FIELD EVALUATION OF WATER CONSUMPTION AND DRAINAGE SYSTEM PERFORMANCE WHEN 6.8LPF TOILETS WERE REPLACED BY 4.8LPF TOILETS

Isabella P. Valencio
Orestes M. Goncalves

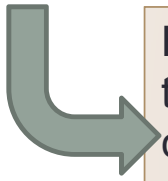
Escola Politecnica
University of São Paulo - Brazil

INTRODUCTION

- The need to reduce water consumption in Brazilian cities has promoted the development of more efficient sanitary appliances, particularly **low flush toilets (4.8 Lpf)**.

- **Actions** to reduce water consumption that **do not depend on the behavior or habits of users**, but, rather, on the characteristics of the water supply system and on technological actions, **are more effective** in reducing water consumption in building.

- The replacement of a 6.8 Lpf toilet for a 4.8 Lpf toilet theoretically reduces water consumption by 2 L at each discharge.



However, the reduction of the discharge volume should be associated to the **performance** of the toilet so that a reduction of the total water consumption may occur. If the toilet does not offer satisfactory performance for a user, he will flush once or twice - and the reduction will not occur.

INTRODUCTION

- The first results were presented at the CIBW062 Symposium **2016**.
- Present the **current results** of a Brazilian study of the performance evaluation of building water and drainage systems with **4.8 Lpf toilets**.

OBJECTIVE

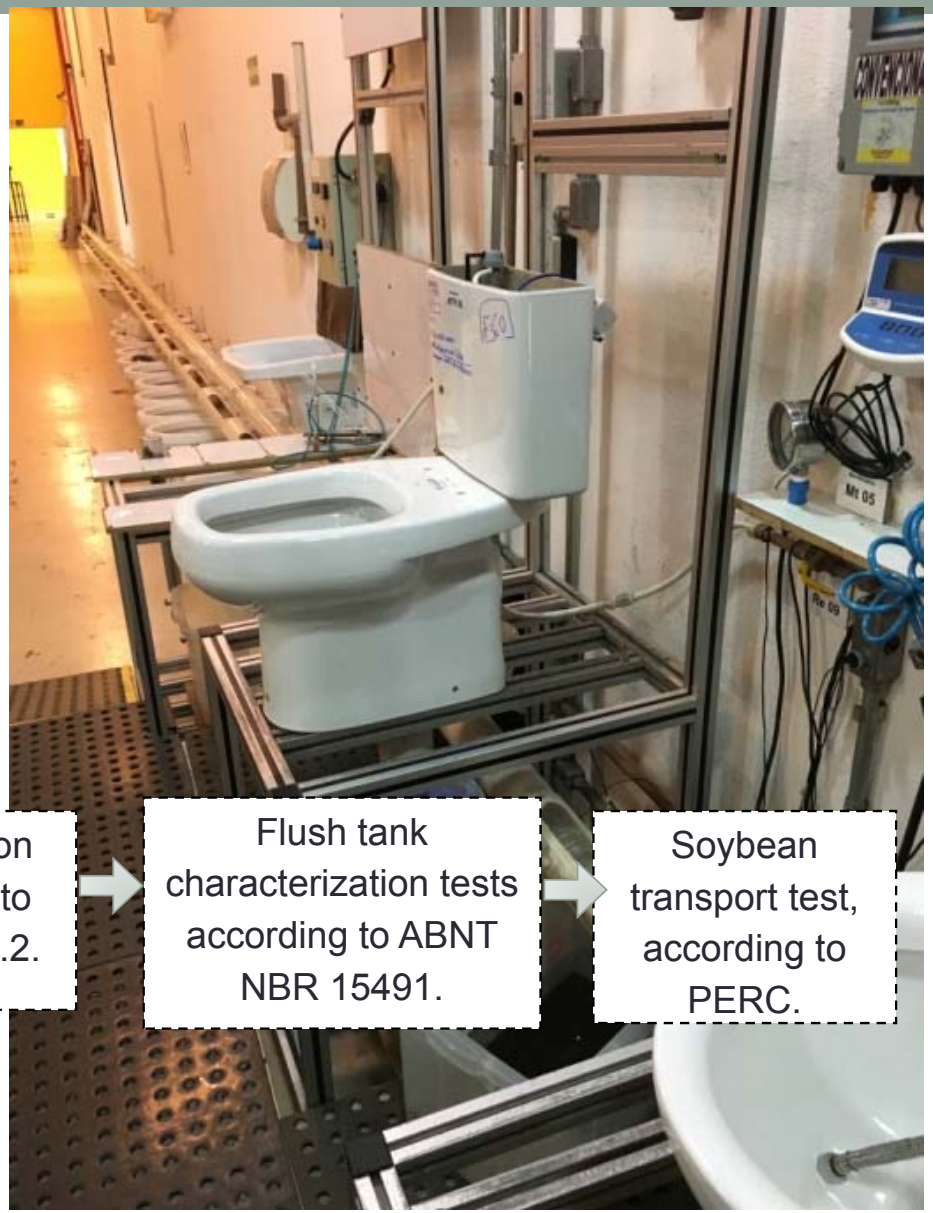
- Evaluation of the impact of replacement of 6.8 Lpf toilets for 4.8 Lpf toilets.

