APPENDIX C

HEC-6 Model Supplemental Tables and Figures

Table C-1: Scour Evaluation History

Submittal	Scenario	Scenario Description	General Conclusions
August 8, 2003 Report - Feasibility study focusing on verifying sequencing and timing of actions relative to flow conditions to determine optimal timing to minimize TSS concentrations	1a	No Action, Average Flows	❖ Significantly changing water surface elevations due to both reservoir drawdown and dam removal appear to be more of a driver in the model predicting significant net scour from the reservoir and resulting increases in TSS concentrations downstream than whether there is average, high, or low flows occuring in the year of the dam removal. ❖ Under all scenarios where dam is removed, most of the sediment in the existing lower reservoir channels (i.e. SAA III) is predicted to scour. ❖ Scheduling signficant drawdown steps to coincide with May and June's seasonal high flows causes more total load to scour but, the high flows dilute sediment scour loads resulting in decreased downstream TSS concentrations compared to other times of the year. This is also the case with scheduling scour events during high flow years versus low flow years.
	1b	No Action, 10-Yr Flow in Year 3	
	2a	EPA's Cleanup Proposal Proposed Action for Lowering Reservoir Level to Facilitate Access for Sheetpile Wall Installation Starting July Yr 1 for 9 months, Average Flow	
	2b	EPA's Cleanup Proposal Proposed Action for Lowering Reservoir Level to Facilitate Access for Sheetpile Wall Installation Starting July Yr 1 for 9 months, 10 Yr Flow in Year 3	
	3a	Staged Reservoir Drawdown with Powerhouse Inlet Conversion in Yr 1, Average Flow	
	3b	Staged Reservoir Drawdown with Powerhouse Inlet Conversion in Yr 1, 10-Yr Flow in Year 3	
	4a	Staged Radial Gate Opening in January Yr 1, Dam Removal in May Yr 1, Average Flow	
	4b	Staged Radial Gate Opening in January Yr 1, Dam Removal in May Yr 1, 10-Yr Flow in Year 3	
	5a	Staged Radial Gate Opening in January Yr 1, Staged Powerhouse Inlets Converted in March Yr 1, Dam Removal Completed in May Yr 2, Average Flow	
	5b	Staged Radial Gate Opening in January Yr 1, Staged Powerhouse Inlets Converted in March Yr 1, Dam Removal Completed in May Yr 2, 10-Yr Flow in Year 3	
	6a	Staged Radial Gate Opening in January Yr 1, Staged Powerhouse Inlets Converted in March Yr 1, Dam Removal Completed in September Yr 2, Average Flow	
	6b	Staged Radial Gate Opening in January Yr 1, Staged Powerhouse Inlets Converted in March Yr 1, Dam Removal Completed in September Yr 2, 10-Yr Flow in Year 3	
	7a	Staged Radial Gate Opening in January Yr 1, Staged Powerhouse Inlets Converted in March Yr 2, Dam Removal Completed in May Yr 3, Average Flow	
	7b	Staged Radial Gate Opening in January Yr 1, Staged Powerhouse Inlets Converted in March Yr 2, Dam Removal Completed in May Yr 3, 10-Yr Flow in Year 3	
	7c	Staged Radial Gate Opening in January Yr 1, Staged Powerhouse Inlets Converted in March Yr 2, Dam Removal Completed in May Yr 3, Low Flow in Year 3	
November 6, 2003 Report - Partial bypass channel in Area I around the SAA III sediments designated by the EPA as having elevated metals was evaluated and compared against some of the August models	1a	No Action, Average Flow	❖ A partial bypass would decrease about 70% of the total sediment load predicted to scour from the lower reservoir (i.e., the SAA III area including existing CFR channel between the dam and Duck Bridge and the BFR channel between the dam and the I-90 bridge) under a dam removal scenario.
	1b	No Action, 10-Yr Flow in Year 3	
	2a	EPA's Cleanup Proposal Proposed Action for Lowering Reservoir Level to Facilitate Access for Sheetpile Wall Installation Starting July Yr 1 for 9 months, Average Flow	
	2b	EPA's Cleanup Proposal Proposed Action for Lowering Reservoir Level to Facilitate Access for Sheetpile Wall Installation Starting July Yr 1 for 9 months, 10 Yr Flow in Year 3	
	3a	Staged Reservoir Drawdown with Powerhouse Inlet Conversion in Yr 1, Average Flow	
	3b	Staged Reservoir Drawdown with Powerhouse Inlet Conversion in Yr 1, 10-Yr Flow in Year 3	
	7a	Staged Radial Gate Opening in January Yr 1, Staged Powerhouse Inlets Converted in March Yr 2, Dam Removal Completed in May Yr 3, Average Flow	
	7b	Staged Radial Gate Opening in January Yr 1, Staged Powerhouse Inlets Converted in March Yr 2, Dam Removal Completed in May Yr 3, 10-Yr Flow in Year 3	
	7c	Staged Radial Gate Opening in January Yr 1, Staged Powerhouse Inlets Converted in March Yr 2, Dam Removal Completed in May Yr 3, Low Flow in Year 3	
	8a	Partial Bypass Channel, Average Flow	
December 29, 2003 Report Supplement - Partial bypass channel modeling was extended downstream to include reach through Bitterroot River confluence	8a	Partial Bypass Channel, Average Flow	❖ Fine sediment (clays and silts) and smaller sands will remain as washload in the downstream reach for all flow conditions modeled ❖ Coarser sands will deposit temporarily in the downstream reach and then move through during the next high flow event.

Table C-2: HEC-6 Input Parameters

Category	Parameter	Value	Source	Comments
Geometry	Cross section	per section	2003 Land and Water Survey	UTM horizontal, NAVD88 vertical
	Reach lengths	per section	2003 Land and Water Survey	
	Overbanks	per section	2003 aerial photography and survey data	
	Roughness coefficient	varies by cross section	Starting values as recommended in RI/FS. Some values were changed during calibration.	
	Contraction/expansion	0.1/0.3	Default values	River planform is fairly uniform (no constrictions), so default values are likely reasonable.
Sediment	Inflowing Sediment Load	varies by hydrograph	USGS regression equations and gage station data.	
	Bed gradation	varies by cross section	Sediment core samples from cross section. If no core available, the gradation from the nearest cross section was used or Turah gradations if it was a gravel reach.	
	Suspended sediment gradation	CFR - from samples BFR - assumed to be same as CFR	Suspended sediment sample gradation data for two samples.	Suspended sediment gradation was assumed to be same for all sediment discharges.
	Moveable bed width	Generally set at area under water, varies by cross section	Default	Some areas of ineffective flow were set from field observations
	Moveable bed depth	Set at bedrock elevation, varies by cross section	2003/2004 Field Sampling Event, extrapolated from sheetpile wall cores adjacent to rivers	
	Cohesive sediment critical threshold values	Shear threshold for deposition = 0.02 lb/ft^2; Shear threshold for erosion = 0.05 lb/ft^2; Shear stress threshold for mass erosion = 0.1 lb/ft^2; Erosion rate of clay and silt = 1.5 lb/ft^2/hr; Slope of erosion rate curve = 60/hour.	Starting values from HEC-6 manual example. Critical deposition value is default. Critical threshold for erosion value compared to range of values in Chow, 1959, Figure 7-11.	These values are very difficult to obtain without specific experiments on the sediments under investigation. Sensitivity of the critical threshold for erosion and deposition tested.
	Sand transport function	Yang	Several total load transport functions were evaluated during the calibration process.	
	Specific Gravity	2.65	Average of 13 samples by CH2MHILL 2002.	
Hydrology	Hydrograph	Water Years 1999 (average annual), 1975 (25-year), 1992 (low flow)	USGS Gage Data	
	Rating curve for Reservoir Drawdown	Operating rule with Powerhouse inlets converted	Northwestern Energy	Converted from MPC Datum to NAVD88 Datum
	Rating curve for Dam Breach	3 curves developed (average annual, 25-yr, and low flow hydrograph)	Developed in Hec-RAS for most downstream cross section assuming uniform flow (normal depth assumption) for the given flow regimes.	
	Rating curve for Radial Gate Full Open and Rating curves for staged Inlet Conversion	Operating rule	Northwestern Energy	Converted from MPC Datum to NAVD88 Datum
	Flow duration	Fractions of of a day	Calibration	
	Temperature	Daily from 1 gage	USGS Gage Data	

Table C-3: HEC-6 Input Parameters Varied for Sensitivity Analysis

Parameter	Values Tested	Comments
Time Steps	0.0001 day, 0.001, 0.005, 0.01, 0.5	Found that 0.01-day time step was within 200 mg/L of results from smaller time steps and had much shorter computation time. This value was used during dynamic events. 0.5 days was used when TSS was at baseline.
Distance Between Cross Sections in CFR and BFR	70 to 150 feet	Shortened distance between cross section until instabilities were eliminated.
Distance Between Cross Sections in Bypass Channel	71 to 100 feet	Shortened distance between cross section until instabilities were eliminated.
Sediment Gradations on BFR	Finer Gradation: 11% Sand, 56% Silt, 33% Clay Coarser Gradation: 14% Gravel, 78% Sand, 6% Silt, 2% Clay	Picked the coarsest and finest gradation of EPA Cores, Sensitivity Analysis performed, Finer gradation from EPA Core 5, Coarser gradation from EPA Core 1B.
Sediment Gradations on CFR	Varied	Used gradations of the closest cores.
Thickness of Cross Section	Set at bedrock elevation, varies by cross section	Bedrock elevations based on 2003/2004 Field Sampling Event.
Discharge	USGS flows for given water years	Used actual flows for the 2002 and 1999 sensitivity analysis.
Critical Shear Stress for Erosion	model used: 0.05 lb/ft2 50% decrease: 0.025 lb/ft2 100% increase: 0.1 lb/ft2	Based on the HEC-6 manual example. Sensitivity performed.
Critical Shear Stress for Deposition	model used: 0.02 lb/ft2 50% decrease: 0.01 lb/ft2 100% increase: 0.04 lb/ft2	Based on the HEC-6 manual example. Sensitivity performed.
Manning's n Values	CFR overbanks range: 0.08 - 0.12 CFR channel range: 0.04 - 0.08 BFR overbanks range: 0.06 - 0.08 BFR channel range: 0.03 - 0.07 Bypass overbanks: 0.03 Bypass channel: 0.06 Bypass channel apron with energy disspator: 0.09	Started out with values recommended in the RI/FS. Some values were then changed due to field observation and then during calibration.

