Squaw Valley Water Quality Investigation Report, Drainage Area of Squaw Creek at the Confluence of the Main Stem and the Olympic Channel

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TABLE OF CONTENTS

1. EXECUTIVE SUMMARY 1

1.1 STUDY SCOPE 1
1.2 KEY FINDINGS 1

2. BACKGROUND AND OBJECTIVES 2

2.1 STUDY AREA 2
2.1.1 Squaw Creek 2
2.1.2 Olympic Channel 2
2.2 HYDROLOGY AND HYDRAULICS 2
2.3 EXISTING WATER QUALITY AND SEDIMENT TRANSPORT CONDITIONS 3
2.4 PROPOSED MODIFICATIONS TO EXISTING CONDITIONS 4
2.5 STUDY OBJECTIVES 4

3. METHODOLOGY 5

3.1 APPROACH 5
3.2 DATA COLLECTION AND ANALYSIS 5
3.3 DEVELOPMENT OF RATING CURVES FOR WATER QUALITY CONSTITUENTS 6
3.4 DEVELOPMENT OF STORM HYDROGRAPHS FOR CONSTITUENT LOADING ESTIMATION 7
3.5 APPLICATION OF RATING CURVES TO STORMWATER FLOWS 7
3.6 CALCULATION OF WATER QUALITY CONSTITUENT LOADINGS FOR EXISTING AND PROPOSED CONDITIONS 8

4. SUMMARY OF HYDROLOGIC AND WATER QUALITY DATA 9

4.1 DATA SOURCES AND CONTENTS 9
4.2 QUALITY AND UTILITY OF DATA 10

5. EXISTING CONDITIONS ANALYSIS 11

5.1 HYDROLOGIC MODELING RESULTS SUMMARY 11
5.2 WATER QUALITY LOADINGS PREDICTED FOR RUNOFF EVENTS 11

6. PROPOSED DEVELOPED CONDITIONS ANALYSIS 13

6.1 SUMMARY OF HYDROLOGIC IMPACTS DUE TO DEVELOPMENT 13
6.2 SUMMARY OF WATER QUALITY MANAGEMENT PRACTICES INCLUDED IN THE PROPOSED PLAN 14
6.3 WATER QUALITY LOADINGS PREDICTED FOR RUNOFF EVENTS 14

7. HYDRO-MODIFICATION FINDINGS 16

8. WATER QUALITY IMPACT FINDINGS 17

8.1 PREDICTED IMPACTS OF THE PROPOSED DEVELOPMENT ON WATER QUALITY 17
8.2 PREDICTED EFFECT OF SEDIMENT MANAGEMENT PRACTICES ON PROPOSED PROJECT WATER QUALITY IMPACTS 17

9. CONCLUSIONS 18

10. REFERENCES 19

LIST OF TABLES

Table 1. Summary of Water Quality and Streamflow Data

Table 2. Summary of Water Quality Constituent Loadings under Existing Conditions

Table 3. Peak Flow and Runoff Volume Comparison for Existing versus Post-Project Conditions

Table 4. Summary of Predicted Water Quality Constituent Loadings Under Proposed Project Conditions

LIST OF FIGURES

Figure 1. Squaw Creek Streamflow Measurements at Selected Locations during 2007-2011

Figure 2. Locations of Water Quality Calculations along Squaw Creek

Figure 3. Example Total Suspended Solids Rating Curve

Figure 4. Squaw Valley Sub-watershed Delineations

Figure 5. Example Hydrographs for the Simulated 100 year Storm Event

Figure 6. Example Total Suspended Solids Loading Curve

Figure 7. Existing Conditions Discharge Hydrographs for the Simulated 2 Year Event

Figure 8. Existing Conditions Discharge Hydrographs for the Simulated 5 Year Event

Figure 9. Existing Conditions Discharge Hydrographs for the Simulated 10 Year Event

Figure 10. Existing Conditions Discharge Hydrographs for the Simulated 100 Year Event

Figure 11. Existing Conditions Predicted Total Suspended Solids Loading

Figure 12. Existing Conditions Predicted Nitrate Nitrogen Loading

Figure 13. Existing Conditions Predicted Total Phosphorous Loading

Figure 14. Proposed Developed Conditions Discharge Hydrographs for the Simulated 2 Year Event

Figure 15. Proposed Developed Conditions Discharge Hydrographs for the Simulated 5 Year Event

Figure 16. Proposed Developed Conditions Discharge Hydrographs for the Simulated 10 Year Event

Figure 17. Proposed Developed Conditions Discharge Hydrographs for the Simulated 100 Year Event

Figure 18. Total Suspended Solids Load Predictions: 100 Year Event, Developed Conditions

LIST OF FIGURES (CONTINUED)

Figure 19. Nitrate Nitrogen Load Predictions: 100 Year Event, Developed Conditions

Figure 20. Total Phosphorous Load Predictions: 100 Year Event, Developed Conditions

Figure 21. Comparison of Total Suspended Solids Loadings to the Meadow: Existing versus Proposed Developed Conditions

Figure 22. Comparison of Nitrate Loadings to the Meadow: Existing versus Proposed Developed Conditions

Figure 23. Comparison of Total Phosphorous Loadings to the Meadow: Existing versus Proposed Developed Conditions

1. EXECUTIVE SUMMARY

1.1 Study Scope

The purpose of the study documented in this report is to:

1. Quantify production and transport of suspended sediment, nutrients, and other stormwater runoff constituents under existing development conditions and

2. Estimate the potential impacts of the proposed Village at Squaw Valley Specific Plan under fully developed conditions.

The methods used in this study focused on analyzing historical measurements of stream flow and water quality parameter concentrations during storm events to create a means for estimating water quality parameter concentrations during simulated storm events. The resultant constituent rating curves were applied to modeled hydrographs for the 2, 5, 10, and 100 year storm events. The calculation of key water quality parameters for each event under both existing and proposed project conditions enable an evaluation of the potential impacts of the proposed project on water quality in Squaw Creek.

1.2 Key Findings

The results of this study indicate that the proposed project will result in:

- A small reduction in peak flows and total flow volume for most storm events;

- No negative impacts on stream bank erosion or channel stability;

- No negative impacts on water quality in Squaw Creek;

- No negative impacts on loading of water quality constituents (total suspended solids, nitrates, and phosphates) by Squaw Creek to the meadow area;

- A small positive impact on water quality, due to predicted small reductions in total suspended solids loadings to the meadow area.

2. BACKGROUND AND OBJECTIVES

2.1 Study Area

The area of study includes the drainage area of Squaw Creek at the confluence of the main stem and the Olympic Channel, below the proposed development area. The drainage area comprises 6.03 square miles and contains an elevation range from 6,200 ft. to 9,000 ft. The hydrologic characteristics of the drainage area are discussed in detail in the Master Drainage Study (MacKay and Somps, 2012; based on the December 2012 Draft Specific Plan) for the Village at Squaw Valley Specific Plan.

2.1.1 Squaw Creek

At present, Squaw Creek flows in a straight constructed trapezoidal channel through most of the project site. The North and South Forks of Squaw Creek join together in the western portion of the project, before flowing to the east through a trapezoidal channel, which continues to the eastern property boundary, discharging to a meandering channel, meadow, and floodplain system in the vicinity of the Resort at Squaw Creek Golf Course pedestrian (and golf cart) bridge. The channel is dynamic as it enters the meadow, actively shifting course and depositing sediment.

2.1.2 Olympic Channel

The Olympic Channel drains portions of the Squaw Valley Parking Lot and mountainous areas to the south. In addition, Searchlight Pond, with a significant watershed draining steep mountainous areas, discharges to a constructed flume and pipe, which discharge to the Olympic Channel, just east of the Ski Area parking lot. This pipe, also referred to as the 'Olympic Drain,' also collects runoff from a portion of parking lot. Similar to Squaw Creek, the Olympic Channel is essentially a straight ditch, and appears to have been additionally modified for flood control and/or drainage purposes in the past.

2.2 Hydrology and Hydraulics

MacKay and Somps (2012) developed a hydrologic model of the watershed using the HEC-HMS software platform and methods outlined by Placer County Flood Control.. At the downstream end of the project reach, they estimate the 2-year peak discharge in Squaw Creek to be approximately 2,000 cfs, the 10-year flow to be approximately 3,300 cfs, and the 100-year flow to range as high as 5,200 cfs, consistent with recent estimates developed by FEMA. Separate hydraulic modeling using the HEC-RAS platform indicates that the existing trapezoidal channel can largely contain the 100-year flow in the vicinity of the parking lot, with

the exception of limited and shallow overflow onto portions of the parking lot and vegetated areas downstream of the Far East Road Bridge. Downstream of the Far East Road crossing, the model predicts that the 100-year flood would inundate areas beyond the top of the channel bank.

The area proposed for development under the Specific Plan is also defined in the drainage study. The proposed area for development comprises 101 acres and is largely level with minimal elevation change. The potential water quality impacts of the proposed development under the specific plan are the subject of this report.

2.3 Existing Water Quality and Sediment Transport Conditions

Sediment transport and productivity in Squaw Creek and its tributaries as it flows through the specific plan area are dominated by flows produced and materials mobilized in the upland watershed areas. Since the specific plan area occupies 2.6 % of the total drainage area, the hydrologic impact of changes in the specific plan area are anticipated to be small. Other water quality parameters, such as nitrates and phosphates, are also dominated by upslope processes. However, production of sediment and other water quality constituents within the specific plan area are significant contributors to the quality of water reaching the meadow area immediately downstream of the specific plan area.

Squaw Creek is listed as impaired due to sediment by the Lahontan Regional Water Quality Control Board (Curtis, 2006). The TMDL for sediment recognizes ski-runs and dirt roads as primary sediment sources, with urban runoff, dirt roads, and road sand as secondary sources. Implementation of the TMDL focuses on tracking compliance with existing regulatory actions, and monitoring channel bed conditions in lower Squaw Creek. Target in-stream conditions include a relative decrease in fines and sand, increased size of bed material, and higher scores on periodic bio-assessments. Conditions also include an overall 25% reduction in sediment delivery from the watershed, including a 25% reduction in sediment delivery from residential and commercial areas. The TMDL also allocates 150 tons/year of additional sediment loading due to future development. Management of suspended sediment transport through and sediment production in the specific plan area are important factors in meeting the suspended sediment TMDL.

2.4 Proposed Modifications to Existing Conditions

Details of the proposed development associated with the specific plan are provided in the Drainage Study (MacKay and Somps, 2012) and in associated specific plan documents (December 2012 Draft Specific Plan). While significant changes in facilities and buildings will occur within the specific plan area, these changes will result in a negligible change in impervious area, minimal changes in slope, and an overall reduction in parking and roadway surfaces which produce runoff. As shown in the Master Drainage Study, minimal changes in stormwater runoff and peak flow rates in Squaw Creek will result from the proposed development.

2.5 Study Objectives

The purpose of the study documented in this report is to:

1. Quantify production and transport of suspended sediment, nutrients, and other stormwater runoff constituents under existing development conditions and

2. Predict the potential impacts of the proposed Specific Plan under fully developed conditions.

Final design of stormwater treatment and management measures (BMPs) and in-channel sediment management measures and prediction of the impacts of those measures on water quality in Squaw Creek are in progress, and will be described in a separate report. These improvements will include Low-Impact Development (LID) approaches such as vegetated swales and pervious pavements, as well as in-line stormwater treatment devices. In addition, a number of floodplain and wetland improvements are proposed for the Squaw Creek and Olympic Channel corridors to increase the level of water quality treatment associated with the project. Water Quality impacts associated with these treatment features are not evaluated in this study. Rather, we aim to investigate the water quality impacts associated with the proposed (unmitigated) development, prior to LID, stormwater BMP, and wetland/floodplain treatment.

3. METHODOLOGY

3.1 Approach

Two approaches to water quality analyses and prediction were considered: a) constituent production and transport modeling and b) collection and analysis of existing water quality and flow data. The latter, data oriented approach was selected for several reasons:

1. Several studies of Squaw Creek water quality and sediment production have been reported over more than 30 years;

2. Long term field sampling data and developed area runoff, including flow rate, sediment concentration, and nutrient concentration, were available; and

3. The proposed development was expected to have minimal effects on constituent production in the Squaw Creek watershed, and so could be handled appropriately by applying relationships determined from historical data and modeled hydrology.

3.2 Data Collection and Analysis

An effort was made to locate and obtain all flow and water quality data collected by multiple parties, including:

- Squaw Valley Ski Corporation water quality monitoring reports,

- Squaw Village Neighborhood Company water quality monitoring reports, and

- Sedimentology studies (Hecht and Jett, 1988; Woyshner and Hecht, 1988)).

In addition, suspended sediment and flow data for nearby watersheds were considered in analyzing the Squaw Creek data.

The sampling data sets contained the following constituent data:

- Ph
- Total phosphorous
- Chloride
- Nitrate, nitrite and Kjeldahl nitrogen
- Total dissolved solids

- Turbidity and
- Flow rate
- Total suspended solids1

The data were not consistent in coverage or in frequency of sampling. Therefore, the data sets were evaluated for quality and representativeness (leading to discarding of some records) and then combined to produce one temporal data set. A selection of years containing the largest number of valid sampling records and also containing representative high flow events was selected for detailed analysis. This record period was January 1, 2007 through December 31, 2011. A plot of Squaw Creek discharge measurements for that period is shown in Figure 1.

3.3 Development of Rating Curves for Water Quality Constituents

The availability of substantial water quality sampling data for Squaw Creek enabled a 'rating-curve' based approach to evaluation of water quality conditions under existing conditions and predicting impacts of proposed development. Rating curves are used to represent relationships between flow rate and production (or loading) of a measurable constituent by a watershed. The curves are constructed by fitting a line or lines to available measurements of that constituent versus flow rate. It is important that the processes represented by the measurements be reasonably static in a statistical sense during the period of record used. In other words, the conditions that generate the constituent loading do not change significantly during the period of record.

Data from the multiple data sets for the selected period (1/1/2007-12/31/2011) were used to create the rating curves. The sampling locations for these data are shown in Figure 2. The sampling sites were selected to represent existing (pre-project) conditions at the following stream locations:

- Confluence of the North and South Forks of Squaw Creek
- Discharge of the Olympic Channel to Squaw Creek

[1] The terms 'suspended sediment' and 'total suspended solids' are used interchangeably in this report, based on the findings of McGraw and others (2001), who evaluated the relationship between total suspended solids and suspended sediment concentration at monitoring sites in the Middle Truckee River watershed, and found a nearly one-to-one relationship between the two.

- Downstream of the existing Village

A fourth rating curve was calculated from these three to represent the contribution of the existing developed area and adjacent localized undeveloped areas to water quality loadings in Squaw Creek. This calculation involved subtracting loadings at the confluence from loadings downstream of the village. An example of the resulting rating curves is shown in Figure 3, which illustrates suspended sediment rating curves for each contributing area.

