Note: *This Section dated December 2006, replaces the Section VI.2.6.1. published in August 2006. In this context Appendix P was added December 2006.*

VI.2.6.1. Downstream Flows During Construction and Impoundment

VI.2.6.1.1. Relevance of Downstream Flows in the Context of Downstream Dams Constructions

By the time Yusufeli Dam is in it's second year of construction, Deriner Reservoir which ends below Artvin Dam will already be there in the downstream (Deriner Dam is presently under construction and it is planned that Deriner will be in operation by the end of 2009.

Therefore, relevance of downstream effects from Yusufeli on the Coruh River channel and it's aquatic life is given for the 19 km of river reach between Yusufeli and Artvin dams until the filling of Artvin Dam.

It is planned that Artvin Dam will be completed at the same time as Yusufeli, and its construction takes 5.5 years. Thus it can be assumed that during the interim period of construction of about 8 years there will still be a Coruh River channel along this reach. Also the downstream section of Coruh will be impacted by the construction activities of Artvin Dam, such as by relocation roads construction above the future impoundment level. After Yusufeli and Artvin Reservoirs are established, the whole river reach from the Yusufeli Reservoir headwater down to Muratli Dam will have transformed from a running natural river in to a cascade of reservoirs without any notable running section in-between.

VI.2.6.1.2. Downstream Flows During Dam Construction

During construction, the Coruh flows will pass the dam construction site via 2 diversion tunnels. No significant retention at the upstream coffer dam, which serves the diversion tunnels, is anticipated, as the capacity of the diversion tunnels (1,530 m³/sec) is dimensioned for complete passage of arriving flows (incl. floodwater). Therefore, during construction the river downstream of the dam site will receive the complete natural inflow.

The flow pattern in the Coruh River will be affected during filling of the reservoir (impounding) and operation of the project. The impact of construction on the flow will be insignificant, when compared with the other phases. For construction basically the river will be diverted to the diversion tunnels to facilitate work in a dry area at the dam site. By this, the flow pattern will not be affected.

VI.2.6.1.3. Downstream Flows During Impoundment

The impoundment of the reservoir will be undertaken according to a detailed schedule, which will start 76 months after start of construction. Periods of technical measuring and monitoring are included as well as the wet test of the turbines. The duration of the filling process depends on the start month of the filling and the prevailing natural seasonal dynamics of inflows to the reservoir during the filling period. It is estimated that the reservoir will be filled within 6 to 14 months (cf. Table VI.11 and Appendix P for details). The filling process involves that water is retained in the reservoir and consequently no water would be discharged, except for the defined monitoring and test periods, until it was filled. In order to avoid that the downstream river section of the dam falls dry during impoundment[10] which would have adverse consequences for aquatic life, a technical solution was developed to provide a continuous minimum flow of 22 m³/sec[11] during the impoundment process (see Appendix P for principle-drawing).

Initial Impoundment

Impoundment starts with the closure of the diversion tunnels No.1 and No.2[12]. At the initial impoundment stage, 2 pipes are used to provide water through diversion tunnel No.2[13] until impoundment level has reached elevation 552 masl. which is the sill elevation of the bottom outlet intake structure[14]. Until the rising water level provides to supply these pipes, there will be a short time of 0.5 up to 4.5 hours with no flow and it may take further 3 hrs to 28 hrs until the full 22 m³/sec discharge is available depending on the start month and the actual inflow. It will take between 1 day (assuming average May inflows) and 13 days (assuming average January inflows) until the water level behind the dam reaches the bottom outlet intake level at 552 masl. under continuous provision of 22 m³/sec. [15]

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[10] The Artvin sub-catchment (between Yusufeli and Artvin dams) is only fed by some creeks and runoff from the valley slopes. The yield from the 290 km² is about 3 m³/sec on long-term average. Therefore, when the Coruh flow at the Yusufeli dam site was stopped for the period indicated above, no continuous river flow in the downstream section would be sustained. It can be expected that the sections closest to the Yusufeli dam site would fall dry first. Possibly some sinks in the riverbed would trap water and only various small pools would remain.

[11] This is the minimum residual flow calculated by the $Q_{7,10}$ method, for details see Section VI.2.6.3.1.

[12] At the closure of the diversion tunnels the water level is assumed at 503.5 masl, which is the invert elevation of Tunnel No.1.

