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The Regional Carbonate-Rock Aquifer in Nevada: The Source of Warm Springs in Lake Mead NRA, and the Target for Ground-Water Development

William P. Van Liew, P.E., Hydrologist
NPS Water Resources Division
Fort Collins, CO

Presented at NPS Water Professionals Meeting
November 17, 2004

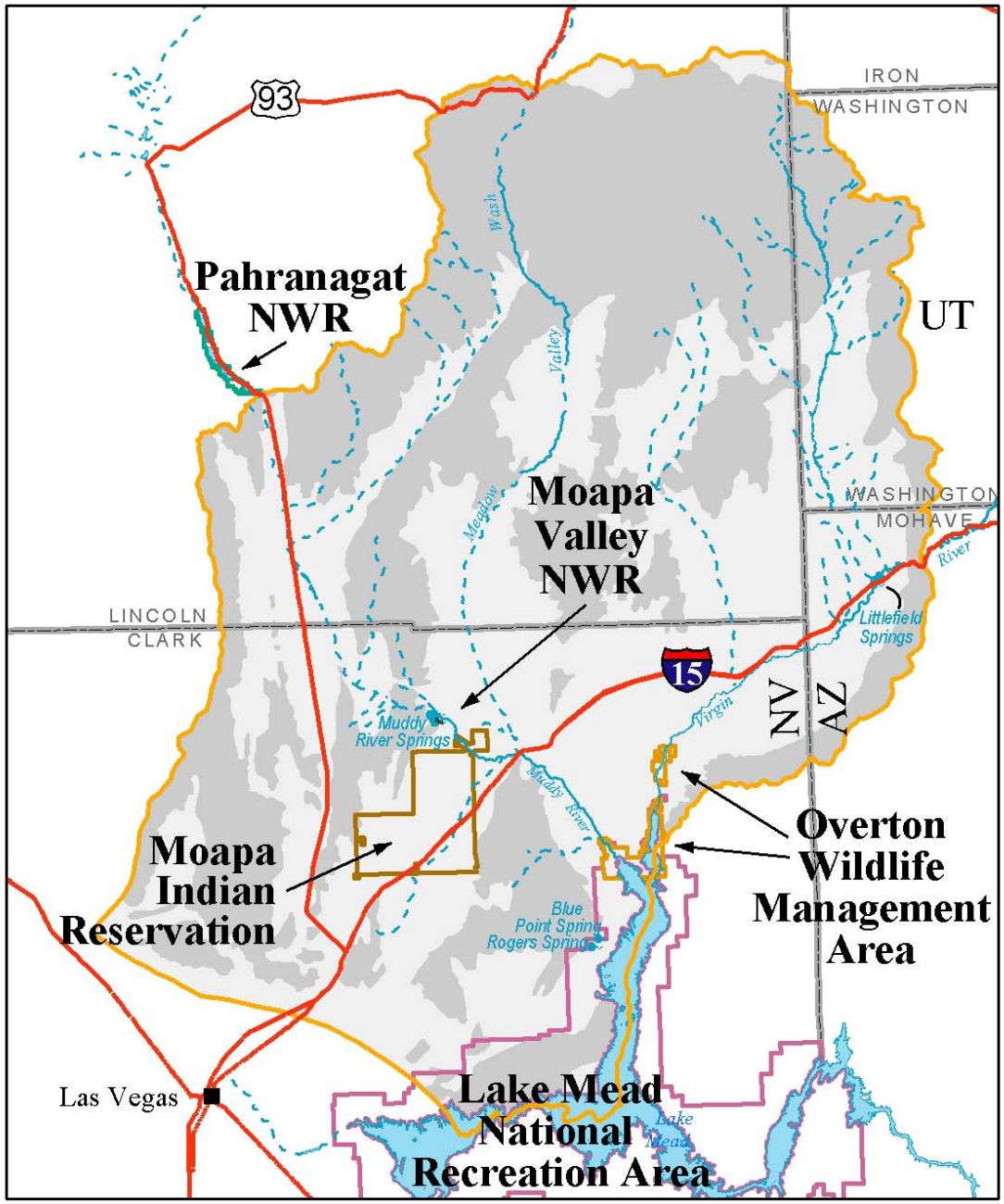
Outline of Presentation

- LAME Water Resources
- Overview of Regional Aquifer System
- The Source of LAME Water Resources
- Ground-Water Development

LAME Water Resources of Interest

- Rivers
  - Muddy River
  - Virgin River
- "Regional" Springs
  - Muddy River Springs
  - Rogers and Blue Point Springs

Selected Public Land Units of Interest



EXPLANATION

- Basin Fill
- Consolidated Rock
- Lower Colorado Flow System
- Spring
- Intermittent Stream
- Perennial Stream
- NWR National Wildlife Refuge

Geology modified from Plume and Carlton (1988)

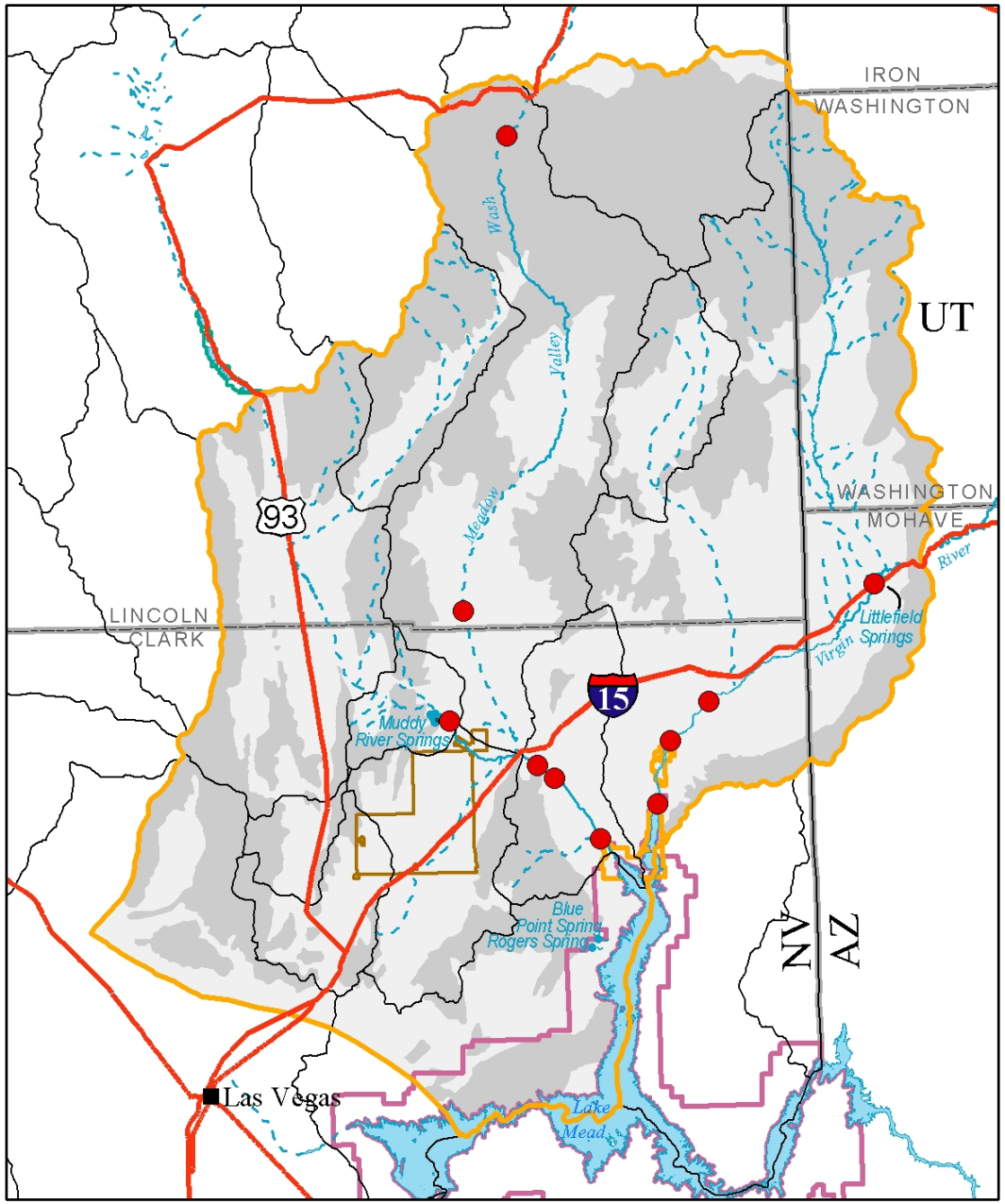
Base modified from USGS digital data, 1:100,000 and USGS GAP Analysis data.

N

0 5 10

Miles

Locations of USGS Streamflow-Gaging Stations



EXPLANATION

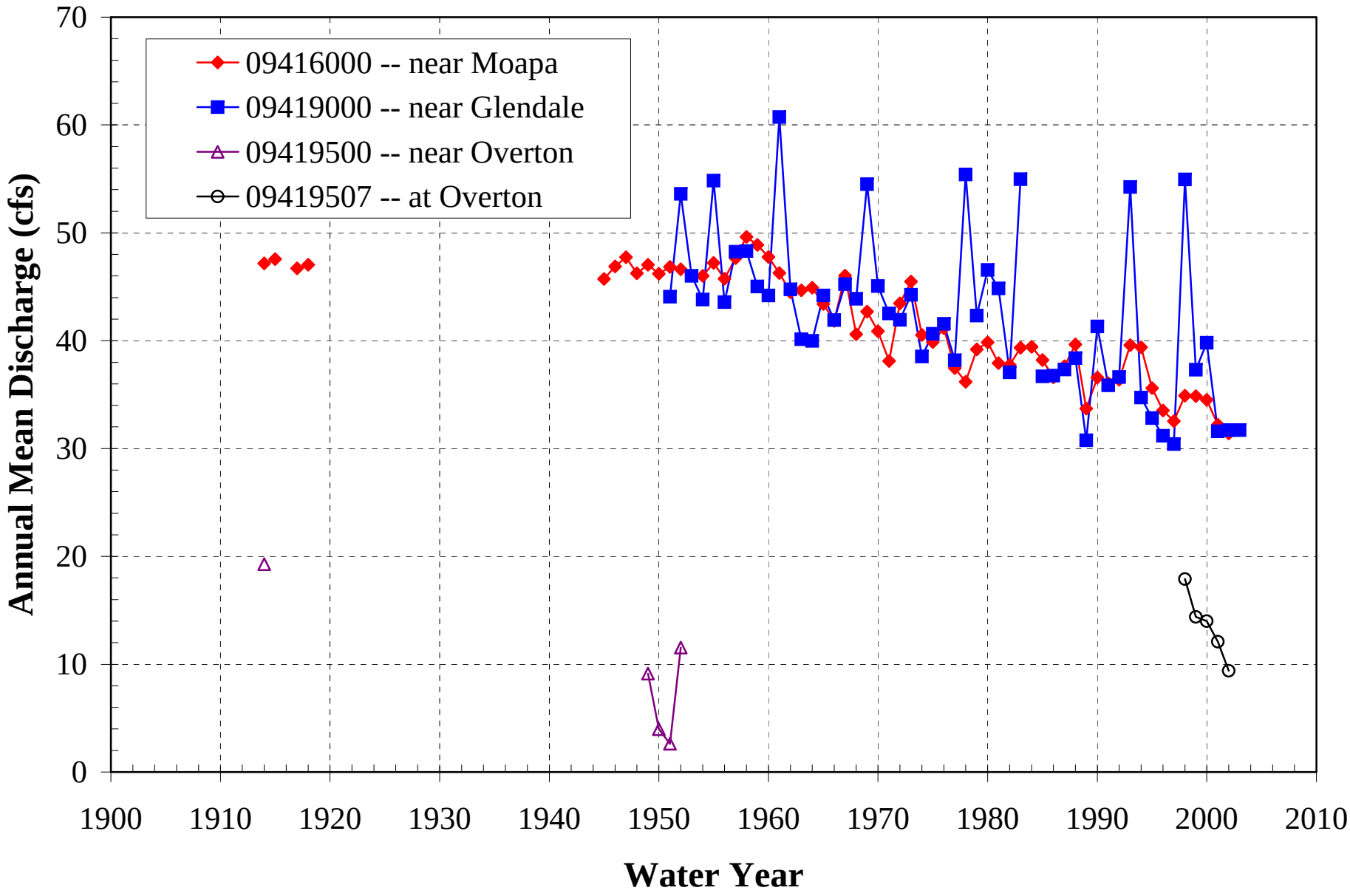
- USGS Streamflow-gaging Station
- Hydrographic Basins
- Basin Fill
- Consolidated Rock
- Lower Colorado Flow System
- Spring
- Intermittent Stream
- Perennial Stream
- Moapa Valley NWR
- Pahranagat NWR
- Moapa Indian Reservation
- Lake Mead NRA
- Overton WMA

Geology modified from Plume and Carlton (1988).
Flow systems modified from Harrill and Prudic (1998).
Base modified from USGS digital data, and other sources

N

0 5 10
Miles

Streamflow Along the Muddy River, 1914 - 2003



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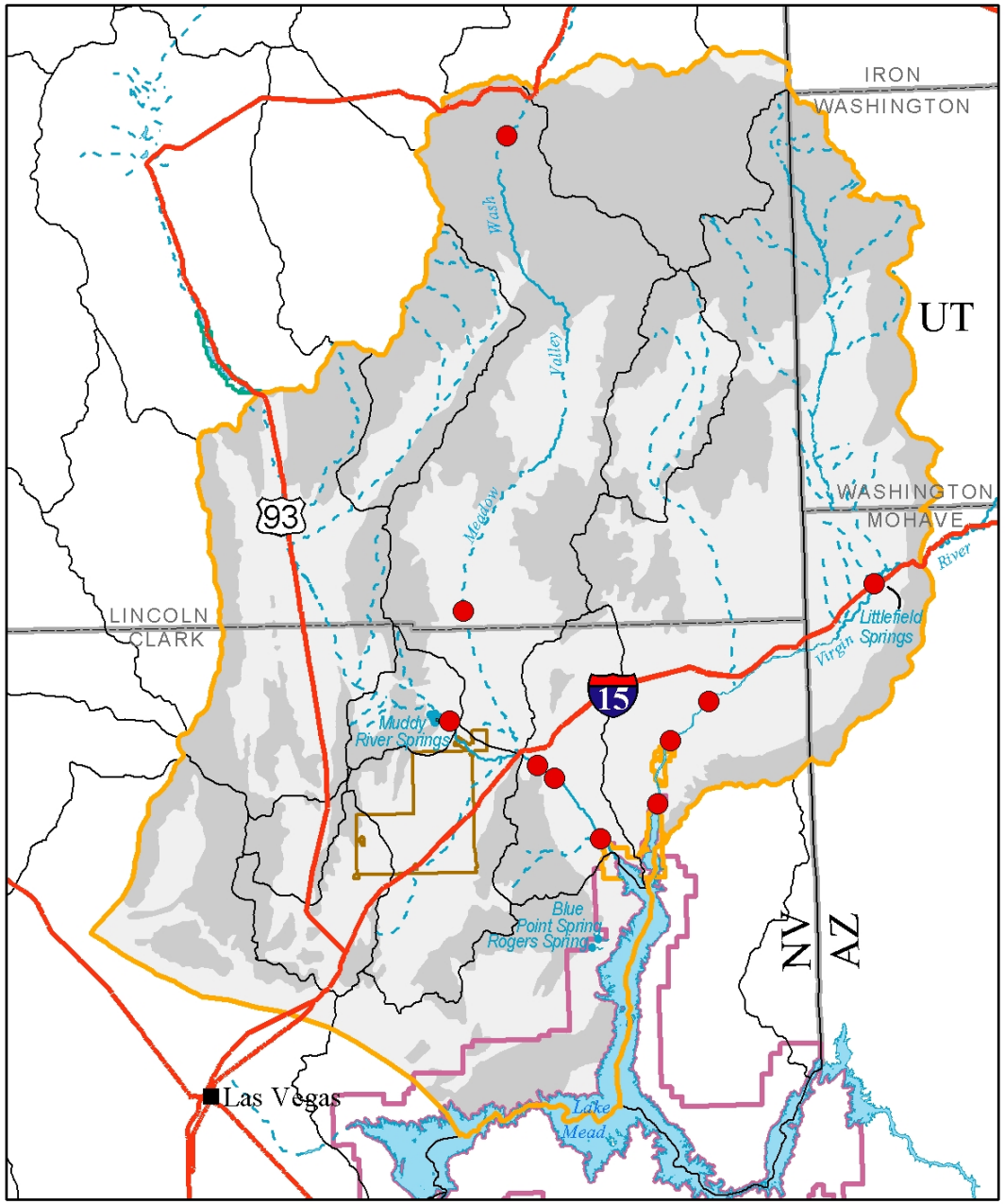
Locations of USGS Streamflow-Gaging Stations



EXPLANATION

- USGS Streamflow-gaging Station
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Geology modified from Plume and Carlton (1988).
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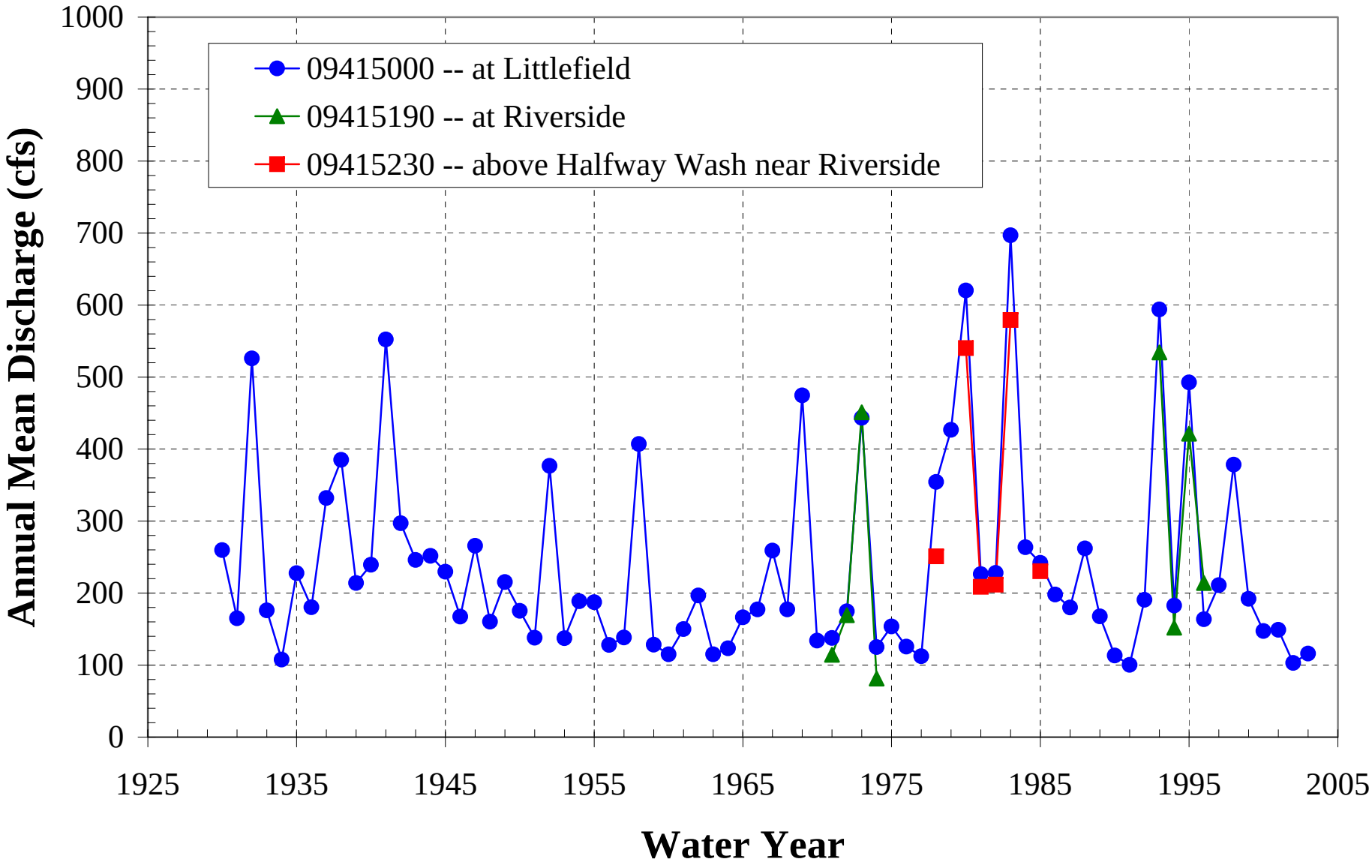
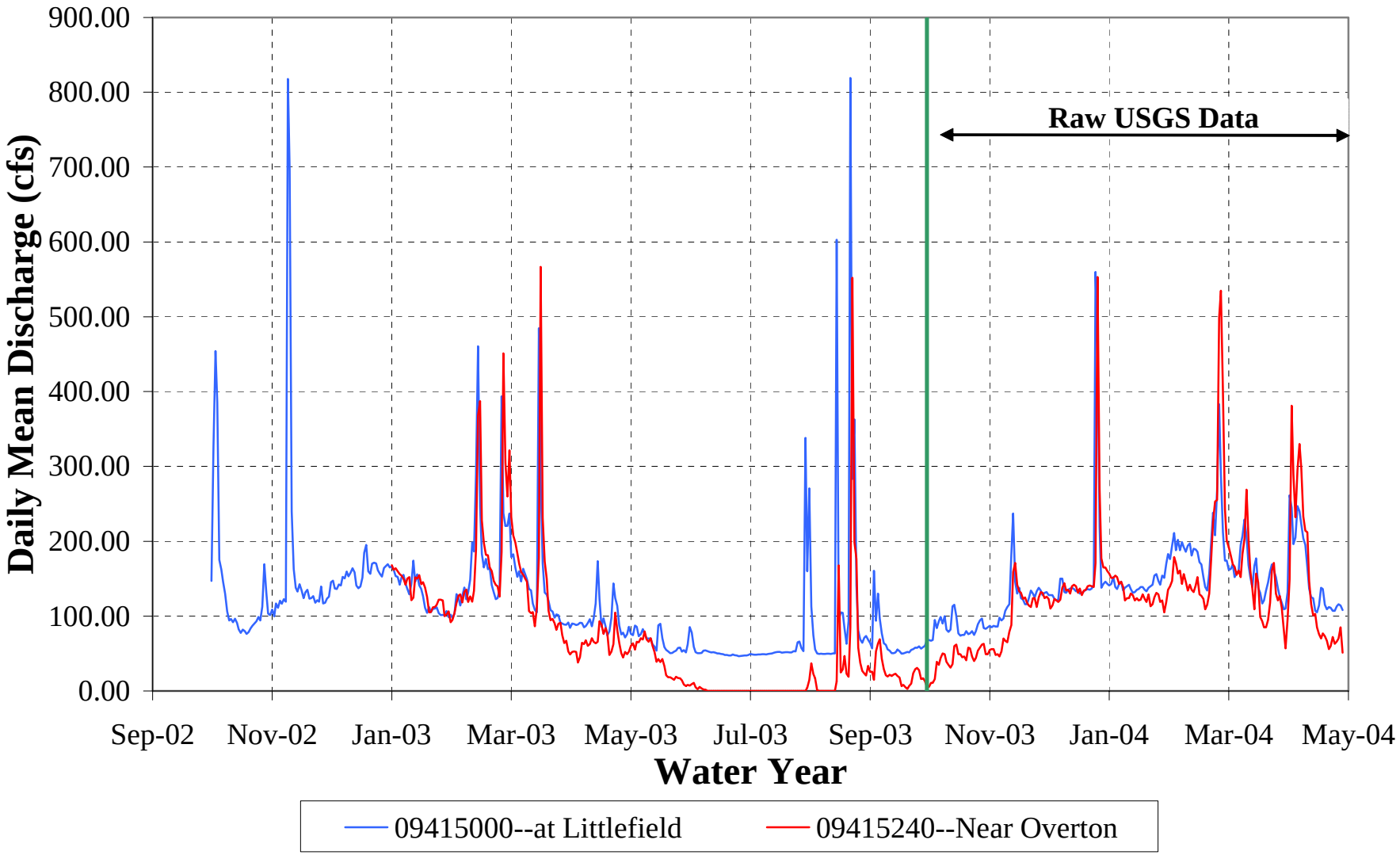
N

