Devils Lake Infrastructure Protection Study

Summaries of Previous Investigations of Devils Lake Features

(Sections 2.1 through 2.25)

Prepared for

The U.S. Army Corps of Engineers
St. Paul District

by

Barr Engineering Company

January 10, 2003

BARR

2.1 Summary of Economic Analysis Investigation for Feature 1: Churchs Ferry

2.1.0 Flood Protection Strategy

The Economic Analysis of Devils Lake Alternatives indicated that the flood protection strategy with the largest net benefits for Churchs Ferry was relocation of structures.

2.1.1 General Information

Feature Type: Community

Location: Churchs Ferry is located approximately 23 miles northwest of Devils Lake, ND on US Highway 2. The accompanying Figure 2.1-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: Churchs Ferry is a community of approximately 77 people (based on 2000 census). Since this census was completed, many of the residences have been relocated.

Significance: The value of all the communities in this study is high because of the density of infrastructure in this primarily rural section of North Dakota. Churchs Ferry has been affected by the rising lake level over the last few years, and more structures could be affected by rising lake levels.

Damages: The flooding of Churchs Ferry would result in the following damages:

- loss of 3 homes
- loss of a grain elevator
- loss of a church

Owner/Sponsor: The community of Churchs Ferry is responsible for managing and maintaining Churchs Ferry.

Lead Federal Agency: Corps would take the lead for Churchs Ferry for any flood protection work that may take place. Federal Emergency Management Agency (FEMA) would coordinate relocation of structures.

2.1.2 Feature Protection

History of Flood Protection: In the past, flood protection for Churchs Ferry has consisted of constructing a levee to 1451.5 and conducting a buyout program which was implemented in 2000. Only 3 residents decided to forego the buyout offer, all of which are located between 1456 and

1464. The existing sewage lagoons are serving only the 3 remaining residences. The cost to protect the lagoons is $150,000, which is greater than the value of these 3 homes. Therefore, it was assumed that if the lake rose to the level of the lagoons, they would be abandoned and damages would be ignored. It was assumed that the existing levee would not be raised because the cost of raising it would greatly exceed the value of the few structures that it would protect.

General Protection Strategy: The Economic Analysis identified and evaluated the following approach for protecting Churchs Ferry:

- relocation of 3 homes, a grain elevator, and a church

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake considered various protection strategies, with flood-protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.1-2 shows the decision tree for Churchs Ferry. As shown on Figure 2.1-2, the stepwise approach to flood protection for Churchs Ferry consisted of the following:

1. At lake elevation 1447, the structures below 1456 would be relocated.
2. At lake elevation 1455, relocation would occur for structures between elevations 1456 and 1464.

The maximum protection strategy that was analyzed at the first action level was relocating all structures below elevation 1464. (Note that for the Economic Analysis of Devils Lake, the decision regarding relocation of structures is made at a time when the lake is one foot below the low structure elevation.)

Interdependencies: The protection of Churchs Ferry is related to the protection of the highways that serve it. These highways include:

- Feature 13: US Highway 2
- Feature 16: US Highway 281 (South of US Highway 2)
- Feature 17: US Highway 281 (North of US Highway 2)

These highways are critical for Churchs Ferry in that they provide the main transportation routes in and out of the community.

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.1.3 Feature Economics

Damages: For Churchs Ferry the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for Churchs Ferry are summarized in the accompanying Table 2.1-1.

The first portion of the table shows the damages that are associated with each action level (1447 and 1455), each representing damages within a range of lake levels. The second portion of the table is a breakdown of the damages associated with each action level. Damages listed include houses, a grain elevator, and a church.

Unit costs for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for Churchs Ferry are listed in the Churchs Ferry Economic Analysis Assumptions listing, attached to this Section 2.1.

Costs: The costs of providing flood protection for Churchs Ferry are detailed in the accompanying Table 2.1-2. Unit costs, data sources, and relevant assumptions are listed.

The first portion of the table shows the cost of relocations that are associated with each action level (1447 and 1455). The second portion of the table is a breakdown of the relocations associated with each action level and their costs.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for Churchs Ferry are listed in the Churchs Ferry Economic Analysis Assumptions listing, attached to this Section 2.1.

2.1.4 Results of Economic Analysis

The results of the Economic Analysis for Churchs Ferry are listed in Table 2.1-3.

Stochastic Analysis Results: The stochastic analysis indicated that the strategy with the largest net benefits for Churchs Ferry was incremental relocation of structures. This strategy is highlighted on the decision tree (Figure 2.1-2). The annual net benefits for this strategy were less than zero (-$700). The negative net benefits indicate that this strategy is not economically justified. The BCR for this strategy was approximately one (1.00). The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood-protection strategies were also analyzed for three specific climate futures. For Churchs Ferry, the flood protection strategy and the economic indices for each of the three climate futures are as follows:

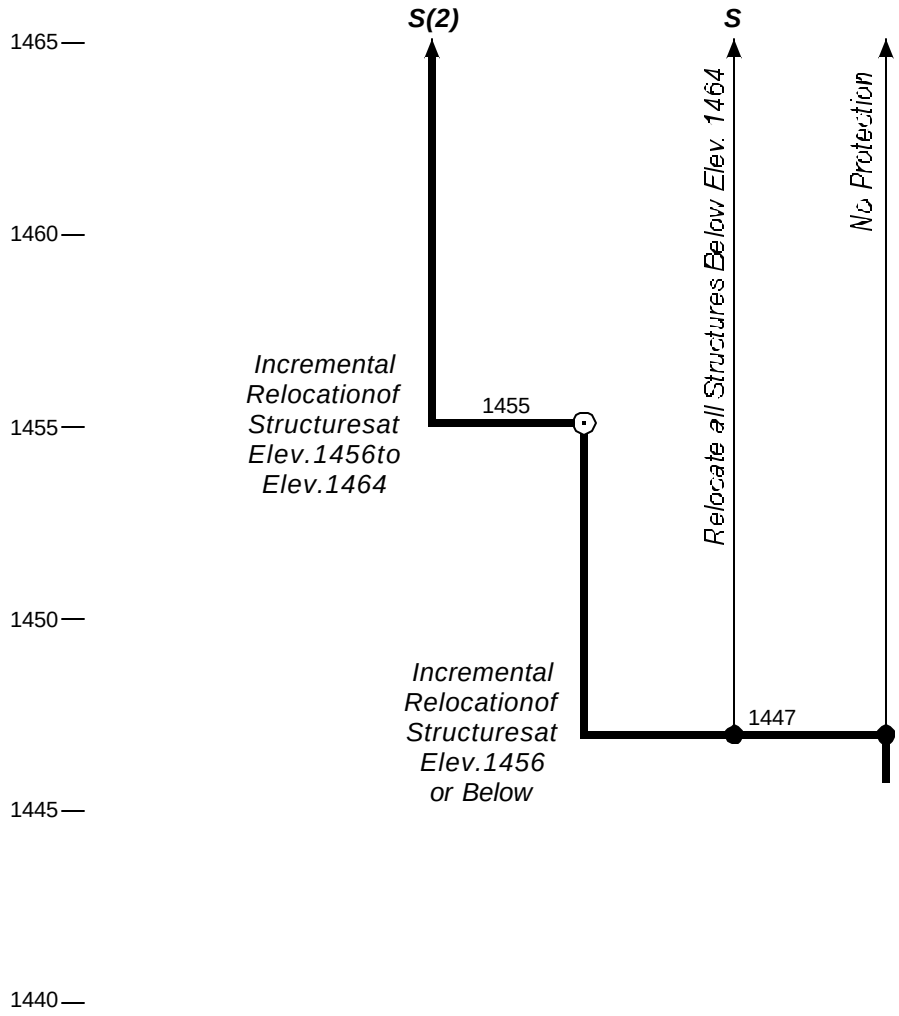
- Wet Future – For the wet future, the strategy with the largest net benefits was shown to be two incremental relocations of structures. For this strategy, the net benefits were -$5,300 and the BCR was 0.98, indicating that this strategy was not economically justified.
- First Moderate Future – For the first moderate future, the strategy with the largest net benefits was shown to be three incremental relocations of structures. For this strategy, the net benefits were -$400, and the BCR was 0.91, indicating that this strategy was not economically justified.
- Second Moderate Future – For the second moderate future, the strategy with the largest net benefits was shown to be three incremental relocations of structures. For this strategy, the net benefits were -$400, and the BCR was 0.91, indicating that this strategy was not economically justified.

Figure 2.1-1

LOCATION MAP
FEATURE 1: CHURCHS FERRY
Devils Lake Infrastructure
Protection Study

Data: 1997 USGS Digital Ortho Quad

Barr: Arcview3.1,OPT2615, i:\client\devilslake\gis\dlip\features\communities\01_churchesferry\projects\basemap_01.apr, Layout: Layout: Section 2 Figure, lkp, Thu Dec 05 10:40:37 2002



Note: NoStructuresareLocatedBetween1451and1456

FloodProtectionStrategy

Decisionrequiredatthispoint

Triggerpointforaction,nodecisionneeded

L(1) Incrementalleveeraise(numberoftimes)

L LeveeraisetoElev.1468

S(1) Structurerelocation(numberoftimes)

S RelocateallstructuresbelowElev.1464

Figure2.1-2

DECISION TREE
FEATURE 1:CHURCHSFERRY
DevilsLakeInfrastructure ProtectionStudy

P:\3\36\020\DECISIONTREES\2002FIGURES\FIGURE2_01.CDR RLG 01-02-03

Table 2.1-1

Flood Damages
Feature 1: Churchs Ferry
Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Lake Elevation	Structure Elevation Range	Structures and Infrastructure
	(MSL)	(MSL)	(THOUSANDS)
AL1	1447	Below 1456	$5,314
AL2	1455	1456 - 1464	$140

DAMAGE BREAKDOWN

AL1: Lake Elevation 1447					AL2: Lake Elevation 1455				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Grain Elevator	1	EA	$5,314,000	$5,314	House	3	EA	$12,000	$36
					Church	1	EA	$104,000	$104
Total				**$5,314**	**Total**				**$140**

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.1-2

Flood Protection Costs
Feature 1: Churchs Ferry
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	S(2) Incremental Relocation at AL1, AL2	S Relocate All Structures at AL1
	(MSL)	(THOUSANDS)	
AL1	1447	$5,314	$5,591
AL2	1455	$277	$0

COST BREAKDOWN

Strategy		S(2)					S(2)				
		S									
		Lake Elevation 1447					Lake Elevation 1455				
		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Incremental Relocation											
	Move	Grain Elevator	1	EA	$5,314,000	$5,314	House	3	EA	######	$204
							Church	1	EA	######	$73
		Subtotal				$5,314	Subtotal				$277
		Total				**$5,314**	**Total**				**$277**

Notes:

1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. The costs for the Relocate All Structures at AL1 strategy (S) is equal to the sum of all relocations that have not been included in incremental relocations.

Table 2.1 - 3

Economic Analysis of Strategies for Churchs Ferry
(Feature 1)

Stochastic Analysis (ST)
Mean Value over 10,000 Traces (Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$333,300	$333,300	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$349,800	$349,800	$0	$0	$333,300	-$16,600	0.95
S(2)	2 Incremental Relocations	$0	$0	$334,000	$334,000	$0	$0	$333,300	-$700	1.00

Wet Future Scenario (WF)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$339,000	$339,000	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$351,000	$351,000	$0	$0	$339,000	-$12,000	0.97
S(2)	2 Incremental Relocations	$0	$0	$344,200	$344,200	$0	$0	$339,000	-$5,300	0.98

Moderate Future 1 Scenario (M1)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$333,700	$333,700	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$351,000	$351,000	$0	$0	$333,700	-$17,400	0.95
S(2)	2 Incremental Relocations	$0	$0	$333,700	$333,700	$0	$0	$333,700	$0	1.00

Moderate Future 2 Scenario (M2)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$333,700	$333,700	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$351,000	$351,000	$0	$0	$333,700	-$17,400	0.95
S(2)	2 Incremental Relocations	$0	$0	$333,700	$333,700	$0	$0	$333,700	$0	1.00

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.
* Total benefits are calculated as the totall damages incurred for the "No Protection strategy" minus the totall damages for the strategy implemented (F(S)).

Attachment to 2.1:
Churchs Ferry Economic Analysis Assumptions

A. General Assumptions

1. Farmland losses were not included in this feature. These losses were included in Feature 8.1: Devils Lake Rural Areas.

B. Levees

1. It was assumed that the existing levee would not be raised because the cost of raising it would greatly exceed the value of the few structures that it would protect.

2. The top of the existing levee is at 1451.5.

C. Residential And Commercial Property

1. For relocation strategies, a decision was assumed to be made when the lake is 1 foot below the level of the low structure. This was based on the existing process which is influenced by the availability of movers, the estimated lake rise each spring, and the restrictions of funding programs. Depending on the slope of the land, wave action may affect structures that are several feet above the lake's level.

2. The average relocation cost for a house is $68,000. This cost was obtained from the North Dakota - North Central Planning Council and represents the average cost to relocate a residence during the buyout program conducted in Churchs Ferry in 2000. The $68,000 includes the following costs: demolition of the existing house, purchase of an equivalent house in a nearby community, purchase of a lot, legal, appraisal, and management fees. Only 3 residents decided to forego the buyout offer, all of which are located between 1456 and 1464.

3. The cost for relocation/rebuilding of commercial and public facilities was assumed to be 100% of the value of the structure and property.

4. In 1998, the grain elevator had an insured value of $5.1 million according to Jarvis Haugeberg, grain elevator operator. This value was updated for inflation by multiplying it by the ENR Building Cost Index of 1.042. This accounts for 4.2% inflation during the period from 1998 to February 2001. The updated value is $5.3 million.

5. The 1998 average depreciated replacement value of a house was estimated to be $24,000 (*Economics Database Update for the Lands and Developments Feasibility Study, Devils Lake,* Watts & Associates, Inc., October, 1997). According to the Ramsey County Assessor, the remaining houses in Churchs Ferry are worth ½ of their 1998 value. Therefore, the average value of the 3 remaining houses in Churchs Ferry was estimated to be $12,000.

6. In 1998, the value of the church was estimated to be $100,000, including the value of the parcel. This value was updated for inflation by multiplying it by the ENR Building Cost Index of 1.042. This accounts for 4.2% inflation during the period from 1998 to February 2001. The updated value is $104,000.

7. The existing Sewage lagoons are serving only the 3 remaining residences. The cost to protect the lagoons is $150,000, which is greater than the value of these 3 homes. Therefore, it was assumed that if the lake rose to the level of the lagoons, they would be abandoned and damages would be ignored.

2.2 Summary of Economic Analysis Investigation for Feature *2*: City of Devils Lake

2.2.0 Flood Protection Strategy

The Economic Analysis of Devils Lake Alternatives indicated that the flood protection strategy with the largest net benefits for City of Devils Lake was incremental levee construction.

2.2.1 General Information

Feature Type: Community

Location: The City of Devils Lake is located in north central North Dakota 89 miles west of Grand Forks and 121 miles east of Minot on US Highway 2. It is the county seat for Ramsey County. The city is located along a portion of the north shore of Devils Lake and is currently protected by a levee that was constructed by the Corps. The accompanying Figure 2.2-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: The City of Devils Lake is a community of 7,222 people (based on 2000 census).

Significance: The City of Devils Lake is important because it is the largest city between Grand Forks and Minot and ranks as the 11th largest city in North Dakota.

Damages: The flooding of the City of Devils Lake would result in the following damages:

- loss of homes
- loss of historical buildings
- loss of commercial properties
- loss of public property including parks and land owned by Ramsey County and City of Devils Lake
- loss of Devils Lake Cemetery
- loss of schools including Minnie H Elementary School, Sweetwater Elementary, Prairieview Elementary School, Central Middle School, Harmony House, Lake Area Vo-Tech Center, North Dakota School for the Deaf
- loss of churches including Assembly of God Church, Christ Free Lutheran Church, St. Joseph Catholic Church, Lakewood Bible Camp Assembly of God
- loss of tax revenues

- loss of Devils Lake Airport.

Owner/Sponsor: The Devils Lake City Commission is responsible for managing and maintaining the City of Devils Lake.

Lead Federal Agency: Corps would take the lead for the City of Devils Lake for any flood protection work that may take place. Federal Emergency Management Agency (FEMA) would coordinate relocation of structures.

2.2.2 Feature Protection

History of Flood Protection: In the past, flood protection for City of Devils Lake has consisted of levee construction and incremental levee raises, road raises and relocations. The City of Devils Lake levee was raised and extended in recent years under emergency authority.

General Protection Strategy: The Economic Analysis identified and evaluated several different approaches for protecting the City of Devils Lake. These included:

- continued levee raises to protect the city
- relocation of the affected structures

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake considered various protection strategies, with flood-protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.2-2 shows the decision tree for the City of Devils Lake. As shown on Figure 2.2-2, the stepwise approach to flood protection for the City of Devils Lake consisted of the following:

1. At lake elevation 1449, a decision would be made as to whether all of the structures below 1453 should be relocated or the existing levee raised to a top at 1460 to protect these structures. The first increment of the relocation strategy also includes raising the sections of ND Highway 20 and US Highway 2 that are behind the levee up to 1468.

2. If incremental relocation was selected at the first action level, at lake elevation 1452, a decision would be made as to whether to relocate structures between elevations 1453 and 1458 or relocate all structures below 1464.

   If the levee were raised at the first action level, at lake elevation 1452, a decision would be made as to whether the structures below 1464 should be relocated or the existing levee raised to a top at 1465 to protect these structures.

3. If incremental relocation was selected at the second action level, at lake elevation 1457, all structures below 1464 would be relocated.

If the levee were raised at the second action level, at lake elevation 1457, a decision would be made as to whether the structures below 1464 should be relocated or the existing levee raised to a top at 1470 to protect these structures.

Two maximum protection strategies were analyzed at the first action level: relocating all structures below elevation 1464 or raising the existing levee top to 1470. (Note that for the Economic Analysis of Devils Lake, the decision regarding relocation of structures is made at a time when the lake is one foot below the low structure elevation. The decision regarding whether or not to raise a levee is made at a time when the lake is one foot below the existing level of protection.)

Interdependencies: The protection of the City of Devils Lake is related to the protection of the following features:

- Feature 10: Canadian Pacific Railroad (City of Devils Lake to Harlowe)
- Feature 11: Burlington Northern Railroad (Along US Highway 2)
- Feature 13: US Highway 2
- Feature 15: ND Highway 57 (between BIA Highway 1 and US Highway 281)
- Feature 18: ND Highway 19
- Feature 20: ND Highway 20 (North of the City of Devils Lake)
- Feature 21: ND Highway 20 (City of Devils Lake Levee to ND Highway 57)
- Feature 22: ND Highway 20 (ND Highway 57 to Tokio)

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.2.3 Feature Economics

Damages: For the City of Devils Lake, the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for the City of Devils Lake are summarized in the accompanying Table 2.2-1.

The first portion of the table shows the damages that are associated with each action level (1449, 1452, and 1457), each representing damages within a range of lake levels. The second portion of the table is a breakdown of the damages associated with each action level. Damages listed include residential, commercial, church, school, and city structures, as well as utilities, airport, and a cemetery.

Unit costs for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for the City of Devils Lake are listed in the City of Devils Lake Economic Analysis Assumptions listing, attached to this Section 2.2.

Costs: The costs of providing flood protection for the City of Devils Lake are detailed in the accompanying Table 2.2-2. Unit costs, data sources, and relevant assumptions are listed.

The first portion of the table shows the costs associated with relocation and levee raises at each action level (1449, 1452, and 1457). The second portion of the table is a breakdown of the costs associated with each strategy and each action level. Strategies include incremental relocation and incremental levee raise.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for the City of Devils Lake are listed in the City of Devils Lake Economic Analysis Assumptions listing, attached to this Section 2.2.

2.2.4 Results of Economic Analysis

The results of the Economic Analysis for the City of Devils Lake are listed in Table 2.2-3.

Stochastic Analysis Results: The stochastic analysis indicated that the flood protection strategy with the largest net benefits for the City of Devils Lake was three incremental levee raises. This strategy is highlighted on the decision tree (Figure 2.2-2). The annual net benefits for this strategy were greater than zero ($4,771,300). The BCR for this strategy was greater than one (6.71). These results indicate that this strategy is economically justified. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For the City of Devils Lake, the identified strategy and the economic indices for each of the three climate futures are as follows:

- Wet Future – For the wet future, the flood protection strategy with the largest net benefits was shown to be three incremental levee raises. For this strategy, the net benefits were $11,735,600 and the BCR was 4.33, indicating that this strategy was economically justified.
- First Moderate Future – For the first moderate future, the flood protection strategy with the largest net benefits was shown to be three incremental levee raises. For this strategy, the net benefits were $4,711,600 and the BCR was 18.32, indicating that this strategy was economically justified.

- Second Moderate Future – For the second moderate future, the flood protection strategy with the largest net benefits was shown to be three incremental levee raises. For this strategy, the net benefits were $7,843,400, and the BCR was 5.27, indicating that this strategy was economically justified.

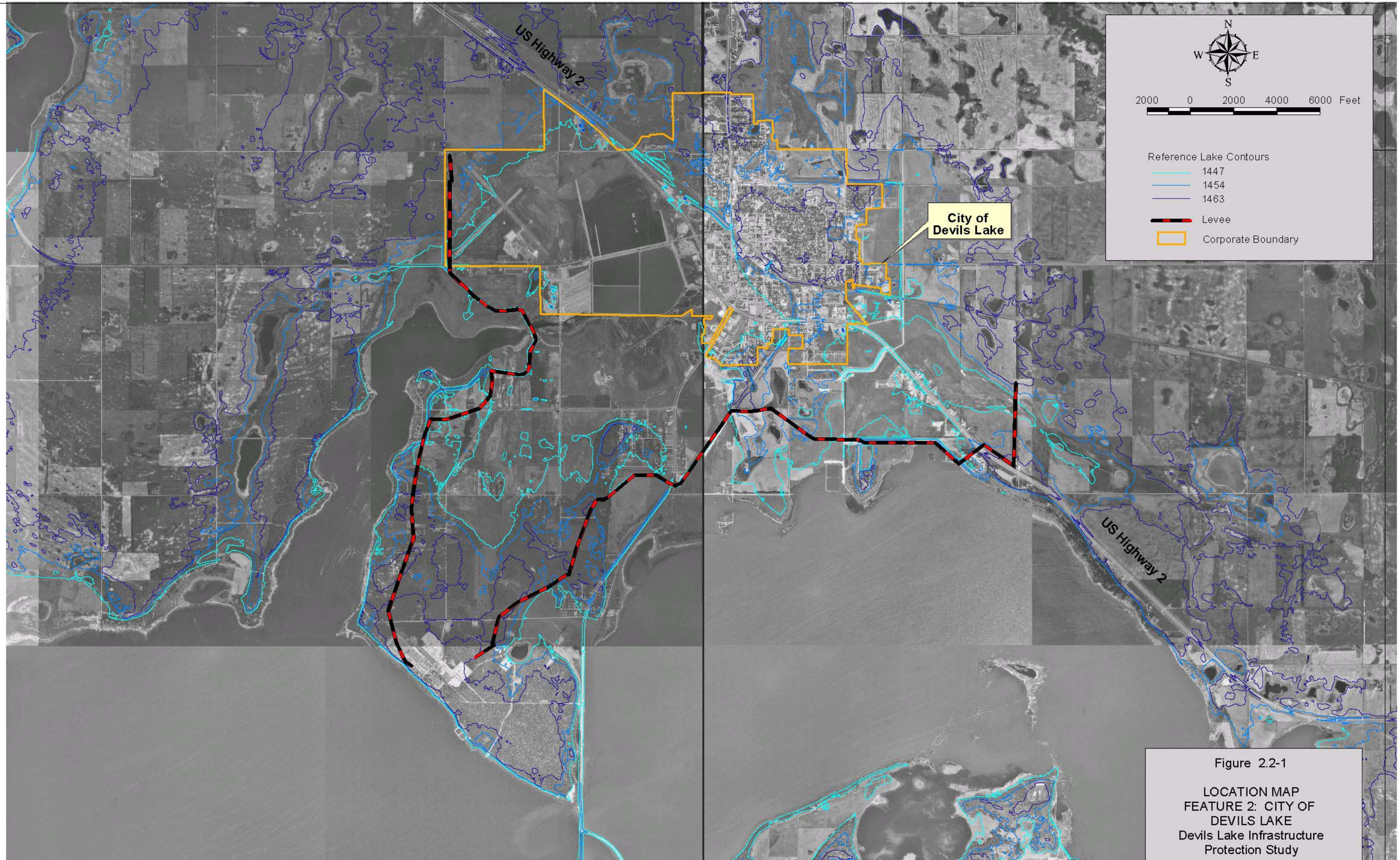
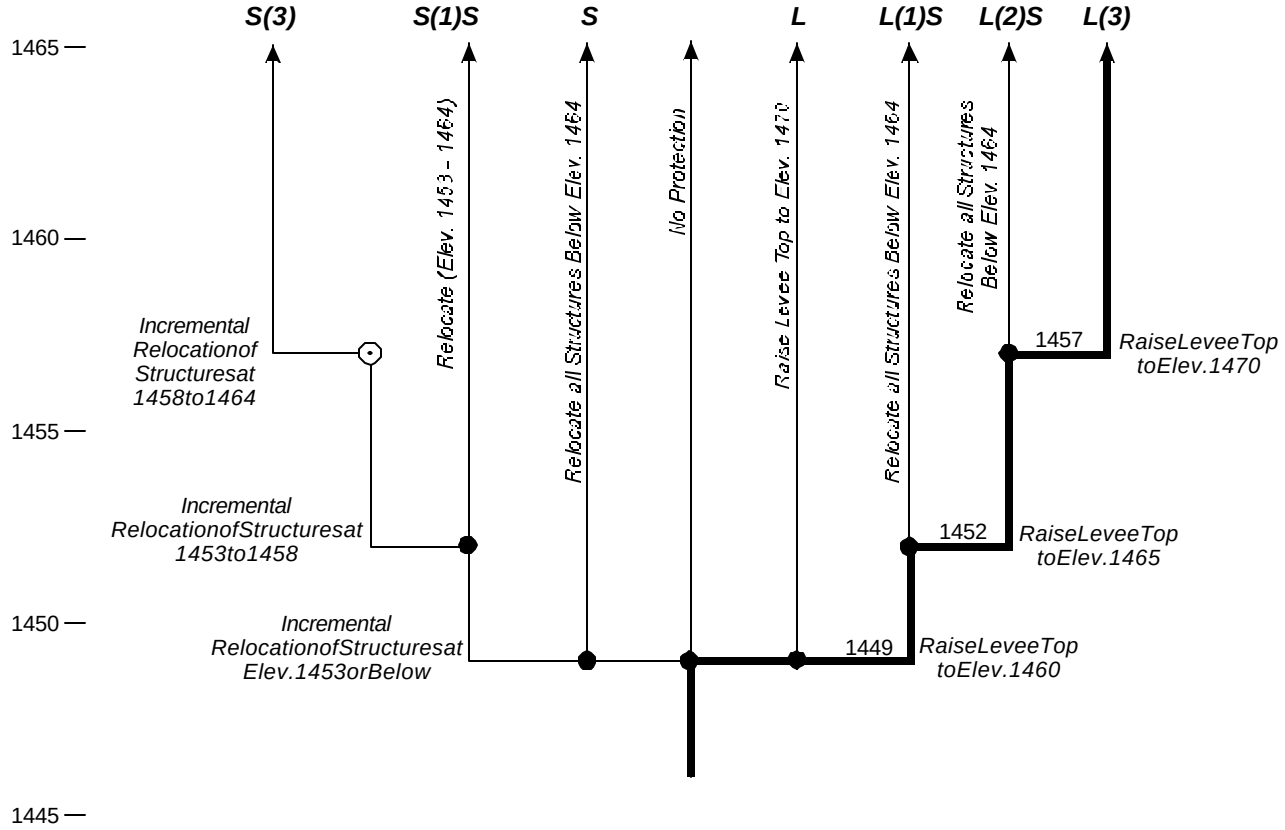


Figure 2.2-1

LOCATION MAP
FEATURE 2: CITY OF DEVILS LAKE
Devils Lake Infrastructure Protection Study

Barr: Arcview 3.1, OPT2615, I:\Client\DevilsLake\Gis\DLIPFeatures\Communities\02_DevilsLake\Project\devilslake_02.apr, Layout: Sec. 2 - 2001 Levee Analysis, lkp, Mon Dec 09 10:24:32 2002

Data: 1997 USGS Digital Ortho Quad



FloodProtectionStrategy

Decisionrequiredatthispoint

Triggerpointforaction,nodecisionneeded

L(1) Incrementalleveeraise(numberoftimes)

L LeveeraisetoElev.1470

S(1) Structurerelocation(numberoftimes)

S RelocateallstructuresbelowElev.1464

Figure2.2-2

DECISION TREE
FEATURE 2:CITYOFDEVILSLAKE
DevilsLakeInfrastructure ProtectionStudy

P:\3\36\020\DECISIONTREES\2002FIGURES\FIGURE2_02.CDR RLG 01-02-03

Table 2.2-1

Flood Damages

Feature 2: City of Devils Lake

Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Lake Elevation (MSL)	Structure Elevation Range (MSL)	Structures and Infrastructure (THOUSANDS)
AL1	1449	Below 1453	$177,259
AL2	1452	1453 - 1458	$50,462
AL3	1457	1458 - 1464	$77,659