[13] 2 pipes of 1.20 m diameter are planned as auxiliary intake at the entrance of the diversion tunnel No.2. At the start of impounding entrance of both Tunnels (No.1 and No.2) will be closed. These pipes open into the tunnel on either side right after the stop logs. The auxiliary intakes, equipped with closure gates, shall function until the water level reaches 552 masl, which is the sill elevation of the proper bottom outlet intake (see Appendix P).

[14] The diversion tunnel No.2, which will serve as the future bottom outlet works, incorporates a permanent intake structure in the form of a vertical shaft with a sill elevation at 552.0 m ASL (see Appendix P).

[15] This estimate is based on the average long-term dry and wet inflow rates, however this period may also be also shorter or longer (< 1 day up to 20 days) when looking at extreme dry or wet year flows.

Further Impoundment and Turbine Wet Tests

Until further impoundment has reached the low water level (L.W.L. 670 m ASL), which is the lowest level for the turbines to operate, continuous 22 m³/sec water will be released to the downstream via the bottom outlet during 4 filling periods of various durations (as indicated in Table VI.11) and in between measuring and monitoring periods (7 days each) where the natural inflow will be discharged. During wet test of each turbine 107 m³/s will be released during a period of about 1.5 months. In the case natural inflows exceed the capacity of the bottom outlet (ca. 156.6 m³/s) and the discharge from the turbines, the spillway will be operated to keep the water level at 710 m ASL. At the time planned for the wet tests, the water released during the wet tests will flow into the Artvin Reservoir since Artvin Dam is planned to be completed simultaneously with Yusufeli Dam. For the case that Artvin construction is delayed, peak flows of 107 m^3/sec for 8 hour periods each day from each turbine will be released into the Coruh downstream, both during wet tests and during operation. For the remaining 16 hours the bottom outlet will be operated to discharge 22 m³/s. From this release no adverse flood impacts are anticipated, as this discharge is less than the long term average natural flow in the moths April to June.

The most feasible months for commencement of impounding would be October and November and also December, which enables realization of the reservoir impounding and completion of wet tests within the period foreseen in the General Work Programme of the Project. These months provide for steady and slow filling which is desirable out of dam safety reasons. From engineering point of view, rapid filling of the reservoir is extremely detrimental to the dam structure. These months would also be beneficial from ecological consideration, as during this time of the year the biological activity is generally low and the green biomass of vegetation is at its annual minimum. This seasonal aspect would be matching well with the in-lake water quality issues, as low initial inflow water temperatures will reduce the decay rates and enhance the solubility of oxygen. Filling then continues during the maximum runoff season up to the complete filling of the reservoir (710 masl.). Table VI.11 provides as summary of the impoundment scheme, while Appendix P provides the detailed calculations.

Table VI.11. Impoundment Scheme

Activity	**Duration [days] for Start Month Nov.** (in parenthesis range of all Months)	**Downstream release [m³/s]**	**Reservoir Water Level [m ASL]**
Filling up to the intake of the Bottom Outlet	8 (1 to 13)	22	From 500 to 552
Filling	60 (5 to 74)	22	From 552 to 600
Measuring & Monitoring	7	= Inflow	at 600
Filling	64 (1 – 80)	22	From 600 to 625
Measuring & Monitoring	7	= Inflow	at 625
Filling	22 (4 to 115)	22	From 625 to 650
Measuring & Monitoring	7	= Inflow	at 650
Filling	22 (6 to 127)	22	From 650 to 670
Wet test of turbines, Filling	52	107/8hrs + 22/16hrs	From 670 to 710

Note: *As part of this revision the 2nd and 3rd Paragraphs of Impacts Section VI.3.3.2.2, p.114 (as published August 2006) are replaced by one paragraph and should read as follows:*

"During impoundment, the continuous provision of 22 m³/sec discharge (cf. Section VI.2.6.1.3) will allow to sustain aquatic life in the downstream river section during this period. Also according to the planned impoundment scheme, reduced flows will commence outside of the reproductive season of the fish. It is anticipated that the cyprinid river fish will populate the future Artvin reservoir. DSI will monitor the fish life after the formation of the reservoir. It is general practice of DSI to restock the reservoirs with fish species resembling the appropriate composition for the lake habitat."

