Scientific Research and Essays Vol. 7(3), pp. 288-299, 23 January, 2012
Available online at http://www.academicjournals.org/SRE
DOI: 10.5897/SRE10.833
ISSN 1992-2248 ©2012 Academic Journals

Full Length Research Paper

Water supply crisis in Ankara: Review and comparison of the "1995 master plan report on Ankara water supply project"

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Accepted 31 October, 2011

The purpose of this study was to compare technical recommendations for water supply projects for the city of Ankara, Turkey with institutional decisions that led to a water supply crisis during a drought in August, 2007. The authors provide an evaluation of government institutions responsible for planning and provision of Ankara's water supply and treatment, and an analysis and comparison of the "1995 Master Plan Report on Ankara Water Supply Project" commissioned by Turkey's General Directorate of State Hydraulic Works (DSI) and assigned to Japan's Pacific Consultants International Group. The comparison reveals that Ankara's water authorities did not heed to the advice of technical recommendations. Such planning failures led to a delay in necessary project implementation to prevent water shortages in the case of drought, uneconomical and unsustainable water pipeline transmission routes, and a loss of public trust in the authorities. Moreover, concerns and criticisms of civil society organizations were not taken into account by the water authorities in a constructive manner. Lack of dialogue and consultation among the stakeholders exacerbated the crisis and prevented opportunities to reach participative and democratic management and use of limited water resource in the city. As Ankara's urban population is rapidly increasing so will the potable and industrial water needs. Streamlining the way in which the city manages water will be necessary to ensure a sustainable water future.

Key words: Water crisis, Ankara water, drought preparedness, Mediterranean water management, urban water.

INTRODUCTION

As climate change increases the likelihood of droughts in semi-arid regions and as urban populations burgeon, drinking water supplies will be increasingly stressed. Drinking water shortages are endemic to the Mediterranean region (a historical example being the drought that hit Athens, Greece between 1989 and 1991 (Kaika, 2003)). The importance of drought preparedness cannot be understated and examinations of recent supply crises provide valuable lessons for the future. One such case is the 2007-2008 water supply crisis in Ankara, Turkey.

Located in the semi-arid central Anatolia region, Ankara witnesses seasonal and yearly variation in precipitation (Figure 1). Such variation has been identified as an impediment to making long-range water planning decisions in the Mediterranean Region (Iglesias et al, 2007; Ceylan, 2002). Statistics indicate Ankara can expect a drought once every four years and that the return period for a severe drought that affects 50% of the

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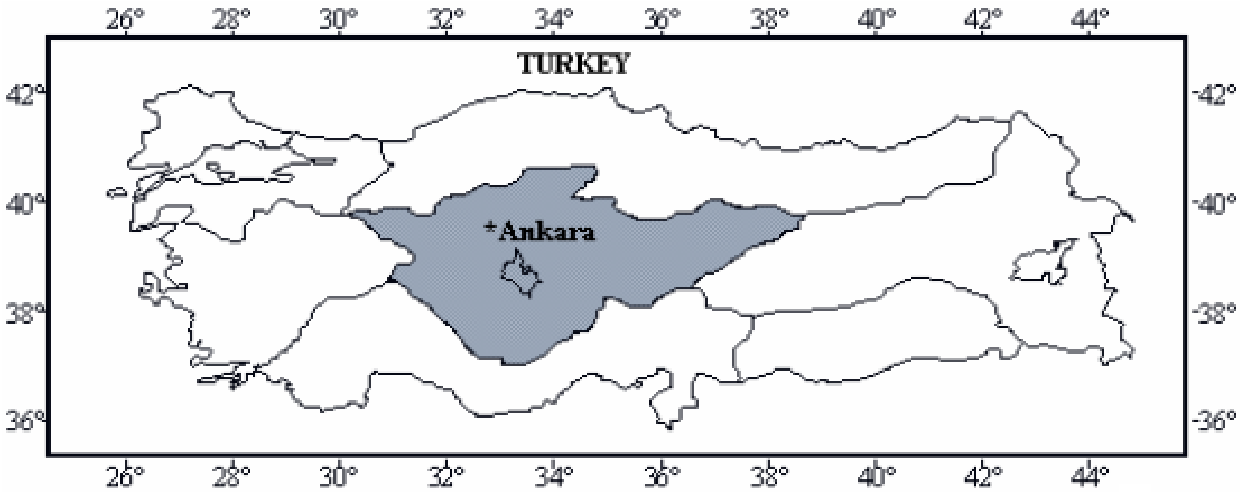
Abbreviations: ASKI, Ankara water and sewerage administration; **DSI,** general directorate of state hydraulic works; **MEF,** the ministry of environment and forestry; **MP,** master plan.



- **2010 population**: 4.5-5 million people (estimate)
- **Population increase during past 40 years**: 400%
- **Urban Population Share 2010**: 65%
- **Projected Urban Share 2025**: 85 %
- **Water Stress Factors**: Population growth, increased standard of living
- **Climate**: Mediterranean Macroclimate (first degree mesothermal semi-arid)
- **Periods of severe drought**: 1973, 1977, 1984, 1989-91, 1999-2000, 2006-08

Figure 1. Location of Ankara in Turkey and key facts. Ankara is located in Central Anatolia (the shaded region), which is within the Mediterranean Macroclimate (first degree mesothermal semi-arid climate) region. Source: Yildiz (2007), Atmis et al. (200)7.

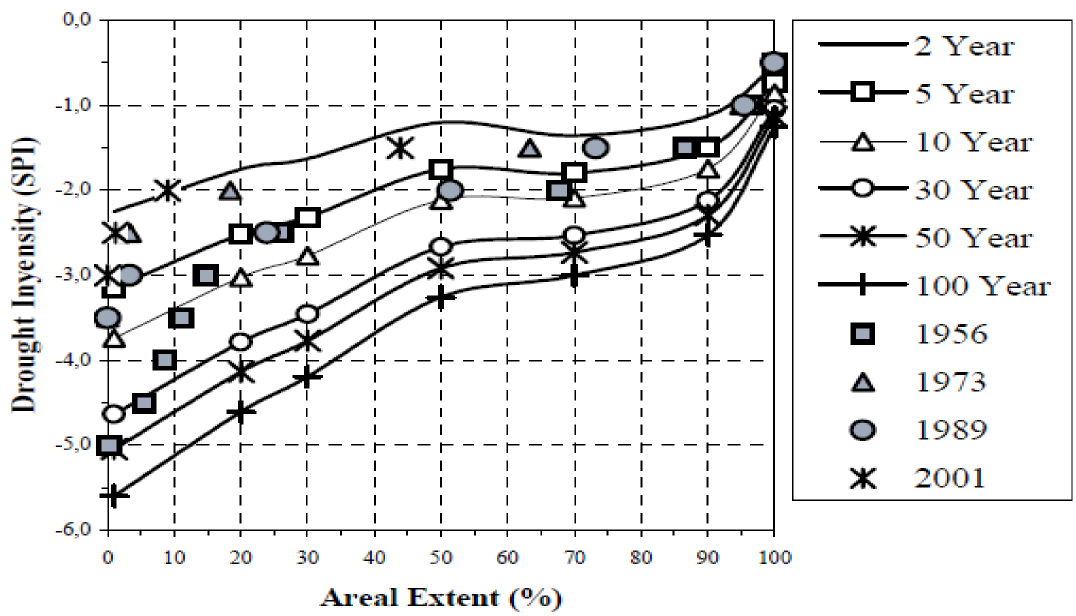


Figure 2. Drought intensity areal extent-frequency curve for Central Anatolia. This graph depicts the drought intensity-areal extent-frequency curve for the Central Anatolian Region with selected historical droughts in the area. The various year increments are recurrence intervals (Yildiz, 2007).

region is 5 years (Figure 2).

