Responses to FERC Additional Information Request OP-1

(d) Sediment Transport

Final Report

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SCHEDULE A: ADDITIONAL INFORMATION REQUEST OP-1 SEDIMENT TRANSPORT OPERATIONAL SCENARIO

Time Required: 9 months

(d) Sediment transport

In order to assist us with evaluating the effects of your proposed and alternative operations on erosion and sediment transport, please provide the following information:

(i) Develop flow duration curves at Pine Bar (RM 227.5), Salt Creek Bar (RM 222.4), Fish Trap Bar (RM 216.4), and the China Bar (RM 192.3) for the extreme low (1992), low (1994), medium (1995), high (1999), and extreme high (1997) flow years for proposed operations and for each of the operational scenarios and sub-scenarios identified above. Plot horizontal lines for Q1.0, Q1.5 (the peak flows that have a 1.0 and 1.5 year average recurrence interval) and flows at which incipient motion of medium sand (1 mm) occurs at each site as determined in Part 3 of AIR S-1, Sediment Transport. (Please indicate the period of record that was used to determine the Q1.0 and Q1.5 flows, and indicate whether these represent peak instantaneous or peak daily average flows.) If the duration or extent of sand mobilization under proposed operations varies significantly from any of the operational scenarios or sub-scenarios, please evaluate the potential impacts of these changes, such as accelerated sandbar erosion.

Please prepare your responses to parts (d), (e), (f) and (g) of this AIR after consultation with NOAA Fisheries, U.S. Fish and Wildlife Service (FWS), U.S. Forest Service (FS), U.S. Bureau of Land Management (BLM), Idaho Department of Fish and Game (IDFG), Idaho Department of Environmental Quality (IDEQ), Oregon Department of Fish and Wildlife (ODFW), Oregon Department of Environmental Quality (ODEQ) Columbia River Inter-Tribal Fish Commission (CRITFC), Nez Perce Tribe (NPT), Shoshone-Bannock Tribes (SBT), Shoshone-Paiute Tribes of the Duck Valley Indian Reservation (SPT), Burns Paiute Tribe (BPT), the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), and the Confederated Tribes of Warm Springs (CTWS). Include comments from the consulted entities on your response to items (d), (e), (f) and (g) and your response to their comments with your filing.

In all parts of your response where graphics are requested, full page black-and-white graphics should be provided to ensure readability in both hard copy and electronic formats. In order to facilitate side-by-side comparisons, please provide the graphs that we ask for in subparts (e)(i) through (e)(iii) and subparts (f)(i) and (f)(ii) of this AIR for both current and your proposed operations.[1]

1. INTRODUCTION

This Additional Information Request (AIR) asks for two general categories of information; flow duration curves of Proposed Operations and scenarios identified in the May 4, 2004 AIR, and some evaluation of potential impacts measured in terms of difference of mobility of sand between Proposed Operations and the scenario's, where the difference is significant. Per the AIR, flow duration curves were developed at Pine Bar (RM 227.5), Salt Creek Bar (RM 222.4), Fish Trap Bar (RM 216.4), and China Bar (RM 192.3)

[1] In AIR OP-2, Current Operations Scenarios, we ask you to determine whether your proposed operations are the same as your current operations.

for five years (1992, 1994, 1995, 1999, and 1997) with each year representing a condition of extreme low through extreme high flows (Parkinson 2003a).

In the second part of the AIR, FERC requested “If the duration or extent of sand mobilization under proposed operations varies significantly from any of the operations scenarios or sub-scenarios, please evaluate the potential impacts of these changes, such as accelerated sandbar erosion.” To address this component of the AIR, we examined the mobility at each bar for each scenario and year, and then compared to Proposed Operations. Significance criteria should be established such that changes that will not result in a measurable difference in sandbar area over the long term (multi-year) are not significant while changes that could result in a measurable trend of increase or decrease in sandbar area over the long term are significant. Mobility by itself does not indicate whether erosion or deposition is taking place and if it is assumed increased mobility is erosion, that still does not indicate whether or not the material eroded at that point will simply be deposited on another part of the sandbar or if it will be transported downstream and thus removed from the sandbar.

Given these factors, we did not determine a formal definition of significance but instead, summarized, presented, and discussed the analyses and resulting information. However it should be noted that the ratio of area mobilized relative to area inundated expressed as a percent does not increase or decrease more than 1% for any scenario and that the variation between years is much greater (often an order of magnitude) than the variation between Proposed Operations and any scenario. This would indicate that the differences in mobilization due to the different scenarios would not have a measurable impact on the sandbars studied. This is consistent with the information presented in Technical Report E.1-1 (Parkinson 2003b) and our conclusion that the sandbars are dynamic features that can grow, shrink, and change shape in response to varying flows in the river.

2. RESPONSES

2.1. Response to OP-1(d) Operational Scenarios—Sediment Transport

(d) Sediment transport

In order to assist us with evaluating the effects of your proposed and alternative operations on erosion and sediment transport, please provide the following information:

(ii) Develop flow duration curves at Pine Bar (RM 227.5), Salt Creek Bar (RM 222.4), Fish Trap Bar (RM 216.4), and the China Bar (RM 192.3) for the extreme low (1992), low (1994), medium (1995), high (1999), and extreme high (1997) flow years for proposed operations and for each of the operational scenarios and sub-scenarios identified above. Plot horizontal lines for Q1.0, Q1.5 (the peak flows that have a 1.0 and 1.5 year average recurrence interval) and flows at which incipient motion of medium sand (1 mm) occurs at each site as determined in Part 3 of AIR S-1, Sediment Transport. (Please indicate the period of record that was used to determine the Q1.0 and Q1.5 flows, and indicate whether these represent peak instantaneous or peak daily average flows.) If the duration or extent of sand mobilization under proposed operations varies significantly from any of the operational scenarios or sub-scenarios, please evaluate the potential impacts of these changes, such as accelerated sandbar erosion.

Please prepare your responses to parts (d), (e), (f) and (g) of this AIR after consultation with NOAA Fisheries, U.S. Fish and Wildlife Service (FWS), U.S. Forest Service (FS), U.S. Bureau of Land Management (BLM), Idaho Department of Fish and Game (IDFG), Idaho Department of Environmental Quality (IDEQ), Oregon Department of Fish and Wildlife (ODFW), Oregon Department of Environmental Quality (ODEQ) Columbia River Inter-Tribal Fish Commission (CRITFC), Nez Perce Tribe (NPT), Shoshone-Bannock Tribes (SBT), Shoshone-Paiute Tribes of the Duck Valley Indian Reservation (SPT), Burns Paiute Tribe (BPT), the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), and the Confederated Tribes of Warm Springs (CTWS). Include comments from the consulted entities on your response to items (d), (e), (f) and (g) and your response to their comments with your filing.

In all parts of your response where graphics are requested, full page black-and-white graphics should be provided to ensure readability in both hard copy and electronic formats. In order to facilitate side-by-side comparisons, please provide the graphs that we ask for in subparts (e)(i) through (e)(iii) and subparts (f)(i) and (f)(ii) of this AIR for both current and your proposed operations.[2]

Flow Duration Curves

The flow duration curves at the four (4) sandbars are based on annual time series of Hells Canyon Dam discharges simulated by CHEOPS (Parkinson 2003a) for Proposed Operations and each of the scenarios identified in the May 4, 2004 Request for Additional Information. In all, there are 55 time series representing the scenarios, and 5 for proposed operations, for a total of 60. Each of the 60 annual time series of Hells Canyon Dam discharges was routed to the four sand bars using the Hells Canyon MIKE 11 Hydrodynamic Model (Parkinson 2003a), where hourly discharges were extracted from the model results.

[2] In AIR OP-2, *Current Operations Scenarios,* we ask you to determine whether your proposed operations are the same as your current operations.

The flow duration curves were developed using this hourly data. By using hourly data to develop the flow duration curves, flow variations including load following are represented. These plots are shown as Figures 1 through 240.

Included on each flow duration curve are horizontal lines representing the peak flows with a 1.5 and 1.0-year average recurrence interval, the $Q_{1.5}$ and $Q_{1.0}$, respectively. The $Q_{1.5}$ and $Q_{1.0}$ were determined using instantaneous discharges from the USGS Snake River at Hells Canyon Dam ID-OR State Line gage (13290450) for the period 1966–2001, inclusive (36 years). The $Q_{1.5}$ is from a USGS frequency analysis using the Weibull distribution according to Bulletin 17-B Guidelines. The resulting $Q_{1.5}$ is 39,721 cfs.

The $Q_{1.0}$ requested by FERC is less well defined in the literature. A one-year return flow by definition has a probability of exceedance equal to 100%. Probability plots of flows do not include probabilities of 100% so a traditional approach could not be used. The minimum instantaneous annual peak flow has a probability of 100%. Using the same period of record used to determine $Q_{1.5}$, the $Q_{1.0}$ is 22,200 cfs.

Also included on each flow duration curve are horizontal lines representing the discharge at which mobilization of 1 mm particles begins in the areas where sand occurs. The discharge at which mobilization begins for each bar was determined by comparing the area mobilized to the sand area inundated for each requested discharge. When this ratio exceeded 1% the bar was determined to be mobile. A plot of the percentage of inundated sand area mobilized is shown in Figure 241 and these data are shown in Table 1.

Incipient Motion of Sand

We used substrate maps developed for aquatics studies and research related to the relicensing effort to define the boundaries of the sand areas at the sandbar locations. The classification of substrate in these investigations is based on a visual determination using a referenced measuring rule or Mylar grid and a modified Brusven scale (Groves and Chandler 1999) where the sand-pebble classification includes sizes smaller than 6mm. While this technically includes sizes larger than sand, in practical terms areas falling into this class are dominated by sand (not pebble) sizes. IPC recently (November 2004) collected additional information on substrate of the exposed portions of the sandbars and this information was used to verify and update the substrate maps.

Incipient motion of sediment has been defined in a number of ways by various researchers. Definitions have been based on either visual observation or theoretical calculations and range from motion of any sediment particle through motion of a certain percentage of surface particles to general motion of the bed. For the purposes of responding to this Additional Information Request, incipient motion of sand was determined to be the point when the calculated applied shear stress equaled or exceeded the calculated critical shear stress for a 1 mm sized particle. This is consistent with the approach used in the FLA. Applied shear stress and critical shear stress for a 1 mm particle size as requested in AIR S-1(c) were determined using results from a two-dimensional hydraulic model (Parkinson 2003a) on a cell by cell basis for each sand bar and discharge. Details of the procedure are presented in the response to AIR S-1.

Analysis of Sand Mobilization

Per the AIR S-1 we have evaluated conditions of mobility for 1 mm particle sizes in the sand substrate areas at the four sandbars. We have not specifically evaluated erosion, deposition, or transport of 1 mm particle sizes. We evaluated impacts at the four bars by following the same procedure of comparing results for each scenario against the Proposed Operations:

- Areas of mobility (m^2) at each bar were determined by simulating discharges of 5,000 cfs to 30,000 cfs at 5,000 cfs increments using the 2-D model for each site. Mobility of 1.0 mm sand was evaluated at each of these six flows. The approach is discussed in AIR S-1 (c).

- Each simulated discharge was assumed to represent mobility for a range of flows from half way to the next lower flow to half way up to the next higher flow (e.g., the mobility calculated for 10,000 cfs was assumed to represent mobility for flows from 7,500 cfs to 12,500 cfs).

- We applied the flow vs. mobile area function described above to each hour of the year using hydrographs of hourly discharge for Proposed Operations and each scenario. These results yield an area of sand mobilized for each hour of the year and account for wetting and drying as hourly flows change.

- The mobilized sand area and total inundated sand areas were summed up over the year. These values have the units of area*time (m^2*hours). These values were divided by the number of hours in the year to get an annual average value for inundated sand and mobilized sand areas. These values have the units of area (m^2). By doing a summation over the year, increases in mobilized area are balanced by decreases in mobilized area on a one for one basis and the summation represents a net annual value (either increase or decrease).

- We then compared the results for Proposed Operation and the individual scenarios in two ways. The first way was to evaluate how much the mobilized area increased or decreased relative to Proposed Operations. The second way was to determine if the ratio of mobilized area to inundated area (%) changed under the scenario relative to Proposed Operations. Comparing the areas mobilized to the inundated areas gives a relative sense of the level of mobilization that occurs under different scenarios. Figure 242 displays an example of a sandbar showing the areas and formulas used for this analysis.

- For purposes of comparison, we examined the cumulative areas of sand inundated by each scenario and Proposed Operations. The inundated area is the total wet area of sand, mobile and stable. The inundated and mobile areas for each sandbar are shown in Table 1[3].

General Results

Summaries of the differences in areas of sand mobilized between Proposed Operations and the individual scenarios are included in Tables 2a through 12b. The Tables 'a' show the inundated and mobile area for Proposed Operations and the scenario and present the change in the mobile area between the scenario and Proposed Operations as a percentage. Tables 'b' show the ratio of area mobilized to the inundated area (%).

The following subsections include discussions of the individual scenarios relative to Proposed Operations. The discussion of Scenario 1a includes more detail than the other scenarios to demonstrate how the information in the tables can be used.

Scenario 1a

Tables 2a and 2b summarize data for Scenario 1a. The percentage difference between the Scenario and Proposed Operations ranges from a positive 40 percent (Scenario mobilized area is greater than under Proposed Operations) to a negative 76 percent (Proposed Operations mobilized area is greater than under the Scenario). However, the negative 76 percent is for the mobilized area going from about 1 m^2 to essentially 0 m^2. The change in percentage of area mobilized ranged from a negative 1.2 percent (Proposed Operations percent mobilized area is greater than under the Scenario) to 3.5 percent (Scenario percent mobilized is greater than under Proposed Operations).

Positive and negative changes seem to be fairly randomly distributed between bars and flow years. China Bar generally shows the least change due to the scenario and Pine Bar and Fish Trap both show the greatest changes with Pine Bar having both positive and negative changes and Fish Trap showing more negative changes.

[3] Areas in Table 1 have been updated to reflect final results of the MIKE 21C mobility modeling.

Average over the 5 years shows that Scenario 1a mobilizes about $32m^2$ and $9m^2$ more area than Proposed Operation at Pine Bar and China Bar, respectively. Scenario 1a mobilizes about $2m^2$ and $16m^2$ less area than Proposed Operation at Salt Creek and Fish Trap, respectively (Table 2a). In none of the years does the percentage of mobilized area change by more than 1 percent (Table 2b).

Summing the area mobilized under the scenario and Proposed Operations for all four bars and all five years shows that the area mobilized under the scenario is about 1.4% greater than the area mobilized under Proposed Operations.

Scenario 1b

Tables 3a and 3b summarize data for Scenario 1b. Average over the 5 years shows that Scenario 1b mobilizes about $33m^2$ and $9m^2$ more area than Proposed Operation at Pine Bar and China Bar, respectively. Scenario 1b mobilizes about $2m^2$ and $15m^2$ less area than Proposed Operation at Salt Creek and Fish Trap, respectively. In none of the years does the percentage of mobilized area change by more than 1 percent.

Summing the area mobilized under the scenario and Proposed Operations for all four bars and all five years shows that the area mobilized under the scenario is about 1.8% greater than the area mobilized under Proposed Operations.

Scenario 1c

Tables 4a and 4b summarize data for Scenario 1c. Average over the 5 years shows that Scenario 1c mobilizes about $20m^2$ and $6m^2$ more area than Proposed Operation at Pine Bar and China Bar, respectively. Scenario 1c mobilizes about $1m^2$ and $8m^2$ less area than Proposed Operation at Salt Creek and Fish Trap, respectively. In none of the years does the percentage of mobilized area change by more than 0.5 percent.

Summing the area mobilized under the scenario and Proposed Operations for all four bars and all five years shows that the area mobilized under the scenario is about 1.0% greater than the area mobilized under Proposed Operations.

Scenario 1d

Tables 5a and 5b summarize data for Scenario 1d. Average over the 5 years shows that Scenario 1d mobilizes about $11m^2$ and $2m^2$ more area than Proposed Operation at Pine Bar and China Bar, respectively. Scenario 1d mobilizes about $2m^2$ less area than Proposed Operation at Fish Trap and Salt

Creek shows no difference. In none of the years does the percentage of mobilized area change by more than 0.4 percent.

Summing the area mobilized under the scenario and Proposed Operations for all four bars and all five years shows that the area mobilized under the scenario is about 1.0% greater than the area mobilized under Proposed Operations.

Scenario 1e

Tables 6a and 6b summarize data for Scenario 1e. Average over the 5 years shows that Scenario 1e mobilizes about $2m^2$ and $1m^2$ more area than Proposed Operation at Pine Bar and China Bar, respectively. Scenario 1e mobilizes about $3m^2$ less area than Proposed Operation at Fish Trap and Salt Creek shows no difference. In none of these cases does the percentage of mobilized area change by more than 0.5 percent.

Summing the area mobilized under the scenario and Proposed Operations for all four bars and all five years shows that the area mobilized under the scenario is about 0.2% greater than the area mobilized under Proposed Operations.

Scenario 1f

Tables 7a and 7b summarize data for Scenario 1f. Average over the 5 years shows that Scenario 1f mobilizes about $28m^2$ and $6m^2$ more area than Proposed Operation at Pine Bar and China Bar, respectively. Scenario 1f mobilizes about $2m^2$ and $11m^2$ less area than Proposed Operation at Salt Creek and Fish Trap, respectively. In none of these cases does the percentage of mobilized area change by more than 1 percent.

Summing the area mobilized under the scenario and Proposed Operations for all four bars and all five years shows that the area mobilized under the scenario is about 1.8% greater than the area mobilized under Proposed Operations.

Scenario 2

Tables 8a and 8b summarize data for Scenario 2. Average over the 5 years shows that Scenario 2 mobilizes about $6m^2$ and $2m^2$ more area than Proposed Operation at Pine Bar and China Bar respectively. Scenario 2 mobilizes about $1m^2$ more area than Proposed Operation at Salt Creek and Fish Trap shows no difference. In none of these cases does the percentage of mobilized area change by more than 0.5 percent.

Summing the area mobilized under the scenario and Proposed Operations for all four bars and all five years shows that the area mobilized under the scenario is about 0.8% greater than the area mobilized under Proposed Operations.

Scenario 3

Tables 9a and 9b summarize data for Scenario 3. Average over the 5 years shows that Scenario 3 mobilizes about 8m^2 more area than Proposed Operation at China Bar. Scenario 3 mobilizes about 24m^2 less area than Proposed Operation at Pine Bar. Fish Trap and Salt Creek show no difference. In none of these years does the percentage of mobilized area change by more than 0.5 percent.

Summing the area mobilized under the scenario and Proposed Operations for all four bars and all five years shows that the area mobilized under the scenario is about 0.7% less than the area mobilized under Proposed Operations.

Scenario 4

Tables 10a and 10b summarize data for Scenario 4. Average over the 5 years shows that Scenario 4 mobilizes about 29m^2 and 10m^2 more area than Proposed Operation at Pine Bar and China Bar respectively. Scenario 4 mobilizes about 2m^2 and 10m^2 less area than Proposed Operation at Salt Creek and Fish Trap respectively. In none of these years does the percentage of mobilized area change by more than 1 percent.

Summing the area mobilized under the scenario and Proposed Operations for all four bars and all five years shows that the area mobilized under the scenario is about 2.3% greater than the area mobilized under Proposed Operations.

Scenario 5

Tables 11a and 11b summarize data for Scenario 5. Average over the 5 years shows that Scenario 5 mobilizes about 2m^2 and 1m^2 more area than Proposed Operation at Pine Bar and China Bar respectively. Scenario 5 mobilizes about 4m^2 and 29m^2 less area than Proposed Operation at Salt Creek and Fish Trap respectively. In none of these cases does the percentage of mobilized area change by more than 1 percent.

Summing the area mobilized under the scenario and Proposed Operations for all four bars and all five years shows that the area mobilized under the scenario is about 1.3% less than the area mobilized under Proposed Operations.

Scenario 6

Tables 12a and 12b summarize data for Scenario 6. Average over the 5 years shows that Scenario 6 mobilizes about 43m^2 less area than Proposed Operation at Pine Bar. Scenario 5 mobilizes about 6m^2, 15m^2 and 1m^2 more area than Proposed Operation at Fish Trap, China Bar and Salt Creek Bar respectively. In none of these cases does the percentage of mobilized area change by more than 1 percent.

Summing the area mobilized under the scenario and Proposed Operations for all four bars and all five years shows that the area mobilized under the scenario is about 0.4% less than the area mobilized under Proposed Operations.

Summary of Results

The results show that there is a lot of variability in the area of sandbar mobilized from year to year as well as between scenarios. In fact, in most cases, the variability between years (extremely dry to extremely wet) is an order of magnitude or more greater than the difference between the Proposed Operation and any of the scenarios.

It should be noted that a much higher percentage of China Bar is mobile (on the order of 60%) relative to the total inundated sand area than the other three sandbars (on the order of a few percent). However, sandbar monitoring discussed in both IPC Technical Reports (Parkinson 2003b) and other researchers (Grams & Schmidt 1999) indicate that while China Bar has areas of both erosion and deposition, its volume has been relatively stable compared with the other three sandbars. This affirms that mobility alone is not a sufficient indicator of sandbar degradation or growth.

Reviewing the results indicates that the difference in area mobilized (expressed as a percentage) is a larger number than the difference in percent of area mobilized. This is because the base number when calculating just the difference in area mobilized is a much smaller number than the total inundated area. Therefore, a relatively small difference in area mobilized appears large in percentage terms when compared to another mobilized area but small relative to the whole inundated area. For example, Table 2a shows that at Pine Bar under Proposed Operations for 1992, there is approximately 10,795 m^2 of sand that is inundated and about 147 m^2 of this area is mobilized. Under Scenario 1a the area mobilized decreases to 109m^2 or a decrease of 26%. However, as shown in Table 2b, the percentage of the inundated portion of the bar that is mobile only changes from 1.4% to 1.0% or a reduction of 0.4% (Note: Table 2b shows –0.3% due to rounding). Most of the bars show both increase and decrease in the area mobilized depending on the year and scenario. Fish Trap tends to consistently show an increase in area mobilized under the scenarios. Salt Creek generally shows very little change regardless of the year or scenario. Pine Bar fluctuates the most widely; showing both increases and decreases in sand mobilized through the years and scenarios. China Bar has the highest percentage of sand area mobilized but this sandbar also shows the least difference in percent of sand area mobilized between Proposed Operations and any of the scenarios.

The average of the sandbar area mobilized over the five years evaluated at Pine Bar and China Bar is generally increased under the scenario flow and the area at Fish Trap is generally decreased under the scenario flow. Salt Creek generally shows little or no difference between the Proposed Operation and any of the scenarios except during 1992 (extreme low flows). Assuming that each bar is of equal importance or equally representative, we calculated the average difference of the ratio of sand area mobilized to inundated area across the four bars. *In none of the scenarios or years does the ratio of area mobilized over all four bars differ by more than 1 percent with respect to Proposed Operations*. Also, in all cases, the variation from year to year is much greater (often an order of magnitude greater) than the variation between Proposed Operations and any scenario.

3. CONSULTATION

USFS and BLM OP-1(d) Response to Comments

This section provides IPC's responses to agency comments from consultation for the HCC AIR OP-1(d). Comments were received for the USFS and BLM. These comments can be found in Appendix A.

Comments from the USFS and BLM are very similar. Responses to comments provided below follow the outline of the USFS document. Comments addressed are summarized and shown in underlined italics. Responses follow in regular text.

Attachment 1

Site Descriptions

No descriptions of the site boundaries is shown.

The boundaries are illustrated for each site on Figures B-1 to B-24 of AIR S-1.

Samples should have been taken from each site and analysis conducted for specific beach material. Or, at least use data from FLA E.1-2.

FERC requested that IPC conduct mobility analysis at the four sites for 1.0 mm sands. The analyses were responsive to FERC's request and were conducted using 1.0 mm sand.

Flow Duration Curves

Flow Duration Curves describe the frequency of flows of various magnitudes. The flow duration curves do not describe the frequency of wetting and drying for each scenario. This would assist in understanding how frequently sand is mobilized, and may assist in understanding other erosive mechanisms.

There appears to be some confusion about how the analysis was conducted, and text in OP-1(d) has been modified to clarify the analysis. Hydrographs of hourly discharges for each year of proposed operations and each scenario were used to develop the flow duration curves. The hydrographs of the same hourly data were also used to determine mobility for each hour of a year; flow duration curves were not directly used to determine mobility throughout the year. By using the hourly data rather than flow duration curves in determining mobility or stability, cycles of wetting and drying are in fact part of the analysis and results presented in OP-1(d).

Incipient Motion of Sand

Median sand size is much smaller than 1.0 mm requested, ranging from <0.3 – 0.6 mm. Consequently, flows calculated for incipient in this analysis will be much greater than those which will actually entrain sandbar sediment.

The comment implies that the agencies believe the bars are in actuality much more mobile than the modeling results indicate for a 1.0 mm particle size. If the bars are in fact much more mobile than predicted, bed load monitoring at the sandbars should demonstrate this.

IPC conducted bed load sampling as requested in AIR S-1(e) at the four bars at requested discharges. The sampling results generally indicate that in some cases there is no mobility in the sand areas that modeling predicts to be mobile for 1.0 mm particle sizes and there are very few cases where positive samples were collected in areas predicted to be stable. This suggests that the mobility modeling (for 1.0 mm sizes) is reasonable and may actually overestimate areas of mobility for any bed load (which is consistent with IPC's opinion that the modeling assumptions are in general conservative). While the agencies' hypothesis is understandable, the empirical information collected at the four bars doesn't support it.

The USFS states that since FERC left meaning of incipient motion unspecified, IPC defined incipient motion as a condition when 1% of an inundated area had applied shear stresses greater than the calculated critical shear stress for a 1.0 mm particle.

This is partially true, but apparently needs clarification. IPC defines incipient motion as a condition when the applied shear stress exceeds the critical shear stress, which is determined for each cell. A sand bar is considered to be mobile when more than 1% of the inundated area of sand at a bar has an applied shear stress that exceeds the critical shear stress (which IPC believes is a conservative threshold to determine bar mobility). Mobility of sand and the overall mobility of a bar is not the same thing.

The critical and applied shear stress was determined for each cell using a two-dimensional model (MIKE 11).

The two-dimensional results were determined with MIKE 21C, which is a 2-D curvilinear model. MIKE 11 is a 1-D model.

These threshold flows are approximately shown on each of Figures 1–240, although they have been inexplicably rounded to the nearest 5,000 cfs.

IPC did not “inexplicably” round off to the nearest 5,000 cfs. On the contrary, the information presented is responsive to FERC’s request. FERC clearly requested analysis in 5,000 cfs increments and the estimates of sand mobility are based on these flows.

More information needed to evaluate results

Information on cell size, maps of sand bars with extent of sand area are in AIR S-1.

Analysis of Sand Mobilization

IPC’s analysis approach likely results in imprecise results that significantly underestimate sandbar sediment entrainment, especially for flow scenarios that have higher percentages of large flows.

1. *It is not clear how the areas of potential sediment transport for flows greater than 30,000 cfs were determined. Speculating, two likely possibilities are that (1) those periods where flow was greater than 30,000 cfs were not considered in the analysis, or (2) if they were, only the areas with critical shear stresses sufficient to mobilize 1 mm sand at the 30,000 cfs discharge were considered mobile no matter by how much the actual discharge exceeded 30,000 cfs.*

The modeling addressed the incipient motion or mobility in each cell. It did not assess the sediment transport in each cell.

It is unnecessary for the agencies to speculate; we clearly state that each of the requested discharges represents flow from half way down to the lower flow or half way up to the next higher flow. Since 30,000 cfs is the highest increment; it is used from 27,500 and up.

2. *The step function with 5,000 cfs intervals likely minimizes differences in calculated sand entrainment areas between scenarios. It would have been relatively straightforward to use an empirical function to relate area mobilized to discharge. This approach reduces the resolution of the analysis.*

IPC does not have empirical data that would have lent to developing an empirical relationship of mobile areas between simulated discharges. IPC does agree that it would be possible to apply a continuous analytical expression between the discharges simulated. However, any assumed analytical function between the simulated discharges could be subject to criticism (just as the step function has been).

It is not clear that assuming a functional relationship for conditions between simulated discharges would improve the resolution of the analysis. It would make the results appear continuous, but would not add resolution. It would, however, provide some variability that would be a function of the assumed relationship (not of the physical processes). Although we considered it in developing the analysis, it is doubtful that this would be any more beneficial to the analysis than the step function that was used, and it could give the impression that more information exists than actually does.

3. *IPC's procedure to compare the extent of sand mobilization for proposed operations with the various specified scenarios cannot be fully assessed because there is insufficient information of the underlying assumptions, especially those justifying "balancing" or "offsetting" periods of greater mobile areas with periods of less mobile areas. The simplest and most straightforward approach to assessing the aerial "extent of sand mobilization" for each flow scenario is to combine the "mobile area function" for each sand bar with the particular flow distribution function to give a cumulative area (on an annual basis) subject to 1 mm sand entrainment.*

There appears to be some confusion about how the analysis was conducted, and text in OP-1(d) has been modified to clarify the analysis. Hydrographs of hourly discharges for each year of proposed operations and each scenario were used to develop the flow duration curves. The hydrographs of the same hourly data were also used to determine mobility for each hour of a year; flow duration curves were not directly used to determine mobility throughout the year. The area mobilized for proposed operations and each scenario was summed for every hour and then divided by the number of hours in a year (areas without mobility are not part of the summation), which gives the average annual mobilized area (m^2) that is in tables Xa of OP-1(d).

With the exception of the units of the resulting area mobilized (m^2 or m^2*hrs) and the format of the tables, IPC believes the results the USFS is looking for are in OP-1(d).

*This result would be in units of m^2*hrs similar to IPC's computation procedure but would not involve explicit "offsetting."*

USFS appears to misunderstand the offsetting discussed. If USFS chooses to do the evaluation on a cumulative basis with different units, the annual average areas (m^2) can be easily multiplied by the number of hours in the year (365*24=8,760). The results won't change, the numbers will be larger, but the percent difference between the scenarios and proposed operations will remain the same.

However, from IPC's description (pg.5), areas during periods of calculated immobility are apparently subtracted from the cumulative total.

IPC never discusses subtracting immobile areas from a total. We simply note that by summing up the differences over a year, negative values (that is the mobile area under the alternative is more than under the proposed operation) will "offset" positive differences (where the mobile area under the proposed operation is larger than under the alternative). Immobile areas are not used in the calculation other than to represent total area. The USFS's proposed cumulating approach does exactly the same thing.

This is completely invalid unless it is assumed that periods of immobility result in deposition that balances erosion on a time equivalent basis. This is stated on page 5 as "we assumed that any decrease in the area of mobilization was no impact and represented opportunities for deposition"

The methodology is valid and this sentence in OP-1(d) has been modified in an attempt to make it less confusing.

This assumption is invalid because of the clear evidence of diminished supply of sediment feeding most sand bars and the highly nonlinear character of sediment entrainment.

This statement implies that the USFS is assuming that any condition of mobility correlates to transport of sands away from sandbars. The counts of sandbars presented in the FLA and AIR S-1(g) show that the number of sandbars has increased during periods of higher flows (1973–1977 and 1982–1997). For the number of sandbars to increase during some periods, it is not possible for them to be in a continuous condition of sand being transported downstream. In fact, for the number of bars to ever increase, there must be deposition of sands under some conditions (likely from sources below HCD). This said, IPC agrees that there has been a diminished supply of sediment feeding most sandbars. In fact, in the FLA IPC presented that over 87% of the watershed that contributed sediment to the Hells Canyon reach was already blocked off (including the Boise and Payette that drain the Idaho Batholith) at the time the HCC was constructed.

Another aspect of this analysis mutes the effects of larger flows (those creating areas of sand mobility) on potential sand mobilization, thus understating the potential effects of scenarios with flow-duration curves skewed towards flows exceeding the transport thresholds. While Idaho Power perhaps meets the letter of the AIR request in determining "extent of sand mobilization," it does not meet the spirit of the analysis by failing to make any attempt to consider differences in sediment volume entrained between the suite of scenarios. In a shear stress approach to calculating sediment transport, bedload transport rates are commonly related to the "excess shear" above critical transport conditions. This relation is nonlinear. For example, the commonly used Meyer-Peter and Müller (1948) equation for bedload transport reduces to:

$q \propto \left(\tau_o - \tau_c\right)^{1.5}$*, where q is the bedload transport rate per unit width,* τ_o *is the applied shear stress, and* τ_c *is the critical shear stress for the particle size of interest (Julien, 1994, pg 161-162). Because transport is related to the difference between the applied and critical shear stress, bedload transport rates increase markedly once the critical shear stress value is exceeded for a specific area. Simply assessing the area affected by sediment transport for a particular scenario gives incomplete information of the likely affects of that scenario on sediment mobilization. A more valid assessment, hence more valid comparisons between scenarios, would result from applying an excess shear calculation to the analysis so to estimate potential volumes entrained. While for a variety of reasons the resulting values may not be very accurate, such an analysis would provide the most complete information for comparison purposes and is clearly within the capabilities of the models and data available.*

IPC recognizes that sediment transport, as a function of bed shear is non-linear. The USFS states that due to this non-linearity, bed load transport rates will increase markedly once the critical shear stress has been exceeded. Thus, implying that transport rates increase non-linearly with river discharge.

The Schoklitsch equation computes bed load per unit width as a function of excess discharge. The relationship between bed load and discharge is linear ($Q^{1.0}$). Simons and Senturk (1992) present excess shear transport equations in terms of excess discharge. This relationship shows bed load as a function of discharge raised to the 6/5 power ($Q^{6/5}$), which is close to unity.

The USFS acknowledges that the information resulting from using transport equations may not be very accurate, and IPC agrees. Most sediment transport equations assume that supply is not a limiting factor (i.e., it is unlimited). This is not the case in many gravel bed rivers, and certainly not the case in Hells Canyon. Therefore, using them for this type of application is of dubious value.

4. *The most valid and clear comparison would be a simple table (and a single corresponding chart) modeled after Table 2a that for each bar and for each scenario that presents the correctly calculated (see comments above) total annual mobilized area (in m^2*hours). There is no clear reason why these values should be normalized to bar area.*

In IPC's opinion, it is much easier and much more clear to evaluate a number by saying, for example, the percentage of bar mobilized changes from 10% to 12% than to evaluate a number that says, for example, one alternative has 1,312,538 m^2*hrs of sand mobile and the other alternative has 1,575,046 m^2*hrs of sand mobile. If the USFS would rather evaluate larger numbers, the annual areas mobilized in tables Xa of OP-1(d) can be multiplied by 8,760 hours/year. Regardless of the units, the results will be the same.

The normalization adopted by IPC simply creates very small numbers without adding information,

The intent wasn't to add information. The intent was to make the analysis easier to understand. It matters not what units are used; the difference between the scenarios and proposed operations will remain the same.

hence supporting obtuse statements such as "In none of the scenarios or years does the ratio of area mobilized over all four bars differ by more than 1 percent with respect to Proposed Operations".

Contrary to the USFS's opinion, there is nothing "obtuse" about a simple summary statement of fact. The results are not suggesting that there is no mobility at the bars. Rather, on an annual basis, the difference in area mobilized between the scenarios and proposed operations is relatively small.

In reality, even with the flawed calculation procedures, the percent changes in absolute area are much greater, ranging up to 71% as shown in Table 2a.

The 71% change that the USFS notes is a change from an area of 0.90 m^2 to 0.26 m^2 ((0.9-0.26)/0.9). It is extremely doubtful, as the USFS seems to indicate, that a difference in mobilized area of 0.64 m^2 averaged over a year is significant. In fact, this is an excellent illustration of why IPC provided both percentage changes and area changes. If you look at the results on a cumulative basis, they would go from 7,884 m^2*hrs to 2,278 m^2*hrs. While this result yields larger numbers in different units that are less discernable, the percentage change remains the same as that represented in the response to this AIR.

Summary

It should also be noted that this approach – the critical tractive force approach – which was the logical analysis approach adopted by IPC given the request to determine incipient motion conditions – may not be relevant to other important erosional mechanisms affecting sandbars, such as sapping (owing to daily flow ramping cycles). The studies conducted so far as part of the relicensing effort have not shed sufficient light on the processes forming, maintaining, and eroding sandbars so that we can confidently and quantitatively predict their behavior on the basis of a single process model.

IPC agrees that the approach is reasonable given the request. The question of mobility through the range of flows readily influenced by operations of the HCC is certainly relevant. And, applying critical tractive force to address the question is certainly appropriate. IPC also recognizes that critical tractive force may not address all potential causes of sandbar erosion.

A number of studies have been conducted throughout the relicensing process, none of which have identified a single process as a primary mechanism that can fully explain sandbar processes in Hells Canyon. While IPC doubts there is a single process or factor that will explain everything, IPC agrees there are other processes that can be evaluated. The USFS and BLM both mention sapping of the bars, and the BLM suggest that wake erosion could be a factor. Either of these may be an important mechanism in sandbar processes.

4. ACKNOWLEDGMENTS

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Mike Butler, IPC – GIS analysis

Sharon Parkinson, IPC – MIKE 11, CHEOPS

Sherrill Doran, CH2Mhill - approach

James M. Milligan, University of Idaho (Retired) - approach

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Table 1. Mobile and Inundated Areas of Sandbars.

Flow	Mobile Area	Inundated Area	Mobile Area as a Percent of Inundated Area
cfs	m^2	m^2	%
Pine Bar			
5000	0	9,595	0%
10000	51	10,854	0%
15000	1,053	12,123	9%
20000	309	12,625	2%
25000	855	13,131	7%
30000	1,276	13,391	10%
Salt Creek Bar			
5000	0	4,422	0%
10000	0	5,202	0%
15000	2	5,583	0%
20000	11	5,753	0%
25000	25	5,889	0%
30000	126	6,060	2%
Fish Trap Bar			
5000	0	1,180	0%
10000	15	1,685	1%
15000	213	2,203	10%
20000	449	3,244	14%
25000	731	4,036	18%
30000	1,132	4,509	25%
China Bar			
5000	386	765	50%
10000	670	988	68%
15000	761	1,184	64%
20000	755	1,479	51%
25000	850	1,698	50%
30000	928	1,903	49%

Table 2a. Percent Change in Sandbar Mobility Under Scenario 1a Compared with Proposed Operations.

	1992 Extreme Low	1994 Low	1995 Medium	1999 High	1997 Extreme High	*Average*
Pine Bar (RM227.5)						
Innundated Area (PO)[1]	10,795	11,386	12,486	12,774	13,064	***12,101***
Innundated Area (Sc)[2]	10,800	11,603	12,437	12,862	13,076	***12,156***
Mobilized Area (PO)[3]	147	319	716	941	1,062	***637***
Mobilized Area (Sc)[4]	109	447	649	1,128	1,012	***669***
Salt Creek (RM222.4)						
Innundated Area (PO)	5,120	5,347	5,739	5,841	5,942	***5,598***
Innundated Area (Sc)	5,136	5,440	5,725	5,864	5,944	***5,622***
Mobilized Area (PO)	1	2	35	57	74	***34***
Mobilized Area (Sc)	0	1	33	57	70	***32***
Fish Trap (RM216.4)						
Innundated Area (PO)	1,828	2,110	3,243	3,569	3,969	***2,944***
Innundated Area (Sc)	1,769	2,062	3,181	3,508	3,991	***2,902***
Mobilized Area (PO)	49	114	490	646	796	***419***
Mobilized Area (Sc)	26	97	464	642	786	***403***
China Bar (RM192.3)						
Innundated Area (PO)	869	970	1,309	1,420	1,538	***1,221***
Innundated Area (Sc)	859	979	1,291	1,413	1,537	***1,216***
Mobilized Area (PO)	591	663	789	829	861	***747***
Mobilized Area (Sc)	600	704	781	839	856	***756***
Pecent Change between Scenario and Proposed Operation[5]						
Pine Bar	-26%	40%	-9.4%	20%	-4.7%	***4.1%***
Salt Creek	-76%	-52.3%	-5.3%	-1.3%	-5.8%	***-28.2%***
Fish Trap	-48%	-15%	-5.3%	-0.7%	-1.2%	***-14%***
China Bar	1.6%	6.1%	-1.1%	1.2%	-0.5%	***1.5%***
Average Over All Bars [6]	***-6.7%***	***13.7%***	***-5.1%***	***7.7%***	***-2.5%***	***1.4%***

[1]Area of sand (m^2) innundated under the Proposed Operation (PO) on an average annual basis (summed hourly values divided by the number of hours in the year)

[2]Area of sand (m^2) innundated under the scenario (Sc) on an average annual basis (summed hourly values divided by the number of hours in the year)

[3]Area of mobile sand (m^2) under the Proposed Operation (PO) on an average annual basis (summed hourly values divided by the number of hours in the year)

[4]Area of mobile sand (m^2) under the scenario (Sc) on an average annual basis (summed hourly values divided by the number of hours in the year)

[5]Percentage change in area of mobile sand [(4)-(3)]/(3). Positive value means percentage of sand mobilized under the scenario is higher than the percentage of sand mobilized under Proposed Operations.

[6]This average is an area weighted average because it computes the summed area over four beaches to calculate percentages. The value is different than the average of the percentages.

Table 2b. Change in Percentage of Sandbar Area Mobile Under Scenario 1a Compared with Proposed Operations.

Sandbar	1992 Extreme Low	1994 Low	1995 Medium	1999 High	1997 Extreme High	*Average*
Pecentage of Sand Area Mobilized Under Proposed Operation[1]						
Pine Bar	1.4%	2.8%	5.7%	7.4%	8.1%	***5.1%***
Salt Creek	0.0%	0.0%	0.6%	1.0%	1.3%	***0.6%***
Fish Trap	2.7%	5.4%	15%	18%	20%	***12%***
China Bar	68%	68%	60%	58%	56%	***62%***
Average Over All Bars[4]	***4.2%***	***5.5%***	***8.9%***	***10%***	***11%***	***8.1%***
Pecentage of Sand Area Mobilized Under Scenario[2]						
Pine Bar	1.0%	3.9%	5.2%	8.8%	7.7%	***5.3%***
Salt Creek	0.0%	0.0%	0.6%	1.0%	1.2%	***0.5%***
Fish Trap	1.5%	4.7%	15%	18%	20%	***12%***
China Bar	70%	72%	60%	59%	56%	***63%***
Average Over All Bars[4]	***4.0%***	***6.2%***	***8.5%***	***11%***	***11%***	***8.2%***
Evaluate Difference in Percentage of Sand Area Mobilized Under Scenario and Proposed Operation[3]						
Pine Bar	-0.3%	1.1%	-0.5%	1.4%	-0.4%	***0.2%***
Salt Creek	0.0%	0.0%	0.0%	0.0%	-0.1%	***0.0%***
Fish Trap	-1.2%	-0.7%	-0.5%	0.2%	-0.4%	***-0.5%***
China Bar	1.8%	3.5%	0.2%	1.0%	-0.3%	***1.3%***
Average Over All Bars	***0.1%***	***1.0%***	***-0.2%***	***0.6%***	***-0.3%***	***0.2%***

[1]Percentage of innundated sand area mobilized under the Proposed Operations.

[2]Percentage of innundated sand area mobilized under the scenario.

[3]Change in the percentage of sand area moblized (2)-(1). Positive value means a higher percentage of sand area is mobilized under the scenario than under the Proposed Operations.

[4]This average is an area weighted average because it computes the summed area over four beaches to calculate percentages. The value is different than if you just averaged the percentages.

Table 3a. Percent Change in Sandbar Mobility Under Scenario 1b Compared with Proposed Operations.

	1992 Extreme Low	1994 Low	1995 Medium	1999 High	1997 Extreme High	*Average*
Pine Bar (RM227.5)						
Innundated Area (PO)[1]	10,795	11,386	12,486	12,774	13,064	***12,101***
Innundated Area (Sc)[2]	10,827	11,566	12,484	12,858	13,074	***12,162***
Mobilized Area (PO)[3]	147	319	716	941	1,062	***637***
Mobilized Area (Sc)[4]	131	428	667	1,104	1,018	***670***
Salt Creek (RM222.4)						
Innundated Area (PO)	5,120	5,347	5,739	5,841	5,942	***5,598***
Innundated Area (Sc)	5,144	5,426	5,739	5,863	5,944	***5,623***
Mobilized Area (PO)	1	2	35	57	74	***34***
Mobilized Area (Sc)	0	1	33	55	71	***32***
Fish Trap (RM216.4)						
Innundated Area (PO)	1,828	2,110	3,243	3,569	3,969	***2,944***
Innundated Area (Sc)	1,779	2,051	3,215	3,516	3,987	***2,910***
Mobilized Area (PO)	49	114	490	646	796	***419***
Mobilized Area (Sc)	30	94	473	639	786	***404***
China Bar (RM192.3)						
Innundated Area (PO)	869	970	1,309	1,420	1,538	***1,221***
Innundated Area (Sc)	863	974	1,300	1,413	1,537	***1,217***
Mobilized Area (PO)	591	663	789	829	861	***747***
Mobilized Area (Sc)	602	700	783	837	856	***756***
Pecent Change between Scenario and Proposed Operation[5]						
Pine Bar	-10.5%	34%	-6.8%	17%	-4.1%	***6.0%***
Salt Creek	-71%	-52.9%	-5.7%	-3.4%	-5.2%	***-27.7%***
Fish Trap	-40%	-18%	-3.6%	-1.2%	-1.2%	***-13%***
China Bar	1.9%	5.5%	-0.7%	1.0%	-0.5%	***1.4%***
Average Over All Bars[6]	***-3.1%***	***11.3%***	***-3.7%***	***6.5%***	***-2.2%***	***1.8%***

[1]Area of sand (m^2) innundated under the Proposed Operation (PO) on an average annual basis (summed hourly values divided by the number of hours in the year)

[2]Area of sand (m^2) innundated under the scenario (Sc) on an average annual basis (summed hourly values divided by the number of hours in the year)

[3]Area of mobile sand (m^2) under the Proposed Operation (PO) on an average annual basis (summed hourly values divided by the number of hours in the year)

[4]Area of mobile sand (m^2) under the scenario (Sc) on an average annual basis (summed hourly values divided by the number of hours in the year)

[5]Percentage change in area of mobile sand [(4)-(3)]/(3). Positive value means percentage of sand mobilized under the scenario is higher than the percentage of sand mobilized under Proposed Operations.

[6]This average is an area weighted average because it computes the summed area over four beaches to calculate percentages. The value is different than the average of the percentages.

Table 3b. Change in Percentage of Sandbar Area Mobile Under Scenario 1b Compared with Proposed Operations.

Sandbar	1992 Extreme Low	1994 Low	1995 Medium	1999 High	1997 Extreme High	*Average*
Pecentage of Sand Area Mobilized Under Proposed Operation[1]						
Pine Bar	1.4%	2.8%	5.7%	7.4%	8.1%	***5.1%***
Salt Creek	0.0%	0.0%	0.6%	1.0%	1.3%	***0.6%***
Fish Trap	2.7%	5.4%	15%	18%	20%	***12%***
China Bar	68%	68%	60%	58%	56%	***62%***
Average Over All Bars[4]	***4.2%***	***5.5%***	***8.9%***	***10%***	***11%***	***8.1%***
Pecentage of Sand Area Mobilized Under Scenario[2]						
Pine Bar	1.2%	3.7%	5.3%	8.6%	7.8%	***5.3%***
Salt Creek	0.0%	0.0%	0.6%	0.9%	1.2%	***0.5%***
Fish Trap	1.7%	4.6%	15%	18%	20%	***12%***
China Bar	70%	72%	60%	59%	56%	***63%***
Average Over All Bars[4]	***4.1%***	***6.1%***	***8.6%***	***11%***	***11%***	***8.2%***
Evaluate Difference in Percentage of Sand Area Mobilized Under Scenario and Proposed Operation[3]						
Pine Bar	-0.1%	0.9%	-0.4%	1.2%	-0.3%	***0.2%***
Salt Creek	0.0%	0.0%	0.0%	0.0%	-0.1%	***0.0%***
Fish Trap	-1.0%	-0.8%	-0.4%	0.1%	-0.3%	***-0.5%***
China Bar	1.8%	3.4%	0.0%	0.9%	-0.2%	***1.2%***
Average Over All Bars	***0.1%***	***0.9%***	***-0.2%***	***0.5%***	***-0.2%***	***0.2%***

[1]Percentage of innundated sand area mobilized under the Proposed Operations.

[2]Percentage of innundated sand area mobilized under the scenario.

[3]Change in the percentage of sand area moblized (2)-(1). Positive value means a higher percentage of sand area is mobilized under the scenario than under the Proposed Operations.

[4]This average is an area weighted average because it computes the summed area over four beaches to calculate percentages. The value is different than if you just averaged the percentages.

Table 4a. Percent Change in Sandbar Mobility Under Scenario 1c Compared with Proposed Operations.

	1992 Extreme Low	1994 Low	1995 Medium	1999 High	1997 Extreme High	*Average*
Pine Bar (RM227.5)						
Innundated Area (PO)[1]	10,795	11,386	12,486	12,774	13,064	***12,101***
Innundated Area (Sc)[2]	10,821	11,477	12,493	12,840	13,074	***12,141***
Mobilized Area (PO)[3]	147	319	716	941	1,062	***637***
Mobilized Area (Sc)[4]	148	364	683	1,022	1,070	***657***
Salt Creek (RM222.4)						
Innundated Area (PO)	5,120	5,347	5,739	5,841	5,942	***5,598***
Innundated Area (Sc)	5,137	5,392	5,742	5,860	5,943	***5,615***
Mobilized Area (PO)	1	2	35	57	74	***34***
Mobilized Area (Sc)	0	1	33	57	73	***33***
Fish Trap (RM216.4)						
Innundated Area (PO)	1,828	2,110	3,243	3,569	3,969	***2,944***
Innundated Area (Sc)	1,789	2,057	3,237	3,564	3,979	***2,925***
Mobilized Area (PO)	49	114	490	646	796	***419***
Mobilized Area (Sc)	35	96	481	647	796	***411***
China Bar (RM192.3)						
Innundated Area (PO)	869	970	1,309	1,420	1,538	***1,221***
Innundated Area (Sc)	863	967	1,307	1,422	1,540	***1,220***
Mobilized Area (PO)	591	663	789	829	861	***747***
Mobilized Area (Sc)	598	685	786	834	861	***753***
Pecent Change between Scenario and Proposed Operation[5]						
Pine Bar	1%	14%	-4.7%	9%	0.7%	***4.0%***
Salt Creek	-57%	-40.8%	-3.6%	-1.4%	-1.8%	***-21.0%***
Fish Trap	-28%	-16%	-1.9%	0.2%	0.0%	***-9%***
China Bar	1.1%	3.3%	-0.4%	0.6%	0.1%	***0.9%***
Average Over All Bars[6]	***-0.8%***	***4.4%***	***-2.3%***	***3.5%***	***0.3%***	***1.0%***

[1]Area of sand (m^2) innundated under the Proposed Operation (PO) on an average annual basis (summed hourly values divided by the number of hours in the year)

[2]Area of sand (m^2) innundated under the scenario (Sc) on an average annual basis (summed hourly values divided by the number of hours in the year)

[3]Area of mobile sand (m^2) under the Proposed Operation (PO) on an average annual basis (summed hourly values divided by the number of hours in the year)

[4]Area of mobile sand (m^2) under the scenario (Sc) on an average annual basis (summed hourly values divided by the number of hours in the year)

[5]Percentage change in area of mobile sand [(4)-(3)]/(3). Positive value means percentage of sand mobilized under the scenario is higher than the percentage of sand mobilized under Proposed Operations.

[6]This average is an area weighted average because it computes the summed area over four beaches to calculate percentages. The value is different than the average of the percentages.

Table 4b. Change in Percentage of Sandbar Area Mobile Under Scenario 1c Compared with Proposed Operations.

Sandbar	1992 Extreme Low	1994 Low	1995 Medium	1999 High	1997 Extreme High	*Average*
Pecentage of Sand Area Mobilized Under Proposed Operation[1]						
Pine Bar	1.4%	2.8%	5.7%	7.4%	8.1%	***5.1%***
Salt Creek	0.0%	0.0%	0.6%	1.0%	1.3%	***0.6%***
Fish Trap	2.7%	5.4%	15%	18%	20%	***12%***
China Bar	68%	68%	60%	58%	56%	***62%***
Average Over All Bars[4]	***4.2%***	***5.5%***	***8.9%***	***10%***	***11%***	***8.1%***
Pecentage of Sand Area Mobilized Under Scenario[2]						
Pine Bar	1.4%	3.2%	5.5%	8.0%	8.2%	***5.2%***
Salt Creek	0.0%	0.0%	0.6%	1.0%	1.2%	***0.6%***
Fish Trap	2.0%	4.6%	15%	18%	20%	***12%***
China Bar	69%	71%	60%	59%	56%	***63%***
Average Over All Bars[4]	***4.2%***	***5.8%***	***8.7%***	***11%***	***11%***	***8.2%***
Evaluate Difference in Percentage of Sand Area Mobilized Under Scenario and Proposed Operation[3]						
Pine Bar	0.0%	0.4%	-0.3%	0.6%	0.1%	***0.2%***
Salt Creek	0.0%	0.0%	0.0%	0.0%	0.0%	***0.0%***
Fish Trap	-0.7%	-0.8%	-0.3%	0.1%	-0.1%	***-0.3%***
China Bar	1.2%	2.4%	-0.1%	0.3%	0.0%	***0.7%***
Average Over All Bars	***0.1%***	***0.5%***	***-0.2%***	***0.2%***	***0.0%***	***0.1%***

[1]Percentage of innundated sand area mobilized under the Proposed Operations.

[2]Percentage of innundated sand area mobilized under the scenario.

[3]Change in the percentage of sand area moblized (2)-(1). Positive value means a higher percentage of sand area is mobilized under the scenario than under the Proposed Operations.

[4]This average is an area weighted average because it computes the summed area over four beaches to calculate percentages. The value is different than if you just averaged the percentages.

Table 5a. Percent Change in Sandbar Mobility Under Scenario 1d Compared with Proposed Operations.

	1992 Extreme Low	1994 Low	1995 Medium	1999 High	1997 Extreme High	*Average*
Pine Bar (RM227.5)						
Innundated Area (PO)[1]	10,795	11,386	12,486	12,774	13,064	***12,101***
Innundated Area (Sc)[2]	10,805	11,432	12,474	12,773	13,060	***12,109***
Mobilized Area (PO)[3]	147	319	716	941	1,062	***637***
Mobilized Area (Sc)[4]	142	400	678	954	1,067	***648***
Salt Creek (RM222.4)						
Innundated Area (PO)	5,120	5,347	5,739	5,841	5,942	***5,598***
Innundated Area (Sc)	5,129	5,363	5,738	5,842	5,940	***5,602***
Mobilized Area (PO)	1	2	35	57	74	***34***
Mobilized Area (Sc)	1	1	36	59	75	***34***
Fish Trap (RM216.4)						
Innundated Area (PO)	1,828	2,110	3,243	3,569	3,969	***2,944***
Innundated Area (Sc)	1,807	2,060	3,249	3,569	3,968	***2,931***
Mobilized Area (PO)	49	114	490	646	796	***419***
Mobilized Area (Sc)	42	104	491	650	799	***417***
China Bar (RM192.3)						
Innundated Area (PO)	869	970	1,309	1,420	1,538	***1,221***
Innundated Area (Sc)	865	965	1,310	1,422	1,538	***1,220***
Mobilized Area (PO)	591	663	789	829	861	***747***
Mobilized Area (Sc)	593	673	787	830	861	***749***
Pecent Change between Scenario and Proposed Operation[5]						
Pine Bar	-3%	25%	-5.3%	1%	0.5%	***3.7%***
Salt Creek	-28%	-33.1%	2.7%	2.2%	1.3%	***-10.9%***
Fish Trap	-14%	-9%	0.1%	0.5%	0.4%	***-4%***
China Bar	0.3%	1.5%	-0.2%	0.2%	0.1%	***0.4%***
Average Over All Bars[6]	***-1.3%***	***7.3%***	***-1.9%***	***0.7%***	***0.4%***	***1.0%***

[1]Area of sand (m^2) innundated under the Proposed Operation (PO) on an average annual basis (summed hourly values divided by the number of hours in the year)

[2]Area of sand (m^2) innundated under the scenario (Sc) on an average annual basis (summed hourly values divided by the number of hours in the year)

[3]Area of mobile sand (m^2) under the Proposed Operation (PO) on an average annual basis (summed hourly values divided by the number of hours in the year)

[4]Area of mobile sand (m^2) under the scenario (Sc) on an average annual basis (summed hourly values divided by the number of hours in the year)

[5]Percentage change in area of mobile sand [(4)-(3)]/(3). Positive value means percentage of sand mobilized under the scenario is higher than the percentage of sand mobilized under Proposed Operations.

[6]This average is an area weighted average because it computes the summed area over four beaches to calculate percentages. The value is different than the average of the percentages.

Table 5b. Change in Percentage of Sandbar Area Mobile Under Scenario 1d Compared with Proposed Operations.

Sandbar	1992 Extreme Low	1994 Low	1995 Medium	1999 High	1997 Extreme High	*Average*
Pecentage of Sand Area Mobilized Under Proposed Operation[1]						
Pine Bar	1.4%	2.8%	5.7%	7.4%	8.1%	***5.1%***
Salt Creek	0.0%	0.0%	0.6%	1.0%	1.3%	***0.6%***
Fish Trap	2.7%	5.4%	15%	18%	20%	***12%***
China Bar	68%	68%	60%	58%	56%	***62%***
Average Over All Bars[4]	***4.2%***	***5.5%***	***8.9%***	***10%***	***11%***	***8.1%***
Pecentage of Sand Area Mobilized Under Scenario[2]						
Pine Bar	1.3%	3.5%	5.4%	7.5%	8.2%	***5.2%***
Salt Creek	0.0%	0.0%	0.6%	1.0%	1.3%	***0.6%***
Fish Trap	2.3%	5.1%	15%	18%	20%	***12%***
China Bar	69%	70%	60%	58%	56%	***63%***
Average Over All Bars[4]	***4.2%***	***5.9%***	***8.7%***	***11%***	***11%***	***8.2%***
Evaluate Difference in Percentage of Sand Area Mobilized Under Scenario and Proposed Operation[3]						
Pine Bar	0.0%	0.7%	-0.3%	0.1%	0.0%	***0.1%***
Salt Creek	0.0%	0.0%	0.0%	0.0%	0.0%	***0.0%***
Fish Trap	-0.4%	-0.4%	0.0%	0.1%	0.1%	***-0.1%***
China Bar	0.5%	1.3%	-0.2%	0.0%	0.0%	***0.3%***
Average Over All Bars	***0.0%***	***0.4%***	***-0.1%***	***0.1%***	***0.0%***	***0.1%***

[1]Percentage of innundated sand area mobilized under the Proposed Operations.

[2]Percentage of innundated sand area mobilized under the scenario.

[3]Change in the percentage of sand area moblized (2)-(1). Positive value means a higher percentage of sand area is mobilized under the scenario than under the Proposed Operations.

[4]This average is an area weighted average because it computes the summed area over four beaches to calculate percentages. The value is different than if you just averaged the percentages.

Table 6a. Percent Change in Sandbar Mobility Under Scenario 1e Compared with Proposed Operations.

	1992 Extreme Low	1994 Low	1995 Medium	1999 High	1997 Extreme High	*Average*
Pine Bar (RM227.5)						
Innundated Area (PO)[1]	10,795	11,386	12,486	12,774	13,064	***12,101***
Innundated Area (Sc)[2]	10,812	11,411	12,474	12,771	13,060	***12,106***
Mobilized Area (PO)[3]	147	319	716	941	1,062	***637***
Mobilized Area (Sc)[4]	146	353	680	949	1,067	***639***
Salt Creek (RM222.4)						
Innundated Area (PO)	5,120	5,347	5,739	5,841	5,942	***5,598***
Innundated Area (Sc)	5,131	5,358	5,737	5,840	5,940	***5,601***
Mobilized Area (PO)	1	2	35	57	74	***34***
Mobilized Area (Sc)	1	2	35	58	75	***34***
Fish Trap (RM216.4)						
Innundated Area (PO)	1,828	2,110	3,243	3,569	3,969	***2,944***
Innundated Area (Sc)	1,812	2,075	3,246	3,564	3,968	***2,933***
Mobilized Area (PO)	49	114	490	646	796	***419***
Mobilized Area (Sc)	44	105	489	645	799	***416***
China Bar (RM192.3)						
Innundated Area (PO)	869	970	1,309	1,420	1,538	***1,221***
Innundated Area (Sc)	866	967	1,309	1,420	1,538	***1,220***
Mobilized Area (PO)	591	663	789	829	861	***747***
Mobilized Area (Sc)	593	671	787	829	861	***748***
Pecent Change between Scenario and Proposed Operation[5]						
Pine Bar	-1%	11%	-5.1%	1%	0.5%	***1.2%***
Salt Creek	-24%	-24.8%	1.9%	0.2%	1.3%	***-9.1%***
Fish Trap	-12%	-8%	-0.2%	-0.2%	0.4%	***-4%***
China Bar	0.3%	1.1%	-0.2%	0.1%	0.1%	***0.3%***
Average Over All Bars[6]	***-0.7%***	***2.9%***	***-1.9%***	***0.3%***	***0.4%***	***0.2%***

[1]Area of sand (m^2) innundated under the Proposed Operation (PO) on an average annual basis (summed hourly values divided by the number of hours in the year)

[2]Area of sand (m^2) innundated under the scenario (Sc) on an average annual basis (summed hourly values divided by the number of hours in the year)

[3]Area of mobile sand (m^2) under the Proposed Operation (PO) on an average annual basis (summed hourly values divided by the number of hours in the year)

[4]Area of mobile sand (m^2) under the scenario (Sc) on an average annual basis (summed hourly values divided by the number of hours in the year)

[5]Percentage change in area of mobile sand [(4)-(3)]/(3). Positive value means percentage of sand mobilized under the scenario is higher than the percentage of sand mobilized under Proposed Operations.

[6]This average is an area weighted average because it computes the summed area over four beaches to calculate percentages. The value is different than the average of the percentages.

Table 6b. Change in Percentage of Sandbar Area Mobile Under Scenario 1e Compared with Proposed Operations.

Sandbar	1992 Extreme Low	1994 Low	1995 Medium	1999 High	1997 Extreme High	*Average*
Pecentage of Sand Area Mobilized Under Proposed Operation[1]						
Pine Bar	1.4%	2.8%	5.7%	7.4%	8.1%	***5.1%***
Salt Creek	0.0%	0.0%	0.6%	1.0%	1.3%	***0.6%***
Fish Trap	2.7%	5.4%	15%	18%	20%	***12%***
China Bar	68%	68%	60%	58%	56%	***62%***
Average Over All Bars[4]	***4.2%***	***5.5%***	***8.9%***	***10%***	***11%***	***8.1%***
Pecentage of Sand Area Mobilized Under Scenario[2]						
Pine Bar	1.3%	3.1%	5.4%	7.4%	8.2%	***5.1%***
Salt Creek	0.0%	0.0%	0.6%	1.0%	1.3%	***0.6%***
Fish Trap	2.4%	5.1%	15%	18%	20%	***12%***
China Bar	68%	69%	60%	58%	56%	***62%***
Average Over All Bars[4]	***4.2%***	***5.7%***	***8.7%***	***11%***	***11%***	***8.1%***
Evaluate Difference in Percentage of Sand Area Mobilized Under Scenario and Proposed Operation[3]						
Pine Bar	0.0%	0.3%	-0.3%	0.1%	0.0%	***0.0%***
Salt Creek	0.0%	0.0%	0.0%	0.0%	0.0%	***0.0%***
Fish Trap	-0.3%	-0.3%	-0.1%	0.0%	0.1%	***-0.1%***
China Bar	0.4%	1.0%	-0.1%	0.1%	0.0%	***0.3%***
Average Over All Bars	***0.0%***	***0.2%***	***-0.1%***	***0.0%***	***0.0%***	***0.0%***

[1]Percentage of innundated sand area mobilized under the Proposed Operations.

[2]Percentage of innundated sand area mobilized under the scenario.

[3]Change in the percentage of sand area moblized (2)-(1). Positive value means a higher percentage of sand area is mobilized under the scenario than under the Proposed Operations.

[4]This average is an area weighted average because it computes the summed area over four beaches to calculate percentages. The value is different than if you just averaged the percentages.

Table 7a. Percent Change in Sandbar Mobility Under Scenario 1f Compared with Proposed Operations.

	1992 Extreme Low	1994 Low	1995 Medium	1999 High	1997 Extreme High	*Average*
Pine Bar (RM227.5)						
Innundated Area (PO)[1]	10,795	11,386	12,486	12,774	13,064	***12,101***
Innundated Area (Sc)[2]	10,817	11,510	12,499	12,853	13,073	***12,150***
Mobilized Area (PO)[3]	147	319	716	941	1,062	***637***
Mobilized Area (Sc)[4]	145	426	670	1,059	1,024	***665***
Salt Creek (RM222.4)						
Innundated Area (PO)	5,120	5,347	5,739	5,841	5,942	***5,598***
Innundated Area (Sc)	5,137	5,402	5,744	5,864	5,944	***5,618***
Mobilized Area (PO)	1	2	35	57	74	***34***
Mobilized Area (Sc)	0	1	32	57	71	***32***
Fish Trap (RM216.4)						
Innundated Area (PO)	1,828	2,110	3,243	3,569	3,969	***2,944***
Innundated Area (Sc)	1,783	2,037	3,240	3,552	3,985	***2,919***
Mobilized Area (PO)	49	114	490	646	796	***419***
Mobilized Area (Sc)	33	94	478	648	788	***408***
China Bar (RM192.3)						
Innundated Area (PO)	869	970	1,309	1,420	1,538	***1,221***
Innundated Area (Sc)	863	967	1,306	1,421	1,538	***1,219***
Mobilized Area (PO)	591	663	789	829	861	***747***
Mobilized Area (Sc)	599	690	785	836	857	***753***
Pecent Change between Scenario and Proposed Operation[5]						
Pine Bar	-1%	34%	-6.5%	12%	-3.6%	***7.0%***
Salt Creek	-64%	-52.6%	-6.6%	-0.9%	-4.1%	***-25.7%***
Fish Trap	-32%	-18%	-2.5%	0.2%	-0.9%	***-11%***
China Bar	1.3%	4.0%	-0.6%	0.9%	-0.4%	***1.0%***
Average Over All Bars[6]	***-1.3%***	***10.2%***	***-3.2%***	***5.1%***	***-1.9%***	***1.8%***

[1]Area of sand (m^2) innundated under the Proposed Operation (PO) on an average annual basis (summed hourly values divided by the number of hours in the year)

[2]Area of sand (m^2) innundated under the scenario (Sc) on an average annual basis (summed hourly values divided by the number of hours in the year)

[3]Area of mobile sand (m^2) under the Proposed Operation (PO) on an average annual basis (summed hourly values divided by the number of hours in the year)

[4]Area of mobile sand (m^2) under the scenario (Sc) on an average annual basis (summed hourly values divided by the number of hours in the year)

[5]Percentage change in area of mobile sand [(4)-(3)]/(3). Positive value means percentage of sand mobilized under the scenario is higher than the percentage of sand mobilized under Proposed Operations.

[6]This average is an area weighted average because it computes the summed area over four beaches to calculate percentages. The value is different than the average of the percentages.

Table 7b. Change in Percentage of Sandbar Area Mobile Under Scenario 1f Compared with Proposed Operations.

Sandbar	1992 Extreme Low	1994 Low	1995 Medium	1999 High	1997 Extreme High	*Average*
Pecentage of Sand Area Mobilized Under Proposed Operation[1]						
Pine Bar	1.4%	2.8%	5.7%	7.4%	8.1%	***5.1%***
Salt Creek	0.0%	0.0%	0.6%	1.0%	1.3%	***0.6%***
Fish Trap	2.7%	5.4%	15%	18%	20%	***12%***
China Bar	68%	68%	60%	58%	56%	***62%***
Average Over All Bars[4]	***4.2%***	***5.5%***	***8.9%***	***10%***	***11%***	***8.1%***
Pecentage of Sand Area Mobilized Under Scenario[2]						
Pine Bar	1.3%	3.7%	5.4%	8.2%	7.8%	***5.3%***
Salt Creek	0.0%	0.0%	0.6%	1.0%	1.2%	***0.6%***
Fish Trap	1.9%	4.6%	15%	18%	20%	***12%***
China Bar	69%	71%	60%	59%	56%	***63%***
Average Over All Bars[4]	***4.2%***	***6.1%***	***8.6%***	***11%***	***11%***	***8.2%***
Evaluate Difference in Percentage of Sand Area Mobilized Under Scenario and Proposed Operation[3]						
Pine Bar	0.0%	0.9%	-0.4%	0.9%	-0.3%	***0.2%***
Salt Creek	0.0%	0.0%	0.0%	0.0%	-0.1%	***0.0%***
Fish Trap	-0.8%	-0.8%	-0.4%	0.1%	-0.3%	***-0.4%***
China Bar	1.4%	2.9%	-0.2%	0.5%	-0.2%	***0.9%***
Average Over All Bars	***0.1%***	***0.8%***	***-0.3%***	***0.4%***	***-0.2%***	***0.2%***

[1]Percentage of innundated sand area mobilized under the Proposed Operations.

[2]Percentage of innundated sand area mobilized under the scenario.

[3]Change in the percentage of sand area moblized (2)-(1). Positive value means a higher percentage of sand area is mobilized under the scenario than under the Proposed Operations.

[4]This average is an area weighted average because it computes the summed area over four beaches to calculate percentages. The value is different than if you just averaged the percentages.

Table 8a. Percent Change in Sandbar Mobility Under Scenario 2 Compared with Proposed Operations.

	1992 Extreme Low	1994 Low	1995 Medium	1999 High	1997 Extreme High	*Average*
Pine Bar (RM227.5)						
Innundated Area (PO)[1]	10,795	11,386	12,486	12,774	13,064	***12,101***
Innundated Area (Sc)[2]	10,835	11,416	12,446	12,784	13,052	***12,107***
Mobilized Area (PO)[3]	147	319	716	941	1,062	***637***
Mobilized Area (Sc)[4]	131	400	677	950	1,058	***643***
Salt Creek (RM222.4)						
Innundated Area (PO)	5,120	5,347	5,739	5,841	5,942	***5,598***
Innundated Area (Sc)	5,144	5,355	5,729	5,845	5,938	***5,602***
Mobilized Area (PO)	1	2	35	57	74	***34***
Mobilized Area (Sc)	1	1	38	59	75	***35***
Fish Trap (RM216.4)						
Innundated Area (PO)	1,828	2,110	3,243	3,569	3,969	***2,944***
Innundated Area (Sc)	1,814	2,060	3,249	3,593	3,970	***2,937***
Mobilized Area (PO)	49	114	490	646	796	***419***
Mobilized Area (Sc)	40	106	498	655	797	***419***
China Bar (RM192.3)						
Innundated Area (PO)	869	970	1,309	1,420	1,538	***1,221***
Innundated Area (Sc)	869	963	1,311	1,427	1,537	***1,221***
Mobilized Area (PO)	591	663	789	829	861	***747***
Mobilized Area (Sc)	599	669	787	831	861	***749***
Pecent Change between Scenario and Proposed Operation[5]						
Pine Bar	-10.9%	25%	-5.4%	0.9%	-0.4%	***1.9%***
Salt Creek	-31%	-31.3%	9.4%	2.0%	0.3%	***-10.1%***
Fish Trap	-18%	-8%	1.5%	1.4%	0.1%	***-4.5%***
China Bar	1.4%	0.8%	-0.2%	0.3%	0.0%	***0.4%***
Average Over All Bars[6]	***-2.2%***	***7.0%***	***-1.5%***	***0.8%***	***-0.1%***	***0.8%***

[1]Area of sand (m^2) innundated under the Proposed Operation (PO) on an average annual basis (summed hourly values divided by the number of hours in the year)

[2]Area of sand (m^2) innundated under the scenario (Sc) on an average annual basis (summed hourly values divided by the number of hours in the year)

[3]Area of mobile sand (m^2) under the Proposed Operation (PO) on an average annual basis (summed hourly values divided by the number of hours in the year)

[4]Area of mobile sand (m^2) under the scenario (Sc) on an average annual basis (summed hourly values divided by the number of hours in the year)

[5]Percentage change in area of mobile sand [(4)-(3)]/(3). Positive value means percentage of sand mobilized under the scenario is higher than the percentage of sand mobilized under Proposed Operations.

[6]This average is an area weighted average because it computes the summed area over four beaches to calculate percentages. The value is different than the average of the percentages.

Table 8b. Change in Percentage of Sandbar Area Mobile Under Scenario 2 Compared with Proposed Operations.

Sandbar	1992 Extreme Low	1994 Low	1995 Medium	1999 High	1997 Extreme High	*Average*
Pecentage of Sand Area Mobilized Under Proposed Operation[1]						
Pine Bar	1.4%	2.8%	5.7%	7.4%	8.1%	***5.1%***
Salt Creek	0.0%	0.0%	0.6%	1.0%	1.3%	***0.6%***
Fish Trap	2.7%	5.4%	15%	18%	20%	***12%***
China Bar	68%	68%	60%	58%	56%	***62%***
Average Over All Bars[4]	***4.2%***	***5.5%***	***8.9%***	***10%***	***11%***	***8.1%***
Pecentage of Sand Area Mobilized Under Scenario[2]						
Pine Bar	1.2%	3.5%	5.4%	7.4%	8.1%	***5.1%***
Salt Creek	0.0%	0.0%	0.7%	1.0%	1.3%	***0.6%***
Fish Trap	2.2%	5.1%	15%	18%	20%	***12%***
China Bar	69%	69%	60%	58%	56%	***63%***
Average Over All Bars[4]	***4.1%***	***5.9%***	***8.8%***	***11%***	***11%***	***8.2%***
Evaluate Difference in Percentage of Sand Area Mobilized Under Scenario and Proposed Operation[3]						
Pine Bar	-0.2%	0.7%	-0.3%	0.1%	0.0%	***0.1%***
Salt Creek	0.0%	0.0%	0.1%	0.0%	0.0%	***0.0%***
Fish Trap	-0.5%	-0.3%	0.2%	0.1%	0.0%	***-0.1%***
China Bar	0.9%	1.0%	-0.2%	-0.1%	0.0%	***0.3%***
Average Over All Bars	***0.1%***	***0.4%***	***-0.1%***	***0.0%***	***0.0%***	***0.1%***

[1]Percentage of innundated sand area mobilized under the Proposed Operations.

[2]Percentage of innundated sand area mobilized under the scenario.

[3]Change in the percentage of sand area moblized (2)-(1). Positive value means a higher percentage of sand area is mobilized under the scenario than under the Proposed Operations.

[4]This average is an area weighted average because it computes the summed area over four beaches to calculate percentages. The value is different than if you just averaged the percentages.

Table 9a. Percent Change in Sandbar Mobility Under Scenario 3 Compared with Proposed Operations.

	1992 Extreme Low	1994 Low	1995 Medium	1999 High	1997 Extreme High	*Average*
Pine Bar (RM227.5)						
Innundated Area (PO)[1]	10,795	11,386	12,486	12,774	13,064	***12,101***
Innundated Area (Sc)[2]	10,896	11,517	12,469	12,766	13,059	***12,141***
Mobilized Area (PO)[3]	147	319	716	941	1,062	***637***
Mobilized Area (Sc)[4]	140	279	671	923	1,053	***613***
Salt Creek (RM222.4)						
Innundated Area (PO)	5,120	5,347	5,739	5,841	5,942	***5,598***
Innundated Area (Sc)	5,168	5,413	5,735	5,839	5,942	***5,619***
Mobilized Area (PO)	1	2	35	57	74	***34***
Mobilized Area (Sc)	1	2	35	58	76	***34***
Fish Trap (RM216.4)						
Innundated Area (PO)	1,828	2,110	3,243	3,569	3,969	***2,944***
Innundated Area (Sc)	1,847	2,136	3,255	3,569	3,981	***2,958***
Mobilized Area (PO)	49	114	490	646	796	***419***
Mobilized Area (Sc)	47	107	491	646	803	***419***
China Bar (RM192.3)						
Innundated Area (PO)	869	970	1,309	1,420	1,538	***1,221***
Innundated Area (Sc)	880	987	1,310	1,421	1,541	***1,228***
Mobilized Area (PO)	591	663	789	829	861	***747***
Mobilized Area (Sc)	607	693	787	828	861	***755***
Pecent Change between Scenario and Proposed Operation[5]						
Pine Bar	-5%	-13%	-6.3%	-2%	-0.8%	***-5.3%***
Salt Creek	-7%	-5.4%	1.4%	1.0%	2.6%	***-1.6%***
Fish Trap	-4%	-6%	0.2%	0.0%	0.9%	***-2%***
China Bar	2.7%	4.4%	-0.3%	-0.1%	0.0%	***1.4%***
Average Over All Bars[6]	***0.9%***	***-1.7%***	***-2.3%***	***-0.7%***	***0.0%***	***-0.7%***

[1]Area of sand (m^2) innundated under the Proposed Operation (PO) on an average annual basis (summed hourly values divided by the number of hours in the year)

[2]Area of sand (m^2) innundated under the scenario (Sc) on an average annual basis (summed hourly values divided by the number of hours in the year)

[3]Area of mobile sand (m^2) under the Proposed Operation (PO) on an average annual basis (summed hourly values divided by the number of hours in the year)

[4]Area of mobile sand (m^2) under the scenario (Sc) on an average annual basis (summed hourly values divided by the number of hours in the year)

[5]Percentage change in area of mobile sand [(4)-(3)]/(3). Positive value means percentage of sand mobilized under the scenario is higher than the percentage of sand mobilized under Proposed Operations.

[6]This average is an area weighted average because it computes the summed area over four beaches to calculate percentages. The value is different than the average of the percentages.

Table 9b. Change in Percentage of Sandbar Area Mobile Under Scenario 3 Compared with Proposed Operations.

Sandbar	1992 Extreme Low	1994 Low	1995 Medium	1999 High	1997 Extreme High	*Average*
Pecentage of Sand Area Mobilized Under Proposed Operation[1]						
Pine Bar	1.4%	2.8%	5.7%	7.4%	8.1%	***5.1%***
Salt Creek	0.0%	0.0%	0.6%	1.0%	1.3%	***0.6%***
Fish Trap	2.7%	5.4%	15%	18%	20%	***12%***
China Bar	68%	68%	60%	58%	56%	***62%***
Average Over All Bars[4]	***4.2%***	***5.5%***	***8.9%***	***10%***	***11%***	***8.1%***
Pecentage of Sand Area Mobilized Under Scenario[2]						
Pine Bar	1.3%	2.4%	5.4%	7.2%	8.1%	***4.9%***
Salt Creek	0.0%	0.0%	0.6%	1.0%	1.3%	***0.6%***
Fish Trap	2.6%	5.0%	15%	18%	20%	***12%***
China Bar	69%	70%	60%	58%	56%	***63%***
Average Over All Bars[4]	***4.2%***	***5.4%***	***8.7%***	***10%***	***11%***	***8.0%***
Evaluate Difference in Percentage of Sand Area Mobilized Under Scenario and Proposed Operation[3]						
Pine Bar	-0.1%	-0.4%	-0.4%	-0.1%	-0.1%	***-0.2%***
Salt Creek	0.0%	0.0%	0.0%	0.0%	0.0%	***0.0%***
Fish Trap	-0.1%	-0.4%	0.0%	0.0%	0.1%	***-0.1%***
China Bar	1.0%	1.8%	-0.2%	-0.1%	-0.1%	***0.5%***
Average Over All Bars	***0.2%***	***0.2%***	***-0.1%***	***-0.1%***	***0.0%***	***0.0%***

[1]Percentage of innundated sand area mobilized under the Proposed Operations.

[2]Percentage of innundated sand area mobilized under the scenario.

[3]Change in the percentage of sand area moblized (2)-(1). Positive value means a higher percentage of sand area is mobilized under the scenario than under the Proposed Operations.

[4]This average is an area weighted average because it computes the summed area over four beaches to calculate percentages. The value is different than if you just averaged the percentages.

Table 10a. Percent Change in Sandbar Mobility Under Scenario 4 Compared with Proposed Operations.

	1992 Extreme Low	1994 Low	1995 Medium	1999 High	1997 Extreme High	*Average*
Pine Bar (RM227.5)						
Innundated Area (PO)[1]	10,795	11,386	12,486	12,774	13,064	***12,101***
Innundated Area (Sc)[2]	10,865	11,564	12,499	12,853	13,073	***12,171***
Mobilized Area (PO)[3]	147	319	716	941	1,062	***637***
Mobilized Area (Sc)[4]	147	429	670	1,059	1,024	***666***
Salt Creek (RM222.4)						
Innundated Area (PO)	5,120	5,347	5,739	5,841	5,942	***5,598***
Innundated Area (Sc)	5,159	5,425	5,744	5,864	5,944	***5,627***
Mobilized Area (PO)	1	2	35	57	74	***34***
Mobilized Area (Sc)	0	1	32	57	71	***32***
Fish Trap (RM216.4)						
Innundated Area (PO)	1,828	2,110	3,243	3,569	3,969	***2,944***
Innundated Area (Sc)	1,796	2,052	3,240	3,552	3,985	***2,925***
Mobilized Area (PO)	49	114	490	646	796	***419***
Mobilized Area (Sc)	34	95	478	648	788	***409***
China Bar (RM192.3)						
Innundated Area (PO)	869	970	1,309	1,420	1,538	***1,221***
Innundated Area (Sc)	869	974	1,306	1,421	1,538	***1,222***
Mobilized Area (PO)	591	663	789	829	861	***747***
Mobilized Area (Sc)	608	699	785	836	857	***757***
Pecent Change between Scenario and Proposed Operation[5]						
Pine Bar	0%	35%	-6.5%	12%	-3.6%	***7.4%***
Salt Creek	-64%	-52.4%	-6.6%	-0.9%	-4.1%	***-25.6%***
Fish Trap	-31%	-17%	-2.5%	0.2%	-0.9%	***-10%***
China Bar	2.8%	5.3%	-0.6%	0.9%	-0.4%	***1.6%***
Average Over All Bars[6]	***0.1%***	***11.4%***	***-3.2%***	***5.1%***	***-1.9%***	**2.3%**

[1]Area of sand (m^2) innundated under the Proposed Operation (PO) on an average annual basis (summed hourly values divided by the number of hours in the year)

[2]Area of sand (m^2) innundated under the scenario (Sc) on an average annual basis (summed hourly values divided by the number of hours in the year)

[3]Area of mobile sand (m^2) under the Proposed Operation (PO) on an average annual basis (summed hourly values divided by the number of hours in the year)

[4]Area of mobile sand (m^2) under the scenario (Sc) on an average annual basis (summed hourly values divided by the number of hours in the year)

[5]Percentage change in area of mobile sand [(4)-(3)]/(3). Positive value means percentage of sand mobilized under the scenario is higher than the percentage of sand mobilized under Proposed Operations.

[6]This average is an area weighted average because it computes the summed area over four beaches to calculate percentages. The value is different than the average of the percentages.

Table 10b. Change in Percentage of Sandbar Area Mobile Under Scenario 4 Compared with Proposed Operations.

Sandbar	1992 Extreme Low	1994 Low	1995 Medium	1999 High	1997 Extreme High	*Average*
Pecentage of Sand Area Mobilized Under Proposed Operation[1]						
Pine Bar	1.4%	2.8%	5.7%	7.4%	8.1%	***5.1%***
Salt Creek	0.0%	0.0%	0.6%	1.0%	1.3%	***0.6%***
Fish Trap	2.7%	5.4%	15%	18%	20%	***12%***
China Bar	68%	68%	60%	58%	56%	***62%***
Average Over All Bars[4]	***4.2%***	***5.5%***	***8.9%***	***10%***	***11%***	***8.1%***
Pecentage of Sand Area Mobilized Under Scenario[2]						
Pine Bar	1.4%	3.7%	5.4%	8.2%	7.8%	***5.3%***
Salt Creek	0.0%	0.0%	0.6%	1.0%	1.2%	***0.6%***
Fish Trap	1.9%	4.6%	15%	18%	20%	***12%***
China Bar	70%	72%	60%	59%	56%	***63%***
Average Over All Bars[4]	***4.2%***	***6.1%***	***8.6%***	***11%***	***11%***	***8.2%***
Evaluate Difference in Percentage of Sand Area Mobilized Under Scenario and Proposed Operation[3]						
Pine Bar	0.0%	0.9%	-0.4%	0.9%	-0.3%	***0.2%***
Salt Creek	0.0%	0.0%	0.0%	0.0%	-0.1%	***0.0%***
Fish Trap	-0.8%	-0.8%	-0.4%	0.1%	-0.3%	***-0.4%***
China Bar	1.9%	3.4%	-0.2%	0.5%	-0.2%	***1.0%***
Average Over All Bars	***0.3%***	***0.9%***	***-0.3%***	***0.4%***	***-0.2%***	***0.2%***

[1]Percentage of innundated sand area mobilized under the Proposed Operations.

[2]Percentage of innundated sand area mobilized under the scenario.

[3]Change in the percentage of sand area moblized (2)-(1). Positive value means a higher percentage of sand area is mobilized under the scenario than under the Proposed Operations.

[4]This average is an area weighted average because it computes the summed area over four beaches to calculate percentages. The value is different than if you just averaged the percentages.

Table 11a. Percent Change in Sandbar Mobility Under Scenario 5 Compared with Proposed Operations.

	1992 Extreme Low	1994 Low	1995 Medium	1999 High	1997 Extreme High	*Average*
Pine Bar (RM227.5)						
Innundated Area (PO)[1]	10,795	11,386	12,486	12,774	13,064	***12,101***
Innundated Area (Sc)[2]	10,736	11,520	12,532	12,787	13,057	***12,126***
Mobilized Area (PO)[3]	147	319	716	941	1,062	***637***
Mobilized Area (Sc)[4]	99	408	785	991	914	***639***
Salt Creek (RM222.4)						
Innundated Area (PO)	5,120	5,347	5,739	5,841	5,942	***5,598***
Innundated Area (Sc)	5,108	5,409	5,752	5,840	5,941	***5,610***
Mobilized Area (PO)	1	2	35	57	74	***34***
Mobilized Area (Sc)	0	1	32	50	69	***30***
Fish Trap (RM216.4)						
Innundated Area (PO)	1,828	2,110	3,243	3,569	3,969	***2,944***
Innundated Area (Sc)	1,759	2,036	3,153	3,466	3,964	***2,876***
Mobilized Area (PO)	49	114	490	646	796	***419***
Mobilized Area (Sc)	27	90	463	603	767	***390***
China Bar (RM192.3)						
Innundated Area (PO)	869	970	1,309	1,420	1,538	***1,221***
Innundated Area (Sc)	852	967	1,290	1,392	1,526	***1,206***
Mobilized Area (PO)	591	663	789	829	861	***747***
Mobilized Area (Sc)	588	694	788	824	845	***748***
Pecent Change between Scenario and Proposed Operation[5]						
Pine Bar	-33%	28%	9.6%	5%	-14.0%	***-0.8%***
Salt Creek	-68%	-54.9%	-8.3%	-13.1%	-7.5%	***-30.3%***
Fish Trap	-46%	-21%	-5.5%	-6.7%	-3.6%	***-17%***
China Bar	-0.5%	4.5%	-0.1%	-0.5%	-1.8%	***0.3%***
Average Over All Bars[6]	***-9.4%***	***8.6%***	***1.9%***	***-0.2%***	***-7.1%***	***-1.3%***

[1]Area of sand (m^2) innundated under the Proposed Operation (PO) on an average annual basis (summed hourly values divided by the number of hours in the year)

[2]Area of sand (m^2) innundated under the scenario (Sc) on an average annual basis (summed hourly values divided by the number of hours in the year)

[3]Area of mobile sand (m^2) under the Proposed Operation (PO) on an average annual basis (summed hourly values divided by the number of hours in the year)

[4]Area of mobile sand (m^2) under the scenario (Sc) on an average annual basis (summed hourly values divided by the number of hours in the year)

[5]Percentage change in area of mobile sand [(4)-(3)]/(3). Positive value means percentage of sand mobilized under the scenario is higher than the percentage of sand mobilized under Proposed Operations.

[6]This average is an area weighted average because it computes the summed area over four beaches to calculate percentages. The value is different than the average of the percentages.

Table 11b. Change in Percentage of Sandbar Area Mobile Under Scenario 5 Compared with Proposed Operations.

Sandbar	1992 Extreme Low	1994 Low	1995 Medium	1999 High	1997 Extreme High	*Average*
Pecentage of Sand Area Mobilized Under Proposed Operation[1]						
Pine Bar	1.4%	2.8%	5.7%	7.4%	8.1%	***5.1%***
Salt Creek	0.0%	0.0%	0.6%	1.0%	1.3%	***0.6%***
Fish Trap	2.7%	5.4%	15%	18%	20%	***12%***
China Bar	68%	68%	60%	58%	56%	***62%***
Average Over All Bars[4]	***4.2%***	***5.5%***	***8.9%***	***10%***	***11%***	***8.1%***
Pecentage of Sand Area Mobilized Under Scenario[2]						
Pine Bar	0.9%	3.5%	6.3%	7.8%	7.0%	***5.1%***
Salt Creek	0.0%	0.0%	0.6%	0.9%	1.2%	***0.5%***
Fish Trap	1.5%	4.4%	15%	17%	19%	***11%***
China Bar	69%	72%	61%	59%	55%	***63%***
Average Over All Bars[4]	***3.9%***	***6.0%***	***9.1%***	***11%***	***11%***	***8.0%***
Evaluate Difference in Percentage of Sand Area Mobilized Under Scenario and Proposed Operation[3]						
Pine Bar	-0.4%	0.7%	0.5%	0.4%	-1.1%	***0.0%***
Salt Creek	0.0%	0.0%	-0.1%	-0.1%	-0.1%	***-0.1%***
Fish Trap	-1.2%	-1.0%	-0.4%	-0.7%	-0.7%	***-0.8%***
China Bar	1.0%	3.3%	0.8%	0.9%	-0.6%	***1.1%***
Average Over All Bars	***-0.2%***	***0.8%***	***0.2%***	***0.1%***	***-0.6%***	***0.1%***

[1]Percentage of innundated sand area mobilized under the Proposed Operations.

[2]Percentage of innundated sand area mobilized under the scenario.

[3]Change in the percentage of sand area moblized (2)-(1). Positive value means a higher percentage of sand area is mobilized under the scenario than under the Proposed Operations.

[4]This average is an area weighted average because it computes the summed area over four beaches to calculate percentages. The value is different than if you just averaged the percentages.

Table 12a. Percent Change in Sandbar Mobility Under Scenario 6 Compared with Proposed Operations.

	1992 Extreme Low	1994 Low	1995 Medium	1999 High	1997 Extreme High	*Average*
Pine Bar (RM227.5)						
Innundated Area (PO)[1]	10,795	11,386	12,486	12,774	13,064	***12,101***
Innundated Area (Sc)[2]	11,058	11,500	12,510	12,694	13,062	***12,165***
Mobilized Area (PO)[3]	147	319	716	941	1,062	***637***
Mobilized Area (Sc)[4]	140	305	654	815	1,058	***594***
Salt Creek (RM222.4)						
Innundated Area (PO)	5,120	5,347	5,739	5,841	5,942	***5,598***
Innundated Area (Sc)	5,248	5,402	5,750	5,819	5,941	***5,632***
Mobilized Area (PO)	1	2	35	57	74	***34***
Mobilized Area (Sc)	0	2	36	61	75	***35***
Fish Trap (RM216.4)						
Innundated Area (PO)	1,828	2,110	3,243	3,569	3,969	***2,944***
Innundated Area (Sc)	1,854	2,115	3,334	3,635	4,017	***2,991***
Mobilized Area (PO)	49	114	490	646	796	***419***
Mobilized Area (Sc)	35	105	510	662	810	***425***
China Bar (RM192.3)						
Innundated Area (PO)	869	970	1,309	1,420	1,538	***1,221***
Innundated Area (Sc)	897	980	1,329	1,431	1,549	***1,237***
Mobilized Area (PO)	591	663	789	829	861	***747***
Mobilized Area (Sc)	645	688	789	823	863	***762***
Pecent Change between Scenario and Proposed Operation[5]						
Pine Bar	-5%	-4%	-8.6%	-13%	-0.4%	***-6.4%***
Salt Creek	-59%	-17.9%	3.4%	5.5%	1.5%	***-13.3%***
Fish Trap	-29%	-8%	4.1%	2.4%	1.8%	***-6%***
China Bar	9.2%	3.7%	0.0%	-0.6%	0.3%	***2.5%***
Average Over All Bars[6]	***4.1%***	***0.1%***	***-2.0%***	***-4.6%***	***0.5%***	***-0.4%***

[1]Area of sand (m^2) innundated under the Proposed Operation (PO) on an average annual basis (summed hourly values divided by the number of hours in the year)

[2]Area of sand (m^2) innundated under the scenario (Sc) on an average annual basis (summed hourly values divided by the number of hours in the year)

[3]Area of mobile sand (m^2) under the Proposed Operation (PO) on an average annual basis (summed hourly values divided by the number of hours in the year)

[4]Area of mobile sand (m^2) under the scenario (Sc) on an average annual basis (summed hourly values divided by the number of hours in the year)

[5]Percentage change in area of mobile sand [(4)-(3)]/(3). Positive value means percentage of sand mobilized under the scenario is higher than the percentage of sand mobilized under Proposed Operations.

[6]This average is an area weighted average because it computes the summed area over four beaches to calculate percentages. The value is different than the average of the percentages.

Table 12b. Change in Percentage of Sandbar Area Mobile Under Scenario 6 Compared with Proposed Operations.

Sandbar	1992 Extreme Low	1994 Low	1995 Medium	1999 High	1997 Extreme High	*Average*
Pecentage of Sand Area Mobilized Under Proposed Operation[1]						
Pine Bar	1.4%	2.8%	5.7%	7.4%	8.1%	***5.1%***
Salt Creek	0.0%	0.0%	0.6%	1.0%	1.3%	***0.6%***
Fish Trap	2.7%	5.4%	15%	18%	20%	***12%***
China Bar	68%	68%	60%	58%	56%	***62%***
Average Over All Bars[4]	***4.2%***	***5.5%***	***8.9%***	***10%***	***11%***	***8.1%***
Pecentage of Sand Area Mobilized Under Scenario[2]						
Pine Bar	1.3%	2.6%	5.2%	6.4%	8.1%	***4.7%***
Salt Creek	0.0%	0.0%	0.6%	1.0%	1.3%	***0.6%***
Fish Trap	1.9%	5.0%	15%	18%	20%	***12%***
China Bar	72%	70%	59%	58%	56%	***63%***
Average Over All Bars[4]	***4.3%***	***5.5%***	***8.7%***	***10%***	***11%***	***8.0%***
Evaluate Difference in Percentage of Sand Area Mobilized Under Scenario and Proposed Operation[3]						
Pine Bar	-0.1%	-0.1%	-0.5%	-1.0%	0.0%	***-0.3%***
Salt Creek	0.0%	0.0%	0.0%	0.1%	0.0%	***0.0%***
Fish Trap	-0.8%	-0.5%	0.2%	0.1%	0.1%	***-0.2%***
China Bar	3.9%	1.7%	-0.9%	-0.8%	-0.3%	***0.7%***
Average Over All Bars	***0.7%***	***0.3%***	***-0.3%***	***-0.4%***	***0.0%***	***0.1%***

[1]Percentage of innundated sand area mobilized under the Proposed Operations.

[2]Percentage of innundated sand area mobilized under the scenario.

[3]Change in the percentage of sand area moblized (2)-(1). Positive value means a higher percentage of sand area is mobilized under the scenario than under the Proposed Operations.

[4]This average is an area weighted average because it computes the summed area over four beaches to calculate percentages. The value is different than if you just averaged the percentages.

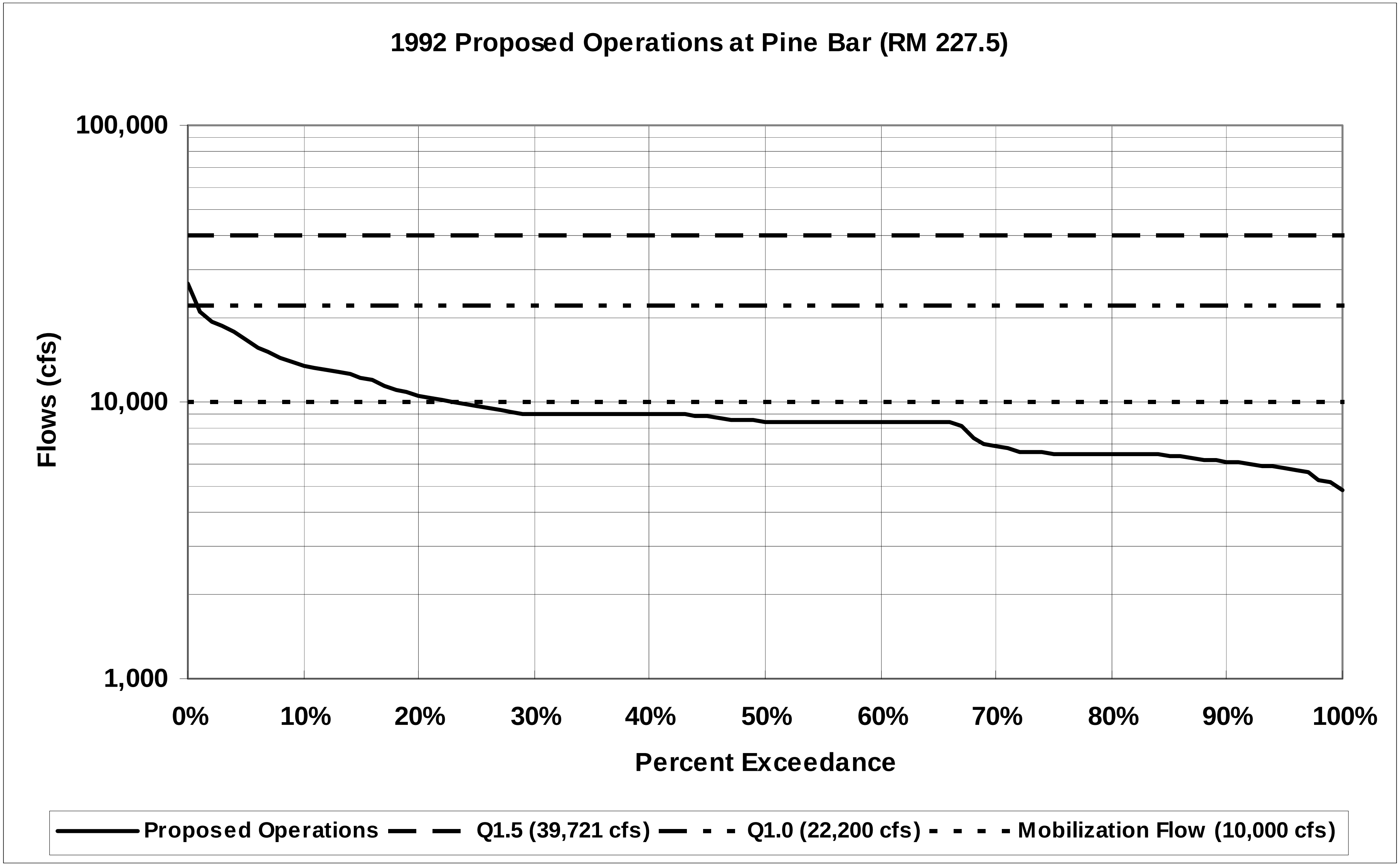


Figure 1. Flow-duration curve for 1992 Proposed Operations at Pine Bar (RM 227.5).

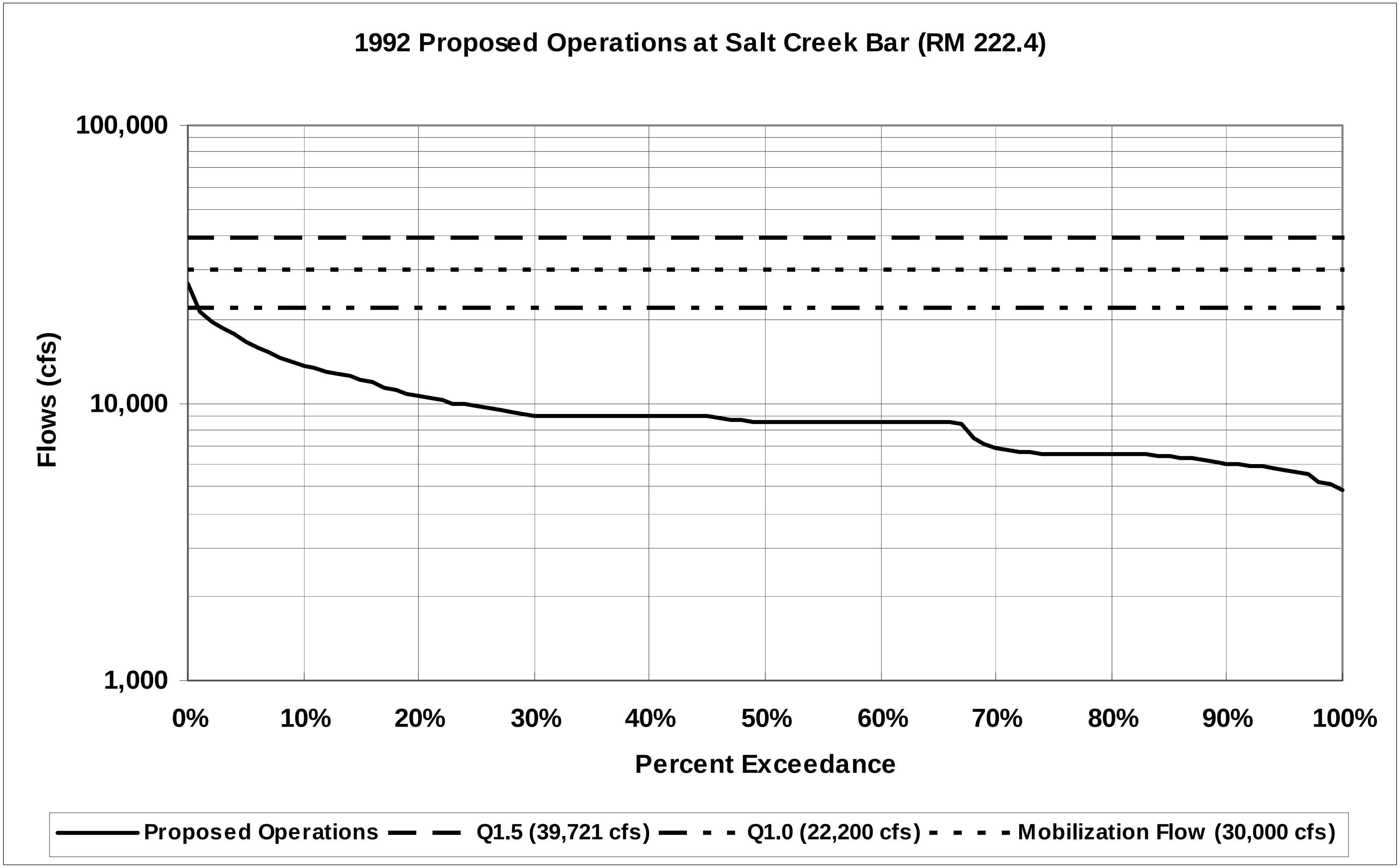


Figure 2. Flow-duration curve for 1992 Proposed Operations at Salt Creek Bar (RM 222.4).

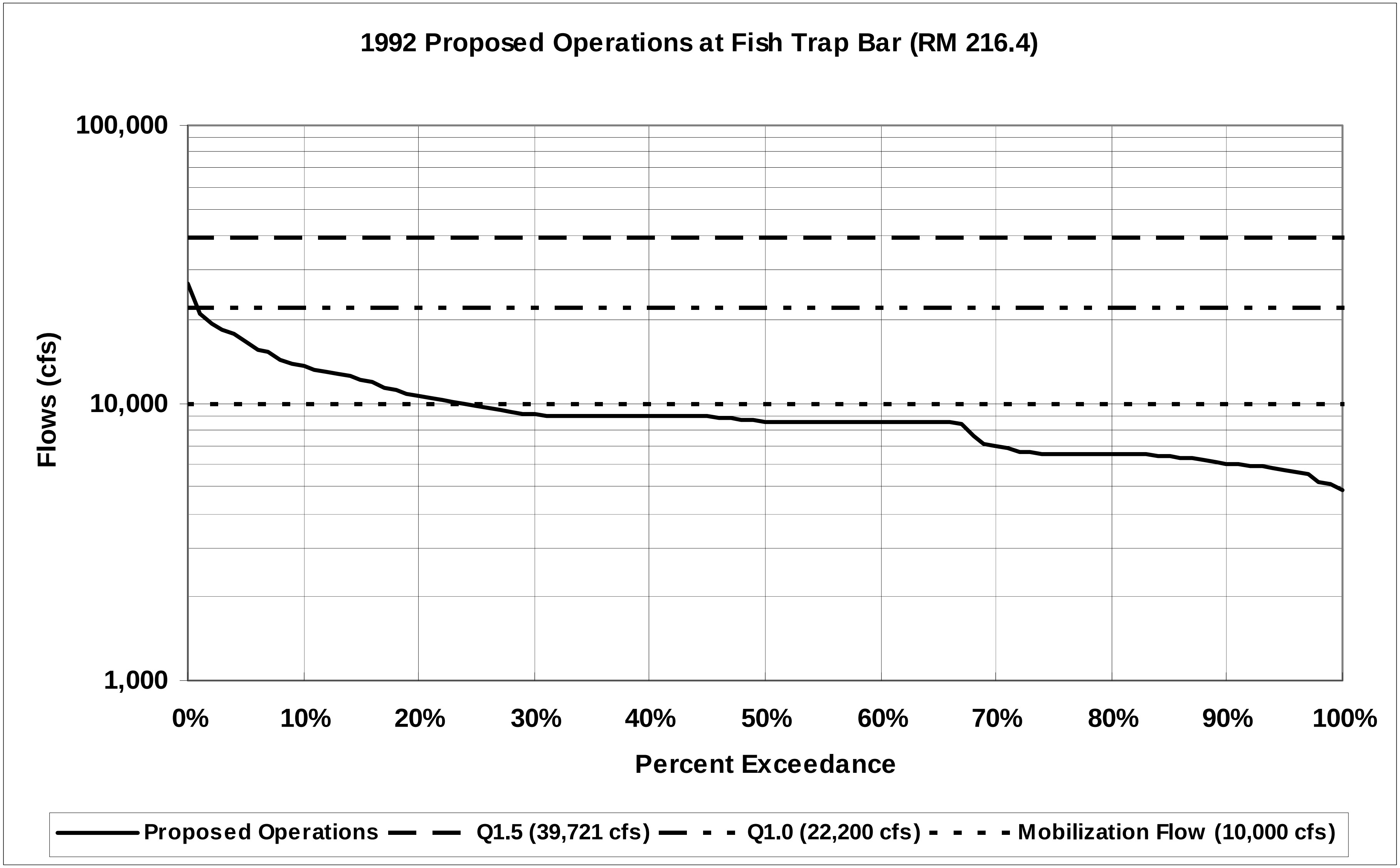


Figure 3. Flow-duration curve for 1992 Proposed Operations at Fish Trap Bar (RM 216.4).

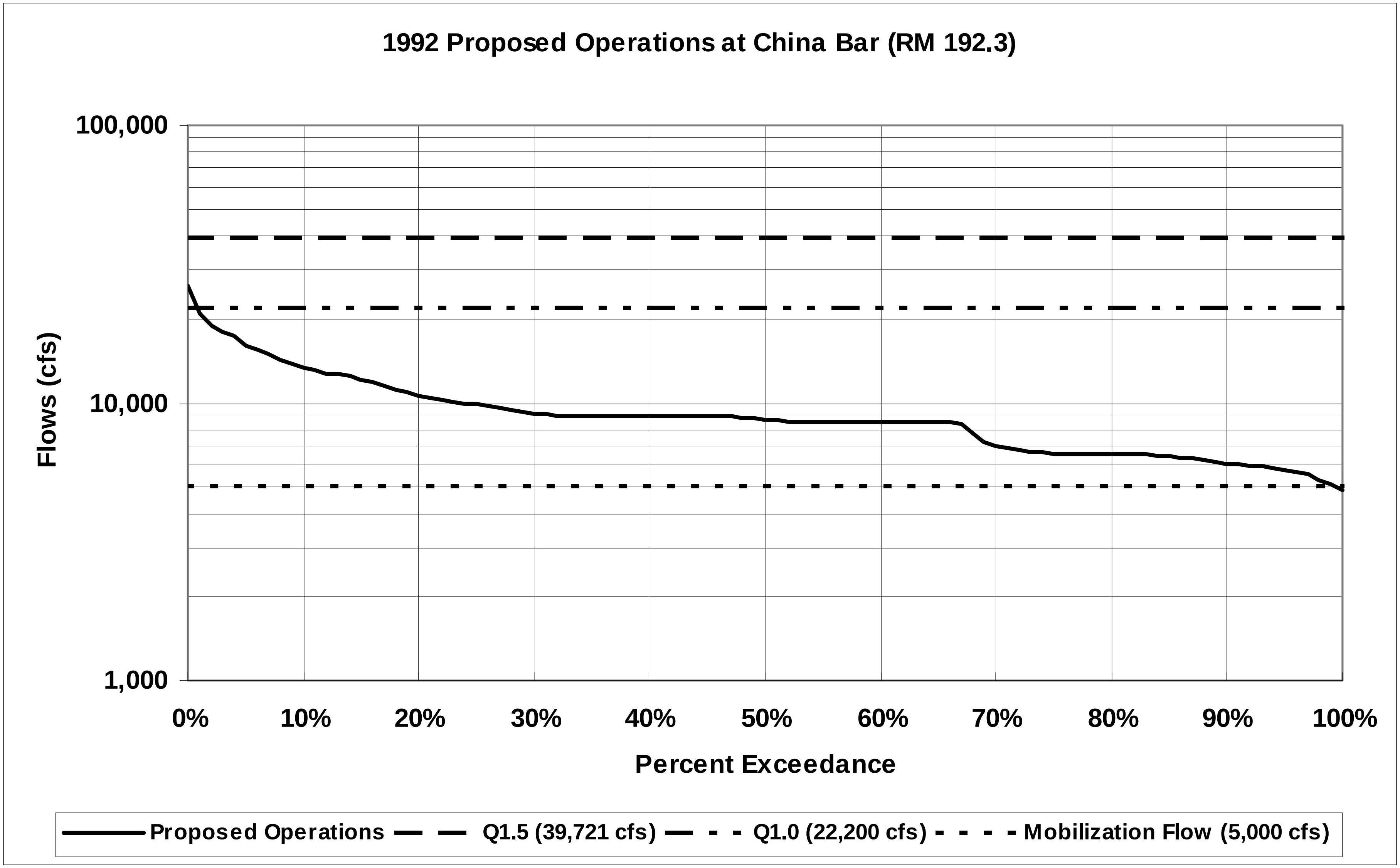


Figure 4. Flow-duration curve for 1992 Proposed Operations at China Bar (RM 192.3).

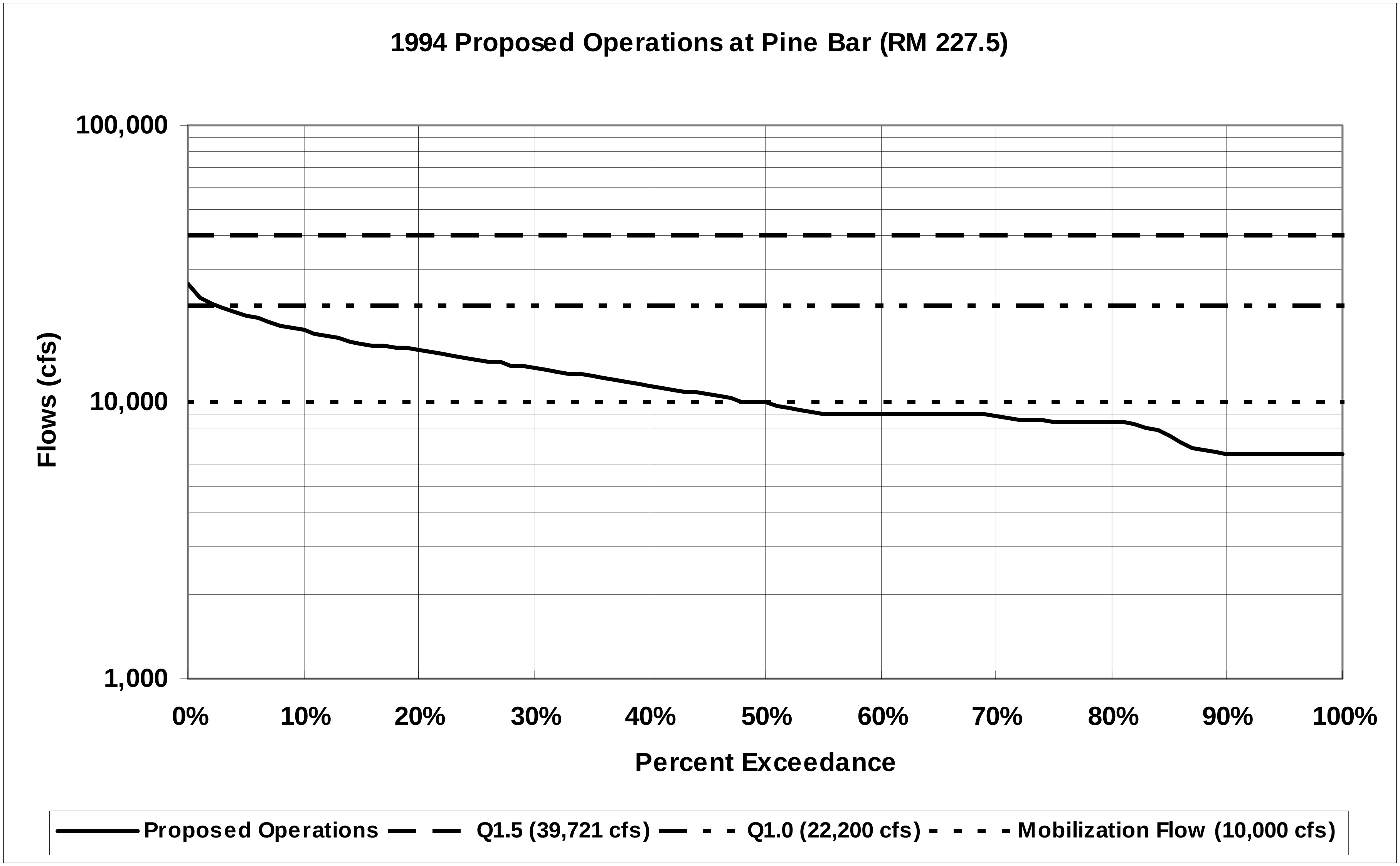


Figure 5. Flow-duration curve for 1994 Proposed Operations at Pine Bar (RM 227.5).

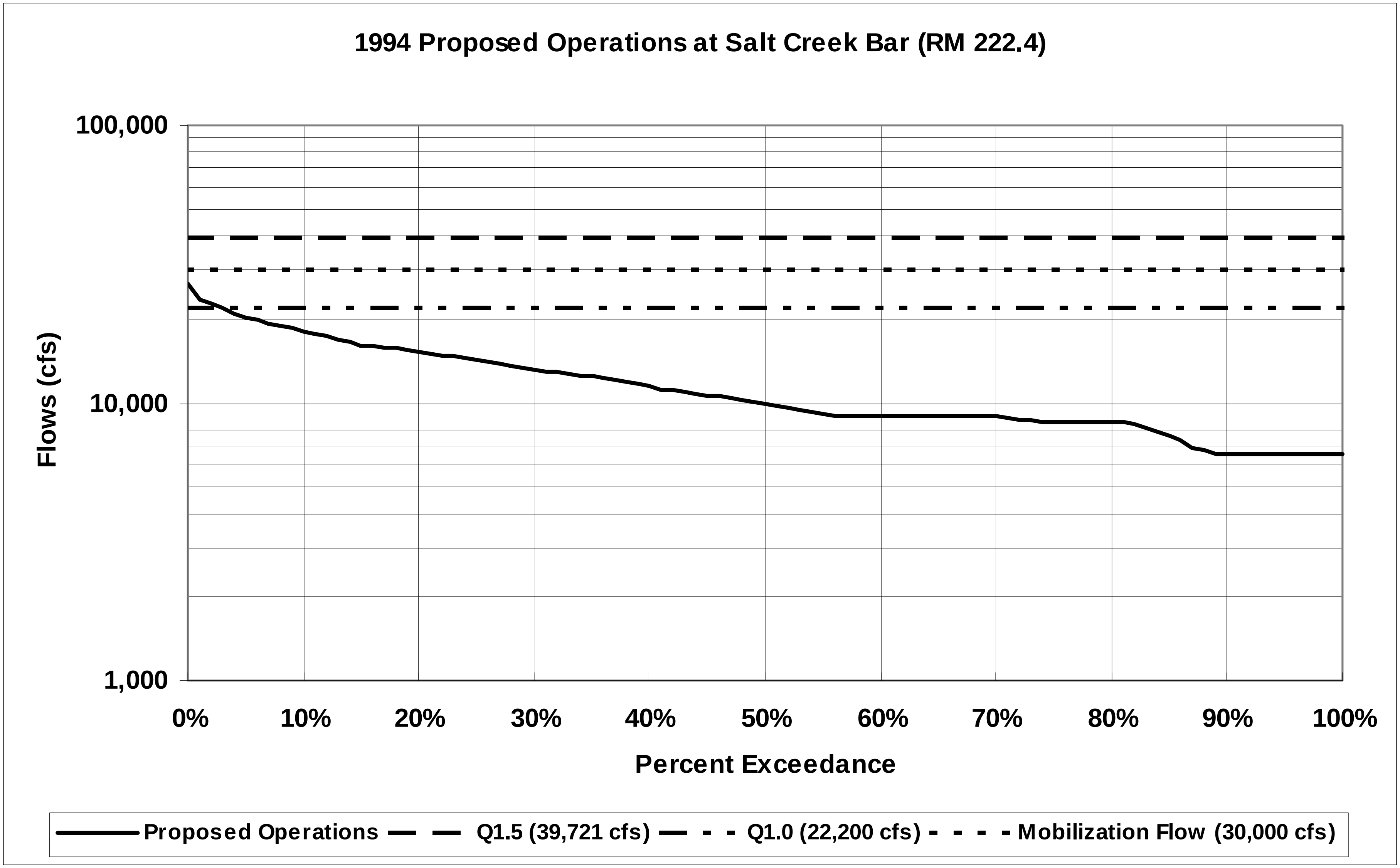


Figure 6. Flow-duration curve for 1994 Proposed Operations at Salt Creek Bar (RM 222.4).

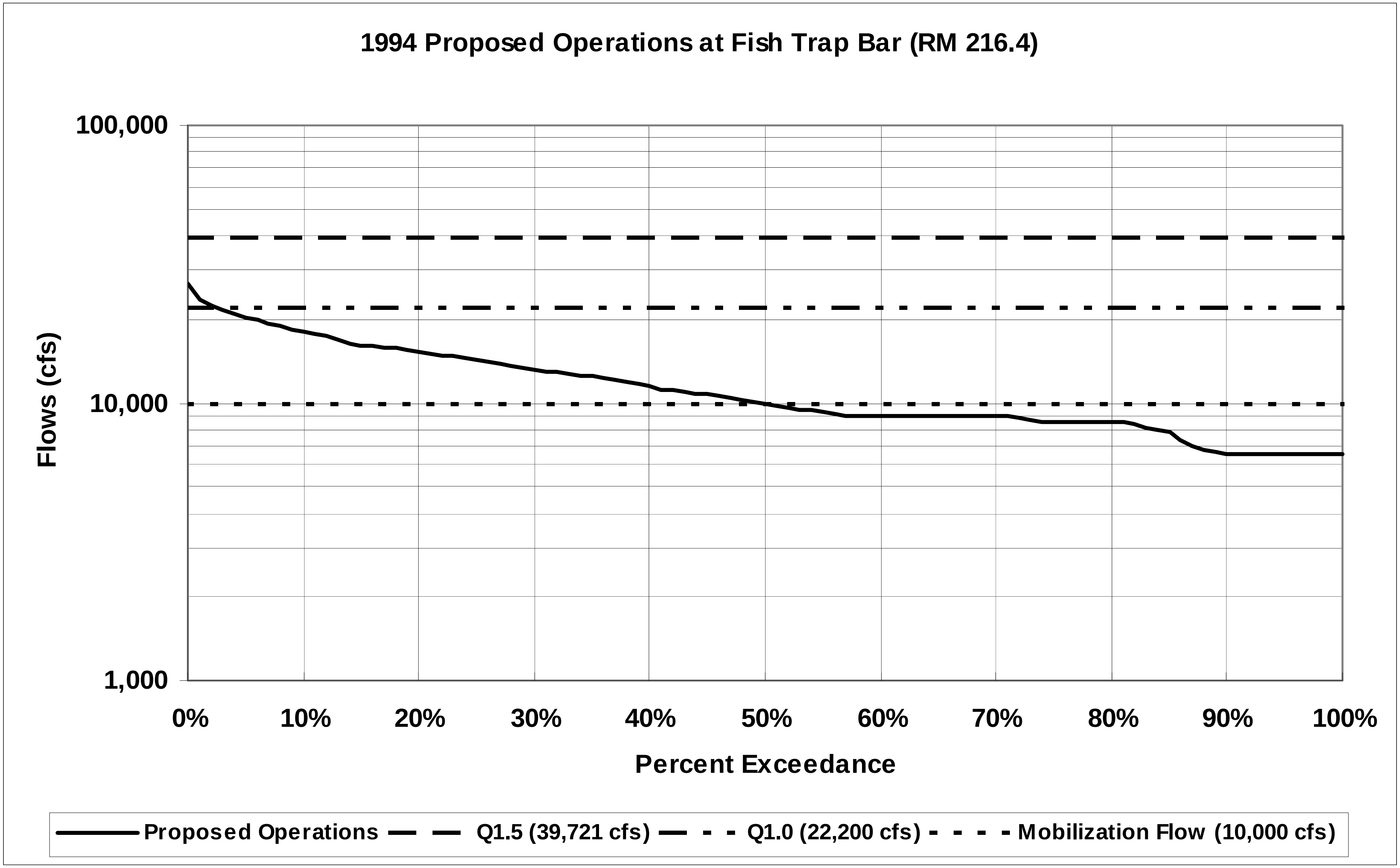


Figure 7. Flow-duration curve for 1994 Proposed Operations at Fish Trap Bar (RM 216.4).

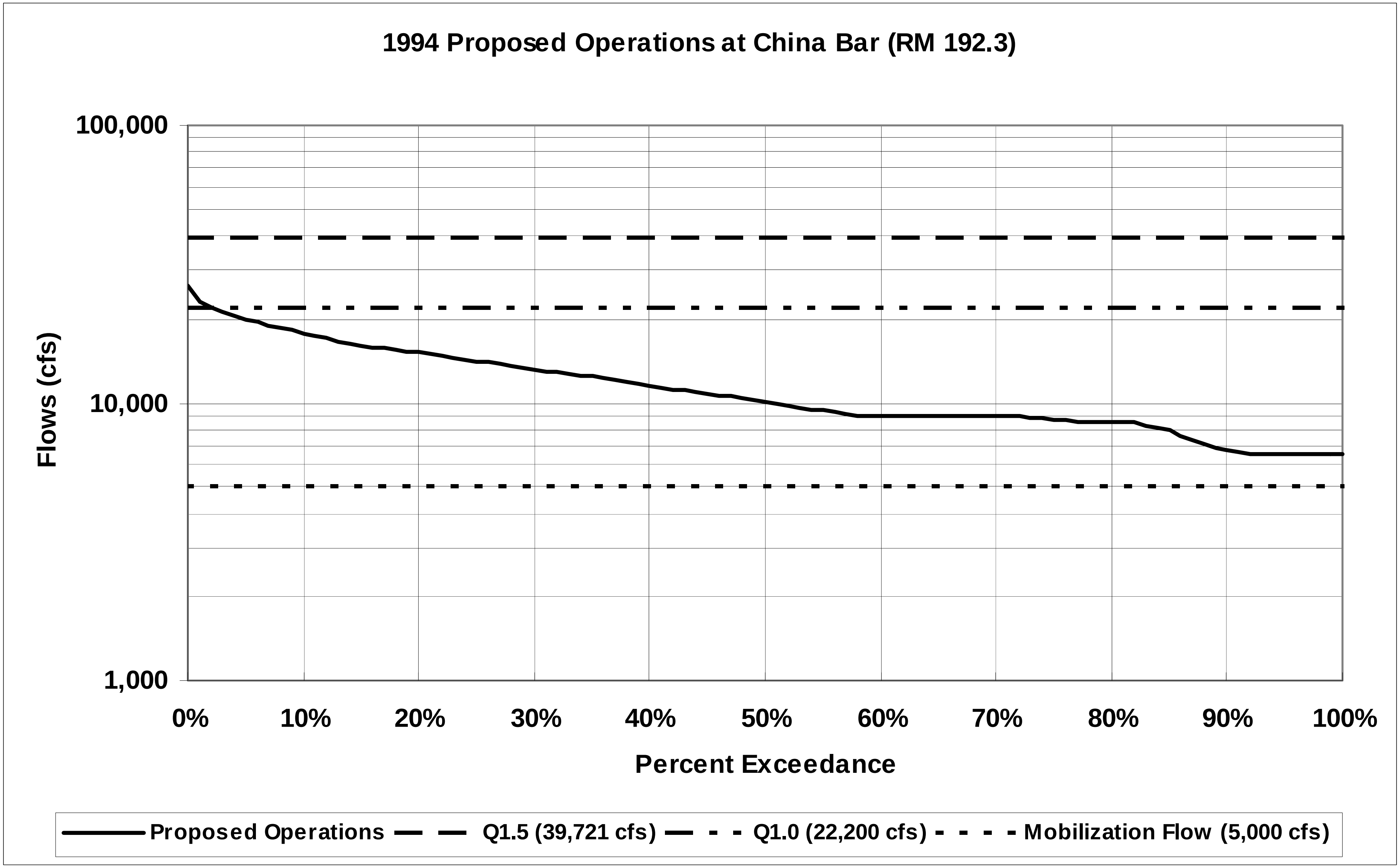


Figure 8. Flow-duration curve for 1994 Proposed Operations at China Bar (RM 192.3).

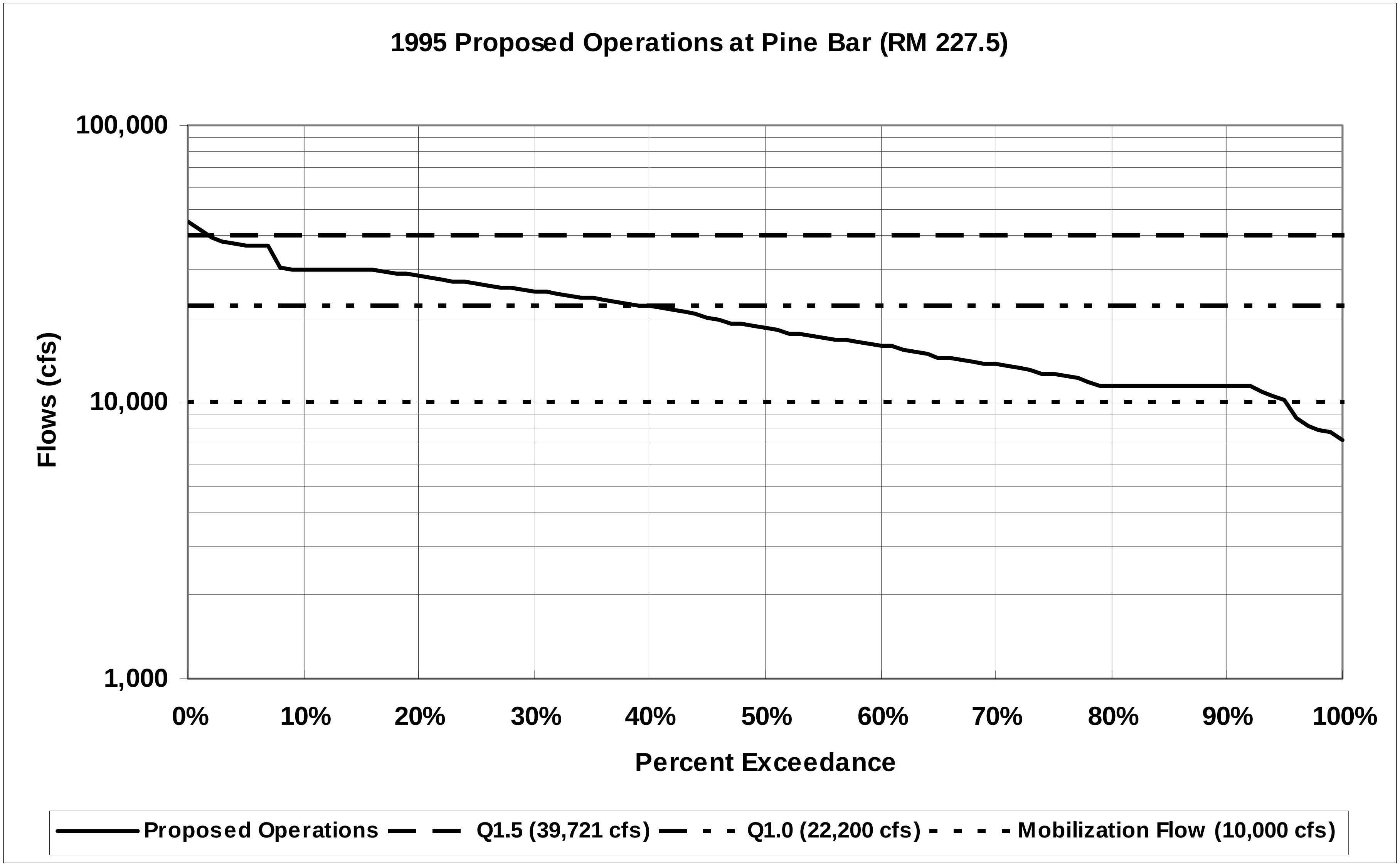


Figure 9. Flow-duration curve for 1995 Proposed Operations at Pine Bar (RM 227.5).

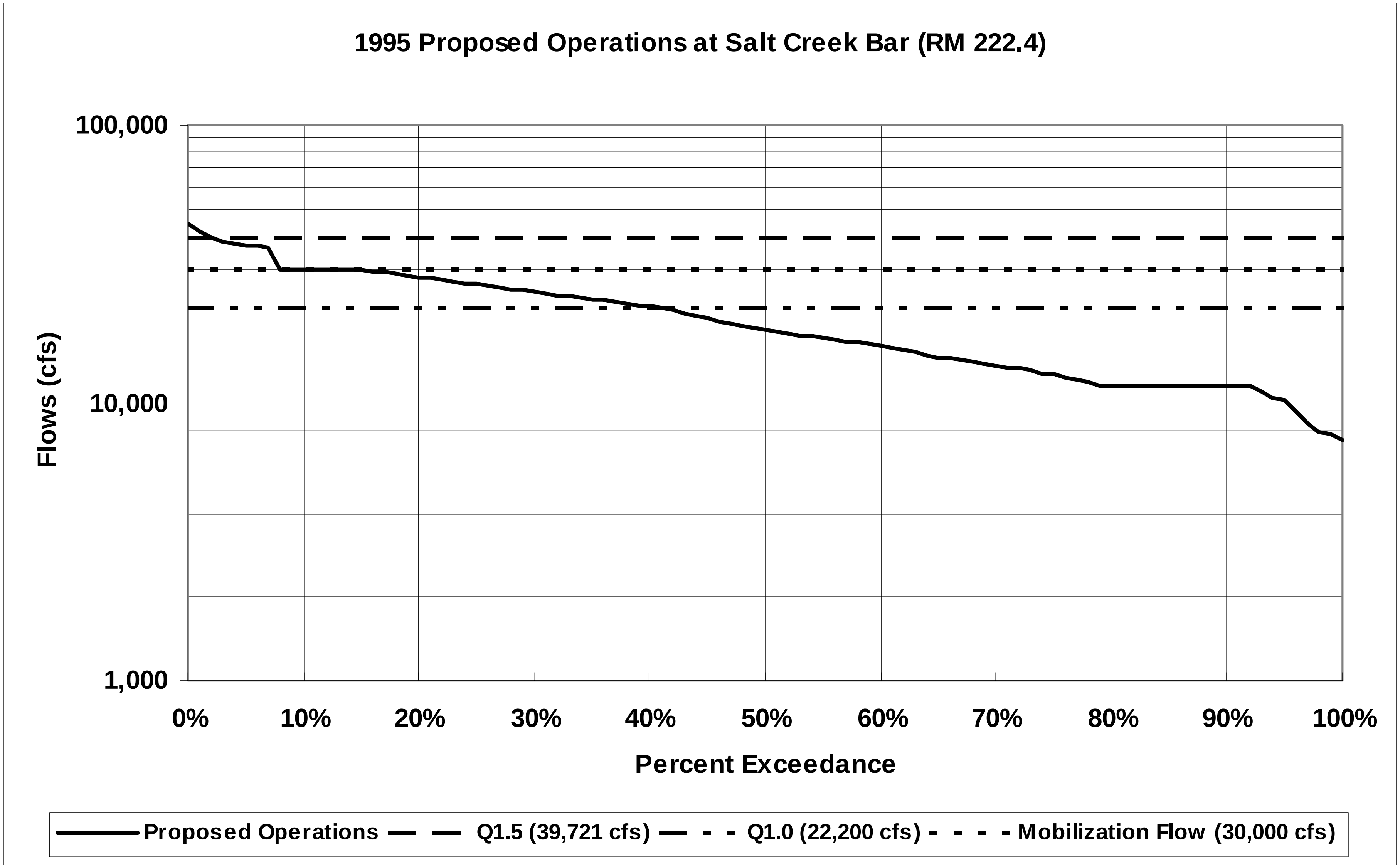


Figure 10. Flow-duration curve for 1995 Proposed Operations at Salt Creek Bar (RM 222.4).

