CONVERSION OF DEVSARI HEP (252MW) FROM STORAGE TO RUN OF THE RIVER SCHEME ON TECHNICAL, SOCIOECONOMIC AND ENVIRONMENTAL ISSUES

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ABSTRACT:

India ranks third in the world after China, USA and Russia in terms of number of dams. India has so far constructed about 4818 large dams which have provided about 225 BCM of storage. Another 375 large dams with storages of about 63.9 BCM are under construction. Thus, while there is obvious need to construct storage dams for the water resource development of the nation, there is also need to have more number of diversion dams as part of run of the river schemes for optimum development of hydropower.

While on one hand, storage schemes yield multipurpose benefits like irrigation, hydropower, flood and silt control, on the other hand various associated issues like environmental degradation, Resettlement and Rehabilitation and earthquake hazards also need proper attention and solution.

Devsari Hydro Electric Project (DHEP) in Uttarakhand was originally conceived as storage scheme with 90 m high concrete gravity dam having installed capacity and design energy as 300 MW and 856 MU respectively. However, in view of huge submergence involved (522 ha) and other technical and environmental issues, it was modified into a Run of the River (RoR) scheme with much less submergence (82 ha) having 35 m high concrete gravity dam with installed capacity of 252 MW .This paper discusses the various alternatives for arriving at the most optimum solution involving least submergence and maximum power benefits taking into considerations various technical, socio- economic and environmental issues involved.

1. Brief description of Devsari Hydro Electric Project

Devsari HEP is project located in Chamoli District of Uttrakahand having a installed capacity of 252 MW. It is located on River Pinder which originated from Pindari Glacier. It is run-of –the-river scheme with all components except dam and pothead yard, located underground. Its diversion structure 1.75 km downstream of confluence River Pinder and Kailganga is a concrete gravity dam 35 m (from river bed level) high, having five low level sluices to pass design discharge of 6969 cumec and facility for flushing of silt annually. The live storage of the Devsari dam reservoir with FRL at El 1300 m is 9.02 MCM .The reservoir shall also act as desilting basin. The head race tunnel carrying water to the surge shaft is 17.9 km long having 6.9 m diameter designed for discharge of 120.76 cumec. The surge shaft of 21.5 m diameter has a depth of 78 m. It is restricted orifice type. One steel lined vertical pressure shaft, 4.8 m dia having length of 248 m take off from the surge shaft and connect to three units of power plant after trifurcating into 2.77 m dia meter branches .Each of the three units are francis turbine operating under rated head of 230.42 m utilizing a discharged of 120.76 cumec These are

housed in an underground cavern of size 80 m(l)X20m(w)X 39.86 m(h).The layout of the project is shown as Figure 1 below.

