PONTIFICIA UNIVERSIDAD CATÓLICA DEL PERÚ

FACULTAD DE CIENCIAS E INGENIERÍA

ANEXOS

ANÁLISIS Y MODELAMIENTO DE FLUJOS DE ESCOMBROS EN LA ZONA DE MARANURA LA CONVENCIÓN – CUSCO, PERÚ

Tesis para optar el Título de **INGENIERO CIVIL,** que presenta el bachiller:

Frank Eduardo Escusa Arosquipa

ASESOR: M.Sc. Richard Paul Pehovaz Alvarez

Lima, Julio del 2016

Índice

A.1 Procesamiento Meteorológico

Las ecuaciones y metodologías empleadas para el procesamiento de la información pueden encontrarse en cualquier manual de hidrología y/o estadística. Los empleados en el presente trabajo son los siguientes:

- Chow, V. T., Maidment, D., & Mays, L. (1988). Applied Hydrology. Singapur, Singapur: McGraw-Hill.
- Feldman, A. (2000). Hydrologic Modeling System HEC-HMS Technical Reference Manual. Washington, Estados Unidos: US Army Corps of Engineers.
- Maidment, D. (1993). Handbook of Hydrology (1st ed.). Nueva York, Estados Unidos: McGraw-Hill.
- McCuen, R. (1998). Hydrologic Analysis and Desing (2nd ed.). Nueva Jersey, Estados Unidos: Prentice Hall, Inc.
- Natrella, M., Croarkin, C., & Guthrie, W. (2010). e-Handbook of Statistical Methods. Nueva York, Estados Unidos: NIST/SEMATECH.
- Natural Resources Conservation Service. (1997). National Engineering Handbook - Part 630 Hydrology. Washington, Estados Unidos: US Department of Agriculture.

En el presente proyecto, fueron utilizadas dos estaciones meteorológica, la estación Quillabamba (Lat: 12° 51’ S; Lon: 72° 41’ O) y la estación Maranura (Lat: 12° 57’ S; Lon: 72° 40’ O). La primera fue empleada como base de la pluviometría, y la segunda para validar el uso de dicha estación en la zona de estudio. El detalle de cada estación se encuentra en los capítulos A.1.1 y A.1.2.

A.1.1 Estación Quillabamba

Información proporcionada gracias el Servicio Nacional de Meteorología e Hidrología del Perú (SENAMHI).

ESTACION: QUILLABAMBA(000606) DRE-12	LONG.	: 72° 41'	W		DPTO.	: CUSCO
	LAT.	: 12° 51'	S		PROV.	: LA CONVENCION
PARAMETRO: PRECIPITACIÓN MAX EN 24 HRS. (mm)	ALT.	: 990	msnm		DIST.	: STA. ANA

AÑO	ENE	FEB	MAR	ABR	MAY	JUN	JUL	AGO	SEP	OCT	NOV	DIC	MÁXIMO
1965	19.0	31.0	41.0	36.0	2.0	1.0	21.0	21.8	10.4	37.0	24.2	15.7	41.0
1966	18.0	35.5	14.5	12.5	26.2	5.5	7.2	8.0	21.0	22.8	38.0	17.7	38.0
1967	17.0	30.0	25.0	12.2	7.2	8.0	18.0	8.9	15.0	18.2	17.5	25.3	30.0
1968	38.7	19.6	35.0	31.2	4.7	1.6	17.0	12.9	9.9	13.5	17.7	36.7	38.7
1969	19.9	20.8	26.5	22.3	11.0	30.0	6.5	5.9	7.5	12.5	35.0	22.2	35.0
1970	34.8	11.6	40.2	29.5	26.8	9.4	7.2	5.2	15.0	22.0	12.8	29.5	40.2
1971	15.0	42.5	22.0	24.3	15.5	29.7	1.5	3.7	15.0	8.8	17.7	17.2	42.5
1972	32.0	16.4	35.4	16.6	13.7	3.0	5.4	25.2	8.8	7.0	25.5	42.7	42.7
1973	28.6	33.4	19.5	26.2	12.9	8.0	20.0	24.8	14.3	34.0	35.7	30.8	35.7
1974	30.6	28.2	25.9	26.6	4.0	5.5	20.8	24.5	17.7	13.0	18.0	22.0	30.6
1975	42.2	32.5	39.8	33.0	14.5	7.5	9.0	16.5	14.2	16.5	42.4	32.6	42.4
1976	35.0	33.5	26.5	21.5	10.9	4.0	2.9	27.3	33.0	15.2	11.5	29.8	35.0
1977	31.0	40.2	21.9	9.3	35.6	1.4	18.0	1.2	21.1	8.5	19.8	28.3	40.2
1978	35.8	21.0	21.2	15.8	60.2	7.5	S/D	S/D	S/D	36.4	14.5	44.8	60.2
1979	30.6	20.7	18.8	16.2	11.4	S/D	10.5	1.3	2.8	11.2	31.2	33.4	33.4
1980	19.8	32.1	27.2	38.1	17.0	7.0	23.5	12.3	16.0	16.3	20.0	23.3	38.1
1981	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	0.0
1982	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	0.0
1983	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	0.0
1984	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	0.0
1985	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	0.0
1986	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	0.0
1987	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	0.0
1988	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	0.0
1989	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	0.0
1990	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	0.0
1991	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	0.0
1992	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	0.0
1993	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	0.0
1994	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	0.0
1995	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	S/D	0.0
1996	S/D	21.0	18.0	15.4	21.0	2.5	6.1	16.7	17.8	17.5	17.0	20.5	21.0
1997	30.7	40.2	20.2	17.2	11.0	16.8	3.0	29.5	20.0	32.4	32.0	20.9	40.2
1998	39.4	24.5	38.4	19.2	4.2	4.8	S/D	1.0	63.8	24.8	12.0	34.3	63.8

1999	27.5	59.0	46.4	49.5	26.5	6.4	6.6	S/D	13.7	26.5	20.5	25.9	59.0
2000	57.9	44.7	20.0	15.5	7.6	15.8	0.6	14.2	17.0	25.3	13.1	20.0	57.9
2001	44.7	44.3	30.3	14.0	10.6	2.2	15.0	9.5	11.2	S/D	33.2	16.5	44.7
2002	21.8	54.5	47.1	10.3	9.2	5.5	12.9	23.1	8.0	25.3	25.2	57.1	57.1
2003	46.2	36.0	30.0	24.6	5.6	3.4	5.0	27.5	22.3	20.4	22.3	27.0	46.2
2004	21.2	31.0	21.8	S/D	18.4	6.6	38.1	14.5	14.0	19.2	28.9	20.0	38.1
2005	29.4	28.3	28.2	26.2	24.6	6.9	20.3	5.2	15.7	18.5	8.1	40.6	40.6
2006	49.0	23.4	43.6	39.2	4.2	8.2	4.5	14.8	5.9	18.8	25.9	26.9	49.0
2007	52.6	18.9	20.3	31.5	17.3	10.2	7.1	S/D	5.5	38.0	32.3	19.7	52.6
2008	53.1	22.8	15.6	34.0	7.9	0.6	10.8	19.2	18.5	24.2	16.2	27.8	53.1
2009	26.2	38.2	28.0	9.8	6.5	2.3	7.8	4.0	5.0	33.2	54.0	25.2	54.0
2010	18.4	83.8	36.8	26.8	7.6	9.4	9.0	13.4	22.2	54.6	25.4	26.6	83.8
2011	24.2	34.6	30.4	28.0	15.2	12.0	12.4	26.8	7.8	49.0	34.0	31.0	49.0
2012	30.4	38.2	21.4	26.8	10.4	18.6	10.2	16.2	S/D	12.4	12.4	38.8	38.8
2013	20.6	34.6	30.2	38.0	7.6	10.0	4.4	34.0	26.4	31.4	31.2	34.2	38.0
2014	39.4	46.0	42.0	14.8	22.4	S/D	17.6	4.6	16.0	19.0	29.0	30.6	46.0
MÁXIMO	57.9	83.8	47.1	49.5	60.2	30.0	38.1	34.0	63.8	54.6	54.0	57.1	83.8

ESTACION: QUILLABAMBA(000606) DRE-12	LONG.	: 72° 41'	W		DPTO.	: CUSCO
	LAT.	: 12° 51'	S		PROV.	: LA CONVENCION
PARAMETRO: TEMPERATURA MEDIA MENSUAL	ALT.	: 990	msnm		DIST.	: STA. ANA

AÑO	**ENE**	**FEB**	**MAR**	**ABR**	**MAY**	**JUN**	**JUL**	**AGO**	**SEP**	**OCT**	**NOV**	**DIC**
1971	22.9	22.6	23.7	23.3	23.2	22.5	23.0	24.4	25.2	24.7	25.8	24.1
1972	23.2	23.3	23.5	23.7	23.8	23.7	24.0	23.5	24.3	25.7	24.5	24.5
1973	24.0	24.2	24.1	24.0	23.8	23.3	22.4	23.5	24.1	24.7	24.3	23.3
1974	22.4	22.4	23.6	23.3	23.6	23.4	22.6	22.2	24.2	24.7	25.4	24.5
1975	24.0	23.1	23.4	23.8	23.3	22.7	22.4	23.6	23.7	24.7	24.6	23.7
1976	22.8	23.3	23.7	23.8	22.5	23.3	22.8	22.8	22.5	25.6	25.5	24.4
1977	23.6	23.3	23.8	23.9	23.4	23.7	22.8	24.2	23.3	25.6	24.8	24.5

A.1.2 Estación Maranura

Información proporcionada gracias el Servicio Nacional de Meteorología e Hidrología del Perú (SENAMHI).

ESTACION: MARANURA(000676) DRE-12	LONG.	: 72° 40'	W		DPTO.	: CUSCO
	LAT.	: 12° 57'	S		PROV.	: LA CONVENCION
PARAMETRO: PRECIPITACIÓN MAX EN 24 HRS. (mm)	ALT.	: 1063	msnm		DIST.	: MARANURA

AÑO	ENE	FEB	MAR	ABR	MAY	JUN	JUL	AGO	SEP	OCT	NOV	DIC	MÁXIMO
1971	12.0	26.0	35.0	21.0	7.0	15.0	4.0	4.0	13.0	16.0	32.0	23.4	35.0
1972	45.0	18.0	32.2	13.2	8.0	4.0	12.6	8.4	9.0	12.0	29.6	33.0	45.0
1973	30.4	19.4	29.0	30.0	14.0	3.4	22.4	14.6	17.2	20.2	30.0	30.5	30.5
1974	25.8	22.5	23.8	22.8	6.8	6.6	8.9	29.0	3.7	10.0	14.6	23.4	29.0
1975	40.0	25.0	17.0	30.0	20.0	20.0	S/D	9.0	12.0	10.0	45.0	40.0	45.0
1976	31.0	40.0	45.0	13.0	18.0	S/D	S/D	10.0	28.0	S/D	15.0	19.0	45.0
1977	27.0	40.0	26.0	15.0	6.0	S/D	15.0	5.0	18.0	32.0	30.0	22.0	40.0
MÁXIMO	45.0	40.0	45.0	30.0	20.0	20.0	22.4	29.0	28.0	32.0	45.0	40.0	45.0

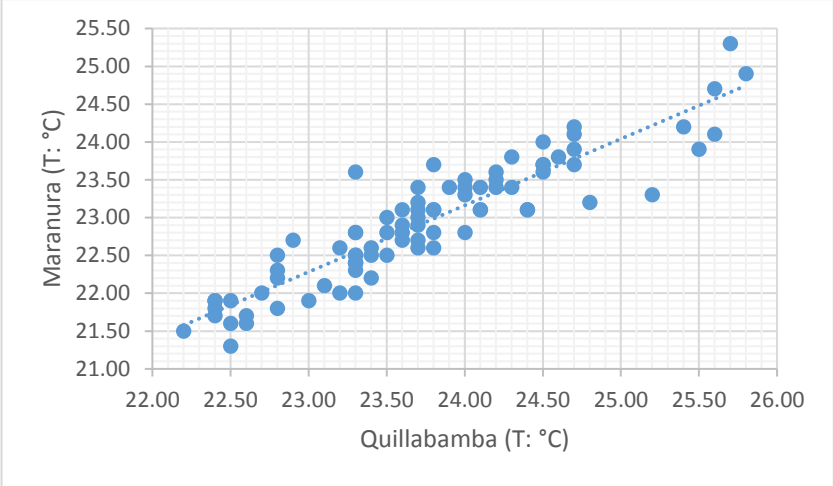
ESTACION: MARANURA(000676) DRE-12	LONG.	: 72° 40'	W		DPTO.	: CUSCO
	LAT.	: 12° 57'	S		PROV.	: LA CONVENCION
PARAMETRO: TEMPERATURA MEDIA MENSUAL	ALT.	: 1063	msnm		DIST.	: MARANURA

AÑO	ENE	FEB	MAR	ABR	MAY	JUN	JUL	AGO	SEP	OCT	NOV	DIC
1971	22.7	21.6	22.7	22.5	22.6	21.6	21.9	23.1	23.3	23.9	24.9	23.1
1972	22.0	22.8	22.5	23.1	23.7	23.2	23.5	22.8	23.8	25.3	23.7	24.0
1973	23.3	23.4	23.4	23.4	23.1	22.5	21.8	23.0	23.1	24.2	23.4	22.4
1974	21.7	21.9	22.7	22.4	22.8	22.5	21.7	21.5	23.5	23.7	24.2	23.7
1975	22.8	22.1	22.2	23.1	22.8	22.0	21.9	22.9	23.0	24.1	23.8	22.9
1976	21.8	22.0	22.6	22.8	21.9	22.4	22.3	22.2	21.3	24.7	23.9	23.1
1977	23.1	22.3	22.6	23.4	22.6	23.4	22.5	23.6	23.6	24.1	23.2	23.6

A.1.3 Correlación Meteorológica

Se realiza entre los registros de ambas estaciones mencionadas previamente en A.1.1 y A.1.2 para establecer el grado de correlación que guardan entre sí.

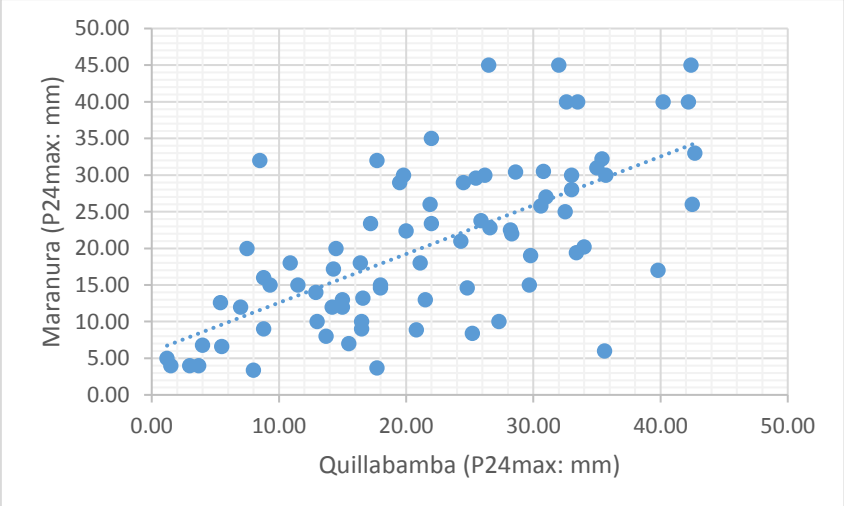
A.1.3.1 Temperatura



Parámetro	Valor
rxy (Pearson)	0.91646737
ρ (Spearman)	0.93180115
τ (Kendall)	0.76305221
γ (Goodman y Krustal)	0.81795818

La gráfica y los coeficientes de correlación calculados muestran un ajuste decente, por lo que se deduce que las condiciones de temperatura en ambas zonas son similares.

A.1.3.2 Precipitación Máxima en 24 horas



Parámetro	Valor
rxy (Pearson)	0.66400207
ρ (Spearman)	0.66886563
τ (Kendall)	0.48393379
γ (Goodman y Krustal)	0.49159248

La gráfica y los coeficientes de correlación calculados muestran relativa dispersión, sin embargo el rango de valores en los cuales ambas estaciones trabajan no son tan diferentes, y los coeficientes calculados no indican que existe correspondencia suficiente para considerar válidos los valores de lluvia en las inmediaciones de una estación como en la de otra.

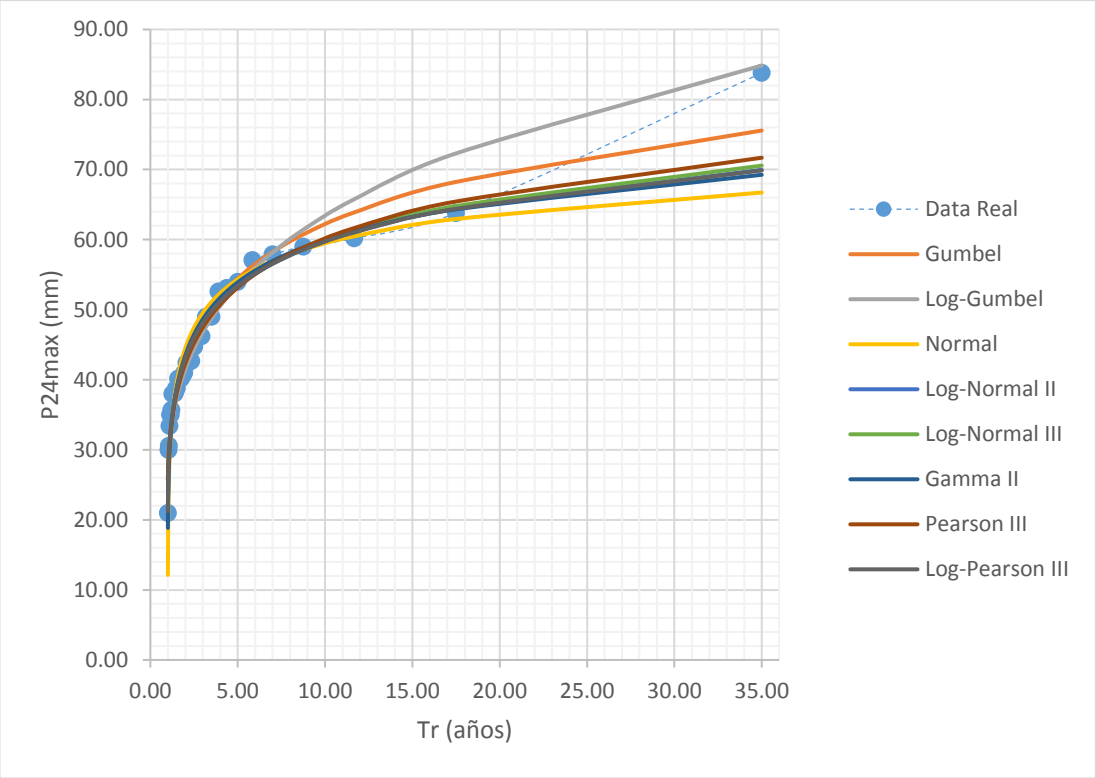
A.1.4 Distribuciones Probabilísticas

Se emplearon múltiples distribuciones probabilísticas para adecuar el ajuste de un registro pluviométrico como es el observado en la sección A.1.1 y obtener así precipitaciones máximas para diferentes periodos de retorno.

Tr	Data Real	Gumbel	Log-Gumbel	Normal	Log-Normal II	Log-Normal III	Gamma II	Pearson III	Log-Pearson III
35.00	83.80	75.57	84.85	66.72	69.97	70.56	69.25	71.69	69.87
17.50	63.80	68.24	72.31	62.95	64.44	64.79	64.31	65.44	64.39
11.67	60.20	63.88	65.76	60.47	61.06	61.28	61.20	61.64	61.03
8.75	59.00	60.73	61.41	58.56	58.56	58.70	58.87	58.86	58.55
7.00	57.90	58.25	58.18	56.96	56.56	56.64	56.96	56.64	56.56
5.83	57.10	56.19	55.62	55.57	54.87	54.91	55.34	54.77	54.87
5.00	54.00	54.42	53.51	54.32	53.40	53.40	53.90	53.16	53.40
4.38	53.10	52.86	51.72	53.17	52.08	52.05	52.61	51.73	52.09
3.89	52.60	51.45	50.16	52.10	50.88	50.83	51.42	50.44	50.89
3.50	49.00	50.16	48.77	51.09	49.77	49.71	50.32	49.26	49.79
3.18	49.00	48.98	47.53	50.13	48.74	48.66	49.28	48.16	48.76
2.92	46.20	47.87	46.40	49.21	47.77	47.68	48.29	47.14	47.79
2.69	46.00	46.83	45.35	48.31	46.84	46.74	47.35	46.17	46.87
2.50	44.70	45.84	44.39	47.44	45.96	45.85	46.44	45.25	45.98
2.33	42.70	44.89	43.48	46.58	45.11	45.00	45.56	44.38	45.13
2.19	42.50	43.98	42.63	45.73	44.29	44.17	44.71	43.54	44.31
2.06	42.40	43.10	41.82	44.89	43.48	43.36	43.87	42.73	43.50
1.94	41.00	42.25	41.05	44.06	42.70	42.57	43.04	41.94	42.72
1.84	40.60	41.41	40.31	43.22	41.92	41.80	42.22	41.18	41.94
1.75	40.20	40.59	39.59	42.37	41.15	41.03	41.41	40.43	41.18
1.67	40.20	39.78	38.90	41.51	40.39	40.27	40.60	39.69	40.41
1.59	40.20	38.97	38.22	40.64	39.63	39.51	39.78	38.96	39.65
1.52	38.80	38.17	37.56	39.74	38.86	38.75	38.95	38.24	38.88
1.46	38.70	37.36	36.90	38.82	38.09	37.98	38.11	37.52	38.10
1.40	38.10	36.54	36.25	37.85	37.30	37.20	37.25	36.80	37.31
1.35	38.10	35.70	35.59	36.85	36.49	36.40	36.36	36.07	36.50
1.30	38.00	34.84	34.93	35.78	35.65	35.57	35.43	35.33	35.66
1.25	38.00	33.94	34.25	34.63	34.77	34.71	34.45	34.56	34.77
1.21	35.70	32.99	33.55	33.38	33.83	33.79	33.41	33.77	33.84
1.17	35.00	31.97	32.81	31.99	32.82	32.80	32.27	32.94	32.82

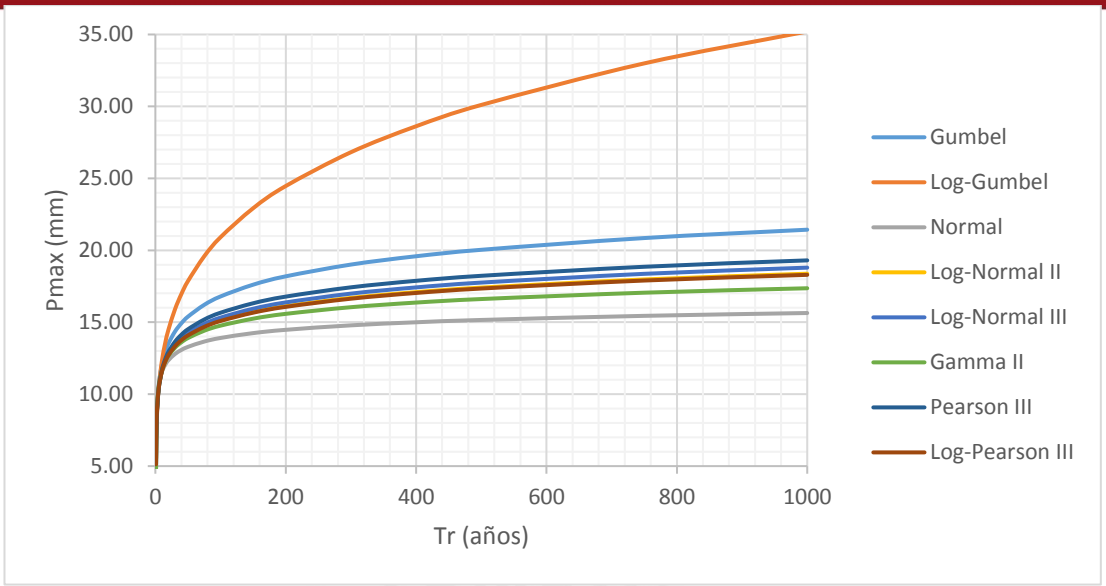
1.13	35.00	30.85	32.02	30.39	31.70	31.71	31.00	32.05	31.69
1.09	33.40	29.56	31.13	28.48	30.41	30.45	29.53	31.07	30.39
1.06	30.60	27.97	30.08	26.00	28.81	28.91	27.69	29.92	28.79
1.03	30.00	25.73	28.64	22.22	26.53	26.72	25.04	28.42	26.50
1.00	21.00	20.55	25.58	12.14	21.30	21.75	18.84	25.73	21.23

En un gráfico resumen, se obtiene lo siguiente:



Extrapolando los valores hasta $T_r = 100$, se obtienen los siguientes valores.

Tr	Gumbel	Log-Gumbel	Normal	Log-Normal II	Log-Normal III	Gamma II	Pearson III	Log-Pearson III
1.00	4.98	5.55	4.28	5.13	5.17	4.84	5.50	5.12
2.00	8.28	8.04	8.63	8.36	8.34	8.43	8.21	8.36
5.00	10.56	10.38	10.54	10.36	10.36	10.46	10.31	10.36
10.00	12.07	12.30	11.54	11.59	11.62	11.63	11.67	11.58
15.00	12.92	13.53	12.03	12.25	12.31	12.25	12.42	12.25
20.00	13.51	14.47	12.36	12.71	12.79	12.67	12.93	12.70
30.00	14.35	15.89	12.79	13.34	13.44	13.23	13.64	13.32
40.00	14.93	16.97	13.08	13.77	13.90	13.61	14.14	13.75
50.00	15.39	17.86	13.29	14.11	14.25	13.90	14.51	14.08
75.00	16.21	19.59	13.66	14.71	14.88	14.41	15.19	14.68
100.00	16.79	20.91	13.91	15.12	15.32	14.76	15.66	15.09
150.00	17.61	22.92	14.24	15.71	15.94	15.25	16.32	15.66
200.00	18.19	24.47	14.47	16.12	16.38	15.58	16.78	16.07
300.00	19.01	26.82	14.78	16.69	16.99	16.05	17.43	16.64
400.00	19.59	28.62	15.00	17.09	17.42	16.37	17.88	17.03
500.00	20.04	30.10	15.16	17.41	17.76	16.61	18.23	17.34
750.00	20.85	32.99	15.44	17.97	18.36	17.05	18.86	17.90
1000.00	21.43	35.21	15.64	18.37	18.80	17.36	19.30	18.29



A.1.5 Pruebas de Ajuste de Bondad

Para discriminar el uso de las distribuciones presentadas en A.1.4, se emplearon pruebas de ajuste de bondad como son Kolmogorov-Smirnov, Chi Cuadrado y Anderson-Darling.

A.1.5.1 Prueba de Kolmogorov-Smirnov

Se comparará un valor límite con un valor máximo admisible para diferentes valores de fiabilidad α.

Orden (n)	P24max (mm)	Tr	Dn Gumbel	Dn Log-Gumbel	Dn Normal	Dn Log-Normal II	Dn Log-Normal III	Dn Gamma II	Dn Pearson III	Dn Log-Pearson III
1.00	83.80	35.00	0.01555	0.00160	0.02818	0.02405	0.02316	0.02581	0.02164	0.02420
2.00	63.80	17.50	0.02918	0.04024	0.00790	0.00462	0.00702	0.00406	0.01104	0.00428
3.00	60.20	11.67	0.03423	0.03838	0.00368	0.00900	0.01110	0.01146	0.01386	0.00875
4.00	59.00	8.75	0.01935	0.02056	0.00715	0.00555	0.00365	0.00179	0.00166	0.00574
5.00	57.90	7.00	0.00458	0.00282	0.01734	0.01971	0.01806	0.01467	0.01695	0.01986
6.00	57.10	5.83	0.01315	0.01725	0.03123	0.03681	0.03537	0.03077	0.03501	0.03691
7.00	54.00	5.00	0.00736	0.00703	0.00771	0.01214	0.01178	0.00204	0.01531	0.01202
8.00	53.10	4.38	0.00468	0.02234	0.00185	0.02242	0.02245	0.01118	0.02740	0.02224
9.00	52.60	3.89	0.02359	0.04311	0.01352	0.04025	0.04051	0.02839	0.04629	0.04003
10.00	49.00	3.50	0.02800	0.00489	0.06369	0.02122	0.01915	0.03646	0.00648	0.02174
11.00	49.00	3.18	0.00057	0.03346	0.03512	0.00736	0.00942	0.00789	0.02209	0.00683
12.00	46.20	2.92	0.04649	0.00518	0.09850	0.04930	0.04587	0.06494	0.02768	0.05001
13.00	46.00	2.69	0.02375	0.01800	0.07668	0.02728	0.02377	0.04286	0.00521	0.02801
14.00	44.70	2.50	0.03449	0.00952	0.09230	0.04267	0.03866	0.05738	0.01798	0.04345
15.00	42.70	2.33	0.07053	0.02608	0.13171	0.08555	0.08104	0.09760	0.05824	0.08635
16.00	42.50	2.19	0.04866	0.00441	0.10988	0.06432	0.05978	0.07602	0.03687	0.06512
17.00	42.40	2.06	0.02345	0.02068	0.08467	0.03943	0.03488	0.05095	0.01192	0.04023

18.00	41.00	1.94	0.04288	0.00179	0.10249	0.06294	0.05836	0.07152	0.03534	0.06370
19.00	40.60	1.84	0.02828	0.01145	0.08691	0.04937	0.04482	0.05698	0.02202	0.05011
20.00	40.20	1.75	0.01376	0.02437	0.07118	0.03581	0.03131	0.04240	0.00885	0.03652
21.00	40.20	1.67	0.01481	0.05294	0.04261	0.00724	0.00274	0.01383	0.01972	0.00795
22.00	40.20	1.59	0.04338	0.08151	0.01403	0.02133	0.02583	0.01474	0.04829	0.02062
23.00	38.80	1.52	0.02239	0.05305	0.02906	0.00240	0.00175	0.00513	0.02208	0.00301
24.00	38.70	1.46	0.04741	0.07742	0.00352	0.02247	0.02658	0.02003	0.04670	0.02187
25.00	38.10	1.40	0.05471	0.08056	0.00717	0.02896	0.03284	0.02829	0.05151	0.02841
26.00	38.10	1.35	0.08328	0.10913	0.03574	0.05753	0.06141	0.05686	0.08008	0.05699
27.00	38.00	1.30	0.10832	0.13342	0.06138	0.08245	0.08629	0.08208	0.10469	0.08191
28.00	38.00	1.25	0.13689	0.16199	0.08995	0.11102	0.11486	0.11065	0.13326	0.11049
29.00	35.70	1.21	0.08566	0.09049	0.05515	0.05885	0.06141	0.06533	0.07146	0.05857
30.00	35.00	1.17	0.09096	0.08880	0.06611	0.06450	0.06659	0.07294	0.07338	0.06431
31.00	35.00	1.13	0.11953	0.11737	0.09468	0.09307	0.09517	0.10151	0.10195	0.09288
32.00	33.40	1.09	0.09774	0.07972	0.08616	0.07313	0.07410	0.08547	0.07262	0.07313
33.00	30.60	1.06	0.05127	0.01342	0.06063	0.03253	0.03173	0.04886	0.01632	0.03279
34.00	30.00	1.03	0.06640	0.02677	0.07938	0.04917	0.04808	0.06577	0.03042	0.04946
35.00	21.00	1.00	0.00081	0.00285	0.01953	0.00045	0.00107	0.00441	0.00285	0.00034
			0.13689	0.16199	0.13171	0.11102	0.11486	0.11065	0.13326	0.11049
		Δ α=0.01	0.13208	0.10698	0.13726	0.15795	0.15411	0.15832	0.13571	0.15848
		Δ α=0.02	0.12384	0.09874	0.12902	0.14971	0.14587	0.15008	0.12747	0.15024
		Δ α=0.05	0.08736	0.06226	0.09254	0.11323	0.10939	0.11360	0.09099	0.11376
		Δ α=0.10	0.06496	0.03986	0.07014	0.09083	0.08699	0.09120	0.06859	0.09136

Todas las distribuciones evaluadas pasan la prueba con holgura.