3.4 Development of Storm Hydrographs for Constituent Loading Estimation

Work done during the Master Drainage Plan development was used to define storm event hydrographs at the four key locations discussed above. The HEC-1 hydrologic simulation package was used to develop hydrographs for the 2, 5, 10, and 100 year storm events for all sub-watersheds contributing flows to Squaw Creek, including sub-watersheds in the project area. The Master Drainage Report (MacKay and Somps, 2012) provides details of the methodologies, input data, and simulation results. Figure 4 depicts the sub-watershed boundaries within the Squaw Valley vicinity.

Sub-watershed runoff hydrographs were combined as appropriate to produce flow hydrographs at the three previously defined locations for the four design storms. Aggregated and routed flows produced by HEC-1 were used to include timing effects in the calculations. A fourth set of hydrographs for the discharge of Squaw Creek to the meadow below the village area was computed by combining the Olympic Channel hydrograph with the "Squaw Creek Below Village" hydrograph. Figure 5 shows the resultant hydrographs for the 100 year storm event.

3.5 Application of Rating Curves to Stormwater Flows

The developed rating curves provide relationships between flow rate (cubic feet per second) and water quality constituent loading (tons/day). Each curve is represented by a power function which has the best fit to the monitoring data. The rating curve power functions for Total Suspended Solids, Nitrate Nitrogen, and Total Phosphorous were used to calculate the flux of those constituents from the 15 minute hydrograph flow rates. Figure 6 provides an example of a resulting loading curve for Total Suspended Solids.

3.6 Calculation of Water Quality Constituent Loadings for Existing and Proposed Conditions

The fluxes computed using the rating curves were then integrated (summed) over the full 24 hour hydrograph for each storm event and each location to obtain constituent loadings. Loadings were developed for the four key locations previously described and for the 2, 5, 10, and 100 year storm events. These loading estimates provide a means for comparing the loadings from the project area versus loadings from the other sub-watersheds contributing to Squaw Creek. They also provide a means for predicting changes in loadings due to the proposed project, through adjustment of the storm event hydrographs and the loading rating curves to represent the impacts of the proposed project.

4. SUMMARY OF HYDROLOGIC AND WATER QUALITY DATA

4.1 Data Sources and Contents

Five sources of water quality monitoring data were obtained and evaluated in this study:

- Squaw Valley Ski Corporation (SVSC) sampling reports and records;
- Squaw Valley Ski Corporation monitoring analysis (SVM&R) files;
- Squaw Village VMF treatment system (VMF) monitoring reports;
- Squaw Valley Neighborhood (SVNC) monitoring data; and
- Sediment related field work and sampling reported in several papers

Periods of record and types of data from each source are summarized in Table 1. Monitoring data was found for years going back to 1992. Additional sediment data were available from studies during 1987 and 1988. Constituents included in reported results varied with the source and sample dates. Constituents include:

- Total suspended solids (TSS)
- Turbidity (Turb)
- Total dissolved solids (TDS)
- Nitrate nitrogen
- Nitrite nitrogen
- Total nitrogen
- Total phosphorous (P)
- Chlorides (Cl)
- Iron (Fe)
- pH
- Oil and Grease

Table 1. Summary of Water Quality and Streamflow Data

Data Source	Period of Record	Measurements
Squaw Valley Ski Corporation (SVSC) sampling reports and records	2007-2011	Multiple stations; pH, TSS, P, Cl, N, TDS, Turb, flow
Squaw Valley Ski Corporation (SVSC) turbidity monitoring records	1992-2000	Multiple stations; turbidity
Squaw Valley Ski Corporation monitoring analysis (SVM&R) files	1992-2000	Multiple stations; Turb, TSS, TDS, N, P, Cl, Fe
Squaw Village VMF treatment system (VMF) monitoring reports	2006-2011	VMF influent, effluent, bypass; P, N, TVSS, Turb, TSS, flow
Squaw Valley Neighborhood (SVNC) monitoring data	2007-2011	3 stations; P, N, Turb, TSS, Oil/Grease, Fe
Sediment related field work and sampling (Hecht and Jett, 1988 and Woyshner and Hecht, 1988)	1986-1987	5 stations; water level, flow rate, N, TOC, TDS, TSS, bedload

4.2 Quality and Utility of Data

Much of the monitoring data is fragmented, with partial results. Sampling dates are not consistent, because most samples were triggered by flow events, as required by various permits. A portion of the sampling event data does not include flow rates at the sampling point. Some reported values were deemed to be erroneous, due to the value being outside of the typical range. Sampling records that did not contain flow measurement and/or appeared erroneous were mostly not used. For some well-populated records, flow rates were estimated using nearby flow measurements at roughly the same time, scaled by watershed size.

An evaluation of the entire data set revealed that the 2007 to 2011 period produced the most complete records and largest amount of data. This period was used for the water quality analysis. The availability and apparent quality of specific measurements in the data set indicated that total suspended solids, nitrate nitrogen, and total phosphorous would provide the highest quality predictions of water quality loadings to Squaw Creek. These three constituents also provide reasonably good indicators of water quality conditions in the creek. Nitrate N correlates fairly well with other forms of nitrogen, while total phosphorous represents the variability of all forms of phosphorous. TSS is a good surrogate for fine sediment concentrations. Fine sediment transport is of particular interest as it is the subject of the one TMDL requirement for Squaw Creek and the Truckee River. Metals measurements are not common in the data set, precluding any evaluation of metals in Squaw Creek.

5. EXISTING CONDITIONS ANALYSIS

5.1 Hydrologic Modeling Results Summary

Details of the hydrologic modeling are presented in the Drainage Study. Plots of streamflow at the four analysis locations (squaw Creek north and south fork confluence, intervening/project area, Olympic Channel, and Squaw Creek downstream of the project area) are provided for the 2, 5, 10 and 100 year storm events in Figures 7-10.

5.2 Water Quality Loadings Predicted for Runoff Events

The previously described analytic methods were applied to obtain TSS, nitrate and phosphorous loading predictions for the four storm events at the four analysis locations. Plots of predicted loadings for these constituents resulting from the 100 year event are shown in Figures 11-13. Table 2 provides a summary of total loadings for these constituents resulting from all storm events at the four locations.

Table 2. Summary of Predicted Water Quality Constituent Loadings under Existing Conditions

Location/Measurement**	2 Year Event	5 Year Event	10 Year Event	100 Year Event
Confluence				
Total Suspended Solids	71	127	168	385
Nitrate-N	202	259	290	420
Total Phosphorous	127	174	202	320
Intervening Area				
Total Suspended Solids	29	55	76	200
Nitrate-N	5	3	3	0
Total Phosphorous	0	0	0	0
Olympic Channel				
Total Suspended Solids	17	61	104	340
Nitrate-N	30	39	45	67
Total Phosphorous	6	8	8	12
Total to Meadow				
Total Suspended Solids	117	243	348	925
Nitrate-N	237	301	338	487
Total Phosphorous	133	182	210	332

** Reported P and N loading numbers are in ***pounds***; TSS loading numbers are in ***tons***

As can be seen in the plots, nearly 50% of the suspended sediment load and 85% of nitrate load and 95% of phosphate load to the meadow appear to be contributed by the drainage areas tributary to the confluence of the south and north forks of Squaw Creek. The project area and adjacent intervening areas are calculated to account for approximately 21 percent of total

suspended sediment loading in the system. Nitrate and phosphate loadings from the project and adjacent areas were found to be negligible. The Olympic Channel, however, appears to contribute 35 percent of the total suspended sediment load to the meadow, and a 14 percent contribution to nitrates. These contributions are large when compared with the total area drained by the Olympic Channel and the flow rates associated with the storm events. Approximately 15 percent of the drainage area contributing to the Olympic Channel is in the project area, while most of the watershed is located at upper elevations, upstream of Searchlight Pond and the Olympic Drain.

Under existing conditions, the contributions of the project area to water quality in Squaw Creek as it enters the meadow and to loadings to the meadow are calculated to be less than 5% of the total for nitrates and phosphorous and 10 to 15% for total suspended solids.

6. PROPOSED DEVELOPED CONDITIONS ANALYSIS

6.1 Summary of Hydrologic Impacts due to Development

Runoff from the Squaw Creek watershed was modeled using HEC-1 (MacKay and Somps, 2012). The details of these simulations are presented in the Drainage Study report. The simulations accomplished up to the time of this report include the effects of land use, slope, ground cover, and pervious surface changes due to the proposed development. They do not include any planned surface runoff management structures, practices (Best Management Practices), or planned stormwater treatment systems, and are therefore considered to be conservative estimates of project impacts.

Plots of streamflow at the analysis locations (including Squaw Creek confluence, developed area, Olympic Channel, and total flow downstream of the project area) are provided for the 2, 5, 10 and 100 year storm events in Figures 14-17. Table 3 provides a comparison of peak flow and total runoff volume for existing conditions versus after the proposed development.

Table 3. Peak Flow and Runoff Volume Comparison for Existing versus Post Project Conditions

Location/Measurement**	2 Year Event	5 Year Event	10 Year Event	100 Year Event
Total Volume from Intervening Area				
Existing Conditions	180	225	253	352
Post Project Conditions	176	225	258	359
Peak Flow from Intervening Area				
Existing Conditions	178	240	280	415
Post Project Conditions	175	236	277	426
Total Volume to Meadow				
Existing Conditions	2438	3119	3498	5028
Post Project Conditions	2264	3005	3516	5050
Peak Flow to Meadow				
Existing Conditions	2254	3072	3586	5418
Post Project Conditions	2180	3015	3563	5445

** Reported total volume in **acre-ft.**; reported peak flow in **cubic feet per second**

As is shown in the plots as well as the table, the impact of the proposed development on peak and total storm flows is small. For the "intervening area", which contains the proposed project, a slight reduction in both peak and total storm flows is predicted for the 2, 5, and 10 year events. A slight increase is predicted for the 100 year event.

6.2 Summary of Water Quality Management Practices Included in the Proposed Plan

No water quality management practices were included in the analyses. Rather, we have conservatively assumed that constituent production will remain as is under existing conditions, without accounting for mitigating effects of water quality BMPs and control features.

6.3 Water Quality Loadings Predicted for Runoff Events

Using rating curves representative of existing conditions, the previously-described analytic methods were applied to obtain TSS, nitrate and phosphorous loading predictions for the four storm events at the four analysis locations under proposed conditions. Plots of predicted loadings for these constituents resulting from the 100 year event are shown in Figures 18-20. Table 4 provides a summary of proposed conditions loadings for these constituents resulting from all storm events at the four locations. The relative contributions of each sub-area, including the intervening area (which includes the proposed project) are nearly the same as those predicted for existing conditions.

Table 4. Summary of Predicted Water Quality Constituent Loadings with Proposed Project

Location/Measurement**	2 Year Event	5 Year Event	10 Year Event	100 Year Event
Confluence				
Total Suspended Solids	63	120	170	390
Nitrate-N	188	250	292	421
Total Phosphorous	116	166	203	323
Intervening Area				
Total Suspended Solids	25	53	78	203
Nitrate-N	7	4	3	0
Total Phosphorous	0	0	0	0
Olympic Channel				
Total Suspended Solids	13	49	88	296
Nitrate-N	27	36	43	64
Total Phosphorous	6	8	9	11
Total to Meadow				
Total Suspended Solids	101	222	336	889
Nitrate-N	222	290	338	485
Total Phosphorous	122	174	212	334

** Reported P and N loading numbers are in pounds; TSS loading numbers are in tons

Graphical comparisons of TSS, nitrate and phosphorous predicted loadings to the meadow for the existing and proposed project conditions and for the 2, 10, and 100 year events are presented in figures 21-23. Prior to stormwater treatment, TSS loadings are anticipated to be reduced by

approximately 4% under the proposed project conditions for the 100 and 10 year events; TSS loadings for the 2 year event are anticipated to be reduced by closer to 20% under the proposed project conditions. Nitrogen and phosphorous loadings are anticipated to be essentially unchanged for the 100 and 10 year events, but are found to be reduced by approximately 6% for the 2 year event.

Changes in storm runoff due to the proposed project are predicted to have no negative impact on water quality for Squaw Creek flows entering the meadow and on loadings to the meadow. The proposed project is anticipated to reduce total suspended solids loading to the meadow by 4 to 25%. Much of the reduction in TSS loading can be attributed to changes in the collection and transport of runoff that enters the Olympic Channel under existing conditions. Some of that runoff will be redirected through the proposed development. When runoff and water quality management features are added to the project plan, further reductions in TSS, nitrate and phosphorous loadings are likely.

7. HYDRO-MODIFICATION FINDINGS

Hydrologic impacts due to the proposed project were previously summarized and discussed. The net effects of the proposed project on flows in Squaw Creek and local runoff within the project area are a very small reduction in peak flows and total flows for most storm events that were considered. Lower peak and total flows, combined with channel improvements and water quality management features may slightly reduce erosive forces and sediment transport and enhance channel stability both within the project area and downstream of the project, in the meadow area. The net effects of the proposed project on flow rates, channel stability, and sediment transport will be minimal, but slightly beneficial.

8. WATER QUALITY IMPACT FINDINGS

8.1 Predicted Impacts of the Proposed Development on Water Quality

The proposed project is predicted to have a net positive impact on water quality in Squaw Creek downstream of the project and to slightly reduce TSS, nitrate and phosphorous loadings to the meadow.

8.2 Predicted Effect of Sediment Management Practices on Proposed Project Water Quality Impacts

Changes in sediment management practices within the project area and in the upslope watersheds were not considered in these analyses and are not reported herein.

9. CONCLUSIONS

The analyses used in this study rely on water quality and flow data collected during the 2007-2011 period to define relationships between stream flow rate and concentrations of water quality constituents for four locations in the Squaw Creek tributary system. These relationships, called rating curves, are used to predict water quality constituent loadings at those locations, including loadings to the meadow downstream of the proposed project. The relationships are then applied to changes in storm runoff due to the proposed project, producing predicted water quality loadings under proposed project conditions. The results of these predictions are necessarily dependent on the veracity and representativeness of the collected data. While the precise numerical predictions provided by the calculations are subject to uncertainly, the relationships between predicted loadings for different storm events and for existing versus proposed development conditions are likely to be reliable and representative.

The results of this study indicate that the proposed project will have no negative impacts on water quality in Squaw Creek and no negative impacts on loading of water quality constituents (specifically total suspended solids, nitrates, and phosphates) by Squaw Creek to the meadow area. The results do indicate a small positive impact on water quality, due to predicted small reductions in total suspended solids loadings to the meadow area.

The reported results do not consider the effect of runoff management or water quality management features (BMPs) on water quality and loadings to the meadow. Such features, once designed and included in water quality predictions, are likely to further increase the predicted positive impacts of the proposed project on Squaw Creek water quality.