Further: *in Chapter VIII.3.2.5 the Box VIII.1 is replaced by the new Table VI.11*

Appendix P: Impoundment Scheme and Continuous Discharge Solution

APPENDIX P

Impoundment Scheme
and
Continuous Discharge Solution

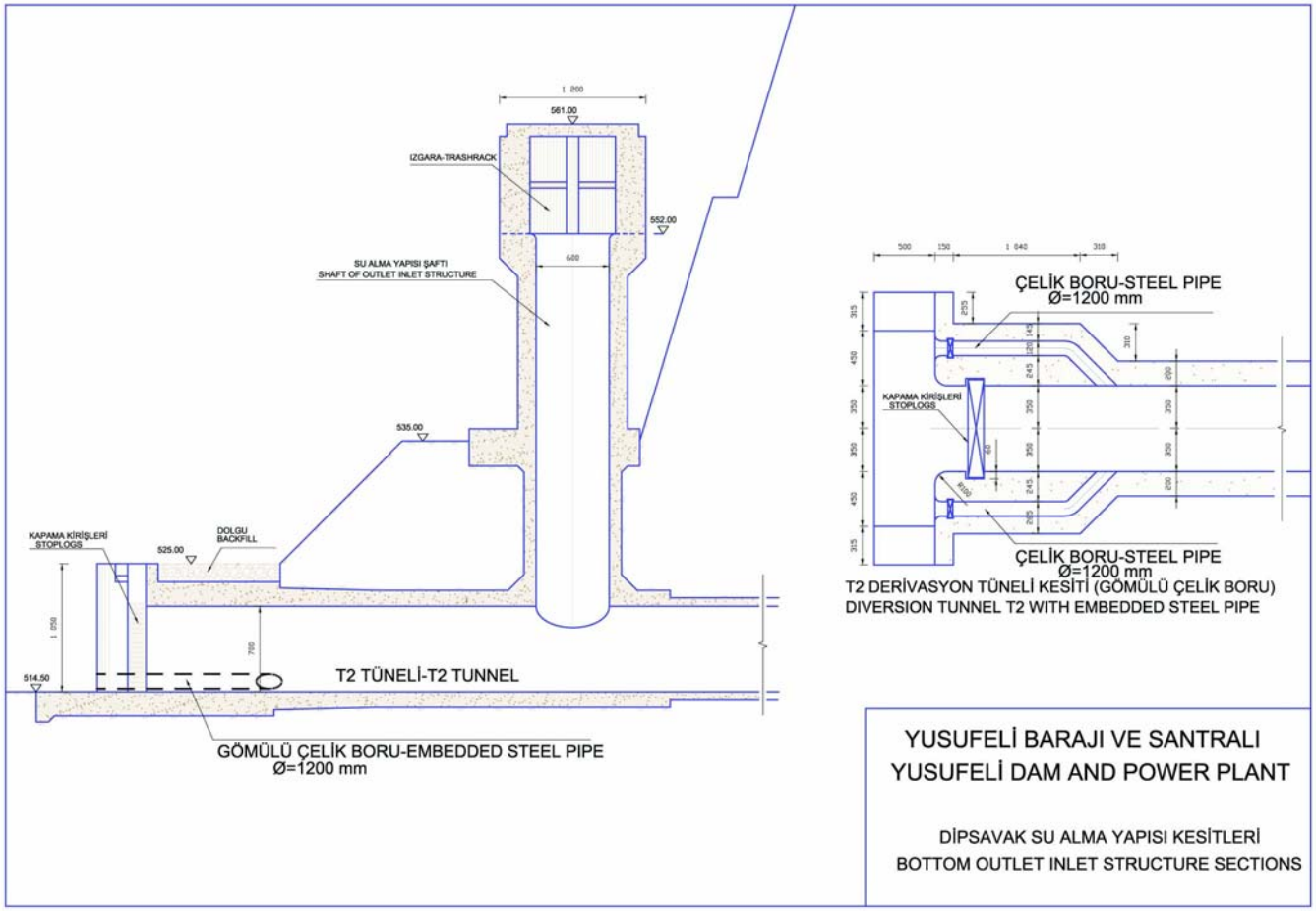
YUSUFELİ DAM AND HEPP CONSTRUCTION - RESERVOIR IMPOUNDMENT

	Duration to Reach Elev.552m	Reservoir impoundment between Elev. 500~600 m			Monitoring at Elev. 600 m			Reservoir impoundment between Elev. 600~625 m			Monitoring at Elev. 625 m			Reservoir impoundment between Elev. 625~650 m			Monitoring at Elev. 650 m			Reservoir impoundment between Elev. 650~670 m			Sub Total days	Wet Test Finish dates			Total Impoundment Duration Days
		Start	Finish	Duration days	Start	Finish	Duration days	Start	Finish	Duration days	Start	Finish	Duration days	Start	Finish	Duration days	Start	Finish	Duration days	Start	Finish	Duration days		Unit No.1 52 days	Unit No.2 52 days	Unit No.3 52 days	
January	13	01.01.2013	07.03.2013	65	08.03.2013 600,25	14.03.2013 600,25	7	15.03.2013 601,13	03.04.2013 622,92	20	04.04.2013 624,38	10.04.2013 631,86	7	11.04.2013 634,08	20.04.2013 649,62	10	21.04.2013 650,46	27.04.2013 655,16	7	28.04.2013 656,50	06.05.2013 668,86	9	125	27.06.2013	18.08.2013	09.10.2013	**281**
February	10	01.02.2013	18.03.2013	45	19.03.2013 600,57	25.03.2013 600,57	7	26.03.2013 601,44	07.04.2013 625,44	13	08.04.2013 626,63	14.04.2013 634,33	7	15.04.2013 634,33	23.04.2013 649,79	9	24.04.2013 650,60	30.04.2013 655,31	7	01.05.2013 657,23	08.05.2013 668,84	8	96	29.06.2013	20.08.2013	11.10.2013	**252**
March	4	01.03.2013	31.03.2013	30	01.04.2013 603,08	07.04.2013 615,70	7	08.04.2013 618,74	10.04.2013 623,64	3	11.04.2013 625,08	17.04.2013 632,54	7	18.04.2013 634,76	27.04.2013 650,07	10	28.04.2013 650,86	04.05.2013 657,89	7	05.05.2013 659,82	11.05.2013 669,38	7	71	02.07.2013	23.08.2013	14.10.2013	**227**
April	2	01.04.2013	08.04.2013	7	09.04.2013 599,60	15.04.2013 612,86	7	16.04.2013 615,70	19.04.2013 623,63	4	20.04.2013 625,08	26.04.2013 632,53	7	27.04.2013 634,76	04.05.2013 649,69	8	05.05.2013 651,10	11.05.2013 659,29	7	12.05.2013 661,00	17.05.2013 668,94	6	46	08.07.2013	29.08.2013	20.10.2013	**202**
May	1	01.05.2013	06.05.2013	5	07.05.2013 601,68	13.05.2013 621,71	7	14.05.2013 621,71	14.05.2013 625,01	1	15.05.2013 627,01	21.05.2013 640,36	7	22.05.2013 642,54	25.05.2013 649,08	4	26.05.2013 650,56	01.06.2013 658,08	7	02.06.2013 660,49	12.06.2013 669,83	11	42	03.08.2013	24.09.2013	15.11.2013	**198**
