BEFORE THE NATIONAL GREEN TRIBUNAL,
(PRINCIPAL BENCH) NEW DELHI

ORIGINAL APPLICATION NO. 988 OF 2018

IN THE MATTER OF:

Dr. Balkrishna A. Shelar ... Applicant

Versus

State of Maharashtra & Ors. ... Respondents

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Executive Engineer,
Kolhapur Irrigation Division (North)
Kolhapur.

Kolhapur Irrigation Department
Through its Principal Secretary,
State of Maharashtra
Having Office at:
Kolhapur Irrigation Division (North)
Sinchan Bhawan, Tarabai Park,
Kolhapur – 416003

Date:18.02.2020
Place: New Delhi

STATUS REPORT BY THE KOLHAPUR IRRIGATION DEPARTMENT, STATE OF MAHARASHTRA, IN COMPLIANCE OF THE ORDER DATED 27.09.2019 PASSED BY THE HON'BLE NATIONAL GREEN TRIBUNAL, IN ORIGINAL APPLICATION NO. 988/2018

1. This Hon'ble Tribunal on a letter addressed by one Dr. Balkrishna A. Shelar treated the same as an Application bearing O.A. No. 988/2018 under section 14 of the National Green Tribunal Act, 2010 raising an issue pertaining to the pollution of River Panchganga in District Kolhapur, Maharashtra on account of illegal construction due to the builder-government nexus. This Hon'ble Tribunal vide its order dated 03.01.2019 directed the Maharashtra Pollution Control Board and the District Magistrate, Kolhapur to submit an action taken report before this Hon'ble Tribunal.

2. In pursuance thereof, the O.A. No. 988/2018 was listed before the Hon'ble Tribunal for hearing on 05.04.2019, wherein this Hon'ble Tribunal directed the Additional Chief Secretary, Urban Development, the State of Maharashtra to oversee remedial action and ensure that the polluting activities are discontinued. The Hon'ble Tribunal also directed the Municipal Commissioner of the Kolhapur Municipal Corporation to remain present in person with the compliance report.

3. The Hon'ble Tribunal, further considered the matter on 27.09.2019 and directed the Irrigation Department to complete the process of demarcation of the 'red' and 'blue' lines within one month and furnish its compliance report through the Principal Secretary, Irrigation Department by email within one month. Thus, in terms of the direction dated 27.09.2019, the Irrigation Department was directed to complete the demarcation of the red and the blue line within one month from

27.09.2019. Accordingly, the Kolhapur Irrigation Department, State of Maharashtra in compliance of the order dated 27.09.2019 submits as follows:

a) The Western Zone Bench of this Hon'ble Tribunal in O.A. No. 25/2014 vide its order dated 27.03.2015 had directed that the finalization of the blue and red flood line was the duty of the Water Resource Department, Government of Maharashtra. The copy of the order dated 27.03.2015 passed by the Hon'ble Tribunal in O.A. No. 25/2014 is enclosed herewith as **ANNEXURE A-1**.

b) Thereafter, the Water Resource Department directed that the technical circular and guidelines published by the Executive Director, MERI, Nasik, vide DSO/PB-4/1582 dated 16.11.2015 were to be implemented. Also, the guidelines for flood estimation report for Krishna and Peener Sub-zone -3(h)(revised) September, 2000 published by the Central Water Commission were also available.

c) The first phase of marking a blue and red line included demarcation of flood line along the river Panchganga and its tributaries and the said work included a distance of 16.30 kms from Shivaji Bridge to the National Highway Bridge. The work was entrusted to Sarathi Engineers, Pune and the same was accepted vide Tender No. B-1/SE/4 for the year 2016-17. The survey of the flood prone area was done by using DGPS Technology as recommended by the Government for which reference level of GTS Branch of the Public Works Department was taken.

d) Subsequently, relying on available data of the *'Sarita Mapan Kendra'* and by using the Gumbell's method as per the guidelines published by

the Executive Director, MERI, Nasik, vide DSO/PB-4/1582 dated 16.11.2015, flood frequency analysis was done for the 16.30 kms stretch of the Panchganga River. On the basis of the such hydrological study, a 25 years and 50 years floodline was finalized and confirmed.

e) Thereafter, on 29.04.2019, the Kolhapur Irrigation Division submitted the report of the Commutation of HFL and hydraulic study of River Panchganga and its tributaries to the Indian Institute of Technology, Bombay, Powai for verification of the flood values and inundation levels (blue and red lines) along the selected segments of these rivers corresponding to 25 and 100 years return periods. The Indian Institute of Technology, Bombay, Powai, by a report dated 18.05.2019 confirmed the results of the flood analysis undertaken by the Water Resource Department along with M/s Sarathi Engineers. The copy of the report dated 18.05.2019 of the Indian Institute of Technology, Bombay, Powai is enclosed herewith and marked as **ANNEXURE A-2**.

f) Thus, in terms of the report dated 18.05.2019, the Indian Institute of Technology, Bombay, Powai had approved the results of the flood analysis and had found the procedures adopted by the Water Resource Department in order. Thus, as on 18.05.2019, the flood and inundation levels (red and blue line) computed by the Water Resources Department along with M/s Sarathi Engineers, Pune were in place. The blue and red lines therefore were demarcated as on 18.05.2019 for River Panchganga and its tributaries.

g) On 07.06.2019, the Kolhapur Irrigation Division vide its letter bearing 3054 sent the Commutation of HFL and hydraulic study of River Panchganga and its tributaries for demarcation of blue and red line

with detailed block contour survey along with the IIT Bombay report to the Chief Engineer, Water Resource Department for further directions.

h) Unfortunately, during the monsoon of 2019 there were heavy floods in the city of Kolhapur in the month of August, 2019. Until 2019, the data recorded showed that the highest flood situation witnessed was in the year 2005 having flood level of 1.85 mtrs. However, the floods witnessed during the monsoons of 2019 were highest recorded in 31 years and the flood level in 2019 was 6 feet more than the levels of the flood in the year 2005. The demarcation and the inundation levels computed which were approved by the IIT, Bombay were in May, 2019 and had not considered the levels witnessed due to floods during the monsoon of 2019.

i) In terms of the flood levels rising during the monsoon of 2019, it was decided to restudy the flood lines accordingly. Thus, all the data with regard to the flood discharge was taken into consideration from the year 1979 to 2019. In terms thereof, an improvised flood discharge was taken into account by using Regression Analysis (By Gumbell method) for 25 years and 100 years.

j) In furtherance of the unlikely event of the heavy floods during the monsoons of August, 2019, the Water Resources Department directed M/s. Sarathi Engineers to conduct hydrological study and demarcation of the blue and red line by determining the floodline for the rivers viz. Bhogavati (5 kms), Panchganga (15 kms), Dudhganga (5 kms), Tulsi (3 kms), Dhamani (3 kms) and Kumbhi (5 kms) along with determining the flood discharge level of the river Panchganga. The

said study also included the stretch of 16.30 kms of the river Panchganga. The said study was carried out by M/s. Sarathi Engineers from 12.09.2019 to 15.11.2019. While conducting the said study, the members of Sarathi Engineers, Pune adopted the HEC-RAS simulation methodology for computation of blue line and flood line for River Bhogawati, Panchganga, Doodhganga, Tulshi, Dhamani and Kumbhi. For the purpose of commutation of the flood discharge, flood frequency method mentioned in the technical circular and guidelines, published by the Executive Director, MERI, Nasik vide DSO/PV-4/1582 dated 16.11.2015 was adopted. Central Water Commissions, hydrological stations at Terwad, Tal: Shirol, Dist: Kolhapur on River Panchganga at downstream of point of consideration of calculation of flood line. A flood discharge data at this station was available from the year 1979-2019 which was extracted from the India Wris website. Accordingly, the catchment area was computed and by regression, analysis, values of flood at required points were computed. The Chief Engineer, Water Resource Department, Pune has approved the flood discharge values on 27.11.2019. the values are as below:

River	Reach of calculation	Catchment Area Sq. Km.	1:25 flood Discharge		1:100 flood Discharge	
			C (Coefficient)	Discharge Cumecs	C (Coefficient)	Discharge Cumecs
Panchaganga	Terwad	2425	69.73	3434	88.44	4355
	Prayag Chikhali	1126.03	69.73	2340	88.44	2968
	Shivaji Bridge	1788.93	69.73	2949	88.44	3740
	National Highway	1938.52	69.73	3070	88.44	3894

The copy of the Technical Note on the Commutation of Blue and Red Flood Line and Hydraulic Study of selective portion of River Panchganga with detailed block contour survey is enclosed herewith as **ANNEXURE A-3**.

k) Furthermore, on 27.11.2019, the Kolhapur Irrigation Department sent a letter bearing No. 6208 to the Water Resources Department seeking permission to carry out a hydrological study and demarcate the blue and red line by determining the floodline for the rivers viz. Bhogawati, Panchganga, Dudhganga, Tulsi, Dhamani and Kumbhi and also to determine the discharge level of the river Panchganga.

l) The Water Resources Department replied to the letter of the Kolhapur Irrigation Department No. 6208 on 27.11.2019 whereby it was informed that hydrological study and demarcation of the blue and red line by determining the floodline for the rivers viz. Bhogavati (5 kms), Panchganga (15 kms), Dudhganga (5 kms), Tulsi (3 kms), Dhamani (3 kms) and Kumbhi (5 kms) along with determining the flood discharge level of the river Panchganga is already being conducted by M/s. Sarathi Engineers. The said study also included the stretch of 16.30 kms of the river Panchganga. It was informed by the Water Resources Department that the inundation levels as determined by M/s. Sarathi Engineers were correct. Vide the said letter dated 27.11.2019, the Water Resources Department accepted the flood discharge levels as derived by M/s. Sarathi Engineers on the basis of the 25 year and 100 year flood line subject to certain recommendations suggested to the Kolhapur Irrigation Department for the demarcation of the Blue and Red line along the river

Panchganga. The copy of the letter dated 27.11.2019 issued by the Water Resources Department, Pune, Maharashtra to the Kolhapur Irrigation Department is enclosed herewith and marked as **ANNEXURE A-4**.

m) According to the study conducted by M/s. Sarathi Engineers using the DGPS technology and HEC-RAS methodology, the obtained contour of the river and other related information, the red and blue line came to be demarcated on the maps. The said Hydraulic Study of selective portion of River Panchganga was further sent for vetting to the IIT, Powai, Bombay vide a letter dated IIT Bombay ProjectNo. DRD/CE/MCD-14/19-20 which were vetted and replied on 29.11.2019 as suggested by the Water Resources Department in its letter dated 27.11.2019. The scope of the study before the IIT, Mumbai was to verify the flood and inundation level computations blue and red lines of the river stretches submitted by the Kolhapur Irrigation Department, Maharashtra whereby the flood and water level calculations were made by M/s. Sarathi Engineers, Pune. The Flood events under consideration were '1 in 25 years' and '1 in 100 years'. The IIT Bombay concluded its report by observing that in light of the available hydrological information, the procedures followed as well as the methods adopted and the parameters selected were as per common engineering practice and judgment and therefore were found to be in order. The IIT, Bombay therefore, confirmed the results of the flood analysis given in the attached report. The copy of the Report filed by the IIT, Powai, Bombay of the Consultancy Project

Titled: Verification of Flood Calculations for Rivers Panchganga is enclosed herewith as **ANNEXURE A-5.**

n) Presently, a study has been conducted with regard to the stretch of 16.30 kms of the Panchganga River, however during the study it was realized that there exists a bridge of the National Highway at S. No. 16/100 forming a part of the said stretch of 16.30 kms of the Panchganga River and there being a debris on the sides under the bridge, it has affected in the natural flow of the river Panchganga which therefore affects the flow of the river at S. No. 14/600. It is therefore imperative that a detailed independent survey be conducted with regard to the flood line from S. No. 14/600 and a study of flow characteristics has to be conducted for the remaining stretch of 16.30 kms. Therefore, the floodline for the stretch of 14.60 Kms. of river Panchganga has been already submitted, however, the study with regard to the remaining stretch of the river Panchganga has to be freshly considered.

