

PRIORITIZATION CRITERIA FOR DEBRIS FLOW ENGINEERING WORKS TO PROTECT PIPELINES IN THE BRAZILIAN SERRA DO MAR REGION, SÃO PAULO

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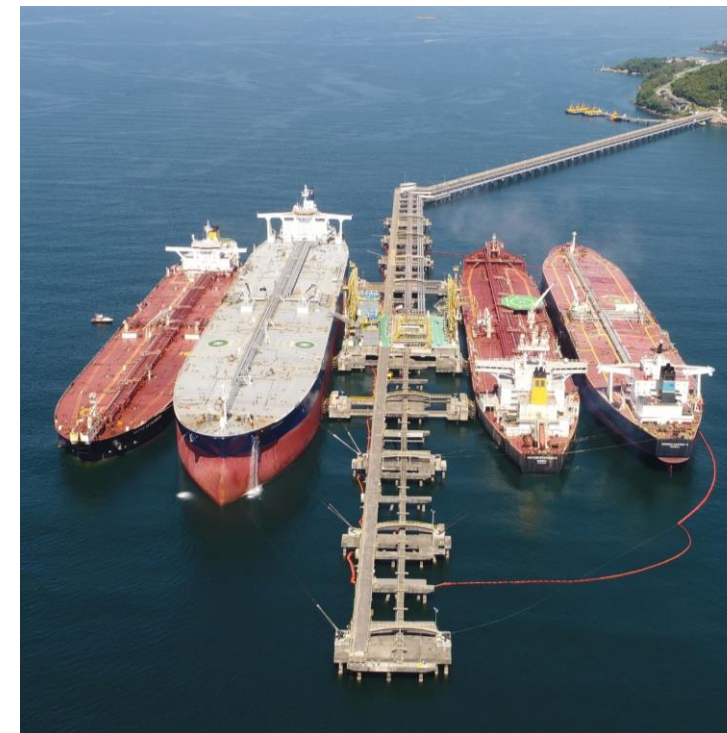
Presented by Hudson Régis Oliveira, M.Sc.

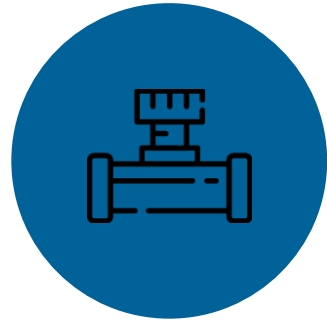
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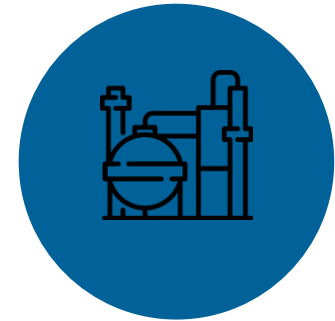
Transpetro

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8,500 km of pipelines
10 million m³ of oil capacity



