THE ASCE/EWRI STANDARD GUIDELINES FOR MANAGED AQUIFER RECHARGE

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OUTLINE

- Development of the Standard
- Overview of the Standard

WHAT IS
MANAGED AQUIFER RECHARGE?

- It is the <u>intentional</u> recharge of water to aquifers for subsequent use or for environmental benefit

- Does not include incidental or unmanaged recharge
  - leaky pipes
  - stormwater runoff
  - septic system leach fields

- MAR involves the planning, design, construction, and O&M for both water quantity and quality

WHY ARE MAR GUIDELINES NEEDED?

- Provides a comprehensive resource of information for those new to MAR
- Provides a standard process for all steps needed to develop a successful MAR project
- Provides guidance on potential problems so they can be managed before full scale operation

ASCE/EWRI PUBLICATION PROCESS

- A Committee was formed with volunteers approved by the ASCE Codes and Standards Committee
- Committee goal was to review and update the 2001 ASCE *Standard Guidelines for Artificial Recharge*
- Individual chapters developed independently by subgroups and balloted by the full Committee
- Chapters were revised & re-balloted until approved
- ASCE public comment on the draft Standard
- ASCE Codes and Standard Committee reviewed and approved the document for publication

MAR GUIDELINES SUBCOMMITTEE

Dr. Gordon McCurry	Editor, Co-Chair	McCurry Hydrology, LLC, Boulder, CO
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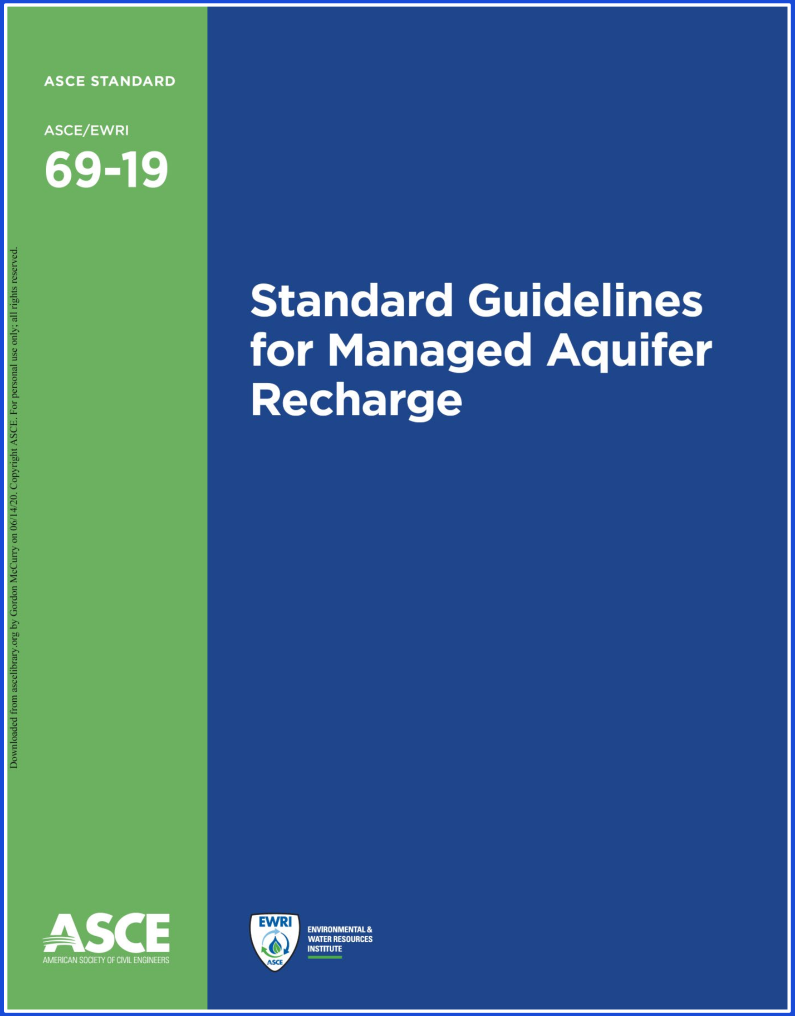
Mr. Cortney Brand	Member	Leonard Rice Engineers, Denver, CO
Mr. Devin Galloway	Member	USGS, Sacramento, CA
Mr. David Pyne	Member	ASR Systems LLC, Gainesville, FL

THE RESULT:
MAR STANDARD GUIDELINES

- Includes background information and the full range of activities for MAR projects