o) The 1:5000 map depicting the Kolhapur City and adjoining villages came to be prepared and the demarcation of the blue and red line has been done on the said map. It is pertinent to mention that considering the major floods of the year 2019, that occurred in the month of August, which was more than 100 years flood line, the Kolhapur Irrigation Department has also demarcated a Green Line on the 1:5000 map. The demarcated floodline was then affirmed by the Executive Engineer and Superintending Engineer after surveying the river Panchganga. Accordingly, demarcation of Blue and Red line in terms of 25 and 100 years floodline was accepted subject to certain

conditions. The copy of the letter dated 04.12.2019 bearing No. 5080 of 2019 written by the Chief Engineer, Water Resources Department, Pune, to the Superintending Engineer, Kolhapur Irrigation Department accepting the demarcation of blue and red line in the catchment area of River Panchganga is enclosed herewith as **ANNEXURE A-6.**

p) Furthermore, the Kolhapur Irrigation Department wrote a letter dated 07.12.2019 to the Commissioner, Municipal Corporation, Kolhapur stating that the demarcation of the blue and red line for the river Panchganga has been approved by the Water Resources Department, Pune and have been incorporated in the map in 1:5000 proportion. The Commissioner, Municipal Corporation, Kolhapur has also been informed that considering the floods of August, 2019, a green line was also demarcated along the river Panchganga. The Commissioner, Municipal Corporation, Kolhapur was also directed to take steps in order to implement the map as finalized by the Water Resources Department, Pune. A copy of the letter dated 07.12.2019 bearing No. 7870 of 2019 written by the Kolhapur Irrigation Department addressed to the Commissioner, Municipal Corporation, Kolhapur directing to implement the 1:5000 maps demarcating the red, blue and green line for the river Panchganga along with the maps is enclosed herewith as **ANNEXURE A-7 (Colly).**

Whatever stated hereinabove is in accordance with the directions of this Hon'ble Tribunal dated 27.09.2019 and the Kolhapur Irrigation Dept has undertaken compliance of the order in accordance with law.

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Executive Engineer,
Kolhapur Irrigation Division (North)
Kolhapur.

Kolhapur Irrigation Department
Through its Principal Secretary,
State of Maharashtra
Having Office at:
Kolhapur Irrigation Division (North)
Sinchan Bhawan, Tarabai Park,
Kolhapur – 416003

Date: 21.02.2020
Place: New Delhi

ANNEXURE A-1

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BEFORE THE NATIONAL GREEN TRIBUNAL

(WESTERN ZONE) BENCH, PUNE

APPEAL NO.25 OF 2014(WZ)

CORAM :

HON'BLE SHRI JUSTICE V.R. KINGAONKAR
(JUDICIAL MEMBER)

HON'BLE DR. AJAY A.DESHPANDE
(EXPERT MEMBER)

In The Matter of:

1. **MR. SARANG YADVADKAR,**
   Age: 55 Years, Occ: Architect
   R/AT: a-9, Pradnyangad Aparments,
   S.No.119/3, Behind Navshya Maruti,
   Sinhagad Road, Pune-411030.

2. **NARENDRA SUNDERLAL CHUGH,**
   Age: 55 Years, Occ: Business
   R/at: 15/3, PWD Quarters,
   R/at:15/3, PWD Quarters,
   Pimpri Colony, Pune-411017

APPELLANTS

VERSUS

1. **THE STATE OF MAHARASHTRA,** 140
Through Water Resources Department,
Government of Maharashtra,
Madame Kama Marg, Hutatma Rajguru Chowk
Mantralaya, Mumbai-400032.

.....**RESPONDENT**

Counsel for Appellant(s):

Mr Asim Sarode a/w Alka Babaladi Pratap Vitankar.

Counsel for Respondent(s):

Mr. D.D.Shinde for Respondent No.1.

Date: March 27th 2015.

P.C.

Heard Learned Counsel for the parties. Learned Counsel for the Respondent No.1, placed on record Govt. Resolution (GR) dated 2nd March, 2015. By the said Resolution, referred to above, the previous Resolution dated 8.8.2014, stands amended and the ambiguity/vagueness regarding certain words, which gave leverage for construction of any building or like activity within area, near embankment of the River and implementation of RRZ policy, could have been done, is

claimed to be removed. The present GR dated 2nd March 2015, shows that 'blue line' has to be drawn by the Irrigation Department after the demand is received from the Collector of any other department in which the city/Taluka/village area, where it is found that there is possibility of danger of flood like situation nearby the river zone.

2. Though, such DPR is required to be prepared by the Chief Engineer of the Irrigation Department and is required to be put in public domain of the Govt. of Maharashtra, as per the said GR, yet, condition that such DPR, shall be prepared when concerned Collector or other department shall demand and thereafter it shall be prepared by the Irrigation department, is improper, having regard to the 'Precautionary Principle' enumerated in Section 20 of the NGT Act, 2010. The reason is not far to seek. The GR itself shows that purport of the Resolution dated 2nd March, 2015, is to ensure that 'blue line' needs to be determined and drawn for the purpose of avoiding possible damage of flood and possibility of illegal construction within No Development Zone (NDZ) area. Thus, it is manifest that GR itself is issued with an intention to avoid any kind of

environmental damage, as a result of flood in the flood prone area. In other words, it is intention of the State Govt. to adopt the 'Precautionary Principle' in this behalf. In our opinion, while issuing GR in question, one of the important intention of the State Govt. is also to avert illegal construction, which subsequently is required to be demolished/dismantled by incurring heavy expenditure, because, which the State Exchequer is loaded with. Apart from this the GR dated 2nd March,2015, may have been issued to avoid extraneous influences, which may put on the officers of the Irrigation Department to overlook illegal constructions irrespective of the same being executed by giving goby to 'blue line', within NDZ area and against the RRZ policy. Having regard to purposive interpretation of GR dated 2nd March, 2015, we are inclined to give following directions:

a) In all areas where there is reportedly excessive raining and where there is probability of endangering human life or properties, due to floods caused by the rains, hailstorms or, any such reason, which may be noticed by the Collector or, other authorities, they may report same to the

Irrigation Department and irrespective of such reports, whether report is received or not, the Irrigation Department on its own, shall prepare DPR of the cities/villages and other places prone to floods. We have used expression 'other places', which is inclusive because there are certain Talukas and villages in Konkan regain, which are flood prone due to excessive raining, during rainy season, which are also required to be identified;

b) The Irrigation Department may call for information by email from all the Collector offices, immediately, which can be collected within two (2) weeks from all the districts, particularly situated on the coastal stretches where rains are likely to occur before early Monsoon, in comparison that of other districts and thereafter from other collectorates;

c) The Irrigation Department, on its own, shall identify flood prone areas, including the cities like Pune, Mumbai, Lonawala, Wai, Sangli, Karhad, Nashik, Nanded etc. whichever are known due to peculiarity of heavy river flows, the stock of water and population, where the bank of river, including old constructions adjoining to river, which were constructed much earlier to the GR;

d) The Geo-mapping of such rivers, which are possibly likely to endanger environment due to probability of causing floods, shall be carried out within reasonable period, through authentic agency, but shall not detain the Irrigation department from completing the work of preparing DPR on priority basis, where the city area, Talukas and the places are already known or commonly identified as notorious for being probable to cause environmental damage due to floods from drawing of further line and preparing DPR in this regard;

e) The Authenticate sketch of such 'blue line' and DPR, shall be submitted to the Divisional Commissioner of each region, wherever the identification is so made on priority basis in sequential order, such as, Pune Region, Nashik Region, Konkan Region, Aurangabad Region, so on and so forth. On basis of such DPR, and further line of each flood prone area/cities, even if, the Irrigation Department has shown tentative 'blue line' as blue line which needs to be finalized, then also no construction shall be permitted/finalized by the authorities which may cause environmental degradation at least within distance of fifty (50) meters from such blue line

within NDZ area by the Municipal Corporations/Councils/Panchayats.

f) The DPR and 'blue line' shall be prepared within period of twelve (12) weeks' hereafter and be indicated at the website of Govt. Environment Department / Irrigation Department.

With above directions, the Appeal is disposed of. No costs.

....., JM
(Justice V. R. Kingaonkar)

....., EM
(Dr.Ajay A. Deshpande)

Date: March 27th, 2015.

NGT

– TRUE COPY –

भारतीय प्रौद्योगिकी संस्थान मुंबई
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ANNEXURE A-2

May 18, 2019

To:
Dy. Executive Engineer
Kolhapur Irrigation Division (North)
Sunchan Bhavan, Tarabai Park,
Kolhapur 416 003

Your Ref.: Ko_pa_vi(U)/Pra_sha-3/3207 dated 29.04.2019

Sub.: Flood analysis for Rivers Dudhaganga, Panchaganga, Bhogavati, Kumbhi, Tulshi and Dhamani

(I I T Bombay Project No. DRD/CE/MCD-3/19-20)

Dear Sir:

Please find enclosed our report on the above mentioned consultancy work. We thank you for giving us the opportunity to carry out this interesting study.

Truly,

Dr M C Deo
Institute Chair Professor
Department of of Civil Engineering
Indian Institute of Technology Bombay
Powai, Mumbai 400076
Phone: (+91) (0) 22 2576 7330; (+91) (0) 22 2576 8330
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→ Report : 11 pages
+ Vetted Report

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Verification of Flood Calculations

for Rivers Dudhaganga, Panchaganga, Bhogavati, Kumbhi, Tulshi and Dhamani

(No. DRD/CE/MCD-3/19-20)

Department of Civil Engineering
Indian Institute of Technology Bombay
Powai, Mumbai 400 076

Prof. M C Deo

May, 2018

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Report of the Consultancy Project titled:

Verification of Flood Calculations for

Rivers Dudhaganga, Panchaganga, Bhogavati, Kumbhi, Tulshi and Dhamani

Introduction

As per letter No.Kopavi(U)/Prasha-3/3207/2019 dated 29.04.2019, Dy. Executive Engineer, Kolhapur Irrigation Division, (North), Kolhapur, Maharashtra State, requested Indian Institute of Technology (IIT) Bombay, to carry out the hydrological study of rivers: **Dudhaganga, Panchaganga, Bhogavati, Kumbhi, Tulshi and Dhamani** falling under the jurisdiction of Kolhapur Irrigation Division (North). The work consisted of verification of the flood values and inundation levels (blue and red lines) along the selected segments of these rivers and corresponding to 25 and 100 years' return periods.

The location map of the area under consideration is given in Fig. 1.

The lengths of different river segments under consideration are as per Table 1.

Table 1. The lengths of various river stretches

Sl. No.	River	Length of the stretch (km)
1	Dudhaganga	4.6
2	Panchaganga	16.3
3	Bhogavati	5.1
4	Tulshi	3.7
5	Dhamani	3.5
6	Kumbhi	5.3

Powai, Mumbai - 400 076.

Scope of the Work

The scope of this study was to verify the flood and inundation level computations blue and red lines) of the river stretches submitted by the client, M/s Deputy Executive Engineer, Kolhapur Irrigation Division (North), Kolhapur. The flood and water level calculations were made by M/s Sarathi Engineers, Pune. The flood events under consideration are '1 in 25 years' and '1 in 100 years'. (These are subsequently called '25-year' and '100-year' floods, respectively in this report.) The 25- and 100-year floods were estimated using the method of flood frequency analysis for River Panchaganga and its tributaries: Bhogavati, Tulshi, Dhamani and Kumbhi. This was done in light of availability of the recorded values of river discharge (as recorded on the Government of India's WARIS website) located at Terward (Taluka Shirol; Dist : Kolhapur) along the Panchaganga river at the downstream of the concerned river stretches (Fig. 1). The use of the method of flood frequency analysis in place of the Unit Hydrograph Method approach was made after obtaining the approval to do so from the Chief Engineer as mentioned in the report submitted to us for its vetting. As regards the river Dudhaganga, the conventional method of unit hydrograph (UHG) was used since no such recording station was located along its flow. The implementation of this method was done on the basis of recommendations of the guidelines of Maharashtra Engineering Research Institute (MERI)'s circular no. DSO/PB-4/1582 dated 16.11.2005 and those of the Central Water Commission (CWC), applicable for Krishna and Pennar Basins. The inundation levels were worked out using the well-known software: HEC-RAS.