DAMAGE BREAKDOWN

AL1: Lake Elevation 1447					AL2: Lake Elevation 1451					AL3: Lake Elevation 1456				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Assessed Residential and Commercia	1	LS	############	$124,065	Assessed Residential and Commercia	1	LS	$34,373,000	$34,373	Assessed Residential and Commercia	1	LS	$67,083,000	$67,083
Churches and Schools	1	LS	$7,540,000	$7,540	Utilities	1	LS	$9,769,000	$9,769	Utilities	1	LS	$8,782,000	$8,782
Utilities	1	LS	$33,160,000	$33,160	City Property	1	LS	$1,916,000	$1,916	City Property	1	LS	$1,794,000	$1,794
Airport	1	LS	$11,837,000	$11,837	Cemetary	1	LS	$4,404,000	$4,404					
City Property	1	LS	$613,000	$613										
Cemetary	1	LS	$44,000	$44										
Total				**$177,259**	**Total**				**$50,462**	**Total**				**$77,659**

Notes:

1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.2-2

Flood Protection Costs

Feature 2: City of Devils Lake

Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	S(3) Incremental Relocation at AL1,AL2,AL3	S(1)S Incremental Relocation at AL1; Relocate All Structures at AL2	S Relocate All Structures at AL1	L Maximum Protection Levee Raise at AL1	L(1)S Raise Levee at AL1; Relocate All Structures at AL2	L(2)S Raise Levee at AL1, AL2; Relocate All Structures at AL3	L(3) Raise Levee at AL1, AL2, AL3
	(MSL)	(THOUSANDS)						
AL1	1449	$199,536	$199,536	$318,597	$81,442	$9,595	$9,595	$9,595
AL2	1452	$46,681	$119,061	$0	$0	$318,597	$46,476	$46,476
AL3	1457	$72,380	$0	$0	$0	$0	$318,597	$25,371

COST BREAKDOWN

Strategy		S(3)					S(3)					S(3)				
		S(1)S					S(1)S					S(1)S				
		S														
		L(1)S														
		L(2)S														
		Lake Elevation 1449					Lake Elevation 1452					Lake Elevation 1457				
Strategy		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Incremental Relocation																
	Move	Assessed Residential &					Assessed					Assessed				
		Commercial	1	LS	$109,668	$109,668	Residential &	1	LS	$27,385	$27,385	Residential &	1	LS	$59,430	$59,430
		Churches and Schools	1	LS	$7,403	$7,403	Utilities	1	LS	$12,974	$12,974	Utilities	1	LS	$11,126	$11,126
		Utilities	1	LS	$42,153	$42,153	City Property	1	LS	$1,949	$1,949	City Property	1	LS	$1,824	$1,824
		Airport	1	LS	$15,712	$15,712	Cemetary	1	LS	$4,373	$4,373					
		City Property	1	LS	$608	$608										
		Cemetary	1	LS	$13	$13										
		Subtotal				$175,557	Subtotal				$46,681	Subtotal				$72,380
	Road Raise	US 2 - Segment 971 - 2600' from 1465 to 1470														
		Fabric Liner	28,306	SY	$1.25	$35										
		Aggregate Base Course	2,239	CY	$20.00	$45										
		Fill	57,296	CY	$4.50	$258										
		Riprap	18,870	CY	$20.00	$377										
		Bituminous	4,195	TON	$45.00	$189										
		US 2 - Segment 969 - 3900' from 1465 to 1470														
		Fabric Liner	42,458	SY	$1.25	$53										
		Aggregate Base Course	3,358	CY	$20.00	$67										
		Fill	85,944	CY	$4.50	$387										
		Riprap	28,305	CY	$20.00	$566										
		Bituminous	6,292	TON	$45.00	$283										
		Subtotal				$2,260										
		Highway 20 - 1 Mile from 1435 to 1468														
		Fabric Liner	225,002	SY	$1.25	$281										
		Aggregate Base Course	4,547	CY	$20.00	$91										
		Fill	1,671,413	CY	$4.50	$7,521										
		Riprap	150,001	CY	$20.00	$3,000										
		Bituminous	8,518	TON	$45.00	$383										
		Highway 20 - 1 Mile from 1440 to 1468														
		Fabric Liner	195,087	SY	$1.25	$244										
		Aggregate Base Course	4,547	CY	$20.00	$91										
		Fill	1,281,280	CY	$4.50	$5,766										
		Riprap	130,058	CY	$20.00	$2,601										
		Bituminous	8,518	TON	$45.00	$383										
		Subtotal				$20,362										
		1998 Total				$22,622										
		2001 Total (add inflation)				$23,980										
		Total				$199,536	Total				$46,681	Total				$72,380
		L														
		L(1)S														
		L(2)S					L(2)S									
		L(3)					L(3)					L(3)				
Incremental Levee Raise																
	Levee	Performance/Payment Bond	1	JB	$29,664	$30	Performance/Paymen	1	JB	$142,935	$143	Performance/Payment	1	JB	$89,802	$90
		Clearing & Grubbing	0	AC	$1,925	$0	Clearing & Grubbing	20	AC	$1,925	$39	Clearing & Grubbing	10	AC	$1,925	$19
		Removals	0	AC	$825.00	$0	Removals	20	AC	$825.00	$17	Removals	10	AC	$825.00	$8
		Stripping	0	CY	$1.25	$0	Stripping	106,000	CY	$1.25	$133	Stripping	16,000	CY	$1.25	$20
		Inspection Trench	0	LF	$3.75	$0	Inspection Trench	8,500	LF	$3.75	$32	Inspection Trench	8,500	LF	$3.75	$32
		Impervious Fill	154,583	CY	$4.40	$680	Impervious Fill	#######	CY	$4.40	$14,079	Impervious Fill	456,940	CY	$4.40	$2,011
		Bedding	43,976	CY	$35.00	$1,539	Bedding	86,051	CY	$35.00	$3,012	Bedding	98,826	CY	$35.00	$3,459
		Riprap	82,455	CY	$45.00	$3,710	Riprap	161,362	CY	$45.00	$7,261	Riprap	185,299	CY	$45.00	$8,338
		Sand Drain	0	CY	$20.00	$0	Sand Drain	185,000	CY	$20.00	$3,700	Sand Drain	0	CY	$20.00	$0
		Topsoil (4")	14,753	CY	$1.25	$18	Topsoil (4")	107,852	CY	$1.25	$135	Topsoil (4")	25,029	CY	$1.25	$31
		Seed	27	AC	$900	$24	Seed	201	AC	$900	$181	Seed	47	AC	$900	$42
		Pump Station	0	EA	$1,000,000	$0	Pump Station	0	EA	$1,000,000	$0	Pump Station	0	EA	#######	$0
		Subtotal				$6,002	Subtotal				$28,730	Subtotal				$14,051
		Contingency (30%)				$1,801	Contingency (30%)				$8,619	Contingency (30%)				$4,215
		Subtotal w/ Contingency				$7,803	Subtotal w/ Contingency				$37,349	Subtotal w/ Contingency				$18,266
		Engineering and Design (6%)				$468	Engineering and Design (6%)				$2,241	Engineering and Design (6%)				$1,096
		Supervision and Administration (10%)				$780	Supervision and Administration (10%)				$3,735	Supervision and Administration (10%)				$1,827
		1998 Total				$9,051	1998 Total				$43,325	1998 Total				$21,188
		2001 Total (add inflation)				$9,594	2001 Total (add inflation)				$45,924	2001 Total (add inflation)				$22,460
		2001 Adjusted Total				$9,595	2001 Adjusted Total				$45,925	2001 Adjusted Total				$22,427
							Pump Modifications	1	JB		$21	Pump Modifications	1	JB	#######	$2,944
							Runway Extensions	1	JB		$530					
		Total				$9,595	Total				$46,476	Total				$25,371

ANNUAL OPERATION AND MAINTENANCE COSTS

Action Level	Lake Elevation	Levee Maintenance
	(MSL)	(THOUSANDS)
AL1	1449	$6
AL2	1452	$7
AL3	1457	$11

Notes:

1. AL = Decision/Action Level specified on decision tree.

2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

3. The costs for the Relocate All Structures at AL1 strategy (S) is equal to the sum of all relocations that have not been included in incremental relocations.

Table 2.2 - 3

Economic Analysis of Strategies for City of Devils Lake
(Feature 2)

Stochastic Analysis (ST)
Mean Value over 10,000 Traces (Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$5,607,400	$5,607,400	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$8,628,400	$8,628,400	$0	$0	$5,607,400	-$3,021,100	0.65
L	Raise Levee Top to 1470	$2,205,700	$4,600	$0	$2,210,300	$0	$0	$5,607,400	$3,397,100	2.54
L(1)S	1 Levee Raise: Then Relocate	$259,900	$1,500	$3,292,800	$3,554,200	$0	$0	$5,607,400	$2,053,200	1.58
L(2)S	2 Levee Raises: Then Relocate	$740,200	$2,100	$1,170,100	$1,912,400	$0	$0	$5,607,400	$3,695,000	2.93
L(3)	3 Levee Raises	$833,400	$2,700	$0	$836,100	$0	$0	$5,607,400	$4,771,300	6.71
S(1)S	1 Incremental Relocation: Then Relocate All Remaining	$0	$0	$6,634,500	$6,634,500	$0	$0	$5,607,400	-$1,027,100	0.85
S(3)	3 Incremental Relocations	$0	$0	$6,152,200	$6,152,200	$0	$0	$5,607,400	-$544,900	0.91

Wet Future Scenario (WF)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$15,259,300	$15,259,300	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$18,804,800	$18,804,800	$0	$0	$15,259,300	-$3,545,400	0.81
L	Raise Levee Top to 1470	$4,807,000	$10,300	$0	$4,817,300	$0	$0	$15,259,300	$10,442,000	3.17
L(1)S	1 Levee Raise: Then Relocate	$566,300	$1,200	$14,686,200	$15,253,700	$0	$0	$15,259,300	$5,500	1.00
L(2)S	2 Levee Raises: Then Relocate	$2,708,700	$2,800	$10,136,100	$12,847,600	$0	$0	$15,259,300	$2,411,700	1.19
L(3)	3 Levee Raises	$3,515,900	$7,700	$0	$3,523,700	$0	$0	$15,259,300	$11,735,600	4.33
S(1)S	1 Incremental Relocation: Then Relocate All Remaining	$0	$0	$17,265,600	$17,265,600	$0	$0	$15,259,300	-$2,006,300	0.88
S(3)	3 Incremental Relocations	$0	$0	$16,231,900	$16,231,900	$0	$0	$15,259,300	-$972,600	0.94

Moderate Future 1 Scenario (M1)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$4,983,800	$4,983,800	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$8,957,600	$8,957,600	$0	$0	$4,983,800	-$3,973,800	0.56
L	Raise Levee Top to 1470	$2,289,800	$4,600	$0	$2,294,400	$0	$0	$4,983,800	$2,689,300	2.17
L(1)S	1 Levee Raise: Then Relocate	$269,800	$2,300	$0	$272,100	$0	$0	$4,983,800	$4,711,600	18.32
L(2)S	2 Levee Raises: Then Relocate	$269,800	$2,300	$0	$272,100	$0	$0	$4,983,800	$4,711,600	18.32
L(3)	3 Levee Raises	$269,800	$2,300	$0	$272,100	$0	$0	$4,983,800	$4,711,600	18.32
S(1)S	1 Incremental Relocation: Then Relocate All Remaining	$0	$0	$5,610,100	$5,610,100	$0	$0	$4,983,800	-$626,300	0.89
S(3)	3 Incremental Relocations	$0	$0	$5,610,100	$5,610,100	$0	$0	$4,983,800	-$626,300	0.89

Moderate Future 2 Scenario (M2)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$9,680,300	$9,680,300	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$14,686,200	$14,686,200	$0	$0	$9,680,300	-$5,006,000	0.66
L	Raise Levee Top to 1470	$3,754,200	$7,900	$0	$3,762,100	$0	$0	$9,680,200	$5,918,100	2.57
L(1)S	1 Levee Raise: Then Relocate	$442,300	$1,500	$9,528,600	$9,972,500	$0	$0	$9,680,300	-$292,300	0.97
L(2)S	2 Levee Raises: Then Relocate	$1,832,300	$4,500	$0	$1,836,800	$0	$0	$9,680,300	$7,843,400	5.27
L(3)	3 Levee Raises	$1,832,300	$4,500	$0	$1,836,800	$0	$0	$9,680,300	$7,843,400	5.27
S(1)S	1 Incremental Relocation: Then Relocate All Remaining	$0	$0	$12,758,800	$12,758,800	$0	$0	$9,680,300	-$3,078,600	0.76
S(3)	3 Incremental Relocations	$0	$0	$10,594,100	$10,594,100	$0	$0	$9,680,300	-$913,800	0.91

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.
*Total benefits are calculated as the totall damages incurred for the "No Protection strategy" minus the totall damages for the strategy implemented (F(S)).

Attachment to 2.2:
City of Devils Lake Economic Analysis Assumptions

A. General Assumptions

1. The area included in the City of Devils Lake feature is the land currently protected by the levees and the area within the Devils Lake city limits.

2. For relocation strategies, structures were assumed to be relocated to high ground north and/or east of the existing city. A precise location was not determined, since the cost of relocation would not be significantly different.

3. Existing levees were assumed to be built to elevation 1457 (top of levee), based on plans for work performed in 1998 (*Devils Lake, ND Bi-Weekly Report,* St. Paul District Corps of Engineers, January 22, 1998).

4. The value of land outside of the Devils Lake city limits was estimated to be $400 per acre (*Corps of Engineers,* April, 2001)

5. The values of the properties described below were determined in 1998. These values were updated for inflation by multiplying them by 1.09, which accounts for an inflation rate of 3% per year from 1998 to February 2001. This inflation rate was obtained from the Devils Lake City Assessor.

   a. The value of land for airport relocation was estimated at $500 per acre in 1998. The updated value is $545 per acre.

   b. The estimated value of commercial property within the Devils Lake city limits was $10,000 per acre in 1998. The updated value is $10,900 per acre.

   c. The estimated value of parkland within the Devils Lake city limits was $5,000 per acre in 1998. The updated value is $5,450.

6. The cost of rebuilding or relocating utility systems and associated features was included in relocation strategies. These costs do not address the costs of demolition of the existing features. Detailed review of demolition costs was beyond the scope of this study.

7. For all relocation strategies, raising portions of both ND Highway 20 and US Highway 2 behind the levee to the maximum level was included in the relocation costs at the first action level when a relocation strategy was chosen. The analysis assumed these sections of highways behind the existing levees was raised in one increment up to elevation 1468. US Highway 2 was assumed to be relocated to higher land adjacent to the Burlington Northern Railroad tracks, for close proximity to the high ground in the downtown area.

B. Levees

1. A decision was assumed to be made when the lake is 1 foot below the design level of protection (i.e., 1 foot below the lower limit of the required freeboard of a levee).

2. It was assumed that the existing levees are built with adequate base to raise the levee to elevation 1460. The parameters used to design the existing levees allow for a 15-foot top width at elevation 1460, with a 6H:1V lakeward slope and 3H:1V landward slope.

3. Proposed incremental levee raises to elevation 1460 were based on plans by the Corps of Engineers.

4. The freeboard for the existing levee is 7 feet with the top of levee at 1457.

5. The levee raise from elevation 1460 to 1470 will require filling on the landward side of the existing levee. The estimated costs of a levee raise from elevation 1460 to 1465 included adequate overbuild for a future raise to elevation 1470. The top width of the levee at elevation 1465 would be 60 feet.

6. The cost of stripping additional topsoil between each levee raise was considered to be incidental. The cost of stripping topsoil to extend the levee on undisturbed ground was included.

7. Based on a brief review of an air photo, 9,000 linear feet of tree removal was estimated to be required above elevation 1460. The costs for the levee raise from elevation 1460 to 1465 included the cost of clearing 20 acres to widen the levee base to the maximum width and extend the levee over previously undisturbed areas. The costs for the levee raise from elevation 1465 to 1470 included the cost of clearing 10 acres to extend the levee over previously undisturbed areas.

8. The costs of incremental levee raises and pump modifications were determined in 1998. These costs were updated for inflation by multiplying it by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001.

C. Residential and Commercial Properties

1. In 1998, the assessed values of residential and commercial structures were obtained from the municipal GIS database. These values were increased based on data from the City of Devils Lake Assessor for the period from 1998 to February 2001. Values were multiplied by a factor of 1.075 (to account for new development of 2.5% per year) and a factor of 1.09 (to account for inflation of 3% per year).

2. For relocation strategies, a decision was assumed to be made when the lake is 1 foot below the level of the low structure. This was based on the existing process which is influenced by the availability of movers, the estimated lake rise each spring, and the restrictions of funding programs. Depending on the slope of the land, wave action may affect structures several feet above the lake's level.

3. On the 1994 USGS quadrangle map, small buildings outside the Devils Lake city limits were assumed to denote single residential dwellings. Each square was counted as a single residence, unless field investigation indicated otherwise (i.e., structure was already gone or abandoned or the structure was a garage instead of residential dwelling). Additional residences that were not indicated on the quadrangle map were counted based on visits to the city.

4. Subdivision boundaries in the Creel Township area were identified based on visits to the city (*Devils Lake Creel Township Levee Assessment*, Barr Engineering Company, August 20, 1997). Average values of residences within these boundaries were obtained from the 1997 report. These values were multiplied by a factor of 1.075 (to account for new development of 2.5% per year) and a factor of 1.09 (to account for inflation of 3% per year) for the increase during the period from 1998 to February 2001.

5. The value of residences outside of the Devils Lake city limits (described in item number 3 above) were estimated based on the 1998 residential average within the city (from the municipal GIS database). These values were multiplied by a factor of 1.075 (to account for new development of 2.5% per year) and a factor of 1.09 (to account for inflation of 3% per year) for the increase during the period from 1998 to February 2001. Specific assumptions for the 1998 values included:

   a. If a residence was part of "small tracts of land" in the Midland Atlas, the average value used for the residential dwelling was $41,950 (lot value and improvement value). The updated value is $49,950.

   b. If a residence was on land with an identified owner in the Midland Atlas, the lot value was estimated by multiplying the parcel size shown in the Midland Atlas by $300 per acre (the agricultural land value). This lot value was added to $34,664 per residential dwelling, the estimated average improvement value, to give a total value for lot and improvements. The updated values are $400 per acre for lots and $40,620 for improvements.

   c. In the absence of flood protection measures, damages were assumed to occur at the lowest elevation at which a residential structure was affected by rising lake levels. Land could be affected at lower elevation but this land loss was not included until the dwelling was affected. Seepage into basements was not considered.

6. On the 1994 quadrangle map, larger plain rectangles (not small squares) outside the Devils Lake city limits were assumed to denote commercial buildings. Each rectangle was counted as a single commercial building.

7. Commercial buildings outside of the Devils Lake city limits were assumed to have average values based on the 1998 commercial average within the city (from the municipal GIS database). These values were multiplied by a factor of 1.075 (to account for new development of 2.5% per year) and a

factor of 1.09 (to account for inflation of 3% per year) for the increase during the period from 1998 to February 2001. Specific assumptions for the 1998 values included:

a. If a commercial building was part of "small tracts of land" in the Midland Atlas, the average value of the commercial building used was $94,785 (lot value plus improvement value). The updated value is $111,060.

b. If a commercial building was on land with an identified owner in the Midland Atlas, the lot value was estimated by multiplying the parcel size shown in the Midland Atlas by $300 per acre (the agricultural land value). This lot value was added to $74,743 per commercial building (the estimated average improvement value) to give an estimated total value of lot and improvement. The updated values are $400 per acre for lots and $87,580 for improvements.

c. In the absence of flood protection measures, damages were assumed to occur at the lowest elevation at which a structure was affected by rising lake levels. Land could be affected at lower elevations but these losses were only included at the elevation at which the structure began to be affected.

8. The area identified as "Bible Camp" on the 1994 quadrangle map was outlined based on field observation (Lakewood Bible Camp). The structures within the Lakewood Bible Camp boundaries were not included in the above residential or commercial values.

   a. All but one small building (small square on topo) was at an elevation greater than 1465. Although the buildings in the Camp are on high ground, the Bible Camp would be surrounded by the lake without the existing levee and it would not have access. Therefore, for all relocation strategies, the entire camp was assumed to be damaged at the first relocation action level, with damages assumed to occur at that level.

   b. The replacement cost of the Bible Camp was assumed to be the insured value of the structures. In 1998, the insured value was $2,462,000. This value was multiplied by a factor of 1.09, to account for inflation of 3% per year, during the period from 1998 to February 2001. The updated value is $2,683,580.

9. The value of the golf course was assumed to be $2,300,000 (*Devils Lake Creel Township Levee Assessment*, Barr Engineering Company, August 20, 1997). This value is in 1998 dollars; therefore it was multiplied by a factor of 1.09, to account for inflation of 3% per year, during the period from 1998 to February 2001. The updated value is $2,500,000.

10. Land in the Midland Atlas that had a total acreage, but did not have structures noted on the quadrangle map, was valued at $400 per acre (the agricultural land value as stated above).

11. In the absence of flood protection measures, damages to structures were assumed to occur at the lowest elevation at which structures were affected, except as follows:

    a. Damages to the golf course were assumed to occur at the first action level where the levee is not raised. The golf course is protected by the city levee and damages would only happen if the levee was abandoned; the first potential abandonment would be at action level 1450. Assuming there was no levee at elevation 1450, a large portion of the golf course would be inundated by the lake, and the golf course was assumed to be inoperable.

    b. Damages to land that contains no structures or improvements were estimated to occur at the lowest elevation at which the land was affected. Damages to land were grouped between action levels, and were assumed to occur when the water surface is 1 foot below the action level. This may 'front-end load' the damages; however, only small parcels of land were analyzed for this feature, and the effects of this assumption are not expected to be significant. Conversely, wave action could affect land several feet above the lake's level and, therefore, actual damages might occur before the lake reaches the parcel's lowest elevation.

    c. The Bible Camp is excepted as noted in item 8 above.

12. Land outside the city limits that is within the assumed levee alignment and above the maximum lake level would become isolated and inaccessible if the levee is not raised and the lake rises to 1463. The values for the land and structures in these isolated areas were calculated and included as damages for relocation strategies. Conversely, for strategies where levees remain in place, these amounts were included as damages prevented.

13. In the absence of the existing levee, the subdivision located southwest of the intersection of ND Highway 20 and Ramsey County 1 would become isolated and surrounded by the lake above elevation 1440. However, the access road is relatively short and the costs of raising the access would be minimal compared to the costs of relocating the subdivision. Because ND Highway 20 within the levee is assumed to remain open with or without the levee in place, the area was assumed to have access even if the existing levee was removed. For relocation strategies, relocation of these houses was assumed to occur at the elevation of the structure (not the elevation at which the area becomes isolated). Similarly, for levee strategies, damages prevented for this area were assumed to occur at the elevation of the structures.

14. All structures and property below elevation 1450 were grouped to compute damages in the absence of flood protection measures. For relocation strategies, when the lake reaches action level 1449 (1 foot below the level of protection of the existing levee), all structures within the current levee alignment that are below elevation 1450 would be relocated.

15. In the absence of flood protection measures, damages to structures and property were assumed to be equal to the depreciated replacement values discussed above. Conversely, if protection is provided, all or a portion of the potential damages would be treated as damages prevented.

16. The costs for relocating or rebuilding commercial structures were estimated to be 100% of the assessed value of the improvement and 100% of the assessed value of the lot.

17. The costs for relocation of residential structures were estimated to be 70% of the assessed value of the improvement and 100% of the assessed value of the lot.

D. Public Properties

1. The values and costs for the public property described below in items 2 – 6, were determined in 1998. These 1998 dollars were multiplied by a factor of 1.09 to account for inflation of 3% per year during the period from 1998 to February 2001. This inflation rate was obtained in conversations with the Ramsey County Assessor and the City of Devils Lake Assessor.

2. Estimated values for property owned by Ramsey County were based on telephone conversations with staff at the County Assessor's office.

3. Estimated values for properties owned by the City of Devils Lake were based on telephone conversations with Gary Martinson, City Assessor.

4. The value of public properties was based on the estimated insured replacement values of the structures.

5. In the absence of flood protection measures, relocation or rebuild costs were assumed to equal the value of the structure.

6. Relocation costs for the cemetery are based on telephone conversation with the City Assessor. The cemetery charges $300 to move a burial. Assuming that relocating the cemetery would result in further moving distances, $500 was used for moving each burial. Relocation included the cost to purchase 80 acres of new land at $300 per acre and relocating 8,000 burials at $500 each. The updated values are $400 per acre for land and $545 per burial for relocating. In the absence of flood protection measures, damages to the cemetery included 80 acres at $1,000 per acre and 8,000 burials at $500 each. The updated values are $1,090 per acre for land and $545 per burial for relocating.

E. School and Churches

1. All costs and values described below in items 2 – 6 were determined in 1998. These 1998 dollars were multiplied by a factor of 1.075 (to account for new development of 2.5% per year) and a factor of 1.09 (to account for inflation of 3% per year) for the increase during the period from 1998 to

February 2001. These inflation rates were obtained in conversations with the City of Devils Lake Assessor.

2. For schools and churches, insured values of the structure were used when available. According to the City Assessor, insured replacement values are typically much greater than assessed values. Therefore, land values were not added to determine the total value. Insured values for several schools were obtained from telephone conversations with the Devils Lake school administrator. Insured values for several churches were obtained from telephone conversations with church administrators. All other school and church values were estimated using *RS Means Building Construction Cost Data, 56th Annual Edition*, 1998. If only total insured values were provided, the structure was assumed to have a value of 75% of the total insured value.

3. Insured values included the value of only the structures. The insured value of contents was not included in the insured value.

4. Several institutions between elevation 1460 and 1462 were assumed to be relocated or rebuilt for the relocation strategies. It appears likely that several of these facilities could be protected with a ring dike or levee more economically than they could be relocated, provided that access is maintained. However, this study did not analyze this option.

5. The relocation or rebuild cost was assumed to be 100% of insured value of the structure.

6. In the absence of flood protection measures, damages were assumed to be 100% of insured value of the structure.

F. Utilities

1. The costs of relocating utilities described below in items 2 – 9 were obtained in 1998. These 1998 dollars were updated for inflation by multiplying it by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001.

2. Individual utility service connections were included with assessed lot values. However, the cost to replace utility infrastructure was calculated separately for relocation strategies and to determine the benefit provided for flood protection measures.

3. Gas main costs associated with relocation strategies were based on discussions with Montana Dakota Utilities (MDU) staff. In the absence of flood protection measures, damages were assumed to equal the relocation or rebuild cost. Costs were distributed on a per-user basis.

4. Relocation costs for electrical infrastructure were based on conversations with Otter Tail Power staff. In the absence of flood protection measures, damages were assumed to equal the relocation cost.

5. Relocation costs for telephone infrastructure were based on conversations with North Dakota Telephone Company staff. In the absence of flood protection measures, damages were assumedto equal the relocation cost. The costs did not include the cost of fiber optic cables. Costs were distributed on a per-user basis.

6. For relocation strategies, costs for the wastewater treatment system were based on conversations with the City Engineer and the City Assessor and on Environmental Protection Agency (EPA) construction costs. The cost includes construction of a new wastewater treatment plant and distribution system and the closing of the existing lagoons. In the absence of flood protection measures, damages were assumed to be 75% of the rebuild cost, due to depreciation of the existing system. Although land application disposal was assumed in this study, the City Engineer indicated that a lagoon system may be required.

7. For strategies that include levee protection, it was assumed that the lagoons would continue to function as the lake continues to rise. A brief analysis of groundwater in the area indicates that it would not affect the operation of lagoons in the area *(Hydrogeology of the Shallow Water Table at the City of Devils Lake, North Dakota*, North Dakota State Water Commission, 1998).

8. For relocation strategies, costs for the water treatment system were based on conversations with the City Engineer and the City Assessor and on EPA construction costs. The cost includes construction of a new plant, a 500,000-gallon water tower, a 3,000,000-gallon reservoir, four supply wells, and a distribution system. The actual system may include tapping into and treating surface water. However, the scope of the study did not include review of specific treatment system alternatives. In the absence of flood protection measures, advance replacement of infrastructure was assumed to be 75% of the rebuild cost to factor in the effects of depreciation.

9. For relocation strategies, costs for the storm sewer system were based on a conversation with the City Engineer. The cost was based on converting the $7,000,000 upgrade performed in 1978 to 1998 costs using historical cost indexes (*RS Means Building Construction Cost Data, 56th Annual Edition*, 1998). The estimated cost to rebuild the system was $14,968,000. The updated cost is $15,866,080. In the absence of flood protection measures, damages were assumed to be 75% of the rebuild cost due to depreciation. The costs were distributed on a per-user basis.

G. Devils Lake Airport

1. The costs to relocate the airport and build a runway extension, described below in items 2 – 6, were determined in 1998. These costs were updated for inflation by multiplying the airport by a factor of 1.09 (to account for an inflation rate of 3% per year) and the runway extension was multiplied by the ENR Construction Cost Index of 1.06 (to account for 6% inflation from 1998 to February 2001). The inflation rate was obtained from the City of Devils Lake Assessor.

2. Airport relocation costs were developed based on telephone conversations with the Airport District Engineer and the airport consultant at the firm of Kadrmis, Lee & Jackson.

3. Airport relocation costs included 15% for various engineering, administrative, and environmental review costs. In addition to engineering design, the relocation of the new airport would require detailed studies including preparation of an Environmental Impact Statement (EIS) to assess the social, economic and environmental effects of the project.

4. Due to depreciation, the value of the existing airport ("damages prevented") was assumed to be 75% of the value to relocate/rebuild.

5. Raising the existing levee to elevation 1457 would require extending Runway 321 by 170 feet due to FAA clearance regulations. The runway extension cost of $261,000 was included in the levee cost at action level 1449. The updated cost is $276,660. This cost does not include the cost to demolish sections of the existing runway that would no longer be useable.