0 5 10
Miles

Streamflow Along the Virgin River, 1929 - 2003



Daily Mean Streamflow Along Virgin River



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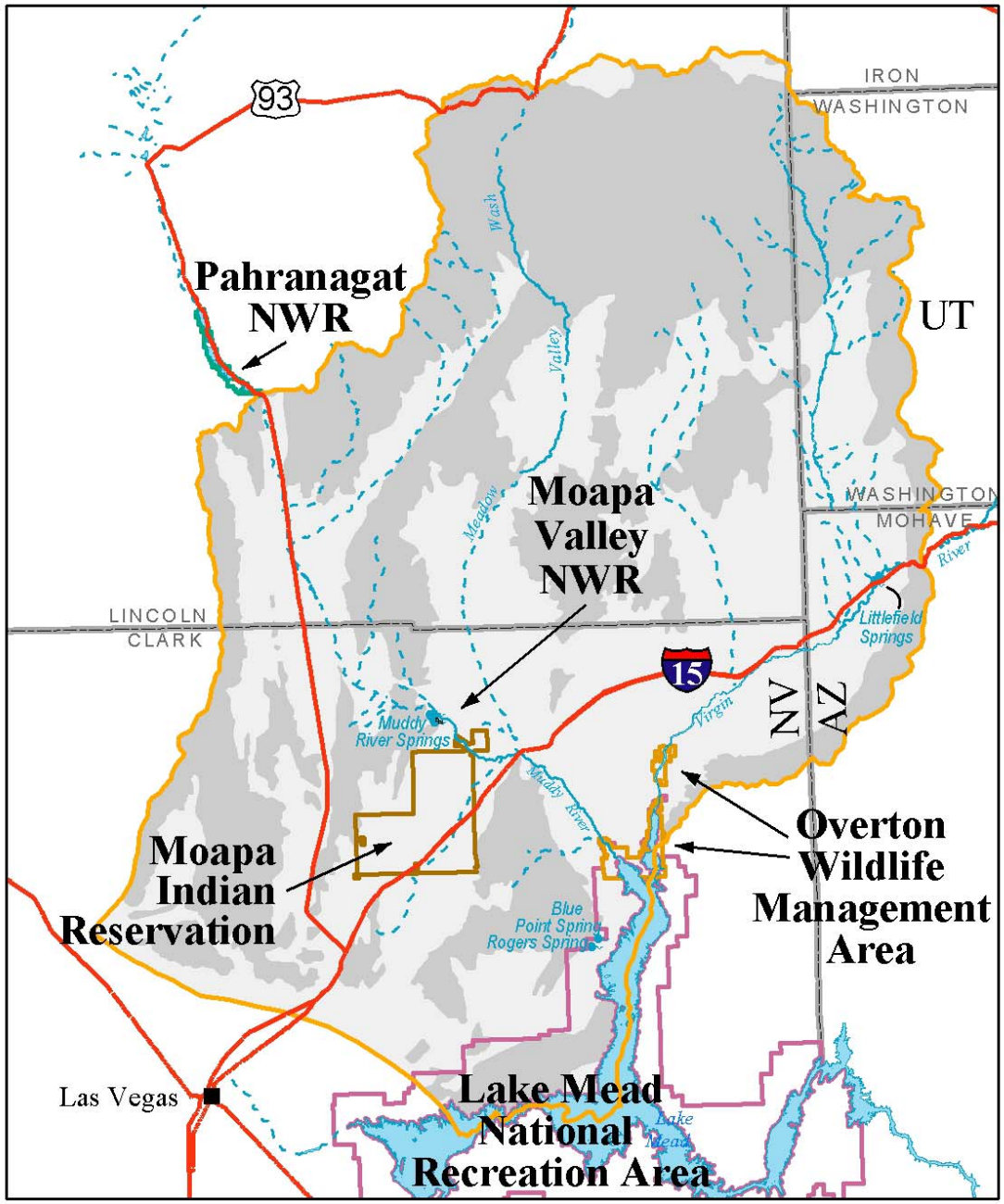
Selected Public Land Units of Interest



EXPLANATION

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Geology modified from Plume and Carlton (1988)

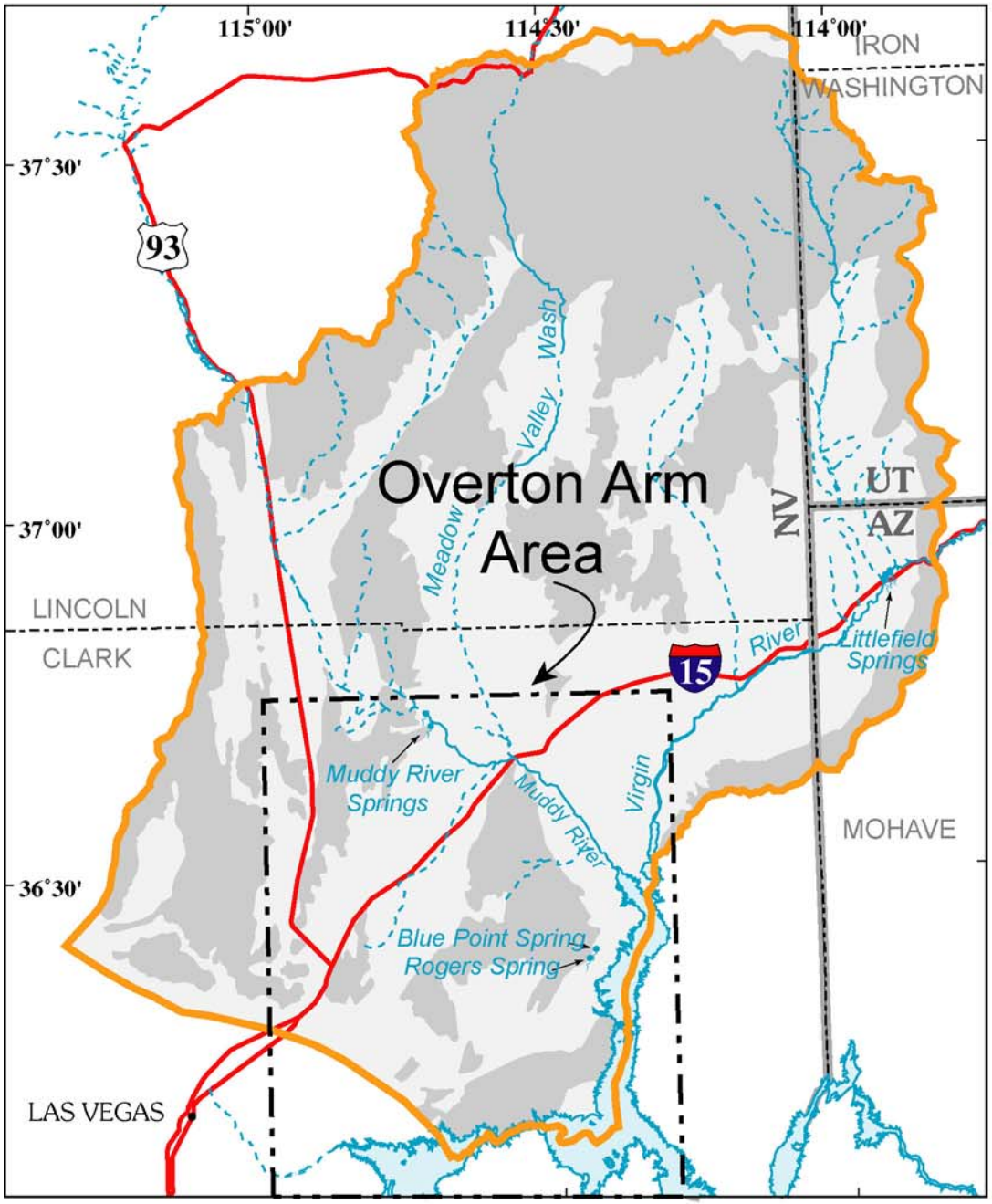
Base modified from USGS digital data, 1:100,000 and USGS GAP Analysis data.

N

0 5 10

Miles

Overton Arm Area



EXPLANATION

- Overton Arm area of Lake Mead National Recreation Area
- Intermittent Stream
- Perennial Stream
- Lower Colorado Flow System
- Consolidated Rock
- Basin Fill
- Spring

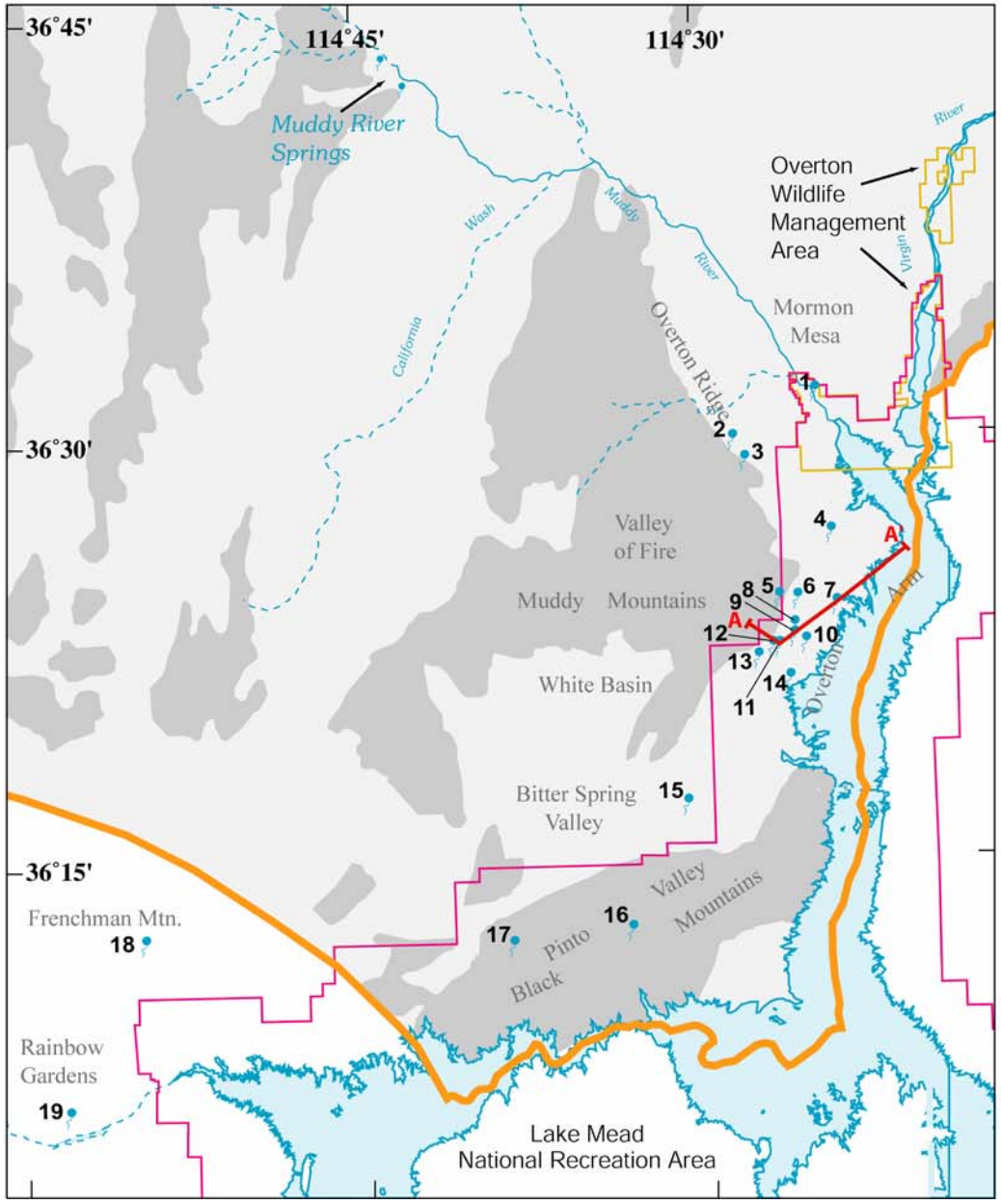
N

0 10 20

Miles

Geology modified from Plume and Carlton (1988)
Base modified from USGS digital data, 1:100,000

Springs in the Overton Arm Area of Lake Mead



EXPLANATION

- Study Area
- Trace of Cross Section
- Spring
- Consolidated Rock
- Basin Fill

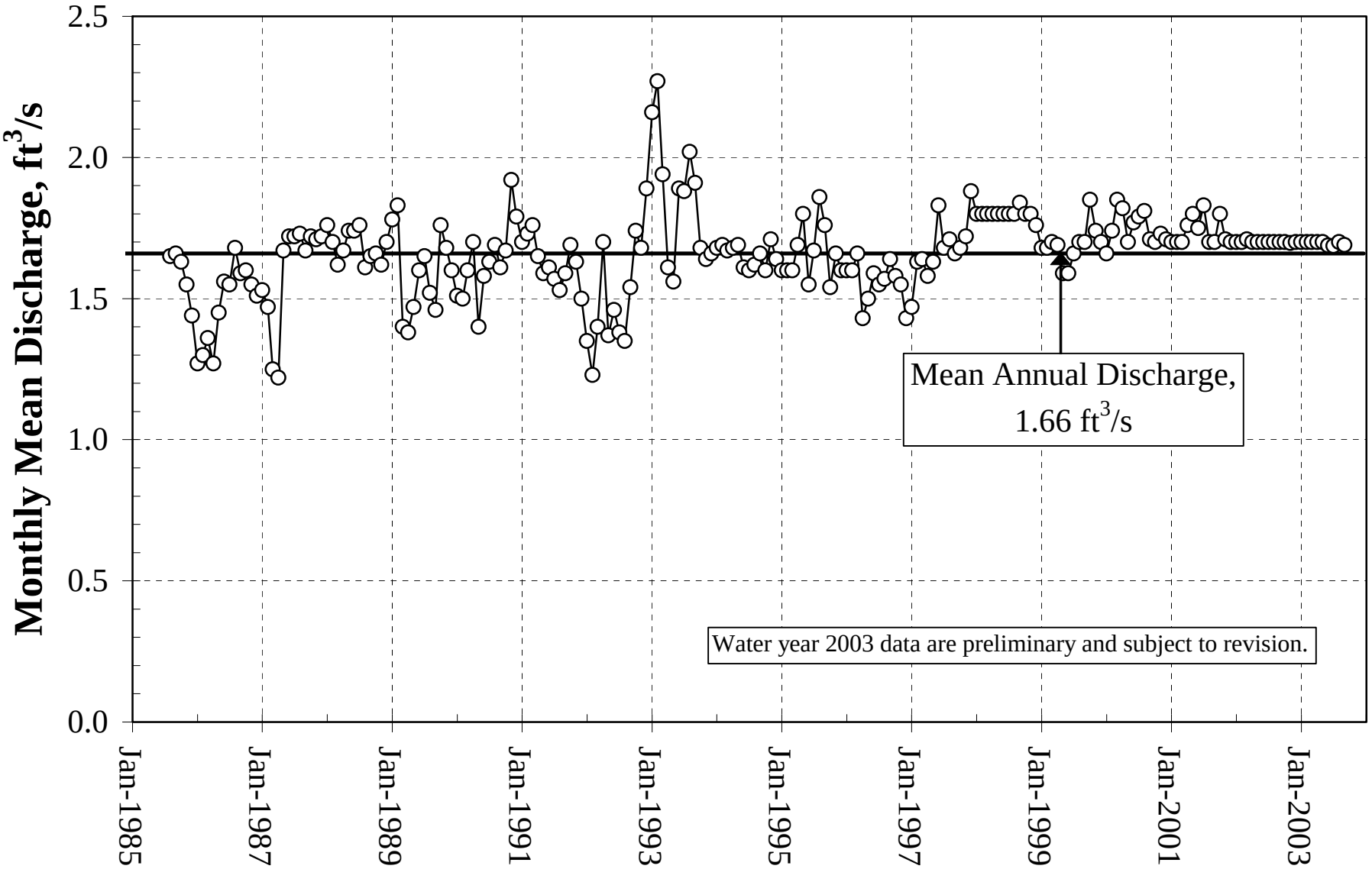
0 10

Miles

Geology modified from Plume and Carlton (1988)

Base modified from USGS digital data, 1:100,000 and USGS GAP Analysis data.

Rogers Spring Discharge, 1985 - 2003



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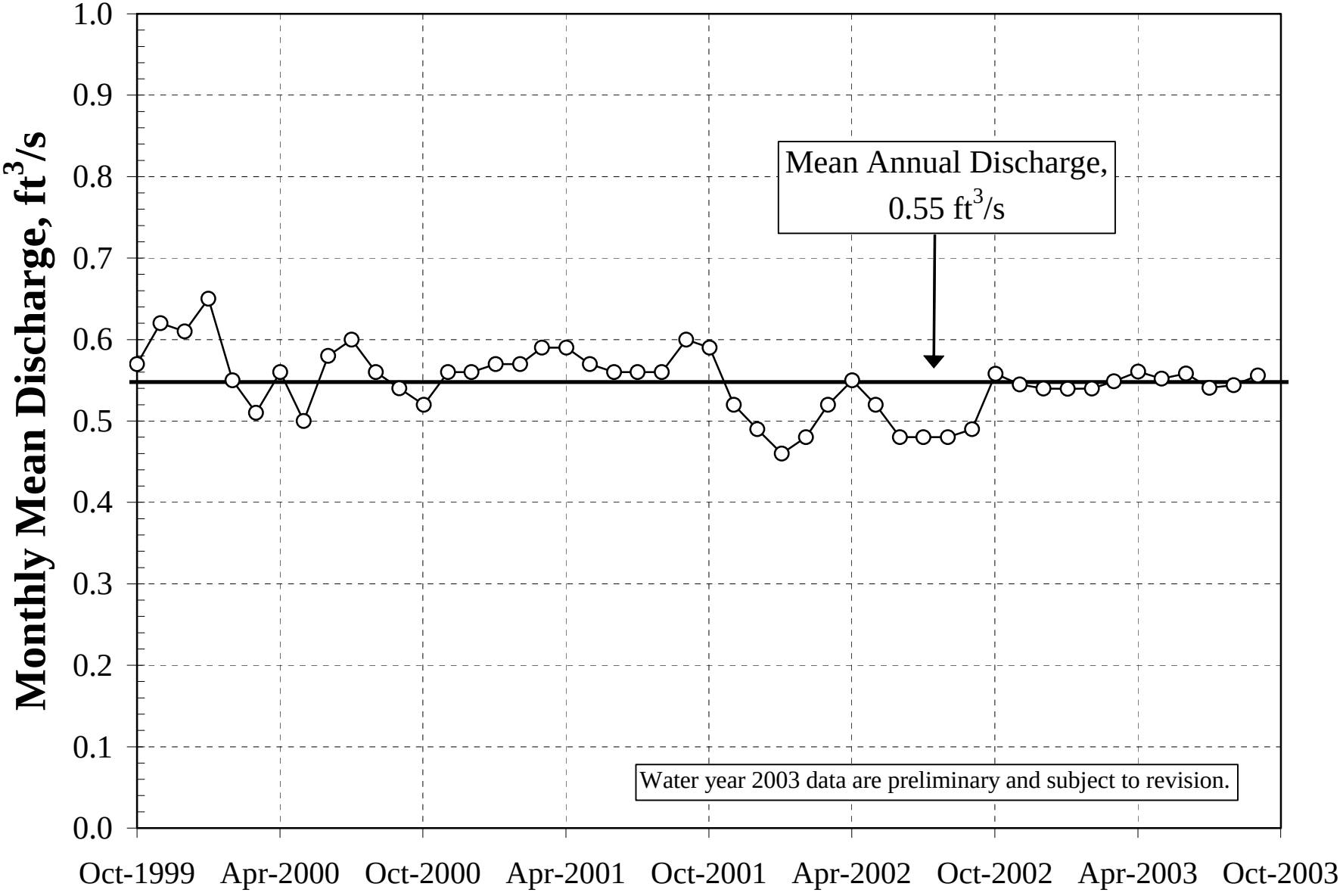
Blue Point Spring Discharge, 1999 - 2003



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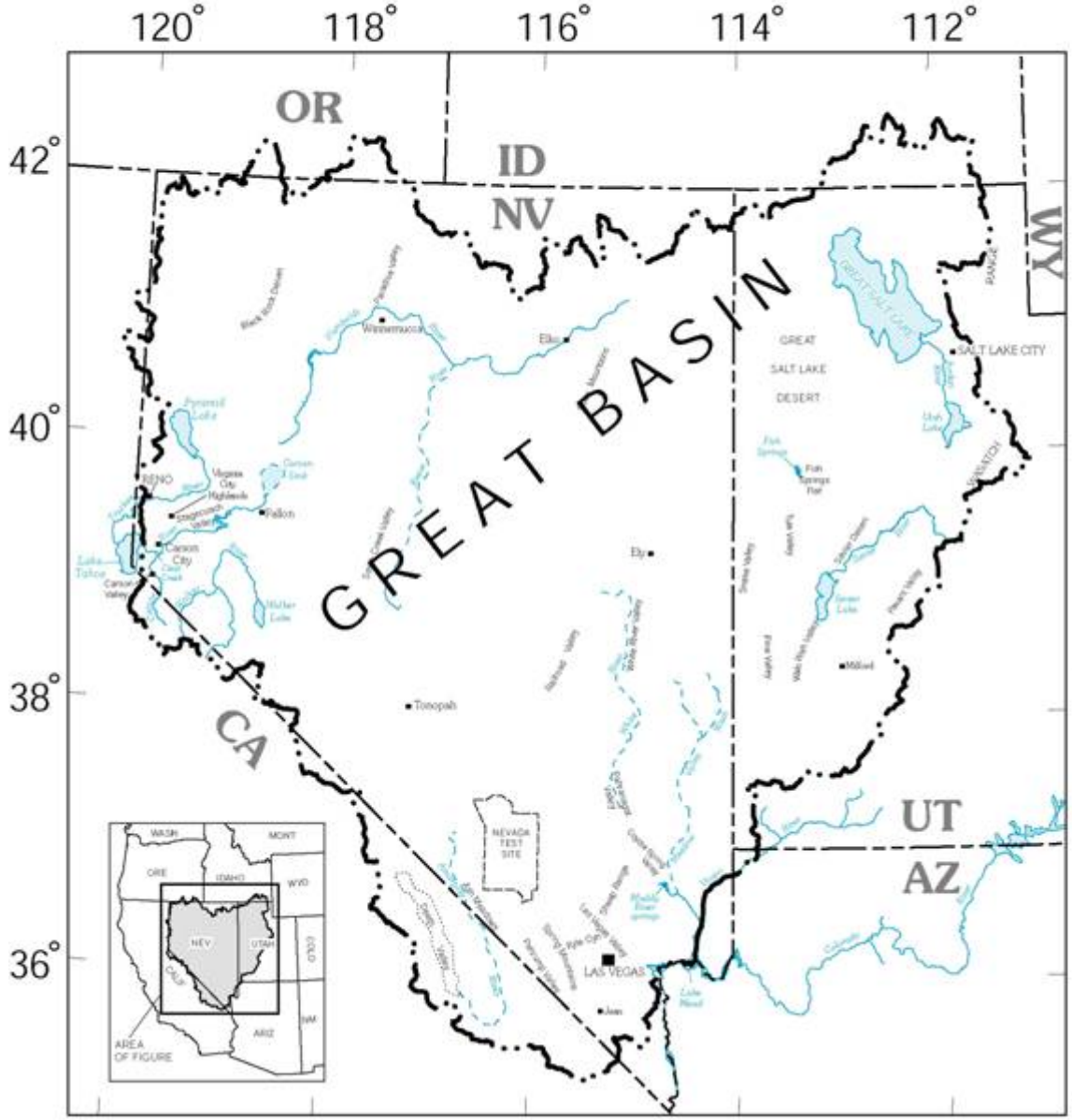
Overview of Regional Aquifer System

