

DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
CEMP-R Washington, DC 20314-1000

DG 1110-1-1

Design Guide
No. 1110-1-1

12 November 1999

Engineering and Design
DESIGN GUIDANCE FOR GROUND WATER/FUEL EXTRACTION
AND GROUND WATER INJECTION SYSTEMS

Table of Contents

Subject	Paragraph	Page
CHAPTER 1 - GENERAL CHARACTERISTICS OF A GROUNDWATER/FUEL EXTRACTION AND GROUND WATER INJECTION PROJECT	1.0	1-2
Introduction	1.1	1-2
Extraction and Injection System	1.2	1-2
Project Phases	1.3	1-4
Remedial Investigation/Feasibility Study Phase	1.3.1	1-4
Design Phase	1.3.2	1-6
Construction Phase Design Interaction	1.3.3	1-6
Startup Phase	1.3.4	1-7
Operation/Maintenance Phase	1.3.5	1-8
Legal and Regulatory Considerations	1.4	1-8
Regulatory Agency Interaction	1.4.1	1-9
System Permitting Requirements	1.4.2	1-10
CHAPTER 2 - PROBLEMS ASSOCIATED WITH GROUND WATER EXTRACTION AND INJECTION SYSTEMS LEADING TO POOR PERFORMANCE OR UNACCEPTABLE RESULTS	2.0	2-1
Problems, Causes, and Solutions	2.1	2-1
Extraction Unit	2.1.1	2-1
Transport Unit	2.1.2	2-12
Injection Unit	2.1.3	2-13

TABLE OF CONTENTS, Continued

Subject	Paragraph	Page
CHAPTER 3 - PLANNING FOR GROUND WATER/FUEL EXTRACTION AND GROUND WATER INJECTION SYSTEM	3.0	3-1
Remedial Investigation/Feasibility Study	3.1	3-1
Site Conditions	3.1.1	3-1
Contamination Sources and Type Characterization	3.1.2	3-3
Hydrogeology/Soil Characterization	3.1.3	3-3
Ground Water Characterization	3.1.4	3-7
LNAPL Characterization	3.1.5	3-13
Regulatory Issues/Permits	3.1.6	3-16
Feasibility Study	3.1.7	3-16
Design	3.2	3-25
Design of Extraction/Injection Units	3.2.1	3-25
Pump Design	3.2.2	3-34
Piping Design	3.2.3	3-37
Treatment Unit Design	3.2.4	3-40
Electrical/Control Specifications	3.2.5	3-42
Construction	3.3	3-43
Preconstruction Review	3.3.1	3-43
Construction	3.3.2	3-46
Post Construction	3.3.3	3-50
Startup/Baseline Performance	3.4	3-51
Subsurface Components	3.4.1	3-51
Pumps	3.4.2	3-52
Systems	3.4.3	3-53
Baseline Measurements	3.4.4	3-53
Operating Performance	3.5	3-54
Chemical Characteristics	3.5.1	3-55
Physical Characteristics	3.5.2	3-55
Biological Characteristics	3.5.3	3-58
Maintenance	3.5.4	3-59

LIST OF APPENDICES

Subject	Appendix	Page
References	A	A-1
Remedial Investigation/Design Basis Checklist	B	B-1
List of Acronyms	C	C-1

TABLE OF CONTENTS, Continued

LIST OF TABLES

Subject	Table	Page
Ground Water Extraction/Transport/Injection System Problems and Possible Causes	2-1	2-19
Extraction Unit Troubleshooting	2-2	2-21
Transport Unit Troubleshooting	2-3	2-24
Injection Unit Troubleshooting	2-4	2-25
Analytical Methods for Cation-Anion Balance	3-1	3-10
Interpretation of Chemical Water Analyses and Analytical Methods	3-2	3-11
Considerations for System Design	3-3	3-62

LIST OF FIGURES

Subject	Figure	Page
Ground Water Extraction, Treatment, and Injection System (Typical Layout)	1-1	1-3
Injection Well Cross Section	2-1	2-16
Troubleshooting Flow Chart - Low Initial Water Extraction Rate	2-2	2-27
Troubleshooting Flow Chart - Water Extraction Rate Declining Over Time	2-3	2-30
Troubleshooting Flow Chart - Extraction Unit - Low LNAPL Removal Rates	2-4	2-32
Troubleshooting Flow Chart - Extraction System/ Inadequate Plume Capture	2-5	2-34
Transport Unit Troubleshooting	2-6	2-35
Injection Unit Troubleshooting - Low Initial Injection Rates	2-7	2-38
Troubleshooting Flow Chart - Injection Rate Declining Over Time	2-8	2-41
Injection Unit Troubleshooting - Injection Pushing Plume in Wrong Direction	2-9	2-43
Injection Unit Troubleshooting - Mounding/Flooding ...	2-10	2-44
Ground Water Extraction, Treatment, and Injection System (Sample Location Diagram)	3-1	3-39