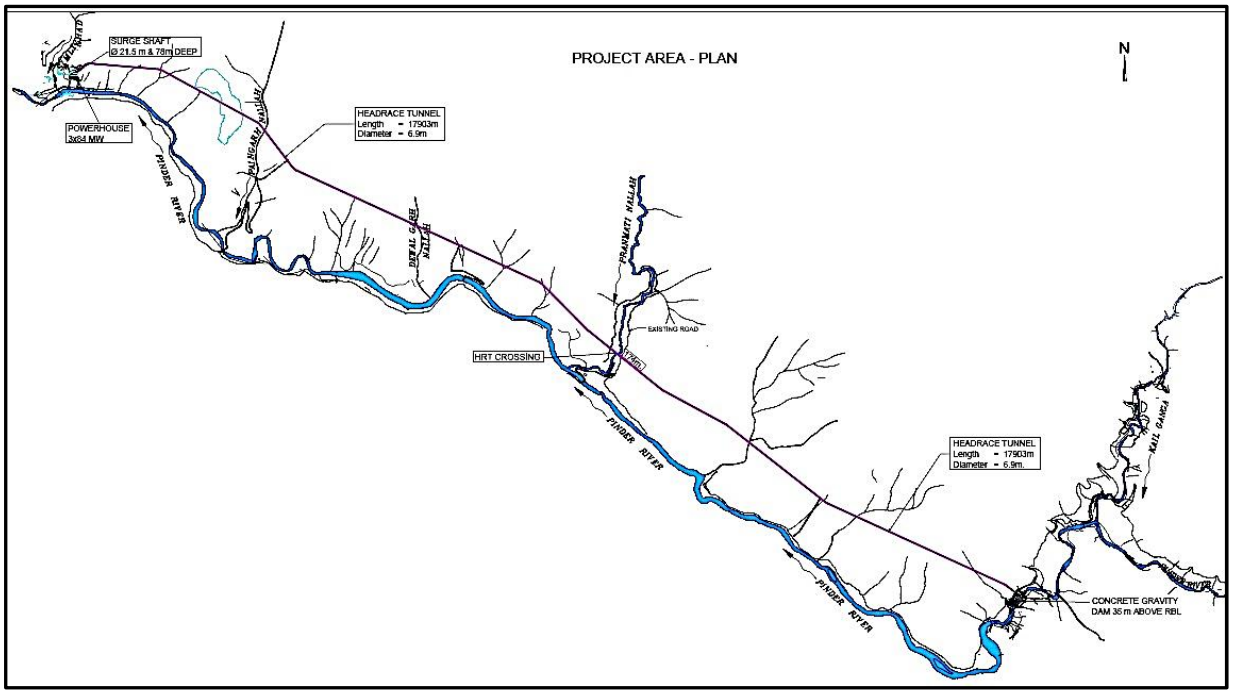

Figure 1: Layout of the Devsari HEP, Uttarakhand

2. Alternative studies Conducted For Conversion From Storage To Run-Of – The River Scheme

Following four alternative studies were carried out taking into consideration Technical, Socio- economic and environmental factors

- **Alternative 1** 90 m high dam at 1.75 km D/S of confluence of River Pinder and Kail Ganga having FRL= El 1370 m with TWL= El 1120 m and HRT Length =12.445 km
- **Alternative 2** 60 m high dam at 1.75 km D/S of confluence of River Pinder and Kail Ganga having FRL= El 1325 m with TWL= El 1120 m and HRT length=12.445 km
- **Alternative 3** 35 m high dam at 1.75 km D/S of confluence of River Pinder and Kail Ganga having FRL = El 1300 m with TWL = El 1120 m and HRT length =12.445 km
- **Alternative 4** 35 m high dam at 1.75 km D/S of confluence of River Pinder and Kail Ganga having FRL =El 1300 m with TWL =El 1046.5 m and HRT length=17.9 km

3. Alternative 1: 90 m high dam at 1.75 km D/S of confluence of River Pinder and Kail Ganga having FRL= El 1370 m with TWL= El 1120 m and HRT Length =12.445 km

a) Technical Considerations

In this alternative, dam is located at 1.75 km D/S from confluence of Pinder river wth Kailgnaga. In the PFR prepared for this alternative ,the installed capacity was 300 MW based on design discharge of 149.37 cumec .However during detailed studies conducted based on the topographical, hydrological and geological data it was found that installed capacity shall be 250 MW with following features given in table -1

Table-1: Features of the Alternative: 1

Components	Detail
Installed Capacity	250 MW
Dam Location	1.75 km d/s of confluence
Dam height	90m -from river bed level
FRL	El 1370m
Gross Storage	192 MCM
Live Storage	83.5MCM
HRT Length	12.445 km
Design Discharge	120.76 cumec
Powerhouse Location	Downstream of Pranmati Nallah
Tail water Level	El 1120 m
Design Energy	890MU

Besides the above factors, feasibility of constructing 90 m high dam at the present locations has been found to be unviable on following consideration:

Geology

Physical inspection of left bank at dam site shows that the river terraces deposits occupied 4-5m above river level almost 100m upstream of dam axis of left abutment. Also, along the dam axis, left abutment is occupied with slope wash materials and thereafter the rock appears to lie under a veneer of debris. The rock exposures are not visible at higher levels which indicate that lot of stripping will be required for the left abutment. The rocks are also traversed by three set of joints i.e., one set parallel to foliation with 2-3 cm opening and another two sets inclined and perpendicular to the foliation. The strike of foliation is northeast-southwest with 50°-60°dip in northwest direction i.e. dipping towards river side.

