describes camping as “one of North Dakota state parks most popular activities”, noting that camping nights in the state parks increased by 35% from 2019 to 2020 (Bangsund & Hodur, 2021, pg 8).[26]

Devils Lake, ND, is about 70 miles further; similar to Turtle River, Grahams Island State Park offers nightly but not monthly or seasonal camping. There are many private campgrounds in the surrounding area that offer seasonal camping. A check of some of the facilities in the area, however, indicates that their seasonal reservations are 100% booked.[27] For longer-term campers at the LDRA, camping access is limited: seasonal sites nearby are fully booked, and even traveling an hour away may not be enough to guarantee access.

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[26] While there is not evident excess capacity for seasonal camping, it is possible that some of the monthly campers might shift to nightly reservations if that is the limit of what is readily available.

[27] Eastbay Campground confirmed that their seasonal sites are 100% booked; according to their website they offer 298 seasonal sites (Eastbay, 2026). Woodland Resort offers 157 seasonal sites that have been 100% booked for the past 19 years (Blanchfield, 2026).

Table 50 summarizes the estimated total annual general recreation days at the LDRA and the percentage of those, by activity, estimated to be absorbed by other recreational facilities in the region under the FWOFI scenario.[28]

Table 50- Annual Recreation Days at the Larimore Dam Recreation Area

Activity	Annual General Recreation Days	% absorbed by region under FWOFI	% of activity lost under FWOFI	LDRA recreation days that stay in the region, FWOFI
(1)	(2)	(3)	(4)	(5)
Access Pass (day)	7,352	50%	50%	3,676
Access Pass (annual)	1,997	25%	75%	499
Camping (nightly)	1,818	50%	50%	909
Camping (monthly)	1,386	25%	75%	347
Camping (seasonal)	29,215	25%	75%	7,304
SUM	41,768			12,734

*[23] To avoid double-counting access passes, the number of daily passes was reduced by the estimated number of nightly camping reservations: 2,779 daily passes – 551 nightly camping reservations = 2,228. 2,228 * 3.3 people per vehicle = 7,352. The number of annual passes was reduced by the number of monthly and seasonal campers: 274 annual passes minus 125 seasonal reservations and minus 28 monthly camping reservations = 121 annual passes. We assumed each annual pass was used 5 times, with 3.3 people per vehicle, leading to 1,997 general recreation days tied to annual passes. Annual recreation days for camping account for the number of sites available, the length of the season, and the 2024 reservation data.*

[24] Monthly camping reservations were estimated with 50% utilization for purposes of recreation days; 67% for seasonal sites. Nightly and monthly camping assume 3.3 people per site; seasonal sites use 2.28 people per site based on the average number of persons per ND household (Bangsund & Hodur, 2021; Census, 2024b).

In Table 50, column 2 reports the number of general recreation days estimated at the LDRA from each activity, based on the numbers provided by the LDRA Manager, Census data, and a report on recreation at ND State Parks (Bornsen, 2025; Census, 2024b; Bangsund & Hodur, 2021). Column 3 reports the percentage of that activity estimated to be absorbed by other recreation facilities in the region should the recreation facilities at the LDRA no longer be available. Column 5 is the product of columns 2 and 3. The information here will be used to estimate the value of recreational activities under the different outcomes. The recreational benefit of the Preferred Alternative is that it forestalls the loss in recreation value that occurs under the other alternatives.

3. The Value of Recreation at the LDRA

The PR&G describes how we value a good or service:

> The general measurement standard of the value of goods and services is defined as a user's willingness to pay (WTP) for each increment of output from an investment. Such a value would be

[28] These absorption percentages are our best estimates based on local communications; they are specific to this project. Seasonal camping accounts for more than half of the general recreation days. If the absorption rate for this activity were to drop from 25% to 0%, it would ultimately increase the difference in expected annual value between the FWOFI and the NAA from ($168,935) to ($211,588) – increasing the amount of the loss. If all of the seasonal camping were absorbed within the region (none was lost), the impact of the FWOFI outcome, relative to the NAA, on the expected annual value of recreation would be ($40,973). In each case, the benefit-cost ratio of the FWOFI outcome remains negative.

obtained if the "seller" of the output were able to apply a variable unit price and charge each user an individual price to capture the full value of the output to the user. (USDA, 2017, pg 37).