- The study was conduct in twos phases:

  - The **first phase** – **lab phase** - was performed by evaluating in the laboratory 20 toilets with 4,8Lpf.
  - The **second phase** - **field monitoring phase** - was conducted during 8 months and consisted of the verification of the reduction of water consumption by replacement 6,8Lpf toilets by 4,8Lpf toilets.

LABORATORY PHASE

The objective was characterized, in the laboratory, 4,8Lpf toilets in Brazilian conditions of plumbing installation and **evaluate the transport of solid criteria** in order to determine if the reduction of the water volume in toilets affects negatively the performance of building drainage system.



Toilets characterization tests according to ABNT NBR 15097.

Waste extraction test according to ASME A112.19.2.

Flush tank characterization tests according to ABNT NBR 15491.

Soybean transport test, according to PERC.

LABORATORY PHASE

REFERENCE DOCUMENT	TESTS PERFORMED
ABNT NBR 15097:2011	Water consumption test; splashing water; trap seal restoration test; surface wash test; granule and ball test; mixed media test; spheres removal; drain line transport characterization test.
ABNT NBR 15491:2010:	Filling time; overflow test for gravity flush tanks; Tightness float tap; Tightness gravity flush tank; Tightness of the float; Drive effort; Resistance to the drive mechanism; Resistance to the use; Resistance to static charge.
ASME A112.19.2: 2013	Waste extraction test




LABORATORY PHASE

- 20 different models of 4.8 Lpf toilets were tested from different manufacturers.

Some toilets were designed to operate with 4.8 Lpf

Volume
4.8Lpf

Some toilets were designed to operate with 6.8 Lpf but regulated to 4.8 Lpf.

Volume initial - 6.8Lpf
A regulation of the flush tank was made so that it provided the volume of 4.8Lpf.

LABORATORY PHASE - RESULTS

The results show:

- ✓The 20 toilets are able to remove a minimum of polypropylene spheres required by the Brazilian Standard (80 spheres) by the toilet itself;

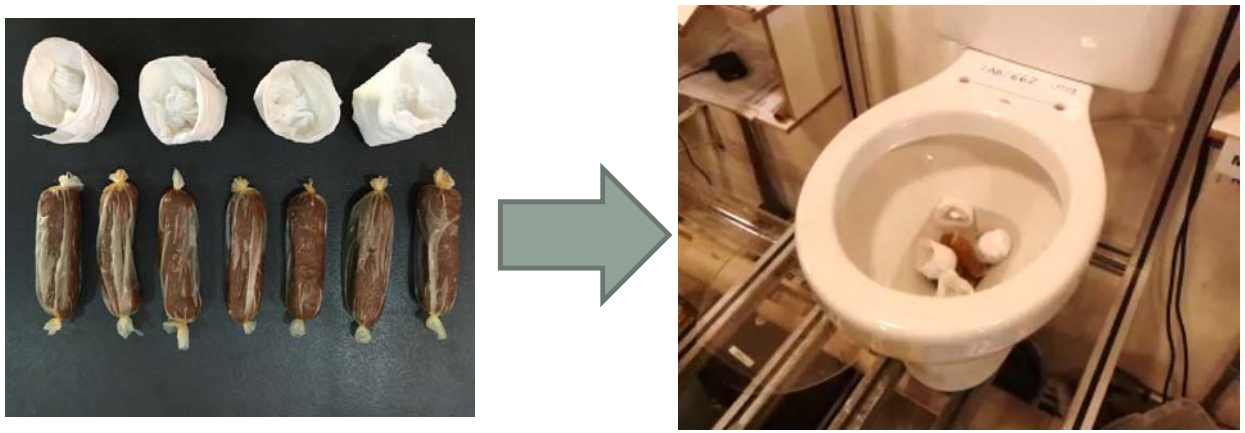
- ✓4 toilets do not carry the media through the minimum distance (10,0m) required by the Brazilian standard NBR 15097 (ABNT, 2011);