- Includes case studies illustrating key steps in MAR development

- Published in May 2020 as ASCE/EWRI Standard Guideline 69-19

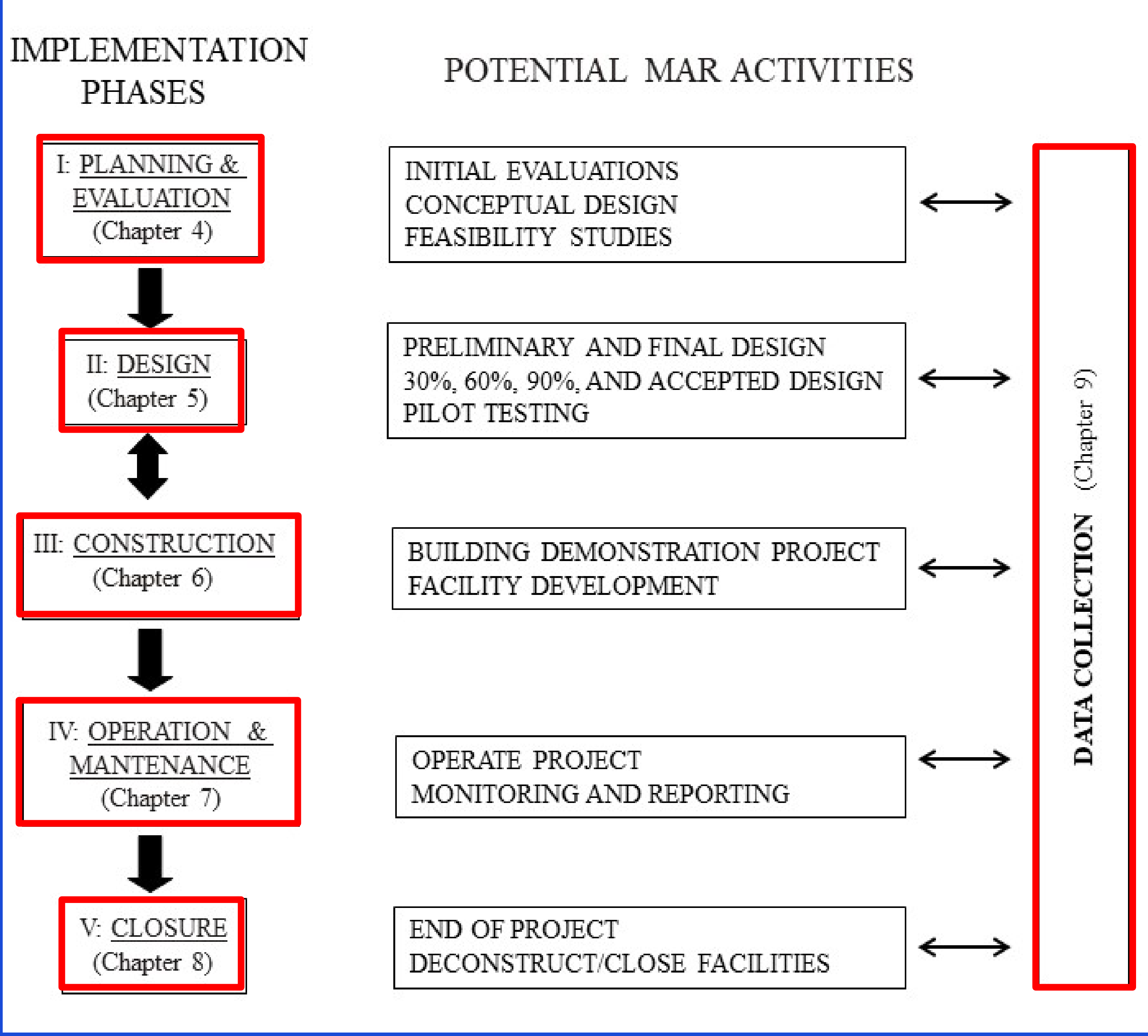


OVERVIEW OF THE MAR GUIDELINES

1. Introduction
2. Groundwater Fundamentals and Occurrence
3. Managed Aquifer Recharge Concepts
4. Planning
5. Design
6. Construction
7. Operations and Maintenance
8. Closure
9. Data Collection and Analysis

Appendices

CHAPTER 1: INTRO & ROADMAP



CHAPTER 3:
MAR CONCEPTS

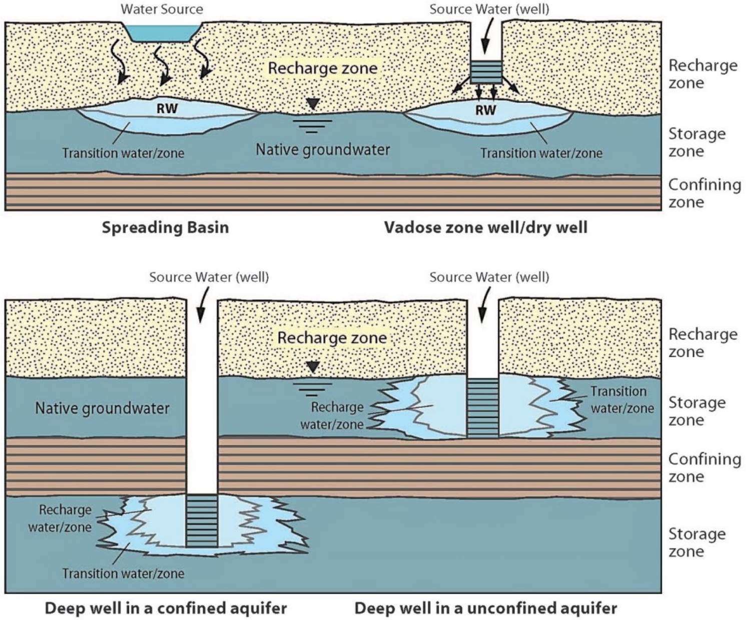


Figure 3-2. Hydrological components and processes for three recharge methods.
Note: RW = recharge water.

Table 3-1. Major Characteristics of Aquifer Recharge Methodologies.

