China Opens the Floodgates: Huge Project To Address Water Scarcity

by Mary Burdman

Oct. 9—After investing more than a decade in constructing dams, canals, tunnels, and the world's most modern aqueduct, and just as long in intensive measures to improve and protect water quality in the upper Yangtze River system, China has completed the Central Route of its huge South-North Water Transfer Project (SNWTP). The Project Commission under the State Council announced Sept. 29 that all 55 construction units on the new water diversion route have passed a final check and are set to begin operation in late October, China Central Television reported. This is the second of three man-made rivers in the world's largest inter-basin water transfer project,[1] which is now bringing water from the Yangtze River system in south-central China to the densely populated, but very dry Northern Plain, China's "breadbasket," its biggest population center, and a key industrial region.

This new man-made river is longer than Europe's Rhine, an unprecedented achievement. Yet, so great is the challenge of "Quenching a Mighty Thirst"—as CCTV titled its recent series on the project—that the water to be delivered to the capital, Beijing, will only meet a third of its rapidly growing requirements.

Even while constructing the first two routes of the SNWTP, the Chinese government is developing other means to meet its huge water needs. In 2012, the government radically increased its commitment to desalination of seawater—by far the greatest reserve of water on Earth—and to improving the efficiency of water usage and management in agriculture and industry. This will require unprecedented investment in modern technology and infrastructure, to modernize every sector of the Chinese economy—agriculture, industry, energy generation—at the same time. No one has ever done anything quite like this before. Achieving this goal will be a crucial part of the "Peaceful Rise of China."

With its space, nuclear, and high-speed-rail programs, China is developing the scientific and technological capabilities to make this grand transition. The SNWTP, which cuts northward across the west-east flow of all China's main rivers, is also changing the nation's geography. The purpose is to save the greatly overtaxed Yellow River, cradle of Chinese civilization, and break open the bottleneck that the lack of water is imposing on urbanization, agriculture, and industry in the Northern Plain. At the same time, it is widely recognized in China that water transfer alone cannot solve the problems, and comprehensive, advanced water management must be pursued.

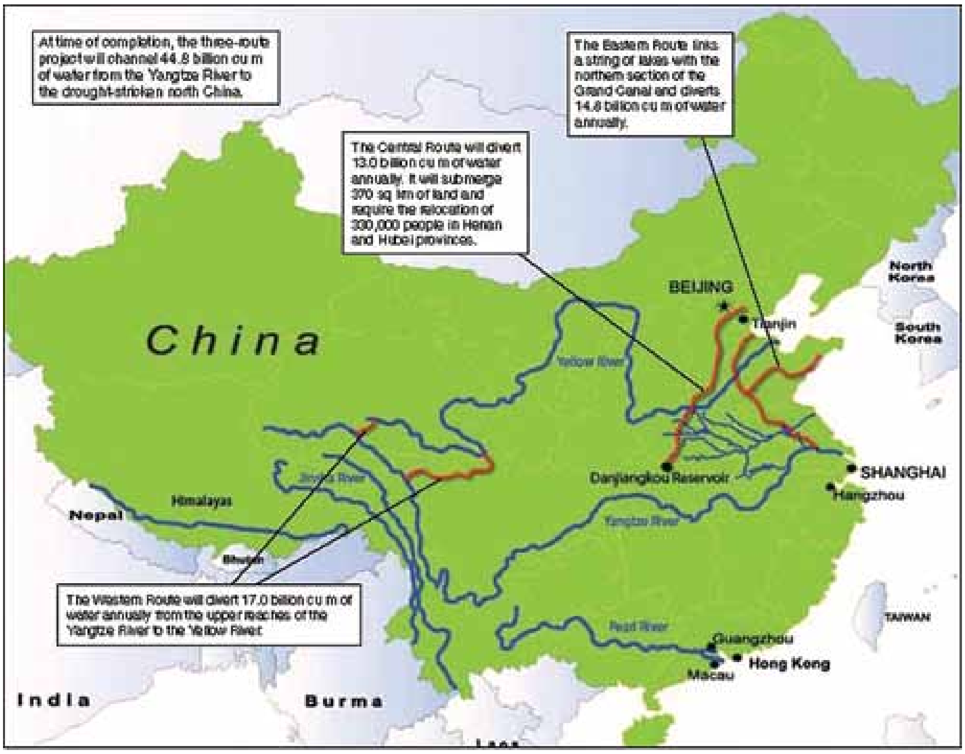
In December 2013, the Eastern Route, which follows China's ancient Grand Canal, was the first to open, taking water from the lower Yangtze to Shandong Province, on the lower reaches of the Yellow River, along China's eastern coastline. Building the Center Route, which starts much farther inland, on the Yangtze tributary Han River, required much more investment and new construction. An even more challenging section, the Western Route, intended to connect the headwaters of the Yangtze with the Yellow River in the Tibetan Plateau at an elevation of 3,000-5,000 meters, is still in the planning stage.