The right bank occupied by an overburden of 12-15m thick slope wash material below the road level. Above the road level and along dam axis, exposure of augen gneiss/mylonitic gneiss with occasionally pyritiferous muscovite schists and micaceous quartzites with well-developed foliation joints are seen. Rocks are exposed on the right bank of river bed as well as on Debal-Tharali road section which is approximately 88m above the River bed level. The quartzite-

phyllite sequence of rocks exposed at the site strikes N10E°-S10W° and dip 40° towards NW i.e. downstream. The rocks are traversed by few sets of joints.

A thrust is observed near confluence of Kail Ganga and Pinder river and truncated by another fault which is aligned parallel to the Pinder river i.e. NW-SE direction(GSI, Dehradun, 2007).

The Devsari HEP reservoir area is devoid of any lime/calcareous formations of highly previous gravelly material. The ground in this area contains fractured and sheared quartzite/phyllite and schists which are relative permeable. This may result in water loss from the reservoir if water level is increased above an altitude of El 1335m. There are no adverse features for seepage losses from the reservoir below this level.

Hence, the geology of reservoir is not suitable for constructing a dam above El 1335 m, both in Kailganga valley and Pinder valley because of presence of multiple shears and disturbed rock strata. A fault trending NNE-SSW has been noticed along river Kail Ganga (figure-2).

These disturbed strata on saturation with the filling of dam beyond El 1335 m may result in multiple slides and destabilization of both the banks in the reservoir. Since the rock/strata above El 1335m is not water tight and whole area cannot be treated, if water level is increased above El 1335m, this might result in heavy water loss from the reservoir.