- Great Basin Regional Aquifer System
- Colorado Regional Ground-Water Flow System of Nevada
- Lower Colorado Flow System
- LAME Water Resources

Great Basin Regional Aquifer System



EXPLANATION

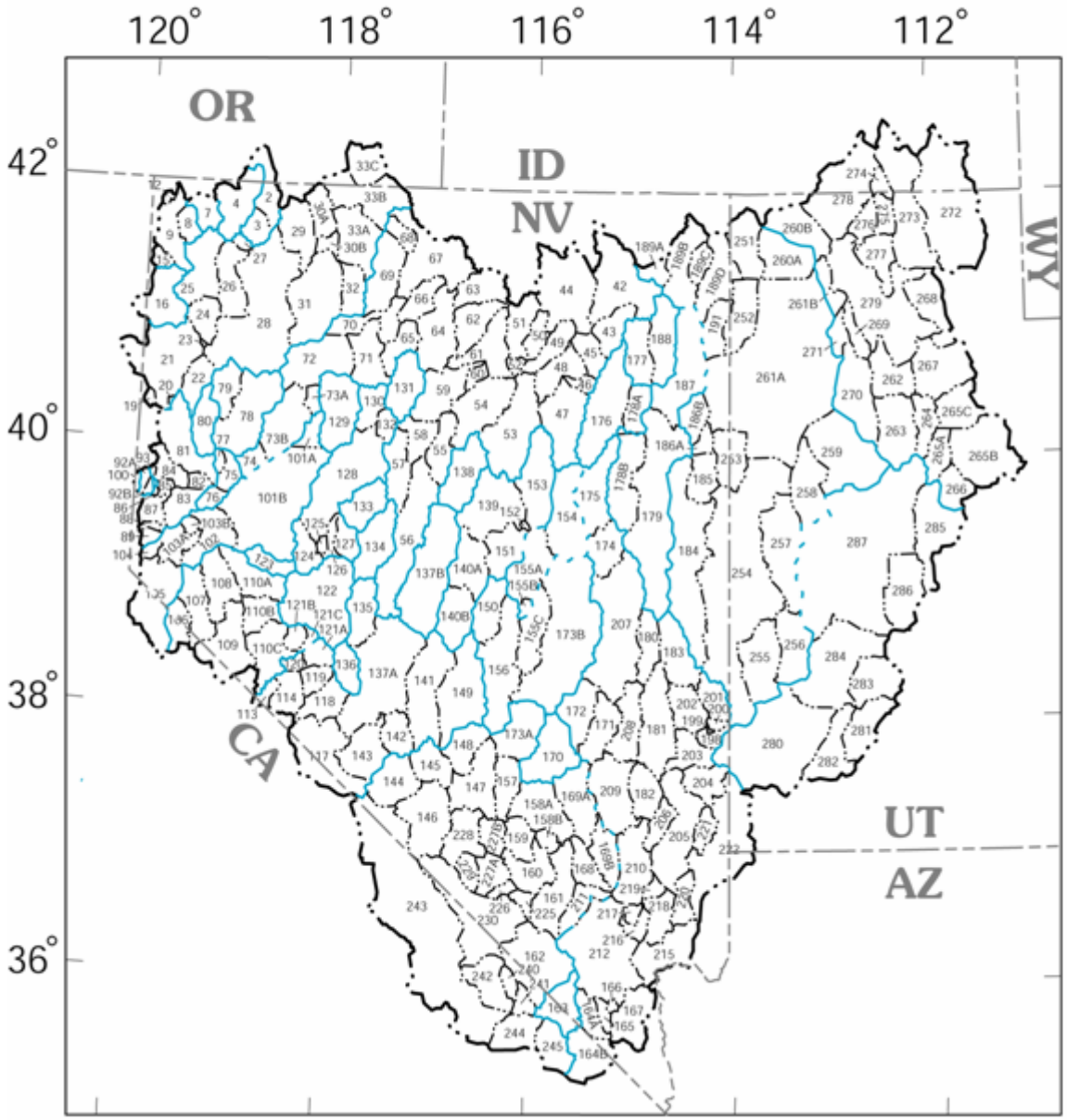
Great Basin Regional Aquifer System

0 50 100 MILES

0 50 100 KILOMETERS

Figure modified from USGS (Harrill and Prudic, 1998).

Hydrographic Areas



EXPLANATION

Boundary of major flow system

Boundary of hydrographic area

0 50 100 MILES

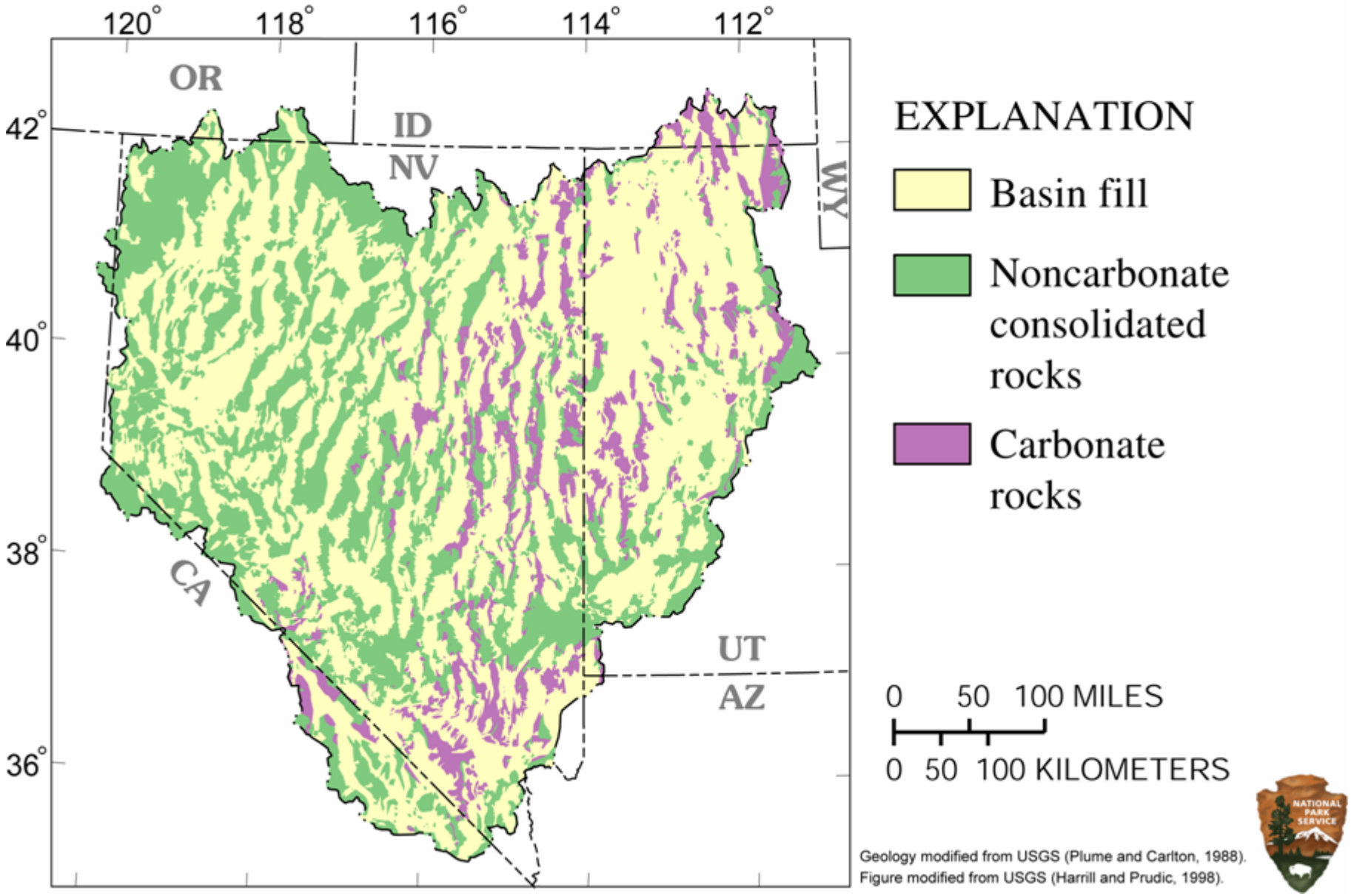
0 50 100 KILOMETERS

Figure modified from USGS (Harrill and Prudic, 1998).

Principal Aquifer Types

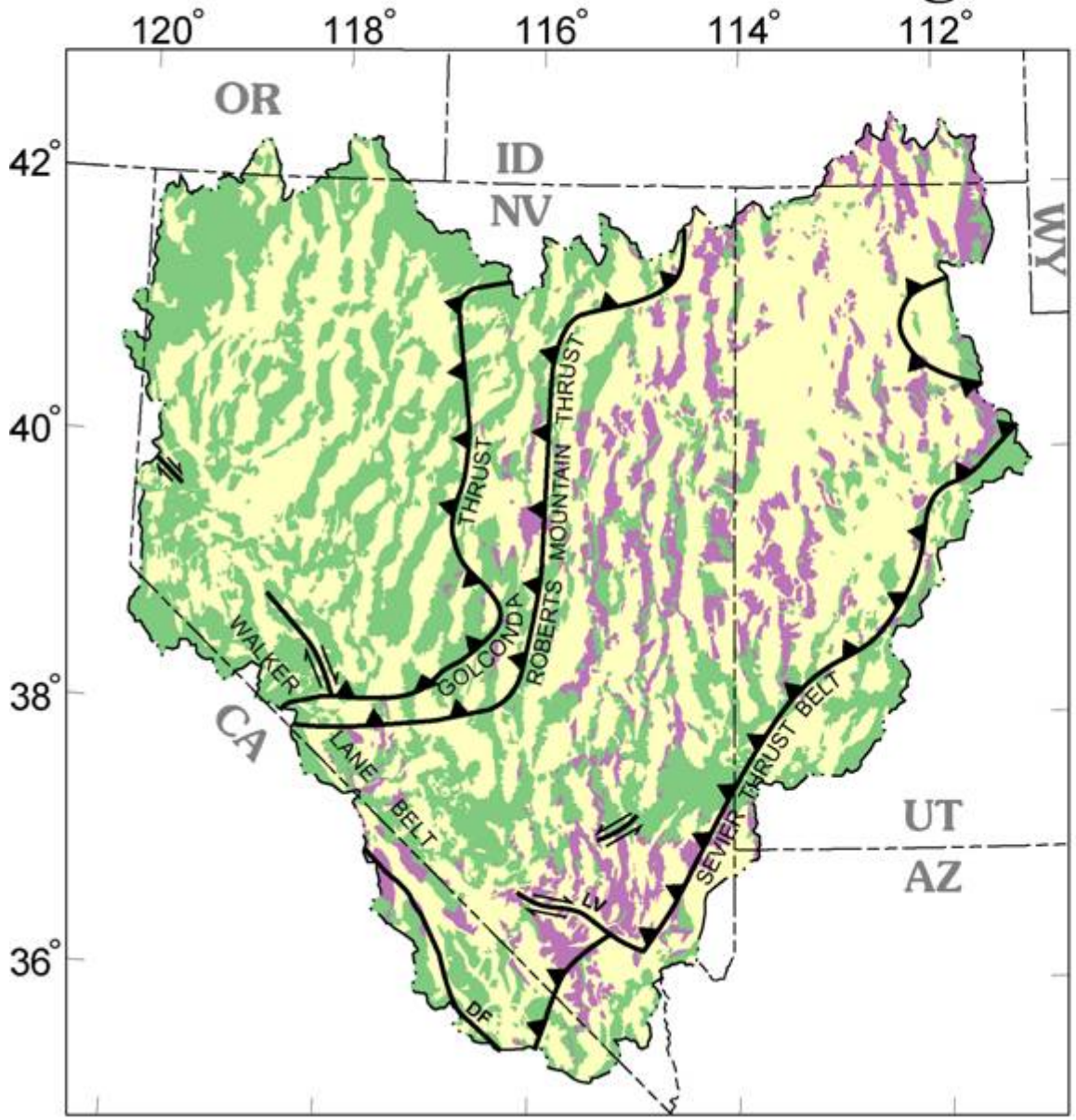
- Basin-Fill Aquifers
- Regional Carbonate-Rock Aquifer

Generalized Hydrogeologic Units



Geology modified from USGS (Plume and Carlton, 1988).
Figure modified from USGS (Harrill and Prudic, 1998).

Generalized Hydrogeologic Units and Selected Geologic Features



EXPLANATION

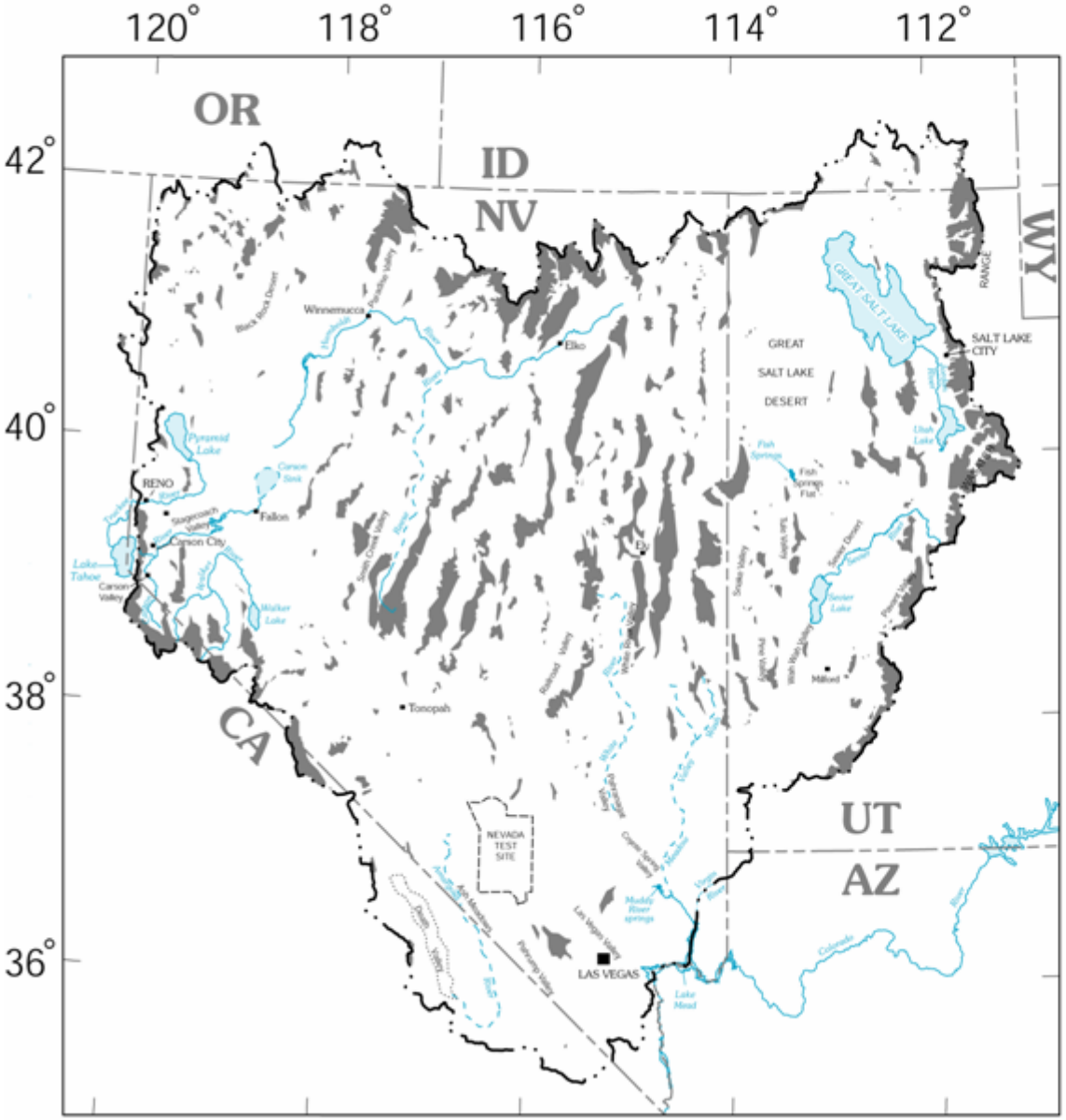
- Basin fill
- Noncarbonate consolidated rocks
- Carbonate rocks
- Thrust fault
- Strike-slip fault

0 50 100 MILES

0 50 100 KILOMETERS

Geology modified from USGS (Plume and Carlton, 1988).
Figure modified from USGS (Harrill and Prudic, 1998).

Source Areas of Ground-Water Recharge



EXPLANATION

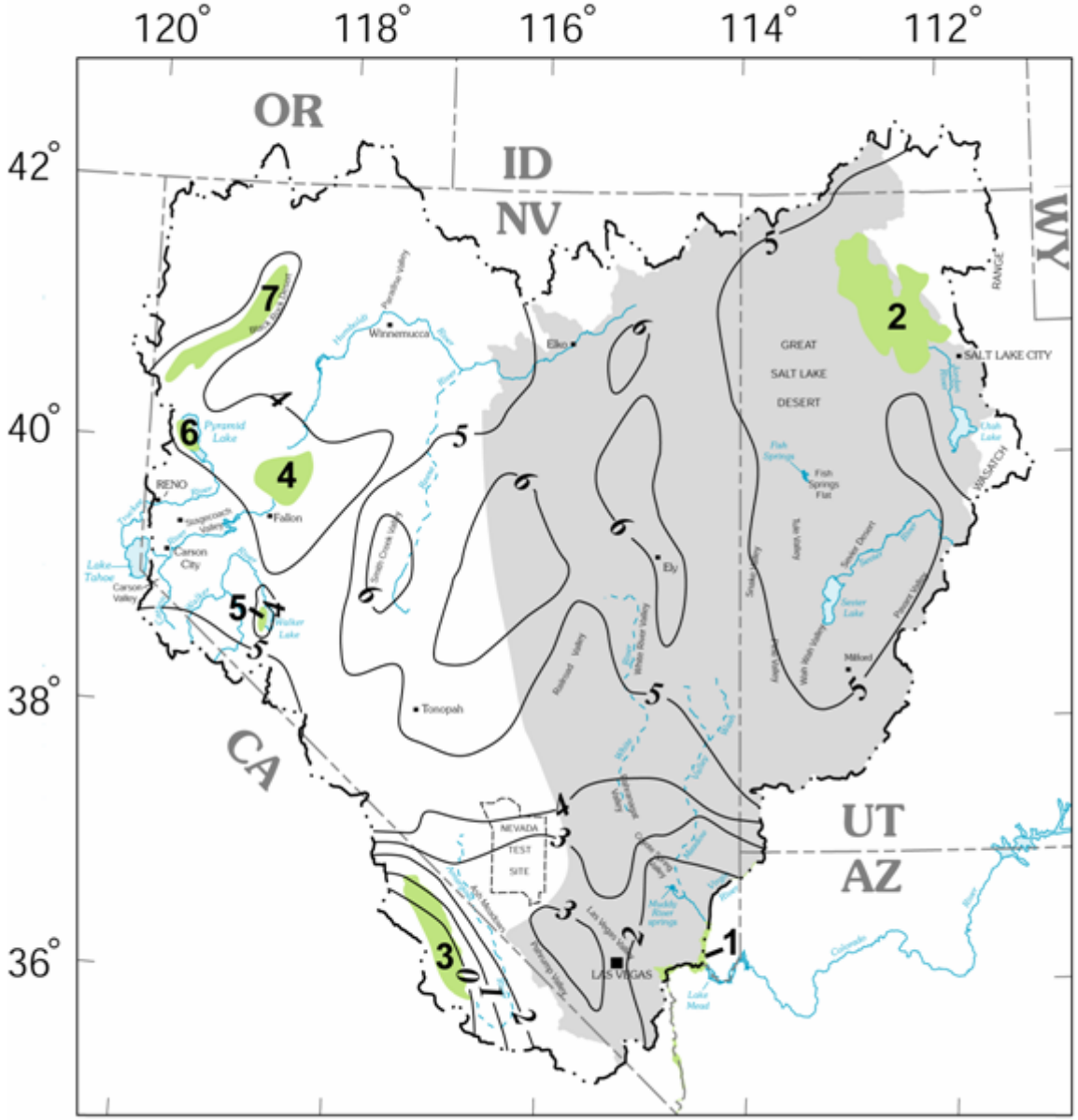
Major source area for ground-water recharge

0 50 100 MILES

0 50 100 KILOMETERS

Figure modified from USGS (Harrill and Prudic, 1998).

