Nuclear NAWAPA XXI, Desalination, and The New Economy

by Michael Kirsch

This is the third in our series of articles from the 21st Century Science & Technology Special Report, "Nuclear NAWAPA XXI: Gateway to the Fusion Economy" (http://21stcenturysciencetech.com/Nuclear_NAWAPA.html).

An economy is an integrated process, whose character is to constantly evolve as such. Today, that evolution must be spearheaded by a 21st-Century North American Water and Power Alliance (NAWAPA XXI), driven by fission, with a fusion economy on the horizon.

The completed NAWAPA XXI will be more than delivery corridors of freshwater: It will be the bounding infrastructure network of a more advanced economy and society, and a scientific resource management of a new kind. With the widespread application of fission for electricity, heat, and desalination, combined with a system of continental water resource management, the several crises in water, food, energy, transportation, jobs, etc., all merely symptoms of the failure to implement these measures decades ago, will be solved.

For this, a complete dedication of human and productive resources currently existing in the United States, Canada, and Mexico, will be required. Their economies will be put into high gear, requiring assistance from China, South Korea, and Japan for the mass-production of the latest nuclear power plants and machine tools. A rapid training program to produce the necessary skilled labor will be initiated. These include workers in the construction crafts, machine-tool operators, engineers, and scientists of all kinds.

Even before construction of a full NAWAPA XXI system begins, coastal desalination, desalination of irrigation wastewater, groundwater, and Southwest river water, through the mass production of fission reactors, will raise the level of productivity of our lands and cities and halt the collapse. Food production will be maintained, coastal cities will be sustained, and large areas of agricultural land will increase yields in the short term, supporting the growth process.

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Plasma Thermal Spraying: a plasma torch shoots a jet of plasma (on the order of 10,000°C) into which materials are introduced, melted, and sprayed onto a substrate.

Drawing upon the built-up skilled labor and industrial capacity associated with this process, construction on the core trunk line of NAWAPA XXI will begin. The higher quality of concentration, skill, and foresight of engineers and the labor force will shorten the timetable. Scientists will have been using these new nuclear plants as locations for research and application of the most advanced technologies available, including those associated with fusion, plasma processing, and power. Commercialized fourth-generation nuclear reactors and nuplexes will be introduced into the early phases of NAWAPA XXI construction and planning.

New mining technologies will be developed, and new types of minerals will be processed and available to industry. Cutting-edge technologies will be applied throughout the machine-tool sector and the manufacturing and transportation processes. New careers in sciences of all kinds will be needed for exploring, designing, constructing, manufacturing, and managing of an integrated water and power system, and establishing infrastructure and cities at higher levels of technology than ever before.

In short, an economy unrecognizable from today's vantage point will emerge, making possible the most productive relationship between mankind and the biosphere yet achieved.

This process of development is described in what follows, beginning with the wide application of Kennedy-era nuclear desalination plans.

Phase 1:
NAWAPA XXI Treaty and Application of Nuclear Desalination

The Model for Nuclear Desalination

The most advanced research for large-scale desalination was launched under President John F. Kennedy, but was never implemented. To this day, these designs are the most ambitious, rational, and scientific, and are therefore the model for today.

In January 1963, Kennedy formed a task group within the Executive Office of Science and Technology to investigate the use of large nuclear reactors for desalination. The desalination process is very energy-intensive, which is why nuclear desalination is the most efficient. Working closely with the Atomic Energy Commission (AEC) and the Department of Interior, the task group issued its report in March 1964, five months after the President's assassination. Its report estimated that if an appropriate research and development program were actively pursued, large-scale, dual-purpose installations could produce 1,000 to 1,900 megawatts of electricity and 500 to 800 million gallons of water per day (0.6-0.9 million acre feet per year, MAFY). The report also suggested a program to develop and demonstrate a plant operating with an 8,300-megawatt (thermal) reactor,[1] producing approximately 1,400 MWt of electricity and 600 million gallons of water per day (0.7 MAFY).[2]

This 8,300 MWt[3] reactor was the 1975 goal. The 1970 goal was set for plants of intermediate size.

The task group proposed producing half a dozen intermediate-sized units, two in southern California, one in the greater New York area, several for the Gulf Coast, and one in Florida.

The Metropolitan Water District (MWD) of southern California was the first site for such nuclear desalination, and entered into a contract with the Department of the Interior and the AEC in 1964 for a detailed economic and engineering study of dual-purpose nuclear desalination plants, with 50 to 150 million gallons per day (mgd) production capacity, to be in operation by 1970. James Ramsey of the AEC remarked, "Such a project could convert more water from the sea than all the other seawater conversion units currently operating in the world." The 150 mgd plant was to produce enough water for a city of about 750,000, with a power output of 1.8 GW, exceeding that of the Hoover Dam, or enough for a city of about 2 million. Two large conventional light-water nuclear reactors, of about 3,000 MWt each, were to be the energy source, and the water plant was to consist of three large, multi-stage flash distillation sections, each producing 50 million gallons of water per day. The plant would have been 30 times larger than the largest existing water-desalination plant at that time.

Other plans were underway for Texas, Arizona, New York, and Florida. For example, in July 1964, Glenn Seaborg, chairman of the AEC, proposed a dual-purpose plant for Key West, Fla., of intermediate size, up to 1.5 GWt, producing 150 mgd.

In a 1966 AEC report, an even larger reactor was illustrated in a drawing, showing a nuclear-powered seawater-conversion plant that would produce 1 billion gallons of freshwater per day and 4.5 GW of power. The report suggested that "by the 1980s, plants embodying several nuclear reactors in a single installation, with a total capacity as high as 25,000 thermal megawatts, could be in operation. A plant like this would produce 5,950 electrical megawatts at 1.6 mills per kilowatt-hour and 1,300 mgd at 19¢ per thousand gallons."[4]

Eisenhower's Atoms for Peace program, as continued by Kennedy, created a dynamic of creativity throughout government institutions, where what was practical and possible was of a qualitatively different nature than today.

By cutting out nuclear, water shortages were guaranteed. Since the 1960s, there has not been a water shortage, but rather a nuclear shortage.

Today, in the short term, the "intermediate-sized" 150 mgd desalination plants of the Kennedy era should immediately be built. Coastal desalination for industrial and municipal use will provide for cities, offset demands on limited water for agriculture, and solve the problem of saltwater intrusion. Agricultural wastewater desalination combined with groundwater desalination will increase crop yields, and reclaim land abandoned due to high salinity and lack of water. Saline river water, a major problem in nearly every western river in the United States, can be treated. Water quality in thousands of inland cities can be improved. As the larger desalination plants become available, in addition to increasing the amount of all of the above, sufficient quantities of water could be made available for new agriculture.

Coastal Water

In places like the southern California coastal area, desalination plants could meet all or part of its demand from the Colorado River, thereby freeing the river water to meet municipal and industrial deficiencies of inland areas in the region. The added coastal water would be an indirect addition to the normal river flow, since through appropriate agreements, less would be drawn from the river for southern California than at present. In addition, the present, disastrous agricultural situation, in which large areas of California agriculture are shutting down due to water demands by municipal areas, could be relieved.

Other coastal areas require desalination plants, such as the industrialized section of the Texas Gulf Coast. The area from Houston to Corpus Christi has long ex-

