UNIÓN TEMPORAL – ISMOCOL JOSHI PARKO

2012 UPDATE TO THE 2010 PALAGUA FIELD ESIA

Environmental and Social Impact of a 32-well expansion project planned for 2010

JULY 2012

Table of Contents

EXECUTIVE SUMMARY 1
A. DESCRIPTION OF THE PROJECT 1
A.1 CHARACTERISTICS OF THE PROJECT 1
A.1.1 TECHNICAL DESCRIPTION OF THE PROJECT 1
A.1.2 LOCATION OF THE PROJECT 1
B. IDENTIFICATION OF THE HOSTS, OPERATORS AND CONTRACTORS ... 4
C. ENVIRONMENTAL CONDITIONS BASE LINE 5
C.1 CLIMATIC ASPECTS 6
C.2 SOIL, GEOLOGY, GEOMORPHOLOGY AND GEOTECHNICS 6
C.3 VEGETATION 7
C.4 USE, DEVELOPMENT AND ALLOCATION OF NATURAL RESOURCES ... 8
D. APPLICABLE ENVIRONMENTAL STANDARDS 9
D.1 AIR QUALITY 10
D.2 WATER QUALITY 10
D.2.1 DRINKING WATER 10
D.2.2 SURFACE WATER IN PALAGUA LAKE 11
D.2.3 UNDERGROUND WATER 12
D.3 SOIL QUALITY 12
D.4 NOISE 13
E. PROPOSED MITIGATION MEASURES 13
E.1 GUIDELINES FOR THE EVALUATION AND MANAGEMENT RISK FOR OIL AND GAS DEVELOPMENT 13
E.2 GENERAL GUIDELINES ON ENV. HEALTH AND SAFETY 15
E.3 EMERGENCY AND CONTINGENCY PLAN – GENERAL 15
F. NET ENVIRONMENTAL IMPACT 15
F.1 PHYSICAL-BIOTIC COMPONENT 16
F.2 SOCIO-ECONOMIC AND CULTURAL COMPONENT 16
F.3 RISK ANALYSIS 16
CHAPTER 1 PRELIMINARY 17
1.1 INTRODUCTION 17
1.2 OBJECTIVES 18
1.2.1 GENERAL OBJECTIVE 18
1.2.2 SPECIFIC OBJECTIVES 18
1.3 JUSTIFICATION AND SCOPE 19
1.4 METHODOLOGY 19
1.4.1 GATHERING OF BASIC INFORMATION 19
1.4.2 SECONDARY BASIC INFORMATION 20
1.4.3 ANALYSIS OF INFORMATION 20

1.5 BACKGROUND 21
CHAPTER 2 POLITICAL, LEGAL AND MANAGERIAL FRAMEWORK 22
2.1 APPLICABLE LAWS AND REGULATIONS (COLOMBIAN) 22
2.2 INTERNATIONAL TREATIES AND POLLUTION STANDARDS 23
2.3 APPLICABLE ENVIRONMENTAL STANDARDS 25
CHAPTER 3 PROJECT BASELINE 26
A. PROJECT AREA DELIMITATION 26
A.1 LOCATION OF THE PROJECT 26
A.1.1 LOCATION OF WELLS TO BE DRILLED 27
A.1.2 TRANSPORTATION ROUTES 28
A.1.3 DESCRIPTION OF THE OPERATIONAL PROCESS 29
A.2 DESCRIPTION OF THE PROJECT 29
A.2.1 ACCESS ROADS 32
A.2.2 DRILLING LOCATIONS 32
A.2.2.1 CONSTRUCTIVE METHODS 33
A.2.2.2 TEMPORARY FACILITIES 34
A.2.2.3 EARTHMOVING 36
A.2.2.4 LABOR FORCE REQUIREMENTS 36
A.2.2.5 EQUIPMENT REQUIREMENTS 36
A.2.2.6 FINAL DISPOSAL PLACE OF MATERIAL FROM THE DRILLING 37
A.2.2.7 USE, EXPLOITATION AND EFFECT OF NATURAL RESOURCES 37
A.3 DRILLING ACTIVITIES, BASIC INFRASTRUCTURE AND EQUIPMENT 38
A.3.1 DRILLING EQUIPMENT 39
A.3.1.1 GENERAL DRILLING DESIGN OF THE DEVELOPMENT WELLS 41
A.3.1.2 REQUIRED PERSONNEL 42
A.3.1.3 EFFECT ON NATURAL RESOURCES 43
A.3.2 ARTIFICIAL LIFTING SYSTEM 44
A.3.2.1 PRODUCTION TESTS 46
A.4 FLOW LINES 46
A.4.1 PIPE RACKS, STORAGE OF MATERIALS AND WORKSHOPS 47
A.4.2 LAND MOVEMENTS 47
A.4.3 CONSTRUCTIVE METHODS AND SUPPORT FACILITIES 47
A.4.4 LOCATION OF THE RUBBISH DUMPS 47
A.4.5 USE, IMPACT AND MANAGEMENT OF NATURAL RESOURCES 47
A.4.6 LABOR FORCE REQUIREMENTS 48
A.4.7 PUMPING STATIONS AND TRAPS 48
A.4.8 VALVES TO BE INSTALLED 48
A.5 DISMANTLING, ABANDONMENT AND RECUPERATION 48
A.5.1 DISMANTLING 48
A.5.2 ABANDONMENT 49

A.5.3 RECOVERY 49
A.5.3.1 FINAL CLEAN OUT 49
A.5.3.2 RECOVERY OF IMPACTED AREAS 49
B. PHYSICAL GEOGRAPHY 50
B.1 ABIOTIC MEDIUM 50
B.1.1 CLIMATOLOGIC ASPECTS 52
B.1.2 HYDROLOGY 64
B.1.2.1 HYDROGEOLOGY 65
B.1.3 REGIONAL GEOLOGY 65
B.1.3.1 STRATIGRAFY 67
B.1.3.2 STRUCTURAL GEOLOGY 69
B.1.3.3 GEOMORPHOLOGY 70
B.1.3.4 GEOTECHNICAL CHARACTERISTICS OF THE ZONE 70
B.1.4 SOILS 71
B.1.4.1 USES OF THE SOIL 73
B.1.4.2 CATTLE USE 74
B.1.4.3 AGRICULTURAL USE 74
B.1.4.4 INDUSTRIAL USE 75
B.1.4.5 EXPOSED AREAS 75
B.1.4.6 HYDRIC USE 76
C. NATURAL THREATS AND RISK 76
D. BIOTIC ENVIRONMENT 79
E. HUMAN ENVIRONMENT 90
F. ENVIRONMENTAL QUALITY OF THE AREA OF THE PROJECT 106
F.1 AIR QUALITY 106
F.1.1 METHODS AND EQUIPMENT CALIBRATION 106
F.1.2 MEASUREMENT DATES AND LOCATIONS 107
F.1.3 APPLICABLE REGULATIONS 109
F.1.3.1 AIR QUALITY INDEX (AQI) 109
F.1.3.2 COLOMBIAN AIR QUALITY STANDARDS 109
F.1.3.3 CALCULATION OF LOCAL STANDARDS 110
F.1.4 MEASUREMENTS DATA 111
F.1.5 ANALYSIS OF MEASUREMENTS 112
F.1.5.1 SUSPENDED PARTICULATE MATERIAL (SPM) 112
F.1.5.2 GASES 114
F.1.5.3 SUMMARY OF GAS MONITORING 118
F.1.5.4 SUMMARY OF MONITORING THE AIR QUALITY INDEX (AQI) 118
F.1.6 CONCLUSIONS FROM THE AIR QUALITY STUDY 119
F.1.7 GREENHOUSE GAS EMISSIONS 119
F.2 WATER QUALITY 122

F.2.1 DRINKABLE WATER 122
F.2.2 SURFACE WATERS OF PALAGUA LAKE 122
F.2.2.1 LAKE PALAGUA SURFACE WATER ANALYSIS RESULTS 125
F.2.2.2 ANALYSIS OF SURFACE WATER IN CREEKS OF PALAGUA FIELD 131
F.2.2.3 ADDITIONAL SURFACE WATER MONITORING EFFORTS 133
F.2.2.4 ANALYSIS OF SEDIMENTS IN PALAGUA LAKE AND CREEKS 137
F.2.3 UNDERGROUND WATER TESTING (Shallow, 3-4m deep wells)..... 141
F.2.4 WASTE WATER MANAGEMENT..... 148
F.2.4.1 DOMESTIC WASTE WATER 148
F.2.4.2 INDUSTRIAL WASTE WATER..... 148
F.2.4.3 INJECTION PLANT OF RESIDUAL WATER 152
F.3 SOIL QUALITY 157
F.3.1 PRINCIPLES OF BIODEGRADATION OF HYDROCARBONS..... 157
F.3.2 TREATMENT UTILIZING THE TECHNOLOGY OF LAND FARMING..... 158
F.3.3 BIOREMEDIATION TREATMENT..... 159
F.3.3.1 BIO NUTRIENTS 159
F.3.3.2 CONDITIONING OF THE MIXTURE 160
F.3.3.3 PROCESS OF BIO REMEDIATION 160
F.3.3.4 PREPARATION OF THE MIXTURE OF TREATMENT..... 160
F.3.3.5 COMPLETION OF THE BIOREMEDIATION PROCESS..... 161
F.3.4 SOIL SAMPLING FROM THE PALAGUA LANDFARMING AREA..... 162
F.3.5 SOIL QUALITY RESULTS..... 163
F.4 LOWLANDS IN THE PALAGUA FIELD..... 165
F.5 NOISE..... 168
F.5.1 EVALUATION INDEXES AND NOISE STANDARDS 168
F.5.2 FIELD EVALUATION 172
F.5.3 DATA COLLECTION AND RESULTS 173
F.5.3.1 DAYTIME DATA 174
F.5.3.2 NIGHTTIME DATA 177
F.5.4 DATA ANALYSIS..... 180
F.5.5 CONCLUSIONS..... 180
G. ARCHEOLOGICAL, HISTORICAL AND CULTURAL RESOURCES..... 180
G.3 PRESENCE OF NATIVE OR AFRICAN-COLOMBIAN COMMUNITIES... 180
CHAPTER 4 POTENTIAL IMPACT ON ENVIRONMENT, HEALTH AND SAFETY 181
4.1 IMPACT IDENTIFICATION AND EVALUATION..... 181
4.2 ENVIRONMENTAL ASSESSMENT 181
4.2.1 AFFECTED ENVIRONMENT..... 181
4.2.2 IDENTIFICATION OF IMPACT 182
4.3 IMPACT EVALUATION FOR ACTIVITIES TO BE EXECUTED 182
4.3.1. METHOD OF IMPACT EVALUATION 182

4.3.1.1 IMPACT IDENTIFICATION 185
4.3.1.2 IDENTIFYING IMPACT CAUSE-EFFECT FACTORS 190
4.3.1.3 QUALITATIVE ASSESSMENT OF ENVIRONMENTAL IMPACT 190
4.4 ENVIRONMENTAL ASSESSMENT WITHOUT THE PROJECT 195
4.5 ASSESSMENT WITH PROJECT 195
4.6 ENVIRONMENTAL INDICATORS 198
4.7 ENVIRONMENTAL IMPACT SENSITIVITY ANALYSIS 200
4.7.1 EVALUATION RESULTS 201
4.7.1.1 WITHOUT PROJECT SCENARIO ASSESSMENT 201
4.8 RESULTS ANALYSIS WITH PROJECT SCENARIO 204
4.9 RESULTS OF THE SENSITIVITY ANALYSIS 208
4.10 ENVIRONMENTAL INDEXES OR INDICATORS 209
4.10.1 ENVIRONMENTAL QUALITY INDEXES (EQI) 209
4.10.2 DETERMINATION OF THE (EQI) 210
4.11 IMPACTS FROM RISKS 213
4.11.2 IMPACT ASSESSMENT MATRIX 221
4.12 SOCIAL COMPONENT – SOCIAL MANAGEMENT 225
4.12.1 SOCIAL MANAGEMENT RESPONSIBILITIES AND ACTIVITIES 226
CHAPTER 5 ENVIRONMENTAL MANAGEMENT SYSTEM 237
5.1 INTRODUCTION 237
5.2 OBJECTIVES OF THE ENVIRONMENTAL MANAGEMENT PLAN 237
5.3 ACTIVITIES OF THE EMVIRONMENTAL MANAGEMENT SYSTEM 237
5.4 ORGANIZATION OF THE EMS 238
5.4.1 ORGANIZATIONAL STRUCTURE AND RESPONSIBILITY 239
5.4.2 PLANNING 241
5.4.3 IMPLEMENTATION 243
5.4.4 CONTROL AND FOLLOW UP 245
CHAPTER 6 ENVIRONMENTAL MITIGATION AND PREVENTION MEASURES 247
6.1 INTRODUCTION 247
6.2 ENVIRONMENTAL MITIGATION AND PREVENTION MEASURES 247
6.3 ORGANIZATION OF THE ENVIRONMENTAL MANAGEMENT 248
6.3.1 ENVIRONMENTAL INDICATORS 249
6.4 GENERAL GUIDELINES FOR ENV. HEALTH AND SAFETY 251
6.4.1 GENERAL GUIDELINES ON SOCIAL MANAGEMENT 252
6.4.1.1 Information and Communication Guideline 252
6.4.1.2 Guideline for Hiring Local Work Force 254
6.4.1.3 Guidelines for Education and Training of Work Staff 256
6.4.1.4 Archeological Information Guideline 258
6.4.2 GENERAL GUIDELINE ON ENVIRONMENTAL MITIGATION AND PREVENTION MEASURES 259

6.4.2.1 Guideline on Environmental Management of Production Testing 259
6.4.2.2 Pipeline (Flow Line) Management Guideline..... 261
6.4.2.3 Guideline of Monitoring and Tracking to Disposition of Industrial Water and Drilling Solids 263
6.4.2.4 Guidelines on Waste Management 267
6.4.3 GENERAL GUIDELINES ON HEALTH AND OCCUPATIONAL SAFETY 269
6.4.3.1 Sign Posting Guideline (Access Road, Location, Flow Line) 269
6.4.3.2 Guideline of Handling and Storage of Chemical Products 271
6.4.4 GENERAL GUIDELINES FOR HEALTH AND SAFETY OF THE COMMUNITY 273
6.4.4.1 Guideline of Control and Monitoring to the Social Management Program..... 273
6.4.4.2 Guideline of Dump Areas, Land Removal and Fillings Management at the Locations 275
6.4.4.3 Guideline of Drainage Management of Access Roads and Locations..... 276
6.4.5 GENERAL GUIDELINES FOR CONSTRUCTION AND DECOMMISSIONING..... 278
6.4.5.1 Environmental Alternatives Guideline (Abandonment Stage) 278
6.4.5.2 Liquid Waste Management Guideline (Abandonment Stage) 280
6.5 GUIDELINES FOR THE EVALUATION AND MANAGEMENT RISK FOR OIL AND GAS DEVELOPMENT..... 282
6.5.1 ASSESSMENT OF RISK OF EMISSIONS INTO THE AIR 283
6.5.2 WASTEWATER DISCHARGE MANAGEMENT – EFFLUENTS..... 285
6.5.3 SOLID AND LIQUID WASTE MANAGEMENT..... 288
6.5.3.1 Solid Waste Management 288
6.5.3.2 Liquid Waste Management 292
6.5.4 ASSESSMENT OF RISK FROM NOISE GENERATION..... 293
6.5.5 TERRESTRIAL IMPACT MANAGEMENT OF THE PROJECT 295
6.5.5.1 Conformation and Stabilization of slopes at the locations..... 295
6.5.5.2 Environmental Revegetation and Recovery of the Surrounding Area..... 296
6.5.6 SPILLS..... 298
6.5.6.1 Environmental Management of Production Testing 298
6.5.6.2 Waste Management and Pollution Control 300
6.5.7 ASSESMENT AND MANAGEMENT RISK FOR BLOW OUT..... 303
6.5.8 MEASURES FOR ENERGY SAVING AND EFFICIENT USE..... 310
6.5.9 WATER CONSERVATION MEASURES 312
6.5.10 WATER QUALITY..... 313
6.6 EMERGENCY AND CONTINGENCY PLAN - GENERAL..... 314
6.6.1 INTRODUCTION 314
6.6.2 APPLICABLE DEFINITIONS 314
6.6.3 LEGAL FRAMEWORK 315

6.64 SCOPE 317
6.6.5 OBJECTIVES 317
6.6.5.1 MAIN OBJECTIVE 317
6.6.5.2 SPECIFIC OBJECTIVES 317
6.6.6 RESPONSIBLE PERSONNEL FOR THE PROCEDURES 318
6.6.7 ANTHROPOGENIC RISK ASSESSMENT 318
6.6.7.1 EVALUATION OF THE VARIOUS THREATS 318
6.6.7.2 MONITORING AND EVALUATION 324
6.6.8 REACTION GROUP ORGANIZATION & OPERATING PROCEDURES 324
6.6.8.1 ORGANIZATIONAL STRUCTURE OF THE RESPONSE TEAM 324
6.7 CONTINGENCY PLAN IN CASE OF FIRE OUTBREAK 328
6.7.1 CAUSE 328
6.7.2 PREVENTATIVE MEASURES 328
6.7.3 GENERAL PRECAUTIONS 329
6.7.4 RESPONSIBILITY 329
6.7.5 POTENTIAL HAZARDS 331
6.7.5.1 STORAGE TANKS 331
6.7.5.2 CONTAINERS AND PORTABLE STORAGE TANKS 333
6.7.5.3 PIPING SYSTEMS 334
6.7.5.4 ELECTRICAL EQUIPMENT AND INSTALLATIONS 335
6.7.5.5 OPERATIONS 335
6.7.5.6 CUTTING, WELDING AND/OR OPEN FLARE WORK 336
6.7.5.7 FLAMMABLE AND COMBUSTIBLE MATERIALS 337
6.7.5.8 OFFICE FIRES 338
6.7.6 ALTERNATE METHODS OF FIRE CONTROL 338
6.7.6.1 CONTROLLED BURN 338
6.7.6.2 MANUAL CONTROL AND EXTINGUISHMENT 339
6.7.7 PALAGUA AND CAIPAL FIRE FIGHTING SYSTEM 339
6.7.7.1 FOAM SYSTEM 341
6.7.7.2 FOAM STORAGE TANK 342
6.7.7.3 WATER DISTRIBUTION AND FOAM SOLUTION NETWORKS 343
6.7.7.4 SYSTEM OF SPRINKLER RINGS FOR WATER COOLING TANKS 343
6.7.7.5 SPRINKLER SYSTEM AT THE VASCONIA PIPELINE 343
6.7.7.6 ANTI-FIRE MONITORING WATER OUTLETS 343
6.7.7.7 ANTI-FIRE CABINETS 343
6.7.7.8 ANTI-FIRE HOSES 344
6.7.7.9 WATER TANK STORAGE 344
6.7.8 AFTER THE CONTINGENCY 351
6.7.9 REVIEWING AND RECORD KEEPING 351
6.7.9.1 FIRE RISK SURVEY 351

6.7.9.2 GENERAL FIRE PREVENTION CHECKLIST 352
6.7.9.3 EXITS CHECKLIST 353
6.7.9.4 FLAMMABLE AND COMBUSTIBLE MATERIALS CHECKLIST 354
6.8 OTHER CONTINGENCIES IN THE FIELD 355
6.8.1 CONTINGENCY PLAN: BOMBING WITH EXPLOSIVES IN THE AREA . 355
6.8.1.1 CAUSES 355
6.8.1.2 PREVENTIVE MEASURES 355
6.8.1.3 PROCEDURE 356
6.8.1.4 AFTER THE CONTINGENCY 357
6.8.2 CONTINGENCY PLAN IN CASE OF EARTHQUAKES 357
6.8.2.1 CAUSES 357
6.8.2.2 PREVENTIVE MEASURES 357
6.8.2.3 PROCEDURE 358
6.8.2.4 AFTER THE CONTINGENCY 359
6.8.3 CONTINGENCY PLAN IN CASE OF EXPLOSION 359
6.8.3.1 CAUSE 359
6.8.3.2 PREVENTIVE MEASURES 359
6.8.3.3 PROCEDURE 360
6.8.3.4 AFTER THE CONTINGENCY 360
6.9 EMERGENCY PLAN 361
6.9.1 INSTITUTIONALIZATION OF THE EMERGENCY PLAN 361
6.9.2 DISCLOSURE OF THE EMERGENCY PLAN 361
6.9.3 EDUCATION AND TRAINING OF RESPONSE TEAM 361
6.9.4 PLAN OF EMERGENCY CONTROL ACTIONS 362
6.9.5 OPERATING PROCEDURE OF THE EMERGENCY BRIGADES 362
6.9.6 EMERGENCY EQUIPMENT 363
6.9.7 SUPPORT AGENCIES 365
6.9.8 EVACUATION PLAN 365
6.9.8.1 OBJECTIVE 365
6.9.8.2 RESPONSIBILITIES – EXECUTIVE LEVEL 365
6.9.8.3 LEVEL COORDINATOR AND EMERGENCY RESPONSE TEAMS 366
6.9.8.4 COMMUNICATION EQUIPMENT 366
6.9.8.5 EVACUATION ROUTES 367
6.9.9 ROLES AND RESPONSIBILITIES OF THE BRIGADERS 368
6.9.9.1 EMERGENCY COORDINATOR 368
6.9.9.2 FIRE CONTROL GROUP 369
6.9.9.3 FIRST AID GROUP 371
6.9.9.4 SUPPORT AND CONTROL GROUP 373

List of Tables

Table 1 COORDINATES OF THE 32 DEVELOPMENT WELLS IN 2012 3
Table 2 PHYSICAL-CHEMICAL ANALYSIS OF WATER FROM WATER WELL PW-1 (88.5m depth) ... 11
Table 3 SUMMARY OF GUIDELINES OF ENVIRONMENTAL, HEALTH AND SAFETY PROGRAM 14
Table 4 SUMMARY OF GUIDELINES OF THE ENVIRONMENTAL MANAGEMENT PROGRAM 15
Table 5 COLOMBIAN LEGAL FRAMEWORK 23
Table 6 COORDINATES OF THE 32 DEVELOPMENT WELLS TO BE DRILLED IN 2012 27
Table 7 ACTIVITIES DURING DRILLING 30
Table 8 REQUIRED EQUIPMENT TO ADAPT THE LOCATION AND ACCESS ROADS 36
Table 9 GENERAL DRILLING DESIGN OF THE DEVELOPMENT WELLS 42
Table 10 REQUIRED PERSONNEL DURING THE DRILLING OF THE DEVELOPMENT WELLS 42
Table 11 METEOROLOGICAL STATIONS USED FOR WEATHER CHARACTERIZATION 52
Table 12 HYDRIC BALANCE, PUERTO BOYACA 61
Table 13 TEMPERATURE, BAROMETRIC PRESSURE, HUMIDITY AND WIND 63
Table 14 SUSCEPTIBILITY TO GEOLOGICAL THREATS 77
Table 15 NATURAL HAZARD AREAS 77
Table 16 SPECIES OF VEGETATION PRESENT IN THE STUDY AREA 84
Table 17 IMPORTANT SPECIES IN THE STUDY AREA 86
Table 18 ADMINISTRATIVE DIVISION OF THE AREA 93
Table 19 POPULATION OF PUERTO BOYACA MUNICIPALITY 94
Table 20 ILLITERACY INDICATORS FOR THE PUERTO BOYACA MUNICIPALITY 95
Table 21 MONITORING SITES FOR THE AIR QUALITY STUDY 108
Table 22 AIR QUALITY INDEX CATEGORIES 109
Table 23 MAXIMUM PERMISSIBLE LEVELS OF CRITICAL CONTAMINANTS 110
Table 24 LOCAL AIR QUALITY STANDARDS 111
Table 25 SPM AND O_3 MEASUREMENTS 111
Table 26 NO_X, SO_X AND CO MEASUREMENTS 112
Table 27 STATISTICAL ANALYSIS OF SPM DATA 113
Table 28 STATISTICAL ANALYSIS OF NO_X DATA 114
Table 29 STATISTICAL ANALYSIS OF O_3 DATA 115
Table 30 STATISTICAL ANALYSIS OF SO_X DATA 116
Table 31 STATISTICAL ANALYSIS OF CO DATA 117
Table 32 COMPARISON OF RECORDED CONCENTRATIONS OF GASES TO PERMISSIBLE VALUES. 118
Table 33 AIR QUALITY INDEX DETERMINED FOR THE AREA OF STUDY 119
Table 34 FUEL PRODUCTION AND CONSUMPTION FOR 2012 137
Table 35 BURNED AND FLARED FUEL WITH CORRESPONDING CO2 EMISSIONS 121
Table 36 GEOGRAPHIC COORDINATES OF SURFACE WATER SAMPLING SITES 123
Table 37 ANALYSIS RESULTS OF SURFACE WATER IN PALAGUA LAKE (Part 1 of 2) 126
Table 38 ANALYSIS RESULTS OF SURFACE WATER IN THE PALAGUA LAKE (Part 2 of 2) 127
Table 39 CLASSIFICATION OF WATER IN TERMS OF CONDUCTIVITY 129

Table 40 CLASSIFICATION OF WATER IN TERMS OF HARDNESS 129
Table 41 CLASSIFICATION OF WATER IN TERMS OF DQO AND DBO_5 131
Table 42 ANALYSIS OF SURFACE WATER IN CREEKS 132
Table 43 COORDINATES OF ADDITIONAL SURFACE WATER MONITORING POINTS 134
Table 44 LOCATION A01 134
Table 45 LOCATION A02 134
Table 46 LOCATION A03 135
Table 47 LOCATION A04 135
Table 48 LABORATORY RESULTS OF MEASURED BODIES OF WATER 136
Table 49 IN SITU AND LAB ANALYSIS OF SEDIMENTS IN PALAGUA LAKE AND CREEKS 138
Table 50 COORDINATES OF THE 19 MONITOR WELLS 142
Table 51 ANALYSIS RESULTS OF UNDERGROUND WATERS OF PM-1 TO PM-19 143
Table 52 RODIER UNDERGROUND WATER CLASSIFICATION 145
Table 53 REYNOLDS UNDERGROUND WATER CLASSIFICATION SYSTEM 146
Table 54 QUALITY OF TREATED DOMESTIC WASTE WATER 148
Table 55 PHYSICAL AND CHEMICAL CONTROL PARAMETERS – PALAGUA FIELD, 2011 150
Table 56 OPERATING CONDITIONS OF WATER INJECTION PLANT 153
Table 57 OPERATIONAL PARAMETERS OF THE WATER INJECTION PLANT (PIA) 154
Table 58 CHEMICALS USED IN THE TREATMENT OF RESIDUAL WATER 154
Table 59 WATER ANALYSIS OF THE RESIDUAL WATER TREATMENT PLANT 156
Table 60 FINAL DISPOSAL OF TREATED DRILLING CUTTINGS 162
Table 61 LAB RESULTS FOR TREATED SOILS FROM A DRILLING CUTTING 164
Table 62 SOLIDS GENERATED FROM DRILLING A WELL 165
Table 63 LOWLAND FLOODING AREA 1 167
Table 64 LOWLAND FLOODING AREA 2 167
Table 65 LOWLAND FLOODING AREA 3 167
Table 66 LOWLAND FLOODING AREA 4 167
Table 67 LOWLAND FLOODING AREA 5 168
Table 68 MAXIMUM PERMISSIBLE NOISE LEVEL STANDARDS 169
Table 69 MONITORING SITES OF TESTING CONDUCTED ON MARCH 20, 2012 172
Table 70 HOURLY NOISE EMISSION 173
Table 71 MONITORING POINT 1 DAYTIME MEASUREMENTS 174
Table 72 MONITORING POINT 2 DAYTIME MEASUREMENTS 175
Table 73 MONITORING POINT 3 DAYTIME MEASUREMENTS 176
Table 74 MONITORING POINT 1 NIGHTTIME MEASUREMENTS 177
Table 75 MONITORING POINT 2 NIGHTTIME MEASUREMENTS 178
Table 76 MONITORING POINT 3 NIGHTTIME MEASUREMENTS 179
Table 77 LAeq READINGS VS NOISE LIMITS BY THE LAW 180
Table 78 ENVIRONMENTAL FACTORS 186
Table 79 CRITERIA TO DEVELOP THE IMPORTANCE MATRIX 191
Table 80 IMPACT IMPORTANCE 192

Table 81 LEVELS OF SIGNIFICANCE FOR IMPACTS VALUES 193
Table 82 ENVIRONMENTAL ASSESSMENT RESULTS 197
Table 83 PROPOSED INDICATORS FOR ENVIRONMENTAL FOLLOW-UP AND ASSESSMENT 199
Table 84 SOUND INTENSITY 202
Table 85 VEGETATION PROFILE OF PALAGUA FIELD 203
Table 86 VALUE RATING OF ENVIRONMENTAL COMPONENTS 212
Table 87 CONTRACTING LOCAL MANUAL LABOR 226
Table 88 FUNDAMENTAL ELEMENTS OF A MANAGEMENT SYSTEM 239
Table 89 UT-IJP EMS – POSITIONS AND THEIR FUNCTIONS 240
Table 90 COMPREHENSIVE LIST OF LAWS GOVERNING THE ECP 316
Table 91 EXISTING POTENTIAL THREATS 319
Table 92 PROBABILITY OF OCCURRENCE OF THE EMERGENCY 320
Table 93 VULNERABILITY OF THE PEOPLE RELATED THREAT/RISK 320
Table 94 ANTHROPOGENIC THREATS 321
Table 95 NATURAL HAZARDS 321
Table 96 ORIGIN OF TECHNOLOGICAL THREATS 322
Table 97 EMERGENCY HAZARDS GENERATORS 323
Table 98 STATION NO. 1 339
Table 99 STATION NO. 2 340
Table 100 STATION NO. 4 340
Table 101 WATER TANK CAPACITY 344
Table 102 ACTIONS IN CASE OF FIRE THREAT 350
Table 103 PROCEDURE IN CASE OF ATTACK WITH EXPLOSIVES IN THE SECTOR 356
Table 104 ECP-1 PROCEDURE IN CASE OF EARTHQUAKE 358
Table 105 WHAT TO DO IN CASE OF EXPLOSION 360
Table 106 SEQUENCE OF ACTION IN CASE OF EMERGENCY 363
Table 107 MINIMUM EQUIPMENT FOR EMERGENCY CARE AT CAMP SITES AND WORK FRONTS. 364
Table 108 MINIMUM EQUIPMENT FOR EMERGENCIES AT OFFICES AND/OR CAMP SITES 364
Table 109 EMERGENCY TELEPONE FIXED LINES, MOBILE AND AVANTEL 365
Table 110 EVACUATION ROUTES 367

List of Figures

Figure 1 General Location of the Palagua field 2
Figure 2 Location Scheme and Mobilization Routes to the Wells 28
Figure 3 Stages of the Execution and Organization of the Drilling Project 31
Figure 4 Placement of Drilling Equipment 33
Figure 5 Flow Chart for Handling of Oily Water 35
Figure 6 Types of Drilling Bits Used in Rotating Drilling 39
Figure 7 Mud Cycle in Drilling 40
Figure 8 Pump Pressure with Gas & Liquid 45
Figure 9 Total Monthly Values – Precipitation – Puerto Boyacá Station 53
Figure 10 Monthly Maximum Values – Precipitation – Puerto Boyacá Station 53
Figure 11 Total Annual Cumulative Values – Precipitation – Puerto Boyacá Station 54
Figure 12 Monthly Maximum Values - Precipitation – Puerto Boyacá Station 54
Figure 13 Total Monthly Values – Precipitation – Padilla Station 55
Figure 14 Total Annual Values – Precipitation – Padilla Station 55
Figure 15 and Figure 16 Ratio of temperature to elevation 56
Figure 17 Temperature – Puerto Boyacá Station – Monthly Mean Values 57
Figure 18 Temperature – Annual Mean Values – Puerto Boyacá Station 57
Figure 19 Relative Humidity – Monthly Mean Values – Puerto Boyacá Station 58
Figure 20 Relative Humidity – Annual Minimum Values – Puerto Boyacá Station 59
Figure 21 Yearly Cloudiness Values 60
Figure 22 Hydric Balance, Puerto Boyacá Station 62
Figure 23 Division of the Rural Areas (by percentages) 94
Figure 24 Public Health Puerto Boyacá Municipality 97
Figure 25 Drinking Water and Basic Sanitation, Municipality of Puerto Boyacá 102
Figure 26 Coverage of Electricity and Fixed Telephony 103
Figure 27 Hi-Volume Sampler with Mass Control 122
Figure 28 Digital Environment Ozone Test Meter 106
Figure 29 RAC 3-gas Sampler 107
Figure 30 SPM Found in the Area of Influence in Palagua Field 113
Figure 31 NO_x Found in the Area of Influence in Palagua Field 114
Figure 32 O_3 Found in the Area of Influence in Palagua Field 115
Figure 33 SO_x Found in the Area of Influence in Palagua Field 116
Figure 34 CO Found in the Area of Influence in Palagua Field 118
Figure 35 Tendencies of Conductivity and Dissolved Solids 128
Figure 36 Tendencies of Suspended Solids and Turbidity 130
Figure 37 Tendency of Cadmium vs ISQG-PEL 139
Figure 38 Tendency of Zinc vs ISQG-PEL 140
Figure 39 Tendency of Chromium vs ISQG-PEL 140
Figure 40 Ion Balance 147

Figure 41 TDS/Conductivity Ratio 147
Figure 42 Residual Water Injection 2010 and 2011 149
Figure 43 Analysis of Total Dissolved Solids – 2011 151
Figure 44 Turbidity Analysis - 2011 151
Figure 45 Schematic of the Water Injection Plant 155
Figure 46 Biodegration Process 158
Figure 47 Scheme of the Mixture for the Treatment 159
Figure 48 Sample zones of the Land Farming in Palagua Field 161
Figure 49 Critical Lowland Areas 166
Figure 50 Impact Assessment Methodology 184
Figure 51 Risk Assessment 214
Figure 52 Organizational Structure for the Application of the EMS 239
Figure 53 Areas in the Palagua field Susceptible to Spills 302
Figure 54 Summary of Risks that Generate Emergencies 323
Figure 55 Organizational Structure of the Response Team 325
Figure 56 Anti-fire system distribution in Palagua field 345
Figure 57 Distribution of gun barrel tanks at Palagua field 346

List of Photos

Photo 1 and Photo 2 Rocky outcrops 6
Photo 3 and Photo 4 Overview of existing vegetation in the Project area 7
Photo 5 Development wells – Palagua Field 26
Photo 6 and Photo 7 Access to wells in the Palagua Field 32
Photo 8 Conduction of groundwater PW-1 – Administrative area of the Palagua field 37
Photo 9 Forest component at the project area 38
Photo 10 Water well PW - 1 43
Photo 11 and Photo 12 Air balanced pumping unit (left) and conventional pumping unit, Palagua field . 46
Photo 13 and Photo 14 Flow lines with manifold at Palagua field 46
Photo 15 and Photo 16 General view of the project area 51
Photo 17 Palagua Lake 64
Photo 18 and Photo 19 Conduction system of water for human consumption 65
Photo 20 and Photo 21 Geological shape of low rounded Hills within the area 66
Photo 22 Low wetlands Zone, conformed of silt and argil 67
Photo 23 Outcrop of sand and silt horizons, Palagua field 68
Photo 24 Hills of the Mesa Formation which have been intervened 69
Photo 25 General view of the geological formation of the zone 69
Photo 26 Geomorphologic unit of rounded top hills in the zone of the Project 70
Photo 27 Presence of low consistency soils given an inadequate drain 71
Photo 28 and Photo 29 Areas for the use of stockbreeding 74

Photo 30 and Photo 31 Areas of agricultural use 74
Photo 32 and Photo 33 Sector of Industrial Use 75
Photo 34 Palagua Lake – Hydric source of greatest importance 76
Photo 35 Appearance of low flood land areas 81
Photo 36 and Photo 37 Social Structures and Housing in the Rural Area of Palagua field 90
Photo 38 and Photo 39 Educational institutions existing in the Palagua rural area 92
Photo 40 and Photo 41 Palagua Alliance School 95
Photo 42 and Photo 43 Tourist sites - Palagua Lake and La Cristalina Creek 99
Photo 44 Well PW-1 provides water for industrial and domestic use 101
Photo 45 Cattle ranching in Puerto Boyacá 104
Photo 46 Palagua Lake – Point 1 Photo 47 Palagua Lake – Point 2 123
Photo 48 Palagua Lake – Point 3 Photo 49 Palagua Lake – Point 4 124
Photo 50 Palagua Lake – Point 5 Photo 51 Palagua Lake – Point 6 124
Photo 52 Palagua Lake – Point 7 Photo 53 Palagua Creek 124
Photo 54 Agualinda Creek Photo 55 El Tambo Creek 124
Photo 56 API separator 152
Photo 57 Water treatment plant at Palagua field 153
Photo 58 Industrial pools of water storage 155
Photo 59 Botadero 3 Photo 60 Taking a soil sample in Botadero 3 163
Photo 61 Taking a soil sample in P-96 Photo 62 P-96 163
Photo 63 Chaparro road after repairs 227
Photo 64 - 65 - 66 Community meeting promoting socialization of contingency plan 228
Photo 67 - 68 - 69 Road safety training to the students of the Palagua-Alliance School 228
Photo 70 - 71 - 72 Giving assistance to the community after the monsoon rains 229
Photos 73, 74, 75, 76, 77, and 78 Health squad workshops and activities 230
Photo 79 - 80 - 81 Environmental workshops for the children of the Palagua-Alliance School 231
Photo 82 - 83 - 84 End of year graduation ceremony and activities 231
Photo 85 - 86 - 87 Assistance to schoolchildren for purchase of school kits 232
Photo 88 - 89 - 90 Assistance to schoolchildren with purchases of clothing and shoes 232
Photo 91 and Photo 92 Playground equipment for the children of the Palagua-Alliance School 233
Photo 93 - 94 - 95 Halloween celebration for neighborhood children 233
Photo 96 - 97 - 98 Celebrating Christmas with neighborhood children 234
Photos 99, 100, 101, 102, 103, and 104 Practical training in vertical rescue operations 235
Photos 105, 106, 107, 108, 109, and 110 Programs on general safety and personal safety in the field 235
Photo 111 - 112 - 113 Training in the use of fire extinguishing equipment 236
Photos 114, 115, 116, 117, 118, and 119 Scheduled training for the Emergency Brigade 236
Photo 120 and Photo 121 Weekly testing of the firefighting system in Palagua field 331
Photo 122 and Photo 123 Emergency team (Brigade) training at UT-IJP, Palagua field 331
Photo 124 and Photo 125 Foam and water firefighting truck for the Palagua field 341
Photo 126 and Photo 127 Training on the firefighting truck 341

EXECUTIVE SUMMARY

A. DESCRIPTION OF THE PROJECT

The drilling of 32 development wells in the year 2012 is a continuation of ongoing work of Union Temporal – Ismocol Joshi Parko (UT – IJP) in the development of the Palagua field (hereafter referred to as Palagua field). This is an expansion of an already existing project on the site of an existing oil field. No new land needs to be acquired for this expansion project. All required concessions for this project have been obtained from the Colombian government. No local inhabitants from the communities in and around the Palagua field will be physically or economically displaced. Since there are no Indigenous Peoples in the area, the cultural heritage will not be impacted. All of this information is available in the Environmental and Social Impact Assessment that was conducted in 2010 (hereafter referred to as 2010 ESIA) for a similar project in the same area. Environmental Base Line conditions were established in the 2010 ESIA. The Base Line information will be updated to include the impact of 40 wells that were drilled since the 2010 study and the potential impact of the 32 wells in the current project. The environmental impact of these 32 new wells is expected to be very small due to the use of existing roads, existing well location pads and existing production facilities.

An Environmental Plan was developed from the components and programs which resulted from the analysis of the impact assessment. This plan is aimed at prevention, control, mitigation, recovery, and compensations of impacts that occur during project activities. Updates to the Environmental Plan and mitigation measures are also provided as necessary.

A.1 CHARACTERISTICS OF THE PROJECT

A.1.1 TECHNICAL DESCRIPTION OF THE PROJECT

UT-IJP became the Palagua field operator in 2001. Since then, various activities such as rehabilitation of oil wells, drilling, and the application of production technologies have enhanced the field oil production rates from 2500 barrels of oil per day in 2001 to 5000 barrels per day in March 2010.

A.1.2 LOCATION OF THE PROJECT

The location of the project remains the same as in the 2010 ESIA but is also included here for ease of comprehension. The Palagua production field is located 30 kilometers away from the municipality of Puerto Boyacá, Departamento Boyacá (Department/State), in the basin of the middle Magdalena Valley, about 7 km east of the Vasconia Station of Empresa Colombiana De Petroleos, ECOPETROL SA, at a height of 137 meters above sea level.

igure 1 General Location of the Palagua field

SPANISH TO ENGLISH TRANSLATION KEY:

Top map:

Campo Palagua:	Palagua Field
Pto Boyacá:	Puerto Boyacá
Dpto. De Boyacá:	Department of Boyacá

Bottom map:

** Left hand side:*

Troncal de la Paz:	Main road from la Paz
Estación Vasconia:	Vasconia Station
Campo Teca:	Teca Field
Campo Cocorná:	Cocorná Field
Río Magdalena:	Magdalena River

** Right hand side:*

Zona Industrial Palagua:	Palagua Industrial Area
Est. #:	Station #
PIA:	Water Injection Plant
Bat. #:	Battery #
Ciénaga de Palagua:	Palagua Marsh
Sendero:	Path
Estación Velázquez 26:	Velázquez Station 26
Batallón Bárbula:	Bárbula Battalion
Zona Industrial Omimex:	Omimex Industrial Area
Aeropuerto:	Airport

The current project involves the drilling of development oil wells of directional type to reach areas of the field that have not been drained by existing wells in the Palagua field. The drilling campaign will be carried out from existing well pads using 17 different well clusters. This eliminates the need to bring in materials to construct new well pads. Consequently, this reduces the amount of water needed for well pad construction. The proposed 2012 drilling locations are listed in Table 1, below. Their location is shown on the map in Annex 1.

Table 1 COORDINATES OF THE 32 DEVELOPMENT WELLS IN 2012

Coordinate System: Gauss-Kruger Bogota
Geographix Project: Palagua (N&E)
Data: Bogota Observatory

#	Name	Y	X	Drill Site
1	C-38	1168540.07	953542.96	C-010
2	P-236	1164268.867	952410.758	P-197
3	P-244	1166466.85	952057.64	P-048
4	P-250	1165254.89	952016.6	P-030
5	P-251	1167243.57	951627.32	P-046
6	P-252	1166179.698	952429.842	P-086B
7	P-253	1166202.11	952423.59	P-086B
8	P-255	1165915.78	952393.05	P-086A
9	P-256	1165542.871	952489.226	P-133
10	P-257	1162619.966	952760.237	P-010
11	P-258	1162543.421	952605.226	P-138
12	P-259	1162658.386	952806.464	P-010
13	P-261	1163740.03	951512.92	P-122
14	P-262	1164314.227	952385.919	P-197
15	P-263	1166845.619	951675.444	P-137
16	P-264	1164048.381	952014.465	P-169
17	P-265	1164037.662	952010.577	P-169
18	P-266	1165266.76	952366.85	P-222
19	P-267	1165250.46	952359.22	P-222
20	P-268	1165245.279	952349.061	P-222
21	P-269	1166840.237	951658.267	P-137
22	P-270	1166566.11	951549.764	P-042
23	P-271	1166555.797	951554.626	P-042
24	P-272	1166514.531	951203.396	P-036
25	P-273	1166525.831	951204.917	P-036
26	P-274	1166849.608	951664.762	P-137
27	P-275	1166854.99	951681.938	P-137
28	P-276	1166446.304	952091.038	P-048
29	P-277	1164058.774	952869.24	P-088
30	P-278	1163602.483	952741.408	P-077
31	P-279	1165739.509	951836.94	P-072
32	P-280	1165749.01	951830.637	P-072

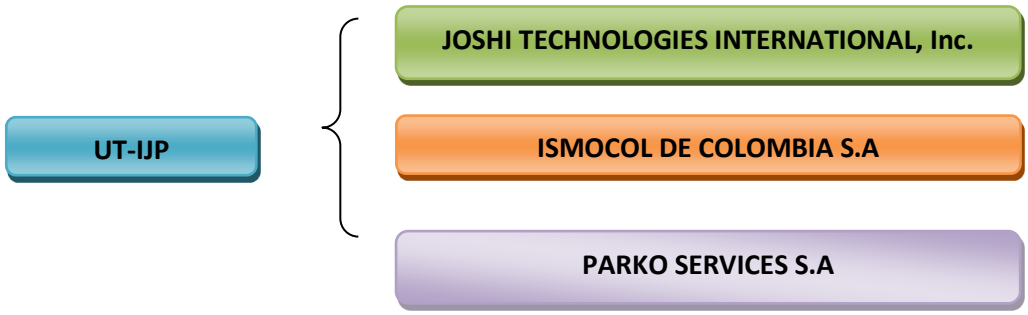
The areas selected for the drilling of the development wells do not require large movements of earth or forestry management (cutting or removal of species-forestry), or water sources involving a complex change in the environmental management.

The Palagua Oil Field has an extensive road infrastructure both internally and externally. Regular maintenance is carried out to facilitate access to selected areas. Therefore, the areas selected do not require construction of new roads since development wells will be drilled from existing locations with good access roads in place.

The new project involves the drilling of 32 development wells to reach areas of the site that have not yet been drained by the existing production wells. The series of activities to be undertaken for the drilling of these wells remains the same as in the ESIA 2010.

B. IDENTIFICATION OF THE HOSTS, OPERATORS AND CONTRACTORS

The Union Temporal (UT-IJP) consists of the following companies:



The companies that are members of the Union Temporal (UT-IJP) will make the following contributions:

a) JOSHI TECHNOLOGIES INTERNATIONAL, Inc.: Will provide the technology, the knowledge and the design of the well stimulation, the Work-over, the design and completion of wells, the geological and oilfield studies, will take part in the management of oil and gas production activities of the field, will assist with the management of the project, the engineering, the operation and the supply and management of purchases, will act as co-operator, will also provide training services, supplies and R&D (research and development) functions.

b) ISMOCOL DE COLOMBIA S.A.: Will provide logistic and the necessary infrastructure support for the execution and compliance with the CONTRACT, management of the project, engineering, operation of the field, the supply and management of purchases, the building, the services, the relationship with customers and other agencies. Ismocol has the following ISO certificates:

Standard	Valid even	Certification
ISO 9001:2000	November 14th 2010	CO231235 by Bureau Veritas
ISO 14001:2004	November 17th 2012	CO231236 by Bureau Veritas
OHSAS 18001:2007	October 13th 2011	CO230762 by Bureau Veritas
Ismocol Activities: CONSTRUCTION, OPERATION AND MAINTENANCE OF OIL PIPE LINES AND GAS PIPELINES, COLLECTING LINES AND CONDUCTION IN GENERAL; CONSTRUCTION OF CIVIL WORKS, ELECTROMECHANICAL, INSTRUMENTATION SET-UPS AND IN GENERAL ALL THE WORKS OF INFRASTRUCTURE FOR THE AREA OF HYDROCARBONS AND BESIDES INDUSTRY'S SECTORS; CONSTRUCTION, OPERATION AND MAINTENANCE OF: OIL FACILITIES, INDUSTRIAL PLANTS, PETROCHEMICAL PLANTS, REFINERIES AND FACILITIES OF PRODUCTION; CONSTRUCTION OF TANKS; DRILLING EQUIPMENT SUPPLY OF OIL, GAS AND WATER WELLS AND SERVICE TO WELLS; ADMINISTRATION, OPERATION AND MAINTENANCE OF OIL FIELDS.		

c) PARKO SERVICES S.A: Will provide technical assistance and purchase management support necessary for the execution and compliance with CONTRACT.

In consideration of clause 4.19 of the CONTRACT UT-IJP is the project operator.

Contractors:

HALLIBURTON
An American company specialized in drilling, cementing, logging and other oil services.

SCHLUMBERGER
An American company specialized in electrical logging and gravel packing.

ISMOCOL DE COLOMBIA
A Colombian company specialized in construction, operation and maintenance of oil pipelines and gas pipelines and drilling equipment for the supply of oil and gas.

C. ENVIRONMENTAL CONDITIONS BASE LINE

The project is located in the Rural Area Palagua, municipality of Puerto Boyacá, Boyacá Department, at 137 meters above sea level. The Palagua oil field is approximately 7 km east of the Vasconia Station of the Empresa Colombiana de Petroleos, ECOPETROL SA.

C.1 CLIMATIC ASPECTS

At the Palagua oil field the annual average temperature ranges between 26 ° C and 31° C. Rainfall since 1989 holds an average of 2589 mm; the relative humidity in the area of influence of the wells under study varies throughout the year between 61% and 86%, and cloud presents an average value of 3 octas.

C.2 SOIL, GEOLOGY, GEOMORPHOLOGY AND GEOTECHNICS

Photo 1 and Photo 2 Rocky outcrops

The ground soils in the area have developed from clay and sandy material. The soil is characterized as shallow with fluctuating underground water level. In the Palagua field, the organic layer is shallow and steep in some areas.

The hydro - geological behavior in the Palagua field is determined by the geomorphology of the terrain and its lithological composition, which determine the mechanical, physical, and hydraulic properties of the rock.

In the Palagua field, there is an outcrop of sedimentary rocks of the Tertiary age to recent deposits, while in the underground the age of formations ranges from the Tertiary to Triassic – Jurassic periods.

The production area of the Palagua oil field is located in the basin of the Middle Magdalena River Valley (VMM), in the foothills of the Eastern Cordillera. It is bound on the east by the faults of the Foothills of

the Eastern Cordillera, and to the West by the faults of the Central Cordillera. The tectonic depression is molded throughout the area, mainly because of the tertiary period rocks, which present some over-thrusting with vertical dips in the high part, but in depth they are leaning toward the eastern side.
The project´s area is characterized by having the following geological faults:

- Mesa Formation (Tsm)
- Real Formation (Tmr)
- Colorado Formation (Toc)
- Mugrosa Formation (Tom)
- Esmeralda Formation
- La Paz Formation

C.3 VEGETATION

Photo 3 and Photo 4 Overview of existing vegetation in the Project area

The population of flora is made up of trees and bushes arranged in narrow strips. It should be noted that the project's influence on this vegetation is low, because the direct involvement in the development of the activities does not impact the area. The area involved has no woody vegetation; it is an area with a covering of weed species and low stubble, or underbrush.

In the area of flooding lowlands (valleys), the vegetation is characterized by strips of fixed and floating macrophytes, reeds, and some shrub and woody species around the drains. Some associated species are: *Azolla polyrrhiza, Pistia sp., Typha sp., Bidens sp., Eleocharis sp.* However, drilling locations are in the hilltop areas and not in valleys or lowlands.

C.4 USE, DEVELOPMENT AND ALLOCATION OF NATURAL RESOURCES

During the execution of this work, the materials used are the soil resource, land covering material and water resource.

- ***Water Resource:*** All the water required for domestic use and industrial use shall be taken from PW-1 underground, 85 meter deep water well, located within the administrative area. The granting of groundwater was established by CORPOBOYACA by Resolution 463 of June 8, 2005. The estimated average consumption is of 0.3 liters per second.

- ***Construction Material:*** The material required for improving drilling locations will be acquired through commercial agencies located in Puerto Boyacá that have the corresponding environmental permit granted by the Regional Autonomous Corporation - CORPOBOYACÁ. Part of the material used will come from the area of former Station No. 3.

- ***Forest Resource:*** During the construction of locations, forest resources will not be affected, since the drilling of new wells will only use existing well locations.

- ***Dumping:*** During construction work, debris or refuse will not be generated; therefore, permit for the disposal of construction materials will not be required.

The wells will be drilled in previously existing locations and there will be no cafeteria for the employees at the location, hence, additional involvement of natural resources will be minimal.

- ***Liquid Industrial and Domestic Wastes:*** These are formed mainly by runoff water (contaminated and uncontaminated), domestic wastewaters, industrial waters, and oily residues. Following is a description of each.

- ***Runoff water***. For the management of rainwater at the locations we have perimeter channels with sediment recollection and drainage structures in order to channel the waters into the surrounding environment without affecting the current hydrodynamics. The rainwater that collects in the channels within the location will be lead to the oil trap and then to the Industrial Waste Water Treatment Plant (PIA) of the field.

- ***Domestic Waters.*** Water used in human activity such as bathrooms, kitchens and sinks is treated in a septic system which includes several tanks and filters. Approximately 150 gallons of domestic waste water is generated daily. This represents a minimum amount in comparison with the 11,000 barrels per day of produced water for oil wells in the Palagua field.

- ***Industrial Waters***. It is the liquid that comes from the residual mud and water from separation of cutting and drilling fluids. These waters are directed into the tanks where coagulant chemicals,

flocculants and clarifiers are injected enhancing water separation. Then water is pumped to a sedimentation tank from where it is collected with the vacuum truck and then disposed of in the Waste Water Treatment Plant (API) of the field. The waste water plant injects all the produced water back into the formation from which it came at a depth of about 4000 ft.

- ***Residual Waste Oils***: They are composed mainly of oil burned in the various engines of the equipment; these will be stored on location in fifty-five (55) gallon drums, and then they will be transported to the dump site of the Palagua battery.

- ***Dumping***: All domestic and industrial liquid waste shall be subjected to primary treatment at the location to subsequently be taken to the separation system at Battery No.1, and then taken to the Water Treatment plant of the Palagua Field. Therefore, no dumping permit is required for the drilling of development wells.

- ***Domestic Solid Waste:*** It is that produced in the project's offices as personal hygiene, and food waste, among others. These wastes are composed of cardboard, glass, food waste, paper and aluminum. Household waste is taken to the temporary storage site in the Industrial Area of the Palagua Field, and subsequently collected by Public Companies of Puerto Boyacá.

- ***Industrial Solid Waste:*** It is considered waste such as cuttings from the separation of the solids control equipment, and also waste or surplus product of the cementing, scrap metal, wood, filters, packaging and others from the maintenance of machinery and equipment.

Drilling cuttings and waste mud will be removed from the location to be stabilized with lime for dehydration and will be finally stabilized in the land farming area. The scrap metal will be taken to the storage yard for such types of waste located at the Palagua Battery. The contaminated soils will be transported for bioremediation in the land farming area. Oil-infused waste is stored in the existing collection area (dump site) in the Industrial Area of Palagua Field for subsequent shipping and incineration in the kilns of Holcim at Nobsa, Boyacá.

D. APPLICABLE ENVIRONMENTAL STANDARDS

With respect to the Environmental Quality standards and guidelines at a national and international level (Environmental Health and Safety Guidelines from the World Bank for Onshore Operations), these are environmental management instruments that consist of parameters and obligations that aim to regulate and protect the public health and environmental quality. In the Palagua field, UT-IJP performs monitoring activities to measure the quality of the air, water and soil, to ensure that the company activities have not caused a health risk for the people that work in the company, or to the community near the project and the environmental impacts have been mitigated.

D.1 AIR QUALITY

The results obtained in the Palagua field were compared with Resolution 601 of April, 2006, (601/2006) fulfilling the standards established by the Ministry of Environment and Territorial Development (M.A.V.D.T in Spanish) and the Environmental, Health, and Safety (EHS) Guidelines of the World Bank – used by the International Finance Corporation (IFC).
The conclusions are:

- Out of the three monitoring stations, all of them comply with the annual local air quality standard and most of the levels reported in the Palagua field are low.
- We comply with Colombian regulations and IFC standards for nitrous oxide, sulphur dioxide, particulate material higher than 10 microns (PM 10), and ozone levels in the air.
- In general, air quality in the Palagua field is good.

D.2 WATER QUALITY

D.2.1 DRINKING WATER

Samples of water used for domestic and industrial consumption were taken from the water wellhead PW-1 and storage tank outlet and tested by the laboratory ASINAL LTDA.

The following table shows the results of the analysis.

Table 2 PHYSICAL-CHEMICAL ANALYSIS OF WATER FROM WATER WELL PW-1 (88.5m depth)

PARAMETERS	UNITS	TECHNIQUE OF ANALYSIS AND/OR EQUIPMENT USED	RESULTS AT THE TOP OF THE WELL	RESULTS AT THE POINT OF CONSUMPTION	MAXIMUM LIMITS Decree 475/98
pH	Units	pH meter	8.8	8.7	6.5 – 9
Conductivity	µS/cm	Conductivity meter	212	211	50 - 1000
Total Alkalinity	mg CaCO3 / L	Metric Title	88	79	100
Total Hardness	mg CaCO3 / L	Metric Title	16	10	150
Turbidity	NTU	Nephelometric	1	1.1	< 5
Total Solids	Mg / L	Gravimetric	114	109	< 500
Total Dissolved Solids – TDS	mg/L	Electrometric	111	109	Not Rated
Total Suspended Solids	Mg/L	Dried Filtration at 105 °c	3	<1	Not Rated
Real Colour, Hazen Units	Hazen Units (Pt-Co)	Colorimeter	5	5	< 15
Chlorides	Mg Cl - / L	Conductivity meter	5	7	250
Nitrites	Mg NO2 - / L	Spectrometer UV	< 0.01	< 0.01	0.03
Phosphates	Mg PO4 -3 / L	Spectrometer UV	0.02	0.04	Not Rated
Sulphates	mg SO4 -2/ L	Spectrometer UV	1	1	250
Total Iron	mg Fe +++/ L	3500- B S. M. 21 ST Editions	0.28	< 0.01	0.3
Total Coli forms	UFC/100 cm^3	Filtration through membrane	0	0	0
Escherichia coli.	UFC/100 cm^3	Filtration through membrane	0	0	0

As the table shows, the well water meets all the environmental guidelines as issued in the Decree 475 from the Health Ministry on March 10, 1998, as well as those for the International Finance Corporation (IFC) and the World Health Organization (WHO) Guidelines for Drinking-Water Quality.

D.2.2 SURFACE WATER IN PALAGUA LAKE

In July 2001, the National Oil Company ECOPETROL handed over the Palagua and Caipal oil fields to UT-IJP for their operation under an incremental production contract. The field was operated by Texaco from 1957 onwards. Thus, Ecopetrol and Texaco operated the Palagua Caipal field from 1957 till 2000.

Prior to taking over the field, UT-IJP conducted an environmental base study. One of the important conclusions of 2000 Environmental Base line study was that Lake Palagua was polluted and lacked oxygen in water. To this effect, Ecopetrol took over the responsibility of correcting the situation. As per the agreement between Ecopetrol and UT-IJP, it is Ecopetrol's responsibility to pay for and arrange to remedy environmental damage, if any, prior to the year 2000. The lack of oxygen in the lake water was due to the presence of a plant called "Tarulla." Since 2004 and onward, Ecopetrol removes these plants from the lake. This has resulted in an increase in oxygen in the lake water and fish have returned to the Lake.

Thus, there is a significant improvement in the quality of lake water from the year 2001 to 2010. Additionally, the Palagua Lake water will not be affected by drilling of the proposed additional 32 wells.

D.2.3 UNDERGROUND WATER

In the year 2000, prior to UT-IJP taking over the field, the Colombian Environmental Ministry asked Ecopetrol to install ground water monitoring stations and correct the ground water problems, if any. To comply with the order, Ecopetrol installed 19 monitoring shallow wells (3 to 4 meters deep) to monitor ground water. Some of the problems found have been fixed by Ecopetrol over time. In the last 10 years, there is a significant improvement in the ground water quality.

Most of the ground water problems were found near Battery No. 1, where there was a spill and a fire in 1996. There are ground water monitoring stations in Battery No1. Two stations out of three stations now are free of any hydrocarbons.

Additionally, most of the measurement stations show no damage due to BTEX (benzene, toluene, ethylbenzene, xylenes) or phenols. In general, due to Ecopetrol's efforts, the quality of the underground water has improved significantly in the last 10 years. Additionally, drilling of the proposed development wells for this expansion project would have no effect on this underground water.

D.3 SOIL QUALITY

Due to previous hydrocarbon operations in the field, the Colombian Petroleum Institute (ICP from Ecopetrol) provides technical advice for the land farming of this field. ICP performed a physic-chemical characterization of the soil.

The soil in the Palagua Field was evaluated according to the legislation in the Louisiana Administrative Code, Natural Resources, Subsection 1, State-wide Order No. 29b. This norm contains the requisites for in-situ storage, treatment, and disposal of non-hazardous residues.

The conductivity and concentrations of grease, oil, and metals (silver, arsenic, barium, cadmium, lead, selenium, zinc and mercury) in the monitored soil in Palagua field are below the permitted limits in the Louisiana norm.

The pH levels in the site samples are slightly outside the range as per the Louisiana norms. In general, the soil in the area is of an alkaline nature.

D.4 NOISE

The monitoring of environmental noise in the Production Area of PALAGUA FIELD corresponding to possible noise emission sources during production and operation show:

- Noise level measurements in the study area were low, with ranges around 58.4 - 64.9 dBA during the day and 50.5 - 62.6 dBA at night.
- Noise levels measured are below the maximum permissible limit of 75 dBA during the day and 70 dBA at night for an area classified as Sector C, industrial use zone.
- This indicates neither noise pollution nor a risk factor for workers and communities.

E. PROPOSED MITIGATION MEASURES

The measures aimed at prevention, control, mitigation, recovery, and compensation of impacts that occur during project activities are presented in a series of components and programs that make up the Proposed Mitigation Actions (PMA). These components and programs are the result of the analysis of the impact assessment. Accordingly, the Environmental Management Plan is developed.

E.1 GUIDELINES FOR THE EVALUATION AND MANAGEMENT RISK FOR OIL AND GAS DEVELOPMENT

The following table contains a summary of the guidelines of the Environmental, Health and Safety Program that have been developed.

Table 3 SUMMARY FO THE GUIDELINES OF THE ENVIRONMENTAL, HEALTH AND SAFETY PROGRAM

PROGRAM	DOCUMENT REFERENCE NUMBER		ENVIRONMENTAL, HEALTH AND SAFETY MANAGEMENT GUIDELINES	
COMPREHENSIVE PROGRAM OF EVALUATION AND MANAGEMENT OF RISKS AND SPECIFIC POTENTIAL IMPACTS OF THE PROJECT	6.5.1		Assessment and management of risk and potential impacts of emissions into the air	
	6.5.2		Wastewater discharge management – Effluents	
	6.5.3	6.5.3.1	Solid waste management	Solid and liquid waste management
		6.5.3.2	Liquid waste management	
	6.5.4		Assessment and management of risk and potential impacts from noise generation	
	6.5.5	6.5.5.1	Conformation and stabilization of slopes at the locations	Terrestrial impact management
		6.5.5.2	Environmental revegetation and recovery of the surrounding area	
	6.5.6	6.5.6.1	Environmental management of production testing	Spills
		6.5.6.2	Waste management and pollution control	
	6.5.7		Assessment And Management Risk For Blow Out (Well Control Policy)	
	6.5.8		Measures for energy saving and efficient use	
	6.5.9		Water consumption measures	
	6.5.10		Water quality	

E.2 GENERAL GUIDELINES ON ENVIRONMENTAL HEALTH AND SAFETY

The table below contains a summary of the guidelines of the Environmental Management Program.

Table 4 SUMMARY OF GUIDELINES OF THE ENVIRONMENTAL MANAGEMENT PROGRAM

SECTION	Number in the document		GUIDELINE OF ENVIROMENTAL MANAGEMENT
SOCIAL MANAGEMENT	6.4.1	6.4.1.1	Information and communication guideline
		6.4.1.2	Guideline for hiring local work force
		6.4.1.3	Guidelines for education and training of staff of the work staff
		6.4.1.4	Archeological information guideline
ENVIROMENTAL	6.4.2	6.4.2.1	Guideline on environmental management of production testing
		6.4.2.2	Pipeline (flow line) management guideline
		6.4.2.3	Guideline of monitoring and tracking to disposition of industrial water and drilling solids
		6.4.2.4	Guidelines on waste management
HEALTH AND OCCUPATIONAL SAFETY	6.4.3	6.4.3.1	Signposting guideline (access road, location, flow line)
		6.4.3.2	Guideline of handling and storage of chemical products
HEALTH AND SAFETY OF THE COMMUNITY	6.4.4	6.4.4.2	Guideline of control and monitoring to the social management program
		6.4.4.3	Guideline of dump areas, land removal and land-fills management at the locations
		6.4.4.4	Guideline of drainage management of access roads and locations
CONSTRUCTION AND DECOMMISSIONING	6.4.5	6.4.5.1	Environmental alternatives guideline (abandonment stage)
		6.4.5.2	Liquid waste management guideline (stage of abandonment)

E.3 EMERGENCY AND CONTINGENCY PLAN – GENERAL

This section establishes the mechanisms and response actions to attend in a timely and effective manner any partial or total disruption of activities of the 32-well expansion project for drilling of development wells in Palagua field. It also seeks to reduce the environmental impact caused to the affected area. Appropriate measures and equipment are in place in the field to handle emergencies such as fire and blow out of the wells.

F. NET ENVIRONMENTAL IMPACT

According to the assessment of the different environmental aspects involving the drilling of development wells, comparing them with the present baseline, **these activities do not change or alter significantly the current environmental conditions of the region.**

F.1 PHYSICAL-BIOTIC COMPONENT

The current operation of the Palagua oil field does not significantly affect the regional environmental status; as it is expected that the drilling of development wells does not alter this situation, which, according to different studies, remains constant or tends to decline. It is considered that the machinery, equipment, and vehicles used in the area will not generate emissions in quantities that exceed the values laid down in the regulations.

The noise impact is considered tolerable, and its effects are restricted to the areas of operation. The duration of the noise is short and the reversibility and recoverability of the initial conditions of the environment is high.

The effect of drilling activities on bodies of water is insignificant. Although the project includes drilling of additional wells, the new wells use the existing well locations. Hence, there is no effect on bodies of water in the area.

The current situation shows that the conditions for the geospheric component of the area will not be affected significantly, since there are already internal and external access roads that allow access to the wells.

Additionally, the current tree population will not be affected by the installation of equipment, or by operation of the development wells.

F.2 SOCIO-ECONOMIC AND CULTURAL COMPONENT

The study area of this project includes the Palagua oil field, a rural area of the municipality of Puerto Boyacá. The proposed development drilling program will not make a significant change the socioeconomic conditions of the study area. Only minor change will be generated in the behavior of the population. The project will improve the general institutional infrastructure of the Palagua area.

F.3 RISK ANALYSIS

The results of the analysis indicate that the risks are not highly significant for the environmental components. The most important risks to be managed are the management of equipment, possible gas leaks, product spills, fire and well blow out.

CHAPTER 1 PRELIMINARY

1.1 INTRODUCTION

The Municipality of Puerto Boyacá, specifically the area where the Palagua and Caipal Fields are located, has become a highly competitive territory at a regional level in the hydrological production, agricultural, oil, technology development and tourism sectors, allowing its inhabitants to keep a social wellbeing in a pleasant environment and with institutions to achieve individual and collective development. The present study is framed within the municipal, national and international policies and with the following objectives:

- To develop projects based on the law that enables the population of the area of direct and indirect influence of the Palagua and Caipal Development Fields to strive for a better life.
- To preserve the ecological and cultural heritage that exists in the municipalities of the area.
- To strengthen the territorial development in a balanced and sustainable way.
- To create a policy to strengthen institutions in the area of Palagua and Caipal Development Fields.

The present document is written in compliance with the requirements established by the Environmental Legislation[1]. It contains the social, environmental and industrial safety components for Development Wells C-38, P-236, P-244, P-250, P-251, P-252, P-253, P-255, P-256, P-257, P-258, P-259, P-261, P-262, P-263, P-264, P-265, P-266, P-267, P-268, P-269, P-270, P-271, P-272, P-273, P-274, P-275, P-276, P-277, P-278, P-279, and P-280, IN THE PALAGUA AND CAIPAL FIELDS LOCATED IN THE MUNICIPALITY OF PUERTO BOYACA, DEPARTMENT OF BOYACA – COLOMBIA.

It contains proposing strategies to improve the physical conditions that guarantee a safe environment where activities based on sustainable development can take place. It consists basically of: Objectives of environmental management, Justification and General Scope, General Description of the Processes and Activities in the project, Base Line conditions of the potentially altered zones, Environmental Risk Analysis, and Environmental Measures for mitigation, control, compensation and/or prevention. It also includes Monitoring Plan, Contingency Plan, Follow-up Plan, and Schedule for the Environmental Management Plan, and Environmental Impact assessment, according to the international and national Environmental Legislation.

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[1] *Especially the requirements established in the International and Colombian Environmental Law 99/93 and Decree 1753/94*
[2] CUNESA ,VICENTE. "Methodological guide for the evaluation of environmental impact. (Methodological Guide To Evaluate Environmental

To execute the Environmental and Industrial Safety Assessment, a multi-disciplinary group of professionals and specialists in different areas was formulated, which developed the corresponding studies based on the Quality Standards to achieve a sustainable development between the activities that would take place at Development Wells C-38, P-236, P-244, P-250, P-251, P-252, P-253, P-255, P-256, P-257, P-258, P-259, P-261, P-262, P-263, P-264, P-265, P-266, P-267, P-268, P-269, P-270, P-271, P-272, P-273, P-274, P-275, P-276, P-277, P-278, P-279, and P-280.

1.2 OBJECTIVES

1.2.1 GENERAL OBJECTIVE

To perform the environmental, health and industrial safety assessment for development drilling of oil wells in the Palagua Field. Additionally, to identify, define and assess the impact that can be generated on natural resources and the physical, biotic and social medium, during the development drilling of oil wells. To facilitate the execution of Environmental Management through programs to prevent, mitigate, correct and compensate for the negative effects caused by possible impacts on natural resources and environment. Additionally, to develop plans for Follow-up and Monitoring of the environmental measures adopted. To address contingencies that may occur during the development of the project and its operation.

1.2.2 SPECIFIC OBJECTIVES

- To identify the most important environmental areas that require special handling such as critical, sensitive or very important environment ecosystems.
- To describe, characterize and analyze the environment (geographic, historic, biotic and social) in the area where the project under study takes place.
- To assess the possible vulnerability of the natural and social ecosystems affected by the project.
- To identify, measure, assess and evaluate the impacts produced by the project. To establish the probability of its occurrence, magnitude, and duration. To establish its reversibility and permanent status, both in its installation and drilling stages at the Palagua – Caipal Field.
- To present record sheets of the actions to prevent, mitigate and compensate the negative effects and potentiate the positive effects produced by the development at each stage of the project.