Regional Ground-Water Flow Potential



EXPLANATION

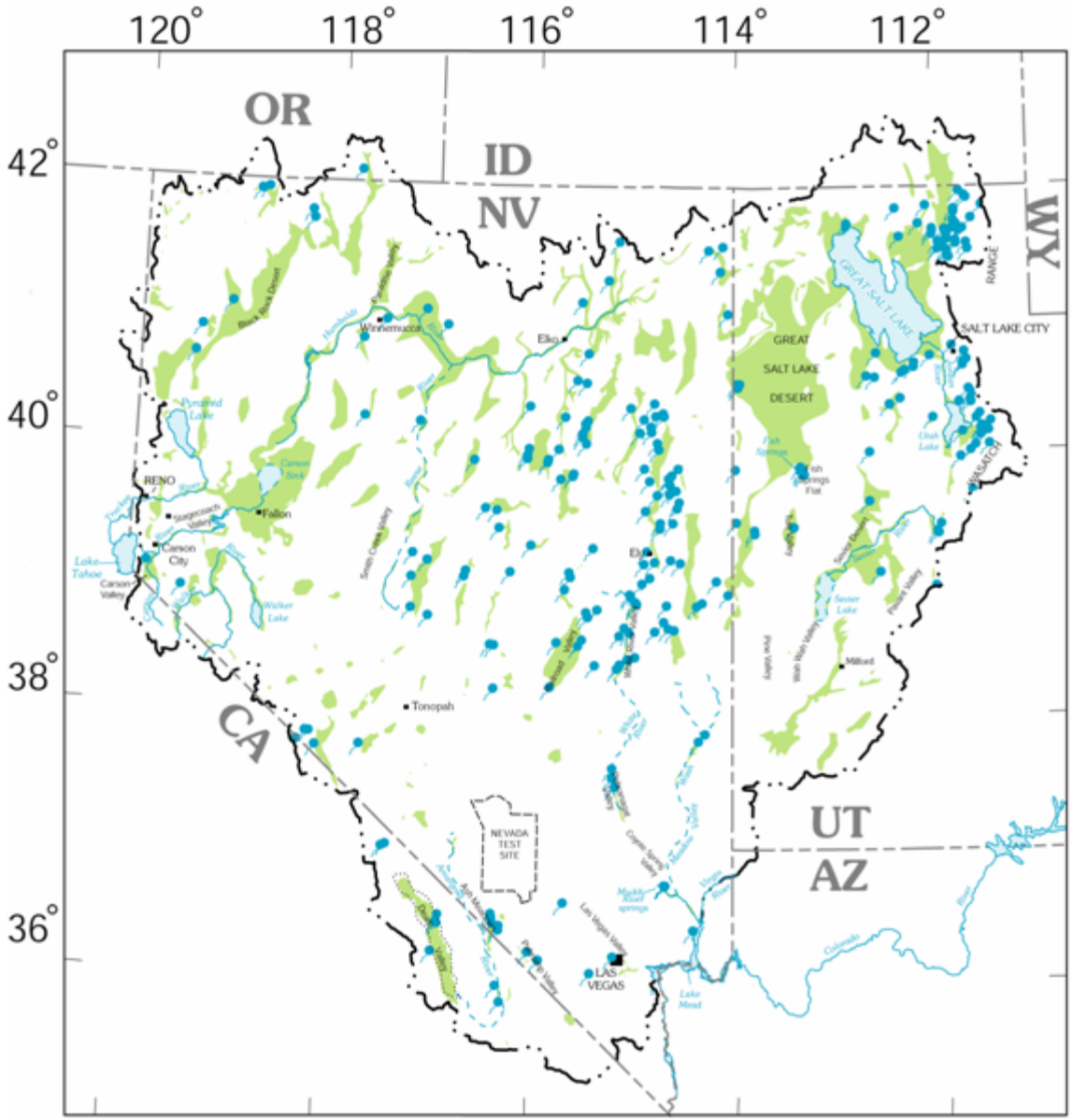
- Carbonate-rock province
- Regional-discharge area
- −3− Line of equal regional-flow potential

0 50 100 MILES

0 50 100 KILOMETERS

Figure modified from USGS (Harrill and Prudic, 199

Location of Ground-Water Discharge



EXPLANATION

Area of shallow ground-water discharge by evapotranspiration

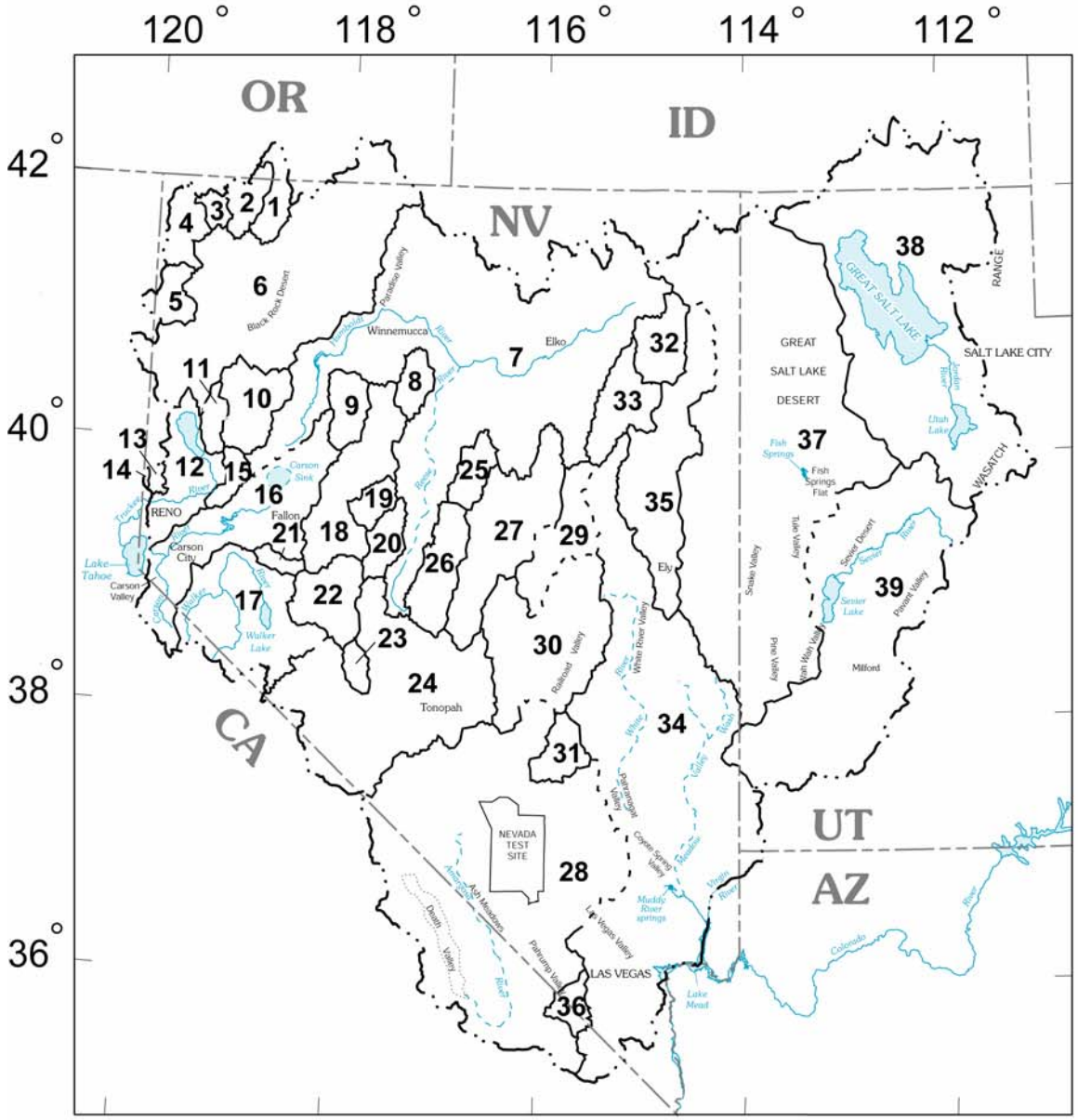
Large spring

0 50 100 MILES

0 50 100 KILOMETERS

Figure modified from USGS (Harrill and Prudic, 1998).

Major Ground-Water Flow Systems



EXPLANATION

— Boundary of major flow system

0 50 100 MILES

0 50 100 KILOMETERS

Figure modified from USGS (Harrill and Prudic, 199

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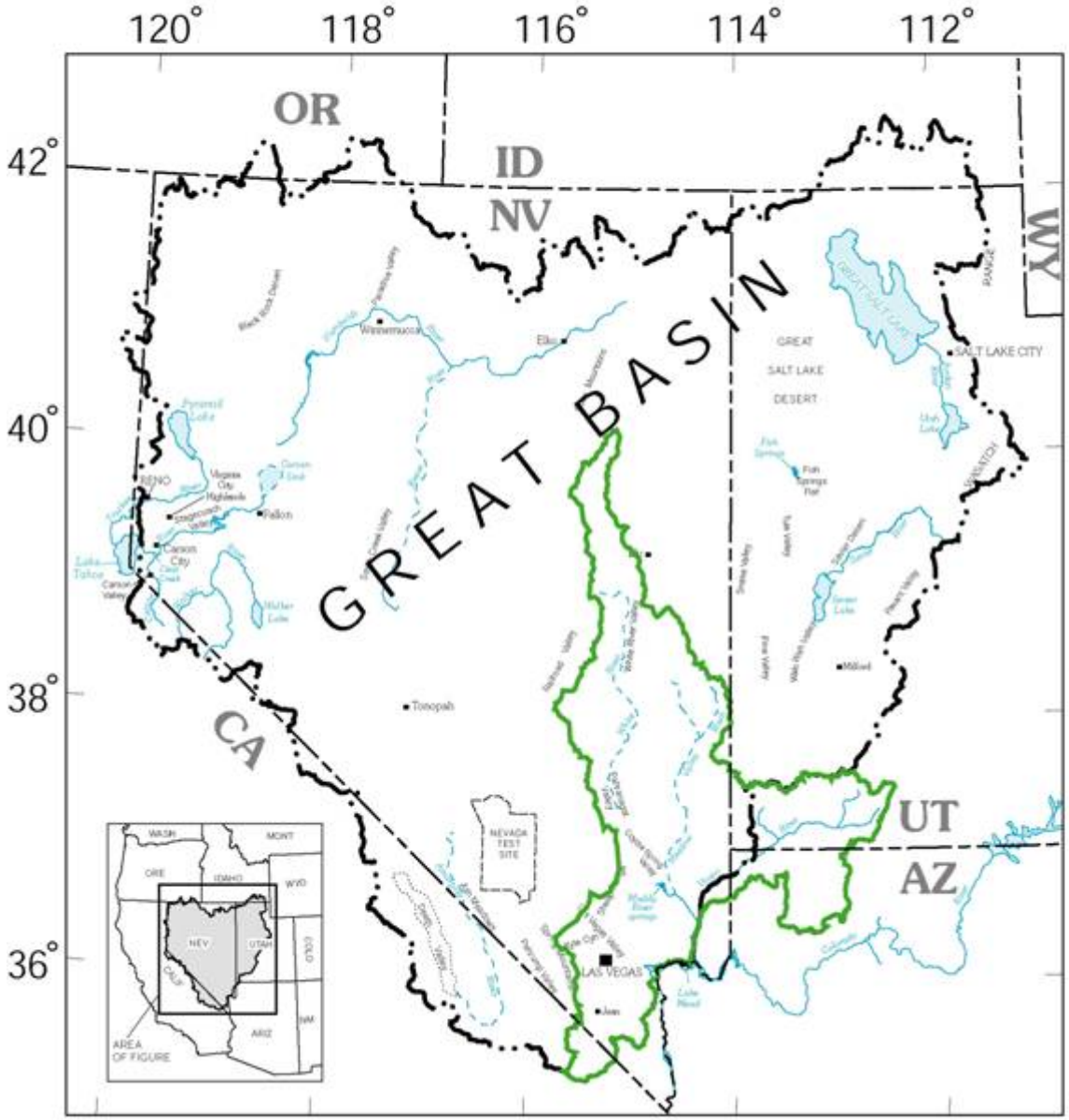
The Colorado Flow System of Nevada



EXPLANATION

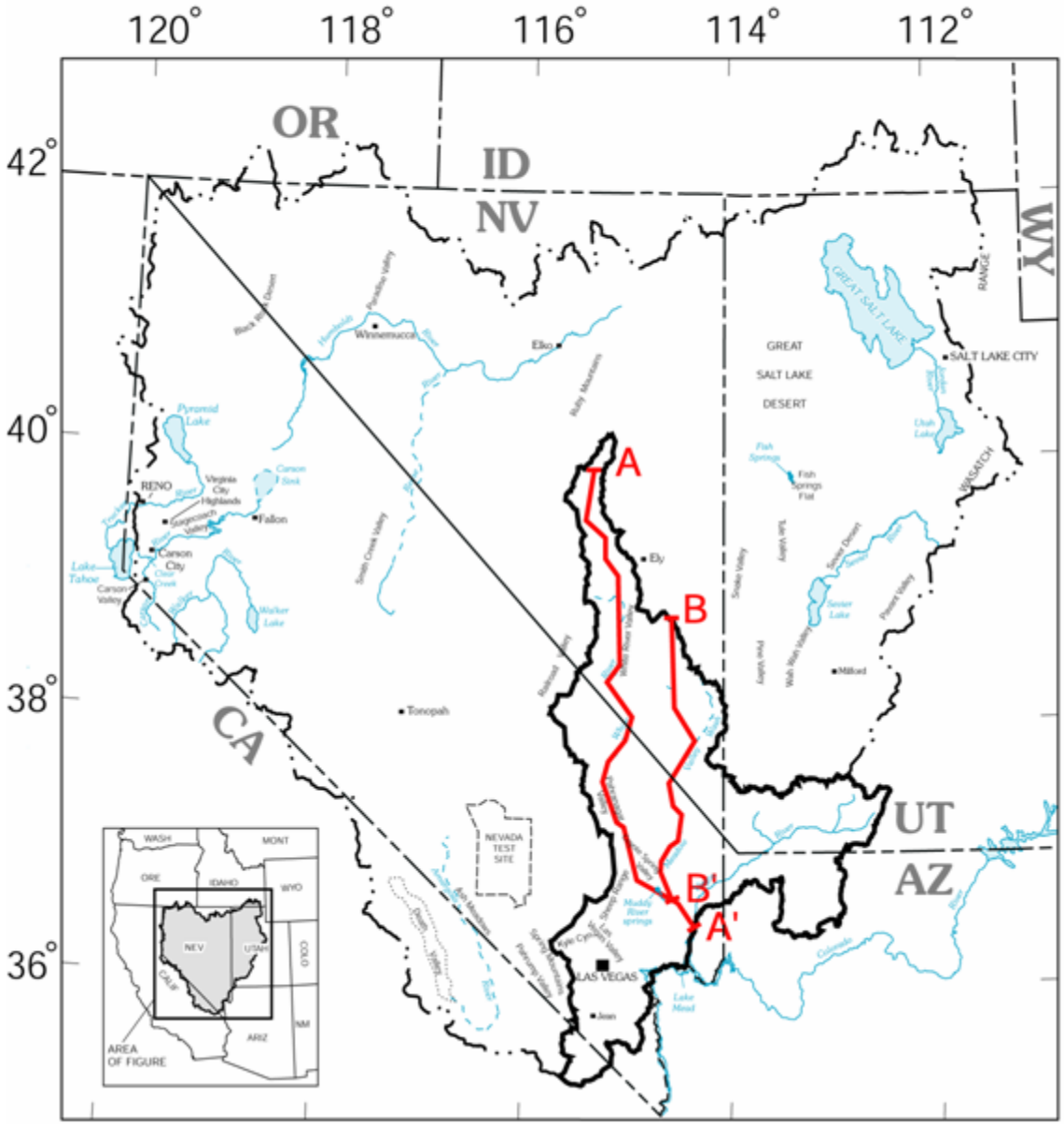
- Great Basin Regional Aquifer System
- Colorado Regional Ground Water Flow System

0 50 100 MILES

0 50 100 KILOMETERS

Figure modified from USGS (Harrill and Prudic, 1998).

Trace of Cross Sections A-A' and B-B'



EXPLANATION

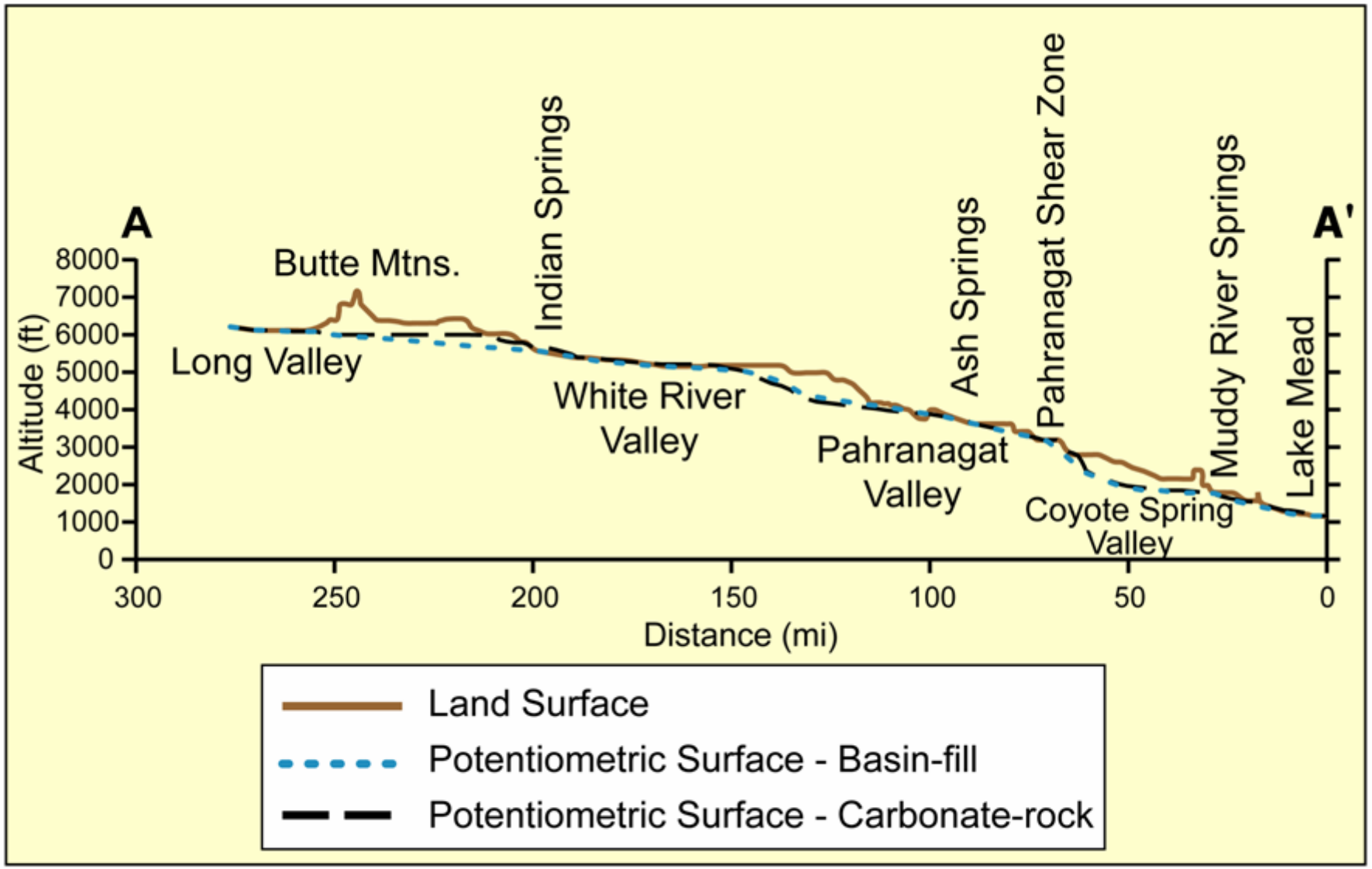
- Colorado Regional Ground Water Flow System
- Trace of Cross Section

0 50 100 MILES

0 50 100 KILOMETERS

Figure modified from USGS (Harrill and Prudic, 1998).

Cross-Sectional Diagram A-A' - White River Drainage

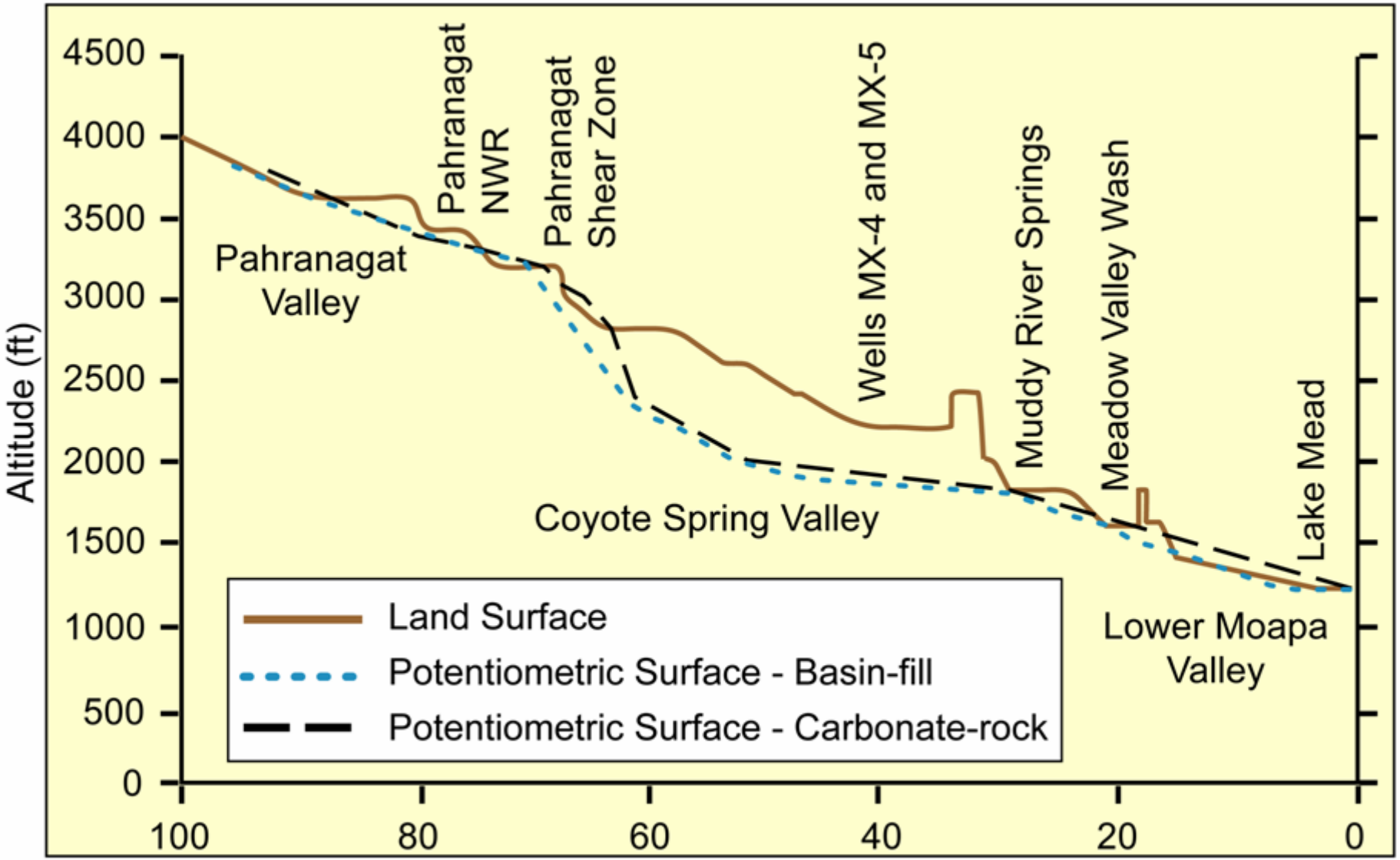


Land surface from USGS topographic maps, 1:250,000

Potentiometric-surface from USGS HA-694-B (Thomas and others, 1986)

Vertical Exaggeration = 50x

Cross-Sectional Diagram - Lower White River Drainage

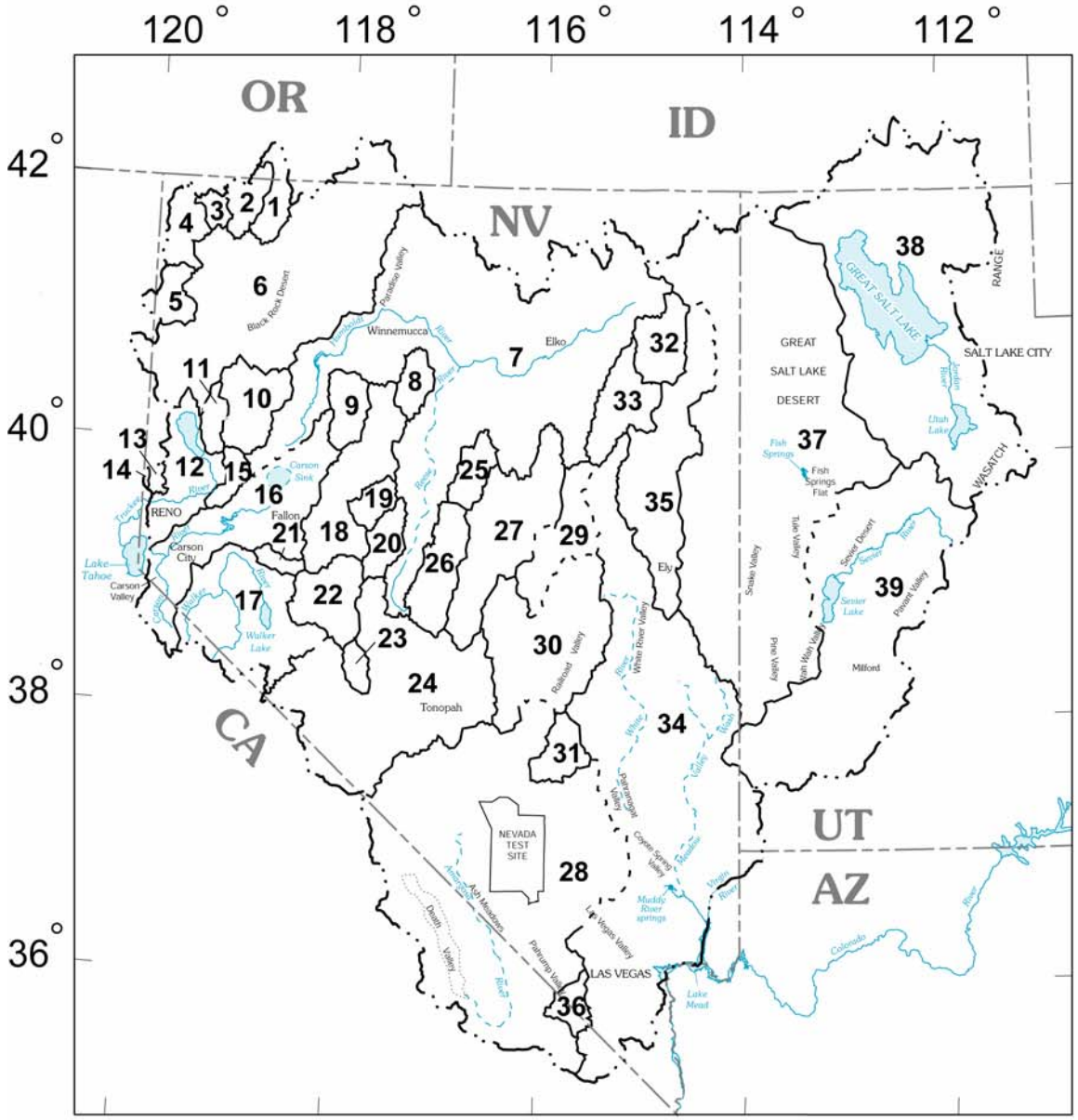


Land surface from USGS topographic maps, 1:250,000

Potentiometric-surface from USGS HA-694-B (Thomas and others, 1986)