6. Raising the levee to elevation 1465 would require additional expansion of the runway. The estimated cost of $500,000 was assumed to occur at action level 1452. The updated cost is $530,000. Extending the runway in smaller increments was not feasible due to disruption of air traffic. This cost does not include the cost to demolish sections of the existing runway that would no longer be useable.

2.3 Summary of Economic Analysis Investigation for Feature 3: Fort Totten

2.3.0 Flood Protection Strategy

The Economic Analysis of Devils Lake indicated that the flood protection strategy with the largest net benefits for Fort Totten was incremental relocation.

2.3.1 General Information

Feature Type: Community

Location: Fort Totten is located along the south side of Devils Lake on the Spirit Lake Nation reservation in Benson County. The majority of the town is adjacent to ND Highway 57 just northeast of the intersection of ND Highway 57 and BIA Highway 1. The accompanying Figure 2.3-1 shows the feature's location, location of structures, approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: Fort Totten is an unincorporated community of 952 people (based on 2000 census).

Significance: The value of all the communities in this study is high because of the density of infrastructure in this primarily rural section of North Dakota. Although Fort Totten has not been significantly affected by the rising lake level to date, it is a relatively large community and major center of activity for the Spirit Lake Nation.

Damages: The flooding of Fort Totten would result in the following damages:

- Loss of 14 homes at lake elevation of 1463

When the water level reaches 1451, one (1) home would be impacted. When the water level reaches 1456, a total of six (6) homes would be impacted, and when the water level reaches 1463, a total of fourteen (14) homes would be impacted. "Impacted" means water levels would be above or within one foot of the foundation of the house.

Owner/Sponsor: The Spirit Lake Nation is responsible for managing and maintaining Fort Totten.

Lead Federal Agency: The Corps of Engineers would take the lead for Fort Totten for any flood protection work that may take place. Federal Emergency Management Agency (FEMA) would coordinate relocation of structures.

2.3.2 Feature Protection

History of Flood Protection: In the past, flood protection for Fort Totten has consisted of relocating the sewage lagoons. The sewage lagoons located near the lake in the Fort Totten area are no longer in use. New sewage lagoons were constructed on higher ground immediately west of this location. The old lagoons near the lake had a majority of the wastewater removed by pumping into the new sewage lagoons. There is still a direct pumping pipeline from the old disposal ponds to the new ponds. The pipeline serves two purposes:

1. To pump the remaining wastewater from the old eastern sewage lagoons to the new western sewage lagoons.

2. To be used in case of an emergency where the new western sewage lagoons would be unusable.

It was assumed that the eastern ponds will not be needed during flooding events and can be abandoned if necessary.

General Protection Strategy: The Economic Analysis of Devils Lake identified and evaluated several different approaches for protecting Fort Totten. These included:

- Construction of levees to protect a small number of homes along the northeast side of Fort Totten. Since the cost of these levees would be far in excess of the estimated value of the structures at each action level, the levee protection strategy was not pursued further.

- Relocation of the affected homes.

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake considered various protection strategies, with flood-protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.3-2 shows the decision tree for Fort Totten. As shown on Figure 2.3-2, the stepwise approach to flood protection for Fort Totten consisted of the following:

1. At lake elevation 1447, a decision would be made as to whether the structures between 1448 and 1452 should be relocated or a levee constructed to protect these structures. The preliminary analysis indicated that construction of a levee for protecting Fort Totten was greater than the value of the property and was not economically justified, and therefore it was not analyzed.

2. At lake elevation 1451, relocation would occur for structures between elevations 1452 and 1457.

3. At lake elevation 1456, relocation would occur for structures between elevations 1457 and 1464.

The maximum protection strategy that was analyzed at the first action level was relocating all structures below elevation 1464. (Note that for the Economic Analysis of Devils Lake, the decision regarding relocation of structures or whether or not to construct a levee is made at a time when the lake is one foot below the low structure elevation.)

Interdependencies: Flood protection for Fort Totten is related to the protection of the highways that serve it. These highways include:

- Feature 14: ND Highway 57 (between ND Highway 20 and BIA Highway 1)
- Feature 15: ND Highway 57 (between BIA Highway 1 and US Highway 281)
- Feature 21: ND Highway 20 (City of Devils Lake Levee to ND Highway 57)
- Feature 22: ND Highway 20 (ND Highway 57 to Tokio)
- Feature 24: BIA Highway 6

These highways are critical for Fort Totten in that they provide the main transportation routes in and out of the community.

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.3.3 Feature Economics

Damages: For Fort Totten the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for Fort Totten are summarized in the accompanying Table 2.3-1.

The first portion of the table shows the damages that are associated with each action level (1447, 1451, and 1456), each representing damages within a range of lake levels. The second portion of the table is a breakdown of the number of houses associated with each action level and cost of damages. Damages listed include houses only. The action levels identified (1447, 1451, and 1456) should not be confused with the three reference lake levels (1447, 1454, and 1463).

Unit costs for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for Fort Totten are listed in the Fort Totten Assumptions listing, appended to this Section 2.3.

Costs: The costs of providing flood protection for Fort Totten are detailed in the accompanying Table 2.3-2. Unit costs, data sources, and relevant assumptions are listed.

The first portion of the table shows the cost of relocating the houses at each action level (1447, 1451, and 1456). The second portion of the table is a breakdown of the number of houses associated with each action level and their costs. The second portion of the table also includes the cost of protecting the houses with a levee constructed to 1470.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for Fort Totten are listed in the Fort Totten Assumptions listing, appended to this Section 2.3.

2.3.4 Results of Economic Analysis

The results of the Economic Analysis for Fort Totten are listed in Table 2.3-3.

Stochastic Analysis Results: The stochastic analysis indicated that the flood protection strategy with the largest net benefits for Fort Totten was three incremental relocations of structures. This strategy is highlighted on the decision tree (Figure 2.3-2). The annual net benefits for this strategy were less than zero (-$1,000). The BCR for this strategy was less than one (0.91). These results indicate that this strategy is not economically justified. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood-protection strategies were also analyzed for three specific climate futures. For Fort Totten, the identified strategy and the economic indices for each of the three climate futures are as follows:

- Wet Future – For the wet future, the flood protection strategy with the largest net benefits was shown to be three incremental relocations of structures. For this strategy, the net benefits were -$3,600 and the BCR was 0.91, indicating that this strategy was not economically justified.

- First Moderate Future – For the first moderate future, the flood protection strategy with the largest net benefits was shown to be three incremental relocations of structures. For this strategy, the net benefits were -$400, and the BCR was 0.91, indicating that this strategy was not economically justified.

- Second Moderate Future – For the second moderate future, the flood protection strategy with the largest net benefits was shown to be three incremental relocations of structures. For this strategy, the net benefits were -$1,300, and the BCR was 0.91, indicating that this strategy was not economically justified.

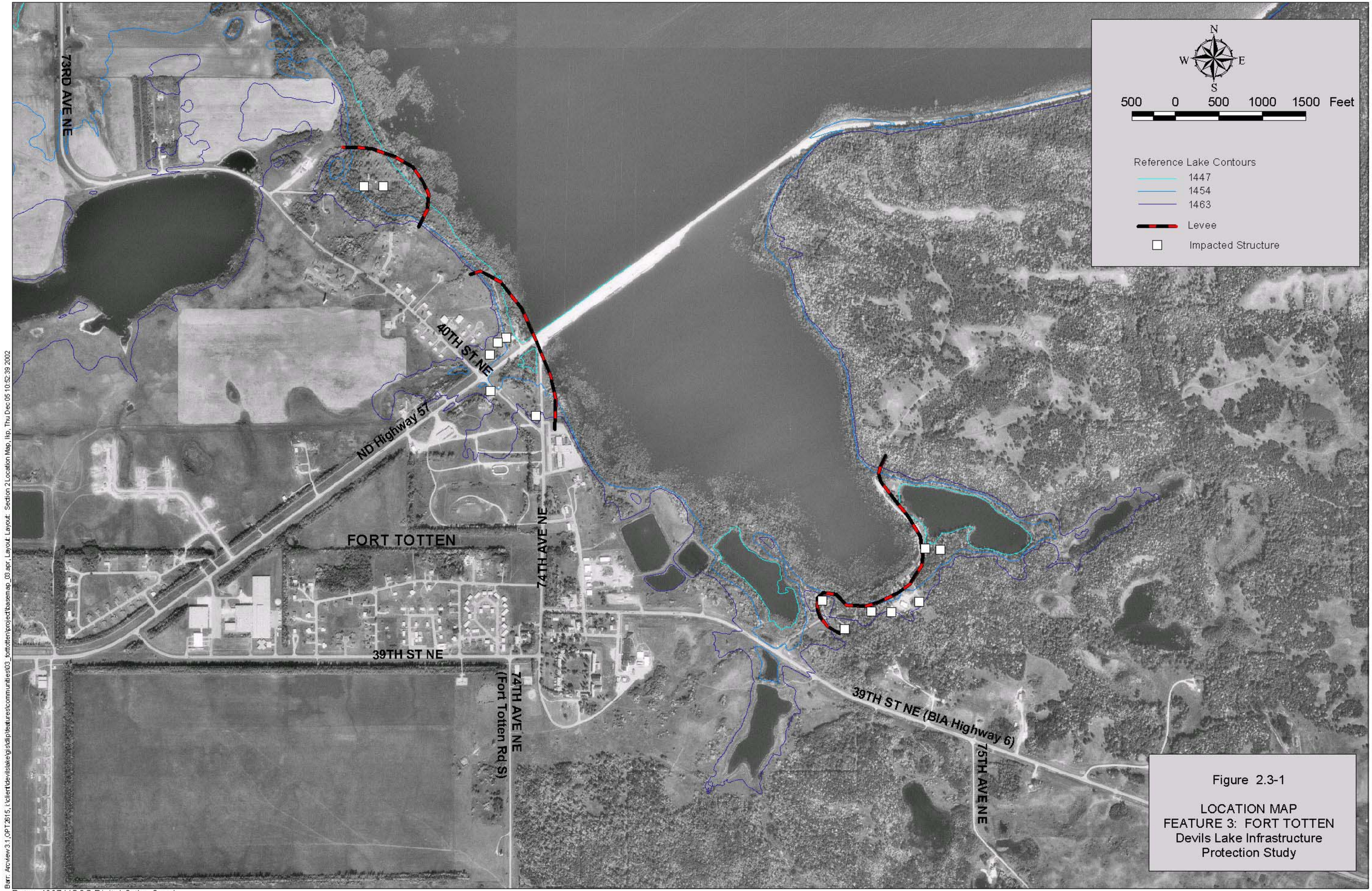
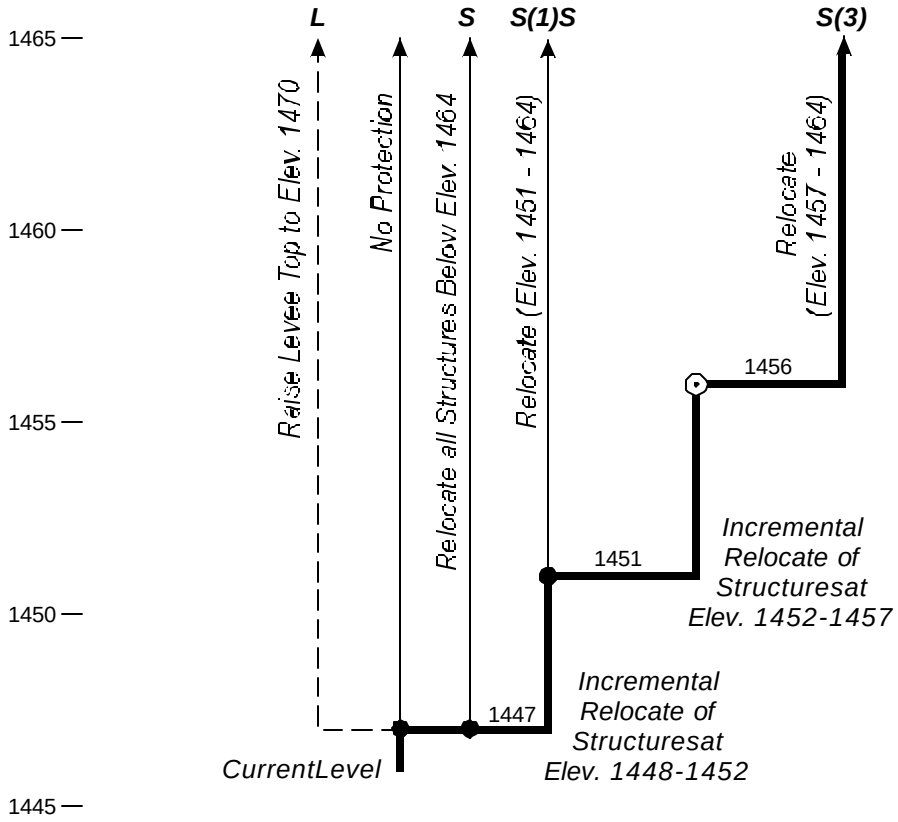


Figure 2.3-1

LOCATION MAP
FEATURE 3: FORT TOTTEN
Devils Lake Infrastructure
Protection Study

Barr: Arcview 3.1, OPT 2815, i:\client\devilslake\gis\dlp\features\communities\03_forttotten\project\basemap_03.apr, Layout: Section 2 Location Map, Thu Dec 05 10:52:39 2002

Data: 1997 USGS Digital Ortho Quad



FloodProtectionStrategy

Decisionrequiredatthispoint

Triggerpointforaction,nodecisionneeded

L(1) Incrementalleveeraise(numberoftimes)

L LeveeraisetoElev.1470

S(1) Structurerelocation(numberoftimes)

S RelocateallstructuresbelowElev.1464

Strategy notanalyzed

Figure2.3-2

DECISION TREE
FEATURE 3:FORTTOTTEN
DevilsLakeInfrastructure ProtectionStudy

Table 2.3-1

Flood Damages
Feature 3: Fort Totten
Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Lake Elevation	Structure Elevation Range	Structures and Infrastructure
	(MSL)	(MSL)	(THOUSANDS)
AL1	1447	Below 1452	$62
AL2	1451	1452 - 1457	$310
AL3	1456	1457 - 1464	$496

DAMAGE BREAKDOWN

AL1: Lake Elevation 1447					AL2: Lake Elevation 1451					AL3: Lake Elevation 1456				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
House	1	EA	$62,000	$62	House	5	EA	$62,000	$310	House	8	EA	$62,000	$496
Total				**$62**	**Total**				**$310**	**Total**				**$496**

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.3-2

Flood Protection Costs

Feature 3: Fort Totten

Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation (MSL)	S Relocate All Structures at AL1	S(1)S Incremental Relocation at AL1; Relocate All Structures at AL2	S(3) Incremental Relocation at AL1, AL2, AL3
		(THOUSANDS)		
AL1	1447	$952	$68	$68
AL2	1451	$0	$884	$340
AL3	1456	$0	$0	$544

COST BREAKDOWN

Strategy		S														
		S(1)S					S(1)S									
		S(3)					S(3)					S(3)				
		Lake Elevation 1447					Lake Elevation 1451					Lake Elevation 1456				
Incremental Relocation		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
	Move	House	1	EA	$68,000	$68	House	5	EA	$68,000	$340	House	8	EA	$68,000	$544
		Subtotal				$68	Subtotal				$340	Subtotal				$544
		Total				**$68**	**Total**				**$340**	**Total**				**$544**

Strategy		Lake Elevation 1447				
Maximum Protection Levee Raise*		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
	Levee	Performance/Pay	1	JB	$46,807	$47
		Impervious Fill	552,992	CY	$4.40	$2,433
		Bedding	42,805	CY	$35.00	$1,498
		Riprap	80,259	CY	$45.00	$3,612
		Sand Drain	49,925	CY	$20.00	$999
		Topsoil (4")	6,804	CY	$1.25	$9
		Seed	13	AC	$876	$11
		Pump Station	1	EA	$800,000	$800
		Subtotal				$9,408
		Contingency (30%)				$2,822
		Subtotal w/ Contingency				$12,231
		Engineering and Design (6%)				$734
		Supervision and Administration (10%)				$1,223
		1998 Total				$14,188
		2001 Total (add inflation)				$14,191
		2001 Adjusted Total				$14,190
	Pump Station	Pump Station	3	EA	$283,000	$849
		Subtotal				$849
		Total				**$15,039**

* This maximum protection levee raise cost was not analyzed in our conceptual model due to its excessive cost.

Notes:

1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. The costs for the Relocate All Structures at AL1 strategy (S) is equal to the sum of all relocations that have not been included in incremental relocations.
4. 2001 Total for levee cost is equal to the 1998 Total cost minus the pump station cost multiplied by 6% to increase for inflation.
5. 2001 Adjusted Total adjusts detailed cost breakdown to match the 2001 totals.

Table 2.3 - 3

Economic Analysis of Strategies for Fort Totten
(Feature 3)

Stochastic Analysis (ST)
Mean Value over 10,000 Traces (Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$10,200	######	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$59,600	$59,600	$0	$0	$10,200	-$49,400	0.17
S(1)S	1 Incremental Relocation: Then Relocate All Re	$0	$0	$15,900	$15,900	$0	$0	$10,200	-$5,700	0.64
S(3)	3 Incremental Relocations	$0	$0	$11,200	$11,200	$0	$0	$10,200	-$1,000	0.91

Wet Future Scenario (WF)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$36,900	######	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$59,800	$59,800	$0	$0	$36,900	-$22,800	0.62
S(1)S	1 Incremental Relocation: Then Relocate All Re	$0	$0	$47,600	$47,600	$0	$0	$36,900	-$10,700	0.78
S(3)	3 Incremental Relocations	$0	$0	$40,500	$40,500	$0	$0	$36,900	-$3,600	0.91

Moderate Future 1 Scenario (M1)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$3,900	$3,900	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$59,800	$59,800	$0	$0	$3,900	-$55,900	0.07
S(1)S	1 Incremental Relocation: Then Relocate All Re	$0	$0	$4,300	$4,300	$0	$0	$3,900	-$400	0.91
S(3)	3 Incremental Relocations	$0	$0	$4,300	$4,300	$0	$0	$3,900	-$400	0.91

Moderate Future 2 Scenario (M2)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$13,800	######	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$59,800	$59,800	$0	$0	$13,800	-$46,000	0.23
S(1)S	1 Incremental Relocation: Then Relocate All Re	$0	$0	$32,400	$32,400	$0	$0	$13,800	-$18,600	0.43
S(3)	3 Incremental Relocations	$0	$0	$15,100	$15,100	$0	$0	$13,800	-$1,300	0.91

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.
* Total benefits are calculated as the total damages incurred for the "No Protection strategy" minus the total damages for the strategy implemented (F(S)).

Attachment to 2.3:
Fort Totten Economic Analysis Assumptions

A. General Assumptions

1. Estimated damages included only the homes in the immediate area of Fort Totten. According to the League of Cities office in Bismarck, the area is not incorporated. The few homes outside of the immediate area were included in computations for Feature 8.1: Devils Lake Rural Areas.

B. Levee

1. A decision was assumed to be made when the lake is 1 foot below the design level of protection (i.e., 1 foot below the lower limit of the required freeboard of a levee).

2. In Fort Totten, most of the houses to be protected are arranged linearly and parallel to the land contours. The levees required to protect the homes would therefore be extremely long. A preliminary cost estimate (1998 dollars) indicated that the cost of construction and maintenance of these levees would be approximately $14 million to protect to the maximum lake level. The cost of incremental levee raises would be $2.5 and $8.5 million at action levels 1446 and 1451, respectively. Since the cost of these levees would be far in excess of the estimated value of the structures at each action level, the levee protection strategy was not pursued further. Therefore, only relocation strategies were analyzed for Fort Totten.

3. For levee protection, it was assumed that 5 feet of freeboard would be required at action levels 1447 and 1451, and that 7 feet of freeboard would be required at the maximum lake level. The assumed freeboard was based on the proposed freeboard for the City of Devils Lake and the high waves predicted for this area.

C. Residential and Commercial Properties

1. For relocation strategies, a decision was assumed to be made when the lake is 1 foot below the level of the low structure. This was based on the existing process which is influenced by the availability of movers, the estimated lake rise each spring, and the restrictions of funding programs. Depending on the slope of the land, wave action may affect structures several feet above the lake's level.

2. The average value of a house in Fort Totten was estimated to be $62,000. This figure was obtained from the Federal Emergency Management Agency (FEMA) and represents the average value of a house located on the Spirit Lake Nation Reservation. The value for each house was determined for FEMA by certified flood insurance adjusters and was based on total habitable square footage of the buildings and standardized real estate appraisals (*FEMA*, personal communication, March, 2001). These values did not include the value of land on which the houses were located.

3. Relocation cost for a house was estimated to be $68,000. This cost was obtained from the North Dakota-North Central Planning Council and represents the average cost to relocate a residence during the buyout program conducted in Churchs Ferry (2000). The $68,000 includes the following costs: demolition of the existing house, purchase of an equivalent house in a nearby community, purchase of a lot, legal, appraisal, and management fees. It was assumed relocation costs would be approximately the same in Fort Totten as they were in Churchs Ferry.

4. The disposal ponds located near the lake in the Fort Totten area are no longer in use. New disposal ponds were constructed on higher ground west of this location. The old ponds near the lake had a majority of the wastewater removed by pumping into the new disposal ponds, according to Neil Austin of the Spirit Lake Nation Indian Health Service. There is still a direct pumping pipeline from the old disposal ponds to the new ponds. The pipeline serves two purposes:

   a. To pump the remaining wastewater from the old eastern ponds to the new western ponds.

   b. To be used in case of an emergency where the new western ponds would be unusable.

   Therefore, it was assumed that the eastern ponds will not be needed during flooding events and can be abandoned if necessary.

2.4 Summary of Economic Analysis Investigation for Feature 4: Minnewaukan

2.4.0 Flood Protection Strategy

The Economic Analysis of Devils Lake Alternatives indicated that the flood protection strategy with the largest net benefits for the City of Minnewaukan was incremental levee construction.

2.4.1 General Information

Feature Type: Community

Location: The City of Minnewaukan is located on the west side of Devils Lake in Benson County, ND. The community of Fort Totten lies to the southeast and the community of Churchs Ferry lies to the north of the City of Minnewaukan. Currently, US Highway 281 (South of US Highway 2) passes through the city limits. The accompanying Figure 2.4-1 shows the feature's location and approximate extents, and the inundation extents at the reference lake levels (1447, 1454, and 1463).

Description: Minnewaukan is a city with a population of 318 (based on 2000 census), and is the County Seat of Benson County. The city covers approximately 250 acres and includes residential and commercial development, municipal facilities (public library, courthouse, fairgrounds, etc.), utility infrastructure (roads, sewers, electrical, telephone, etc.), and transportation infrastructure (local streets and US Hwy 281 (South of US Highway 2)).

Significance: Minnewaukan is important because it is a densely populated area that contains property of significant value and historical significance. The value of all the communities in this study is high because of the density of the infrastructure in this primarily rural section of North Dakota. The surrounding infrastructure includes major transportation routes for nearby population and industry. Minnewaukan contains County Seat facilities including the county fairgrounds and courthouse. There are numerous commercial and residential properties that would be affected by rising lake levels, particularly for lake levels above 1455.

Damages: The flooding of the City of Minnewaukan would result in the following damages:

- Loss of homes – The total value of homes at the 1451 lake level is minimal. The number and combined value of homes increases significantly at about elevation 1455. Approximately 90% of the single-family homes in the city lie above 1455. The majority of the property at risk in the city is located between 1456 and 1463.

- Loss of historical buildings – The Benson County Courthouse and Grace Episcopal Church are listed in the National Register of Historic Places. Existing damage estimates include only

the assessed value of the property and do not account for HTRW considerations. The Benson County Courthouse has an estimated value in excess of $1,800,000, making it the most expensive single property in the city, and accounting for over 10% of the total value of all property within the city.

- Loss of commercial and municipal properties – As with homes in the city, the majority of commercial and municipal properties at risk are between 1456 and 1463. Significant properties in the city include the public school, the grain elevator, the museum, and three churches. These items taken together account for approximately 10% of the total value of all property within the city.
- Loss of tax revenues.
- Loss of access on major highways and rail lines.

Owner/Sponsor: The City of Minnewaukan, City Council is responsible for managing and maintaining day-to-day administration of the city.

Lead Federal Agency: The Corps of Engineers would take the lead for the City of Minnewaukan for any flood protection work that may take place. Federal Emergency Management Agency (FEMA) would coordinate relocation of structures.

2.4.2 Feature Protection

History of Flood Protection: In the past, flood protection for the City of Minnewaukan has consisted of the following:

- Moving the sewage treatment ponds to higher ground (1995). The top of the dike around the sewage treatment ponds is believed to be above 1463.
- Installation of a back-up water supply line from the water plant north of town, extending south from the water plant to the west of the city, then extending east through the city to the water tower.
- Installation of drainage features to prevent flooding from the unnamed coulee on the northwest side of the city, including enlarging culverts under the railroad and highways on the north end of town.
- Abandoning certain portions of the county fairgrounds.

General Protection Strategy: The Economic Analysis identified and evaluated several different approaches for protecting the City of Minnewaukan. These included:

- Construction of a levee around the city

- Relocation of the affected structures through FEMA funding programs
- Combination levee and relocation of US Highway 281 (South of US Highway 2) as a flood barrier

Several different flood barrier options were reviewed and two of the options were evaluated to determine the least costly alternative as a flood barrier option:

- Levee with riprap for wave protection
- Levee with roller-compacted concrete (RCC) for wave protection

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake considered various protection strategies, with flood protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.4-2 shows the decision tree for the City of Minnewaukan. As shown on Figure 2.4-2, the stepwise approach to flood protection for the City of Minnewaukan consisted of the following:

1. At lake elevation 1447, all structures below elevation 1451 would be relocated.
2. At lake elevation 1450, a decision would be made as to whether the structures between 1451 and 1456 should be relocated or a levee should be constructed to a top of 1461 to protect these structures.
3. If incremental relocation was selected at the first action level, at lake elevation 1455, all structures below 1464 would be relocated.

   If the levee were constructed at the first action level, at lake elevation 1455, a decision would be made as to whether the structures between 1451 and 1464 should be relocated or the existing levee raised to a top at 1468 to protect these structures.

Two maximum protection strategies were analyzed at the first action level: relocating all structures below elevation 1464 or raising the existing levee top to 1468. (Note that for the Economic Analysis of Devils Lake, the decision regarding relocation of structures or whether or not to construct a levee is made at a time when the lake is one foot below the low structure elevation. The decision regarding whether or not to raise a levee is made at a time when the lake is one foot below the existing level of protection.)

Interdependencies: Protection of the City of Minnewaukan is related to the protection of US Highway 281 (South of US Highway 2). US Highway 281 passes through the city limits and is the major thoroughfare for traffic. Relocation or raise of US Highway 281 will affect access to the city and will also affect the location of the city in any relocation alternatives. In addition,

previous studies considered using US Highway 281 as a combination road and levee, thus affecting funding and location of the road/levee.

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.4.3 Feature Economics

Damages: For the City of Minnewaukan, the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for the City of Minnewaukan are summarized in the accompanying Table 2.4-1.

The first portion of the table shows the damages that are associated with each action level (1450 and 1455), each representing damages within a range of lake levels. The second portion of the table is a breakdown of the damages associated with each action level. Damages listed include a wide range of structures, including homes, apartments, churches, a library, courthouse, city lots, land, businesses, a school, a trailer court, grain elevator, a museum, and a park.

Unit costs for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for the City of Minnewaukan are listed in the City of Minnewaukan Economic Analysis Assumptions listing, attached to this Section 2.4.

Costs: The costs of providing flood protection for the City of Minnewaukan are detailed in the accompanying Table 2.4-2. Unit costs, data sources, and relevant assumptions are listed.

The first portion of the table shows the cost for each strategy for each action level (1450 and 1455). This includes:

- Incremental relocation
- Maximum protection levee at first action level
- Raise levee at first action level and then relocate all structures
- Incremental levee raise
- Relocate all structures at first action level

The second portion of the table is a breakdown of the strategy costs for each strategy and each action level.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of

the economic analysis for the City of Minnewaukan are listed in the City of Minnewaukan Economic Analysis Assumptions listing, attached to this Section 2.4.

2.4.4 Results of Economic Analysis

The results of the Economic Analysis for the City of Minnewaukan are listed in Table 2.4-3.

Stochastic Analysis Results: The stochastic analysis indicated that the flood protection strategy with the largest net benefits for the City of Minnewaukan was two incremental levee raises. This strategy is highlighted on the decision tree (Figure 2.4-2). The annual net benefits for this strategy were greater than zero ($58,500). The BCR for this strategy was greater than one (1.52). These results indicate that this strategy was economically justified. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For the City of Minnewaukan, the identified strategy and the economic indices for each of the three climate futures are as follows:

- Wet Future – For the wet future, the flood protection strategy with the largest net benefits was shown to be two incremental levee raises. For this strategy, the net benefits were $434,400 and the BCR was 2.09, indicating that this strategy was economically justified.
- First Moderate Future – For the first moderate future, the flood protection strategy with the largest net benefits was shown to be incremental relocations of structures. For this strategy, the net benefits were $27,200, and the BCR was 1.24, indicating that this strategy was economically justified.
- Second Moderate Future – For the second moderate future, the flood protection strategy with the largest net benefits was shown to be incremental relocations of structures. For this strategy, the net benefits were $44,500, and the BCR was 1.24, indicating that this strategy was economically justified.

