Attachment 22

Gahcho Kué Flow Mitigation Plan (June 2012)

TECHNICAL MEMORANDUM

DATE June 29, 2012 **PROJECT No.** 11-1365-0012/DCN-068

TO Andrew Williams
De Beers Canada Inc.

CC Veronica Chisolm, De Beers Canada Inc.

FROM Kasey Clipperton, Golder Associates Ltd. **EMAIL** kclipperton@golder.com

GAHCHO KUÉ FLOW MITIGATION PLAN (JUNE 2012)

Current Conditions

Natural barriers to fish movement between Kennady Lake and Lake 410 are known to persist at a Kennady Lake outflow of 0.23 m^3/s; however, it is expected that under natural conditions, Arctic grayling are likely able to migrate and spawn in most years. Without mitigation, the reduction in flows predicted during the operations and closure (refilling) phases of the Gahcho Kué Project, as described in the 2012 EIS Supplement, have the potential to frequently prevent Arctic grayling spawning migrations due to natural barriers that persist at low flows, and to reduce the available habitat area for spawning and rearing through reductions in wetted area. A flow mitigation plan is proposed to augment flows downstream of Area 8 during operations and refilling to avoid potential harmful population level effects on the fish community between Area 8 and Lake 410.

Barriers persist downstream of Kennady Lake at a discharge of 0.23 m^3/s and are absent at a discharge of 0.78 m^3/s (DeBeers 2010). The transition discharge at which barriers no longer persist is currently under investigation through ongoing field programs. The objective of the flow mitigation plan is to

- sustain the Arctic grayling population and avoid a harmful alteration to fish habitat during operations and refilling by providing upstream migration access for Arctic grayling 3 out of 4 years;
- then maintain suitable habitat conditions during egg incubation and for fry rearing in each of the spawning years;
- allow for outmigration in the late summer to overwintering habitats; and
- provide a seasonally appropriate hydrograph based on the natural timing and duration of high flow and low flow events.

Providing access a minimum of 3 out of 4 years would result in a high suitability value, based on spawning access criteria (Hubert et al. 1985), and would be similar to pre-development conditions. It is assumed that by providing flows suitable for Arctic grayling, other species will also be protected.

Mitigation Flows

Pumping to waters downstream of the isolated areas of Kennady Lake (i.e., augmenting flows into Area 8) will need to be sustained through both the spawning migration period and also during the egg incubation period to reduce the risk of desiccation of eggs, and allow sufficient time for fry to emerge and move into suitable habitats prior to the flow decreasing. The timing and duration of flow augmentation for each life stage of Arctic grayling is provided in Table 1. For the purpose of developing flow targets for the conceptual flow mitigation plan, it has been assumed that some fish passage will be provided at a discharge of about 0.4 m^3/s. This assumption will be tested with ongoing monitoring programs that commenced in 2011. Once the passage requirement has been met, there is also a need to provide flow augmentation to maintain suitable wetted area within spawning habitats during both the spawning period and incubation period, which can last anywhere from 5 to 7 weeks (Table 1).

Table 1: Timing and Duration of Flow Augmentation for Arctic grayling

Life Stage	Timing	Duration	Comments
Spawning	Early to mid-June	2 – 3 weeks	Augmentation for duration of June to allow for 2-3 week window of opportunity for spawning to occur (assumes about a 1 week lag from pumping to flow increases in the channels)
Incubation and Fry Emergence	Late June to July	3 – 4 weeks	Naturally attenuate after spawning to July pumping levels to minimize potential for egg desiccation or stranding of emerging fry
Fry Rearing, Adult and Juvenile Foraging	July and August	n/a	Maintain habitat (wetted width and depth) in channels to support seasonal feeding
Outmigration	Late August to mid-September	n/a	Overwintering movements to lakes typically begins in late August through mid-September. Ramp down pumping and natural attenuation of flows after pumping stops will minimize stranding and cue outmigration

