Analysis of Selected Scenarios

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A mathematical model of a stream system is a powerful tool for estimating the effects that changes in the stream system geometry might have on past and future floods. The Nooksack River, like most rivers in populated areas, is constantly being changed in various ways. Efforts to manage the River to minimize the potential threat of floods involves analysis of various possible future states of the stream system, called scenarios, to determine what are the outcomes of a given set of management actions. Below we consider several scenarios for both the Reach1 through Reach 4 (R1–R4) model and the Reach 5 (R5) model.

Definition of the Scenarios: R1–R4

In order to evaluate various management actions we must define a scenario. In this context it is the collection of assumptions about the state of the geometry of the stream, the flood that occurs, and the performance of levees and other structures. Geometry includes the state of the levees, bridges, and the nature of the stream channels. Two scenarios are required to evaluate each change. One scenario establishes a base condition and the other evaluates the changed conditions and then the difference in results between the two defines the effects of the change. This is using the model in a differential or relative analysis mode by looking at the difference caused by a carefully selected set of changes. All other aspects of the model are left unchanged.

The scenarios will be defined for the two models, R1–R4 and for the model of Reach 5. The scenarios from R1-R4 are inherited by the R5 model because the flow at Everson Main Street is the primary flow of interest in Reach 5. Additional changes or management options in Reach 5 will then add scenarios. These are presented after the results of the scenarios in R1–R4 are given.

The scenarios in R1–R4 are:

Scenario 1: Base State This is the base scenario used to evaluate the effects of the management options modeled in scenarios 2 and 3

1. Geometry: Approximation to 2002 conditions for levees, cross sections based on the 1993 DTM, new bridge at Everson and the Lagerway Dike extension is in place.
2. Hydrology: Flow at Deming has a 100-year peak flow and a hydrograph that is based on flow-duration studies to approximate large floods. We will call it a 100-year hydrograph even though such an entity does not in fact exist. It is a convenient hydrological fiction that we any others commonly use.
3. Performance: No flood fights or failures, no log jams, nor debris assumed on bridges.
4. Tide series: Derived following National Ocean Service guidelines for Bellingham Bay. This series is also used in Lummi Bay.

Scenario 2: No Overflow This scenario is used with scenario 1 to evaluate the effect of raising the bank of the Nooksack to the point that there is no overflow at Everson. The only flow in Johnson Creek is that coming from the drainage area of Johnson Creek. It is defined by:

1. Geometry: Bank near Everson raised to prevent all overflow to Canada but same as Scenario 1 otherwise.
2. Hydrology: Same as scenario 1
3. Performance: Flood fight modeled that prevents all overflow to Canada
4. Tide series: Same as scenario 1

Scenario 3: 1990 Overflow This scenario is used with scenario 1 to evaluate the effect of allowing a peak overflow like that simulated in the 1990 flood to flow across Everson Main Street. Thus the bank near Everson is raised but not as much as in Scenario 2.

1. Geometry: Raise the bank near Everson to limit peak overflow to a value close to that simulated for the 1990 flood at Everson Main Street. Otherwise the same as in scenario 1.
2. Hydrology: Same as scenarios 1 and 2
3. Performance: /Flood fight modeled that limits the overflow peak to that simulated in 1990 at Everson Main Street.
4. Tide series: Same as scenarios 1 and 2

Results from Scenario Runs

The results for scenarios 1, 2, and 3 for maximum flow and maximum water-surface elevation are given in Table 1–1 at selected locations. Table 1–2 presents the differences in maximum elevation, maximum flow, and the relative differences in maximum flow for the same locations. Table 1–3 gives the estimated duration of flow over selected road and an estimated maximum depth of water on the road. Figure 1–1 shows the cumulative storage change in the stream system for each of the scenarios.

TABLE 1–1: Scenario Results: Extremes at Selected Locations

Location of Result	Node in Model	Base State Max. Elev. (ft.)	Base State Max. Flow (cfs)	No Overflow Max. Elev. (ft.)	No Overflow Max. Flow (cfs)	1990 Overflow Max. Elev. (ft.)	1990 Overflow Max. Flow (cfs)
Everson Bridge	D4141	83.69	57,650	84.99	67,534	84.26	6,2215
Everson MnStrt	D4541	83.59	10,883	76.91	81	83.04	5,972
Everson- LB Flow	D4341	86.36	4,034	88.62	4,984	87.58	4558
Thiel Road-Nksk	D3087	63.57	35,513	63.65	35,827	63.61	35,676
Thiel Road-Scott	D3286	56.20	15,093	56.55	21,544	56.37	18,098
KammCrk Dprsn	D3499	58.34	10,812	58.98	14,684	58.66	12,676
Hannegan Rd-Nksk	D3129	58.21	31,592	58.41	31,600	58.31	31,597
Hannegan Rd-Scott	D3329	50.00	18,175	50.77	25,301	50.39	21,532
Guide-SthDryBrdg	D3677	49.44	23,045	50.05	27,081	49.75	25,242
Guide-Nksk	D3177	48.87	22,372	49.23	22,381	49.06	22,376
Guide-NrthDryBrdg	F3998	47.38	19,337	48.32	22,421	47.91	21,069
Guide-NrthDryBrdg OvrQ	F3999	47.38	30	48.32	2,869	47.91	962
Choke Point	U2008	48.27	40,245	48.62	43,015	48.45	41,664
Nr Lattimore Lv-Nksk	D2130	34.70	32,991	35.80	36,979	35.26	35,028
Nr Lattimore Lv-RB	D2530	34.69	28,012	35.80	33,108	35.25	30,647
I-5 Under Bridge	F1221	33.38	60,915	34.54	64,077	33.95	63,527
I-5 North Ovrq	F1220	33.38	0	34.54	39,73	33.96	1,111
I-5 South OvrQ	F2517	33.59	224	34.71	2,368	34.15	1,020
UpsRRBrdg Ferndale	D1007	30.58	60,302	32.26	62,830	31.29	62,663
Ferndale-USGS	D1010	28.33	60,302	29.18	62,826	28.76	62,662
Slater Rd-LFP	D1248	15.75	25,873	16.24	30,644	16.02	28,443
Slater Rd-Nksk	D1048	19.35	32,683	19.47	33,662	19.42	33,195
Lummi LPR JK	F1985	6.17	122	8.49	1,589	7.81	152
Marine Drive-LFP	D1284	13.80	23,605	14.11	26,669	13.97	25,304
Marine Drive-Nksk	D1084	13.04	28,817	13.27	29,739	13.17	29,290
Marine Drive-RFP	D1409	10.93	5,379	11.34	7,060	11.15	6,258
Marine Drive-RnBS	D1509	11.06	946	11.47	962	11.28	958