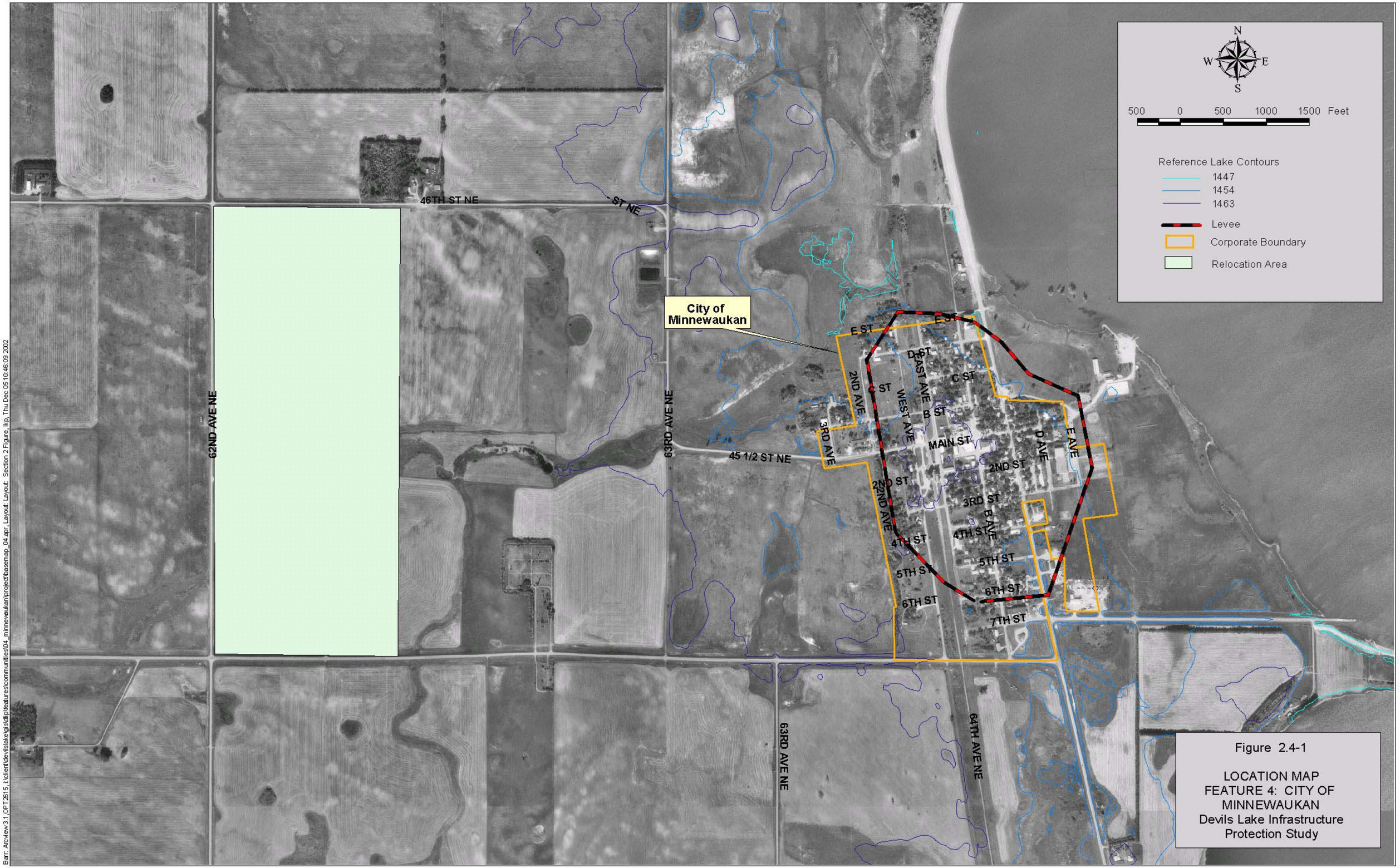
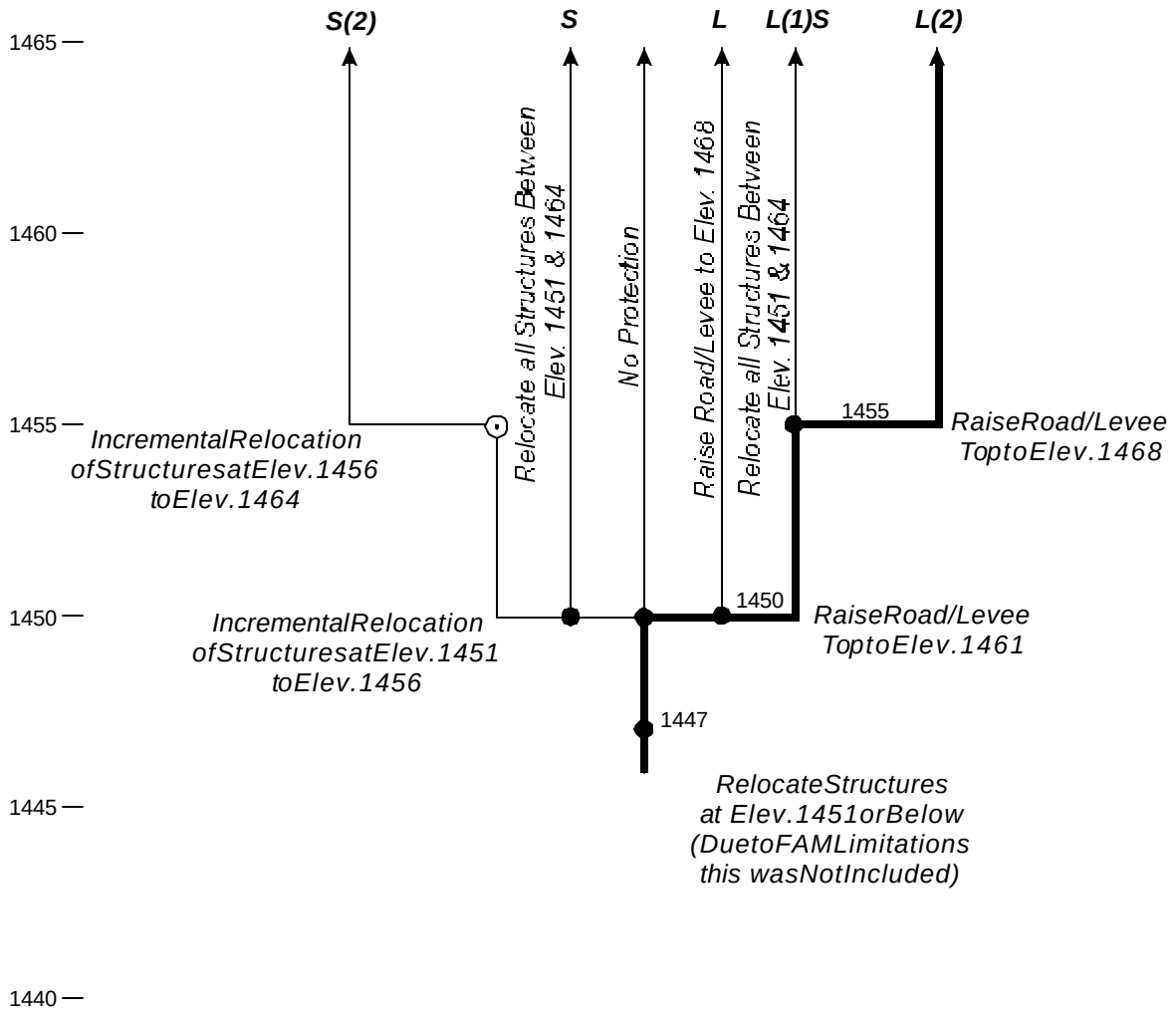


Figure 2.4-1

LOCATION MAP
FEATURE 4: CITY OF MINNEWAUKAN
Devils Lake Infrastructure Protection Study

Data: 1997 USGS Digital Ortho Quad

Barr: Arcview3.1,OPT2615, i:\client\devilslake\gis\dlip\features\communities\04_minnewaukan\project\basemap_04.apr, Layout: Layout: Section 2 Figure, lkp, Thu Dec 05 10:46:09 2002



FloodProtectionStrategy

Decisionrequiredatthispoint

Triggerpointforaction,nodecisionneeded

L(1) Incrementalleveeraise(numberoftimes)

L LeveeraisetoElev.1468

S(1) Structurerelocation(numberoftimes)

S RelocateallstructuresbelowElev.1464

Figure2.4-2

DECISION TREE
FEATURE 4:CITYOFMINNEWAUKEN
DevilsLakeInfrastructure ProtectionStudy

P:\1036020\DECISIONTREES\2002FIGURES\FIGURE2_04.CDR RLG 01-02-03

Table 2.4-1

Flood Damages
Feature 4: City of Minnewaukan
Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Lake Elevation (MSL)	Structure Elevation Range (MSL)	Structures and Infrastructure (THOUSANDS)
AL1	1450	Below 1456	$4,997
AL2	1455	1451 - 1464	$14,471

DAMAGE BREAKDOWN

Strategy	AL1: Lake Elevation 1447					AL2: Lake Elevation 1450					AL3: Lake Elevation 1455				
	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Incremental Relocation	Church	1	EA	$287,000	$287	House	45	EA	$88,000	$3,960	House	108	EA	$88,000	$9,504
						HUD Unit + Lots	1	EA	$219,070	$219	Business	23	EA	$42,500	$978
							16	EA	$313	$5	Minnewaukan Residence	2	EA	$101,500	$203
						Apartments/Senior Residenc	1	EA	$46,000	$46	Church	3	EA	$287,000	$861
						Business	3	EA	$42,500	$128	Library	1	EA	$43,800	$44
						School	1	EA	$550,000	$550	Courthouse	1	EA	$1,808,900	$1,809
						Lots	194	EA	$313	$61	Lots	391	EA	$313	$122
						Land	21.5	ACR	$400	$9	Land	109.4	ACR	$400	$44
						Trailer Court	1	EA	$19,760	$20	Grain Elevator	1	EA	$750,200	$750
											Museum	1	EA	$125,000	$125
											Park	1	EA	$31,200	$31
	Total				**$287**	**Total**				**$4,997**	**Total**				**$14,471**
Incremental Levee Raise						House	45	EA	$88,000	$3,960	House	108	EA	$88,000	$9,504
						HUD Unit + Lots	1	EA	$219,070	$219	Business	23	EA	$42,500	$978
							16	EA	$313	$5	Minnewaukan Residence	2	EA	$101,500	$203
						Apartments/Senior Residenc	1	EA	$46,000	$46	Church	3	EA	$287,000	$861
						Business	3	EA	$42,500	$128	Library	1	EA	$43,800	$44
						School	1	EA	$550,000	$550	Courthouse	1	EA	$1,808,900	$1,809
						Lots	194	EA	$313	$61	Lots	391	EA	$313	$122
						Land	21.5	ACR	$400	$9	Land	109.4	ACR	$400	$44
						Trailer Court	1	EA	$19,760	$20	Grain Elevator	1	EA	$750,200	$750
											Museum	1	EA	$125,000	$125
											Park	1	EA	$31,200	$31
						Total				**$4,997**	**Total**				**$14,471**

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. Operation and maintenance costs apply to levee strategies, and include operation and maintenance of pumping stations and levee embankments, These costs are incurred annually, each year that the levee remains in place.

Table 2.4-2

Flood Protection Costs

Feature 4: City of Minnewaukan

Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	S(2) Incremental Relocation at AL1, AL2	S Relocate all Structures at AL1	L Maximum Protection Levee at AL1	L(1)S Raise Levee at AL1; Relocate All Structures at AL2	L(2) Raise Levee at AL1, AL2
	(MSL)	(THOUSANDS)				
AL1	1450	$4,031	$16,342	$7,802	$5,349	$5,349
AL2	1455	$12,311	$0	$0	$16,342	$2,453

COST BREAKDOWN

		S(2)					S(2)				
		S					S				
		L(1)S					L(1)S				
		Lake Elevation 1450					Lake Elevation 1455				
Strategy		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Incremental Relocation											
	Move	Houses	45	EA	$68,000	$3,060	House @ $68,000/EA	108	EA	$68,000	$7,344
		HUD Unit + Lots	1	EA	$153,349	$153	Business @ $42,500/EA	23	EA	$42,500	$978
			16	EA	$313	$5	Minnewaukan Residences	2	EA	$101,500	$203
		Apartments/Senior Residence	1	EA	$46,000	$46	Church @ $287,000	3	EA	$287,000	$861
		Business @ $42,500/EA	3	EA	$42,500	$128	Library	1	EA	$43,800	$44
		School	1	EA	$550,000	$550	Courthouse	1	EA	$1,808,900	$1,809
		Lots @ $313/EA	194	EA	$313	$61	Lots @ $313/EA	391	EA	$313	$122
		Land @ $400/ACR	21.5	ACR	$400	$9	Land @ $400/ACR	109.4	ACR	$400	$44
		Trailer Court	1	EA	$19,800	$20	Grain Elevator	1	EA	$750,200	$750
							Museum	1	EA	$125,000	$125
							Park	1	EA	$31,200	$31
		Subtotal				$4,031	Subtotal				$12,311
		Total				**$4,031**	**Total**				**$12,311**
		L					L				
		L(2)					L(2)				
		L(1)S									
Incremental Levee Raise											
	Levee	East Levee					East Levee				
		Performance/Payment Bond	1	JB	$3,573	$4	Performance/Payment Bond	1	JB	$2,639	$2.6
		Stripping (6")	3,593	CY	$1.25	$4	Stripping (6")	1,808	CY	$1.25	$2.3
		Inspection Trench	3,800	LF	$3.75	$14	Inspection Trench	0	LF	$3.75	$0
		Impervious Fill	26,599	CY	$4.22	$112	Impervious Fill	48,349	CY	$4.22	$204
		RCC	11,689	CY	$40.00	$468	RCC	7,941	CY	$40.00	$318
		Topsoil (4")	1,516	CY	$2.08	$3	Topsoil (4")	1,028	CY	$2.08	$2.1
		Seed	3	ACR	$929.17	$3	Seed	2	ACR	$929.17	$1.9
		Pedestrian Handrail	3,800	LF	$29.00	$110	Pedestrian Handrail	0	LF	$29.00	$0
		Subtotal				$718	Subtotal				$531
		Contingency (30%)				$215	Contingency (30%)				$159
		Subtotal w/ Contingency				$934	Subtotal w/ Contingency				$690
		Engineering and Design (15%)				$140	Engineering and Design (15%)				$103
		Supervision and Administration (7.5%)				$70	Supervision and Administration (7.5%)				$52
		Rural Real Estate	2	ACR	$270	$1	Rural Real Estate	1	ACR	$270	$0.3
		Urban Real Estate	2	ACR	$3,485	$9	Urban Real Estate	2	ACR	$3,485	$5.0
		Real Estate Administration (20%)				$2	Real Estate Administration (20%)				$1.1
		East LeveeTotal				$1,155	East LeveeTotal				$851
		West Levee					West Levee				
		Performance/Payment Bond	1	JB	$4,039	$4	Performance/Payment Bond	1	JB	$4,540	$5
		Stripping (6")	4,225	CY	$1.25	$5	Stripping (6")	3,866	CY	$1.25	$5
		Inspection Trench	5,700	LF	$3.75	$21	Inspection Trench	1,700	LF	$3.75	$6
		Impervious Fill	22,056	CY	$4.22	$93	Impervious Fill	60,392	CY	$4.22	$255
		RCC	12,911	CY	$40.00	$516	RCC	14,630	CY	$40.00	$585
		Topsoil (4")	1,628	CY	$2.08	$3	Topsoil (4")	1,946	CY	$2.08	$4
		Seed	3	ACR	$929.17	$3	Seed	4	ACR	$929.17	$4
		Pedestrian Handrail	5,700	LF	$29.00	$165	Pedestrian Handrail	1,700	LF	$29.00	$49
		Subtotal				$812	Subtotal				$913
		Contingency (30%)				$244	Contingency (30%)				$274
		Subtotal w/ Contingency				$1,055	Subtotal w/ Contingency				$1,187
		Engineering and Design (15%)				$158	Engineering and Design (15%)				$178
		Supervision and Administration (7.5%)				$79	Supervision and Administration (7.5%)				$89
		Rural Real Estate	3	ACR	$270	$1	Rural Real Estate	3	ACR	$270	$1
		Urban Real Estate	2	ACR	$3,485	$8	Urban Real Estate	2	ACR	$3,485	$13
		Real Estate Administration (20%)				$2	Real Estate Administration (20%)				$3
		West LeveeTotal				$1,304	West LeveeTotal				$1,470
		1998 Total				$2,458	1998 Total				$2,322
		2001 Total (add inflation)				$2,606	2001 Total (add inflation)				$2,461
	Interior Drainage	Interior Drainage	1	EA	$2,163,400	$2,163					
		Subtotal				$2,163					
	Relocate	House @ $68,000/EA	7	EA	$68,000	$476					
		Business @ $42,500/EA	2	EA	$42,500	$85					
		Trailer Court	1	EA	$19,800	$20					
		Subtotal				$581					
		Total				$5,350	Total				$2,461
		2001 Adjusted Total				**$5,349**	**2001 Adjusted Total**				**$2,453**

ANNUAL OPERATION AND MAINTENANCE COSTS

Lake Elevation	Pump Operation and	Levee Maintenance	Total Operation and
(MSL)	(THOUSANDS)		

1450	$2	$5	$7
1456	$4	$4	$8

Notes:

1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. The maximum protection strategy for this feature is equal to the sum of the incremental relocation costs at each action level.
4. The maximum protection levee raise cost of not analyzed due to its excessive cost.
5. 248 lots were assumed to be saved by the levee. However, up to 52 lots may actually be under the footprint of the levee or outside the levee. For this reason, the damages prevented for this strategy may be slightly less than those used in our analysis.
6. For all strategies, a church valued at $277,000 to be moved at Elevation 1447, was not included due to FAM limitations.
4. 2001 Total for levee cost is equal to the 1998 Total cost multiplied by 6% to increase for inflation.
5. 2001 Adjusted Total adjusts detailed cost breakdown to match the 2001 totals.

Table 2.4 - 3

Economic Analysis of Strategies for City of Minnewaukan (Feature 4)

Stochastic Analysis (ST)
Mean Value over 10,000 Traces (Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$170,700	#######	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$295,400	$295,400	$0	$0	$170,700	-$124,700	0.58
L	Raise Top of Levee to 1468	$141,000	#####	$0	$143,300	$0	$0	$170,700	$27,500	1.19
L(1)S	1 Incremental Levee Raise: Relocae All Structures Below	$96,700	#####	$90,800	$188,700	$0	$0	$170,700	-$18,000	0.90
L(2)	2 Levee Raises	$110,300	#####	$0	$112,200	$0	$0	$170,700	$58,500	1.52
S(2)	2 Incremental Relocations	$0	$0	$141,300	$141,300	$0	$0	$170,700	$29,500	1.21

Wet Future Scenario (WF)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$831,500	#######	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$906,700	$906,700	$0	$0	$831,500	-$75,300	0.92
L	Raise Top of Levee to 1468	$432,900	#####	$0	$439,900	$0	$0	$831,400	$391,500	1.89
L(1)S	1 Incremental Levee Raise: Relocae All Structures Below	$296,800	#####	$625,800	$924,500	$0	$0	$831,500	-$93,000	0.90
L(2)	2 Levee Raises	$390,700	#####	$0	$397,100	$0	$0	$831,500	$434,400	2.09
S(2)	2 Incremental Relocations	$0	$0	$695,100	$695,100	$0	$0	$831,500	$136,300	1.20

Moderate Future 1 Scenario (M1)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$140,500	#######	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$459,400	$459,400	$0	$0	$140,500	-$319,000	0.31
L	Raise Top of Levee to 1468	$219,400	#####	$0	$222,700	$0	$0	$140,500	-$82,200	0.63
L(1)S	1 Incremental Levee Raise: Relocae All Structures Below	$150,400	#####	$0	$153,100	$0	$0	$140,500	-$12,600	0.92
L(2)	2 Levee Raises	$150,400	#####	$0	$153,100	$0	$0	$140,500	-$12,600	0.92
S(2)	2 Incremental Relocations	$0	$0	$113,300	$113,300	$0	$0	$140,500	$27,200	1.24

Moderate Future 2 Scenario (M2)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$230,400	#######	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$753,300	$753,300	$0	$0	$230,400	-$523,000	0.31
L	Raise Top of Levee to 1468	$359,600	#####	$0	$365,400	$0	$0	$230,300	-$135,100	0.63
L(1)S	1 Incremental Levee Raise: Relocae All Structures Below	$246,600	#####	$0	$251,300	$0	$0	$230,400	-$21,000	0.92
L(2)	2 Levee Raises	$246,600	#####	$0	$251,300	$0	$0	$230,400	-$21,000	0.92
S(2)	2 Incremental Relocations	$0	$0	$185,800	$185,800	$0	$0	$230,400	$44,500	1.24

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.

* Total benefits are calculated as the totall damages incurred for the "No Protection stragegy" minus the totall damages for the strategy implemented (F(S)).

Attachment to 2.4:
City of Minnewaukan Economic Analysis Assumptions

A. General Assumptions

1. It was assumed that the low structure in the city lies at elevation 1448, based on maps supplied by the city staff showing curb and gutter elevations, selected survey points, and personal conversations with the County Assessor.

B. Levees

1. A decision was assumed to be made when the lake is 1 foot below the design level of protection (i.e., 1 foot below the lower limit of the required freeboard of a levee).

2. The costs of levee protection did not consider the cost of undefined supplemental protection for higher levels along an unnamed coulee along the northwest city limits during runoff events.

3. Levees were assumed to require 5 feet of freeboard.

4. The levee design was obtained from the *Devils Lake, Minnewaukan Federal Interest Study*, Barr Engineering Company, September 29, 1998. That report provided two options for structural protection: a levee and a road/levee. Continued viability of the City is dependent on not only the levee but also on keeping US Highway 281 open to provide access. If the levee option is chosen, US Highway 281 south of US Highway 2 will be raised.

5. The analysis of incremental levee raises would not allow a relocation of structures prior to construction of the first levee raise. Therefore, the first relocation at elevation 1447.0 was not included in the analysis. The value of this relocation ($0.3 million) is minimal when compared to the total values at higher elevations ($4.0 to $12.3 million).

C. Residential and Commercial Buildings

1. For relocation strategies, a decision was assumed to be made when the lake is 1 foot below the level of the low structure. This was based on the existing process which is influenced by the availability of movers, the estimated lake rise each spring, and the restrictions of funding programs. Depending on the slope of the land, wave action may affect structures several feet above the lake's level.

2. The average value of a house in Minnewaukan is estimated to be $88,000. This figure was obtained from the Federal Emergency Management Agency (FEMA) and represents the average value of rural houses located around Devils Lake, excluding houses on the Spirit Lake Nation Reservation. The value for each house was determined for FEMA by certified flood insurance adjusters and was based on total habitable square footage of the buildings and standardized real estate appraisals (*FEMA*, personal communication, March, 2001). These values did not include the value of the land on which

the houses were located. The $88,000 average was based on rural houses only, therefore houses in the Cities of Minnewaukan and Devils Lake were not included in the analysis. However, the analysis did include many houses in the area surrounding Minnewaukan. Therefore, it was assumed that the average value of a residence in Minnewaukan was same as in the surrounding area.

3. The values and relocation costs for the structures and properties described below are in 1998 dollars. These values and costs were updated for inflation by multiplying them by the ENR Building Cost Index of 1.042. This accounts for 4.2% inflation during the period from 1998 to February 2001. Specific assumptions for the 1998 values included:

   a. For the park and the athletic fields, the same values were used as in the ongoing study for the city. A value of $25,000 was used for the park as well as the athletic fields. The updated value is $26,050.

   b. The value of all churches was approximated using the $275,000 insured value of the structure only for Trinity Lutheran Church. The updated value is $286,550.

   c. The value of the Courthouse was estimated using the 1997 Swift and Marshall Book replacement value for a good Class C building, at $100 per square foot for the top three floors and $74 per square foot for the basement. The courthouse has approximately 14,403 square feet on the top three floors. The basement was assumed to be 4,000 square feet. Therefore, the estimate replacement value of the Courthouse was $1,736,000. The updated value is $1,808,912.

   d. The value of the Museum was estimated at $100,000, based on a conversation with Garvin Plumber, Museum operator, and increased to $120,000 to reflect the depreciated replacement value. The updated value is $125,040.

   e. Costs for the swimming pool, school, and library were estimated using a value of 25% of the low end of the 1997 Means Cost Estimate. The low-end estimates were used based on the comparatively low values of structures in a small city. Since only the square footage for the school was available, the square footage was assumed for the other structures at:

      i. Swimming pool building = 450 square feet

      ii. Library = 2,000 square feet

   f. The estimated values for the structures mentioned above include the value of the lots. According to the City Assessor, each lot had an assessed value of $300. The updated value is $312. The lot sizes of some larger structures were determined from the city map as follows:

      i. West Bay Housing (Individual HUD home) = 16 lots

      ii. Trailer court = 20 lots

4. For relocation strategies, it was assumed that the pool and park were not relocated. The pool is in very poor condition, and has not been used in recent years because of its poor condition.

5. Relocation costs were assumed to be 70% of the assessed value of trailer courts and HUD homes (West Bay units) plus 100% of the assessed values of the lot.

6. Relocation costs for homes were estimated to be $68,000. This cost was obtained from the North Dakota-North Central Planning Council and represents the average cost to relocate a residence during the buyout program conducted in Churchs Ferry (2000). The $68,000 includes the following costs: demolition of the existing house, purchase of an equivalent house in a nearby community, purchase of a lot, and legal, appraisal, and management fees. It was assumed relocation costs would be approximately the same in Minnewaukan as they were in Churchs Ferry.

7. The cost for relocation/rebuilding of commercial and public facilities was assumed to be 100% of the value of the structure and property.

8. The land value for Minnewaukan is estimated to be $400/acre. This value was provided by the Corps of Engineers (April, 2001) and is an estimate of the average value of all land surrounding Devils Lake.

2.5 Summary of Economic Analysis Investigation for Feature 5: St. Michael

2.5.0 Flood Protection Strategy

The Economic Analysis of Devils Lake Alternatives indicated that the flood protection strategy with the largest net benefits for St. Michael was relocation of structures (homes and sewage lagoon).

2.5.1 General Information

Feature Type: Community

Location: St. Michael is located along the south side of Devils Lake in Benson County. The majority of the town is adjacent to BIA Highway 1 just north of the intersection of BIA Highway 1 and BIA Highway 6. The accompanying Figure 2.5-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: St. Michael is an unincorporated town. St. Michael has been protected from the rising lake waters by roads that are currently acting as dams (see analysis of Feature 25).

Significance: The value of all the communities in this study is high because of the density of infrastructure in this primarily rural section of North Dakota. Although St. Michael has not been significantly affected by the rising lake level to date, several homes and a sewage lagoon could be affected by rising lake levels.

Damages: The flooding of St. Michael would result in the following damages:

- Loss of 25 homes at 1463
- Loss of a sewage lagoon

Owner/Sponsor: The Spirit Lake Nation is responsible for managing and maintaining St. Michael.

Lead Federal Agency: The Corps of Engineers would take the lead for St. Michael for any flood protection work that may take place. Federal Emergency Management Agency (FEMA) would coordinate relocation of structures.

2.5.2 Feature Protection

History of Flood Protection: In the past, flood protection for St. Michael has consisted of raising berms around the sewage lagoon. The Bureau of Indian Affairs installed additional

protection for the St. Michael sewage lagoons in 1997 to prevent damage due to the high lake level. The Economic Analysis estimated the relocation cost for the sewage lagoon to be $159,000.

General Protection Strategy: The Economic Analysis identified and evaluated several different approaches for protecting St. Michael. These included:

- Construction of a levee to protect the most vulnerable (north) part of town. Since the cost of the levee would be far in excess of the estimated value of the structures at each action level, the levee protection strategy was not pursued further.
- Relocation of the town's sewage lagoon and the affected homes.

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake considered various protection strategies, with flood protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.5-2 shows the decision tree for St. Michael. As shown on Figure 2.5-2, the stepwise approach to flood protection for St. Michael consisted of the following:

1. At lake elevation 1447, a decision would be made as to whether the structures below 1451 should be relocated or a levee constructed to protect these structures. This first decision would need to be made when the adjacent roads are no longer acting as dams (see analysis of Feature 25). The preliminary analysis indicated that construction of a levee for protecting St. Michael was greater than the value of the property and was not economically justified, and therefore it was not analyzed.
2. At lake elevation 1450, relocation would occur for structures between 1451 and 1456.
3. At lake elevation 1455, relocation would occur for structures between 1456 and 1464.

The maximum protection strategy that was analyzed at the first action level was relocating all structures below 1464. (Note that for the Economic Analysis of Devils Lake, the decision regarding relocation of structures or whether or not to construct a levee is made at a time when the lake is one foot below the low structure elevation.)

Interdependencies: The protection of St. Michael is related to the protection of the highways that serve it. These highways include:

- Feature 23: BIA Highway 1 between ND Highway 57 and BIA Highway 6
- Feature 24: BIA Highway 6 from ND Highway 20 to Fort Totten

These highways are critical for St. Michael in that they provide the main transportation routes in and out of the community.

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.5.3 Feature Economics

Damages: For St. Michael, the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for St. Michael are summarized in the accompanying Table 2.5-1.

The first portion of the table shows the damages that are associated with action level (1447, 1450, and 1455), each representing damages within a range of lake levels. The second portion of the table is a breakdown of the damages associated with each action level. Damages listed include houses and the sewage lagoon.

Unit costs for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for St. Michael are listed in the St. Michael Economic Analysis Assumptions listing, attached to this Section 2.5.

Costs: The costs of providing flood protection for St. Michael are detailed in the accompanying Table 2.5-2. Unit costs, data sources, and relevant assumptions are listed.