Vertical Exaggeration = 75x

Major Ground-Water Flow Systems



EXPLANATION

— Boundary of major flow system

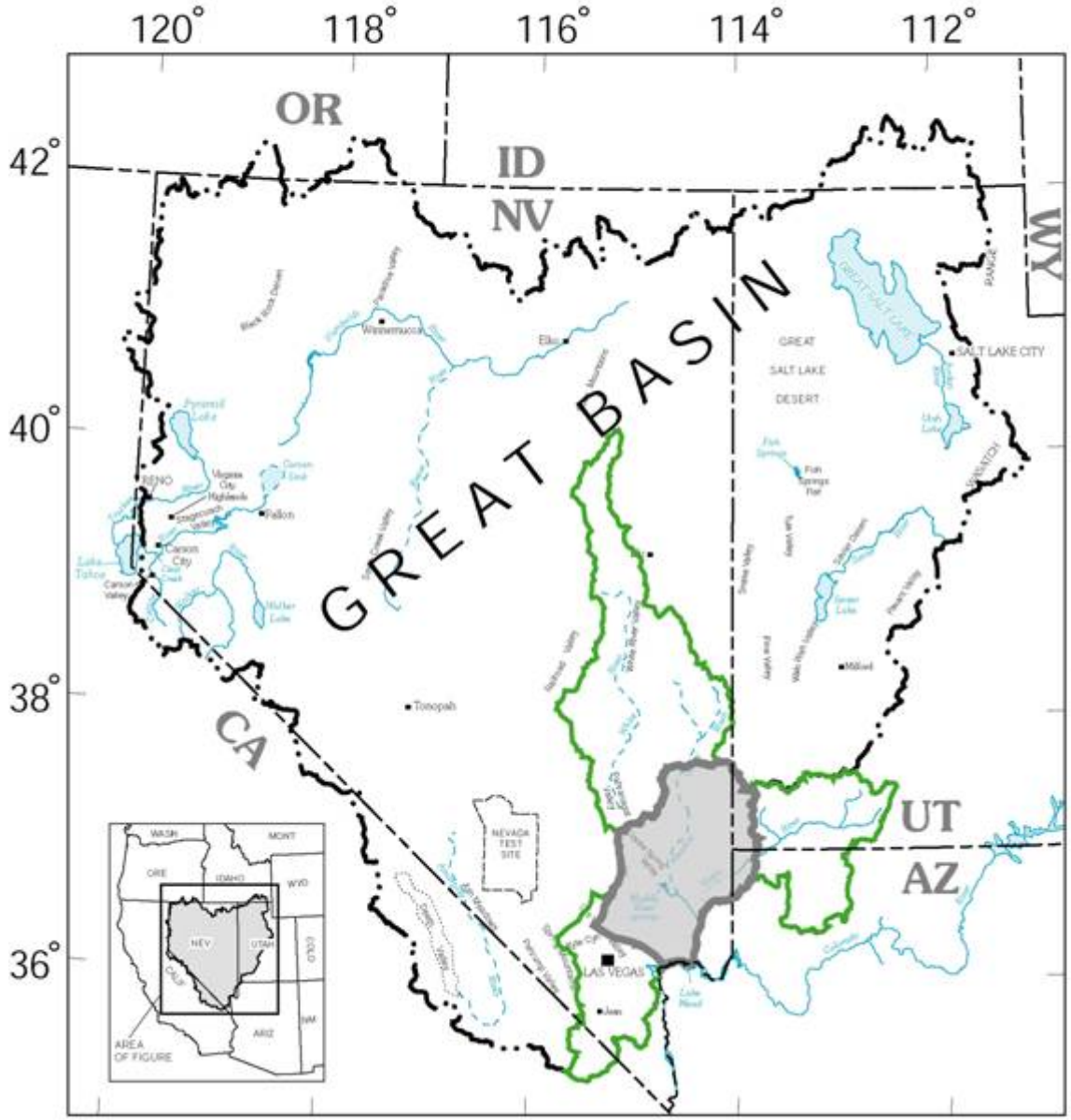
0 50 100 MILES

0 50 100 KILOMETERS

Figure modified from USGS (Harrill and Prudic, 199

NATIONAL PARK SERVICE

The Lower Colorado Flow System of Nevada



EXPLANATION

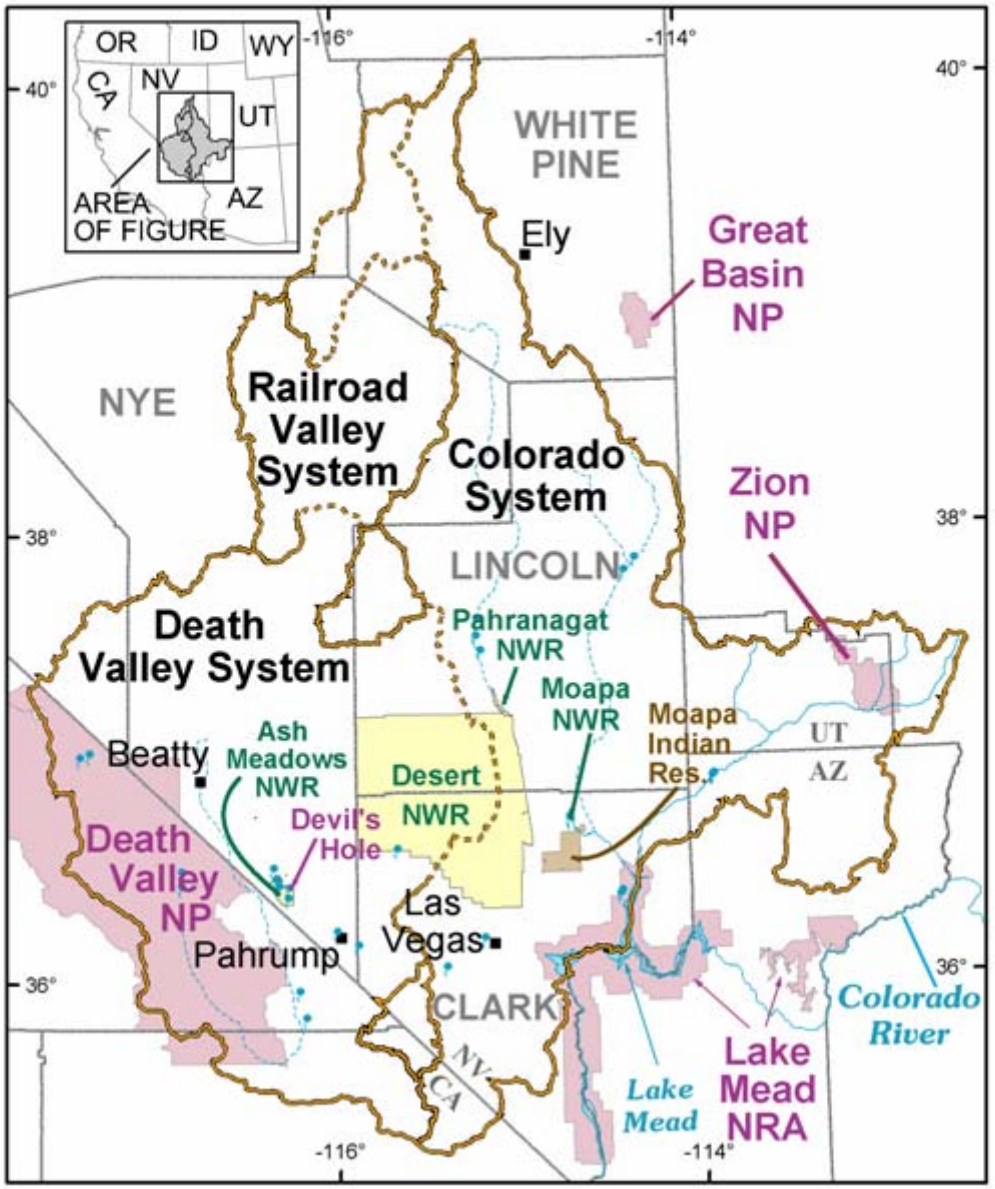
- Great Basin Regional Aquifer System
- Colorado Regional Ground Water Flow System
- Lower Colorado Flow System

0 50 100 MILES

0 50 100 KILOMETERS

Figure modified from USGS (Harrill and Prudic, 1998).

Major Ground-Water Flow Systems in Southern Nevada



EXPLANATION

- Boundary of major flow system -- Dashed where uncertain
- Intermittent Streams
- Perennial Streams
- Spring

N

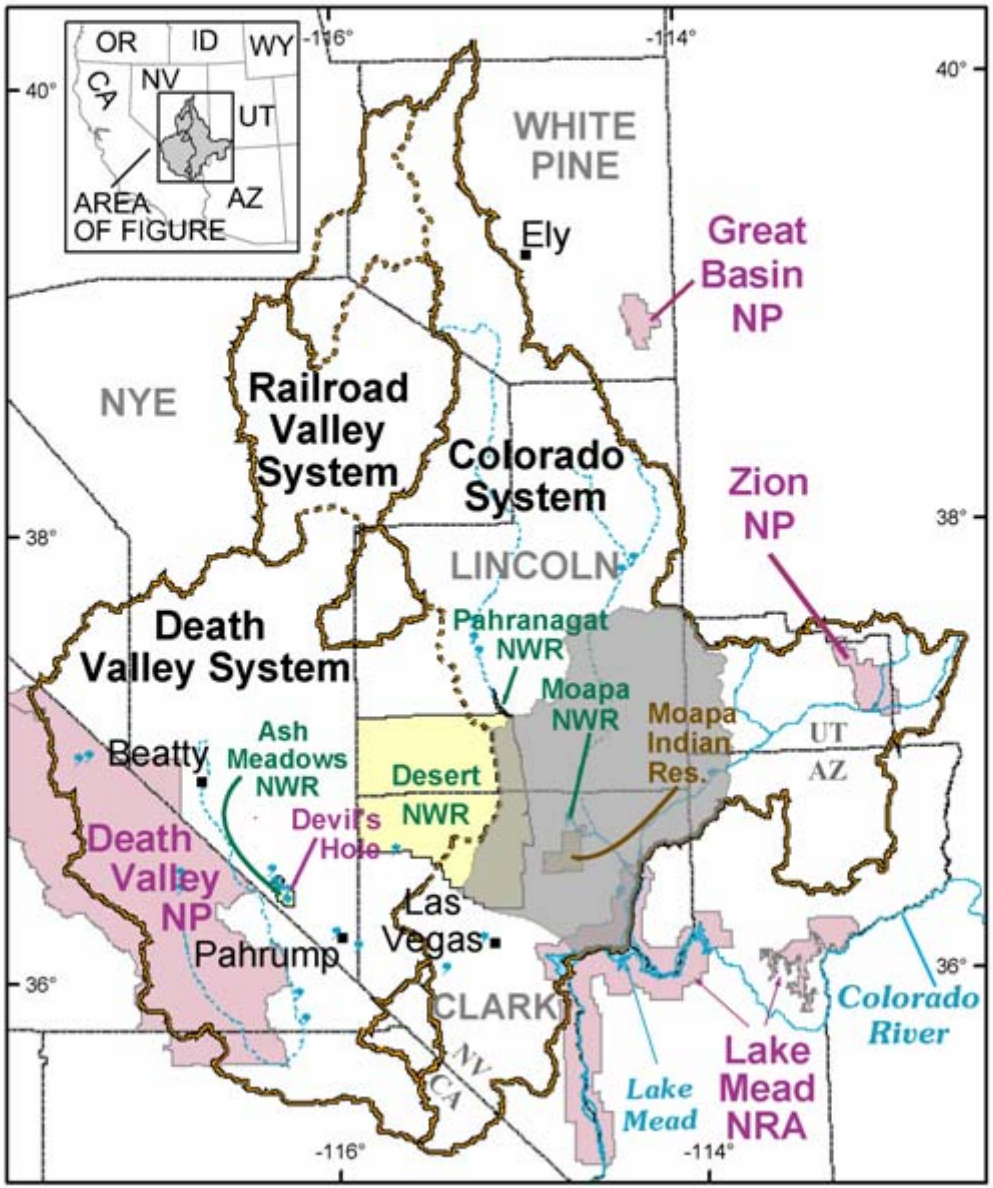
0 50 100

Miles

Flow systems modified from Harrill and Prudic (1998).

Base modified from USGS digital data, 1:100,000, and other sources.

Location of the Lower Colorado Flow System



EXPLANATION

- Boundary of major flow system -- Dashed where uncertain
- Intermittent Streams
- Perennial Streams
- Spring
- Lower Colorado Flow System

N

0 50 100

Miles

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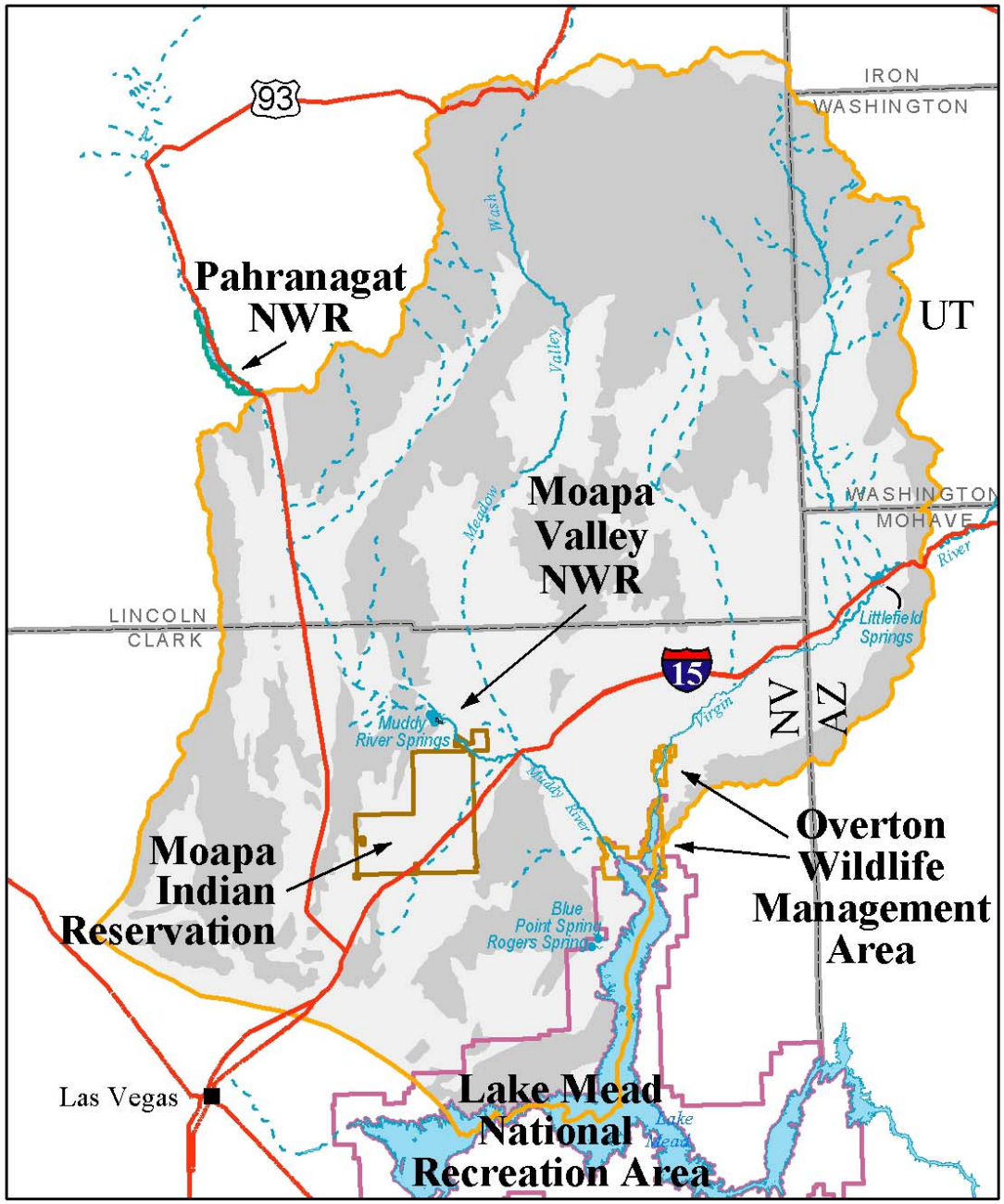
Base modified from USGS digital data, 1:100,000, and other sources.

Selected Public Land Units of Interest



EXPLANATION

- Basin Fill
- Consolidated Rock
- Lower Colorado Flow System
- Spring
- Intermittent Stream
- Perennial Stream
- NWR National Wildlife Refuge

Geology modified from Plume and Carlton (1988)

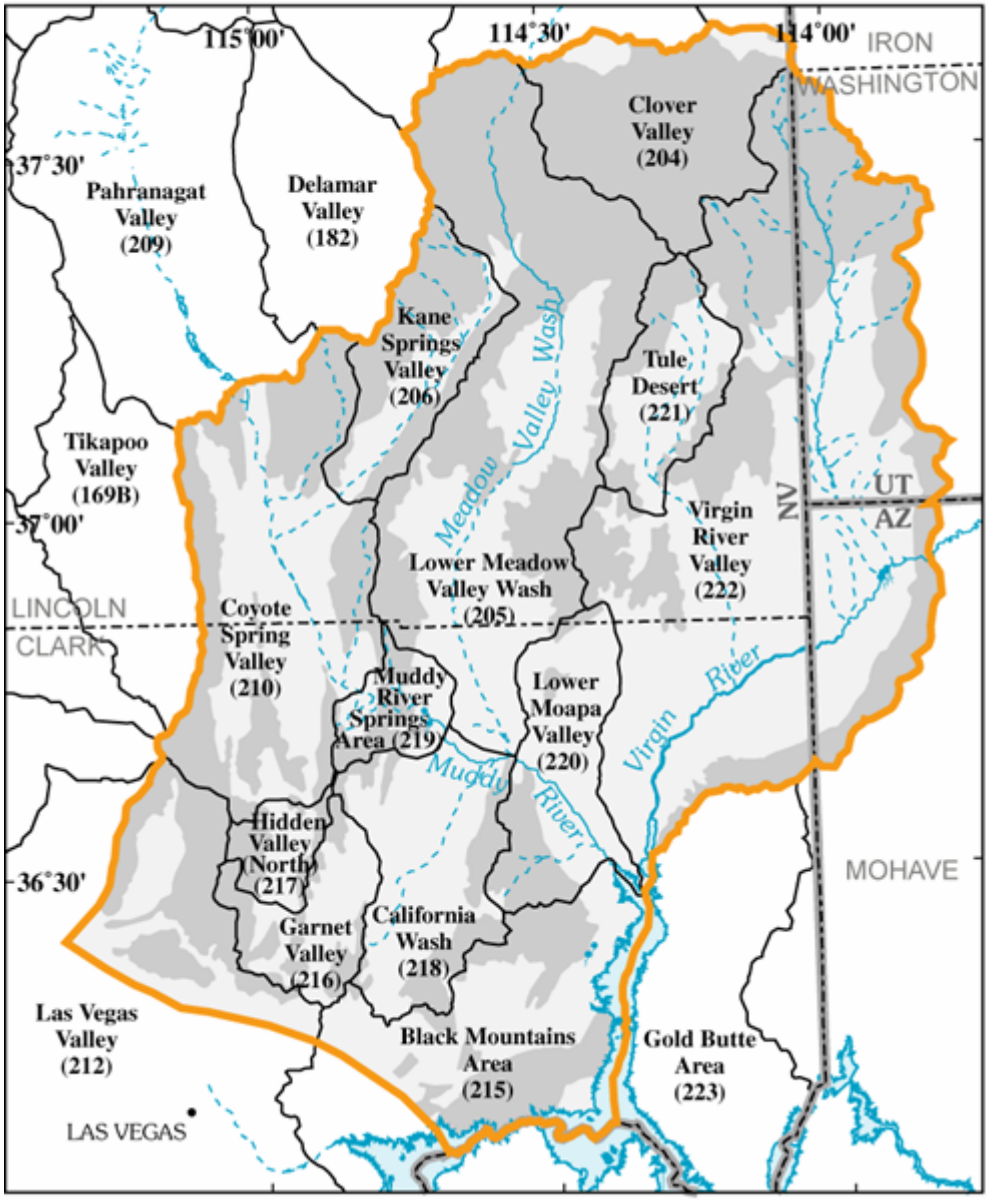
Base modified from USGS digital data, 1:100,000 and USGS GAP Analysis data.