- To consult the public and private, international and national plans that will take place in the area of study, to assess the existing global, national, regional and local standards of the project.

- To gather the information needed about natural resources to be intervened, used or affected by the installation and operation of the Development Wells C-38, P-236, P-244, P-250, P-251, P-252, P-253, P-255, P-256, P-257, P-258, P-259, P-261, P-262, P-263, P-264, P-265, P-266, P-267, P-268, P-269, P-270, P-271, P-272, P-273, P-274, P-275, P-276, P-277, P-278, P-279, and P-280.

- To design an Environmental Follow-up and Monitoring Program that allows assessing the efficiency of the measures designed in the Environmental Management plan.

- To prepare the Contingency Plan based on the identification and assessment of possible accidents and anticipated risks related to the development and normal operation of the project.

1.3 JUSTIFICATION AND SCOPE

The present study complies with the current established environmental regulations for the project of DEVELOPMENT DRILLING of OIL WELLS AT THE PALAGUA FIELD, LOCATED IN THE MUNICIPALITY OF PUERTO BOYACA, and DEPARMENT OF BOYACA within established guidelines on environment, health and safety, as per the Good International Industrial Practice (GIIP) and the World Bank Operational Policy.

The scope of the document is to obtain the guidelines to manage the environmental, health and safety components and the social aspects during the execution of activities to prevent, mitigate, and control possible effects and to potentiate positive impacts during the development of the project.

1.4 METHODOLOGY

The Environmental and Industrial Safety Assessment is done by gathering primary information and visiting and inspecting. Bibliographic references were compiled to ascertain methods used to assess environmental and social factors to obtain a characterization of the impacts the project could cause on the current local and regional environment and the way to prevent environmental damage, if any.

1.4.1 GATHERING OF BASIC INFORMATION

The elements of judgment and analysis of the environmental study were obtained both from primary as well as secondary sources.

To gather the basic primary information field visits were carried out as well as, photographic records, blueprints, analysis of the activities that take place during the installation and drilling of the wells at the Palagua – Caipal Field, temporary placement and spatial map of the elements that generate potential threats, observation of the scenic and landscape components, relationship between the existing vegetation in the area surrounding the intervention zone, maps that support the mitigation, correction, control or compensation activities, among others. To obtain secondary information search, revision, assessment and transcription of the information was gathered from state and private sources.

Environmental management was performed to optimize, rationalize and restrict the use of renewable and non-renewable natural resources during the development drilling in the Palagua field.

The environmental impacts were identified and then qualitatively assessed to determine the effect on the ecosystems and the degree of vulnerability of the communities and their current cultural heritage. The strategies, plans, programs and mechanisms of the Environmental Management Plan suggest solutions for the possible impacts identified at the assessment stage.

The analysis of the resulting thematic information was fully carried out through modern information systems and Interdisciplinary groups consisting of specialized professionals that participated in the execution of the present Environmental Study.

1.4.2 SECONDARY BASIC INFORMATION

- Measurements and studies carried out at Palagua and Caipal Fields.
- Revision of existing bibliography at the Union Temporal-IJP.
- Land Zoning Plan of the Municipality of Puerto Boyacá, Department of Boyacá.
- Climatic and meteorological information of the area.
- Information of demographic and socio-economic matters of the area resulting from the Land Zoning Plan of Puerto Boyacá and DANE.

1.4.3 ANALYSIS OF INFORMATION

For the analysis of each of the environmental components (biotic, hydrosphere, geospheric, social, hydric, etc.), an objective assessment was carried out, based primarily on the identification of the actual state of each of the components in the environment (without the project) and the way it would probably be affected by the proposed activities during the development of the project. Environmental

impacts in the area of influence created by the alteration of any component of the environment were identified by magnitude and importance.

The environmental assessment of the project essentially consisted of confirming the actions and activities prone to produce environmental alterations in the area of influence. The purpose is to identify, describe, qualify and quantify the significant environmental impacts, both during the installation and the operation of the project.

For the environmental assessment the methodology proposed by CONESA was used since it was considered as appropriate for the natural and social characteristics of the area of influence and the specifications of the project.

The Environmental Management Plan was prepared based on the set of strategies, plans, programs and designs needed to prevent, control, mitigate, compensate or correct the environmental impacts generated in each of the stages and activities of the project.

1.5 BACKGROUND

Drilling is the only way of knowing if hydrocarbon deposits actually exist, even with the results of previously performed seismic and geological research.

In Colombia, the depth of a well will normally be between 2,000 and 25,000 feet, depending on the region and the depth at which the formation containing the oil is located.

At the Palagua field, an exploratory well was drilled (first well that has been drilled in an area that had not been geologically explored – "A-3"), in the year 1954, by the Texas Petroleum Company, who through Resolution 1092 of November of 1956, earned the Exploration Concession. In 1987, the Field was returned to the Colombian State to be managed by ECOPETROL through Resolution No. 293 of 1983 until today.

The Colombian Petroleum Company – ECOPETROL, offers the operation of Palagua – Caipal Field through an Incremental Production Contract – IPC for improving the recovery factor of the oilfield, by means of habilitation, technological application and drilling of wells. With regard to the development wells the aim is to recover oil from the non-drained proved reserves. The Union Temporal-IJP began its development activities at the Palagua field in the year 2001.

Taking into account that the Palagua field began activities before Law 99 of 1983, it did not require an Environmental License to operate. In the year 2000, ECOPETROL S.A. presented operational plans to the Ministry of Environment. Today, the Colombian Ministry of Environment, Housing and Territorial Development monitors activities through the Environmental Management Plan for Palagua and Caipal

Fields; this document contains the management measures approved for the current operations and to environmentally endorse future activities related to the Field development.

The present Environmental Management Plan for the Development Wells C-38, P-236, P-244, P-250, P-251, P-252, P-253, P-255, P-256, P-257, P-258, P-259, P-261, P-262, P-263, P-264, P-265, P-266, P-267, P-268, P-269, P-270, P-271, P-272, P-273, P-274, P-275, P-276, P-277, P-278, P-279, and P-280, corresponding to the Palagua and Caipal Fields, is a basic tool that contains the environmental measures and actions during the execution of the project, that is considered as of relatively low significance impact, due to the fact that the new wells are drilled from an existing locations, where there is no need to build new access roads or to build big embankments, and hence, there is no additional effect on natural resources in the area.

At the end of the project is proposed a Closure and Abandonment Program that establishes the required measures for the recuperation and renewal of the area where the wells are located.

For the drilling activities of the development wells described in the Environmental Management records, no known additional permits or authorizations are required.

CHAPTER 2 POLITICAL, LEGAL AND MANAGERIAL FRAMEWORK

2.1 APPLICABLE LAWS AND REGULATIONS (COLOMBIAN LEGISLATION)

The legal and regulatory framework that serves as reference for the preparation of the present study is governed particularly within Law 99/93, decree 1220 of 2005 and decree 500 of 2006. With regard to the general regulatory framework, applicable laws and regulations are presented in Table 5 below.

Table 5 COLOMBIAN LEGAL FRAMEWORK

COLOMBIAN LEGAL FRAMEWORK		
CONSTITUTIONAL REGULATIONS	Environmental Protection Principles. Co-responsibility State – Community natural resources-Nation Environmental Cleanup as public service. Right to a healthy environment. Natural Resources Planning under the State's responsibility Law 100 of 1993. Social Security Structure – Professional Risks System Duty of Colombians protection and conservation of environment.	Constitution of 1991. Article 8 N.C. Article 49 N.C. Article 79 N.C. Article 80 N.C. Article 82 N.C. Article 95 N.C. Article 58 N.C. Article 329 N.C. Article 330 N.C. Article 55 Transitory
LEGAL REGULATIONS	National Code of Renewable Natural Resources and Protection of Environment Objectives and organic structure of the Ministry of Environment, Housing and Land Development	Decree 2811/74 Law 99/93 Decree-216/2003
STATUTORY REGULATION	Mines Code Environmental Licenses Forest Use (if required) River bed intervention (if required) Water Management Concession (if required) Permit for liquid waste discharge (if required) Transportation, Management and Disposal of Slag and Solid Waste	Law 685 of 2001 Decree 1220 of 2005 Law 1021 of 2006 Law 1021 of 2006 Decree 1541 of 1978 Decree 1584 of 1984 Decree 948 of 1995 Resolution 0627 of 2001 Resolution 909 of 2008 Resolution 541 of 1994 Decree 1713 of 2002 (modified by Decree 838 of 2005) Decree 4741 of 2005
LANDSCAPE	Right to enjoy urban and rural landscape. Landscape protection	Art.302-304 C.R.N.R. D.1715/78

2.2 RELEVANT INTERNATIONAL TREATIES AND STANDARDS USED TO EVALUATE POLLUTION

The following are some the most relevant worldwide treaties:

- United Nations Sustainable Development Summit, Johannesburg, South Africa, September 2,002.

- Earth Summit 1,992, Rio de Janeiro, Brazil, inter-relates Sustainable Development, Climate Change and Biological Diversity.

- Resolution 54/175 of 2000, issued by the United Nations General Assembly, taking into account the right for Pure Water as a Human Fundamental Right.
- Agenda 21 on Sustainable Development International Treaties.
- Ramsar Convention 1971, on Wetlands of International Interest.
- Mar del Plata Action Plan, Argentina 1977, Hydric Resources Management from a perspective of improvement in economic and social conditions for humanity.
- Helsinki Convention 1997, Protection and Use of Trans-boundary Watercourses and International Lakes.
- The Millennium Summit on Potable Water and Basic Sanitation, Colombia 2009. La Cumbre del Milenio de Agua Potable y Saneamiento Básico, Colombia 2009.
- International Convention for the Prevention of Pollution of the Sea by Oil
- United Nations Conference on the Environment, Stockholm 1972.
- Kyoto Protocol 2002, on Climate Change and Greenhouse Gas Emissions.

Other International Conventions

- United Nations International Convention on Biological Diversity.
- Vienna Convention, for the Protection of the Ozone Layer.
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).
- Convention on Migratory Species of Wild Animals (CMS).
- Basel Convention on the Control of Trans-boundary Movement of Hazardous Wastes and their Disposal.
- Rotterdam Convention On the Prior Informed Consent Procedure for certain hazardous Chemical products and Pesticides in international trade, 2004
- Montreal Protocol on Substances That Deplete the Ozone Layer, 1987

With respect to the areas of Industrial Health and Safety, the following are listed:

- International Work Regulations (NIT)
- Technical Regulation on Business Behavior, 1: SA8000 and FLO (Fair Labeling Organization).
- Occupational Health and Safety Regulations IRAM 3800 and OHSAS 18001. (Accident prevention and in consequence business profitability).
- Technological Standards – ANSI, NIOSH

2.3 APPLICABLE ENVIRONMENTAL STANDARDS – ENVIRONMENTAL GUIDELINES ON HEALTH AND SAFETY FOR OIL EXPLOITATION DEVELOPMENT

The oil sector corporations have included environmental quality management systems among their operative policies. Apart from observing the increasingly more rigorous and punitive Environmental Legislation with those that commit crimes against the environment, the environmental quality management improves the efficiency of the corporations and at the same time reduces the risk of possible accidents and their respective sanctions, achieving an ecologic image that contributes while improving its competitiveness.

ISO 14000 is among the international environmental quality systems. It is important to highlight the environmental management regulations (ISO 14001 and 14004); environmental audit and related investigation (ISO 14010, 14011 and 14012); environmental performance evaluation (14031); the environment labeling (14022, 14023); the life cycle (14040, 14041); terms and definitions (14050) and product environmental standards (14060).

CHAPTER 3 PROJECT BASELINE

A. PROJECT AREA DELIMITATION

Photo 5 Development wells – Palagua Field

In 2001, the Incremental Production Contract (CPI) was signed between Ecopetrol and UT-IJP (Union Temporal-Ismocol, Joshi, and Parko). Since then, old wells have been activated and new wells have been drilled. This has allowed fulfilling the established base production and incremental production, which is the main objective of the contract.

Through the CPI contract, UT-IJP plans to drill 32 additional wells during 2912. Since the drilling of 32 development wells in the year 2012 is a continuation of ongoing work of Union Temporal – Ismocol Joshi Parko (UT – IJP) in the development of the Palagua field, the project baseline remains the same. (See: Annex 1 for a complete map of the Palagua project).

A.1 LOCATION OF THE PROJECT

The Palagua – Caipal oil fields represent one of the population centers in the municipality of Puerto Boyacá. The fields are located 30 kilometers from the urban limits of the municipality of Puerto Boyacá, Department of Boyacá, in the basin of the Middle Magdalena Valley, approximately 7 kilometers east of ECOPETROL's Vasconia Station at an altitude of 137 meters above sea level.

A.1.1 LOCATION OF WELLS TO BE DRILLED

Table 6 lists the preliminary coordinates of the 32 wells to be drilled in 2012 and the existing surface locations from where they will be drilled.

Table 6 COORDINATES OF THE 32 DEVELOPMENT WELLS TO BE DRILLED IN 2012

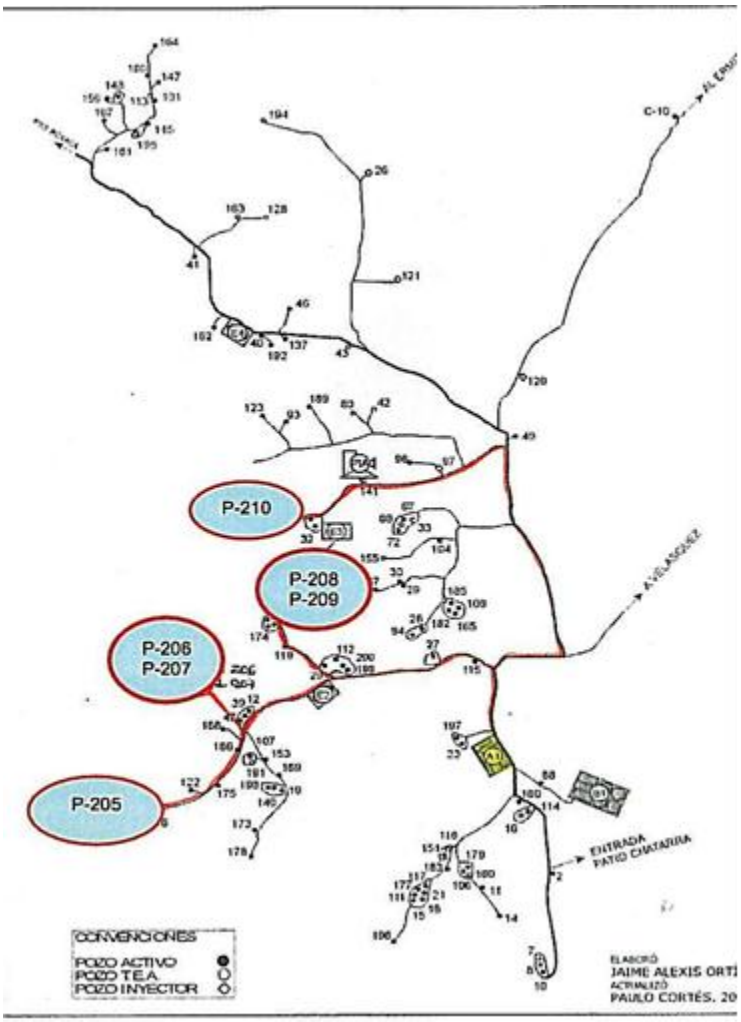
Coordinate System: Gauss-Kruger Bogota
Geographix Project: Palagua (N&E)
Data: Bogota Observatory

#	Name	Y	X	Drill Site
1	C-38	1168540.07	953542.96	C-010
2	P-236	1164268.867	952410.758	P-197
3	P-244	1166466.85	952057.64	P-048
4	P-250	1165254.89	952016.6	P-030
5	P-251	1167243.57	951627.32	P-046
6	P-252	1166179.698	952429.842	P-086B
7	P-253	1166202.11	952423.59	P-086B
8	P-255	1165915.78	952393.05	P-086A
9	P-256	1165542.871	952489.226	P-133
10	P-257	1162619.966	952760.237	P-010
11	P-258	1162543.421	952605.226	P-138
12	P-259	1162658.386	952806.464	P-010
13	P-261	1163740.03	951512.92	P-122
14	P-262	1164314.227	952385.919	P-197
15	P-263	1166845.619	951675.444	P-137
16	P-264	1164048.381	952014.465	P-169
17	P-265	1164037.662	952010.577	P-169
18	P-266	1165266.76	952366.85	P-222
19	P-267	1165250.46	952359.22	P-222
20	P-268	1165245.279	952349.061	P-222
21	P-269	1166840.237	951658.267	P-137
22	P-270	1166566.11	951549.764	P-042
23	P-271	1166555.797	951554.626	P-042
24	P-272	1166514.531	951203.396	P-036
25	P-273	1166525.831	951204.917	P-036
26	P-274	1166849.608	951664.762	P-137
27	P-275	1166854.99	951681.938	P-137
28	P-276	1166446.304	952091.038	P-048
29	P-277	1164058.774	952869.24	P-088
30	P-278	1163602.483	952741.408	P-077
31	P-279	1165739.509	951836.94	P-072
32	P-280	1165749.01	951830.637	P-072

A.1.2 TRANSPORTATION ROUTES

Access to well locations from the urban limits of Puerto Boyacá is through the main road, "Troncal de la Paz", heading to the North. About 3 km north of ECOPETROL's Vasconia Station, is a road (in good condition) approximately 12 km long, heading east, that takes one to the Palagua field.

The new wells will be drilled from the existing active well locations and all the locations have internal access roads. Therefore, there is no environmental effect in the areas where the new wells are to be drilled.



SPANISH TO ENGLISH TRANSLATION KEY:

Al Ermitaño	to Ermitaño
A Velasquez	to Velasquez
Desmantelada	Dismantled
Pozo Activo	Active Well
Pozo Tea	Flare Well
Pozo Inyector	Injection Well

Figure 2 Location Scheme and Mobilization Routes to the Wells

A.1.3 DESCRIPTION OF THE OPERATIONAL PROCESS

The process as described in 2010 ESIA remains the same. However, in the 4th paragraph of section A.1.3 only 4 injector wells were listed for use in the field. There are now 6 wells that are used on a rotating basis as injector wells. Therefore, it can now be said that, "Finally, the treated water is reinjected into the reservoir through existing injector wells. In the Palagua field, there are six injector wells: P-26, P-97, P-120, P-121, P-194 and P-195. Generally, four wells are in use at any given time while two wells are held in stand-by for contingencies."

A.2 DESCRIPTION OF THE PROJECT

The project consists of drilling 32 development wells to reach areas of the oilfield that have not yet been drained by the existing wells. The drilling of the development wells of Palagua field requires a series of sequential activities to be performed, in order, described below:

1. Location of the well is decided based upon biotic, geologic, social and stratigraphic criteria.

2. Preparation of the Management Plan for approval of the Ministry of Environment, Housing and Land Development and the Regional Autonomous Corporation of Boyacá.

3. Improving existing roads so that the vehicles can transport the required equipment for the operation.

4. Creation and improvement of the well site to place the rig and related equipment. It should be stable enough since the equipment is quite heavy.

5. Building of perimeter channels to manage rainwater.

6. Installation of drilling equipment and waste management facilities.

7. Beginning of drilling work to a desired depth.

8. Dismantling of the drilling rig so as to continue the with completion tasks at the well.

9. Connection of the production pipelines to the existing infrastructure.

10. Removal of the mud from the well site and beginning of the recovery plan of the intervened area.

Table 7 contains the logic sequence with a short description of the activities that take place during the drilling of a development well. Figure 3 demonstrates the different stages in which the drilling project is developed.

Table 7 ACTIVITIES DURING DRILLING

ACTIVITY	DESCRIPTION
Selection of the project area	• According to oilfield and geologic studies. • Low environmental impact area. • Easy execution of civil work according to topography.
Environmental Development Plan - EDP	• Submission of the document and respective management plan to the Environmental Authorities (CORPOBOYACÁ y MAVDT)
Road improvement	• Adaptation of the road to comply with technical specifications using motor graders. • Stabilization and compacting of the road using road rollers and compacters.
Location leveling	• Movement of land to re-level the soil. • Load-bearing capacity tests.
Equipment transport and installation	• Rig drilling equipment, control equipment and storage of solids, cementation equipment, electrical recording equipment, electrical generator, mud pumps, pipelines.
Drilling	• Drill to the depth where according to the design of the well the surface casing will set. • Take out the drilling pipes. • Install the surface casing. • Cementation of the surface coating. • Continue drilling to the desired depth. • Take electrical records to identify the interval of the productive formation. • During the whole drilling period the drilling cuttings are treated and dehydrated and the mud residue is treated to recover products and improve the quality of the liquid waste to be sent to the Water Injection Plant.
Equipment dismantling	• Dismantling of the equipment used in the operation. • Final disposal of the drilling cuttings. • Mud residue disposal.
Well completion	• Install the casing pipes. • Cementation of the casing. • Seat the shoe to for securing the casing. • Open by perforating the productive interval. • Install pumps. • Install pressure regulators.
Connection to existing infrastructure	• Installation of the production lines from the well to the nearest collector.

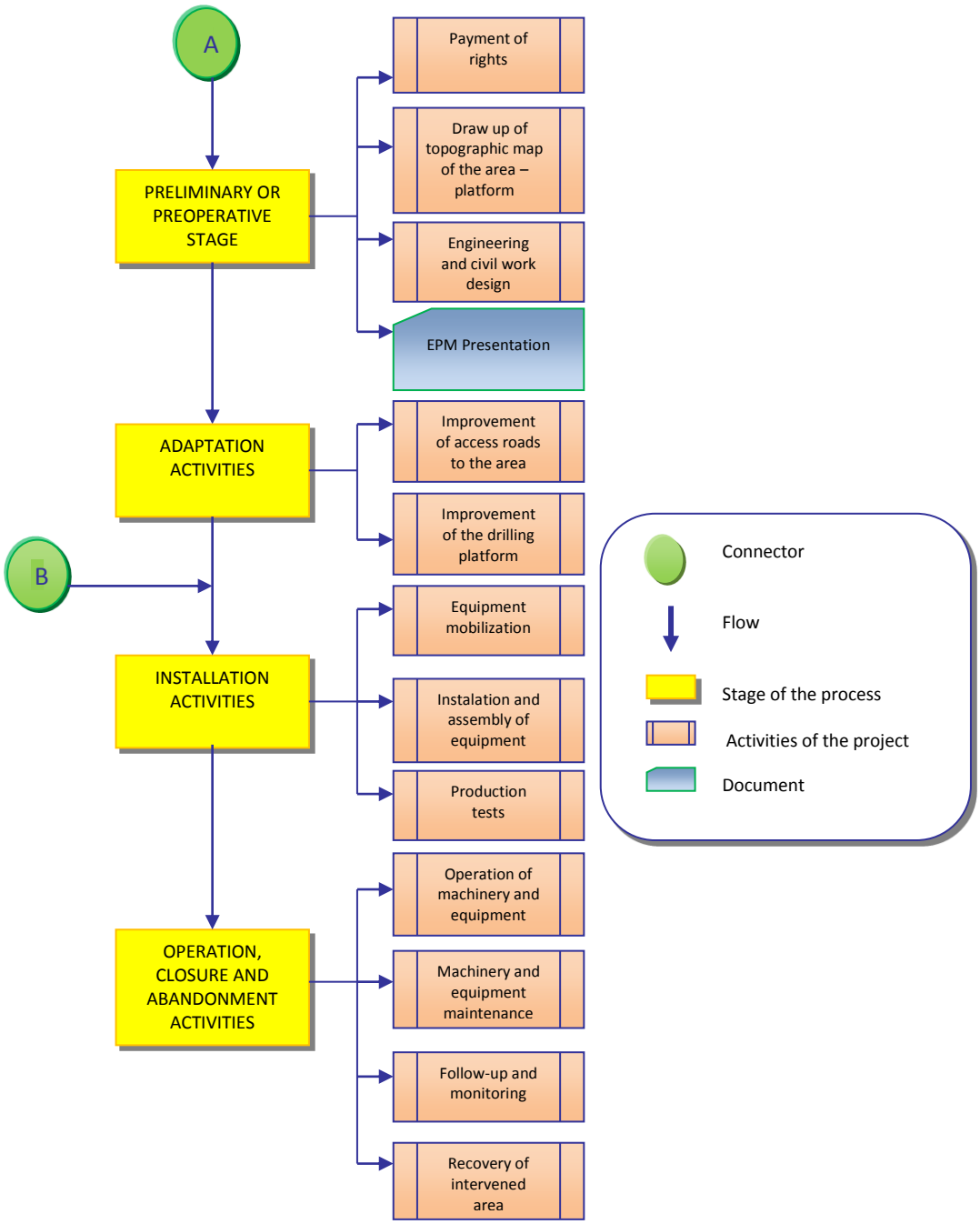


Figure 3 Stages of the Execution and Organization of the Drilling Project

A.2.1 ACCESS ROADS

The main access road to the Palagua Field from the Pan-American highway is periodically repaired using asphalt emulsion. Unpaved roads provide access to the wells and are in good condition for traffic of vehicles and the type of heavy machinery used during drilling.

Photo 6 and Photo 7 Access to wells in the Palagua Field

As noted earlier, there is no need to build new access roads for the drilling campaign since all the wells will be drilled from existing locations. It will only be necessary to perform some land-leveling works to the access roads.

A.2.2 DRILLING LOCATIONS

All locations will be leveled and some civil work is required such as construction of channels to handle rainwater, stabilization of slopes, construction of grease traps, and construction of cellars and channels to handle oily water. The designs of each of the civil works depend on the condition of each location and the layout of the drilling equipment. Figure 4 shows a diagram of the distribution of the drilling equipment.

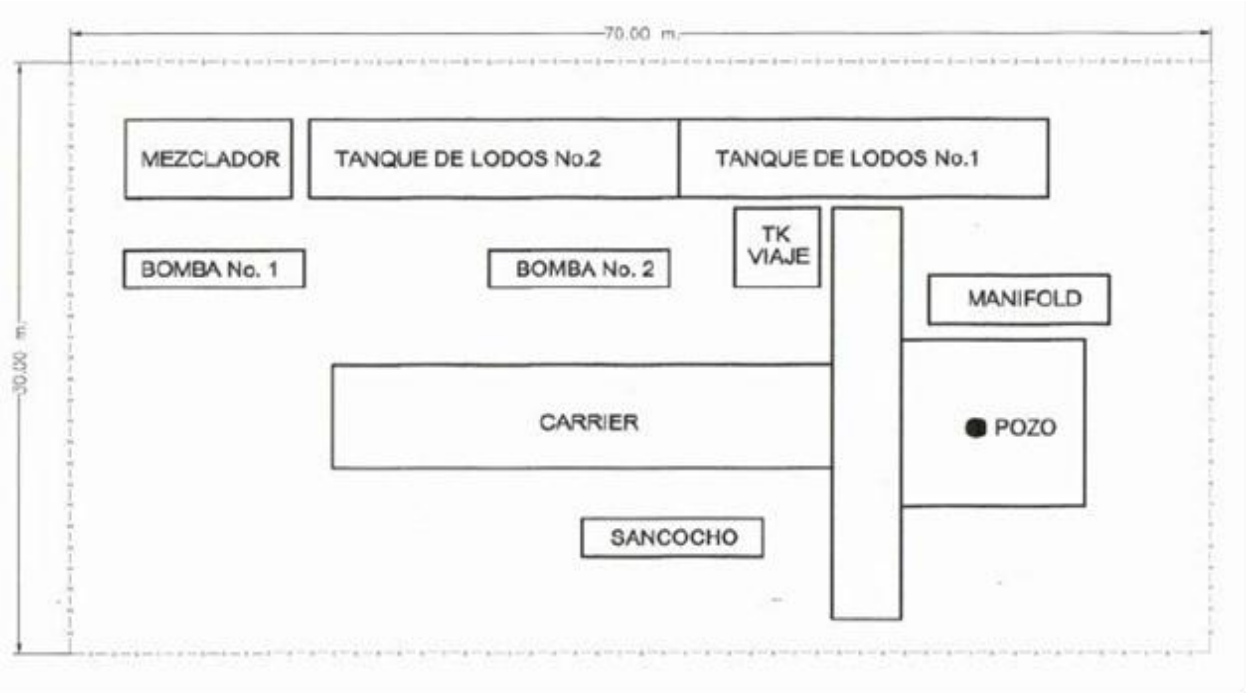


Figure 4 Placement of Drilling Equipment

SPANISH TO ENGLISH TRANSLATION KEY:

- Ubicación del equipo de perforación:	Placement of the drilling equipment
- Mezclador:	Mixer
- Tanque de Lodos:	Mud Tank
- Bomba:	Pump
- TK Viaje:	Trip Tank
- Pozo:	Well
- Sancocho:	Burner

The following equipment will be used for the improvement of the drilling locations: motor grader, back hoe, bulldozer, dump trucks, vehicles and other minor tools. No camp is required during these works because the required personnel will be from the Palagua rural area and from Puerto Boyacá.

A.2.2.1 CONSTRUCTIVE METHODS

The locations of the new wells will be prepared to offer the stability required during drilling. Other activities consist of compacting and leveling the ground.

The material extracted in the improvement at the locations, will be reused as filler at the other locations, wherever it is needed.

The construction of concrete channels, drainages and other civil works will take place after the location is compacted and leveled.

The compacting and leveling work will be done with a vibro-compacter roller until it reaches the required compacting levels (modified proctor test minimum 95%).

Once the platform is leveled and compacted, a special, non-permeable layer of special material is installed over the drilling platform. Thus, during the drilling operation, the ground is protected from the fluids used in the operations. On the edges of the leveled ground, ditches and filters for runoff water are installed.

A.2.2.2 TEMPORARY FACILITIES

Personnel lodging at the locations will be minimal. A dual purpose portable camp will be installed, i.e. for office space and lodging. Operation personnel will use hotels in Puerto Boyacá.

During the drilling activities there will be no need for special support facilities like heliports or workshops, since the work needed will be done at the Industrial Area of Palagua Field or, if needed, at specialized workshops in Puerto Boyacá.

Each of the facilities and systems required within the drilling are described below.

- **A retention area around the drill hole**. Will be built in reinforced concrete of 3000 psi. Its dimensions are 2 m x 2 m x 2 m (internal measures); with a wall thickness of 0.25 m reinforced with a double Q5 mesh.

- **Drilling rig base**. In reinforced concrete of 3000 psi and a thickness of 0.25 m reinforced with a double Q7 mesh. The drilling rig will be installed on this base.

- **Oily Water Handling System**. Around the drilling rig there will be rectangular type ditches of 0.2 m width, 0.15 m depth and a 0.25% slope, with wall thickness of 0.1 m in reinforced concrete of 3000 psi and Q4 mesh connected to the grease trap (See Figure 5.)

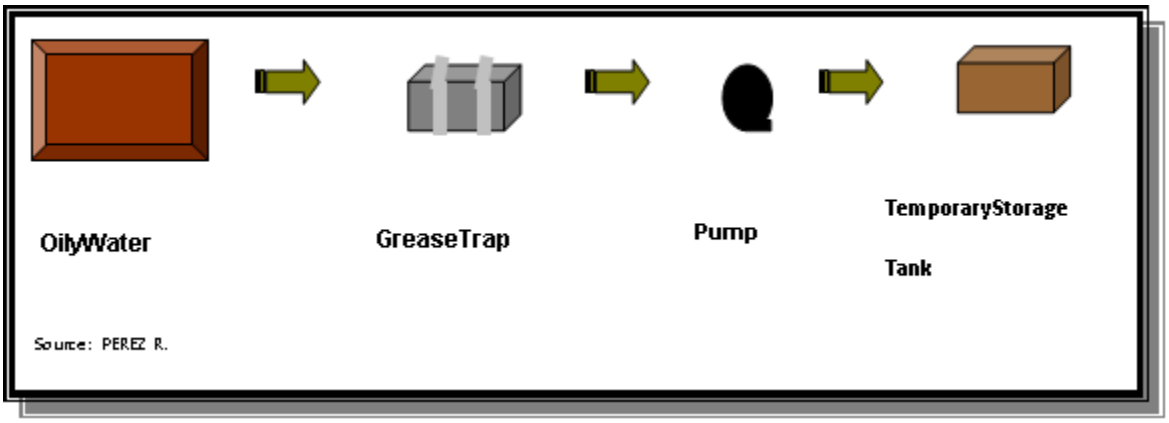


Figure 5 Flow Chart for Handling of Oily Water

- **Edge Ditches for Rainwater Handling**. There are edge ditches all around the area; the ones to be built will have a trapezoid shape with 0.3 m in depth and 0.8 m top width, variable depth and a slope of 25% starting at 0.10 m. Built in concrete of 2500 psi and with a wall thickness of 0.08 m and corners reinforced with 3/8" rod. These ditches will take the water to the grease trap.

- **Treatment of drilling cuttings**. The drilling cuttings are initially passed through the dewatering system, where water is separated. Afterwards, they are taken in a sealed dump truck up to the treatment facility in the "land-farming" area in the Palagua Field.

- **Grease trap**. This is a system to retain grease carried by industrial water. Inside it, there is a partition to retain greasy material. The effluent is sent to the water treatment tanks and later transported to the water treatment facility of Station No. 1, for disposal it the injection wells. The traps will be built in waterproof concrete of 3000 psi with double Q4 mesh and sika V-15 tape at the joints to avoid leakage. Its dimensions are 3.0 m length x 1.20 m width x 1.4 m depth.

- **Cuttings pool.** Not required. The drill cuttings will be taken to the land-farming area where they will get the treatment needed.

- **Waste Water Treatment**. The waste treatment equipment of the operation is a Red-fox system and its effluent will be taken to an 80 Bls capacity tank, and then to Battery No. 1 in the Palagua Field. Treated water could be used in irrigating roads or watering areas surrounding the locations, if the water quality is in compliance with the regulations set forth in Decree 1594/94.

- **Treatment tanks.** They are a series of portable tanks provided with shakers in which water coming from the well is collected. This water will be chemically stabilized and afterwards sent to the API in Station No. 1 at Palagua Field.

- **Fence.** There are no houses near the areas where drilling will take place. Therefore, a fence with linked mesh is not required. In some sectors a barbed wire fence will be installed to prevent livestock from entering the drilling area. This will be done with used pipes of 2 inches of diameter buried at 30 cms and at intervals of 2 meters, with 3 lines of barbed wire number 12.

A.2.2.3 EARTHMOVING

Earthmoving will be minimal and the moved soil will be used together with the available land-farming material for filling of slopes and conditioning of roads and placements.

A.2.2.4 LABOR FORCE REQUIREMENTS

In the construction stage, a civil engineer, a construction work supervisor, heavy machinery operators (motor grader, back hoe, bulldozer, motor graders, dump truck) and other workers will be needed. Around 20 unskilled laborers are to be hired from the Palagua rural area.

A.2.2.5 EQUIPMENT REQUIREMENTS

Table 8 shows the equipment to be used during the work:

Table 8 REQUIRED EQUIPMENT TO ADAPT THE LOCATION AND ACCESS ROADS

EQUIPMENT	QUANTITY
Back hoe	1
Bulldozer	1
Motor grader	1
6m3 dump truck	5
Motor pump	2
Vibro-compactor 10T	1
compactor FROG	2
Tank truck	1
Concrete vibrators	2
Concrete mixer sacks	2

Source: UT-IJP

A.2.2.6 LOCATION OF THE FINAL DISPOSAL PLACE OF MATERIAL RESULTING FROM THE DRILLING

The location and road will be compacted and leveled with the removed material, i.e. cutting/filling. In the event that the removed material exceeds the material requirements of the leveling, it will then be used during the area restoration and/or to stabilize the slopes.
For the temporary storage of inert material, a place that does not pollute the soil will be developed far from water bodies (30 meters), so that they do not interfere in the natural re-vegetation and natural drainages. Also, it will be properly covered to avoid dragging of particles to the atmosphere and the draining to a body of water.

A.2.2.7 USE, EXPLOITATION AND EFFECT OF NATURAL RESOURCES

During the execution of this work, materials used are water resource, covering material and soil resource.

- **Water Resource**

Photo 8 Conduction of groundwater PW-1 – Administrative area of the Palagua field

All the water required both for domestic and industrial use will be extracted from the groundwater well PW-1. The groundwater permit was granted by Corpoboyacá through Resolution 463 of June 8 of 2005, for a period of 5 years. It is estimated an average consumption of 0.3 liters per second.

- **Covering/filling material**

The material required for the conformation of locations will be acquired through trading companies located in Puerto Boyacá that have the environmental permit issued by the Regional Autonomous

Corporation – CORPOBOYACA. The area of the old Station No. 3 will provide part of the filling material to be used.

- **Forest Resource**

Photo 9 Forest component at the project area

The forest resource will not be affected since the drilling of new wells will be done in existing well locations.

- **Pouring**

While the construction work takes place no pouring will be generated, therefore, a pouring permit will not be needed.

- **Use of River Water**

There is no need to get a permit for the use of river water, due to the fact that the needed water for the operation will be extracted in the field from well PW-1 that has an existing permit issued by CORPOBOYACA to take out 3.6 liters of water per second.

A.3 DRILLING ACTIVITIES, BASIC INFRASTRUCTURE AND EQUIPMENT

Development well drilling begins by erecting the drilling rig with all its accessories; drilling of the hole at the established depth, completing the well, and starting the production tests.

A.3.1 DRILLING EQUIPMENT

For the drilling of the development wells at Palagua Field, conventional drilling equipment will be used.

A tri-cone bit with tungsten carbide teeth is used to break the underground rocks and to open the hole. The drilling bit is connected to the surface by a series of pipes known as drilling string, which provides the bit with energy generated at the rotary table by the engines.
The drilling string is composed of the kelly (square pipe), kelly bushings and the rotary table. The descent and ascent tasks of the drilling string are done by the winch.

To avoid collapse of the hole that has been drilled, a pipeline called "casing" is installed that protects the hole. This operation is repeated every time the drilling goes deeper, so that at the end the well is completely piped. This is a carbon steel pipe and it is supported around with concrete, between the wall of the hole and the outside of the pipe.

The following are short descriptions of the most important components of the equipment and drilling tools:

Drilling bits. Cutting or boring elements are used in drilling oil wells. Bits used in rotary drilling are roller-cone bits consisting of the cutting elements and the circulating element which permits the passage of drilling fluid. These bits use the hydraulic force of the fluid stream to drill more deeply, see Figure 6.

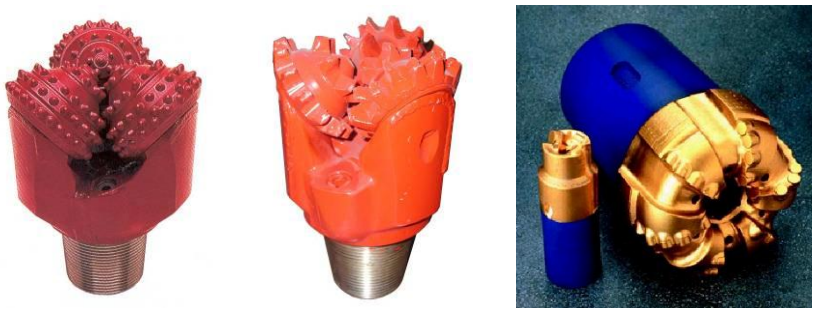


Figure 6 Types of Drilling Bits Used in Rotating Drilling

Drilling Pipe or "String": This is a column or string of drill pipe with attached tool joints that transmits fluid and rotational power from the Kelly to the drill collars and the bit. It is composed of pipes and heavy steel collars.

Winch: It is the drum in which the steel cable is rolled to allow lifting and lowering of the string according to the needs of the well.

Mud System: A set of hoses, pumps, accessories, and tanks used to circulate the drilling mud inside the drilling pipes. When the mud (drilling liquid) returns to the surface, it brings the underground cuttings that the bit has drilled. Mud also helps in lubricating the bit and in firmly supporting the walls of the well. (See Figure 7.)

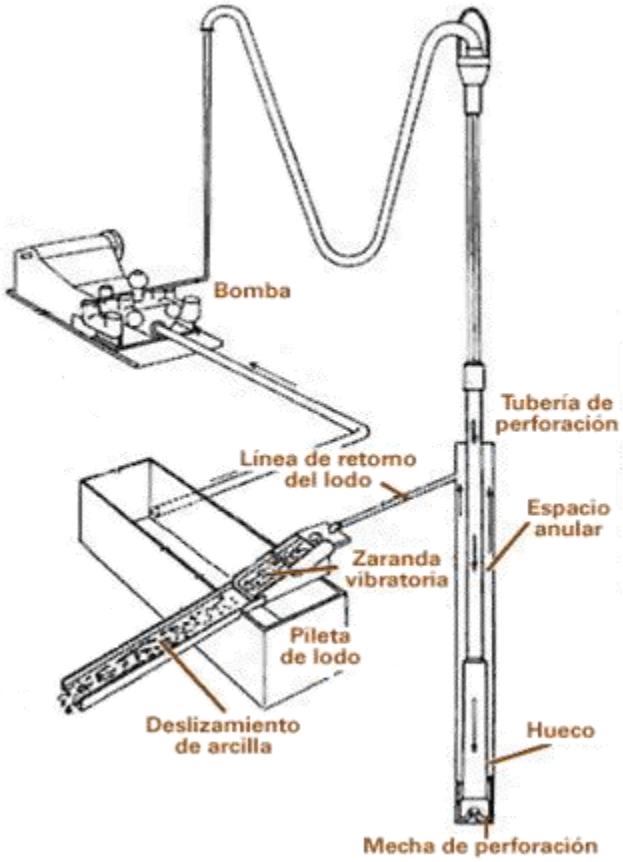


Figure 7 Mud Cycle in Drilling

SPANISH TO ENGLISH TRANSLATION KEY:

- Bomba: Pump
- Línea de retorno del lodo: Mud return line
- Zaranda Vibratoria: Shale shaker
- Pileta de lodo: Sludge pool
- Deslizamiento de archilla: Clay sliding
- Tubería de Perforación: Drilling pipes
- Espacio anular: Anular space
- Hueco: Hole
- Mecha de perforación: Drill bit

The drilling mud is composed of fluids that are circulated in the oil and gas wells to clean the hole, to lubricate the drilling bit, and to balance the formation pressure so that the hole remains open.

The drilling mud that will be used is water based, and is recycled continuously, keeping the proper density and viscosity according to the well design.

The mud that reaches the surface passes through a series of shaking meshes (filters) known as "shale shakers", in which the liquid and solid phases of the mud are separated. The liquid fractions are pumped to the mud tanks to be reused. The solid phase is analyzed by the geologists to obtain information from each formation that has been drilled. It is then sent to the drying system (dewatering) from where it is taken to the land-farming area at the Palagua field.

Cementation Equipment: This equipment injects the concrete that is used to adhere the casing to the well walls. The concrete is specially designed according to the depth and lithological composition of the well.

Instrumentation: To monitor the progress of the drilling, the equipment has a series of accessories such as: a) Manometer, to measure the mud b) Tachometer, to measure the rotation speed of the string and the drilling bit; c) The indicator of weight on the drilling bit measures the weight that is on the bit and what part of that weight is on the steel wire that supports the string; d) Torsion indicator, to control that the torque on the pipeline; and e) The deviation indicator to show well inclination.

Chemical substances and supplies: The mud under consideration to be used is water-based, a mixture of water and clays (bentonite) with some additives such as barite and lignosulfonates that are used according to the drilling needs. These products are easily flocculated and stabilized.

A.3.1.1 GENERAL DRILLING DESIGN OF THE DEVELOPMENT WELLS

According to the prognosis of the new wells, the procedure for the drilling is as follows: Drill a hole with a 17-1/2" bit from the surface to a depth of 20 to 25 feet and install a pipe of 13-3/8" diameter to stabilize it, this pipe is called conductor pipe. Then, drill with a 12 1/4" bit to a depth of 800 feet and lower casing of 9 5/8" diameter. Afterwards drill with an 8 1/2" bit to the objective depth and lower the final production casing of 7" diameter. (See Table 9).

Table 9 GENERAL DRILLING DESIGN OF THE DEVELOPMENT WELLS

WELL DRILLING			
Stage	Diameter of the Hole (inches)	Diameter of the Casing (inches)	Depth (feet)
SURFACE COVERING	17 1/2	13 3/8	20
Middle covering	12 1/4	9 5/8	800
Production liner	8 1/2	7	4,600

SOURCE: PJV-IJP 2004.

A.3.1.2 REQUIRED PERSONNEL

Two groups of personnel are needed for the drilling, one is a group that directly takes part in the drilling work, and another is a support group for certain activities related to the drilling.

Personnel from the region are classified as unskilled labor, and their selection will be coordinated by the representatives of the Community Action Council of the Rural District of Palagua, offering participation to neighbor rural towns such as Muelle Velásquez, El Chaparro and El Ermitaño. Table 10 is a list of the personnel that will work in the drilling activities.

Table 10 REQUIRED PERSONNEL DURING THE DRILLING OF THE DEVELOPMENT WELLS

REQUIRED PERSONNEL			
QUALIFIED	**No.**	**UNSKILLED**	**No.**
Well Manager	1	Oilfield Workers (4 per shift)	12
Well Manager Assistant	1	Cleaning Personnel	2
Geology Supervisor	1	Sample Picker (1 per shift)	3
Tool pusher	1	Security guard (1 per 12 hour shift)	3
Shift Managers (12 hour shifts)	2		
Driller	2		
Monkey Board Worker	2		
Logger	1		
Mechanical Floor Assistants	1		
Electrician	1		
Warehouseman Nurse	1		
Freight Elevator Operator	1		
Mud Engineer	1		
Environmental Auditor	1		
TEMPORARY			
Electric Record (3)	3		
Cementation Team (2)	3		
Core Pipe Operator (1)	1		
Pipeline Inspector (1).	1		

SOURCE: UT-IJP

A.3.1.3 EFFECT ON NATURAL RESOURCES

Considering that the wells will be drilled from the existing locations, and the fact that there will not be a cafeteria at the location, the additional impact on natural resources will be minimal.

Photo 10 Water well PW - 1

- ***Water collection:*** Water is needed for both domestic and industrial use during the preparation of the drilling location (approximately 1.2 l/sec.). The water source is water well PW-1. The concession of underground water was set forth by Resolution 463 of June 8, 2005, and for a period of 5 years.

- ***Industrial and Domestic Liquid Waste:*** This includes run-off, domestic waters, industrial waters, and oily waste.

  - *Run-off Water.* To handle and control rainwater at the locations, there are border channels for drainage to channel water to the surrounding area without affecting the existing hydro dynamics. The rainwater that accumulates in the channels will be sent to the oil trap and then to the Waste Water Treatment System (PIA) of the Field.

  - *Domestic Water.* This results from the functioning of sanitary services and personal hygiene activities. This water will be treated at an activated Sludge aerobic treatment plant known as "Red Fox" Unit. Its effluent will be taken to a tank and from there it will be sent to the water treatment system of the Field. Occasionally, if required, the access roads will be sprinkled or irrigated. Before doing so, it will be verified if the effluent complies with all the established parameters in Decree 1594/84 and other applicable guidelines.

- *Industrial Water.* These are liquids from mud and from the separation that takes place at the "Dewatering" unit. This water is taken to tanks where a conventional physical-chemical treatment is used (with injection of coagulant, flocculants and clarifying chemicals). It is then stored in a sedimentation tank, from where it is taken by truck to the water injection plant in the field.

- *Oily Waste.* This is waste oil from the engines of various machinery and equipment. This is stored at the location in 55-gallon drums, and then taken to the sump of the Palagua battery for disposal. Contractors have been told to avoid doing engine maintenance at the location.

- *Waste Water Disposal:* All the domestic and industrial liquid waste will undergo primary treatment at the location to be sent afterwards to the water injection system at Battery No. 1 (Station No. 1) Given the above, a surface discharge or pouring permit will not be needed for the drilling of these development wells.

- ***Domestic Solid Waste:*** This waste is composed of cartons, glass, food waste, paper and aluminum that comes from the offices, performance of personal hygiene, or food scraps. It will be classified at the source for easier handling. The domestic waste will be taken to the temporary storage place at the Industrial Area of Palagua Field to be collected afterwards by the Public Utilities Companies of Puerto Boyacá.

- ***Industrial Solid Waste:*** This includes cuttings or drilling waste at the dewatering system, the waste or remains of concrete from the cementations, scrap iron, wood, filters, unusable accessories, packaging and other materials resulting from maintenance of machinery and equipment.

  The cuttings and mud disposal collected from the location will be treated with lime for dehydration. Then it will be taken to the land-farming area for bio-remediation. Later it will be mixed with the soil available from the leveling work, and it will be used for erosion control.

  The scrap iron will be taken to the storage yard at the Palagua Battery. The contaminated soil will be sent to the bioremediation yard located next to the Water Injection Plant (PIA) in the landfarming area. The waste impregnated with hydrocarbons, will be stored at the warehouse at the Industrial Area of the Palagua field to be sent for incineration at Holcim in Nobsa, Boyacá.

A.3.2 ARTIFICIAL LIFTING SYSTEM

Mechanical pumping units will be installed in the new wells. Four fundamental parts comprise the mechanical pumping system: main engine, surface pumping unit, rods string and downhole pump. The engine provides the energy needed for the surface pumping unit so that it can perform the oscillatory

movement that in turn is transmitted to the rods string to activate reciprocating movement at the downhole pump.

The downhole pump has two valves; one is the standing vale and the other is the traveling valve, with the latter being connected to the rod string. In the ascending run of the string, the ball of the traveling valve becomes seated and this action lifts fluid into the pump, while at the same time, the standing valve floats allowing the fluid to migrate into the pump. During the descending run of the rod string, the standing ball valve becomes seated as a result of the weight of the fluid over it. This action prevents fluid from exiting the valve the way that it entered on the upstroke. The traveling valve then floats, allowing the fluid to exit above the traveling valve. This process is repetitive as a result of the reciprocating action of the sucker rod unit, which lifts the fluid from the bottom of the well to the surface.

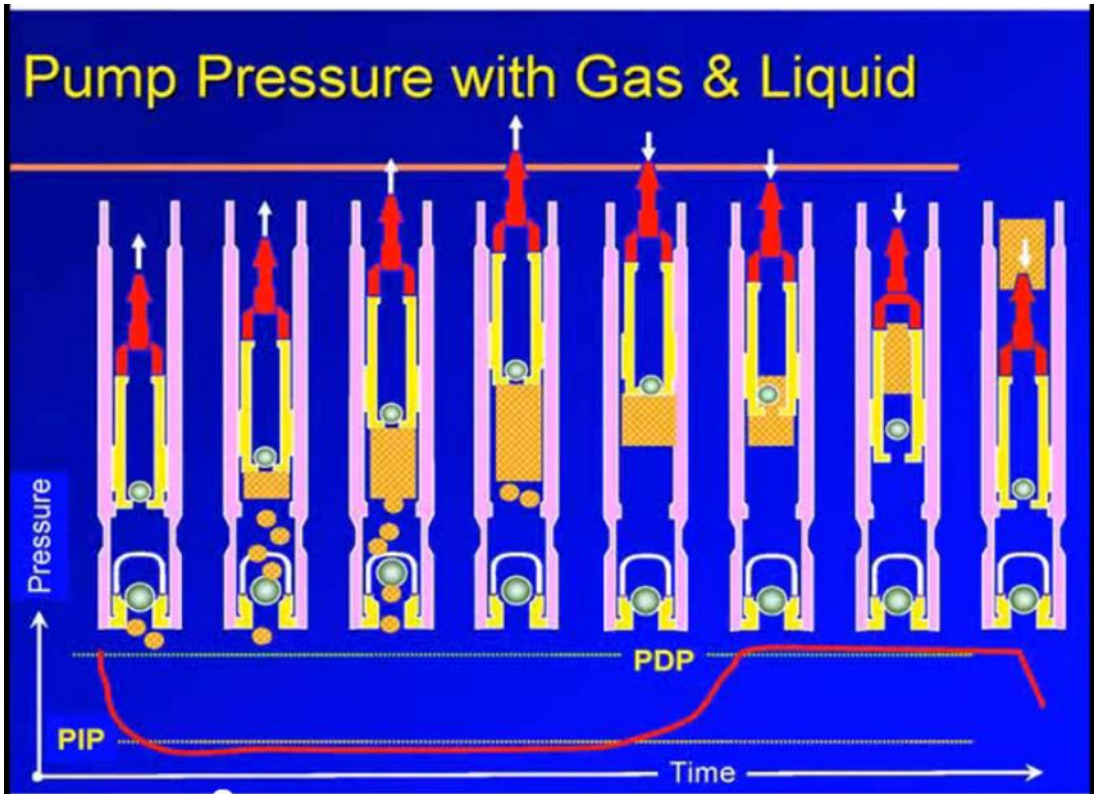


Figure 8 Pump Pressure with Gas & Liquid

There are three kinds of mechanical pumping units: Conventional, air balanced and special geometry. The conventional one uses a counterweight as an aid during the ascendant run and the air-balanced unit uses a pneumatic cylinder.

Photo 11 and Photo 12 Air balanced pumping unit (left) and conventional pumping unit, Palagua field

A.3.2.1 PRODUCTION TESTS

After completing the well and installing a pump, the connections on the surface are used to tie up the production line of the well to the existing network of flow lines, and then the well is tested. For testing the well, a tank and a separator are required to evaluate the well potential.

A.4 FLOW LINES

Photo 13 Flow lines with manifold at Palagua field

Photo 14 Flow lines with manifold at Palagua field

At the Palagua field there are flow lines, branches and common flow lines to transport the crude oil. The flow lines are short pipelines of 2 ⅞" size that join the wellhead and the production branches, which in turn connect to the common flow lines that are connected to the gathering stations. After the primary treatment at the stations, the crude oil is sent to Battery No. 1 (Principal Battery or Station No. 1) via pipeline. All the pipelines are located along the access roads to monitor their physical conditions reducing the risk of leaks and failure.
Additionally, parallel to the pipelines from the wells to the stations, there are flow lines, known as test lines, which transport the individual production of each well for the flow measurement.

As in all locations where proposed wells will be drilled, there are already existing production and test lines. It is only necessary to install a small 2 ⅞" flow line from the well-head to the flow lines and the test lines.

A.4.1 LOCATION OF PIPE RACKS, STORAGE OF MATERIALS AND WORKSHOPS

All the pipes, materials and accessories required to drill wells, will be temporarily stored at the gathering center of Battery No. 1 to be then taken to the drilling locations when they are needed.

A.4.2 LAND MOVEMENTS

To install the flow lines it will not be necessary to move land since flow lines are already installed on the ground surface.

A.4.3 CONSTRUCTIVE METHODS AND SUPPORT FACILITIES

All facilities and accessories for flow line installation will be done at the workshops of the Union Temporal IJP at the Palagua field, and hence the laying of the flow lines will not require additional facilities.

A.4.4 LOCATION OF THE RUBBISH DUMPS

No rubbish dumps will be required.

A.4.5 USE, IMPACT AND MANAGEMENT OF NATURAL RESOURCES

The flow lines will be installed on the surface in areas that have been previously used and the lines will be very short, hence, there is no additional impact on the environment.

A.4.6 LABOR FORCE REQUIREMENTS

The following personnel are needed to install the flow lines:

- 1 Supervisor
- 1 API Welders
- 2 Welding helpers
- 1 Crane operator
- 2 Workers

A.4.7 PUMPING STATIONS AND TRAPS

It will not be necessary to install pumping stations, as the well head pressure is enough to transport the crude oil to Station No. 2 (Battery No. 2).

A.4.8 VALVES TO BE INSTALLED

A series of valves will be installed at the wellhead to control the flow of the well. This group of valves is commonly known as the Christmas tree.

A.5 DISMANTLING, ABANDONMENT AND RECUPERATION

The dismantling, abandonment and recovery stage is important to keep the balance between the oil production activity and the ecosystem. In this stage, the objective is to mitigate the impact of the drilling of the development well.

A.5.1 DISMANTLING

The dismantling of facilities and equipment consists of removing the portable structures used during drilling, such as: drilling rig, solids control equipment, portable tanks for mud preparation, “Dewatering” units, cementation unit, etc. Also, cement or concrete structures have to be demolished, such as: ditches and grease traps within the location. The fixed grease traps are cleaned and the drainages are emptied and sealed afterwards. In case the traps are not demolished, they are filled with excavation material. The pipes that are not removed have to be sealed to prevent the production of fluids that may affect the stability of the terrain. Additionally, all the oily waste has to be removed from the location, disposing of it at the bioremediation yards (land farming unit).

A.5.2 ABANDONMENT

The drilling project is made up of different activities, some of them are temporary (road and facilities construction, etc.) that require to be closed after the completion of the drilling activity. Production activities go on until the end of the project for productive wells. For the appropriate disposal of various environmental issues arising due to drilling of wells, one has to establish from the beginning, and keep during the execution, a restructuring and abandonment plan.

The abandonment activities include the dismantling of the pipes used in the management of waters from septic tanks, sanitary latrines or activated Sludge units (as is the case in the current project).

In the abandonment stage the affected areas have to be re-vegetated at the edges of the location. Before the reconstruction at the area takes place, the final stabilization works have to be carried out.

A.5.3 RECOVERY

The re-vegetation consists of the vegetal enrichment of the area. It is recommended to plow the terrain in order to aerate it and to help water infiltration. A layer of organic soil has to be set out in those areas that are more deteriorated or where there is a difficulty of re-vegetation.

A.5.3.1 FINAL CLEAN OUT

In this stage, all foreign material has to be removed from the area. Consequently, the clean out will cover all the places occupied by the facilities, as well as the other places that were used by the drilling project.

For the temporary activities like road construction and drilling installation, the final clean out will take place after the dismantling of the rig and the equipment. Also, clean-out will be done during the execution of the works along with the progress and development of the different stages and activities. A final inspection has to be done by the operator and the Environmental Inspector to confirm the final clean-up.

A.5.3.2 RECOVERY OF IMPACTED AREAS

The areas that have been impacted due to the drilling activities and that are not needed for the operation of the well should undergo a recuperation process such as re-vegetation. Arboreal, bushy or herbaceous species can be selected for the recovery, depending on the vegetation cover that was removed and the characteristics of the area to be recovered. In general, during the first years for the

recovery, if possible, species that grow fast should be selected, that can develop a good cover and foliage.

The recommended height to plant them depends on the species (between 50 cms to 1.5 m) and it is recommended to space out the arboreal species approximately every 10 to 15 m, place them in holes of 40 X 40 cms and should not be lower than 30 cms in height from the neck of the root.
It is recommended that the planting be done when the first rains fall, and hence the seedling can take advantage of all the humidity to adapt to their new place without dying or withering.

B. PHYSICAL GEOGRAPHY

To identify the environmental impact, it is necessary to establish the area of influence that refers to the sector that may alter the physical, biotic and socioeconomic surroundings, as a result of the **32-WELL EXPANSION PROJECT OF DEVELOPMENT WELL DRILLING IN THE PALAGUA FIELD** (located in the municipality of Puerto Boyacá, Department of Boyacá). Hence, the area of influence was defined as the area that will have impact on its environment and social environment.

For the purpose of environmental impact, two main areas of influence were determined, one indirect (IAI) and one direct (DAI).

- Indirect Area of Influence (IAI)

According to the environmental requirements, the Indirect Area of Influence, IAI, is restricted to biotic, abiotic, socioeconomic and cultural aspects with respect to the area directly used by the project and that during its execution may have environmental impact

B.1 ABIOTIC MEDIUM

Photo 15 and Photo 16 General view of the project area

B.1.1 CLIMATOLOGIC ASPECTS

To identify the climatologic behavior of the project's area of influence, weather records reported by IDEAM (Instituto de Hidrología, Meteorología y Estudios Ambientales – Hydrological, Meteorological and Environmental Studies Institute) Puerto Boyacá and Padilla stations, located close to the field in the Department of Boyacá were consulted.

Table 11 METEOROLOGICAL STATIONS USED FOR WEATHER CHARACTERIZATION

CODE	TS	STATION	ELEVATION (m.o.s.l.)	YEAR		COORDINATES	
				INST.	SUSP.	LATITUDE	LONGITUDE
2311501	OC	PUERTO BOYACÁ	350	AUG 1994	-	05º57` N	74º36` W
2311006	PG	PADILLA	100	MAY 1984	-	06º12` N	74º22` W

TS: Type of Station OC: Ordinary Climatologic PG: Rainfall
Source: IDEAM

The general conditions of the mid-Magdalena Valley are determined mainly by the following factors: latitude, temperature, rainfall, relative humidity, winds, geomorphology and solar radiation.

The behavior of each of the climatic variables analyzed for the area where the project is located is presented below.

- **Precipitation**

Atmospheric phenomenon consisting of a water precipitation in the form of liquid drops, whose diameter is found usually between 0.5 and 7 mm, and that falls at a speed of around 3 m/s.

The station of Puerto Boyacá shows an increase tendency of the precipitation from 1,398.9 mm in 1976 to 2,584 mm in 1,989; maintaining constant values in recent and current years. See Figures 9 and 10.

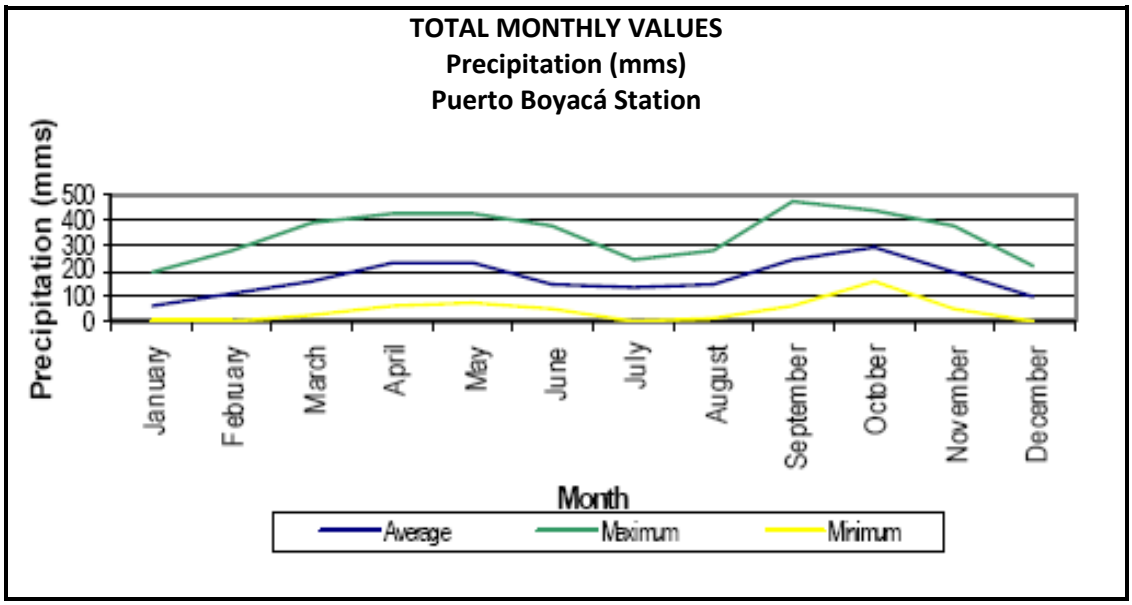


Figure 9 Total Monthly Values – Precipitation – Puerto Boyacá Station

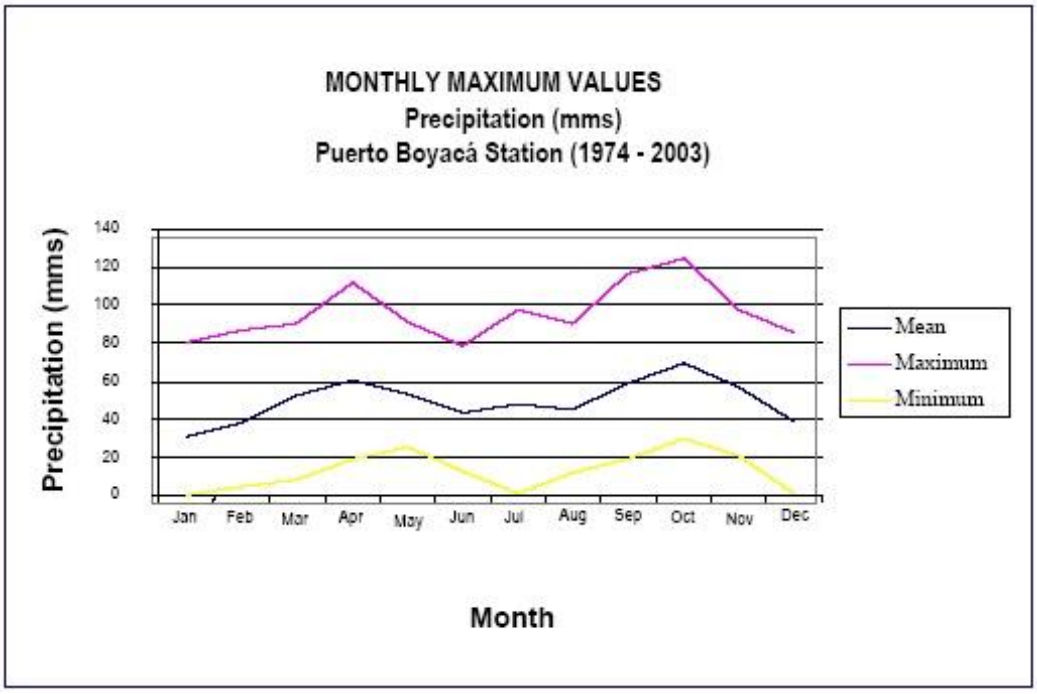


Figure 10 Monthly Maximum Values – Precipitation – Puerto Boyacá Station

The regional behavior presents two peaks and two valleys, showing a bimodal behavior, according to the monthly averages obtained. (See Figures 11 and 12).

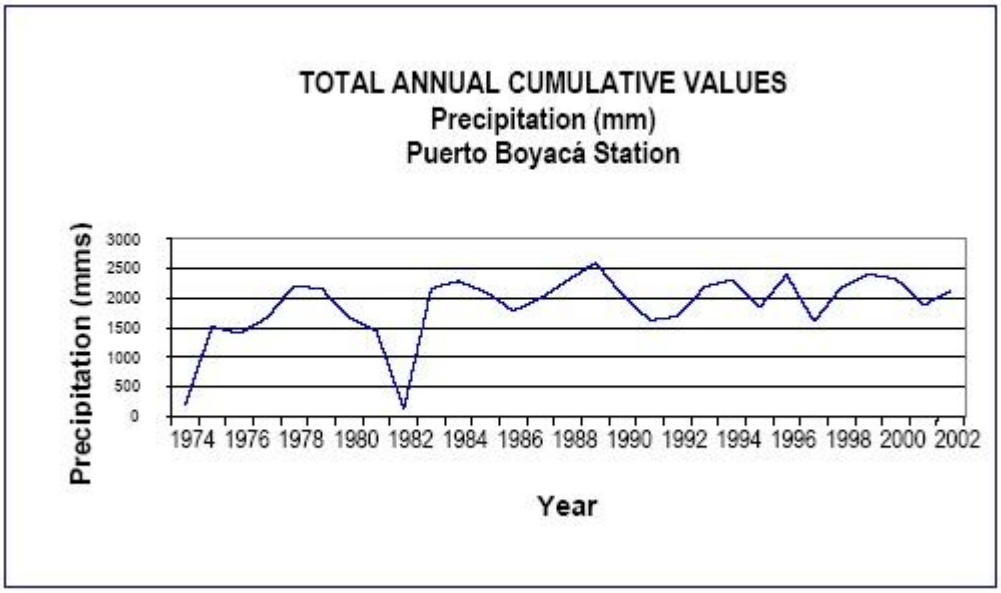


Figure 11 Total Annual Cumulative Values – Precipitation – Puerto Boyacá Station

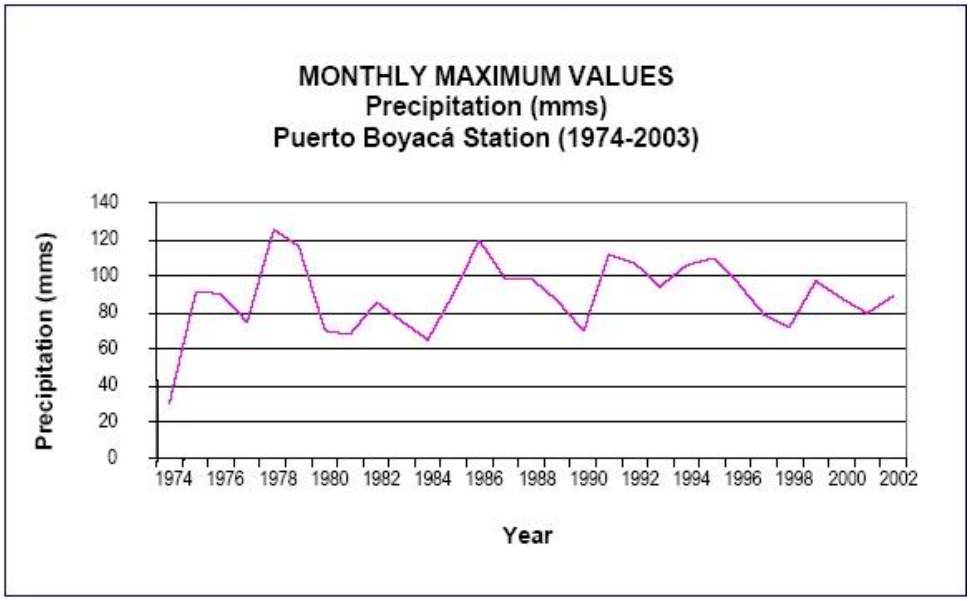


Figure 12 Monthly Maximum Values - Precipitation – Puerto Boyacá Station

The records at the Padilla Station show that the high precipitation periods correspond to the months of April to May (monthly precipitation of 220 and 290 mm) and from September to December with 360 mm of precipitation. (See Figures 13 and 14).

