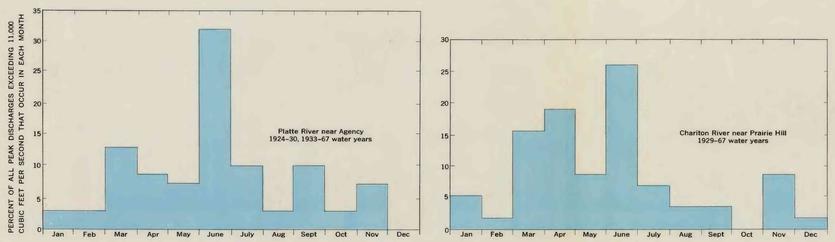
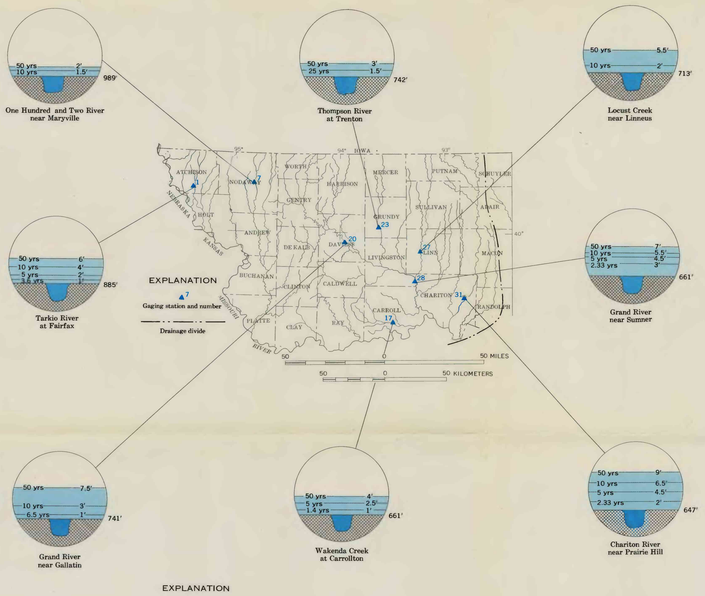
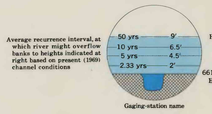
FLOODING



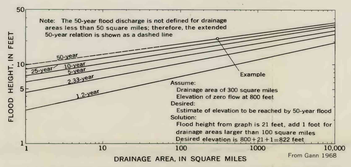
ON STREAMS IN NORTHWESTERN MISSOURI, APPROXIMATELY 25 PERCENT OF ALL FLOODS CAN BE EXPECTED TO OCCUR DURING THE MONTH OF JUNE.—*Floods are least likely to occur in December; however they may occur in any month.*



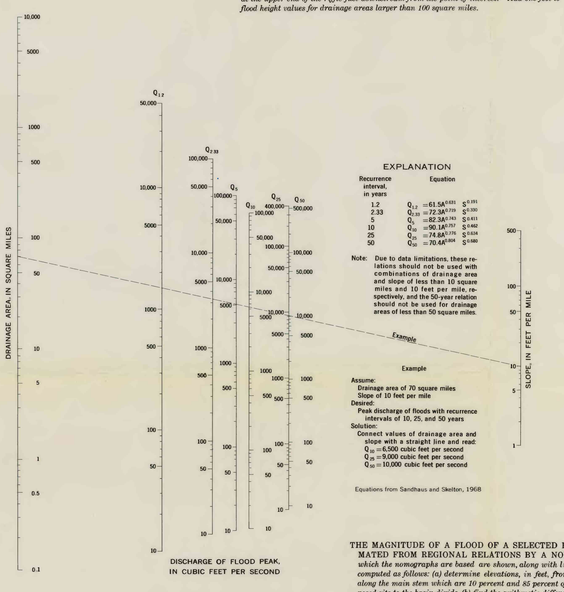
EXPLANATION



FLOOD HEIGHT-FREQUENCY RELATIONS, SHOWN FOR SELECTED GAGING STATIONS, PROVIDE ESTIMATES OF HEIGHTS AND FREQUENCY OF FLOODING IN THE VICINITY OF THE GAGE.—*The channel capacity of many of the larger streams has been increased by channel improvements and levee construction resulting in bankfull discharges generally occurring less often (about once every 1.4 or 5 years) than for natural channels (about once every 1.5 years). River-bank elevations near the gage may be estimated from topographic maps.*