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FIGURES

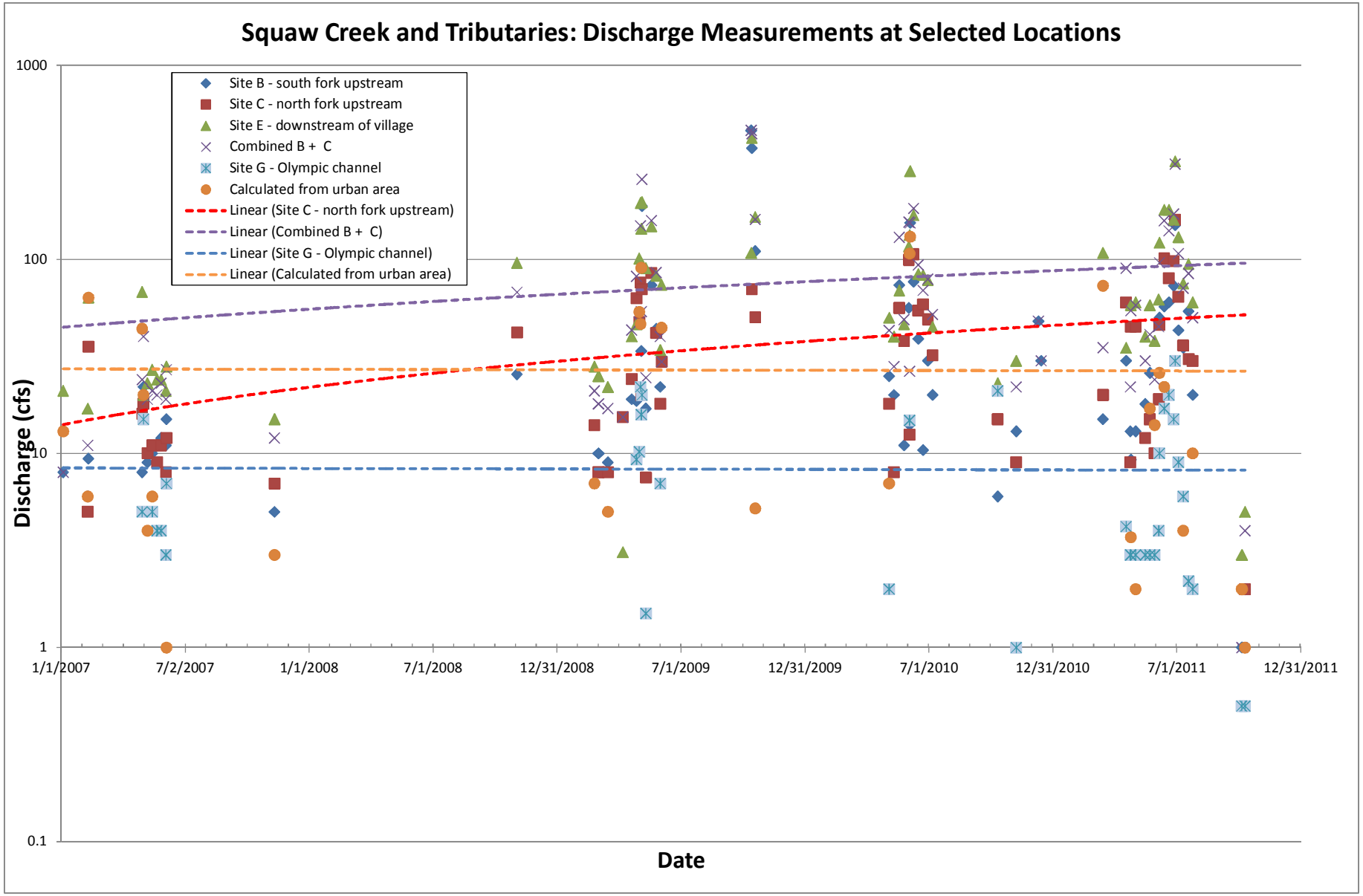

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Figure 1. Squaw Creek Streamflows at Selected Locations for 2007-2011

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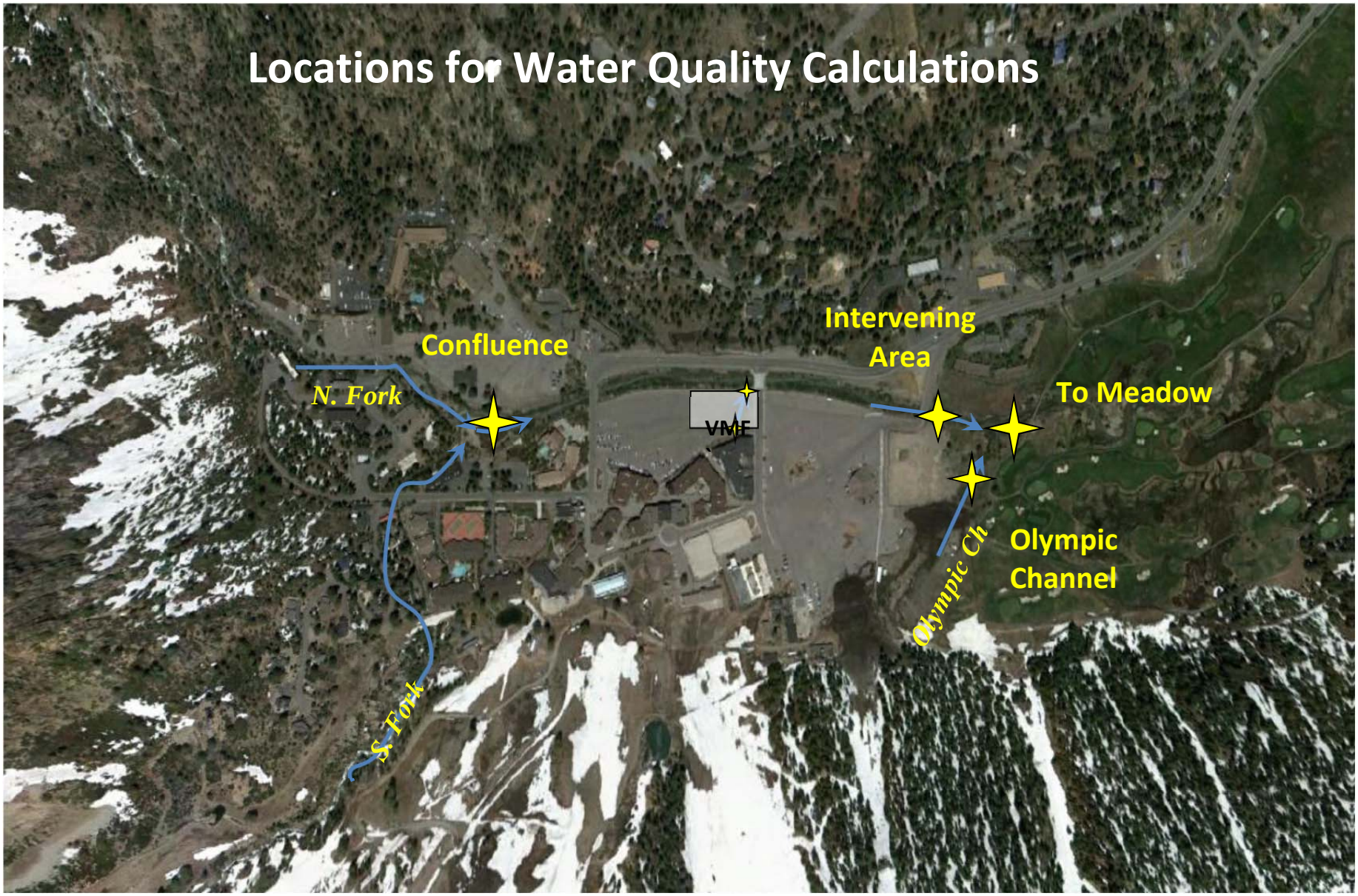

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Figure 2. Locations of Water Quality Calculations along Squaw Creek

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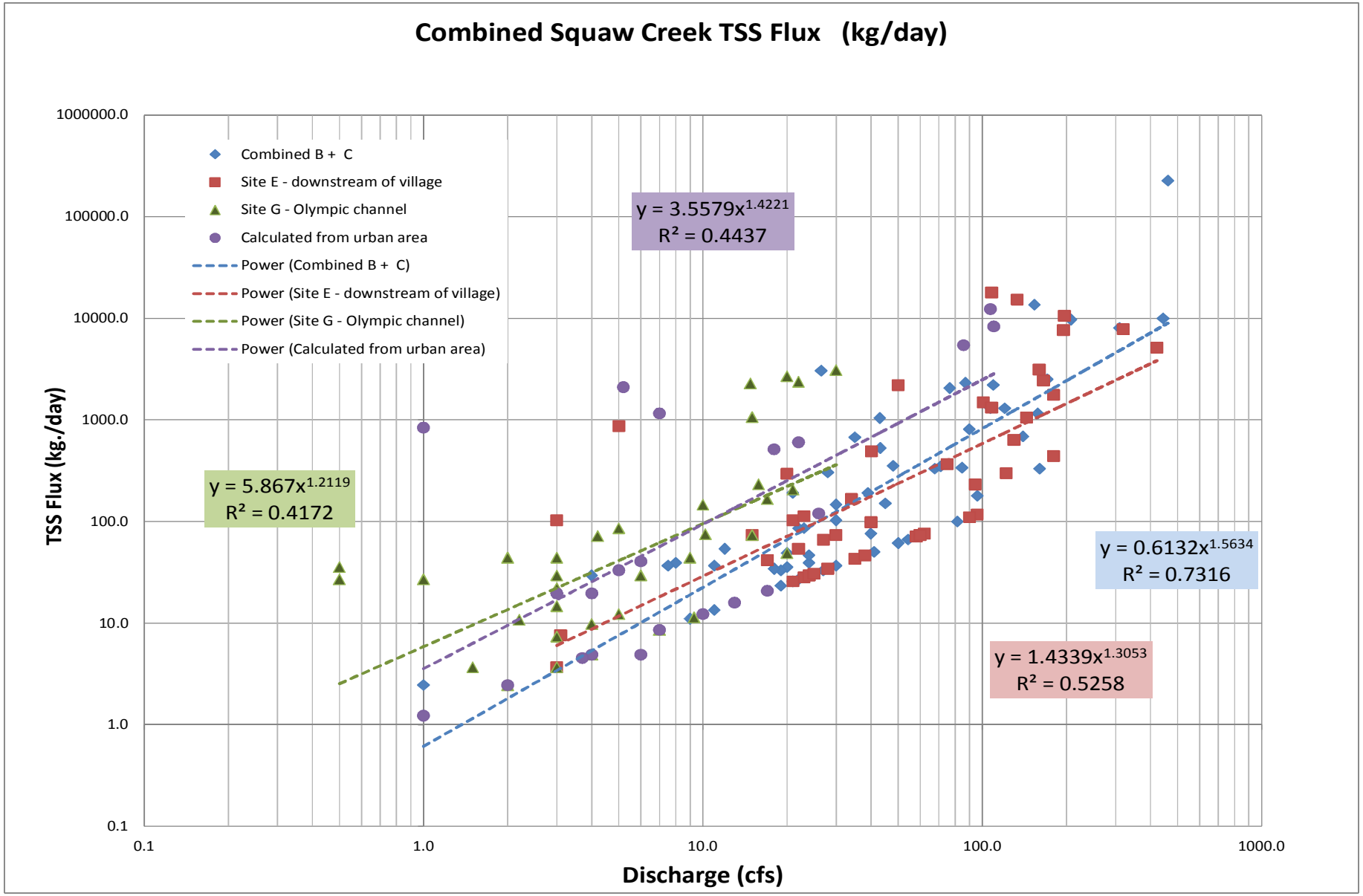

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Figure 3. Example Total Suspended Sediment Rating Curve

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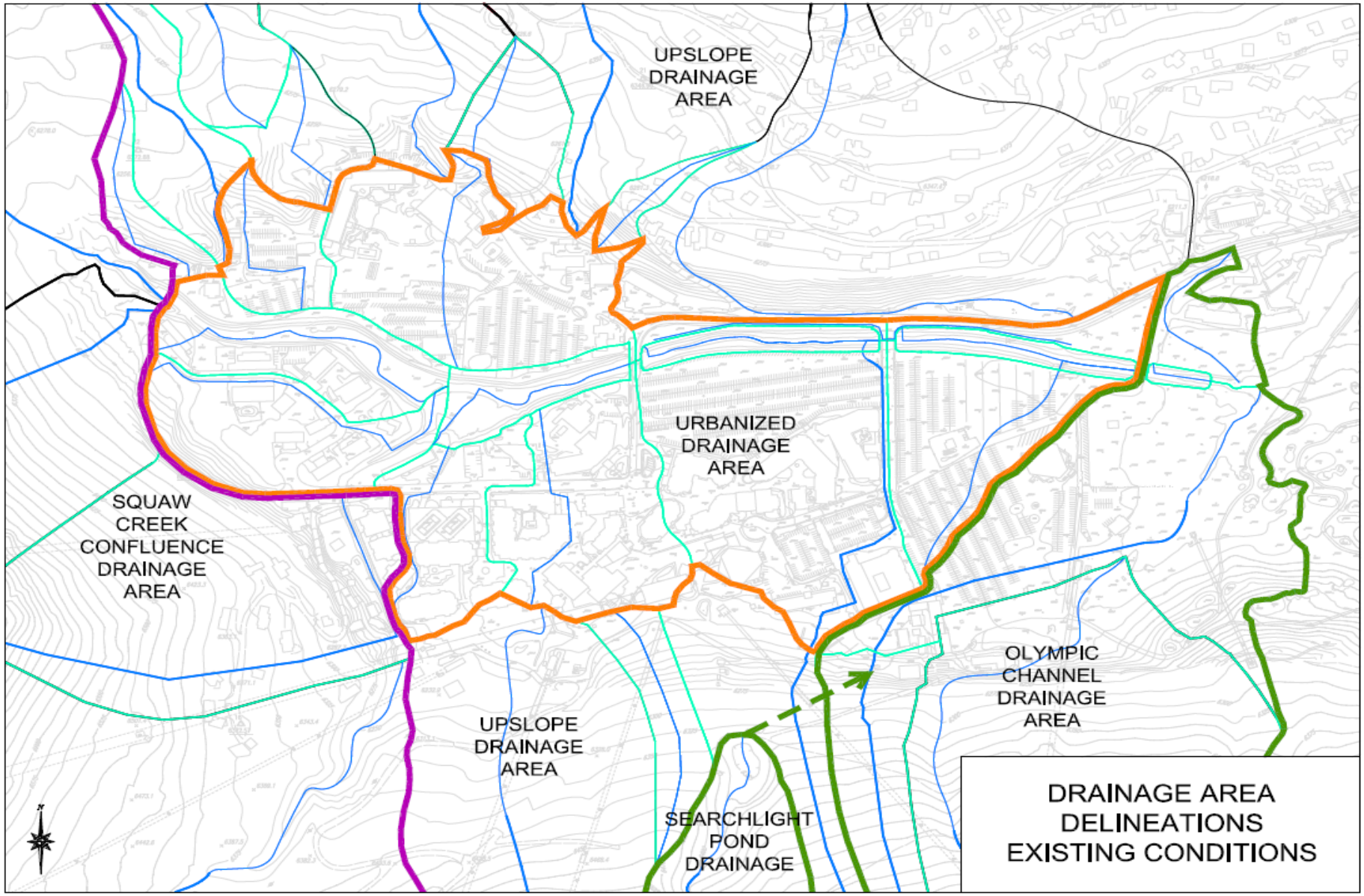