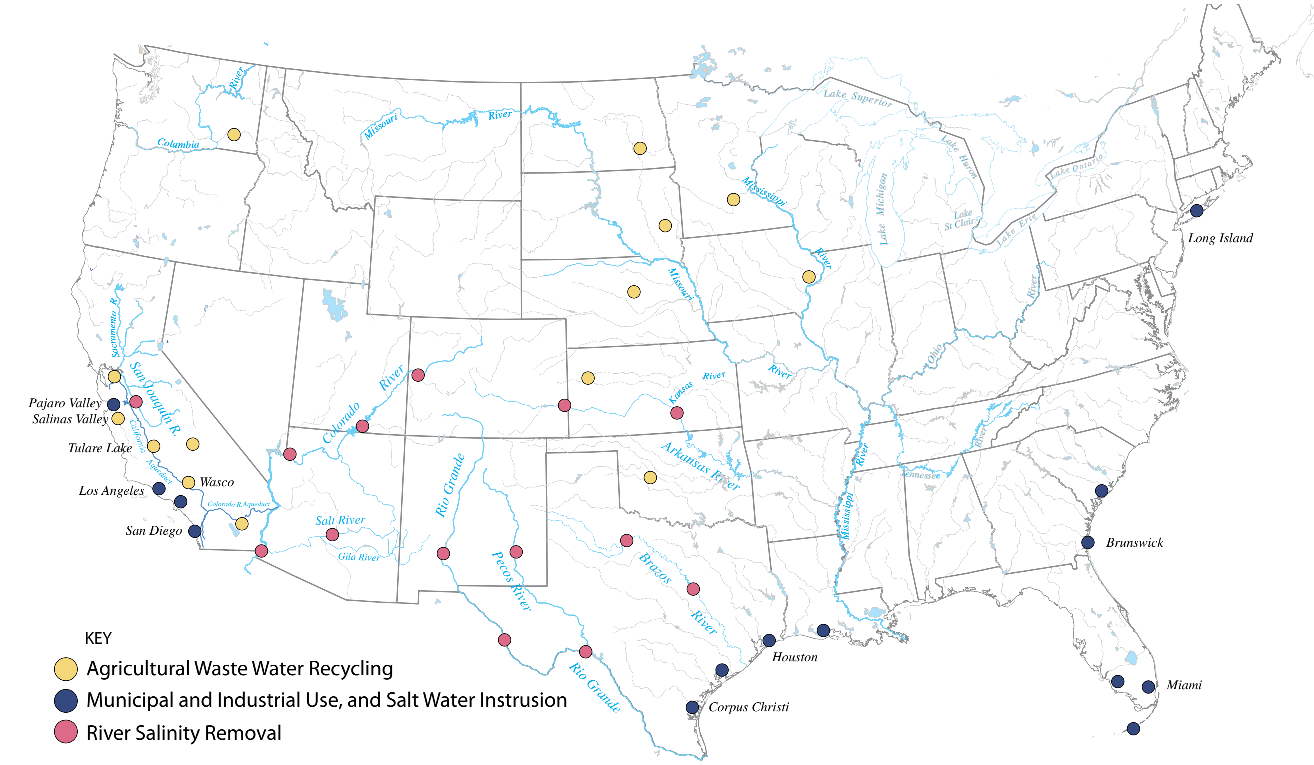
1. MWt denotes thermal power produced by a reactor, which is compared with MWe, which is the electrical power it produces.

2. The AEC contract was with E.I. Du Pont de Nemours and Co.: Contract AT (07-2)-1. Scope: To evaluate the feasibility of building and define the major engineering problems in the design and construction of heavy water moderated power reactors of 3,500 MWt and 8,300 MWt.

3. For scale, a 1,500 MWt desalination plant, producing 150 mgd, would provide twice the current water use of the city of San Francisco. Four of these plants, or one plant of 8,300 MWt, would provide the current water use of Los Angeles.

4. Grace Urrows, "Nuclear Energy for Desalting," AEC: 1966. Part of the Understanding the Atoms Series.

FIGURE 1
Proposed Locations for 42 Nuclear Desalination Plants



perienced critical shortages.

Saltwater intrusion is also a problem requiring the wide use of desalination plants. In coastal areas throughout the United States, pumping of fresh groundwater supplies frequently causes saltwater intrusion when the freshwater is pumped to the surface before it can be naturally recharged. When seawater fills the void, the usual result is groundwater that is too brackish for most uses. Already in 1979, this problem was a subject of Congressional study.

One such coastal desalination plant is finally under construction. In 2016, the Carlsbad desalination project in San Diego County, Calif., is expected to be completed. This plant, driven by natural gas, will produce 50 mgd (0.056 MAFY) of desalinated seawater and provide 10% of the total drinking water needed by San Diego, sufficient for about 300,000 people. While this plant will be the largest desalination plant in the Western Hemisphere, and the first large-scale desalination plant on the West Coast, its production is only one-third the capacity of the 150 mgd plants planned by the Kennedy Administration for operation in 1970.

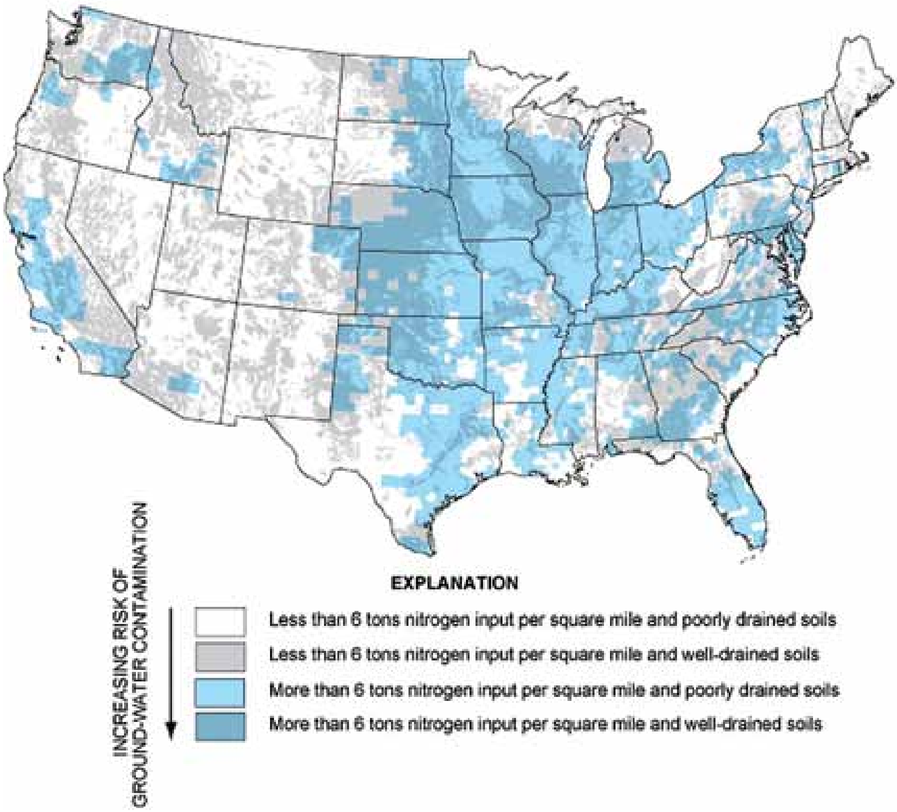
Nuclear desalination plants should be built to offset groundwater usage causing saltwater intrusion, as well as to create large supplies for municipal and industrial use. Areas reporting high impact of intrusion and where supplying municipal demand could augment normal river supplies are: San Diego and Los Angeles, Calif.; Houston and Corpus Christi, Tex,; Louisiana; Key West and southern Florida; Georgia; and South Carolina.

Agricultural Wastewater

Agricultural wastewater is a resource currently being wasted, whereas it could be desalinated and reused. This is particularly necessary in California's Central Valley, which grows 30-40% of the nation's produce.

In the California water system, and other irrigation canals in the Southwest, the increasing salinity of the water through reuse and evaporation causes less agricultural yield further along the canals and aqueducts. This water should be recycled through nuclear desalination plants built along the aqueducts, with the irrigation wastewater serving as coolant. After desalination, the agricultural wastewater could then be put back into the canal. As an example, irrigation wastewater in parts of the western San Joaquin Valley has risen to the point

FIGURE 2
Risk of Groundwater Contamination



United States Geological Survey, January 2013

that it has poisoned the crops in a part of the Westlands Water District, so that there are now nearly a half million acres of unusable land. In addition, a large accumulation of selenium, boron, and salts from the natural drainage in the Kesterson National Wildlife Refuge to the north of Los Banos on the east side of the San Luis Reservoir has poisoned the ability to grow crops.

A series of nuclear power plants could be built along the California Aqueduct to produce both freshwater and electricity for farms and cities. The new system of desalination plants would begin with one at the southern end of the San Francisco Delta, where salts accumulate in the Delta sloughs. Salts would be removed before the water is pumped into the aqueducts. More reactors would then be built along the west side of the San Joaquin Valley, in parallel to the aqueduct of freshwater flowing to the south through the so-called San Luis Drainway, in order to remove the partly saline irrigation wastewater so that it would not accumulate in the soils. Contaminated irrigation wastewater and groundwater would be pumped from the aquifers and passed through treatment systems for boron and selenium removal, and desalinated to remove and recover the salts. Desalinated water could then be returned to the California Aqueduct canals.

Nuclear reactors built in the San Joaquin Valley could use an annual supply of over 750,000 acre feet per year of irrigation wastewater for cooling, plus the large volumes of brackish water now sitting under the Westlands Water District and elsewhere in the San Joaquin Valley. The earlier proposal for a five-unit plant of 5 GW at Wasco, Calif., in the southwestern part of the San Joaquin Valley, is one such candidate.