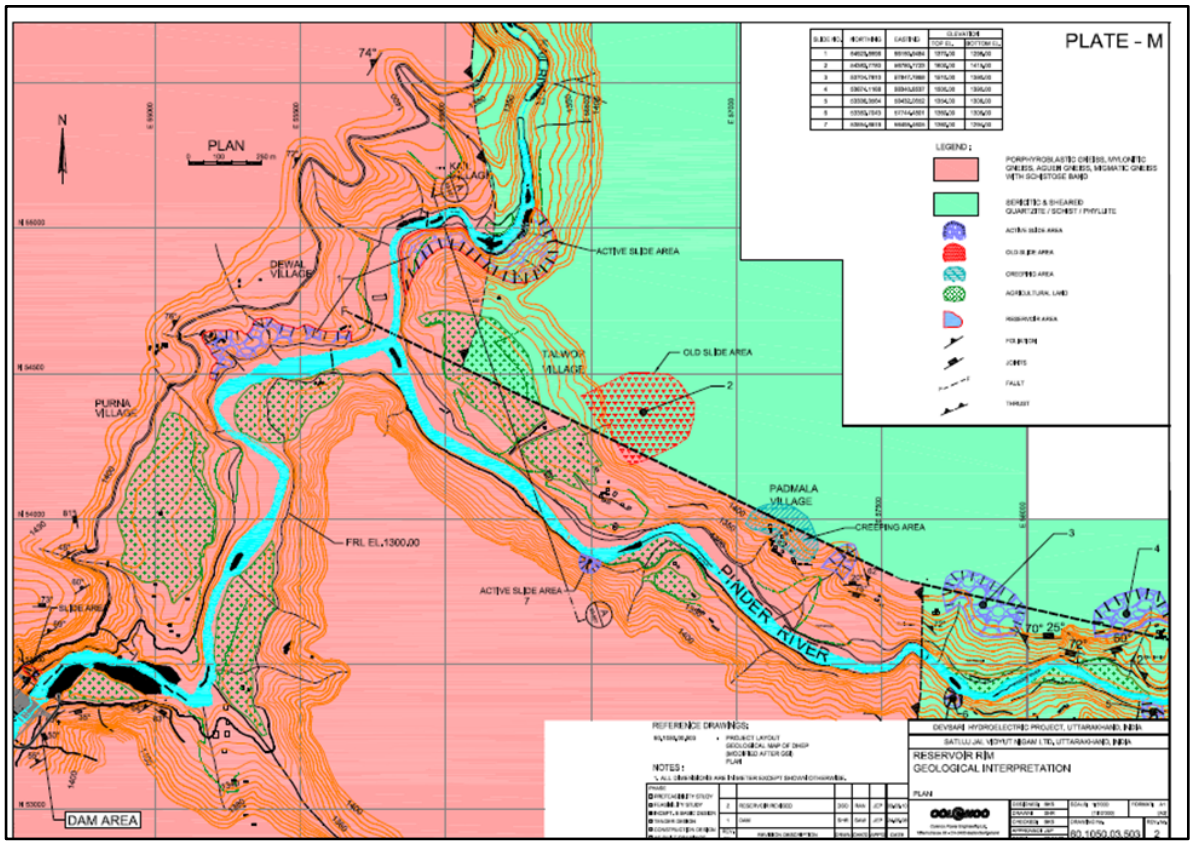

Figure-2: Geological map of the reservoir area

b) Socio-economic considerations

Submergence

The storage scheme with 90m dam height involves large submergence involving 522 ha of total land (203.6 ha of Agriculture Private land, 47 ha of Private scrub land, 182.7 ha of forest land and 88.7 ha of river bed). The list of villages getting submerged is depicted in Table-2, below:

Table-2: List of villages getting submerged

Name of Village	Approx. El	Population (Approx)
Shoding	1285 -1290 m	100-125
Padmalla	1360-1410 m	300-350
Purna	1290-1410 m	800-850
Talore	1350-1390 m	350-400
Sailkhola	1340-1360 m	1650-1750
Boragad	1360-1380 m	450-600
Artha	1350-1370 m	100-150
Jainbist	1340-1370 m	75-100
Deval market	1352-1360 m	1150-1160
Kail	1310-1330m	450-500
Rain	1340-1400 m	300-350
Odar	1340 - 1360 m	850-900
Garsu	1355-1370 m	200-250

According to Table-3, 13 villages having population of approximately 5000 are likely to be submerged/ affected photographs of some of these are depicted below:

Photo1: Padamala Village : El ±1360 to El 1410 m

Photo 2: Saikholla Village: ElL±1340 to El 1360 m

Photo3: Talore village: El±1350 to El 1390 m

Photo 5: Odar Village: El±1340 to El 1360 m

Photo 6: Dewal Market :El ±1360

Besides the above villages, the storage scheme involved submergence of many historical/religious places and public structures such as Main road leading to Deval Market and other villages. This road goes upto the border connecting number of villages on route and is main road being used for Nanda Devi Raj Jat Yatra and Rupkund. , Nanda Devi Temple at Purna,Shiv mandir at Sailkhola village (1346m) ,Shiv Mandir near Devsari bridge ,Devasri Bridge ,Jainbist bridge and road in Kailganga valley, PHC Near Deval, Inter college at Boragaad

The photographs showing the important structures, historical place are below:

Photo7: Historical Nanda Devi temple

Photo 8: Historical Shiv temple

Photo 9: Inter college at Boragaad village

c) Environmental Considerations

The Pinder valley upstream of confluence is full of dense forest consisting of Deodar, Pine, Chir and the protected species viz. Banz Oak (the major species given below). The storage scheme will involve submergence/cutting of more than 20,000 trees. The photo 10 below showing dense forest under submergence area

Photo 10: Dense forest under submergence

d) Discussions on Alternative-1

The studies carried out as mentioned above clearly lead to conclusion that going ahead with a storage scheme having 90m high dam was not feasible from technical, socio-economic and environmental considerations.

4. Alternative 2: 60 m high dam at 1.75 km D/S of confluence of River Pinder and Kail Ganga having FRL= El 1325 m with TWL= El 1120 m and HRT length=12.445 km

a) Technical considerations

In this alternative study dam height has been considered 60m at the same location. With this alternative, the installed capacity of the project works out to 201 MW. Description of the Alternative -2 is shown in Table-3 below:

Table-3: Description of the Alternative 2

Components	Details
Installed Capacity	201 MW
Dam height(from river bed level)	60m
Dam Location	1.75 km d/s of confluence
FRL	El1325m
HRT Length	12.445 km
Design Discharge	120.76 cumec
Powerhouse Location	Downstream of Pranmati Nallah
Tail water Level	El 1120 m
Design Energy	753.36MU

Besides lesser installed capacity, feasibility of constructing 60 m high dam at the present location has been found to be unviable on the grounds explained below:

Geology

As discussed under alternate 1(a), the geology of the reservoir area was still not favorable for the construction of 60m high dam as many shears/discontinuities exposed in the Kailganga valleys around El $\pm$ 1315m on the road to Melkhet near bridge may get activated by the water level of the reservoir resulting in multiple slides and destabilization of left bank of Kailganga river.

