XVI World Water Congress
International Water Resources Association (IWRA)
Cancun, Quintana Roo. Mexico. 29 May- 3 June, 2017

National Water Commission

Dam Management in Mexico

Cajon de Peña Dam, Jalisco State

May 29, 2017

During extraordinary hydrometeorological events, it is important for the safety of dams, population and infrastructure located downstream to maintain a permanent surveillance on the climatological, meteorological, hydrological and hydraulic forecast scenarios in order to reduce the risks that could be generated by a sudden discharge or dam failure.

Proper monitoring enables adequate and timely decision-making on storage management through an operation policy in accordance with the evolution of the reservoir and rainfall forecast.

The operation of the Cajon de Peña dam in Jalisco during Hurricane Patricia in 2015 is particularly analysed.

The National Water Commission (CONAGUA), through the Technical Division (SGT) has the authority to monitor and assess the development of severe weather events that may influence the basins, channels and storage dams, and implement actions to mitigate their negative effects.

In Mexico, policy management of Hydraulic Works including reservoirs is dictated by the Technical Committee of Hydraulic Works Operation (CTOOH), which is a multidisciplinary group composed of experts in different areas of knowledge.

In order to support this decision-making, SGT provides evidence, such as: record of reservoir evolution; hydrological forecast of reservoirs for inputs of 2, 25, 50, 75 and 98% of occurrence through continuity equation modelling, channel capacity downstream of dams, whose water volume causes no damage, water volumes extracted under irrigation schemes, drinking water demand or requirements of the national electricity system.

SGT has reviewed over recent years the operating policies of the 50 dams that have such policy, changing the "abrupt" extractions for smoothed discharges in order to reduce damage downstream; the "steps" below OHWL were removed and design floodwaters were revised to update protocols.

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Hurricane Patricia

From September 2014 to March 2016 an anomaly in the Pacific region temperature occurred, creating favourable conditions for hurricane development. This situation worsened during October 2015.

Date	Anomaly Temp.	Date	Anomaly Temp.
Sep 14	0.5	July 15	1.6
Oct 14	0.5	Aug 15	2.1
Nov 14	0.9	Sep 15	2.3
Dec 14	0.8	Oct 15	4.9
Jan 15	0.5	Nov 15	3.0
Feb 15	0.6	Dec 15	2.8
Mar 15	0.6	Jan 16	2.6
April 15	0.8	Feb 16	2.4
May 15	1.0	Mar 16	1.7
June 15	1.3		

Hurricane Patricia can be regarded as the most intense tropical cyclone ever observed in the Western Hemisphere with maximum sustained winds of 346 km/h.

Hurricane	Date	Max winds (Km/h)	Pressure (hPa)
Patricia	20-24 Oct 2015	346	872
Linda	9-17 Sept 1997	295	902
Kenna	22-26 Oct 2002	270	913
Odile	10-19 Sept 2014	220	918