21 On Shore Terminals
28 Marine Terminals
540 Tanks



36 Ships



5326 Employees



IPG 2023

INTERNATIONAL PIPELINE GEOTECHNICAL CONFERENCE

23 y 24 de Noviembre. Bogotá D.C. - Colombia

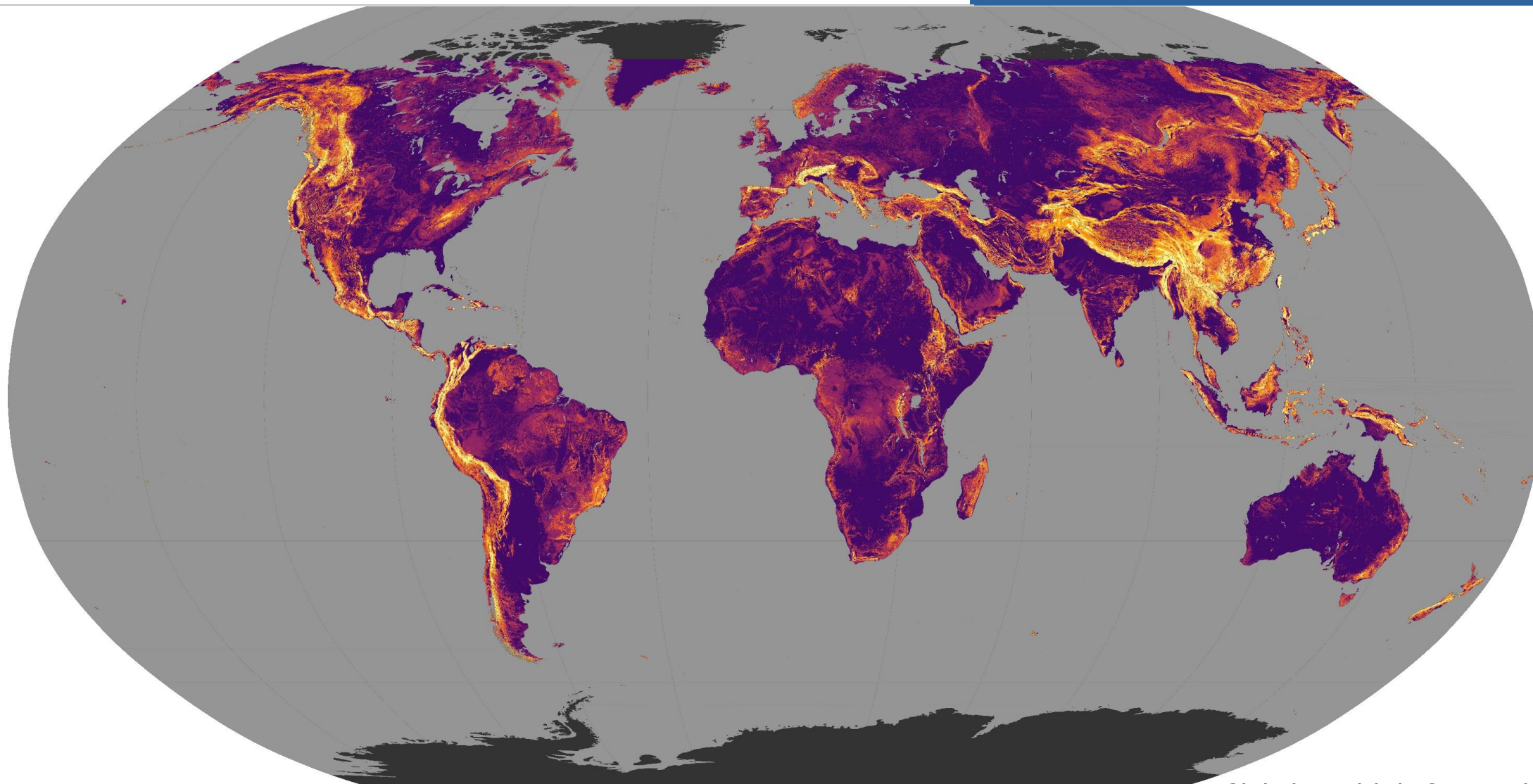
Con el apoyo de:



Organiza:

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+



6ª CONFERENCIA INTERNACIONAL GEOTECNIA DE DUCTOS

Slight

Landslide Potential

Moderate

Severe

Global Landslide Susceptibility Map,
2000-2013

Nasa, Earth Observatory (2017)

Serra do Mar (Sea Ridge):

- Extension of 1,500 km;
- Rainfall volumes between 2,000 mm to 2,500 mm annually;
- Slopes with declivity between 35° to 40° ;
- Common mass movements:
Debris flows, slumps, creeps;
- Usually shallow landslides, with 1,5 m to 2,0 m depth.