Effect of Stopping All Overflow to Canada

This effect is briefly summarized in the differences between the Base State and the No Overflow set of columns in Tables 1-2 and 1.3. Allowing no overflow puts more water into the flood plains of the Nooksack with an increase of one-third foot or more. Some locations experience an increase in water level on the order of one foot. Flow increases in the flood plains are on the order of 25 percent and in some cases more than this. Flow increases in the Nooksack main channel are small with most of the water flowing over the banks and levees into the flood plain where there is greater capacity for flow and for storage. From Figure 1–1 stopping all overflow to Canada adds about 9,400 acre-feet of storage to the stream system.

The most significant change noted in these tables is, however, that stopping all overflow to Canada would require that Interstate Highway 5 and the Guide Meridian Road, both major north-south routes, be closed for about 15 hours. The flow on Interstate 5 could also damage the road.

TABLE 1–2: Scenario Results: Absolute and Relative Differences

Location of Result	Node in Model	No Overflow – Base Diff. MaxZ (ft)	Diff. MaxQ (cfs)	%Diff. MaxQ	1990 Overflow – Base Diff. MaxZ (ft.)	Diff. MaxQ (cfs)	%Diff. MaxQ
Everson Bridge	D4141	1.30	9,884	17.1	0.57	4,565	7.9
Everson MnStrt	D4541	-6.68	-10,802	-99.3	-0.55	-4,911	-45.1
Everson- LB Flow	D4341	2.26	950	23.6	1.22	524	13.0
Thiel Road-Nksk	D3087	0.08	314	0.9	0.04	163	0.5
Thiel Road-Scott	D3286	0.35	6,451	42.7	0.17	3,005	19.9
KammCrk Dprsn	D3499	0.64	3,872	35.8	0.32	1,864	17.2
Hannegan Rd-Nksk	D3129	0.20	8	0.0	0.10	5	0.0
Hannegan Rd-Scott	D3329	0.77	7,126	39.2	0.39	3,357	18.5
Guide-SthDryBrdg	D3677	0.60	4,036	17.5	0.31	2,197	9.5
Guide-Nksk	D3177	0.36	9	0.0	0.19	4	0.0
Guide-NrthDryBrdg	F3998	0.95	3,084	15.9	0.54	1,732	9.0
Guide-NrthDryBrdg OvrQ	F3999	0.95	2,840	9,603.7	0.54	932	3,152.7
Choke Point	U2008	0.36	2,770	6.9	0.19	1,419	3.5
Nr Lattimore Lv-Nksk	D2130	1.10	3,988	12.1	0.56	2,037	6.2
Nr Lattimore Lv-RB	D2530	1.12	5,096	18.2	0.56	2,635	9.4
I-5 Under Bridge	F1221	1.16	3,162	5.2	0.58	2,612	4.3
I-5 North Ovrq	F1220	1.17	3,973		0.58	1,111	
I-5 South OvrQ	F2517	1.11	2,144	9,56.0	0.55	795	354.7
UpsRRBrdg Ferndale	D1007	1.68	2,528	4.2	0.71	2,361	3.9
Ferndale-USGS	D1010	0.85	2,524	4.2	0.43	2,360	3.9
Slater Rd-LFP	D1248	0.49	4,771	18.4	0.27	2,570	9.9
Slater Rd-Nksk	D1048	0.12	979	3.0	0.06	512	1.6
Lummi LPR JK	F1985	2.32	1,467	1,207.1	1.64	30	24.7
Marine Drive-LFP	D1284	0.30	3,064	13.0	0.17	1,699	7.2
Marine Drive-Nksk	D1084	0.23	922	3.2	0.13	473	1.6
Marine Drive-RFP	D1409	0.41	1,681	31.3	0.22	879	16.3
Marine Drive-RnBS	D1509	0.41	16	1.7	0.22	12	1.3

TABLE 1–3: Scenario Results: Road Overflow Durations and Maximum Depths

Location of Result	Node in Model	Base State Flow Duration (hours)	Base State Max. Depth (feet)	No Overflow Flow Duration (hours)	No Overflow Max. Depth (feet)	1990 Overflow Flow Duration (hours.)	1990 Overflow Max. Depth (feet)
Everson MnStrt	D4541	30	1.8	—	—	24	1.4
Hannegan Rd-Scott	D3329	51	2.1	51	2.6	51	2.4
Guide-NrthDryBrdg OvrQ	F3999	6	0.1	18	0.7	16	0.4
I-5 North Ovrq	F1220	—	—	16	0.7	12	0.4
I-5 South OvrQ	F2517	13	0.4	20	1.1	19	0.7
Slater Rd-LFP	D1248	74	4.1	74	4.7	74	4.5
Marine Drive-LFP	D1284	55	2.2	55	2.4	55	2.4
Marine Drive-RFP	D1409	173	2.4	173	2.6	173	2.5

In both cases the flow control is at critical depth so that the velocities would be high.

Effect of Limiting Overflow to Canada to 1990 Peak Flow

These effects are similar but reduced somewhat in intensity. Again most of the additional flow appears in the flood plains of the Nooksack. The road closures would be about the same with perhaps a few hours reduction on Interstate 5 and Guide Meridian Road.

Definition of the Scenarios: R5

Scenario 5-1:Full OvrQ

1. Geometry: Approximation to 2002 conditions for levees, cross sections based on the 1993 DTM
2. Hydrology: Full overflow from 100-year flood as computed at Everson Main Street.
3. Performance: Southern British Columbia Railroad (SBCRR)fill north of the International Border is assumed to fail in a manner outline by UMA in previous work. This failure is similar to that experienced in the 1990 flood.