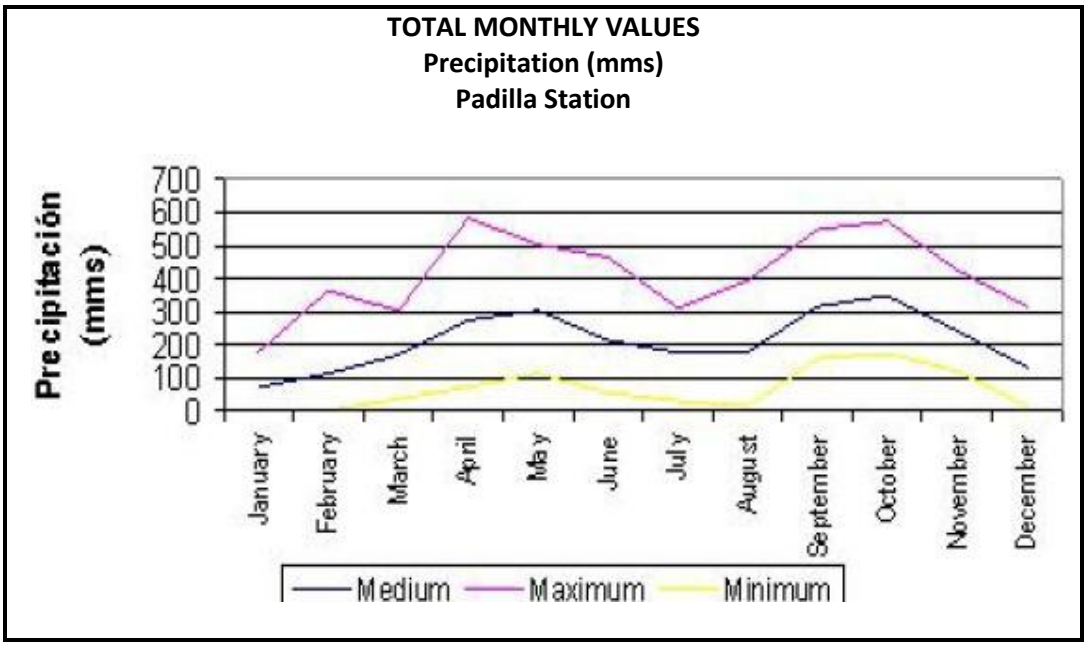


Figure 13 Total Monthly Values – Precipitation – Padilla Station

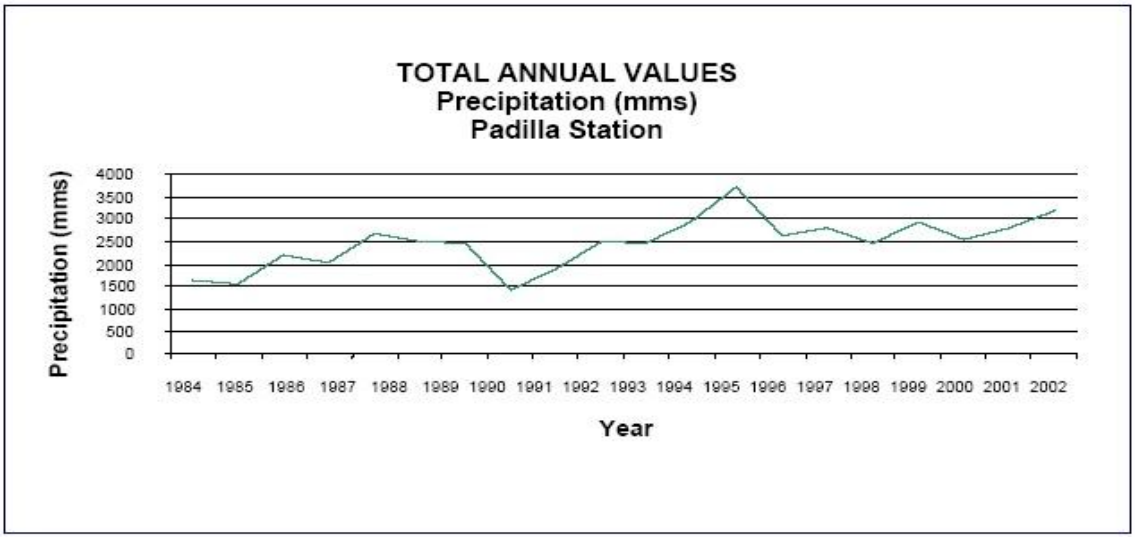


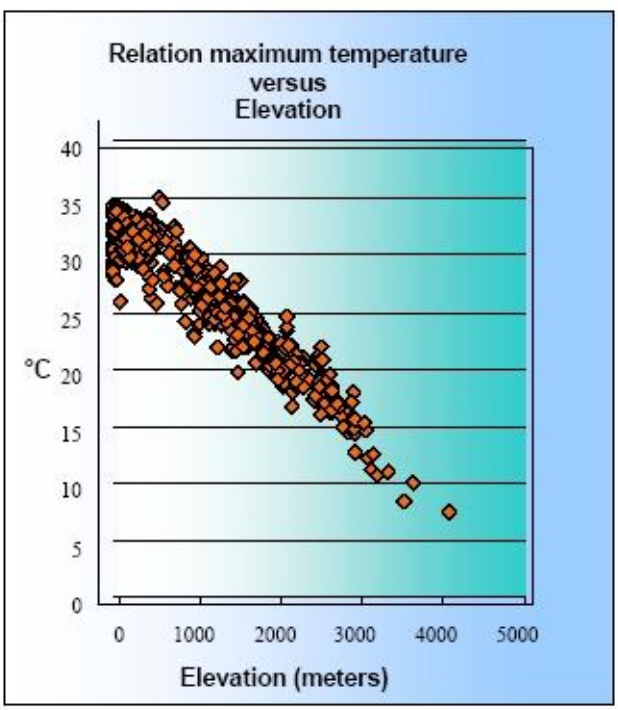
Figure 14 Total Annual Values – Precipitation – Padilla Station

- **Temperature**

The mean annual temperature is between 26 ºC and 31 ºC with an average of 27.8 ºC. The period with highest temperature coincides with the driest season, and the coldest period with the period of highest rains. (See Figures 3.B-8 through 3.B-10).

The minimum temperatures are during the months of April, May and September with values of 17.4 ºC, 16.8 ºC and 19.0 ºC respectively, related to the months of maximum precipitations in the area.

The mean temperature is characterized by the presence of the thermal levels, caused by the decrease of the temperature when the altitude above sea level increases. In the valleys of the most important rivers, like Magdalena, located within the area of the project, the highest values are recorded, between 24 and 28 ºC. Temperature keeps a close correlation with elevation, as it can be seen on the dispersion graphs. The mean temperature can be roughly determined, as well as its extremes (maximum mean and minimum mean) according to the relation shown below.



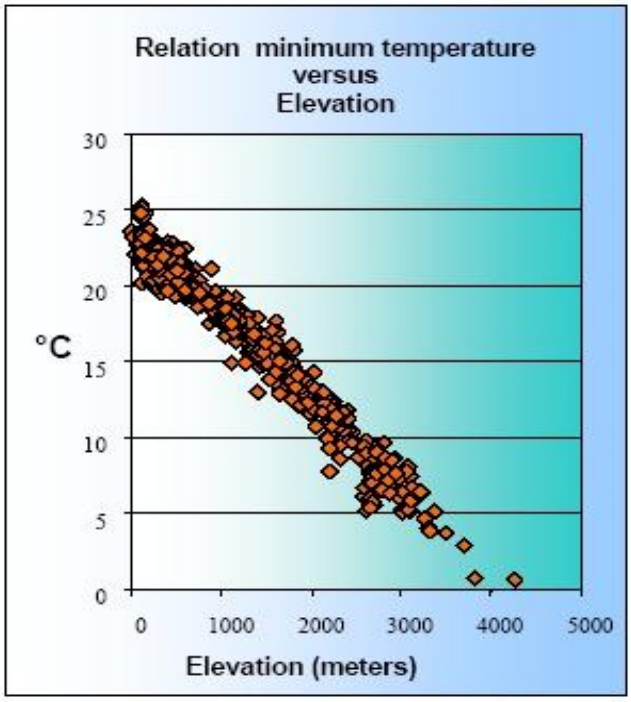


Figure 15 and Figure 16 Ratio of temperature to elevation

The maximum temperatures recorded are found during the months of March, July and August with a value of 40 ºC for the first month and of 41.2 ºC for the last two months.

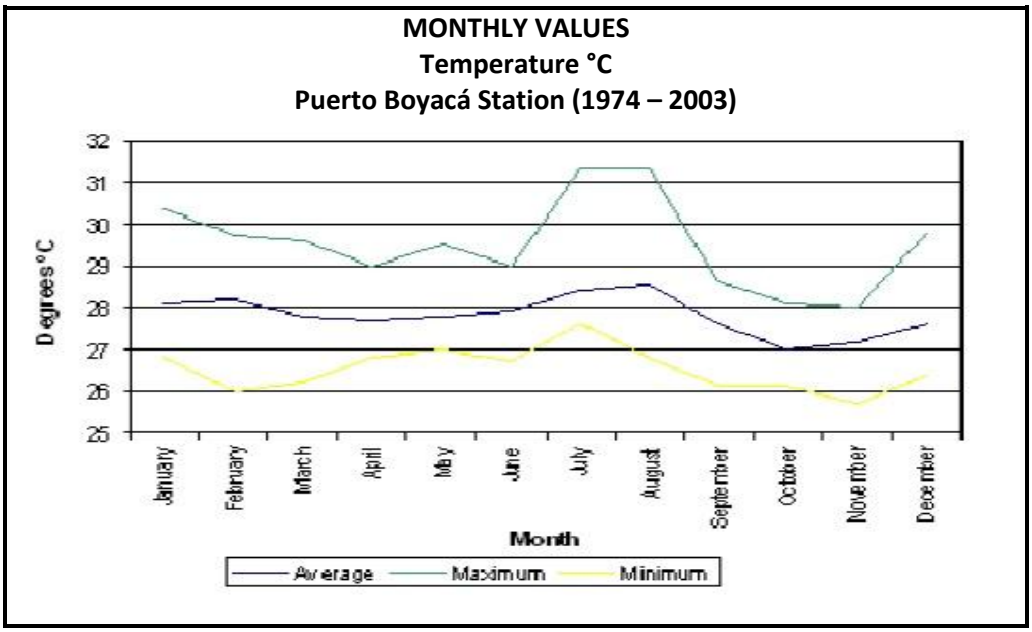


Figure 17 Temperature – Puerto Boyacá Station – Monthly Mean Values

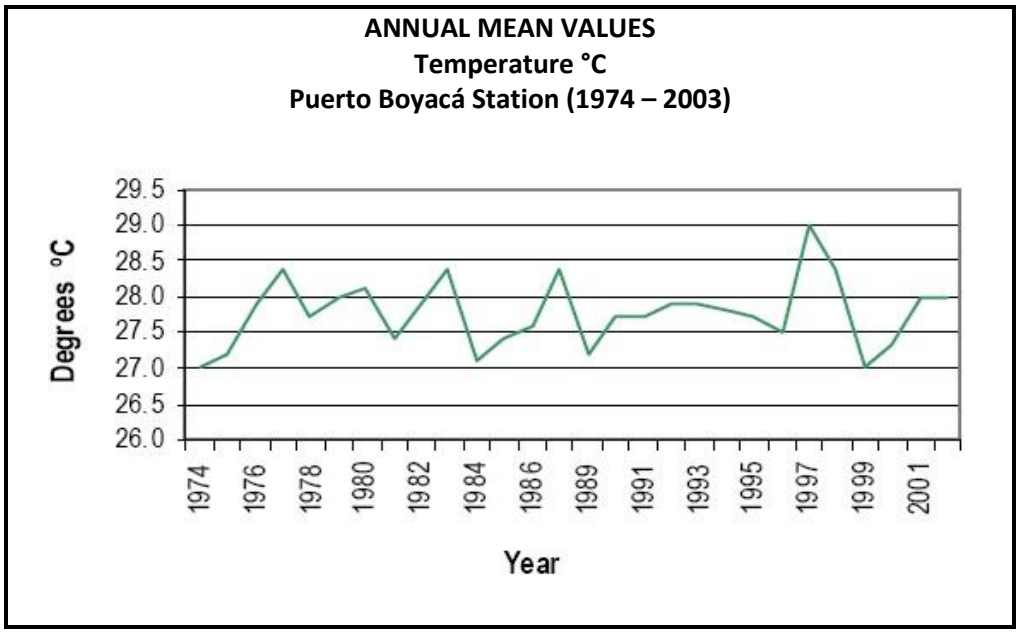


Figure 18 Temperature – Annual Mean Values – Puerto Boyacá Station

- **Relative Humidity**

This parameter has a similar behavior to the rain parameter.

The relative humidity in the area of influence of the project presents monthly variations through the year between 61% and 86%. The months of July and August have the lowest monthly average records, with monthly mean values of 65% and 61%, respectively. The months with highest relative humidity are March, September and October with a monthly mean value of 86% according to the records of the Puerto Boyacá Station. This parameter is determined by the ratio between temperature and precipitation.

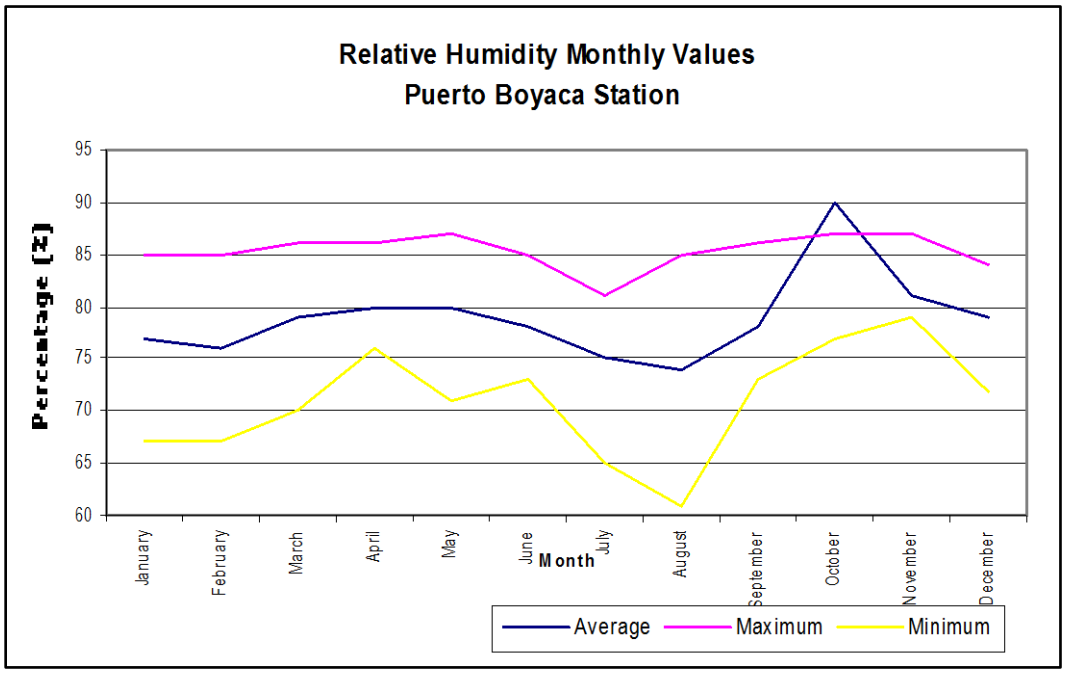


Figure 19 Relative Humidity – Monthly Mean Values – Puerto Boyacá Station

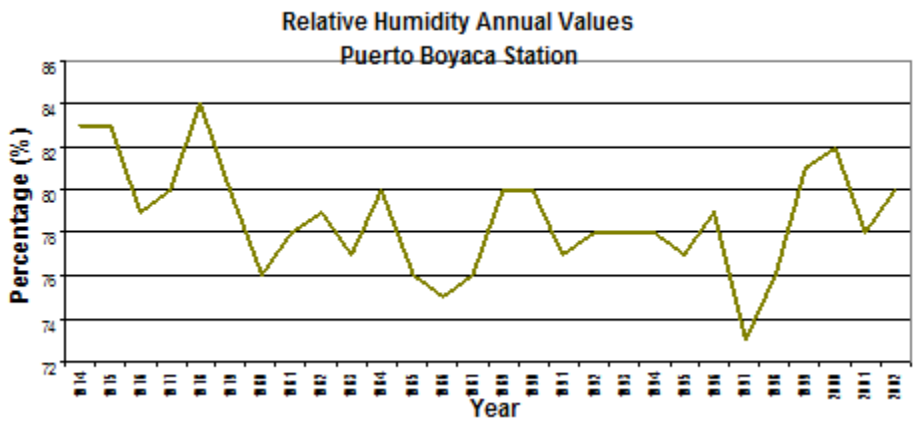


Figure 20 Relative Humidity – Annual Minimum Values – Puerto Boyacá Station

- **Cloud Cover**

According to records from Puerto Boyacá Station, the historic data by year and the monthly maximum, minimum and mean of cloud cover in the area of influence of the project vary through the year from 2 to 8 oktas with a mean value of 3 oktas. (See Figure 21). The months with the lowest mean records are from May to September and again from November to February, with a monthly mean value of 2 oktas. The months with the highest records are March, October and November with a monthly mean value of 8 oktas.

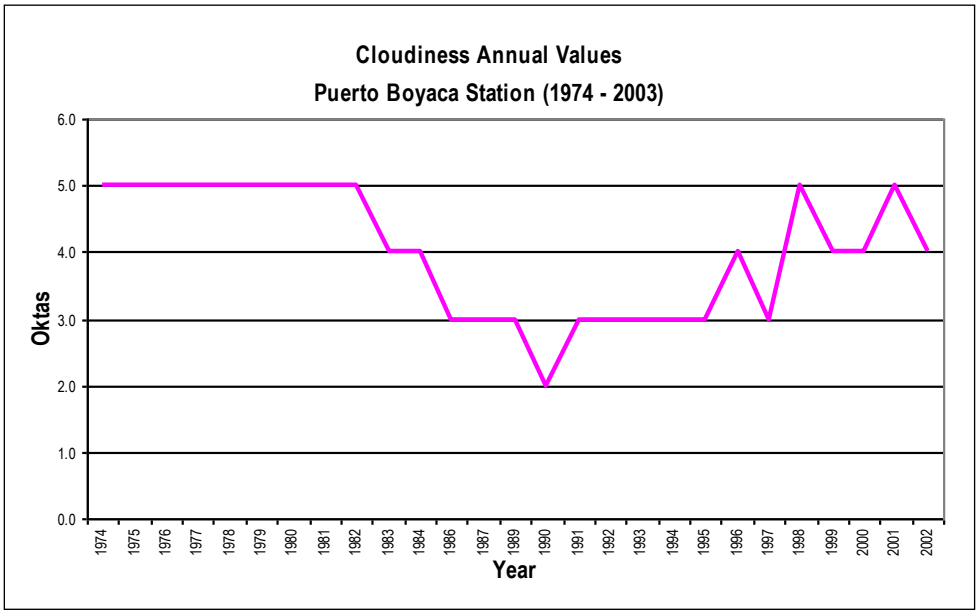


Figure 21 Yearly Cloudiness Values

- **Winds**

At the Puerto Boyacá Station, the winds that come from the Northeast represent 15% of the annual total registered. Other data shows that winds from the East represent 10.6%, and winds from the North represent 8% of the annual total.

The predominant winds from the Northeast are trade winds that have high humidity and generate precipitation during the two rainy seasons.

Daily variations in the wind speed are a result of temperature changes in the different layers of the atmosphere that produce changes in pressure and air currents that alternate in the different strata.
The maximum speed of the wind occurs at mid-day, with averages of 2.5 m/s and minimum speed is usually in the early hours of the day with an average value of 0.8 m/s.

- **Hydric Balance**

To calculate the climatic hydric balance, the soil needs of humidity are quantified using the precipitation and temperature data recorded at the Puerto Boyacá Station. This establishes the availability of water in an area, and the temporary relationship between hydric supply and demand.

The potential evapotranspiration (mm) is calculated by using the theory of C. W. Thornthwaite (1948 in Socolmet), which is based on monthly temperature values (in degrees Celsius) and monthly total values

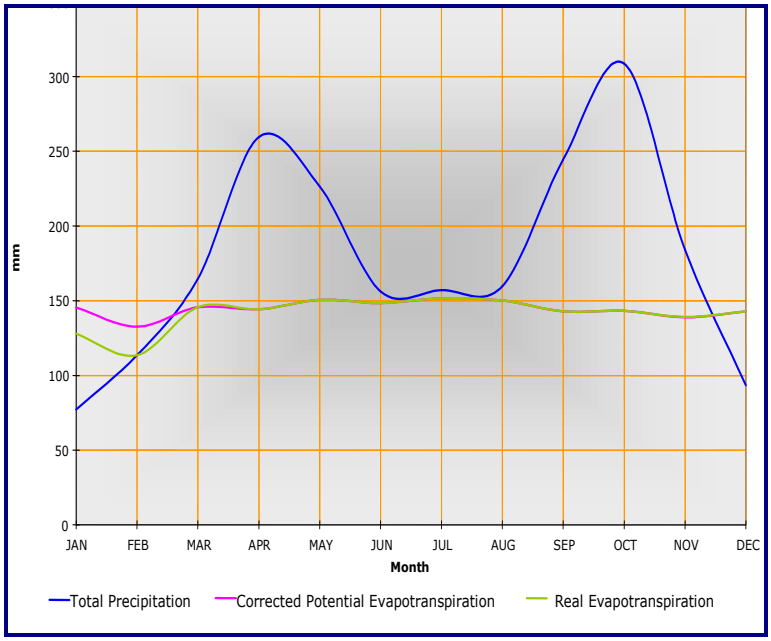
of precipitation (in mm). Thornthwaite defines it as the quantity of water transferred to the atmosphere, under ideal conditions of soil humidity, and vegetation.

Table 12 and Figure 22, show the resulting potential evapotranspiration (PET) and the Hydric Balance. It can be observed that a considerable part of the year shows an excess of water in the soil (from April to November) with an annual total of 444.92 mm.

Table 12 HYDRIC BALANCE, PUERTO BOYACA

PARAMETER	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Mean Temperature (ºC)	28	28	27.6	27.6	27.8	28	28.1	28.2	27.6	26.9	27.1	27.6
Total Precipitation (mm)	77.2	113.5	164.6	259.6	226.4	156.2	157.1	159.6	244.4	308.6	184.1	93.4
Heat Index	13.58	13.5	13.28	13.28	13.43	13.58	13.65	13.74	13.28	12.78	13	13.28
Constant (a)	0.72	0.722	0.718	0.718	0.72	0.72	0.72	0.72	0.71	0.71	0.71	0.71
Potential Evapotranspiration (mm)	142.6	142.65	141.37	141.37	142	142.65	142.97	143.1	141.37	139.18	140.5	141.37
Coefficient (F)	1.02	0.93	1.03	1.02	1.06	1.04	1.06	1.05	1.01	1.03	0.99	1.01
Corrected Potential Evapotranspiration	145.5	132.6	145.6	144.2	150.5	148.3	151.5	150.2	142.8	143.3	139.09	142.78
Storage	0	0	18.99	100	100	100	100	100	100	100	100	50.62
Storage Variation	50.62	0	18.99	81.01	0	0	0	0	0	0	0	49.38
Excess	-	-	-	34.4	75.88	7.85	5.56	9.35	101.62	165.25	45.01	-
Deficit	17.68	19.16	-	-	-	-	-	-	-	-	-	-
Real Evapotranspiration (ETPr)	127.82	113.5	145.61	144.19	150.52	148.35	151.54	150.25	142.78	143.35	139.09	142.78

Source: Environmental Management Plan Palagua FIELD. ASETEC LTDA, 2001. – PBOT Municipality of Puerto Boyacá – Boyacá



Source: Environmental Management Plan Palagua field, ASETEC LTDA, 2001.

Figure 22 Hydric Balance, Puerto Boyacá Station

The first two months of the year (January and February) show a period of water deficit in the soil where the potential evapotranspiration (ETP) surpasses the precipitation values, causing a hydric deficit of 36.84 mm annually. In the remaining months of the year, there is water storage in the soil.

- **Climatic Classification**

Climate is important, from a physical-biotic point of view due to its direct intervention in the evolution of soil and landscape. The temperature and precipitation parameters allow one to define, classify and zone the climate in a given region.

Based on the climatic classification by Koppen based on temperature, elevation and precipitation, in general, the area has a “humid warm climate; tropical rainy of savannah".

According to the ecological classification based on the life zones by L. R. Holdrige (IGAC 1977), who considers bio-temperature, precipitation and humidity as factors used in determining the life zones, the area under study corresponds to Basal Altitudinal Level (since it is located at an altitude of less than 200 meters above sea level), to the Tropical latitudinal region and to the Tropical humid forest (T-hf) Life Zone. The vegetation coverage of the area is located at the Mid-Magdalena Valley, according to Cuatrecasas, belongs to the Equatorial zone from 0 to 1100 meters above sea level.

Table 13 TEMPERATURE, BAROMETRIC PRESSURE, HUMIDITY AND WIND

Point	Temperature °C	Relative Humidity %	Speed of Wind (m/s)	Predominant Direction of the Wind	Barometric Pressure (mm Hg)
1	19,16	76,00	1,4	SE	553,36
2	20,38	49,27	2,23	ENE – ESE	553,36
3	21,05	44,88	2,06	S	564,35
4	20,61	45,65	2,58	N	563,58
5	21,92	39,67	2,94	NNE	562,94
6	22,67	35,88	2,65	N	562,47
7	23,1	33,7	2,41	SE	561,773
8	21,93	38,89	1,50	SE	561,296
9	19,65	49,83	2,44	S	560,345
10	20,91	47,65	1,94	S	556,224
11	20,67	46,37	2,74	SSW	563,711
12	14,96	76,71	0,06	WSW – WNW	553,299
13	17,07	59,41	2,94	S	546,557
14	15,97	61,65	0,65	SW	542,759
15	15,17	66,69	2,50	NNE	537,738
16	13,66	70,44	1,00	SE	533,908
17	12,92	76,69	0,94	SSE	533,906
18	13,66	72,18	2,24	SE	532,463
19	14,61	66,45	2,85	N	531,273
20	17,66	58,44	1,06	S	534,384
21	18,14	53,59	2,35	SSW	539,161
22	19,30	48,96	2,96	SE	542,020
23	19,40	48,79	2,84	S	544,656
24	21,70	44,67	2,98	S	547,977
25	21,96	43,28	2,78	SSE	553,089
26	24,00	37,07	2,11	SSE	558,154
27	23,17	39,18	2,71	SW	526,536
28	20,76	48,11	2,98	S	560,387
29	18,76	52,78	2,94	SSE	560,674
30	17,79	56,72	1,28	E – NNE	560,427
31	17,86	62,61	1,17	WSW	560,427

SOURCE: IDEAM

B.1.2 HYDROLOGY

Photo 17 Palagua Lake

From the regional point of view, the area of Palagua field is located in the Eastern margin of the middle Magdalena River basin. It is in the North sector of the Palagua sub-river basin and in the South margin of El Tambo sub-river. The Palagua and El Tambo sub-rivers merge in the Magdalena River, which is an important national fluvial artery.

The morphological characteristics of the zone include permanent or lentic water deposits (like the Palagua lake), many natural depressions, and swamps.

The Palagua lake is located about 5 km east of the Magdalena River bank, with an area of approximately 170 Ha. This is a natural resource with hydrological and ecological functions due to its biological and scenic diversity. This lake is a part of the area of direct influence of the Palagua field and the Velasquez field to the south. The lake belongs to a lentic water body, located in the flood plain of the Magdalena River as part of the regulation systems of volume of flow of the river.

The Palagua lake fills up during the rainy season. In addition, it is possible to observe that the lake is in a process of filling rather than eutrophication considering the loss of vegetation coverage that protected it, and the constant and continuous addition of sediment.

According to the topographical characteristics, the zone is dominated by a series of hills and depressions that store water during the rainy seasons and the overflow of the Magdalena River.

B.1.2.1 HYDROGEOLOGY

Photo 18 and Photo 19 Conduction system of water for human consumption

The underground water is used mainly for human and domestic consumption, agriculture and livestock. In the Palagua field, there are two wells. The well supplying water for the Palagua district (PW-1), is in the installations of the operations base of UT- IJP duly licensed by CORPOBOYACA, located in the Alto Flores, at 850 meters North-East of the administrative office of the Palagua field. This water well has a total depth of 88.5 meters. Although reports show that close to 90% of the inhabitants of the rural area of Puerto Boyacá get their supply from similar wells, the density of the population in the area is low.

The geological units considered as aquifers correspond to non-consolidated units of conglomerates, sandstone, arcillites, and tuffs with high to moderate permeability, which represent aquifers of regional extension. These units correspond to conglomerates of La Mesa formation, that conform two levels as aquifer, a free one and a semi-confined one, and the recent alluvial deposits that conform an accumulated under-ground water level.

In the La Mesa formation, water production wells have been drilled at a depth of between 110 and 283 meters, with a rate up to 10 liters per second of good water quality, suitable for human consumption. The recent alluvial deposits show a fluctuation in the water table at a regional scale of 8.8 to 13.93 meters, resulting in a free aquifer.

(See: Annex 2, Map 3 and Map 6.2).

B.1.3 REGIONAL GEOLOGY

The Palagua field is located geologically in the basin of the Middle Valley of the Magdalena River, on the foothill of the Eastern mountain range. This region limits to the North-East with the La Salina fault and to the South-East with the Cambras fault; to the West with the Palestina, Jetudo and Cocorná faults and

belongs to a basin nestled amid the mountain range, tilted to the East, with homoclinal tendency, disturbed by some folds and faults. Its structural formation corresponds to an asymmetric Teutonic depression with two well defined margins. The Teutonic depression is shaped in the entire zone, mainly, by tertiary rocks which present some overlapped stratum dips which are quite vertical in the upper part, but as it deepens they slant to the West. The structures present in the region are:

- Couples of anticlines –synclines, asymmetric along the western Edge of the Eastern mountain range, to the South of Bucaramanga, East of Palagua of Miocene age, as the anticline and syncline of Jesús Maria, Cooper; anticlines of Pradera, Portones, and Pauna.

- A mega fault tending towards synestral, associated with marginal riding folds -- Bucaramanga fault.

- System of riding folds of La Salina, Fault of Dos Hermanos to the East of Palagua lake.

- Normal faults, short spaced, along the Eastern Edge of the Central mountain range. To these groups belong the faults of Casabe, Cimitarra, and Cantagallo.

A Group of minor elapsing faults that can clearly be seen in some areas, such as Opon and Las Monas, which are a result of the renewal of old foundation faults.

Photo 20 and Photo 21 Geological shape of low rounded Hills within the area

Referring to the Teutonic evolution, the Middle Valley of the Magdalena River has been affected by expansive and compressive tectonic events. The expansive events cover a space between the Old Triassic and the Upper Cretaceous. The Teutonic compressive phase began in the Paleocene and continues until nowadays. (See: Annex 2, Map 4 - Geological)

B.1.3.1 STRATIGRAFY

The geological formations from bottom to top, or from the most ancient to the most recent, are the following: Umir (Ksu) formation, Tertiary: Lizama (Tpl) formation, of the Chorro group: La Paz (Tel) formation and Esmeraldas (Tee) formation, of the Chuspas group: Mugrosa (Tom) formation and Colorado (Toc) formation, from Real Group (Tmr) and of the Tertiary-Quaternary: the Mesa Group (TQpm).

A description of the geological Formations or lithological units present in the area of the project and of its area of influence, such as the Real (Tmr) formation and the Mesa (TQpm) formation, are the formations of interest for the project:

- **Above Ground Stratigraphic Units**

Recent Alluvial Deposits (Qal): Deposits constituted by silt, sand, and in a smaller proportion by quartz gravel, metamorphic and volcanic rocks. They are located to the East of the area of interest. These deposits have different thickness depending on the shape of the area of deposit. These deposits are characterized by manifesting in its granulometry silts and clay with minor contributions of gravel and sand.

Alluvial Fan Deposits (Qcal): These are represented by alluvial fans deposited by the currents that originate in the sector, forming terraces of sand and gravel composition.

In the zone of influence, the alluvial deposits coming from fans due to its granulometric composition have gravel and sand horizons that can be can used as sources of material for the landfills.

Fluvial Lacustrine Deposits (Qfl): Fluvial Lacustrine deposits from swamps and sloughs conformed by silt and argil deposited on the lower and depressive zones of the area.

Photo 22 Low wetlands Zone, conformed of silt and argil

Due to the topographic characteristics and the system of wetlands, this unit is saturated; the thickness of these deposits varies from 2.5 meters to 6.0 meters.

Mesa Aquifer (Tsm): It consists of compact polimictic conglomerates with cherty edges, basalt, and andesine, openings, agglomerations, and tuffs. They are interpolations of shale, sandstone tuffs, and gravel with edges of volcanic Rocks in the valley of the Magdalena River. The thickness of this unit varies between 250 to 300 m. This formation is found locally covered by recent alluvial deposits. It sets itself up in an important regional aquifer, from the Plio-Pleistocene. It is located to the East of the area of interest.

Photo 23 Outcrop of sand and silt horizons, representative of the Mesa Formation, in the area surrounding the Palagua field

This formation is affected by the Velazquez fault which is responsible for the depressions where the Palagua and El Tambo Swamps are located; the latter being outside the area of interest. Additionally, to the West of Puerto Boyacá the Cambras fault contacts the Mesa Formations. This is also located outside the area of study.

The Mesa Formation in the Middle Magdalena Valley: There is very little data on this unit of the Magdalena Valley. WHEELER (1935, p. 37) was the first to name this region that covers the area between the Rivers Sogamoso and Carare.

Photo 24 Hills of the Mesa Formation which have been intervened and raised to form platforms for exploration labors

B.1.3.2 STRUCTURAL GEOLOGY

Photo 25 General view of the geological formation of the zone

Regionally, the area of the Palagua field is dominated by a monocline. The layers are in the direction of N 10º E with a dip of 5-15º to the Southeast, presenting regional platforms towards the East. The monocline is affected by the Velázquez fault, which shows a Northeast-Southwest direction and a series of perpendicular faults to the main fault. This fault gives way to an alignment of depressions, which form the Palagua swamp.

The zone corresponds to a pseudo-geosyncline, developed in the orogeny of the Andes mountain range. During the process of elevation of the Andes mountain range, these basins were formed.

B.1.3.3 GEOMORPHOLOGY

The area of study is characterized for presenting two Geological forms that are described below:

Low hills with flat top: They appear in the flat zones of the area of interest, as remnants of the old surface of the Mesa Formation. The erosive processes and the gradual transformation into rounded top hills. This unit presents a flat top and short slopes of medium inclination.

Rounded top hills: It is the predominant geomorphology of the zone characterized by interconnected hills of rounded top, with low slopes and little inclination; they show dendric to subdendric drainage. The wetland system takes the dendric form of the characteristic drainage of the hills.

Photo 26 Geomorphologic unit of rounded top hills in the zone of the Project

B.1.3.4 GEOTECHNICAL CHARACTERISTICS OF THE ZONE

The area where the development wells are located is composed of sand and silt soils that belong to the Mesa Formation; these soils are of competent character, with a good capacity of support.

Photo 27 Presence of low consistency soils given an inadequate drain

The fine character soils of the La Mesa Formation are poorly drained soils and therefore retain rain water at surface level, generating local stagnation of water that could be detrimental for the exploration activities because of the loss of consistency of the soils due to the presence of water. Leveling and adjustment of the land is recommended in the places where this type of stagnation of water occurs.

To address this issue, as noted in Section A.3.1.3, drains are established around the drillsite to collect water and dispose of it in an environmentally safe manner.

B.1.4 SOILS

The Associations of the soils present in the area of the project were determined from the information registered in the General Study of Soils of the Western part of the Department of Boyacá.

- **Soils of Lacustrine-River Plain**

The landscape is homogenous and corresponds to the Marañal Association (MÑ). This unit of soils takes up the lacustrine plain of the Palagua Lake. The terrain of this landscape is flat with undulated micro-terrain and a slope of less than 3%.

The climate of the area of interest is humid warm and the vegetation formation (or Life Zone, according to the system of L.R. Holdridge), is Tropical rain forest (T-rf). The vegetation of the lacustrine zone (lowlands) has not been intervened by UT-IJP.

The soils that make up this formation have developed from the organic material, which rests on clayish or sandy material; and is characterized for being superficial, limited by the fluctuating under-ground water level, that at some times of the year can reach to the surface.

This Association is made up of the Marañal (Fibric Tropohemist), Peñoncito (Typic Tropaquept) and Palagua (Typic Psammaquent) groups. Their presence in the unit corresponds to 50, 30, and 20%, respectively.

- **Hill Soils**

They are elevations with less that 100m heights between hill tops, which were possibly terraces. However, due to their strong dissection, they were molded into hills.

The Associations SONORA (SO) and PIZZARRA (PI) belong to these soils.

- ✓ **SONORA ASSOCIATION (SO):**

This cartographic unit is found in strongly dissected low hills. The terrain of this landscape can be formed slightly undulated to highly broken, with slopes between 3 to 50%. The climate where this Association is found is warm-humid and the vegetable formation, according to L.R. Holdridge system, is Tropical rain forest (rf-T). The wooded vegetation has been almost completely destroyed to give way to extensive cattle ranching exploitations. The zone shows slight to severe laminar erosion and in some sections, one can see gullies.

The soils that make up this Association have formed from tufaceous sandstone and they are characterized for being moderately deep to superficial. The superficial horizons rest on a B to C alteration horizon.

This Association is made up of the Sonora (Typic Eutropept), Cadelsa (Typic Eutropept), with inclusions of Barlovento (Typic Tropaquept) and Estrella (Oxic Dystropept) soils. The Sonora represents 50% of the Association while Cadelsa represents 30%.

The following phases have been separated by inclines and erosion:

Sobc2: Slightly undulated to undulated terrain, inclines 3-7 and 7-12% and moderate erosion.

Socd2: Undulated to strongly undulated terrain, inclines 7-12 and 12-25%, moderate erosion.

Sode2: Strongly undulated to strongly broken terrain, inclines of 12-25% and 25-50%, moderate erosion.

Sode3: Strongly undulated to strongly broken terrain, inclines of 12-25 and 25-50% and severe erosion.

From the soils of this Association, the Sode3 phase can be seen near the area of the drilling project.

- ✓ **PIZARRA ASSOCIATION (PI):**

This unit is located in the middle hills of the Western Slope of the Eastern Cordillera. The terrain of this landscape varies between strongly undulated to broken, with inclines from 7 to 50%.

The climate of the region is warm humid and, according to the Holdridge system, is a tropical rain forest, in which the natural vegetation has been almost completely destroyed due to extensive livestock ranching.

The soils that make up this formation have formed from clays and compact sands from the Tertiary. They are moderately deep to superficial. The superficial horizons of dark colors rest on a B to a C alteration.

The limit of the unit is abrupt with the Carangal (CN), Porvenir (PV), Abarco (AB), Marañal (MÑ), San Felipe (SF), Cocomono (CC) and Trique (EB) associations, and with the Notora (NT), Balú (BL) and Alto Bonito (BT) associations. The soils are regularly distributed within the unit.

The groups Pizarra (Typic Eutropept) by 50%, and Tebaira (Typic Troporthent) by 40% make part of this association. There are also inclusions of the Estrella (Oxic Dystropept) and Barlovento (Typic Tropaquept) soils.

These soils show good development and are beginning to suffer degradation due to the lack of vegetable cover.

These soils have a high saturation of bases (alkaline) despite the shortage of total bases and the slightly acid reaction; the presence of carbon is very small in the entire outline.

B.1.4.1 USES OF THE SOIL

In the study area, land use has been affected since 1929, by the presence of the TEXAS PETROLEUM COMPANY (TEXACO). Since then, the rain forest ecosystem was modified mainly by the commercial extraction and burning of valuable vegetation species. As a result of this exogenous factor, this area has little vegetation.

Aside from oil exploitation there were other activities such as deforestation (wood exploitation) and cattle ranching, which came along with the arrival of settlers to the area that lead to reductions in vegetation.

Most of the homes have established a basic subsistence agricultural system, which implies the removal of marginal vegetation and drainage. Additional activity includes planting of species for domestic

consumption such as cassava, plantains, corn, and in a fewer quantity lemon, guava, sour sop tree, and mango, among others.

Continued deforestation for the establishment of new pastures has reduced the supply and quality of the water, not only for animal consumption, but also for domestic use and human consumption. This situation turns worse during the days of lower rainfall or "summer" between June and August. Consequently, the supply and availability of good quality forage that meets the maintenance requirements for cattle production, is substantially reduced, and occasionally precarious. This situation requires producers to reduce livestock inventories during this time or simply move them to other farms, thus increasing deforestation and expanding the agricultural boundary.

B.1.4.2 CATTLE USE

Photo 28 and Photo 29 Areas for the use of stockbreeding

This area is used for breeding cattle, horses and minor species. Cattle are bread for both meat and milk. The mostly widespread species are: Zebu and Brownish-gray Swiss cattle. There is also a representative inventory of horses. Minor species include poultry, pigs, sheep and goats.

B.1.4.3 AGRICULTURAL USE

Photo 30 and Photo 31 Areas of agricultural use

In the area of influence, there are only subsistence agricultural farms due to the hilly terrain or lowlands. Some of the local crops are plantain, corn, yucca, mango, sorghum, and citrus fruits.

B.1.4.4 INDUSTRIAL USE

This area also has oil fields. The study area refers to the Palagua fields and all the infrastructure related with the oil industry. (Tanks, flow lines, batteries, wells).

Photo 32 and Photo 33 Sector of Industrial Use

B.1.4.5 EXPOSED AREAS

This refers to the area without a vegetable cover. In the area of the field, it relates to those places that are eroded mainly due to the flow of rain water. It is important to point out that most of the hills of the area of study show processes of slight to severe erosion, produced by the action of rainwater and further aggravated due to cattle ranching.

B.1.4.6 HYDRIC USE

Photo 34 Palagua Lake – Hydric source of greatest importance

The exposed area also includes the rivers, lakes, small lakes, creeks, bayous, streams, pools, and other natural or artificial bodies of still or fresh water. In the area of influence, this category mainly includes the Palagua Lake.

(See: Annex 2, Map 5 - Potential Land Use)

C. NATURAL THREATS AND RISK

Natural threats and risks are defined as those events that can cause harm to people and property. Threats are classified according to degree of intensity. There is high threat when the conditions for occurrence of the natural event are the most favorable, low threat when the conditions are less favorable and medium threat when there are intermediate conditions between the first and the second.

C.1 HISTORY

As per the Basic Plan for Land Use Planning (PBOT) in the municipality of Puerto Boyacá for the area where the Palagua field is located, possible natural hazards include landslides, seismic activity and floods. For the Palagua well area, the possible natural threats are described in Table 14.

Table 14 SUSCEPTIBILITY TO GEOLOGICAL THREATS

THEMATICAL CONVENTION	SUSCEPTIBILITY	CHARACTERISTICS
	Areas of geological instability (susceptibility of Rotational and Transnational type sliding)	Landslide phenomena with rock or ground detachment.
	Areas susceptible of being flooded	Events that occur sporadically due to overflowing in the lower reaches of streams (flooding) brought on by heavy rains.
	Seismic risk areas	The Project area is an intermediate seismic risk area.
	Intervention Areas without restriction	Corresponds to the areas to be intervened by the project and where there is no restriction for its implementation.
	Intervention Area with restriction	Areas that will be intervened with the project's work and require special measures in order to protect some resource.

SOURCE: LAND MANAGEMENT PLAN – PBOT Puerto Boyacá – Boyacá

Natural Hazard Areas: The risks and threats that may affect the area's population are classified according to Table 15.

Table 15 NATURAL HAZARD AREAS

TYPE	CHARACTERIZATION
Sliding	Corresponds to the immediate vicinity to the Magdalena River which presents erosions and landslides
Flooding	It is observed in the savanna zone, where the rivers expand in the winter time affecting the surrounding areas (especially the river bed and its banks).
Fire	Forest areas are susceptible to forest fires in summer time.
Geological Faults	The Municipality is classified as an intermediate seismic risk zone.

SOURCE: Land Management Plan – PBOT Puerto Boyacá – Boyacá

Risk is the probability of harm or loss of property and people in case of the occurrence of a determined event. Due to its geomorphology, geology, climate, and hydrology the municipality of Puerto Boyacá is subject to different types and severity of natural hazards. The following natural hazards are possible in the Palagua field area:

- Climatic hazards/threats: Caused by water phenomena such as floods, drought, or climatic events such as hailstorms. In the Palagua field area there are sectors subject to flooding such as the area surrounding the Palagua Lake and in some lowlands as evidenced in Map #4-Amenazas Rural in Annex 2.

- Threats by erosion: Erosion is a constant threat in the municipality, mainly in the hillside areas devoted to agricultural activities. In the Palagua field area, because of its flat to undulating topography, there is a threat of sheet erosion along the hillside.

- Mass movements: In the Palagua area, as in most of the municipality's area this is a low impact phenomenon.

- Forest fires: The areas with the highest probability of occurrence of forest fires are located on the belt of forested hills where there are wooded areas corresponding to parts of the villages Puerto Gutiérrez, El Marañal, El Pescado, Puerto Niño, Ermitaño, and small areas of Palagua village.

- Within the Palagua field area, as in the sectors of oil production, the risk of fire is present due to the fuel storage, but UT-IJP has taken actions and measures for the prevention and control of fires.

A map of the hazards and risks in Colombia can be found in Annex 2, Map 6.1.

C.2 POLICIES AND STRATEGIES FOR THREAT CONTROL

The municipality of Puerto Boyacá's policy is to monitor threatened areas in those sectors that require action so as to develop the guidelines and priorities in case of an eventuality.

Prevention as a pillar for national development and environmental protection is enshrined in Law 99 of 1993; the state as protector of life and property of the Colombian people (Political Constitution of Colombia) requires the Government to take actions to minimize the loss of people and property due to the occurrence of potentially harmful events.

C.2.1 STRATEGIES

1. Develop and implement a prevention and emergency care plan, according to the guidelines of the Department of the Interior and the Departmental Committee for Prevention of Risks and Disasters.

2. Develop studies to identify areas for the location of temporary shelters for the relocation of people whose homes are at risk.

3. Update the information (every 3 years) of the hazard and risk zones in the urban and rural areas.

C.3 POLICIES AND STRATEGIES FOR RISK CONTROL

- **Threat from Landslides -** ***Short and Medium Term Actions***

Slope stabilization is recommended (gabions, retaining walls, etc.); having previously carried out the aforementioned studies.

- **Threat from Fire -** ***Medium Term Actions***

Have adequate firefighting equipment in the Palagua oil fields.

- **Threat from Floods**

All the wells in the field are drilled from the top of the hills. Thus, the risk of flooding is absent in the drilling areas.

D. BIOTIC ENVIRONMENT

The following is a description of the vegetation and fauna diversity, natural habitats, renewable and nonrenewable resources related to the area of influence of the 32-well expansion project for development well drilling in the Palagua field. The description is based on available information, the results of indirect photo interpretation, and field visits.

(See: Annex 2, Map 7 - Life Zones, Map 8 - Estrategics Ecosystem, and Map 9 - Wildlife and Natural Resources)

D.1 VEGETAL COVERAGE

The soil studies carried out in the areas of influence were oriented towards identifying its physical and chemical characteristics, and its current status regarding degradation phenomena (erosion, denudation, flooding, and skeletization) in order to determine its quality, specifications and potential use.

The study of this area shows pastures and natural vegetation in low flood lands, mostly herbaceous, and areas with underbrush.

The forestry component (trees, forests and forestry activities) is scarce in the area. Forests or trees are located on the banks of rivers and streams in an early stage of growth along the roads. A few scattered trees remain in the area.

The proposed new wells are to be drilled from the existing well locations, where no vegetation exists. Thus, proposed wells will not change the local vegetation.

D.2 VEGETATION UNITS

The following coverage units were identified and classified into four main areas: low flood land vegetation; stubble or underbrush; improved pastures, and vegetation associated to natural [or dried (dissected) surface] savannahs and crops.

(See: Annex 2, Map 10 - Current Land Use)

D.2.1 LOW FLOOD LAND VEGETATION

The flood land is the lowest land in the area. It has surface soils to moderately deep soils. They are flat concave surfaces with slopes of less than 1%. They are located north of the Palagua Lake and Palagua Port. The plant population in this area is maintained throughout the year.
The plant species in the area include fixed and floating macrophytes, reeds, and some tree and shrub species which can be found around the drains. Some of the associated species include: *Potamogeton sp. Polyrrhiza Azolla, Pistia sp., Wolffia Colombian Sccirpus sp., Typha sp. Bidens sp., Eleocharis sp.*

The inhabitants of the region call this type of vegetation "plugs". These “plugs” are usually located in the surrounding hills. The predominant vegetation includes platanillo, bijao, (*Heliconia bihai L.*) rushes, and tree species with BHD (Breast Height Diameter) less than 10 centimeters such as cecropia, vara santa (*tripalis*), corozo palm, noli palm, chota lata (spiny palm), guayabillo (*Eugenia pachychlamys*), churimbo macho (Inga Sp), and olivon, among others.

Photo 35 Appearance of low flood land areas

D.2.2 IMPROVED PASTURE AND NATURAL GRASSLANDS

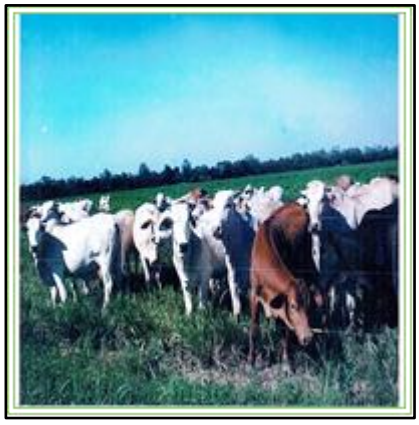
Native pasture lands are especially important. They are currently made up of natural enriched pastures and introduced grasses. Depleted pastures of native grasses are propagated with new grasses.

In the hills of the study area there are only a few isolated tree species such as palms *(Roystonea regia)*, guayacán *(Tabebuia roseae)*, hobo (*spondias mombin*), iguá (pithecellobium guachapele), algarrobillo (*Ceratonia siliqua)*, teak, guava *(Psidium guajava L.),* Lemon *(Citrius sp),* Aceituno (*Zanthoxylum flavum),* solera *(Tilia sp.),* Totumo (*Crescentia cujete),* Dindo *(Chlorophora tinctoria),* Chicalá, uvero, and tachuelo (*Picteti Aculeata),* among others. These trees and shrubs are usually planted by the farmers, to make live fences to provide shade for livestock, or they grow naturally.

The most common grass species in the area are: India *(Panicum maximum),* Pangola (*Digitaria decumbens),* Brachiaria *(Brachiaria spp.)* Carimagua *(Andropogon gayanus)*, and Pasto Aleman – German Grass*(Echinochloa polystachya*). The latter is very common in the flood lands.

Due to extensive cattle ranching, large portions of natural vegetation are disappearing.

The main use of this area is cattle ranching for meat and dairy industries.



D.2.3 CROPS

Both the field visit and the analysis of the area of the oil wells and their direct area of influence indicate that there are no established crops.

However, it is common, to find subsistence crops in areas adjacent to homes near water bodies (lentic, lotic or runoff), or in small isolated areas.

Some of the common species are: orange, lemon, tangerine, mango, papaya, guava, lemon, guanábana and mango fruit trees. Some give crops twice a year while others such as plantain, banana, and cassava, give an annual crop.

D.2.4 STUBBLE OR UNDERBRUSH

This classification corresponds to a type of vegetation in various stages. It arises as a result of tree cutting, forest burning, and turning the land into pastures and grasslands, which are later abandoned and recover naturally through different stages.

Units with shrubs and underbrush are located on the runoff draining areas. These units are usually surrounded by bushes and small trees with heights ranging from 2 to 15 m. In a few locations distant from the wells, they can be seen as dense spots of vegetation in low, humid lands that tend to flood. Some of the trees observed in the area were: caucho (*Ficus* sp.), hobo (*Spondias mombin*), palmas, Guásimo (*Guazuma ulmifolia*), Yarumo (*Cecropia peltata*), Gallinero o Payandé (*Pithecellobium dulce*), guamo (*Inga* sp.), samán (*Samanea saman*), iguá (*Pseudosamanea guachapele*) among others

- **Vegetation and Description of Strata**

The sector has three strata: arboreal, shrubs and herbaceous. The herbaceous layer, composed of grasses and weeds is predominant at different altitudes on the hills. The herbaceous strata are composed mostly of pasture to feed livestock. Among the grasses, we have: Brachiaria (*Braquiaria* sp.) and Carimagua (*Andropogon gayanus),* india (*Panicum maximum*), Pangola (*Digitaria decumbens*), and Pasto Alemán (*Echinochloa polystachya*).

The arboreal and shrub species were found scattered in the hills, forming part of a hedge of live barriers, or were found in floodable areas. They have different heights and stages of growth. Trees range in height from 5-15 m, shrubs grow up to 2 m and some herbaceous species are 1 m tall. The diameters of the tree trunks range from 30 to 80 cm.

Table 16 SPECIES OF VEGETATION PRESENT IN THE STUDY AREA

COMMON NAME	SCIENTIFIC NAME	COMMON NAME	SCIENTIFIC NAME
Java Plum	*Spondias mombin*	Yellow cedar	*Pseudosamanea guachapele*
Mango	*Mangifera indica*	Mimosa	*Mimosa* sp.
Western Cashew	*Anacardium occidentale*	Ficus	*Ficus* sp.
Guarita	*Astronium* sp.	Fustic tree	*Chlorophora tinctoria*
Wild sweet sop	*Annona* sp.	Myrsine	*Rapanea guinensis*
Monkey pepper	*Xylopia aromatic*	Sweet guava	*Psidium guajava*
Yagua palm	*Scheelea butyraceae*	Lathropopis	*Lathropopis* sp.
Lata palm	*Bactris minor*	Ant tree	*Triplaris americana*
American oil palm	*Elaeis oleífera*	West Indian elm	*Guazuma ulmifolia*
Coconut palm	*Cocos nucifera*	Teak	*Tectona grandis*
Calabash	*Crescentia cujete*	Miconia	*Miconia* sp.
Jacaranda	*Jacaranda* sp.	Mimosa	*Mimosa* sp.
Trumpet tree	*Tabebuia rosea*	Mastranto	*Hyptis brachyata*
Balsa	*Ochroma lagopus*	Panama hat plant	*Carludovica palmata*
Snake wood	*Cecropia* sp.	False bird of paradise	*Heliconia* sp.
Panama hat plant	*Carludovica palmata*	Calathea	*Calathea* sp.
Almendro	*Terminalia* sp.	Guinea grass	*Panicum maximum*
Leche leche	*Sapium marmieri*	Gamba grass	*Andropogon gayanus*
Gliricidia	*Gliricidia sepium*	German grass	*Echinochloa polystachya*
Colombian mahogany	*Cariniana pyriformis*	Thatching grass	*Hyparhenia rufa*
Monkey pod	*Pithecellobium dulce*		
Barbados cherry	*Bunchosia* sp.	Surinam grass	*Brachiaria decumbens*
Barbados cedar	*Cedrela odorata*	Golden leatherfern	*Acrostichum* sp.
Guamo plant	*Inga* sp.	Rain tree	*Samanea saman*

SOURCE: Palagua Field Observations

- **Endangered Species**

This area has been highly affected by deforestation throughout the years. As a consequence, secondary vegetation has developed, with species that adapt and tolerate disturbances in the natural environment.

One activity that has affected the vegetation is the tree cutting and burning of the forest done by the village settlers. Felling (tree cutting) is carried out mainly to obtain wood, and burning is practiced to preserve grasslands from weed invasion and to extend the cattle ranching areas. However, these activities have been diminishing in the region due to the presence of Technical Assistance (Agricultural Technical Service Unit) and the vigilant presence of CORPOBOYACÁ (Corporación Autónoma Regional de Boyacá). The latter corporation controls the output of wood by farmers and traders to urban centers, in order to protect the forests from being completely cut down.

- **Vegetation of Economic and Cultural Importance**

These are important plant species used to obtain medicinal substances, edible fruits, timber, firewood, and other uses. These plants and trees are listed in the Table 17.

- **Vegetation in the areas of the development wells**

The development wells for which this study is conducted are located in high lands areas surrounded by flood lands. There is no vegetation in the proposed well site area.

The construction of each well site will not have a major technical and environmental relevance, since it does not require the construction of access roads and the existing fluid pipes tangentially cross the location. There is no need for a special type of engineering or forestry work.

Table 17 IMPORTANT SPECIES IN THE STUDY AREA

COMMON NAME	SCIENTIFIC NAME	USE AND ECOLOGICAL IMPORTANCE
Anón de monte/ Golden Sugar Apple	*Annona* sp.	Timber tree with medicinal properties and edible fruit. Timber used to hold fishing nets and ropes because of its weight. It has been used in medicine to relieve ulcers, diarrhea in children, headaches, malignant tumors, etc..
Yarumo/Trumpet tree	*Cecropia peltata*	The cooking of their roots and leaves is ant bilious. It is useful for colds and asthma. Source of fiber and paper pulp.
Samán/Rain Tree	*Samanea saman*	Provides protection to river banks and it is important because it gives shadow to cattle.
Abarco/Colombian Mahogany	*Cariniana pyriformis*	Timber tree. Its wood is used in bodywork.
Matapalo/Fig tree	*Ficus* sp.	Useful species to establish and initiate the process of recovery of vegetation in deforested riverbanks. The latex or milk is used as a parasite purgative.
Guamo/Ice Cream Bean	*Inga* sp.	Useful to protect riverbanks in areas low dissection. Its fruits are tasty.
Teak	*Tectona grandis*	Timber tree, used for hedges or live barriers.
Dinde/Gingerwood	*Chlorophora tinctoria*	Its wood is heavy and hard, it is very popular in construction. It produces a dye that is used in textiles. It is a useful species for erosion control.
Matarratón/Mouse Killer	*Gliricidia sepium*	It is used for production of forage because of the large protein value in its leaves. It is used as a live barrier or hedge. The liquid produced from the cooked leaves is used in baths to relieve skin diseases. It is useful for erosion control and as nitrogen fixing, and suitable for soil remediation.
Guayacán/Ironwood	*Lignum vitae*	Timber tree. The wood is highly prized in fine furniture industry.

SOURCE: Green Mantle of the Earth. (Manto Verde de la Tierra) CAS. 1999.

D.3 FAUNA

The wildlife resource is of great importance in ecosystems due to the large contribution to the diversity of species inhabiting a geographic region, which depends on both abiotic factors (temperature, water availability, rainfall, elevation above sea level, etc.) and biotic factors.

Animal species are very sensitive to disturbances that alter their habitat and environment. This is corroborated by the extinction of several species in Colombia. Despite the existence of laws,

resolutions, and decrees for their protection, such as the 2811, of 1974; and the existence of Ministry of the Environment, hunting and the indiscriminate destruction and illegal wildlife trade, remains a problem for the Colombian government and others worldwide. The natural wildlife has decreased mainly due to the logging of the forest, livestock farming, and thoughtless hunting in the past.

However, there are a few captive wildlife land mammals such as cerillo *(Tayassu spp),* tapir *(Tapirus terrestris),* capybaras *(Hodrochoerus hydrochaeris),* and reptiles such as the tortoise *(Geochelone denticulata*) and the Iguana (*Iguana iguana*) in their natural environment.

The **tapir, sachavaca** or **anta** *(Tapirus terrestris)* is a mammal of the perissodactyle family of South American tapirs. It measures between 1.7 and 2.5 m long and weighs up to 270 kg, its tail is 5 to 10 cm long, measured at the cross, it is from 75 to 110 cm, its body varies from greyish-brown to dark brown and has white tips at the ears. Its upper lip ends with a trunk. It has a thin straight line of hair from the tail to the neck.

The tapir lives in forests with high rainfall, and near swamps and rivers, at an altitude ranging from sea level up to 1,700 meters above sea level. It is usually found near water since it is a good swimmer. It is herbivorous and uses its proboscis (motile nose) to eat leaves, branches, fruit, etc.

The **capybara (***Hydrochoerus hydrochaeris***)** is a rodent species of the Caviidae family native of South America. It is currently the largest rodent (in size and weight) in the world, and lives in herds in savannas, rivers, marshes and wetlands of South America.

The capybara has a barrel shaped body, and a small head. Its reddish brown coat in the upper body turns brownish yellow at the bottom. It can grow to 130 centimeters long and weigh up to 65 kilograms. The capybara has slightly webbed feet, lacks a tail and has twenty teeth. Its hind legs are slightly longer than the front ones, and their muzzles are blunt. The eyes, nostrils and ears are at the top of the head. Females are slightly heavier than males.

The yellow-footed land motelo **tortoise** of the Amazon or jungle tortoise *(Geochelone denticulata)* is a turtle that lives in the tropical rainforest. It is native of South America, and can be found in the jungles of Colombia, Venezuela, Guiana, Brazil, Ecuador, Peru, Bolivia and Paraguay.

The shell of the jungle tortoise measures from 50 to 65 cm in males and between 65 cm and 75 cm in females, and its color is dark brown (not black) with clear or yellow circles. The under part of the shell (plastron) is brown with yellow squares and appears flattened in females while concave in males. It has multiple yellow spots on the legs and head.

In its natural habitat, it has a wide range of food available. Herbs, tropical fruits and leaves are its main food source. It also eats snails, worms and insects.

They mature sexually when they are between 5 and 7 years old. The male is usually very territorial. During foreplay, it follows the female continually and bites, taps and presses her until she accepts him. After that, the female lays 3 to 8 eggs. This happens up to 7 times a year. The eggs require an incubation period of about 4 to 5 months, at a temperature of 28 ° to 29 ° C and high humidity.

The **Iguana**, teyú or **green iguana** *(Iguana iguana)* is a large arboreal lizard from Central and South America. It measures up to 2 m long from head to tail and can weigh over 15 kg. It belongs to the mayor and more complicated group of dinosaurs of the New World to which most species belong. It is included in the Iguana family

Iguana can measure from 1.5 to 2 meters. They are herbivores and reproduce by eggs, which are placed underground during the month of February (austral summer). They reach sexual maturity at 16 months of age, but are considered adults at 36 months, when they measure 70 cm in length.

The green color of their skin allows it to perfectly mimic vegetation that exists in their environment. Its skin is covered with small scales, with a dorsal ridge that runs from head to tail, and is quite visible in males.

All iguanas have short legs and five toes on each foot, which end in sharp claws. Its tail is long and thin and bordered by a row of sharp dorsal scales. This animal sometimes makes puffing sounds. It has scales, a gular pouch in the throat and a dorsal border, and saliva-like liquid, which males use to mark their territory.

According to information obtained from the villagers, other fauna in the flood lands consist of an abundant population of birds and reptiles which have maintained the ecological balance.

D.3.1 HYDRO BIOTIC POPULATION

In studies made in the existing surface water sources in the Palagua field regarding the identification of biotic communities, populations of Periphyton have been found as primary producers and Bentos as secondary consumers in the food chain.

Figure 3.D - 1 Hydrofauna sampling Palagua field

The samples taken help determine the water quality through the consideration of the composition and abundance of such species.

Aside from **Bentos,** (agents that remain or are fixed to the bottom of the sea or fresh waters, communities of animals or plants living on the ocean floor), and **Periphyton** (organisms that grow on surfaces free of objects submerged in water which it covers or wraps around with a slippery surface; a community of organisms that grows, settles down on an inanimate, organized or alive substrate, that is not part of the benthos complex whose members are tiny or microscopic). There are also abundant **Aquatic Macrophytes** which are macroscopic forms of aquatic vegetation. They include macroalgae, pteridophytes - mosses, ferns adapted to aquatic life - and angiosperms, which have also been detected. They have adapted to life in form of thin cuticles, non-functional stomata, and slightly lignified structures.

Species from the genus *Closterium (Mougeotia,* in greater abundance, *Euglenophyta (Euglena, Phacus, and Trachelomonas Lepocinclis)* have been identified. Among the aquatic macroinvertebrate communities present are Nekton, Neuston, and Benthos, species that respond rapidly to environmental pressure, and are susceptible to changes in water quality.

Regarding the predominant class Insect, the following orders have been identified in the area. **Diptera** (order of insects that have sucking mouthparts or stings and only two membranous wings like flies and mosquitoes), **Coleoptera** (order of chewing insects that has a hard exoskeleton and two hard wings called elytra, which cover in turn two membranous wings, like the beetle or ladybird), **Hymenoptera** (insect order with a chewing, sucking or licking mouth, complex metamorphosis, two pairs of wings and, in many species, social behavior) and **Odonata.** (The order **Odonata** includes insects such as dragonflies and damselflies. They are all Paleópter, insects that cannot fold their wings. They live in association with aquatic environments which are necessary for the development of their larvae. They don´t have a pupal stage. They have two pairs of wings with complex venation, which is an important taxonomic character for classification).

E. HUMAN ENVIRONMENT

This analysis determines the influence of the proposed drilling and development of the Palagua field oil wells on the community, located in the Palagua Rural area; in the municipality of Puerto Boyacá, Boyacá.

Photo 36 and Photo 37 Social Structures and Housing in the Rural Area of Palagua field

E.1 INFLUENCE AREAS

The area of influence of the project refers to the area of social and environmental context which could be affected by the impacts (positive and/or negative) produced on the physical, biotic, and social variables by the activities of the project. For the Environmental Assessment of the Project, two areas of influence are defined, a Direct Influence Area (DIA) and an Indirect Influence Area (IIA).

E.1.1 DIRECT INFLUENCE AREA (DIA)

The direct influence area corresponds to the area where the work and activities required to drill the development will be carried since that they will cause the major environmental and/or social impacts. The Palagua Rural Area, in the municipality of Puerto Boyacá, is the area where new wells are proposed.

- **The Palagua Rural Area**

Located in the heart of the Middle Magdalena river basin, the Velasquez, Teca, Nare, Jasmine, Moriche and Chicalá oil fields are operated by Mansarovar. Cocorná field is also located here and it is operated by Ecopetrol.

The history of oil exploitation in the sub-region Middle Magdalena began with Velasquez field which is south of Palagua Lake. It was the first field discovered by the Texas Petroleum Company in the mid-50s.

The Texas Petroleum Company began the process of hiring unskilled labor from the village population. The community directly benefited from this through the provision food and housing improvement, among other things, which were provided directly by the company.

Towards 1979 and 1980, there was migration of a great part of the population of the rural area, due to existing conflicts over territorial control between armed groups, and in the end, only a few families and a store were left in the rural area of Palagua.

With the decrease of the conflict in the territory and the arrival of Empresa Colombiana de Petroleos, ECOPETROL in 1986, the displacement situation normalized and a new process of immigration to the sector initiated, which was attributed to the employment prospects in livestock farming and oil extraction activities.

Between 1995 and 2003, Ecopetrol and other oil field operators have paid for the operation of their oil fields in the Middle Magdalena Valley. The enhancement of social benefits for the area is greatly reflected in the more than $ 146,500 million in royalties, $1,645 million in taxes, and the $6,358 million in transportation taxes that have been collected by the government from Ecopetrol and others.

The social contribution to the communities surrounding these areas is reflected in health care provided to more than 3,500 people with paid doctors and the supply of free medicines.

Another of the contributions is the support given to education, including the reconstruction of old schools, and building of new ones, and the provision of books and school kits. Likewise, support has been given to the employment generation through support to micro companies. Businesses such as a recycling company, a corn flailer, production of ice cream, fast food and sewing shop are part of those that have been sponsored.

Photo 38 and Photo 39 Educational institutions existing in the Palagua rural area

E.1.2 INDIRECT INFLUENCE AREA (IIA)

The Indirect Influence Area is considered the area where the project activities are not performed; however, some indirect impacts may result from the drilling project. This area comprises the geographical coverage of the municipality of Puerto Boyacá, Boyacá.

- **Boyacá Department**

The department (state) of Boyacá is located in the central part of Colombia, limiting to the North with the departments of Santander and Norte de Santander, the departments of Arauca and Casanare to the East, the department of Cundinamarca to the South, and the department of Antioquia to the West.

Before the conquest, the Boyacá state was inhabited by numerous Indian tribes, especially belonging to the Caribbean linguistic families (Muzos and Citaráes) in the Magdalena Valley and Chibchas in the central territory. Many of these indigenous communities had a peaceful attitude. This situation facilitated racial mixing in this region.

The state's economy depends mainly on farming, food processing and mining.

- **Puerto Boyacá Municipality**

The municipality includes all the area known as the Vasquez Territory, which was named in honor of the Independence Martyr Cayetano Vasquez.

Surrounding the oil installations, large areas cultivate rice, maize, banana, and cassava (manioc). Wood logging was also developed. In late 1957, the village opened a road to Puerto Niño. The four kilometer road was built in 40 days by the Texas Petroleum Company. This was the first land road for the rising new city. Soon industries such as the first gas station, and the first transportation company also began to emerge.

- **Population Settlements**

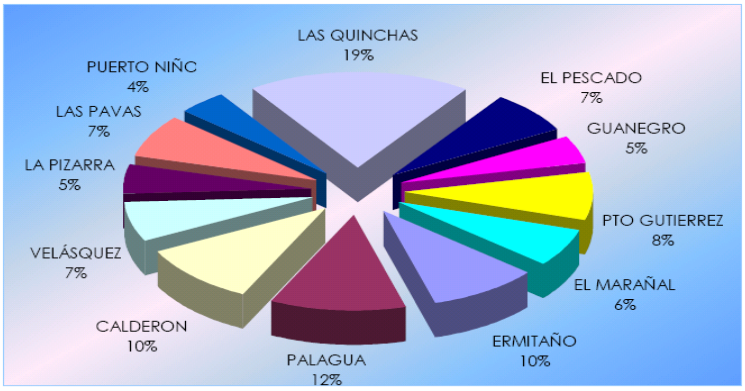
Currently the municipality of Puerto Boyacá has nineteen (19) settlements or population centers, which are distributed in the two main townships or administrative districts in the municipality. The following table is a summary of the above information.

Table 18 ADMINISTRATIVE DIVISION OF THE AREA

TOWN SHIP	RURAL AREA / Km²	POPULATION CENTER
1. Vasconia-Puerto Serviéz 465.99 Km.²	1.Palagua / 173.54	1.Cruce Palagua 2.Cruce El Chaparro
	2.Calderón / 150.78	3. Muelle Velásquez
	3. El Ermitaño / 141.67	4. El Ermitaño
2.Puerto Pinzón 1.017.45 Km²	3.Velásquez / 100.45	5.El Marfil
	4. Las Quinchas / 282.67	6. Puerto Pinzón
	5.La Pizarra / 72.09	7. La Pizarra 8. La Ceiba
	6.Las Pavas / 107.14	9. El Okal 10. Puerto Romero
	7.Guanegro / 70.35	11. Guanegro
	8.Puerto Gutiérrez / 118.92	12.Kilómetro 25
	9.El Marañal / 94.02	13. Unión Pto. Gutiérrez.
	10.El Pescado / 109.81	14. El Trique 15. El Pescado
	11.Puerto Niño / 62.01	16.Puerto Niño 17.Km. 1½ 18. Km. 2½ 19. Km. 11

Source: PBOT Basic Plan of Territorial Development, Municipality / Puerto Boyacá. 2005

The municipality of Puerto Boyacá consists of 12 rural areas which belong to the two townships of the Vasconia Territory - Puerto Serviez and Puerto Pinzón.