To meet one of the objectives of the flow mitigation plan, which is to provide conditions suitable for successful spawning 3 out of 4 years to sustain the fish population, different flow augmentation targets were identified based on water-year type by sorting the hydrologic time series into 4 categories (or quartiles): wet, wet-average, dry-average and dry. Operationally, each water-year type will be predicted based on the late winter snow-pack depth. Essentially, the expected mean June flow will be used to determine the quartiles for each year. The mean June flow was selected, as it is likely a good indicator of the potential availability of spawning habitat each year, and under operations, the potential to provide increased access to, and availability of, spawning habitat will be greatest during wetter years. During wet and average-wet years, flow augmentation is maintained at higher levels for a longer period with the goal of providing good recruitment years and to provide for a similar duration of peak flows as observed under natural flow conditions. During the average-dry conditions, June augmentation remains the same to allow for fish passage, although the lower natural run-off will act to reduce the amount of available spawning habitat. As a result, the flow augmentation targets for the remainder of the year under these conditions are lower than wet years, reflecting the overall reduced availability of habitat under natural conditions. During dry years, the only flow augmentation proposed is that a minimal peak is provided during June (not specifically to provide fish passage) and an outflow of 0.1 m^3/s is maintained at the outlet of Area 8 in July and August to maintain a minimal level of habitat in the streams and connection to downstream lakes (Table 2). During dry years, available water for pumping would be limited, as the source watersheds would also be experiencing drier than normal conditions.

A preliminary look at the potential flow regime under the proposed conceptual flow mitigation is provided as flow duration curves in Figures 1 through 3. Example years of what the potential flow mitigation would achieve under each water-year type are provided in Figures 4 though 7. These figures have been generated by simply adding the flow rules directly to the predicted daily operation flows and have included a 7-day ramping down period to simulate the transition of pumping volumes between months and the natural lake attenuation that would occur. The purpose of the ramping period is to minimize the risk of stranding and provide adequate time for fish to move to alternate habitats with decreasing flows.

Table 2: Conceptual Flow Augmentation Targets above Predicted Operational Flows

Year Type	Area 8 Outflow Augmentation Targets		
	June	**July**	**August**
Wet	0.30 - 0.40 m^3/s	Ramp down over 7 day period to 0.30 m^3/s	Ramp down over 7 day period to 0.20 m^3/s
Wet-Average	0.30 - 0.40 m^3/s	Ramp down over 7 day period to 0.20 m^3/s	Ramp down over 7 day period to 0.10 m^3/s
Dry-Average	0.30 m^3/s	Ramp down over 7 day period to 0.10 m^3/s	As required to maintain a minimum flow of 0.10 m^3/s
Dry	0.10 m^3/s	As required to maintain a minimum flow of 0.10 m^3/s	As required to maintain a minimum flow of 0.10 m^3/s

The proposed conceptual flow mitigation plan is expected to maintain the Arctic grayling population at near pre-development levels during operations and refilling. The conceptual flow mitigation plan has been developed based on habitat availability and spawning access information from existing fish habitat baseline studies, with specific attention paid to the timing, magnitude and duration of flows under natural conditions. The flow augmentation rates have been set as minimum augmentation targets, and additional water (not exceeding the natural flow magnitude) may be directed downstream of Area 8 based on site water conditions.

Sources of Water

The proposed primary long-term source of water for the flow mitigation plan will be via pumping from Lake N11. Pumping infrastructure will eventually be required within Lake N11 for the Project, so no additional disturbance would be necessary relative to what has already been identified for the Project. The N watershed is relatively large, and the volume of water required for flow mitigation is lower than the pumping volume assessed for closure activities, with the same mitigation measures implemented to protect flows in the N watershed under dry conditions. As a result, the conclusions of the assessment for the N watershed would not change as a result of pumping for flow mitigation. During closure (refilling), the pumping volume from Lake N11 would remain unchanged; however, a portion of the water that would have gone to Kennady Lake would be directed towards Area 8, which would increase the duration required for refilling of Kennady Lake.

During the initial years of operations, there may be other sources of water closer to Area 8 that may be available to supply some or all of the water required for the flow mitigation plan. The specific design of the infrastructure and operational procedures to support the flow mitigation plan will be developed during the detailed design phase. At the detailed design phase, additional alternative sources of water would be investigated for feasibility to support the downstream flow mitigation, for example, pumping from the water management pond or Area 7 when water quality is suitable to do so. Implementation of the flow mitigation plan will likely result in the extension of the refilling period of Kennady Lake, as water is diverted to Area 8 for downstream flow mitigation.

