Cascaded Hydroelectric Power Plant at Narmada River Calculate Water Traveling Time Using HEC –RAS and Arc GIS and HEC Geo RAS

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***ABSTRACT*: -** *The hydroelectric plant is located in the Cascade bloc on the Narmada River, must be operated and short-term planning is a very difficult task for any operational authority. In this document, three basic software were used: Hydrological Engineering Center - River Analysis Systems (HEC-RAS) and Arc GIS and HEC Geo RAS. Temporary programming of the cascade hydroelectric scheme means water discharge, water storage and spillage for each tank 'J' in all programming periods (for 24 hours) to minimize deviations between load demand and generation. to find out. Subject to restrictions. Particle Swarm Optimization (PSO) and its alternatives have successfully utilized to resolve this difficulty. We need to continuously compute the distance among power plants and waterways. The travel time between RABS and ISP is 58 hours, ISP 9 hours in OSP, OSP 9 hours in MSP and MSP 51 hours in SSP. These representations utilized for the problem of optimization of cascading hydraulic programming.*
Keywords:* *HEC-RAS, Arc GIS, HEC-Geo-RAS, RBPH, CHPH.

1. INTRODUCTION

As traditional fossil fuels run out and electricity use keeps climbing, the power industry is feeling the pressure. People in the field are searching for cleaner energy sources, better efficiency, and smarter technology to keep up—and to ease environmental worries. Within the Indian context, thermal generation dominates the electricity production mix compared to hydropower generation—a scenario that proves problematic given climate change challenges and finite energy resource availability.
Out of total hydro power plant installed capacity in Madhya Pradesh 4448 MW major portion i.e. 3533 MW are located at Narmada River. Out of Five major projects located at River in cascade fashion three projects are having huge hydraulic coupling, hence this thesis will determine the proper operation policy or optimal generation scheduling of these hydro power projects so that the water resources of the river can be effectively utilized. The water flow in the Narmada River at the height about 1100 meter and river bed of Narmada as shown in figure1.

Figure 1. Diagram of Narmada River bed

Narmada River is the main source of power generation in the state. The creation of reservoir in series contemplates for the development in the Valley of Main River. Developed Narmada cascaded hydroelectric system is a step in this direction to effectively utilized the water resources of the river. Narmada cascaded hydroelectric system in India includes five major hydro projects at the upper, middle and lower basin of river starting from Rani Avanti Bai Sagar (RABS) located in Madhya Pradesh to terminating at Sardar Sarovar (SSP) in Gujarat as shown in the location diagram Figure. Between RABS to SSP there are three other projects namely Indira Sagar (ISP), Omkareshwar (OSP) and Maheshwar (MSP).
The hydroelectric installations referenced above incorporate River Bed Power Houses (RBPHs), whose technical parameters are documented in the tabular format associated with the river's right bank location. Throughout the Narmada River basin, the enumerated hydropower facilities operate as multi-objective schemes, fulfilling dual requirements of

agricultural water supply and electrical energy production. To harness the hydraulic energy inherent in water discharged via irrigation distribution systems from these installations, Canal Head Power Houses (CHPHs) have been either operationalized or remain in progressive phases of construction and implementation.

Development of these low head small hydro projects on the existing irrigation canals provide the energy benefits and play a considerable role in local area development. In CHPHs power is generated throughout the day as per requirement of water. As there is no pond to store the daily requirement of irrigation hence it is not possible to operate these plants as peak station. CHPHs will not utilize all the irrigation releases for power generation due to the technical difficulties. Power house has been designed for minimum and maximum releases. Beyond maximum release water is by passed via irrigation outlet.

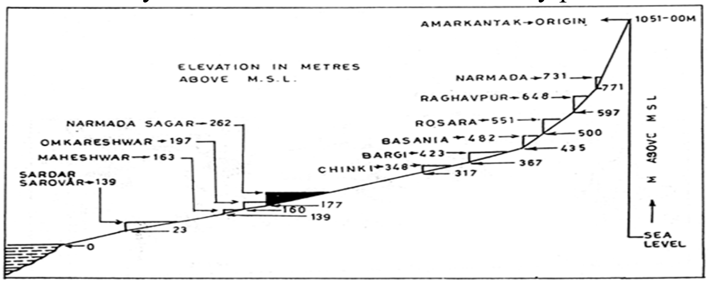

Figure 2. Hydro project At Narmada River in Cascade Fashion

Out of above five major RBPH' s all are in operation except Maheshwar hydro power plant as it is under construction owned by S. Kumar limited. The Share of utilizable flow among the party states shown in table 1.

