

Inventing needs: expertise and water supply in late eighteenth- and early nineteenth-century Paris

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Abstract. The aim of this paper is to investigate the notion of need, in this case an entire city's global need for water. This was a notion invented by Paris technicians between 1760 and 1804 in the context of several water supply projects, notably two river diversion schemes, those of the Yvette and the Ourcq, where the concept was much discussed. Different ways of considering the question of need – such as water resources, consumption and use, whether present or future – were strongly related to engineers' or scientists' conceptions of their own work. State engineers claimed they could make objective estimates of future needs with no reference to either value judgements or political intentions, a position which made it possible to keep strong control over the decision in the name of the state. In contrast, a practically trained engineer working outside the state corps claimed that in the case of expertise about the future, estimates would depend strongly on political intentions, norms and ideals, so the government should first give an outline of its intended actions. The paper studies the differences between these two approaches to the concept of need, especially how they articulated knowledge about what *is* and knowledge about what *ought to be*, present and future. The paper ends by linking these differences to conceptions of what was supposed to be technical or political in such projects and of what role engineers intended to play in the decision-making process.

Historians of the Paris water supply agree that in the modern period there was severe water scarcity. Most reach this conclusion by comparing estimates of the limited water available through the public fountains with the much larger average needs of the Paris population.¹ This assumption is questionable for at least two reasons. First, it is difficult to get a proper idea of the distribution and consumption of water in Paris in that period. Supply cannot be identified solely with that from the fountains. Second, how should the concept of need be defined? Most writers in fact make use here not only of a specific concept of need and of its value, but indeed of the entire argument of a few late eighteenth-century scientists, engineers and entrepreneurs who proposed various water supply projects and tried to convince authorities that there was a lack of water in Paris which their projects could satisfy. The idea of a global water need for a whole city was

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1 L. Beaumont-Maillet, *L'Eau à Paris*, Paris, 1991; Ph. Cebron de l'Isle, *L'Eau à Paris au 19e siècle*, Paris, 1991. These authors also insist on the growth of population during the eighteenth century while noting little infrastructural change before the last decades of that century.

invented by these very technicians. As this paper shows, they had quite divergent approaches and divergent concepts of need.

The aim of this paper is not to discuss the reality of an alleged lack of water in eighteenth-century Paris. It will not question whether there was then water scarcity in Paris. The very meaning of this scarcity, in fact, is difficult to assess: were people really suffering from a lack of water or did their culture involve life with small quantities of water, with very little bathing and washing?² The aim is rather to study the invention of various concepts of need, the emergence in the second half of the eighteenth century and the beginning of the nineteenth century of voices speaking of global need. Since the notion of need was introduced in the context of water supply projects for Paris so as to argue for the necessity of these enterprises, I will look at some of these projects and investigate their various definitions, estimates and uses of need.

It is seldom known, unfortunately, on what kind of knowledge and opinions a given estimate of need was based: these might have been hygienist doctrines, knowledge of water quality required for certain practical uses and so on. The analysis will thus focus on what is known and on what actors said about their estimates. We will try to follow the consequences of their choices without speculating about why they omitted or included matters for consideration. This paper shows that those who used notions of need, mainly scientists and engineers, considered the question in ways very much related to the conception they had of their own work, of their role as engineers. The estimate of need seems a typical engineering activity, articulating present and future politics and techniques. As Ken Alder has put it,

Where science is supposedly directed toward what *is*, engineering is directed toward what *ought* to be. This means that engineering is a purposeful, future-oriented activity, one which takes cognizance of present circumstances only insofar as they can be shaped to achieve desired results. And who decides what results are desired? The engineers? Their paymasters? Or those who actually perform the labour which brings those results into being? Such are the questions which make engineering a worthy topic of study. They remind us that engineering is a contentious art, that engineering is always social engineering, and that designing an artifact is in some sense a political act.³

Such a distinction between science and engineering is more theoretical than real, for engineers often ground their proposals on science-like knowledge. The will to design, to act in the world, is not uncommon in science. Simon Schaffer for example has recently argued that natural philosophers in late eighteenth-century Britain could seek to judge

2 Even historians who avoid the comparison of need with water resources are stunned by the small quantity of water at the disposal of the inhabitants of Paris during the modern period. The various estimates of this quantity are commonly between four and ten litres per person per day for the ordinary uses of daily life. Even Daniel Roche in his *History of Everyday Things*, who presents the modern period as an age of scarce water and rightly relates this scarcity to a whole system of social values and habits, describes water in Paris as a luxury, and sees a 'probable deterioration' of the situation during the eighteenth century. This is in fact questionable, because of a significant improvement in distribution in the last decades of the century. D. Roche, *Histoire des choses banales – Naissance de la consommation dans les sociétés traditionnelles, XVIIIe–XIXe siècles*, Paris, 1997, 173–4.

3 K. Alder, *Engineering the Revolution: Arms and Enlightenment in France, 1763–1815*, Princeton, 1997, 12.

and govern the world of trade and industry through modelling. He identifies as a major philosophical problem of this challenge the ‘possibility of inferring prescriptions from descriptions’.⁴ Rather than two distinct domains, what *is* and what *ought to be* are articulated both in science and engineering. They can be articulated in different ways, which reveal the political role intended as proper by the scientist or engineer.

Water in eighteenth-century Paris

In order to introduce these water supply projects one should first briefly describe the water resources of eighteenth-century Paris. There were a few aqueducts in Paris, mainly the aqueduc d’Arcueil, coming from the south and constructed at the beginning of the seventeenth century. There were also two important hydraulic machines taking water from the River Seine, also dating to the seventeenth century, the pumps of Notre-Dame and the Samaritaine, installed on bridges. The aqueduct and pumps were still the main water infrastructures of the city at the beginning of the eighteenth century, but had been designed mainly to supply the royal palaces of the Luxembourg and the Louvre and their respective gardens, then secondarily a few *Hôtels*, palaces of the nobility and religious institutions. Only a small part of this water was conducted to a few public fountains, about sixty at the beginning of the century, a number that would increase to about a hundred at the end of the century.⁵

In any case, the fountains only provided a small part of the water used in Paris. An important proportion was drawn from numerous wells, notorious for the bad quality of their water due to the vicinity of cesspools.⁶ These wells were also the main water resource for business activity too distant from the river. But the greater part of domestic use was provided by water carriers. These were of two kinds. Those on foot carried two buckets of about fifteen litres each, taking their water from the fountains (in fact trying to control access to these fountains) or directly from the river. Another class of water carrier used carts and were able to transport huge barrels of river water throughout the city.⁷

4 S. Schaffer, ‘Fish and ships: models in the age of reason’, in *Models: The Third Dimension of Science* (ed. S. de Charadevian and N. Hopwood), Stanford, 2004, 71–105, 71. Compare, more generally, *The Moral Authority of Nature*, a book concerned with ‘how humans use nature [things as they are] to think about standards of the good, the beautiful, the just, and the valuable [things as they ought to be].’ L. Daston and F. Vidal, ‘Doing what comes naturally’, in *The Moral Authority of Nature* (ed. L. Daston and F. Vidal), Chicago, 2004, 1–20, 1.