Scenario 5-2:Full OvrQ No Fail

1. Geometry: Approximation to 2002 conditions for levees, cross sections based on the 1993 DTM
2. Hydrology: Full overflow from 100-year flood as computed at Everson Main Street.
3. Performance: SBCRR fill does not fail.

Scenario 5-3:Full OvrQ X Store

1. Geometry: Approximation to 2002 conditions for levees, cross sections based on the 1993 DTM. Selected roads in the overflow corridor are raised from 1 to 8 feet to pond water enroute to Canada. Drainage takes place through existing culverts.
2. Hydrology: Full overflow from 100-year flood as computed at Everson Main Street.
3. Performance: Southern British Columbia Railroad fill north of the International Border is assumed to fail in a manner outline by UMA in previous work. This failure is similar to that experienced in the 1990 flood.

Scenario 5-4:No OvrQ

1. Geometry: Approximation to 2002 conditions for levees, cross sections based on the 1993 DTM,
2. Hydrology: No overflow from Nooksack River
3. Performance: Southern British Columbia Railroad fill north of the International Border does not fail.

Scenario 5-5:1990 OvrQ

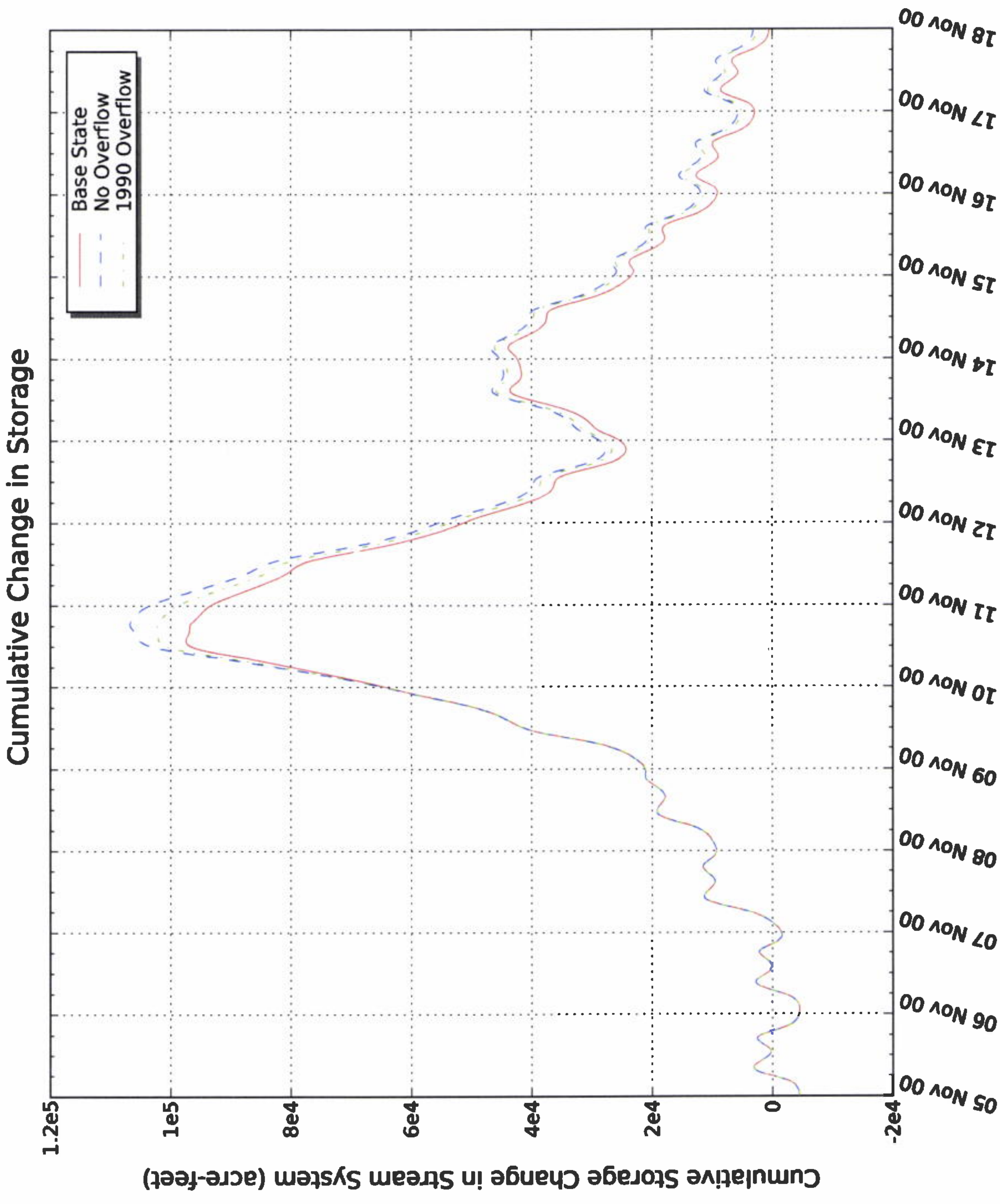

Figure 1: Cumulative Storage Change in the Stream system

1. Geometry: Approximation to 2002 conditions for levees, cross sections based on the 1993 DTM,
2. Hydrology: Overflow peak at Everson Main Street limited to the 1990 simulated peak. Bank of Nooksack where overflows occur is raised as needed to reduce the peak.
3. Performance: Southern British Columbia Railroad fill north of the International Border is assumed to fail in a manner outline by UMA in previous work. This failure is similar to that experienced in the 1990 flood.

Scenario 5-6:1990 OvrQ X Store

1. Geometry: Approximation to 2002 conditions for levees, cross sections based on the 1993 DTM. Selected roads in the overflow corridor are raised from 1 to 8 feet to pond water enroute to Canada. Drainage takes place through existing culverts.
2. Hydrology: Overflow peak at Everson Main Street limited to the 1990 simulated peak. Bank of Nooksack where overflows occur is raised as needed to reduce the peak.
3. Performance: Southern British Columbia Railroad fill north of the International Border is assumed to fail in a manner outline by UMA in previous work. This failure is similar to that experienced in the 1990 flood.

