

PCA Case No. 2023-01

IN THE MATTER OF AN ARBITRATION

-before-

THE COURT OF ARBITRATION CONSTITUTED
IN ACCORDANCE WITH THE INDUS WATERS TREATY 1960

-between-

THE ISLAMIC REPUBLIC OF PAKISTAN

-and-

THE REPUBLIC OF INDIA

CERTIFIED TRANSCRIPT
(SITE VISIT)

COURT OF ARBITRATION:

Professor Sean D. Murphy (Chairman)
Professor Wouter Buytaert
Mr. Jeffrey P. Minear
Judge Awn Shawkat Al-Khasawneh
Dr. Donald Blackmore

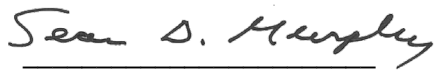
SECRETARIAT:

The Permanent Court of Arbitration

ON BEHALF OF THE COURT OF
ARBITRATION:

CERTIFIED PURSUANT
TO
PARAGRAPH 19 OF ANNEXURE G

25 April 2024



Professor Sean D. Murphy
Chairman

Arbitration pursuant to Article IX and Annexure G
of the Indus Waters Treaty 1960

NJHEP Dam Site
Pakistan-administered
Kashmir and Jammu Region

Day 3
Site Visit

Thursday, 25th April 2024

Before:

PROFESSOR SEAN D MURPHY
PROFESSOR WOUTER BUYTAERT
MR JEFFREY P MINEAR
DR DON BLACKMORE
MR STEPHEN POMPER, NEUTRAL OBSERVER

BETWEEN:

THE ISLAMIC REPUBLIC OF PAKISTAN
-and-
THE REPUBLIC OF INDIA

Transcript produced by Anne-Marie Stallard, Lisa Gulland
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1 Thursday, 25 April 2024
 2 (10.09 am)
 3 Bridge viewing
 4 MR MIANA: Okay, gentlemen, Mr Chairman and the members of
 5 the court, again good morning to all of you.
 6 From here we can see to the downstream side of the
 7 dam site. To the left we have the right bank, because
 8 the flow is in this direction. And to our right is our
 9 left bank. And this is the embankment dam to the
 10 left-hand side. At left is the crest opening of the two
 11 flap gates. Beside this we have the three radial gates
 12 which are visible in the black over there, and with them
 13 we have the undersluice over there, where the small
 14 water is coming out.
 15 At the moment the total flow coming downstream is
 16 250 plus or minus. So this varies about according to
 17 the inflows, as well as the level regulations.
 18 There is also a natural stream coming from this
 19 upstream side, you can see in the downstream of this
 20 one. And beside this undersluice we have the desanders
 21 over there, and at the end of the desanders we have the
 22 collecting canal over there.
 23 From there, collecting canal inside the mountain
 24 headrace internal starts. So this was just an overview
 25 of the dam from the downstream side so that you can

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1 familiarise with these components.
 2 The left side is the Panjal formation, and the right
 3 side is the Murree formation. So the more about the
 4 geology will be explained by the geologist, just to give
 5 you an idea about that one. So if you have any
 6 questions about this one, I'm ready to answer that.
 7 MR MINEAR: Is this rockfill here?
 8 MR MIANA: (Inaudible) this is the rockfill at left side,
 9 yes. And at right side is concrete dam.
 10 THE CHAIRMAN: And the channel on the left, that's the
 11 channel you spoke of yesterday; is that correct?
 12 MR MINEAR: The coffer.
 13 THE CHAIRMAN: The coffer.
 14 MR MIANA: No, no, these are the crest openings over there.
 15 We've got two flap gates.
 16 THE CHAIRMAN: Okay.
 17 MR MINEAR: Further to the left, what is --
 18 THE CHAIRMAN: The opening?
 19 MR MINEAR: There was a coffer dam that was mentioned
 20 yesterday, is that right?
 21 MR MIANA: Rockfill dam, not coffer dam.
 22 MR MINEAR: Okay. Thank you.
 23 MR MIANA: At present 10-15 cumecs from undersluice, and the
 24 rest from the flap gates. So if the flow increases then
 25 we have the option for the radial gates 1, 2 and 3.

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1 THE CHAIRMAN: And those are closed right now.
 2 MR MIANA: Because the outflows are not too much to operate
 3 them, and the small opening of that gate is not
 4 recommended.
 5 PROFESSOR BUYTAERT: What is the long-term average discharge
 6 of the Neelum?
 7 MR MIANA: From flap gates it's 300 cumecs from each side.
 8 PROFESSOR BUYTAERT: So a long-term average discharge of
 9 around 300?
 10 MR MINEAR: Not now. At the moment it's 250.
 11 PROFESSOR BUYTAERT: So now it's below the long-term
 12 average?
 13 MR MIANA: It's below the long-term average from flap gates.
 14 Because the level is also 1,011.9 metres, something
 15 around this one. So that's the lower than maximum level
 16 of 1,015 metres. That's why we cannot operate, we will
 17 make some discharge from the flap gates.
 18 PROFESSOR BUYTAERT: What season is at the highest flow?
 19 MR MIANA: It's already setting in.
 20 PROFESSOR BUYTAERT: Yes, okay.
 21 MR MIANA: So we can expect that when it will rain in
 22 Kashmir upstream, obviously the flow is coming.
 23 PROFESSOR BUYTAERT: Yes. Thank you.
 24 THE CHAIRMAN: Very good.
 25 MR MINEAR: Do you consider this a high sediment load at

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1 this point, is this a high sediment load for you?
 2 MR MIANA: We have to check the data. I'm not sure about
 3 that.
 4 MR MINEAR: Okay, thank you.
 5 (10.12 am)
 6 (Pause)
 7 (10.25 am)
 8 Presentation 3: Dam and Reservoir General Site Orientation
 9 MR MIANA: Thank you very much. My name is Muhammad Arfan,
 10 as you already know very well.
 11 For presentation number 3, while we are here. From
 12 this place we have now the chance to see the dam
 13 physically from the upstream side, and the downstream
 14 side we have already seen from the bridge. And from
 15 here, we will be looking physically the various
 16 components of the dam, and same we'll also be presenting
 17 the presentation material very briefly.
 18 With me, my co-presenter is Mr Alauddin. You
 19 already know him. He was the general manager at this
 20 project up until April 2019, and now he is working with
 21 us as an advisor to the company.
 22 So let us start with this presentation. The
 23 sequence of the presentation will be that firstly I will
 24 briefly introduce the Neelum-Jhelum Hydropower Project
 25 and point out the various physical features so you have

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1 some sense of layout about this one.
 2 And second, Mr Nayyar Alauddin will then say a few
 3 brief words about the process of NJHEP design and the
 4 construction. And finally we will give you some
 5 briefing about the safety precautions while travelling
 6 around the dam.
 7 (Slide 2) So this is NJHEP within Pakistan. So
 8 overall the Ministry of Water administers the water
 9 management within Pakistan, and under the Ministry of
 10 Water Resources we have the Water and Power Development
 11 Authority, which is commonly known as WAPDA. And under
 12 the WAPDA the Neelum-Jhelum company was formed, and this
 13 project had been constructed under the Neelum Jhelum
 14 Hydropower Company.
 15 Basically, Neelum Jhelum Hydropower Company works
 16 with an independent board of directors. Among the --
 17 the chairman of the board of directors is our chairman
 18 WAPDA, Lt Gen (Retd) Sajjad Ghani, and also one of the
 19 members of the board of directors with me, Mr Syed Mehar
 20 Ali Shah, is also a member of the board of directors.
 21 (Inaudible) some independent and some other officials.
 22 So Neelum-Jhelum power plant, which is 969 MW, is being
 23 operationalised under this scenario in Pakistan. Next,
 24 please.
 25 (Slide 4) So this is a map. We have already seen

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1 some similar map yesterday, but this will tell you more
 2 about the orientation, about the area, about this one.
 3 So this is the Neelum-Jhelum where we are standing over
 4 here, and from this we have the tunnelling system: the
 5 single tunnel, then the twin tunnel, and then we have
 6 the powerhouse in the Chattar Klass near Muzaffarabad.
 7 And then we have the tailrace tunnel that discharges the
 8 water in that River Jhelum again.
 9 So we are taking the water from the Neelum, which is
 10 coming from the upstream side, the Indian side, and then
 11 we are diverting the same water to the River Jhelum. On
 12 the map, this is the upper limb of the River Jhelum,
 13 where we have the Uri 2 showing in this map, in the
 14 Indian side. And there we have the proposed Kohala
 15 Hydroelectric Power.
 16 This red line is showing the line of control, and we
 17 can physically see that this mountain behind us is
 18 basically showing there is a control of line. So we are
 19 very much near to the line of control. And we can also
 20 see some prominent cities over there. Islamabad is over
 21 here, with this mountain here, city of Pakistan, and
 22 Muzaffarabad is over here, and this is the KP area of
 23 Pakistan.
 24 Next slide, please (Slide 5). So about the NJHEP
 25 design feature, I would request Mr Nayyar to please come

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1 and explain about these things.
 2 MR ALAUDDIN: Mr Chairman and members of the court, as
 3 Mr Arfan has already introduced, my name is Nayyar
 4 Alauddin. I am working in this project since 2011 and
 5 I was also the director of this project. You will be
 6 seeing me a couple of times, a few times during the
 7 presentation and during the site visit.
 8 (Slide 6) So, sir, this is the photograph of the
 9 headwork of Neelum-Jhelum Project. Starting from here,
 10 you see this is the Neelum River coming from the line of
 11 control. As you can see, right there is the Neelum
 12 River. Now, this becomes a point, because we have
 13 constructed the dam here. The length of our reservoir
 14 is about 4.5 kilometres. From here to here, the
 15 distance is approximately, or the length is about
 16 250 metres.
 17 So water from this reservoir comes to pass through
 18 this intakes gauge, and through this intakes gauge water
 19 goes into the desander structure and at the end of the
 20 desander structure there's a collecting canal. I shall
 21 show you from there. And then it goes into the headrace
 22 tunnel, and then goes up through the powerhouse through
 23 four number turbines, we generate 969 MW of electricity.
 24 (Slide 7) some basic statistics of the project.
 25 Neelum-Jhelum has an installed capacity of 969 MW. Its

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1 live storage is 3.8 million cubic metres, where it's
 2 dead storage is 6.2 million cubic metres. It has
 3 a catchment area of about 6,809 square kilometres. Its
 4 mean average flow is 283 cumecs.
 5 In this river, the flow varies, the discharge
 6 varies. During the low flow -- during the winter season
 7 we get low flow, low discharge, and during the high flow
 8 season we get more water. But the mean average flow is
 9 283 cumecs.
 10 So this project has been designed for a 1,000-year
 11 flood for 7,600 cumecs, and probable maximum flood which
 12 can pass through this radial gates and the flap gates is
 13 12,500 cubic metres.
 14 Through these radial gates we can pass about --
 15 through the spillway we can pass about 11,500 cumecs,
 16 and through our flap gates we can pass about 900 cumecs,
 17 so that's how. And as well as through the undersluice
 18 gate we can pass 166 cumecs of water. So that's how the
 19 probable maximum flow of 12,500 cumecs can easily pass
 20 through this structure without overtopping.
 21 (Slide 8) Now I shall brief you about the history of
 22 the project and the different implementation stages of
 23 the project. This project was early conceived after
 24 1980, when the government decided to construct the
 25 Neelum-Jhelum Hydroelectric Project. And based on that,

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1 in 1984 and 1987, initial feasibility and design was
 2 prepared. But that design was for a smaller project of
 3 550 MW. Its intake was here at Nausari, but the
 4 powerhouse was located at the upper limb of the Jhelum
 5 River. So it was then a little shorter project of 550
 6 MW.
 7 So after the feasibility and this completion of
 8 design, the government approved their project at a cost
 9 PKR 15 billion in 1998. But unfortunately the project
 10 could not be constructed because of several reasons.
 11 Subsequently, the government decided to have further
 12 exploration on that, and studies for enhancing its
 13 generation capacity, or studies for increasing its
 14 capacity, I mean from 550 to 969 MW, was planned, and
 15 for that purpose you see the revised feasibility study
 16 in 1996 and design completed in 1997 for a 969 MW
 17 project instead of a 550 MW project.
 18 Design completed of 969 MW in 1997 and the detailed
 19 design completed in 1998. Based on that, in 2002 the
 20 government approved that project at a cost of
 21 84 billion. You see, you are seeing this PC-1, what is
 22 this PC-1? This PC-1 is basically a pro forma and
 23 document on the basis of each committee approves any
 24 project in Pakistan. So PC-1 of the project was
 25 approved, at a cost of PKR 84 billion.

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1 concrete gravity dam and rockfill dam.
 2 The sequence of the different stages of the
 3 constructions are, in 2013 we completed the desander
 4 excavation work, which was a major task. In 2014,
 5 powerhouse excavation was completed, and in 2016 the
 6 diversion dam was completed.
 7 In 2011, the river was diverted through a diversion
 8 tunnel of 500 kilometres, and after that you see work on
 9 the dam had already been started.
 10 In 2017, we completed the excavation and lining of
 11 a 28-kilometre headrace tunnel, as well as 3.5-kilometre
 12 tailrace tunnel.
 13 So as a result of all this completion of work we
 14 commissioned our first unit in 2018, in April 2018, the
 15 first unit was commissioned, and in December 2018, the
 16 fourth and last unit was commissioned. Since then, this
 17 project is generating power, which is going into the
 18 National Grid system.
 19 (Slide 10) So these are some photographs of the
 20 civil works carried out. Because now the structure is
 21 ready and most of the components are submerged in water.
 22 So you can see, this is the desander structure. These
 23 are the inlet gates you can see, one, two, three, four,
 24 five, six. There are six inlet gates, and underneath
 25 there are sluicing gates.