This indicates that the major problem encountered in reducing the discharge volume can be the removal of solids from drainage and sewage system.

LABORATORY PHASE - RESULTS

- The waste extraction test was performed in 13, approved previously, of the 20 initial toilets.

- Of these, five were considered approved (38%).



LABORATORY PHASE - RESULTS

- **All toilets designed to operate with 6.8 Lpf, but regulated to 4.8 Lpf failed the laboratory tests**. This proves that simply reducing the water level in the flush tank is not a viable solution to reduce toilet water consumption.

- At the end of the laboratory phase, 5 toilets were considered approved, which represents 25% of the toilets.

FIELD PHASE

The field study was conducted to verify:

- How the toilets approved in the laboratory study behave in the field;
- The correlation of the results obtained in the field with the results of the laboratory tests;
- If there was an effective reduction of water consumption and, if this reduction implies impacts on public sewage and building drainage systems.

For such purposes, two steps were carried out: **a monitoring of the toilet water consumption** and **real-time videos in the sewage system**.

FIELD PHASE

- The field phase site was conducted in the Housing Development Victoria, in Osasco city (10 km far from São Paulo - Brazil), was designed to low-income population.

FIELD PHASE

- The housing development consists of twelve town houses (six houses on the first floor and six on the second floor).

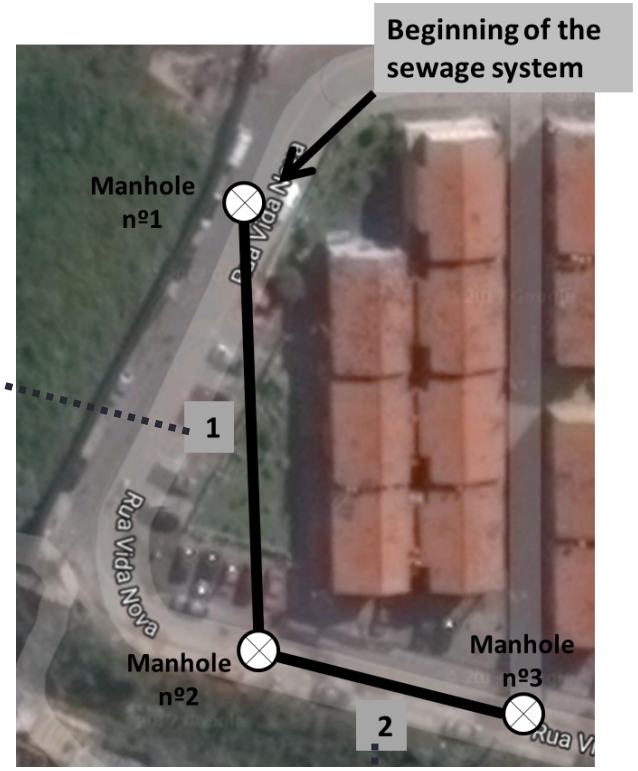
Residents of houses nº09 and nº23 did not allow monitoring process.

The 5 toilets considered to have been approved in the laboratory study, were installed in the field.