5 P.-S. Girard, *Recherches sur les eaux publiques de Paris, les distributions qui en ont été faites, et les divers projets qui ont été proposés pour en augmenter le volume*, Paris, 1812; Beaumont-Maillet, op. cit. (1), 85; Roche, op. cit. (2), 167. The quantity flowing from these fountains experienced major seasonal fluctuations; a minimum of two thousand cubic metres in 1700 and a maximum of eight thousand cubic metres at the end of the century seems a sensible, though rough, estimate.

6 Beaumont-Maillet, op. cit. (1), 15. They were probably over 20,000, but this is difficult to assess since the first inventory of the Paris wells was made in 1870, with an estimate of 30,000.

7 For a description of the various activities of these carriers see *Mémoire des frères Vachette*, frimaire year 9 (December 1800), Archives nationales, Paris (subsequently AN), box F14–685. For estimates of the number of carriers, compare with the situation in 1820 (1,338 carriers by foot registered, while the distribution by pipe had significantly increased); *Recherches statistiques sur la ville de Paris et le département de la Seine*, Paris,

Thus the main water resource was the river and the main problems were the problems of the river: winter ice hindered access to the water and the functioning of machines; summer drought reduced the river to one-fifth of its flow, turning it into a small and muddy stream. Some scientists like Jussieu were able to link the state of the river in the summer and the outbreak of epidemics such as that of 1731.⁸ Otherwise the flow of the river was generous, but the water was extremely polluted by human activities and waste. In the 1780s Louis-Sébastien Mercier could ironically present the Seine as a ‘stream as large and black as the Styx, thick and silty’.⁹ There had always been critics of water quality, but in mid-century strong opposition to the Seine water emerged, provoking a reaction by such people as the famous apothecary Parmentier who championed this water.¹⁰ At the same time, often in connection with the question of water quality, the theme of water lack began to appear as a motive for new water supply projects presented as indispensable to public welfare.¹¹ In the second half of the century the monarchy and the municipality, which had the monopoly of water infrastructures in Paris, began to encourage private initiatives but kept a watchful eye on the quality of projects. Very few of the numerous projects proposed were finally deemed satisfactory and even fewer were carried out.¹² There were two kinds of project corresponding to two attitudes towards the Seine’s water: pumping in the Seine or diverting a distant river. The main example of the pumping solution was offered by the Périer brothers’ company, which installed British steam engines in the 1770s and 1780s. But the company finally failed due to financial problems and, indirectly, to the resistance of the water carriers. No further pumps were built. The best example of the alternative solution was provided in the 1760s by Antoine Deparcieux, who proposed diverting

1823. If one takes ten thousand carriers by foot in 1800 (which would be a high estimate) and an average of twenty trips per day and per carrier, they had a capacity of six thousand cubic metres a day.

8 Jussieu, ‘Examen des causes qui ont altéré l’eau de la Seine, pendant la sécheresse de l’année 1731’, in *Mémoires de l’Académie royale des sciences, Année 1733*, Paris, 1735, 351–60.

9 ‘Un ruisseau large et noir comme le Styx, épais et limoneux.’ L.-S. Mercier, *Tableau de Paris*, Paris, 1994, 848. Mercier also criticized the laundresses working on the river inside Paris, the trash and the sewers running into the Seine. This and all other translations are my own, unless otherwise noted.

10 A. A. Parmentier, *Dissertation sur la nature des eaux de la Seine, avec quelques observations relatives aux propriétés physiques et économiques de l’eau en général*, Paris, 1787. Parmentier did not ignore the pollution, which was obvious to all, but developed a theory where joint stream and air motion could produce a regeneration both of water and air; pollution thus became a necessary part of the complex production of good water and the Seine water, though muddy, should be preferred to transparent water, whose apparent purity could hide the worst qualities. But Parmentier recommended taking water at some distance from the bank and let it rest in a ‘fontaine’, a traditional vessel used in Paris homes to ‘purify’ the water, to eliminate floating and sinking materials. More generally, on water purity in the late eighteenth century, see F. Graber, ‘La Délibération technique – Disputes d’ingénieurs des Ponts et Chaussées sous le Consulat – L’Affaire du canal de l’Ourcq’, *thèse*, EHESS, Paris, 2004, 259–310. On the quarrel between the ‘Sequanistes’ and the ‘Anti-sequanistes’, the pros and cons of Seine water, see Beaumont-Maillet, *op. cit.* (1), 23.

11 For an account of these projects see Girard, *op. cit.* (5), 60–108.

12 On the respective roles of monarchy and municipality in the late eighteenth-century water supply projects for Paris see D. Massounie, ‘Monuments hydrauliques urbains: aqueducs, châteaux d’eau et fontaines dans la ville moderne, 1661–1791’, *thèse*, University Paris 1, 2000, 18–87. Massounie (*ibid.*, 27), notes that the multiplication of private projects in the second half of the eighteenth century rather benefited the king’s authority, for all profit-oriented water supply projects had to obtain a *privilege d’exploitation* by the royal authorities.

the River Yvette in the south of Paris. Project costs were prohibitive and it was not carried out. A similar authorized project finally failed at the end of the 1780s.¹³

This paper focuses on the two projects where the notion of need was most discussed. The first is the project of Deparcieux, the most acclaimed of all projects. The approach to needs proposed by Deparcieux was taken as an example by most project authors during the rest of the century. Secondly, and at greater length, I discuss the Ourcq diversion project, finally carried out by the Bonaparte government at the beginning of the nineteenth century, having appropriated the idea from a late eighteenth-century private company. This case is especially interesting, because it has occasioned many disagreements on the question of needs.

