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Problem of Pipe Scaling in the Distribution Network of the Mbour 2 Thies District

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ABSTRACT

The purpose of this work is to contribute to the improvement of the district's drinking water supply system in order to guarantee sufficient quantities of water by 2051. We presented the study area, made a diagnosis of the drinking water network before making a proposal for a solution. The diagnosis of the network was made by calculating the current water needs of the population using Excel software and by simulating the operation of the network on Epanet. The latter showed that the populations of the Mbour 2 district face enormous problems of access to drinking water. And these problems are due to the reduction in diameters caused by the deposition of pie in the pipes. The needs assessment allowed us to estimate future consumption at 1.098 m^3/s in 2051 while drilling production is at 3.064 m^3/s. From there we see the drilling can feed Mbour 2 if there is not a possible problem So it is imperative to make a limestone treatment to protect the pipes and have good drinking water. Faced with this situation. we have created a network network of Mbour 2 with the new castle R7 bis which receive fresh water from Lake Guiers in order to have a perfect dilution and also propose a renewal of the clogged pipes by choosing larger diameters. The results of the simulation with the use of the PICCOLO software showed pressure values greater than 2 bar in the Mbour 2 network which translate into a continuous availability of water without pressure drop.

Keywords: Scaling. Drinking water supply. Mbour 2. Pressure. Simulation

1. INTRODUCTION

Access to drinking water is an important issue in the world. The mission of a drinking water service is to ensure the production and distribution of drinking water of good quality and in sufficient quantity. respecting regulations and ensuring the safeguarding of heritage. These requirements require to properly size the network but also to maintain it in a satisfactory state [1]. The city of Thies. more particularly the district of Mbour 2 has been experiencing problems of access to drinking water for several years. This situation is due on the one hand to a high rate of population growth and on the other hand to a scaling problem* which is the major problem encountered by the population of Thies. The drinking water supply network of Thies is very rich in limestone. Scaling which is the deposit of pie on an object or inside a pipe that is to say the concentric deposit of pie in a pipe. Water is one of the most precious goods. without it nothing grows and nothing lives. Despite its abundance on earth. only 2.5% of the water available on the planet is freshwater. consumable. Essential for our survival. drinking water is not accessible to all in the same way. which promotes the development of undernutrition [2].

According to the World Health Organization (WHO). less than 50% of cases of undernutrition among children are due to the consumption of unsafe drinking water [3]. Access to water is an indicator representing the proportion of the population with reasonable access to an adequate amount of drinking water. According to the WHO. the adequate amount of drinking water is at least 20 liters of water per capita per day. "Reasonable access" is generally understood to mean a supply of drinking water available within a fifteen minute's walk of the place of residence [4. 5].

Today. nearly 2.2 billion people do not have access to water. This means that they either do not have access to their homes. they have access to a well that is more or less far from their home or they have water sources that they consume without knowing whether the water is treated or not. An estimated 3.6 billion people worldwide live in areas where water is a potentially scarce resource. accessible at least one month a year [6].

Africa is subject to a paradox. its hydraulic potential is great. but its exploitation is complex. The volume of groundwater in Africa provides an annual source 100 times larger than rainfall and 20 times larger than lakes [7].

This difficulty of access to water has a huge impact on different levels. At the social level. lack of access to water can lead to conflicts within and between communities. But it is on the economic level that the impact is greatest [8].

The ever-increasing urbanization of certain cities. population growth. and the increase in the standard of living of populations are all parameters that influence the demand for drinking water [9].

In Thies. as elsewhere in Senegal. efforts are being made to provide the population with an adequate drinking water supply system. with a view to improving the living conditions of the population. Despite the efforts made by the Senegalese State in this area. problems still persist [10].

The population is growing rapidly and the need for domestic. industrial and agricultural water is increasing over time. Access to this water is an increasingly serious problem and many solutions are being sought to remedy it. Indeed. with the problem of scaling and with the population explosion. Thies is often faced with a problem of drinking water supply. Access to drinking water is one of the major challenges that central and local actors must meet.

The main objective of this study is to improve drinking water supply conditions in the Mbour 2 district.