Parameter	Surface Infiltration	Vadose Zone Injection	Subsurface Injection
Facility type	Recharge basins	Vadose zone wells	Recharge wells
Aquifer type	Unconfined	Unconfined	Unconfined or confined
Pretreatment requirements	Low/minimal technology	Prevention of clogging and biofouling	Prevention of clogging and biofouling
Estimated major capital costs	Low to high (depending on local land values)	Low to medium	Medium to high
Capacity	1,000–20,000 m^3/ha/day	1,000–3,000 m^3/day per well	2,000–15,000 m^3/day per well
Maintenance requirements	Drying and scraping	Drying and disinfection	Disinfection and backflushing
Estimated lifecycle	>100 years	5–20 years	25–50 years
Location of aquifer–water contact	Vadose zone and saturated zone	Vadose zone and saturated zone	Saturated zone

CHAPTER 4: PLANNING

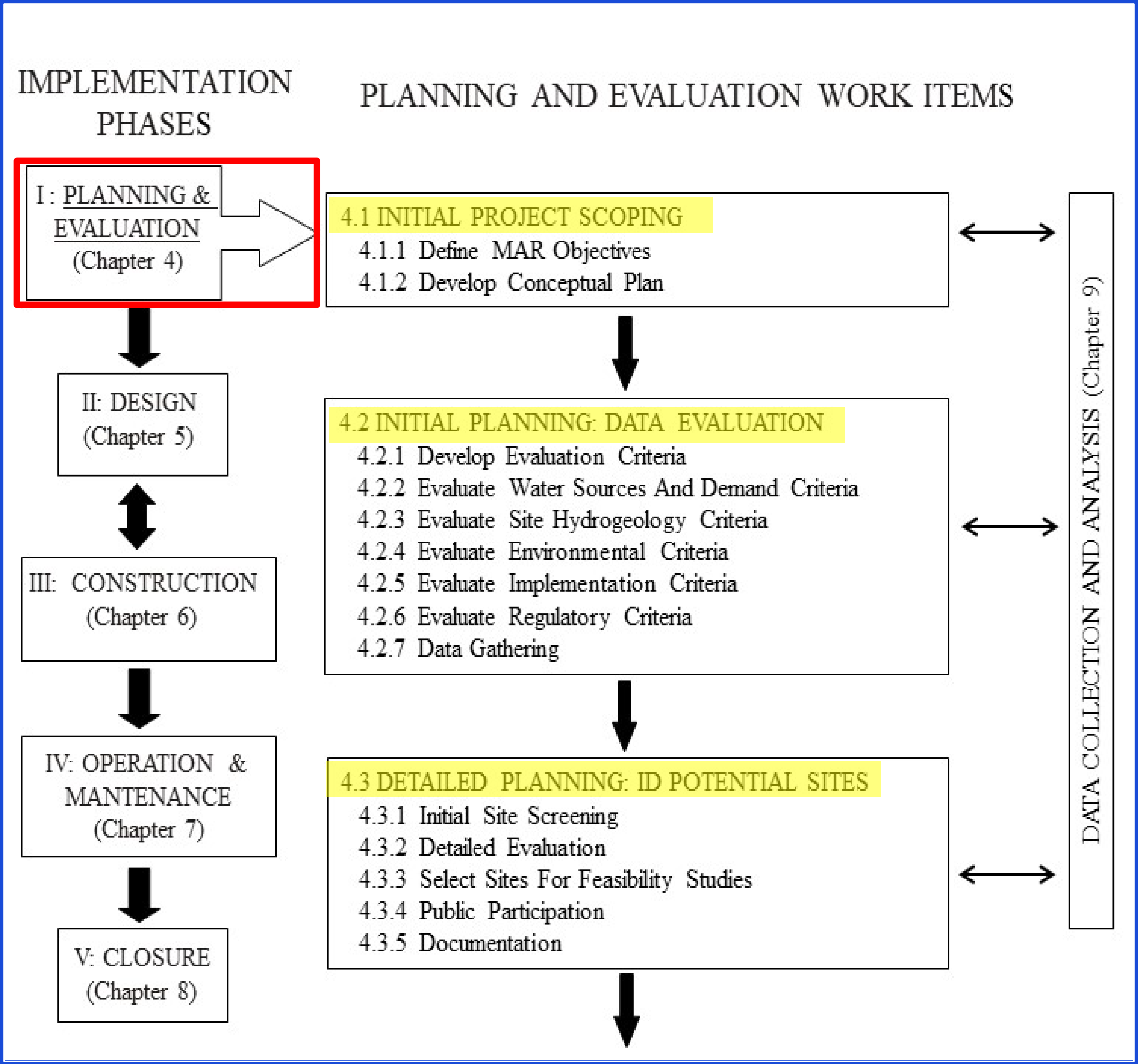


Table 4-1. MAR Evaluation Criteria.