The lack of water in Northern China has created a real economic bottleneck. China is approximately the size of the continental United States and located at about the same latitude, but it supports well over four times the population, more than 1.35 billion people, most of whom are crowded into the North China Plain and Yangtze Valley at population densities rivaling that of Belgium. Population density is about 400 people per square kilometer for the 440 million who live in the North China Plain; another 400 million live in the Yangtze Valley, where density is about 225 per km^2.

China's land, especially in the very threatened Yellow River region, has been cultivated for millennia; many regions have been deforested; in recent decades, rapid industrialization has led to serious pollution of

1. See Mary Burdman, "China Is Completing the Greatest Water Project in World History," *EIR*, Nov. 16, 2102.

FIGURE 1
Watering the North



Source: Chinese Ministry of Water Resources, futuretimeline.net; Will Fox

air, water, and the land. China has huge water resources, but, due to the sheer size of its population and underdeveloped agriculture and industry, per-capita resources are very low. In 2009, the World Bank estimated that Chinese industry uses ten times more water per production unit than the average industrialized nation, due to its less efficient technology. China continues to be dependent on coal—a big water consumer and polluter—as its primary energy source. Finally, in the past decade, China has made a rapid shift from an overwhelmingly rural to an over 50% urban nation, which will double, at least, per-capita domestic water usage.

'Built To Last a Century'

The new SNWTP route is making an essential contribution to breaking the economic bottleneck. The Central Route starts from the Danjiangkconou Reservoir on the Han River in Hubei Province, in the center of the country. The water will flow downhill and northwards over 1,400 km, through canals, tunnels, and aqueducts, to 20 cities, supplying an area of some 150,000 square kilometers. When the reservoir holds enough water, the channel will initially carry over 9.5 billion m^3 of water a year to cities including Beijing (population over 21 million) and Tianjin (population over 14 million). By 2030, the plan is to increase water volume to 13-14 million m^3 a year.

To give an idea of the regional water requirements, a proposed Beijing-Tianjin "greater metropolitan area," including parts of Hebei Province, will have a population of 130 million! Official estimates put annual water requirements at well over 200 billion m^3 by 2050. If all three sections of the SNWDP are completed by then, it will supply a total of 44.8 billion m^3.

The top priority for using the water will be domestic consumption and industry, since water quality is much better in the Han and other upper Yangtze tributaries, than in the severely polluted Eastern Canal.

The Central Route crosses some 170 rivers, including the valleys of the Yangtze, Huaihe, Huanghe (Yellow River), and Haihe. Engineers constructed aqueducts, canals, and tunnels over and underneath the rivers to keep out polluted water. The new aqueduct over the Tuanhe River is currently the world's largest, and will carry 420 m^3 of water per second. On Sept. 22, CCTV correspondent Han Bin reported that the over 9-km bridge-raised aqueduct is the "world's biggest, most sophisticated aqueduct ever built. China's water diversion project is unprecedented in water volume and distance, and it includes some of the most challenging engineering feats ever seen." Han Bin quotes senior engineer Yu Pengtao: "This aqueduct is no doubt the number one such construction in the world, in regards to water capacity, and scale and weight. The design requires high precision and a scientific approach." This project "is built to last a century." In Beijing, which will receive about two-thirds of the Central Route water, facilities "as high as a 15-story building" were built underground to ensure

FIGURE 2
The Central Route

http://www.nsbd.gov/cn/english/english.htm

water quality, limit evaporation, and leave surface areas free.