The HEC-RAS Software System

The Hydraulic Engineering Centre (HEC)'s River Analysis System (RAS) software, abbreviated as HEC-RAS, is popular software to simulate steady and unsteady open channel flows. HEC is a part of U S Army Corps of Engineers. HEC-RAS involves the use of energy balance equation to analyze the steady flow conditions and combination of 1-Dimenional mass balance and momentum balance principles to deal with unsteady flows. The steady flow

assumption is valid if the flow is gradually varied (in the absence of structures obstructing the flow, where it changes rapidly), if it is 1-Dimensional (no flow from the lateral side) and if the bed slope is small (less than around 1:10).

In the steady flow or constant discharge analysis it is the energy equation that is mainly used: however for critical flow conditions at a certain stretch the momentum equation is employed. The energy equation is based on the principle of conservation of total energy, i. e., the summation of the elevation of river bed above the datum, water depth and the velocity head at a given cross section is same as the one at the next cross section, but with addition of the energy loss due to friction and contraction/expansion over the reach in between. This equation is solved by using a simple iterative procedure. The solution is based on a variety of assumptions and simplifications of the complex physical processes representing river flows. Although workable in practice its accuracy depends on such modeling details and also that of the input information supplied.

The input ideally required to run this modeling software is of two types: geometric and hydraulic. The geometric input belongs to a schematic river representation, division of the total river reach into a large number of sub-reaches, cross sections of all such reaches, and the parameters related to design and operation of reservoir, dam, and spillway, if involved. The hydraulic input belongs to separately calculated catchment floods of 25 or 100 years' return at every cross section, initial boundary conditions (discharge, water level) along all reaches, dam-gate opening conditions, if applicable; downstream boundary conditions, Manning's coefficient for both channel and bank portions.

The **Inundation Analysis**

Modeling Issues and Parameter Selections

As per the discussions held with representatives of the client it is noted that following choices were made while running the HEC-RAS software.

The HEC-RAS 4.1 2010 BETA version was used. The software was run for the steady state condition. It is known that this assumption is workable, though not appropriate for the cases of lateral inflows and obstructed flows, where unsteady flow situations prevail. However in the absence of required information on various hydraulic, hydrologic and geo-morphological parameters as well as that of any flow measurements and in consonance with the requirement of adhering to the Guidelines of Central Water Commission (CWC) and Irrigation Department, the steady state or constant flow assumption was adopted.

The geographical input was collected from topographical surveys of the river made by a Differential Global Positioning System (DGPS). It is understood that the river cross sections were surveyed at every 100 m interval, well beyond the likely flood levels and that each section consisted of 30 m interval depth readings within the river and on both sides of it. For this purpose the DGPS control points were fixed at every 1 km interval. The free catchment area was determined from the topo-sheets and using the Autocad software.

As regards the Manning's coefficient a lower value of 0.03 was used for the river channel and a higher one of 0.05 was employed for the river bank, which appears to be in order.

It was noticed that calibration of the HEC-RAS model with observations or historical flood marks was not specifically done in view of the widespread acceptance of this software over different parts of the world. However it was indicated to us that the Irrigation Department had sometimes back separately tallied the software output with available historical flood marks.

The 25-year and 100-year flood discharges and the river cross section data formed the major input to the HEC RAS software that gave flood water levels at each cross section.

Based on the above information the contour maps are to be prepared on 1:5000 and 1:1500 scale maps at every 1 km length to delineate the blue and red lines as per 25 and 100-year flood discharges.

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Calculation of the 25- and 100-year Floods at the gauged river

As mentioned earlier the 25- and 100-year floods were estimated using the method of flood frequency analysis for River Panchaganga and its tributaries: Bhogavati, Tulshi, Dhamani and Kumbhi. This was done considering the availability of river gauge data, on the India WARIS web site, at Terwad, (Taluka Shirol: Dist.: Kolhapur) along the Panchaganga river at the downstream of the concerned river stretches (Fig. 1). As regards the river Dudhaganga, the conventional method of unit hydrograph (UHG) was used since no such recording station was located along its flow. The flood frequency analysis was done using the Gumbel's probability distribution.

The Gumbel Distribution

The use of this extreme value probability distribution is popular worldwice and in India. (Singh, 1998; Subramanya, 1994). In this distribution the flood discharge, for a given return period or probability of occurrence, is calculated as below:

$$y = \bar{y} - K\sigma \qquad (1)$$

Where, y = river discharge (typically annual mean); $\bar{y}$ = mean of y, K = frequency factor dependent on the selected return period and sample size, determined from the frequency factor Table specified for this distribution, and σ = standard deviation of y.

We however mention that a better way would have been to additionally use alternative distributions such as log-Pierson Type III and Weibull, and judge the supremacy of one of these alternatives by conducting the goodness of fit tests, namely, Anderson Darling and Kolmogorov-Smirnov.

The data used to fit the Gumbel distribution was in the form of annual maximum discharge measurements of 36 years' duration recorded at the Terwad gauge station.

Resulting Flood Discharges at the gauged station 153

The values of 25-year and 100-year floods made as per the Gumbel's distribution mentioned above at the point of study were 3203.65 cumecs and 4034.97 cumecs, respectively (Page 5 of the submitted report).

From the above values the conveyance coefficient was calculated to arrive at discharges at intermediate stations. This was done by dividing the end point discharge by the square root of the total catchment area.

Calculation of the 25- and 100-year Floods at the ungauged river

The flood calculations for River Dudhaganga were based on the conventional method of unit hydrograph (UHG), described in details in various text books, such as Singh (1998) and Subramanya (1994). This method of rainfall to runoff conversion is approximate but widely used and workable for smaller catchments, especially when detailed hydro-meteorological and topographic data are not available.

The analysis was done on the basis of guidelines given in Technical Circular No. DSO/PB-4/1582, dated 16.11.2015 of Director General, MERI, Nashik.

To begin with, the statistical slope was calculated over various segments of the river and as per the catchment areas. Thereafter the parameters required for arriving at the synthetic unit hydrograph, namely, time to peak and total time, discharge per sq. km, critical widths of hydrograph and those of rising limbs at the level of 50 and 75 percent of peaks were evaluated along with the storm base period and peak discharge.

The above analysis pointed out to the use of appropriate storm duration for UHG calculations.

Thereafter, areal rainfall values were estimated from the 25 and 100 years' iso-pluvial [illegible] corresponding to the given latitude and longitude ranges. Guidance from Central Water Commission (1993) was used for this purpose.

After applying the temporal (storm lasting for less than 24 hr) as well as spatial (catchment area related) reduction factors, the daily average rainfall for 25-year and 100-year [illegible] were estimated.

Based on the above critical rainfall values the evaluations of 25-year and 100-year return [illegible] were made separately and as follows:

The preceding computations led to the plot of the synthetic unit hydrograph (1 cm, 1 hr). This facilitated arrangement of rainfall excess versus UHG ordinates and yielded the total surface flow against various UHG ordinates after adding the constant value of the base flow. This finally yielded the discharge values for 25-year and 100-year flood events at the terminal [illegible].

While the 25-year flood was calculated using the above step (free-catchment flood), the 100-year flood was obtained by adding the design discharge of the spillway of an upstream Dam to the free-catchment flood up to the point of interest (as per the guidelines of Technical Circular [illegible]/2015, applicable for rivers with Dams). The discharge coming from River Vedaganga joining before the point of interest was accounted for.

Resulting **Flood Discharges at the ungauged station**

The values of 25-year and 100-year floods made as per the Gumbel's method mentioned above at the point of study were 1750.13 cumecs and 2179.21 cumecs, respectively (Page 48 and 56 of the submitted report).

The above 25-year and 100-year floods at the terminal station gave the values of corresponding conveyance which in turn produced the 25-year and 100-year flood discharges at intermediate stations as per the catchment area reductions and the conveyance factors.

The HEC-RAS Output

The final values of the 25- and 100-yr floods so derived were used as input to run the HEC-RAS software in order to delineate the blue and red lines, or prohibitive and restrictive lines, respectively, along the considered stretches of the rivers.

The main outcome of running the HEC-RAS software system with the input mentioned in the preceding sections consisted of water surface elevation, flow velocity and area, top width of the river section, all at every 100 m along each river segment. At every chainage the values of Froude number also get calculated and this showed that generally everywhere the flow conditions were sub-critical.

The output from the HEC-RAS software, shown in the report of the client, would enable the plots of the 25-year (blue) and 100-year (red) flood lines at the various stretches of the rivers on the basis of the topographic survey referred to earlier.

Concluding Remarks

We have carefully studied the procedures followed and the assumptions made as discussed above as well as various choices exercised while running the HEC-RAS software and arriving at the results presented in the report and submitted to us. We carried out this work as per the documents supplied and according to the information gathered through discussions with representatives of the client.

We are of the view that in light of the available hydrological information the procedures followed as well as the methods adopted and the parameters selected are as per common engineering practice and judgment, and are thus in order.

We therefore confirm the results of the flood analysis given in the attached report.

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It is however expressed that these days state of the art methods based on solution of continuity and momentum equations of unsteady flows using advanced numerical procedures than those considered in the study are available. However they require an exhaustive amount of hydro-meteorological and geo-morphological data collected through remote sensing and in-situ observations. A comprehensive data collection, analysis and verification program is therefore recommended for implementation into the future, preferably by a reputed organization working at an international level.

References

Central Water commission (1993): Workshop on Rationalization of Design Storm Parameters for Design Flood Estimation, Hydrology Organization, Central Water Commission, New Delhi, December, 1993.

Singh V P (1998): "Elementary Hydrology", Prentice Hall

Subramanya K (1994): "Engineering Hydrology", Tata McGraw Hills

Enclosures

Fig. 1 River key map,

The report submitted for verification

Scanned by CamScanner

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Fig. 1. : Key map of the rivers

- TRUE COPY -

ANNEXURE A-3

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TECHNICAL NOTE

Computation of Blue and Red Flood Line and Hydraulic study of selective portion of Panchaganga River

In the court of Hon. National Green Tribunal (Western Zone) Pune Writt petition no.25/2014 for the cause of finalizing blue and red flood line of rivers in the State of Maharashtra was admitted by Mr. Sarang Yadvadkar against Government of Maharashtra. In this peition Hon. National Green Tribunal (Western Zone) Pune on the date 27/03/2015 Ordered that finalizing blue and red flood line is the duty of Water Resource Department of Government of Maharashtra.

Water Resource Department given directions to follow the Technical circular and Guidelines published by Executive Director MERI Nashik vide DSO/PB-4/1582, on the date 16/11/2015. vide govt letter (न्यायाप्र – 2014 / (प्र. क्र. 424/2014)/ सिं व्य (न) दि. 18/11/2015.Also Guidelines for Flood Estimation Report For Krishna And Penner Sub Zone – 3(h) (Revised) September 2000 published by Central Water Commission are available.

The work of carrying out hydrological study and marking blue and red flood line in selected patches on River Bhogawati, Panchganga, Dudhganga, Tulshi, Dhamani and Kumbhi was entrusted to Sarathi Engineers, Pune vide accepted tender no.B-1/SE/4, year 2016-17. The work includes Bhogavati 5.10 Km, Panchaganga 16.30Km, Dudhaganga 5.00 Km, Tulashi 3.70 Km, Dhamani 3.50 Km and Kumbhi River 5.10 Km river length.

Methodology :- The general method and directives to avoid such artificial encroachments in the normal flood course of rive are paraphrased in the Government resolution no. DSO/PB-4/1582, dt.16/11/2015.

Analysis of flood values available from CWC Hydrological station at Terwad Tal Shirol. Data is available from year 1979 to 2019.

As per the directives in above mentioned in above circular Blue line and Red line corresponding to 1 in 25 years and 1 in 100 years flood respectively are computed.