Category	Criterion	Description/Applicability
Water sources and demand	Availability of water	Whether water is available physically or institutionally; trends and variability
	Proximity of source water	Distance from water source to MAR site
	Source water quality	Quality of source water untreated or post-treated
	Estimates of water demand	Trends and variability in demand from MAR site under anticipated operation scenarios
Site hydrogeology	Hydrogeologic suitability	Whether aquifer characteristics will allow anticipated recharge
	Amount of available storage	Physical space in aquifer, unsaturated pore space for unconfined aquifers, pressure head and porosity for confined aquifers
	Residence time	How long water will stay under dominion and control for aquifer setting
	Induced seismicity	Likelihood of causing a seismic event
Environmental considerations	Waterlogging and nonbeneficial use	Where elevated water table conditions may affect soils and structures or be lost through evapotranspiration
	Habitat concerns	Possible effect on sensitive environments
	Effects on aquifer water quality	Effects of introducing water with differing chemistry
Implementation	Proximity to existing infrastructure	Affects overall cost
	Proximity to demand	Affects overall cost
	Land ownership and use	Affects cost and permitting
	Cost	Total cost to implement and maintain
	Site access and security	Affects cost and permitting; applies to protection of water supply
	Conditions surrounding site	Affect costs, permitting, and environmental considerations
Regulatory considerations	Permitting and other regulatory requirements	Affect cost and permitting

CH 4: Example Site Selection Process and Site Scoring

Evaluation Criteria	Criteria Description	Scoring Measures High 10 9 8	Medium 7 6 5 4	Low 3 2 1
Hydrogeologic considerations				
1. Aquifer storage capacity	Available capacity for recharge	>0.6 m^3/m^2 (2 AF/ac)	0.1–0.6 m^3/m^2 (0.25–2 AF/ac)	<0.1 m^3/m^2 (9 < 0.25 AF/ac)
2. Hydrogeologic suitability • Unconfined aquifers • Confined aquifers	Potential rate of aquifer recharge —Estimated from aquifer K values —Estimated from aquifer T values	>10 m/day (>250 ft/day) >300 m^2/day (>900 ft^2/day)	1.0–10.0 m/day (50–250 ft/day) 100–300 m^2/day (300–900 ft^2/day)	<1.0 ft/day (<50 ft/day) <100 m^2/day (9 < 300 ft^2/day)
3. Residence time • Unconfined aquifers • Confined aquifers	Duration recharged water is in aquifer Subcrop proximity to alluvial aquifers	>1 year >5 km (>3 mi)	4 months–1 year 1.6–5 km (1–3 mi)	<4 months <1.6 km (<1 mi)
Environmental considerations				
4. Water quality	Aquifer water quality with respect to state standards, soil leaching potential	No standards exceeded; minimal leaching potential	Limited areas where standards exceeded; minor leaching potential	Large areas where standards exceeded; strong leaching potential
5. Habitat concerns	Presence of threatened and endangered species habitat; effect on wetlands	Minor area of T&E habitat; no effect on wetlands	Some T&E habitat; some wetlands affected	Much T&E habitat; wetlands affected
6. Waterlogging and nonbeneficial use	Potential to create high water table and increased ET by phreatophytes	Low concerns for waterlogging effects	Medium concerns for waterlogging effects	High concerns for waterlogging effects
Implementation considerations				
7. Landownership and land use considerations	Proportion of area with accessible public land, multiple jurisdictions	Many areas of public and nonurban land	Some areas of public and nonurban land	Mostly private and/or urban land
8. Existing infrastructure	Proximity of infrastructure (pipelines, ditches, etc.) and available capacity	Suitable infrastructure <10 km (<6 mi) from area	Suitable infrastructure 10–30 km (6–20 mi) from area	Suitable infrastructure >30 km (>20 mi) from area
9. Proximity to areas with demand	Recharge areas nearby to areas of projected unmet demand in 2030	Near areas with demands >4,000 m^3/year (>10,00 AF/yr)	Near areas with demands of 2,000–4,000 m^3/year (5000–10,000 AF/yr)	Near areas with demands <2,000 m^3/year (<5,000 AF/yr)
10. Implementation costs • Unconfined aquifers • Confined aquifers	Relative land costs for construction Depth to aquifer and proximity to existing high-capacity wells	Low cost <75 m 9 (<250 ft); many wells in area	Medium cost 75–300 m (250–1,000 ft); few wells in area	High cost >300 m (>1,000 ft); no wells in area