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1 Unfortunately, even after the approval the work on
 2 the project could not be started due to several reasons.
 3 In 2005, we had a major earthquake in this area. There
 4 was a lot of destruction, about 76,000 people died due
 5 to that earthquake.
 6 Our design of, you see design, the original design
 7 was based on the old seismic parameters. In 2005 the
 8 earthquake -- we recorded different seismic parameters
 9 compared with the original design. So it was thought to
 10 change the design based on the new seismic parameters.
 11 So in 2005 and 2006, tenders were invited, and in
 12 2007 contract was awarded to a consortium of two Chinese
 13 companies, Messrs China Gezhouba Group Company, and
 14 Messrs China Machinery Electric Corporation. China
 15 Gezhouba Group Company was contractor for the civil
 16 work, whereas China Machinery Electric Corporation was
 17 the contractor for the EMH work.
 18 (Slide 9) Works on the project started in
 19 January 2008. But I told you that the design was
 20 changed. After the award of the contract, the process
 21 for changing the design was started. I shall give you
 22 a couple of examples during my presentation, in position
 23 number 5. Initially, simply briefly, I'll tell you, for
 24 example the dam was a concrete gravity dam. But later
 25 on it was changed to a hybrid structure. I mean

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1 Here you can see our spillways. This location is
 2 for the debris channel and the rockfill dam, which at
 3 that point of time were not ready.
 4 (Slide 11) It's a very good view of our spillway.
 5 You see the sizes of the spillways is that its height is
 6 15 metres, its width is 12 metres. So I've already
 7 mentioned that we can pass 12,500 cumecs of water
 8 through these spillways. You can see here, this is the
 9 inlet or diversion tunnel. The diversion was started
 10 here. This was the coffer dam construction, so that
 11 water may not go to the construction site.
 12 (Slide 12) Now about the tunnelling. From this
 13 collecting canal, from the end point of the desander
 14 structure up to 0.8 kilometres, it is a single tunnel of
 15 about 10.5-metre internal diameter. After that it
 16 bifurcates into the twin tunnel, the twin tunnel of
 17 19 kilometres. Then again it combines and becomes one
 18 channel, and then up to the powerhouse it is a single
 19 tunnel, and then water goes into the powerhouse.
 20 The diameter of these twin tunnels -- finished
 21 diameter -- was about 8 metres.
 22 (Slide 13) So I think you will know that
 23 in July 2022 a part of the -- a 50-metre part of the
 24 tailrace collapsed due to this generation from this
 25 project stopped. Immediately the remedial works on the

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1 tailrace started, day and night were carried out, and
 2 after 12 months -- I mean, in August 2023, the project
 3 was recommissioned and now, so far, it is satisfactorily
 4 functioning.
 5 About the tailrace damages, there would be
 6 a separate briefing on that.
 7 (Slide 15) So these are some of the brief history
 8 and implementations of the project, and now I would ask
 9 Mr Miana to say some advices on the safety of the
 10 project.
 11 MR MIANA: So regarding the safety rules, usually we use the
 12 rubber soles, like hiking boots or tennis shoes.
 13 I think we all have the similar kind of that one. So
 14 perfect. And the visitor must wear hard hats, if you
 15 need for them, and go around further presentation number
 16 7, and along with the safety vests, high-vis safety
 17 vests. We have already arranged for that one. We will
 18 also be following the safety section, written in a
 19 different location over there. And in case we have to
 20 go inside the water or inside the galleys downstairs,
 21 then we have to use the waterproof boots that are there.
 22 But at this moment we're not going there.
 23 Please keep a safe distance from all handrails and
 24 guardrails. We will also have the cotton gloves, or the
 25 hand gloves over there, so that we can use that just to

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1 that diversion.
 2 DR BLACKMORE: What's the maximum flow you've passed through
 3 the dam?
 4 MR ALAUDDIN: It is about 2,100, or 2,200 or something.
 5 DR BLACKMORE: Did you experience any issues?
 6 MR ALAUDDIN: No, we didn't.
 7 DR BLACKMORE: A lot of debris?
 8 MR ALAUDDIN: Debris you see naturally comes, and we carried
 9 out the survey of the river from time to time to assess
 10 that.
 11 DR BLACKMORE: Okay, thank you.
 12 MR ALAUDDIN: Welcome.
 13 PROFESSOR BUYTAERT: A couple of questions. I think slide 2
 14 on the overall governance, who operates -- I think the
 15 next one. Yes, it doesn't really matter. The one with
 16 WAPDA. It was earlier. It doesn't really matter.
 17 In Pakistan, who operates the power distribution
 18 network?
 19 MR MIANA: (Inaudible: off microphone) The system is that
 20 the generation is separate. Transmission from the
 21 generation side is separate, and from the transmission
 22 to distribution is a separate network.
 23 For the distribution we have the different
 24 companies, the different regional companies, so they are
 25 responsible for the distribution of the power to the

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1 avoid our hands from dirt. So these are small safety
 2 rules.
 3 So if you have any questions we are available.
 4 MR ALAUDDIN: Yes, if you have any questions.
 5 Questions from THE COURT
 6 THE CHAIRMAN: So one question I have is, has this dam ever
 7 been overtopped?
 8 MR ALAUDDIN: No, it hasn't.
 9 THE CHAIRMAN: And the diversion dam that you mentioned
 10 diverted the water on the far side of the river.
 11 MR ALAUDDIN: Diversion tunnel, there are two things,
 12 diversion dam is the dam. Diversion tunnel is
 13 500 metres, which starts just upstream of the existing
 14 structure, through which it is under the mountain and
 15 goes like this.
 16 THE CHAIRMAN: The far side.
 17 MR ALAUDDIN: On the far side, yes.
 18 THE CHAIRMAN: And so the dam itself, the diversion dam
 19 itself would be somewhere up here before the tunnel.
 20 MR ALAUDDIN: It's there.
 21 THE CHAIRMAN: Right here?
 22 MR ALAUDDIN: Yes.
 23 THE CHAIRMAN: Ah, okay.
 24 MR MIANA: There is a chance that we will go for the
 25 presentation no. 7 walkaround, we will see the outlet of

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1 residents, commercial and industrial.
 2 PROFESSOR BUYTAERT: A follow-up question. Does Pakistan
 3 have a power industry regulator which oversees the
 4 different companies that both provide and distribute the
 5 power?
 6 MR MIANA: At the moment I do not have the idea and the
 7 information about that. I will get it and I will come
 8 back to you.
 9 PROFESSOR BUYTAERT: That's fine.
 10 Then a few questions about the hydrology. I don't
 11 know who is best placed. So I understand that the wet
 12 season is during summer. What is the month of the
 13 highest discharge, typically?
 14 MR ALAUDDIN: It is July.
 15 PROFESSOR BUYTAERT: Okay, yes.
 16 MR ALAUDDIN: In July we get maximum discharge.
 17 PROFESSOR BUYTAERT: And what is the reason for the highest
 18 discharge? Is it simply because it's the highest
 19 rainfall, or is there a contribution of glacier melt and
 20 potentially snowfall.
 21 MR ALAUDDIN: It's ice melt basically.
 22 PROFESSOR BUYTAERT: Sorry?
 23 MR ALAUDDIN: Ice melt.
 24 PROFESSOR BUYTAERT: Ice melt. Okay. Yes. Because my
 25 follow-up question was about the distribution between

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1 direct run-off from rainfall, glacier and ice melt and
 2 snowmelt. What, roughly, do you have any idea of the
 3 relative contribution of those three?
 4 MR ALAUDDIN: No, sorry. I don't have a precise idea on
 5 that.
 6 PROFESSOR BUYTAERT: Yes. But there is substantial ice
 7 contribution?
 8 MR ALAUDDIN: Yes, we will respond to it.
 9 PROFESSOR BUYTAERT: What about snowmelt contribution, is
 10 that substantial?
 11 MR ALAUDDIN: We think that is substantial, because of this
 12 the water comes --
 13 PROFESSOR BUYTAERT: And I guess that probably comes earlier
 14 in the season when snow -- what is the peak of the
 15 snowmelt? Do you see any peak as a result of snowmelt
 16 when temperatures increase?
 17 MR ALAUDDIN: It probably starts in April.
 18 PROFESSOR BUYTAERT: April. So right now?
 19 MR ALAUDDIN: Yes.
 20 PROFESSOR BUYTAERT: Yes. Okay.
 21 Do you see any impact of snowmelt on sediment loads,
 22 or icemelts? How does that vary throughout the year?
 23 MR ALAUDDIN: We are monitoring and studying this because it
 24 is a complicated -- it's not -- it's complicated
 25 behaviour of these things, assessment and concluding

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1 discharge?
 2 MR ALAUDDIN: Sorry?
 3 MR MINEAR: How far back do your records go with regard to
 4 historic discharge here?
 5 MR ALAUDDIN: Sorry, I could not follow your question.
 6 MR MINEAR: Do you have historic records of discharges?
 7 MR ALAUDDIN: Yes, we have.
 8 MR MINEAR: And how many years back do you go?
 9 MR ALAUDDIN: You see our record starts many, many years
 10 back. But we have designed this project based on
 11 accurate data collected from 1992 and onwards five to
 12 six years.
 13 MR MINEAR: Thank you.
 14 THE CHAIRMAN: Well, you can see that your presentation
 15 provoked a number of questions from us. Thank you very
 16 much for the overview presentation. It's very helpful.
 17 And thank you for arranging for perfectly nice weather
 18 for this visit.
 19 I think we don't have any further questions, so
 20 perhaps we'll move on to the next stage of the day.
 21 Although I think perhaps we'll try to do a single
 22 photograph of the court members with the dam in the
 23 background, if we can arrange that, either here or just
 24 down below, perhaps.
 25 MR MIANA: Before going down can we explain a little bit

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1 this takes time.
 2 PROFESSOR BUYTAERT: Yes. Thank you.
 3 MR ALAUDDIN: You are welcome.
 4 MR MINEAR: Do you have gauges upstream in which you can
 5 monitor monthly mean discharges? Is that something that
 6 you monitor?
 7 MR ALAUDDIN: Yes, there are gauges. There are three gauges
 8 at different intervals through which we collect data.
 9 MR MINEAR: Thank you.
 10 PROFESSOR BUYTAERT: Quickly, what type of gauge is that, do
 11 you happen to know?
 12 MR ALAUDDIN: These are basically -- these are automatic
 13 gauges which provides data through the satellite to our
 14 control room.
 15 PROFESSOR BUYTAERT: But are they water level gauges,
 16 combined with --
 17 MR ALAUDDIN: Yes, level gauges.
 18 PROFESSOR BUYTAERT: Do you know the rating?
 19 MR ALAUDDIN: Discharge gauges.
 20 PROFESSOR BUYTAERT: Okay, but what exactly do they measure?
 21 Because typically you have a water level gauge, which is
 22 then converted into discharge with a rating curve --
 23 MR ALAUDDIN: Yes. The same thing, yes.
 24 PROFESSOR BUYTAERT: Okay, thank you.
 25 MR MINEAR: How far back do your records go with regard to

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1 about the upstream side of the dam?
 2 THE CHAIRMAN: Sure, absolutely.
 3 MR ALAUDDIN: So if you please come here.
 4 So you can see that this is the Neelum River coming
 5 from the line of control side. This is our reservoir.
 6 As I mentioned, this land is about 4.5 kilometres.
 7 So on this side you have seen the same structure
 8 from the downstream side. Now we are the upstream side.
 9 You see just at the right you can see the rockfill dam.
 10 The significance, what is the significance of the
 11 rockfill dam? That will be explained in the coming
 12 presentation, as it has been said, for any effect of the
 13 fault line.
 14 Now you see the two gates there. These are the flat
 15 gates. This is a debris channel. It has two functions.
 16 During the high flow season we pass the water,
 17 (indistinct) water, through these gates. Also the
 18 floating debris are also removed from it.
 19 You see this red line, this we call log boom. The
 20 purpose of the log boom is that the debris should not go
 21 over the intake, on this part near the intake. So it
 22 keeps debris here. And you see when we -- with the
 23 passage of time, this debris flows towards the debris
 24 channel. Had it not been -- this red line not there,
 25 there would be a heap of debris in front of the intake

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1 structure.
 2 With this debris channel we have the undersluice --
 3 sorry, the spillways, which are not visible.
 4 Now, you can see from here, from this side, this is
 5 our desander structure. Under this you see the floating
 6 debris, and that trash cleaning machine is removing the
 7 debris also. So here we have six intake gates through
 8 which water goes into the desander structure. At the
 9 end of the desander structure, at the end you can see
 10 the structure for the collecting canal. From the
 11 collecting canal water goes into this head regulator.
 12 In the desander stretch velocities slow down so that
 13 the sediment may settle at the bottom, and for that
 14 there is a sluicing arrangement.
 15 So these are some of the salient features. If you
 16 have any questions, you are welcome.
 17 Questions from THE COURT
 18 DR BLACKMORE: You seem to have plenty of plastic.
 19 MR ALAUDDIN: Yes.
 20 PROFESSOR BUYTAERT: How often is the sediment removed from
 21 the desander? So how is it removed?
 22 MR ALAUDDIN: Actually, these are removed, continuous
 23 monitoring of the sediment is carried out in the
 24 desander structures. But the maximum limit which we are
 25 now following is that when a layer of, say, 1 metre is

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1 deposited, we carry out the sluicing of the sediments.
 2 But even then, from time to time, whenever we feel, we
 3 regularly take samples of the water and we see the
 4 behaviour of the sediment. It's not fixed that we wait
 5 for 1 metre. It can be whenever the operator realises
 6 that the sluicing is required, he carries it out.
 7 You see, we also take samples from the collecting
 8 canal. That tells us the concentration of the
 9 sediments, which are passing from the desander structure
 10 going in there. If the construction becomes high, even
 11 then we carry out the sluicing of the desander
 12 structure.
 13 PROFESSOR BUYTAERT: Okay. So you sluice it out when it
 14 accumulates too much. How often does it happen? Or is
 15 it highly variable?
 16 MR ALAUDDIN: At the time I will tell you that in this
 17 desander structure, after three or four months, if you
 18 don't carry out the sluicing of the desander structure,
 19 after three months and a half months, or four months,
 20 a layer of 1 metre sediment is deposited, which is
 21 reflective that our design of the intake structure and
 22 the design of the desander is very effective.
 23 PROFESSOR BUYTAERT: Do you ever empty them entirely and
 24 completely clean them out?
 25 MR ALAUDDIN: This one?

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1 PROFESSOR BUYTAERT: Yes.
 2 MR ALAUDDIN: We time to time do that, yes. And there will
 3 be a separate briefing on the sediment trapping
 4 capacity.
 5 PROFESSOR BUYTAERT: Okay.
 6 MR ALAUDDIN: The garbage we have prepared for the desander
 7 structures.
 8 DR BLACKMORE: Is the desander a critical -- many of these
 9 facilities don't have a desander, so would you say
 10 that's a critical part of your operation? If you had to
 11 pass that sediment at that level through the power
 12 station, what would be the outcome?
 13 MR ALAUDDIN: Then simply we think that more sediment will
 14 go and will damage our runners, turbines.
 15 DR BLACKMORE: We're yet to talk to how often you've got to
 16 maintain your runners, but I'm just wondering, with or
 17 without -- some of these facilities don't have
 18 desanders, so I'm just interested.
 19 MR ALAUDDIN: So it is basically -- it is -- you see, it
 20 depends, there can be a number of options for it. There
 21 are projects without desanders like this.
 22 DR BLACKMORE: Okay. So we'll call this one a Rolls Royce
 23 project with the sander.
 24 Excellent, thank you.
 25 (10.56 am)

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1 (A short adjournment)
 2 (11.33 am)
 3 THE CHAIRMAN: Okay, I think we are ready to resume with
 4 presentation 4, whenever you are ready.
 5 Presentation 4: Overview of Dam Site Physical Location
 6 and Elements
 7 DR HAYAT: Mr Chairman, members of the Court of Arbitration,
 8 good morning. I am Dr Tahir Hayat and it's a pleasure
 9 to address you again. I am presenting with Mr Umar
 10 Farooq. Can you raise your hand, please? He is
 11 a senior engineer at National Engineering Services,
 12 Pakistan, NESPAK. And Mr Fiaz Hanif Sendhu, chief
 13 geologist/consultant of Tarbela 5th Extension Project.
 14 Together we will address the geographic,
 15 topographic, hydrological and geological issues relevant
 16 to the Himalayan run-of-the-river design, construction
 17 and operation.
 18 We will proceed in three parts.
 19 First, I'll provide you with an overview of the
 20 physical and social geography and topography covering
 21 the Indus basin and the areas around the Neelum-Jhelum
 22 Hydroelectric Project.
 23 In the second part, Mr Farooq will take you through
 24 the hydrology of the region, and point out some specific
 25 features relevant to Neelum-Jhelum Hydropower Project.