The first scenario will serve as the base conditions for all others. That is, the effect of scenarios 502 through 5-6 will be estimated relative to what happens if nothing is done to change the overflow and its effects.

Tables 1–4 and 1–5 show the results for each scenario, again giving the maximum elevation and the maximum flow at selected locations in Reach 5. Some locations will not have an elevation because flow given is from a summation taken over two or more nodes to represent a total.

TABLE 1–4: Scenario Results: Extremes at Selected Locations in Reach 5

Location of Result	Node in Model	Full OvrQ Max. Elev. (ft.)	Full OvrQ Max. Flow (cfs)	Full OvrQ No Fail Max. Elev. (ft.)	Full OvrQ No Fail Max. Flow (cfs)	Full OvrQ X Store Max. Elev. (ft.)	Full OvrQ X Store Max. Flow (cfs)
Tom Rd-Trib 3	D6234	73.88	10,021	73.88	10,021	80.57	5,180
Hampton Rd-JC	D5060	73.57	270	73.57	270	79.89	811
Van Buren Ovrq	many	—	653	—	653	—	4,777
Lindsay Rd-JC	D5088	70.27	461	70.27	461	74.45	1,611
Lindsay Rd-JC Trib 3	D6288	69.95	10,356	69.94	10,354	74.48	9,067
Badger Rd-JC	D5142	63.78	1,443	63.78	1,443	65.63	2,661
Badger Rd-JC Trib 1	D6442	64.28	1,860	64.28	1,860	66.19	992
Badger Rd-Jc Trib 1 of 1	D6342	65.69	6,767	65.69	6,766	66.50	3,307
Clearbrook Rd-JC	D5198	58.15	1,199	58.15	1,199	58.81	1,858
Clearbrook Rd-JC Trib 1	D6498	58.20	1,443	58.20	1,443	59.21	109
Clearbrook Rd-JC Trib 1 of 1	D6648	57.79	3,895	57.79	3,894	59.28	27
Clearbrook Rd-BnCrk	D6854	47.67	2,047	47.67	2,046	47.77	228
Garrison Rd-JC	D5268	48.77	1,322	48.77	1,322	50.52	2,070
Garrison Rd-BnCrk	D6836	50.07	236	50.07	236	50.83	673
Garrison Rd-REFLRW	D6936	48.66	2,855	48.66	2,854	50.82	1,615
Halverstick Rd-JC	D5325	44.59	1,814	44.59	1,814	44.69	1,745
Sumas-JC at BNRR	D5336	44.43	2,943	44.43	2,944	44.34	2,840
Sumas-JC at BNRR	D5566	44.51	4,913	44.51	4,916	44.42	4,648
Sumas-BnCrk at BNRR	D6878	46.43	402	46.43	402	45.79	326
Huntingdon	U366	33.08	2,119	33.38	2,031	33.06	2,113
Bndry Rd 1	D664	34.30	1,466	34.30	1,467	34.28	1,394
2nd and Bndry Rd	F433	35.37	1,870	35.37	1,871	35.34	1,807
Bndry Rd 2	D674	31.83	2,156	32.12	2,158	31.80	2,041
Bndry Rd 3	F439	31.96	612	32.12	507	31.93	574
Bndry Rd 4	F438	31.96	519	32.12	707	31.93	486
Bndry Rd 5	F440	33.58	923	33.68	1,092	33.56	882
USA out	many	—	11,914	—	11,910	—	11,295
Cherry Rd-JC	D600	41.18	3,303	41.18	3,303	41.11	3,338
Heron Lane-JC	D616	38.42	1,503	38.42	1,503	38.39	1,494

The effect of the assumed failure of the SBCRR is nil. Table 1–6 shows the difference between Scenarios 5–1 and 5–2 and with the exception of some small elevation increases near Boundary Road, the changes are zero or essentially so. Consequently, because it appears more probable, all subsequent scenarios, with the exception of the no overflow case, assume that the SBCRR fails in the manner sketched by UMA based on the 1990 failure.

The effect of adding extra storage by raising selected roads in the overflow corridor when the full overflow is applied at Everson Main Street is given in Table 1–7. Roads were raised from 1 foot to about 7 feet from the current elevation of the road. A series of ponding areas was thus formed starting at Tom Road and ending at Halverstick and Hill Roads not far from Sumas. The effect of this added storage on the flow across the border was small with only a five percent