River Water

All western rivers have salinity problems, with the chief factors being an arid climate, natural saline springs, erosion of geological formations, and runoff, and the secondary factors being the return flows from agricultural use and reservoir evaporation.[5]

Increasing salinity in the Colorado River, as well as the Rio Grande, Pecos, San Joaquin, Brazos, and Arkansas rivers could immediately be relieved by building dual-purpose nuclear desalination plants along the most saline regions of the river. Proposed locations on the map (**Figure 1**) are based on reported salinity levels. The Yuma, Ariz., desalination plant (YDP), belatedly completed in 1992, could be expanded as required.

Agricultural and Industrial Land

While numerous areas of agricultural land are unusable due to the dropping of aquifers, vast areas of shallow groundwater, though annually replenished with rainwater, are saline or contain other contaminants, and are thus unusable now, simply due to lack of desalination.

Lawrence Livermore National Laboratory discussed an example of this problem for California in 2004, stating that "many wells closed by nitrate contamination could be reopened if a cost-effective treat-

5. http://www.usbr.gov/uc/progact/salinity/ pdfs/PR23final.pdf

Mineral Content per Cubic Mile of Seawater

Mineral	Weight, in tons
Sodium Chloride	120,000,000
Magnesium Chloride	18,000,000
Magnesium Sulfate	8,000,000
Calcium Sulfate	6,000,000
Potassium Sulfate	4,000,000
Calcium Carbonate	550,000
Magnesium Bromide	350,000
Bromine	300,000
Strontium	60,000
Boron	21,000
Fluorine	6,400
Barium	900
Iodine	100 to 1200
Arsenic	50 to 350
Rubidium	200
Silver	up to 45
Copper, Manganese, Zinc, Lead	10 to 30
Gold	up to 25
Radium	About 1/6 (ounce)
Uranium	7

Source: "Saline Water Demineralization and Nuclear Energy in the California Water Plan," Bulletin No. 93, State of California Department of Water Resources, Dec. 1960.

ment were found."[6] Similar areas of nitrate contamination exist around the country, concentrated in agricultural areas, especially near the High Plains, and restoring such groundwater could salvage a large area of agricultural land in the short term. Tulare Lake Basin and Salinas Valley in California, and Suffolk County (Long Island) in N.Y., are all regions highly in need of nitrate removal through nuclear purification plants. Northern Nebraska, southern Minnesota, eastern North Dakota, western Kansas, western Oklahoma, and eastern Iowa are also areas of high nitrogen input and high aquifer vulnerability. (See **Figure 2**.)

In addition to agriculture, numerous inland cities, far from the coast, could immediately be maintained through use of dual-purpose nuclear powered desalination plants. In urban areas, populations add large amounts of wastes, including salts, to surface and ground waters, making downstream waters less and less potable. Thousands of communities throughout the United States, now depending on brackish water, could use nuclear desalination to meet current demands, before greatly augmenting their supply as the larger continental runoff system comes online.

Large-Scale Agricultural Supply

While the above applications of nuclear desalination would mostly indirectly supply agricultural use by offsetting demand and restoring groundwater supplies, larger desalination plants, such as the proposed 8,300 MWt reactors capable of producing 800 mgd, could produce water directly for agriculture during the construction phase of the larger system.[7] For example, the San Joaquin and Imperial valleys, which are in terrible drought, could be supplied by coastal desalination, pumped to the California Aqueduct System, which could then be brought directly into the California Water System.

Harvesting Resources from Seawater

A 1966 AEC report on nuclear desalination discussed plans for harvesting resources from seawater, giving as their chief example the chemical removal of scale accumulation in pipes and vessels of desalination plants,[8] which would not only increase the efficiency of seawater distillation, but would also convert the separated scale-forming material to high-grade fertilizer. Scientists working with the Office of Saline Water in North Carolina in the 1960s, estimated that about 37 tons of fertilizer could be produced for each million gallons of seawater processed.

Additional mineral by-product development and utilization plans have been developed, such as creating magnesium ammonia phosphate from seawater, which can be used as fertilizer for many plants including tree seedlings, grasses, and vegetables. By fully exploiting nuclear heat for desalination, trillions of gallons of sea-

6. Arnie Heller, Lawrence Livermore National Laboratory, *S & TR Magazine*, 2004, https://www.llnl.gov/str/JulAug04/Newmark.html.

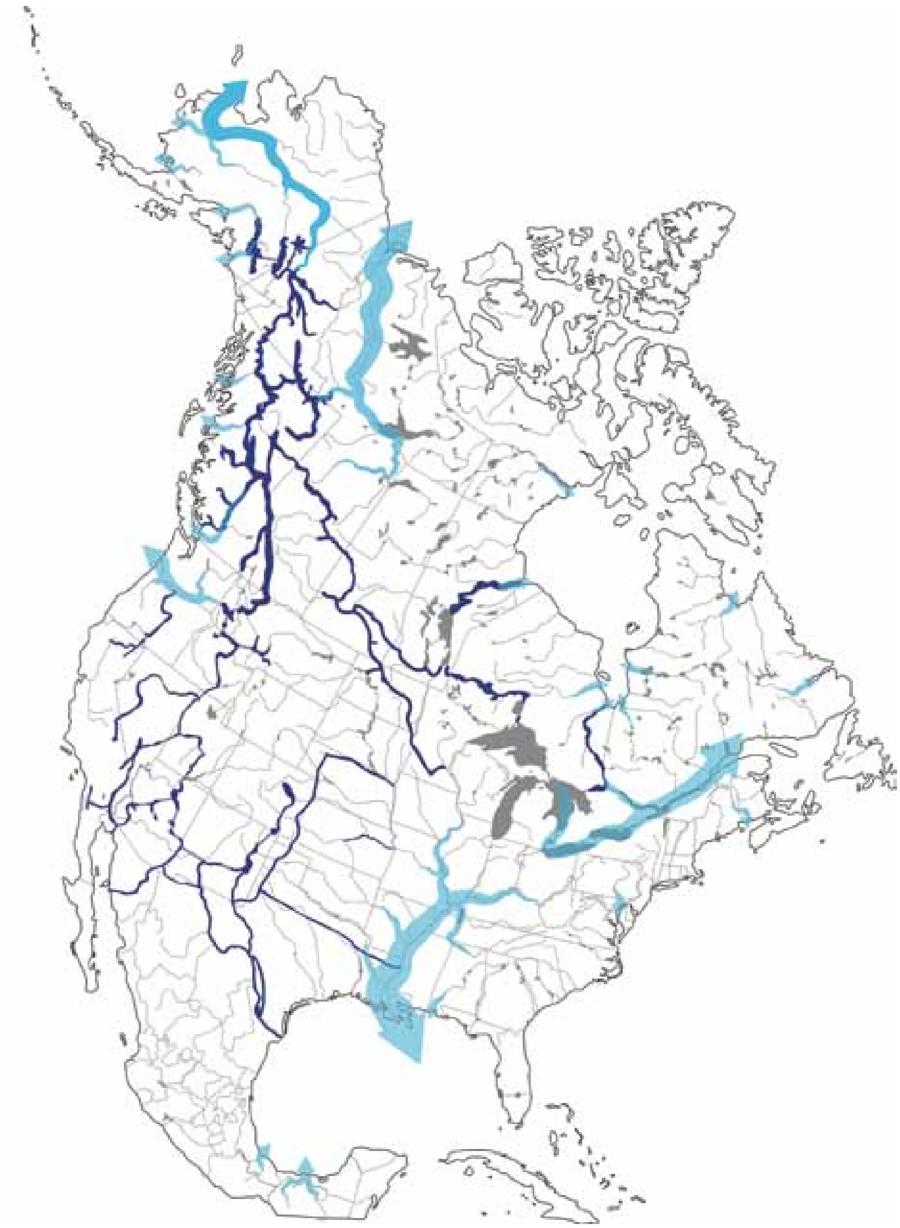
7. As an example of needed capacity for agriculture, California applies 34 million acre feet of year to produce 9.6 million acres of crops.

8. Scale is composed primarily of calcium carbonate, magnesium hydroxide, and calcium sulphate present in seawater. It gradually forms deposits on heated surfaces, clogs the equipment, and must be periodically removed.

water a year will be processed, and it will become efficient to concentrate minerals from the water, in addition to making use of the salt itself. Instead of waste, the byproducts of desalination will become valuable resources.

In the next section, we investigate in detail the NAWAPA XXI distribution system itself, and then the requirements of Phases 1 and 2 for mass producing nuclear power plants and other materials.