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Figure 4. Squaw Valley Sub-watershed Delineations

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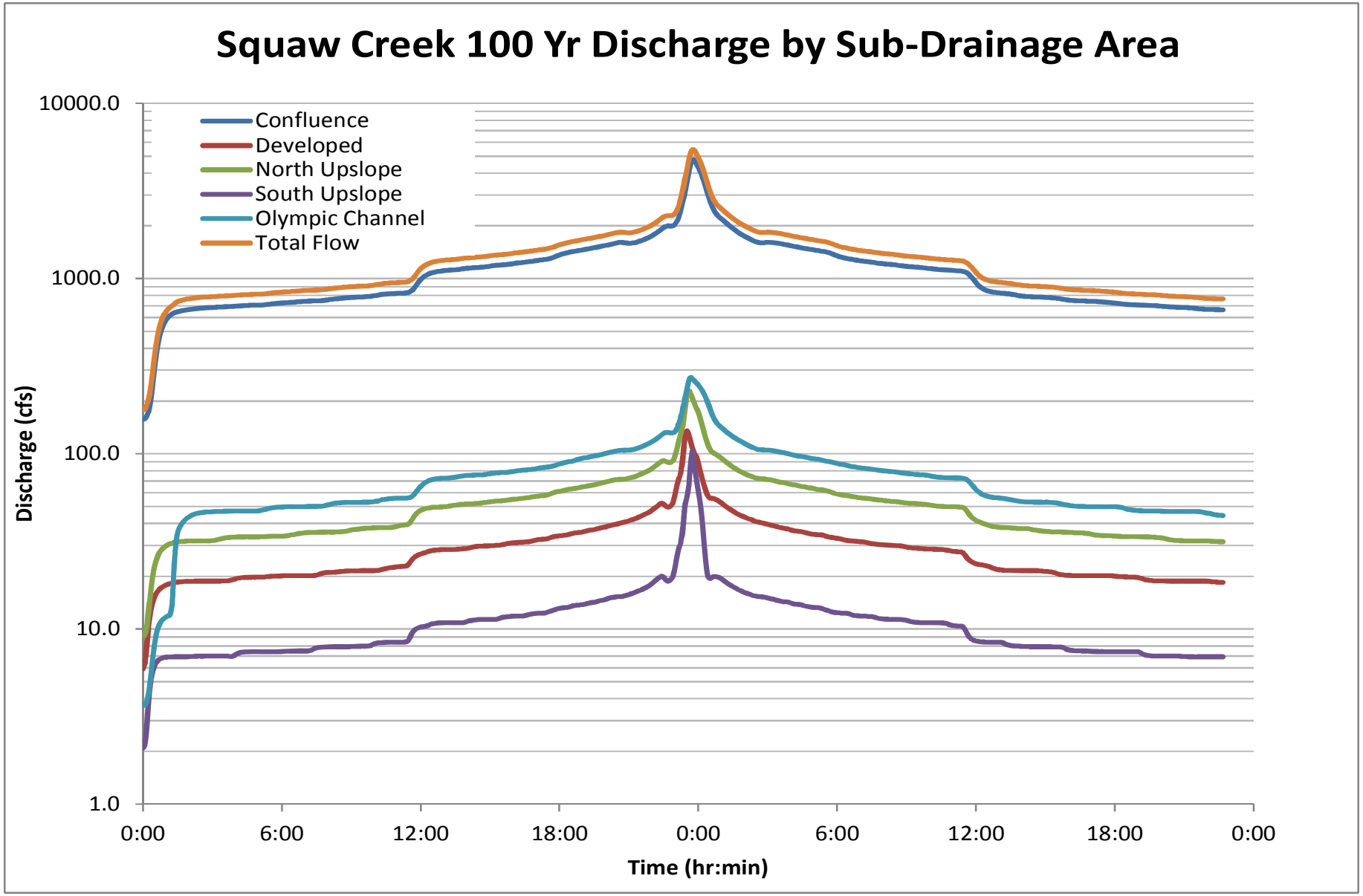

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Figure 5. Example Hydrographs for the Simulated 100 year Storm Event

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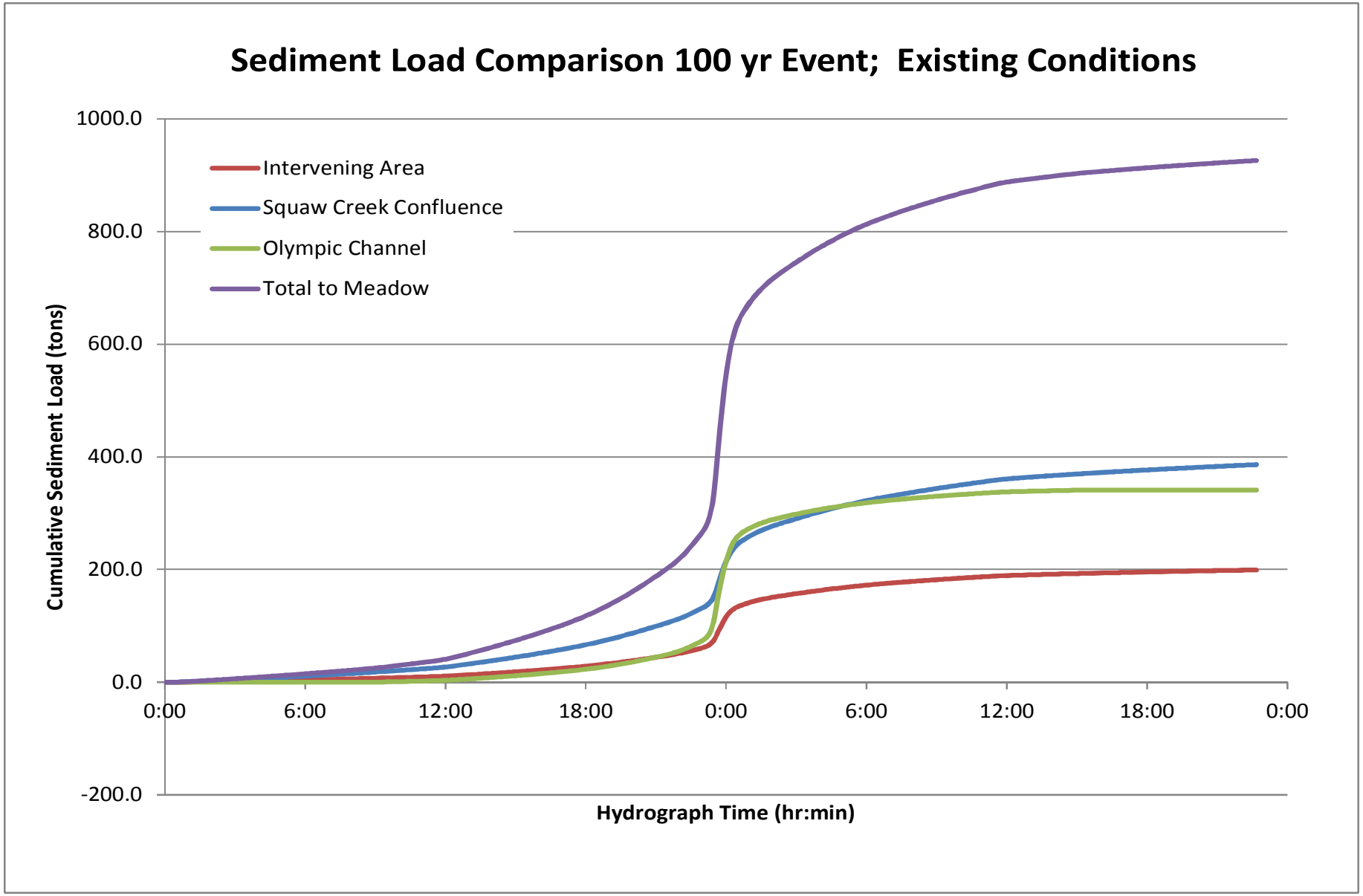

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Figure 6. Example Total Suspended Solids Loading Curve

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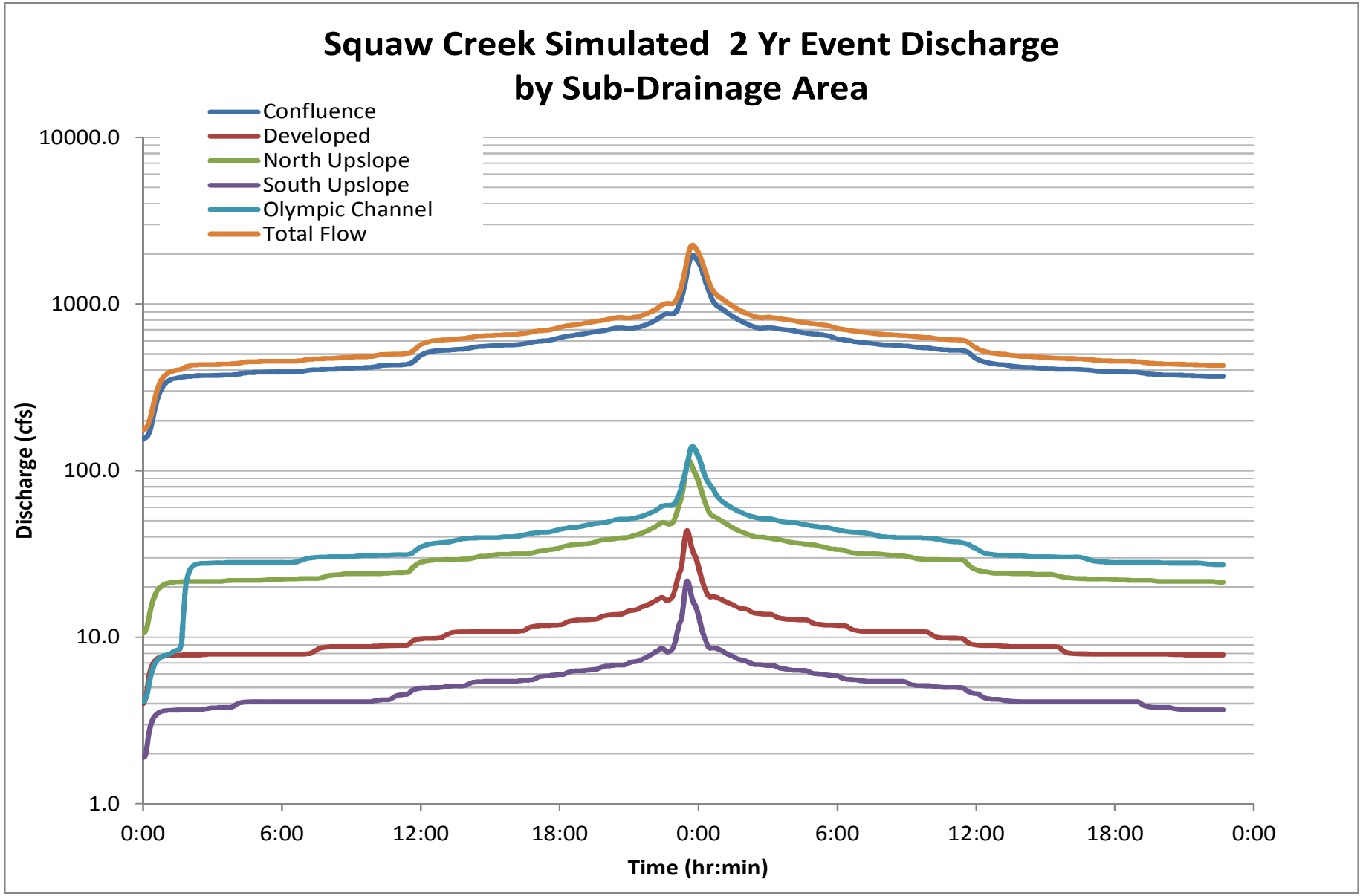

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Figure 7 . Existing Conditions Discharge Hydrographs for the Simulated 2 Year Event

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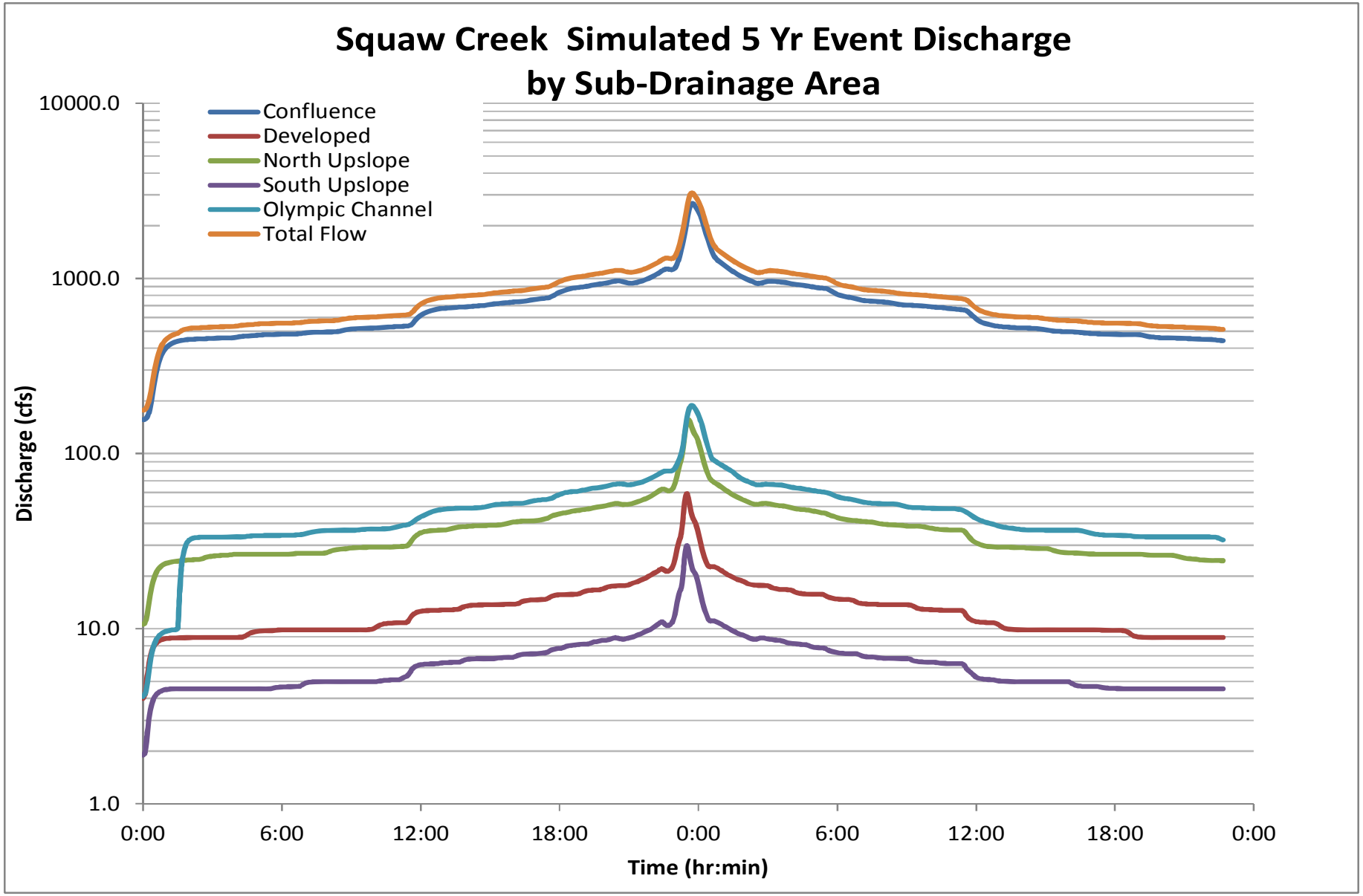