ESTIMATES OF FLOOD HEIGHTS AT UNGAGED SITES CORRESPONDING TO SELECTED FREQUENCIES CAN BE OBTAINED FROM REGIONAL FLOOD HEIGHT-FREQUENCY RELATIONS.—*Average standard errors for these relations range from 21 percent for the 50- and 25-year floods to 35 percent for the 1.5-year flood. Flood height is defined as the vertical distance above the elevation of zero flow or the lowest point at the upper end of the riffle just downstream from the point of interest. Add one foot to flood height values for drainage areas larger than 100 square miles.*



THE MAGNITUDE OF A FLOOD OF A SELECTED FREQUENCY CAN BE ESTIMATED FROM REGIONAL RELATIONS BY A NOMOGRAPH.—*The equations on which the nomographs are based are shown, along with limitations on their use. Slope is computed as follows: (a) determine elevations, in feet, from a topographic map at points along the main stem which are 10 percent and 85 percent of the total distance from the proposed site to the basin divide, (b) find the arithmetic difference between these elevations and divide by the distance between two points, in miles.*

WATER USE

Approximately 78 percent of the 882 million gallons of water withdrawn each day in northwestern Missouri is used for cooling purposes by electric power plants. These plants pump water either from the Missouri River or from impoundments and most of the water is returned to the source after use.

Public supplies account for the second most important use of water in the area. The average per capita use of towns with greater than 1,000 population is about 100 gallons per day. The higher per capita use indicated for some towns reflects the use of water by industries.

Another important use of water is the dilution of sewage wastes. Most of the larger towns in the area furnish primary or secondary sewage treatment, but many of the smaller towns lack sewage treatment facilities. Unless sufficient water is available for dilution, the quality of water in streams receiving even treated sewage effluent may be adversely affected.

Although public water supplies were available in most of the larger towns prior to 1960, the total number of public supplies has almost tripled since that time owing to the construction of new supplies in small towns and rural areas. The increasing availability of public water supplies and the completion of the inter-state highway system may, in time, help to reverse the downward trend in population of several of the counties in the area.

SUMMARY OF MUNICIPAL WATER SUPPLIES FOR TOWNS IN NORTHWESTERN MISSOURI WITH POPULATIONS GREATER THAN 1,000

[From Missouri Division of Health, 1966]