FIGURE 3
Continental NAWAPA XXI Runoff Collection and Distribution System



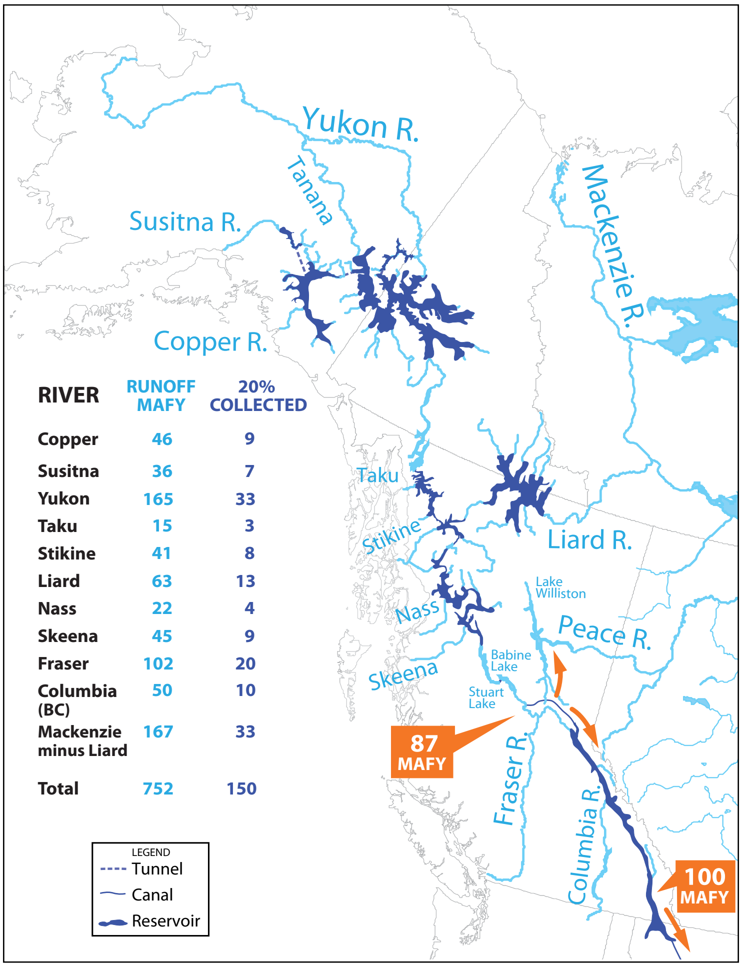
Phase 2:
The Runoff Distribution System

While the above measures are taken, the three nations of the North American continent will simultaneously be gearing up for the larger continental system, designed to yield the greatest results in the process of its construction. Once the design phase is completed and construction begins, it is feasible, with an accelerated timetable and the application of new technologies, that pieces of the system could begin coming online years after it begins, and the main trunk line completed in 10 to 15 years. What follows is the description of the completed system and the amounts of water to be distributed.

The western part of the North American continent has a wide discrepancy of rainfall distribution due to the particularities of the Pacific Ocean weather system. The area stretching from Alaska and Yukon down to Washington State has 40 times the annual river runoff of the southwest United States and northern Mexico. Through utilization of continental topographical characteristics, a 2,000-mile reservoir system can collect and distribute runoff in the most efficient manner possible.

As a first approximation for the design, it is proposed that 20% of the runoff of each northern river to be incorporated into the system be collected for distribution. By utilizing nuclear power for the required pumping systems, described below, all of the water collected will be available for delivery, rather than being used to generate hydropower to drive the pumping systems, as the original design required.

FIGURE 4
Northern Collection System



RIVER	RUNOFF MAFY	20% COLLECTED
Copper	46	9
Susitna	36	7
Yukon	165	33
Taku	15	3
Stikine	41	8
Liard	63	13
Nass	22	4
Skeena	45	9
Fraser	102	20
Columbia (BC)	50	10
Mackenzie minus Liard	167	33
Total	752	150

The runoff of the rivers shown here in Alaska, Yukon, the Northwest Territories, and British Columbia is a portion of the total annual runoff flowing into the Arctic and Pacific oceans. Adding the runoff of several Alaskan rivers, including the Nushagak, Kenai, Alsek, and Kusokwim, along with other coastal runoff of British Columbia, brings the total from 752 MAFY to approximately 1,300 MAFY of runoff for the region.

The collections from the Susitna, Copper, Yukon, and Taku rivers are pumped from 2,100 to 2,400 feet into the Stikine Reservoir, which receives collection from the Liard Reservoir, before joining with the Nass and Skeena reservoirs, themselves flowing into Babine and Stuart lakes at 2,330 feet elevation (see **Figure 4**). If 20% of each river's annual mean runoff is collected, approximately 87 MAFY on average would flow out of Stuart Lake into a man-made canal.

Of the 87 MAFY flowing out of Stuart Lake, some 70 MAFY will be pumped into the Rocky Mountain Trench Reservoir, while around 17 MAFY will be diverted into Lake Williston for the Prairie Canal, where it will join the 33 MAFY collected from the Mackenzie basin streams (see box, "Great Plains Canal"). In the Rocky Mountain Trench, 20 MAFY will be added from the upper reaches of the Fraser River, and 10 MAFY will be added from the upper Columbia. The 100 MAFY flowing out of the Rocky Mountain Trench will be pumped through the Sawtooth Lift and diverted multiple ways throughout the Southwest and northern Mexico (see boxes on the following pages).

Once the completed NAWAPA XXI system is built, water will be able to be delivered to every major river system and region of the continent, west and north of the Mississippi. All of the plans will form an interconnected grid across the continent, which will be managed as a single system.

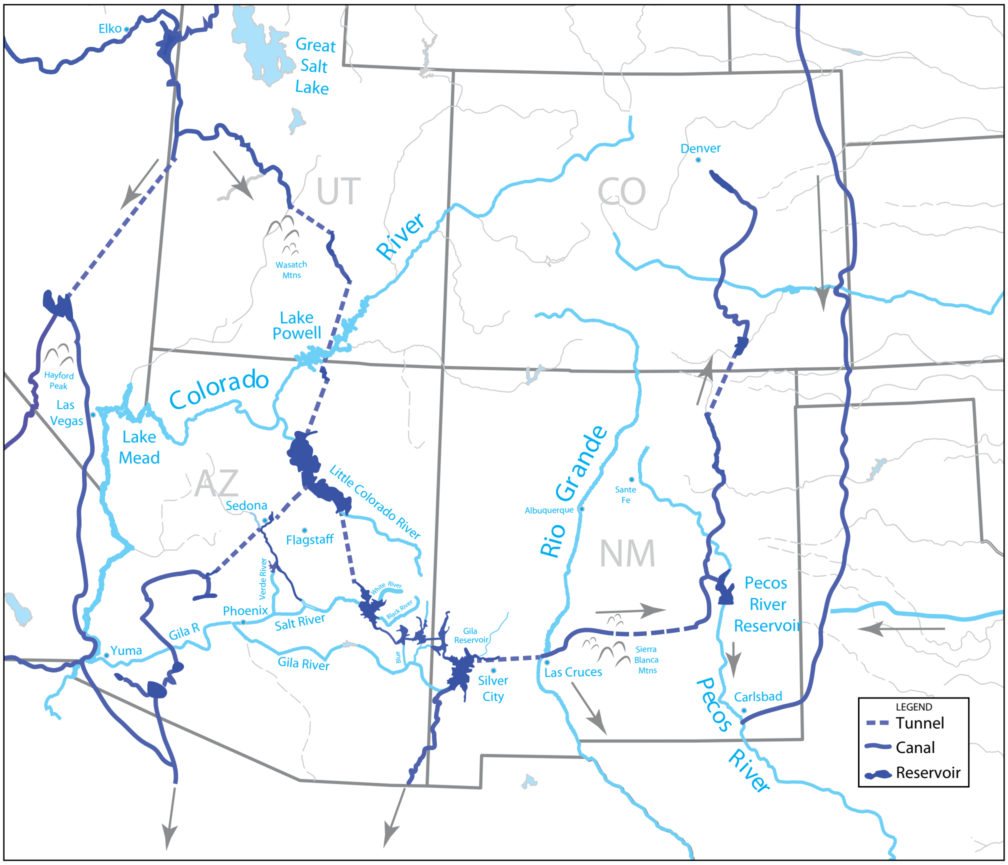
Nuclear desalination facilities along the completed NAWAPA XXI irrigation systems will augment the effect of the canals by recycling water more quickly, as well as increasing the total amount of water available.

Phase 3 begins when NAWAPA XXI comes into operation, where the completed system will allow for wide-scale biospheric engineering and directed water recycling, creating a broader hydrological effect than the direct water contributions from the distribution system itself.