The availability of water for refilling Kennady Lake under the flow mitigation plan will be assessed with the update to the hydrologic model.

Future Work and Adaptive Management

Results from 2011 monitoring confirmed the presence of barriers at a discharge of less than 0.20 m^3/s. Due to the early timing and short duration of peak flows in the spring of 2011, a direct assessment of fish passage was not achieved; however, Arctic grayling were observed throughout the streams downstream of Kennady Lake and successful spawning was confirmed. This observation, associated with the low magnitude and short duration flow peak of about 0.5 m^3/s experienced in 2011, would suggest that the preliminary flow augmentation target to provide fish passage is in alignment with those presented in Table 2, and only minor adjustments to the conceptual flow mitigation plan may be necessary in the future as part of adaptive management measures.

Additional field surveys are occurring in 2012 as part of ongoing monitoring programs to validate the assumptions in this Plan: namely, the flow at which barriers to migration persist and on the availability and suitability of spawning and rearing habitat at a wide range of flows. Preliminary results from the 2012 field program are supporting the assumptions of the flow mitigation plan around passage flows. A field report outlining the results of the field assessments and implications on the flow mitigation will be available in September 2012.

Initially, the focus of future downstream flow monitoring programs will be on the June migration period to ensure that any plan that is implemented will provide access to the spawning habitat based on the stated objectives. Future monitoring once the flow mitigation plan has been implemented will be used to inform aspects of the flow mitigation plan (such as, ramping rates to avoid fish stranding, duration of flow augmentation targets for each life stage, etc.), but are not critical to the development of the plan at this stage of project planning. The details of the monitoring program will be incorporated into the overall Aquatic Effects Monitoring Program (AEMP) as part of the permitting process. A successful flow mitigation plan will be measured by achieving the desired biological objective while minimizing the level of disturbance to the adjacent landscape.

Closure

We trust the above meets your present requirements. If you have any questions or require additional details, please contact the undersigned.

GOLDER ASSOCIATES LTD.

Kasey Clipperton, B.Sc., M.E.Des.
Associate, Senior Fisheries Biologist

Gary Ash, M.Sc., P. Biol.
Principal

References

De Beers (De Beers Canada Inc.). 2010. *Environmental Impact Statement for the Gahcho Kué Project. Volumes 1, 2, 3a, 3b, 4, 5, 6a, 6b, 7 and Annexes A through N.* Submitted to Mackenzie Valley Environmental Impact Review Board. December 2010.

De Beers. 2012. *Environmental Impact Statement Supplemental Information Submission for the Gahcho Kué Project*. Submitted to the Mackenzie Valley Environmental Impact Review Board. April 2012.

Hubert, W. A., R. S. Helzner, L. A. Lee, and P. C. Nelson. 1985. *Habitat suitability index models and instream flow suitability curves: Arctic grayling riverine populations.* U.S. Fish Wild. Serv. Rep. 82(10.110). 34 p.