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1 And thirdly, of course, Mr Sendhu will come in to
 2 address you on geology of the region, and particularly
 3 the Neelum Valley and the dam axis.
 4 Again, please feel free to ask any questions at your
 5 convenience during or after the presentations.
 6 Slide number 2, please. I'll start with the
 7 geography and topography of this region. As will be
 8 clear when I make my presentation, and the others also,
 9 the Indus basin is actually the lifeblood of Pakistan's
 10 water supply, and the only river basin of any
 11 consequence within our country.
 12 Slide number 3, please. This slide shows
 13 a schematic representation of the principal rivers of
 14 Indus basin, and the catchment areas of the eastern and
 15 the western rivers. In the first place, please note the
 16 line of control. So this is the international boundary,
 17 and then this is the line of control.
 18 The Indus River is 3,200 kilometres long, and its
 19 basin encompasses a total area of approximately
 20 862,700 square kilometres. The Indus basin area in
 21 Pakistan is made up of the Indus River. So the Indus
 22 River, if I may point out here, this is the Indus River.
 23 So the Indus River in Pakistan is made up of the
 24 Indus River and six major tributaries. The western
 25 rivers are the Indus, Chenab and Jhelum. I'll point

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1 which then flows into the Arabian sea.
 2 The only river coming from the other side is the
 3 Kabul River, which comes from Afghanistan, enters into
 4 Pakistan, and downstream of Tarbela it joins the Indus
 5 River.
 6 So the green shading in this map shows the catchment
 7 area of the Western Rivers, all of this green area. And
 8 the somewhat yellow shading shows the catchment area of
 9 the Eastern Rivers.
 10 Slide number 4, please. Next we see the same map,
 11 but this time showing the glaciers and snow cover, which
 12 is shown in this greyish colour in this area. The grey
 13 colouring shows the snow or ice cover. The major
 14 contributor of river flows is meltwater from snow and
 15 glaciers in the Karakoram and Himalayan mountain ranges.
 16 In fact, Indus is one of the most meltwater dependent
 17 river basins in the world.
 18 So the combination of snow and glacial melt accounts
 19 for -- and that's your question maybe -- about 70-80% of
 20 the total flows in the basin rivers. The remaining
 21 flows are contributed by rainfall, mostly in the monsoon
 22 period, in the later part of summer: June, July, August.
 23 DR BLACKMORE: Just a question then. So how far does the
 24 monsoon push in? Does the monsoon push right the way
 25 through into that upper area of the Indus?

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1 those out later, so Jhelum, Chenab, Indus. And the
 2 eastern rivers are Ravi, Sutlej and Beas. Sutlej, Beas,
 3 Ravi.
 4 The Indus River originates in the Tibetan Highlands
 5 and then flows through Indian Administered Kashmir,
 6 enters Pakistan. This is Gilgit-Baltistan, near Gilgit.
 7 By the way, this is where we are building the Daimer
 8 Basha Dam near the town of Chilas. There is Tarbela
 9 Dam, which is on Indus, flows through KPK, Punjab, down
 10 to Sindh, near Hyderabad. And then near Karachi it
 11 falls into the Arabian Sea. So this is the path it
 12 traverses.
 13 The Chenab River, this one, originates in
 14 Himachal Pradesh state of India, and passes through the
 15 Indian Administered Kashmir before entering Pakistan in
 16 the Punjab province in Pakistan.
 17 The third Western River is the Jhelum River. It
 18 originates in the Indian Administered Kashmir, and then
 19 it is joined by the Neelum River, which is not shown
 20 here, but in the next diagram I will show. We are
 21 actually somewhere here (indicates). So the Neelum
 22 River actually flows almost along the line of control,
 23 and joins the Jhelum River here, at Muzaffarabad. And
 24 then it flows down; this is Mangla dam. And of course
 25 all the rivers ultimately meet and they fall into Indus,

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1 DR HAYAT: Monsoon basically affects middle and southern
 2 parts of Pakistan.
 3 DR BLACKMORE: Yes.
 4 DR HAYAT: Mostly. But they do enter into the northern
 5 areas also. And as I said, previously they were
 6 supposed to be up to Dasu Project area, we were seeing
 7 signs of monsoon rain. But this, in the last one
 8 decade, we have seen that the monsoons or related rains
 9 have also crossed this previous sort of a boundary, and
 10 gone up to as high as about this area also. So this is
 11 almost all of Pakistan.
 12 DR BLACKMORE: Sorry, but what's the elevation, when you've
 13 got the Indus coming around the top?
 14 DR HAYAT: At Basha, the Indus elevation is about 950 metres
 15 above mean sea level, so it's not that high. But it
 16 rises very rapidly because we have, as you know, some of
 17 the highest mountain ranges in this area. So like K2
 18 and Gasherbrum, Broad Peak, Nanga Parbat, to name some
 19 of the few.
 20 So, yes. So at this point in time it's about at
 21 950, at this place. That I know exactly, above mean sea
 22 level.
 23 THE CHAIRMAN: And is the increased effects of the monsoon
 24 higher further north due at all to climate change
 25 conditions, or not?

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1 DR HAYAT: We believe so. It's always -- you know, climate
 2 change is still -- I mean, you can -- even your app on
 3 there says it's so many percentage chance of rain, you
 4 know. It's a probability. So we can say that it's --
 5 we are quite sure that it's part of the climate change
 6 that these things are happening.
 7 THE CHAIRMAN: And that in turn affects the way that you
 8 operate the dam, in that if you've got greater hydro
 9 coming through, water coming through, you need to open
 10 your gates at certain times; is that correct?
 11 DR HAYAT: Definitely, because the operation of the gates
 12 always depends on the amount of water that you're -- so
 13 you balance in terms of: you want to fill the reservoir
 14 because you need the water, so you ... and plus, if you
 15 know -- and because there are gauging stations all the
 16 way through. So you have -- and the dams are mostly,
 17 you know, in this reach down there.
 18 So you have anywhere from 24 to 78 hours, or
 19 72 hours of warning that a flood is coming. So the
 20 operator then has the option to know whether he has the
 21 capacity within the reservoir to fill that incoming
 22 flood; or if he thinks that he's short of that, then
 23 he'll open the spillway gates. And sometimes they do it
 24 before the storm arrives so that he can have more
 25 capacity to absorb whatever is the volume expected at

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1 that point in time.
 2 THE CHAIRMAN: Thank you.
 3 DR BLACKMORE: Can I just ask one more question, sorry.
 4 I think these are important questions for us in terms of
 5 looking at the hydrology. So in the last decade, we've
 6 got more energy in the monsoons, pushing it further
 7 north. So that's likely to be a climate change
 8 response. Like, it could be in the balance of
 9 probabilities something else, but it's unlikely. So if
 10 that's occurring, we're going to see increases in the
 11 probable maximum floods along through this region.
 12 The other issue for me is how many -- when you get
 13 to the top of the Indus, or along the -- when you start
 14 to go through the very high peaks, do you know what
 15 percentage of the glaciers are below 5,000 metres?
 16 DR HAYAT: I don't have off top of my head.
 17 DR BLACKMORE: Is it the vast majority of glaciers?
 18 DR HAYAT: More than 18,000 glaciers, so I'll have to come
 19 back to you on that one, you know: how many are 5,000,
 20 5,000-6,000, 7,000. I'll have to get back to you on
 21 that.
 22 DR BLACKMORE: The reason for the question is that the
 23 science evidence is showing that glaciers below
 24 5,000 metres are much more affected now by the climate
 25 change impact, and those above it are less affected. So

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1 from a hydrology perspective, it's an important issue in
 2 terms of the reliability of flows and the timing of
 3 peaks, that's all.
 4 DR HAYAT: I think in the next part of the presentation,
 5 Mr Farooq will be explaining the hydrology much more in
 6 detail. So he will be having more details on that, and
 7 I think he'll be answering many of your questions at
 8 that time.
 9 MR MINEAR: Excuse me, this area here is outside the
 10 catchment here. Is that all low land? It surprises me
 11 that immediately adjacent to the Indus River you have
 12 an area that is not included in the --
 13 DR HAYAT: This must be draining to the other side, sir,
 14 then. Not into the Indus. So this part would be
 15 draining to the Indus River, whereas this one will be
 16 sloped somewhere towards that side, so that it will be
 17 going to the other side, into the Arabian Sea.
 18 THE CHAIRMAN: Okay. Dr Hayat, please proceed.
 19 DR HAYAT: So Mr Farooq, as I said, will explain that heavy
 20 reliance on snow and glacial melt and flows in Indus are
 21 then definitely subject to seasonal variations: more in
 22 summers, less in winters.
 23 So the climate patterns do not just vary according
 24 to season but across the length of the Indus basin. So
 25 this is coming to your question partly.

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1 In the upper Indus basin, which is the areas of the
 2 Himalayas, Karakoram and Hindu-Kush ranges -- by the
 3 way, this is the place, near Gilgit, where all these
 4 three ranges meet: the Karakoram, the Himalayas and the
 5 Hindu-Kush -- most precipitation occurs in winter and
 6 spring, in terms of falling snow, especially in higher
 7 elevations.
 8 The lower Indus Basin has subtropical and arid and
 9 semi-arid temperature, which is this area. And the
 10 precipitation is mostly from monsoons: rains from July
 11 to September.
 12 The Indus Basin has an average annual precipitation,
 13 both rain and snow, ranging from 100-500 mm in the lower
 14 basin, to 2,000 mm and above in the Himalayan foothills
 15 and higher mountains.
 16 So the Indus Basin has, as I said, about 18,495
 17 [glaciers] -- somebody has counted, but I would say
 18 18,500, let's say. And they span about 21,193 square
 19 kilometres. So it is one of the highest concentrations
 20 of glaciers in the world, I would say.
 21 The climate change has caused warming and
 22 accelerated glacial melt, which is your observation,
 23 very correct. As you can imagine, the waters of the
 24 Indus Basin are therefore unusually exposed to the
 25 impacts of the increasing temperature and associated

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1 change of climate.
 2 Although there is considerable uncertainty -- as
 3 I said, you know there's probabilities, and this and
 4 that -- as to the exact consequence of this climate
 5 change, two patterns are predicted.
 6 First, several studies predict that there will be
 7 a significant decrease in total water availability. One
 8 study predicts about 17% by the end of this century.
 9 Secondly, increasing heat will put more demand for
 10 water for irrigation, because a lot of water will be
 11 getting evaporated, which is the principal water used in
 12 Pakistan, actually.
 13 Slide number 5, please. Now I'll show you the map
 14 showing the population density in the Indus Basin. And
 15 if you look at the region, you know, it goes from --
 16 basically, the population density is number of persons
 17 per square kilometre. So it goes from less than 20 to
 18 all the way to greater than 2,000.
 19 Now, you can see the Indus Basin here, which
 20 I showed you before. And you can see that the
 21 significant part of population of Pakistan is
 22 water-dependent, and this is from Indus Basin, and that
 23 is where the population is centered. You see all this
 24 red area, which is centred around the Indus Basin and
 25 its tributaries, all of it. So this is why I say this

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1 industrial use. So there is that increase that is
 2 compounded as the time goes by.
 3 Slide number 6, please. So next I turn to the
 4 demand for power supplied by hydroelectric plants. I'll
 5 show you a series of slides that give you a snapshot of
 6 the area and local demand centres. In fact, the
 7 Neelum-Jhelum Hydropower Project, which by now I'm sure
 8 you -- we are sitting here right now, and this is the
 9 tunnel and this is the powerhouse area, and it crosses
 10 the Jhelum at this point in time.
 11 So this actually supplies to a single grid in
 12 Pakistan. It has no specific demand centre: it actually
 13 goes into the bigger basket of power which is then
 14 distributed all over Pakistan.
 15 So the green plants are the ones which are actually
 16 in operation, like the Neelum-Jhelum here, Patrind here.
 17 Those which are under construction: Kohala in red. And
 18 others which are under planning or designing in
 19 different colours, along different rivers here. This
 20 only shows up to Mangla Dam.
 21 So what happens in a bigger basket that you have is
 22 that if one hydropower plant is deficient, that does not
 23 make it ineffective: then other plants kick in, and
 24 there is more flexibility if you have a lot of plants
 25 feeding into one grid system. You have more

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1 is the lifeline, and life and blood of Pakistan. So
 2 this contributes 95% of the total water sources of
 3 Pakistan, the Indus Basin.
 4 So the Indus Basin is home to a population of
 5 240 million people, out of which 78% live in Pakistan
 6 and 17% live in India. The remaining 5% live in
 7 Afghanistan and China. The population is increasing,
 8 and quite rapidly. It is predicted that the population
 9 within the Indus Basin will rise to 383 million by 2050.
 10 So from 240 [million], it will rise to 383 million by
 11 2050.
 12 Pakistan's population has increased by about 3%
 13 since 1961. So by 2050 it is predicted that we'll have
 14 about 400 million people. About 40% of our current
 15 population lives in urban areas. By 2050, this number
 16 would have jumped to 50%. So out of 400 million people,
 17 by 2050, 200 million will be living in urban areas.
 18 So the density that you see here, and the growing
 19 size of Pakistan's population in the Indus Basin, has
 20 very important consequences for water management: (a),
 21 there will be higher demand, and that is food demand,
 22 because you have to feed 400 million people, so required
 23 increased agricultural output and irrigation, which
 24 requires water. And the increased urban population will
 25 also have water requirement for domestic use and

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1 flexibility.
 2 Slide number 7, please.
 3 PROFESSOR BUYTAERT: Sorry, can I ask a quick question on
 4 your previous slide?
 5 DR HAYAT: Please.
 6 PROFESSOR BUYTAERT: What is the difference between the red
 7 and the purple?
 8 DR HAYAT: Okay. The purple triangles are the planned
 9 plants, and the red triangles are those which are under
 10 construction.
 11 PROFESSOR BUYTAERT: Okay, because number 9 seems to be on
 12 top of the mountain, or perhaps that's on a tributary.
 13 Do you know why ...
 14 DR HAYAT: Number 9 here?
 15 PROFESSOR BUYTAERT: Yes.
 16 DR HAYAT: Yes. So number 9 is under construction.
 17 PROFESSOR BUYTAERT: Yes, but what type of plant is that?
 18 Because it seems to be off the main river, so I assume
 19 it's the tributary --
 20 DR HAYAT: It's on one of the tributaries.
 21 PROFESSOR BUYTAERT: Okay, yes, thank you.
 22 THE CHAIRMAN:
 23 DR HAYAT: But I can get you the number, and from that we
 24 can refer to it.
 25 PROFESSOR BUYTAERT: Okay.