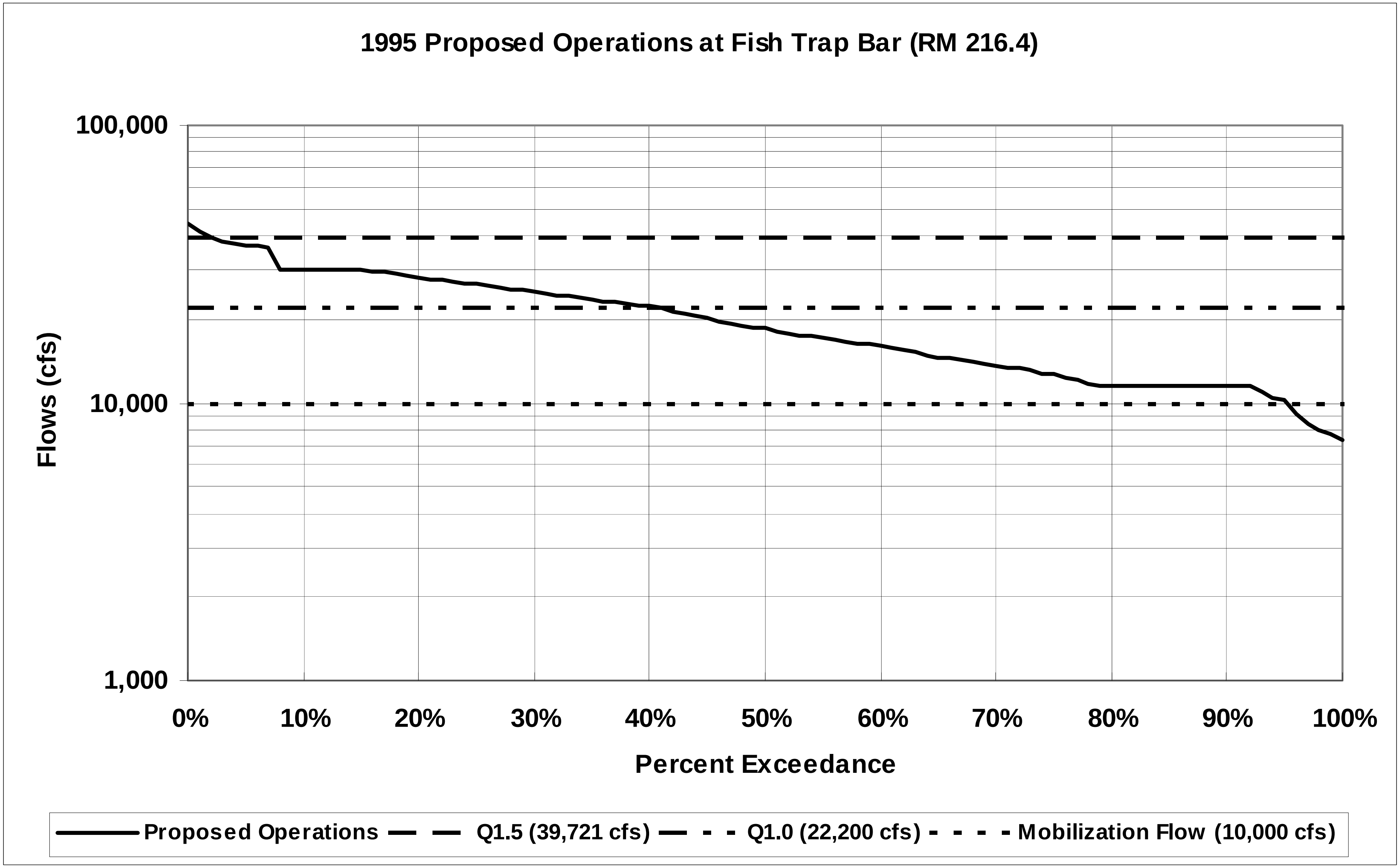


Figure 11. Flow-duration curve for 1995 Proposed Operations at Fish Trap Bar (RM 216.4).

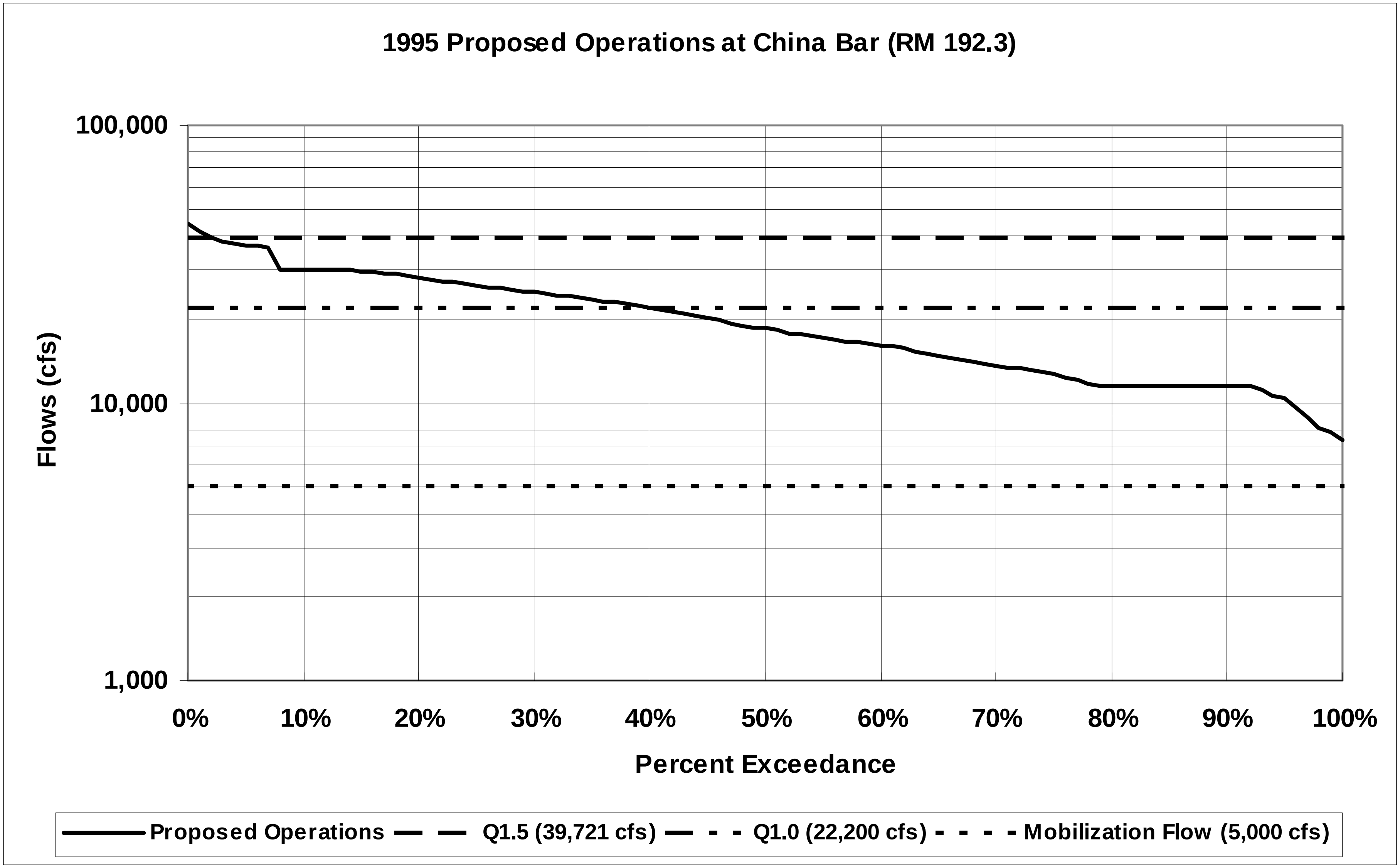


Figure 12. Flow-duration curve for 1995 Proposed Operations at China Bar (RM 192.3).

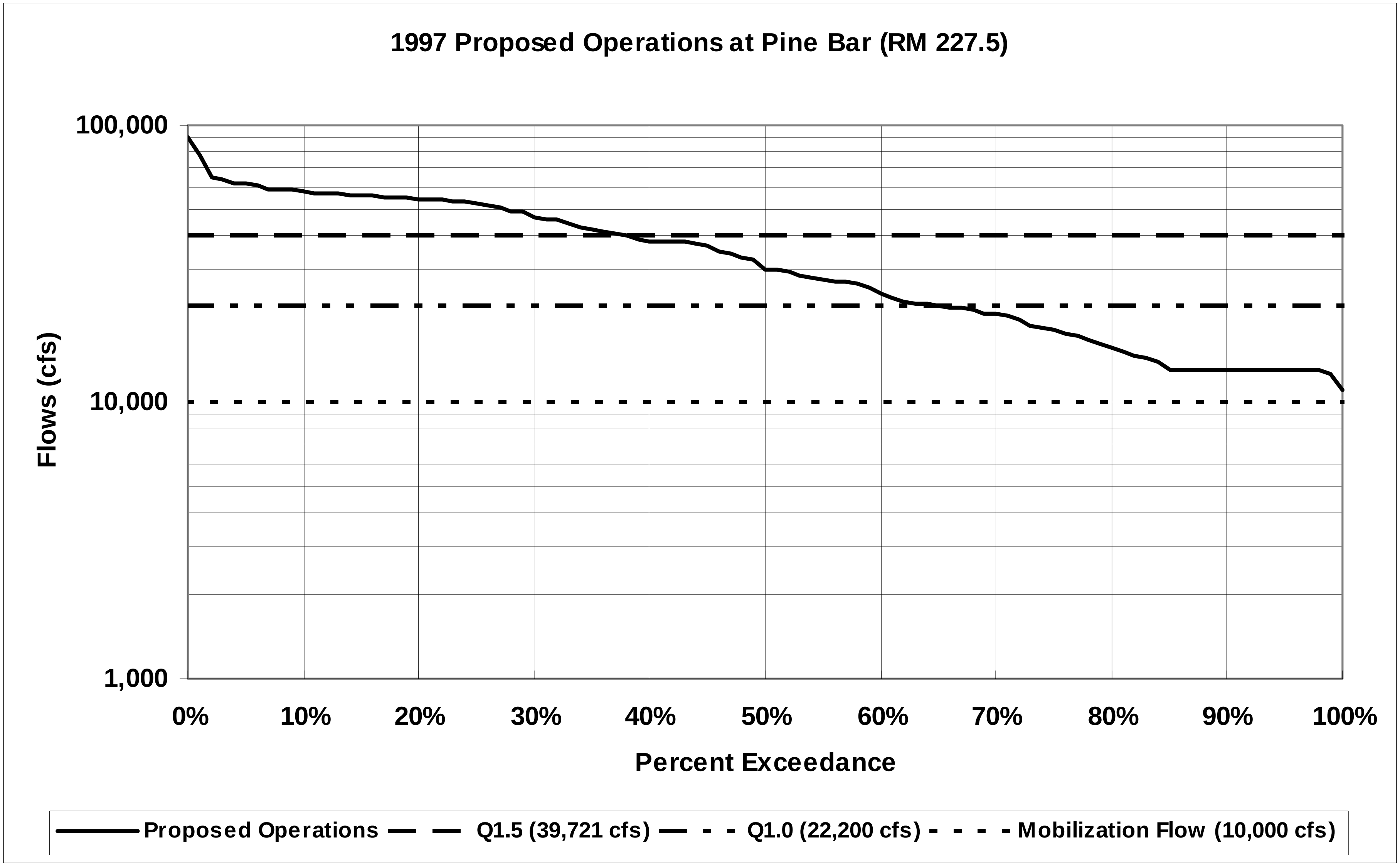


Figure 13. Flow-duration curve for 1997 Proposed Operations at Pine Bar (RM 227.5).

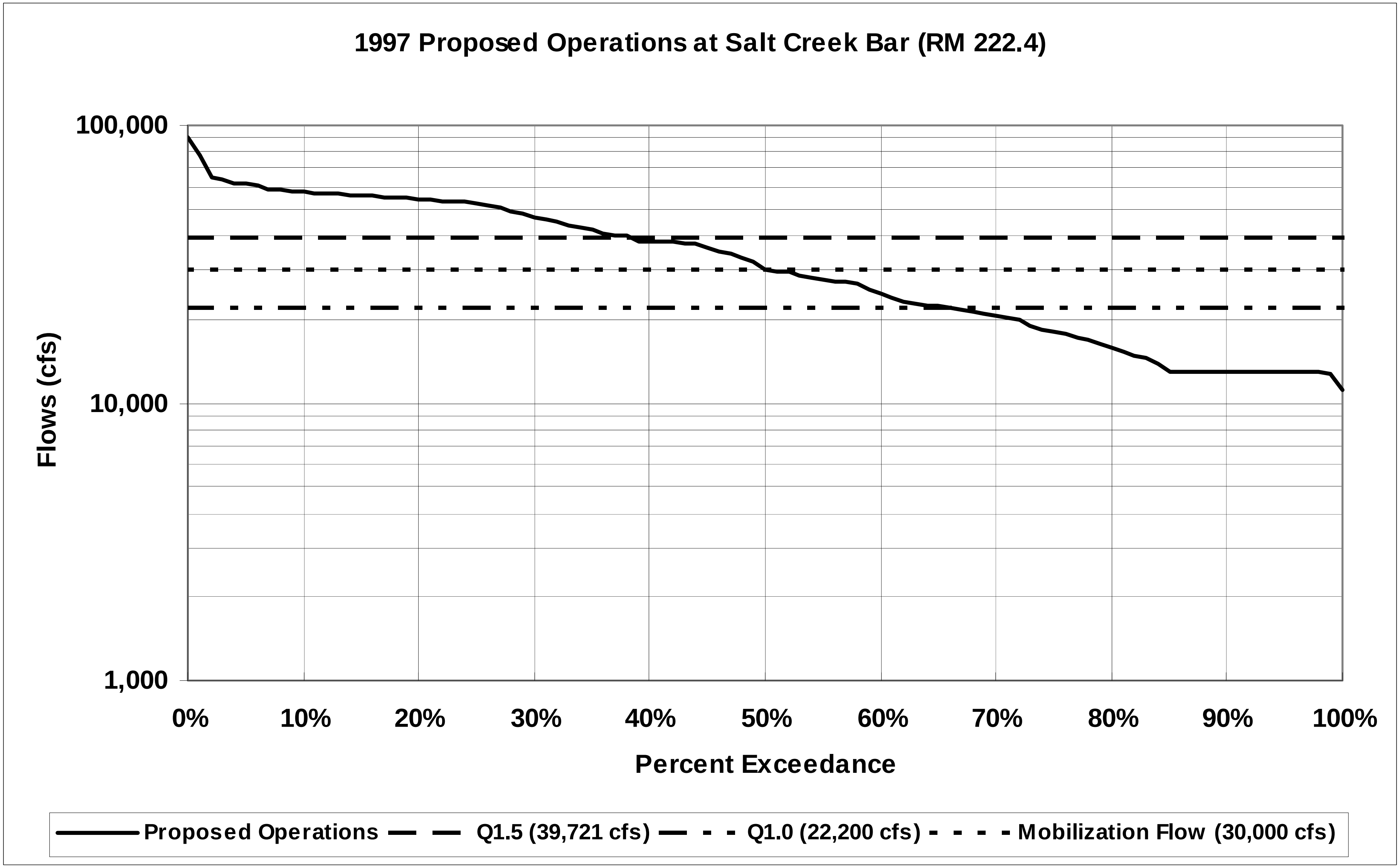


Figure 14. Flow-duration curve for 1997 Proposed Operations at Salt Creek Bar (RM 222.4).

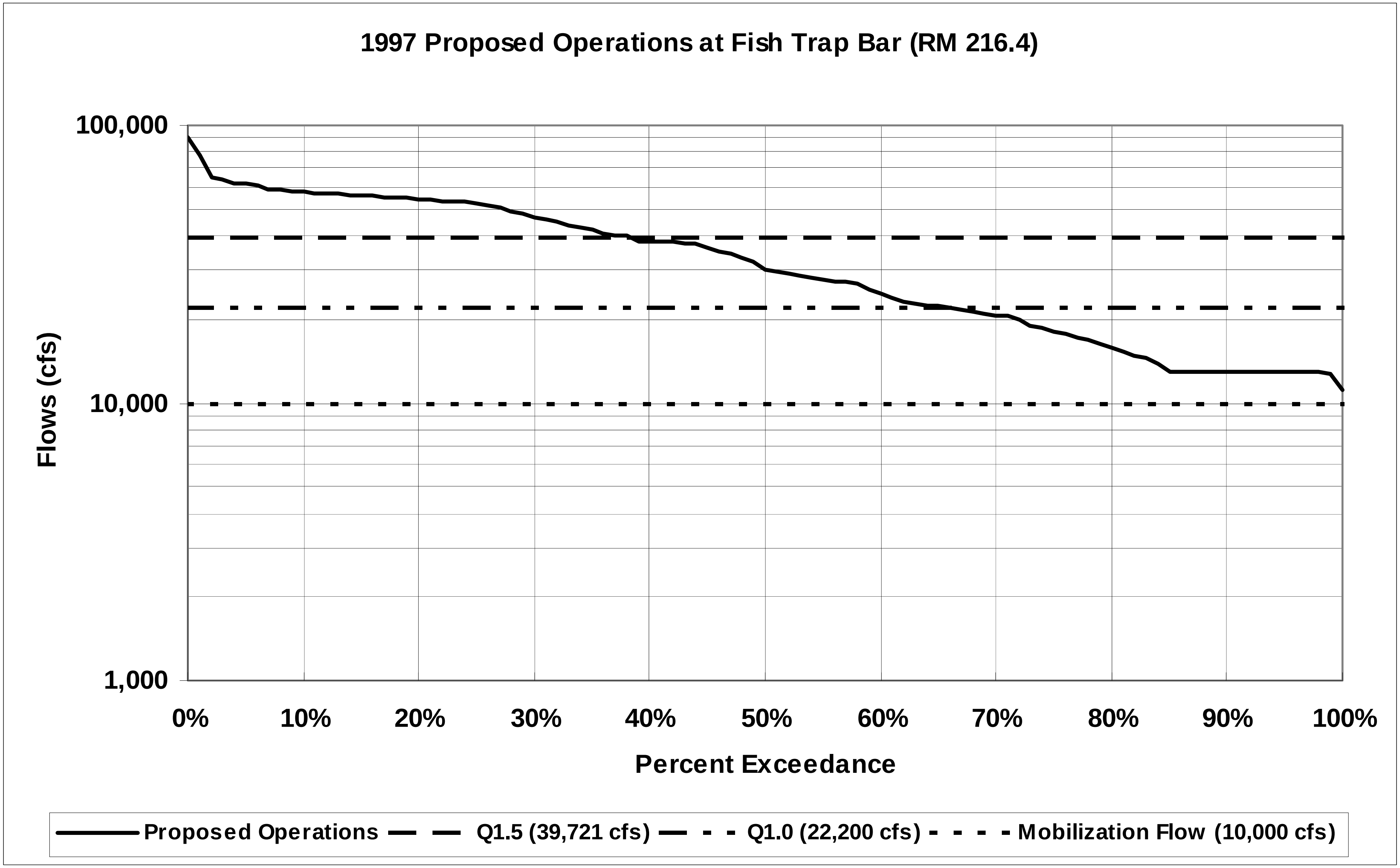


Figure 15. Flow-duration curve for 1997 Proposed Operations at Fish Trap Bar (RM 216.4).

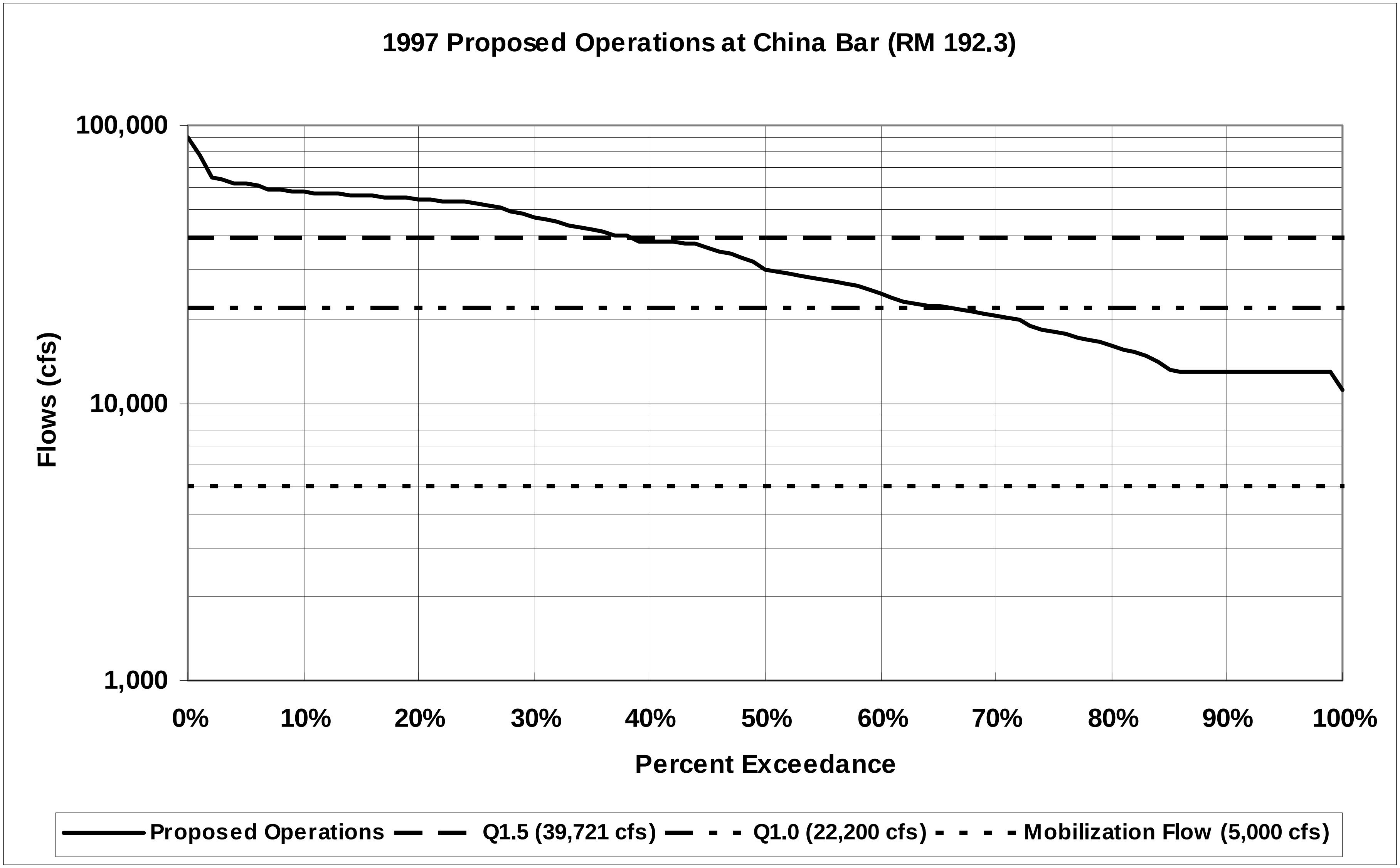


Figure 16. Flow-duration curve for 1997 Proposed Operations at China Bar (RM 192.3).

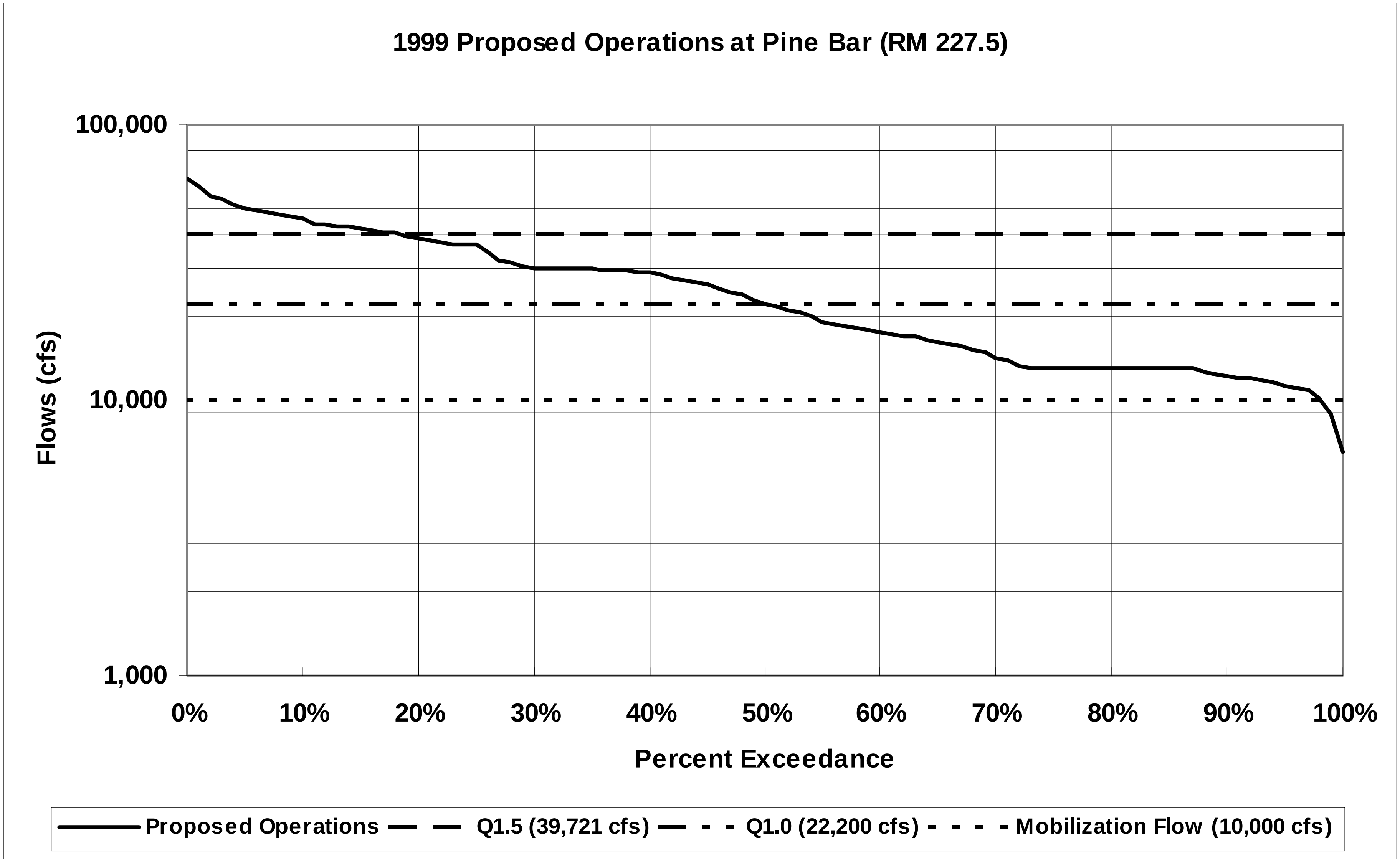


Figure 17. Flow-duration curve for 1999 Proposed Operations at Pine Bar (RM 227.5).

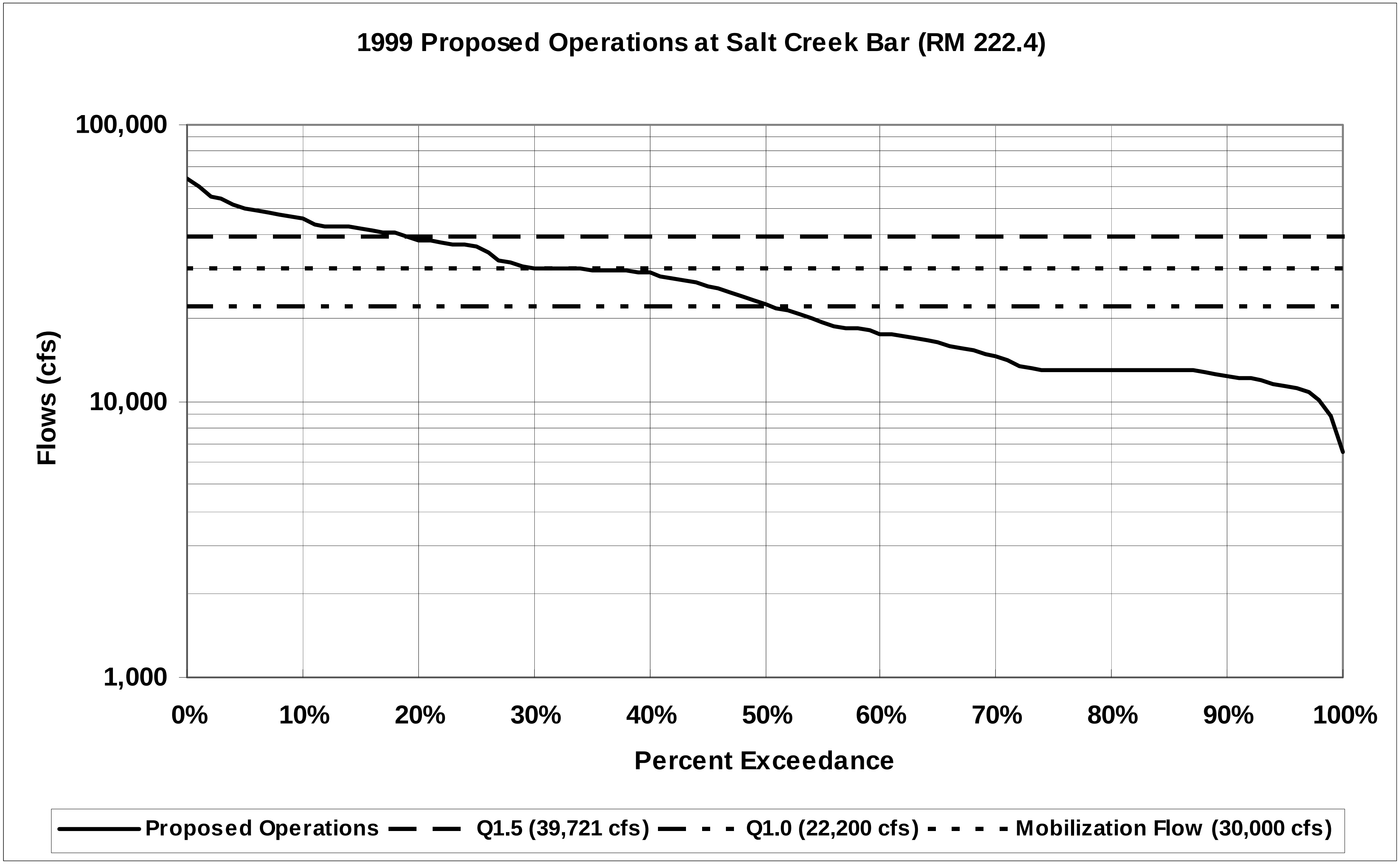


Figure 18. Flow-duration curve for 1999 Proposed Operations at Salt Creek Bar (RM 222.4).

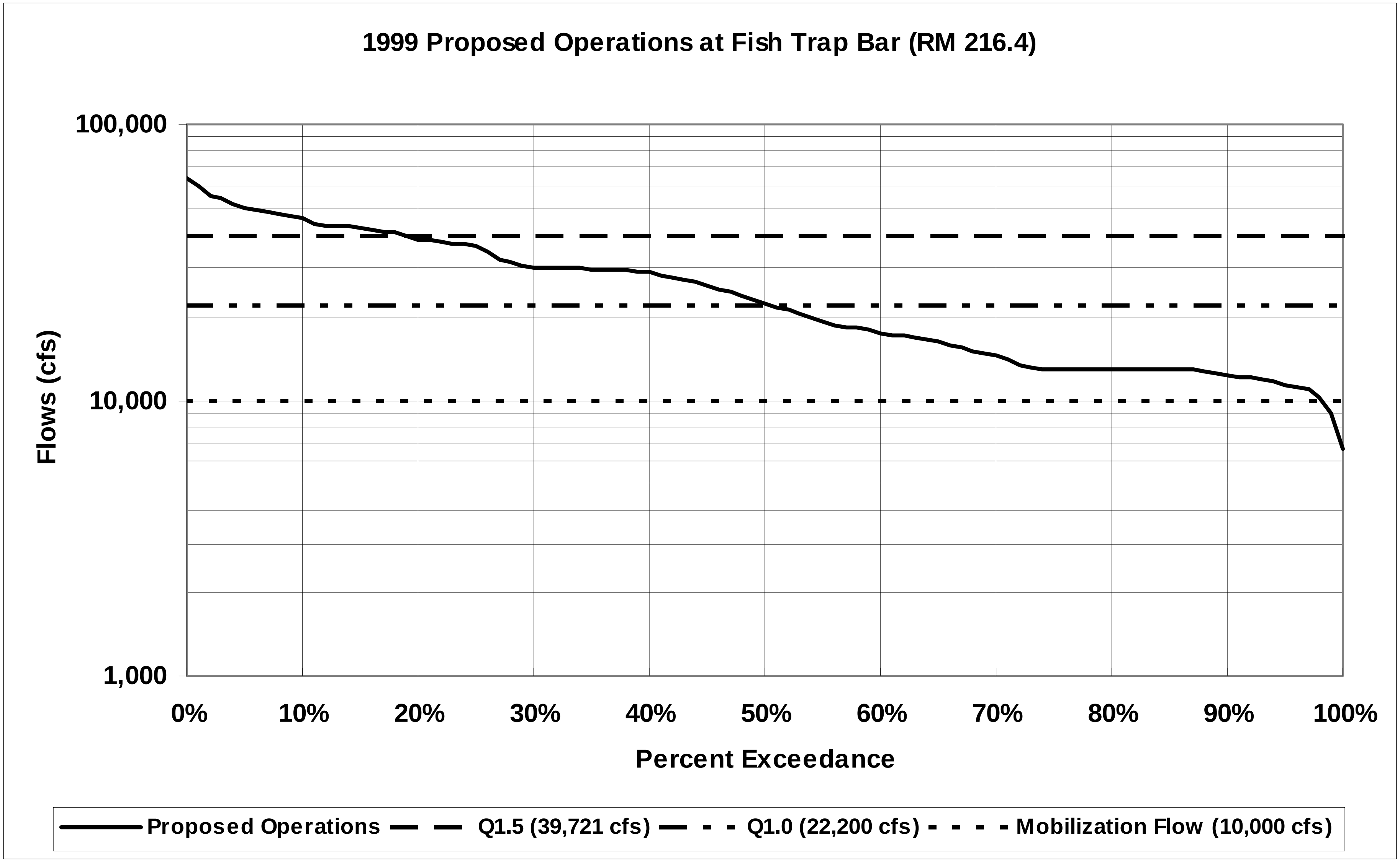


Figure 19. Flow-duration curve for 1999 Proposed Operations at Fish Trap Bar (RM 216.4).

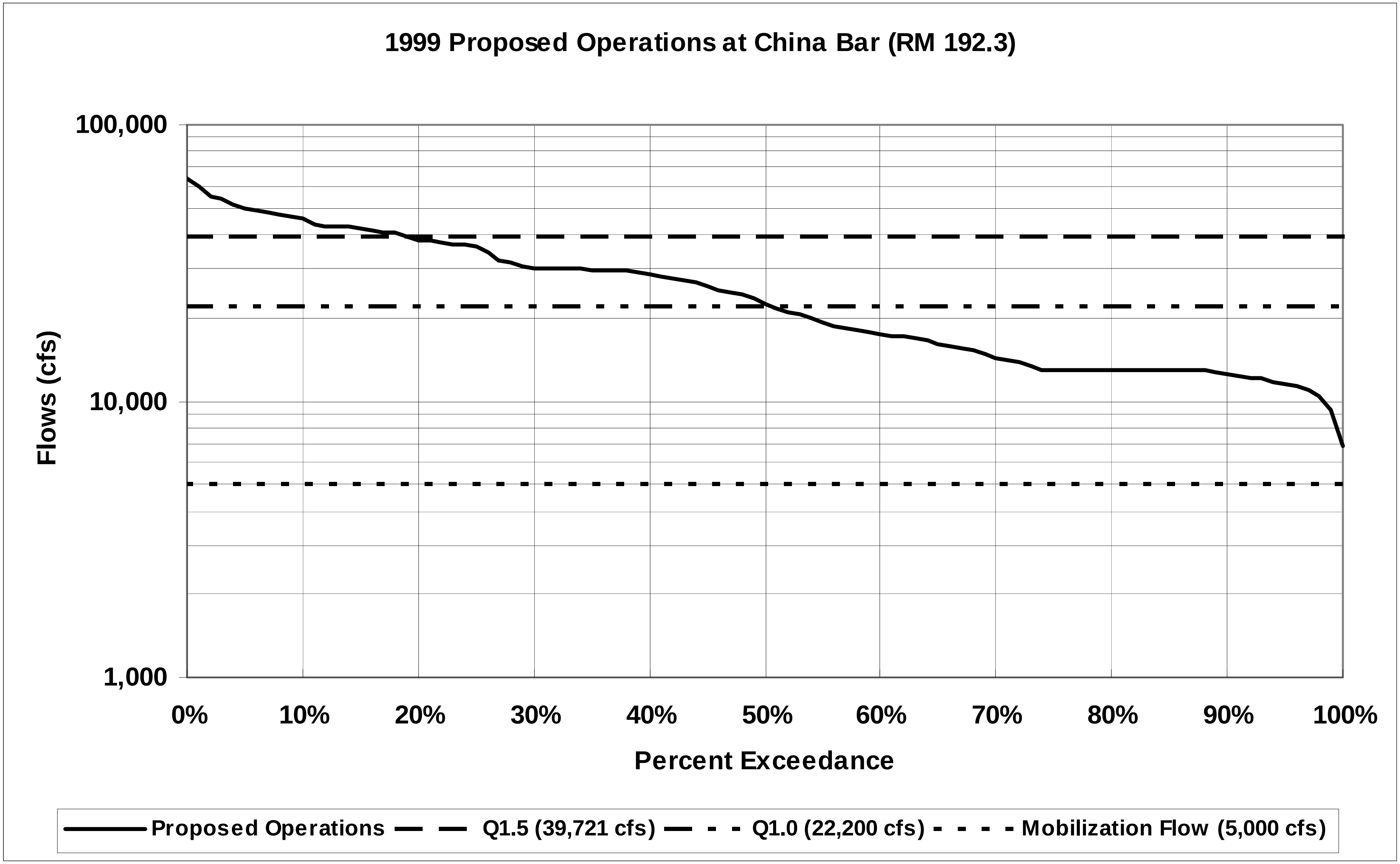


Figure 20. Flow-duration curve for 1999 Proposed Operations at China Bar (RM 192.3).

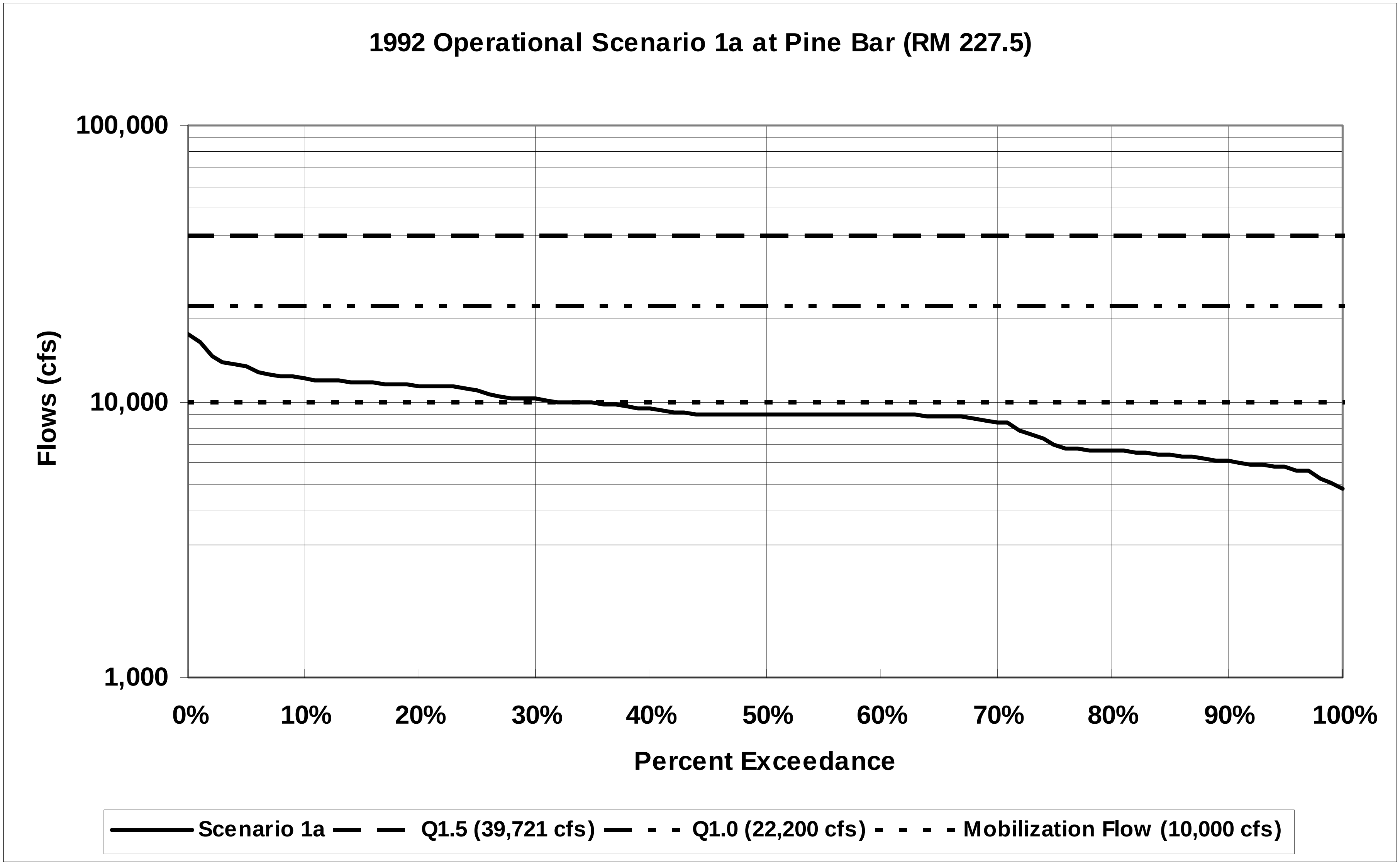


Figure 21. Flow-duration curve for 1992 Operational Scenario 1a at Pine Bar (RM 227.5).

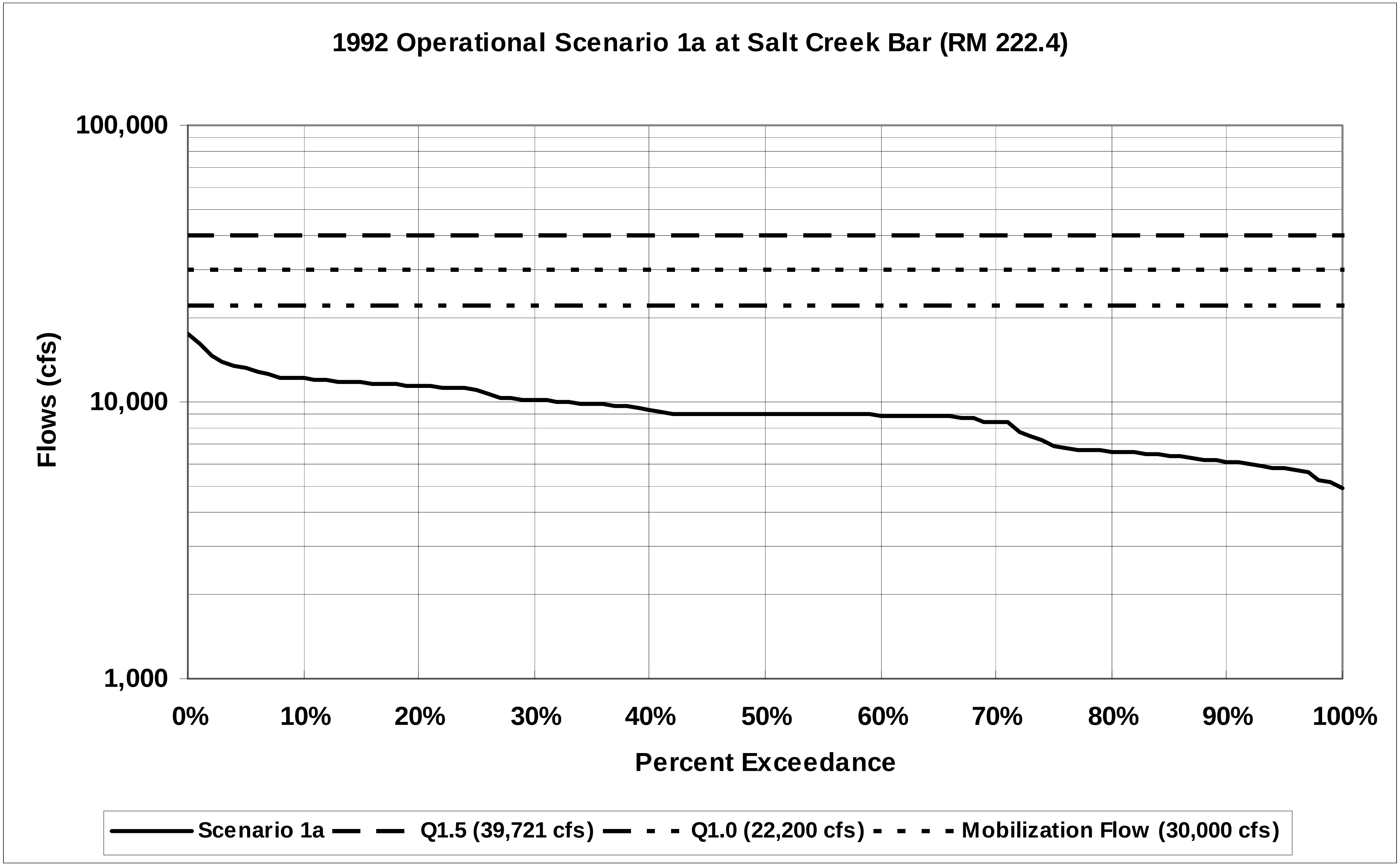


Figure 22. Flow-duration curve for 1992 Operational Scenario 1a at Salt Creek Bar (RM 222.4).

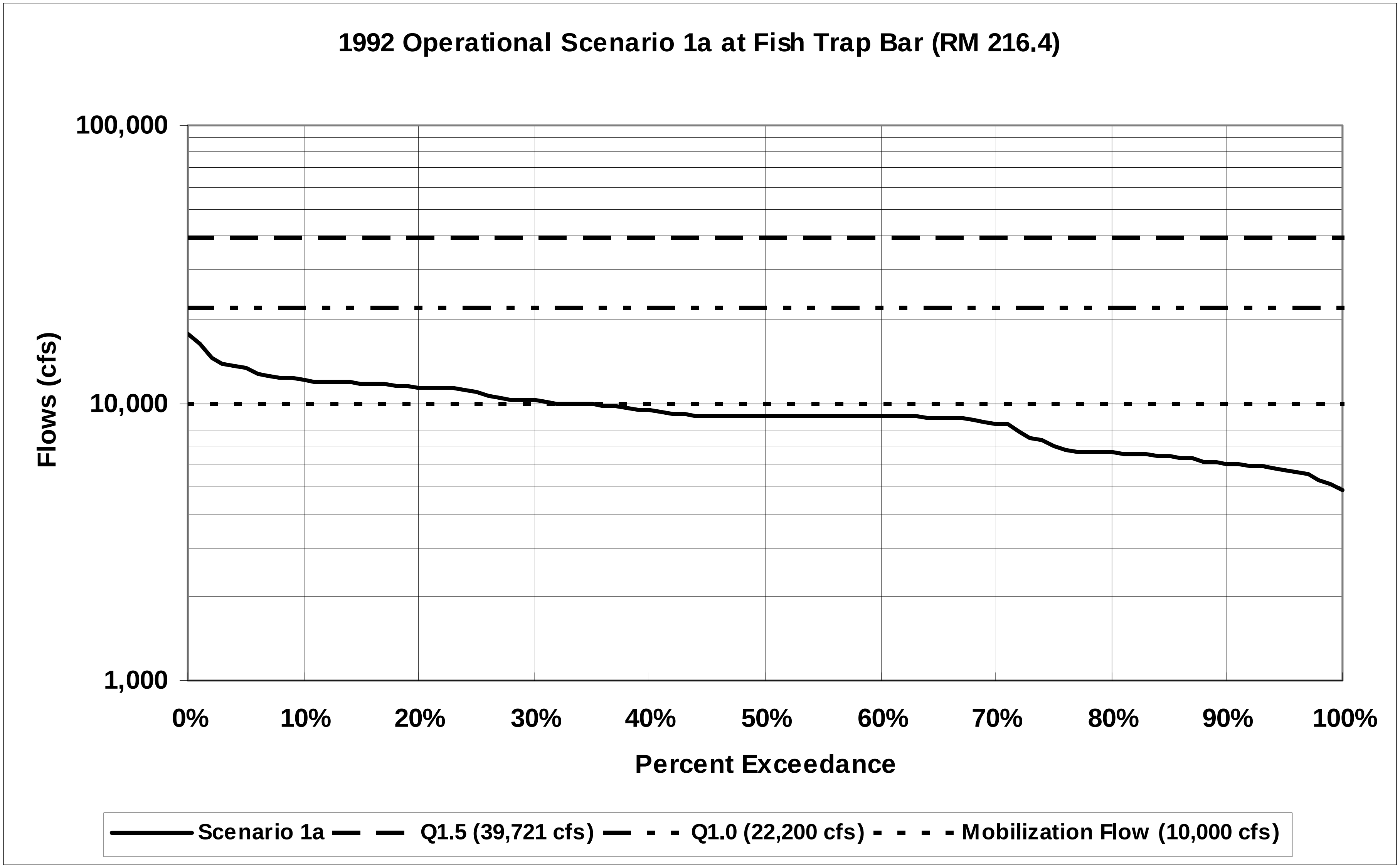


Figure 23. Flow-duration curve for 1992 Operational Scenario 1a at Fish Trap Bar (RM 216.4).

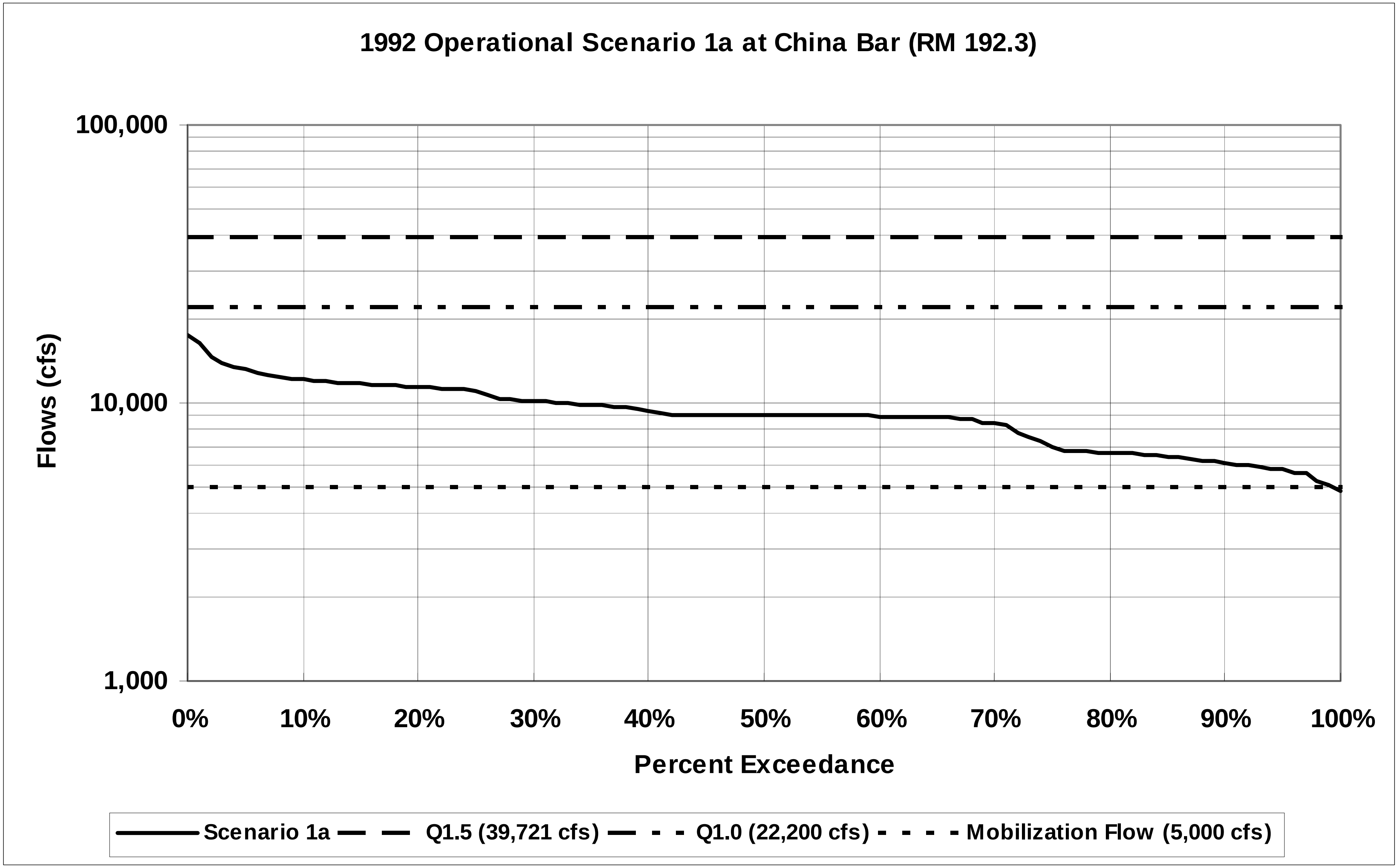


Figure 24. Flow-duration curve for 1992 Operational Scenario 1a at China Bar (RM 192.3).

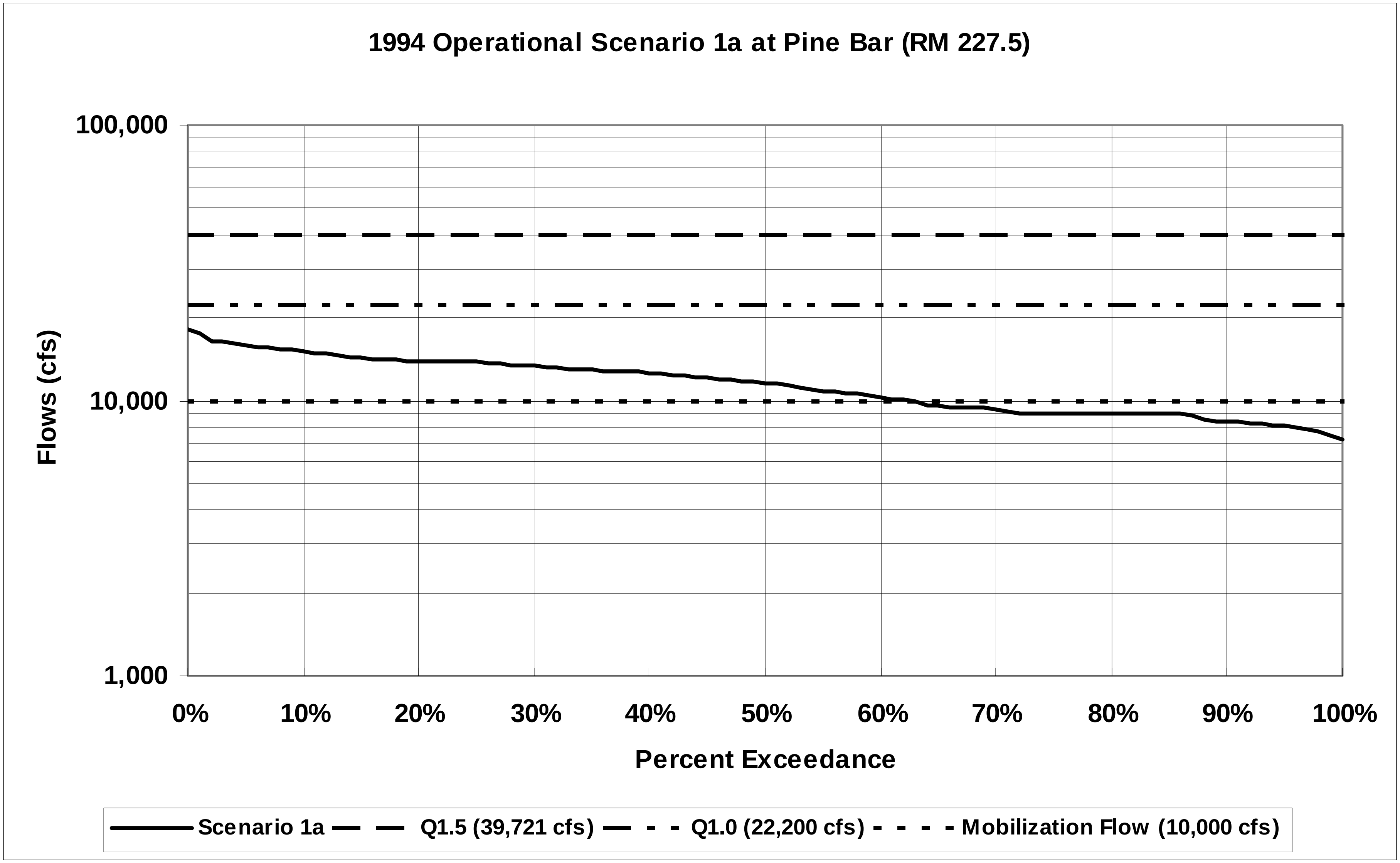


Figure 25. Flow-duration curve for 1994 Operational Scenario 1a at Pine Bar (RM 227.5).

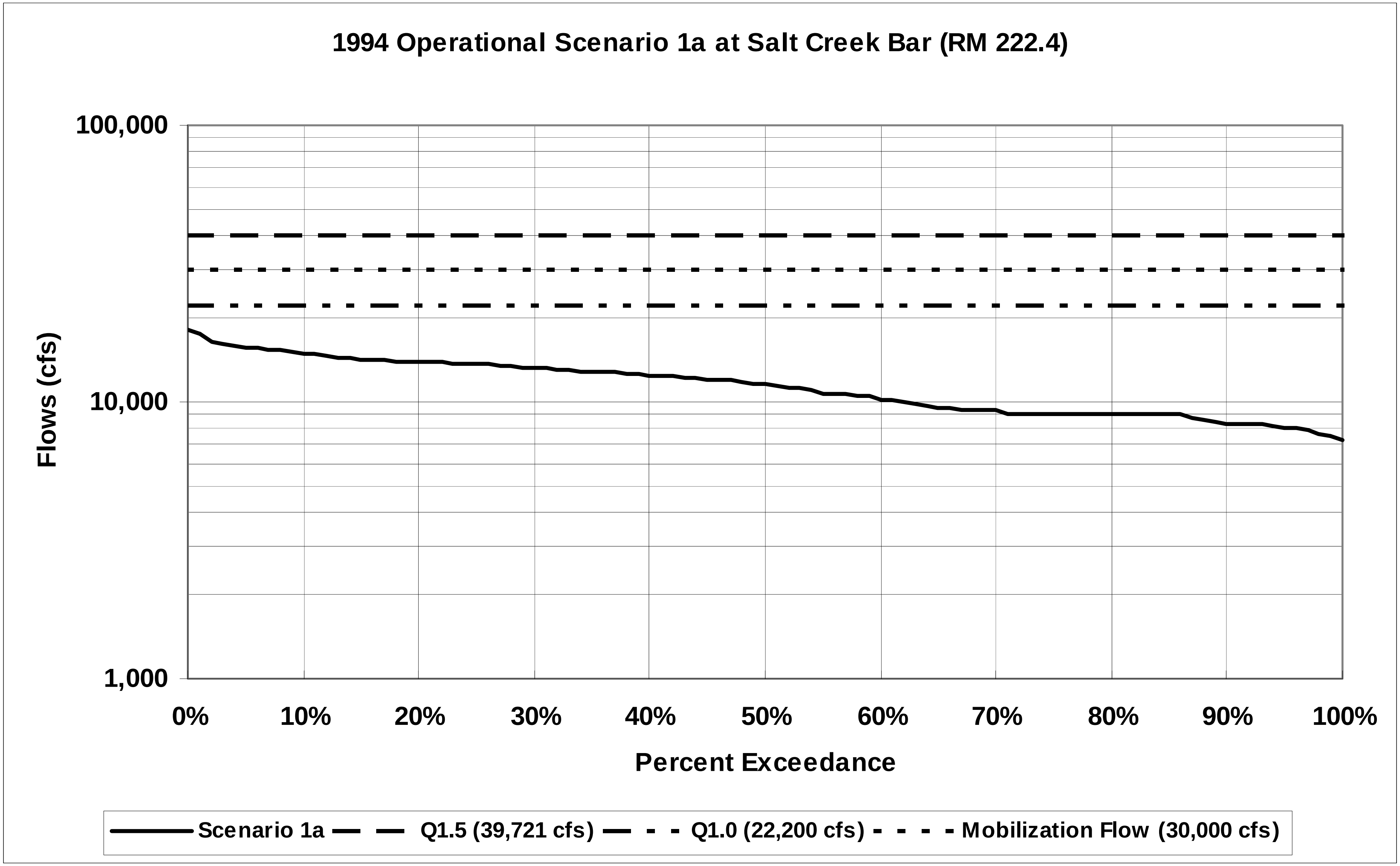


Figure 26. Flow-duration curve for 1994 Operational Scenario 1a at Salt Creek Bar (RM 222.4).

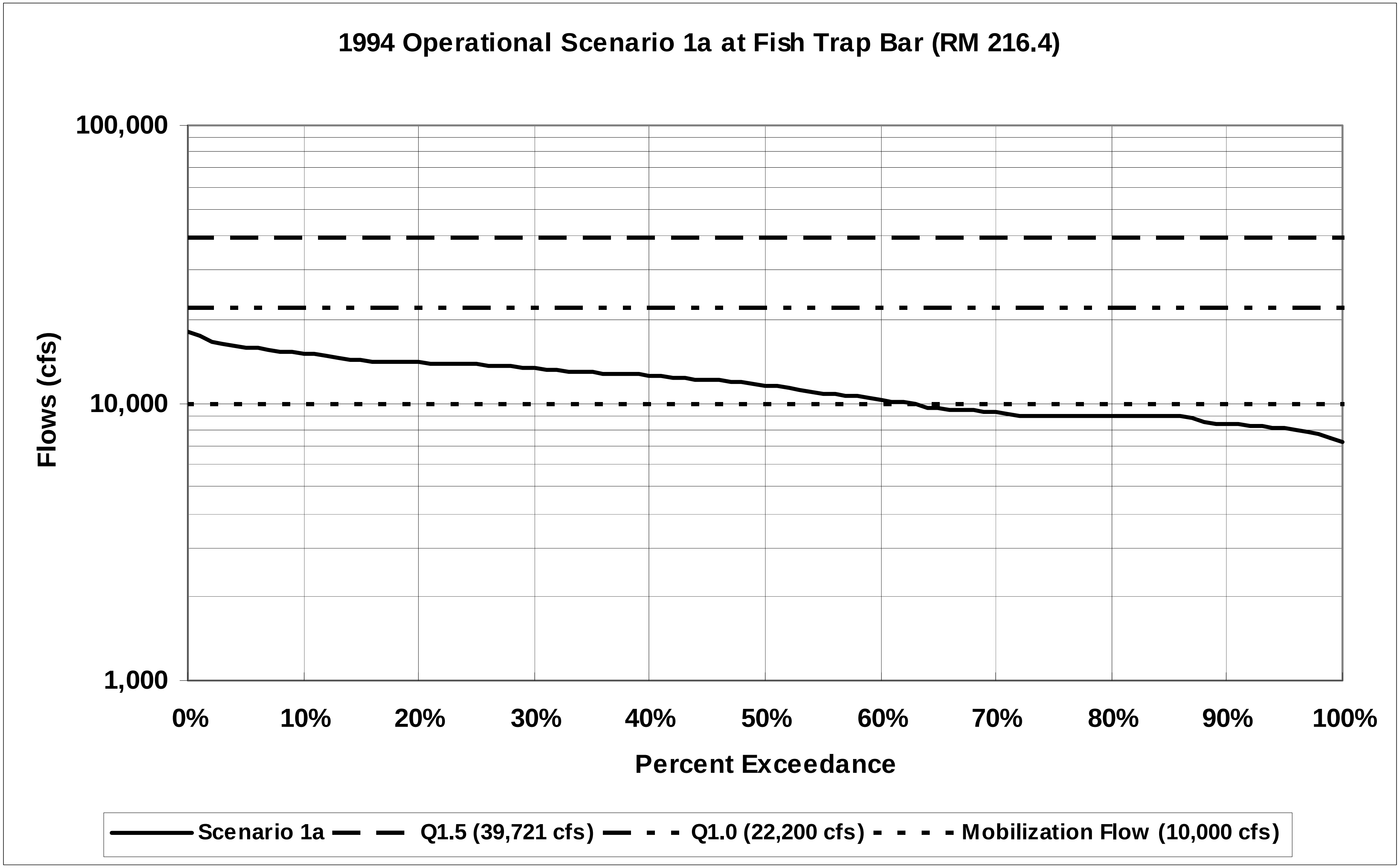


Figure 27. Flow-duration curve for 1994 Operational Scenario 1a at Fish Trap Bar (RM 216.4).

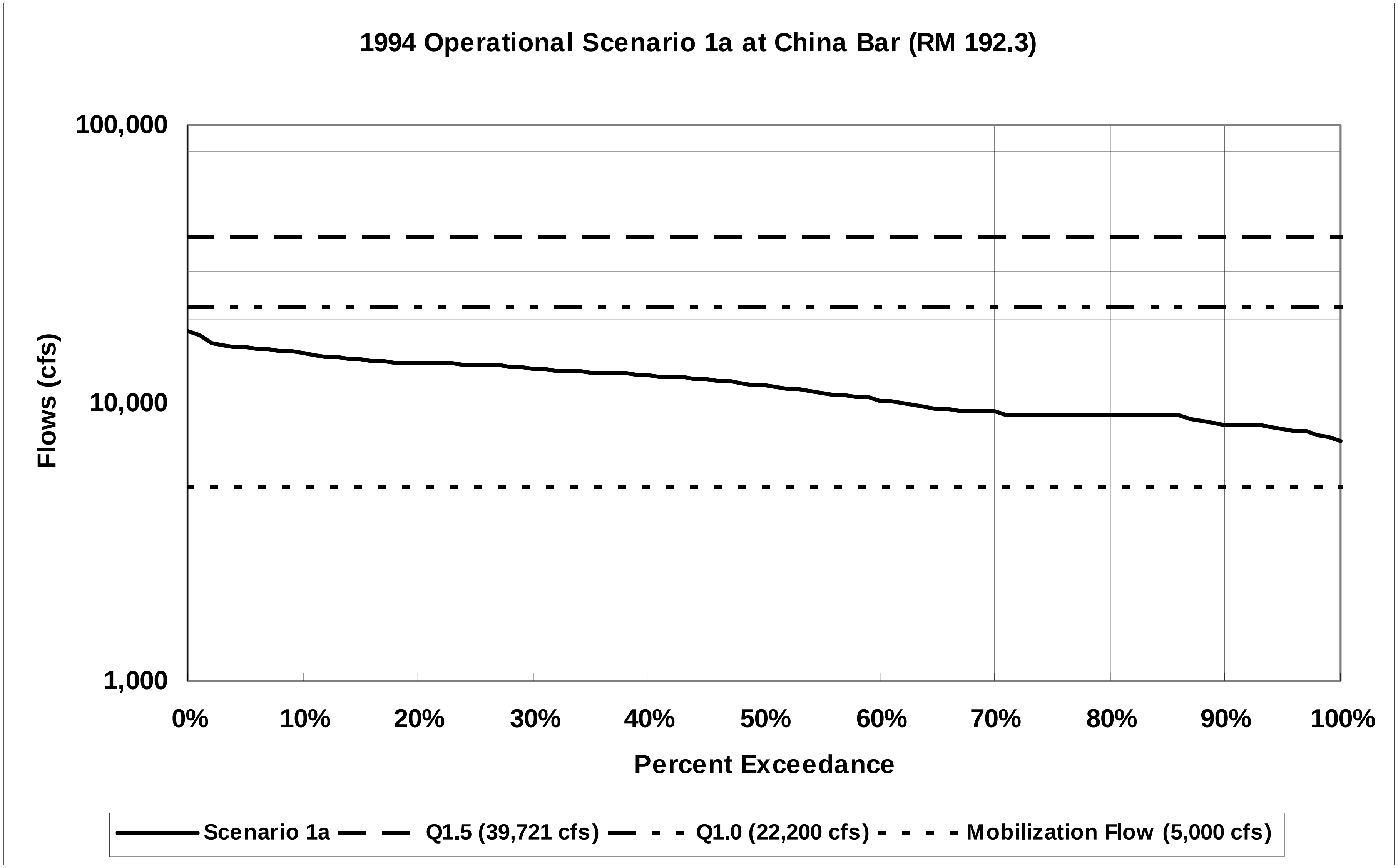


Figure 28. Flow-duration curve for 1994 Operational Scenario 1a at China Bar (RM 192.3).

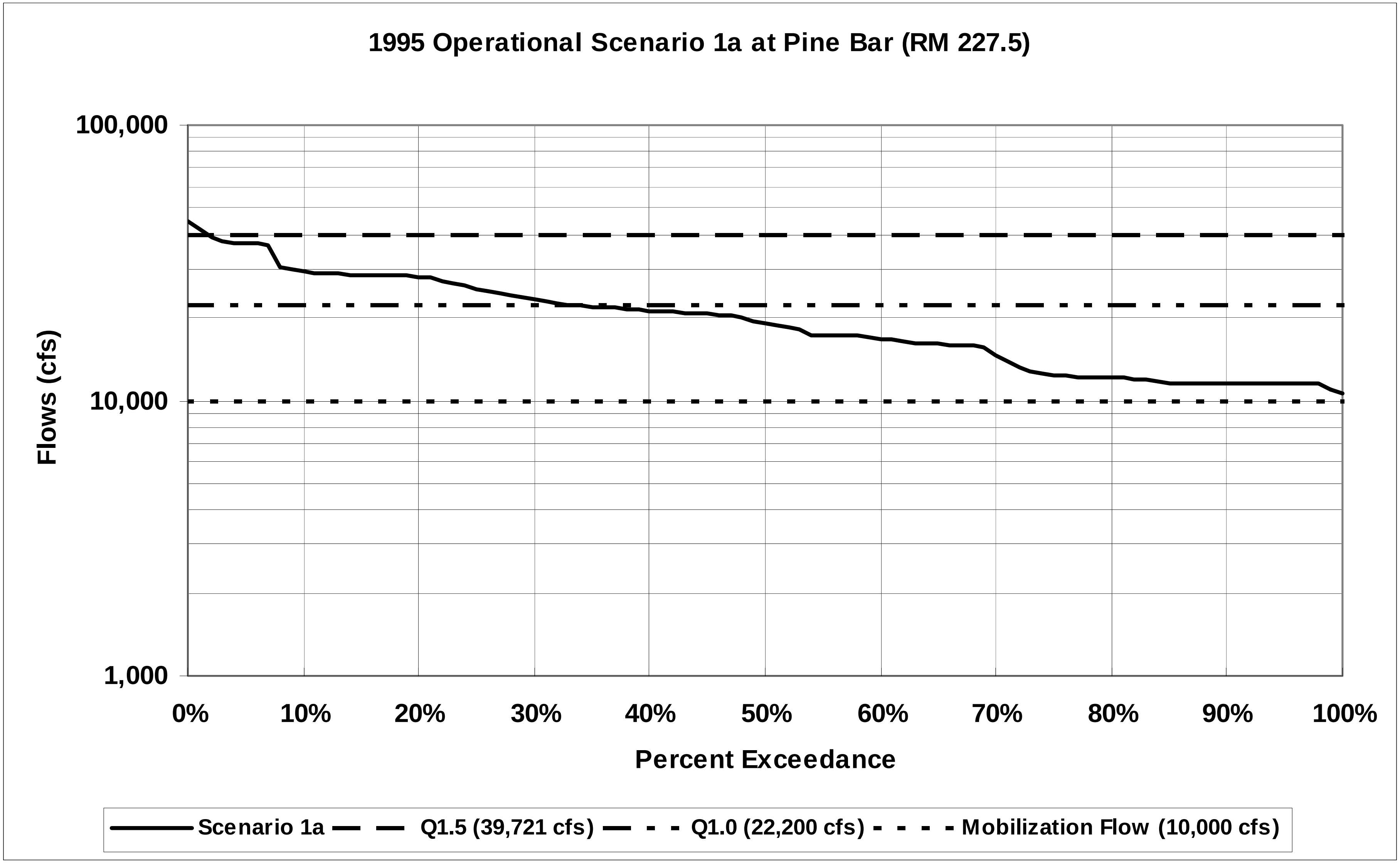


Figure 29. Flow-duration curve for 1995 Operational Scenario 1a at Pine Bar (RM 227.5).

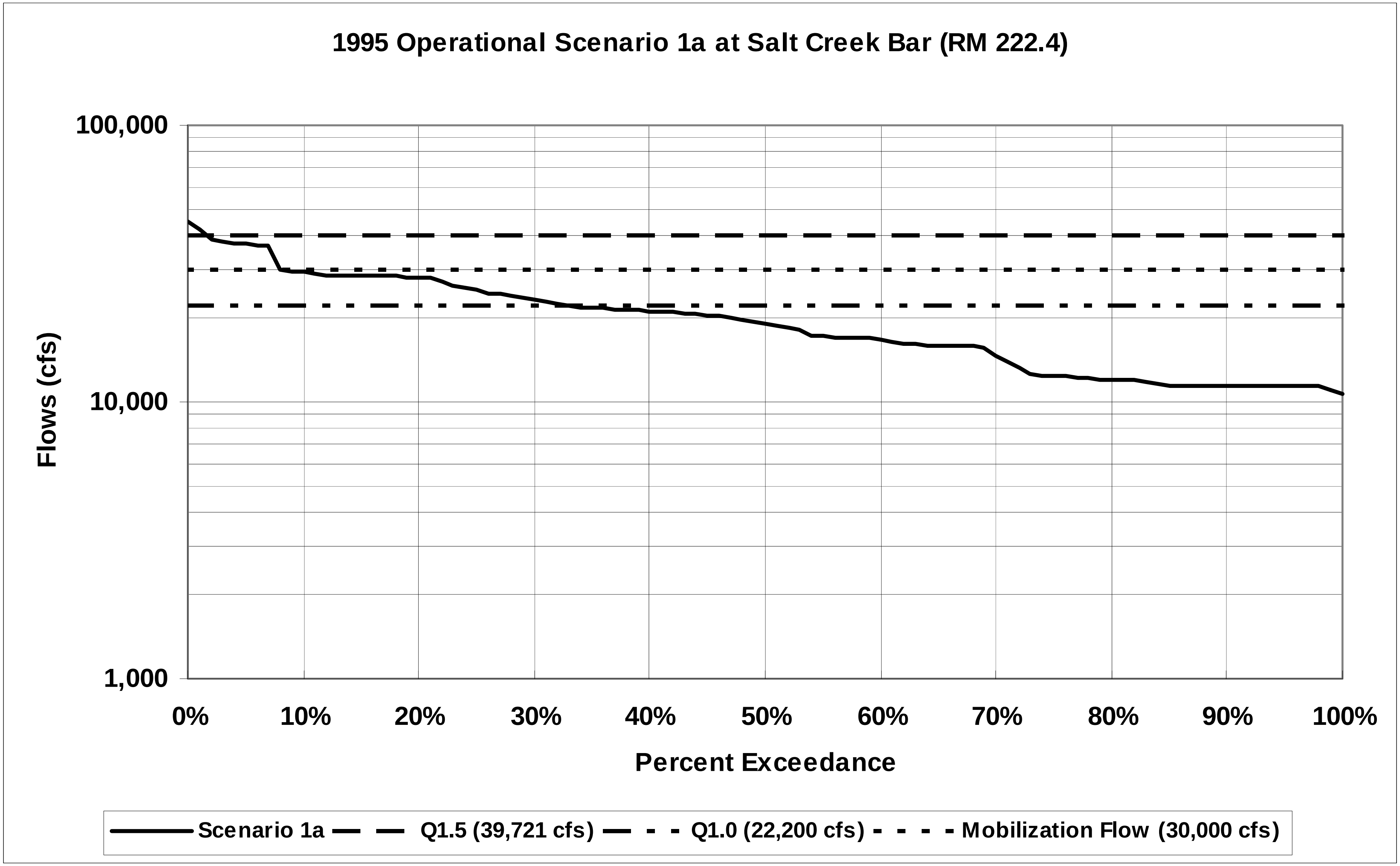


Figure 30. Flow-duration curve for 1995 Operational Scenario 1a at Salt Creek Bar (RM 222.4).

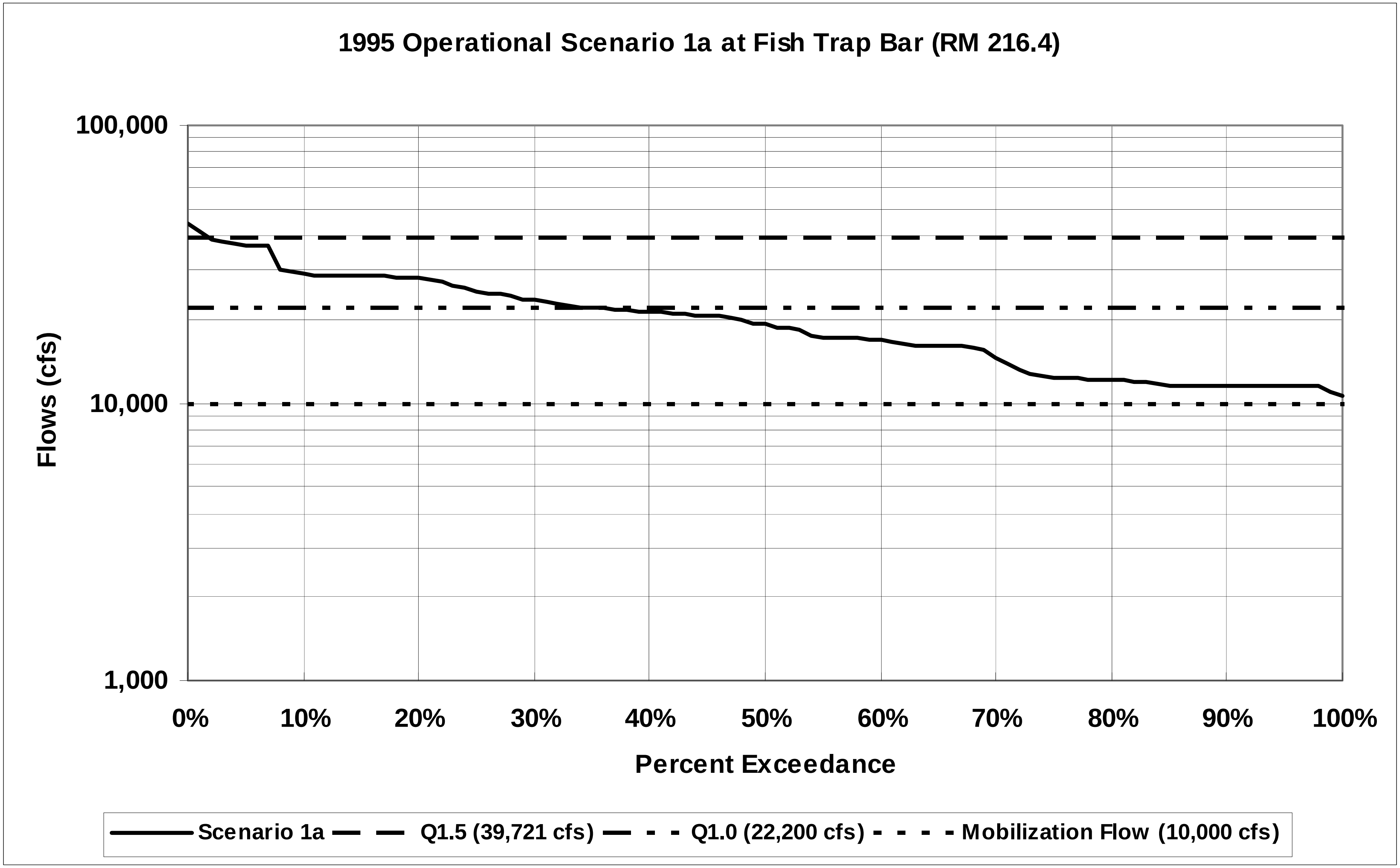


Figure 31. Flow-duration curve for 1995 Operational Scenario 1a at Fish Trap Bar (RM 216.4).

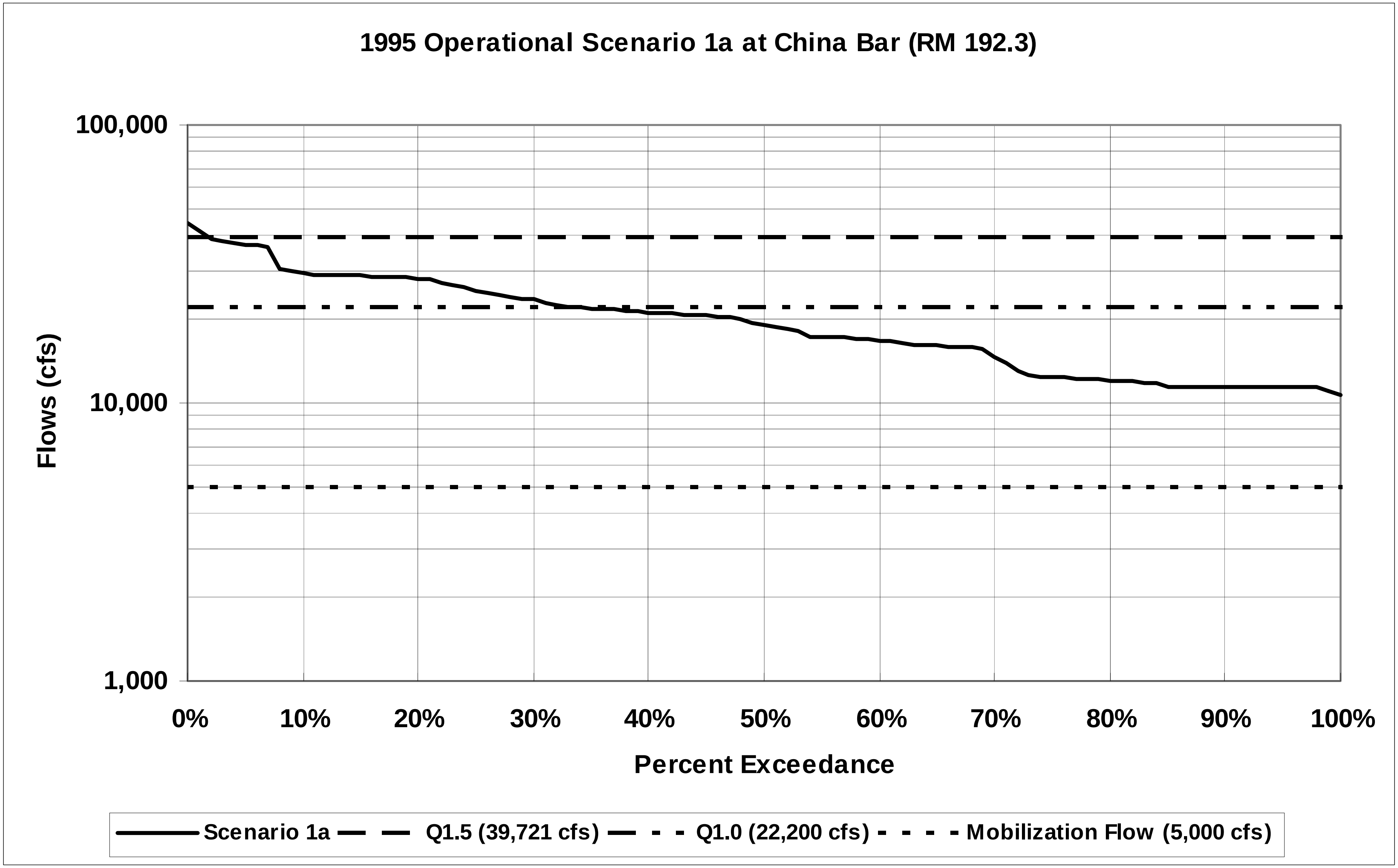


Figure 32. Flow-duration curve for 1995 Operational Scenario 1a at China Bar (RM 192.3).

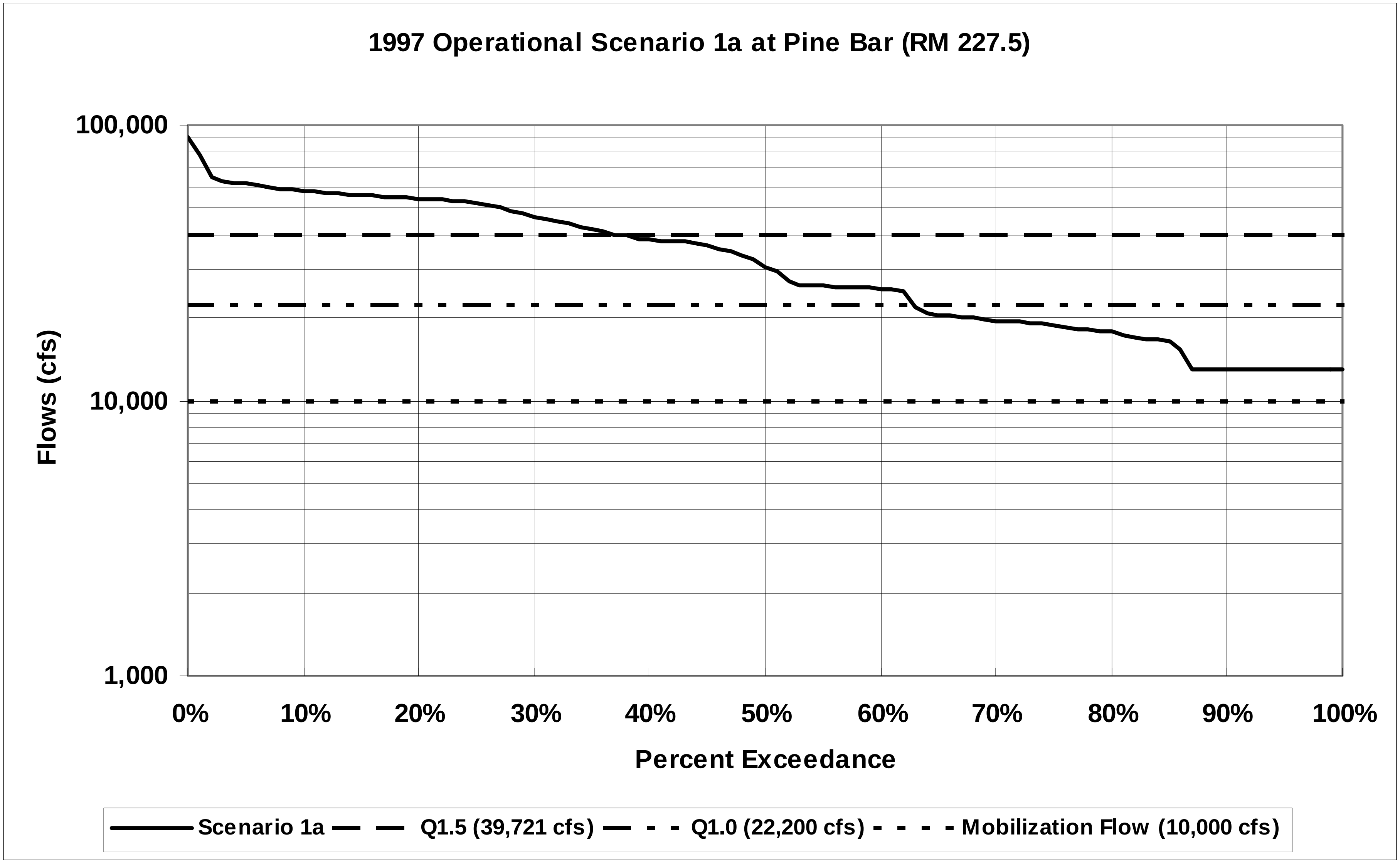


Figure 33. Flow-duration curve for 1997 Operational Scenario 1a at Pine Bar (RM 227.5).

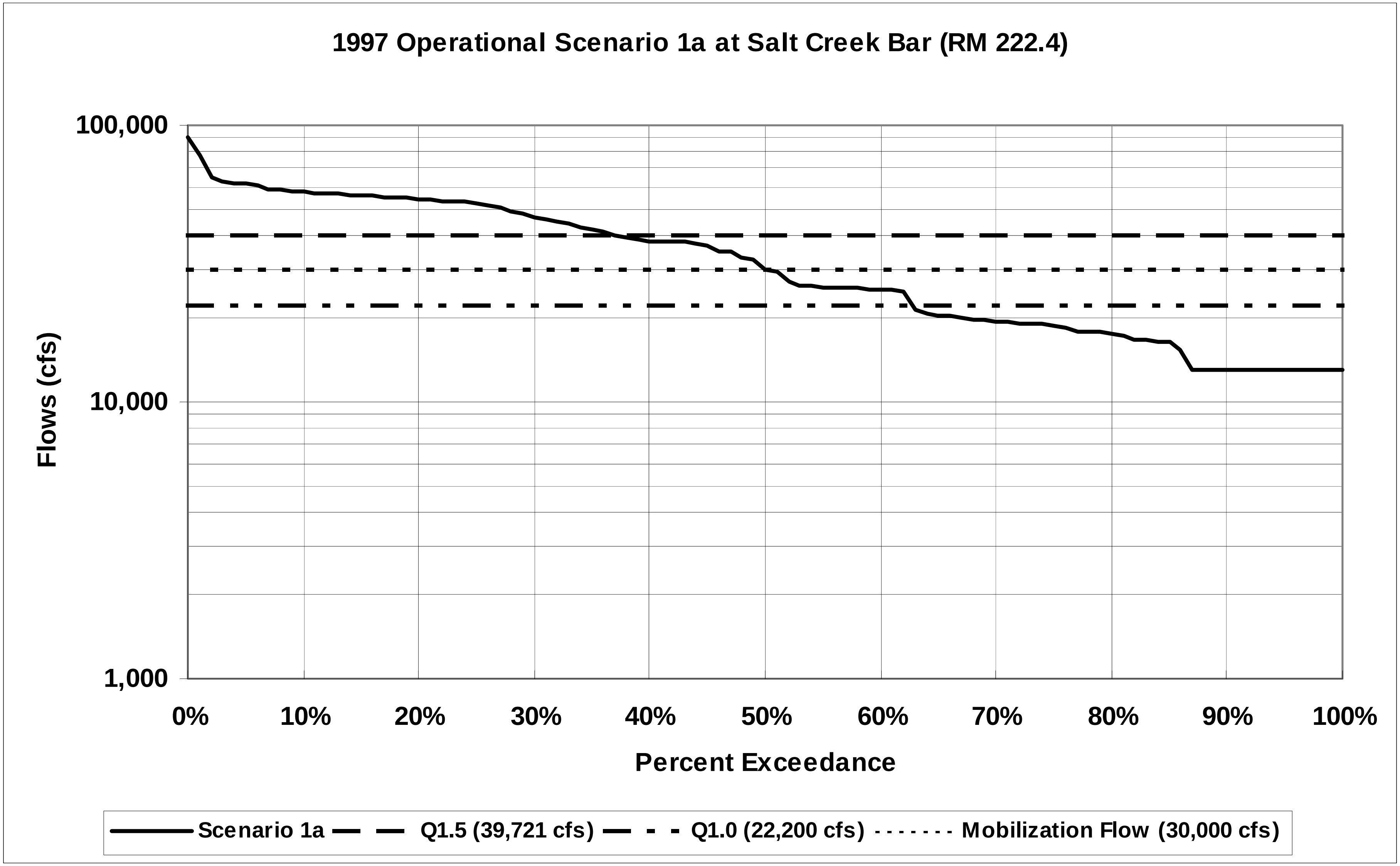


Figure 34. Flow-duration curve for 1997 Operational Scenario 1a at Salt Creek Bar (RM 222.4).

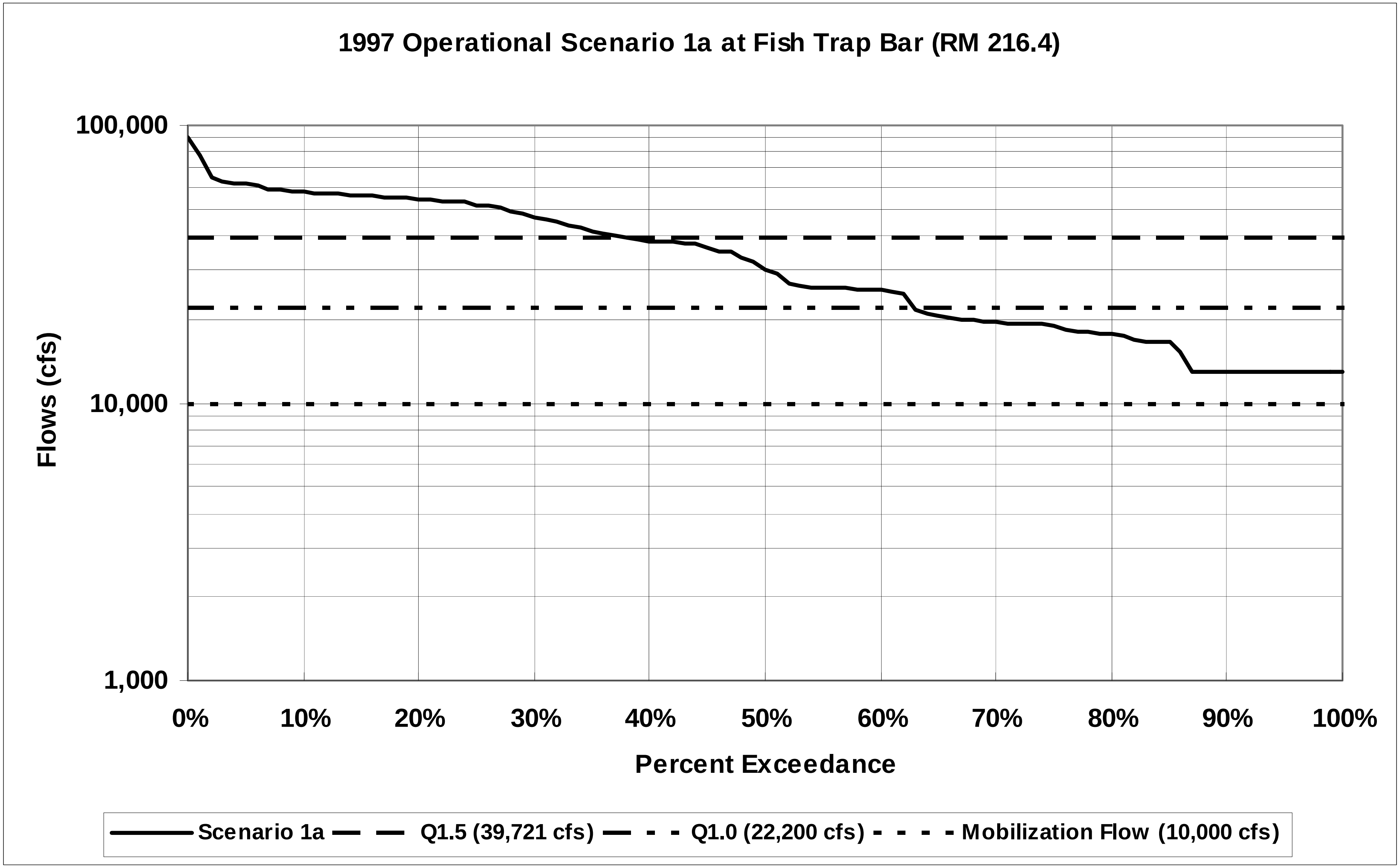


Figure 35. Flow-duration curve for 1997 Operational Scenario 1a at Fish Trap Bar (RM 216.4).

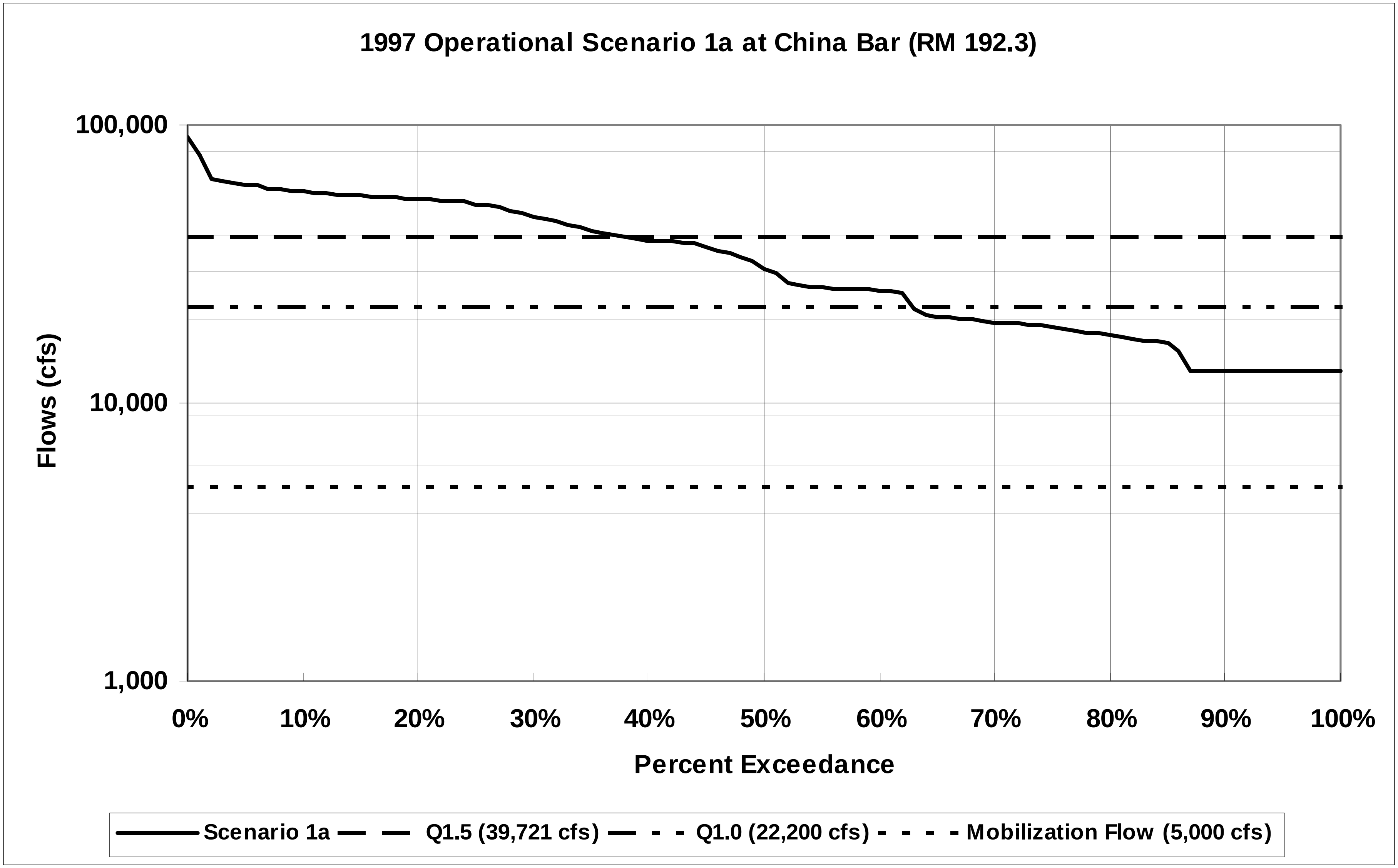


Figure 36. Flow-duration curve for 1997 Operational Scenario 1a at China Bar (RM 192.3).

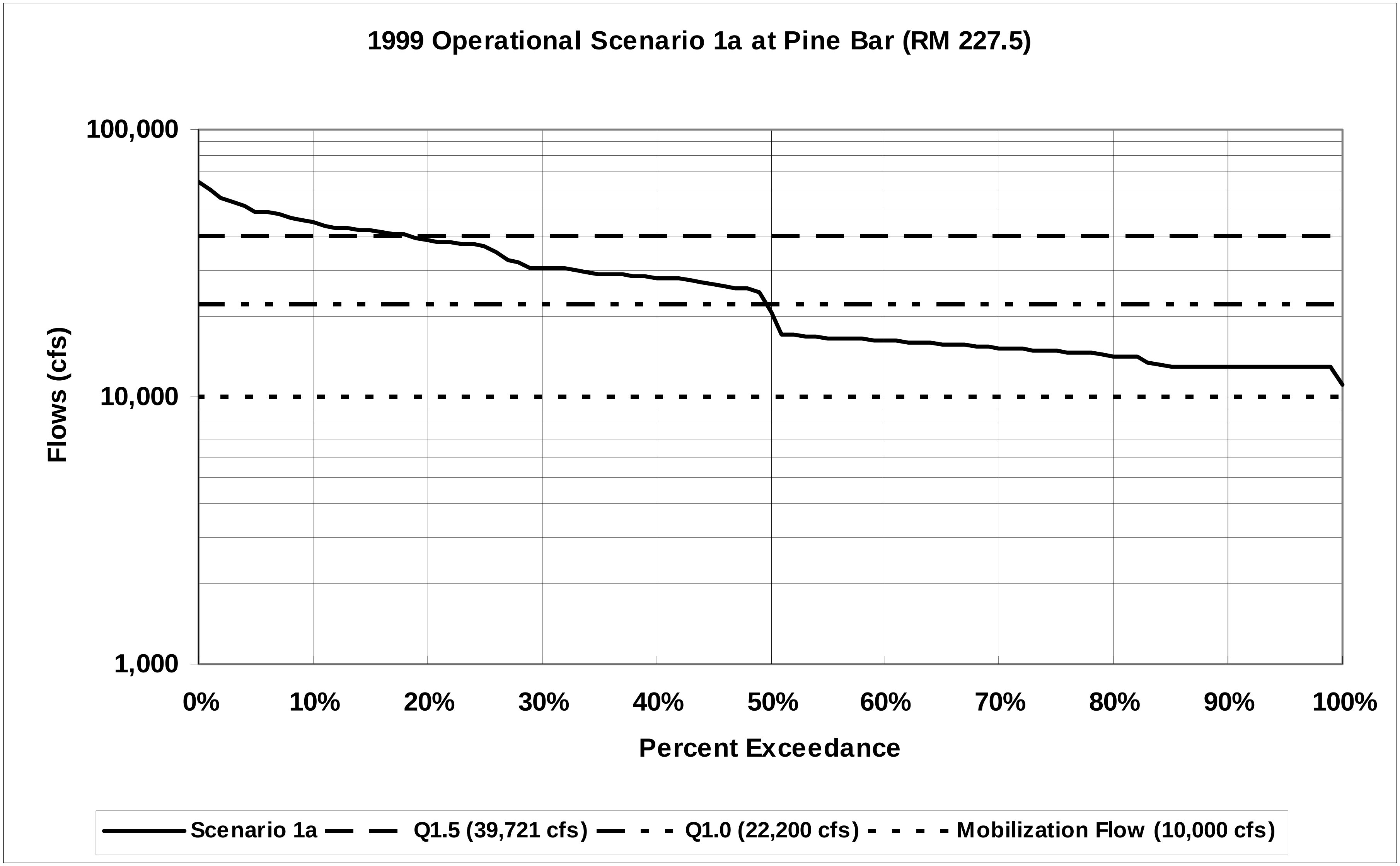


Figure 37. Flow-duration curve for 1999 Operational Scenario 1a at Pine Bar (RM 227.5).

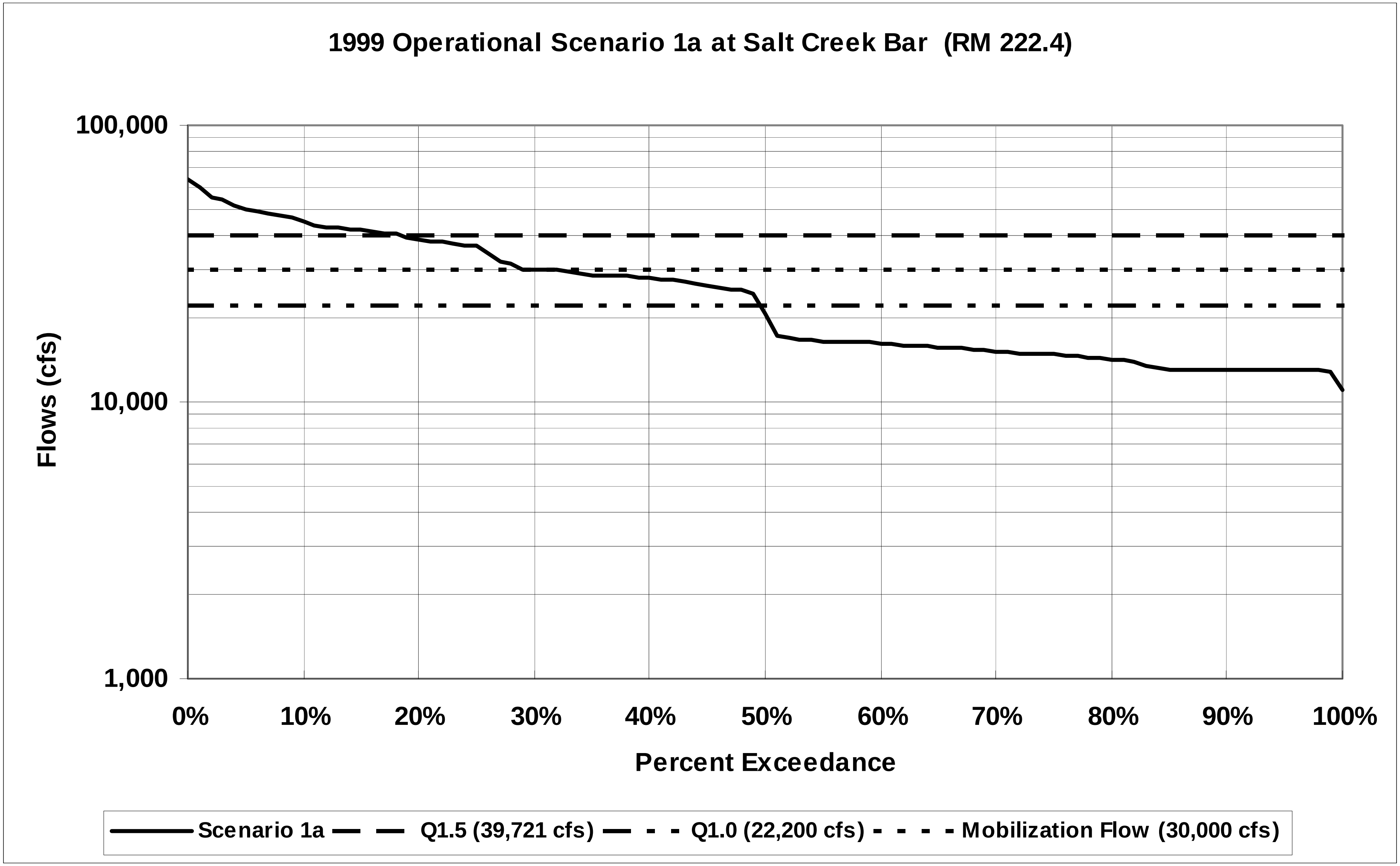


Figure 38. Flow-duration curve for 1999 Operational Scenario 1a at Salt Creek Bar (RM 222.4).

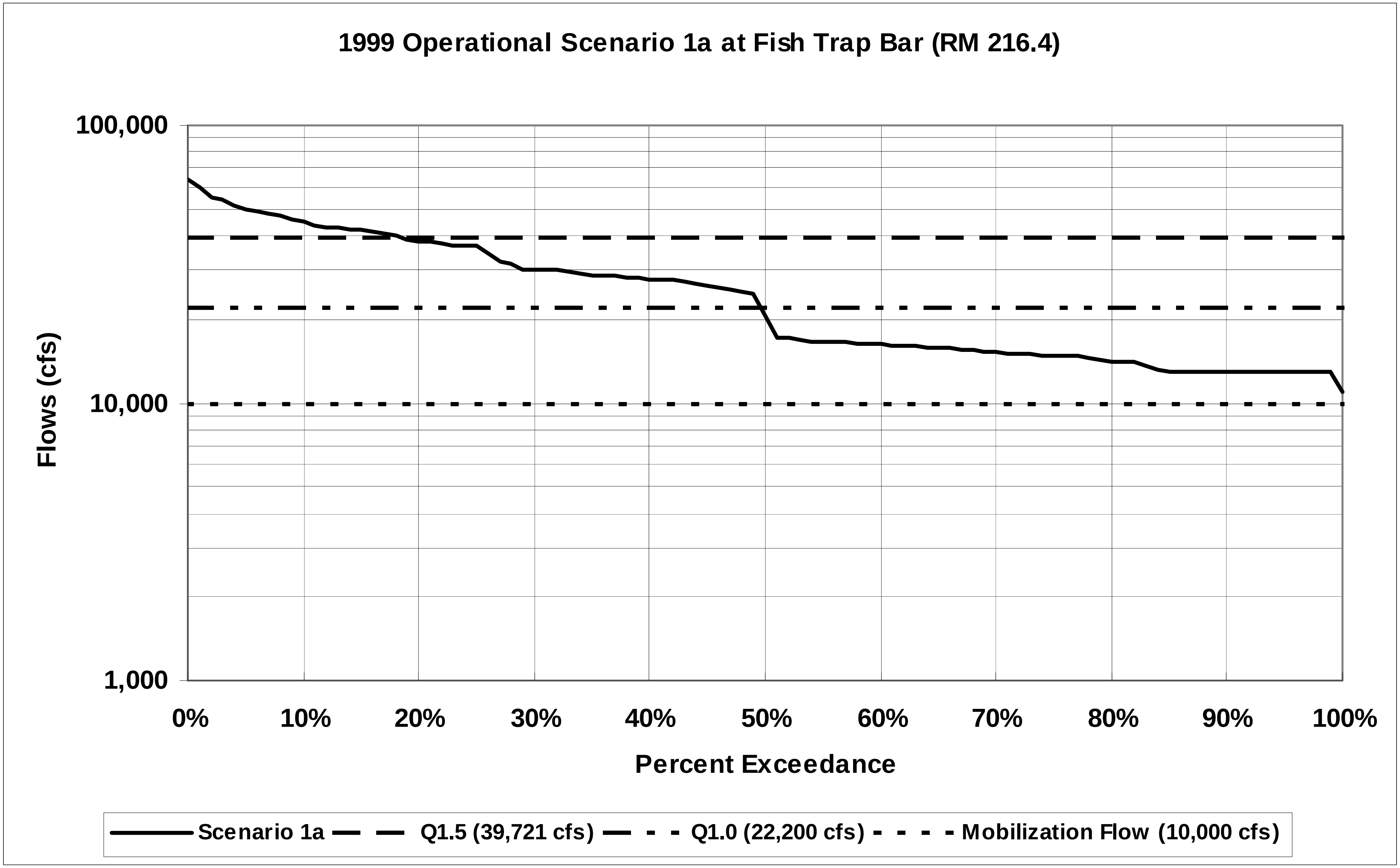


Figure 39. Flow-duration curve for 1999 Operational Scenario 1a at Fish Trap Bar (RM 216.4).

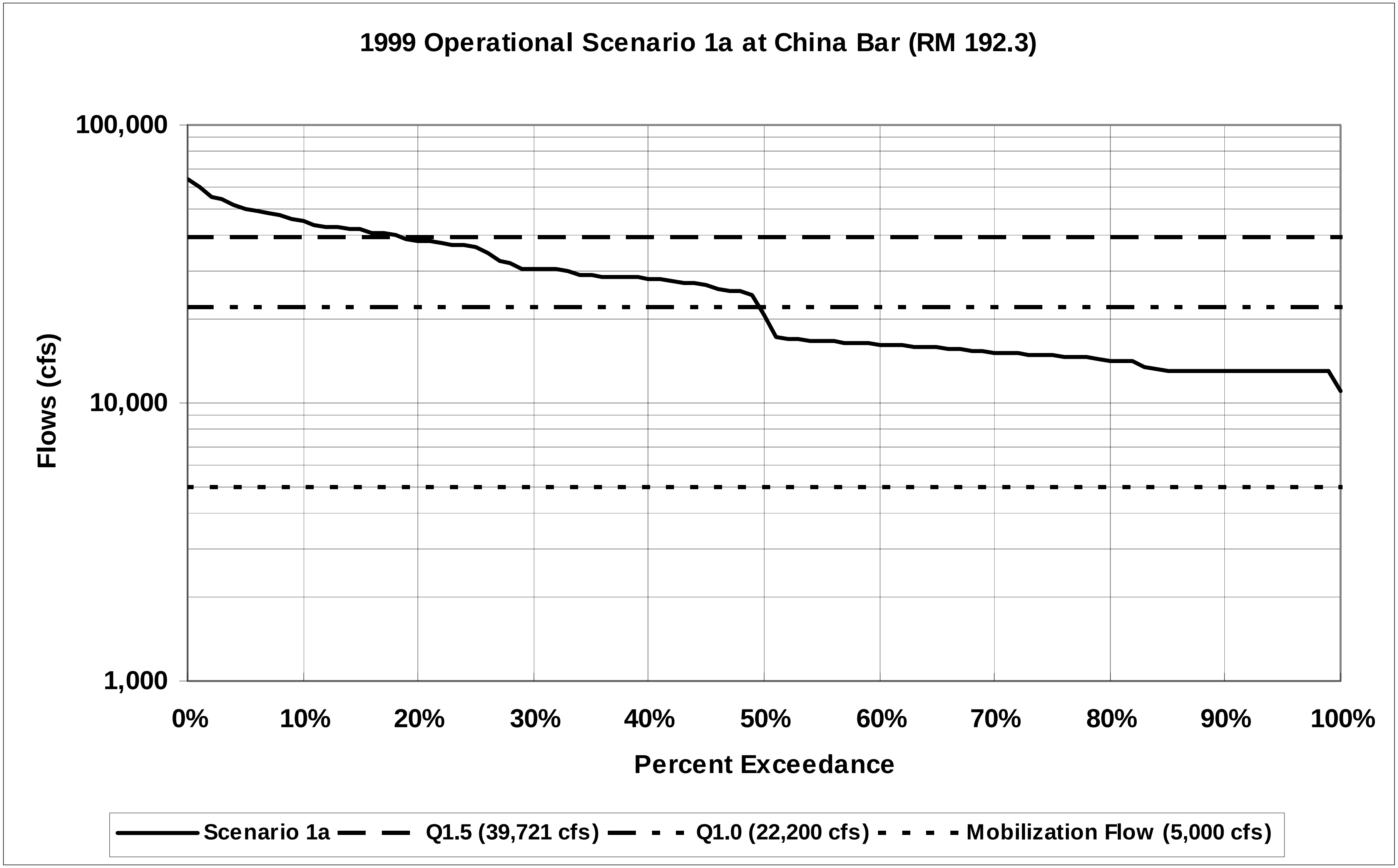


Figure 40. Flow-duration curve for 1999 Operational Scenario 1a at China Bar (RM 192.3).

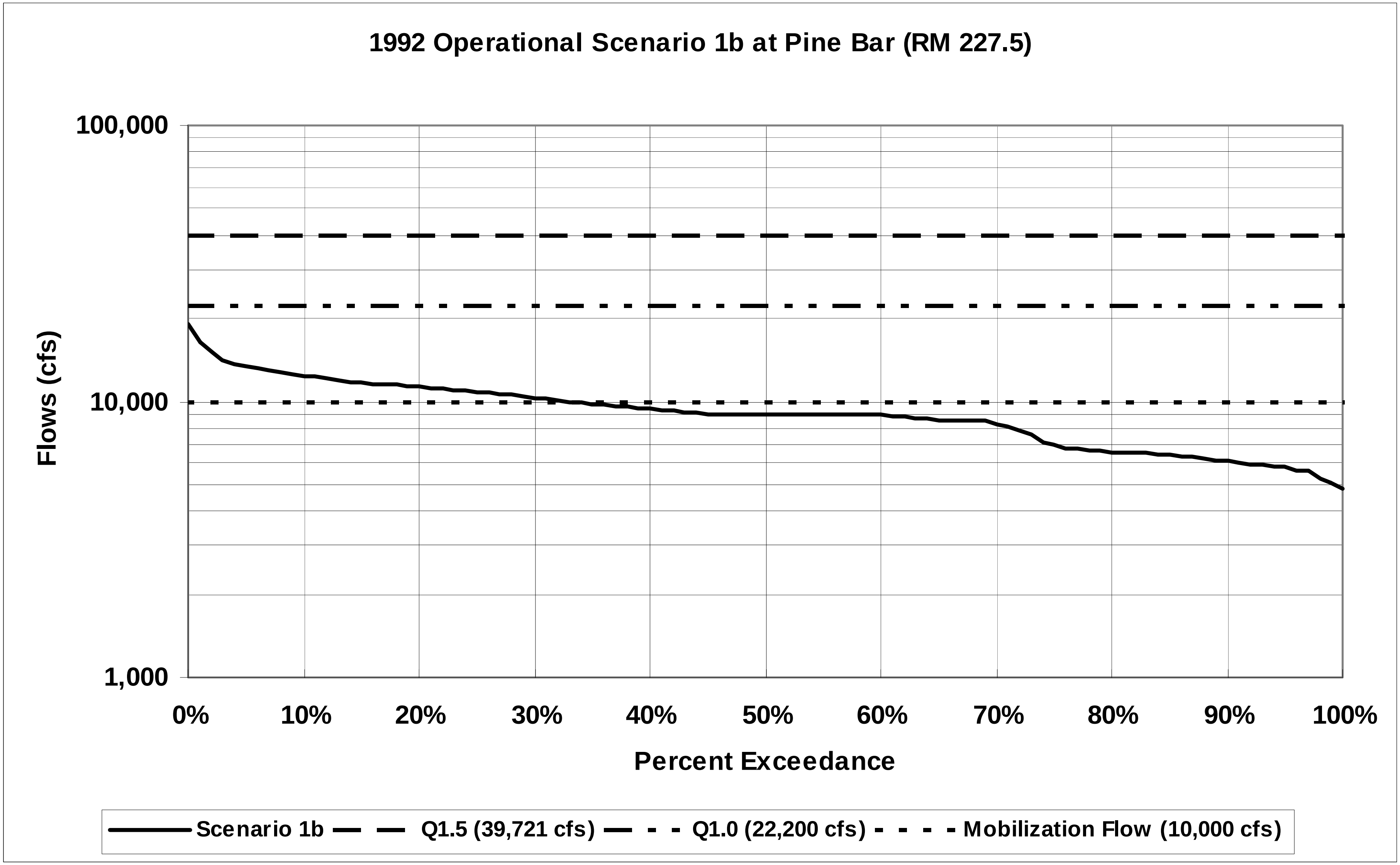


Figure 41. Flow-duration curve for 1992 Operational Scenario 1b at Pine Bar (RM 227.5).

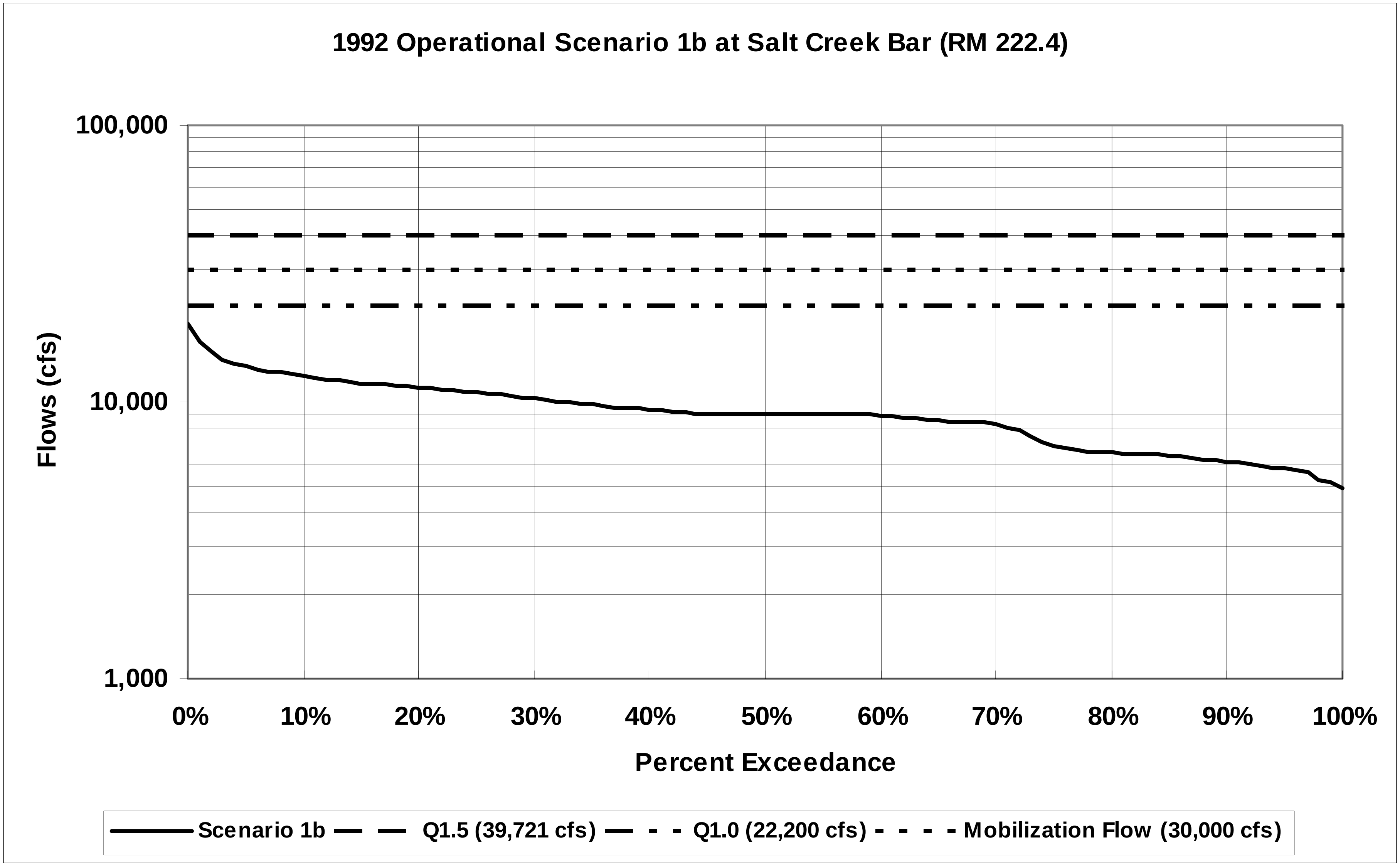


Figure 42. Flow-duration curve for 1992 Operational Scenario 1b at Salt Creek Bar (RM 222.4).

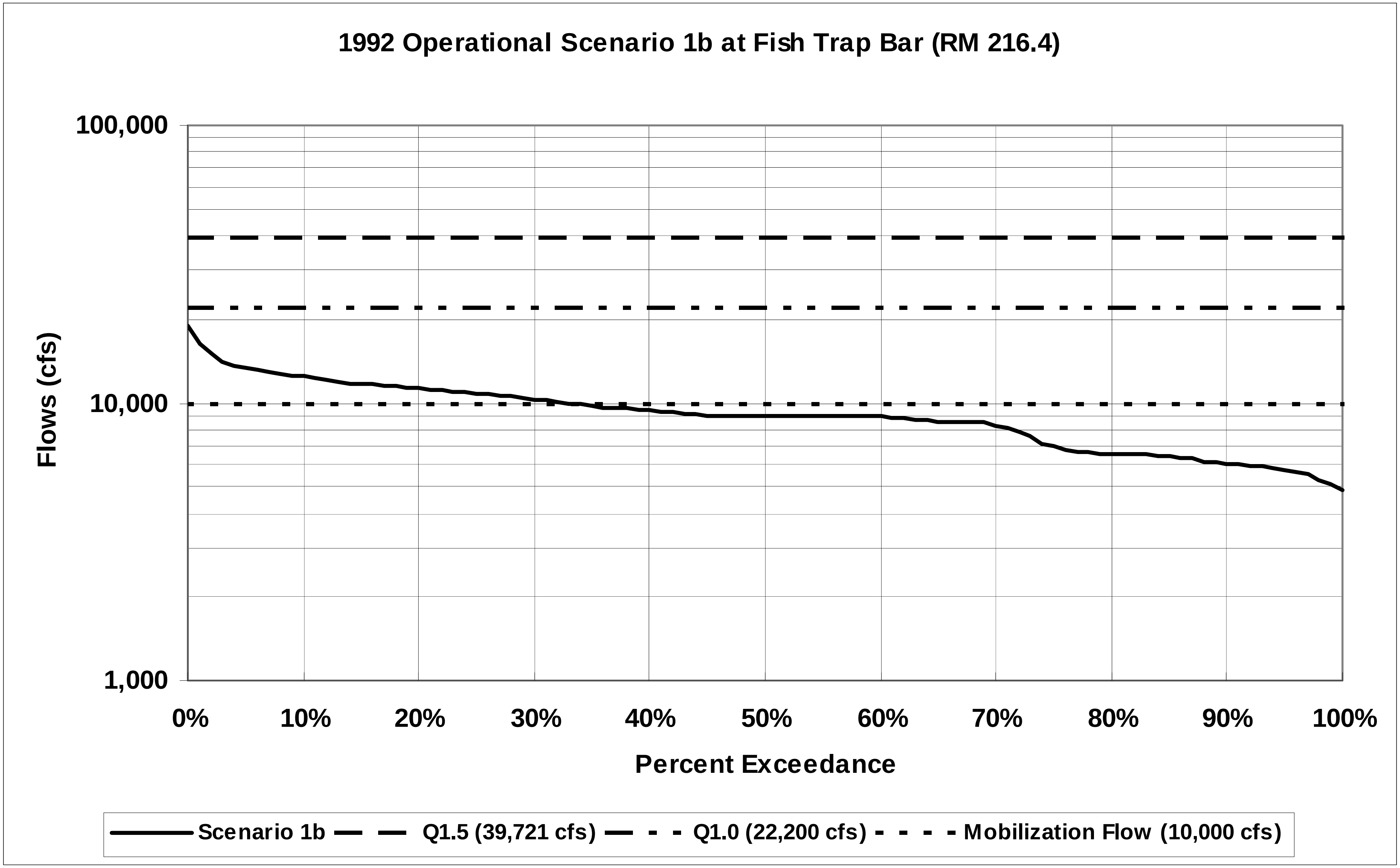


Figure 43. Flow-duration curve for 1992 Operational Scenario 1b at Fish Trap Bar (RM 216.4).

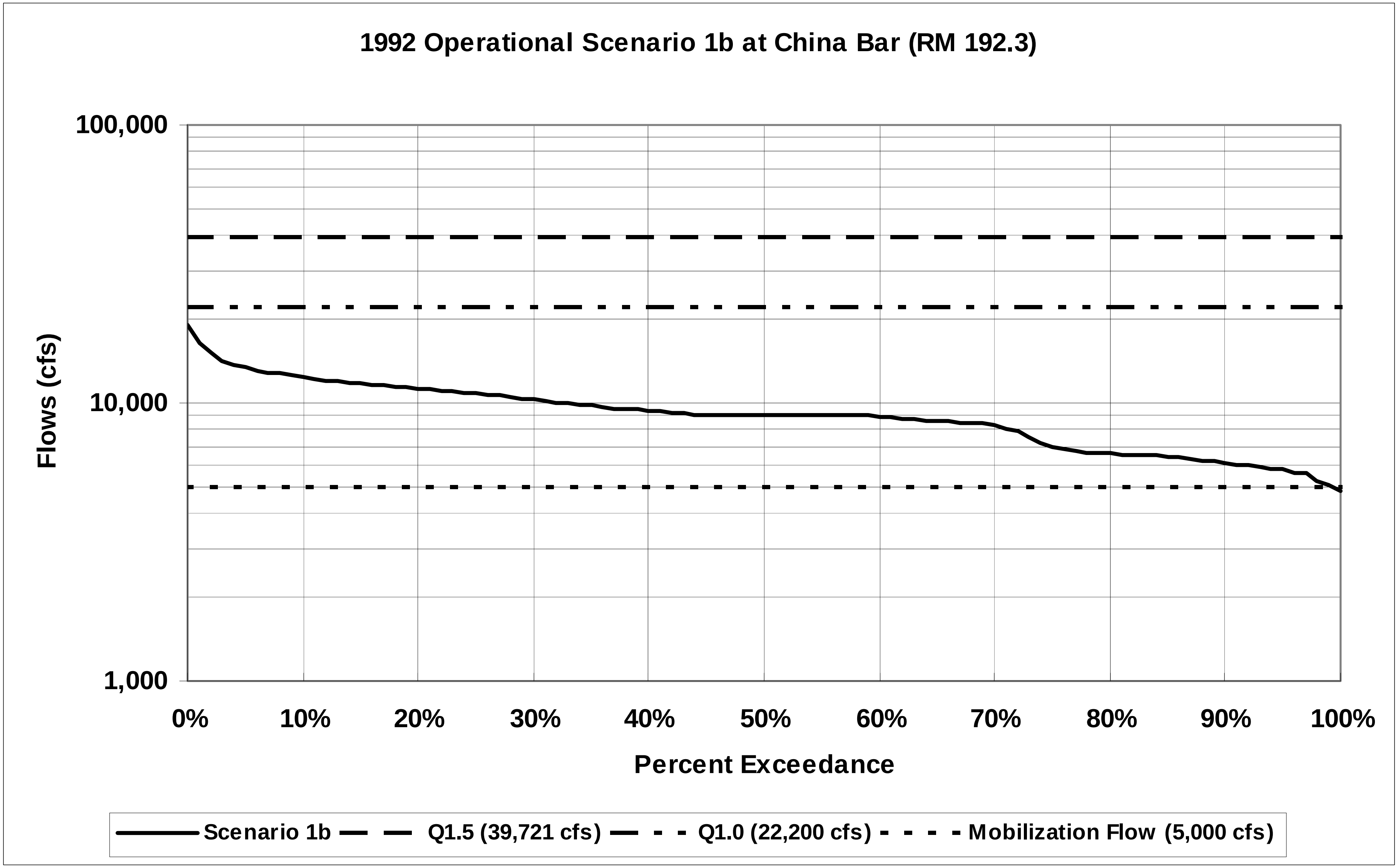


Figure 44. Flow-duration curve for 1992 Operational Scenario 1b at China Bar (RM 192.3).