The first portion of the table shows the cost of relocations at each action level (1447, 1450, and 1455). The second portion of the table is a breakdown of the relocations associated with each action level and their costs. The second portion of the table also includes the cost of protecting the houses and sewage lagoon with a levee constructed to 1470.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for St. Michael are listed in the St. Michael Economic Analysis Assumptions listing, attached to this Section 2.5.

2.5.4 Results of Economic Analysis

The results of the Economic Analysis for St. Michael are listed in Table 2.5-3.

Stochastic Analysis Results: The stochastic analysis indicated that the flood protection strategy with the largest net benefits for St. Michael was three incremental relocations of structures. This strategy is highlighted on the decision tree (Figure 2.5-2). The annual net benefits for this strategy were less than zero (-$900). The BCR for this strategy was less than one (0.96). These results indicate that this strategy was not economically justified. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For St. Michael, the identified strategy and the economic indices for each of the three climate futures are as follows:

- Wet Future – For the wet future, the flood protection strategy with the largest net benefits was shown to be three incremental relocations of structures. For this strategy, the net benefits were -$5,900 and the BCR was 0.92, indicating that this strategy was not economically justified.

- First Moderate Future – For the first moderate future, the flood protection strategy with the largest net benefits was shown to be incremental relocations of structures. For this strategy, the net benefits were -$200, and the BCR was 0.99, indicating that this strategy was not economically justified.

- Second Moderate Future – For the second moderate future, the flood protection strategy with the largest net benefits was shown to be incremental relocations of structures. For this strategy, the net benefits were -$300, and the BCR was 0.98, indicating that this strategy was not economically justified.

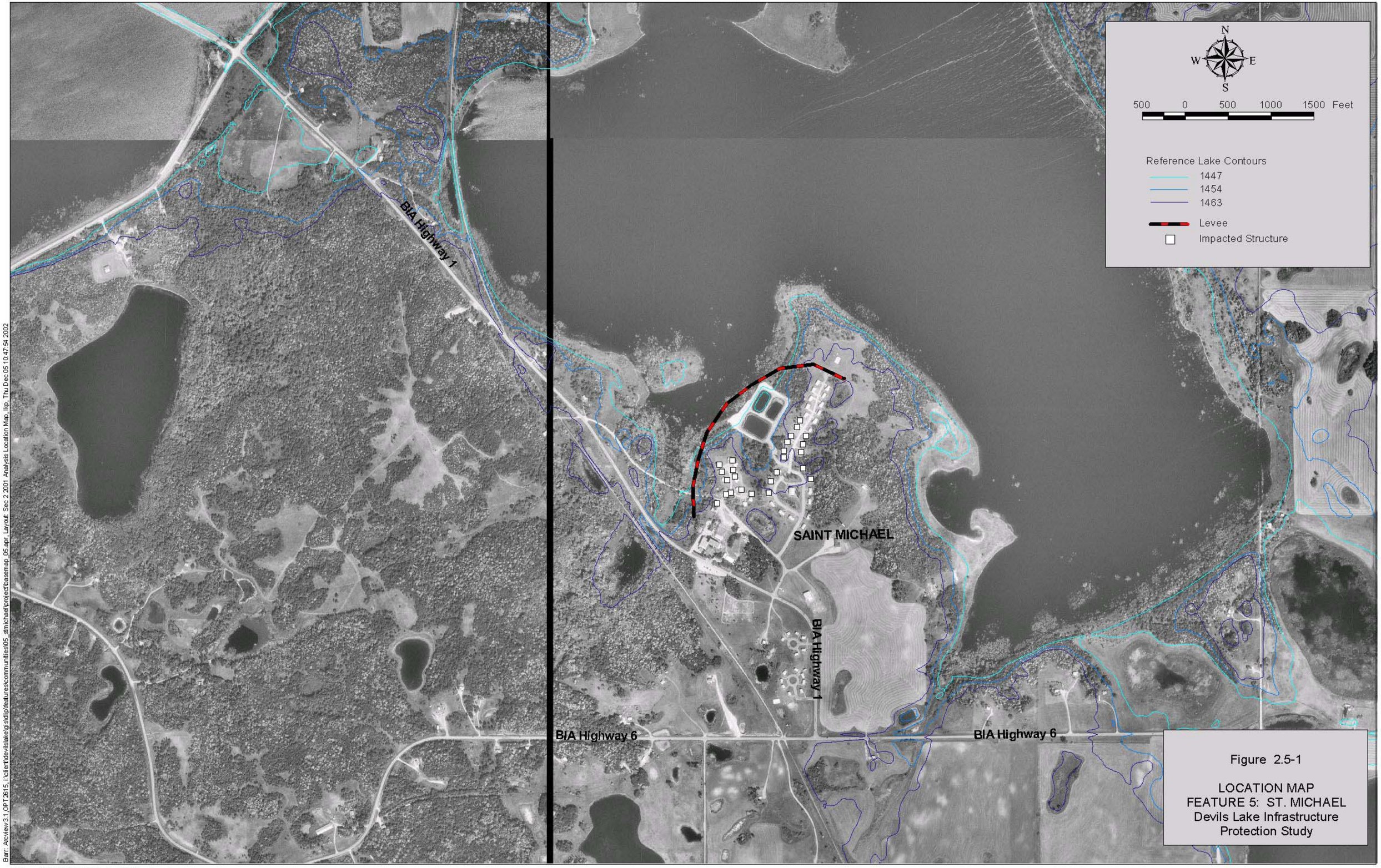
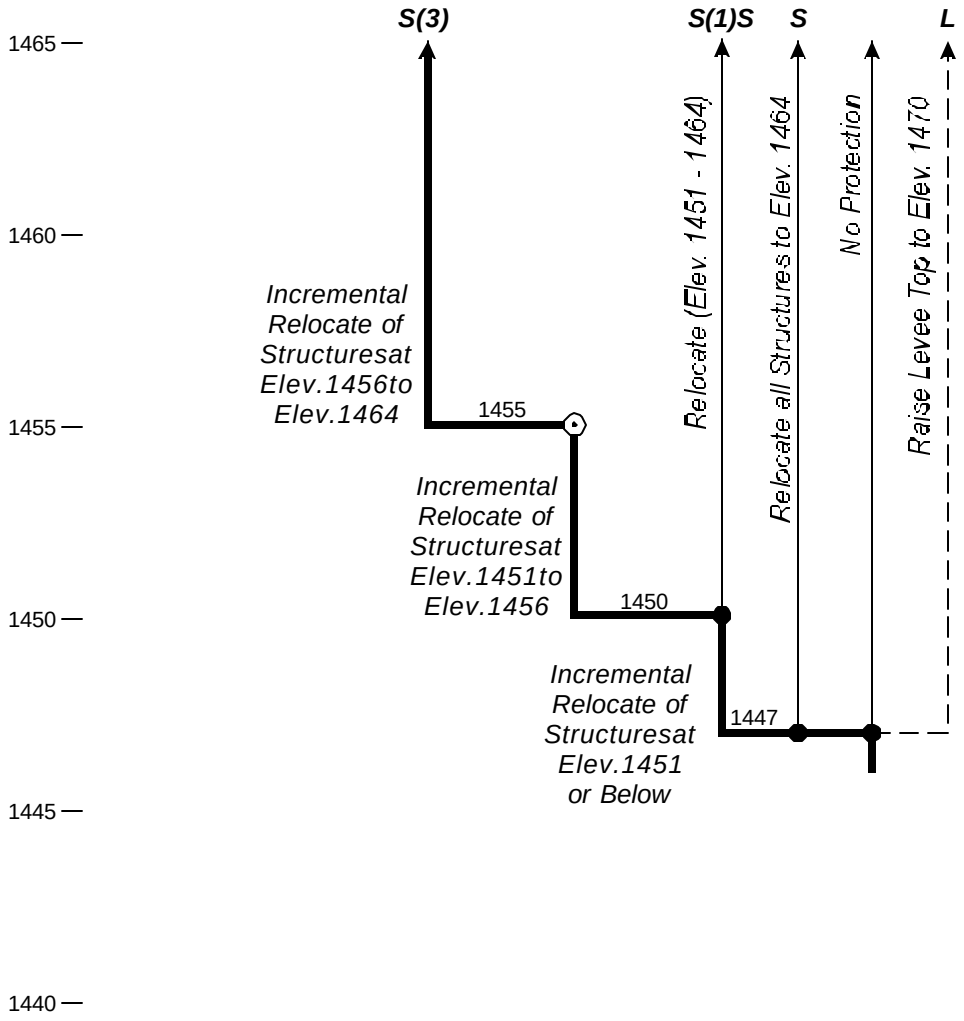


Figure 2.5-1

LOCATION MAP
FEATURE 5: ST. MICHAEL
Devils Lake Infrastructure
Protection Study

Data: 1997 USGS Digital Ortho Quad

Barr: Arcview 3.1, OPT 2615, i:\client\devilslake\gis\dllp\features\communities\05_stmichael\project\basemap_05.apr, Layout: Sec 2 2001 Analysis Location Map, Hp, Thu Dec 05 10:47:54 2002



FloodProtectionStrategy

Decisionrequiredatthispoint

Triggerpointforaction,nodecisionneeded

L(1) Incrementalleveeraise(numberoftimes)

L LeveeraisetoElev.1470

S(1) Structurerelocation(numberoftimes)

S RelocateallstructuresbelowElev.1464

Strategy notAnalyzed

Figure2.5-2

DECISION TREE
FEATURE 5: ST. MICHAEL
DevilsLakeInfrastructure ProtectionStudy

P:\1436\020\DECISIONTREES\2002FIGURES\FIGURE2_05.CDR RLG 01-02-03

Table 2.5-1

Flood Damages

Feature 5: St. Michael

Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Lake Elevation	Structure Elevation Range	Structures and Infrastructure
	(MSL)	(MSL)	(THOUSANDS)
AL1	1447	Below 1451	$159
AL2	1450	1451 - 1456	$62
AL3	1455	1456 - 1464	$1,488

DAMAGE BREAKDOWN

AL1: Lake Elevation 1447					AL2: Lake Elevation 1450					AL3: Lake Elevation 1455				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Sewage Treatment Lagoon	1	EA	$159,000	$159	House	1	EA	$62,000	$62	House	24	EA	$62,000	$1,488
Total				**$159**	**Total**				**$62**	**Total**				**$1,488**

Notes:

1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.5-2

Flood Protection Costs

Feature 5: St. Michael

Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	S (3) Incremental Relocation at AL1, AL2, AL3	S(1)S Incremental Relocation at AL1; Relocate All Structures at AL2	S Relocate all Structures at AL1
	(MSL)	(THOUSANDS)		
AL1	1447	$159	$159	$1,859
AL2	1450	$68	$1,700	$0
AL3	1455	$1,632	$0	$0

COST BREAKDOWN

Strategy		S(3) / S(1)S / S — Lake Elevation 1447 Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	S(3) / S(1)S / S — Lake Elevation 1450 Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	S(3) / S(1)S / S — Lake Elevation 1455 Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Incremental Relocation																
	Move	Sewage Treatment Lagoon	1	EA	$159,000	$159	House	1	EA	$68,000	$68	House	24	EA	$68,000	$1,632
		Subtotal				$159	Subtotal				$68	Subtotal				$1,632
		Total				**$159**	**Total**				**$68**	**Total**				**$1,632**

Strategy		Lake Elevation 1447 Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Maximum Protection Levee Raise*						
	Levee	Performance/Payment E	1	JB	$26,893	$27
		Stripping	12,366	CY	$1.25	$15
		Inspection Trench	3,226	LF	$3.75	$12
		Impervious Fill	392,914	CY	$4.40	$1,729
		Bedding	22,656	CY	$35.00	$793
		Riprap	42,480	CY	$45.00	$1,912
		Sand Drain	27,870	CY	$20.00	$557
		Topsoil (4")	3,542	CY	$1.25	$4
		Seed	7	ACR	$900.00	$6
		Pump Station	1	EA	$350,000	$350
		Subtotal				$5,406
		Contingency (30%)				$1,622
		Subtotal w/ Contingency				$7,028
		Engineering and Design (6%)				$422
		Supervision and Administration (10%)				$703
		1998 Total				$8,152
		2001 Total (add inflation)				$8,270
		2001 Adjusted Total				$8,271
	Pump Station	Pump Station	1	EA	$371,000	$371
		Subtotal				$371
		Total				**$8,642**

* This maximum protection levee raise cost was not analyzed in our conceptual model due to its excessive cost.

Notes:

1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. The costs for the Relocate All Structures at AL1 strategy (S) is equal to the sum of all relocations that have not been included in incremental relocations.
4. 2001 Total for levee cost is equal to the 1998 Total cost minus the pump station cost multiplied by 6% to increase for inflation.
5. 2001 Adjusted Total adjusts detailed cost breakdown to match the 2001 totals.

Table 2.5 - 3

Economic Analysis of Strategies for St. Michael (Feature 5)

Stochastic Analysis (ST) — Mean Value over 10,000 Traces (Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$19,400	$19,400	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$116,300	$116,300	$0	$0	$19,400	-$97,000	0.17
S(1)S	1 Incremental Relocation: Then Relocate All Remaining	$0	$0	$40,700	$40,700	$0	$0	$19,400	-$21,400	0.48
S(3)	3 Incremental Relocations	$0	$0	$20,200	$20,200	$0	$0	$19,400	-$900	0.96

Wet Future Scenario (WF) — (Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$70,400	$70,400	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$116,700	$116,700	$0	$0	$70,400	-$46,300	0.60
S(1)S	1 Incremental Relocation: Then Relocate All Remaining	$0	$0	$104,300	$104,300	$0	$0	$70,400	-$33,900	0.67
S(3)	3 Incremental Relocations	$0	$0	$76,300	$76,300	$0	$0	$70,400	-$5,900	0.92

Moderate Future 1 Scenario (M1) — (Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$11,800	$11,800	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$116,700	$116,700	$0	$0	$11,800	-$105,000	0.10
S(1)S	1 Incremental Relocation: Then Relocate All Remaining	$0	$0	$57,800	$57,800	$0	$0	$11,800	-$46,100	0.20
S(3)	3 Incremental Relocations	$0	$0	$11,900	$11,900	$0	$0	$11,800	-$200	0.99

Moderate Future 2 Scenario (M2) — (Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$12,800	$12,800	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$116,700	$116,700	$0	$0	$12,800	-$103,900	0.11
S(1)S	1 Incremental Relocation: Then Relocate All Remaining	$0	$0	$88,400	$88,400	$0	$0	$12,800	-$75,500	0.14
S(3)	3 Incremental Relocations	$0	$0	$13,100	$13,100	$0	$0	$12,800	-$300	0.98

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.

* Total benefits are calculated as the total damages incurred for the "No Protection strategy" minus the total damages for the strategy implemented (F(S)).

Attachment to 2.5:
St. Michael Economic Analysis Assumptions

A. Levees

1. It was assumed that 7 feet of freeboard would be required for levee protection at the maximum lake level, based on the proposed freeboard for the City of Devils Lake and the high waves predicted for this area.

2. A decision was assumed to be made when the lake is 1 foot below the design level of protection (i.e., 1 foot below the lower limit of the required freeboard of a levee).

3. It was assumed that any levee constructed for the community would protect the sewage lagoons. The top of the existing sewage lagoons is at elevation 1451. The lagoons were assumed to be affected at action level 1447 because of potential wave damage.

4. For strategies that include levee protection, it was assumed that the lagoons would continue to function as the lake continues to rise. A brief analysis of groundwater in the area indicates that it would not affect the operation of lagoons in the area *(Hydrogeology of the Shallow Water Table at the City of Devils Lake, North Dakota*, North Dakota State Water Commission, 1998).

5. Construction costs for pump stations to remove interior drainage behind the levee were estimated to be $350,000. This cost is in 1998 dollars, therefore it was updated for inflation by multiplying it by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001. The updated cost is $371,000.

6. A preliminary cost estimate (1998 dollars) indicated that the cost of a levee would be approximately $8 million to protect to the maximum lake level. The cost of incremental levee raises would be $4.0 and $5.0 million at elevations 1447 and 1450, respectively. Since the cost of the levees would be far in excess of the estimated value of the structures at each action level, the levee protection strategy was not pursued further. Therefore, only relocation strategies were analyzed for St. Michael.

B. Residential and Commercial Properties

1. For relocation strategies, a decision was assumed to be made when the lake is 1 foot below the level of the low structure. This was based on the existing process which is influenced by the availability of movers, the estimated lake rise each spring, and the restrictions of funding programs. Depending on the slope of the land, wave action may affect structures several feet above the lake's level.

2. The average value of a house in St. Michael was estimated to be $62,000. This figure was obtained from the Federal Emergency Management Agency (FEMA) and represents the average value of a house located on the Spirit Lake Nation Reservation. The value for each house was determined for FEMA by certified flood insurance adjusters and was based on total habitable square footage of the

buildings and standardized real estate appraisals (*FEMA*, personal communication, March, 2001). These values did not include the value of land on which the houses were located.

3. Relocation costs for homes were estimated to be $68,000. This cost was obtained from the North Dakota-North Central Planning Council and represents the average cost to relocate a residence during the buyout program conducted in Churchs Ferry (2000). The $68,000 includes the following costs: demolition of the existing house, purchase of an equivalent house in a nearby community, purchase of a lot, and legal, appraisal, and management fees. It was assumed relocation costs would be the approximately the same in St. Michael as they were in Churchs Ferry.

4. The cost for relocation/rebuilding of commercial and public facilities was assumed to be 100% of the value of the structure and property.

5. For relocation strategies, the advanced replacement of the lagoon was estimated at $150,000 (*Devils Lake Spirit Lake Nation Reservation Alternatives Assessment*, Barr Engineering Company, October, 1997). This cost is in 1998 dollars, therefore it was updated for inflation by multiplying it by the ENR Construction Cost Index of 1.06. The updated cost is $159,000.

2.6 Summary of Economic Analysis Investigation for Feature 6: Gilbert C. Grafton Military Reservation

2.6.0 Flood Protection Strategy

The flood protection strategy that was analyzed for Gilbert C. Grafton Military Reservation (Camp Grafton) in the Economic Analysis of Devils Lake Alternatives was to provide shoreline and levee protection for Avenue A, levee protection for the munitions training facility, and raise the main access road to the camp.

2.6.1 General Information

Feature Type: State Facility

Location: Gilbert C. Grafton Military Reservation is located approximately 6 miles south southwest of the City of Devils Lake along the west side of ND Highway 20. The accompanying Figure 2.6-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: Gilbert C. Grafton Military Reservation is the main training site for the North Dakota Army National Guard. It is a 1,600-acre camp, accommodating up to 3,000 soldiers with housing, dining hall facilities, field, and classroom training facilities. This main camp facility is also associated with the 10,000 acre Camp Grafton South training area, located 35 miles to the south.

Significance: Camp Grafton is important because it is the major training facility for the North Dakota Army National Guard, and its operation has a major economic impact on the community

Damages: The flooding of Camp Grafton would result in the following damages:

- loss of access to this important training facility
- loss of training facilities
- loss of commerce associated with Camp operation, visitors

Owner/Sponsor: The North Dakota Army National Guard is responsible for managing and maintaining Camp Grafton.

Lead Federal Agency: The State of North Dakota would take the lead for Camp Grafton for any flood protection work that may take place. It is unlikely that federal agency involvement would be necessary.

2.6.2 Feature Protection

History of Flood Protection: In the past, flood protection for Camp Grafton has generally consisted of access road raises. The camp pumps seepage water from several low areas west of ND Highway 20 to maintain a portion of their training facilities. The sewer system has been converted to Ramsey County Rural Utility Service.

General Protection Strategy: The Economic Analysis identified and evaluated a combination approach for protecting Camp Grafton. This approach assumed:

- ND Highway 20 is assumed to be raised to provide access to the camp
- Camp Grafton will not close, even if water surfaces reach maximum level, because a significant portion of the facility property is above Elevation 1475
- The main gate is the only gate that will be maintained and raised
- Buildings will not be moved
- A levee will be constructed to protect the munitions storage area
- Riprap will be installed to protect the lakeward side of Avenue A

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake Alternatives considered various protection strategies, with flood protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.6-2 shows the decision tree for Gilbert C. Grafton Military Reservation. As shown on Figure 2.6-2, the stepwise approach to flood protection for Gilbert C. Grafton Military Reservation that was analyzed consisted of the following:

1. At lake elevation 1447, the munitions facility levee would be constructed and the access road would be raised to 1452.5.
2. At lake elevation 1451.5, the munitions facility levee and access road would be raised to 1457.5.
3. At lake elevation 1456.5, the munitions facility levee and access road would be raised to 1462.5.
4. At lake elevation 1461.5, the munitions facility levee and access road would be raised to 1468.

The maximum protection strategy that was analyzed at the first action level was raising the access road and constructing the levees to 1468. (Note that for the analysis, the decision regarding

whether or not to raise the road is made at a time when the lake is one foot below the minimum access road elevation that resulted from the most recent raise.)

Interdependencies: The protection of Camp Grafton is related to the protection of ND Highway 20. Without a road raise on ND Highway 20, there is no access to Camp Grafton at the main entrance.

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.6.3 Feature Economics

Damages: For Camp Grafton, the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for Camp Grafton are summarized in the accompanying Table 2.6–1.

The first portion of the table shows the damages that are associated with each action level (1447, 1451.5, 1456.5, and 1461.5), each representing damages within a range of lake levels. The second portion of the table is a breakdown of damages to buildings that would be inundated by rising waters. These damages are based on capitalized values of the buildings impacted, as provided by camp operations staff. Inundated land values are also listed, using a standard assessed value per acre.

Unit costs for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for Gilbert C. Grafton Military Reservation are listed in the Feature 6 Assumptions listing, appended to this Section 2.6.

Costs: The costs of providing flood protection for Camp Grafton are detailed in the accompanying Table 2.6-2. Unit costs, data sources, and relevant assumptions are listed. The first portion of the table shows the cost of each strategy for each action level (1447, 1451.5, 1456.5, and 1461.5).

Protection strategies consisted of:

- Main access road raise
- Munitions area levee raise
- Avenue A slope protection

The second portion of the table is a breakdown of the costs for raising the camp entrance road, constructing a levee to protect the munitions storage facility, and installing riprap and levees

along Avenue A. Road raise costs are broken down into fabric liner, fill, and riprap. Levee construction is broken down into impervious fill, bedding, riprap, sand drain, topsoil, seed, and pump station costs. Riprap costs are divided into bedding and riprap costs.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for Camp Grafton are listed in the Feature 6 Assumptions listing, appended to this Section 2.6.

2.6.4 Results of Economic Analysis

The results of the Economic Analysis for Camp Grafton are listed in Table 2.6-3.

Stochastic Analysis Results: The flood protection strategy that was evaluated is incremental raises of the munitions facility levee and access road, and is highlighted on the decision tree (Figure 2.6-2). The net benefits for this strategy were less than zero (-$237,600). The BCR for this strategy was less than one (0.11). These results indicate that this strategy was not economically justified. The remaining damages to Camp Grafton land (that are currently being protected by ND Highway 20) was computed to have a present worth value of $4,700, annualized. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For Gilbert C. Grafton Military Reservation, the identified strategy and the economic indices for each of the three climate futures are as follows:

- Wet Future – For the wet future, the flood protection strategy had negative net benefits (-$562,700) and the BCR was 0.01, indicating that this strategy was not economically justified. The remaining damages to Camp Grafton land were computed to have a present worth value of $9,200, annualized.

- First Moderate Future – For the first moderate future, the flood protection strategy had net benefits that were –$195,000 and the BCR was 0.01, indicating that this strategy was not economically justified. The remaining damages to Camp Grafton land were computed to have a present worth value of $3,700, annualized.

- Second Moderate Future – For the second moderate future, the flood protection strategy had net benefits that were -$288,500 and the BCR was 0.01, indicating that this strategy was not economically justified. The remaining damages to Camp Grafton land were computed to have a present worth value of $5,600, annualized.

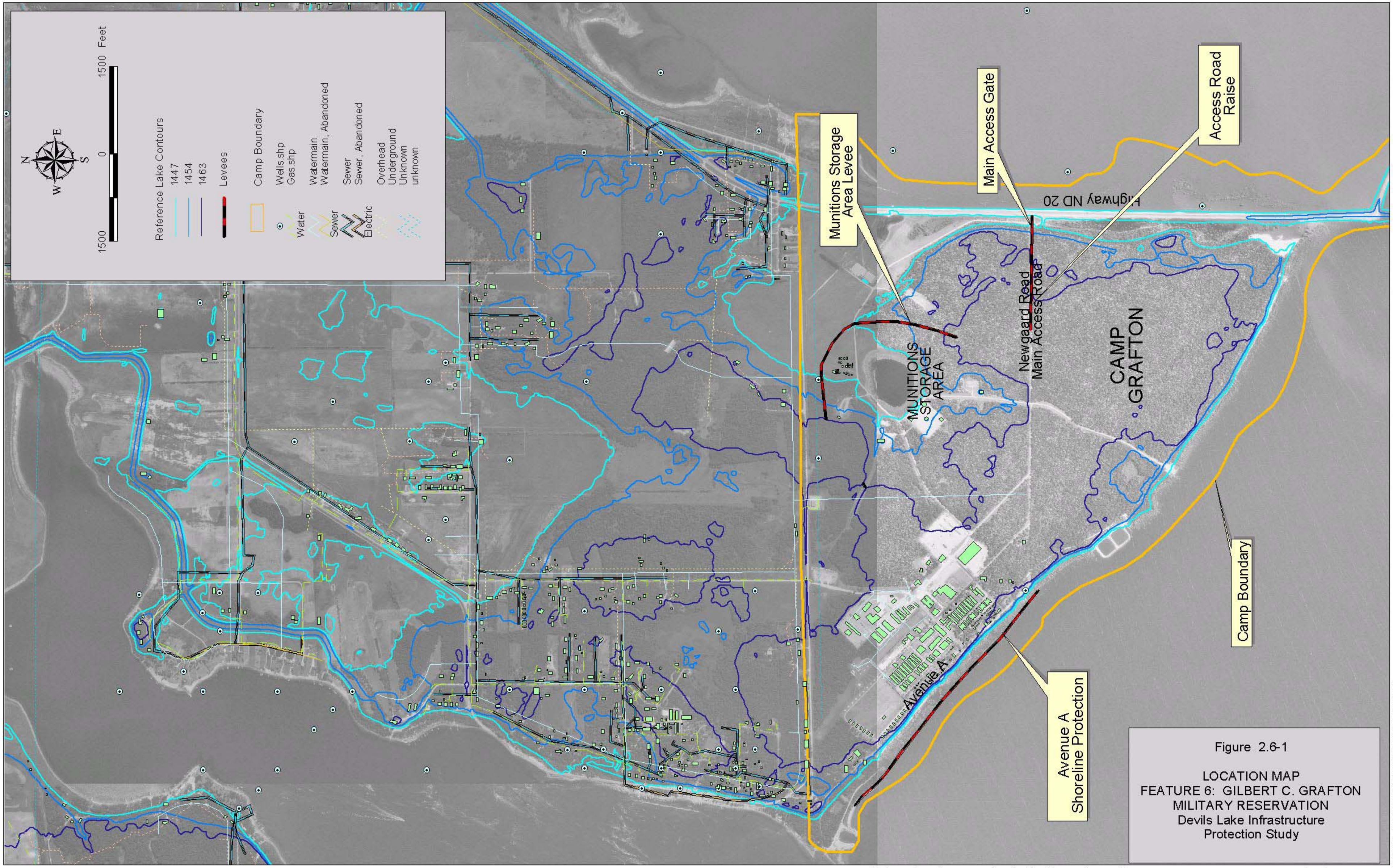
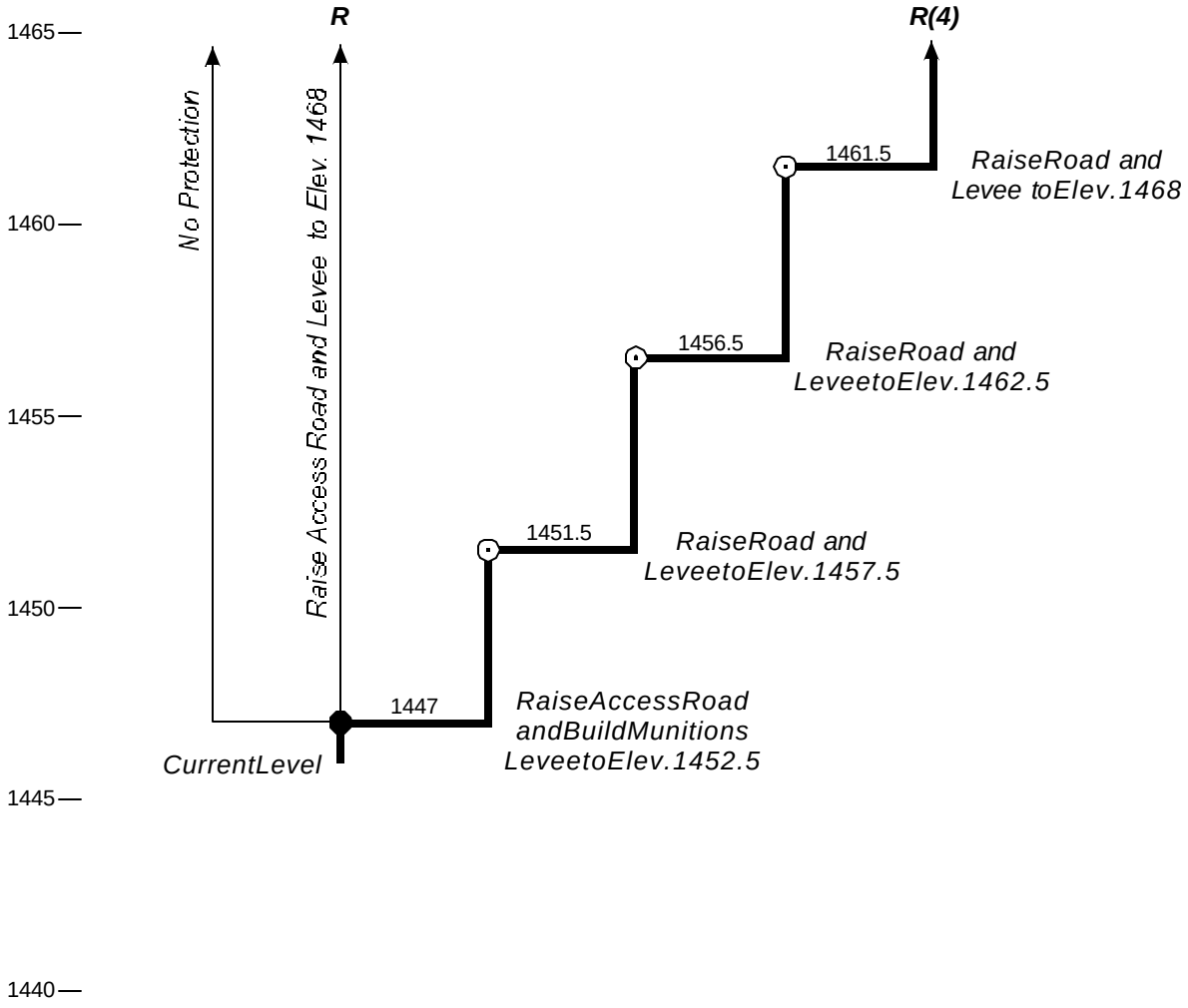


Figure 2.6-1

LOCATION MAP
FEATURE 6: GILBERT C. GRAFTON MILITARY RESERVATION
Devils Lake Infrastructure Protection Study

DATA: 1997 USGS Digital Ortho Quad

Bar: ArcView3.1,PIIIAF,1:\Client\DevilsLake\Gis\DLIP Features\StaterFeatures\06_Grafton\Projectbasemap_06.apr, Layout: Section 2 Figure Camp Grafton, lkp, Wed Oct 30 16:05:09 2002



FloodProtectionStrategy

Decisionrequiredatthispoint

Triggerpointforaction,nodecisionneeded

R(1) Incrementalroad raise(numberoftimes)

R Raiseroadtoelev.1468

Figure2.6-2

DECISION TREE
FEATURE6:GILBERTC. GRAFTON
MILITARY RESERVATION
DevilsLakeInfrastructure ProtectionStudy

P:\4036\020\DECISIONTREES\2002FIGURES\FIGURE2_06.CDR RLG 01-02-03

Table 2.6-1

Flood Damages

Feature 6: Gilbert C. Grafton Military Reservation

Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Lake Elevation	Structure Elevation Range	Structures and Infrastructure	Land
	(MSL)	(MSL)	(THOUSANDS)	
AL1	1447	Below 1452	$45	$58
AL2	1451	1452 - 1457	$0	$65
AL3	1456	1457 - 1462	$0	$65
AL4	1461	1462 - 1464	$34,732	$72

DAMAGE BREAKDOWN

AL1: Lake Elevation 1447					AL2: Lake Elevation 1451					AL3: Lake Elevation 1456					AL4: Lake Elevation 1461				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure																			
Munitions Area Buildings Includes Ammo Storage Office and 4 Ammo Storage Bunkers	1	EA	$45,000	$45											Total Buildings (Less Camp Grafton South)	1	EA	$25,155,000	$25,155
															Infrastructure	1	EA	$9,577,000	$9,577
Total				**$45**	**Total**				**$0**	**Total**				**$0**	**Total**				**$34,732**
Land																			
Land	147	ACR	$400	$59	Land	163	ACR	$400	$65	Land	163	ACR	$400	$65	Land	180	ACR	$400	$72
2001 Adjusted Total				$58															
Total				**$58**	**Total**				**$65**	**Total**				**$65**	**Total**				**$72**

Notes:

1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. 2001 Adjusted Total adjusts detailed damage breakdown to match the 2001 totals.