Scientific institutions that study the effect of moisture in arid regions toward effecting changes in local climate and weather patterns, will collaborate in planning specific types of land cover for specific regions, and using other techniques of weather modification. Reservoirs will also be maintained to maximize aquaculture.

Potential MAFY Distribution

Oregon	5	N. Mexico	22
Utah	4	Alberta	4.5
Nevada	8	Saskatchewan	7.5
California	22	Manitoba	7.5
Arizona	14	High Plains	20
New Mexico	11	Great Lakes	20
Texas	14	Total	160



Colorado-Rio Grande Distribution System

NAWAPA XXI will tunnel into the Great Basin and the Colorado Basin, creating reservoirs on the tributaries of the Colorado River, which will feed water into its main stem.

A large distribution reservoir, up to four times the size of the Hoover Dam's Lake Mead, will be formed in the Little Colorado River Valley. Out of this central reservoir, tunnels and canals will form three reservoirs on the tributaries of the Salt River, three reservoirs on the tributaries of the Gila River, and a large reservoir on the headwaters of the Gila River itself. A tunnel will connect a reservoir formed on the Gila River to the Rio Grande Basin, crossing and supplying water to the Rio Grande River, and forming a large reservoir on the Pecos River, which will supply West Texas, and Mexico, and connect to eastern Colorado.

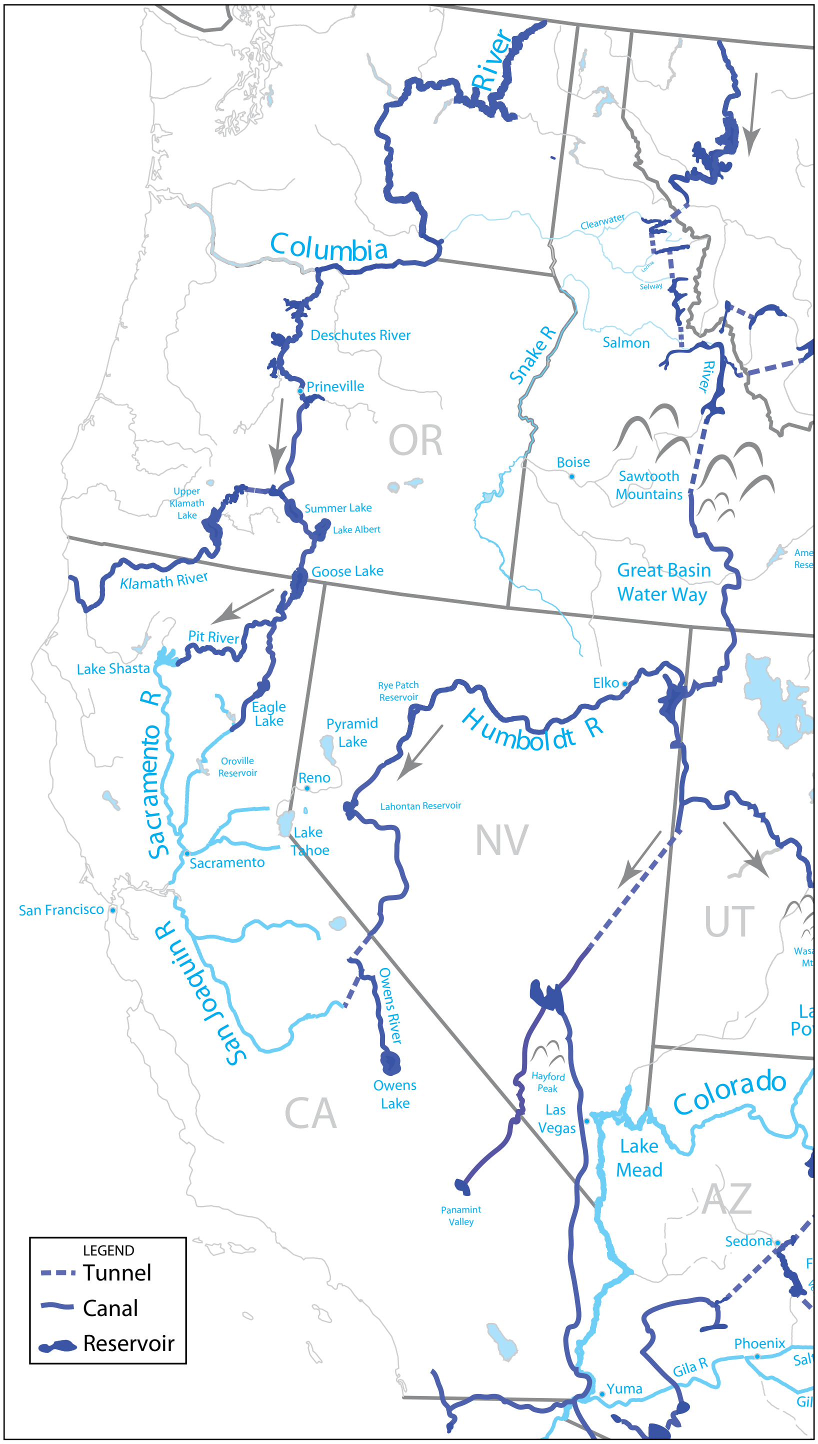
Throughout the Colorado and Rio Grande basins, groundwater pumping costs will be eliminated and farmland restored, and with the water added to Utah, Arizona, New Mexico, and West Texas alone, 14 million acres of farmland could be opened up. The average 11 MAFY currently flowing through the Colorado River will be increased over 100% through these added reservoirs; the Pecos and Rio Grande rivers will become full and flow year-round.

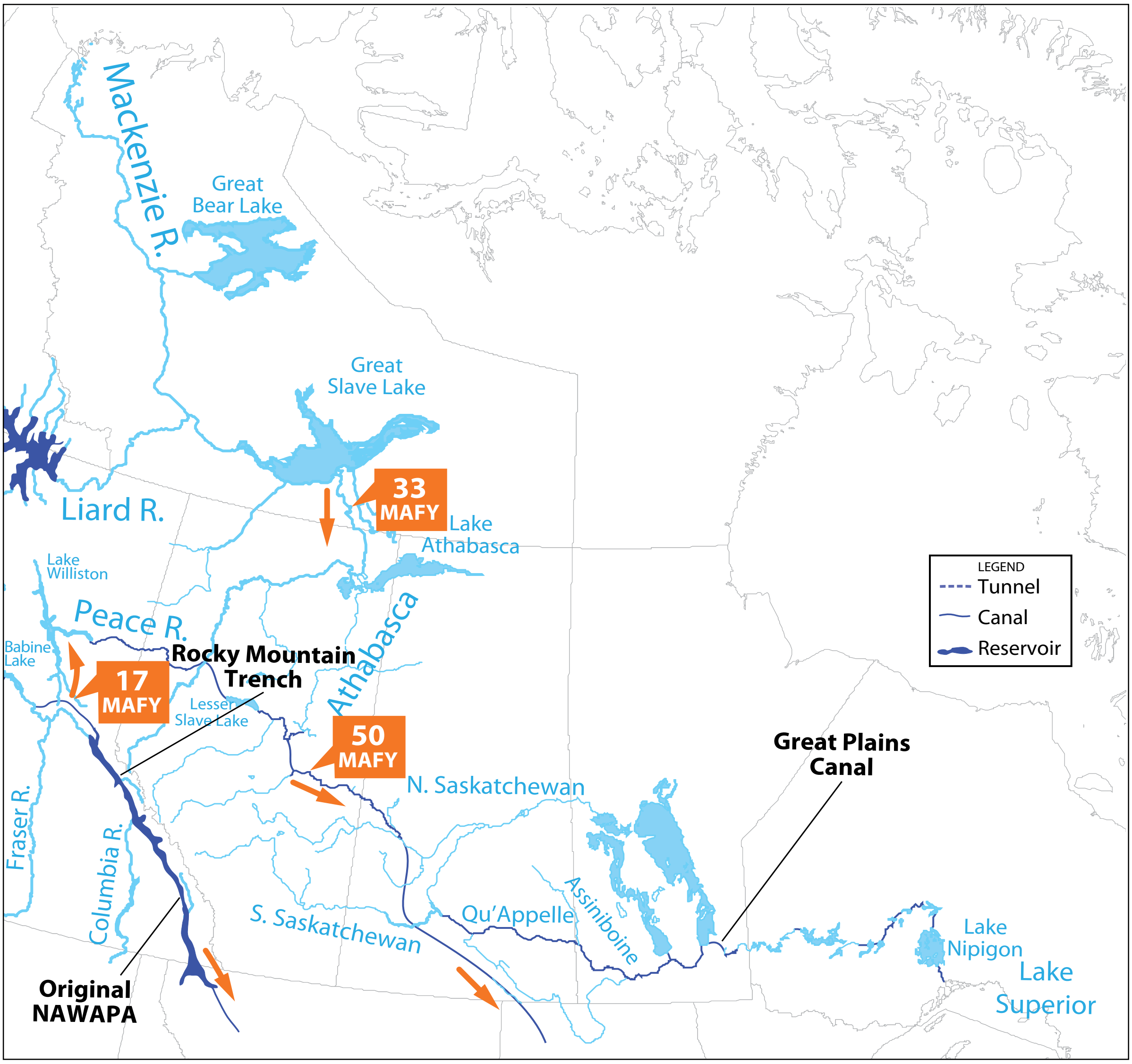
Approximately 30 new reservoirs will be formed in New Mexico, Arizona, Nevada, Utah, and Colorado, changing local climates and expanding recreation. The storage capacity of the Rio Grande Basin will be more than doubled, from 20 MAF to 54 MAF. The Colorado Basin storage will be increased from 61 MAF, largely from Lake Mead and Lake Powell, to 230 MAF. A 7-MAF reservoir will also be formed 50 miles north of Las Vegas, just north of Hayford Peak in the Sheep Mountain range, distributing water to southern Nevada and paralleling the Colorado River, supplying water to farms before continuing south to Mexico and the Imperial Valley.