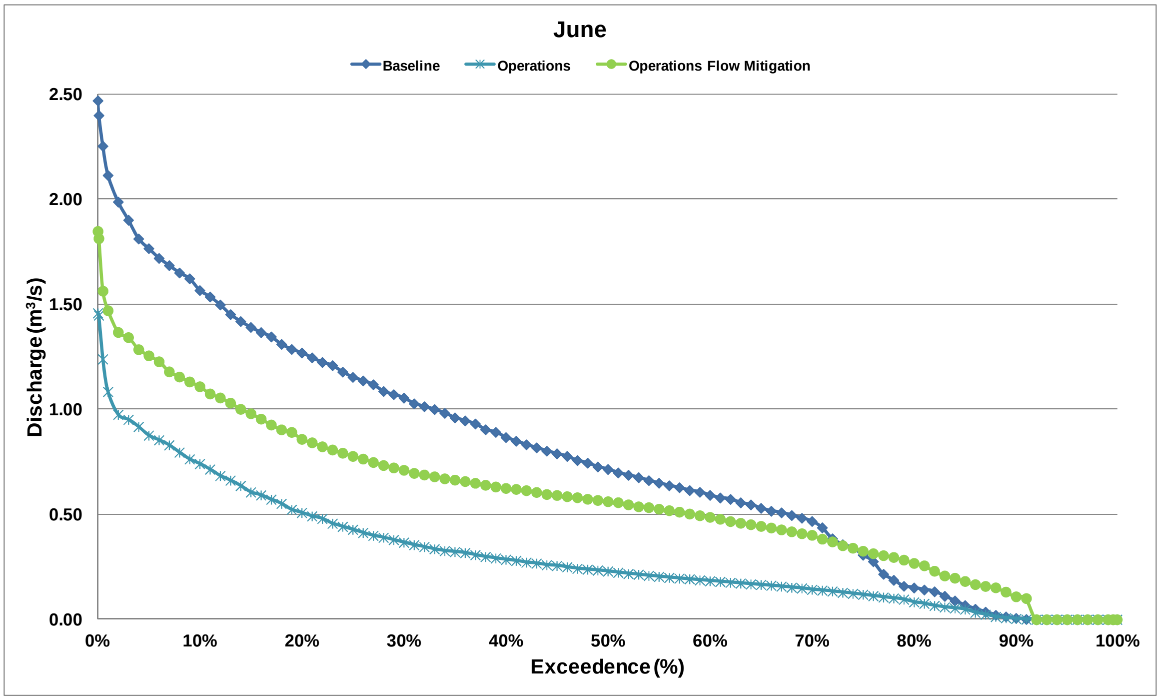

Figure 1: June Mitigation Flow Exceedence Curve

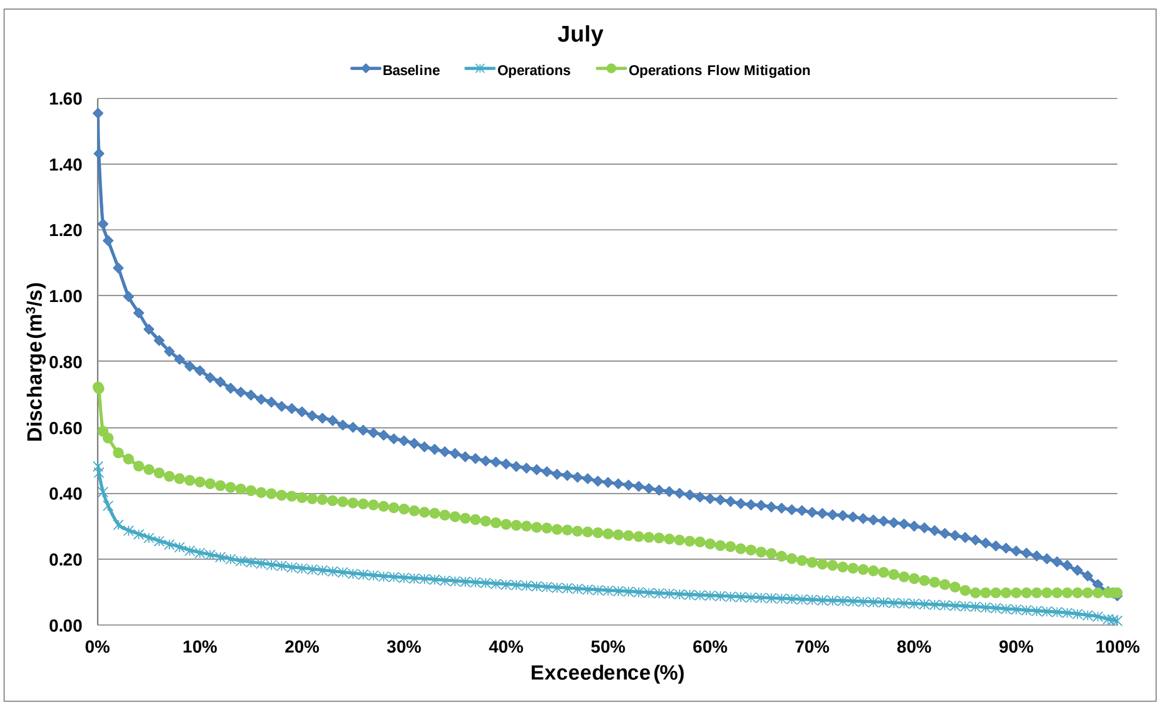