The classical approach to need: Deparcieux and the Yvette project

What was presumably the first approach to the water-need issue was offered by Antoine Deparcieux (1703–68), a member of the Académie des sciences, who proposed a project for the diversion of the Yvette, a small river about thirty kilometres south of Paris.¹⁴ The degradation of the hydraulic machines inside Paris, in spite of important and regular repairs, led the city of Paris to ask the Académie des sciences in 1760 to examine these machines and propose some measures. With two other members Deparcieux took part in this consultation and together they proposed urgent changes in the machines themselves. But in 1762 Deparcieux presented a memoir to the Académie which proposed the replacement of the fragile machines by a diversion of the Yvette. He would try to convince the city and the state to pay for his expensive enterprise, but the project would not be carried out. Deparcieux would get involved in a public debate fuelled by proponents of alternative pumping solutions, especially about the costs of his project and the respective qualities of Yvette and Seine water.¹⁵ The long and vigorous controversy around the Deparcieux project drew attention to this scheme, thus giving it a role as a standard against which rival schemes were judged. It became the model for all diversion projects. Deparcieux's approach to need was thus followed, with very few changes, by most of the entrepreneurs and engineers involved in similar projects until the beginning of the nineteenth century.

In his 1762 memoir on the Yvette project Deparcieux estimated the quantity of water necessary for a big city to be approximately twenty litres per day and per person.¹⁶ He

13 On both the pumps and the Yvette project see Beaumont-Maillet, *op. cit.* (1), 96–115; J. Bouchary, *L'Eau à Paris à la fin du 18e siècle – La Compagnie des eaux de Paris et l'entreprise de l'Yvette*, Paris, 1946; Girard, *op. cit.* (5), 66–100. After the failure of the Périer brothers, mainly due to over-speculation on their shares, a former artillery officer, Fer de la Nouerre, proposed building the Yvette canal without surfacing, thus significantly reducing costs. Work began in 1788 but quickly came to a halt due to protests by residents over questions of property and subsistence since the project also intended to divert the Bièvre, a river very important for the manufacturing activities of the Faubourg Saint-Marceau.

14 Antoine Deparcieux was a mechanic and mathematician, creator of hydraulic machines for several noblemen.

15 Girard, *op. cit.* (5), 63–70.

16 The traditional unit for flow measurements, *le pouce d'eau*, literally 'inch of water', is about nineteen cubic metres per day. Cebren de l'Isle, *op. cit.* (1), 75.

did not say how he had arrived at this number but deemed it an average need, ‘perhaps a bit too much for the ordinary citizen and too little for the big Houses’.¹⁷ Supposing the number of people living in Paris to be 800,000, Deparcieux concluded that an average of 16,000 cubic metres a day was needed for the private use of water in the city. Deparcieux compared this need to an estimate of the available water resources. He reckoned that aqueducts and pumps provided only 4,600 cubic metres, of which part belonged to the king and part was undrinkable. Deparcieux therefore reduced the estimate of the water resources to 3,600 cubic metres, at best, because the machines on the river were frequently out of order. He presented the important gap between the water resources (3,600) and the need (16,000) as a major argument for his enterprise. In order to solve the issue of this alleged lack of water, Deparcieux suggested diverting the river Yvette, which could provide all year round a minimum of 24,000 cubic metres. The excess eight thousand cubic metres were to be used for other purposes, mainly the cleaning of the streets and firefighting.

Deparcieux’s approach to need was extremely original. The idea that a certain quantity of water was necessary for individual uses was not new, though it was seldom expressed in terms of necessity or minimum, and seldom as a subject in its own right. Jaucourt, for example, describing various cistern techniques in the *Encyclopédie* in 1753, calculated that a house with a given roof surface under a given precipitation (corresponding to rather dry climates) would be able to collect over a year an average of two hundred *pintes* a day, which made about eight *pintes* per person (if one took twenty-five persons living in the house). This is about 7.5 litres per person. This quantity Jaucourt deemed to be ‘more than enough for all the uses of daily life’, a common statement.¹⁸ But such ideas remained at the individual or family level. The main originality of Deparcieux is that he estimated a global need for a whole city. This of course was related to the originality of his enterprise: provision of water for the whole city. The concept of need would remain a special feature of later projects, mainly diversion schemes, intended to supply the whole city. The concept would only marginally be used in pumping projects, since these usually proposed only limited systems at the scale of one or two neighbourhoods that could, at least in principle, be extended and revised. By contrast, after Deparcieux diversion projects were usually concerned with the whole city. Interestingly, the concept of global need and the idea of providing water for a whole city appeared when authorities began to consider water a matter of public welfare – it was expected, at least rhetorically, that water supply projects should increase public welfare.¹⁹ The concept of global need was in this respect quite useful, since it implicitly meant that the project involved care for all and water provision for everyone.

17 A. Deparcieux, ‘Mémoire sur la possibilité d’amener à Paris, à la même hauteur à laquelle y arrivent les eaux d’Arcueil, mille à douze cents pouces d’eau’, in *Histoire de l’Académie Royale des Sciences, année 1762*, Paris, 1764, 342.

18 ‘Citerne’, in *Encyclopédie, ou Dictionnaire raisonné des sciences, des arts et des métiers*, 17 vols., Paris, 1753, iii, 487. Jaucourt borrowed the entire example from a 1703 *mémoire* by the astronomer La Hire (‘Sur l’eau de la pluie et sur l’origine des Fontaines; avec quelques particularités sur la construction des citernes’, in *Mémoires de l’Académie Royale des Sciences, année 1703*, Paris, 1720, 68).

19 Water, however, was not a public utility in the eighteenth century. A first step towards such a conception of water was made by Bonaparte’s government, which argued that Paris water should be the

In Deparcieux's approach need only made sense in comparison with resources: the project was supposed to address a lack of water. The way the estimate of water resources was worked out is of particular interest. Significantly, Deparcieux did not take into account the main water resource of the period, namely the water carriers. It was probably impossible for Deparcieux to make an estimate of the number of these carriers and their capacity. This water resource was not measurable and Deparcieux only took into account what could be measured – the aqueducts and pumps. But the practical difficulty of measurement exactly fitted the aim of the project, since for Deparcieux the water carriers were not to be counted as a water resource. They did not appear in his calculations because his project precisely intended to do without them. Deparcieux wanted to develop the distribution of water in the city by the creation of numerous fountains. Therefore he was only interested in the existing fountains, not in other water resources that would have to be replaced. Deparcieux's project presupposed a social redefinition. The new water supply of Paris would get rid of a great number of the water carriers. Some of those on foot with buckets would be able to continue their activity, but only from the new fountains to the houses. They would no longer be a water resource but instead a mere link in a water distribution system centred around the fountains. The project, through its definition of the water supply, decided what had to be taken into account in the estimate.