Construction started in December 2003, when the dam forming the Danjiangkou Reservoir, originally built in the 1960s-70s, was raised from 162 meters to 176 meters to lift the water level. However, the reservoir has been filling much more slowly than originally foreseen. As of Aug. 20, 2014, the Danjiangkou water level was still far below the designated 170 meters which will make it possible to send the planned amount of water north. In the future, the Central Route will be extended south to the Yangtze, to make it possible to take water from the Three Gorges Dam reservoir. During periods of flooding in the Yangtze system, even more water could be sent north, to actually replenish the heavily exploited groundwater reserves around Beijing.

"Despite the environmental and social impact, the government remains determined, saying the project could break the bottleneck of development and growth," Han Bin said on Sept. 15. "No doubt, the water from the south will buy China time, yet it may never be enough to quench China's mighty thirst." Official estimates put total demand in northern China at over 200 billion m^3 by 2050; all three SNWDP routes will supply only a little over one fourth of that.

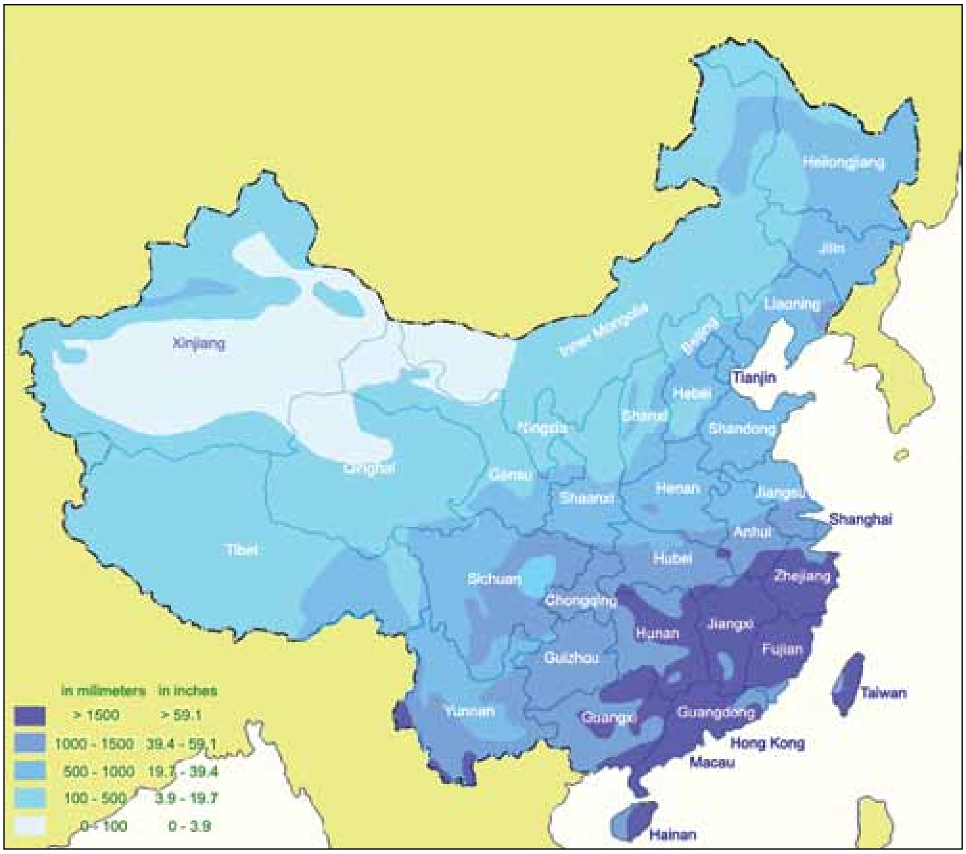
The potential for transfer was based on calculations of water flows in past decades. These did not include the demands of urban expansion. In addition, weather patterns have been changing over the decades since planning began: Rainfall in the Northern Plain has decreased, and rainfall patterns have become more erratic in water-rich central and southern China.

