Geological Mapping along left bank of the River Alaknanda between Marwadi Bridge and Vishnuprayag

By

Uttarakhand Landslide Mitigation and Management Centre (ULMMC)

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1.0 INTRODUCTION:

The Higher Himalayan region is frequently affected by natural hazards such as earthquakes, landslides, subsidence, glacier bursts, and flash floods. Joshimath, situated in the tectonically active young fold Himalayan mountain range, has also experienced subsidence issues since long, which was accelerated during January 2023. The town has a documented history of landslides, subsidence, and flash floods, with numerous cracks appearing in roads, walls, and house floors over time (Bera et al., 2023).

Joshimath is located in Chamoli district of Uttarakhand State of the India (**Figure1**). On January 2, 2023, Joshimath experienced significant ground subsidence, accompanied by a sudden burst of new water seepage in the Marwari area. This event necessitated the evacuation of approximately 1,000 residents from unsafe areas and vulnerable buildings (Bera et al., 2023). Joshimath is built on a substantial accumulation of old landslide debris and moraine deposits, with overburden material exceeding 200 meters in thickness in some areas (Geological Survey of India, 2024).

The recent subsidence was confined to a linear array from north-northwest (NNW) to south-southeast (SSE), stretching from Marwari to Sunil ward. The slope from Auli to Marwari is characterized by numerous natural springs, indicating saturation and the presence of perched water bodies, which exacerbate slope instability by increasing pore pressure. Notably, the Narsingh Mandir structure remained unaffected during this subsidence event. The new seepage at Marwari was linked to a perched water body (Geological Survey of India, 2024).

In response to letter no. 89/19/ULMMC/2024-25 dated 24th, May 2024, a field visit was carried out between 27th May 2024 to 6th June 2024 by a team of ULMMC experts, including Dr. Raghuveer Negi (Geologist) and Mr. Deepak Bhatt (Surveyor) in order to conduct large scale geological mapping along left bank of the River Alaknanda between Marwadi Bridge and Vishnuprayag. In this field USDMA consultants (Mr. Ashish Kaushik, Mr. Yogesh Uniyal, and Mr. Vivek Tiwari) joint control room Joshimath, was actively involved in geological mapping.

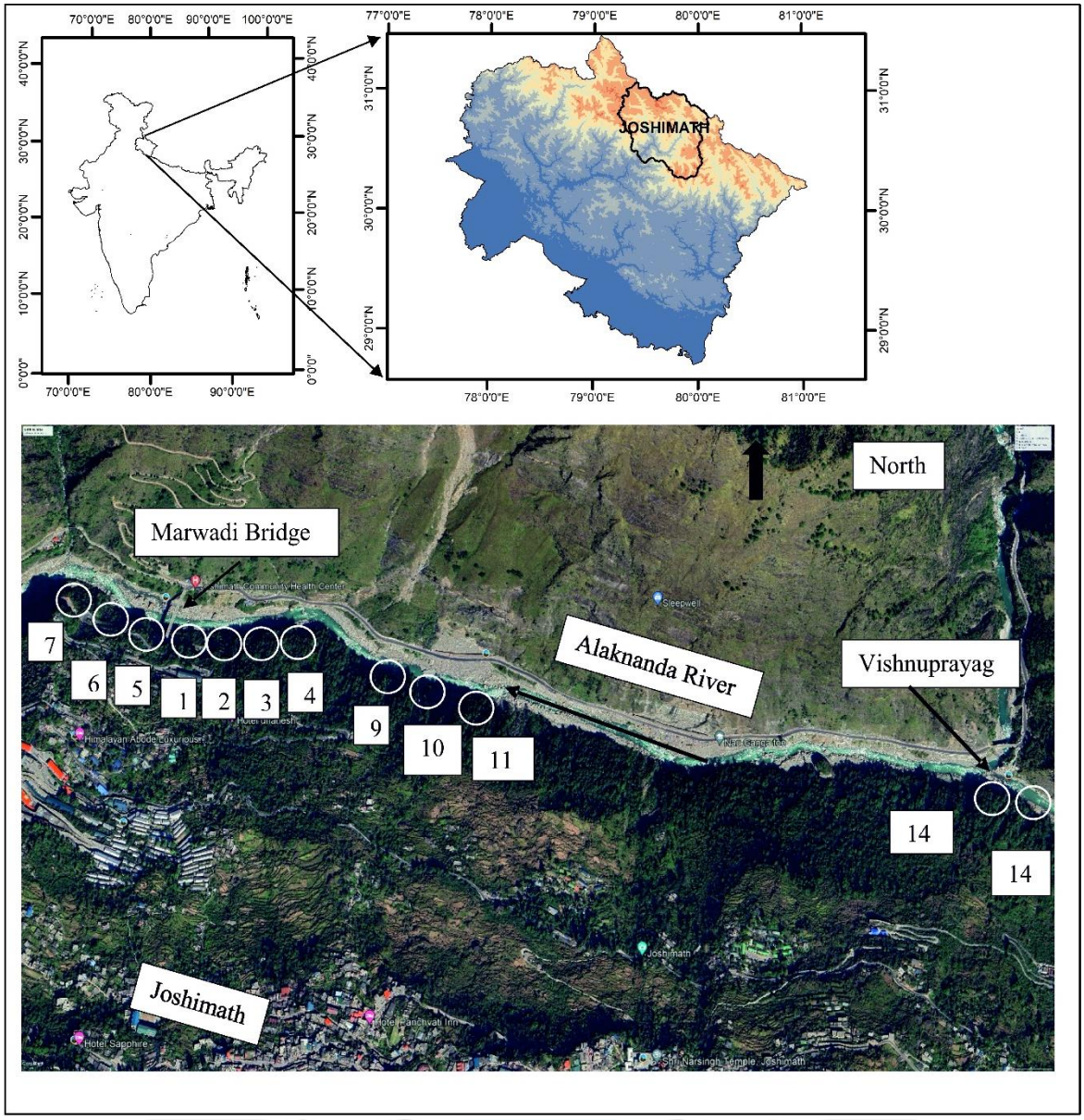


Figure 1: Location map of Joshimath.

2.0 GENERAL GEOLOGY

Joshimath is situated in close proximity of the Main central thrust (MCT), a dynamic geological region. This area is divided by several linear elastic shear zones, creating numerous tectonic slices of varying sizes. The area exposes rocks from the Central Crystalline Group, which are thrusted over the Garhwal Group of rocks, specifically the Chamoli and Pipalkoti Formations (**Figure 2**). (Geological Survey of India, 2024). This thrusting occurs along a major northerly dipping tectonic discontinuity known as the MCT (Geological Survey of India, 2024).

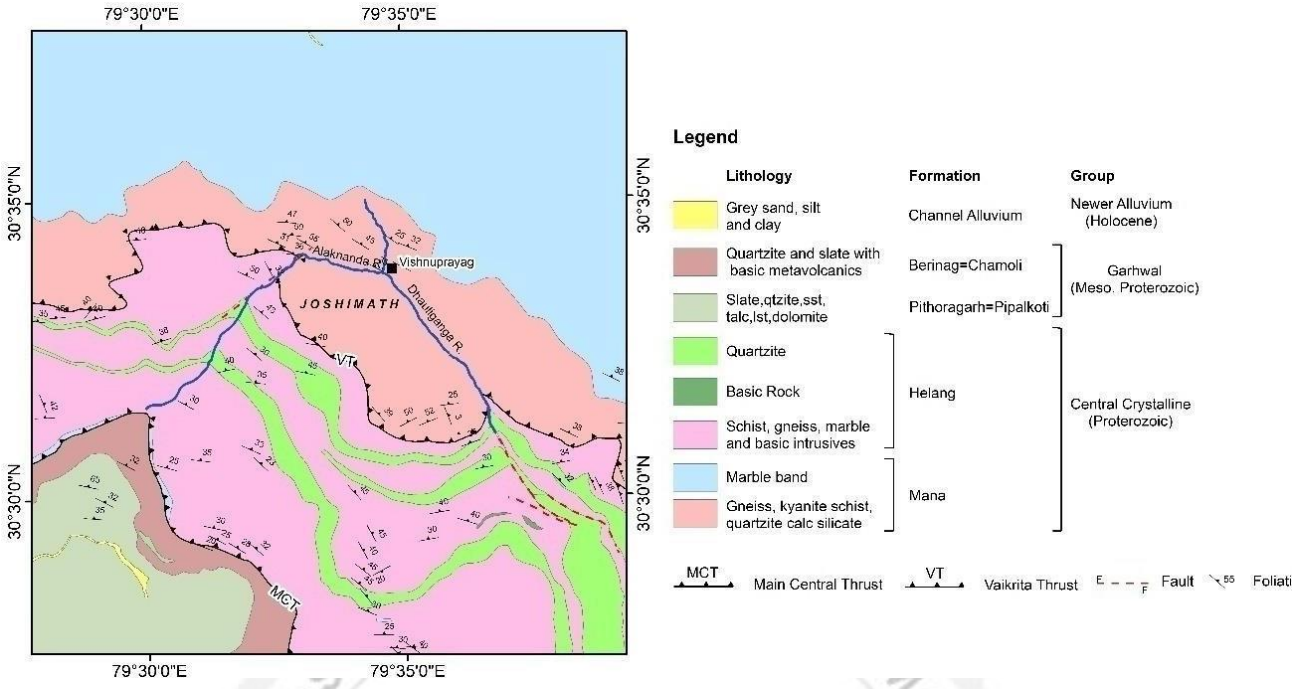


Figure 2: *Regional geological map of the Joshimath area (Geological Survey of India, 2024).*

3.0 GEOLOGICAL MAPPING

The boundary of different surface features and lithology was demarcated with the help of Total Station (TS) and Differential Geographical positioning System (DGPS) (**Figure 3**). The geological field data were collected along the left bank of the River Alaknanda between Marwadi bridge and Vishnuprayag at different elevations in according to IS codes (IS 11315 part 1). The geological plan and L-sections (**Figure 4**) of the area have been prepared from the data collected in the field on scale of 1:2500 and 1:500. The L-sections have been prepared which are given in the annexures 2. The Geological map (Figure 4) also shows the major landslides along the left bank of the river.

Figure 3: Geological mapping using total station.

Geologically, study area is composed of slope wash material, river born material, and biotite - gneiss rock (**Figure 4**). The Proterozoic rock sequences of the Mana Formation, part of the Central Crystalline Group, are prominently visible along the Alaknanda River section, from Marwari Bridge to Vishnuprayag (Geological Survey of India, 2024). In the Joshimath area, the most evident rock type along this river section is biotite-gneiss, which belongs to the Mana Formation (**Figure 2**).