A.1.5.2 Prueba de Chi Cuadrado

Se comparará un valor límite con un valor máximo admisible para diferentes valores de fiabilidad α.

Intervalos	Lim superior	Ni	X2p Gumbel	X2p Log-Gumbel	X2p Normal	X2p Log-Normal II	X2p Log-Normal III	X2p Gamma II	X2p Pearson III	X2p Log-Pearson III
0-30	30.00	1.00	1.625	0.453	2.043	1.088	1.055	1.605	0.549	1.097
30-32	32.00	2.00	0.053	0.001	0.482	0.142	0.116	0.189	0.008	0.145
32-34	34.00	1.00	0.529	1.035	0.153	0.439	0.475	0.343	0.765	0.434
34-36	36.00	3.00	0.220	0.000	0.954	0.257	0.221	0.437	0.053	0.264
36-39	39.00	6.00	1.465	0.482	3.022	1.330	1.253	1.884	0.834	1.347
39-42	42.00	5.00	0.480	0.208	0.786	0.294	0.286	0.485	0.238	0.297
42-45	45.00	4.00	0.101	0.100	0.055	0.015	0.018	0.040	0.035	0.014
45-49	49.00	2.00	0.928	0.661	1.505	1.300	1.249	1.293	1.045	1.307
49-53	53.00	3.00	0.002	0.077	0.283	0.060	0.043	0.097	0.005	0.062
53-56	56.00	2.00	0.022	0.224	0.092	0.000	0.002	0.006	0.026	0.000
56-59	59.00	2.00	0.231	0.694	0.003	0.160	0.181	0.080	0.276	0.155

59-61	61.00	2.00	1.947	3.188	1.030	1.874	1.934	1.515	2.181	1.859
61-63	63.00	0.00	0.652	0.518	0.778	0.639	0.633	0.697	0.608	0.640
63-65	65.00	1.00	0.373	0.701	0.278	0.460	0.464	0.350	0.497	0.457
65-∞	∞	1.00	1.074	1.468	0.108	0.403	0.464	0.371	0.574	0.394
			9.703	9.810	11.571	8.459	8.395	9.391	7.693	8.474
		Δ α=0.001	23.207	23.100	21.339	24.451	22.869	23.519	23.571	22.790
		Δ α=0.010	16.514	16.407	14.646	17.758	16.330	16.826	17.032	16.251
		Δ α=0.025	13.634	13.527	11.766	14.878	13.525	13.946	14.227	13.446
		Δ α=0.050	11.323	11.216	9.455	12.567	11.280	11.635	11.982	11.201
		Δ α=0.100	8.846	8.739	6.978	10.090	8.880	9.158	9.582	8.801

Todas las distribuciones evaluadas pasan la prueba con holgura.

A.1.5.3 Prueba de Anderson-Darling

Se calculará cual es el valor máximo de fiabilidad α para cada distribución.

Orden (n)	P24max (mm)	S Gumbel	S Log-Gumbel	S Normal	S Log-Normal II	S Log-Normal III	S Gamma II	S Pearson III	S Log-Pearson III
1.00	83.80	-1.158	-2.114	-1.588	-0.479	-0.497	-0.693	-0.480	-0.476
2.00	63.80	-12.734	-10.679	-11.037	-9.693	-9.786	-10.870	-8.806	-9.691
3.00	60.20	-15.764	-13.369	-14.232	-12.575	-12.669	-13.928	-11.777	-12.576
4.00	59.00	-21.805	-20.519	-19.020	-18.150	-18.357	-19.347	-18.387	-18.136
5.00	57.90	-25.976	-25.679	-22.481	-22.191	-22.468	-23.196	-23.071	-22.167
6.00	57.10	-25.880	-25.427	-22.743	-22.241	-22.495	-23.286	-23.029	-22.220
7.00	54.00	-30.185	-29.532	-27.916	-26.779	-26.995	-27.974	-27.499	-26.767
8.00	53.10	-36.535	-37.420	-33.239	-33.187	-33.492	-33.942	-34.648	-33.157
9.00	52.60	-35.871	-36.583	-32.947	-32.702	-32.981	-33.483	-34.034	-32.677
10.00	49.00	-40.423	-40.076	-39.598	-37.969	-38.107	-39.053	-38.602	-37.967
11.00	49.00	-38.838	-38.504	-38.045	-36.480	-36.612	-37.522	-37.089	-36.478
12.00	46.20	-44.281	-43.469	-44.857	-42.697	-42.725	-43.750	-42.803	-42.710
13.00	46.00	-43.081	-42.304	-43.694	-41.620	-41.642	-42.615	-41.700	-41.633
14.00	44.70	-47.551	-47.226	-48.164	-46.588	-46.599	-47.273	-46.677	-46.597
15.00	42.70	-50.314	-49.590	-51.818	-50.046	-49.972	-50.633	-49.665	-50.065
16.00	42.50	-48.385	-47.668	-49.892	-48.198	-48.121	-48.743	-47.794	-48.218
17.00	42.40	-47.056	-46.538	-48.369	-46.939	-46.871	-47.375	-46.604	-46.955
18.00	41.00	-48.981	-48.556	-50.484	-49.365	-49.267	-49.566	-48.867	-49.382
19.00	40.60	-50.213	-50.281	-51.317	-50.857	-50.778	-50.763	-50.491	-50.867
20.00	40.20	-48.408	-48.520	-49.485	-49.156	-49.073	-48.993	-48.774	-49.165
21.00	40.20	-45.672	-45.827	-46.638	-46.396	-46.321	-46.214	-46.053	-46.403
22.00	40.20	-46.265	-46.774	-46.915	-47.236	-47.174	-46.810	-46.993	-47.238
23.00	38.80	-48.390	-49.167	-49.043	-49.924	-49.843	-49.168	-49.612	-49.924
24.00	38.70	-45.086	-45.832	-45.692	-46.563	-46.486	-45.831	-46.270	-46.563

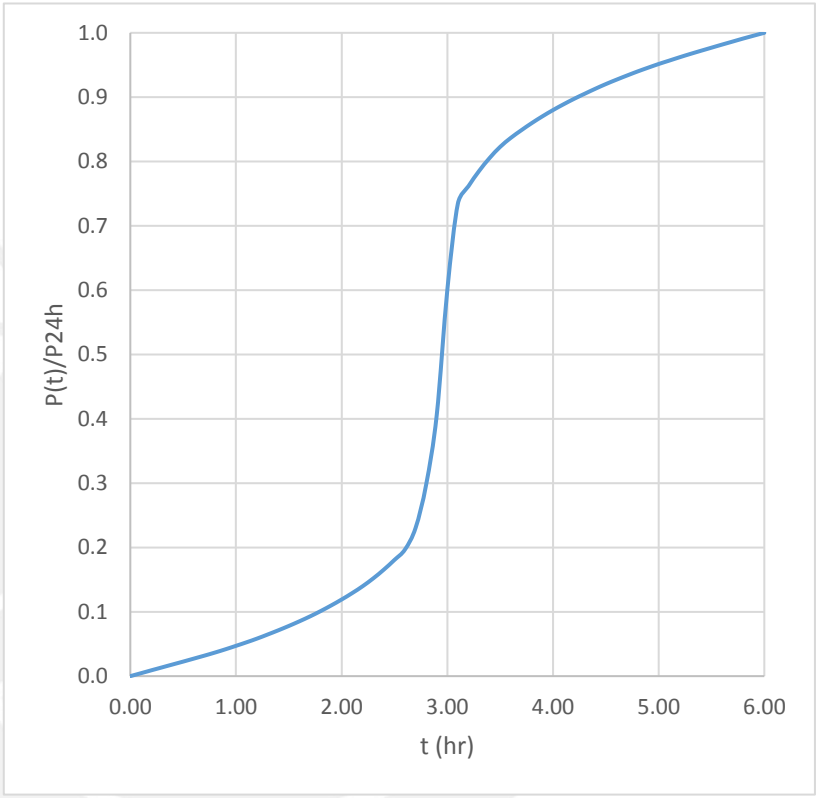
25.00	38.10	-46.974	-47.762	-47.869	-49.084	-48.969	-48.111	-48.664	-49.085
26.00	38.10	-42.500	-43.213	-43.310	-44.410	-44.305	-43.529	-44.029	-44.410
27.00	38.00	-43.220	-43.482	-45.053	-45.836	-45.648	-44.951	-45.143	-45.848
28.00	38.00	-38.769	-38.924	-40.588	-41.206	-41.024	-40.427	-40.536	-41.218
29.00	35.70	-38.111	-38.804	-39.732	-40.827	-40.658	-39.785	-40.355	-40.835
30.00	35.00	-36.263	-36.654	-38.833	-39.365	-39.137	-38.443	-38.758	-39.383
31.00	35.00	-30.308	-30.500	-32.768	-33.010	-32.799	-32.289	-32.432	-33.028
32.00	33.40	-25.959	-26.619	-27.962	-28.410	-28.247	-27.649	-28.187	-28.423
33.00	30.60	-21.713	-23.689	-22.768	-23.842	-23.777	-22.878	-24.589	-23.841
34.00	30.00	-14.412	-15.670	-15.711	-16.017	-15.945	-15.463	-16.547	-16.022
35.00	21.00	-9.951	-17.542	-11.658	-11.429	-11.551	-10.819	-18.787	-11.421
	Sumatoria	-1247.029962	-1254.511769	-1255.468233	-1241.468688	-1241.391053	-1245.375489	-1247.753284	-1241.542371
	A2	0.629	0.843	0.871	0.471	0.468	0.582	0.650	0.473
	A2*	0.644	0.863	0.891	0.481	0.479	0.596	0.665	0.484
	p (A2*=>0.6)	0.093	0.027	0.023	0.234	0.237	0.122	0.082	0.232
	p (0.34<=A2*<0.6)	0.090	0.022	0.019	0.232	0.235	0.120	0.079	0.229
	p (0.2<=A2*<0.34)	0.996	1.000	1.000	0.800	0.793	0.983	0.998	0.806
	p (A2*<0.2)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	α max	0.093	0.027	0.023	0.232	0.235	0.120	0.082	0.229

Las distribuciones Log-Gumbel y Normal tienen valores de fiabilidad bajos, por lo cual no son recomendables. Se opta por utilizar la distribución Gumbel debido a que presenta una confiabilidad aceptable y representa eventos extremos.

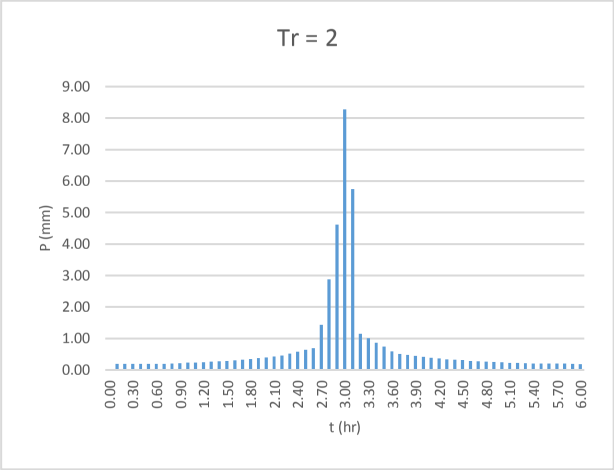
A.1.6 Generación de Hietogramas de Diseño

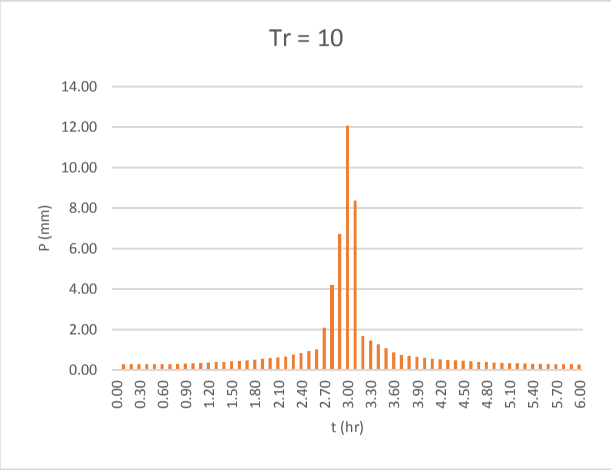
El hietograma de diseño fue definido tomando una lámina de precipitación máxima en 24 horas y distribuyéndola según una curva característica. Se empleó en particular la curva del NRCS tipo II para una duración máxima de 6 horas.

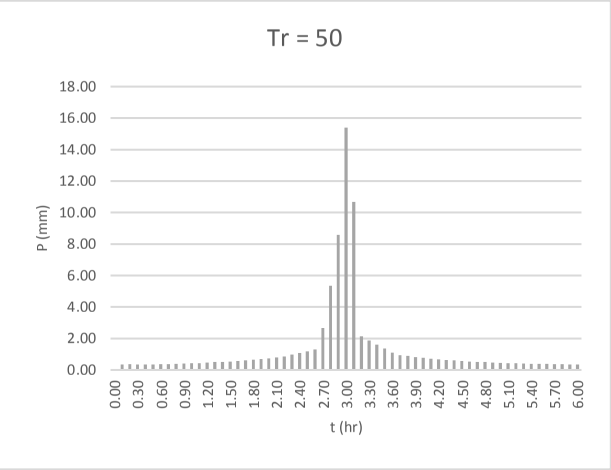
t (hr)	P(t)/P24
0.00	0.0000
0.10	0.0045
0.20	0.0091
0.30	0.0136
0.40	0.0181
0.50	0.0226
0.60	0.0272
0.70	0.0318
0.80	0.0366
0.90	0.0417
1.00	0.0471
1.10	0.0526
1.20	0.0584
1.30	0.0647
1.40	0.0712
1.50	0.0780
1.60	0.0852
1.70	0.0928
1.80	0.1010
1.90	0.1098
2.00	0.1191
2.10	0.1291
2.20	0.1399
2.30	0.1521
2.40	0.1657
2.50	0.1807
2.60	0.1970
2.70	0.2306
2.80	0.2980
2.90	0.4061
3.00	0.6001
3.10	0.7347
3.20	0.7616
3.30	0.7851
3.40	0.8054
3.50	0.8227
3.60	0.8366
3.70	0.8485
3.80	0.8598
3.90	0.8702
4.00	0.8799
4.10	0.8889
4.20	0.8974
4.30	0.9053
4.40	0.9130
4.50	0.9203
4.60	0.9271
4.70	0.9336
4.80	0.9399
4.90	0.9458
5.00	0.9515
5.10	0.9568
5.20	0.9621
5.30	0.9672
5.40	0.9721
5.50	0.9769
5.60	0.9817
5.70	0.9864
5.80	0.9911
5.90	0.9956
6.00	1.0000

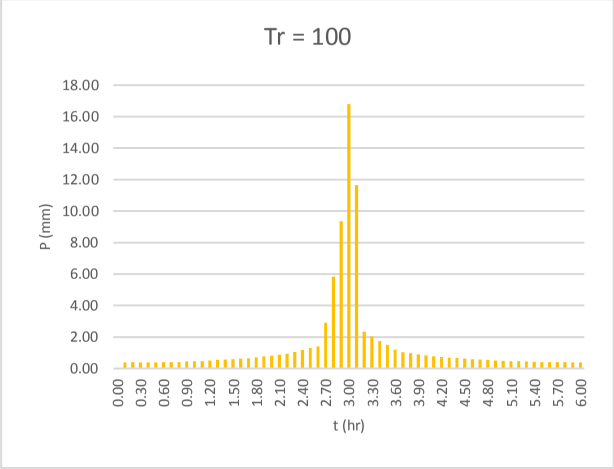


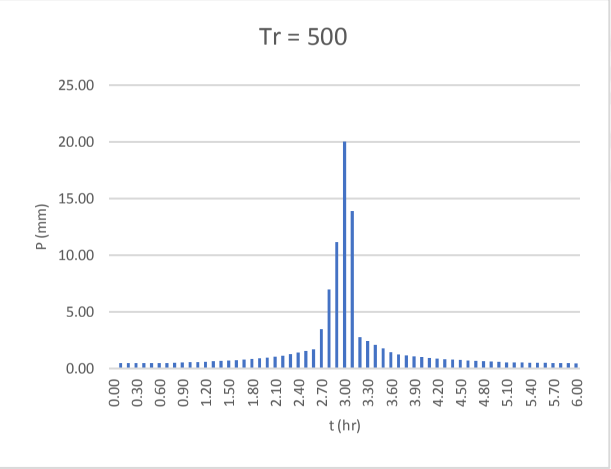
A.1.6.1 Resumen de Hietogramas de Diseño

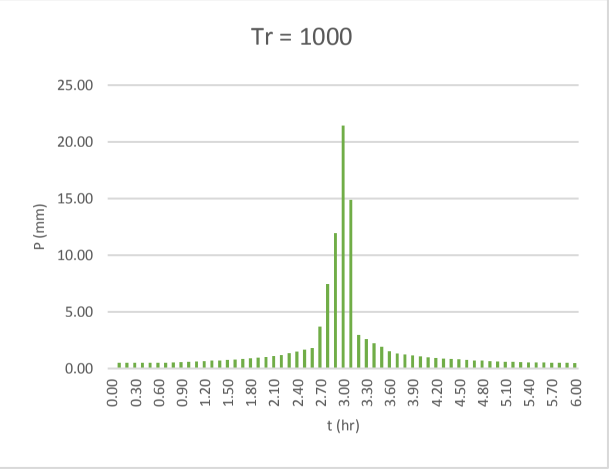












A.1.6.2 Tabla Resumen – Hietogramas

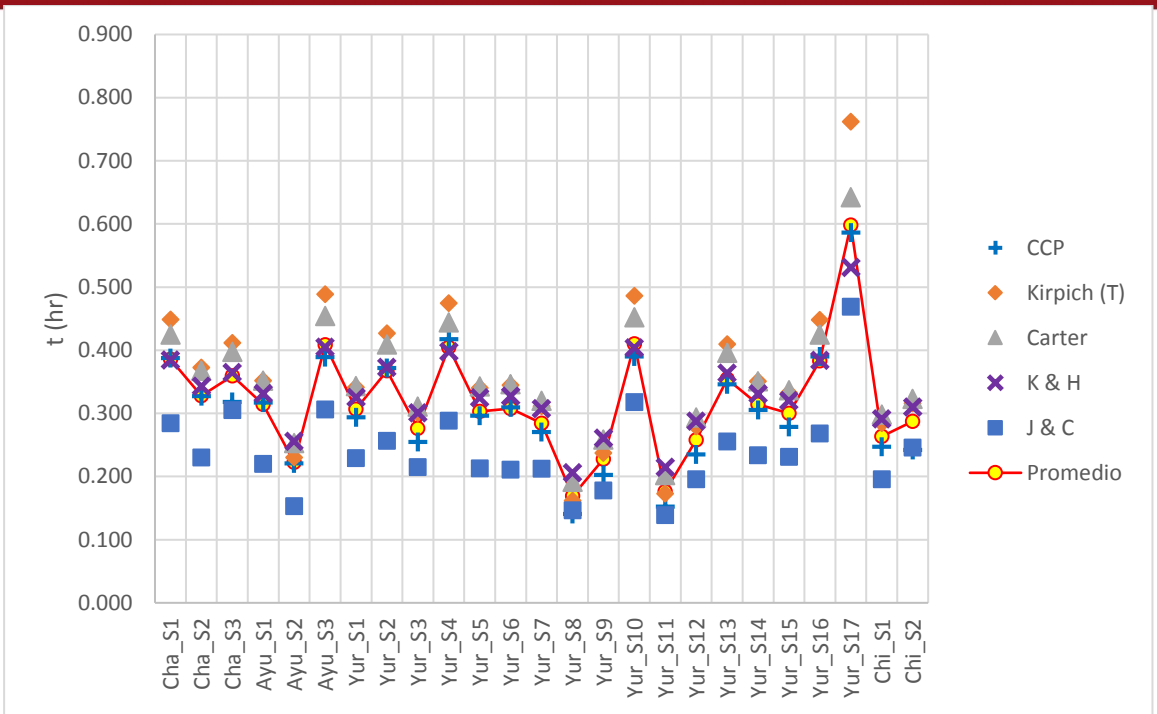
t (hr)	Tr = 2	Tr = 10	Tr = 50	Tr = 100	Tr = 500	Tr = 1000
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.10	0.19	0.28	0.36	0.39	0.46	0.50
0.20	0.20	0.29	0.36	0.40	0.48	0.51
0.30	0.19	0.28	0.36	0.39	0.46	0.50
0.40	0.19	0.28	0.36	0.39	0.46	0.50
0.50	0.19	0.28	0.36	0.39	0.46	0.50
0.60	0.20	0.29	0.36	0.40	0.48	0.51
0.70	0.20	0.29	0.36	0.40	0.48	0.51
0.80	0.20	0.30	0.38	0.42	0.50	0.53
0.90	0.22	0.32	0.40	0.44	0.53	0.56
1.00	0.23	0.34	0.43	0.47	0.56	0.60
1.10	0.23	0.34	0.44	0.48	0.57	0.61
1.20	0.25	0.36	0.46	0.50	0.60	0.64
1.30	0.27	0.39	0.50	0.55	0.65	0.70
1.40	0.28	0.40	0.52	0.56	0.67	0.72
1.50	0.29	0.42	0.54	0.59	0.70	0.75
1.60	0.31	0.45	0.57	0.62	0.74	0.80
1.70	0.32	0.47	0.60	0.66	0.78	0.84
1.80	0.35	0.51	0.65	0.71	0.85	0.91
1.90	0.38	0.55	0.70	0.76	0.91	0.97
2.00	0.40	0.58	0.74	0.80	0.96	1.03
2.10	0.43	0.62	0.79	0.87	1.03	1.10
2.20	0.46	0.67	0.86	0.93	1.12	1.19
2.30	0.52	0.76	0.97	1.06	1.26	1.35
2.40	0.58	0.85	1.08	1.18	1.40	1.50
2.50	0.64	0.93	1.19	1.30	1.55	1.66
2.60	0.70	1.01	1.29	1.41	1.68	1.80
2.70	1.43	2.09	2.67	2.91	3.47	3.71
2.80	2.88	4.19	5.35	5.83	6.96	7.45
2.90	4.61	6.72	8.57	9.36	11.16	11.94
3.00	8.28	12.07	15.39	16.79	20.04	21.43
3.10	5.74	8.37	10.68	11.65	13.90	14.87
3.20	1.15	1.67	2.13	2.33	2.78	2.97
3.30	1.00	1.46	1.86	2.03	2.43	2.60
3.40	0.87	1.26	1.61	1.76	2.10	2.24
3.50	0.74	1.08	1.37	1.50	1.79	1.91
3.60	0.59	0.86	1.10	1.20	1.44	1.54
3.70	0.51	0.74	0.94	1.03	1.23	1.31
3.80	0.48	0.70	0.90	0.98	1.17	1.25
3.90	0.44	0.65	0.82	0.90	1.07	1.15
4.00	0.41	0.60	0.77	0.84	1.00	1.07
4.10	0.38	0.56	0.71	0.78	0.93	0.99
4.20	0.36	0.53	0.67	0.74	0.88	0.94
4.30	0.34	0.49	0.63	0.68	0.82	0.87
4.40	0.33	0.48	0.61	0.67	0.80	0.85
4.50	0.31	0.45	0.58	0.63	0.75	0.81
4.60	0.29	0.42	0.54	0.59	0.70	0.75
4.70	0.28	0.40	0.52	0.56	0.67	0.72
4.80	0.27	0.39	0.50	0.55	0.65	0.70
4.90	0.25	0.37	0.47	0.51	0.61	0.65
5.00	0.24	0.35	0.45	0.49	0.59	0.63
5.10	0.23	0.33	0.42	0.46	0.55	0.59
5.20	0.23	0.33	0.42	0.46	0.55	0.59
5.30	0.22	0.32	0.40	0.44	0.53	0.56
5.40	0.21	0.30	0.39	0.42	0.51	0.54
5.50	0.20	0.30	0.38	0.42	0.50	0.53
5.60	0.20	0.30	0.38	0.42	0.50	0.53
5.70	0.20	0.29	0.37	0.41	0.49	0.52
5.80	0.20	0.29	0.37	0.41	0.49	0.52
5.90	0.19	0.28	0.36	0.39	0.46	0.50
6.00	0.19	0.27	0.35	0.38	0.45	0.49

A.1.7 Descripción de las Quebradas y sus Propiedades

A.1.7.1 Cálculo del Tiempo de Concentración

Mediante la formulación descrita en el documento principal del presente proyecto, además de conocidas las características de cada sub-cuenca, se calcula el tiempo de concentración para cada sub-cuenca.

Código	L (m)	dH (m)	S (m/m)	Manning	CCP	Kirpich (T)	Carter	K & H	J & C	Promedio
Cha_S1	5231.865	1461.220	0.191	0.030	0.388	0.448	0.425	0.384	0.284	0.386
Cha_S2	4937.246	1908.562	0.275	0.030	0.327	0.373	0.368	0.343	0.230	0.328
Cha_S3	3629.076	817.608	0.115	0.030	0.318	0.412	0.397	0.365	0.305	0.359
Ayu_S1	4645.568	1728.552	0.282	0.030	0.317	0.352	0.352	0.331	0.220	0.314
Ayu_S2	3188.001	1427.840	0.400	0.030	0.221	0.230	0.253	0.256	0.153	0.223
Ayu_S3	5626.623	1800.450	0.176	0.030	0.389	0.489	0.454	0.405	0.306	0.409
Yur_S1	3952.499	1294.697	0.221	0.030	0.294	0.341	0.343	0.325	0.229	0.307
Yur_S2	5662.203	2065.463	0.254	0.030	0.372	0.427	0.409	0.373	0.256	0.367
Yur_S3	3225.990	1020.521	0.205	0.030	0.255	0.300	0.311	0.301	0.215	0.276
Yur_S4	5885.980	1718.482	0.208	0.030	0.417	0.475	0.444	0.398	0.288	0.404
Yur_S5	4536.258	1914.721	0.294	0.030	0.296	0.340	0.342	0.325	0.213	0.303
Yur_S6	4802.628	2026.920	0.318	0.030	0.310	0.345	0.346	0.327	0.211	0.308
Yur_S7	3626.609	1238.979	0.236	0.030	0.271	0.311	0.320	0.308	0.212	0.284
Yur_S8	1384.984	379.267	0.190	0.030	0.140	0.161	0.192	0.206	0.147	0.169
Yur_S9	2549.423	913.402	0.236	0.030	0.203	0.237	0.259	0.261	0.178	0.227
Yur_S10	5160.562	1381.295	0.150	0.030	0.390	0.486	0.452	0.404	0.318	0.410
Yur_S11	1849.023	733.194	0.283	0.030	0.152	0.173	0.202	0.215	0.139	0.176
Yur_S12	3228.462	1263.310	0.248	0.030	0.235	0.279	0.294	0.288	0.196	0.258
Yur_S13	5128.592	1847.853	0.232	0.030	0.346	0.410	0.396	0.364	0.255	0.354
Yur_S14	4080.119	1289.378	0.220	0.030	0.305	0.351	0.351	0.331	0.234	0.314
Yur_S15	3637.866	1159.845	0.200	0.030	0.279	0.333	0.337	0.320	0.231	0.300
Yur_S16	5861.178	2025.868	0.240	0.030	0.390	0.448	0.425	0.384	0.268	0.383
Yur_S17	7624.249	1543.899	0.102	0.030	0.586	0.762	0.642	0.531	0.469	0.598
Chi_S1	3380.863	1270.826	0.259	0.030	0.247	0.285	0.298	0.291	0.196	0.263
Chi_S2	2805.853	765.068	0.137	0.030	0.242	0.316	0.323	0.310	0.246	0.287



Graficando los valores obtenidos por cada metodología y realizando una línea promedio, se puede apreciar que existe un ajuste en la mayoría de sub-cuencas evaluadas.