Figure 2: July Mitigation Flow Exceedence Curve

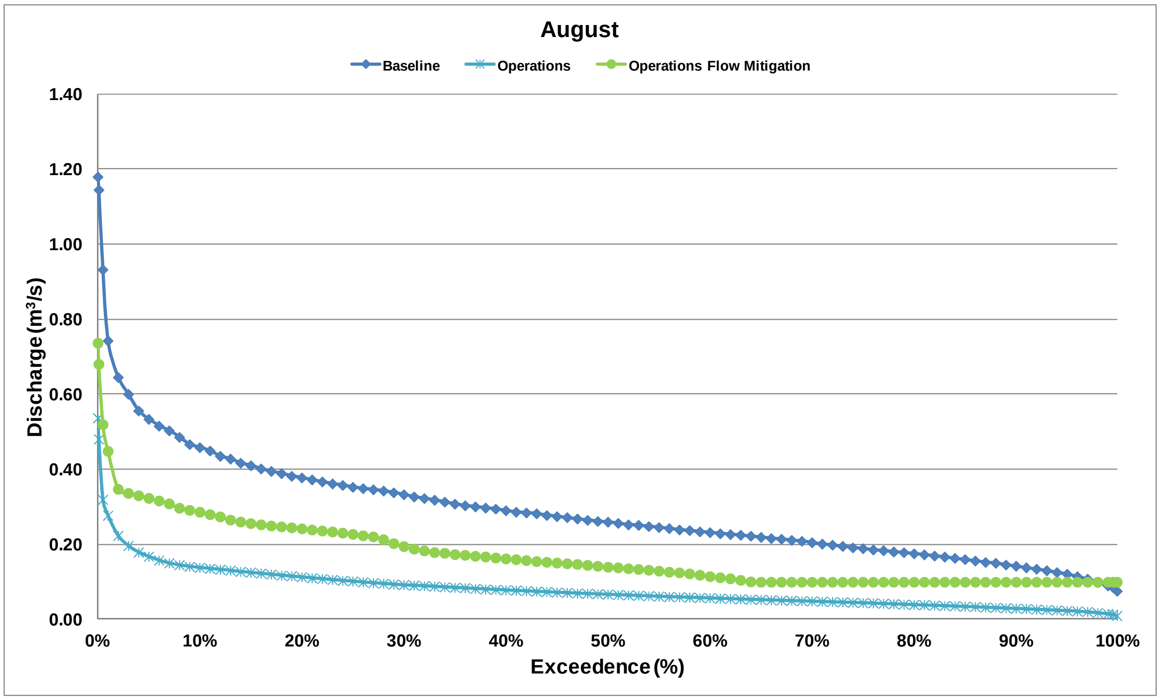

Figure 3: August Mitigation Flow Exceedence Curve