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1 THE CHAIRMAN: Can I ask, doctor, of the ones that exist and
 2 the ones that are planned, roughly what's the percentage
 3 between the run-of-river dams and the storage dams?
 4 DR HAYAT: Storage dams are few. Storage sites are few. So
 5 in terms of percentage, I don't have off my head. But,
 6 for example, if you look at the Indus cascade, we have
 7 Bunji, we have Basha, we have Dasu, Patan, Thakot. Out
 8 of these, only Basha is a storage dam.
 9 Similarly, on the Indus we have -- only storage
 10 is -- the other one is Kalabagh, which is in cold
 11 storage right now. So that is the other.
 12 So most of those plants are power plants,
 13 run-of-the-river, most of them. If you need an exact
 14 percentage --
 15 THE CHAIRMAN: No, no, no, that's fine. I was just curious
 16 generally.
 17 DR HAYAT: Generally.
 18 THE CHAIRMAN: Yes.
 19 DR HAYAT: Generally.
 20 THE CHAIRMAN: Very good.
 21 DR HAYAT: Yes, sir.
 22 DR BLACKMORE: While we're talking hydropower, I just want
 23 to go on to pumped hydro, because you have a relatively
 24 small amount of storage-backed hydro, so you're on
 25 run-of-the-river. I'm just wondering whether there is

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1 All the others are run-of-the-river. Kohala is under
 2 construction.
 3 DR BLACKMORE: Sorry, Mangla -- the release pattern for
 4 Mangla is around irrigation, not power. So is it
 5 primarily you're using the water -- while it's
 6 storage-backed hydro, the primary call is for
 7 irrigation, and power is a useful outcome?
 8 DR HAYAT: Your observation is correct, sir.
 9 DR BLACKMORE: Okay. I just wanted to make sure. Thanks.
 10 DR HAYAT: Slide number 8, please. So here we are looking
 11 at the transmission lines. And as I said earlier, you
 12 know, this is the transmission line that is coming from
 13 Neelum-Jhelum, and it is feeding into a main grid. So
 14 most of -- the highest transmission line voltage that we
 15 have is 525/500 kV, which is shown in this magenta or
 16 red sort of colour. The greens ones are 220 kV.
 17 Then of course this is the transmission voltage. As
 18 you go down, then you step down -- this is transmission
 19 voltage. They you step down from 525 to 220, from 220
 20 to 110, 110 to 66, and all the way down till you go to
 21 the household or industries.
 22 But this shows the main -- so it is one complete --
 23 so the idea is to show that this is one complete grid
 24 from Karachi all the way to the north, in which all
 25 these plants feed in, and then it is distributed. So

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1 a role -- have you seen a role in Pakistan for pumped
 2 storage to meet peaking demands? Or is that somewhere
 3 in the future?
 4 DR HAYAT: To the best of my knowledge, sir, no.
 5 DR BLACKMORE: Okay.
 6 THE CHAIRMAN: Okay, doctor, thank you.
 7 DR HAYAT: Thank you, sir.
 8 Can we move to slide number 7, please. So this is
 9 the area we look closer to the -- near the Neelum-Jhelum
 10 Project. This is the place where we are right now. And
 11 this is the line of control, as was pointed out to you.
 12 This is the tunnels passing. And this is the powerhouse
 13 location, you can see the load centres near it. So
 14 Islamabad is here. We have Abbottabad and other cities
 15 which are closer by.
 16 But, as I said, this is not a specific plant that
 17 feeds only these load centres, but it -- in the next
 18 slides you will see it feeds into one big grid.
 19 So actually, this Neelum-Jhelum, it operates in
 20 conjunction with two other plants, and one is this. We
 21 have Patrind somewhere around here, and of course Kohala
 22 is under construction. And Karot, which is down here
 23 somewhere, which is off the map somewhere here, near
 24 Mangla. So Patrind is 150 MW and Karot is 720 MW. And
 25 Mangla is of course 1,000 MW, and it's a storage dam.

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1 whole of the Pakistan is connected to one single grid.
 2 Slide number 9, please. Now, the principal
 3 immediate effect of any hydropower is caused by filling
 4 of the reservoir, and we inundate the area. And you saw
 5 the reservoir here also when you were on top of that
 6 building, which causes water level to rise. So the
 7 reservoir gives the run-of-the-river hydropower live
 8 storage, as I talked about yesterday, within that 24 or
 9 one-day cycle, so that you can have peak demand and all
 10 those things, and create generating head.
 11 So the reservoir, normally in these run-of-the-river
 12 projects, it's in a narrow valley, which is constrained
 13 by its size. So therefore, as a consequence, the
 14 reservoir could be many kilometres long.
 15 So the reservoir will be filled, actually, to the
 16 predefined level of an ungated spillway. If you have
 17 an ungated spillway, the maximum level that the
 18 reservoir will obtain will be that of the ungated
 19 spillway. And as the river rises above the ungated
 20 spillway, it will automatically spill over. And of
 21 course, if you have flood, there will be some flood
 22 surcharge over and above that.
 23 If you have gates, then the maximum level of the
 24 reservoir is controlled by the top of the gates. So the
 25 top of the gates defines your reservoir level. And

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1 there, when there's more water, they are open to release
 2 excess water.
 3 So in mountainous areas, you know, dam sites are
 4 quite narrow, which can pose quite a few challenges.
 5 Limited area, you have to put a lot, many things
 6 together. So the width of the valley and ability to
 7 pass the design flow through the spillway, how much
 8 space you need, if you have desanders, how you fit all
 9 these things together. And you have seen an example of
 10 how we have done it in Neelum-Jhelum, and we have done
 11 some excavation and things like that.
 12 Now, I'll describe what happened to Neelum-Jhelum
 13 with that specific case when they filled the reservoir.
 14 Next slide, please. So in slide number 10, you will
 15 see this is a Google image of the area before
 16 construction of the project. So this is the dam site.
 17 The dam total width is about 250 metres. That is after
 18 excavation and everything. And at full pondage level,
 19 which is 1,015 metres above sea level, you can see this
 20 is the contour which was predicted, that this would be
 21 the extent of the reservoir created. So you can see,
 22 compared to its maximum width of 250 metres, the width
 23 actually also decreases, and it is quite a rectilinear
 24 sort of feature that is created in a normal Himalayan
 25 run-of-the-river project.

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1 Now I will go to slide number 11, please. And here
 2 you see satellite imagery after the dam was constructed.
 3 So this is the dam, and this is the -- you can see the
 4 reservoir, and this is about 4.5 kilometres from the
 5 dam. So this is the effect that a run-of-the-river in
 6 Himalayas, and the specific example of Neelum-Jhelum
 7 has.
 8 So by constructing a 47-metre high dam, the
 9 reservoir extends about 4.5 kilometres either side. So
 10 the higher the dam, the longer the reservoir.
 11 So that concludes my part of the presentation. Next
 12 will be hydrology, to be dealt with by Mr Umar Farooq.
 13 If at this point in time you have questions, please.
 14 Questions from THE COURT
 15 THE CHAIRMAN: Before we let you go, doctor, I do have
 16 a couple of questions.
 17 So the reason why most of the dams in Pakistan are
 18 run-of-the-river dams is because it's not, in terms of
 19 the topography, possible to have a storage dam? Is that
 20 the main difference/reason?
 21 DR HAYAT: You are quite right, sir, in that sense. Because
 22 for a storage dam, you require -- topography is one of
 23 the major features, as well as geology.
 24 Most of Pakistan is actually quite flat. As you go
 25 down from Islamabad then up to Karachi, it is all flat

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1 land, basically. So there's hardly -- because for dams,
 2 you need a space in which you can construct the dam and
 3 have it contained, sort of a reservoir. And normally
 4 you would look -- on a river when you're designing
 5 a dam, you look for a place where the river is narrow,
 6 i.e. there is a natural constriction of the river, but
 7 behind it you have an open valley, so that with each
 8 metre height of the dam you get more storage.
 9 Like in this valley, this is okay for
 10 run-of-the-river. But if you have a very steep valley,
 11 you can hardly store any water in that. So you look for
 12 a valley which is -- at the dam site it will be narrow,
 13 so that you can save on the construction of the dam and
 14 it will be easier to build the dam. But behind the dam
 15 you have an open wide valley in which you can store
 16 water. So those storage dam sites, you know, they are
 17 a gift of nature in any country that you get those
 18 sites, and you try to maximise on those. And other than
 19 that, then you go for run-of-the-rivers.
 20 THE CHAIRMAN: Is one way to think about the difference
 21 between a run-of-river dam and a storage dam that, for
 22 a run-of-river dam, you are able to have some amount of
 23 reservoir or pondage, but only enough to smooth out, on
 24 a daily basis, the peaks; whereas for a storage dam you
 25 are able to smooth out the entire year?

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1 DR HAYAT: Very good, sir. I think you have hit the nail on
 2 the head.
 3 THE CHAIRMAN: I get a degree, I think!
 4 DR BLACKMORE: I've just got a couple of questions about the
 5 storage dams. So let's deal with Mangla for a moment,
 6 because it's downstream. And I'm not aware: does that
 7 have a reregulating pondage downstream of the dam? So
 8 you just release in peak, keep the flow downstream of
 9 the dam, even for what you need for irrigation, but
 10 enables you to use the power stations for peaking power?
 11 Tarbela does, but I'm not sure --
 12 DR HAYAT: Tarbela has that reregulation going for
 13 Ghazi Barotha. And to the best of my knowledge -- but
 14 I'll refer that question to one of my colleagues sitting
 15 here -- to the best of my knowledge --
 16 DR BLACKMORE: It doesn't.
 17 DR HAYAT: -- Mangla does not have. Am I correct?
 18 Mangla does not have one. (Pause)
 19 THE CHAIRMAN: Just to remind everyone, we need to create
 20 a transcript of this, in part so our colleague, Judge
 21 Awn Al-Khasawneh can benefit from our conversation. So
 22 whenever anyone speaks, let's have a microphone in front
 23 of you.
 24 That's not to cut anyone off: we want the
 25 information. It's just we want to capture it.

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1 MR MINEAR: Two quick questions. First, were any villages
 2 inundated by the creation of this reservoir? Was anyone
 3 displaced as a result of this?
 4 DR HAYAT: Few peoples displaced. There were few huts and
 5 all others in the reservoir. But it was a narrow area.
 6 So to give you the exact number, I will refer this to
 7 Mr Ayub Malik: I think he may have the answer of the
 8 exact number. But it was few.
 9 Once the mic is with you, can you answer that
 10 question, please?
 11 MR MALIK: There were some houses where we went on the top,
 12 where you saw that and where the desander is excavated.
 13 There was a few houses that have been relocated. And
 14 there was a girls' school there that WAPDA built on
 15 a replacement area. That school was built, and the
 16 people who were relocated from here were given
 17 compensation for that land.
 18 So very few: I think it was hardly 100 people were
 19 relocated from this area.
 20 MR MINEAR: If I could just go back to slide 5 for a second.
 21 DR HAYAT: Please.
 22 MR MINEAR: I was curious about this area south of the
 23 Indus. It does not receive any irrigation water from
 24 the Indus? Or does it get adequate water, or is it just
 25 not farmed in that area?

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1 the exact timeline on the life of the project and they
 2 keep on doing some exercises to maximise the life of
 3 these projects.
 4 For example, at Mangla, they have done a lot of work
 5 in the catchment area by building small check dams,
 6 plantation, because that checks the amount of sediment.
 7 And it has had an effect, it has had a definite effect
 8 on the sediments that flows in, because of the type of
 9 the catchment that it has.
 10 In terms of the exact number or time or the
 11 estimate -- it is always an estimate, it is never
 12 an exact number. So both for Mangla and Tarbela, there
 13 are studies with ballpark figures of how the sediment is
 14 moving, and how long it will take to move to a certain
 15 position.
 16 If you want that information in detail, we'll
 17 provide you. I don't have it at my fingertips at this
 18 point in time.
 19 DR BLACKMORE: I know a fair bit about Tarbela but I don't
 20 know anything about Mangla. So I just wanted to
 21 understand, because it's such a key piece of
 22 infrastructure for Pakistan, and if it has a life of
 23 50 years you'd start to worry. If it has a life of
 24 500 years you'd be less worried. So I just wanted to
 25 understand where you were on that journey.

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1 DR HAYAT: I think it's not farmed in that area. Part of
 2 it, if I'm correct -- if my high school lessons are
 3 correctly remembered -- quite of it is desert area.
 4 MR MINEAR: Okay, thank you.
 5 DR BLACKMORE: I'm going to come back to the question of
 6 sediment, because every time I look out at these
 7 mountains I worry about it, as you do.
 8 So you've got run-of-the-river dams, and you've got
 9 sediment management to make sure that, in the end, the
 10 sediment goes downstream. Then at the end of this
 11 you've got Mangla. We won't deal with Tarbela, we'll
 12 stick with Mangla.
 13 So is there an estimate of the lifetime of that dam?
 14 Because there's only a finite amount of time that you
 15 can put sediment into it before you start to impact its
 16 capacity. I'm just wondering whether there's -- and
 17 they're very difficult to flush. Like, this dam is very
 18 easy to flush. Mangla is, you know, almost impossible
 19 to flush. I'm just wondering whether there's some work
 20 being done that would give us an idea of the likely
 21 lifespan of Mangla.
 22 DR HAYAT: You're aware, sir, there are several studies
 23 being done, have been done, both the two main reservoirs
 24 that we have, Mangla and Tarbela. And they have
 25 sediment coming in, as you know. The exact number and

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1 DR HAYAT: As you know also, sir, we went for a heightening
 2 of Mangla Dam. So we have increased its capacity.
 3 DR BLACKMORE: I've seen it. It's very nice.
 4 THE CHAIRMAN: Very good. I think that's it for our
 5 questions. So, Dr Hayat, I guess it's Mr Farooq next.
 6 (12.12 pm)
 7 (Pause)
 8 (12.15 pm)
 9 THE CHAIRMAN: So, Mr Farooq, whenever you are ready.
 10 MR FAROOQ: Mr Chairman and members of the Court of
 11 Arbitration, I am Muhammad Umar Farooq, working as
 12 senior engineer in the water and agricultural division
 13 of NESPAK. You will be hearing from me a couple of
 14 times during the course of these presentations. My
 15 focus for now is a short presentation on hydrology.
 16 Slide number 13. This map shows the entire area of
 17 the Indus Basin, falling within the territories under
 18 the control of four states: in green, approximately 59%
 19 of the Indus Basin area is in Pakistan, which includes
 20 the area of Pakistan Administered Kashmir; approximately
 21 21% of the Indus Basin area is in India, which includes
 22 the area of Indian Administered Kashmir, as you can see
 23 here in blue colour; the rest of the 20% area is almost
 24 equally divided between Afghanistan and China.
 25 The hydrologists divide Pakistan's territory into

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1 three hydrological units. By far the largest is the
 2 Indus Basin, which covers approximately 65% of
 3 Pakistan's territorial land. The two other basins
 4 include an endorheic basin in the Kharan Desert in
 5 western Balochistan, which has no outlet to the sea, it
 6 is here. And the other is Makran coastal basin, which
 7 directly drains into the sea here.

8 The Indus Basin is heavily influenced by winter
 9 precipitation in the high mountains in the form of
 10 snowfall, by summer monsoon rains, and by the upper
 11 atmospheric phenomenon. The extensive 2022 flooding,
 12 which displaced around 7.6 million population, was
 13 attributed to two atmospheric rivers that passed over
 14 southern Pakistan. These so-called atmospheric rivers
 15 are long narrow zones of wind that carry the water
 16 vapours out of the tropics. An average atmospheric
 17 river can carry roughly the amount equal to a month's
 18 flow of Mississippi River of the United States of
 19 America, and an exceptionally strong atmospheric river
 20 can transport water vapours about 15 times of that
 21 amount.