Between 2006 and 2008, Ankara witnessed one such period. The water levels in the dams that supply the main drinking water network were below 5% capacity in the summer of 2007 and nearly empty in the summer of 2008 (Figure 3). In August of 2007, the city implemented a two-

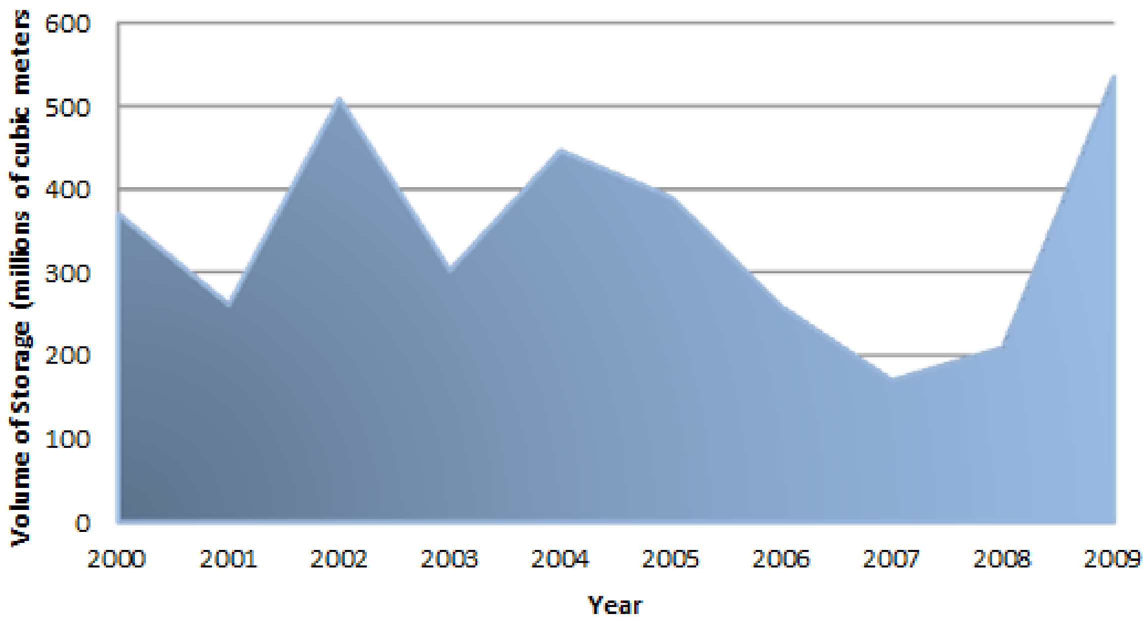


Figure 3. Volume of water retained in Ankara's drinking water reservoirs. According to official figures, Ankara's water sources have a total capacity of 1.5 billion m^3. The volume in August of 2007 dropped to 50 million m^3, or below 5% capacity. By the summer of 2009 the reservoirs had returned to 24% capacity due to above average rainfall (ASKI).

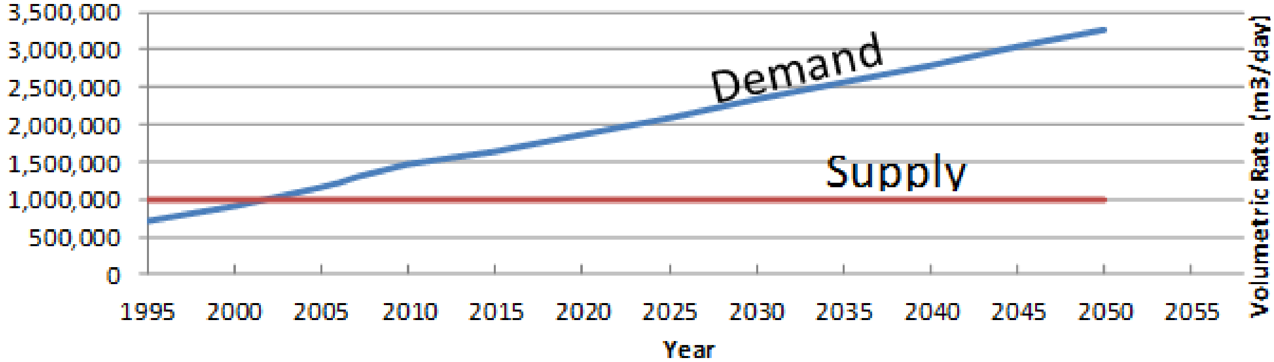


Figure 4. Estimated water supply and demand of Ankara prior to kizilirmak addition . Currently, Ankara is served by five dammed reservoirs constructed over the last thirty years at the request of the 1969 Master Plan. These are Kurtbogazi, Camlidere, Egrekkaya, Akyar, and Cubuk, which provide approximately 341 million cubic meters per year. Its current yearly drinking water demand is approximately 334,194,000 cubic meters per year (ASKI).

days-on, two-days-off strategy to conserve water, dividing the city into two sections that alternately faced 48-h water cuts. Water for vital operations such as hospitals had to be provided in tanker trucks. Because of a water main burst due to pressure differentials from the water cuts (also known as water hammer), some districts were without water for up to ten consecutive days and experienced flooding

To add water to Ankara's depleted reservoir supply the "Kizilirmak River Rehabilitation Project" broke ground in April of 2007. Three adjacent pipelines 130 km in length were constructed over the course of the following 11 months to transfer water from the Kesikkopru Reservoir located on the Kizilirmak River to the Ivedik water treatment plant 10 km north of Ankara, the hub of a centralized distribution network. Figure 4 shows the estimated supply and demand for drinking water in Ankara and Figure 5 shows the location of the city's reservoirs and treatment plant. In April of 2010, the World Water Organization presented the municipality of Ankara, Turkey with its "Best Practice Award" for the "Kizilirmak River Rehabilitation Project" at the United Nations