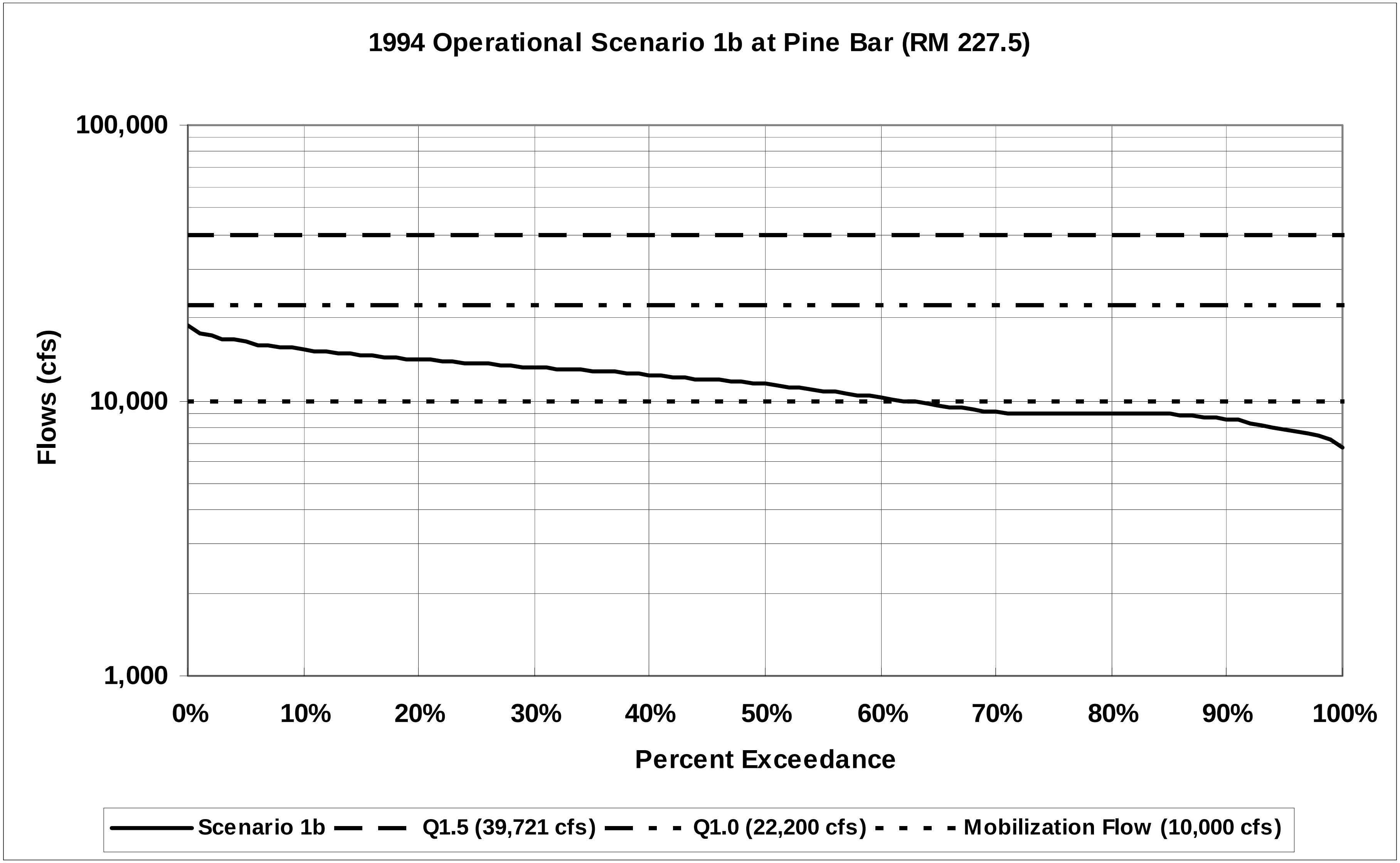


Figure 45. Flow-duration curve for 1994 Operational Scenario 1b at Pine Bar (RM 227.5).

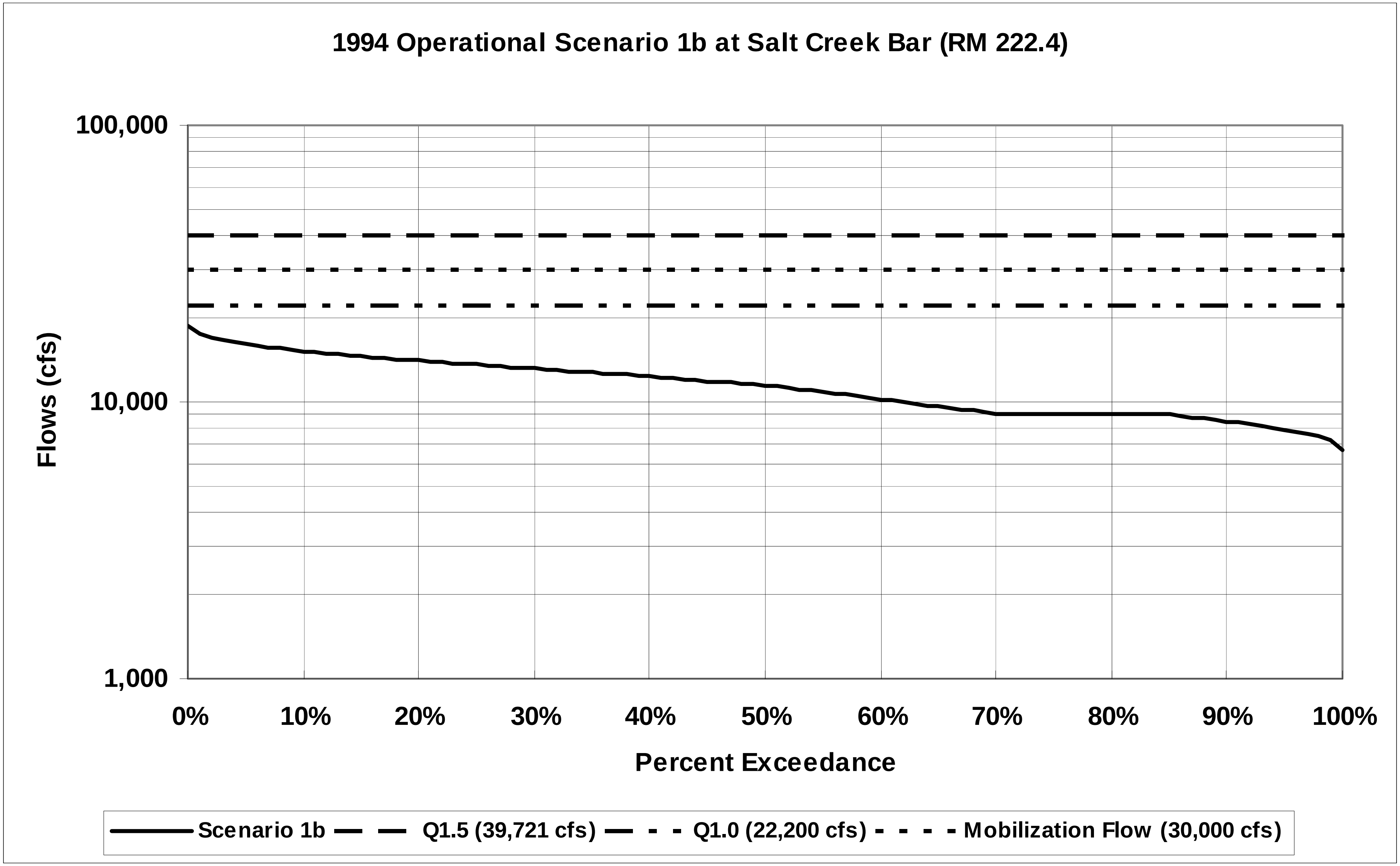


Figure 46. Flow-duration curve for 1994 Operational Scenario 1b at Salt Creek Bar (RM 222.4).

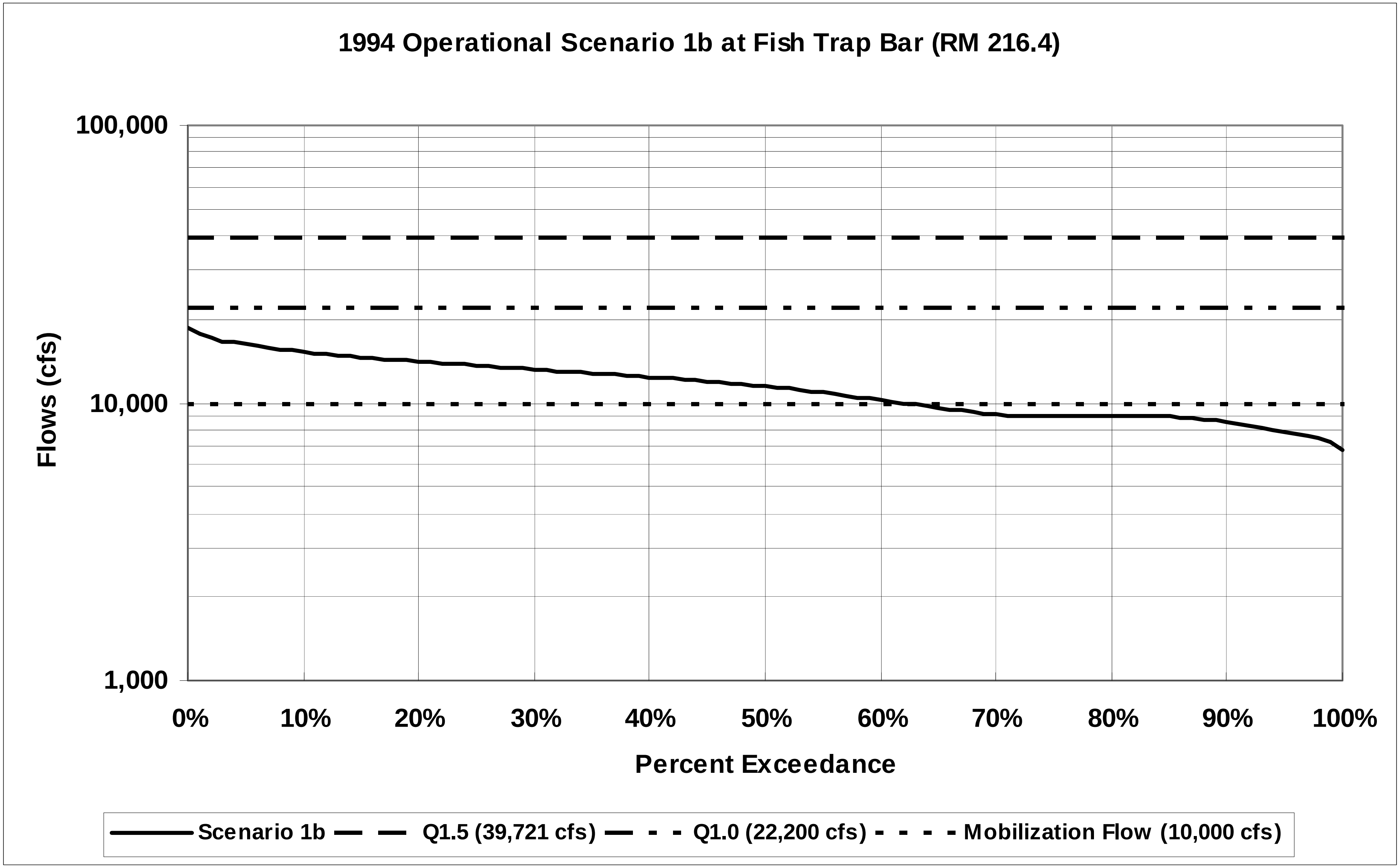


Figure 47. Flow-duration curve for 1994 Operational Scenario 1b at Fish Trap Bar (RM 216.4).

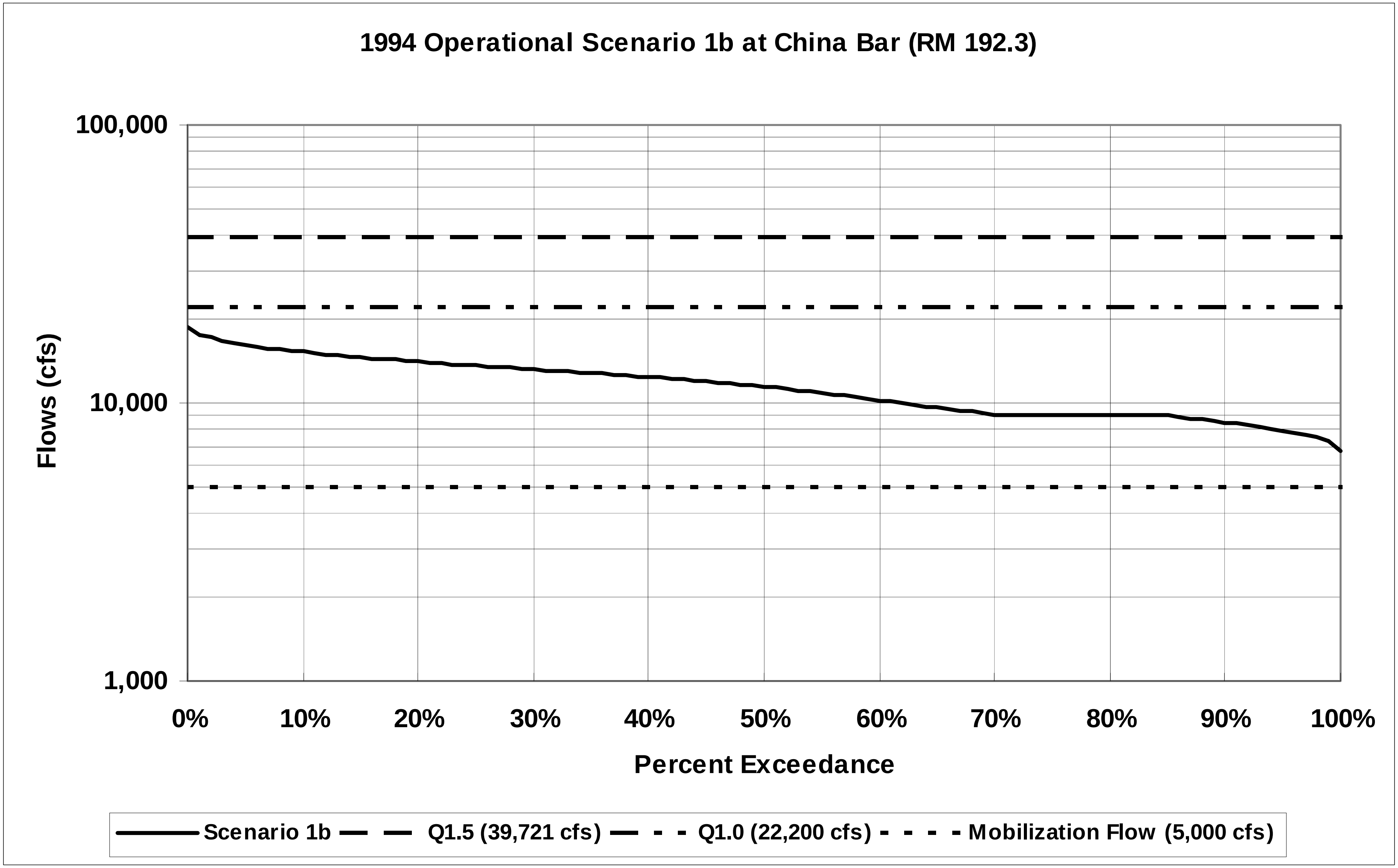


Figure 48. Flow-duration curve for 1994 Operational Scenario 1b at China Bar (RM 192.3).

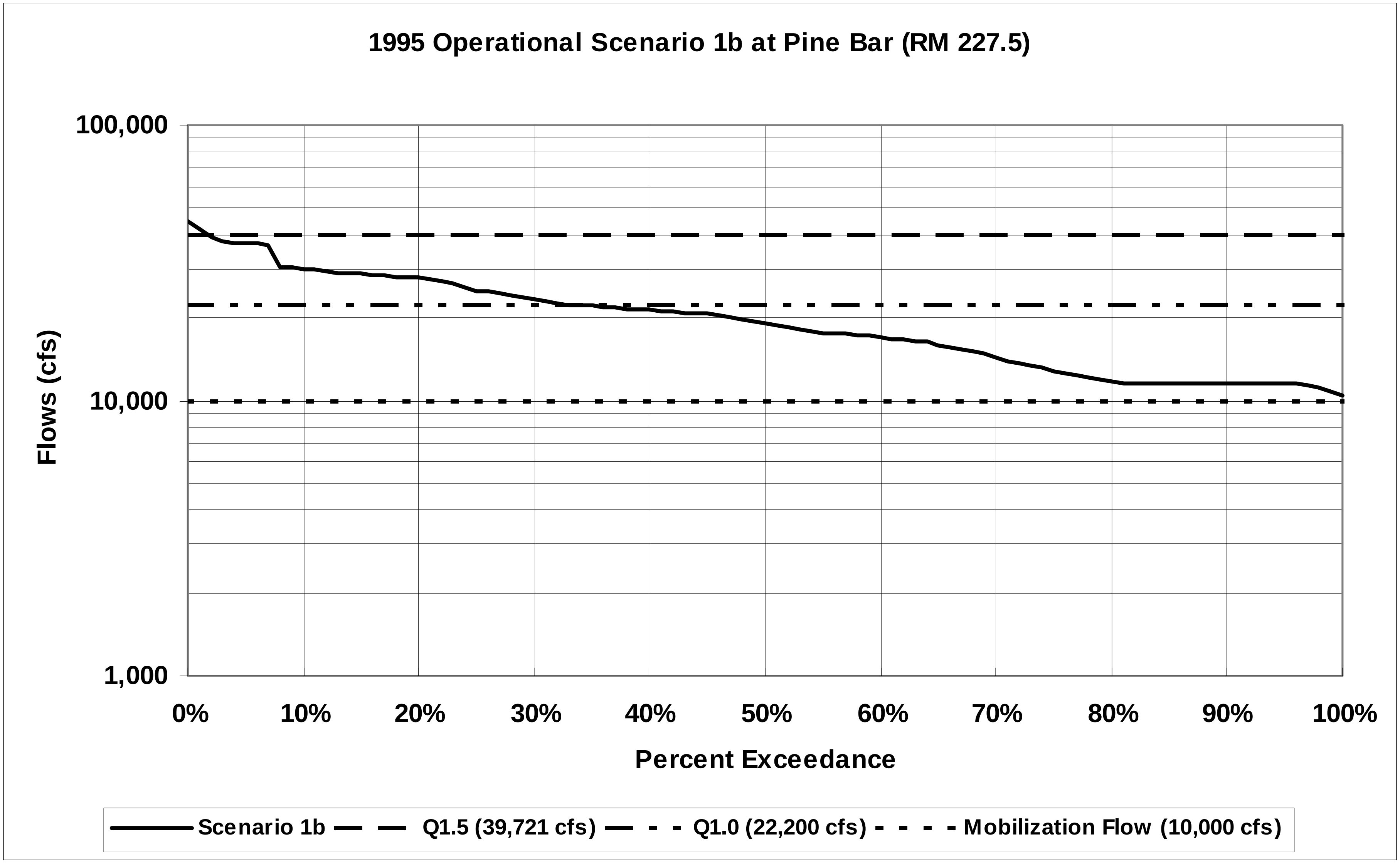


Figure 49. Flow-duration curve for 1995 Operational Scenario 1b at Pine Bar (RM 227.5).

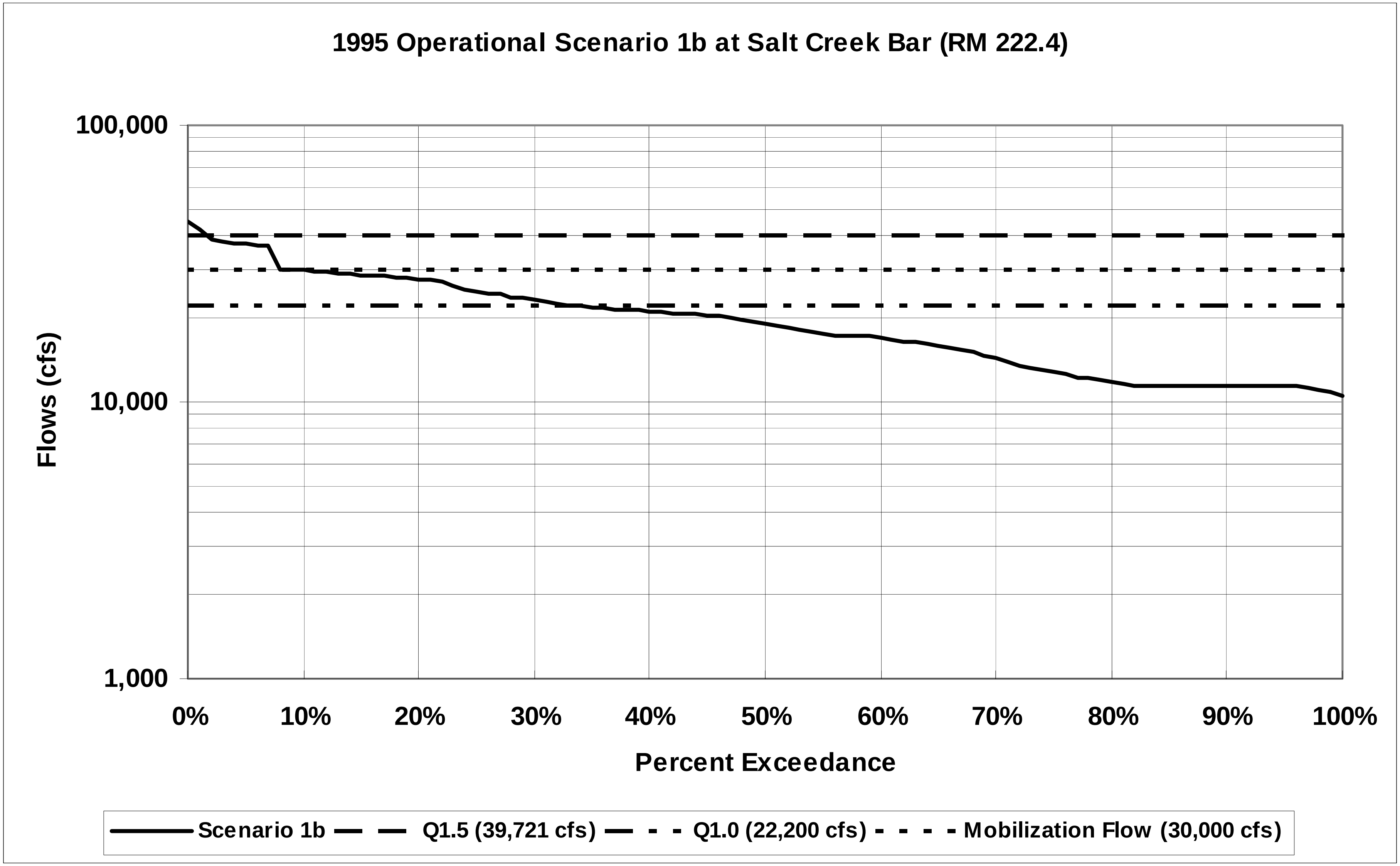


Figure 50. Flow-duration curve for 1995 Operational Scenario 1b at Salt Creek Bar (RM 222.4).

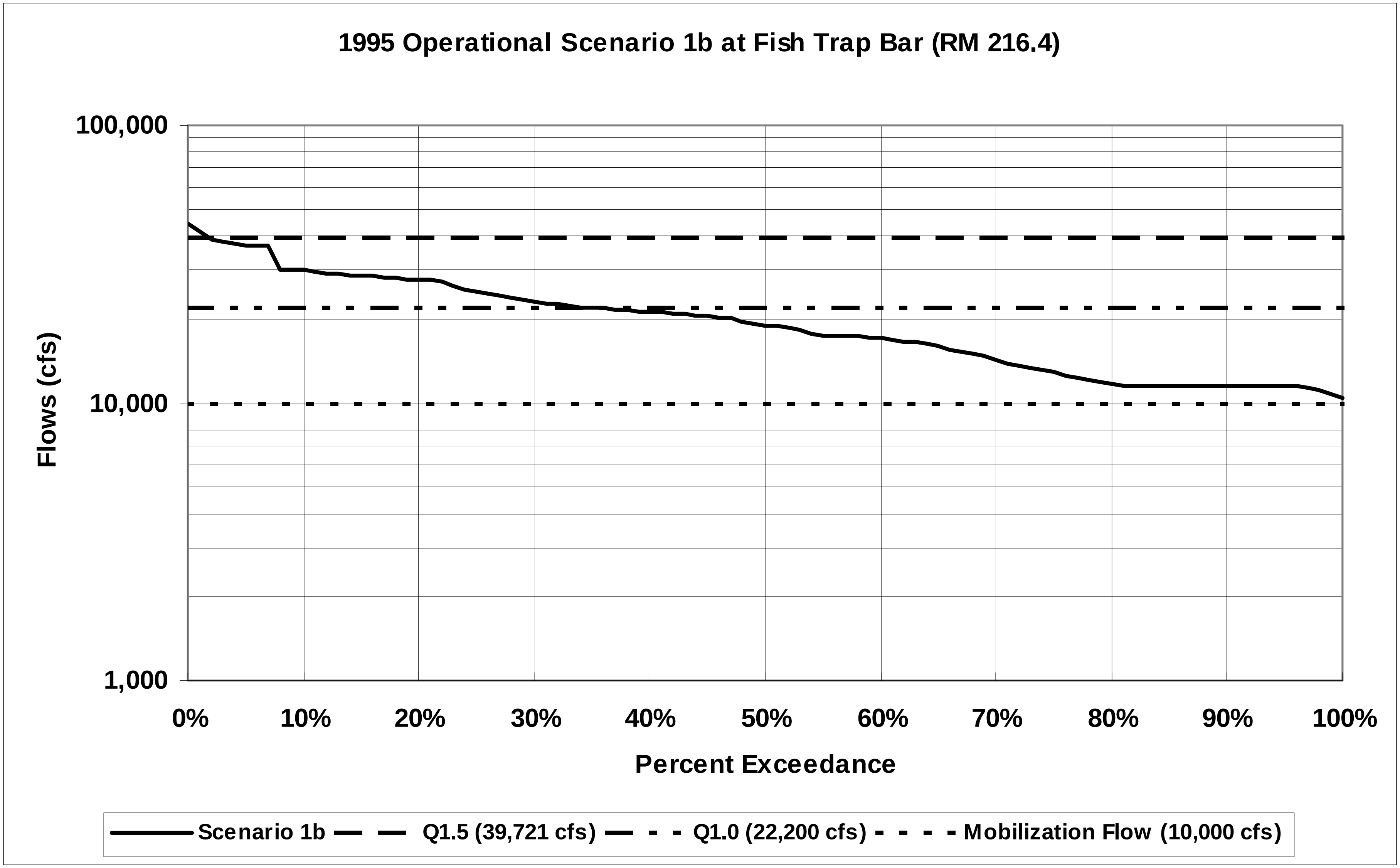


Figure 51. Flow-duration curve for 1995 Operational Scenario 1b at Fish Trap Bar (RM 216.4).

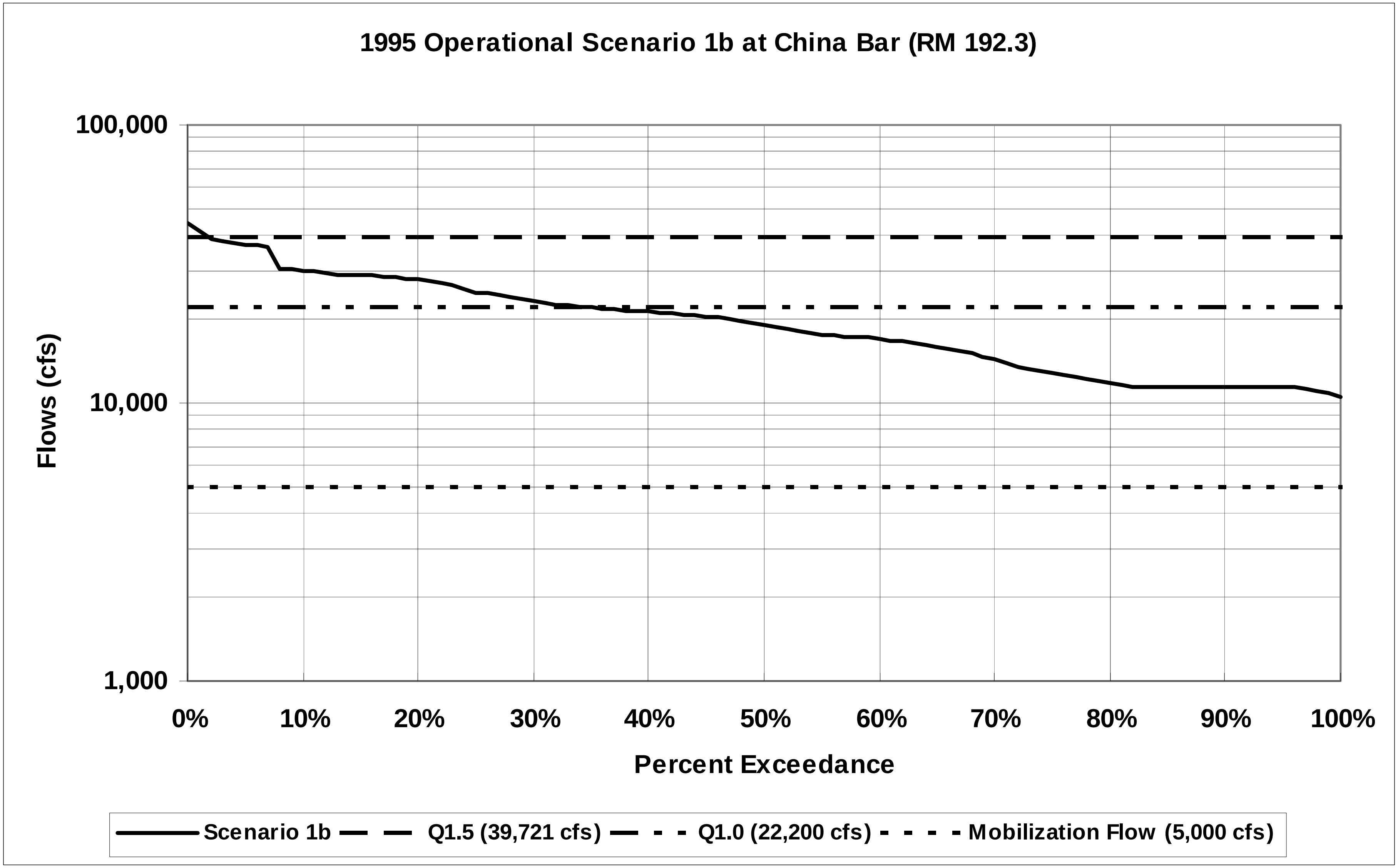


Figure 52. Flow-duration curve for 1995 Operational Scenario 1b at China Bar (RM 192.3).

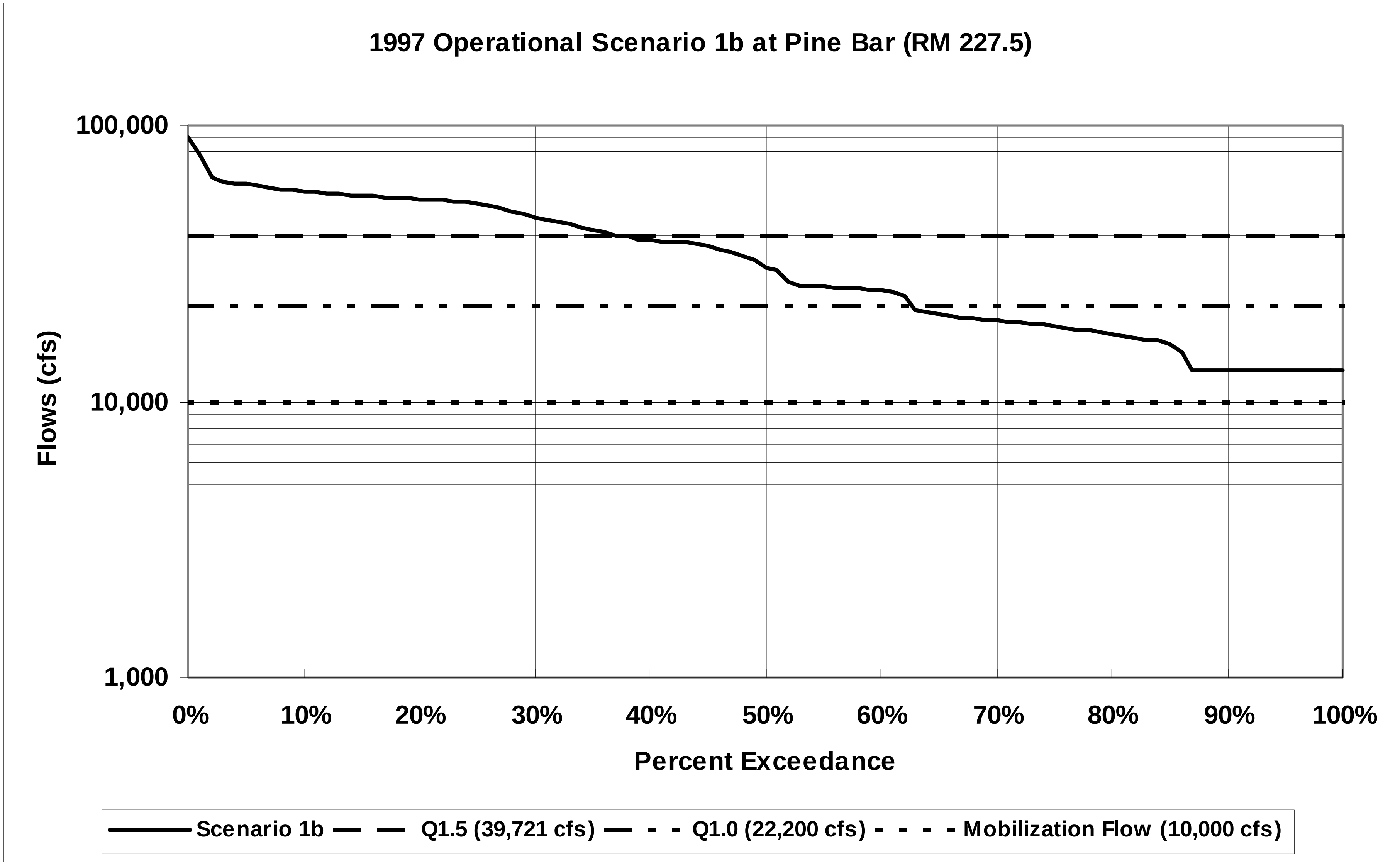


Figure 53. Flow-duration curve for 1997 Operational Scenario 1b at Pine Bar (RM 227.5).

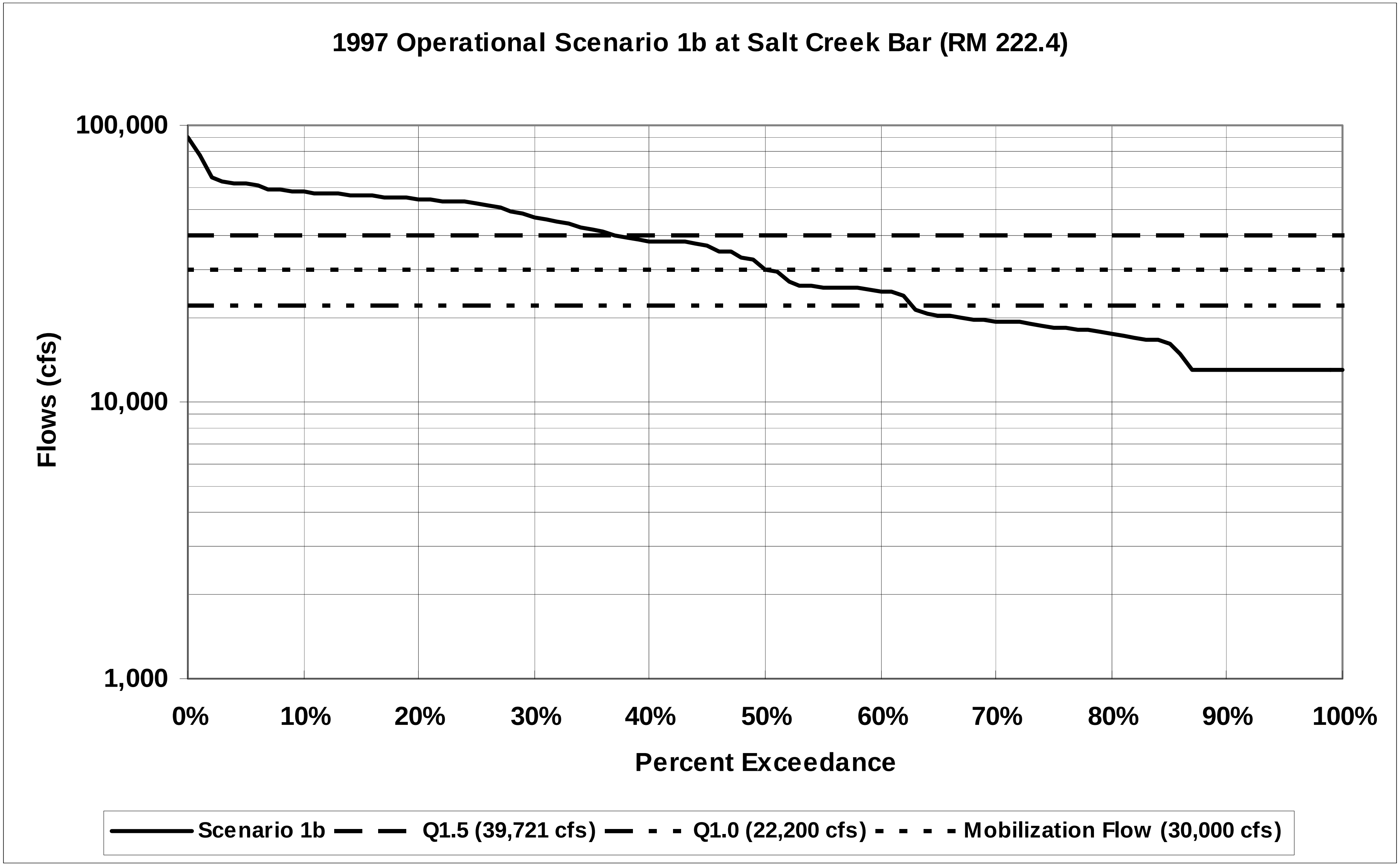


Figure 54. Flow-duration curve for 1997 Operational Scenario 1b at Salt Creek Bar (RM 222.4).

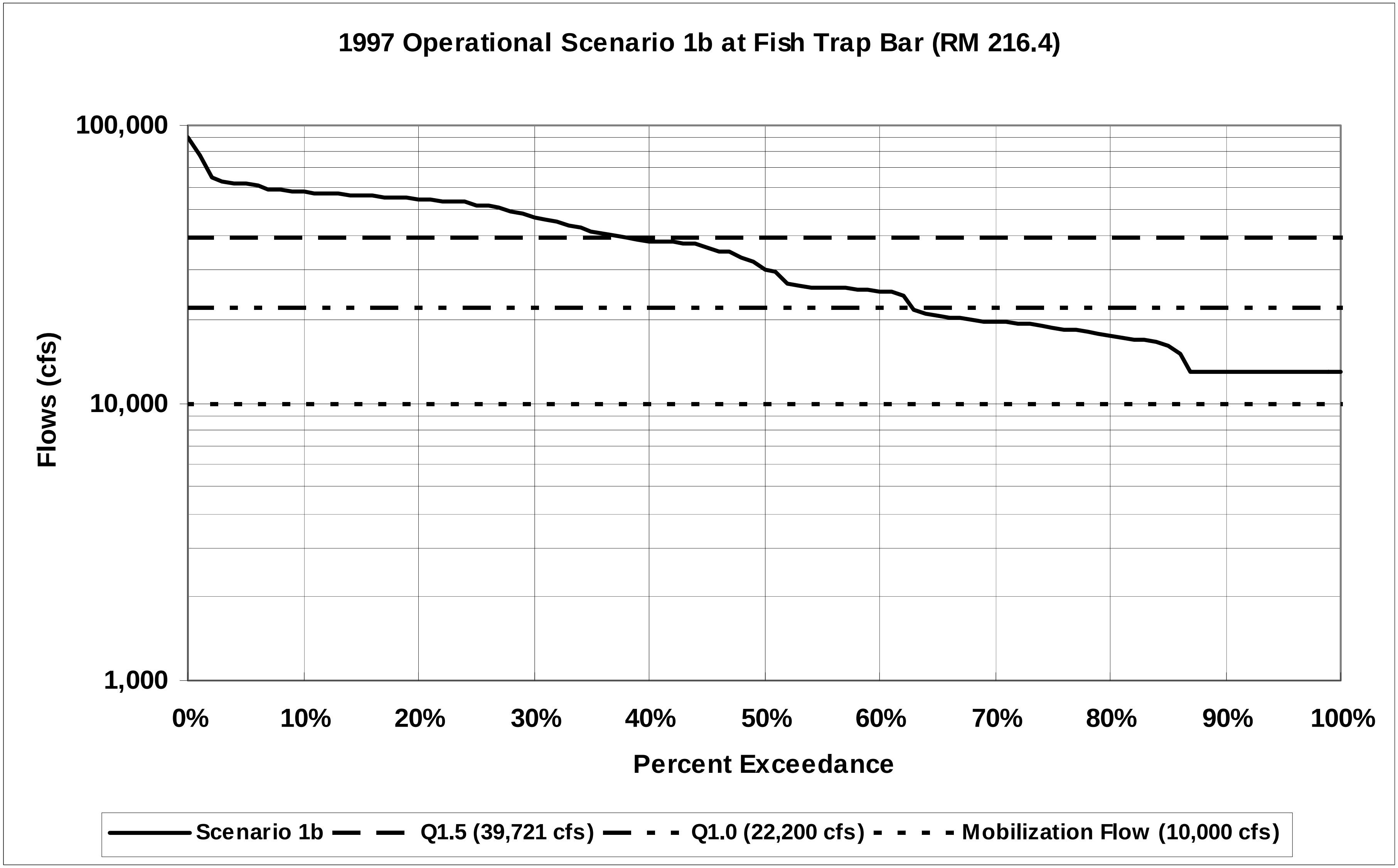


Figure 55. Flow-duration curve for 1997 Operational Scenario 1b at Fish Trap Bar (RM 216.4).

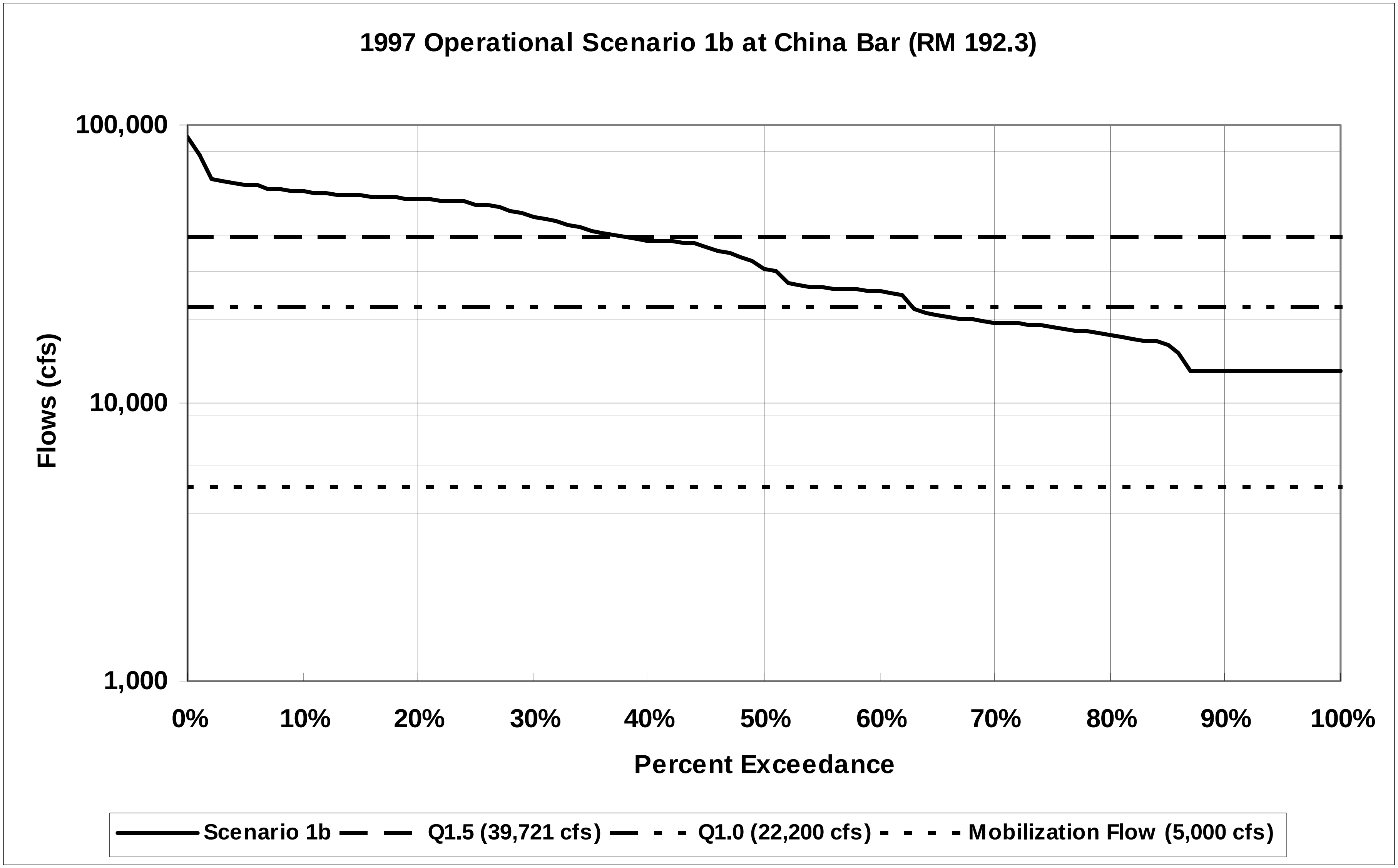


Figure 56. Flow-duration curve for 1997 Operational Scenario 1b at China Bar (RM 192.3).

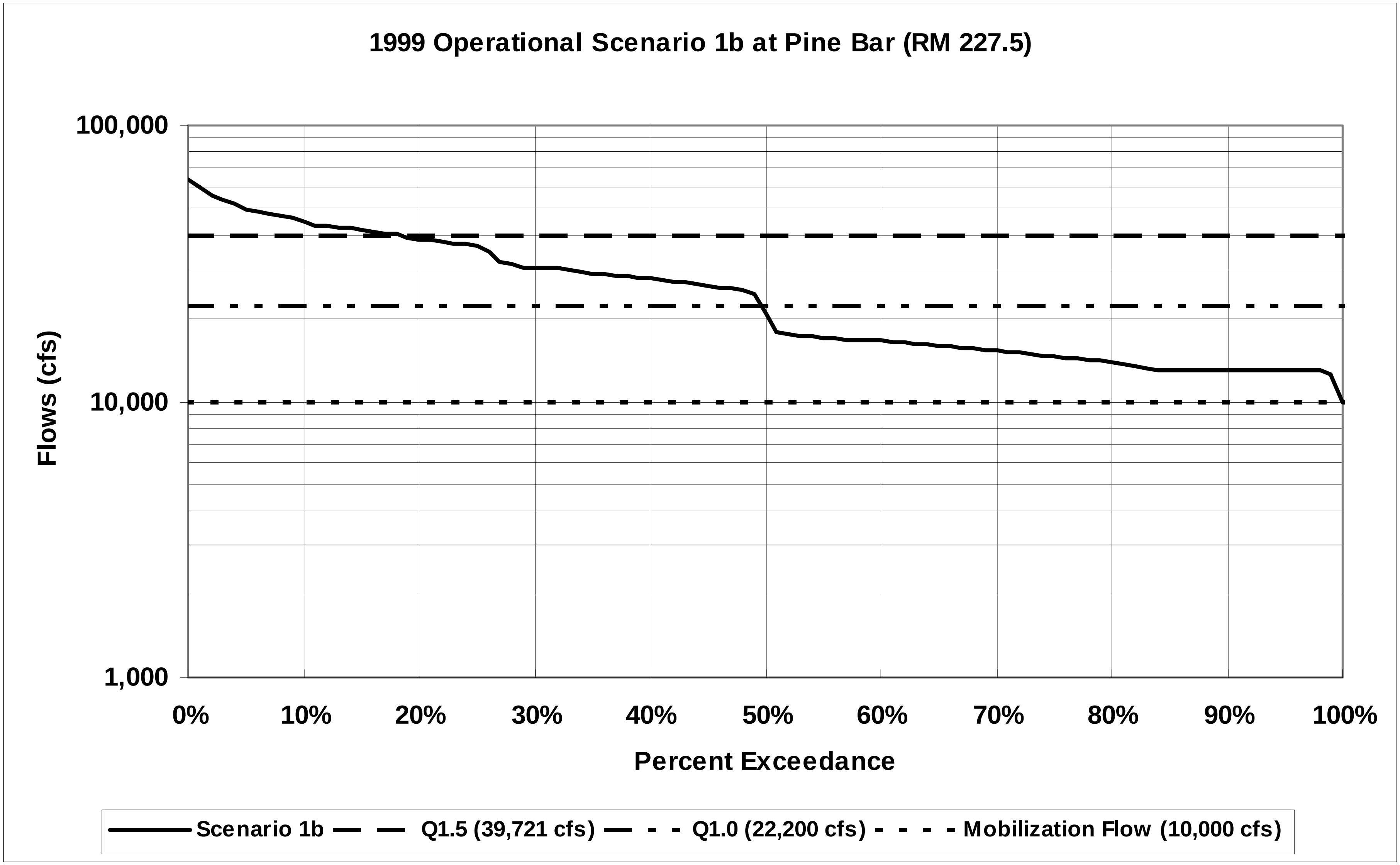


Figure 57. Flow-duration curve for 1999 Operational Scenario 1b at Pine Bar (RM 227.5).

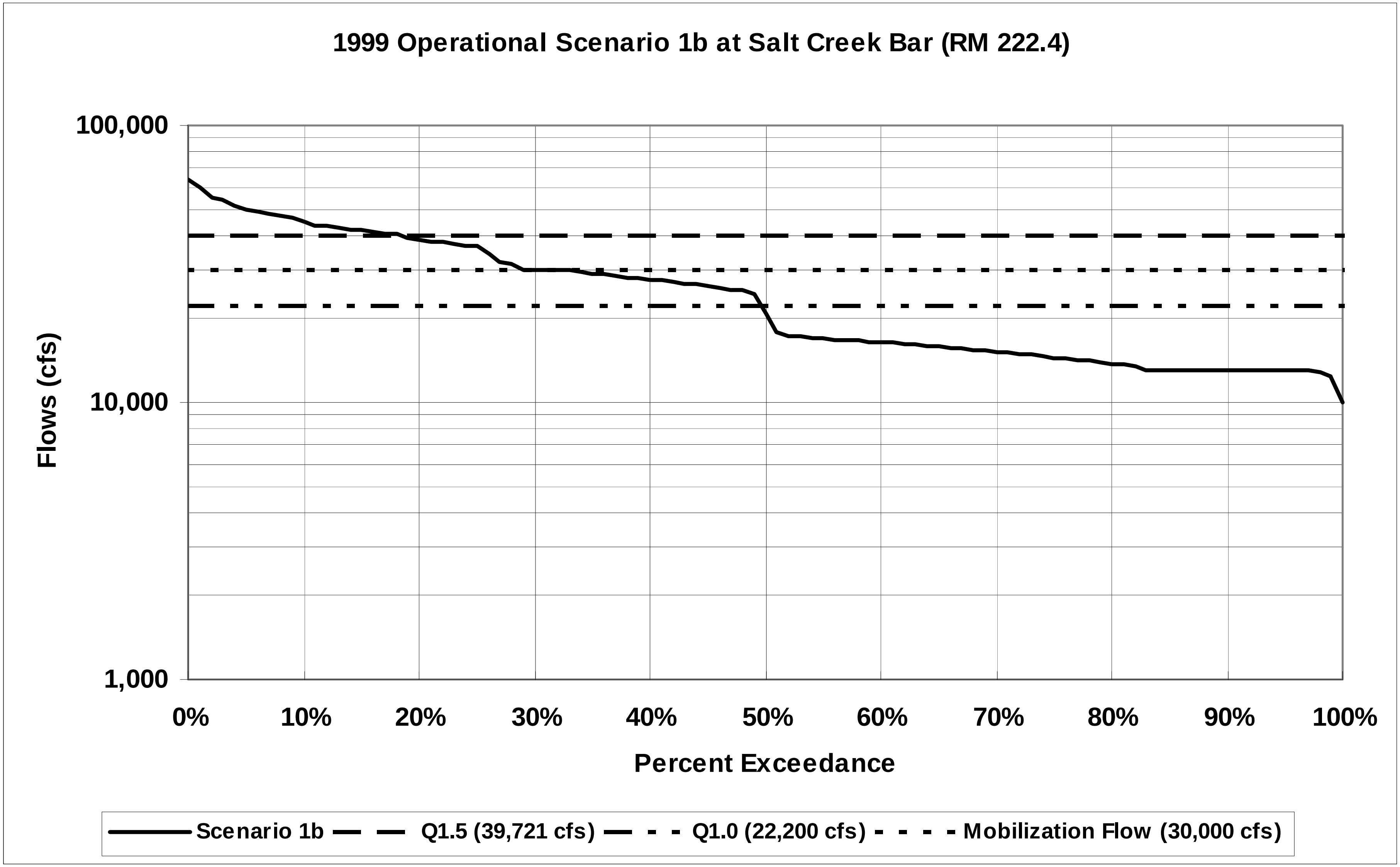


Figure 58. Flow-duration curve for 1999 Operational Scenario 1b at Salt Creek Bar (RM 222.4).

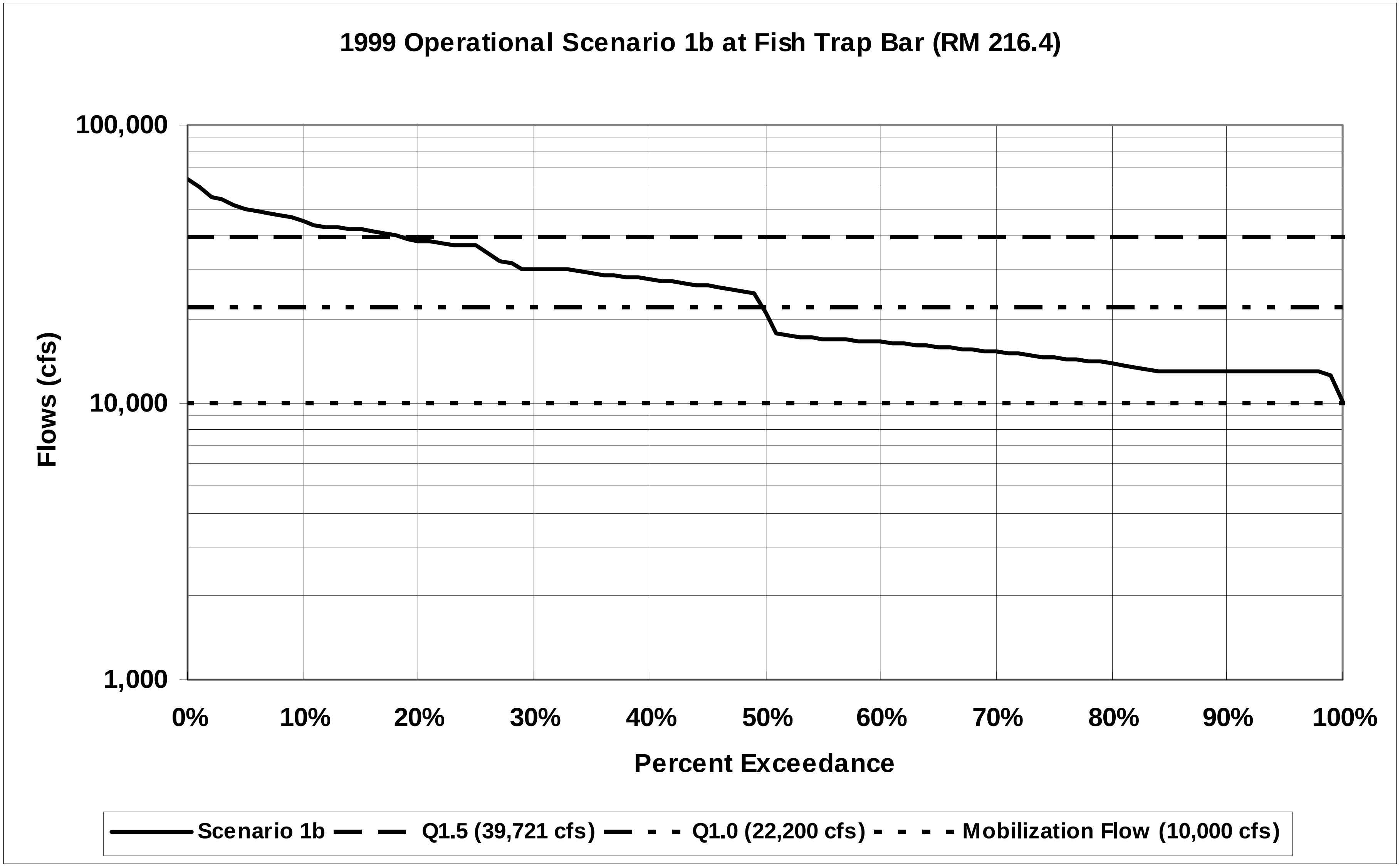


Figure 59. Flow-duration curve for 1999 Operational Scenario 1b at Fish Trap Bar (RM 216.4).

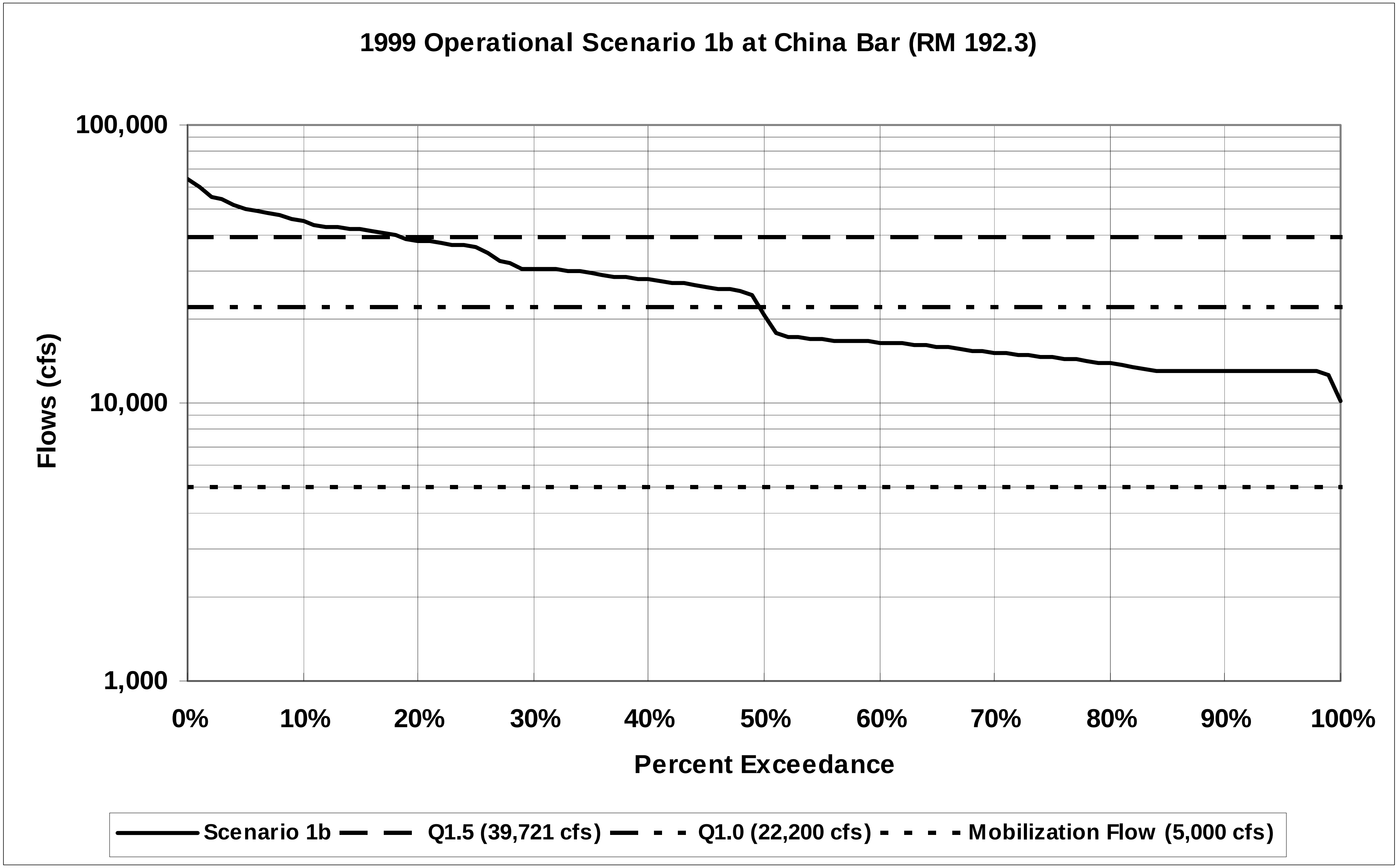


Figure 60. Flow-duration curve for 1999 Operational Scenario 1b at China Bar (RM 192.3).

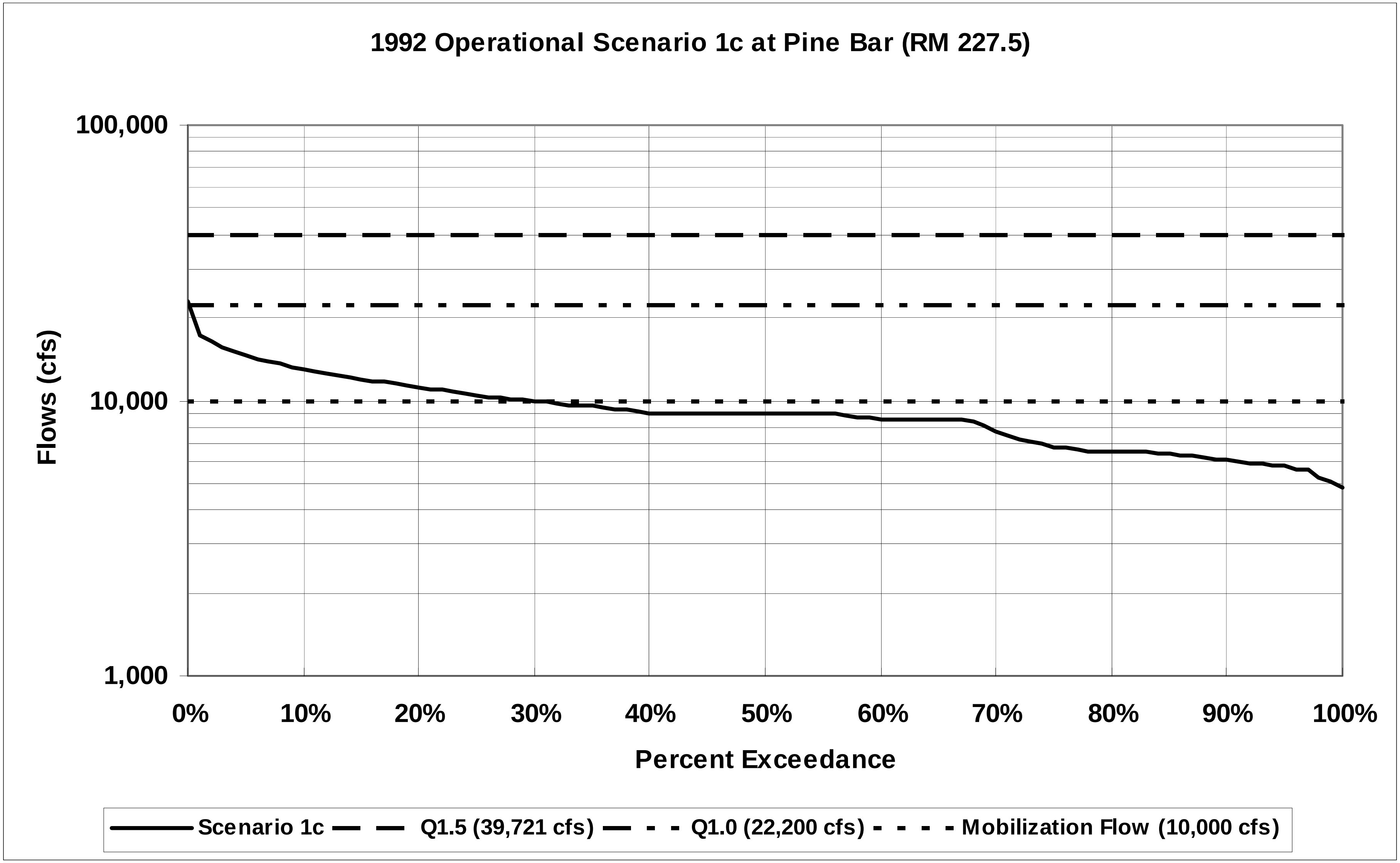


Figure 61. Flow-duration curve for 1992 Operational Scenario 1c at Pine Bar (RM 227.5).

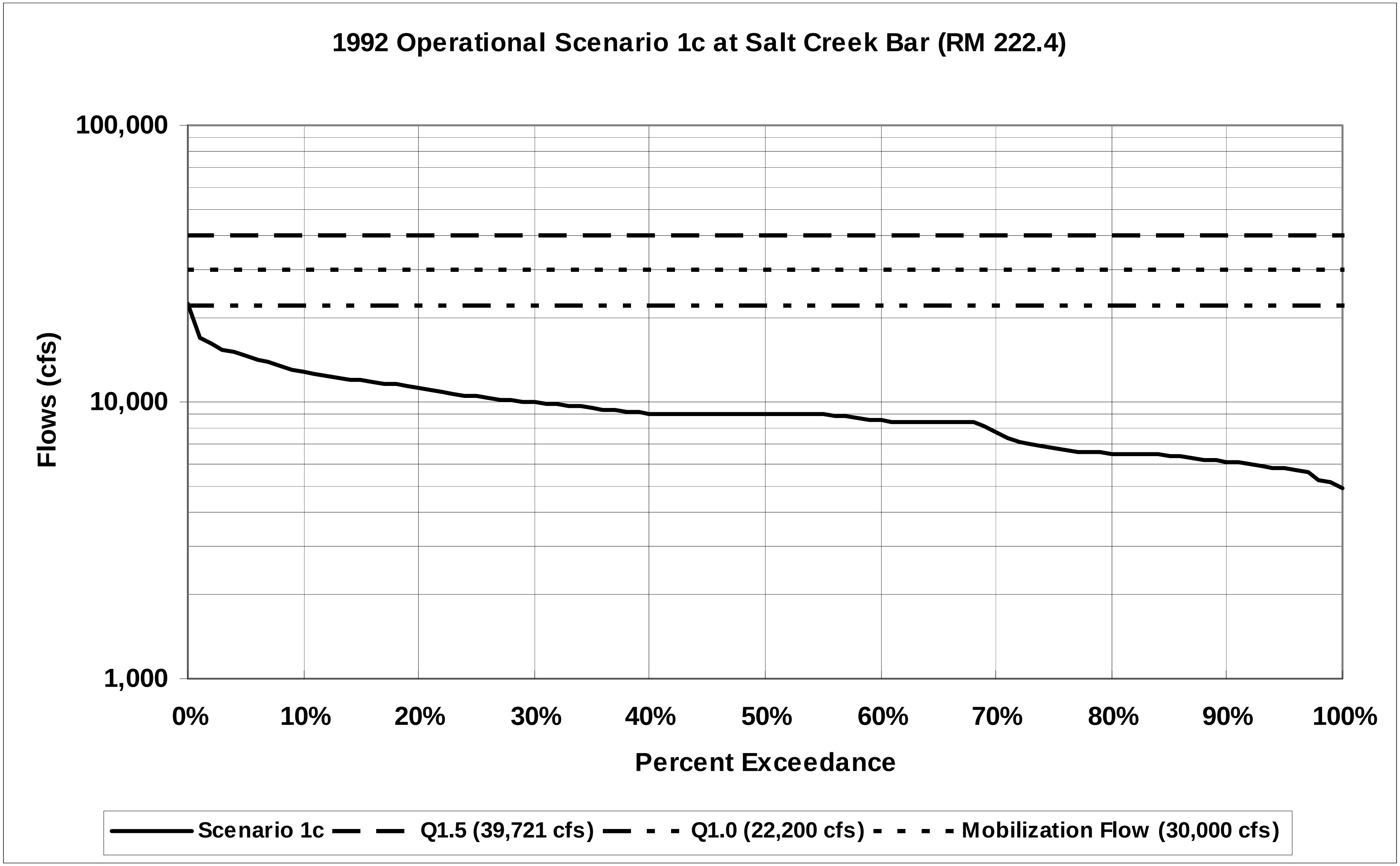


Figure 62. Flow-duration curve for 1992 Operational Scenario 1c at Salt Creek Bar (RM 222.4).

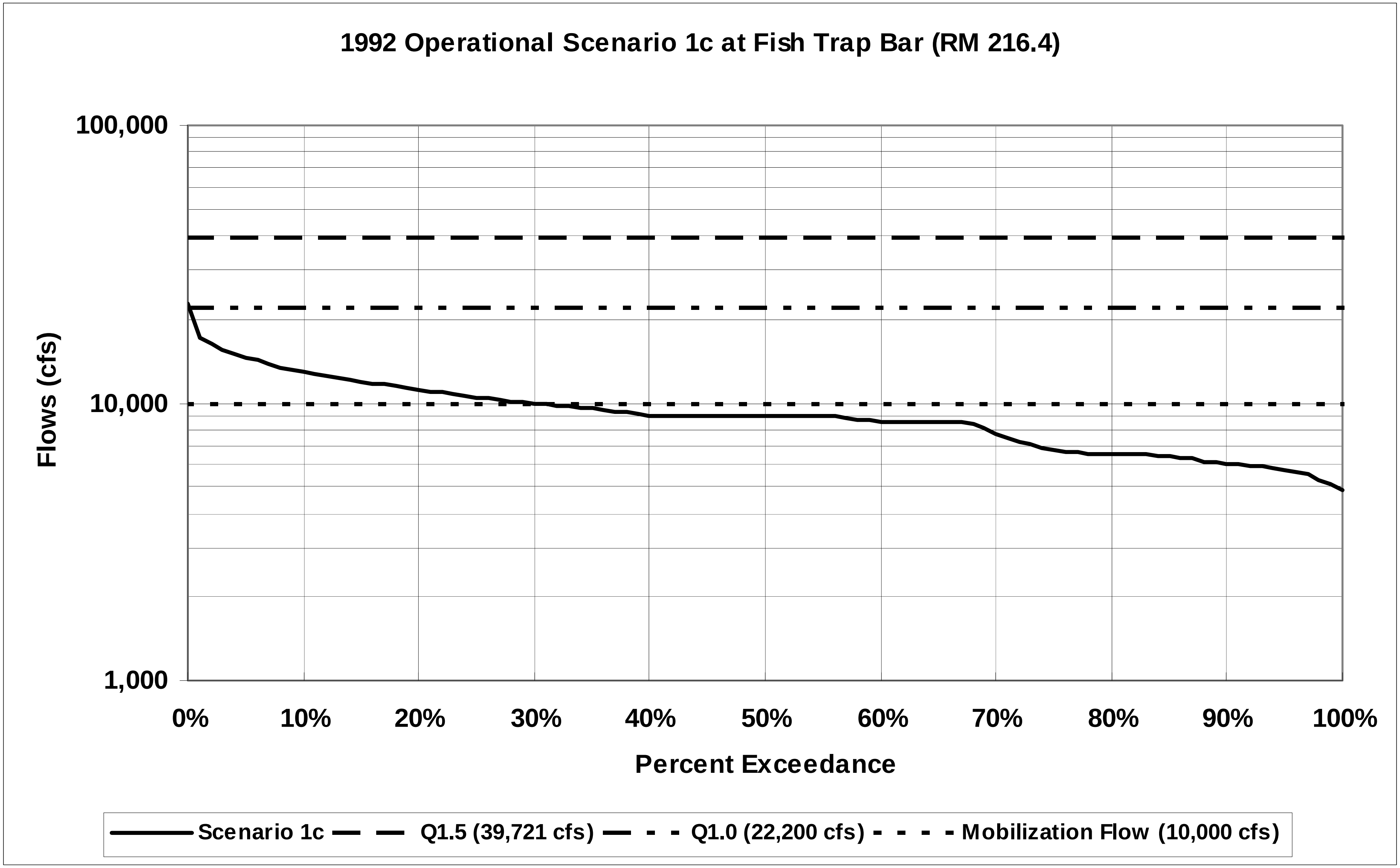


Figure 63. Flow-duration curve for 1992 Operational Scenario 1c at Fish Trap Bar (RM 216.4).

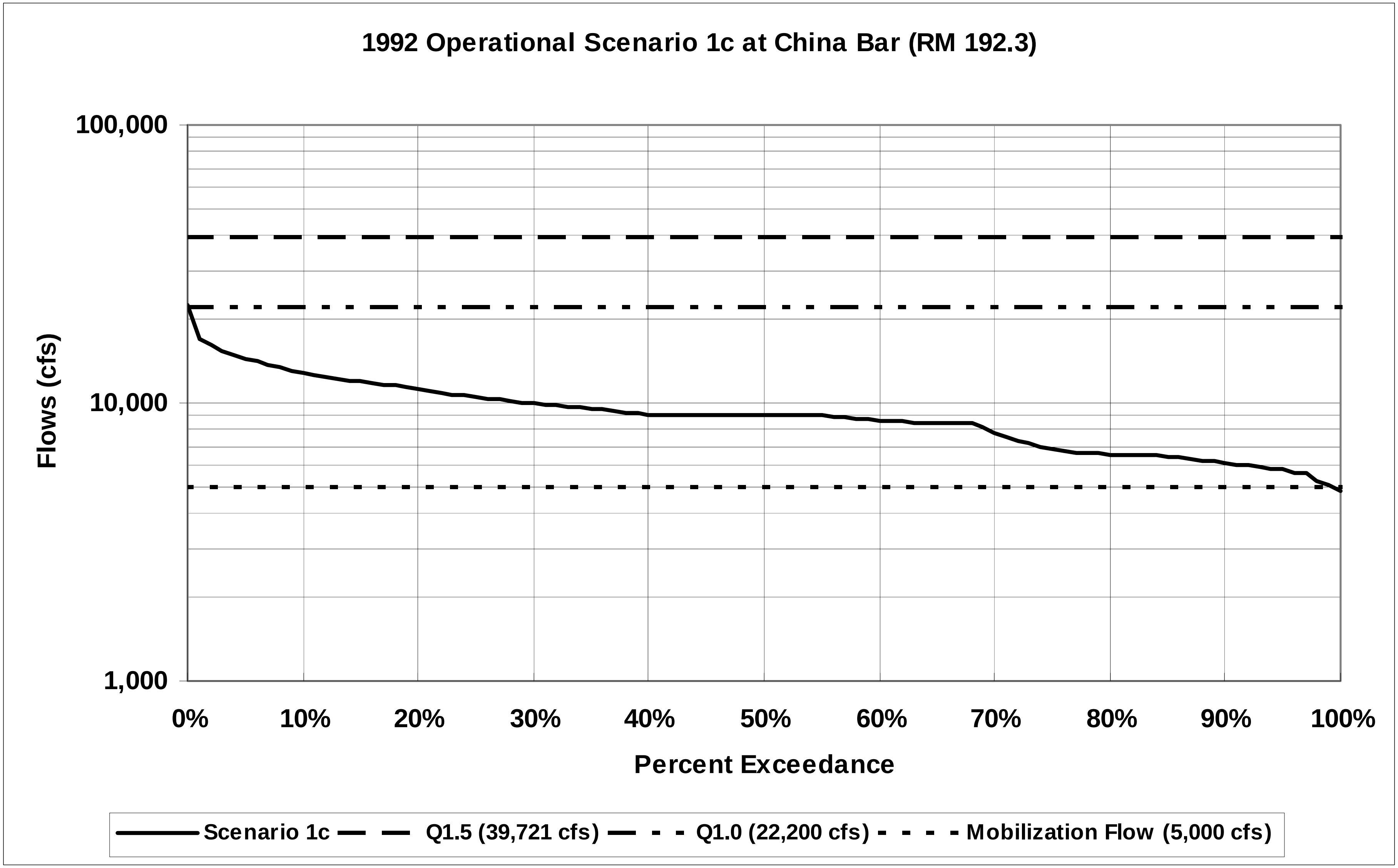


Figure 64. Flow-duration curve for 1992 Operational Scenario 1c at China Bar (RM 192.3).

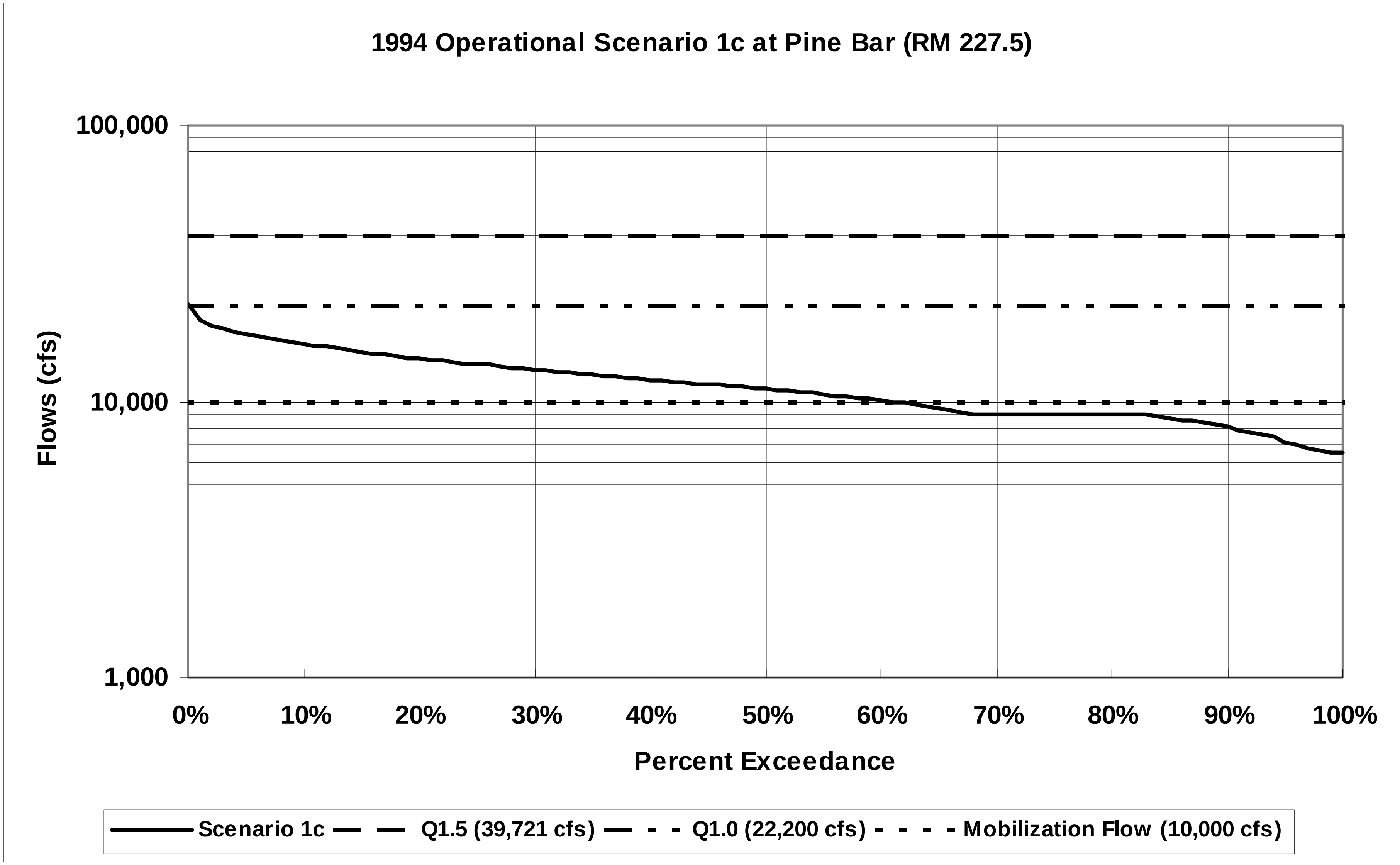


Figure 65. Flow-duration curve for 1994 Operational Scenario 1c at Pine Bar (RM 227.5).

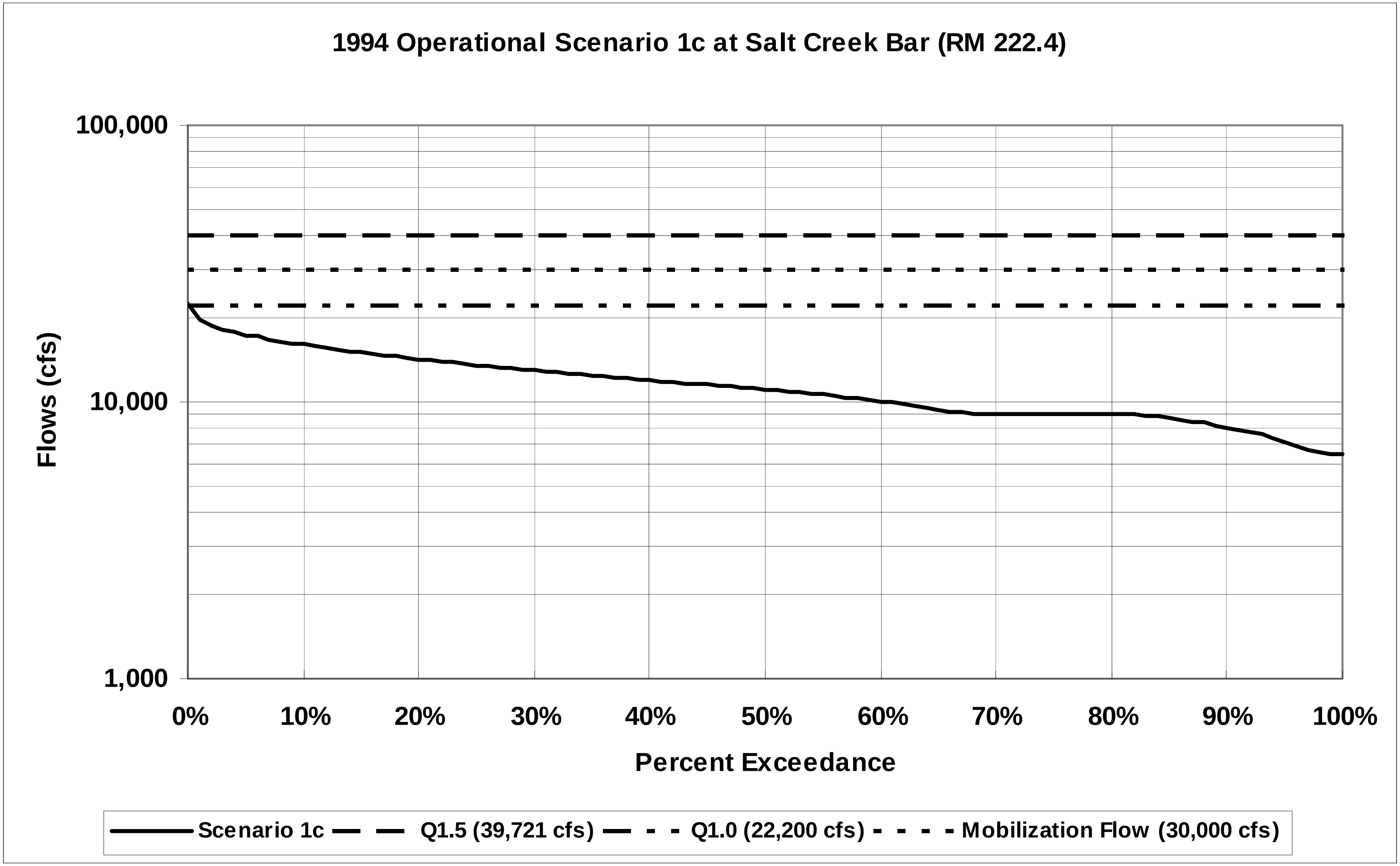


Figure 66. Flow-duration curve for 1994 Operational Scenario 1c at Salt Creek Bar (RM 222.4).

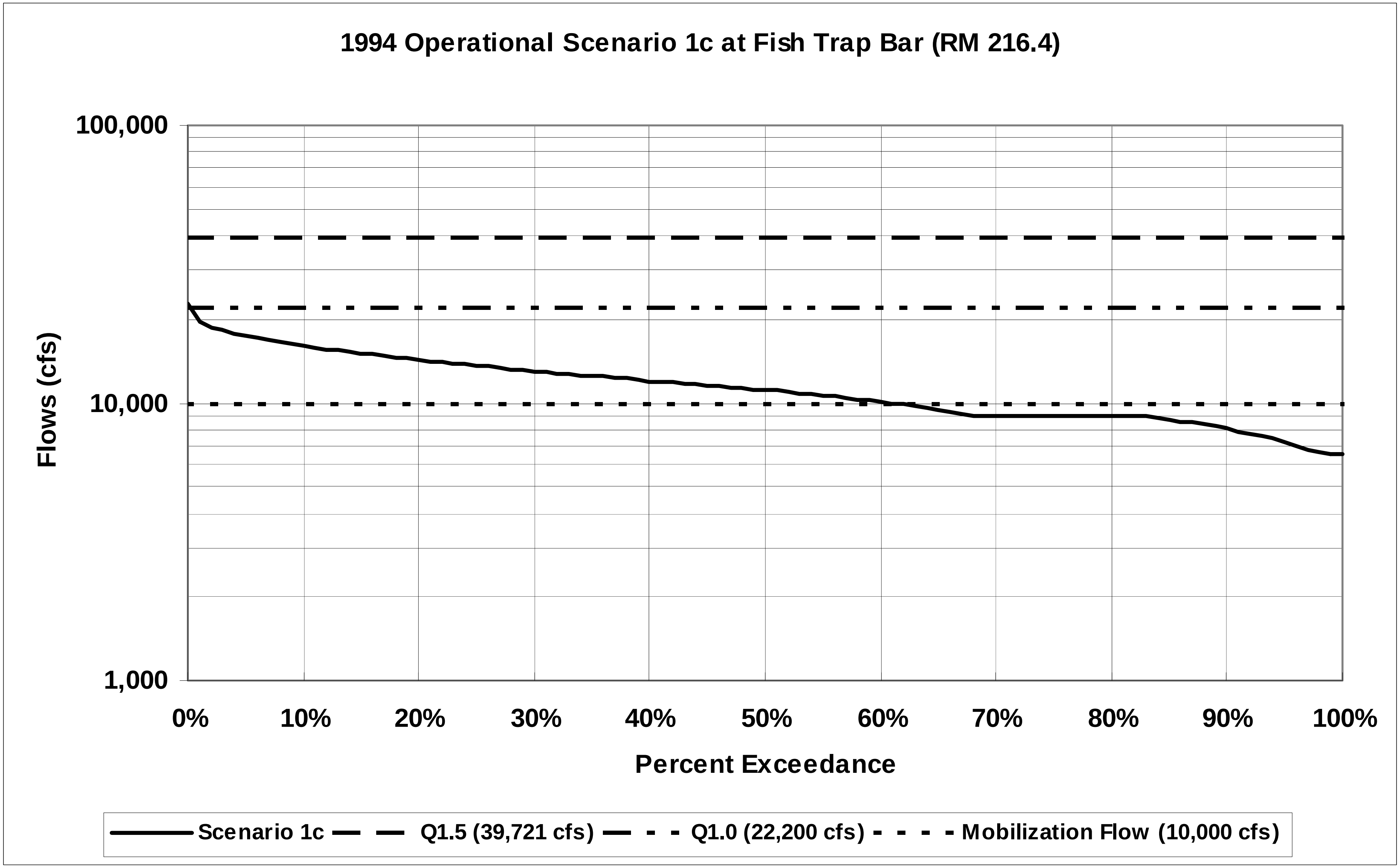


Figure 67. Flow-duration curve for 1994 Operational Scenario 1c at Fish Trap Bar (RM 216.4).

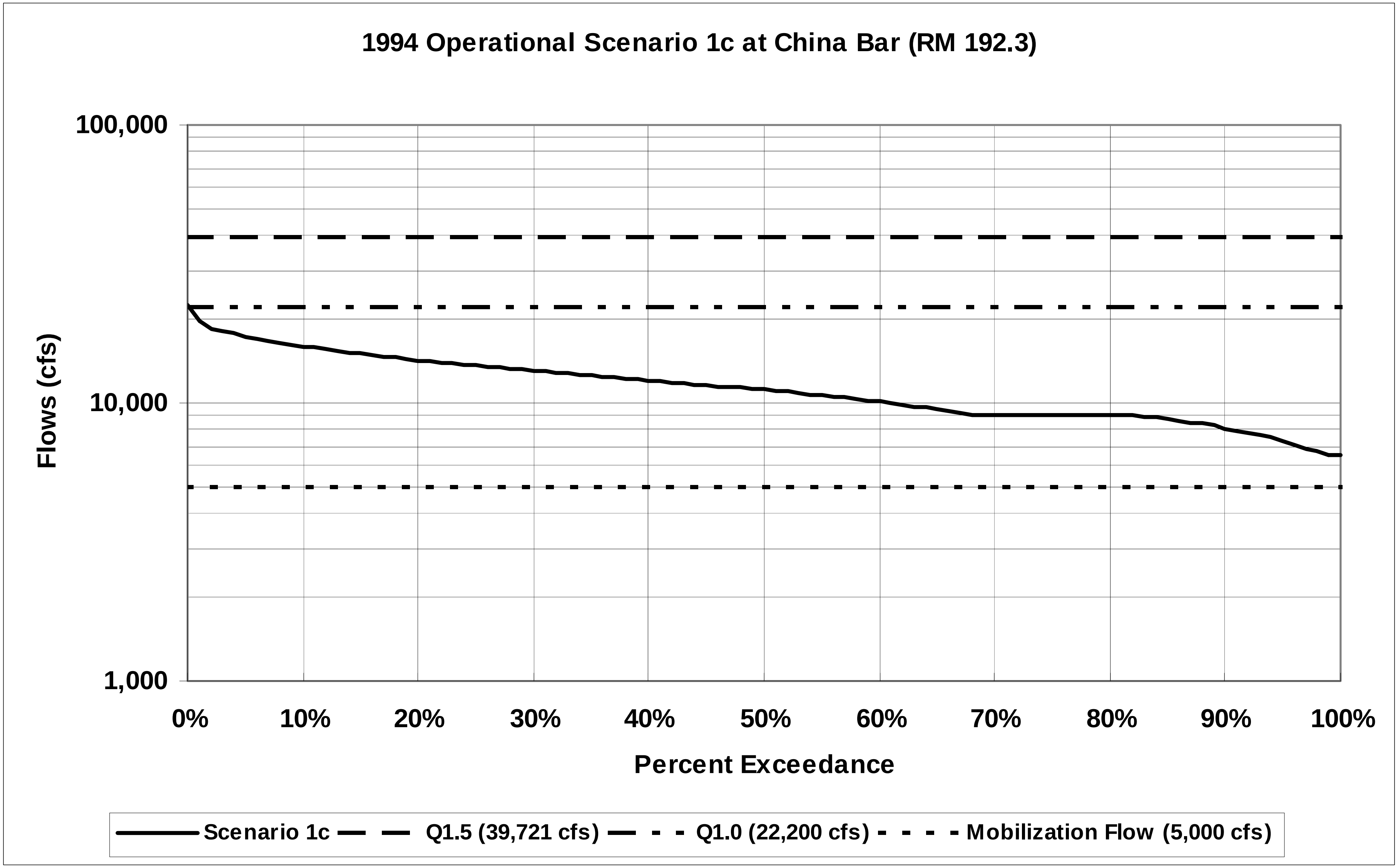


Figure 68. Flow-duration curve for 1994 Operational Scenario 1c at China Bar (RM 192.3).

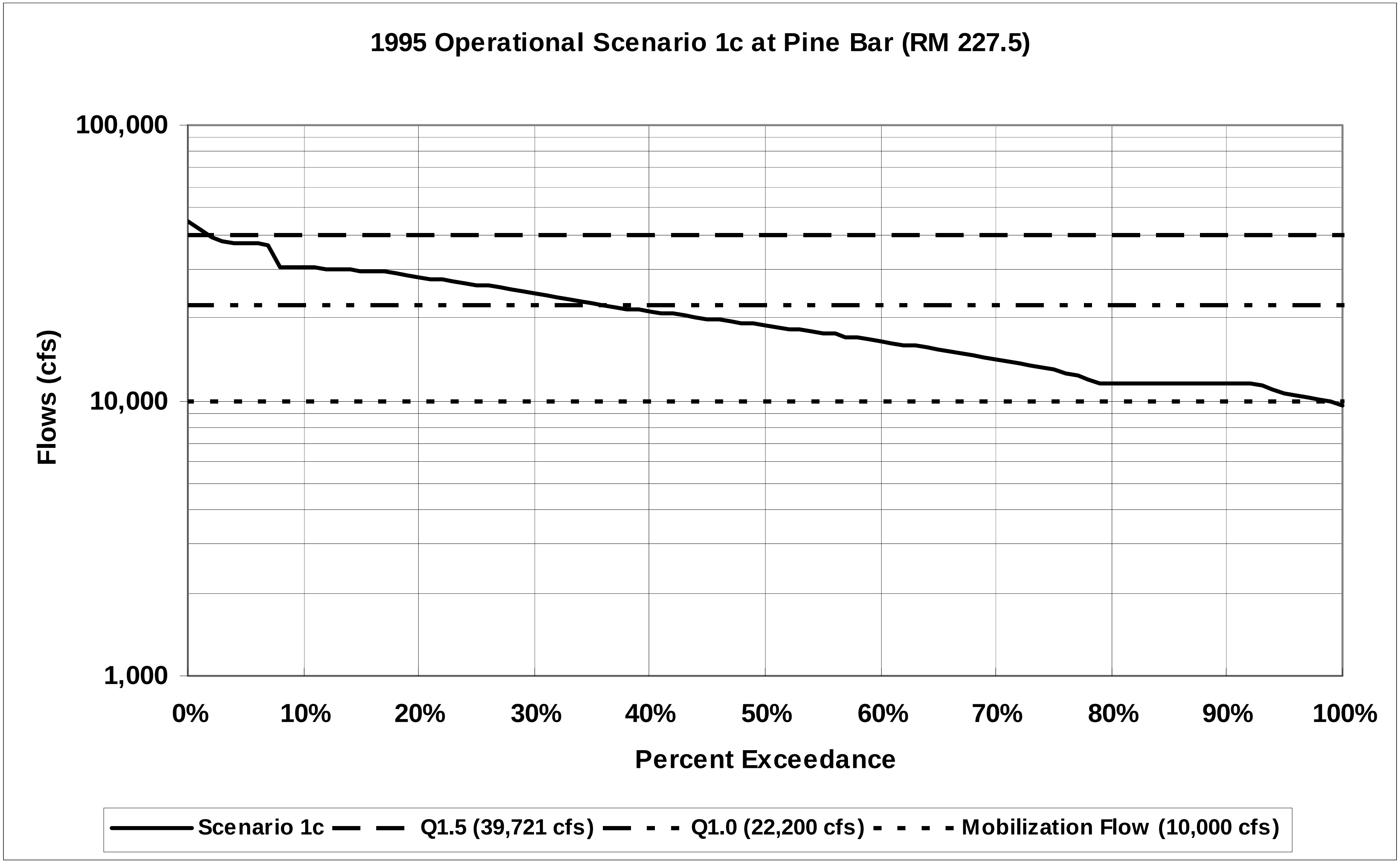


Figure 69. Flow-duration curve for 1995 Operational Scenario 1c at Pine Bar (RM 227.5).

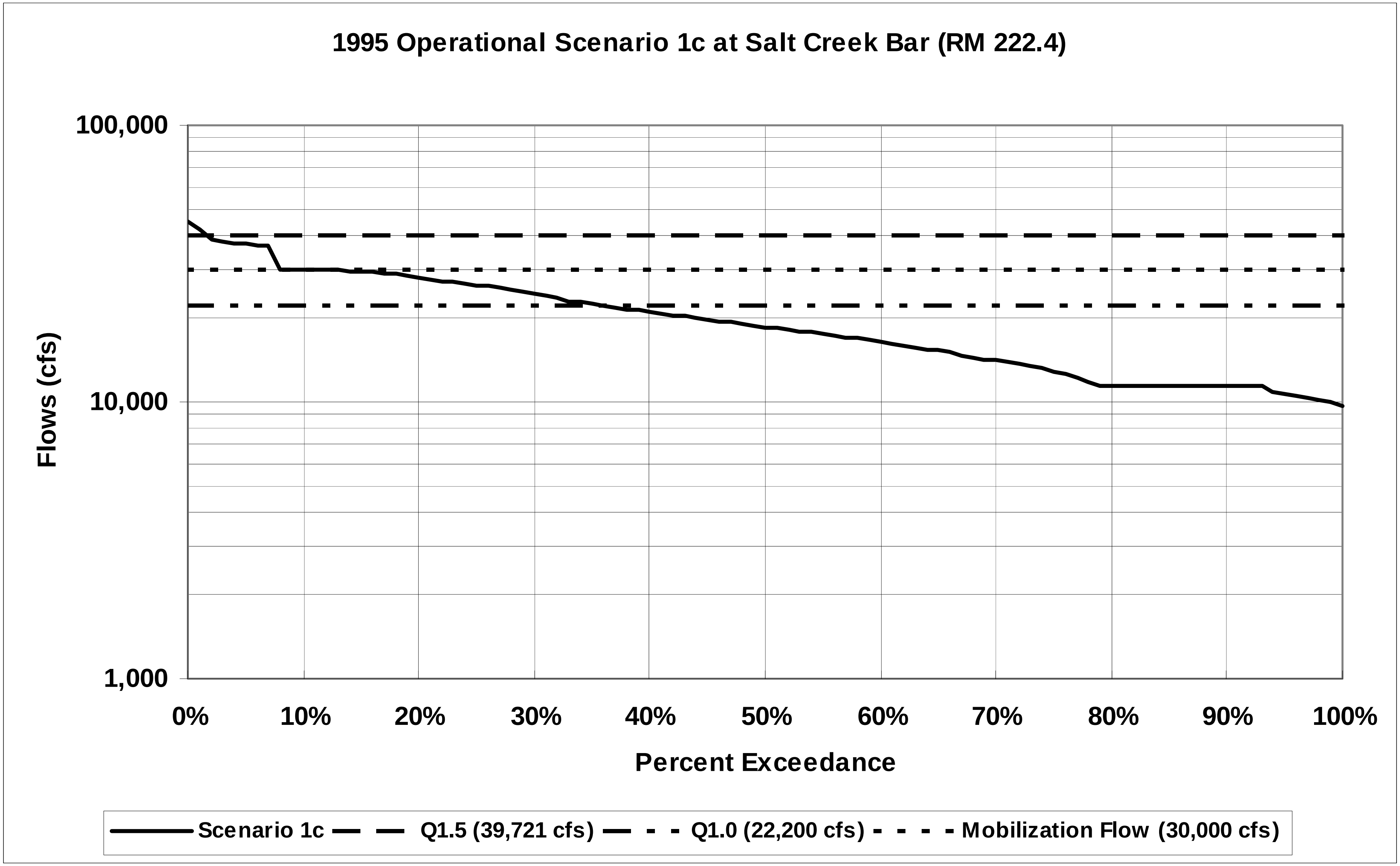


Figure 70. Flow-duration curve for 1995 Operational Scenario 1c at Salt Creek Bar (RM 222.4).

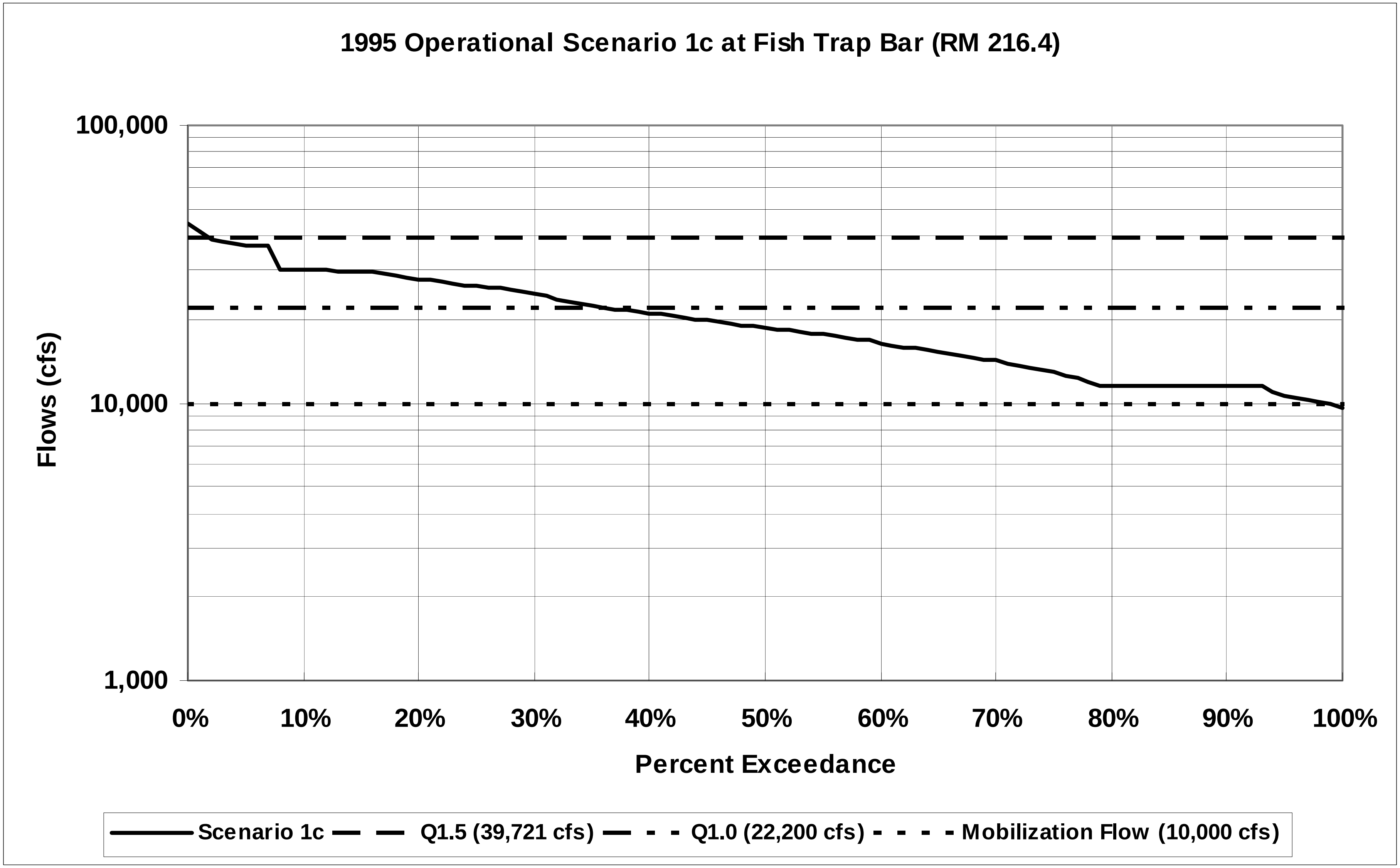


Figure 71. Flow-duration curve for 1995 Operational Scenario 1c at Fish Trap Bar (RM 216.4).

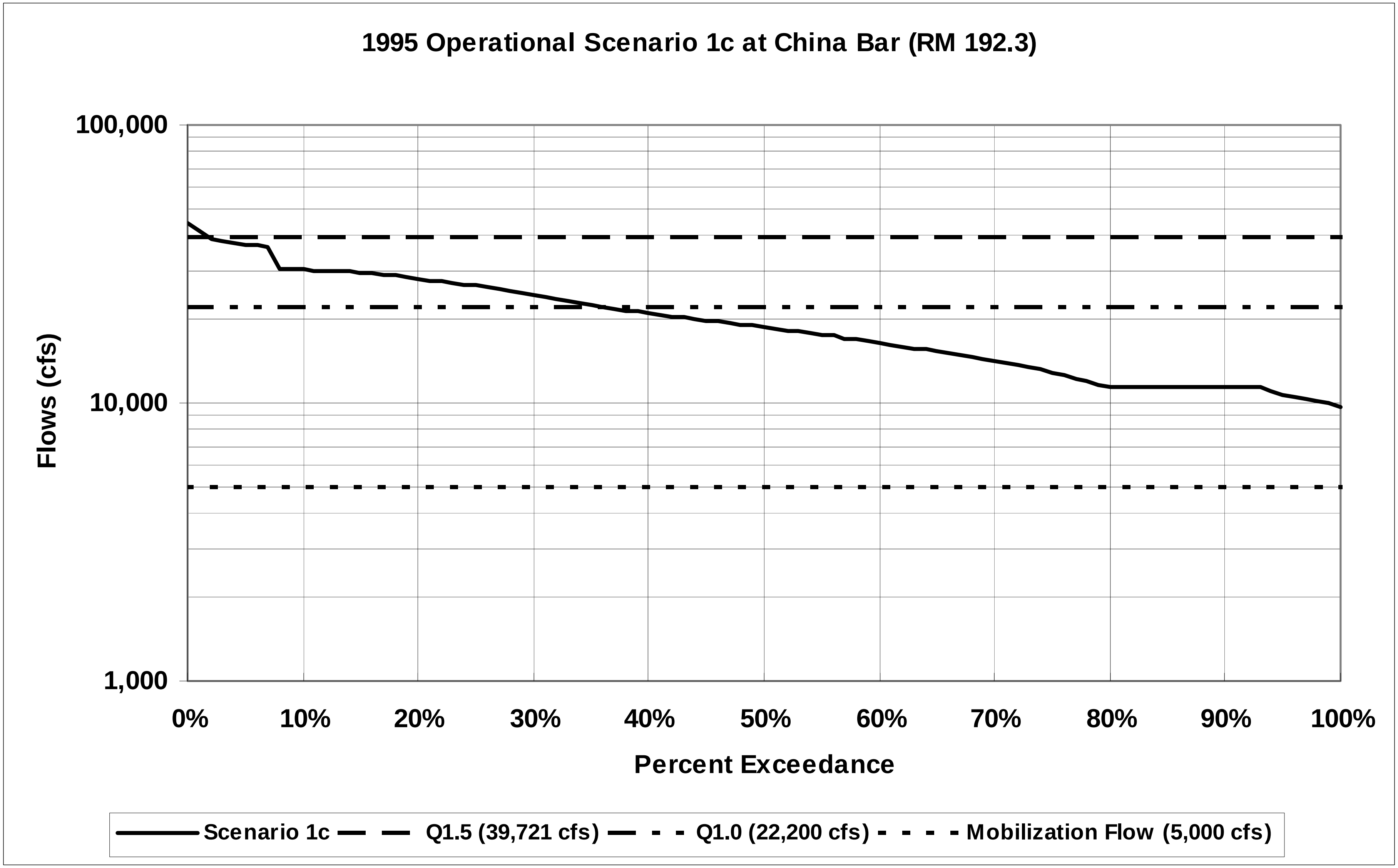


Figure 72. Flow-duration curve for 1995 Operational Scenario 1c at China Bar (RM 192.3).

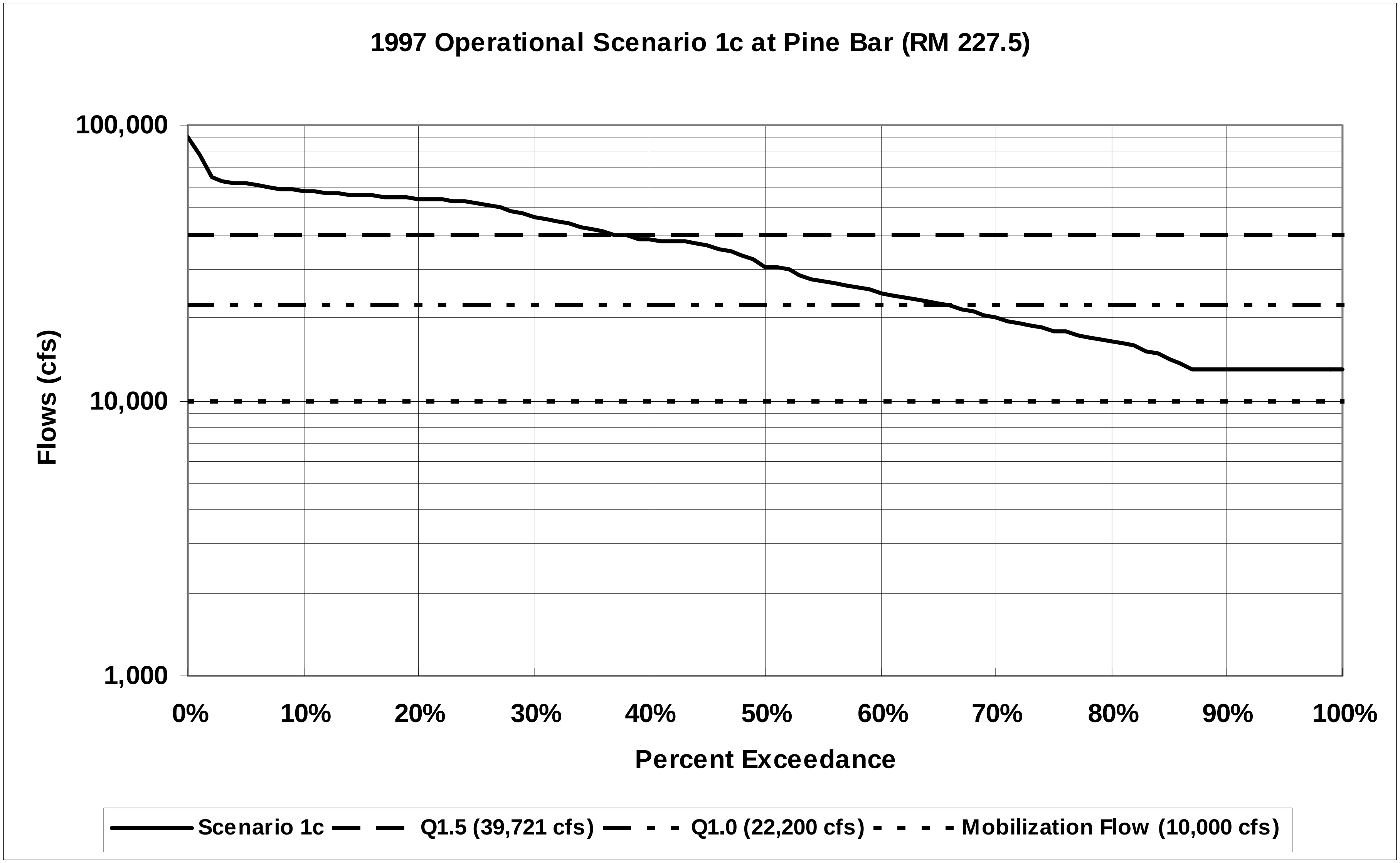


Figure 73. Flow-duration curve for 1997 Operational Scenario 1c at Pine Bar (RM 227.5).

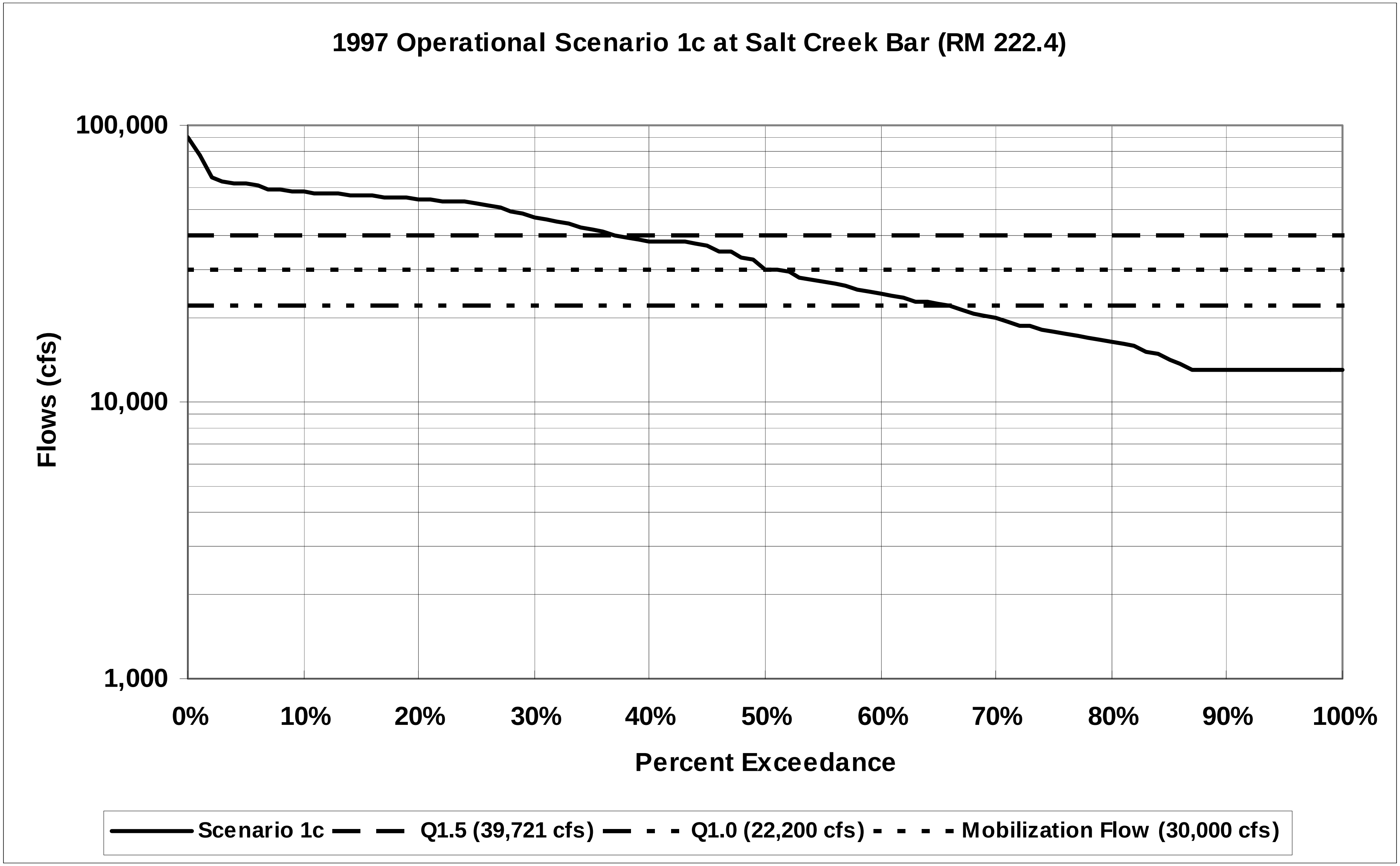


Figure 74. Flow-duration curve for 1997 Operational Scenario 1c at Salt Creek Bar (RM 222.4).

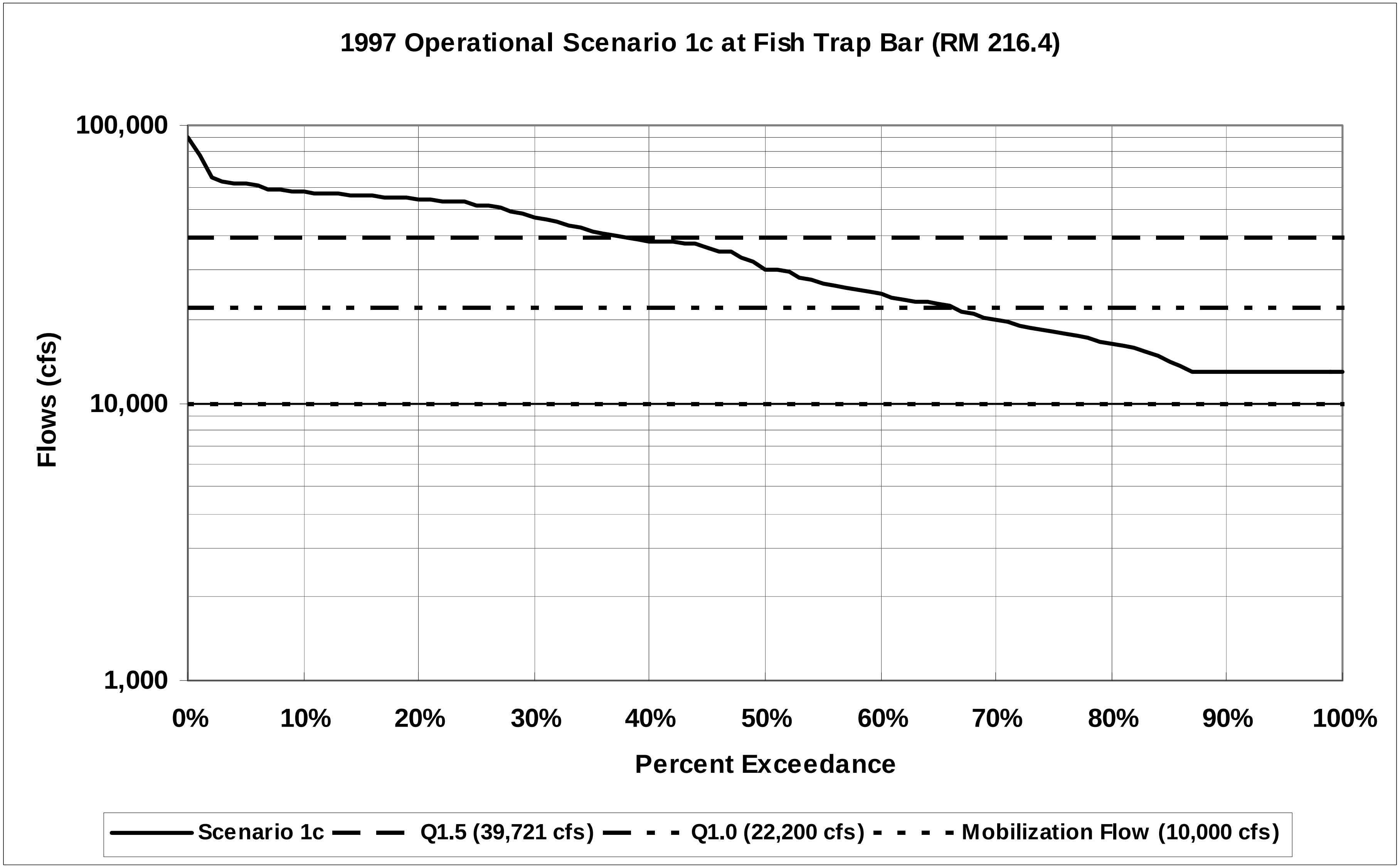


Figure 75. Flow-duration curve for 1997 Operational Scenario 1c at Fish Trap Bar (RM 216.4).

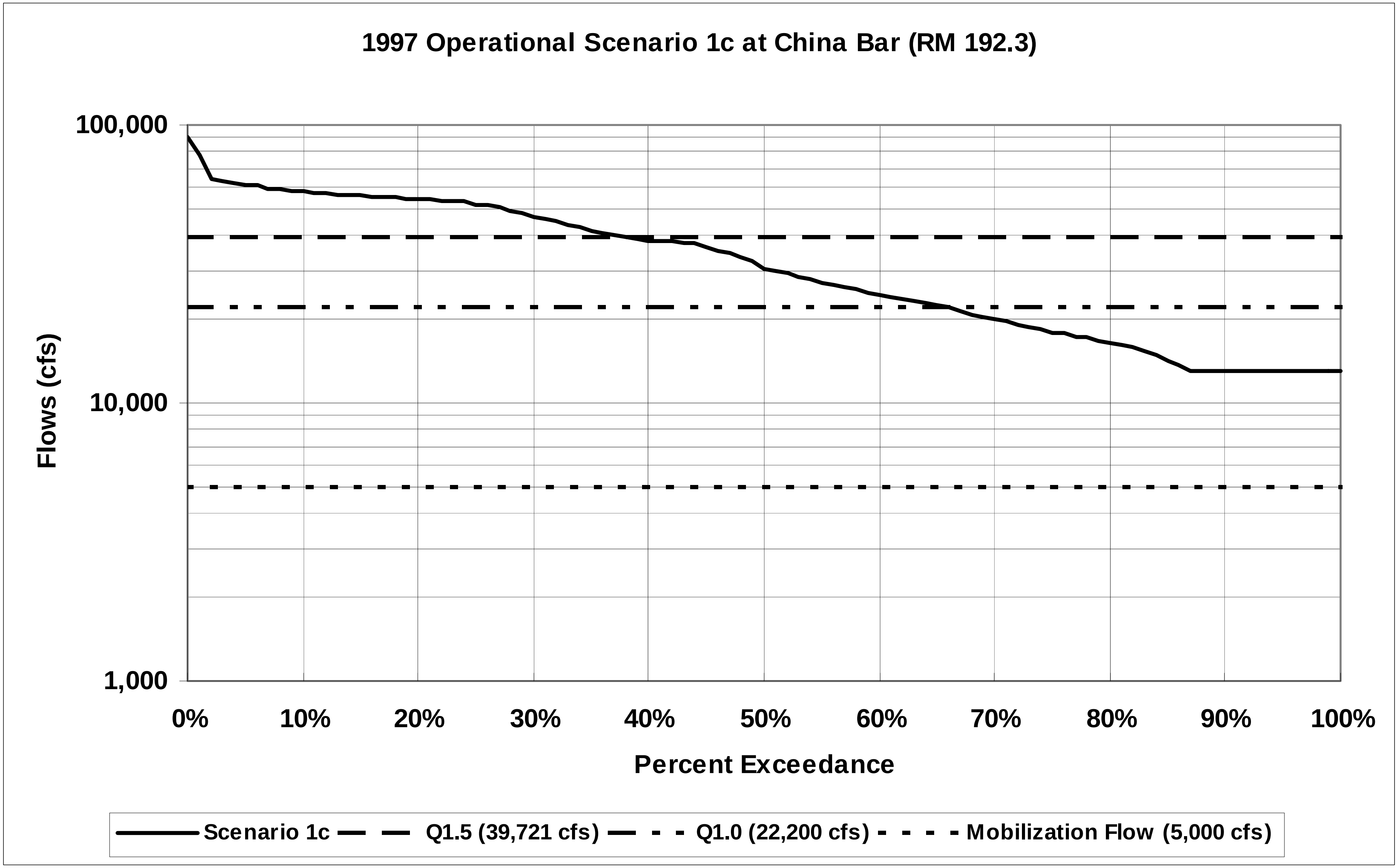


Figure 76. Flow-duration curve for 1997 Operational Scenario 1c at China Bar (RM 192.3).

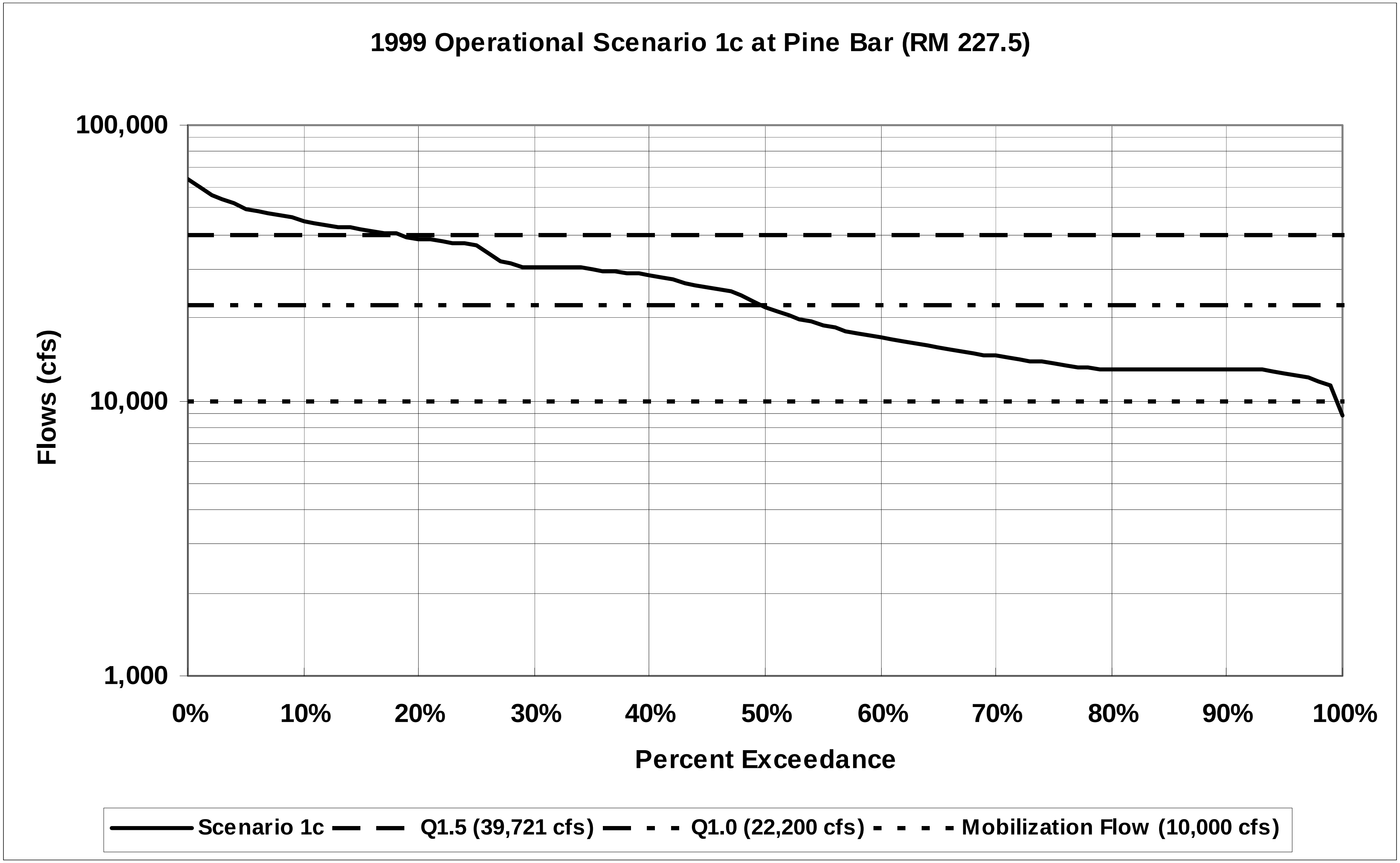


Figure 77. Flow-duration curve for 1999 Operational Scenario 1c at Pine Bar (RM 227.5).

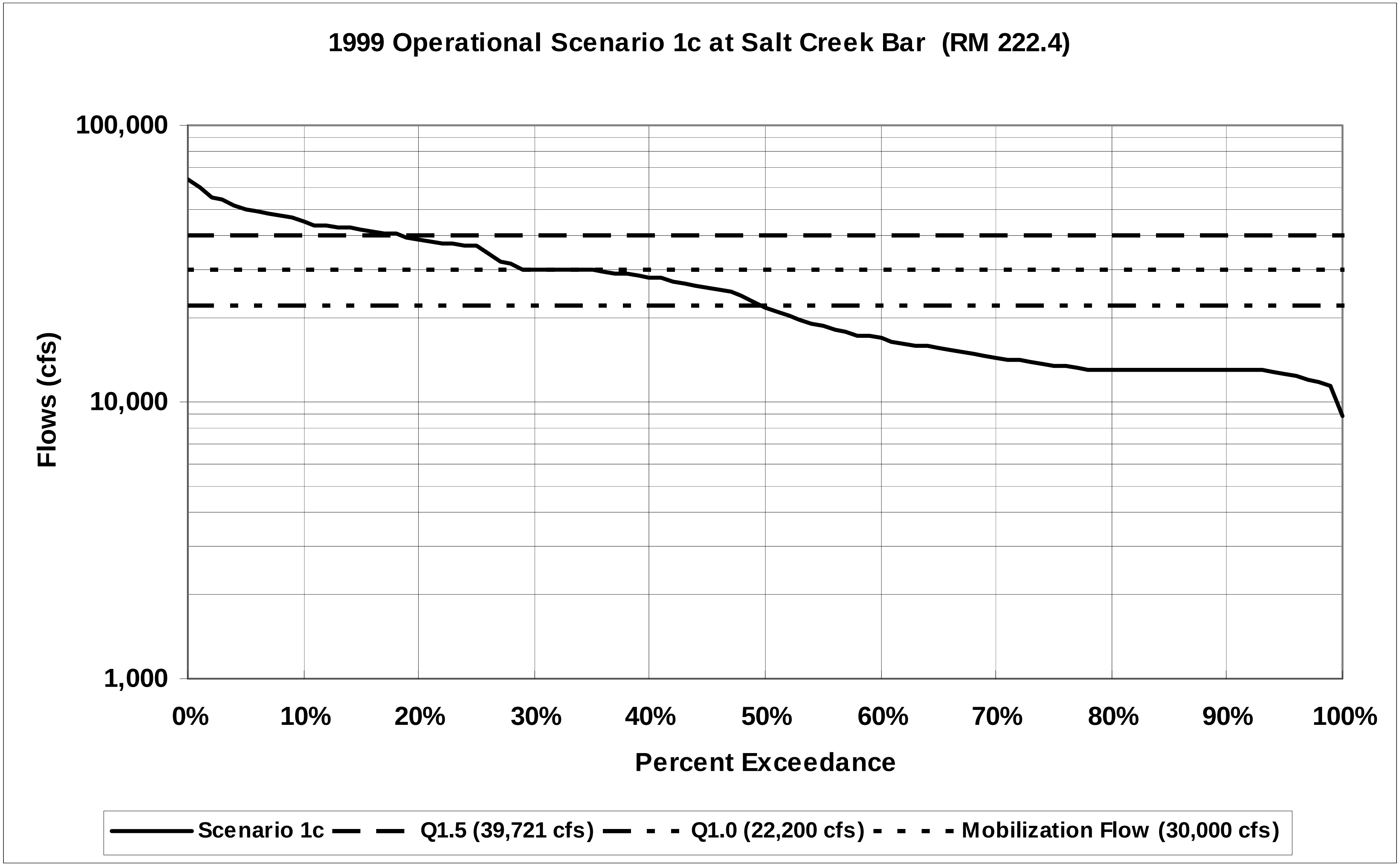


Figure 78. Flow-duration curve for 1999 Operational Scenario 1c at Salt Creek Bar (RM 222.4).