Notes:
CFR = Clark Fork River
BFR = Blackfoot River

Sensitivity Analysis Results

Table C-4: Comparison of Predicted and 2002 Measured Tons of Sediment Passing the Gage with Different Sediment Transport Functions

Sediment Transport Function	Volume (tons)	% Difference from Measured
2002 Measured	**66,248**	
Our Model (Yang)	88,237	33%
Madden 63	91,565	38%
Madden 85	93,322	41%
Copeland	61,268	-8%
50% crit	88,024	33%
100% crit	87,224	32%

Table C-5: Comparison of Predicted and 1999 Measured Tons of Sediment Passing the Gage with Different Sediment Transport Functions

Sediment Function	Volume (tons)	% Difference from Measured
1999 Measured	**88,405**	
Our Model (Yang)	132,995	101%
Copeland	86,179	30%

Table C-6: Comparison of Predicted Tons of Sediment Passing the Gage with Varied Critical Shear Stress

Parameter	Volume (tons)	% Difference from Model
2002 Model	**88,237**	
50% decrease of critical shear stress for deposition	88,024	0%
100% increase of critical shear stress for depostion	87,224	-1%
50% decrease of critical shear stress for erosion	87,466	-1%
100% increase of critical shear stress for erosion	84,528	-4%

Table C-7: Comparison of Predicted Tons of Sediment Passing the Gage with Varied Sediment Gradations on the Blackfoot River

Parameter	Volume (tons)	% Difference from Measured
2002 Measured	**66,248**	
EPA Core 5 - Finer Gradation (Our Model)	88,237	33%
EPA Core 1B - Coarser Gradation	87,445	32%

Figure C-1a: Comparison of the CFR Inflowing Sediment Load Rating Curves Provided by the USGS and the Curve Used in the Model After Calibration Adjustments for Bed Load

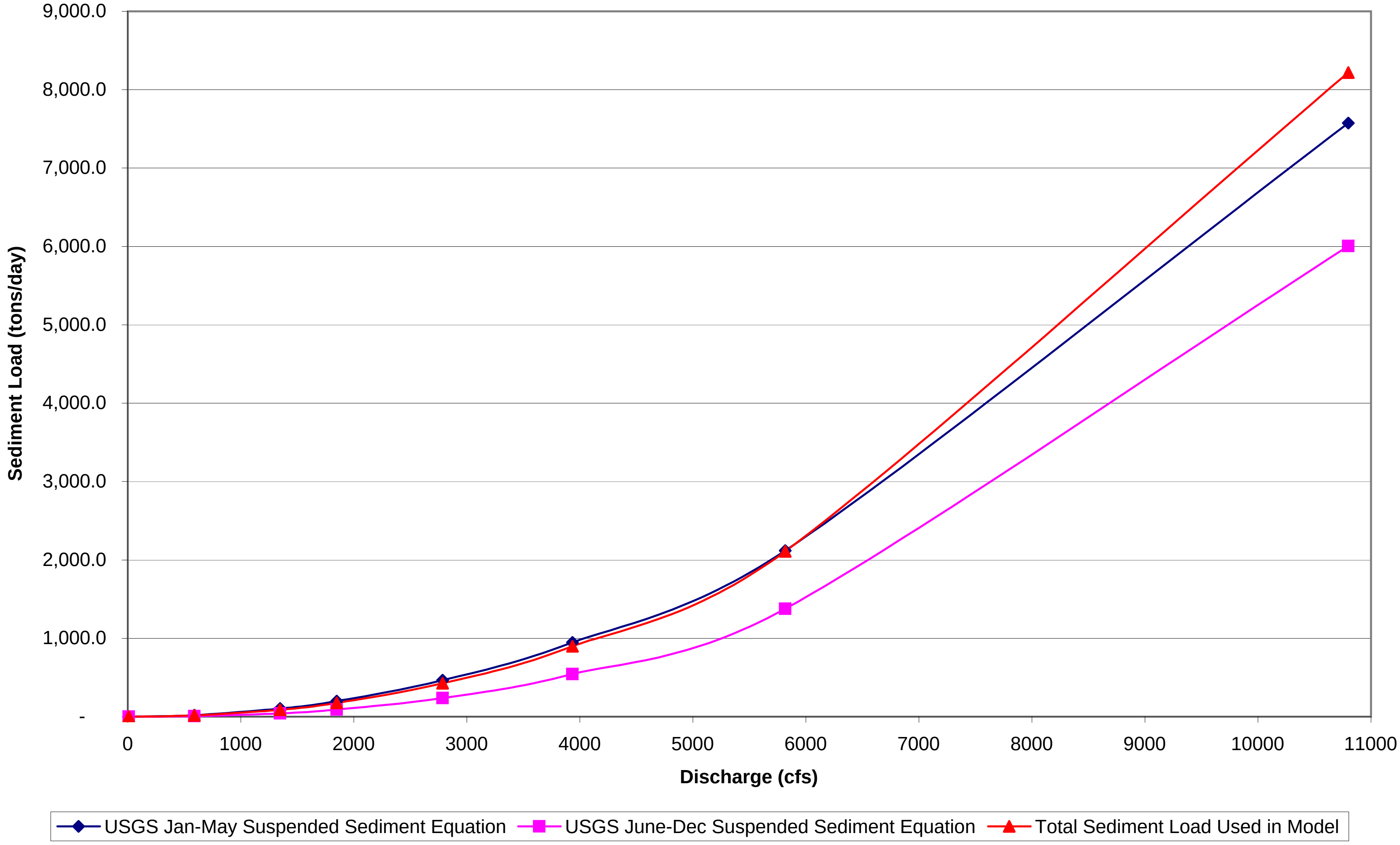
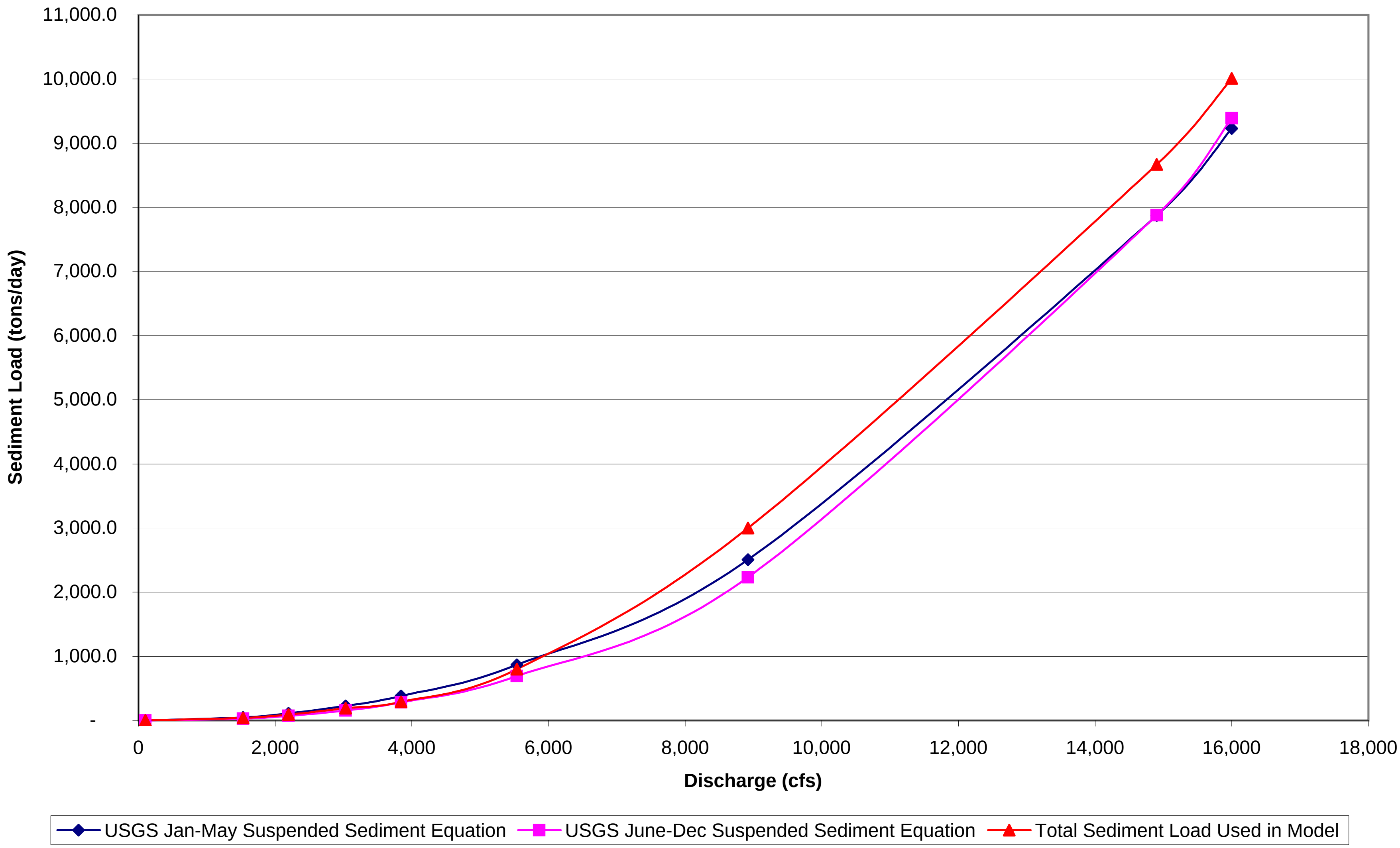
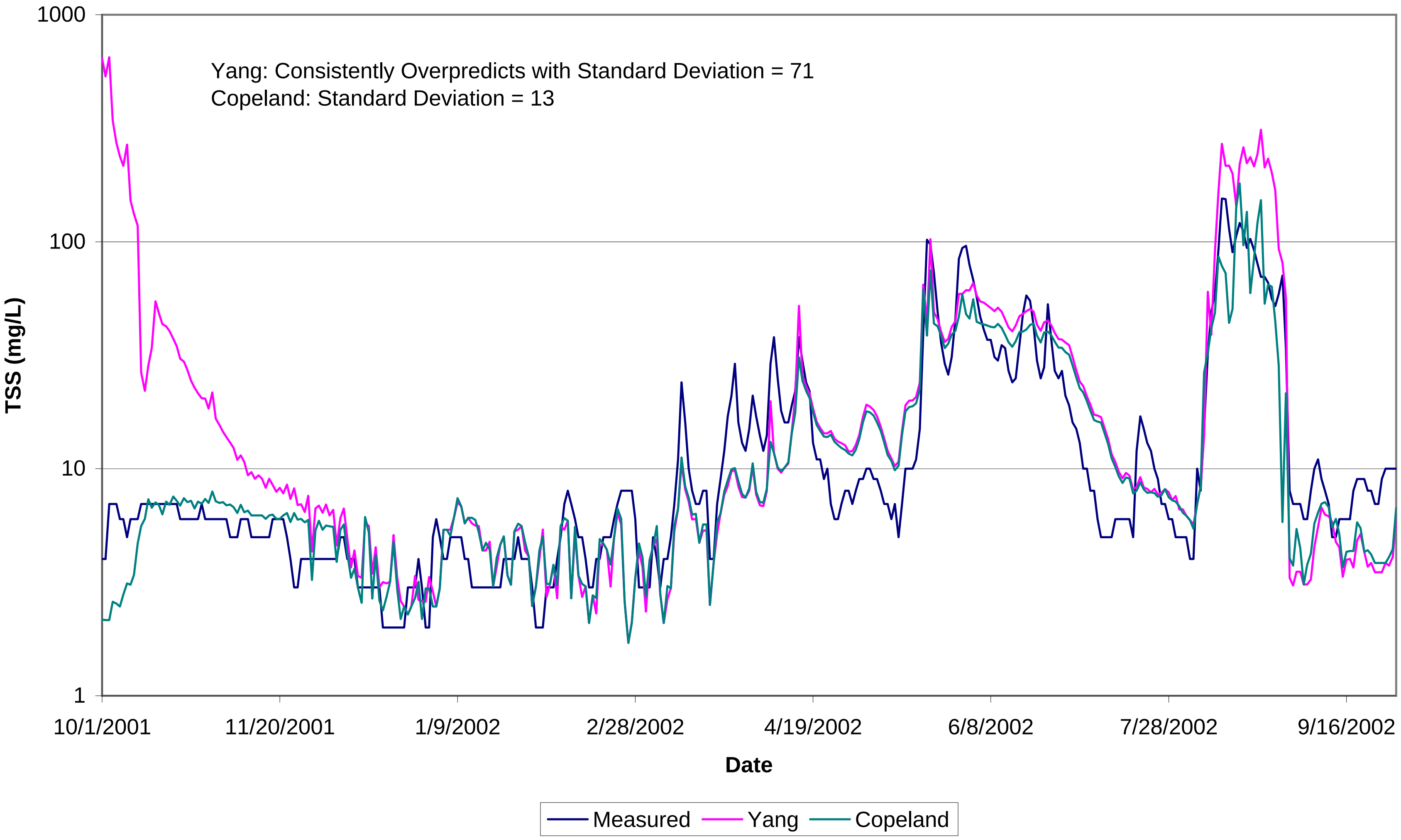