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Figure 8 . **Existing Conditions Discharge Hydrographs for the Simulated 5 Year Event**

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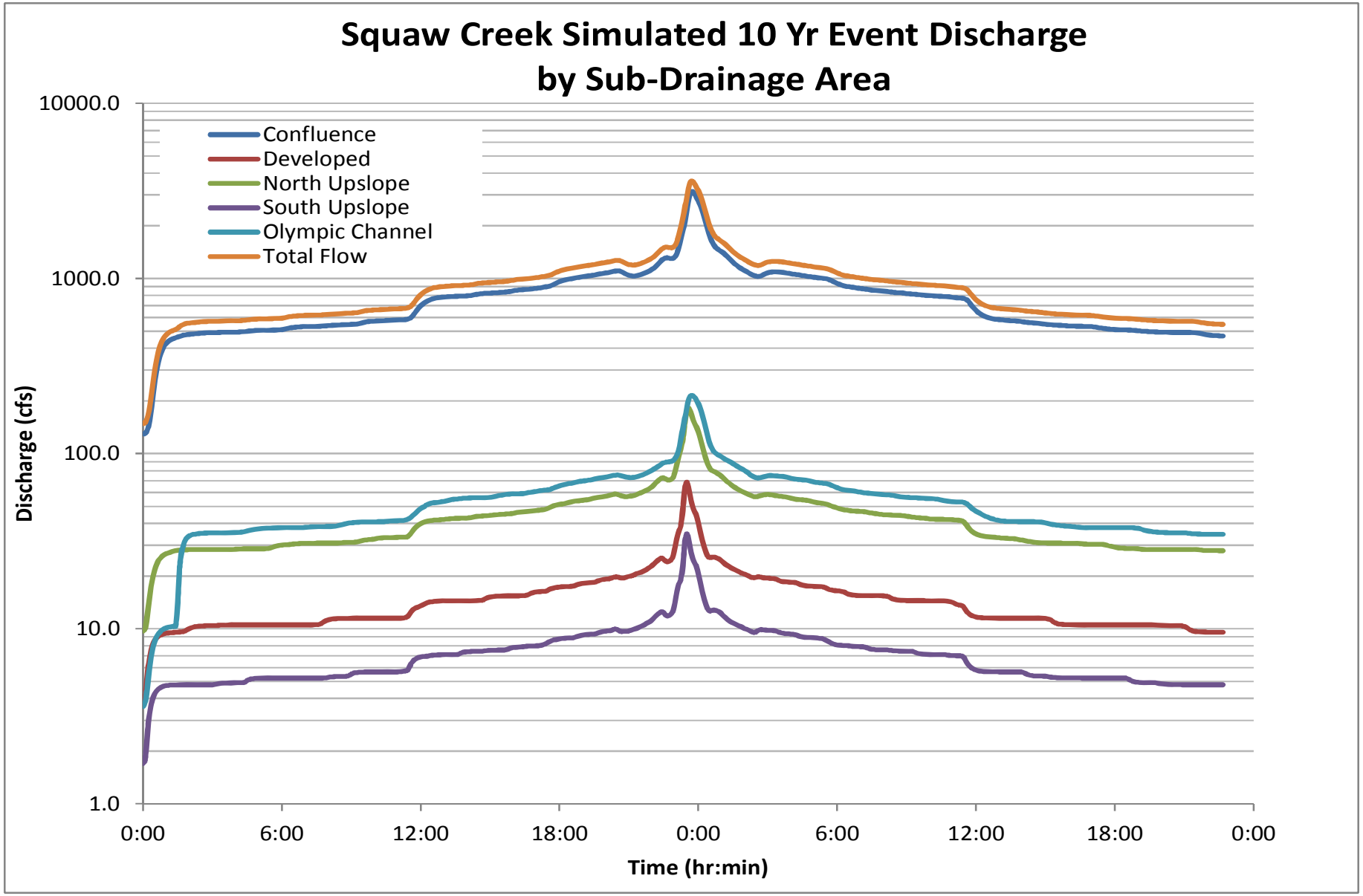

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Figure 9. **Existing Conditions Discharge Hydrographs for the Simulated 10 Year Event**

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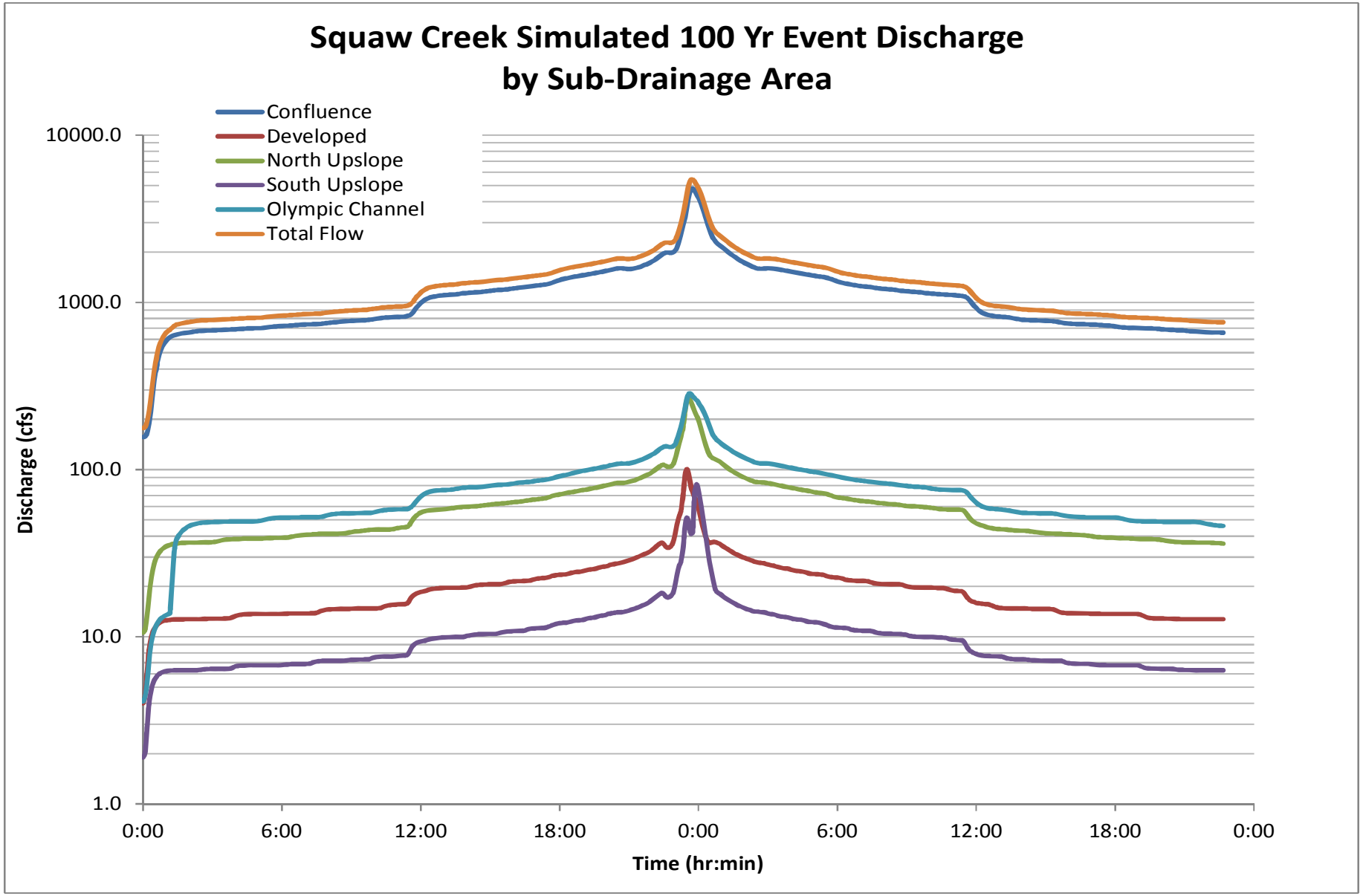

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Figure 10 . Existing Conditions Discharge Hydrographs for the Simulated 100 Year Event

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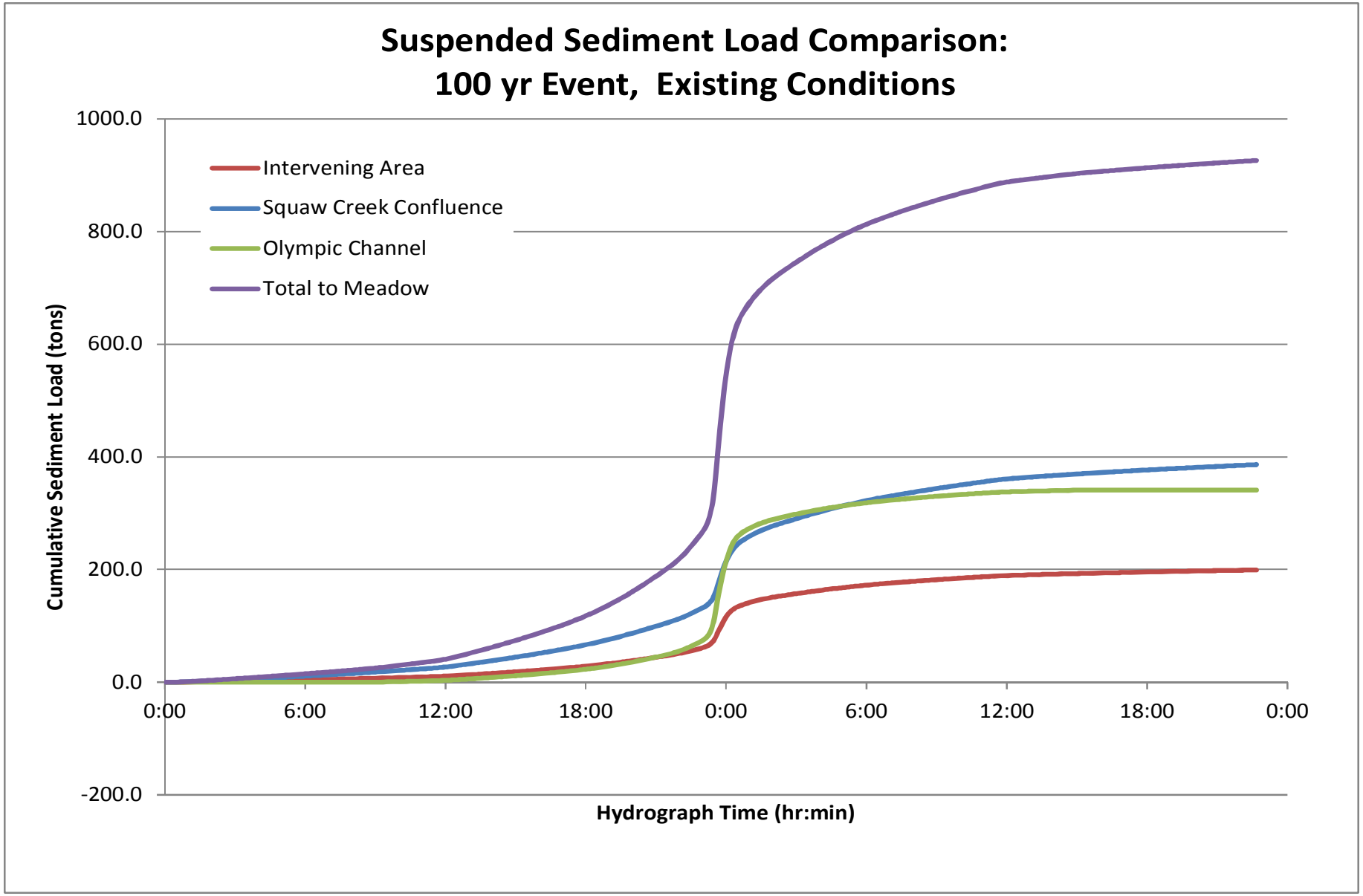

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Figure 11. Existing Conditions Predicted Total Suspended Solids Loading

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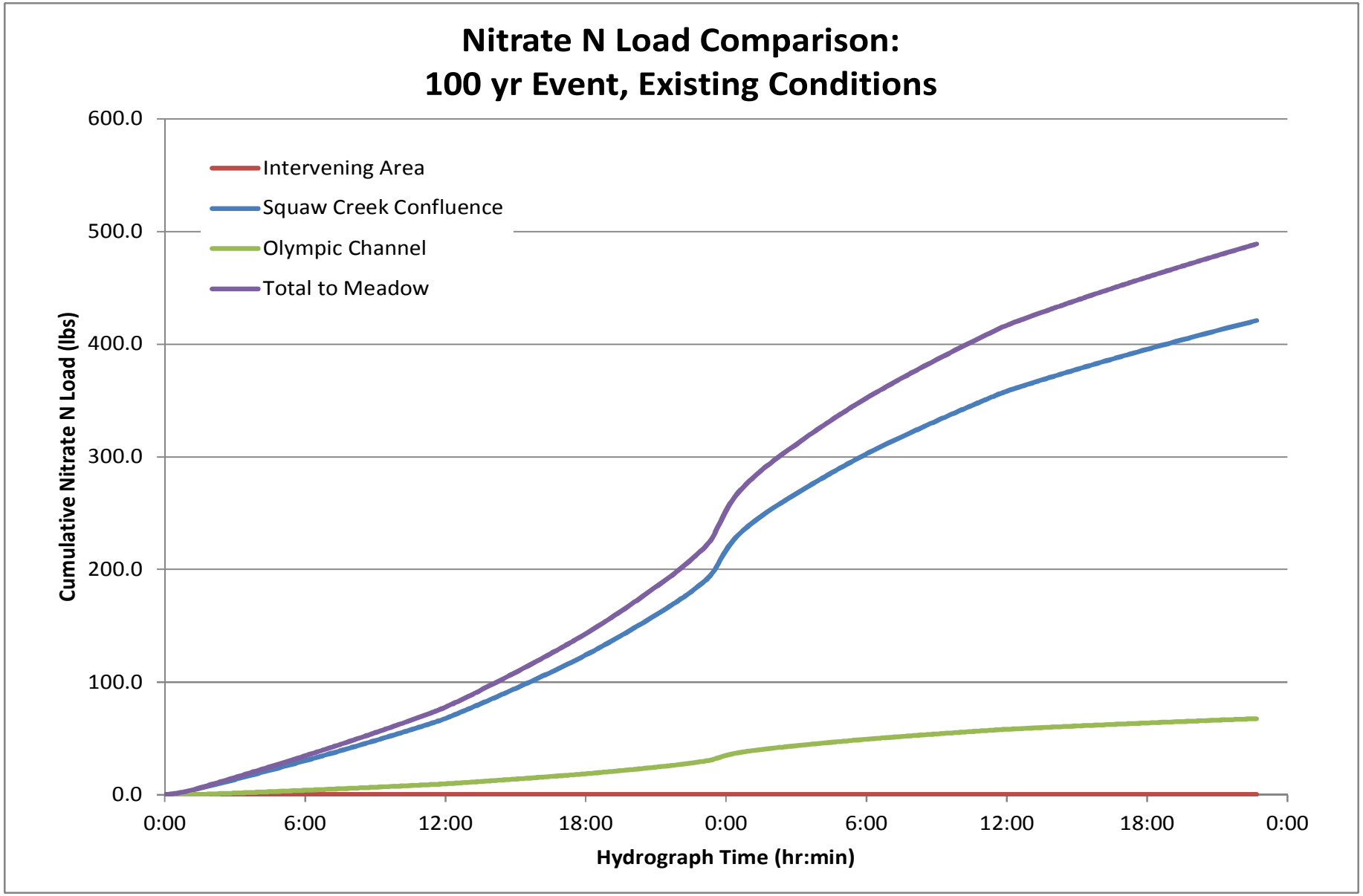