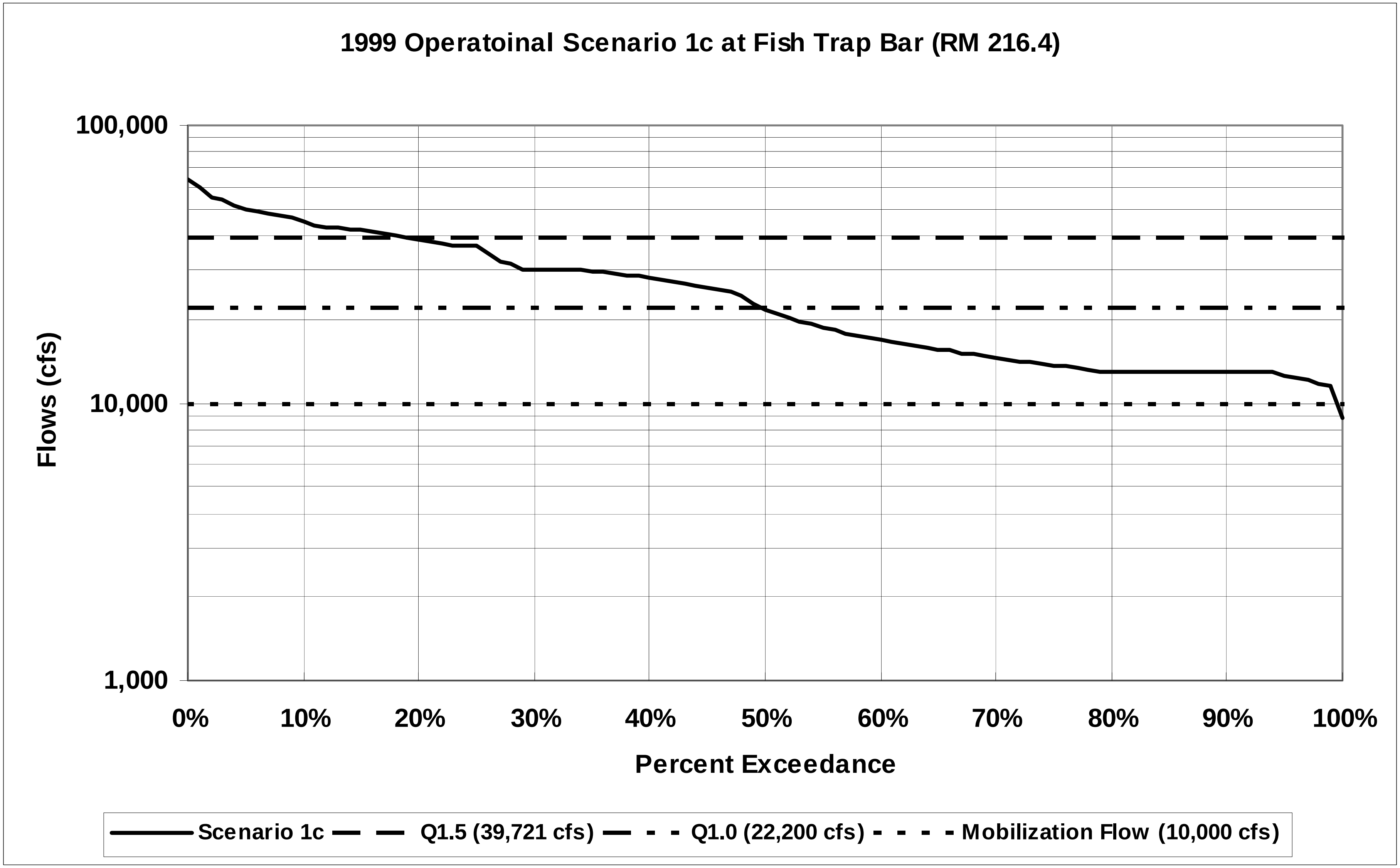


Figure 79. Flow-duration curve for 1999 Operational Scenario 1c at Fish Trap Bar (RM 216.4).

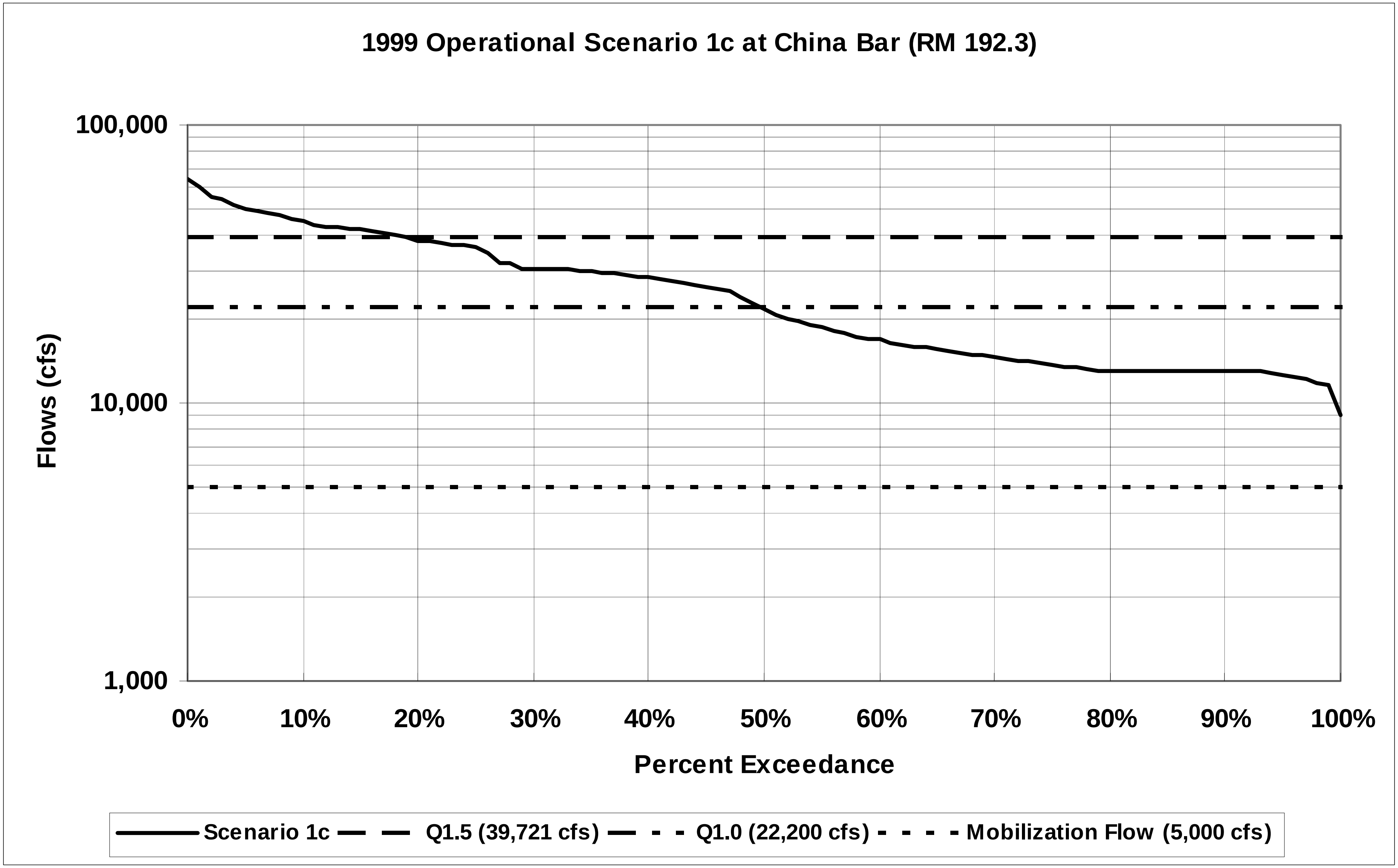


Figure 80. Flow-duration curve for 1999 Operational Scenario 1c at China Bar (RM 192.3).

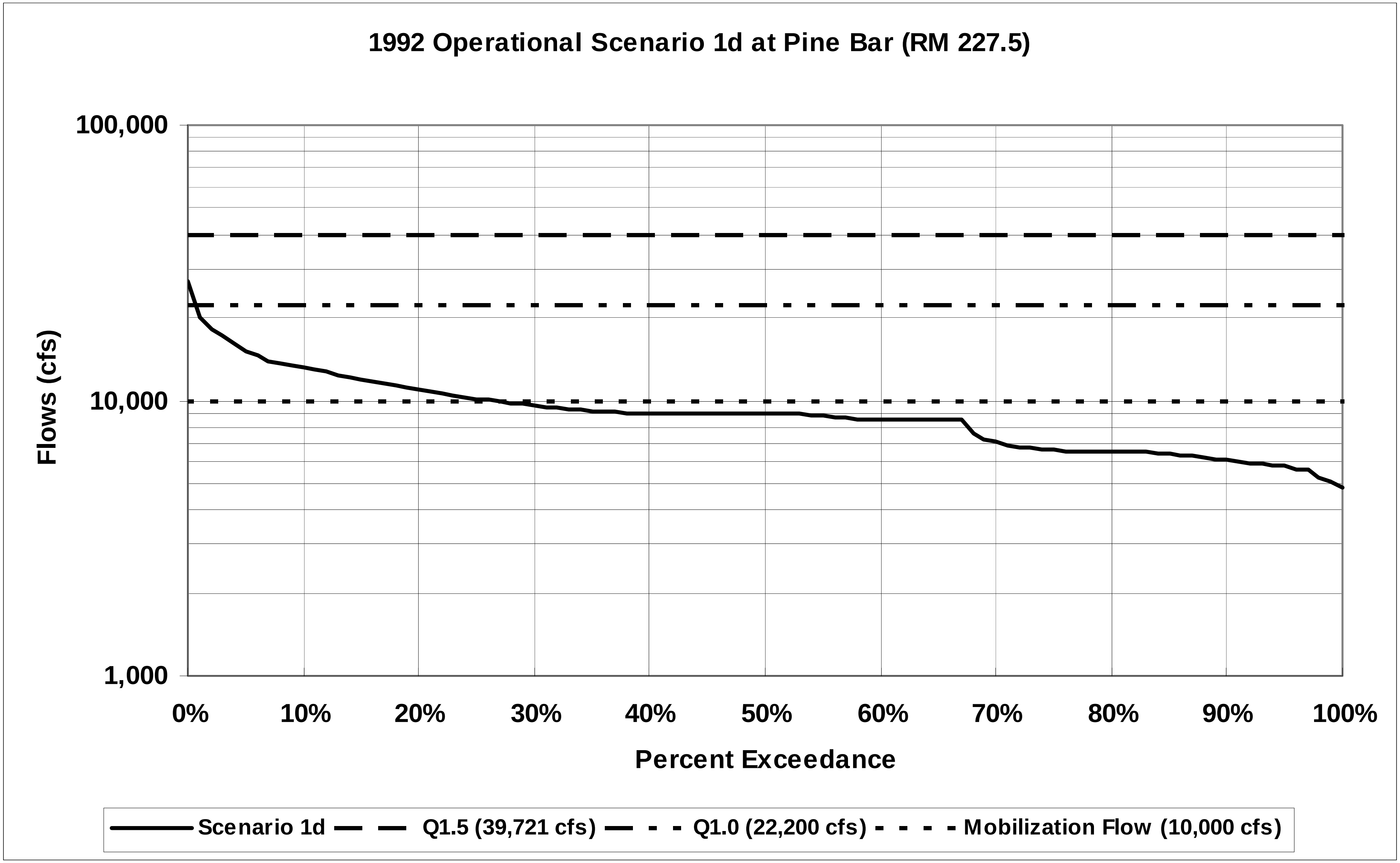


Figure 81. Flow-duration curve for 1992 Operational Scenario 1d at Pine Bar (RM 227.5).

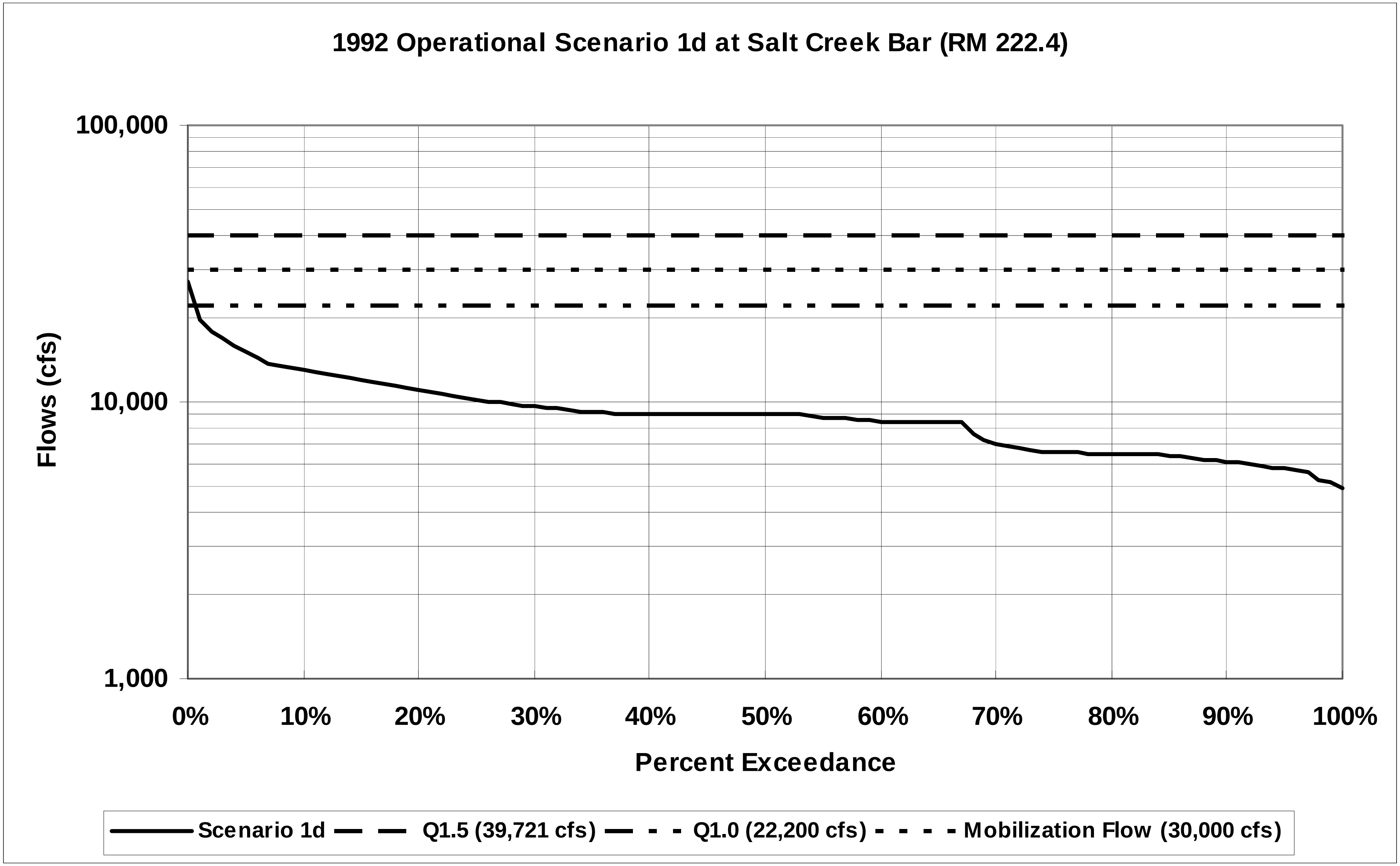


Figure 82. Flow-duration curve for 1992 Operational Scenario 1d at Salt Creek Bar (RM 222.4).

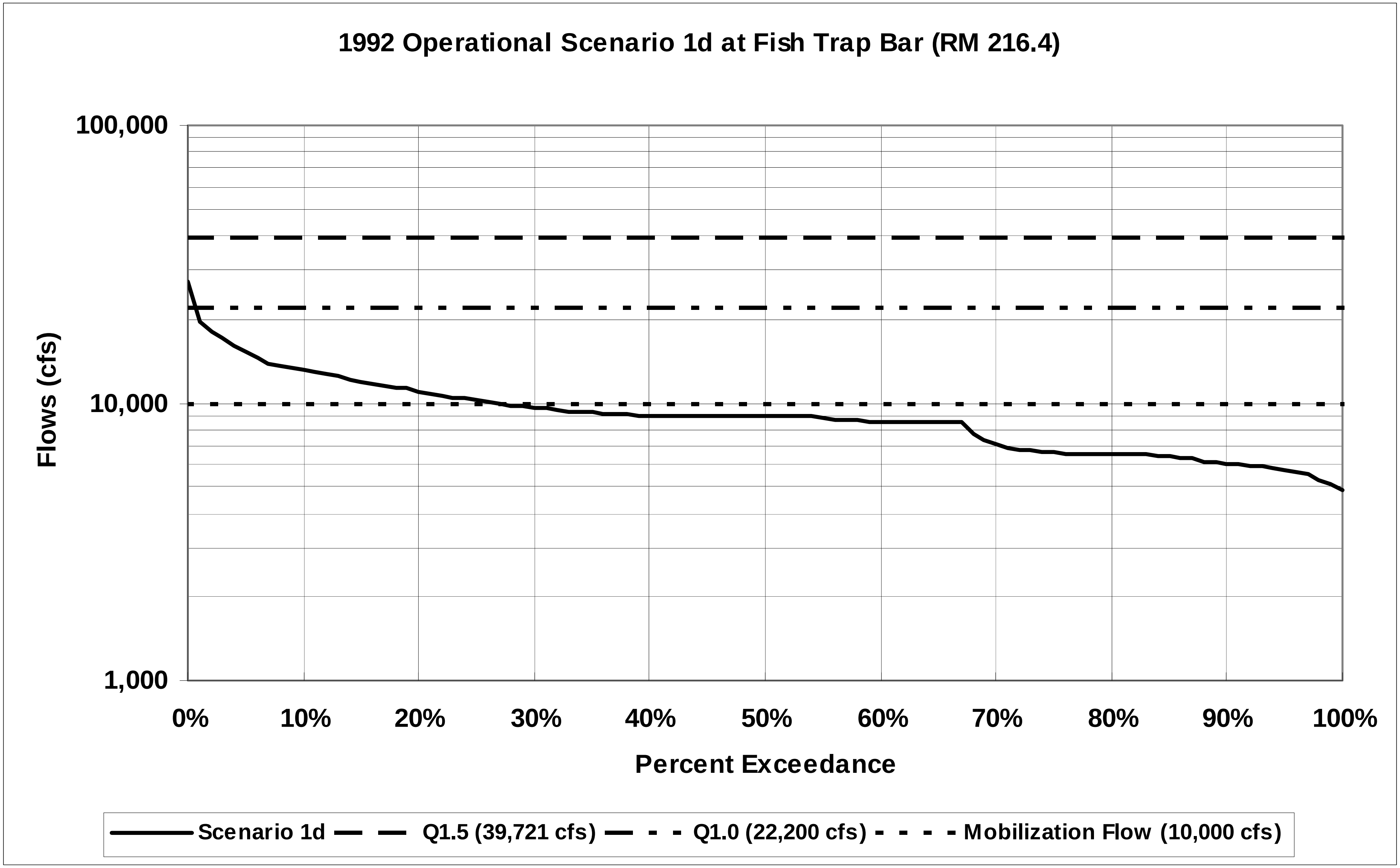


Figure 83. Flow-duration curve for 1992 Operational Scenario 1d at Fish Trap Bar (RM 216.4).

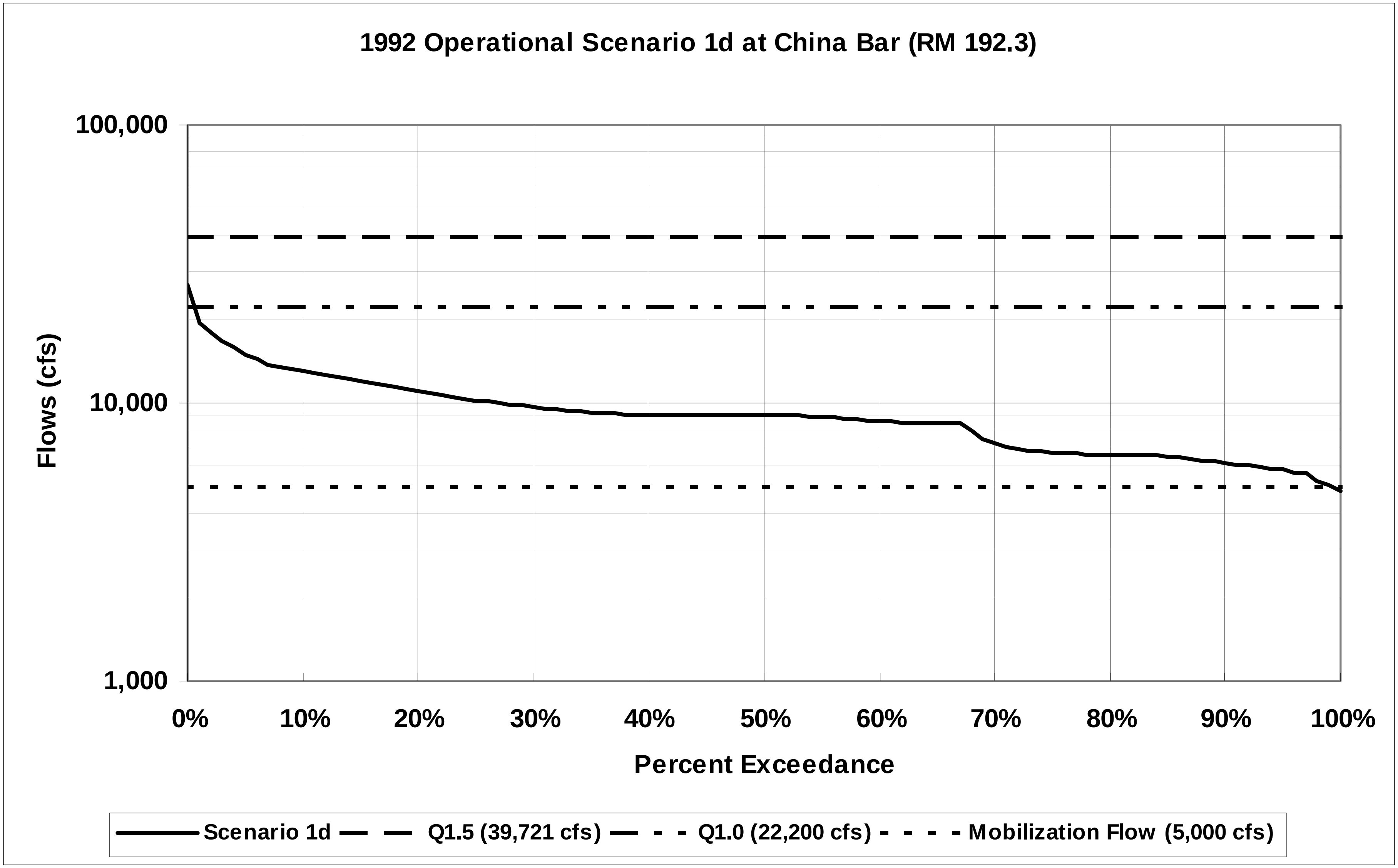


Figure 84. Flow-duration curve for 1992 Operational Scenario 1d at China Bar (RM 192.3).

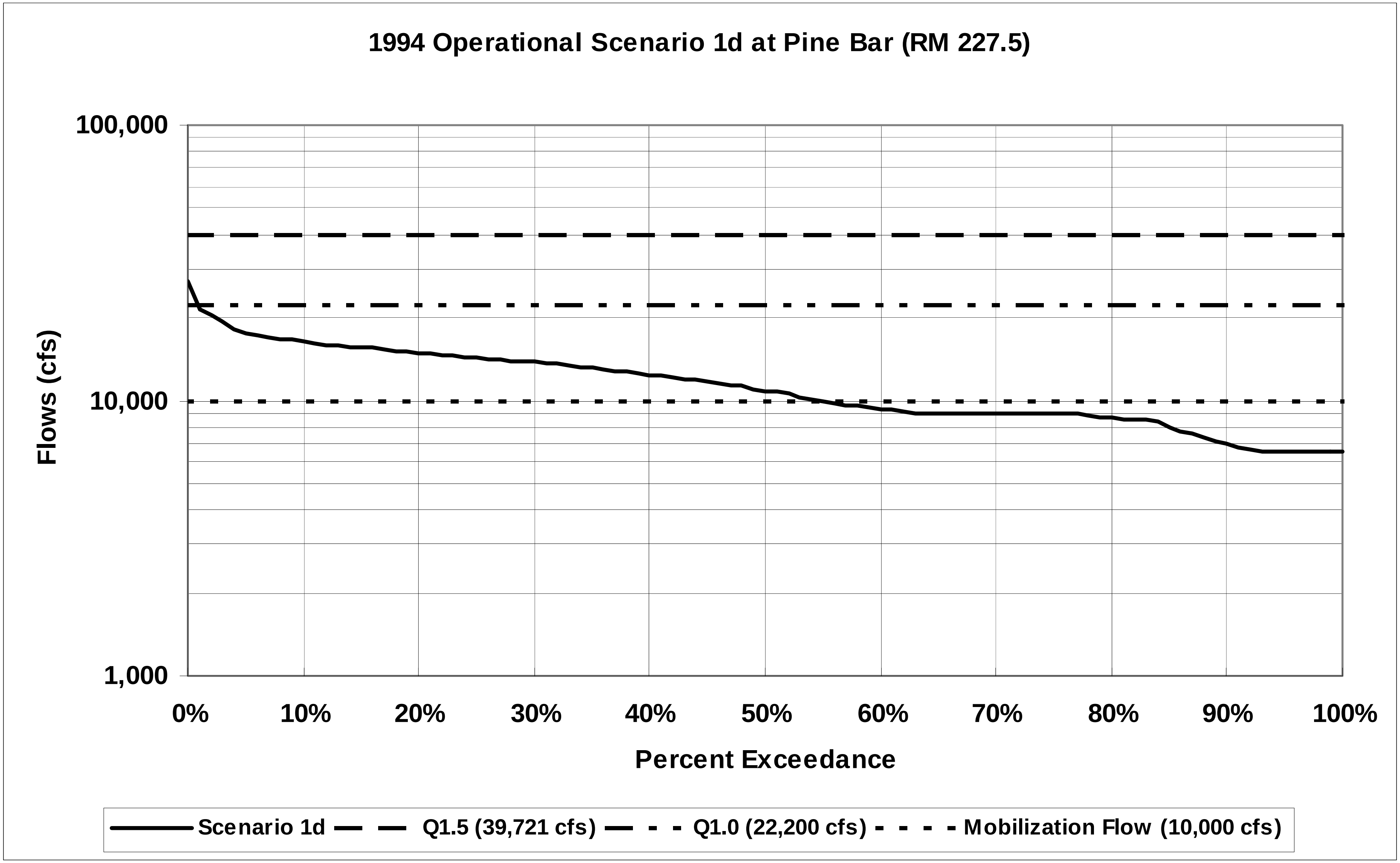


Figure 85. Flow-duration curve for 1994 Operational Scenario 1d at Pine Bar (RM 227.5).

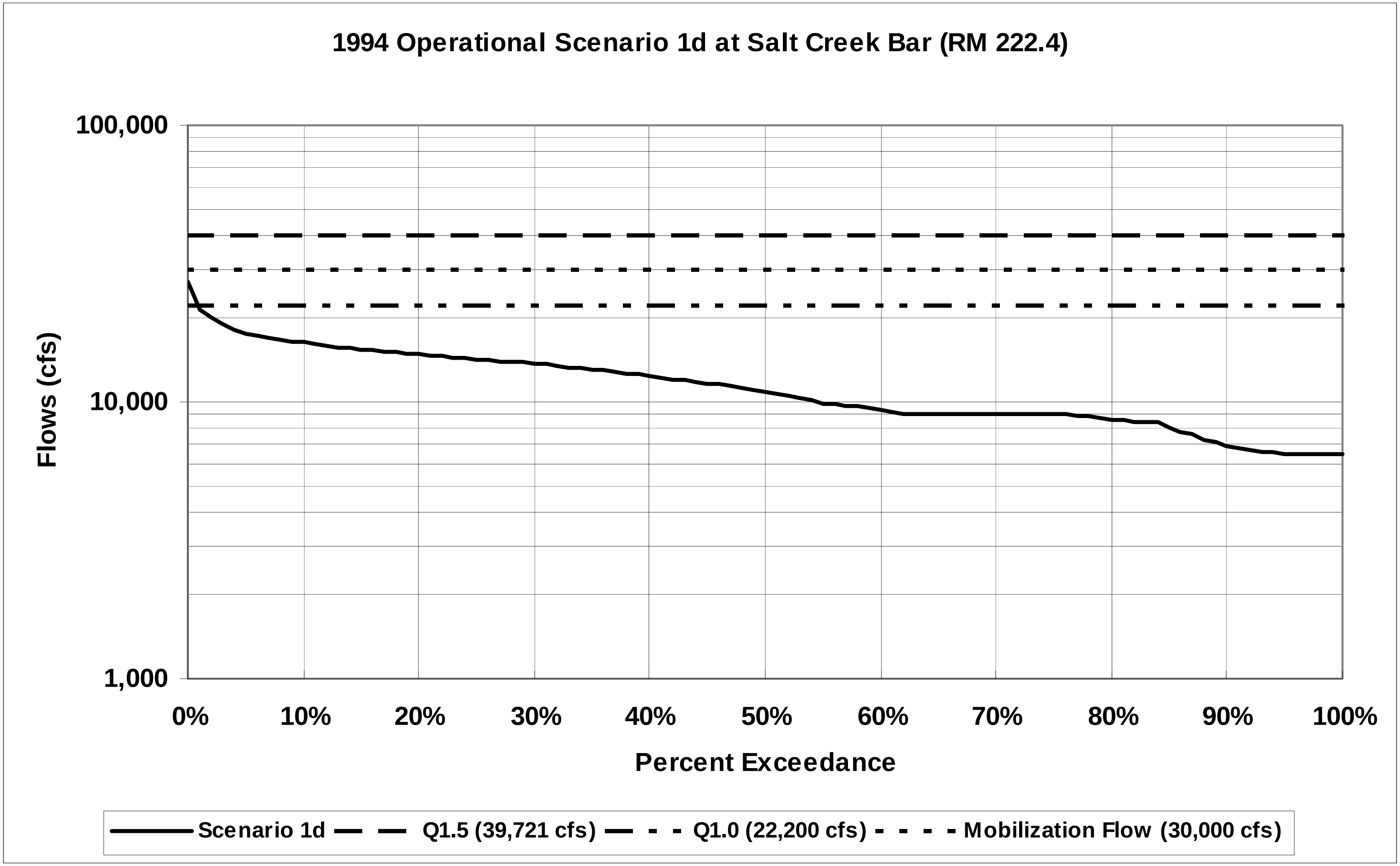


Figure 86. Flow-duration curve for 1994 Operational Scenario 1d at Salt Creek Bar (RM 222.4).

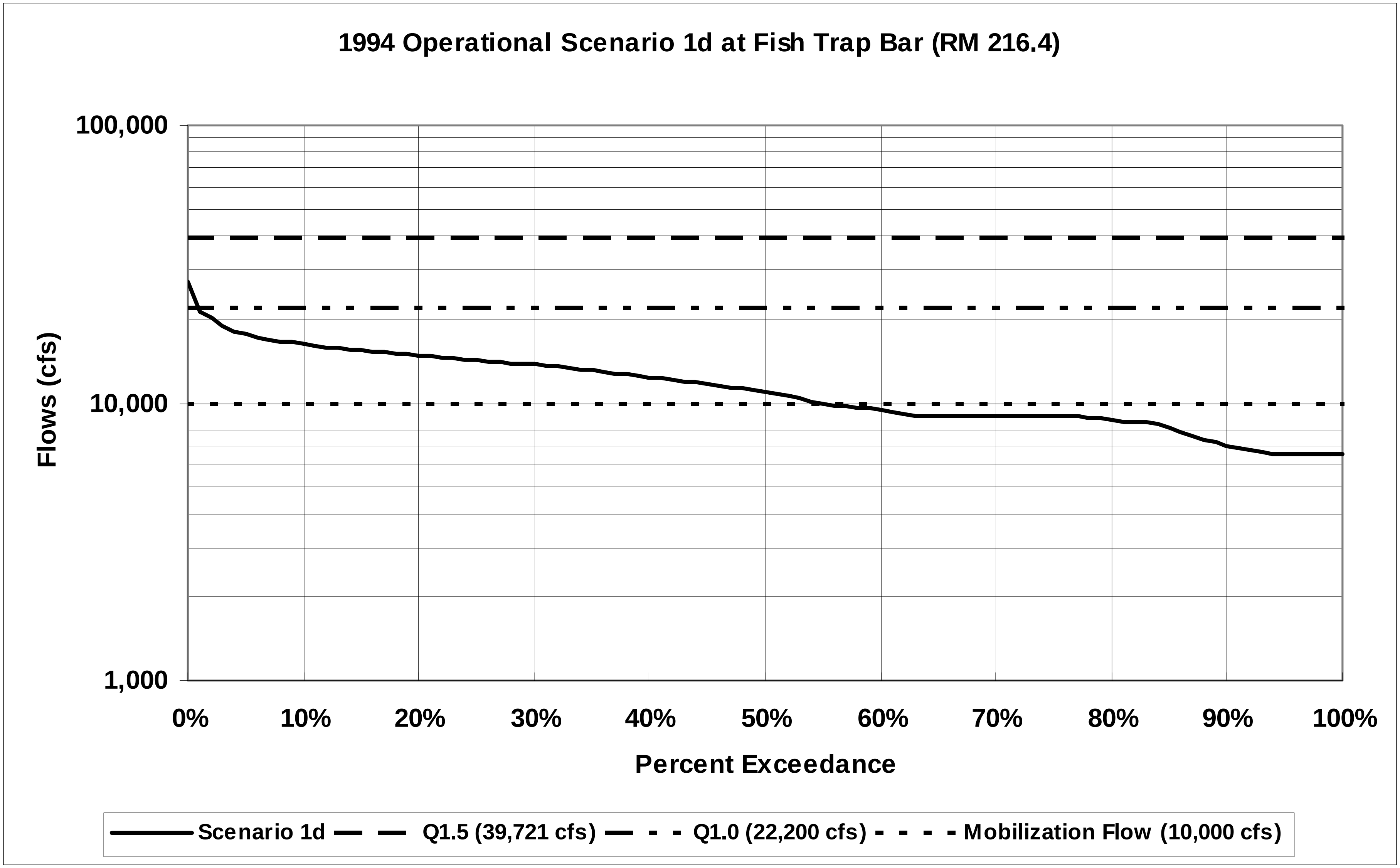


Figure 87. Flow-duration curve for 1994 Operational Scenario 1d at Fish Trap Bar (RM 216.4).

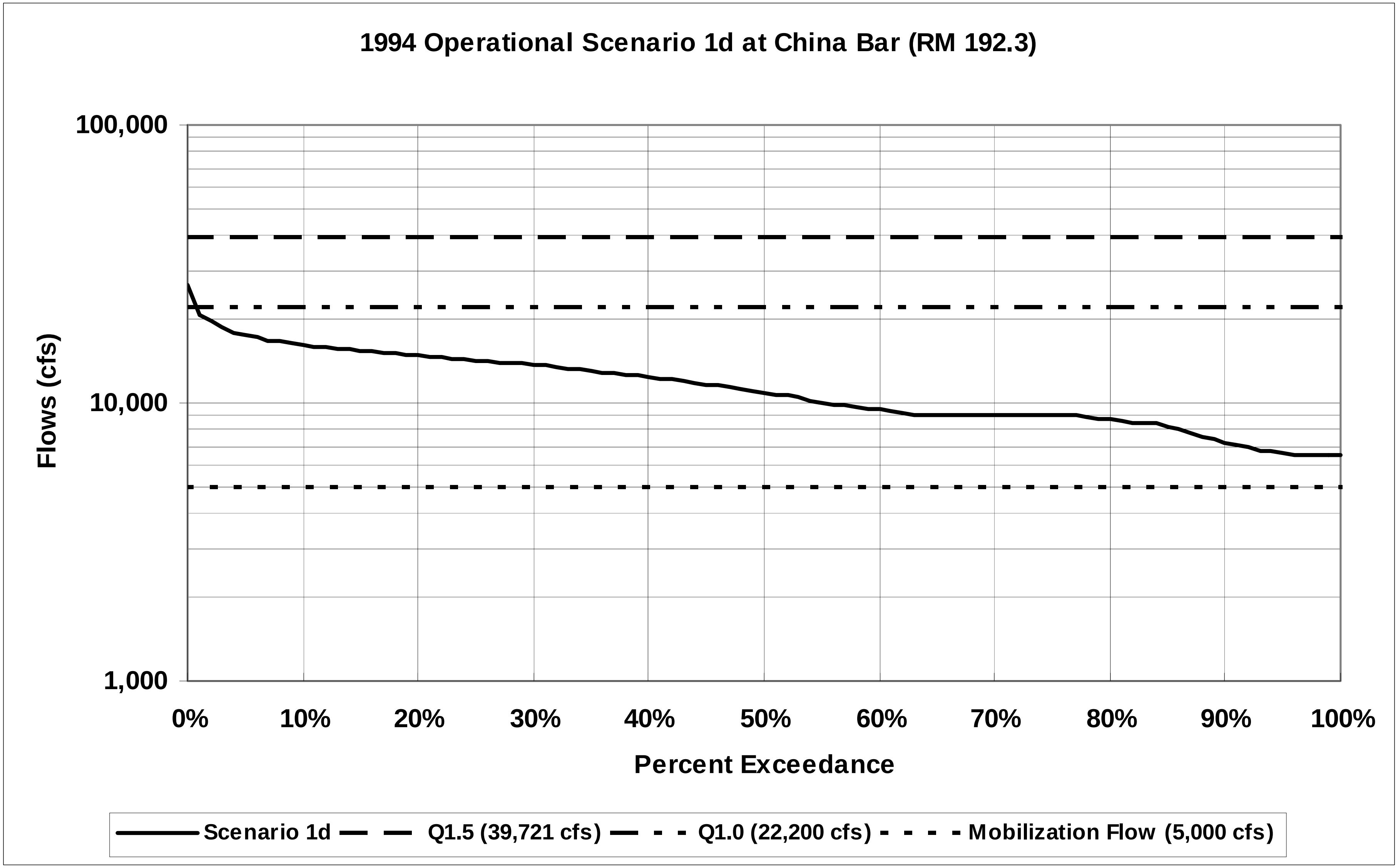


Figure 88. Flow-duration curve for 1994 Operational Scenario 1d at China Bar (RM 192.3).

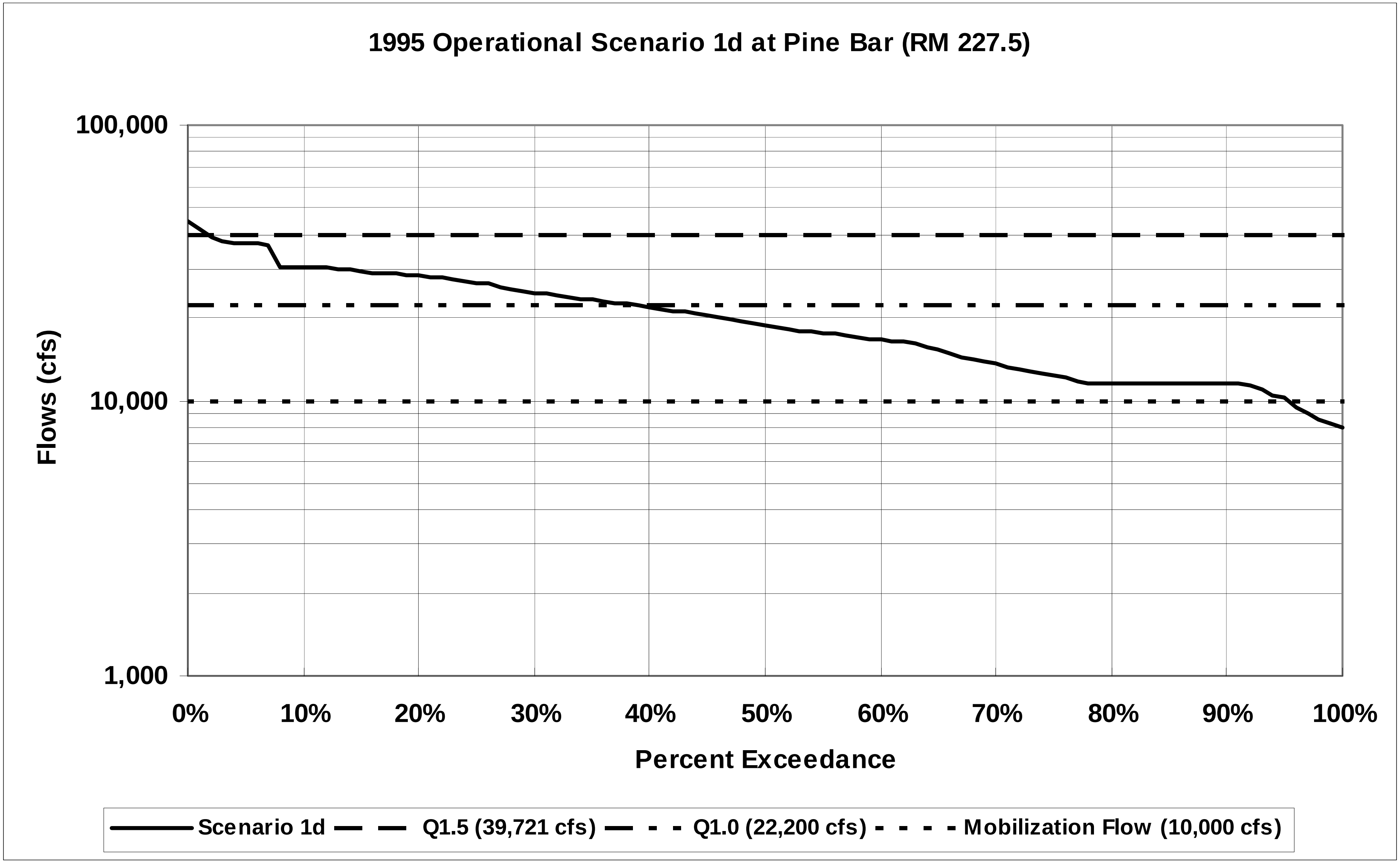


Figure 89. Flow-duration curve for 1995 Operational Scenario 1d at Pine Bar (RM 227.5).

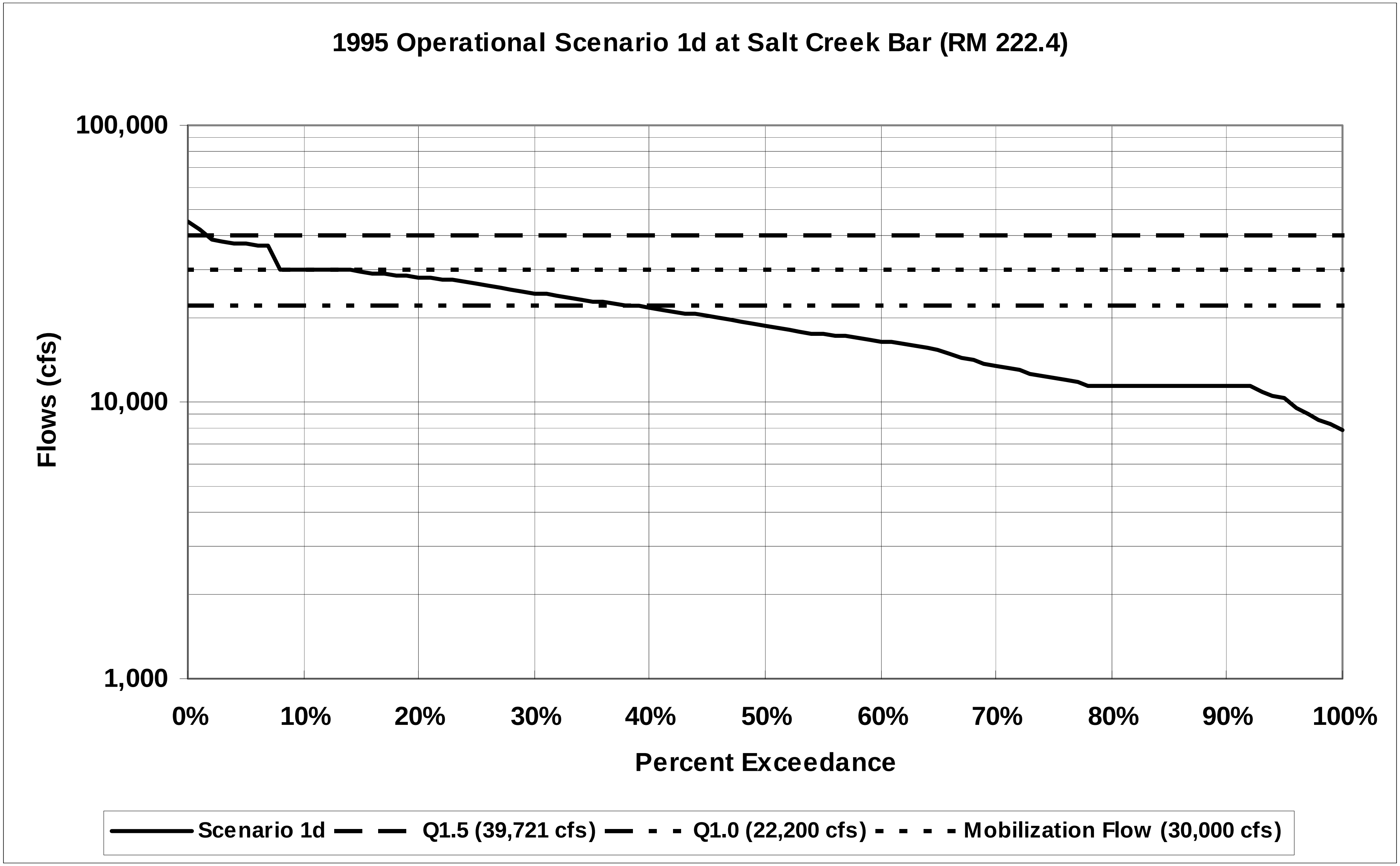


Figure 90. Flow-duration curve for 1995 Operational Scenario 1d at Salt Creek Bar (RM 222.4).

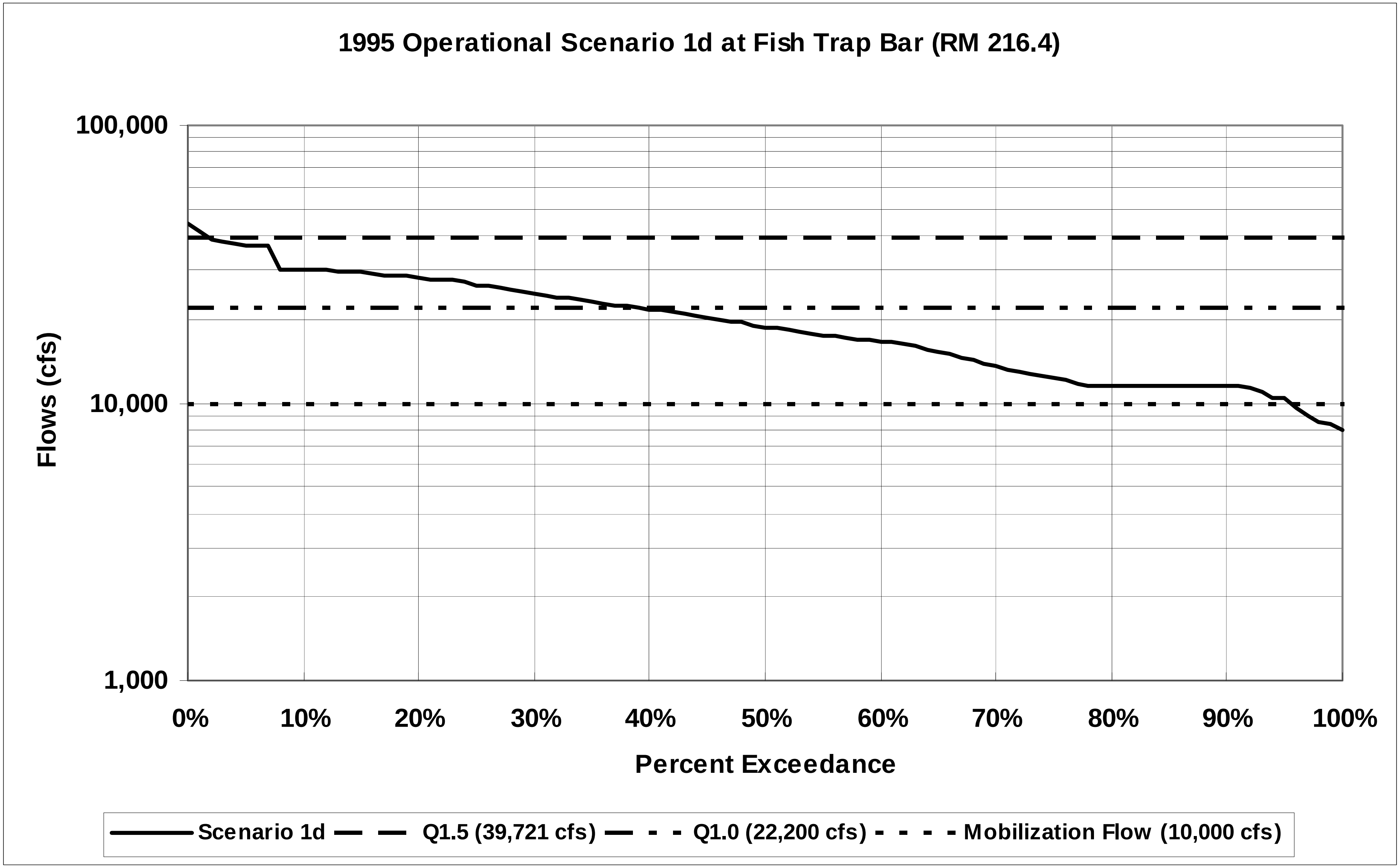


Figure 91. Flow-duration curve for 1995 Operational Scenario 1d at Fish Trap Bar (RM 216.4).

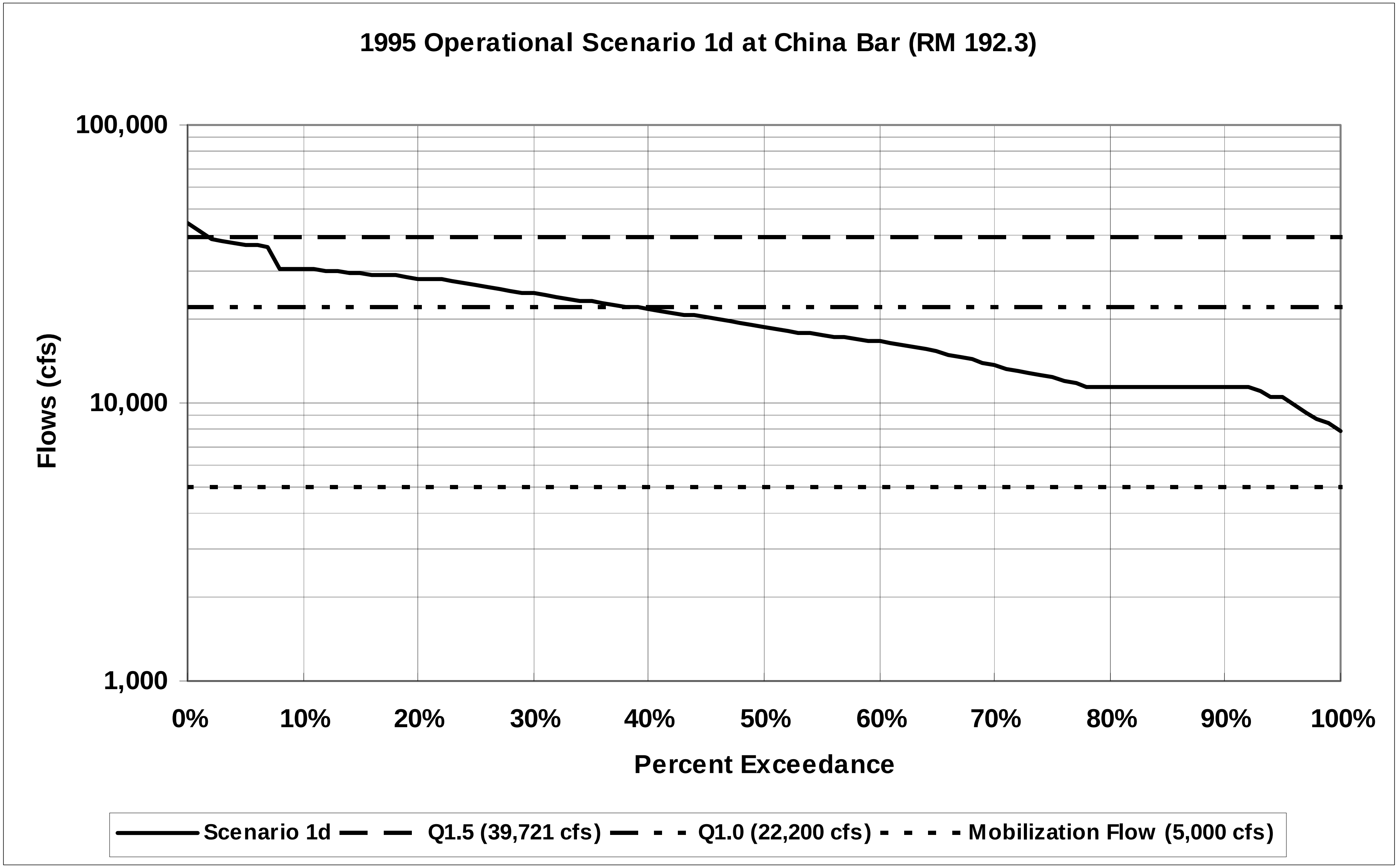


Figure 92. Flow-duration curve for 1995 Operational Scenario 1d at China Bar (RM 192.3).

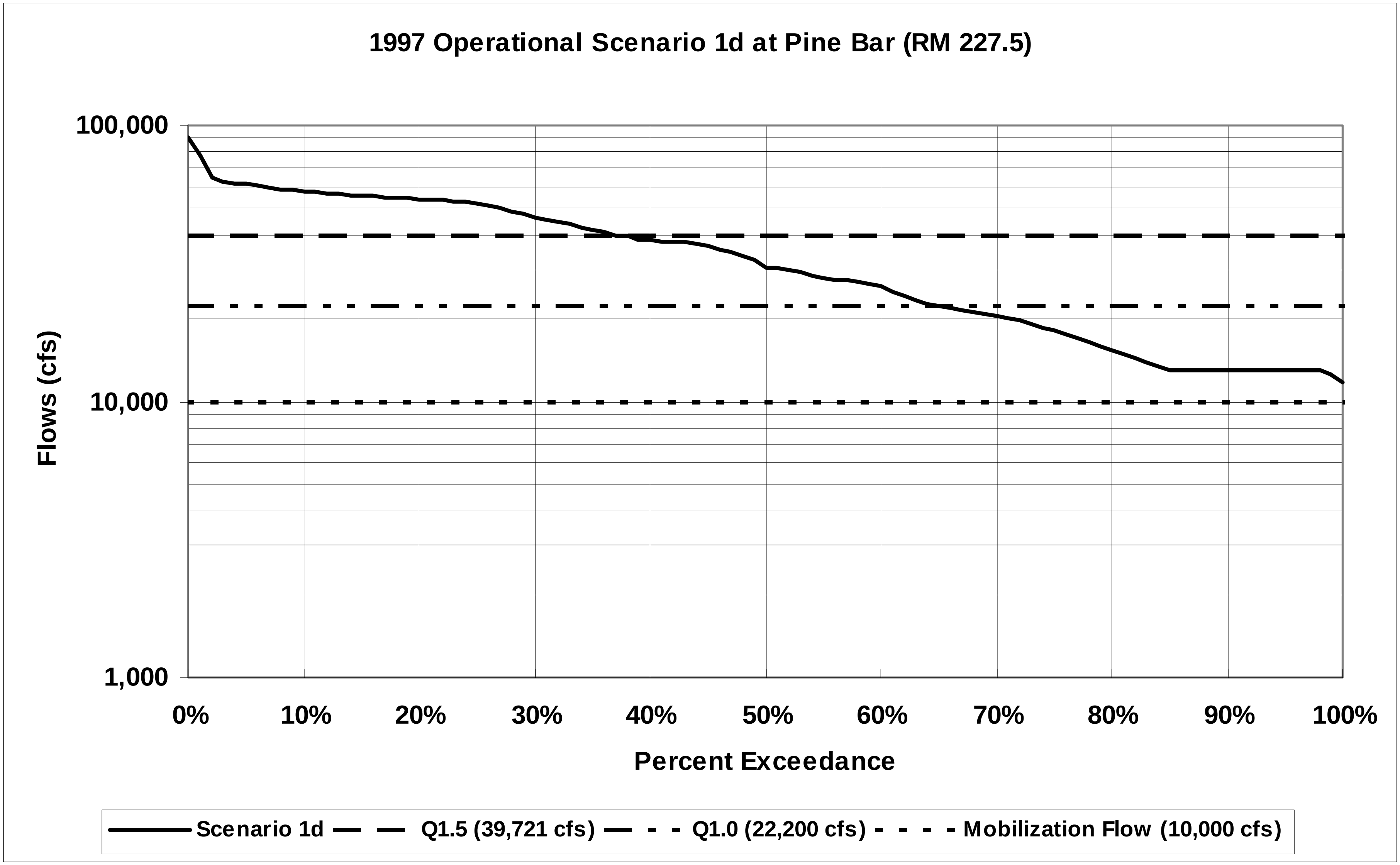


Figure 93. Flow-duration curve for 1997 Operational Scenario 1d at Pine Bar (RM 227.5).

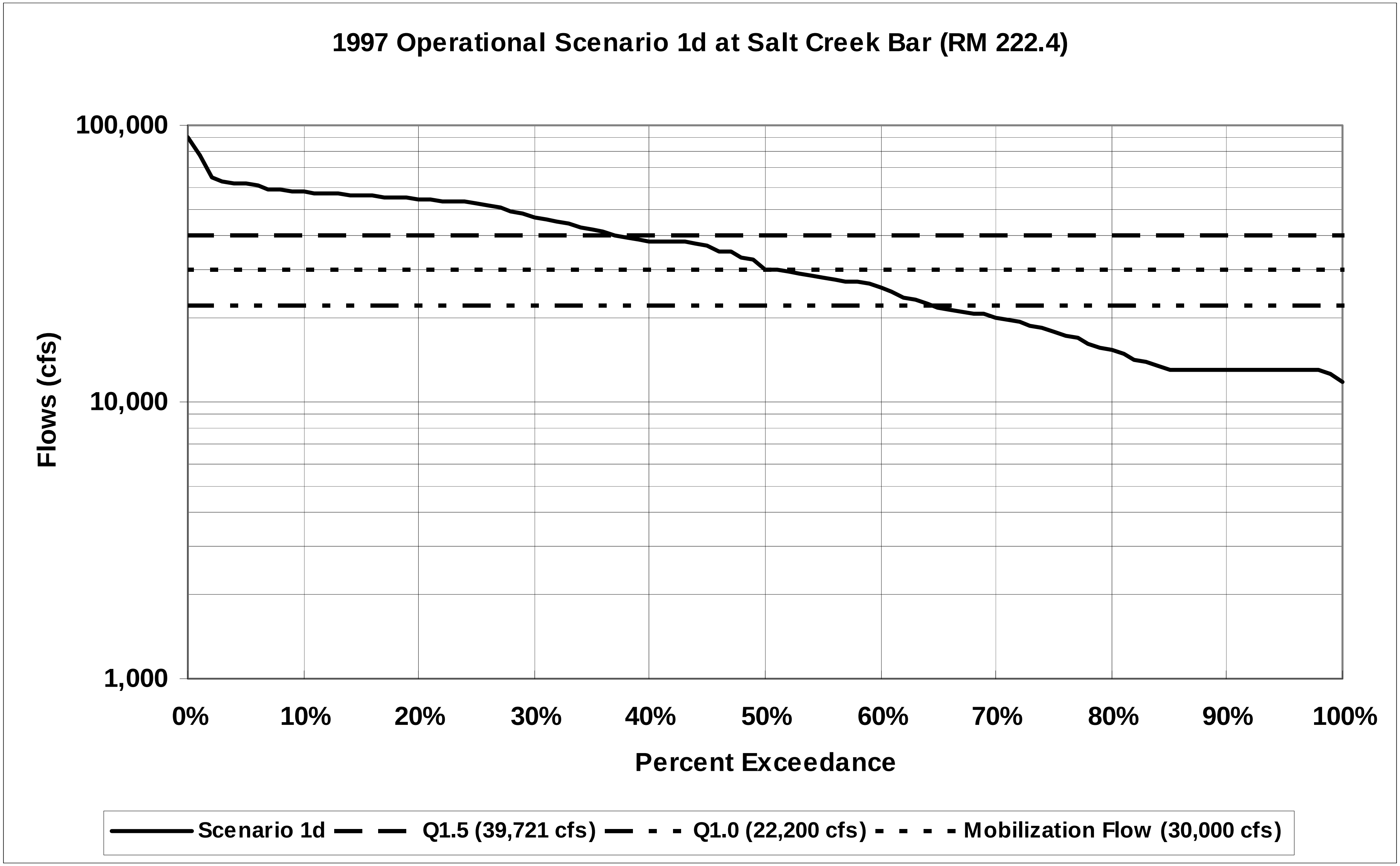


Figure 94. Flow-duration curve for 1997 Operational Scenario 1d at Salt Creek Bar (RM 222.4).

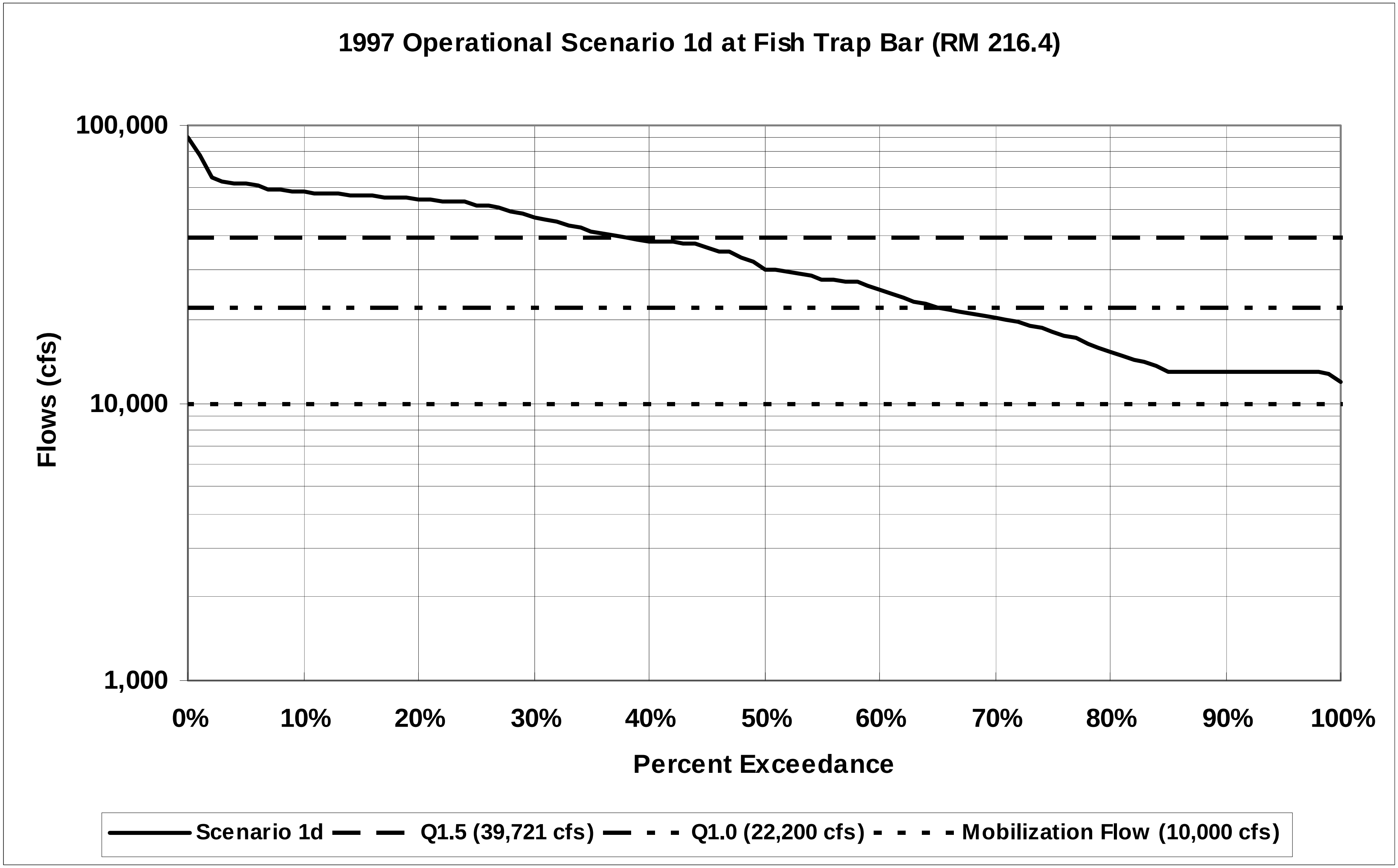


Figure 95. Flow-duration curve for 1997 Operational Scenario 1d at Fish Trap Bar (RM 216.4).

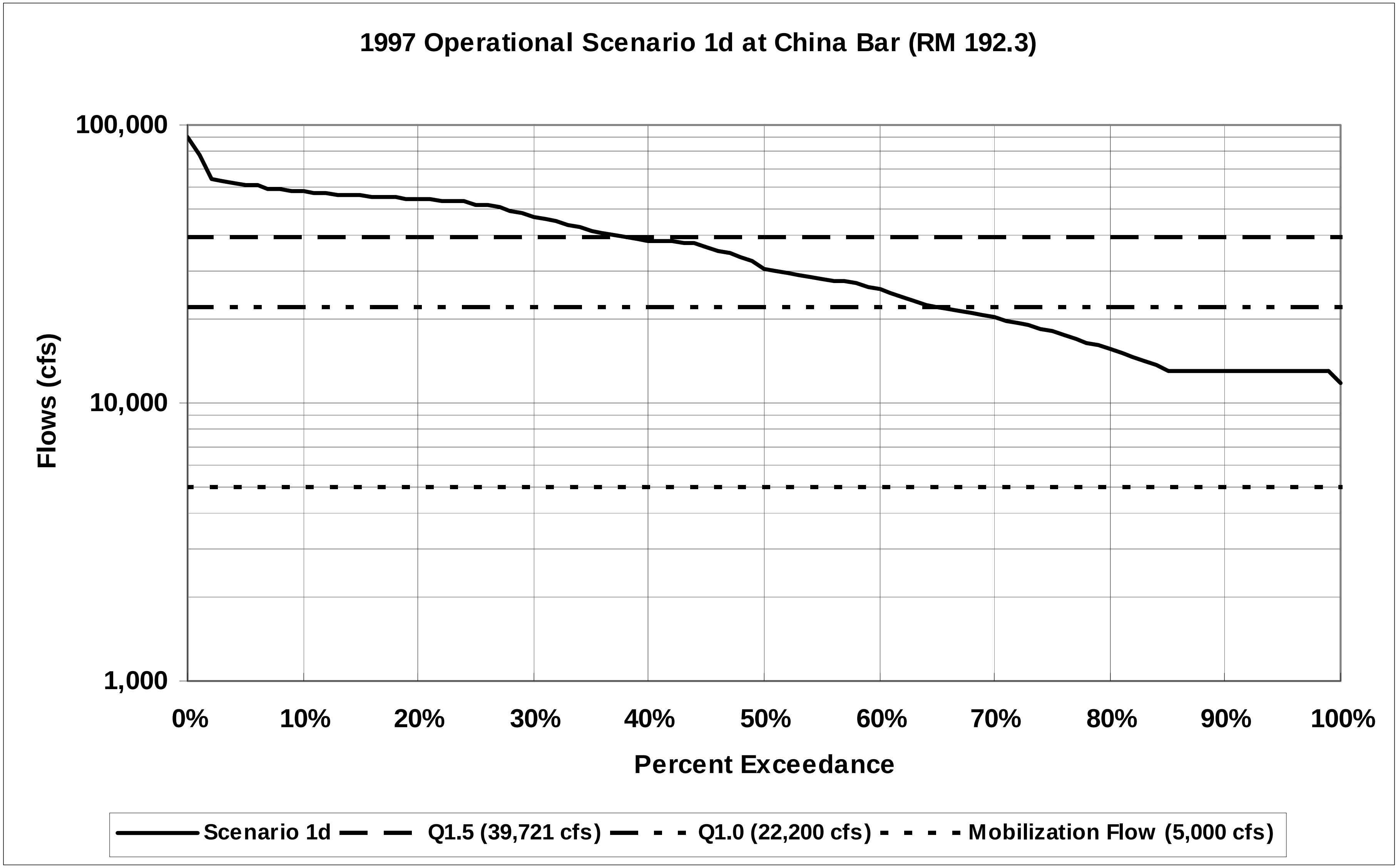


Figure 96. Flow-duration curve for 1997 Operational Scenario 1d at China Bar (RM 192.3).

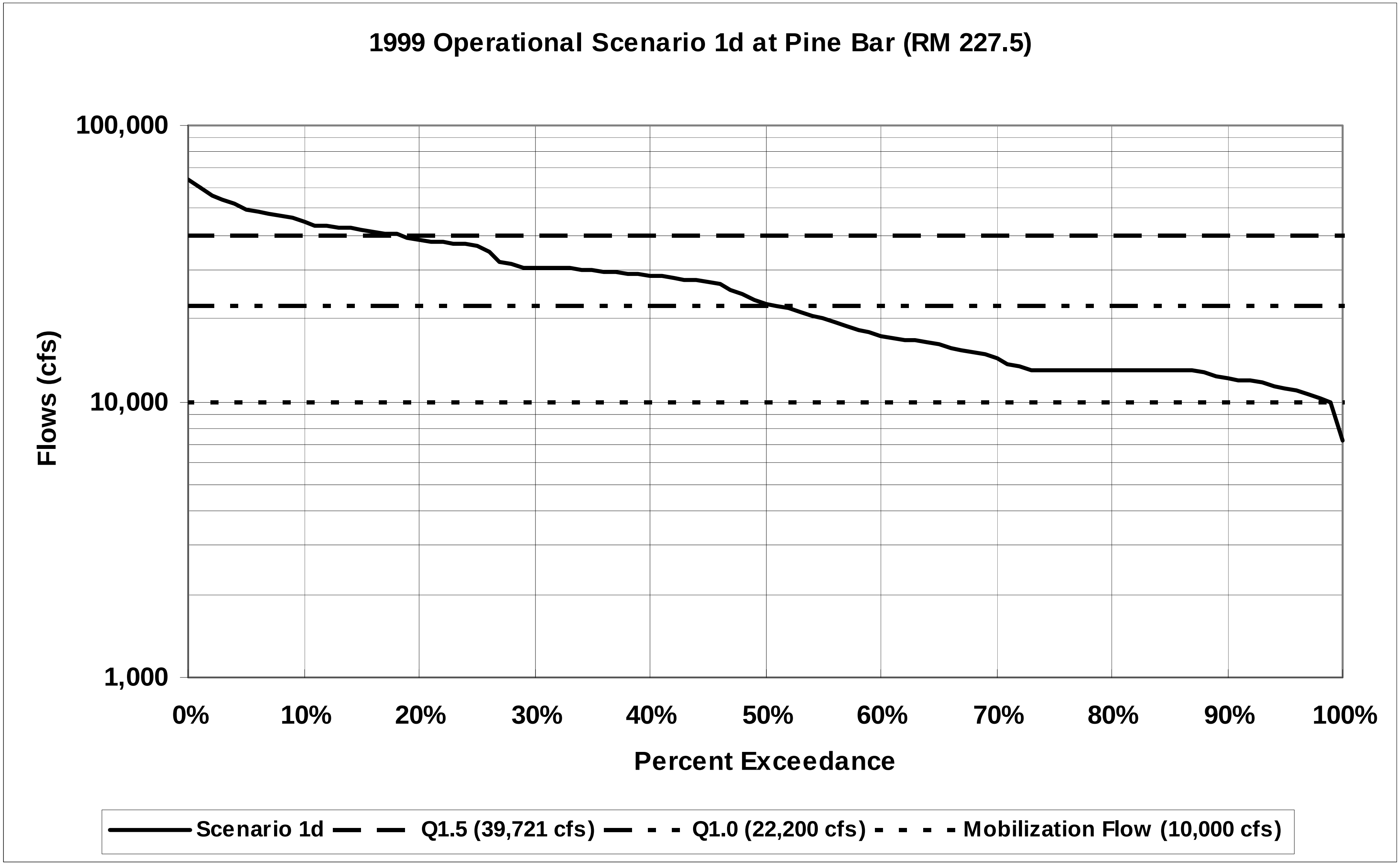


Figure 97. Flow-duration curve for 1999 Operational Scenario 1d at Pine Bar (RM 227.5).

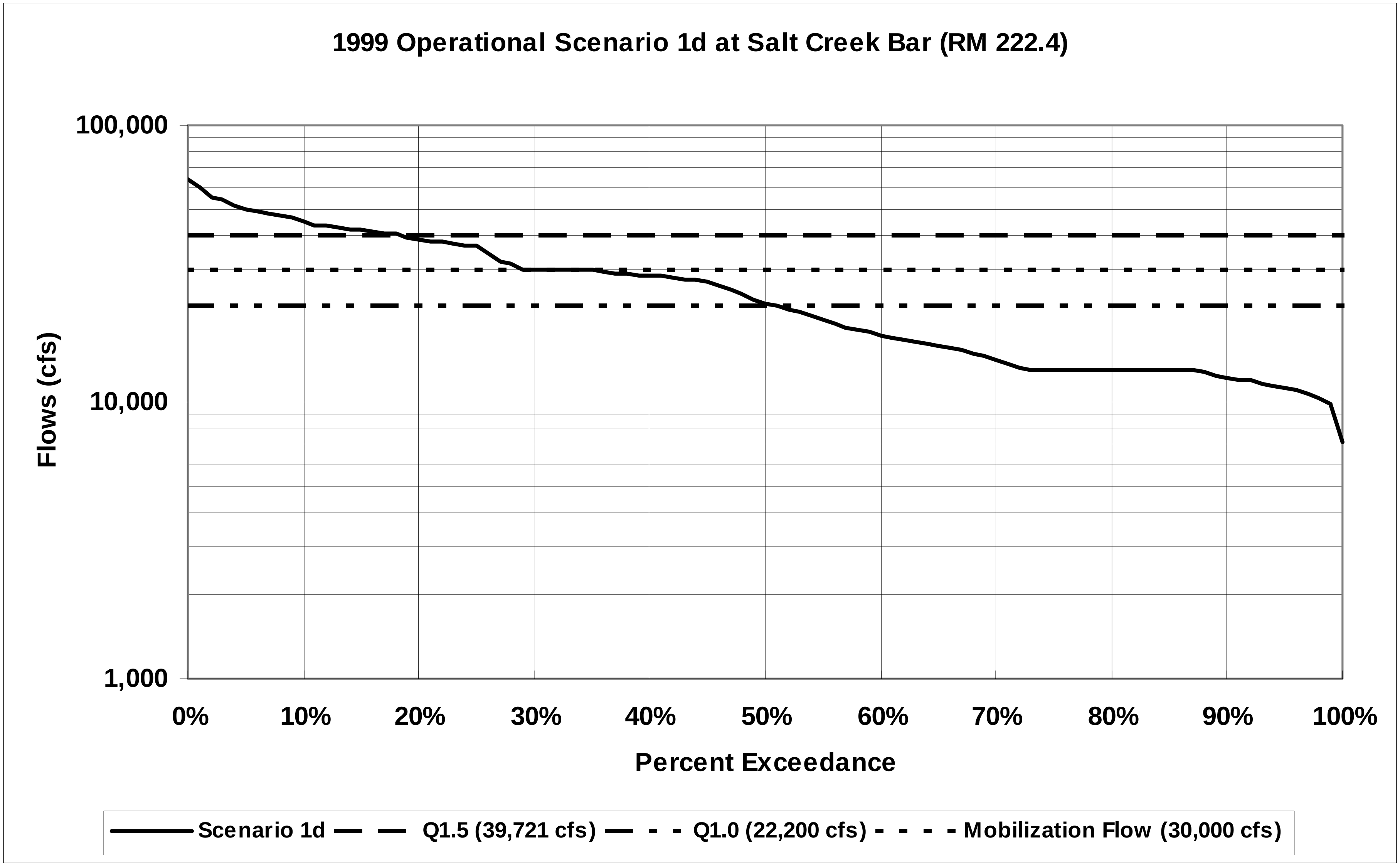


Figure 98. Flow-duration curve for 1999 Operational Scenario 1d at Salt Creek Bar (RM 222.4).

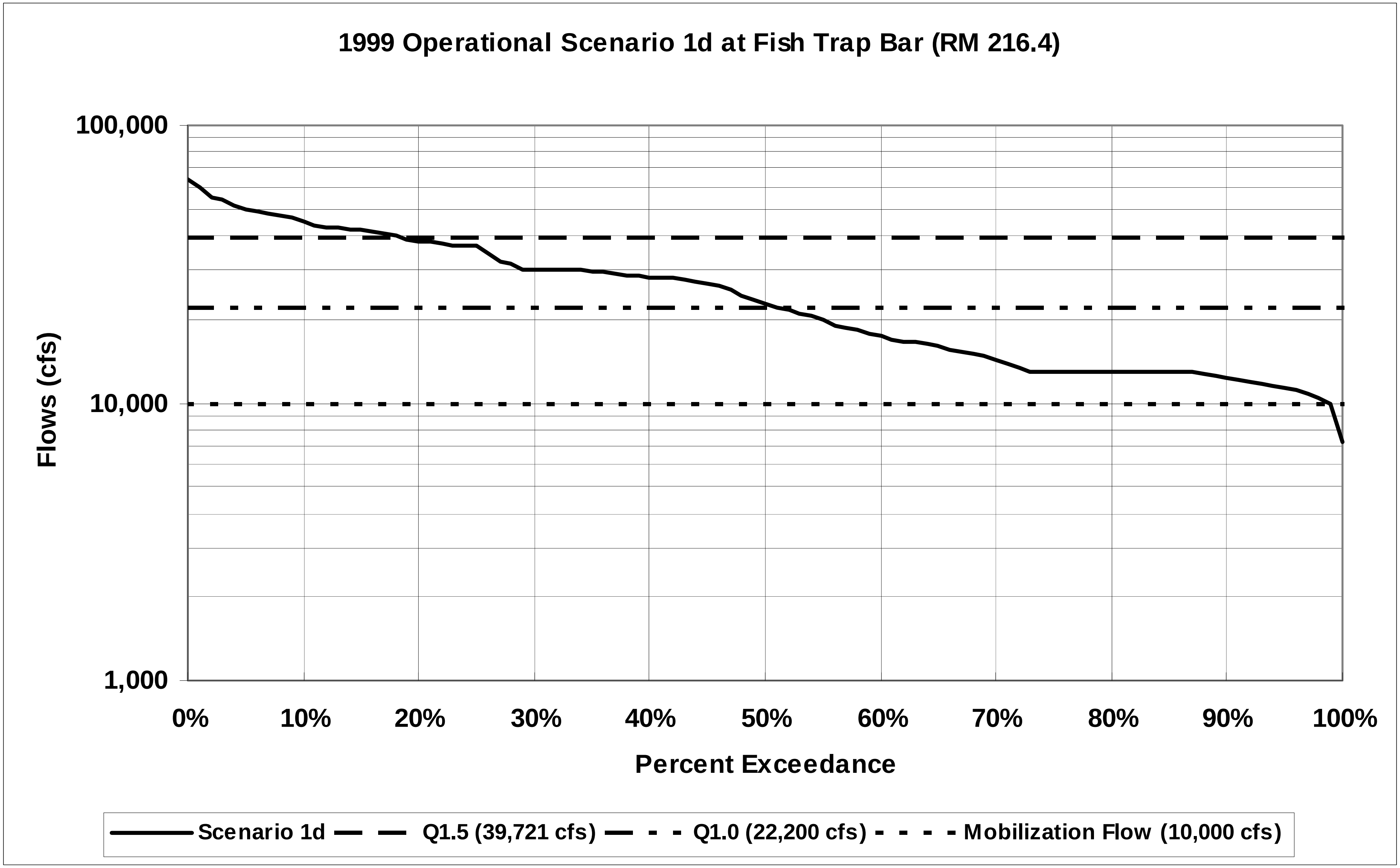


Figure 99. Flow-duration curve for 1999 Operational Scenario 1d at Fish Trap Bar (RM 216.4).

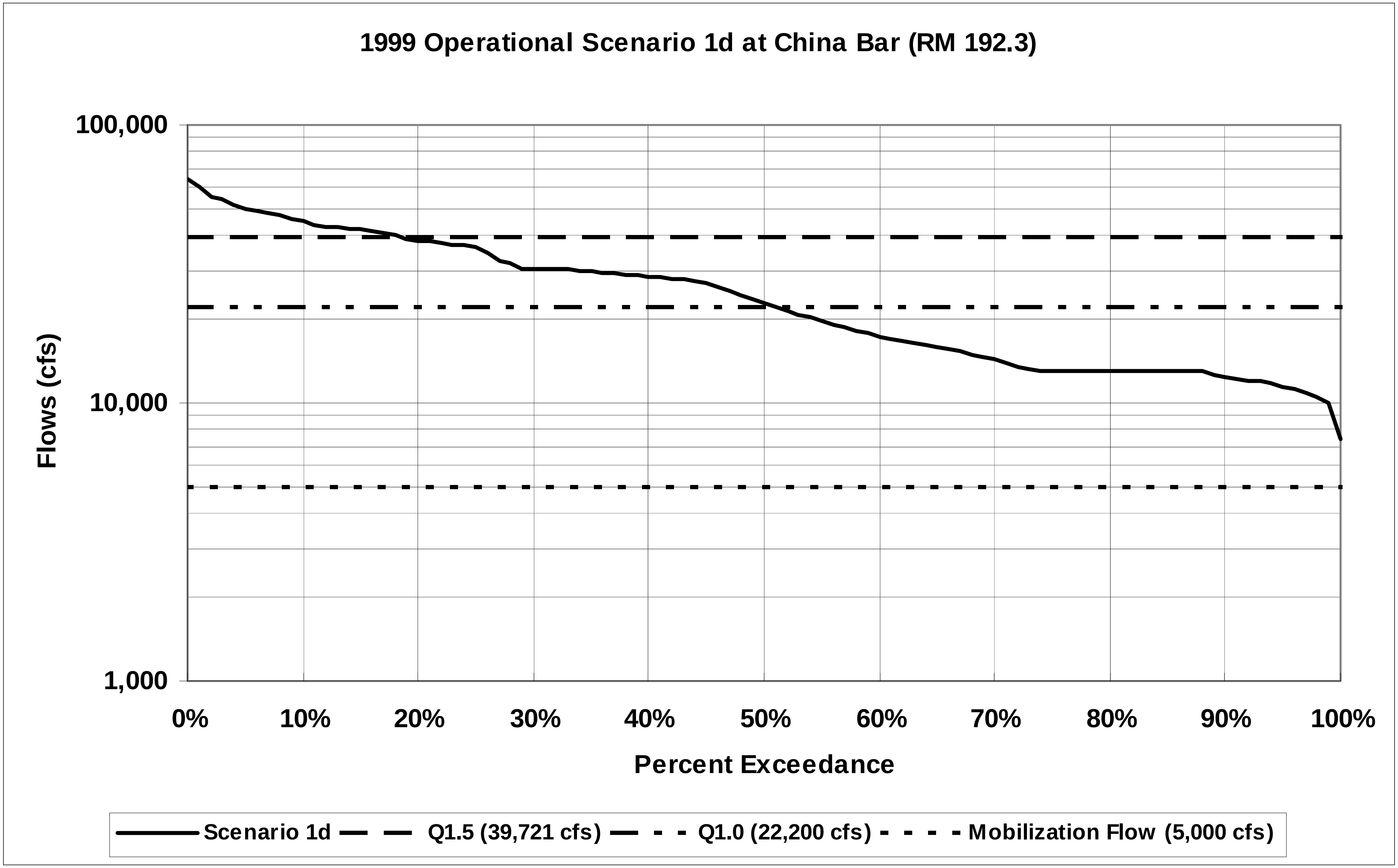


Figure 100. Flow-duration curve for 1999 Operational Scenario 1d at China Bar (RM 192.3).

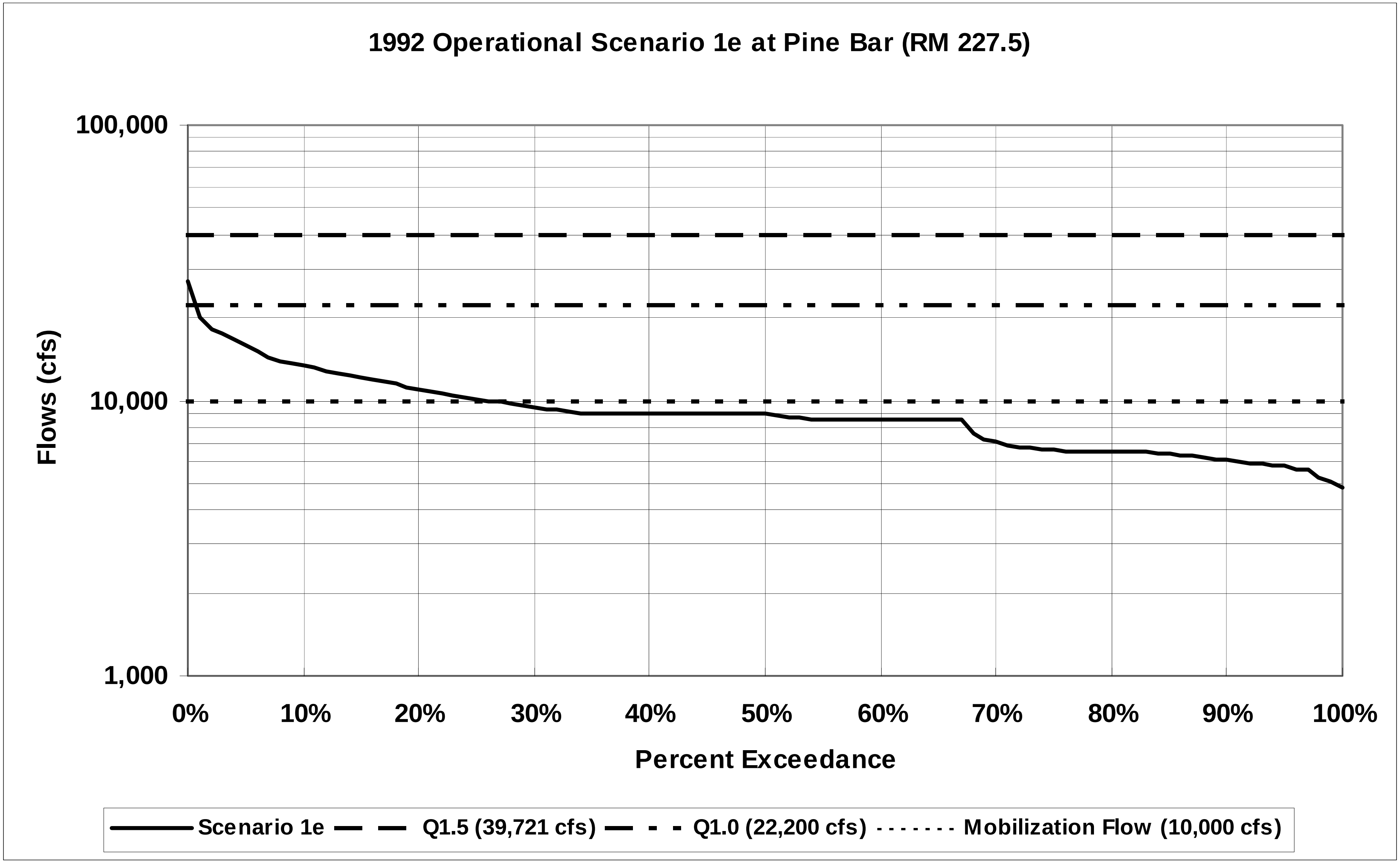


Figure 101. Flow-duration curve for 1992 Operational Scenario 1e at Pine Bar (RM 227.5).

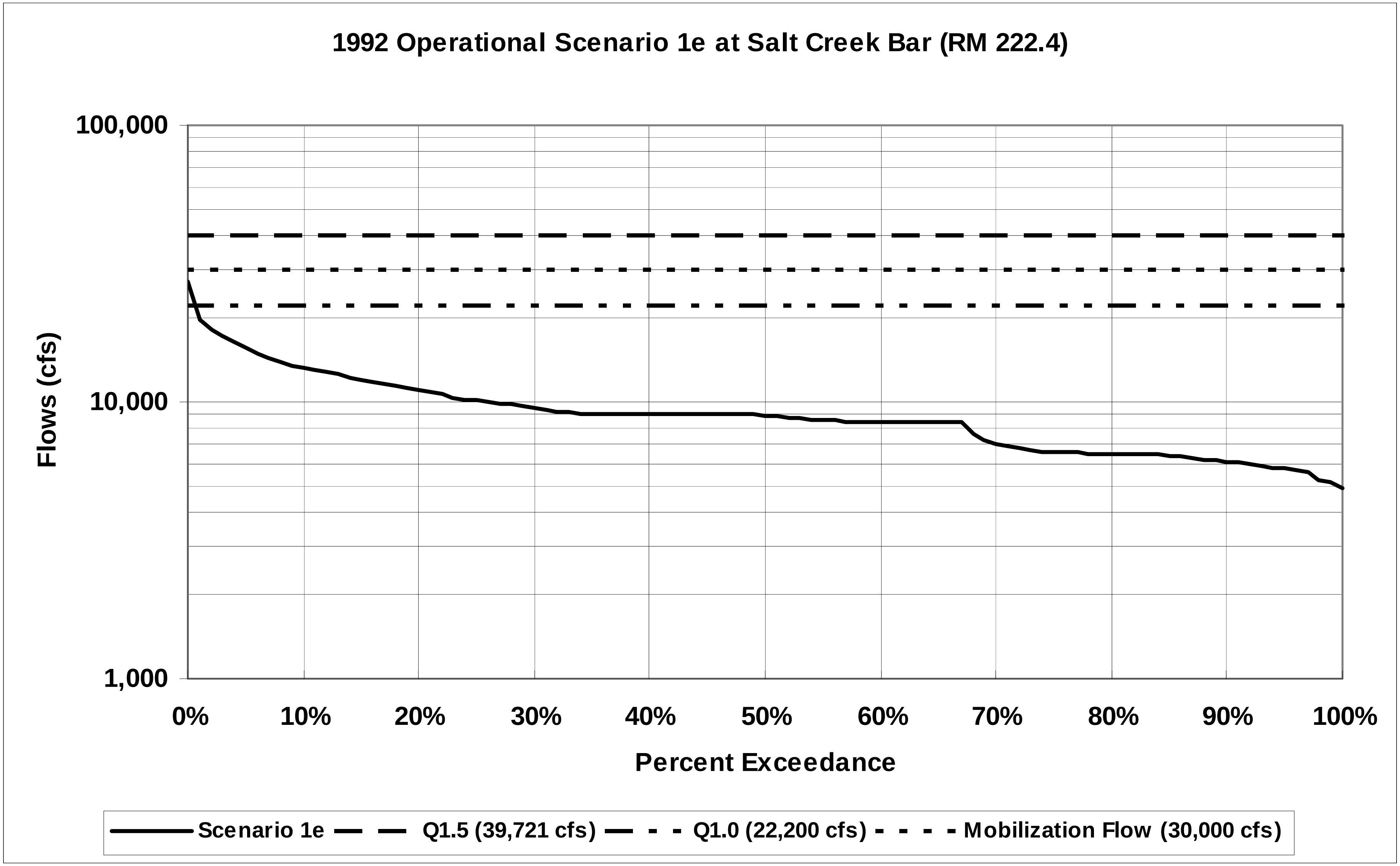


Figure 102. Flow-duration curve for 1992 Operational Scenario 1e at Salt Creek Bar (222.4).

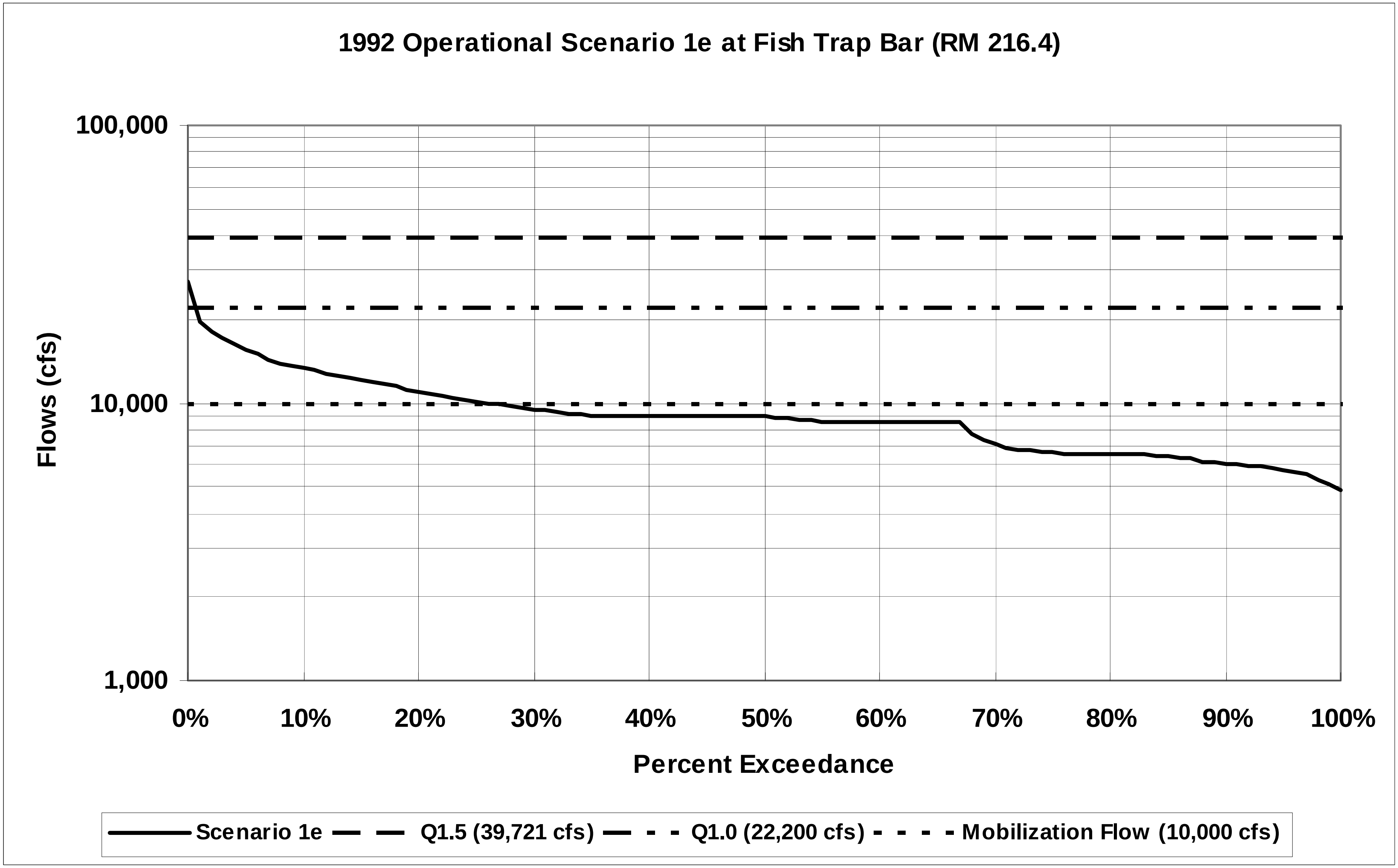


Figure 103. Flow-duration curve for 1992 Operational Scenario 1e at Fish Trap Bar (RM 216.4).

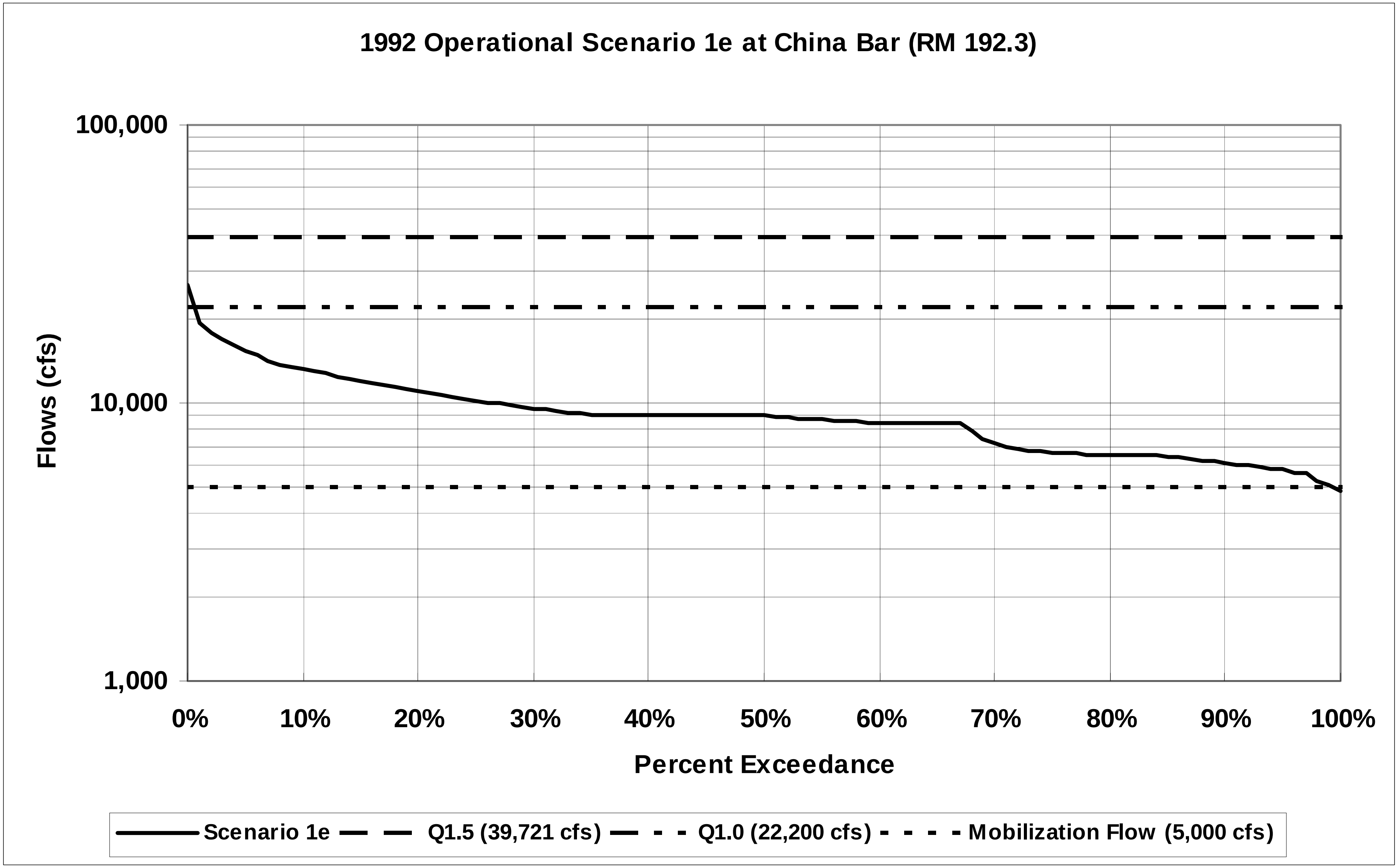


Figure 104. Flow-duration curve for 1992 Operational Scenario 1e at China Bar (RM 192.3).

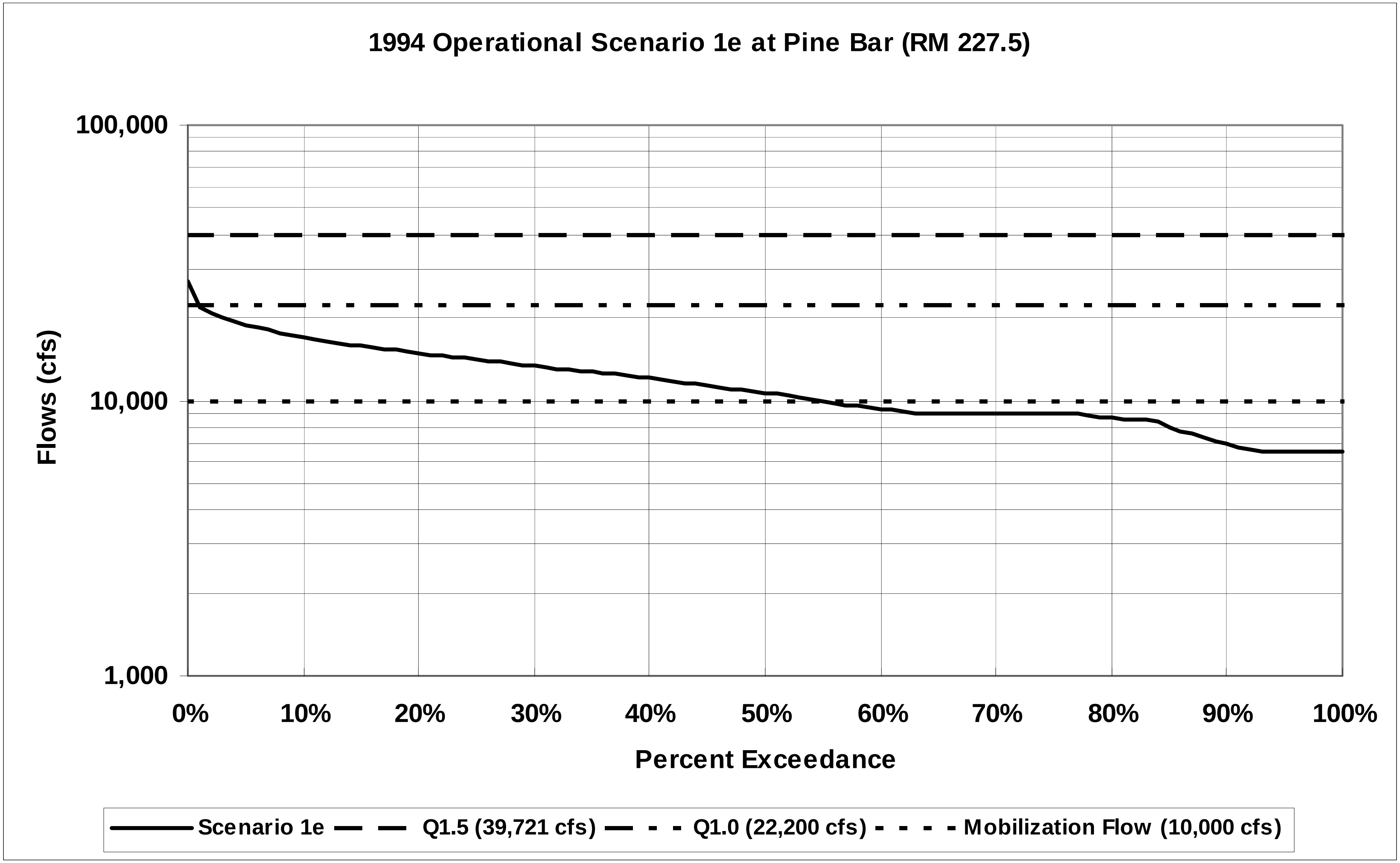


Figure 105. Flow-duration curve for 1994 Operational Scenario 1e at Pine Bar (RM 227.5).

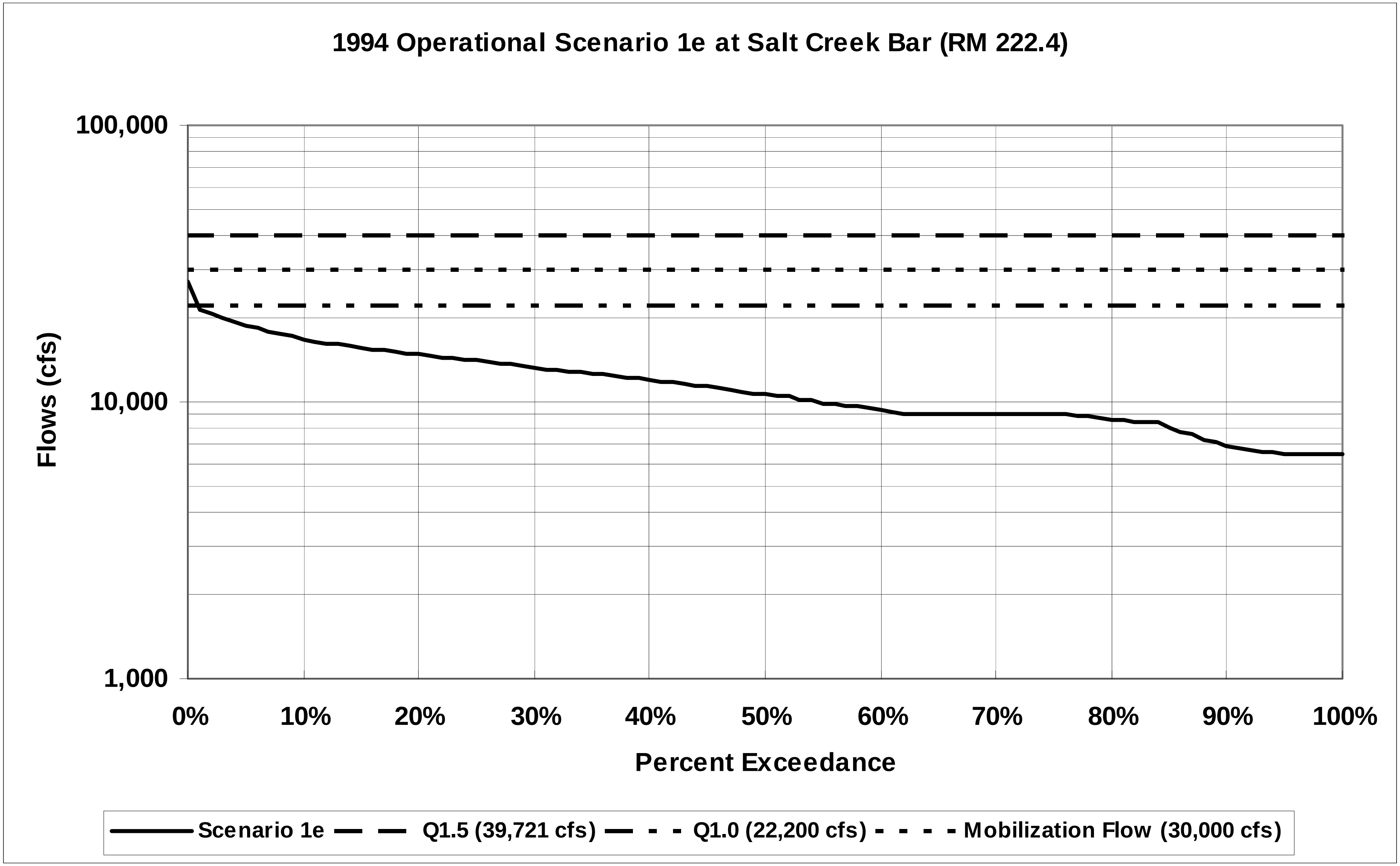


Figure 106. Flow-duration curve for 1994 Operational Scenario 1e at Salt Creek Bar (RM 222.4).

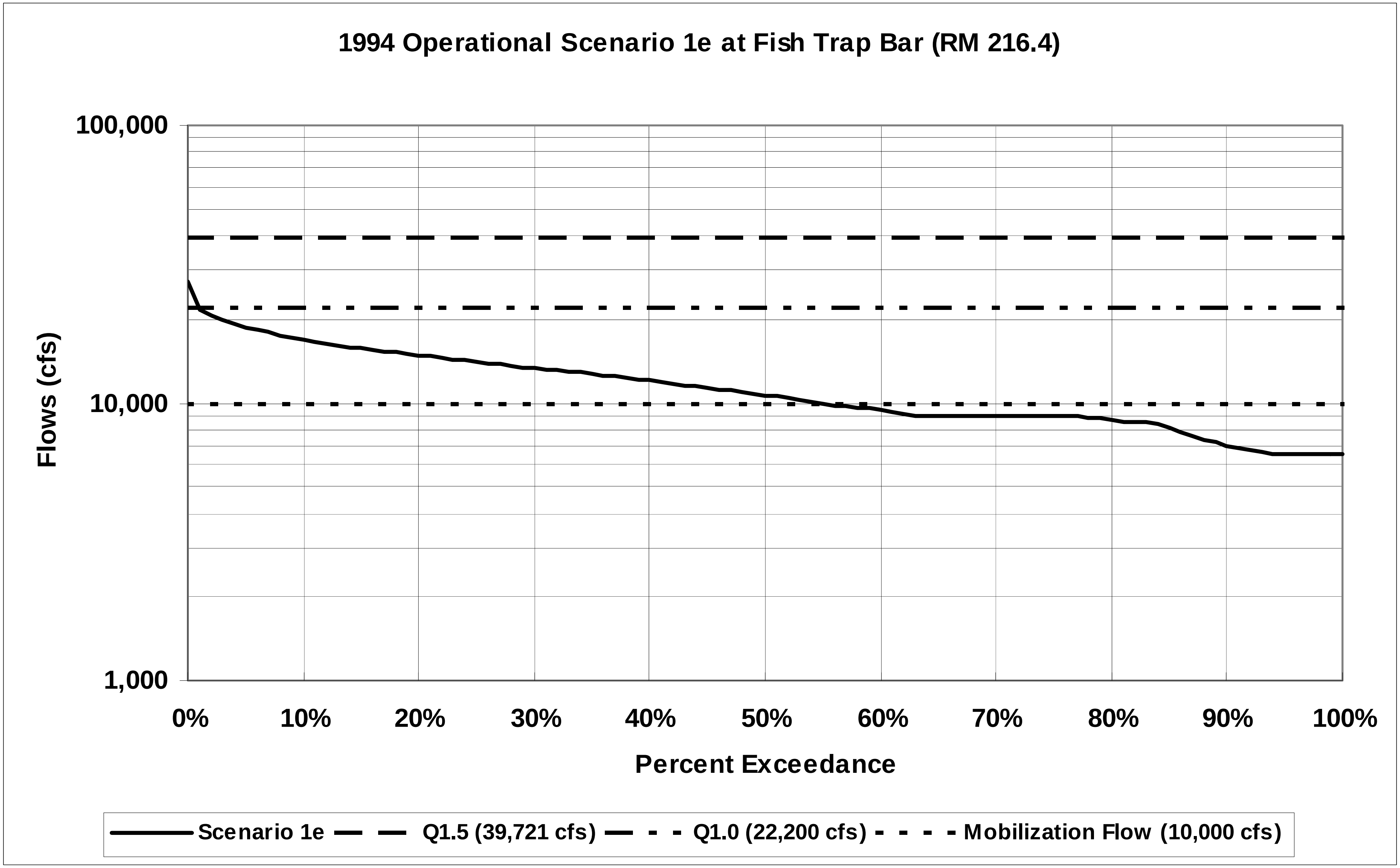


Figure 107. Flow-duration curve for 1994 Operational Scenario 1e at Fish Trap Bar (RM 216.4).

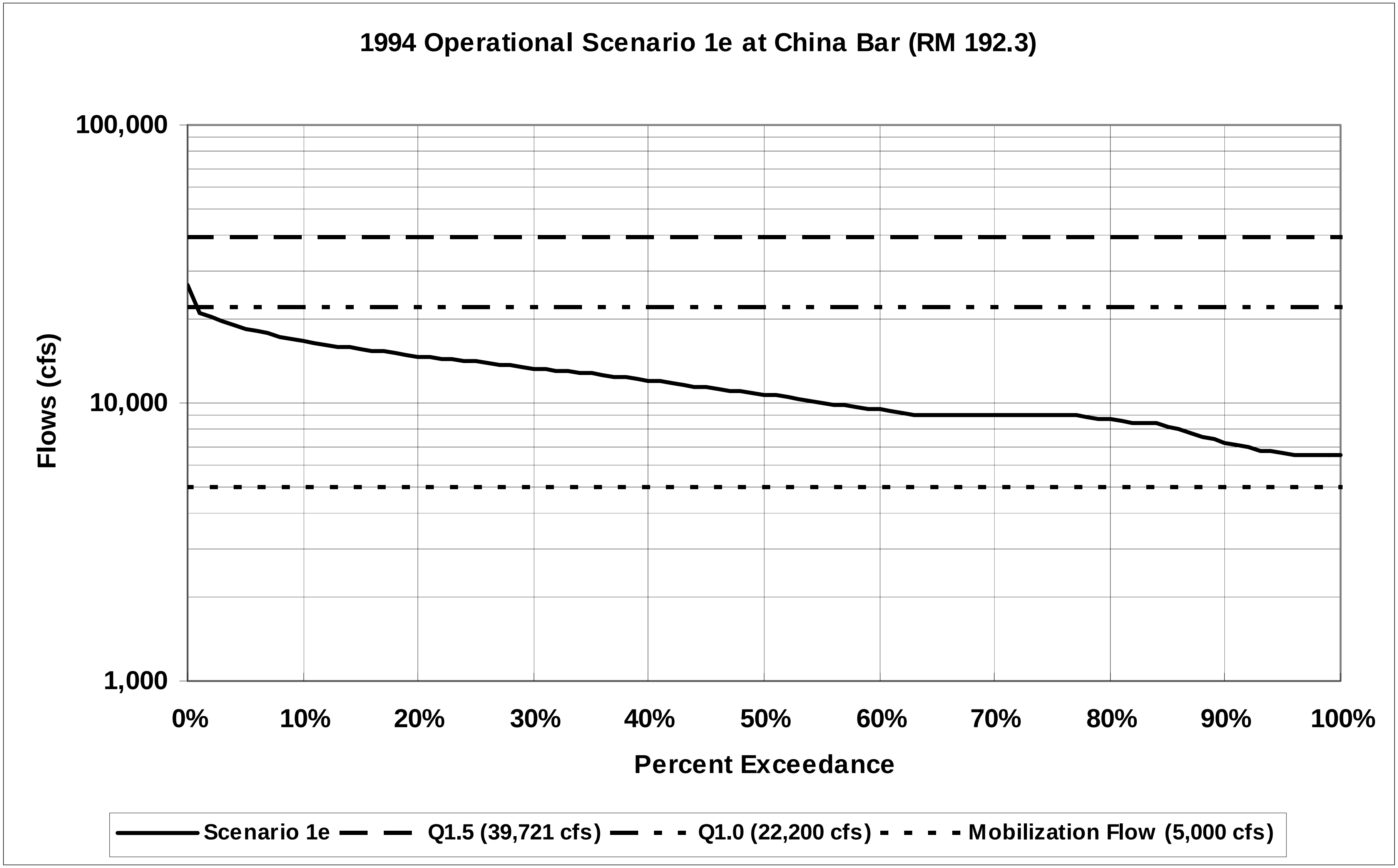


Figure 108. Flow-duration curve for 1994 Operational Scenario 1e at China Bar (RM 192.3).

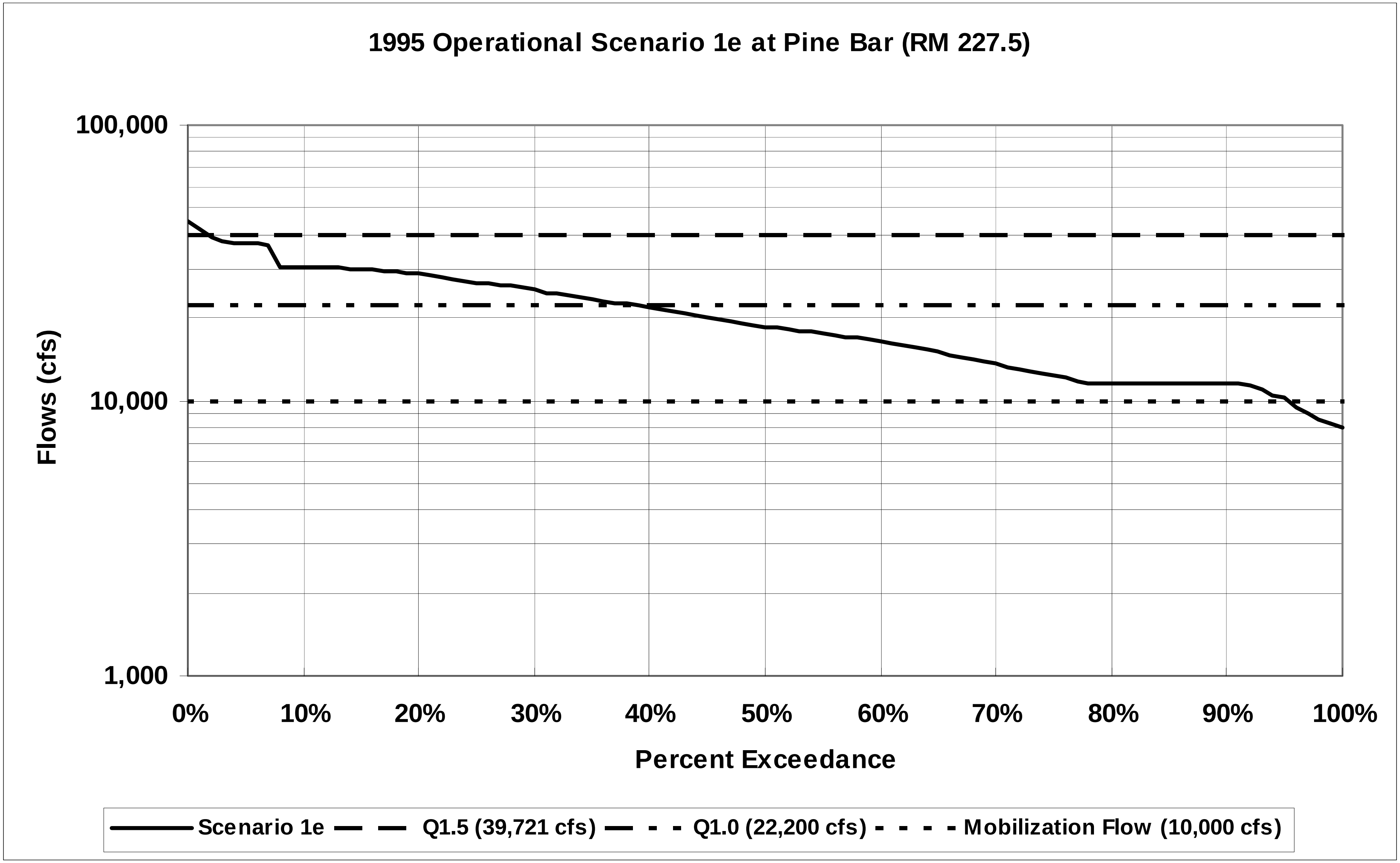


Figure 109. Flow-duration curve for 1995 Operational Scenario 1e at Pine Bar (RM 227.5).

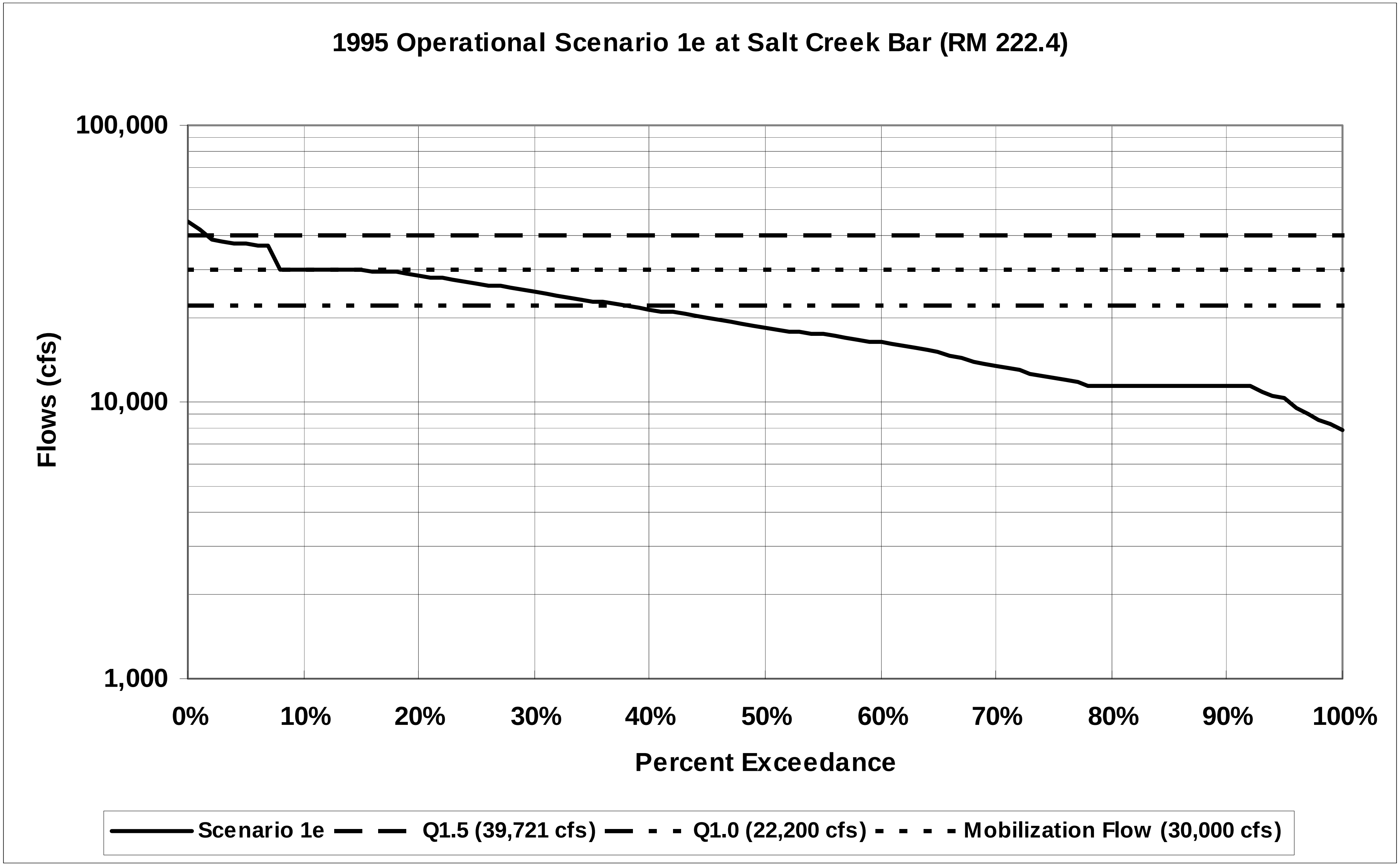


Figure 110. Flow-duration curve for 1995 Operational Scenario 1e at Salt Creek Bar (RM 222.4).

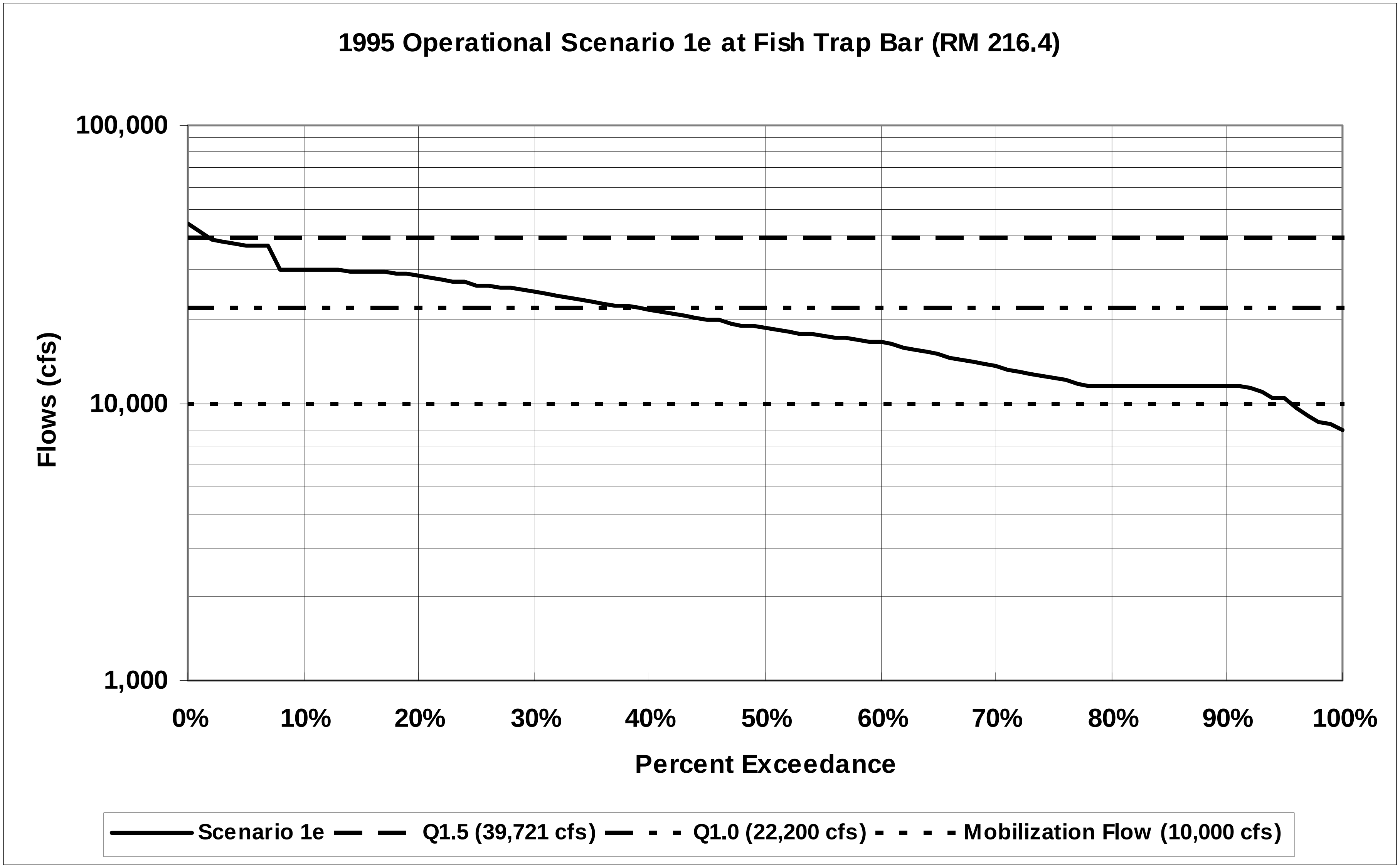


Figure 111. Flow-duration curve for 1995 Operational Scenario 1e at Fish Trap Bar (RM 216.4).

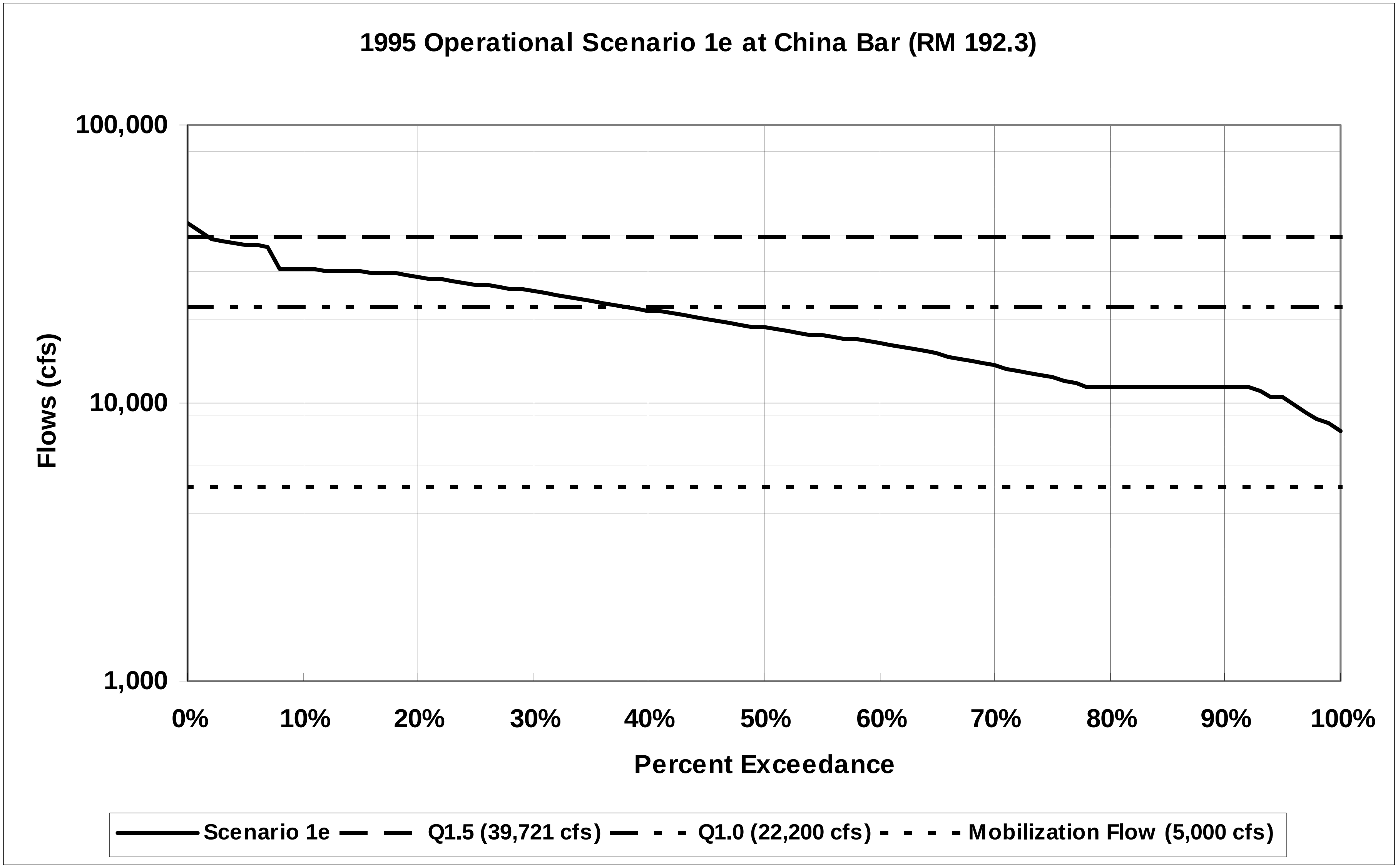


Figure 112. Flow-duration curve for 1995 Operational Scenario 1e at China Bar (RM 192.3).

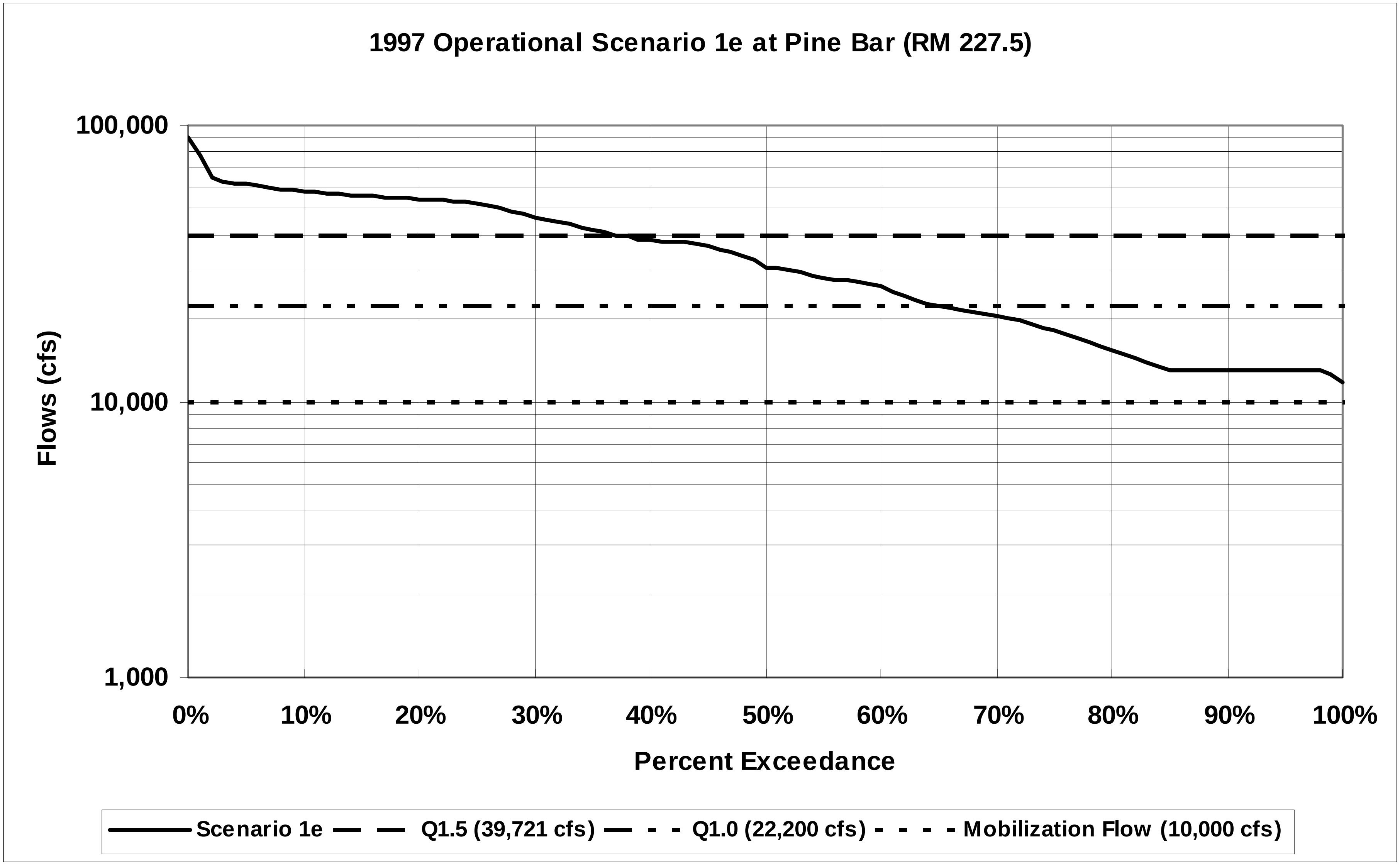


Figure 113. Flow-duration curve for 1997 Operational Scenario 1e at Pine Bar (RM 227.5).