2. Equipment and methods

2.1. Presentation of the city of Thies study

The region of Thies. located in the west of Senegal at 14°46' North - 16°54' West. is limited to the east by Fatick and Diourbel. to the west by Dakar and the Atlantic Ocean. to the north by Louga and to the south by the Fatick region. It thus covers nearly 3.4% of the country's surface area (Figure 1).

The Thies network is composed of:

- 10 boreholes
- 04 water castles
- A booster station.

The linear number of networks is 612 km and consists of pipes with diameters ranging from 63 to 500 mm. It also consists of PVC diameter (which occupies on average 70% of the network) and cast iron.

The town of Thies is supplied by drilling and also pitting on ALG 1. 2 and 3.

Table 1 shows the characteristics of the different discharge pumps of the boreholes that supply Thies.

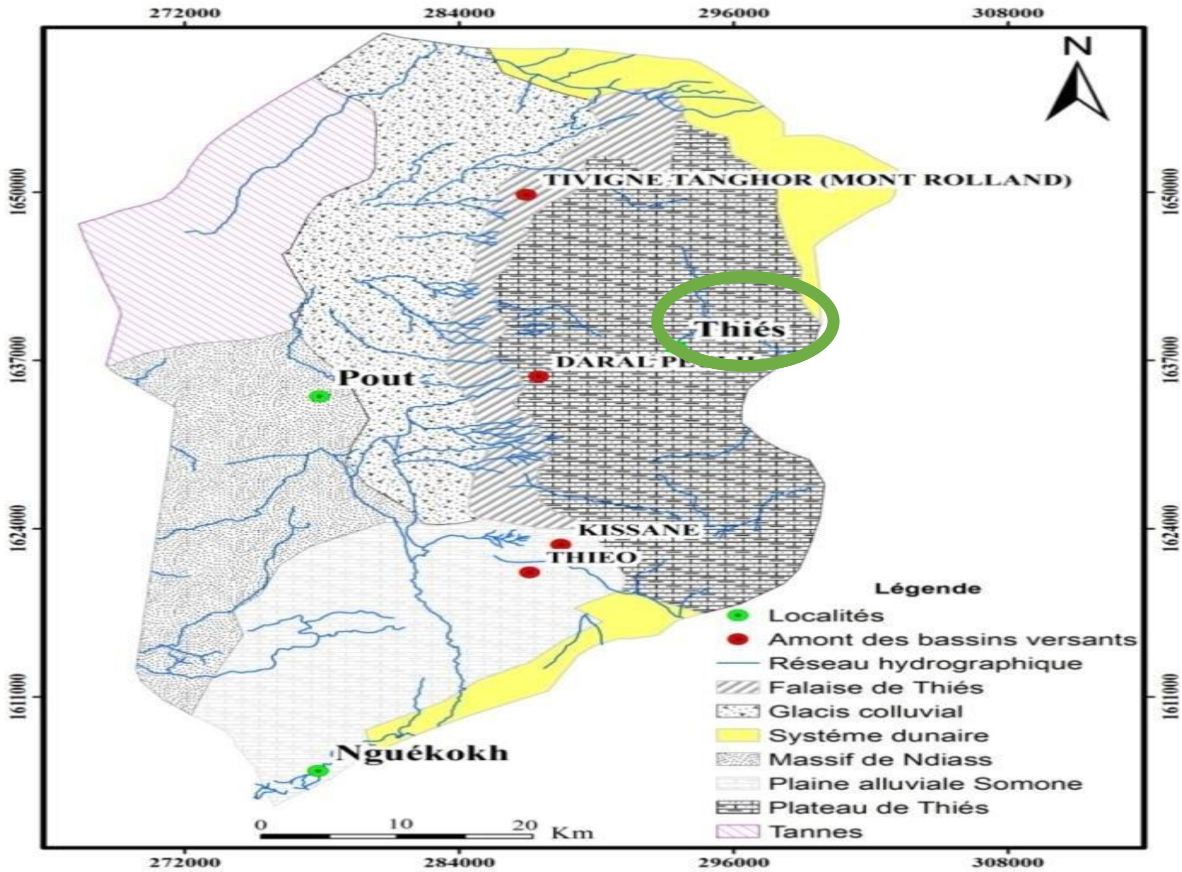


Figure 1: Location of the city of Thies

Table 1 : Pump characteristics

ITEM	DRILLING	FLOW	TOTAL MANOMETRIC HEIGHT
1	F1 TER THIES	80	182
2	F2 THIES	90	160
3	F3 THIES BIS	120	150
4	F4 THIES	120	200
5	F5 BIS THIES	70	180
6	F6 THIES	120	150
7	F8 THIES	80	200
8	F9 THIES	150	180
9	F10 THIES BIS	120	200
10	F11 THIES	120	180
11	F13 THIES (Stopped)	150	240