Biotite gneiss is a metamorphic rock characterized by its layered or banded appearance, resulting from the alignment of mineral grains under high pressure and temperature. Its primary components include biotite, quartz, and feldspar, often accompanied by other minerals such as garnet or sillimanite. The presence of biotite, a dark mica mineral, imparts a distinctive dark color and a shiny, flaky appearance.

The biotite-gneiss in the Joshimath area is slightly weathered (**Figure 5**) and exhibits minor jointing and fracturing. Consequently, the biotite-gneiss in this area is classified as having fair to good rock mass quality (**Figure 6**). The dip of foliation ranges between 17° and 61° with a dip direction between N032° and N358°. Joint set J2 dips between 72° and 89° with a dip direction

between N117° and N135°. Joint set J3 dips between 58° and 89° with a dip direction between N074° and N099°. Joint set J4 dips between 23° and 44° with a dip direction between N256° and N284°. There is also a random joint set dipping between 63° and 85° with a dip direction between N143° and N165° (**Figure 7**, Annexure 1).

The Biotite-Gneiss dips northerly, and the majority of the joint sets show trends along N-S, WNW-ESE, and NE-SW directions (**Figure 8**).

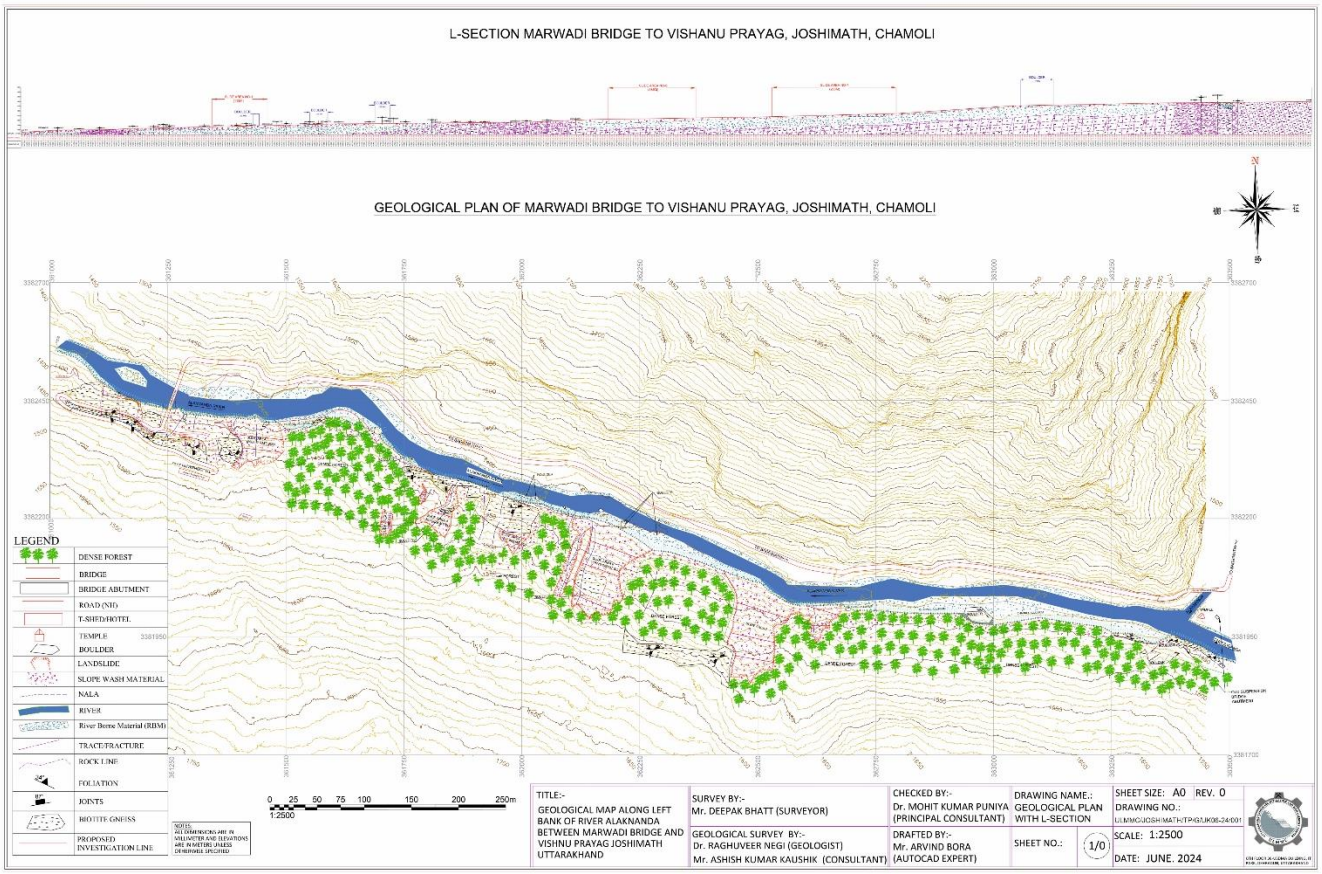
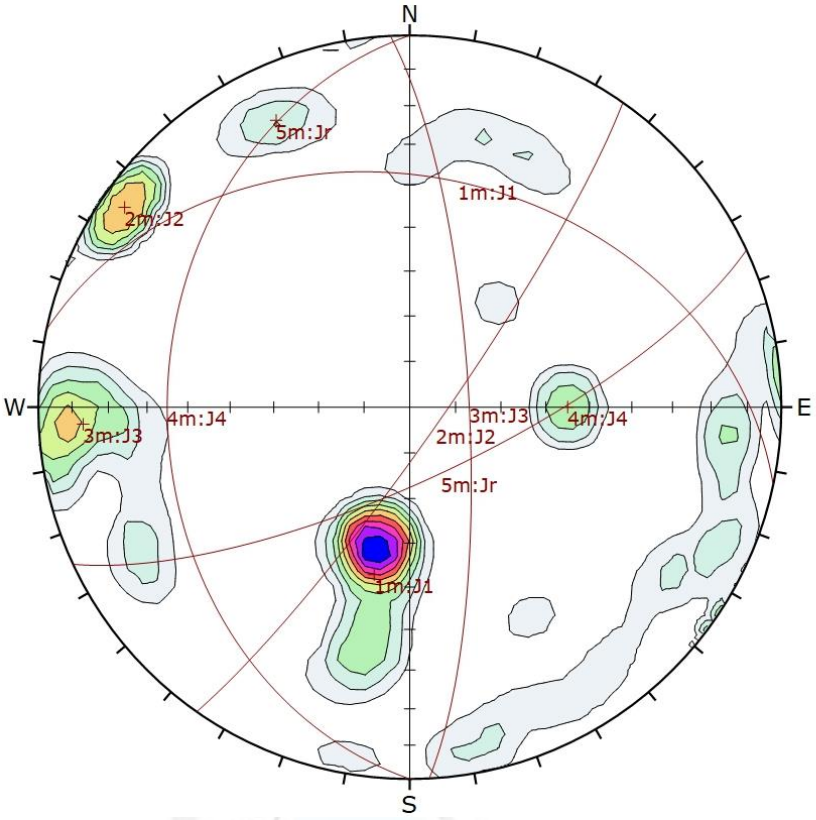


Figure 4: Geological Plan and L-section of Left Bank of the River Alaknanda between Marwadi Bridge and Vishnuprayag.

Figure 5: Field Photograph is showing biotite - gneiss evident along Alaknanda River, Near Marwadi Bridge Joshimath.

Figure 6: Field photograph is showing foliation plane (along geological hammer) of biotite - gneiss outcrop on left bank of the river Alaknanda, at Vishnuprayag.



Color	Density Concentrations
	0.00 - 1.50
	1.50 - 3.00
	3.00 - 4.50
	4.50 - 6.00
	6.00 - 7.50
	7.50 - 9.00
	9.00 - 10.50
	10.50 - 12.00
	12.00 - 13.50
	13.50 - 15.00

Maximum Density	14.95%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
Mean Set Planes				
1m		38	12	J1
2m		83	125	J2
3m		77	87	J3
4m		35	270	J4
5m		74	155	Jr

Plot Mode	Pole Vectors
Vector Count	58 (58 Entries)
Hemisphere	Lower
Projection	Equal Area

Figure 7: Stereographic projections major discontinuity of left bank of River Alaknanda between Marwadi Bridge and Vishnuprayag.

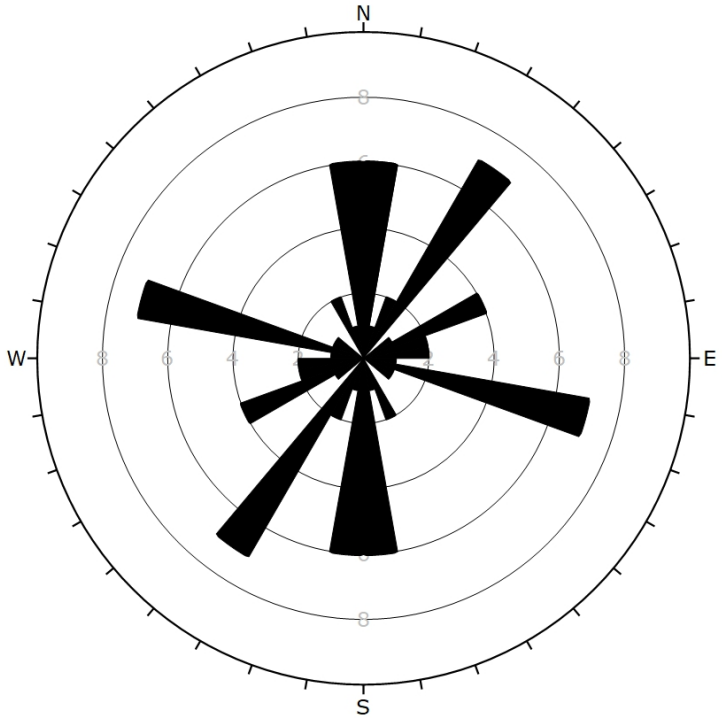


Figure 8: Rose diagram showing trends of major discontinuity along left bank of River Alaknanda between Marwadi Bridge and Vishnuprayag

6.0 LANDSLIDES

The total mapped and surveyed stretch along the left bank of the Alaknanda River is approximately 2,733 meters in length. Within this stretch, seven landslides have been identified. Of these, three major landslides are situated directly on the riverbank, covering a total length of 566 meters. The outcrop of biotite-gneiss extends for about 687 meters, while large boulders along the left bank cover approximately 150 meters. The rest of the area is covered by forest and slope wash material. Immediate toe protection is required for the 566-meter length of the river stretch to prevent further toe erosion and landslide activity. The landslides are occurring in the old landslides/moraine deposits, which is mainly composed of boulders of gneiss, and soils.