Table 1. Share of utilizable flow among the party states

S. no.	Party state	Ratio	MCM	Maf
1	Madhya Pradesh	73.2/112	16979	13.7637
2	Gujarat	35.3/112	8375	6.7878
3	Rajasthan	2.2/112	468	0.3778
4	Maharashtra	1.3/112	232	0.1895
	Total	112/112	26054	21.1188

Table 2. Share of state in power Generation and water

Party state	Share of Party state	
	Power from SSP (%)	Narmada water at SSP (MAF)
Madhya Pradesh	57.2	18.28
Gujarat	16.5	9.36
Rajasthan	26.3	0.29
Maharashtra	-	0.80
Total	100	28.73

2 Hydrologic Engineering Center - River Analysis System

HEC-RAS represents a numerical modeling platform developed for analyzing hydraulic behavior in natural watercourses, riverine systems, and unconfined flow conduits. Initial software iterations preceding Version 5.0.1 employed one-dimensional computational frameworks that inherently excluded direct representation of hydraulic phenomena arising from cross-sectional geometry variations, meandering configurations, and multi-dimensional flow dynamics. When Version 5.0.1 came out, it was a big step forward. HEC-RAS software goes far beyond simple hydraulic calculations. It enables two-dimensional hydrodynamic modelling and sediment transport analysis, making it an indispensable tool for investigating rivers and floodplains. Developed by the Hydrologic Engineering Centre (HEC) in Davis, California, HEC-RAS provides engineers with an effective method for analysing water movement in natural and man-made watercourses and for accurately identifying flood hazard zones.

The software is frequently used to predict potential water levels in open channels a crucial aspect of flood management, urban planning, and insurance assessment. Furthermore, HEC-RAS facilitates the evaluation and design of hydraulic structures such as bridges, culverts, and levee systems, and assists engineers in redesigning or optimizing waterways to improve safety and efficiency.

One of the key advantages of HEC-RAS is its free access: The software can be downloaded free of charge from the official HEC website, allowing professionals and researchers unrestricted use. The platform is also reviewed by experts and continuously updated, ensuring its scientific credibility and technical reliability. Furthermore, a global community of certified experts actively contributes by providing support, exchanging ideas, and even developing customized extensions or functional improvements. This makes HEC-RAS not only a powerful tool but also a collaborative engineering ecosystem.

Conversely, certain operational constraints exist; practitioners may experience computational convergence challenges during transient flow analyses, especially within high-gradient or rapidly varying hydraulic environments. Nonetheless, judicious model configuration and calibration procedures can frequently ameliorate such numerical difficulties.

We have start first to open Arc map 10.2 software, in this software to first to download a digital elevation model (.dem) file, this image was satellite to capture a respective image we have to required.

Double click on icon of Arc Map 10.2 and following a step.

Step 1) Open new Project file: - In this step to create a new project file.

Step 2) Add new .dem file and Open tin file and go to arc toolbox, click on 3D analyst tools, click on conversion, click on raster to TIN

Step 3) Initially, the TIN file is loaded into the system, after which the RAS Geometry interface is accessed to establish a new RAS layer. This layer facilitates the delineation of the primary watercourse alignment. The flow path configuration incorporates three distinct line classifications: the central channel axis, left floodplain boundary, and right floodplain boundary. These designated flow path trajectories serve a critical function in computing longitudinal distances along the downstream direction between successive cross-sectional profiles in both the principal channel and the peripheral floodplain zones.

Step 4) Click on RAS Geometry and go for create RAS layer, open stream centerline.

Step 5) Click on RAS Geometry and go for create RAS layer, open bank lines.

Step 6) Click on RAS Geometry and go for create RAS layer, open flow path centerline.

Step 7) Click on RAS Geometry and go for create RAS layer, open XS cut lines.

Step 8) Click on RAS Geometry and go for open stream centerline Attributes and go for ALL.

Step 9) Click on RAS Geometry and go for open XS cut lines Attributes and go for ALL.