General Geography :- Five tributaries of River Panchganga have it's origin in western ghat region. The other major nallas have discharge contributions. Western ghat portion is densely covered with vegetation and mainly comprises of reserved forest of Dajipur sanctuary and which goes on thinning gradually along the river length on D/S.

Rainfall :- The entire river length could be broadly classified as heavy rainfall zone in western ghats, moderate rainfall zone in end reach. However the reach under consideration lies in heavy rainfall zone and moderate rainfall zone.

Catchment :- The catchment is fan shaped in initial reach and then onwards fern leaf shape. Steep slopes are observed in ghat region, but in the plains the river gradient is flat, due to which prolonged storm base periods are seen.

The catchment is intercepted especially in ghat region by storages @ Radhanagari, Tulshi, Kumbhi and Kasari dam.

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Computation Of Flood Discharge -

The Flood discharge is computed by Flood Frequency Method mentioned in Technical circular and Guidelines published by Executive Director MERI Nashik vice DSO/PB-4/1582, on the date 16/11/2015.chapter no 2.

There is Central Water Commissions Hydrological Station at Terwad Tal Shirol Dist Kolhapur on the river Panchaganga. This station is at down stream of point of consideration of calculation of flood line. Flood Discharge Data from the year 1979 to 2019 is available. This data is extracted from India Wris web site . The catchment area is computed and by regration analysis values of flood at required points are computed. (Calculations attached.) The Chief Engineer (W R), Water Resource Department Pune has approved the flood discharge values vide letter no मु अ (जसं) / का अ 2 / उ अ 3/ प्रशा 7 / (195/2018) / 4931 दि. 27/11/2019 The values are as below.

River	Reach of calculation	Catchment Area Sq. Km.	1:25 flood Discharge		1:100 flood Discharge	
			C (Coefficient)	Discharge Cumecs	C (Coefficient)	Discharge Cumecs
Panchaganga	Prayag Chikhali	1126.03	69.73	2340	88.44	2968
	Shivaji Bridge	1788.93	69.73	2949	88.44	3740
	National Highway	1938.52	69.73	3070	88.44	3894
	Terwad	2425	69..73	3434	88.44	4355

Field survey :- The field survey is carried out by DGPS instrument. Cross sections are taken at every 100 m interval along the river in the reaches of rivers mentioned in above table.

HEC-RAS flood simulation study :- As per the guidelines issued vide above referred Technical circular HEC- RAS SOFTWARE is used for flood simulation study. The input of field data like cross sections and hydrological data like discharge is given to the software, The outcome of simulation study through HEC RAS software i.e. flood levels at respective cross sections are tabulated below

The final outcome as described above is attached herewith and the red line is finalized accordingly.

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BLUE LINE LEVELS

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Chainage	Discharge (m3/s)	Bed level (m)	Flood level (m)	E.G. Elev (m)	Froude No
0	2949	529.49	544.36	544.39	0.11
100	2949	529.49	544.29	544.38	0.17
200	2949	529.48	544.15	544.34	0.24
300	2949	529.47	544.23	544.28	0.14
400	2949	529.47	544.25	544.26	0.06
500	2949	529.46	544.23	544.25	0.09
600	2949	529.45	544.21	544.25	0.13
700	2949	529.45	544.2	544.24	0.12
800	2949	529.44	544.17	544.22	0.16
900	2949	529.43	544.18	544.2	0.12
1000	2949	529.43	544.17	544.19	0.11
1100	2949	529.43	544.17	544.18	0.1
1200	2949	529.42	544.16	544.17	0.1
1300	2949	529.42	544.16	544.17	0.09
1400	2949	529.4	544.15	544.16	0.09
1500	2949	529.4	544.14	544.15	0.09
1600	2949	529.39	544.14	544.15	0.09
1700	2949	536.42	544.12	544.14	0.1
1800	2949	529.38	544.11	544.13	0.12
1900	2949	529.38	544.09	544.12	0.12
2000	2949	529.38	544.08	544.11	0.13
2100	2949	529.37	544.04	544.1	0.16
2200	2949	529.37	544	544.07	0.17
2300	2949	529.36	543.99	544.05	0.16
2400	2949	529.36	543.99	544.03	0.13
2500	2949	529.35	543.98	544.02	0.14
2600	2949	529.35	543.94	544	0.16
2700	2949	529.34	543.93	543.98	0.15
2800	2949	529.34	543.92	543.96	0.15
2900	2949	529.33	543.92	543.95	0.12
3000	2949	529.33	543.91	543.94	0.12
3100	2949	529.32	543.9	543.93	0.13
3200	2949	529.31	543.88	543.92	0.14
3300	2949	529.3	543.86	543.9	0.14
3400	2949	529.3	543.85	543.88	0.13
3500	2949	529.29	543.83	543.87	0.15
3600	2949	529.29	543.81	543.85	0.17
3700	2949	529.28	543.79	543.83	0.17
3800	2949	529.28	543.76	543.81	0.17
3900	2949	529.27	543.73	543.79	0.15
4000	2949	529.26	543.73	543.77	0.12
4100	2949	529.24	543.73	543.76	0.12
4200	2949	529.22	543.7	543.75	0.14
4300	2949	529.22	543.68	543.74	0.15
4400	2949	529.21	543.68	543.72	0.12
4500	2949	529.2	543.69	543.71	0.08

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BLUE LINE LEVELS

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Chainage	Discharge (m3/s)	Bed level (m)	Flood level (m)	E.G. Elev (m)	Froude No
4600	2949	529.18	543.68	543.7	0.09
4700	2949	529.12	543.67	543.7	0.09
4800	2949	528.9	543.64	543.69	0.14
4900	2949	528.89	543.62	543.67	0.13
5000	2949	528.89	543.62	543.66	0.13
5100	2949	528.88	543.61	543.65	0.12
5200	2949	528.86	543.6	543.64	0.13
5300	2949	528.86	543.59	543.62	0.13
5400	2949	528.85	543.56	543.61	0.15
5500	2949	528.84	543.55	543.59	0.15
5600	2949	528.83	543.54	543.57	0.14
5700	2949	528.82	543.52	543.56	0.14
5800	2949	528.81	543.51	543.54	0.13
5900	2949	528.8	543.5	543.53	0.11
6000	2949	528.79	543.5	543.52	0.09
6100	2949	528.78	543.48	543.51	0.11
6200	2949	528.77	543.48	543.5	0.09
6300	2949	528.76	543.47	543.5	0.1
6400	2949	528.76	543.47	543.49	0.1
6500	2949	528.75	543.45	543.48	0.13
6600	2949	528.75	543.44	543.47	0.13
6700	2949	528.74	543.42	543.46	0.13
6800	2949	528.74	543.39	543.44	0.15
6900	2949	528.73	543.4	543.42	0.09
7000	2949	528.72	543.41	543.42	0.04
7100	2949	528.72	543.4	543.41	0.08
7200	2949	528.71	543.38	543.41	0.12
7300	2949	528.71	543.36	543.39	0.14
7400	2949	528.7	543.33	543.38	0.15
7500	2949	528.7	543.31	543.36	0.15
7600	2949	528.69	543.3	543.34	0.14
7700	2949	528.69	543.29	543.33	0.13
7800	2949	528.68	543.28	543.31	0.13
7900	2949	528.68	543.27	543.3	0.12
8000	2949	528.67	543.26	543.29	0.1
8100	2949	528.66	543.26	543.28	0.09
8200	2949	528.66	543.26	543.28	0.08
8300	2949	528.65	543.26	543.27	0.06
8400	2949	528.64	543.26	543.27	0.07
8500	2949	528.63	543.25	543.27	0.09
8600	2949	528.62	543.24	543.26	0.12
8700	2949	528.62	543.21	543.25	0.15
8800	2949	528.61	543.19	543.23	0.15
8900	2949	528.6	543.19	543.21	0.12
9000	2949	528.6	543.18	543.2	0.09
9100	2949	528.59	543.16	543.2	0.14

BLUE LINE LEVELS

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Chainage	Discharge (m3/s)	Bed level (m)	Flood level (m)	E.G. Elev (m)	Froude No
9200	2949	528.59	543.14	543.18	0.16
9300	2949	528.59	543.1	543.16	0.15
9400	2949	528.58	543.1	543.14	0.15
9500	2949	528.58	543.1	543.13	0.09
9600	2949	528.57	543.11	543.12	0.06
9700	2949	528.57	543.06	543.11	0.13
9800	2949	528.56	542.96	543.09	0.2
9900	2949	528.56	542.81	543.05	0.24
10000	2949	528.55	542.91	542.97	0.15
10100	2949	528.54	542.88	542.95	0.18
10200	2949	528.54	542.87	542.93	0.17
10300	2949	528.53	542.86	542.91	0.13
10400	2949	528.52	542.84	542.89	0.16
10500	2949	528.51	542.76	542.86	0.22
10600	2949	528.46	542.76	542.82	0.17
10700	2949	528.41	542.68	542.79	0.21
10800	2949	528.38	542.66	542.76	0.2
10900	2949	528.37	542.55	542.72	0.29
11000	2949	528.35	542.58	542.65	0.18
11100	2949	528.34	542.56	542.63	0.18
11200	2949	528.32	542.53	542.6	0.19
11300	2949	528.3	542.52	542.57	0.16
11400	2949	528.29	542.51	542.55	0.14
11500	2949	528.29	542.51	542.54	0.12
11600	2949	528.28	542.49	542.53	0.13
11700	2949	528.27	542.47	542.51	0.15
11800	2949	528.27	542.43	542.49	0.19
11900	2949	528.26	542.39	542.46	0.22
12000	2949	528.25	542.35	542.42	0.2
12100	2949	528.24	542.3	542.39	0.23
12200	2949	528.24	542.27	542.35	0.22
12300	2949	528.22	542.24	542.31	0.2
12400	2949	528.21	542.21	542.29	0.19
12500	2949	528.2	542.19	542.25	0.19
12600	2949	528.2	542.16	542.22	0.19
12700	2949	528.18	542.14	542.2	0.18
12800	2949	528.18	542.11	542.18	0.18
12900	2949	528.17	542.09	542.15	0.18
13000	2949	528.16	542.05	542.12	0.19
13100	2949	528.16	542.01	542.09	0.21
13200	2949	528.15	541.98	542.06	0.21
13300	2949	528.15	541.95	542.03	0.19
13400	2949	528.14	541.92	542	0.22
13500	2949	528.14	541.85	541.95	0.27
13600	2949	528.13	541.81	541.9	0.23
13700	2949	528.12	541.75	541.85	0.26

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BLUE LINE LEVELS

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Chainage	Discharge (m3/s)	Bed level (m)	Flood level (m)	E.G. Elev (m)	Froude No
13800	2949	528.12	541.68	541.8	0.26
13900	2949	528.11	541.62	541.75	0.26
14000	2949	530.53	541.56	541.71	0.26
14100	2949	527.4	541.54	541.66	0.23
14200	2949	527.39	541.5	541.62	0.25
14300	2949	527.39	541.46	541.57	0.22
14400	2949	527.38	541.44	541.53	0.22
14500	2949	527.37	541.43	541.49	0.19
14600	2949	527.37	541.42	541.47	0.16
14700	2949	527.36	541.4	541.44	0.17
14800	2949	527.36	541.38	541.42	0.16
14900	2949	527.35	541.37	541.4	0.15
15000	2949	527.34	541.36	541.39	0.11
15100	2949	527.33	541.25	541.37	0.22
15200	2949	527.31	541.13	541.32	0.28
15300	2949	527.3	541.1	541.25	0.29
15400	2949	527.29	541.06	541.18	0.27
15500	2949	527.29	541.01	541.13	0.25
15600	2949	527.28	541.04	541.08	0.16
15700	2949	527.28	541.05	541.06	0.09
15800	2949	527.26	541.03	541.05	0.11
15900	2949	527.26	541	541.04	0.15
16000	2949	527.25	540.96	541.02	0.19
16100	2949	527.24	540.92	541	0.16
16200	2949	527.21	540.91	540.98	0.14
16300	3070	527.2	540.87	540.96	0.17