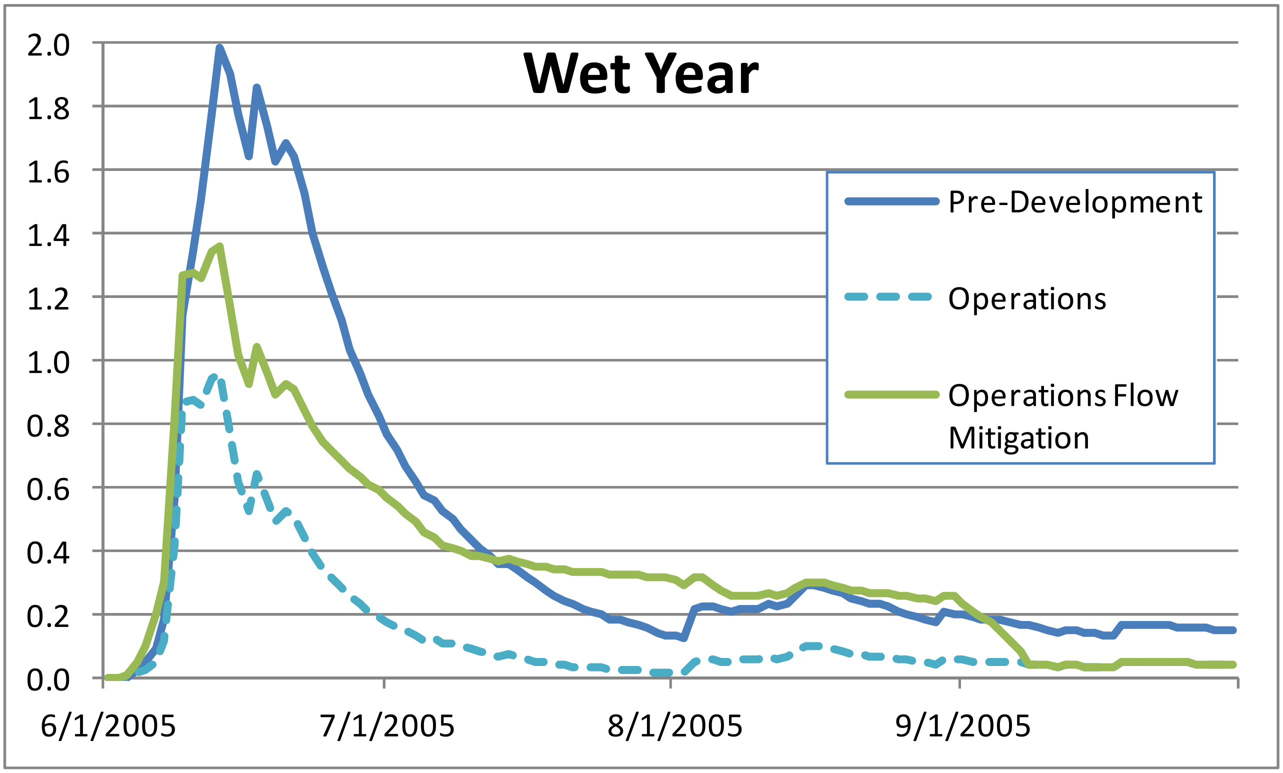

Figure 4: Example “Wet” Year Conceptual Flow Mitigation

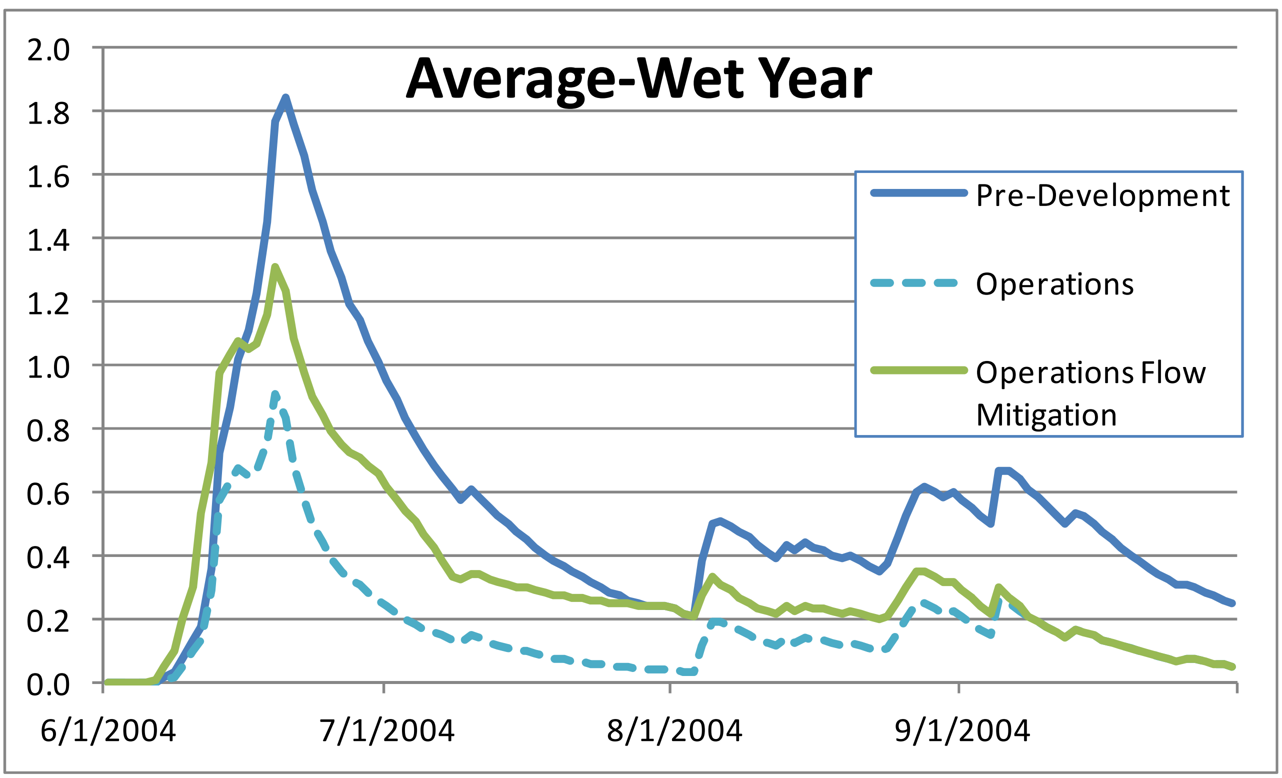