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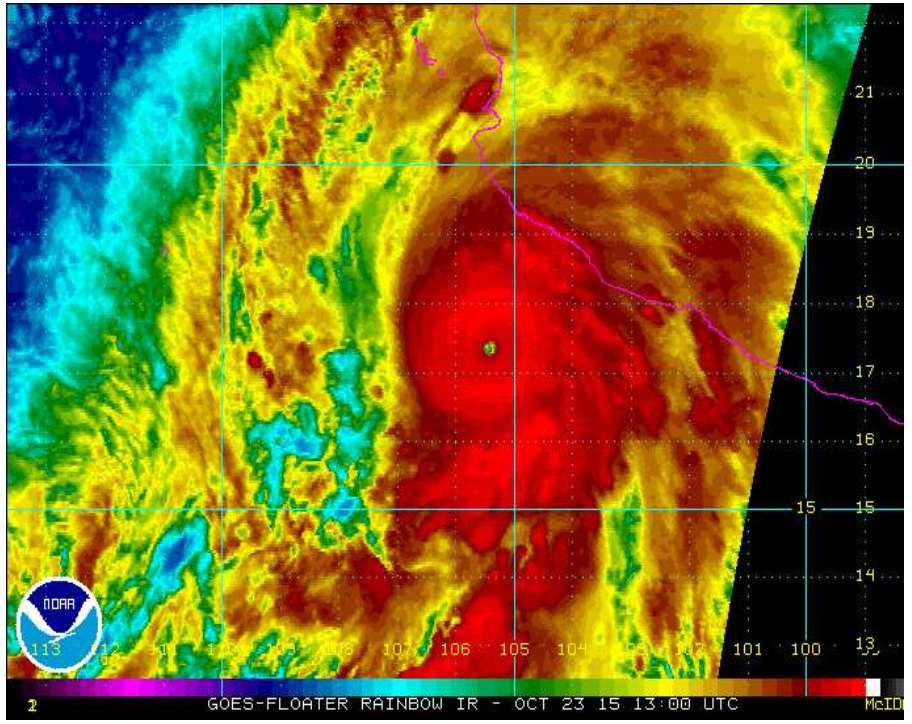
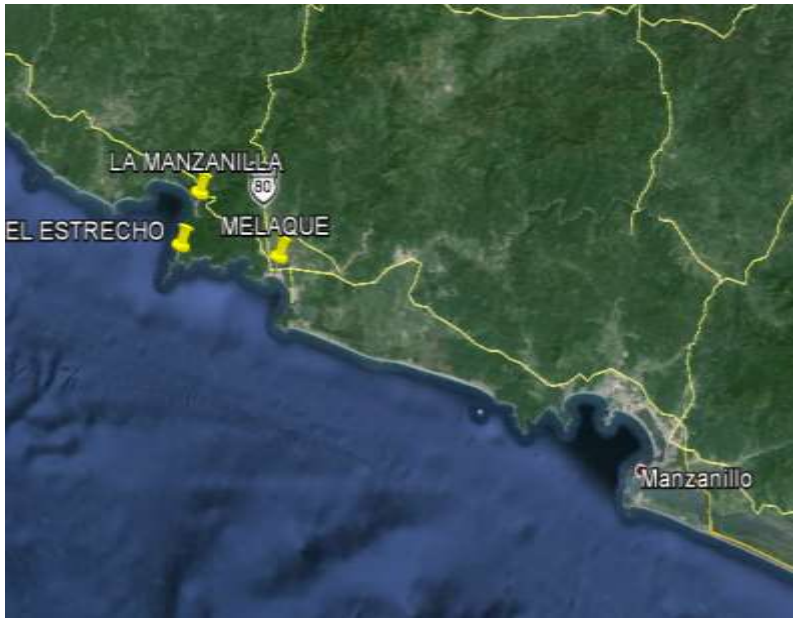
Hurricane Patricia Trajectory



Hurricane Patricia at 7:00 hrs 23/Oct/2015

According to Weather Alert No. 068-15, 23 October 2015, the National Water Commission reported at 18:00 hrs. Mexico Central Time, that Category 5 Hurricane Patricia would make landfall in the vicinity of Tenacatita, Cuestecomate and Navidad Bays, a region where the towns of El Estrecho, La Manzanilla and Melaque are located, in the municipalities of La Huerta and Cihuatlán, Jalisco