22 Slide number 14.

23 DR BLACKMORE: Sorry, can I ask a question?
 24 Are these atmospheric rivers which we are seeing
 25 more and more -- I saw one in America recently, and

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1 the town of Gurez, about 12 kilometres upstream of the
 2 line of control.

3 To the centre left of the map, here is the
 4 Neelum-Jhelum Hydroelectric Project. Kishenganga River,
 5 as it passes through the line of control, its name
 6 changes to the Neelum River, and this Neelum-Jhelum
 7 Hydroelectric Project is situated on Neelum River here.
 8 It diverts the flows of the Neelum River through
 9 a tunnel and powerhouse and discharges into the Jhelum
 10 River here. The flows that are being diverted at
 11 Kishenganga Hydroelectric Project are not available for
 12 hydropower generation at Neelum-Jhelum Hydroelectric
 13 Project.

14 Slide number 15. Mr Chairman and members of the
 15 court, as you would have seen on the drive from the
 16 hotel to the dam site, Neelum River is flowing quite
 17 strongly, but not at its full level. You can still see
 18 some rocks visible in the water. At the moment, the
 19 river is flowing at a rate of about 250 cumecs but the
 20 flow will be around 1,200 cumecs or more in the month of
 21 July due to monsoon rains.

22 This graph shows the daily discharge in cubic metres
 23 per second for the years 1993 and 1994, showing
 24 a typical seasonal pattern of Himalayan rivers. The
 25 flow in Kishenganga on Neelum River is strongly

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1 we've had one in Australia in the last six months -- are
 2 they becoming an increased phenomenon, or have they been
 3 around for -- is it being driven by climate change and
 4 increased energy, or has it been a part of the system
 5 for hundreds of years and we're just noticing them
 6 more --

7 MR FAROOQ: Sir, I see it as a part of the climate change
 8 phenomenon. For example, we have two severe floods in
 9 Pakistan in the last 13 years. One was in 2010, and the
 10 most recent flood was in 2022. So, yes, we can consider
 11 that these are due to the climate change. Climate
 12 change could be one of the phenomena that is driving
 13 these types of atmospheric rivers in such a severe
 14 condition.

15 Slide number 14. Now we have a closer look at the
 16 tributaries of the Indus Basin, or I would say Indus
 17 River. As Dr Hayat mentioned earlier, the Indus Basin
 18 is comprised of Indus River, and six of its major
 19 tributaries: River Jhelum, Chenab, Ravi, Sutlej and Beas
 20 join the Indus River at the left bank from the east
 21 side, and Kabul River joins the Indus River at the right
 22 bank from the west.

23 In the centre of the map, as shown in the orange
 24 triangle, it is the India's Kishenganga Hydroelectric
 25 Project, which is situated on the Kishenganga River near

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1 seasonal. The highest flow occurs from the month of May
 2 to the month of August, due to snowmelt in the upper
 3 catchment, and monsoon rainfalls in the lower catchment.
 4 Meltwater begins to start in spring, and monsoon rains
 5 typically occur from May to August and into September,
 6 and there is a long dry period from October to the end
 7 of March.

8 Slide number 16. This slide shows the daily
 9 sediment inflow in tonnes per day for the same period of
 10 1993 and 1994. As you can see, it broadly tracks the
 11 flow of the Neelum River, as shown on the previous
 12 slide, and the importance of floods on the sediment
 13 transport is clear. Notice that the sediment transport
 14 drops to near zero in the dry season, despite continuing
 15 water flows, as you can see here.

16 During the winter, the dry season, the rivers run
 17 clear, but the dry season is also the only time of the
 18 year that sediment on the riverbed can be observed,
 19 because the bed is entirely submerged during the wet
 20 season.

21 Sediment flow rates are measured by sampling the
 22 sediment concentrations in the river during the wet
 23 season, and based on the observations and measurement of
 24 the size of the sediment on the riverbed during the dry
 25 season, the winters.

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1 Different types of samplings during both wet and dry
 2 season is needed to better quantify the sediment
 3 transport. As we will come to discuss in the
 4 forthcoming presentation, the equilibrium between
 5 sediment inflow and outflow is important for maintaining
 6 the live storage. Several techniques can be used for
 7 this purpose.
 8 Slide number 17. This slide summarises the inflow
 9 of sediment by month for multiple years of data. As was
 10 shown for the 1993 and 1994 data, almost all the
 11 sediment is delivered in the summer months, and
 12 virtually no sediment transport in the winter months or
 13 dry season.
 14 Mr Chairman, this concludes my portion of this
 15 presentation on hydrology. I will now hand over to my
 16 colleague, Mr Sendhu, who will address you on geology,
 17 and before I do, if you have any questions, then
 18 I'm here to answer.
 19 Questions from THE COURT
 20 THE CHAIRMAN: Thank you, Mr Farooq. I think we do have at
 21 least one question.
 22 DR BLACKMORE: So if we go back to slide 15, please, sir.
 23 So when we are going through the dry season -- this is
 24 just a typical one. So we're going through the dry
 25 season, the capacity of the power station and tunnels is

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1 200 plus cubic metres a second.
 2 MR FAROOQ: 280.
 3 DR BLACKMORE: Yes. So we're way below that for five or six
 4 months of the year, or five months of the year, if
 5 I'm reading it correctly. So what is the decision on
 6 how much water you generate and how much you leave in
 7 the river? So what's your environmental flow or
 8 compensation flow strategy for this dam?
 9 MR FAROOQ: For now, as the lowest recorded daily inflow at
 10 this dam site is about 20 cumecs, so the WAPDA is
 11 ensuring to release at least this amount downstream of
 12 the dam.
 13 PROFESSOR BUYTAERT: A related question. So from when to
 14 when is the plant able to perform at maximum power
 15 production?
 16 MR FAROOQ: So, sir, the design discharge of the intake is
 17 280 cumecs, and from this graph I can show you that you
 18 can see from May to the month of August the plant will
 19 be generating its installed capacity, or will be
 20 operating at full capacity, and for the rest of the
 21 months it will not be.
 22 PROFESSOR BUYTAERT: And so for the rest, is the
 23 environmental flow always 20, or does it depend on the
 24 inflow?
 25 MR FAROOQ: I mean, it depends upon the inflow.

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1 PROFESSOR BUYTAERT: Okay.
 2 MR FAROOQ: The plant will not be operating for 24 hours of
 3 the day, but at least for part of the day, depending
 4 upon whatever we are getting flow at the dam site.
 5 PROFESSOR BUYTAERT: Okay. And then I think the operation
 6 is determined both by the amount that appears in the
 7 river and I guess also the loads, the demand for
 8 electricity and the variation throughout the day; is
 9 that right?
 10 MR FAROOQ: Partly. I mean, normally we have high demands
 11 in the evening and it is -- I mean, there are many
 12 factors, but one factor is that how the operator wants
 13 to run the plant. But as usually we have high demand in
 14 the evening, so most of the time we don't operate the
 15 run-of-river plant in the morning and collect the water
 16 in the operating pool and then release it in the evening
 17 when the demands are high.
 18 PROFESSOR BUYTAERT: Okay. Thank you. Do you want to
 19 follow up on that?
 20 Then I'll just ask my second question. So thank you
 21 for giving the overview of the hydrology of the entire
 22 country. For the Neelum basin in particular, would you
 23 know what the average precipitation is over the Neelum
 24 basin?
 25 MR FAROOQ: I don't have the average value over the whole

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1 Neelum catchment. But here where we are right now, in
 2 Muzaffarabad, the precipitation is of the order of
 3 1,400 mm per year.
 4 PROFESSOR BUYTAERT: Okay.
 5 MR FAROOQ: But definitely as we go more in the north the
 6 precipitation reduces, and I don't have the exact figure
 7 for the whole catchment.
 8 PROFESSOR BUYTAERT: Okay. And then perhaps asking again
 9 the question I asked earlier about the method for
 10 measuring streamflow. Would you happen to know what
 11 method was used here?
 12 MR FAROOQ: Yes. So I can tell you, sir, that WAPDA has
 13 a dedicated department named Surface Water Hydrology
 14 Project, or SWHP. It has a monitoring network across
 15 all of the major rivers in Pakistan, and what they do is
 16 they install gauges -- they normally record manually --
 17 they record manually at the gauges and they maintain
 18 a log for each site, and then they carry out the
 19 physical flow measurements at each site to develop
 20 a relationship between the gauge and the discharge.
 21 PROFESSOR BUYTAERT: Mm-hm.
 22 MR FAROOQ: Then the data is transported to their head
 23 office in Lahore where they apply some quality checks
 24 and water balance techniques to ensure the quality of
 25 the data. And after ensuring the quality of the data,

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1 they translate the daily recorded gauges into the
 2 discharge series and then they publish it. And that is
 3 basically the data the designers rely for design of any
 4 hydropower project or development of water
 5 infrastructure.
 6 PROFESSOR BUYTAERT: Yes. Would you happen to know the
 7 method that is used for the flow measurements?
 8 MR FAROOQ: So basically surface water hydrology follows the
 9 guidelines as set forth by the USGS, and currently they
 10 are doing the physical flow measurements by current
 11 meter method.
 12 PROFESSOR BUYTAERT: Okay, yes.
 13 MR FAROOQ: And for all the measurements, whether they are
 14 flow measurements or sediment measurements, the
 15 standards to follow is the USGS.
 16 PROFESSOR BUYTAERT: Yes. And the water level measurements
 17 that are done manually as well, do you know how often
 18 they are typically done? Is that daily, or perhaps
 19 hourly?
 20 MR FAROOQ: Yes. At least that -- I can tell you in the
 21 high flow season or summers, at the key locations the
 22 gauge is recorded at one-hour interval, or you can say
 23 that there are 24 values in a day. And in winters they
 24 may be recording, say, four to six observations in
 25 a day, and depending upon whether it is a key location

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1 or not.
 2 PROFESSOR BUYTAERT: Okay. Thank you.
 3 DR BLACKMORE: Just something I didn't understand. I don't
 4 understand a lot, but I didn't understand this, so we'll
 5 try and work through it a little bit.
 6 So when you're releasing water through the power
 7 station and at some parts of the day you've switched off
 8 the power station, you're not generating, and other
 9 parts, for peak, you are, that tells me that you've got
 10 to have some operational pondage here.
 11 MR FAROOQ: Yes.
 12 DR BLACKMORE: I wasn't clear that there is an operational
 13 pondage. I thought it was a run-of-river facility. So
 14 what percentage of the dam capacity is in this operating
 15 range that you can use for meeting peak demands?
 16 MR FAROOQ: Sir, the total capacity, or the gross capacity
 17 of the reservoir is around 10 million cubic --
 18 10 million cubic metres, and out of the 10 million cubic
 19 metres, 3.8 million cubic metres is the capacity of the
 20 operational pool.
 21 DR BLACKMORE: And what's the operational range?
 22 MR FAROOQ: The full pond level is at 1,015 metres above the
 23 mean sea level, and the minimum drawdown level is at
 24 1,008 metres. So it creates an operational range of
 25 around 7 metres.

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1 DR BLACKMORE: Okay. Thank you.
 2 THE CHAIRMAN: Great. Thank you very much, Mr Farooq. Are
 3 you finished with your presentation? I think so.
 4 MR FAROOQ: Yes, I am.
 5 THE CHAIRMAN: Thank you very much. That's very helpful.
 6 And I think now we have Mr Sendhu.
 7 (12.30 pm)
 8 MR SENDHU: Mr Chairman and members of the Court of
 9 Arbitration, my name is Fiaz Hanif Sendhu. Presently
 10 I am working at Tarbela 5th Extension Hydropower Project
 11 as the chief geologist. Before that I have worked as
 12 the resident geologist at this Neelum-Jhelum
 13 Hydroelectric Project.
 14 I have more than 35 years of experience. I have the
 15 honour to address you on the geology of the region and
 16 dam site. The geology of the region is very complex and
 17 challenging, due to pressing and folding of the strata
 18 and rocks in the region.
 19 Slide number 19, please. This slide is showing the
 20 tectonic map of the region. Neelum-Jhelum Hydroelectric
 21 Project lies in these Himalayas, there is the dam site.
 22 The Himalayas are geologically young mountains,
 23 developed as a result of collision between several
 24 continental and microcontinental plate fragments. The
 25 northwestern part of the Himalayas is subdivided into

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1 units: Sub Himalaya -- this is also called the foothills
 2 of the Himalayas; Lesser Himalayas; Kohistan sequence;
 3 and Higher Himalayas.
 4 These units are separated by a series of parallel to
 5 sub-parallel thrust faults. This is the main boundary
 6 thrust, this is going like this, this is main central
 7 thrust, and this is main mantle thrust. These faults
 8 were developed due to collision between Eurasian plate
 9 and the Indian plate. Here is the Eurasian plate and
 10 here is the Indian plate along this MCT fault, Indian
 11 plate is subducting below the Eurasian plate. Due to
 12 Earth's subduction, stresses were developed towards the
 13 south side, and due to these compressions and stresses,
 14 these faults were generated. The MBT, main boundary
 15 thrust, passes below the dam foundation here.
 16 Another important feature of this area is the
 17 Hazara-Kashmir syntaxial bend. All the lineaments and
 18 strata in this area have taken a bend of 160 degrees.
 19 Sediments deposited in this core of the bend with the
 20 passage of time were converted to sedimentary rocks, and
 21 in this other area, these are metamorphic rocks.
 22 The region is tectonically active and geologically
 23 complex. This makes it challenging to build hydropower
 24 plants, but it can be done, as Neelum-Jhelum
 25 Hydroelectric Project shows.

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1 Slide number 20, please. This slide shows the
 2 geology of the Kashmir region. All three types of
 3 rocks, sedimentary rocks, metamorphic rocks, and igneous
 4 rocks, are present in this region. Neelum-Jhelum
 5 Hydroelectric Project is located in the sedimentary
 6 rocks of this yellow, and here this is Neelum-Jhelum dam
 7 site and this is tunnel, it is mostly located into the
 8 sedimentary rocks. Only dam site, right abutment of the
 9 dam, is lying on the metamorphic rocks.
 10 Next slide (21), please. These sedimentary rocks
 11 I'm talking about are unstable due to weak layering and
 12 tectonic deformations, because due to this bend these
 13 have become deformed and sheared. This slide is showing
 14 the geology of Neelum Valley. These are the sedimentary
 15 rocks. This yellow colour, this is the Murree
 16 formation, and the red and maroon are the Hazara
 17 formation and Tanol formation. These are metamorphic
 18 rocks. These names, Murree formation and Hazara and
 19 Tanol formation, these are stratigraphic names given by
 20 the Stratigraphic Committee of Pakistan, who
 21 differentiate the same type of rocks deposited in the
 22 same period. Also, there is metamorphic rock. This is
 23 Panjal formation. This is a group of metamorphic rocks.
 24 Next slide, please, 22. This slide is
 25 a cross-section of the geology at the dam site. The

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1 DR BLACKMORE: It's freshwater. Because I can't see
 2 anything else in it.
 3 MR SENDHU: Because these sediments, all these sediments, as
 4 previously I have said, in the core these were sediments
 5 of previous already-existing rocks, they are sediments
 6 transported with the water, with the rain and with the
 7 gravity, and deposited, and then they were converted
 8 into the rocks.
 9 DR BLACKMORE: How old? How old are the sedimentary rocks?
 10 MR SENDHU: Yes?
 11 DR BLACKMORE: How old? What age?
 12 MR SENDHU: These sedimentary rocks are from 5.5 million to
 13 23 million years before, Miocene age.
 14 And second, this one is siltstone rock. It is
 15 a sedimentary rock that is composed mostly of silt. It
 16 is a type of mud rock with low clay content. So its
 17 maroon colour, reddish colour, is due to argillaceous
 18 material, due to clays.
 19 And the third one is graphite schist. We don't have
 20 the sample of this rock -- this is metamorphic rock --
 21 because a 7-8 metre bed was encountered during the
 22 excavation, and then it was buried under the dam
 23 structure. So at present we don't have its sample. It
 24 is medium to large-sized crystals. It is weak to
 25 moderately weak. It can easily split into thin flakes.