CH 5: DESIGN

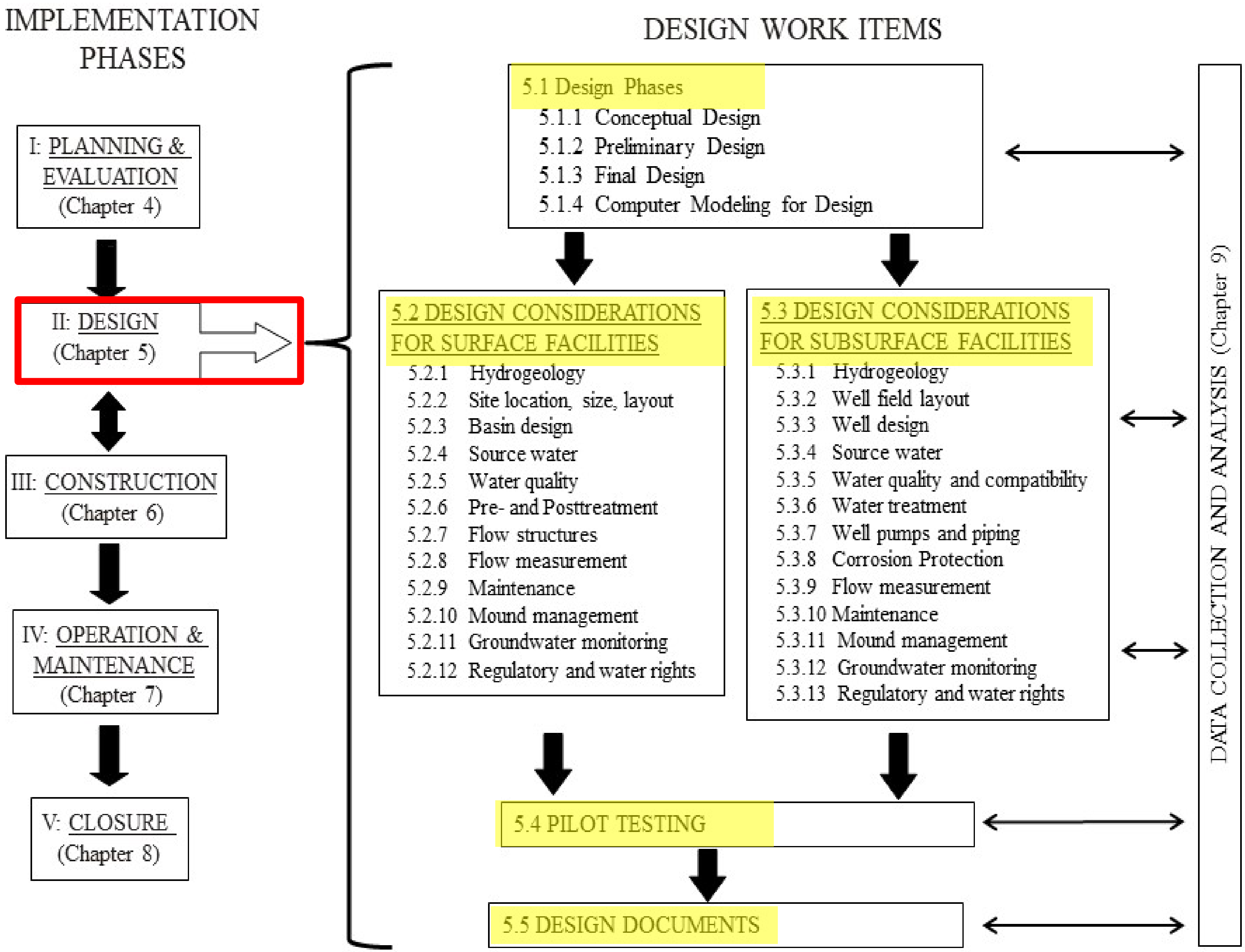