OSBAT Basin Studies – Water Crossings Priorization for Preventive Protection

Hydrological basins
discretization

Susceptibility ranking
through a qualitative
method

8 basins were select for
further studies



OSBAT Basin Studies – Water Crossings Priorization for Preventive Protection

$$FS = \sum PS_i \cdot w_i$$

Catchment	score	Rank
1	1.90	5
2	1;60	6
3	1.00	8
4	1.41	7
5	2.24	4
6	3.86	3
7	4.31	1
8	4.19	2

PARAMETER	CLASS	WEIGHT	PARAMATER VALUE	PARTIAL SCORE
RAINFALL (mm/h)	R1	3,0	>80	10
	R2		60 - 80	6,6
	R3		30 - 60	3,3
	R4		<30	0
SLOPE ANGLE (DEGREES)	S1	2,5	>45	10
	S2		45 - 30	6,6
	S3		15 - 30	3,3
	S4		<15	0
STREAM DECLIVITY (DEGREES)	D1	0,5	>25	10
	D2		15 - 25	6,6
	D3		10 - 15	3,3
	D4		<10	0
WATERSHED AREA (km²)	A1	1,0	<5	10
	A2		5 - 10	6,6
	A3		10 - 20	3,3
	A4		>20	0
WATERSHED HEIGHT (m)	H1	1,0	>750	10
	H2		500 - 750	6,6
	H3		200 - 500	3,3
	H4		<200	0
LAND USAGE AND OCCUPATION (%)	V1	0,5	90 - 100	10
	V2		50 - 90	6,6
	V3		30 - 50	3,3
	V4		<30	0
GEOMORPHOLOGY	G1	1,5	G1	10
	G2		G2	6,6
	G3		G3	3,3
	G4		G4	0

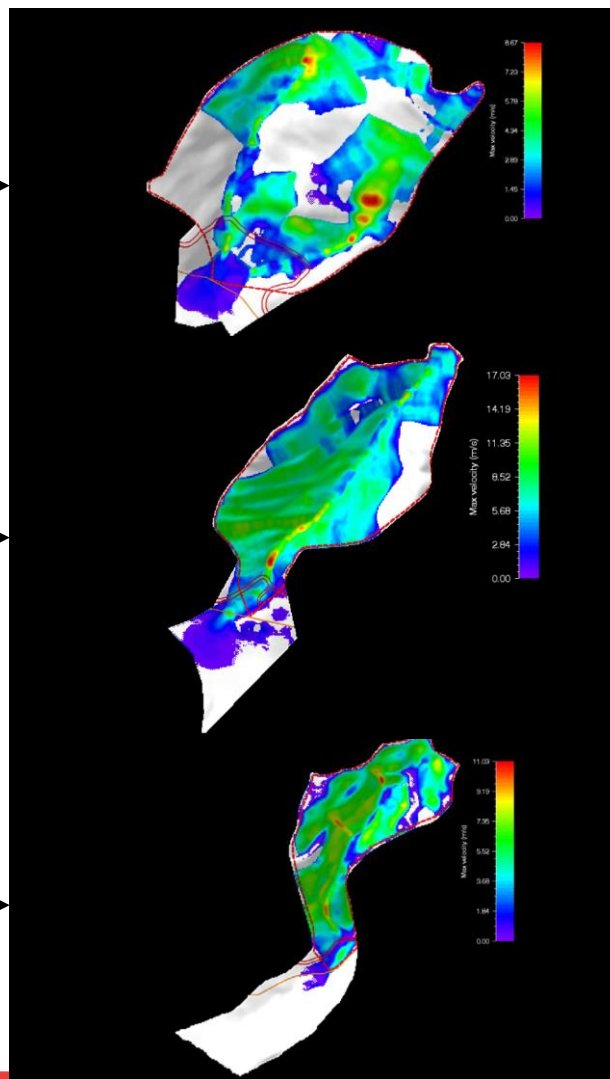
Refinement of the Studies in Catchments 6, 7 and 8

Catchments

6 (km 12+280)

7 (km 11+050)

8 (km 9+600)



RAMMS

Discharge Hydrograph Method Rainfall
return periods: 25, 50, 100 and 200
Years

Erosion process speed: 0.025 m/s

Friction parameters: $\mu = 0.2$, $\xi = 120$
m/s².