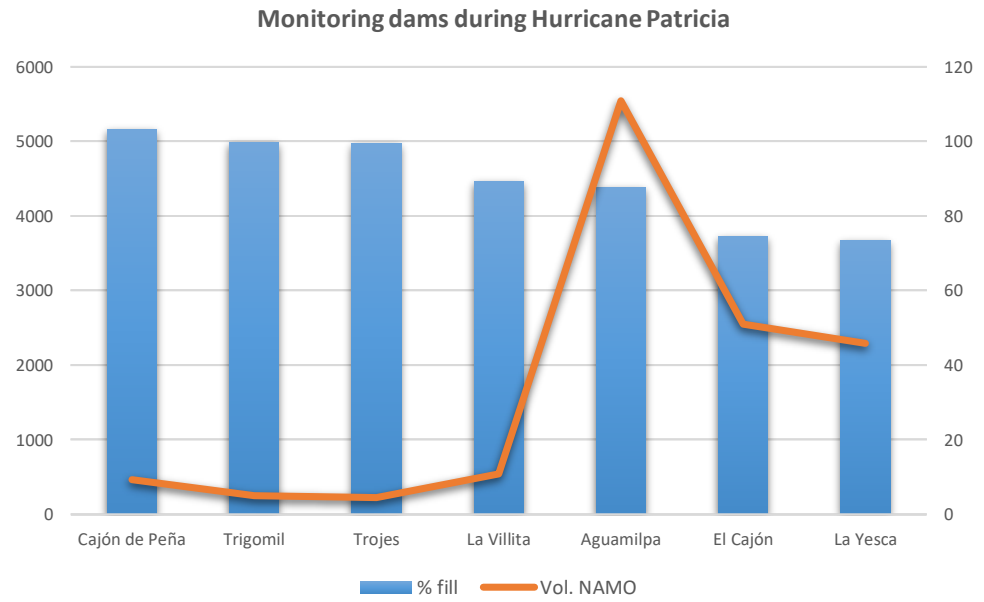


CONAGUA through SGT monitored the hurricane and the conditions and evolution of dams likely to receive sudden inflows from rainfall generated by the hurricane.

Thus, 29 dams remained under permanent surveillance in order to carry out in a timely manner the management, control and discharge of storage volumes that were deemed necessary

Nombre de presa	Actual	NAMO	% llenado
	(hm3)		
Aguamilpa, Nay.	4850	5540	87.55
El Cajón, Nay	1899.64	2551.7	74.45
La Yesca, Jal.	1687.55	2292.92	73.60
José Ma. Morelos, Mich.	482.9	540.8	89.29
Cajón de Peña, Jal.	480.87	466.69	103.04
Trigomil, Jal.	248.92	250	99.57
Trojes, Col.	219.41	220.81	99.37
Tacotán, Jal.	149.34	149.24	100.07
Basilio Badillo, Jal	134.2	145.72	92.09
San Juanico, Mich.	57.6	60.48	95.24
La Vega, Jal.	49.48	44	112.45
Laguna de Amela, Col.	38.11	38.34	99.40
Vicente C. Villaseñor, Jal.	14.44	14.44	100.00
Laguna Colorada, Jal.	13.32	12.8	104.06
Tenasco, Jal.	5.97	10.5	56.86
Copándaro, Mich.	6.19	6.5	95.23
El Trigo, Jal.	2.58	4.4	58.64
Santa Elena, Dgo.	14.7	15.1	97.35
Santiago Bayacora, Nay.	130.15	130.05	100.08
Guadalupe Victoria	83.09	84.75	98.04
Achimec, Zac.	7.17	6.74	106.38
Excame, Zac.	51.82	71.61	72.36
El Chique, Zac.	139.48	139.95	99.66
Tayahua, Zac.	31.63	31.6	100.09
San Pedro Piedra Gorda, Z	0	5	0.00
San Marcos	s/d	3.5	s/n
El Cazadero, Zac.	22.14	22.13	100.05
Jocoque, Ags.	10.97	10.98	99.91
Niágara, Ags	16.33	16.19	100.86

Of all dams under surveillance, the Cajon de Peña dam was considered to be the most at risk, because it was located approximately 60 km from the eye of the hurricane; it would be the first landfall impact zone; it had a storage of 480 hm^3, 5% higher than OHWL (466.69 hm^3); it is a curtain of graduated materials; and about 13,000 inhabitants were living downstream, according to INEGI census of 2010