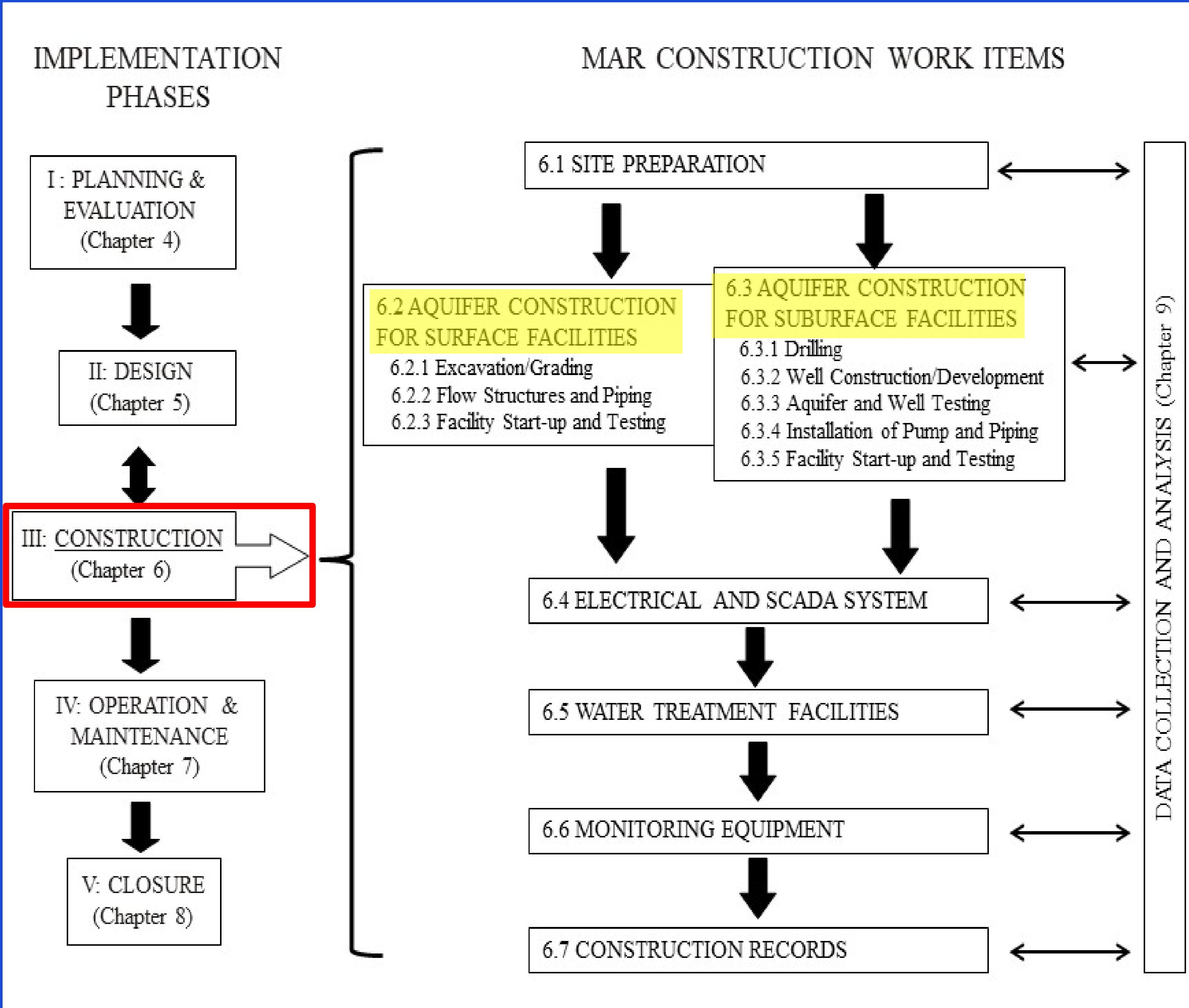
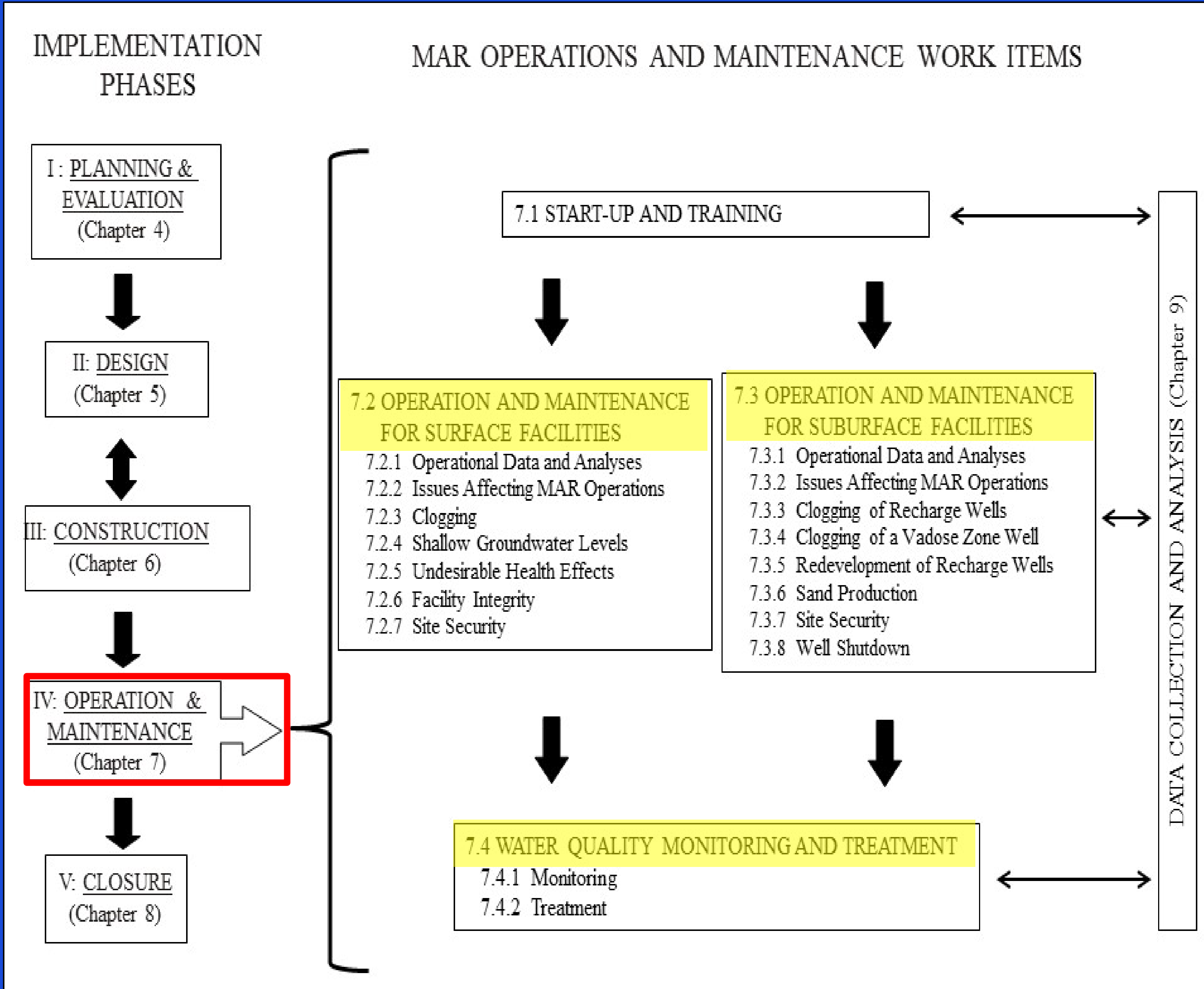