A.1.7.2 Resumen de las Propiedades de las Quebradas

Código	A (m2)	P (m)	L (m)	dH (m)	S (m/m)	Manning	CN	Ia (mm)	tc (hr)
Cha_S1	8796654	15646	5231.865	1461.220	0.191	0.030	50.072	12.664	0.386
Cha_S2	5833159	13586	4937.246	1908.562	0.275	0.030	50.505	12.446	0.328
Cha_S3	1359271	9890	3629.076	817.608	0.115	0.030	62.990	7.462	0.359

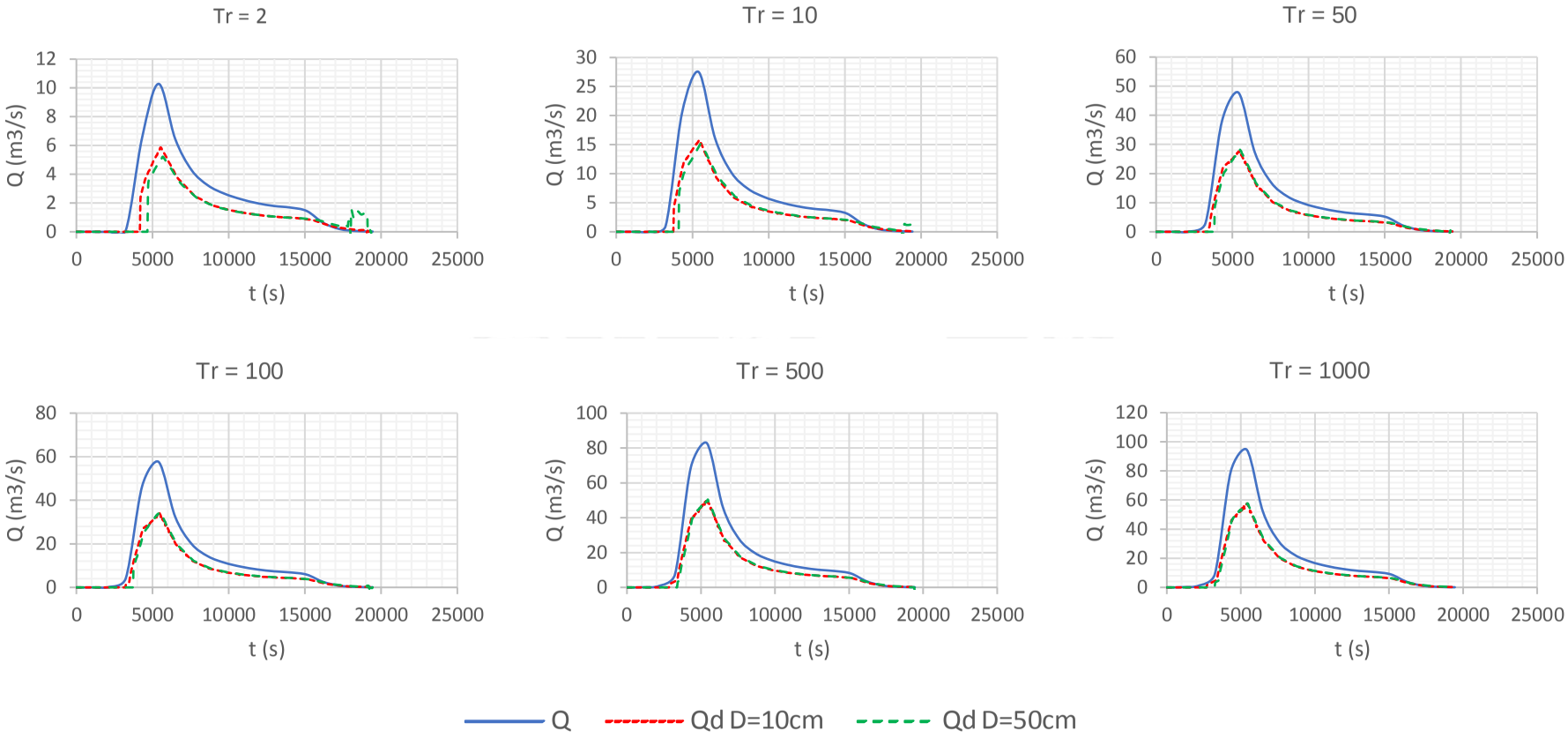
Código	A (m2)	P (m)	L (m)	dH (m)	S (m/m)	Manning	CN	Ia (mm)	tc (hr)
Ayu_S1	5372288	12700	4645.568	1728.552	0.282	0.030	44.340	15.943	0.314
Ayu_S2	2279026	9474	3188.001	1427.840	0.400	0.030	45.880	14.981	0.223
Ayu_S3	6923065	15698	5626.623	1800.450	0.176	0.030	62.652	7.571	0.409

Código	A (m2)	P (m)	L (m)	dH (m)	S (m/m)	Manning	CN	Ia (mm)	tc (hr)
Yur_S1	3361908	10740	3952.499	1294.697	0.221	0.030	62.154	7.733	0.307
Yur_S2	2635917	15074	5662.203	2065.463	0.254	0.030	64.931	6.859	0.367
Yur_S3	1734418	8468	3225.990	1020.521	0.205	0.030	49.950	12.725	0.276
Yur_S4	3157486	21358	5885.980	1718.482	0.208	0.030	51.913	11.764	0.404
Yur_S5	3909856	12194	4536.258	1914.721	0.294	0.030	74.911	4.253	0.303
Yur_S6	2368274	11698	4802.628	2026.920	0.318	0.030	65.858	6.584	0.308
Yur_S7	1828669	9386	3626.609	1238.979	0.236	0.030	35.839	22.736	0.284
Yur_S8	145087	3754	1384.984	379.267	0.190	0.030	44.104	16.096	0.169
Yur_S9	1080518	8510	2549.423	913.402	0.236	0.030	43.577	16.444	0.227
Yur_S10	4404149	13140	5160.562	1381.295	0.150	0.030	45.092	15.464	0.410
Yur_S11	236526	6074	1849.023	733.194	0.283	0.030	49.077	13.178	0.176
Yur_S12	2475924	12142	3228.462	1263.310	0.248	0.030	46.936	14.358	0.258
Yur_S13	6554952	14626	5128.592	1847.853	0.232	0.030	77.427	3.702	0.354
Yur_S14	2082137	9376	4080.119	1289.378	0.220	0.030	43.845	16.266	0.314
Yur_S15	2106819	11728	3637.866	1159.845	0.200	0.030	51.082	12.162	0.300
Yur_S16	7409783	16872	5861.178	2025.868	0.240	0.030	51.445	11.987	0.383
Yur_S17	5565506	18064	7624.249	1543.899	0.102	0.030	55.582	10.149	0.598

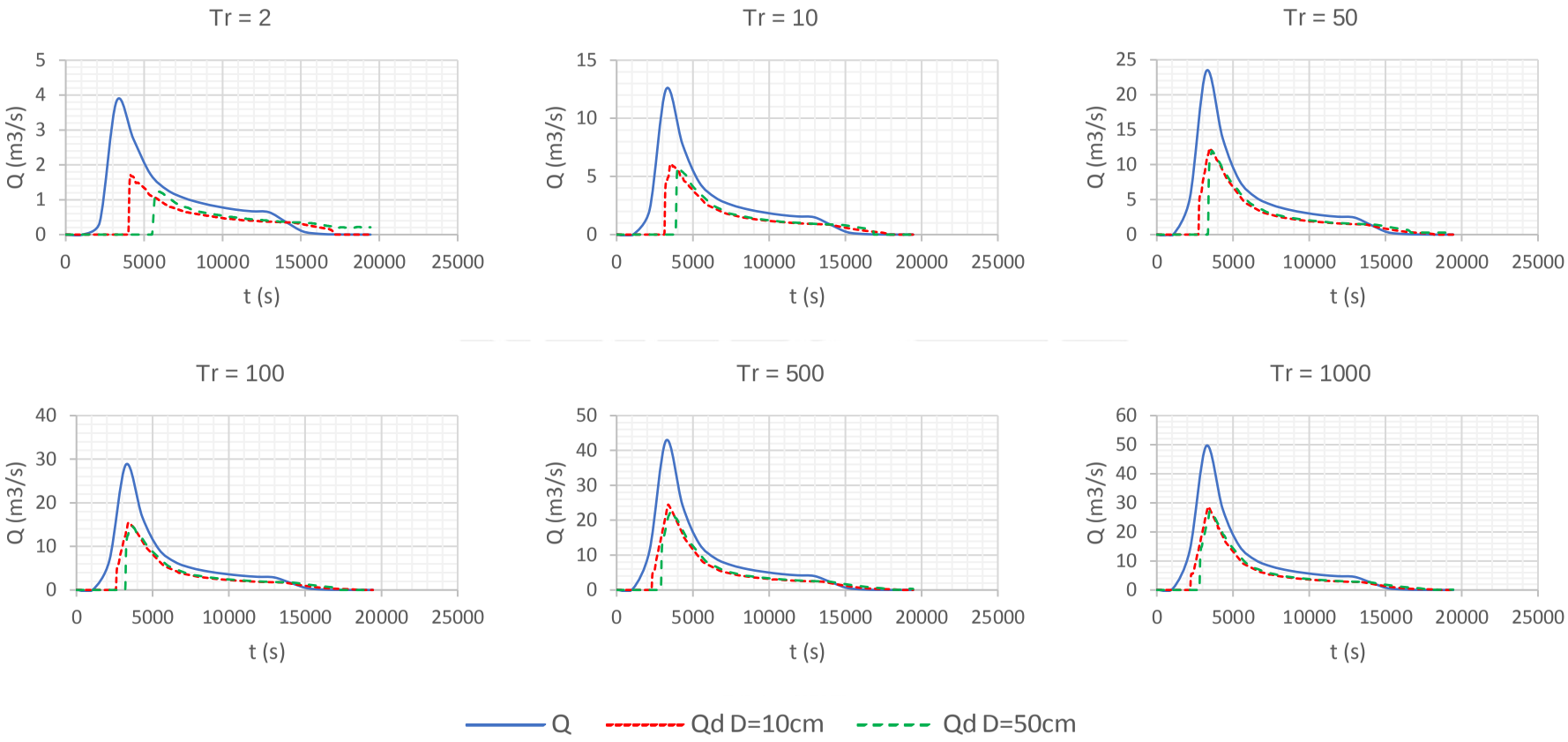
Código	A (m2)	P (m)	L (m)	dH (m)	S (m/m)	Manning	CN	Ia (mm)	tc (hr)
Chi_S1	2832180	9642	3380.863	1270.826	0.259	0.030	49.589	12.911	0.263
Chi_S2	913628	9054	2805.853	765.068	0.137	0.030	59.658	8.588	0.287

A.1.8 Hidrogramas de Avenida y Flujo de Escombros

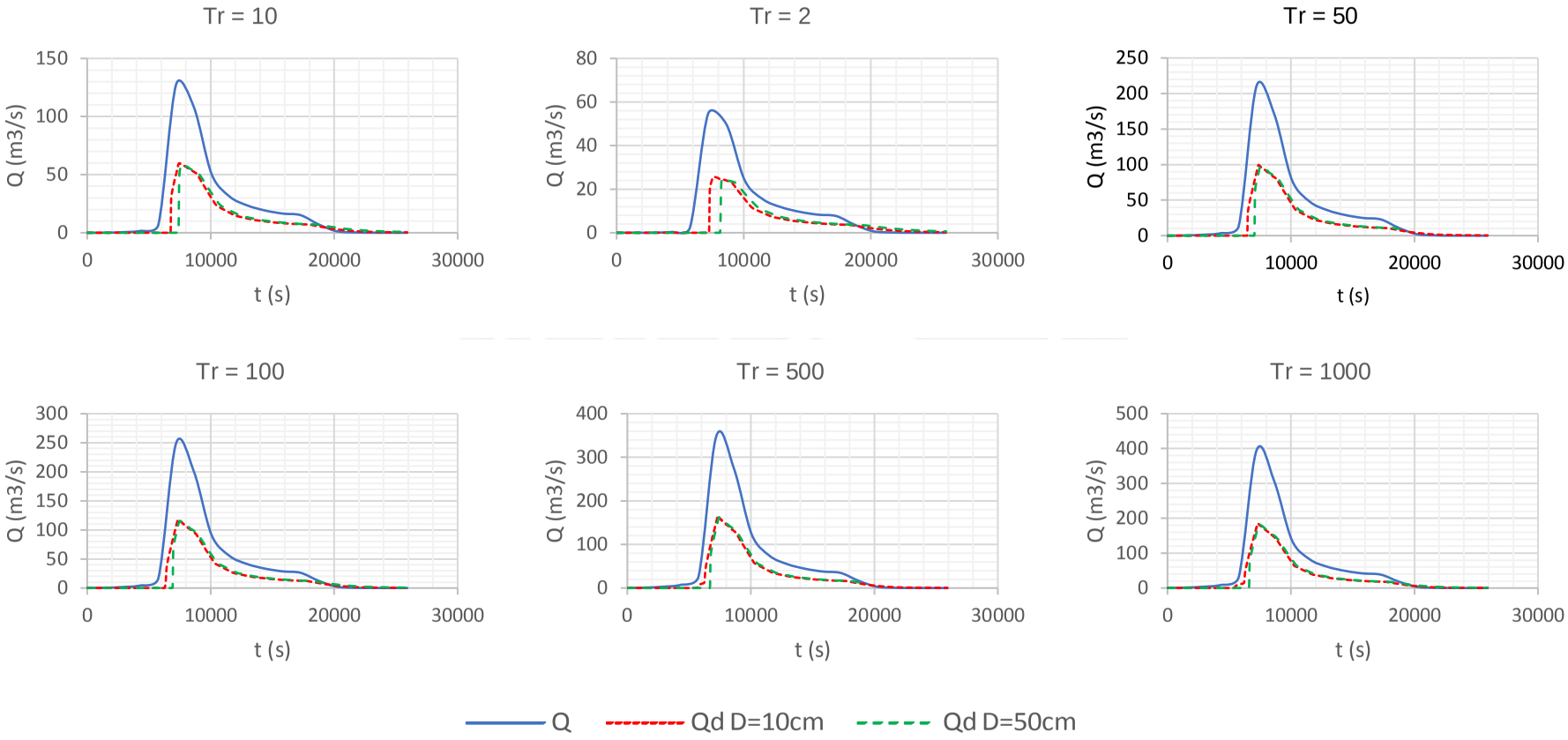
A.1.8.1 Quebrada Chaupimayo



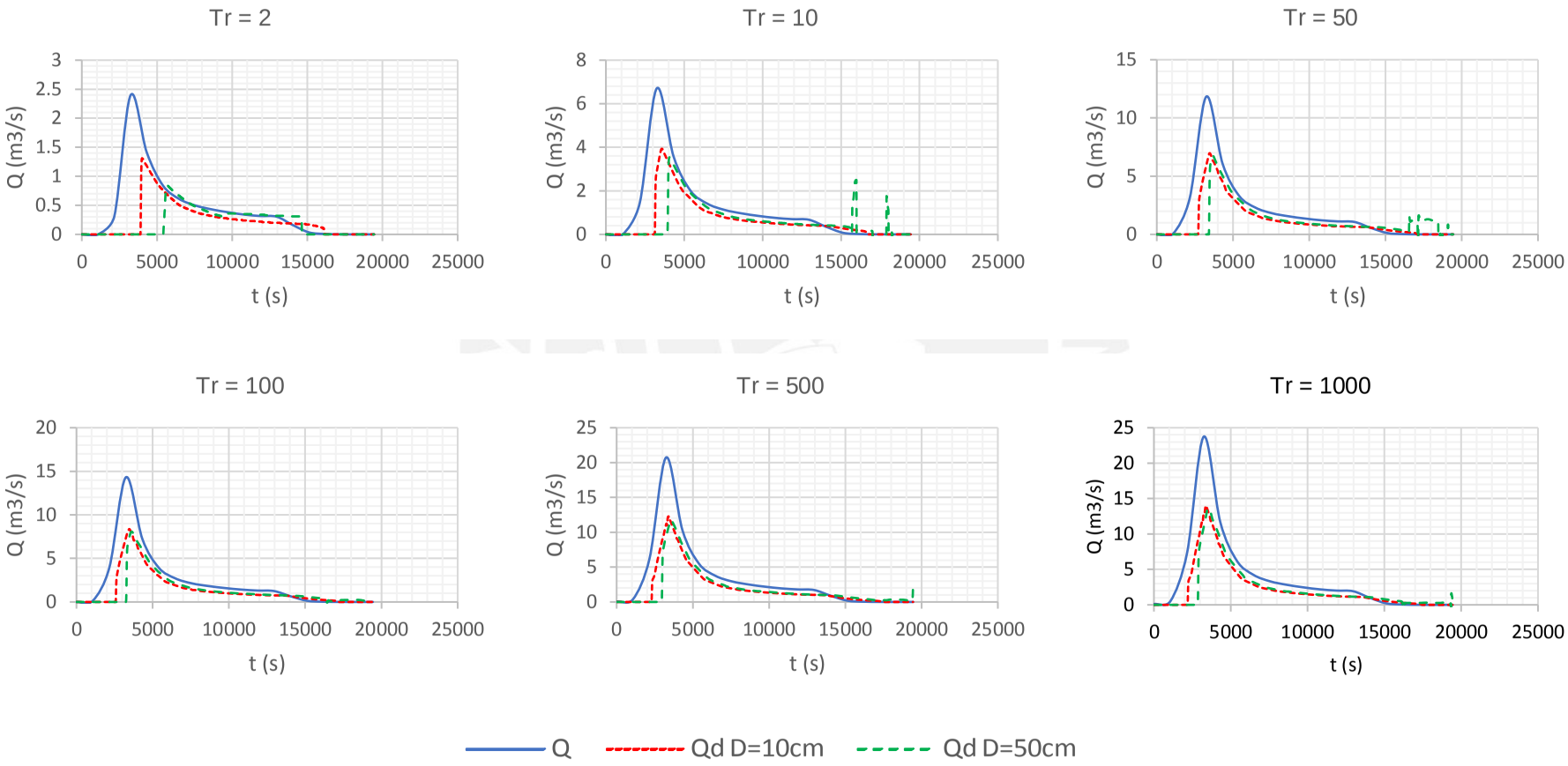
A.1.8.2 Quebrada Ayunay



A.1.8.3 Quebrada Yuracmayo



A.1.8.4 Quebrada Chinche



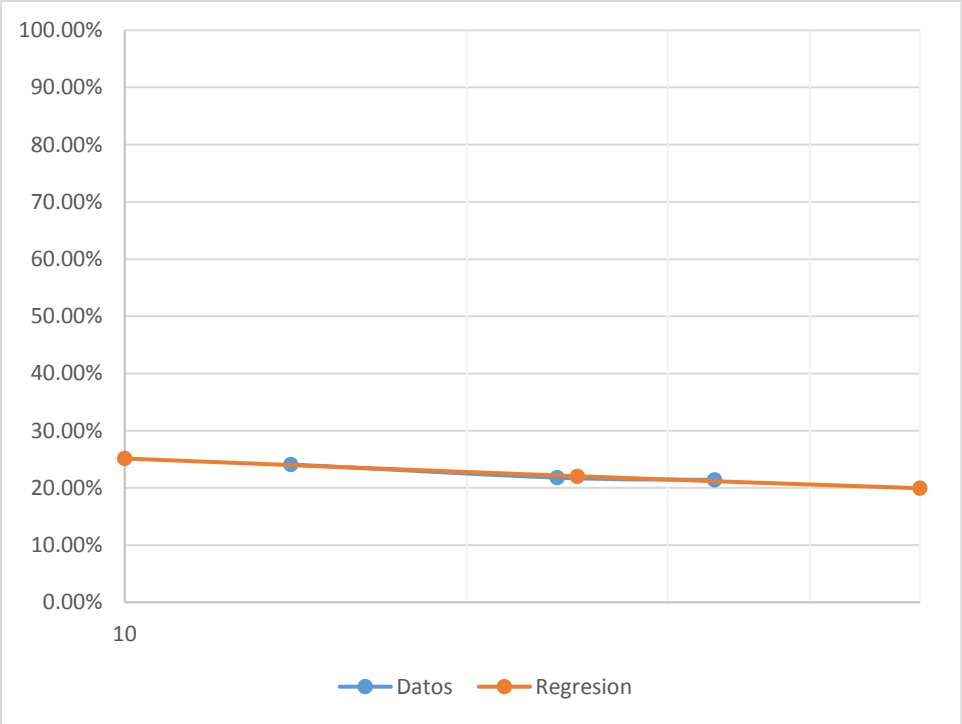
A.2 Procesamiento Geotécnico

Efectuado mediante los lineamientos de las normas ASTM mencionadas en el documento principal del presente trabajo.

A.2.1 Límites de Atterberg

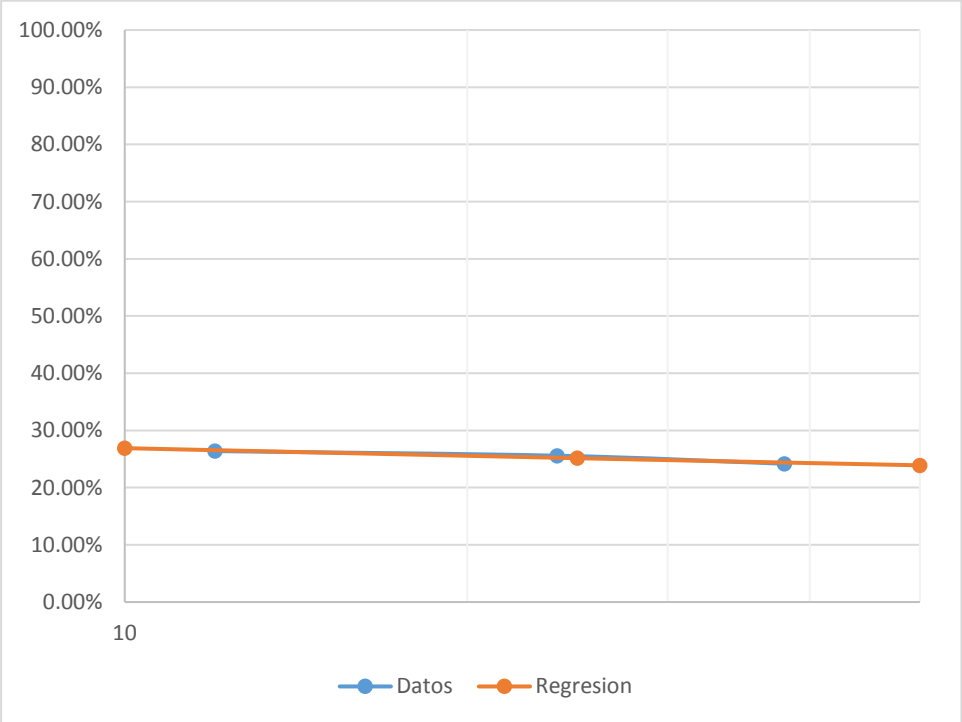
Muestra Nro. 1

Limite Liquido				Limite Plastico	
N° Ensayo	1	2	3	1	2
P. Capsula (gr)	28.71	27.43	21.55	12.84	9.59
C+Suelo H (gr)	37.00	34.75	29.38	25.47	22.23
C+Suelo S (gr)	35.39	33.44	28.00	23.70	20.45
N° Golpes	14	24	33		
P. Agua (gr)	1.61	1.31	1.38	1.77	1.78
P. Suelo S (gr)	6.68	6.01	6.45	10.86	10.86
w (%)	24.10%	21.80%	21.40%	16.30%	16.39%
Regresion					
x	y	Log(x)	Log(y)	Log(x)Log(y)	$Log(x)^2$
14	0.2410	1.1461	-0.6180	-0.7083	1.3136
24	0.2180	1.3802	-0.6616	-0.9132	1.9050
33	0.2140	1.5185	-0.6697	-1.0169	2.3059
Sub Total		4.0449	-1.9492	-2.6383	5.5245
β	-0.1439	R(10)	25.14%	LP	16
Log(α)	-0.4557	R(25)	22.03%	LL	22
α	0.3502	R(50)	19.94%	IP	6



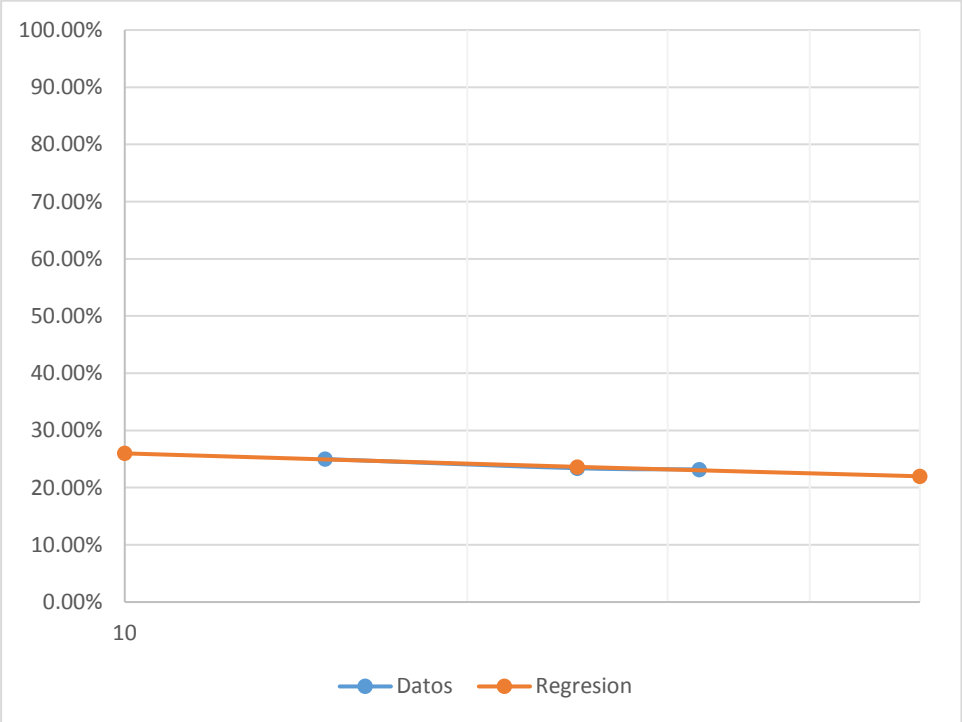
Muestra Nro. 2

Limite Liquido				Limite Plastico	
N° Ensayo	1	2	3	1	2
P. Capsula (gr)	28.70	23.80	28.13	7.66	13.55
C+Suelo H (gr)	39.81	32.98	39.17	23.80	28.04
C+Suelo S (gr)	37.49	31.11	37.02	21.41	25.88
N° Golpes	12	24	38		
P. Agua (gr)	2.32	1.87	2.15	2.39	2.16
P. Suelo S (gr)	8.79	7.31	8.89	13.75	12.33
w (%)	26.39%	25.58%	24.18%	17.38%	17.52%
Regresion					
x	y	Log(x)	Log(y)	Log(x)Log(y)	$Log(x)^2$
12	0.2639	1.0792	-0.5785	-0.6243	1.1646
24	0.2558	1.3802	-0.5921	-0.8172	1.9050
38	0.2418	1.5798	-0.6165	-0.9739	2.4957
Sub Total		4.0392	-1.7870	-2.4154	5.5653
β	-0.0734	R(10)	26.90%	LP	17
Log(α)	-0.4969	R(25)	25.15%	LL	25
α	0.3185	R(50)	23.90%	IP	8



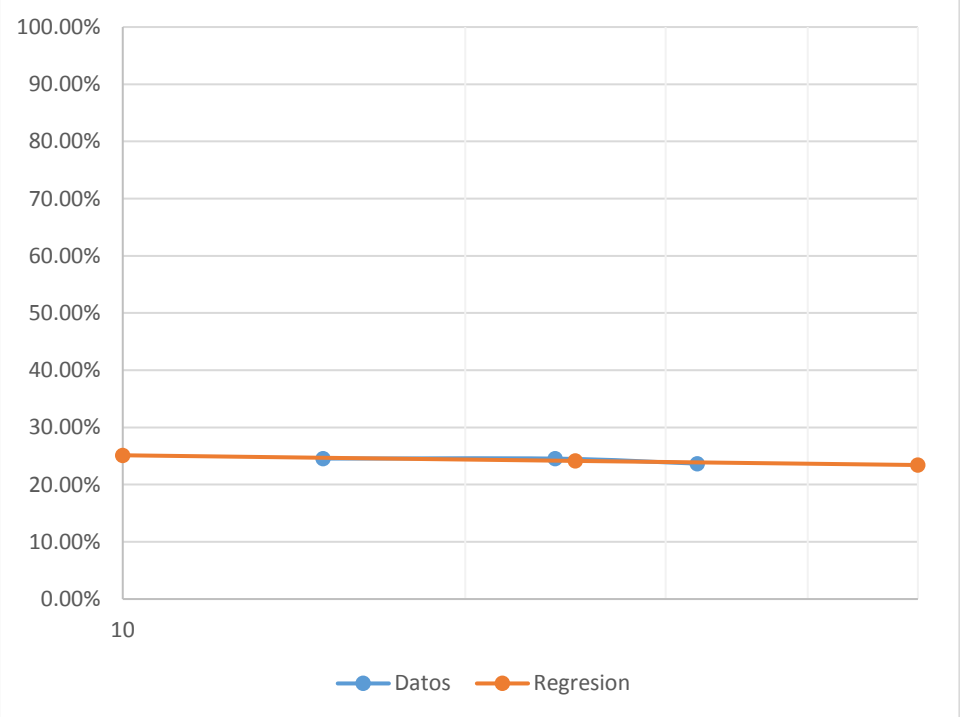
Muestra Nro.3

Limite Liquido				Limite Plastico	
N° Ensayo	1	2	3	1	2
P. Capsula (gr)	28.59	23.81	21.54	12.84	9.60
C+Suelo H (gr)	35.19	30.72	29.19	24.30	21.69
C+Suelo S (gr)	33.87	29.41	27.75	22.77	20.06
N° Golpes	15	25	32		
P. Agua (gr)	1.32	1.31	1.44	1.53	1.63
P. Suelo S (gr)	5.28	5.60	6.21	9.93	10.46
w (%)	25.00%	23.39%	23.19%	15.41%	15.58%
Regresion					
x	y	Log(x)	Log(y)	Log(x)Log(y)	$Log(x)^2$
15	0.2500	1.1761	-0.6021	-0.7081	1.3832
25	0.2339	1.3979	-0.6309	-0.8820	1.9542
32	0.2319	1.5051	-0.6347	-0.9554	2.2655
Sub Total		4.0792	-1.8677	-2.5454	5.6029
β	-0.1039	R(10)	25.99%	LP	15
Log(α)	-0.4813	R(25)	23.63%	LL	24
α	0.3302	R(50)	21.99%	IP	8



Muestra Nro. 4

Limite Liquido				Limite Plastico	
N° Ensayo	1	2	3	1	2
P. Capsula (gr)	12.40	23.76	28.64	7.67	13.36
C+Suelo H (gr)	23.61	36.90	41.70	16.95	22.90
C+Suelo S (gr)	21.40	34.31	39.20	15.56	21.48
N° Golpes	15	24	32		
P. Agua (gr)	2.21	2.59	2.50	1.39	1.42
P. Suelo S (gr)	9.00	10.55	10.56	7.89	8.12
w (%)	24.56%	24.55%	23.67%	17.62%	17.49%
Regresion					
x	y	Log(x)	Log(y)	Log(x)Log(y)	$Log(x)^2$
15	0.2456	1.1761	-0.6099	-0.7172	1.3832
24	0.2455	1.3802	-0.6100	-0.8419	1.9050
32	0.2367	1.5051	-0.6257	-0.9418	2.2655
Sub Total		4.0615	-1.8455	-2.5009	5.5537
β	-0.0436	R(10)	25.13%	LP	18
Log(α)	-0.5562	R(25)	24.15%	LL	24
α	0.2779	R(50)	23.43%	IP	7