Figure C-1b: Comparison of the BFR Inflowing Sediment Load Rating Curves Provided by the USGS and the Curve Used in the Model After Calibration Adjustments for Bed Load



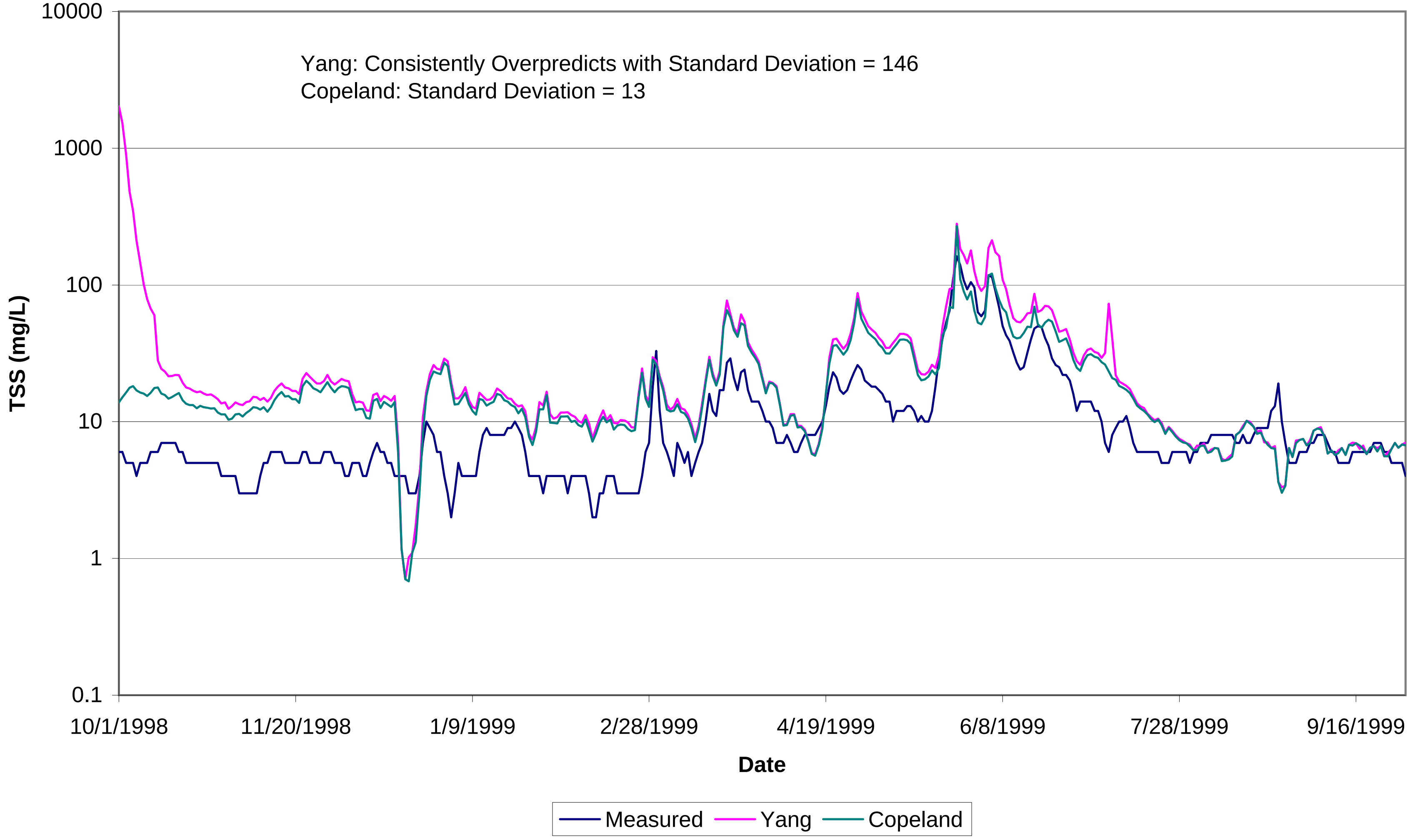
H:\Projects\Milltown RD-RA\Scour Evaluation\May 17, 2004 Submittal\Appendices\App C\Fig C-1a & b Inflowing Sediment LoadFig C-1b