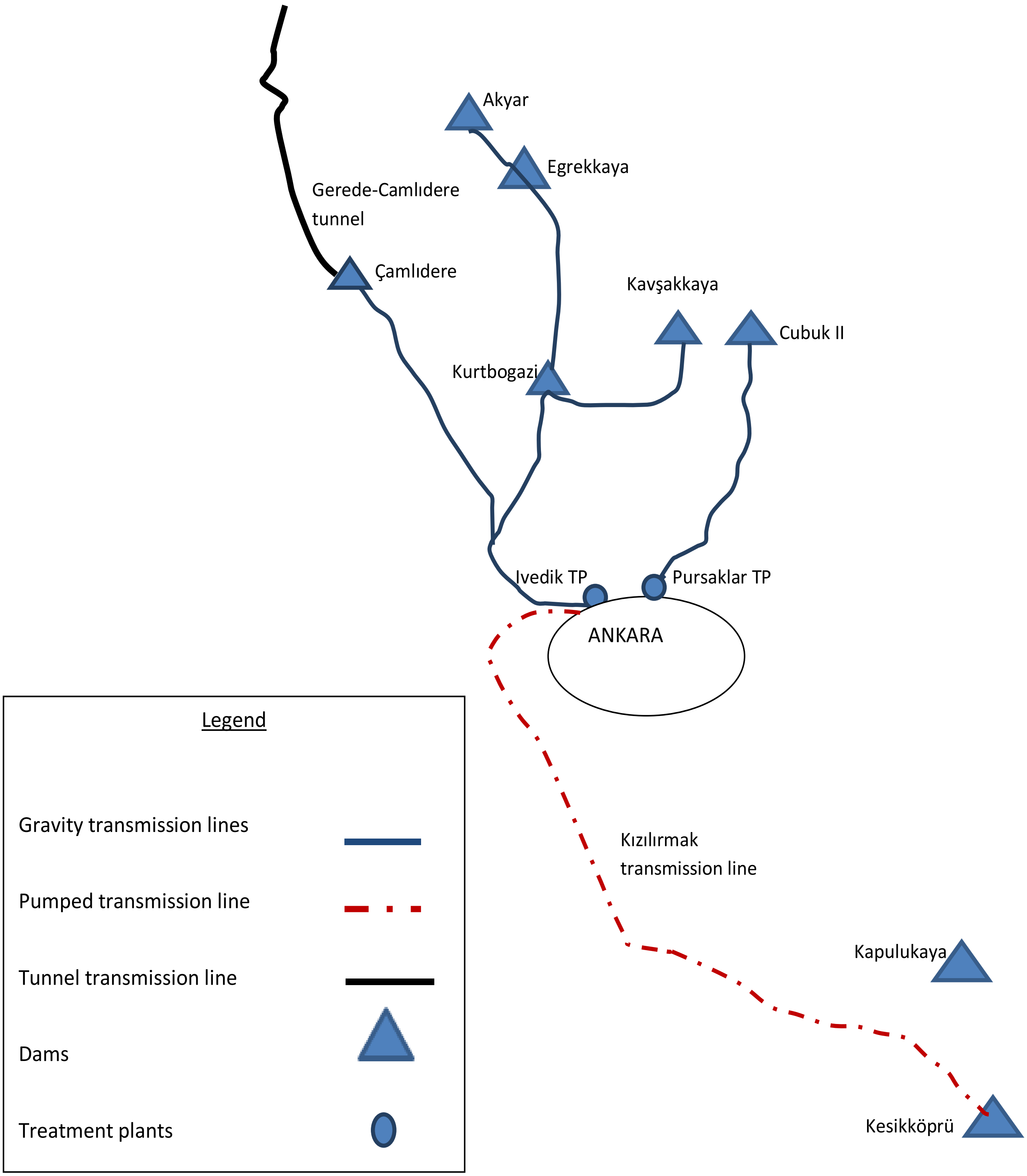
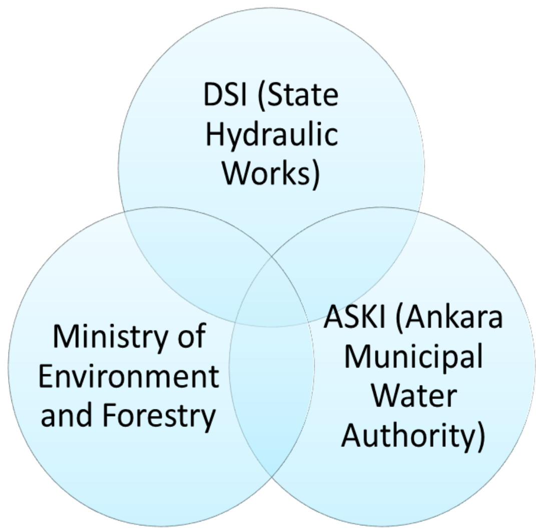


Figure 5. Schematic map of Ankara's dams and transmission lines (Gravity transmission lines are in service at present, pumped transmission line used during drought and tunnel is under construction).

headquarters in New York City. On the surface, it may appear that Ankara's rapid response to water shortages was commendable. However, the use of the Kizilirmak River was controversial and highly publicized throughout the country owing to questions over its perceived safety for use in the drinking water supply. Additionally,



PLANNING

Stage-1: DSI hires private engineering consulting firm to compose 50-year Master Plan

Stage-2: Master Planners determine most economical, timely, and technically sound plan of action

Stage-3: DSI recommends to ASKI and MEF the preferred plan of action

Stage-4: ASKI and MEF are entrusted to take into consideration the recommendations of master plan and execute to the best of their ability

EXECUTION

Stage-5: MEF ensures environmental regulations are met (ie. Wastewater treatment plants must be implemented upstream of drinking water withdrawal points)

Stage-6: ASKI raises funds (from the city if approved by the mayor, EU accession funds, among other means) and contracts engineering firms to construct water supply projects

Figure 6. Drinking water supply procurement planning process. Public water supply in Ankara is managed by three separate agencies, each with separate and interrelated responsibilities. Two of them are National ministries and one, ASKI, is municipal.

technical experts and water policy critics had warned and public officials were well aware that existing water supply would run short in the early 2000's if new water sources were not exploited. This article intends to show that the costs associated with the "Kizilirmak River Rehabilitation Project" were unnecessarily high and that long term strategic planning, reform of infrastructure delivery methods, and prudent decision making could have prevented the crisis altogether.

MATERIALS AND METHODS

The authors analyzed the "1995 Master Plan (MP) Report on Ankara Water Supply Project" commissioned by Turkey's General Directorate of State Hydraulic Works (hereafter with Turkish acronym; DSI) and assigned to Japan's Pacific Consultants International Group. The primary purpose of the 1995-MP was to determine which water source, the Gerede River or the Kizilirmak River, should be exploited first to service Ankara's demand until 2050. By determining whether or not the 1995-MP recommendations were implemented as intended, it lays a foundation for further research on the lack of success in transferring planning phase work into the execution phase and more broadly on the timely implementation of water projects to prepare for droughts.

The 1995-MP took into account all previous major Master Plan reports and feasibility studies for Ankara. These include the 1969 "Ankara Project Report on Feasibility and Master Plan for Water Supply" prepared by Camp-Harris-Medera, the 1983 "Ankara Water Supply Project Preliminary Report" by DSI, the 1987 "Gerede-Camlidere Diversion Project Master Plan Report" by a Turkish engineering company (Suis Proje) for DSI, the 1992 "Gerede System Preliminary Investigation Revised Report" by DSI, and the 1992 "Kizilirmak System Master Plan Report" by DSI (MP, 1995, Vol. I: 2 to 30 – 2-33).