TABLE 1–5: Scenario Results: Extremes at Selected Locations in Reach 5

Location of Result	Node in Model	No OvrQ Max. Elev. (ft.)	No OvrQ Max. Flow (cfs)	1990 OvrQ Max. Elev. (ft.)	1990 OvrQ Max. Flow (cfs)	1990 OvrQ X Store Max. Elev. (ft.)	1990 OvrQ X Store Max. Flow (cfs)
Tom Rd-Trib 3	D6234	71.33	118	73.11	5,300	80.13	2,121
Hampton Rd-JC	D5060	71.05	119	73.52	255	79.73	739
Van Buren Ovrq	many	—	0	—	463	—	2,922
Lindsay Rd-JC	D5088	67.70	119	69.82	160	73.99	849
Lindsay Rd-JC Trib 3	D6288	67.33	101	69.37	5,740	74.00	3,872
Badger Rd-JC	D5142	60.76	220	62.90	892	63.56	1,321
Badger Rd-JC Trib 1	D6442	49.77	0	63.05	753	65.77	414
Badger Rd-Jc Trib 1 of 1	D6342	54.82	0	65.21	4,103	65.96	1,178
Clearbrook Rd-JC	D5198	54.21	220	57.56	934	57.54	1,115
Clearbrook Rd-JC Trib 1	D6498	54.97	26	58.05	1,245	58.68	105
Clearbrook Rd-JC Trib 1 of 1	D6648	53.45	0	57.16	1,947	58.71	23
Clearbrook Rd-BnCrk	D6854	43.92	40	46.89	847	46.99	222
Garrison Rd-JC	D5268	45.06	238	48.49	1,281	48.77	1,351
Garrison Rd-BnCrk	D6836	47.54	40	49.76	209	49.75	210
Garrison Rd-REFLRW	D6936	44.20	6	48.15	1,675	49.36	400
Halverstick Rd-JC	D5325	37.78	223	43.12	1,681	40.84	1,246
Sumas-JC at BNRR	D5336	37.44	225	42.73	1,903	40.16	810
Sumas-JC at BNRR	D5566	37.29	12	42.80	2,631	40.14	1,016
Sumas-BnCrk at BNRR	D6878	40.07	45	45.80	327	43.81	215
Huntingdon	U366	32.53	1836	32.89	2,029	32.73	1,956
Bndry Rd 1	D664	33.18	0	34.05	616	33.76	126
2nd and Bndry Rd	F433	34.18	28	35.07	1,194	34.67	503
Bndry Rd 2	D674	30.86	146	31.44	1,088	31.15	518
Bndry Rd 3	F439	31.28	6	31.74	305	31.59	131
Bndry Rd 4	F438	31.28	4	31.74	260	31.59	119
Bndry Rd 5	F440	33.04	250	33.38	614	33.24	448
USA out	many	—	2272	—	6,740	—	3,836
Cherry Rd-JC	D600	37.27	237	40.29	2,913	39.28	1,627
Heron Lane-JC	D616	37.16	253	38.05	1,132	37.71	787

reduction obtained with major changes in the overflow corridor. As Table 1–7 shows there were major changes, as expected, in areas behind roads that had been raised. The limits on raising roads were generally set by levels at the edges of the overflow corridor. Raising railroads was not considered even remotely feasible so these often set a limit on the increase in water level. This of course assumes that the railroad fills wills sustain the increased heads and that any culverts will have flap gates installed to prevent backflow from the overflow corridor.

Raising the selected roads added 3070 acre-feet to the maximum amount of water stored in the overflow corridor during the flood event. However, this increased storage only reduced the peak flow at the international border by about 600 ft^2/s. Why such a small reduction? The small reduction occurs because much of the storage is filled before the peak flow reaches the storage. For

TABLE 1–6: Scenario Results: Effect of Assumed Failure of SBCRR Fill

Location of Result	Node in Model	Full OvrQ Diff. MaxZ (ft)	NFI – Full OvrQ Diff. MaxQ (cfs)	%Diff. MaxQ
Tom Rd-Trib 3	D6234	0.00	0	0.0
Hampton Rd-JC	D5060	0.00	0	0.0
Van Buren Ovrq	many	—	0	0.0
Lindsay Rd-JC	D5088	0.00	0	0.0
Lindsay Rd-JC Trib 3	D6288	0.00	-2	0.0
Badger Rd-JC	D5142	0.00	-1	0.0
Badger Rd-JC Trib 1	D6442	0.00	0	0.0
Badger Rd-Jc Trib 1 of 1	D6342	0.00	-2	0.0
Clearbrook Rd-JC	D5198	0.00	0	0.0
Clearbrook Rd-JC Trib 1	D6498	0.00	0	0.0
Clearbrook Rd-JC Trib 1 of 1	D6648	0.00	-1	0.0
Clearbrook Rd-BnCrk	D6854	0.00	0	0.0
Garrison Rd-JC	D5268	0.00	0	0.0
Garrison Rd-BnCrk	D6836	0.00	0	0.0
Garrison Rd-REFLRW	D6936	0.00	0	0.0
Halverstick Rd-JC	D5325	0.00	0	0.0
Sumas-JC at BNRR	D5336	0.00	0	0.0
Sumas-JC at BNRR	D5566	0.00	3	0.1
Sumas-BnCrk at BNRR	D6878	0.00	0	0.0
Huntingdon	U366	0.29	-88	-4.2
Bndry Rd 1	D664	0.00	2	0.1
2nd and Bndry Rd	F433	0.00	2	0.1
Bndry Rd 2	D674	0.29	2	0.1
Bndry Rd 3	F439	0.16	-105	-17.2
Bndry Rd 4	F438	0.16	188	36.1
Bndry Rd 5	F440	0.10	169	18.3
USA out	many	—	-4	0.0
Cherry Rd-JC	D600	0.00	0	0.0
Heron Lane-JC	D616	0.00	0	0.0

storage to be effective, it must be available near the peak. This can be accomplished by protecting the storage from the earlier flows and them making it available near the peak. However, to do this often proves difficult, and may require real-time quantitative information on the flood hydrograph. Another means to accomplish a greater reduction is to have much larger storage so that additional storage remains when the peak arrives at the ponding area. That will prove difficult to accomplish in the overflow corridor.

Table 1–8 shows the outcome of not permitting overflow at Everson Main Street. As would be expected there is a significant reduction in water levels and flows through the overflow corridor. The only flows are those derived by runoff from the Sumas River itself. However, as shown above for Reaches 1 through 4, there are major increases in flooding with some heavily traveled roads closed for 15 hours or more for this scenario.

Limiting the overflow by raising the bank near Everson has the effects shown in Table 1–9. Again as would be expected such a change at Everson will cause major reductions in both flow and water level in the overflow corridor. But again, Reaches 1 through 4 have significant road closures that do not exist in the Full Overflow scenario, the base scenario for all comparisons shown here. There are also increases in flow and water level in the flood plains of the Nooksack some of which could be increased enough to damage roads or other structures.

The effects of the final scenario, combining extra storage with reduction in the peak flow at Everson Main Street, are shown in Table 1–10. This table shows what would be expected: major reductions for the flow at the border but with major increases in the overflow corridor and in Reaches 1 through 4. Notice that the increase in water level upstream of Tom Road is only $0.5ft$ less than the case with the full overflow and extra storage.