Table 2.6-2

Flood Protection Costs

Feature 6: Gilbert C. Grafton Military Reservation

Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation	R Raise Access Road and Build Munitions Levee at AL1	R(4) Raise Access Road and Build Munitions Levee at AL1, AL2, AL3, AL4
	(MSL)	(THOUSANDS)	
AL1	1447	$25,226	$3,151
AL2	1451	$0	$3,124
AL3	1456	$0	$5,958
AL4	1461	$0	$12,993

COST BREAKDOWN

Strategy		R																			
		R(4)					R(4)					R(4)					R(4)				
		Lake Elevation 1447					Lake Elevation 1451					Lake Elevation 1456					Lake Elevation 1461				
Incremental Raise		Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
	Road Raise	Military Entrance Road - 430' Long					Military Entrance Road - 690' Long					Military Entrance Road - 1300' Long					Military Entrance Road - 2600' Long				
		Fabric Liner	1,511	SY	$1.25	$2	Fabric Liner	2,424	SY	$1.25	$3	Fabric Liner	4,568	SY	$1.25	$6	Fabric Liner	10,048	SY	$1.25	$13
		Fill	6,849	CY	$4.50	$31	Fill	14,820	CY	$4.50	$67	Fill	35,146	CY	$4.50	$158	Fill	94,003	CY	$4.50	$423
		Riprap	1,007	CY	$20.00	$20	Riprap	1,616	CY	$20.00	$32	Riprap	3,045	CY	$20.00	$61	Riprap	6,699	CY	$20.00	$134
		1998 Total				$53	1998 Total				$102	1998 Total				$225	1998 Total				$570
		2001 Total (add inflation)				$56	2001 Total (add inflation)				$108	2001 Total (add inflation)				$238	2001 Total (add inflation)				$604
												2001 Adjusted Total				$239					
	Levee Raise	Performance/Paymen	1	JB	$9,634	$10	Performance/Paymen	1	JB	$8,377	$8	Performance/Payment	1	JB	$16,795	$17	Performance/Payment	1	JB	$27,145	$27
		Impervious Fill	33,600	CY	$4.40	$148	Impervious Fill	86,000	CY	$4.40	$378	Impervious Fill	160,066	CY	$4.40	$704	Impervious Fill	335,966	CY	$4.40	$1,478
		Bedding	6,488	CY	$35.00	$227	Bedding	10,814	CY	$35.00	$378	Bedding	18,534	CY	$35.00	$649	Bedding	28,895	CY	$35.00	$1,011
		Riprap	12,166	CY	$45.00	$547	Riprap	20,275	CY	$45.00	$912	Riprap	34,751	CY	$45.00	$1,564	Riprap	54,179	CY	$45.00	$2,438
		Sand Drain	0	CY	$20.00	$0	Sand Drain	0	CY	$20.00	$0	Sand Drain	21,650	CY	$20.00	$433	Sand Drain	24,372	CY	$20.00	$487
		Topsoil (4")	1,510	CY	$1.25	$2	Topsoil (4")	2,072	CY	$1.25	$3	Topsoil (4")	3,361	CY	$1.25	$4	Topsoil (4")	4,709	CY	$1.25	$6
		Seed	3	ACR	$900.00	$3	Seed	4	ACR	$900.00	$4	Seed	6	ACR	$900.00	$5	Seed	9	ACR	$900.00	$8
		Pump Station	1	EA	########	$1,000	Pump Station	0	EA	$1,000,000	$0	Pump Station	0	EA	$1,000,000	$0	Pump Station	0	EA	$1,000,000	$0
		Subtotal				$1,937	Subtotal				$1,684	Subtotal				$3,376	Subtotal				$5,456
		Contingency (30%)				$581	Contingency (30%)				$505	Contingency (30%)				$1,013	Contingency (30%)				$1,637
		Subtotal w/ Contingency				$2,518	Subtotal w/ Contingency				$2,189	Subtotal w/ Contingency				$4,389	Subtotal w/ Contingency				$7,093
		Engineering and Design (6%)				$151	Engineering and Design (6%)				$131	Engineering and Design (6%)				$263	Engineering and Design (6%)				$426
		Supervision and Administration (10%)				$252	Supervision and Administration (10%)				$219	Supervision and Administration (10%)				$439	Supervision and Administration (10%)				$709
		1998 Total				$2,920	1998 Total				$2,539	1998 Total				$5,091	1998 Total				$8,228
		2001 Total (add inflation)				$3,096	2001 Total (add inflation)				$2,692	2001 Total (add inflation)				$5,397	2001 Total (add inflation)				$8,722
		2001 Adjusted Total				$3,095						2001 Adjusted Total				$5,395					
	Avenue A Riprap/Levee Raise						Riprap	3,900	CY	45	$176	Riprap	3,900	CY	45	$176	Performance/Payment	1	JB	$11,413	$11
							Bedding	975	CY	35	$34	Bedding	975	CY	35	$34	Impervious Fill	50,633	CY	$4.40	$223
							Subtotal				$210	Subtotal				$210	Bedding	8,831	CY	$35.00	$309
							Contingency, Engineering & Design,				$96	Contingency, Engineering & Design,				$96	Riprap	16,559	CY	$45.00	$745
							Supervision & Administration (46%)					Supervision & Administration (46%)					Topsoil (4")	1,926	CY	$1.25	$2
							1998 Total				$306	1998 Total				$306	Seed	4	ACR	$900.00	$4
							2001 Total (add inflation)				$324	2001 Total (add inflation)				$324	Pump Station	1	EA	$1,000,000	$1,000
																	Subtotal				$2,294
																	Contingency (30%)				$688
																	Subtotal w/ Contingency				$2,983
																	Engineering and Design (6%)				$179
																	Supervision and Administration (10%)				$298
																	1998 Total				$3,460
																	2001 Total (add inflation)				$3,668
																	2001 Adjusted Total				$3,667
		Total				**$3,151**	**Total**				**$3,124**	**Total**				**$5,958**	**Total**				**$12,993**

Notes:

1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. The costs for the Relocate All Structures at AL1 strategy (S) is equal to the sum of all relocations that have not been included in incremental relocations.
4. 2001 Total for levee cost is equal to the 1998 Total cost multiplied by 6% to increase for inflation.
5. 2001 Adjusted Total adjusts detailed cost breakdown to match the 2001 totals.

Table 2.6 - 3

Economic Analysis of Strategies for Gilbert C. Grafton State Military Reservation (Feature 6)

Strategy		Stochastic Analysis (ST) Mean Value over 10,000 Traces (Annual)							
		COST			DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Road Raise	Levee & Riprap	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E=D	F = E(No Protection) - E(S) *	G = F - C	I = F / C
No Protection	No Protection or Relocation	$0	$0	$0	$35,300	$35,300	$0	$0	--
R	Raise Road and Munitions Levee to 1468	$63,000	$1,515,300	$1,578,300	$4,700	$4,700	$30,500	-$1,547,800	0.02
R(4)	4 Road and Munitions Levee Raises	$6,200	$262,000	$268,200	$4,700	$4,700	$30,500	-$237,600	0.11

Strategy		Wet Future Scenario (WF) (Annual)							
		COST			DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Road Raise	Levee & Riprap	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E=D	F = E(No Protection) - E(S) *	G = F - C	I = F / C
No Protection	No Protection or Relocation	$0	$0	$0	$12,000	$12,000	$0	$0	--
R	Raise Road and Munitions Levee to 1468	$63,200	$1,520,700	$1,583,800	$9,200	$9,200	$2,800	-$1,581,000	0.00
R(4)	4 Road and Munitions Levee Raises	$17,400	$548,100	$565,500	$9,200	$9,200	$2,800	-$562,700	0.00

Strategy		Moderate Future 1 Scenario (M1) (Annual)							
		COST			DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Road Raise	Levee & Riprap	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E=D	F = E(No Protection) - E(S) *	G = F - C	I = F / C
No Protection	No Protection or Relocation	$0	$0	$0	$6,500	$6,500	$0	$0	--
R	Raise Road and Munitions Levee to 1468	$63,200	$1,520,700	$1,583,800	$3,700	$3,700	$2,800	-$1,581,000	0.00
R(4)	4 Road and Munitions Levee Raises	$3,500	$194,400	$197,800	$3,700	$3,700	$2,800	-$195,000	0.01

Strategy		Moderate Future 2 Scenario (M2) (Annual)							
		COST			DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Road Raise	Levee & Riprap	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E=D	F = E(No Protection) - E(S) *	G = F - C	I = F / C
No Protection	No Protection or Relocation	$0	$0	$0	$8,400	$8,400	$0	$0	--
R	Raise Road and Munitions Levee to 1468	$63,200	$1,520,700	$1,583,800	$5,600	$5,600	$2,800	-$1,581,000	0.00
R(4)	4 Road and Munitions Levee Raises	$6,700	$284,500	$291,300	$5,600	$5,600	$2,800	-$288,500	0.01

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.

* Total benefits are calculated as the total damages incurred for "No Protection strategy" minus the total damages for the strategy implemented (E(S)).

Attachment to 2.6:
Gilbert C. Grafton State Military Reservation Economic Analysis Assumptions

A. General Assumptions

1. It was assumed that ND Highway 20 access would be kept open to provide access to the Camp roads. These costs are not included in this feature and are analyzed separately in Feature 21: ND Highway 20 (City of Devils Lake Levee to ND Highway 57).

2. Camp Grafton is valued at approximately $35 million, not including land. These capitalized costs were provided by Captain Clark Johnson, Civil Engineer, Camp Grafton.

3. It was assumed that during high water conditions, the main gate (Gate #6 with access from Highway 20) would be the only access route that would be maintained and raised (based on conversations with Captain Clark Johnson).

4. It was assumed that the Camp would not close, even if the lake reaches its maximum level. A significant portion of the land area and all of the structures are above elevation 1463. Camp Grafton South (30 miles south) would be unaffected and could be used for maneuvers and activities that require a larger area.

5. It was assumed that the sewer system would be fully converted to the Ramsey County Rural Sewer system before lagoons were inundated (State Flood Coordination Center, Staff meeting, November 18, 1997).

6. There are currently no open culverts located under Highway 20 near Camp Grafton, and the area west of ND Highway 20 has been kept dry in recent years with pumping. It was assumed that culverts would be installed under ND Highway 20 to relieve pressure, resulting in flooding of the low areas west of ND Highway 20. It was assumed this would occur at the first action level (elevation 1447) and, thereafter, all lands west of ND Highway 20 would be inundated by lake levels higher than the elevations of those lands.

B. Levees and Roads

1. The maximum road and levee elevation was assumed to be elevation 1468, assuming a 5-foot freeboard above the maximum lake level of 1463.

2. Roads were assumed to be raised when the water surface elevation is within 1 foot of the lowpoint of the road.

3. It was assumed that a levee would be constructed to protect the munitions storage area from flooding (based on conversations with Captain Clark Johnson, Civil Engineer, Camp Grafton).

4. Riprap protection was assumed to be required to protect the lakeward side of Avenue A (conversation with Captain Clark Johnson, Civil Engineer, Camp Grafton). It was assumed that the riprap would extend from elevation 1452.5 to 1461 (based on the May 1997 3-foot contour map) and would be 2 feet thick.

5. It was assumed that a dike would be constructed along Avenue A if the water surface reached an elevation of 1461.5 to protect against wave action.

C. Structures

1. Buildings were not assumed to be moved, because most buildings are above elevation 1464 (based on conversations with Lieutenant Colonel Gary Doll, Camp Grafton).

2. Building values were based on the capitalized cost, which was computed as the original cost plus improvements. This is probably a low estimate, as some buildings were constructed in the 1940s and the replacement value would be much higher (based on conversations with Captain Clark Johnson, Civil Engineer, Camp Grafton).

3. The land value for Camp Grafton is estimated to be $400/acre. This value was provided by the Corps of Engineers (personal communication, April, 2001) and is an estimate of the average value of all land surrounding Devils Lake.

2.7 Summary of Economic Analysis Investigation for Feature 7: Grahams Island State Park

2.7.0 Flood Protection Strategy

The flood protection strategy that was analyzed in the Economic Analysis of Devils Lake Alternatives for Grahams Island State Park (Grahams Island) was to raise the access road and relocate impacted structures and facilities.

2.7.1 General Information

Feature Type: State Facility

Location: Grahams Island State Park is located 10 miles west of the City of Devils Lake, 5 miles south of ND Highway 19 along the border between Benson and Ramsey counties. The accompanying Figure 2.7-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: Grahams Island State Park is the largest and most developed state park facility on Devils Lake, with campground, beach, harbor, ranger and manager facilities, activity center, and trails. The campground covers 1,100 acres, and has space for 100 campers, as well as 4 sleeping cabins. The park has potable water and sewer lines, with an on-site treatment facility. All other structures and land that are located on Grahams Island were included in Feature 8.1, Rural Areas.

Significance: Grahams Island State Park is important because it is considered a major tourist attraction in the area. It is the largest and most used state park facility around Devils Lake. Park staff estimate that a total of 72,800 visitors used the park in 1995. Access to the park is affected by rising water levels; the Park was closed in 1997 when the access road was under water. During 1997, approximately $2.2 million was invested in raising the access road to the park. In 1999, the Park had 73,770 visitors.

Damages: The flooding of Grahams Island would result in the following damages:

- Loss to utility infrastructure
- Loss of residential buildings
- Loss of recreational buildings and facilities
- Loss of facility access
- Loss of user fees
- Loss of usable land

Owner/Sponsor: The North Dakota Parks and Recreation Department, is responsible for operating and maintaining the Grahams Island State Park.

Lead Federal Agency: The State of North Dakota would take the lead for Feature 7 for any flood protection work that may take place. The Federal Highway Administration would take the lead for any federal involvement in road raises.

2.7.2 Feature Protection

History of Flood Protection: In the past, flood protection for Grahams Island has consisted of raising the access road to the park and relocating buildings and other facilities to higher ground.

General Protection Strategy: The Economic Analysis identified and evaluated a combination approach for protecting Grahams Island. The approach included:

- Relocation of buildings
- Relocation / replacement of comfort station and lift station
- Relocation / replacement of a picnic area
- Raise the access road

Protection Strategy by Lake Level: The Economic Analysis of Devils Lake Alternatives considered various levels of protection strategies, with flood protection decisions being made at various lake levels as Devils Lake continued to rise. Figure 2.7-2 shows the decision tree for Grahams Island State Park. As shown on Figure 2.7-2, the stepwise approach to flood protection for Grahams Island State Park that was analyzed consisted of the following:

1. At lake elevation 1447, structures below 1450.5 would be relocated.
2. At lake elevation 1449.5, a decision would be made as to whether the structures the between 1450.5 and 1455 should be relocated with the access road raised to 1455 or relocation of all structures above 1450.5 with temporary closure of the access road.
3. At lake elevation 1454, a decision would be made as to whether the structures the between 1455 and 1457.5 should be relocated with the access road raised to 1457.5 or relocation of all structures above 1455 with temporary closure of the access road.
4. At lake elevation 1456.5, a decision would be made as to whether the structures the between 1457.5 and 1462.5 should be relocated with the access road raised to 1462.5 or relocation of all structures above 1457.5 with temporary closure of the access road.

5. At lake elevation 1461.5, a decision would be made as to whether the structures the between 1462.5 and 1464 should be relocated with the access road raised to 1468 or relocation of all structures above 1462.5 with temporary closure of the access road.

The maximum protection strategy that was analyzed at the first action level was relocation of all structures on the island and raising the access road to elevation 1468. (Note that for the analysis, the relocation of structures is made at a time when the lake is one foot below the low structure elevation. The decision regarding whether or not to raise the road is made at a time when the lake is one foot below the minimum access road elevation that resulted from the most recent raise.)

Interdependencies: The protection of Grahams Island access from the north is related to protection of Feature 18, ND Highway 19. Highway 19 is necessary to maintain access to the county road that provides access to Grahams Island.

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.7.3 Feature Economics

Damages: For Grahams Island State Park, the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for Grahams Island State Park are summarized in the accompanying Table 2.7–1.

The first portion of the table shows the damages that are associated with each action level (1447, 1449.5, 1454, 1456.5, and 1461.5), each representing damages within a range of lake levels. The second portion of the table is a breakdown of damages to Grahams Island facilities inundated by rising waters. These damages are based on values provided for these facilities by park staff. Inundated land values are also listed, using standard assessed value per acre.

Unit costs for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for Grahams Island State Park are listed in the Feature 7 Assumptions Listing, appended to this Section 2.7.

Costs: The costs of providing flood protection for Grahams Island State Park are detailed in the accompanying Table 2.6-2. Unit costs, data sources, and relevant assumptions are listed.

The first portion of the table shows the cost of each strategy for each action level (1447, 1449.5, 1454, 1456.5, and 1461.5). The second portion of the table lists costs for relocating a residential structure and two associated buildings, replacing a comfort station and lift station, and road raises. Road raise costs are broken down into fabric liner, aggregate base, fill and riprap.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for Grahams Island State Park are listed in the Feature 7 Assumptions listing, appended to this Section 2.7.

2.7.4 Results of Economic Analysis

The results of the Economic Analysis for Grahams Island are listed in Table 2.7-3.

Stochastic Analysis Results: The flood protection strategy that was analyzed was incremental relocation of structures and raising the access road. This strategy is highlighted on the decision tree (Figure 2.7-2). The net benefits for this strategy were less than zero (-$46,200). The BCR for this strategy was less than one (0.64). These results indicate that this strategy was not economically justified. The present worth annual lost business damages that would be prevented by this strategy are computed at $64,700 (averaged over 10,000 traces). The remaining damages to State Park lands were computed to have a present worth value of $11,600, annualized. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For Grahams Island State Park, the identified strategy and the economic indices for each of the three climate futures are as follows:

- Wet Future – For the wet future, the flood protection strategy had negative net benefits (-$38,400) and a BCR of 0.92, indicating that this strategy was not economically justified under this future. For this future, the present worth annualized lost business damages that would be prevented were computed at $453,200. The remaining damages to State Park lands were computed to have a present worth value of $13,300, annualized.

- First Moderate Future – For the first moderate future, the flood protection strategy had net benefits that were -$51,600, and the BCR was 0.52, indicating that this strategy was not economically justified under this future. For this future, the present worth annualized lost business damages that would be prevented were computed at $28,100. The remaining damages to land were computed to have a present worth value of $11,600, annualized.

- Second Moderate Future – For the second moderate future, the flood protection strategy had net benefits that were $25,600, and the BCR was 1.11, indicating that this strategy was economically justified under this future. For this future, the present worth annualized lost business damages that would be prevented were computed at $239,800. The remaining damages to land were computed to have a present worth value of $12,200, annualized.

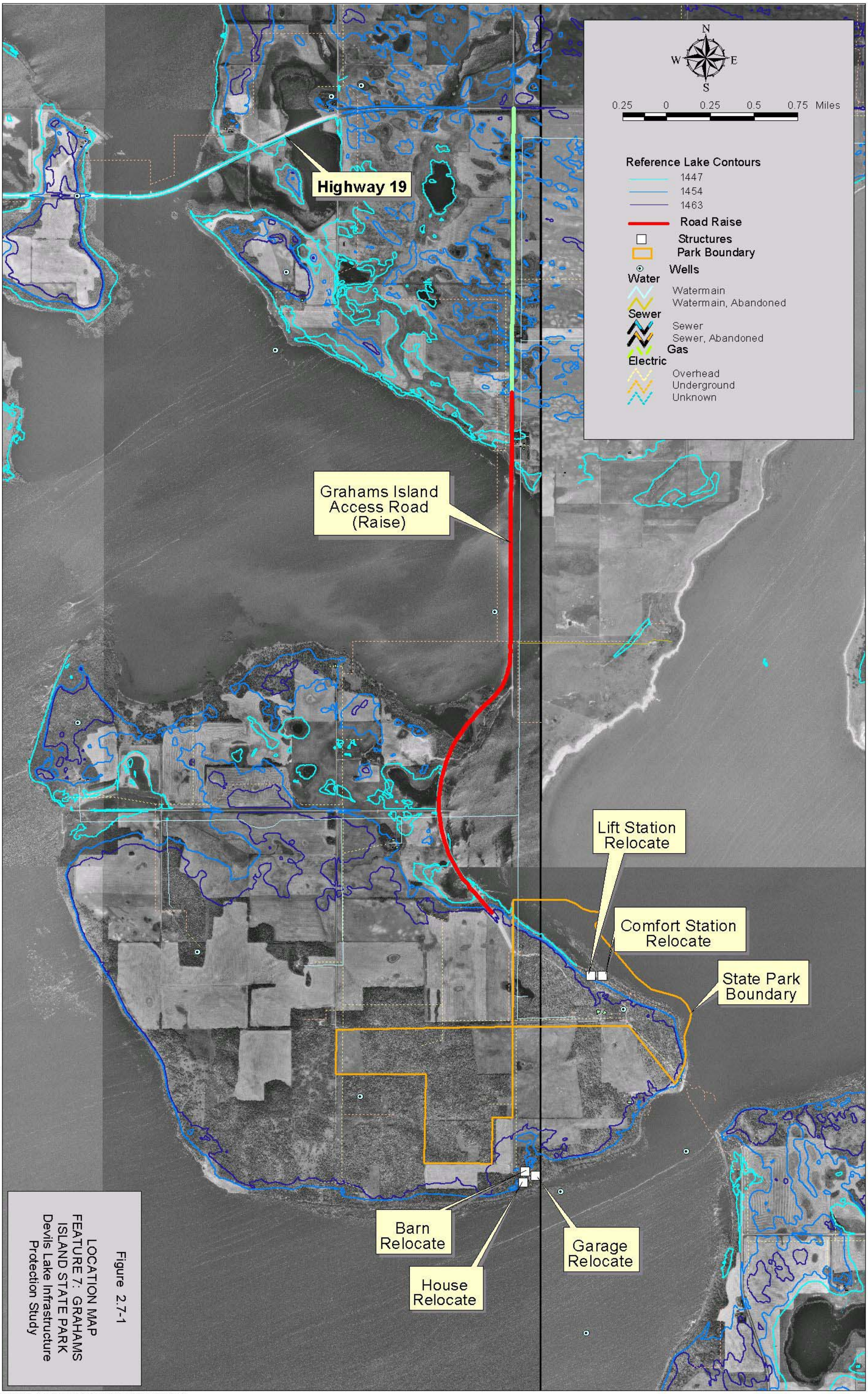
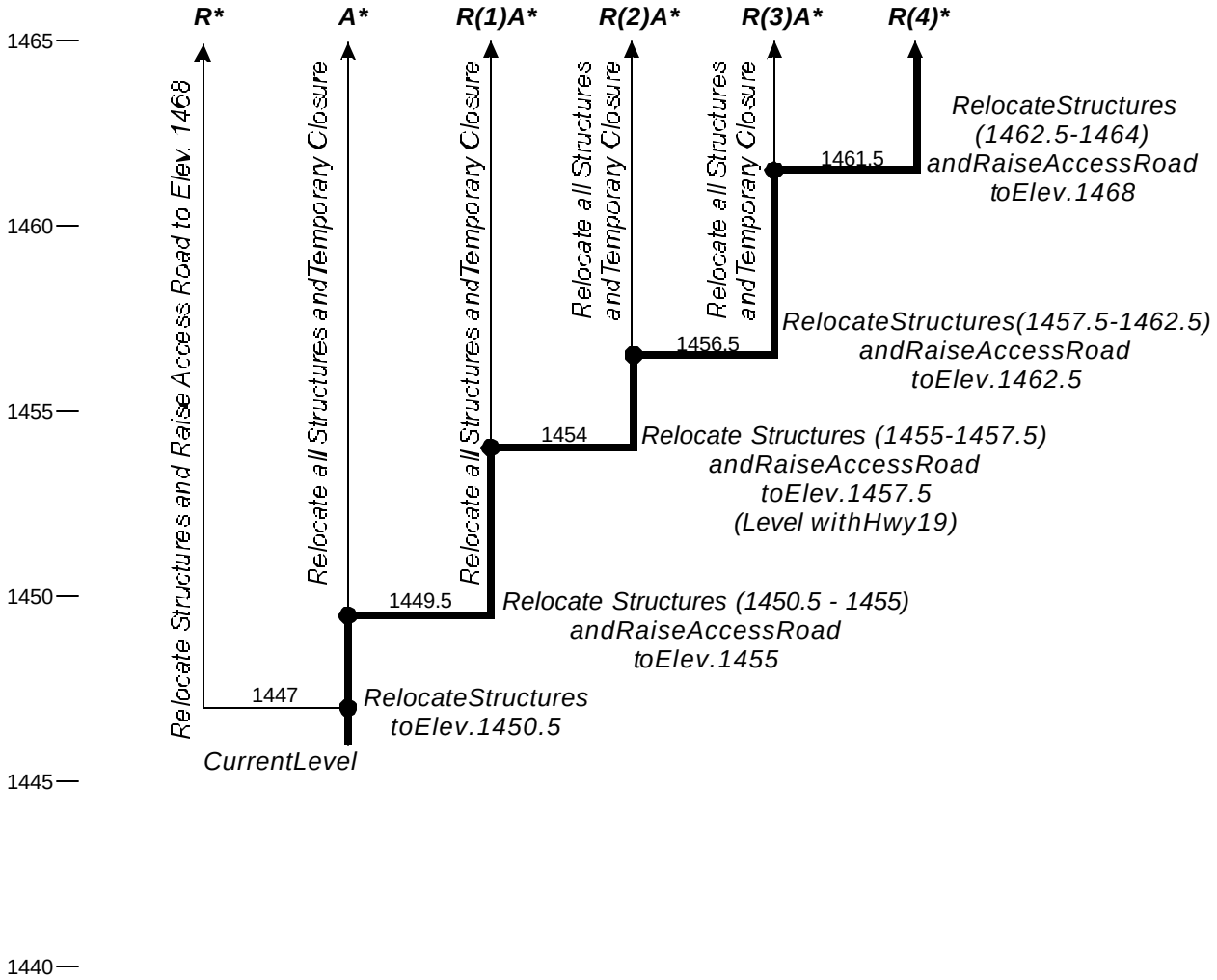