Understanding the role of water authorities in urban (Ankara's) water planning

Three government agencies are responsible for urban water supply planning in Ankara (Figure 6). The General Directorate of State Hydraulic Works (DSI) was established by Law No. 6200 in 1953 (DSI, 2009). DSI is empowered to plan, design, construct and operate dams, and domestic water and irrigation schemes. Hence, DSI is entrusted with (Law No. 1053) the provision of water supply for cities with more than 100,000 inhabitants, provided that the government authorises DSI and that the concerned city council also approves.[1] Traditionally it acted under the aegis of the Ministry of Energy and Natural Resources but with a government decree issued (and approved by the President) on August 30, 2007, DSI has been attached to the Ministry of Environment and Forestry[2]. Regional Directorates representing the 25 major river basins in the country are responsible for preparing Master Plans which set priorities for the development of water resources in their respective basins.

Law No. 1580 on Municipalities (1930)[3] assigned numerous powers and duties to municipalities[4]. These include the construction of urban water supply and sewerage systems, and wastewater treatment plants. Municipalities usually prefer to combine water and

1 Article 10 of Law No. 1053 has recently been amended. The Amended Law No. 5625 has revoked the city criteria (cities with a population of which is over 100,000) and extended the duties of DSI. Thus, since 2007, DSI has been authorized for domestic and industrial water supply of 3,225 settlements all over Turkey, which have municipality administrations. The Law stipulates that, if necessary, DSI could give priority to wastewater treatment plants in progress.

2 With a Government Decree, the Ministry of Environment and Forestry has been recently reorganized under the title of Ministry of Forestry and Water Affairs on June 29, 2011

3 It was replaced by Law No. 5393 on Municipalities in 2005.

4A municipal administration can be established in settlements having more than 5,000 inhabitants.

urban transport services as a means of obtaining revenue and cross-subsidizing public services. In the non-metropolitan areas, the primary concern of local government is usually water supply rather than wastewater disposal and treatment. However, separating water supply and sewerage services under different management lines prevent an integrated approach (Cinar 2009, 351).

Although, Law No. 1053 (1968) assigned DSI to manage water supplies and treatments for all settlements over 100,000 people, the metropolitan municipality of Ankara has been given autonomy as the main water authority for the city. Ankara Water and Sewerage Administration (here after Turkish acronym, ASKI) is responsible for the operation and maintenance of projects assigned and recommended by DSI. ASKI oversees the operation of Ankara's 1.2 million cubic meter daily capacity treatment plants, Ivedik Water Treatment Plant (IWTP). Since Ankara is a relatively large municipality in Turkey, ASKI has been able to secure direct financial support from the European Union's pre-accession funds, and as such takes on more large-scale project planning that would otherwise be delegated to DSI.

The third entity, the Ministry of Environment and Forestry (MEF), is a national entity and is governed by The Law of the Environment (No. 4856) enacted in 1983. The "By-Law on Water Pollution Control" of 1988 (No. 19919) revised in 2004 (No. 25687) and 2008 (No. 26786) aims to protect ground and surface water potential, define methods, establish technical norms, and take measures at the administrative level to reduce sources of pollution (DSI, 2009). This would include ensuring settlements in the watershed are equipped with domestic and industrial wastewater treatment plants. Although MEF is responsible of inspection, monitoring and controlling, DSI, provincial governors, municipalities and Water and Sewage Administrations (such as ASKI) are also bounded by this By-Law.

Though, the organizational structure for urban water planning and protection does not display a complex picture at the first sight, new institutions were introduced without properly delineating the mandates between them and the existing ones. To illustrate, when the Metropolitan Municipalities were established in large provinces in 1981, they were entrusted with functions such as flood protection, financing, and implementing water supply and sewerage systems, which used to be entirely within mandates of DSI and the Bank of Provinces[5]. The overlaps and conflicting mandates of these institutions caused not only bureaucratic competition and rivalries but more importantly caused delayed response to crisis situations. Hence, much criticism has concentrated on the lack of coordination among the responsible water authorities (Chamber of Civil Engineers, 2009).

1995 master plan review: Kizilirmak and Gerede alternatives

Servicing Ankara's long-term (until 2050) water demand depends on the utilization of two new sources: the Gerede River and the Kizilirmak River passing 100 kilometers northwest and 130 kilometers east, respectively, of Ankara. DSI hired Japan's Pacific Consultants International Group to compose the "Master Plan Report on Ankara Water Supply Project" in July of 1995. The primary purpose of the report was to determine which water source should be utilized first, and in what year that additional supply would be required.

Kizilirmak river

The Kizilirmak River originates in the eastern Anatolian highlands and drains into the Black Sea in northern Turkey. It is Turkey's longest river (1,350 kilometers in length) and has a watershed area of approximately 28,604 square kilometers. It passes closest to Ankara when it is approximately 130 kilometers southeast of the city. Hirfanli, Kesikkopru and Kapulukaya hydroelectric dams operate in this region (listed upstream to downstream, south to north) along a 100-km stretch of the Kizilirmak River.

Kizilirmak has the potential to supply Ankara's water network 500 million cubic meters annually (MP Vol. II, pg. 8-133). The 1995 Master Plan recommended that this water be delivered in three stages of 166.67 cubic meters yearly (MP Vol. II: 8 to 137, Table 8.52).

Kizilirmak water quality

Gypsum, a highly soluble mineral, occupies about 50% of the upper Kizilirmak basin, and large capacity springs issuing from the karstified gypsum discharge into the Kizilirmak River, thereby increasing the TDS (Total Dissolved Solid) and hardness, sulphate and calcium concentrations in the Kizilirmak River (Gunlay, 2002; Kacaroglu et al., 2001). The 1995-MP confirmed that sulphate (SO_4^-) and chloride (Cl^-) were present in concentrations at 400 mg/l and 204 mg/l, respectively, at the reservoirs that would be used for retrieval (MP, 1995, Vol. I, pg. 7-9, Table 7.4). A 2008 study conducted by Middle East Technical University found the SO_4^- and Cl^- concentrations to be 328 mg/l and 256 mg/l, respectively, where Kizilirmak water is withdrawn for use in drinking water supplies at Kesikkopru reservoir site (Demirer, 2008).

The Turkish 266 Standard and World Health Organization's standard for SO_4^- in drinking water is 250 mg/l. Studies "indicate a laxative effect on humans when exposed to drinking water concentrations of 1000 to 1200 mg/l, but no increase in diarrhea, dehydration or weight loss (WHO, 2004)." Sulphate causes a bitter taste in water at concentrations over 250 mg/l. Conventional water treatment processes cannot treat salts and salt forming ions such as SO_4^- and Cl^-. The most common method employed in newly constructed desalination plants is Reverse Osmosis, where the saline water is pressure fed through membranes, producing purified water for drinking and highly concentrated briny water as a by-product. Because of the large catchment area of the Kizilirmak River, the 1995-MP defined pollution as difficult to track and prevent (MP, 1995, Vol. I, pg. 7). Until recently the main cities upstream of Kesikkopru Reservoir, Nevsehir (population.310,344), Kirsehir (p.105,826), Kayseri (population.1,165,088), and Sivas (population 300,795), lacked wastewater treatment plants. The 1995-MP evaluated the water pollution level of the Kizilirmak based on the "Water Pollution Control Regulation" published in the Official Gazette No. 19919 on 4/9/1988 (MP, 1995, Vol. I, pg. 7-1). After evaluation of physical and inorganic chemical, organic, inorganic pollution, and bacterial parameters it was determined that Kizilirmak was Class III[5] polluted water (MP, 1995, Vol. 1, pg. 7-1). Not all of the major upstream cities have established wastewater treatment plants, but efforts have been underway since 2004 to construct plants in each of the cities with EU pre accession funds: (Baltaci, Fikriye, Manager of Environmental Section at DSI, personal communication, July 24, 2009).