Figure 2 shows the plots of the total flow at the International border for five out the six scenarios. The scenario for the SBCRR not failing was not included because it would plot the same as the base scenario with failure of the SBCRR. It is interesting to note that there is considerable volume of flow across the border even without overflow at Everson Main Street. Thus Figure 3 shows the cumulation of the flows across the border for the same scenarios and the same time span. The no overflow case shows that about $20,000acre - feet$ of water crossed the border in the eight-day span of time. Limiting the flow at Everson Main Street increases that value to about $26,000acre - feet$. This adds 30 per cent to the volume. The full overflow case shows about $35,000acre - feet$ of water crossing the border which adds about 75 percent to the volume. This is more than twice as much as when the peak flow is limited to the 1990 value. The reduction in volume of water crossing Everson Main Street is the principal reason for the greater effectiveness of the extra storage when the peak flow at Everson Main Street is limited to its approximate 1990 value. The available storage behind the roads remains the same but the volume of flow has been reduced by $9,000/15,000 = 0.6$.

TABLE 1–7: Scenario Results: Effect of Extra Storage with Full Overflow

Location of Result	Node in Model	Full OvrQ Diff. MaxZ (ft)	XStr – Diff. MaxQ (cfs)	Full OvrQ %Diff. MaxQ
Tom Rd-Trib 3	D6234	6.70	-4,841	-48.3
Hampton Rd-JC	D5060	6.32	542	200.6
Van Buren Ovrq	many	—	4,124	631.5
Lindsay Rd-JC	D5088	4.18	1,150	249.3
Lindsay Rd-JC Trib 3	D6288	4.53	-1,289	-12.4
Badger Rd-JC	D5142	1.86	1,218	84.4
Badger Rd-JC Trib 1	D6442	1.91	-868	-46.7
Badger Rd-Jc Trib 1 of 1	D6342	0.81	-3,460	-51.1
Clearbrook Rd-JC	D5198	0.66	659	55.0
Clearbrook Rd-JC Trib 1	D6498	1.02	-1,334	-92.4
Clearbrook Rd-JC Trib 1 of 1	D6648	1.48	-3,868	-99.3
Clearbrook Rd-BnCrk	D6854	0.10	-1,819	-88.9
Garrison Rd-JC	D5268	1.75	748	56.6
Garrison Rd-BnCrk	D6836	0.76	437	185.1
Garrison Rd-REFLRW	D6936	2.16	-1,240	-43.4
Halverstick Rd-JC	D5325	0.11	-69	-3.8
Sumas-JC at BNRR	D5336	-0.09	-103	-3.5
Sumas-JC at BNRR	D5566	-0.09	-266	-5.4
Sumas-BnCrk at BNRR	D6878	-0.63	-76	-18.9
Huntingdon	U366	-0.03	-5	-0.3
Bndry Rd 1	D664	-0.02	-71	-4.9
2nd and Bndry Rd	F433	-0.03	-62	-3.3
Bndry Rd 2	D674	-0.04	-115	-5.3
Bndry Rd 3	F439	-0.02	-39	-6.3
Bndry Rd 4	F438	-0.02	-33	-6.4
Bndry Rd 5	F440	-0.02	-41	-4.5
USA out	many	—	-619	-5.2
Cherry Rd-JC	D600	-0.07	34	1.0
Heron Lane-JC	D616	-0.03	-10	-0.6

TABLE 1–8: Scenario Results: Effect of No Overflow at Everson Main Street

Location of Result	Node in Model	No OvrQ – Full OvrQ Diff. MaxZ (ft)	Diff. MaxQ (cfs)	%Diff. MaxQ
Tom Rd-Trib 3	D6234	-2.55	-9,903	-98.8
Hampton Rd-JC	D5060	-2.52	-150	-55.7
Van Buren Ovrq	many	—	-653	-100.0
Lindsay Rd-JC	D5088	-2.58	-342	-74.1
Lindsay Rd-JC Trib 3	D6288	-2.62	-10,255	-99.0
Badger Rd-JC	D5142	-3.02	-1,224	-84.8
Badger Rd-JC Trib 1	D6442	-14.51	-1,860	-100.0
Badger Rd-Jc Trib 1 of 1	D6342	-10.87	-6,767	-100.0
Clearbrook Rd-JC	D5198	-3.94	-980	-81.7
Clearbrook Rd-JC Trib 1	D6498	-3.23	-1,417	-98.2
Clearbrook Rd-JC Trib 1 of 1	D6648	-4.35	-3,895	-100.0
Clearbrook Rd-BnCrk	D6854	-3.75	-2,007	-98.1
Garrison Rd-JC	D5268	-3.70	-1,084	-82.0
Garrison Rd-BnCrk	D6836	-2.53	-196	-83.2
Garrison Rd-REFLRW	D6936	-4.46	-2,849	-99.8
Halverstick Rd-JC	D5325	-6.80	-1,591	-87.7
Sumas-JC at BNRR	D5336	-6.98	-2,719	-92.4
Sumas-JC at BNRR	D5566	-7.22	-4,902	-99.8
Sumas-BnCrk at BNRR	D6878	-6.35	-357	-88.8
Huntingdon	U366	-0.55	-282	-13.3
Bndry Rd 1	D664	-1.12	-1,466	-100.0
2nd and Bndry Rd	F433	-1.19	-1,841	-98.5
Bndry Rd 2	D674	-0.98	-2,010	-93.3
Bndry Rd 3	F439	-0.67	-606	-98.9
Bndry Rd 4	F438	-0.67	-515	-99.1
Bndry Rd 5	F440	-0.54	-673	-73.0
USA out	many	—	-9,642	-80.9
Cherry Rd-JC	D600	-3.91	-3,066	-92.8
Heron Lane-JC	D616	-1.26	-1,250	-83.1