Step 10) Click on RAS Geometry and go for create RAS layer setup

Step 11) Click on RAS Geometry and go for Export RAS Data

The RAS Geometry component delivers functionality for preliminary geospatial data preparation necessary for HEC-RAS hydrodynamic computations. In contrast, the RAS Mapping component supports subsequent processing of HEC-RAS computational outcomes, permitting the development of inundation extent cartography and geospatial representation of modeling outputs.

3. Viewing the Results

In test system has used in five major hydro power plant located in Narmada River. We have calculated the distance between RABS to ISP such about 494.5 km and water discharge average velocity of between respective plant is 1.39m/sec. then calculated the time traveling 54.48 hours. Such the distance between ISP to OSP such about 39.5 km and water discharge average velocity of between respective plant is 1.11m/sec. then calculated the time traveling 9.37 hours. The distance between OSP to Mandleshwer project such about 47.1 km and water discharge average velocity of between respective plant is 1.42 m/sec. then calculated the time traveling 9.22 hours. The distance between Mandleshwer project to SSP such about 223 km and water discharge average velocity of between respective plant is 1.19 m/sec. then calculated the time traveling 51 hours.

Table 3. Calculate water traveling time between respective hydro power plant

	RABS to ISP	ISP to OSP	OSP to mandleshwer	Mandleshwer to SSP
Distance(m)	494592.306 Meter	39524.714 Meter	47136.75 Meter	222926.8 Meter
Time(Hours)	54.48 Hours	9.37 Hours	9.22 Hours	51 Hours

Once the calculations finish, the software gives you a bunch of ways to look at your results. You can check out cross-section views, long profiles, detailed profile plots, stage-discharge curves, and even 3D views. If you need the numbers, you can pull up tables for single cross-sections or summaries for groups of sections.

Table 4. View Summary output table of the river

Reach	River Sta	Profile	(cfs) Q Total	(ft) Min Ch El	(ft) W.S. Elev	(ft) E.G. Elev	(ft/ft) E.G. Slope	(ft/s) Vel Chnl	(sq ft) Flow Area	(ft) Top Width
osp	9.565061	PF 1	10	524.28	795.39	795.4	0.028641	0.72	14.86	0.07
osp	8.959977	PF 1	10	534.06	795.39	795.4	0.02964	0.8	14.48	0.07
osp	8.371964	PF 1	10	550.39	795.39	795.4	0.034123	0.86	13.53	0.07
osp	7.797929	PF 1	10	564.01	795.39	795.39	0.019939	0.69	14.43	0.07
osp	7.710052	PF 1	10	537.01	795.39	795.39	0.027194	0.75	14.95	0.07
osp	7.135771	PF 1	10	524.38	795.39	795.39	0.023302	0.68	14.67	0.07
osp	5.978624	PF 1	10	495.77	795.39	795.39	0.01938	0.62	16.14	0.07
osp	5.388348	PF 1	10	572.05	795.38	795.39	0.031088	0.86	13.45	0.07
osp	4.909687	PF 1	10	507.84	795.38	795.39	0.015064	0.58	17.12	0.07
osp	4.265243	PF 1	10	568.31	795.38	795.39	0.028459	0.8	14.52	0.07
osp	3.778181	PF 1	10	506.66	795.38	795.39	0.044141	0.73	13.37	0.07
osp	3.333799	PF 1	10	556.2	795.38	795.39	0.029424	0.8	14.15	0.07
osp	3.041286	PF 1	10	541.57	795.38	795.38	0.029073	0.78	14.52	0.07
osp	2.079197	PF 1	10	507.32	795.38	795.38	0.026004	0.72	15.77	0.07
osp	0.165704	PF 1	10	737.47	795.12	795.36	0.9867	3.89	2.57	0.06
osp	0.157907	PF 1	10	500.46	795.27	795.29	0.065582	0.9	11.12	0.06
osp	0.150463	PF 1	10	600.53	795.21	795.28	0.570177	2.03	4.93	0.03
osp	0.145582	PF 1	10	503.97	795.24	795.26	0.070279	0.92	10.84	0.06
osp	0.140043	PF 1	10	493.64	795.24	795.25	0.033577	0.82	14.24	0.07
osp	0.133391	PF 1	10	509.97	795.24	795.25	0.039403	0.78	12.79	0.07
osp	0.126683	PF 1	10	503.38	795.23	795.25	0.176497	1.2	9.02	0.06
osp	0.119872	PF 1	10	528.35	795.22	795.24	0.145276	1.19	8.42	0.06
osp	0.113376	PF 1	10	512.43	795.22	795.24	0.131649	1.04	9.77	0.06
osp	0.107324	PF 1	10	500.46	795.22	795.23	0.02497	0.7	15.94	0.07

osp	0.101574	PF 1	10	521.36	795.22	795.23	0.027269	0.71	14.05	0.07
osp	0.065284	PF 1	10	559.25	795.22	795.23	0.031464	0.83	13.76	0.07
osp	0.014708	PF 1	10	578.41	795.22	795.23	0.03001	0.84	13.49	0.07