Even in wetter conditions, the amount of water being diverted to Beijing will meet barely one third of the city's water needs. Beijing now faces an annual shortage of 1.5 billion m^3, with current resources for 15 million people, not the 21 million who live there now. This past Summer, daily water usage hit a record 3.1 million m^3, just 80,000 m^3 less than the city's capacity. Continuous drought since 1999 has curtailed water resources, while the population grew from 12.6 million in 1999 to 21.1 million in 2013. Many Beijingers living in older housing without running water, and have been digging their own wells, draining groundwater supplies. When the Center Route water arrives, the city will attempt to shut these household wells, to help restore groundwater. Some of the water will also be stored in three reservoirs as a strategic reserve, *China Daily* reported Sept. 23.

Decades of drought in North and Central China have exacerbated the pressure, and groundwater levels are sinking fast. China's *First National Water Census Bulletin*, published in March 2013, showed just 22,900 rivers, less than half of the 50,000 rivers shown on maps published two decades ago. While the current three-year survey by the Ministry of Water Resources and the National Bureau of Statistics may have been more accurate than earlier ones, there is little question that falling groundwater levels have drained surface rivers and lakes.

To reach water, well diggers in the North China Plain have to go as far as 500 meters below the surface, CCTV reported May 15. In Hebei Province, which surrounds Beijing, as much as 5 billion m^3/year is being pumped out of the ground. *China Daily* on Sept. 23 quoted SNWTP Deputy Director Yu Youjun on the effect this is having. China Geological Survey research shows that the North China Plain is among the worst affected by land subsidence, due to excessive groundwater extraction, he said. About 8,000 km^2 of land around Tianjin has been subsiding since the 1970s; in Tanggu, a district of Tianjin, the land has sunk by well over 3 meters, and at Cangzhou, by 2.4 meters. In the Yangtze Delta, about 10,000 km^2 have sunk by over 200 mm; around Shanghai, it is close to 3 meters. "Without the project, Beijing and Tianjin may face severe land subsidence due to years of excessive groundwater pumping, threatening city security," Yu said. To help preserve the diminishing water table, he said, a 30- to 60-meter-wide green belt of grass and trees is being planted along the Central Route.

FIGURE 3
Average Annual Precipitation in China and Taiwan



Wikipedia/Alan Mak

The Great Water Clean-Up

The *real* water crisis is not lack of water; water is never "used up," but is always recycled from ocean to land to atmosphere; for humanity, the crisis is the lack of *clean water*. That is the reality for the greatest concentration of population in the world, in Asia and Africa. Only full-scale water management can solve this crisis. Official UN and other figures estimate that some 800,000 to 1.1 billion people in the world do not have access to clean water, but this is a serious understatement.

In March, Prime Minister Li Keqiang declared a "war on pollution," to be waged with as much commitment as China's s war on poverty. The Ministry of Environmental Protection estimates that at least 280 million Chinese are drinking unsafe water, while over 70% of surface water and 60% of underground water does not meet the national safety standard. Even worse, in 15% of the big river basins, the water is "Grade V"—unsafe for any use at all, and extremely difficult to purify. About 20% of Chinese farmland, an area the size of Belgium, is so badly polluted that it cannot be used to grow food. Overuse of fertilizers and pesticides and waste from inefficient and underdeveloped industry are causing the pollution. To protect water purity for the SNWTP Central Route, over 1,000 polluting industries, often former "pillar industries," have been shut down all along the way, causing economic hardship and unemployment. Restrictions have been placed on fishing and farming, and many hundreds of new sewage and waste treatment facilities and monitoring stations have been built. On Sept. 23, the SNWTP confirmed that water quality was safe in 80% of the places monitored. Yu Youjun (cited above) told *China Daily* that it took "10 years of pollution control" to achieve this goal, although the water is still only Grade II purity. Maintaining purity will be one of the most intensive efforts for the project, journalist Han Bin told CCTV.