A.2.2 Gravedad Específica – Densidad

A.2.2.1 Fracción Fina

Muestra Nro. 1

Gs	Pic 1	Pic 2
T (°C)	21	21
α	0.9998	0.9998
Ws (gr)	40	40
W1 (gr)	377.66	360.04
W2 (gr)	352.07	334.44
Vs (cm^3)	14.41	14.4
Gs	2.775295	2.777222

Muestra Nro. 2

Ensayo 2	Pic 1	Pic 2
T (°C)	24	24
α	0.9991	0.9991
Ws (gr)	40	40
W1 (gr)	360.09	377.53
W2 (gr)	334.42	351.87
Vs (cm^3)	14.33	14.34
Gs	2.788835	2.78689

A.2.2.2 Fracción Gruesa

	Muestra N°			
	1	2	3	4
P. Suelo S.S.S. + Bandeja (gr)	1704.45	1776.60	1633.55	1613.05
P. Bandeja (gr)	110.75	112.37	133.03	131.10
P. Suelo S.S.S. (gr)	1593.70	1664.23	1500.52	1481.95
P. Suelo S.S.S. + Cesta Sum. (gr)	1751.20	1799.90	1699.00	1686.90
P. Cesta Sumergida (gr)	755.40	755.40	755.40	755.40
P. Suelo S.S.S. Sum (gr)	995.80	1044.50	943.60	931.50
P. Suelo Seco + Bandeja (gr)	1667.95	1743.00	1598.68	1580.62
P. Suelo Seco (gr)	1557.20	1630.63	1465.65	1449.52
Volumen Suelo S.S.S. (cm^3)	597.90	619.73	556.92	550.45
Gs	**2.6044489**	**2.63119423**	**2.63170653**	**2.63333636**
Agua Absorbida (gr)	36.50	33.60	34.87	32.43
w (%)	2.34%	2.06%	2.38%	2.24%

A.2.2.3 Densidad del Conjunto Volumétrico

Gs Grava	2.63	Gs Arena	2.78	Peso Inicial (gr)	11866.00			
D (mm)	**Pas. Acumulado (%)**	**Ret. Acumulado (%)**	**Por. Retenido (%)**	**P. Retenido (gr)**	**V. Retenido (cm^3)**	**Por. Retenido (%)**	**Ret. Acumulado (%)**	**Pas. Acumulado (%)**
75.0000	100.00%	0.00%	0.00%	0.00	0.00	0.00%	0.00%	100.00%
50.0000	95.88%	4.12%	4.12%	489.03	186.28	4.20%	4.20%	95.80%
37.5000	93.87%	6.13%	2.01%	237.97	90.65	2.05%	6.25%	93.75%
25.0000	87.18%	12.82%	6.70%	794.50	302.65	6.83%	13.08%	86.92%
19.0000	80.04%	19.96%	7.14%	846.65	322.51	7.28%	20.35%	79.65%
9.5000	62.77%	37.23%	17.27%	2049.28	780.63	17.61%	37.97%	62.03%
4.7500	47.96%	52.04%	14.82%	1757.98	669.66	15.11%	53.08%	46.92%
2.0000	34.59%	65.41%	13.37%	1586.46	604.33	13.64%	66.71%	33.29%
0.8500	25.51%	74.49%	9.07%	1076.65	387.00	8.73%	75.45%	24.55%
0.4250	17.19%	82.81%	8.32%	987.73	355.03	8.01%	83.46%	16.54%
0.2500	13.47%	86.53%	3.72%	441.19	158.59	3.58%	87.04%	12.96%
0.1060	11.06%	88.94%	2.42%	286.61	103.02	2.32%	89.36%	10.64%
0.0750	10.73%	89.27%	0.33%	38.99	14.01	0.32%	89.68%	10.32%
0.0480	8.85%	91.15%	1.88%	222.54	79.99	1.80%	91.48%	8.52%
0.0341	8.40%	91.60%	0.45%	53.37	19.19	0.43%	91.91%	8.09%
0.0280	7.95%	92.05%	0.45%	53.37	19.19	0.43%	92.35%	7.65%
0.0243	7.95%	92.05%	0.00%	0.00	0.00	0.00%	92.35%	7.65%
0.0173	7.05%	92.95%	0.90%	106.75	38.37	0.87%	93.21%	6.79%
0.0127	6.60%	93.40%	0.45%	53.37	19.19	0.43%	93.65%	6.35%
0.0091	5.25%	94.75%	1.35%	160.12	57.56	1.30%	94.94%	5.06%
0.0065	4.35%	95.65%	0.90%	106.75	38.37	0.87%	95.81%	4.19%
0.0046	3.45%	96.55%	0.90%	106.75	38.37	0.87%	96.68%	3.32%
0.0033	3.40%	96.60%	0.06%	6.99	2.51	0.06%	96.73%	3.27%
0.0023	2.50%	97.50%	0.90%	106.74	38.37	0.87%	97.60%	2.40%
0.0014	1.71%	98.29%	0.78%	92.81	33.36	0.75%	98.35%	1.65%
Bandeja	0.00%	100.00%	1.71%	203.39	73.11	1.65%	100.00%	0.00%
Gs Mezcla	**2.68**		Total	11866.00	4431.92		**Fracción Gruesa (%)**	**66.71%**
							Fracción Fina (%)	**33.29%**

A.2.3 Ensayo Triaxial

ENSAYO TRIAXIAL CONSOLIDADO NO DRENADO (CU) NTP 339.166 (ASTM D 4767)

Solicitante TESIS FRANK EDUARDO ESCUSA AROSQUIPA	Expediente **14-253**
Proyecto FLUJOS ESCOMBROS MARANURA-LA CONVENCION-CUZCO	
Muestra Profundidad 1.50 m	Fecha : 19 Mov 2014

CARACTERISTICAS DE LOS ESPECIMENES

Tipo de muestra: Inalterada
Peso esp. solidos Gs: 2.78

Especimen		A	B	C
Diámetro	cm	10.00	10.00	10.00
Altura	cm	20.00	20.00	20.00
Humedad inicial		6.8%	5.9%	6.7%
Humedad final		11.1%	11.0%	11.0%
Saturacion inicial		43.6%	40.0%	40.8%
Saturación final		100.0%	100.0%	100.0%
Relacion de vacios	e	0.44	0.41	0.45
Porosidad	n	30.3%	29.2%	31.2%
Densidad inicial	g/cm³	2.07	2.09	2.04
Densidad final	g/cm³	2.15	2.19	2.12
Densidad seca	g/cm³	1.94	1.97	1.91
Presión de cámara	kg/cm²	7.00	8.00	10.00
Contra presión	kg/cm²	6.00	6.00	6.00
Coeficiente de poros	B	0.99	0.99	0.99

PONTIFICIA UNIVERSIDAD CATÓLICA DEL PERÚ
LABORATORIO DE MECÁNICA DE SUELOS

MANUEL A. OLCESE FRANZER
Ingeniero Civil CIP 12969
Jefe del Laboratorio

Av. Universitaria 1801, San Miguel. Telefono: 6262000 Anexo 4561. suelos@pucp.edu.pe

ENSAYO TRIAXIAL CONSOLIDADO NO DRENADO (CU) NTP 339.166 (ASTM D 4767)

Solicitante TESIS FRANK EDUARDO ESCUSA AROSQUIPA	Expediente **14-253**
Proyecto FLUJOS ESCOMBROS MARANURA-LA CONVENCION-CUZCO	
Muestra Profundidad 1.50 m	Fecha : 19 Mov 2014

CARACTERISTICAS DE LOS ESPECIMENES EN LA FALLA

FALLA DEFINIDA CONFORME A LA NORMA NTP 339.166 (ASTM D 4767)

Especimen		A	B	C
MAXIMA RELACION DE TENSIONES				
σ'_1/σ'_3 máximo		3.43	3.44	3.17
σ'_1	kg/cm²	0.56	1.61	3.28
σ'_3	kg/cm²	0.16	0.47	1.03
u	kg/cm²	0.86	1.57	3.04
ε	%	2.00	15.00	15.00
A_f		2.14	1.37	1.35
MAXIMO ESFUERZO DESVIADOR				
$\sigma'_1 - \sigma'_3$ máximo	k	0.57	1.13	2.23
σ'_1	k	0.85	3.18	6.33
σ'_3	k	0.28	0.47	1.03
u	k	0.73	1.57	3.04
ε	%	15.00	15.00	15.00
A_f		1.30	1.40	1.37

PONTIFICIA UNIVERSIDAD CATÓLICA DEL PERÚ
LABORATORIO DE MECÁNICA DE SUELOS

MANUEL A. OLCESE FRANZERO
Ingeniero Civil CIP 12969
Jefe del Laboratorio

Av. Universitaria 1801, San Miguel. Telefono: 6262000 Anexo 4561. suelos@pucp.edu.pe

ENSAYO TRIAXIAL CONSOLIDADO NO DRENADO (CU) NTP 339.166 (ASTM D 4767)

Solicitante TESIS FRANK EDUARDO ESCUSA AROSQUIPA	Expediente **14-253**
Proyecto FLUJOS ESCOMBROS MARANURA-LA CONVENCION-CUZCO	
Muestra Profundidad 1.50 m	Fecha : 19 Nov 2014

Especimen A

ε %	$\sigma_1 - \sigma_3$ kg/cm²	u kg/cm²	σ'_3 kg/cm²	σ'_1 kg/cm²	σ'_1/σ'_3	p' kg/cm²	q kg/cm²
0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00
0.10	0.38	0.29	0.73	1.11	1.52	0.92	0.19
0.20	0.47	0.47	0.55	1.03	1.86	0.79	0.24
0.30	0.50	0.57	0.45	0.96	2.11	0.70	0.25
0.40	0.50	0.64	0.38	0.89	2.31	0.64	0.25
0.50	0.48	0.70	0.32	0.80	2.47	0.56	0.24
0.60	0.48	0.73	0.28	0.76	2.67	0.52	0.24
0.80	0.47	0.78	0.24	0.71	2.93	0.47	0.23
1.00	0.44	0.81	0.21	0.65	3.11	0.43	0.22
1.20	0.43	0.83	0.19	0.62	3.27	0.41	0.22
1.40	0.41	0.84	0.18	0.59	3.24	0.39	0.20
1.60	0.40	0.85	0.17	0.57	3.37	0.37	0.20
1.80	0.40	0.85	0.17	0.57	3.36	0.37	0.20
2.00	0.40	0.86	0.16	0.56	3.43	0.36	0.20
2.38	0.40	0.86	0.16	0.56	3.42	0.36	0.20
2.75	0.37	0.85	0.17	0.54	3.19	0.36	0.19
3.13	0.36	0.84	0.18	0.54	3.01	0.36	0.18
3.50	0.35	0.84	0.18	0.53	2.91	0.36	0.17
3.88	0.33	0.83	0.19	0.52	2.75	0.35	0.16
4.25	0.33	0.83	0.19	0.52	2.72	0.35	0.16
4.63	0.33	0.82	0.20	0.52	2.68	0.36	0.16
5.00	0.33	0.81	0.21	0.54	2.57	0.37	0.16
5.38	0.33	0.81	0.21	0.54	2.54	0.38	0.17
5.75	0.34	0.81	0.21	0.55	2.59	0.38	0.17
6.13	0.35	0.81	0.21	0.56	2.64	0.39	0.18
6.50	0.36	0.81	0.21	0.58	2.69	0.40	0.18
6.88	0.36	0.80	0.22	0.58	2.62	0.40	0.18
7.25	0.36	0.79	0.23	0.58	2.58	0.41	0.18
7.63	0.36	0.79	0.23	0.59	2.56	0.41	0.18

(Continua.....)

LABORATORIO DE MECÁNICA DE SUELOS

MANUEL A. OLCESE FRANZERO
Ingeniero Civil CIP 12969
Jefe del Laboratorio

Av. Universitaria 1801, San Miguel. Telefono: 6262000 Anexo 4561. suelos@pucp.edu.pe

ENSAYO TRIAXIAL CONSOLIDADO NO DRENADO (CU) NTP 339.166 (ASTM D 4767)

Solicitante TESIS FRANK EDUARDO ESCUSA AROSQUIPA	Expediente **14-253**
Proyecto FLUJOS ESCOMBROS MARANURA-LA CONVENCION-CUZCO	
Muestra Profundidad 1.50 m	Fecha : 19 Nov 2014

Especimen A

ε %	$\sigma_1 - \sigma_3$ kg/cm²	u kg/cm²	σ'_3 kg/cm²	σ'_1 kg/cm²	σ'_1/σ'_3	p' kg/cm²	q kg/cm²
8.00	0.37	0.79	0.23	0.60	2.61	0.42	0.19
8.38	0.37	0.79	0.23	0.60	2.60	0.42	0.19
8.75	0.38	0.79	0.23	0.61	2.65	0.42	0.19
9.13	0.39	0.79	0.23	0.63	2.70	0.43	0.20
9.50	0.40	0.79	0.23	0.63	2.74	0.43	0.20
9.88	0.42	0.78	0.24	0.67	2.73	0.45	0.21
10.25	0.43	0.78	0.24	0.68	2.78	0.46	0.22
10.63	0.45	0.77	0.25	0.70	2.82	0.48	0.23
11.00	0.47	0.77	0.25	0.72	2.87	0.48	0.23
11.38	0.47	0.77	0.25	0.72	2.87	0.48	0.23
11.75	0.46	0.77	0.25	0.72	2.83	0.48	0.23
12.13	0.47	0.76	0.26	0.73	2.81	0.50	0.24
12.50	0.49	0.75	0.27	0.75	2.82	0.51	0.24
12.88	0.51	0.75	0.27	0.78	2.90	0.52	0.25
13.25	0.53	0.75	0.27	0.79	2.97	0.53	0.26
13.63	0.53	0.74	0.28	0.81	2.91	0.55	0.27
14.00	0.56	0.73	0.28	0.84	2.95	0.56	0.28
14.38	0.56	0.73	0.28	0.84	2.96	0.56	0.28
14.75	0.57	0.73	0.28	0.85	2.98	0.57	0.28
15.13	0.58	0.73	0.28	0.86	3.03	0.57	0.29
15.50	0.59	0.73	0.28	0.88	3.09	0.58	0.30
15.88	0.59	0.73	0.28	0.88	3.08	0.58	0.30
16.25	0.59	0.73	0.28	0.88	3.09	0.58	0.30
16.63	0.61	0.73	0.28	0.89	3.13	0.59	0.30
17.00	0.62	0.73	0.29	0.92	3.12	0.60	0.31
17.75	0.61	0.73	0.29	0.90	3.13	0.60	0.31
18.50	0.62	0.72	0.30	0.92	3.09	0.61	0.31
19.25	0.64	0.72	0.30	0.94	3.12	0.62	0.32
20.00	0.65	0.72	0.30	0.95	3.14	0.63	0.32

PONTIFICIA UNIVERSIDAD CATÓLICA DEL PERÚ
LABORATORIO DE MECÁNICA DE SUELOS

MANUEL A. OLCESE FRANZERO
Ingeniero Civil CIP 12969
Jefe del Laboratorio

Av. Universitaria 1801, San Miguel. Telefono: 6262000 Anexo 4561. suelos@pucp.edu.pe

ENSAYO TRIAXIAL CONSOLIDADO NO DRENADO (CU) NTP 339.166 (ASTM D 4767)

Solicitante TESIS FRANK EDUARDO ESCUSA AROSQUIPA	Expediente **14-253**
Proyecto FLUJOS ESCOMBROS MARANURA-LA CONVENCION-CUZCO	
Muestra Profundidad 1.50 m	Fecha : 19 Nov 2014

Especimen B

ε %	$\sigma_1 - \sigma_3$ kg/cm²	u kg/cm²	σ'_3 kg/cm²	σ'_1 kg/cm²	σ'_1/σ'_3	p' kg/cm²	q kg/cm²
0.00	0.00	0.00	2.00	2.00	1.00	2.00	0.00
0.10	0.08	0.20	1.84	1.92	1.04	1.88	0.04
0.20	0.25	0.33	1.71	1.96	1.15	1.84	0.12
0.30	0.42	0.42	1.62	2.04	1.26	1.83	0.21
0.40	0.60	0.52	1.52	2.12	1.40	1.82	0.30
0.50	0.71	0.61	1.43	2.14	1.50	1.79	0.36
0.60	0.82	0.70	1.34	2.15	1.61	1.75	0.41
0.80	0.91	0.86	1.18	2.09	1.77	1.63	0.45
1.00	0.92	0.99	1.05	1.97	1.88	1.51	0.46
1.20	0.92	1.14	0.90	1.82	2.02	1.36	0.46
1.40	0.91	1.26	0.78	1.70	2.17	1.24	0.46
1.60	0.90	1.36	0.68	1.59	2.32	1.13	0.45
1.80	0.89	1.43	0.61	1.50	2.45	1.06	0.44
2.00	0.88	1.47	0.57	1.44	2.55	1.01	0.44
2.38	0.86	1.52	0.51	1.38	2.68	0.95	0.43
2.75	0.86	1.55	0.49	1.35	2.77	0.92	0.43
3.13	0.85	1.57	0.47	1.32	2.82	0.90	0.43
3.50	0.85	1.58	0.46	1.31	2.85	0.88	0.42
3.88	0.85	1.59	0.45	1.30	2.87	0.87	0.42
4.25	0.84	1.59	0.45	1.29	2.89	0.87	0.42
4.63	0.84	1.60	0.44	1.28	2.89	0.86	0.42
5.00	0.84	1.59	0.44	1.28	2.89	0.86	0.42
5.38	0.86	1.59	0.45	1.30	2.92	0.87	0.43
5.75	0.87	1.60	0.44	1.31	2.96	0.88	0.43
6.13	0.87	1.60	0.44	1.32	2.98	0.88	0.44
6.50	0.88	1.60	0.44	1.33	3.00	0.88	0.44
6.88	0.90	1.59	0.44	1.34	3.02	0.89	0.45
7.25	0.91	1.59	0.45	1.36	3.04	0.90	0.46
7.63	0.93	1.59	0.45	1.37	3.07	0.91	0.46

(Continua.....)

LABORATORIO DE MECÁNICA DE SUELOS

MANUEL A. OLCESE FRANZERO
Ingeniero Civil CIP 12969
Jefe del Laboratorio

ENSAYO TRIAXIAL CONSOLIDADO NO DRENADO (CU) NTP 339.166 (ASTM D 4767)

Solicitante TESIS FRANK EDUARDO ESCUSA AROSQUIPA — Expediente **14-253**

Proyecto FLUJOS ESCOMBROS MARANURA-LA CONVENCION-CUZCO

Muestra — Profundidad 1.50 m — Fecha : 19 Mov 2014

Especimen B

ε %	$\sigma_1 - \sigma_3$ kg/cm²	u kg/cm²	σ'_3 kg/cm²	σ'_1 kg/cm²	σ'_1/σ'_3	p' kg/cm²	q kg/cm²
8.00	0.94	1.59	0.45	1.39	3.10	0.92	0.47
8.38	0.95	1.60	0.44	1.39	3.17	0.91	0.47
8.75	0.96	1.60	0.44	1.40	3.20	0.92	0.48
9.13	0.97	1.60	0.44	1.41	3.22	0.92	0.49
9.50	0.99	1.60	0.44	1.42	3.25	0.93	0.49
9.88	1.00	1.60	0.44	1.44	3.26	0.94	0.50
10.25	1.01	1.59	0.45	1.45	3.26	0.95	0.50
10.63	1.01	1.59	0.45	1.46	3.26	0.95	0.51
11.00	1.02	1.59	0.45	1.47	3.28	0.96	0.51
11.38	1.03	1.59	0.45	1.49	3.28	0.97	0.52
11.75	1.04	1.59	0.45	1.49	3.29	0.97	0.52
12.13	1.04	1.58	0.46	1.50	3.27	0.98	0.52
12.50	1.05	1.58	0.46	1.51	3.29	0.98	0.53
12.88	1.06	1.58	0.46	1.52	3.32	0.99	0.53
13.25	1.07	1.58	0.46	1.53	3.34	0.99	0.54
13.63	1.08	1.58	0.46	1.54	3.34	1.00	0.54
14.00	1.09	1.57	0.46	1.56	3.35	1.01	0.55
14.38	1.11	1.57	0.47	1.58	3.39	1.02	0.56
14.75	1.13	1.57	0.47	1.59	3.40	1.03	0.56
15.13	1.13	1.57	0.47	1.60	3.41	1.04	0.57
15.50	1.14	1.57	0.47	1.61	3.44	1.04	0.57
15.88	1.16	1.57	0.47	1.63	3.49	1.05	0.58
16.25	1.17	1.58	0.46	1.63	3.55	1.05	0.59
16.63	1.19	1.58	0.46	1.65	3.57	1.05	0.59
17.00	1.20	1.57	0.47	1.66	3.57	1.06	0.60
17.75	1.21	1.57	0.46	1.67	3.60	1.07	0.60
18.50	1.23	1.57	0.47	1.70	3.62	1.08	0.61
19.25	1.25	1.57	0.47	1.72	3.66	1.09	0.62
20.00	1.27	1.57	0.47	1.74	3.70	1.10	0.6

LABORATORIO DE MECÁNICA DE SUELOS

MANUEL A. OLCESE FRANZERO
Ingeniero Civil CIP 12969
Jefe del Laboratorio

Av. Universitaria 1801, San Miguel. Telefono: 6262000 Anexo 4561 suelos@pucp.edu.pe

ENSAYO TRIAXIAL CONSOLIDADO NO DRENADO (CU) NTP 339.166 (ASTM D 4767)

Solicitante TESIS FRANK EDUARDO ESCUSA AROSQUIPA	Expediente **14-253**
Proyecto FLUJOS ESCOMBROS MARANURA-LA CONVENCION-CUZCO	
Muestra Profundidad 1.50 m	Fecha : 19 Nov 2014

Especimen C

ε %	$\sigma_1 - \sigma_3$ kg/cm²	u kg/cm²	σ'_3 kg/cm²	σ'_1 kg/cm²	σ'_1/σ'_3	p' kg/cm²	q kg/cm²
0.00	0.00	0.00	4.00	4.00	1.00	4.00	0.00
0.10	0.40	0.24	3.83	4.24	1.11	4.04	0.20
0.20	0.66	0.40	3.68	4.33	1.18	4.00	0.33
0.30	0.93	0.54	3.53	4.46	1.26	4.00	0.46
0.40	1.19	0.73	3.35	4.54	1.36	3.95	0.59
0.50	1.36	0.88	3.20	4.56	1.43	3.88	0.68
0.60	1.53	1.06	3.02	4.55	1.51	3.78	0.76
0.80	1.75	1.39	2.69	4.44	1.65	3.56	0.88
1.00	1.94	1.67	2.41	4.35	1.80	3.38	0.97
1.20	2.11	2.00	2.08	4.20	2.01	3.14	1.06
1.40	2.25	2.26	1.82	4.07	2.23	2.95	1.12
1.60	2.26	2.47	1.61	3.87	2.40	2.74	1.13
1.80	2.25	2.63	1.44	3.69	2.56	2.57	1.12
2.00	2.21	2.73	1.35	3.56	2.64	2.45	1.11
2.38	2.17	2.85	1.23	3.40	2.76	2.31	1.08
2.75	2.13	2.92	1.16	3.29	2.83	2.23	1.07
3.13	2.10	2.96	1.11	3.21	2.88	2.16	1.05
3.50	2.08	2.99	1.09	3.17	2.91	2.13	1.04
3.88	2.07	3.01	1.07	3.13	2.93	2.10	1.03
4.25	2.06	3.03	1.05	3.11	2.96	2.08	1.03
4.63	2.05	3.04	1.04	3.09	2.97	2.07	1.02
5.00	2.04	3.04	1.04	3.08	2.97	2.06	1.02
5.38	2.04	3.04	1.04	3.08	2.97	2.06	1.02
5.75	2.04	3.05	1.03	3.07	2.99	2.05	1.02
6.13	2.05	3.05	1.03	3.07	3.00	2.05	1.02
6.50	2.05	3.05	1.03	3.08	3.00	2.05	1.03
6.88	2.05	3.05	1.03	3.08	3.00	2.05	1.03
7.25	2.06	3.05	1.03	3.09	3.01	2.06	1.03
7.63	2.07	3.05	1.03	3.10	3.02	2.06	1.03

(Continua.....)

UNIVERSIDAD CATÓLICA DEL PERÚ — LABORATORIO DE MECÁNICA DE SUELOS

MANUEL A. OLCESE FRA ZERO
Ingeniero Civil CIP 12969
Jefe del Laboratorio

Av. Universitaria 1801, San Miguel. Telefono: 6262000 Anexo 4561. suelos@pucp.edu.pe

ENSAYO TRIAXIAL CONSOLIDADO NO DRENADO (CU) NTP 339.166 (ASTM D 4767)

Solicitante TESIS FRANK EDUARDO ESCUSA AROSQUIPA	Expediente **14-253**
Proyecto FLUJOS ESCOMBROS MARANURA-LA CONVENCION-CUZCO	
Muestra Profundidad 1.50 m	Fecha : 19 Nov 2014

Especimen C

ε %	$\sigma_1 - \sigma_3$ kg/cm²	u kg/cm²	σ'_3 kg/cm²	σ'_1 kg/cm²	σ'_1/σ'_3	p' kg/cm²	q kg/cm²
8.00	2.08	3.05	1.03	3.11	3.03	2.07	1.04
8.38	2.09	3.07	1.01	3.09	3.08	2.05	1.04
8.75	2.09	3.07	1.01	3.10	3.08	2.05	1.05
9.13	2.10	3.07	1.01	3.11	3.09	2.06	1.05
9.50	2.12	3.07	1.01	3.12	3.11	2.06	1.06
9.88	2.12	3.07	1.01	3.13	3.11	2.07	1.06
10.25	2.14	3.07	1.01	3.15	3.11	2.08	1.07
10.63	2.16	3.06	1.02	3.17	3.12	2.09	1.08
11.00	2.16	3.06	1.02	3.18	3.13	2.10	1.08
11.38	2.16	3.05	1.02	3.19	3.11	2.11	1.08
11.75	2.17	3.05	1.02	3.19	3.11	2.11	1.08
12.13	2.17	3.05	1.03	3.20	3.12	2.11	1.09
12.50	2.18	3.05	1.03	3.21	3.13	2.12	1.09
12.88	2.18	3.05	1.03	3.21	3.13	2.12	1.09
13.25	2.19	3.05	1.03	3.22	3.14	2.12	1.10
13.63	2.19	3.05	1.03	3.22	3.13	2.12	1.09
14.00	2.20	3.05	1.03	3.22	3.14	2.12	1.10
14.38	2.21	3.05	1.03	3.24	3.15	2.14	1.11
14.75	2.23	3.04	1.03	3.26	3.15	2.15	1.11
15.13	2.24	3.04	1.04	3.27	3.16	2.16	1.12
15.50	2.25	3.04	1.03	3.28	3.17	2.16	1.12
15.88	2.26	3.04	1.03	3.29	3.18	2.16	1.13
16.25	2.15	3.06	1.02	3.16	3.11	2.09	1.07
16.63	2.17	3.06	1.02	3.18	3.13	2.10	1.08
17.00	2.20	3.05	1.02	3.22	3.14	2.12	1.10
17.75	2.21	3.05	1.02	3.23	3.16	2.13	1.10
18.50	2.23	3.05	1.03	3.25	3.17	2.14	1.11
19.25	2.24	3.05	1.03	3.27	3.19	2.15	1.12
20.00	2.23	3.05	1.03	3.26	3.17	2.14	1.1

LABORATORIO DE MECÁNICA DE SUELOS

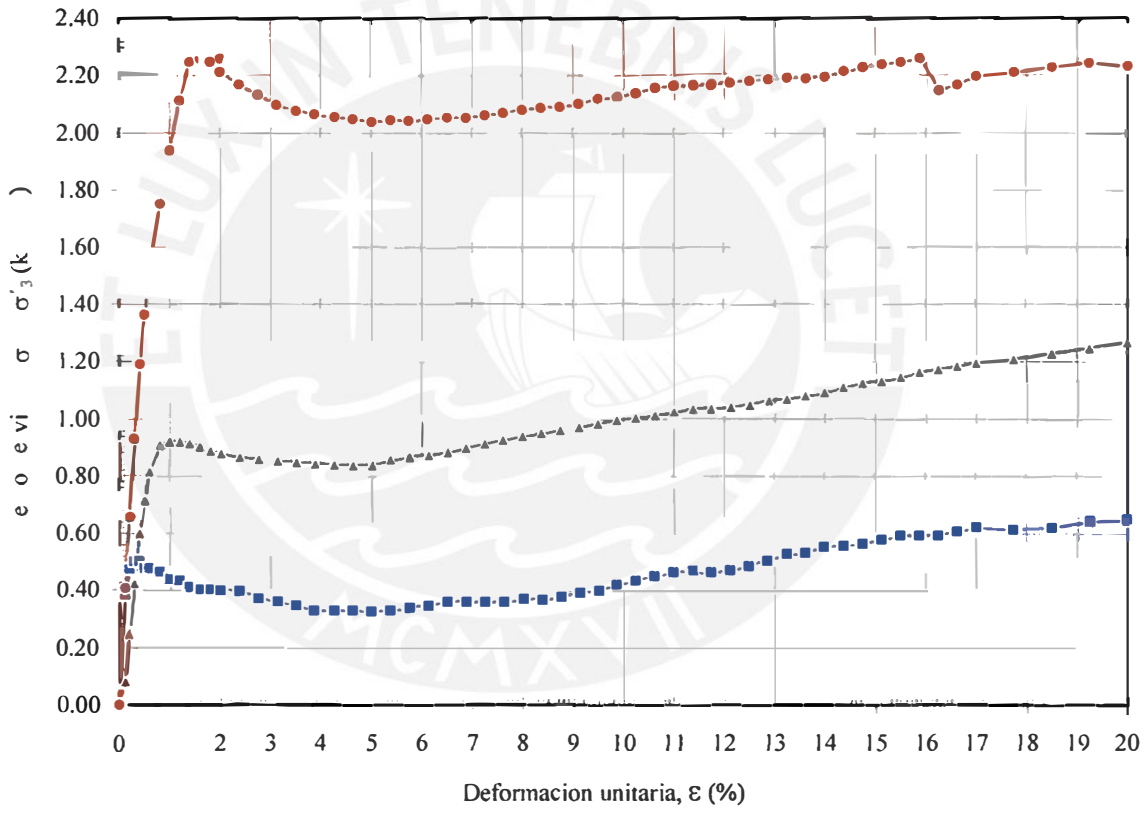
MANUEL A. OLCESE FRANZERO
Ingeniero Civil CIP 12969
Jefe del Laboratorio