FIELD PHASE

- This housing development was selected because the critical characteristics of the drainage network:

Diameter of the pipeline: 150mm
Slope angle: 8.9% (or 0.089m/m)
Distance of Manhole 1 to Manhole 2: 39,60m



Diameter of pipeline: 150mm
Slope angle 1.4% (or 0.014m/m)
Distance of Manhole 2 to Manhole 3: 27.85m

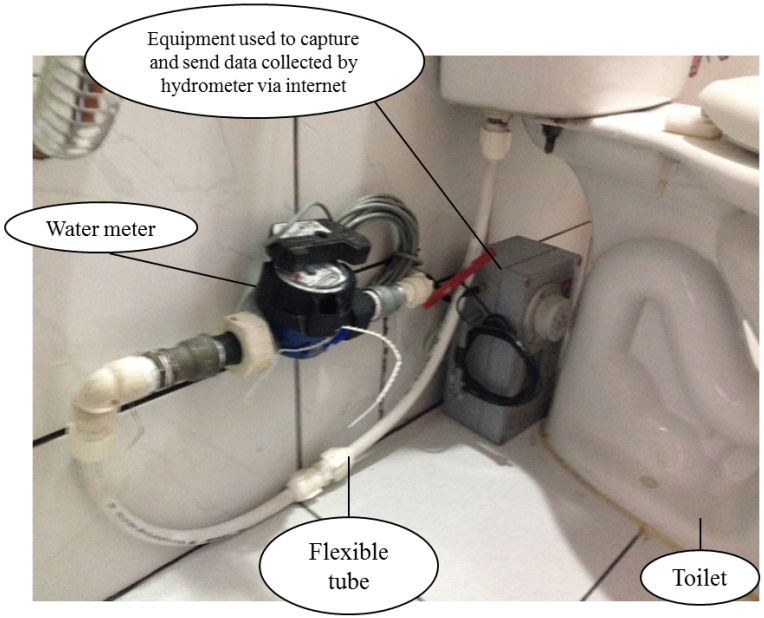
FIELD PHASE

- Questionnaires to characterize the habits of inhabitants was applied initially.
- It was possible to understand the routine of the inhabitants, including the pick period use of the bathroom and period of the day when the house is empty.
- It was realized a geometric survey of houses to define the toilet model more appropriate for each bathroom to avoid installation problems.

FIELD PHASE

- It was installed a water meter in each toilet (between the wall and the flexible supplying the flush tank) for monitoring the water consumption of toilets.

- The accumulated data volume and flow are sent remotely via Internet every minute.



FIELD PHASE

Monitoring of water consumption

Toilet water consumption per house, when the **6.8 Lpf** toilets were considered

House	6,8Lpf toilet water consumption per day(L)	Total water consumption per house per day - last year's average (L)	Toilet water consumption/total water consumption	6,8Lpf toilet water consumption per day per inhabitant (L/person/day)
3	35.0	92.3	37.90%	**17.5**
5	23.9	141.0	17.00%	**12.0**
7	37.9	220.5	17.20%	**126**
11	56.8	992.3 (*)	5.70%(*)	**15.2**
13	25.0	138.5	18.10%	**12.5**
15	103.9	430.8	24.10%	**20.8**
17	44.0	553.8	7.90%	**147**
19	45.9	441.0	10.40%	**115**
21	42.8	192.3	22.30%	**21.4**
25	81.1	425.6 (*)	19.10%(*)	**27.0**
Average	**49.5 L**	**276.3 L**	**19.4%**	**16.6**

FIELD PHASE

Monitoring of water consumption

Toilet water consumption per house, when the **4.8 Lpf** toilets were considered

House	4,8Lpf toilet water consumption per day(L)	Total water consumption per house per day after the replacement (L)	Toilet water consumption/total water consumption	4,8Lpf toilet water consumption per day per inhabitant (L/person/day)
3	22.7	60.0	37.8%	**11.4**
5	21.1	140.0	14.8%	**10.6**
7	25.4	263.3	9.6%	**8.5**
11	127.9	643.3(*)	19.9%(*)	**25.6**
13	36.9	130.0	28.4%	**18.5**
15	114.1	360.0	31.7%	**22.8**
17	58.5	596.7	9.8%	**19.5**
19	63.5	330.0	19.2%	**15.9**
21	33.2	130.0	25.5%	**16.6**
25	78.3	440.0(*)	17.8%(*)	**26.1**
Average	**58.2**	**251.6**	**22.1%**	**17.6**