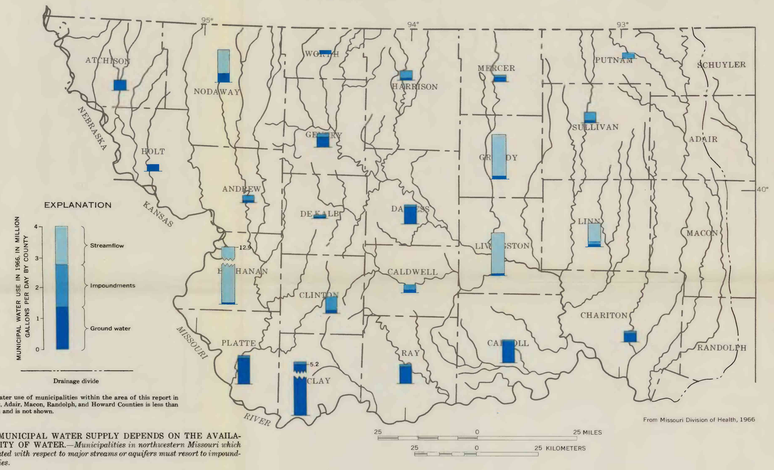
County	City or town	Year started	Population served	Source of supply [1]	Treatment plant capacity (mgd)	Average daily use (mgd)	Per capita use [2] (gpd)
Andrew	Savannah	1907	2,700	Imp. and 1 well	0.50	0.19	70
Atchison	Rockport	1900	1,500	2 wells	.36	.10	63
	Tarkio	1941	2,100	1 well	.29	.16	76
Buchanan	St. Joseph	1881	83,000	Missouri River	21.0	12.9	155
Caldwell	Hamilton	1923	1,500	Imp.	.20	.15	100
Carroll	Carrollton	1941	4,200	4 wells	1.08	.60	143
Chariton	Brunswick	1919	1,420	2 wells	.38	.09	63
	Salisbury	1922	1,300	6 wells	.47	.16	127
Clay	Claycomo		1,423	Kansas City			
	Excelsior Springs	1906	6,850	2 wells	1.50	.80	117
	Gladstone	1960	10,500	2 wells	3.00	.86	84
	Liberty	1962	11,000	3 wells	2.50	.90	82
	North Kansas City	1912	6,500	4 wells	4.70	2.50	385
	Smithville	1927	1,780	Imp. and Little Platte R.	.35	.12	65
Clinton	Cameron	1919	4,150	3 Imp.	1.12	.34	82
	Lathrop	1923	1,000	3 wells	.16	.07	70
	Plattsburg	1939	1,460	2 Imp.	.36	.10	72
Daviess	Gallatin	1898	1,700	3 wells	.36	.15	88
De Kalb	Maysville [3]	1932	800	Imp.	.39	.08	106
Gentry	Albany	1951	1,650	2 wells	.48	.23	139
	King City	1923	1,650	2 Imp.	.36	.10	95
	Stanberry	1883	1,350	3 wells	.14	.09	67
Grundy	Trenton	1923	6,800	Thompson R. to Imp.	3.00	1.30	191
Harrison	Bethany	1937	3,000	2 Imp.	.72	.20	67
Holt	Mound City	1890	1,230	2 wells	.29	.11	89
	Oregon	1912	1,500	3 wells	.29	.10	63
Linn	Brookfield	1891	5,000	Yellow Cr. to Imp.	.54	.40	80
	Marceline	1909	2,900	Mussel Fk. to Imp.	1.40	.18	60
Livingston	Chillicothe	1877	9,650	Grand River	2.08	1.30	135
Mercer	Princeton	1896	1,400	4 wells	.28	.14	100
Nodaway	Maryville	1882	7,807	102 R. to Imp.	2.07	.90	115
Platte	Parkville	1942	8,500	3 wells	1.29	.69	71
	Platte City	1930	1,200	3 wells	.43	.14	112
	Weston	1930	1,000	2 wells	.36	.10	100
Putnam	Unionville	1921	1,900	3 Imp.	.28	.17	89
Randolph	Huntsville	1950	1,500	Moberly		.05	33
Ray	Richmond	1898	5,250	3 wells	1.00	.40	76
	Orrick	1956	1,000	1 well	.22	.07	70
Sullivan	Milan	1922	1,550	2 Imp.	.65	.25	161
Worth	Grant City	1930	1,120	3 wells	.22	.08	67

[1] Imp.—Impoundment(s).
[2] Average of indicated per capita uses is 99.7 gpd.
[3] Largest town in county.

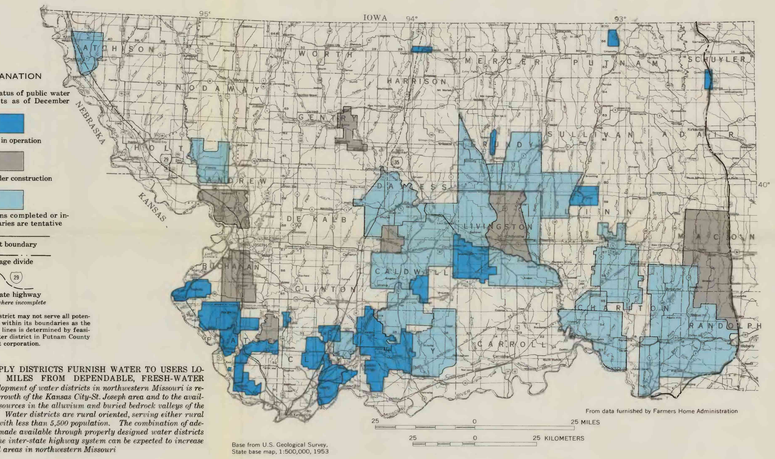
ESTIMATED WATER USE IN NORTHWESTERN MISSOURI DURING 1966, IN MILLIONS OF GALLONS PER DAY