June	2	01.06.2013	09.06.2013	8	10.06.2013 601,09	16.06.2013 612,80	7	17.06.2013 615,64	22.06.2013 627,01	6	23.06.2013 628,07	29.06.2013 635,18	7	30.06.2013 637,26	21.07.2013 649,76	22	22.07.2013 649,76	28.07.2013 649,76	7	29.07.2013 650,27	02.12.2013 669,96	127	184	23.01.2014	16.04.2014 (83)	07.06.2014	**371**
July	4	01.07.2013	23.07.2013	22	24.07.2013 600,93	30.07.2013 601,87	7	31.07.2013 603,05	05.10.2013 625,15	67	06.10.2013 624,90	12.10.2013 625,15	7	13.10.2013 625,15	04.02.2014 649,96	115	05.02.2014 649,96	11.02.2014 649,96	7	12.02.2014 650,12	06.04.2014 669,75	54	279	28.05.2014	19.07.2014	09.09.2014	**435**
August	9	01.08.2013	07.10.2013	67	08.10.2013 600,05	14.10.2013 600,05	7	15.10.2013 600,46	17.12.2013 624,84	64	18.12.2013 624,84	24.12.2013 624,84	7	25.12.2013 625,09	26.03.2014 650,07	92	27.03.2014 650,07	02.04.2014 651,64	7	03.04.2014 652,99	17.04.2014 669,71	15	259	08.06.2014	30.07.2014	20.09.2014	**415**
September	12	01.09.2013	08.11.2013	68	09.11.2013 600,19	15.11.2013 600,19	7	16.11.2013 600,66	29.01.2014 624,94	75	30.01.2014 624,94	05.02.2014 624,94	7	06.02.2014 625,16	03.04.2014 650,27	57	04.04.2014 651,06	10.04.2014 655,75	7	11.04.2014 657,10	22.04.2014 669,77	12	233	13.06.2014	04.08.2014	25.09.2014	**389**
October	10	01.10.2012	28.11.2012	58	29.11.2012 600,00	05.12.2012 600,00	7	06.12.2012 600,38	23.02.2013 625,01	80	24.02.2013 625,01	02.03.2013 625,01	7	03.03.2013 625,01	05.04.2013 648,52	34	06.04.2013 649,42	12.04.2013 655,55	7	13.04.2013 656,89	25.04.2013 669,61	13	206	16.06.2013	07.08.2013	28.09.2013	**362**
November	8	01.11.2012	31.12.2012	60	01.01.2013 600,15	07.01.2013 600,15	7	08.01.2013 601,15	12.03.2013 625,30	64	13.03.2013 625,30	19.03.2013 625,30	7	20.03.2013 625,80	10.04.2013 649,42	22	11.04.2013 650,28	17.04.2013 654,99	7	18.04.2013 656,33	29.04.2013 669,14	12	179	20.06.2013	11.08.2013	02.10.2013	**335**
December	10	01.12.2012	13.02.2013	74	14.02.2013 600,24	20.02.2013 600,24	7	21.02.2013 600,62	28.03.2013 624,93	36	29.03.2013 624,93	04.04.2013 629,67	7	05.04.2013 631,82	15.04.2013 649,59	11	16.04.2013 650,43	22.04.2013 655,14	7	23.04.2013 656,48	03.05.2013 669,61	11	153	24.06.2013	15.08.2013	06.10.2013	**309**