In Deparcieux's approach, lack of water thus only made sense in regard to a certain idea of distribution which did not take into account the water carriers. A similar point can be made for most of the water supply projects of the late eighteenth century: the lack of water, as conceived by the authors of these projects, entrepreneurs, scientists or engineers, was worked out in relation to an idea of the distribution, and often water carriers were not part of that idea.²⁰ Each project was in some form a measurement of need and at the same time provided a solution to that problem. The estimate of need depended strongly on the project itself, its purposes and choices, but in the case of Deparcieux this was not yet an explicit theme.

How the practical engineer saw need – Bralle's estimate

In later projects water resources were deemed very small in comparison with need, so that need finally became the sole subject of debate. This was especially the case in the final and largest eighteenth-century project, completed in the first years of the nineteenth century, the diversion of the River Ourcq. In 1799 two entrepreneurs, Solages and Bossu, proposed a new version of their diversion project of the Ourcq. They had put forward similar projects since the mid-1780s.²¹ Like all their fellow entrepreneurs they stressed how serious was the lack of water in Paris to show the indispensability

government's property since people could not be submitted to the power of private companies in such an important subject. Graber, *op. cit.* (10), 116.

²⁰ The project of the Périer brothers, for example, was even more uncompromising towards the water carriers because it intended to bring water directly to houses.

²¹ More precisely, these two entrepreneurs had taken the idea from another, Brullée, who first proposed an Ourcq project in 1785. Girard, *op. cit.* (5), 107–10.

of their enterprise. But they had not provided any figures for this alleged lack.²² So the new government of the Consulate, very interested from the start in projects for Paris water supply, which Bonaparte deemed politically useful, decided to consult an expert.²³ François-Jean Bralle (1750–1831) had been the water specialist for the royal administrator of the province of Picardy in the 1770s, and then for the Paris area in the 1780s.²⁴ He kept a similar position during the Revolution as chief engineer of hydraulics in Paris and was also responsible for the famous hydraulic machine of Marly which supplied water to Versailles.²⁵

Bralle was asked by the government to decide as a specialist about the needs of Paris in order to ‘determine the quantity to be supplied by the company’, to be set out in legislation should the project be adopted.²⁶ His estimate was supposed to have an advisory function but of a rather prescriptive nature, since the government had announced its intention to integrate the engineer’s estimate into this law. But in his report of 10 December 1799, Bralle did not consider this task to be a simple one. On the contrary, it seemed to him very difficult to achieve without further instructions:

In order to fulfil the wishes of the Minister, I would have needed to know what the intentions of the government are in this respect, that is, if he wants to restrict himself to the bare essentials, or if convinced of the advantages ... of an abundant distribution of water ... he would decide to take advantage of the construction of the canal ... to bring the largest possible quantity of water. Lacking positive information that would have been necessary to me, I will take as a basis of my estimate, conditions equally distant from both prodigality and parsimony.²⁷

This is an important point. Bralle stated that there could be no possible estimate without a plan of action. He acknowledged what has already been noted in Deparcieux’s approach. What was to be counted as need depended on the project, on one’s intention and defined purpose. But Bralle went further, stating that this first intention had to come from the government. Only the government had the legitimacy to decide what

22 This was not an uncommon attitude among entrepreneurs who seem to have had greater difficulties in formulating numerical estimates of needs. When they knew the classical estimate of Deparcieux, they usually repeated it, but mostly they simply proposed a dramatic description of the difficulties in getting water. See for example *Mémoire des frères Vachette*, frimaire year 9 (December 1800), AN box F14–685.

23 On Bonaparte’s water policy see Graber, *op. cit.* (10), 113–18.

24 The state did not ask the Ponts-et-Chaussées in this case, since this corps had no special expertise on water supply and waterways at the time. On Bralle’s interesting career see his administrative file, AN box F14–2180², especially Bralle to the Conseiller d’Etat chargé des Ponts et Chaussées, 20 October 1807. In 1807, when the various Paris water services were unified, he was at last incorporated in the Ponts-et-Chaussées corps.

25 On the Machine de Marly see T. Brandstetter, ‘“The most wonderful piece of machinery the world can boast of”’: the water-works at Marly, 1680–1830’, *History and Technology* (2005), 21, 205–20.

26 Bralle to Laplace (minister of the interior at the time), 19 frimaire year 8 (10 December 1799), AN box F14–685.

27 ‘*Pour bien remplir les vœux du ministre j’aurais eu besoin de connaître quelles peuvent être les intentions du gouvernement à cet égard, c’est-à-dire, s’il veut se borner au strict nécessaire, ou si convaincu des avantages ... d’une abondante distribution d’eau ... il se déterminait à profiter de la construction du canal dont il s’agit pour en amener la plus grande quantité possible; manquant de renseignements positifs qui m’eussent été nécessaires, je prendrai pour base de mes évaluations un terme également éloigné de la prodigalité et de la parcimonie*’. Bralle, *op. cit.* (26).

should be done. This was not a new attitude in public works, where the state had often been the initiator of projects, generally through the Ponts-et-Chaussées, the corps of state engineers specializing in public works. But this had not been the case with water supply and waterways projects, in which the state had not previously been much involved. Such projects were usually proposed by private companies with no previous state intervention.

Bralle insisted on the government's prerogatives; the estimate of the engineer and the constraints thereafter imposed on the entrepreneurs should only reflect the government's choice. He thus gave a radical answer to the typical problem of expertise: should specialized knowledge or political legitimacy decide on technical projects?²⁸ But this conception of the respective roles of government and engineer somewhat called into question the expertise demanded from him – an estimate which could be directly integrated into a law. In Bralle's view there was no engineer who could objectively determine the needs of Paris and no government which could take necessary measures by following the expert's conclusions. The whole process had to be worked out in the opposite manner: the government should first make a general choice between 'prodigality and parsimony', or even more precisely by analysing the possible uses of the water, before the engineer could really estimate Parisian needs. It was not the engineer who established the facts on which the government's decision would rely. It was the government's intention that enabled the engineer to establish the facts in accordance with that decision.