FIELD PHASE

Toilet water consumption per person

Houses	toilet water consumption per day per inhabitant (L/person/day)		Difference in water consumption	
	6.8 Lpf toilets	4.8 Lpf toilets	(L/person/day)	(%)
House nº3 (toilet nº11)	17,5	11,4	6,1	35%
House nº5 (toilet nº11)	12,0	10,6	1,4	12%
House nº7 (toilet nº2)	12,6	8,5	4,1	33%
House nº11 (toilet nº13)	15,9	25,6	-9,7	-61%
House nº13 (toilet nº13)	12,5	18,5	-6	-48%
House nº15 (toilet nº15)	20,8	22,8	-2	-10%
House nº17 (toilet nº15)	14,7	19,5	-4,8	-33%
House nº19 (toilet nº20)	11,5	15,9	-4,4	-38%
House nº21 (toilet nº20)	21,4	16,6	4,8	22%
House nº25 (toilet nº2)	27,0	26,1	0,9	3%
Average	**16,6**	**17,6**	-1,0	-8%

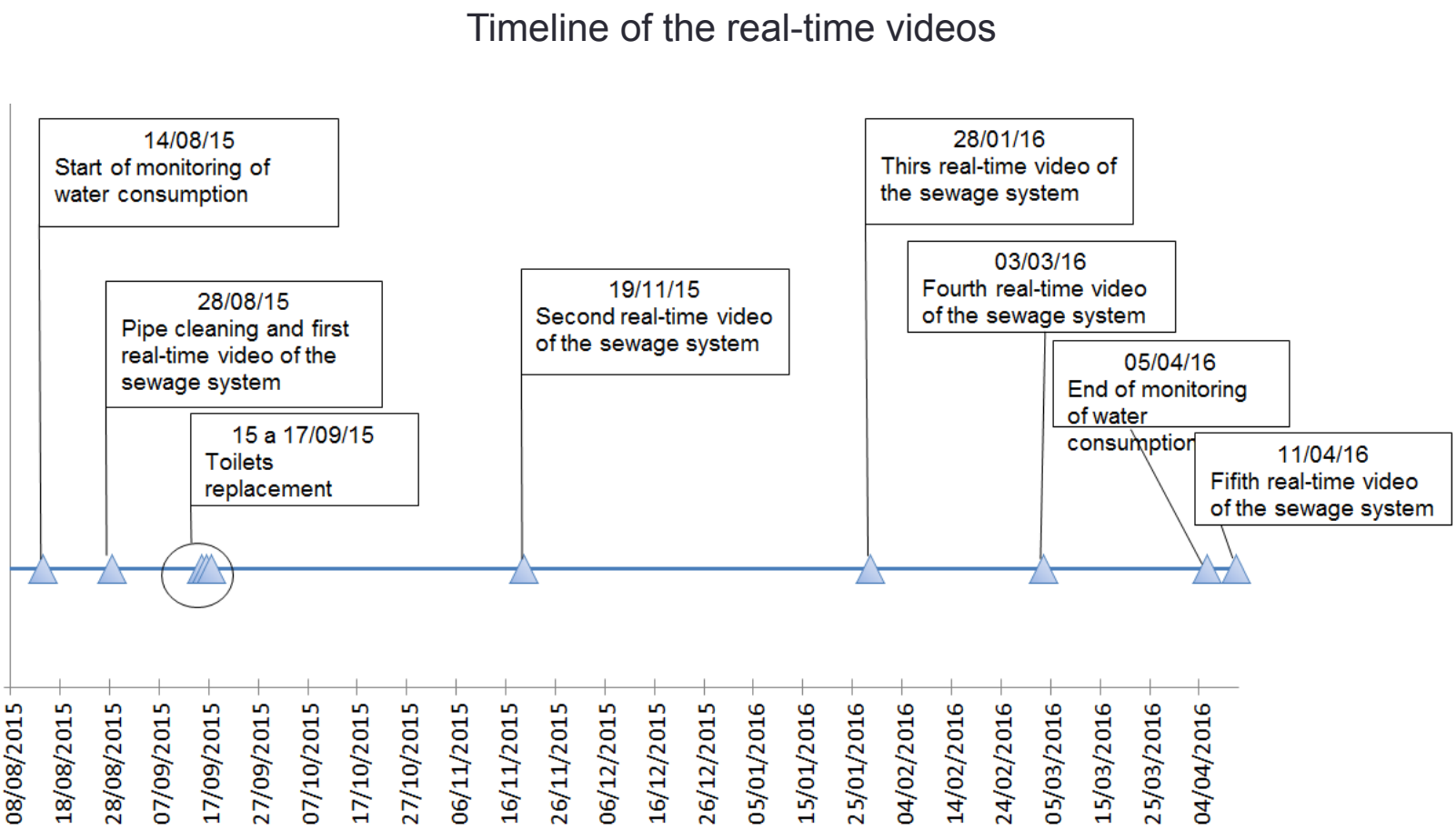
- Houses 3, 5, 7, and 21 showed a significant reduction in toilet water consumption.
- House 25 reduced 3% of consumption, which can be considered constant. However, in House 7, where the same 4.8 Lpf toilet model was installed, a 33% reduction in toilet water consumption was observed.
- Houses 11, 13, 15, 17, and 19 showed an increase in toilet water consumption.