6.1. Landslide Zone 1

The landslide observed near Marwadi Bridge on the left bank of the River Alaknanda is situated between chainage 402 and 520 meters. The slope is experiencing failure in the 340° N direction through a rotational mode of failure. The slope material predominantly consists of old landslide deposits or moraine, which are primarily composed of large boulders of biotite-gneiss intermixed with soil (**Figure 9**).

The affected area covers approximately 8988 square meters (**Table 1**), with a maximum length of 125 meters. The primary factors contributing to the instability of this slope include toe erosion and the impact of drainage that traverse the middle and boundary of the slide zone.

Table 1: Area of different landslide zones, along left Bank of River Alaknanda between Marwadi Bridge and Vishnuprayag, Joshimath.

S.N.	Landslide zones	Area (m^2)
1	Landslide zone 1	8988.614
2	Landslide zone 2	1184.047
3	Landslide zone 3	370.84
4	Landslide zone 4	3811.628
5	Landslide zone 5	1731
6	Landslide zone 6	19729.64
7	Landslide zone 7	23103.427
9	**Area of Riverside zones**	**51821.681**
10	Others landslide zones	7097.515
11	**Total area effected by landslide**	**58919.196**

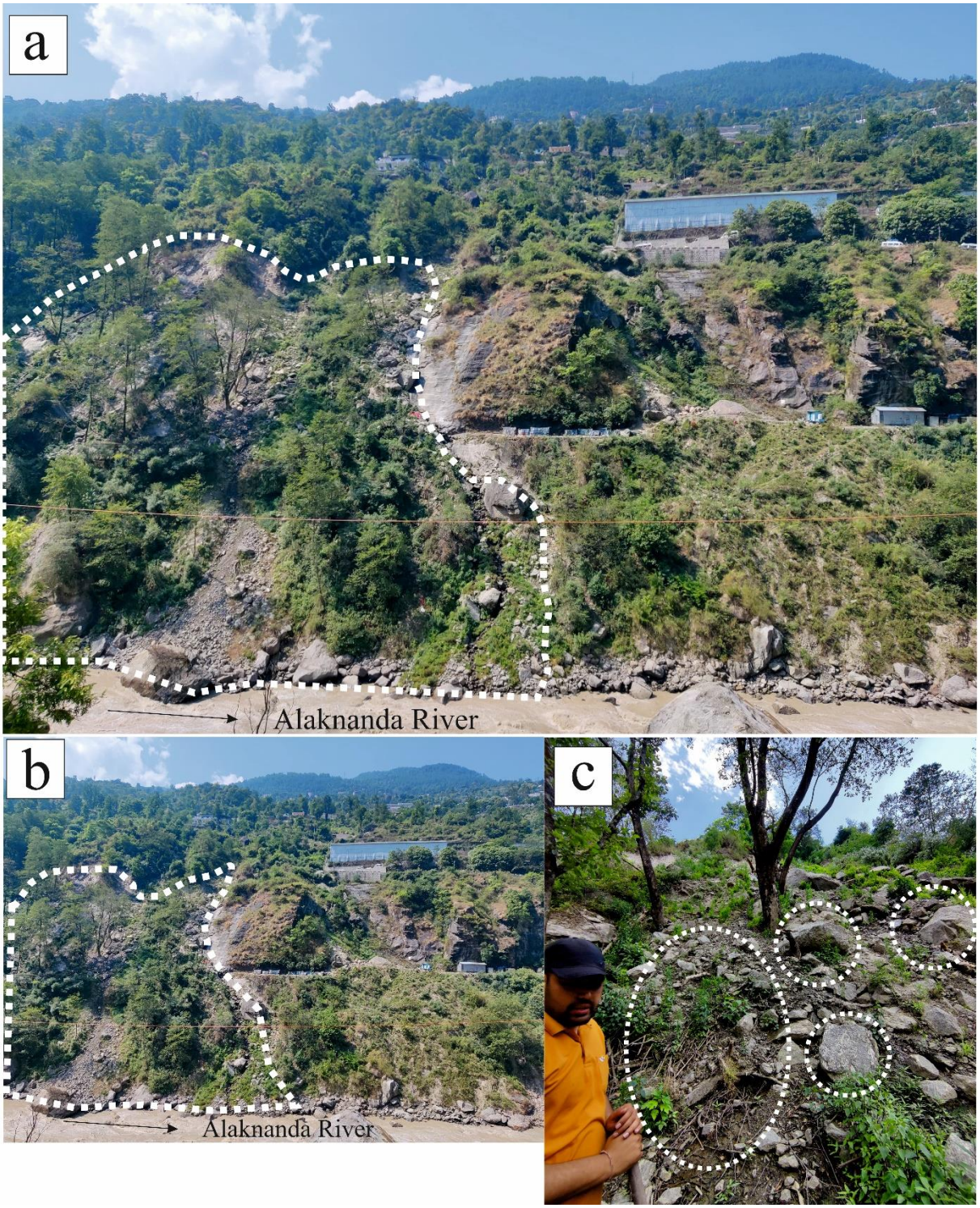


Figure 9: Field photograph showing (a) and (b) landslide zone 1, and (c) boulders and debris material of the affected zone.

6.2 Landslide No 2

A small debris slide, with a length of 54 meters and a width of 24 meters, covering an area of 1184 square meters (**Table 1**), was observed along the left bank of the River Alaknanda (Figure 4). The slid material consists of boulders, debris, and soil.

6.3 Landslide No. 3

A debris landslide in the old landslide deposits may be triggered during the monsoon, evidenced by signs of running water. However, during the site visit, no flowing or dripping water was observed (**Figure 10**). The slide encompasses an area of 370 square meters (**Table 1**), with a maximum length of 54 meters and a width of 24 meters.

Biotite gneiss is visible at the toe of the slide, providing protection against river-induced toe erosion. The landslide material primarily consists of old landslide or moraine deposits, mainly composed of biotite-gneiss boulders, debris, and soil. The slide zone is predominantly surrounded by a lush green forest, adding to the overall stability and ecological context of the area (**Figure 10**).

Figure 10: Filed photograph showing landslide zone 3, left bank of River Alaknanda, Joshimath.

6.4 Landslide No 4

Another debris landslide occurred along the left bank of the River Alaknanda between Marwadi Bridge and Vishnuprayag (**Figure 11**). The landslide zone is composed of biotite gneiss, and debris of old landslide/moraine. These deposits primarily consist of boulders, debris, and soil.

The slide zone covers an area of 3811 square meters (**Table 1)**, with a length of 101 meters and a width of 65 meters.

The slope also contains biotite-gneiss rock below the crown and at the toe (**Figure 11**). The main factors affecting the slope stability include the steepness of the slope and the drainage system passing through the middle of the slope.

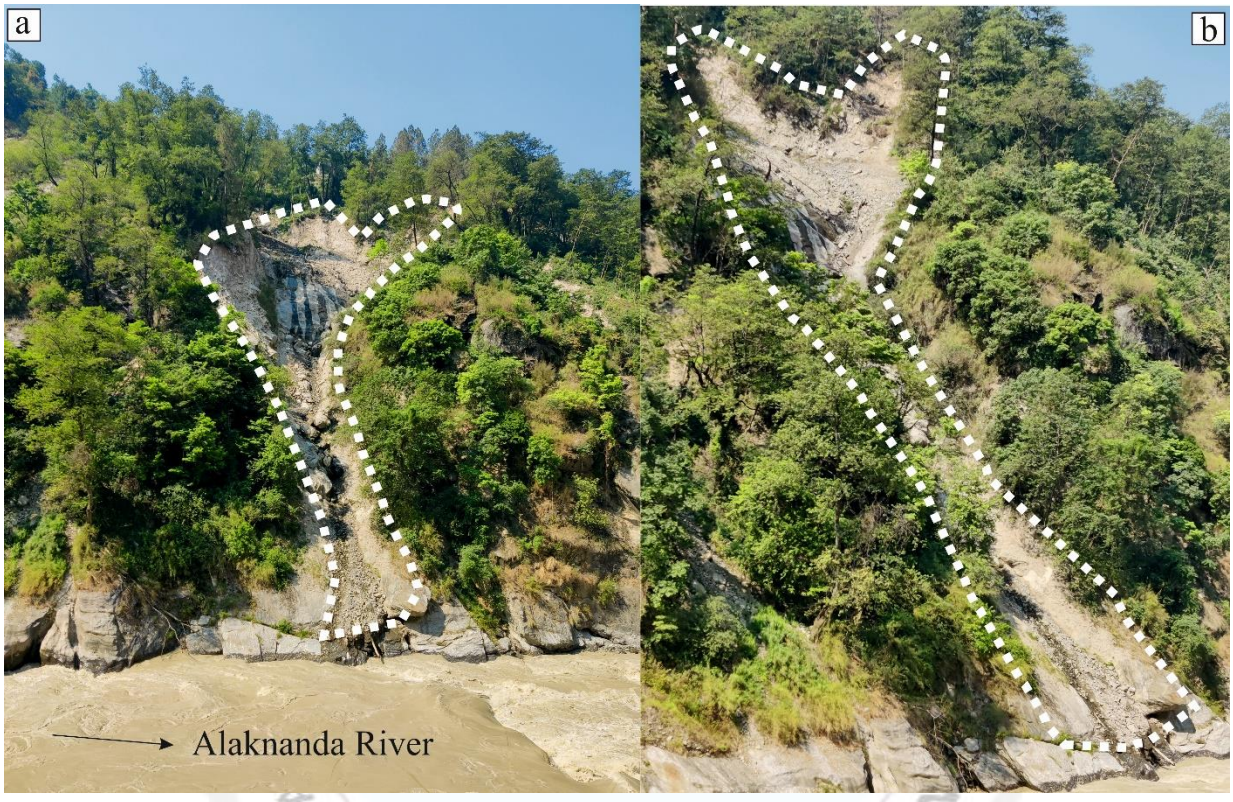


Figure 11: Field photograph showing landslide zone 4 along left bank of river Alaknanda between Marwadi Bridge and Vishnuprayag, Joshimath.