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1 older rocks of metamorphic rocks have been thrust
 2 up -- this is the fault line -- have been thrust up
 3 and come into contact with the younger age rocks of the
 4 sedimentary rocks. They have moved from a horizontal to
 5 vertical position, because the position is horizontal,
 6 but due to thrusting they have been shifted to the
 7 vertical, to these deformations.
 8 Mr Chairman and members, I have displayed some
 9 samples of the rocks just for your visual observation.
 10 THE CHAIRMAN: Thank you.
 11 MR SENDHU: This is sandstone. This is sedimentary rock.
 12 It forms when grains of the sand are cemented together
 13 over long periods of time. It is a hard rock, but due
 14 to stresses it has been deformed. In slide 27 we'll see
 15 how this hard rock has been deformed and folded.
 16 DR BLACKMORE: Sorry, question: does this have a marine
 17 phase, or has it been freshwater?
 18 MR SENDHU: Sorry.
 19 DR BLACKMORE: Has it been laid down under the sea or laid
 20 down under freshwater, this rock, this sediment?
 21 MR SENDHU: I'm sorry, I couldn't understand you. Sorry.
 22 DR BLACKMORE: No, it's alright. I'm just wondering whether
 23 this was laid down as a sediment in a freshwater
 24 environment?
 25 MR SENDHU: Yes, yes.

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1 And the next here is greenstone rock. This is
 2 metamorphic rock, and it has been metamorphosed from the
 3 igneous rocks.
 4 MR MINEAR: From igneous rocks?
 5 MR SENDHU: Yes. In this area it is converted from basalt
 6 to greenstone.
 7 THE CHAIRMAN: It does have a greenish look to it.
 8 MR SENDHU: Yes, it is due to -- it's some mineral content
 9 epidote and chlorite. Those minerals have this greenish
 10 colour.
 11 Slide 23, please. This is fault contact, MBT.
 12 Lower is sedimentary rocks. These are the siltstone,
 13 this is sandstone, and above are Panjal formation group
 14 of metamorphic rocks. This picture was taken about
 15 1 kilometre downstream from the dam axis. This is at
 16 the right bank of the dam, and this fault slowly moves
 17 into the river, and at dam site it shifted below the dam
 18 foundation.
 19 Then after 500 metres upstream from the dam, it
 20 shifted towards the left bank of the river. So in
 21 1.5 kilometres, the fault shifted from the right bank to
 22 the left bank, passing below the dam foundation.
 23 Next slide number 24, please. This slide shows the
 24 main boundary thrust at the Neelum-Jhelum Hydroelectric
 25 dam site. Here was a dam site, and this fault was

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1 buried under the river alluvium at dam site, and these
 2 MDBH, these are the main dam boreholes. These three
 3 boreholes were drilled to determine the depth of the
 4 sound rock for placing the dam foundation and for
 5 locating the contact of the fault. These boreholes were
 6 drilled into the riverbed.
 7 DR BLACKMORE: Sorry. So given that you've got a fault
 8 running up the river, basically, do we have any estimate
 9 of when it was last active? When the fault was last
 10 active, when it was moving?
 11 MR SENDHU: It is not active. I am coming next to that.
 12 DR BLACKMORE: Oh, okay. Sorry.
 13 MR SENDHU: The right abutment of the rockfill dam is
 14 resting on the metamorphic rocks. So these are the
 15 Panjal formation metamorphic rocks, right abutment of
 16 the rockfill dam is lying on these rocks, and diversion
 17 tunnel also crosses through these metamorphic rocks.
 18 Upstream from this picture is the inlet, and this is the
 19 outlet of the diversion tunnel. At the time of this
 20 picture, the excavation was in progress from both ends
 21 of the diversion tunnel.
 22 In 2005, an earthquake occurred in Muzaffarabad and
 23 adjoining areas. This earthquake was along the
 24 Muzaffarabad Fault. During construction in 2008,
 25 designers had to examine the main boundary thrust to

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1 determine the impacts of the 2005 earthquake on the
 2 fault. A geological field survey found no signs of
 3 movement along the MBT. Surveys could not prove any
 4 rupture along the MBT fault at the dam site, but it
 5 cannot be ruled out that there could be a future
 6 movement on the main boundary thrust at the dam site
 7 during the lifetime of the project.
 8 So keeping in view these risks of movement along
 9 this MBT fault during the lifetime of the project, the
 10 dam design was changed. Previously it was concrete
 11 gravity dam. Then it was redesigned as a composite dam.
 12 A rockfill dam with clay core covering the fault zone on
 13 the right side and the concrete dam with gated spillway
 14 and other structures on the left side.
 15 Next, 25.
 16 PROFESSOR BUYTAERT: Do you have an estimate of what is the
 17 potential direction of the movement here at this
 18 location? I know that on the continental scale it's
 19 a subduction, but is it also the same direction you
 20 expect here, or might there be lateral movements?
 21 MR SENDHU: Actually the angle of the fault in the
 22 cross-section we are seeing, that is about 85 degrees.
 23 So it is expected to move along that plane.
 24 PROFESSOR BUYTAERT: Okay, yes. Thank you.
 25 MR SENDHU: Slide 25.

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1 DR BLACKMORE: Just -- you may not be the right person to
 2 ask but I'm going to ask it anyway, put it on notice.
 3 So when you've put your flexible part of the dam in
 4 place, the rockfill dam, what was the impervious layer
 5 that you have used in that?
 6 MR SENDHU: Clay core.
 7 DR BLACKMORE: Is it clay core?
 8 MR SENDHU: Clay core, yes.
 9 DR BLACKMORE: Yes, okay. Thank you.
 10 MR SENDHU: Slide [25], please.
 11 This is during the excavation of the foundation.
 12 This is in the cross-section of this fault. This is the
 13 contact of the fault, the sharp contact. This is
 14 sedimentary rocks, these are siltstones, these are
 15 sandstones, and this is graphite schist.
 16 Slide 26. These pictures show the impacts of MBT
 17 fault on the rocks. Deformation and open joints can be
 18 seen. These hard and brittle rocks have been broken and
 19 big cavities have developed. A lot of efforts had to be
 20 made to strengthen the foundation rocks. Tonnes of
 21 cement was injected to consolidate the dam foundation
 22 rocks. These rocks were encountered on the right bank
 23 below the rockfill dam foundation.
 24 Next, please, [slide] 27. This is, finally, here
 25 are photos of the effect of compression on the

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1 sedimentary rocks. In this area you can see this hammer
 2 is placed for the scale, to visualise the size of these
 3 micro folds. This is the same hammer I have placed
 4 here, just to understand (indicates).
 5 Due to these folds, we have challenges with
 6 collapses, rockfalls, and landslides.
 7 Next, [slide] 28.
 8 So thank you, sirs, if you have any questions.
 9 Questions from THE COURT
 10 THE CHAIRMAN: Thank you, Mr Sendhu.
 11 You just mentioned landslides. Have there been
 12 landslides up upstream or downstream from the dam since
 13 it was put into operation?
 14 MR SENDHU: Landslides, the studies were carried out by
 15 NESPAK into the reservoir area, and they recommended
 16 some measures. But landslides, in the reservoir area,
 17 we have not found any landslide yet.
 18 THE CHAIRMAN: Okay. Yes.
 19 DR BLACKMORE: Sorry, I have two questions.
 20 So where did you find the clay for the clay core?
 21 Where did the clay come from? In this valley or some
 22 other area?
 23 MR SENDHU: Yes, this was away -- now I am not remembering
 24 the name, but this was the source from some other site.
 25 DR BLACKMORE: Somewhere here?

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1 MR SENDHU: Not somewhere here. At a distance.
 2 DR BLACKMORE: Okay. Because I would have been mystified if
 3 you had been able to find it here.
 4 So the second question is, when you're looking at
 5 that folded rock in the foundation -- and I think
 6 I asked the question yesterday but I'll ask it again.
 7 So when you were grouting and putting grout into this --
 8 MR SENDHU: Yesterday, yes.
 9 DR BLACKMORE: Yes, and it looks to me like it would take
 10 a very large amount of grout.
 11 MR SENDHU: Yes.
 12 DR BLACKMORE: But you only went 20 metres for 60-metre-high
 13 structures.
 14 MR SENDHU: Yesterday you asked that question about the
 15 depths.
 16 DR BLACKMORE: Yes.
 17 MR SENDHU: And because this was 7 or 8 years before this
 18 work was carried out, so I told 24 metres.
 19 DR BLACKMORE: 24.
 20 MR SENDHU: No, but it was not, then suddenly after that
 21 I recalled that these are the depth of the drainage
 22 holes. The grouting depths for primary holes were
 23 35 metres and secondary was 25 metres and tertiary was
 24 15 metres. And these depths were variable. Along the
 25 slopes, these were 10 metres. And towards the left side

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1 MR FAROOQ: (Inaudible: off microphone) ... by Mr Buytaert
 2 when we were at the left bank, you asked, or maybe
 3 Mr Blackmore, what is the length of record available for
 4 a gauging station record.
 5 So the maximum length of data that is available, it
 6 is at Muzaffarabad station, Neelum River at
 7 Muzaffarabad, and it starts from 1963, and to date the
 8 record is available. And the slide 14, I think, shows
 9 also the currently operational gauging locations on
 10 Neelum River.
 11 PROFESSOR BUYTAERT: Those stations are upstream or
 12 downstream of the confluence?
 13 MR FAROOQ: It is basically upstream of the confluence --
 14 PROFESSOR BUYTAERT: Just to repeat my question: is the
 15 gauging station in Muzaffarabad upstream or downstream
 16 of the confluence?
 17 MR FAROOQ: So it is upstream of the confluence and exactly
 18 on Neelum River.
 19 PROFESSOR BUYTAERT: Yes, thank you.
 20 MR FAROOQ: Thank you.
 21 THE CHAIRMAN: Okay. So I think now we're finished. See
 22 you shortly at lunch.
 23 (12.52 pm)
 24 (A short adjournment)
 25 (1.54 pm)

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1 of the dam, there was alluvium, so a grouting tunnel was
 2 formed and 5 metres into the rock, that was grouted.
 3 DR BLACKMORE: Thank you.
 4 MR MINEAR: Since we have a geologist here, what is the
 5 composition of the sediment that flows into the
 6 reservoir here? What is the composition? Is it
 7 sandstone or schist, or ...
 8 MR SENDHU: The composition of these rocks?
 9 MR MINEAR: Of the sediment that flows down from upstream.
 10 MR SENDHU: There are some samples that have been placed
 11 there of the sediments from the river. And our
 12 hydrologist, I think he will explain these samples that
 13 are lying there.
 14 MR MINEAR: We'll get some later. Okay, thank you.
 15 THE CHAIRMAN: Okay, I think we have no other questions for
 16 you, Mr Sendhu. Thank you very much for your
 17 presentation. It was very helpful.
 18 So I think we've now finished this presentation.
 19 MR MIANA: (Inaudible: off microphone). After the lunch we
 20 will go for presentation number 7, walk around the dam
 21 site.
 22 THE CHAIRMAN: Okay. So for about 10 minutes we'll get
 23 ourselves organised and then we will have lunch.
 24 MR MIANA: Yes, okay.
 25 THE CHAIRMAN: Very good. Thank you so much.

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1 Presentation 7: Dam and Reservoir Inspection (I)
 2 MR MIANA: Mr Chairman, members of the Court of Arbitration,
 3 now we'll start the presentation no. 7, which is
 4 a walkthrough of the dam area all together.
 5 We will first go to the control room. We'll just
 6 have a look at the control room, what parameters we are
 7 getting inside the control room. Then we'll go up to
 8 the dam site and we'll have a look round up there. And
 9 then we'll go to the desander site and then finally
 10 collecting tunnel, and then we'll see the HRT, which
 11 we cannot see!
 12 THE CHAIRMAN: Okay, very good.
 13 MR MIANA: So let's start.
 14 THE CHAIRMAN: Thank you.
 15 MR MIANA: Thank you.
 16 With me in this presentation, Mr Nayyar will also
 17 accompany me, he is my co-presenter, and also
 18 Mr Ayub Malik and Dr Tahir will assist me if there are
 19 some questions.
 20 THE CHAIRMAN: Thank you.
 21 MR MIANA: So let's start. (Pause)
 22 So this is the control room for the operation and
 23 the regulation of the water from the dam site. We
 24 already explained about the available facility for the
 25 regulation of water through different sources, like the

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1 radial gates, the flap gates, the undersluice and the
 2 two HRTs to the powerhouse.
 3 So these are the level indicators over here, the
 4 three level indicators over here. At the moment we have
 5 1,011.9, whereas the maximum level for the reservoir is
 6 1,015. So almost 3 metres below that one, at the moment
 7 we are maintaining this level. The slight difference is
 8 due to the position of the sensor over there. There are
 9 two others located at the same level. Maybe it's some
 10 calibration issue.
 11 On this side we get the information regarding every
 12 event that occurs, where we have the instrumentation and
 13 the control. So everything is recorded over here, with
 14 the date, month, hour, minute and even second. So that
 15 records. Some are in the white, which are just
 16 information; some are in the pink, which are also some
 17 warning. But when it is in the red, then it is news
 18 that we need some action to do that one.
 19 This one is our CCTV. They are just having around
 20 all the facility, with CCTV cameras around there.
 21 Behind these screens, on the main screen we have the
 22 discharge data that we just described over here. At the
 23 moment we have the full station over there. From there
 24 we can get -- this is the Taubat. It's just near to the
 25 line of control at 9 kilometres?

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1 MR ALAUDDIN: -- not cumecs.
 2 So this brown line is the Taubat discharge, one of
 3 the gauges there, and the other one is Shadra. The
 4 other two gauges so far, due to some issues, [are] not
 5 giving reading. Otherwise there are four gauges
 6 upstream of that dam site.
 7 THE CHAIRMAN: Wouter, let's give you a microphone for you,
 8 sir. Thank you.
 9 PROFESSOR BUYTAERT: Thank you.
 10 What is the sudden surge between 12 and -- is it
 11 24/25 April? That doesn't look like a very natural peak
 12 in the discharge. Is that --
 13 MR MIANA: This one?
 14 PROFESSOR BUYTAERT: Yes.
 15 MR MIANA: That was when in the catchment area the flow was
 16 very high.
 17 PROFESSOR BUYTAERT: Okay. So I would expect it to increase
 18 like that as a result. But why does it then suddenly
 19 decrease?
 20 MR MIANA: That is the rain for two or three days.
 21 PROFESSOR BUYTAERT: Okay. So really continuous rain, then
 22 it stopped?
 23 MR MIANA: Yes.
 24 PROFESSOR BUYTAERT: Okay. Thank you.
 25 MR MIANA: So this is an overview of the control room.