The *National Resource Economics Handbook, part 611*, identifies the Unit Day Value (UDV) method as one of the methods available to estimate the recreation benefit provided by the LDRA (NRCS, 1998).

General recreation days include activities such as swimming, picnicking, and boating: "the great majority of all recreation activities associated with water projects" (U.S. Army Corps of Engineers [USACE], 2023).[29] Use of the UDV method is consistent with prior NRCS ND projects, and follows the guidance from the National Resource Economics Handbook: "Of the three methods P&G recognized for estimating recreation value, the Unit Day Value (UDV) procedure has been the most commonly used in NRCS. The Handbook further describes the UDV as "the recommended method for NRCS activities" (NRCS, 1998, pg 5-3).

The UDV can be used to "approximate the average willingness to pay of users of Federal or Federally assisted recreation resources." Using the FY 2024 guidance, the Unit Day Value for the LDRA was estimated at $11.68 (USACE, 2023).[30]

The discussion of recreational values on the archived NRCS Technical and Economics References site cautions that the UDV may be an underestimate (Buland, 2026; NRCS 2022a). A 2021 study of the value of state parks in North Dakota reported spending on a single-day visit, within the park and local area, at $54.43 per person (Bangsund & Hodur, 2021). This value, though includes items such as shopping, groceries, and equipment rental, that extend beyond the value of the use of the site. The recreation value needs to focus specifically on use of the site, rather than a broader definition that incorporates all spending in conjunction with the trip (NRCS, 1998). The State Parks study estimates entry fees and passes for single day visits at $10.70 per person.

The Recreation Use Values Database (RUVD) identifies recreation values for several hundred studies across the country, organized by census region and by recreational activity. The RUVD Summary describes the use value estimates as "measures of net willingness to pay or consumer surplus for recreational access to specific sites" (Rosenberger, 2016a, b). An indexed value of selected activities to match those identified on the LDRA website, for studies completed within the Midwest Census Region, yields an average value of $27.76.[31] While the benefit transfer approach may be utilized, it is important to consider the applicability of the data (U.S. Geological Survey [USGS], 2022). In this case, the RUVD estimates within the Midwest Census Region included 10 estimates for beach activities and 215 for fishing, but only 1 each for swimming and picnicking, 3 for camping, and 4 for non-motorized boating.

Use of the UDV data to estimate recreation value ($11.68) is consistent with prior practice and follows existing guidance.[32]

[29] General recreation is defined as "involving primarily those activities that are attractive to the majority of outdoor users and that generally require the development and maintenance of convenient access and adequate facilities" (NRCS, 1983, pg 84).

[30] This value was determined in consultation with NRCS staff in the local (Grand Forks) area. This value is based on an above-average total rating against 5 criteria: recreation experience, availability of opportunity, carrying capacity, accessibility, and environmental quality (USACE, 2023; Bjorg, 2026).

[31] The Midwest Census Region includes North Dakota, South Dakota, Nebraska, Kansas, Minnesota, Iowa, Missouri, Wisconsin, Illinois, Michigan, Indiana, and Ohio.

[32] While there are references that suggest a higher value, neither is an easy substitute. The spending values in the study on state parks include shopping, equipment rental, and entertainment – all expenses that are not specifically for use of the recreation facility. Bangsund and Hoder also note that the data collection at state parks happens differently: on a per entry or per visit basis, rather than per user-day (2021). The RUVD data includes few estimates, within the entire Midwest Census Region, for some of the most popular activities at the LDRA.

The expected annual value of recreation under each scenario is calculated in the tables below and then summarized in Table 54.

Under the NAA, the full value of recreation days follows the Preferred Alternative except under the breach event, when recreation days drop to zero.

Table 51- Expected Annual Value of Recreation, NAA

Expected Annual Recreation Value: No Action Alternative (full breach)						
Flood Event	Probability	Difference	Recreation Value	Average Value	Expected Annual Value	Cumulative EA Value
2	0.50000		$487,849		146,355	146,355
		0.30000		487,849		
5	0.20000		487,849		48,785	195,140
		0.10000		487,849		
10	0.10000		487,849		29,271	224,411
		0.06000		487,849		
25	0.04000		487,849		9,757	234,167
		0.02000		487,849		
50	0.02000		487,849		4,878	239,046
		0.01000		487,849		
100	0.01000		487,849		3,903	242,949
		0.00800		487,849		
500	0.00200		487,849		356	243,304
		0.00146		243,924		
1844	0.00054		0		0	$243,304
SUM					$243,304	

The $487,849 recreation value in column 4 is the product of the $11.68 UDV and the full estimate of annual general recreation days at the LDRA ($11.68 * 41,768).