6.5 Landslide No 5

A debris slide covering an area of 1731 square meters (**Table 1)**, with a maximum length of 62 meters and a width of 61 meters, is observed along the left bank of the River Alaknanda between Marwadi Bridge and Vishnuprayag (**Figure 12**). The landslide zone is primarily protected by a biotite-gneiss outcrop at the toe (Figure 12). Although the rock outcrop shows potential for planar and wedge failure, no signs of rock failure are currently observed on the slope. The stability of the slope is thus maintained, but continuous monitoring is recommended to detect any changes that may indicate future instability. Also the landslide zone (**Figure 12**) is suggested to mitigate in order to prevent further slope failure.

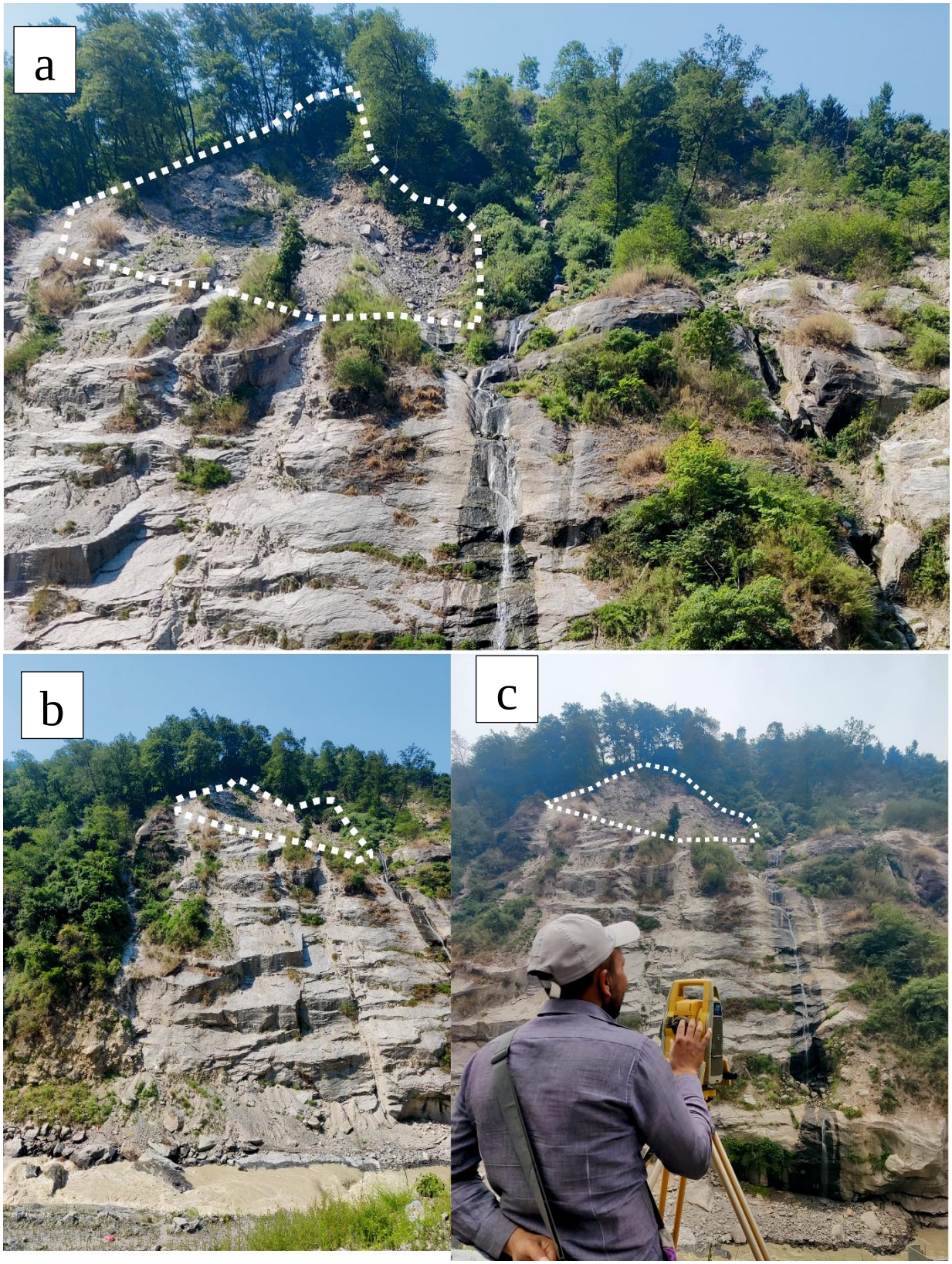


Figure 12: Field photograph showing landslide zone 5along left bank of River Alaknanda, Joshimath.

6.6 Landslide No 6

A debris slide is observed along the left bank of the River Alaknanda, covering an area of 19,729 square meters (**Table 1)**, with a maximum length of 209 meters. The slope is primarily composed of debris material from old landslide or moraine deposits and is failing through a rotational mode of failure (**Figure 13**). The potential causes of this failure include toe erosion and drainage systems passing through the slope. Treatment of the slope is essential to prevent future slope failure and ensure the stability of the area.

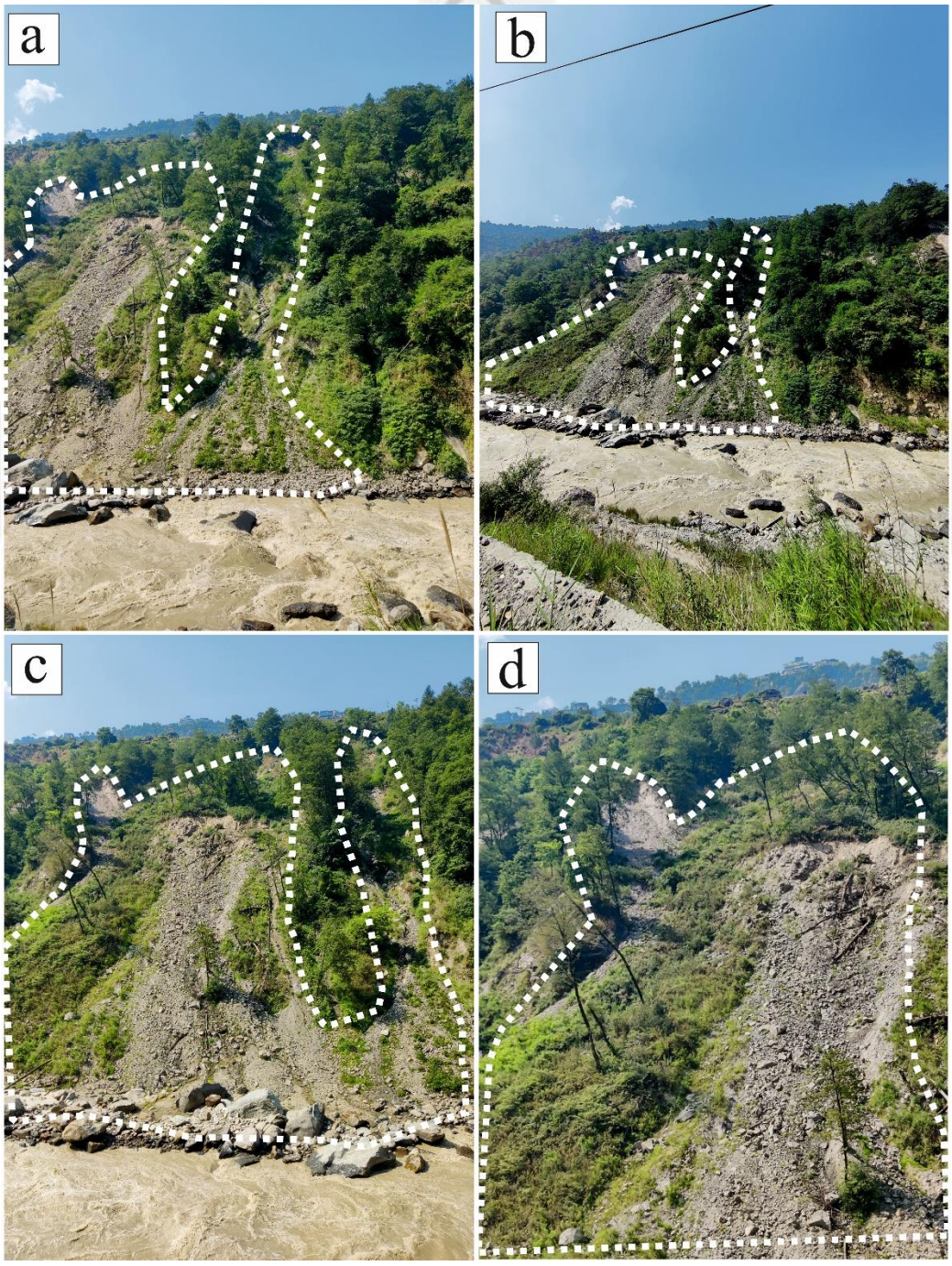


Figure 13: Filed photograph of the landslide zone 06, along left bank of the River Alaknanda

6.7 Landslide No 7

Another debris slide is observed near Vishnuprayag on the left bank of the River Alaknanda, between chainage 1583 to 1853 meters (**Figure 4; Figure 14**). The slide area covers 23,103 square meters (**Table 1)**, with a chainage length of 263 meters and a maximum length of 209 meters. The slide material primarily consists of boulders, rock debris, and soil. Toe erosion is identified as one of the primary factors accelerating slope instability.