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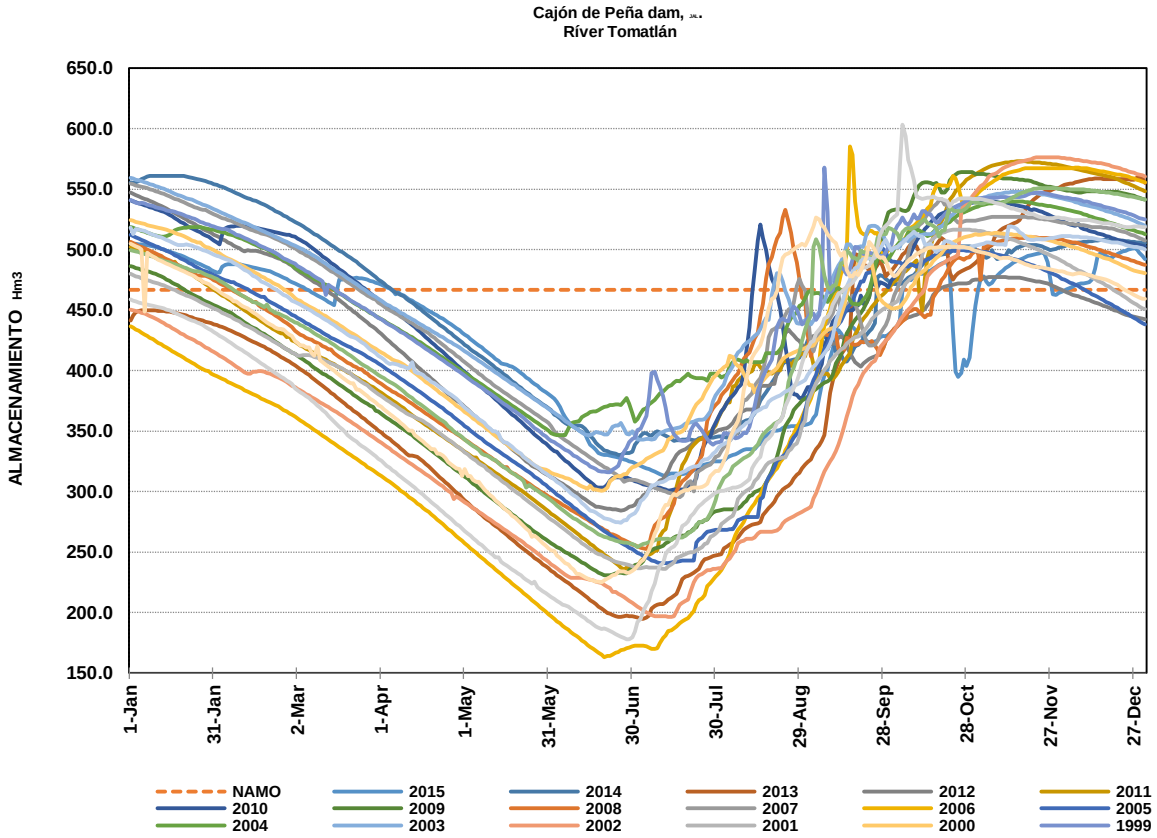
Cajon de Peña Dam in Jalisco State

It was built between 1974-1976 by the Secretariat of Hydraulic Resources (SRH). It is located in the Tomatlan River, 16.8 km upstream of Tomatlan, Jalisco.

The dam consists of a main curtain and four closing dikes of graded materials. The curtain has a length of 1015m, maximum height of 68m from the excavation, crown width of 10m to a 142m elevation; clay core covered with selected gravel-sand filters, bank 0.7: 1 on both sides; gravel-sand supports were placed on filters to a side bank 2:1, covered with muck and tumbled stones.

Design flood is 4,380 m^3/s, spillway is located on the right side of the curtain, it has direct discharge into the channel, controlled by five radial gates, 8m width, 12m height, for a regularised discharge of 4,000 m^3/s.

This dam often has high storage volumes, generating spills in different months due to the high potential of the Tomatlan River runoff, in comparison to the reservoir capacity.



Dam management in 2015

As previously described, CONAGUA through the SGT keeps national dams under permanent surveillance, checking dam levels before the onset of the rainy season or during an extraordinary weather event.

This was the case of Cajon de Peña dam prior to the rainy season of 2015.

By the end of the dry season, the dam stored volume was 476.74 hm^3, which is higher than its OHWL (466.69 hm^3), Chart 4; preventive withdrawals were conducted to allow for new storage to receive runoffs generated during the following rainy season.