FIGURE 5.1. Details of the Design Phase of a MAR Project.

CH 6: CON-STRUC-TION



CH 7: O&M


IMPLEMENTATION PHASES
MAR OPERATIONS AND MAINTENANCE WORK ITEMS
I: PLANNING & EVALUATION (Chapter 4)
II: DESIGN (Chapter 5)
III: CONSTRUCTION (Chapter 6)
IV: OPERATION & MAINTENANCE (Chapter 7)
V: CLOSURE (Chapter 8)
7.1 START-UP AND TRAINING
7.2 OPERATION AND MAINTENANCE FOR SURFACE FACILITIES
7.2.1 Operational Data and Analyses
7.2.2 Issues Affecting MAR Operations
7.2.3 Clogging
7.2.4 Shallow Groundwater Levels
7.2.5 Undesirable Health Effects
7.2.6 Facility Integrity
7.2.7 Site Security
7.3 OPERATION AND MAINTENANCE FOR SUBURFACE FACILITIES
7.3.1 Operational Data and Analyses
7.3.2 Issues Affecting MAR Operations
7.3.3 Clogging of Recharge Wells
7.3.4 Clogging of a Vadose Zone Well
7.3.5 Redevelopment of Recharge Wells
7.3.6 Sand Production
7.3.7 Site Security
7.3.8 Well Shutdown
7.4 WATER QUALITY MONITORING AND TREATMENT
7.4.1 Monitoring
7.4.2 Treatment
DATA COLLECTION AND ANALYSIS (Chapter 9)

CH 9: DATA COLLECTION FOR MAR PROJECTS

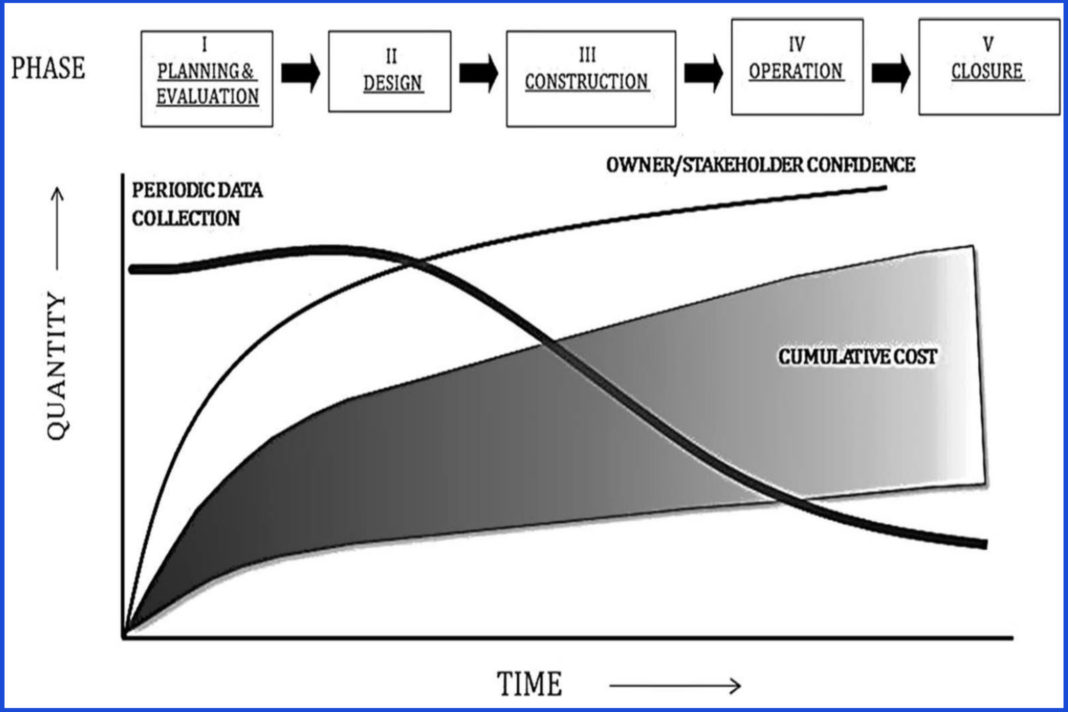


Table 9-1. MAR Data Needs and Types for MAR Feasibility Studies.

MAR Component	Data Types
Source water	Water availability (quantity and timing) Trends and variability
Water demand	Trends and variability
Water quality	Trends and variability
Method (surface basin spreading or subsurface well injection)	Land availability and/or ownership Topographic information Groundwater levels (target aquifers) Surface infiltration rates and vadose zone properties Regulatory
Aquifer storage recovery	Geologic and geophysical data to define aquifer geometry and extents Aquifer properties Groundwater occurrence and flow data Groundwater quality data to determine compatibility with source water
Impacts	Regulatory Land use Vicinity well owners within the area of influence Regional water level data and monitoring Water rights Land subsidence

APPENDICES

A. Glossary of Terms

B. Notations and Symbols

C. Selected MAR Regulations in the United States
- Federal regulations
- Arizona
- California
- Colorado
- Nebraska
- New Mexico
- Texas

D. Case Studies

CASE STUDIES: SURFACE SPREADING

	Surface Facilities	Year Constructed	Location	Recharge Method	Size
1	Bear Canyon Recharge Project	2009	Albuquerque, NM	Surface recharge in natural arroyo	4.1M m^3/yr 3 MGD
2	OCWD Surface Water Recharge Operations	1936 - 2012	Anaheim, CA	Santa Ana River Channel	28-50M m^3/yr 20–36 MGD
3	Rancho California Water District	2000	Temecula, CA	Off-channel spreading basins	31M m^3/yr 22 MGD
4	Tamarack Ranch Recharge Project	2007	Sterling, CO	Surface recharge basins	15M m^3/yr 11 MGD
5	Southern Avra Valley Storage and Recovery Project	2008	Tucson, AZ	Surface recharge basins	80M m^3/yr 58 MGD
6	Montebello Forebay Spreading Grounds	1937–1955	Pico Rivera, CA	In-stream check dams and off-channel spreading basins	164M m^3/d 118 MGD (avg 1959 to 2016)