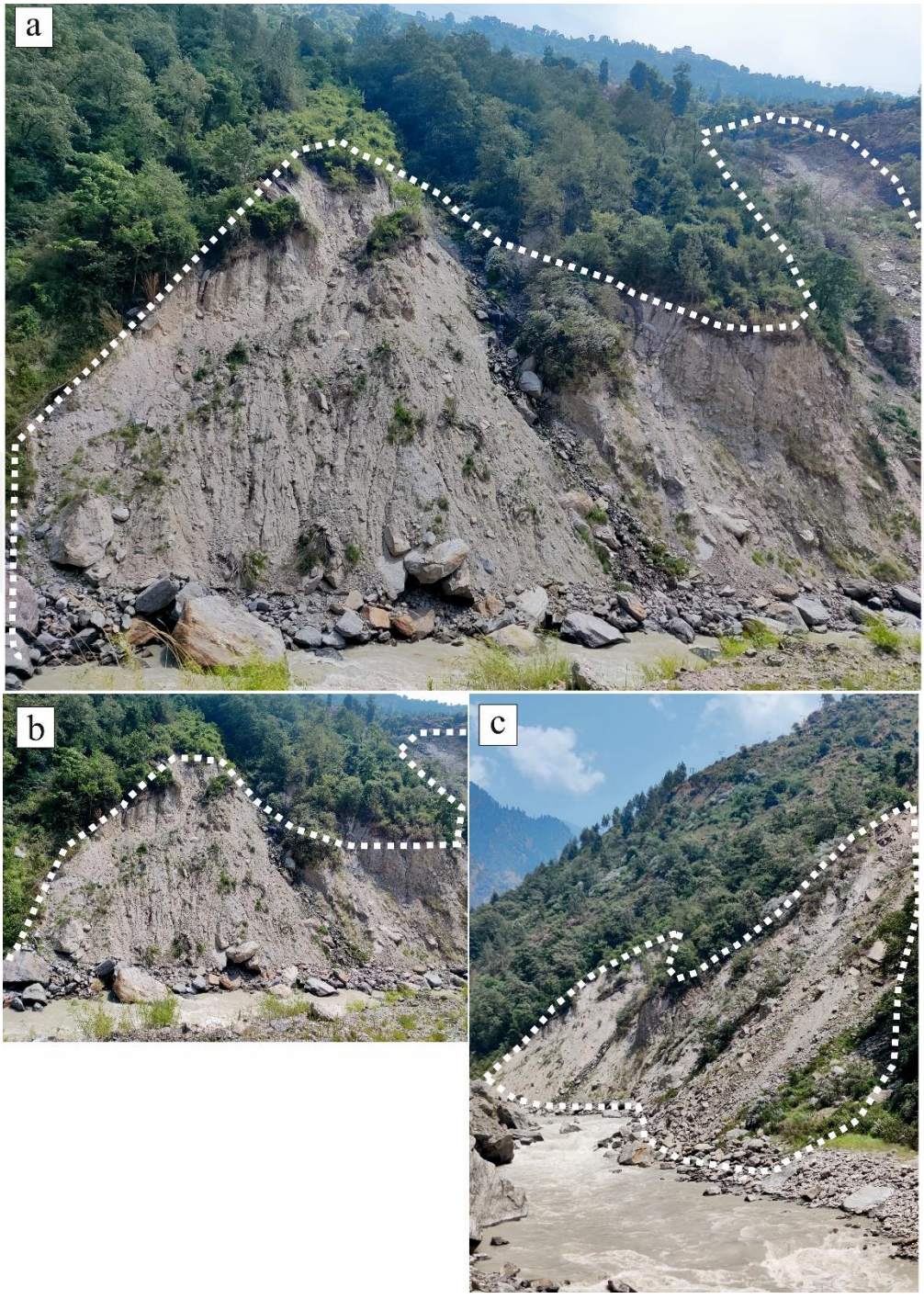


Figure 14: Field photograph showing landslide zone 7, along left bank of River Alaknanda, near Vishnupryag.

7.0 CONCLUDING REMARKS

The surveyed 2,733-meter stretch along the left bank of the Alaknanda River reveals significant slope instability, with seven identified landslides. Three major landslides, directly impacting the riverbank over 566 meters, highlight urgent need of mitigations. These landslides, primarily in old landslides/moraine deposits that mainly consist of biotite-gneiss and soil, are exacerbated by toe erosion and drainage issues. Key zones include the unstable 8988-square-meter area near Marwadi Bridge, a 23,103-square-meter slide near Vishnuprayag, and others ranging from 370 to 19,729 square meters. The total area affected by the landslides along the left bank of the Alaknanda River between Marwadi Bridge and Vishnuprayag is 58,919 square meters, out of which 51,821.6 square meters are in three major slide zones that are directly along the riverbank. Immediate toe protection and slope stabilization measures are essential to prevent further erosion and ensure long-term stability.

It is also imperative to conduct comprehensive geotechnical and geophysical investigations, including drilling, before designing toe protections and mitigation measures for the landslide zones. This approach ensures long-term stability. The following geotechnical analysis and geophysical investigations should be conducted before implementing any mitigation measures for slope failures and toe protection: Electrical Resistivity Tomography (ERT), Seismic Reflection Tomography (SRT), and Multi-Channel Analysis of Surface Waves (MASW). These investigations should cover a length of 1,040 meters, as per the proposed investigation lines in Figure 4, and reach a depth of 50 meters at the landslide sites.

- Tri-axial test/Direct Shear test of the of soil and rock [IS 2720 Part 11; IS 13047 /IS 2720 part 13 and 39 (Part 1 and 2)]
- Bulk and dry density of the soil and rocks (IS 2720 Part 3_1; IS 13030)
- Porosity and Permeability test of the soil and rock (IS 2720 part 17; IS 5529 part 1 and 2; IS 13030)
- Uniaxial compressive strength of (IS 2720 Part 10; IS 9143)
- Grain size analysis of the soil (IS 2720 Part 4)
- Atterberg limit of the soil (IS 2720 Part 5)

References

Geological Survey of India, 2024. chromeextension://efaidnbmnnnibpcajpcglclefindmkaj/ https://employee.gsi.gov.in/cs/groups/public/documents/document/dmkx/mjy4/~edisp/dcport1gsigovi1268955.pdf

Bera, B., Saha, S., & Bhattacharjee, S. (2023). Sinking and sleeping of Himalayan city Joshimath. Quaternary Science Advances, 12, 100100.

Annexure 1

L01 (Near Marwadi Bridge)			
Set number		J1	J2
Dip Amount		35	80
Dip Direction		15	330
Joint Descriptions	**Persistence (m)**	10	1-2
	Spacing (cm)	40 - 100	>200
	Aperture (mm)	Tight	Open
	Roughness	Rough Irregular	
Rock Mass Descriptions	**Rock Type**	Gneiss	
	Strength	Moderate to Strong	
	No. of joints sets	2	
	Degree of Weathering	Slightly weathered	
	Geological Structure	Massive to Slightly Jointed	
	Water inflow	Flowing	
	RQD	60-70%	

L02 (Near Marwadi Bridge)				
Set number		J1	J2	J3
Dip Amount		34	75	60
Dip Direction		25	150	85
Joint Descriptions	**Persistence (m)**	2-3	1-2	1-2
	Spacing (cm)	30- 100	> 200	>200
	Aperture (mm)	Tight	Tight	Open
	Roughness	Rough Irregular		
Rock Mass Descriptions	**Rock Type**	Gneiss		
	Strength	Moderate to High		
	No. of joints sets	3		
	Degree of Weathering	Sligtly weathered		
	Geological Structure	Sliglty Jointed		
	Water inflow	Damp		
	RQD	60-70%		

L03 (Near Marwadi Bridge)				
Set number		J1	J2	J3
Dip Amount		45	83	52
Dip Direction		10	125	10
Joint Descriptions	**Persistence (m)**	4	1-2	2-3
	Spacing (cm)	30 to 100	> 200	>200
	Aperture (mm)	Tight	Tight	Tight
	Roughness	Rough Irregular		
Rock Mass Descriptions	**Rock Type**	Gneiss		
	Strength	Strong		
	No. of joints sets	3		
	Degree of Weathering	Slightly weathered		
	Geological Structure	Slightly Jointed,		
	Water inflow	Flowing		
	RQD	65-75%		

L04 (Near Marwadi Bridge)				
Set number		J1	J2	J3
Dip Amount		28	70	60
Dip Direction		15	305	10
Joint Descriptions	**Persistence (m)**	10	0.5-1	0.5-1
	Spacing (cm)	30 to 80	>200	>200
	Aperture (mm)	Tight	Open	Open
	Roughness	Rough Irregular		
Rock Mass Descriptions	**Rock Type**	Gneiss		
	Strength	Moderate to High		
	No. of joints sets	3		
	Degree of Weathering	Slightly weathered		
	Geological Structure	Slightly jointed		
	Water inflow	Dry		
	RQD	60-70%		

L05 (Near Marwadi Bridge)					
Set number		J1	J2	J3	J4
Dip Amount		27	75	80	64
Dip Direction		15	340	92	190
Joint Descriptions	**Persistence (m)**	1	1	1-2	1-2
	Spacing (cm)	30-100	>200	>200	>200
	Aperture (mm)	Tight	Partially Open	Partially Open	Partially Open
	Roughness	Rough Irregular			
Rock Mass Descriptions	**Rock Type**	Gneiss			
	Strength	Moderate to Strong			
	No. of joints sets	3			
	Degree of Weathering	Slightly weathered			
	Geological Structure	Moderately jointed			
	Water inflow	Dry			
	RQD	45-55%			

L06 (Near Marwadi Bridge)					
Set number		J1	J2	J3	J4
Dip Amount		30	75	70	70
Dip Direction		10	320	85	160
Joint Descriptions	**Persistence (m)**	1	1-2	1-2	1-3
	Spacing (cm)	>200	>200	>200	>200
	Aperture (mm)	Tight	Partially Open	Moderately Wide	Moderately Wide
	Roughness	Rough Irregular			
Rock Mass Descriptions	**Rock Type**	Gneiss			
	Strength	Moderate to Strong			
	No. of joints sets	3			
	Degree of Weathering	Slightly weathered			
	Geological Structure	Slightly Jointed			
	Water inflow	Dry			
	RQD	50-60%			

L07 (Near Marwadi Bridge)					
Set number		J1	J2	J3	J4
Dip Amount		30	80	85	55
Dip Direction		15	350	80	180
Joint Descriptions	**Persistence (m)**	1	1	1-2	1- 2
	Spacing (cm)	30-70	>200	>200	>200 cm
	Aperture (mm)	tight	tight	open	open
	Roughness	Rough Irregular			
Rock Mass Descriptions	**Rock Type**	Gneiss			
	Strength	Strong			
	No. of joints sets	4			
	Degree of Weathering	Slightly weathered			
	Geological Structure	Slightly Jointed			
	Water inflow	Dry			
	RQD	60-70%			

L09				
Set number		J1	J2	J3
Dip Amount		320	75	65
Dip Direction		15	275	15
Joint Descriptions	**Persistence (m)**	4-5	4-5	9-10
	Spacing (cm)	40-90	>200	>200
	Aperture (mm)	Tight	Partially open	Partially open
	Roughness	Rough Irregular		
Rock Mass Descriptions	**Rock Type**	Gneiss		
	Strength	Strong		
	No. of joints sets	3		
	Degree of Weathering	Slightly weathered		
	Geological Structure	Slightly Jointed		
	Water inflow	Damp		
	RQD	60-70%		