Av. Universitaria 1801, San Miguel. Telefono: 6262000 Anexo 4561. suelos@pucp.edu.pe

ENSAYO TRIAXIAL CONSOLIDADO NO DRENADO (CU) NTP 339.166 (ASTM D 4767)

Solicitante	TESIS FRANK EDUARDO ESCUSA AROSQUIPA	Expediente	14-253
Proyecto	FLUJOS ESCOMBROS MARANURA-LA CONVENCION-CUZCO		
Muestra	Profundidad 1.50 m	Fecha	: 19 Mov 2014

DEFORMACIÓN vs ESFUERZO DESVIADOR (ε vs $\sigma'_1 - \sigma'_3$)



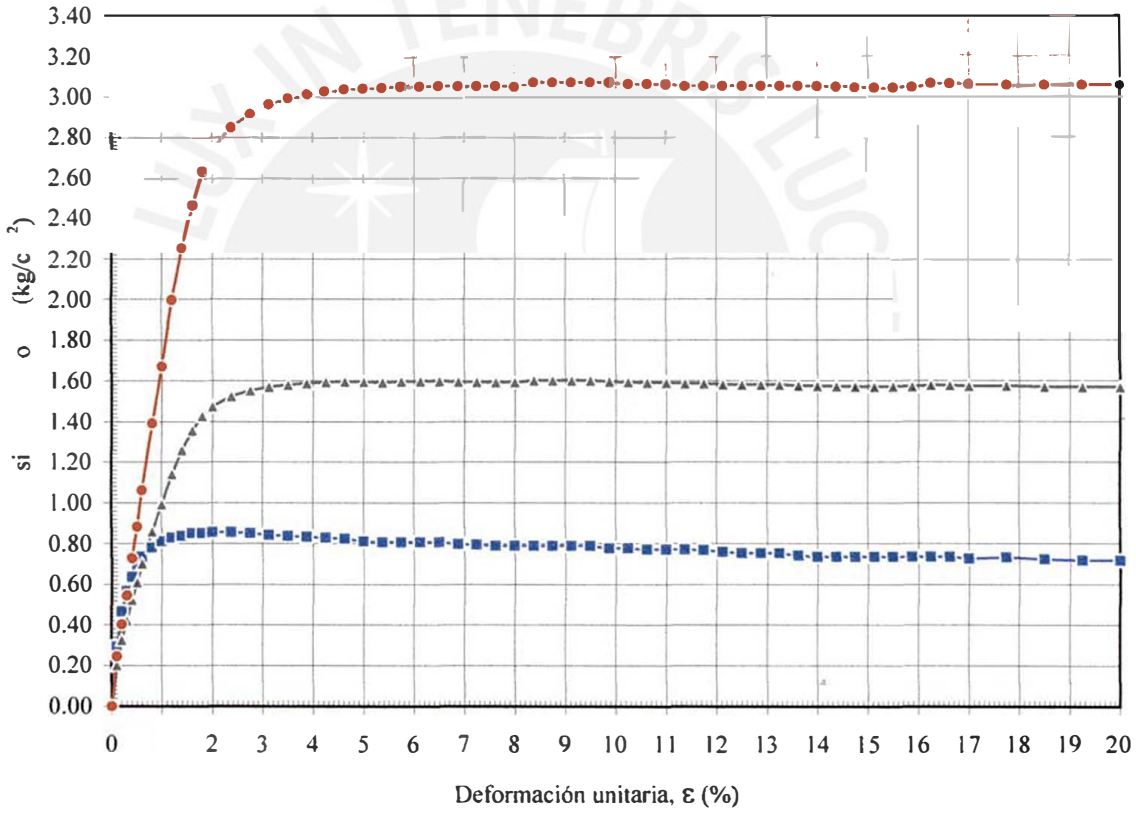
MANUEL A. OLCESE FRANZERO
Ingeniero Civil CIP 12969
Jefe del Laboratorio

Av. Universitaria 1801, San Miguel. Telefono: 6262000 Anexo 4561. suelos@pucp.edu.pe

ENSAYO TRIAXIAL CONSOLIDADO NO DRENADO (CU) NTP 339.166 (ASTM D 4767)

Solicitante TESIS FRANK EDUARDO ESCUSA AROSQUIPA	Expediente **14-253**
Proyecto FLUJOS ESCOMBROS MARANURA-LA CONVENCION-CUZCO	
Muestra Profundidad 1.50 m	Fecha : 19 Mov 2014

DEFORMACIÓN vs PRESIÓN DE POROS (ε vs u)



UNIVERSIDAD CATÓLICA DEL PERÚ – LABORATORIO DE MECÁNICA DE SUELOS

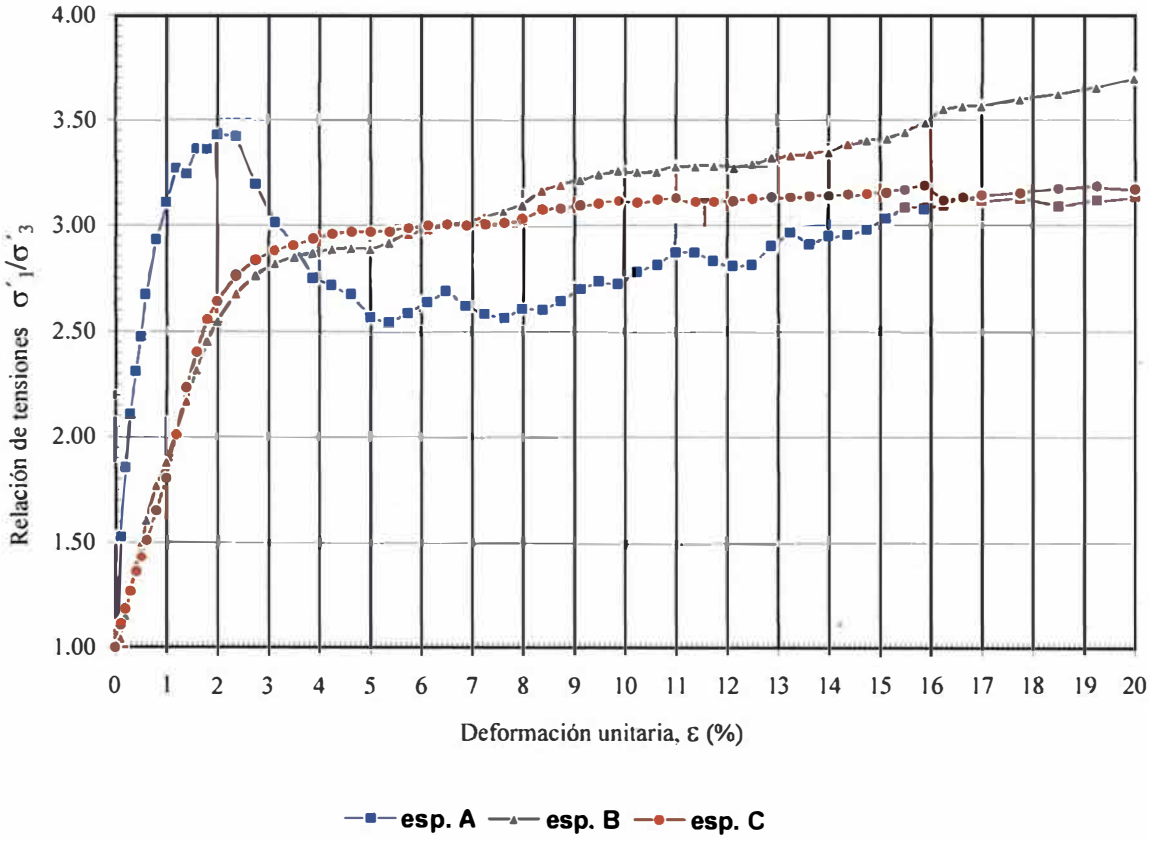
MANUEL A. OLCESE FRANZERO
Ingeniero Civil CIP 12969
Jefe del Laboratorio

Av. Universitaria 1801, San Miguel. Telefono: 6262000 Anexo 4561. suelos@pucp.edu.pe

ENSAYO TRIAXIAL CONSOLIDADO NO DRENADO (CU) NTP 339.166 (ASTM D 4767)

Solicitante TESIS FRANK EDUARDO ESCUSA AROSQUIPA	Expediente **14-253**
Proyecto FLUJOS ESCOMBROS MARANURA-LA CONVENCION-CUZCO	
Muestra Profundidad 1.50 m	Fecha : 19 Mov 2014

DEFORMACIÓN vs RELACIÓN DE TENSIONES (ε vs σ'_1/σ'_3)



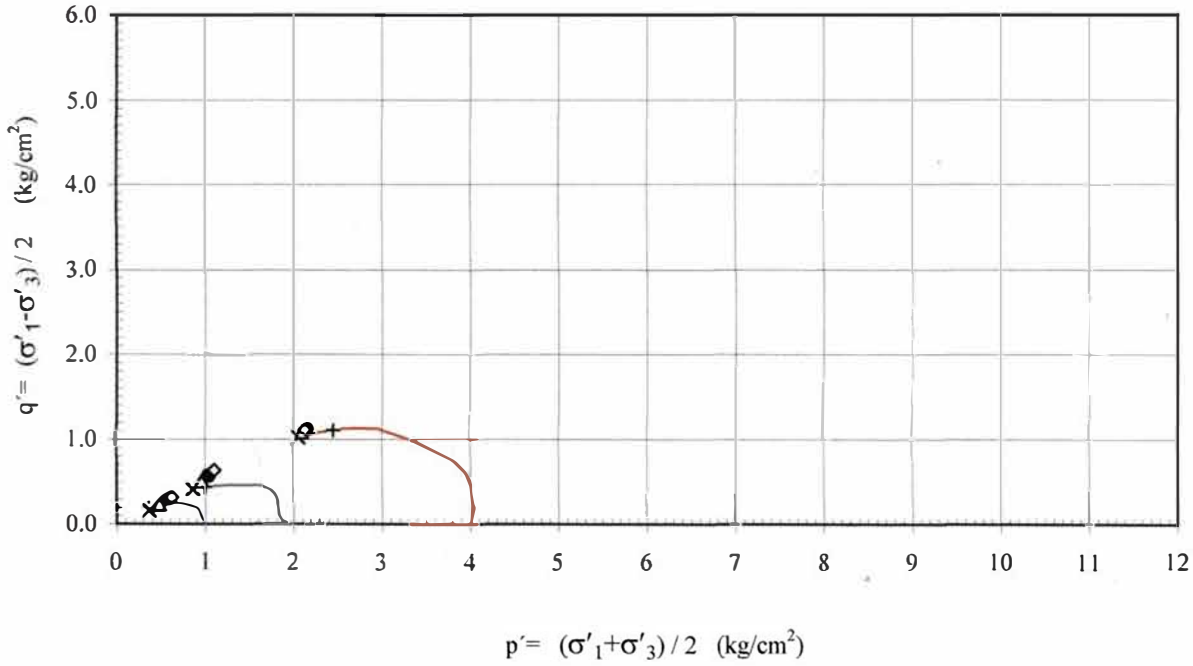
MANUEL A. OLCESE FRANZERO
Ingeniero Civil CIP 12969
Jefe del Laboratorio

Av. Universitaria 1801, San Miguel. Telefono: 6262000 Anexo 4561. suelos@pucp.edu.pe

ENSAYO TRIAXIAL CONSOLIDADO NO DRENADO (CU) NTP 339.166 (ASTM D 4767)

Solicitante TESIS FRANK EDUARDO ESCUSA AROSQUIPA	Expediente **14-253**
Proyecto FLUJOS ESCOMBROS MARANURA-LA CONVENCION-CUZCO	
Muestra Profundidad 1.50 m	Fecha : 19 Nov 2014

TRAYECTORIA DE TENSIONES



esp. A esp. B esp. C + 2.5% × 5% △ 10% ● 15% ◇ 20%

UNIVERSIDAD CATÓLICA DEL PERÚ
LABORATORIO DE MECÁNICA DE SUELOS

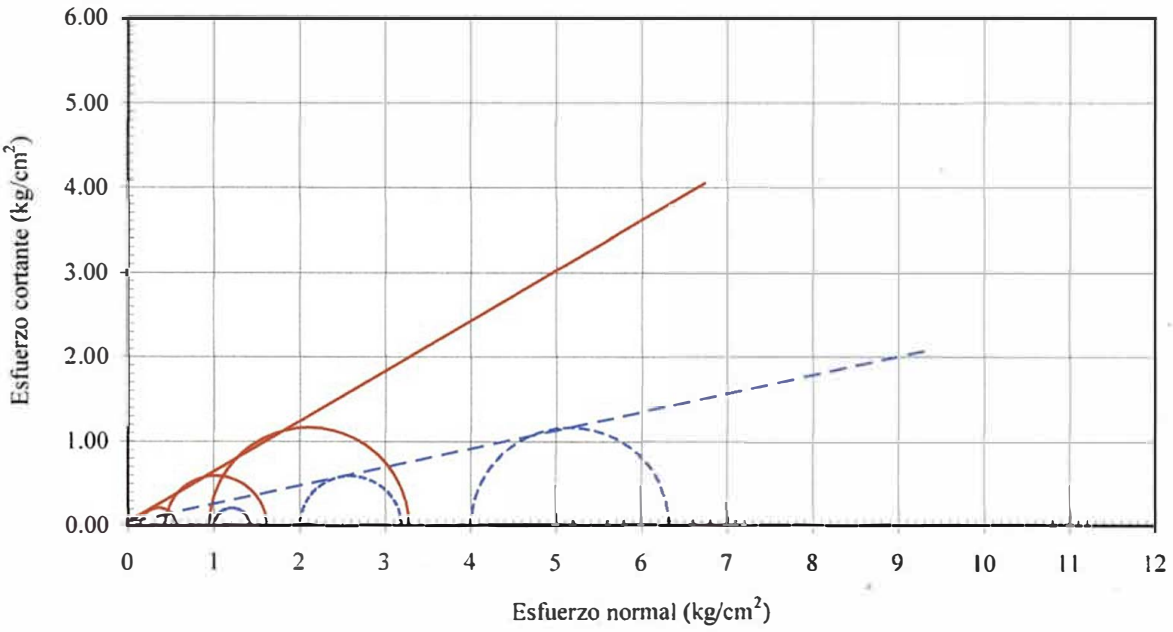
MANUEL A. OLCESE FRANZERO
Ingeniero Civil CIP 12969
Jefe del Laboratorio

Av. Universitaria 1801, San Miguel. Telefono: 6262000 Anexo 4561. suelos@pucp.edu.pe

ENSAYO TRIAXIAL CONSOLIDADO NO DRENADO (CU) NTP 339.166 (ASTM D 4767)

Solicitante TESIS FRANK EDUARDO ESCUSA AROSQUIPA	Expediente **14-253**
Proyecto FLUJOS ESCOMBROS MARANURA-LA CONVENCION-CUZCO	
Muestra Profundidad 1.50 m	Fecha : 19 Nov 2014

ENVOLVENTE DE FALLA - RELACIÓN DE TENSIONES MÁXIMA



c = 0.05 kg/cm² Ø = 12°

c' = 0.05 kg/cm² Ø' = 31°

UNIVERSIDAD CATÓLICA DEL PERÚ
LABORATORIO DE MECÁNICA DE SUELOS

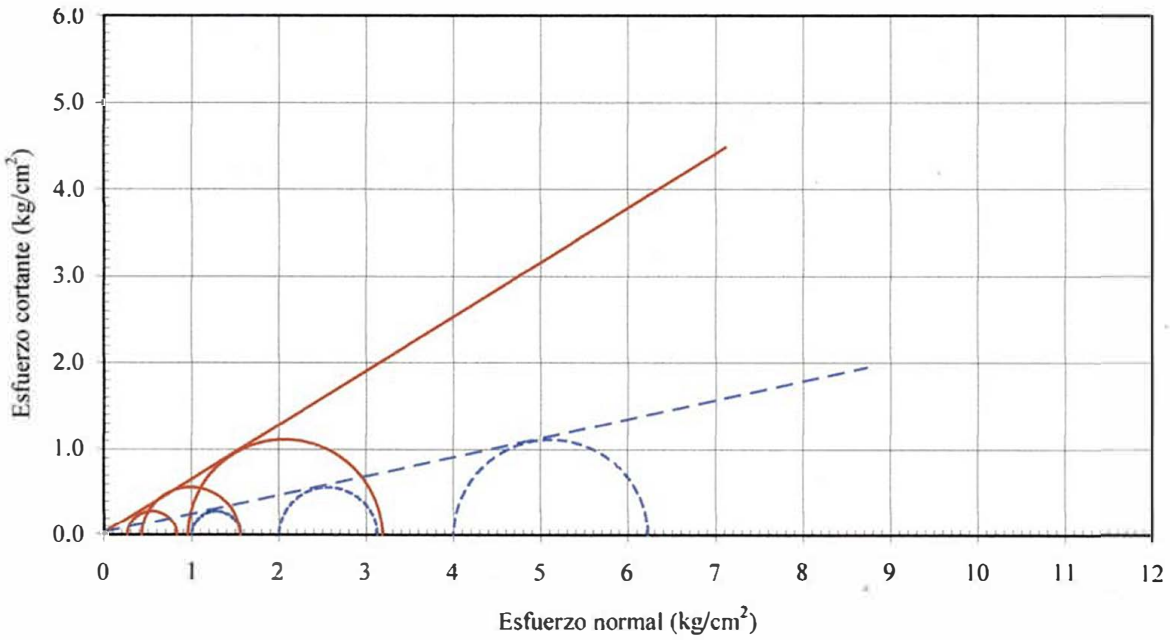
MANUEL A. OLCESE FRANZERO
Ingeniero Civil CIP 12969
Jefe del Laboratorio

Av. Universitaria 1801, San Miguel. Telefono: 6262000 Anexo 4561. suelos@pucp.edu.pe

ENSAYO TRIAXIAL CONSOLIDADO NO DRENADO (CU) NTP 339.166 (ASTM D 4767)

Solicitante TESIS FRANK EDUARDO ESCUSA AROSQUIPA	Expediente **14-253**
Proyecto FLUJOS ESCOMBROS MARANURA-LA CONVENCION-CUZCO	
Muestra Profundidad 1.50 m	Fecha : 19 Mov 2014

ENVOLVENTE DE FALLA - ESFUERZO DESVIADOR MÁXIMO



σ1 – σ3 σ'1 – σ'3

c = 0.03 kg/cm² Ø = 12°

c' = 0.03 kg/cm² Ø' = 32°

PONTIFICIA UNIVERSIDAD CATÓLICA DEL PERÚ
LABORATORIO DE MECÁNICA DE SUELOS

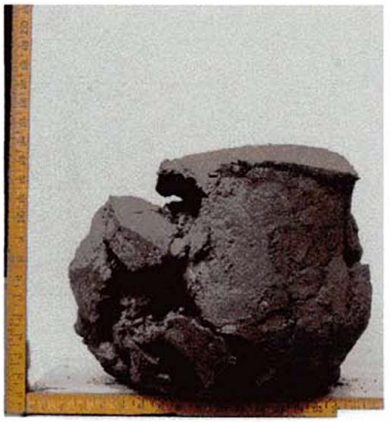
MANUEL A. OLCESE FRANZERO
Ingeniero Civil CIP 12969
Jefe del Laboratorio

Av. Universitaria 1801, San Miguel. Teléfono: 6262000 Anexo 4561. suelos@pucp.edu.pe

ENSAYO TRIAXIAL CONSOLIDADO NO DRENADO (CU) NTP 339.166 (ASTM D 4767)

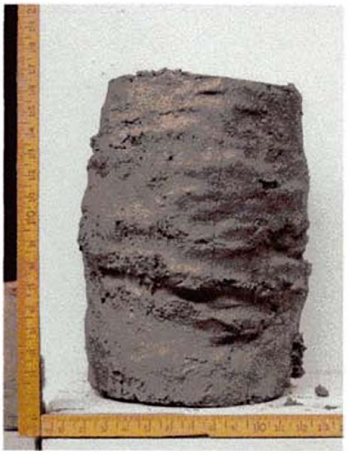
Solicitante TESIS FRANK EDUARDO ESCUSA AROSQUIPA	Expediente **14-253**
Proyecto FLUJOS ESCOMBROS MARANURA-LA CONVENCION-CUZCO	
Muestra Profundidad 1.50 m	Fecha : 19 Nov 2014

FOTOS



Especimen A

Especimen B



Especimen C

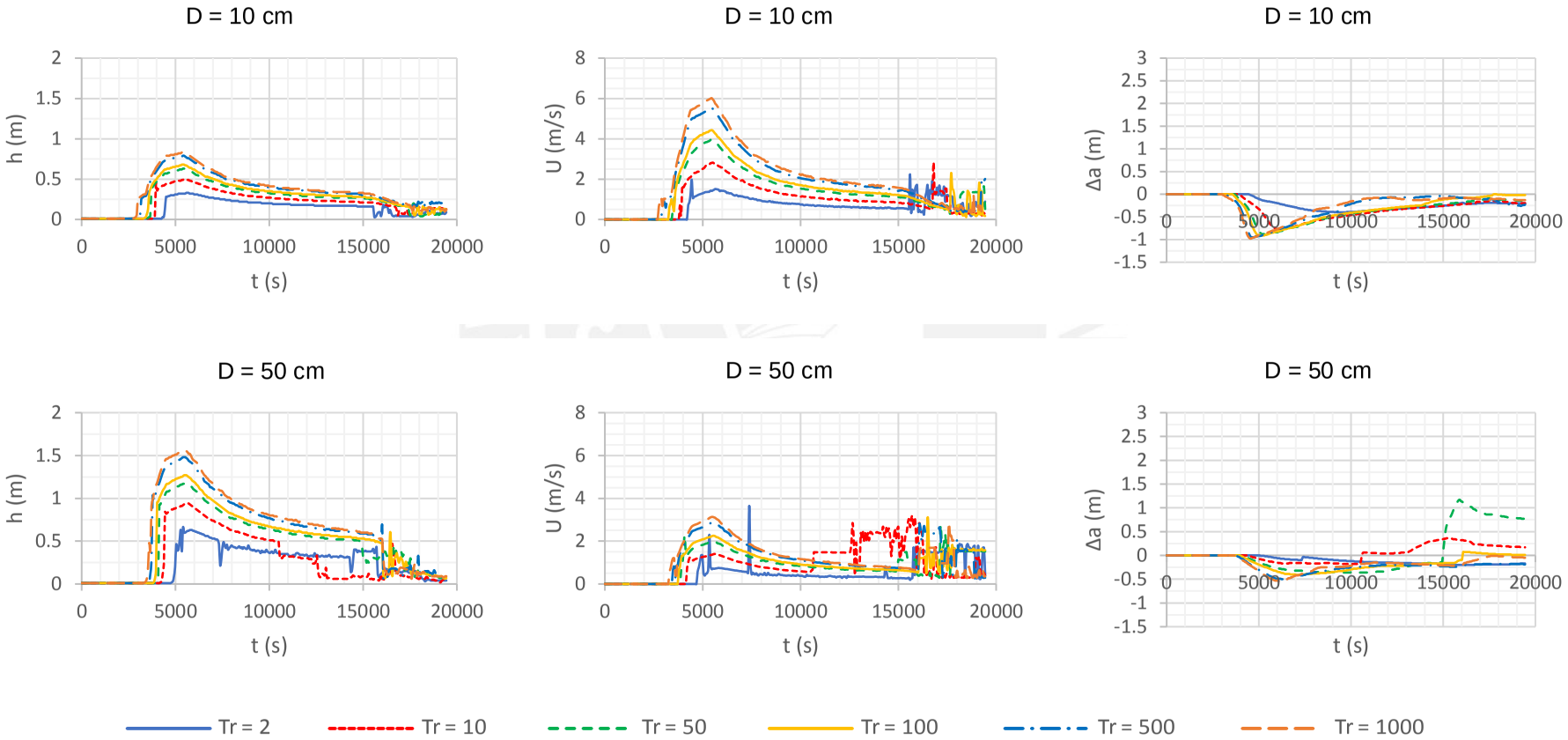
MANUEL A. OLCESE FRANZERO
Ingeniero Civil CIP 12969
Jefe del Laboratorio

Av. Universitaria 1801, San Miguel. Teléfono: 6262000 Anexo 4561. suelos@pucp.edu.pe

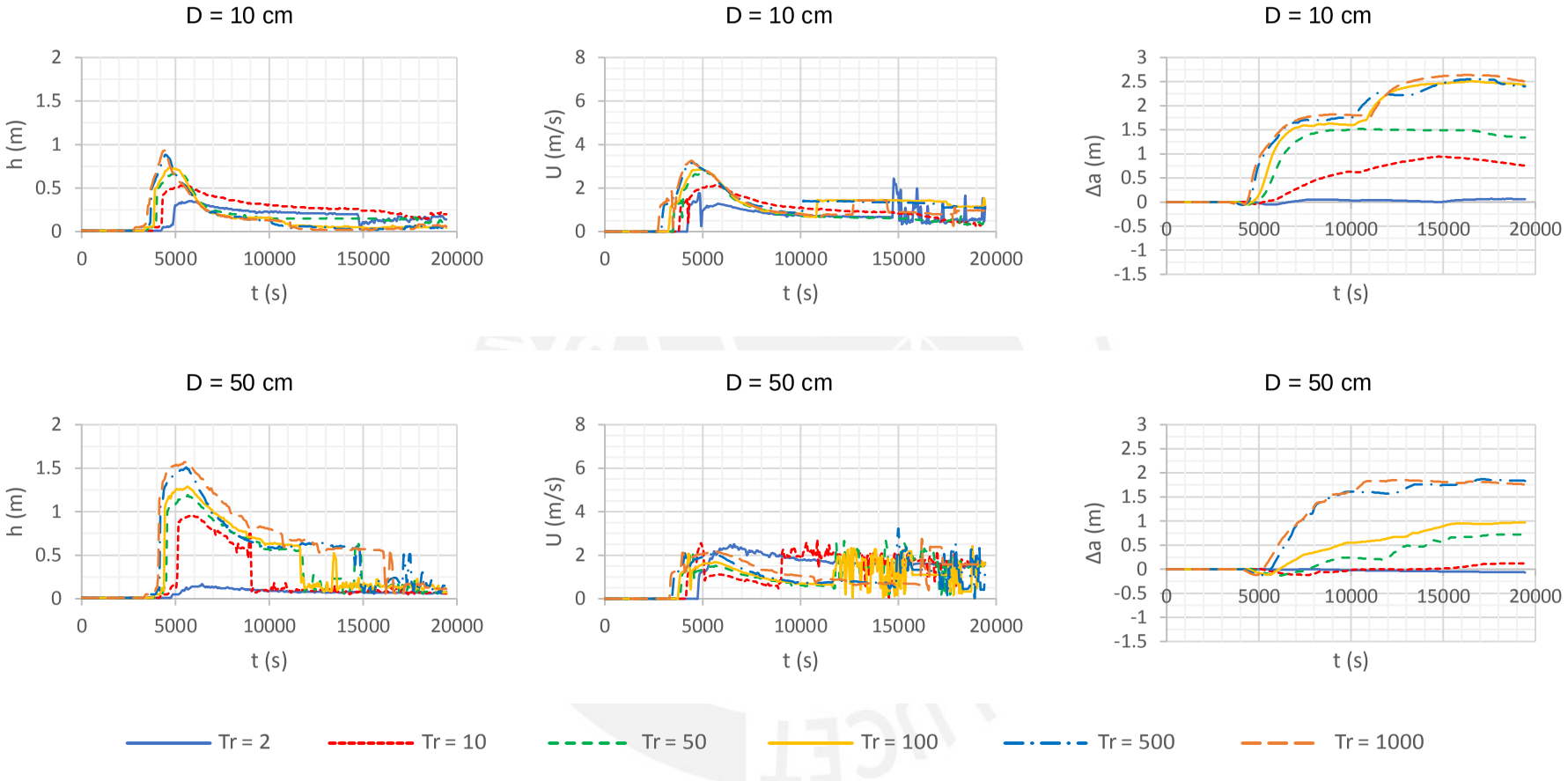
A.3 Registro Tiempo-Historia (Kanako 2D)

A.3.1 Quebrada Chaupimayo

A.3.1.1 Punto de Control Cha P1 (ID-1751)