TABLE 1–9: Scenario Results: Effect of Limiting Overflow Peak to that of 1990

Location of Result	Node in Model	1990 OvrQ – Full OvrQ Diff. MaxZ (ft)	Diff. MaxQ (cfs)	%Diff. MaxQ
Tom Rd-Trib 3	D6234	-0.76	-4,721	-47.1
Hampton Rd-JC	D5060	-0.05	-15	-5.4
Van Buren Ovrq	many	—	-190	-29.1
Lindsay Rd-JC	D5088	-0.45	-302	-65.4
Lindsay Rd-JC Trib 3	D6288	-0.57	-4,616	-44.6
Badger Rd-JC	D5142	-0.88	-551	-38.2
Badger Rd-JC Trib 1	D6442	-1.23	-1,108	-59.5
Badger Rd-Jc Trib 1 of 1	D6342	-0.48	-2,665	-39.4
Clearbrook Rd-JC	D5198	-0.58	-265	-22.1
Clearbrook Rd-JC Trib 1	D6498	-0.15	-199	-13.8
Clearbrook Rd-JC Trib 1 of 1	D6648	-0.64	-1,949	-50.0
Clearbrook Rd-BnCrk	D6854	-0.78	-1,200	-58.6
Garrison Rd-JC	D5268	-0.28	-41	-3.1
Garrison Rd-BnCrk	D6836	-0.31	-27	-11.5
Garrison Rd-REFLRW	D6936	-0.51	-1,180	-41.3
Halverstick Rd-JC	D5325	-1.47	-133	-7.3
Sumas-JC at BNRR	D5336	-1.70	-1,040	-35.4
Sumas-JC at BNRR	D5566	-1.72	-2,282	-46.4
Sumas-BnCrk at BNRR	D6878	-0.62	-75	-18.5
Huntingdon	U366	-0.20	-89	-4.2
Bndry Rd 1	D664	-0.25	-849	-57.9
2nd and Bndry Rd	F433	-0.30	-675	-36.1
Bndry Rd 2	D674	-0.39	-1,067	-49.5
Bndry Rd 3	F439	-0.21	-308	-50.2
Bndry Rd 4	F438	-0.21	-259	-49.9
Bndry Rd 5	F440	-0.20	-309	-33.5
USA out	many	—	-5,174	-43.4
Cherry Rd-JC	D600	-0.90	-390	-11.8
Heron Lane-JC	D616	-0.37	-372	-24.7

TABLE 1–10: Scenario Results: Effect of Limiting Overflow Peak to that of 1990 with Extra Storage

Location of Result	Node in Model	1990 OvrQ – Full OvrQ Diff. MaxZ (ft)	Diff. MaxQ (cfs)	%Diff. MaxQ
Tom Rd-Trib 3	D6234	6.26	-7,900	-78.8
Hampton Rd-JC	D5060	6.16	469	173.9
Van Buren Ovrq	many	—	2,269	347.5
Lindsay Rd-JC	D5088	3.71	388	84.1
Lindsay Rd-JC Trib 3	D6288	4.06	-6,484	-62.6
Badger Rd-JC	D5142	-0.22	-122	-8.5
Badger Rd-JC Trib 1	D6442	1.49	-1,447	-77.8
Badger Rd-Jc Trib 1 of 1	D6342	0.27	-5,590	-82.6
Clearbrook Rd-JC	D5198	-0.61	-84	-7.0
Clearbrook Rd-JC Trib 1	D6498	0.48	-1,339	-92.7
Clearbrook Rd-JC Trib 1 of 1	D6648	0.92	-3,873	-99.4
Clearbrook Rd-BnCrk	D6854	-0.68	-1,825	-89.2
Garrison Rd-JC	D5268	0.00	29	2.2
Garrison Rd-BnCrk	D6836	-0.33	-26	-11.1
Garrison Rd-REFLRW	D6936	0.70	-2,455	-86.0
Halverstick Rd-JC	D5325	-3.75	-568	-31.3
Sumas-JC at BNRR	D5336	-4.26	-2,133	-72.5
Sumas-JC at BNRR	D5566	-4.37	-3,897	-79.3
Sumas-BnCrk at BNRR	D6878	-2.62	-187	-46.5
Huntingdon	U366	-0.36	-163	-7.7
Bndry Rd 1	D664	-0.54	-1,340	-91.4
2nd and Bndry Rd	F433	-0.69	-1,366	-73.1
Bndry Rd 2	D674	-0.68	-1,637	-76.0
Bndry Rd 3	F439	-0.37	-481	-78.6
Bndry Rd 4	F438	-0.37	-400	-77.0
Bndry Rd 5	F440	-0.34	-475	-51.5
USA out	many	—	-8,078	-67.8
Cherry Rd-JC	D600	-1.90	-1,677	-50.8
Heron Lane-JC	D616	-0.71	-716	-47.7