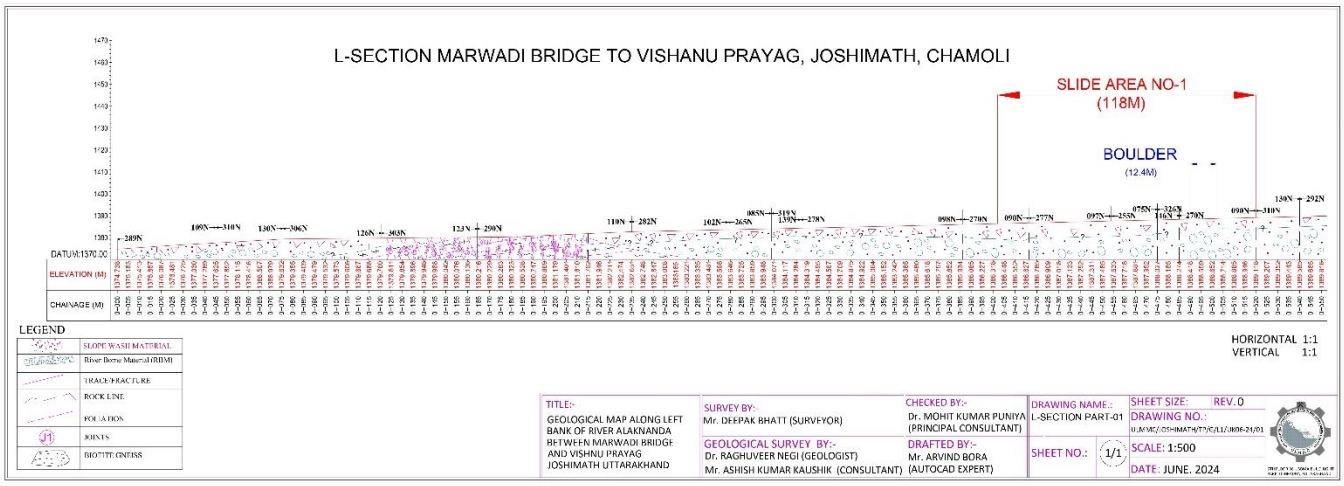
L10			
Set number		J1	J2
Dip Amount		30	75
Dip Direction		15	270
Joint Descriptions	**Persistence (m)**	10	1-2
	Spacing (cm)	40-100	>200
	Aperture (mm)	Tight	open
	Roughness	Rough Irregular	
Rock Mass Descriptions	**Rock Type**	Gneiss	
	Strength	Moderate to Strong	
	No. of joints sets	2	
	Degree of Weathering	Slightly weathered	
	Geological Structure	Slightly jointed	
	Water inflow	Flowing	
	RQD	50-55%	

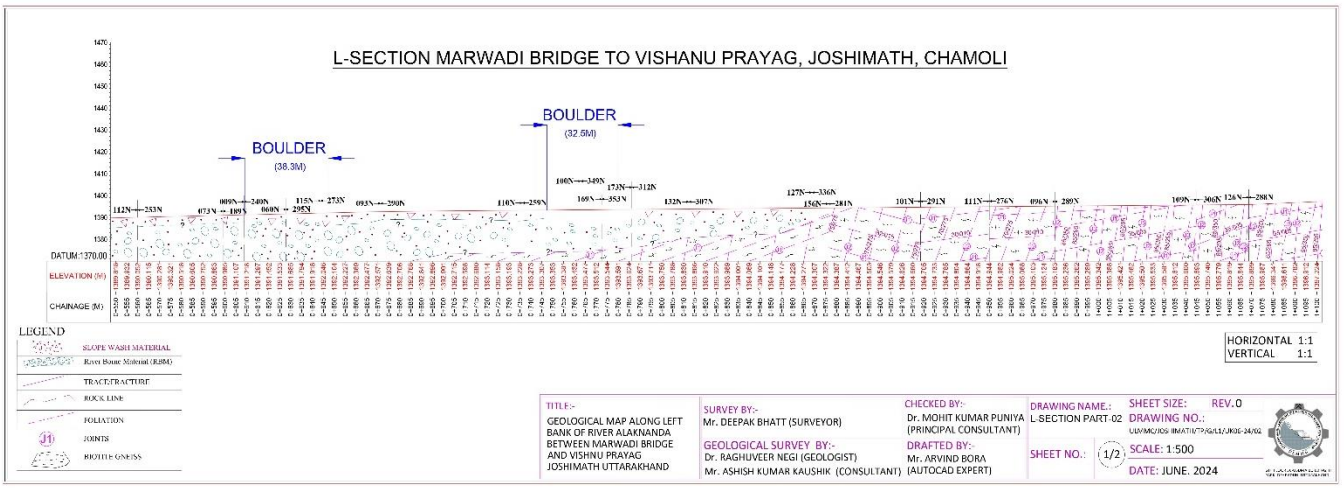
L11				
Set number		J1	J2	J3
Dip Amount		35	85	85
Dip Direction		5	295	350
Joint Descriptions	**Persistence (m)**	1-5	1-5	10
	Spacing (cm)	>200	>200	>200
	Aperture (mm)	Tight	Wide	Wide
	Roughness	Rough Irregular		
Rock Mass Descriptions	**Rock Type**	Gneiss		
	Strength	Moderate to Strong		
	No. of joints sets	3		
	Degree of Weathering	Slightly weathered		
	Geological Structure	Slightly jointed		
	Water inflow	Flowing		
	RQD	60-65%		

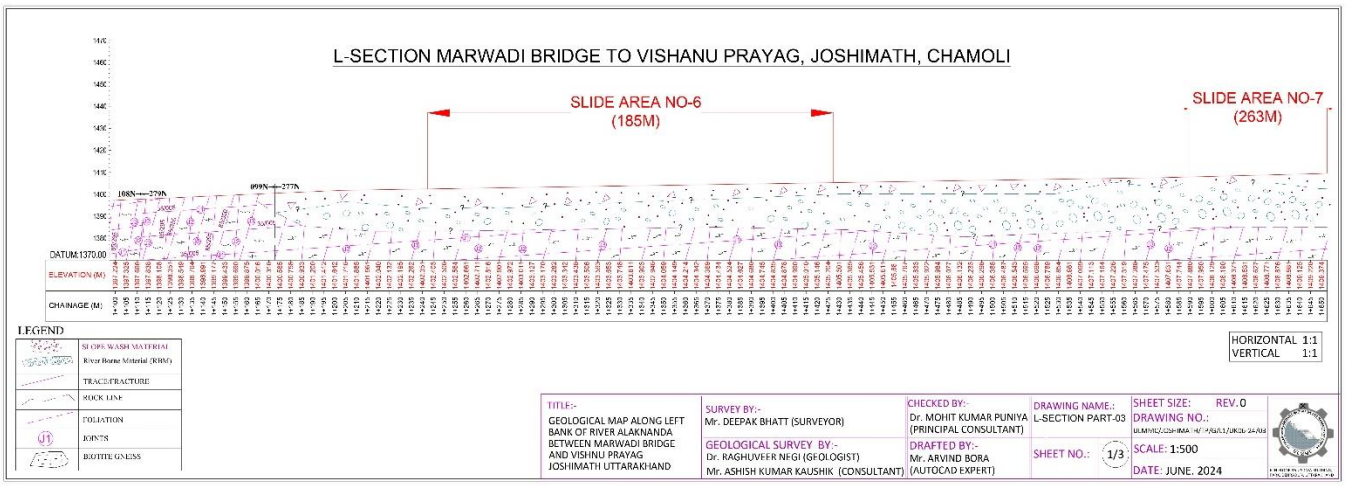
L13 (Vishnuprayag)				
Set number		J1	J2	J3
Dip Amount		40	55	65
Dip Direction		10	330	200
Joint Descriptions	**Persistence (m)**	1	1-2	1-2
	Spacing (cm)	>200	>200	>200
	Aperture (mm)	Tight	Partial Open	Open
	Roughness	Rough Irregular		
Rock Mass Descriptions	**Rock Type**	Gneiss		
	Strength	Strong		
	No. of joints sets	3		
	Degree of Weathering	Slightly weathered		
	Geological Structure	Slightly Jointed		
	Water inflow	Dry		
	RQD	70-75%		

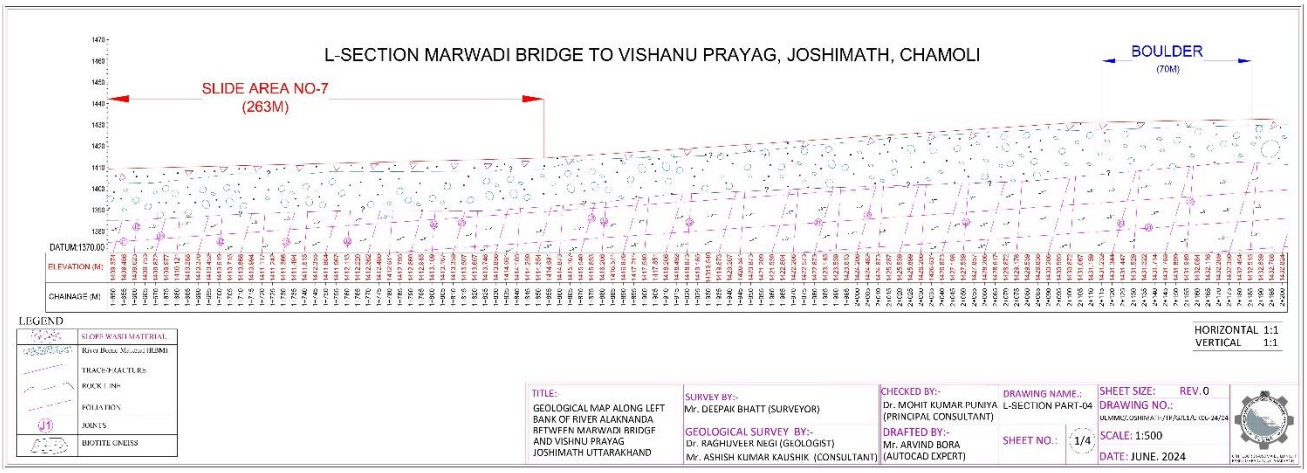
L14 (Vishnuprayag)				
Set number		J1	J2	J3
Dip Amount		55	80	85
Dip Direction		15	330	10
Joint Descriptions	**Persistence (m)**	10	1-2	2-3
	Spacing (cm)	>200	>200	>200
	Aperture (mm)	Tight	Partially open	open
	Roughness	Rough Irregular		
Rock Mass Descriptions	**Rock Type**	Gneiss		
	Strength	Strong		
	No. of joints sets	3		
	Degree of Weathering	Slightly weathered		
	Geological Structure	Slightly Jointed		
	Water inflow	Flowing		
	RQD	60-70%		