2.2. MATERIALS AND METHODS

The technical and social data were transmitted to us by the ANSD (National Agency of Statistics and Demography) and the SEN'EAU (Water of Senegal) of Thies in the form of Word and Excel files. They concern the population of the year 2013.

The software used in this work are : Google Earth. Word. Excel. Epanet and AutoCAD.

For the estimation of the evolution of the population we used the geometric method:

$P_n = P_2 (1+r)^n$ (1)

Pn = Population at the end of the time interval n;

P2 = Population at the beginning of the time interval n ;

n : time interval in years that is equal to (tn-t2) ;

r : Annual geometric growth rate

For the calculation of linear pressure losses we retain Manning Strickler's expression :

$$H_f = \frac{10.29 x L x Q^2}{Ks^2 D^{16/3}} \quad (2)$$

For the calculation of linear pressure losses we use the expression the general formula

$\Delta H = K \times \frac{V^2}{2g}$ (3)

The formula used for the prediction of scaling following the decrease in diameter during the operating period can then be determined by the following relationship:

$Dt = Do - \Delta$ (4)

Where :

Dt: the diameter after "t" years of operation in mm;

Do : the initial diameter before operation in mm ;

Δ : the quantity of scale deposited after "t" years of operation in mm;

$\Delta = k \times t$

k : the annual increase in scale deposition which can be assimilated to an average scaling rate in mm/year;

t: Number of years the pipeline has been in operation.

In this study. we will treat the Mbour 2 network with a view to providing sustainable solutions to the scaling problem noted in this district which is fed by a groundwater aquifer (Maestrichtian aquifer) with drilling F11.

We will perform a hydraulic simulation of the operation of the current and future network. To the extent that it allows us to verify whether the distribution network fulfills or will fulfill its main functions. in accordance with the requirements in force. namely to serve drinking water to the population with a required pressure between 1.5 and 4 bars.

Figure 3 shows the hydraulic diagram of Mbour 2 of the city of Thies.

Pipes :

Figure 2: Mbour 2 drinking water supply network

Mbour 2 has a mesh drinking water supply network as shown in Figure 3. Existing pipes with diameters of 63 mm PVC (70%) are then in the majority of 110 mm.

3. RESULTS AND DISCUSSION

This section will mention the different results obtained after diagnosis of the network.Table 2 shows the evolution of the population of Mbour 2 from 2013 to 2051. which represents the horizon of the project.

Table 2 : Evolution of the population of Thies Ouest and Mbour 2 from 2013 to 2051

Designation		2013	2021	2031	2041	2051
Population	Thies West	76 516	95 433	125 785	165 791	218 520
	Mbour 2	3 203	3 995	5 266	6 940	9 147
Growth	2.8 %					

Consumption will be determined on the basis of population trends. In this study we set a CUG (Global Unit Consumption) of 40 liters/day/person.

Table 3 shows the evolution of the population as well as the evaluation of current and future consumption of Mbour 2