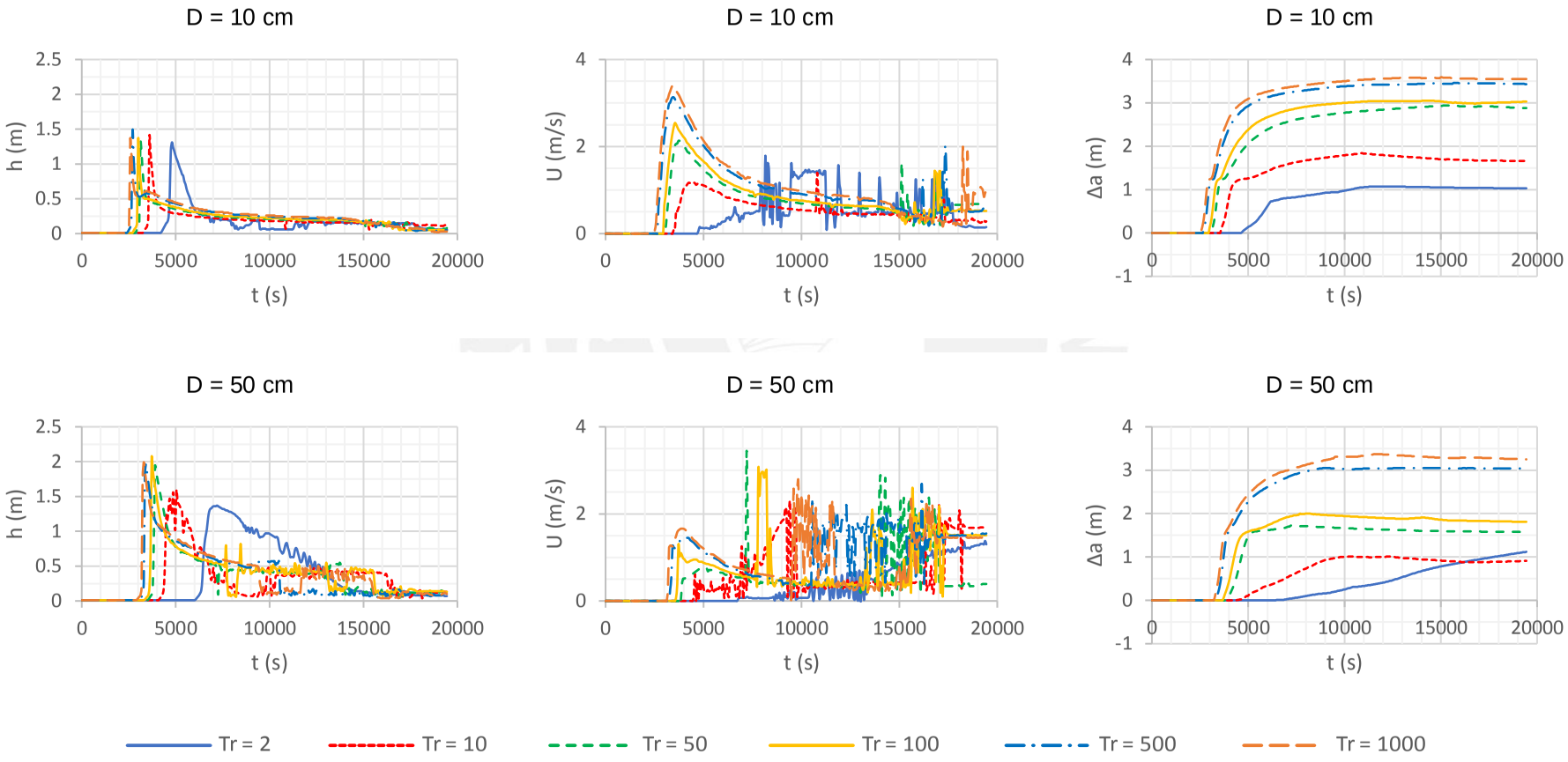


A.3.1.2 Punto de Control Cha P2 (ID-4757)

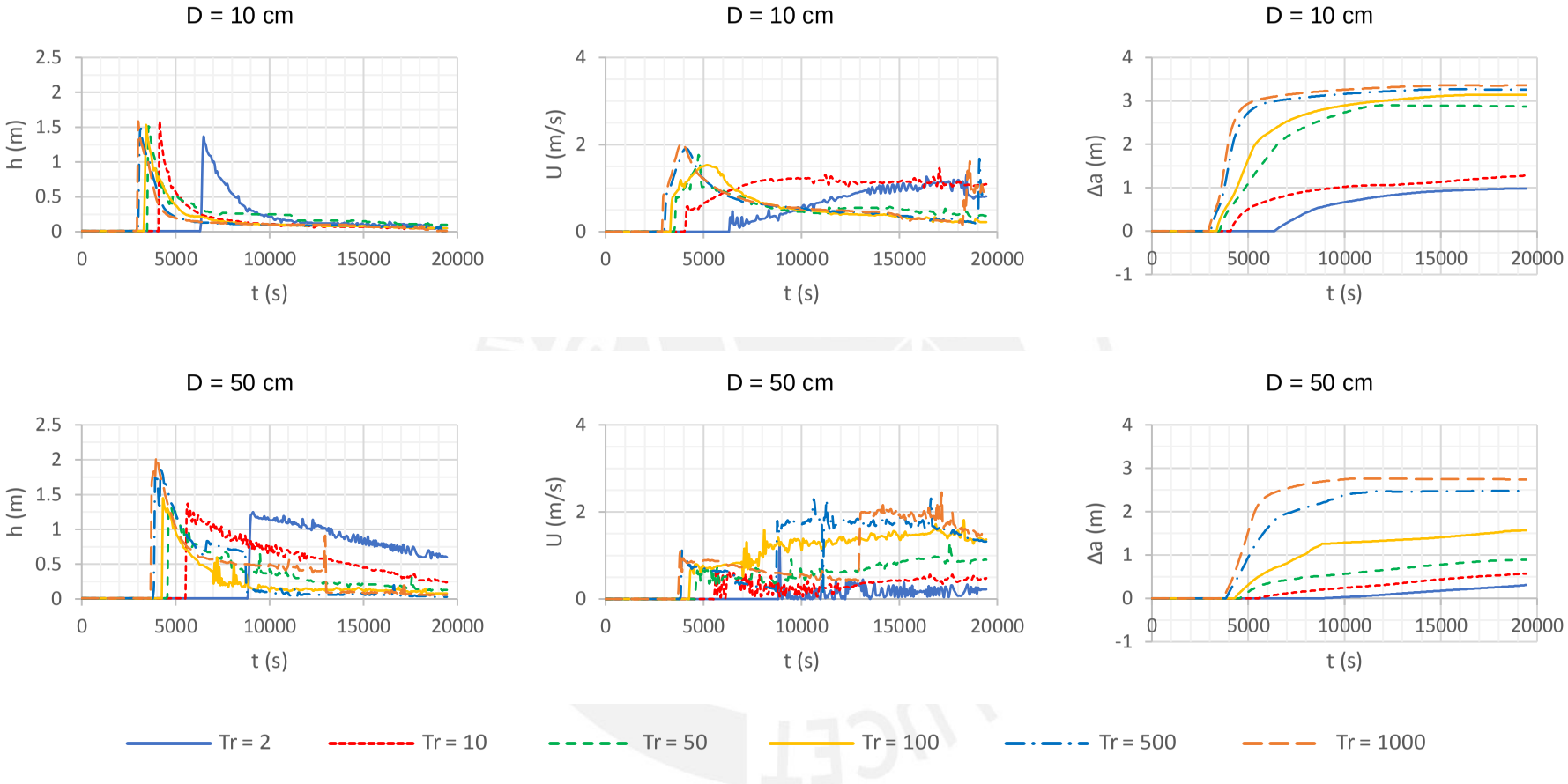


A.3.2 Quebrada Ayunay

A.3.2.1 Punto de Control Ayu P1 (ID-3052)

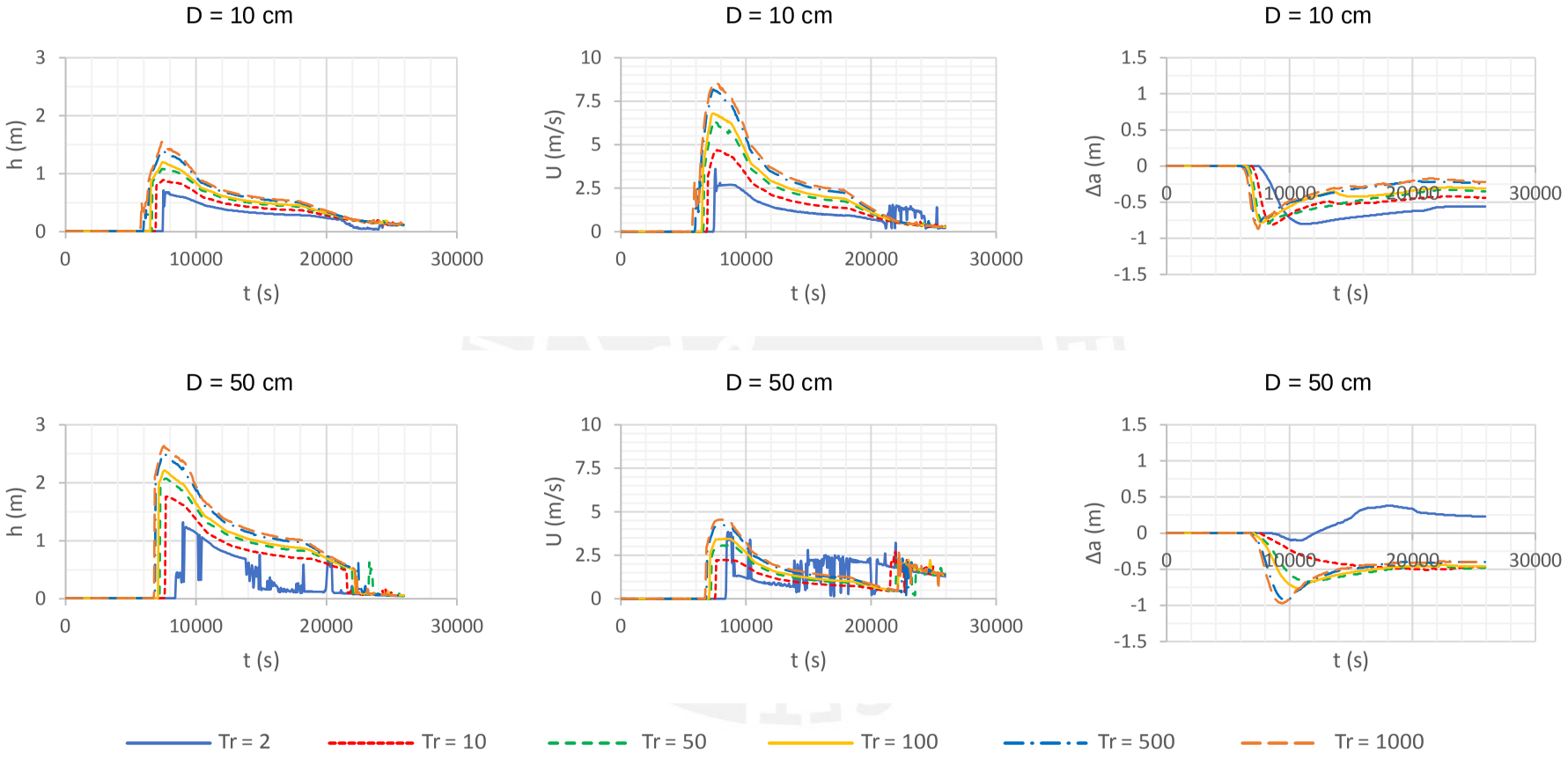


A.3.2.2 Punto de Control Ayu P2 (ID-6371)

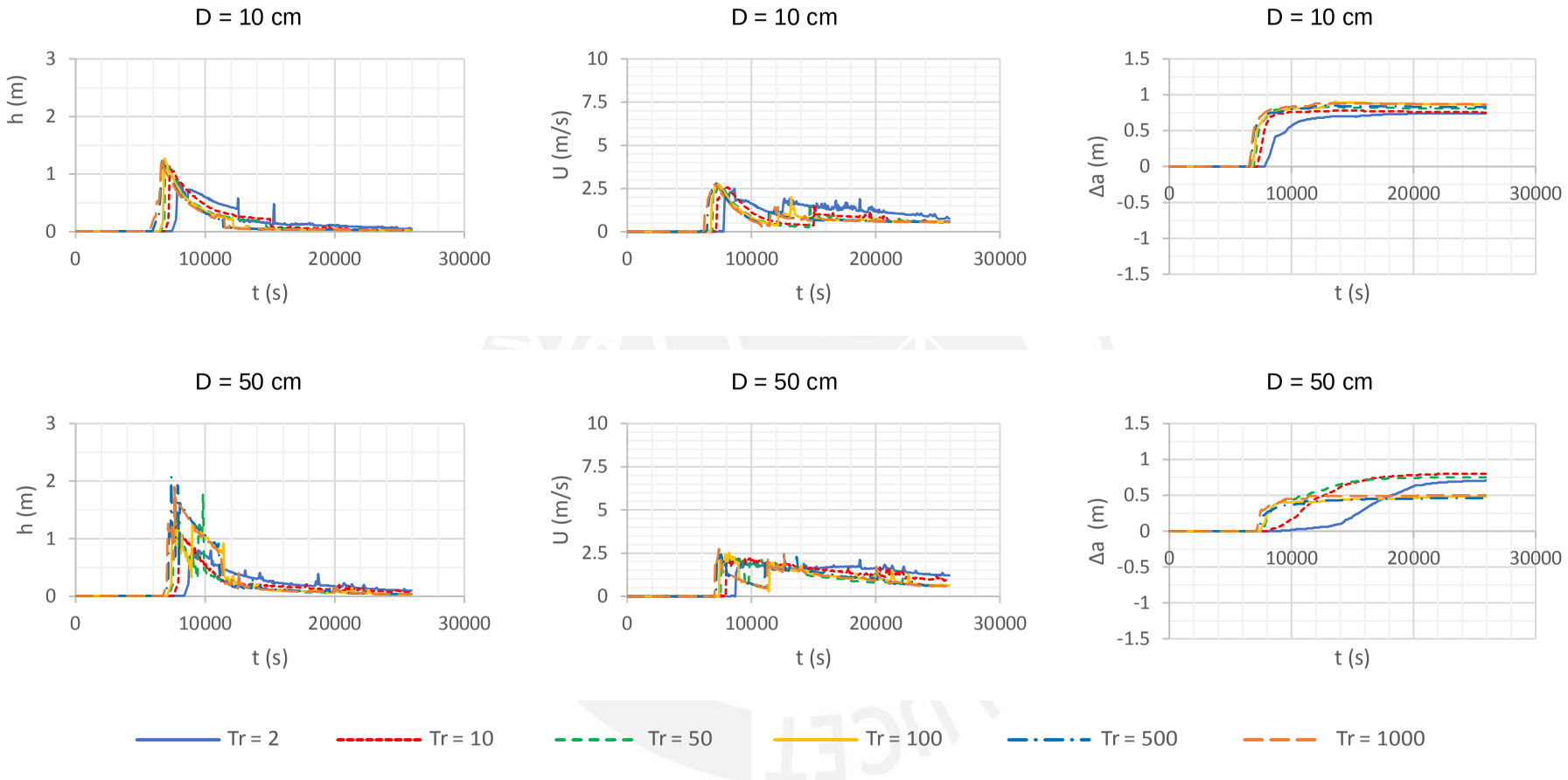


A.3.3 Quebrada Yuracmayo

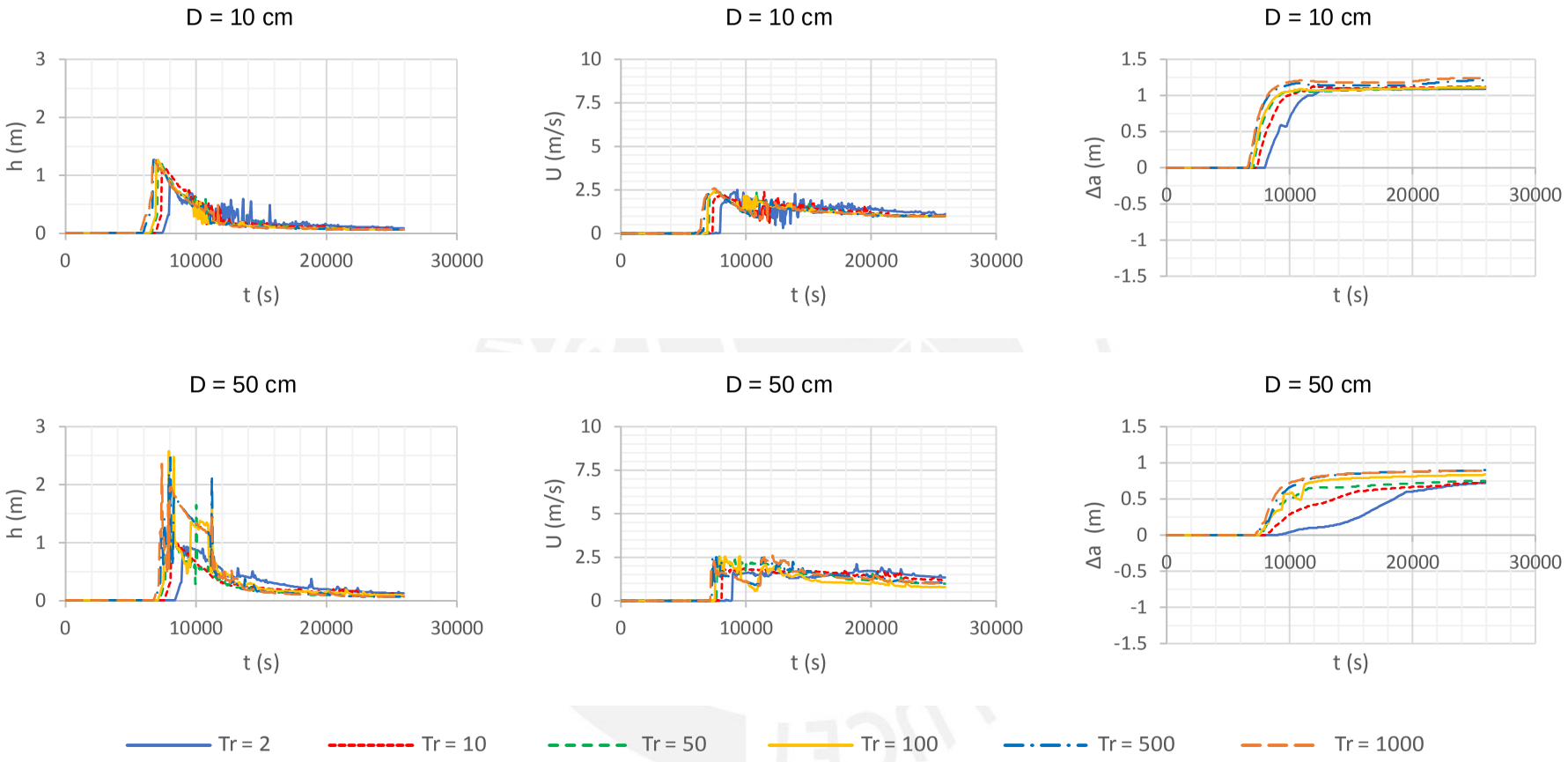
A.3.3.1 Punto de Control Yur P1 (ID-1148)



A.3.3.2 Punto de Control Yur P2 (ID-4371)

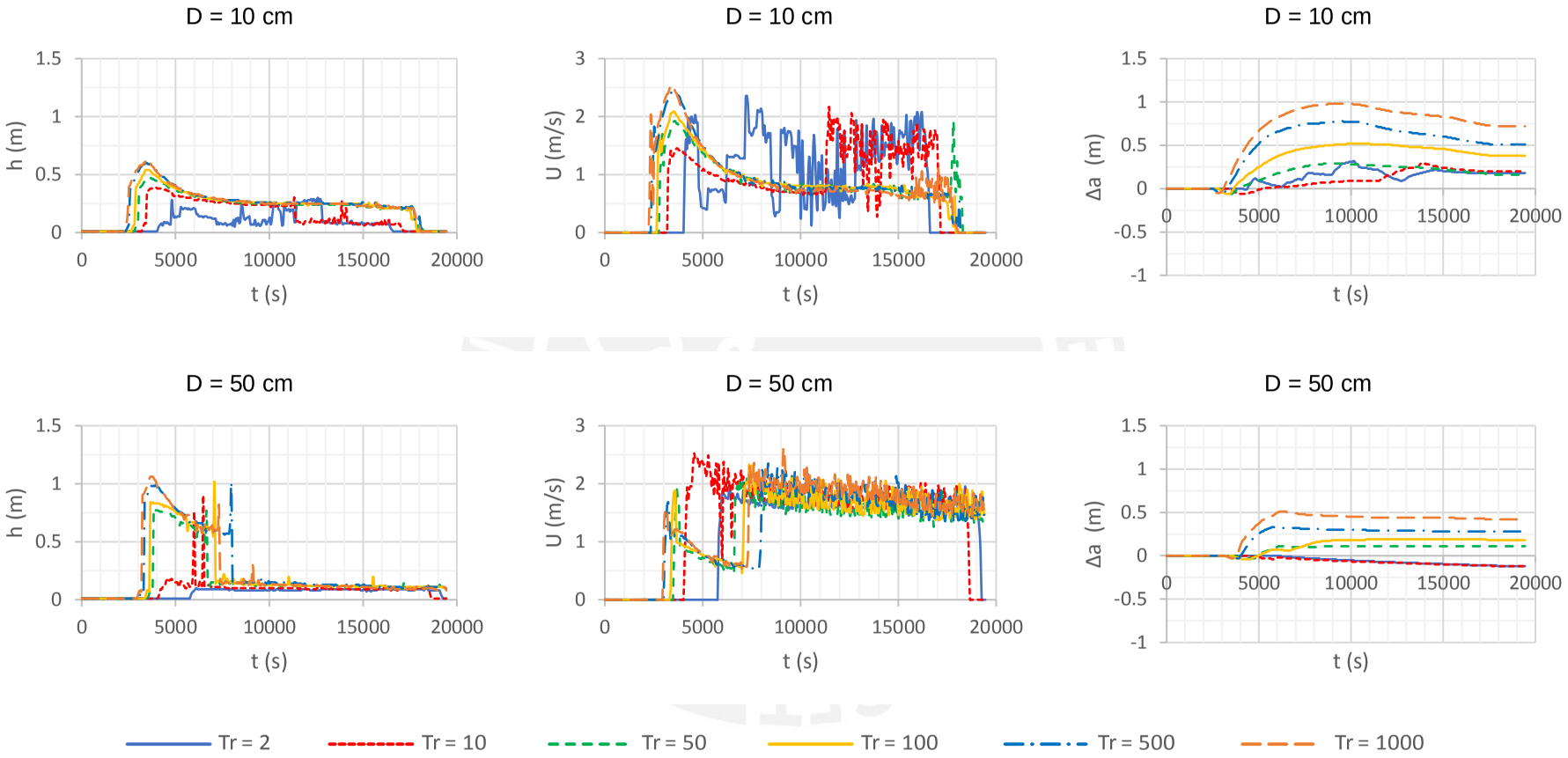


A.3.3.3 Punto de Control Yur P3 (ID-7077)

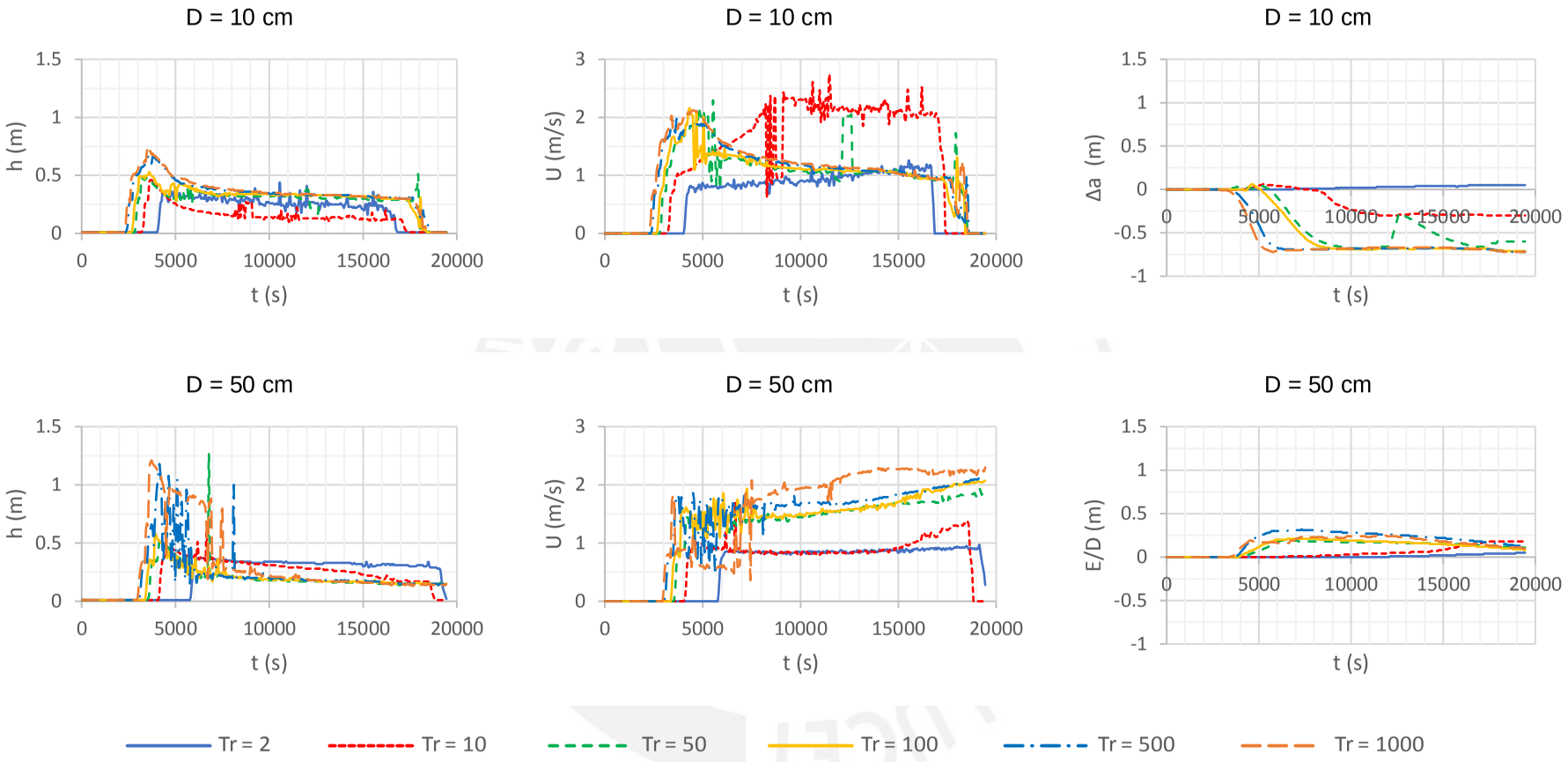


A.3.4 Quebrada Chinche

A.3.4.1 Punto de Control Chi P1 (ID-2644)



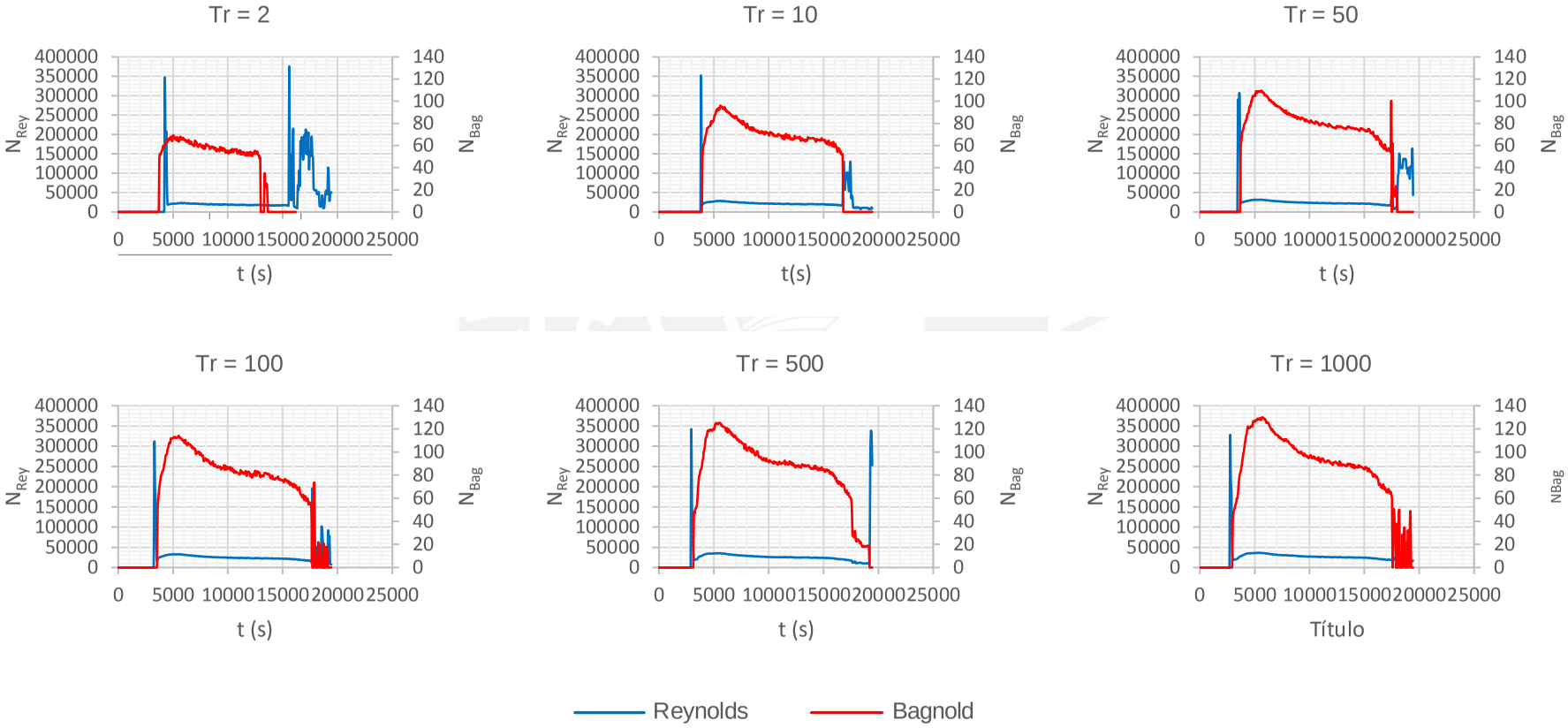
A.3.4.2 Punto de Control Chi P2 (ID-5541)