FIELD PHASE

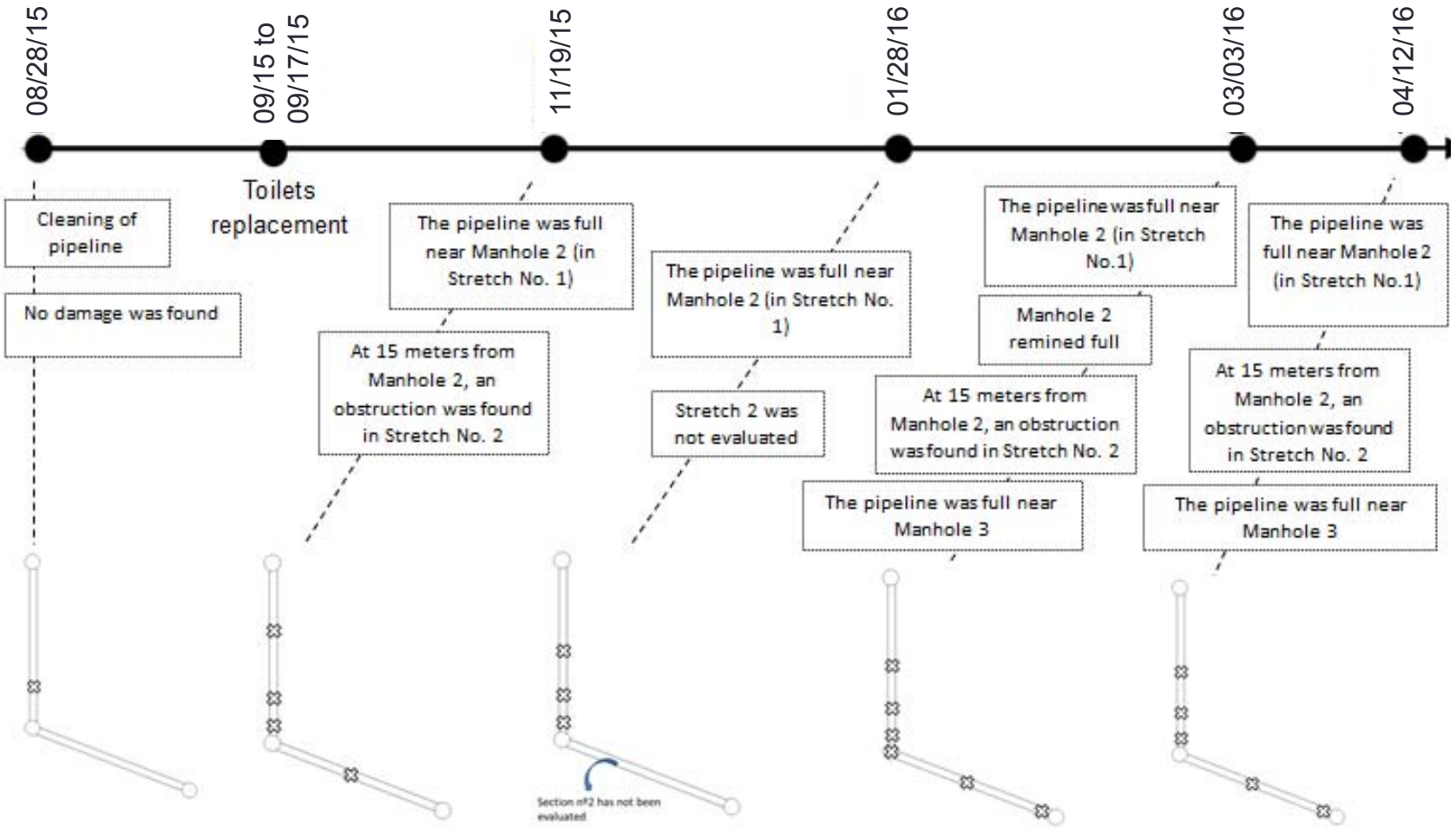
- The real time video system was used to verify possible initial blockage in the sewage system and to check if after the installation of 4,8Lpf toilets occurs some blockage or clogging the pipe.