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Figure 12. Existing Conditions Predicted Nitrate Nitrogen Loading

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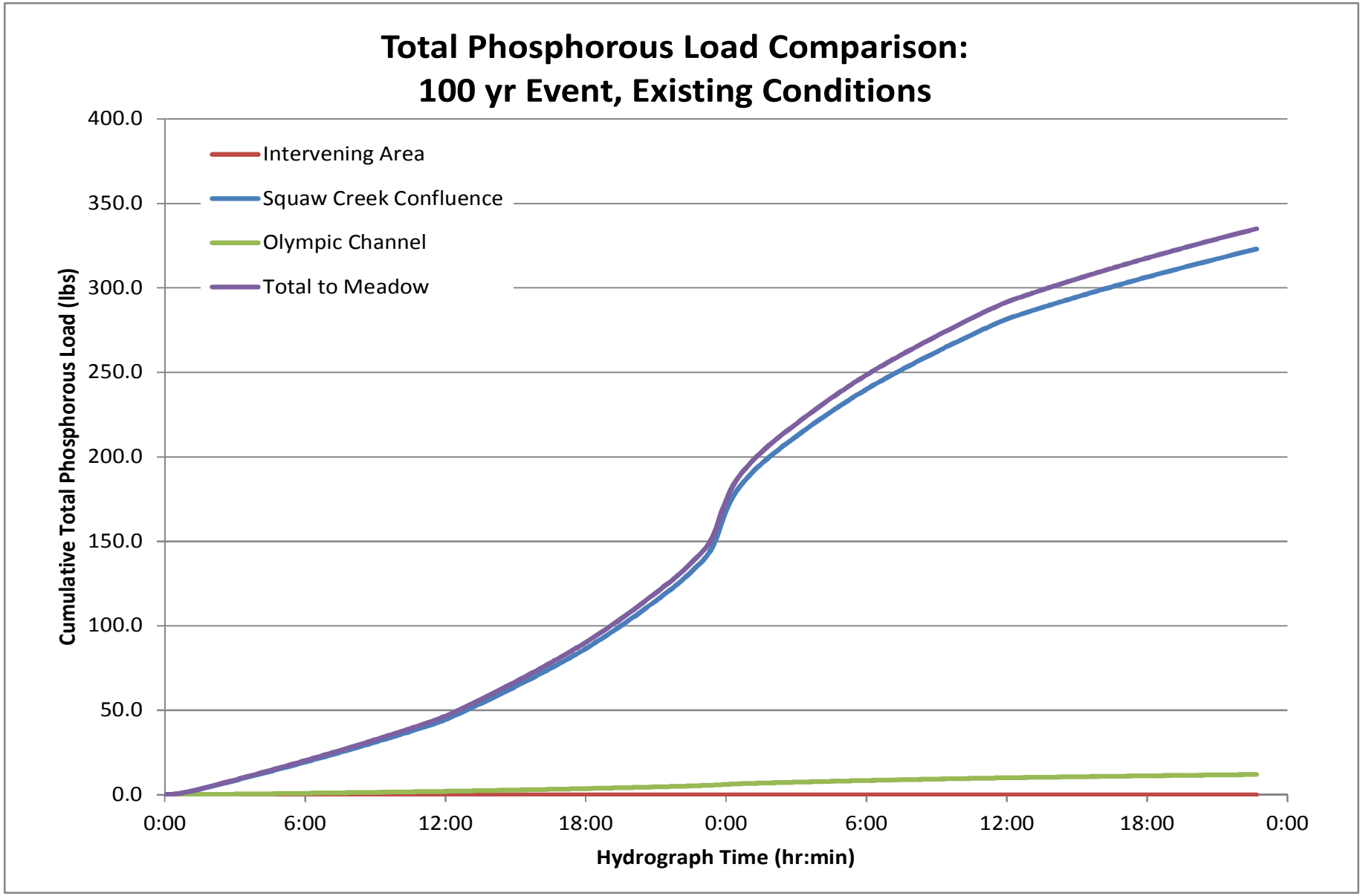

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Figure 13. Existing Conditions Predicted Total Phosphorous Loading

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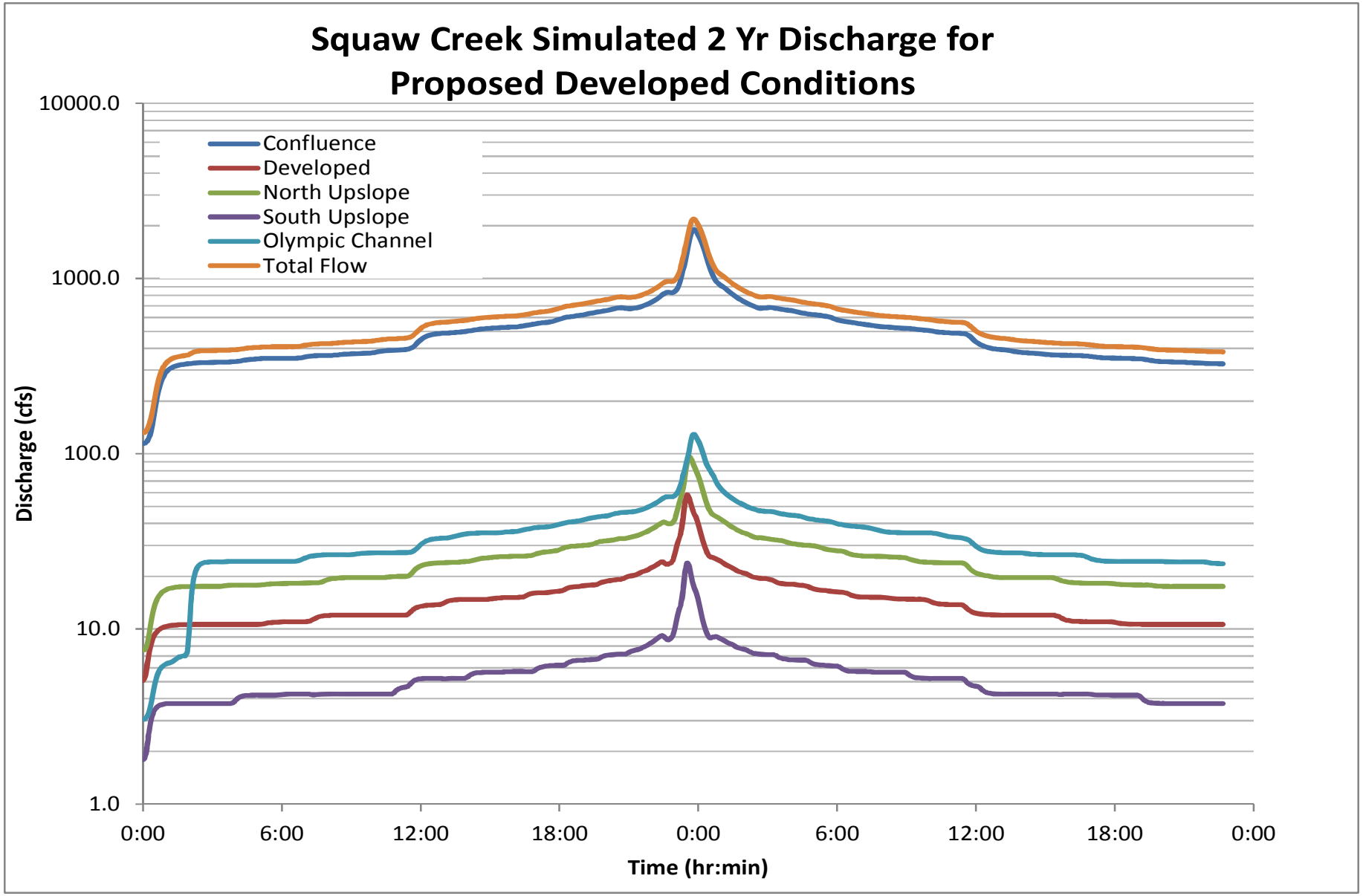

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Figure 14. **Proposed Developed Conditions Discharge Hydrographs for the Simulated 2 Year Event**

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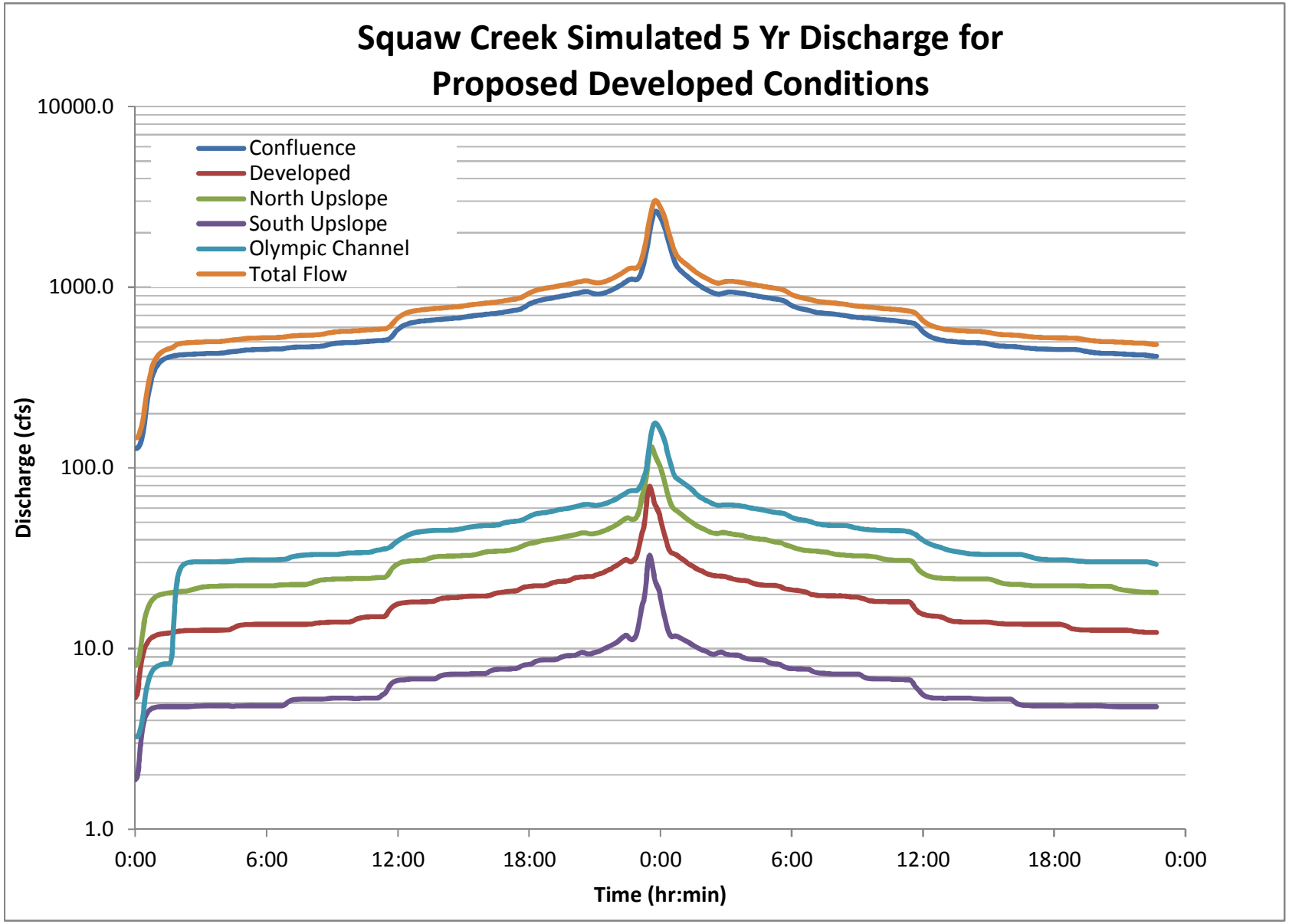

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Figure 15. **Proposed Developed Conditions Discharge Hydrographs for the Simulated 5 Year Event**