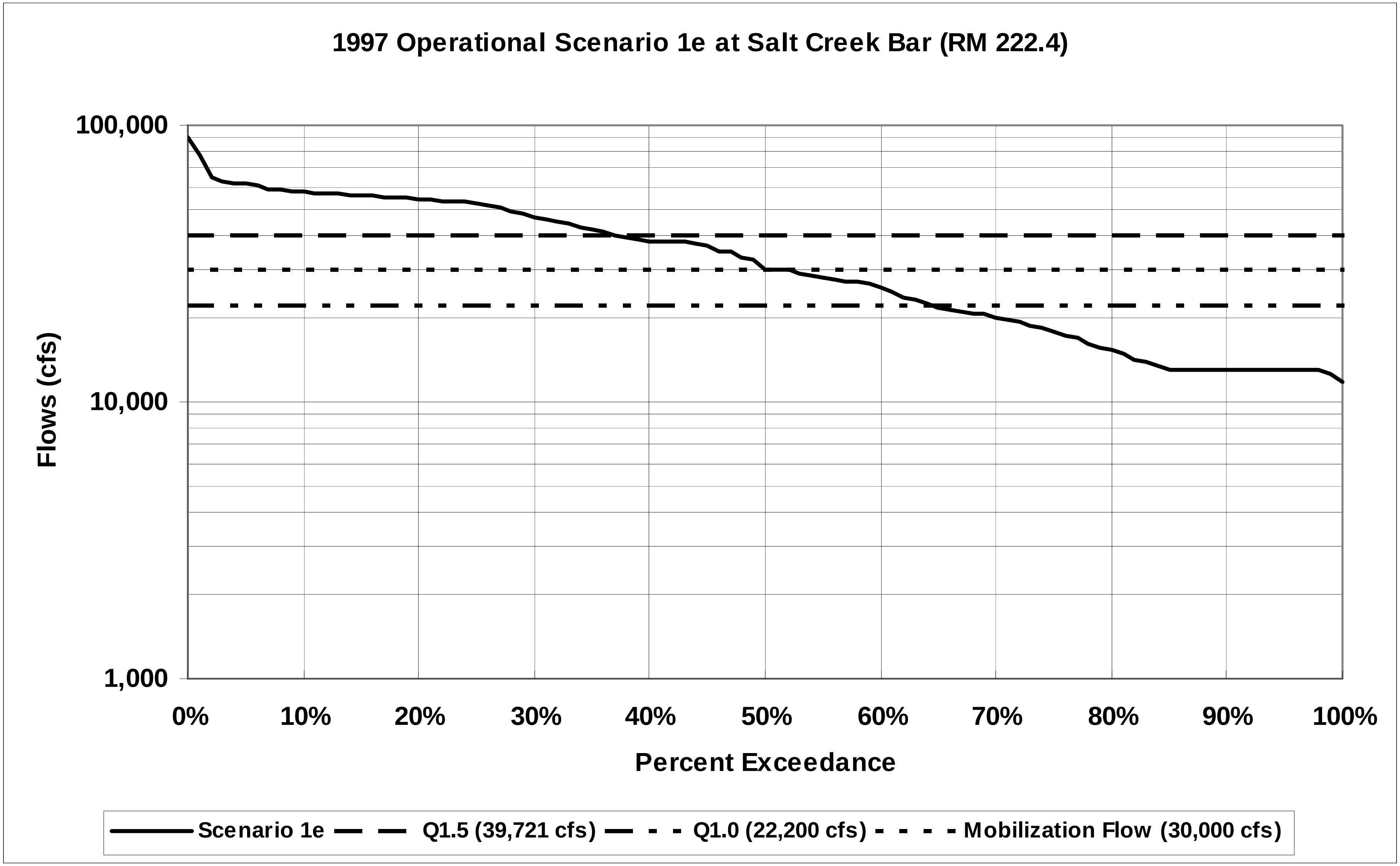


Figure 114. Flow-duration curve for 1997 Operational Scenario 1e at Salt Creek Bar (RM 222.4).

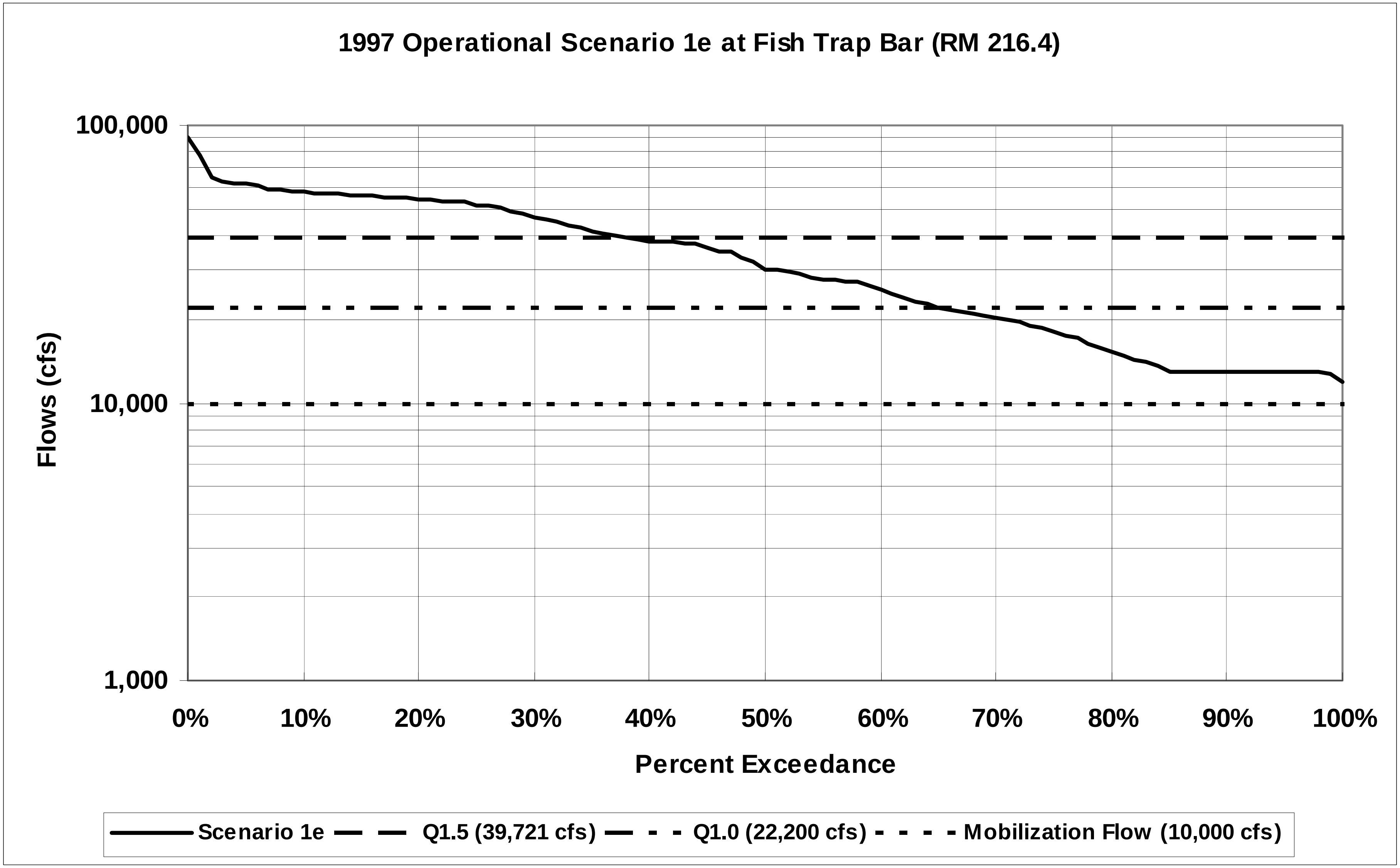


Figure 115. Flow-duration curve for 1997 Operational Scenario 1e at Fish Trap Bar (RM 216.4).

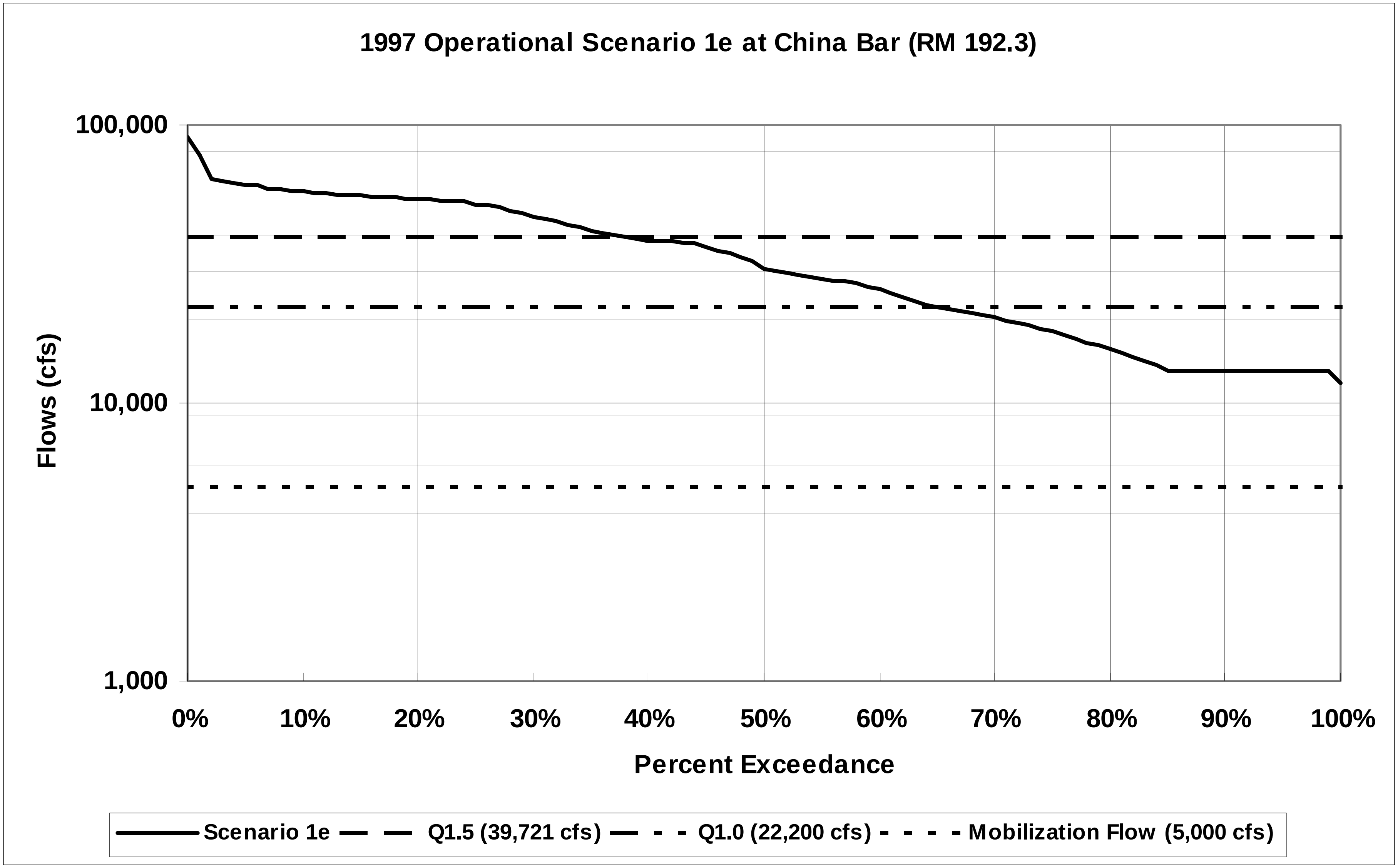


Figure 116. Flow-duration curve for 1997 Operational Scenario 1e at China Bar (RM 192.3).

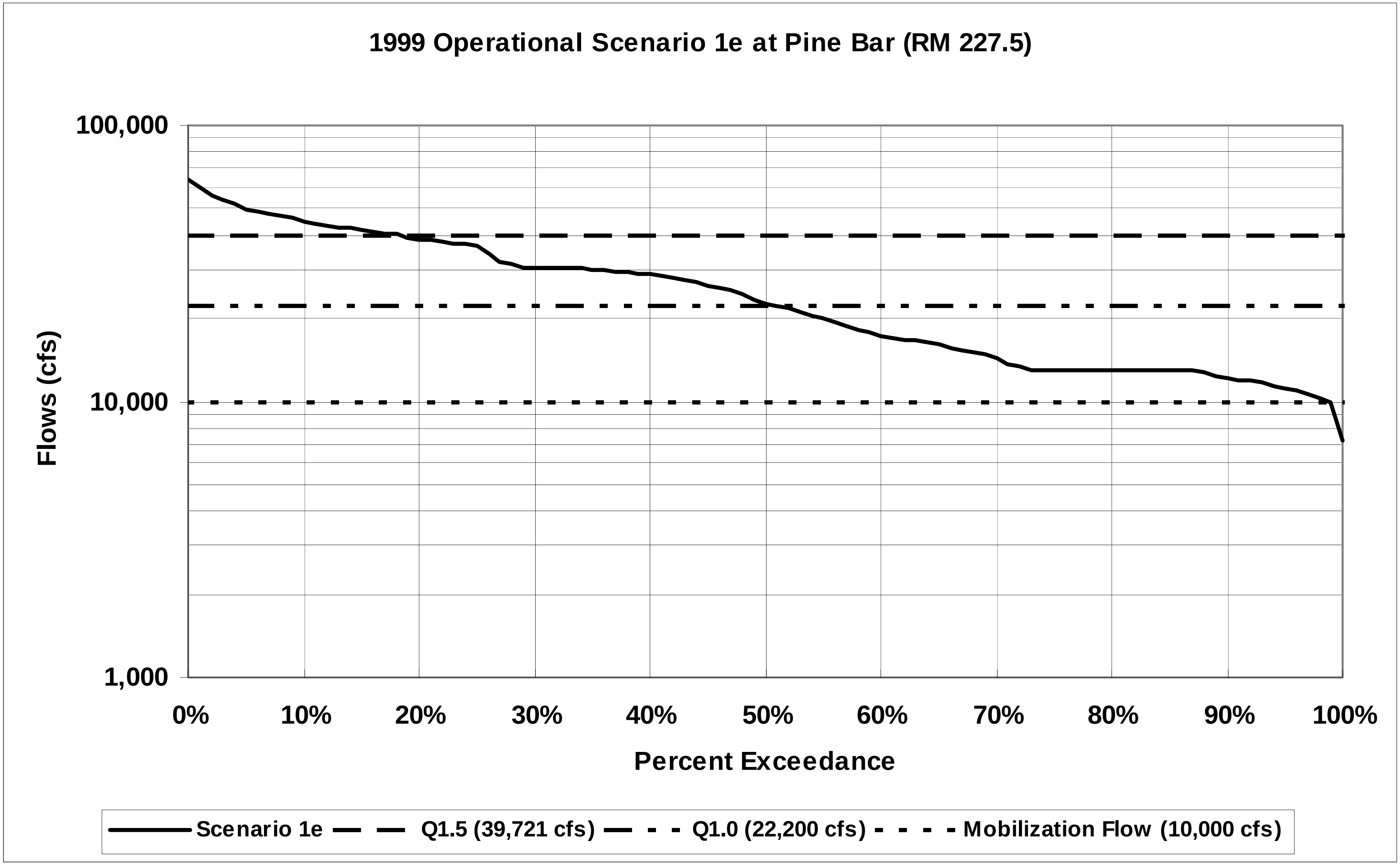


Figure 117. Flow-duration curve for 1999 Operational Scenario 1e at Pine Bar (RM 227.5).

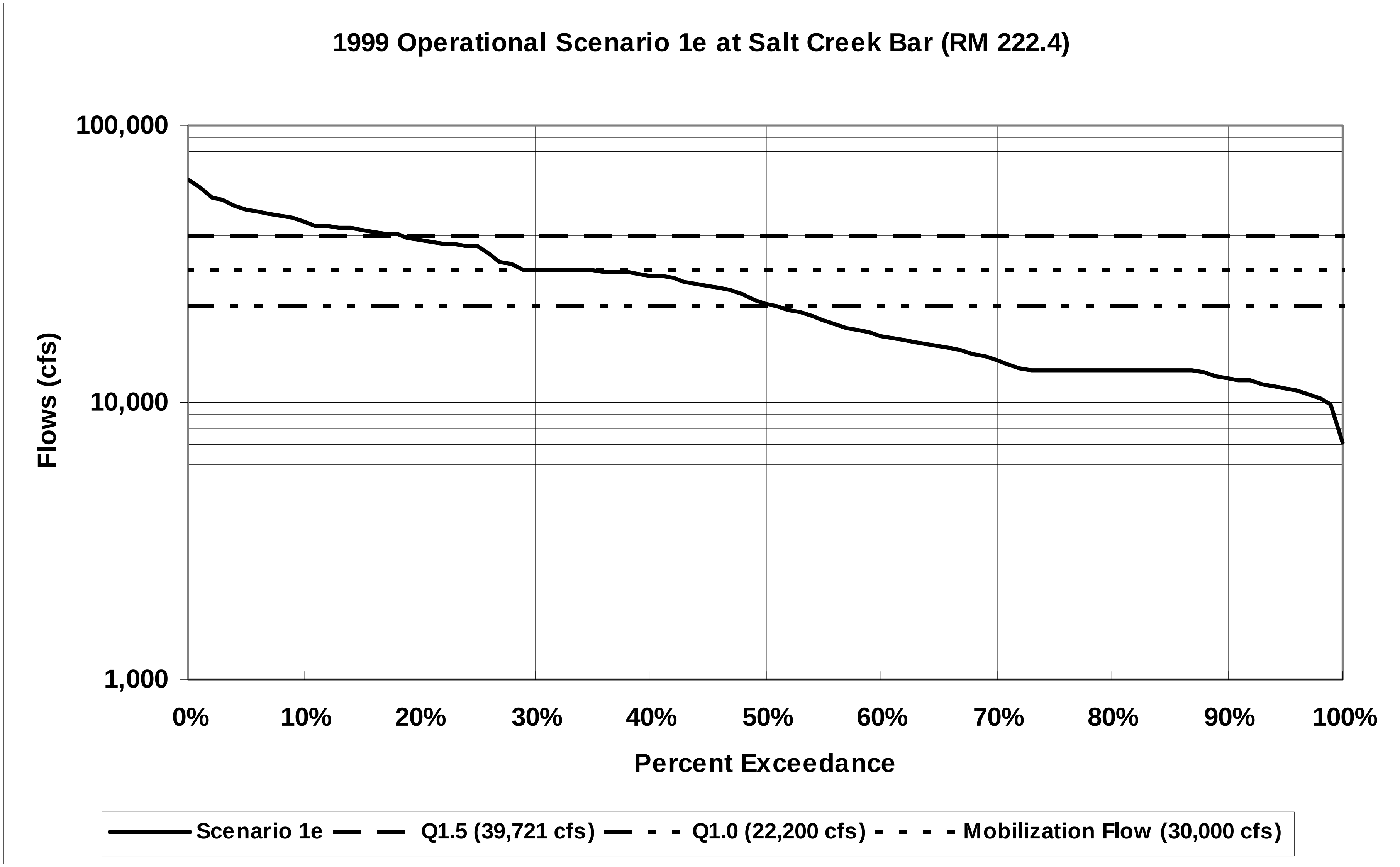


Figure 118. Flow-duration curve for 1999 Operational Scenario 1e at Salt Creek Bar (RM 222.4).

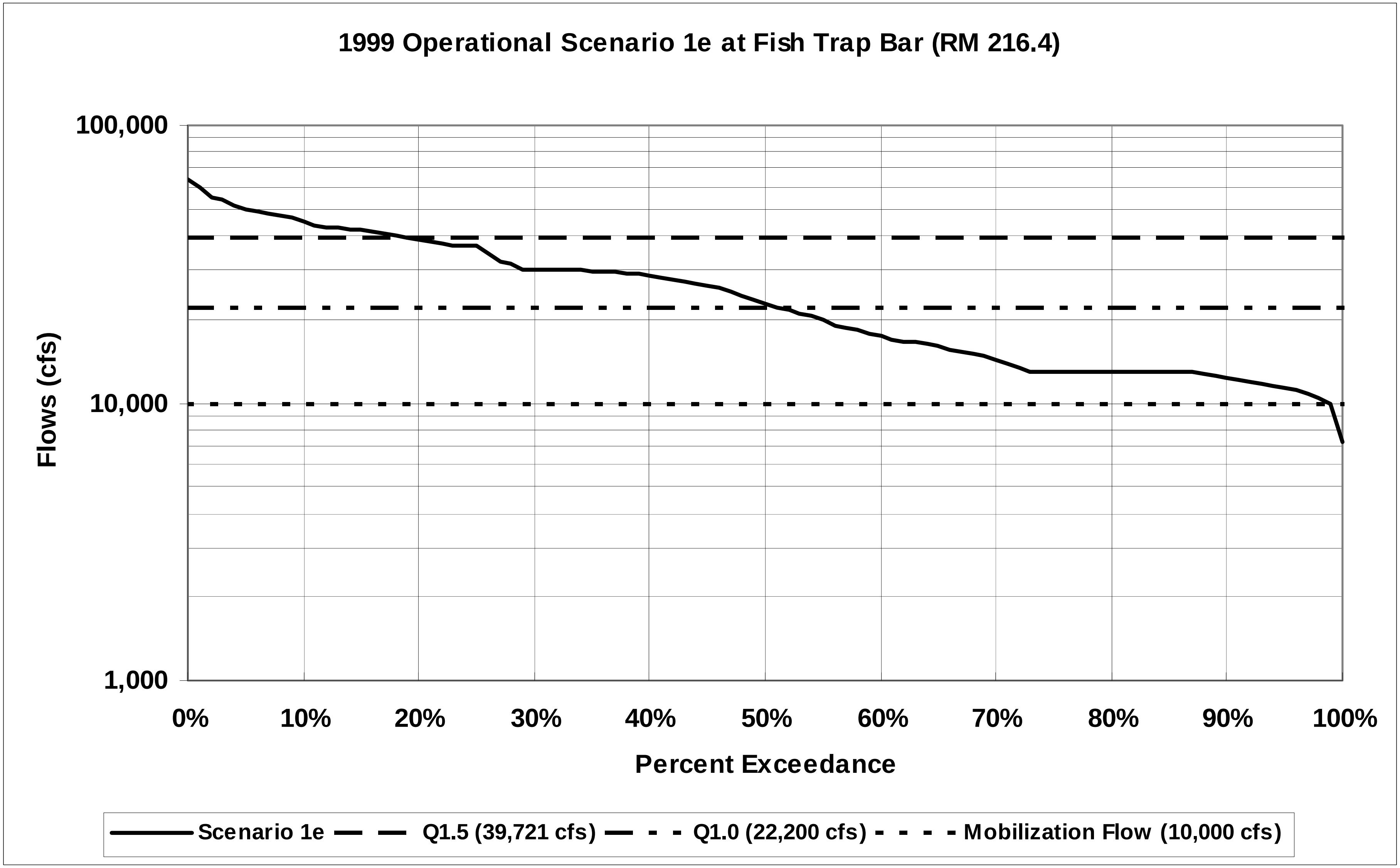


Figure 119. Flow-duration curve for 1999 Operational Scenario 1e at Fish Trap Bar (RM 216.4).

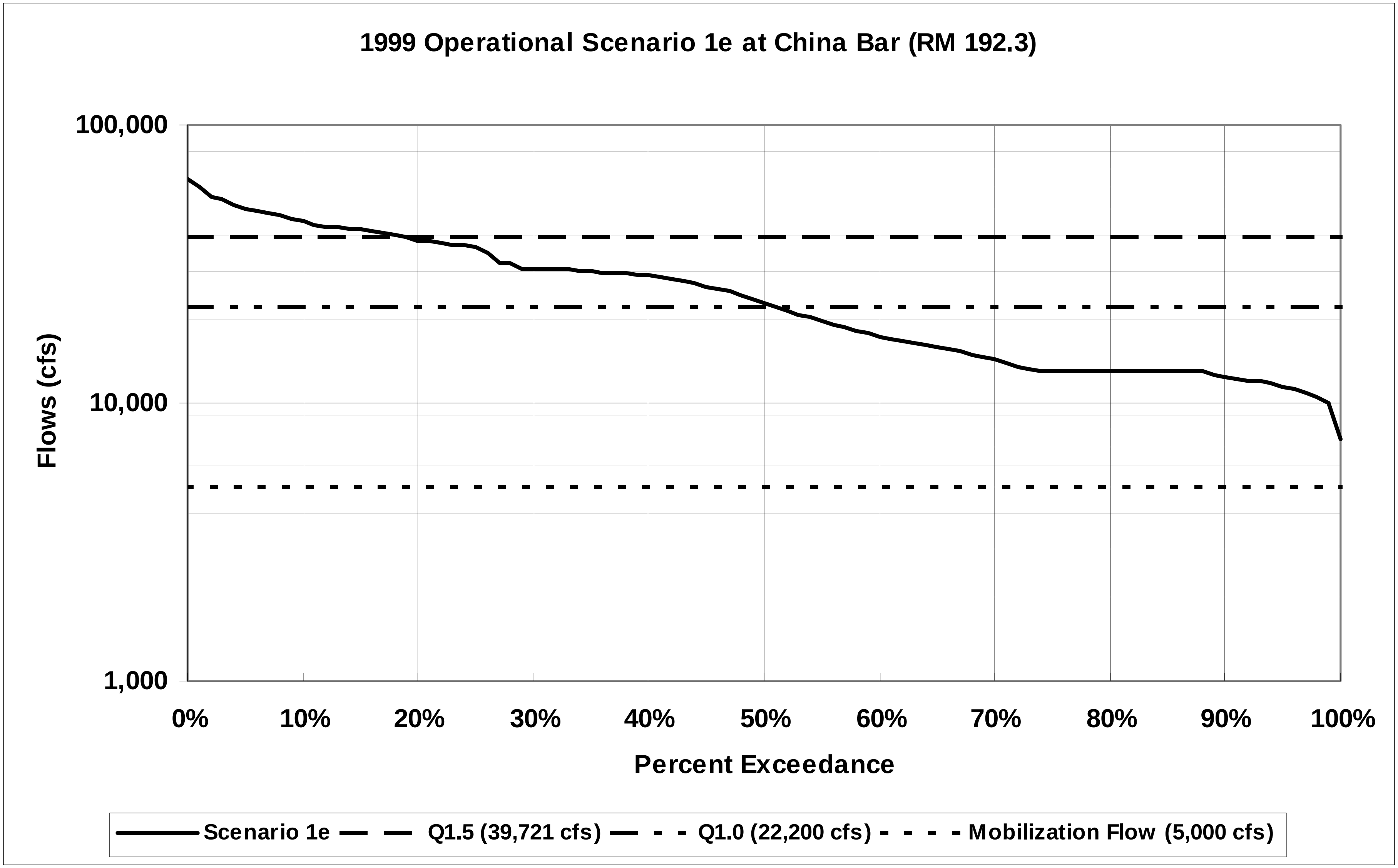


Figure 120. Flow-duration curve for 1999 Operational Scenario 1e at China Bar (RM 192.3).

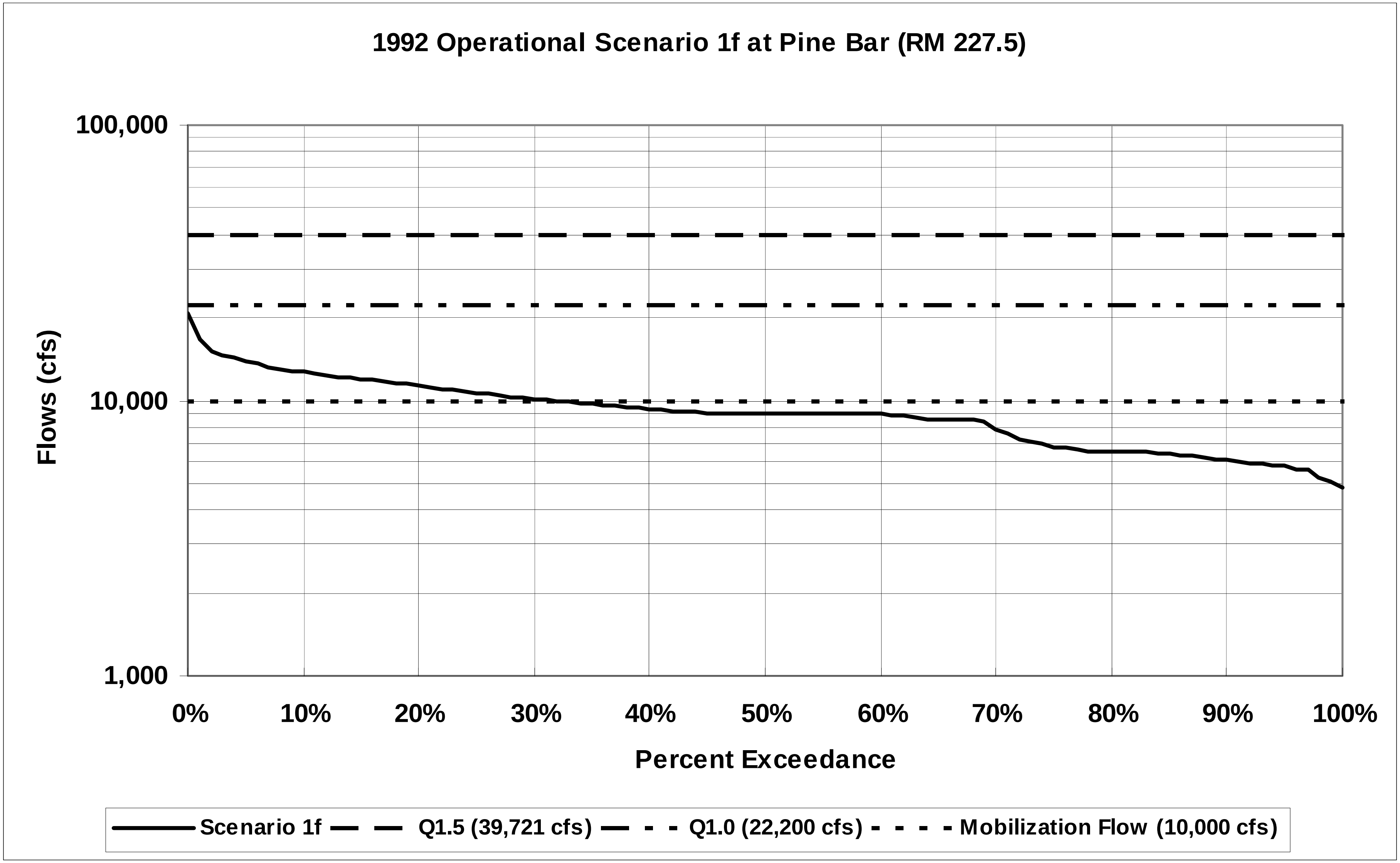


Figure 121. Flow-duration curve for 1992 Operational Scenario 1f at Pine Bar (RM 227.5).

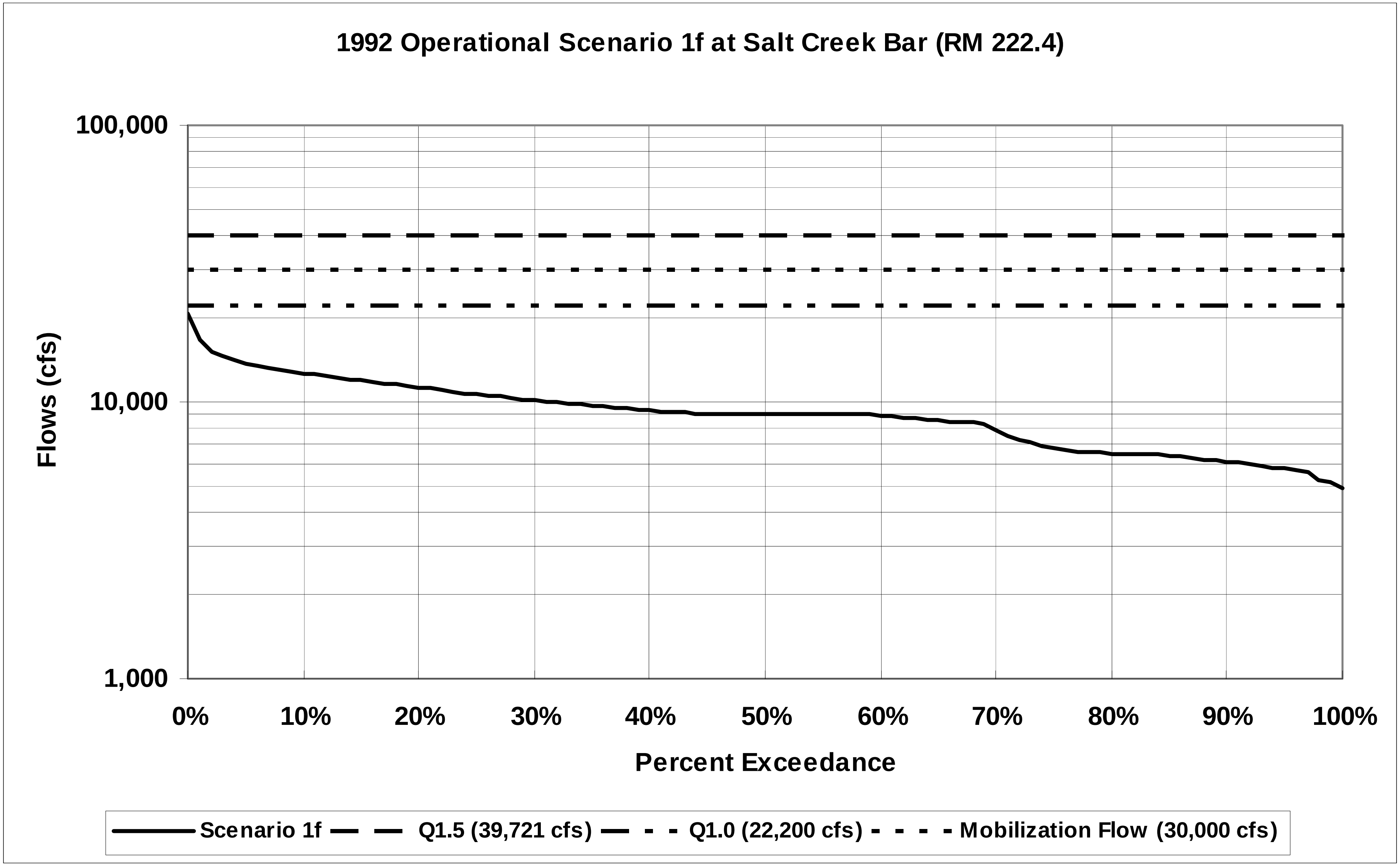


Figure 122. Flow-duration curve for 1992 Operational Scenario 1f at Salt Creek Bar (RM 222.4).

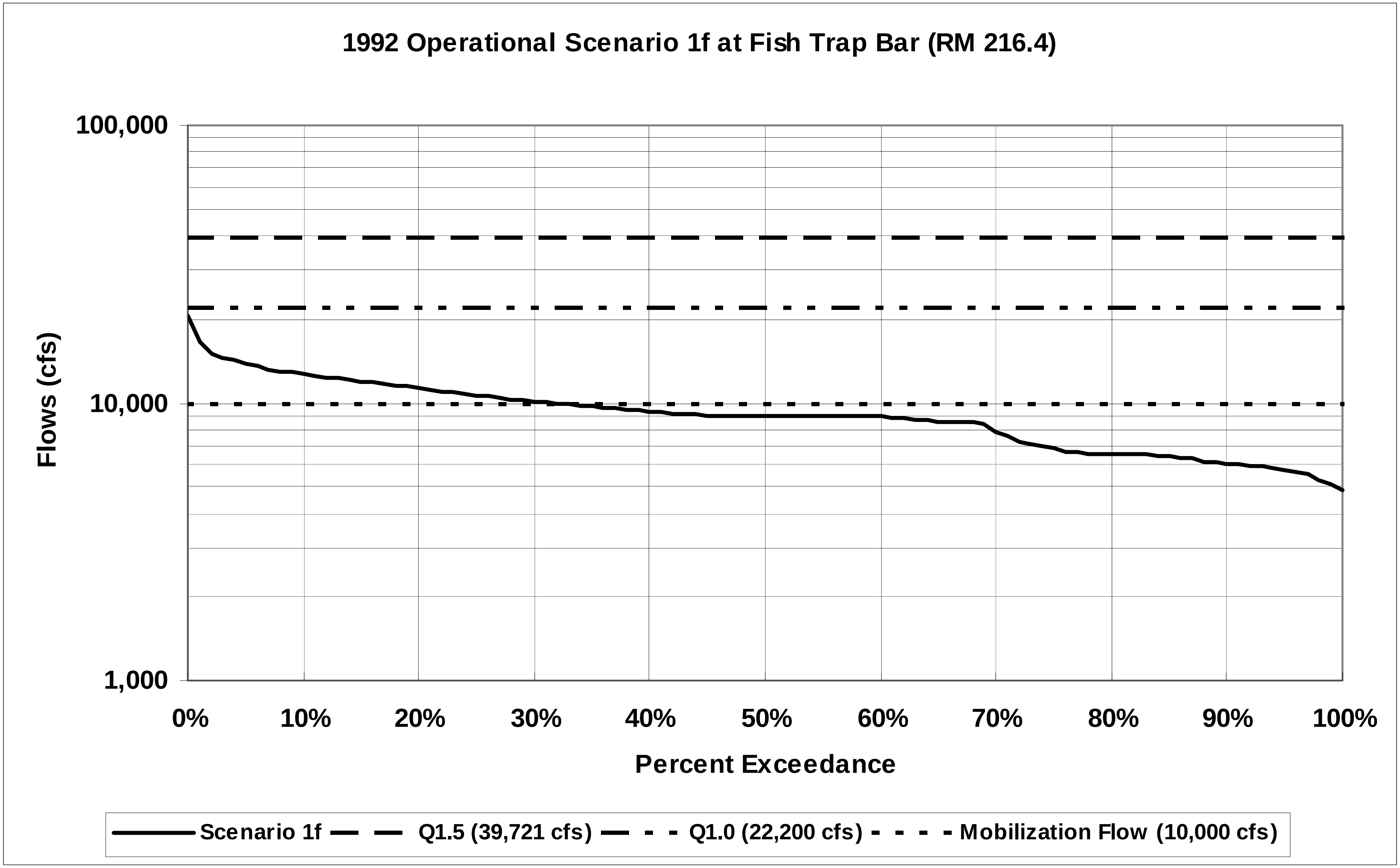


Figure 123. Flow-duration curve for 1992 Operational Scenario 1f at Fish Trap Bar (RM 216.4).

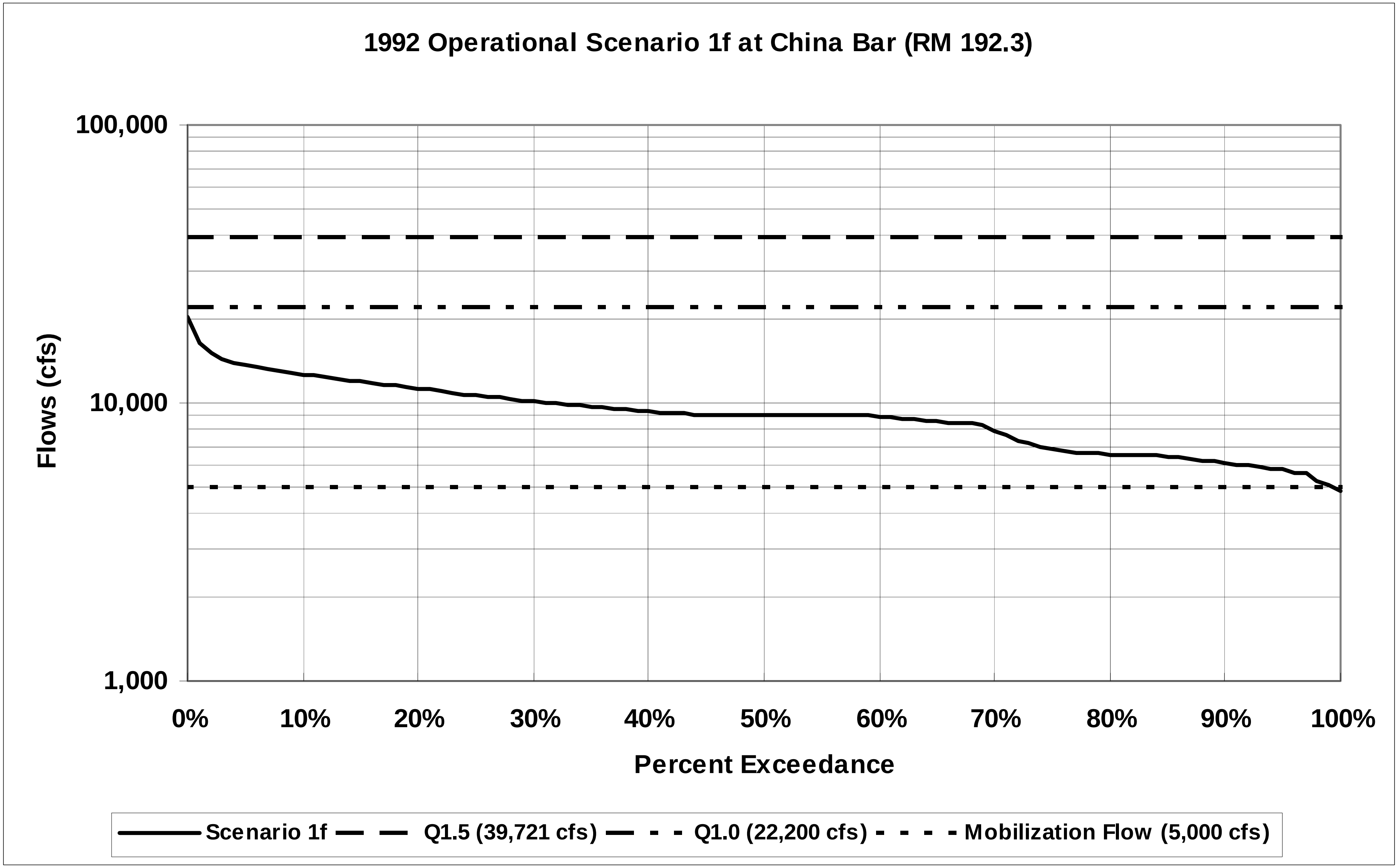


Figure 124. Flow-duration curve for 1992 Operational Scenario 1f at China Bar (RM 192.3).

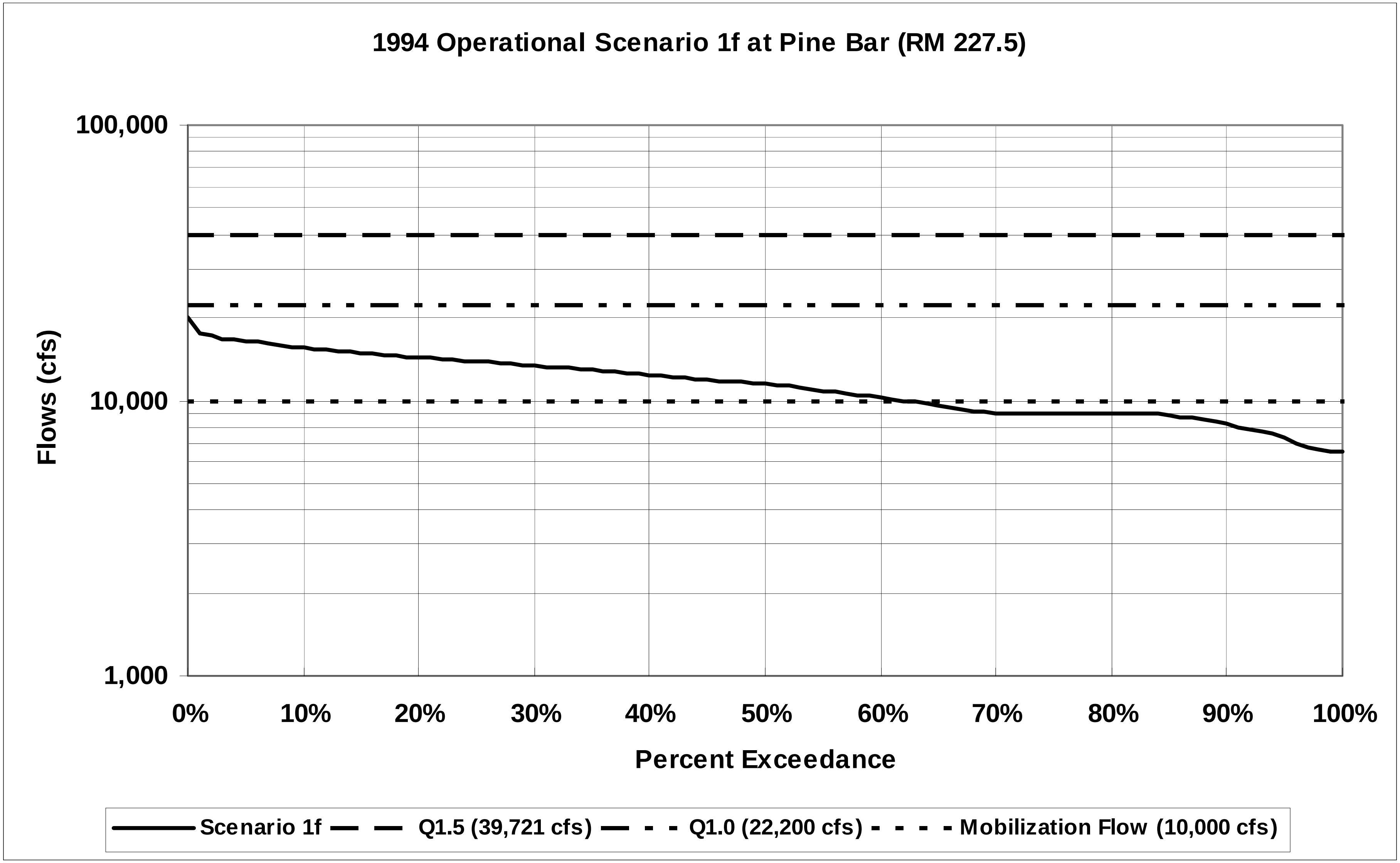


Figure 125. Flow-duration curve for 1994 Operational Scenario 1f at Pine Bar (RM 227.5).

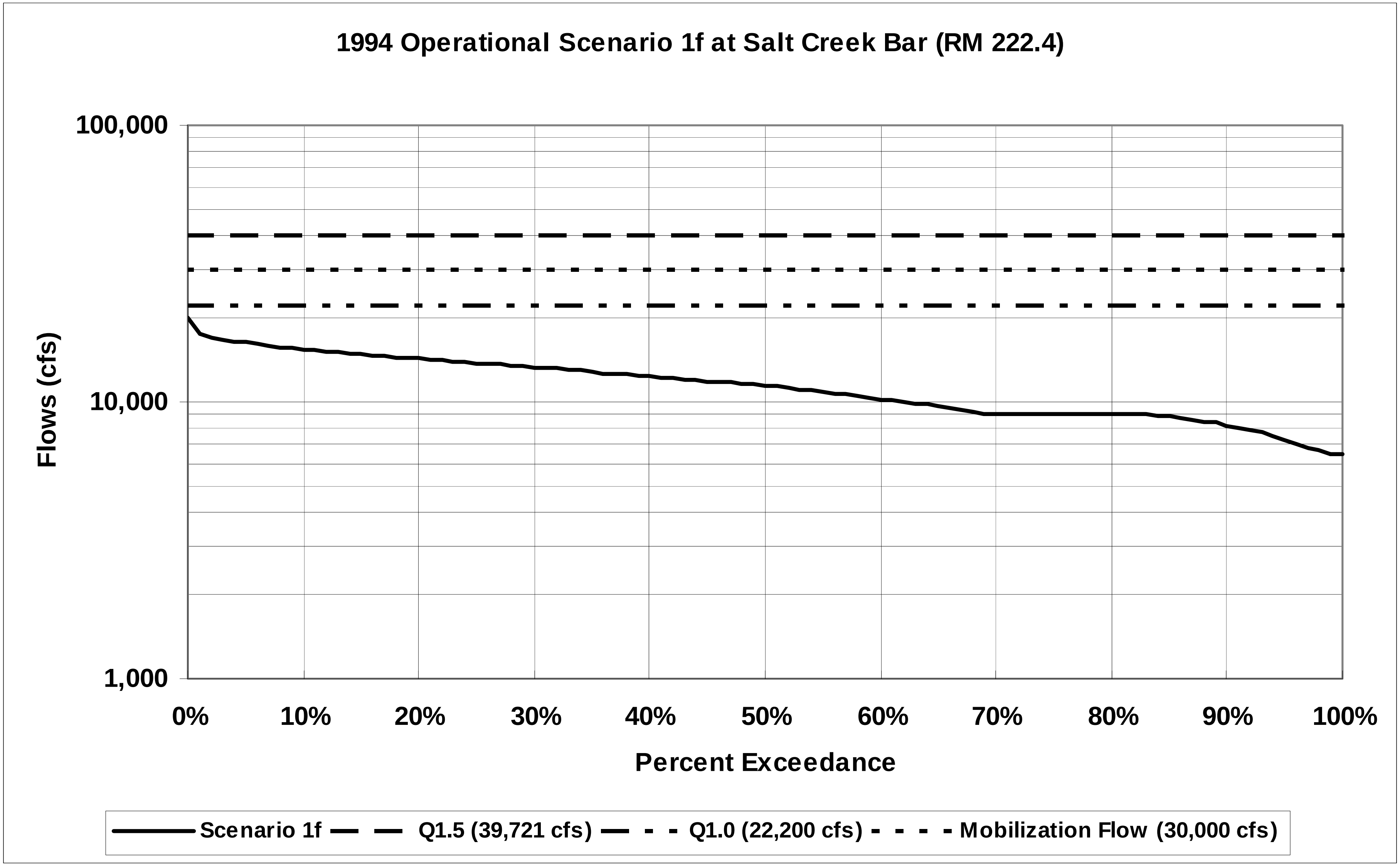


Figure 126. Flow-duration curve for 1994 Operational Scenario 1f at Salt Creek Bar (RM 222.4).

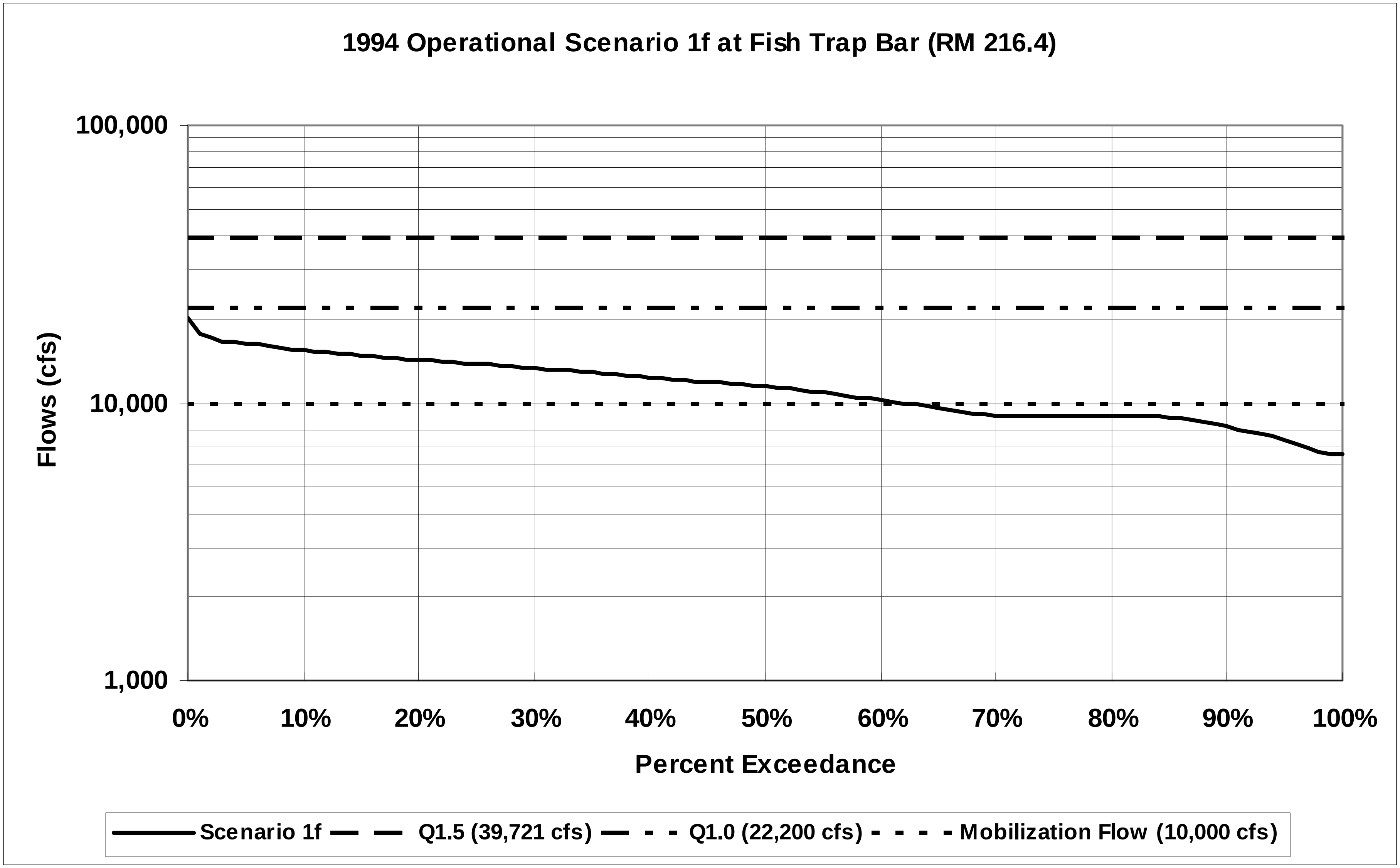


Figure 127. Flow-duration curve for 1994 Operational Scenario 1f at Fish Trap Bar (RM 216.4).

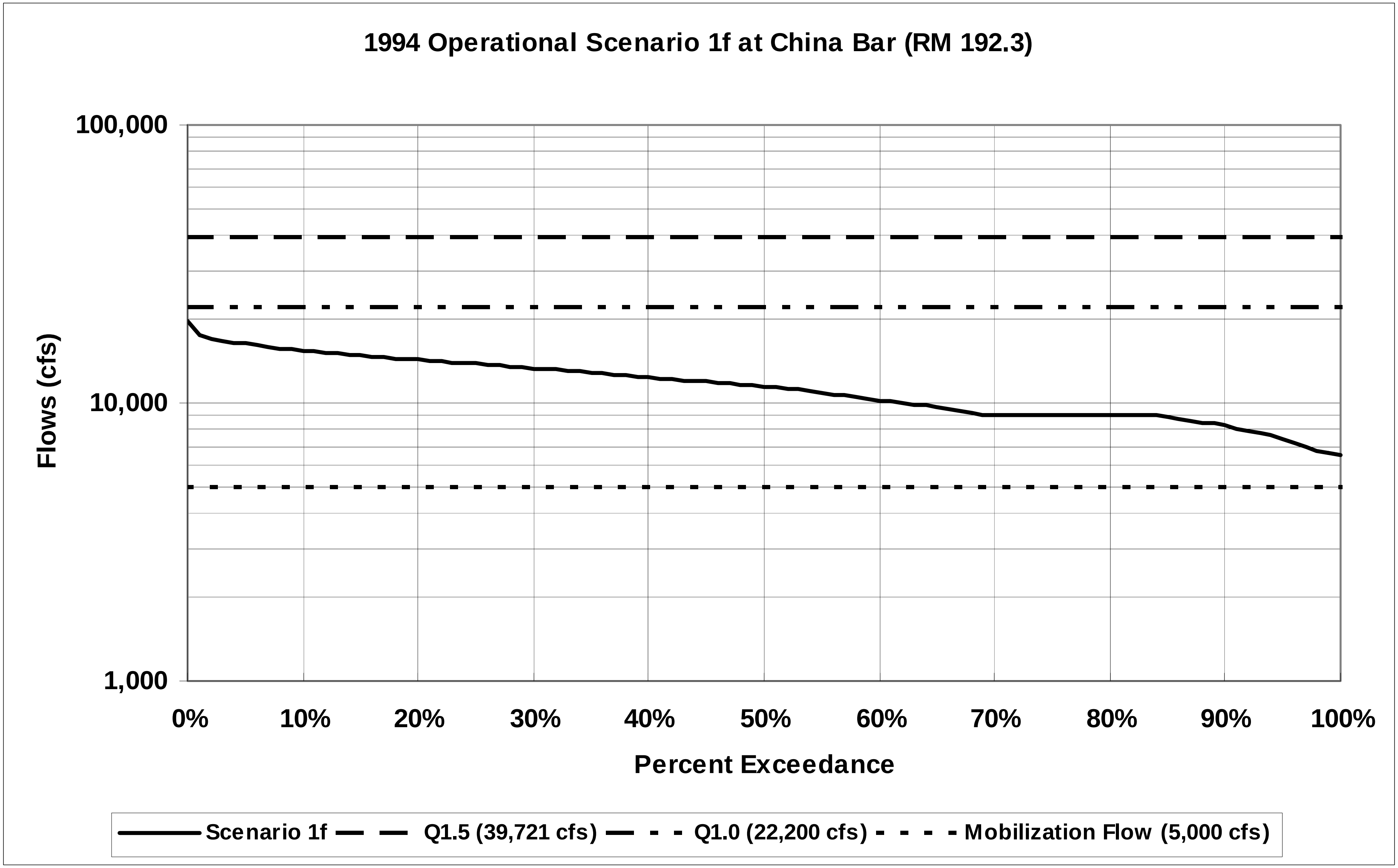


Figure 128. Flow-duration curve for 1994 Operational Scenario 1f at China Bar (RM 192.3).

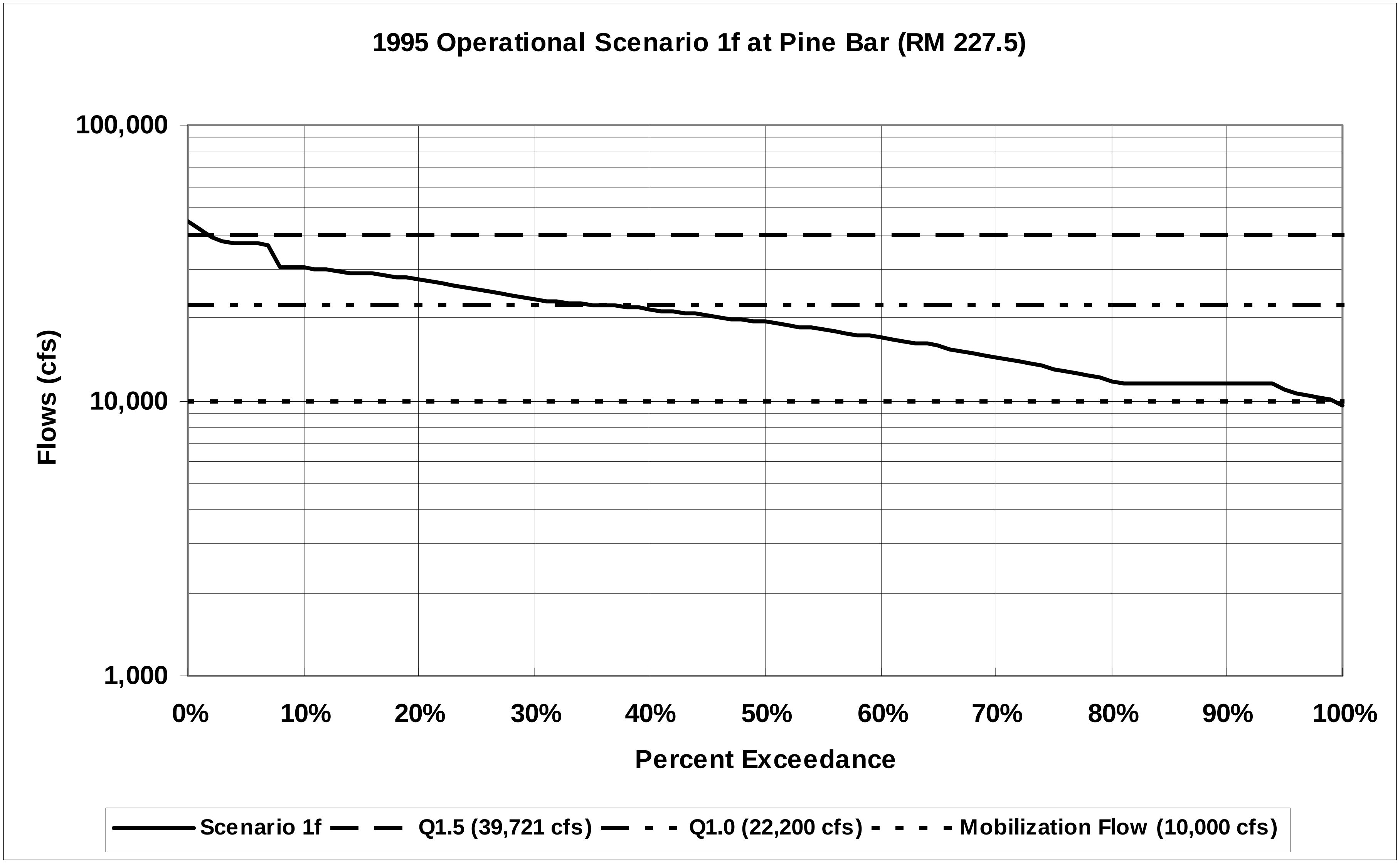


Figure 129. Flow-duration curve for 1995 Operational Scenario 1f at Pine Bar (RM 227.5).

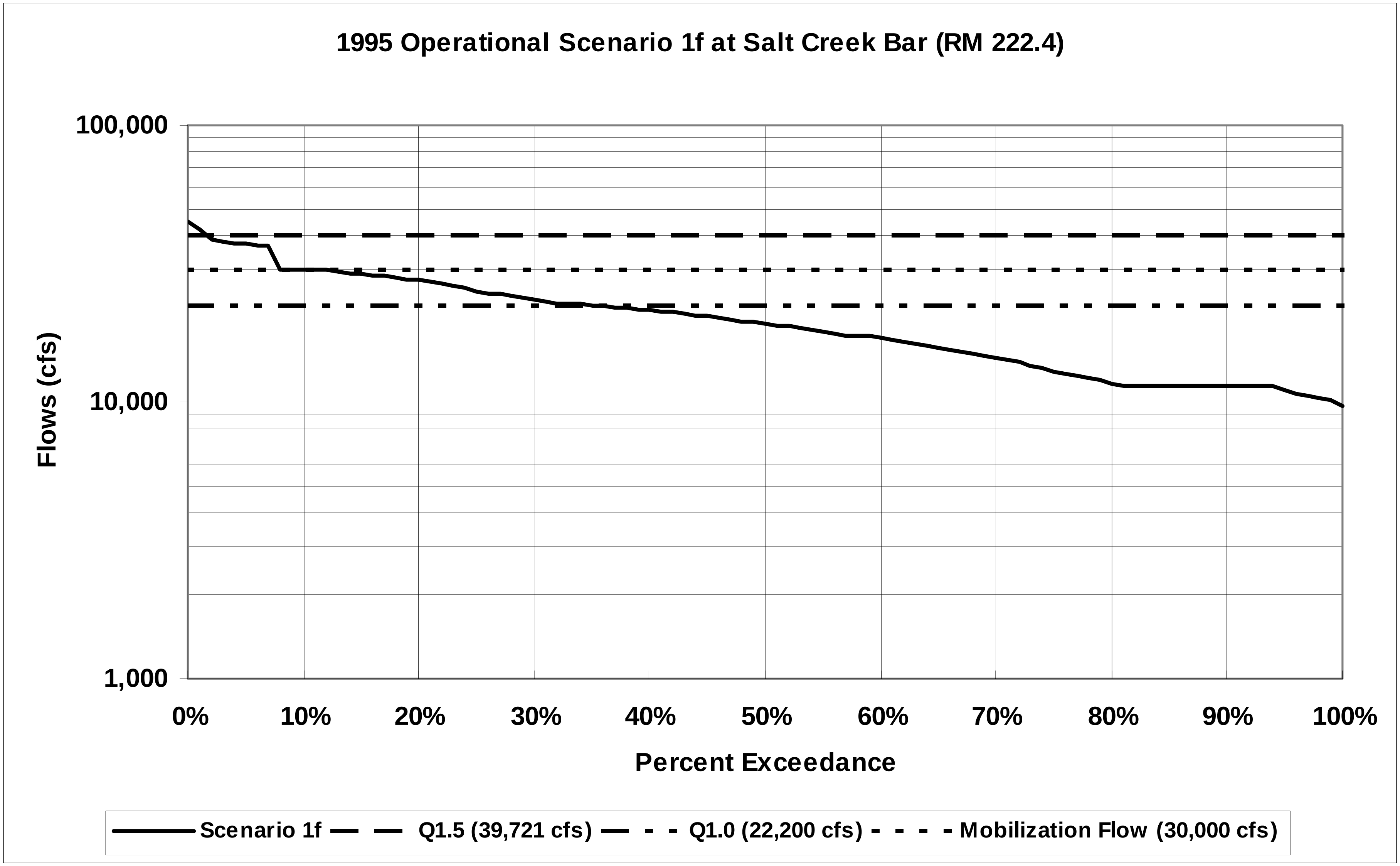


Figure 130. Flow-duration curve for 1995 Operational Scenario 1f at Salt Creek Bar (RM 222.4).

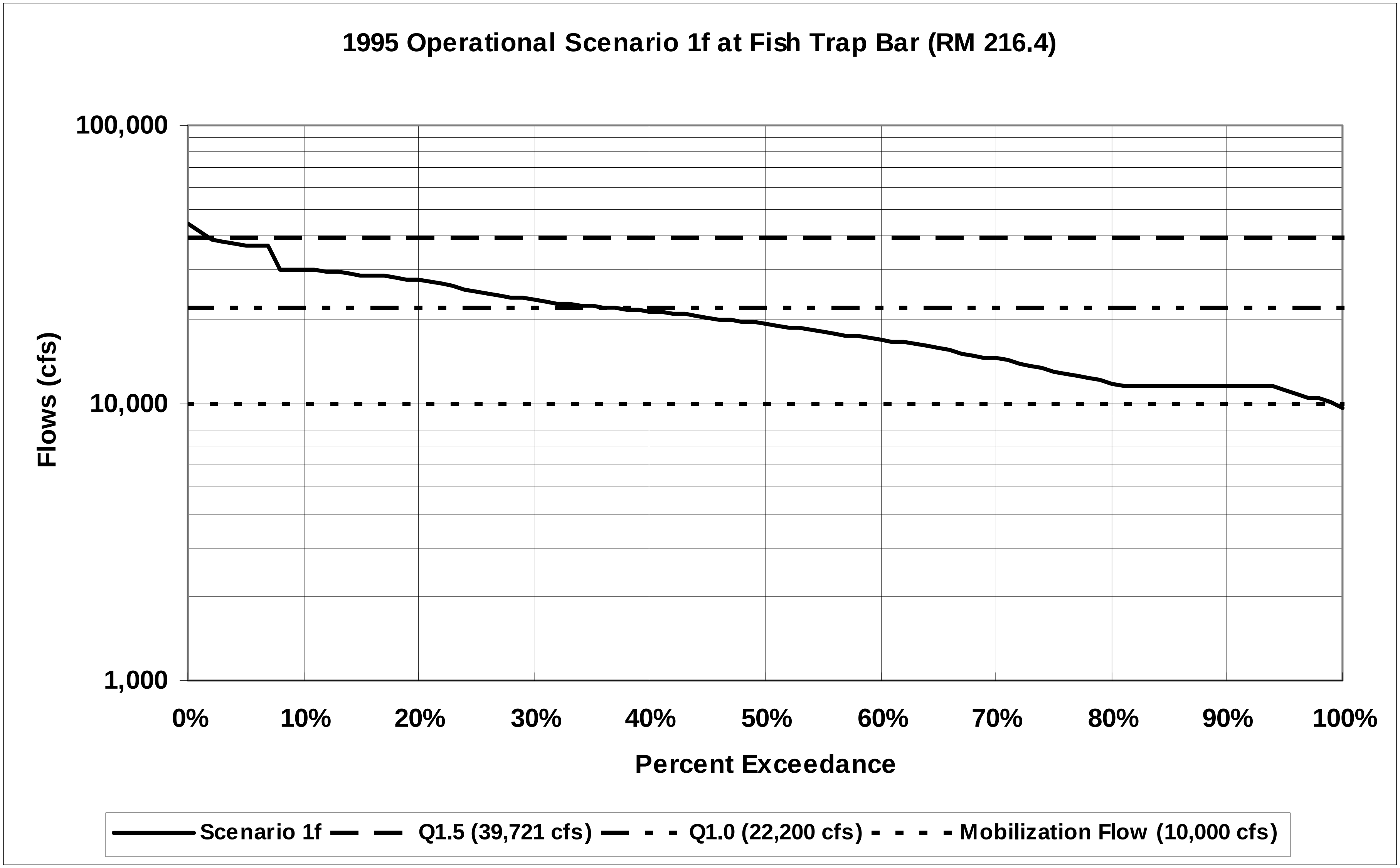


Figure 131. Flow-duration curve for 1995 Operational Scenario 1f at Fish Trap Bar (RM 216.4).

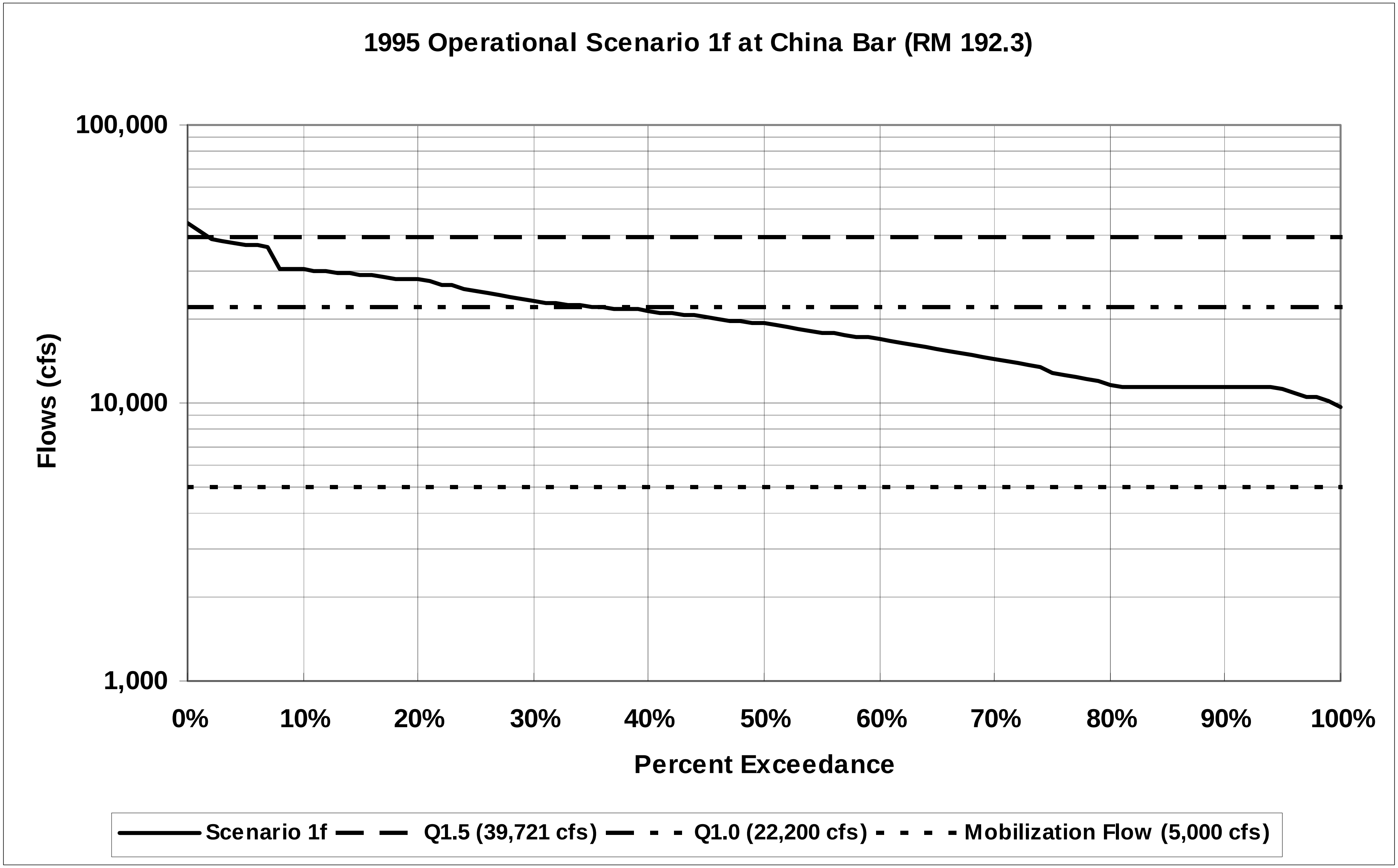


Figure 132. Flow-duration curve for 1995 Operational Scenario 1f at China Bar (RM 192.3).

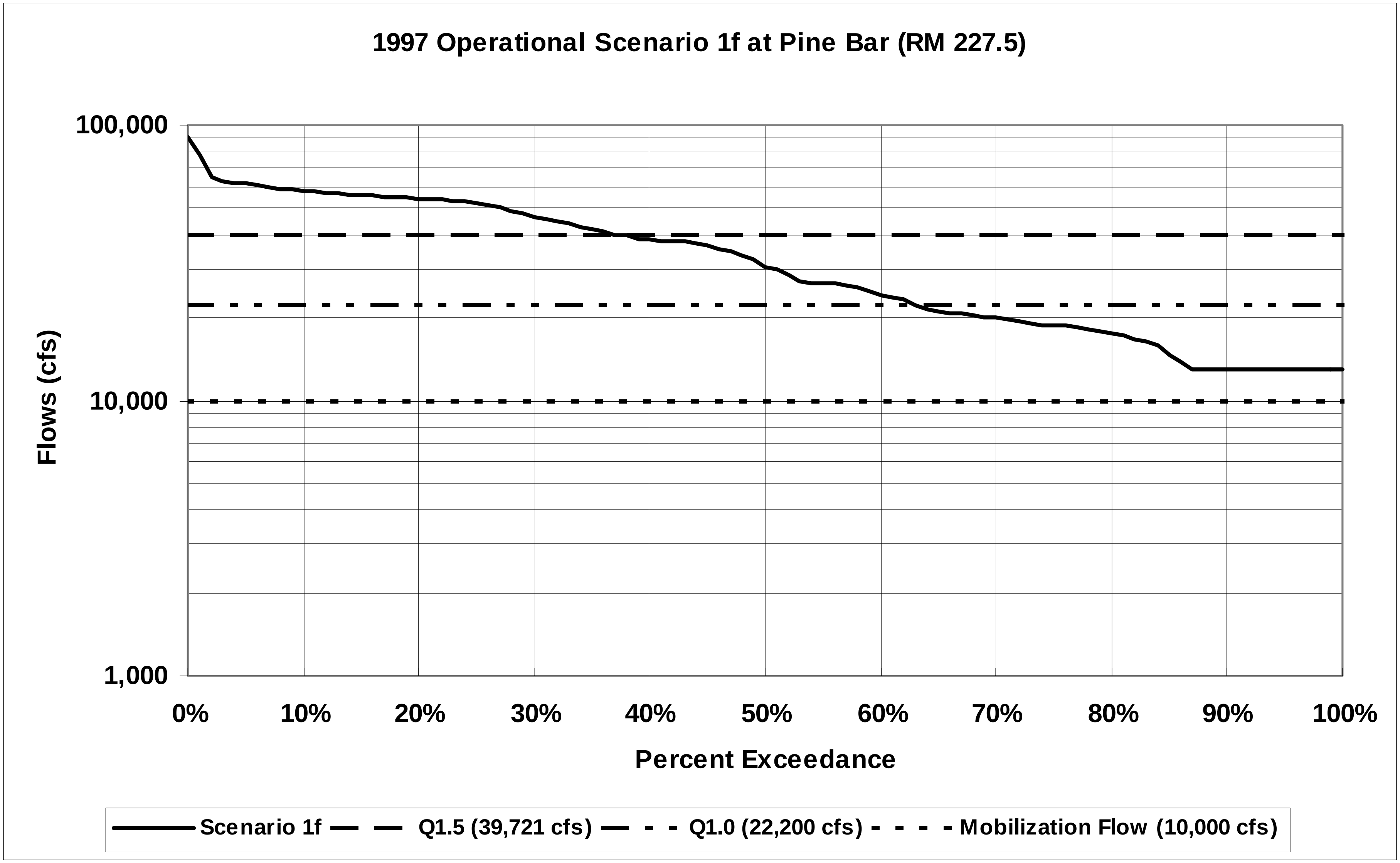


Figure 133. Flow-duration curve for 1997 Operational Scenario 1f at Pine Bar (RM 227.5).

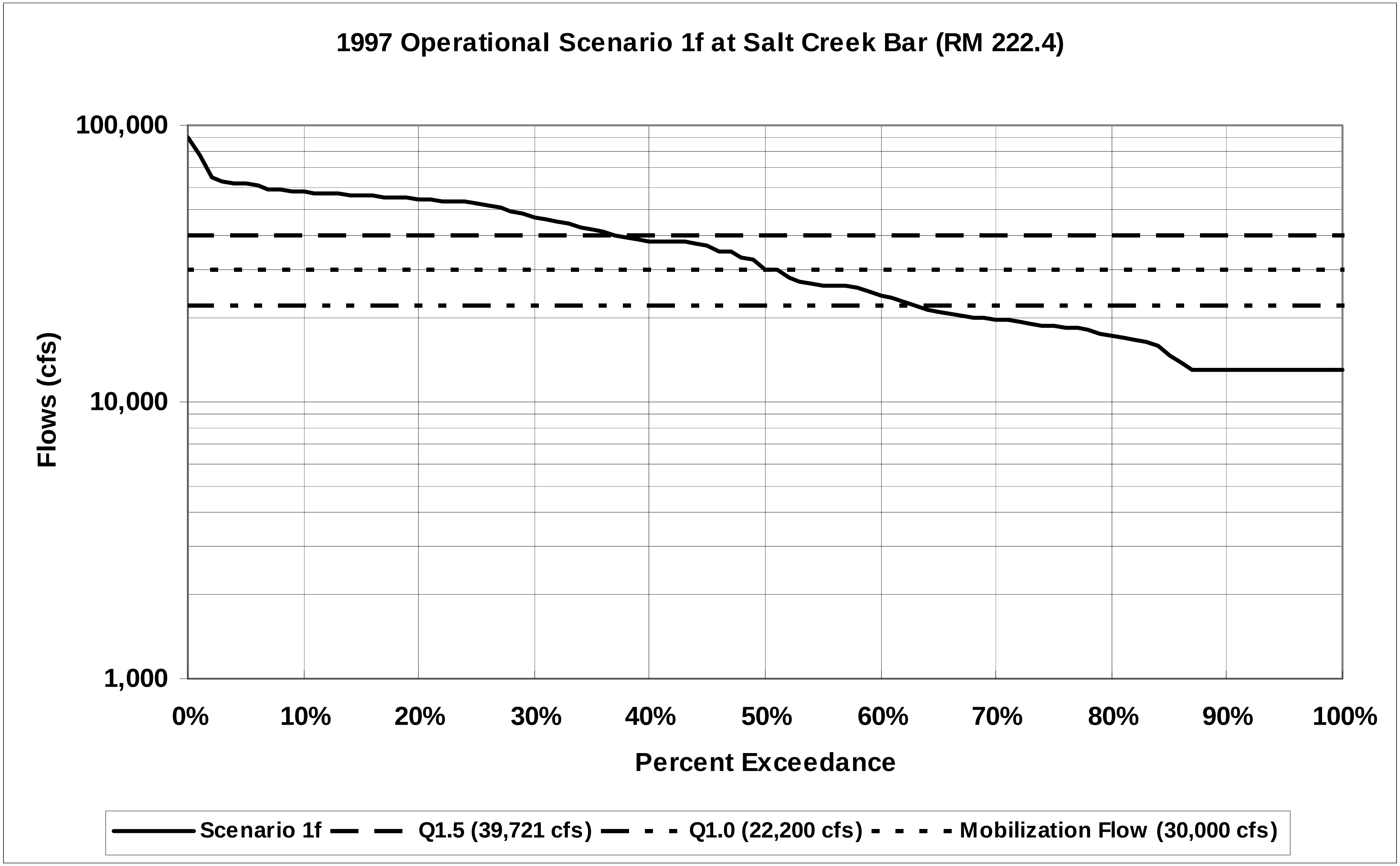


Figure 134. Flow-duration curve for 1997 Operational Scenario 1f at Salt Creek Bar (RM 222.4).

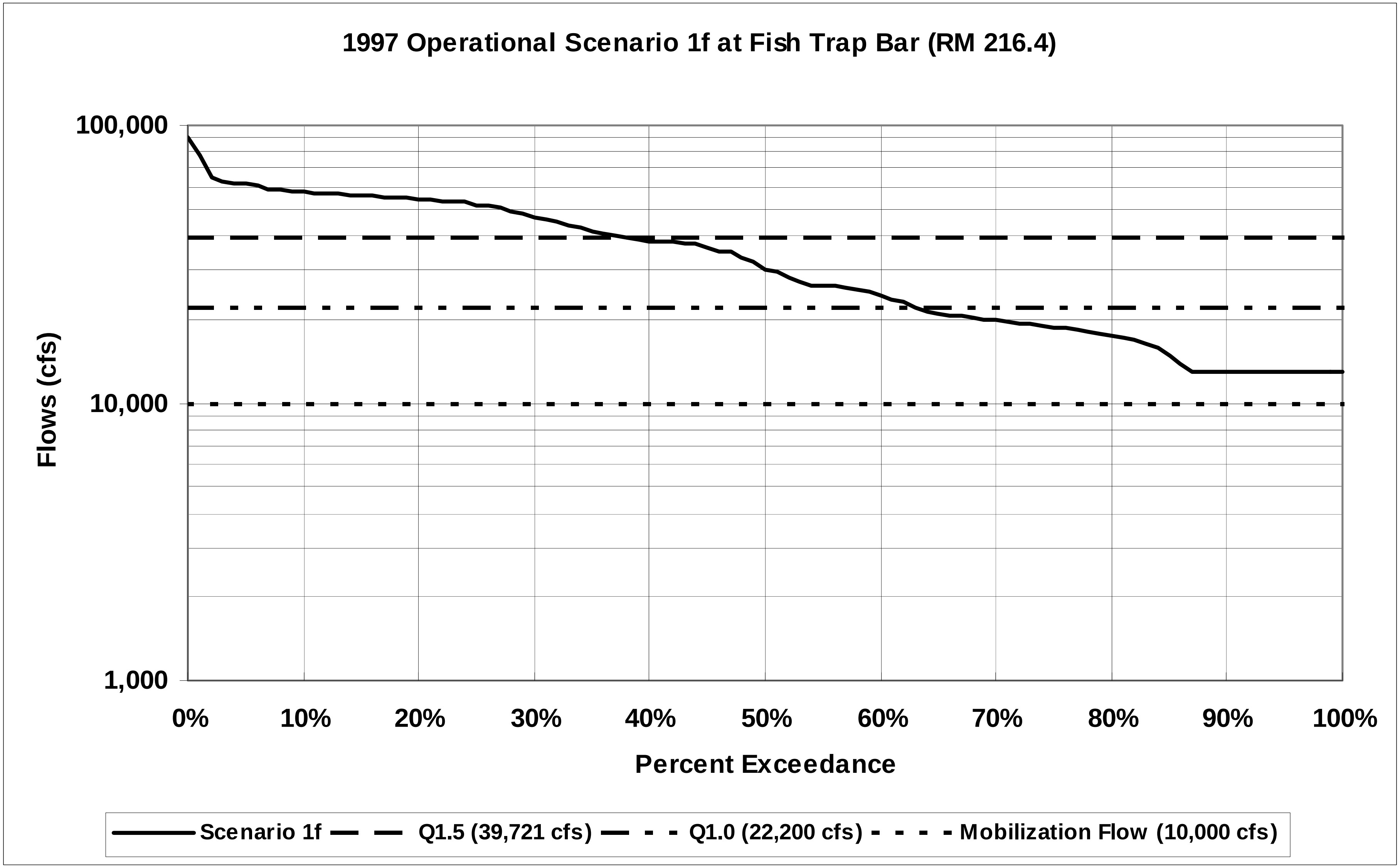


Figure 135. Flow-duration curve for 1997 Operational Scenario 1f at Fish Trap Bar (RM 216.4).

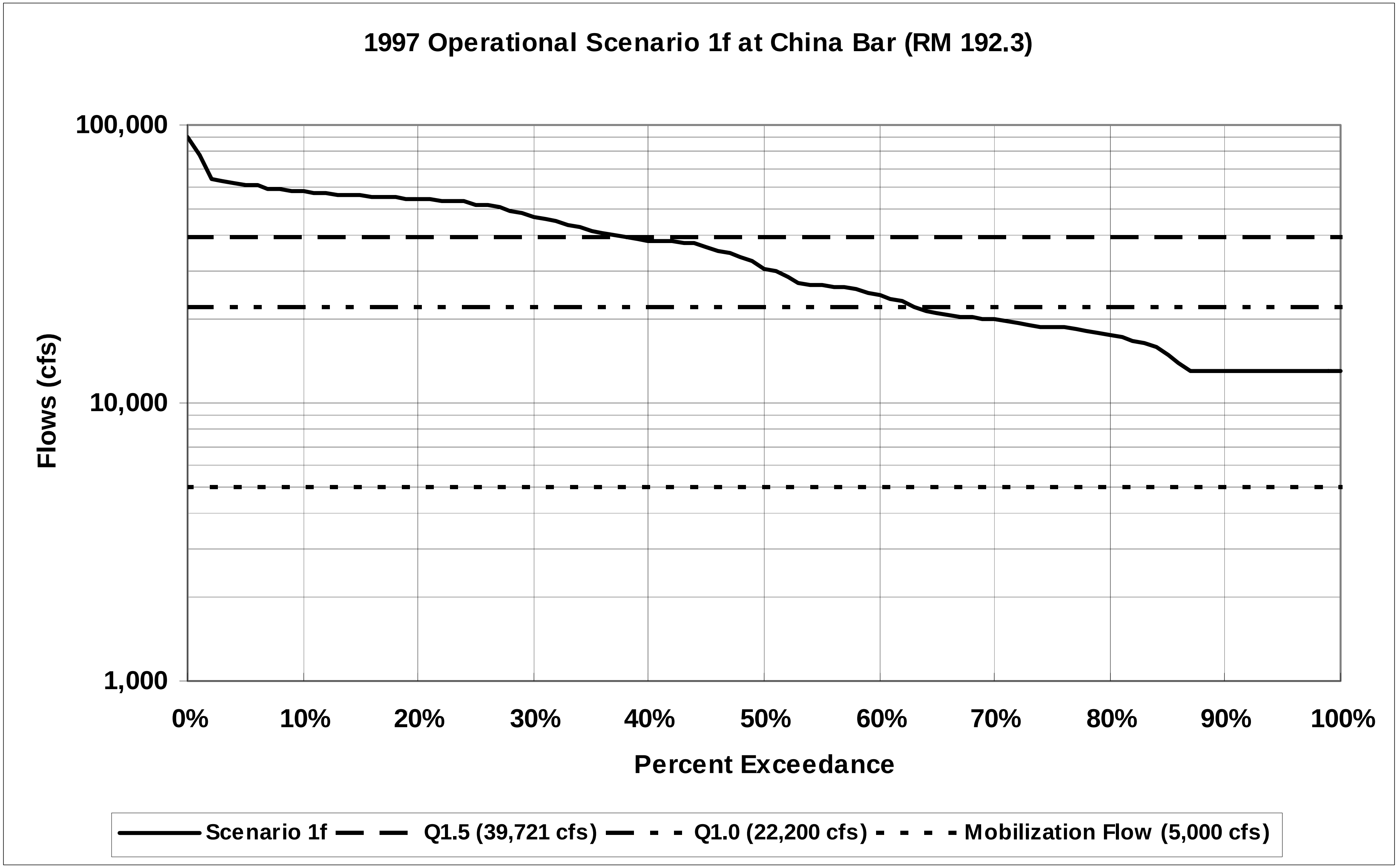


Figure 136. Flow-duration curve for 1997 Operational Scenario 1f at China Bar (RM 192.3).

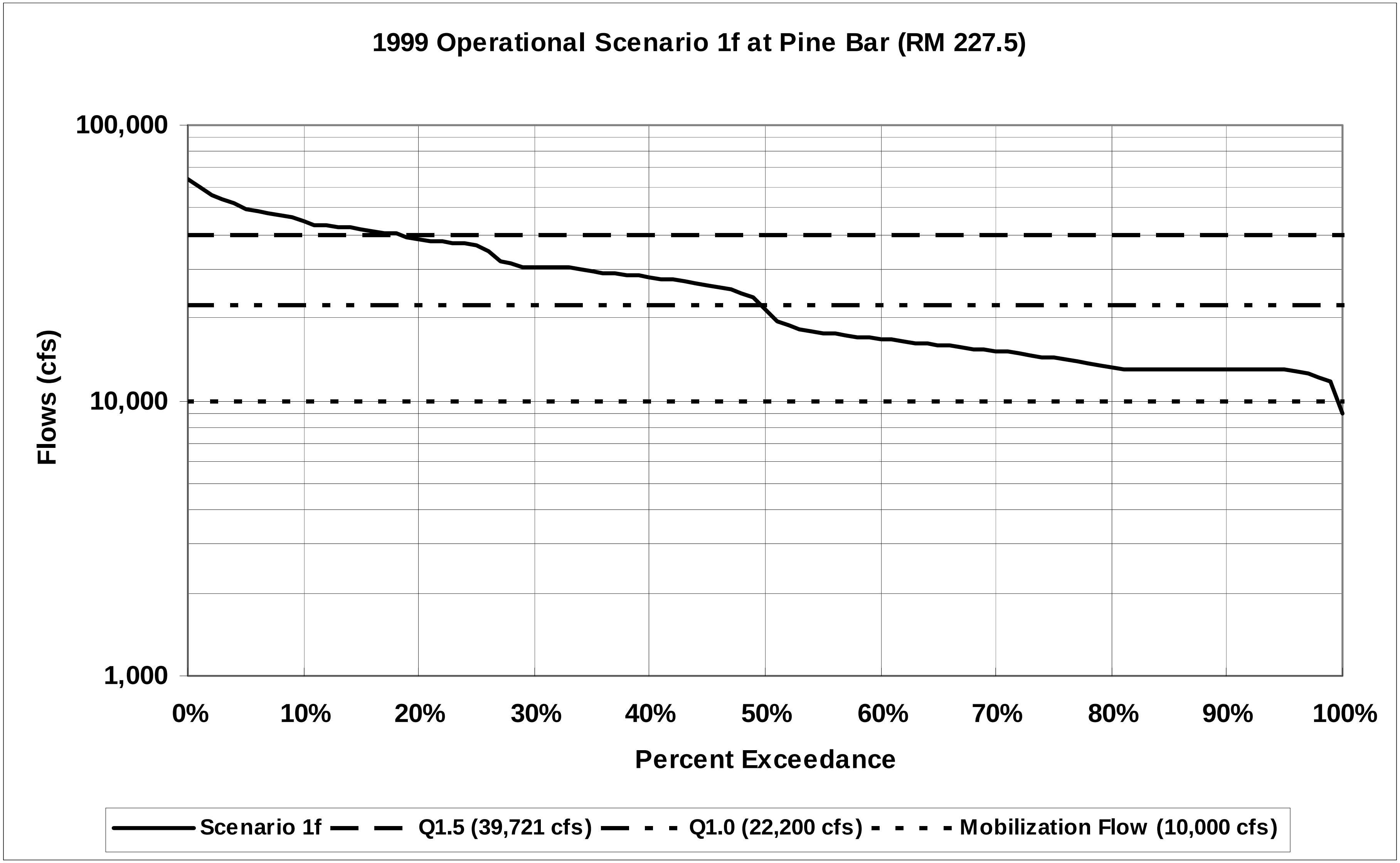


Figure 137. Flow-duration curve for 1999 Operational Scenario 1f at Pine Bar (RM 227.5).

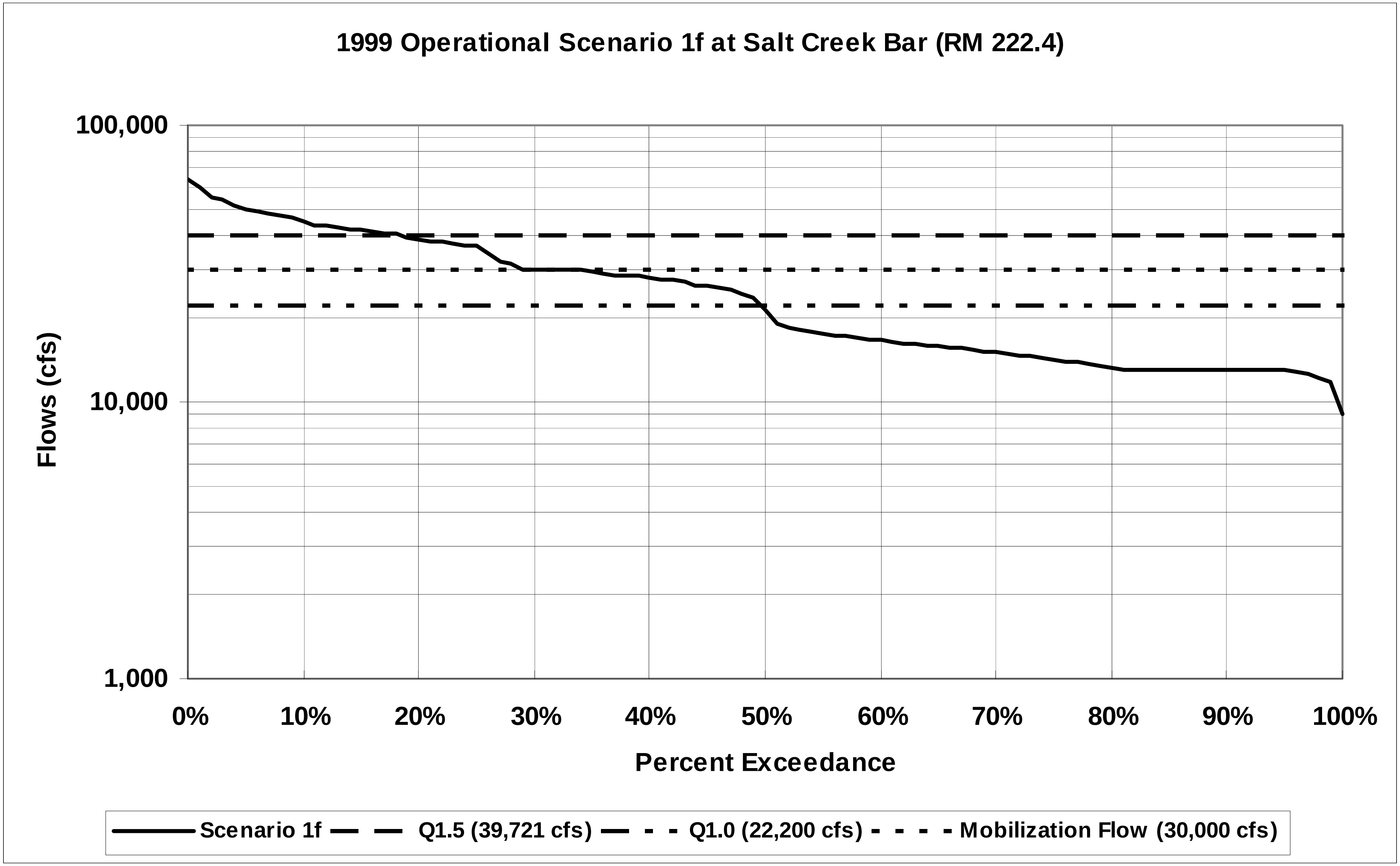


Figure 138. Flow-duration curve for 1999 Operational Scenario 1f at Salt Creek Bar (RM 222.4).

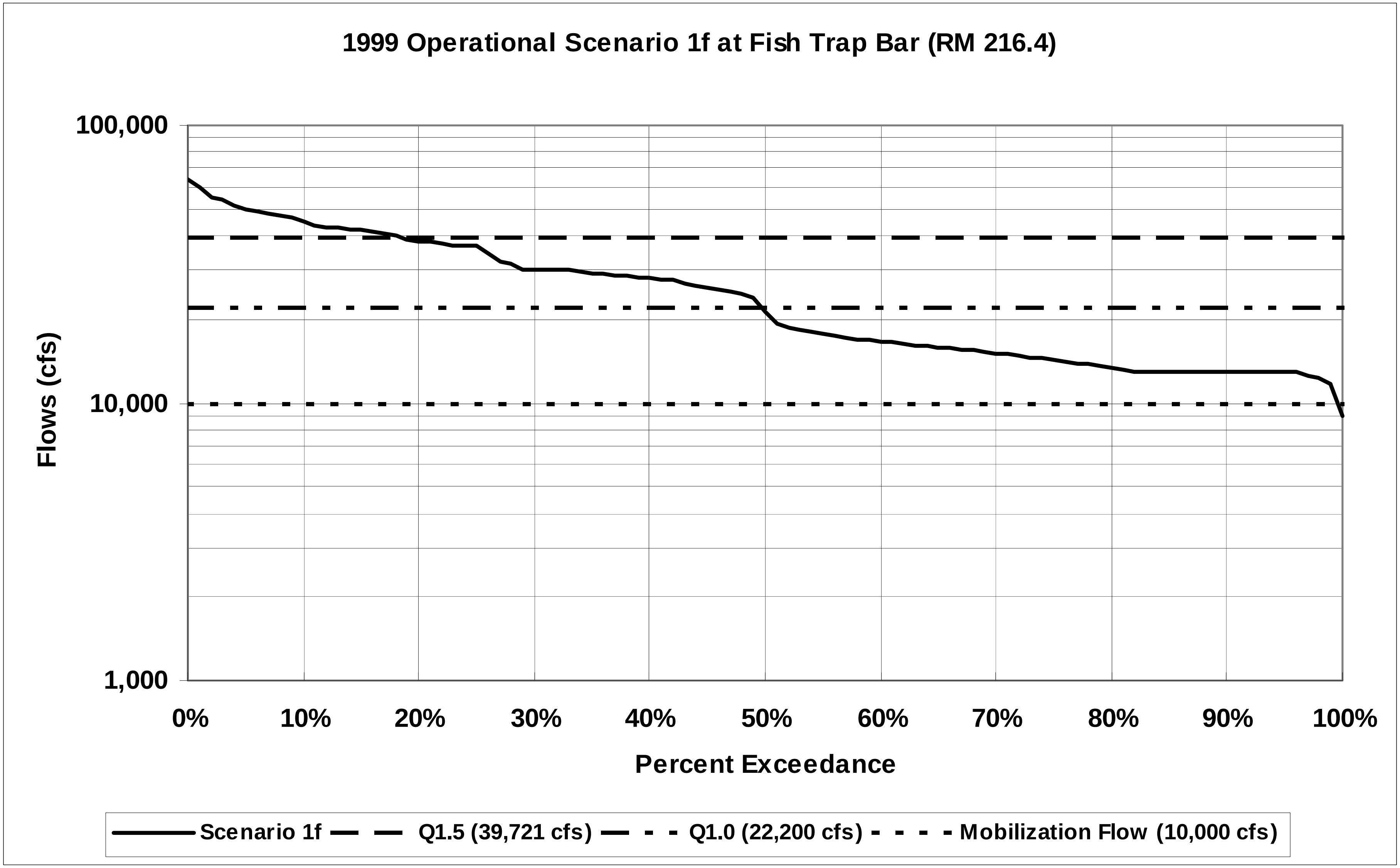


Figure 139. Flow-duration curve for 1999 Operational Scenario 1f at Fish Trap Bar (RM 216.4).

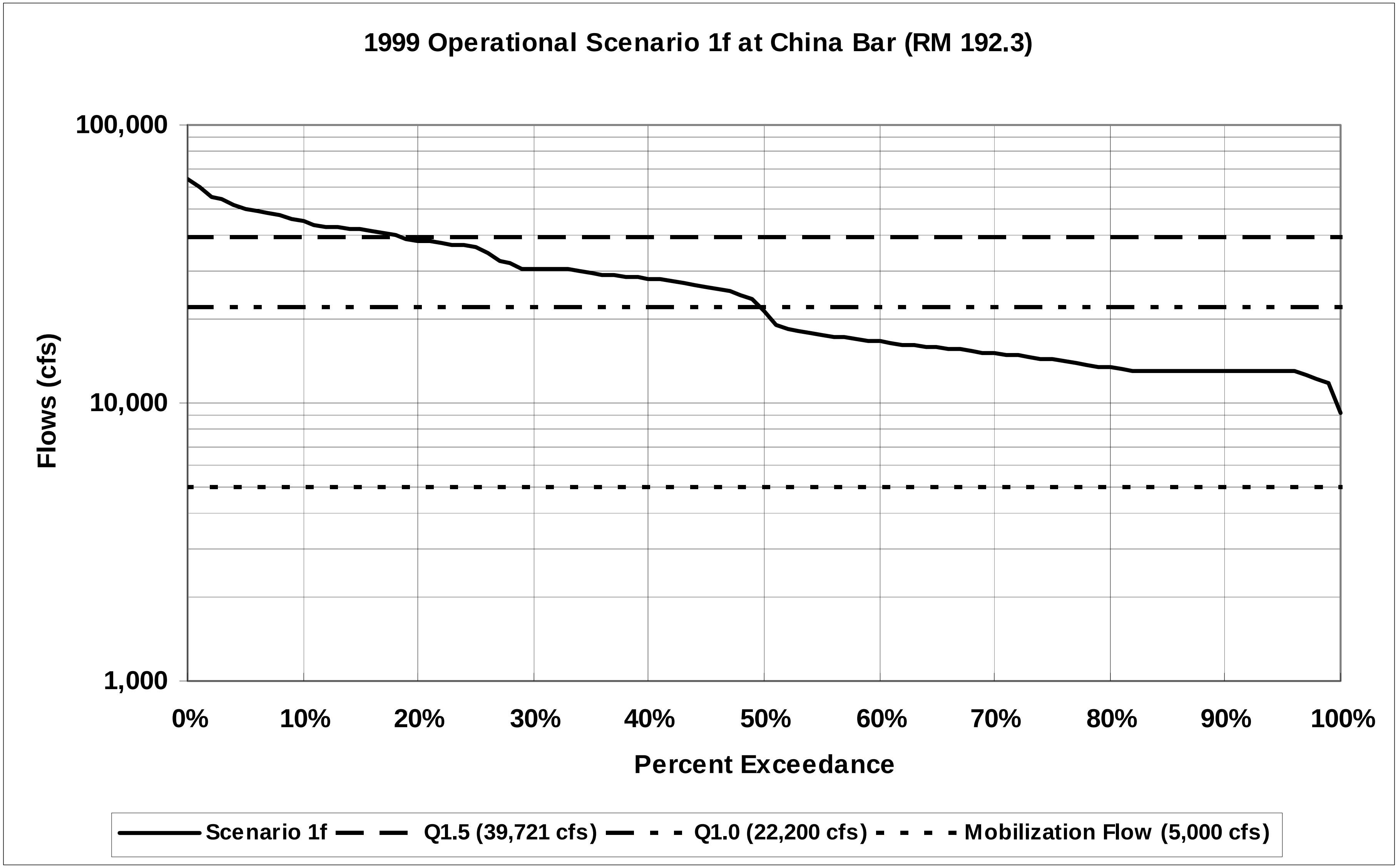


Figure 140. Flow-duration curve for 1999 Operational Scenario 1f at China Bar (RM 192.3).

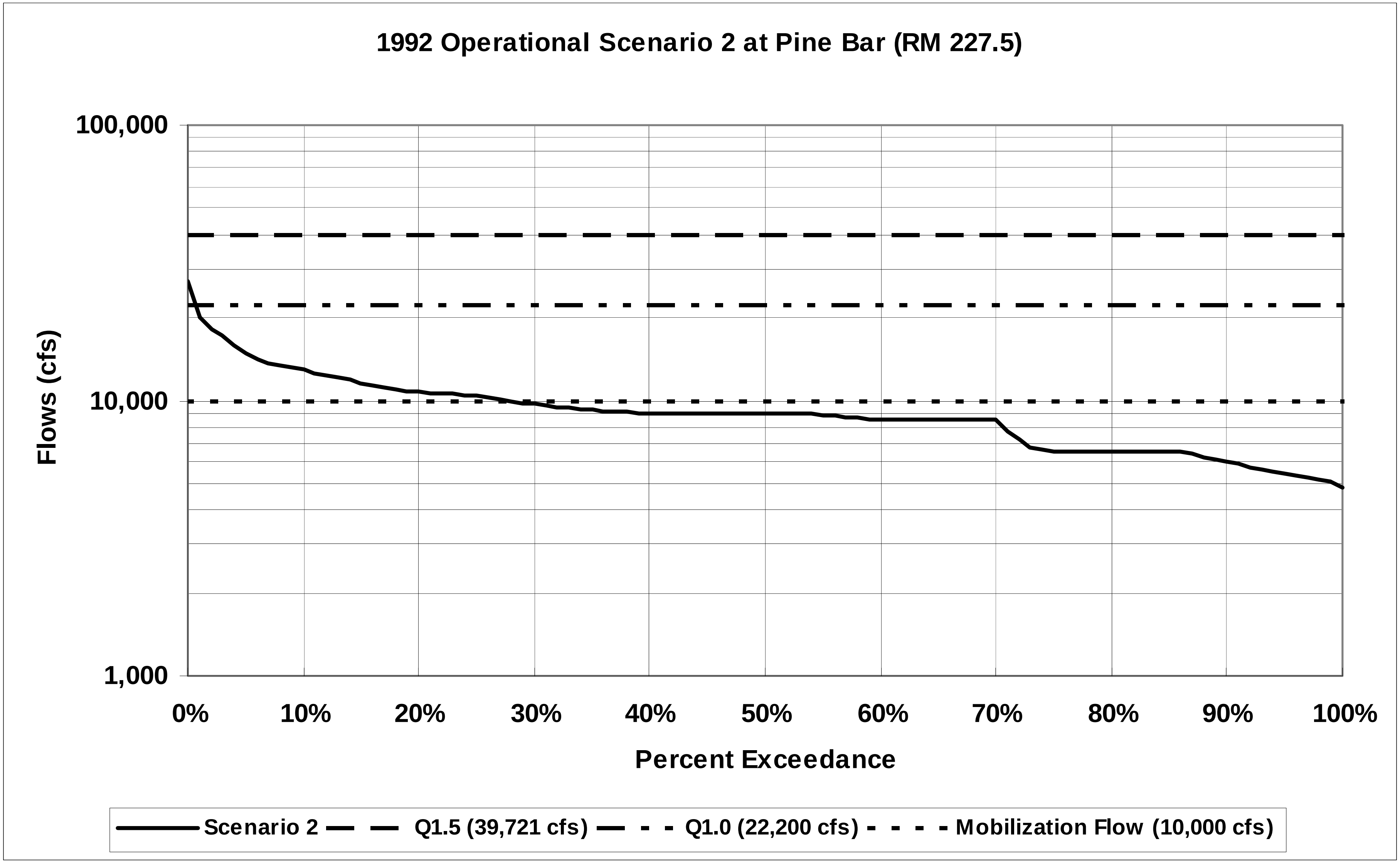


Figure 141. Flow-duration curve for 1992 Operational Scenario 2 at Pine Bar (RM 227.5).

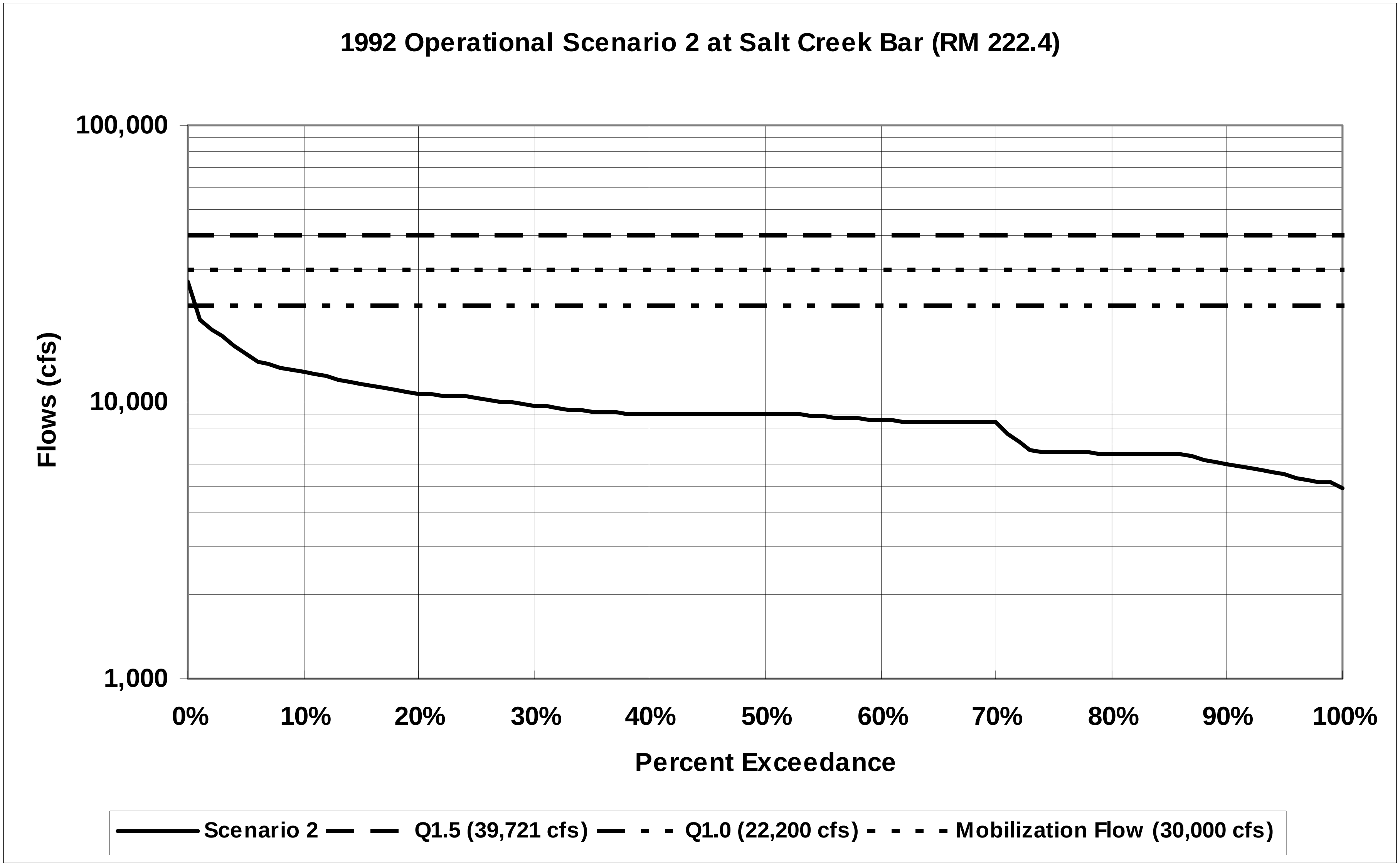


Figure 142. Flow-duration curve for 1992 Operational Scenario 2 at Salt Creek Bar (RM 222.4).

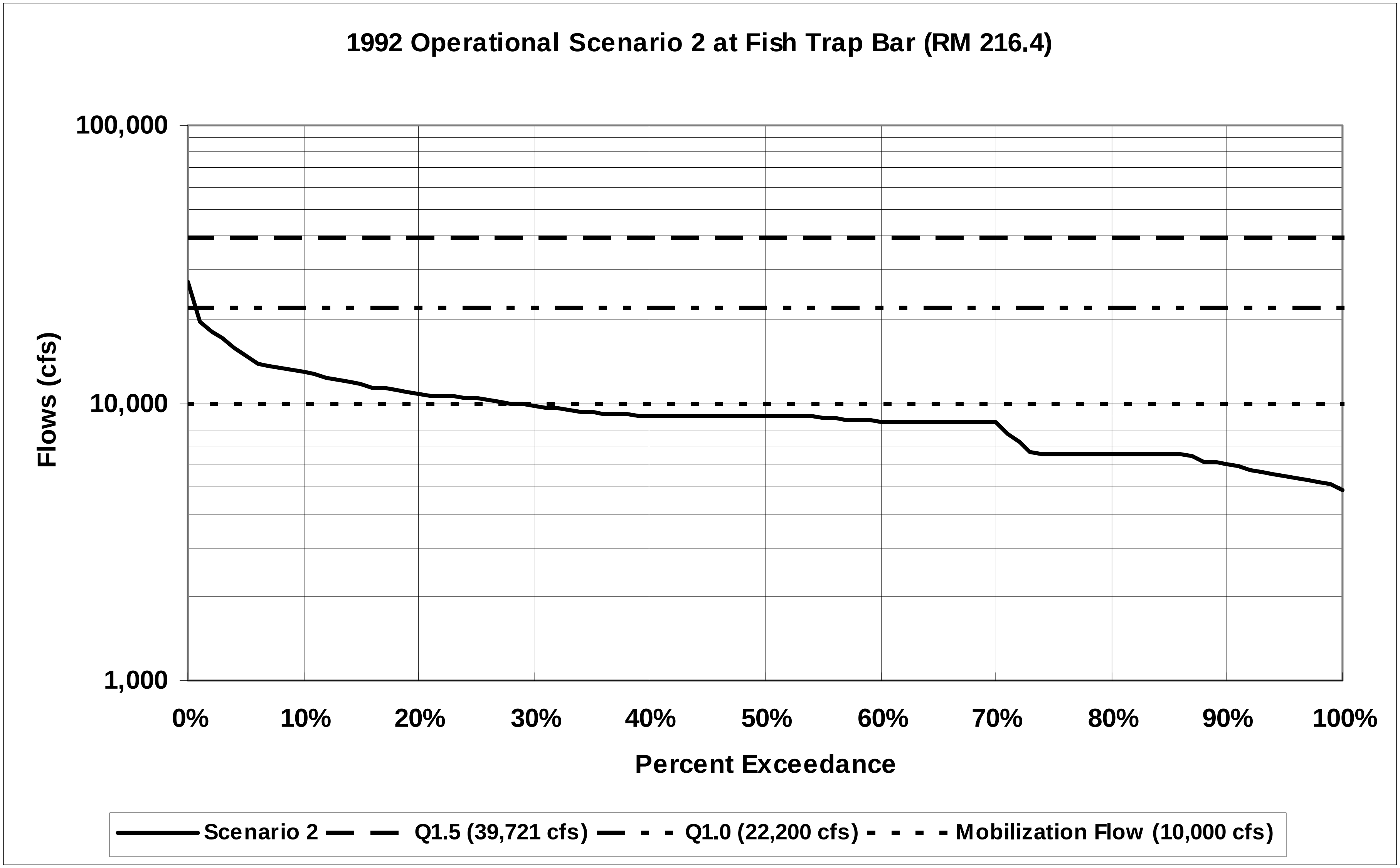


Figure 143. Flow-duration curve for 1992 Operational Scenario 2 at Fish Trap Bar (RM 216.4).

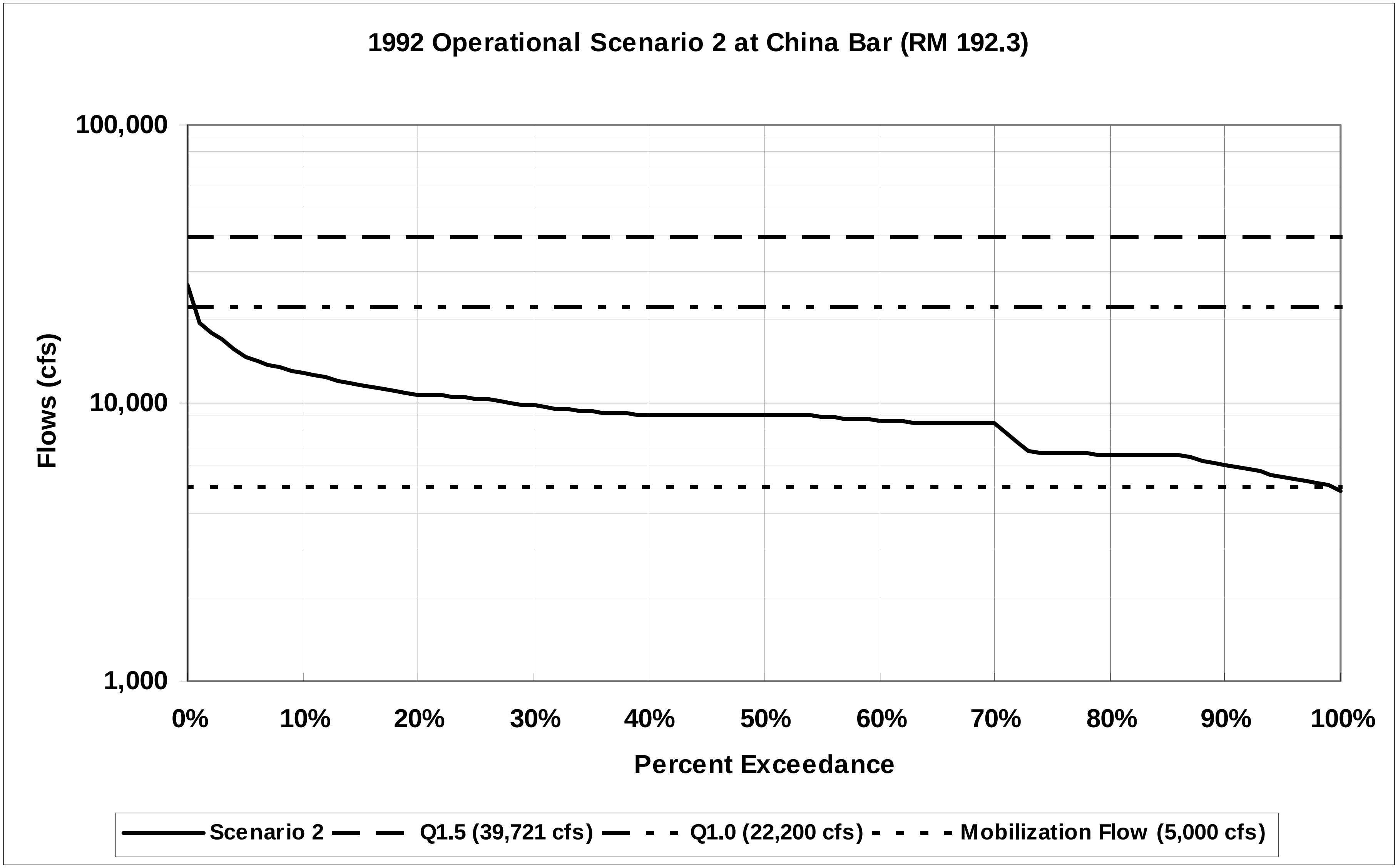


Figure 144. Flow-duration curve for 1992 Operational Scenario 2 at China Bar (RM 192.3).

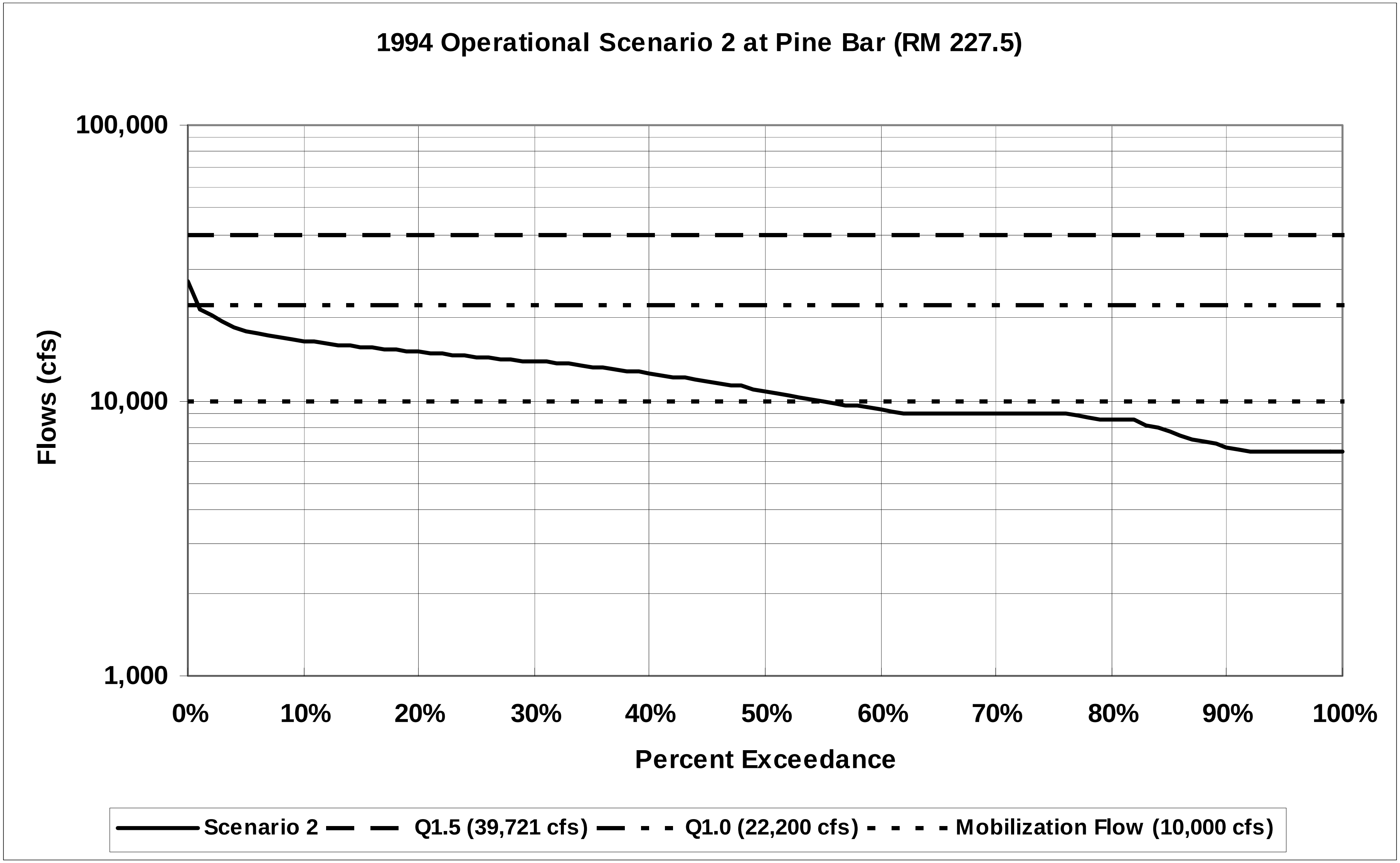


Figure 145. Flow-duration curve for 1994 Operational Scenario 2 at Pine Bar (RM 227.5).

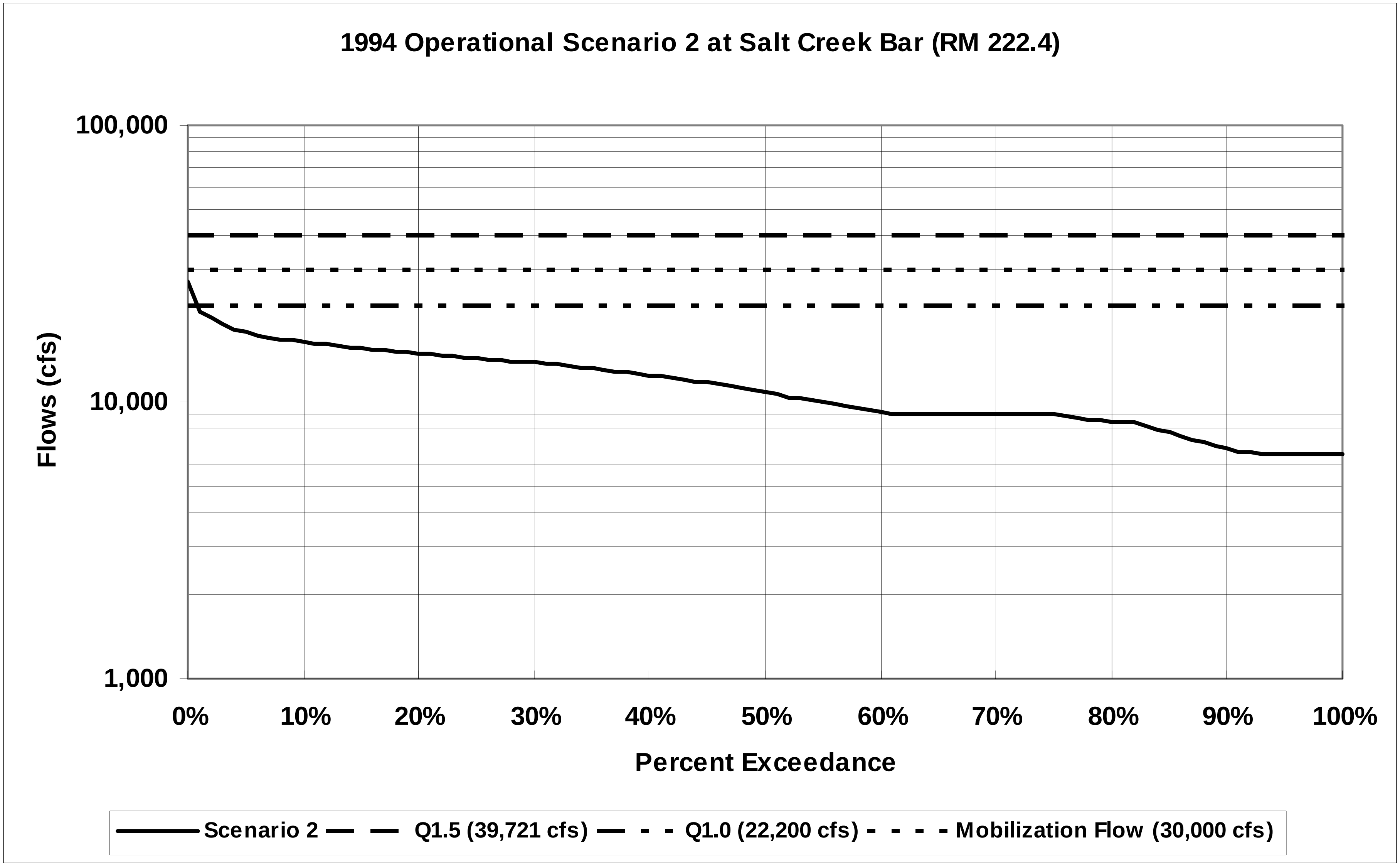


Figure 146. Flow-duration curve for 1994 Operational Scenario 2 at Salt Creek Bar (RM 222.4).

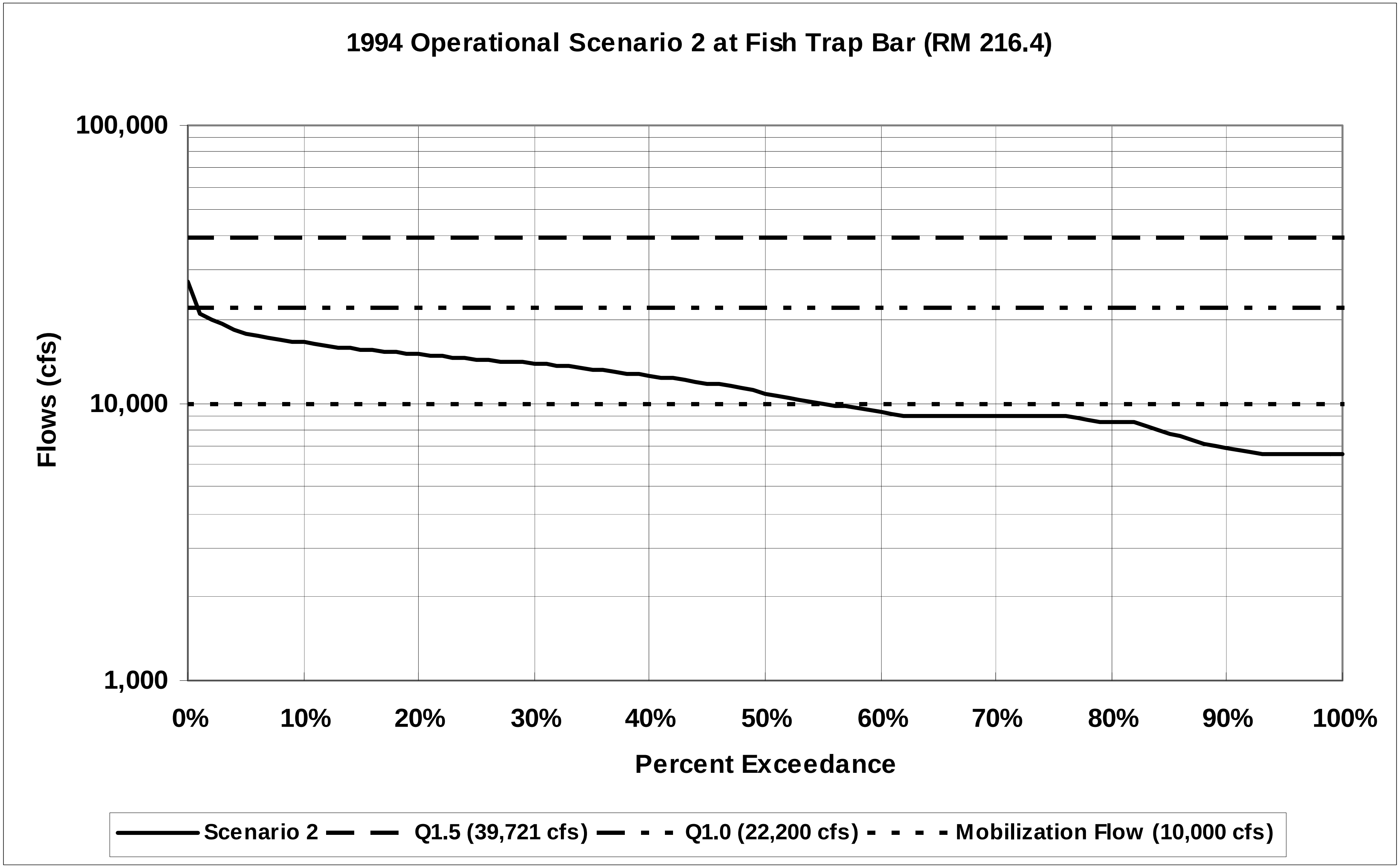


Figure 147. Flow-duration curve for 1994 Operational Scenario 2 at Fish Trap Bar (RM 216.4).