Use	Streamflow [a]	Granted water [a]	Impoundments	Total	Percent of total
Electric power	340	1	[b] 345	686	78
Public supply	103	20	2	125	14
Industrial	6	26	0	32	4
Stock	9	10	9	28	3
Rural domestic	0	8	1	9	1
Irrigation	.1	2	0	2.1	0
Total	458.1	67	357	882.1	100
Percent of total	52	8	40	100	

[a] Includes water pumped from Missouri River and alluvial fill by Kansas City and other users south of the river. Does not include water used on Kansas and Nebraska side of the river.
[b] Based on water use for 1965.



THE SOURCE OF A MUNICIPAL WATER SUPPLY DEPENDS ON THE AVAILABILITY AND QUALITY OF WATER.—*Municipalities in northwestern Missouri which are inconveniently located with respect to major streams or aquifers must resort to impoundments for water supplies.*



PUBLIC WATER-SUPPLY DISTRICTS FURNISH WATER TO USERS LOCATED SEVERAL MILES FROM DEPENDABLE, FRESH-WATER SOURCES.—*The development of water districts in northwestern Missouri is related to the suburban growth of the Kansas City-St. Joseph area and to the availability of fresh-water sources in the alluvium and buried bedrock valleys of the Grand River Valley. Water districts are rural oriented, serving either rural areas or small towns with less than 5,500 population. The combination of adequate water supplies made available through properly designed water districts and the extension of the inter-state highway system can be expected to increase the population of rural areas in northwestern Missouri*

MUNICIPAL SEWAGE TREATMENT IS PROVIDED BY MOST TOWNS IN NORTHWESTERN MISSOURI WITH A POPULATION GREATER THAN 1,000.—*The type of treatment most frequently provided can be classified as secondary with approximately 80 to 90 percent BOD (biochemical oxygen demand) removal. Lagoons are utilized in approximately 65 percent of the treatment facilities. Private septic tanks or lagoons are generally utilized in the smaller towns where municipal treatment is not provided.*

Owing to the low base-flow characteristics of headwater streams with drainage areas less than about 200 square miles (on low-flow frequency test, sheet 3), little, if any, natural flow is available for waste dilution in these streams during low-flow periods and any flow during such periods may be derived primarily from municipal sewage effluent. High fecal coliform counts (>100,000/100 ml) have been noted even on larger streams such as the Platte, Thompson, Grand, and Missouri Rivers.