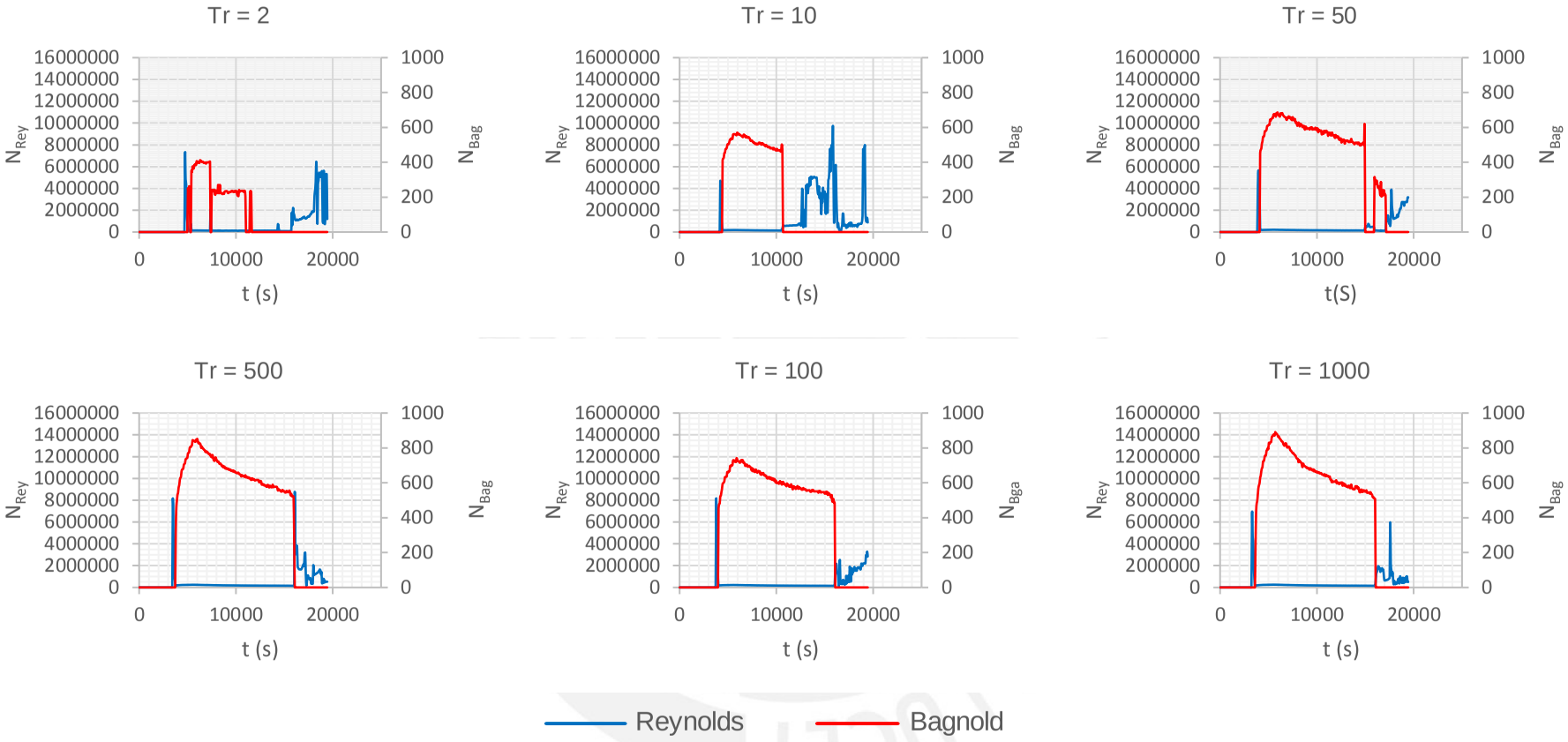
A.4 Evaluación de Números Adimensionales (N_{Rey} & N_{Bag})

A.4.1 Quebrada Chaupimayo

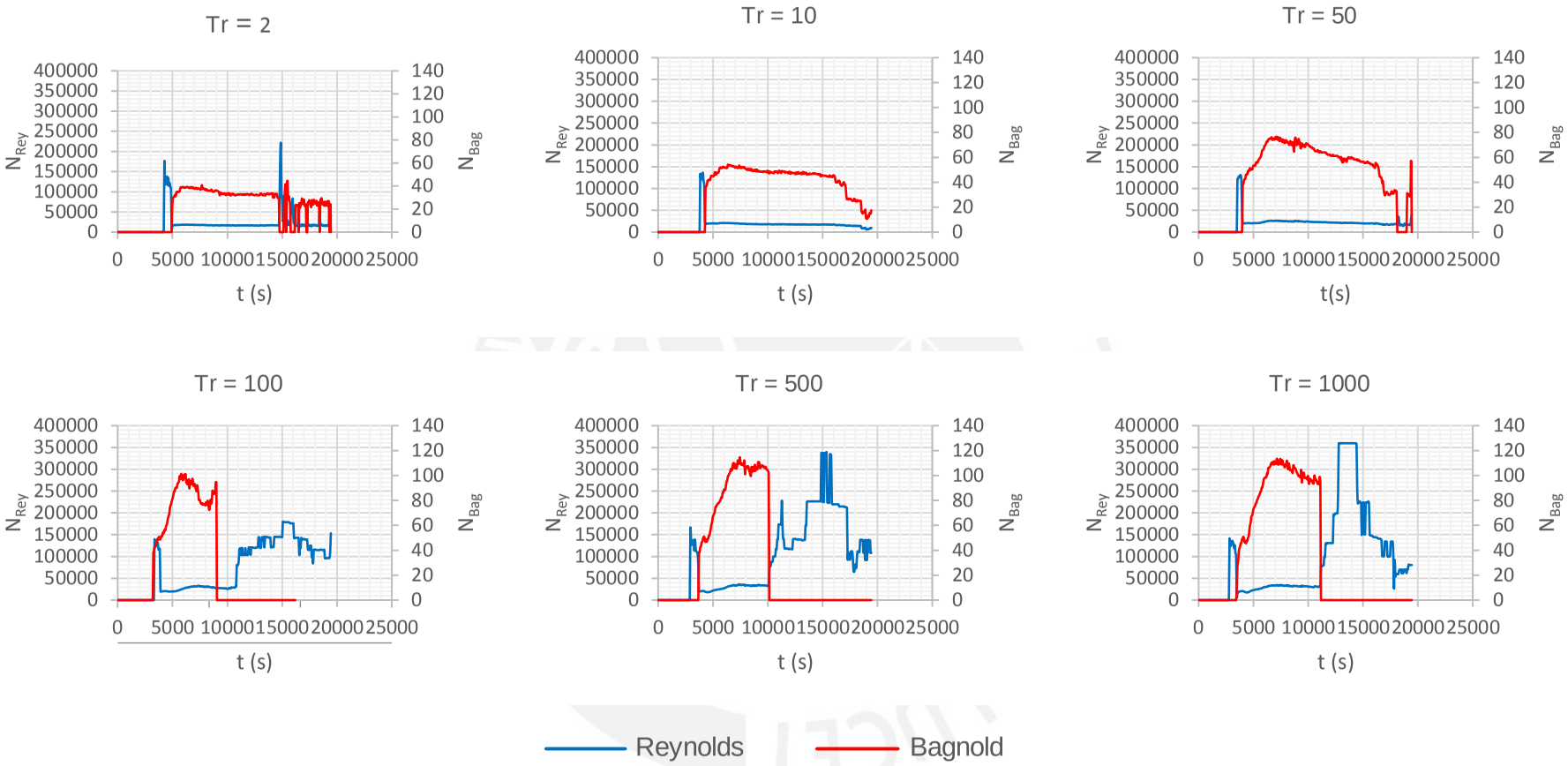
A.4.1.1 Punto de Control Cha P1, D = 10 cm (ID-1751)



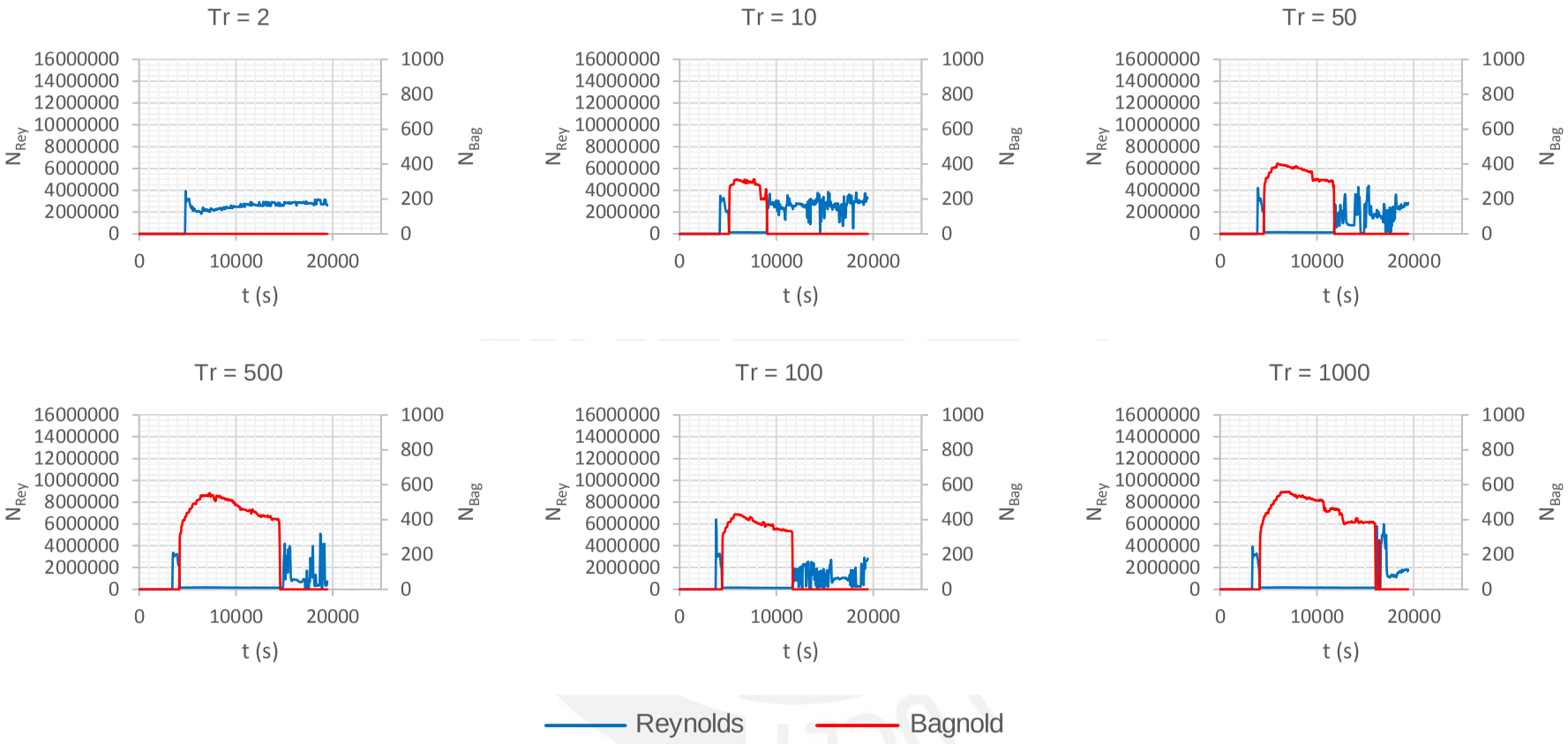
A.4.1.2 Punto de Control Cha P1, D = 50 cm (ID-1751)



A.4.1.3 Punto de Control Cha P2, D = 10 cm (ID-4757)

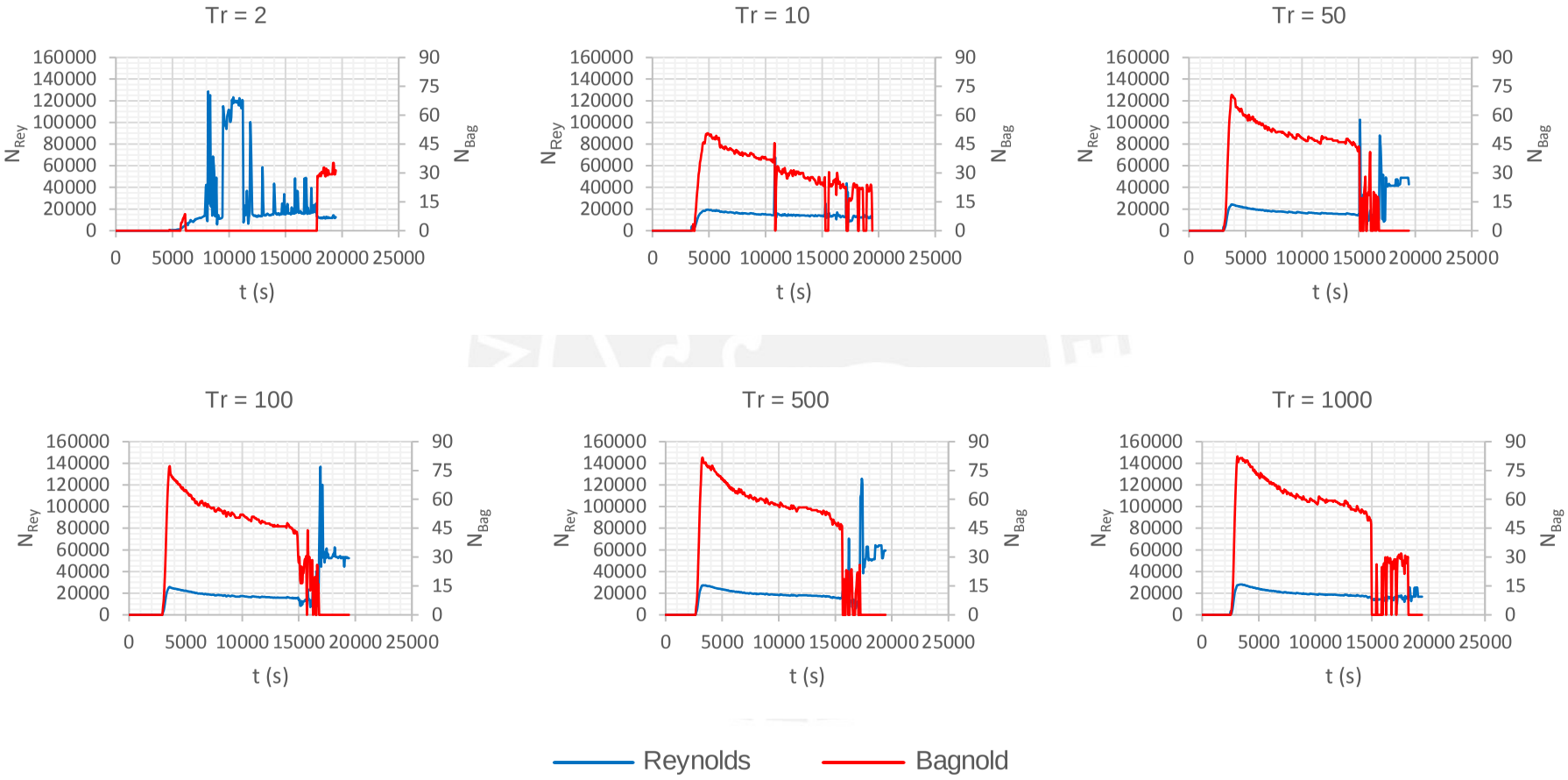


A.4.1.4 Punto de Control Cha P2, D = 50 cm (ID-4757)

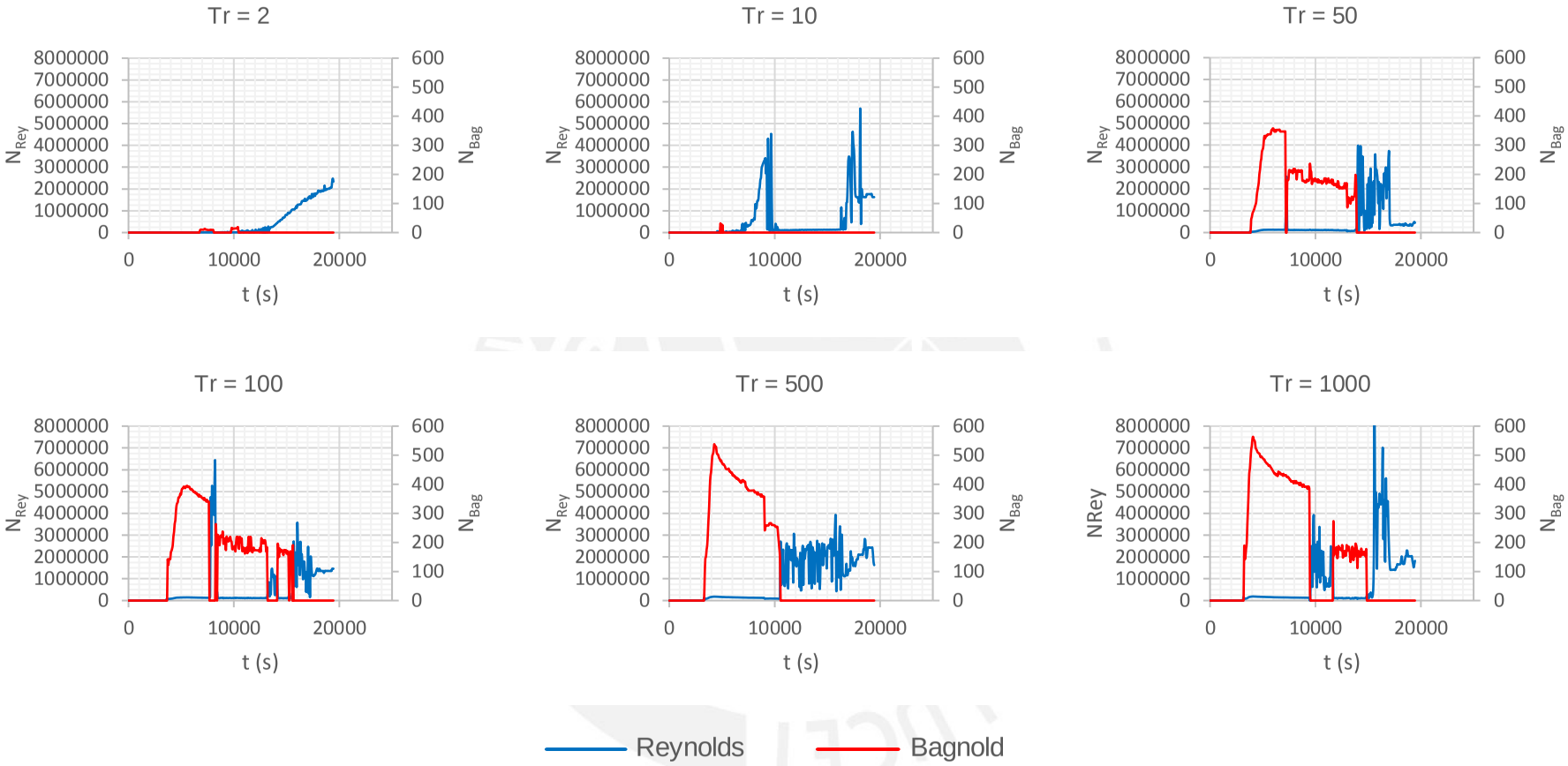


A.4.2 Quebrada Ayunay

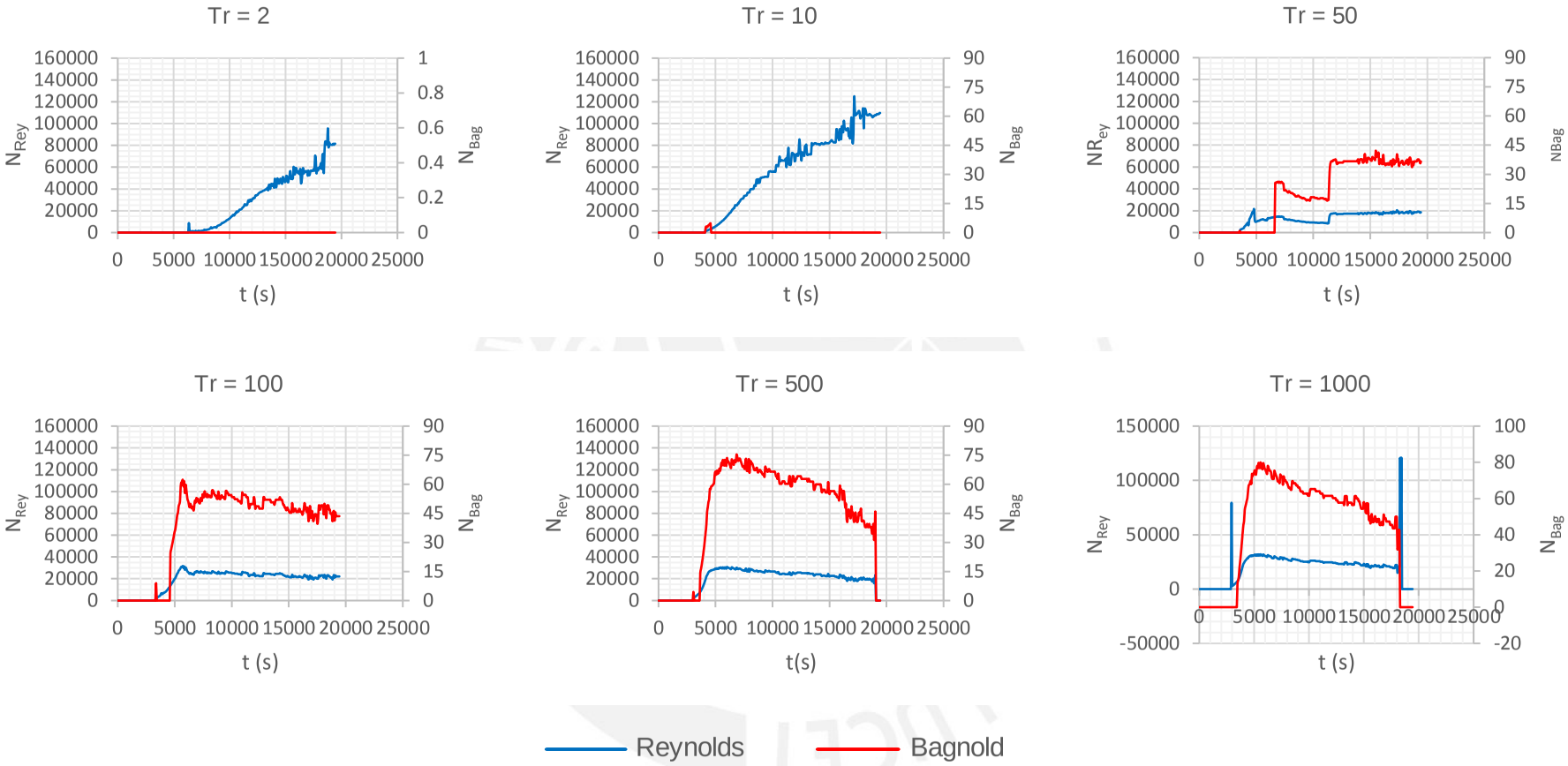
A.4.2.1 Punto de Control Ayu P1, D = 10 cm (ID-3052)



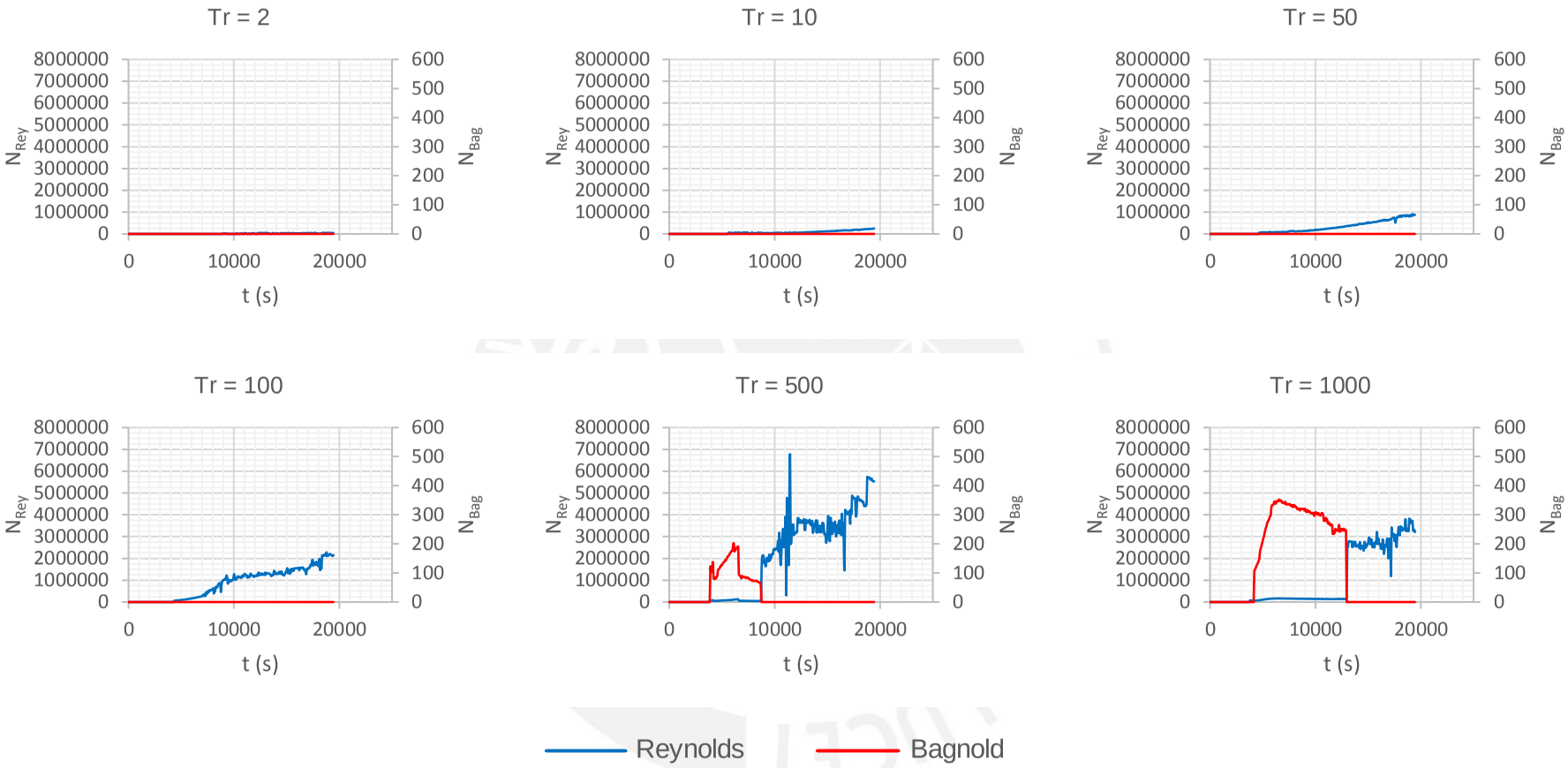
A.4.2.2 Punto de Control Ayu P1, D = 50 cm (ID-3052)



A.4.2.3 Punto de Control Ayu P2, D = 10 cm (ID-6371)

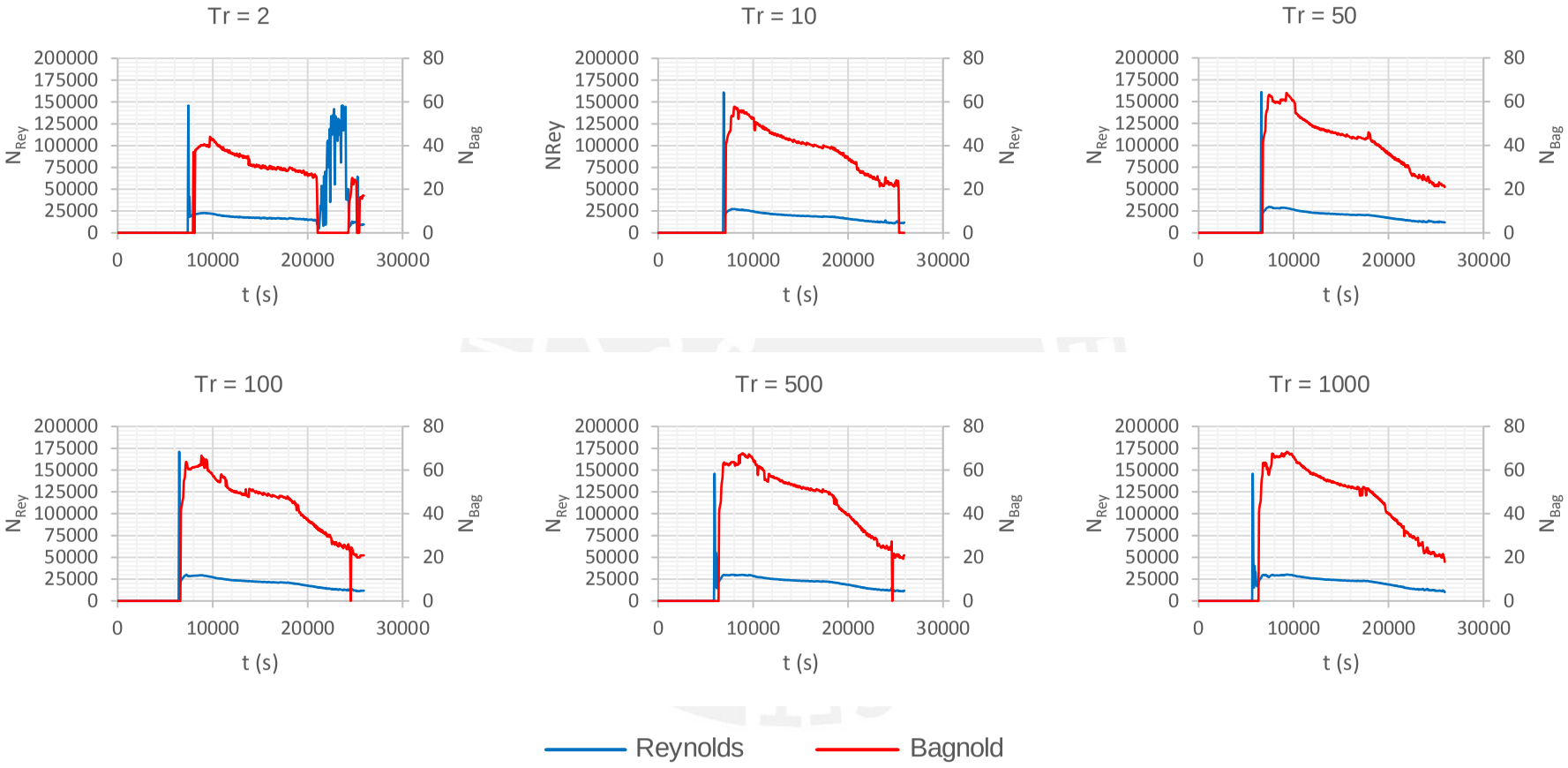


A.4.2.4 Punto de Control Ayu P2, D = 50 cm (ID-6371)