Under the Preferred Alternative, the value of recreation days would continue unabated.

Table 52- Expected Annual Value of Recreation, Preferred Alternative

Expected Annual Recreation Value: Preferred Alternative (structural rehabilitation)						
Flood Event	Probability	Difference	Recreation Value	Average Value	Expected Annual Value	Cumulative EA Value
2	0.50000		$487,849		146,355	146,355
		0.30000		487,849		
5	0.20000		487,849		48,785	195,140
		0.10000		487,849		
10	0.10000		487,849		29,271	224,411
		0.06000		487,849		
25	0.04000		487,849		9,757	234,167
		0.02000		487,849		
50	0.02000		487,849		4,878	239,046
		0.01000		487,849		
100	0.01000		487,849		3,903	242,949
		0.00800		487,849		
500	0.00200		487,849		711	243,660
		0.00146		487,849		
1844	0.00054		487,849		265	$243,924
SUM					$243,924	

Under the FWOFI alternative, the constructed breach would result in a significant loss of recreation activity. Some of the activity would be absorbed by other recreational facilities within the region, and that is captured in the lower expected annual value of recreation activity under this alternative.

Table 53- Expected Annual Value of Recreation, FWOFI

Expected Annual Recreation Value: Future without Federal Investment (no dam)						
Flood Event	Probability	Difference	Recreation Value	Average Value	Expected Annual Value	Cumulative EA Value
2	0.50000		$148,739		44,622	44,622
		0.30000		148,739		
5	0.20000		148,739		14,874	59,496
		0.10000		148,739		
10	0.10000		148,739		8,924	68,420
		0.06000		148,739		
25	0.04000		148,739		2,975	71,395
		0.02000		148,739		
50	0.02000		148,739		1,487	72,882
		0.01000		148,739		
100	0.01000		148,739		1,190	74,072
		0.00800		148,739		
500	0.00200		148,739		217	74,289
		0.00146		148,739		
1844	0.00054		148,739		81	$74,369
SUM					$74,369	

The $148,739 recreation value in column 4 is the product of the UDV and the estimated number of recreation days that remain in the region under the FWOFI alternative ($11.68 * 12,734).

4. Summary

Table 54 brings the data from the preceding three tables together to facilitate the calculation of the value of recreation that would be protected under the Preferred Alternative or lost under the FWOFI outcome.

Table 54- Summary of Expected Annual Value of Recreation

Flood Event	Exceedance Probability	NAA		Preferred		FWOFI	
		Value	Contribution to EAD	Value	Contribution to EAD	Value	Contribution to EAD
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2 yr	0.50000	$487,849	146,355	487,849	146,355	148,739	44,622
5 yr	0.20000	487,849	48,785	487,849	48,785	148,739	14,874
10 yr	0.10000	487,849	29,271	487,849	29,271	148,739	8,924
25 yr	0.04000	487,849	9,757	487,849	9,757	148,739	2,975
50 yr	0.02000	487,849	4,878	487,849	4,878	148,739	1,487
100 yr	0.01000	487,849	3,903	487,849	3,903	148,739	1,190
500 yr	0.00200	487,849	356	487,849	711	148,739	217
1844 yr	0.00054	0	0	487,849	265	148,739	81
SUM			243,304		243,924		$74,369

Similar to the previous summary tables, columns 1 and 2 report the flood event, and the pairs of columns to the right report expected annual values for the three scenarios. These calculations are distinct in that they report the expected annual value, rather than expected annual damages. The benefit to the Preferred Alternative, here, is that it would avoid the reduction to recreation value anticipated to occur under the FWOFI through a constructed breach, or in response to an uncontrolled breach in the NAA.