- The camera is connected to a monitor that displays the image filmed live streaming.

FIELD PHASE

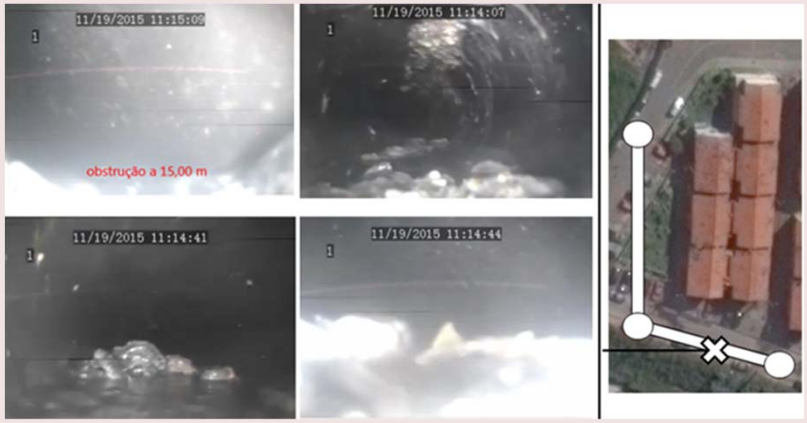

Timeline of the real-time videos
14/08/15
Start of monitoring of water consumption
28/08/15
Pipe cleaning and first real-time video of the sewage system
15 a 17/09/15
Toilets replacement
19/11/15
Second real-time video of the sewage system
28/01/16
Thirs real-time video of the sewage system
03/03/16
Fourth real-time video of the sewage system
05/04/16
End of monitoring of water consumption
11/04/16
Fifith real-time video of the sewage system
08/08/2015
18/08/2015
28/08/2015
07/09/2015
17/09/2015
27/09/2015
07/10/2015
17/10/2015
27/10/2015
06/11/2015
16/11/2015
26/11/2015
06/12/2015
16/12/2015
26/12/2015
05/01/2016
15/01/2016
25/01/2016
04/02/2016
14/02/2016
24/02/2016
05/03/2016
15/03/2016
25/03/2016
04/04/2016

FIELD PHASE


08/28/15
09/15 to 09/17/15
11/19/15
01/28/16
03/03/16
04/12/16
Cleaning of pipeline
No damage was found
Toilets replacement
The pipeline was full near Manhole 2 (in Stretch No. 1)
At 15 meters from Manhole 2, an obstruction was found in Stretch No. 2
The pipeline was full near Manhole 2 (in Stretch No. 1)
Stretch 2 was not evaluated
Section nº2 has not been evaluated
The pipeline was full near Manhole 2 (in Stretch No.1)
Manhole 2 remined full
At 15 meters from Manhole 2, an obstruction was found in Stretch No. 2
The pipeline was full near Manhole 3
The pipeline was full near Manhole 2 (in Stretch No.1)
At 15 meters from Manhole 2, an obstruction was found in Stretch No. 2
The pipeline was full near Manhole 3