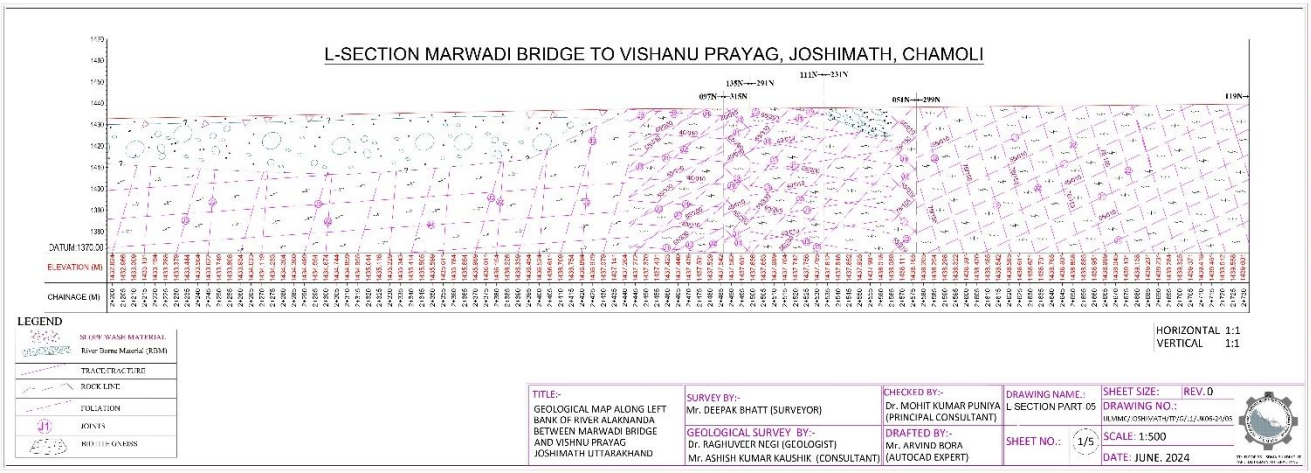
Annexure 2


L-SECTION MARWADI BRIDGE TO VISHANU PRAYAG, JOSHIMATH, CHAMOLI
SLIDE AREA NO-1
(118M)
BOULDER
(12.4M)
DATUM:1370.00
ELEVATION (M)
CHAINAGE (M)
LEGEND
SLOPE WASH MATERIAL
River Borne Material (RBM)
TRACE/FRACTURE
ROCK LINE
FOLIATION
JOINTS
BIOTITE GNEISS
HORIZONTAL 1:1
VERTICAL 1:1
TITLE:-
GEOLOGICAL MAP ALONG LEFT BANK OF RIVER ALAKNANDA BETWEEN MARWADI BRIDGE AND VISHNU PRAYAG JOSHIMATH UTTARAKHAND
SURVEY BY:-
Mr. DEEPAK BHATT (SURVEYOR)
GEOLOGICAL SURVEY BY:-
Dr. RAGHUVEER NEGI (GEOLOGIST)
Mr. ASHISH KUMAR KAUSHIK (CONSULTANT)
CHECKED BY:-
Dr. MOHIT KUMAR PUNIYA (PRINCIPAL CONSULTANT)
DRAFTED BY:-
Mr. ARVIND BORA (AUTOCAD EXPERT)
DRAWING NAME.:
L-SECTION PART-01
SHEET NO.:
1/1
SHEET SIZE:
REV.0
DRAWING NO.:
SCALE: 1:500
DATE: JUNE. 2024

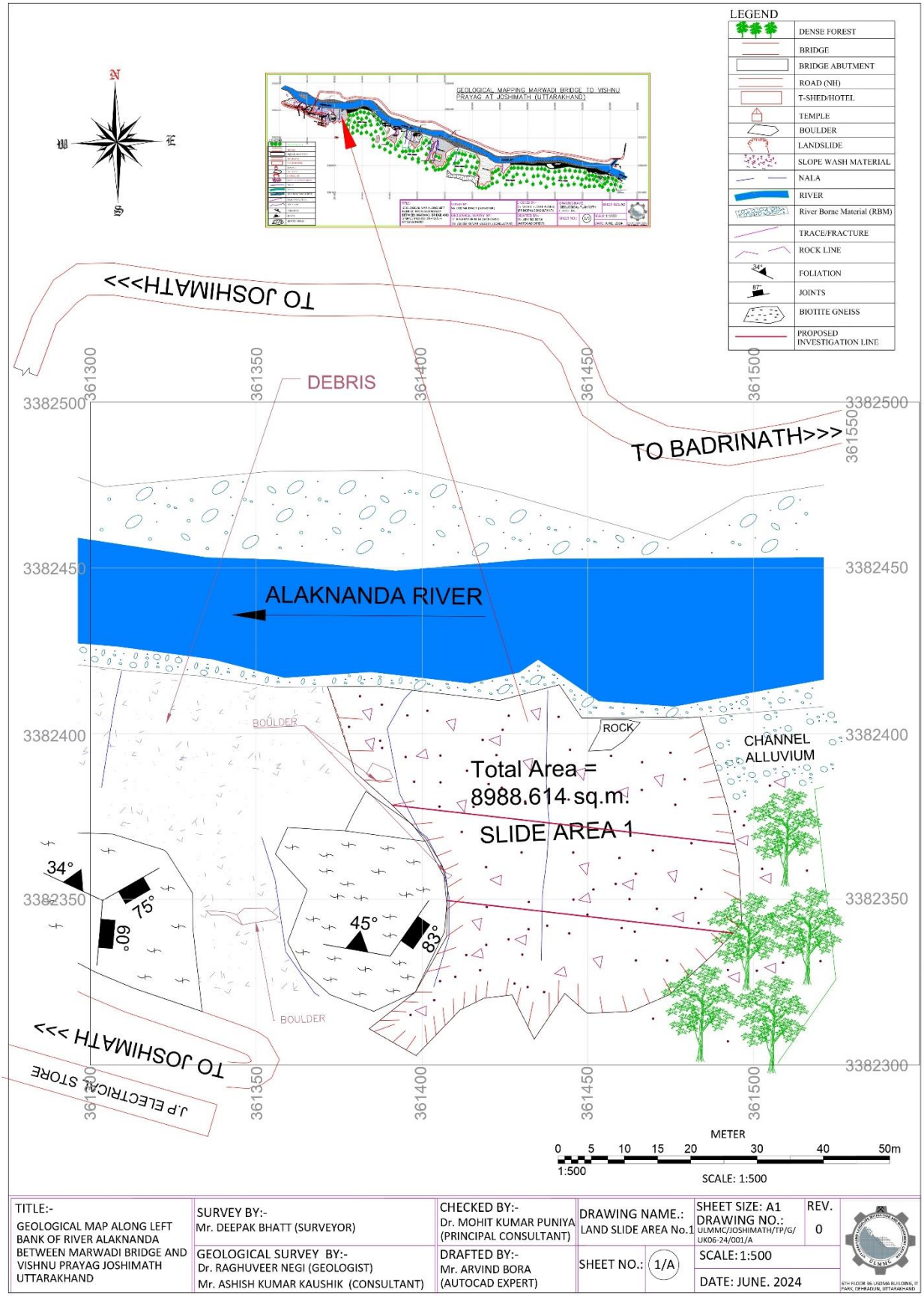

L-SECTION MARWADI BRIDGE TO VISHANU PRAYAG, JOSHIMATH, CHAMOLI
BOULDER
(38.3M)
BOULDER
(32.5M)
DATUM:1370.00
ELEVATION (M)
CHAINAGE (M)
LEGEND
SLOPE WASH MATERIAL
River Borne Material (RBM)
TRACE/FRACTURE
ROCK LINE
FOLIATION
JOINTS
BIOTITE GNEISS
HORIZONTAL 1:1
VERTICAL 1:1
TITLE:-
GEOLOGICAL MAP ALONG LEFT BANK OF RIVER ALAKNANDA BETWEEN MARWADI BRIDGE AND VISHNU PRAYAG JOSHIMATH UTTARAKHAND
SURVEY BY:-
Mr. DEEPAK BHATT (SURVEYOR)
GEOLOGICAL SURVEY BY:-
Dr. RAGHUVEER NEGI (GEOLOGIST)
Mr. ASHISH KUMAR KAUSHIK (CONSULTANT)
CHECKED BY:-
Dr. MOHIT KUMAR PUNIYA (PRINCIPAL CONSULTANT)
DRAFTED BY:-
Mr. ARVIND BORA (AUTOCAD EXPERT)
DRAWING NAME.:
L-SECTION PART-02
SHEET NO.:
1/2
SHEET SIZE:
REV.0
DRAWING NO.:
SCALE: 1:500
DATE: JUNE. 2024


L-SECTION MARWADI BRIDGE TO VISHANU PRAYAG, JOSHIMATH, CHAMOLI
SLIDE AREA NO-6
(185M)
SLIDE AREA NO-7
(263M)
DATUM:1370.00
ELEVATION (M)
CHAINAGE (M)
LEGEND
SLOPE WASH MATERIAL
River Borne Material (RBM)
TRACE/FRACTURE
ROCK LINE
FOLIATION
JOINTS
BIOTITE GNEISS
HORIZONTAL 1:1
VERTICAL 1:1
TITLE:-
GEOLOGICAL MAP ALONG LEFT BANK OF RIVER ALAKNANDA BETWEEN MARWADI BRIDGE AND VISHNU PRAYAG JOSHIMATH UTTARAKHAND
SURVEY BY:-
Mr. DEEPAK BHATT (SURVEYOR)
GEOLOGICAL SURVEY BY:-
Dr. RAGHUVEER NEGI (GEOLOGIST)
Mr. ASHISH KUMAR KAUSHIK (CONSULTANT)
CHECKED BY:-
Dr. MOHIT KUMAR PUNIYA (PRINCIPAL CONSULTANT)
DRAFTED BY:-
Mr. ARVIND BORA (AUTOCAD EXPERT)
DRAWING NAME.:
L-SECTION PART-03
SHEET NO.:
1/3
SHEET SIZE:
REV.0
DRAWING NO.:
SCALE: 1:500
DATE: JUNE. 2024