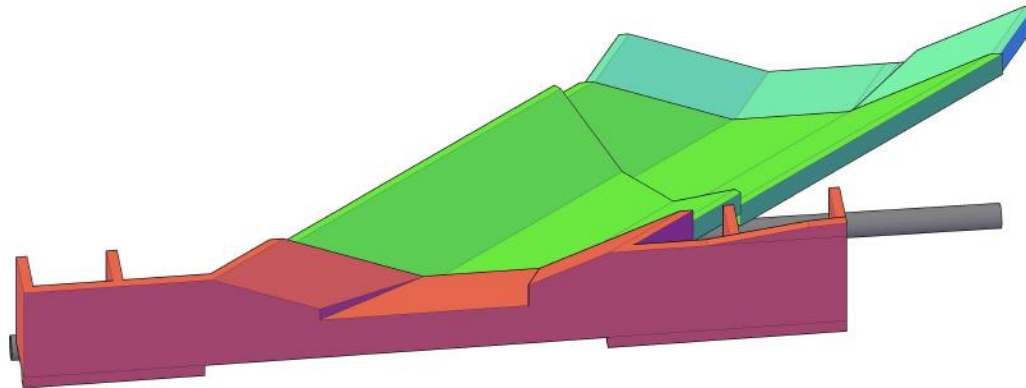
For the simulation of debris flow, the
Area Release Method was also used.
landslides with 4 thicknesses (0.10,
0.50, 1.00, and 1.50 m)

Refinement of the Studies in Catchments 6, 7 and 8

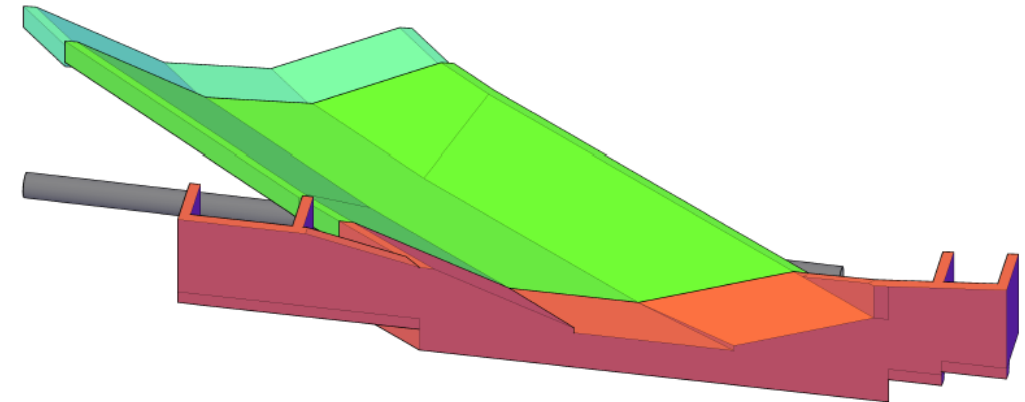
Debris volume exceeds the available
reservoir area in catchments 6 and 7