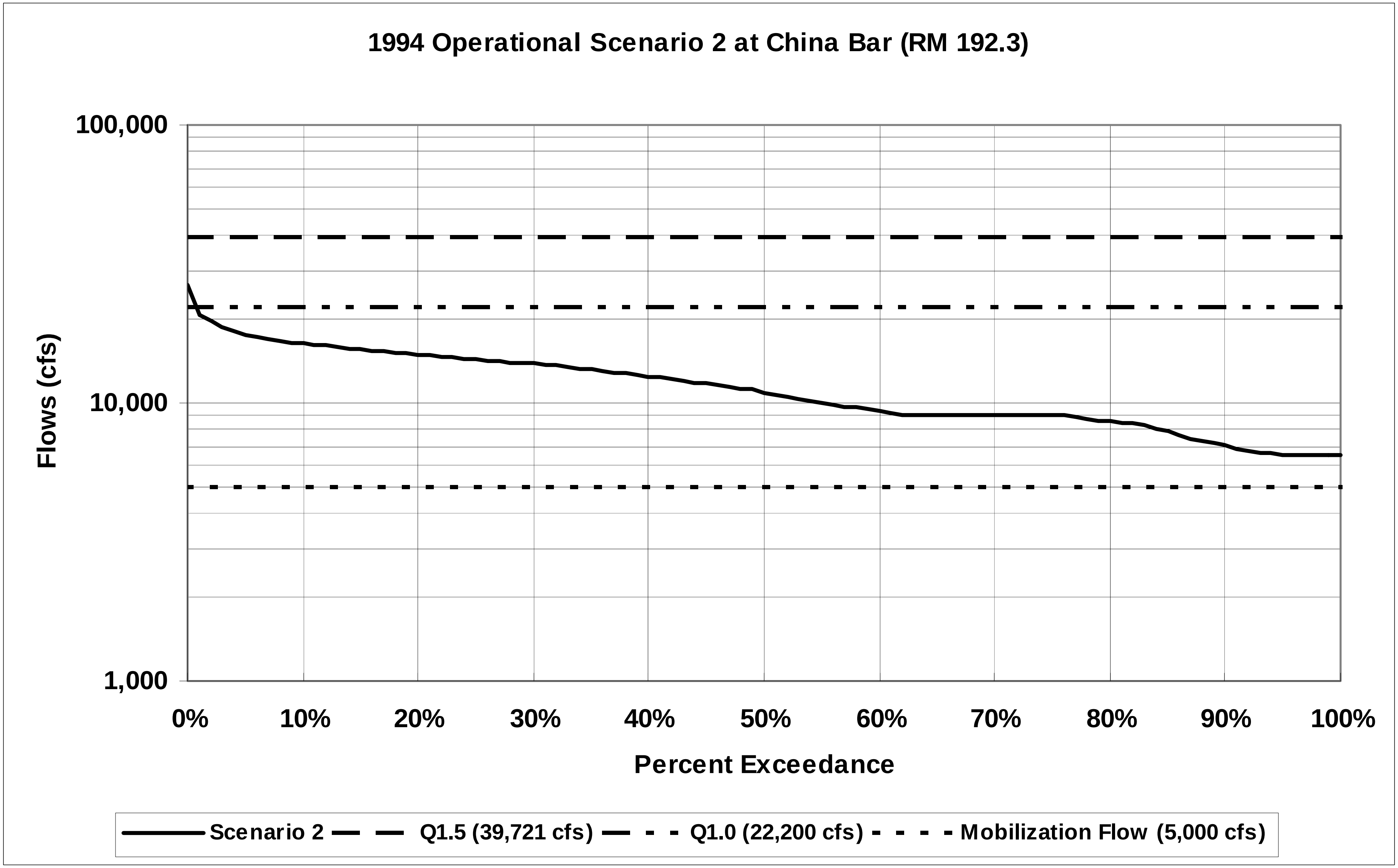


Figure 148. Flow-duration curve for 1994 Operational Scenario 2 at China Bar (RM 192.3).

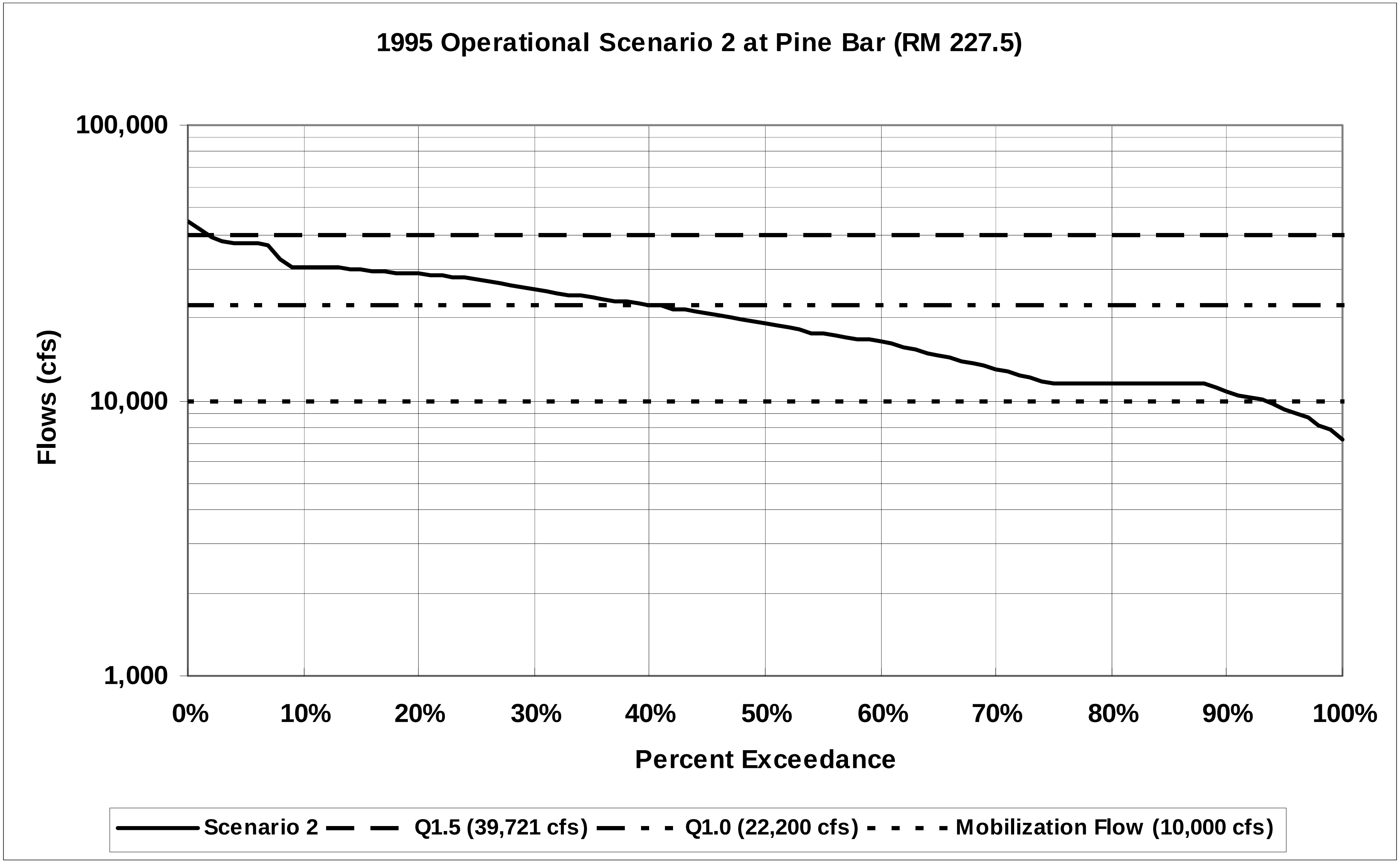


Figure 149. Flow-duration curve for 1995 Operational Scenario 2 at Pine Bar (RM 227.5).

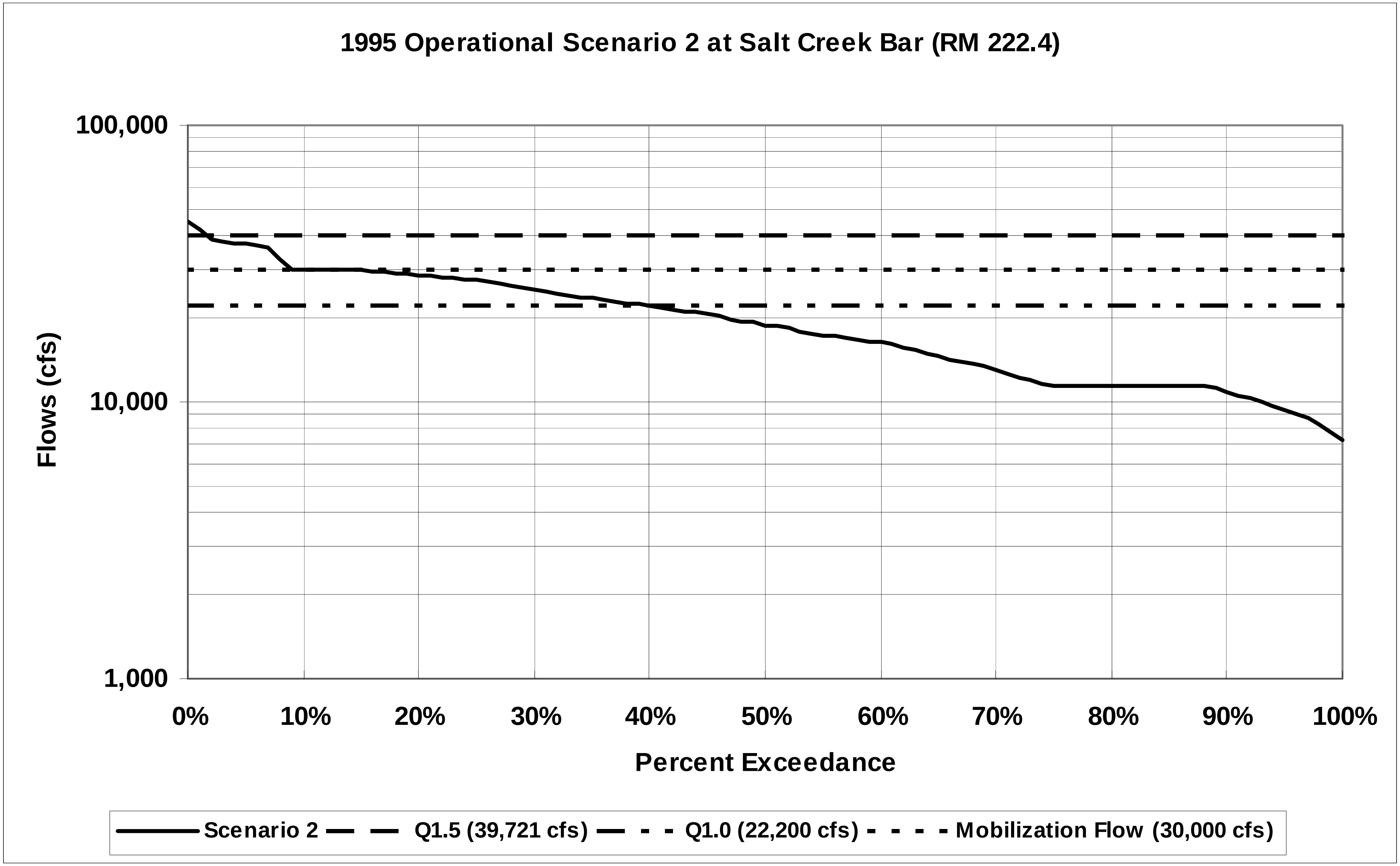


Figure 150. Flow-duration curve for 1995 Operational Scenario 2 at Salt Creek Bar (RM 222.4).

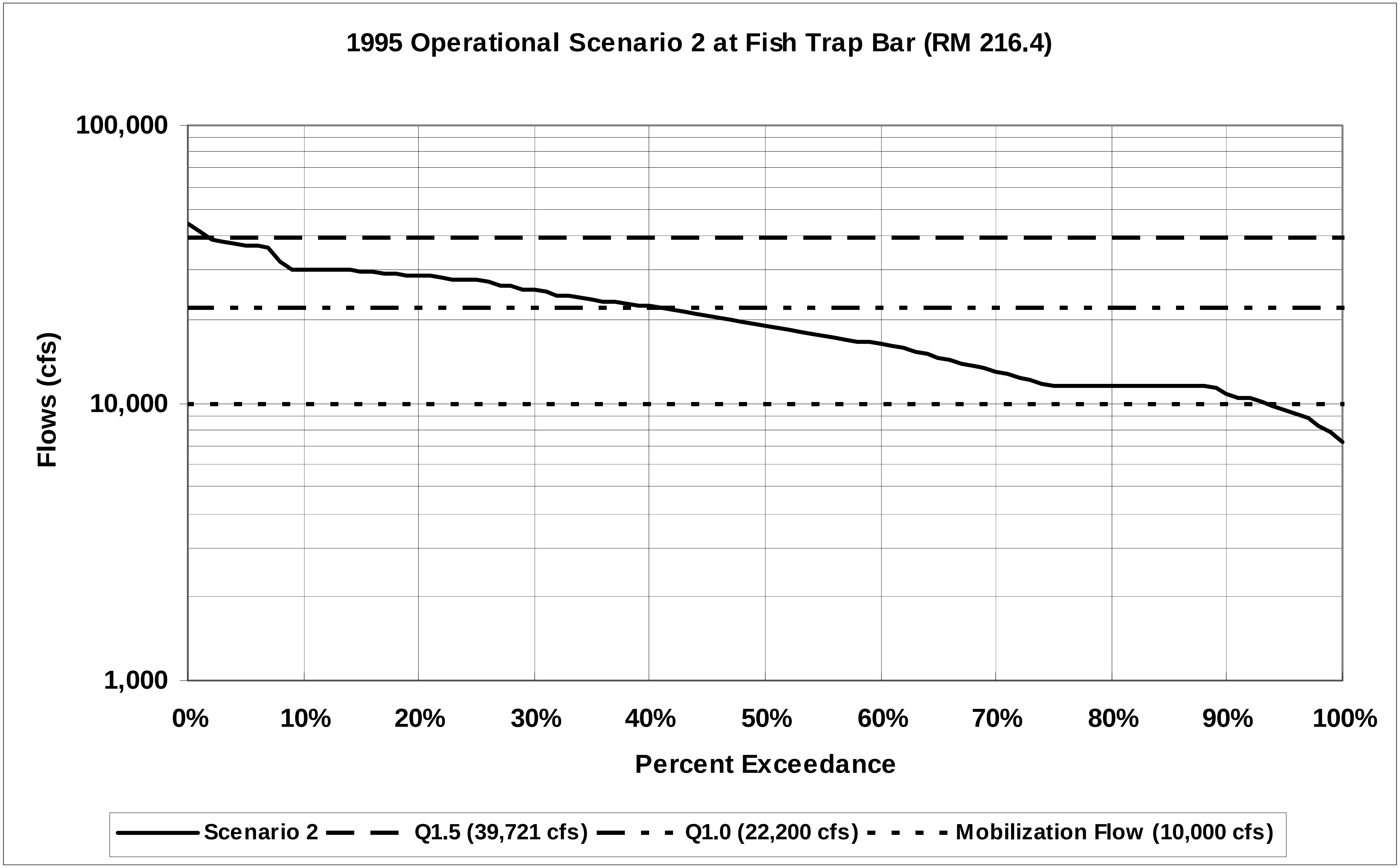


Figure 151. Flow-duration curve for 1995 Operational Scenario 2 at Fish Trap Bar (RM 216.4).

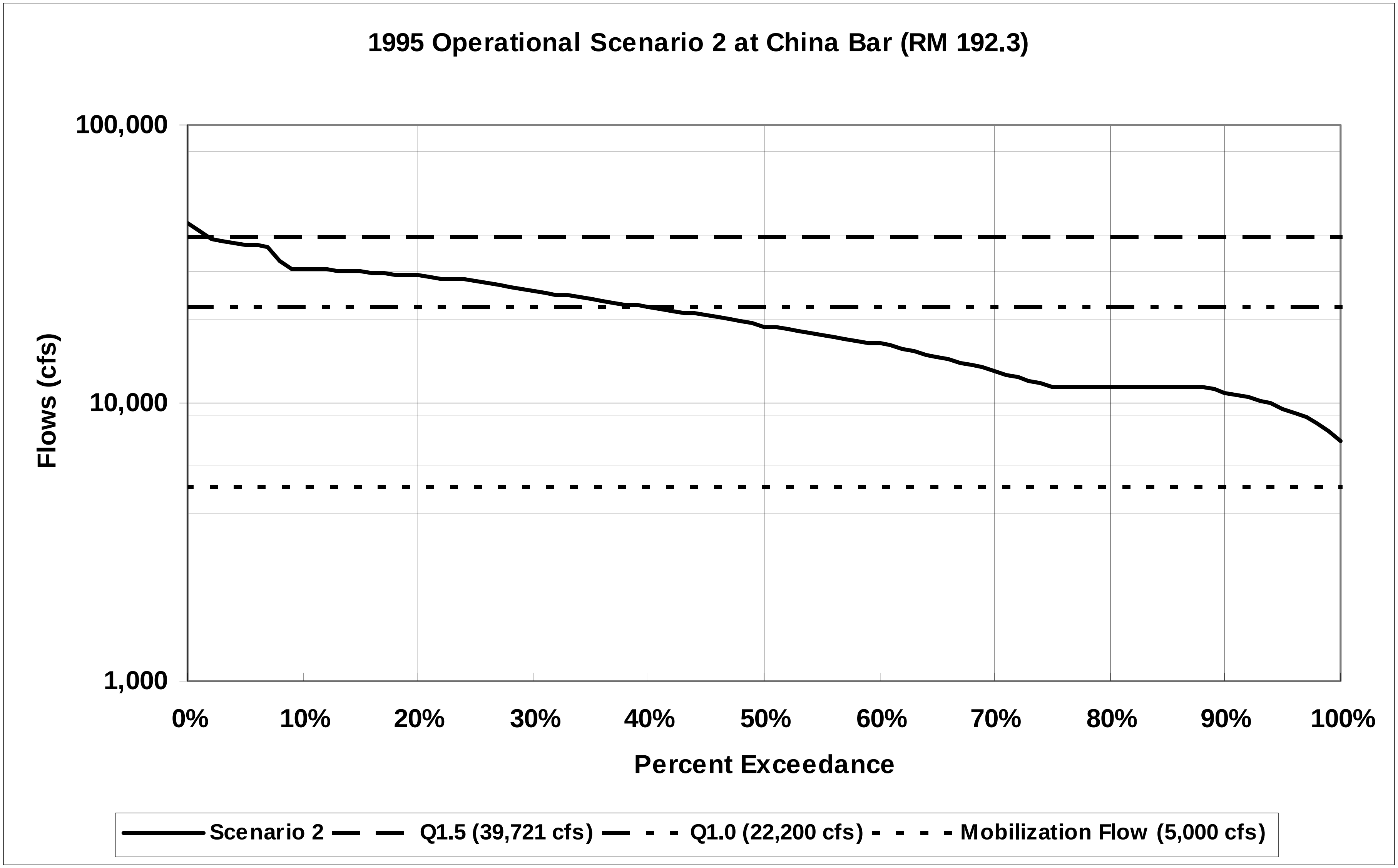


Figure 152. Flow-duration curve for 1995 Operational Scenario 2 at China Bar (RM 192.3).

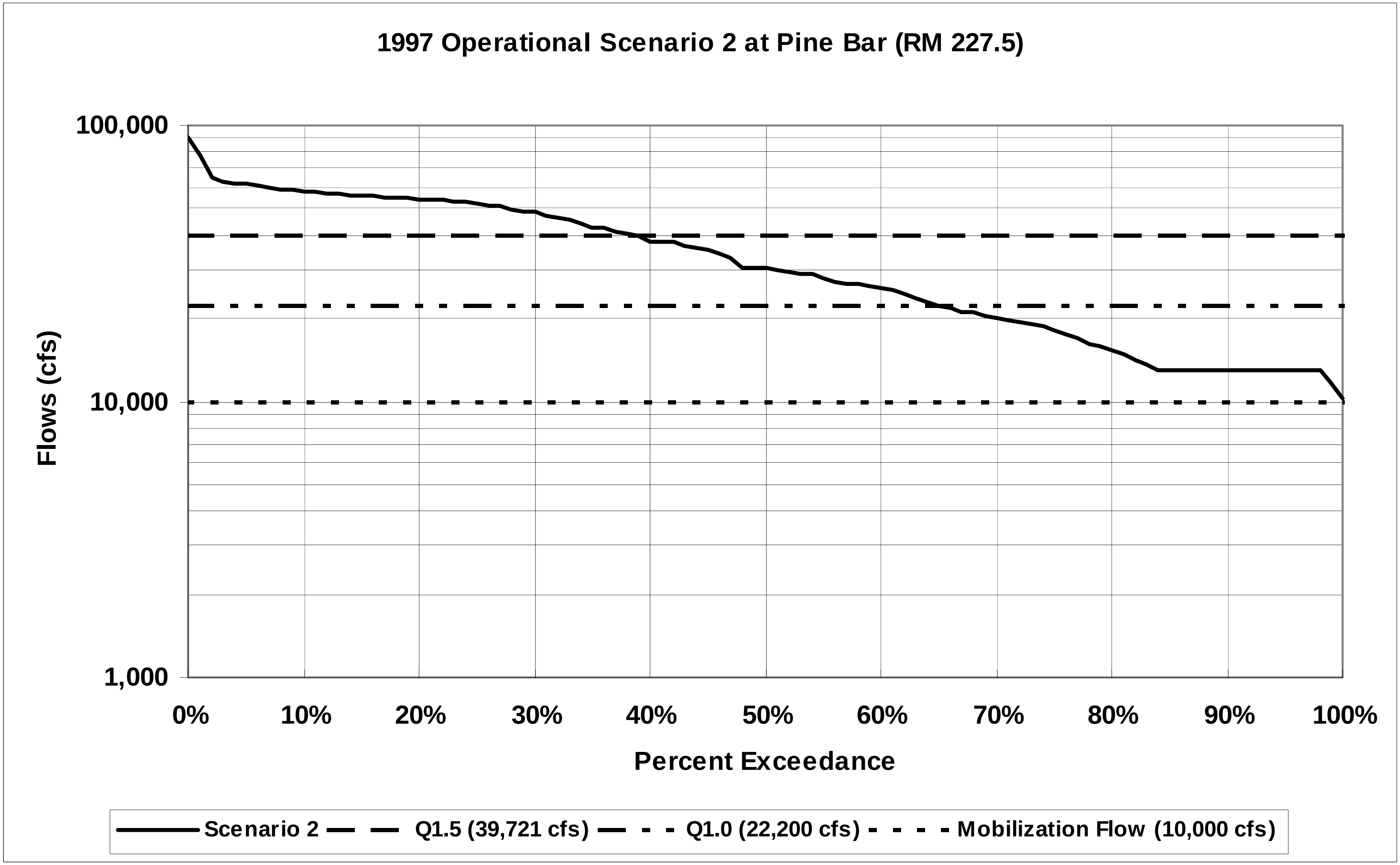


Figure 153. Flow-duration curve for 1997 Operational Scenario 2 at Pine Bar (RM 227.5).

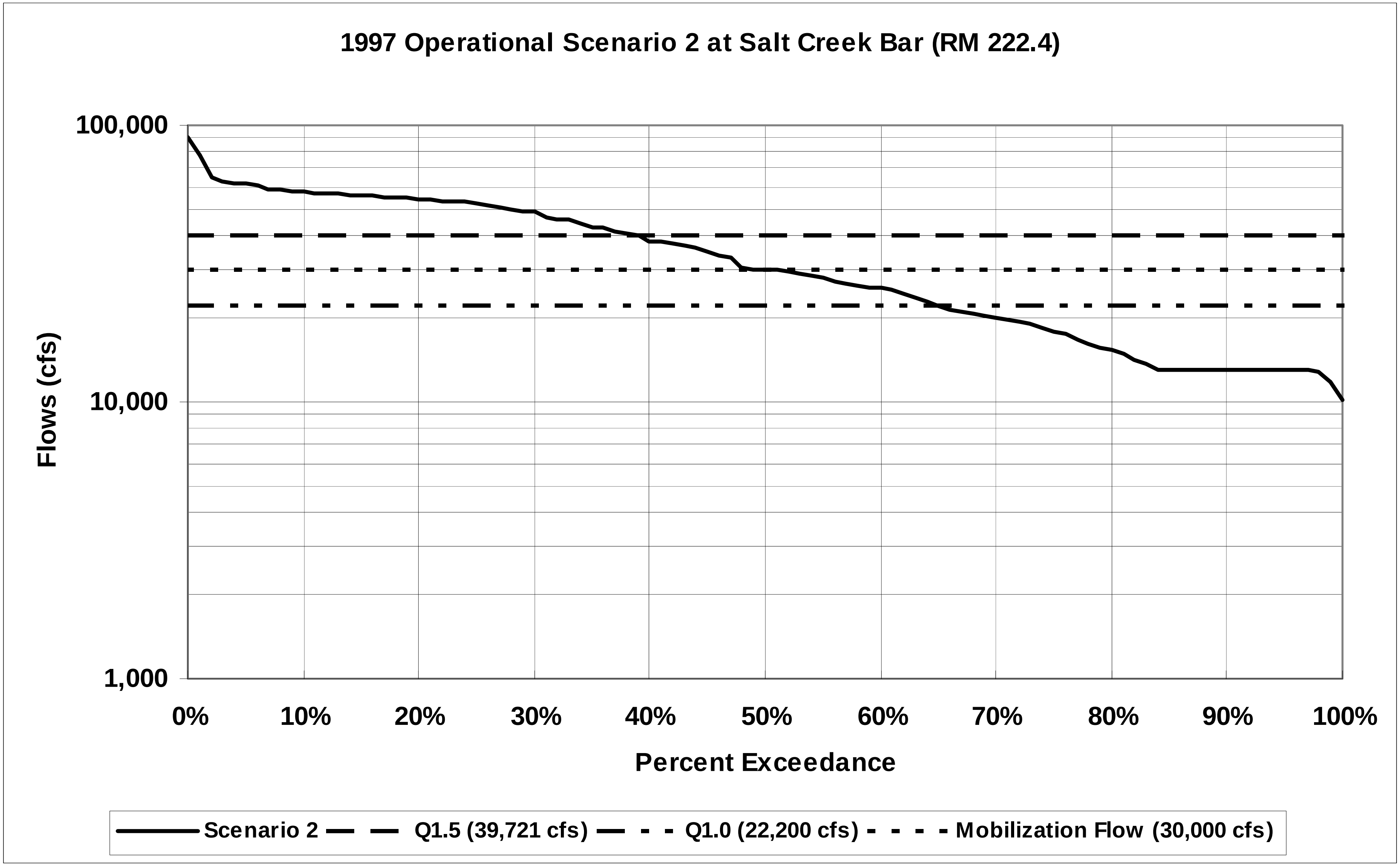


Figure 154. Flow-duration curve for 1997 Operational Scenario 2 at Salt Creek Bar (RM 222.4).

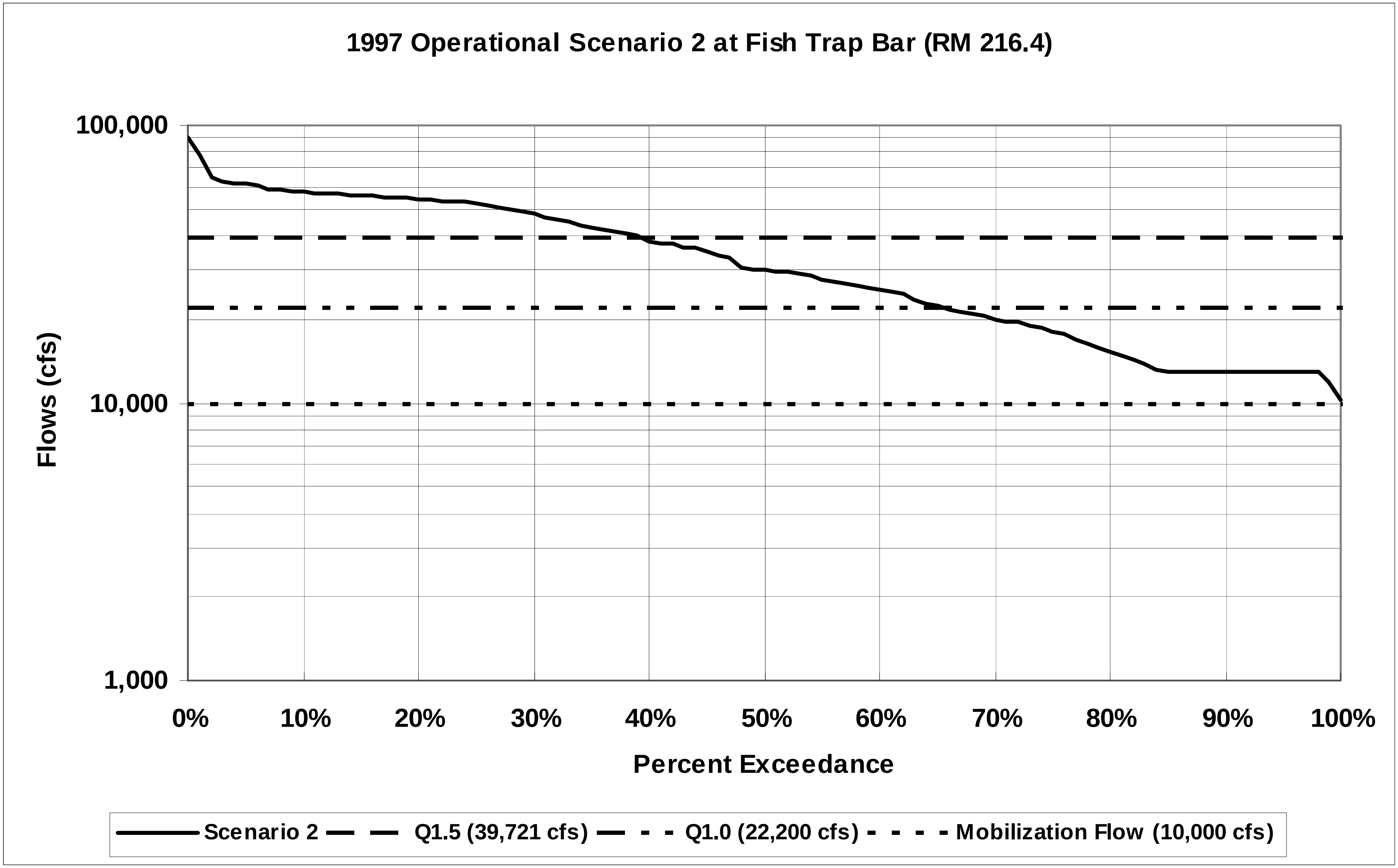


Figure 155. Flow-duration curve for 1997 Operational Scenario 2 at Fish Trap Bar (RM 216.4).

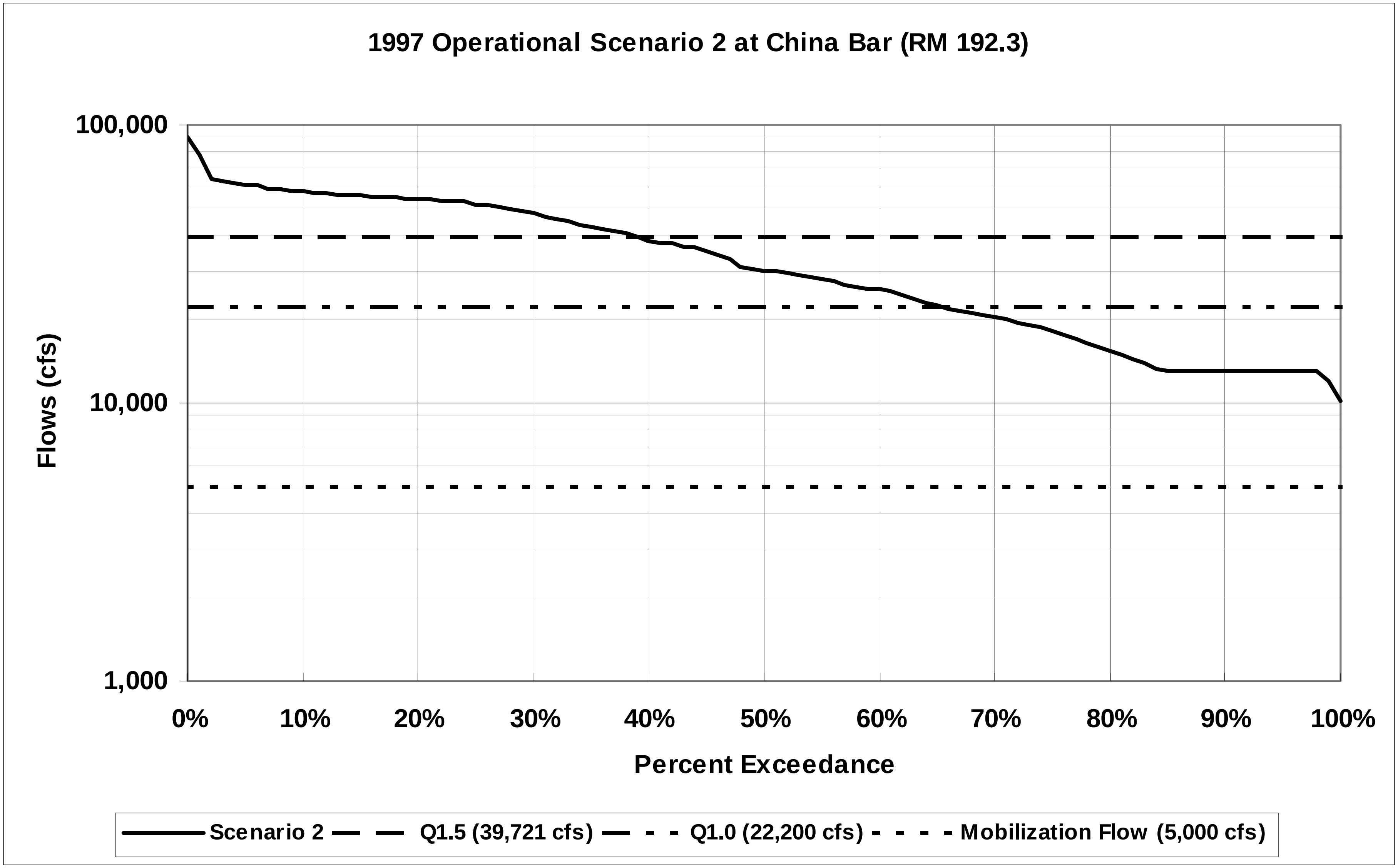


Figure 156. Flow-duration curve for 1997 Operational Scenario 2 at China Bar (RM 192.3).

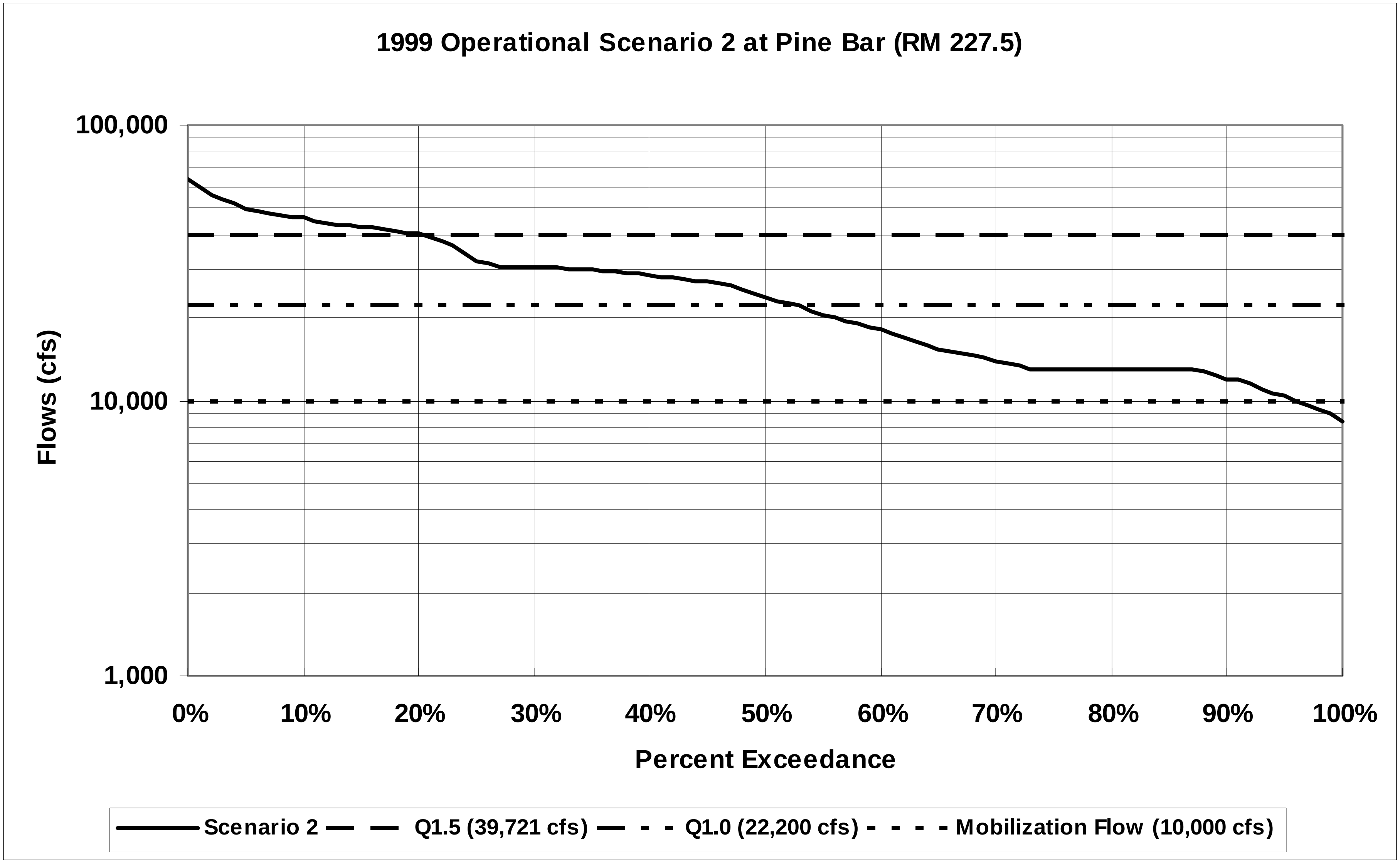


Figure 157. Flow-duration curve for 1999 Operational Scenario 2 at Pine Bar (RM 227.5).

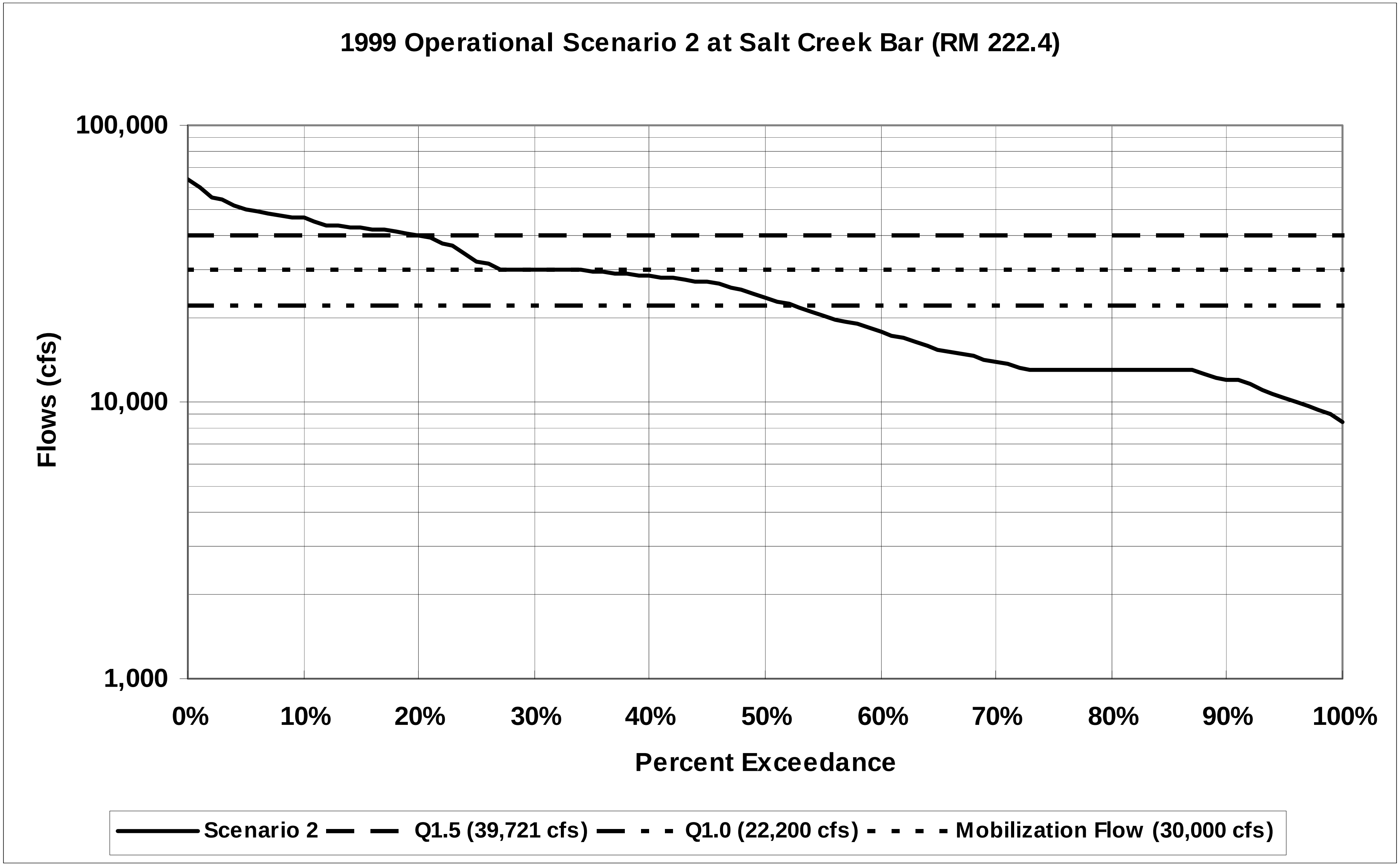


Figure 158. Flow-duration curve for 1999 Operational Scenario 2 at Salt Creek Bar (RM 222.4).

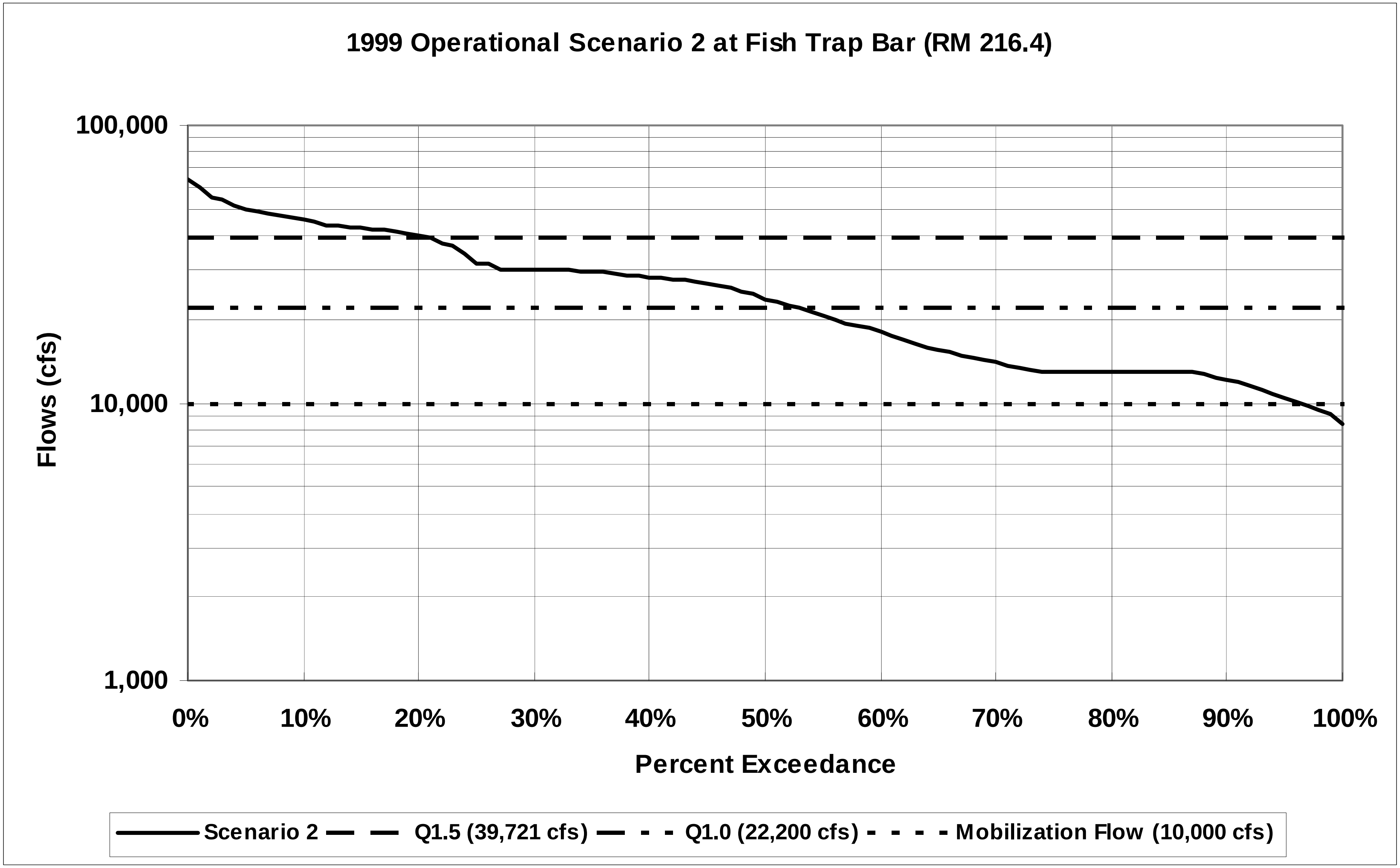


Figure 159. Flow-duration curve for 1999 Operational Scenario 2 at Fish Trap Bar (RM 216.4).

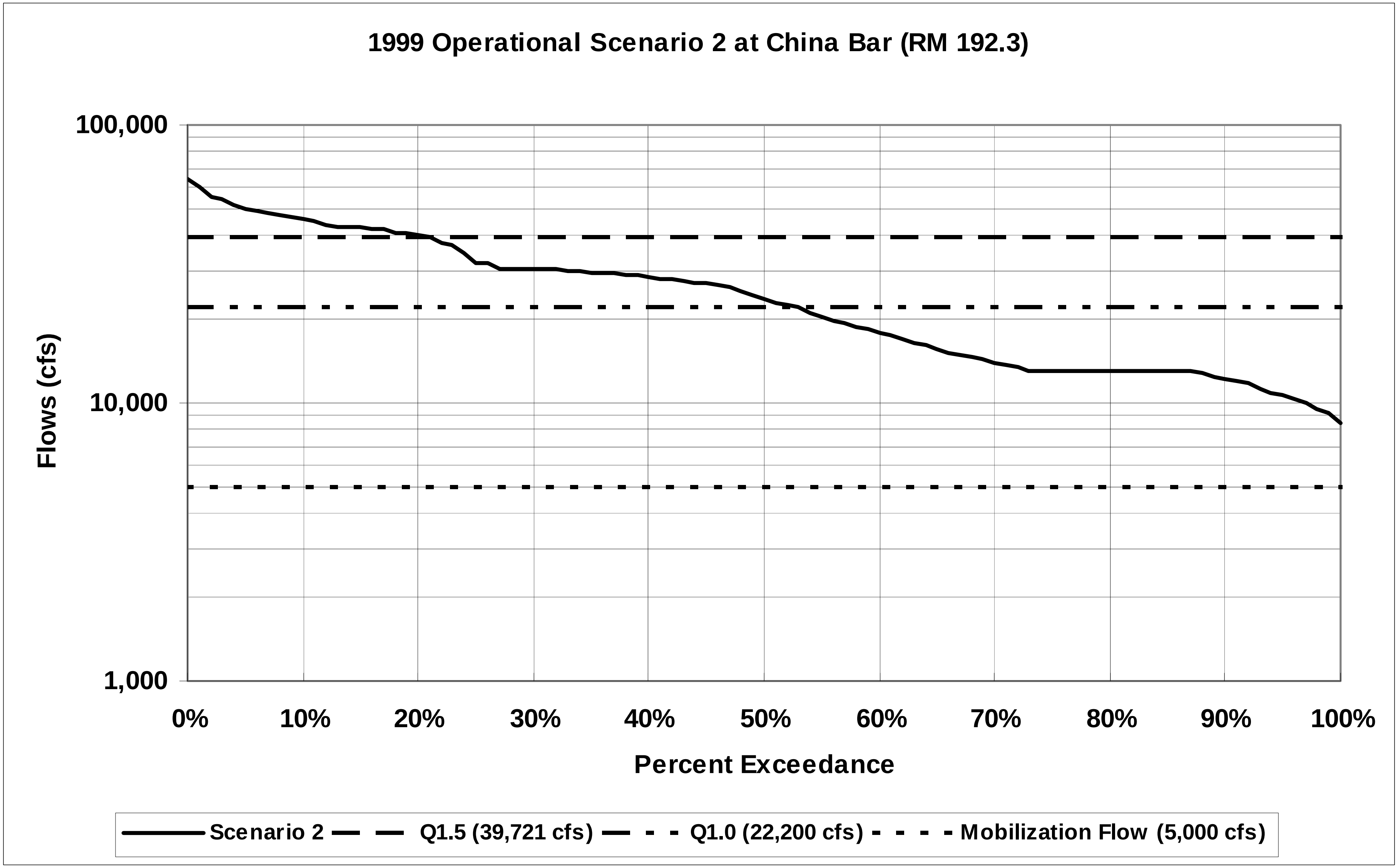


Figure 160. Flow-duration curve for 1999 Operational Scenario 2 at China Bar (RM 192.3).

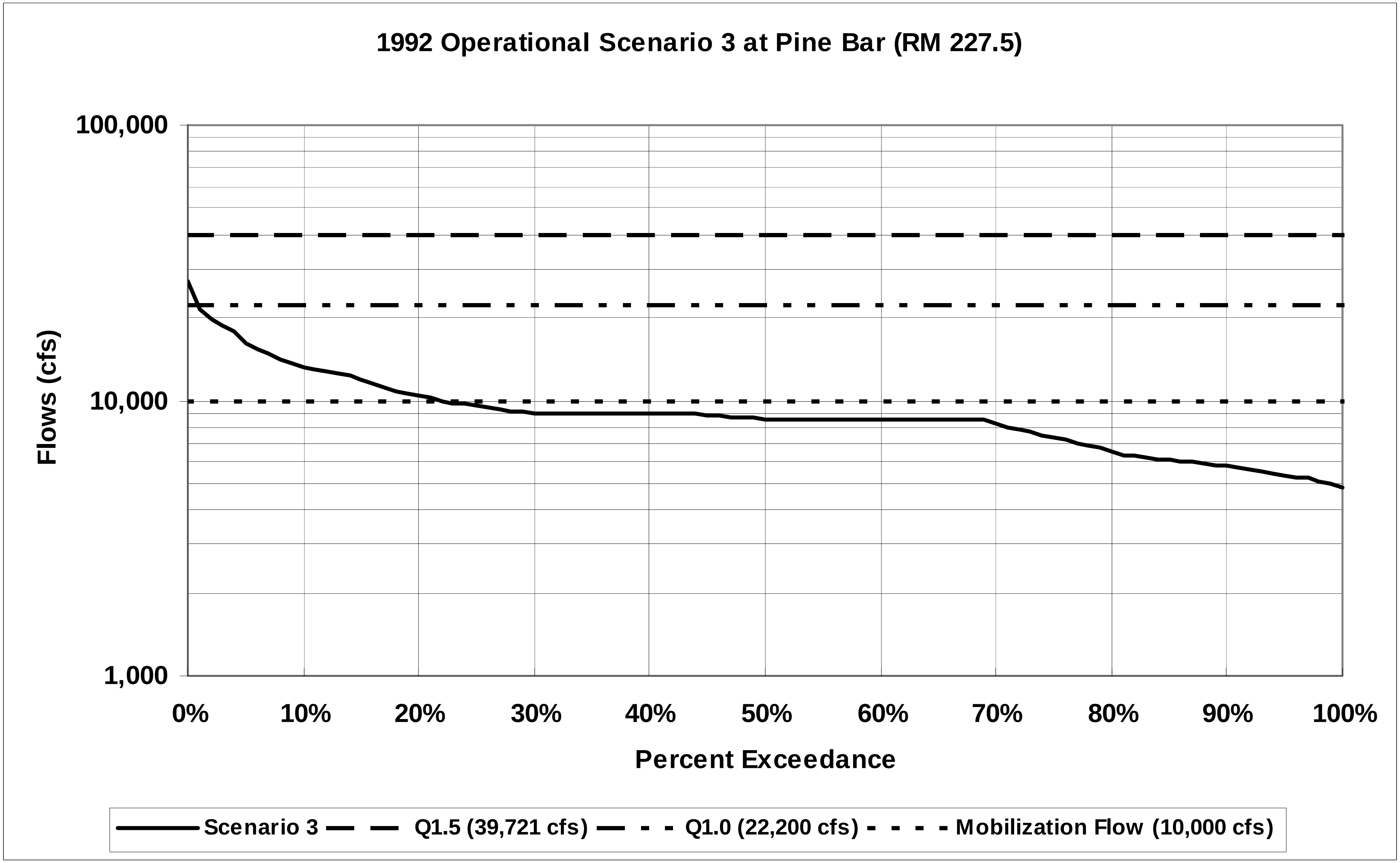


Figure 161. Flow-duration curve for 1992 Operational Scenario 3 at Pine Bar (RM 227.5).

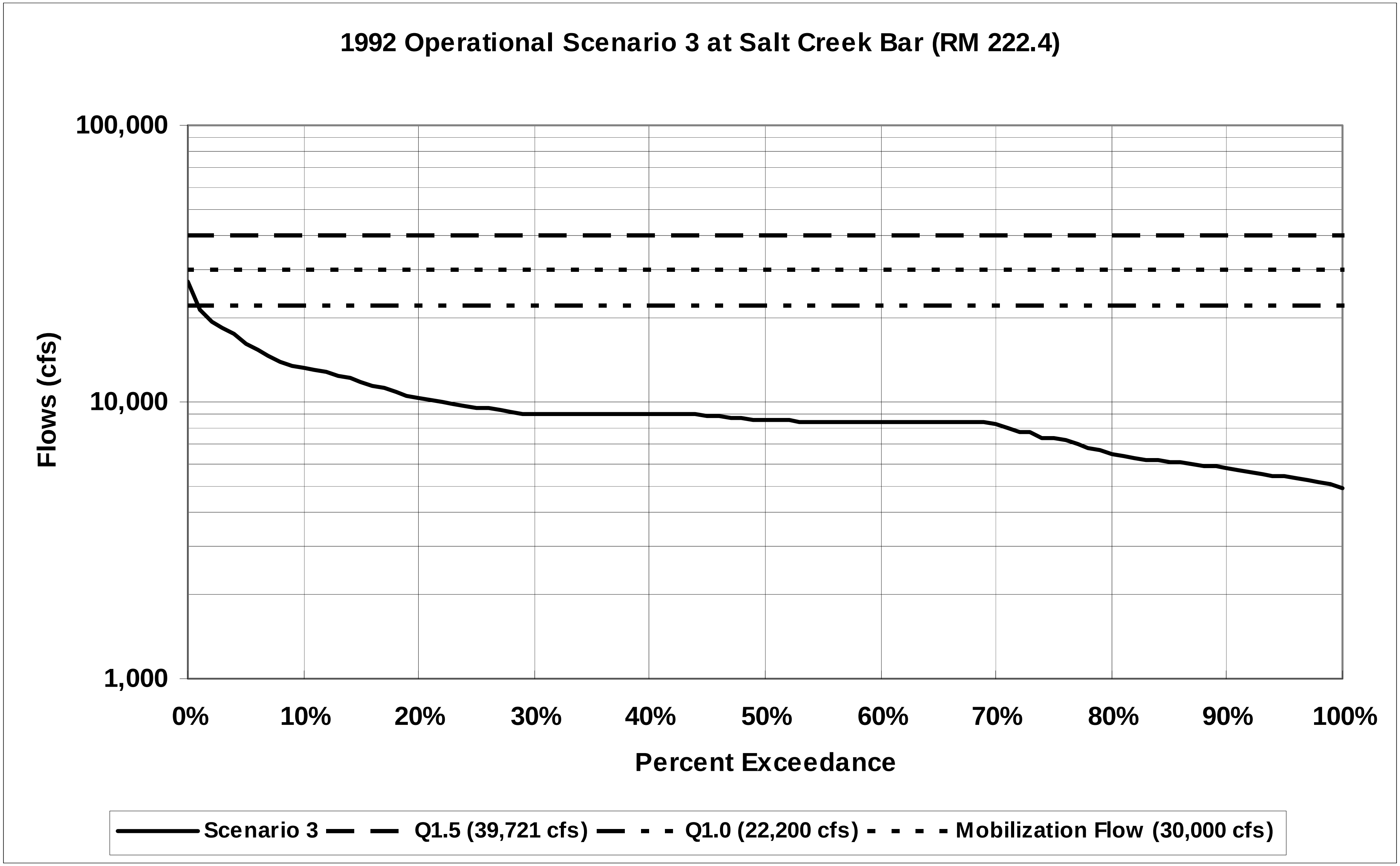


Figure 162. Flow-duration curve for 1992 Operational Scenario 3 at Salt Creek Bar (RM 222.4).

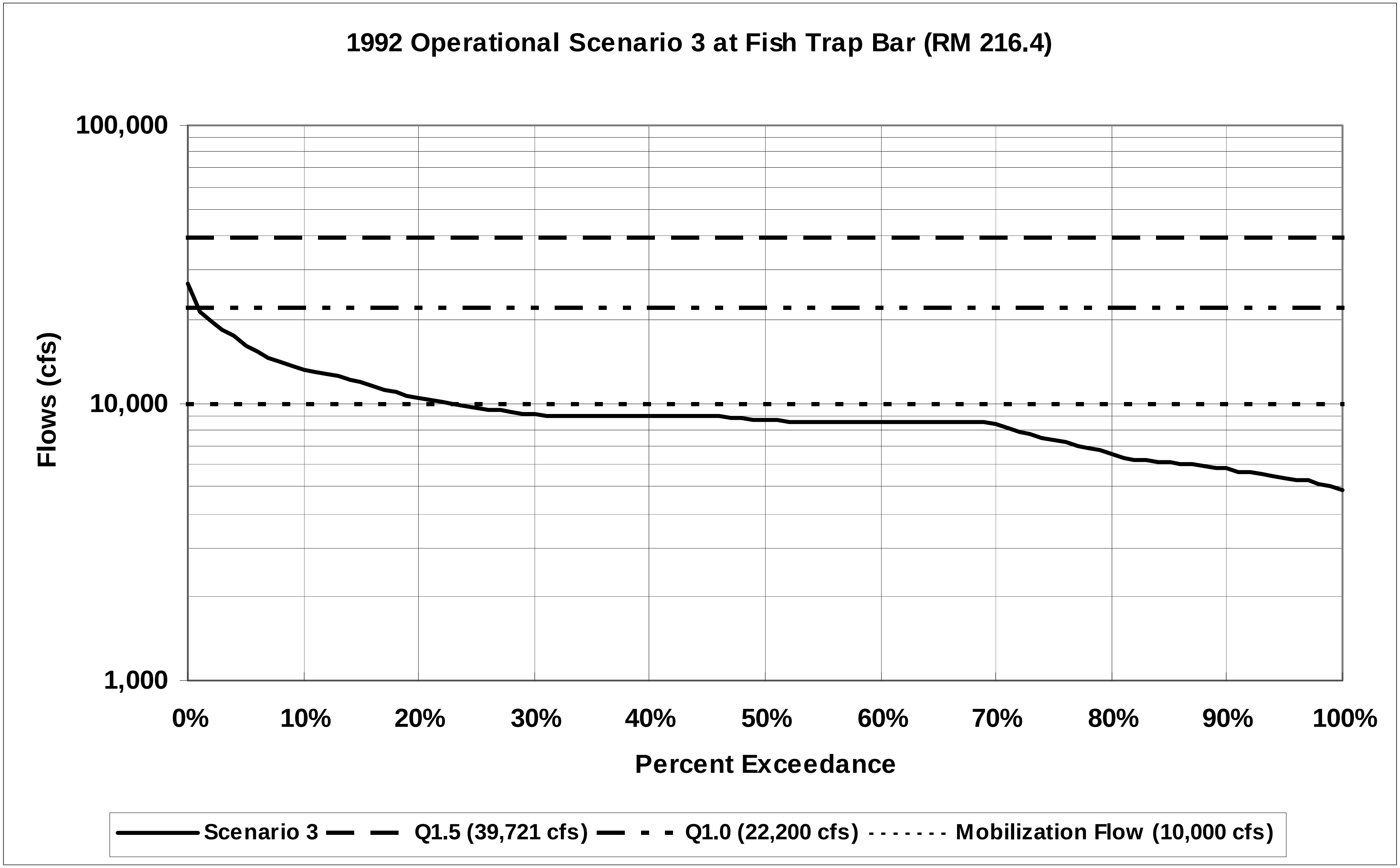


Figure 163. Flow-duration curve for 1992 Operational Scenario 3 at Fish Trap Bar (RM 216.4).

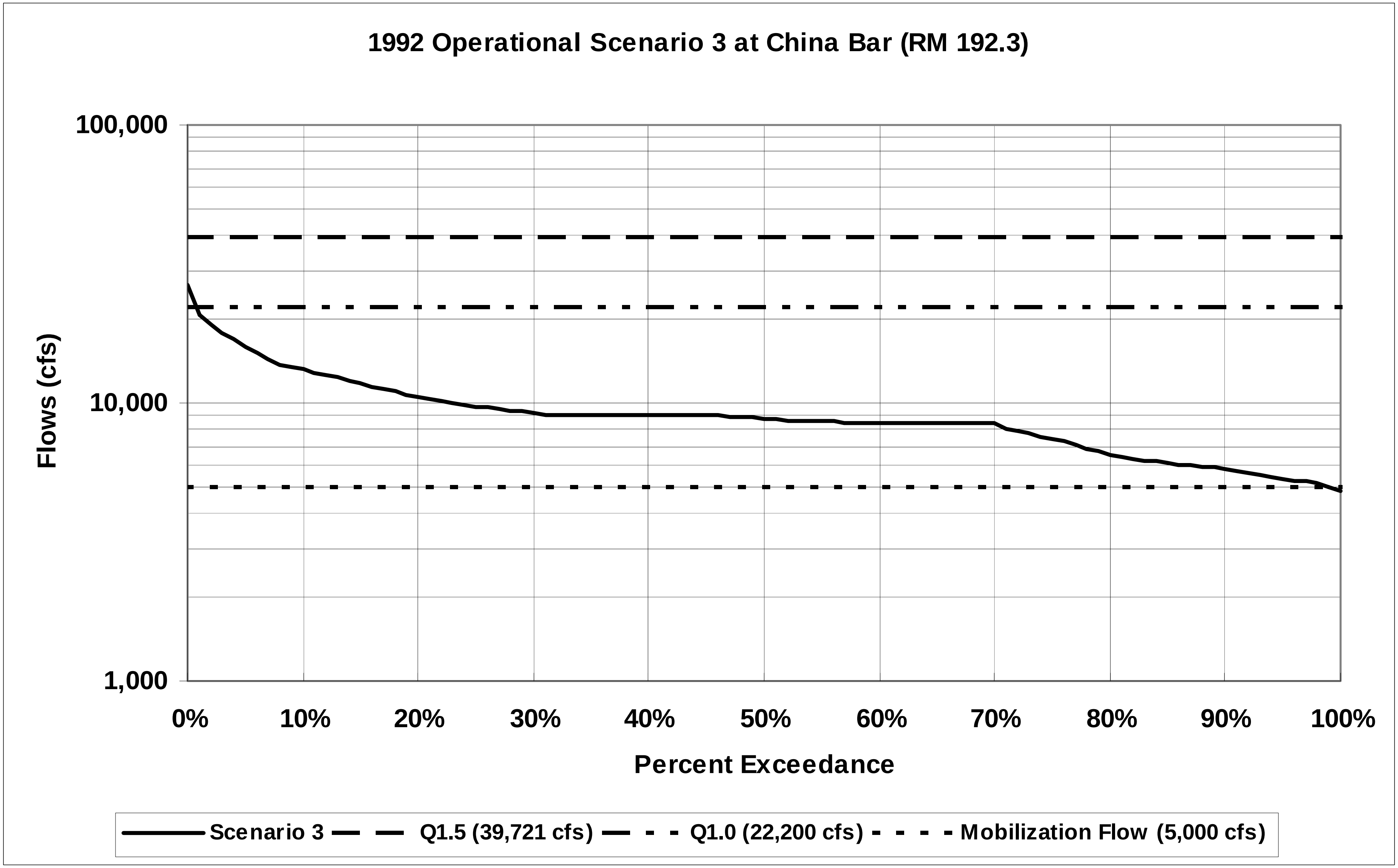


Figure 164. Flow-duration curve for 1992 Operational Scenario 3 at China Bar (RM 192.3).

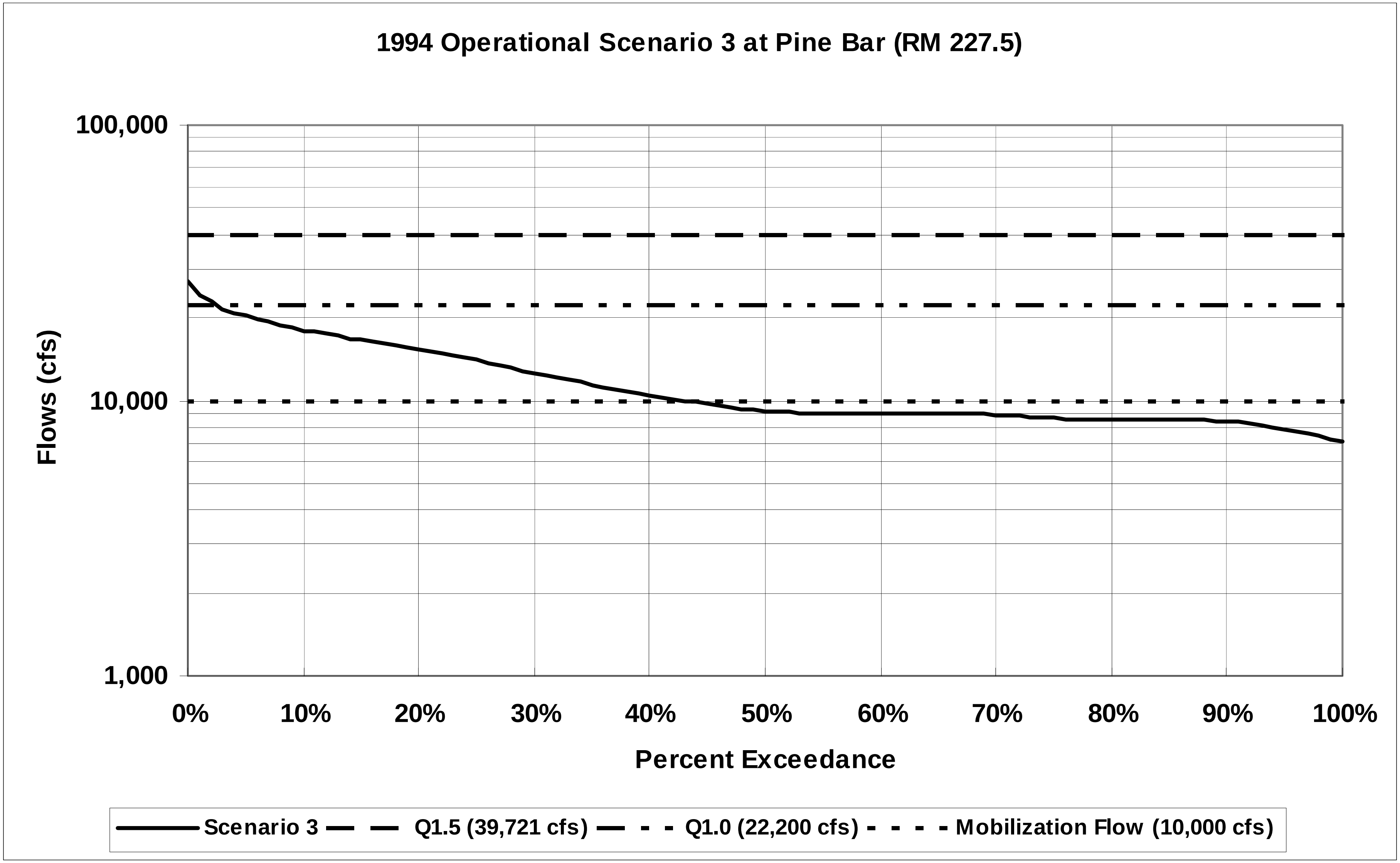


Figure 165. Flow-duration curve for 1994 Operational Scenario 3 at Pine Bar (RM 227.5).

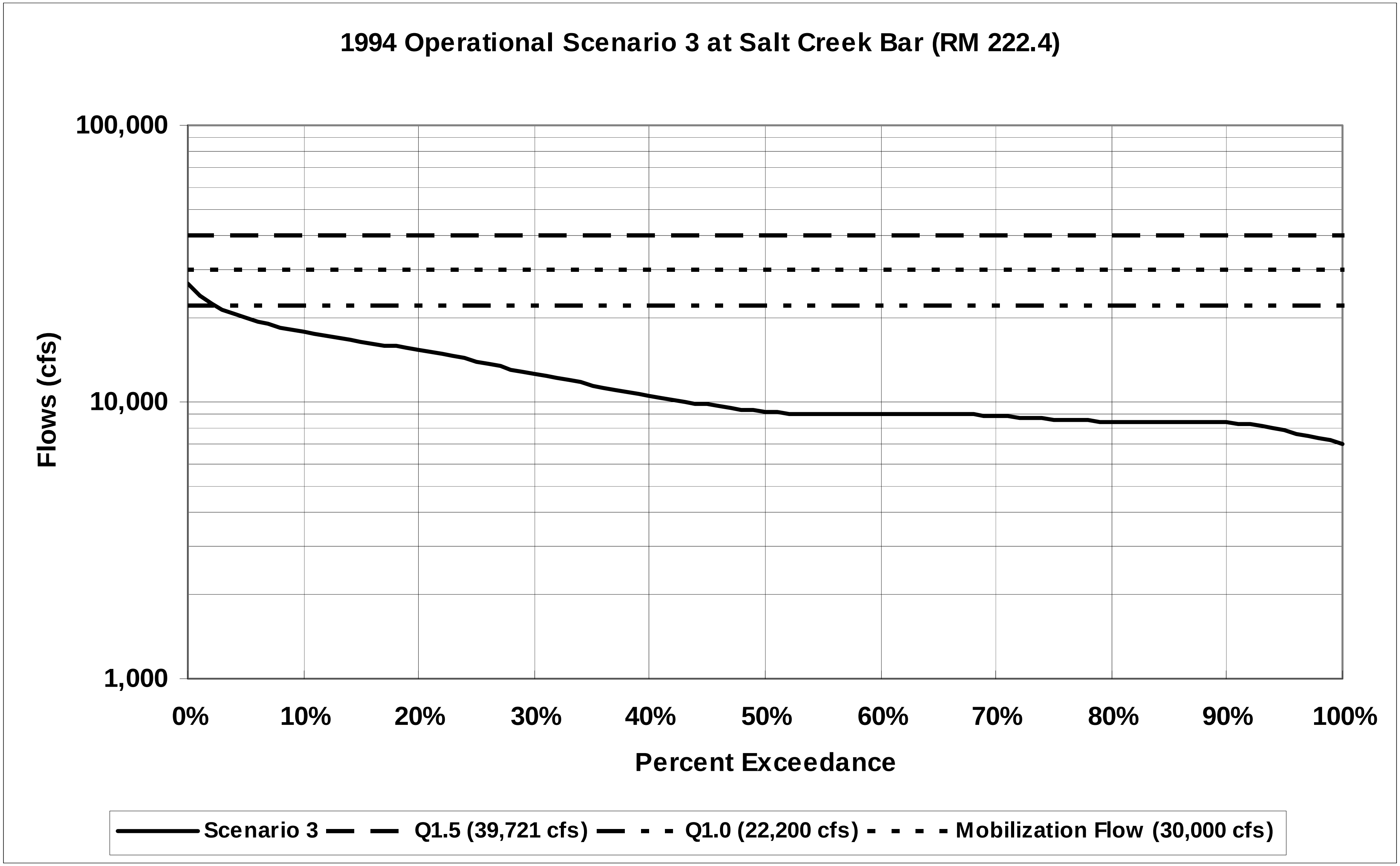


Figure 166. Flow-duration curve for 1994 Operational Scenario 3 at Salt Creek Bar (RM 222.4).

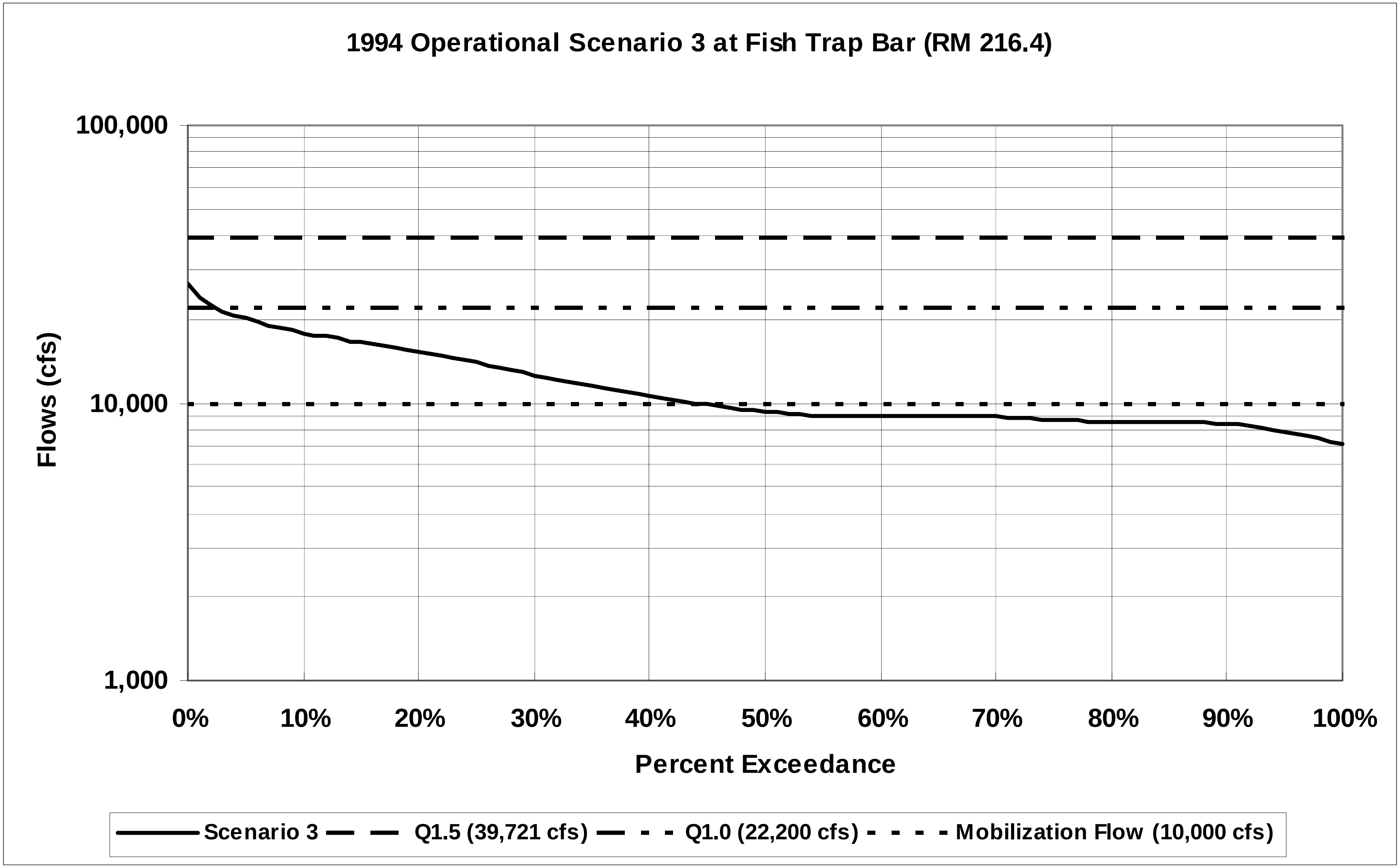


Figure 167. Flow-duration curve for 1994 Operational Scenario 3 at Fish Trap Bar (RM 216.4).

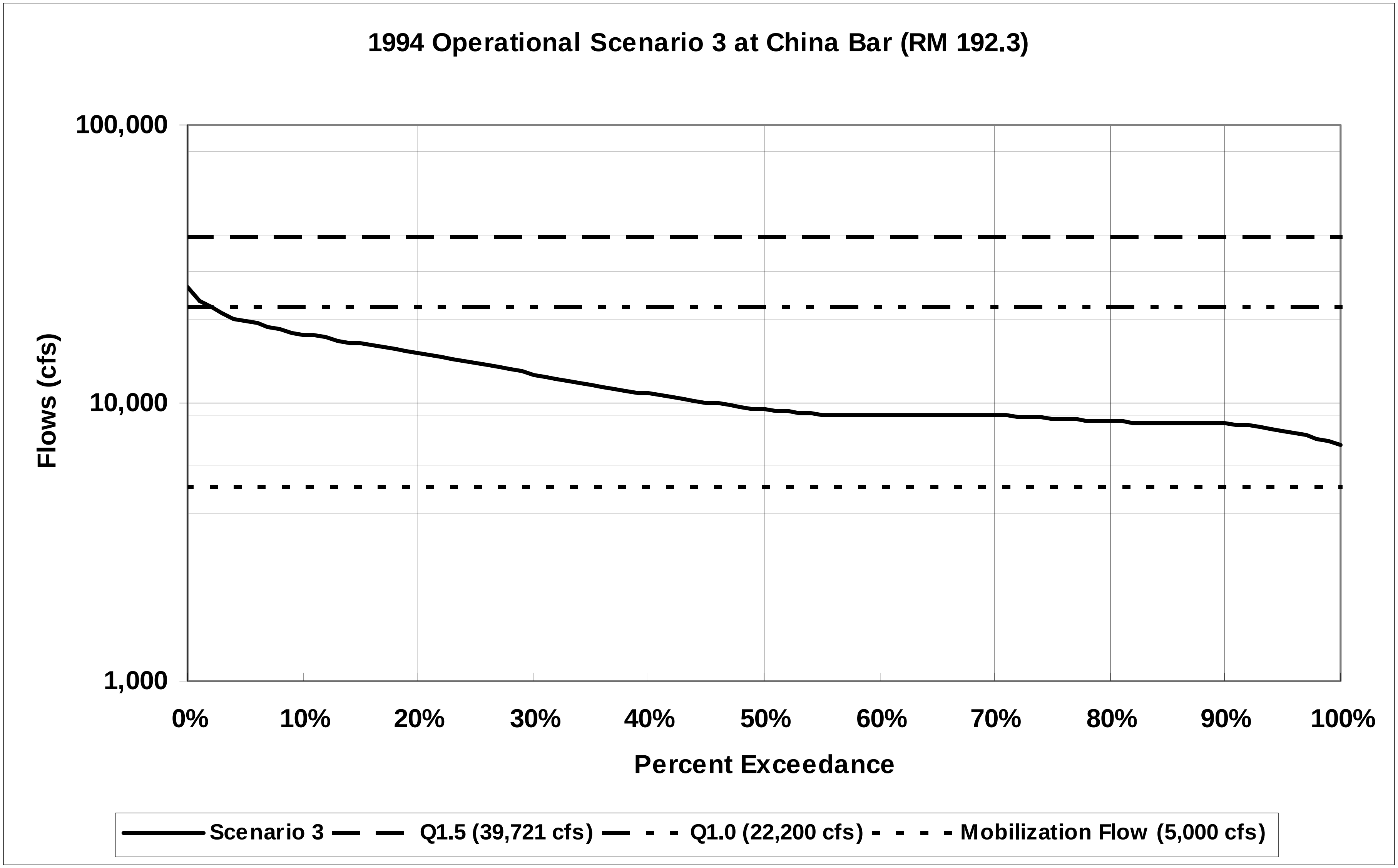


Figure 168. Flow-duration curve for 1994 Operational Scenario 3 at China Bar (RM 192.3).

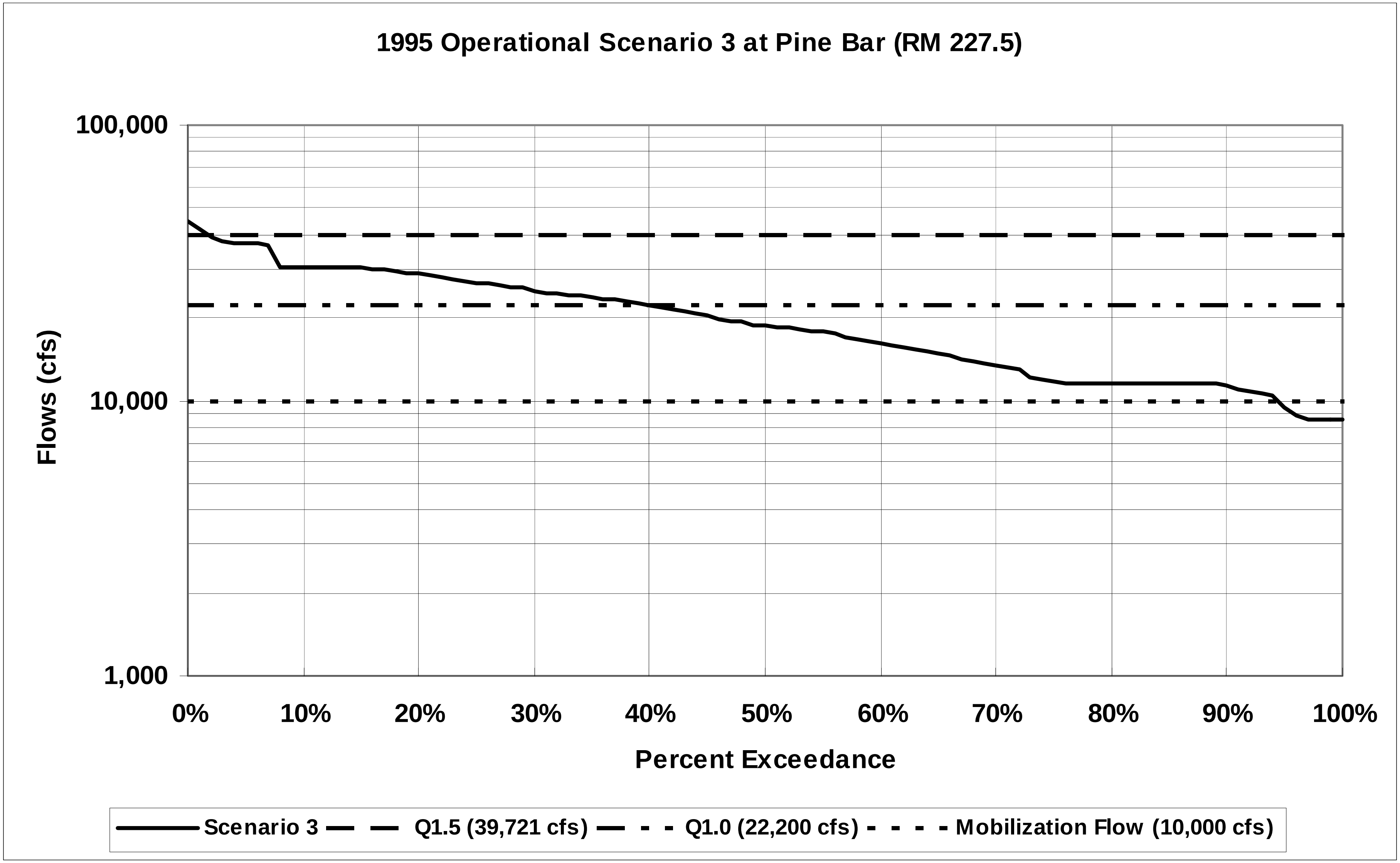


Figure 169. Flow-duration curve for 1995 Operational Scenario 3 at Pine Bar (RM 227.5).

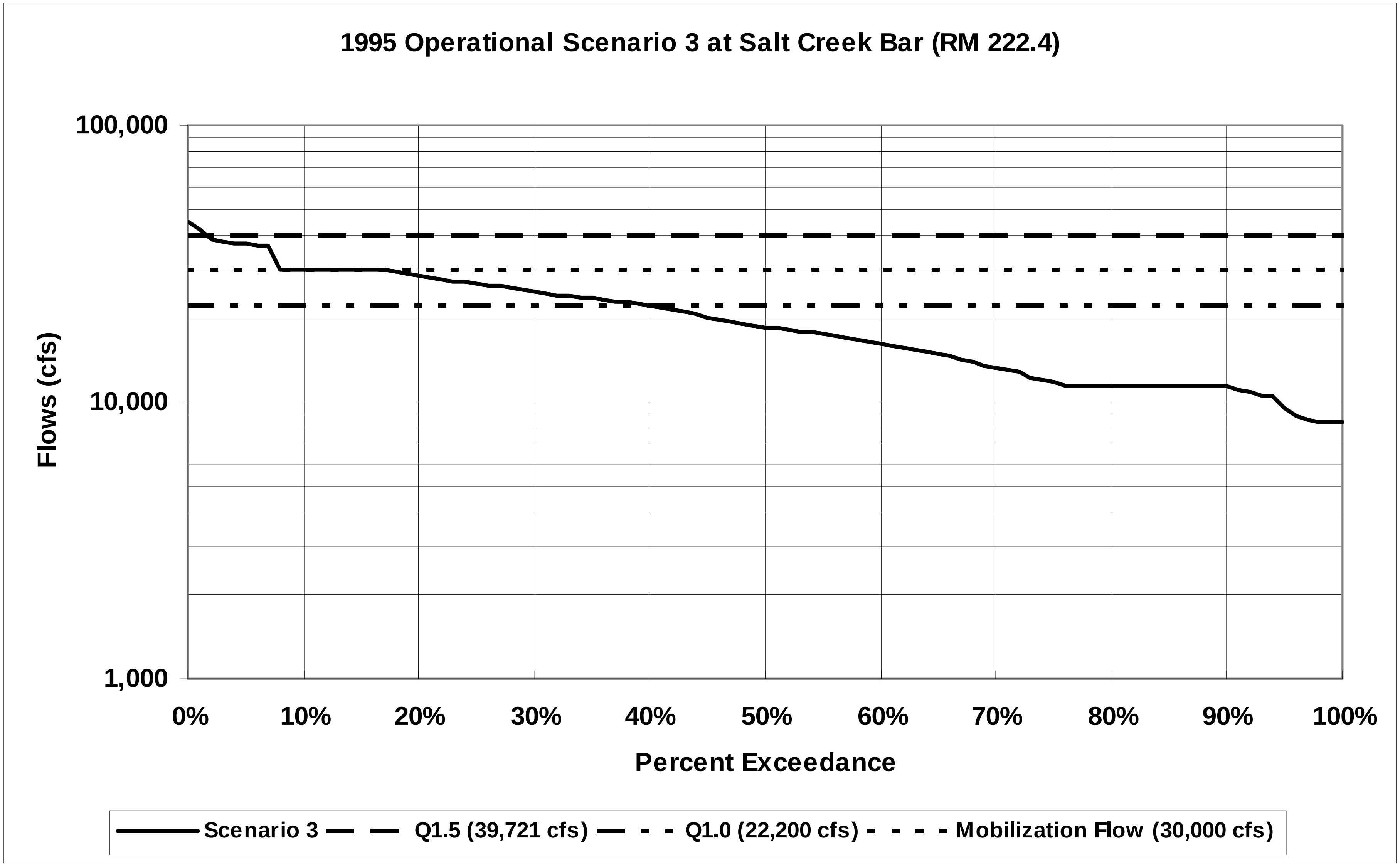


Figure 170. Flow-duration curve for 1995 Operational Scenario 3 at Salt Creek Bar (RM 222.4).

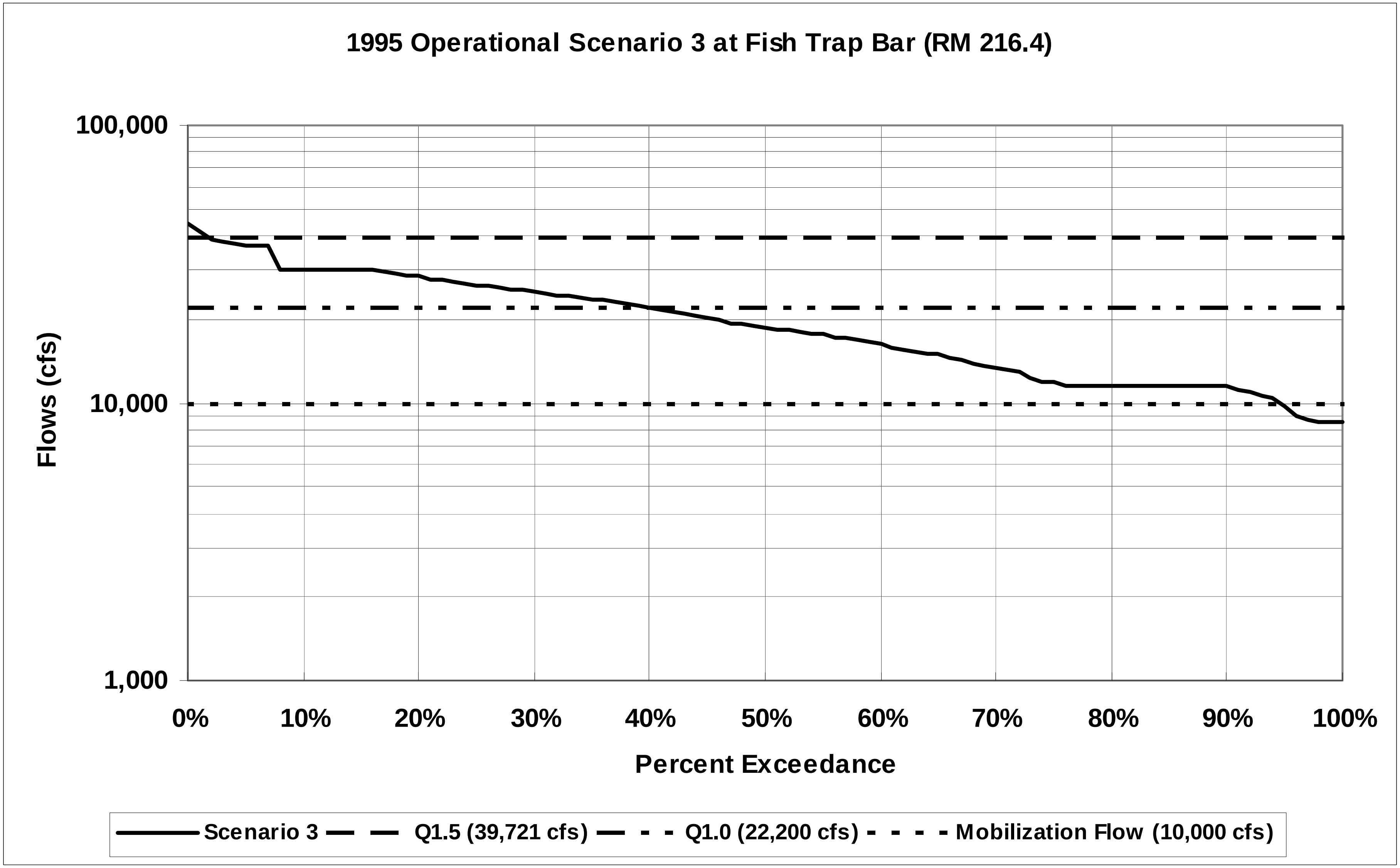


Figure 171. Flow-duration curve for 1995 Operational Scenario 3 at Fish Trap Bar (RM 216.4).

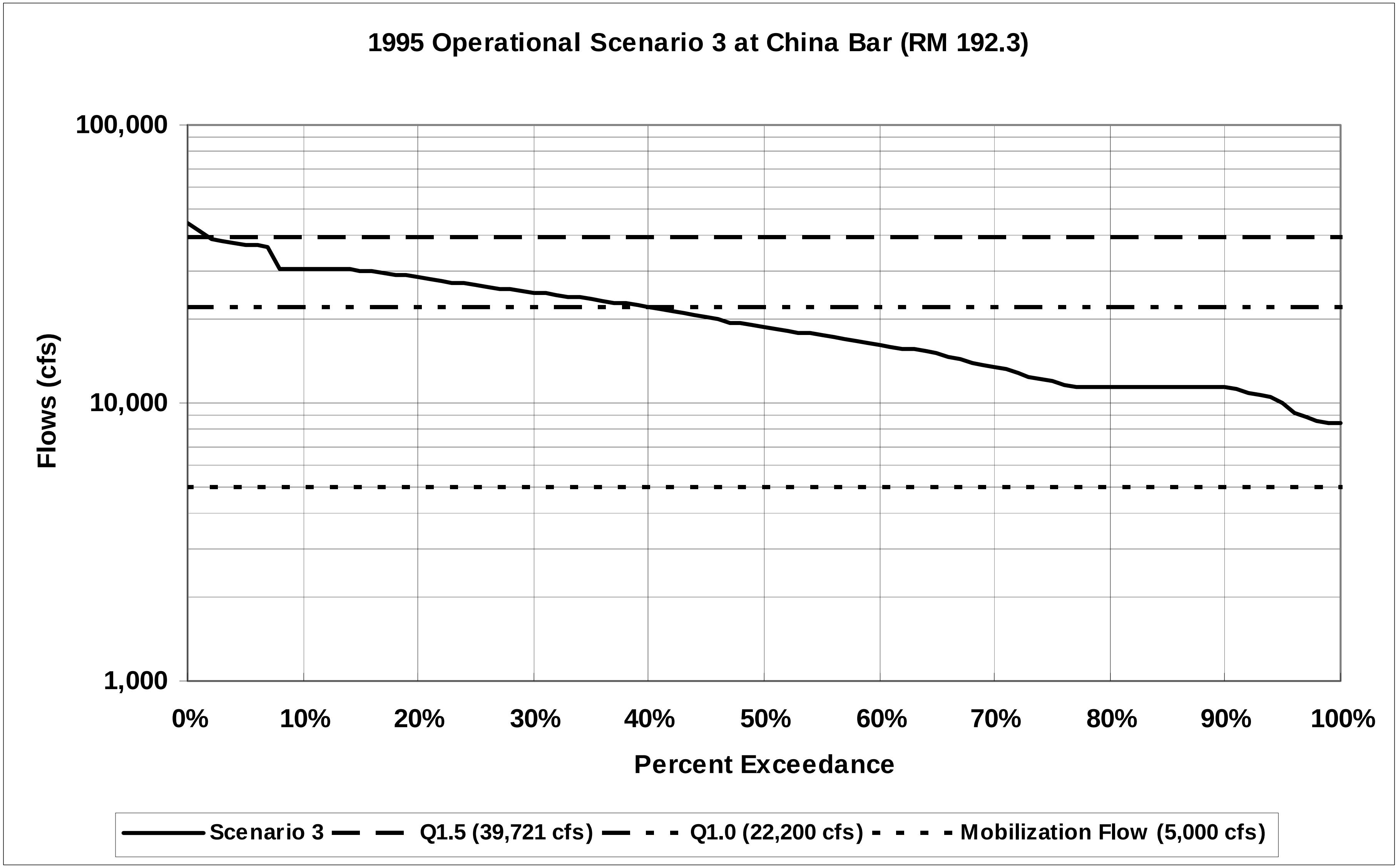


Figure 172. Flow-duration curve for 1995 Operational Scenario 3 at China Bar (RM 192.3).

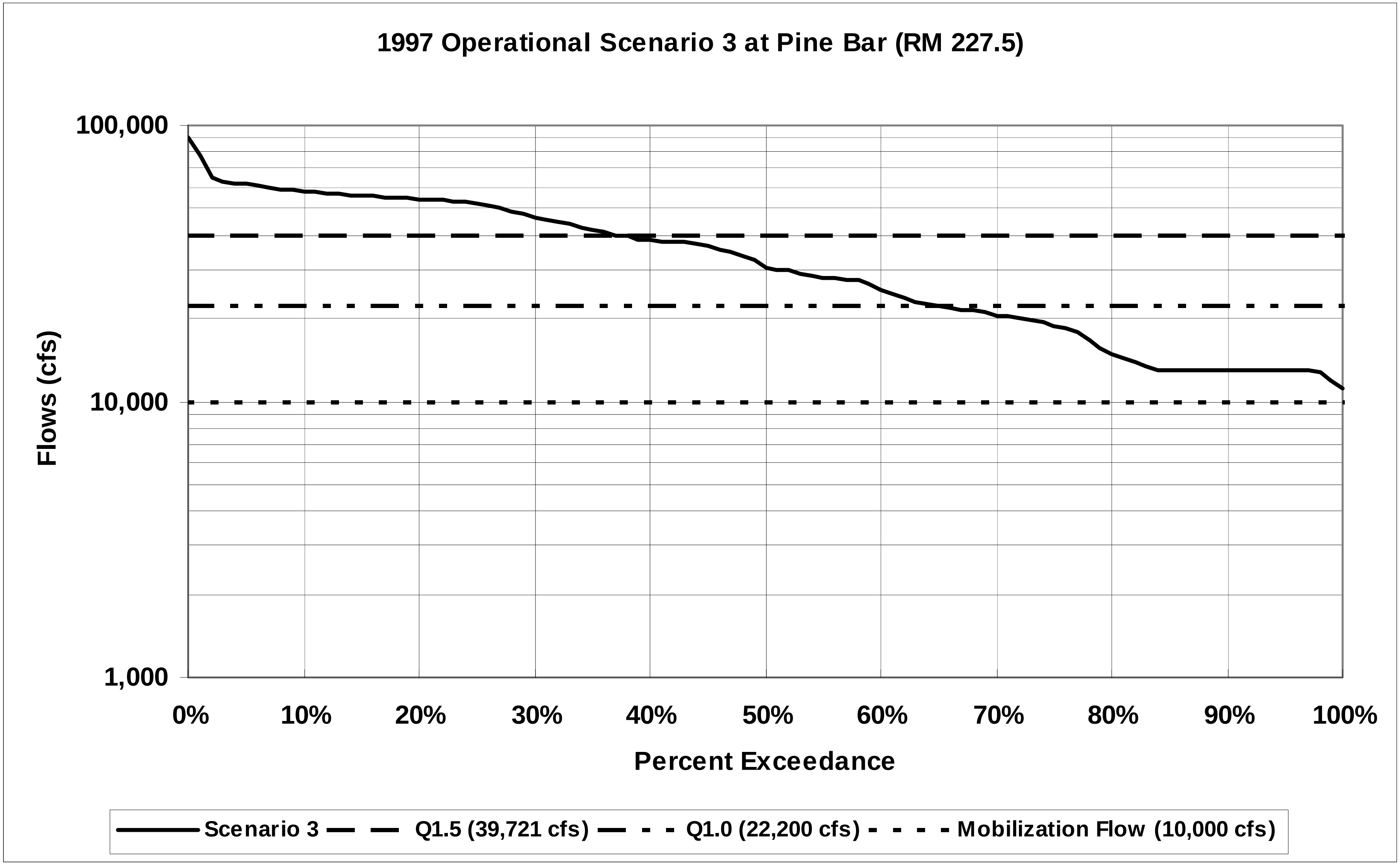


Figure 173. Flow-duration curve for 1997 Operational Scenario 3 at Pine Bar (RM 227.5).

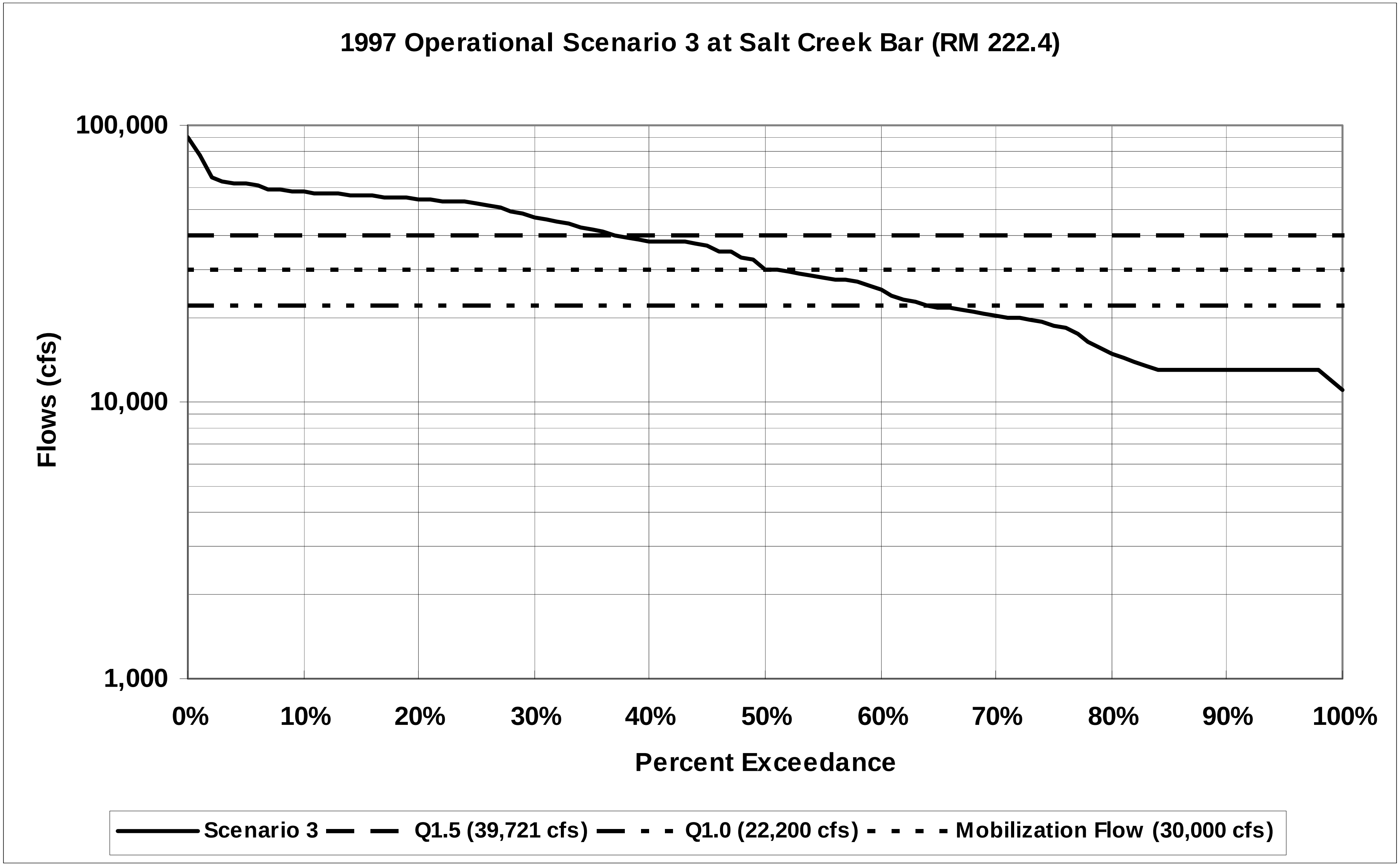


Figure 174. Flow-duration curve for 1997 Operational Scenario 3 at Salt Creek Bar (RM 222.4).

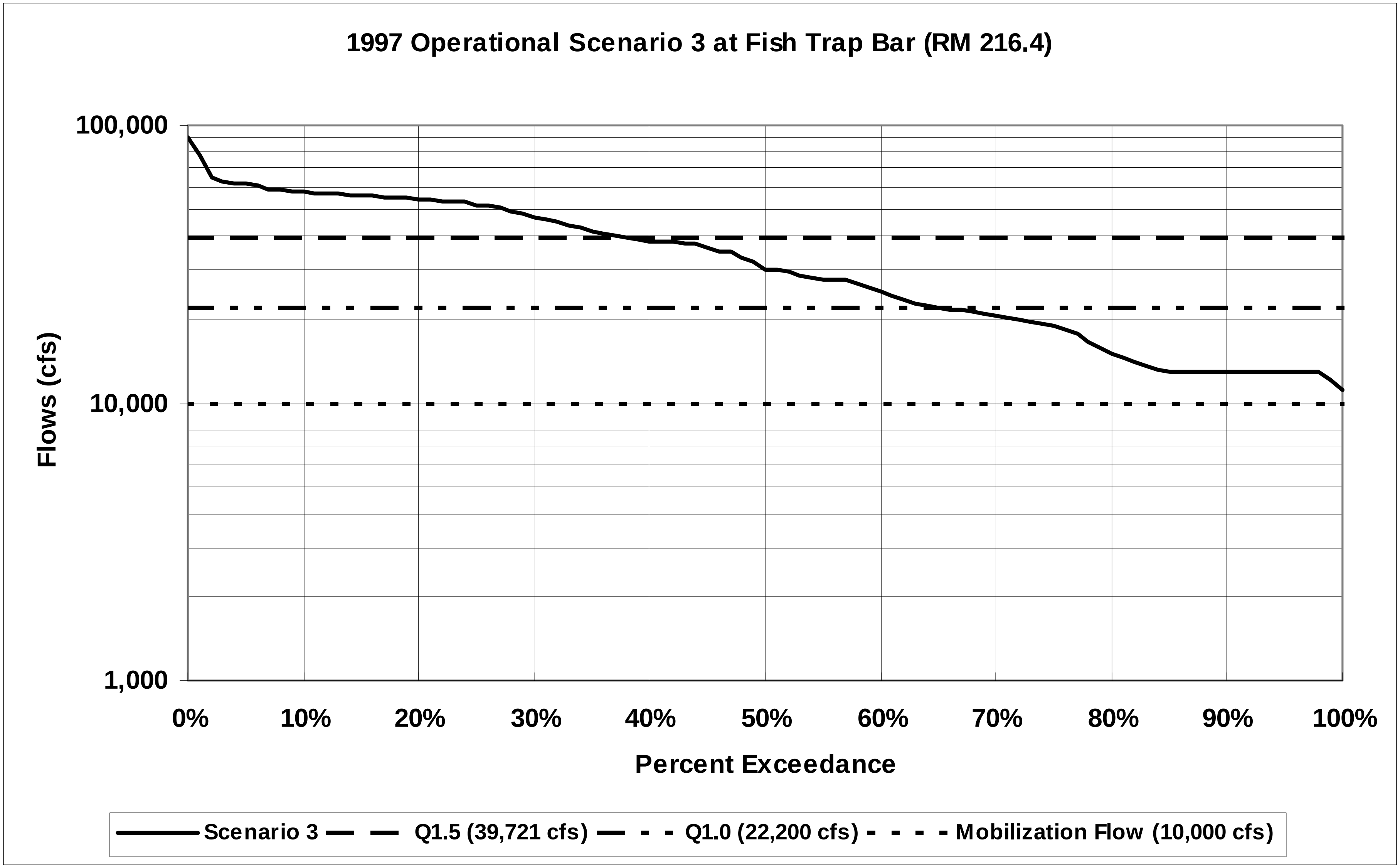


Figure 175. Flow-duration curve for 1997 Operational Scenario 3 at Fish Trap Bar (RM 216.4).

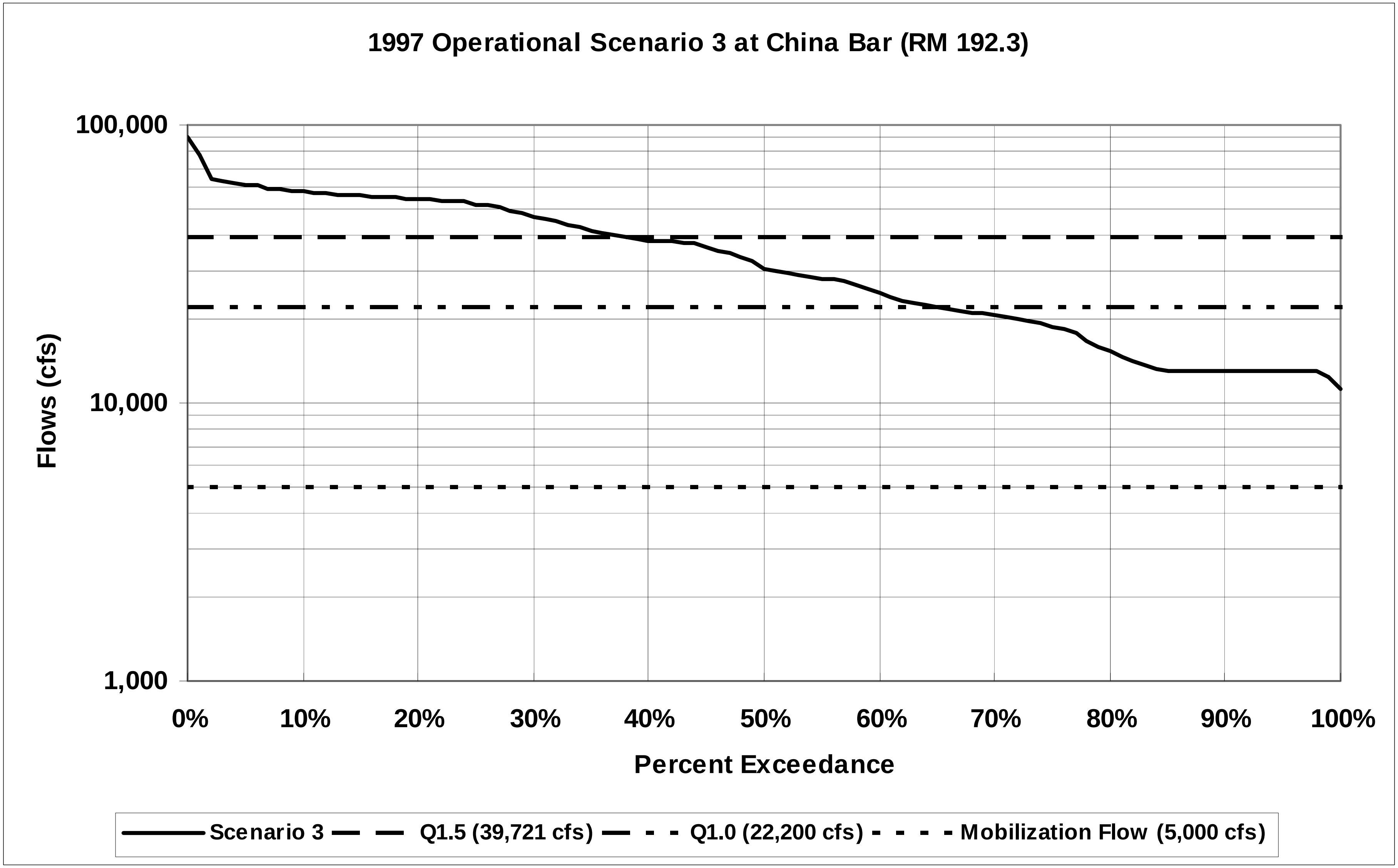


Figure 176. Flow-duration curve for 1997 Operational Scenario 3 at China Bar (RM 192.3).

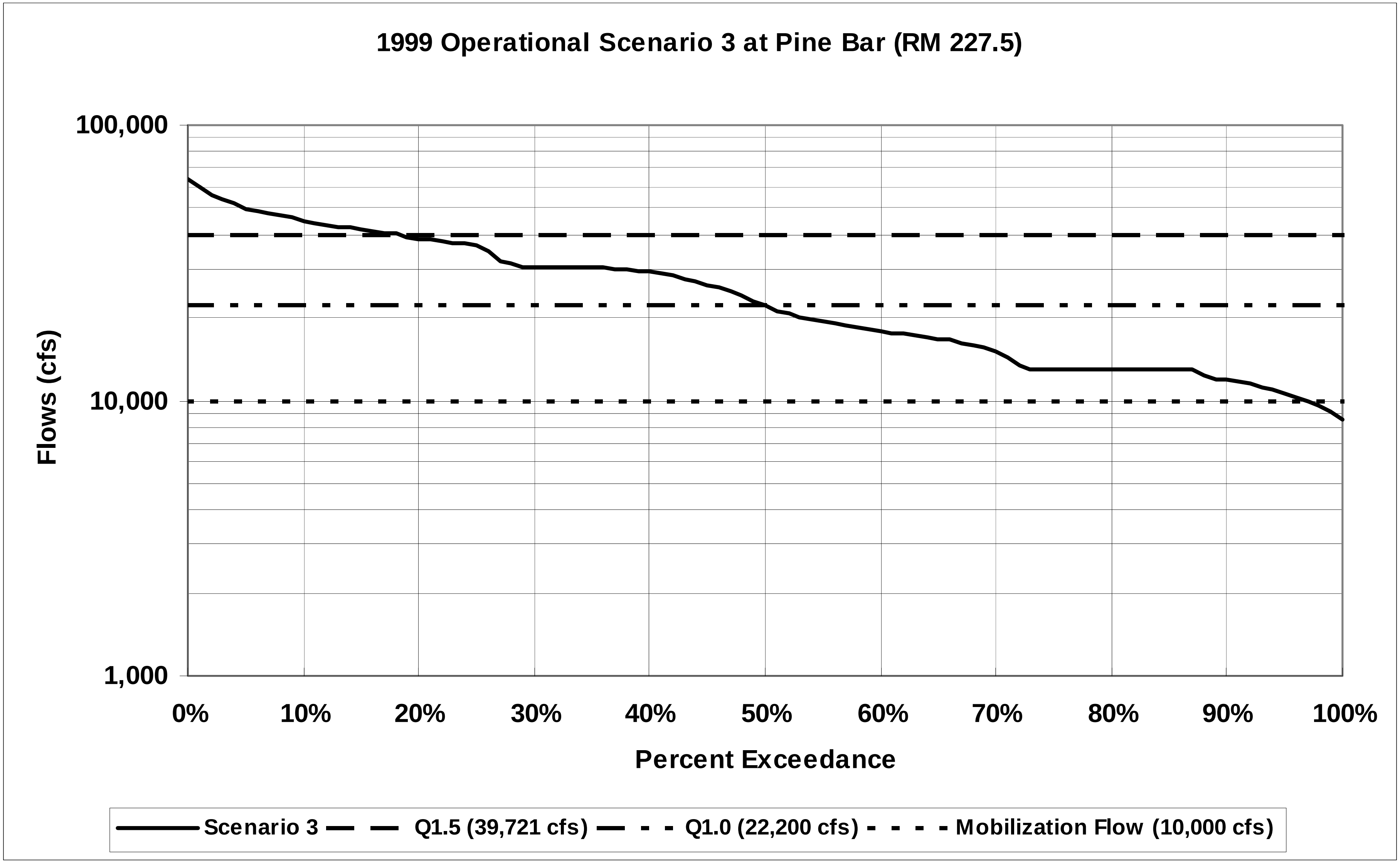


Figure 177. Flow-duration curve for 1999 Operational Scenario 3 at Pine Bar (RM 227.5).

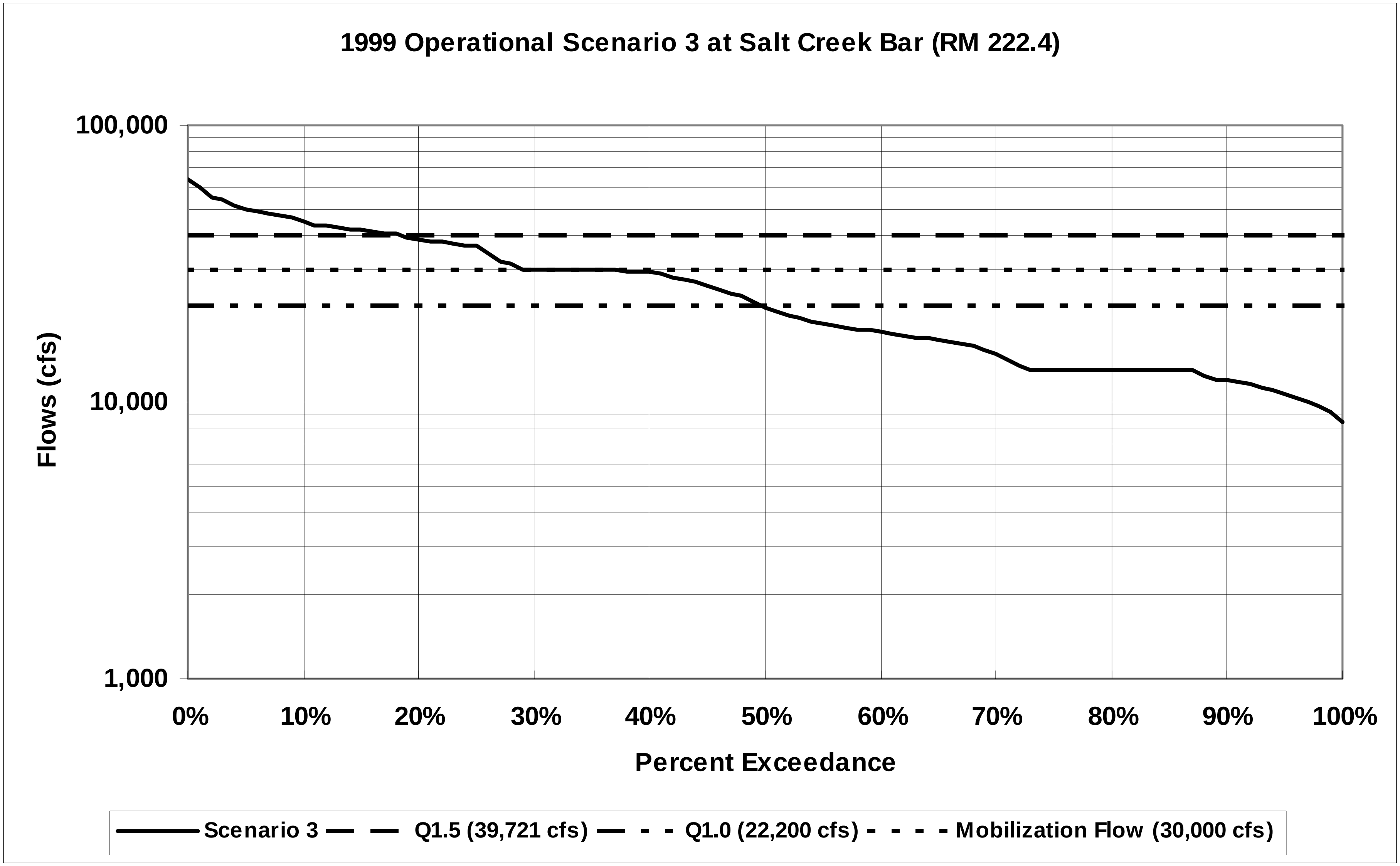


Figure 178. Flow-duration curve for 1999 Operational Scenario 3 at Salt Creek Bar (RM 222.4).

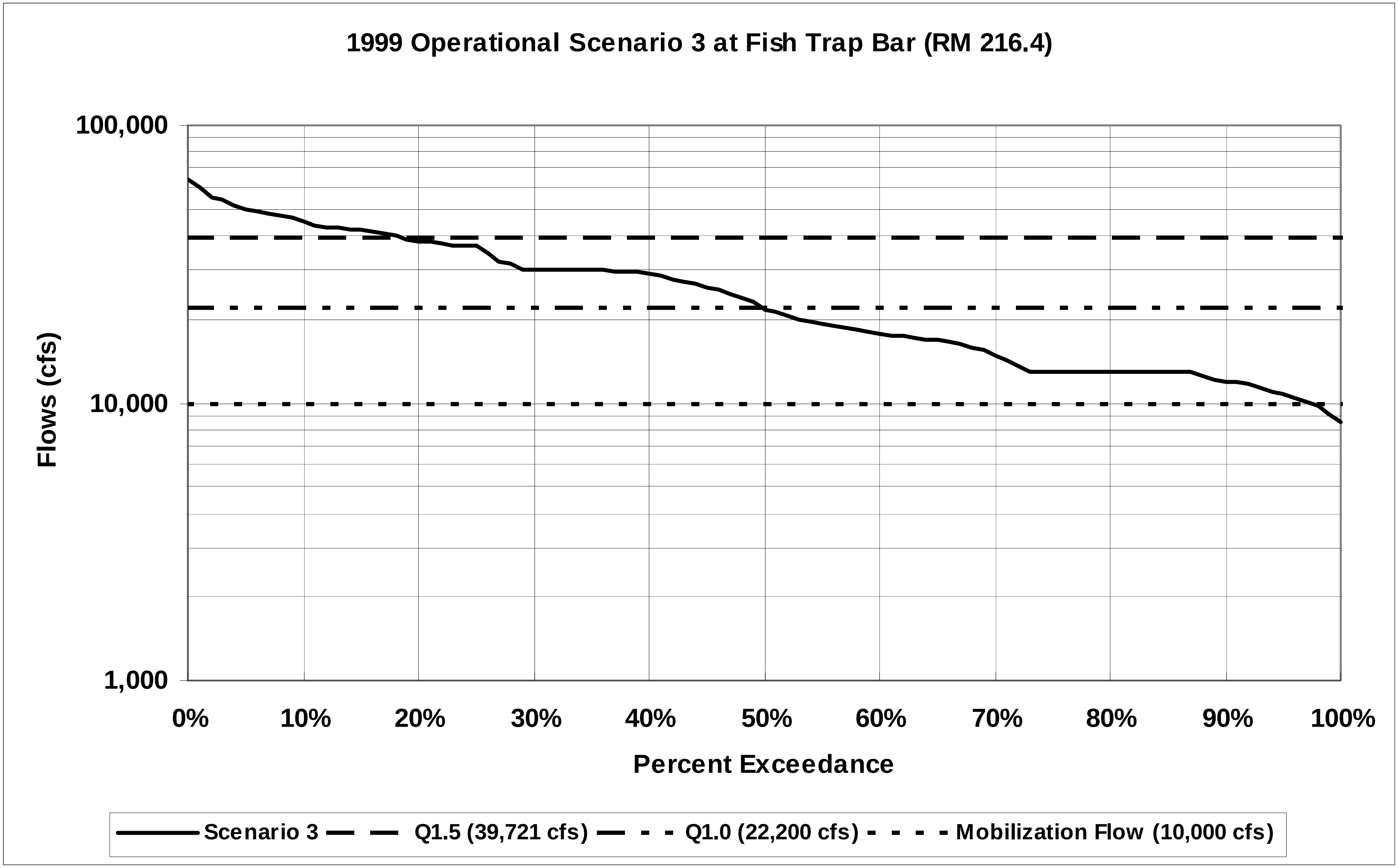


Figure 179. Flow-duration curve for 1999 Operational Scenario 3 at Fish Trap Bar (RM 216.4).

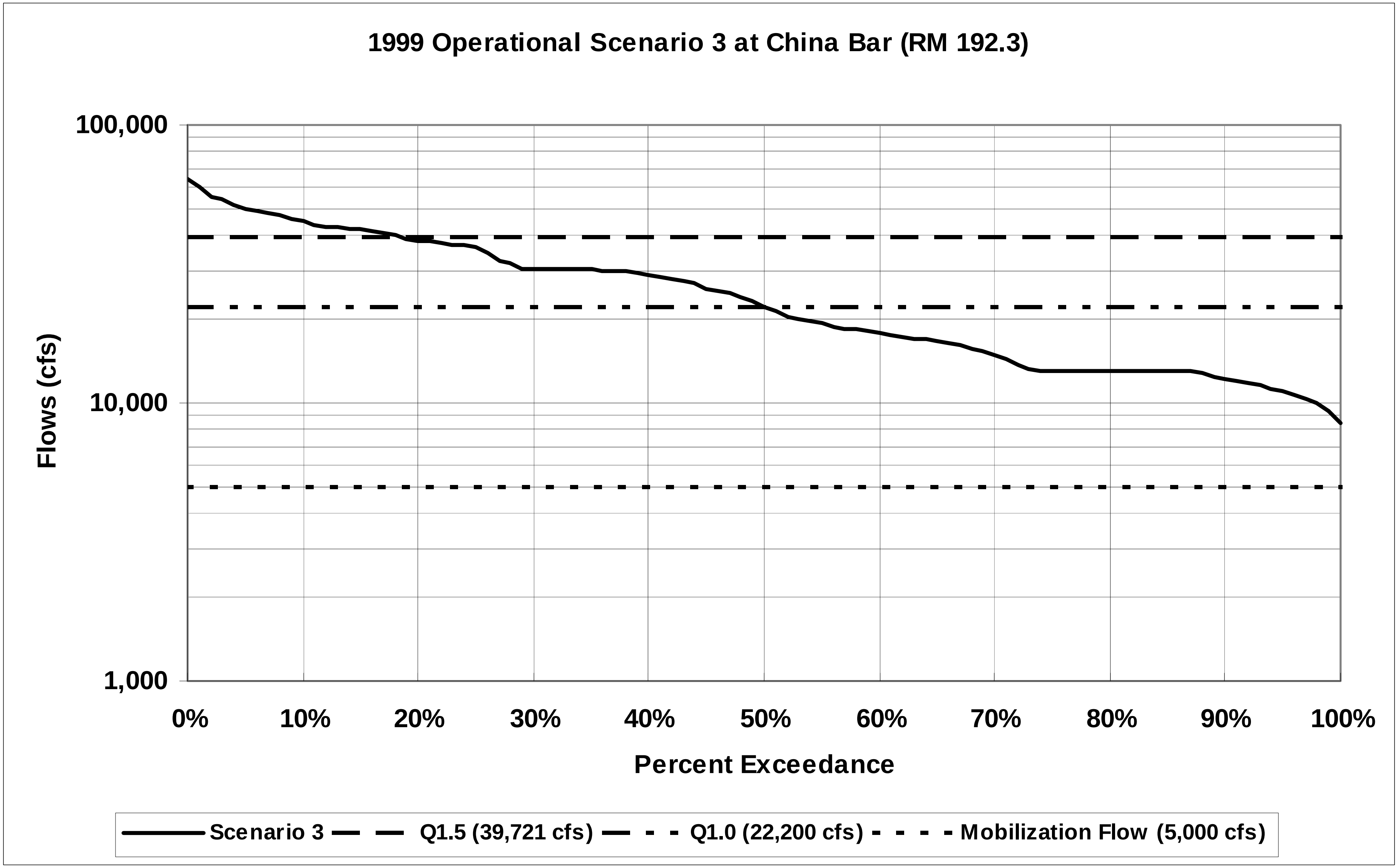


Figure 180. Flow-duration curve for 1999 Operational Scenario 3 at China Bar (RM 192.3).

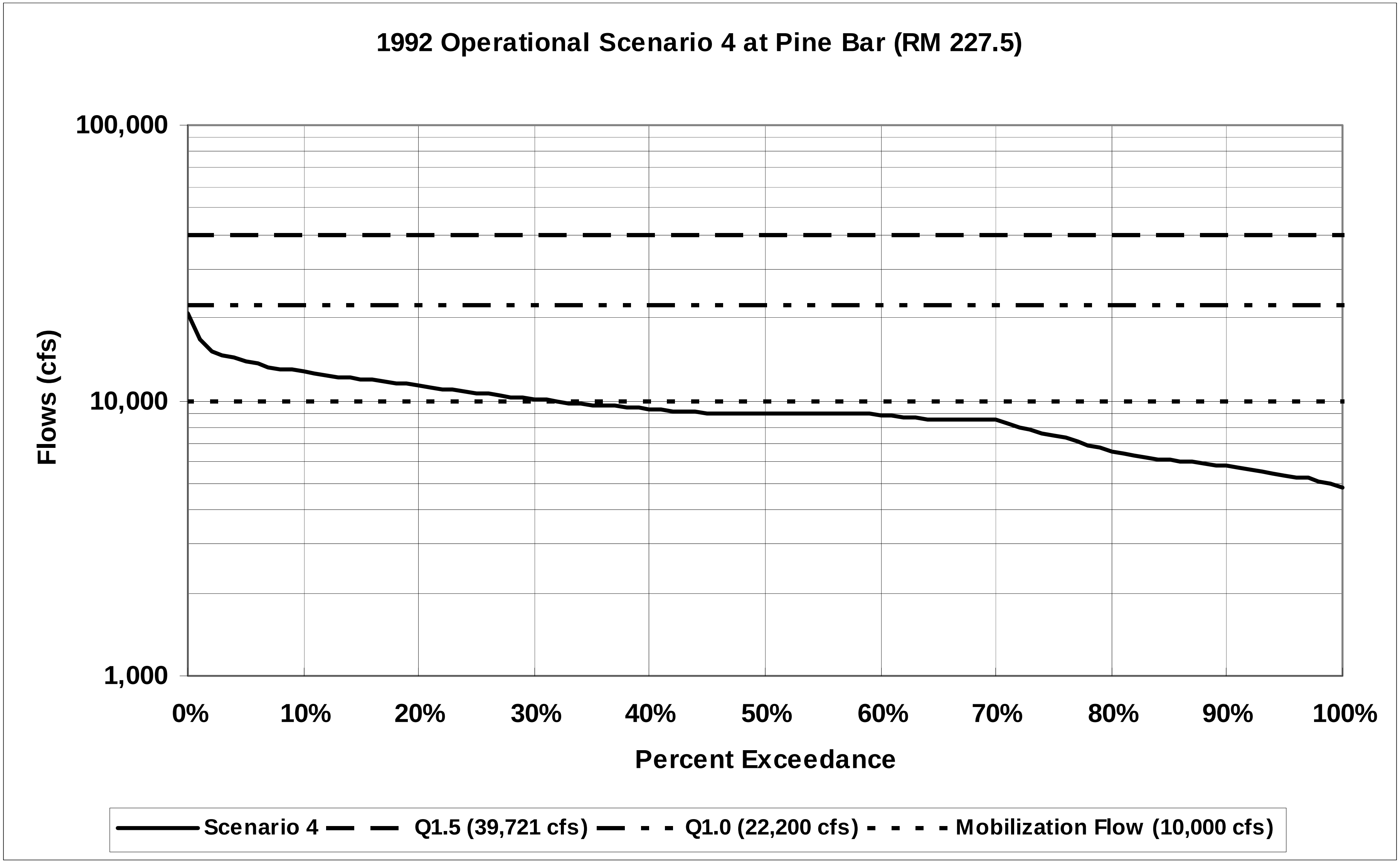


Figure 181. Flow-duration curve for 1992 Operational Scenario 4 at Pine Bar (RM 227.5).

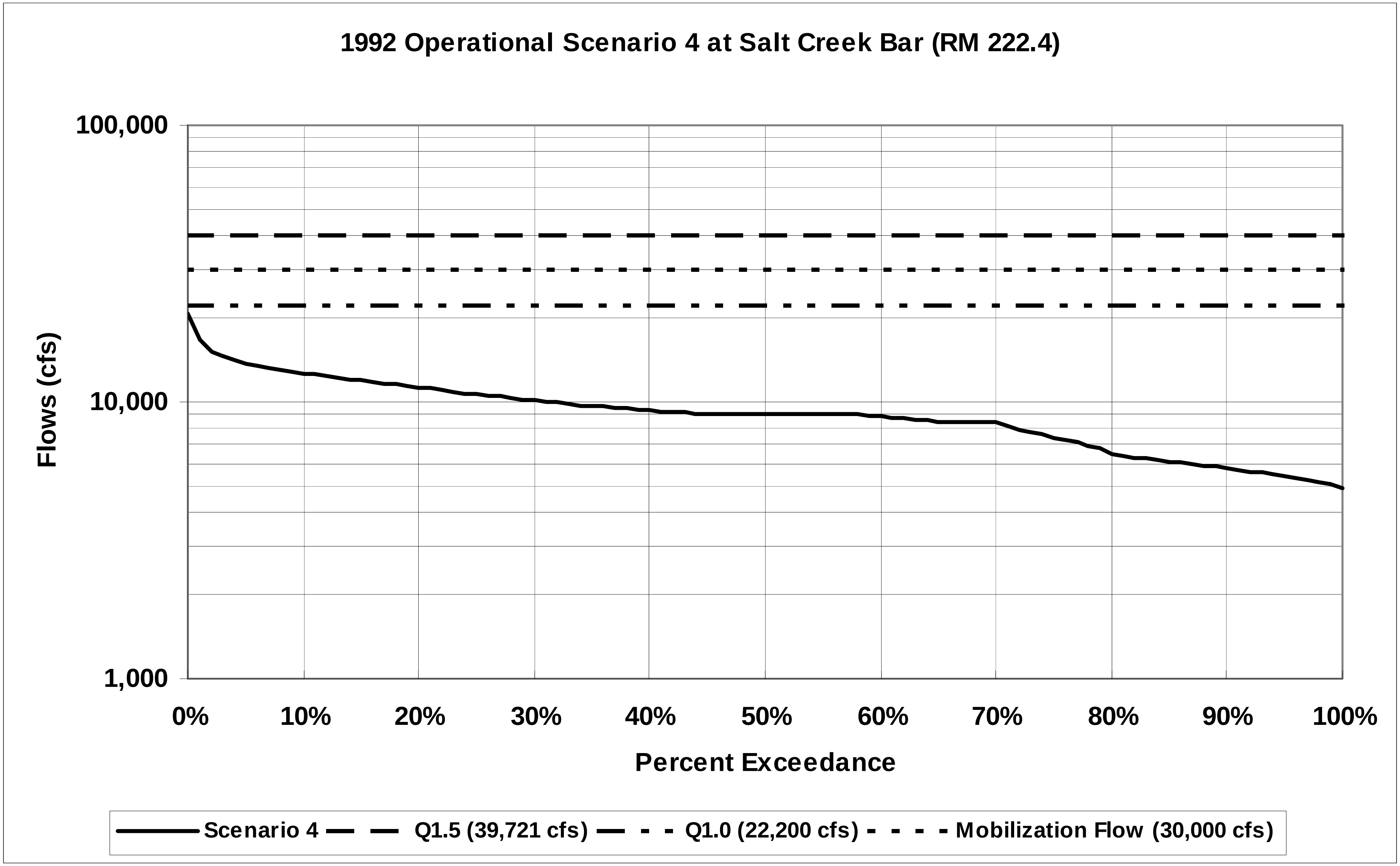


Figure 182. Flow-duration curve for 1992 Operational Scenario 4 at Salt Creek Bar (RM 222.4).