The nature of the engineer's activity and knowledge was being questioned here. Bralle's statement about the necessity of an initial intention only made sense because matters handled by engineers did not exist independently of such an intention, a will to act in a certain way. Water need was not a natural object to be simply measured by a specific method. On the contrary, it had to be defined and this definition depended on the intention one had. Knowledge about the world as it is differs from knowledge about the world as it ought to be. The Ponts-et-Chaussées engineers clearly preferred the first kind of knowledge, which consisted of establishing facts about the existing world. Bralle, an engineer with a more practical culture of hydraulics, independent of the state corps, was different in this respect. He considered that, in the context of a project, knowledge about things as they ought to be was essential; need only made sense in respect to a certain idea of the future, which should first have been defined.

Bralle's approach seems quite apparent. A project is related to the future, it deals with norms and ideals, not only with things as they are. In this respect one could follow Aristotle's distinction in his *Rhetoric* between arguments that aim at establishing facts (the judicial mode) and arguments about human affairs with a view to action under uncertainty, where the question is to decide what is best to be done in the future (the

28 On the question of expertise in late eighteenth-century Europe see E. J. Engstrom, V. Hess and U. Thoms (eds.), *Figurationen des Experten – Ambivalenzen der wissenschaftlichen Expertise im ausgehenden 18. und frühen 19. Jahrhundert*, Frankfurt am Main, 2005, especially 7–17; H. Vérin, 'Expertise et Etat fondé en raison au XVIIIe siècle', in *L'Expertise* (ed. R. Damien), Besançon, 2001. A recent contribution to the issue of science and the state is S. Jasanoff (ed.), *States of Knowledge: The Co-production of Science and Social Order*, London, 2004.

deliberative mode).²⁹ One argues in different ways or speaks to different people depending on whether one is concerned with the present or the future. Yet the Ponts-et-Chaussées engineers collapsed this distinction. Bralle acknowledged that needs were not numerical facts that could be established objectively; they could not be determined independently of intentions and choices, ideals and hopes. He pointed out that the government had asked him to decide about the future, about the quantity of water that should be brought to Paris. Asked for his opinion on the administration of human affairs, Bralle did not refuse to answer. Having emphasized that it was in fact a government's prerogative, he expressed his opinion on what should be done. How did Bralle conduct his estimate? He began with a reference to authorities on that matter: 'all the scientists', he said, 'consider that a big city needs approximately 20 litres per day and per person'. This was the classical figure proposed by Deparcieux, usually accepted in subsequent estimates. But Bralle was very sensitive to the difference between what is and what ought to be and made it clear that this figure was not an estimate of the present consumption of Paris:

The consumption of water is probably much less today, because scarceness makes people sparing; but when the abundance will have removed the difficulties that one experiences in getting water in the neighbourhoods remote from the river, the needs will increase and it is wise to anticipate that the consumption could then reach the above estimate.³⁰

Like Deparcieux, Bralle considered that the quantity of twenty litres per day per person matched average need, the quantity that anyone would consume were there no problems in getting water. These supply problems precisely accounted for the important difference between need and present consumption. But unlike Deparcieux, for whom twenty litres were an invariable need, Bralle considered that an increase in water resources would lead to an increase of consumption and that one should therefore think big. In Bralle's scheme twenty litres was rather a projection. Bralle definitely rejected the idea that present consumption could be a relevant measurement of what had to be done, a position very different from that of the Ponts-et-Chaussées engineers. From this individual need, supposing a population of 600,000 people, Bralle deduced the need of Paris as 12,000 cubic metres. This result differed from that of Deparcieux because Bralle considered a smaller population. In the absence of a reliable census one could only speculate on such a matter. Besides the inhabitants' needs, Bralle drew up a detailed inventory of other uses of water. These included the public buildings such as hospices, jails, the Museum d'histoire naturelle, and the Palaces of the Louvre, the Tuileries and so on, to a total of four thousand cubic metres. On the other hand, he reckoned up decorative fountains, horses' watering places,³¹ baths, washhouses and street and sewer cleaning, all 'objects of pleasure and healthiness', giving at least 40,000

²⁹ Aristote, *Rhétorique*, Book 1, Paris, 1998, 30–3.

³⁰ 'La consommation d'eau est sans doute beaucoup moindre aujourd'hui parce que la disette rend économe; mais lorsque l'abondance écartera les difficultés qu'on éprouve à se procurer de l'eau dans les quartiers éloignés de la rivière, les besoins se multiplieront et il est sage de prévoir qu'alors la consommation pourra atteindre l'évaluation ci-dessus.' Bralle, op. cit. (26).

³¹ Horses were very important water consumers: 20,000 to 30,000 in number consumed twenty to thirty litres a day each. Roche, op. cit. (2), 159.

cubic metres. The total need of Paris was therefore of the order of 56,000 cubic metres. The approach is quite remarkable: Bralle was the only engineer whose estimate of the need was based on a calculated inventory of possible uses. Though Bralle's estimate was presented as an argument in favour of his opinion that the 'largest possible quantity' of water should be brought to Paris, he made it possible for the government to choose what uses should be preferred.³²

The state engineers: Bruyère's estimate and the Ponts-et-Chaussées

Bralle's report argued in favour of a very large quantity of water. The government therefore decided to have the entrepreneur's project examined by the Ponts-et-Chaussées corps.³³ This corps of state engineers was in charge of all works of roads and bridges, on which it exercised a complete monopoly over design and implementation. But before the French Revolution these engineers managed neither water supply nor waterways. Until then they were sometimes asked to produce, examine or even construct such projects, but they had no exclusivity and were not the main experts on these questions. The technical part was usually examined by the Académie des sciences or by an architect working for a city or a province. The Revolution gave the Ponts-et-Chaussées a larger responsibility, especially over waterways.³⁴ But since the engineers had not before been specialists in these matters, their expertise could be challenged by others. This helps explain, for example, how Bralle could have been asked in the first place. The canal projects of the Consulate period reveal that the state engineers had no fixed way of dealing with canals. In many respects their knowledge was quite uncertain.³⁵ The consideration is significant when one seeks to explain how and why these engineers would try to present themselves as the sole possible experts on these matters.