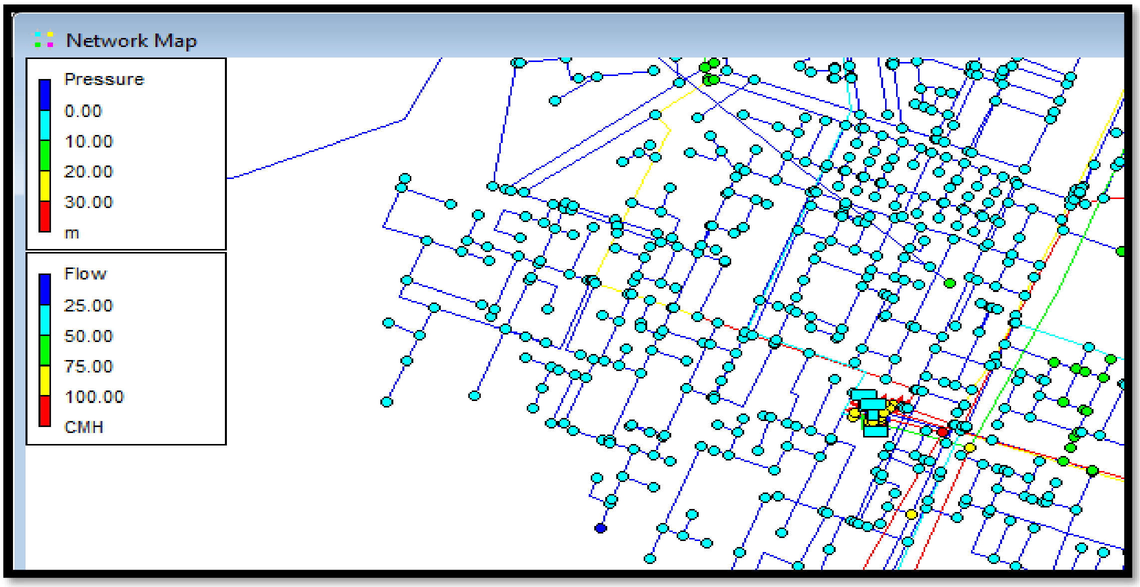
Table 3 : Evolution of the population and water consumption of Mbour 2 from 2021 to 2051

Designation	Units		2021	2031	2041	2051
Populations	hab		3 995	5 266	6 940	9 147
Domestic consumption	m^3/j		160	211	278	366
Non-domestic consumption	% Cd		20	20	20	20
	Cnd	m^3/j	32	42	56	73
Average daily consumption Cmj	m^3/j		192	253	334	439
Peak Day Demand	Daily peak coefficient		2	2	2	2
	Djp	m^3/j	384	506	668	878
Water losses in the network	Loss coefficient in %		50	50	50	50
	Losses	m^3/j	96	127	167	220
Production requirements of the day	m^3/j		480	633	835	1098
Hourly peak flow calculation (Qph)	Hourly peak coefficient		3	3	3	3
	Qph	m^3/h	60	79.125	104.375	137.25
	Qph	l/s	16.67	21.98	28.99	38.125

The elements found in this table will allow us to calculate the flow (hourly peak flow) to be integrated into the Epanet software to meet the water demand of the population of Mbour 2 until 2051. Thus, in this study, to ensure a good water supply of this locality until 2051, we will integrate a flow of 38,125 l/s in the Mbour 2 network.

After entering all the network elements on Epanet. we start the network simulation. We notice that this simulation was successful.

Figure 3 shows the behavior of the network without scaling.



Legends :

Pipes :

Nodes :

Figure 3: Mbour 2 hydraulic network without scaling

We see that the dimensioning of the network with the real diameters considering that there is no scaling we see that it has no problems. The results obtained after simulation also showed that the drinking water supply of Mbour 2 is correct with a minimum pressure of 2 bars so not too much pressure drop that can lead to a decrease in pressure.

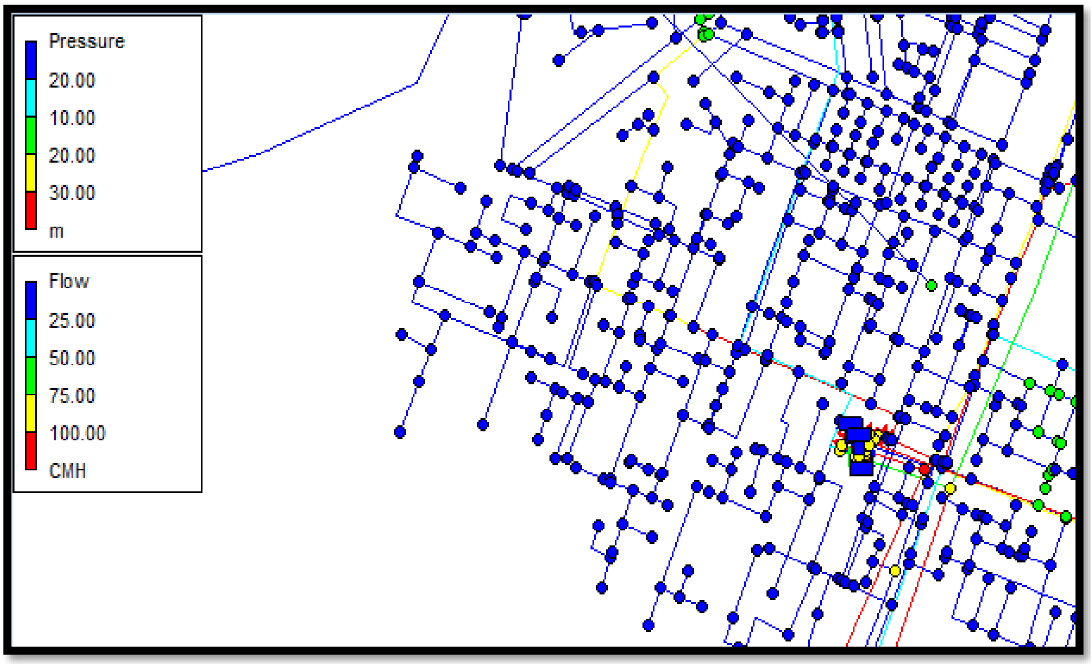
However. after a few years of operation. we noticed low pressures that led to water