Kayseri's new wastewater treatment plant has a capacity of 110,000 cubic meters per day (Arslan-Alaton et al., 2007). The plant includes nitrogen and phosphorous removal, and discharges into Karasu creek, which empties into the Kizilirmak River.

According to Arslan-Alaton et al. (2007), the plant is operating efficiently and effluent is within Turkish standards with regard to organic matter, pH, and other parameters. They also state that there is no heavy metal problem with the Kayseri wastewater.

A recent study identifies environmental degradation of one of Ankara's drinking water supply reservoirs, Kurtbogazi, due to wastewater discharges from squatter settlements and agricultural

5 Class I: High quality water; Class II: Slightly polluted water; Class III: Polluted water; Class IV: Extremely polluted water.

Table 1: Kizilirmak System Alternatives Evaluated in the 1995 Master Plan

Annual Water Supply Capacity (Completion year)	***Reservoir:*** ***units***	***Kapulukaya*** ***A***	***B***	***C***	***Hirfanli***	***Kesikkopru***
1st Stage (2003)	million cu. m.	166.67	166.67	166.67	166.67	166.67
2nd Stage Accum. Tot. (2017)	million cu. m.	333.3	333.3	333.3	333.3	333.3
3rd Stage Accum. Tot. (2029)	million cu. m.	500	500	500	500	500
Reservoirs						
Catchment Area	sq. km	28,604	28,604	28,604	26,200	26,530
Annual Inflow	million cu. m.	2,557	2,557	2,557	2,614	2,453
Effective Storage capacity	million cu. m.	110	110	110	1,980	60
Water transmission pipeline						
Total Capacity	cu. m. per sec.	20	20	20	20	20
1st Stage (2003)	cu. m. per sec.	7	7	7	7	7
2nd Stage Accum. Tot. (2017)	cu. m. per sec.	13	13	13	13	13
3rd Stage Accum. Tot. (2029)	cu. m. per sec.	20	20	20	20	20
Total Length	km	50	85	12	81	77
Pump station head						
Station-1	m	213	150	142	100	165
Station-2	m	254	310	320	260	260
Tunnel						
Total length	m	10,800	6,400	33,950	8,350	8,350
Construction period						
Tunnel	Years	5	5	8	5	5
Treatment Plant	Years	3	3	3	3	3
Total project cost (Net present value)*	million USD	1,047	1,334	1,094	1,368	1,335

*value does not include reverse osmosis treatment cost

Source: MP Vol. II, pg. 8-137, Table 8.52

activities within the absolute and proximate zones of the watershed as well as drought impacts (Altin et al., 2010). The authors assert that the reservoir is not in line with environmental policies for surface water to be used in the drinking supply, yet Ankara still utilizes it.

Another issue of concern among the public is that of heavy metals in the Kizilirmak River. One study (Akbulut et al., 2009) identified heavy metal accumulation in fish of one of the tributaries of Kizilirmak. Another study (Yilmaz, 2007) found heavy metal accumulation in sediments upstream of Kesikkopru reservoir. The 1995 Master Plan stated that there was not adequate information available regarding the heavy metal concentrations in the reservoirs and that such studies needed to be completed (MP, 1995, Vol. I, pg. 7-21).

Master plan construction alternatives for Kizilirmak

Five alternatives based on existing dams were compared for Kizilirmak. Each alternative was considered with 3-stage construction in years 2003, 2017, and 2029 (MP, 1995, Vol. II, pg. 8-137, Table 8.52) (Table 1).

The Northern most dam, Kapulukaya, was evaluated with three possible diversion routes (A, B, C). The Elmadag mountain range lies in-between Kapulukaya and Ankara. Kapulukaya-A involved constructing a tunnel through the mountain range to feed the water by way of gravity to a treatment plant at Bayindir. Option B evaluated a route that bypassed the mountain range along a hillside to a treatment plant at Bayindir. Option C evaluated crossing a plain south of the mountains and transferring water to a treatment plant at Golbasi. The intermediary dam, Kesikkopru, and the southernmost dam, Hirfanli, were evaluated with one diversion route each. The topographical conditions of both of these routes are gentler than from Kapulukaya to Ankara, and transmission would involve relatively less tunnel construction. In these two alternatives, water would be transmitted to a new water treatment plant at Golbasi, and fed to Ankara. In all five alternatives, two pumping stations would be required (MP, 1995, Vol. II, pg. 8-137, Table 8.52).

Kapulukaya A, was chosen as the best alternative in terms of net present value cost (MP Vol. II, pg. 8-177). The main costs differentials were as follows: The total cost of penstock line was 3 or

Table 2. Gerede system alternatives evaluated in the 1995 Master Plan.

Annual water supply capacity (Completion year)	***Reservoir:*** ***units***	***Isikli*** ***A-1***	***A -2***	***A-3***	***A-4***
1st Stage (2003)	million cu. m.	188	188	188	188
2nd Stage Accum. Tot. (2019)	million cu. m.	255	255	255	255
3rd Stage Accum. Tot. (2024)	million cu. m.	289	289	289	289
Reservoir					
Catchment Area	sq. km	1,278	1,278	1,278	1,278
Annual Inflow	million cu. m.	325	325	325	325
Effective Storage capacity	million cu. m.	28	28	28	28
Water transmission pipeline					
Total Capacity	cu. m. per sec.	30	30	30	30
1st Stage (2003)	cu. m. per sec.	10	10	10	10
2nd Stage Accum. Tot. (2019)	cu. m. per sec.	20	20	20	20
3rd Stage Accum. Tot. (2024)	cu. m. per sec.	30	30	30	30
Total Length	m	8,675	14,960	17,360	19,185
Pump station head					
Station-1	m	88	138	138	138
Station-2	m		106	162	107
Station-3	m				110
Tunnel					
Total length	m	16,800	9,400	5,000	2,500
Camlidere pipeline length	m	36,700	36,700	36,700	36,700
Construction period					
Tunnel	Years	8	5	5	5
Treatment Plant	Years	3	3	3	3
Total project cost (Net present value)*	million USD	912	830	806	831

*value does not include the lifespan electricity costs for pumping
Source: MP Vol. II, pg. 8-8, Table 8.1.

more orders of magnitude higher for Hirfanli and Kesikkopru when compared to Kapulukaya diversion routes. Secondly, the total cost of civil works was least expensive in Kapulukaya-A compared to the alternatives. For example, the estimated cost of pipeline materials and construction alone was 380 million USD for Kesikkopru diversion versus 247 million USD for Kapulukaya-A (MP, 1995, Vol. II, pg. 8-178, Table 8.75).