Columns 3 and 4 report outcomes for the NAA; columns 5 and 6 for the Preferred Alternative. They are identical through most flood events, with the recreation value under the NAA dropping to 0 in the event of a breach. The difference in expected annual value between the Preferred and No Action Alternatives is the annual recreation benefit to the Preferred Alternative: $620. The difference in expected annual value between the FWOFI and NAA is the annual recreation benefit to the FWOFI outcome: $74,369 - $243,304 = ($168,935). The Preferred Alternative protects $169,555 in recreation value compared to the FWOFI outcome.

The probability of a breach in any given year is so small that the value of recreation under the NAA closely tracks the recreation value under the Preferred Alternative. As the sponsors have noted, though, that closely tracking NAA dollar value cannot be evaluated separately from the risk it carries to human life.

E. Administrative Cost Increases to the National Flood Insurance Program (NFIP)

When compared to the NAA baseline, as required by National Instruction 390-303, the Preferred Alternative does not change the number of residential structures within the 100-year floodplain (NRCS, 2022b).

Under the FWOFI outcome, three additional residential structures would lie within the 100-year floodplain, and so would be required to participate in the National Flood Insurance Program (NFIP). Each structure that participates in the NFIP incurs administrative costs; increasing the number of dwellings required to participate increases these administrative costs. This increased cost is an additional quantifiable impact of the FWOFI outcome.

Townsley (2016, as cited in the North Branch Park River Economics Evaluation) estimated the 2015 average administrative cost at $308.53 per NFIP policy (Gannett Fleming, 2022). Data from the GDP-Implicit Price Deflators (IPD) was used to index this administrative cost to 2024 values.[33]

Table 55- Estimated Average Administrative Costs per NFIP Policy

Average Administrative Cost per Policy ($2015)[34]	$308.53
GDP-Implicit Price Deflator (2024/2015)[35]	1.258
2015 IPD	96.968
2024 IPD	121.953
Average Administrative Cost per Policy	$388.13

The data for GDP, Government Consumption Expenditures and Gross Investment, Federal, Nondefense spending was used to calculate an indexed 2024 value of $388.13 in administrative cost per NFIP policy. As the average administrative cost per policy is $388.13, the total estimated additional cost is $1,164.39.

(1) (121.953 / 96.968) = 1.258 * 308.53 = $388.13 — *administrative cost per policy*
(2) $388.13 * 3 = $1,164.39 — *total administrative cost increase*

F. Summary of Project Benefits

The FY 2026 discount rate for watershed projects was set at 3.25% per National Bulletin 200-26-2 (NRCS, 2026). The project life is 100 years.

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[33] The Bureau of Economic Analysis (BEA) defines an implicit price deflator as “the ratio of the current-year dollar value of a series, such as gross domestic product (GDP), to its corresponding chained-dollar value, multiplied by 100.” (BEA, 2009)

[34] This is based on Exhibit D.4-33 “Estimation of Average Administrative Costs Associated with the NFIP Per Policy” (Gannett Fleming, 2022). Per that source, it was adapted from Townsley (2016) and cited NFIP data from Actuarial Rate Review in Support of the Recommended October 1, 2011, Rate and Rule Changes; Thomas L. Hayes, ACAS, MAAA Actuary and D. Andrew Neal, FSA Actuary Federal Insurance and Mitigation Administration (FIMA).

[35] GDP-IPD annual data, 2015 and 2024, from BEA Table 1.1.9; 2017 is the base year (BEA, 2026a).

Table 56- Benefits Summary, Preferred Alternative

Category	Expected Annual Values		Annual Benefit (damage reduction or avoided loss)	Present Value of Benefits
	NAA	Preferred Alternative		
Structures and Vehicles	$357,182	$336,227	$20,955	$618,442
Agricultural Land	1,152,315	1,135,306	17,009	501,985
Roadway Inventory	172,311	171,489	822	24,260
Recreation Value	$243,304	$243,924	620	18,298
SUM			$39,406	$1,162,985

The population at risk (PAR) from dam failure is 87. The preferred structural rehabilitation does not change the height nor the reservoir capacity of the dam, and so the PAR would remain the same.

IV. Project Costs

The Watershed Plan provides detailed cost breakdowns; a summary of the costs and outlay timeline is below.