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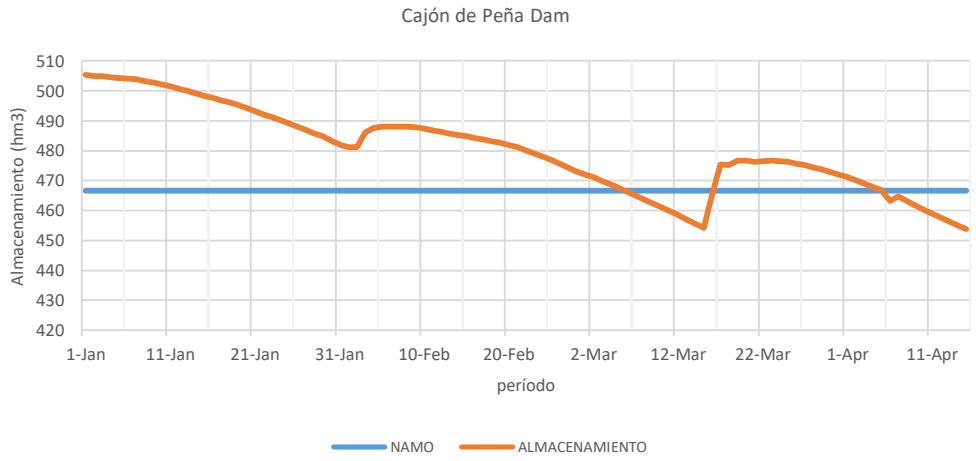
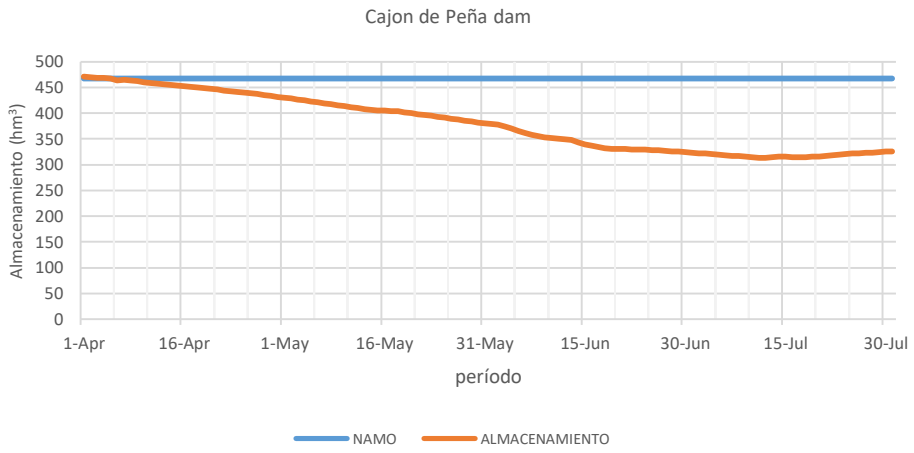
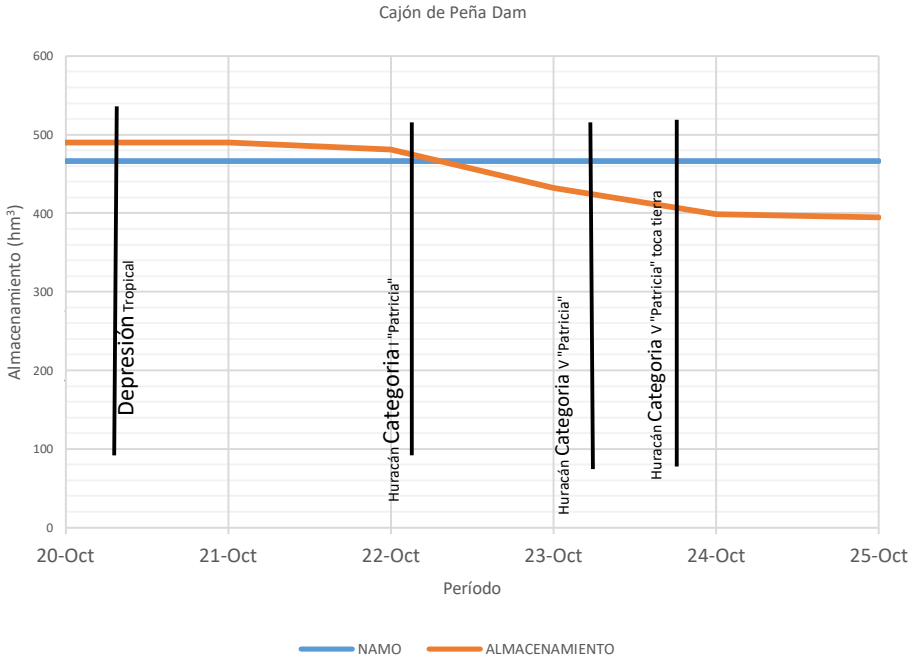




These control withdrawals were conducted under the Gate Operating Policy endorsed by the Division of Technical Affairs (SGT) and the Lerma-Santiago-Pacific (OCLSP) Basin Organization.