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1 MR ALAUDDIN: 200 kilometres.
 2 MR MIANA: No, no, 9 kilometres from the ... 9 kilometres
 3 from the (inaudible). And with this, the second is at
 4 Shadra?
 5 CONTROL ROOM OPERATOR: Karimabad.
 6 MR MIANA: This is Karimabad. The next one?
 7 CONTROL ROOM OPERATOR: Shadra.
 8 MR MIANA: Third one is Shadra. And the fourth one?
 9 CONTROL ROOM OPERATOR: Islamapura.
 10 MR MIANA: The Islamapura.
 11 CONTROL ROOM OPERATOR: 15 kilometres from this.
 12 MR MIANA: So this is the most nearest to this one.
 13 So we get the information starting from the
 14 Kishenganga (indistinct) of the Neelum River, and we get
 15 through flow station [...] we are getting. And
 16 altogether with this, the route of the Neelum River, we
 17 get the data. And accordingly we manage during the
 18 flood season.
 19 THE CHAIRMAN: I see.
 20 MR MIANA: So this is the graph that we get from this one.
 21 MR ALAUDDIN: So this graph is showing the discharges number
 22 on this Y-axis. It means that it's 2.5 cumecs, starting
 23 point. 2,500 cusecs (indistinct), water is coming. So
 24 that's why this is scale in cusecs --
 25 MR MIANA: Cusecs, not the cumecs.

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1 THE CHAIRMAN: This is a very important room, I think.
 2 MR MIANA: Yes.
 3 THE CHAIRMAN: Very good. Thank you. (Pause)
 4 MR MIANA: If you like, you can take a helmet. This is
 5 a hi-vis, you can also wear this one. (Pause)
 6 This is the same building that we just came from
 7 here, the dining room and the conference room. And this
 8 is our emergency power supply in case of failure of the
 9 public network. So we have the two diesel generators
 10 over here, and we have the tank capacity of almost
 11 12,000 litres for the generation. And with this
 12 capacity, we can generate further four days, continuous
 13 operation. Because this is in the far-flung area. So
 14 any kind of landslide in this may entrap the electricity
 15 for more time. So instead of one, we have put two
 16 diesel generators. These are some of the switch rooms
 17 over there for this one.
 18 We have already seen in the morning, and from the
 19 top of that point. The desanders are on our left. And
 20 we're just heading towards the concrete (inaudible) dam
 21 that starts from here, and that is almost 160 metres?
 22 MR ALAUDDIN: Yes.
 23 MR MIANA: Plus the earthfill and rockfill dam is there.
 24 MR ALAUDDIN: Total length from here to that end is
 25 250 metres. The intake structure is 88 metres. Then

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1 the composite dam is 160 metres.
 2 MR MIANA: Okay. (Pause)
 3 So we are on the top of the dam. Not so big, but
 4 still we're on top.
 5 So we can see from here the upstream side and this
 6 one. So here we have the building, we were there in the
 7 morning. And prior to that, we were on the (indistinct)
 8 side, on the downstream side, and now we are at the dam
 9 site. So I am just going through the dam site, I will
 10 explain this one.
 11 Here we can see there's a log boom over there, just
 12 to stop the floating debris over there. But the debris
 13 size is very small. We can take out the boulders but
 14 the small cannot be taken out, even with this grab. You
 15 can see they are taking out this one. Which is
 16 continuous also during the monsoon, and monsoon starting
 17 soon. So this debris is coming from the upstream side,
 18 even underwater it's coming, and it comes to the surface
 19 at this point.
 20 THE CHAIRMAN: So you never get water coming --
 21 MR MIANA: Never.
 22 THE CHAIRMAN: -- never get water coming over on to the top?
 23 MR MIANA: No, no.
 24 MR ALAUDDIN: No, no.
 25 THE CHAIRMAN: And that's because your freeboard is high

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1 there. So major excavation work was involved for the
 2 desander structure.
 3 DR BLACKMORE: Where did you put all the spoil? Where did
 4 you put all the spoil? Where did you put the rock?
 5 MR ALAUDDIN: We had allocated lands for depositing the
 6 spoil material.
 7 DR BLACKMORE: Okay.
 8 MR ALAUDDIN: Some of the aggregates which were useful are
 9 also utilised again here.
 10 DR BLACKMORE: Okay.
 11 MR MIANA: So I think this was the part of that excavation?
 12 MR ALAUDDIN: Yes.
 13 MR MIANA: So you can see the extent how we have excavated
 14 from there. So this is the remaining of that one.
 15 THE CHAIRMAN: Good.
 16 MR MIANA: This is our intake gates for the desanders. We
 17 have two intake gates on either side, one is on this one
 18 and one is on that side, for the desander. And the
 19 control of that desander is there, if I can take you
 20 to it. (Pause)
 21 So these are the control panels, electrical control
 22 panels for the hydraulic hoist, number 1 and then
 23 number 2, left and right. These are the motors. These
 24 are the hydraulic hoists used for that one. And these
 25 are the controlling valves for the flow water, either

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1 enough that it prevents --
 2 MR MIANA: Yes. I think this level is 1,019?
 3 MR ALAUDDIN: It is 1,019, yes.
 4 MR MIANA: 1,019.
 5 THE CHAIRMAN: Okay.
 6 MR MIANA: And our maximum operating level is 1,015. So we
 7 have 4-metre freeboard over there.
 8 MR MINEAR: What conditions -- when you have surplus
 9 storage, how high would the water come up here?
 10 MR MIANA: We do not pass 1,015.
 11 MR MINEAR: Okay.
 12 THE CHAIRMAN: And can I ask: am I correct that this is
 13 earthen up here (indicating), and this is concrete down
 14 here, or ...?
 15 MR ALAUDDIN: Yes, this is a roller-compacted concrete. The
 16 purpose is to stabilise the side slopes.
 17 THE CHAIRMAN: Yes.
 18 MR ALAUDDIN: This is the purpose of this.
 19 THE CHAIRMAN: Yes, okay.
 20 Please.
 21 PROFESSOR BUYTAERT: So was this part excavated, or what's
 22 the reason that this slope is so unstable?
 23 MR ALAUDDIN: Yes, this -- you see, if you can see the
 24 mountain, this was all mountain here. This has been
 25 excavated. It was, you can see, almost like this going

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1 forcing up or down.
 2 THE CHAIRMAN: There's one intake or two intakes for each
 3 desander?
 4 MR MIANA: Two.
 5 THE CHAIRMAN: Two intakes for each desander.
 6 MR MIANA: Two (Inaudible).
 7 THE CHAIRMAN: Okay. So there's six total?
 8 MR MIANA: Six total. And three undersluice.
 9 THE CHAIRMAN: Three undersluice?
 10 MR MIANA: That we saw in the morning: one was in operation.
 11 So these are this one, one that side and then this one.
 12 We can go on that side. (Pause)
 13 DR BLACKMORE: How long does the water take to pass through
 14 the desanding chamber?
 15 THE CHAIRMAN: Say it again.
 16 DR BLACKMORE: How long does the water take to pass
 17 through --
 18 MR MIANA: Very minimum.
 19 DR BLACKMORE: At the design flow, not a low flow?
 20 MR ALAUDDIN: You see, we reduce the velocity to 0.2 metres
 21 per second. So it takes a lot of time to ...
 22 DR BLACKMORE: Yes.
 23 MR MIANA: And what is the length, this one?
 24 MR ALAUDDIN: This length is 275 metres.
 25 MR MIANA: So you can divide the depth and width, then you

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1 get the second.
 2 DR BLACKMORE: And depth?
 3 MR ALAUDDIN: Depth ...
 4 MR MIANA: 22 metres.
 5 MR ALAUDDIN: Width is 25 metres, depth is 22 metres.
 6 MR MIANA: 22 metres. Alright.
 7 DR BLACKMORE: Okay. And what percentage of silt do you get
 8 out? From the input water, what percentage of the sand
 9 and silt do you get out?
 10 MR ALAUDDIN: In terms of parts per million, when water goes
 11 to the desander and up to this, maximum is up to 30 ppm.
 12 DR BLACKMORE: Right.
 13 MR ALAUDDIN: 30 milligrams per litre.
 14 DR BLACKMORE: Yes.
 15 MR ALAUDDIN: So it means that the desanders' efficiency of
 16 trapping the sediment is quite good.
 17 DR BLACKMORE: Okay.
 18 MR ALAUDDIN: That 30 ppm is maximum. Most of the time, we
 19 found the concentration less than 30 in the collecting
 20 canal.
 21 DR BLACKMORE: So what is the concentration coming in?
 22 MR ALAUDDIN: For example, it's normally more than 100,
 23 normally more.
 24 DR BLACKMORE: Okay. And when you take it out, you're going
 25 to sort of remove most of the large particles. So

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1 MR ALAUDDIN: Yes. So from here you can have an idea of the
 2 freeboard.
 3 DR BLACKMORE: So how often do you have to repaint the
 4 gates, do you have to take them out and maintain them?
 5 I see you've got all the gear here, the cofferdams.
 6 MR MIANA: Yes.
 7 DR BLACKMORE: So do you take the gates out every one year,
 8 three years, five years, to maintain --
 9 MR MIANA: You mean the radial gates?
 10 DR BLACKMORE: Yes.
 11 MR MIANA: Painting of the radial gates, if you want to
 12 paint on the upstream side, then you have to put these
 13 stoplogs over there.
 14 DR BLACKMORE: Yes, yes. Cofferdams in, yes.
 15 MR MIANA: Because these are normally painted with the epoxy
 16 paint, which is a good quality, so that takes a long
 17 time for the repainting.
 18 DR BLACKMORE: Yes. Because there's a lot of erosive
 19 material going past it, even with epoxy paints.
 20 MR MIANA: Yes, yes.
 21 DR BLACKMORE: So is it five years, ten years?
 22 MR MIANA: Actually just forecasting five years. So still
 23 we are in sixth year of operation.
 24 DR BLACKMORE: Oh, you haven't started yet! Okay.
 25 MR ALAUDDIN: Still, even after four/five years, the paint

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1 you're going to have 30 ppm and it'll be relatively
 2 small?
 3 MR ALAUDDIN: Yes. Actually the design has been made in
 4 such a way that particles more than 0.16 millimetres,
 5 greater than that, 0.15 or 0.16 millimetres, settle down
 6 at the bottom, and particles less than or lighter than
 7 that go through.
 8 DR BLACKMORE: Go through.
 9 MR MINEAR: They are suspended, mostly.
 10 DR BLACKMORE: Okay.
 11 MR MIANA: This is for the number 3.
 12 We can go around to see the river from the top.
 13 If you want, the Court can have the photo over here.
 14 This is a good photo here because behind is a good
 15 scenery for this one.
 16 So here is the reservoir, smaller one, not the big
 17 one, and the river is coming from that side. And on
 18 your left we have the three radial gates, 1, 2 and 3;
 19 and to the end of that one, we have the two floodgates,
 20 the crest opening over there. And beside that, we have
 21 the upstream dam over there.
 22 MR ALAUDDIN: Now you see the level, 1,015. That is the
 23 1,015 maximum level of the reservoir, written there in
 24 red.
 25 THE CHAIRMAN: Okay.

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1 is in very good condition.
 2 DR BLACKMORE: Because I know on my dams, when I had to do
 3 the same thing, it was a massive task. My gates were
 4 30 metres wide, so a different structure.
 5 MR MIANA: It is a massive job, taking all the --
 6 DR BLACKMORE: A big job.
 7 MR MIANA: The big job, yes.
 8 DR BLACKMORE: Big job.
 9 PROFESSOR BUYTAERT: Another question about the gates. How
 10 often do you open them, or what's the ratio between them
 11 being open and closed?
 12 MR MIANA: This one?
 13 PROFESSOR BUYTAERT: Yes.
 14 MR MIANA: Actually this depends upon the inflows.
 15 PROFESSOR BUYTAERT: Yes.
 16 MR MIANA: So when the inflows exceed the capacity of two
 17 flap gates, we have then the undersluice. Then there's
 18 no other chance just to operate this one.
 19 PROFESSOR BUYTAERT: Okay. So they're mostly used to get
 20 the water out?
 21 MR MIANA: Yes.
 22 PROFESSOR BUYTAERT: Are they also used for the sediment
 23 control?
 24 MR MIANA: Yes, for the flushing of the reservoir.
 25 PROFESSOR BUYTAERT: Flushing. Okay, yes.

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1 DR BLACKMORE: So do you use them to flush when the
 2 reservoir's got high flow or do you lower the reservoir
 3 to flush?
 4 MR MIANA: The recommended is in the high flow, because in
 5 the high flow you can flush more effectively.
 6 DR BLACKMORE: Yes, yes. So what do you do?
 7 MR MIANA: In the high flow. We flushed last year in
 8 August.
 9 DR BLACKMORE: Oh, okay, so in high flow.
 10 MR MIANA: July. In July.
 11 DR BLACKMORE: Okay. And how long do you have to take to
 12 flush? How many days?
 13 MR MIANA: This takes a long time, because we have to
 14 control the level step by step.
 15 DR BLACKMORE: Yes.
 16 MR MIANA: Immediately, because these (indistinct) are
 17 discharged with this water. So we have to go very
 18 slowly just to get the water outside there.
 19 (Videographer's note: due to loss of audio, part of the tour
 20 is missing from this section. The missing part was
 21 re-recorded the following day)
 22 MR MIANA: For the sediment (indistinct), they use this
 23 crane, put that down, this one, take the sample over
 24 there, and they get analysis from the (inaudible).
 25 MR ALAUDDIN: This is also used for checking the speed,

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1 velocity, because it is a requirement. Suppose velocity
 2 is higher than 0.1 (indistinct), so sediments will not
 3 be settling and they will be going inside. So due to
 4 this, we check the velocity in the desander, as well as
 5 water samples also taken too.
 6 THE CHAIRMAN: It looks like you could catch a whale with
 7 this!
 8 MR ALAUDDIN: Yes! (Pause)
 9 MR MIANA: With the difference of colours, we can recognise
 10 the brownish and the whitish: Murree formation, and the
 11 other is the Panjal formation.
 12 THE CHAIRMAN: Yes, I can see that.
 13 MR MIANA: I also like the green, that one.
 14 THE CHAIRMAN: The greenstone, yes.
 15 MR MIANA: The greenstone over there. Mr Fiaz was
 16 explaining about that one and showing some stone over
 17 there.
 18 THE CHAIRMAN: Exactly. (Pause)
 19 MR ALAUDDIN: So at the end we have sets of gates. We have
 20 four gates for the outlet gates, through which water
 21 goes into the collecting canal and then into the
 22 headrace tunnel. At the bottom there are four gates of
 23 2.5-metre height and 4-metre width, at the bottom. So
 24 there are eight gates. The lower gates are for flushing
 25 the sediments, and the upper gates for supplying water

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1 to the tunnel.
 2 THE CHAIRMAN: I see. And those upper gates have a screen
 3 on them?
 4 MR ALAUDDIN: No screen.
 5 MR MIANA: Screen is in the underwater.
 6 THE CHAIRMAN: By the time the water gets here, it's --
 7 MR ALAUDDIN: It's already clean.
 8 THE CHAIRMAN: Yes. (Pause)
 9 MR MIANA: So first we'll look at that one, then we'll come
 10 back over here. (Pause)
 11 So this is 75-metre-square area.
 12 MR ALAUDDIN: Square metres, 75 square metres.
 13 THE CHAIRMAN: Does that tunnel still ...
 14 MR MIANA: Yes, it (inaudible) has been blocked.
 15 THE CHAIRMAN: It's been blocked?
 16 MR MIANA: [...] blocked from the upstream side.
 17 MR MALIK: (Indistinct) gate on the upstream side, [...] and
 18 then the [...] floodgates in the middle.
 19 THE CHAIRMAN: Okay.
 20 MR MINEAR: May I ask: how many people work here? How many
 21 people work here at the dam site?
 22 MR MIANA: At the maximum level, it was about 7,000.
 23 MR MALIK: 2,000 people were working for the dam
 24 construction.
 25 MR MINEAR: Okay. And how many does it take to operate it?