shortages in this area while the flow provided by drilling F11 covers the water demand. This is explained by the fact that the water of Thies is rich in limestone hence the phenomenon of scaling.
Table 4 summarizes the new diameters after years of operation.

Table 4 : Summary of the different diameters after years of operation

Year of operation	Initial diameter	63	90	110	160	200	250	300
	α	0.279	0.253	0.236	0.197	0.170	0.142	0.119
1st year (t=1 an)	Dt	45.424	67.218	84.089	128.520	165.927	214.425	264.342
	Δ	17.576	22.782	25.911	31.480	34.073	35.575	35.658
Year 2(t=2 years)	Dt	27.849	44.435	58.178	97.040	131.855	178.850	228.685
	Δ	35.151	45.565	51.822	62.960	68.145	71.150	71.315
Year 3 (t=3 years)	Dt	10.273	21.653	32.268	65.560	97.782	143.275	193.027
	Δ	52.727	68.347	77.732	94.440	102.218	106.725	106.973

We note that after 3 years of operation of the network, an advanced reduction in the diameter of the pipes. This reduction is linked by the presence of limestone in water which causes the phenomenon of clogging of pipes as shown in table 4.
Figure 4 shows the behaviour of the network after (3) years of operation



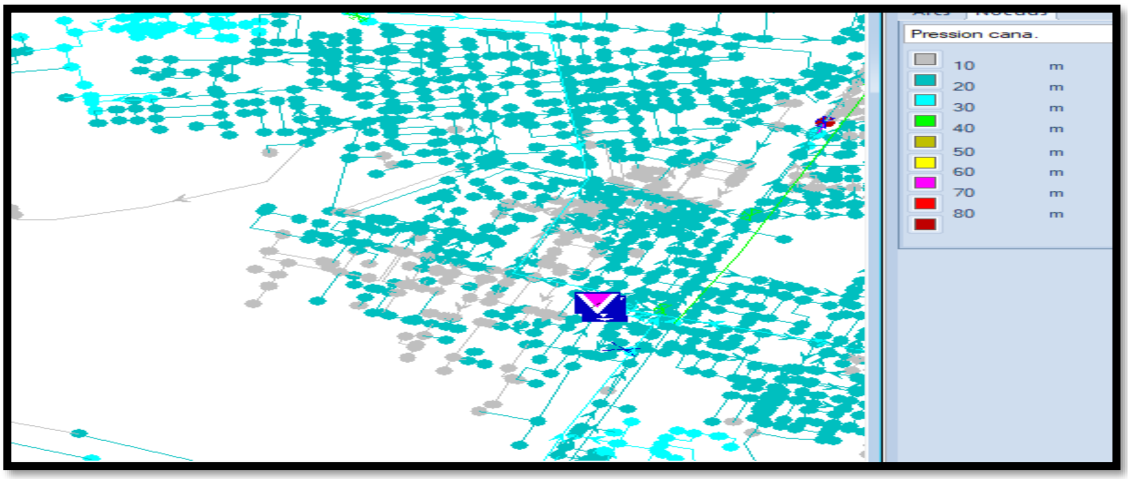
Legends :
Pipes :
Nodes :
Figure 4: Mbour 2 hydraulic network after 3 years of operation