CASE STUDIES: WELL RECHARGE

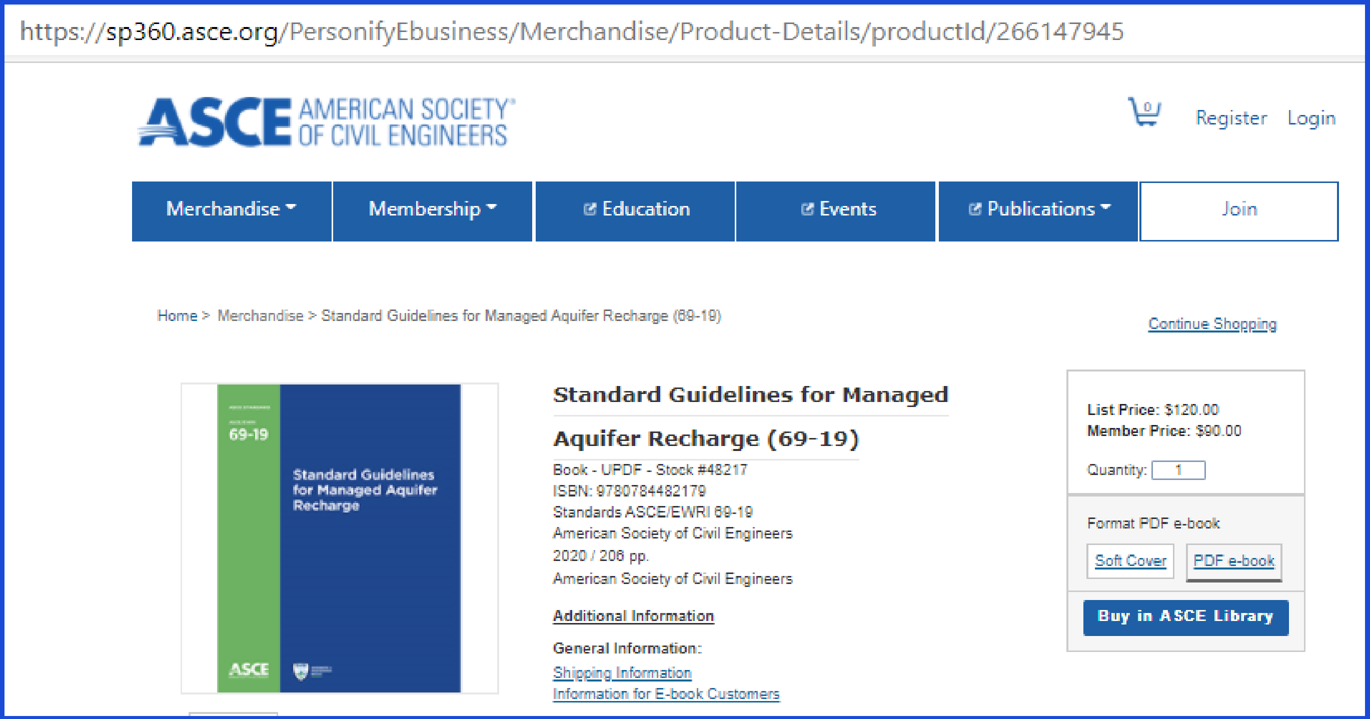
	Subsurface Facilities	Year Constructed	Location	No. of Wells (Depth)	Size
7	Denver Basin Aquifer Recharge Demonstration Project	1996	Denver, CO	1 Well (475 m; 1,556 ft)	1582 m^3 1.283 AF in 4 years
8	OCWD Talbert Gap Seawater Intrusion Barrier	1975	Anaheim, CA	36 wells (30-213m;100–700 ft)	28-50M m^3/yr 20–36 MGD
9	Phoenix ASR Well	2010	Phoenix, AZ	1 Well (432m; 1,420 ft)	3.4M m^3/yr 2.5 MGD
10	Rio Rancho Direct Injection Demonstration Project	2013	Rio Rancho, NM	1 Well (518m; 1,700 ft)	1.4M m^3/yr 1 MGD
11	El Paso Clean Water Recharge	1984	El Paso, TX	10 Wells (193-269m; 632–881 ft)	10.4M m^3/yr 10 MGD
12	City of Beaverton ASR Program	2001 2005	Beaverton, OR	3 wells (152m; 500 ft)	1.9M m^3/yr 1.4 MGD

SUMMARY AND CONCLUSIONS

- The MAR Standard Guidelines developed by practitioners using a rigorous peer review process
- The MAR Standard Guidelines describes all aspects of a MAR project, geared towards those familiar groundwater investigations
- The MAR Standard Guidelines will facilitate increased use of this water resource management technique

HOW TO OBTAIN A COPY

- Go to the ASCE website link: HTTPS://SP360.ASCE.ORG/PERSONIFYEBUSINESS/MERCHANDISE/PRODUCT-DETAILS/PRODUCTID/266147945
- Google 'ASCE Standard Guideline 69-19'



THANK YOU

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