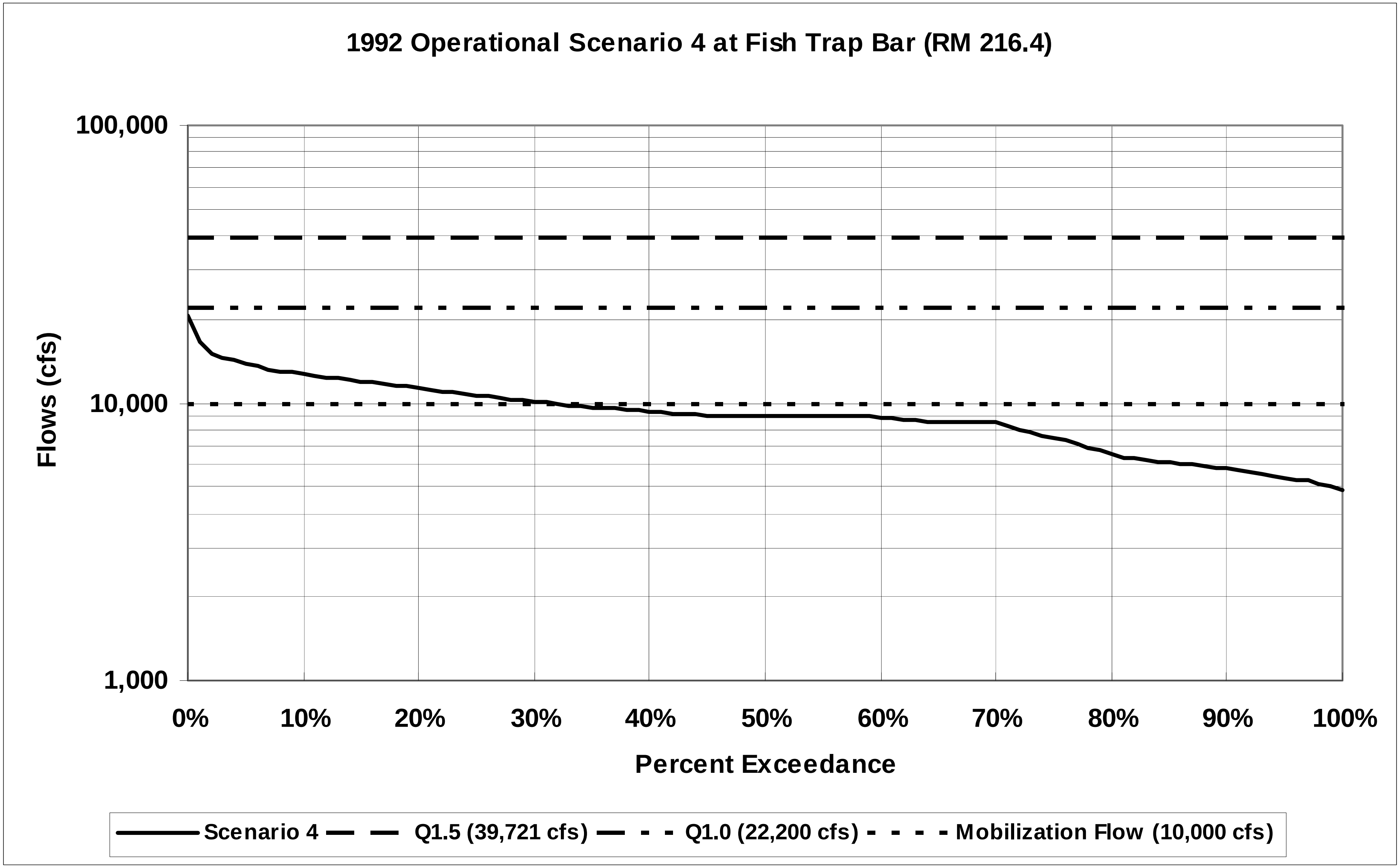


Figure 183. Flow-duration curve for 1992 Operational Scenario 4 at Fish Trap Bar (RM 216.4).

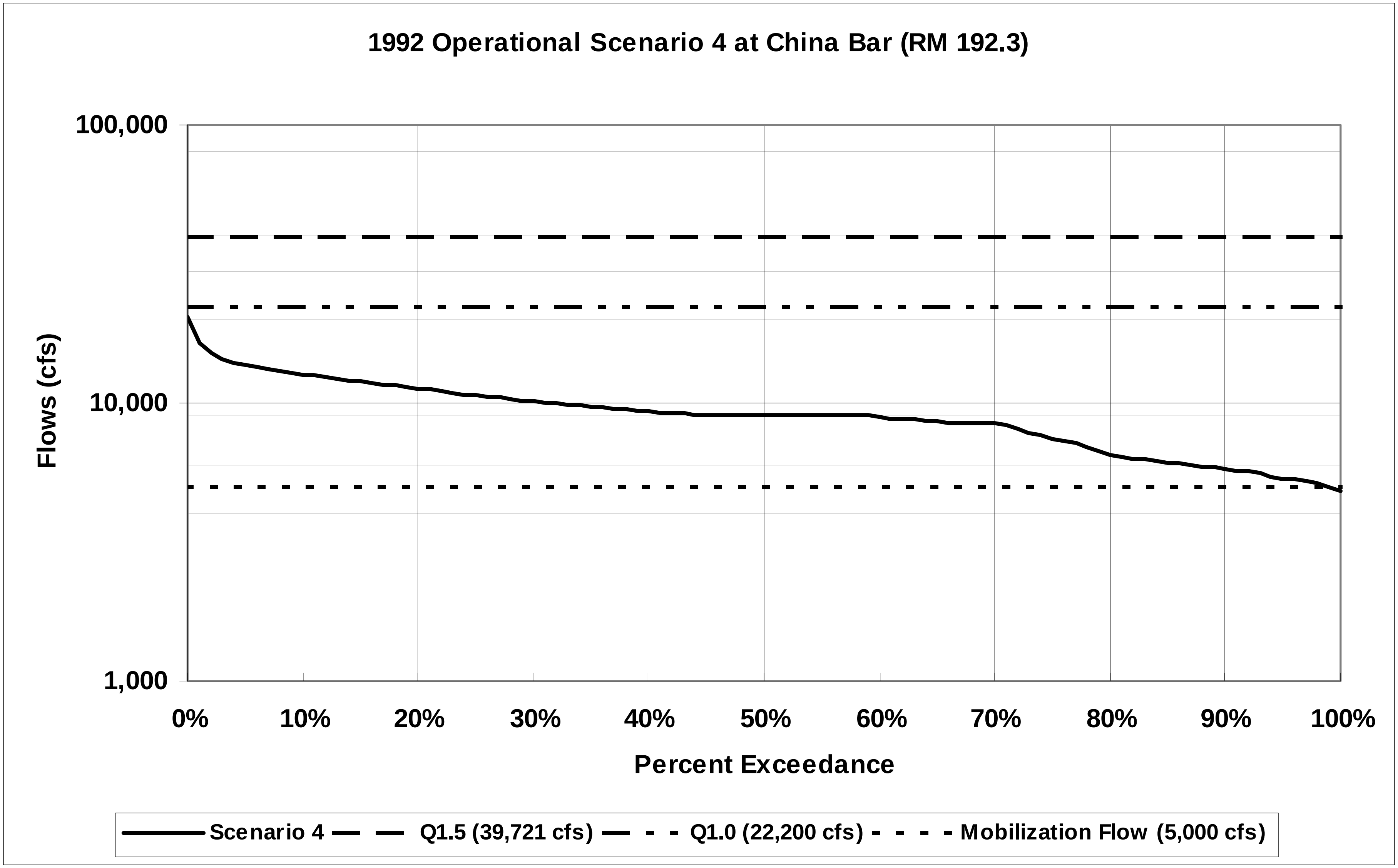


Figure 184. Flow-duration curve for 1992 Operational Scenario 4 at China Bar (RM 192.3).

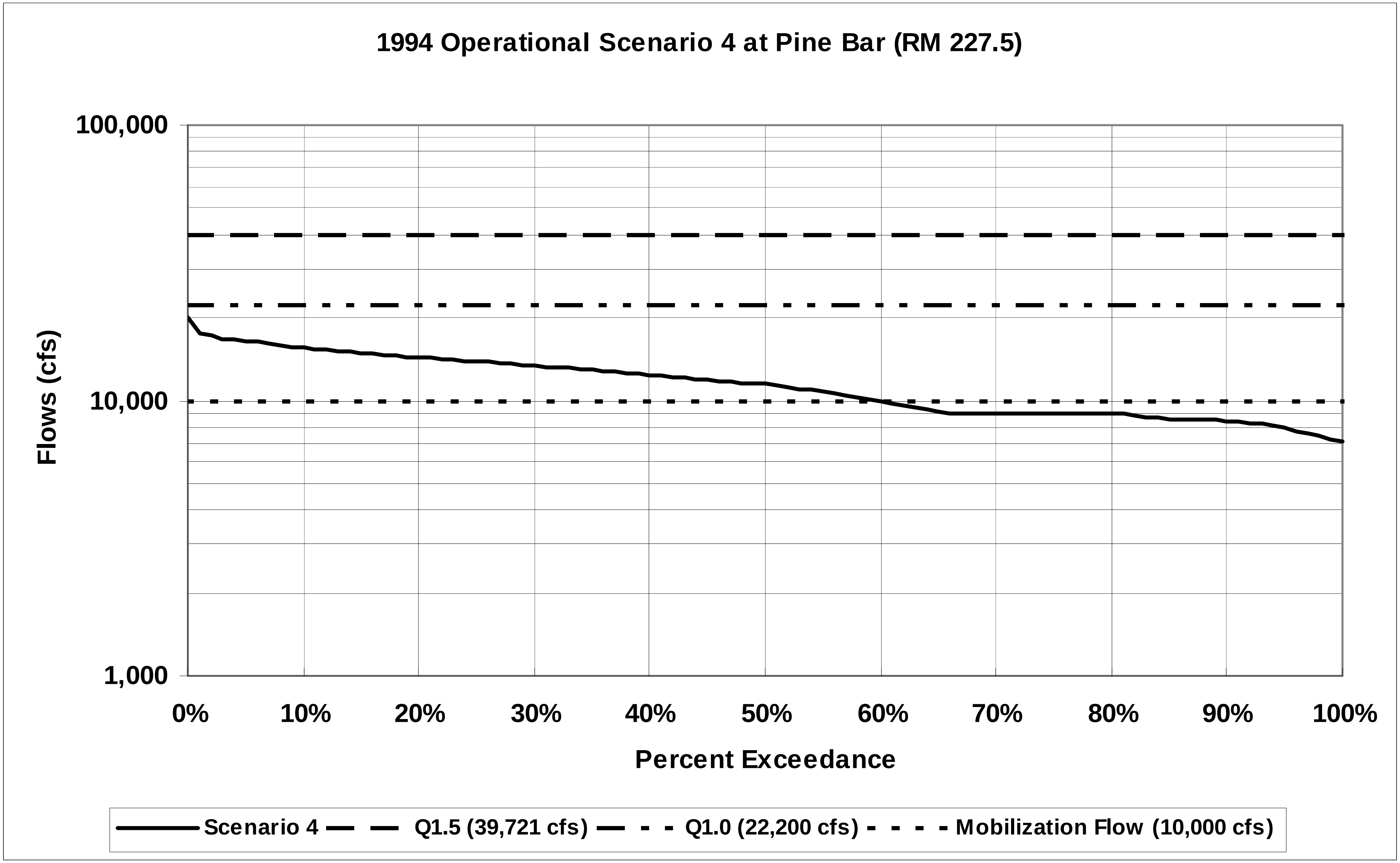


Figure 185. Flow-duration curve for 1994 Operational Scenario 4 at Pine Bar (RM 227.5).

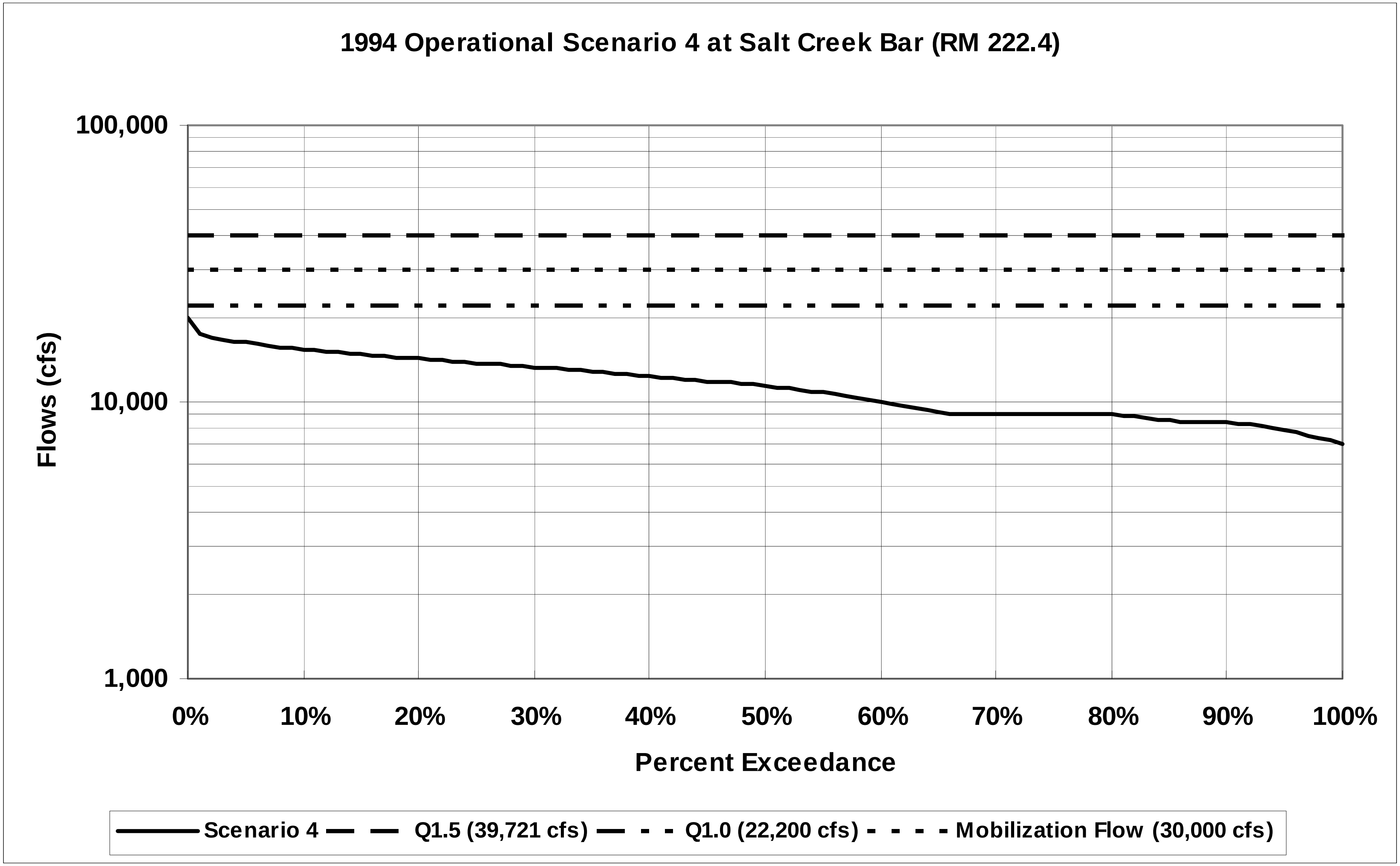


Figure 186. Flow-duration curve for 1994 Operational Scenario 4 at Salt Creek Bar (RM 222.4).

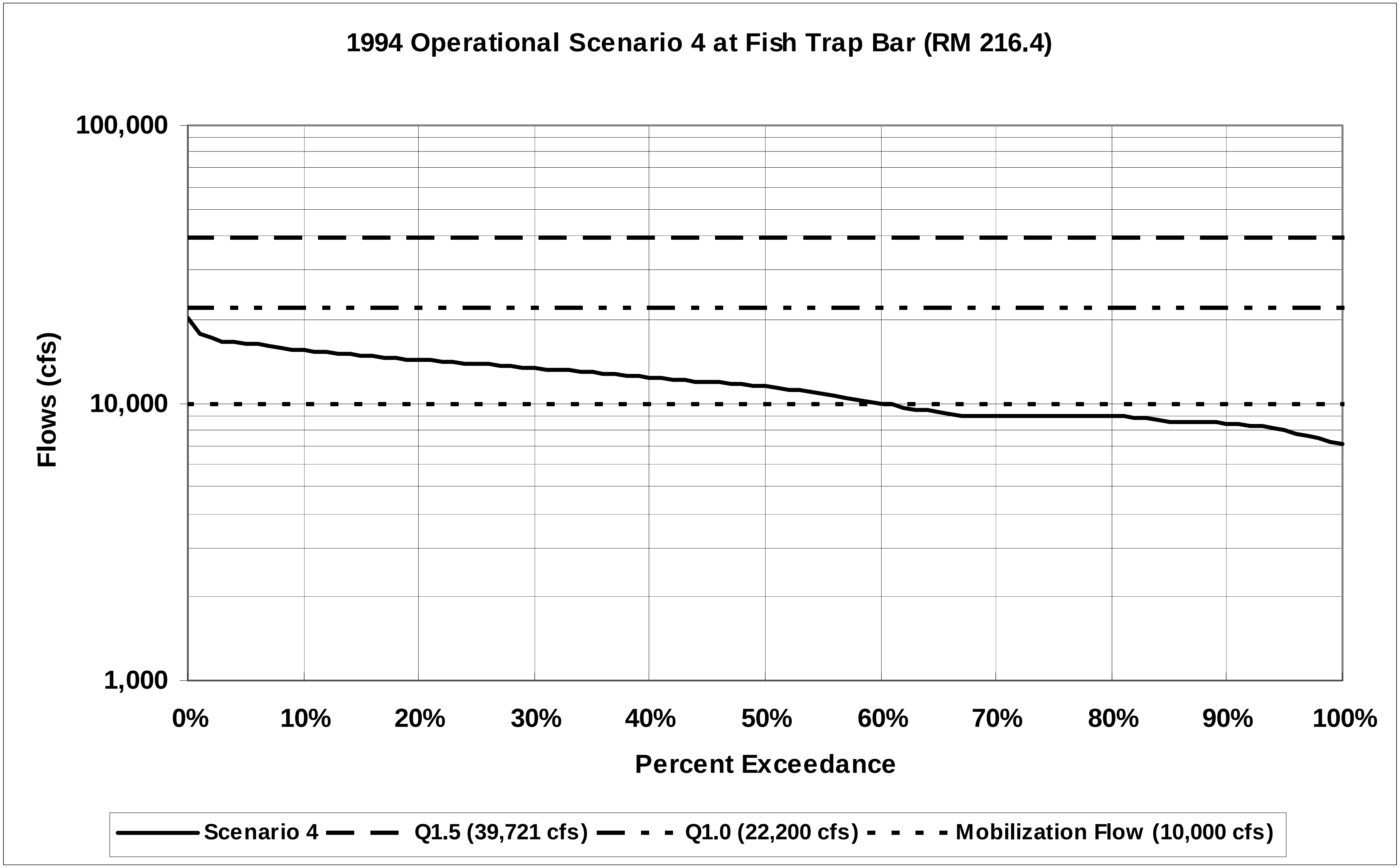


Figure 187. Flow-duration curve for 1994 Operational Scenario 4 at Fish Trap Bar (RM 216.4).

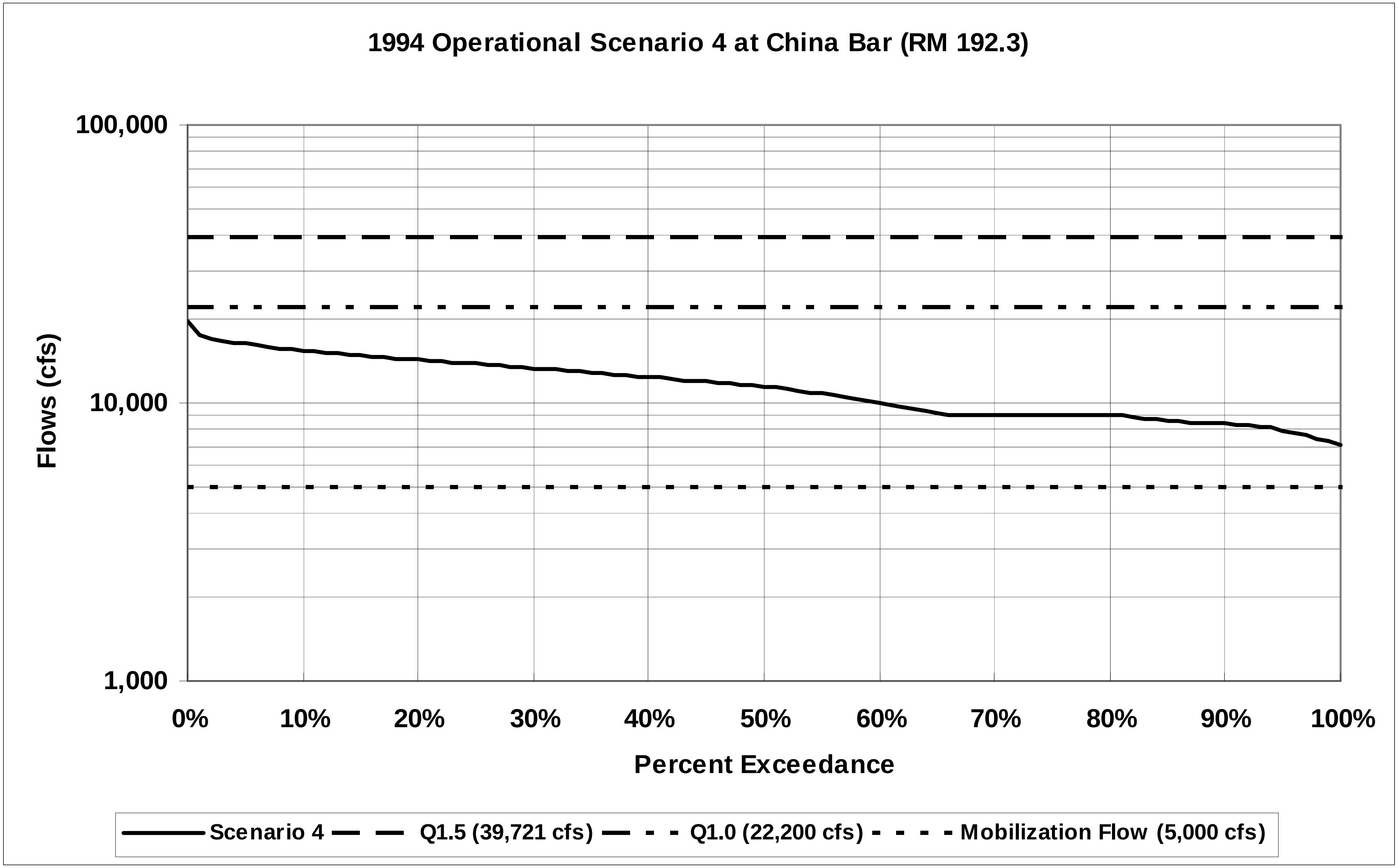


Figure 188. Flow-duration curve for 1994 Operational Scenario 4 at China Bar (RM 192.3).

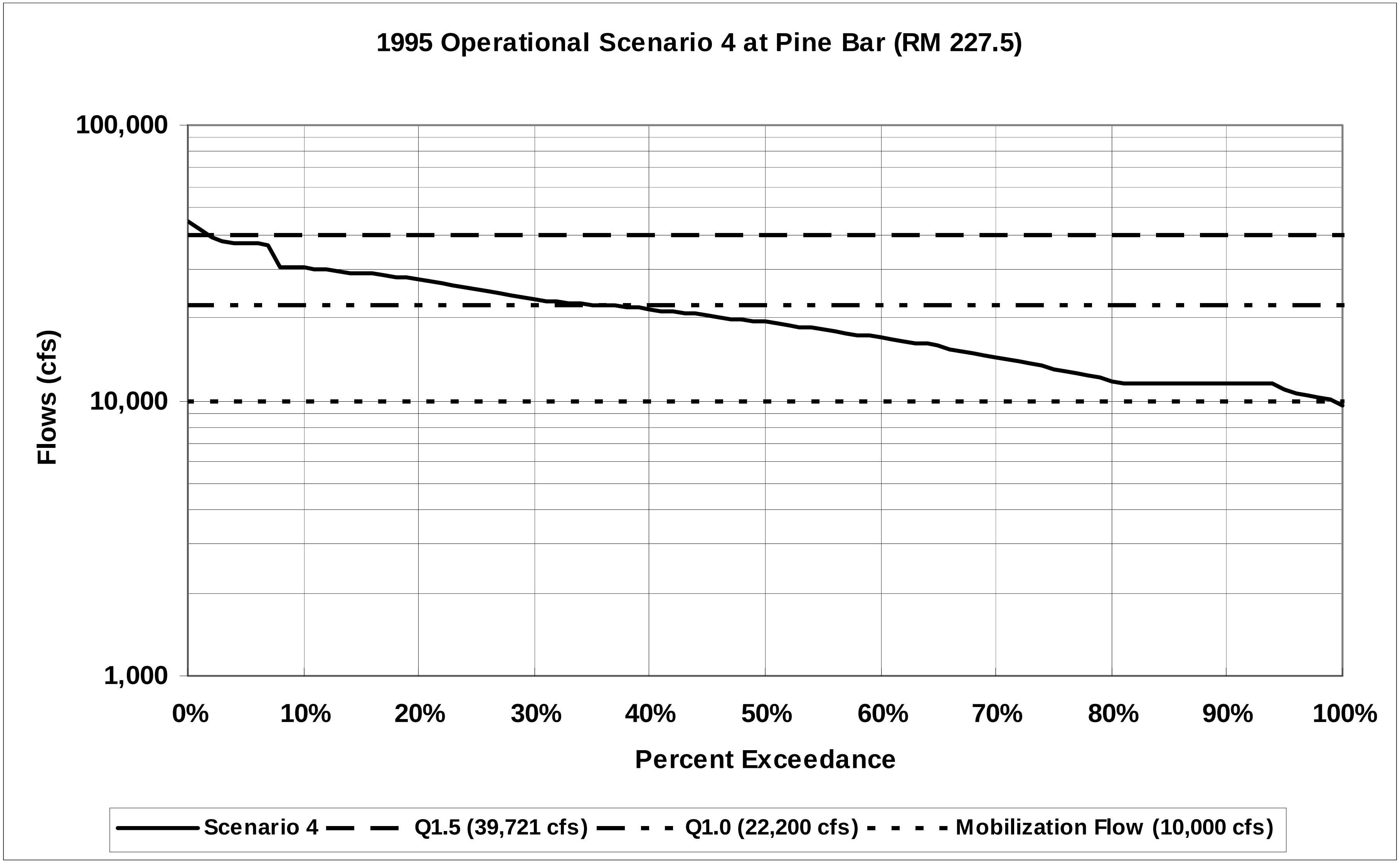


Figure 189. Flow-duration curve for 1995 Operational Scenario 4 at Pine Bar (RM 227.5).

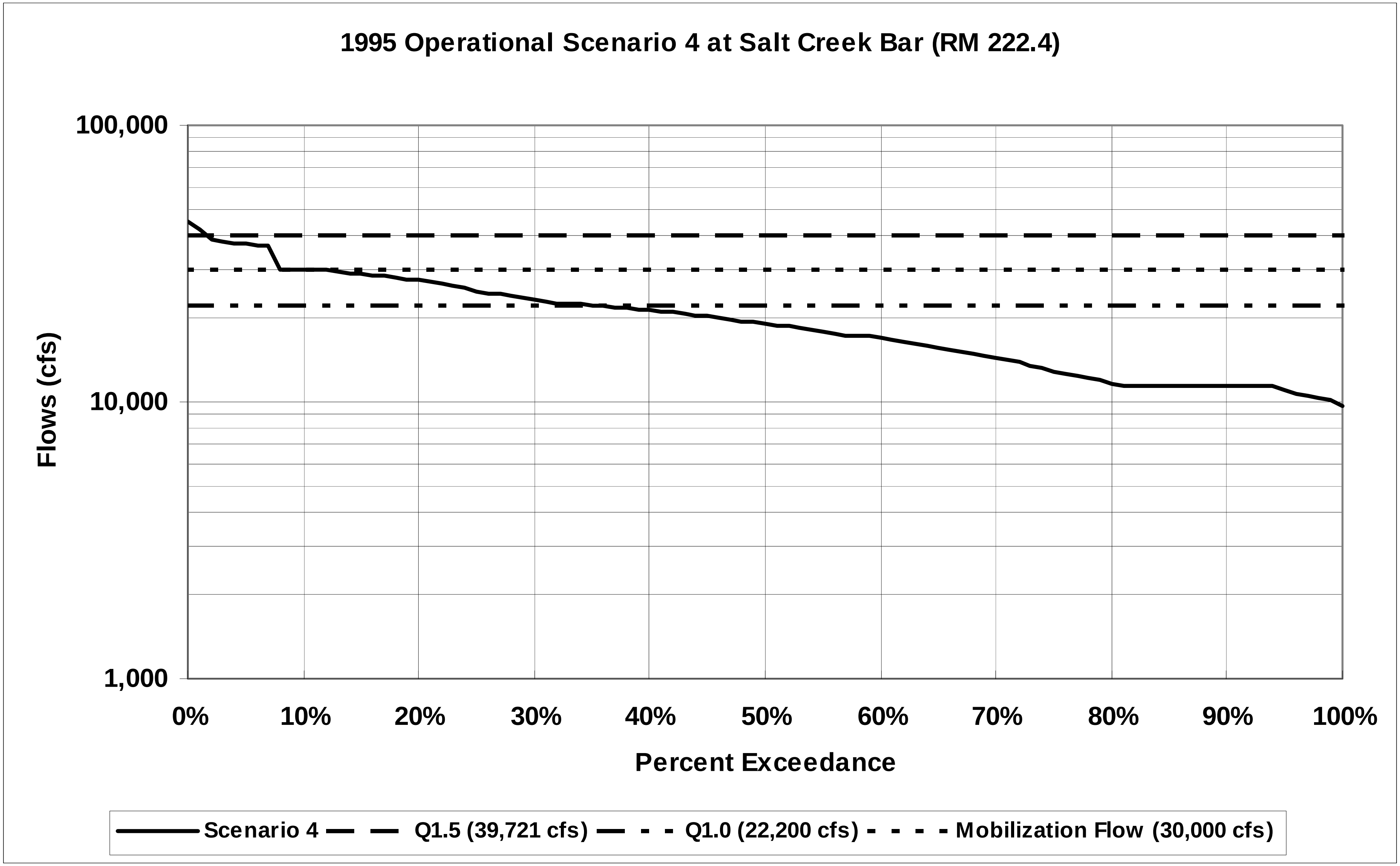


Figure 190. Flow-duration curve for 1995 Operational Scenario 4 at Salt Creek Bar (RM 222.4).

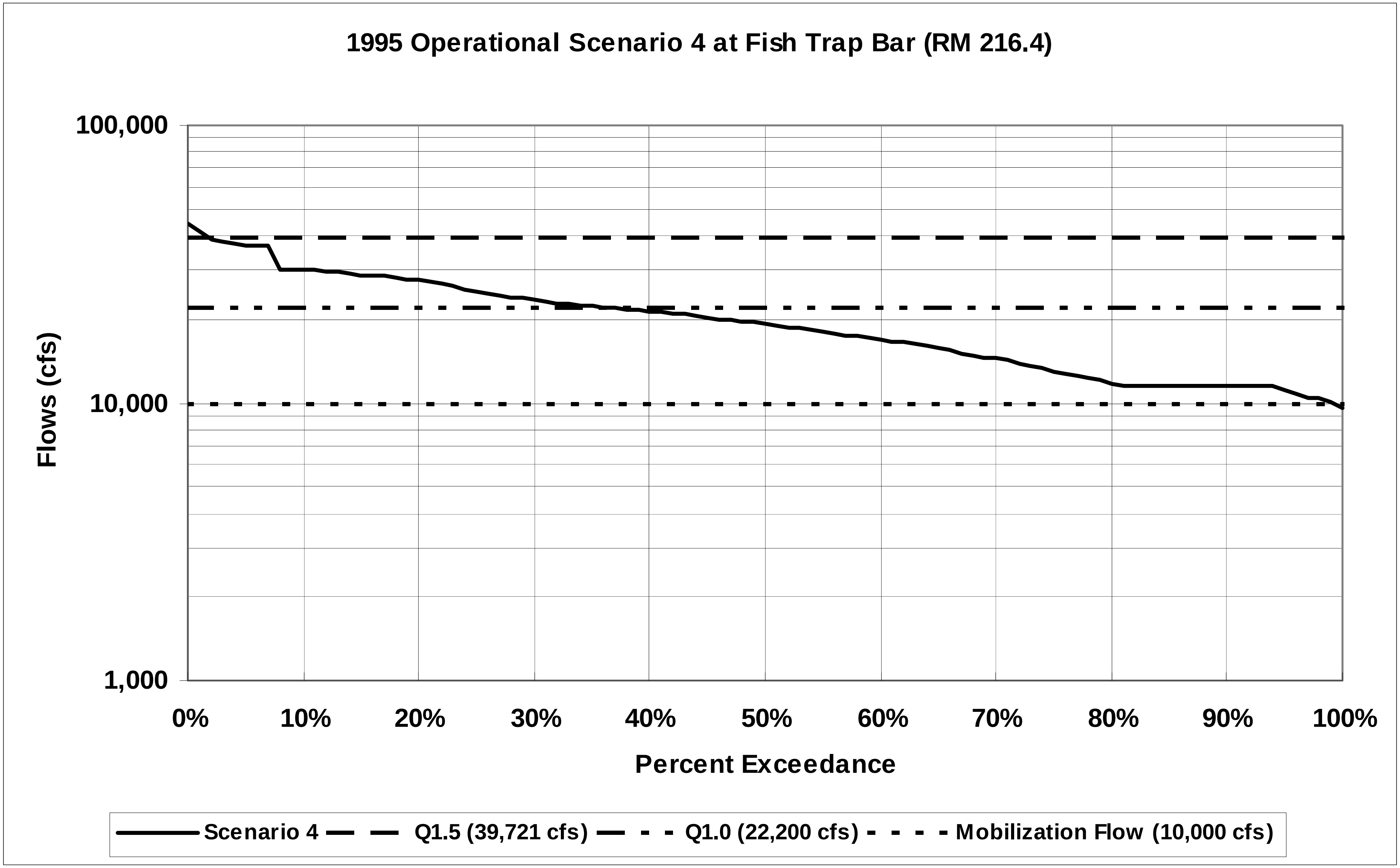


Figure 191. Flow-duration curve for 1995 Operational Scenario 4 at Fish Trap Bar (RM 216.4).

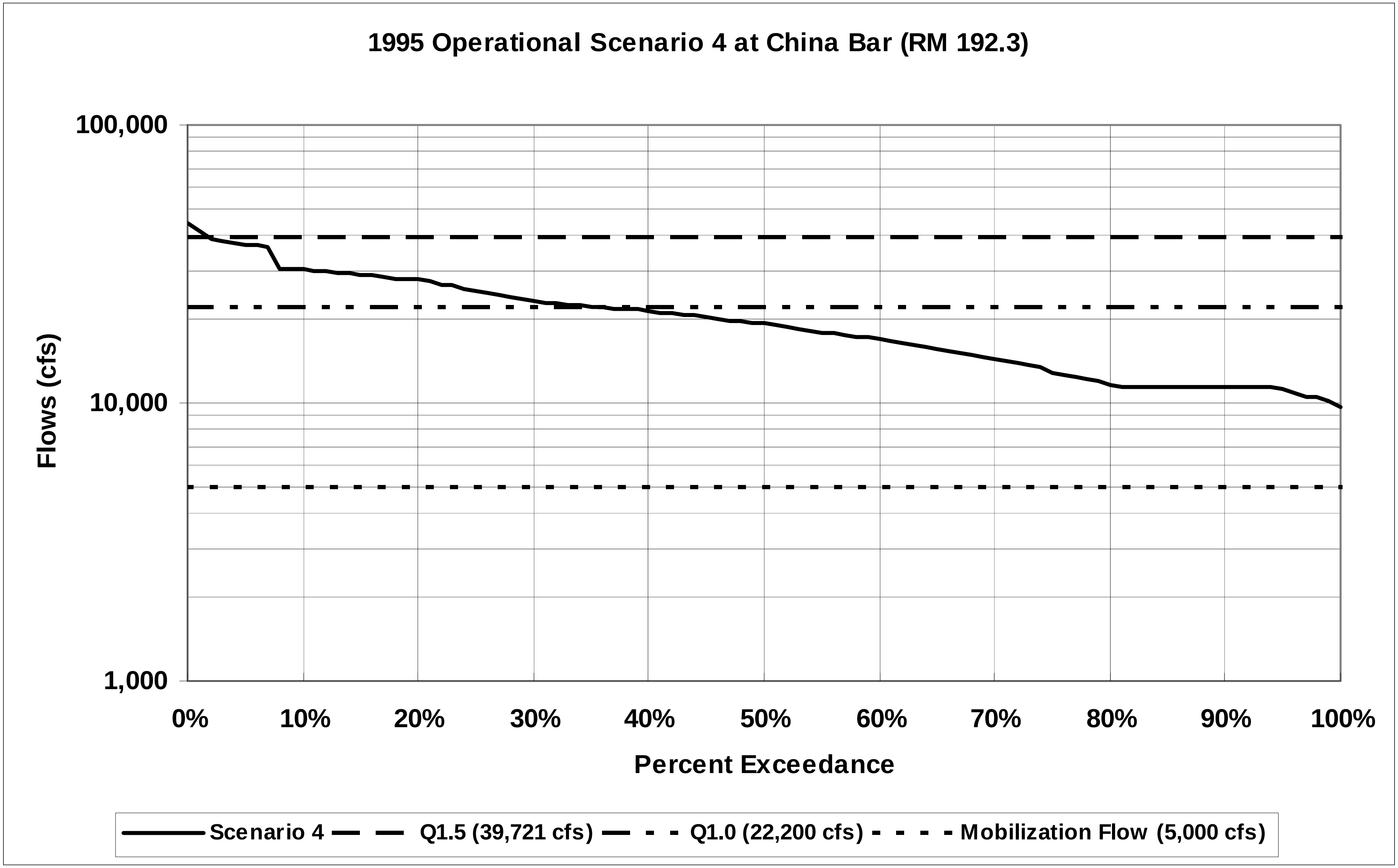


Figure 192. Flow-duration curve for 1995 Operational Scenario 4 at China Bar (RM 192.3).

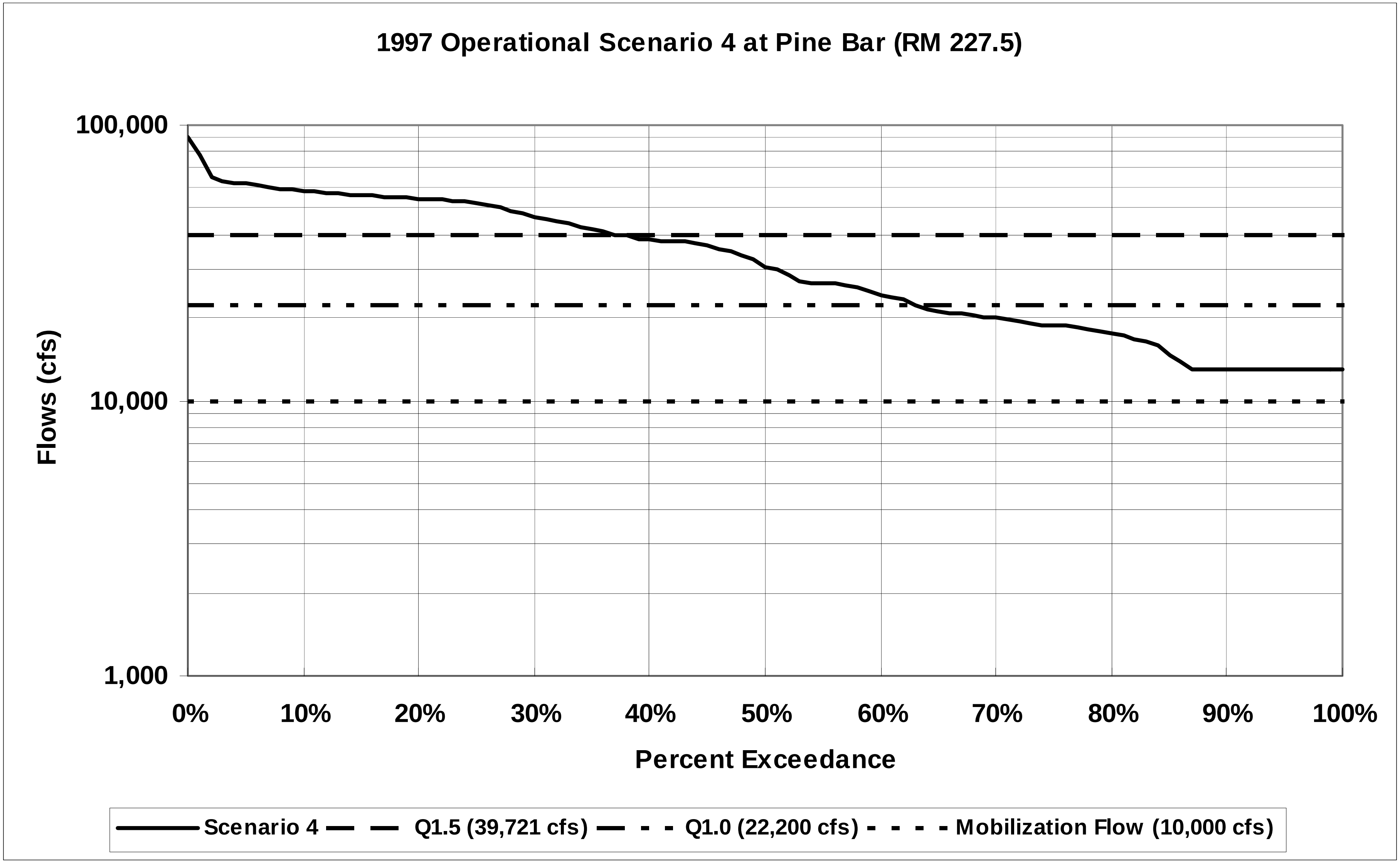


Figure 193. Flow-duration curve for 1997 Operational Scenario 4 at Pine Bar (RM 227.5).

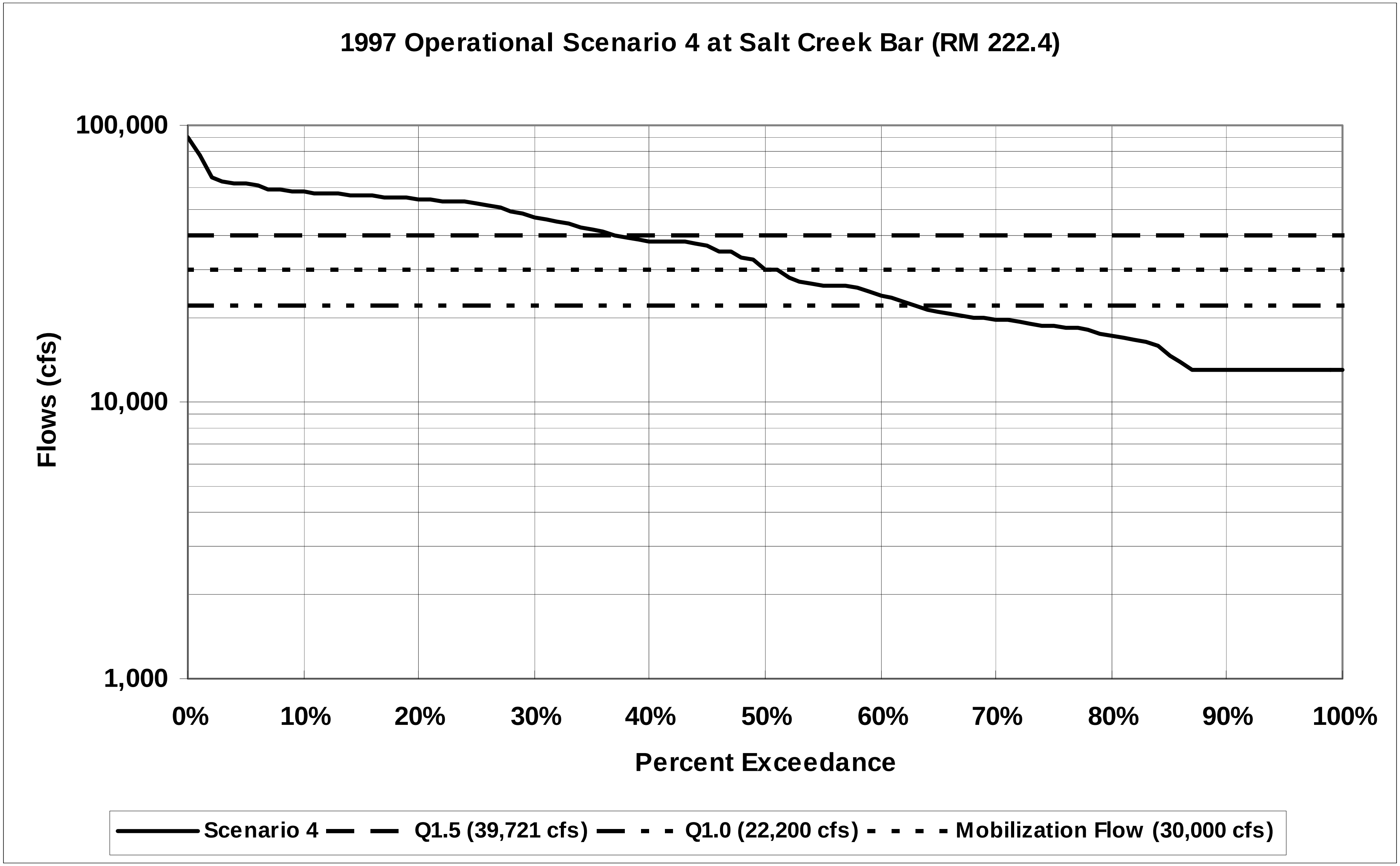


Figure 194. Flow-duration curve for 1997 Operational Scenario 4 at Salt Creek Bar (RM 222.4).

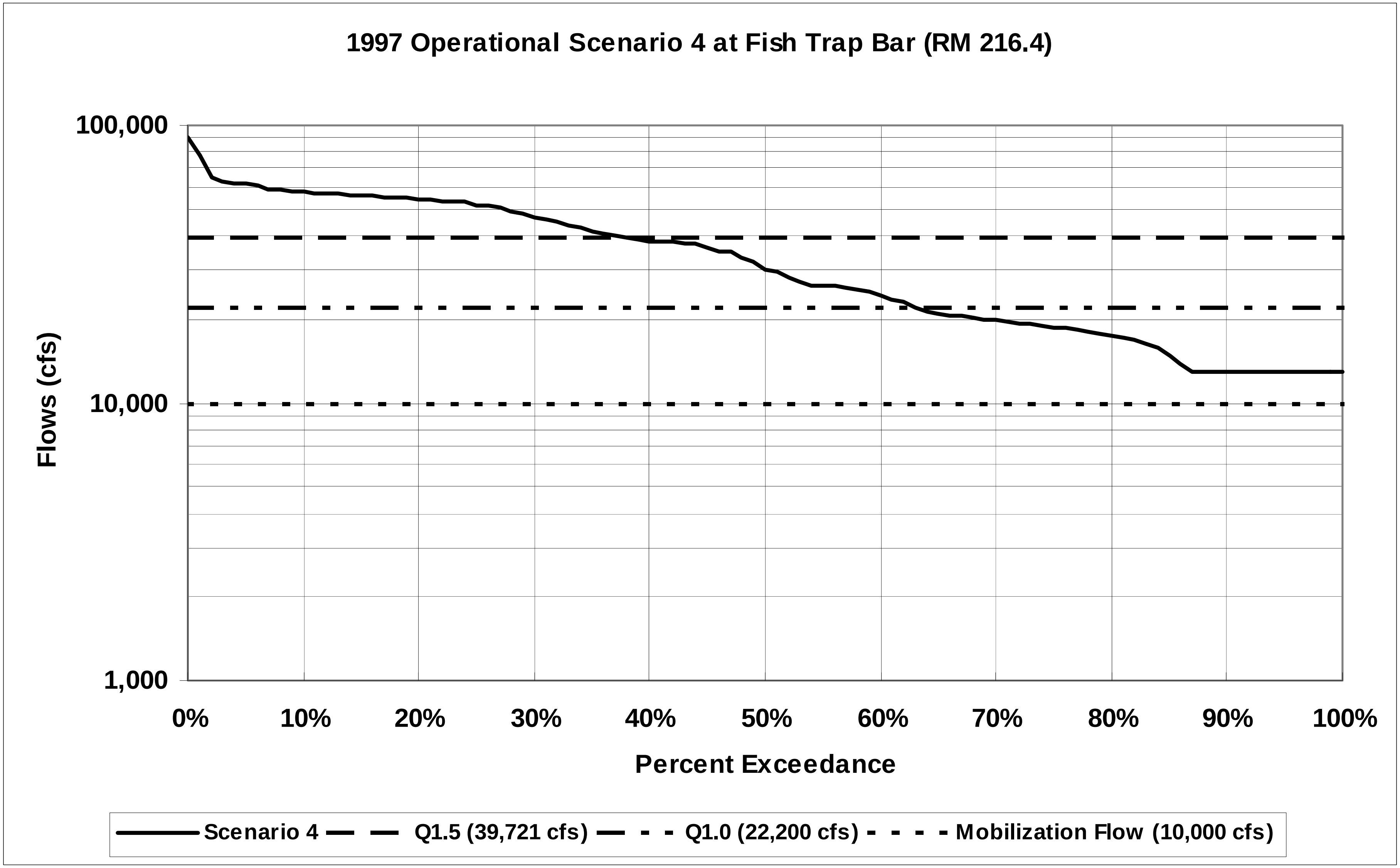


Figure 195. Flow-duration curve for 1997 Operational Scenario 4 at Fish Trap Bar (RM 216.4).

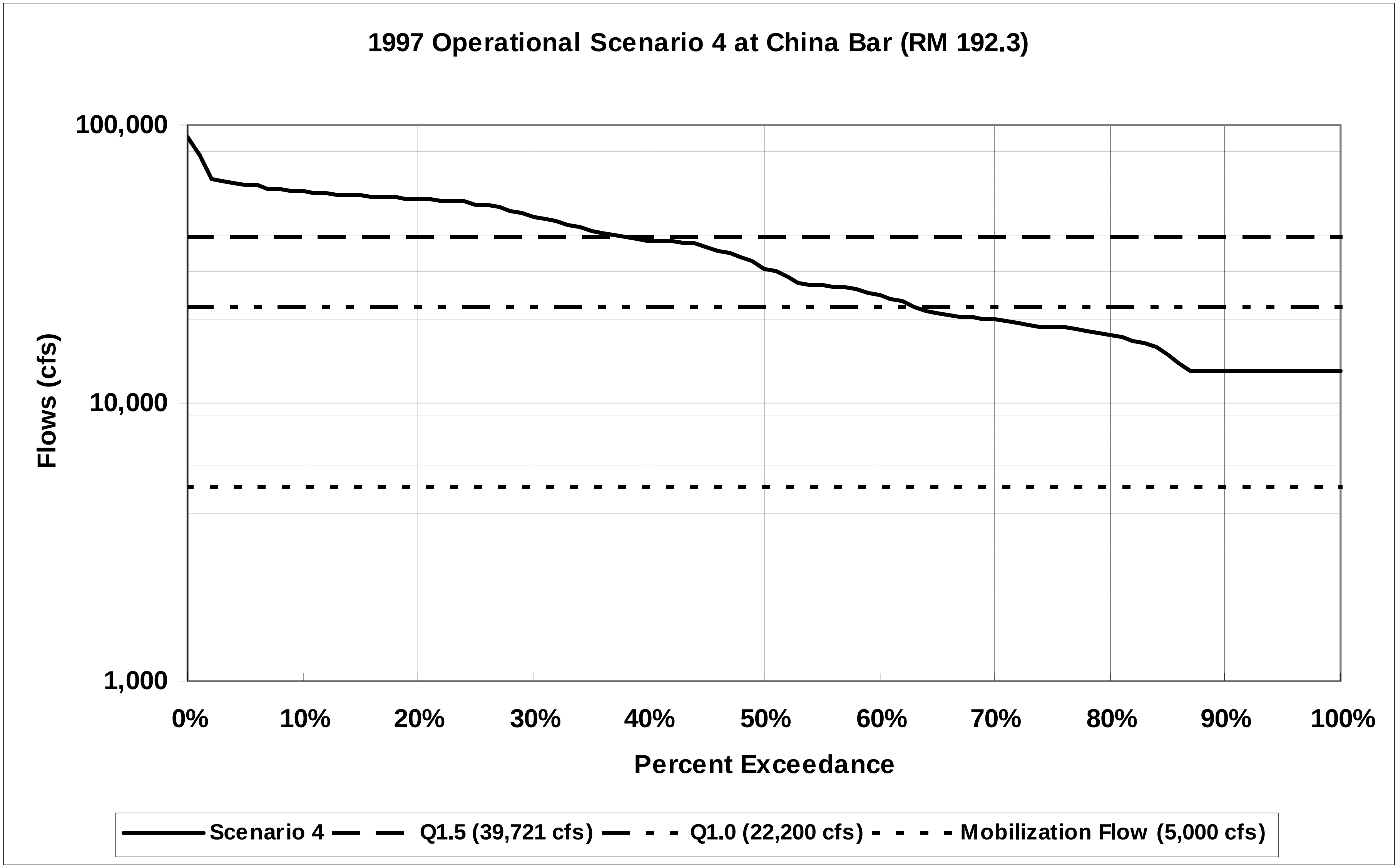


Figure 196. Flow-duration curve for 1997 Operational Scenario 4 at China Bar (RM 192.3).

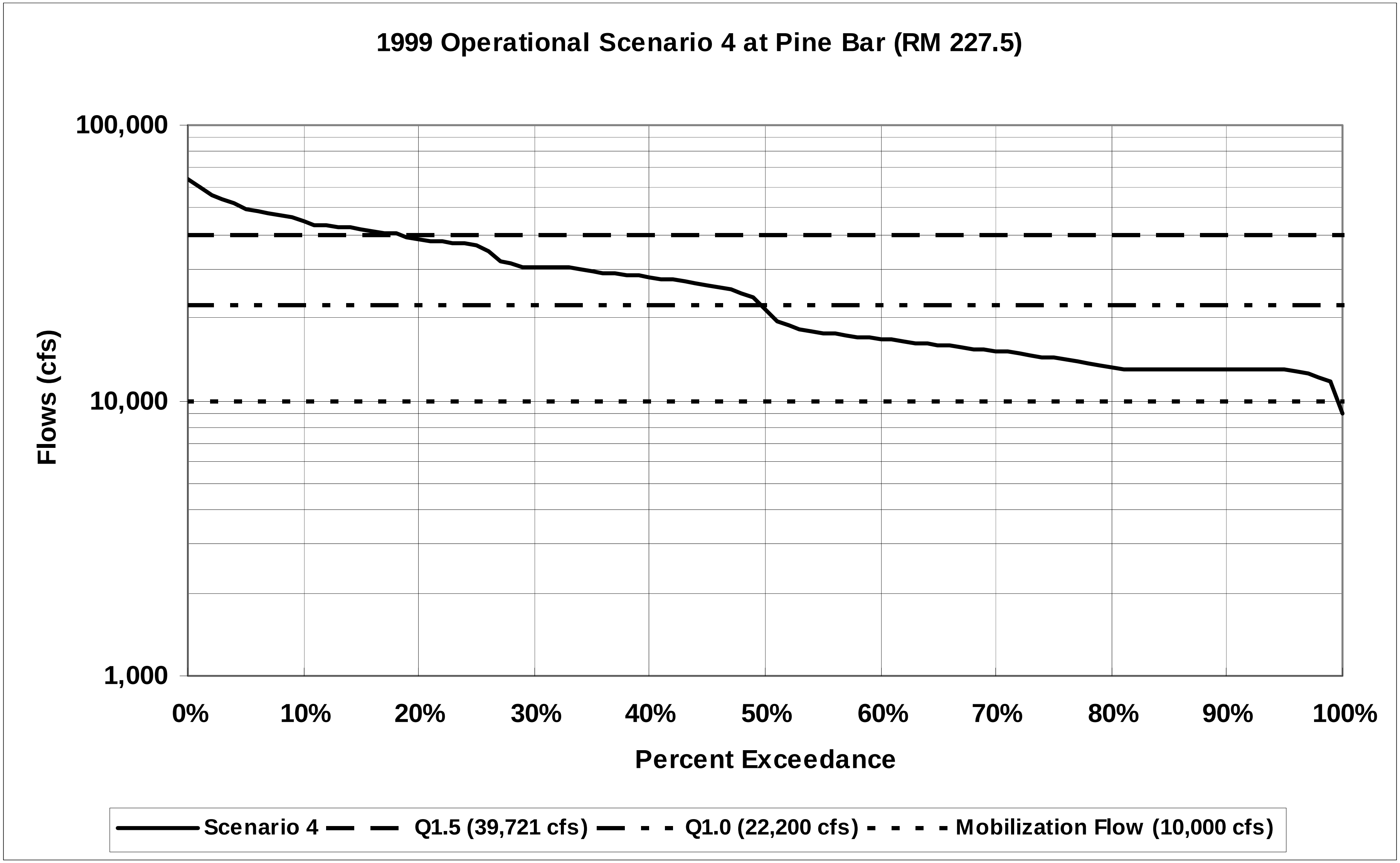


Figure 197. Flow-duration curve for 1999 Operational Scenario 4 at Pine Bar (RM 227.5).

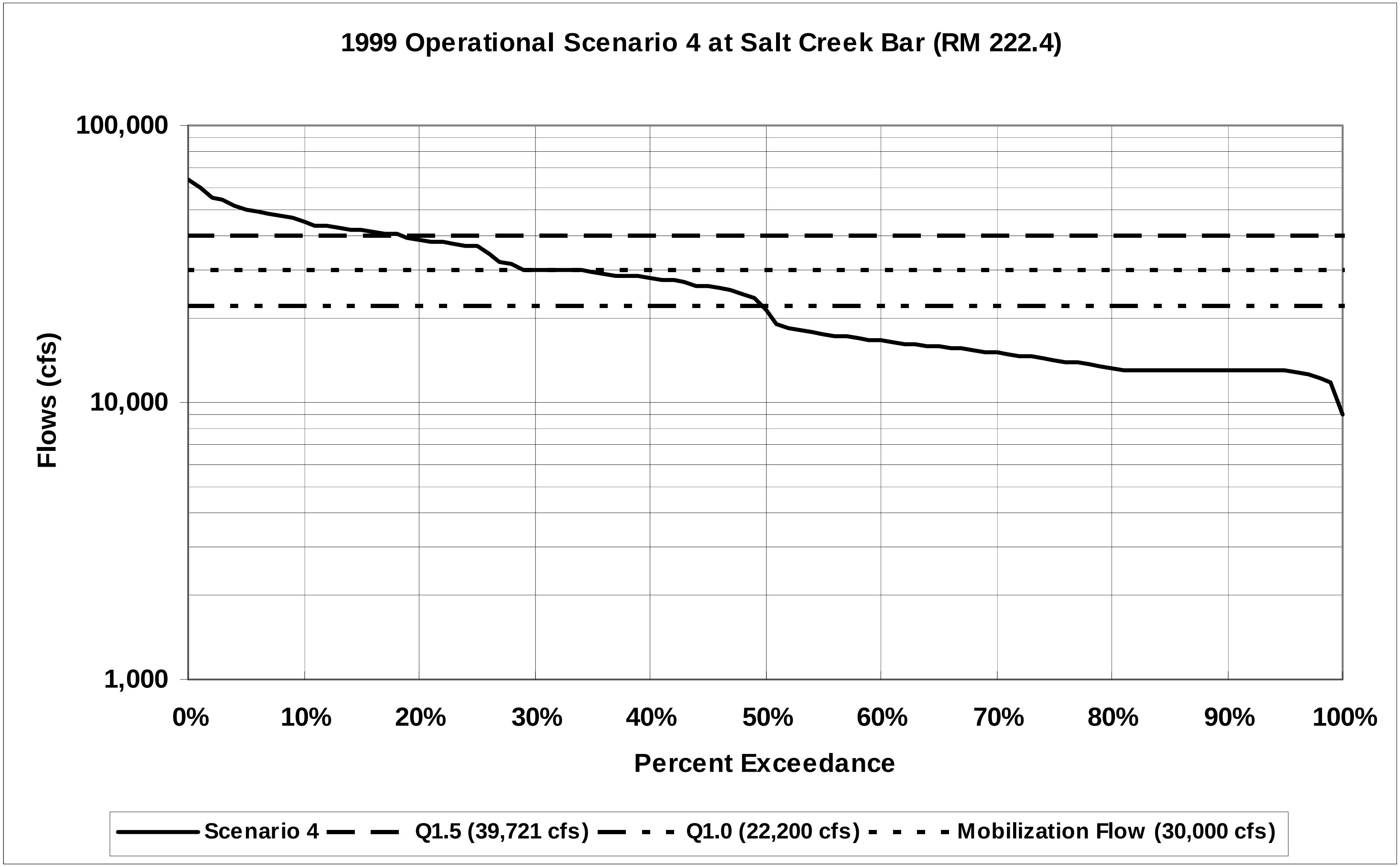


Figure 198. Flow-duration curve for 1999 Operational Scenario 4 at Salt Creek Bar (RM 222.4).

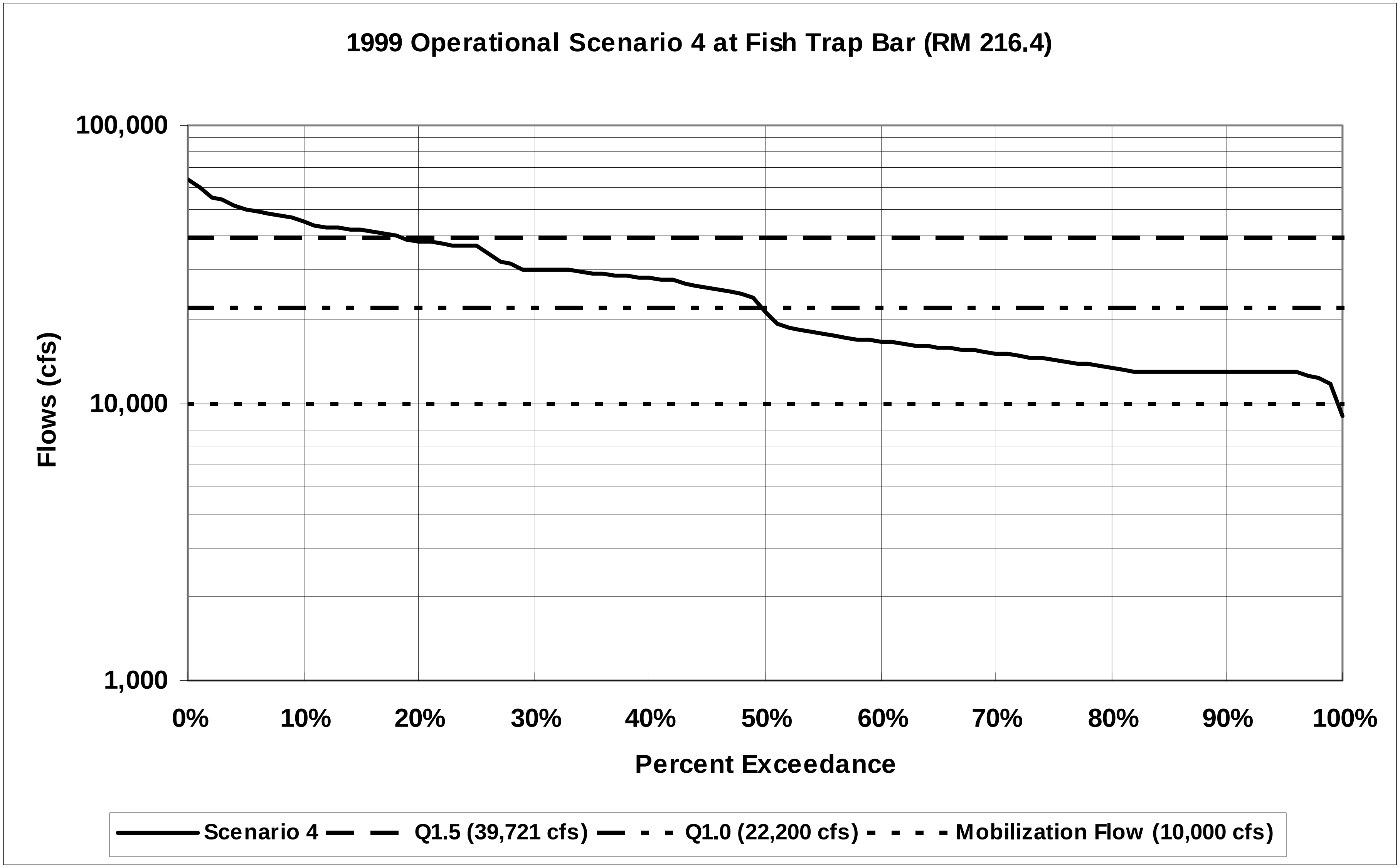


Figure 199. Flow-duration curve for 1999 Operational Scenario 4 at Fish Trap Bar (RM 216.4).

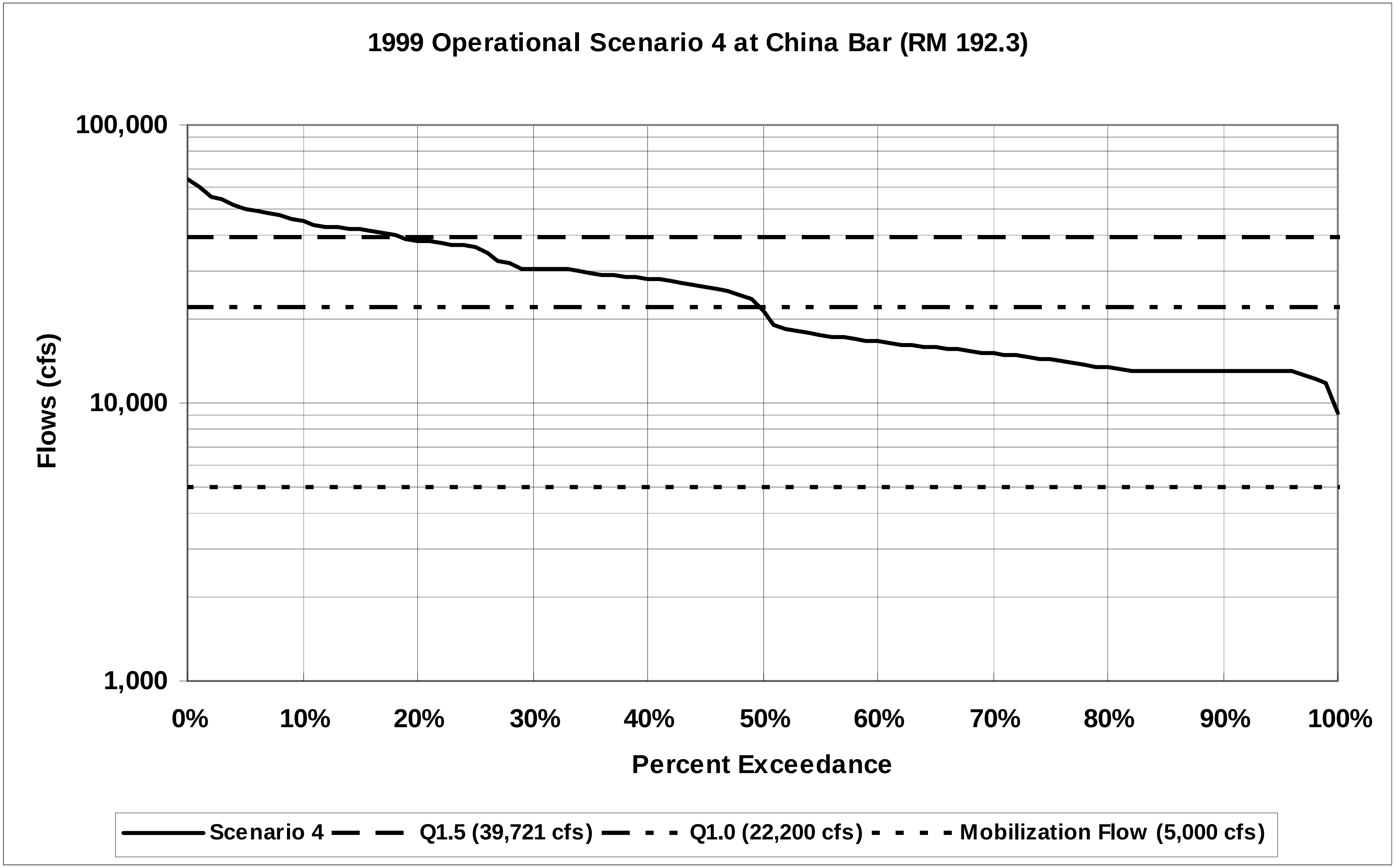


Figure 200. Flow-duration curve for 1999 Operational Scenario 4 at China Bar (RM 192.3).

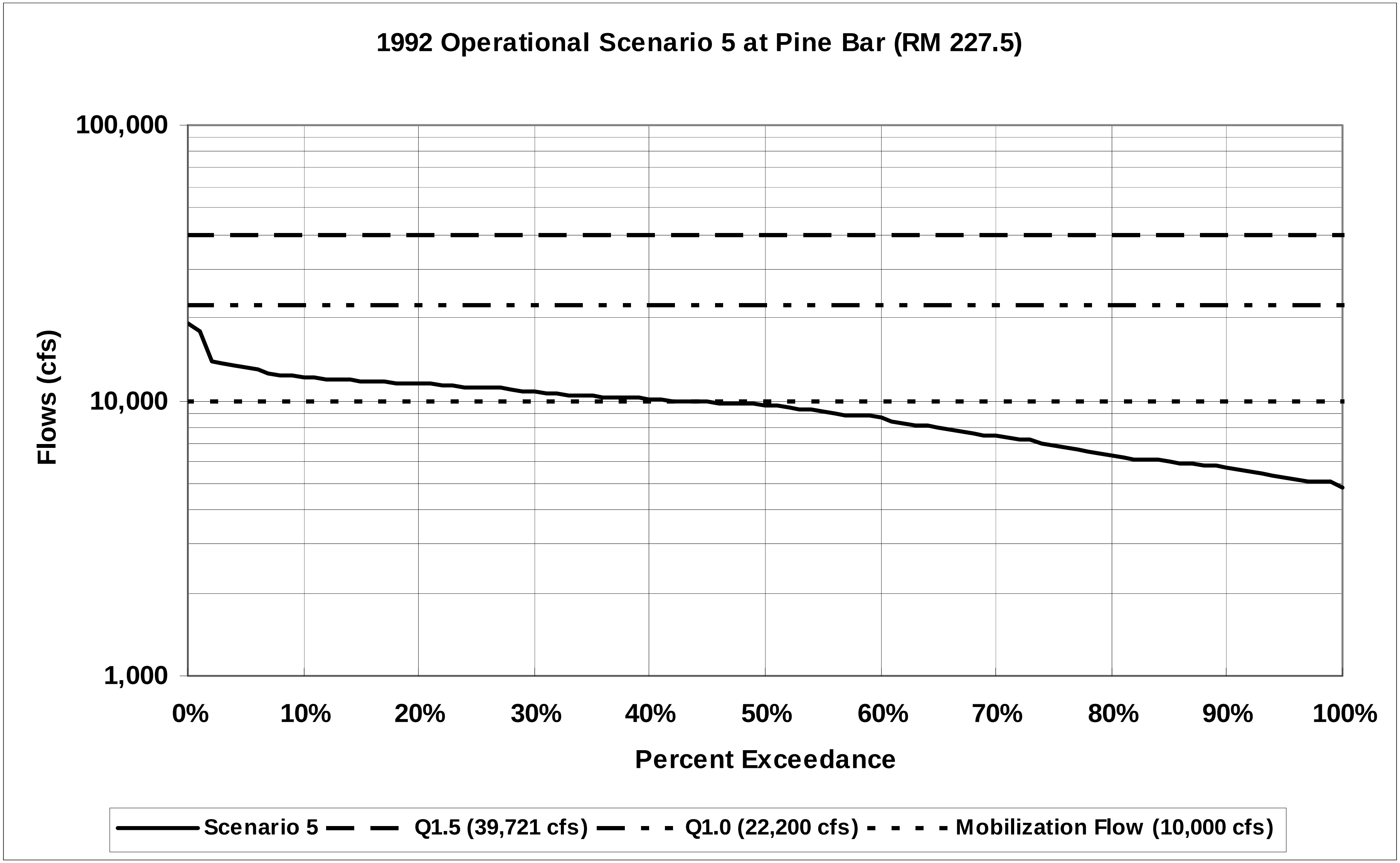


Figure 201. Flow-duration curve for 1992 Operational Scenario 5 at Pine Bar (RM 227.5).

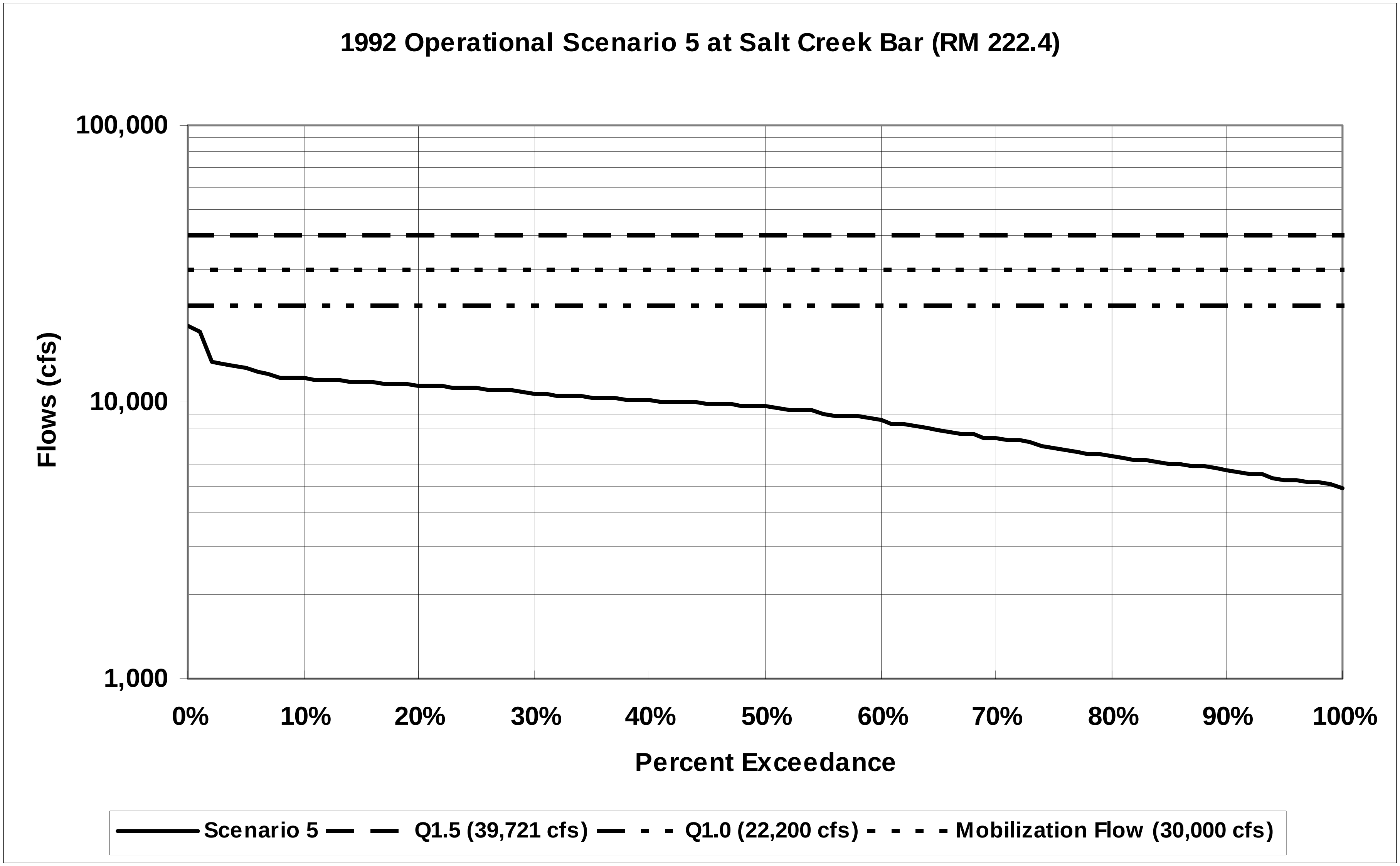


Figure 202. Flow-duration curve for 1992 Operational Scenario 5 at Salt Creek Bar (RM 222.4).

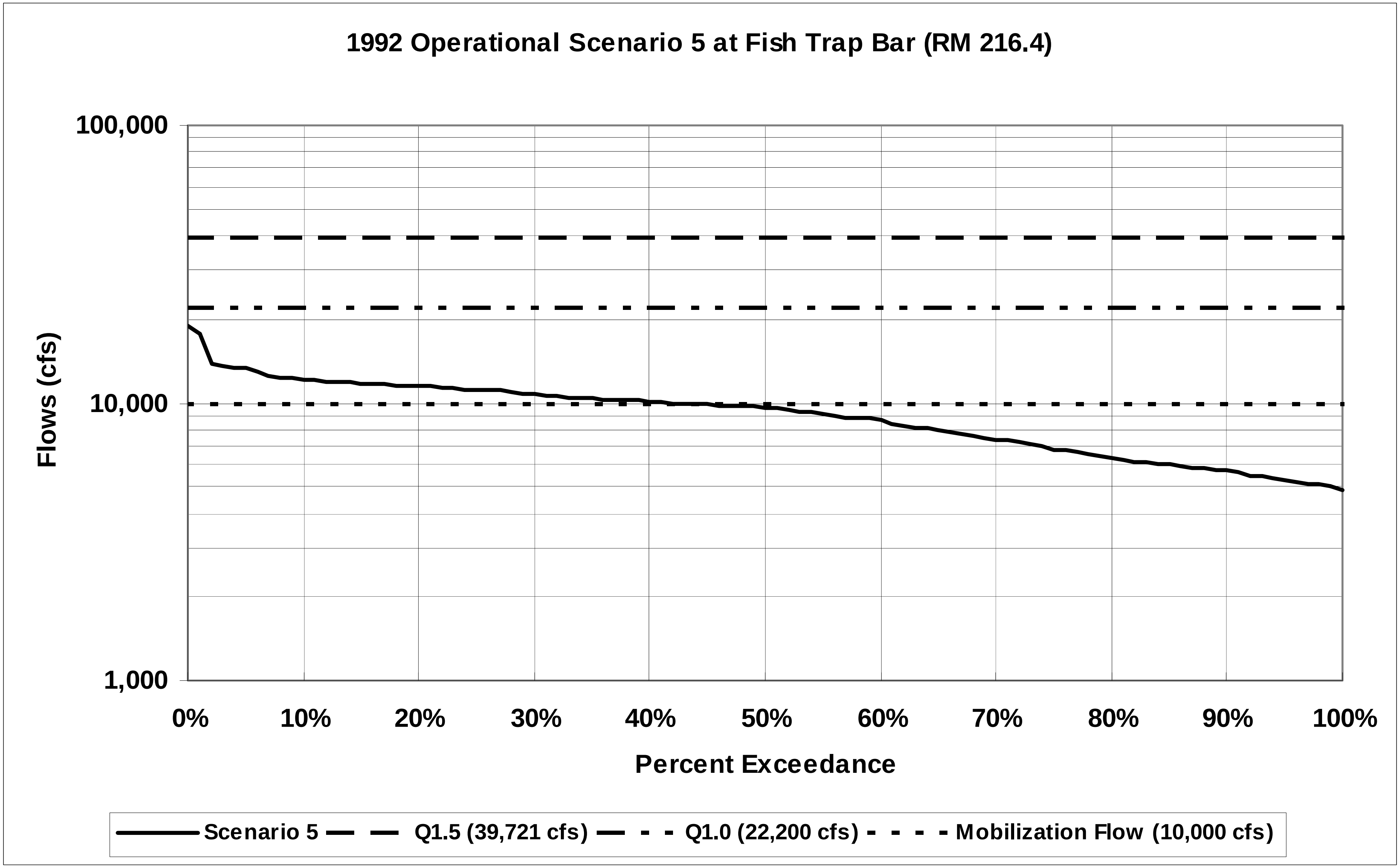


Figure 203. Flow-duration curve for 1992 Operational Scenario 5 at Fish Trap Bar (RM 216.4).

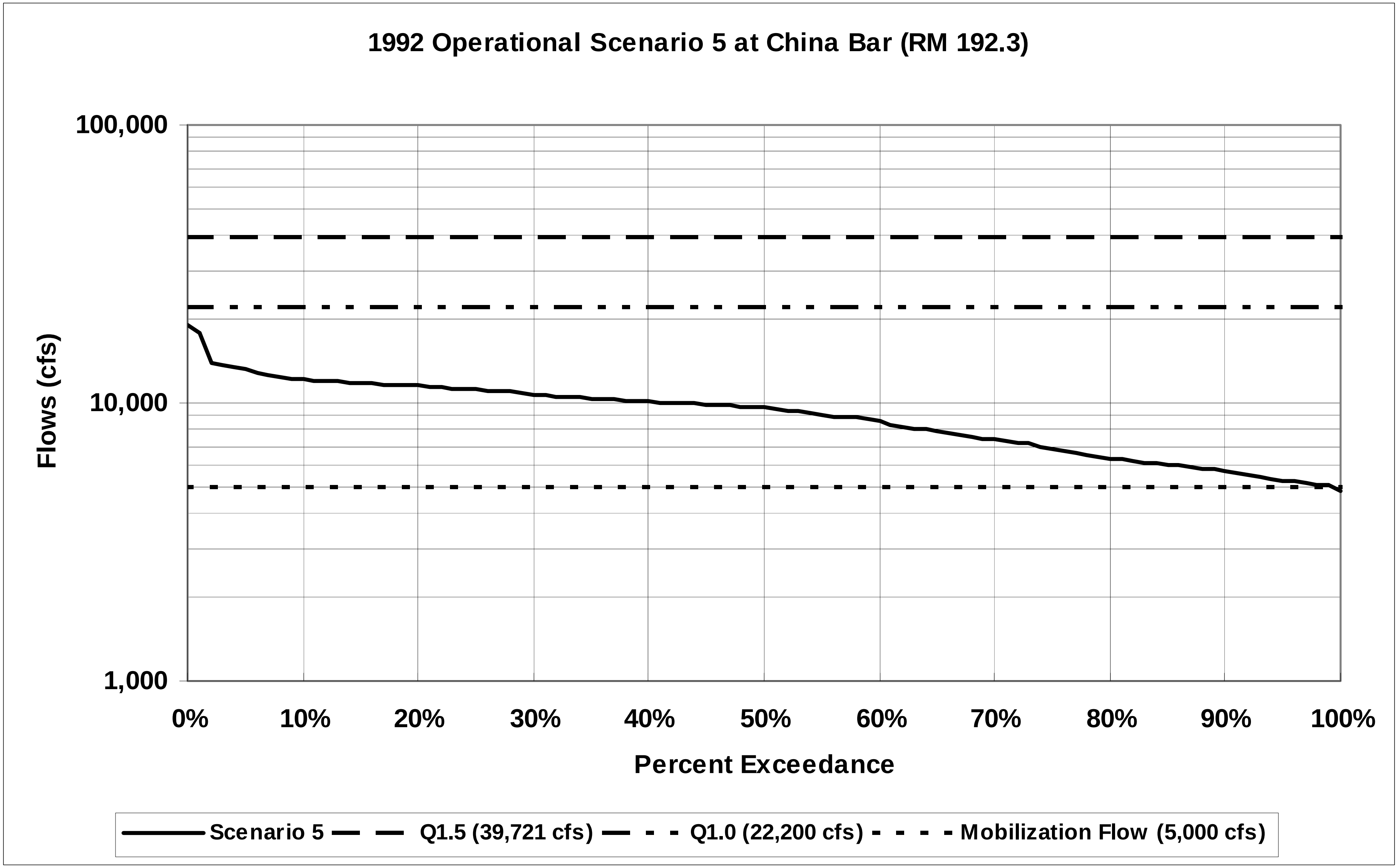


Figure 204. Flow-duration curve for 1992 Operational Scenario 5 at China Bar (RM 192.3).

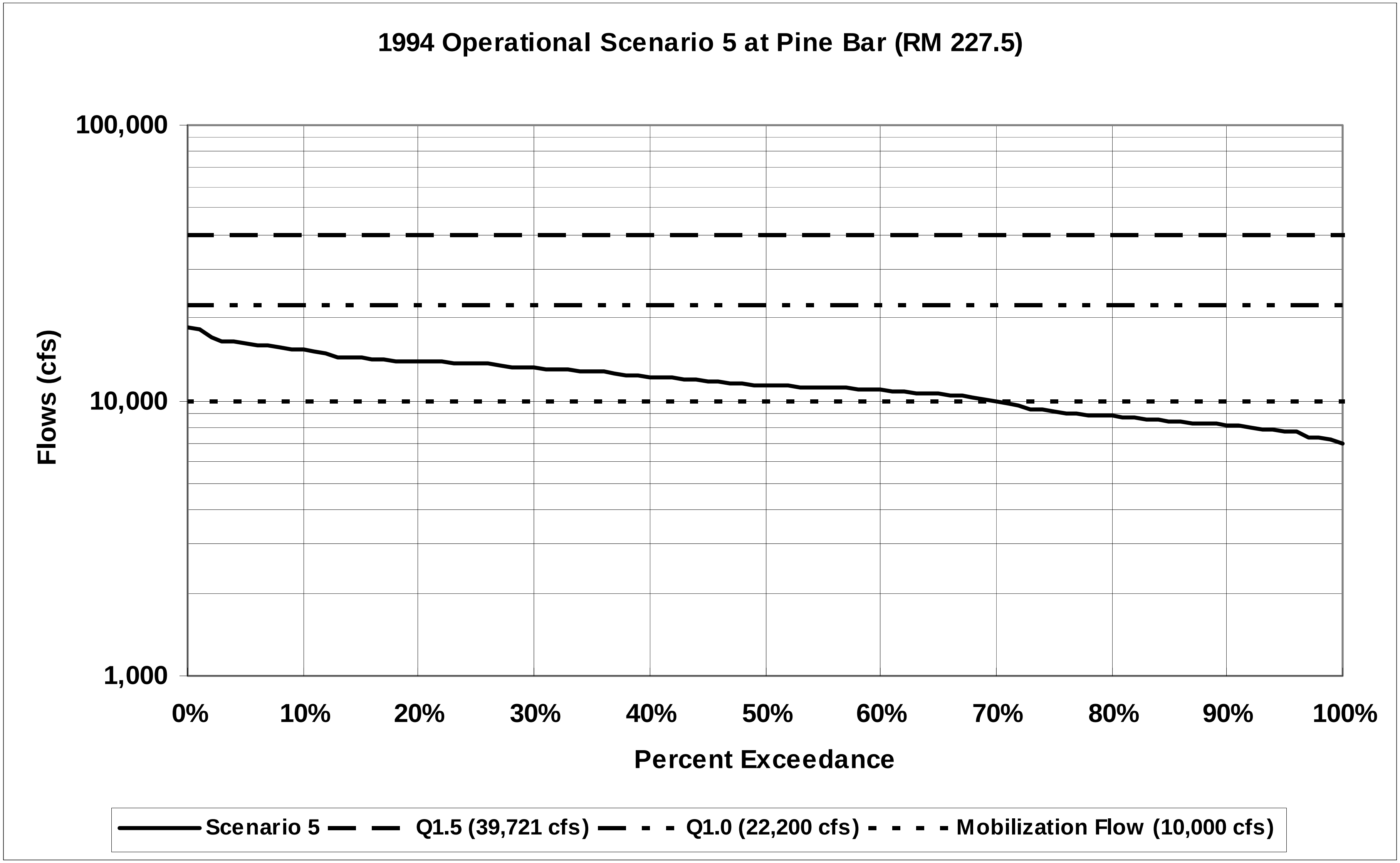


Figure 205. Flow-duration curve for 1994 Operational Scenario 5 at Pine Bar (RM 227.5).

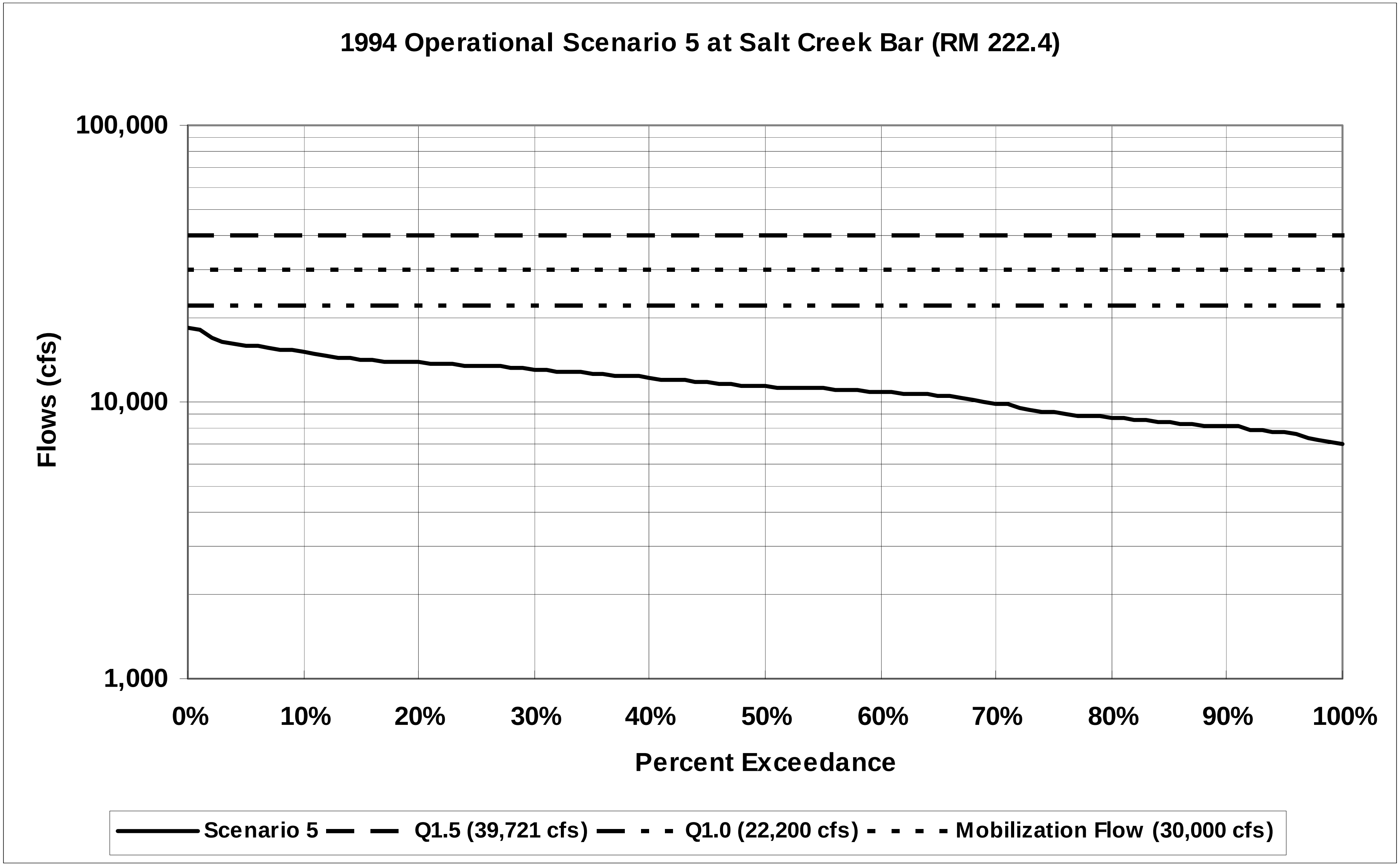


Figure 206. Flow-duration curve for 1994 Operational Scenario 5 at Salt Creek Bar (RM 222.4).

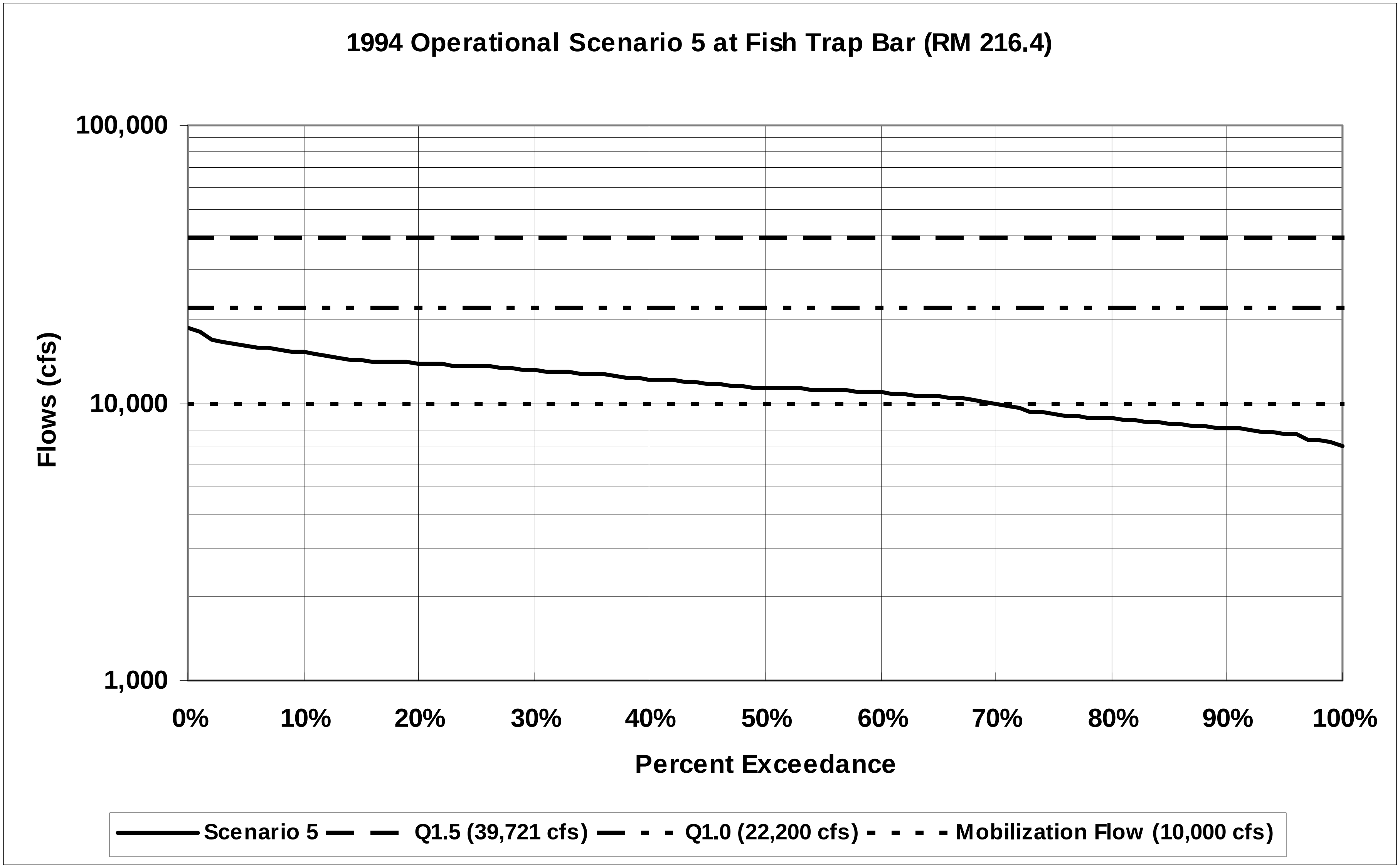


Figure 207. Flow-duration curve for 1994 Operational Scenario 5 at Fish Trap Bar (RM 216.4).

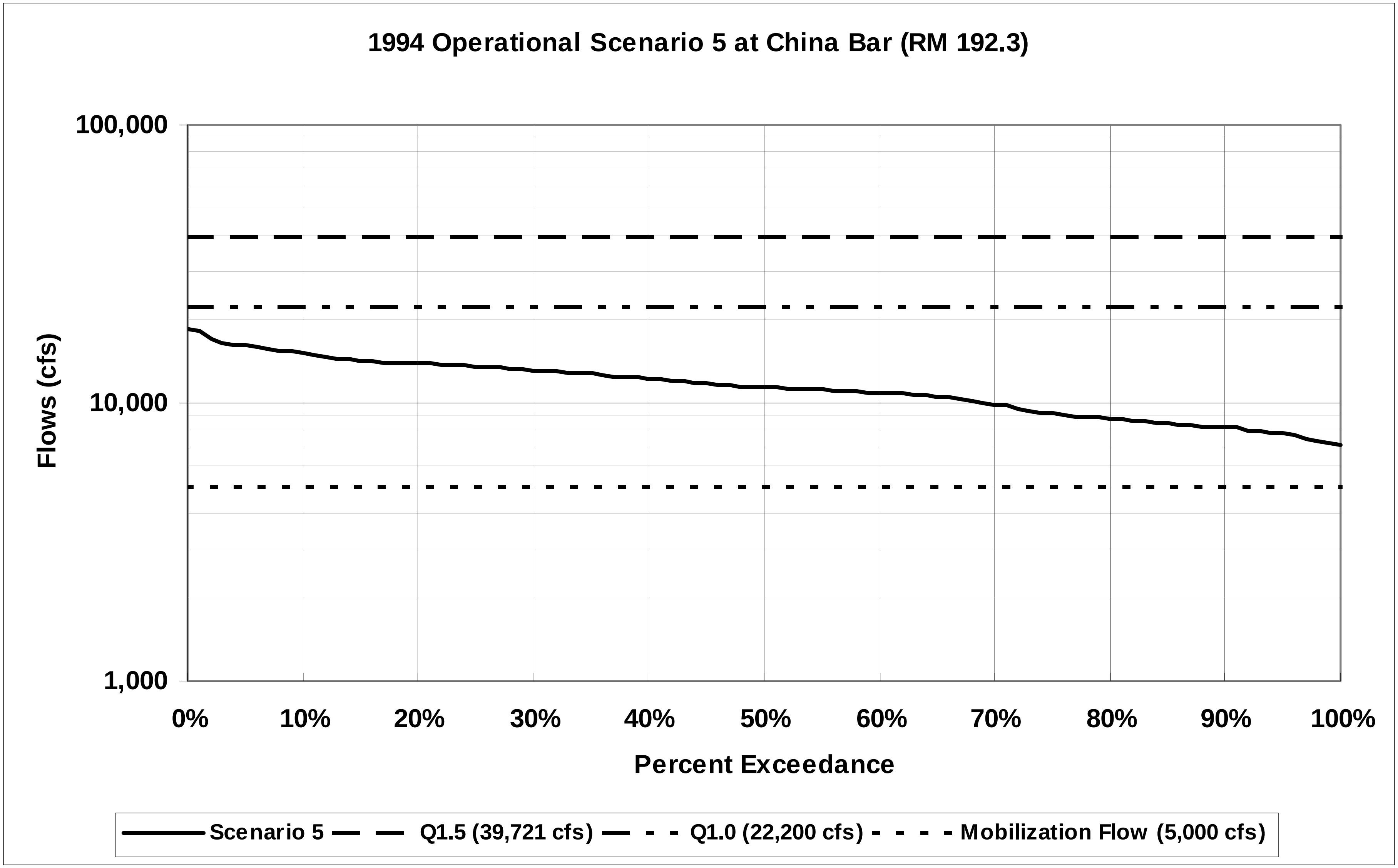


Figure 208. Flow-duration curve for 1994 Operational Scenario 5 at China Bar (RM 192.3).

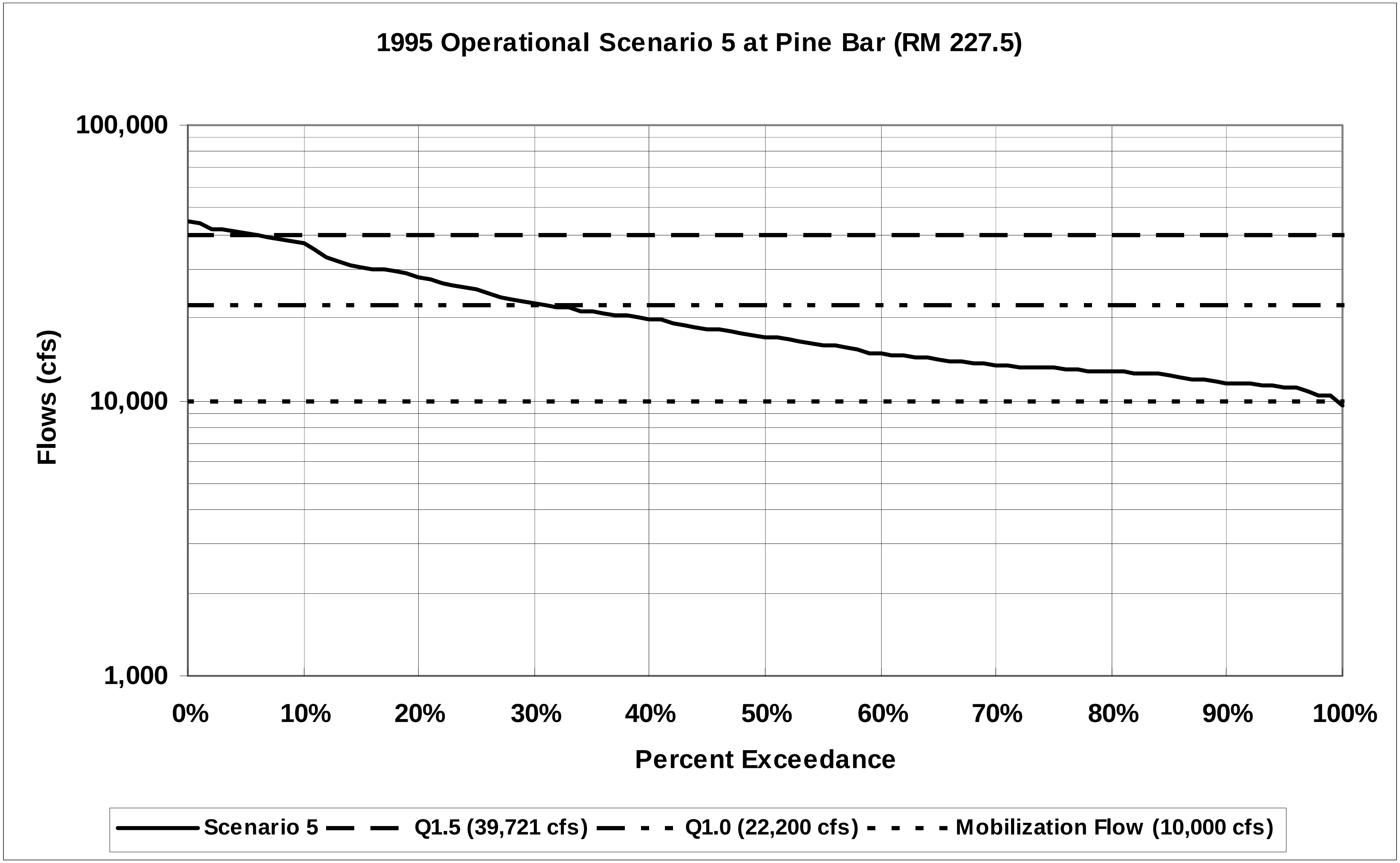


Figure 209. Flow-duration curve for 1995 Operational Scenario 5 at Pine Bar (RM 227.5).

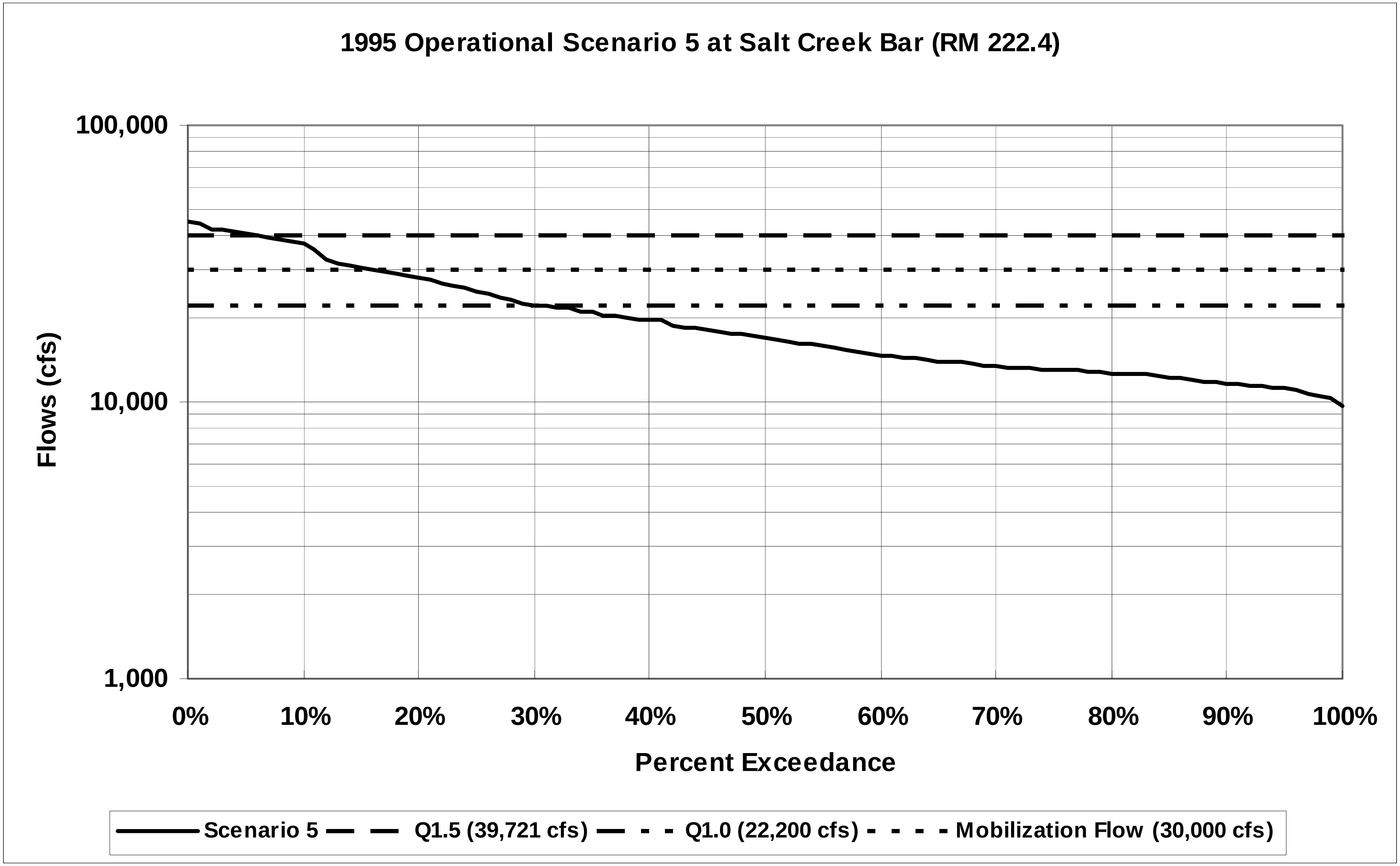


Figure 210. Flow-duration curve for 1995 Operational Scenario 5 at Salt Creek Bar (RM 222.4).

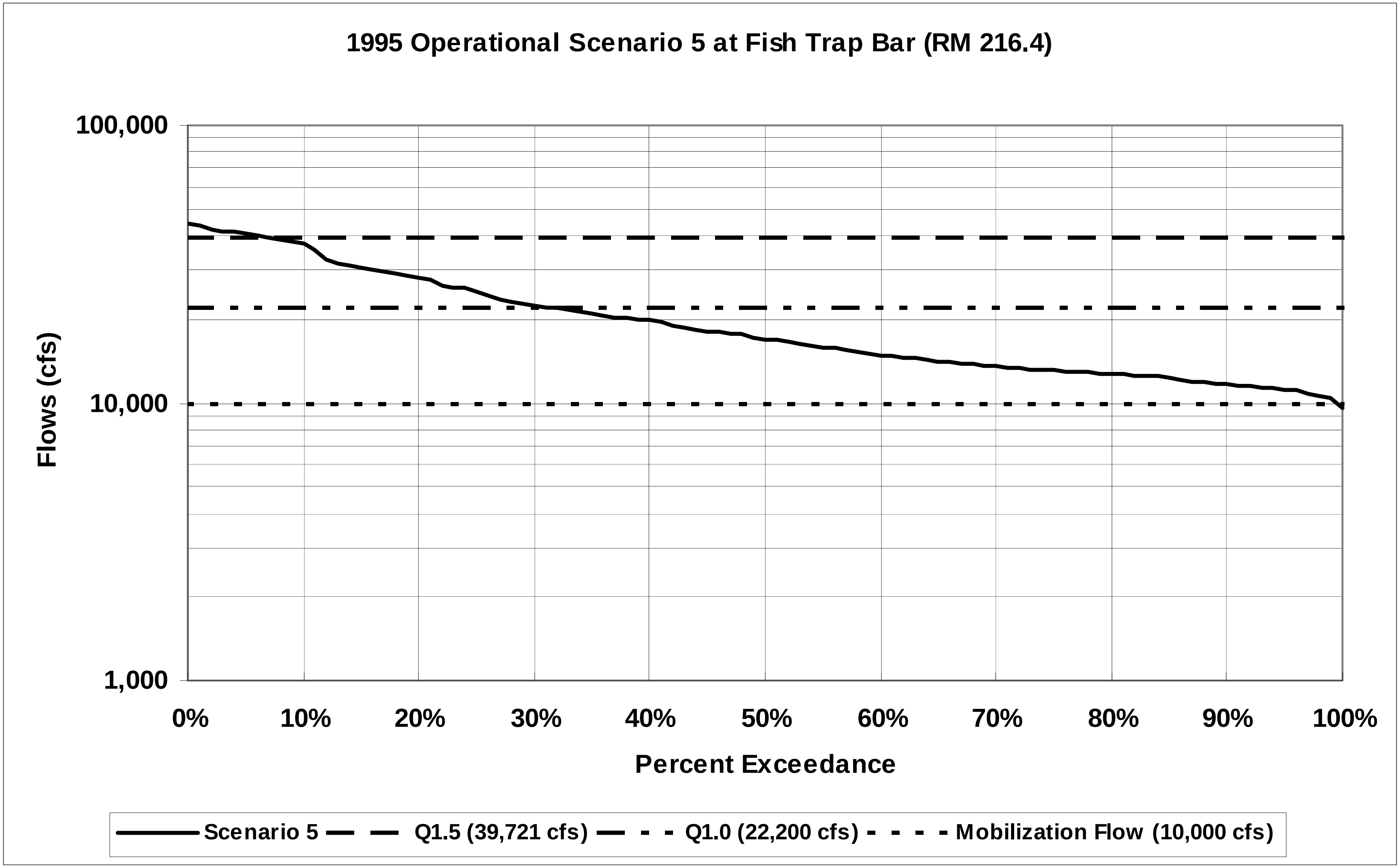


Figure 211. Flow-duration curve for 1995 Operational Scenario 5 at Fish Trap Bar (RM 216.4).

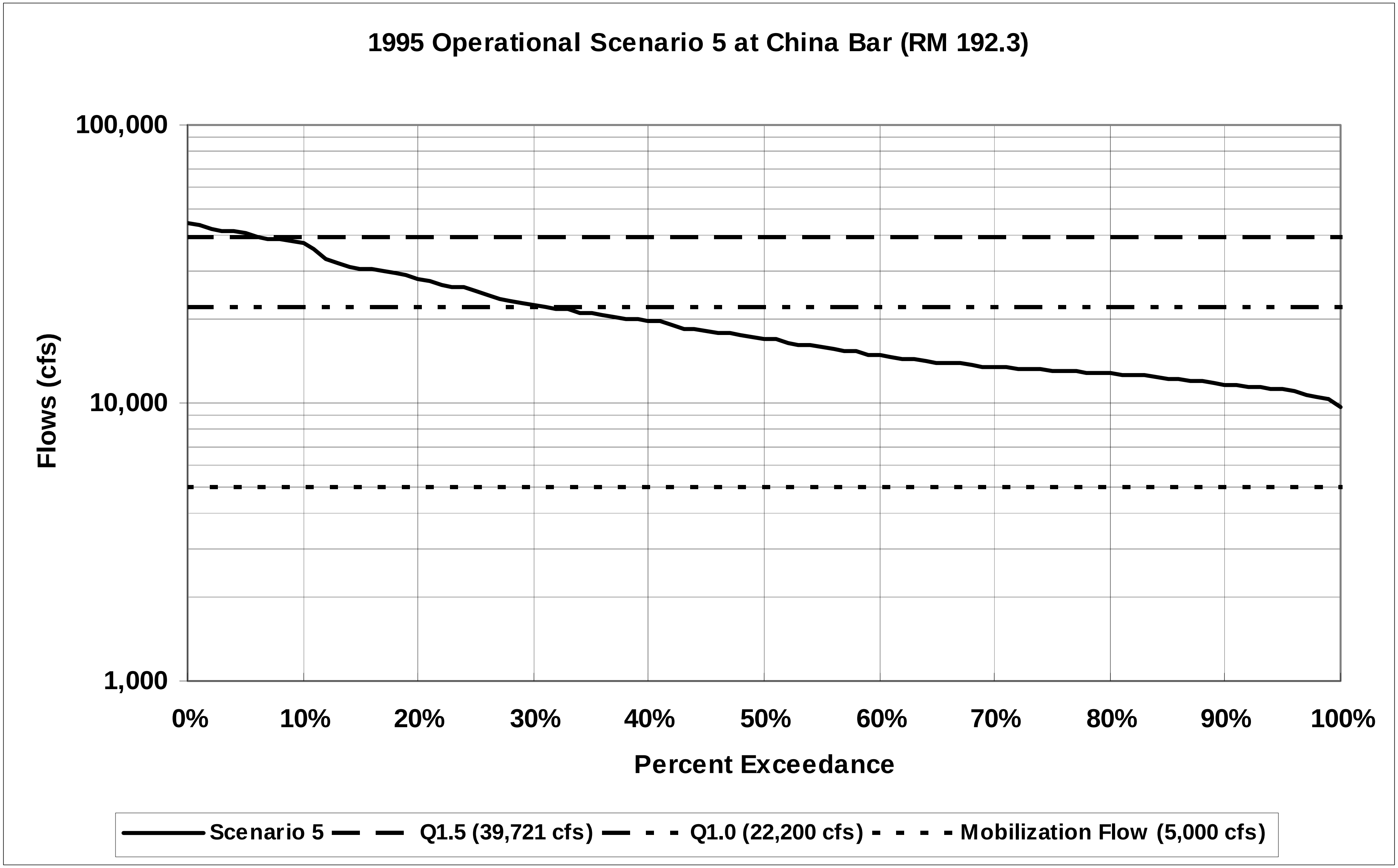


Figure 212. Flow-duration curve for 1995 Operational Scenario 5 at China Bar (RM 192.3).

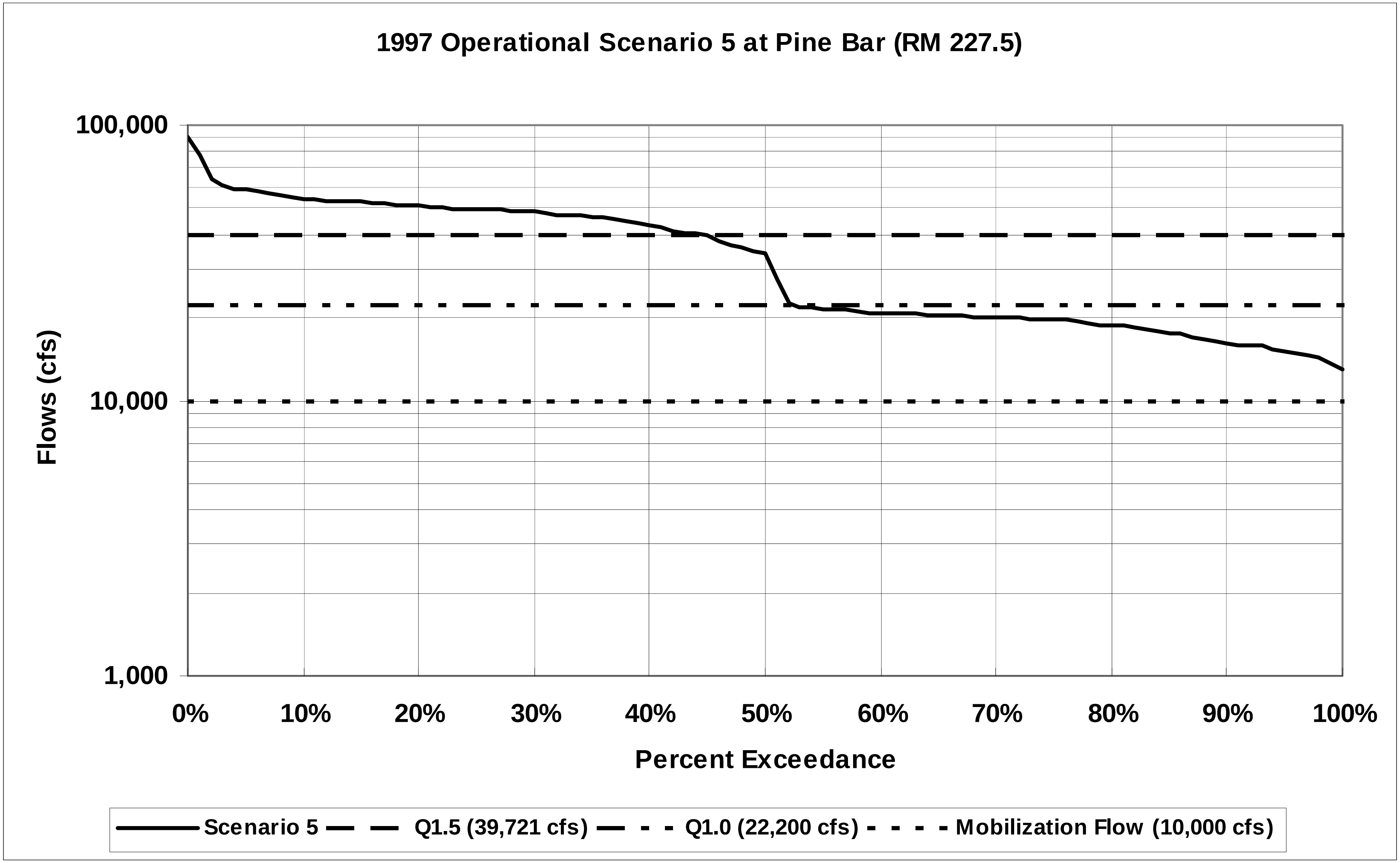


Figure 213. Flow-duration curve for 1997 Operational Scenario 5 at Pine Bar (RM 227.5).

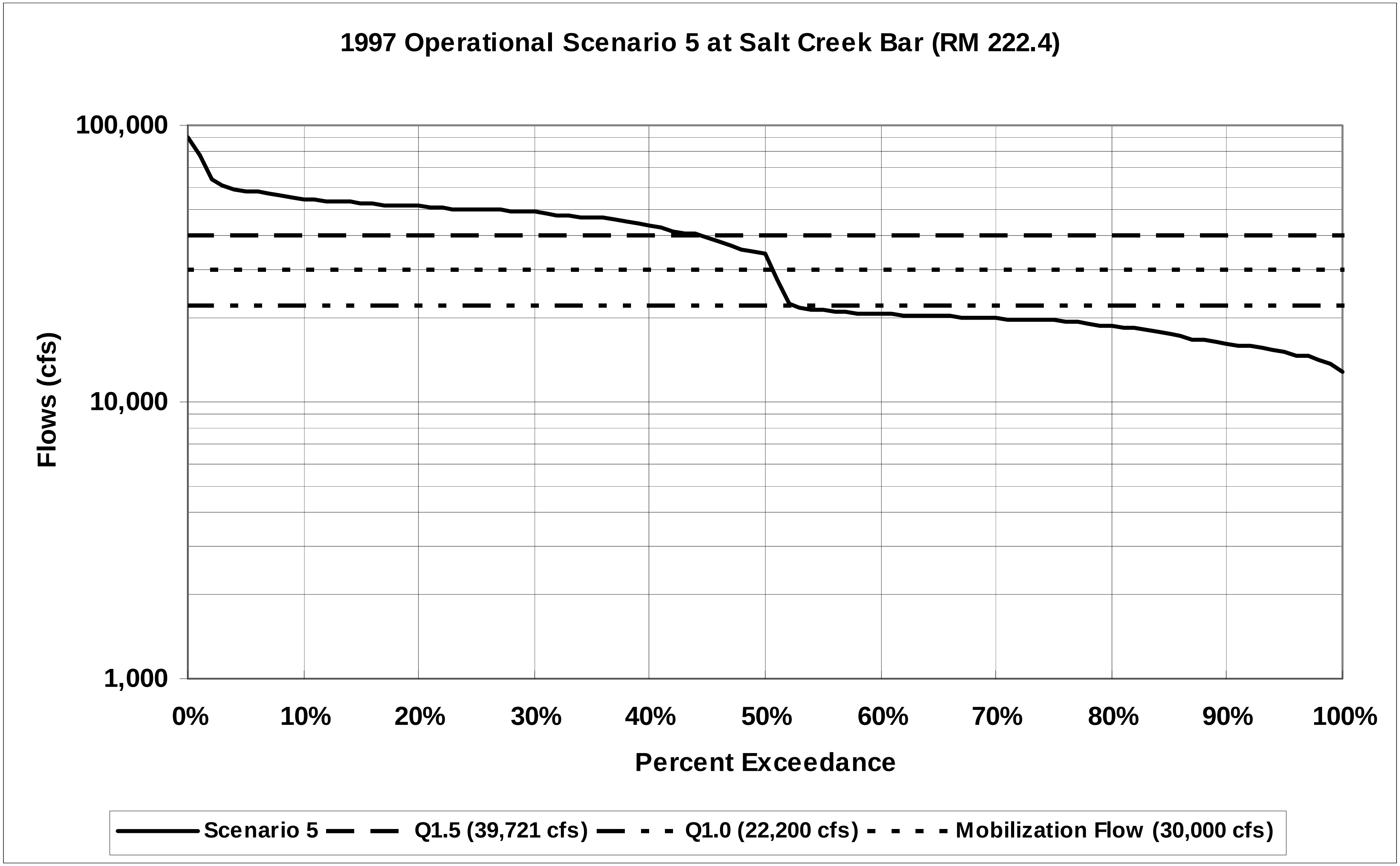


Figure 214. Flow-duration curve for 1997 Operational Scenario 5 at Salt Creek Bar (RM 222.4).

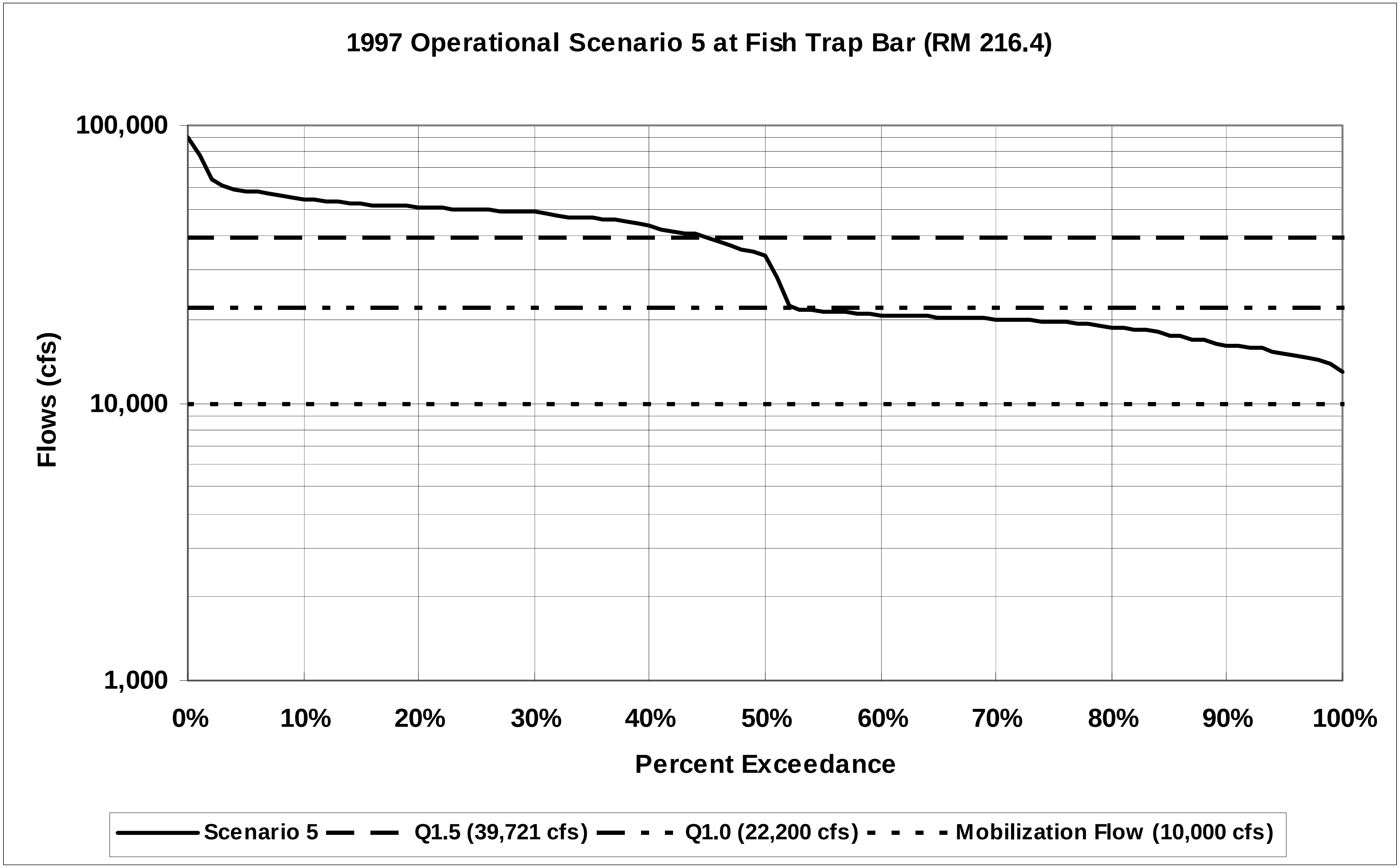


Figure 215. Flow-duration curve for 1997 Operational Scenario 5 at Fish Trap Bar (RM 216.4).

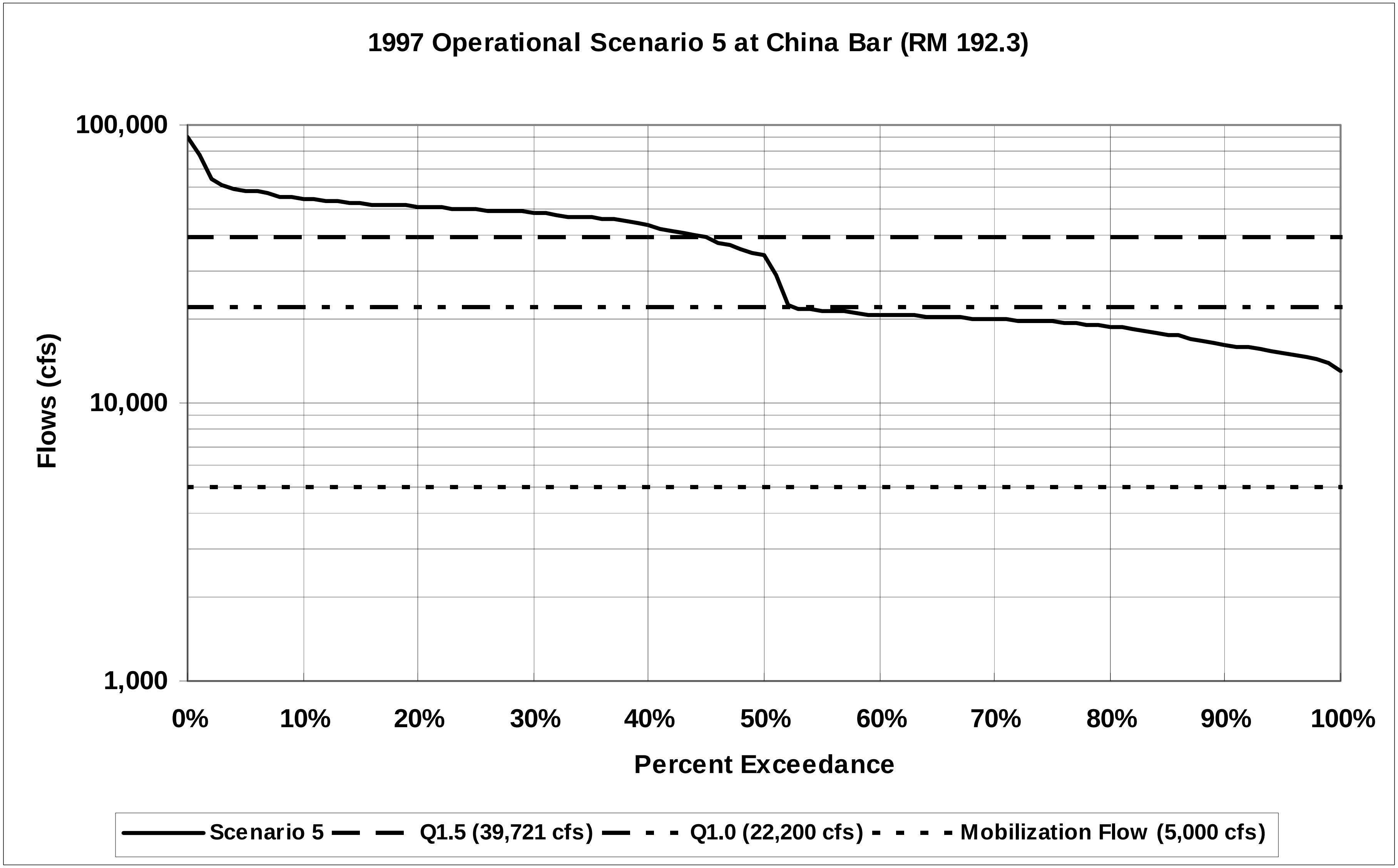


Figure 216. Flow-duration curve for 1997 Operational Scenario 5 at China Bar (RM 192.3).