Gerede River

The main water source of the Gerede project is the 1278 square kilometers drainage area of the Ulusu-Gerede stream that forms the upstream part of the Filyos river basin (MP, 1995, Vol. II, pg. 8-2). Gerede has the potential to supply Ankara's water network 289 million cubic meters per year (MP, 1995, Vol. II, pg. 8-8, Table 8.1).

Master Plan construction alternatives for Gerede (Table 2)

In order to minimize the required volume of the new reservoir (to reduce the impact on Gerede city), an intermediary reservoir between Gerede and Ankara, Camlidere, with a capacity of more than 1 billion m^3, is to be the regulator of the diverted water. Therefore, the construction of a pipeline/tunnel system from the Gerede River to Camlidere Reservoir 30 km east is required. Similarly, since Camlidere is fed to Ivedik water treatment plant, Gerede would be treated at Ivedik WTP and the treatment plant will require expansion upon the addition of Gerede.

Though the water intake site is located 150 m higher than Camlidere Reservoir, the Korogulu mountain range lies in-between. To divert the water without pumping would require the construction of a 32 km long tunnel through the mountain range. The beginning portion of the tunnel would occur in a geologic area distributed with montmorillonite rich rock, which is problematic for tunnel excavation. Some risks include readiness of decomposition in water and landslides, as seen from previous experience in Japan (MP, 1995, Vol. II, pg. 8-41). Furthermore, the excavation area is rich in agglomerate and lava, which make the area susceptible to water inflow under high groundwater pressure. Because of the geotechnical difficulties with tunnel excavation at the lower elevations, three other alternatives were evaluated that included

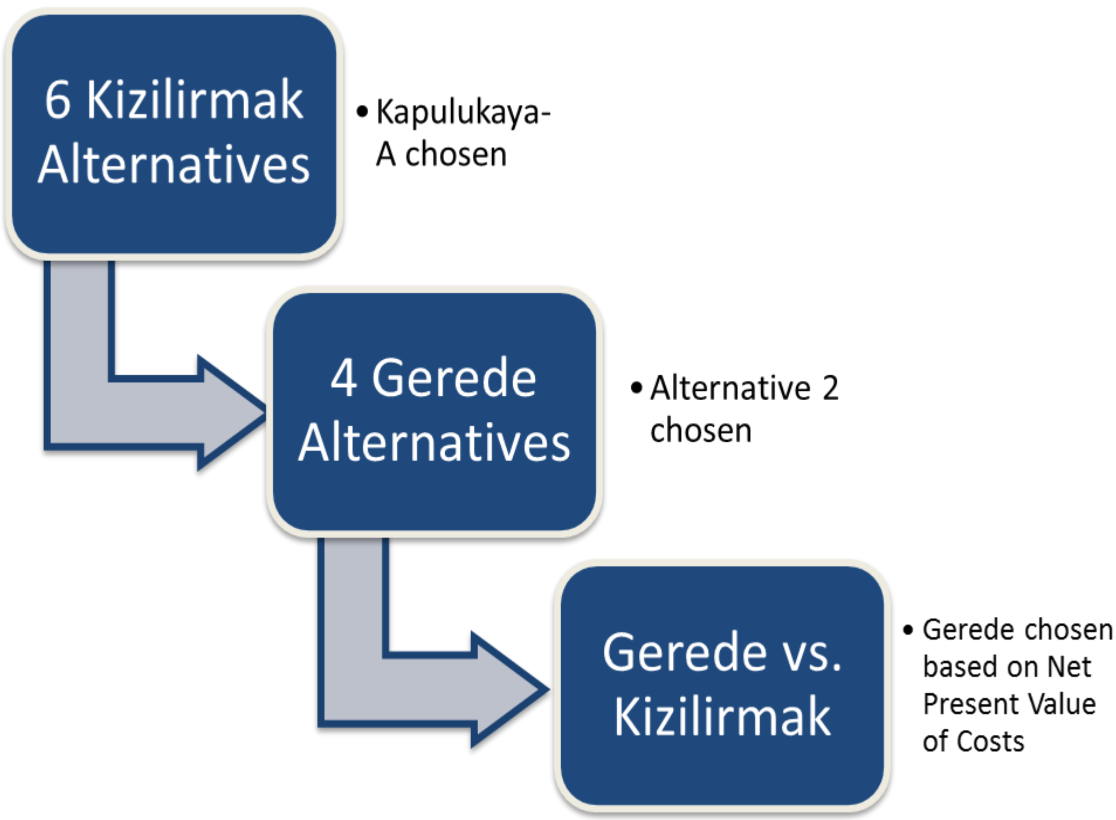


Figure 7. General decision process for the determination of final alternative (Determined by Pacific Consultant's International Group, the master planners hired by DSI). This chart shows the decision process of determining which system, and alternative within that system, is most economical to pursue first. The 1995-MP determined Gerede A2 was the most economical.

pumping stations and tunnels located at higher elevations in the mountain range (MP, 1995, Vol. II, pg. 8-40, Table 8.21). Alternative I, with the longest tunnel excavation and highest initial cost, had a higher net present value (NPV) in terms of cost (that is, It was the most expensive). The unit water cost of alternative I and IV were also judged to be 3% higher than Alternatives II and III. II and III follow the same route, but the tunnels are at different elevations (MP, 1995, Vol. II, pg. 8-60, Table 8.26). Therefore, alternatives II and III were judged to be nearly equivalent in terms of construction cost. However, since alternative III requires a higher pumping head and thus higher energy costs through the lifespan of the project alternative II was chosen for comparison with Kizilirmak.

Determination of best implementation sequence

After being evaluated independently of one another (Figure 7) the Kapulukaya-A and Gerede were compared with each other. It was estimated that if implemented in 2003, Gerede's 289 million cubic meters yearly potential (spread over three stages of construction) added to existing supply could service demand until 2027. At that point, Kizilirmak's 500 million cubic meters yearly supply would be added and would service demand past 2050 (MP, 1995, Vol. II, pg. 8-229, Table 8.100). The second alternative was to implement Kizilirmak in 2003, in which case demand would be serviced past 2050 (MP, 1995, Vol. II, pg. 8-230, Table 8.101). Therefore the two sequences considered were (MP, 1995, Vol. II, pg. 8-226): 1) Gerede (2003) + Kizilirmak (2027) and 2) Kizilirmak (2003) only.

Without Kizilirmak's desalination taken into account, Gerede was deemed cheaper during the first twenty years of operation, and the two essentially equal in cost afterwards. However, with reverse osmosis, Kizilirmak became significantly more expensive than Gerede. They estimated that the NPV of costs for the Gerede + Kizilirmak, Kizilirmak only, and Kizilirmak with desalination were 557 million USD, 638 million USD, and 1 billion USD, respectively (MP, 1995, Vol. II, pg. 8-233, Fig. 8.32). Additionally, because of the size of the Kizilirmak River basin pollution is difficult to track. Therefore, it was advised that smaller water projects such as Gerede should be launched first and larger ones implemented as Ankara's population increases (MP, 1995, Vol. I, pg. 7).