WATER RESOURCES EVALUATION

Problem or potential	Alternatives to problems	Considerations	Information needed	Selected sources of information [1]
Water supply.	Missouri River.	Adequate quantities for municipal, industrial, and irrigation supplies. High silt content, high coliform counts. Treatment required to meet Public Health Service standards. Public water supply districts furnish fresh water to users unfavorably located with respect to the Missouri River and other fresh-water sources.	Water-quality data. Time-of-travel and dispersion studies. Short and long-term predictions of quantity and quality of flow.	U.S.G.S., WRD; Corps; Mo. Div. H.; Mo. W.P.B.; Local treatment plants.
	Tributary streams.	Natural flow generally inadequate during mild droughts except in downstream reaches of Nodaway, Thompson, Grand, and Chariton Rivers. Sand-bottom channels may cause intake problems. Quality variable. Generally high silt content. High coliform counts in some streams. Treatment required.	Water-quality data. Time-of-travel studies. Storage estimates for low-flow augmentation. Seepage measurements to define surface water-ground water relationships.	U.S.G.S., WRD; Corps; Mo. Div. H.; Mo. W.P.B.; Local treatment plants.
	Impoundments.	Terrain and soils suitable for construction in most areas. May be used to augment low flow of streams. Used by several towns to supplement streamflow sources during periods of low or zero flow. Watershed should be adequately protected.	Hydrologic data for design of reservoirs and spillway capacities for large and small impoundments. Knowledge of geology and sedimentation and seepage rates. Knowledge of chemical and biological changes occurring in impoundments.	U.S.G.S., WRD; Corps; S.C.S.; Mo. G.S.; Mo. Div. H.
	Missouri River alluvium.	Well yields of 1,000 to 2,000 gpm are possible. Yields of wells located near the river are sustained at high levels by induced infiltration while yields of wells located near the valley wall may be lower due to boundary conditions. Hard, calcium bicarbonate type water with high iron content. Treatment required.	Knowledge of aquifer characteristics for well-field design. Water-quality data.	Mo. G.S.; U.S.G.S., WRD; Corps; Mo. Div. H.; Local well drillers.
	Tributary alluvium.	Yields variable, depending on saturated thickness and permeability of deposits. Yields exceed 50 gpm in parts of Tarkio, Nodaway, Thompson, Grand, and Chariton Valleys. Aquifer thicknesses about 40 feet or less. Artificial recharge through spreading pits can increase perennial supply of water. Hard, calcium bicarbonate type water with high iron content. Treatment required.	Knowledge of aquifer characteristics for well-field design. Knowledge of hydraulic connection existing between streams and alluvium and between alluvium and buried glacial channels. Water-quality data.	Mo. G.S.; U.S.G.S., WRD; Corps; Mo. Div. H.; Local well drillers.
	Glacial drift.	Wells drilled in buried glacial valleys typically yield 30 to 500 gpm but may yield as much as 1000 gpm. Where outwash deposits exist between the buried valleys, adequate supplies for domestic or small municipal needs can be obtained. Where outwash deposits are thin or absent, water supplies are undependable. Generally a hard, calcium bicarbonate-sodium sulfate type water with medium to high iron content. Treatment required.	Knowledge of aquifer characteristics for well-field design. Piezometric maps to show recharge areas and movement of water. Water-quality data to show relation between ground water in Pennsylvanian bedrock, glacial aquifers, tributary alluvium, and streams.	Mo. G.S.; U.S.G.S., WRD; Mo. Div. H.; Local well drillers.
	Bedrock.	Shallow rock wells are used locally for rural domestic supplies but the dissolved-solids content often exceeds 1,000 mg/l and yields are very low. The dissolved-solids content of bedrock wells greater than 200 to 300 feet in depth ranges from 2,000 to more than 20,000 mg/l.	Knowledge of aquifer characteristics for future development of water supplies by desalination and for underground waste disposal. Understanding of regional groundwater movement and of recharge and discharge areas. Water-quality data.	Mo. G.S.; U.S.G.S., WRD; Mo. Div. H.; Local well drillers.
Flooding.	Headwater and (or) mainstem reservoirs.	Multipurpose reservoirs also help meet water supply and recreation needs. Federal participation generally required. Nine reservoirs authorized for future construction by Corps of Engineers. One watershed project completed by Soil Conservation Service, and 15 others in various stages of planning. Thomas Hill Reservoir, constructed by Associated Electric Cooperative of Springfield, Mo., furnishes protection for downstream reaches of Middle Fork Chariton River. Valuable farmland removed from production in reservoir areas.	Hydrologic data for comprehensive river-basin planning. Streamflow data for reservoir design and operation. Geologic data for reservoir sites. Hydrologic data for predicting reservoir sedimentation and seepage rates. Hydrologic data for flood forecasting.	Corps; S.C.S.; U.S.G.S., WRD; Mo. G.S.; Mo. W.R.B.; ESSA, W.B.