Source: PBOT Basic Plan of Territorial Development, Municipality / Puerto Boyacá. 2005

Figure 23 Division of the Rural Areas (by percentages)

E.2 SOCIAL SERVICES STRUCTURE

E.2.1 POPULATION

The population of the municipality of Puerto Boyacá, according to the census of June 2005 is 50,301 inhabitants. Fifty percent (50%) of the population is women and 50% is men. Thirty-three percent (33%) of the population lives in rural areas and 67% in urban areas. On average, there are 34.17 inhabitants per square km.

Table 19 POPULATION OF PUERTO BOYACA MUNICIPALITY

State (Department)	Municipality	Surveyed Population – June 2005 Census		
		Total Population	Municipal Seat Population	Rural Population
Boyacá	Puerto Boyacá	50,301	33,806	16,495

Source: DANE (National Statistics Center) Census DANE. 2005

E.2.2 EDUCATION

According to the information stated in the PBOT, the Basic Plan of Territorial Development, (in Spanish - Plan Básico de Ordenamiento Territorial), for the Municipality of Puerto Boyacá, in 2005, the population

has access to educational programs in pre-school, elementary school, academic, commercial, and/or technical high school as well as agricultural university and intermediate level. Adult training programs are offered by SENA and other non-governmental entities. There are also institutions offering informal education programs, job training, and preparation for high school.

There are 62 institutions of formal education in Puerto Boyacá. In the urban sector, coverage for school-age population reaches 82.6% in thirteen (13) schools; while in the rural sector this coverage reaches only 62% and is being provided by 48 government institutions.

The data recorded in the PBOT, shows that 16% of people who make up the population are illiterate. In terms of distribution by area, 13% of the illiterates live in the municipal seat. For the rest of the territory this percentage reaches 23%. The following table shows the illiteracy rates in the municipality.

Table 20 ILLITERACY INDICATORS FOR THE PUERTO BOYACA MUNICIPALITY

Area	Total Inhabitants %	Literate Persons %	Illiterate Persons %	No information Available %
Municipal Seat Population	69%	87%	13%	0
Rural Population	31%	76%	23%	1
Total	100%	84	16%	0

Source: Dane Evaluating Work Inspection Task Team PBOT Basic Plan of Territorial Development, Municipality, Puerto Boyacá

The elementary school Palagua - Alliance, with eighty (80) students and three (3) teachers, is located in the area of direct influence. This school was built by the Texas Petroleum Company in 1966, and upgrading and maintenance has been carried out by local governments with the support and participation of ECOPETROL, the community, and UT-IJP, the current oil and gas producer of the Palagua field. The school is in good condition.

Photo 40 and Photo 41 Palagua Alliance School

E.2.3 HEALTH

José Cayetano Vásquez Hospital, a State Social Enterprise, is currently the main provider of first and second level health services, and its coverage comprises entire urban area and twenty rural areas.

The municipality has 14 health posts in rural areas, of which only those located at the populated centers of La Pizarra, Puerto Serviez, and La Ceiba offer permanent services.

The environmental health office is a unit of the José Cayetano Vásquez Hospital responsible for developing related and planned activities under the PAB - Plan de Atención Básica Municipal -(Municipal Basic Health Plan). The development of programs for environmental sanitation and public health surveillance is funded by the state and the municipality's own resources, receiving municipal administration, counseling and coordination from the Health Department of Boyacá.

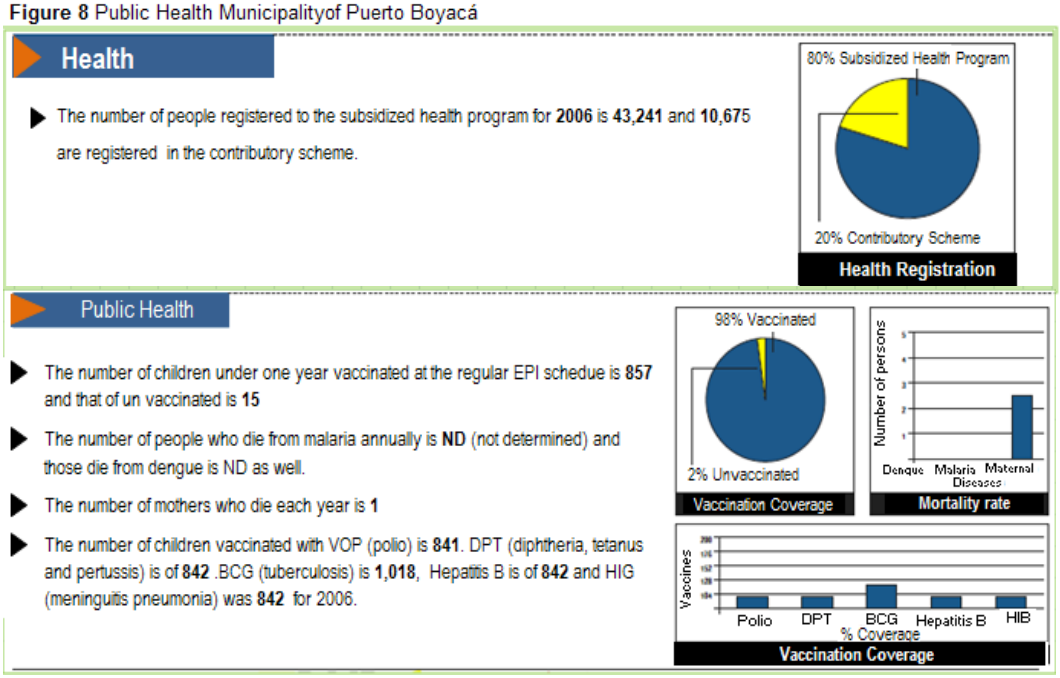
For 1993 the birth rate of the municipality was 2.2% Data shows the main causes of death are heart failure, vascular brain disease, sepsis, diabetes, intracranial trauma, among others; in addition to security problems and public order issues.

In the rural area, the health posts that provide the service and have supplies are: Puerto Serviez on the rural area El Ermitaño (The Hermit), Puerto Calderón in La Ceiba and La Pizarra (The Slate) in the rural area of La Pizarra (The Slate). These post offer health services to the central and northern areas of the municipality.

The low health service coverage in rural areas is manifested by higher rates of mortality. The main causes of this low coverage include: the sparsely populated areas, difficult road access, poor quality water supply and sanitation services, poor preventive health services, poor housing conditions and poor eating habits.

The figure below illustrates Public Health indicators including: Immunization Coverage, Mortality Rate, and the number of people registered or affiliated to the Health System at the Puerto Boyacá Municipality.

Figure 8 Public Health Municipalityof Puerto Boyacá



Source: Census 2005

Figure 24 Public Health Puerto Boyacá Municipality

The Palagua Rural Area has a health post, built in 1996, that was being served by a health promoter. Periodically health brigades and preventive medicine are carried out at the facility.

E.2.4 HOUSING

SISBEN, the Beneficiary Selection System for granting state subsidies, reports the existence of 5700 households at the rural areas, 8595 at the major town, and 425 households that are properties of the state.

The Rural Areas show a predominance of villages or settlements with zinc covered or thatched - roofed houses, rough walls, some with brick or cement blocks, and earthen floors. Only a few of the existing houses use concrete. A high percentage of these settlement houses and villages are located on roadsides (taking possession of land by poaching rights), where they border large estates, without following any type of urban planning or system.

At the Palagua municipality, most houses are built with wooden walls or crude lumber, palm or zinc roofs, and floors made mostly on natural earth or packed soil. Little concrete is used in the buildings.

E.2.5 RECREATION AND SPORTS

The municipality has as a coordinating office, the Municipal Institute of Recreation and Sports, a legal entity with administrative autonomy and independent assets. The resources are allocated to it by the Mayor in accordance with the plans, programs, and projects which are submitted by the entity to his office.

Among the sports scenarios available to the municipality may be included:

- Ramón Rapelo Municipal Stadium
- Cycling Schools
- Private Pools
- Private Motocross Track
- Chess Club
- Parks with games, rides, and other mechanical attractions
- Main Park

In addition, there are 14 municipal sports facilities, of which five are public, one is private and the others belong to educational institutions.

In the rural areas, most schools can boast one or multiple sports courts, but usually with inadequate infrastructure with access being limited to the most proximate residents. Therefore, most rural dwellers are not allowed to enjoy these benefits.

Mamagay Court is the most used sports facility by the inhabitants of the Palagua municipality, along with the multiple sports court at the school, which was completed in the year 1997. Its maintenance has been supported by ECOPETROL and UT-IJP, and is currently in good condition, frequently used by the school-age population.

E.2.6 CULTURE AND TOURISM

Photo 42 and Photo 43 Tourist sites - Palagua Lake and La Cristalina Creek

Tourism has become one of the strategic lines for regional and local development given the comparative advantages of its unique location; its rich landscaping rising from its water sources.

Puerto Boyacá stands out as one of the main young municipalities of the country. In a short time, it has had a rapid development in the areas in which it operates.

There is an office in the municipality, Casa de La Cultura, which serves as a stage for dance events, a theater, and music concerts. Roughly 70% of the urban population benefits from the Casa de La Cultura.

E.2.7 JOB SOURCES

The Municipality has created alliances to generate sources of permanent employment, which includes:

1) Business Forum, showing the benefits of Puerto Boyacá and tax incentives for the establishment of companies.

2) Strengthening of the Microenterprise Fund, linking private sector companies, government agencies, and international organizations.

3) Creation of micro - enterprises of medium and short term productive projects.

For all the street vendors, shopkeepers, small traders and micro enterprises, there is a training program of job skills, production and marketing given by the National Learning Service, SENA.

The Municipality finances productive projects through the Fund Microenterprise and gives support to the project in the marketing and commercialization of its products or services to projects of food production and services.

E.2.6 PUBLIC UTILITIES

The identified domestic public services available are: water, sewage, electricity, public lighting, telephone (fixed and mobile), domestic gas, and TV communications.

E.2.6.1 WATER

The municipality of Puerto Boyacá created the Public Services Company of Puerto Boyacá ESP, which is responsible for providing water supply services, sewerage, and trash collecting.

With regard to the rural supply of water, as stated by the municipal administration, the service has increased its coverage in recent years, meeting 65% of the rural area's water needs.. Nevertheless many places are lacking in water treatment plants and some of them are deficient due to malfunction or to an increase in the population that they must cover (as is the case of Puerto Serviez).

The Palagua Rural Area has had water supply service since 1987. In this same year, the INAS (Instituto Nacional de Agua y Saneamiento - National Institute of Water and Sanitation), at the request of the JAC (Junta de Acción Comunal), the Community Action Board, drilled the water well Flores 1 for human consumption, located on the right side of the road to the village of El Chaparro. In 1991, the City Administration provided the plumbing for the installation of distribution networks. In 1992, ECOPETROL built an elevated storage tank which increased the coverage of this service. Currently, the service is administered by the Aqueduct Board and covers about 74 homes. Other houses located in the area of the Palagua Lake get their water from artisan wells.

The Municipal Administration recently drilled a deep well with its respective elevated tank, located on the land on the Los Machines farm, covering the full water supply service to the entire rural area.

The Palagua field has the PW-1 Well located within the industrial area which provides water for industrial and domestic activities.

Photo 44 Well PW-1 provides water for industrial and domestic use

E.2.8.2 SEWER SYSTEM

In the year 1999, according to Public Enterprises of Puerto Boyacá ESP, the system should be providing service to 28,150 inhabitants. According to figures reported by the SISBEN for urban areas, the urban population for 2002 was 33,049 inhabitants and there were a total of 6,273 subscribers.

The municipal administration built seven (7) septic tanks and sewage networks for the Palagua Rural Area in 1997. Its coverage reaches at least 19 households out of which 12 are connected.

The homes that do not have septic tank and sewage service discharge wastewater directly to a distant lowland.

E.2.8.3 TRASH COLLECTION

For the utility company of Puerto Boyacá, there are 6,273 registered subscribers distributed as follows: E-1 (1074), E-2 (2965), E-3 (1789), Small Farmers (30). In summary, there are 5,829 residential subscribers and 444 non-residential subscribers.

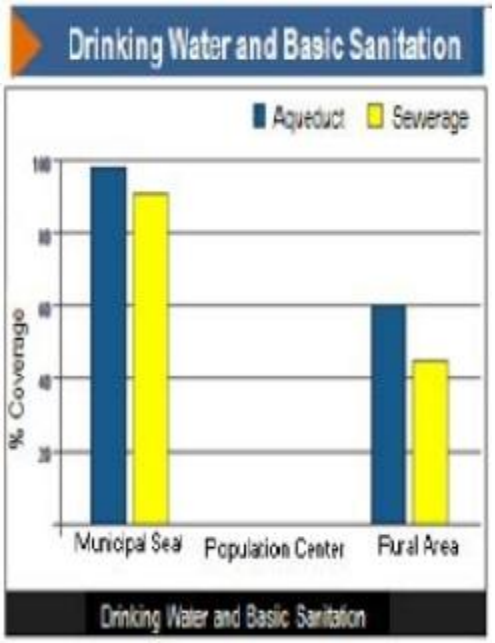
In relation to the rural area, the number of potential users is 5,700 houses. At the present time the service is provided in a very sporadic manner. This activity was carried out with the participation of the community, through environmental education work, and then it was delegated to the community action boards.

Twenty six (26) tons of municipal solid waste residues are generated per day, plus 3 Ton / day that arrive from rural areas. The generation rate of Urban Waste (Ru) is: Ru = 0.79 kg/person/day and the generation rate of Rural Waste (Rr) is: Rr = 0.14 kg/person/day.

The final disposal is a landfill that is located in the rural area. At the Palagua field, garbage collection is performed periodically throughout the rural area by the collection vehicle assigned by the municipality. The area generates about ten (10) 55-gallon drums. Solid wastes are classified in advance, placed in bags for easier handling, and put into containers or bins.

Conclusion

The municipality of Puerto Boyacá has a water supply service that covers 97.57% in the urban area, 91% sewerage coverage in the urban area, and a landfill location for solid waste disposal.



- For 2005, the aqueduct has a coverage of 97.5% in municipal areas, ND for population centers and 60.30% for rural areas
- In 2005, the sewer system covers 91.10% of the areas of the municipal seats, ND for the population centers, and 45.45% for rural areas
- The number of sites for solid waste disposal in the municipality is 1.

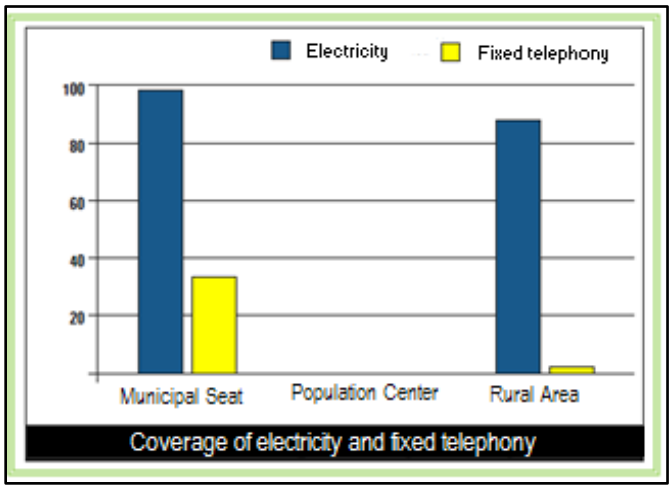
Source: Dane. (National Statistics Center) Census 2005

Figure 25 Drinking Water and Basic Sanitation, Municipality of Puerto Boyacá

E.2.8.4 ELECTRIC POWER

Based on Electric Power Company, Boyacá S. A.'s figures, there are 9,558 registered subscribers, of which 6,663 are urban, 2,895 are rural, and approximately 1,600 don't have legal access to public services. The number of potential users reaches 12,959.

Coverage rates are established according to census figures and SISBEN (96.13 % is for urban areas and 82,36 % for rural areas). Coverage in the Palagua Rural Area reaches about 95% of the homes.



Source: Dane. (National Statistics Center) Census 2005

Figure 26 Coverage of Electricity and Fixed Telephony

E.2.8.5 HOUSEHOLD GAS

The company ALCANOS DE COLOMBIA S.A., E.S.P, with headquarters based in Neiva is responsible for the provision of this service in the urban area. Currently it serves about 4,000 users from different sectors of the municipality.

For rural areas the supply of gas is carried by trucks that have permanent routes and some rural area distribution sites. The service is maintained constantly.

E.2.8.6 TELEPHONE

Similarly to the rest of the country, two systems provide telephone communication services in the municipality. The first provides telephone services using a physical phone through the (Empresa Nacional de Telecomunicaciones) TELECOM ESP National Telecommunications Company, and the second is private business Mobile telephone services such as: COMCEL, MOVISTAR and TIGO.

(See: Annex 2, Map 11 - Public Service Infrastructure)

E.3 ECONOMICS FACTORS

The municipality of Puerto Boyacá currently has an economic structure based on livestock, agriculture, fisheries, timber, mining, and hunting industries.

E.3.1 AGRICULTURE DEVELOPMENT

The Municipal Unit for Agricultural Technical Assistance UMATA (Unidad Municipal de Asistencia Técnica Agropecuaria) shows the following statistics: the planted area is around 1,035 hectares. This activity generates only 6% of the available employment. The bulk of production is for subsistence utilization and consumption markets in the nearby area. Only a small surplus is taken to markets in other locations.

(See: Annex 2, Map 12 - Agrological Classification)

E.3.2 FARMING AND LIVESTOCK EXPLOITATION

Eighty point seven percent (80.7%) of the productive land in the municipality is covered with grassland, having natural or improved pastures. The town is widely recognized as a ranching location. The more recent livestock data reports 138,562 head of cattle, mainly from the Brahma and native breeds, 1,870 buffalo, 5,265 horses, 1,064 sheep, 639 pigs, and 163 goats.

Photo 45 Cattle ranching in Puerto Boyacá

Farmers in the region maintain their dual purpose (meat & milk) herds in small to medium size premises, and destine large farms for cattle fattening.

The average cattle slaughter for consumption in urban areas is 270 heads per month and fifty (50) head for the rural sector.

The livestock business in the area generates 61.9% of rural employment.

E.3.2.1 FISHERIES EXPLOITATION

Fishing is considered the oldest and the most widely spread economic activity in the area because of the many different water resources of the region, particularly near the Magdalena River.

In Puerto Boyacá, there are five (5) settlements of commercial fishermen clearly identified which are: Pueblo Nuevo Neighborhood, and the townships of Puerto Serviez, Puerto Niño, and three settlements around the area of Velásquez. In accordance with estimates of the INCODER territorial office, about 800 fishermen are devoted to this activity.

The main species caught are: bocachico, catfish, capaz, blanquillo, dorada, and comelón.

E.3.2.2 TREE CUTTING

For several years, the increasing expansion of the agricultural frontier has been promoting major changes in the vegetation cover in the region, giving way to large cattle ranches and affecting some forests and fragile ecosystems.

The involvement of the Autonomous Regional Corporation (CAR), and the Instituto Colombiano Agropecuario (ICA), through controls on tree cutting (felling) and marketing, training farmers and settlers, and carrying out reforestation activities has decreased rates of extraction of forest species. The most common species of trees in the region are: caracoli, yellow, ceiba, hobo, charcoal, coco twine, Juana mestiza, abarco, carob, sapan and cedar.

E.3.2.3 MINING

The exploitation of hydrocarbons is exerted mainly in the municipality in the fields Velasquez, Jazmín and Palagua.

ECOPETROL's Vasconia station located close to Puerto Boyacá receives crude oils produced from different fields in the Country. These crudes are mixed in this station and are transported through the pipeline that runs to the oil refinery in Coveñas.

Other mining activities are related to the exploitation of gravel and sand for the building and construction industry carried out in the Magdalena River area. It is estimated that this activity involves about a hundred people in the municipality.

Livestock farming and oil drilling have been the most important economic activities for several years in the Palagua Rural Area.

F. ENVIRONMENTAL QUALITY OF THE AREA OF THE PROJECT

This section describes the evaluations of the environment in and around the Palagua field. This evaluation focuses in determining the presence of pollutants in the air, water, soil and sound pressure level (noise levels) that are commonly related with the hydrocarbon operation.
These parameters are compared with local and international regulations.

F.1 AIR QUALITY

In March and April, 2012, PSL PROANALISIS LTDA spent 18 days in Palagua and Caipal Fields to determine air quality. The goal of the project was to measure concentrations of nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), ozone and suspended particulate material (SPM) in the vicinity of known sources of air emissions, and compare them to the permissible values stated by Resolution 610 of 2010 issued by the Colombian Ministry of Environment Sustainable Development.

F.1.1 METHODS AND EQUIPMENT CALIBRATION

- **METHODS**

Suspended particulate material (SPM) was measured using a variable speed High Volume Sampling unit with mass flow controller as shown in Figure 27. CO and ozone were measured using a portable, digital CEM CO 180 meter shown in Figure 28. This meter has a measurement range of 1-1000 µg/m3 and a resolution of 1ppm.

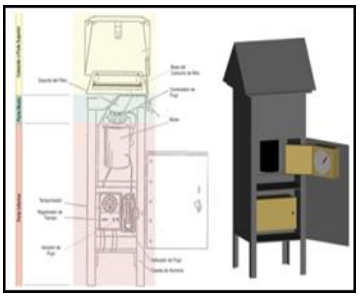


Figure 27 Hi-Volume Sampler with Mass Control

Figure 28 Digital Environment Ozone Test Meter

NO_2 and SO_2 were measured using an RAC 3-gas sampling train assembly as shown in Figure 29.

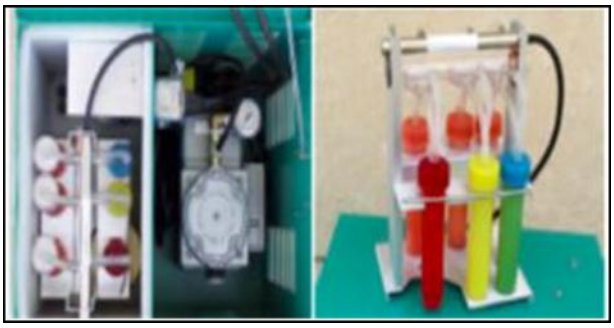


Figure 29 RAC 3-gas Sampler

- **EQUIPMENT CALIBRATION**

The US EPA Document EPA-600/4-77-027a entitled Quality Assurance Handbook for Air Pollution Measurement Systems was used as a guideline to calibrate gas equipment and monitoring protocol.

F.1.2 MEASUREMENT DATES AND LOCATIONS

Measurements were taken over an 18-day period (March 28 to April 14, 2012). Data were collected from sites in Battery No. 1, Gathering Station No. 2 in Palagua Field, and Gathering Station No. 3 in Caipal Field as shown in Table 21.

Table 21 MONITORING SITES FOR THE AIR QUALITY STUDY

STATION	COORDINATES	PHOTOGRAPHIC RECORD
Station 1 Palagua Field Battery No.1	East: 0952932 North: 1163727	
Station 2 Palagua Field Gathering Station No. 2	East: 0952022 North: 1164313	
Station 3 Caipal Field Gathering Station No. 3	East: 0953898 North: 1169851	

Monitoring conditions

During monitoring, the weather was dry with sunny days. The barometric pressure was 747.75 mm Hg, and the average temperature was 38.8° C. The wind speed conditions observed were considered light to breezy.

F.1.3 APPLICABLE REGULATIONS

F.1.3.1 AIR QUALITY INDEX (AQI)

The AQI is an index for reporting daily air quality. It tells how clean or polluted the air is along with what health effects it may or may not have on the public. The US Environmental Protection Agency (EPA) calculates the AQI for five major air pollutants: ground-level ozone, particle pollution (also known as particulate matter), carbon monoxide, sulfur dioxide, and nitrogen dioxide.

The AQI, a unit-less parameter, is divided into six categories as shown in Table 22.

Table 22 AIR QUALITY INDEX CATEGORIES

AQI values	Levels of health concern	Colors
0 – 50	Good	Green
51 – 100	Moderate	Yellow
101 – 150	Unhealthy for sensitive groups	Orange
151 – 200	Unhealthy	Red
201 – 300	Very Unhealthy	Purple
301 – 500	Hazardous	Maroon

(**Source:** EPA. 2003)

F.1.3.2 COLOMBIAN AIR QUALITY STANDARDS

Resolution 610 of 2010 establishes the maximum permissible levels of critical contaminants at referenced conditions of 25° C and 760mm Hg in Colombia.

Table 23 shows the Ambient Air Quality Standards of the above Resolution 610/2010.

Table 23 MAXIMUM PERMISSIBLE LEVELS OF CRITICAL CONTAMINANTS

CONTAMINANT	EXPOSURE TIME	MAXIMUM PERMISSIBLE LEVEL [µg/m^3]
SPM	Day (24 hours)	300
	Year	100
SO_2	Day (24 hours)	250
	Year	80
	3 Hours	750
NO_2	Day (24 hours)	150
	Year	100
	1 Hour	200
CO	8 hours	10,000
	1 hour	40,000
O_3	8 hours	80
	1 hour	120

Note: µg/m^3 under standard conditions of 298.15 ºK and 101.325 KPa (25ºC and 760 mm Hg).

F.1.3.3 CALCULATION OF LOCAL STANDARDS

Resolution 610/2010 includes an equation to calculate the maximum permissible values of air quality at temperatures and barometric pressures different from the referenced conditions; it is as follows:

$$N_L = NCR * P_bL/760 * (298\ K)/((273 + °C)\ )$$

Where:

N_L = Local Norm.
NCR = Reference Condition Norm.
P_{bL} = Local Barometric Pressure (mm of Hg).
°C = Average Local Temperature (°C)

Table 24 shows the local air quality standards which were calculated by applying the local temperature and barometric conditions to the above equation.

Table 24 LOCAL AIR QUALITY STANDARDS

CONTAMINANT	EXPOSURE TIME	MAXIMUM PERMISSIBLE [µg/m^3]
SPM	Day (24 hours)	282.07
SO_2	Day (24 hours)	235.06
NO_2	Day (24 hours)	141.04
CO	8 hours	9402.35
O_3	8 hours	75.22

F.1.4 MEASUREMENTS DATA

Tables 25 and 26 include information on all of the sample sites from the study where there were measurable concentrations of SPM, O_3, NO_2, SO_2 and CO.

Table 25 SPM AND O_3 MEASUREMENTS

DATE	ST. 1	ST. 2	ST. 3	ST. 1	ST. 2	ST. 3
	SPM [µg/m^3]			O_3 [µg/m^3]		
March 28 2012	46.11	57.94	45.10	ND	0.73	ND
March 29 2012	47.58	46.31	41.17	ND	ND	ND
March 30 2012	46.33	55.22	40.10	ND	0.66	ND
March 31 2012	41.10	51.27	41.53	ND	ND	ND
April 01 2012	50.12	50.15	43.51	0.1	ND	ND
April 02 2012	39.56	48.52	40.60	ND	ND	ND
April 03 2012	43.87	44.39	39.17	ND	ND	ND
April 04 2012	41.55	47.92	40.15	ND	ND	ND
April 05 2012	51.12	50.10	39.87	0.14	ND	ND
April 06 2012	43.18	41.62	35.18	ND	ND	ND
April 07 2012	38.67	40.66	34.87	ND	ND	ND
April 08 2012	40.92	47.11	30.20	ND	ND	ND
April 09 2012	39.81	45.27	41.22	ND	ND	ND
April 10 2012	40.70	56.27	46.75	ND	0.87	0.61
April 11 2012	44.67	45.29	40.17	ND	ND	ND
April 12 2012	45.12	59.60	44.28	0.12	0.92	0.57
April 13 2012	39.13	44.18	40.10	ND	ND	ND
April 14 2012	40.18	47.81	43.55	ND	ND	ND

ND: Not Detected.

Table 26 NO_X, SO_X AND CO MEASUREMENTS

DATE	ST. 1	ST. 2	ST. 3	ST. 1	ST. 2	ST. 3	ST. 1	ST. 2	ST. 3
	NO_X [µg/m^3]			SO_X [µg/m^3]			CO [µg/m^3]		
March 28 2012	6.33	13.89	13.4	ND	12.51	ND	ND	917	802
March 29 2012	ND	ND	ND	ND	ND	ND	ND	ND	ND
March 30 2012	7.18	14.02	11.38	ND	12.6	ND	114	1147	917
March 31 2012	ND	8.36	7.92	ND	ND	ND	ND	ND	ND
April 01 2012	9.57	11.62	10.17	ND	ND	ND	114	1032	688
April 02 2012	8.55	10.97	10.5	ND	ND	ND	ND	917	573
April 03 2012	ND	ND	ND	ND	ND	ND	ND	ND	ND
April 04 2012	ND	ND	ND	ND	ND	ND	ND	ND	ND
April 05 2012	10.29	12.33	12.51	ND	ND	ND	229	1032	802
April 06 2012	ND	ND	ND	ND	ND	ND	ND	ND	ND
April 07 2012	ND	ND	ND	ND	ND	ND	ND	ND	ND
April 08 2012	ND	8.97	8.11	ND	ND	ND	ND	917	458
April 09 2012	7.47	7.11	ND	ND	ND	ND	ND	802	ND
April 10 2012	ND	15.26	14.22	ND	13.27	12.66	ND	1147	917
April 11 2012	ND	6.97	6.55	ND	ND	ND	ND	688	229
April 12 2012	9.16	14.67	13.91	ND	12.58	12.5	114	1032	802
April 13 2012	ND	ND	ND	ND	ND	ND	ND	ND	ND
April 14 2012	5.84	9.66	7.41	ND	ND	ND	ND	229	ND

ND: Not Detected.

F.1.5 ANALYSIS OF MEASUREMENTS

F.1.5.1 SUSPENDED PARTICULATE MATERIAL (SPM)

Levels of SPM recorded are within the stipulated limits of the cited ruling at 15.3 % of the maximum permissible value. The results show that suspended particulate matter concentration ranged from 30.20 µg/m^3 to 59.60 µg/m^3. Station 2 at Gathering Station No.2 had the highest levels of SPM (59.6 µg/m^3). As stated, the levels of SPM are not harmful to human health or the environment. Table 27 is the statistical analysis of SPM data.

Table 27 STATISTICAL ANALYSIS OF SPM DATA

STATISTICAL DATA	STATION 1	STATION 2	STATION 3
Data points	18	18	18
Geometrical Average	43.166	48.592	40.223
Median	42.365	47.865	40.385
Standard Deviation	3.786	5.429	3.938
Parameters for T Distribution	2.262	2.262	2.262
Confidence Interval µ1	41.166	45.724	38.143
Confidence Interval µ2	45.166	51.460	42.303
Percentile 25	40.310	45.275	39.928
Percentile 75	45.863	50.990	43.015
Highest Value Recorded	51.12	59.6	46.75
Day of Recording	05/04/12	04/12/12	04/10/12
Lowest Value Recorded	38.67	40.66	30.2
Day of Recording	04/07/12	04/07/12	04/08/12
Confidence Interval	2.00	2.868	2.080

Figure 30 shows the SPM concentrations measured at the three stations during monitoring.

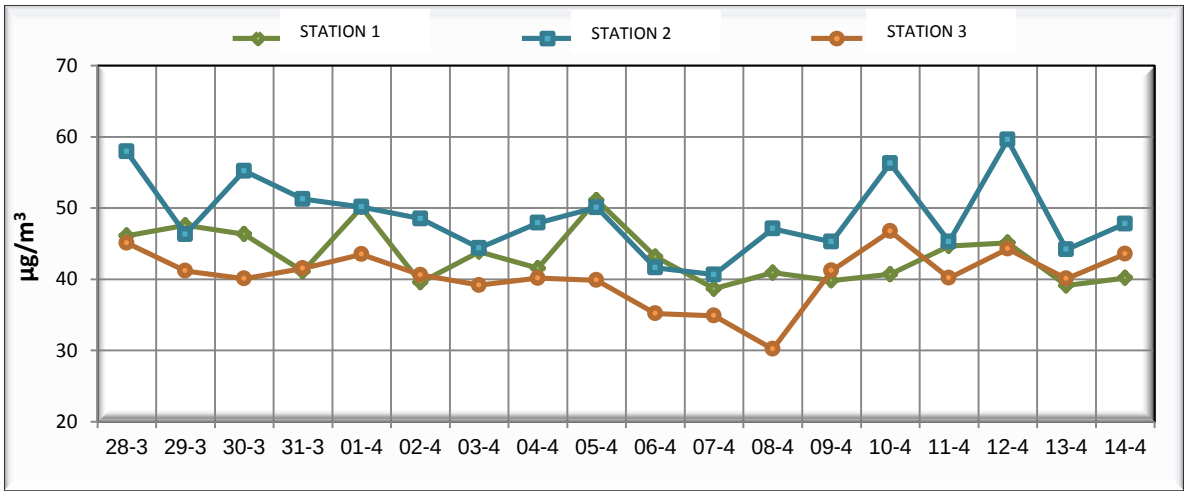


Figure 30 SPM Found in the Area of Influence in Palagua Field

F.1.5.2 GASES

- **NO_x**

Daily average concentrations of nitrogen oxides do not exceed the Air Quality Standard for NO_2, which is 150 µg/m^3. Station 2 has the highest frequency and the highest concentrations of NO_2 reported (7 to 15 µg/m^3). Even the highest concentrations found at Station 2 represent only 4.57% of the limit value.

All the values recorded are generally low and are also far less than the standard of the World Health Organization and the European Standard for air quality of 40 µg/m^3. Table 28 shows the statistical analysis of NO_x data.

Table 28 STATISTICAL ANALYSIS OF NO_X DATA

STATISTICAL DATA	STATION 1	STATION 2	STATION 3
Data points	18	18	18
Geometrical Average	3.577	7.435	6.449
Median	0.000	8.665	7.665
Standard Deviation	4.240	5.905	5.702
Parameters for T Distribution	2.262	2.262	2.262
Confidence Interval µ1	1.337	4.315	3.437
Confidence Interval µ2	5.817	10.555	9.461
Percentile 25	0.000	0.000	0.000
Percentile 75	7.398	12.153	11.160
Highest Value Recorded	10.29	15.26	14.22
Day of Recording	04/05/12	04/10/12	04/10/12
Confidence Interval	2.240	3.120	3.012

Figure 31 shows the trend of NO_x concentrations measured at the three stations during monitoring.

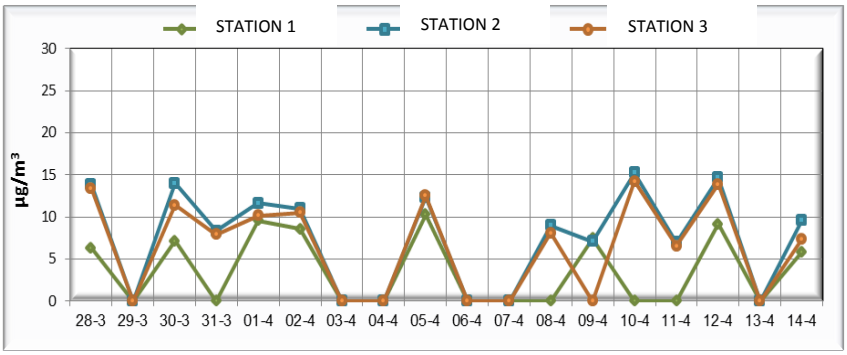


Figure 31 NO_x Found in the Area of Influence in Palagua Field

- **Ozone (O_3)**

O_3 is a secondary contaminant, and its presence in the air is due principally to the reaction of nitrous oxides with volatile organic compounds. It was found in low quantities (lower than the detection limit), and can be argued that traces of this gas are the result of gas burning in production zones in addition to the combustion gases from vehicles and boilers.

The data obtained do not show an active contamination agent in the air in the area of influence in Palagua Field, and do not exceed the permissible limit of 80 µg/m^3 according to the cited ruling. Table 29 shows the statistical analysis of O_3 data.

Table 29 STATISTICAL ANALYSIS OF O_3 DATA

STATISTICAL DATA	STATION 1	STATION 2	STATION 3
Data points	18	18	18
Geometrical Average	0.020	0.177	0.066
Median	0.000	0.000	0.000
Standard Deviation	0.047	0.344	0.191
Parameters for T Distribution	2.262	2.262	2.262
Confidence Interval µ1	0.,000	0.000	0.000
Confidence Interval µ2	0.045	0.358	0.166
Percentile 25	0.000	0.000	0.000
Percentile 75	0.000	0.000	0.000
Highest Value Recorded	0.14	0.92	0.61
Day of Recording	04/05/12	04/12/12	04/10/12
Confidence Interval	0.025	0.182	0.101

Figure 32 shows the trend of O_3 concentrations measured at the three stations during monitoring.

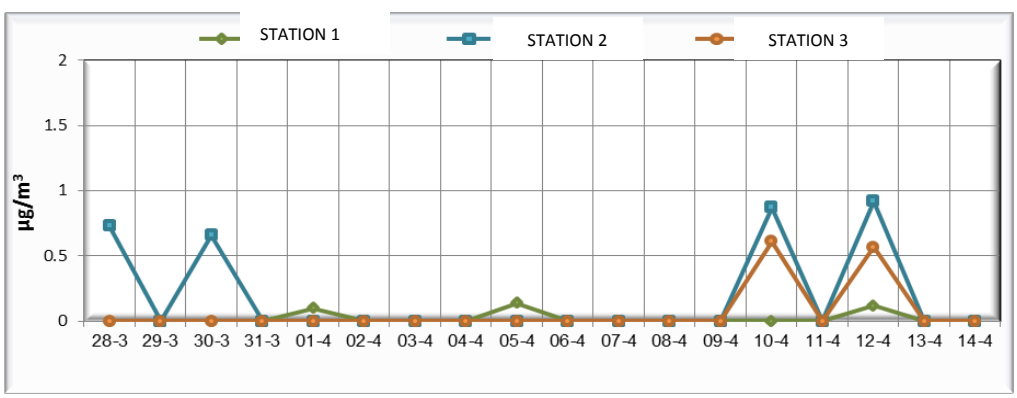


Figure 32 O_3 Found in the Area of Influence in Palagua Field

- **Sulfur Oxide (SO_x)**

The data indicate that during the 18-day period of monitoring, levels of SO_x were detected on four days at Station 2, and on two days at Station 3. This was due to the temporary increase in activities using machinery that could emit appreciable amounts of this pollutant into the atmospheric environment. The overall average value was 12.7 µg/m^3, which is a satisfactory level. Air quality by Resolution 610/2010 stipulates a maximum value of 250 µg/m^3 per day (24 hours), and WHO recommends a much lower average value of 20 µg/m^3. Table 30 shows the statistical analysis of SO_x data.

Table 30 STATISTICAL ANALYSIS OF SO_X DATA

STATISTICAL DATA	STATION 1	STATION 2	STATION 3
Data points	18	18	18
Geometrical Average	0.000	2.831	1.398
Median	0.000	0.000	0.000
Standard Deviation	0.000	5.452	4.068
Parameters for T Distribution	2.262	2.262	2.262
Confidence Interval µ1	-	-0.049	-0.751
Confidence Interval µ2	-	5.711	3.547
Percentile 25	0.000	0.000	0.000
Percentile 75	0.000	0.000	0.000
Highest Value Recorded	-	13.27	12.66
Day of Recording	-	04/10/12	04/10/12
Confidence Interval	-	2.880	2.149

Figure 33 shows the trend of SO_x concentrations measured at the three stations during monitoring.

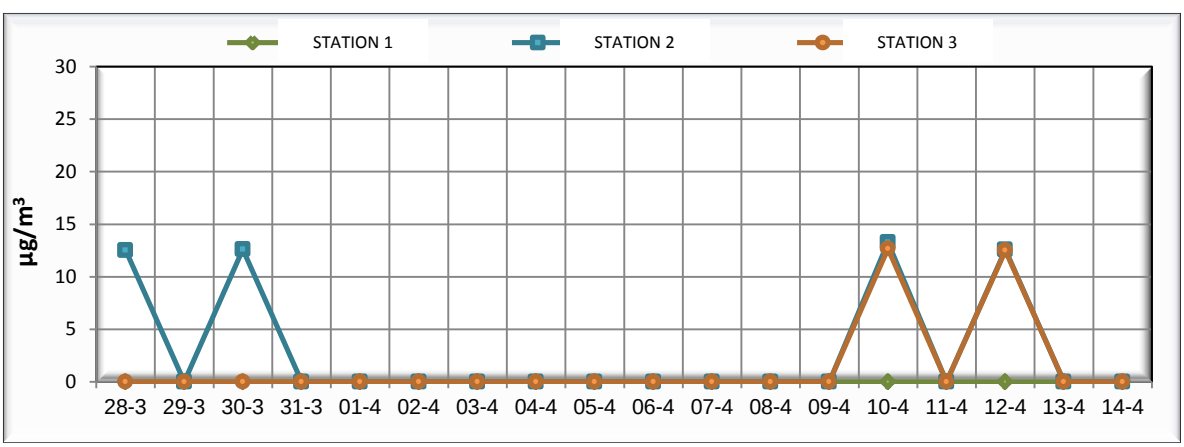


Figure 33 SO_x Found in the Area of Influence in Palagua Field

- **Carbon Monoxide (CO)**

Around 70% of the carbon monoxide detected is present due to incomplete combustion of fuel in vehicles and pump motors. The study shows a detection frequency between 22.2 and 61.1%. Station 2 has the highest concentration of CO, at a level of 1147 µg/m^3. This is also the highest average value and can be attributed to the temporary increase in vehicular activities on the site during the sampling period. The levels of CO in the area are satisfactory according to Resolution 610/2010 with only a 12% variance from the permissible standard. Table 31 shows the statistical analysis of CO data.

Table 31 STATISTICAL ANALYSIS OF CO DATA

STATISTICAL DATA	STATION 1	STATION 2	STATION 3
Data points	18	18	18
Geometrical Average	109.500	586.667	393.778
Median	100.000	745.000	164.500
Standard deviation	30.297	446.736	340.775
Parameters for T Distribution	2.262	2.262	2.262
Confidence Interval µ1	93.494	350.654	213.745
Confidence Interval µ2	125.506	822.679	573.811
Percentile 25	100.000	100.000	100.000
Percentile 75	100.000	1003.250	773.500
Highest Value Recorded	229	1147	917
Day of Recording	04/05/12	03/30/12	03/30/12
Confidence Interval	16.006	236.012	180.033

Figure 34 shows the trend of CO concentrations measured at the three stations during monitoring.

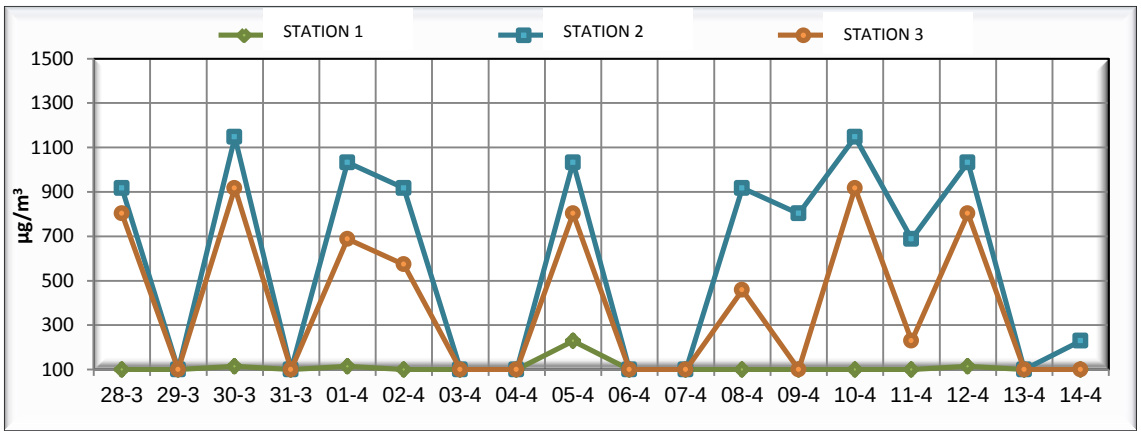


Figure 34 CO Found in the Area of Influence in Palagua Field

F.1.5.3 SUMMARY OF GAS MONITORING

Table 32 shows average concentrations of the gases evaluated under the conditions created by the three stations, as compared to the maximum permissible level in the current regulation controlling air quality.

Table 32 COMPARISON OF RECORDED CONCENTRATIONS OF GASES TO PERMISSIBLE VALUES

STATION	NO_2 [µg/m^3]	SO_2 [µg/m^3]	CO [µg/m^3]	O_3 [µg/m^3]
1	3.577	0.000	109.500	0.020
2	7.435	2.831	586.667	0.177
3	6.449	1.398	393.778	0.066
Colombian Norm. Resolution 610/10 MESD, [µg/m^3]	141.04	235.06	9402.35	75.22
Number of data points	72	72	72	72
Number of data points exceeding the standard	0	0	0	0
% of data points exceeding the standard	0.00%	0.00%	0.00%	0.00%
% of maximum permissible value	4.57%	0.59%	4.19%	0.23%

F.1.5.4 SUMMARY OF MONITORING THE AIR QUALITY INDEX (AQI)

An Air Quality Index for every air pollutant was determined by doing a statistical analysis on the data collected from the three stations. The results of AQIs and their respective colors and level descriptors are shown in Table 33.

Table 33 AIR QUALITY INDEX DETERMINED FOR THE AREA OF STUDY

CONTAMINANTS		STATIONS		
		1	2	3
NO_2	VALUE	0	0	0
	DESCRIPTOR	Good	Good	Good
SO_2	VALUE	0	2	1
	DESCRIPTOR	Good	Good	Good
CO	VALUE	1	6	4
	DESCRIPTOR	Good	Good	Good
O_3	VALUE	0	0	0
	DESCRIPTOR	Good	Good	Good

The previous table indicates good air quality in Palagua Field and demonstrates that neither the health of the community or other aspects of the environment (flora, fauna, countryside, properties, etc.) are being impacted by our operations in Palagua field.

F.1.6 CONCLUSIONS FROM THE AIR QUALITY STUDY

From the information provided in the study by PSL PROANALISIS LTDA, the following conclusions can be drawn:

- The recorded concentrations of gas contaminants (NO_2, CO, SO_2 and O_3) and suspended particulate matter in the area of influence in Palagua Field are below the maximum permissible levels set by Resolution 610 in 2010.

- The low frequency detection of gases like sulfur dioxide, oxides of nitrogen and ozone shows that the zones in Palagua Field have minimal air contamination.

- Air Quality is at a satisfactory level and air pollution is very low. There is no evidence of adverse effects on human health in the area of influence in Palagua Field according to the AQI indicators.

- Monitoring Station 2 (largest gathering station in Palagua field) had the highest average concentrations of the monitored gases. This can be attributed to the temporary increase in industrial activity and the heavy traffic in that zone during the days of monitoring.

F.1.7 GREENHOUSE GAS EMISSIONS

(The section on Greenhouse Gas Emissions appeared as F.1.4 in the 2010 ESIA)

The following is a summarization of the estimated greenhouse gas (GHG) emissions **for the entire Palagua Project including wells drilled through December 2011 and proposed new wells of the current expansion project.**

The additional gas production from the 21 new wells drilled in 2011 (as reported in Loan 3 ESIA Supplement June 2012) together with the decline in the gas production of the old wells and the forecast gas production from the wells in the expansion project, yields a total rate of 2,200 Mscf/day (thousand standard cubic feet per day).

This information is shown in the tables on the following page. Table 34 shows the estimated fuel production and consumption data for 2012 and Table 35 shows the estimated fuel burned and flared during the year 2012 and the corresponding CO_2 emissions.

Table 34 FUEL PRODUCTION AND CONSUMPTION FOR 2012

GAS PRODUCTION AND DATA			
Rate	2,200	Mscf/day	
Production per year	803	MMscf/yr	
Gas calorific value	905	BTU/scf	
GAS CONSUMPTION			
Process (heater treaters)	570	Mscf/day	
Power Plant	430	Mscf/day	
Flared	1,200*	Mscf/day	
DIESEL CONSUMPTION			
Drilling rigs (two rigs)	1,100	gal/day	384 days/yr
Workover rig T-2	320	gal/day	312 days/yr
Workover rig T-4	320	gal/day	240 days/yr
Vehicles (18 units)	90	gal/day	290 days/yr
Calorific value	5.53E +06	BTU/bbl	
Density	7.07	lbs/gal	

* UT-IJP is in the process of expanding the electrical generation plant to minimize gas flaring

Mscf = Thousand standard cubic feet, MMscf = Million standard cubic feet, BTU = British thermal units, gal = gallon, lb = pound

Table 35 BURNED AND FLARED FUEL WITH CORRESPONDING CO2 EMISSIONS

COMBUSTION SOURCES	AMOUNT, scf/yr * 10^6	CO_2 EMISSIONS, short ton/yr	
A. Gas burned in ICUs	156.95	6,220	LHV basis, 75% load and 52.91$CO_2/10^6$ emission factor
Gas burned in ECUs	208.05	12,483	60 tonnes $CO_2/10^6$ scf emission factor
Gas flared	438.0	21,706	0.0547 tonnes/10^6 BTU emission factor
Total emissions due to gas combustion		**40,409**	**Short tonnes per year**
B. Diesel burned in ICUs	625,140[1]	60,951	LHV basis, 75% load and 0.00742 tonnes $CO_2/10^6$ btu emission factor
Total emissions due to diesel combustion		60,951	**Short tonnes per year**
Estimated GHG emitted in 2012		**101,361**	**Short tonnes/year**

1 This figure is expressed in gal/year
ICUs: Internal combustion units
ECUs: External combustion units

F.2 WATER QUALITY

In July 2001, the National Oil Company ECOPETROL handed over the Palagua and Caipal oil fields to the UT-IJP for their operation under an incremental production contract. The field was operated by Texaco from 1957 onwards. Thus, Ecopetrol and Texaco operated the Palagua Caipal field from 1957 till 2000.

Prior to taking over the field, UT-IJP did environmental base study. As per the agreement between Ecopetrol and UT-IJP, it is Ecopetrol's responsibility to pay for and arrange to remedy, environmental damage, if any, prior to the year 2000. Thus, as per the contract ECOPETROL is responsible of the environmental liabilities and the required monitoring and remediation/elimination activities for the non-recovered environmental impacts prior to year 2000.

F.2.1 DRINKABLE WATER

The source of the drinkable water is the shallow, active aquifers significantly above the Tune formation (2800' below subsea level in average for Palagua area). There is one water-well, PW-1, that produces from an aquifer at 180' (88 m) below the surface.

Drinkable water aquifers are identified by resistivity measurements taken with electric logs every time a well is drilled.

Oil wells at the field are completed with steel casing from the bottom to the surface, guaranteeing no communication between oil bearing zones and drinkable water zones.

F.2.2 SURFACE WATERS OF PALAGUA LAKE

During October 2011, samples of surface waters and sediments were taken from ten (10) location points, in all. Seven location points are on Palagua Lake and three points are from the surrounding creeks. Table 36 lists the geographic coordinates of these 10 sampling location points. Photos for the points are also shown.

Table 36 GEOGRAPHIC COORDINATES FOR LOCATION OF SURFACE WATER SAMPLING SITES

Location	Sampling sites	Coordinates	
		N	W
PALAGUA LAKE	POINT 1. Mouth of Agualinda Creek in Palagua Lake	06º 03' 48.2"	074º 29' 46.6"
	POINT 2. Opposite site to mouth of Agualinda Creek	06º 03' 58.99	74º 29' 49.1"
	POINT 3. On the shore, close to ECOPETROLS' Dock	06º 03' 53.8"	074º 30' 09.7"
	POINT 4. Center of Palagua Lake in front of ECOPETROL's Dock	06º 03' 45.6"	074º 30' 23.7"
	POINT 5. Palagua Creek Spreading, behind the "Fantasía Island"	06º 03' 59.0"	074º 30' 37.3"
	POINT 6. Entrance to Palagua Creek	06º 03' 39.3"	074º 31' 09.3"
	POINT 7. Site located between Palagua Creek and Velazquez Port	06º 03' 00.9"	074º 30' 15.5"
CREEKS	Palagua Creek	06º 03' 40.5"	074º 32' 55.2 "
	Agualinda Creek	06º 02' 47.3"	074º 28' 36.3"
	El Tambo Creek	06º 07' 03.6"	074º 29' 51.3"

The following Photos 46 to 52 show the sites monitored in Palagua Lake, and Photos 53 through 55 show the three creek monitoring sites in Palagua Field.

Photo 46 Palagua Lake – Point 1

Photo 47 Palagua Lake – Point 2

Photo 48 Palagua Lake – Point 3

Photo 49 Palagua Lake – Point 4

Photo 50 Palagua Lake – Point 5

Photo 51 Palagua Lake – Point 6

Photo 52 Palagua Lake – Point 7

Photo 53 Palagua Creek

Photo 54 Agualinda Creek

Photo 55 El Tambo Creek

F.2.2.1 LAKE PALAGUA SURFACE WATER ANALYSIS RESULTS

The surface waters of Palagua Lake and the Agualinda, Palagua and El Tambo creeks were evaluated with respect to Article 38 of Decree 1594/84 by Minister of Health, which establishes the quality criteria of water for human and domestic consumption prior to conventional treatment.

Samples were taken over the course of several days from October 4 to 8, 2011. During the days of monitoring it was noted that:

- The days of October 4 to 8 were generally sunny.
- Heavy rains occurred during the night of October 5.
- For reasons of safety, water flow rates were not measured due to strong currents.
- Some materials like leaves, wood sticks and roots were floating in Palagua Lake and the Agualinda and Palagua Creeks.
- Foam was also noted in the Agualinda and Palagua Creeks.
- Water from the monitored sites is used for cattle and fishing.

The samples were collected following the specifications established in the AWWA method 1060/05 “Collection and Preservation” of Standard Methods, Ed. 21 of 2005 and USEPA SW 846 “Methods for Evaluating Solid Waste- Physical/Chemical Methods”.

Tables 37 and 38 show the in-situ and lab tests results of surface water samples taken from Palagua Lake.

Table 37 ANALYSIS RESULTS OF SURFACE WATER IN PALAGUA LAKE (Part 1 of 2)

SURFACE WATER SAMPLING IN PALAGUA LAKE	Data point	POINT 1	POINT 2	POINT 3	POINT 4	POINT 5	POINT 6	POINT 7	COLOMBIA ENVIRONMENT LAW-DECREE 1594/84 ART. 38
		Palagua Lake: Mouth of Agualinda Creek in Palagua Lake	Palagua Lake: Opposite side to Agualinda Creek mouth	Palagua Lake: On the shore close to ECP's Dock	Palagua Lake: in front of ECOPETROL's Dock	Palagua Lake:Palgua Creek spreading, behind the Fantasía Island	Palagua Lake: entrance to Palagua Creek	Palagua Lake: Between Palagua Creek and Velasquez's Dock	
	SAMPLING DATE	04-Oct-2011	05-Oct-2011	05-Oct-2011	08-Oct-2011	07-Oct-2011	06-Oct-2011	07-Oct-2011	
PARAMETERS	Units	200677198	200677642	200677643	200678470	200678330	200677792	200678331	
IN SITU DATA									
DISSOLVED OXYGEN	mg O_2/L	0.7	1.3	4	2	1	4.5	5.5	NR
pH / T (° C)	Uni. pH	6.42/27.5	6.47/27.8	6.61/32.1	6.67/31.9	6.47/30.	6.94/32.0	7.04/34.0	NR
WATER TEMPERATURE	ºC	27.5	27.8	32.1	31.9	30.0	32.0	34.0	5.0-9.0
AIR TEMPERATURE	ºC	27.9	31.5	42.1	36	33.3	30.3	34.3	
LAB ANALYSIS									
ALKALINITY	mg CaCO3/L	22.8	24.6	24.7	28.1	27.5	29.2	27.1	NR
TOTAL ACIDITY	µg/L	-12100	-74000	-12000	-15500	-15600	-18600	-16600	NR
CONDUCTIVITY / T (° C)	uS/cm/ºC	56.8/25.0	58.4/25.0	61.3/25.0	71.2/25.0	74.9/25.0	75.2/25.0	68.2/25.0	NR
TOTAL HARDNESS	mg CaCO3/L	18.5	17.1	17.7	24.7	30	21.8	23.6	NR
COLOR	U Pt-Co	158	151	147	174	183	154	217	75.0
DQO	mg O2/L	64.6	48.2	48.1	76.7	49.5	62.8	49.5	NR
DBO5	mg O2/L	2.35	3.32	3.78	5.38	2.84	5.79	2.53	NR
DISSOLVED CYANIDE	mg CN/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.2
CHLORIDES	mg/L	1.07	1.20	1.37	3.01	4.02	3.29	2.80	250.0
O&G-HCs	mg/L	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	no film allowed
NON POLAR HYDROCARBONS	mg/L	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	NR
SULPHATES	mg SO4/L	0.61	0.67	0.67	0.54	<0.50	<0.50	<0.50	100.0
NITRATES	mg NO3/L	0.21	0.28	0.40	0.50	<0.090	0.32	0.21	10.0
NITRITES	mg NO2/L	<0.070	<0.029	<0.029	<0.070	<0.070	<0.070	<0.070	1.0
AMMONIA NITROGEN	mg NH3/L	<0.49	<0.49	<0.49	<0.49	<0.49	<0.49	<0.49	1.0
KJELDAHL NITROGEN	mg N/L	1.17	<1.00	1.00	1.10	<1.00	1.03	1.26	NR
TOTAL NITROGEN	mg N/L	1.94	1.8	1.92	2.16	<1.65	1.91	2.03	NR
DISSOLVED SOLIDS	mg/L	78.7	86.0	64.6	71.6	80.6	71.6	58.8	NR
SUSPENDED SOLIDS	mg/L	12.2	7.8	17.6	9.9	<5.00	5.25	13.2	NR
TOTAL SOLIDS	mg/L	97.9	109	84	91.4	105	87.6	192	NR
DISSOLVED PHOSPHORUS	mg P/L	<0.010	0.033	0.037	0.17	0.044	0.028	0.093	NR
DISSOLVED PHOSPHATE	mg PO4/L	<0.031	0.10	0.11	0.52	0.14	0.086	0.29	NR
TOTAL PHOSPHORUS	mg P/L	0.13	0.039	0.035	0.24	0.068	0.049	0.11	NR
TOTAL PHOSPHATE	mg PO4/L	0.4	0.12	0.11	0.74	0.21	0.15	0.34	NR
TURBIDITY	NTU	23.2	23.1	22.3	16.4	13.1	15.4	15.4	NR
METALS									
CHROMIUM+6	mg Cr+6/L	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	0.05
IRON	mg/L	1.089	1.257	1.040	1.226	0.905	0.909	0.938	NR
SILICON	mg/L	7.959	8.391	7.887	8.731	8.922	9.107	8.906	NR
CADMIUM	microg/L	0.0490	0.043	0.0380	0.0260	<0.020	<0.020	0.0240	10*
LEAD	microg/L	0.359	0.209	0.0960	0.102	<0.033	<0.033	0.0800	50*
VANADIUM	microg/L	3.32	3.27	3.15	2.11	1.88	2.46	2.19	NR
ZINC	microg/L	<15.2	<15.2	<15.2	<15.2	<15.2	<15.2	<15.2	15000*
BARIUM	microg/L	62.3	60.0	60.0	67.0	70.6	68.8	67.8	1000*
MOLIBDENUM	microg/L	0.300	0.332	0.336	0.658	0.470	0.218	1.60	NR
MERCURY	microg/L	<0.441	<0.441	<0.441	<0.441	<0.441	<0.441	<0.441	2*
NR: Not reported									

Table 38 ANALYSIS RESULTS OF SURFACE WATER IN THE PALAGUA LAKE (Part 2 of 2)

SURFACE WATER SAMPLING IN PALAGUA LAKE	Data point	POINT 1	POINT 2	POINT 3	POINT 4	POINT 5	POINT 6	POINT 7	COLOMBIA ENVIRONMENT LAW-DECREE 1594/84 ART. 38
		Palagua Lake: Mouth of Agualinda Creek in Palagua Lake	Palagua Lake: Opposite side to Agualinda Creek mouth	Palagua Lake: On the shore close to ECP's Dock	Palagua Lake: in front of ECOPETROL's Dock	Palagua Lake:Palgua Creek spreading, behind the Fantasía Island	Palagua Lake: entrance to Palagua Creek	Palagua Lake: Between Palagua Creek and Velasquez's Dock	
	SAMPLING DATE	04-Oct-2011	05-Oct-2011	05-Oct-2011	08-Oct-2011	07-Oct-2011	06-Oct-2011	07-Oct-2011	
PARAMETERS	Units	200677198	200677642	200677643	200678470	200678330	200677792	200678331	
PHENOL ANALYSIS									
PHENOL	mg/L	<1.70E-4	<1.70E-4	<1.70E-4	<1.70E-4	<1.70E-4	<1.70E-4	<1.70E-4	0.002
2-CHLORO-PHENOL	mg/L	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	0.002
2-METHYLPHENOL	mg/L	<1.60E-4	<1.60E-4	<1.60E-4	<1.60E-4	<1.60E-4	<1.60E-4	<1.60E-4	0.002
3-METHYLPHENOL+4-METHYLPHENOL	mg/L	<1.70E-4	<1.70E-4	<1.70E-4	<1.70E-4	<1.70E-4	<1.70E-4	<1.70E-4	0.002
2-NITROPHENOL	mg/L	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	0.002
2-4-DIMETHYLPHENOL	mg/L	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	0.002
2-4-DICHLOROPHENOL	mg/L	<1.60E-4	<1.60E-4	<1.60E-4	<1.60E-4	<1.60E-4	<1.60E-4	<1.60E-4	0.002
2-6-DICHLOROPHENOL	mg/L	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	0.002
4-CHLORO-3-METHILPHENOL	mg/L	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	0.002
2-3-5-TRICHLOROPHENOL	mg/L	<3.40E-4	<3.40E-4	<3.40E-4	<3.40E-4	<3.40E-4	<3.40E-4	<3.40E-4	0.002
2-4-6-TRICHLOROPHENOL	mg/L	<3.30E-4	<3.30E-4	<3.30E-4	<3.30E-4	<3.30E-4	<3.30E-4	<3.30E-4	0.002
2-4-5-TRICHLOROPHENOL	mg/L	<3.50E-4	<3.50E-4	<3.50E-4	<3.50E-4	<3.50E-4	<3.50E-4	<3.50E-4	0.002
2-3-4-TRICHLOROPHENOL	mg/L	<3.40E-4	<3.40E-4	<3.40E-4	<3.40E-4	<3.40E-4	<3.40E-4	<3.40E-4	0.002
2-3-6-TRICHLOROPHENOL	mg/L	<3.40E-4	<3.40E-4	<3.40E-4	<3.40E-4	<3.40E-4	<3.40E-4	<3.40E-4	0.002
4-NITROPHENOL	mg/L	<4.70E-4	<4.70E-4	<4.70E-4	<4.70E-4	<4.70E-4	<4.70E-4	<4.70E-4	0.002
2,3,5,6-TETRACHLOROPHENOL	mg/L	<4.20E-4	<4.20E-4	<4.20E-4	<4.20E-4	<4.20E-4	<4.20E-4	<4.20E-4	0.002
2,3,4,5-TETRACHLOROPHENOL	mg/L	<4.10E-4	<4.10E-4	<4.10E-5	<4.10E-6	<4.10E-7	<4.10E-8	<4.10E-9	0.002
2,3,4,6-TETRACHLOROPHENOL	mg/L	<4.10E-4	<4.10E-4	<4.10E-4	<4.10E-4	<4.10E-4	<4.10E-4	<4.10E-4	0.002
2-METHYL-4-6-DINITROPHENOL	mg/L	<9.90E-4	<9.90E-4	<9.90E-4	<9.90E-4	<9.90E-4	<9.90E-4	<9.90E-4	0.002
3,4,5-TETRACHLOROPHENOL	mg/L	<3.90E-4	<3.90E-4	<3.90E-4	<3.90E-4	<3.90E-4	<3.90E-4	<3.90E-4	0.002
PENTACHLOROPHENOL	mg/L	<5.80E-4	<5.80E-4	<5.80E-4	<5.80E-4	<5.80E-4	<5.80E-4	<5.80E-4	0.002
DINOSEB	mg/L	<5.60E-4	<5.60E-4	<5.60E-4	<5.60E-4	<5.60E-4	<5.60E-4	<5.60E-4	0.002
PAH'S ANALYSIS									
NAPHTALENE	mg/L	<1.60E-4	<1.60E-4	<1.60E-4	<1.60E-4	<1.60E-4	<1.60E-4	<1.60E-4	NR
ACENAPHTHILENE	mg/L	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	NR
ACENAPHTHENE	mg/L	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	NR
FLUORENE	mg/L	<2.00E-4	<2.00E-4	<2.00E-4	<2.00E-4	<2.00E-4	<2.00E-4	<2.00E-4	NR
PHENANTHRENE	mg/L	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	NR
ANTHRACENE	mg/L	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	NR
FLUORANTHENE	mg/L	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	NR
PYRENE	mg/L	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	NR
BENZ(A)ANTHRACENE	mg/L	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	NR
CHRYSENE	mg/L	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	NR
BENZO(B)FLUORANTHENE	mg/L	<2.60E-4	<2.60E-4	<2.60E-4	<2.60E-4	<2.60E-4	<2.60E-4	<2.60E-4	NR
BENZO(K)FLUORANTHENE	mg/L	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	NR
BENZO(A)PYRENE	mg/L	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	NR
INDENO(1,2,3-CD)PYRENE	mg/L	<3.60E-4	<3.60E-4	<3.60E-4	<3.60E-4	<3.60E-4	<3.60E-4	<3.60E-4	NR
DIBENZ(A,H,)ANTHRACENE	mg/L	<4.10E-4	<4.10E-4	<4.10E-4	<4.10E-4	<4.10E-4	<4.10E-4	<4.10E-4	NR
BENZO(G,H,I)PYRELENE	mg/L	<4.00E-4	<4.00E-4	<4.00E-4	<4.00E-4	<4.00E-4	<4.00E-4	<4.00E-4	NR
NR: Not reported									

According to the above results, the following is concluded:

- The pH values as well as the concentrations of anions like chlorides, sulphates, nitrates, nitrites, ammonia nitrogen; phenol compound and metals like hexavalent chromium, cadmium, zinc, lead, barium and mercury meet the levels stipulated in Article 38 of Decree 1594/84 of Colombian Environment Law.

- O&G-HCs and non-polar hydrocarbons concentrations of <2.00 mg/L and <1.00 mg/L, respectively are lower than the minimum amount detectable by the lab methods. Additionally, no evidence of any fat/oil film was noted.

- PAHs recorded concentrations lower than the minimum amount detectable by lab methods.

- True color of water bodies range between 147 and 217 Upt-Co levels, which are over the value of 75 Upt-Co permitted by Law. However, the coloration of natural water "not contaminated" can be caused by humic substances and tannic acids that can naturally be present in surface waters.

- Alkalinity found in a low range of 22.8 to 29.2 mg CaCO3/L indicates that the water of Palagua Lake is poor in accumulation of nutrients. In general terms, total alkalinity is relatively low for continental tropical aquatic systems, up to 70 mg CaCO3/L (Cantera et al, 2009)

- Conductivity in Palagua Lake was found in a range of 56.8 to 75.2 micro ohms/cm and dissolved solids between 58.8 to 86.0 mg/L as shown in Figure 35.

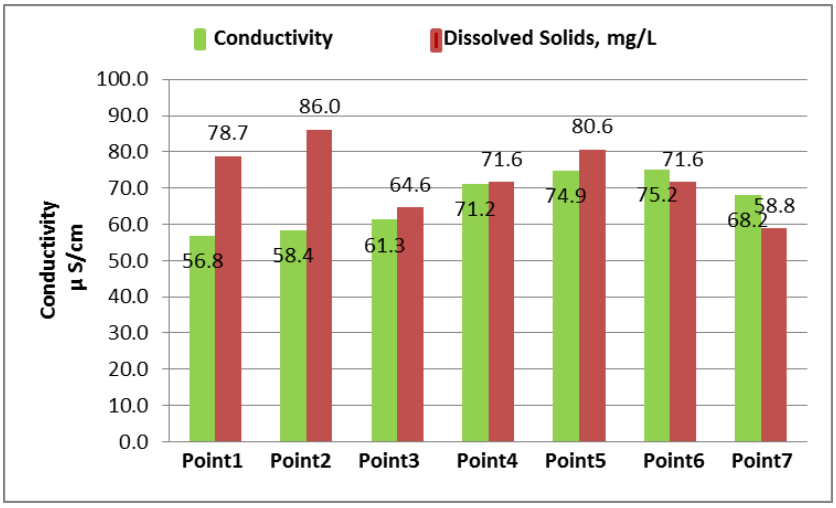


Figure 35 Tendencies of Conductivity and Dissolved Solids

- The presence of dissolved salts in the waters indicates the grade of mineralization of the same. In accordance with the reported conductivity, this indicates that Palagua lake water has very weak mineralization. Table 39 shows the relationship between conductivity and the grade of mineralization (Rodier, 1998).

Table 39 CLASSIFICATION OF WATER IN TERMS OF CONDUCTIVITY

conductivity < 100 µS/cm	very weak mineralization
100 µS/cm < conductivity < 200 µS/cm	weak mineralization
200 µS/cm < conductivity < 333 µS/cm	accentuated moderate mineralization
333 µS/cm < conductivity < 666 µS/cm	moderate mineralization
666 µS/cm < conductivity < 1000 µS/cm	important mineralization
conductivity > 1000 µS/cm	excessive mineralization

Source: RODIER, J. 1998. Water Analysis

- Hardness found in a range of 17.1 to 30.0 mg CaCO3/L indicates that water of the Palagua Lake is soft based on the range of 0-75 mgCaCO3/L established by Romero, 2005, as shown in Table 40.

Table 40 CLASSIFICATION OF WATER IN TERMS OF HARDNESS

Hardness concentration mg $CaCO_3$/L	Water classification
0 - 75	Soft
75 - 150	Moderate hard
150 - 300	Hard
>300	Excessive hard

Source: ROLDAN, 2008. Fundamentals of Neo Tropical Limnology

- Turbidity levels found in a range of 13.1 to 23.2 NTU are related to suspended solids found in a range of <5.0 to 17.6 mg/L as shown in Figure 36. Turbidity levels ≥ 200 NTU indicate a drastic alteration at trophic levels (Cantera et al, 2009).