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Red Fina

RED LINE LEVELS

Chainage	Discharge (m3/s)	Bed level (m)	Flood level (m)	E.G. Elev (m)	Froude No
0	3740	529.49	545.29	545.32	0.1
100	3740	529.49	545.22	545.3	0.17
200	3740	529.48	545.17	545.28	0.2
300	3740	529.47	545.21	545.24	0.12
400	3740	529.47	545.22	545.23	0.06
500	3740	529.46	545.2	545.23	0.08
600	3740	529.45	545.19	545.22	0.11
700	3740	529.45	545.18	545.21	0.11
800	3740	529.44	545.17	545.2	0.13
900	3740	529.43	545.17	545.19	0.1
1000	3740	529.43	545.17	545.18	0.08
1100	3740	529.43	545.17	545.18	0.08
1200	3740	529.42	545.16	545.17	0.08
1300	3740	529.42	545.16	545.17	0.07
1400	3740	529.4	545.15	545.16	0.08
1500	3740	529.4	545.15	545.16	0.07
1600	3740	529.39	545.15	545.16	0.07
1700	3740	536.42	545.14	545.15	0.08
1800	3740	529.38	545.13	545.15	0.1
1900	3740	529.38	545.12	545.14	0.1
2000	3740	529.38	545.11	545.13	0.11
2100	3740	529.37	545.08	545.12	0.13
2200	3740	529.37	545.05	545.11	0.15
2300	3740	529.36	545.05	545.09	0.14
2400	3740	529.36	545.05	545.08	0.11
2500	3740	529.35	545.03	545.07	0.12
2600	3740	529.35	545.01	545.06	0.14
2700	3740	529.34	545.01	545.04	0.13
2800	3740	529.34	545	545.03	0.12
2900	3740	529.33	545	545.02	0.1
3000	3740	529.33	544.99	545.02	0.1
3100	3740	529.32	544.99	545.01	0.1
3200	3740	529.31	544.98	545	0.11
3300	3740	529.3	544.96	544.99	0.12
3400	3740	529.3	544.96	544.98	0.11
3500	3740	529.29	544.95	544.97	0.11
3600	3740	529.29	544.93	544.96	0.13
3700	3740	529.28	544.92	544.95	0.12
3800	3740	529.28	544.91	544.94	0.12
3900	3740	529.27	544.89	544.93	0.12
4000	3740	529.26	544.89	544.92	0.1
4100	3740	529.24	544.88	544.91	0.1
4200	3740	529.22	544.88	544.9	0.11
4300	3740	529.22	544.85	544.89	0.13
4400	3740	529.21	544.85	544.88	0.11
4500	3740	529.2	544.86	544.87	0.07
4600	3740	529.18	544.85	544.87	0.08

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RED LINE LEVELS

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Chainage	Discharge (m3/s)	Bed level (m)	Flood level (m)	E.G. Elev (m)	Froude No
4700	3740	529.12	544.85	544.87	0.08
4800	3740	528.9	544.82	544.86	0.12
4900	3740	528.89	544.81	544.85	0.11
5000	3740	528.89	544.81	544.84	0.1
5100	3740	528.88	544.81	544.83	0.1
5200	3740	528.86	544.81	544.83	0.1
5300	3740	528.86	544.8	544.82	0.1
5400	3740	528.85	544.78	544.81	0.11
5500	3740	528.84	544.78	544.8	0.11
5600	3740	528.83	544.77	544.79	0.1
5700	3740	528.82	544.76	544.79	0.1
5800	3740	528.81	544.76	544.78	0.1
5900	3740	528.8	544.75	544.77	0.09
6000	3740	528.79	544.75	544.77	0.08
6100	3740	528.78	544.74	544.76	0.09
6200	3740	528.77	544.74	544.76	0.07
6300	3740	528.76	544.74	544.75	0.08
6400	3740	528.76	544.74	544.75	0.08
6500	3740	528.75	544.73	544.74	0.09
6600	3740	528.75	544.72	544.74	0.09
6700	3740	528.74	544.71	544.73	0.1
6800	3740	528.74	544.7	544.73	0.11
6900	3740	528.73	544.7	544.72	0.08
7000	3740	528.72	544.71	544.71	0.03
7100	3740	528.72	544.7	544.71	0.07
7200	3740	528.71	544.68	544.7	0.09
7300	3740	528.71	544.67	544.7	0.11
7400	3740	528.7	544.66	544.69	0.11
7500	3740	528.7	544.65	544.68	0.11
7600	3740	528.69	544.65	544.67	0.1
7700	3740	528.69	544.65	544.66	0.09
7800	3740	528.68	544.64	544.66	0.09
7900	3740	528.68	544.64	544.65	0.08
8000	3740	528.67	544.63	544.65	0.08
8100	3740	528.66	544.63	544.65	0.07
8200	3740	528.66	544.63	544.64	0.06
8300	3740	528.65	544.63	544.64	0.05
8400	3740	528.64	544.63	544.64	0.05
8500	3740	528.63	544.63	544.64	0.06
8600	3740	528.62	544.62	544.63	0.08
8700	3740	528.62	544.61	544.63	0.09
8800	3740	528.61	544.6	544.62	0.09
8900	3740	528.6	544.6	544.62	0.08
9000	3740	528.6	544.6	544.61	0.06
9100	3740	528.59	544.59	544.61	0.1
9200	3740	528.59	544.58	544.6	0.1
9300	3740	528.59	544.57	544.59	0.11

RED LINE LEVELS

Chainage	Discharge (m3/s)	Bed level (m)	Flood level (m)	E.G. Elev (m)	Froude No
9400	3740	528.58	544.56	544.58	0.11
9500	3740	528.58	544.56	544.58	0.07
9600	3740	528.57	544.56	544.57	0.05
9700	3740	528.57	544.54	544.57	0.1
9800	3740	528.56	544.48	544.56	0.15
9900	3740	528.56	544.45	544.54	0.17
10000	3740	528.55	544.49	544.51	0.1
10100	3740	528.54	544.48	544.5	0.12
10200	3740	528.54	544.47	544.49	0.11
10300	3740	528.53	544.46	544.49	0.09
10400	3740	528.52	544.45	544.48	0.11
10500	3740	528.51	544.42	544.47	0.14
10600	3740	528.46	544.42	544.45	0.11
10700	3740	528.41	544.39	544.44	0.14
10800	3740	528.38	544.37	544.43	0.14
10900	3740	528.37	544.34	544.41	0.17
11000	3740	528.35	544.35	544.39	0.12
11100	3740	528.34	544.35	544.38	0.11
11200	3740	528.32	544.34	544.37	0.12
11300	3740	528.3	544.33	544.36	0.1
11400	3740	528.29	544.33	544.35	0.09
11500	3740	528.29	544.33	544.35	0.08
11600	3740	528.28	544.32	544.34	0.09
11700	3740	528.27	544.31	544.34	0.1
11800	3740	528.27	544.3	544.33	0.11
11900	3740	528.26	544.29	544.32	0.11
12000	3740	528.25	544.28	544.31	0.11
12100	3740	528.24	544.28	544.3	0.11
12200	3740	528.24	544.27	544.29	0.11
12300	3740	528.22	544.26	544.29	0.11
12400	3740	528.21	544.26	544.28	0.1
12500	3740	528.2	544.25	544.27	0.09
12600	3740	528.2	544.25	544.26	0.09
12700	3740	528.18	544.24	544.26	0.09
12800	3740	528.18	544.24	544.25	0.09
12900	3740	528.17	544.23	544.25	0.09
13000	3740	528.16	544.23	544.24	0.09
13100	3740	528.16	544.22	544.24	0.1
13200	3740	528.15	544.21	544.23	0.1
13300	3740	528.15	544.21	544.22	0.09
13400	3740	528.14	544.2	544.22	0.09
13500	3740	528.14	544.2	544.21	0.1
13600	3740	528.13	544.19	544.2	0.09
13700	3740	528.12	544.18	544.2	0.1
13800	3740	528.12	544.17	544.19	0.1
13900	3740	528.11	544.17	544.18	0.1
14000	3740	530.53	544.16	544.18	0.1

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RED LINE LEVELS

Chainage	Discharge (m3/s)	Bed level (m)	Flood level (m)	E.G. Elev (m)	Froude No
14100	3740	527.4	544.15	544.17	0.09
14200	3740	527.39	544.15	544.17	0.09
14300	3740	527.39	544.15	544.16	0.08
14400	3740	527.38	544.14	544.15	0.08
14500	3740	527.37	544.14	544.15	0.07
14600	3740	527.37	544.14	544.15	0.07
14700	3740	527.36	544.14	544.14	0.06
14800	3740	527.36	544.13	544.14	0.06
14900	3740	527.35	544.13	544.14	0.06
15000	3740	527.34	544.13	544.14	0.06
15100	3740	527.33	544.12	544.13	0.08
15200	3740	527.31	544.1	544.13	0.1
15300	3740	527.3	544.1	544.12	0.09
15400	3740	527.29	544.1	544.11	0.08
15500	3740	527.29	544.1	544.11	0.07
15600	3740	527.28	544.1	544.11	0.06
15700	3740	527.28	544.1	544.1	0.05
15800	3740	527.26	544.1	544.1	0.05
15900	3740	527.26	544.09	544.1	0.06
16000	3740	527.25	544.09	544.1	0.07
16100	3740	527.24	544.08	544.09	0.08
16200	3740	527.21	544.07	544.09	0.07
16300	3894	527.2	544.07	544.09	0.07

Sarathi Engineers
Kothrud Pune

Sectional Officer
Bavada Irrigation Section
Kolhapur

Assistant Engineer Gr-I
Panchaganga Irrigation Sub Division
Kolhapur

Executive Engineer
Kolhapur Irrigation Divisicn (N)
Kolhapur

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ANNEXURE A-4

MAHARASHTRA KRISHNA DAM DEVELOPMENT CORPORATION 168

CHIEF ENGINEER (JAS), WATER WORKS DEPARTMENT, PUNE

SINCHANBHAVAN, MANGALWARPETH, BANER ROAD, PUNE-411011

OFFICE (020)26120505/26125074 FAX (020)26126015

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Out ward No. Mua(jsan)/Kaa-2/ua-5/4931/2019 Date-27/11/2019

To,

Superintendent Engineer,

Kolhapur Irrigation Department,

Kolhapur

Sub: To conduct study of water of river Bhogawati, Panchaganga, Dudhganga, Tulshi, Dhamani, Kumbhiand to decide the maximum level of flood level, survey of same level line and to draw red and blue Flood line

To decide flood abandonment of Panchaganga river

Ref: 1. Letter bearing out ward no A.(Jasan)/Kaa-2/ua-3/Prasha-7/(195/2018)/1532 dated 01/04/2019

2. Superintendent Engineer, Kolhapur Irrigation department, Kolhapur office letter no. KOPAM/Prasha/Dep-1/6208 dated 27/11/2019.

To conduct study of water of river Bhogawati, Panchaganga, Dudhganga, Tulshi, Dhamani, Kumbhiand to decide the maximum level of flood level, survey of same level line and to draw red and blue Flood line is in progress by the M/s Sarathi Engineers Pune. In the said circular Bhogawati 5 K.m., Panchaganga 15 k.m., Dudhganga 5 k.m., Tulshi 3 k.m., Dhamani 3 k.m., Kumbhi 5 k.m. are included. In which Kolhapur City Panchaganga River Shivaji Bridge to National Highway 16.30 km length is included.

In order to decide the flood line government had given directions and orders from time to time. After studying the English circular no. DSO/PB-4/1582 dated 16/11/2015 of Director General MERI Nashik, on Panchaganga river at Terwad there is central department's Sarita Measurement Centre and Panchaganga River comes under Gauged Catchment. From year 1989 to 2015 on the basis of the said centre and due to available support system regression analysis (By Gumbell Method) the counting had been done of the flood abandonment, and said abandonment had been sanctioned for the said are vide ref letter no. (1).