The chief engineer, Louis Bruyère (1758–1831), worked for a year on the verification of the Ourcq project. The verification of a project was usually limited to an analysis of the documents presented by the entrepreneur or engineer. It was usually made by the inspector in charge of the district where the project was to be carried out, then presented to the assembly of the corps, which decided collectively what to do. In some cases, however, some complementary measures, mainly levels, gauges or drills, were deemed necessary and an engineer chosen for this mission, such as Bruyère in this case. Bruyère clearly took advantage of the verification to proceed to a more detailed study and to conceive a project of his own. In his April 1802 report to the assembly of the corps, Bruyère declared the Ourcq diversion project impossible, mainly because of some levelling errors, and suggested a different idea: the diversion of the Beuvronne, a smaller

32 There was a general danger in presenting different possibilities, since this could reveal the arbitrary character of a project or lead to difficulties in comparing different projects. See Graber, *op. cit.* (10), 567–9.

33 On the Ponts-et-Chaussées corps see A. Picon, *L'Invention de l'ingénieur moderne – L'École des Ponts et Chaussées, 1747–1851*, Paris, 1992; J. Petot, *Histoire de l'administration des Ponts et Chaussées, 1599–1815*, Paris, 1958; Graber, *op. cit.* (10).

34 Picon, *op. cit.* (33), 209–15; Graber, *op. cit.* (10), 36.

35 Graber, *op. cit.* (10), Chapters 5 to 7.

river much closer to Paris than the Ourcq. Bruyère estimated its daily flows as between 20,000 and 34,000 cubic metres. With Bralle's estimate of need (56,000 cubic metres) the Beuvronne would have been insufficient. Indeed, Bruyère did not accept that estimate and made a new one that would posit a much smaller need. He rejected previous estimates, emphasizing their discrepancies and the interest of the various estimators, since they usually wanted to convince the government or their shareholders that they were going to make incredible profits. Bruyère insisted that a wise government should not tolerate any kind of swindle and that therefore 'it [was] high time not to delude oneself' on that matter.³⁶

Bruyère made a distinction between two approaches. On the one hand there was the strategy of interested entrepreneurs who wanted to deceive the government with self-interested and necessarily unreasonable promises; on the other hand estimates were made by the figure of the state engineer who, representing the state, should measure reality and separate truth from error. The uncertainty of grandiose, exaggerated and interested speculations without any technical foundations was to be contrasted with the certainty of the state engineer, whose skills made it possible to measure all things correctly and to decide about possibility and benefit without exaggeration. In Bruyère's conception the state engineer was the one who could measure reality, who could make all estimates without reference to value judgements and intentions of any kind, especially political. Unlike Bralle, Bruyère thought an objective estimate not only possible but precisely the job of a state engineer.³⁷ This was his competence, his activity, and he made it in the government's name. In fact, in this approach, there was no place for the government itself, because it could only be the victim of speculators who took advantage of its incompetence and technical ignorance. Working for the good of the state, the state engineer could and should take the place of the government, because he was the only one who could make the difference between a brilliant but unfounded proposition and the bare facts. Implicitly, nobody working outside the state, however knowledgeable, could possibly propose a project for the public welfare. This was very different from Bralle's conception of a strong government, not easily influenced and the sole legitimate decision-maker. In both cases, an explicit relation was made between the respective roles of the government and the engineer and the nature of the engineer's knowledge, especially the nature of his estimates.

What did Bruyère's allegedly objective estimate look like? 'One has got into the habit of supposing' approximately twenty litres per day per person, the classic figure of Deparcieux once again.³⁸ But Bruyère considered this quantity to be '*considérable*' and supposed that the people who had first made this estimate must have included all the collective uses of water: the cleaning of the streets, bathhouses and firefighting. Bruyère did not treat Deparcieux and his followers as self-interested entrepreneurs. He introduced the classic figure with a certain respect, but only because he could give it an

36 'Il est temps de ne plus s'abuser sur cette évaluation.' L. Bruyère, *Rapport du 9 floréal an 10 sur les moyens de fournir l'eau nécessaire à la ville de Paris*, Paris, 1804, 13.

37 Here 'objective' is not an actor's category. I use the word in the sense of a pretence to deal with facts and truth.

38 'On a été dans l'habitude de supposer'. Bruyère, *op. cit.* (36), 13.

unfavourable interpretation: he deemed twenty litres too much for the needs of the inhabitants alone. In order to estimate the real needs of these people, Bruyère applied a very simple principle, one very common among Ponts-et-Chaussées engineers of the time. He looked at current consumption: 'It is a fact, and everybody can check it, that a family of 10 individuals only consumes an average of ... approximately 69 litres a day'.³⁹ One had only to look around. Facts were to be found in the real world. With an average individual need of less than seven litres, Bruyère came up with a total need for the inhabitants of Paris, supposed to be no more than 720,000, of five thousand cubic metres. Bruyère supported this small figure with an estimate of the distribution at the fountains in Paris. The similarity of the two figures for individual consumption and fountain supply should have been obvious, but once again the fountain flows were a quantity that could be measured in the present world; they were facts.

Bruyère knew the needs of Paris by looking at consumption. He did not intend to increase the available quantity of water, but only to improve its distribution and quality. He took into account a possible increase of consumption because if water became easier to get, people would probably use more, but he thought that an increase to seven thousand cubic metres from the present consumption of five thousand would be extreme. So he considered seven thousand to be an absolute limit for the inhabitants' needs.⁴⁰ This was a small quantity compared to the 12,000 of Bralle or the 16,000 of Deparcieux. It made the volume of the Beuvronne, the river he intended to divert, appear more than sufficient. Indeed, Bruyère's 20,000- to 34,000-cubic metre estimate of its flows left a significant remainder for collective uses, such as street cleaning, bathhouses and so on, uses which Bruyère did not examine in any detail.

Bruyère wanted his estimate to be 'reasonable'. One should not be misled by great expectations and should limit oneself as much as possible to facts and certainties, to things that could be measured. That is why he simply refused to take into account the quantity of water that should be diverted for purposes of 'public amenities'.⁴¹ These he considered to be 'arbitrary projects'. Since an engineer only made objective estimates, he could only consider things which could be measured in the existing world, typically the consumption of the inhabitants, and had to leave out all the uses which could not be measured, uses which were innumerable and could be imagined to be as large as one wanted. 'I will not even try to determine such quantity', Bruyère declared. But neither did he leave it to the government to decide about such arbitrary uses: 'It would certainly be very beautiful to see the waters gush out and flow in every public square; but before one devotes oneself to a grand luxury, one must first provide the most

39 'Il est de fait, et chacun peut s'en convaincre, qu'une famille composée de 10 individus, ne consomme moyennement que ... environ 69 litres.' Bruyère, op. cit. (36), 13.