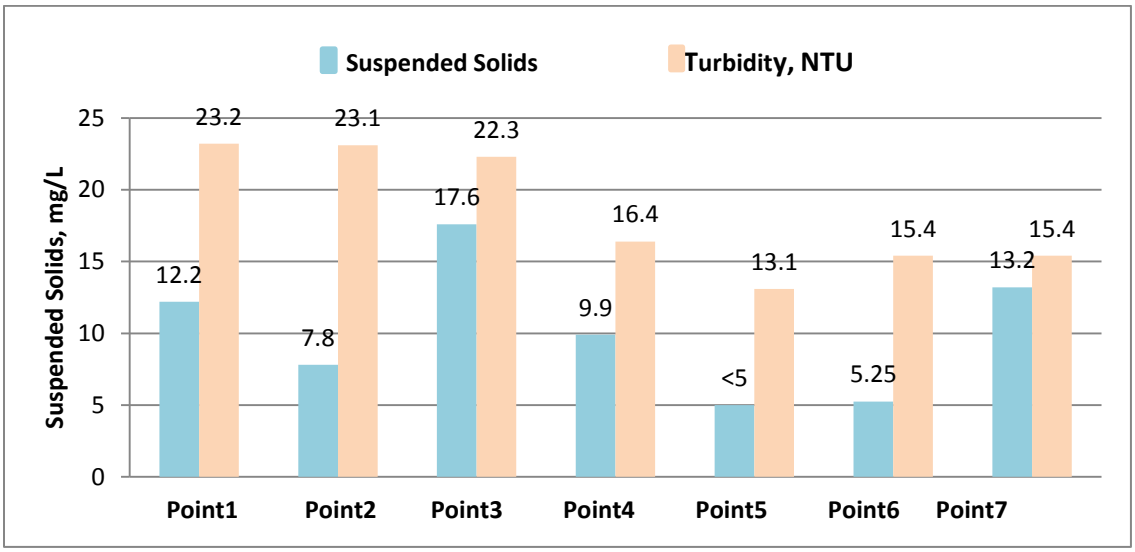


Figure 36 Tendencies of Suspended Solids and Turbidity

- Total phosphorous (P) was detected in the range of 0.035 to 0.24 mg P/L, falling in the standard of the low range found in natural waters which is 0.01 to 1 mg P/L (Romero, 2005). The P concentrations in Palagua Lake are attributable to phosphorus found in fertilizers and detergents used by farmers and nearby communities.

- Total nitrogen levels <2.16 mg N/L are in accordance to those in natural water without contamination which have nitrogen concentration of 0.18 to 3.0 mg N/L (Romero, 2005).

- DQO concentrations are in a range of 48.1 to 76.7 mg O_2/L, and DBO_5 in a range of 2.35 to 5.79 mg O_2/L, indicating presence of high levels of organic matter which can be harmful to water bodies. The most probable cause of contamination is due to effluents of residual domestic waters of people living nearby Palagua Lake. Standards (as per Sanchez, 2007) for concentrations of DQO and DBO_5 can be found in Table 41 on the following page.

Table 41 CLASSIFICATION OF WATER IN TERMS OF DQO AND DBO_5

DQO Concentration, mg/L	DBO_5 Concentration, mg/L	Water quality	Description
≤ 10	≤ 3	Excellent	No contamination
10 < DQO ≤ 20	3 < DBO_5 ≤ 6	Good quality	Surface water with low content of biodegradable and non-biodegradable organic matter
20 <DQO ≤ 40	6 < DBO_5 ≤ 30	Acceptable	Surface water with symptom of contamination having capacity to assimilate and degrade a wastewater contaminants
40 < DQO ≤ 200	30 < DBO_5 ≤ 120	Contaminated	Surface water receiving effluents of residual domestic waters
>200	>120	Strong contamination	Surface water with high impact of wastewater effluents

Source: Sanchez, 2007

F.2.2.2 ANALYSIS OF SURFACE WATER IN CREEKS OF PALAGUA FIELD

Samplings were also taken from the creeks. The results and analysis from those samplings can be found in the table below. Table 42 shows in situ and laboratory tests results of surface waters in Palagua, Agualinda and El Tambo Creeks.

Table 42 IN SITU AND LAB ANALYSIS OF SURFACE WATER IN AGUALINDA, PALAGUA, AND EL TAMBO CREEKS

SURFACE WATERS PALAGUA FIELD	SAMPLE IDENT.	AGUALINDA	PALAGUA	EL TAMBO	DECREE 1594/84 ART. 38
SUBMISSION: 100113179	DATE OF SAMPLING	4-Oct-11	6-Oct-11	8-Oct-11	
Component	Unit	200677199	200677793	200678471	
IN SITU DATA					
FLOW RATE	L/sg	NM	NM	NM	NR
DISSOLVED OXYGEN	mg O2/L	1.4	0.7	3.1	NR
WATER TEMPERATURE	ºC	26.9	27.9	30.1	NR
PH/T (GR C)	Uni. PH	6.58/26.9	6.42/27.9	6.47/30.1	5.0 – 9.0
AIR TEMPERATURE	ºC	29	27.4	36.3	NR
LABORATORY ANALYSIS					
PHYSICO-CHEMICAL ANALYSIS					
TOTAL ALKALINITY	mg CaCO3/L	26.3	28.3	21.8	NR
TOTAL ACIDITY	microg/L	-13400	-14400	-1230	NR
CONDUCTIVITY	µS/cm/ºC	62.1/25.0	73.1/25.0	52.3/25.0	NR
TOTAL HARDNESS	mg CaCO3/L	20.2	24.5	23.8	NR
TRUE COLOR	U Pt-Co	148	189	296	75
DQO	mg O2/L	64	64.6	114	NR
DBO5	mg O2/L	2.48	4.57	2.56	NR
DISSOLVED CYANIDE	mg CN/L	<0.010	<0.010	<0.010	0.2
CHLORIDES	mg/L	1	2.79	0.91	250
O&G - HCs	mg/L	<2.00	<2.00	<2.00	Not visible film accepted
NON-POLAR HYDROCARBONS	mg/L	<1.00	<1.00	<1.00	NR
SULFATES (SO4)	mg SO4=/L	0.78	0.94	<0.50	400
NITRATES (NO3)	mg NO3/L	0.22	0.32	<0.090	10
NITRITES (NO2)	mg NO2/L	<0.70	<0.70	<0.70	1
AMMONIA NITROGEN	mg NH3/L	<0.49	<0.49	<0.49	1
KJELDAHL NITROGEN	mg N/L	<1.00	<1.00	<1.00	NR
TOTAL NITROGEN	mg/L	1.78	1.98	2.46	NR
DISSOLVED SOLIDS	mg/L	82.2	83.8	85.6	NR
SUSPENDED SOLIDS	mg/L	22.7	9.7	76.9	NR
TOTAL SOLIDS	mg/L	111	99.8	178	NR
DISSOLVED PHOSPHOROUS	mg P/L	<0.010	0.042	0.08	NR
DISSOLVED PHOSPHATE	mg PO4-3/L	<0.031	0.13	0.25	NR
TOTAL PHOSPHOROUS	mg P/L	0.046	0.08	0.11	NR
TOTAL PHOSPHATE	mg PO4-3/L	0.14	0.25	0.34	NR
TURBIDITY	NTU	28.9	25.7	111	NR
METAL ANALYSIS					
CHROMIUM+6	microg/L	<0.015	<0.015	<0.015	0.05
IRON	mg/L	1.087	2.033	7.862	NR
SILICON	mg/L	8.105	8.335	8.471	NR
CADMIUM	microg/L	0.075	0.196	0.231	10.0 *
LEAD	microg/L	0.459	0.55	1.34	50.0 *
VANADIUM	microg/L	3.86	4.31	8.63	NR
ZINC	microg/L	<15.2	<15.2	<15.2	15000
BARIUM	microg/L	74.4	70.3	137	1000
MOLYBDENUM	microg/L	0.254	1.09	0.757	NR
MERCURY	microg/L	<0.441	<0.441	<0.441	2
LABORATORY ANALYSIS					
PHENOL ANALYSIS					
PHENOL	mg/L	<1.70E-4	<1.70E-4	<1.70E-4	0.002
2-CHLOROPHENOL	mg/L	<2.20E-4	<2.20E-4	<2.20E-4	0.002
2-METHYLPHENOL	mg/L	<1.60E-4	<1.60E-4	<1.60E-4	0.002
3-METHYLPHENOL+4METHYLPHENOL	mg/L	<1.70E-4	<1.70E-4	<1.70E-4	0.002
2-NITROPHENOL	mg/L	<2.20E-4	<2.20E-4	<2.20E-4	0.002
2,4-DIMETHYLPHENOL	mg/L	<2.80E-4	<2.80E-4	<2.80E-4	0.002
2,4-DICHLOROPHENOL	mg/L	<1.60E-4	<1.60E-4	<1.60E-4	0.002
2,6-DICHLOROPHENOL	mg/L	<2.80E-4	<2.80E-4	<2.80E-4	0.002
4-CHLORO-3-METHYLPHENOL	mg/L	<2.80E-4	<2.80E-4	<2.80E-4	0.002
2,3,5-TRICHLOROPHENOL	mg/L	<3.40E-4	<3.40E-4	<3.40E-4	0.002
2,4,6-TRICHLOROPHENOL	mg/L	<3.30E-4	<3.30E-4	<3.30E-4	0.002
2,4,5-TRICHLOROPHENOL	mg/L	<3.50E-4	<3.50E-4	<3.50E-4	0.002
2,3,4-TRICHLOROPHENOL	mg/L	<3.40E-4	<3.40E-4	<3.40E-4	0.002
2,3,6-TRICHLOROPHENOL	mg/L	<3.40E-4	<3.40E-4	<3.40E-4	0.002
4-NITROPHENOL	mg/L	<4.70E-4	<4.70E-4	<4.70E-4	0.002
2,3,5,6-TETRACHLOROPHENOL	mg/L	<4.20E-4	<4.20E-4	<4.20E-4	0.002
2,3,4,5-TETRACHLOROPHENOL	mg/L	<4.10E-4	<4.10E-4	<4.10E-4	0.002
2,3,4,6-TETRACHLOROPHENOL	mg/L	<4.10E-4	<4.20E-4	<4.20E-4	0.002
2-METHYL-4,6-DINITROPHENOL	mg/L	<9.90E-4	<9.90E-4	<9.90E-4	0.002
3,4,5-TRICHLOROPHENOL	mg/L	<3.90E-4	<3.90E-4	<3.90E-4	0.002
PENTACHLOROPHENOL	mg/L	<5.80E-4	<5.80E-4	<5.80E-4	0.002
DINOSEB	mg/L	<5.60E-4	<5.60E-4	<5.60E-4	0.002
ANALYSIS OF POLYAROMATIC HYDROCARBONS PAHs					
NAPHTHALENE	mg/L	<1.60E-4	<1.60E-4	<1.60E-4	NR
ACENAPHTHILENE	mg/L	<1.90E-4	<1.90E-4	<1.90E-4	NR
ACENAPHTHENE	mg/L	<1.90E-4	<1.90E-4	<1.90E-4	NR
FLUORENE	mg/L	<2.00E-4	<2.00E-4	<2.00E-4	NR
PHENANTHRENE	mg/L	<2.20E-4	<2.20E-4	<2.20E-4	NR
ANTHRACENE	mg/L	<2.20E-4	<2.20E-4	<2.20E-4	NR
FLUORANTENE	mg/L	<2.20E-4	<2.20E-4	<2.20E-4	NR
PYRENE	mg/L	<2.20E-4	<2.20E-4	<2.20E-4	NR
BENZO(A)ANTHRACENE	mg/L	<2.50E-4	<2.50E-4	<2.50E-4	NR
CHRYSENE	mg/L	<2.50E-4	<2.50E-4	<2.50E-4	NR
BENZO(B)FLUORANTENE	mg/L	<2.60E-4	<2.60E-4	<2.60E-4	NR
BENZO(K)FLUORANTENE	mg/L	<2.80E-4	<2.80E-4	<2.80E-4	NR
BENZO(A)PYRENE	mg/L	<2.80E-4	<2.80E-4	<2.80E-4	NR
INDENO(1,2,3-CD)PYRENE	mg/L	<3.60E-4	<3.60E-4	<3.60E-4	NR
DIBENZO(A,H)ANTHRACENE	mg/L	<4.10E-4	<4.10E-4	<4.10E-4	NR
BENZO(G,H,I)PERYLENE	mg/L	<4.00E-4	<4.00E-4	<4.00E-4	NR

NM: Not measured NR: Not reported

*Units of ruling are in mg/L; however lab units are in µg/L due to very low concentrations found in samples

Based on the results of the above table, the following conclusions can be drawn:

- pH values and concentrations of dissolved cyanide, anions like chlorides, sulfates, nitrites and nitrates, nitrogen ammonia, phenol compounds, and metals like cadmium, chromium, lead, zinc, barium, and mercury were found within the limits stipulated by the Law.

- True color values oscillate between 148 and 296 Upt-Co, levels found out of the range of 75 Upt-Co permissible by the Law. The color of the "not-contaminated" natural water may be caused principally by humic substances and tannic acids that may be found in the natural waters (Orozco, 2003).

- O&G-HCs and non-polar hydrocarbons concentrations of <2.00 mg/L and <1.00 mg/L, respectively, are below the range detectable by lab methods. Additionally, no evidence of any fat/oil film was noted.

- According to the hardness results, the waters analyzed from the creeks may be classified as soft for being in the range of 0-75 mg/L (Romero, 2002).

- Conductivity was found in a range of 52.3 to 73.1 µ ohms/cm, and dissolved solids between 82.2 to 85.6 mg/L, which indicate that water from creeks has a very weak mineralization as compared to water classification by Rodier, 1998.

- Creek El Tambo has the highest concentration of suspended solids of 76.9 mg/L, and Creeks Agualinda and Palagua contain 22.7 and 9.70 mg/L, respectively. These values of suspended solids are normal for lotic systems where water is in permanent movement. Turbidities follow the same tendency of SS as shown in Figure 36.

- DQO is in the range of 64.0 to 114.0 mg O2/L, and DBO5 in the range of 2.48 to 4.57 mg O_2/L. Dissolved oxygen was found in concentrations lower than 1.4 mg O_2/L in Agualinda and Palagua Creeks whereas El Tambo Creek reported 3.1 mg O_2/L, which is favorable for an aquatic ecosystem. Based on the reported concentrations of DBO_5, Agualinda and El Tambo creeks are classified as excellent quality water, and Palagua Creek as good quality water. (Sanchez, 2007)

F.2.2.3 ADDITIONAL SURFACE WATER MONITORING EFFORTS

In addition to the water analysis done in October 2011, another surface water analysis taken from four (4) additional location points was conducted in March 2012. The geographic coordinates of these 4 sampling location points are listed in Table 43. These additional surface water monitoring points can be seen on a map of the overall Palagua project included as Annex 1.

Table 43 COORDINATES OF ADDITIONAL SURFACE WATER MONITORING POINTS

Designation	Location	Coordinates	
		N	E
A01	Body of water Casa Roja	1.166.197	0.952.579
A02	Fish pond - Palagua School	1.163.978	0.952.725
A03	Body of water in farm Los Lagos	1.169.658	0.953.950
A04	Pond in farm Los Machines	1.166.208	0.952.339

Tables 44 through 47 give a visual of each of the additional monitoring sites along with the in situ conditions of the water at each location.

Table 44 LOCATION A01

Body of water Casa Roja			
in situ Parameters			
pH	Conductivity [µS/cm]	Sample T. [°C]	
7.1	102.7	29.7	

Table 45 LOCATION A02

Fish pond - Palagua School			
in situ Parameters			
pH	Conductivity [µS/cm]	Sample T. [°C]	
8.05	185.3	28.7	

Table 46 LOCATION A03

Body of water in farm Los Lagos			
in situ Parameters			
pH	**Conductivity** [µS/cm]	**Sample T.** [°C]	
7.14	154.9	29.7	

Table 47 LOCATION A04

Body of water in farm Los Machines			
in situ Parameters			
pH	**Conductivity** [µS/cm]	**Sample T.** [°C]	
7.5	58	34.7	

The samples taken from each body of water were transported to the lab for further analysis. Table 48 shows the results of this analysis.

Table 48 LABORATORY RESULTS OF MEASURED BODIES OF WATER

PARAMETERS	BODIES OF WATER					DECREE 1594/84 OF QUALITY CRITERIA FOR RESOURCE DESTINATION			
	UNITS	CASA ROJA	FISH POND	FARM LOS LAGOS	FARM LOS MACHINES	ART. 38[1]	ART. 39[2]	ART. 40[3]	ART. 41[4]
Temperature	°C	29.7	28.7	29.7	34.7	*	*	*	*
pH	Units	7.1	8.05	7.14	7.5	5,0-9,0	6,5-8,5	4,5-9,0	*
Conductivity	µS /cm	102.7	185.3	154.9	58	*	*	*	*
Phenols	mg/L	ND<0,001	ND<0,001	ND<0,001	ND<0,001	0.002	0.002	*	*
Zinc	mg Zn /L	ND<0.01	ND<0.01	ND<0.01	ND<0.01	15	15	2	25
Selenium	mg Se /L	ND<0.005	ND<0.005	ND<0.005	ND<0.005	0.01	0.01	0.02	*
Arsenic	mg As /L	ND<0,01	ND<0,01	ND<0,01	ND<0,01	0.05	0.05	0.1	0.2
Lead	mg Pb/L	ND<0,005	ND<0,005	ND<0,005	ND<0,005	0.05	0.05	5	0.1
Barium	mg Ba /L	ND<0.1	ND<0.1	ND<0.1	ND<0.1	1	1	*	*
PAH	mg TPH/L	ND<0,1	ND<0,1	ND<0,1	ND<0,1	*	*	*	*
Chlorides	mg Cl^- / L	6.5	6.2	5.5	3.2	250	250	*	*
Fats and Oil	mg G&A /L	0.32	0.25	0.32	0.36	NPV	NPV	*	*
Cadmium	mg Cd /L	ND<0.01	ND<0.01	ND<0.01	ND<0.01	0.01	0.01	0.01	0.05
Copper	mg Cu /L	ND<.0.01	ND<0.01	ND<0.01	ND<0.01	1	1	0.2	0.5
Mercury	mg Hg/L	ND<0,001	ND<0,001	ND<0,001	ND<0,001	0.002	0.002	*	0.01

[1] Decree 1594/84 Quality criteria of resource for human consumption with conventional treatment
[2] Decree 1594/84 Quality criteria of resource for human consumption with disinfectant treatment
[3] Decree 1594/84 Quality criteria of resource for agriculture
[4] Decree 1594/84 Quality criteria of resource for livestock
[5] When the resource is used for irrigation of fruits and short stem vegetables

According to the above results, the following is concluded:

- ✓ The evaluation of all physical and chemical parameters of water bodies assessed in this study shows results within the allowable ranges established by the regulations. All samples meet the criteria for acceptable quality of the destined use of the water.

- ✓ Temperature records are normal for this type of water indicating good quality, allowing the normal functioning of aquatic life, and use of the water for domestic purposes.

- ✓ The pH units recorded for monitoring points A01, A03, and A04 indicate that the pH level of the water is neutral in nature, while the pH level of the water at monitoring point A02 is alkaline. These pH levels are in line with the ranges established by the current environmental regulations, so there is no negative influence on the development of aquatic life.

- ✓ The conductivity parameter recorded low concentrations, indicating low dissolved solids content and good quality. Decree 1594/84 does not set maximum permissible limits for the parameter of conductivity.

- ✓ There was low content of fats and oils and no visible evidence of these compounds in the bodies of water. Total phenols were not detected. Favorable condition indicated little contamination.

- ✓ There were no concentrations of PAH (polycyclic aromatic hydrocarbons) in any of the ponds in the study.

- ✓ In none of the analyzed water bodies was there evidence of heavy metals (zinc, selenium, arsenic, lead, barium, cadmium, copper and mercury). These metals were not detected, or they are in such low concentrations that they fall below the lab test limits.

- ✓ The chlorides have very low concentrations, being insignificant compared with the values established by the standard. Therefore, there should be no problems of odors or flavors in these waters.

- ✓ In conclusion, according to the results obtained, there is no pollution from the activities of UT-IJP, in accordance with the regulations. Therefore, the water can be used for the purposes of human consumption, agriculture and livestock in accordance with Articles 38, 39, 40 and 41 of Decree 1594/84.

F.2.2.4 ANALYSIS OF SEDIMENTS IN PALAGUA LAKE AND CREEKS

Sediments were evaluated with respect to the international ruling, Canadian Sediment Quality Guidelines for the Protection of Aquatic Life 2002, which establishes criteria for contaminated soils. Colombia does not have any regulation about this matter.

This international ruling stipulates two criteria: ISQGs (Interim sediment quality guidelines) and PELs (probable effect levels). The ISQ Guidelines contain two concentrations, the ISQG-Low concentration (or trigger value) and the ISQG-High concentration. The trigger value is a threshold concentration, and for any measurement below this concentration, the frequency of adverse biological effects is expected to be very low. The ISQG-High value is intended to represent a concentration, and any measurement above the value would indicate a situation in which adverse biological effects are expected to occur more frequently. It can also be stated that exceeding the (low) trigger value concentrations does not necessarily mean that adverse biological effects will occur in the sediments.

Table 49 shows lab analysis of sediments of Palagua Lake and Creeks Agualinda, Palagua and El Tambo.

Table 49 IN SITU AND LAB ANALYSIS OF SEDIMENTS IN PALAGUA LAKE AND CREEKS

PALAGUA FIELD SEDIMENTS	SAMPLE ID.	POINT 1. Mouth of Agualinda Creek in Palagua Lake	POINT 2. Opposite site to mouth of Agualinda Creek	POINT 3. On the shore, close to ECOPETROLS' Dock	POINT 4. Center of Palagua Lake in front of ECOPETROL's Dock	POINT 5. Palagua Creek Spreading, behind the "Fantasía Island"	POINT 6. ENTRANCE TO PALAGUA PIPELINE	POINT 7. Site located between Palagua Creek and Velazquez Port	Agualinda Creek	Palagua Creek	El Tambo Creek	CANADIAN SEDIMENT QUALITY GUIDELINES FOR THE PROTECTION OF AQUATIC LIFE, 2001. Table 1. Interim freshwater sediment quality guidelines (ISQGs) and probable effect levels (PELs)	
SUBMISSION: 100113179	SAMPLING DATE	4-Oct-11	5-Oct-11	5-Oct-11	8-Oct-11	7-Oct-11	6-Oct-11	7-Oct-11	4-Oct-11	6-Oct-11	8-Oct-11		
Component	**Unit**	**200677200**	**200677644**	**200677645**	**200678472**	**200678334**	**200677794**	**200678335**	**200677201**	**200677795**	**200678473**	**ISQG**	**PEL**
***IN SITU* ANALYSIS**													
pH / T (º C), SOIL RELATION 1:5	pH Units	6.10/19.9	6.07/20.7	5.90/20.5	6.08/20.9	6.13/20.4	5.85/20.4	6.04/20.7	6.45/20.2	5.91/20.6	5.85/20.0	**NR**	**NR**
CONDUCTIVITY RELATION	µS/cm/ºC	132/25.0	134/25.0	189/25.0	144/25.0	174/25.0	226/25.0	211/25.0	29.1/25.0	44.3/25.0	10.5/25.0	**NR**	**NR**
CHLORIDES	mg Cl-/kg	<3.70	<3.70	51.0	64.5	67.0	51.5	86.0	<3.70	<3.70	<3.70	**NR**	**NR**
POLYAROMATIC HYDROCARBONS PAHs													
NAPHTHALENE	µg/L	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016	0.0346*	0.391*
ACENAPHTILENE	µg/L	<0.019	<0.019	<0.019	<0.019	<0.019	<0.019	<0.019	<0.019	<0.019	<0.019	0.00587*	0.128*
ACENAPHTHENE	µg/L	<0.019	<0.019	<0.019	<0.019	<0.019	<0.019	<0.019	<0.019	<0.019	<0.019	0.00671*	0.0889*
FLUORINE	µg/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	0.0212*	0.144*
PHENANTHRENE	µg/L	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	0.0419*	0.515*
ANTHRACENE	µg/L	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	0.0469*	0.245*
FLUORANTINE	µg/L	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	0.111*	2.355*
PYRENE	µg/L	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	0.053*	0.875*
BENZO(A)ANTHRACENE	µg/L	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	0.0317*	0.385*
CHRYSENE	µg/L	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	0.0571*	0.862*
BENZO(B)FLUORANTINE	µg/L	<0.026	<0.026	<0.026	<0.026	<0.026	<0.026	<0.026	<0.026	<0.026	<0.026	**NR**	**NR**
BENZO(K)FLUORANTENE	µg/L	<0.028	<0.028	<0.028	<0.028	<0.028	<0.028	<0.028	<0.028	<0.028	<0.028	**NR**	**NR**
BENZO(A)PYRENE	µg/L	<0.028	<0.028	<0.028	<0.028	<0.028	<0.028	<0.028	<0.028	<0.028	<0.028	0.0319*	0.782*
INDENO(1,2,3-CD)PYRENE	µg/L	<0.036	<0.036	<0.036	<0.036	<0.036	<0.036	<0.036	<0.036	<0.036	<0.036	**NR**	**NR**
DIBENZO(A,H)ANTHRACENE	µg/L	<0.041	<0.041	<0.041	<0.041	<0.041	<0.041	<0.041	<0.041	<0.041	<0.041	0.00622*	0.135*
BENZO(G,H,I)PERYLENE	µg/L	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	**NR**	**NR**
METALS													
BARIUM	mg/Kg	358	480	428	450	459	391	441	343	243	79.23	**NR**	**NR**
CADMIUM	mg/Kg	**2.835**	**3.414**	**3.856**	**2.012**	**1.680**	**1.764**	**1.707**	**2.836**	**4.878**	0.384	0.6	3.5
CHROMIUM	mg/Kg	37.28	35.52	30.94	**53.57**	**37.94**	29.83	34.18	**42.18**	**44.80**	13.00	37.3	90.0
MOLYBDENUM	mg/Kg	0.426	1.648	1.483	1.521	1.056	1.612	1.53	0.494	6.72	0.407	**NR**	**NR**
LEAD	mg/Kg	9.484	13.02	14.39	17.35	15.54	12.45	14.39	10.74	19.49	5.556	35.0	91.3
VANADIUM	mg/Kg	53.15	64.11	58.43	95.46	66.92	63.95	64.45	69.02	123	35.44	**NR**	**NR**
IRON	% weight	1.86	1.84	1.68	3.00	2.32	1.80	1.94	1.62	3.21	1.39	**NR**	**NR**
ZINC	mg/Kg	**136**	**139**	**147**	**137**	108	103	110	93.99	**243**	42.63	123	315
MERCURY	µg/Kg	113	138	150	117	127	92.2	116	30.4	86.2	31.9	170*	486*

NR: Not reported *Units are in mg/L; however lab units are in µg/L due to very low concentrations found in samples

From the results listed in the above table, the following conclusions can be made regarding sediments:

- pH was found to be between 5.85 to 6.45 presenting the lowest value in Point 6 at Palagua Lake, and the highest level in Agualinda Creek.
- Chlorides concentrations vary from the minimum quantifiable by lab methods of 3.70 mg Cl/kg, to 86 mg Cl/kg detected in Point 7 at Palagua Lake.
- Conductivity was found in a range of 10.5 to 226 µS/cm
- Concentration of PAH was lower than the minimum quantifiable by lab methods. Also PAH levels meet the standard allowable by the Canadian regulation.

- Lead and mercury concentrations were less than the ISQG levels set for the cited international ruling which indicate that such concentrations would not generate any adverse biological effect in the microorganisms having contact with these metals.

- Cadmium concentrations in a range of 1,680 to 3,414 mg/kg are in the ISQG and PEL levels in which adverse biological effects may occur. The cadmium concentrations in El Tambo Creek are less than the ISQG level. This would not generate any adverse biological effect. However, at Point 3 (Palagua Lake shore) and Palagua Creek, reported cadmium concentrations are above the PEL level at which adverse biological effects occur frequently. These high levels of cadmium are attributable to anthropogenic activity of nearby houses. Figure 37 shows the tendency of cadmium at the monitored sites.

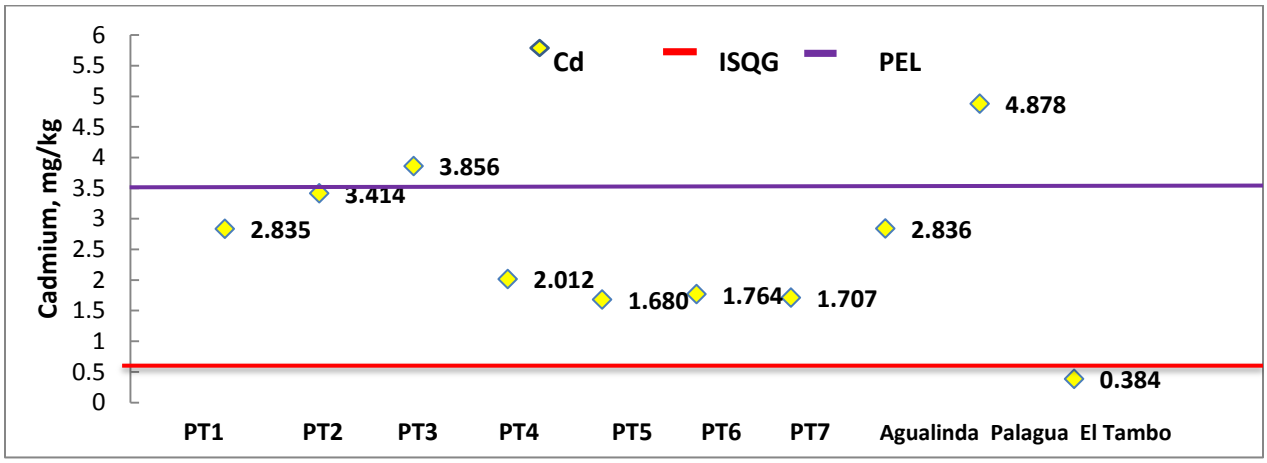


Figure 37 Tendency of Cadmium vs ISQG-PEL

- Zinc concentrations at Palagua Lake in Points 1, 2, 3 and 4, and in Palagua Creek are in the ISQG and PEL levels in which adverse biological effects may occur.

- Chromium concentrations in Points 4 and 5 at Palagua Lake, and the points in Agualinda and Palagua Creeks are in the ISQG and PEL levels in which adverse biological effects may occur.

Figures 38 and 39 indicate tendency of zinc and chromium at sites monitored.

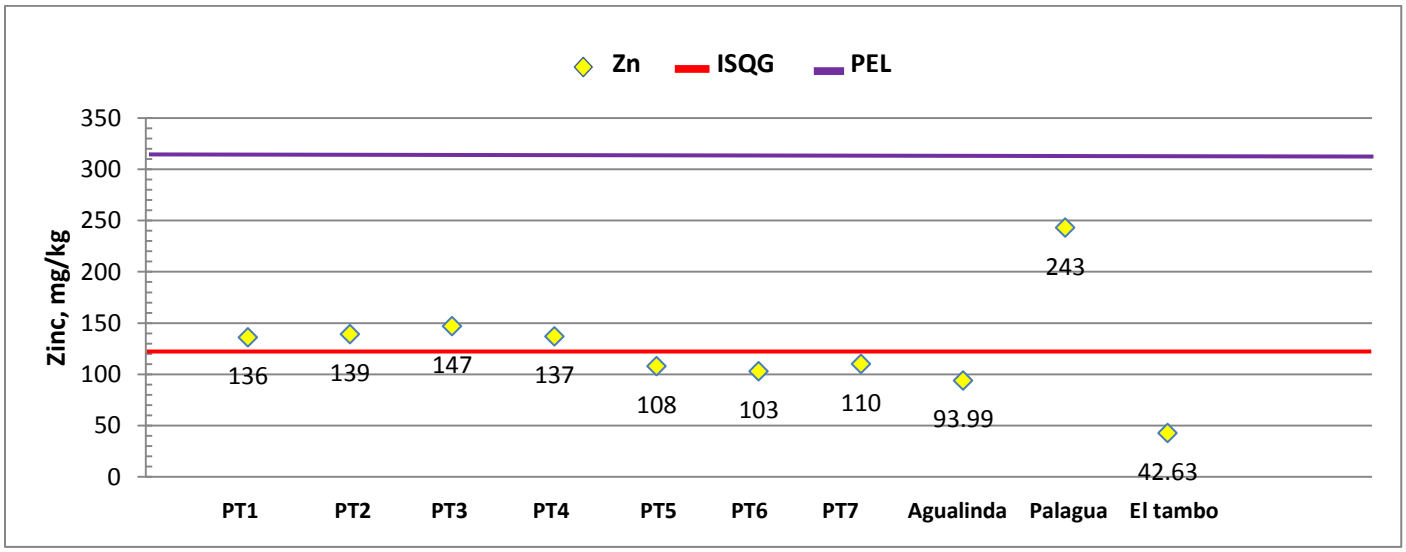


Figure 38 Tendency of Zinc vs ISQG-PEL

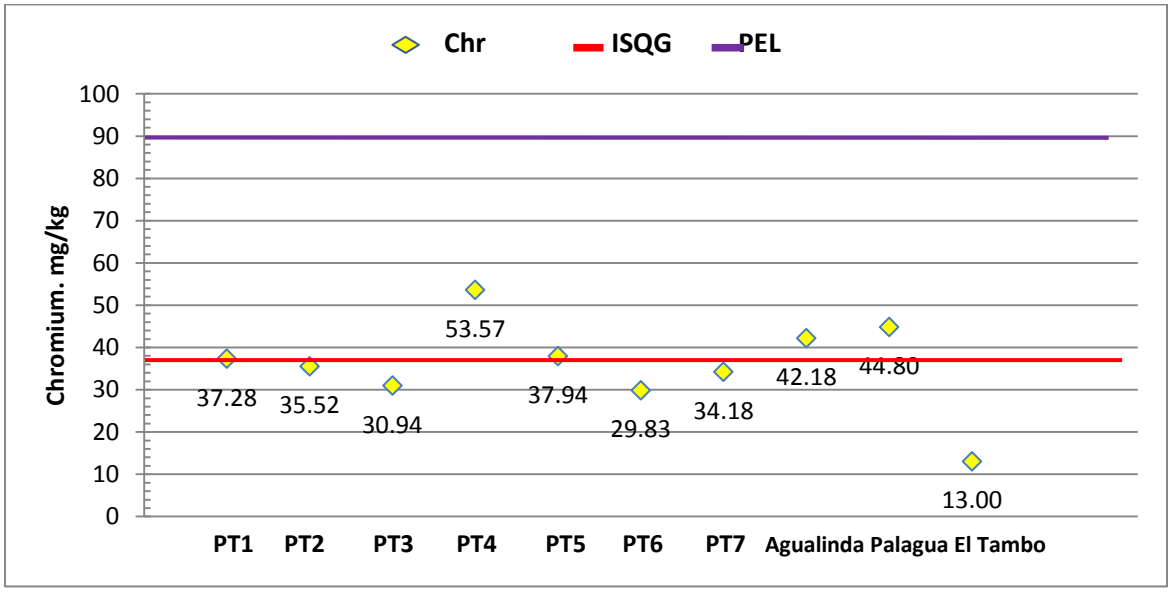


Figure 39 Tendency of Chromium vs ISQG-PEL

Toxological Study

Toxicity tests of the samples of the sites monitored did not find any evidence of acute toxicity, measured as LC50, or sub-acute toxicity (NOAEC). Samples of sediment and surface waters analyzed were classified within the No-Observed-Acute Toxicity Range. Nevertheless, a negative (although not significant level of $p<0.05$) response was noted in the population of Daphnia pulex exposed to sediment elutriates of samples collected in Points 3 and 6, at Palagua Lake.

Generally, it may be concluded that there is no evidence that the operation in Palagua field is causing or may cause in the near future any detriment to the populations of planktonic invertebrates represented in this study by Daphnia pulex.

F.2.3 UNDERGROUND WATER TESTING (Shallow, 3-4m deep wells)

Monitoring and sampling activities were conducted on October 8 through 11, 2011, in accordance with the ongoing Groundwater Monitoring Program. To meet this program we have a network of 19 monitor wells (PM wells) in the Palagua and Caipal fields. Four of the wells are not monitored due to various reasons; the wells PM-11, PM-14 and PM-15 were found dry and well PM-7 was found covered temporally due to civil works in the land farming area. Table 50 depicts the coordinates of the wells monitored for this study.

Table 50 COORDINATES OF THE 19 MONITOR WELLS

Well	Location	Coordinates	
		N	W
PM-1	Battery No. 1 behind TK-12000	06º 04' 30.6"	074º 30' 07.9"
PM-2	Old junk yard	06º 04' 19.9"	073º 30' 11.0"
PM-3	Close to Palagua Lake	06º 03' 57.9"	074º 30' 14.6"
PM-4	P-221 in the Monkey Watcher	06º 04' 28.7"	074º 30' 45.5"
PM-5	Forward P-153	06º 04' 49.1"	074º 30' 42.6"
PM-6	In old well P-187	06º 05' 21.6"	074º 30' 46.5"
PM-8	Close to Palagua Lake behind P-10	06º 03' 59.9"	074º 30' 17.9"
PM-9	Close to Palagua Lake	06º 04' 03.0"	074º 30' 11.2"
PM-10	In Battery No. 1 behind gas treatment zone	06º 04' 34.3"	074º 30' 06.8"
PM-12	Behind P-112 and P-20	06º 05' 01.9"	074º 30' 47.1"
PM-13	Close to P-32 in the API area	06º 05' 39.2"	074º 30' 57.7"
PM-16	Beyond P-125	06º 05' 12.7"	074º 31' 03.2"
PM-17	Behind fence in Battery No 1 close to PM-14	06º 04' 30.1"	074º 31' 03.2"
PM-18	Close to PM-14	06º 04' 29.6"	074º 30' 08.1"
PM-19	Close to PM-18	06º 04' 29.2"	074º 30' 08.7"

The underground waters were evaluated with respect to the National Environmental Regulation (Decree 1594/84, Art. 38 of the Ministry of Health) and the Canadian Legislation *Alberta Risk Management Guidelines for Petroleum Storage Tank Sites, Table 4- 2001*). Table 51 shows the results of *in situ* and laboratory analyses of the underground water from these monitor wells.

Table 51 IN SITU AND LAB ANALYSIS RESULTS OF UNDERGROUND WATERS OF PM-1 TO PM-19

PALAGUA FIELD UNDERGROUND WATERS	SAMPLE ID.	PM-1	PM-2	PM-3	PM-4	PM-5	PM-6	PM-8	PM-9	DECREE 1594/84 ART. 38	Alberta Risk Management Guidelines for Petroleum storage tank sites 2001 Table 4. Generic Hydrocarbon Criteria for the Groundwater Ingestion Pathway
		LOCATED IN BATTERY No. 1 BEHIND TK-12000	LOCATED AT OLD JUNK YARD	LOCATED CLOSE TO PALAGUA LAKE	LOCATED IN P-221 IN THE MONKEY WATCHER	LOCATED FORWARD P-153	LOCATED IN OLD WELL P-187	LOCATED CLOSE TO PALAGUA LAKE BEHIND WELL P-10	LOCATED CLOSE TO PALAGUA LAKE		
SUBMISSION: 100113179	SAMPLING DATE	10-Oct-11	10-Oct-11	10-Oct-11	8-Oct-11	8-Oct-11	8-Oct-11	10-Oct-11	10-Oct-11		
Component	**Unit**	**200679232**	**200679233**	**200679234**	**200678463**	**200678464**	**200678465**	**200679235**	**200679236**		
***IN SITU* ANALYSIS**											
DEPTH	m	4.54	3.78	3.84	2.15	3.57	2.88	2.61	3.03	NR	NR
DISSOLVED OXYGEN	mg O_2/L	0.0	4.1	1.0	0.0	1.5	1.4	2.2	2.3	NR	NR
PH/T (º C)	pH units	6.28/31.3	7.34/31.6	6.50/30.7	6.60/33.9	6.79/32.1	7.44/32.2	7.87/31.6	7.05/31.4	5.0 - 9.0	NR
WATER TEMPERATURE	ºC	31.3	31.6	30.7	33.9	32.1	32.2	31.6	31.4	NR	NR
LABORATORY ANALYSIS											
PHYSICAL AND CHEMICAL ANALYSIS											
PH / T (º C) IN WATER	pH units	6.29/22.4	7.36/22.0	6.62/22.3	6.75/23.6	6.69/23.7	7.60/23.8	7.94/22.2	7.22/22.2	5.0 - 9.0	NR
TOTAL ALKALINITY	mg $CaCO_3$/L	248	210	225	629	164	1167	293	225	NR	NR
CARBONATES	mg CO_3=/L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NR	NR
BICARBONATES	mg HCO_3-/L	303	256	275	768	201	1424	357	274	NR	NR
CHLORIDES	mg/L	18.9	3.92	43.9	199	69.9	98.0	5.95	1.33	250.0	NR
CONDUCTIVITY	µS/cm/ºC	492/25.0	439/25.0	575/25.0	1719/25.0	628/25.0	2510/25.0	547/25.0	429/25.0	NR	NR
PHENOLS	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.002	NR
GREASES AND OILS - HYDROCARBONS	mg/L	7.56	<2.00	<2.00	<2.00	<2.00	2.59	<2.00	2.08	don't accept visible film	NR
NON-POLAR HYDROCARBONS	mg/L	1.70	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	NR	NR
NITRATES (NO_3)	mg NO_3-N/L	4.20	0.75	0.44	2.55	0.86	<0.11	0.18	<0.090	10.0	NR
NITRITES (NO_2)	mg NO_2-N/L	<0.029	<0.029	**7.92**	<0.011	<0.011	<0.011	<0.029	<0.029	1.0	NR
AMMONIA NITROGEN	mg NH_3-N/L	**4.16**	<0.49	**6.59**	**2.31**	0.51	<0.49	<0.49	<0.49	1.0	NR
TOTAL DISSOLVED SOLIDS	mg/L	327	339	341	1015	271	1498	351	303	NR	NR
SULFATES	mg SO_4=/L	2.76	13.3	<0.50	16.4	29.0	23.1	2.51	2.14	400.0	NR
ANALYSIS OF DISSOLVED METALS											
CALCIUM	mg/L	21.61	2.777	10.34	98.83	39.36	17.29	10.86	40.86	NR	NR
MAGNESIUM	mg/L	11.19	2.101	10.09	68.17	40.04	42.34	5.773	1.925	NR	NR
SODIUM	mg/L	115	99.86	96.91	202	71.84	608	121	45.91	NR	NR
POTASSIUM	mg/L	1.897	0.951	1.826	5.099	3.484	0.205	1.284	0.136	NR	NR
MANGANESE	mg/L	2.381	0.00692	0.907	6.830	1.558	0.0296	0.000590	0.00306	NR	NR
IRON	mg/L	7.966	0.614	0.126	0.555	0.142	0.0547	0.0369	0.187	NR	NR
ALUMINUM	mg/L	0.0551	0.467	0.0327	0.00252	<0.00214	0.0268	0.0321	0.138	NR	NR
TOTAL METAL ANALYSIS											
HEXAVALENT CHROMIUM	mg Cr_{+6}/L	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	0.05	NR
ARSENIC	µg/L	14.0	6.08	**85.9**	**221**	42.9	**106**	4.20	3.34	50*	NR
SELENIUM	µg/L	0.985	<0.389	<0.389	<0.389	1.49	<0.389	<0.389	<0.389	10*	NR
CADMIUM	µg/L	0.296	0.181	0.621	1.01	1.49	1.74	0.559	1.48	10*	NR
LEAD	µg/L	10.3	5.32	19.6	3.84	33.4	48.6	5.05	10.4	50*	NR
VANADIUM	µg/L	44.3	86.8	123	17.6	119	246	70.8	102	NR	NR
ZINC	µg/L	73.4	37.1	71.0	31.0	135	320	50.5	105	15000*	NR
BARIUM	µg/L	537	145	960	764	591	944	182	196	1000*	NR
MOLYBDENUM	µg/L	0.828	2.78	0.514	10.9	2.41	30.3	12.6	<0.029	NR	NR
COPPER	µg/L	14.1	9.32	27.8	11.7	35.8	87.0	13.6	31.4	1000*	NR
NICKEL	µg/L	14.8	12.6	15.6	6.94	32.8	118	18.0	31.2	NR	NR
MERCURY	µg/L	<0.441	<0.441	<0.441	<0.441	<0.441	<0.441	<0.441	<0.441	2*	NR
ANALYSIS OF POLYAROMATIC HYDROCARBONS (PAHs)											
NAPHTHALENE	mg/L	<1.60E-4	<1.60E-4	<1.60E-4	<1.60E-4	<1.60E-4	<1.60E-4	<1.60E-4	<1.60E-4	NR	NR
ACENAPHTILENE	mg/L	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	NR	NR
ACENAPHTHENE	mg/L	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	NR	NR
FLUORINE	mg/L	<2.00E-4	<2.00E-4	<2.00E-4	<2.00E-4	<2.00E-4	<2.00E-4	<2.00E-4	<2.00E-4	NR	NR
PHENANTRENE	mg/L	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	NR	NR
ANTHRACENE	mg/L	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	NR	NR
FLUORANTENE	mg/L	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	NR	NR
PYRENE	mg/L	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	NR	NR
BENZO(A) ANTHRACENE	mg/L	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	NR	NR
CHRYSENE	mg/L	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	NR	NR
BENZO(B) FLUORANTENE	mg/L	<2.60E-4	<2.60E-4	<2.60E-4	<2.60E-4	<2.60E-4	<2.60E-4	<2.60E-4	<2.60E-4	NR	NR
BENZO(K) FLUORANTENE	mg/L	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	NR	NR
BENZO(A) PYRENE	mg/L	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	NR	NR
INDENO(1,2,3-CD) PYRENE	mg/L	<3.60E-4	<3.60E-4	<3.60E-4	<3.60E-4	<3.60E-4	<3.60E-4	<3.60E-4	<3.60E-4	NR	NR
DIBENZO(A,H) ANTHRACENE	mg/L	<4.10E-4	<4.10E-4	<4.10E-4	<4.10E-4	<4.10E-4	<4.10E-4	<4.10E-4	<4.10E-4	NR	NR
BENZO(G,H,I) PERYLENE	mg/L	<4.00E-4	<4.00E-4	<4.00E-4	<4.00E-4	<4.00E-4	<4.00E-4	<4.00E-4	<4.00E-4	NR	NR
ANALYSIS OF BTEXs											
BENZENE	µg/L	<2.76	<2.76	<2.76	<2.76	<2.76	<2.76	<2.76	<2.76	NR	5*
TOLUENE	µg/L	<2.23	<2.23	<2.23	<2.23	<2.23	<2.23	<2.23	<2.23	NR	24*
ETHYLBENZENE	µg/L	<1.82	<1.82	<1.82	<1.82	<1.82	<1.82	<1.82	<1.82	NR	2.4*
m+p-XYLENE	µg/L	<1.85	<1.85	<1.85	<1.85	<1.85	<1.85	<1.85	<1.85	NR	300* (Xylenes)
o-XYLENE	µg/L	<2.30	<2.30	<2.30	<2.30	<2.30	<2.30	<2.30	<2.30	NR	
IONIC BALANCE	**NA***	**1.4**	**1.0**	**1.0**	**1.1**	**1.5**	**1.2**	**1.0**	**0.9**	NR	NR
TDS CALCULATED/CONDUCTIVITY	**NA***	**0.69**	**0.57**	**0.55**	**0.57**	**0.57**	**0.59**	**0.59**	**0.53**	NR	NR
TDS MEASURED/TDS CALCULATED	**NA***	**1.0**	**1.3**	**1.1**	**1.0**	**0.8**	**1.0**	**1.1**	**1.3**	NR	NR
ANALYSIS OF EXTRACTABLE HYDROCARBONS (HCs)											
DECANE	mg/L	**1.07E-02**	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	NR	NR
UNDECANE	mg/L	**1.39E-02**	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	NR	NR
DODECANE	mg/L	**9.10E-03**	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	NR	NR
TRIDECANE	mg/L	**9.70E-03**	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	NR	NR
TETRADECANE	mg/L	**1.18E-02**	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	NR	NR
PENTADECANE	mg/L	**2.19E-02**	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	NR	NR
HEXADECANE	mg/L	**2.95E-02**	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	NR	NR
HEPTADECANE	mg/L	**3.17E-02**	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	NR	NR
PRYSTANE	mg/L	**2.55E-02**	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	NR	NR
OCTADECANE	mg/L	**3.38E-02**	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	NR	NR
PHYTANE	mg/L	**4.15E-02**	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	NR	NR
NONADECANE	mg/L	**2.91E-02**	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	NR	NR
EICOSANE	mg/L	**2.69E-02**	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	NR	NR
HENEICOSANE	mg/L	**2.51E-02**	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	NR	NR
DOCOSANE	mg/L	**2.50E-02**	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	NR	NR
TRICOSANE	mg/L	**2.97E-02**	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	NR	NR
TETRACOSANE	mg/L	**2.15E-02**	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	NR	NR
PENTACOSANE	mg/L	**3.31E-02**	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	NR	NR
HEXACOSANE	mg/L	**2.51E-02**	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	NR	NR
HEPTACOSANE	mg/L	**2.57E-02**	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	NR	NR
OCTACOSANE	mg/L	**2.49E-02**	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	NR	NR
NONACOSANE	mg/L	**1.77E-02**	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	NR	NR
TRIACONTANE	mg/L	**2.08E-02**	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	NR	NR
HENTRIACONTANE	mg/L	**1.04E-02**	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	NR	NR
DOTRIACONTANE	mg/L	**1.09E-02**	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	NR	NR
TRITRIACONTANE	mg/L	**1.04E-02**	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	NR	NR
TETRATRIACONTANE	mg/L	**3.20E-03**	<1.10E-04	<1.10E-04	<1.10E-04	<1.10E-04	<1.10E-04	<1.10E-04	<1.10E-04	NR	NR
PENTATRIACONTANE	mg/L	<1.20E-04	<1.20E-04	<1.20E-04	<1.20E-04	<1.20E-04	<1.20E-04	<1.20E-04	<1.20E-04	NR	NR
HEXATRIACONTANE	mg/L	<1.30E-04	<1.30E-04	<1.30E-04	<1.30E-04	<1.30E-04	<1.30E-04	<1.30E-04	<1.30E-04	NR	NR
HEPTATRIACONTANE	mg/L	<1.40E-04	<1.40E-04	<1.40E-04	<1.40E-04	<1.40E-04	<1.40E-04	<1.40E-04	<1.40E-04	NR	NR
OCTATRIACONTANE	mg/L	<1.70E-04	<1.70E-04	<1.70E-04	<1.70E-04	<1.70E-04	<1.70E-04	<1.70E-04	<1.70E-04	NR	NR
TETRACONTANE	mg/L	<2.50E-04	<2.50E-04	<2.50E-04	<2.50E-04	<2.50E-04	<2.50E-04	<2.50E-04	<2.50E-04	NR	NR

NR: Not reported **NA:** not analyzed due to interference by high chloride content **NA*:** not applicable

Table 51 continued

PALAGUA FIELD SUBTERRANEAN WATERS	SAMPLE ID.	PM-10	PM-12	PM-13	PM-16	PM-17	PM-18	PM-19	DECREE 1594/84 ART. 38	Alberta Risk Management Guidelines for Petroleum storage tank sites 2001 Table 4. Generic Hydrocarbon Criteria for the Groundwater Ingestion Pathway
		LOCATED IN BATTERY 1 BEHIND GAS TREATMENT ZONE	LOCATED BEHIND P-112 AND P-20	LOCATED CLOSE TO P-32 IN API AREA	LOCATED AT BOTTOM OF P-125	LOCATED BEHIND FENCE OF BATTERY 1 CLOSE TO PM-14	LOCATED CLOSE TO PM-14	LOCATED CLOSE TO PM-18		
SUBMISSION: 100113179	SAMPLING DATE	10-Oct-11	8-Oct-11	8-Oct-11	8-Oct-11	11-Oct-11	11-Oct-11	11-Oct-11		
Component	**Unit**	**200679237**	**200678446**	**200678467**	**200678468/69**	**200679654**	**200679655**	**200679656**		
***IN SITU* ANALYSIS**										
DEPTH	m	2.48	3.75	3.82	1.89	0.49	0.71	0.27	NR	NR
DISSOLVED OXYGEN	mg O_2/L	3.1	0.0	0.0	1.7	0.0	0.0	0.0	NR	NR
PH/T (º C)	pH units	6.79/31.7	6.03/30.0	6.59/35.5	7.69/33.3	6.37/30.6	5.81/30.9	6.06/31.3	5.0 - 9.0	NR
WATER TEMPERATURE	ºC	31.7	30.0	35.5	33.3	30.6	30.9	31.3	NR	NR
LABORATORY ANALYSIS										
PHYSICAL AND CHEMICAL ANALYSIS										
PH / T (º C) IN WATER	pH units	6.93/22.5	7.03/23.7	6.59/23.7	7.80/23.4	6.39/21.1	5.93/21.2	6.14/21.1	5.0 - 9.0	NR
TOTAL ALKALINITY	mg $CaCO_3$/L	230	375	366	1182	76.3	244	286	NR	NR
CARBONATES	mg CO_3=/L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NR	NR
BICARBONATES	mg HCO_3-/L	280	458	446	1442	93.1	298	349	NR	NR
CHLORIDES	mg/L	0.79	14.0	166	47.1	4.72	**4210**	**1575**	250.0	NR
CONDUCTIVITY	µS/cm/ºC	445/25.0	660/25.0	1434/25.0	2245/25.0	162/25.0	14030/25.0	5330/25.0	NR	NR
PHENOLS	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.002	NR
GREASES AND OILS - HYDROCARBONS	mg/L	2.31	2.60	<2.00	2.63	4.96	5.08	24.8	don't accept visible film	NR
NON-POLAR HYDROCARBONS	mg/L	<1.00	<1.00	<1.00	<1.00	<1.00	1.85	6.38	NR	NR
NITRATES (NO_3)	mg NO_3-N/L	0.95	<0.090	3.75	0.96	0.37	NA	<0.090	10.0	NR
NITRITES (NO_2)	mg NO_2-N/L	<0.029	<0.029	<0.011	<0.029	<0.029	0.012	**9.35**	1.0	NR
AMMONIACAL NITROGEN	mg NH_3-N/L	<0.49	<0.49	**3.88**	<0.49	<0.49	**35.5**	**14.2**	1.0	NR
DISSOLVED SOLIDS	mg/L	270	358	938	1447	124	7453	3166	NR	NR
SULFATES	mg SO_4=/L	4.80	7.89	38.8	42.3	0.66	<4.00	<4.00	400.0	NR
ANALYSIS OF DISSOLVED METALS										
CALCIUM	mg/L	73.82	33.14	58.97	14.78	9.754	554	216	NR	NR
MAGNESIUM	mg/L	3.242	67.37	27.85	26.88	1.831	203	48.67	NR	NR
SODIUM	mg/L	14.25	57.03	230	652	27.11	2004	779	NR	NR
POTASSIUM	mg/L	0.450	0.391	2.496	0.789	0.256	14.21	10.75	NR	NR
MANGANESE	mg/L	0.0371	3.032	3.102	0.0466	0.146	11.19	2.175	NR	NR
IRON	mg/L	0.205	0.274	0.711	0.104	0.443	145	3.814	NR	NR
ALUMINUM	mg/L	0.0547	0.149	<0.214	0.0799	0.253	<0.214	<0.214	NR	NR
TOTAL METAL ANALYSIS										
HEXAVALENT CHROMIUM	mg Cr_{+6}/L	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	0.05	NR
ARSENIC	µg/L	1.18	**265**	9.65	15.3	4.01	24.4	30.0	50*	NR
SELENIUM	µg/L	<0.389	0.830	4.72	0.838	0.793	<10.0	<10.0	10*	NR
CADMIUM	µg/L	1.34	2.87	0.910	0.271	1.12	0.319	2.59	10*	NR
LEAD	µg/L	4.25	42.2	7.04	5.22	31.4	8.67	**63.4**	50*	NR
VANADIUM	µg/L	13.3	264	17.4	80.5	84.2	14.6	173	NR	NR
ZINC	µg/L	246	208	47.0	37.8	105	<152	376	15000*	NR
BARIUM	µg/L	153	**1477**	662	225	722	**13900**	**7012**	1000*	NR
MOLYBDENUM	µg/L	0.315	0.944	1.44	24.6	0.715	<0.290	0.455	NR	NR
COPPER	µg/L	41.5	96.8	23.6	17.5	75.5	15.1	92.2	1000*	NR
NICKEL	µg/L	11.5	61.1	14.5	13.4	25.4	25.5	68.1	NR	NR
MERCURY	µg/L	<0.441	<0.441	<0.441	<0.441	<0.441	<0.441	<0.441	2*	NR
ANALYSIS OF POLYAROMATIC HYDROCARBONS (PAHs)										
NAPHTHALENE	mg/L	<1.60E-4	<1.60E-4	<1.60E-4	<1.60E-4	<1.60E-4	<1.60E-4	<1.60E-4	NR	NR
ACENAPHTILENE	mg/L	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	NR	NR
ACENAPHTHENE	mg/L	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	<1.90E-4	NR	NR
FLUORINE	mg/L	<2.00E-4	<2.00E-4	<2.00E-4	<2.00E-4	<2.00E-4	<2.00E-4	**7.20E-03**	NR	NR
PHENANTRENE	mg/L	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	**1.66E-02**	NR	NR
ANTHRACENE	mg/L	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	NR	NR
FLUORANTENE	mg/L	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	NR	NR
PYRENE	mg/L	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	<2.20E-4	NR	NR
BENZO(A) ANTHRACENE	mg/L	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	NR	NR
CHRYSENE	mg/L	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	<2.50E-4	NR	NR
BENZO(B) FLUORANTENE	mg/L	<2.60E-4	<2.60E-4	<2.60E-4	<2.60E-4	<2.60E-4	<2.60E-4	<2.60E-4	NR	NR
BENZO(K) FLUORANTENE	mg/L	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	NR	NR
BENZO(A) PYRENE	mg/L	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	<2.80E-4	NR	NR
INDENO(1,2,3-CD) PYRENE	mg/L	<3.60E-4	<3.60E-4	<3.60E-4	<3.60E-4	<3.60E-4	<3.60E-4	<3.60E-4	NR	NR
DIBENZO(A,H) ANTHRACENE	mg/L	<4.10E-4	<4.10E-4	<4.10E-4	<4.10E-4	<4.10E-4	<4.10E-4	<4.10E-4	NR	NR
BENZO(G,H,I) PERYLENE	mg/L	<4.00E-4	<4.00E-4	<4.00E-4	<4.00E-4	<4.00E-4	<4.00E-4	<4.00E-4	NR	NR
ANALYSIS OF BTEXs										
BENZENE	µg/L	<2.76	<2.76	<2.76	<2.76	<2.76	<2.76	<2.76	NR	5*
TOLUENE	µg/L	<2.23	<2.23	<2.23	<2.23	<2.23	**4.267**	<2.23	NR	24*
ETHYLBENZENE	µg/L	<1.82	<1.82	<1.82	<1.82	<1.82	**5.001**	<1.82	NR	2.4*
m+p-XYLENE	µg/L	<1.85	<1.85	<1.85	<1.85	<1.85	**13.06**	<1.85	NR	300* (Xylenes)
o-XYLENE	µg/L	<2.30	<2.30	<2.30	<2.30	<2.30	**10.15**	<2.30	NR	
IONIC BALANCE	**NA***	**1.0**	**1.2**	**1.2**	**1.2**	**1.1**	**1.1**	**1.0**	NR	NR
STD CALCULATED/CONDUCTIVITY	**NA***	**0.53**	**0.62**	**0.53**	**0.66**	**0.57**	**0.52**	**0.53**	NR	NR
STD MEASURED/STD CALCULATED	**NA***	**1.1**	**0.9**	**1.2**	**1.0**	**1.3**	**1.0**	**1.1**	NR	NR
ANALYSIS OF EXTRACTABLE HYDROCARBONS (HCs)										
DECANE	mg/L	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	**4.40E-03**	**1.52E-02**	NR	NR
UNDECANE	mg/L	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	**8.70E-03**	**1.81E-02**	NR	NR
DODECANE	mg/L	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	**3.70E-03**	**1.08E-02**	**7.35E-02**	NR	NR
TRIDECANE	mg/L	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	**4.40E-03**	**2.87E-02**	**1.05E-01**	NR	NR
TETRADECANE	mg/L	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	**5.80E-03**	**4.72E-02**	**1.21E-01**	NR	NR
PENTADECANE	mg/L	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	**8.70E-03**	**5.02E-02**	**2.81E-01**	NR	NR
HEXADECANE	mg/L	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	**1.45E-02**	**5.09E-02**	**2.79E-01**	NR	NR
HEPTADECANE	mg/L	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	**1.38E-02**	**7.23E-02**	**3.22E-01**	NR	NR
PRYSTANE	mg/L	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	**2.06E-02**	**8.00E-02**	**3.57E-01**	NR	NR
OCTADECANE	mg/L	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	**2.32E-02**	**8.74E-02**	**3.59E-01**	NR	NR
PHYTANE	mg/L	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	**2.83E-02**	**1.04E-01**	**5.33E-01**	NR	NR
NONADECANE	mg/L	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	**2.58E-02**	**4.67E-02**	**4.98E-01**	NR	NR
EICOSANE	mg/L	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	**2.82E-02**	**7.05-02**	**4.88E-01**	NR	NR
HENEICOSANE	mg/L	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	**2.92E-02**	**5.05E-02**	**4.14E-01**	NR	NR
DOCOSANE	mg/L	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	**2.43E-02**	**6.32E-02**	**3.94E-01**	NR	NR
TRICOSANE	mg/L	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	**2.93E-02**	**4.65E-02**	**3.37E-01**	NR	NR
TETRACOSANE	mg/L	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	**3.18E-02**	**4.27E-02**	**4.43E-01**	NR	NR
PENTACOSANE	mg/L	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	**4.52E-02**	**4.78E-02**	**3.87E-01**	NR	NR
HEXACOSANE	mg/L	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	**3.24E-02**	**9.09E-02**	**3.54E-01**	NR	NR
HEPTACOSANE	mg/L	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	**3.88E-02**	**8.43E-02**	**3.28E-01**	NR	NR
OCTACOSANE	mg/L	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	**3.67E-02**	**6.58E-02**	**2.71E-01**	NR	NR
NONACOSANE	mg/L	<8.00E-05	<8.00E-05	<8.00E-05	<8.00E-05	**4.22E-02**	**4.65E-02**	**2.65E-01**	NR	NR
TRIACONTANE	mg/L	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	**4.26E-02**	**5.17E-02**	**2.59E-01**	NR	NR
HENTRIACONTANE	mg/L	<9.00E-05	<9.00E-05	<9.00E-05	<9.00E-05	**3.59E-02**	**5.13E-02**	**2.59E-01**	NR	NR
DOTRIACONTANE	mg/L	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	**2.28E-02**	**3.68E-02**	**1.16E-01**	NR	NR
TRITRIACONTANE	mg/L	<1.00E-04	<1.00E-04	<1.00E-04	<1.00E-04	**2.31E-02**	**3.26E-02**	**1.03E-01**	NR	NR
TETRATRIACONTANE	mg/L	<1.10E-04	<1.10E-04	<1.10E-04	<1.10E-04	**1.41E-02**	**1.57E-02**	**6.91E-02**	NR	NR
PENTATRIACONTANE	mg/L	<1.20E-04	<1.20E-04	<1.20E-04	<1.20E-04	**1.16E-02**	**1.42E-02**	**6.38E-02**	NR	NR
HEXATRIACONTANE	mg/L	<1.30E-04	<1.30E-04	<1.30E-04	<1.30E-04	<1.30E-04	**1.01E-02**	**4.24E-02**	NR	NR
HEPTATRIACONTANE	mg/L	<1.40E-04	<1.40E-04	<1.40E-04	<1.40E-04	<1.40E-04	<1.40E-04	**3.08E-02**	NR	NR
OCTATRIACONTANE	mg/L	<1.70E-04	<1.70E-04	<1.70E-04	<1.70E-04	<1.70E-04	<1.70E-04	**2.19E-02**	NR	NR
TETRACONTANE	mg/L	<2.50E-04	<2.50E-04	<2.50E-04	<2.50E-04	<2.50E-04	<2.50E-04	<2.50E-04	NR	NR

NR: Not reported **NA:** not analyzed for interference by high chloride content **NA*:** not applicable

The results of the analyses in Table 51 indicate the following:

- pH was measured in the range of 5.81 to 7.87 meeting the range stipulated by Article 38 of the mentioned Decree (5.0 – 9.0 units of pH).

- Dissolved oxygen was found at concentrations in the range of 0.0 to 4.1 mg O_2/L. The low values of dissolved oxygen in some wells are considered normal for this type of water, in which contact with air is minimal.

- Since the pH of all samples was less than 8.3, no carbonate ions were detected. Average bicarbonate ion concentration for twelve wells was 299 mg HCO_3/L (range: 93-458 mg HCO_3/L), compared to 1,211 mg HCO_3/L (range: 768-1.442 mg HCO_3/L) for three wells.

- The average conductivity was 486 µS/cm (Range: 162-660 µS/cm) for wells PMs-1, 2, 3, 5, 8, 9, 10, 11, 12 and 17. The remaining wells were in the range of 1,434 to 14,030 µS/cm, representing weak to moderate mineralization. The relationship between conductivity and mineralization is called Rodier's relationship and is shown in Table 52.

Table 52 RODIER UNDERGROUND WATER CLASSIFICATION

Conductivity, µS/cm	Grade of mineralization
< 100	Very weak
100 > k < 200	Weak
200 > k < 333	Slightly moderate
333 > k < 666	Moderate
666 > k < 1000	Slightly strong
> 1000	Strong

- Total dissolved solids (TDS) were found at concentrations in the range of 124 to 938 mg/L in wells PMs-1, 2, 3, 5, 8, 9, 10, 12, 13 and 17, which indicates fresh water. Slightly saline water with TDS between 1,015 to 7,453 mg/L was found in wells PM-4, 6, 16, 18 and 19. Based on Reynolds classification (2002), underground water is fresh for TDS measurements less than 1000 mg/L and slightly saline for TDS measurements between 1,000 to 10,000 mg/L. Table 53 describes the various classes of water quality.

Table 53 REYNOLDS UNDERGROUND WATER CLASSIFICATION SYSTEM

Water Quality	TDS (mg/L)
Fresh	< 1,000
Slightly to moderately saline	1,000 to 10,000
Very saline	10,000 to 100,000

- Chloride was measured at concentrations of 0.79 mg/L to 199mg/L in 14 wells, within the limit of Colombian law (250 mg/L). As with dissolved-solids content, isolated occurrences of well water with high chloride analysis in concentrations of 1,575 mg/L and 4,210 mg/L were found in wells PM-18 and PM-19, respectively.

- Nitrites, ammonia nitrogen, nitrates, sulfates, and metals (hexavalent chromium, arsenic, selenium, cadmium, lead, zinc, barium, copper, and mercury) were found at concentrations within the limits permitted by the Colombian Law. The only exceptions to the reported values are nitrites (PM-3 and PM-19), ammonia nitrogen (PM-1, PM-3, PM-4, PM-13, PM-18 and PM-19), arsenic (PM-3, PM-4, PM-6 and PM-12), lead (PM-19), and barium (PM-12, PM-18 and PM-19).

- All monitoring wells show low concentrations of oil and grease with the exception of PM-19 which shows concentrations of oil and grease (24.8 mg/L) and non-polar hydrocarbons (6.38mg/L). The results for the other wells are in the limit or below the minimum quantifiable concentrations by the methods used in the laboratory.

- PAH levels were found at concentrations below the detectable limit in all samples, with the exception of well PM-19.

- In all the monitor wells except well PM-18, Phenol and BTEXs (benzene, toluene, ethyl benzene, and xylene) concentrations were below the detectable limit by the methods used in the laboratory.

- HCs (extractable hydrocarbon) were at a level below the minimum amount quantifiable for the methods used in the laboratory. This excludes the results obtained for extractable hydrocarbons (HCs) in wells PM-1, PM-17, PM-18 and PM-19.

- In most of the wells, the underground water is chemically stable. The ion balance (anions/cations) and TDS/conductivity ratio are shown below in Figures 40 and 41, respectively.