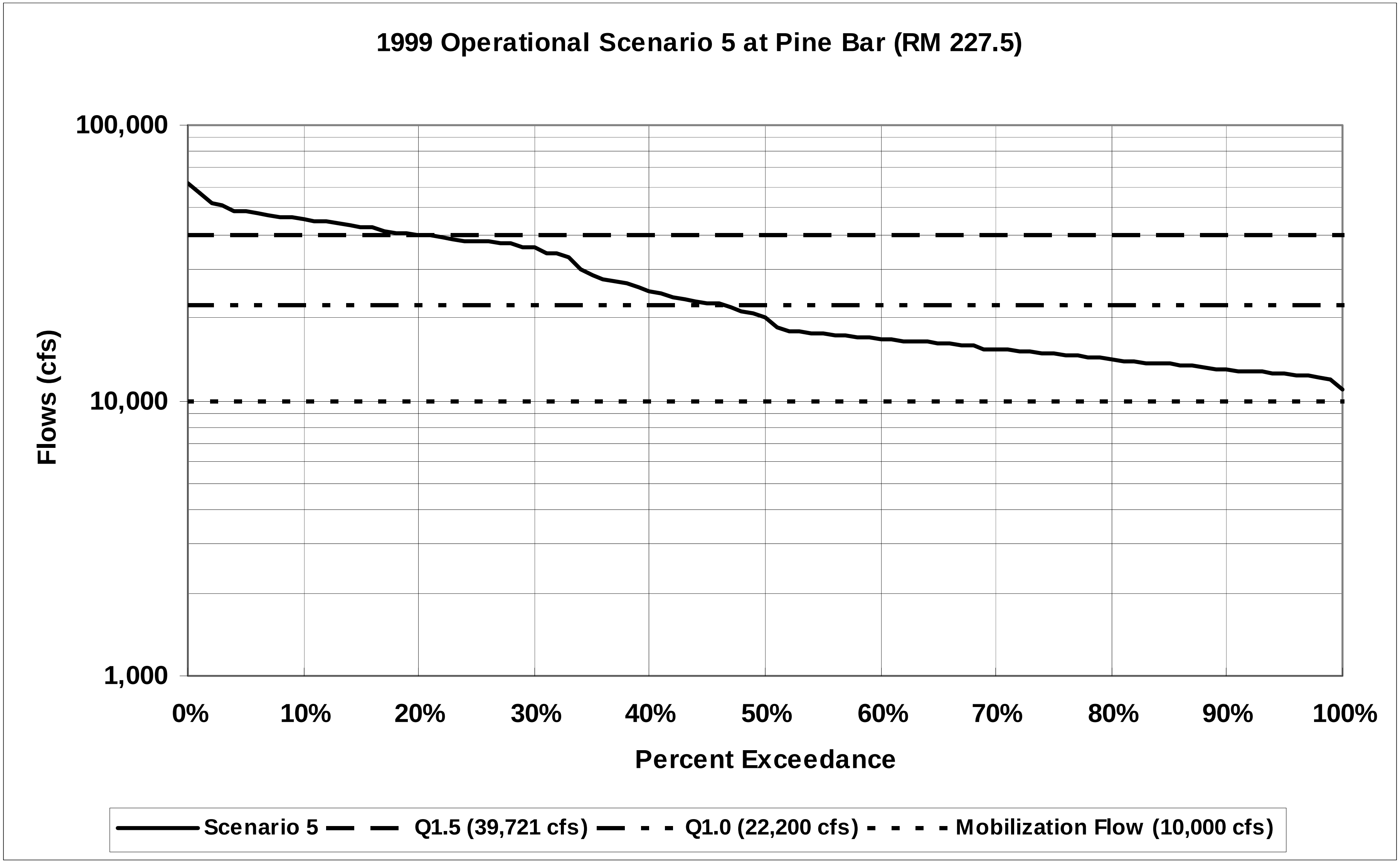


Figure 217. Flow-duration curve for 1999 Operational Scenario 5 at Pine Bar (RM 227.5).

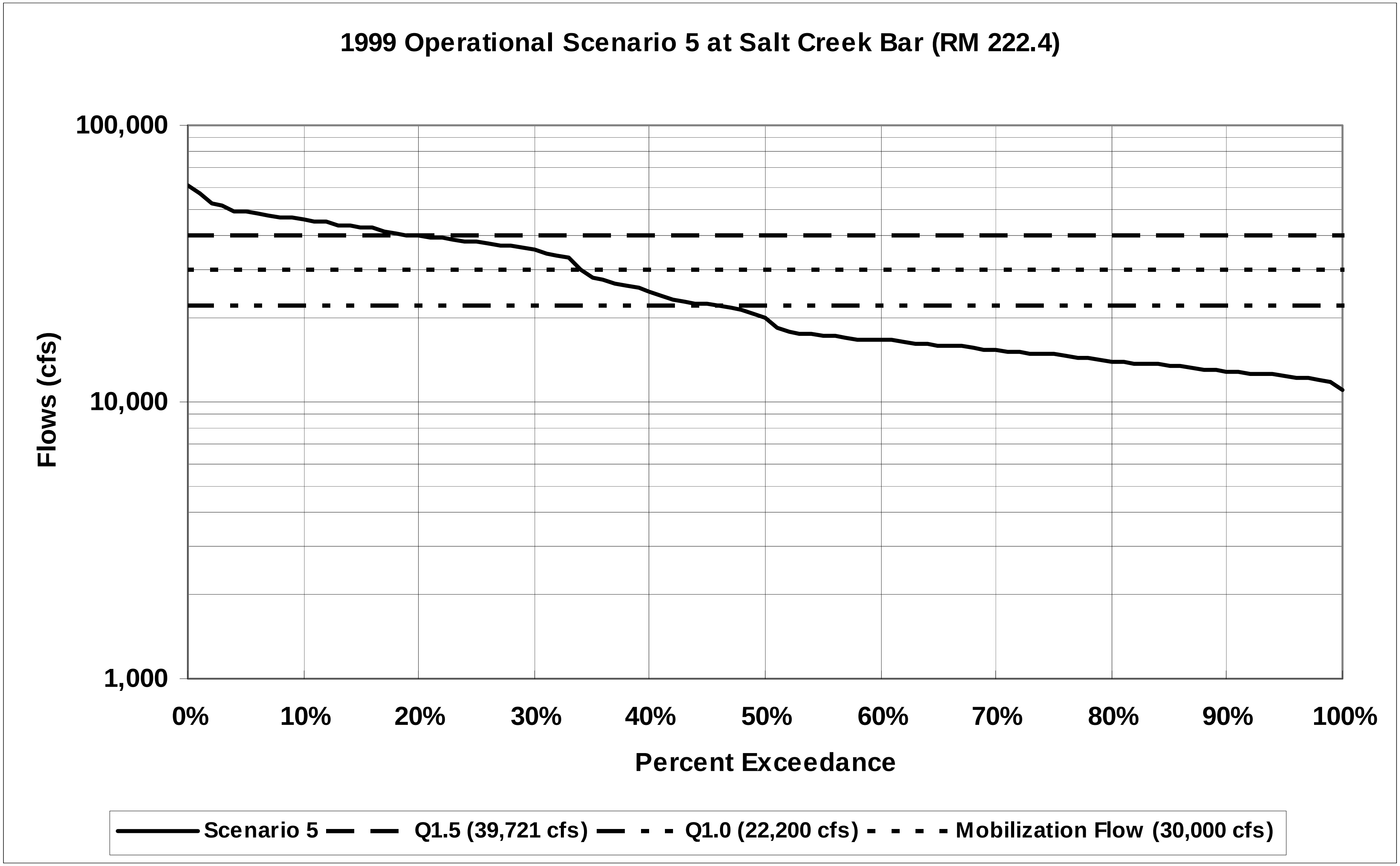


Figure 218. Flow-duration curve for 1999 Operational Scenario 5 at Salt Creek Bar (RM 222.4).

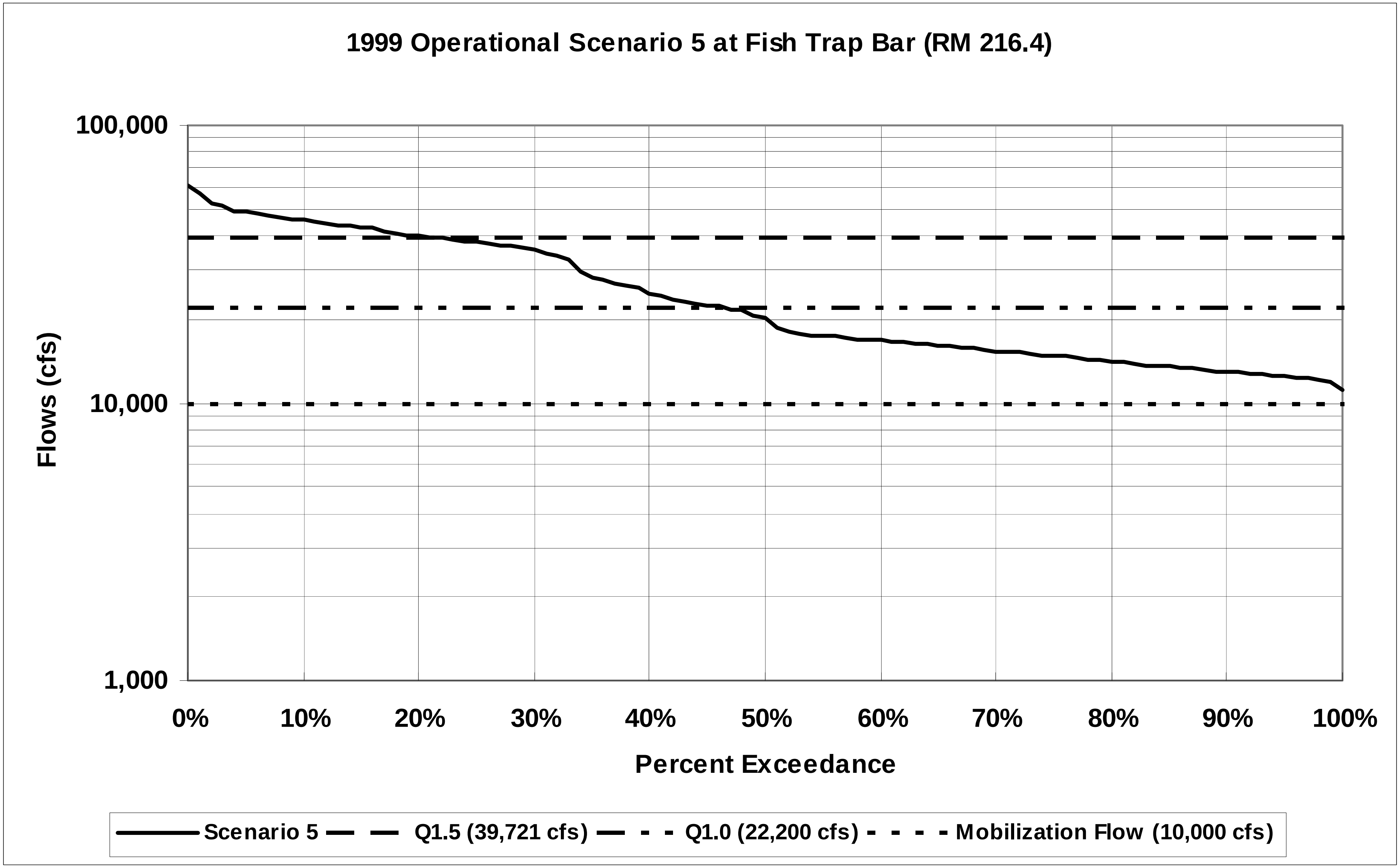


Figure 219. Flow-duration curve for 1999 Operational Scenario 5 at Fish Trap Bar (RM 216.4).

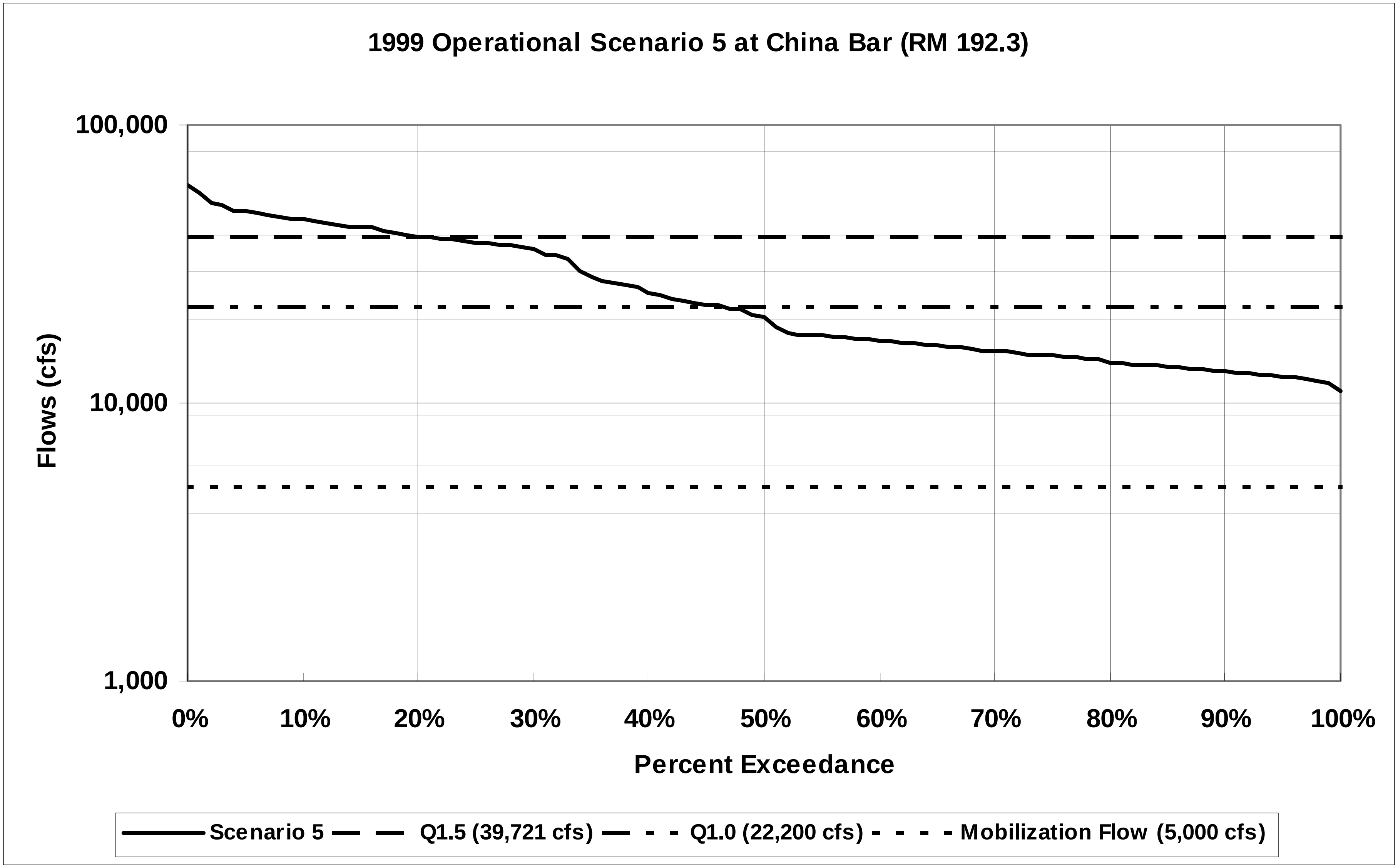


Figure 220. Flow-duration curve for 1999 Operational Scenario 5 at China Bar (RM 192.3).

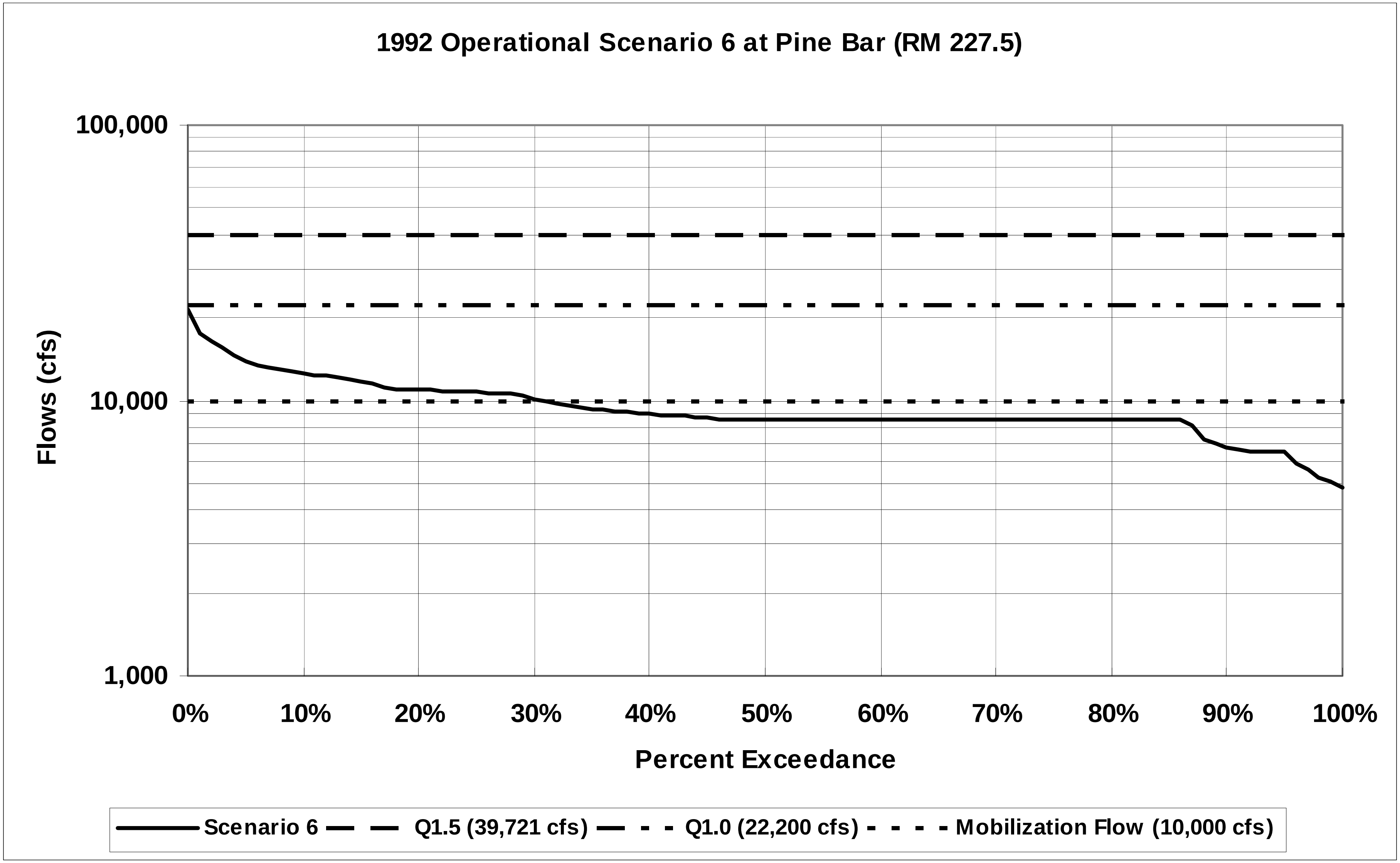


Figure 221. Flow-duration curve for 1992 Operational Scenario 6 at Pine Bar (RM 227.5).

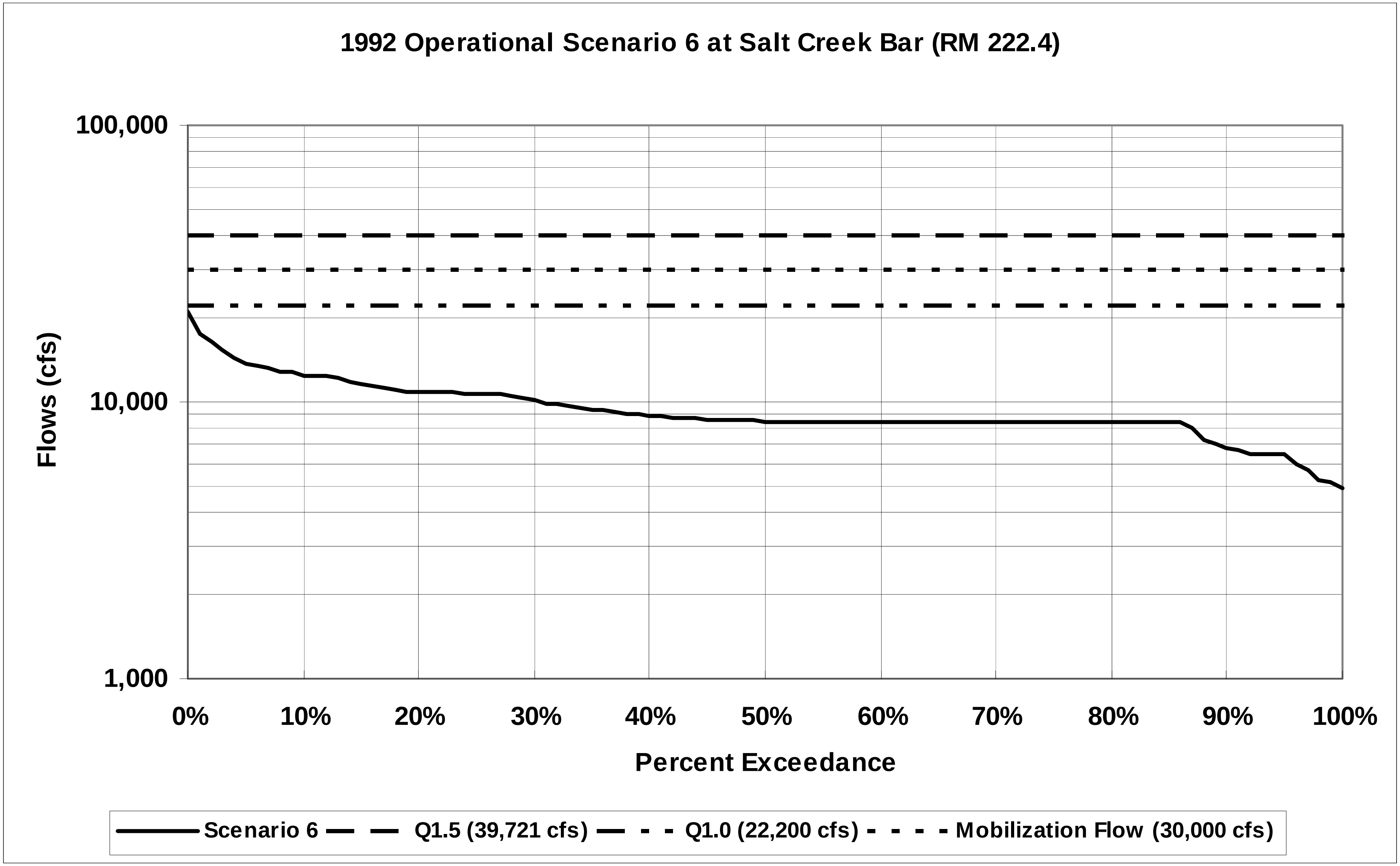


Figure 222. Flow-duration curve for 1992 Operational Scenario 6 at Salt Creek Bar (RM 222.4).

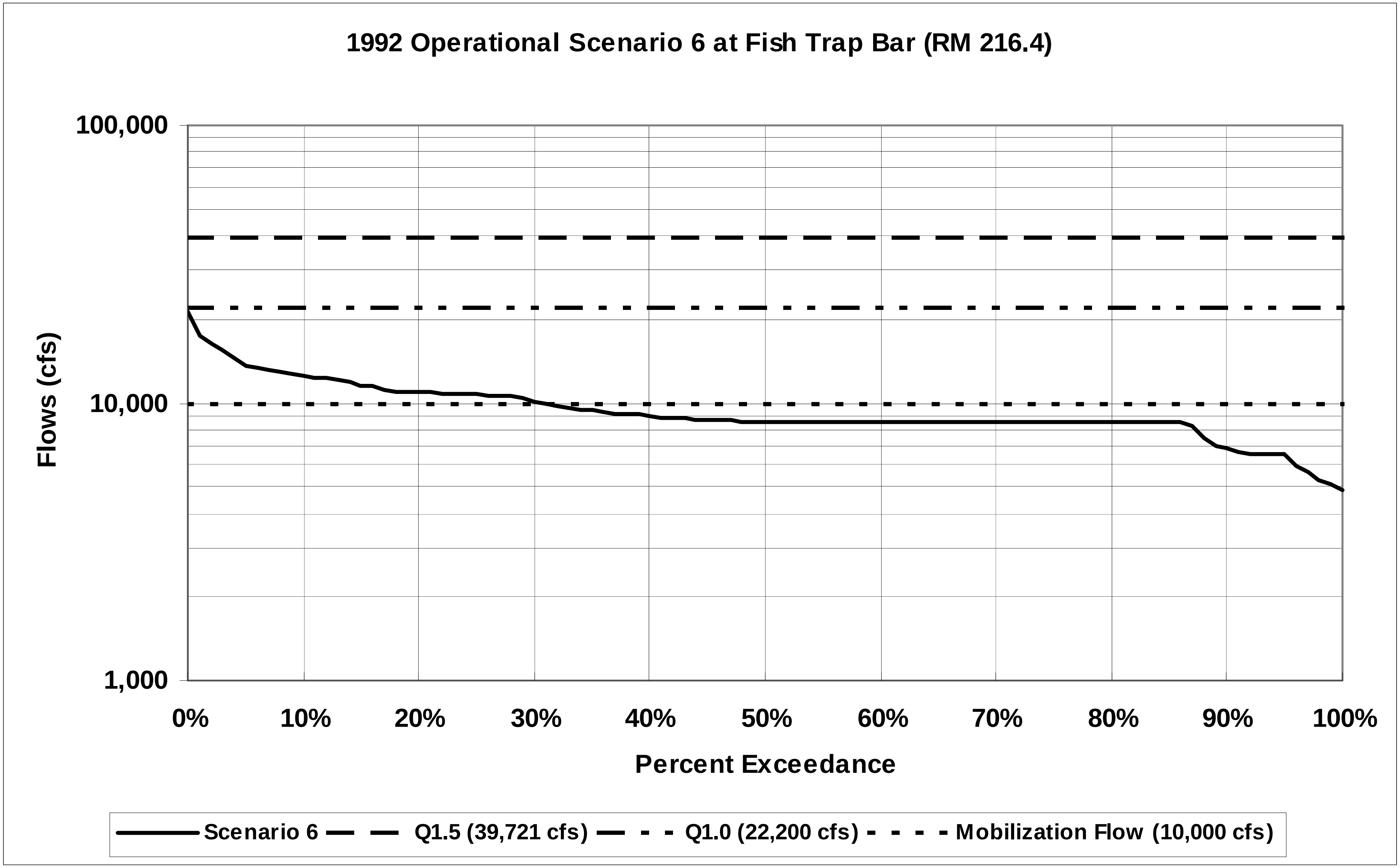


Figure 223. Flow-duration curve for 1992 Operational Scenario 6 at Fish Trap Bar (RM 216.4).

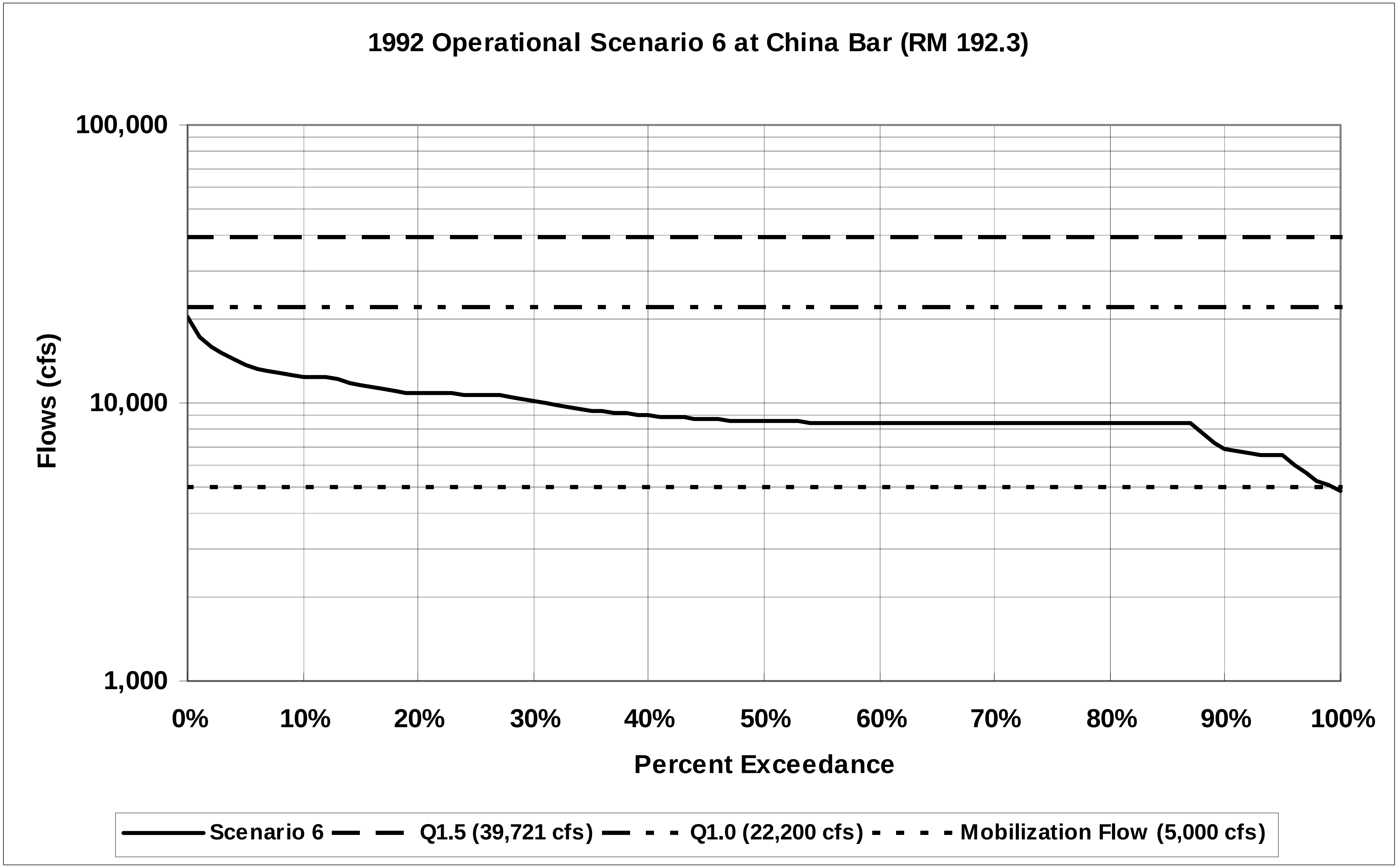


Figure 224. Flow-duration curve for 1992 Operational Scenario 6 at China Bar (RM 192.3).

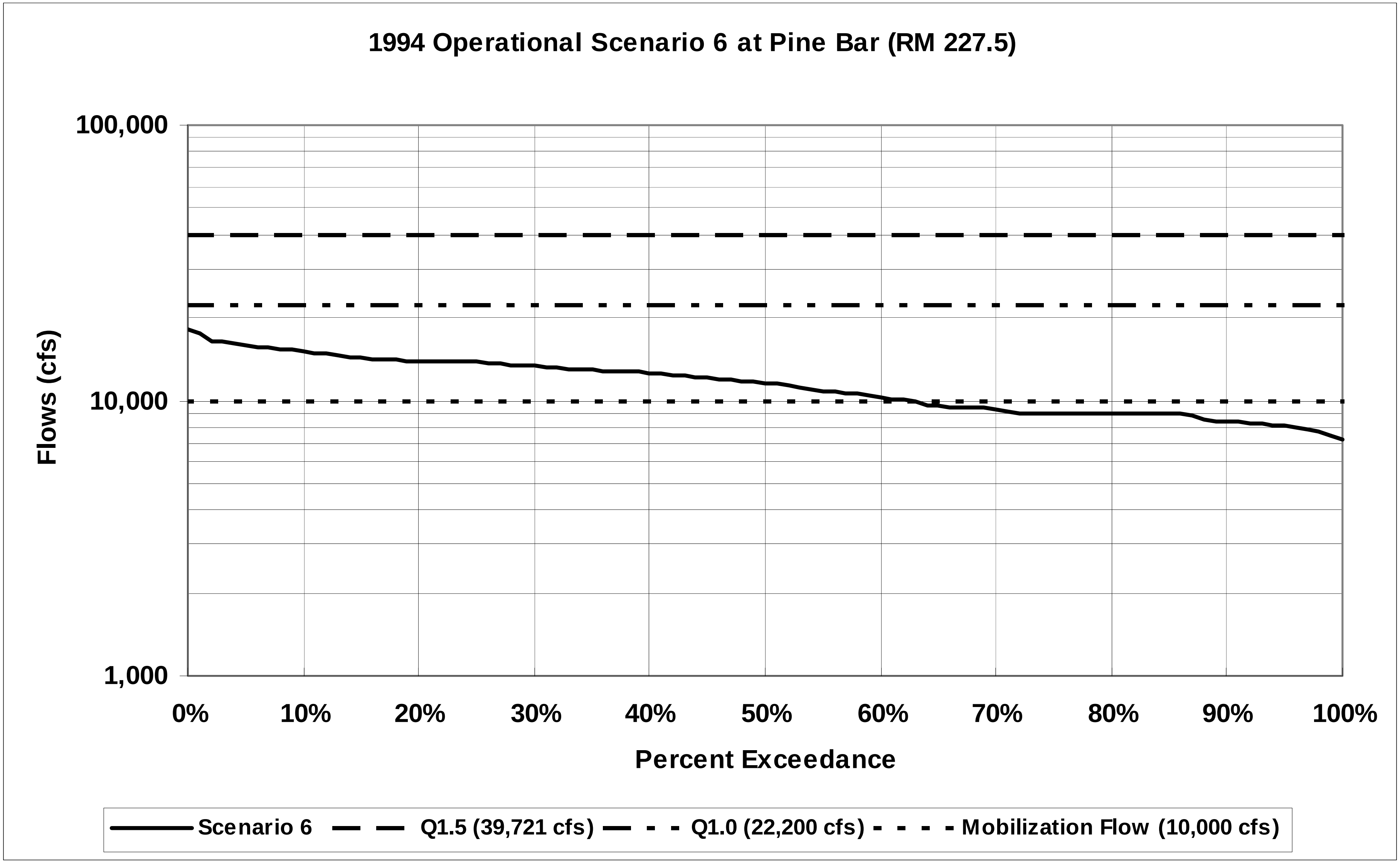


Figure 225. Flow-duration curve for 1994 Operational Scenario 6 at Pine Bar (RM 227.5).

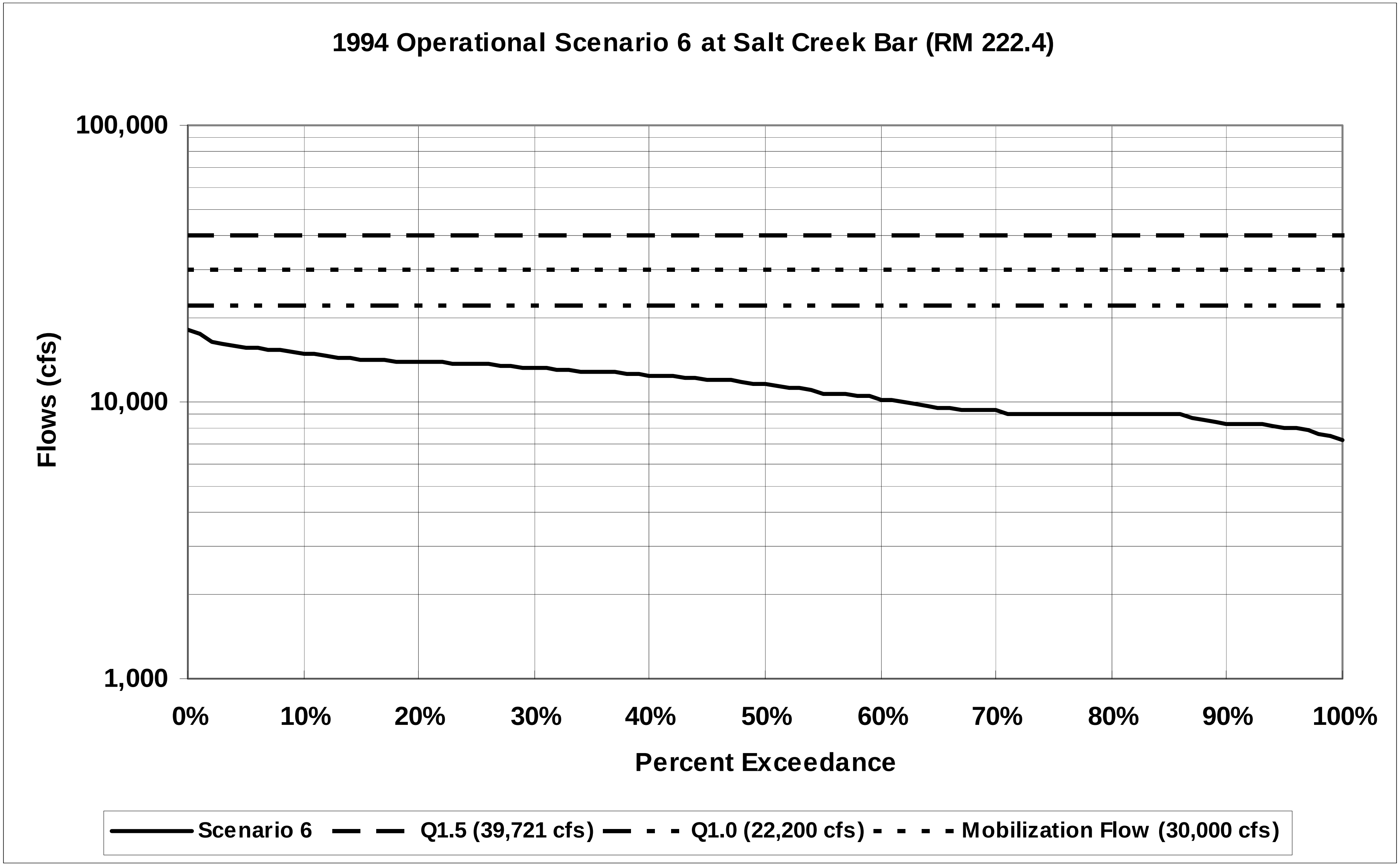


Figure 226. Flow-duration curve for 1994 Operational Scenario 6 at Salt Creek Bar (RM 222.4).

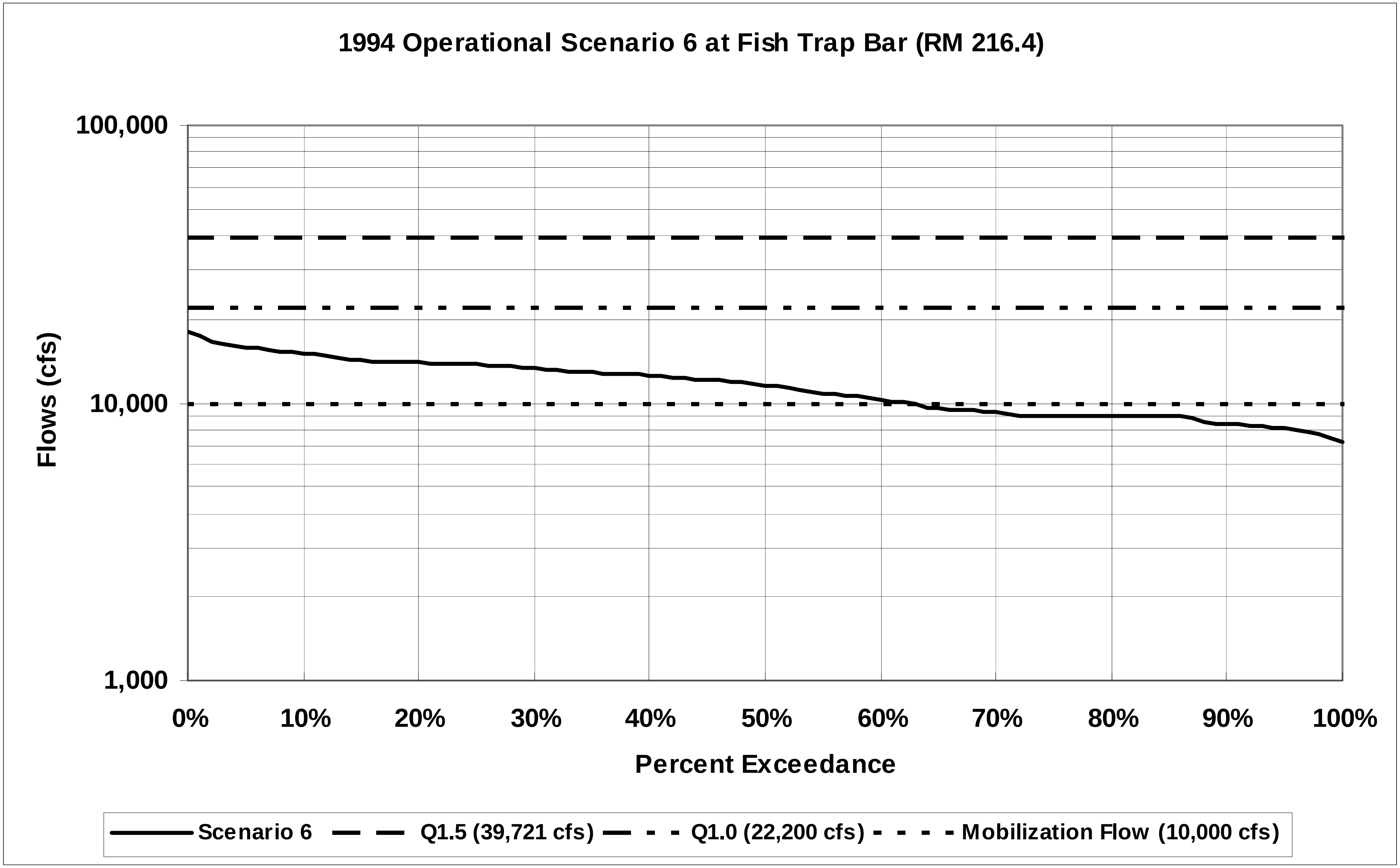


Figure 227. Flow-duration curve for 1994 Operational Scenario 6 at Fish Trap Bar (RM 216.4).

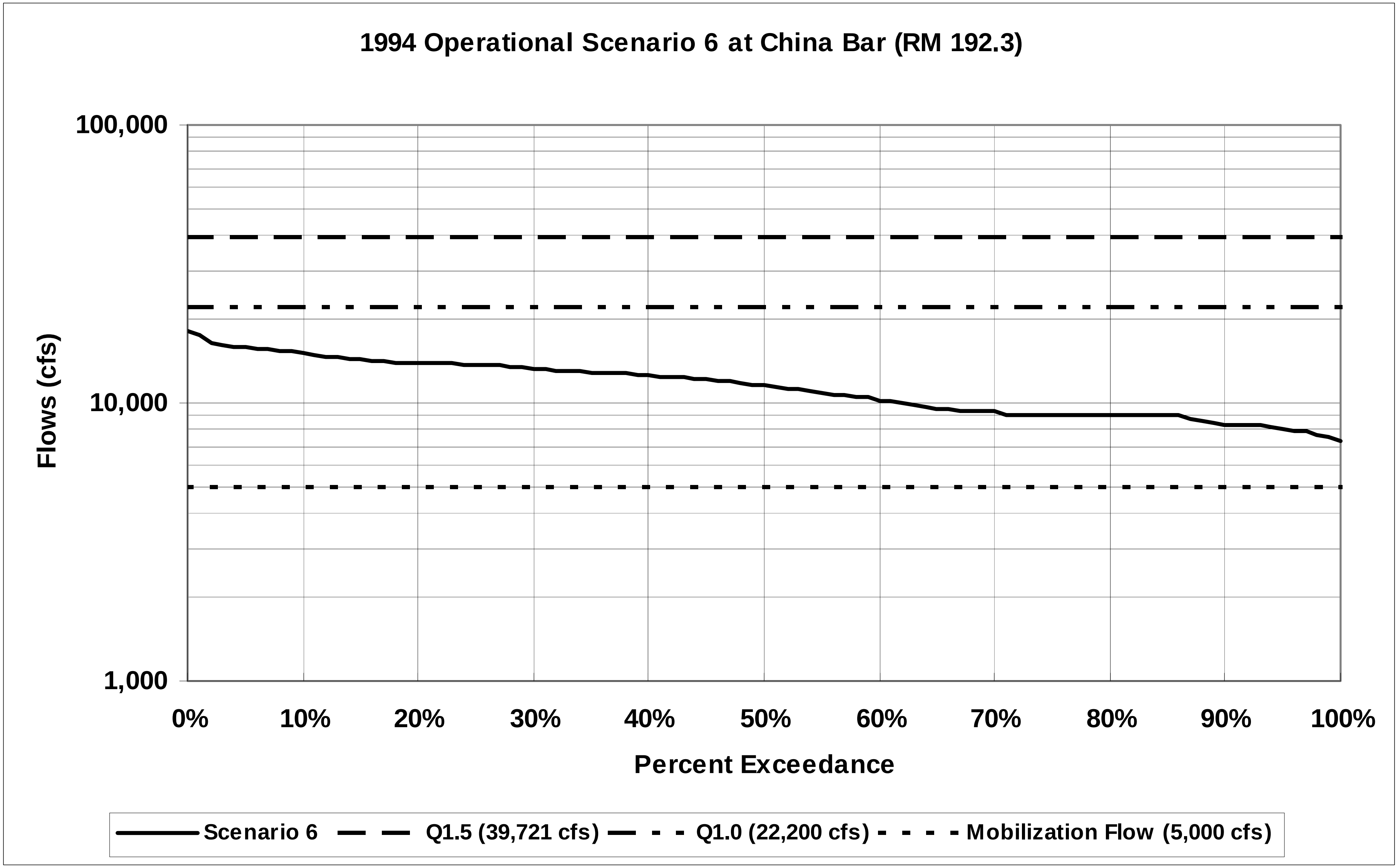


Figure 228. Flow-duration curve for 1994 Operational Scenario 6 at China Bar (RM 192.3).

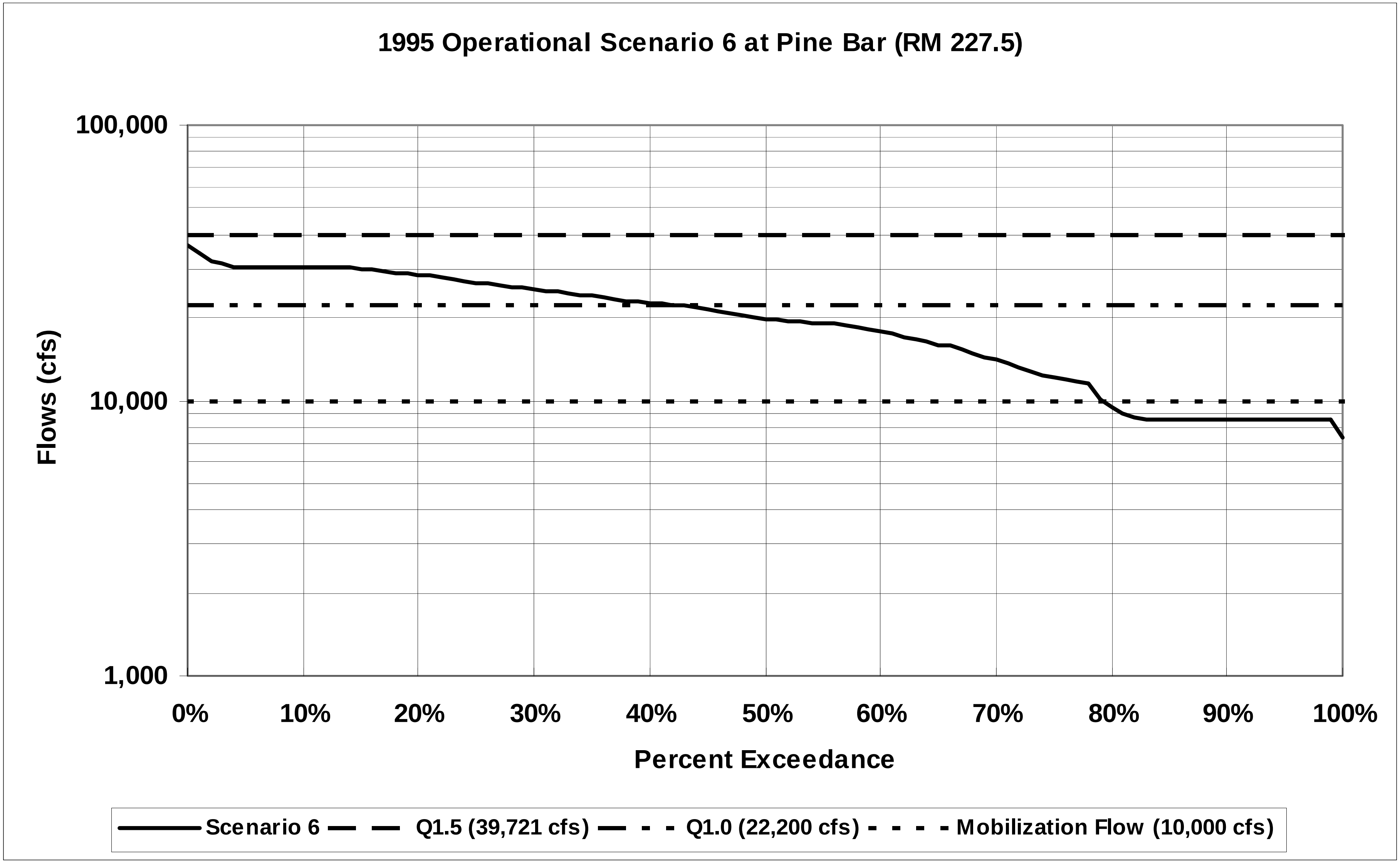


Figure 229. Flow-duration curve for 1995 Operational Scenario 6 at Pine Bar (RM 227.5).

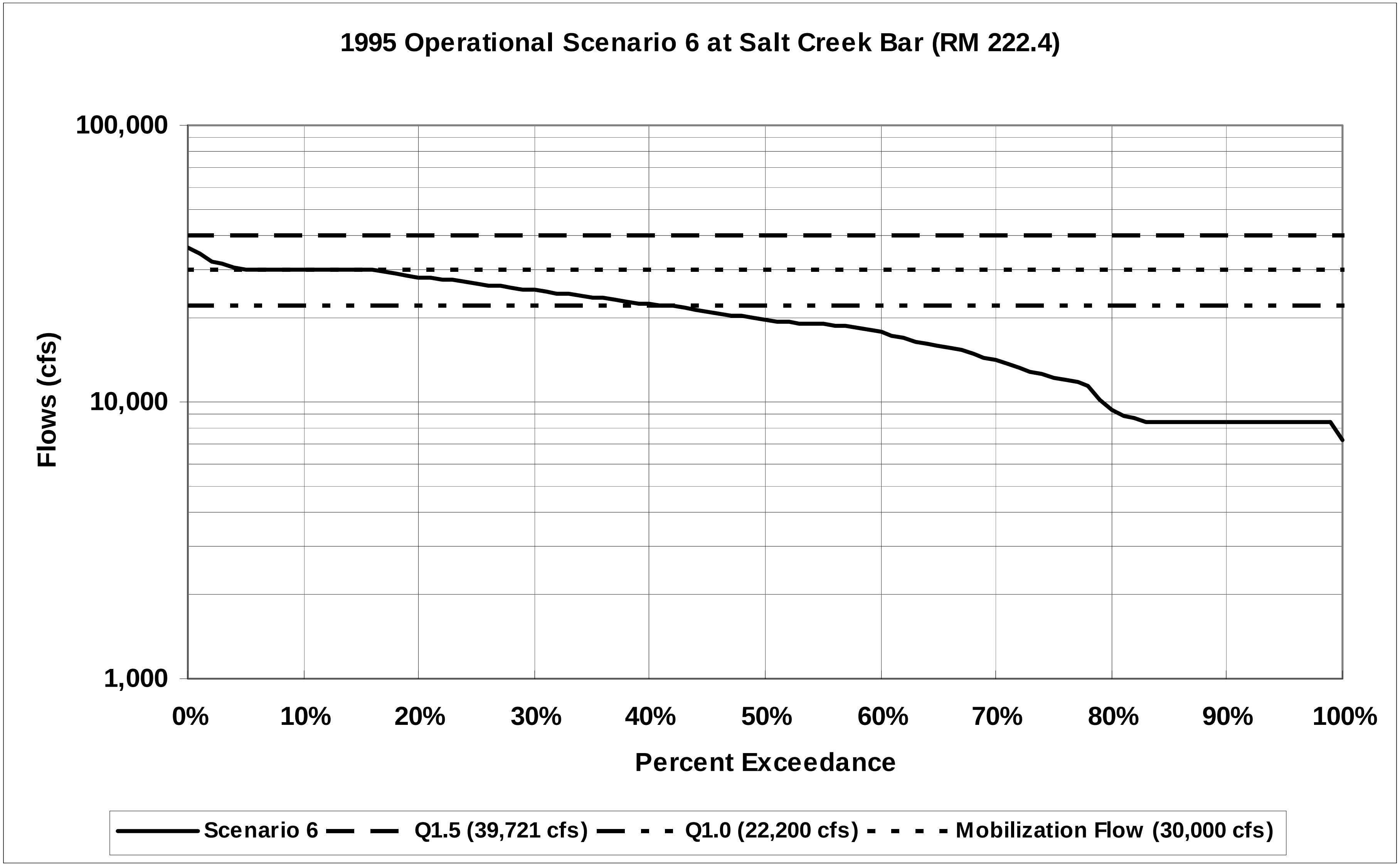


Figure 230. Flow-duration curve for 1995 Operational Scenario 6 at Salt Creek Bar (RM 222.4).

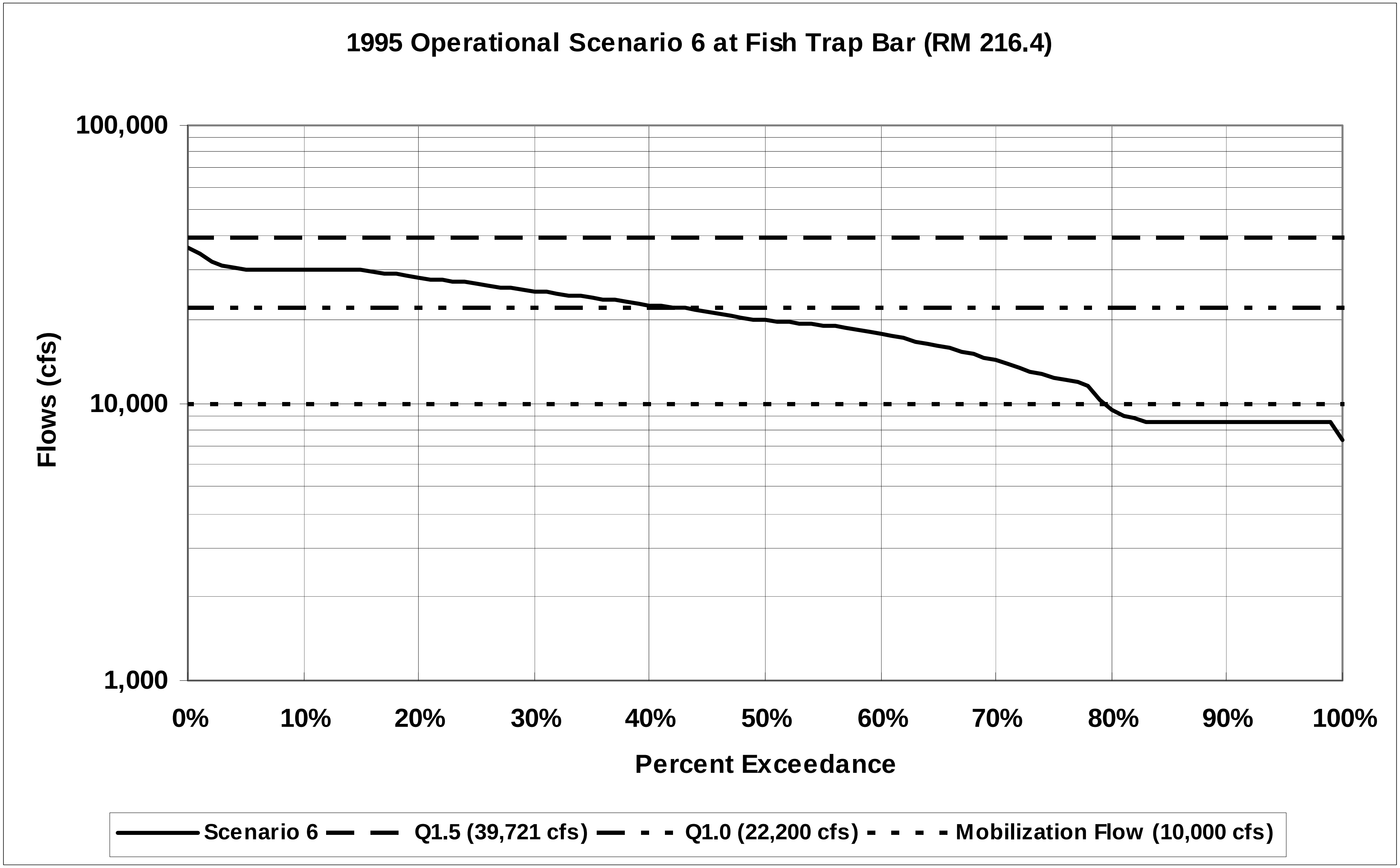


Figure 231. Flow-duration curve for 1995 Operational Scenario 6 at Fish Trap Bar (RM 216.4).

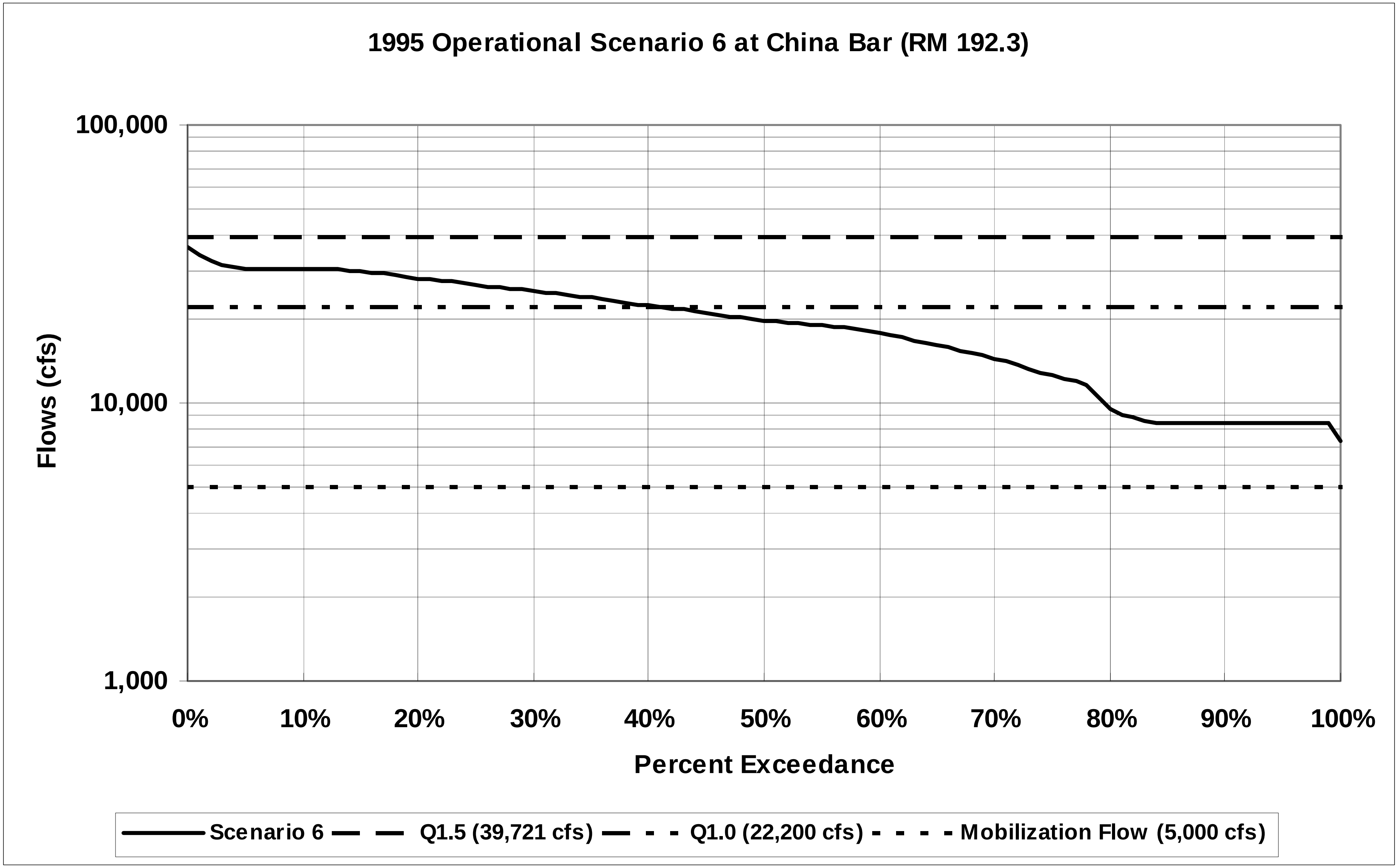


Figure 232. Flow-duration curve for 1995 Operational Scenario 6 at China Bar (RM 192.3).

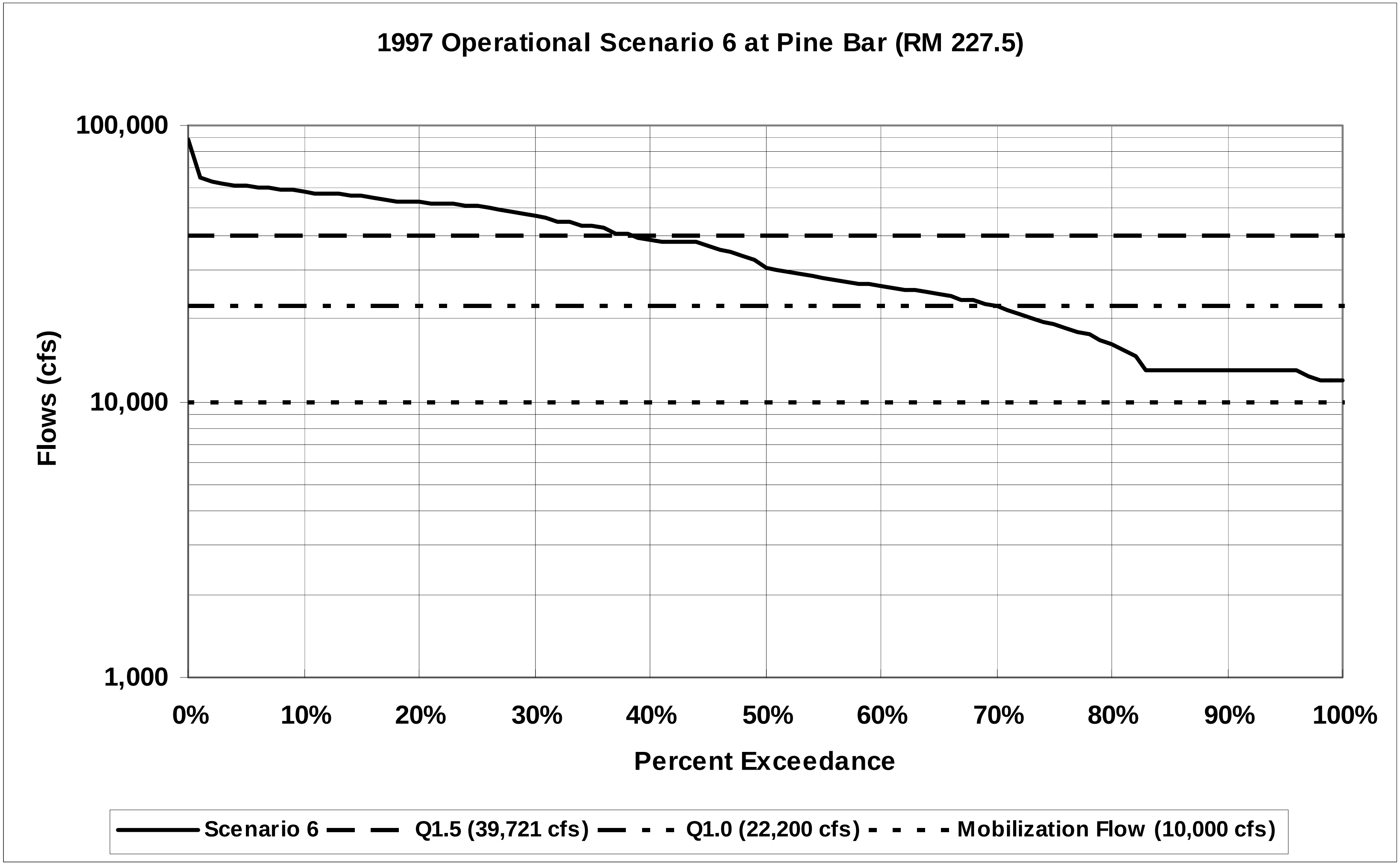


Figure 233. Flow-duration curve for 1997 Operational Scenario 6 at Pine Bar (RM 227.5).

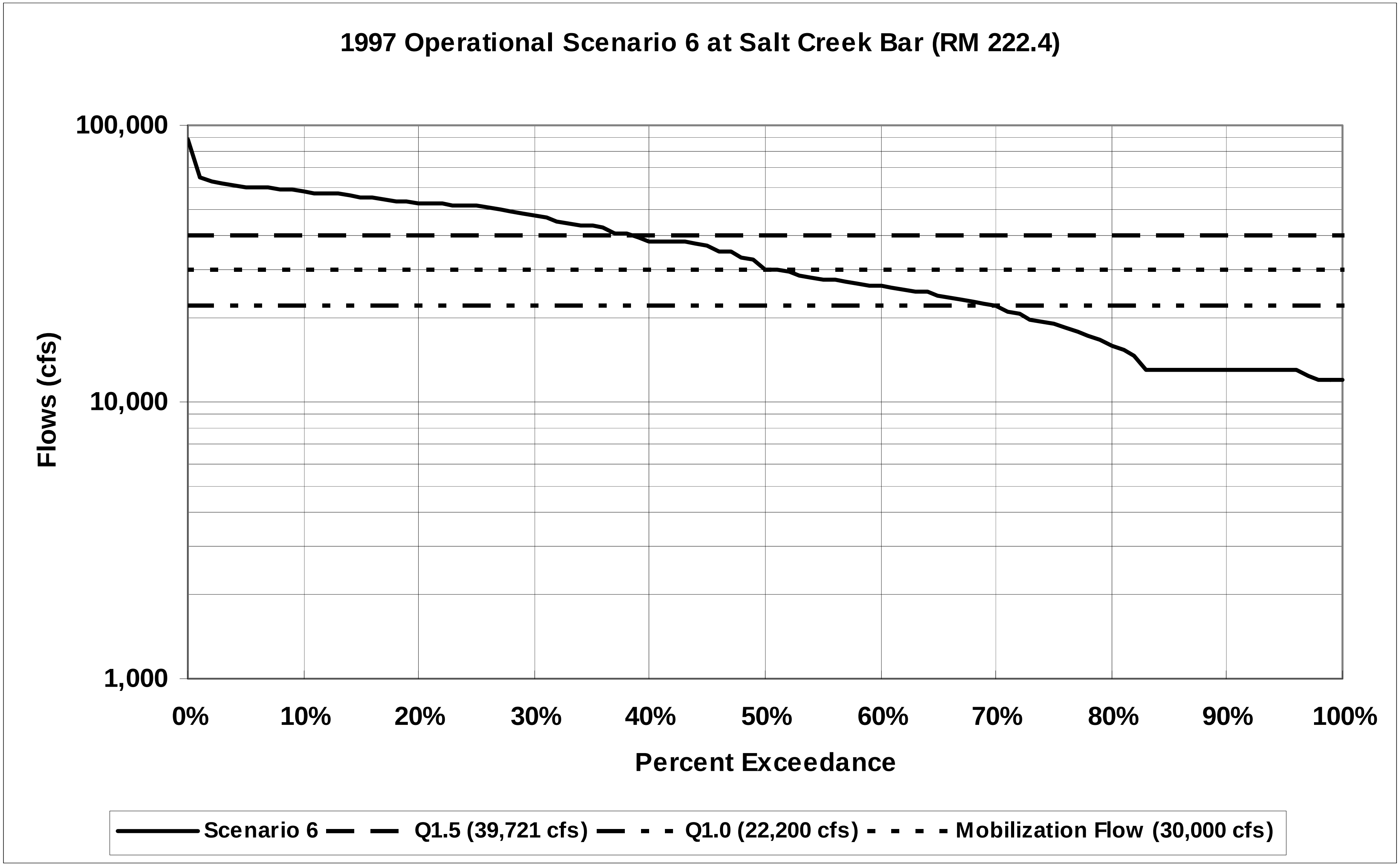


Figure 234. Flow-duration curve for 1997 Operational Scenario 6 at Salt Creek Bar (RM 222.4).

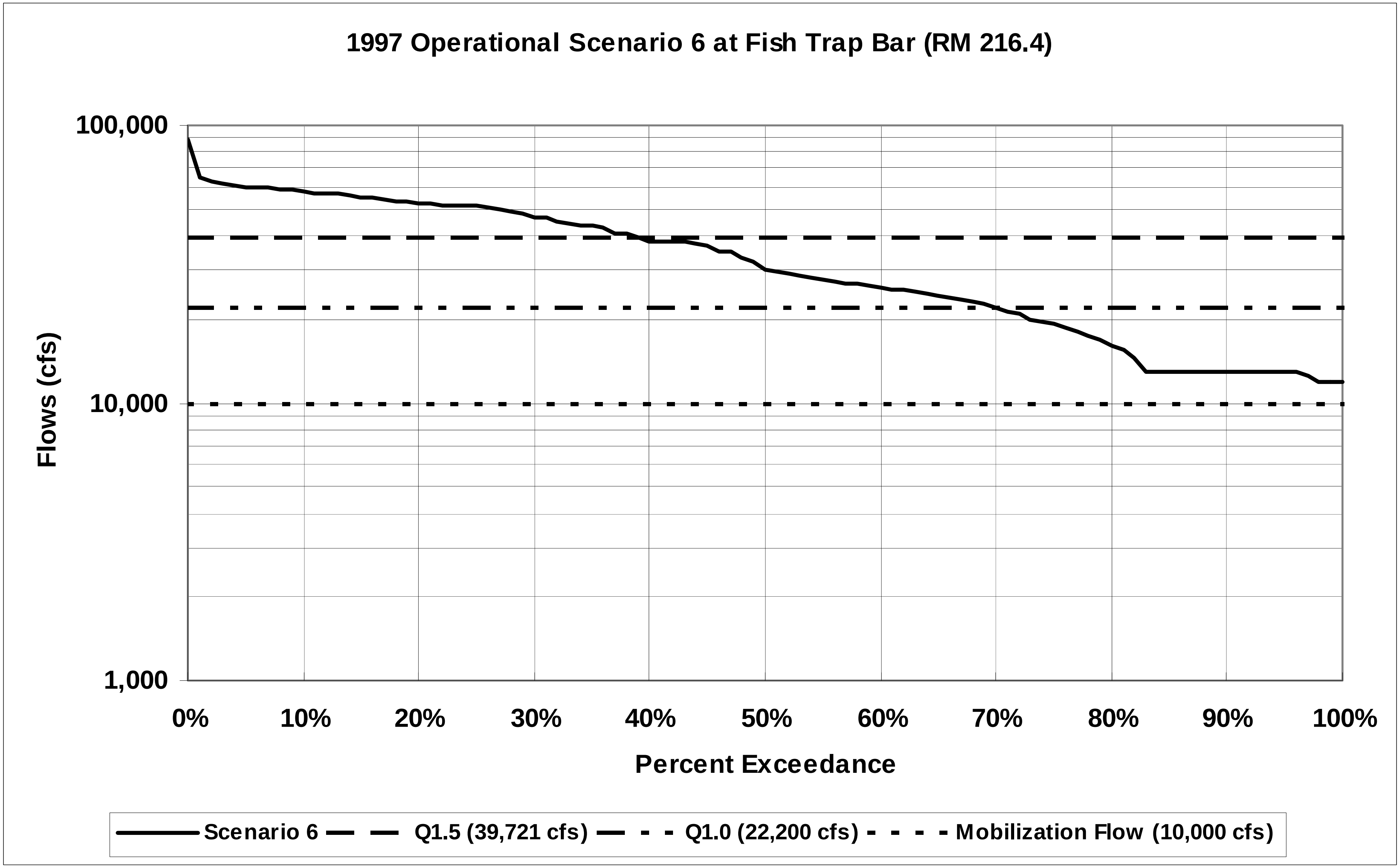


Figure 235. Flow-duration curve for 1997 Operational Scenario 6 at Fish Trap Bar (RM 216.4).

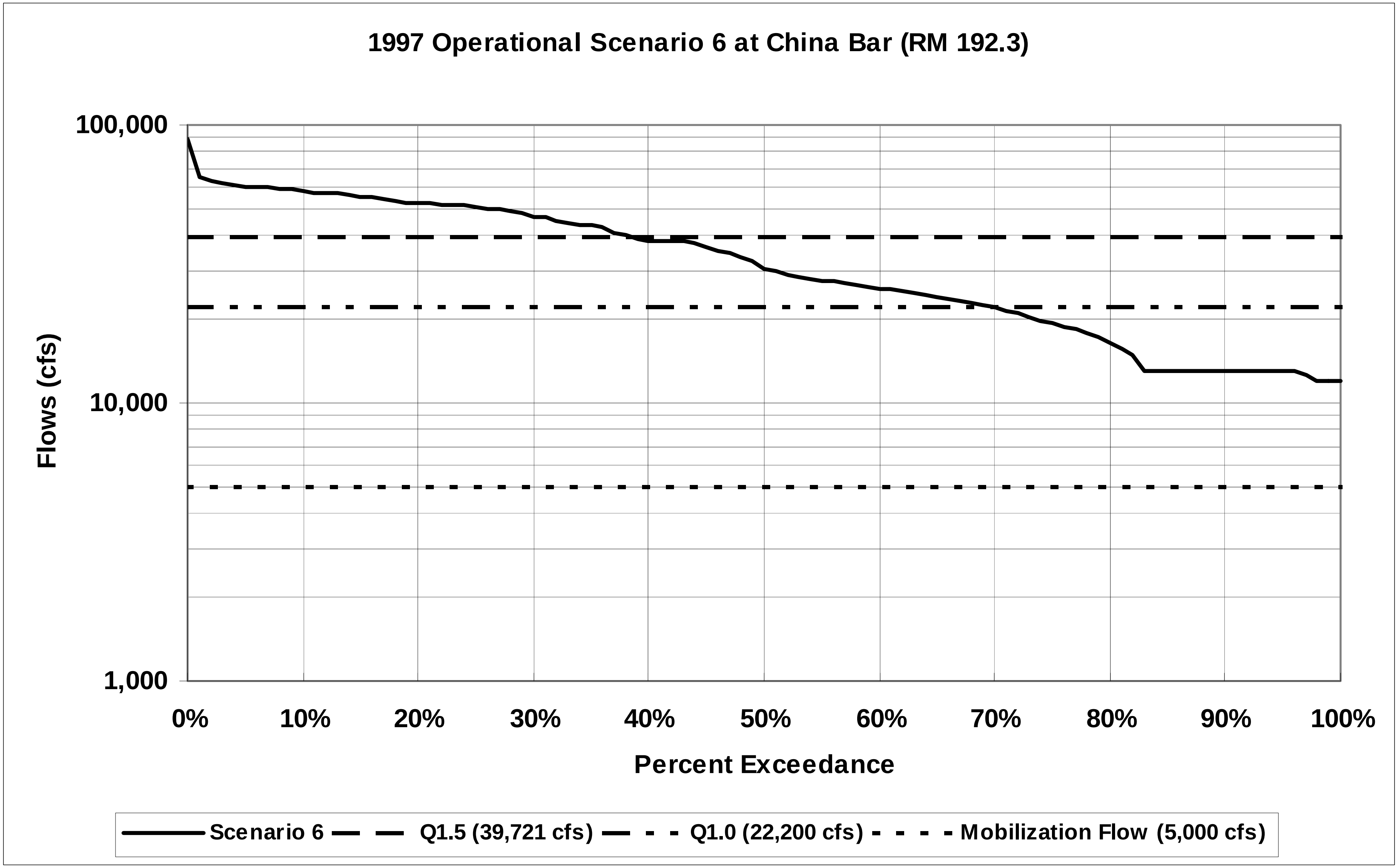


Figure 236. Flow-duration curve for 1997 Operational Scenario 6 at China Bar (RM 192.3).

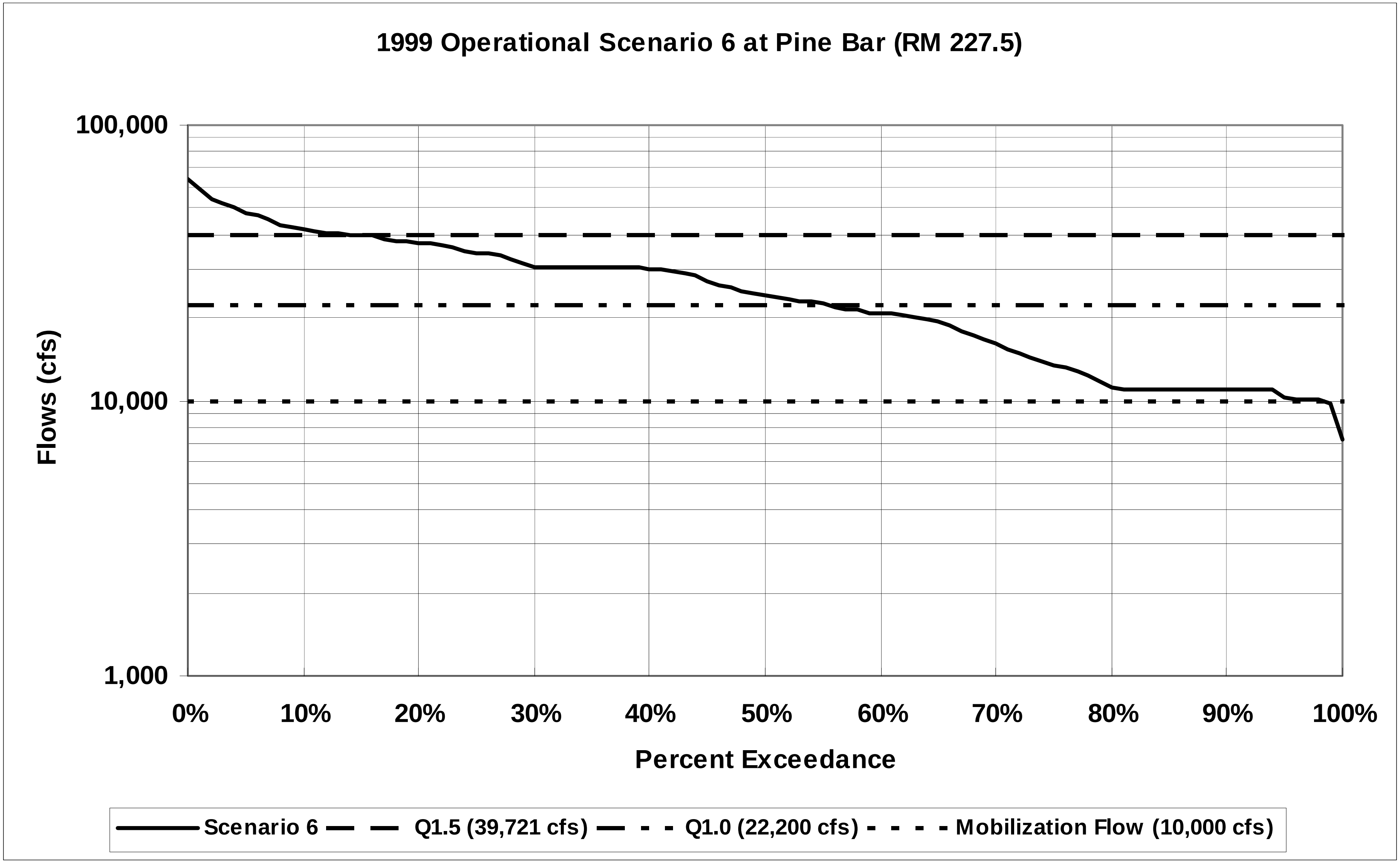


Figure 237. Flow-duration curve for 1999 Operational Scenario 6 at Pine Bar (RM 227.5).

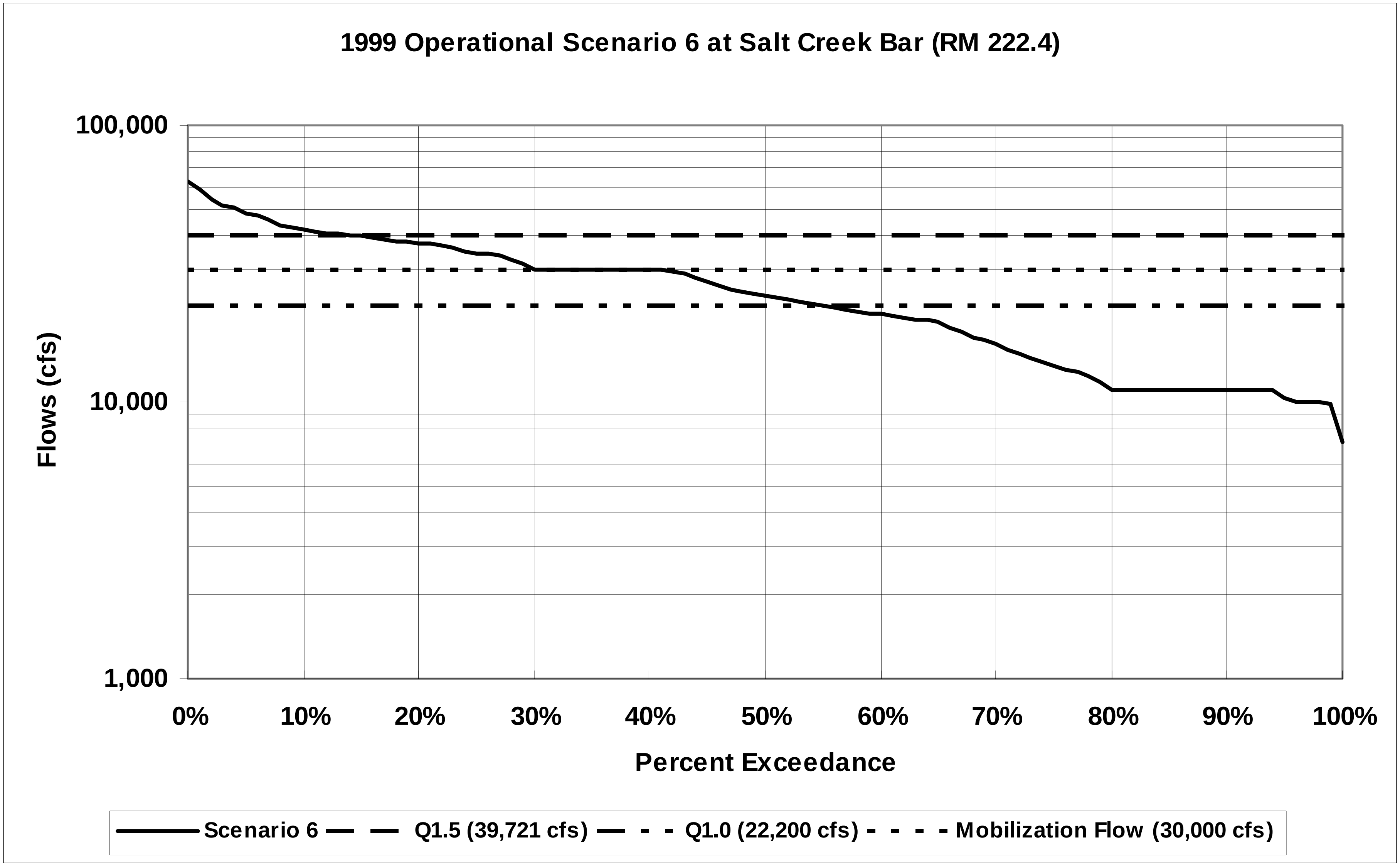


Figure 238. Flow-duration curve for 1999 Operational Scenario 6 at Salt Creek Bar (RM 222.4).

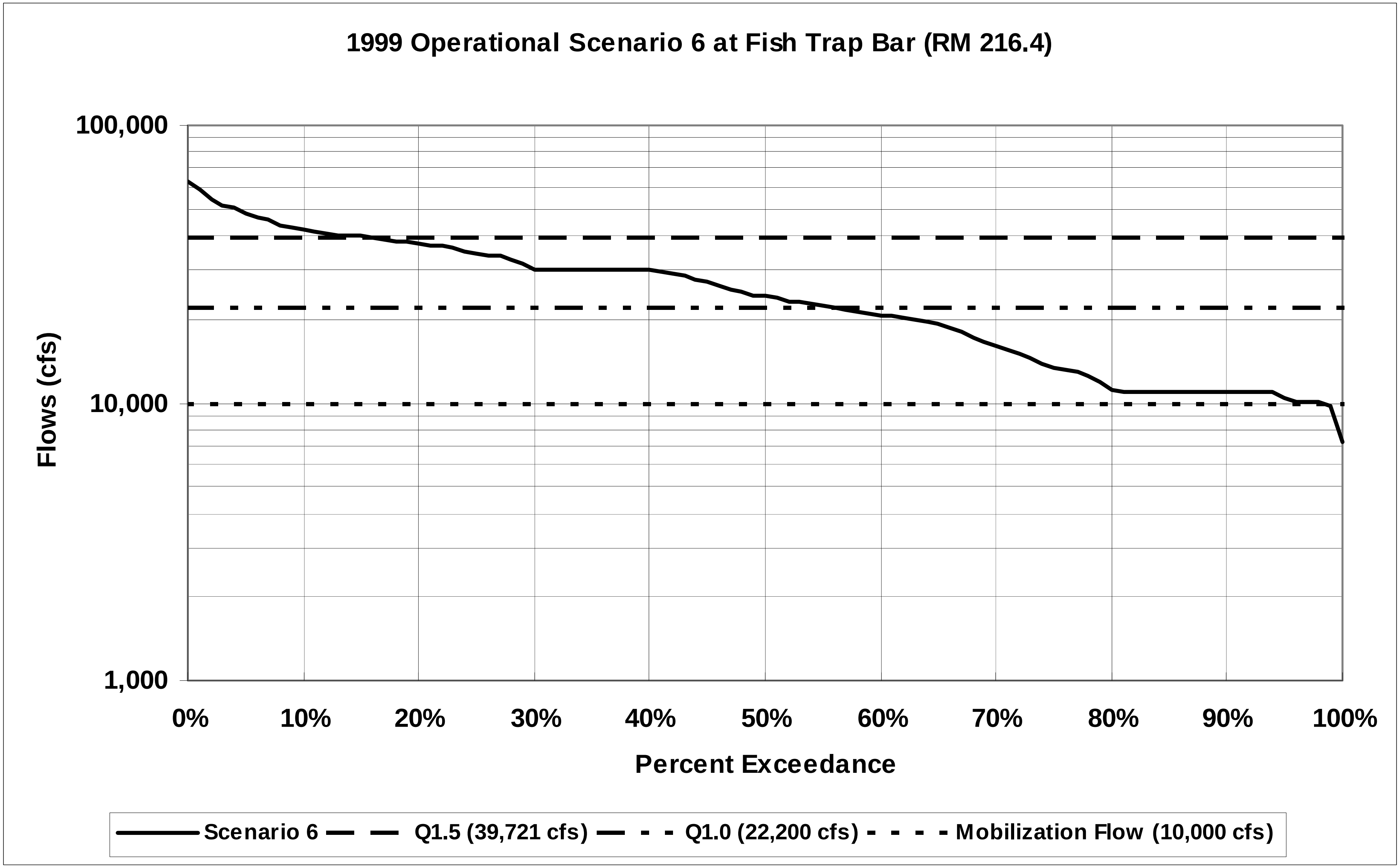


Figure 239. Flow-duration curve for 1999 Operational Scenario 6 at Fish Trap Bar (RM 216.4).

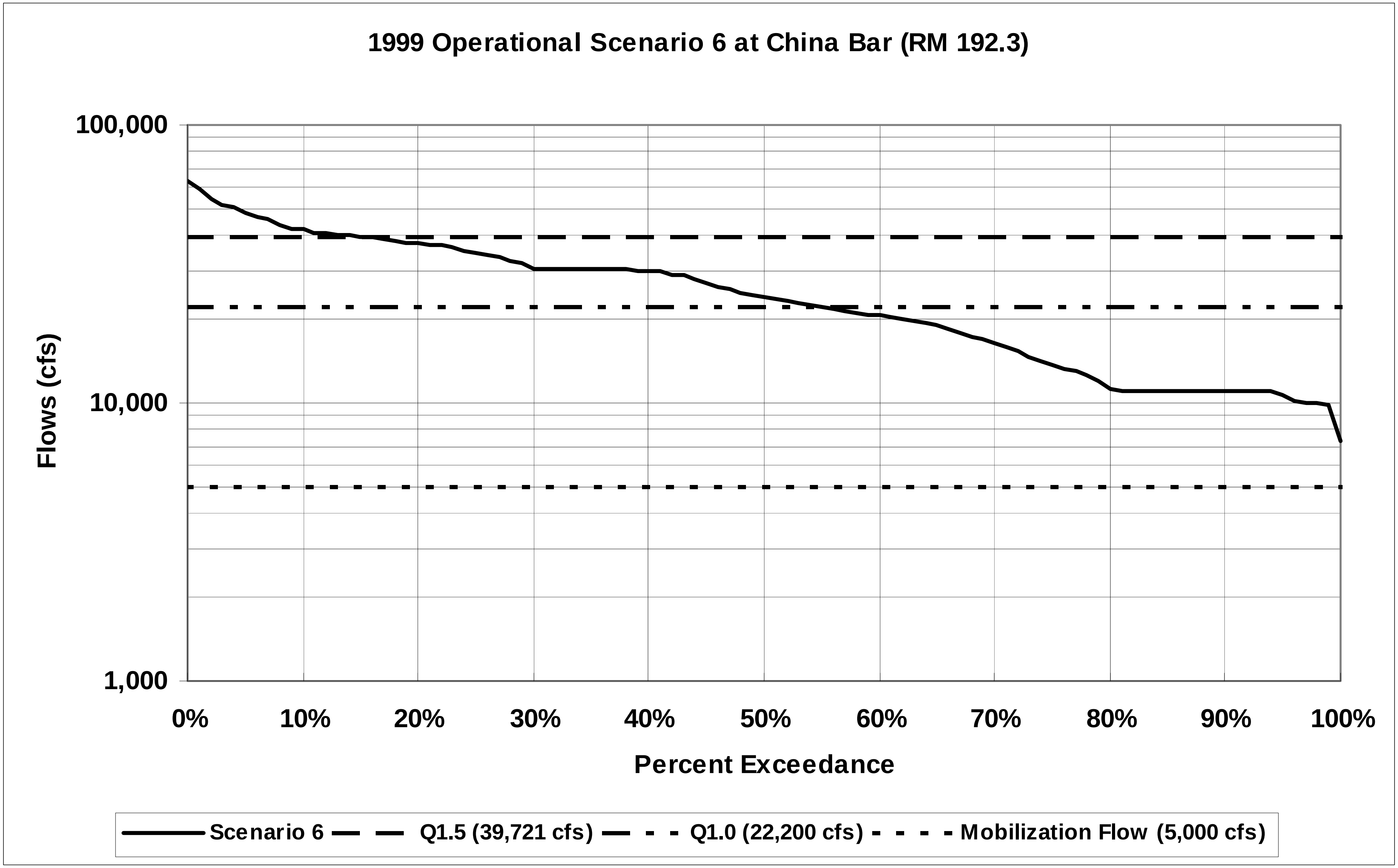


Figure 240. Flow-duration curve for 1999 Operational Scenario 6 at China Bar (RM 192.3).

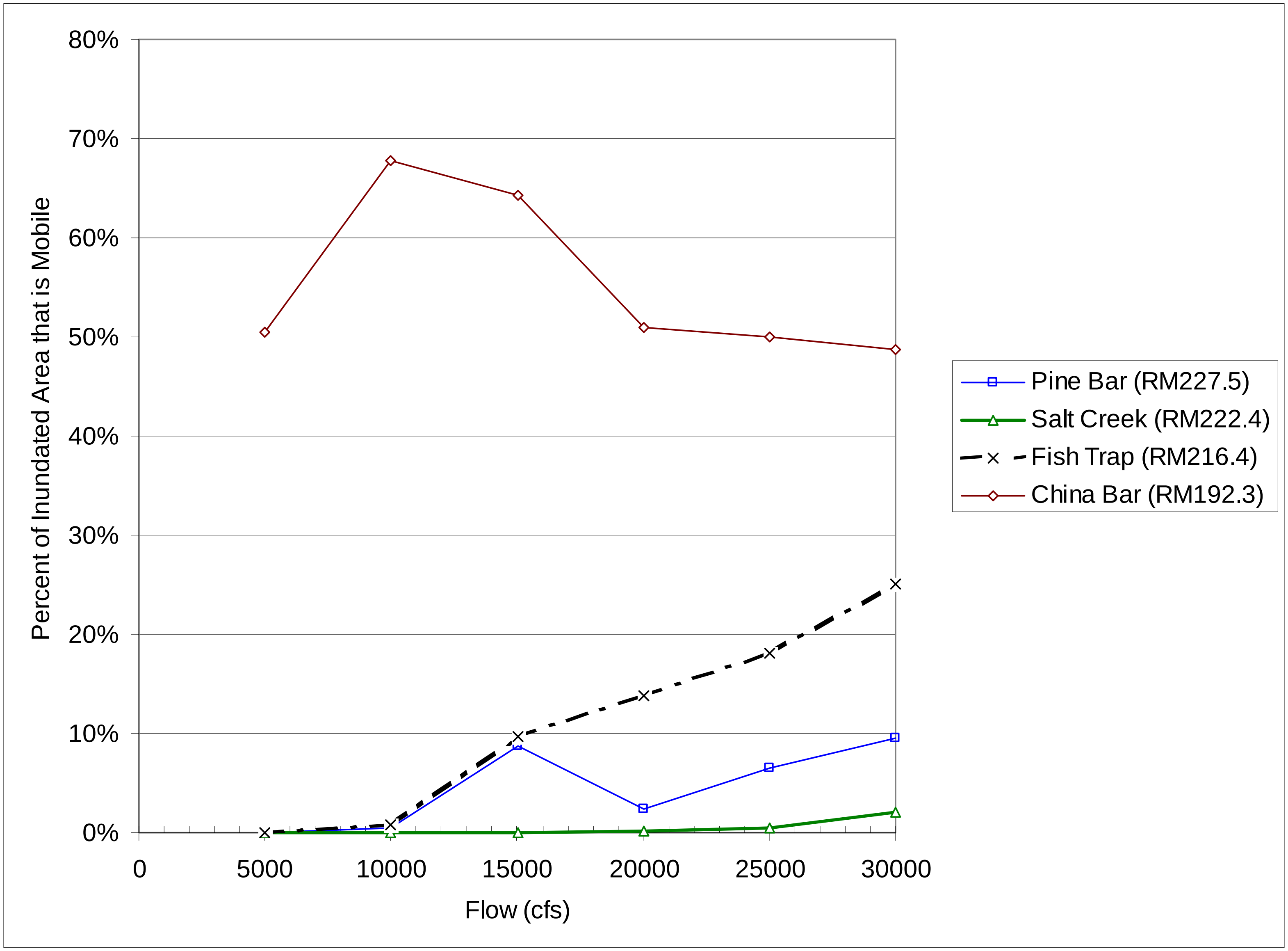
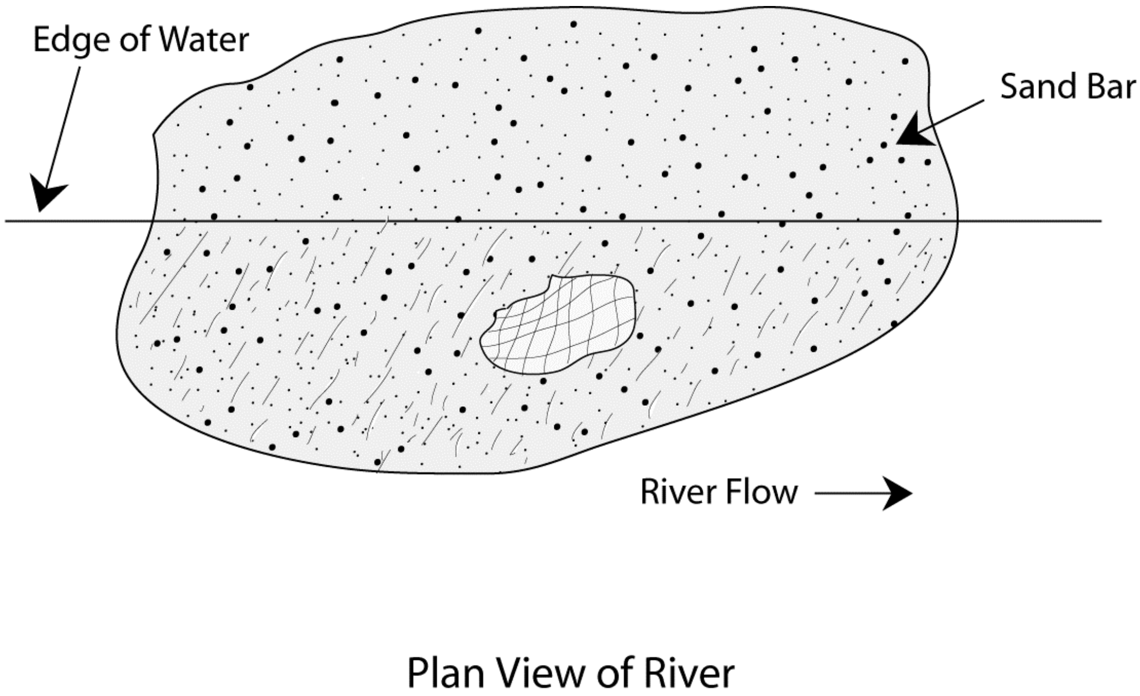


Figure 241. Percentage of Sandbar Area that is Mobile Relative to Inundated Area.



Calculations

Percent change in sand bar mobility: (Table "a")

$$\left(\frac{Ms - Mp}{Mp}\right) \times 100$$

Change in percentage of mobile sand bar area: (Table "b")

$$\left(\frac{Ms}{As}\right) \times 100 - \left(\frac{Mp}{Ap}\right) \times 100$$

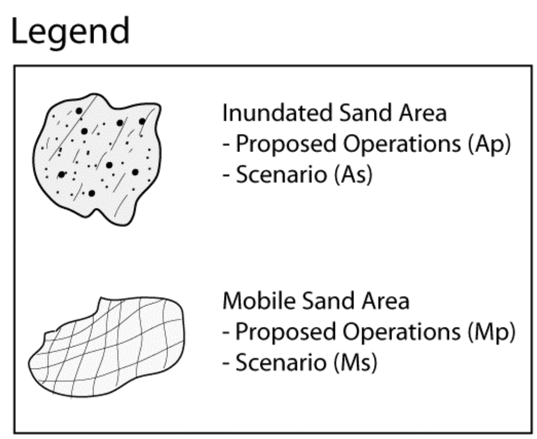


Figure 242. Schematic of Sandbar Inundated and Mobile Areas and Associated Calculations.

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
VALE DISTRICT
100 Oregon Street
Vale, Oregon 97918
http://www.or.blm.gov/Vale/

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January 18, 2005

Craig Jones
Idaho Power Company
PO Box 70
Boise ID 83707

Dear Mr. Jones;

Thank you for the opportunity to comment on your recently completed AIR, OP-1(f). BLM has an interest in the outcome of the Aquatic and Operational Resource issues for the Hells Canyon Complex because of the large quantity of BLM managed lands affected by the project. We offer the attached comments to your draft AIR Response OP-1(f) for your use in finalizing this important document.

We look forward to continued cooperation in working with the aquatic and operational issues in the relicensing of the Hells Canyon Complex. For more information please contact me at 541-523-1308. My mailing address is: BLM, 3165 10th St. Baker City OR 97814.

Sincerely,

Dorothy Mason

Dorothy Mason
OR/WA and ID BLM
Relicensing Team Lead

One Attachment

Cc: Alan Mitchnick, FERC
Hells Canyon Complex P-1971 Service List

BLM COMMENTS OP-1(f) Sediment Transport 1/18/05

The approaches adopted by Idaho Power to (1) determine flow duration curves and(2) determine and define flows resulting in incipient motion a the four sandbars(for the specified 1 mm grain size) are probably appropriate and reasonably accurate. Although this conclusion is tentative because of incomplete supporting documentation at this point. The calculations of duration and extent of sand mobilization for the Proposed Operation and specified scenarios do not provide an adequate basis for interpreting differences between scenarios on sandbar mobility. Nevertheless, a few changes in calculation procedures could provide much more robust determinations.

It is not clear that the conceptual basis of sandbar erosion implicitly assumed by FERC in this Additional Information Request is valid. First, by considering critical conditions for 1 mm sand size as indicative of the potential for sandbar erosion, the calculations probably result in substantial underestimation of the potential erosion, since the median particle size for all four considered sand bars is much smaller than 1 mm. Second, the critical tractive force approach, which was the logical analysis approach adopted by Idaho Power given the request to determine incipient motion conditions, may not be relevant to other important erosional mechanisms affecting sandbars, such as sapping (owing to annual flow ramping cycles) or wake erosion.

The studies conducted so far as part of the relicensing effort, have not shed sufficient light on the processes forming, maintaining, and eroding sandbars so that we can confidently and quantitatively predict their behavior on the basis of a single process model.

Major analysis deficiencies include the following:

1. Apparently only discharges to 30,000 cfs were considered in assessing sandbar mobility.

2. For discharges up to 30,000 cfs, areas of bar mobility were calculated using a step function approach with 5000 cfs intervals, thus leading to very imprecise estimates of bar mobility when integrated over the flow-duration curves, thus reducing the ability to make meaningful comparisons between scenarios that may have subtle but important differences.

3. Idaho Power's approach to summing, on an annual basis, areas subject to sand mobilization seems to inappropriately use an "offsetting" calculation procedure, whereby times of immobility are apparently subtracted from times of mobility on a one-for-one basis. It seems that the simplest and most straightforward approach to assessing the aerial "extent of sand mobilization" for each flow scenario is to combine a continuous "mobile area function" for each sand bar with each particular flow duration curve to give a cumulative area(on an annual basis) subject to 1 mm sand entrainment for each scenario. This result would be in units of m2*hrs similar to Idaho Power's computation procedure but would not involve explicit "offsetting." In this way, time periods for which there is no area mobilized would not add to the cumulative total of area*hours of mobile sand bar, as is appropriate

for determining the total aerial extent of plausible sand entrainment integrated over a year. The simplest and most informative presentation of results would be to show the annual totals for each bar for each flow scenario.

4. Bedload transport depends non-linearly on excess shear. By just considering sandbar areas above and below critical shear stress values, the analysis mutes the effects of larger flows for which sediment transport could be expected to be exponentially greater.

5. The analysis methods are sufficiently flawed—no apparent hydraulics data for flows greater than 30,000 cfs, the coarse "step function" for determining areas of mobility, and the unclear "offsetting" arithmetic treatment of mobile and immobile sand bar areas—that the overall results cannot be used to compare scenarios, especially for documenting the effects of different scenarios for specific flow years. Additionally, Idaho Power's presentation is much more complicated than need be. The most valid and clear comparison would be a simple table (and a single corresponding chart) that presents the correctly calculated total annual mobilized area for each scenario and water year. There is no clear reason why these values should be normalized to bar area or averaged among bars or by year. The normalization adopted by Idaho Power simply creates very small numbers without adding information, hence supporting obtuse statements such as "In none of the scenarios or years does the ratio of area mobilized over all four bars differ by more than 1 percent with respect to Proposed Operations." In reality, even with the flawed calculation procedures, the percent changes in absolute area are much greater, ranging up to 71%.

From:	Heidi Hull/VLFO/OR/BLM/DOI
Recipients:	cjones@idahopower.com, daubach@idahopower.com, Dorothy Mason/VLFO/OR/BLM/DOI@BLM,(bcc: Heidi Hull/VLFO/OR/BLM/DOI)
Subject:	OP-1(d) Sediment Transport - Resend
Date:	01:44:32 PM Today

Dear Mr. Jones and Ms. Aubach:

A FedEx letter will be delivered to your office tomorrow morning with the Bureau of Land Management's comments on OP-1(d) comments. The letter accompanying those comments state they are for OP-1(f) Aquatic and Operational Resources issues. Please accept this email as a correction for that document. The letter should state the comments are for OP-1(d) Sediment Transport.

The Bureau of Land Management's comments for OP-1(f) will follow on Friday, January 21st.

If you have any questions, please contact me at 541-523-1325 or Dorothy Mason at 541-523-1308.

Thank you,
Heidi Hull
Administrative Assistant

United States Department of Agriculture | Forest Service | Wallowa-Whitman National Forest | 1550 Dewey Ave.
P.O. Box 907
Baker City, OR 97814

File Code: 2770
Date: January 14, 2005

Mr. Craig Jones
Project Manager
Idaho Power Company
P.O. Box 70
Boise, ID 83707

Re: Additional Information Request (AIR) OP-1(d) (Sediment Transport)

Dear Mr. Jones:

The Federal Energy Regulatory Commission (FERC) directed Idaho Power Company (IPC) to allow identified agencies and Native American Tribes a 30-day review and comment period of IPC's response to FERC's AIR OP-1(d) (Sediment Transport) prior to the final submission to FERC. The USDA Forest Service (FS) appreciates the opportunity to comment on IPC's AIR OP-1(d) report.

The FS comments in Attachment I address the methods and presentation of the analysis conducted in the report. The report is difficult to review thoroughly because the details and data of the underlying analyses are not available. Apparently, they are to be included in report AIR S-1, which will not be available until February. Consequently, comments will be primarily directed at the overall approach, described in pages 1-6, and presentation of results, summarized in pages 6-12 as well as in 23 tables and 242 figures.

The comments in Attachment I also describe several shortcomings with the assumptions, calculations, and presentation of the analysis.

- The definition of "medium sand" as 1 mm should have been clarified, as medium sand is usually classified as 0.25 to 0.5 mm.
- The analysis of mobilization needs to be improved as outlined in the attachment.
- A decrease in mobilization between scenarios should not be assumed to infer deposition.

We look forward to participating in additional reviews of this issue on Hells Canyon Complex project. If you have any questions regarding this response, please contact Lynn Roehm, Wallowa-Whitman National Forest Hydropower Coordinator, at (541) 523-1316 or Margaret Beilharz, RHAT Hydrologist, at (541) 822-7228.

Sincerely,

/s/ Steven A. Ellis
STEVEN A. ELLIS
Forest Supervisor

Enclosure

cc: FERC – Alan Mitchnick, BLM – Dorothy Mason, NOAA – Ritchie Graves, USFWS – Jim Esch, IDFG – Scott Grunder, IDEQ – Cyndi Grafe, ODFW – Colleen Fagan, ODEQ – Paul Devito, CRITFC – Jennifer Forenza, Nez Perce Tribe – Greg Haller

ATTACHMENT I

USDA Forest Service Response to IPC's AIR OP-1(d) Report

OP-1(d) – Sediment Transport

These comments address the methods and presentation of the analysis conducted for the report "Responses to FERC Additional Information Request OP-1; (d) Sediment Transport Draft Report" of December 2004, by Shaun K. Parkinson, Kelvin Anderson, and Jeff Conner. The report is difficult to review thoroughly because the details and data of the underlying analyses are not available. Apparently they are to be included in report AIR S-1, which will not apparently be available until February. Consequently, comments will be primarily directed at the overall approach, described in pages 1-6, and presentation of results, summarized in pages 6-12 as well as in 23 tables and 242 figures.

The Additional Information Request OP-1 Sediment Transport Operation Scenario for the Hells Canyon Project by the Federal Energy Regulatory Commission (FERC) specifies certain analyses, including (1) development of flow-duration curves at four sand bar locations for several proposed and specified operation scenarios, (2) determination of flows at each sand bar for which there is incipient motion of 1-mm sand, and (3) an evaluation of potential effects of proposed operations on the four sand bars if "the duration or extent of sand mobilization under proposed operations varies significantly from any of the operation scenarios or sub-scenarios."

IPC has conducted analyses addressing each aspect of this additional information request, although as mentioned above, the details of the analyses have not been provided so it is difficult to check their methods and results. These comments address each aspect of the analysis, but will emphasize sand bar sediment entrainment since this is apparently the motivating concern for the additional study.

Site Descriptions

No description of the boundaries of the site is shown. The particle size distribution of the sand deposits in these areas should be sampled for accurate prediction of mobilization of the specific beach material. At least, the particle size distributions described in FLA Appendix E.1-2. Figure 21 should be used.

Flow duration curves

As requested, IPC determined flow duration relations for each of the four sand bars for each of the 60 time series (55 representing FERC-specified scenarios, and 5 represent proposed operations). These are presented in Figures 1 through 240. The flow duration curves were constructed using hourly time steps, which is appropriate for the subsequent analysis of sand bar inundation and sediment entrainment given the flow management assumed in the various scenarios. While flow duration curves describe the frequency of flows of particular magnitudes, they do not describe the frequency of wetting and drying for each scenario. This information, related to the frequency and extent of inundation from cycling of operations would assist in understanding how frequently mobilization is initiated, and may assist in understanding other erosive mechanisms.

IPC was also asked to plot lines representing the "the peak flows that have a 1.0 and 1.5 year average recurrence interval." It is not clear what motivated this request since these values are not used in any subsequent analysis, but IPC did calculate a 1.5 year recurrence interval (67% annual peak exceedance probability) peak discharge of 39,721 cubic feet per second (cfs) using standard and appropriate methods. A 1.0 year recurrence interval flow cannot be statistically defined (it is the flow with 100% chance of being exceeded in a given year), so IPC, as a reasonable alternative, plotted the minimum annual peak flow for the period of record (22,200 cfs). By definition the annual peak flow is the level which all peak flows exceed. The USGS Statistics (available on their website) verify that 22,200 cfs was the lowest peak since 1966. The range of peak flows has been between 22,200 and 103,000 cfs. More importantly perhaps is to recognize that the daily mean flow for months of January through June have been above 20,000 cfs based on the past 39 year record (USGS data), and the median daily flow (50% exceedence) under proposed operations is 15,000 cfs (FLA Figure B-4).

Incipient motion of sand

FERC requested determination of the flows at each of the four sand bars for "which incipient motion of medium sand (1 mm) occurs…" The 1 mm particle size criteria specified by FERC is curious since the median sand size for the sand bars is much smaller, ranging from <0.3 to 0.6 mm (IPC Technical Report E.1-1 Figure F-21). Consequently, the flows calculated for incipient motion in this analysis will be much greater than those which will actually entrain sandbar sediment. In their Final License Application, (Appendix E.1-1 Table 15) IPC identified "medium sand" as 0.25 to 0.5 mm, and Very Coarse Sand as 1 to 2 mm. We believe that IPC should have clarified the discrepancy with FERC before proceeding with the modeling. The analysis should be conducted on the median size of the material on each bar, either based on site-specific samples. Samples of current conditions would provide the most accurate information, however particle size distributions, as presented in the FLA Technical Report E.1-1 would be an improvement. FERC needs to check on the consistency of sizes being modeled for the AIR S-1 Report.

FERC does not specify what constitutes "incipient motion," which can have wide meaning (Buffington and Montgomery, 1997). For this analysis IPC defined incipient motion for a particular sand bar to be when more than 1% of the inundated area of the bar had applied shear stresses greater than "the calculated critical shear stress for a 1 mm sized particle." IPC calculated applied and critical shear stress values for each sand bar (on a cell-by-cell basis) and for each scenario with a two-dimensional hydraulic model (MIKE 11). These threshold flows are approximately shown on each of figures 1-240, although they have been inexplicably rounded to the nearest 5000 cfs. Given the language of FERC's information request, this (aside from the rounding) is probably a reasonable approach to determine flows associated with incipient transport at each bar, although it is not possible to evaluate their results without information on the critical shear stress value they employed, the computational cell size, and maps of the sand bars showing the extent of sand areas considered in the analysis. Perhaps these details are forthcoming in the AIR S-1 report.

Analysis of sand mobilization

This component of the analysis addresses potential effects of various flow scenarios on entrainment of sandbar sediment, addressing whether or not "the duration or extent of sand mobilization under proposed operations varies significantly from any of the operation scenarios or sub-scenarios." IPC's approach to this was basically an arithmetic accounting of the areas experiencing critical transport conditions (as calculated on a cell-by-cell basis) for 1 mm diameter sand for each flow scenario (presumably represented by the 240 flow duration curves of figures 1-240). Here, IPC's analysis approach likely results in imprecise results that significantly underestimate sandbar sediment entrainment, especially for flow scenarios that have higher percentages of large flows. The following step-by-step assessment of IPC's approach will elaborate:

1. *Areas of mobility were determined by simulating discharges of 5,000 cfs to 30,000 cfs at 5,000 cfs increments using the 2-D model for each sites. Mobility of 1.0 mm sand was evaluated at each of*

these six flows.

Presumably mobility at each cell (of unspecified dimensions) was determined for each flow. An issue here is that apparently only discharges to 30,000 cfs were considered. Many of the flow scenarios have substantial periods of time where flow exceeds 30,000 cfs—some with flows as great as 90,000 cfs. It is not clear how the areas of potential sediment transport for flows greater than 30,000 cfs were determined. Speculating, two likely possibilities are that (1) those periods where flow was greater than 30,000 cfs were not considered in the analysis, or (2) if they were, only the areas with critical shear stresses sufficient to mobilize 1 mm sand at the 30,000 cfs discharge were considered mobile no matter by how much the actual discharge exceeded 30,000 cfs. Both of these treatments would lead to substantial underestimates of the area subject to sediment entrainment. Because the operational scenarios change the magnitude and frequency of flows above 30,000 cfs by changing storage patterns, the effect of the full range of flows needs to be shown. The modeling should be conducted for flows that inundate any sand deposits at the site.

2. *Each simulated discharge was assumed to represent mobility for a range of flows from half-way to the next lower flow to halfway to the next higher flow…*

This "step-function" approach, with 5000 cfs intervals, likely minimize differences in calculated sand entrainment areas between scenarios that might have subtle differences in operational strategies. It also seems completely unnecessary, since it would have been relatively straightforward to determine continuous empirical functions relating area mobilized to discharge for each sandbar from the data summarized in Table 1, and then apply those relations to the proposed operations. Without detailed comparisons between of the scenarios, it is difficult predict the effects of the "step function" approach in terms of over- or underestimating areas of entrainment for particular scenarios. But this approach certainly reduces the resolution of the analyses. For example, for 1992 proposed operations, more than 80% of the flow duration is between 2500 and 12,500 cfs, which under IPC's approach would be binned into only two calculated values for area where critical transport conditions are exceeded. Likewise for 1994, more than 50% of the flow would be similarly discretized into only two values. For 1995, about 60% of the duration would be discretized into only three values by the calculations for 10,000, 15,000, and 20,000 cfs. For the each of the high flow years of 1997 and 1999, about 40% of the duration would be binned into the 10,000, 15,000, and 20,000 cfs categories. Such coarse characterization of the flow conditions by application of this step function makes meaningless the comparisons between flow scenarios for each given year summarized in Tables 1a through 12b (which show relatively small differences compared to differences between years).

3. *Idaho Power applied the flow vs. mobile area function described above to each hour of the year for the Proposed Operations and each scenario.*

The time step is appropriate but see items 1 and 2 above for comments on flows greater than 30,000 cfs and the "mobile area function."

4. *The mobilized sand area and total inundated sand areas were summed up over the year. These values have the units of area*time (m^2*hours). These values were divided by the number of hours in the year to get an annual average value for inundated sand and mobilized sand areas. These values have the units of area (m^2). By doing a summation over the year, increases in mobilized area are balanced by decreases in mobilized area on a one for one basis and the summation represents a net annual value (either increase or decrease).*

IPC's procedure to compare the extent of sand mobilization for proposed operations with the various specified scenarios cannot be fully assessed because there is insufficient information of the underlying assumptions, especially those justifying "balancing" or "offsetting" periods of greater mobile areas with periods of less mobile areas. The simplest and most straightforward approach to assessing the aerial "extent of sand mobilization" for each flow scenario is to combine the "mobile area function" for each sand bar with the particular flow distribution function to give a cumulative area (on an annual basis) subject to 1 mm sand entrainment. This result would be in units of m^2*hrs similar to IPC's computation procedure but would not involve explicit "offsetting." In this way, time periods for which there is no area mobilized would not add to the cumulative total of area*hours of mobile sand bar, as is appropriate for determining the total aerial extent of plausible sand entrainment integrated over a year. The simplest and most informative presentation of results would be to show the annual totals for each bar for each flow scenario. Likewise, duration of mobile sediment for each bar and for each scenario could be readily calculated, using Idaho Power's criteria that a bar is considered mobile if more than 1% of the bar area experiences critical transport conditions. However, from IPC's description (pg.5), areas during periods of calculated immobility are apparently subtracted from the cumulative total. This is completely invalid unless it is assumed that periods of immobility result in deposition that balances erosion on a time equivalent basis. This is stated on page 5 as *"we assumed that any decrease in the area of mobilization was no impact and represented opportunities for deposition that could counter the effect of a similar increase in mobilization".* This assumption is invalid because of the clear evidence of diminished supply of sediment feeding most sand bars and the highly nonlinear character of sediment entrainment.

Another aspect of this analysis mutes the effects of larger flows (those creating areas of sand mobility) on potential sand mobilization, thus understating the potential effects of scenarios with flow-duration curves skewed towards flows exceeding the transport thresholds. While Idaho Power perhaps meets the letter of the AIR request in determining "extent of sand mobilization," it does not meet the spirit of the analysis by failing to make any attempt to consider differences in sediment volume entrained between the suite of scenarios. In a shear stress approach to calculating sediment transport, bedload transport rates are commonly related to the "excess shear" above critical transport conditions. This relation is nonlinear. For example, the commonly used Meyer-Peter and Müller (1948) equation for bedload transport reduces to:
$q \propto \left(\tau_o - \tau_c\right)^{1.5}$, where q is the bedload transport rate per unit width, τ_o is the applied shear stress, and τ_c is the critical shear stress for the particle size of interest (Julien, 1994, pg 161-162). Because transport is related to the difference between the applied and critical shear stress, bedload transport rates increase markedly once the critical shear stress value is exceeded for a specific area. Simply assessing the area affected by sediment transport for a particular scenario gives incomplete information of the likely affects of that scenario on sediment mobilization. A more valid assessment, hence more valid comparisons between scenarios, would result from applying an excess shear calculation to the analysis so to estimate potential volumes entrained. While for a variety of reasons the resulting values may not be very accurate, such an analysis would provide the most complete information for comparison purposes and is clearly within the capabilities of the models and data available.

5. *For purposes of comparison, we examined the cumulative areas of sand inundated by each scenario and Proposed Operations. The inundated area is the total wet area of sand, mobile and stable. The inundated and mobile areas for each sandbar are shown in Table 1.*

The analysis methods are sufficiently flawed—no apparent hydraulics data for flows greater than 30,000 cfs, the coarse "step function" for determining areas of mobility, and the unclear "offsetting" arithmetic treatment of mobile and immobile sand bar areas—that the results presented in Tables 2-12 are can not be justifiably used to compare scenarios, especially for documenting the effects of different scenarios for specific flow years. Additionally, IPC's presentation is much more complicated than it needs to be. The most valid and clear comparison would be a simple table (and a single corresponding chart) modeled after Table 2a that for each bar and for each scenario that presents the correctly calculated (see comments above) total annual mobilized area (in m^2*hours). There is no clear reason why these values should be normalized to bar area or averaged among bars or by year. The normalization adopted by IPC simply creates very small numbers without adding information, hence supporting obtuse statements such as "*In none of the scenarios or years does the ratio of area mobilized over all four bars differ by more than 1 percent with respect to Proposed Operations*" (their italics). In reality, even with the flawed calculation procedures, the percent changes in absolute area are much greater, ranging up to 71% as shown in Table 2a.

Summary

The approach of using a 2D model to (1) determine flow duration curves and (2) determine and define flows resulting in incipient motion at the four sandbars (for the specified 1 mm grain size) are probably appropriate and reasonable accurate. This modeling should be revised however, using the median sand size for each bar; and calculations should be revised as described above. More complete documentation of sites and assumptions should be provided. The calculations of duration and extent of sand mobilization for the Proposed Operation and specified scenarios do not provide an adequate basis for interpreting differences between scenarios on sandbar mobility. A few changes in calculation procedures could provide much more robust determinations.

The calculations probably result in substantial underestimation of the potential erosion of median sand size as currently modeled and presented. It should also be noted that this approach - the critical tractive force approach—which was the logical analysis approach adopted by IPC given the request to determine incipient motion conditions—may not be relevant to other important erosional mechanisms affecting sandbars, such as sapping (owing to daily flow ramping cycles). The studies conducted so far as part of the relicensing effort have not shed sufficient light on the processes forming, maintaining, and eroding sandbars so that we can confidently and quantitatively predict their behavior on the basis of a single process model.

References

Buffington, J.M., and Montgomery, D.R., 1997, A systematic analysis of eight decades of incipient motion studies, with special reference to gravel-bedded rivers: Water Resources Research, v. 33, pp. 1993-2029.

Julien, P. Y., 1994, Erosion and sedimentation, Cambridge, Cambridge University Press, 280 p.

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December 17, 2004

David Henderson
Bureau of Land Management
100 Oregon Street
Vale, OR 97918

Re: Hells Canyon Additional Information Request OP-1(d) – (Sediment Transport)

Dear Mr. Henderson:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application.

In AIR OP-1(d), the FERC requested specific information related to operational scenarios and sediment transport and directed IPC to consult with various entities (see attached list) about its response to the AIR. Therefore, IPC is requesting your review and comments regarding the draft response to AIR OP-1(d).

The draft response is enclosed on a CD. The FERC has directed IPC to provide a 30-day review and comment period on the draft response. Because of the tight time constraints imposed by the FERC for this AIR, your comments must be delivered to me by no later than January 19, 2005 for inclusion in the final response that will be filed with the FERC. Comments received after this 30-day review period may not be included in the final response.

Please contact me if you have questions or need clarification.

Sincerely,

Craig A. Jones

CAJ/da
Enclosure
Cc: Jim Tucker, IPC
Nathan Gardiner, IPC
Craig Jones, IPC
Jim Vasile, DWT

IDAHO POWER COMPANY
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BOISE, IDAHO 83707

Craig Jones	Phone	208-388-2934
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December 17, 2004

Dorothy Mason
Bureau of Land Management
3165 10th Street
Baker City, OR 97814

Re: Hells Canyon Additional Information Request OP-1(d) – (Sediment Transport)

Dear Ms. Mason:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application.

In AIR OP-1(d), the FERC requested specific information related to operational scenarios and sediment transport and directed IPC to consult with various entities (see attached list) about its response to the AIR. Therefore, IPC is requesting your review and comments regarding the draft response to AIR OP-1(d).

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Sincerely,

Craig A. Jones

CAJ/da
Enclosure
Cc: Jim Tucker, IPC
Nathan Gardiner, IPC
Craig Jones, IPC
Jim Vasile, DWT

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December 17, 2004

Albert Teeman
Burns-Paiute Tribe
100 Pasigo Street
HC 71
Burns, OR 97720

Re: Hells Canyon Additional Information Request OP-1(d) – (Sediment Transport)

Dear Mr. Teeman:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application.

In AIR OP-1(d), the FERC requested specific information related to operational scenarios and sediment transport and directed IPC to consult with various entities (see attached list) about its response to the AIR. Therefore, IPC is requesting your review and comments regarding the draft response to AIR OP-1(d).

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December 17, 2004

Robert Lothrop
Columbia River Inter-Tribal Fish Commission
729 NE Oregon Street, Suite 200
Portland, OR 97232

Re: Hells Canyon Additional Information Request OP-1(d) – (Sediment Transport)

Dear Mr. Lothrop:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application.

In AIR OP-1(d), the FERC requested specific information related to operational scenarios and sediment transport and directed IPC to consult with various entities (see attached list) about its response to the AIR. Therefore, IPC is requesting your review and comments regarding the draft response to AIR OP-1(d).

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December 17, 2004

Gary Burke
Confederated Tribes of the Umatilla Indian Reservation
PO Box 638
Pendleton, OR 97801

Re: Hells Canyon Additional Information Request OP-1(d) – (Sediment Transport)

Dear Mr. Burke:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application.

In AIR OP-1(d), the FERC requested specific information related to operational scenarios and sediment transport and directed IPC to consult with various entities (see attached list) about its response to the AIR. Therefore, IPC is requesting your review and comments regarding the draft response to AIR OP-1(d).

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December 17, 2004

Don Sampson
Confederated Tribes of the Umatilla Indian Reservation
PO Box 638
Pendleton, OR 97801

Re: Hells Canyon Additional Information Request OP-1(d) – (Sediment Transport)

Dear Mr. Sampson:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application.

In AIR OP-1(d), the FERC requested specific information related to operational scenarios and sediment transport and directed IPC to consult with various entities (see attached list) about its response to the AIR. Therefore, IPC is requesting your review and comments regarding the draft response to AIR OP-1(d).

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December 17, 2004

Tribal Chairman
Confederated Tribes of the Warm Springs
PO Box C
Warm Springs, OR 97761-0078

Re: Hells Canyon Additional Information Request OP-1(d) – (Sediment Transport)

Dear Mr. Chairman:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application.

In AIR OP-1(d), the FERC requested specific information related to operational scenarios and sediment transport and directed IPC to consult with various entities (see attached list) about its response to the AIR. Therefore, IPC is requesting your review and comments regarding the draft response to AIR OP-1(d).

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December 17, 2004

Kate Kelly
Idaho Department of Environmental Quality
1445 North Orchard
Boise, ID 83706-2239

Re: Hells Canyon Additional Information Request OP-1(d) – (Sediment Transport)

Dear Ms. Kelly:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application.

In AIR OP-1(d), the FERC requested specific information related to operational scenarios and sediment transport and directed IPC to consult with various entities (see attached list) about its response to the AIR. Therefore, IPC is requesting your review and comments regarding the draft response to AIR OP-1(d).

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December 17, 2004

Tracey Trent
Idaho Department of Fish and Game
600 South Walnut
PO Box 25
Boise, ID 83702

Re: Hells Canyon Additional Information Request OP-1(d) – (Sediment Transport)

Dear Mr. Trent:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application.

In AIR OP-1(d), the FERC requested specific information related to operational scenarios and sediment transport and directed IPC to consult with various entities (see attached list) about its response to the AIR. Therefore, IPC is requesting your review and comments regarding the draft response to AIR OP-1(d).

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December 17, 2004

Rick Eichstaedt
Nez Perce Tribe
PO Box 305
Lapwai, ID 83540

Re: Hells Canyon Additional Information Request OP-1(d) – (Sediment Transport)

Dear Mr. Eichstaedt:

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Please contact me if you have questions or need clarification.

Sincerely,

Craig A. Jones

CAJ/da
Enclosure
Cc: Jim Tucker, IPC
Nathan Gardiner, IPC
Craig Jones, IPC
Jim Vasile, DWT

IDAHO POWER COMPANY
P.O. BOX 70
BOISE, IDAHO 83707

Craig Jones	Phone	208-388-2934
Project Manager	Fax	208-388-6902
Hydro Relicensing Department	E-Mail	cjones@idahopower.com

December 17, 2004

Ritchie Graves
NOAA Fisheries
525 NE Oregon Street, Suite 500
Portland, OR 97232

Re: Hells Canyon Additional Information Request OP-1(d) – (Sediment Transport)

Dear Mr. Graves:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application.

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BOISE, IDAHO 83707

Craig Jones	Phone	208-388-2934
Project Manager	Fax	208-388-6902
Hydro Relicensing Department	E-Mail	cjones@idahopower.com

December 17, 2004

Bob Lohn
NOAA Fisheries
525 NE Oregon Street, Suite 500
Portland, OR 97232-2737

Re: Hells Canyon Additional Information Request OP-1(d) – (Sediment Transport)

Dear Mr. Lohn:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application.

In AIR OP-1(d), the FERC requested specific information related to operational scenarios and sediment transport and directed IPC to consult with various entities (see attached list) about its response to the AIR. Therefore, IPC is requesting your review and comments regarding the draft response to AIR OP-1(d).

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BOISE, IDAHO 83707

Craig Jones	Phone	208-388-2934
Project Manager	Fax	208-388-6902
Hydro Relicensing Department	E-Mail	cjones@idahopower.com

December 17, 2004

Paul DeVito
Oregon Department of Environmental Quality
2146 NE Fourth Street, Suite 104
Bend, OR 97701

Re: Hells Canyon Additional Information Request OP-1(d) – (Sediment Transport)

Dear Mr DeVito:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application.

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BOISE, IDAHO 83707

Craig Jones — Phone 208-388-2934
Project Manager — Fax 208-388-6902
Hydro Relicensing Department — E-Mail cjones@idahopower.com

December 17, 2004

Colleen Fagan
Oregon Department of Fish and Wildlife
107 20th Street
La Grande, OR 97850

Re: Hells Canyon Additional Information Request OP-1(d) – (Sediment Transport)

Dear Ms. Fagan:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application.

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BOISE, IDAHO 83707

Craig Jones	Phone	208-388-2934
Project Manager	Fax	208-388-6902
Hydro Relicensing Department	E-Mail	cjones@idahopower.com

December 17, 2004

Frederick Auck
Shoshone-Bannock Tribe
PO Box 306
Fort Hall, ID 83203

Re: Hells Canyon Additional Information Request OP-1(d) – (Sediment Transport)

Dear Mr. Auck:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application.

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BOISE, IDAHO 83707

Craig Jones		Phone	208-388-2934
Project Manager		Fax	208-388-6902
Hydro Relicensing Department		E-Mail	cjones@idahopower.com

December 17, 2004

Donald Clary
Shoshone-Paiute Tribe
633 West Fifth Street Twenty-First Floor
Los Angeles, CA 90071-2040

Re: Hells Canyon Additional Information Request OP-1(d) – (Sediment Transport)

Dear Mr. Clary:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application.

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Hydro Relicensing Department	E-Mail	cjones@idahopower.com

December 17, 2004

Jeffery Foss
U.S. Fish and Wildlife Service
1387 South Vinnell Way, Suite 368
Boise, ID 83709

Re: Hells Canyon Additional Information Request OP-1(d) – (Sediment Transport)

Dear Mr. Foss:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application.

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BOISE, IDAHO 83707

Craig Jones | Phone 208-388-2934
Project Manager | Fax 208-388-6902
Hydro Relicensing Department | E-Mail cjones@idahopower.com

December 17, 2004

Forest Supervisor
Wallowa-Whitman National Forest
1550 Dewey Avenue
PO Box 907
Baker City, OR 97814

Re: Hells Canyon Additional Information Request OP-1(d) – (Sediment Transport)

Dear Forest Supervisor:

In a letter dated May 4, 2004, the Federal Energy Regulatory Commission (FERC) issued to Idaho Power Company (IPC) an additional information request (AIR) for the Hells Canyon New License Application.

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Idaho Power Company
Hells Canyon Complex (FERC Project No. 1971)
Additional Information Request OP-1(d)- Consulting Entities List

David Henderson	Bureau of Land Management
Dorothy Mason	Bureau of Land Management
Albert Teeman	Burns-Paiute Tribe
Robert Lothrop	Columbia River Inter-Tribal Fish Commission
Don Sampson	Columbia River Inter-Tribal Fish Commission
Gary Burke	Confederated Tribes of the Umatilla Indian Reservation
Olney Patt, Jr.	Confederated Tribes of the Warm Springs
Kate Kelly	Idaho Department of Environmental Quality
Tracey Trent	Idaho Department of Fish and Game
Rick Eichstaedt	Nez Perce Tribe
Ritchie Graves	NOAA Fisheries
Bob Lohn	NOAA Fisheries
Paul DeVito	Oregon Department of Environmental Quality
Colleen Fagan	Oregon Department of Fish and Wildlife
Frederick Auck	Shoshone-Bannock Tribe
Donald Clary	Shoshone-Paiute Tribe
Jeffery Foss	U.S. Fish and Wildlife Service
Forest Supervisor	Wallowa-Whitman National Forest