FIELD PHASE

Detail of the branch verified in the real-time video of 08/28/15

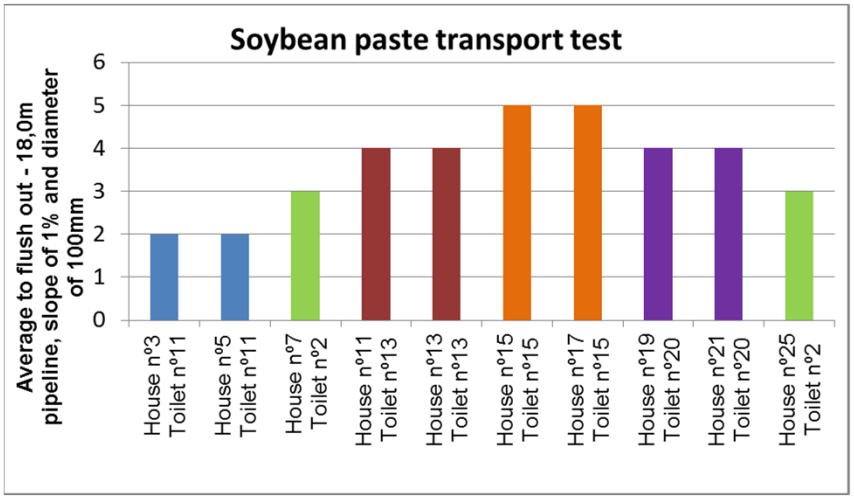


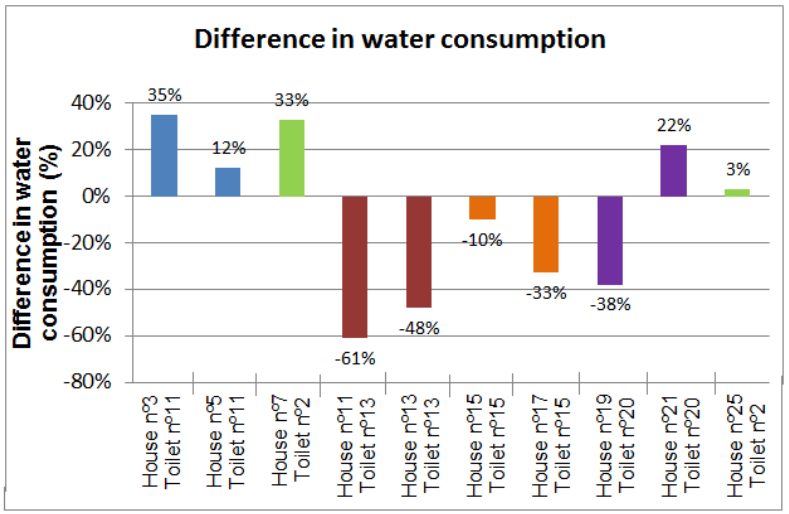
Detail of obstruction noted in real-time video of 11/19/15

Detail of Manhole 2, in the real-time video of 03/03/16

LABORATORY PHASE
X
FIELD PHASE

Graphical comparison between the performance of the toilets in the field and the soybean paste transport test





It was found that those toilets that required **three or less discharges** to remove all media from the 18-meter pipeline in the soybean paste transport test, had good performance in the field, i.e., they **did not offer problems for the users** and **led to a reduction** of toilet water consumption.

THE MAIN CONCLUSIONS

LABORATORY PHASE

- 75% of the evaluated products did not meet the minimum requirements of the current standards → reflects the need for toilet evolution.

- Both toilets designed to work with 4.8 Lpf and **toilets designed to work with 6.8 Lpf, but regulated to 4.8 Lpf** were tested.
  - **All the 6.8Lpf failed** → simply reducing the water level in the flush tank is not a viable solution to reduce toilet water consumption.

THE MAIN CONCLUSIONS

FIELD PHASE

- The toilets with **better performance in the field** were the ones with **better performance in the test of transport of soybean paste**.
- Data monitoring revealed the presence of **successive periodic flushes** in some houses, specifically in those where there was an increase in water consumption after the replacement of the toilets → the reduction of water consumption is not obtained simply by reducing toilet water consumption, and that it is essential that the toilet meet the minimum operating requirements.
- With the real-time video, **deposits of solids were verified in the sewage system** throughout the monitoring, after the toilets were replaced, even with the horizontal collector slope angle of 8.9%.

THANK YOU!

Isabella P. Valencio - isabella_valencio@usp.br
Orestes M. Goncalves - orestes.goncalves@usp.br