Figure 2.7-1
LOCATION MAP
FEATURE 7: GRAHAMS ISLAND STATE PARK
Devils Lake Infrastructure Protection Study

Barr: Arcview 3.3,PIV02, I:\Client\DevilsLake\Gis\DLIP\Features\StateRuralFeatures\07_GrahamsIsland\Project\basemap_07.apr, Layout: Layout: Section 2 Grahams Island, lkp, Mon Dec 30 15:56:30 2002

DATA: 1997 USGS Digital Ortho Quad



FloodProtectionStrategy

Decisionrequiredatthispoint

Triggerpointforaction,nodecisionneeded

A Temporary closureofpark

R(1) Incrementalroad raise(numberoftimes)

***** Inadditiontoroadraisesortemporaryclosure therearealsostructurerelocations

Figure2.7-2

DECISION TREE
FEATURE 7:GRAHAMSISLANDSTATEPARK
DevilsLakeInfrastructure ProtectionStudy

P:\4136020\DECISIONTREES\2002FIGURES\FIGURE2_07.CDR RLG 01-02-03

Table 2.7-1

Flood Damages
Feature 7: Grahams Island State Park
Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Lake Elevation (MSL)	Structure Elevation Range (MSL)	Structures and Infrastructure (THOUSANDS)	Land (THOUSANDS)	Annual Damages (THOUSANDS)
AL1	1447	Below 1450	$75	$157	$516
AL2	1449	1450 - 1455	$255	$19	$516
AL3	1454	1455 - 1457	$0	$11	$516
AL4	1456	1457 - 1462	$0	$21	$516
AL5	1461	1462 - 1464	$15	$23	$516

DAMAGE BREAKDOWN

AL1: Lake Elevation 1447					AL2: Lake Elevation 1449					AL3: Lake Elevation 1454					AL4: Lake Elevation 1456					AL5: Lake Elevation 1461				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure																								
South Employee Residenc	1	EA	$75,000	$75	Loop A Comfort Station	1	EA	$110,000	$110											Picnic Shelter West	1	EA	$15,000	$15
					Loop A Lift Station	1	EA	$30,000	$30															
					South Residence Barn	1	EA	$100,000	$100															
					South Residence Garage	1	EA	$15,000	$15															
Total				**$75**	**Total**				**$255**											**Total**				**$15**
Land																								
Land	393	ACR	$400	$157	Land	48	ACR	400	$19	Land	28	ACR	$400	$11	Land	53	ACR	$400	$21	Land	58	ACR	$400	$23
Total				**$157**	**Total**				**$19**	**Total**				**$11**	**Total**				**$21**	**Total**				**$23**
Annual Damages					**Annual Damages**					**Annual Damages**					**Annual Damages**					**Annual Damages**				
Revenue	1	LS	$516,000	$516	Revenue	1	LS	$516,000	$516	Revenue	1	LS	$516,000	$516	Revenue	1	LS	$516,000	$516	Revenue	1	LS	$516,000	$516
Total				**$516**	**Total**				**$516**	**Total**				**$516**	**Total**				**$516**	**Total**				**$516**

Restoration Damages

Elevation	Restoration Damages (THOUSANDS)	Excavation Quantity	Excavation Units	Excavation Unit Cost	Excavation Value (THOUSANDS)	Fabric Liner Quantity	Fabric Liner Units	Fabric Liner Unit Cost	Fabric Liner Value (THOUSANDS)	Aggregate Base Course Quantity	Aggregate Base Course Units	Aggregate Base Course Unit Cost	Aggregate Base Course Value HOUSAND	Fill Quantity	Fill Units	Fill Unit Cost	Fill Cost (THOUSANDS)
1446	$0																
1447	$0																
1448	$0																
1449	$0																
1449.6	$794	59,675	CY	$2.65	$158	106,563	SY	$1.33	$141	12,788	CY	$21.20	$271	46,888	CY	$4.77	$224
1450	$794	59,675	CY	$2.65	$158	106,563	SY	$1.33	$141	12,788	CY	$21.20	$271	46,888	CY	$4.77	$224
1451	$794	59,675	CY	$2.65	$158	106,563	SY	$1.33	$141	12,788	CY	$21.20	$271	46,888	CY	$4.77	$224
1452	$794	59,675	CY	$2.65	$158	106,563	SY	$1.33	$141	12,788	CY	$21.20	$271	46,888	CY	$4.77	$224
1453	$794	59,675	CY	$2.65	$158	106,563	SY	$1.33	$141	12,788	CY	$21.20	$271	46,888	CY	$4.77	$224
1454	$794	59,675	CY	$2.65	$158	106,563	SY	$1.33	$141	12,788	CY	$21.20	$271	46,888	CY	$4.77	$224
1455	$794	59,675	CY	$2.65	$158	106,563	SY	$1.33	$141	12,788	CY	$21.20	$271	46,888	CY	$4.77	$224
1455.1	$1,013	76,102	CY	$2.65	$202	135,897	SY	$1.33	$180	16,308	CY	$21.20	$346	59,795	CY	$4.77	$285
1456	$1,013	76,102	CY	$2.65	$202	135,897	SY	$1.33	$180	16,308	CY	$21.20	$346	59,795	CY	$4.77	$285
1457	$1,013	76,102	CY	$2.65	$202	135,897	SY	$1.33	$180	16,308	CY	$21.20	$346	59,795	CY	$4.77	$285
1458	$1,013	76,102	CY	$2.65	$202	135,897	SY	$1.33	$180	16,308	CY	$21.20	$346	59,795	CY	$4.77	$285
1459	$1,013	76,102	CY	$2.65	$202	135,897	SY	$1.33	$180	16,308	CY	$21.20	$346	59,795	CY	$4.77	$285
1460	$1,013	76,102	CY	$2.65	$202	135,897	SY	$1.33	$180	16,308	CY	$21.20	$346	59,795	CY	$4.77	$285
1461	$1,013	76,102	CY	$2.65	$202	135,897	SY	$1.33	$180	16,308	CY	$21.20	$346	59,795	CY	$4.77	$285
1462	$1,013	76,102	CY	$2.65	$202	135,897	SY	$1.33	$180	16,308	CY	$21.20	$346	59,795	CY	$4.77	$285
1463	$1,013	76,102	CY	$2.65	$202	135,897	SY	$1.33	$180	16,308	CY	$21.20	$346	59,795	CY	$4.77	$285

Notes:
1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.

Table 2.7-2

Flood Protection Costs
Feature 7: Grahams Island State Park
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	Lake Elevation (MSL)	R* Relocate Structures and Raise Road at AL1	A* Relocate Structures at AL1; Temporary Closure of Park at AL2	R(1)A* Relocate Structures at AL1; Raise Road and Relocate Structures at AL2; Temporary Closure of Park at AL3	R(2)A* Relocate Structures at AL1; Raise Road and Relocate Structures at AL2, AL3; Temporary Closure of Park at AL4	R(3)A* Relocate Structures at AL1; Raise Road and Relocate Structures at AL2, AL3, AL4; Temporary Closure of Park at AL5	R(4)* Relocate Structures at AL1; Raise Road and Relocate Structures at AL2, AL3, AL4, AL5
		(THOUSANDS)					
AL1	1447	$18,002	$56	$56	$56	$56	$56
AL2	1449	$0	$0	$3,713	$3,713	$3,713	$3,713
AL3	1454	$0	$0	$0	$2,229	$2,229	$2,229
AL4	1456	$0	$0	$0	$0	$5,704	$5,704
AL5	1461	$0	$0	$0	$0	$0	$6,300

* In addition to a road raise or temporary closure there are also structure relocations.

COST BREAKDOWN

Strategy		Lake Elevation 1447					Lake Elevation 1449					Lake Elevation 1454					Lake Elevation 1456					Lake Elevation 1461				
		R																								
		A					R																			
		R(1)A					R(1)A																			
		R(2)A					R(2)A					R(2)A														
		R(3)A					R(3)A					R(3)A					R(3)A									
		R(4)A					R(4)A					R(4)A					R(4)A					R(4)A				
Incremental	Relocation	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
	Move	South Employee Residenc	1	EA	$56,000	$56	Loop A Compfort Statio	1	EA	$110,000	$110											Picnic Shelter West	1	EA	$15,000	$15
							Loop A Lift Station	1	EA	$30,000	$30															
							South Residence Barn	1	EA	$75,000	$75															
							South Residence Garag	1	EA	$11,300	$11															
		Subtotal				$56	Subtotal				$226											Subtotal				$15
	Road Raise						County Road #1020					County Road #838					County Road #838					County Road #838				
							Fabric Liner	106,037	SY	$1.25	$133	Fabric Liner	33,937	SY	$1.25	$42	Fabric Liner	24,189	SY	$1.25	$30	Fabric Liner	26,608	SY	$1.25	$33
							Aggregate Base	8,558	CY	$20.00	$171	Aggregate Base	3,520	CY	$20.00	$70	Aggregate Base	0	CY	$20.00	$0	Aggregate Base	0	CY	$20.00	$0
							Fill	196,842	CY	$4.50	$886	Fill	41,067	CY	$4.50	$185	Fill	111,467	CY	$4.50	$502	Fill	167,787	CY	$4.50	$755
							Riprap	70,691	CY	$20.00	$1,414	Riprap	22,624	CY	$20.00	$452	Riprap	16,126	CY	$20.00	$323	Riprap	17,739	CY	$20.00	$355
							1998 Total				$2,603	1998 Total				$750	1998 Total				$854	1998 Total				$1,143
							2001 Total (add inflation)				$2,760	2001 Total (add inflation)				$795	2001 Total (add inflation)				$906	2001 Total (add inflation)				$1,212
							County Road #1021					County Road #1020					County Road #1020					County Road #1020				
							Fabric Liner	27,930	SY	$1.25	$35	Fabric Liner	29,405	SY	$1.25	$37	Fabric Liner	103,640	SY	$1.25	$130	Fabric Liner	79,622	SY	$1.25	$100
							Aggregate Base	2,254	CY	$20.00	$45	Aggregate Base	0	CY	$20.00	$0	Aggregate Base	1,975	CY	$20.00	$40	Aggregate Base	0	CY	$20.00	$0
							Fill	51,848	CY	$4.50	$233	Fill	142,639	CY	$4.50	$642	Fill	517,231	CY	$4.50	$2,328	Fill	617,956	CY	$4.50	$2,781
							Riprap	18,620	CY	$20.00	$372	Riprap	19,604	CY	$20.00	$392	Riprap	69,093	CY	$20.00	$1,382	Riprap	53,081	CY	$20.00	$1,062
							1998 Total				$686	1998 Total				$1,071	1998 Total				$3,878	1998 Total				$3,942
							2001 Total (add inflation)				$727	2001 Total (add inflation)				$1,135	2001 Total (add inflation)				$4,111	2001 Total (add inflation)				$4,178
												County Road #1021					County Road #1021					County Road #1021				
												Fabric Liner	7,745	SY	$1.25	$10	Fabric Liner	15,491	SY	$1.25	$19	Fabric Liner	17,040	SY	$1.25	$21
												Aggregate Base	0	CY	$20.00	$0	Aggregate Base	0	CY	$20.00	$0	Aggregate Base	0	CY	$20.00	$0
												Fill	37,571	CY	$4.50	$169	Fill	93,928	CY	$4.50	$423	Fill	132,250	CY	$4.50	$595
												Riprap	5,164	CY	$20.00	$103	Riprap	10,327	CY	$20.00	$207	Riprap	11,360	CY	$20.00	$227
												1998 Total				$282	1998 Total				$649	1998 Total				$844
												2001 Total (add inflation)				$299	2001 Total (add inflation)				$687	2001 Total (add inflation)				$894
																						Total				**$6,299**
		Total				**$56**	**Total**				**$3,713**	**Total**				**$2,229**	**Total**				**$5,704**	**2001 Adjusted Total**				**$6,300**

Notes:

1. AL = Decision/Action Level specified on decision tree.
2. Elevations for decision/action levels are shown at 1-foot increments, rounded down to the nearest foot.
3. 2001 Total for road raise costs are equal to the 1998 Total cost multiplied by 6% to increase for inflation.
4. 2001 Adjusted Total adjusts detailed cost breakdown to match the 2001 totals.

Table 2.7 - 3

Economic Analysis of Strategies for Grahams Island State Park

(Feature 7)

Stochastic Analysis (ST)
Mean Value over 10,000 Traces (Annual)

Strategy		COST			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Structure Relocation B	Total C = A + B	Restoration D	Land and Structure E	Lost Business F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(No Protection) - G(S)**	To Strategy I = H - C	(BCR) I = H / C
No Protection	Temporary Closure of Road During Floods, No Relocation of Structures	$0	$0	$0	$12,000	$17,200	$64,700	$94,000	$0	$0	--
A*	Relocation of Structure at First Action Level: Then Temporary Closure During Floods	$0	$3,500	$3,500	$12,000	$17,000	$64,700	$93,800	$200	-$3,300	0.06
R*	Relocation of All Structures and Raise Road to 1468	#########	$18,600	$1,126,300	$0	$11,600	$0	$11,600	$82,400	-$1,043,900	0.07
R(1)A*	Relocation of Structure at First and Second Action Levels:1 Road Raise: Then Temporary Closure During Flood	$76,500	$8,500	$85,000	$3,900	$11,500	$24,500	$39,900	$54,100	-$30,900	0.64
R(2)A*	Relocation of Structure at First and Second Action Levels:2 Road Raises: Then Temporary Closure During Floo	$91,800	$8,500	$100,300	$2,600	$11,600	$13,300	$27,500	$66,600	-$33,700	0.66
R(3)A*	Relocation of Structure at First and Second Action Levels:3 Road Raises: Then Temporary Closure During Floo	$115,000	$8,500	$123,500	$500	$11,600	$1,000	$13,200	$80,800	-$42,700	0.65
R(4)*	Relocation of Structure at First, Second, and Fifth Action Levels:4 Road Raises	$120,100	$8,500	$128,500	$0	$11,600	$0	$11,600	$82,400	-$46,200	0.64

Wet Future Scenario (WF)
(Annual)

Strategy		COST			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Structure Relocation B	Total C = A + B	Restoration D	Land and Structure E	Lost Business F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(No Protection) - G(S)**	To Strategy I = H - C	(BCR) I = H / C
No Protection	Temporary Closure of Road During Floods, No Relocation of Structures	$0	$0	$0	$0	$27,500	$453,200	$480,600	$0	$0	--
A*	Relocation of Structure at First Action Level: Then Temporary Closure During Floods	$0	$3,500	$3,500	$0	$26,200	$453,200	$479,400	$1,200	-$2,300	0.34
R*	Relocation of All Structures and Raise Road to 1468	#########	$18,600	$1,130,300	$0	$13,300	$0	$13,300	$467,300	-$663,000	0.41
R(1)A*	Relocation of Structure at First and Second Action Levels:1 Road Raise: Then Temporary Closure During Flood	$193,500	$16,000	$209,500	$10,000	$12,600	$271,200	$293,700	$186,900	-$22,600	0.89
R(2)A*	Relocation of Structure at First and Second Action Levels:2 Road Raises: Then Temporary Closure During Floo	$284,300	$16,000	$300,300	$11,300	$13,300	$219,900	$244,500	$236,100	-$64,300	0.79
R(3)A*	Relocation of Structure at First and Second Action Levels:3 Road Raises: Then Temporary Closure During Floo	$489,600	$16,000	$505,700	$0	$13,300	$0	$13,300	$467,300	-$38,400	0.92
R(4)*	Relocation of Structure at First, Second, and Fifth Action Levels:4 Road Raises	$489,600	$16,000	$505,700	$0	$13,300	$0	$13,300	$467,300	-$38,400	0.92

Moderate Future 1 Scenario (M1)
(Annual)

Strategy		COST			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Structure Relocation B	Total C = A + B	Restoration D	Land and Structure E	Lost Business F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(No Protection) - G(S)**	To Strategy I = H - C	(BCR) I = H / C
No Protection	Temporary Closure of Road During Floods, No Relocation of Structures	$0	$0	$0	$21,000	$18,800	$28,100	$67,900	$0	$0	--
A*	Relocation of Structure at First Action Level: Then Temporary Closure During Floods	$0	$3,500	$3,500	$21,000	$18,800	$28,100	$67,900	$0	-$3,500	0.00
R*	Relocation of All Structures and Raise Road to 1468	#########	$18,600	$1,130,300	$0	$11,600	$0	$11,600	$56,300	-$1,074,000	0.05
R(1)A*	Relocation of Structure at First and Second Action Levels:1 Road Raise: Then Temporary Closure During Flood	$98,000	$9,900	$107,900	$0	$11,600	$0	$11,600	$56,300	-$51,600	0.52
R(2)A*	Relocation of Structure at First and Second Action Levels:2 Road Raises: Then Temporary Closure During Floo	$98,000	$9,900	$107,900	$0	$11,600	$0	$11,600	$56,300	-$51,600	0.52
R(3)A*	Relocation of Structure at First and Second Action Levels:3 Road Raises: Then Temporary Closure During Floo	$98,000	$9,900	$107,900	$0	$11,600	$0	$11,600	$56,300	-$51,600	0.52
R(4)*	Relocation of Structure at First, Second, and Fifth Action Levels:4 Road Raises	$98,000	$9,900	$107,900	$0	$11,600	$0	$11,600	$56,300	-$51,600	0.52

Moderate Future 2 Scenario (M2)
(Annual)

Strategy		COST			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Structure Relocation B	Total C = A + B	Restoration D	Land and Structure E	Lost Business F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(No Protection) - G(S)**	To Strategy I = H - C	(BCR) I = H / C
No Protection	Temporary Closure of Road During Floods, No Relocation of Structures	$0	$0	$0	$15,400	$24,000	$239,800	$279,200	$0	$0	--
A*	Relocation of Structure at First Action Level: Then Temporary Closure During Floods	$0	$3,500	$3,500	$15,400	$23,700	$239,800	$278,900	$300	-$3,200	0.09
R*	Relocation of All Structures and Raise Road to 1468	#########	$18,600	$1,130,300	$0	$12,200	$0	$12,200	$267,000	-$863,300	0.24
R(1)A*	Relocation of Structure at First and Second Action Levels:1 Road Raise: Then Temporary Closure During Flood	$160,800	$14,000	$174,700	$18,600	$12,200	$68,500	$99,200	$180,000	$5,300	1.03
R(2)A*	Relocation of Structure at First and Second Action Levels:2 Road Raises: Then Temporary Closure During Floo	$227,400	$14,000	$241,300	$0	$12,200	$0	$12,200	$267,000	$25,600	1.11
R(3)A*	Relocation of Structure at First and Second Action Levels:3 Road Raises: Then Temporary Closure During Floo	$227,400	$14,000	$241,300	$0	$12,200	$0	$12,200	$267,000	$25,600	1.11
R(4)*	Relocation of Structure at First, Second, and Fifth Action Levels:4 Road Raises	$227,400	$14,000	$241,300	$0	$12,200	$0	$12,200	$267,000	$25,600	1.11

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.375% and rounded to the nearest $100.

* In addition to a road raise or temporary closure, there are also structure relocations.

** Total benefits are calculated as the total damages incurred for "No Protection strategy" minus the total damages for the strategy implemented (G(S)).

Attachment to 2.7:
Grahams Island State Park Economic Analysis Assumptions

A. General Assumptions

1. Access to Grahams Island State Park is dependent on ND Highway 19 remaining open. It was assumed that ND Highway 19 access would be kept open to provide access to the park road. The costs for ND Highway 19 are not included in this feature and are analyzed separately in Feature 18: ND Highway 19. Costs for the park access road from ND Highway 19 to the park were included in the costs of protection for this feature.

B. Roads

1. For the incremental road raise strategies, it was assumed that county roads being used as park access would be raised to the same elevation as ND Highway 19, starting with the first raise at elevation 1449.5 (1 foot below the existing road elevation).

2. For the incremental road raise strategies, it was assumed that the access road would be raised when the lake level is within 1 foot of the low road elevation.

3. The estimated maximum road elevation was elevation 1468, based on a 5-foot freeboard above the maximum lake level of 1463.

4. Road raises within the park boundary were not included because roads within the park are, for the most part, above elevation 1468.

5. If the strategy includes temporary closure during flooding, restoration costs for the access road were included when the lake drops 1 foot below the lowest point on the access road.

6. If the county access road is not raised and access to the park is temporarily lost, the value lost was assumed to equal the unit day value of time lost. The unit day value of time lost was computed as $7 per day (Corps of Engineers, personal communication, March, 2001) times the average annual number of park visitors. In 1999 the park had 73,770 visitors, which is representative of a typical year (based on conversations with Dick Horner, Park Superintendent). This number was used to compute the unit day value of time lost, for a total of $516,000 per year.

C. Structures

1. It was assumed that if access was maintained to the park, structures within the park that would be affected by the lake would be moved to high ground (above elevation 1464.) Structures were assumed to be moved when the lake level was within 1 foot of the structure.

2. The estimated value of structures was full replacement value, since all structures have been built since 1989 (based on conversations with Dick Horner, Park Superintendent).

3. If the park was temporarily closed because of lack of access, buildings at elevations greater than the maximum lake level were assumed to be unaffected. The buildings are primarily used by park staff, and could be temporarily closed while access is unavailable.

4. The land value for Grahams Island State Park is estimated to be $400/acre. This value was provided by the Corps of Engineers (personal communication, April, 2001) and is an estimate of the average value of all land surrounding Devils Lake.

5. Structure relocation costs were estimated to be 75% of the structure value for residential structures (including garages, barns, etc.) and 100% for commercial structures (lift stations, comfort stations, etc.).

6. If the park was temporarily closed because of lack of access, damages to land and structures were assumed to occur as they are affected by the rising lake level.

2.8 Summary of Economic Analysis Investigation for Feature 8: Rural Areas

2.8.0 Flood Protection Strategy

The flood protection strategy that was analyzed in the Economic Analysis of Devils Lake Alternatives for Rural Areas was relocation of structures.

2.8.1 General Information

Feature Type: Rural

Location: Rural structures are located throughout Ramsey, Benson, Nelson, and Towner counties surrounding Devils Lake and Stump Lake. The accompanying Figure 2.8-1 shows the general location covered in this feature. More detailed coverage of the Rural Areas and the inundation extents at the three reference lake levels (1447, 1454, and 1463) are shown on Figures 2.8-1a through 2.8-1e.

Description: Rural Areas consists of structures adjacent to the lake, including farmsteads and farmland, residences, state and regional parks, and communities not already covered as separate features. The rural areas were divided into two areas for purposes of this analysis, based on water level: Devils Lake Rural Areas and Stump Lake Rural Areas.

Significance: Although the cost of individual infrastructure and land components in these rural areas is not high, the total impact of rising lake levels on rural areas is significant.

Damages: The flooding of Rural Areas would result in the following damages:

- loss of homes
- loss of crop and pasture land
- loss of parks and park buildings, infrastructure

Owner/Sponsor: Counties, townships, and small towns would likely be responsible for managing and maintaining these Rural Areas.

Lead Federal Agency: The Corps of Engineers would take the lead for Rural Areas for any flood protection work that may take place. Federal Emergency Management Agency (FEMA) would take the lead for relocation of structures in Rural Areas.

2.8.2 Feature Protection

History of Flood Protection: In the past, flood protection for Rural Areas has consisted of relocation of affected structures.

General Protection Strategy: The Economic Analysis identified and evaluated relocation of affected structures for protecting Rural Areas. The analysis separated the Rural Areas into two discrete areas: Devils Lake Rural Areas (Feature 8.1) and Stump Lake Rural Areas (Feature 8.2).

Protection Strategy by Lake Level (Devils Lake Rural Areas): The Economic Analysis of Devils Lake Alternatives assumed flood protection decisions would be made at various lake levels as Devils Lake continued to rise. Figure 2.8.1-2 shows the decision tree for Devils Lake Rural Areas. As shown on Figure 2.8.1-2, the stepwise approach to flood protection for Devils Lake Rural Areas that was analyzed consisted of the following:

1. At lake elevation 1446.2, structures below 1446.5 would be relocated.
2. At lake elevation 1446.5, structures between 1446.5 and 1448 would be relocated.
3. At lake elevation 1447, structures between 1448 and 1449.5 would be relocated.
4. At lake elevation 1448.5, structures between 1449.5 and 1451 would be relocated.
5. At lake elevation 1450, structures between 1451 and 1452.5 would be relocated.
6. At lake elevation 1451.5, structures between 1452.5 and 1454 would be relocated.
7. At lake elevation 1453, structures between 1454 and 1455.5 would be relocated.
8. At lake elevation 1454.5, structures between 1455.5 and 1457 would be relocated.
9. At lake elevation 1456, structures between 1457 and 1459 would be relocated.
10. At lake elevation 1458, structures between 1459 and 1461 would be relocated.
11. At lake elevation 1460, structures between 1461 and 1464 would be relocated.

The maximum protection strategy that was analyzed at the first action level was relocation of all structures below 1464. (Note that for the analysis, the relocation of structures is made at a time when the lake is one foot below the low structure elevation.)

Protection Strategy by Lake Level (Stump Lake Rural Areas): The Economic Analysis of Devils Lake Alternatives assumed that one flood protection decision would be made as Stump Lake starts to rise. Figure 2.8.2-2 shows the decision tree for Stump Lake Rural Areas. As shown on Figure 2.8.2-2, the stepwise approach to flood protection for Stump Lake Rural Areas that was analyzed consisted of the following:

1. At lake elevation 1440, structures between 1440 and 1445 would be relocated.

(Note that for the analysis, the relocation of structures is made at a time when the lake is one foot below the low structure elevation.)

Interdependencies: Although the Rural Areas are not directly interdependent with other features, the entire rural community is heavily dependent on these other features (roads for access, communities for normal daily activities, hospitals, etc). The rural community is heavily dependent on the protection of US Highway 2 and ND Highway 1.

Table 2.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

2.8.3 Feature Economics

Damages: For Rural Features, the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for Feature 8 are summarized in the accompanying Tables 2.8.1-1 (Devils Lake Rural Areas) and 2.8.2-1 (Stump Lake Rural Areas).

Tables 2.8.1-1 and 2.8.2-1 list damages to rural residential structures and land. The first portion of the table shows the damages that are associated with each action level, each representing damages within a range of lake levels.

Unit costs for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for Rural Areas are listed in the Feature 9 Assumptions listing, appended to this Section 2.8.

Costs: The costs of providing flood protection for Rural Areas are detailed in the accompanying Tables 2.8.1-2 (Devils Lake Rural Areas) and 2.8.2-2 (Stump Lake Rural Areas). Unit costs, data sources, and relevant assumptions are listed.

Tables 2.8.1-2 and 2.8.2-2 list costs for relocating residential structures.

Unit costs for all the cost computations were discussed previously in Section 2.0, and are detailed in Table 2.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for Feature 8 are listed in the Rural Areas Assumptions listing, appended to this Section 2.8.

2.8.4 Results of Economic Analysis

The results for the economic analysis of Rural Areas are presented separately for Devils Lake Rural Areas and Stump Lake Rural Areas.

Devils Lake Rural Areas

The results of the Economic Analysis for Devils Lake Rural Areas are listed in Table 2.8.1-3.

Stochastic Analysis Results: The stochastic analysis indicated that the net benefits for the incremental relocation strategy of Devils Lake Rural Areas were greater than one ($177,500). The BCR was 1.19, indicating that this strategy was economically justified. This strategy is highlighted on the decision tree (Figure 2.8.1-2). The remaining damages to land were computed to have a present worth value of $1,148,200, annualized. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For Devils Lake Rural Areas, the identified strategy and the economic indices for each of the three climate futures are as follows:

- Wet Future – For the wet future, the incremental relocation strategy had net benefits that were greater than one ($369,900). The BCR was 1.21, indicating that this strategy was economically justified. The remaining damages to land were computed to have a present worth value of $3,846,600, annualized.
- First Moderate Future – For the first moderate future, the incremental relocation strategy had net benefits of $151,900, and BCR of 1.18, indicating that this strategy was economically justified. The remaining damages to land were computed to have a present worth value of $805,100, annualized.
- Second Moderate Future – For the second moderate future, the incremental relocation strategy had net benefits of $215,500, and BCR of 1.20, indicating that this strategy was economically justified. The remaining damages to land were computed to have a present worth value of $1,791,100, annualized.

Stump Lake Rural Areas

The results of the Economic Analysis for Stump Lake Rural Areas are listed in Table 2.8.2-3.

Stochastic Analysis Results: The stochastic analysis indicated that the net benefits for the incremental relocation strategy were greater than one ($1,300). The BCR was 1.43, indicating that this strategy was economically justified. This strategy is highlighted on the decision tree (Figure 2.8.2-2). The remaining damages to land were computed to have a present worth value of $120,000, annualized. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: In the economic analysis, flood protection strategies were also analyzed for three specific climate futures. For Stump Lake Rural Areas, the identified strategy and the economic indices for each of the three climate futures are as follows:

- Wet Future – For the wet future, the incremental relocation strategy had net benefits that were greater than one ($3,500). The BCR was 1.43, indicating that this strategy was economically justified. The remaining damages to land were computed to have a present worth value of $272,300, annualized.

- First Moderate Future – For the first moderate future, lake levels do not reach the first damage levels. The remaining damages to land were computed to have a present worth value of $96,500, annualized.

- Second Moderate Future – For the second moderate future, the incremental relocation strategy had net benefits of $2,900, and BCR of 1.43, indicating that this strategy was economically justified. The remaining damages to land were computed to have a present worth value of $205,700, annualized.