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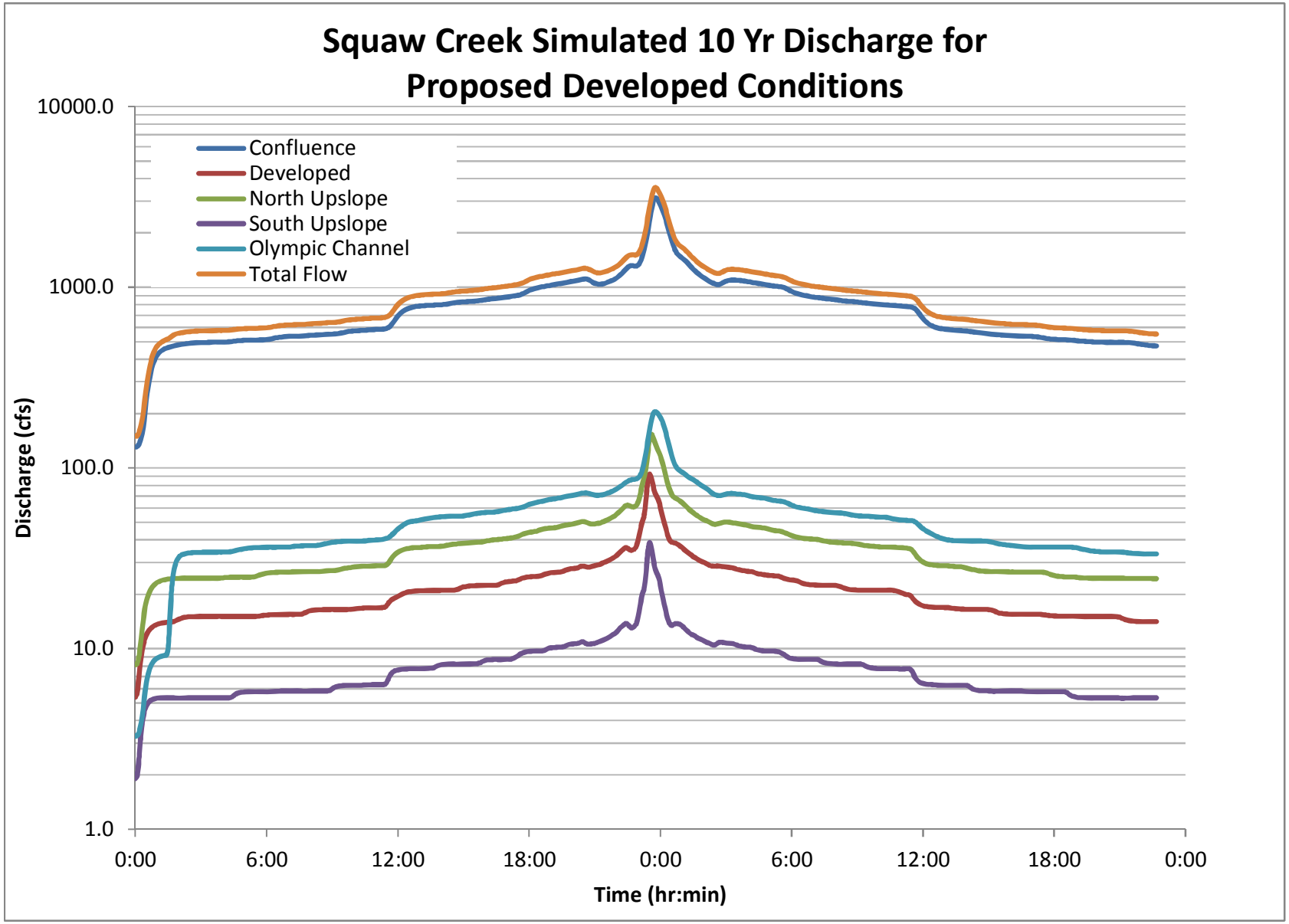

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Figure 16. **Proposed Developed Conditions Discharge Hydrographs for the Simulated 10 Year Event**

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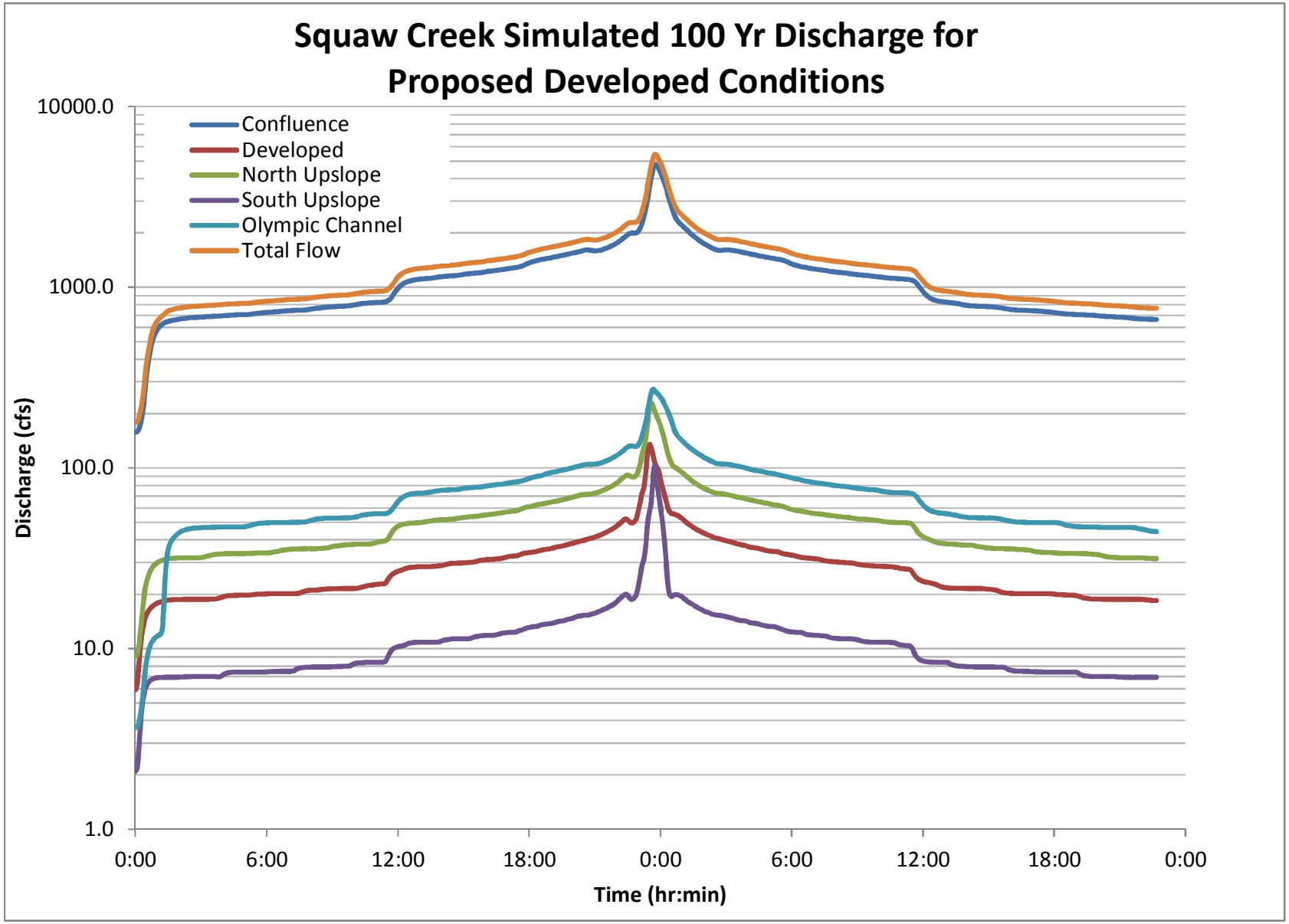

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Figure 17. **Proposed Developed Conditions Discharge Hydrographs for the Simulated 100 Year Event**

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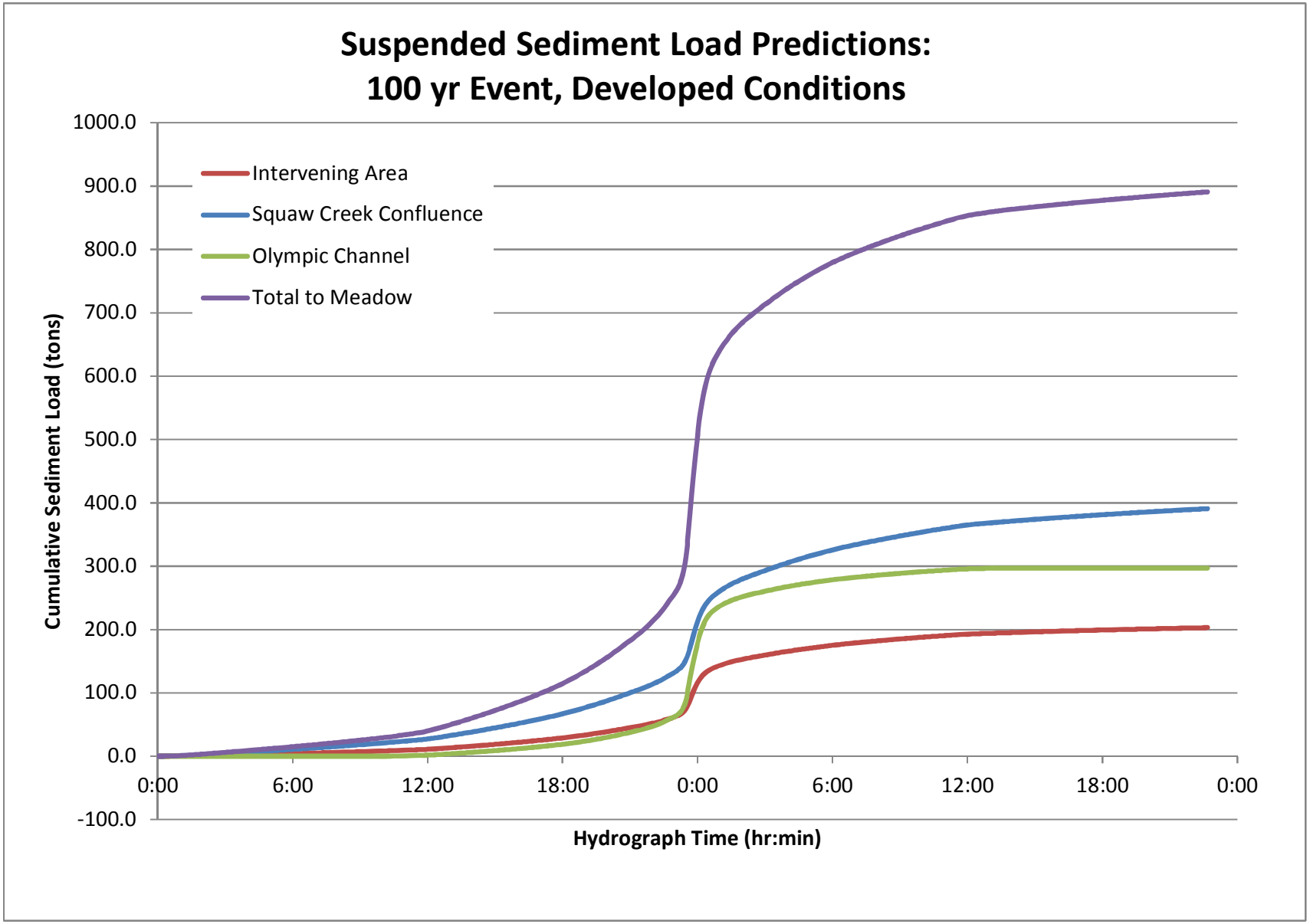

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Figure 18. **Total Suspended Solids Load Predictions: 100 Year Event, Developed Conditions**

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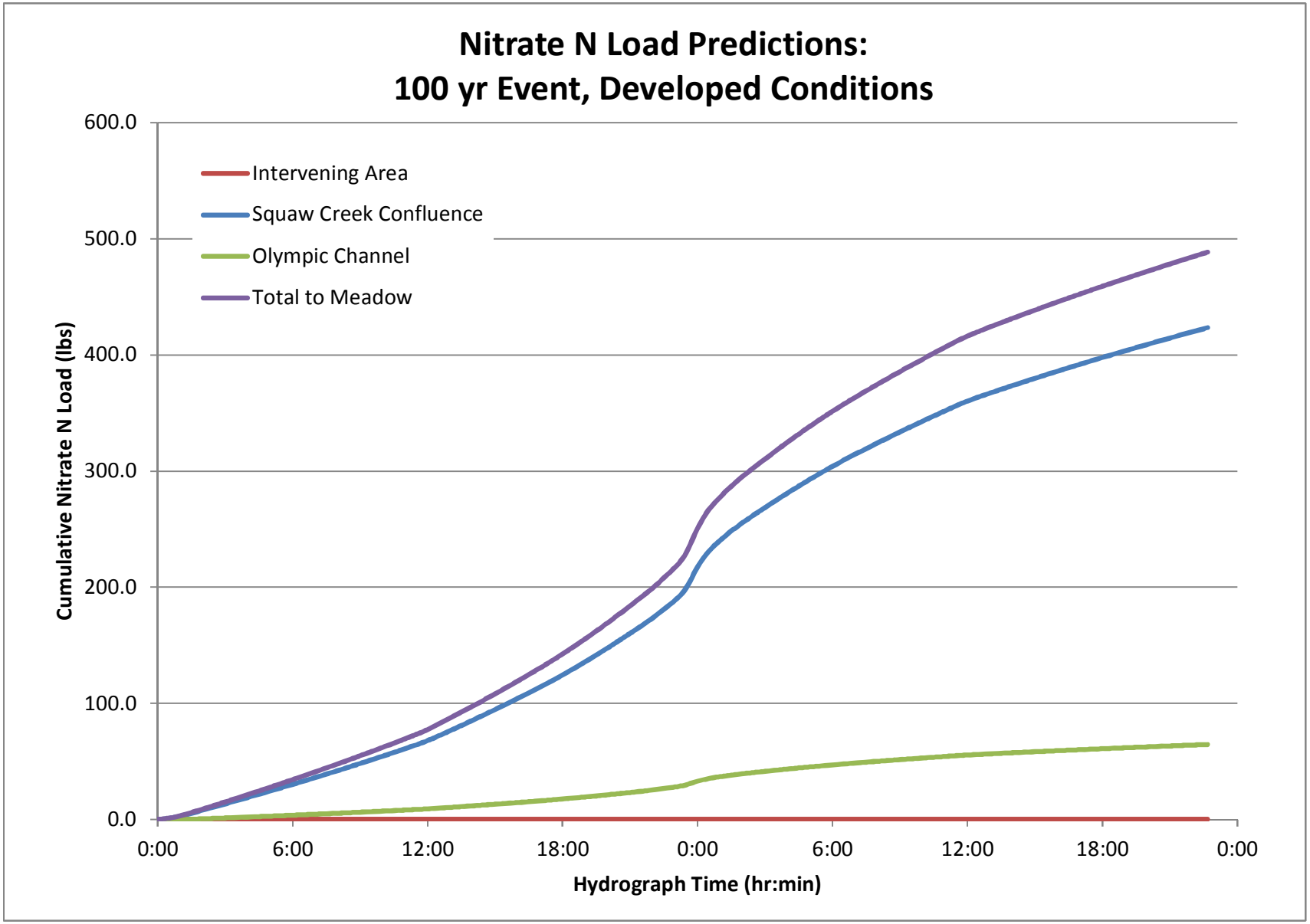

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Figure 19. **Nitrate Nitrogen Load Predictions: 100 Year Event, Developed Conditions**