Engineering solution: concrete channel
with na underlying buried beam wall

Catchment 6



Catchment 7





Refinement of the studies in catchments 6, 7 and 8

Debris volume exceeds the available
reservoir área in catchments 6 and 7

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Catchment 6



Catchment 7



Rainfall event of February, 2023



São Paulo rights of way

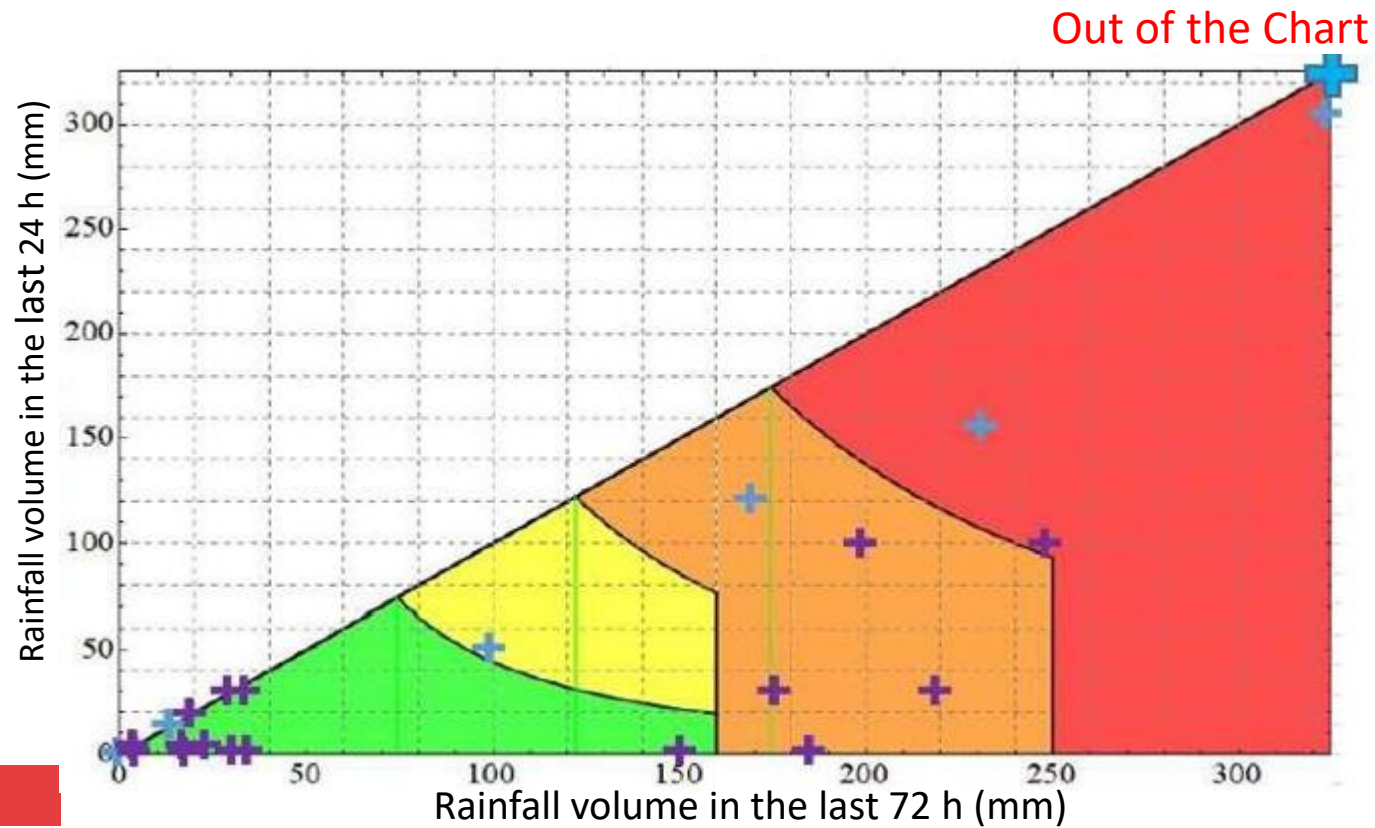


RISK MANAGEMENT



Rainfall event of February, 2023

- Highest rainfall volume ever registered in the shortest time in Brazil: 684 mm in 11 h





Rainfall Event of February, 2023

Schedule

Critical points were identified during aerial surveys and categorized into High Risk (8 points, with 5 points classified as operationally prohibitive for OSBAT) and Moderate Risk (12 points) for the start of intervention. The construction work was divided into phases:

Phase 1

Immediate action works at high-risk points (5 points with high impediments) in the affected areas to restore OSBAT's operational capability, which remained suspended from February 19, 2023, to March 11, 2023.

Low I	22
Low II	12
Moderate III	7
Moderate IV	3
High V	8
High VI	0
TOTAL	52





OSBAT km 11+050



OSBAT km 12+280





OSBAT km 11+050





Conclusions

- The preventive works avoided a pipeline failure at one of the crossings;
- The prioritization criteria developed by IPT had good correlation with the Feb/23 event;
- TRANSPETRO is now continuing the preventive work in other basins and will apply the same study in other pipelines.