CONDITIONS::

1- IN THE ABOVE TABLE, A SUMMARY OF THE OPERATIONAL STUDIES IS PRESENTED. EACH ROW REPRESENTS THE RESERVOIR STUDY CONDUCTED COMMENCING FOR EACH MONTH OF THE YEAR USING LONG TERM AVERAGE MONTHLY FLOWS.
2- MINIMUM DOWNSTREAM DISCHARGE AT ALL TIMES IS MAINTAINED AT 22 M3/SEC THROUGH THE BOTTOM OUTLET.
3- DISCHARGE FROM EACH TURBINE DURING WET TEST AND OPERATION IS CONSIDERED AS 107 M3/SEC FOR 8 HOURS ONLY.
4- FOR THE REMAINING 16 HOURS OF THE DAY BOTTOM OUTLET IS OPERATED AT 22 M3/SEC.
5- DURING IMPOUNDING OF THE RESERVOIR, IN ORDER TO KEEP THE WATER LEVEL AS CONSTANT AS POSSIBLE AT THE PRE-DETERMINED ELEVATIONS FOR MONITORING PURPOSES FOR 7 DAYS THE BOTTOM OUTLET IS OPERATED AT HIGHER DISCHARGES.
6- AFTER COMMENCEMENT OF THE WET TESTS ONCE THE WATER LEVEL REACHES 670 masl, DEPENDING ON THE AVERAGE INFLOW THE RESERVOIR WATER LEVEL IS MAINTAINED AT 710 masl ALLOWING EXCESS FLOWS TO BE DISCHARGED FROM THE SPILLWAY IN ADDITION TO THE POWER PLANT OPERATION AT PEAK MODE (i.e. 8HRS PER DAY) IN SUCH CASE THE BOTTOM OUTLET IS NOT OPERATED.
7- MONITORING PERIODS IN WHICH WATER LEVELS COULD BE HELD CONSTANT ARE HIGH LIGHTED IN BLUE.
8- CROSS HATCHED CELLS EMPHASIZE THE VERY FAST IMPOUNDING OF THE RESERVOIR WHICH IS NOT RECOMMENDED. THEREFORE, COMMENCEMENT OF IMPOUNDING IN THE MONTHS OF JANUARY THROUGH JUNE IS NOT FEASIBLE.
9- ACCORDING TO THE GENERAL WORK PROGRAM THE TIME FORESEEN FOR THE IMPOUNDING OF THE RESERVOIR AND COMPLETION OF THE WET TESTS IS 364 DAYS. START OF IMPOUNDING IN JULY, AUGUST AND SEPTEMBER WILL DELAY THE COMPLETION OF THE PROJECT. THEREFORE START OF IMPOUNDING IN THESE MONTHS IS NOT FEASIBLE EITHER.
10- THE MOST FEASIBLE MONTHS FOR COMMENCEMENT OF IMPOUNDING SEEMS TO BE OCTOBER AND NOVEMBER, AND MAY BE DECEMBER.

Continuous Discharge Solution, Figure 1



Continuous Discharge Solution, Figure 2