After that in the year 2019 Panchaganga River suffered from heavy flood. The abandonment of the said flood had been included and again counting needs to be done. Accordingly 2019's abandonment had been included and counting had been done 1:25 and 1:100 continues flood abandonment nos. had been submitted by M/s Sarathi Engineers Pune

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Accordingly flood abandonment is as under

River	Place of Counting	Water logging area sq km	1:25 flood abandonment (Cubic Meter)		1:25 flood abandonment (Cubic Meter)	
			C (Coefficient)	Abandonment	C (Coefficient)	Abandonment
Panchaganga	PrayagChikhali	1126.06	69.73	2340	88.44	2968
	Shivajipool	1788.93	69.73	2949	88.44	3740

	Bridge on National Highway	1938.52	69.73	3070	88.44	3894
	Terwad	2425	69.73	3434	88.44	4355

M/s Sarathi Engineers Pune had submitted the flood counting as above in detail and said calculation had been verified by the department at their level and found correct and had been recommended for sanction vide reference letter No. (2).

Accordingly Panchaganga River length 16.30 km and 25 tc 100 years continuous counting of above chart flood abandonment had been permitted with following conditions-

1) as per calculation of abandonment of said sanctioned water study and accordingly blue and red flood line levels counting can be done through HEC-RAC software and vetting can be done by Indian Technical Institute Powai Mumbai.

2) In future as mentioned in above chart for the remaining length of the river 25 and 100 years continuous flood abandoning blue flood line and red flood line drawing is considered. The rivers which are joining to this river and other rivers length 25 and 100 years continuous flood abandonment counting is done and central water departments Sarita measurement centre's 25 and 100 years comparison to be made between continues maximum flood abandonment.

3) Vetting had been done by Indian Technical Institute (IIT) Pawai, Mumbai with respect to above referred final flood abandonment to submit the plans with respect to Panchaganga River having area of 16.30 km with respect to flood line blue and red.

Sd/-

Head Engineer (Jasan)

Water word Department, Pune

Copy-For information and further action to Executive Engineer, Kolhapur Irrigation Department (S), Kolhapur.

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ANNEXURE A-5

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Verification of Flood Calculations for River Panchaganga

(No. DRD/CE/MCD-14/19-20)

Department of Civil Engineering
Indian Institute of Technology Bombay
Powai, Mumbai 400 076

Prof. M C Deo

November, 2019

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Report of the Consultancy Project titled:

Verification of Flood Calculations for

Rivers Panchaganga

Introduction

As per letter No.Kopavi(U)/Prasha-3/7628/2019 dated 27.11.2019, Executive Engineer, Kolhapur Irrigation Division, (North), Kolhapur, Maharashtra State, requested Indian Institute of Technology (IIT) Bombay, to carry out the hydrological study of river **Panchaganga** under the jurisdiction of Kolhapur Irrigation Division (North). The work consisted of verification of the flood values and inundation levels (blue and red lines) along the selected segments of these rivers and corresponding to 25 and 100 years' return periods.

The location map of the area under consideration is given in Fig. 1. The length of the river segment under consideration is 16.3 km.

Scope of the Work

The scope of this study was to verify the flood and inundation level computations blue and red lines) of the river stretches submitted by the client, M/s Executive Engineer, Kolhapur Irrigation Division (North), Kolhapur. The flood and water level calculations were made by M/s Sarathi Engineers, Pune. The flood events under consideration are '1 in 25 years' and '1 in 100 years'. (These are subsequently called '25-year' and '100-year' floods, respectively in this report.) The 25- and 100-year floods were estimated using the method of flood frequency analysis. This was done in light of availability of the recorded values of river discharge (as reported on the Government of India's WARIS website) located at Terward (Taluka Shirol; Dist.: Kolhapur) along the Panchaganga river at the downstream of the concerned river stretches (Fig. 1). The implementation of this method was done on the basis of recommendations of the

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guidelines of Maharashtra Engineering Research Institute (MERI)'s circular no. DSO/PB-4/1582 dated 16.11.2005 and those of the Central Water Commission (1993), applicable for Krishna and Pennar Basins. The inundation levels were worked out using the well-known software: HEC-RAS.

The HEC-RAS Software System

The Hydraulic Engineering Centre (HEC)'s River Analysis System (RAS) software, abbreviated as HEC-RAS, is popular software to simulate steady and unsteady open channel flows. HEC is a part of U S Army Corps of Engineers. HEC-RAS involves the use of energy balance equation to analyze the steady flow conditions and combination of 1-Dimensional mass balance and momentum balance principles to deal with unsteady flows. The steady flow assumption is valid if the flow is gradually varied (in the absence of structures obstructing the flow, where it changes rapidly), if it is 1-Dimensional (no flow from the lateral side) and if the bed slope is small (less than around 1:10).

In the steady flow or constant discharge analysis it is the energy equation that is mainly used; however for critical flow conditions at a certain stretch the momentum equation is employed. The energy equation is based on the principle of conservation of total energy, i. e., the summation of the elevation of river bed above the datum, water depth and the velocity head at a given cross section is same as the one at the next cross section, but with addition of the energy loss due to friction and contraction/expansion over the reach in between. This equation is solved by using a simple iterative procedure. The solution is based on a variety of assumptions and simplifications of the complex physical processes representing river flows. Although workable in practice its accuracy depends on such modeling details and also that of the input information supplied.

The input ideally required to run this modeling software is of two types: geometric and hydraulic. The geometric input belongs to a schematic river representation, division of the total river reach into a large number of sub-reaches, cross sections of all such reaches, and the

parameters related to design and operation of reservoir, dam, and spillway, if involved. The hydraulic input belongs to separately calculated catchment floods of 25 or 100 years' return at every cross section, initial boundary conditions (discharge, water level) along all reaches, dam-gate opening conditions, if applicable; downstream boundary conditions, Manning's coefficient for both channel and bank portions.

The Inundation Analysis

Modeling Issues and Parameter Selections

As per the discussions held with representatives of the client it is noted that following choices were made while running the HEC-RAS software.

The HEC-RAS 4.1 2010 BETA version was used. The software was run for the steady state condition. It is known that this assumption is workable, though not appropriate for the cases of lateral inflows and obstructed flows, where unsteady flow situations prevail. However in the absence of required information on various hydraulic, hydrologic and geo-morphological parameters as well as that of any flow measurements and in consonance with the requirement of adhering to the Guidelines of Central Water Commission (CWC) and Irrigation Department, the steady state or constant flow assumption was adopted.

The geographical input was collected from topographical surveys of the river made by a Differential Global Positioning System (DGPS). It is understood that the river cross sections were surveyed at every 100 m interval, well beyond the likely flood levels and that each section consisted of 30 m interval depth readings within the river and on both sides of it. For this purpose the DGPS control points were fixed at every 1 km interval. The free catchment area was determined from the topo-sheets and using the Autocad software.

As regards the Manning's coefficient a lower value of 0.03 was used for the river channel and a higher one of 0.05 was employed for the river bank, which appears to be in order.

It was noticed that calibration of the HEC-RAS model with observations or historical flood marks was not specifically done in view of the widespread acceptance of this software over different parts of the world. However it was indicated to us that the Irrigation Department had sometimes back separately tallied the software output with available historical flood marks.

The 25-year and 100-year flood discharges and the river cross section data formed the major input to the HEC RAS software that gave flood water levels at each cross section.

Based on the above information the contour maps are to be prepared on 1:5000 and 1:1500 scale maps at every 1 km length to delineate the blue and red lines as per 25 and 100-year flood discharges.

Calculation of the 25- and 100-year Floods at the gauged river

As mentioned earlier the 25- and 100-year floods were estimated using the method of flood frequency analysis. The river gauge data of 40 years up to the recent year of 2019 were used. This was based on the Gumbel's probability distribution.

The Gumbel Distribution

The use of this extreme value probability distribution is popular worldwide and in India. (Singh, 1998; Subramanya, 1994). In this distribution the flood discharge, for a given return period or probability of occurrence, is calculated as below:

$$y = \bar{y} + K\sigma_y \qquad (1)$$

Where, y = river discharge (typically annual mean); $\bar{y}$ = mean of y, K = frequency factor dependent on the selected return period and sample size, determined from the frequency factor Table specified for this distribution, and σ_y = standard deviation of y.

We however mention that a better way would have been to additionally use alternative distributions such as log-Pierson Type III and Weibull, and judge the supremacy of one of these alternatives by conducting the goodness of fit tests, namely, Anderson Darling and Kolmogorov-Smirnov.

The data used to fit the Gumbel distribution was in the form of annual maximum discharge measurements of 36 years' duration recorded at the Terwad gauge station.

Resulting Flood Discharges at the gauged station

The values of 25-year and 100-year floods made as per the Gumbel's distribution mentioned above at the point of study were 3434 cumecs and 4355 cumecs, respectively.

From the above values the conveyance coefficient was calculated to arrive at discharges at intermediate stations. This was done by dividing the end point discharge by the square root of the total catchment area.

The HEC-RAS Output

The final values of the 25- and 100-yr floods so derived were used as input to run the HEC-RAS software in order to delineate the blue and red lines, or prohibitive and restrictive zones, respectively, along the considered stretches of the rivers.

The main outcome of running the HEC-RAS software system with the input mentioned in the preceding sections consisted of water surface elevation, flow velocity and area, top width of

the river section, all at every 100 m along each river segment. At every chainage the values of Froude number also get calculated and this showed that generally everywhere the flow conditions were sub-critical.

The output from the HEC-RAS software, shown in the report of the client, would enable the plots of the 25-year (blue) and 100-year (red) flood lines at the various stretches of the rivers on the basis of the topographic survey referred to earlier.

Concluding Remarks

We have carefully studied the procedures followed and the assumptions made as discussed above as well as various choices exercised while running the HEC-RAS software and arriving at the results presented in the report and submitted to us. We carried out this work as per the documents supplied and according to the information gathered through discussions with representatives of the client.

We are of the view that in light of the available hydrological information the procedures followed as well as the methods adopted and the parameters selected are as per common engineering practice and judgment, and are thus in order.

We therefore confirm the results of the flood analysis given in the attached report.

References

Central Water commission (1993): Workshop on Rationalization of Design Storm Parameters for Design Flood Estimation, Hydrology Organization, Central Water Commission, New Delhi, December, 1993.
Singh V P (1998): "Elementary Hydrology", Prentice Hall
Subramanya K (1994): "Engineering Hydrology", Tata McGraw Hills

Enclosures
Fig. 1. River key map,
The report submitted for verification

Dr. M. C. Deo
Professor of Civil Engineering
I. I. T. Bombay

Values of K for the extreme value distribution

(eq 7.1, p.147 of chapter-19-Hydrology part-I)

Return period years	Probability	Reduced variable Y	Record length, years						
			20	30	40	50	100	200	300
1.58	0.63	0.000	-0.492	-0.482	-0.476	-0.473	-0.464	-0.459	-0.450
2.00	0.50	0.367	-0.147	-0.152	-0.155	-0.156	-0.160	-0.162	-0.164
2.33	0.43	0.579	0.052	0.038	0.031	0.026	0.016	0.010	0.001
5	0.20	1.500	0.919	0.866	0.838	0.820	0.779	0.755	0.719
10	0.10	2.250	1.620	1.540	1.500	1.470	1.400	1.360	1.300
20	0.05	2.970	2.300	2.190	2.130	2.090	2.000	1.940	1.870
25			2.447	2.330	2.265	2.223	2.128	2.067	1.990
50	0.02	3.902	3.180	3.030	2.940	2.890	2.770	2.700	2.590
100	0.01	4.600	3.840	3.650	3.550	3.490	3.350	3.270	3.140
200	0.005	5.296	4.490	4.280	4.160	4.080	3.930	3.830	3.680
400	0.0025	6.000	5.150	4.910	4.780	4.560	4.510	4.400	4.230

RIVERGAUGE SITE AT TERWAD ACROSS RIVER PANCHGANGA

FLOOD FREQUENCY ANALYSIS BY GUMBEL'S METHOD

(eq 7.4, p.150 of chapter-19-Hydrology part-I)