We started the simulation with the new diameters. we find that it did not succeed. This can be explained by the fact that there is a significant reduction in distribution pipe diameters caused by pie deposition over the years.
Faced with this situation. we are trying to dilute to reduce the concentration of limestone in this network by proposing a mesh with the new water tower R7 bis of capacity 2.000 m^3 which receives fresh water from Keur Momar Sarr and also a renewal of the impacted sections.
Thus. all diameters below 63 will be replaced by diameters 90. diameters between 63 – 90 mm by 110 mm. diameters 160 will be replaced by 200. Table 5 shows the new diameter values integrated into the software.

Table 5 : Summary of the different diameters after years of operation

CRA Number	Initial node	Final node	Length(m)	Diameter(mm)	Material/Roughness(mm)
15	N01513	N01512	1	250	0.1
57532	N01425	N01452	44.922	250	0.1
57533	N01425	N01408	54.937	90	0.1
57536	N01513	N01546	54.992	250	0.1
57541	N01477	N01512	41.549	250	0.1
57542	N01546	N01561	80.866	160	0.1
57543	N01561	N01583	38.52	110	0.1
57597	N02029	N02032	4.377	110	0.1
57629	N01684	N01687	4.946	90	0.1
57630	N01684	N01696	33.045	90	0.1
57631	N01687	N01673	38.743	90	0.1
57632	N01687	N01727	34.025	90	0.1
57633	N01727	N01735	37.517	90	0.1
57634	N01727	N01729	2.639	90	0.1
57635	N01729	N01711	36.476	90	0.1
57636	N01729	N01764	36.786	90	0.1
57637	N01764	N01783	37.858	90	0.1
57638	N01764	N01768	2.287	90	0.1
57639	N01768	N01750	36.854	90	0.1
57640	N01768	N01807	40.044	90	0.1
57641	N01807	N01798	41.63	90	0.1
57642	N01807	N01852	49.637	90	0.1
57643	N01852	N01836	41.096	90	0.1
57644	N01852	N01881	38.459	90	0.1
57645	N01881	N01886	4.004	90	0.1
57646	N01881	N01896	36.825	90	0.1
57647	N01886	N01876	35.08	90	0.1
57648	N01886	N01924	35.756	90	0.1
57649	N01924	N01927	3.685	90	0.1
57650	N01927	N01912	40.134	90	0.1
57651	N01924	N01935	30.844	90	0.1
57652	N01927	N01962	36.753	90	0.1
57653	N01962	N01949	41.05	90	0.1
57654	N01962	N01965	2.298	90	0.1
57655	N01965	N01979	32.094	90	0.1
57656	N01731	N01630	109.717	90	0.1
57657	N01630	N01638	31.605	90	0.1

The results obtained after simulation with the PICCOLO software showed pressure values greater than 20 m in the network after opening the mesh with the R7 bis castle. These pressure values obtained will ensure the continuous supply of drinking water to the Mbour 2 district and its surroundings. Figure 5 shows the behaviour of the network with the mesh and the renewal of the pipes.



Legends :

: Pressure = 20 m : Pressure = 30m : Pressure = 10m

Figure 5: Mbour 2 hydraulic network after mesh and renewal of pipelines.

CONCLUSION

Limescale manifests itself in the form of layers of scale and does not protect the pipes. contrary to popular belief. Corrosion persists under layers of scale. in both copper and PVC pipes. Limescale deposits even promote microbial colonization and increase water and electricity consumption [11].[12].

The drinking water supply of the city of Thies is 80% ensured by boreholes and these are very rich in limestone.

The diagnosis of the network in Epanet after three years of operation showed an advanced reduction in the size of pipe diameters favoring water shortages in the Mbour 2 area. Faced with this situation. we proposed to create a mesh between the R7 bis water tower which receives fresh water from Lac de Guiers and the discharge pipe of drilling F11 which feeds Mbour 2 in order to have a perfect dilution on the one hand and on the other hand to proceed with the renewal of the clogged pipes.

The simulation with the use of the PICCOLO software with this work showed satisfactory pressure values for the drinking water supply with an average value of 2 bars.

Declaration by Authors

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