N

0 5 10

Miles

Hydrographic Basins



EXPLANATION

- Study Area
- Spring
- Consolidated Rock
- Basin Fill
- Hydrographic Basin

0 20

Miles

Geology modified from Plume and Carlton (1988)

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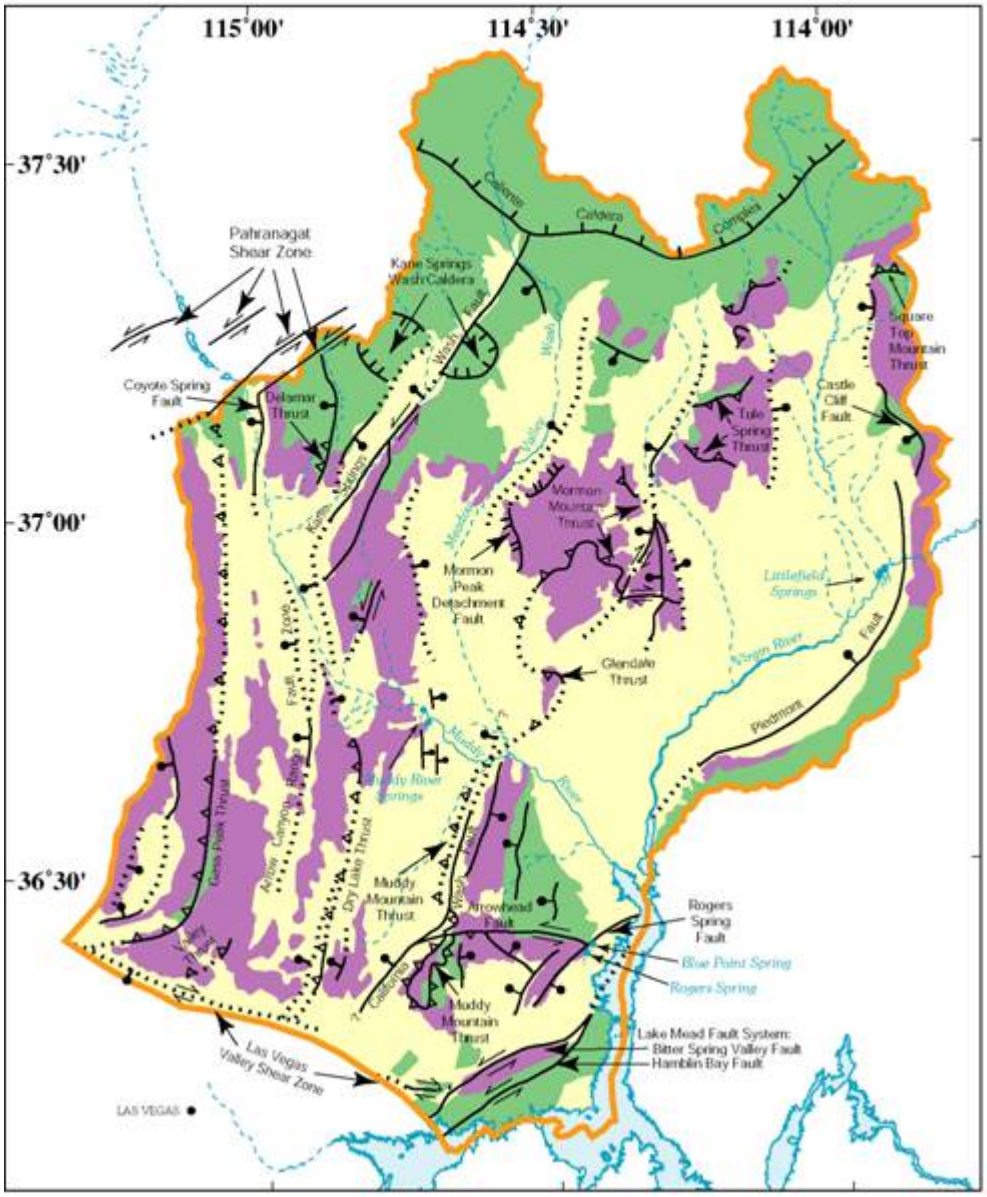
Major Structural Elements and Generalized Hydrogeologic Units



Study Area

High-angle normal fault

Thrust fault

Strike-slip fault

Detachment fault

Oblique-slip fault

Thrust fault reactivated by normal or strike-slip fault

Caldera

Carbonate rocks

Basin Fill

Noncarbonate consolidated rocks

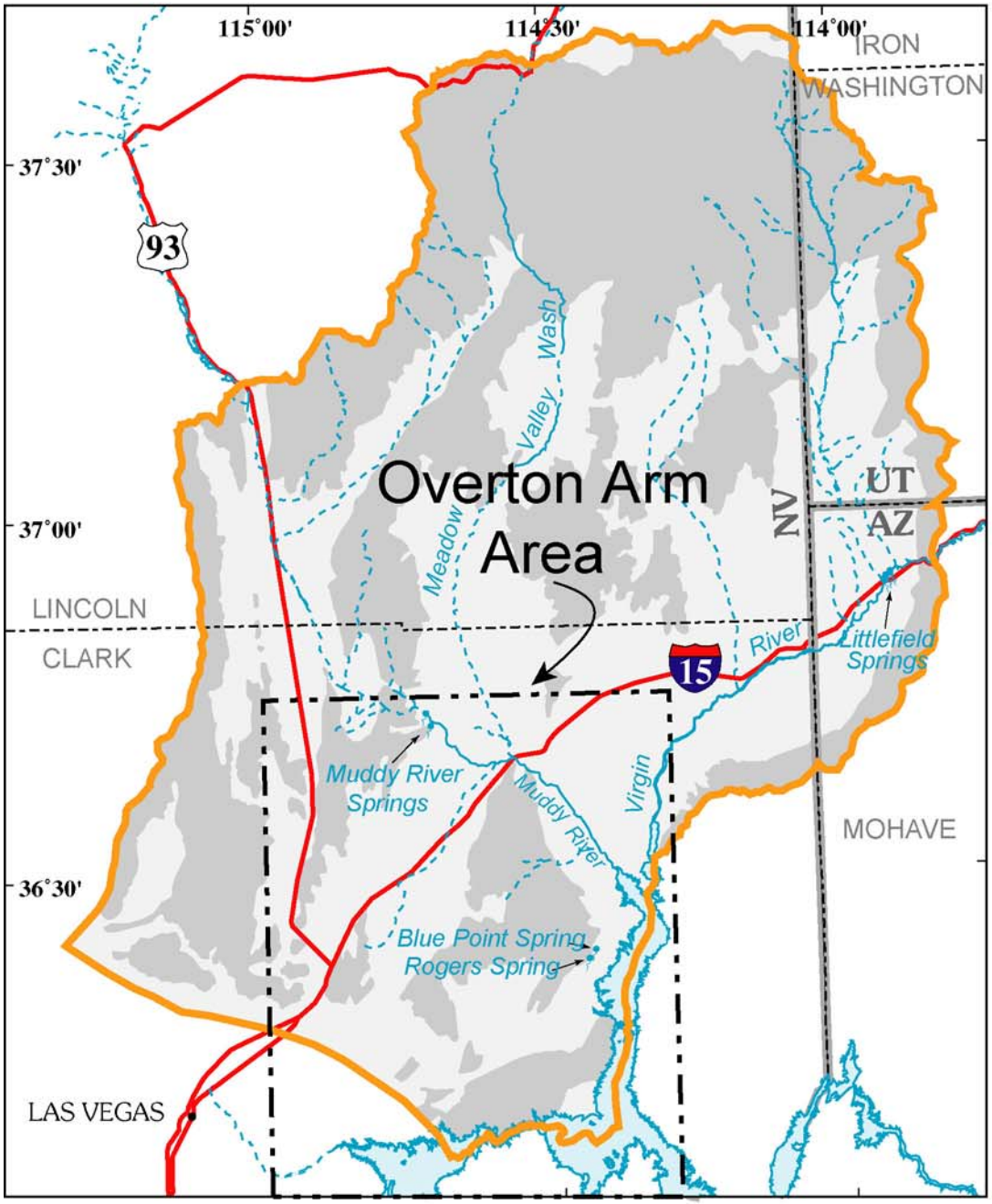
0 20

Miles

Geology modified from Plume and Carlton (1988)

Base modified from USGS digital data, 1:100,000 and USGS GAP Analysis data.

Overton Arm Area



EXPLANATION

- Overton Arm area of Lake Mead National Recreation Area
- Intermittent Stream
- Perennial Stream
- Lower Colorado Flow System
- Consolidated Rock
- Basin Fill
- Spring

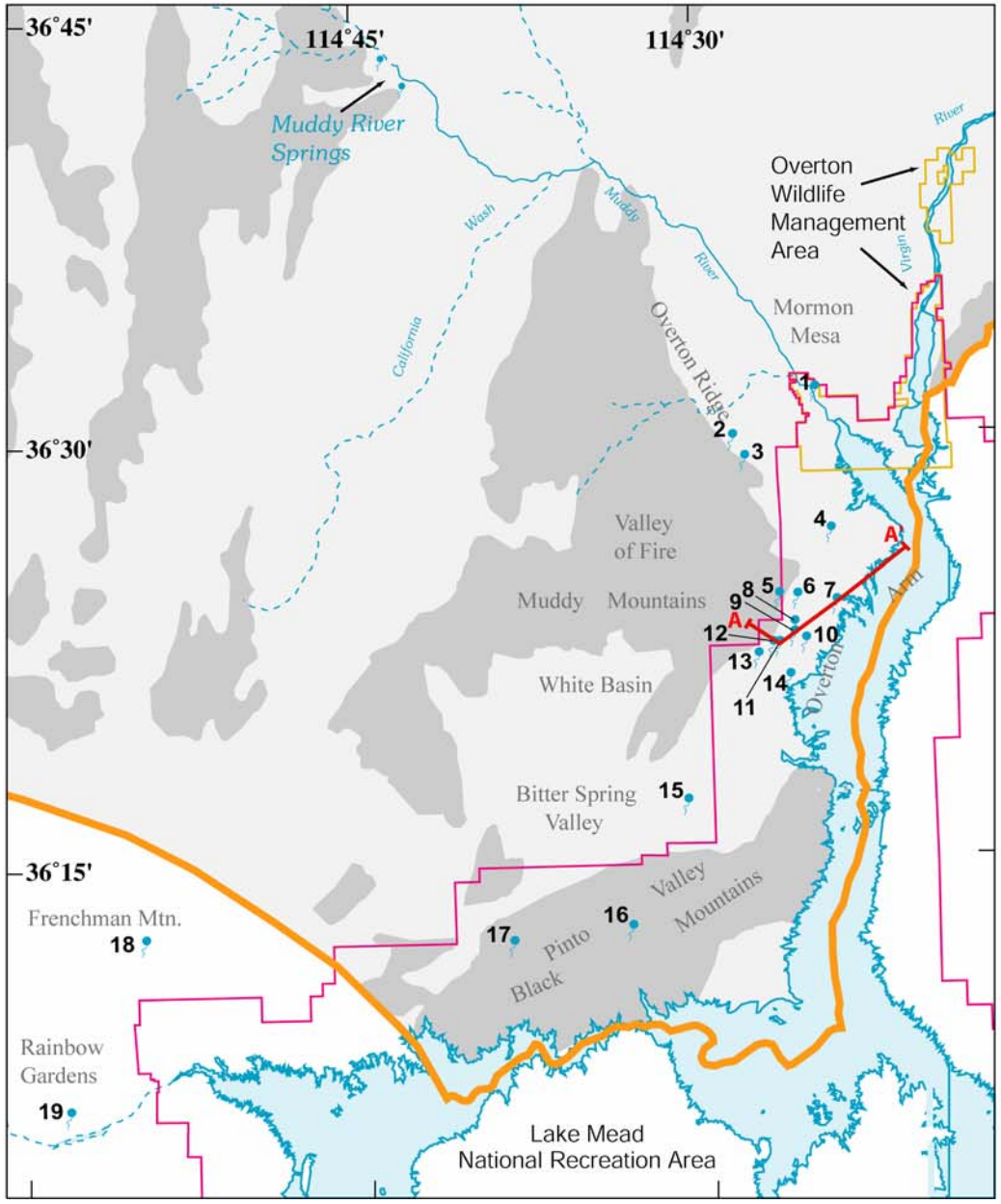
N

0 10 20

Miles

Geology modified from Plume and Carlton (1988)
Base modified from USGS digital data, 1:100,000

Springs in the Overton Arm Area of Lake Mead



EXPLANATION

- Study Area
- Trace of Cross Section
- Spring
- Consolidated Rock
- Basin Fill

0 10

Miles

Geology modified from Plume and Carlton (1988)

Base modified from USGS digital data, 1:100,000 and USGS GAP Analysis data.

Generalized Hydrogeologic Cross-section

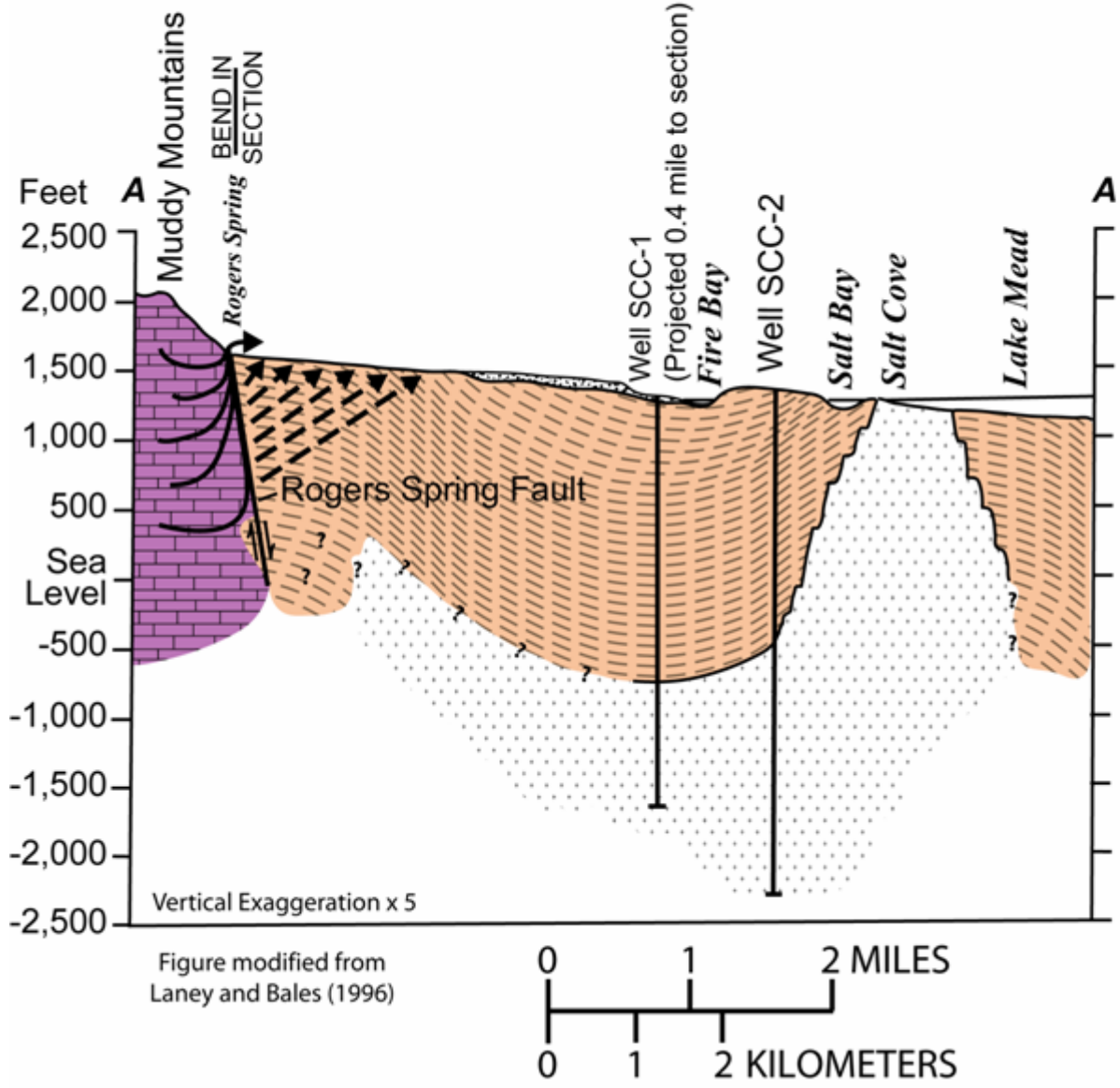


Figure modified from Laney and Bales (1996)

EXPLANATION

OLDER ALLUVIUM
Silty sand and gravel

MUDDY CREEK FORMATION
Clay, shale, siltstone, and gypsum

Halite

PALEOZOIC AND MESOZOIC SEDIMENTARY ROCKS, UNDIFFERENTIATED
Limestone and dolomite

GEOLOGIC CONTACT

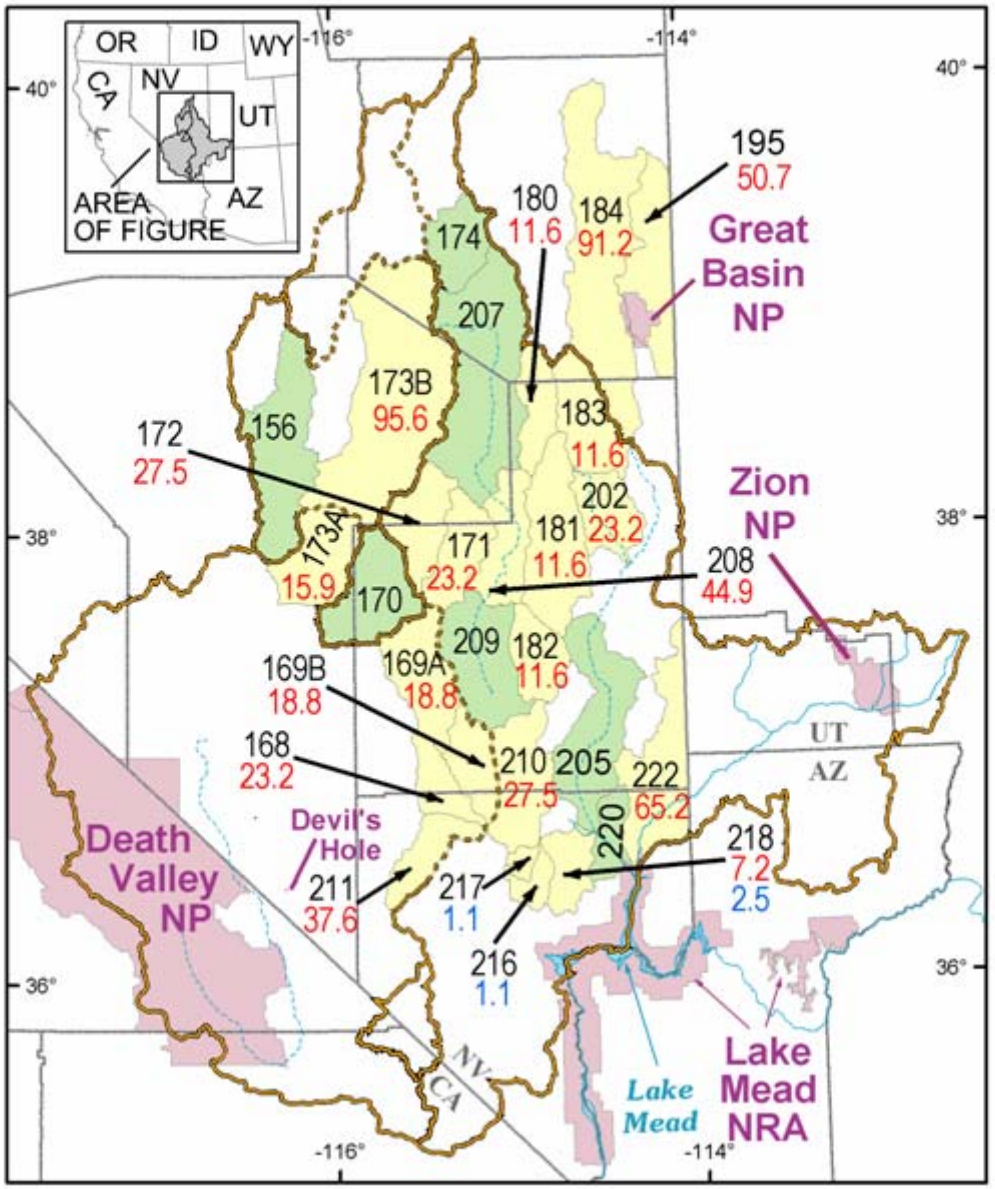
FAULT

DIRECTION OF GROUND-WATER MOVEMENT

Overview of Ground-Water Development Threats

- Las Vegas Valley Water District
- Vidler Water Company, Inc.
- Power Plants
- Overview
  - All Existing Water Rights
  - All Pending Water-Right Applications

Water-Right Applications by LVVWD



EXPLANATION

210	Hydrographic areas where pumping is proposed by LVVWD
209	Hydrographic areas where applications were withdrawn by LVVWD
27.5	Pending applications (afy x 1,000)
2.5	Approved permits (afy x 1,000)
	Boundary of major flow system

N

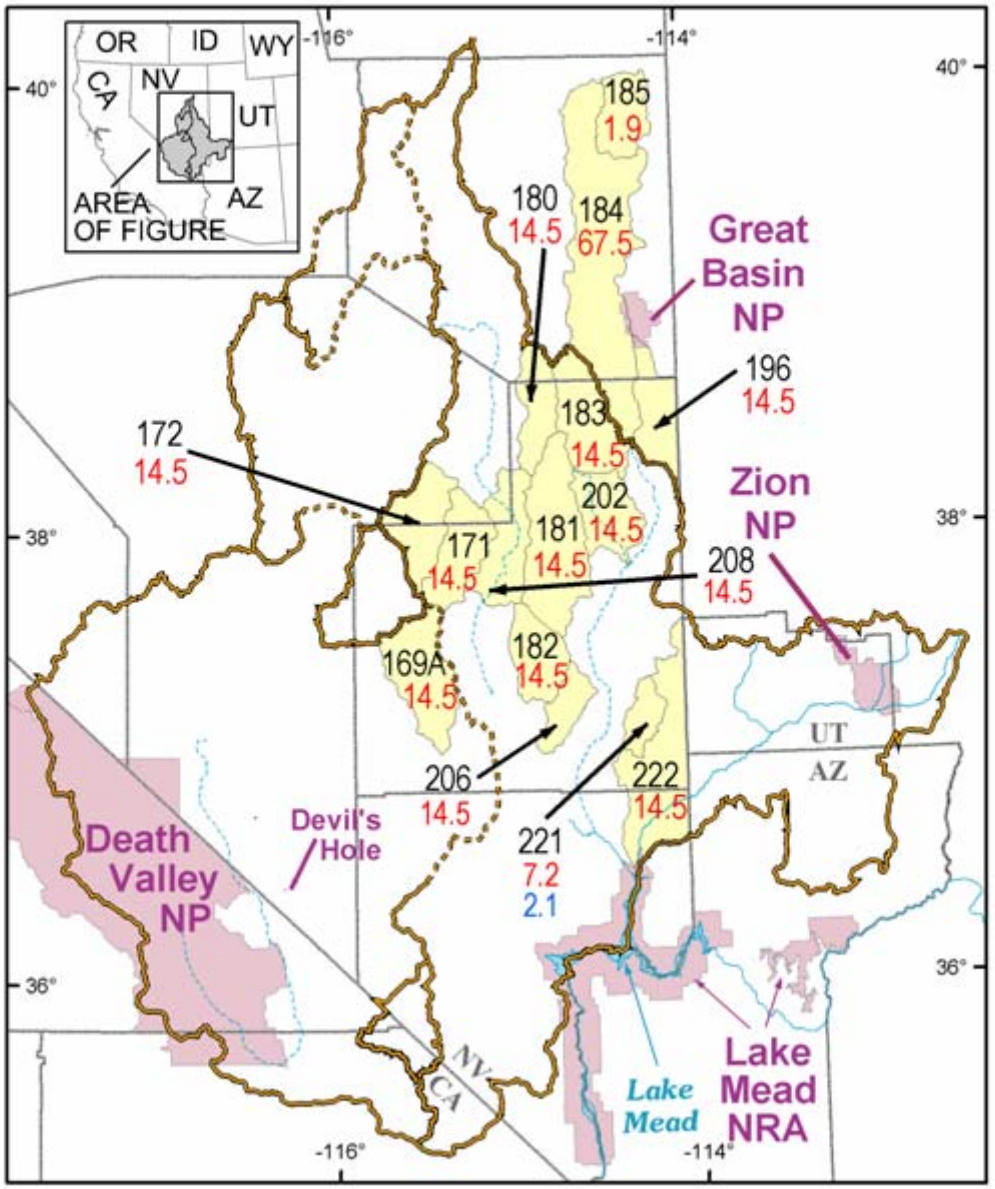
0 50 100

Miles

Flow systems modified from Harrill and Prudic (1998).

Base modified from USGS digital data, 1:100,000, and other sources.

Water-Right Applications by Vidler Water Company



EXPLANATION

- **184** — Hydrographic areas where pumping is proposed by Vidler Water Company
- **67.5** — Pending applications (afy x 1,000)
- **2.1** — Approved permits (afy x 1,000)
- Boundary of major flow system

N

0 50 100

Miles

Flow systems modified from Harrill and Prudic (1998).