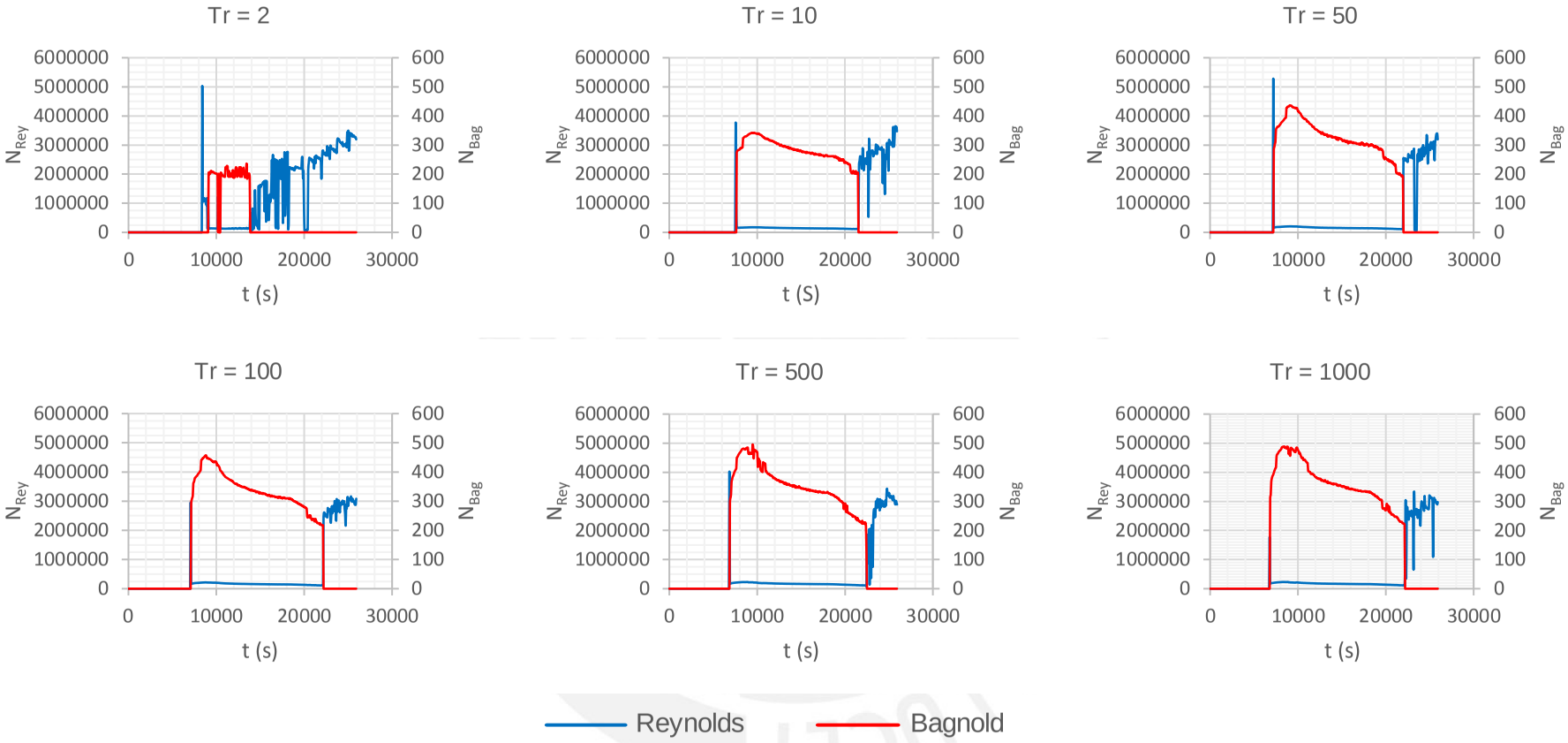


A.4.3 Quebrada Yuracmayo

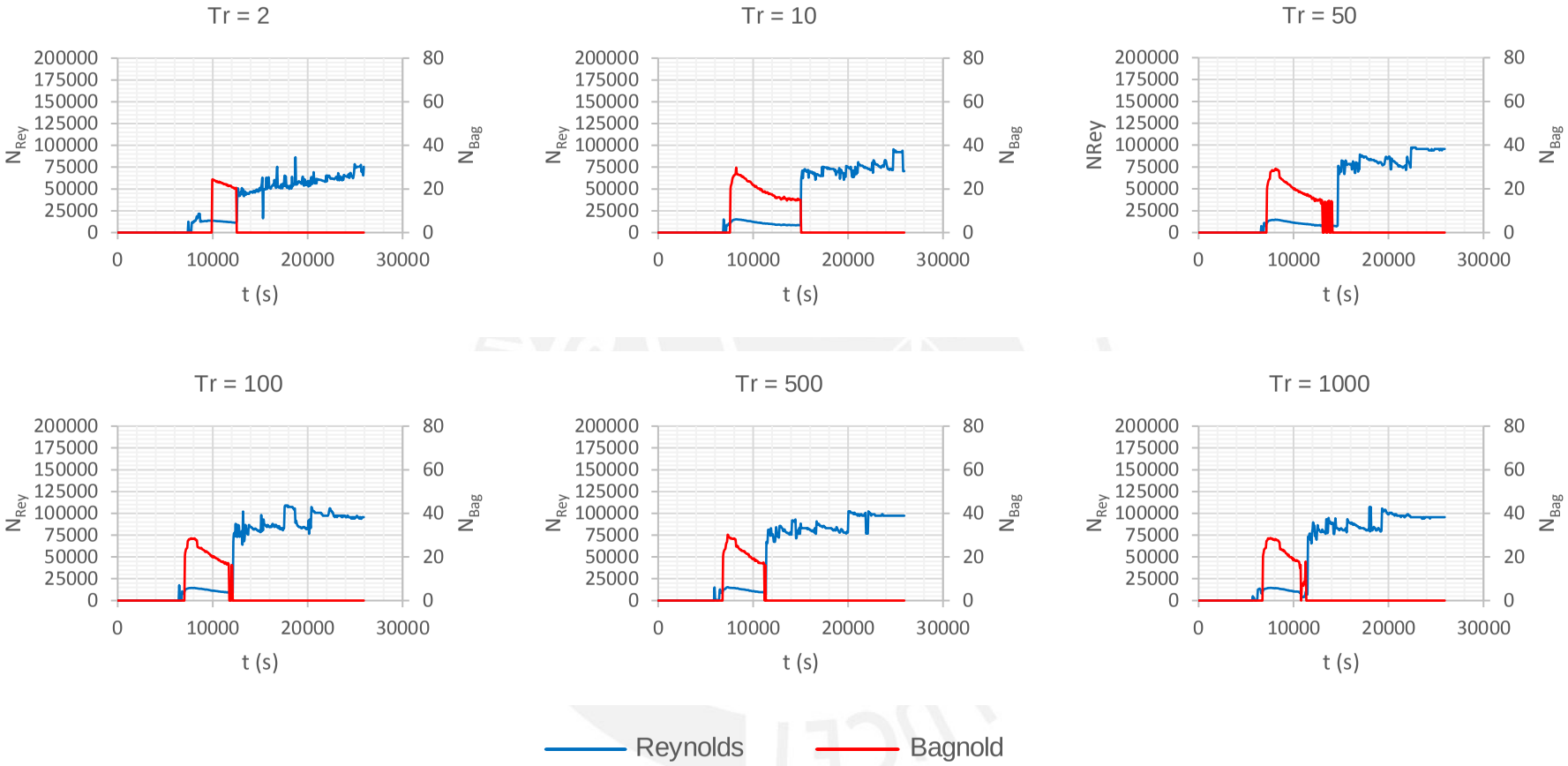
A.4.3.1 Punto de Control Yur P1, D = 10 cm (ID-1148)



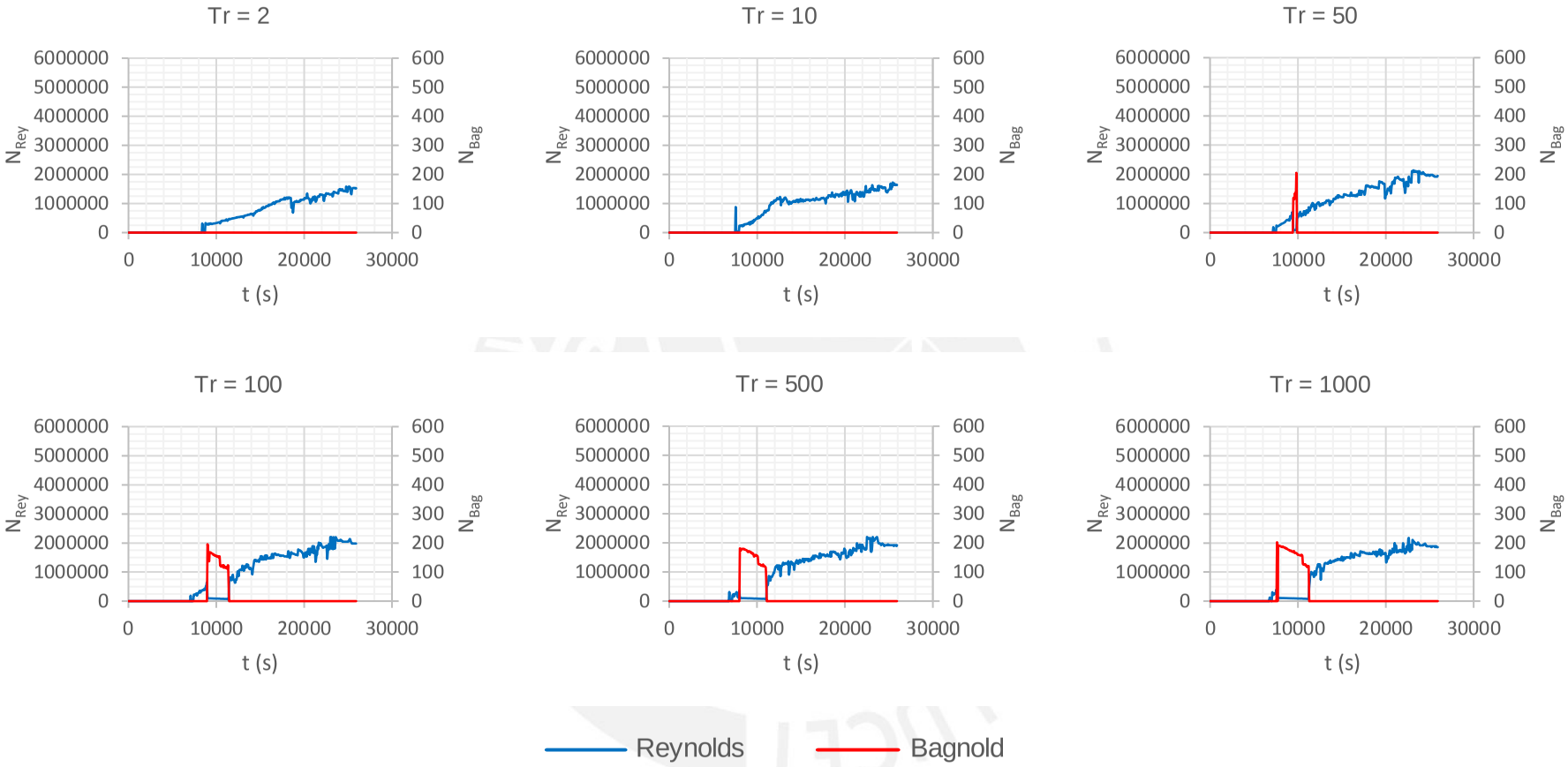
A.4.3.2 Punto de Control Yur P1, D = 50 cm (ID-1148)



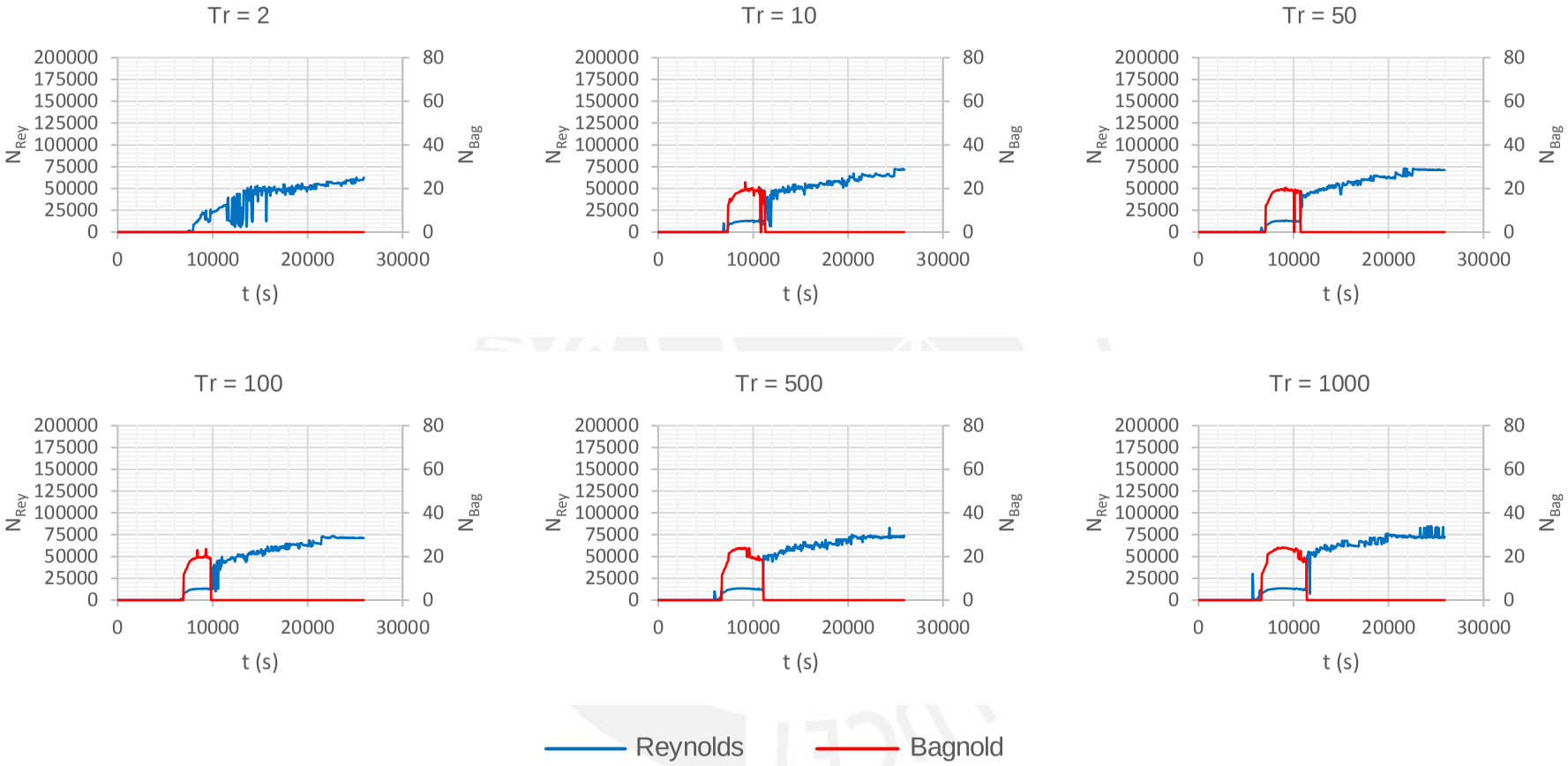
A.4.3.3 Punto de Control Yur P2, D = 10 cm (ID-4371)



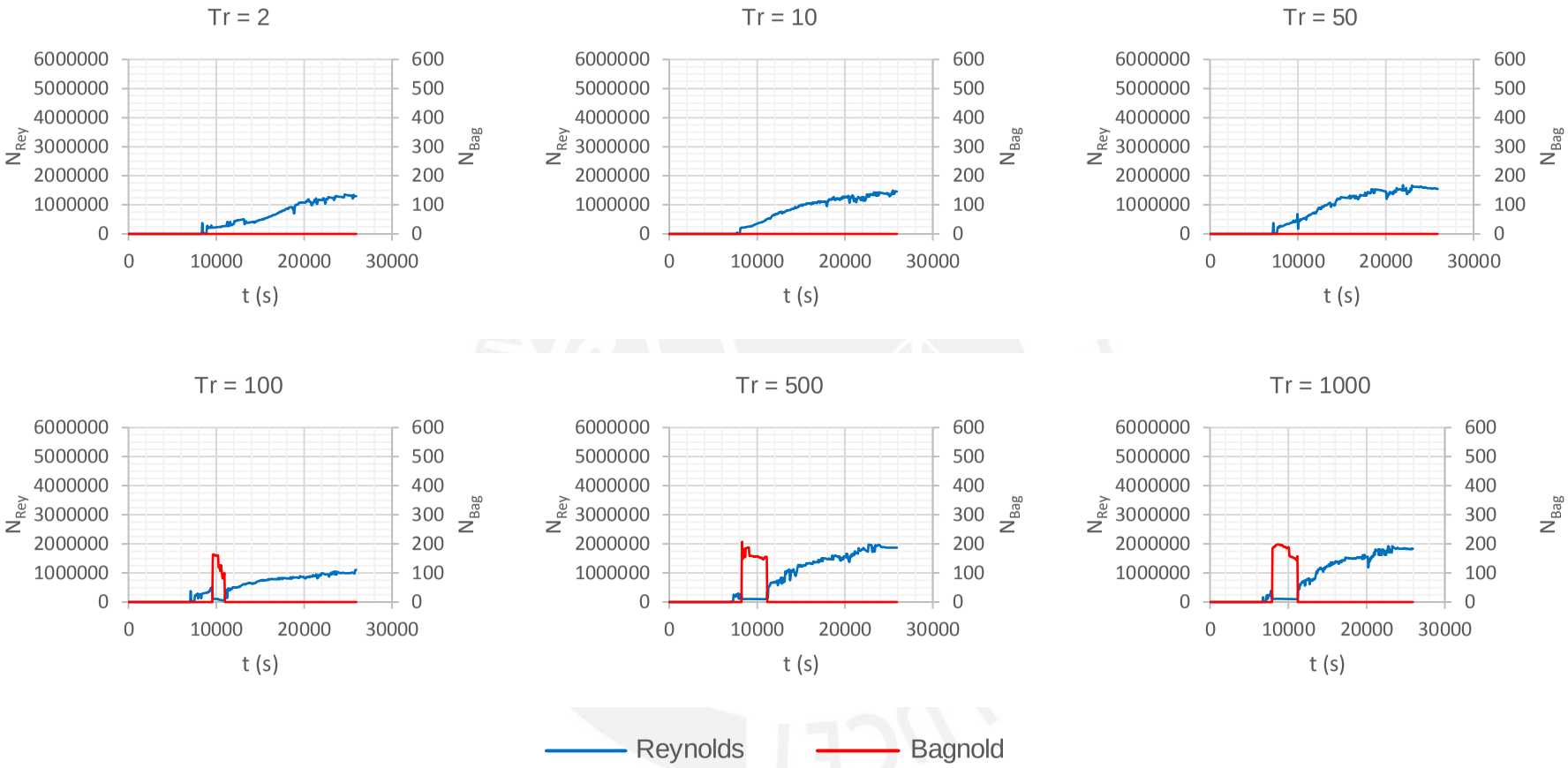
A.4.3.4 Punto de Control Yur P2, D = 50 cm (ID-4371)



A.4.3.5 Punto de Control Yur P3, D = 10 cm (ID-7077)

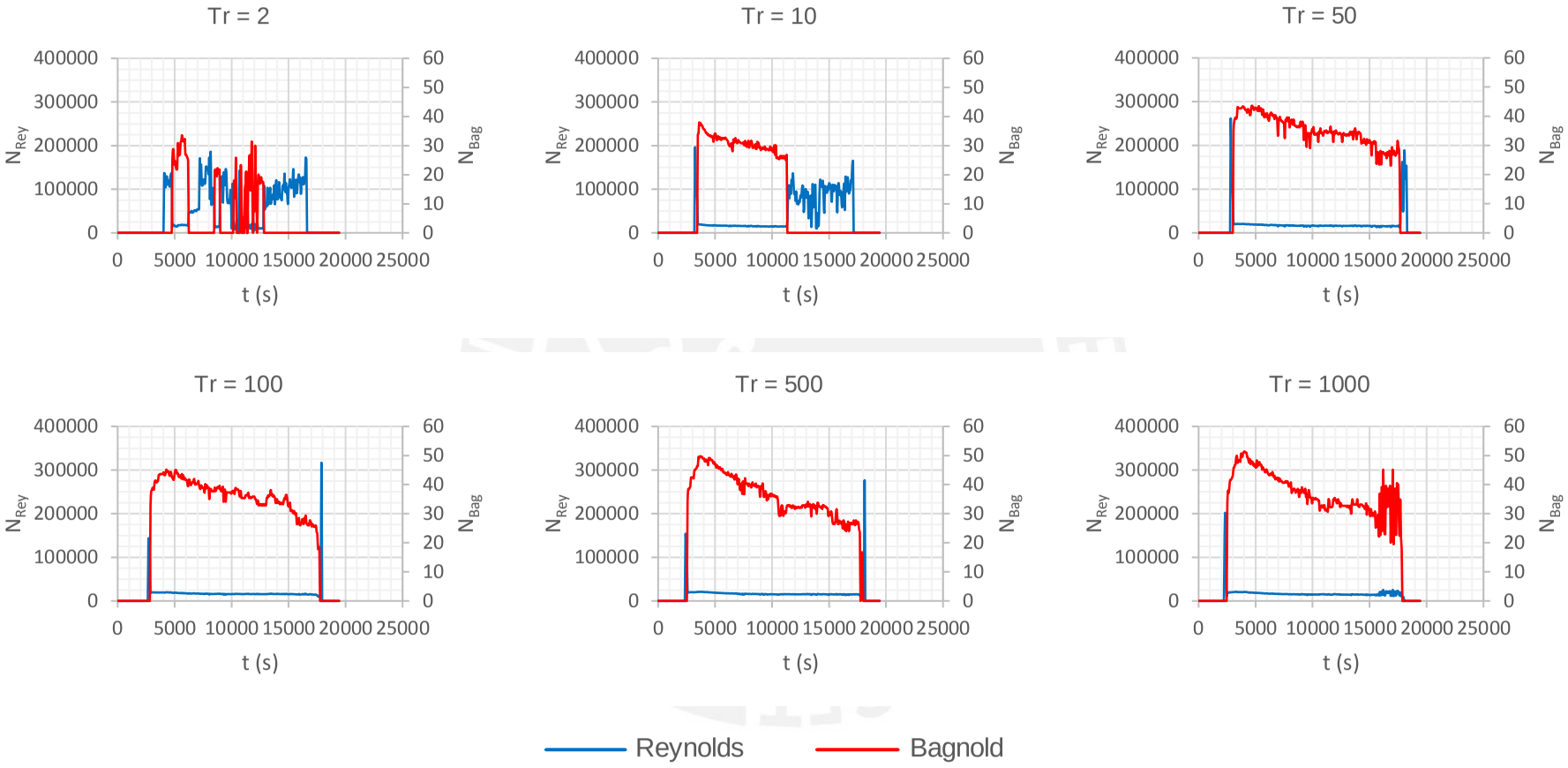


A.4.3.6 Punto de Control Yur P3, D = 50 cm (ID-7077)

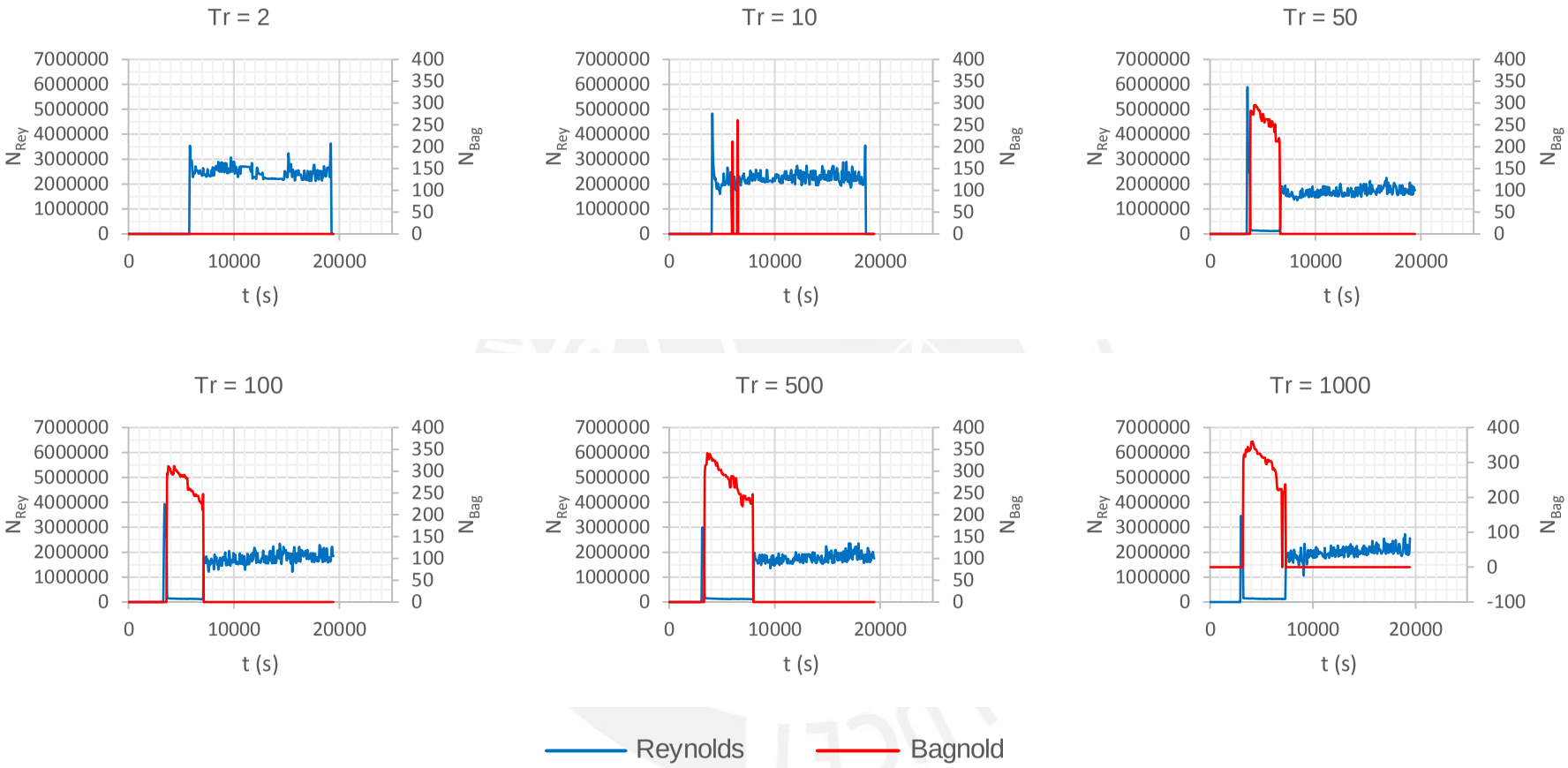


A.4.4 Quebrada Chinche

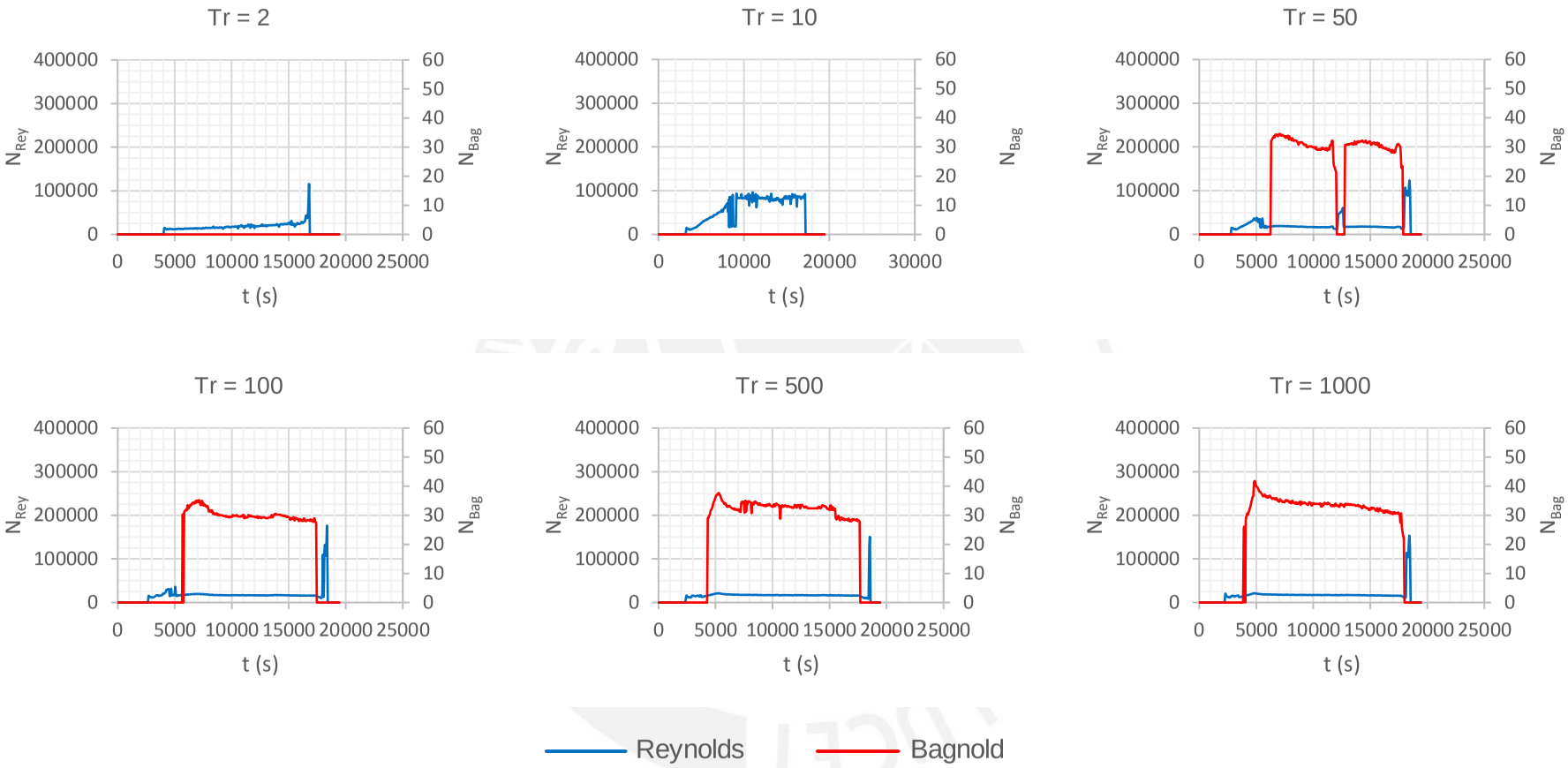
A.4.4.1 Punto de Control Chi P1, D = 10 cm (ID-2644)



A.4.4.2 Punto de Control Chi P1, D = 50 cm (ID-2644)



A.4.4.3 Punto de Control Chi P2, D = 10 cm (ID-5541)



A.4.4.4 Punto de Control Chi P2, D = 50 cm (ID-5541)