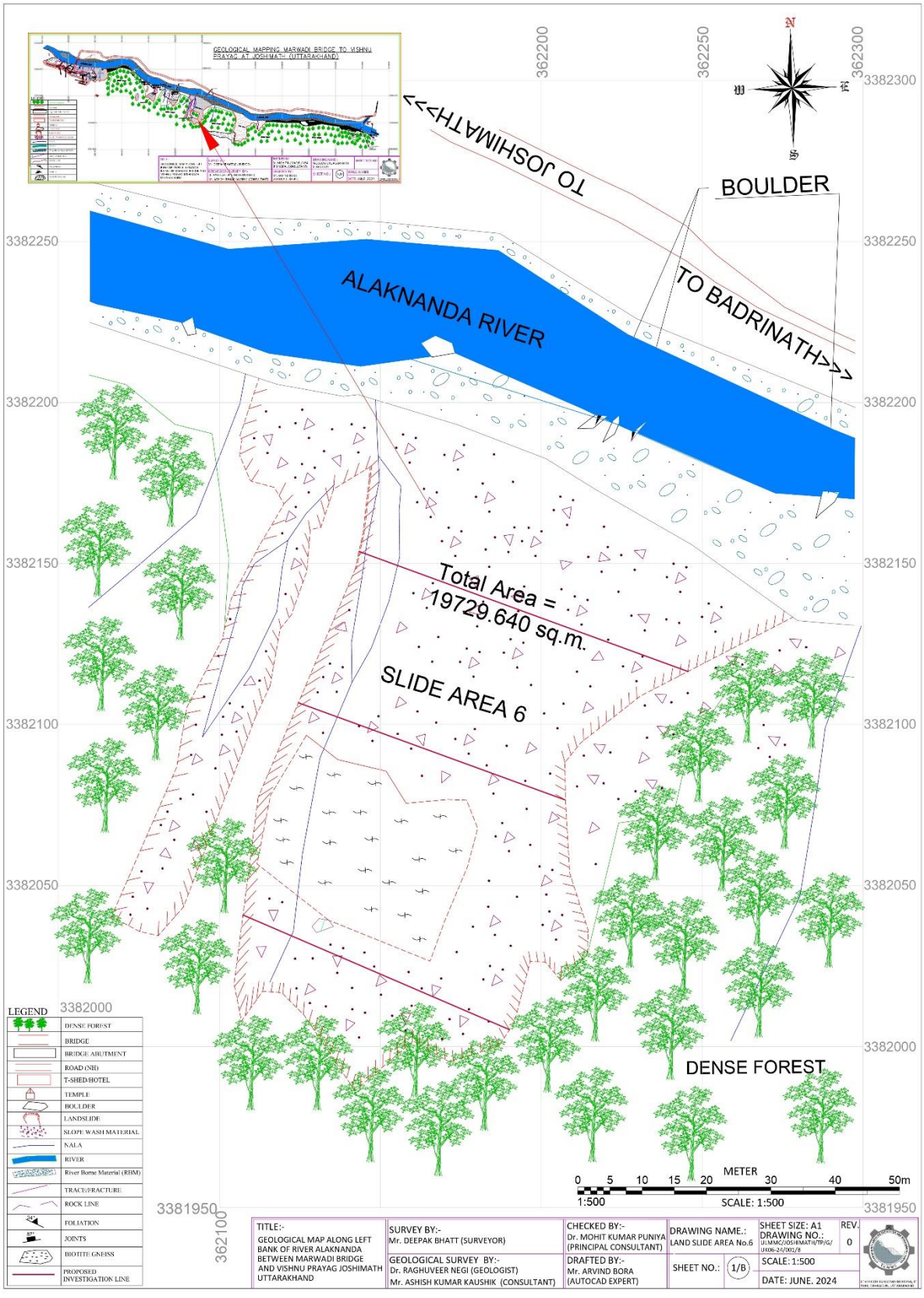




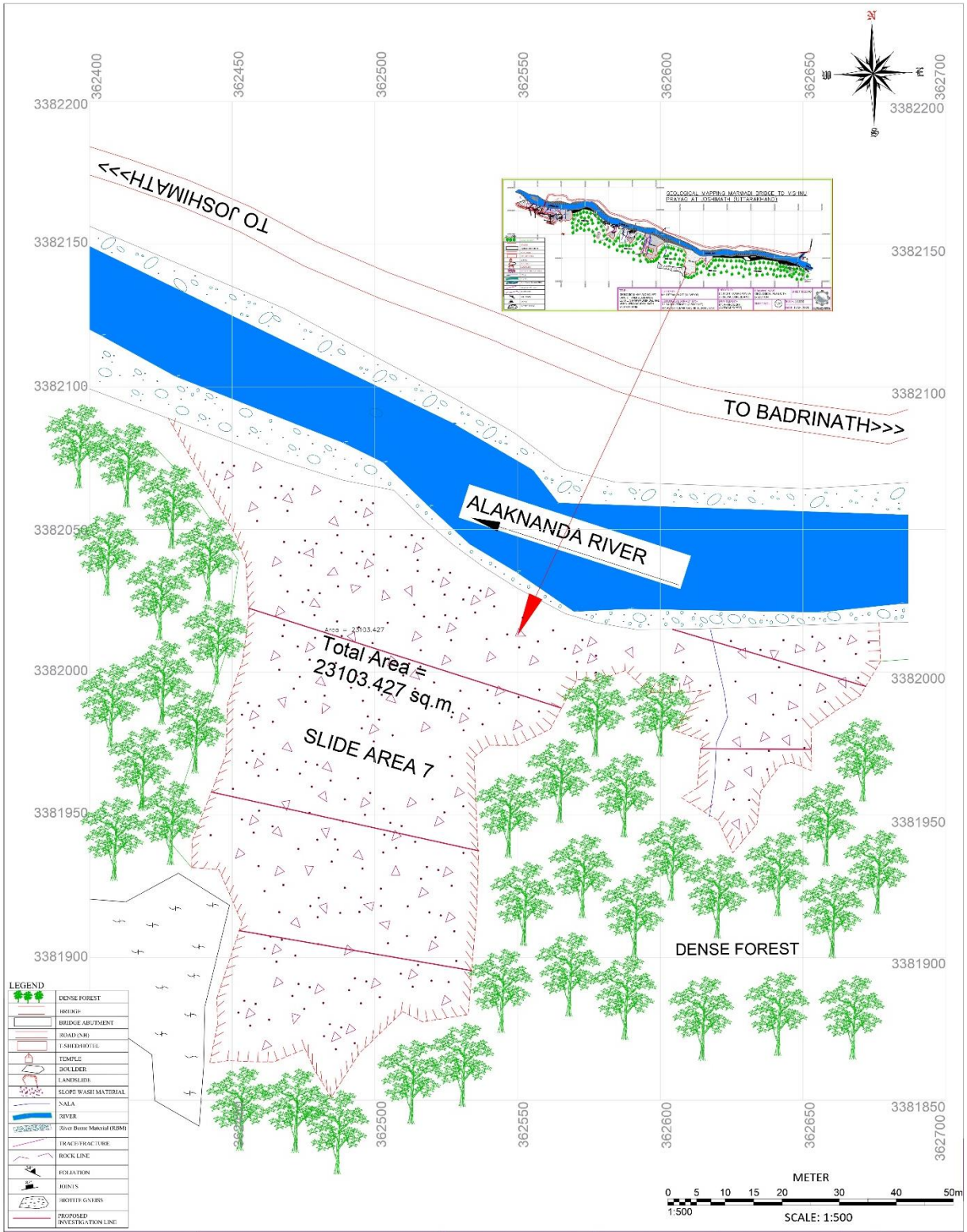
Annexure 3



TITLE:- GEOLOGICAL MAP ALONG LEFT BANK OF RIVER ALAKNANDA BETWEEN MARWADI BRIDGE AND VISHNU PRAYAG JOSHIMATH UTTARAKHAND	SURVEY BY:- Mr. DEEPAK BHATT (SURVEYOR)	CHECKED BY:- Dr. MOHIT KUMAR PUNIYA (PRINCIPAL CONSULTANT)	DRAWING NAME.: LAND SLIDE AREA No.1	SHEET SIZE: A1 DRAWING NO.: ULMMC/JOSHIMATH/TP/G/ UK06-24/001/A	REV. 0
	GEOLOGICAL SURVEY BY:- Dr. RAGHUVEER NEGI (GEOLOGIST) Mr. ASHISH KUMAR KAUSHIK (CONSULTANT)	DRAFTED BY:- Mr. ARVIND BORA (AUTOCAD EXPERT)	SHEET NO.: 1/A	SCALE: 1:500	
				DATE: JUNE. 2024	



TITLE:- GEOLOGICAL MAP ALONG LEFT BANK OF RIVER ALAKNANDA BETWEEN MARWADI BRIDGE AND VISHNU PRAYAG JOSHIMATH UTTARAKHAND	SURVEY BY:- Mr. DEEPAK BHATT (SURVEYOR)	CHECKED BY:- Dr. MOHIT KUMAR PUNIYA (PRINCIPAL CONSULTANT)	DRAWING NAME.: LAND SLIDE AREA No.6	SHEET SIZE: A1 DRAWING NO.: U:\MMC\JOSHIMATH\TP\G\ U\006-24\001/8	REV. 0
	GEOLOGICAL SURVEY BY:- Dr. RAGHUVEER NEGI (GEOLOGIST) Mr. ASHISH KUMAR KAUSHIK (CONSULTANT)	DRAFTED BY:- Mr. ARVIND BORA (AUTOCAD EXPERT)	SHEET NO.: 1/B	SCALE: 1:500	
				DATE: JUNE. 2024	



TITLE:- GEOLOGICAL MAP ALONG LEFT BANK OF RIVER ALAKNANDA BETWEEN MARWADI BRIDGE AND VISHNU PRAYAG JOSHIMATH UTTARAKHAND	SURVEY BY:- Mr. DEEPAK BHATT (SURVEYOR)	CHECKED BY:- Dr. MOHIT KUMAR PUNIYA (PRINCIPAL CONSULTANT)	DRAWING NAME.: LAND SLIDE AREA No.7	SHEET SIZE: A0 DRAWING NO.: ULMMC/JOSHIMATH/TP/G/ UK06-24/001/C	REV. 0
	GEOLOGICAL SURVEY BY:- Dr. RAGHUVEER NEGI (GEOLOGIST) Mr. ASHISH KUMAR KAUSHIK (CONSULTANT)	DRAFTED BY:- Mr. ARVIND BORA (AUTOCAD EXPERT)	SHEET NO.: 1/C	SCALE:1:500	
				DATE: JUNE. 2024	

6TH FLOOR, 36 US266A BUILDING, IT PARK, DEHRADUN, UTTARAKHAND