'More Crop per Drop'

Besides the great clean-up, China is also seriously improving its agricultural water usage. A report by the

Overseas Development Institute of London, "Growing More with Less," issued in September, states that in China, "water withdrawals per hectare of irrigated land have declined by 20% since the early 1990s," and per-capita water withdrawals by 16%, even in water-scarce northern China, as agricultural productivity increased by 130%. Large-scale investment, much better regulation, and improved technology have all contributed, states the report.

On Sept. 29, Vice Minister of Water Resources Li Guoying announced that the amount of water being used to irrigate farmland had been reduced by over 15% per m^2. China has 63.5 million hectares of irrigated farmland, Li said, and advanced water-saving technologies, including spray and drip irrigation, are being used on over 14 million hectares. The target is to use these effective water-saving irrigation methods on over 60% of irrigated land by 2020. Groundwater depletion has been so severe in Hebei Province, that the government announced in September that it would reduce the irrigated wheat crop by more than 50,000 hectares, a 2% decrease. Use of drip technology developed in Israel played a key role in India's "Green Revolution," starting in the 1960s.

Chain of 'Desalination Cities'

New desalination methods are making the process increasingly energy-efficient, and therefore less costly. As a result, even small nations like Cyprus and Israel have shifted to using desalination to provide their primary source of domestic water. China is also looking to make desalination a primary source of water for its coastal region cities, including Beijing and Tianjin. China has the scientific and engineering capabilities to help develop potential new desalination technologies and methods, and is committed to doing so. As China expands its nuclear energy capacity over the coming 50 years, it will be possible to produce really large amounts of desalinated brackish or seawater. In addition, desalination technology is crucial for cleaning up badly polluted water.

In February 2012, China's State Council announced the desalinated water target for the 12th Five-Year Plan (2011-15), based on a program to build a chain of desalination facilities along China's northeastern coast, from the provinces of Shandong to Liaoning.

Although China had failed to meet the target set for the 11th Five Year Plan (2006-10), to produce 1 million m^3 desalinated water per day, the new target of 2.2-2.6 million m^3/day of online capacity by 2015 was larger than expected. The plan is to create 20 coastal "desalination cities," with some of their water supply coming from desalinated water, by 2015. China's coastal islands should get 50% of their water supply this way, and other water-poor regions should get 15%. Desalinated water should supply the needs of about 15 million people.

By 2010, China's actual capacity was estimated by the China Desalination Association to be just 640,000 m^3/day. That has risen since, to about 760,000 m^3/day. Although China, like many other nations, has been working on developing desalination capability since the mid-20th Century, serious investment only began after 2000. Given the complicated requirements, especially for sufficient energy, but also including problems with seawater quality, development has been relatively slow—in Chinese terms, anyway—although that is now changing.

China has some 50 desalination projects; most are used to produce water for industry, including thermal and nuclear power plants, steel plants, and industrial parks. According to the development plan, water desalination projects are the country's "choice for survival," *China Daily* commented. Desalination technologies of all types would also be essential inland, to treat industrial, urban, and agricultural waste water, and to purify brackish or polluted groundwater.

China, like almost every other nation, has taken the decision to expand its desalination capability decades late. The primary challenge is energy: both producing enough energy to power the projects, and the cost, which amounts to about 40-50% of the cost per m^3 of water processed. The only solution for carrying out desalination on the huge scale required in China is using nuclear energy.

As everywhere else, the world financial crisis has taken a toll on Chinese infrastructure investment. Prof. Wang Shichang, director of the Desalination and Membrane Technology Centre at Tianjin University, told *China Daily* that water desalination plants were among the Chinese infrastructure projects halted due to the world financial crisis.