Catchment area 2425 sqkm

Year	Discharge	Descending order	Rank	Return period	$(y-\bar{y})^2$
	cumecs	y	m	T=(n+1)/m	
1	2	3	4	5	6
1979	870	4110	1	42.00	5284218.7
1980	1918	3590	2	21.00	3163926.14
1981	1790	3340	3	14.00	2337054.71
1982	1431	2797	4	10.50	970821.71
1983	1545	2680	5	8.40	754714.15
1984	1795	2553	6	7.00	550182.46
1985	1570	2250	7	6.00	192495.29
1986	2050	2205	8	5.25	155033.43
1987	1392	2200	9	4.67	151121.01
1988	2080	2100	10	4.20	83372.44
1989	2205	2080	11	3.82	72222.72
1990	2250	2050	12	3.50	56998.15
1991	2553	1952	13	3.23	19686.29
1992	1306	1918	14	3.00	11308.80
1993	1447	1900	15	2.80	7875.29
1994	2680	1854	16	2.63	1833.11
1995	1170	1832	17	2.47	430.27
1996	1900	1821	18	2.33	86.54
1997	3590	1795	19	2.21	264.29
1998	1051	1790	20	2.10	451.87
1999	1540	1721	21	2.00	8211.83
2000	890	1570	22	1.91	58205.01
2001	1150	1557	23	1.83	64646.70
2002	1443	1545	24	1.75	70892.87
2003	725	1540	25	1.68	73580.44
2004	1832	1534	26	1.62	76821.07
2005	3340	1464	27	1.56	120707.01
2006	2797	1447	28	1.50	132683.27
2007	1821	1443	29	1.45	135613.33
2008	1952	1431	30	1.40	144899.86
2009	1345	1392	31	1.35	175776.55
2010	1464	1345	32	1.31	217856.63
2011	1721	1306	33	1.27	255284.78
2012	1011	1286	34	1.24	276267.08
2013	1854	1170	35	1.20	411210.73
2014	1534	1150	36	1.17	437261.01
2015	1286	1051	37	1.14	577990.93
2016	2200	1011	38	1.11	641029.45
2017	1557	890	39	1.08	848714.73
2018	2100	870	40	1.05	885965.02
2019	4110	725	41	1.02	1179383.29
	Average.=	1811.26		Total =	20607099.0

Scanned by CamScanner

No of years for which data is available (N)

= 41 nos

Standard deviation

$$= \left\{ \frac{20607098.97}{40} \right\}^{0.50}$$

= 717.76

Coefficient of variation

$$= \frac{717.76}{1811.26} \times 100.00$$

= 39.63

Mean discharge ($\bar{y}$)

= 1811.26 Cumecs

Return period (years)	K values
100	3.544
50	2.935
25	2.261
10	1.497

1 in 100 year return flood discharge

= 1811.26 + {3.544 * 717.76}

= 4354.99 Cumecs

1 in 50 year return flood discharge

= 1811.26 + {2.935 * 717.76}

= 3917.88 Cumecs

1 in 25 year return flood discharge

= 1811.26 + {2.261 * 717.76}

= 3433.99 Cumecs

1 in 10 year return flood discharge

= 1811.26 + {1.497 * 717.76}

= 2885.74 Cumecs

Scanned by CamScanner

DISCHARGE CALCULATIONS FOR RIVER PACHGANGA

Calculated based on the CWC rivergauge station data at TERWAD

As calculated at Terwad (By Gumbell's method)

1 Catchment area (A) = 2425 sqkm

2 1 in 25 flood (Q) = 3434 Cumecs

3 Value of coefficient 'C'

$$C = \frac{Q}{A^{0.5}} = 69.73$$

As calculated at terwad (By Gumbell's method)

1 Catchment area (A) = 2425 sqkm

2 1 in 100 flood (Q) = 4355 Cumecs

3 Value of coefficient 'C'

$$C = \frac{Q}{A^{0.5}} = 88.44$$

STATEMENT SHOWING DISCHARGES @ SELECTED PLACES

Chainage	CA	1 in 25 flood discharge		1 in 100 flood discharge	
		Coefficient	discharge	Coefficient	discharge
	(Sq km)		(Cumecs)		(Cumecs)
6956 (prayag chikhali)	1126.05	69.73	2340	88.44	2968
0 (Shivaji bridge)	1788.93	69.73	2949	88.44	3740
16300 (NH4)	1938.52	69.73	3070	88.44	3894

Calculations for 1 in 25 discharges

1) Bhogawati river

Coefficient of discharge

Discharge Q = 3433.99 cumecs

Catchment Area up to Terwad A = 2425 Sqkm

C = 69.73

Catchment Area up to Point of Consideration on Bhogavati River = 1126.05 Sqkm

free catchment discharge = 2340.0331 cumecs

Say cumecs

2) Kumbhi river

Coefficient of discharge

Discharge	Q =	3433.99 cumecs
Catchment Area up to Terwad	A =	2425 Sqkm
	C =	69.73
Catchment Area up to Point of Consideration on Kumbhi River	=	202.15 Sqkm
free catchment discharge	=	991.471 cumecs
	Say	cumecs

3) Tulashi river

Coefficient of discharge

Discharge	Q =	3433.99 cumecs
Catchment Area up to Terwad	A =	2425 Sqkm
	C =	69.73
Catchment Area up to Point of Consideration on Tulashi River	=	163.81 Sqkm
free catchment discharge	=	892.511 cumecs
	Say	cumecs

4) Dhamani river

Coefficient of discharge

Discharge	Q =	3433.99 cumecs
Catchment Area up to Terwad	A =	2425 Sqkm
	C =	69.73
Catchment Area up to Point of Consideration on Dhamani River	=	197.8 Sqkm
free catchment discharge	=	980.745 cumecs
	Say	cumecs

Calculations for 1 in 100 discharges

1) Bhogawati river

Coefficient of discharge

Discharge	Q =	4354.99 cumecs
Catchment Area up to Terwad	A =	2425 Sqkm
	C =	88.44
Catchment Area up to Point of Consideration on Bhogavati River	=	1126.05 Sqkm
free catchment discharge	=	2967.6326 cumecs
	Say	cumecs

2) Kumbhi river

Coefficient of discharge

Discharge	Q =	4354.99 cumecs
Catchment Area up to Terwad	A =	2425 Sqkm
	C =	88.44
Catchment Area up to Point of Consideration on Kumbhi River	=	202.15 Sqkm
free catchment discharge	=	1257.385 cumecs
	Say	**cumecs**

3) Tulashi river

Coefficient of discharge

Discharge	Q =	4354.99 cumecs
Catchment Area up to Terwad	A =	2425 Sqkm
	C =	88.44
Catchment Area up to Point of Consideration on Tulashi River	=	163.81 Sqkm
free catchment discharge	=	1131.883 cumecs
	Say	**cumecs**

4) Dhamani river

Coefficient of discharge

Discharge	Q =	4354.99 cumecs
Catchment Area up to Terwad	A =	2425 Sqkm
	C =	88.44
Catchment Area up to Point of Consideration on Dhamani River	=	197.8 Sqkm
free catchment discharge	=	1243.782 cumecs
	Say	**cumecs**

SARATHI ENGINEERS PUNE

Submittred By

Sarathi Engineers
Kothrud Pune

Assistant Engineer Gr.I
Panchaganga Irrigation Sub Division
Kolhapur

Sectional Offocer
Bavada Irrigation Section
Kolhapur

Executive Engineer
Kolhapur Irrigation Division (N)
Kolhapur

Dr. [illegible]
Professor
I. I. T. Bom
Powai, Mumbai

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ANNEXURE A-185

MAHARASHTRA KRISHNA DAM DEVELOPMENT CORPORATION

CHIEF ENGINEER (JAS), WATER WORKS DEPARTMENT, PUNE

SINCHANBHAVAN, MANGALWARPETH, BANER ROAD, PUNE-411011

Office (020)26120505/26125074

Fax (020)26126015

e-mail: cewrd.punewrd@maharashtra.gov.in, cewrdpune@gmail.com

Out ward No. Mua(jsan)/Kaa-2/ua-5/_/2019 Dt-/12/2019

No. 5080 Date-04 Dec 2019

To,

Superintendent Engineer,

Kolhapur Irrigation Department, Kolhapur

Sub: With respect to sanctioning of plan in order to draw red and blue line in the flood area of Panchaganga River.

Ref: 1. Letter No. Judicial matter-2014/(424/2014) Government Water irrigation Department Sinvya(M) dated 18/11/2015

2. Letter no. Kopam/prasha/kasha-1/1811 of Superintendent Engineer, Kolhapur Irrigation Department, Kolhapur office dated 27/03/2019

3. Letter No. Mua (Jsan) Kaa-2/ua-3/prasha-7/(195/2018)/1532 of Irrigation Department dated 01/04/2019

4. Superintendent Engineer, Kolhapur Irrigation Department, Kolhapur office letter no. Kopam / prasha / kaksha-1/6208 dated 27/11/2019

5. Letter No. Mua(Jsan)Kaa-2/ua-5/4931 of Regional office dated 27/11/2019

6. Letter No. DRD/CE/MCD-14/19-20 of Indian Technology Institute (IIT) Pawai Mumbai dated 29/11/2019

7. Letter No. Kopam/prasha/kasha-1/6250 of Superinterdent Engineer, Kolhapur Irrigation Department, Kolhapur dated 30/11/2019

In the Matter of Appeal No. 25/2014 filed before Hon'ble National Green Tribunal (West Region) Pune (Shri. Sarang Yadwadkar Pune V/s Maharashtra Government) Hon'ble Tribunal passed an order on 27/03/2015 that water Department should demarcate the lines of flood line (blue) and control (red) with respect to the rivers in Maharashtra.

In order to comply the order passed by the Hon'ble Tribunal and in order to complete the work of demarcation of flood line curing the given time with the recognition of Government Senior Director, Maharashtra Research Institute (Mery), Nashik office published technicalcircular and as per the guidelines the instructions were given to take the action vide letter bearing no. Dnyaypra-2014/(424/2014)/sivya (M) dated 18/11/2015 by Government Water works Department. As per government water work department circular no. purni-2018()182/2018)/sivya (Mahasul) dated 03/05/2018 had published guidelines in order to control the possibility of flood and not to do any kind of construction within the lines of flood area and to plan the restricted flood line and control flood line.

During the first stage of flood line demarcation of rivers in Maharashtra 1st comes the Panchaganga river which is within the region of Kolhapur City. In which the study of flood line demarcation of Shivaji Pool to Nation Highway pool admeasuring 16.30 K.m. by M/s Sarathi Engineers, Pune.

Survey had been conducted with the help of DGPS machine provided by the Government guidelines of Flood affecting area. The reference level of public construction department Bailgotha Kolhapur GTS Bench Mark had been considered.

At the distance of 100 mtr from the river and flood area cutmark has been taken. At the each cutmark at every 30 mtr distance Talank had been taken and the site inspection of said talank area had also been conducted. With reference to the said talank at 0.50 mtr parallel line were drawn. All the said information is available on the village plan and plan of Kolhapur city.

On the banks of river Panchaganga Terwad Taluka Shirol there is central water department's Sartita Measurement centre. Information of flood abandonment of Sartia Measurement Centre is available online. Said Sarita Measurement Centre of flood line calculation is located at about 30 km away from Pune to Bangalore National Highway Bridge. The information of flood abandonment of the said centre is available online since 1979. Flood abandonment of this Sarita Measurement Centre available for the last 34 yrs and as per body of water for 2425 sq.m. area Maharashtra Engineering research institute (Mery), Nashik office circular dated 16/11/2015 the flood frequency analysis had been done with the help of Gumbell's method and after conducting the water study of Panchaganga river with respect to the length of 16.30 km water study had been done for constant 25 yrs and 100 yrs department reference letter no. (2) had been submitted for sanction had been given permission for flood abandonment vide reference letter no. (3) of regional office letter.

During August 2019 Panchagangariver was affected by a huge flood. Due to which Kolhapur City and peripheral area was majorly affected. Till today this was the major flood (6 ft excess flood level than 2005) it has become necessary to count blue line and red line of the flood abandonment.