Figure C-2: Sediment Transport Function Evaluation
Comparison of Predicted Sediment Concentrations Against Measured Concentrations
Water Year 2002



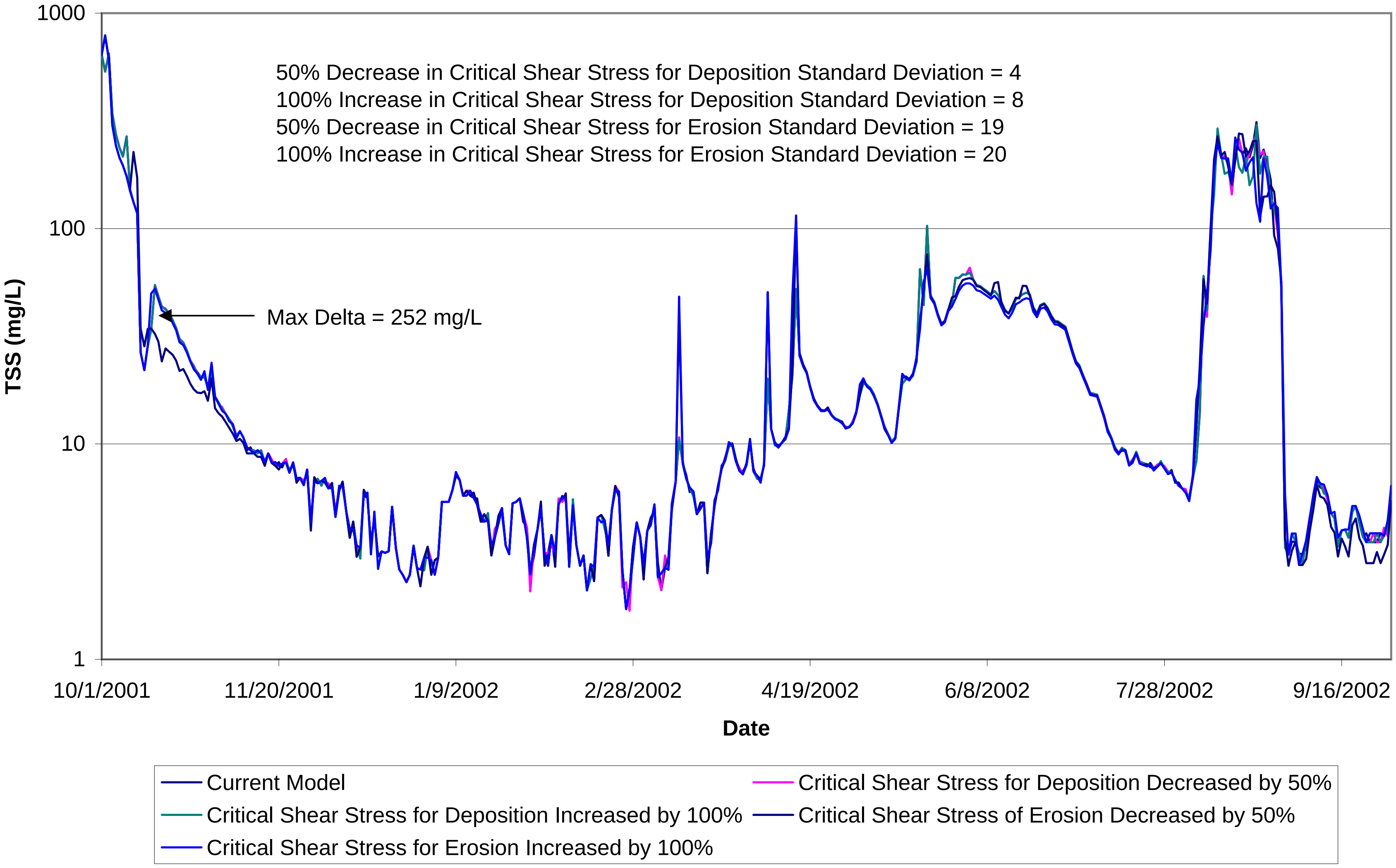
H:\Projects\Milltown RD-RA\Scour Evaluation\May 17, 2004 Submittal\Appendices\App C\Figs C2-5, Tab C4-7 Sensitivity Analysis Fig C-2

Figure C-3: Sediment Transport Function Evaluation:
Comparison of Predicted Sediment Concentrations Against Measured Concentrations
Water Year 1999



H:\Projects\Milltown RD-RA\Scour Evaluation\May 17, 2004 Submittal\Appendices\App C\Figs C2-5, Tab C4-7 Sensitivity Analysis Fig C-3

Figure C-4
Critical Shear Stress Sensitivity Analysis of Sediment Concentrations



H:\Projects\Milltown RD-RA\Scour Evaluation\May 17, 2004 Submittal\Appendices\App C\Figs C2-5, Tab C4-7 Sensitivity Analysis Fig C-4