40 One can link this attitude with a conception of the world centred on stability and ruled by statics, characteristic for the French Enlightenment around figures such as Condillac, Condorcet, Lagrange or Laplace and around concepts of balance or equilibrium, where the time factor was explicitly eliminated from all analysis. But at the turn of the century some individuals like Bralle and Girard were beginning to introduce a more dynamic conception of the world. On statics as typical of French Enlightenment see M. N. Wise (with the collaboration of C. Smith), 'Work and waste: political economy and natural philosophy in nineteenth century Britain (I)', *History of Science* (1989), 27, 263–301.

41 'L'agrément général', Bruyère, op. cit. (36), 13.

necessary thing'.⁴² This priority was not to be understood as temporary. Bruyère left no place in his project for such prodigality. The impossibility of evaluating arbitrary needs coincided with the moral imperative to keep consumption to the essentials, to the minimum. By limiting public action to the essentials – that is, to what could be measured in the real world – Bruyère made sure of the key role of the state engineer in the decision-making process, leaving no space for government interventions. What could be undertaken was limited by the competence of the engineer. This objectivist approach to the estimate of need led to a curious paradox which was in fact typical of these Ponts-et-Chaussées engineers around 1800. They often preferred the world as it is, since things can be measured, to all that could be, rejected as arbitrary, decidable without measure. In order to keep control over the decision they tried to limit discussion about the future to the measurement of the present. It was an interesting paradox for engineers whose central activity was to deal with projects, with anticipation, construction of the future. But they also had a very simple solution to this paradox.

Need or available quantity?

Bruyère's estimate and his concept of the engineer's activity would have considerable influence inside the Ponts-et-Chaussées during the Ourcq canal debates. Even before he finished his report, the government decided to divert the Ourcq. It is unclear if Bruyère's study had been forgotten by the authorities, since he had been working on it for nearly a year, or if they could wait no longer. Bonaparte had ordered the creation of large construction sites in the vicinity of Paris in order to provide work for the destitute. The government decided to construct an Ourcq canal. It did not allow the company of Bossu and Solages to execute their project. The Ponts-et-Chaussées engineers had provided a technical problem, a levelling error, to which the administrators added a legal one. The government took over the idea of the Ourcq canal and in 1802 appointed a Ponts-et-Chaussées engineer as head of the project: Pierre-Simon Girard (1765–1836). Given the prestige of the project, Girard was relatively young. He clearly owed this favour to his extreme loyalty during the final days of the Egypt expedition, of which he had been a member. His privileged status and his unusual approach to the project soon led to a major crisis in the Ponts-et-Chaussées corps, a quarrel among the engineers about what should be done about this diversion.⁴³ Among the many issues involved, a few examples can be given. Should the Ourcq really be diverted, as the government ordered, or rather the smaller and nearer Beuvronne? What route should the diversion take, bypassing the major hills near Paris or cutting through them in monumental straight lines, as proposed by Girard? Could one use the new mathematical theory developed by Girard in order to establish the slope of the canal? Should the new canal be navigable, besides its function as a water-supply canal? This last issue was rather important in

42 'On n'entreprend pas de déterminer une telle quantité.' 'Il serait sans doute fort beau de voir des eaux jaillir et couler en abondance dans toutes les places publiques; mais avant de se livrer à un grand luxe, il faut d'abord pourvoir à l'objet le plus nécessaire.' Bruyère, op. cit. (36), 13.

43 On P.-S. Girard and on the Ourcq canal affair more generally see Graber, op. cit. (10).

relation to the question of need, for the river Ourcq was an important waterway for bringing firewood to Paris and if the river were to be diverted entirely then the new canal would have to take over this navigation function.

In their various reports and memoirs the engineers discussed the advantages and disadvantages of the different quantities of water that could be brought to Paris.⁴⁴ In a manner similar to that of Bralle, they considered need in relation to the possible uses of water. Girard, for example, mentioned the cleaning and the watering of the streets, embellishment by gushing fountains and the functioning of factories and mills.⁴⁵ But unlike Bralle's evaluation, no figures were suggested for the various possible uses. This was not very surprising for some engineers like Girard, Gauthey or Bertrand, who held the radical idea that Paris could never get too much water. One should divert the largest possible quantity, because the possible uses were innumerable and it would in any case be impossible to satisfy them all. These engineers were fascinated by visions of an overflowing city, with water everywhere, described as giving life to the city like the veins and arteries in a body.⁴⁶ While some opponents spoke of excess and evoked the difficulties of dealing with superfluous water, the enthusiasts replied with infinite needs for irrigation in the plains north-east of Paris. In a word, however much water there was, there would be use for it. For these engineers, because the uses were innumerable it was not necessary to make a precise estimate of the quantity needed for each of them for the present. Thus the estimate was made the other way round: one did not measure the quantity needed, but the available quantity. In this approach discussion about the relative importance and advantages of different uses, which should be preferred to others, was postponed for the future.

However, it is worth noting that this reasoning about available water was not specific to the engineers who were in favour of abundance. Even those engineers who claimed to know exactly the needs of Paris, and refused to divert more than was required, proposed to divert all the water available in the river they preferred. The influence of Bruyère was obvious and often explicit in these debates about the Ourcq canal. During this controversy not one engineer proposed an inventory with detailed figures of the different uses, as Bralle had done some years before. But many followed Bruyère's approach and made need coincide with the water available in the river of their choice, mainly the Ourcq or the Beuvronne. One finds only two kinds of estimate in these reports and memoirs. Sometimes protagonists offered an estimate of the consumption of the inhabitants, usually reduced to Bruyère's very small estimate of present consumption, making the bigger Ourcq seem unreasonably large. Sometimes one encounters the estimate of the water available in the river to be diverted, often with very important differences in the estimates, since the flow measurements were not standardized.⁴⁷

44 See, for example, and among many others, the responses of the engineers of the Ponts-et-Chaussées assembly to the consulting request of the Conseiller général, in January–April 1804, Bibliothèque historique de la ville de Paris (subsequently BhvP), manuscripts M 1177.

45 P.-S. Girard, *Mémoire sur une modification proposée au projet général du canal de l'Ourcq*, 27 germinal year 12 (17 April 1804), BhvP M 1177.

46 Bertrand, *Réflexions sur le canal de l'Ourcq*, 3 pluviôse year 12 (24 January 1804), BhvP M 1177.

47 Independently of the accuracy of the various apparatus, the main problem appears to have been the choice of the right moment, depending on the regularity of the weather, the season and the artificial activity of

The coincidence between estimated need and the water resources of the river was sometimes justified.⁴⁸ Indeed, if one started such an important project, the costs and difficulties would not be so different if one diverted only half a river or the entire flow. If one went so far to have a supply of water, then one should take it all; it was better to take maximum advantage of the project, even if the costs were greater.