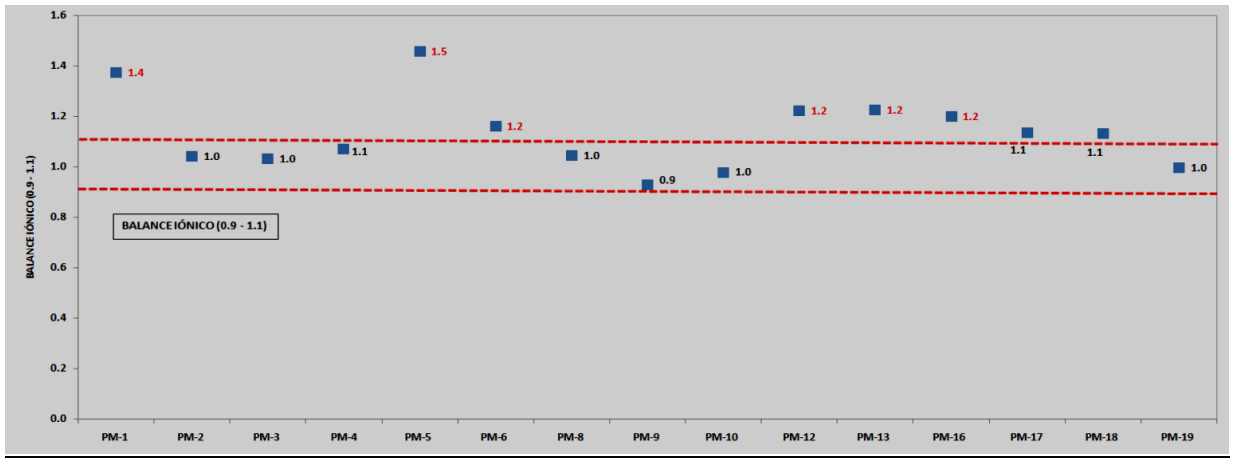


Figure 40 Ion Balance

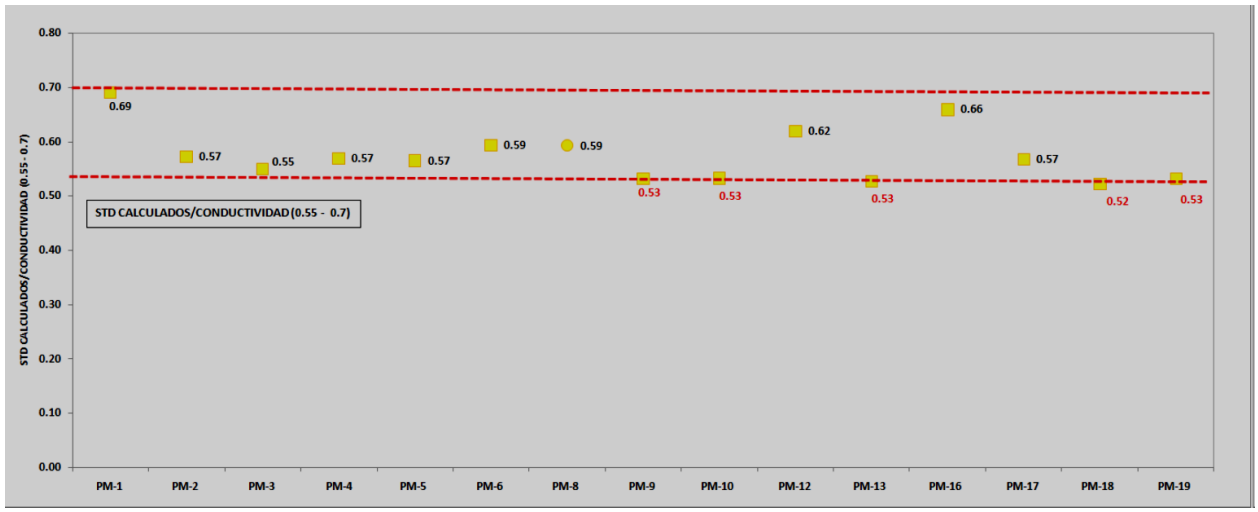


Figure 41 TDS/Conductivity Ratio

- The lab results from studies conducted in 2004 through 2011 allow us to conclude that underground waters with concentrations of oil and grease, phenol, BTEXs, extractable and polyaromatic hydrocarbons are close to or less than the minimum standards. A significant increase was present in the samples evaluated for levels of ammonia nitrogen in most of the waters, exceeding the limits. This is probably due to the fertilizer used by the farmers in the area.

F.2.4 WASTE WATER MANAGEMENT

The information presented here in the 2010 ESIA remains pertinent to the new report being presented for the 32-well expansion project. There are two kinds of so called "Waste Water" in the Palagua oil field, domestic waste water and industrial (produced) waste water.

F.2.4.1 DOMESTIC WASTE WATER

Domestic waste waters at the drilling rig site are from sanitary services and personal cleaning. A water treatment plant known as "Red Fox" is used to treat these waters by using an aerobic treatment of activated muds.

The water treatment plant's outflowing water is collected in a tank. From there, it goes into the industrial water treatment system for the Field. Occasionally, access roads are sprayed or irrigated if conditions of the outflowing water meet the parameters established in Decree 1594/84 and any others that may apply. Table 54 shows the quality of the treated water.

Table 54 QUALITY OF TREATED DOMESTIC WASTE WATER

Parameters	Unit	Reading
pH		6.0
Sulfates	ppm	70
Turbidity	NTU	30
Color	APHA	15
Chlorides	ppm	150
Residual chlorine	ppm	0.1
Oxygen	ppm	5.0
Temperature	ºC	27
Conductivity	µS/ cm	1630
Suspended solids	ppm	40

F.2.4.2 INDUSTRIAL WASTE WATER

Water is produced in conjunction with oil as an emulsion from the oil bearing Tune and Guaduas formations found in the Palagua field. This water passes through a complex treatment system that includes an API oil and water gravity separator and a treatment plant with a capacity to treat 14,000 barrels of water per day with a maximum injection pressure of 2,000 psi. The produced water is cleaned, treated and then reinjected into the reservoir through existing injector wells. In the Palagua field, there are six injector wells: P-26, P-97, P-120, P-121, P-194,

and P-195. Generally, four wells are in use at any given time while two wells are held in stand-by for contingencies.

In 2011, an average 12,000 barrels of residual waters consisting of produced water, fresh water used in the process of desalting crude oil and small amounts of contaminated rainwater were treated per day. The injection pressure averaged 750 psi.

Figure 42 shows the daily average of injected water for 2010 and 2011, by month.

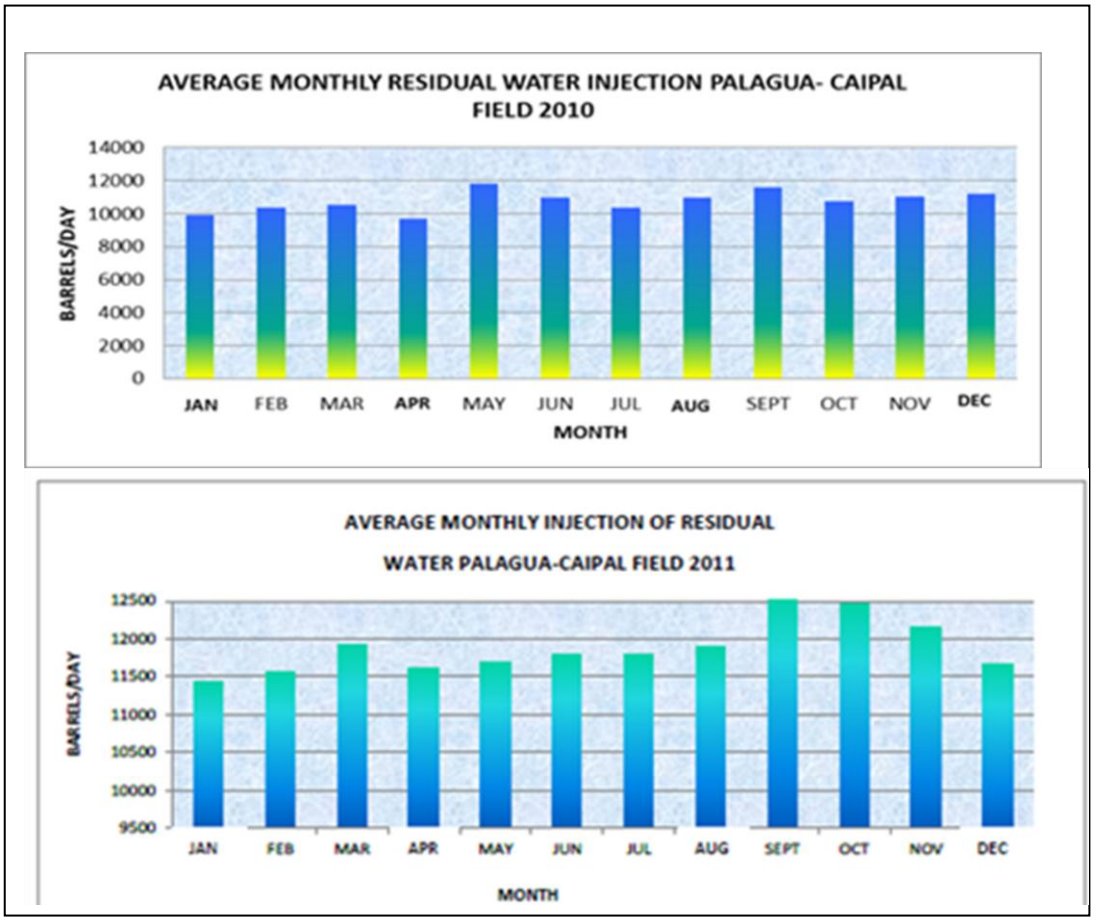


Figure 42 Residual Water Injection 2010 and 2011

The quality of water to be injected is continually monitored and controlled through the measurement of certain parameters as shown in Table 55. Measurements were taken at three control sites: the water inlet referred to in the table as API, the holding tank (TK100) and after

being processed through the filtration system (out filters). Table 55 lists these measurements for January to July of 2011. In all instances, the quality of the water improves as it moves through the treatment plant. Thus, water quality improves significantly prior to re-injection in the reservoir.

Table 55 PHYSICAL AND CHEMICAL CONTROL PARAMETERS – PALAGUA FIELD, 2011

	IN API					IN TK100					OUT FILTERS				
	TSS (ppm)	Turbidity (ppm)	Oils (ppm)	TDS (ppm)	O/D (ppm)	TSS (ppm)	Turbidity (ppm)	Oils (ppm)	TDS (ppm)	O/D (ppm)	TSS (ppm)	Turbidity (ppm)	Oils (ppm)	TDS (ppm)	O/D (ppm)
January	27	58	80	4655		17	20	13	4225		3	4	2	3515	
February	37	59	56	5076	6	20	29	8	4535	1.4	6	7	1	4307	1
March	27.2	34.5	51.6	6617.1	5	16.9	21.8	5.7	6016.3	1.4	4.3	4.7	1.5	5878.4	1
April	36	37	26	5954	5	16	16	8	5272	2	4	4	2	5013	1
May	35.2	42.6	35.2	5819.4	5.4	19.5	18.3	7.1	4859	1.6	6.9	8	1.6	4541.9	1.3
June	28.93	33.70	32.20	6395.00	6.03	15.43	18.29	8.73	6057.40	1.79	4.89	6.54	3.40	5916.00	1.45
July	31.24	37.29	36.16	6361.61	6.29	15.1	15.13	10.13	5930	2.94	3.58	4.58	2	5718.06	1.26

Figures 43 and 44 show the behavior of measured TDS (total dissolved solids) and measured turbidity during 2011. Series 1 (blue line) represents the measurements at the water inlet, Series 2 (red line) represents the measurements in the holding tank – Tank100, and Series 3 (green line) represents the measurements once the water has passed through the filtration system or at the out filters.

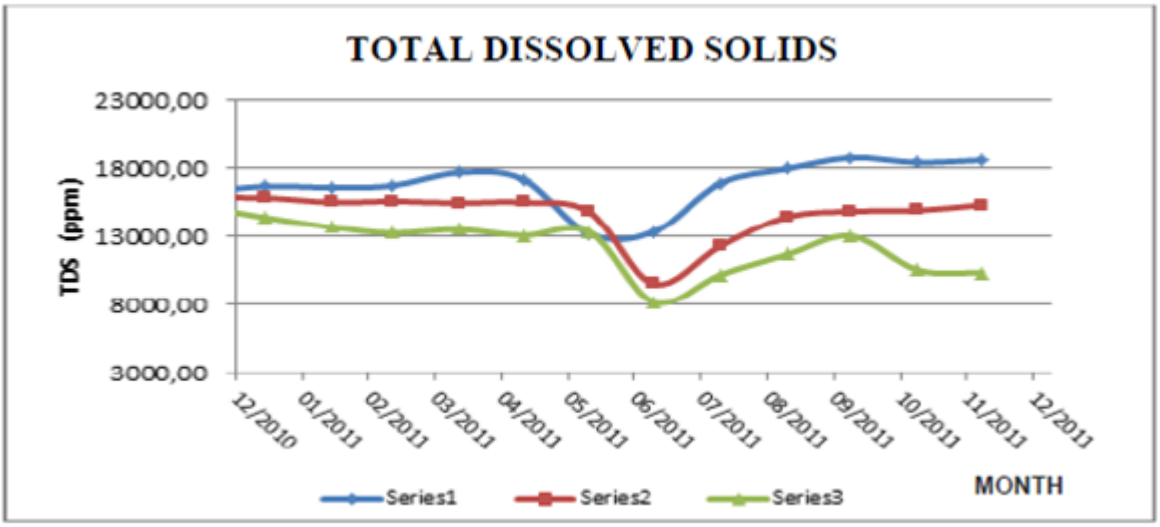


Figure 43 Analysis of Total Dissolved Solids – 2011

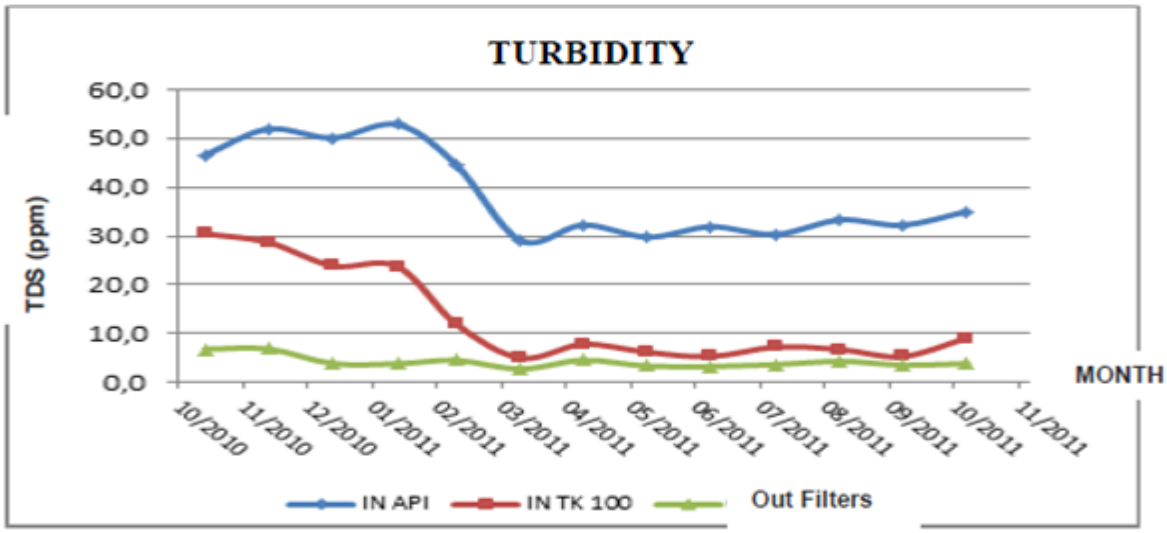


Figure 44 Turbidity Analysis - 2011

F.2.4.3 INJECTION PLANT OF RESIDUAL WATER

Since the construction of the water injection plant in 1994, all produced water at the field is injected, after physico-chemical treatment.

The injection of residual waters system consists of the following stages:

- Clarification: solids removal
- Skimming: residual oil removal
- Filtration: solids / oil removal
- Injection: To the reservoir - Tune Formation

Palagua field produces approximately 11,100 BWPD (barrels of water per day). The produced water is first treated in general separators (commonly known as API separators) by injecting coagulants and flocculants to precipitate the solids that are in suspension. The separated water and oil are taken to different storage tanks in Battery No. 1 and in Stations 2 and 4. Water is then taken to the water injection plant near Battery No. 1 (most commonly known as PIA) using a P-100 A/B/C pump.

Photo 56 API separator

Once water enters the plant, treatment continues with the injection of oxygen scavengers and biocide. The water will continue through a stabilizer tank (TK- 100), and then it is sent to a skimmer tank (TK- 101) using a P-101 A/B/C pump where gravity helps to trap suspended solids and oil. All these processes are designed to achieve a good quality of water for reinjection into the Tune formation.

Photo 57 Water treatment plant at Palagua field

Once the clean water is obtained, it goes directly to the hydrostatic head tank (TK-103) from where water is pumped by three pumps P-109 A/B/C for re-injection in the Palagua Field. The injection is carried out by these three (3) pumps that transport the water through 8" tubing (coated with green color) towards the four injection wells. The water is injected into the Tune formation at 3,200' of average depth. Presently about 11,100 bbl of water are being injected daily into wells P-26, P-120 and P-121. Well P-97 is an additional well that can be used for contingencies.

The operating conditions of the water injection plant are tabulated in Table 56.

Table 56 OPERATING CONDITIONS OF WATER INJECTION PLANT

Capability of design:	12,000 bpd
Maximum Injection Pressure:	2,000 psi
Normal Operation Flow rate:	11,100 bpd
Actual Operation Pressure:	700 psi

Bpd: barrels / day

Figure 45 depicts a schematic of the water injection plant. Here, the tanks, the filtration system and injection pumps can be observed.

The quality of the injected water is controlled daily by measuring the suspended solids, dissolved oxygen and oil in water at the entrance and also at the exit of the plant. Corrosion coupons have also been installed to determine the corrosion and scale formation.

Table 57 OPERATIONAL PARAMETERS OF THE WATER INJECTION PLANT (PIA)

OPERATING PARAMETERS		
Parameters	Concentration	
	Entrance	Exit
Dissolved Oxygen	200-500 ppb	0-50 ppb
Greases and oils	11 ppm	4 ppm
Suspended soils	30 ppm	5 ppm
Temperature	100 °F	100 °F
Carbon Dioxide	18 ppm	18 ppm

The chemicals used in the treatment of residual water are listed in the table below.

Table 58 CHEMICALS USED IN THE TREATMENT OF RESIDUAL WATER

CHEMICAL	Consumption, gpd	Concentration, ppm
Scale inhibitor	2.0	8
Oxygen scavenger	2.0	7
Flocculant (polymer)	0.5	1
Coagulant (polymer)	0.1	5
Biocide	1.4	80

gpd: gallons per day ppm: parts per million

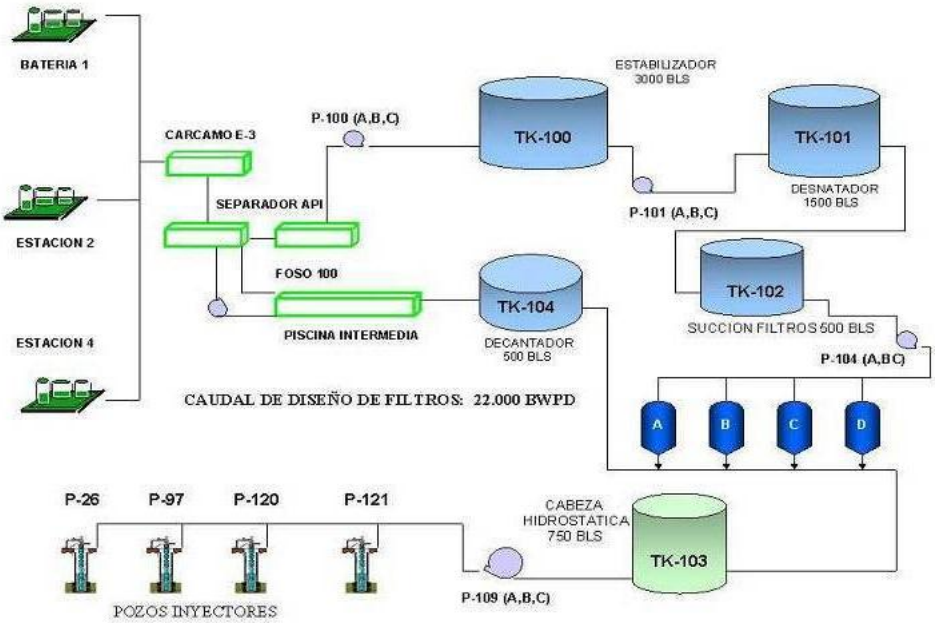


Figure 45 Schematic of the Water Injection Plant

SPANISH TO ENGLISH TRANSLATION KEY

-Bateria 1	Battery 1	-P	Pump
-Estación 2	Station 2	-Caudal de diseño de filtros	Filters design rate
-Estación 4	Station 4	-Estabilizador	Stabilization tank
-Pozos injectors	Injection wells	-Desnatador	Skimmer tank
-Cárcamo	Sump	-Decantador	Precipitation tank
-Separador API	API Separator	-Suction filtros	Suction Filters
-Foso	Ditch	-Cabeza hidrostática	Hydrostatic Head
-Piscina intermedia	Intermediate pool		

Should an operational emergency occur, the field has a pool with extra storage capacity that can be used until the injection plant is commissioned again. The following photo shows the industrial water storage pools available in the field.

Photo 58 Industrial pools of water storage

Table 59 WATER ANALYSIS OF THE RESIDUAL WATER TREATMENT PLANT

RESIDUAL WATERS TREATMENT PLANT LABORATORY ANALYSIS - 2nd SEMESTER 2009					
PARAMETERS	**UNITS**	**API OIL SEPARATOR**	**TANK-100 INLET**	**FILTERS OUTLET**	**PUMPS OUTLET**
PHYSICALS					
Temperature	º C	40	38	38	34
Pressure	psi	14.7	20	20	950
IONS					
Total hardness	ppm CaCO3	5840	5720	5700	5720
Hardness as calcium carbonate	ppm CaCO3	4950	4850	4820	4810
Alkalinity	ppm CaCO3	420	450	420	420
Chlorides	ppm	14000	14000	13980	13950
Sulfites as SO4	ppm	18	18	20	16
Barium	ppm	40	42	45	28
Iron, soluble	ppm	4.2	3.9	4.2	3.98
Iron, total	ppm	7.8	6.4	6.2	6.2
GASES					
Carbon dioxide	ppm	22	20	20	22
H2S	ppm	0.2	0.1	0.1	0.1
Dissolved oxygen	ppm	1000	50	30	10
ELECTROCHEMICALS					
pH		7	6.5	6.8	6.9
Conductivity	uS/cm	33.3	35.1	34.5	32.9
TDS	ppm	19850	19820	19830	19750
CORROSION					
Index/Pit index	MPY				
Amine	ppm	2	2	2	2
OTHERS					
TSS	ppm	152	20	6	4.2
Oil carryover	ppm	498	19	4	3
Turbidity	ppm	315	21	8	5

F.3 SOIL QUALITY

Due to previous hydrocarbon operations in the field, the Colombian Petroleum Institute (ICP from Ecopetrol) provides technical advice for the landfarming of this field. ICP performed a physic-chemical characterization of the soil and (in the absence of local regulations) uses the Louisiana Administrative Code, which establishes the criteria for quality of bioremediation soils, as the comparison standard.

F.3.1 PRINCIPLES OF BIODEGRADATION OF HYDROCARBONS

The biodegradation is a process of oxidation by means of the metabolic action and chemical interaction with microorganisms such as bacteria, actinomycetos and others. Molecular oxygen is important for fast biodegradation of hydrocarbons.

Worldwide, the oil industry has utilized microorganisms for over 50 years for the biodegradation of hydrocarbons in the treatment of residual waters and oily residues. The biodegradation of hydrocarbons is an acceptable treatment for final disposal of oily residues produced in the oil fields. The hydrocarbon molecule is turned into innocuous substances with the oxidation of the hydrocarbon using minimum energy and cost.

The success in the bio treatment requires a specific and healthy microorganism population, oxygen, nutrients and an environment with balanced pH. Figure 46 illustrates this process.

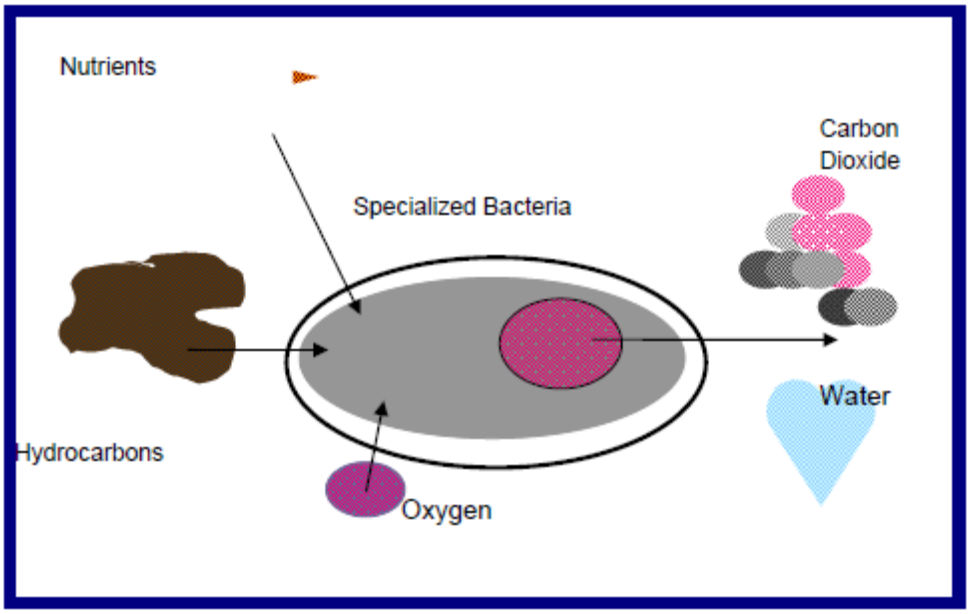


Figure 46 Biodegration Process

Ecopetrol since 1991, through the Colombian Institute of Oil (ICP) has developed and applied successful bioremediation technology along with intensive aeration for the treatment and disposal of oily residues, treatment of residual waters and environmental restoration of grounds impacted by hydrocarbons.

F.3.2 TREATMENT UTILIZING THE TECHNOLOGY OF LAND FARMING

The technology known as land farming, land treatment or land application, is a method for the aerobic biodegradation of hydrocarbons.

This method is applicable to soil that contains oil, water and solids. Its effectiveness depends upon the physical-chemical characteristics of the soil, characteristics and composition of the oily residue, climatic conditions, and humidity.

A representative scheme of the application of the process of biodegradation is shown in Figure 47.

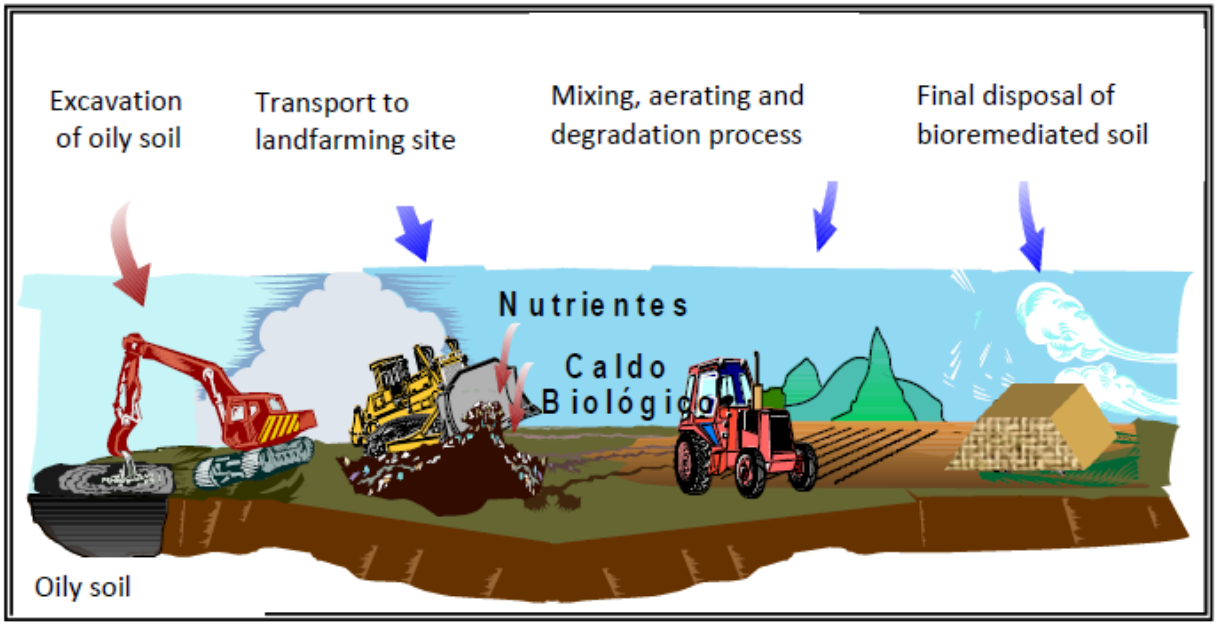


Figure 47 Scheme of the Mixture for the Treatment

F.3.3 BIOREMEDIATION TREATMENT

F.3.3.1 BIO NUTRIENTS

For the process of biodegradation, macro bio nutrient concentrations are utilized in a proportion C:N:P (Carbon:Nitrogen:Phosphorus) of 200:10:1:0.1 or 100:10:1:0.1.

When Carbon, Nitrogen and Phosphorus are not in balance, then commercial inorganic fertilizers are added to the mixture. These fertilizers contain salts like ammonium nitrate (NH_4NO_3), potassium chloride (KCl), potassium nitrate (KNO_3), di-ammoniac sulphate or Super phosphates (P_20_2), and others.

The micronutrients are necessary to maintain adequate environmental conditions for the metabolism of the microbiota in the ground and facilitating the decomposition of organic material. These nutrients are generally found in natural grounds forming compounds like Sulfates, hydroxides or iron, manganese, calcium, magnesium, zinc, cobalt, copper, aluminum oxides, etc.

F.3.3.2 CONDITIONING OF THE MIXTURE

In bioremediation, microorganisms use the hydrocarbon as a source of carbon. For efficient land farming at the Palagua field, the mixture of the material to be treated is prepared with an initial concentration of total hydrocarbons between 6 to 10% of TPH (Total Petroleum Hydrocarbon) in dry weight (w/w). To achieve the proper pH, agricultural lime (CaOH) and magnesium lime were used to adjustment of acidity of the mixture in treatment. The humidity of the mixture is adjusted with addition of water to achieve humidity between 80 and 90% in the treatment system.

F.3.3.3 PROCESS OF BIO REMEDIATION

This process consists of increasing the microorganism's population in the treatment mixture to improve the efficiency of biodegradation. The harvesting of microorganism is accomplished in bioreactors under appropriate environmental conditions to proliferate bacteria in a range of 10E +06 to 10E +09 Ufc/ml.

Once the cultivated microbial is obtained in high concentrations of microorganisms, then the microbial broth is added directly to the mixture of soil and hydrocarbons.

<u>The processes for native microorganisms were developed by Ecopetrol. The certified laboratories of Biotechnologies provide technical support for the application in bioremediation of oily residues.</u>

F.3.3.4 PREPARATION OF THE MIXTURE OF TREATMENT

For the Palagua Field, the initial mixture of oily residues shows TPH around 21%. The homogenization process is accomplished using excavators. The following actions were taken to carry out the bioremediation.

- Movement and mixing of the contaminated material: The areas show different hydrocarbon concentration, so mixing with excavators to achieve a uniform hydrocarbon concentration in the area is required.
- Preparation and sprinkling of the microbial broth:
- Addition of nutrients and lime: The addition of nutrients and the pH control are applied in each zone.
- Aeration: The aeration is carried out by intensive mixing with two excavators.

Figure 48, shows a schematic drawing of the bioremediation plant.

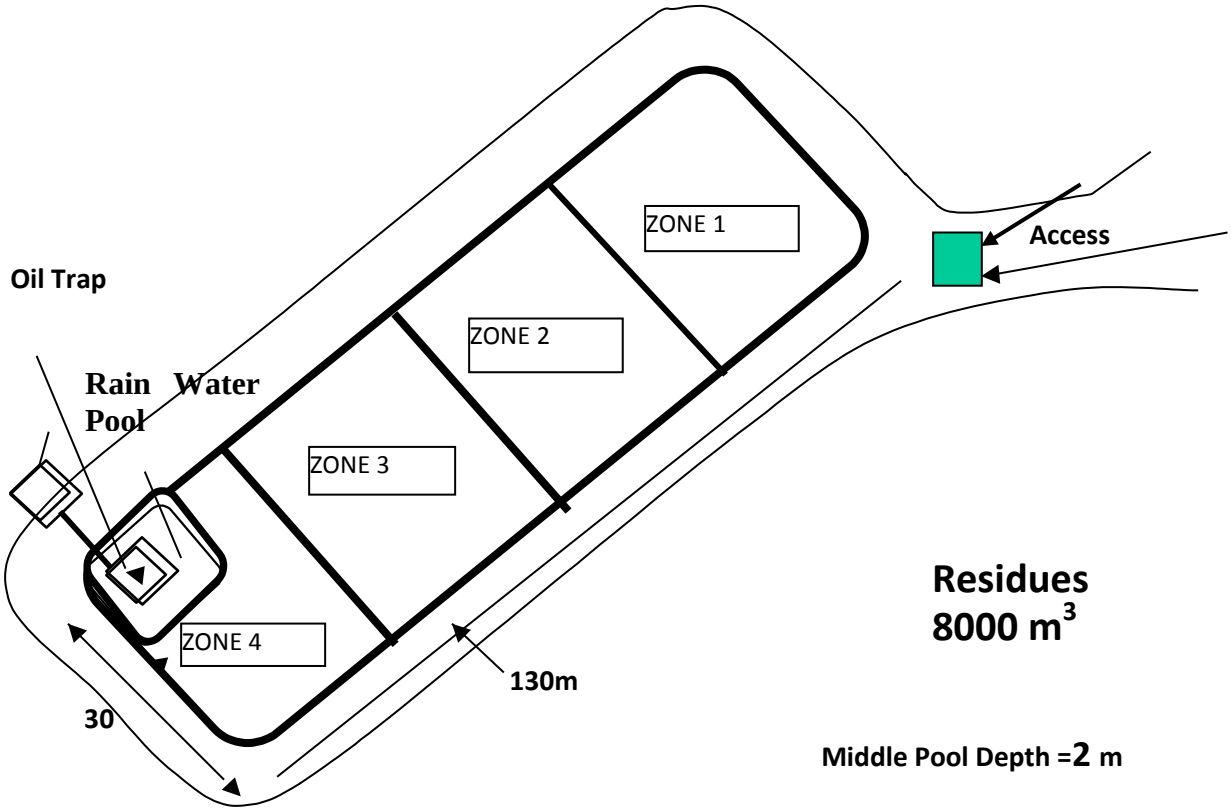


Figure 48 Sample zones of the Land Farming in Palagua Field

The soil mixing, aeration, and sprinkling of microbial and nutrients broth for the removal of hydrocarbon continues until reducing the average TPS to 9% w/w. With the excavator, the mixture is aired to improve the homogenization and the porosity of the system.

F.3.3.5 COMPLETION OF THE BIOREMEDIATION PROCESS

The process of bioremediation for land farming is completed when TPH reaches less than 3% w/w, representing a removal up to 80% of the initial TPH.

According to the experience in Palagua region, the time for the bioremediation process of Land farming is about six (6) to ten (10) months.

The treated material is reused as refill material for the construction of road slopes and for the reforestation of industrial areas.

F.3.4 SOIL SAMPLING FROM THE PALAGUA FIELD LANDFARMING AREA

First, drilling fluid and cuttings are carried through a conventional solid control and a decanter centrifuge and dewatering system to separate liquid and solids. Then, drilling cuttings are transported in containment trucks to the "land farming" area of the Palagua field, for bioremediation treatment using microorganisms (yeasts, bacteria and fungi). Next, nutrients are added, and the land is periodically tilled to bio-degrade wastes into nontoxic residues prior to final disposal. About 480 m3 of drilling wastes per well are deposited in the treatment area. During the treatment process the site is monitored to measure progress and to determine the need for enhancing the biodegradation process. After completing the treatment process and ensuring the drilling wastes are suitable for their intended use, they are transported and disposed of on neighboring farms to be used as a substrate and to aid in the growth of vegetation for restoring slopes. Table 60 lists the two sampling sites with their respective coordinates.

Table 60 LOCATION O F SAMPLING SITES OF FINAL DISPOSAL OF TREATED DRILLING CUTTINGS

Site	Coordinates	
	North	East
Botadero 3	1'165,908	951,685
P-96	1'166,019	951,809

Photos 59 to 62 show the monitored sites for the final disposition of the drilling cuttings.

Photo 59 Botadero 3

Photo 60 Taking a soil sample in Botadero 3

Photo 61 Taking a soil sample in P-96

Photo 62 P-96

F.3.5 SOIL QUALITY RESULTS

Table 61 below shows a simple lab result from two of the monitored sites.

Table 61 LAB RESULTS FOR TREATED SOILS FROM A DRILLING CUTTING

Report No.: 2S-UT IJP -11 **Sampling by**: PSL PROANALISIS

Requested by: UT IJP **Address:** Carrera 19 Nº 35 – 02 OF. 208 Bucaramanga.

Field: Palagua **Sample received by:** YESY AVILA

Sampling date: November 3, 2011 **Sample received on**: November 14, 2011

Sample: Soil **Date of test:** November 22, 2011

Soil Sampling site	Weight of Metal Tray[g]	Weight of Sample + metal tray[g]	Oil, volume [ml]	Oil, mass [g]	Grease %
Botadero #3	84.3692	102.3687	0.1	0.09	0.51
Palagua-96	84.3541	102.9791	0.09	0.08	0.44

Sampling site	pH, units	Conductivity µS/cm	Total hydrocarbons %	Microbial count, UFC/gram
Botadero #3	6.5	102	ND < 0.50	4.520
Palagua-96	6.9	74	ND < 0.50	1.861
Louisiana Code. Natural Resources	6.5 – 9.0	-	3%	-

ND = Not determined due to small trace amount

Table 62 is representative of the accumulated volume of cuttings generated per well.

Table 62 SOLIDS GENERATED FROM DRILLING A WELL

Description	Bbls
Cuttings generated by drilling a well	483
Solids from other sources (casing cementing, cleaning of cellar and tanks, circulation, etc.)	340
Solids from drilling fluid additives	135
Solids from changes in drilling fluid viscosity and density (mud conditioning)	545
Total solids generated from drilling a well	1503

Source: Daily report of costs and operations, Halliburton.

F.4 LOWLANDS IN THE PALAGUA FIELD

For the purpose of this report, the information contained in 2010 ESIA is pertinent here. That information is presented, below. A follow-up study is currently being conducted to bring information of the status of the lowlands up to date.

The Environmental Diagnosis Study of Palagua and Caipal Fields done during the second semester of 2001 measured soil samples in five lowland flooding areas:

Since 2006, a bioremediation process, ECOBIOL, has been implemented in the lowlands by application of microorganisms to accelerate and improve the process of natural decontamination. This process is monitored every year, and in 2009 the “Instituto Colombiano del Petróleo (ICP)” sampled and tested the five lowland areas.

The following tables show the results of such sampling with a comparison to the results from 2007, and also with different standards including the Dutch Standard for oil samples.

According to the table, since 2007, the concentration of hydrocarbon has decreased in all the lowlands and for 2009 the figures are below 1% of hydrocarbon concentration, which is acceptable as per the Canadian Law and Louisiana Regulations for environmentally sensitive areas that have been impacted by hydrocarbon spills.

Also, the concentrations of metals like cadmium and chromium meet all the standards.

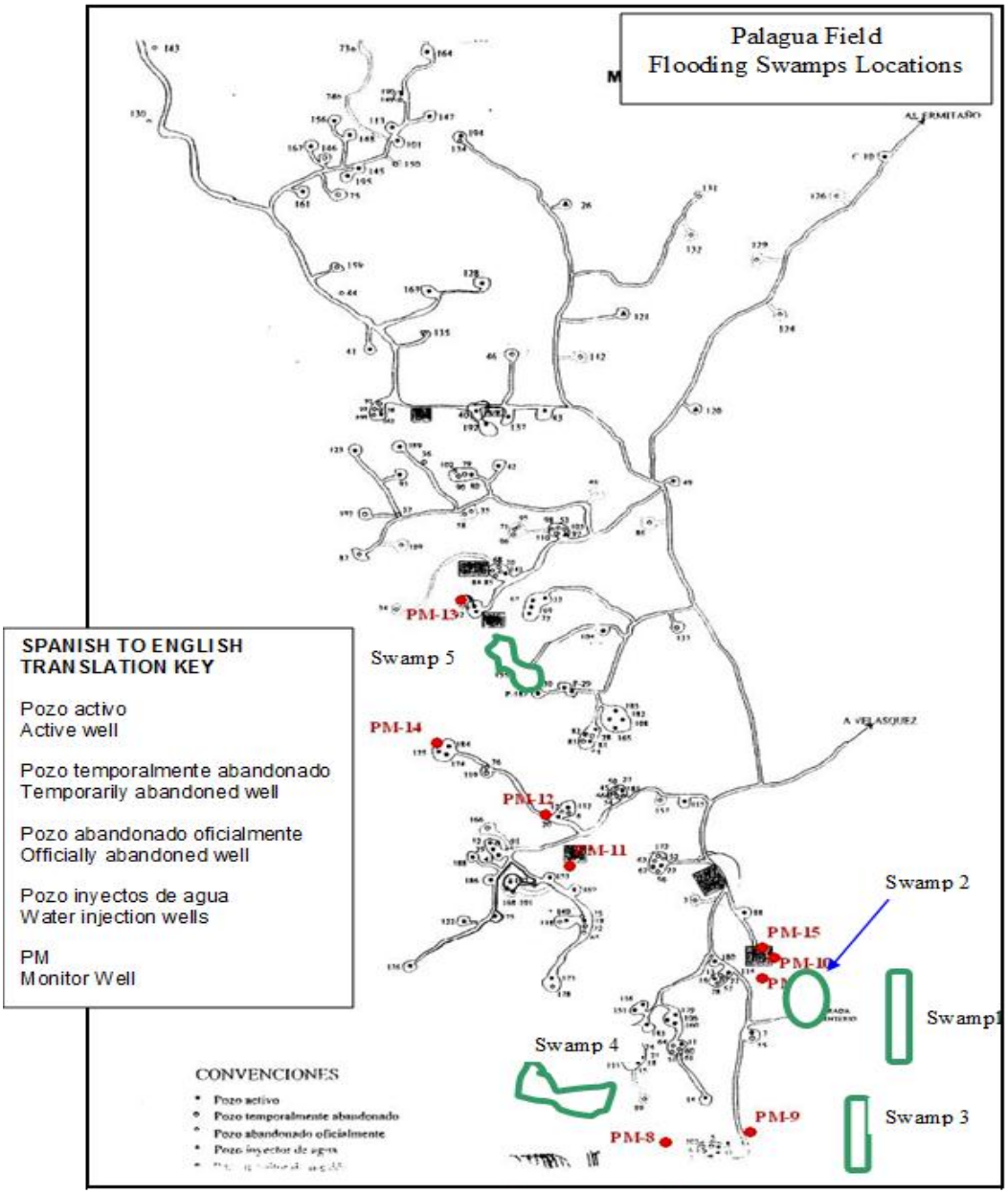


Figure 49 Critical Lowland Areas

Sample results taken from the five lowland areas are outlined in the tables below.

Table 63 LOWLAND FLOODING AREA 1

PARAMETER	PCTTL Tender No 0229 Based on Canadian and American Standards	LOUISIANA 29B	DUTCH STANDARDS Values		LAB. RESULTS	
			Target	Intervention	2007	2009
Cadmium	20 mg/l Cd	10 (mg/Kg)	0.8 (mg/Kg)	12 (mg/Kg)	1.27mg/kg	<0.077mg/kg
Chromium	500 mg/l Cr	500 (mg/Kg)	100 (mg/Kg)	380 (mg/Kg)	11.5mg/kg	15.5mg/kg
TPH	3%	2%	–	–	2.70%	1.79%

Table 64 LOWLAND FLOODING AREA 2

PARAMETER	PCTTL Tender No 0229 Based on Canadian and American Standards	LOUISIANA 29B	DUTCH STANDARDS Values		LAB. RESULTS	
			Target	Intervention	2007	2009
Cadmium	20 mg/l Cd	10 (mg/Kg)	0.8 (mg/Kg)	12 (mg/Kg)	0.470mg/kg	<0.077mg/kg
Chromium	500 mg/l Cr	500 (mg/Kg)	100 (mg/Kg)	380 (mg/Kg)	9.109mg/kg	19.8mg/kg
TPH	3%	2%	–	–	0.96%	0.05%

Table 65 LOWLAND FLOODING AREA 3

PARAMETER	PCTTL Tender No 0229 Based on Canadian and American Standards	LOUISIANA 29B	DUTCH STANDARDS Values		LAB. RESULTS	
			Target	Intervention	2007	2009
Cadmium	20 mg/l Cd	10 (mg/Kg)	0.8 (mg/Kg)	12 (mg/Kg)	1.24mg/kg	<0.077mg/kg
Chromium	500 mg/l Cr	500 (mg/Kg)	100 (mg/Kg)	380 (mg/Kg)	18.6mg/kg	12.2mg/kg
TPH	3%	2%	–	–	0.06%	<0.03%

Table 66 LOWLAND FLOODING AREA 4

PARAMETER	PCTTL Tender No 0229 Based on Canadian and American Standards	LOUISIANA 29B	DUTCH STANDARDS Values		LAB. RESULTS	
			Target	Intervention	2007	2009
Cadmium	20 mg/l Cd	10 (mg/Kg)	0.8 (mg/Kg)	12 (mg/Kg)	1.32mg/kg	<0.077mg/kg
Chromium	500 mg/l Cr	500 (mg/Kg)	100 (mg/Kg)	380 (mg/Kg)	17.1mg/kg	<11.5 mg/L
TPH	3%	2%	–	–	0.05%	<0.03%

Table 67 LOWLAND FLOODING AREA 5

PARAMETER	PCTTL Tender No 0229 Based on Canadian and American Standards	LOUISIANA 29B	DUTCH STANDARDS Values		LAB. RESULTS	
			Target	Intervention	2007	2009
Cadmium	20 mg/l Cd	10 (mg/Kg)	0.8 (mg/Kg)	12 (mg/Kg)	0.457mg/kg	<0.077mg/kg
Chromium	500 mg/l Cr	500 (mg/Kg)	100 (mg/Kg)	380 (mg/Kg)	18.3mg/kg	14.7mg/kg
TPH	3%	2%	–	–	3.41%	0.05%

F.5 NOISE

A one-day monitoring survey was conducted on March 29, 2012, at three (3) different locations in the Palagua Field to evaluate noise pollution, to compare the noise level measurements to the current standard in the Colombian Resolution No. 0627 of April 7, 2006 issued by Ministry of Environment, Housing and Land Development, and to evaluate the potential noise impacts to the communities surrounding the locations. Noise levels were measured continuously during the day and night.

The ongoing oil operations in Palagua Field and their related noise occur within the vicinity of the sites monitored. The major noise sources are related to well drilling, well workovers, production pumps, process equipment, sucker rod pumping system, and the movement of vehicles.

F.5.1 EVALUATION INDEXES AND NOISE STANDARDS

Colombian National Law on environmental noise and noise emissions is regulated by the previously cited Act No. 0627/06 which established the maximum permissible noise emission levels shown in Table 68.

Table 68 MAXIMUM PERMISSIBLE NOISE LEVEL STANDARDS EXPRESSED IN dB(A) BY RESOLUTION 0627/06

SECTOR	ZONING DISTRICTS	DAY 7:01 AM-9:00 PM	NIGHT 9:01 PM- 7:00 AM
Sector A. "Tranquility and Silence"	Hospitals, libraries, nursing homes	55	**45**
Sector B. "Tranquility and Moderate Noise"	Residential zones or zones exclusively set out for home, hotel and lodging development.	65	**50**
	Universities, colleges, schools		
Sector C. "Restricted Intermediate Noise"	Zones with permitted industrial uses, like industries in general, Ports, industrial parks, free zones.	75	**70**
	Commercial, Storage, Industrial centers, sports and recreation centers, gymnasiums, restaurants, bars, taverns, Clubs, bingos, casinos.	70	**55**
	Zones with permitted office uses	65	**50**
	Zones with institutional uses		
	Zones with other related uses, like outdoor mechanical parks, areas destined for outdoor public use.	80	**70**
Sector D. "Suburban or Rural Zone of Tranquility and Moderate Noise"	Suburban residential zones	55	**45**
	Rural inhabited for farming		
	Recreation and resting zones like natural parks and nature reserves		

- **MEASURING EQUIPMENT**

Sound Calibrator 3M	Model QC 10	*Pistonphone*
Specification	ANSI S1.40-1984 and IEC 942:1988 Class 1	
Frequency and Amplitude	1000 Hz - 114 dB	
Accuracy	+/- 0.3dB at 20ºC -760 mmHg	
Temperature and Humidity of operation	-10 ... +50 °C, 5 - 95 % Hr	
Distortion	Less than 1% within temperature and humidity operating ranges. 60 Hz: No measurable effect up to 5 Oersted (1 Oe = 80A/m) 400 Hz: No measurable effect up to 2 Oersted	

Sound Level Meter	YCT Model IEC 651 type II.	*Sonometer.*
Screen	LCD in 5 positions	
Functions	Reports SPL, MAX, MIN, Peak, Ln, Leq, Lavg, Sel, TWA, Taktm, Dose, PDOSE, Ldn, CNEL, Exposure	
Weighting scale:	A, C, Z , Linear	
Response Time	Fast, Slow, Impulse	
Frequency	1KHz Class 2: 20Hz-8Khz; Filters: 1/1 eighth; 1/3 eighth	
Amplitude	8 ranges of dynamic selection in 100dB	
Dynamic Range	0 – 140 dB	
Operation Temperature	0 ... +50 °C, < 80 % Hr	

Global Positioning System (GPS)	GARMIN ETREX SUMMIT	GPS Garmin Etrex Summit
Screen Functions	Report: navigator Electronic digital compass Barometric measurement in mlB 500 waypoints Routes: 20 reversible routes up to 50 waypoints Tracks: Stores up to 10 destinations. Works automatically. Travel Computer: current speed, average speed, Exit time and sun position, maximum speed with origin at zero, travel time and distance traveled.	

Software	QUEST SUITE PROFESSIONAL II	*Software*
Function	Used to store the data recorded in the field	

Portable Wireless Meteorological Station	Control Company 4250	*Meteorological Station*
Screen Functions	Clock : 12 hours A.M. / P.M. time, 24 hours, alarm, date Exterior Thermometer Range: -4 at 140 ° F (-20 at 60 ° C) Resolution: 0.1 ° C Hygrometer indoor and outdoor range: 2 at 98%, Resolution: 1% RH Interior Dew Point Range: 32 at 120°F (0 at 49°C). Barometer: Absolute atmospheric pressure ranges: 795 at 1050 mb and 23.48 at 31.01 in Hg. Resolution: 1 mb, 0.03 in Hg Weather predictions with symbols (sunny, cloudy, rainy) Min/Max Memory, High/Low Alarms Wind: Wind Speed Range: 0.0 at 56.0 m / seg, at 125.3 mph	

F.5.2 FIELD EVALUATION

New testing was conducted on March 20, 2012 at three monitoring sites in the area. Table 69, below, names the monitoring sites with their corresponding coordinates.

Table 69 MONITORING SITES OF TESTING CONDUCTED ON MARCH 20, 2012

Monitoring Point	Name	Planar Coordinates	
		East	North
1	Station 2	0.952.022	1.164.313
2	Caipal	0.953.898	1.169.3851
3	Industrial Area	0.952.663	1.164.163

F.5.3 DATA COLLECTION AND RESULTS

Under Colombian Regulation, the Palagua Field study area is classified as Sector C, for "Restricted Intermediate Noise" levels found in zones with permitted industrial uses. The maximum permissible noise emission levels are 75 dBA during the day and 70 dBA at night. The average energy LAeq (equivalent continuous level of noise) is the most appropriate noise descriptor to use when measuring noise impacts.

All data collected is displayed in the tables that follow. Day and night data is displayed corresponding to the location of the monitoring points with their respective geographic coordinates, frequency band range, and response time that corresponds to the sonometer configuration during the period of data capture which was fixed according to the guidelines of Resolution 0627/06. The reported values Lmax and Lmin correspond to the highest and lowest levels during the period of time of measuring, and Lpk is the highest value of sound pressure level obtained during the same period of time.

Table 70 shows a summarization of the values obtained at each one of the points selected for monitoring of hourly noise emission, diurnal as well as nocturnal, completed March 29, 2012. The recorded Leq (equivalent continuous sound level obtained during the measuring interval) measurements completed in a continuous manner for all points lasting 15 minutes of data capture per point are shown in tables 71 through 76.

Table 70 HOURLY NOISE EMISSION

POINT	SECTOR	LEQ DAY (dB(A))	LEQ NIGHT (dB(A))
POINT 1 (STATION 2)	C	64.9	53.3
POINT 2 (CAIPAL)	C	58.4	62.6
POINT 3 (INDUSTRIAL AREA)	C	61.6	50.5

F.5.3.1 DAYTIME DATA

Table 71 MONITORING POINT 1 DAYTIME MEASUREMENTS

MONITORING POINT 1 (Station 2)			
INFORMATION PANEL			
Coordinates E: 0952022 N: 1164313	Date: 29 OF MARCH, 2012		
	Field Technician: LUIS CLARO		
Photo Record		Cumulative Results – DAY	
		Bandwidth	1/3
		Weighted	A
		Response	SLOW
		Record Rate	60 sec
		Leq	64.9
		Lmax	72.7
		Lmin	62.5
		Lpk	79.6

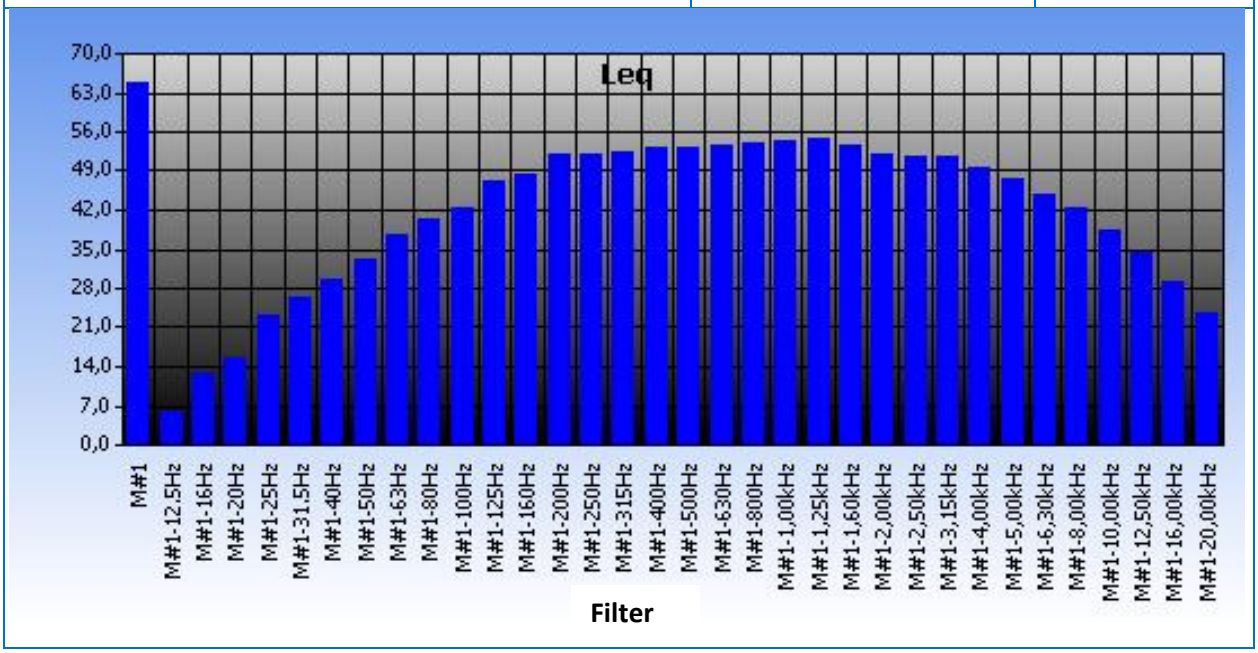


Table 72 MONITORING POINT 2 DAYTIME MEASUREMENTS

MONITORING POINT 2 (Caipal)		
INFORMATION PANEL		
Coordinates **E:** 0953898 **N:** 1169851	Date: 29 OF MARCH, 2012	
	Field Technician: LUIS CLARO	
Photo Record	**Cumulative Results – DAY**	
	Bandwidth	1/3
	Weighting	A
	Response	SLOW
	Record rate	60 sec
	Leq	58.4
	Lmax	69.1
	Lmin	53.3
	Lpk	79.6

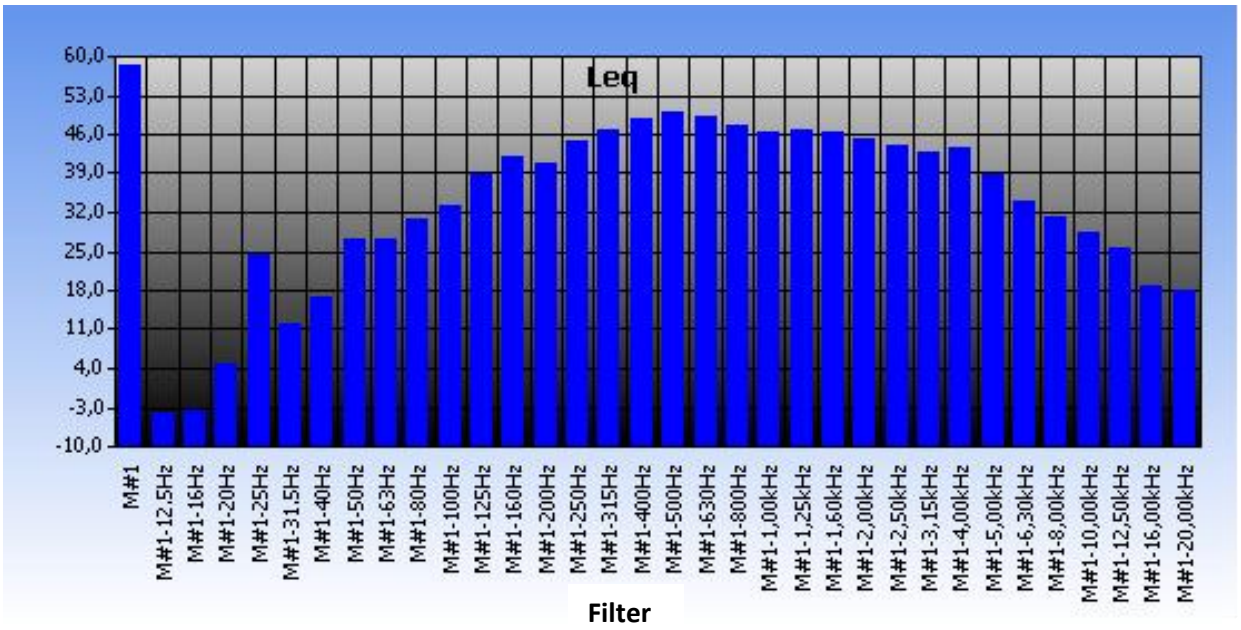
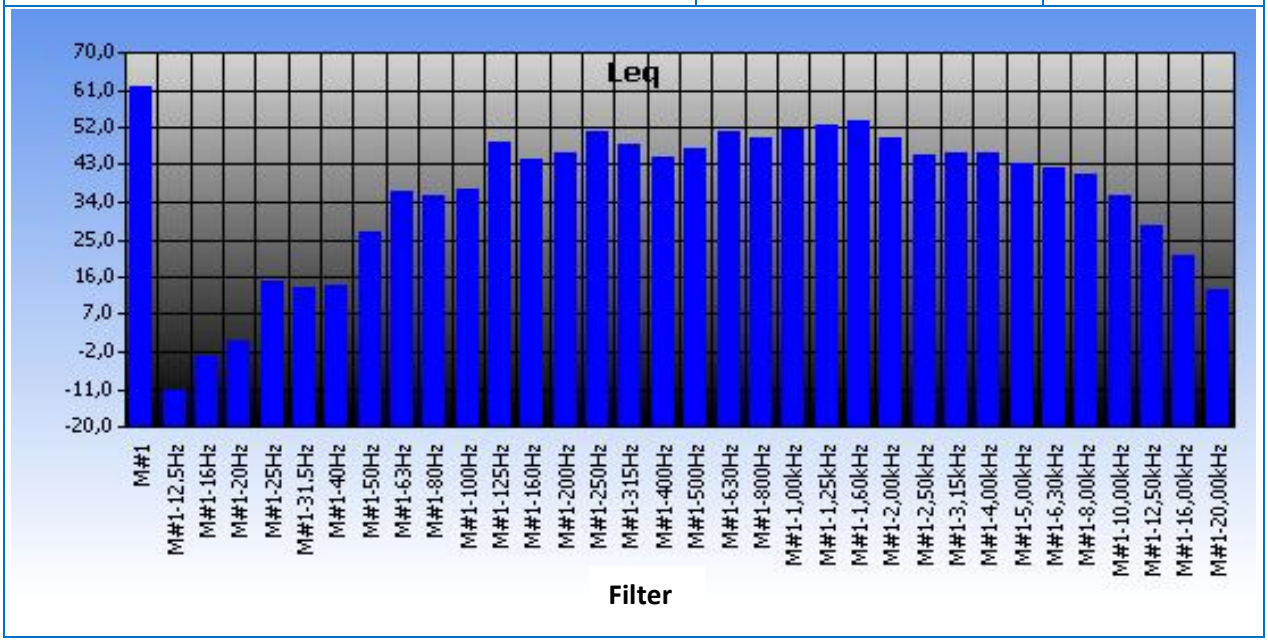


Table 73 MONITORING POINT 3 DAYTIME MEASUREMENTS

MONITORING POINT 3 (Industrial Area)	
INFORMATION PANEL	
Coordinates **E:** 0952663 **N:** 1164163	Date: 29 OF MARCH, 2012 Field Technician: LUIS CLARO

Photo Record	Cumulative Results – DAY	
	Bandwidth	1/3
	Weighting	A
	Response	SLOW
	Record rate	60 sec
	Leq	61.6
	Lmax	66.3
	Lmin	49.3
	Lpk	79.6



F.5.3.2 NIGHTTIME DATA

Table 74 MONITORING POINT 1 NIGHTTIME MEASUREMENTS

MONITORING POINT 1 (Station 2)			
INFORMATION PANEL			
Coordinates E: 0952022 N: 1164313	Date: March 29, 2012		
	Field Technician: LUIS CLARO		
Photo Record		Cumulative Results – NIGHT	
		Bandwidth	1/3
		Weighting	A
		Response	SLOW
		Record Rate	60 sec
		Leq	53.3
		Lmax	66.8
		Lmin	47.4
		Lpk	79.6

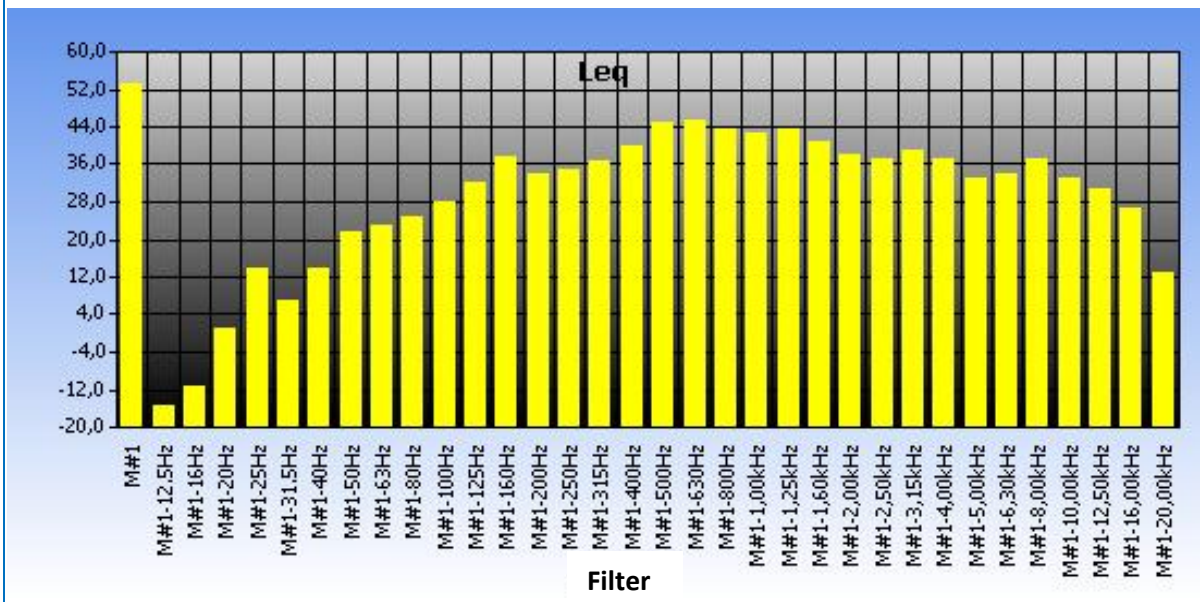


Table 75 MONITORING POINT 2 NIGHTTIME MEASUREMENTS

MONITORING POINT 2 (Caipal)	
INFORMATION PANEL	
Coordinates **E:** 0953898 **N:** 1169851	Date: March 29, 2012 Field Technician: LUIS CLARO

Photo Record	Cumulative Results – NIGHT	
	Bandwidth	1/3
	Weighting	A
	Response	SLOW
	Record Rate	60 sec
	Leq	62.6
	Lmax	70.8
	Lmin	56.7
	Lpk	79.6

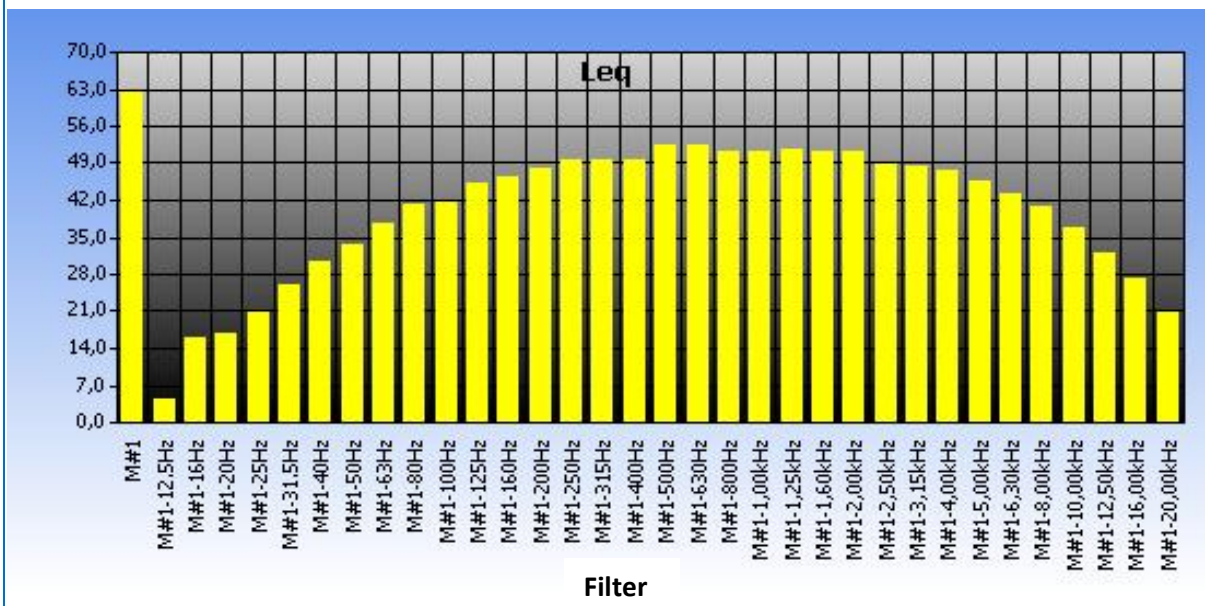
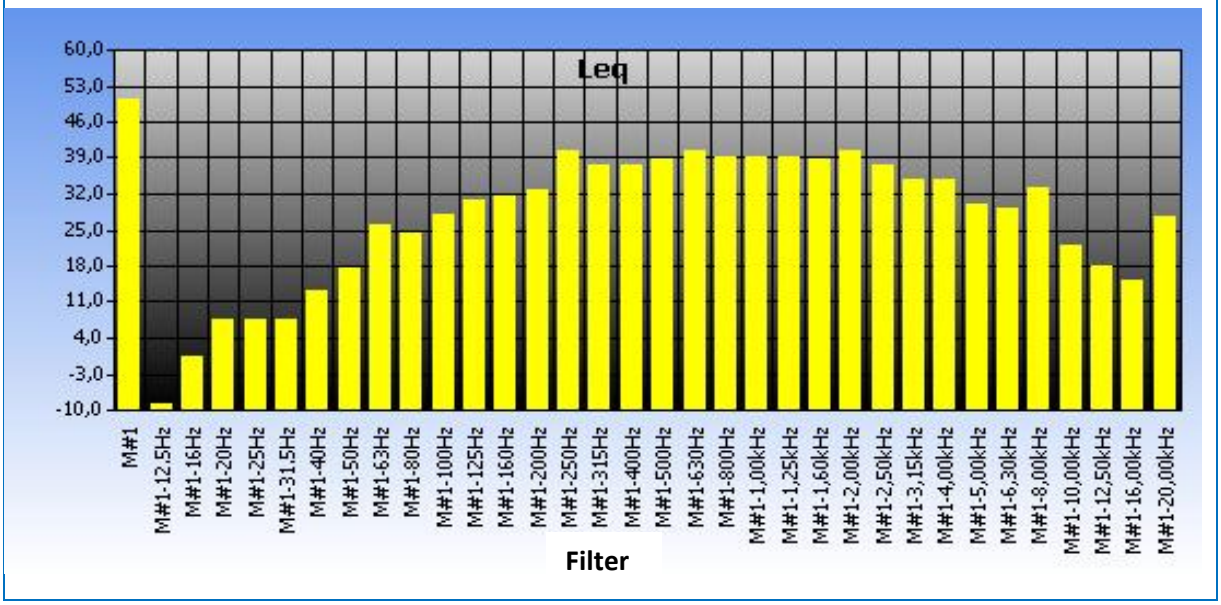


Table 76 MONITORING POINT 3 NIGHTTIME MEASUREMENTS

MONITORING POINT 3 (Industrial Area)	
INFORMATION PANEL	
Coordinates **E:** 0952663 **N:** 1164163	Date: March 29, 2012 Field Technician: LUIS CLARO

Photo Record	Cumulative Results – NIGHT	
	Bandwidth	1/3
	Weighting	A
	Response	SLOW
	Record Rate	60 sec
	Leq	50.5
	Lmax	68.5
	Lmin	39.3
	Lpk	79.6



F.5.4 DATA ANALYSIS

Table 77 is a summary of the equivalent continuous levels of noise, Leq, obtained from each of the monitoring sites (day and night) on March 29, 2012, in comparison with the National Regulation standard.

Table 77 LAeq READINGS VS NOISE LIMITS BY THE LAW

POINT	SECTOR	L_{Aeq} DAY (dB(A))	MAXIMUM PERMISSIBLE DAY (dBA)	L_{Aeq} NIGHT (dB(A))	MAXIMUM PERMISSIBLE NIGHT (dBA)	COMPARISON TO REGULATION
POINT 1 (STATION 2)	C	64.9	75	53.3	70	COMPLIES
POINT 2 (CAIPAL)	C	58.4	75	62.6	70	COMPLIES
POINT 3 (INDUSTRIAL AREA)	C	61.6	75	50.5	70	COMPLIES

F.5.5 CONCLUSIONS

The noise survey results in the report by PSL Proanalisis, LTDA, reveal that:

- Noise level measurements in the study area were low, with ranges around 58.4 - 64.9 dBA during the day and 50.5 - 62.6 dBA at night.
- Noise levels measured are below the maximum permissible limit of 75 dBA during the day and 70 dBA at night for an area classified as Sector C, industrial use zone.
- This indicates neither noise pollution nor a risk factor for workers and communities.