Figure C-5
Bed Gradation Sensitivity Analysis of Sediment Concentrations

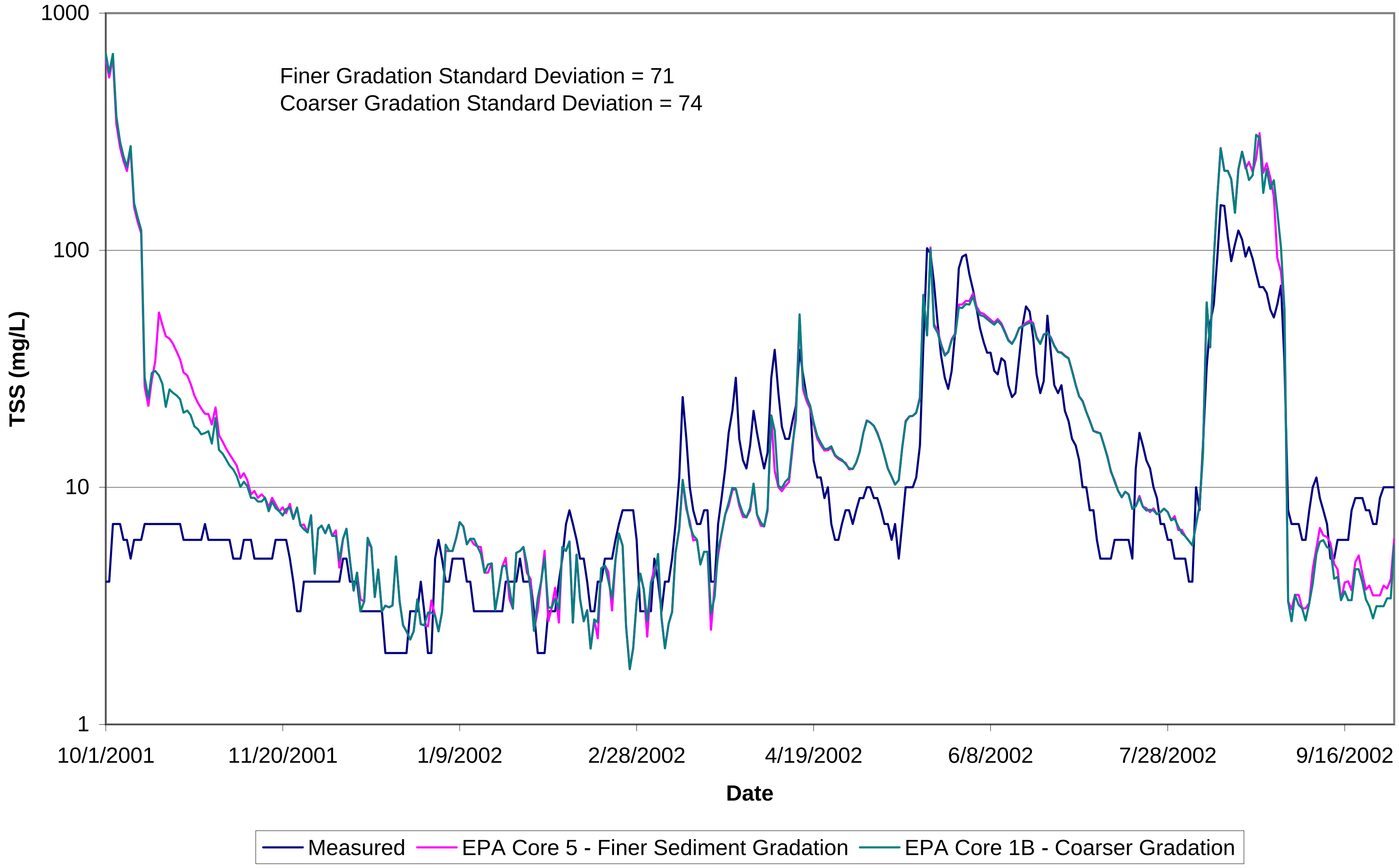
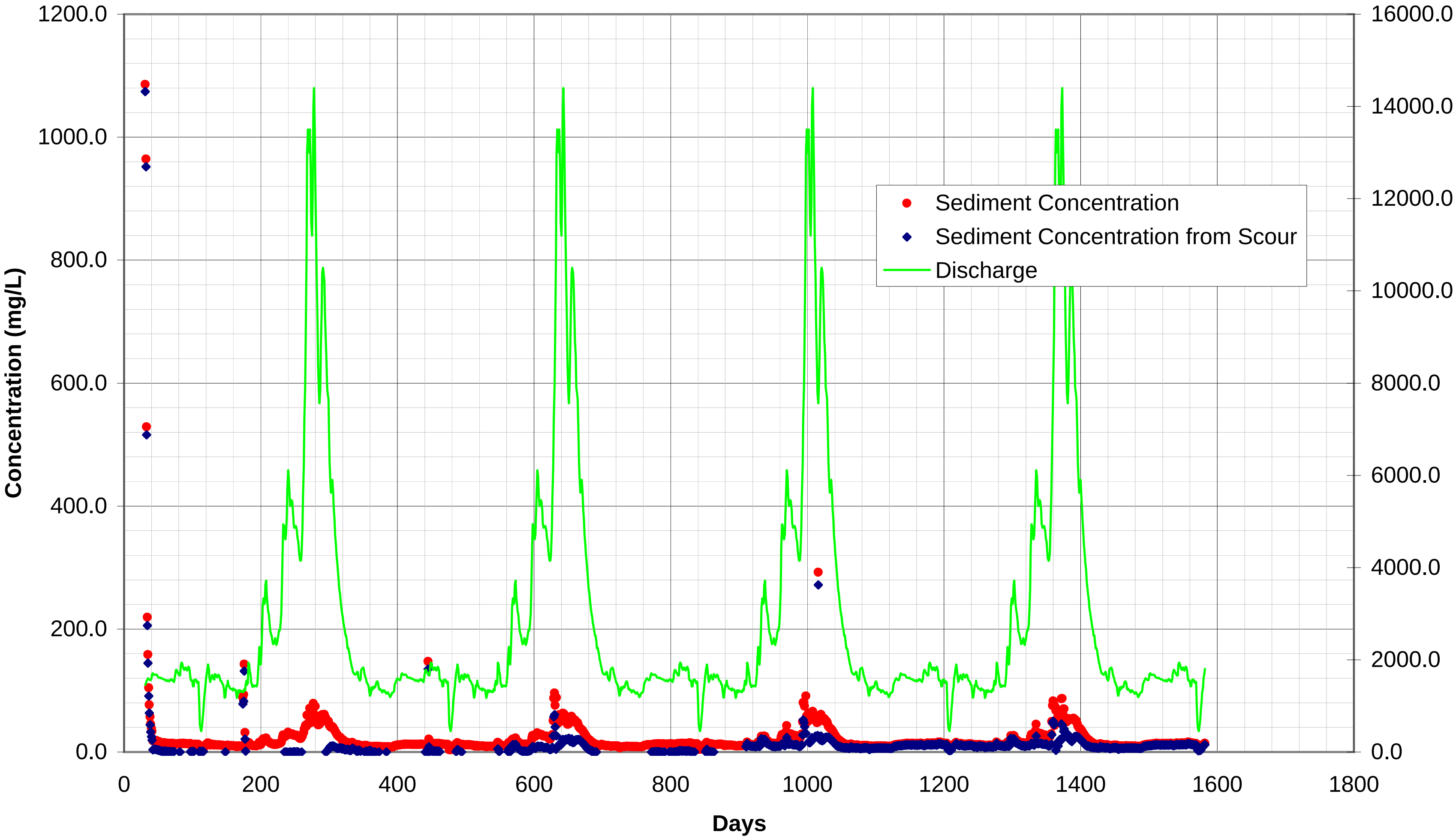
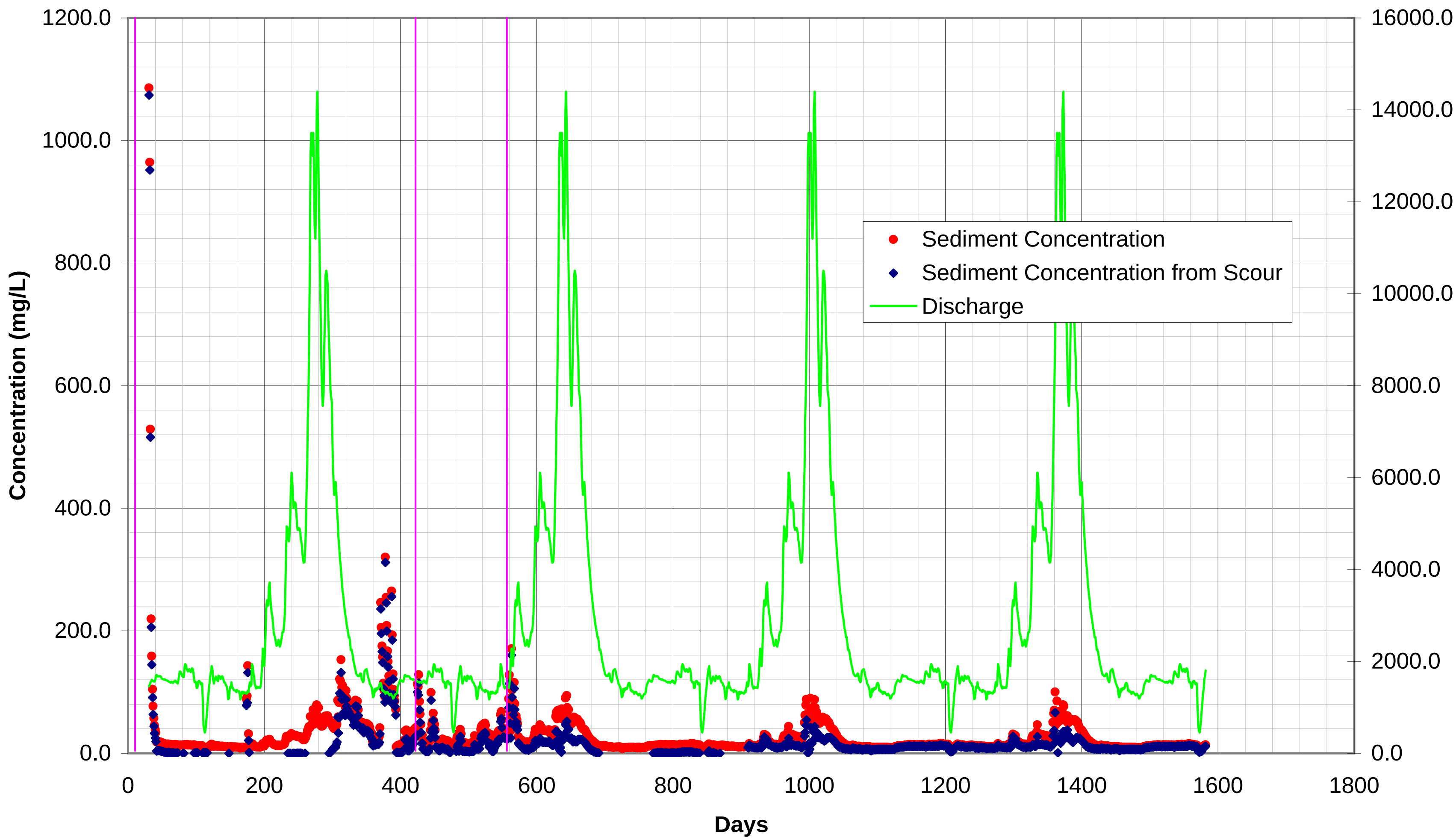


Figure C-6: Total Predicted Sediment Concentrations at Milltown Dam under Scenario 1 No Action