Table 57- Timeline of Estimated Outlays

	2027	2028	2029	2030	2031	2032 and Future Years	Category Sum
Preferred Alternative				construction begins in the fall	construction completed	LDRA use resumes at current levels	
Construction Costs				6,213,766	6,213,766		$12,427,531
Final Engineering Design	304,000	304,000					608,000
Construction Engineering				473,000	473,000		946,000
Project Administration			50,000				50,000
Permits & Easements			11,359				11,359
Wetland Mitigation				57,000			57,000
Annual Sum	304,000	304,000	61,359	6,743,766	6,686,766		14,099,890
Operations & Maintenance Costs						5,000	5,000
FWOFI					estimated controlled breach	no water-based recreation available	
Construction Costs				2,172,900	2,172,900		4,345,800
Final Engineering Design	125,000	125,000					250,000
Construction Engineering				125,000	125,000		250,000
Project Administration			25,000				25,000
Permits & Easements			6,000				6,000
Annual Sum	125,000	125,000	31,000	2,297,900	2,297,900		4,876,800
Operations & Maintenance						1,000	$1,000

The annual spending sums are used to calculate interest during construction for each alternative. The interest during construction is calculated using the mid-life, full expenditure model (Goode, 2024).

V. Economic Analysis Results

Table 58 summarizes the economic results for the Preferred Alternative.

Table 58- Economic Summary, Preferred Alternative

Discount Rate (i)	3.25%	AAE Factor	0.03388
Construction + Project Life	102 years	Construction Year(s)	2030-31
Construction Cost	$12,427,531	Project Life (n)	100 years
Summary (Preferred compared to NAA)			
	Present Value		Average Annual Equivalent (AAE)
Implementation Costs	(14,099,890)		(477,754)
Construction Costs	*(12,427,531)*		*(421,088)*
Final Engineering Design	*(608,000)*		*(20,601)*
Construction Engineering	*(946,000)*		*(32,054)*
Project Administration	*(50,000)*		*(1,694)*
Permits & Easements	*(11,359)*		*(385)*
Wetland Mitigation	*(57,000)*		*(1,931)*
Interest during Construction (mid-life, full expenditure)	(1,173,691)		(39,769)
Total Investment Costs	(15,273,581)		(517,523)
Operations & Maintenance	(147,564)		(5,000)
Total Costs	**(15,421,146)**		**(522,523)**
Reduction in Damages	1,144,687		38,786
Structures & Vehicles	*618,442*		*20,955*
Agricultural Land	*501,985*		*17,009*
Roadway Infrastructure	*24,260*		*822*
NFIP Administration Savings	0		0
Recreation Benefit	18,298		620
Total Benefits	**1,162,985**		**39,406**
Net Annual Benefit (benefits - costs)	**($14,258,161)**		**($483,117)**
Benefit-Cost Ratio (benefits/costs)	**0.1**		**0.1**

The calculations here, as throughout, reflect those benefits that can be assigned monetary value, but do not capture the value of preventing loss of life.

Table 59 presents a similar summary for the Future without Federal Investment.

Table 59- Economic Summary, FWOFI

Discount Rate (i)	3.25%	AAE Factor	0.03388
Construction + Project Life	102 years	Construction Year(s)	2030-31
Construction Cost	$4,345,800	Project Life (n)	100 years

Summary (FWOFI compared to NAA)		
	Present Value	Average Annual Equivalent (AAE)
Implementation Costs	(4,876,800)	(165,243)
Construction Costs	*(4,345,800)*	*(147,251)*
Final Engineering Design	*(250,000)*	*(8,471)*
Construction Engineering	*(250,000)*	*(8,471)*
Project Administration	*(25,000)*	*(847)*
Permits & Easements	*(6,000)*	*(203)*
Wetland Mitigation	*0*	*0*
Interest during Construction (mid-life, full expenditure)	(405,950)	(13,755)
Total Investment Costs	(5,282,750)	(178,998)
Operations & Maintenance	(29,513)	(1,000)
Total Costs	**(5,312,263)**	**(179,998)**
Reduction in Damages	(4,174,420)	(141,444)
Structures & Vehicles	*(1,852,169)*	*(62,758)*
Agricultural Land	*(1,487,331)*	*(50,396)*
Roadway Infrastructure	*(834,919)*	*(28,290)*
NFIP Administration Savings	(34,353)	(1,164)
Recreation Benefit	(4,985,759)	(168,935)
Total Benefits	**(9,194,531)**	**(311,543)**
Net Annual Benefit (benefits - costs)	**($14,506,795)**	**($491,541)**

Table 60 summarizes the costs and benefits of the Preferred Alternative.