G. ARCHEOLOGICAL, HISTORICAL AND CULTURAL RESOURCES

G.3 PRESENCE OF NATIVE AND/OR AFRICAN-COLOMBIAN COMMUNITIES

An official letter from the Ministry of the Interior and Justice (OFI10-6514-GCP-0201) stating there is no record of native communities in the area was presented in the 2010 ESIA. This information still holds true. The letter is included with this report as Annex 3.

CHAPTER 4 POTENTIAL IMPACT ON ENVIRONMENT, HEALTH AND SAFETY

4.1 IMPACT IDENTIFICATION AND EVALUATION

The evaluation of possible environmental impacts includes the area of influence, in which the general conditions of the area's biotic, abiotic and socioeconomic components are investigated in their unaltered states. The goal is to assess the impacts of oil well drilling on the different environmental components in the Palagua field.

This chapter states three (3) evaluations. All are focused on identifying and characterizing impacts. These three (3) actions follow in order of their progression, and include the following: the environmental impact on the area to be directly influenced by activities during the drilling project in the Palagua field, the resulting outline with and without environmental measures, and an assessment of the industrial safety risks involved during drilling. It is important to note that the drilling activities in the Palagua Field will be carried out in the already existing oilfield area. This implies that no new areas will be used, thus, environmental components will not be significantly affected when compared to previous assessments. The results will establish measures and recommendations in the current Environmental Management Plan (EMP) in categories like Hygiene, Industrial Safety, Occupational Health and the Social Management Plan.

4.2 ENVIRONMENTAL ASSESSMENT

In the environmental assessment of the "**32-WELL EXPANSION PROJECT OF DEVELOPMENT WELL DRILLING IN THE PALAGUA FIELD",** located in the municipality of Puerto Boyacá, Department of Boyacá, the possible impacts of activities that may develop during the project are identified and quantified. This includes control, protection, mitigation and compensation measures.

4.2.1 AFFECTED ENVIRONMENT

An affected environment is defined as one that has changed in one or more environmental, socioeconomic or biophysical characteristic over any length of time. Therefore, it is important to determine the most relevant environmental components in the area and for the specific project. The following is a description of the previously mentioned components.

The Environmental Impacts (EI) in this evaluation are those that may result from activities to be implemented during the **32-WELL EXPANSION PROJECT OF DEVELOPMENT WELL DRILLING IN THE PALAGUA FIELD,** located in the municipality of Puerto Boyacá, Department of Boyacá, including changes to Geospheric, Atmospheric, Hydric, Biotic, Socioeconomic and Cultural components. The goal of this

assessment is to establish and coordinate the control, mitigation and compensation measures in the Environmental Management Plan.

4.2.2 IDENTIFICATION OF IMPACT

It is necessary to establish the type and level of change that may occur in the Abiotic, Biotic and Socioeconomic environment as a result of well drilling activities. The impact is based on the profile of the affected area. The profile comes from the Environmental Base Line.

The method selected to detect and quantify the impact is based on a matrix design which compares the project, environment and socioeconomic component. This is to analyze the activities that trigger processes that change the environment of the project.

For this purpose, the sequence ACTION – EFFECT – IMPACT was used with the following definitions:

ACTION: An operation or task required to execute an activity of the project.

EFFECT: A physical, biotic, economic or social process that is activated, suspended or modified by the project's activities.

IMPACT: A change, whether beneficial, harmful or indifferent, that is generated by an action upon the environment or other component.

The following are activities foreseen in the project that may affect the physical, biotic and social aspects, causing an impact.

4.3 IMPACT EVALUATION FOR ACTIVITIES TO BE EXECUTED

4.3.1. METHOD OF IMPACT EVALUATION

The following describes the method proposed by Vicente Conesa[2], used to carry out the identification and assessment of possible impacts that may be generated in the drilling activities of the wells at Palagua – Caipal Field.

[2] CONESA ,VICENTE. Methodological guide for the evaluation of environmental impact. (Methodological Guide To Evaluate Environmental Impact). Editions. Muni Press. Barcelona-Spain 2000.

To identify, predict and evaluate impacts, the Environmental Base Line served as a profile. It is a framework for the analysis of how the project may modify the environment, including the population, its infrastructure and activities.

Also, this information was used to compare aspects of similar areas that are in the drilling stage and/or are neglected, so as to establish the consequences of specific actions.

The environmental assessment includes qualitative procedures, whose results will be analyzed for validity in the following scenarios:

- Scenario without project (S-WP)
- Scenario with project
  - Scenario with project (Without Environmental measures)
  - Scenario with project (With Environmental measures)

The Scenario Without Project is evaluated using the information contained in the Base Line. This includes the structure and dynamics of the current environmental area of study while not considering the activities of the project. In the other scenarios, (With Project, With and Without the Environmental Management Measures) the main impact of actions in the installation stage, adaptation of the area, drilling and dismantling and restoration of Palagua's field are considered both with management measures and without them.

The basic stages of impact evaluation proposed for the project are:

- Impact Identification.
- Qualitative Impact Assessment.

IMPACT ASSESSMENT METHODOLOGY

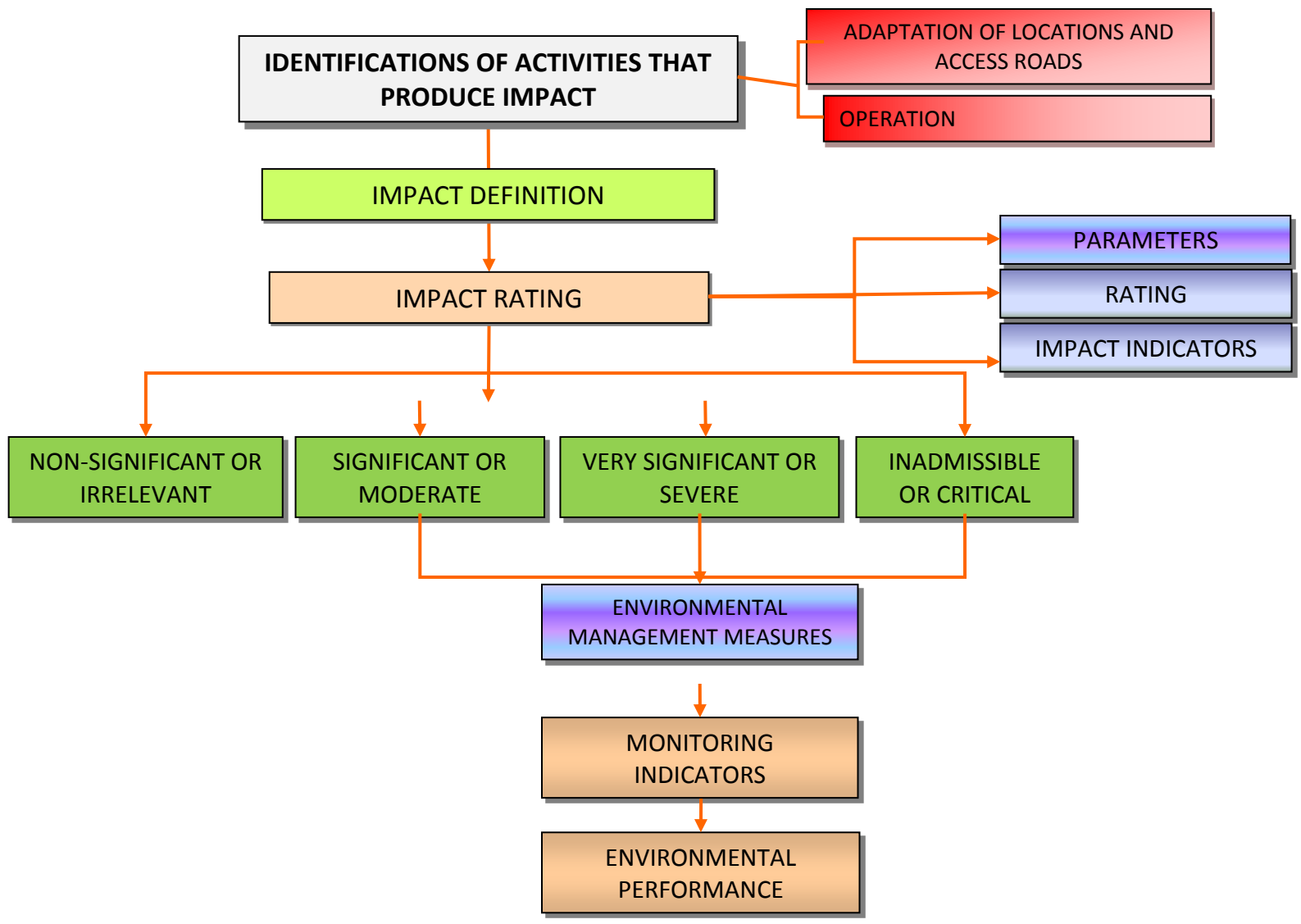


Figure 50 Impact Assessment Methodology

4.3.1.1 Impact Identification

First, the goal is to create a Cause – Effect matrix. This refines the number of situations possible in the project.

The preliminary identification and evaluation of potential environmental impacts was performed according to the following procedure:

- Identification of activities and events that can generate the greatest environmental impacts (Disintegration of the Project).
- Identification of systems, subsystems, environmental components and environmental factors susceptible of being affected.
- Identification of potential environmental impacts expected when comparing the environmental and project components in a simple matrix of interaction and relation (Cause – Effect).

In order to identify project activities that may generate impacts, the project was divided into three stages:

A. Installation and Area Adjustment Stage

This stage includes preliminary activities such as demarcation of the drilling area. Additionally, it includes any influence of the residential community in the area under the influence of Palagua Field.
This stage includes all activities in the Project Description that involve modification to the area under direct influence.

B. Operative – Drilling Stage

This stage corresponds to all the activities identified as well drilling of **PALAGUA FIELD, LOCATED IN THE MUNICIPALITY OF PUERTO BOYACA, DEPARTMENT OF BOYACA.**

Included in the variables for the Preliminary phase are:

- **Manual Labor Recruitment**

This refers to the personnel requirements that a project may generate and the methods used for this recruitment.

- **Area Demarcation**

This refers to the physical demarcation of the work area with any kind of material or element that indicates a restriction for a passer-by or crossing vehicles, whether temporarily or permanently, or creates an access road or roads to the drilling areas.

- **Reforestation**

If the area where the drilling wells are located is covered with weed species, then it does not require reforestation at any of the stage of the project.

Once the activities and events of the project which generate the strongest impact are identified, then other environmental components and/or processes (of the physical, socioeconomic and cultural environment) that can be affected are identified. They are selected based on information from the environmental profile, including zoning of the area of influence.

The same format was used to establish the variables of the project and organize the collected information. The next step was to review, organize and sort out the information in order to find the variables that identify impact. Table 78 includes a list of the variables or environmental indexes used in the assessment.

Table 78 ENVIRONMENTAL FACTORS

SYSTEM	SUBSYSTEM	ENVIRONMENTAL COMPONENT	AFFECTED ENVIRONMENTAL FACTORS
PHYSICAL ENVIRONMENT	INERT ENVIRONMENT	AIR	Air Quality
			Noise Levels
		WATER	Water Quality
		SOIL	Soil Quality
			Stabilization
	BIOTIC ENVIRONMENT	FLORA	Replanting
			Green Spaces
	PERCEPTUAL ENVIRONMENT	LANDSCAPE	Landscape Visual
SOCIOECONOMIC AND CULTURAL ENVIRONMENT	URBAN CENTERS ENVIRONMENT	LOTS	Tenure Type
	SOCIOCULTURAL ENVIRONMENT	SERVICES	Travelling Times and Costs
			Public Utilities
		HUMANS	Social Relations
			Inter-institutional Relations
			Accident Rate
			Risk and Safety
	ECONOMIC ENVIRONMENT	ECONOMY	Labor Supply
			Productive and Service Sector

The components susceptible to being affected are described in the profile done in the Environmental Base Line. The following is a description of each of them.

- **Air Quality – Impact: Increase in Atmospheric Emissions and Particulate Matter**

This refers to the concentration of suspended particles, NOx, SOx, CO; other pollutants would be: hydrogen sulfide (H_2S); volatile organic components (VOC); methane and ethane; benzene, ethylbenzene, toluene, and xylenes (BYEX); glycols; and polycyclic aromatic hydrocarbons (PAHS) present in the project area and that may produce risk, harm or discomfort to people; during installation or operation.

The greenhouse effect gas emissions (GEG) that are significant (>1000,000 tons of CO_2 equivalent per year) from facilities and support activities must be quantified annually as aggregated emissions.

It is important to maximize energy efficiency. The global objective should be to reduce emissions into the air and assess cost effective options from a technical point of view to reduce emissions.

The facilities should be equipped with a dependable gas detection system that can isolate the source of the leakage and reduce the gas leaks. Equipment should be isolated or depressurized in order to reduce the system of pressure, thus reducing the overall flow of a leak. Gas detection mechanisms should also be used to authorize entry and authorize activities performed within confined spaces.

- **Noise Levels – Impact: Increase in Noise Levels**

Audio impacts are calculated via evaluations of noise in the developments near local population settlements. They are the acoustic pressure levels (L) measured in decibel units (dB), that are represented by (Leq), (Lmin), and (Lmax). The greatest impact would be in the sensitive areas. This may be controlled by implementing environmental management measures.

- **Water Quality – Impact: Water Quality Alteration**

This refers to the physical – chemical changes of streams made by toxic substances, sediments, solids, or waste water produced by a project activity. It is considered unlikely to alter a water source, since they are located in areas away from the oil and gas field installation. However, formation water is produced when brought to the surface during hydrocarbon production. Due to its large volume, this stream of water might represent the largest waste product that the oil and gas industry has to manage and dispose of into the earth. The water produced contains a complex mixture of inorganic compounds (dissolved salts, metal traces, suspended particles) and organic compounds (disperse and dissolved hydrocarbons, organic acids) and, in many cases, waste chemical additives (e.g. scale and corrosion inhibitors) that may be added during the hydrocarbon production process.

- **Soil Quality – Impact: Soil Quality Alteration**

This refers to possible changes in the chemical properties of the soil, like pH, Cation Exchange Capacity, salinity, nutrient content and organic matter or a reduction of the possibilities of life in the soil due to building waste (cement, iron, resins, etc.), lubricants, and fuel. In any case it is considered a low environmental impact.

- **Stability – Impact: Soil Stability Alteration**

This refers to the possible soil changes resulting from oil mining and building activities that include seismic tracks, wells, and temporary facilities like base camps for workers, storage of material (pipes), workshops, and access roads. These impacts are considered of low environmental importance.

- **Replanting – Impact: Replanted Areas Intervention**

This refers to the replanting of previously existing trees in the drilling areas. Since the existing tree species in the area will be preserved, there is no need to perform any type of forestry treatment.

- **Green Spaces – Impact: Green Spaces Intervention**

As stated above, the drilling area will not significantly alter a large amount of green spaces, temporarily or permanently, while the installation and drilling activities take place. The permanent effects depend on the restoration of the affected area.

- **Landscape Visual – Impact: Landscape Visual Alteration**

This includes all landscape components; in this case it refers to replanting, green spaces and use of the land with respect to nearness to a town, the number of potential observers, and accessibility to observation and communication points. Once the drilling activities end, it is expected that the effect on the visible landscape be positive.

- **Type of Ownership – Impact: Modification of Tenure Type**

This factor only applies to the resident population of Palagua Field. Different areas will be impacted in different ways according to their type of tenure (owners, tenants, holders).

- **Public Utilities – Impact: Alteration in the Delivery of Public Utilities**

This refers to the possibility of public utility interruption as a result of the installation or operation stage. It is expected to be minimal and not affect the population.

- **Social Relations – Impact: Absence or Presence of Conflict with the Population**

This entails the reaction of the population located in the area under direct or indirect influence. This includes a favorable manifestation (absence of conflict) unfavorable manifestation (presence of conflict) or even indifference to the project.

It is suggested that conflict can be prevented, reduced or mitigated with proper implementation of recommendations made in the Social Management Plan.

- **Inter-institutional Relations – Impact: Absence or Presence of Conflict within Institutions**

This refers to the communication between Institutions related to project development. Also, it refers to the connections established within entities and their activities in the building stage that may be assessed by the number of incidents, problems or difficulties registered in a determined period of time. An adequate arrangement should generate fewer conflicts and setbacks.

- **Accident Rate – Impact: Increase or Decrease in Accident Rate**

This is found through the number of accidents or incidents (of various types) that may occur during the installation and drilling periods. The goal is to effectively establish measures proposed by the Environmental Management Plan.

- **Risk and Safety – Impact: Exposure to Risk Factors**

This refers to the statistics of work accident and incident rates directly related to staff education, training, advisory and follow up as well implementation of strategies proposed in industrial safety plans, occupational health, emergency planning, etc. The above statistics are the baseline used to establish the behavior of this variable. If none are available, then records from other drilling projects within Palagua Field are to be used.

- **Labor Supply – Impact: Change in Employment and Unemployment Levels**

This factor's purpose is to evaluate labor demand in the region and its effects on local labor supply. The measure proposed in the adaptation stage aims to observe statistics that evaluate the impact.

4.3.1.2 IDENTIFYING IMPACT CAUSE-EFFECT FACTORS

To identify impact, it has been proposed to carry out a simple matrix analysis to establish which relations Project-Environment are the most important in different scenarios and sectors which will be presented in depth in the following stages of the environmental assessment.

The identification matrix (found at end of chapter) shows the most relevant activities of the Project during the adaptation and operation stages that produce the highest impact in the columns. It shows the systems, subsystems and environmental factors that are more susceptible of being affected during the execution of the project in the rows. These environmental factors are organized into the physical, socioeconomic and cultural environments and the components air, soil, flora, landscape, services, humans, and economy.

The results of the impact identification are included in the corresponding tables. This creates the base of the other activities of the environmental assessment.

4.3.1.3 QUALITATIVE ASSESSMENT OF ENVIRONMENTAL IMPACT

According to the method proposed by Conesa (2000), the impact is qualified using Impact Importance (II) or an importance matrix that clarifies each impact in specific sectors and situations. The final results of the scenarios are used to make a comparison and thus either establish the effectiveness of considered measures or propose new environmental management and control options.

These matrices identify, prevent and communicate effects on the environment. The elements are: nature, intensity, extension, moment, permanency, reversibility, synergy, accumulation, effect, timing and recoverability (Conesa, 2000).

The parameters to be evaluated and the range described by Conesa (2000) are listed in **Table 79**.

Table 79 CRITERIA TO DEVELOP THE IMPORTANCE MATRIX

CRITERIA	SYMBOL	DESCRIPTION
INTENSITY	I	Frequency of an action on the element in the area of operation. Range: 1 -12, where 1 is minimal effect and12 is total destruction of the element or process in the environment in the area.
EXTENT	EX	Area of influence impacted, including project surroundings. Range: 1-8, where 1 is a localized effect in less than 50 m in the surrounding area, 2 is a partial impact when the extent reaches between 50 and 200 m of the work area, 4 is an extensive impact that reaches between 200 and 500 m of the work area, and 8 is when the effect does not admit a precise location at all within the project surroundings.
MOMENT	MO	The period that the impact is displayed refers to the time between the onset of an action (to) and the beginning of an effect (tj) on the environmental factor under consideration. Range: 1-4, where 1 is Long Term, when the effect takes longer than 5 years to manifest, 2 is Medium Term, a period between 1 and 5 years, and 4 is Immediate, when zero time has elapsed or Short Term, when it is less than a year.
PERMANENCY	PE	The period that the effect will supposedly last from the moment it appears to the moment the previous conditions return by natural means or as a result of corrective measures. Range: 1-4, where 1 is a fleeting effect that lasts less than one year, 2 lasts between 1 and 10 years, and 4 lasts more than 10 years.
REVERSIBILITY	RV	The possibility of reconstructing the element affected by the project. Range: 1-4, where 1 is a short term value, 2 is a medium term value, and 4 is an irreversible effect. The time periods definitions are the same as the previous parameter.
SINERGY	SI	The combination of two or more simple effects. The total impact of simple effects produced simultaneously is higher than the impact of simple effects carried out independently.
ACUMULATION	AC	The progressive increase in amount of the effect when the effect persists from the first manifestation and occurs again. Range: 1-4, where 1 does not produce cumulative effects (simple accumulation), and 4 is the highest accumulation.
EFFECT	EF	The cause – effect relationship, also known as consequences of an action. Range: 1-4, where 1 represents an indirect consequence of an action and 4 is a direct consequence of an action.
PERIODICITY	PR	The repetition of an effect in an unpredictable way (irregular effect), or constant in time (constant effect). Range: 1-4, where the effects are irregular or discontinuous, and 4 when the effects are constant.
RECOVERABILITY	MC	The possibility of a total or partial rebuilding of the environmental element or process affected by the project through the introduction of corrective measures. Range: 1-4, where 1 is completely and immediately recoverable, 2 if it is recoverable within a medium term and 4 if it is partial or if it is irrecoverable via natural actions but is recoverable by introducing compensatory measures.

The rating scales that are assigned to these criteria for the purpose of classifying the Environmental Importance in the process of assessment were taken from Conesa's method, and are presented in **Table 80.**

Table 80 IMPACT IMPORTANCE

NATURE		INTENSITY (I)	Degree of Incidence
Beneficial Impact Harmful Impact	+ -	Low Medium High Very High Total	1 2 4 8 12
EXTENSION (EX)	**Area of Influence**	**MOMENT (MO)**	**Term of Manifestation**
- Punctual - Partial - Extensive - Total - Critical	1 2 4 8 (+4)	Long term Medium term Immediate Critical	1 2 4 (+4)
PERSISTENCY (PE)	**Permanence of the effect**	**REVERSIBILITY (RV)**	**CHARACTER**
- Fleeting - Temporal - Permanente	1 2 4	Short Term Medium term Irreversible	1 2 4
SYNERGY (SI)	**Manifestation regularity**	**ACCUMULATION (AC)**	**Progressive increase**
- Without synergism - Synergic - Very synergic	1 2 4	Simple Cumulative	 1 4
EFFECT (EF)	**Cause/Effect Relation**	**PERIODICITY (PR)**	**Area of Influence**
- Indirect (Secondary) - Direct	1 4	- Periodical - Continuous	1 2
RECOVERABILITY (MC)	**Anthropic Rebuilding**	**IMPORTANCE (II)**	
- Immediately recoverable - Recoverable at a medium term - Mitigable - Irrecoverable	1 2 4 8	I = (3I + 2EX+ MO+ PE+RV+SI+AC+EF+PR+MC)	

The importance of each identified impact for each scenario is established from the following equation proposed by (Conesa):

$$I = (3I + 2EX + MO + PE + RV + SI + AC + EF + PR + MC)$$

The Impact importance (I) according to the proposed equation ranges from 13 to 100. The intermediate values are between 40 and 60 including some of the following circumstances:

- Total intensity but minimal effect on remaining factors.

- Very high or high intensity with high or very high effect on remaining factors.
- High intensity, irrecoverable effect and very high effect on remaining factors.
- Medium or low intensity, irrecoverable effect and very high effect on at least two of the remaining factors.

The impacts with importance values lower than 25 are irrelevant. Impacts with a value of importance of between 25 and 50 are moderate. Impacts with a value between 50 and 75 are severe. Impacts with a value of more than 75 are critical as shown in Table 81.

Table 81 LEVELS OF SIGNIFICANCE FOR IMPACTS VALUES

IMPACT VALUE	IMPACT SIGNIFICANCE
<25	Irrelevant or compatible
25 – 50	Moderate
51 – 75	Severe
>75	Critical

The environmental importance of project actions can be established using results from the matrix. By comparing the results of two different impacts, it can be stated what activities have a greater impact on environmental factors. Also, a score using the above factors can state whether an action is unfavorable, unacceptable, or if an action or modification must take place in order to reverse an unfavorable condition.

To obtain the Absolute Environmental Importance, each row has a weighted sum that indicates the largest incidences, changes or alterations. Each column has a weighted sum to indicate the activities that have the greatest capacity for affecting the environment.

Aspects of the project that generate the highest impacts are identified, evaluated, assessed and quantified. The environmental components and processes that may be affected (such as the physical, socioeconomic and cultural environments) are defined. They are selected based on the characteristics and environmental zoning of the area of influence.

An initial analysis was done with a primary and secondary review by a work group knowledgeable and experienced in the development of this type of study. It was added to other operational information and presented by the Union Temporal IJP, in order to determine potential impacts and adjust the scope of the study, based on Impact Importance:

- The activities proposed in the Project do not cause very significant impact to the environment or natural resources.

- The Project does not require building of access roads to the locations of the new wells, since they will be drilled from existing locations that already have their respective access roads.

- For the drilling, an area of 50 m x 60 m approximately will be adapted on the existing location. To avoid enlarging the area, the only thing to be built will be an embankment with filling material so that it may hold its capacity with only surfacing material. This necessitates dragging material close to 500 m3 for a layer of pavement of 25 cm.

- The impacts are localized to the project area.

In conclusion, the preliminary assessment shows the impact of each project activity on the environment with the following results:

- The area of the location and the access roads are composed of sedimentary rocks intertwined with recent streams from the Magdalena River and its tributary rivers.

- Activities like mobilization of equipment and personnel for the project, as well as the use of machinery and heavy equipment may increase the concentration of particulates, noise and emissions temporarily affecting the air quality.

- The impact on vegetation is considered low since it is an area with vegetation cover considered as pasture and weed species on a hill landscape, with palms and isolated trees and interspersed natural forest relicts scattered in the area. In the low or lacustrine areas the dominant vegetation is made up of palms from the Palm Tree family, including: bijao Calathea lutea, Heliconia from the species Heliconia caribaea Lam, and graminea or poaceae from the species Poaceae Barnhard, among others. The impact on flora is considered temporary, reversible and of low consideration for the area to be used.

- The impacts on terrestrial fauna are imperceptible, since there will be no alteration in the habitats, nestlings, and the wild areas will not be altered in a way which may modify fauna behavior in the area.

- The socioeconomic and cultural impacts are low and temporary. This is the most important factor and of greatest relevance for the project, considering employment generation and the benefits that the population has received.

4.4 ENVIRONMENTAL ASSESSMENT WITHOUT THE PROJECT

In the Base Line of the present study the current state of each of the environmental components in the area of direct and indirect influence is established. The assessment scenario defines the environmental supply and demand in the area.

The assessment without the project, defined as the diagnosis of the area, provides parameters of environmental susceptibility and degrees of intervention that have to be taken into account in the environmental management measures proposed in the Management Plan.

- The area is tectonically complex, which makes it attractive for the development of hydrocarbon projects.

- The area is characterized by low hills with moderate slopes

- The soil has some water erosion due to rainfall and mild to severe laminar erosion. In some sectors there are erosion gullies

- No prevalent species of fauna and flora were identified. The representative species of fauna is iguana. The vegetation is mostly in the low area, which has abundant palms, bijao platanillo and yarumo trees, rubber and mata palo. For the most part, it is an area of pastures with some scattered relicts of interspersed forest in the region

- The population in the rural areas has moved to urban areas, decreasing the population of the farmlands. This is because they do not have access to basic public utilities and services, improvement and automation of agricultural and livestock production, or to increasing productive employment rates. The project tends to slightly improve employment rates in a temporary and localized way.

- The area has medium archeological potential, but specifically the area of the wells does not affect this component. There have been no formal studies for this region of the country. So, there have not been any findings in the last fifty years of activity in the area. It is important to point out that impacts on cultural heritage refer to the harm done by direct intervention of people with the intention to rob tombs, or do irreversible damage to an archeological site is irreversible.

4.5 ASSESSMENT WITH PROJECT

The assessment with the project takes place after the impacts associated with the different activities are made during the execution of the project and identified.

For the physical component six (6) impacts were identified, 100% of them occur during stages 1 and 2, and 50% continued into stage 3. 50% of the impacts identified affect the geospheric component, 17% the hydrospheric and 33% the atmospheric.

For the biotic component, two (2) impacts were identified, which are present during the three stages of the project. 100% of these impacts relate to terrestrial ecosystems due to the effect on the atmospheric component. It is important to make clear that no impacts were identified in aquatic ecosystems as there are no lotic or lentic bodies within the area of influence of the project.

Finally, for the socioeconomic and cultural factor five (5) impacts were identified, occurred during the development of the three stages of project and are related to economic and productive activities and to institutional participation and presence. **Table 82** presents a consolidation of the results that were obtained.

Table 82 ENVIRONMENTAL ASSESSMENT RESULTS

IMPACT		1	2	3
1. Destabilization of slopes		L	L	-
2. Change in use of the land		L	L	-
3. Change in the structure of the soil biota		L	L	-
4. Increased demand of groundwater		L	L	L
5. Increase in sound pressure levels		L	L	L
6. Pollution from COx, NOx,SOx, particles and VOC's		L	L	L
7. Temporary alteration of the habitat		L	L	L
8. Temporary migration of fauna		L	L	L
9. Increased demand of services		L	L	L
10. Change in traditional productive activity		L	L	L
11. Temporary employment generation		L	L	L
12. Increased demand of goods and services		L	L	L
13. Increased inter-institutional relations and activities		L	L	L
• **TOTAL**	H	0	0	0
	M	0	0	0
	L	13	13	10
	H + M + L	13	13	10

Impact of high environmental importance H
Impact of medium environmental importance M
Impact of low environmental importance L

* Stages:
1 –Buildings and adaptations
2 – Drilling
3 – Dismantling and restoration

Source: XIJMA LTDA - MODIFIED PEREZ S.-2007

According to the previous assessment, we find that 100% of the identified impacts occur during stages one and two. 83% occur during the dismantling and restoration stages.

It is important to emphasize that no impacts of high and/or medium environmental importance occur, which is in accordance with the preliminary assessment and with the characteristics of the project.

The impacts identified in the socioeconomic and cultural aspect are qualified as positive as they improve conditions in the region; only bad management would classify them as negative.

No dismantling and clearing, cutting, leveling or major earthwork activities will be carried out. The only excavation that will take place will be of the drilling rig, which is within the respective existing location built many years ago.

Though the area has a tradition of oil extraction, there have been no projects for a few years. Therefore, the community usually exaggerates the project and its scope. Often a community does not know the selection system of non-qualified personnel, the number of vacancies available or the wage level. This can create false expectations that lead to an increase in the cost of goods and services as well as the movement of people from nearby rural areas in search of better job opportunities. Therefore, recruitment is an activity of special treatment because there is currently no clarity to the community about these factors.

During drilling, the most critical aspect is domestic and industrial liquid and solid waste management. The operation of engines and equipment required for drilling generate atmospheric emissions and noise. Atmospheric emissions are considered of low importance, since in other wells has been proven that the level of affectation of the air quality is low, due to the characteristic of the sources of the emissions and to their temporary nature.

During the dismantling stage, the most important impact is social. The staff is laid off and settlements are made for those who must then return to their agricultural and livestock activities with lower wages. At the Palagua Field, this impact has as an aggravating factor which is the potential increase of the economically active population in the area of influence. After the drilling activities end, and once new families settle in the area, the rural area of Palagua must absorb the increased unemployment rate in the working age population.

4.6 ENVIRONMENTAL INDICATORS

The list of indicators included in **Table 83** is shown as model that may serve as reference at the time of defining follow-up indicators for processes directly related to the activity and whose duration is comparable to the duration of the project. It is recommended to begin building based on the information from the environmental management information and completion of the list mentioned

Table 83 PROPOSED INDICATORS FOR ENVIRONMENTAL FOLLOW-UP AND ASSESSMENT

IMPACT	ENVIRONMENTAL INDICATOR	
	NAME / DESCRIPTION	UNIT
PHYSICAL COMPONENT		
Geospheric		
1. Change in soil structure	Soil Loss	%
2. Increase or production of erosion	Erosion (Soil Loss) Area affected by erosion	m^3/Ha/Year Ha
3. Destabilization of slopes	Number of Events Affected Area	Unit Ha
4. Natural landscape modification of landforms	Fragmentation of Coverage	Ha/Unit
5. Change in land use	Change in Use Capability	Class IV – VIII
6. Change in the structure of the soil biota	Change in the Value of the MO	%
Surface water / Ground water		
7. Change in the use of surface water	Current Flow Use	m^3/s %
8. Aquifer Modification	Current Flow – year average	m^3/s
Atmospheric		
9. Increase in sound pressure levels	Sound Pressure	dB(A)
10. Pollution: COx, NOx, SOx, particles and VOC's	Pollutant Concentration	ppm - ppb - gr/sec
BIOTIC COMPONENT		
Terrestrial Fauna and Fauna		
11. Structural Change in the Flora	Loss of Vegetation Cover	m^3/Ha/year
12. Decrease in Vegetation Cover	Type Area Affected x 100 / total area of project	% type area
13. Habitat Alteration	Alteration of Vegetation Cover	% of cover
14. Fauna Migration	Decrease of Species	Nº Organisms Per Area Unit
15. Change of Food Chain	Decrease of Species	Nº Organisms Per Area Unit
SOCIOECONOMIC AND CULTURAL COMPONENT		
Population and Demography		
16. Creation of Community Expectations	Workshops	Number of participants
Public Utilities and Social Services Infrastructure		
17. Increased demand for public services and health	Demand in healthcare attention in the local healthcare centers	% Local consultations / month
Economic and Productive Activities		
18. Temporary Employment Generation	Demand of Non-Qualified Labor Force in the Region	Contracts Tot / month
19. Increased Demand of Goods and Services	Creation of establishments of various services of purchase and sale of food and basic necessities	% new establishments in 6 months
20. Economic Change in Land Use	Area to execute the project and all activities within it	Total of Has. used
Institutional Participation and Presence		
21. Creation of expectations in the institutions	Different proceedings of the Municipal authorities to apply for benefits or claims from project	# claims presented
22. Increased Inter-institutional Relations	Contacts between local and regional entities and companies involved in the project.	Total entities related
Conflicts		
23. Existence of complaints and / or claims	Rights to petition or requests of information regarding the project	# of requests
Archeological Areas		
24. Alteration of cultural and historic registry	Archeological findings	# of findings

To construct reliable and useful indicators five main aspects must be taken into account:

1. **Sustainable Development:** This concept implies the relationship of socioeconomic, cultural and environmental factors in time and space dimensions. Therefore, "sustainable development" must be defined for each scenario according to its characteristics.

2. **Environmental Information:** It is ideal to have an environmental information system that provides an integrated and organized data set to allow the improvement and efficiency of the processes of exchange, dissemination and communication of this information.

3. **Pyramid of Information:** In the decision making process there are three clearly differentiated levels to define the concept of indicators and indexes: Information to aid the managerial process, Information to assign a higher value, and Information to reduce the volume of data by identifying particular variables that have a special significance.

4. **Decision Making Cycle:** It is a dynamic process composed of four stages: identification of problems, formulation of policies and strategies, implementation of policies and actions, and evaluation of policies, strategies and actions. In the previous steps, the indicators allow the synthesis and analysis of technical information, taking specific actions on priority issues, identification of problems, setting development objectives and goals, measuring and reporting of trends, developments and state of the environment.

5. **Conceptual Model and Framework.** The Model PRESSURE – STATE – RESPONSE (PSR) (OCDE, 1991, 1993) is accepted worldwide given its simplicity, its ease of use and the possibility it offers to be applied at different levels, scales and human activities.

Additionally, the building of indicators depends on: the availability and quality of information, the different conditions at the region (physical, biotic, socioeconomic and cultural) and the project to be developed. Any scoring that is intended to be defined will inevitably contain a degree of partiality.

4.7 ENVIRONMENTAL IMPACT SENSITIVITY ANALYSIS

The sensitivity analysis determines the change in environmental conditions, while attempting to correct the subjectivity of the evaluation team in the allocation of values to attributes qualified in the evaluation. The intention of this analysis is to assess the sensitivity of the qualitative attributes defined in the method and rated by the interdisciplinary team, by comparing the evaluated scenario under the following circumstances:

- Optimistic Scenario: evaluates the attributes likely to change, assigning them favorable values as compared to the assessed situation.

- Pessimistic Scenario: assigns values to the above attributes under adverse conditions and therefore assigning them move degrading values as compared to the assessed situation.

This analysis is presented through the matrixes for the scenario without Environmental measures and the scenario With Environmental measures (Matrixes attached). The range of variability of the importance of the impact on each of the relationships between the scenario of assessment and the sensitivity scenarios should not exceed 20%, which is the margin of error that is allowed to be corrected regarding the subjectivity of the evaluation exercise.

4.7.1 EVALUATION RESULTS

4.7.1.1 Without Project Scenario Assessment

The scenario "Without Project" is evaluated using the information in the Base Line Study regardless of the project activities, the results are shown below:

- **Air Quality:** studies and monitoring have been done on air quality in the Palagua field, which establish concentrations of particulate matter, nitrogen oxides, sulfur oxides, carbon monoxide and hydrocarbons, as stated in Base Line of this study. The places where emissions are evident are within the project site and the largest contribution of air emissions comes from automotive traffic flowing through the drilling sites.

- **Noise Levels:** In the Palagua field, high levels of noise are associated with vehicular traffic and the operation of machinery and equipment. However, these levels are considered non-permanent and undetectable because they don´t exceed the permitted limits for noise levels.

Noise pollution is one of the factors that have a greater impact on the working population in terms of occupational diseases derived from industries. Ordinary citizens are also affected by this pollution, which is reflected in the physical and mental health of people with increased levels of aggression, decreased job performance and decreased intellectual performance, sleep disturbance, increased stress and fatigue and loss of hearing.

The human ear has the ability to perceive sounds in a wide range of frequencies through a delicate noise receiver system. Noise is defined as the unpleasant sensation of sound that goes beyond the hearing thresholds of ear pain, this threshold is between 120 and 140 decibels (dB). Below is a scale of intensity in decibels of some of the most common sounds. Observe Table 4.6.

Table 84 SOUND INTENSITY

Intensity (db)	Sound sensation
0	Hearing threshold
15 – 20	whisper
40 – 50	Normal conversation
80	Intense traffic
100	Upsetting
120 – 130	Air plane – Pain threshold

Although the activities taking place in the Palagua field correspond to industrial work, impact by SPL Sound Pressure Levels is low. The Company has taken the preventive and control measures to avoid the problems due to varying degrees of hearing loss. The company carries out periodical epidemiological surveillance, as well as occupational health prevention programs.

- **Reforestation:** In the Palagua field, there are many individual trees. The plantings are distributed amongst bush, tree and shrub sizes. The most common species are found in Table 85.

Table 85 VEGETATION PROFILE OF PALAGUA FIELD

COMMON NAME	SCIENTIFIC NAME	COMMON NAME	SCIENTIFIC NAME
Hobo/Java plum	*Spondias mombin*	Iguá/Cadeno	*Pseudosamanea guachapele*
Mango	*Mangifera indica*	Dormidera/Humble	*Mimosa* sp.
Marañón/Cashew	*Anacardium occidentale*	Matapalo, caucho/Ponenoe fig	*Ficus* sp.
Gusanero/Tigerwood	*Astronium* sp.	Dinde/Fustic tree	*Chlorophora tinctoria*
Anón de monte/Golden Sugar Apple	*Annona* sp.	Cucharo/Myrsine	*Rapanea guinensis*
Palo Seco/Monkey Pepper	*Xylopia aromatica*	Guayabo (dulce)/Guava	*Psidium guajava*
Palma de vino/Yagua palm	*Scheelea butyraceae*	Sapán	*Lathropopis* sp.
Palma de lata/Lata palm	*Bactris minor*	Vara santa/Ant tree	*Triplaris americana*
Palma nolí, corozo/American Oil Palm	*Elaeis oleifera*	Guásimo, Guácimo/Bay Cedar	*Guazuma ulmifolia*
Palma de coco/Coconut palm	*Cocos nucifera*	Teca/Teak	*Tectona grandis*
Totumo/Calabash Tree	*Crescentia cujete*	Tuno	*Miconia* sp.
Gualanday	*Jacaranda* sp.	Dormidera/Humble	*Mimosa* sp.
Flor morado, Guayacán/Trumpet tree	*Tabebuia rosea*	Mastranto/Bolita	*Hyptis brachyata*
Balso/Balsa	*Ochroma lagopus*	Palma iraca/Panama Hat Plant	*Carludovica palmata*
Yarumo o guarumoPumpwood	*Cecropia* sp.	Platanillo/Flase Bird of Paradise	*Heliconia* sp.
Palma iracaPanama Hot Plant	*Carludovica palmata*	Bihao	*Calathea* sp.
Almendro/Almond	*Terminalia* sp.	Pasto guinea/Guinea Grass	*Panicum maximum*
Lechero	*Sapium marmieri*	Carimagua/Gamba	*Andropogon gayanus*
Matarratón/Mouse Killer	*Gliricidia sepium*	Pasto alemán/German Grass	*Echinochloa polystachya*
Abarco or Chibugá	*Cariniana pyriformis*	Pasto puntero/Jaragua Grass	*Hyparhenia rufa*
Ciruelo or Cafe	*Bunchosia* sp.	Braquiaria, pasto alambre/Surinam Grass	*Brachiaria decumbens*
Cedro/Cedar	*Cedrela odorata*	Helecho/Ferns	*Acrostichum* sp.
Guamo	*Inga* sp.	Samán/Rain Tree/Monkey Pod	*Samanea saman*
Payandé, gallinero/Madras thorn	*Pithecellobium dulce*		

SOURCE: Palagua Field Observations

- **Green Areas:** The green areas are constituted mainly by weeds distributed throughout the field.

- **Soil:** According to the soil study of developed in the area, there are:

The Palagua production field is located in the Middle Magdalena Valley, where there is a basin of tectonic origin. The boundary on the East is made of the faults of the foothills of the Cordillera Oriental and to the boundary on the West is made of the faults of the central cordillera. A tectonic depression is molded throughout the area, mainly by Tertiary rocks, which have verticalised thrusts and dips at the higher parts and are leaning toward the east in depth.

Environmental factors, such as tenure type, time and travel costs, utilities, social relationships, inter-institutional relationships, accidents, labor supply, risk and safety are identified as factors affected by the "With Environmental measures Project and Without Environmental measures Project" scenarios. They are not discussed in the "Without Environmental Measures scenario" since the impact on these environmental factors occurs because of the project and there is no baseline data. These environmental factors will be evaluated in the scenario "with project" and measured during the implementation of the project activities through the indicators proposed in the Environmental Management Plan.

4.8 RESULTS ANALYSIS WITH PROJECT SCENARIO

After defining the affected environmental factors and the project activities, they were compared using the impact identification matrix which outlines 64 relationships that reflect the environmental effects. These are indicated in the corresponding matrix.

Of all the relationships established or identified impacts, there were 14 positive relationships, which represent 31.8% of all relationships. The 30 remaining relationships (68.2%) were negative, indicating that at the level of impact identification the proposed activities for this sector exert some adverse changes which obviously have to be prevented, controlled, mitigated or compensated.

Having identified the relationships their importance is determined for each of the impacts for the scenarios "Without Environmental Measures" and "With Environmental Measures". Each of the 64 established relationships were described using qualitative attributes: Intensity (I), Extension (EX), Moment (MO), frequency (PE), reversibility (RV), Synergy (SI), Accumulation (AC), Effect (EF), frequency (PR), Recoverability (MC).

The parameter values of identified impacts show which impacts are the most important and also some characteristics and behaviors of them in order to establish how and through what measures they can be controlled, which is that what arises in the scenario " With Environmental Measures. "

- ***Preliminary Stage***

For this stage, 19 relationships were evaluated; of which 36.8% (8) are positive in their nature and the remaining 63.2% are negative. In the scenario "Without Environmental measures" 15.8% generate a severe impact and 47.4% (a moderate one), the remaining data (36.8%) are positive impacts, therefore do not apply. While the scenario "With environmental measures" has no existing link that generates a severe impact, 47.4% (9 relationships) generate a moderate impact and 15.8% (3 relations) are regarded as irrelevant or compatible impacts, the remaining (36.8%) did not apply.

***Negative impacts*:** The results of impact assessment conclude that during the preliminary stage of the project, the action that generates greatest negative impact on the scenarios "Without Environmental measures" and "With Environmental measures" is corporate management, which is related to the factor of employment opportunity because of the expectations generated by community regarding the exploitation of new wells in the area.

With respect to the forestry intervention activity, the project plans to be developed in areas free of tree plantations, where there are only weeds. Since it is not necessary to build access roads, the impact will be minimal. However, the excavation material extracted will be used in the capping of the areas around the wells as a mitigation measure. Low impact will be controlled during these Project activities.

It is important to note that the reported forest species, correspond to existing paths in the area of influence of the wells, therefore, they are not considered an itemized list or an inventory of species.

The use of existing infrastructure facilities in the area moderately affected air quality. It occurs immediately, generating a direct effect on the environment. The intensity degree is low because the impact was generated by communities. The other drilling well facilities and their operations did not generate any negative environmental impact. The scenario with Environmental measures considered the importance value irrelevant or compatible.

***Positive impacts*:** The action that generates the greatest positive impact in the scenario without measures is the temporary sign posting about environmental factors, social relations, and relations between institutions; this is a preventive activity that aims to anticipate any environmental and social event. In the scenario "with measures" it is more important when applied to social relations as it is a preventive measure, it should cover more than 500 m. This same action when applied to inter institutional relations specifically refers to the degree of participation of related institutions in the region; they should continue to participate during different stages of the project.

The action that generates the least positive impact at this preliminary work stage is the relationship between the fencing of the project and the accident risk factor, which has a transitory impact generated

in a limited area. It generates a direct effect on the environment with short-term reversibility and simple progressive increase. The impact on the environment is low. Other qualitative attributes qualified for this ratio correspond to lower values.

In the scenario "with measures," it is encouraged to recruit labor contracts from previous projects in the area. This will help estimate the percentages of those hired, which will aid in building statistics that can be used in other projects.

- ***Stage of Adaptation of access roads to Wells***

For this stage, 13 relationships were evaluated, since there is already an access road, some areas should be adapted. With the evaluation we have that:

***Negative impacts*:** During this stage the action of the project that generates greatest negative impact on the scenario "Without environmental measures" is material handling resulting from leveling of the road. It relates to the environmental factor of air quality with a value of 38 on a scale of 1 to 100. This impact manifested immediately, with a total coverage area of approximately 500 m, generating a low level of impact. It is a cumulative impact as the generation of particulate matter during the development of this activity occurs on a continuous or repeated basis, generating a direct impact on air quality. The reconstruction of the affected factor (air quality) requires mitigation measures. On the scenario "With Environmental Measures" it decreased by 6.5% but frequency remains very low.

The following are the measures that constitute the best tools to prevent the occurrence of minor or severe injuries among the population that works in the project or those that remain outside the area in the vicinity: maintaining a preventive attitude regarding the procedures of this action, slowing down vehicular traffic through the roads both internally and externally, maintaining signs posting information about the quality of Palagua field.

In a scenario "Without Environmental Measures" the operation of machinery and equipment is related to the environmental risk and safety factor, which generates a significant impact, manifested directly on the human environmental component. It has an average frequency rate that spans a large spectrum, because the worker is permanently exposed to exogenous and endogenous risks. In the scenario "With Environmental measures" this impact decreases by 7.46% because the level of frequency goes from very low to medium if measures are implemented and a preventive attitude is maintained regarding the procedures and operation of this equipment.

Timely, accurate and sufficient information, together with adequate training on the use of Personal Protective Elements and adequate procedures to maintain personal safety, become the ideal tools to prevent the occurrence of mild or serious accidents among the population working on the project or those that remain outside the area but still in the vicinity.

The activity called Informative sign posting generates an impact on the environmental risk and safety factor. It directly affects the human component and manifests itself immediately in a large area of over 500 meters, generating a high frequency rate by exposure of workers to both endogenous and exogenous risk factors.

In the scenario "With Environmental measures" the impact passes from being medium to being a moderate impact. Environmental measures to be taken are preventive.

In the scenario "Without Environmental measures" the operation of machinery and equipment related to the accident factor generates a moderate impact. The impact value barely qualifies, which is why preventive environmental measures must be taken to lower the value of impact. At the moment that an accident occurs, which is caused by the operation of machinery and equipment, that impact will manifest itself immediately, generating a direct effect on the human component.

In the scenario "With Environmental measures" preventive measures should be implemented, such as strict compliance with the procedures set for the operation of machinery and equipment. This would make the frequency of the impact go from medium to medium low decreasing the value of the impact by 5.39% while retaining its moderate nature.

One of the activities that generates less impact in the stage of installation and operation is related to the social factor. It generates a moderate impact as this activity is paired with functions of the Company that has been in operation since 2001. The extension of this impact does not exceed 50 continuous meters, and its effect would be recovered in the short term with the installation of new wells and the regularity of the manifestation of the impact is considered irregular because it is expected that the degree of impact on the factor to be low. Other activity with less impact is excavation, which is associated with stability factors, adaptation of the area.

With the adoption of environmental measures, the impact generated by the stage of installation and operation, concerning the stability factor decreases by 11.11% becoming irrelevant or a compatible impact. In this case, environmental measures are incorporated into the stages of the project through compensation by leveling the neighboring land. There will be no removal of material from the area, because it will be used in shaping the field, which is favored by the characteristics of the soil in the area.

The operation activities in the field and in offices go from being a moderate impact to irrelevant or compatible with the adoption of preventive environmental measures in anticipation of any environmental or social event that compromises the proper environmental management of the Project. This implies that the activity has to be timely in the identification of abnormal situations and has to have appropriate measures such as those stated in the Environmental Management Plan.

Positive impacts: The activity of shaping or grading, allows for the project to keep the landscape component as relates to environmental factors, visual landscape, tree planting, social relations and inter-institutional relationships. This generates a positive impact in both scenarios because the development of this activity gives uniformity to the area, without affecting the current conditions of the soil, improves the visual landscape, consolidates and ensures the continuity of landscape and scenic part through the labor of installing the wells and, at the same time creates and consolidates areas for plants to regrow which will result in improving the quality of the biota of the area.

- ***Operation Phase***

12 relationships were evaluated on this stage where 75% (9) of them are positive in nature and the remaining 25% are negative. Regarding those with negative character of the impact generated, 33.33% of them are moderate and 66.67% are Low. In the scenario with environmental measures, 100% of the relationships with negative impacts generated are moderate.

Negative impacts: At this stage the activity of the Project that generates greater negative impact on the stage "Without environmental measures" is the activity of drilling to extract and transport oil.

The service has two particular characteristics, the first derived from the typical drilling operating conditions and the second derives from the circumstances required for channeling the product, which in some cases depend on the facilities and existing connections. This aspect is particularly relevant in light of the development strategy of the production system. This impact appears immediately in a large area, and is reversible, once this stage is completed.

Positive Impacts*:* The operation for oil drilling and conduction in the Palagua field related to environmental factors, visual landscape, social relations, accident rate, changes in current use, and job opportunities, generates a positive impact in both scenarios. The above taking into account that in the operation phase the landscape design (which is kept) and the operating system have already been implemented. Thus, the development of this activity gives uniformity to the area by improving the visual landscape, favoring the population by improving their quality of life with Company educational programs, and upkeep of access roads to the area.

4.9 RESULTS OF THE SENSITIVITY ANALYSIS

The results obtained in the sensitivity analysis are included under the following scenarios:

In the optimistic scenario "With project Without Environmental Measures" the relationship that showed the greatest variation in the assessment was the operational stage with positive social relations that are scarcely within the range established for the development of a sensitivity analysis value with an amount

of 20%. This changes the impact from medium to moderate. Next is the use of machinery and equipment in the installation area. It requires the adaptation and geo-conformation of the surrounding areas, due to the variation in impact, the general impact changed from medium to low, the latter being the truer representation of the impact.

The stable filling action has an overall positive nature, since it changes the impact on the environment from medium to low.

In the pessimistic scenario the highest value was in material, machinery and equipment management. The impact changed from high to medium because there was no variation in qualitative factors.

The accident rate in machinery and equipment operation changed from high to very high. As above, the variation ranges resulted from the change in the impact due to extension.

In the optimistic scenario "With Environmental measures" Informative sign posting was the only relation whose value went from medium to low. As in the scenario "without Environmental measures" the relations between the optimistic and pessimistic scenarios varied by impact value.

In the pessimistic scenario As happened with the installations and operations in other fields, the impact on field or office operation in social relations changed from medium to low with internal and external sign postings for circulation and drilling areas.

The implementation of new wells did not result in any change with inter-institutional relations in the pessimistic scenario since it is a singular activity and generates a medium degree of incidence on the human component.

Looking at the sensitivity analysis, the intensity and extension factors create the highest variation since they are the most significant in the environmental impact importance calculation. The remaining factors can generate no more variation than 10%.

4.10 ENVIRONMENTAL INDEXES OR INDICATORS

4.10.1 ENVIRONMENTAL QUALITY INDEXES (EQI)

The Environmental Quality Indexes quantify the measurements in the Base Line and include the variations between the situations With and Without project to monitor and follow up on each of the environmental factors.

These indexes are calculated using measurable physical environmental factors during diagnostic activities. They establish current conditions so they may be used for future extrapolation or comparison with regulation values.

No global impact on an environmental factor can be given as the selected parameters are in heterogeneous units. Therefore, the different units need to be homogenized. An alternative is to obtain the environmental quality indexes (EQI) of each environmental parameter.

In order to establish environmental quality values to different impacts, relative transformation curves from previous projects can be used. Every previous project has a variation between 0 and 1. Alternatively, if no comparison curve exists, then the current situation can be compared to previous situations, thereby establishing possible changes and ranges of variations. This makes it easy to assign a situation to an index or comparison.

This situation can be used on variables such as air quality, noise levels, landscape visuals, green spaces, accident rate, among others. Social and community situations are less likely to have a transformation curve, as they have less information.

4.10.2 DETERMINATION OF THE ENVIRONMENTAL QUALITY INDEXES (EQI)

No global impact on an environmental factor can be given as the selected parameters are in heterogeneous units.

Once the impact values for each project activity have been determined, the different units need to be homogenized to obtain the EQI.

Each environmental component with an Environmental Quality Index must have a definition, which has to be dynamic, representative, reproducible and if possible quantifiable.

In the expressed transformation function, each environmental factor is seen as a value between 0 and 1, where 1 is assigned to the optimal or favorable Environmental quality situation and 0 to the most unfavorable. This defines the status of Environmental Quality.

This function can be linear or curved, with a positive or negative slope, or may have a maximum or intermediate minimum point, or other kind of shape according to the ratio Quality – Magnitude.

To develop the present assessment the following indexes were studied and analyzed for the current operation scenarios:

- Air Quality **(EQI-1)**

- Noise Levels **(EQI-2)**
- Establishment of the soil **(EQI-3)**
- Green Areas **(EQI-4)**
- Visual Landscape **(EQI-5)**
- Social Affairs **(EQI-6)**
- Accident Rate **(EQI-7)**

The measurements of noise fulfill following standards:

- **IEC 61672-1 (2003)** (2002-05) - Electroacoustic, Sound level meters, Specifications and Pattern evaluation tests.
- **IEC 61260 (1995-08)** - Electroacoustic, Octave-band and fractional-octave band filters.
- **ANSI S1.11-2004** - American National Standard "Specification for Octave- Band and Fractional-Octave-Band Analog and Digital Filters."
- **ANSI S1.4-1983 (R2001)** - American National Standard "Specification for Sound Level Meters."
- **ANSI S1.43-1997 (R2002)** - American National Standard "Specifications for Integrating Averaging Sound Level Meters."
- **Earlier standards** - IEC 60651 and IEC 60804.

The water measurements are in accordance with the **Standard Methods for the Examination of Water and Wastewater** of the **APHA, AWWA and WEF** in the latest version.

The values for each environmental component are in their respective matrixes. For landscape visuals, the values were obtained by assigning a scale value and broken up into different categories. This proposed method uses a scale of absolute values (Av) that are determined by assigning values to the variables Green Spaces and Land Use; this highlights that the hydrical component for the project is of low importance since there are no still or running waters in the area to be disturbed.

$$Av = GS + LU$$

The addition of these landscape or scenic components will define the values of the indexes (EQI-5) according to the ranges indicated in the following table:

Table 86 VALUE RATING OF ENVIRONMENTAL COMPONENTS

Character	Value
Spectacular	16 to 25
Superb	8 to16
Distinguished	4 to 8
Nice	2 to 4
Simple	1 to 2
Unpleasant	0 to 1

The value obtained from Av is corrected for closeness to human settlements, to internal and external roads and the traffic in them, to the potential population of observers, and the accessibility of the observation points obtaining a relative value.

Finally, the value of the landscape is determined (Lv) through the following equation:

$$L_v = K * Av$$

where:

$$K = 1.125 * [P / d * Ac * S]^{1/4}$$

P = Average size of the population close by (inhabitants in the Area).
d = Average distance in Km, to the closest town,
Ac= Accessibility to observation points or visual basin (Immediate = 4, Good = 3, Medium = 2, Bad = 1 and Inaccessible = 0).
S = Surface from which the visual basin is perceived (Very big = 4, Big = 3, Small = 2 and Very small = 1).

The values of **P** and **d** are established according to the following figures:

Inhabitants	P	Distance (Km)	d
1-1000	1	0-1	1
1000-2000	2	1-2	2
2000-4000	3	2-4	3
4000-8000	4	4-6	4
8000-16000	5	6-8	5
16000-50000	6	8-10	6
50000-100000	7	10-15	7
>100000	8	>15	8

The operation stage was determined using the same method, taking into account the affectation data of the green spaces and the area of social influence.

4.11 IMPACTS FROM RISKS OF INDUSTRIAL SAFETY AND OCCUPATIONAL HEALTH

There is a wide range of impacts of Industrial Safety and Occupational Health risks. This range is directly connected to determining eventual situations that may occur between variables of the project. These variables are considered part of the impact assessment in the installation and operation stage of the project. The risk factors can be divided into two categories: endogenous and exogenous.

The first category, endogenous, comes from factors inherent to project activities. The latter, exogenous, comes from external factors and have nothing to do with the project, but may still generate very significant problems and impacts.

For the purpose of assessing impacts resulting from Industrial Safety and Occupational Health, matrices were developed in which the columns are the selected variables and the rows are the risk variables separated among endogenous containing 8 risk factors, as follows:

- Physical
- Chemical
- Biological
- Physical load
- Psychosocial
- Mechanical
- Electrical
- Basic Sanitation

There are 7 exogenous variables. They vary greatly since they are necessarily outside of any established pattern, as follows:

- Terrorist Attacks
- Social Demonstrations
- Common Delinquency
- Thunderstorms
- Earthquakes
- Flooding
- Damage of public property

Risk assessment is the process for estimating the magnitude of unavoidable risks, obtaining the necessary information for making an appropriate decision on the need for preventive measures, and the type of measures that should be taken.

The risk assessment is composed of the following stages:

- Risk Analysis, through which danger is identified

- Risk Estimation, assessing the probability and the consequences as a whole if the danger manifests.

The risk analysis will provide the range of magnitude of the risk.

- Risk Assessment, considering the risk value and the tolerable risk, a judgment can now be issued on the tolerability of the risk involved.

If the risk is determined to be unacceptable, it is necessary to control the risk by adopting preventive measures:

- Eliminate or reduce the risk through preventive measures at the source or within the organization, using collective protection, individual protection or training and information for workers.

- Periodically check and control the conditions, the organization and work methods and state of health of the workers.

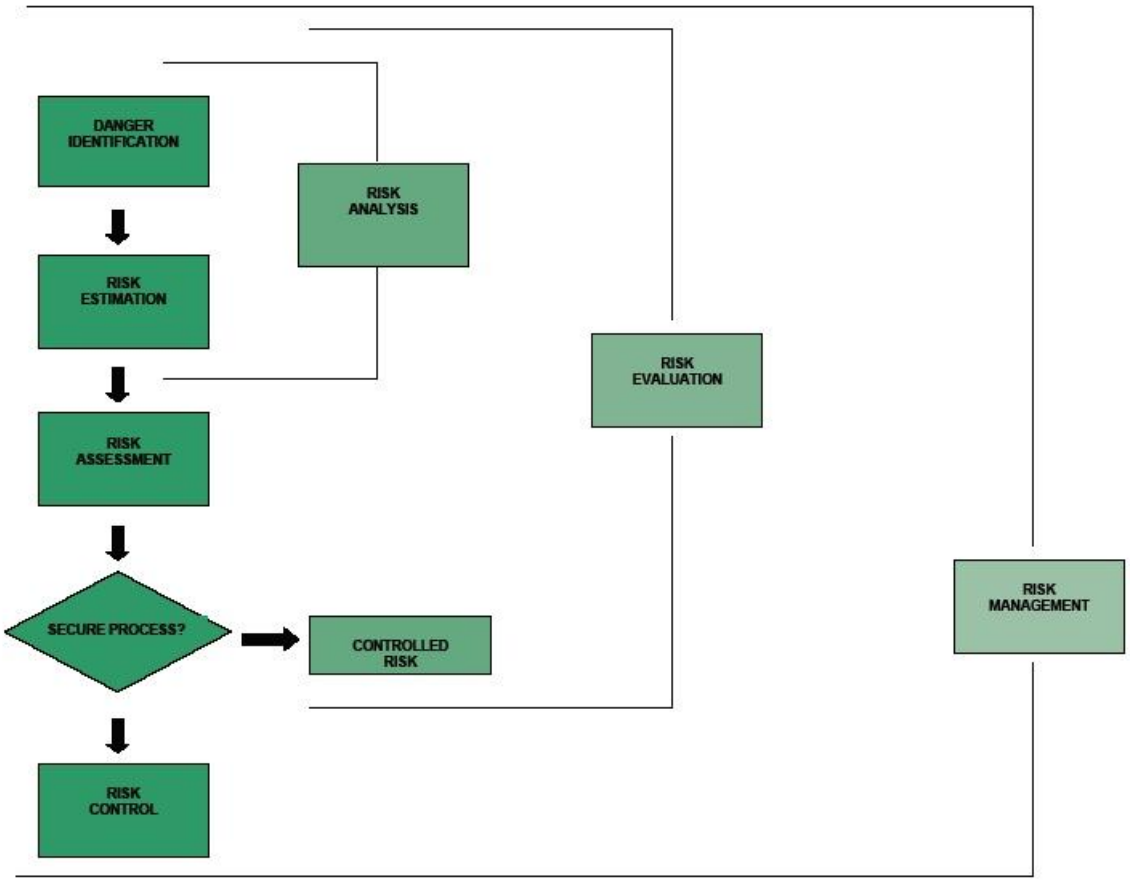


Figure 51 Risk Assessment

The only variables selected were those that have significant risk factors. The rest were discarded, creating a more realistic scenario that highlights only the most important risks.

The considered factors are Consequence (**C**), Exposure (**E**), and Probability (**P**). Each is assigned a value between 1 and 10, and the product between establishes the Danger Level (**DL**) with the following equation:

$$DL = C * E * P$$

The "**Danger Level**" on a scale of 1 to 1,000 has a resulting range of:

Low	1 to 200
Medium	201 to 600
High	601 to 1,000

In the lower part of the matrices, this scale appears as a reference.

The results from the risk assessment, the average for each risk factor, and the average for the different variables of the project are in the attached matrix. The averages for each risk factor are in the final columns and the variables for the project are in the final row. The specific qualifications and assessments for each selected factor are also in the attached tables.

The list below demonstrates the level of the assessed, identified and averaged risks. The risks are listed by degree of repercussion, in descending order, with the highest risk at the top of the list.

Social Demonstrations
Terrorist Attacks
Electrical
Mechanical
Thunderstorms
Flooding
Physical
Physical Load
Psychosocial

The project activities prone to risks to Industrial Safety and Occupational Health are the following, also in order of importance from greatest to least:

Machinery and Equipment Operation
Conductivity Systems

Vehicular Operation
Adaptation of areas of intervention
Geo-conformation of surrounding areas
Maintenance of the internal and external access roads

All the risks defined in this assessment are included in the different environmental management and control proposals included in the Environmental Management Plan (EMP) but especially in the proposals that relate to Safety, Machinery and Equipment and Contingencies, among others.