California Distribution System

Fifty miles east of Elko, Nev., a 7-MAF storage reservoir will be created between Murdoch and Bald Eagle mountains. A 30-mile canal will connect to the Humboldt River, diverting water across the state, ending at the Humboldt Sink, and from there the flow can be linked to Lake Lahontan, of the Truckee Carson Irrigation District, serving northern Nevada, before continuing south and tunneling into the Owens River Valley, refilling Owens Lake over time, and reviving farmland. Upon entering Owens Valley, an additional tunnel can connect the flow to the San Joaquin distribution system, delivering water to most of the San Joaquin Valley.

An alternative plan, requiring more power and complexity, could deliver water directly to southern Oregon, the parched Klamath River, and Lake Shasta. By releasing a portion of the water collected in the Rocky Mountain Trench into the Columbia River reservoir formed by Mica Dam, in British Columbia, water would be pumped out of the Columbia River further south at the Dalles Dam, into a series of reservoirs on the Deschutes River, continuing through central Oregon, and connecting with the Klamath and Pit rivers, the latter supplying water to Lake Shasta, one of the key storage reservoirs of the Central Valley Project.





Great Plains Canal

The 17 MAFY diverted from the northern flow into the Peace River will be joined with 33 MAFY collected from the Peace, Athabasca, and other tributaries of the Mackenzie River Basin or the Mackenzie itself, whose total annual runoff is 230 MAFY. This 50 MAFY will be delivered to the Prairie provinces, the Missouri River, the Mississippi, and the Great Lakes.

Canals will connect the Peace River to Lesser Slave Lake, to the Athabasca, Saskatchewan, and Qu'Appelle rivers. Sufficient water supplies of 20 MAFY will be drawn from the canal for the needs of Alberta, Saskatchewan, and Manitoba; the canal will also be capable of diverting flood waters in the region to areas of drought. A canal branching off the Qu'Appelle River will connect with the Missouri River's Lake Sakakawea, as well as the Mississippi River. The main canal will continue to Lake Winnipeg and Lake Superior, delivering up to 20 MAFY. Additional plans, such as one proposing diversion of 20 MAFY of runoff from Quebec into the Great Lakes, could be incorporated into the final design.

Great Plains Distribution System

Water in the Gret Plains Canal (shown on previous page) will link up with the Missouri River at Lake Sakakawea, as well as run along the Laurentian Continental Divide through the Dakotas, before connecting with the Mississippi River.

Approximately 10 MAFY will be delivered to Lake Sakakawea by way of the Prairie Canal. In addition, 10 MAFY of Missouri River floodwater could be added to an amount to be diverted just downstream of the Fort Randall Dam, on the Nebraska and South Dakota border, and pumped up to a series of reservoirs on the Niobrara River. From there, water would run through a canal engineered to intersect key locations dependent on the Ogallala Aquifer for irrigation.

Missouri River floodwater would be back-pumped from the north side of Kansas City, Kan., along the Kansas River, before being piped to Hutchinson, Kan., where a purification plant could be built to discharge water into the Ogallala Aquifer. Water could also be added to the Arkansas River, along with any other programmed flow of water into the river from other elements of the system.

If excess water were available in years of Mississippi drought, water could be delivered via the Minnesota River into the main stem of the Mississippi. In years of flooding, Mississippi River water could be diverted according to specific elements of the Texas Water plan, intersecting other systems.

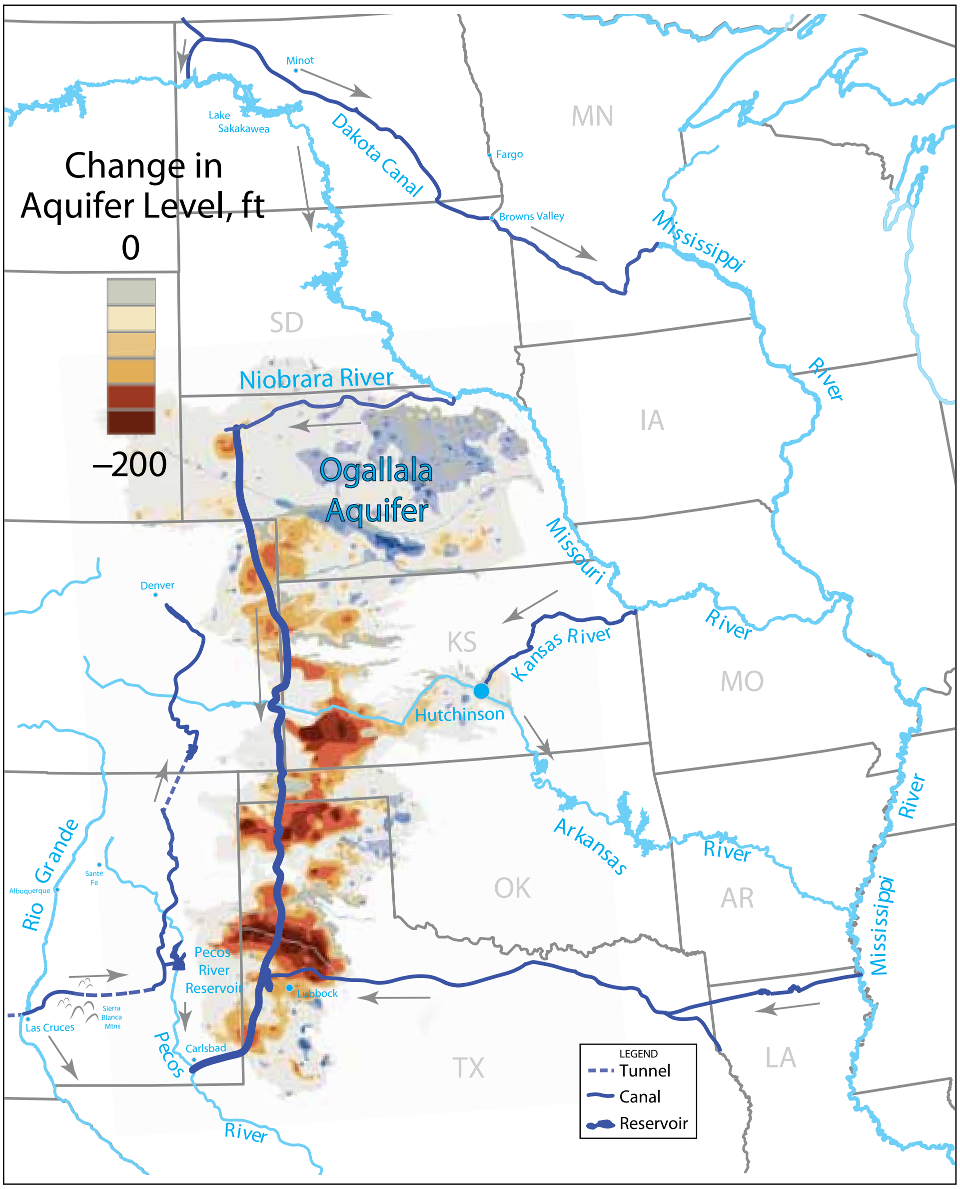
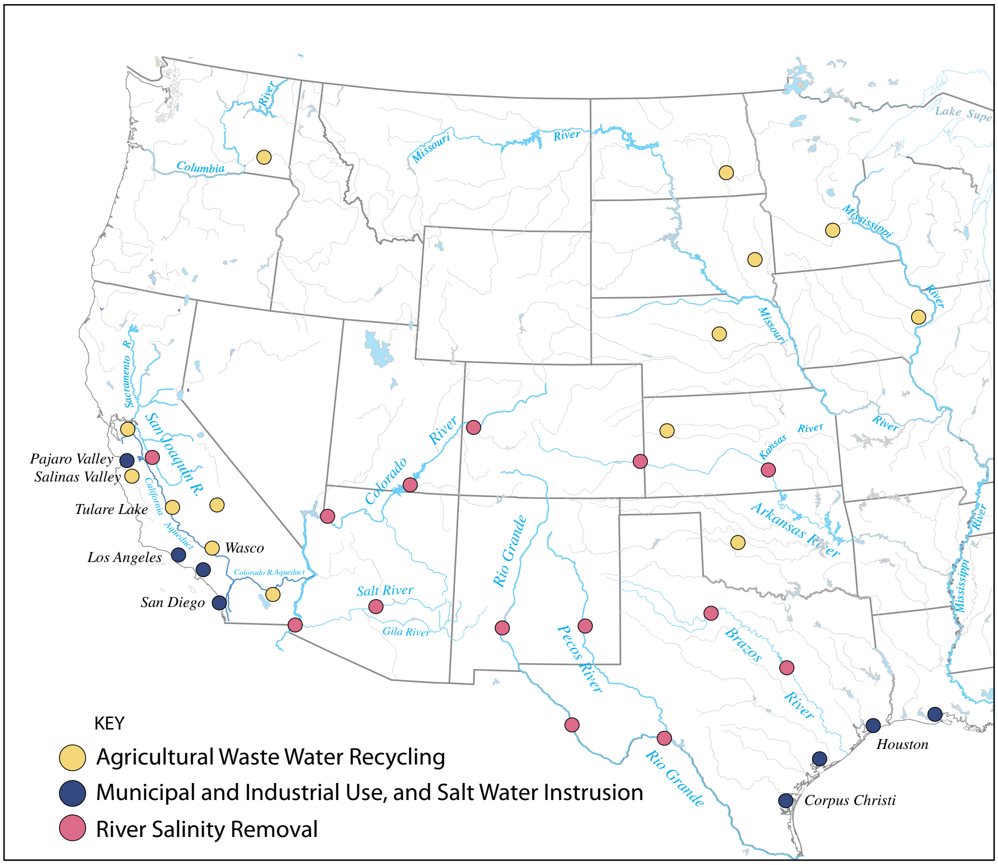