Table 60- Benefit-Cost Summary, Preferred Alternative

Category		Value
1	EAD under the NAA	$1,681,808
2	EAD under the Preferred Alternative	1,643,022
3	Reduction in EAD	38,786
4	Annual Recreation Benefit	620
5	Annual NFIP Benefit	0
6	Total Average Annual Benefit	39,406
7	Construction Cost	12,427,531
8	Implementation Cost	1,672,359
9	Interest during Construction	1,173,691
10	Total PV, Investment Cost	15,273,581
11	Annual Project Cost	517,523
12	Annual Operations & Maintenance	5,000
13	Total Average Annual Cost	522,523
14	Net Annual Benefit	($483,117)
15	**BC Ratio**	**0.1**

[25] *Total Average Annual Benefit (row 6) is the sum of rows 3 - 5.*
[26] *Total PV, Investment Cost (row 10) is the sum of rows 7 - 9.*
[27] *Total Average Annual Cost (row 13) is the sum of rows 11 - 12.*

The rainfall event that could lead to a dam breach is modeled as an 1,844-year event; it has an exceedance probability of 0.00054. Under the No Action Alternative, the existing dam is modeled to continue to function and provide benefits following the Preferred Alternative details, until the breach event. Under the NAA the threat of breach remains and, with it, the threat to human lives.

The Sponsors have indicated their response to the No Action outcome would be to remove this threat through a constructed breach, modeled as the FWOFI condition. The expected annual damages are greater under this condition than those under the NAA.

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VII. Exhibit

A. PAR Worksheet: Computation of Population at Risk during Dam Failure

COMPUTATION OF POPULATION AT RISK (PAR) DURING DAM FAILURE

STATE	North Dakota		BY	Petersen	DATE	4/3/26
DAM	Upper Turtle River Watershed Dam #9 (Larimore)		CHECKED BY		DATE	
YEAR BUILT	1979	DESIGN HAZARD CLASS	S	DRAINAGE AREA	65.50	mi^2
WORK PLAN DATE	5/22/1905	CURRENT HAZARD CLASS	H	DAM HEIGHT	66	ft
sht 2 of 3	HYDROLOGIC FAILURE SCENARIO (ver. 2013-01)				NID ID	ND00391

Structures (Elevated) Impacted by Potential Breach	Number of Structures: Inundation Depth Above Natural Ground <2.0 Ft	Number of Structures: Inundation Depth Above Natural Ground >=2.0 Ft.	Total	PAR per Exposure with Inundation Depths >=2.0 Ft.	PAR
Mobile Homes				3	
Seasonal Use RV's				2	
Other					

Structures (With Foundations) Impacted by Potential Breach	Number of Structures: Inundation Depth Above Natural Ground <1.0 Ft	Number of Structures: Inundation Depth Above Natural Ground >=1.0 Ft.	Total	PAR per Exposure with Inundation Depths >=1.0 Ft.	PAR
Homes	18	15	33	3	45
Seasonal Use Homes and Cabins				1.5	
Duplexes				5	
Apartments					
Commercial Buildings					
Schools (In Use)					
Schools (Not in Use)					
Hospitals					
Other	28	60	88		0

Highways and Railroads	Number of Roads, Highways and Railways: Road Overflow Depth <1.0 Ft	Number of Roads, Highways and Railways: Road Overflow Depth >=1.0 Ft.	Total	PAR per Exposure with Inundation Depths >=1.0 Ft.	PAR
Main Local Roads and Minor State Highways					
Name(s) (if applicable)	9	17	26	2	34
Name(s) (if applicable)				2	
Major State and Minor Federal Highways					
Highway Name(s) or Number(s)				4	
Highway Name(s) or Number(s)				4	
Major Federal and Interstate Highways					
Hwy 2		1	1	8	8
Highway Name(s) or Number(s)				8	
Railroads					
UPSF Freight Traffic Only				3	
Passenger Traffic				20	
TOTAL NUMBER OF PEOPLE AT RISK (PAR)					**87**