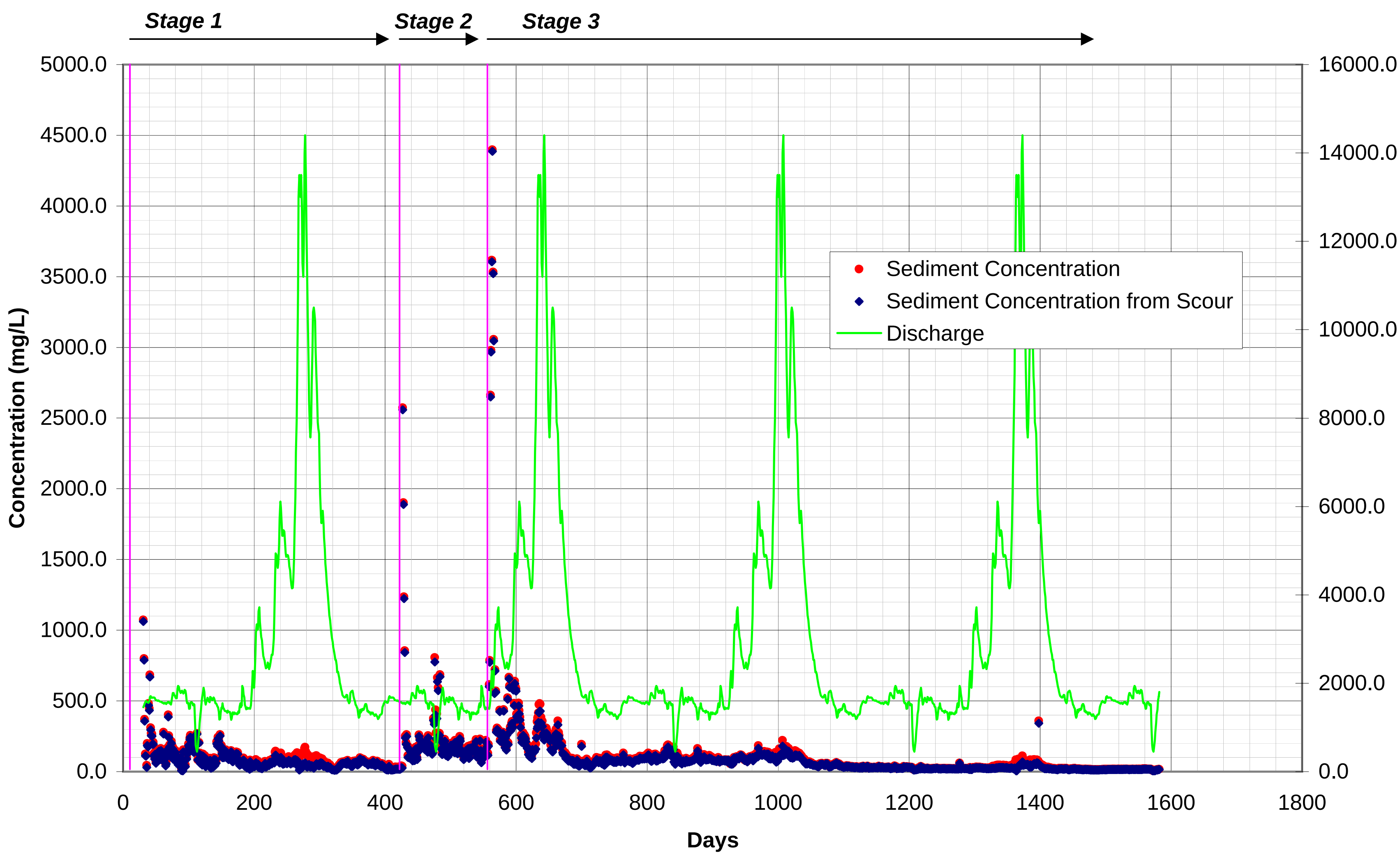
H:\Projects\Milltown RD-RA\Scour Evaluation\May 17, 2004 Submittal\Appendices\App C\Fig C-6 ConcCONTROL Fig C-6

Figure C-7: Total Predicted Sediment Concentrations at Milltown Dam under Scenario 2
EPA's Proposed Plan



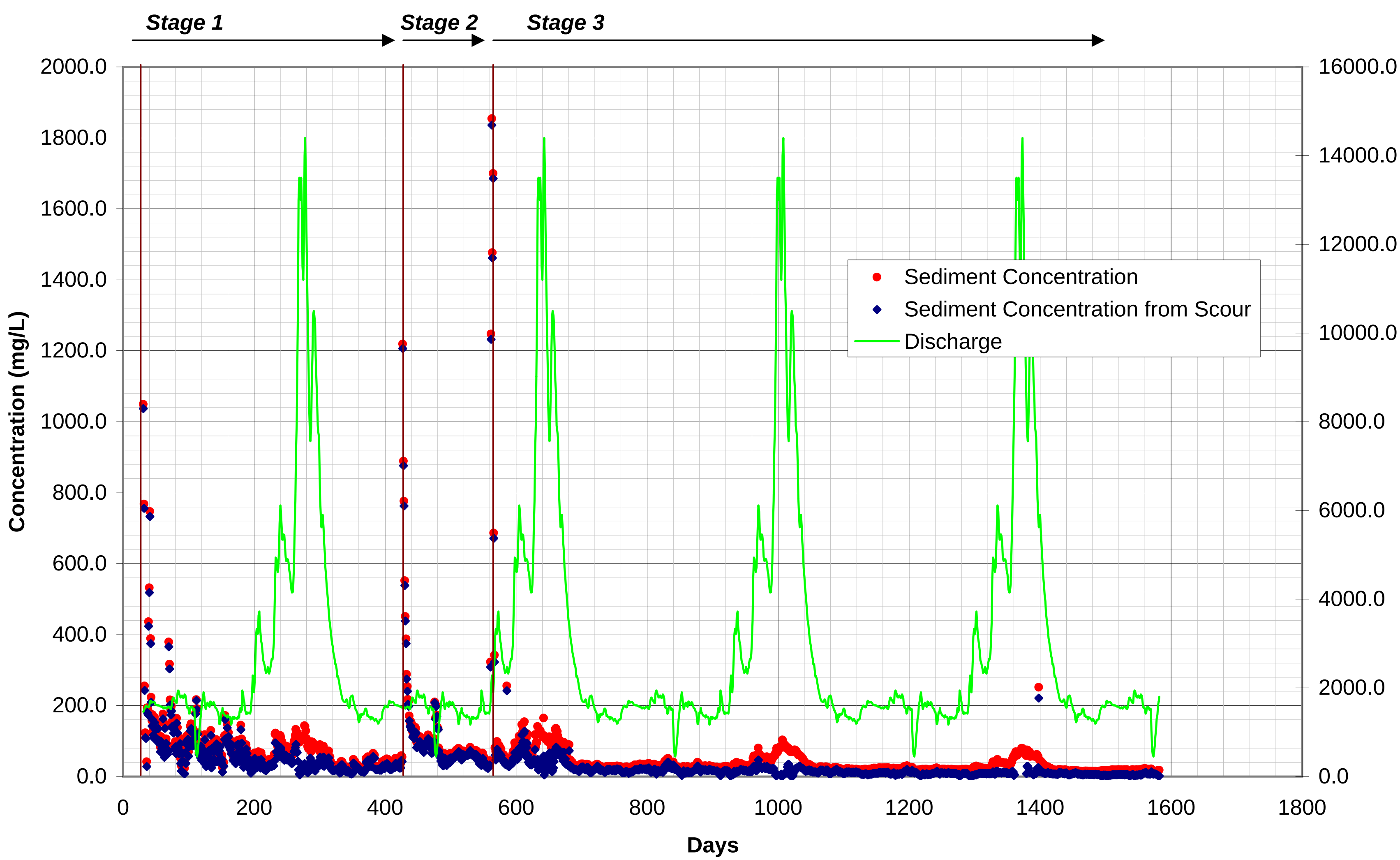
H:\Projects\Milltown RD-RA\Scour Evaluation\May 17, 2004 Submittal\Appendices\App C\Fig C-7 ConcEPA Fig C-7 EPA

Figure C-8: Total Predicted Sediment Concentrations under Scenario 3
Dam Removal with No Bypass



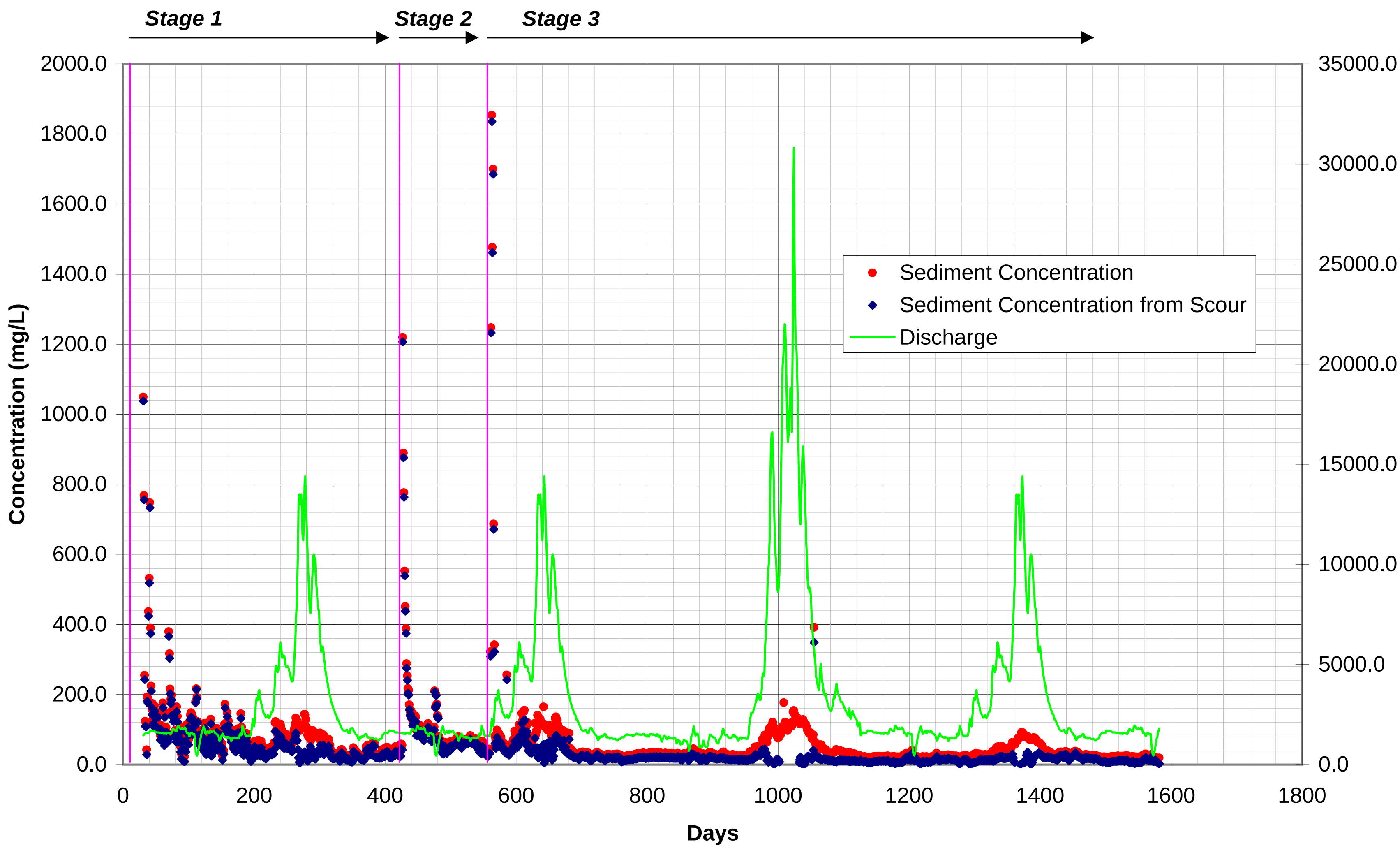
H:\Projects\Milltown RD-RA\Scour Evaluation\May 17, 2004 Submittal\Appendices\App C\Fig C-8 ConcNOBP Fig C-8 NOBP