Figure 5: Example “Average-Wet” Year Conceptual Flow Mitigation

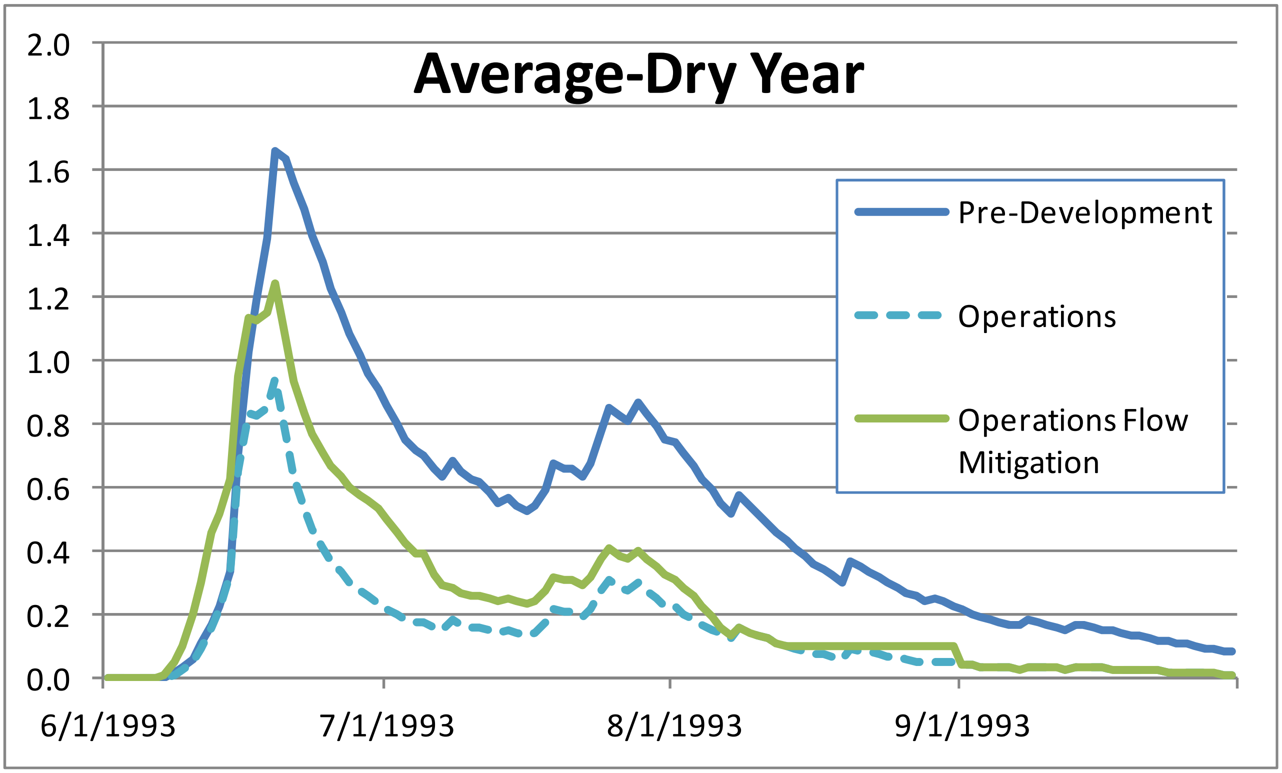

Figure 6: Example "Average-Dry" Year Conceptual Flow Mitigation

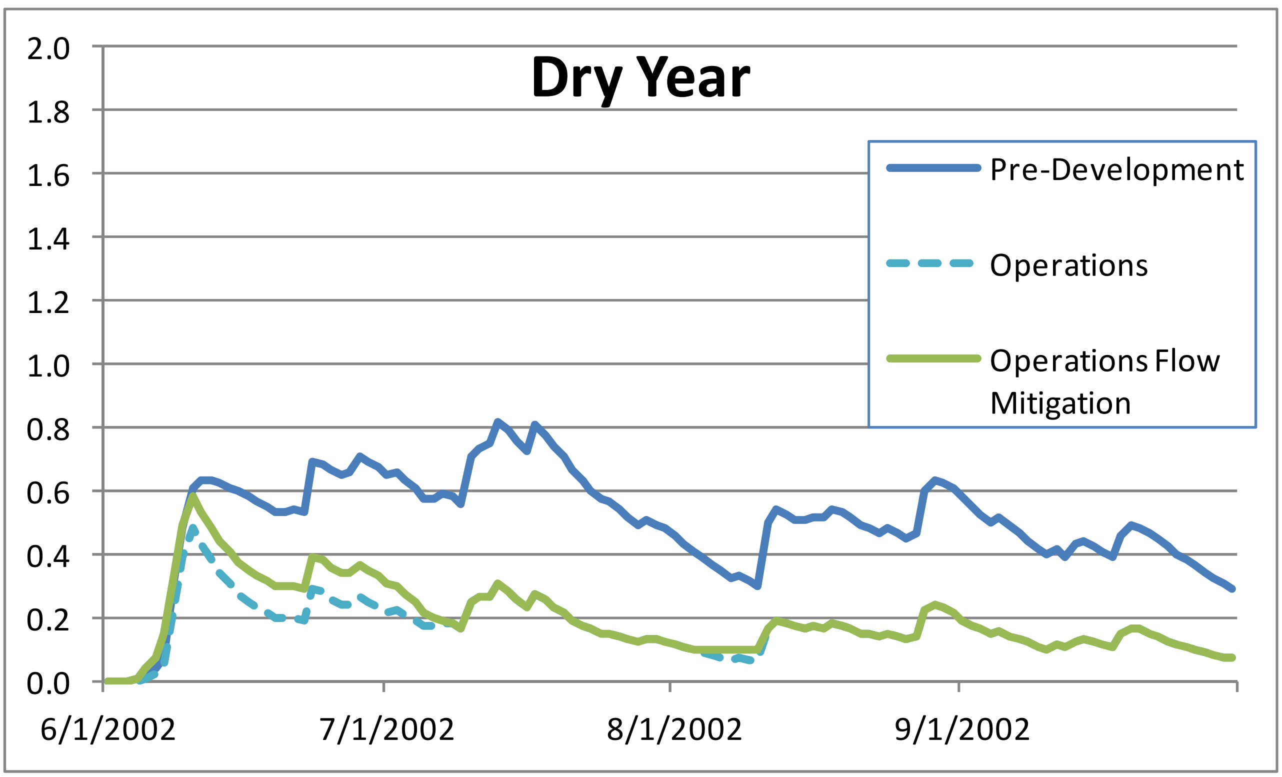

Figure 7: Example "Dry" Year Conceptual Flow Mitigation