b) Socio-economic considerations

Submergence

The scheme with 60m dam height still involves submergence of 220 ha of total land. The list of villages getting submerged is as Table-4 below:

Table-4

Name of Village	Approx. El	Population (approx.)	Families -PAF (approx.)
Shoding	1285-1315 m	750	150
Purna	1290-1410 m	741	153
Kail	1310-1330m	500	100

Besides the above villages, this scheme also involved submergence of historical/religious places and public structures such as: Road leading from Dewal to Melkhet and beyond upto the border connecting number of villages shall get submerged at many reaches on route. PHC at Deval village,Nanda Devi Temple at Purna,Shiv Mandir near Devsari bridge, Devasri Bridge, Jainbist bridge and road in Kailganga valley,PHC Near Dewal.

c) Environmental Considerations

The upstream Pinder valley is full of dense forest consisting of Deodar, Pine, Chir and the protected species viz. Banz Oak (the major species given below). This scheme will still involve submergence/cutting of more than 10,000 trees.

d) Discussions on Alternative-2

The studies carried out as mentioned above clearly lead to conclusion that going ahead with a scheme with 60m high dam was still not feasible from Technical, socio-economic and environmental considerations. Since this scheme still would have involved submergence of religious/historical places and cause social unrest, this alternative was also not considered viable.

5 Alternative 3 — 35 m high dam at 1.75 km D/S of confluence of River Pinder and Kail Ganga having FRL= El 1300 m with TWL= El 1120 m and HRT length=12.445 km

a) Technical Considerations

Feasibility of constructing 35 m high dam at the present location is explained below:

In this alternative study, dam height has been considered as 35m at the same location. With this alternative, the installed capacity of the project works out to 176 MW. Description of the Alternative 3 is shown in table: 5

Table-5: Description of Alternative 3

Components	Details
Installed Capacity	176 MW
Dam height(from river bed level)	35 m
Dam Location	1.75 km d/s of confluence
FRL	El 1300m
HRT Length	12.44 km
Design Discharge	120.76 cumec

Powerhouse Location	Downstream of Pranmati Nallah
Tail water Level	El 1120m
Design Energy	646 MU

Geology

The geology of the reservoir area with a 35m high dam was found favorable for the construction as most of the shears/discontinuities exposed in the Pinder and Kailganga valleys are above El 1315m.Whereas with 35 m high dam, the FRL remains at El 1300m as such and there is no chance of the shears/discontinuities getting charged by the reservoir level. On inspection from left bank of the Pinder river, it was noticed that rock is exposed upto the level of ± 1300m on right bank and chances of water loss from the reservoir is negligible.

b) Socio-economic considerations

Submergence

The storage scheme with 35 m dam height involves minimum submergence of 82 ha of total land including 12 ha of Agriculture Private land, 70 ha of forest land. Only a part of Shoding village involving 26 families is being displaced. This scheme does not involve submergence of any historical/religious places and public structures.

c) Environmental Considerations

This scheme involves cutting of only about 2000 trees in submergence area which is much less than alternative No 1& 2.

d) Discussions on Alternative-3

The studies carried out as mentioned above lead to conclusion that going ahead with 35m high dam involved minimum submergence and hence was most viable dam height from Technical socio economic, and Environmental aspects.

However, another alternative was considered to optimize energy generation discussed here under as Alternative No 4 , in which power House has been shifted further downstream..

6. Alternative 4 — 35 m high dam at 1.75 km D/S of confluence of River Pinder and Kail Ganga having FRL= El 1300 m with TWL= El 1046.5 m and HRT length=17.9 km

a) Technical considerations

In this alternative study dam height has been considered as 35m at the same location but PH has been shifted downstream from the original location to Simli gad. With this alternative, the installed capacity of the project works out to 252 MW . Description of the alternative -4 is shown at table-6:

Table-6: Description of the alternative 4

Components	Details
Installed Capacity	252 MW
Dam height	35m -from river bed level
Dam Location	1.75 km d/s of confluence
FRL	El 1300 m
HRT Length	17.903 km
Design Discharge	120.76 cumec
Powerhouse Location	Upstream of Simli Gaad
Tail water Level	El 1046.45m
Design Energy	937 MU