Based on these cost figures the 1995 Master Plan recommended construction begin on Gerede supply by 1999 at the latest so that the system could be in operation by 2003. Around 2027, when demand would be expected to outstrip Gerede supply, Kizilirmak supply would be added. It was assumed that by 2027, desalination technologies would be less expensive and more efficient relative to technologies available in 1995. The recommended program was as shown in Figure 8.

RESULTS

Interviews with members of DSI indicated that a feasibility study was conducted on the recommended Gerede system in 1998. The construction of a reservoir at Gerede

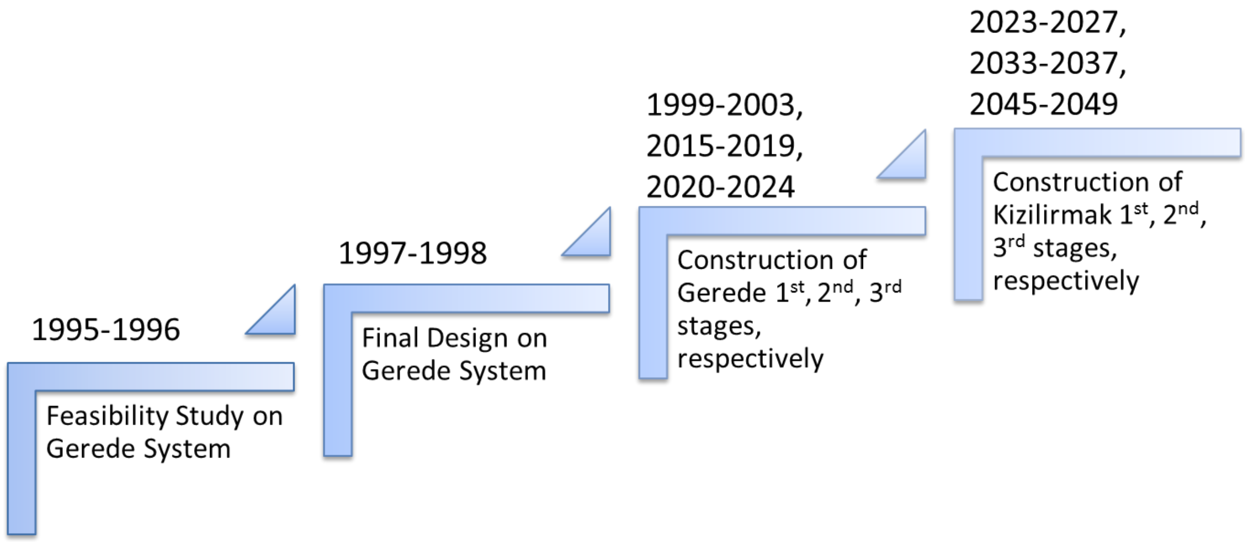


Figure 8. Recommended program of implementation from the 1995 master plan**.** MP Vol. II, pg. 9-1.

would have displaced 91 villages and 41,000 people. Though citizens of Turkey have traditionally been cooperative with resettlement, it has been mentioned as a potential impediment to implementing Gerede as recommended. After the determination that Gerede was not the favored option, ASKI should have embarked on tapping Kizilirmak by the 2004 deadline. Instead, the Mayor of Ankara, Melih Gokcek, prioritized transportation projects over water supply enhancements. ASKI does not lack the necessary personnel, technical, or financial capacity, rather competing priorities and political motives stalled water infrastructure upgrades. It was also a case of national versus local priorities, as DSI allocated much of its attention and resources towards the Southeast Anatolia Project. It was not until 2007, when water supply was all but depleted due to drought and conditions were urgent, that the "Kizilirmak River Rehabilitation Project" was constructed (Figure 9). Water was withdrawn from Kesikkopru Reservoir and consisted of three adjacent pipelines traveling a distance of 128 km for a total pipeline length of 384 km. The transmission route included five pumping stations and gravity feed sections and the water was treated at Ivedik WTP. The 1995-MP estimated it would take five years to build the recommended tunnels for the Kizilirmak and Gerede transmission alternatives, and three years to build additional water treatment capacity. The delay in implementation and the urgency of a crisis situation meant there was not enough time to construct the recommended facilities when new supply was needed. The only viable option was entrenched pipelines along the gentler topography from Kesikkopru reservoir on the Kizilirmak River to Ankara.

The total cost of the "Kizilirmak River Rehabilitation Project" was initially estimated at $350 million (GWI, 2007). This estimate was for a completion date in November 2007 but the project was not complete until March 2008. Therefore, the costs were likely much higher than the initial estimates. Compared to 1995-MP construction cost estimates for Kapulukaya-A ($247 million) the cost was increased by at least 41%. Since the MP envisioned the new Kizilirmak treatment plant to be built south or east of Ankara rather than north (where Ivedik is located) the total length of transmission is extended from 85 km to 128 km in order to reach Ivedik WTP, increasing material costs. The decision to build three pipelines in a single phase long before such capacity would be needed is also poor planning. Because of the opportunity cost associated with the high initial investment of major infrastructure projects it is typical to spread construction over multiple stages in accordance with increasing demand. This distributes capital costs over a longer period of time and ensures that construction employment will be consistent throughout the span of the project.

Additionally, the 1995-MP recommended wastewater treatment plants be built in five upstream cities prevent pollution of the chosen intake site (in this case Kesikkopru reservoir). That environmental planning did not begin until 2004 and is still incomplete. Therefore, "The By-Law on Water Pollution Control" was not satisfied when Kizilirmak was used in the drinking water supply. Further, the 2007 implementation plan did not include the construction of a new water treatment plant because of time constraints and Ivedik WTP is not equipped with technology to remove sulphate and