On 20 October the dam storage recorded was 489.62 hm^3, nearly 5% above OHWL, withdrawals were conducted to allow for new storage to receive expected runoffs, as well as to prevent the reservoir level to reach or exceeded EHWL. If this situation had occurred, it would had lead to structural damage as it is an earthworks dam, and under no circumstances would be possible to allow water level exceed the EHWL projected

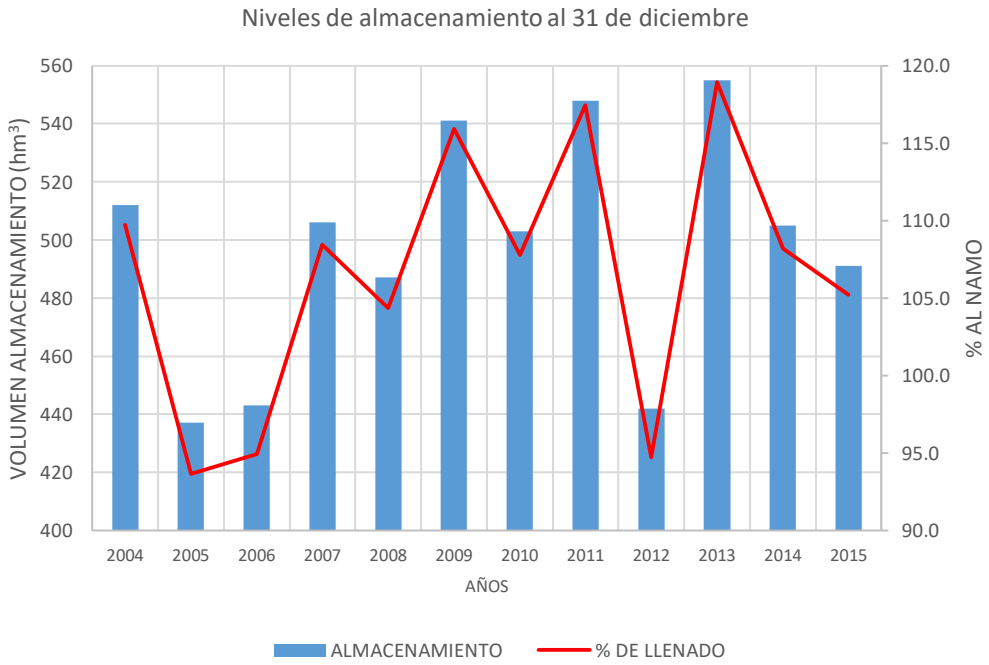


Date	Withdrawal (m^3/s)	Stored volume (hm^3)	Overall % stored
21 October	99.54	489.62	104.9
22 October	351.17	480.86	103.0
23 October	658.59	432.47	92.7
24 October	421.40	398.86	85.5
25 October	0	394.98	84.6

Analysis

Even though Hurricane Patricia generated lower rainfall than it was expected, the preventive withdrawals helped to avoid the reservoir to reach the forecasted storage levels of 562.10 hm^3 at an elevation of 134.07 masl, i. e. 3.69 m above OHWL and the consequential damage to the dam. The population was evacuated in a timely manner.

By the end of the year, given the timely and adequate management of levels in the dam, storage over the OHWL was reached, in spite that the released flows could be considered as a "waste of water".



The new policy implemented by CONAGUA enabled the following key operation objectives of reservoirs to be met:

1) Timely implementation of emergency protocols for population evacuation and protection of their property, and creating temporary shelters.

2) Safeguarding structural, hydrological, hydraulic and functional security of the dam.

3) Linking Federal, State and Municipal Bodies and the scientific and technical community in decision-making.

4) Providing sufficient water to meet the required water demands.

Conclusions

- The operation policy is an ongoing decision-making process to define reservoir storage levels and hence its releases, in order to avoid any damage to the dam and the infrastructure located downstream.

- At present the CONAGUA aims to detect and predict impending extreme events in order to formulate early warnings from monitoring and studying of factors that influence the intensity and frequency of disasters.

- In the case of the Cajon de Peña Dam, Jalisco, permanent surveillance allowed for a series of withdrawals to be conducted in a timely manner in order to provide in advance a margin for manoeuvre in case of possible extraordinary inflows and prevent risks

Conclusions

- This new operating policy implemented by CONAGUA in all dams in the country enabled to stored a volume of 491.95 Mm^3, 5.5% above its OHWL capacity by the end of the year, which proves the proper management of the dam.

“ It is better to prevent than to treat”

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