Figure C-9: Total Predicted Sediment Concentrations at Milltown Dam under Scenario 4a Dam Removal with Full Bypass Channel, Average Flow



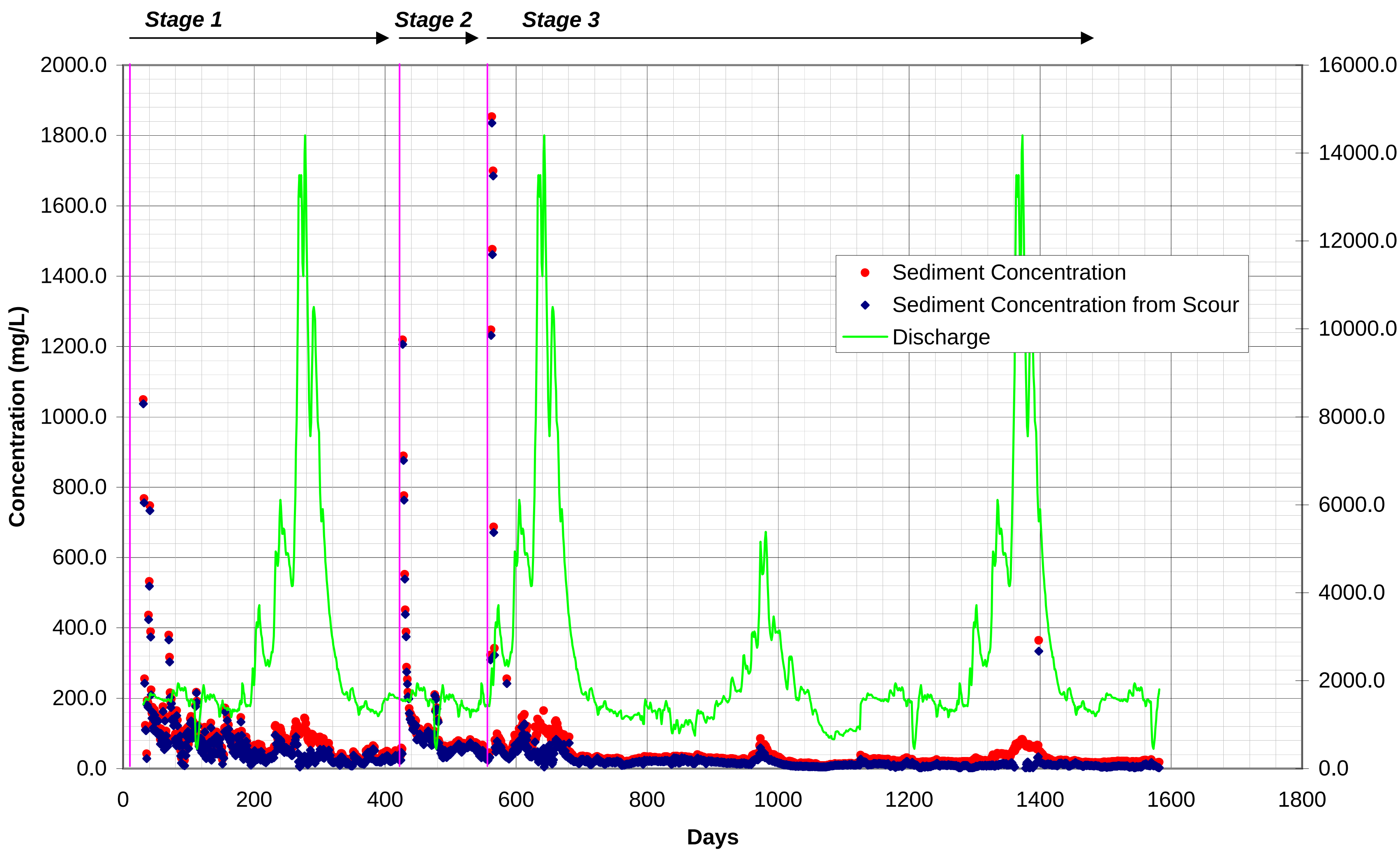
H:\Projects\Milltown RD-RA\Scour Evaluation\May 17, 2004 Submittal\Appendices\App C\Figs C-9, C12 Figure C-9

Figure C-10: Total Predicted Sediment Concentrations at Milltown Dam under Scenario 4b Dam Removal with Full Bypass, 25-Year Event in Water Year 2007



H:\Projects\Milltown RD-RA\Scour Evaluation\May 17, 2004 Submittal\Appendices\App C\Fig C-10 ConcHI Fig C-10 FBPHI_b

Figure C-11: Total Sediment Concentrations at Milltown Dam under Scenario 4C Dam Removal with Full Bypass, Low Flow in Water Year 2007



H:\Projects\Milltown RD-RA\Scour Evaluation\May 17, 2004 Submittal\Appendices\App C\Fig C-11 ConcLO Fig C-11 FBPLO_b

Figure C-12: Yearly Estimated Amount of Bed Material Scoured
Scenario 4a, Dam Removal with Full Bypass Channel, Average Flow

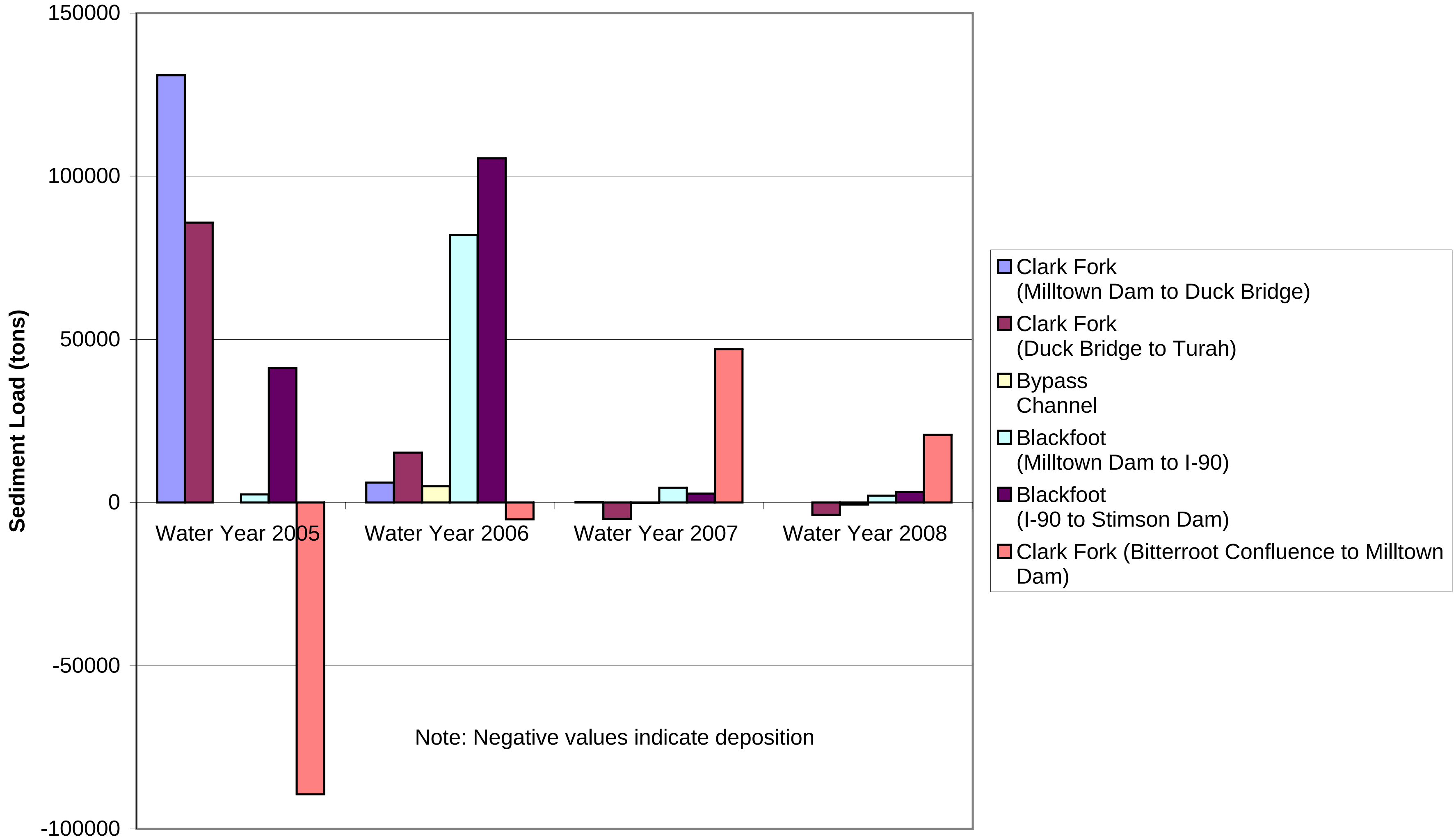


Figure C-13: Yearly Estimated Amount of Bed Material Scoured
Scenario 4b - Dam Removal with Full Bypass Channel - High Discharge in Water Year 2007