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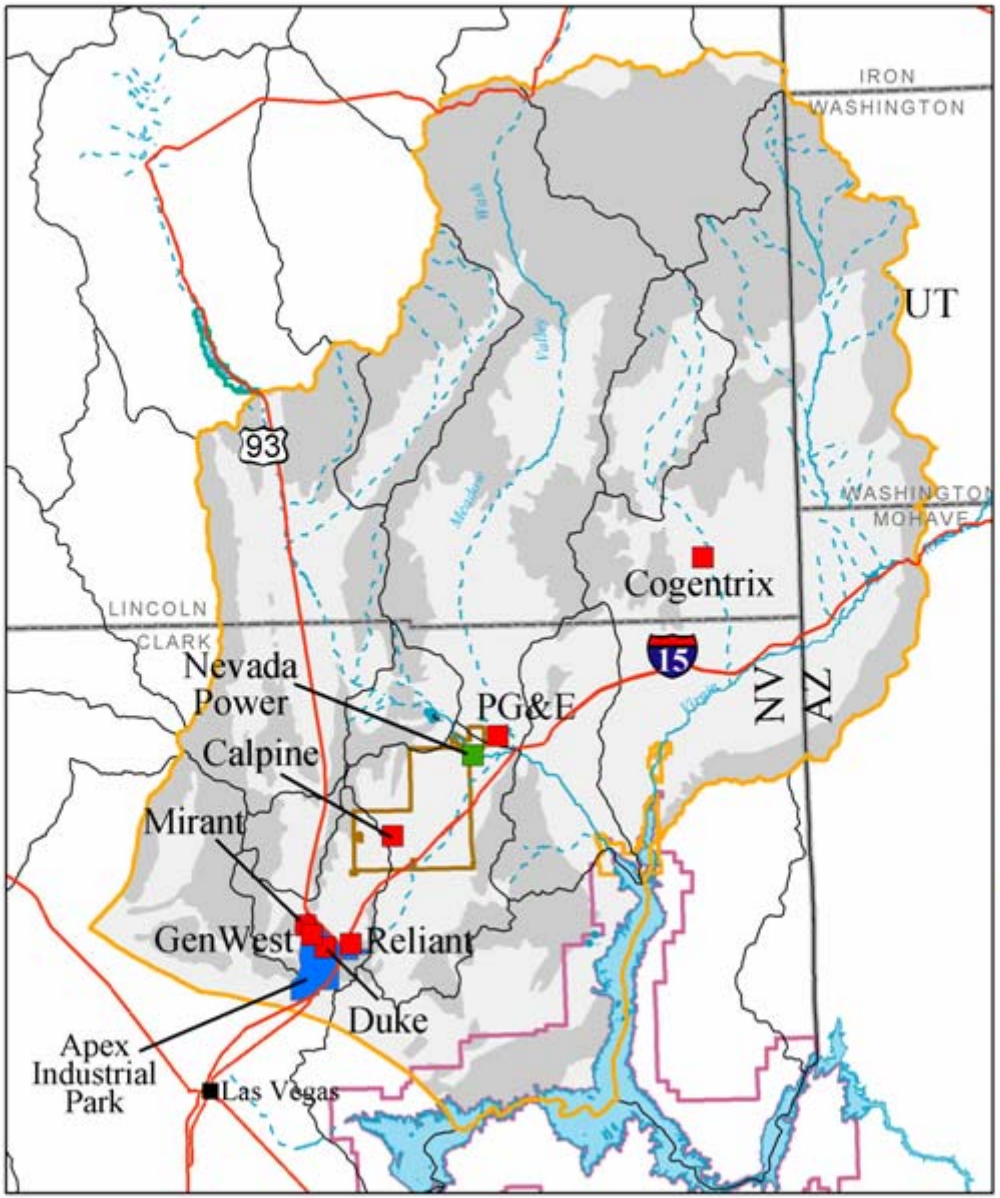
Location of Existing and Proposed Power Plants



EXPLANATION

- Existing Power Plants
- Proposed Power Plants
- Hydrographic Basins
- Basin Fill
- Consolidated Rock
- Lower Colorado Flow System
- Moapa Valley NWR
- Pahranagat NWR
- Moapa Indian Reservation
- Lake Mead NRA
- Overton WMA

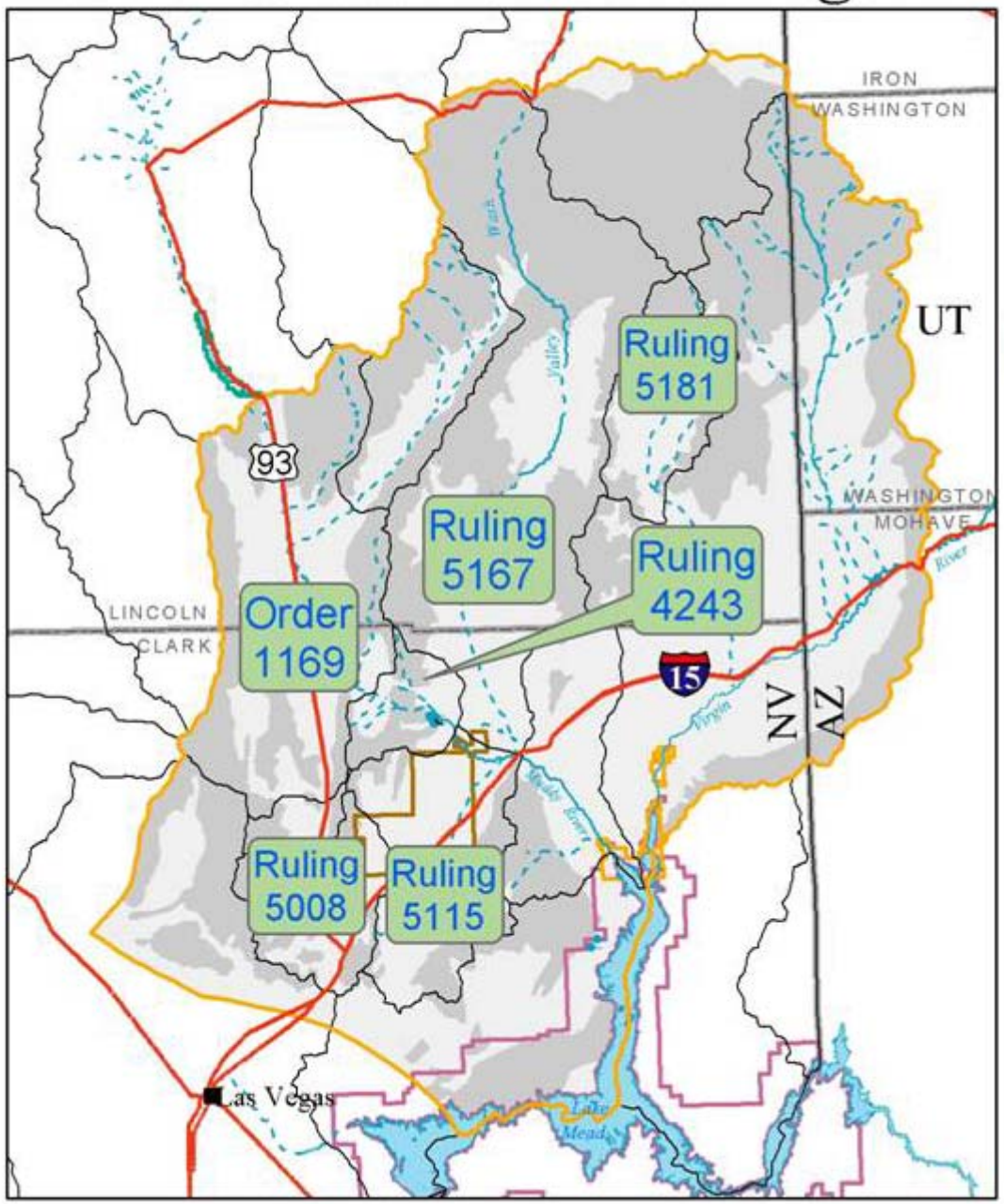
N

0 10 20

Miles

Flow systems modified from Harrill and Prudic (1998). Geology modified from Plume and Carlton (1988). Base modified from USGS digital data, 1:100,000 and other sources.

Recent Nevada State Engineer's Office Decisions



EXPLANATION

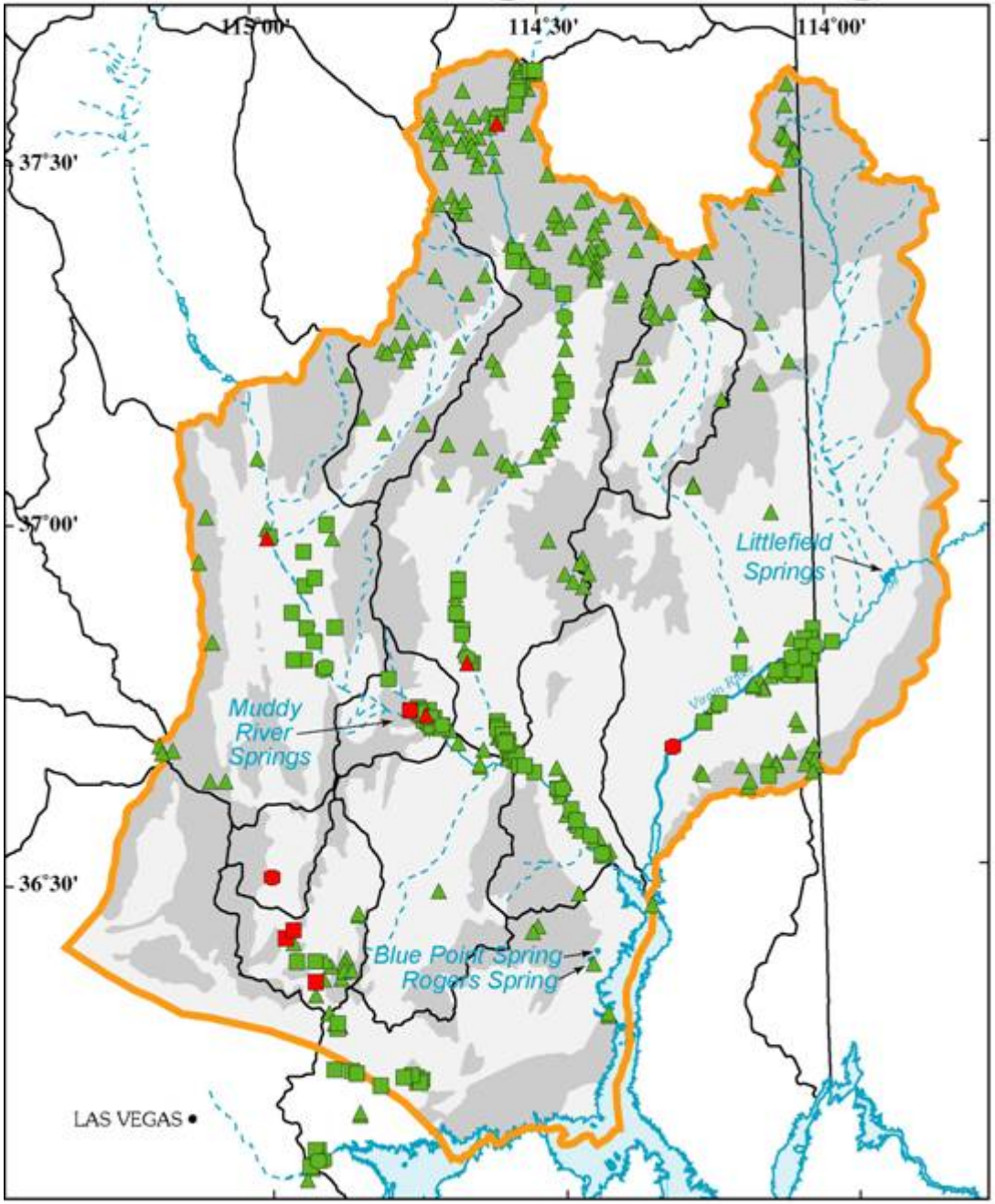
- Hydrographic Basins
- Basin Fill
- Consolidated Rock
- Lower Colorado Flow System
- Spring
- Intermittent Stream
- Perennial Stream
- Moapa Valley NWR
- Pahranagat NWR
- Moapa Indian Reservation
- Lake Mead NRA
- Overton WMA

Geology modified from Plume and Carlton (1988).
Flow systems modified from Harrill and Prudic (1998).
Base modified from USGS digital data, and other sources

N

0 5 10
Miles

POD of Existing Water Rights Protested by the NPS



EXPLANATION

Existing water rights that were protested by NPS

- ▲ Diversion Rate < 1 cfs
- ■ 1 ≤ Diversion Rate < 5 cfs
- ● Diversion Rate ≥ 5 cfs

Existing water rights that were not protested by NPS

- ▲ Diversion Rate < 1 cfs
- ■ 1 ≤ Diversion Rate < 5 cfs
- ● Diversion Rate ≥ 5 cfs

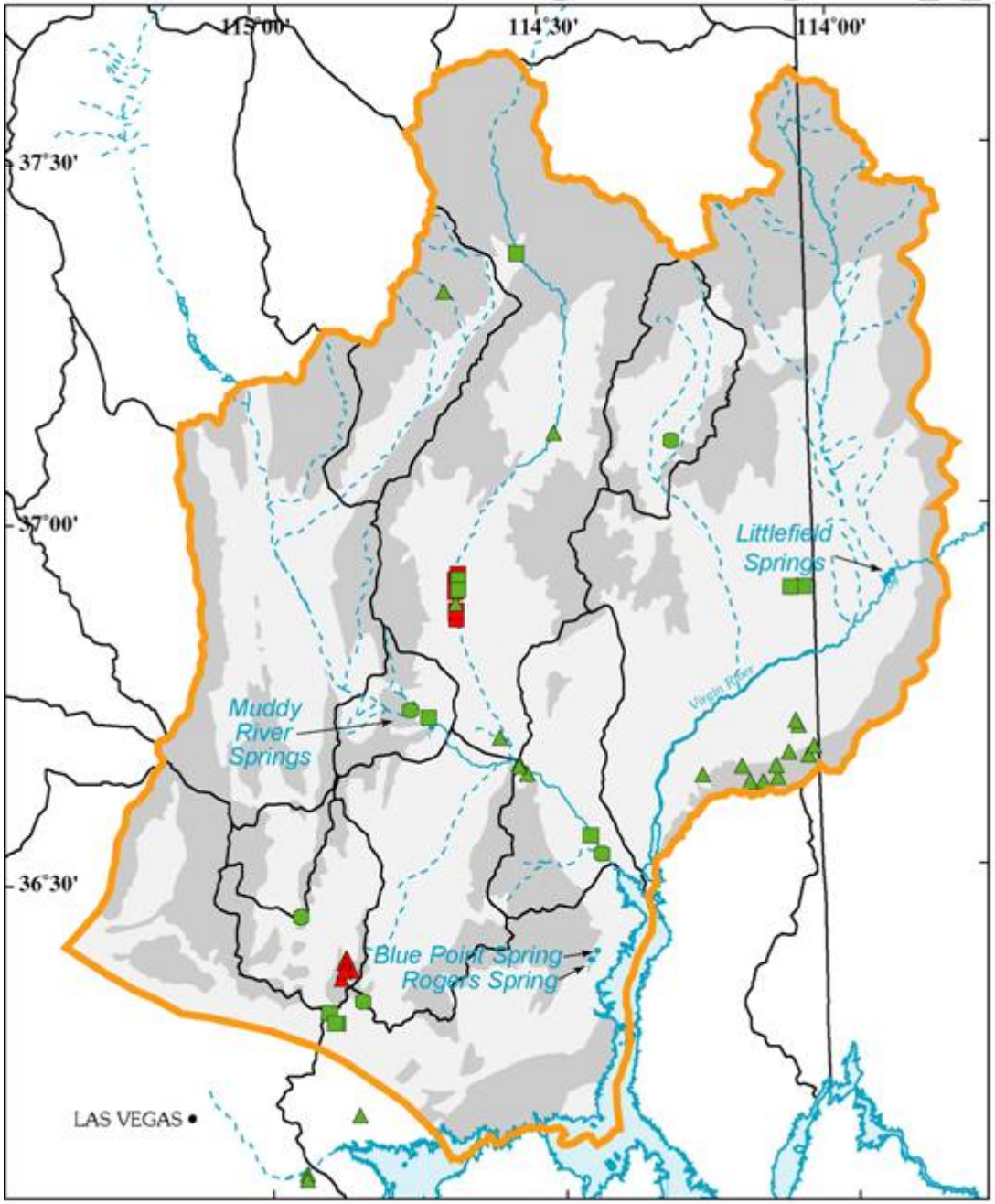
Lower Colorado Flow System

N 0 10 20

Miles

Geology modified from Plume and Carlton (1988)
Base modified from USGS digital data, 1:100,000

POD of Pending Change Applications Protested



EXPLANATION

Pending change applications protested by NPS

- ▲ Diversion Rate < 1 cfs
- ■ 1 ≤ Diversion Rate < 5 cfs
- ● Diversion Rate ≥ 5 cfs

Pending change applications not protested by NPS

- ▲ Diversion Rate < 1 cfs
- ■ 1 ≤ Diversion Rate < 5 cfs
- ● Diversion Rate ≥ 5 cfs

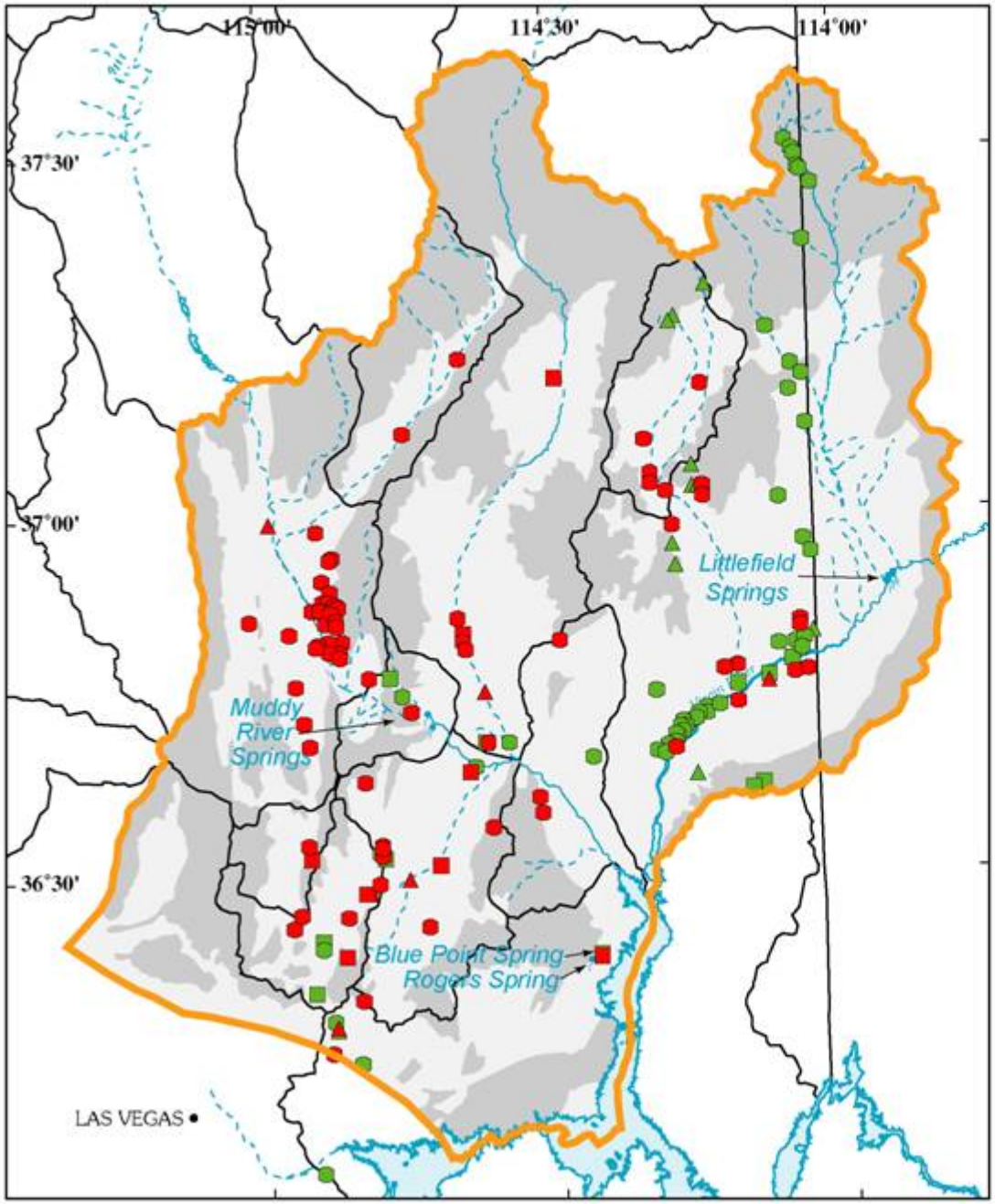
Lower Colorado Flow System

N 0 10 20

Miles

Geology modified from Plume and Carlton (1988)
Base modified from USGS digital data, 1:100,000

POD of Pending Applications Protested Excluding Change Applications



EXPLANATION

Pending applications protested by NPS

- ▲ Diversion Rate < 1 cfs
- ■ 1 ≤ Diversion Rate < 5 cfs
- ● Diversion Rate ≥ 5 cfs

Pending applications not protested by NPS

- ▲ Diversion Rate < 1 cfs
- ■ 1 ≤ Diversion Rate < 5 cfs
- ● Diversion Rate ≥ 5 cfs

Lower Colorado Flow System

N

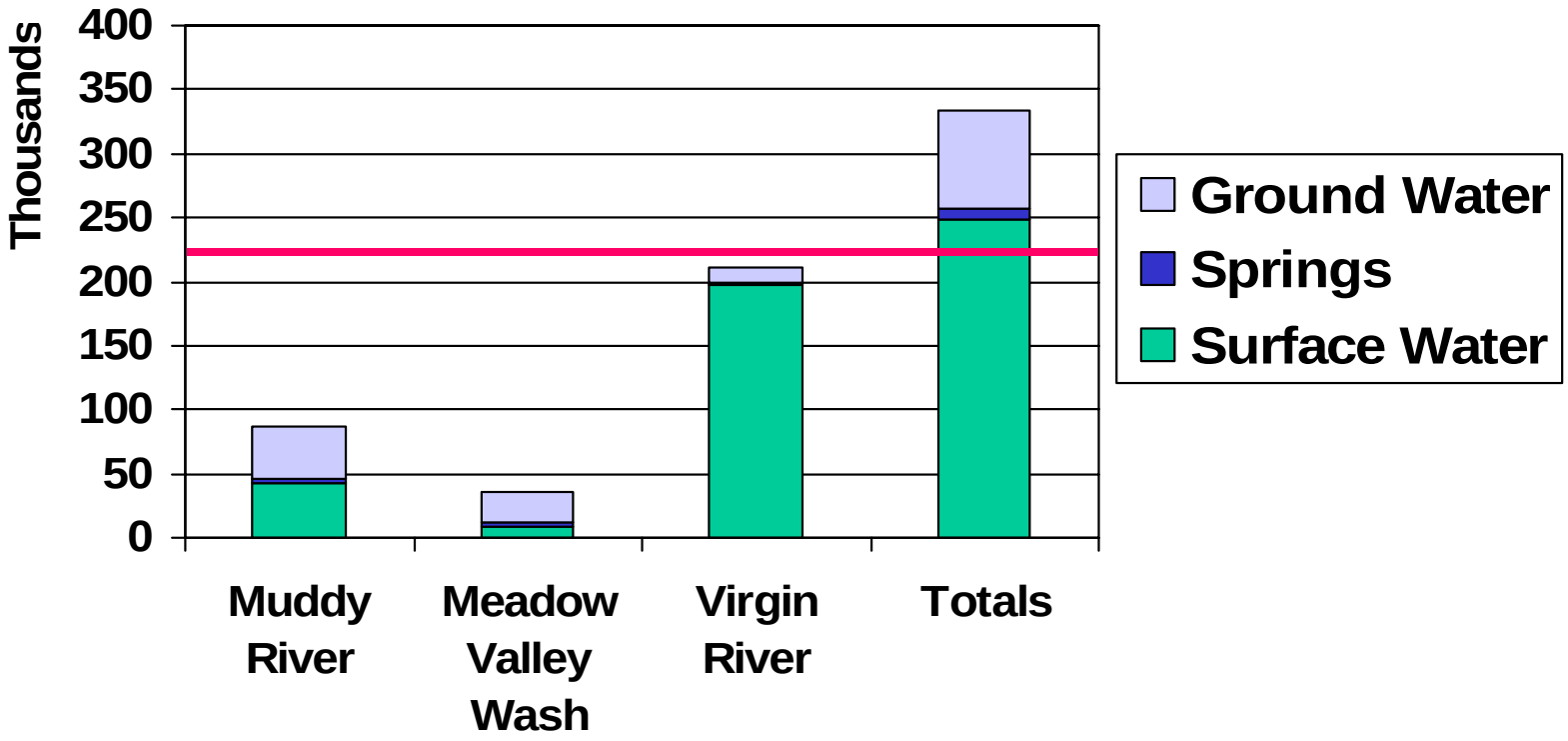
0 10 20

Miles

Geology modified from Plume and Carlton (1988)
Base modified from USGS digital data, 1:100,000