FIGURE 5
Desalination and Distribution



Phase 1 and Phase 2:

Requirements

For the mass production of nuclear power plants for desalination, industry, and pumping systems, an industrial gear-up will be required like that for World War II, and will include agreements with other nations. The thrust of this will be the conversion of our remaining machine-tool capacity, largely centered in the auto plants.

In addition to the already severe deficit of electricity production,[9] were the U.S. to become a productive society, the demands of the evolution of our economy, spearheaded by the 42 nuclear desalination plants proposed for water management, will make this deficit all the more severely felt. Since there is a shortage of electricity everywhere, the quickest route to putting new nuclear power production online will be to make use of the 17 "brownfield" sites around the country, where there is already an operating reactor, and where the site has been prepared for additional units, giving a head start on the infrastructure, manpower, and experience. These sites will be capable of housing 28 new nuclear plants in short order, for the industrial requirements of further mass-producing plants and other equipment. Manufacturing plants will be established for assembly line, standardized, mass production of modular nuclear plants. Pumps, piping, electronic controls, and other nuclear plant components can be produced in upgraded auto parts factories.

The auto sector represents a highly developed capability of the most advanced machine tooling, which can produce the most developed products if it is retooled to that purpose. An auto plant is primarily an arrangement of between 500 and 2,000 machine tools, in a configuration that passes a work piece from one machine to the next, as well as scores of robots. Auto plant conversion will mean not only replacing old assembly lines, but putting in place new machine tools, incorporating the most advanced scientific design.[10]

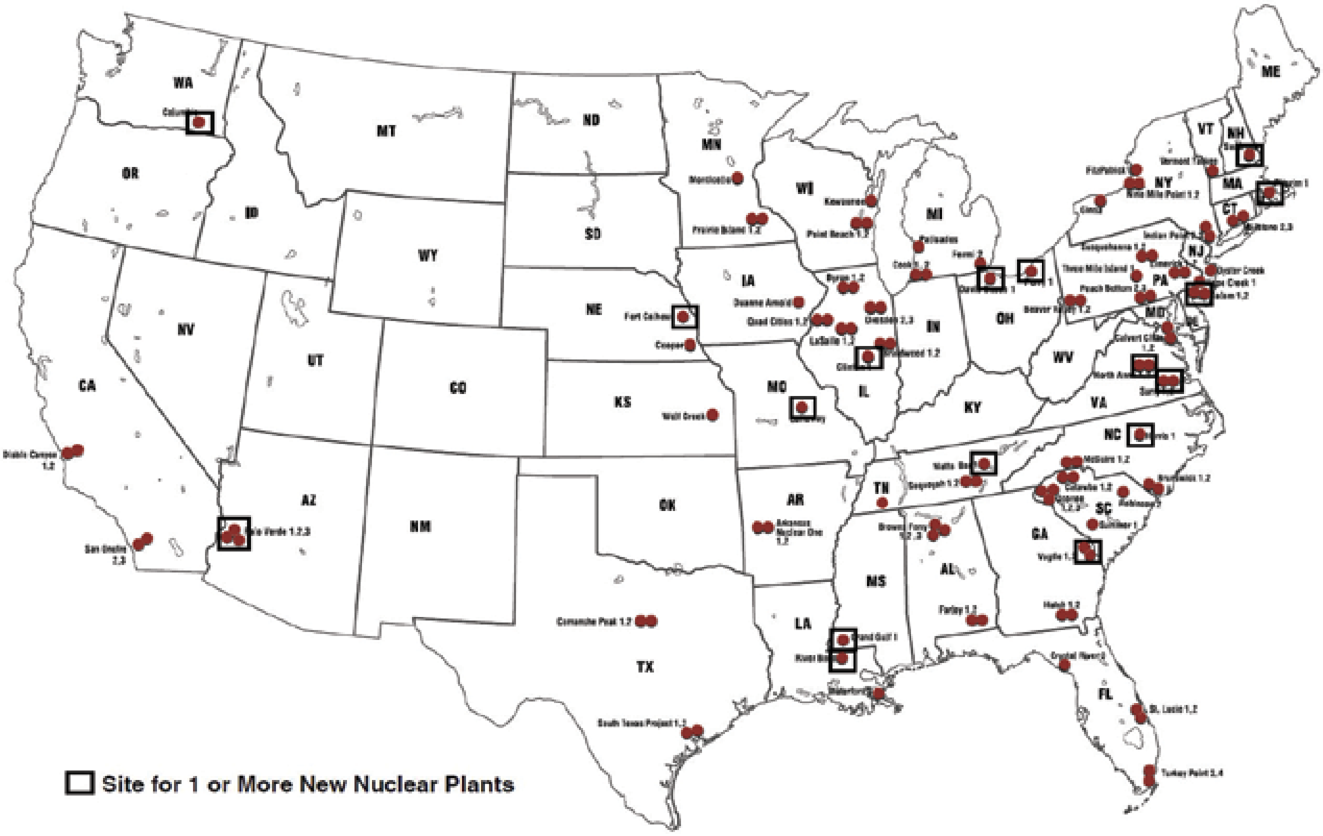
In addition to the needs of industry in the East and Midwest, modular reactors, to be put together in pieces, will be shipped across the country by rail to supply desalination plants required for the West.

9. A doubling of the capacity of the electric grid over the next ten years to meet the current deficit is a low-end baseline estimate.

10. The mass production of nuclear plants will be akin to Franklin Roosevelt's war mobilization, where the whole economy was geared up to turn out war materiel as fast as it could be produced. In the three years of war production, the auto industry built 27,000 planes, 455,000 airplane engines, 25,000 propellers, and more, all at higher tolerances and greater reliability than automobiles.