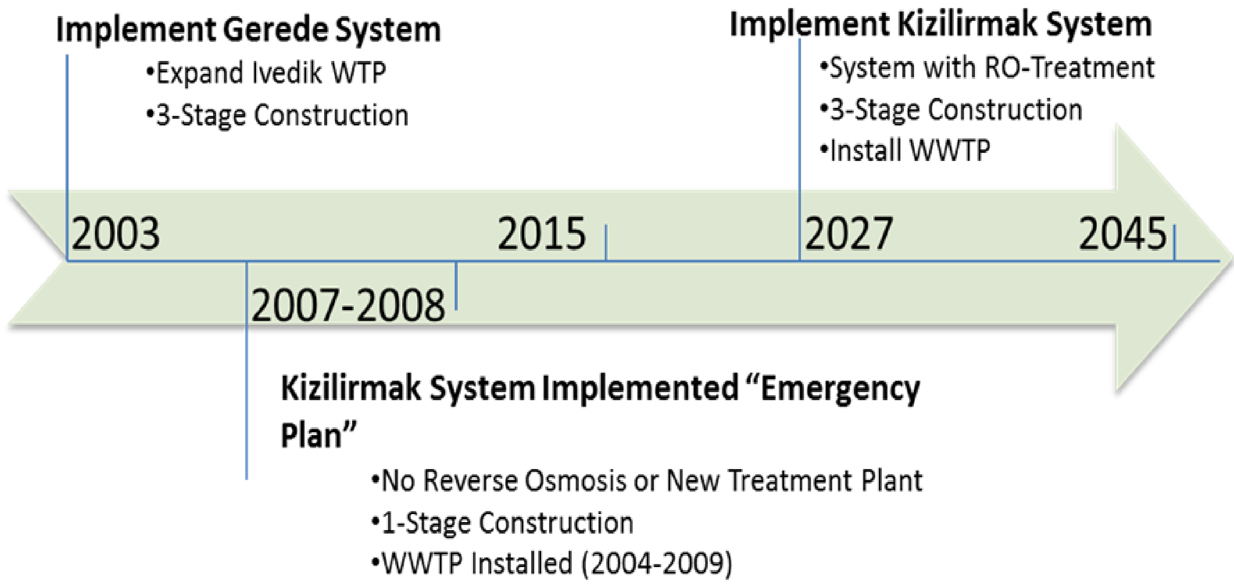


Figure 9. Master plan chronology vs. actual implementation chronology. The top portion of this figure is the chronology suggested by the 1995 Master Plan. The bottom portion is the timeline of actual implementation.

chloride. Rather, Kizilirmak water was mixed at Ivedik WTP with existing water supply so the treatment method was in effect that of dilution. As demand grows Kizilirmak supply will provide the bulk of Ankara's water needs, so dilution is only a temporary solution. In other words, time constraints took precedence over public health.

More recently Ankara began development of Gerede project, where a cross-regulator was installed at Isikli dam site in 2009 as an alternative to a dammed reservoir to minimize the impact on nearby villages (Figure 10).

The so-called "Ankara Water Supply Project" is funded by a 26,826 yen (approximately 312 million USD) Official Development Assistance (ODA) loan from the Japanese Bank for International Cooperation[6]. The project includes a solely gravity fed tunnel, thereby eliminating pumping costs, that will break ground in 2010 and is scheduled for completion in 2013. This route is similar to alternative 1 in the 1995-MP, consisting of a 32 kilometers long tunnel through the Korogulu mountains. As mentioned above, this elevation of the mountain range contains montmorillonite and problems with water intrusion and other construction dangers occur when drilling in this rock.

The Kizilirmak system is not currently in use (as the other reservoirs have been replenished since the last drought), and if current reservoirs remain sufficient until 2013 (the expected date of completion of Gerede) the river may not be used in the drinking water supply for twenty years or longer.

[6] http://www.jica.go.jp/turkey/english/office/topics/news100104.html

DISCUSSION

Adequate water supply secured through strategic long-term investment as recommended in the 1995-MP would have averted the crisis completely. The successful delivery of water infrastructure requires coordination of all interested parties: national ministries, local authorities, and private contractors. This coordination must be carried through from the initial planning stages (Master Plan formation, feasibility studies, fund raising) to the end of the execution stages (selection of contractors, construction, maintenance). In Ankara's case, technical recommendations for the planning phase were not carried on through the decision making chain from the private contractor who composed the plan on behalf of DSI to ASKI who was responsible for implementation.

As a result of the governments' policy of 'decentralization' the municipalities have been empowered with more responsibilities. While this policy may be more efficient for the purposes of meter reading, billing, and other customer interface purposes, a downside to this development is that politics and misplaced local priorities can impede proper implementation as defined by the recommendations of DSI. Further, this decentralization resulted in poor environmental management. The Kizilirmak River basin extends into a number of different municipalities. So while ASKI is responsible for the withdrawal, treatment, and distribution, MEF is responsible for basin management. These two responsibilities are interrelated and should be addressed simultaneously in order to meet the requirements of the By-Law on Water Pollution Control,

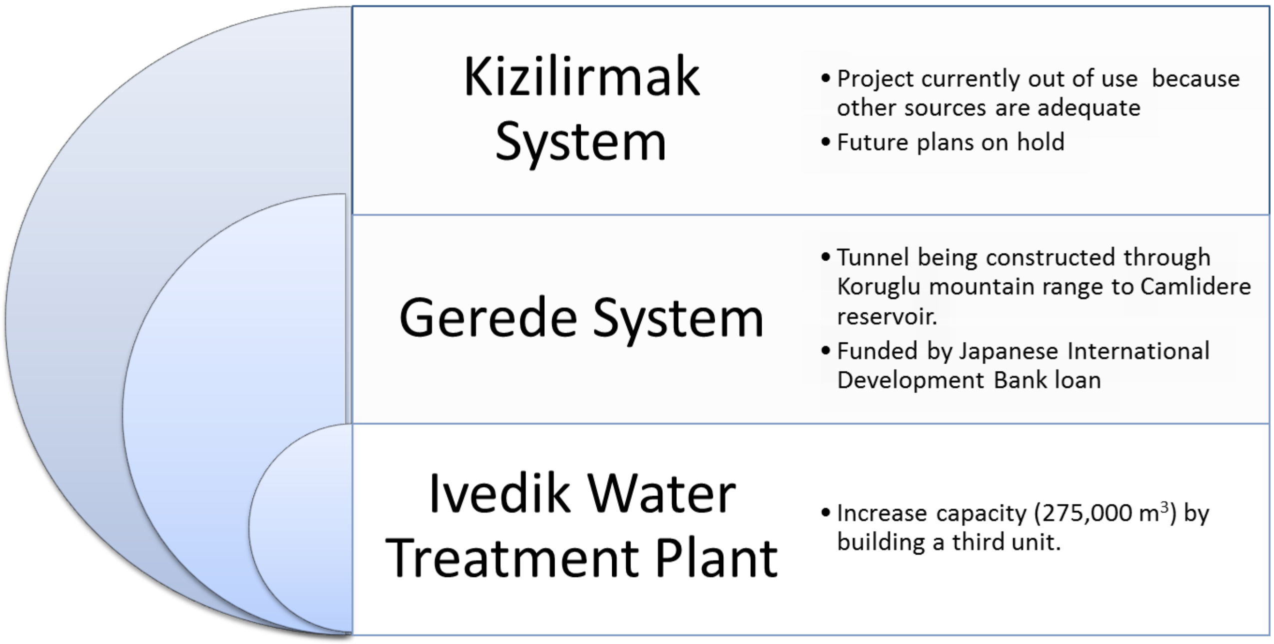


Figure 10. Current status of major drinking water components.

but in this case were not. This serves as an indication of failure of MEF and ASKI to adhere to the advice of DSI in tandem. Technocrats at DSI have suggested the establishment of one agency rather than three and since 2007 DSI has been linked to MEF. Perhaps this linkage will provide better coordination in future projects, though it does not solve the problem of the discord between the national and local authorities.

Suggested reforms include the adoption of comprehensive, long-term drought preparedness strategies since they are more economically efficient than short-term crisis response measures. Reform should also involve stricter mandates requiring the executing bodies to follow through on recommendations of planners, or at the very least provide a basis for the various interested entities to work in tandem. This may be accomplished through public-private-partnerships, continued technical guidance and input from contractors during the feasibility and construction phase, and a streamlining of the institutional structure to reduce the influence of politics in water.

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