4. Concussion

This research paper digs into water flow data from a hydroelectric project on the Narmada River. This three software's used innovative software tools such as ArcGIS, HEC-RAS, and HEC-Geo RAS to investigate the water flow within the reiver in accurate and real-time.

1)These tools precisely tracked the direction and speed of water flow, and consistently estimated the time it takes for water to flow through the dam. This progression allowed for the control and adjustment of electrical energy generation according to demand. Furthermore, instead of simply discharging excess water, it was efficiently operated to ensure additional electrical energy generation, resulting in more unchanging and well-organized electrical energy supply.

2)GIS-based hydraulic modeling not only provides numerical results but also provides detailed spatial information, enabling in-depth studies of specific locations. This is followed by data collection and setup in HEC-Geo RAS, hydraulic calculations in HEC-RAS, and finally, visualization and analysis of the results in ArcGIS.

3)The steady flow calculations used in HEC-RAS are based on the traditional step-backwater method, which is the standard procedure for determining water surface profiles. Following this method minimizes the possibility of common errors in modeling and increases the accuracy of the results.

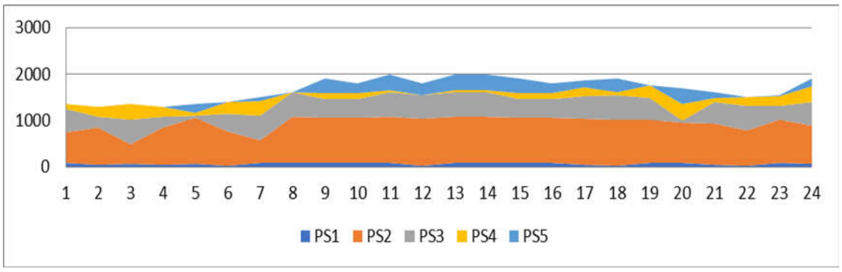

Figure 3. In Case 1, the DED-PSO method successfully optimized energy generation across all riverbed powerhouses of the NCHES system.

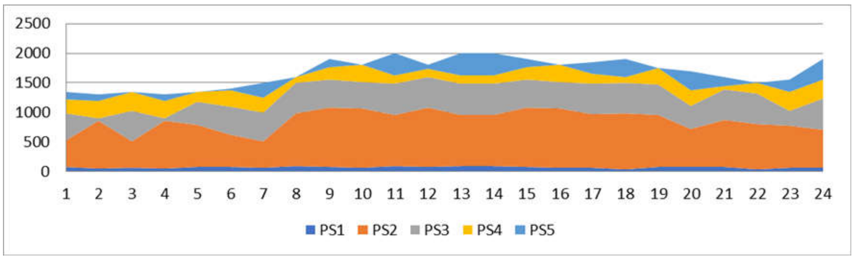

Figure 4. In Case 1, the NSAIW PSO method successfully optimized energy generation across all riverbed powerhouses of the NCHES system.

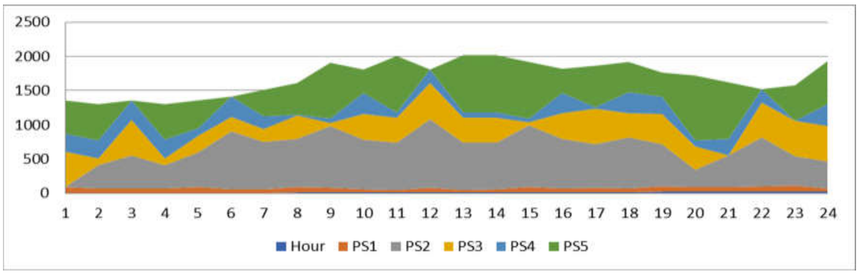

Figure 5. In Case 1, the TVAC-PSO method successfully optimized energy generation across all riverbed powerhouses of the NCHES system.

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