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1 MR MALIK: How many work here at the dam site? 15 people?
 2 20 people?
 3 MR MIANA: No, no, no, it's more than 60 people. We have
 4 two different kinds of sections at dam site. The civil
 5 monitoring is different and the operation and
 6 maintenance section is different. So regulation is done
 7 by the operation and maintenance section, and the other
 8 formation is the dam monitoring. So they are all
 9 working together. So altogether, I think around --
 10 over 65.
 11 PROFESSOR BUYTAERT: The structure down here, is that to
 12 flush the desander?
 13 MR MIANA: Yes.
 14 PROFESSOR BUYTAERT: Okay.
 15 MR MIANA: That's the outlet for the desander.
 16 PROFESSOR BUYTAERT: That's what I thought. Thank you.
 17 MR MIANA: Yes. (inaudible). Flushing out. (Pause)
 18 Actually it's not like this, it is not reflecting.
 19 Basically it is like this. It's not like this. It's
 20 looking like (inaudible) but it's not like [...] high-velocity [...].
 21 If you want to have the photo here, I think this is
 22 better.
 23 THE CHAIRMAN: I don't know. I think maybe we've had enough
 24 photos? Yes, we're okay.
 25

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1 (Photo taken)
 2 (Pause)
 3 THE CHAIRMAN: The water that's coming out of the side ...
 4 MR MIANA: The undersluice.
 5 MR MINEAR: Earlier today we saw a sluice (indistinct),
 6 right?
 7 MR MIANA: In the morning.
 8 MR MINEAR: Yes.
 9 MR MIANA: No, we are (indistinct) now. It depends upon the
 10 inflow. We are maintaining the level. So when the
 11 inflow reduces, we have to adjust the regulation.
 12 THE CHAIRMAN: The inflow for the desander?
 13 MR MIANA: No, no, no. The inflow coming to the dam site.
 14 So when we have to maintain the level, so we regulate
 15 the gates' pressure.
 16 THE CHAIRMAN: Oh, we're not talking about those gates,
 17 we're asking about the water coming out of the ...
 18 MR MIANA: I am also responding the same.
 19 THE CHAIRMAN: Oh.
 20 MR MIANA: So in the morning I (inaudible) 15 cumecs coming
 21 from that side, but at that time our inflows were
 22 higher. But now the inflows to the dam are lesser, so
 23 we are in charge of (inaudible).
 24 MR MINEAR: That's a way to fine-tune the level?
 25 MR MIANA: To fine-tune the level, yes. From this we cannot

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1 fine-tune, but from that we can fine-tune.
 2 PROFESSOR BUYTAERT: Where is the intake of that side gate?
 3 MR MIANA: Intake?
 4 PROFESSOR BUYTAERT: The little side gate, where does it
 5 come from?
 6 MR MIANA: It comes from the intake. We have the three
 7 undersluices --
 8 PROFESSOR BUYTAERT: Ah, okay.
 9 MR MIANA: -- just under the intakes of the water.
 10 PROFESSOR BUYTAERT: The sluice is underneath the water
 11 intake?
 12 MR MIANA: They are underneath [...]
 13 PROFESSOR BUYTAERT: Okay, yes.
 14 MR ALAUDDIN: The setting is that there are six intake gates
 15 of size 4.5 by 4.56. So underneath each, for each gate,
 16 there is a single undersluice gate of size 1 metre high
 17 and 4.5 metres wide. So this is connected with the
 18 undersluice.
 19 PROFESSOR BUYTAERT: Okay. So it's the outlet of those
 20 sluices.
 21 MR ALAUDDIN: Yes. Below there is the invert of this.
 22 MR MIANA: There are three intakes, but coming out is
 23 common.
 24 PROFESSOR BUYTAERT: Thank you.
 25 MR ALAUDDIN: You're welcome.

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1 MR MIANA: Okay, let's move this way. (Pause)
 2 So from here, we pass the collecting canal. This
 3 one. We can see the level as 11.6, like this one, 11.5
 4 over here.
 5 So it goes over there, in front of desanders. We'll
 6 just have a look around all this. (Pause)
 7 Desander number 2.
 8 MR ALAUDDIN: And these are the hydraulic hoists for four
 9 outlet gates.
 10 MR MIANA: So from here, the tunnel HRT starts.
 11 DR BLACKMORE: Okay.
 12 MR MIANA: Not from here, just maybe -- how many metres from
 13 here? Maybe 100 metres, right?
 14 MR ALAUDDIN: Yes, it is a transition phase, 100 metres, up
 15 to that point.
 16 MR MIANA: Up to that point.
 17 THE CHAIRMAN: So when the water is actually taken out of
 18 the desander, is that happening under this or is it over
 19 there? When you take the water to the tunnel --
 20 MR ALAUDDIN: From here.
 21 MR MIANA: From here?
 22 THE CHAIRMAN: -- from down there.
 23 MR ALAUDDIN: From here only, not from there.
 24 MR MIANA: It is directly connected with the desanders. All
 25 three desanders are there, connected.

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1 THE CHAIRMAN: Right.
 2 MR MALIK: Water comes from the intake into the desanders.
 3 It drops the sand, the sediments there. And then the
 4 cleaner water from the higher elevation comes into the
 5 collecting canal and then it goes into that.
 6 And it has got two purposes. One, you see the water
 7 is almost stationary there, when it's there, so it drops
 8 all the silt. And when it comes here, again there's no
 9 turbulence here. So you don't have air vortexes
 10 producing going into the tunnel.
 11 THE CHAIRMAN: So when you close off, let's say, two of
 12 these, and only use one, that one is flowing into this
 13 area here --
 14 MR MIANA: Yes.
 15 THE CHAIRMAN: -- and then into the tunnel?
 16 MR MIANA: Yes.
 17 THE CHAIRMAN: Okay. (Pause)
 18 MR MIANA: We will go around this one.
 19 THE CHAIRMAN: So the tunnel is somewhere over there?
 20 MR MIANA: Yes, it's one like this one. You can't touch!
 21 THE CHAIRMAN: Too bad! Maybe if we dig down a little bit!
 22 MR MINEAR: Can you remind me the diameter of the tunnel,
 23 how large?
 24 MR MIANA: Is it 10.5 metres?
 25 MR ALAUDDIN: 10.5 metres.

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1 THE CHAIRMAN: Good. Questions, anyone?
 2 PROFESSOR BUYTAERT: The tunnel has quite a low gradient,
 3 doesn't it? Would you know how much energy is lost by
 4 friction over the 35 kilometres?
 5 MR MIANA: If we are operating at 969, the head loss is
 6 about 34 metres.
 7 PROFESSOR BUYTAERT: Okay. Out of 400, wasn't it?
 8 MR MIANA: Yes, 420 metres.
 9 PROFESSOR BUYTAERT: So it's less than 10%.
 10 MR MIANA: Yes, less than 10%.
 11 PROFESSOR BUYTAERT: Okay.
 12 MR ALAUDDIN: The original design was mostly
 13 shotcrete-lined, but later on, when we calculated the
 14 losses, the losses were very high. So it was decided
 15 that the drill and blast portion should be
 16 concrete-lined, to have a smooth surface and less
 17 friction.
 18 So that is why -- there was a lot of improvement
 19 after the award of the contract. These were some of the
 20 design changes made later on.
 21 MR MIANA: During the execution of the project.
 22 MR ALAUDDIN: During the execution of the project, exactly.
 23 MR MINEAR: When you switched to the two tunnels, did you
 24 lose more pressure as a result of that, through more
 25 friction because you were sending it through

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1 two tunnels?
 2 MR ALAUDDIN: Twin tunnels, sorry?
 3 MR MINEAR: No, you have a -- this was a split in the
 4 two tunnels.
 5 MR ALAUDDIN: Yes.
 6 MR MINEAR: Does that result in greater friction and greater
 7 pressure loss?
 8 MR ALAUDDIN: Not exactly. Not exactly, yes. Because,
 9 you see, it has been designed in such a way that those
 10 factors have been considered, division or bifurcation.
 11 PROFESSOR BUYTAERT: Was the bifurcation part of the
 12 original design, or was that a solution?
 13 MR ALAUDDIN: Not as -- there was some bifurcation, but not
 14 as we have now.
 15 PROFESSOR BUYTAERT: Okay.
 16 MR ALAUDDIN: We have 19 kilometres of twin tunnel.
 17 Actually this has been designed because when we go --
 18 when we move along the tunnel, the overburden is also
 19 increasing. So due to the high overburden, it was
 20 realised that there was tremendous pressure. So by
 21 making twin tunnels, its cross-section is reduced, and
 22 it's found to be more stable under the high water
 23 pressure.
 24 PROFESSOR BUYTAERT: Yes, with a negligible impact on the
 25 head loss, as I understand it.

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1 MR ALAUDDIN: Yes.
 2 PROFESSOR BUYTAERT: Yes.
 3 DR BLACKMORE: How often do you inspect the tunnel?
 4 MR ALAUDDIN: That's a very good question!
 5 DR BLACKMORE: And my colleague here wants to volunteer!
 6 MR ALAUDDIN: That's a very good question!
 7 Actually so far, since 2018 till now, we haven't
 8 dewatered the tunnel. There are several reasons for it.
 9 You see, this pressure at the end is 420-metre, high
 10 pressure. So if we dewater, there is a concern that --
 11 you see, the concrete lining, it's not impervious; this
 12 is pervious. So it's recharging the sandstone, the
 13 stones there. So the level in the surrounding model is
 14 saturated, but level of the water has risen. So if we
 15 dewater the tunnel, so you see there will be a lot of
 16 pressure on the concrete lining and it may damage.
 17 So this is the reason that we haven't physically
 18 inspected. For physical inspection, dewatering is
 19 required, which we have so far not done.
 20 DR BLACKMORE: Yes.
 21 MR ALAUDDIN: But near future, we are planning to do that.
 22 DR BLACKMORE: So what I used to do, when we had to dewater
 23 tunnels not as long as this, I'd find the youngest
 24 engineer in the team and send them down!
 25 THE CHAIRMAN: Do you ever expect sediment in the tunnel to

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1 increase at an important level, or are you confident
 2 over the life of the dam that the water is so clean
 3 there won't be any sediment build-up?
 4 MR ALAUDDIN: In the tunnel, the velocity is, say, around
 5 3 metres per second, or more than that. So under that
 6 velocity, we don't think that any sediment will settle.
 7 THE CHAIRMAN: Good. Thank you.
 8 MR ALAUDDIN: Thank you.
 9 (The walkaround ended)
 10 (2.29 pm)
 11 (Pause)
 12 (3.30 pm)
 13 Closing remarks
 14 THE CHAIRMAN: So, first of all, the court is very grateful
 15 for the presentations that we received today. They were
 16 extremely helpful, very informative, much appreciated.
 17 Arguably this day was the highlight of the visit in
 18 terms of seeing the dam and walking around it, and we
 19 really did appreciate the opportunity to do that.
 20 We've thought about whether we had any particular
 21 questions for you right now and decided that we don't,
 22 knowing that tomorrow we'll be having fairly in-depth
 23 presentations.
 24 At the same time, we do have an interest in sediment
 25 management issues and environmental management issues.

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1 We're assuming that that's probably going to be covered
 2 tomorrow anyway, but we just thought we would pass to
 3 you our particular interest in that area.
 4 So no particular questions for you for overnight,
 5 but we're certainly looking forward to hearing about it
 6 tomorrow.
 7 SIR DANIEL BETHLEHEM: Thank you, Mr Chairman. And for the
 8 record, and relying on paragraph 3.4 of your site visit
 9 protocol, and the latitude given to lead counsel through
 10 the chairman just to raise an issue. It's simply to
 11 note that as the court was walking around on the site
 12 visit, many of the presenters to come -- and indeed
 13 those who had already presented but will still be in the
 14 room -- did not have the benefit of hearing the question
 15 and answer session, and it may very well be that there
 16 will be a number of questions that will be asked
 17 tomorrow which were, in fact, follow-on questions from
 18 questions that were asked today.
 19 So in true parliamentary fashion, as I'm supposed to
 20 ask a question, my question is: could the members of the
 21 court, if they are asking questions to the presenters
 22 tomorrow that are follow-on questions, please just
 23 identify that they are follow-on questions and what the
 24 question was and what the answer is, so that the
 25 presenters tomorrow are not kind of stumbling into

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1 tomorrow's schedule, I think the plan might be, at least
 2 for those of us in the court, leaving at 8.30 in the
 3 morning, just as we did today, coming back up to the dam
 4 site, having the two presentations with a lunch break in
 5 the middle that we can be a little more generous about,
 6 given that we have a little more flexibility in the
 7 schedule. So we look forward to that.
 8 Very good. And we'll see you tomorrow. Excellent.
 9 (3.34 pm)
 10 (The day concluded)
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1 something that has already been addressed which they
 2 haven't heard.
 3 THE CHAIRMAN: So the idea is if a question tomorrow builds
 4 upon something that came out today in the course of the
 5 walkaround, it's helpful to recall what was asked and
 6 answered today as the foundation for that follow-on
 7 question?
 8 SIR DANIEL BETHLEHEM: Yes, indeed. Also because the
 9 presenters tomorrow and the day after have very
 10 particular expertise, so they may be able to fill out
 11 issues that have already been addressed. But at the
 12 moment they don't know what has been addressed.
 13 But, as I say, this is simply relying on
 14 paragraph 3.4 to identify an issue as a question.
 15 THE CHAIRMAN: I don't see any difficulty in that. We will
 16 do our best to provide that foundation to you. So
 17 I don't see a difficulty.
 18 But let me again reiterate how much I appreciate
 19 Dr Hayat, Mr Farooq, Mr Sendhu's presentation from this
 20 morning, Mr Miana, Mr Alauddin for the walkaround. It
 21 was really quite helpful to us. We're very grateful for
 22 all the efforts you're putting into this site visit and
 23 we're learning a lot, so it's very, very helpful. Thank
 24 you.
 25 Given that, I think we're finished for today, and

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