Besides higher installed capacity, feasibility of constructing 35 m high dam at the present location has been found to be viable on the following grounds :-

Geology

The geology of the reservoir area was favorable for the construction of 35m high dam as most of the shears/discontinuities exposed in the Pinder and Kailganga valleys are above El 1315m. The FRL with a 35 m high dam comes as El 1300 m which is well below the expected shears/discontinuities and there is no chance of charging of discontinuities by the reservoir level. On inspection from left bank of the Pinder River, it was noticed that rock is exposed upto the level of + El1300m and chances of water loss from the reservoir is negligible.

b) Socio-economic considerations

This scheme with 35 m dam height involves submergence of only 82 ha of total land including 12 ha of Agriculture Private land, 70 ha of forest land. Only part of Shoding village involving 26 families is being displaced. This scheme does not involve submergence of any historical/religious places and public structures.

c) Environmental Consideration

This scheme involves cutting of only about 2000 trees in submergence area, which is much less than Alternative 1& 2.

d) Discussions on Alternative-4

The studies carried out with 35m high dam, as mentioned above, clearly lead to conclusion that minimum submergence is involved and hence was most viable dam height from Technical, Socio-economic, and Environmental aspects.

7. Comparison of various alternatives

The comparison of the storage and RoR alternatives is summarized below

Table 7: Comparison of various alternatives

Details	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Location	1.75 km d/s of confluence	1.75 km d/s of confluence	1.75 km d/s of confluence	1.75 km d/s of confluence
Dam Height	90 m	60 m	35 m	35 m
FRL	El 1370m	El 1325m	El 1300m	El 1300m
MDDL	El 1355m	El 1310m	EL 1295m	El 1295 m
Gross Storage	192MCM	65.32 MCM	9.02 MCM	9.02MCM
Live Storage	83.5 MCM	28.64 MCM	3.21 MCM	3.21 MCM
HRT Length	12.445 km	12.445 km	12.445 km	17.9 km
Design Discharge	120.76 cumec	120.76 cumec	120.76 cumec	120.76 cumec
Powerhouse Location	D/s of Pranmati Nallah	D/s of Pranmati Nallah	D/s of Pranmati Nallah	Near Simli gad
Installed capacity	250 MW	201 MW	176 MW	252 MW
Tail water level	El 1120m	El 1120m	El 1120m	El 1046.5 m
Design Energy	890 MU	753.60 MU	646 MU	937 MU

8. Location upstream of Confluence of river Pinder and Kail Ganga

In addition to above alternative location upstream of the confluence was also studied taking into consideration technical, socio economic, environmental angle.

Considering the above aspects, it was not feasible and viable to construct a high dam upstream of confluence on Pinder river upto Milikhet Village. Kailganga water will not be available for use and will remain unutilized. The available design discharge would be only about 87 cumec due to deduction of Kail ganga discharge which contribute 30% of discharge to the Pinder river below the confluence. With this design discharge and keeping the design head same as in the PFR, the installed capacity would be further reduced to 145 MW. With reduced inflows, it would have been uneconomical to construct a storage dam

9. Discussions and Conclusion

Keeping in view the various technical, Social-economic and Environmental considerations and views of GSI **"Alternative 4"** with 35 m high concrete dam having 17.9 km long HRT was considered for adoption and implementation. The installed capacity of the project shall be 252 MW and design energy of 937 MU .The submergence involved shall only be 82 ha with only 26 families of one village getting displaced.

10. References:

i. *Geological note on the "Different alternative studies of Devsari Hydroelectric Project" by Geological Survey of India vide letter No 6079/34/EPE/GSI/ND/2012 dated 06/03/2012*

ii. *Minutes of third meeting of the Standing Technical Committee (STC) on "Conversion of storage scheme to RoR scheme of CEA, CWC, MoEF and the state Government".(vide letter No 4/7/2012-HP&I/511-524 dated 11/05/2012).*

iii. *Report on studies conducted by SJVN Ltd on "Conversion of Storage scheme to RoR scheme "as per observations of Standing Technical Committee(STC) submitted to CEA vide letter no SJVN /DHEP/CEA/11-239-241 dated 07/12/2011.*