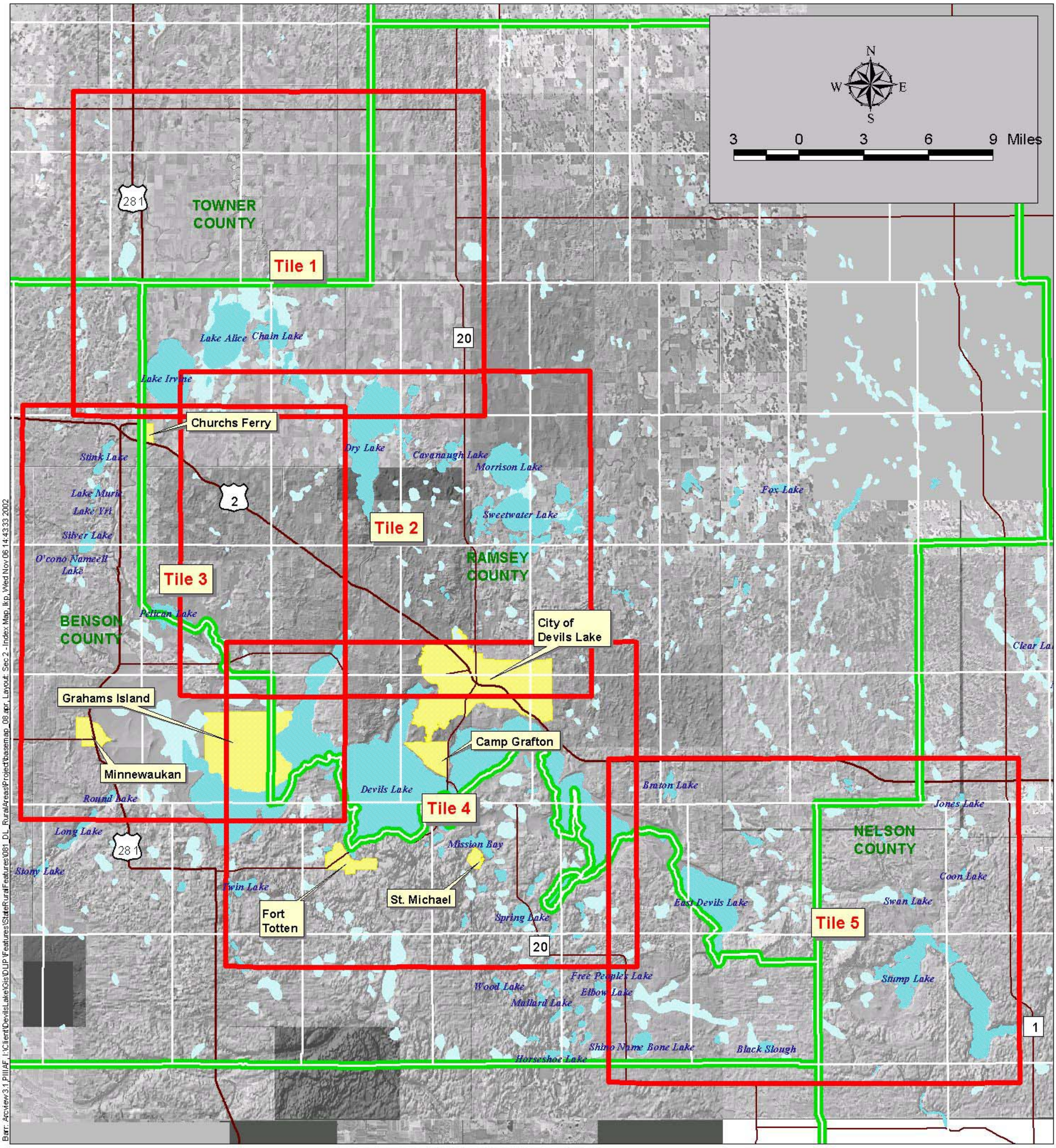
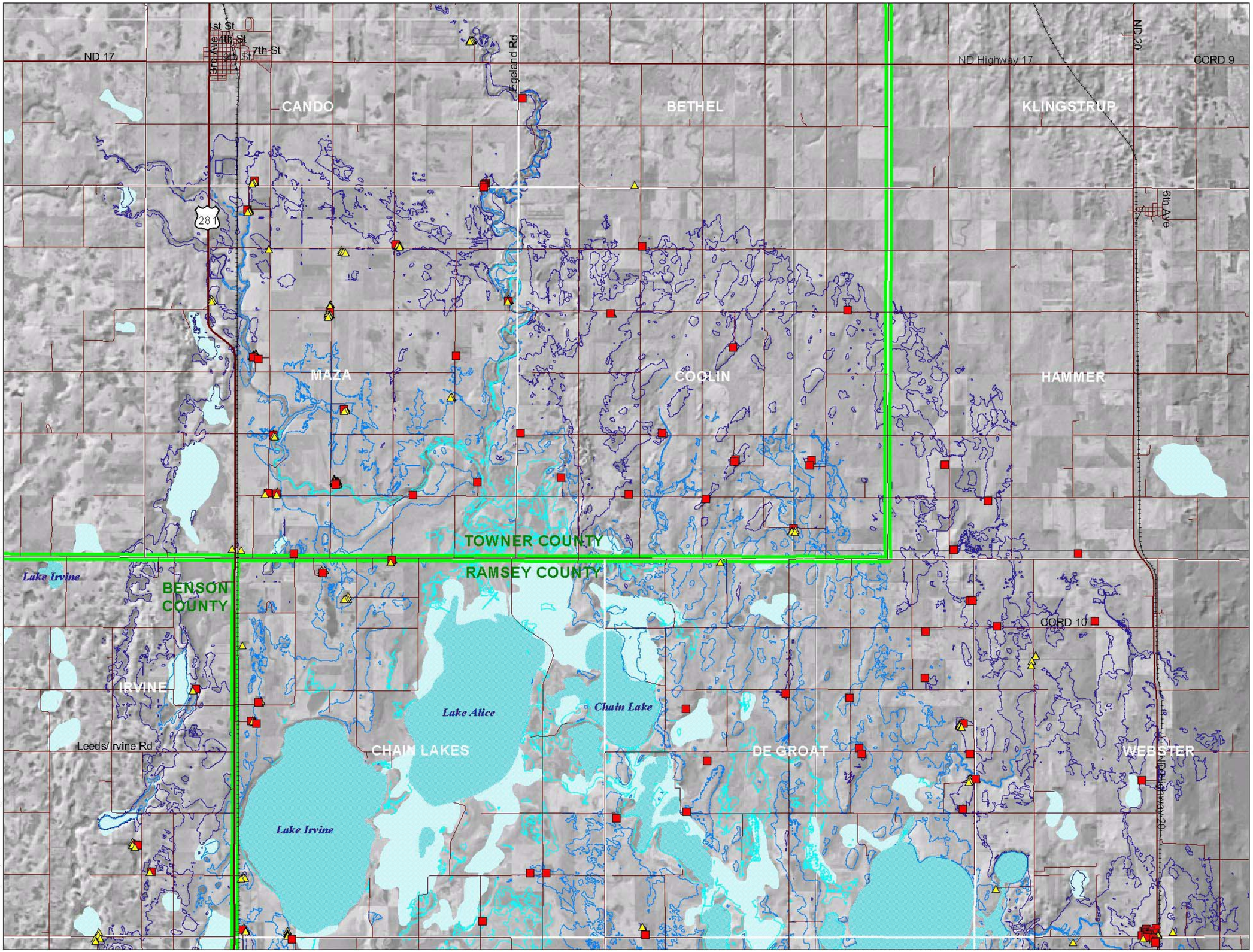


Figure 2.8-1

LOCATION MAP
FEATURE 8: RURAL FEATURES
FIGURE INDEX MAP
Devils Lake Infrastructure
Protection Study

Barr: Arcview3.1,PIII,4F,I:\Client\DevilsLake\Gis\DUP\Features\StateRuralFeatures\061_DL_RuralAreas\Project\basemap_08.apr, Layout: Sec 2 - Index Map, lkp, Wed Nov 06 14:43:33 2002



N
W E
S

0 0.75 1.5 2.25 3 Miles

Reference Lake Contours

1447

1454

1463

Buildings

House

Other Buildings

Townships

Counties

Figure 2.8-1a

LOCATION MAP
FEATURE 8: RURAL FEATURES
(TILE 1)
Devils Lake Infrastructure
Protection Study

Barr: Arcview 3.1, PIII AF, i:\client\devilslake\gis\dlip\features\staterurafeatures\081_dl_ruralareas\projectbasemap_08.apr, Layout: Layout: Sec 2 Tile 1, lkp, Tue Nov 05 10:49:12 2002

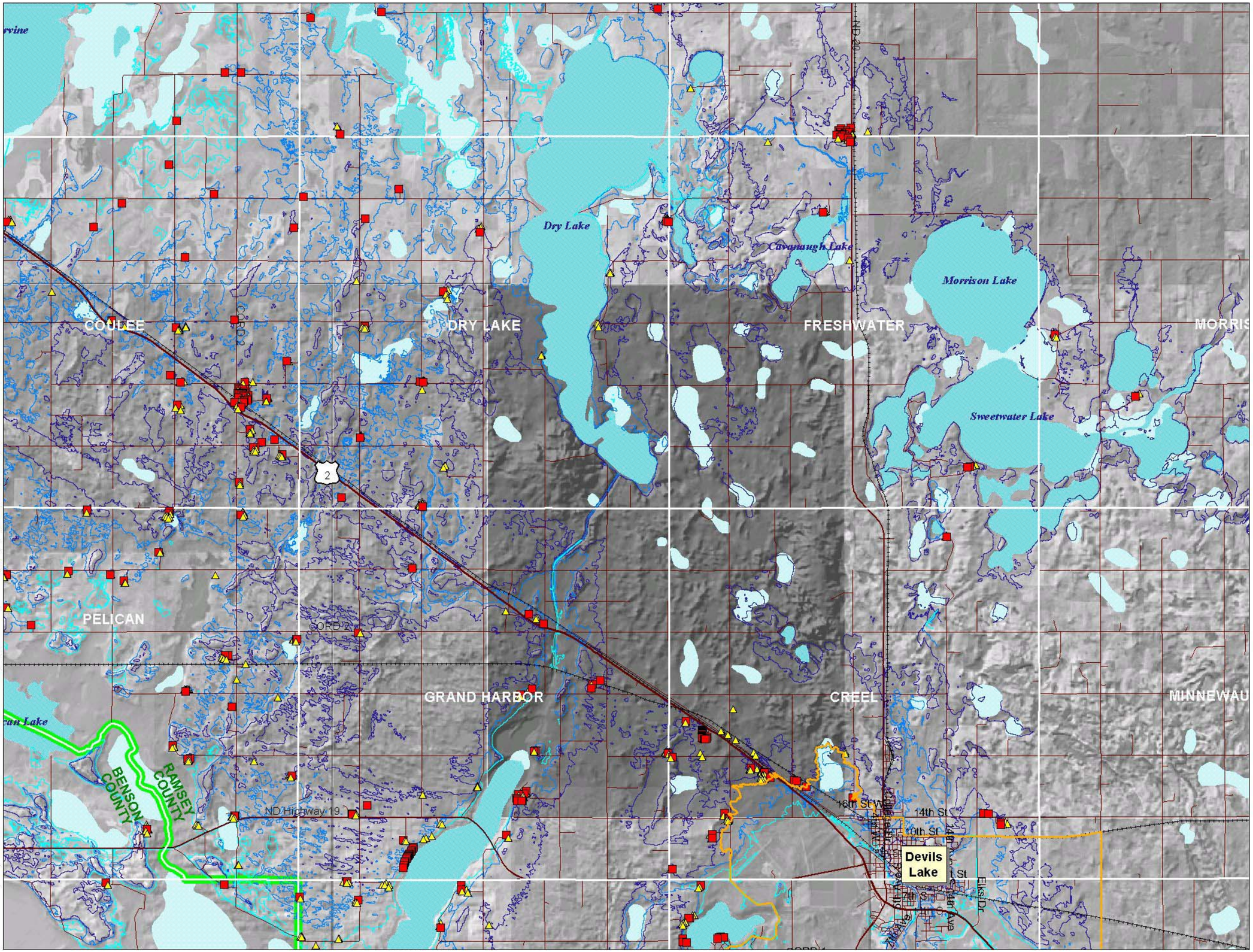


Figure 4.8-1b

LOCATION MAP
FEATURE 8: RURAL FEATURES
(TILE 2)
Devils Lake Infrastructure Protection Study

Barr: ArcView 3.1, PIII/AF, I:\Client\DevilsLake\Gis\DUP\Features\StateRuralFeatures\081_DL_RuralAreas\Project\basemap_08.apr, Layout: Layout: Sec 4 Tile 2, lkp, Tue Nov 05 15:12:49 2002

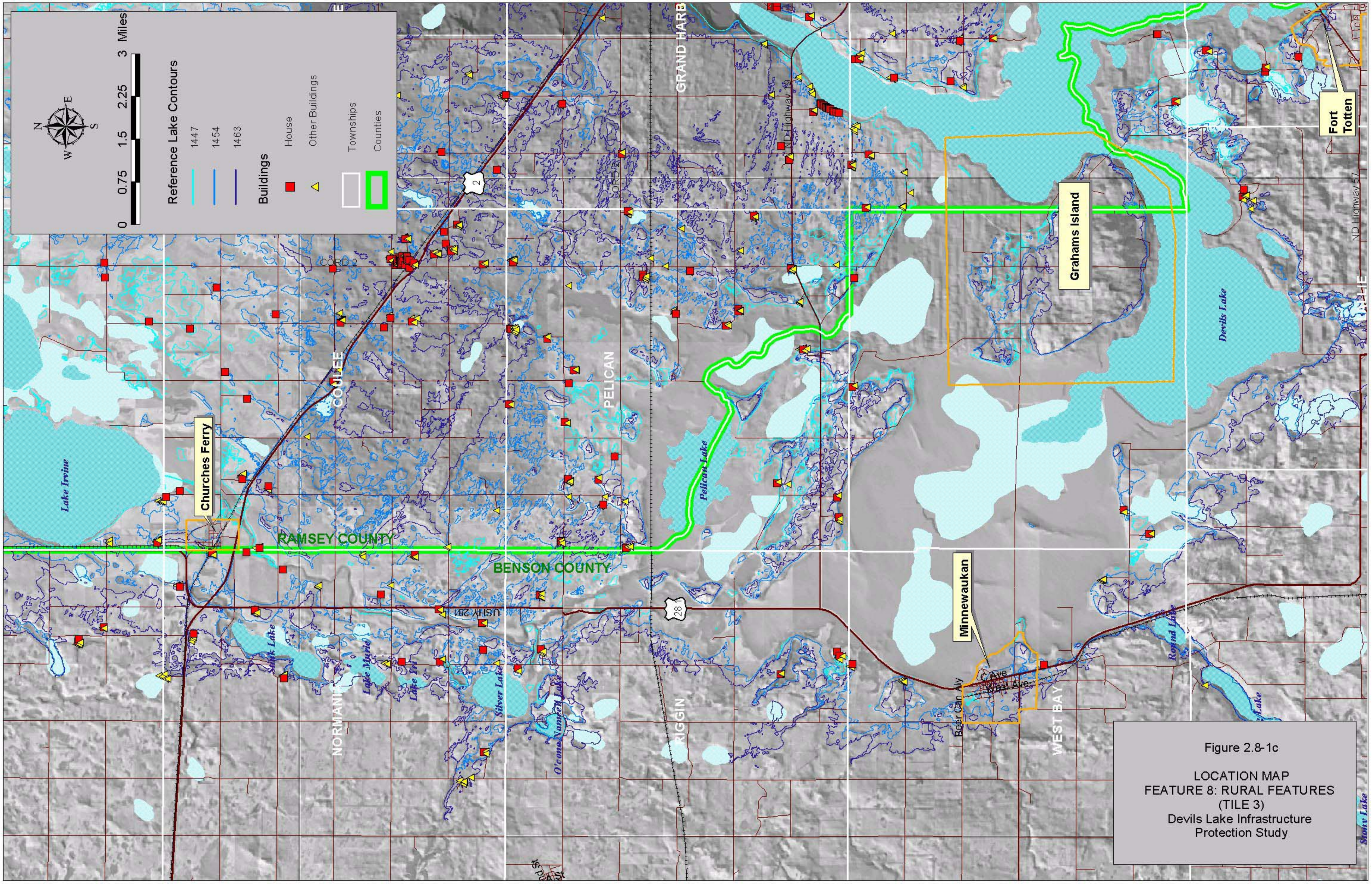


Figure 2.8-1c

LOCATION MAP
FEATURE 8: RURAL FEATURES
(TILE 3)
Devils Lake Infrastructure
Protection Study

Barr: arcview 3.1 ,'PIIIAF ,'i:\client\devil sake\gis\dlp\features\staterural\features\081_dl_rural areas\projectbasemap_08.apr, Layout: Sec 2 Tile 3, lkp, Tue Nov 05 11:28:14 2002

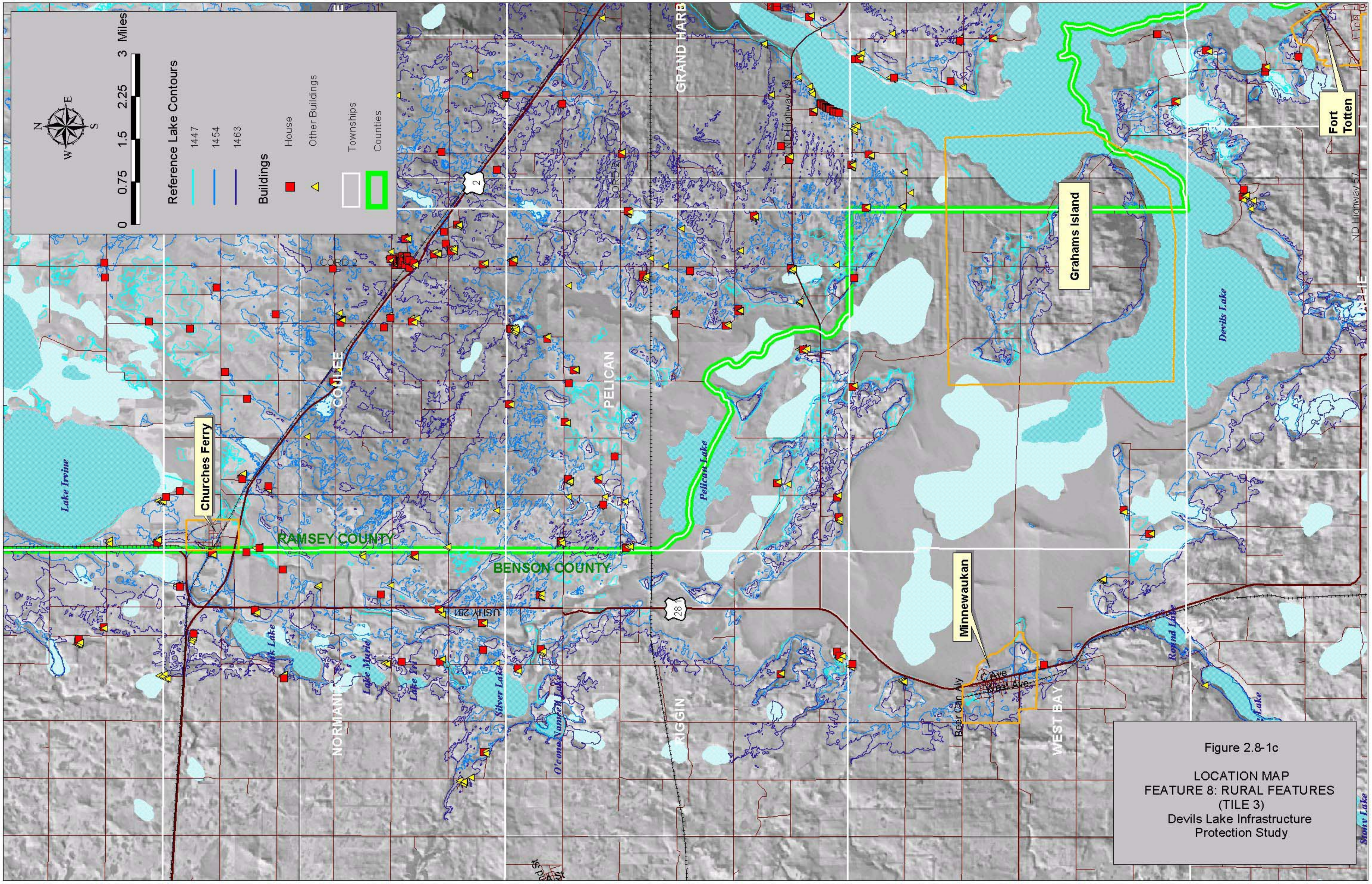
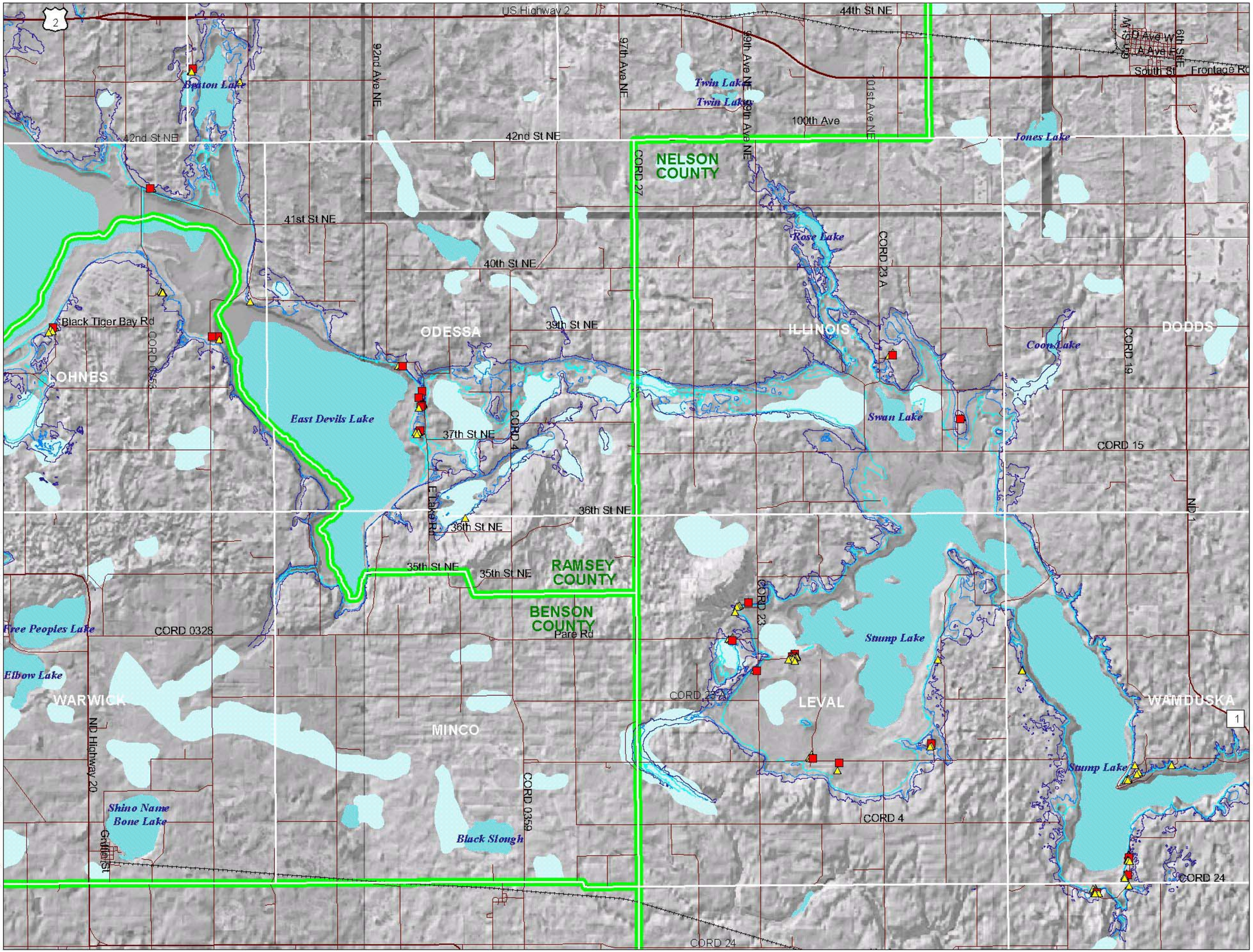


Figure 2.8-1c

LOCATION MAP
FEATURE 8: RURAL FEATURES
(TILE 3)
Devils Lake Infrastructure
Protection Study

Barr: arcview 3.1 ,'PIIIAF ,'i:\client\devil sake\gis\dlp\features\staterural\features\081_dl_rural areas\projectbasemap_08.apr, Layout: Sec 2 Tile 3, lkp, Tue Nov 05 11:28:14 2002



N
W E
S

0 0.75 1.5 2.25 3 Miles

Reference Lake Contours

- 1447
- 1454
- 1463

Buildings

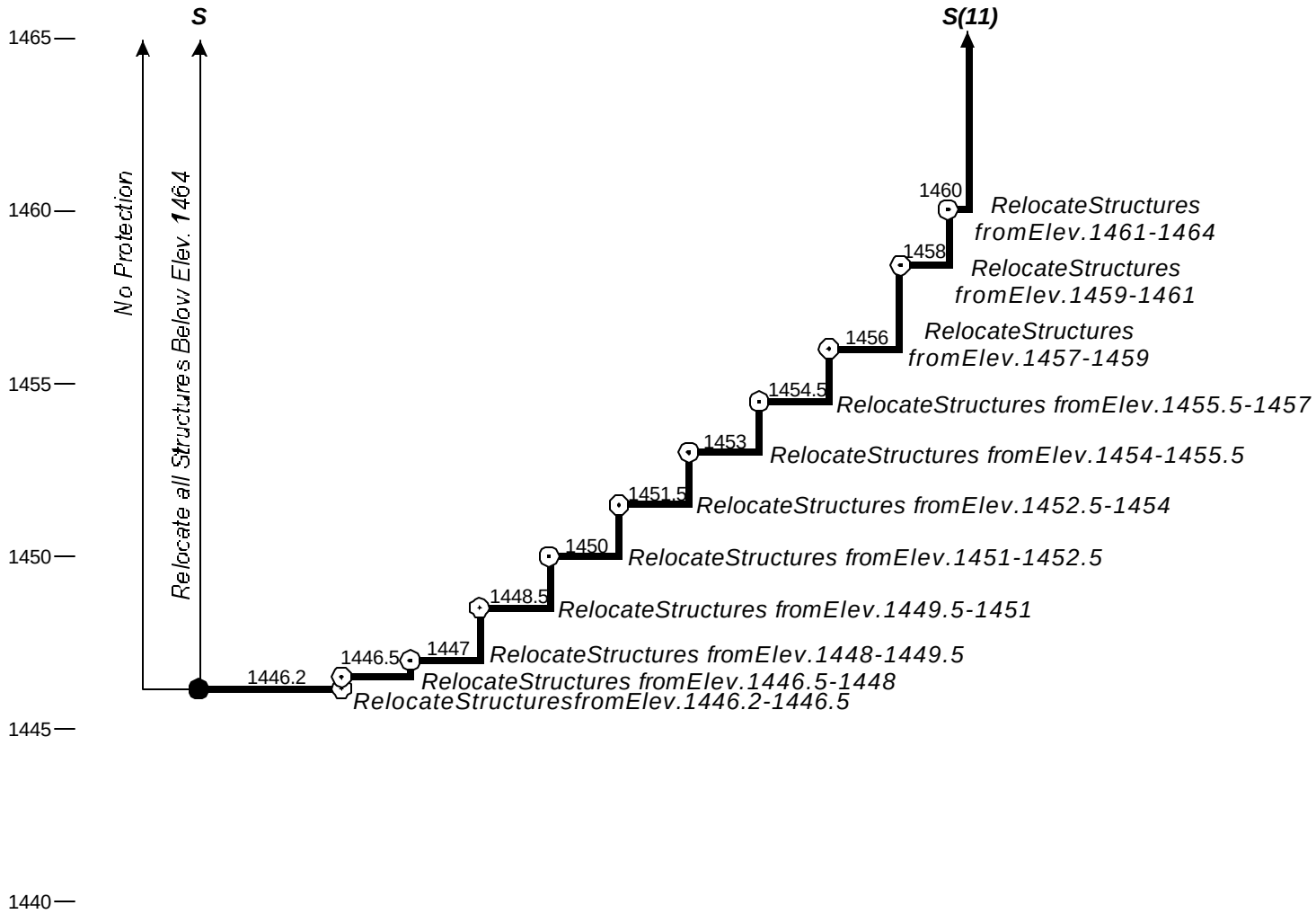
- House
- Other Buildings

- Townships
- Counties

Figure 2.8-1e

LOCATION MAP
FEATURE 8: RURAL FEATURES
(TILE 5)
Devils Lake Infrastructure
Protection Study

Barr: Arcview 3.1, PIII AF, i:\client\devilslake\gis\dlip\features\state\ruralfeatures\081_dl_ruralareas\projectbasemap_08.apr, Layout: Layout: Sec 2 Tile 5, lkp, Tue Nov 05 11:09:29 2002



FloodProtectionStategy

Decisionrequiredatthispoint

Triggerpointforaction,nodecisionneeded

S(1) Incrementalstructurerelocation(number oftimes)

S RelocateallstructuresbelowElev.1464

Figure2.8.1-2

DECISION TREE
FEATURE8.1:RURALAREAS
DevilsLakeInfrastructure ProtectionStudy

P:\1036020\DECISIONTREES\2002FIGURES\FIGURE2_08.1.CDR RLG 01-02-03