FIGURE 6

Ready Sites for 28 New Nuclear Plants, at 17 Current Nuclear Power Locations



Nuclear Energy Institute

Among the 104 nuclear power plants that were cancelled 30 years ago, approximately one third were to be additional units at sites already housing at least one operating nuclear power plant. At these "brownfield" sites, where there is at least one operating plant, a skilled workforce is available, and site preparation work was already done. The overall transportation, energy, and other infrastructure is in place. In some cases, the infrastructure for the additional unit was also in place, and construction of the reactor had begun. When the price of oil quadrupled in 1973, the utilities accelerated their nuclear plans, so they could stop importing expensive oil. As a result of the economic collapse, from President Nixon's 1971 termination of the Bretton-Woods System, and the dramatic economic contraction afterwards, energy prices zoomed. When demand for electricity went to almost zero, more than 100 nuclear plants were canceled.

The industrial capacity built up to produce 42 nuclear desalination plants, and the 28 plants at the brownfield locations, and other industrial demands of Phase 1, will then be applied, at a higher level of technology and integration, to the requirements of Phase 2.

The NAWAPA XXI collection and distribution system described in the previous pages will require the digging and lining of 5,400 miles of canals, 1,200 miles of tunnels, 60 dams, pumping stations, and new rail lines. To drive the pumping systems with nuclear power—thereby augmenting the water available, adding a degree of freedom to the whole system, and requiring fewer dams and projects—about 52 GW of capacity will be needed once the system is running at maximum capacity.

At least 25-30 large 30-foot-diameter tunnel-boring machines will be needed, and perhaps those larger in size for the various 50-foot-diameter tunnels. The pumping systems required to pump the large volumes of water at the Sawtooth Lift and other large lifts of the system will be the largest ever made in terms of head and volume, and on the order of 100,000 to 125,000 horsepower each.

The steel and cement production needs, totaling 300 and 540 million tons, respectively, will require a massive increase in steel and cement mills. Cement produc-

Large-Volume Components for One Nuclear Plant

Equipment	Number	Comments
Pumps, large	70–100	
Pumps, small	80–484	
Tanks	50–150	600–150,000 lbs
Heat Exchangers	12–26	2,100–250,000 lbs
Compressors, vacuum pumps		
Fans	60–120	600–45,000 lbs
Damper/louvers	730–1,170	
Cranes and hoists	25–50	
Diesel generators	2	10 MWe
Prefabricated equipment	65–135	
Instruments	1,850–3,440	
Valves	9,630–17,900	

Bulk Materials for One Nuclear Plant

Concrete, (cubic yards)	423,000
Structural steel, (tons)	19,000
Pipe, more than 2" diameter, (feet)	370,000
Tray/conduit, (feet)	206,000
Cable (feet)	6,980,000

Nuclear Requirements

Pump System	MAFY Lifted	Lift (ft)	Shaft Power (GW)
Taku	52	300	2.5
Fraser	70	670	6.5
Sawtooth	100	2450	35
Niobrara	20	2800	8
Total			52

Gigawatts of nuclear power required for NAWAPA XXI's pump lifts.

tion will need to be developed in areas where little or none currently exists, which will require new sources of limestone, clay, and iron. Moving some 30 billion cubic yards of earth will require an enormous array of heavy cranes and numerous excavators, some specially built for the specific areas. While our mining and milling capacity is large, the U.S. has lost over 80% of its foundry capacity since the 1980s. Most forming and casting of metal is done in foundries abroad. The domestic capacity will need reviving. This will include heavy rolling, forming, casting houses for large components, and metallurgy components.

The hundreds of thousands of auto and aerospace jobs lost since 2005 with the shutdown of industry, and millions of other useful jobs, can be reclaimed. The production of 100 nuclear plants will create 10 million jobs, and Phase 2 will create at least another 7 million jobs.

Throughout the process, in addition to those technologies applied to the machine-tool sector and manufacturing process, other technologies will transform the construction and management process of the system, such as: maglev technology for rail transportation; LIDAR technology in geological mapping for precision design; roller-compacted concrete for quicker and more efficient dam construction; new composite concretes for optimal flow; permafrost engineering advancements for construction in northern British Columbia, Yukon, and Alaska; anchor bolt technology for rail lines in mountainous areas; peaceful nuclear explosives (PNEs) for tunneling.

The infrastructure used to build the more advanced economy, will also establish new corridors of agricultural and industrial development. Along the new corridors, new population centers will be formed around the new routes of resource management and industry. The system will create new cycles of trade and production throughout the continent. New water and transportation routes, via canals and reservoirs, and rail lines, will link the states. Not only will each state become specialized

NAWAPA XXI Production Requirements

	Steel (mil. tons)	Cement (mil. tons)	Earth Moved (mil. cu. yd)	Number	Miles
Pumping Systems	3	4		8	
Dams	300	490	18,570	60	
Tunnels	0	4	670	40	1,200
Tunnel Boring Machines			30		
Canals	0	36	8,280		5,400
Nuclear Plants for Pumps and Desalination	2	8		94	
TOTALS	306	546	27,520		

in new industrial and agricultural products, but the relations among states will be transformed by the new infrastructure system. Every state and province will be going from a currently dying direction, to one of increasing the populations living there, and their living standards. The growth rate will increase as the future becomes possible and realized.

For all of the construction needs described here, the plants will incorporate the nuclear agro-industrial model.[11] Later, the introduction of fusion economy elements will bring the whole economy to a higher-order platform. Let us reverse the four decades of cultural and economic decay that we suffer today, and defeat the malthusians' efforts at population reduction, by creating an economic system capable of defeating their intention. We must pick up where Kennedy left off, and turn our generation of youth and young adults from a wasted generation into the generation that built NAWAPA XXI.

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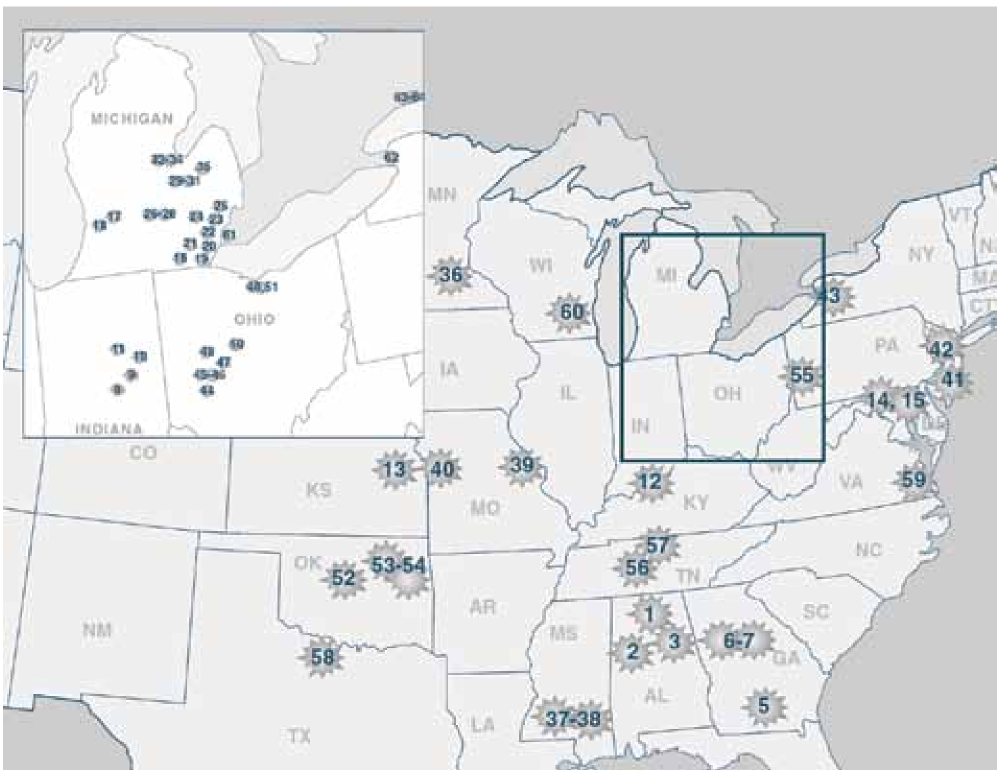
11. As described by Liona Fan-Chiang, "Nuclear Agro-Industrial Complexes for NAWAPA XXI," in the *21st Century Science* report.

FIGURE 7

Retooling Locations for the Mass Production Nuclear Power Plants



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This map shows 64 specific locations for the mass production of nuclear plants, where idle auto capacity existed in 2005 that may still be potential locations for such conversion. Such plants could produce nuclear fuel rods, cranes, pumps, valves, pipes, and other components of nuclear power plants, electric locomotives, high-speed railroad stock, aluminum, plastic injection molding presses, mitre gates for locks and dams, parts for large earth-moving machines, pumping stations, and other infrastructure.