Hence from the year 1979 to 2019 total 41 yrs flood abandonment information has been made available. Now as per revised flood abandonment and water belt regression analysis (By Gumbel Method) 25 yrs and 100 yrs continues revised flood abandonment counted.

Accordingly vide department reference letter no. (4) submitted for sanction for revised flood abandonment as under regional office letter no. Mua(jasan)/kaaa-2/ua-5/4931 dated 27/11/2019 vide (reference letter no. 5) recognition given.

River	Place of Counting	Water loggin g area sq km	1:25 flood abandon ment (Cubic Meter)		1:25 flood abandon ment (Cubic Meter)	
			C (Coefficie nt)	Abandon ment	C (Coefficie nt)	Abandon ment
Panchaga nga	PrayagChi khali	1126. 06	69.73	2340	88.44	2968
	Shivajipool	1788. 93	69.73	2949	88.44	3740
	Bridge on National Highway	1938. 52	69.73	3070	88.44	3894
	Terwad	2425	69.73	3434	88.44	4355

As mentioned above in HEC-RAS computerized sanction flood abandonment, as per the actual survey (DGPS) river cut cross and other related information was given and with the help of software river's blue and red lines 1:5000 were shown on the plan. This water study and HEC –RAS computerised information blue and red line of flood vetting had been done by the Indian Technology Institute

Mumbai (IIT Powai) vide out word letter no. IIT Bombay Project No. DRD/EC/MCD-14/19-20 dated 29/11/2019 (Ref Letter No. 6).

The study of flood of Panchaganga River to Shiva is National Highway Bridge and to the both sides there is dumping done and hence obstructing the natural source of water and same is reduced. Due to which water logging happens and it is seen at S.No 14/600. In order to get technical accuracy from the upper side of S No 14/600 National Highway Flood line to be studied thoroughly and remaining length of flow characteristics to be studied.

Hence the panchaganga River 14.60 km (River S No 6100 to 20.700 km) length flood line had been submitted for sanction in the first phase and the other remaining are flood line to be studied separately.

As per the directions given in Chapter 3.3 and as per available village maps, maps of Kolhapur city survey had been conducted and as per the ratio 1:5000 on the maps as mentioned above blue and red lines of flood had been drawn. On the RajaramKo. P Dam of Panchaganga River the water department Kolhapur irrigation department south does the level of water. On this basis the prediction is done with respect to the flood of Kolhapur city and Panchagangariver. The calculation done at this place blue flood line bottom line is 543.73 mt (44.5") and red line bottom line is 544.89 mtr (48.3"). Accordingly in order to demarcate the blue and red line of flood line of panchaganga river measuring 6.10 to 20.70 and 14.60 k. m. plans had been submitted vide letter no. (7). The gravity of the flood of 2019 was very huge. Apartment from the flood line of red and blue there is also one line shown in green colour in orde- to take precautions as it happened in 2019 .

As per the study of flood water with respect to Panchaganga river the details of flood line to be verified and found correct and hence executive engineer and deputy Engineer had signed on the maps and certified the same. With respect to the past record of 25 yrs and 100

yrs regarding the flood abandonment during the 14.60 k.m. area of Panchaganga river the blue and red flood lines were approved with respect to the above mentioned conditions-

1) as mentioned above it is to verify the constant flood abandonment of Panchaganga river for last 25 yrs and 100 yrs and as per ground ratio blue and red flood line on v llage map gat nos. and flood line map's gat nos are same or not.

2) To verify the Village map and Kantur Map while super imposing the land location and river ratio with google maps.

3) Correction reports with respect to water ratio with respect to Latitude, longitude to be submitted about the panchaganga river at each 100 mtr distance for 25 yrs and 100 yrs with respect to the area where flood came.

4) Panchaganga river's 25 yrs (blue) and 100 years (red) constant flood lines sanctioned plan has been submitted to the respective local department, collector and Kolhapur. Said flood line maps to be uploaded by executive engineer, water works regulatory authority, Pune on the authorized government website.

5) With respect to prohibitive zone from River bed to blue line and blue line to red line with respective restrictive zone as per the circular dated 03/05/2018 of government's water works department it has been informed to take the necessary action. On the map apart from blue flood line and red line on 2019 as per observation ultimate flood line has also shown in green colour. Red line and maximum flood line during the rainy season it has been informed to the respective controlling authority to take proper care with respect to the likely area where flood may occur.

6) As per circular dated 10/07/2019 as per sanction of flood line of Panchaganga river as mentioned above apart from 14.60 km

necessary action to be taken by the respective authority with respect to the remaining belt.

Attached-Sanctioned Flood line maps

Sd/-

(R. D. Mohite)

Head Engineer (jsan)

Water Works Department, Pune

Copy to- Hon'ble Executive Director Maharashtra Krishna Khore Development Mahamandal Pune submitted for information.

Copy to- Executive Engineer, Kolhapur irrigation Departmert (south), Kolhapur submitted for information.

- TRUE COPY -

ANNEXURE A-7

Maharashtra Krishna Dam Development Corporation

Executive Engineer, Kolhapur Irrigation Department (S), Kolhapur

Irrigation Bhavan, Tarabai Park,

Kolhapur -416003

(0231)2654735 e-mail-eekidkop@gmail.com

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Out ward No. KOPAVI(S)/Prasha-3/7870/2019 Date-07/12/2019

To,

Hon'ble Commissioner,

Corporation Kolhapur

Sub- With respect to sanctioning of plan in order to draw red and blue line in the flood area of Panchaganga river

Ref- 1) Letter bearing out wards No Mua/(jasan)/ka.aa.-2/ua-5/5080 dt.04/2/2019 of Head Engineer (Jasan), Water works Department, Pune

2) Maharashtra Government's Circular No. Purni 2018 / (182 / 2018) / sanvya (Mahasul) Mantralaya Mumbai dated 03/05/2018

***

During the first stage of the demarcation of flood line of the rivers situated in Maharashtra, as per study of Panchaganga river flood water study flood line details were verified, and blue and red line of the flood of Panchaganga river Kolhapur city and surrounding area had been recognized by Hon'ble Head Engineer (Jasan) Water works department Pune vide ref no 1. The flood line showing in blue and red is in the proportion of 1:5000 maps are attached herewith for further action.

In order to avoid threat due to flood the constructions should be banned in the vicinity of the flood area and the guidelines and instructions are given with respect to the same by circular ref no 2 by

Attached: Circular and maps 2 nos. and 1 copy

Copy to: Head Executive office Kolhapur City area development department, Central Building, Kolhapur had been sent for information and for further action.

Attached: Circular and Plans 2 in total one copy each

Copy to: Assistant Director, Town Planning Department, Kolhapur Development scheme (Special Section) Rajarampuri, Kolhapur for information and further action.

Attached: Circular and Plans 2 in total one copy each.

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TITLE :- Panchganga River for Demarcation of Blue & Red line

1 | 02

RIVER LENGHT 16300 M.

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LEGEND

SR. NO.	PARTICULARS	SYMBOL

KOLHAPUR IRRIGATION DIVISION (NORTH), KOLHAPUR.

SURVEYED & PREPARED BY

M/s. SARATHI ENGINEERS (ENGINEERS & CONTRACTORS)
FLAT No. 4, LUNAWAT REALITY, PLINTH 4B, NEENA SOC. S.NO. 148,
OPP. TO VANAZ COMPANY, PAUD ROAD, KOTHRUD, PUNE - 411 038
PH. NO. 020 - 2539 6321, CELL NO.- 94222 33033

Name of Work :- Computation of HFL and Hydraulic study of Panchganga River for Demarcation of Blue & Red line with detailed Block contour survey Tal. Karvir & Hatkanagale.

VILLAGE :- BAVADA, AMBEWADI, WADANAGE, NIGAVE DHUMALA, BHUYE, SHIYE, BHUYE, SHIROLI, UNCHGAON, KOLHAPUR

Sectional Engineer Bavada Irrigation Section, Kolhapur	**Assistant Engineer (Gr-1)** Panchaganga Irrigation Sub-Div., Kolhapur	**Executive Engineer** Kolhapur Irrigation Div.(North), Kolhapur.
Superintending Engineer Kolhapur Irrigation Circle Kolhapur	**Chief Engineer** Water Resources Dept. (WR) Pune - 11	

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TITLE :- Panchganga River for Demarcation of Blue & Red line

RIVER LENGHT 16300 M.

2 | 02

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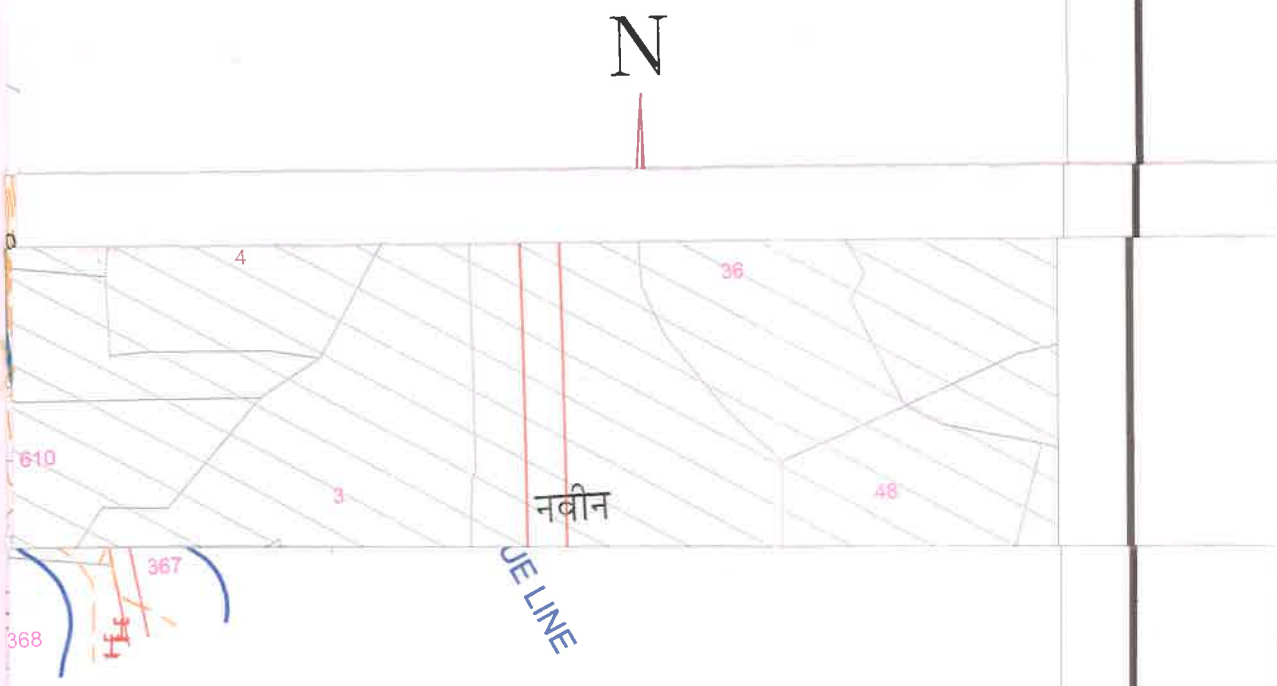

VERIFIED BY ME & FOUND CORRECT

Sectional Officer	Assistant Engineer (Gr-1)	Executive Engineer
Bavada Irrigation Section, Kolhapur	Panchaganga Irrigation Sub-Div., Kolhapur	Kolhapur Irrigation Div.(North), Kolhapur.

RECOMMENDED FOR APPROVAL

VILLAGE :- BAVADA, AMBEWADI, WADANAGE, NIGAVE DHUMALA, BHUYE, SHIYE, BHUYE, SHIROLI, UNCHGAON, KOLHAPUR

Sectional Engineer Bavada Irrigation Section, Kolhapur	**Assistant Engineer (Gr-1)** Panchaganga Irrigation Sub-Div., Kolhapur	**Executive Engineer** Kolhapur Irrigation Div.(North), Kolhapur.
Superintending Engineer Kolhapur Irrigation Circle Kolhapur		**Chief Engineer** Water Resources Dept. (WR) Pune - 11