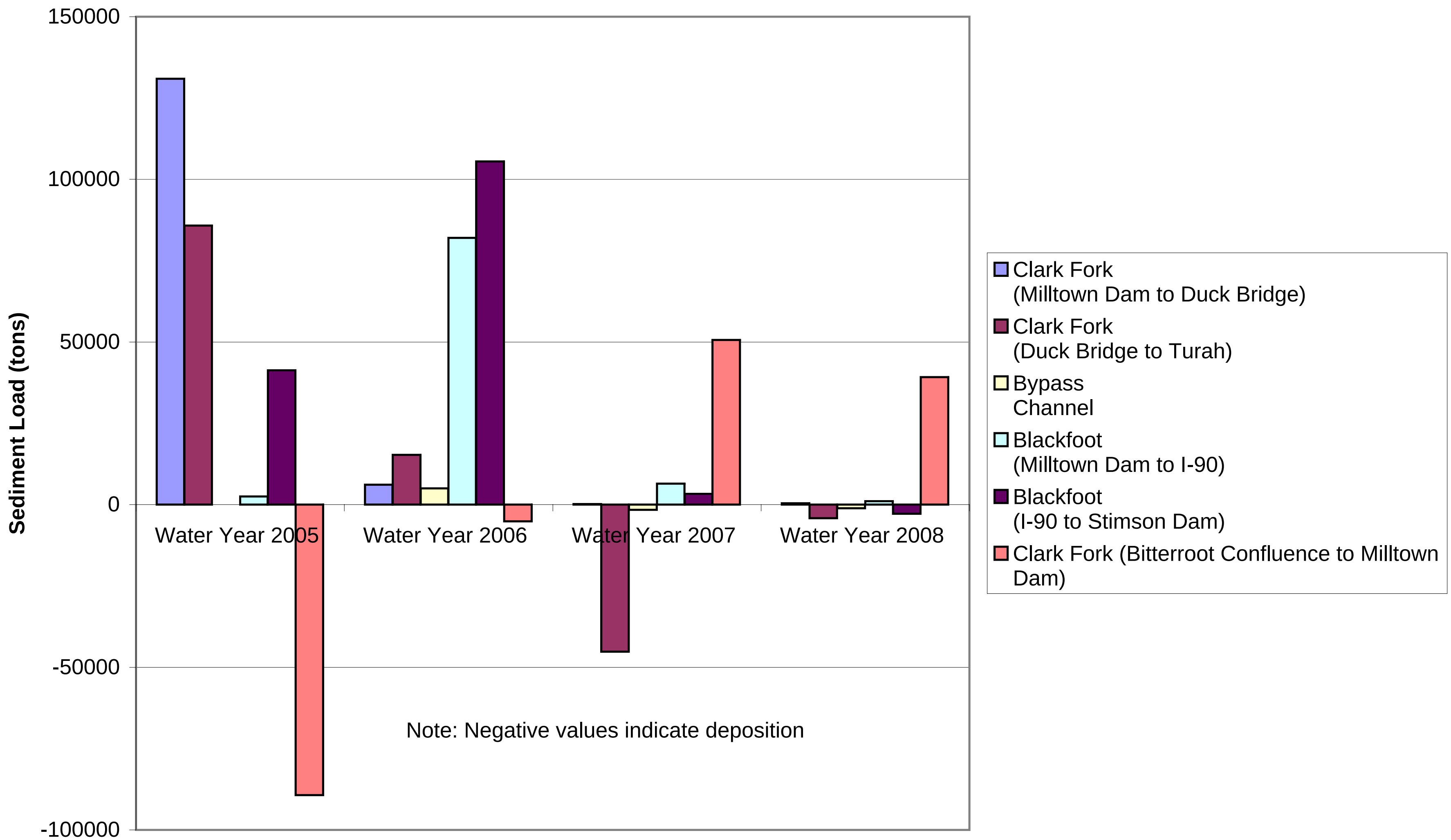
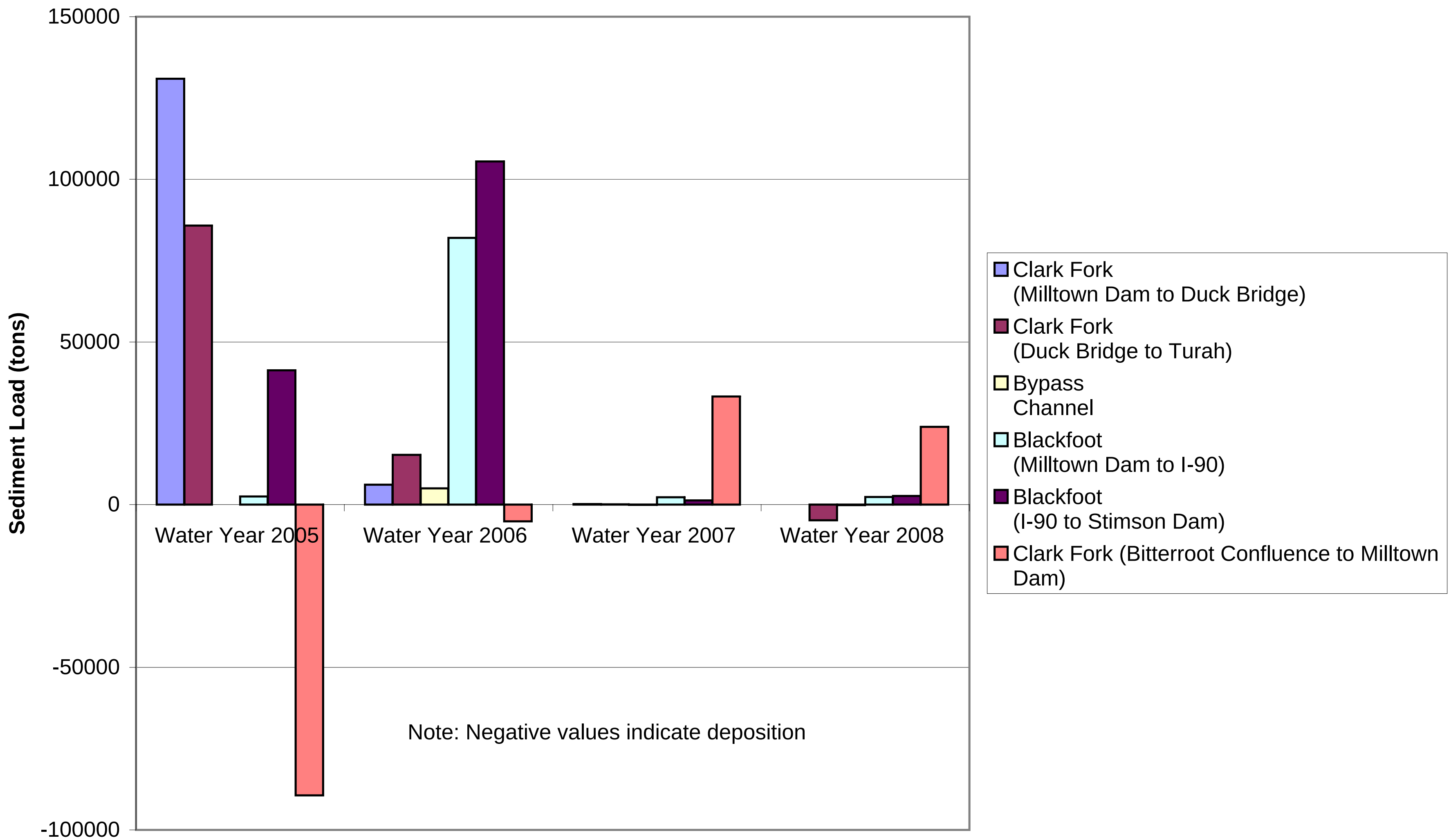


Figure C-14: Yearly Estimated Amount of Bed Material Scoured
Scenario 4c - Dam Removal with Full Bypass Channel, Low Discharge in Water Year 2007



H:\Projects\Milltown RD-RA\Scour Evaluation\May 17, 2004 Submittal\Appendices\App C\Fig C-14,Tab 4-6 PieFBPLO Fig C-14