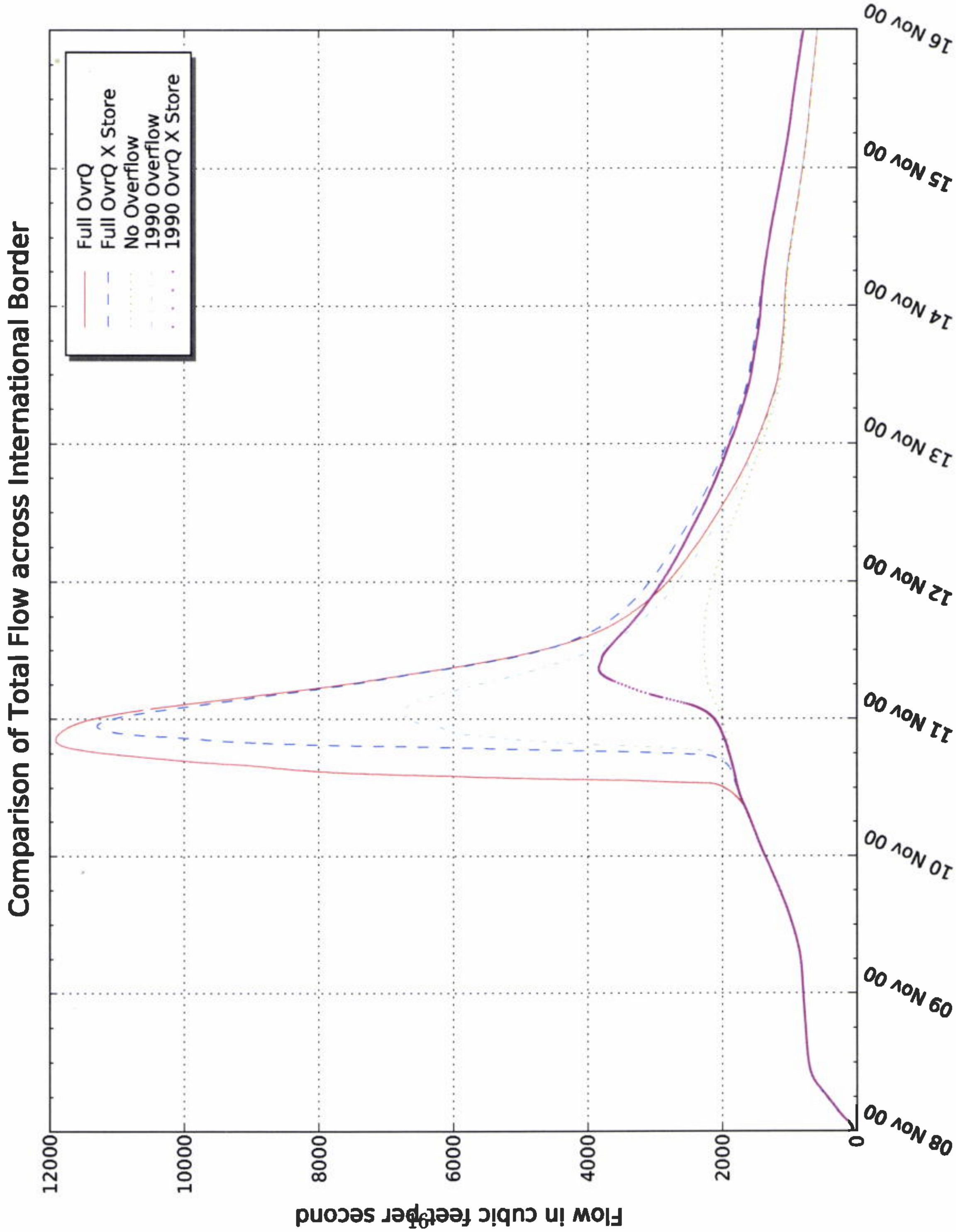

Figure 2: Comparison of Total Flow across International Border

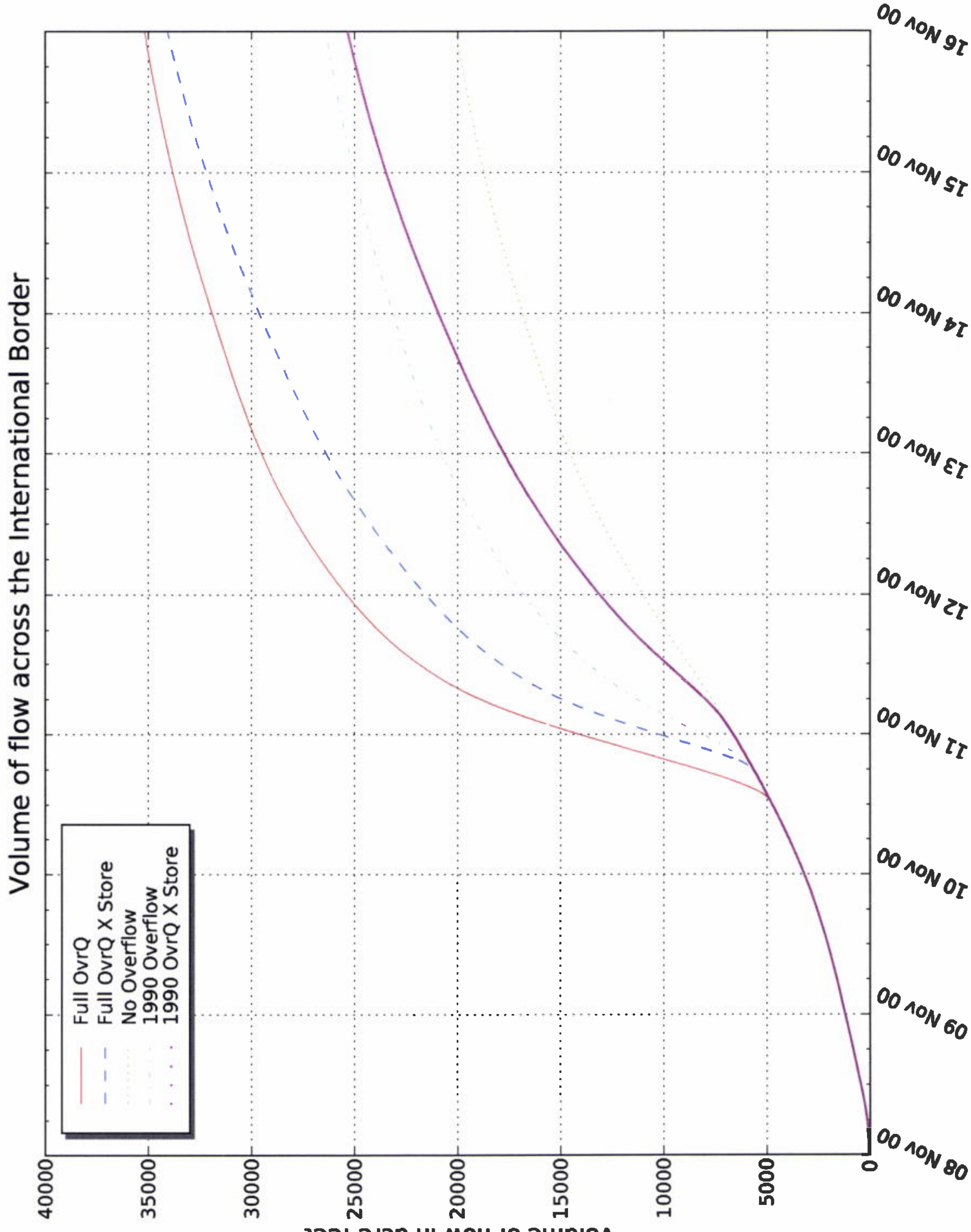

Figure 3: Volume of Flow across the International Border