	Levee construction and (or) channel improvements.	May be accomplished by local or Federal interests. Used in conjunction with flood-control reservoirs and land drainage projects. Expensive and requires maintenance. Levees subject to failure during extreme floods.	Hydrologic data for comprehensive river-basin planning. Flood profiles of previous outstanding floods. Elevation-frequency studies for adequate design. Foundation and seepage studies.	Corps; U.S.G.S., WRD; ESSA, W.B.; Mo. W.R.B.
	Flood-plain zoning.	Local cooperation necessary for success. Requires supervision and enforcement. Maximum benefit in urban areas.	Elevation-frequency studies and design flood profiles for establishing adequately zoned areas. Definition of flood-prone areas to increase public awareness of local flood-plain hazards.	Corps; Mo. W.R.B.; U.S.G.S., WRD
Pollution.	Waste-water treatment.	Required by State water-quality standards. Secondary treatment of wastes to Mo. River required by 1975. Expensive; enforcement necessary. Secondary treatment provided by most towns in area with populations in excess of 1,000. Natural streamflow inadequate for waste dilution in many areas. Inadequate lagoons and septic tanks may pollute streams and ground water.	Definition of assimilative capacity of streams. Water-quality monitoring. Storage requirements for low-flow augmentation.	Mo. W.P.B.; FWQA; Mo. G.S.; U.S.G.S., WRD.
	Underground waste disposal.	Waste-injection wells prohibited by 1971 State law. May contaminate valuable water resources if inadequately designed, constructed, and operated. Restoration of contaminated aquifers is expensive and may require many years.	Complete understanding of hydrologic and geologic setting of proposed disposal areas including quality-of-water data. Monitoring of water quality and movement in receiving and overlying formations.	Mo. W.P.B.; Mo. G.S.; U.S.G.S., WRD; Local mining companies.
	Reclamation of strip-mined areas.	Acid drainage from strip-mined areas pollutes East Fork Chariton River Provides recreation areas, enhances aesthetic values, and results in more efficient use of land and water resources.	Effective and economical methods of reclaiming strip-mined areas.	Mo. W.P.B.; Mo. Cons. Comm.; Mo. G.S.; U.S.G.S., WRD; Local mining companies.
	Reduction of agricultural pollution.	Herbicides and insecticides are toxic to aquatic life. Fertilizers and feedlot wastes can pollute streams and aquifers and provide nutrients for obnoxious plant growth. The sediment load of streams is affected by farming practices.	Better understanding of influence of fertilizers, herbicides, insecticides, and animal wastes on quality of ground and surface waters. Sediment yield data.	Mo. W.P.B.; FWQA; Mo. G.S.; U.S.G.S., WRD; Univ. of Mo., Extension service.
Recreation.	Streams.	Missouri River recreation restricted by high sediment loads and pollution from municipal and industrial wastes. Tributary streams restricted by low-flow conditions, high sediment loads, and high coliform counts.	Storage estimates for low-flow augmentation. Water-quality data to define extent and source of pollution.	Mo. Cons. Comm.; U.S.G.S., WRD; Corps.
	Lakes and ponds.	Several natural lakes exist on the flood plain of the Missouri River. Approximately 240 lakes, mostly manmade, with surface areas in excess of 5 acres are known to exist in the area. May be combined with water supply in some areas.	Hydrologic and geologic data for lake design. Knowledge of sediment yields from drainage areas less than 100 square miles. Knowledge of chemical and biological changes occurring in lake environments.	Mo. Cons. Comm.; S.C.S.; U.S.G.S., WRD; Mo. G.S.
Urbanization.	Planned development with consideration of effects on water resources.	Necessary in preventing depletion and pollution of streams and aquifers in suburban and urban areas. Alteration of natural surface storage and drainage may increase flood heights. Present or potential problem areas include (but not limited to) Buchanan, Platte, Clay, and Ray Counties.	Hydrologic data for predicting the effects of urbanization on the water resources of an area. Comprehensive studies of present and potential problem areas.	U.S.G.S., WRD; Mo. G.S.; FWQA.

[1] Corps, Corps of Engineers; ESSA, W.B., Environmental Science Services Administration, Weather Bureau; FWQA, Federal Water Quality Administration; Mo. Cons. Comm., Missouri Conservation Commission; Mo. Div. H., Missouri Division of Health; Mo. G.S., Missouri Geological Survey and Water Resources; Mo. W.P.B., Missouri Water Pollution Board; S.C.S., Soil Conservation Service; U.S.G.S., WRD, U.S. Geological Survey, Water Resources Division.

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WATER RESOURCES OF NORTHWESTERN MISSOURI

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