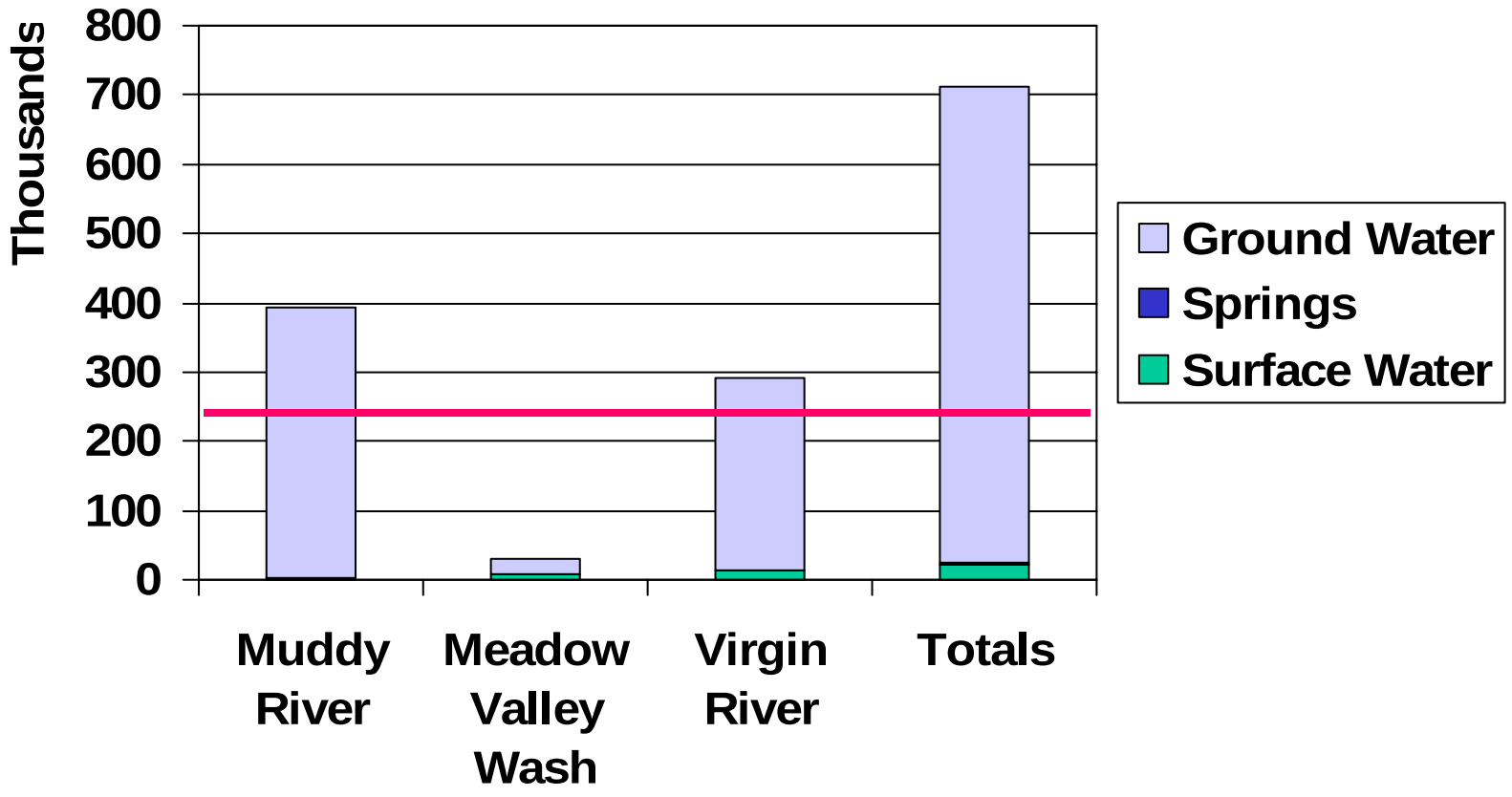
EXPERIENCE YOUR AMERICA

Existing Water Rights in the Lower Colorado Flow System



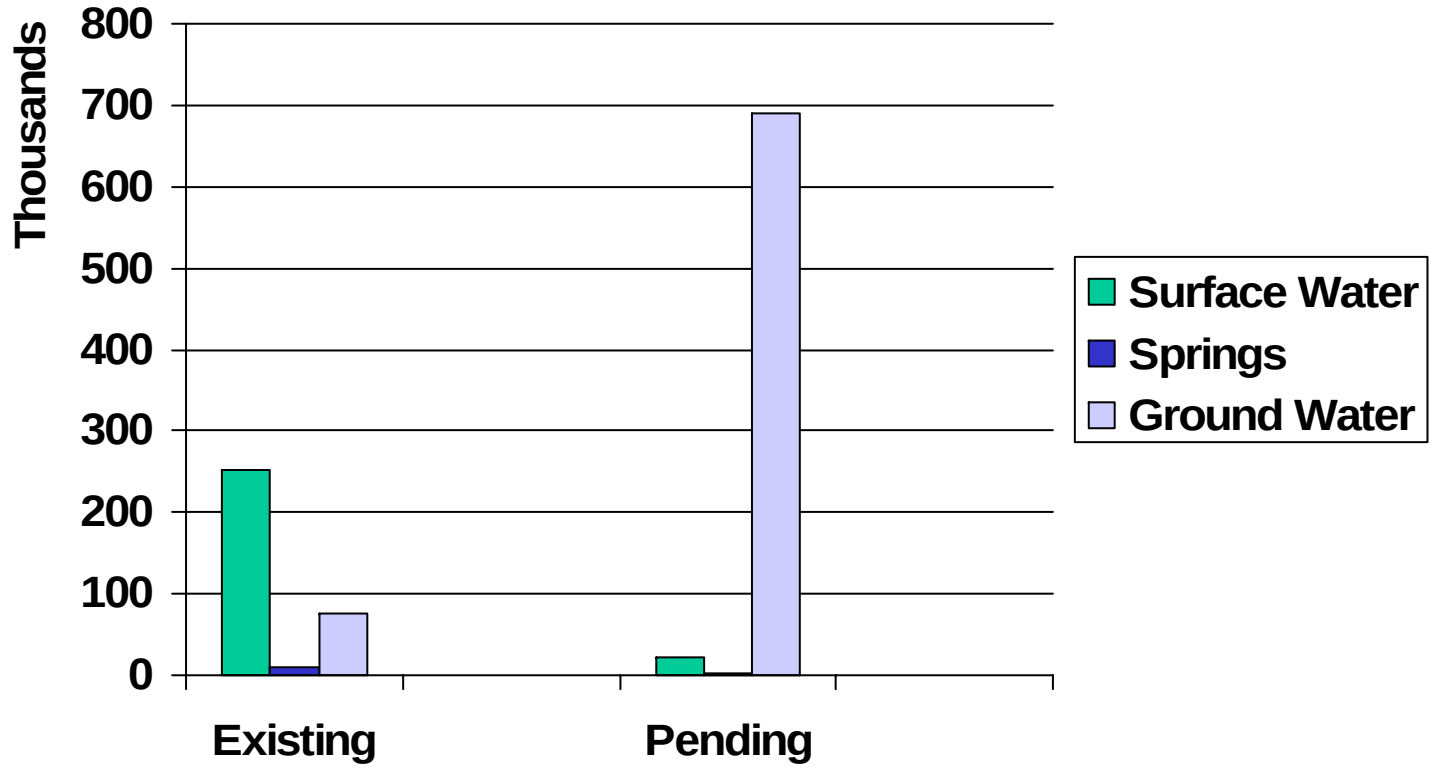
EXPERIENCE YOUR AMERICA

Pending Applications in the Lower Colorado Flow System



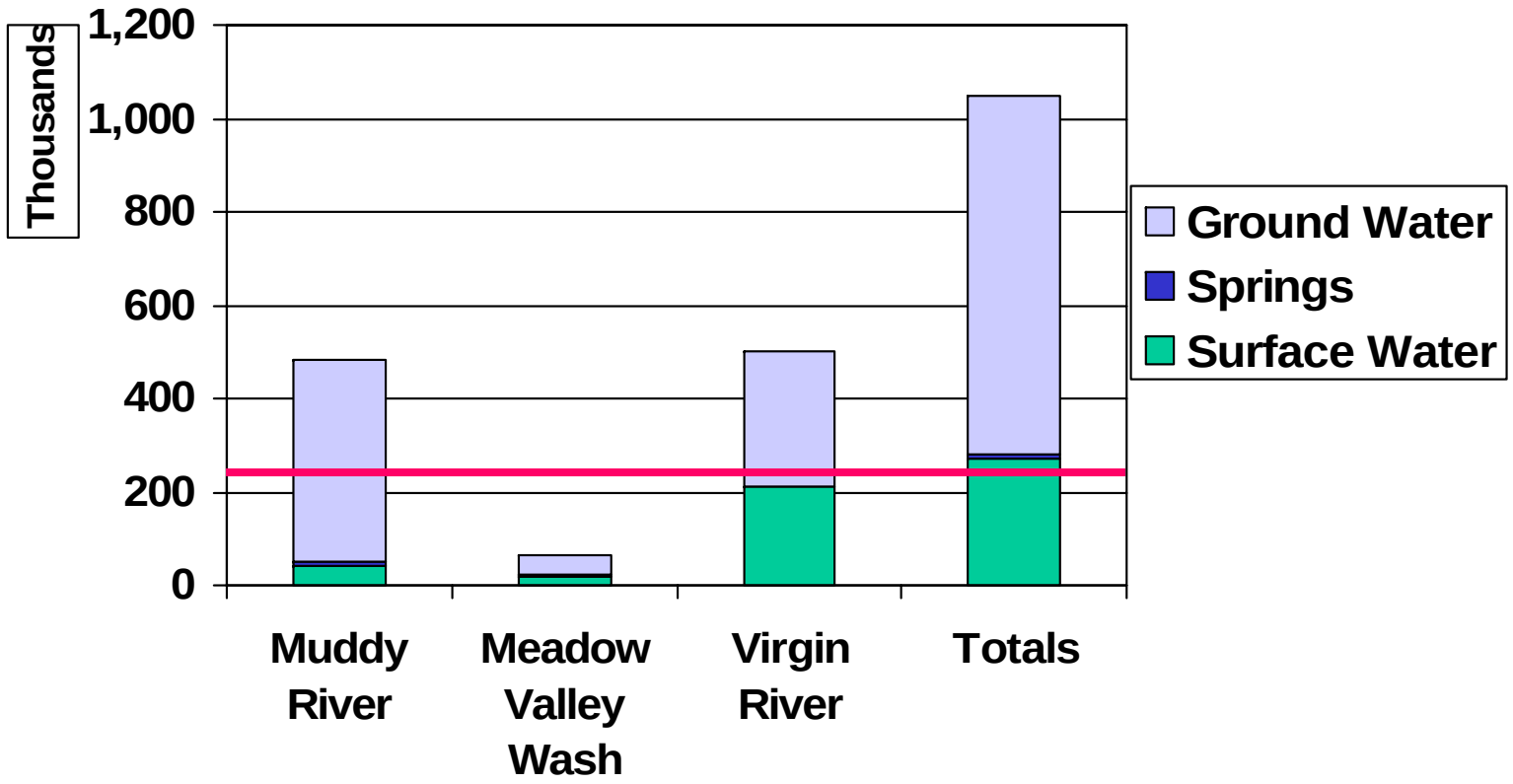
EXPERIENCE YOUR AMERICA

Existing Water Rights and Pending Water-Right Applications



EXPERIENCE YOUR AMERICA

Existing Water Rights and Pending Water-Right Applications



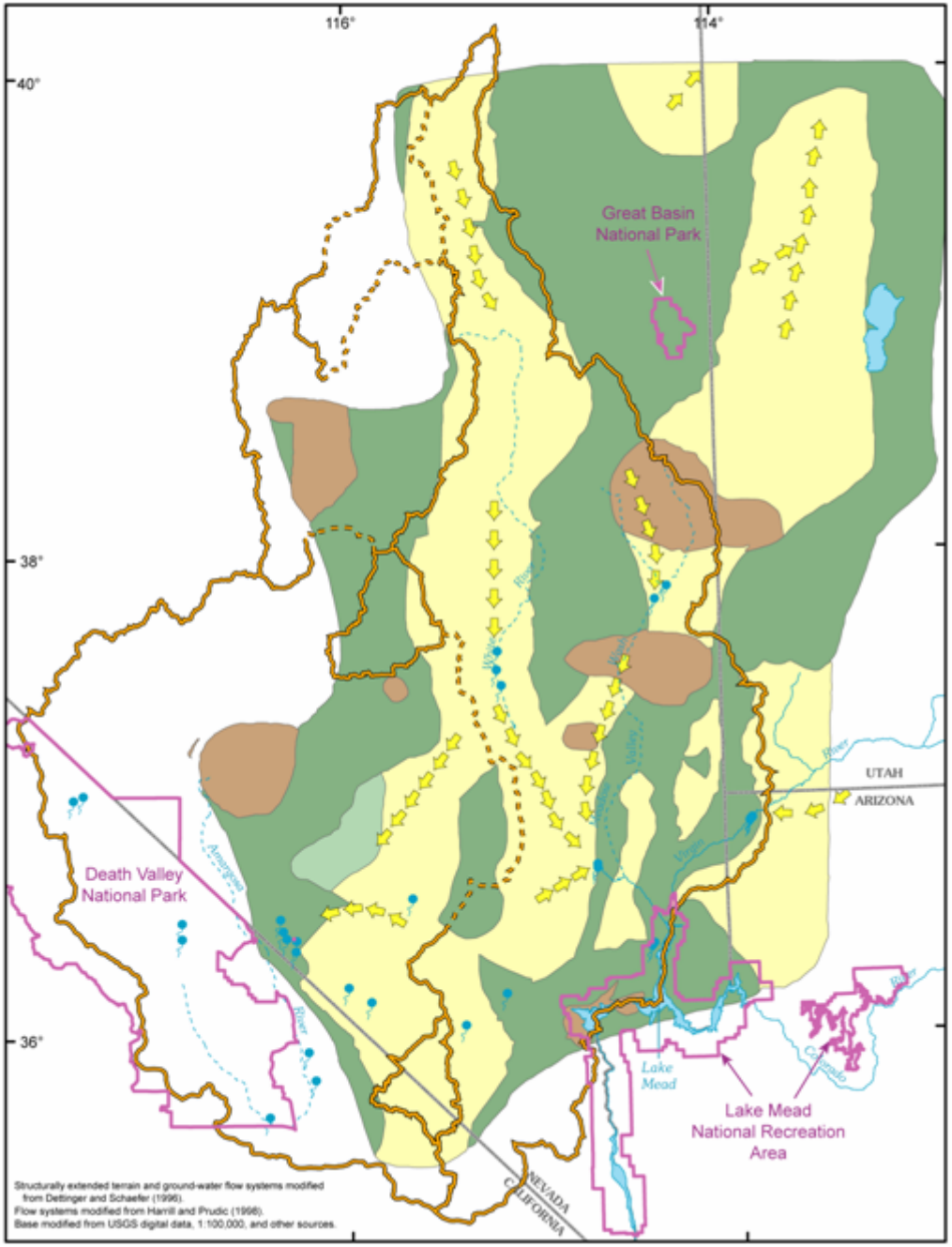
National Park Service

EXPERIENCE
YOUR
AMERICA

National Park Service

EXPERIENCE
YOUR
AMERICA

Structurally extended terrain & ground-water flow systems

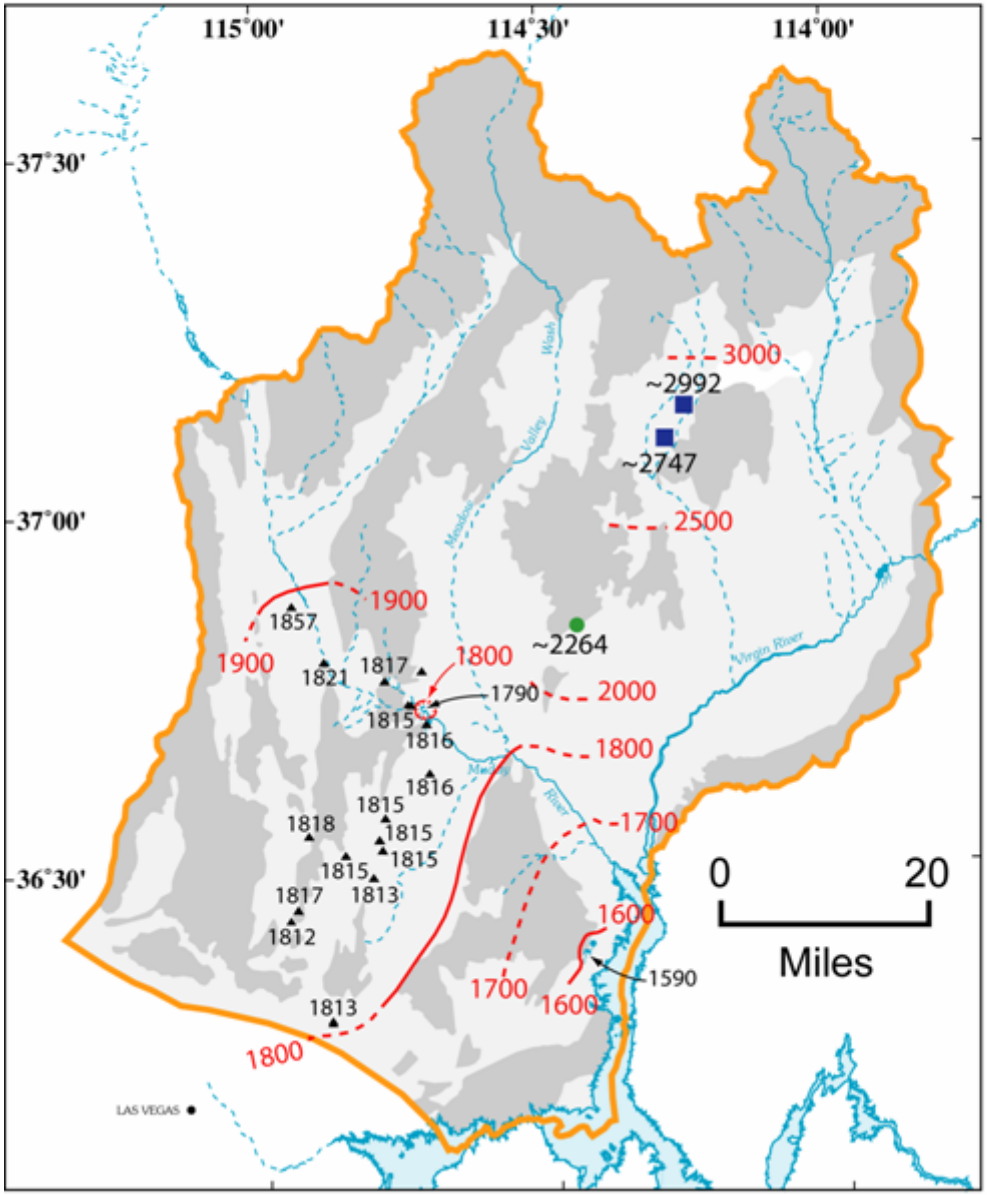


EXPLANATION

- Boundary of major flow system — Dashed where uncertain
- Spring
- Regional Flow Direction
- Caldera or volcanic complex
- Area of slight extension
- Area of transition between slight and extreme extension
- Area of extreme extension

0 50
Miles

Potentiometric Surface of the Regional Carbonate-rock Aquifer



EXPLANATION

–1800– Potentiometric - Surface Contour

1812 ▲ Carbonate well with altitude of water level

~2264 ● Well with approximate altitude of water level

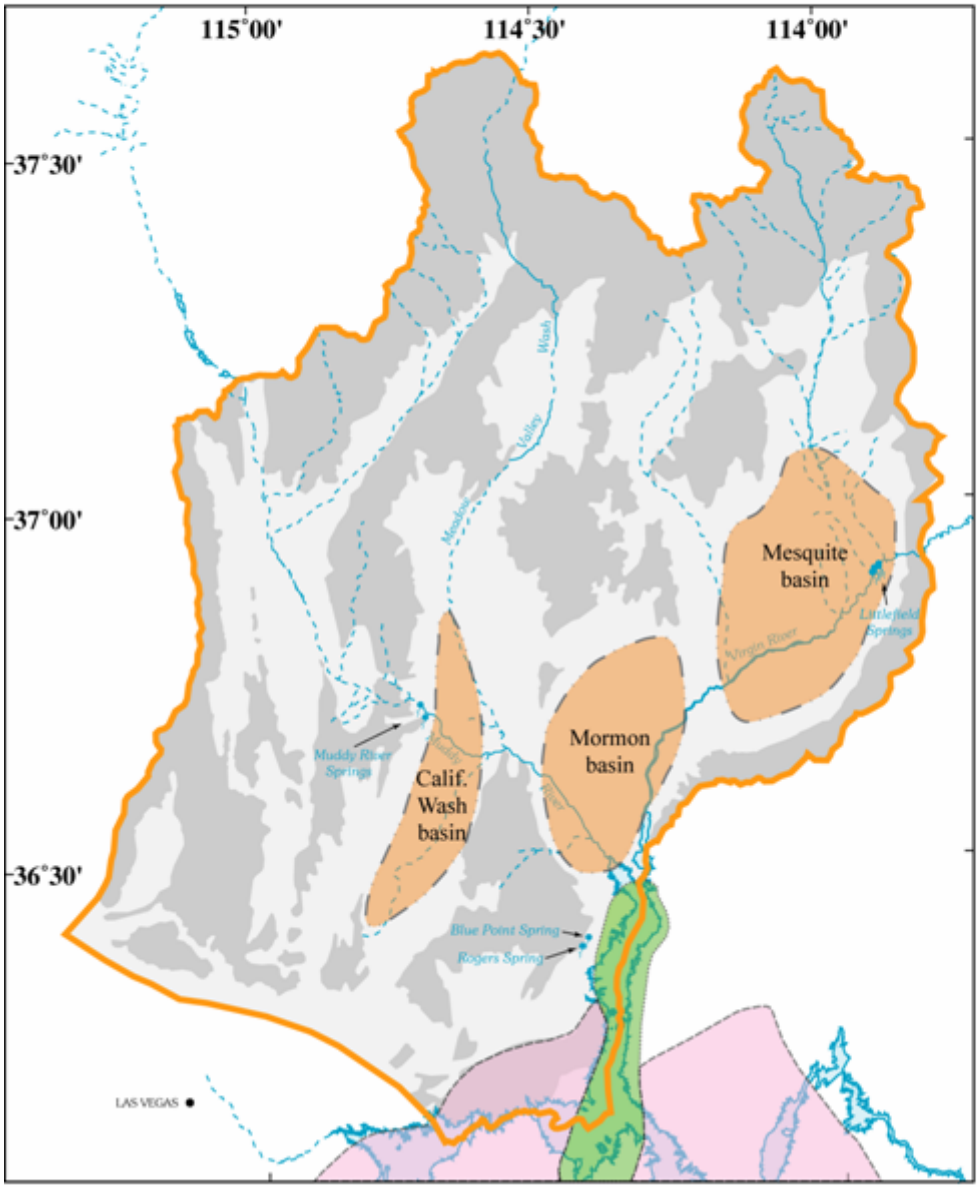
~2747 ■ Well with approximate altitude of water level

Consolidated Rock

Basin Fill

Geology modified from Plume and Carlton (1988)
Base modified from USGS digital data, 1:100,000

Thick basin-fill deposits and other relatively impervious rocks



Study Area

Spring

Consolidated Rock

Basin Fill

Thick basin-fill deposits

Subsurface salt body

Area underlain by Tertiary basin fill, Tertiary volcanic and intrusive rock, and Precambrian crystalline basement, undifferentiated

0 20

Miles

Geology modified from Plume and Carlton (1988)

Base modified from USGS digital data, 1:100,000