Bruyère's influence can be seen in this shared attitude. The engineers only estimated quantities that existed in the present. Their estimate of the future needs of Paris was reduced to the present consumption of the inhabitants and to the flows of the rivers. Instead of starting a discussion about the relative advantages of the different uses, they preferred to choose and measure a river. The future they constructed, the possibilities, were in the world of the present. What had to be discussed was the choice of the river that would be entirely diverted. This choice was very much related to other issues: technical advantages of diverting one river or the other, ease, cost, navigation, quality of the water and so on.⁴⁹

Conclusion

The Ponts-et-Chaussées engineers preferred Bruyère's objective approach: establishing facts and making decisions based on facts. This approach made it possible to reject as arbitrary anything that could not be measured and therefore submitted to their control. If this approach were indeed objective, the engineers' estimates nevertheless relied on an initial intention, a preference for a given solution. An engineer who made his estimate of Parisian need coincide exactly with the river he wanted to divert thus produced an estimate that fitted a purpose. He made things as they are (the river and its flows) match things as they ought to be (need). But unlike Bralle's idea of the initial political – that is, governmental – intention, this strategy, being technical, depended completely on the engineer's competence and not on that of the government. There had to be intentions, but in the case of the Ponts-et-Chaussées engineers these intentions had to be reduced to factual technical matters to appear outside the realm of politics and to secure control over technical decisions for these engineers.

One can thus complete Alder's very general statement about engineering. What ought to be is a political problem, in the broad sense of what concerns a community as a whole. It is a problem of human affairs, in Aristotle's formulation, which are uncertain, strongly related to norms, ideals and hopes. Engineering is the use of knowledge about the world as it is, about things as they behave, and in many cases, as in the sciences, this does not exclude speculations about how things behave, in order to create a future object. Engineering is thus the articulation of knowledge about things as they are and reflection about what they should be. In this articulation lies its mixed nature, balanced between techno-scientific facts and politics. The ways engineers presented this

the river to be measured. On flow measurement techniques and debates among these engineers see Graber, *op. cit.* (10), 425–65.

48 Liard, *Notes relatives à la dérivation de l'Ourcq*, 19 germinal year 12 (9 April 1804), BhvP M 1177.

49 It was, for instance, important to argue that the need was as high as the whole river flow, if one wanted to divert the Ourcq entirely, which was an important argument in favour of the navigability of the new canal.

articulation thus reveal the image of the role they wanted to impose: the reduction of technical enterprise solely to factual terms. Ponts-et-Chaussées engineers could pretend to have no political role at all, while they were indeed taking over the complete decision-making process. It would be interesting for an engineer to present himself as respectful of governmental prerogatives, to emphasize that he did not want to decide about political matters. Like Bralle, he thus appeared as a credible neutral expert, dealing with facts but not taking decisions. The Ponts-et-Chaussées attitude was exactly the opposite: they pretended that there was nothing to decide politically. They even claimed that a political decision on these matters would be useless, since one could not order nature and since the limits of nature were only known by skilled engineers.⁵⁰

French state engineers, the Ponts-et-Chaussées especially, are well known for having had a very strong position inside the state and large control over technical decisions.⁵¹ But this was not a naturally given situation for which these engineers did not have to fight. They were challenged from outside the state by entrepreneurs and architects who constantly claimed that they could perform the same work better and more cheaply, and who took advantage of every crisis or failure of the corps to call for reform. But they were also challenged from inside the state; the government did not always accept the control its engineers tried to keep over technical decisions. During the French Revolution the Assemblée législative almost abolished the corps, which was denounced by some as a guild, an institution appropriating part of the power that legitimately belonged to the nation's representatives. The state tried, especially through its Committee for Public Works, not to leave much to the decision of the engineers and to treat their work as mere implementation. At its start, Bonaparte's government adopted the opposite attitude, emphasizing the technical nature of the engineers' activity and leaving them with considerable autonomy. In March 1801, when asked to pronounce on the best canal to build in order to improve navigation in northern France, the assembly of the Ponts-et-Chaussées proposed two solutions to Bonaparte, leaving it explicitly to him to decide. He returned the question to them, speaking of their ability to consider the 'universality of circumstances'.⁵² But this autonomy did not last long and

50 The engineer Lecreulx could even say, 'In vain has the law ordered the construction [of the canal], its impossibility due to the nature of the ground made this law necessarily powerless.' *'En vain la loi avait ordonné l'exécution [du canal], son impossibilité qui tenait à la nature du terrain rendait nécessairement cette loi sans pouvoir et sans application exécutable.'* Lecreulx, Canal de l'Ourcq, 2 pluviôse year 12 (23 January 1804), BhpP M 1177. During the Ourcq debates the Ponts-et-Chaussées would develop an aggressive tone towards the government, mainly explicable by the relative absence of administrators' authority over a project launched by Bonaparte, therefore strongly linked to the emperor's personal discretion but left unattended during his increasing absence in wartime.

51 Besides the work of Picon, see for instance T. M. Porter, *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life*, Princeton, 1996, 114–47. Porter's main thesis, applied to the later nineteenth century but generalizable, is that the Ponts-et-Chaussées did not need to ground their decisions on quantified knowledge because they were powerful enough to impose them. This thesis can be questioned, because these engineers had to fight for their position and competences and because it is a negative argument: one can find many reasons why they did not need to ground their decisions on quantification alone. See Graber, op. cit. (10), 574–80.

52 *'L'universalité des circonstances.'* Register of the settings of the assembly of the Ponts-et-Chaussées, 15 March 1801, AN box F14* – 10910.

Bonaparte soon adopted a more technical conception of the corps.⁵³ This tension between the state and an administration sometimes perceived as dangerously autonomous continued during the nineteenth century. The position adopted by the Ponts-et-Chaussées engineers in the Ourcq case must thus be seen as a collective strategy to defend their ‘rights’, their control over decisions that the state did not always agree to let them manage.

53 The extremely polemical cases of the Consulate, like the Saint Quentin canal or the Ourcq canal, can be considered both as a result of this autonomy and as a reason for its revocation. For a more general discussion of the complex relationship between technical administration and state see Graber, *op. cit.* (10), 119–20 and 136–54.