Here are highlights from some of the "desalination cities"

• The port city of Tianjin is the key "desalination city" and home to the Dagang power and desalination plant, the oldest in China, which has been producing 3,000 m^3/d for cooling with a U.S.-designed multistage flash (MSF) unit for 15 years. The Tianjin Beijiang Power and Desalination Plant, specially designed and built by Israel's IDE Technologies, is one of the world's largest thermal plants using multi-effect distillation (MED) technology, and the largest desalination plant in China. It began operating in 2010, and produces 200,000 m^3/day, about one third of China's current desalinated water.

• Other coastal cities, including Dalian and Qingdao, are also becoming desalination cities, and Beijing, 200 km inland, announced in May 2011 that desalination would become part of its water-resource strategy. The Beijing Enterprises Water Group is building a second phase of the 50,000 m^3/day desalination plant in Tangshan, Hebei Province. The project will include a 270-kilometer pipeline to take the water from the Bohai Bay coast inland to Beijing.

• In March 2013, the National Development and Reform Commission announced that it would create more desalination centers, including for the cities of Shenzhen and Zhoushan, Luxixiang Island in Zhejiang Province, Binhai New Area in Tianjin, Bohai New Area in Hebei, and a number of industrial parks.

China also plans industrial-scale desalination of sea ice, which is much less saline than seawater, Xinhua reported Jan. 14. A research team from Beijing Normal University signed a sea ice desalination technology transfer agreement with Beijing Huahaideyuan Technology Co. Ltd. The plan is to produce at least 1 billion m^3 of freshwater a year by 2023, which would be approximately enough to meet the current needs of Beijing.

Nuclear Desalination

For China, only nuclear power would provide enough safe, clean, and efficient energy to desalinate water on the scale required. China opened its first nuclear desalination unit last year, as part of the Hongyanhe Nuclear Power Plant, consisting of four Chinese-designed 1,000 MW pressurized water reactors. The plant is 100 km from Dalian, in Liaoning Province. This state-of-the-art nuclear power plant, the first in the northeast, uses German-designed ultrafiltration technology, as well as reverse osmosis for seawater desalination. The Stage I part of the nuclear plant, the part completed, has a maximum capacity of 16,000m^3/d. Construction on the second phase of the project is expected to be completed by the end of 2016.

China has additional nuclear desalination projects. The technology has been under development at the Institute of Nuclear and New Energy Technology of Tsinghua University, west of Beijing, for years. INET's projects include construction of the High Temperature Reactor, a safe and versatile nuclear reactor design, first developed in Germany, but ultimately abandoned there.

In 2008, the Chinese government commissioned INET to produce a feasibility study for a demonstration nuclear seawater desalination plant using the safe 200-MW low-temperature nuclear heating reactor (NHR-200) coupled with MED technology, for Shandong Province.

INET was also commissioned to study construction of a nuclear desalination plant using two dedicated nuclear heating reactors (NHRs). The NHR-200, which was manufactured in China, would use distillation; the NHR-200 does not provide enough power for reverse osmosis, so MED technology was selected. "The nuclear seawater desalination technology coupling NHR-200 with the MED process has shown its huge advantages both in producing freshwater with a competitive cost and in decreasing environmental pollution," INET concluded.

Chinese scientists have also been working on much larger-scale projects. In January 2001, *Beijing Review* reported on a project under discussion at the China Society of Nuclear Science and the Beijing Institute of Nuclear Engineering, to develop the capacity to desalinate as much as 1 billion tons of seawater per year (one ton of water = 1 m^3). On this scale, nuclear power would be the most economical and cleanest source of heat to power the process.

On such a scale, even using more energy-consuming distillation technology, the head of the project, Prof. Li Zhaozong, estimated that the cost of desalinated seawater could be cut to about 1 yuan per ton, a quarter or less of current costs. "Such a large desalination plant needs an investment of several billion yuan, which is reasonable for building infrastructure, " Li notes. "It is also the most economical method among other ones in this regard."

In contrast, water transferred in the South-North Water Transfer Project will cost about 20 yuan (~$3.27) per ton. The future project would use a low-temperature heating reactor, such as those under development at the international fusion power development program, ITER.