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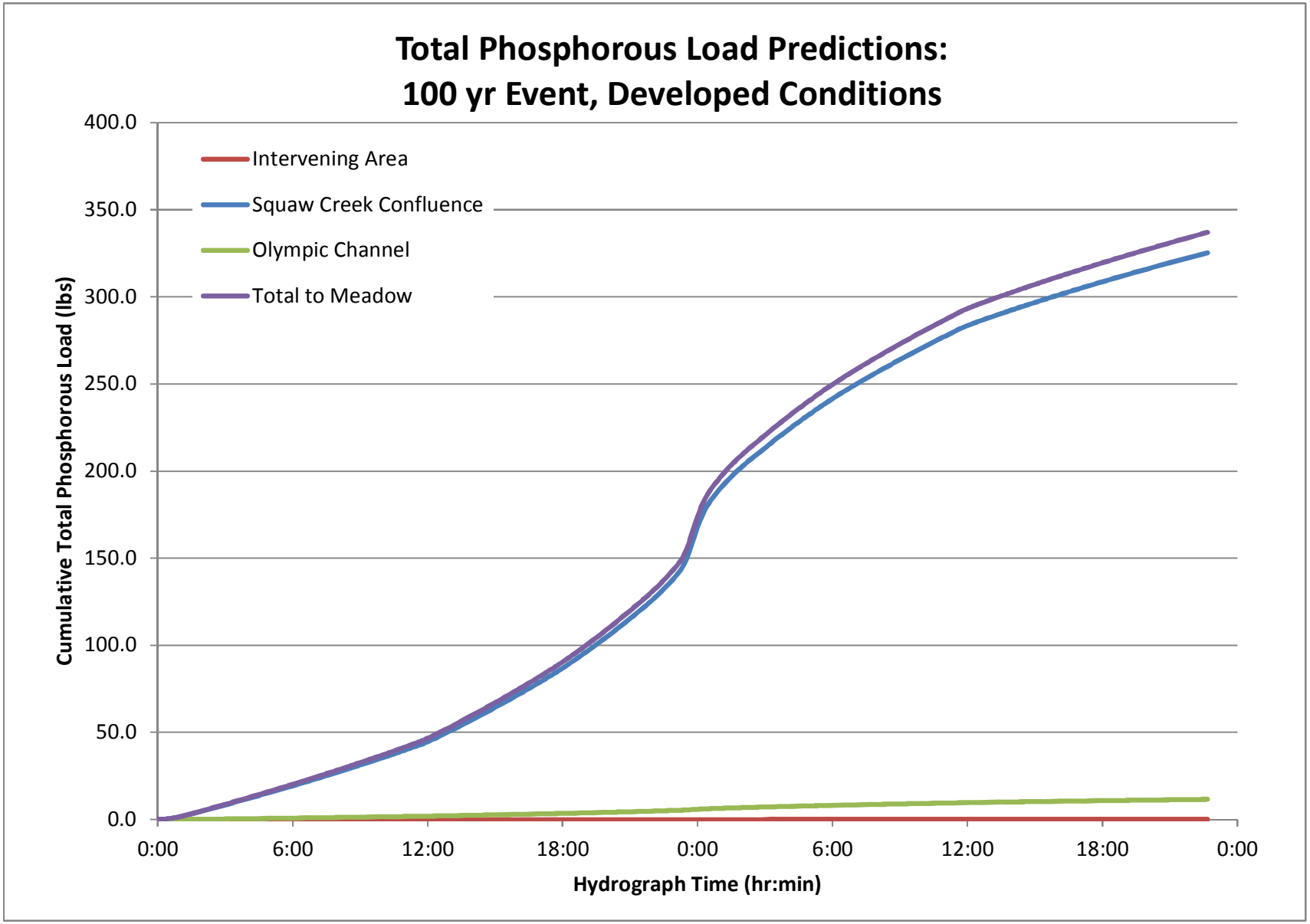

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Figure 20. **Total Phosphorous Load Predictions: 100 Year Event, Developed Conditions**

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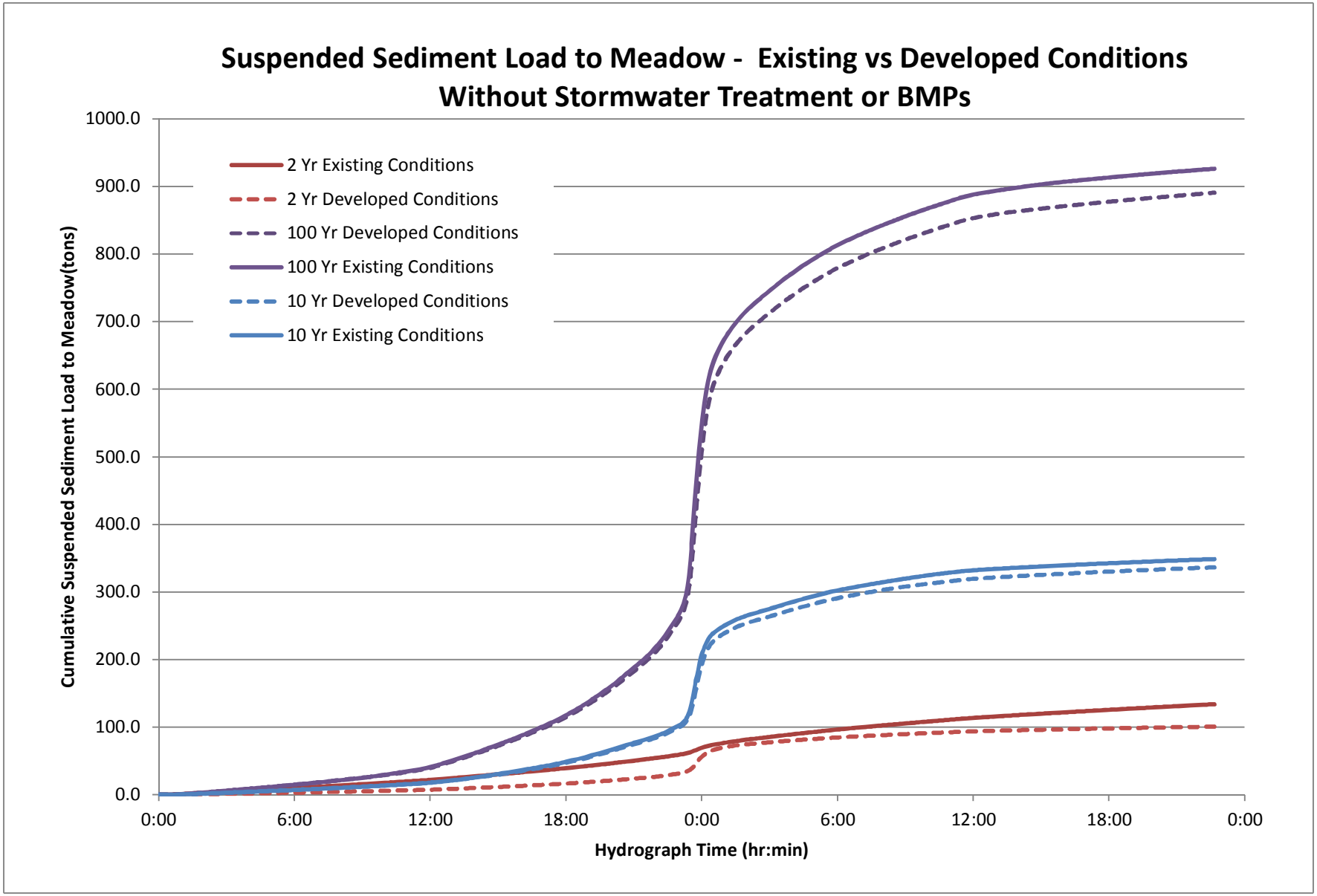

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Figure 21. **Comparison of Total Suspended Solids Loadings to the Meadow: Existing versus Proposed Developed Conditions**

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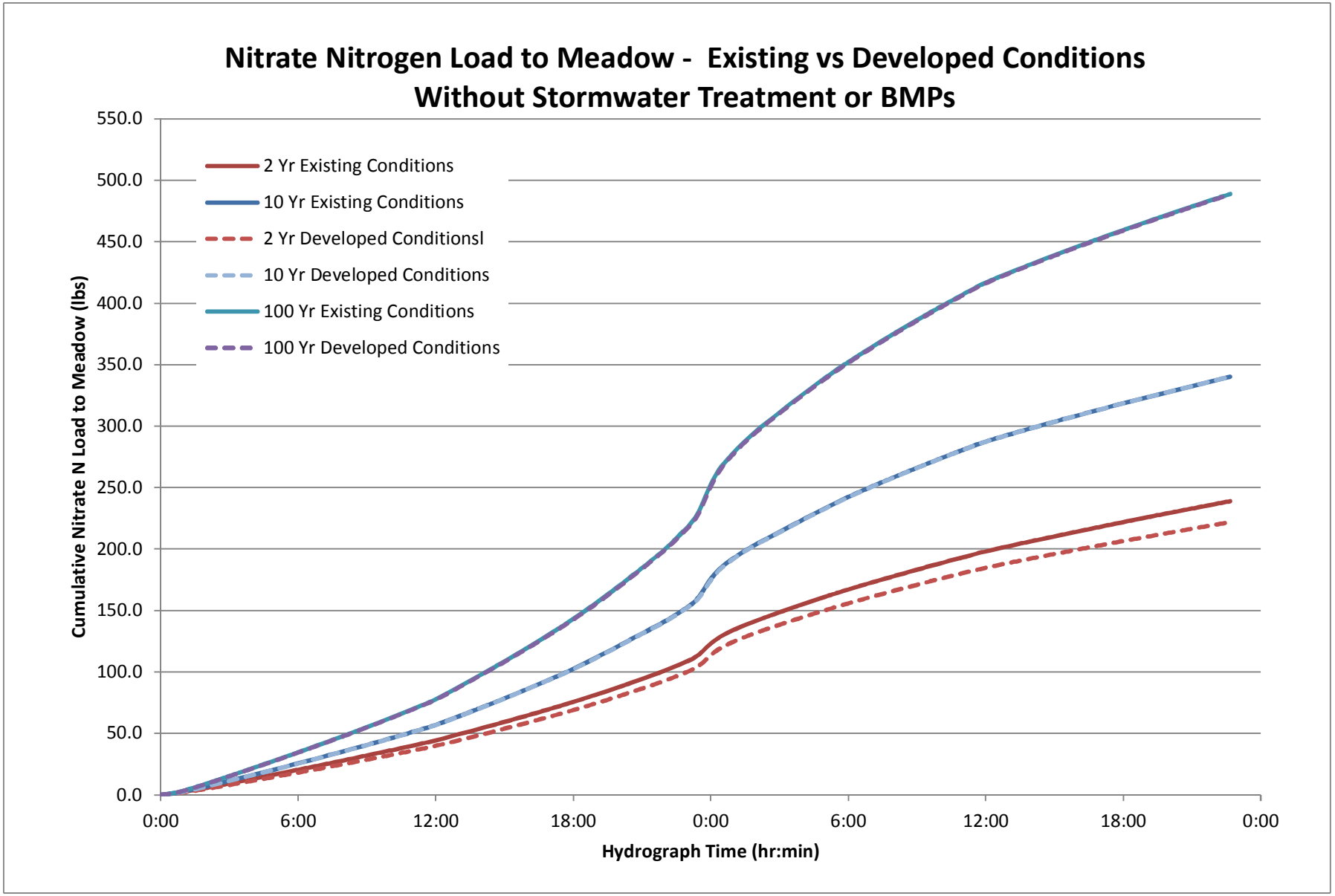

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Figure 22. **Comparison of Nitrate Loadings to the Meadow: Existing versus Proposed Developed Conditions**

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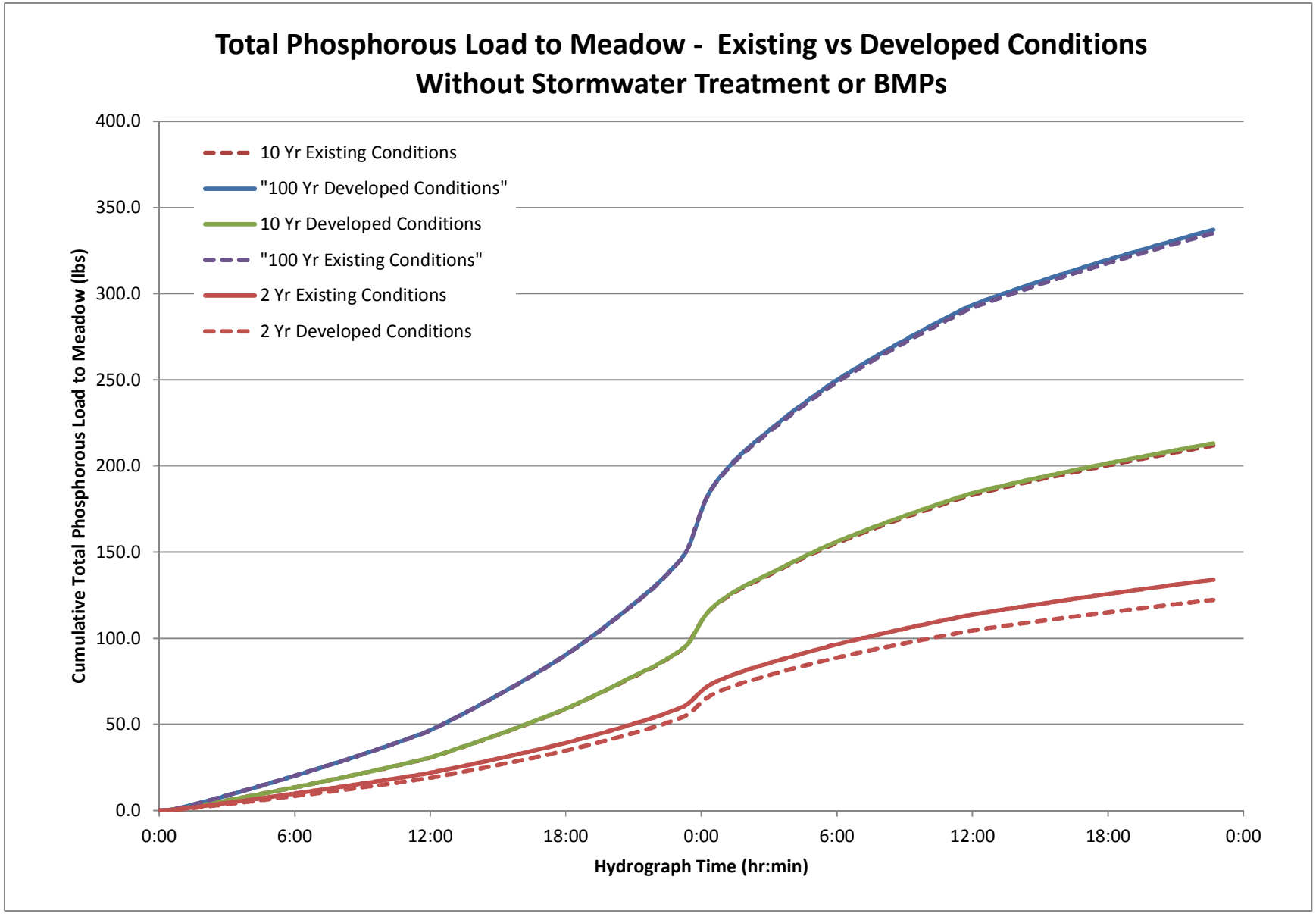

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Figure 23. **Comparison of Total Phosphorous Loadings to the Meadow: Existing versus Proposed Developed Conditions**

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