4.11.1 RISK ASSESSMENT MATRIX

RISK SCENARIO - RISK ASSESSMENT MATRIX (RAM)

SAFETY CONDITIONS											
RISK FACTOR	UNSAFE CONDITION OR ACTION	SOURCE	POSSIBLE ACCIDENT	POSSIBLE INJURIES	CONTROL MEASURES	CONSEQUENCES	EXPOSITION	PROBABILITY	DEGREE OF DANGER	% EXPOSED	DEGREE OF REPERCUSSION
Mechanical	Presence of vehicular flow internal and external to work areas.	Condition directly related to the type of process.	Hit by, run over by, collision against, trapped between, third party injuries (vehicular flow)	Traumas, musculoskeletal injuries, wounds, fractures, death.	Signaling and isolation of the work area with reflective elements. Installation of preventive and regulatory signals.	6	4	2	48	4	192
	Presence of machinery and equipment in the work area.	Condition directly related to the type of process (land leveling, drilling activity)	Hit by, run over by, collision against, trapped between	Traumas, musculoskeletal injuries, wounds, fractures, death.	Keeping away from the excavator turning area, signaling of the work area, reverse gear alarm in the dump trucks and other equipment where may apply, use of reflective vests, pre-operational inspection of vehicles and machinery.	8	7	6	336	4	1344
	Objects on the floor	Lack of order	Falls on the same level	Traumas, musculoskeletal injuries, wounds, fractures.	Order and cleanliness in the work area	8	4	4	128	4	512
	Unloading of pipes	Pipes to be installed	Hit by, trapped between	Traumas, musculoskeletal injuries, wounds, fractures, death.	The unloading of pipes at the installation points will be coordinated, and if needed with the use of mechanical aids, it is forbidden to use ramps and roll the pipes from the platter of the dump truck to the floor, the download must be lifted on rigging tubes that are in good shape and resistant.	9	8	6	432	4	1728
	Storage of pipes	Pipes to be stored	Trapped between, trapped by, hit by, third party injuries	Traumas, musculoskeletal injuries, wounds, fractures, death.	The pipeline will be minted and stored separately at least 1 m from the heads of neighboring properties. Access to third parties will be restricted. The pipes will be stockpiled and supported with wood studs in the cases where they will be kept for a long time to prevent the movement of the pipe into the surrounding area.	6	6	8	288	3	864
	Loading of dump trucks with pipes.	Pipes falling from dump trucks, resulting from not securing pipes at loading or when overloading.	Hit by falling objects, third party injuries	Traumas, musculoskeletal injuries, wounds, death.	Use of helmet, secure pipes to the dump area of the truck or to the platform of the vehicle or dump truck, in case of overhanging, place a DANGER LONG LOAD signal, the dump truck should not exceed a speed of 30 km per hour on the road	4	8	6	192	4	768
	Suspended loads.	Lifting and moving of pipes.	Hit by falling objects	Traumas, musculoskeletal injuries, wounds, death.	Use of helmet, not standing beneath the suspended load, pre-operational inspection of machinery, slings and gear used to lift pipes.	8	8	6	384	3	1152
	Presence of machinery such as excavators and dump trucks in the work area.	Condition directly related to the type of process (loading and unloading of debris, pipes and construction materials and equipment installation)	Hit by, run over by, trapped between	Traumas, musculoskeletal injuries, wounds, fractures, death.	Keep away from the mobilization area of the excavator, signaling of work area, reverse alarm on the dump truck and other incumbent equipment, use of reflective vests, pre-operational inspection of vehicles and machinery.	6	5	8	240	4	960

SAFETY CONDITIONS

RISK FACTOR	UNSAFE CONDITION OR ACTION	SOURCE	POSSIBLE ACCIDENT	POSSIBLE INJURIES	CONTROL MEASURES	CONSEQUENCES	EXPOSITION	PROBABILITY	DEGREE OF DANGER	% EXPOSED	DEGREE OF REPERCUSSION
Mechanical	Entry and exit of vehicles	Equipment transportation	Collided against, run over by, trapped between, trapped by, third party injuries.	Traumas, musculoskeletal injuries, wounds, fractures, death.	Responsibility and prudence of the drivers of machinery and equipment used in the activity, daily check of the dump trucks' state of the brakes, lights, reverse alarm and rearview mirrors.	6	8	6	288	3	864
	Loading of materials and equipment.	Falling objects or elements or tools.	Hit by falling objects.	Traumas, musculoskeletal injuries, wounds, death.	Use of protective helmet, carry out training activities.	6	4	6	144	3	432
	Management and mobilization of machinery and equipment.	Condition related to the type of stage of the project.	Hit by, trapped by, trapped between, run over by.	Traumas, musculoskeletal injuries, wounds, death, third party accidents.	Technical-mechanical inspection of vehicles and machinery that execute the activity. For the mobilization of machinery will be complied with what is established in the Safety Proceedings.	8	6	6	288	4	1152
	Unsafe stacking.	Stockpiling of pipes, materials and diverse elements.	Entrapment	Traumas, wounds, musculoskeletal injuries, death.	Stockpiles secured with structures. Install signage and control third party access to the stacking area.	8	8	6	384	3	1152
	Handling of materials	Handling of materials and abrasive elements.	Contact with	Abrasions, dermatitis	Use of leather work gloves when handling abrasive elements like steel bars.	6	8	6	288	2	576
	Handling of steel bars	Handling of irons	Hit by and contact with abrasive elements	Abrasions, wounds, traumas, fractures.	Use of leather gloves, and steel-toed boots.	4	9	6	216	2	432
Physical	Particulate matter	Loading of excavated material to level the area, which generates particles in the atmosphere as result from the wind.	Projection of particles in the eyes.	Foreign bodies in eyes, eye injuries.	Protection by using safety goggles when by weather conditions (summer or strong winds) there is presence of particulate matter in the work area.	4	8	4	128	4	512

SAFETY CONDITIONS

RISK FACTOR	UNSAFE CONDITION OR ACTION	SOURCE	POSSIBLE ACCIDENT	POSSIBLE INJURIES	CONTROL MEASURES	CONSEQUENCES	EXPOSITION	PROBABILITY	DEGREE OF DANGER	% EXPOSED	DEGREE OF REPERCUSSION
Biological	Exposure to fungi, viruses, bacteria	Lack of care when there is contact with items or substances that may affect workers.	Dermatitis, fungal skin alterations, and viral deseases.	Check on safety inspections, epidemiological surveillance program for possible viral diseases.		6	6	4	144	4	576
Ergonomic	Dynamic loads: efforts to lift, carry or drop loads.	Handling of steel reinforcements, metal formworks, etc.	Lumbar hernia, lumbar discopathy, lumbar tears.	Use of mechanical aids for load handling, training in load management. No person is allowed to handle loads heavier than 30 kg of weight. The installation of signals that weigh more than 25 kg should be done in coordination with other people.		6	8	8	384	2	768
Chemical	Exposure to gases like Co, Nox, Co2 and Sox.	Vehicular, machinery and drilling equipment traffic.	Diseases in the respiratory system (airways and lungs), occupational pneumoconiosis, effect on carboxyhemoglobin formation.	Use of respiratory protection according to the gas found which exceeds the TLV (threshold limit value), training of machinery operators in environmental and safety issues, training will be done bimonthly.		6	8	6	288	4	1152
	Exposure to particulate matter.	Removal of material and leveling produce particulate matter in the atmosphere.	Diseases in the respiratory system (airways and lungs), occupational pneumoconiosis, fibrosis.	Use of respiratory protection.		6	4	4	96	4	384

SAFETY CONDITIONS

RISK FACTOR	UNSAFE CONDITION OR ACTION	SOURCE	POSSIBLE ACCIDENT	POSSIBLE INJURIES	CONTROL MEASURES	CONSEQUENCES	EXPOSITION	PROBABILITY	DEGREE OF DANGER	% EXPOSED	DEGREE OF REPERCUSSION
Locative	Presence of personnel foreign to the project in the work area.	Works in areas of low susceptibility of presence of personnel foreign to the project.	Run over by machinery and dump trucks	Traumas, wounds, musculoskeletal injuries, death.	Prevent access of people foreign to the project activities, keep signaling.	6	4	8	192	2	384
	Objects on the floor.	Lack of order	Falls on the same level	Traumas, musculoskeletal injuries, wounds, fractures.	Removal of material not used in the work area, and if necessary, at this place of stockpiling, a place to store material and work elements will be specified in this storage area.	4	6	6	144	4	576
Public	Presence of vehicular traffic.	Lack of signaling warning the pedestrian of the entry or exit of vehicles.	Run over by vehicles	Traumas, musculoskeletal injuries, wounds, fractures, death.	Install preventive and informative signaling.	6	6	4	96	4	384

4.11.2 IMPACT ASSESSMENT MATRIX

IMPACT ASSESMENT MATRIX

DRILLING CAMPAIGN OF DEVELOPMENT WELLS

PALAGUA - CAIPAL FIELD, PUERTO BOYACA MUNICIPALITY (BOYACA)

SYSTEM	SUB-SYSTEM	ENVIRONMENTAL COMPONENT	ENVIRONMENTAL FACTORS AFFECTED	PHASE OF THE PROJECT												
				PRELIMINARY PHASE OR PREOPERATIVE				PREPARATION ACTIVITIES		INSTALLATION ACTIVITIES			OPERATION, CLOSE AND ABANDONMENT			
				Payment of real property	Topographic assesment of the platform	Civil work design	Presentation of the EPM (PMA in spanish)	Access roads preparation	Drilling site (platforms) preparation	Equipment transportation	Assembling and installation of equipment	Production Tests	Operation of Machinery and Equipment	Machinery and Equipment Maintenace	Follow up and monitoring	Site recovery
PHYSICAL ENVIRONMENT	INERT MEDIA	AIR	AIR QUALITY					N	N	N						
			NOISE LEVELS					N	N	N		P	N			
		WATER	WATER QUALITY													
		SOIL	SOIL QUALITY					P	P			N				P
			STABILITY					P	P							P
		FLORA	FOREST INTERVENTION													
			GREEN SPACES						P						P	P
	VISUAL MEDIA	SITE	LANDSCAPE VISUAL					P	P							P
SOCIO-CULTURAL AND ECONOMIC ENVIRONMENT	POPULATION GROUP	PRECINT	TENURE TYPE	P											P	P
	SOCIO-CULTURAL ENVIRONMENT	SERVICES	TIME AND COSTS OF DISPLACEMENT					P		P						P
			PUBLIC UTILITIES					P								
		HUMAN	SOCIAL SERVICES				P	P		P	P	N				P
			INTERINSTITUTIONAL RELATIONS				P				N	N				P
			ACCIDENT RATE			P	P	P		P						
			RISK AND SAFETY			P	P	N			N					
	ECONOMIC ENVIRONMENT		JOBS OFFERED-LABOR SUPPLY		P			P	P	P	P		P			
			PRODUCTIVE AND SERVICE SECTOR	P		N		P		P						P

N: Negative
P: Positive

DRILLING CAMPAIGN OF DEVELOPMENT WELLS PALAGUA - CAIPAL FIELD, PUERTO BOYACA MUNICIPALITY (BOYACA)

IMPORTANCE AND QUALITATIVE VALORIZATION OF THE ENVIRONMENTAL IMPACT

SCENARIO: PROJECT WITHOUT ENVIRONMENTAL MEASURES

RELATIONS Ai Pi	I	EX	MO	PE	RV	SI	AC	EF	PR	MC	II	CHARACTER	IMPACT SIGNIFICANCE
PRELIMINARY PHASE													
Precinct Management; Type of Tenure	3	2	4	3	2	1	3	2	1	2	31	P	N/A
Services Management	2	4	2	4	2	2	1	2	1	2	30	P	N/A
Job offer and labor supply	8	8	6	2	1	1	1	6	2	0	59	P	Relevant
Green Areas	2	2	4	2	1	2	1	4	1	2	27	N	Moderate
Visual Impact	2	2	2	2	1	2	4	4	1	1	27	N	Moderate
Accident rate	4	2	8	1	1	1	1	4	1	0	33	N	Moderate
Risk and Safety	4	2	4	1	1	2	4	4	1	0	33	N	Moderate
Social Relations	8	4	4	2	1	1	4	4	4	0	52	P	Relevant
Interinstutional Relations	4	2	4	2	1	2	4	4	4	0	37	P	Relevant
Forest intervention	0	0	0	0	0	0	0	0	0	0	0		N/A
SITE PREPARATION PHASE													
Excavations: Air Quality	1	2	2	2	1	2	4	4	2	2	26	N	Moderate
Excavations: Noise Levels	2	2	8	1	1	1	4	4	2	2	33	N	Moderate
Excavations: Water quality	2	1	8	1	1	1	1	1	2	4	27	N	Moderate
Excavations: Stability	4	1	6	1	1	1	1	4	2	4	34	N	Moderate
Excavations: Public Utilities	2	1	8	1	1	1	1	4	2	4	30	N	Moderate
Landfill, Air Quality	4	2	4	1	1	2	4	4	2	2	36	N	Moderate
Landfill, Water Quality	1	2	8	1	1	1	4	4	2	2	30	N	Moderate
Landfill, Stability	2	1	8	4	1	2	1	1	2	0	27	P	N/A
Devegetation; Air Quality	2	2	8	1	1	2	4	4	1	1	32	N	Moderate
Devegetation: Green Areas	2	4	4	2	1	1	1	4	4	4	35	N	Moderate
Machinery and equipment operation:Air quality	2	8	8	1	1	2	4	4	1	1	44	N	Moderate
Machinery and equipment operation:Noise levels	6	2	8	1	1	1	4	4	1	1	43	N	Moderate
Machinery and equipment operation: Soil quality	2	2	4	2	1	1	4	4	2	4	32	N	Moderate
Machiney and equipment operation: Social Relations	2	4	4	2	1	2	1	4	2	2	32	N	Moderate
Machinery and equipment operation: Accident rate	4	6	8	1	1	1	1	4	2	4	46	N	Moderate
Machinery and equipment operation; Risk and Safety	6	8	8	1	1	1	1	4	4	4	58	N	Critic
Complementary activities: Risk and Safety	2	1	8	1	1	1	1	4	2	4	30	N	Moderate
Site component; Revegetation	4	8	4	4	2	2	1	4	1	0	46	P	N/A
Site component; Visual Impact	4	8	4	4	2	2	1	4	4	0	49	P	N/A
Site componnet; Social Relations	4	4	2	4	2	1	1	4	4	0	38	P	N/A
Site component; Interinstitutional relations	4	4	4	4	2	1	1	4	4	0	40	P	N/A
OPERATION PHASE													
Machinery and equipment operation: Visual Impact	42	8	2	2	2	2	1	4	4	0	159	P	N/A
Vehicles operation; Social Relations	2	8	4	2	2	1	1	4	4	0	40	P	N/A
Machinery and equipment operation: Jobs offered	2	1	2	4	2	1	1	4	1	0	23	P	N/A
Maintenance of the road; Social Relations	4	2	2	2	2	1	1	4	4	0	32	P	N/A
Machinery and equipment maintenance; Risk and safety	2	2	6	1	1	1	1	4	2	4	30	N	Moderate
ABANDOMENT AND RECOVERY OF THE AREA PHASE													
Machinery and equipment operation: Visual Impact	4	6	2	2	2	2	1	4	4	0	41	P	N/A
Vehicles operation; Social Relations	2	8	4	2	2	1	1	4	4	0	40	P	N/A
Machinery and equipment operation: Jobs offered	2	1	2	4	2	1	1	4	1	0	23	P	Moderate
Site component	4	2	2	2	2	1	1	4	4	0	32	P	Relevant
Recovered green areas	4	2	8	1	1	1	1	4	2	4	38	N	Relevant

II = (3 I + 2 EX + EF + PR + MC)

I=INTENSITY EX= EXTENSION EF= EFFECT
PR= PERIODICITY MC= RESILIENCY II= IMPORTANCE INDEX

DRILLING CAMPAIGN OF DEVELOPMENT WELLS
PALAGUA - CAIPAL FIELD, PUERTO BOYACA MUNICIPALITY (BOYACA)

IMPORTANCE AND QUALITATIVE VALORIZATION OF THE ENVIRONMENTAL IMPACT

SCENARIO: PROJECT WITH ENVIRONMENTAL MEASURES

RELATIONS Ai Pi	I	EX	MO	PE	RV	SI	AC	EF	PR	MC	II	CHARACTER	IMPACT SIGNIFICANCE
PRELIMINARY PHASE													
Social Management	4	2	4	4	1	1	1	4	1	8	40	N	Moderate
Precinct Management	4	4	4	2	2	2	1	4	1	2	38	N	Moderate
Service Management	2	6	4	2	1	1	1	4	2	0	33	P	N/A
Jobs offered	1	2	4	2	1	2	1	4	1	2	24	N	Irrelevant or compatible
Green areas	1	4	2	2	1	2	4	4	1	1	28	N	Moderate
Visual Impact	4	2	4	1	1	1	1	4	1	0	29	P	N/A
Accident rate	4	2	8	1	1	2	4	4	1	0	37	P	N/A
Risk and Safety	2	4	8	2	1	2	4	4	4	2	41	N	Moderate
Social Relations	1	2	8	2	1	1	1	4	1	2	27	N	Moderate
Interstitutional Relations	8	4	6	2	2	2	4	4	4	0	56	P	N/A
Forest Intervation	4	2	8	2	2	2	4	4	4	0	42	P	N/A
SITE PREPARATION PHASE													
Excavations: Air Quality	2	2	4	2	1	2	4	4	2	2	31	N	Moderate
Excavations: Water Quality	1	2	8	1	1	1	4	4	2	2	30	N	Moderate
Excavations: Stability	1	1	8	1	1	1	1	1	2	4	24	N	Irrelevant or compatible
Excavations: Risk and Safety	2	1	8	1	1	1	1	4	2	4	30	N	Moderate
Excavations: Pubic Utility	2	1	8	1	1	1	1	4	2	4	30	N	Moderate
Landfill: Air Quality	2	2	8	1	1	2	4	4	2	2	34	N	Moderate
Landfill; Water Quality	1	1	6	1	1	1	4	4	2	2	26	N	Moderate
Landfill, Stability	4	1	8	4	1	2	1	1	2	0	33	P	N/A
Devegation: Air quality	2	2	6	1	1	1	4	4	1	2	30	N	Moderate
Devegation: Green areas	4	1	8	1	1	1	1	4	1	1	32	N	Moderate
Machinery and equipment operation:Air quality	1	2	4	1	1	1	4	4	1	2	25	N	Irrelevant or compatible
Machinery and equipment operation:Noise levels	2	2	4	2	1	2	1	4	1	2	27	N	Moderate
Machinery and equipment operation: Soil quality	2	1	4	2	1	1	1	4	1	2	24	N	Irrelevant or compatible
Machiney and equipment operation: Social Relations	1	1	8	1	1	1	1	4	1	4	26	N	Moderate
Machinery and equipment operation: Accident rate	4	1	6	1	1	1	1	4	1	4	33	N	Moderate
Operación de maquinaria y equipos; Riesgo y seguridad.	1	2	8	1	1	2	4	4	1	1	29	N	Moderate
Complementary activities: Risk and Safety	2	2	4	2	1	1	1	4	4	4	31	N	Moderate
Site component; Revegetation	4	8	6	1	1	2	4	4	4	4	54	N	Severe
Site component; Visual Impact	1	4	8	2	1	2	4	4	1	2	35	N	Moderate
Maintenance of the road; Social Relations	2	2	8	2	1	1	1	4	2	2	31	N	Moderate
Site component; Interinstitutional relations	2	2	8	2	1	1	1	4	2	2	31	N	Moderate
OPERATION PHASE													
Machinery and equipment operation: Visual Impact	4	8	4	4	2	2	1	4	4	0	49	P	N/A
Vehicles operation; Social Relations	4	8	4	2	2	1	1	4	4	0	46	P	N/A
Machinery and equipment operation: Jobs offered	8	8	6	2	2	1	1	4	4	0	60	P	N/A
Maintenance of the road; Social Relations	4	1	2	4	2	1	1	4	1	0	29	P	N/A
Machinery and equipment maintenance; Risk and safety	8	2	2	2	2	1	1	4	4	0	44	P	N/A
ABANDOMENT AND RECOVERY OF THE AREA PHASE													
Machinery and equipment operation: Visual Impact	1	2	8	1	1	2	4	4	1	1	29	N	Moderate
Vehicles operation; Social Relations	2	2	4	2	1	1	1	4	4	4	31	N	Moderate
Machinery and equipment operation: Jobs offered	4	8	4	1	1	2	4	4	4	4	52	N	Moderate
Site component	1	4	8	2	1	2	4	4	1	2	35	N	Severe
Recovered green areas	2	2	6	2	1	1	1	4	2	2	29	N	Severe

II = (3 I + 2 EX + EF + PR + MC)

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DRILLING CAMPAIGN OF DEVELOPMENT WELLS IN PALAGUA - CAIPAL FIELD

SENSIBILITY ANALYSIS

SCENARIO: PROJECT WITH ENVIRONMENTAL MEASURES

														OPTIMISTIC SCENARIO													%	PESIMISTIC SCENARIO												
RELATIONSHIPS	I	EX	MO	PE	RV	SI	AC	EF	PR	MC	II	CHARACTER	IMPACT SIGNIFICANCE	I	EX	MO	PE	RV	SI	AC	EF	PR	MC	II	CARÁCTER	SIGNIFICADO DEL IMPACTO		I	EX	MO	PE	RV	SI	AC	EF	PR	MC	II	CHARACTER	IMPACT SIGNIFICANCE
PRELIMINAR PHASE																																								
Social Management	4	4	4	4	1	1	1	4	1	2	38	P	Moderate	4	2	4	4	1	1	1	4	1	2	34	N	Moderate	10.53	2	6	4	4	2	1	1	4	1	2	37	N	Moderate
Precinct Management	8	4	4	2	2	2	1	4	1	2	50	P	Moderate	6	2	4	2	2	2	1	4	2	1	40	N	Moderate	20.00	8	4	4	4	2	2	1	4	1	2	52	N	Severe
Service Management	2	8	4	2	1	1	1	4	2	0	37	P	N/A	4	8	4	2	1	1	1	4	2	0	43	P	N/A	13.95	1	8	4	2	1	1	1	4	2	0	34	P	N/A
Jobs offered	1	2	4	2	1	2	1	4	1	2	24	N	Irrelevant or compatible	1	1	4	2	1	2	1	4	1	2	22	N	Irrelevant or compatible	8.33	2	2	4	2	1	2	1	4	1	2	27	N	Moderate
Green areas	1	4	2	2	1	2	4	4	1	1	28	N	Moderate	1	2	2	2	1	2	4	4	1	1	24	N	Irrelevant or compatible	14.29	2	4	2	2	1	2	4	4	1	1	31	N	Moderate
Visual impact	4	2	8	1	1	1	1	4	1	0	33	P	N/A	4	4	8	1	1	1	1	4	1	0	37	P	N/A	10.81	4	1	6	1	1	1	1	4	1	0	29	P	N/A
Accident rate	4	2	8	1	1	2	4	4	1	0	37	P	N/A	4	4	6	1	1	2	4	4	1	0	39	P	N/A	5.13	4	1	8	1	1	2	4	4	1	0	35	P	N/A
Risk and Safety	2	4	8	2	1	2	4	4	4	2	41	P	Moderate	2	2	8	2	1	2	4	4	4	2	37	N	Moderate	9.76	4	4	8	2	2	2	4	4	4	2	48	N	Moderate
Social Relations	1	2	8	2	1	1	1	4	1	2	27	P	Moderate	1	2	8	1	1	1	1	4	1	2	26	N	Moderate	3.70	2	2	6	2	1	1	1	4	1	2	28	N	Moderate
Interinstitutional Relations	8	4	8	2	2	2	4	4	4	0	58	P	N/A	8	8	6	2	2	2	4	4	4	0	64	P	N/A	9.38	8	4	8	2	1	1	4	4	4	0	56	P	N/A
Forest intervention	4	2	8	2	2	2	4	4	4	0	42	P	N/A	4	4	8	2	2	2	4	4	4	0	46	P	N/A	8.70	4	2	8	2	1	2	4	4	4	0	41	P	N/A
PREPARATION PHASE																																								
Excavations: Air Quality	2	2	4	2	1	2	4	4	2	2	31	N	Moderate	2	1	4	2	1	2	4	4	2	2	29	P	Moderate	6.45	4	2	4	2	1	2	4	4	2	2	37	N	Moderate
Excavations: Noise Levels	1	2	8	1	1	1	4	4	2	2	30	N	Moderate	1	1	8	1	1	1	4	4	2	2	28	P	Moderate	6.67	2	2	8	1	1	1	4	4	2	2	33	N	Moderate
Excavations: Water quality	1	1	8	1	1	1	1	4	2	4	27	P	N/A	1	1	8	1	1	1	1	1	2	4	24	P	Irrelevant or compatible	11.11	2	1	8	1	1	1	1	4	2	4	30	N	Moderate
Excavations: Stability	2	1	8	1	1	1	1	4	2	4	30	P	Moderate	1	1	8	1	1	1	1	4	2	4	27	P	Moderate	10.00	4	1	8	1	1	1	1	4	2	4	36	N	Moderate
Excavations: Risk and Safety	2	1	8	1	1	1	1	4	2	4	30	N	Moderate	1	1	4	1	1	1	1	4	2	4	23	P	Irrelevant or compatible	23.33	4	1	8	1	1	1	1	4	2	4	36	N	Moderate
Excavations: Public Utilities	2	2	8	1	1	2	4	4	2	2	34	N	Moderate	1	2	8	1	1	2	4	4	2	2	31	P	Moderate	8.82	4	2	8	1	1	2	4	4	2	2	40	N	Moderate
Landfill, Air Quality	1	1	8	1	1	1	4	4	2	2	28	N	Moderate	1	1	8	1	1	1	4	4	1	2	27	N	Moderate	3.57	1	2	8	1	2	1	4	4	2	2	31	N	Moderate
Landfill, Water Quality	4	1	8	4	1	2	1	1	2	0	33	P	N/A	4	2	8	4	1	2	1	1	2	0	35	P	N/A	5.71	2	1	8	4	1	2	1	1	2	0	27	P	N/A
Landfill, Stability	2	2	8	1	1	1	4	4	1	2	32	N	Moderate	1	2	4	1	1	1	4	4	1	2	25	N	Moderate	21.88	4	2	4	1	1	1	4	4	1	2	34	N	Moderate
Devegetation: Air Quality	4	1	8	1	1	1	1	4	1	1	32	P	Moderate	2	1	8	1	1	1	4	1	1	1	26	N	Moderate	18.75	4	1	8	2	1	1	1	4	1	1	33	N	Moderate
Devegetation: Green Areas	1	2	8	1	1	1	4	4	1	2	29	N	Moderate	1	1	8	1	1	1	4	4	1	2	27	P	Moderate	6.90	2	2	8	1	1	1	4	4	1	2	32	N	Moderate
Machinery and equipment operation:Air quality	2	2	4	2	1	2	1	4	1	2	27	N	Moderate	2	1	4	2	1	2	1	4	1	2	25	P	Irrelevant or compatible	7.41	2	2	4	2	2	2	1	4	1	2	28	N	Moderate
Machinery and equipment operation:Noise levels	2	1	4	2	1	1	1	4	1	2	24	N	Irrelevant or compatible	1	1	4	2	1	1	1	4	1	2	21	P	Irrelevant or compatible	12.50	2	2	4	2	1	1	1	4	1	2	26	N	Moderate
Machinery and equipment operation: Soil quality	2	1	8	1	1	1	1	4	1	4	29	P	Moderate	1	1	8	1	1	1	1	4	1	4	26	P	Moderate	10.34	4	1	8	1	1	1	1	4	1	4	35	N	Moderate
Machiney and equipment operation: Social Relations	4	1	8	1	1	1	1	4	1	4	35	P	Moderate	2	1	8	1	1	1	1	4	1	4	29	P	Moderate	17.14	4	1	8	1	1	1	1	4	2	4	36	N	Moderate
Machinery and equipment operation: Accident rate	1	2	8	1	1	2	4	4	1	1	29	P	Moderate	1	1	8	1	1	2	4	4	1	1	27	P	Moderate	6.90	2	2	8	1	1	2	4	4	1	1	32	N	Moderate
Machinery and equipment operation: Risk and Safety	2	2	4	2	1	1	1	4	4	4	31	P	Moderate	1	2	4	2	1	1	1	4	4	4	28	P	Moderate	9.68	4	2	4	2	1	1	1	4	4	4	37	N	Moderate
Complementary activities: Risk and Safety	4	8	8	1	1	2	4	4	4	4	56	P	Relevant	2	8	6	1	1	2	4	4	4	4	48	P	Moderate	14.29	8	8	8	1	1	2	4	4	4	4	68	N	Severe
Site component: Revegetation	1	4	8	2	1	2	4	4	1	2	35	P	Moderate	1	2	8	2	1	2	4	4	1	2	31	P	Moderate	11.43	2	4	8	2	1	2	4	4	1	2	38	N	Moderate
Site component: Visual impact	2	2	8	2	1	1	1	4	2	2	31	P	Moderate	1	2	8	2	1	1	1	4	2	2	28	P	Moderate	9.68	2	4	8	2	1	1	1	4	2	2	35	N	Moderate
Site componnet: Social Relations	2	2	8	2	1	1	1	4	2	2	31	P	Moderate	1	2	4	2	1	1	1	4	2	2	24	P	Irrelevant or compatible	22.58	4	2	8	2	1	1	1	4	2	2	37	N	Moderate
Site component: Interinstitutional relations	1	1	8	2	1	1	1	4	4	4	30	P	Moderate	1	1	8	2	1	1	1	1	4	4	27	P	Moderate	10.00	2	1	8	2	1	1	1	4	4	4	33	N	Moderate
OPERATION PHASE																																								
Machinery and equipment operation: Visual impact	4	8	4	4	2	2	1	4	4	0	49	P	N/A	6	8	4	4	2	2	1	4	4	0	55	P	N/A	10.91	4	8	4	2	2	2	1	4	4	0	47	P	N/A
Vehicles operation: Social Relations	4	8	4	2	2	1	1	4	4	0	46	P	N/A	8	8	4	2	2	1	1	4	4	0	58	P	N/A	20.69	2	8	4	2	2	1	1	4	4	0	40	P	N/A
Machinery and equipment operation: Jobs offered	8	8	8	2	2	1	1	4	4	0	62	P	N/A	8	8	8	4	2	1	1	4	4	0	64	P	N/A	3.13	4	8	8	2	2	1	1	4	4	0	50	P	N/A
Maintenance of the road: Sodial Relations	4	1	2	4	2	1	1	4	1	0	29	P	N/A	4	2	2	4	2	1	1	4	1	0	31	P	N/A	6.45	2	1	2	4	2	1	1	4	1	0	23	P	N/A
Machinery and equipment maintenance: Risk and safety	8	2	2	2	2	1	1	4	4	0	44	P	N/A	8	2	4	2	2	1	1	4	4	0	46	P	N/A	4.35	4	4	2	2	2	1	1	4	4	0	36	P	N/A
ABANDONMENT AND AREA RECOVERY PHASE																																								
Machinery and equipment operation: Visual impact	2	2	8	1	1	1	1	4	2	4	32	N	Moderate	2	1	8	1	1	1	1	4	2	4	30	N	Moderate	6.25	4	2	8	1	1	1	1	4	2	4	38	N	Moderate
Vehicles operation: Social Relations	2	2	8	1	1	1	1	4	2	0	28	P	N/A	2	2	8	1	1	1	1	4	2	0	28	P	N/A	0.00	2	1	8	1	1	1	1	4	2	0	26	P	N/A
Machinery and equipment operation: Jobs offered	4	8	4	4	2	2	4	4	4	0	52	P	N/A	8	8	4	4	2	2	4	4	4	0	64	P	N/A	18.75	4	8	4	2	2	2	4	4	4	0	50	P	N/A
Site component	4	8	4	4	2	2	1	4	4	0	49	P	N/A	8	8	4	4	2	2	1	4	4	0	61	P	N/A	19.67	4	4	4	2	2	2	1	4	4	0	39	P	N/A
Recovered green areas	2	8	8	4	2	1	1	4	2	4	48	P	Moderate	2	8	8	4	2	1	1	4	1	4	47	P	Moderate	2.08	4	6	8	4	4	1	1	4	2	4	52	N	Severe
Relocation of public transportation; interinstitutional Relations	2	4	8	4	2	1	1	1	2	4	37	P	Moderate	2	4	8	4	2	1	1	1	1	4	36	P	Moderate	2.70	4	4	8	4	4	1	1	1	2	4	45	N	Moderate

4.12 SOCIAL COMPONENT – SOCIAL MANAGEMENT

UT-IJP is a company committed to social responsibility in the operations of Palagua field and clearly knows the implications of their actions toward the community in the area. We intend our social management program to satisfy the needs and expectations of the community of the Palagua District and those who benefit from the economic activity. We also work to preserve the environment.

Our company management goal is to be socially responsible. Various activities carried out by UT-IJP for the benefit the community fall into three basic categories:

- **Legal:**

Compliance with regulations of the environmental authorities (MAVDT and CORPOBOYACA) regarding the Environmental Management Plan for the Palagua Field operations:

1. Information and communication with the community. (Have meetings to present information for management of natural resources during the project activities)

2. Contracting personnel. (Offer general guidelines for the contracting of local personnel)

3. Relations with the community.

4. Environmental education and training directly related to the project.

- **Operational:**

UT-IJP and the contracted firms, during 2011 operations, published and presented to the Community the materials, goods and services required in the Palagua field. The goal was to offer participation and opportunities to companies, community organizations and citizens of the region. The communities of Palagua, Ermitaño, Chaparro and the Puerto Boyacá districts have participated with and have benefitted from the presence of UT-IJP in the region.

Goods and services that have been acquired by the company and by the contracting companies include: contracted vehicles (trucks, buses), heavy machinery (caterpillars, treads, dump trucks, bulldozers, and compactors), supplies, leasing offices, warehouses, laundry and purchase of minor supplies.

- **Social:**

To relate the activities of UT-IJP in a manner which permits us to contribute to the quality of life and the well-being of the community. Information on the activities developed and initiated during the period from January 2011 to March 2012 is listed in Section 4.12.1 below.

4.12.1 SOCIAL MANAGEMENT RESPONSIBILITIES AND ACTIVITIES

➢ CONTRACTING LOCAL MANUAL LABOR

Table 87 shows the monthly number of unskilled manual laborers that were contracted from the Palagua neighborhoods and neighboring areas with relation to available personnel:

Table 87 CONTRACTING LOCAL MANUAL LABOR

MONTH	TOTAL UNLICENSED MANUAL LABOR PALAGUA NEIGHBORHOOD			CONTRACTING UNLICENSED MANUAL LABOR IN NEIGHBORING AREAS		
	AVAILABLE	CONTRACTED	% OF CONTRACTING	ERMITAÑO	CHAPARRO	PUERTO BOYACA
January	110	40	36%	0	0	1
February	110	80	73%	4	0	1
March	110	95	86%	8	0	1
April	110	105	95%	12	0	1
May	110	108	98%	12	2	1
June	110	107	97%	14	7	1
July	110	106	96%	18	7	2
August	110	108	98%	22	7	2
September	110	110	100%	22	4	2
October	110	109	99%	20	4	2
November	110	109	99%	22	4	2
December	110	95	86%	8	4	2

The contracting of local manual laborers was completed with the help of Palagua area community leaders.

➢ ROAD MAINTENANCE

Periodic inspections are conducted on the main and secondary roads in the Field to ensure that the roads are maintained in good condition. The following maintenance was performed:

- Palagua-Ermitaño road was improved along 5 kilometers of road, with the construction of retaining walls to sustain the road, at a value of $265,000,000 pesos.
- Palagua-Chaparro road was improved along 3 kilometers of road, with the construction of retaining walls to sustain the road, at a value of $125,000,000 pesos.

Photo 63 Chaparro road after repairs

➢ FISH-FARMING PROJECT

UT-IJP is a sponsor for the fish-farming project for the Palagua community. In March 2011, we began the yearly cycle by stocking the pond with 2500 young fish (minnows). Harvesting of these fish began at the end of June 2011. An additional 2500 young fish were placed in the pond in early December 2011.

This project generates income and benefits adults and children from the Palagua community. This project is financed by the profits from the previous three (3) years, and the fish are sold at $3500 pesos/lb. At times throughout the year, and specifically in July 2011, the project contributed 80 adult fish (approximately 500 lbs.) for the lunch of the children at the Palagua Alliance School.

➢ SOCIALIZATION OF THE CONTINGENCY PLAN

A community meeting was held to promote the socialization of the contingency plan for Palagua Field on March 17, 2012.

Photo 64 - Photo 65 - Photo 66 Community meeting promoting socialization of contingency plan

➢ TRAINING AND SOCIAL ACTIVITY REGARDING ROAD SAFETY

We offered training to the Field community as well as to students of the Palagua-Alliance school about road safety, reinforcing the following Topics:

- Road rules for the pedestrian
- Awareness and responsibility
- Automobile speed

Photo 67 - Photo 68 - Photo 69 Road safety training to the students of the Palagua-Alliance School

➢ ASSISTANCE TO THE PALAGUA COMMUNITY

We offered assistance to the Palagua neighborhood community due to the heavy rains (monsoon) that occurred in May, 2011. The following resources were offered to the community:

- Medications
- Plastic and wood materials for temporary homes
- Sheets and blankets, etc.

Photo 70 - Photo 71 - Photo 72 Giving assistance to the community after the monsoon rains

➢ HEALTH SQUAD FOR PALAGUA, ERMITAÑO AND CHAPARRO

We formed a health squad for the Palagua and neighboring communities of Ermitaño and Chaparro from our UT-IJP field employees. This Health Squad will offer medical, periodontal, and basic psychological care programs and workshops to educate the community in good hygiene practices and promote disease prevention.

SPECIFIC OBJECTIVES:

- Enhance the basic physical and mental health of the community
- Devote informational workshops to the preventive practices of family planning and the prevention of sexually transmitted diseases for the adult men and women
- Devote information and orientation to the prevention of cavities and periodontal diseases
- Provide complete dental checkups
- Provide cytology exams (pap smears) and breast screening to adolescent and adult females
- Provide basic parasite control methods and immunizations
- Create recreational activities
- Offer hair dressing services

These programs and workshops are specifically for the benefit of the children and adults of the neighboring communities as well as the employees of UT-IJP.

- The Ermitaño neighborhood consists of approximately 110 families with an average of 3 members/family = 330 people
- The Chaparro neighborhood consists of approximately 65 families with an average of 3 members per family = 195 people
- The Palagua neighborhood consists of approximately 105 families with an average of 3 members per family = 315 people
- There are 287 Palagua field employees. Average attendance was about 60% = 172 people

25. Health lecture

26. Health lecture

27. Hair dressing services

28. Hair dressing services

29. Planned recreational activity

30. Planned recreational activity

Photos 73, 74, 75, 76, 77, and 78 Health squad workshops and activities

➢ ENVIRONMENTAL PROGRAMS AND WORKSHOPS FOR SCHOOL CHILDREN

Environmental programs were created for the schoolchildren of Palagua and Chaparro in 2011, entitled "We Care for the Environment" and "Friend of the Planet". The prime objective was to create an environmental consciousness and reinforce the environmental education that is being developed with the students.

The topics that we discussed with the schoolchildren were:

- Water, a vital resource
- Climate changes
- Palagua reservoir – Natural ecosystem
- Recycling
- Ecological points

Photo 79 - Photo 80 - Photo 81 Environmental workshops for the children of the Palagua-Alliance School

➢ ASSISTANCE IN STUDENT GRADUATIONS

We offered assistance to the local schools for the graduation activities in 2011 in the neighborhoods of Palagua and Ermitaño. The UT-IJP contribution to these activities was $800,000 pesos.

Photo 82 - Photo 83 - Photo 84 End of year graduation ceremony and activities

➢ ASSISTANCE WITH SCHOOL KITS

UT – IJP assisted in the purchase and delivery of school kits to single mothers who are continuing their studies and students of the School Alliance Palagua (March 2012).

Photo 85 - Photo 86 - Photo 87 Assistance to schoolchildren for purchase of school kits

➢ ACADEMIC INCENTIVES TO STUDENTS

We offered academic incentives to the students of the schools of the following neighborhoods: Chaparro, Palagua and Ermitaño. Monies were used for the purchase of clothing and shoes during an afternoon of shopping with the children. The UT-IJP contribution for this activity was $3,200,000 pesos.

Photo 88 - Photo 89 - Photo 90 Assistance to schoolchildren with purchases of clothing and shoes

➢ DONATION OF PLAYGROUND EQUIPMENT

We delivered a children's "play gym" to the student community of the Palagua-Alliance school located in the Palagua neighborhood. The UT-IJP contribution was $8,000,000 pesos for the purchase, delivery and installation of the playground equipment.

Photo 91 and Photo 92 Playground equipment for the children of the Palagua-Alliance School

➢ HALLOWEEN CELEBRATION

We hosted a Halloween celebration with activities and prizes for the children in the local neighborhoods of Palagua, Ermitaño and Chaparro. The cost for this celebration was $4,800,000 pesos.

Photo 93 - Photo 94 - Photo 95 Halloween celebration for neighborhood children

➢ CHRISTMAS CELEBRATION

UT IJP hosted Christmas celebrations with the children from the neighboring areas of Palagua, Ermitaño and Chaparro. Activities included a gift exchange, as shown in the photos below.

Photo 96 - Photo 97 - Photo 98 Celebrating Christmas with neighborhood children

➢ TRAINING IN VERTICAL RESCUE OPERATIONS

On March 10, 2012, rig personnel received training in vertical rescue operations and rescues from high places. Information was presented on the inspection, use and maintenance of height equipment; docking stations; descent by rope; rescue by a rig member and rescue with pulleys. Practical training was given to all rig personnel.

Photo 51

Photo 52

Photo 53

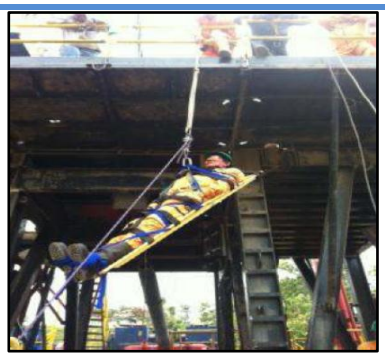


Photo 54

Photo 55

Photo 56

Photos 99, 100, 101, 102, 103, and 104 Practical training in vertical rescue operations

- **"WATCH YOUR FEET" CAMPAIGN**

Various programs were presented to field personnel on general safety and personal safety in the field. Programs included the "Watch Your Feet" campaign, "Safe Stop – Hand Care," and "Acts and Unsafe Conditions".

Photos 105, 106, 107, 108, 109, and 110 Programs on general safety and personal safety in the field

- **"HOW TO USE EXTINGUISHERS"**

Demonstration and practical training in the use of fire extinguishers

Photo 111 - Photo 112 - Photo 113 Training in the use of fire extinguishing equipment

- **TRAINING OF THE EMERGENCY BRIGADE**

Practical training was given to members of the Emergency Fire Brigade

Photos 114, 115, 116, 117, 118, and 119 Scheduled training for the Emergency Brigade

CHAPTER 5 ENVIRONMENTAL MANAGEMENT SYSTEM

5.1 INTRODUCTION

For the development Drilling Program of the Project, an Environmental Management System – EMS is necessary to ensure environmentally safe operations.

The Environmental Management System must include aspects that are critical for the project's development, as well as actions necessary to achieve the goals of each of the environmental management plan.

5.2 OBJECTIVES OF THE ENVIRONMENTAL MANAGEMENT PLAN

- Comply with the obligations as per the Rules and resolutions issued by the Environmental Authority of Colombia.

- Comply with the Environmental Management Plan to meet environmental and social management objectives and obligations.

5.3 ACTIVITIES OF THE EMVIRONMENTAL MANAGEMENT SYSTEM

- Carry out inspections in the areas where the drilling wells are located, using photographic records before, during, and after the intervention. This follows with the activities described in the follow up programs.

- Carry out the programs and actions included in the schedule and follow up methodology of the environmental system.

- Follow up on the corrective actions and the solutions to any non-compliance of environmental and social management through the follow up processes and monitoring, designed by UT-IJP for a permanent control of compliance status.

- If necessary, make corrections during the project´s execution or in the procedures for the execution of activities to comply with the environmental obligations and objectives.

- Schedule and develop specialized activities of control and monitoring, such as:

  - Planned inspections of unsafe actions and conditions, and risk scenarios.
  - Inspection of the equipment, machinery, and tools used for the development of the jobs.

5.4 ORGANIZATION OF THE ENVIRONMENTAL MANAGEMENT SYSTEM

The operative structure for the implementation of the Environmental Management Plan falls upon the Management System established by the Company, which in turn presents as one of its components, the field Superintendent – H.S.E. and the Environment engineer. As in every organization, there are corporate guidelines for the management of the environment. Among these, there are universal environment management practices such as:

- Promote it at all levels of the organization.
- Evaluate the impact of the project activities on the environment.
- Adopt the necessary measures for preventing, eliminating or reducing pollution.
- Establishing and applying verification procedures of compliance with the environmental policy.
- Collaborate with local authorities in establishing procedures for emergency response.
- Take steps to ensure that suppliers implement environmental laws.

Among the benefits of implementing the Environmental Management Plan are:

- Maximize the reasonable use of the resources.
- Correct management and manipulation of waste to minimize costs.
- Prioritize prevention instead of correction.
- Increase the quality and productivity in the job.
- Improvement relationship with the community and environment authority.

The design and implementation of an Environmental Management System is framed in the Plan, Do, Check, Act Cycle; as well as within the four fundamental elements of a management system: Organization, Planning, Implementation, Control and Follow up.

Table 88 FUNDAMENTAL ELEMENTS OF A MANAGEMENT SYSTEM

ORGANIZATION	PLANNING
Organizational Structure Responsibility and functions	Environmental policy and environmental objectives Environmental program planning (Components and Programs)
IMPLEMENTATION	**CONTROL AND FOLLOW UP**
Environmental aspects and impacts Implementation of the environmental program (Components and Programs) Education and training	Monitoring and measurements Follow up of the environmental program (Components and Programs) Review of the Environmental Management System

The Environmental Management objective is the continuous improvement of industrial safety, occupational health, and environmental protection applicable during the development of the project activities.

5.4.1 ORGANIZATIONAL STRUCTURE AND RESPONSIBILITY

The figure below represents the organizational structure of the Company to be applied to the Environmental Management System.

ORGANIZATIONAL STRUCTURE FOR THE APPLICATION OF THE ENVIRONMENTAL MANAGEMENT SYSTEM

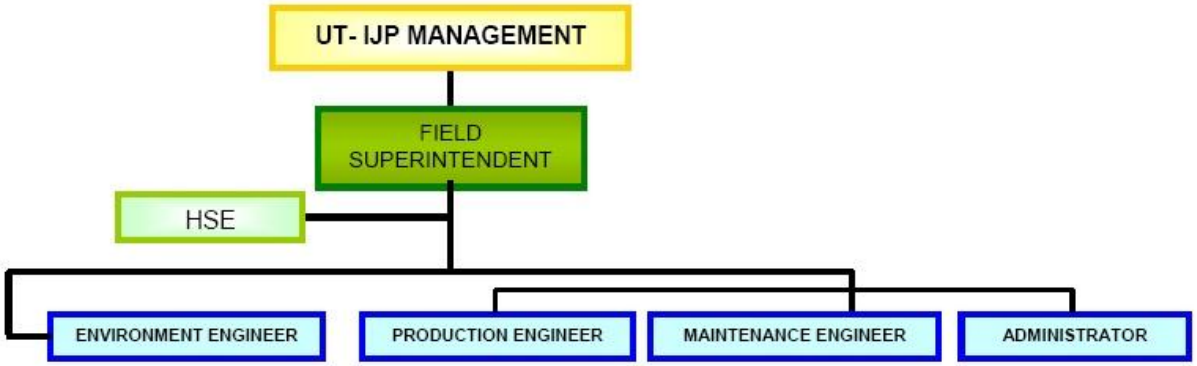


Figure 52 Organizational Structure for the Application of the EMS

The responsibility, authority and interrelation of the personnel that manages, executes and verifies any kind of work or activity that affects the environmental performance, is defined by focusing the positions that require such responsibility. Following are the positions and functions of the UT-IJP's Environmental Management System (EMS).

Table 89 UT-IJP ENVIRONMENTAL MANAGEMENT SYSTEM – POSITIONS AND THEIR FUNCTIONS

POSITION	FUNCTIONS
MANAGER UT-IJP	Responsible for establishing and keeping the occupational health, industrial safety and environment programs up to date within the UT-IJP and all its contractors.
FIELD SUPERINTENDENT	Reports to the Manager of the Provisional Joint Venture IJP the compliance and implementation of the Occupational Health, Industrial Safety and Environment program in the operation Palagua and Caipal Fields To comply with the obligations he or she will perform the following functions: - Implement and enforce all the staff, policies, standards and procedures issued and released by the company regarding Industrial Health, Safety and Environment. - Lead and support all activities scheduled and carried out by the H.S.E. group and control their execution. - Ensure the proper functioning of the Joint Committee on Occupational Health COPASO. - To lead the organization of Medical Emergencies, Fire Prevention and Environmental Emergencies Brigades and support their training and performance. - Support whomever is in charge of the Preventive Medicine, Industrial Safety and Environment functions with their training, diffusion and motivation programs. - Take part in the updating and continuous improvement of the risk and work procedure scenarios, so that they provide better risk control. - Report to management any type of incident that may occur however slight it may be and take part in the investigations when they are of high potential and deliver the investigation report within 5 days, performing analysis of the reasons for the incident and the corresponding preventive measures.

POSITION	FUNCTIONS
ENVIRONMENTAL ENGINEER	Reports to the Field Superintendent and information on coordinating the Occupational Health, Industrial Safety and Environment programs and therefore must verify the filling of attendance registry of the scheduled activities. To comply with the obligations he or she will perform the following functions: - Comply and monitor compliance by all personnel of Policies, Regulations and Proceedings issued and released by the company with regard to Health, Industrial Safety and Environment. - Organize Medical Emergencies, Fire Prevention and Environmental Emergencies Brigades and support training and operation. - Keep HSE records and statistics and send them to management on the first of the month. - Release HSE policies in accordance with issued instructions and verify compliance by staff. - Check the availability of first aid equipment such as stretchers, first aid kit, brigade members and a Medical Emergency Plan. - Coordinate the manufacturing of signals for the areas, according to the needs of Occupational Health, Industrial Safety and Environment. - Release the content of newsletters, posters and announcements on Industrial Safety and Environment. - Keep personnel in state of alertness and positive attitude with respect to Health, Industrial Safety and Environment. - Schedule and implement actions related to handling and final disposal of solid waste. - Coordinate with environmental authorities (MAVDT "Ministry of the Environment, Housing and Land Development" and CORPOBOYACA) the legal procedures that result from the development of the work.

5.4.2 PLANNING

The environmental planning of the drilling project for development wells begins by carrying out of an environmental management plan that can identify the impacts that may be generated, and design the programs that must be implemented to minimize or compensate the negative effects of the project. During this stage, the environmental permits, necessary for the development of the project, must be obtained.

In addition, the legal requirements related to environmental aspects must be identified:

- General environmental standards issued by the Congress of the Republic or the Government through national institutions or agencies so authorized.
- Regional environmental standards issued by CORPOBOYACÁ or the Department of Boyacá.
- Local environmental standards issued by the municipality of Puerto Boyacá.
- National or international technical standards, to which, UT-IJP submits voluntarily.
- Commitments resulting from the environmental license and from the permits, concessions, or authorizations in force.

Environmental Aspects and Impacts

As a first step for the design and implementation of an Environmental Management System, it is necessary to identify the environmental aspects and impacts that are generated by the development project activities. So, for instance, environmental issues such as possible gas emissions and waste water disposal of sewage needs to be considered.

- **Environmental Policy**

In order to minimize the environmental impacts, prevent contamination, preserve the environment, provide protection and safety to the workers, and keep close relationships with the community, local authorities, and the competent environmental authority, there must be a policy for performing activities, implementing practices and measures of environmental management and industrial safety during the drilling of the wells. For this, it is necessary to involve the Environmental Management actions, with the institutions, and with the community involved, in the area of influence of the project.
The UT-IJP has as one of its priorities, in all its activities (building, assembly, operation and services for the oil industry), the protection of the Environment and the continuous improvement of its environmental performance. To achieve a sustainable development, the company is committed to:

1. Complying with the environmental legislation and with other requirements assumed by the company.
2. Identifying and evaluating the environmental impacts of its activities, in order to establish environmental objectives and goals and developing programs to achieve them.
3. Preventing or minimizing pollution or any type of adverse impact to the environment.
4. Training and motivating the employees, so that they perform all the activities with the environment responsibly.

5. Maintaining adequate internal and external information channels, facilitating communications of the company's environmental activities.

The environmental objectives must be the following:

- Identify and prevent the impacts that the activities of the project can have on the environment.
- Guarantee compliance with Environmental Legislation.
- Minimize the use of the primary and secondary resources (soil, water, energy, etc.).
- Reduce the level of contamination caused by the activities of the project.

Planning of the Environmental Program

Within the planning conceptual framework, a formulation of a plan was created, composed of programs and measures of environmental management to be carried out during the development of the project.

5.4.3 IMPLEMENTATION

Training, Knowledge and Competence

The **UT-IJP** will establish the need for training, skill-building and instruction of personnel, as the most important activity to implement and maintain the EMS.

All personnel performing tasks or activities that affect environmental performance or that may jeopardize the area's natural resources must be trained adequately. The assignment of tasks is done based on the capability and suitability of the personnel.

The personnel performing tasks related to EMS as far as training, inspection, tests, verification and administration is qualified based on education, training and experience.

The documents of the personnel related with this requirement are stored and kept. Documents include resumes, courses, training or instruction certificates and grade records.

Implementation of Environmental Program

The object of executing the programs and measures is to comply with existing regulations and Environmental Legislation and also comply with environmental quality standards and parameters required by the environmental authority. Due to constant changes in environmental regulations, the legal requirements must be updated.

EMS implementation is done through the execution of plans designed and presented in the Environmental Management Plan (EMP) to control impacts generated by the project. UT-IJP is responsible of the compliance to the EMP.

Instruction and Training

Environmental Management System instruction and training procedures for operators and workers are of great importance as teaching and disseminating environmental policy, environmental objectives. The programs and activities instill environmental culture, care and management in the operators and workers.

Contingency Plan

Every organization must be prepared for any operational and / or natural risk situation, initially establishing a risk assessment and afterwards the actions to respond to contingencies where responsibilities and roles of people involved are defined. Additionally, one needs to define the resources needed (strategic plan), internal and external means of communication (information plan) and the procedures to be followed in emergency (operative plan).

The UT-IJP as a company engaged in construction, installation, operation and service activities for the oil industry. It has among its priorities to preserve, maintain and improve individual and collective health of its employees and protect the organization from any losses in order to promote welfare of the worker and increase operational productivity.

To accomplish this goal the company constantly develops plans and programs to reach the commitment of the organization, including the following objectives:

1. Implementation, development and continuous improvement of Occupational Health Programs.

2. Maintenance of a healthy and safe work environment, to protect our workers, the subcontractor's workers and the general public through a gradual reduction of occupational hazards that could lead to human and material losses.

3. Comply with all current legal regulations on Occupational Health, as well as other requirements to which the organization subscribes.

According to the commitments described before, all the people working for UT-IJP are responsible of achieving the best performance in Occupational Health, creating self-protection and protection awareness culture. They should also participate to control risks and injuries that may occur.

5.4.4 CONTROL AND FOLLOW UP

Environmental Monitoring Plan

The execution and correct development of the Environmental Management Plan will take place through environmental monitoring and control. The results obtained will be assessed according to the implementation of the programs. It will also establish the problems identified during drilling of development wells, as well as corrective measures to control and correct problems.
In the case of drilling of development wells, external environmental inspectors verify the EMS. They are hired to confirm that the measures designed in the environmental management of the project are executed according to the plan.

The objectives of environmental inspection are:

- Ensure compliance with the environmental management.
- Review environmental protection and management commitments and obligations of contractors during the construction and operation of the project.
- Record the environmental procedures developed for waste management.
- Inspect that the monitoring performed to follow up on the environmental quality of the project complies with the requirements of the environmental legislation.
- Ensure adequate maintenance of facilities and equipment.
- Verify compliance of work according to the designs of the environmental management plan.
- Receive complaints or criticisms from the community for any action generated by the project in order to communicate them to **UT-IJP**.

To comply with the outlined objectives the environmental inspectors shall perform the following actions:

- Control and daily follow up on construction processes and environmental management for contractors, according to the environmental management plan.
- Guide the contractor to adequately comply with current environmental legislation.
- Give lectures and workshops on environmental education to the project workers and the community.

- Prepare the progress and compliance report of the EMP to be sent to the Ministry of Environment and CORPOBOYACÁ.

Review and Improvement (Act)

The whole Environmental Management System shall be reviewed to evaluate the satisfaction and needs of the interested parties, for compliance with environmental regulations, to ensure continuous improvement of environmental performance of the company.

During the different stages of the project it is important to review and control the documentation to ensure that both, the UT-IJP and the environmental authority, use updated versions of the components and programs that constitute the Environmental Management Plan.

The **UT-IJP** within its EMS should identify, collect, codify, classify, store, keep up to date to all the environmental records, and ensure that the system meets the requirements of Rule ISO 14001.

The information included in the records is used to determine the performance and to assess the effectiveness of the measures that have already been implemented.

The control of environmental records reaches, without limitation, to the following:

- Review records of the EMS
- Legal requirements
- Record of permits and compliance
- Environmental aspects
- Incident reports
- Communications with interested parties
- Reports on Non-conformance and corrective actions
- Plans to correct deficiencies
- Environmental inspection programs
- Records of personnel training

Progress and Compliance Reports

For the drilling of development wells, the Environmental Compliance Reports must be submitted to the Ministry of Environment, Housing and Land Development and the Environmental Monitoring and Control Report to the Corporation. This report shows the actions carried out during the period in order to demonstrate the effectiveness of the environmental measures in each of the activities described in the programs.

The review of the EMS is done through different reports submitted by the project's environmental inspection team. During this stage, the purpose is to detect the mistakes that may exist in the EMS and to take the necessary corrective measures.

Also the review determines the effectiveness of the measures proposed to manage the impacts, so that experience gained can be used in future drilling projects.

CHAPTER 6 ENVIRONMENTAL MITIGATION AND PREVENTION MEASURES

6.1 INTRODUCTION

The Environmental Management Plan (EMP) develops the environmental management measures necessary to prevent, mitigate, control, protect and/or compensate the possible impacts caused by the activities of the Drilling of Development Wells in the Palagua field.

The mitigation and prevention measures are developed in this chapter through the programs of the EMP, to be applied exclusively in the area of the Project, which has been structured based on the specific needs identified in the Environmental Base Line. Its purpose consist of providing the necessary tools for the proper management of the elements of the abiotic, biotic, and social sources during the drilling activities of the Project.

6.2 APPLICATION PURPOSES OF THE ENVIRONMENTAL MITIGATION AND PREVENTION MEASURES

In the Environmental Management Programs of the Palagua Field, there is a community management policy, by which social projects are being developed for the benefit of the community.

For the implementation of the Environmental Management Plan there are the following specific purposes:

- Identify the existing environmental problems in the direct and indirect area of influence of the drilling project.
- Define and develop the actions that must be followed for each of the environmental components, whose development shall be parallel to each of the activities of the project, to reduce and/or avoid the effects on the environment.
- Determine the model for the application of the Environmental Management Plan within the drilling area of the wells, its access roads, and streamline.

- Establish the responsibilities of execution of the environmental actions and the respective works of supervision, through the environmental inspection for the development of the Project.
- Follow up and Control through the Reports of Environmental Compliance, REC, from the Ministry.

6.3 ORGANIZATION OF THE ENVIRONMENTAL MANAGEMENT

The measures directed towards the prevention, control, mitigation, protection, recovery or compensation of the impacts arising during the operation of the Project, are presented in a series of components and programs that make up the EMP. These components are the result of the analysis of the evaluation of impacts. The measures to be applied to each program are presented as tables with the following content:

- **Purposes and Goals of the Program.** The scope and purpose for each program is defined.

- **Activities and Impacts to be managed.** The activities that generate impacts and the impacts to be managed are identified through the actions proposed in the program. It establishes the stage or phase in which the measure will be applied.

- **Environmental Impact.** Description of the specific impact or impacts that are to be avoided, mitigated, corrected or compensated when adopting the proposed measures.

- **Management Measures to be implemented.** The environmental management activities to be developed are described. It specifies whether the actions included in the table are preventive, protective, mitigative, corrective, or compensative controls of the mentioned impacts.

- **Type of measure. Actions to be developed.** Presents the measures and criteria of design of the activities in the table; as well as, the strategies that must be followed parallel to the proposed actions.

- **Technologies used.** Theoretical description and conceptual skills or methods that will be used for the proposed actions.

- **Site of Implementation.** Refers to the place of implementation of the Environmental Management Measures.

- **Responsibility of Execution.** The person or persons responsible for the execution of the actions are defined.

- **Applicable Regulation.** The environmental regulation that applies for each program is described.

- **Follow Up indicators.** List of the indicators defined in the environmental evaluation of the project that apply for the follow up work.

- **Execution Timescale.** Defines at what time the different measures of environmental management should be applied.

- **Required Resources and Costs.** Lists the required resources and costs of the execution of the environmental management activity of the project.

- **Responsible for the Follow Up.** Establishes who should perform the follow-up tasks.

- **Expected Results.** Establishes a guideline to conduct the follow up of the actions proposed in the table.

- **Remarks.** Issues to be considered for execution, follow up, or assessment of the actions or measures proposed in the table.

6.3.1 ENVIRONMENTAL INDICATORS

The definition of Environmental Indicators of the follow-up processes directly relates to the actions proposed in the table, and the records that must be kept in their execution. To build indicators that are dependable and useful, four main aspects must be considered:

1. **Sustainable Development:** This concept involves the interrelation of the economic, socio-cultural, and environmental factors. Therefore, the "sustainable development" must be defined for each scenario according to its characteristics.
2. **Environmental Information:** It is ideal to have an environmental information system that provides a set of integrated and organized data that enhances the efficiency in dissemination and communication of information.
3. **Decision Making Cycle:** It is a dynamic process made up of four stages: Identification of Problems, Formulation of policies and strategies, Implementation of policies and strategies, and Assessment of policies, strategies and actions.
4. **Model and Conceptual Framework:** The Model PRESSURE-STATE-RESPONSE (PSR) (OCDE, 1991; 1993) is accepted worldwide due to its simplicity, easy use, and for the responsibility that it provides when applied to different levels, scales, and human activities.

Additionally, the construction of indicators depends on the availability of information and its quality, on the different conditions (physical, biotic, socioeconomic, and cultural) of the region and of the project to be developed.

❖ **PROGRAMS FOR ENVIRONMENTAL MITIGATION AND PREVENTION MEASURES**

6.4 GENERAL GUIDELINES FOR ENVIROMENTAL HEALTH AND SAFETY

The table below contains a summary of the guidelines of the Environmental Management Program. A table for each one of the separate guidelines will follow.

SECTION	Document Reference Number		GUIDELINE OF ENVIROMENTAL MANAGEMENT
SOCIAL MANAGEMENT	6.4.1	6.4.1.1	Information and communication guideline
		6.4.1.2	Guideline for hiring local work force
		6.4.1.3	Guidelines for education and training of staff of the work staff
		6.4.1.4	Archeological information guideline
ENVIROMENTAL	6.4.2	6.4.2.1	Guideline on environmental management of production testing
		6.4.2.2	Pipeline (flow line) management guideline
		6.4.2.3	Guideline of monitoring and tracking to disposition of industrial water and drilling solids
		6.4.2.4	Guidelines on waste management
HEALTH AND OCCUPATIONAL SAFETY	6.4.3	6.4.3.1	Signposting guideline (access road, location, flow line)
		6.4.3.2	Guideline of handling and storage of chemical products
HEALTH AND SAFETY OF THE COMMUNITY	6.4.4	6.4.4.1	Guideline of control and monitoring to the social management program
		6.4.4.2	Guideline of dump areas, land removal and land-fills management at the locations
		6.4.4.3	Guideline of drainage management of access roads and locations
CONSTRUCTION AND DECOMMISSIONING	6.4.5	6.4.5.1	Environmental alternatives guideline (abandonment stage)
		6.4.5.2	Liquid waste management guideline (stage of abandonment)

6.4.1 GENERAL GUIDELINES ON SOCIAL MANAGEMENT

6.4.1.1 Information and Communication Guideline

OBJECTIVE	• Design, develop, and disclose an information system on the drilling project of the Development Wells, in the Palagua – Caipal Field in the municipality of Puerto Boyacá, Boyacá, aimed at the population located in the direct and indirect area of influence, to make the project known and present it to the mass media and other means of communication looking for the most active possible participation from them. • Establish means of Communications among the communities, their leaders, the social leader of the project, and the company.		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restorations / Abandonment**	
ENVIRONMENTAL IMPACT	• Conflicts with the community • Effect of the existing infrastructure • Lack of information from the community affected by the work activities. • Community opposition to the development of the work due to lack of information. • Conflicts of the community with the Leader of the work due to lack of information. • Generating expectations with respect to the benefits that the development of the project represents. • Increase in local and regional inter-institutional relations. • Increase of employment offer. • Strengthening of local and regional area community organizations. • Improvement of the economic conditions of the individuals and the community enterprises that have the opportunity to work or carry out activities in the different stages of the Project (Civil Works building and drilling)		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE TAKEN	• Informing the population residing in the area of influence of the Project about the characteristics of the Project, through informative meetings. • Agree with the participants the date and place of the necessary meetings and workshops.		

	• Make the minutes of meetings and workshops with the constancy of the participants and topics. • Prepare the adequate materials and aids for the presentations for the participant's level.
TECHNOLOGY USED	• Agreement and participation. • Written information and working agenda for the session.
RESPONSIBLE FOR EXECUTION	Palagua – Caipal field superintendent.
EXPECTED RESULTS	• Adequate Management of the expectations in the area of influence of the Project. • Rational participation of the unskilled workers in the region of the Project. • Strengthening of the communities. • Reduction of conflicts between the community and the work executed. • A good image of the Project and of the Company before the community.
REMARKS	Conduct meetings or Workshops in the rural area with regard to the Project as necessary. The success of the social work must be the objective of the work, for which it is recommendable to hire a professional in the social area or community relationships to be in charge of the Management and compliance of the social purposes of the Project. This professional must have an extensive knowledge of social work. He or she must also have the support of the administrative policies and techniques of the Project, establishing direct communication channels. Finally, it is important that the social worker or the representative for the relationship with the community be in permanent communication with the executors of the project in the field to be up to date with the evolution of the project. For the success of the Social Management it is recommendable that all the agreements, and the distribution of the labor participation, etc., be recorded in writing and be signed at every meeting held with the community and its leaders. This will avoid future distortion of the agreements by strangers or sections of the community that do not agree with the projects. Additionally, the results and photography of the community activities must be published on a community laminated bulletin board, placed in the mayor's office and in the rural area for best clarity with the community.

6.4.1.2 Guideline for Hiring Local Work Force

OBJECTIVE	• Present to the Mayor's Office of the Municipality of Puerto Boyacá and to the Inhabitants of the rural district of Palagua, the need for unskilled labor, according to the stages of the Project and the different activities. • Give detailed information about the requirements and commitments entailed in the labor supply of the Project in general, and in each of the stages. • Publicize hiring processes and legal aspects. • Inform about the selection processes, induction, wage and other required aspects, such as exams and others. • Answer the concerns raised by the participants in the different Workshops. • Set the personal profile that is not possible to recruit from the region. • Establish the way of distributing the participation of the unskilled labor for all the areas of influence of the Project.		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restorations / Abandonment**	
ENVIRONMENTAL IMPACT	• Generation of income expectations • Increase of the local, regional and inter-institutional relations • Increase of job offer • Improvement of the quality of life of hired people		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE TAKEN	• Establish the number of personnel required and the requirements for aspiring for the job. • Establish the participation of all the areas of influence of the Project equitably and fairly. • One (1) workshop in the Palagua rural district. • Prepare the minutes of the meetings and workshops		
TECHNOLOGY USED	• Interviews • Written information and work agenda for the session. • Broadcasting on the community radio, if possible.		
APPLICATION SITE	Area corresponding to the Palagua rural area.		

RESPONSIBLE FOR EXECUTION	Palagua – Caipal Field Superintendent
EXPECTED RESULTS	- Adequate Management of the expectations in the area of influence of the Project and prevention of the negative effects that may result from the lack of information relating to real labor need of the Project. - Enablement of the positive effects of the Project and reduction of conflicts with the community that alter the normal performance of the work. - Awareness of the community and its leaders, the magnitude of the temporary employment, and the number of people and services that will be required. - Awareness of the way that unskilled personnel will be requested, of the distribution of jobs that will be applied during all the stages of the Project (civil works, drilling and restoration), and the mechanism for requesting it from the community.
REMARKS	- The Project represents the execution of the employment policies of UT-IJP, and seeks to link local labor in activities to develop. - It is necessary to be clear with the community in terms of staff numbers and work periods in order not to generate false expectations. Likewise, minimize, in any, conflicts between the personnel of the region and foreign personnel.

6.4.1.3 Guidelines for Education and Training of Work Staff

OBJECTIVE	• Include environmental training and environmental safety in the work program, as working tools during the development of the operations of the Project. • Establish among the workers and the managers of the work the commitment to carry out the work considering the environmental commitments generated by the environmental measures and laws. • Present the environmental conditions of the area of influence of the Project, and the existing Environmental Standards, related to the care that must be taken in the use and management of the soil, air, and water resources; and avoid negative effects in the development of the activities of the Project. • Inform about the adequate use of the soil and the adequate Management of the waste. • Raise awareness of the social and cultural aspects of the municipalities and of the rural areas of influence, as well as of the People's Participation.		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Restoration / Abandonment of the Area**	
ENVIRONMENTAL IMPACT	• Alteration of water, soil, biota, quality of the landscape, and historical or cultural heritage. • Awareness of the residents of the area, the social conditions, and the quality of life. • Opportunity for improving the environmental knowledge and management of the workers and of the managers of the work. • Prevention of environmental damage due to disinformation of the operators, workers and engineers.		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE DEVELOPED	**<u>In connection with training:</u>** • At the beginning of the civil Works in the well, a meeting of installation of the HSE Committee will be held. • Daily five minute environmental training indicating the following: **1 - "Social and Cultural Conditions of the Area"** oriented towards presenting the characteristics of the area and towards observing respect for the residents of the area. **2 - "Use and Management of the Natural Resources",** oriented towards the		

	existing Environmental Regulations and Environmental Conditions of the Area, and oriented towards the care that must be taken in the area of the Project.
TECHNOLOGY USED	• Presentation of the programmed Environmental measures and of the activities. • Written Material. • Agreement and Participation.
APPLICATION SITE	In the site of the well, according to the development work and related hiring of personnel. The training programs will take place during the daily work hours.
RESPONSIBLE FOR EXECUTION	UT-IJP Environmental Coordinator.
EXPECTED RESULTS	• Training of the personnel and managers of the Project about environmental regulations, and social conditions of the area. • Adequate Management of the area and prevention of possible negative effects. • Adequate Management of industrial safety aspects during the work.
REMARKS	It is important that the personnel that will be working in the Project take necessary care in their behavior, according to the training that they get in the Workshops and the daily instructions at the beginning of the work day. However, the influence of the Environmental Director is important to maintain the environmental quality in the area. Likewise, the Officials, leaders of each stage of the Project (civil engineers of the work, team supervisor, and well supervisor) must be notified by the Management of **UT-IJP** about the environmental mitigation measures that must be used during their work.

6.4.1.4 Archeological Information Guideline

OBJECTIVE	• Comply with the current legislation on protection of the Nations' Archeological and Historical Heritage, according to what is set forth in Article 11 of Law 163 of 1959, Article 9 of Regulatory Decree 264 of 1963 and Law 397 of August 7 of 1997. • Prevent destruction and alteration of Archeological Heritage through pertinent information on archeological element safeguard. This information has to be submitted to the management, administration and operators of work area.		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restoration / Abandonment**	
ENVIRONMENTAL IMPACT	• Alteration of archeological sites. • Destruction of historical record.		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE TAKEN	Informative talk on the importance of restoration and conservation of archaeological material and sites. The talk should include a general outline of the archeology of the region, its characteristics, current legislation and the necessary measures to implement in case of an archaeological find.		
TECHNOLOGY USED	Billboards and simple presentations		
PLACE OF EXECUTION	Location of wells		
RESPONSIBLE FOR EXECUTION	Environmental Superintendent and Coordinator of **UT-IJP**		
EXPECTED RESULTS	Work staff involvement in archaeological protection, information and cooperation activities in case of an eventual finding.		
REMARKS	The area of the wells and its access roads do not have archeological potential according to the Colombian Institute of Anthropology and History (ICAHN). Train company personnel about the proper actions that need to be taken when materials of historical or cultural interest are discovered.		

6.4.2 GENERAL GUIDELINE ON ENVIRONMENTAL MITIGATION AND PREVENTION MEASURES

6.4.2.1 Guideline on Environmental Management of Production Testing

OBJECTIVE	• Submit the measures for production testing management within the location to minimize the environmental risks that can be generated. • Provide the guidelines for safe transportation of the produced fluids.		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restoration / Abandonment**	
ENVIRONMENTAL IMPACT	Alteration of the physical, chemical and biological properties of water and soil.		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE TAKEN	Have adequate storage and transportation means for the formation fluids produced during the testing. Follow the measures to handle polluted waste generated during production testing.		
TECHNOLOGY USED	• The formation oil and water will be separated and stored in tanks on the location and then will be sent in tank trucks to Palagua Battery. • If there is gas production during the testing, it will be flared so that it allows full combustion to prevent emission of particles, following the regulations with respect to height and placement of the flare and according to the specifications in the Decrees 02/82 and 948/95. • The solid and liquid waste management measures designed for the drilling stage will be followed. • The management of oily waste water will be enforced with respect to its collection. • The storage tanks will be hermetic and equipped with level indicators. • In the event of a leak in the production line, the measures for solid and liquid waste management designed for the drilling stage will be followed. • The equipment used should guarantee minimum oil spill within the location. • The tank trucks used to transport formation fluids should be in good condition with regards to airtightness, and must follow the safety rules in areas of highest risk of leakage.		

PLACE OF EXECUTION	Location of the wells to be drilled.
RESPONSIBLE FOR THE EXECUTION	Production supervisor, under the supervision of the Environmental Coordinator of the **UT- IJP.**
EXPECTED RESULTS	Zero spills of produced fluids Proper disposal of produced water. Proper disposal of solid waste (domestic and industrial) during operation.

6.4.2.2 Pipeline (Flow Line) Management Guideline

OBJECTIVE	Establish the appropriate measures for the environmental management of laying, welding and pipeline radiography activities to be used in the building of the flow line.		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restoration / Abandonment**	
ENVIRONMENTAL IMPACT	• Emissions of gas to the atmosphere. • Negative visual changes. • Pollution of environmental resources due to inappropriate handling of radiographies.		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE TAKEN	• Before laying pipelines, it must be verified that the path is clear of obstacles so as not to create difficulties in areas surrounding the road by depositing pipes in areas that have not been intervened. • All items such as butt welding, scrap metal, and pieces of cut pipe must be stored in properly marked containers along the road for later transportation to the Palagua Battery, where they will be collected and sent to scrap metal recyclers. • The handling of radiographies including fluids should be conducted away from the pipeline laying activities to reduce the risk of animals in the area and workers themselves getting in contact with these materials. • The welding processes should be supervised by the contractor's person in charge, and approved by the inspector designated by the UT-IJP to ensure optimal bonding of the pipe and prevent possible repairs later on. • During construction of the flow line, signs should be installed warning vehicles of the presence of WORKERS ON THE ROAD and use vehicle traffic signals.		
TECHNOLOGY USED	• Welding equipment. • Full topography equipment.		
PLACE OF EXECUTION	Flow lines paths projected for the wells.		
RESPONSIBLE FOR THE EXECUTION	The Well Supervisor, under the supervision of the Environmental Coordinator of the **UT- IJP**		

EXPECTED RESULTS	Adequate management of waste generated during the pipeline building works.
REMARKS	A photographic record or a filmed record of the work should be kept.

6.4.2.3 Guideline of Monitoring and Tracking to Disposition of Industrial Water and Drilling Solids

OBJECTIVE	• Monitor physical, chemical, and bacteriological characteristics of wastewater generated during drilling before and after being treated. • Determine the chemical properties of solid waste from the drilling.		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restoration / Abandonment**	
ENVIRONMENTAL IMPACT	• Effect on natural resources by disposal of treated wastewater. • Effect on ground water by the quality of the drilling cuts.		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE TAKEN	**<u>Monitoring of Waters</u>** • Carry out monitoring of the effluent of the industrial wastewater treatment system of the well before being sent to the Palagua Battery, through composite sampling, analyzing the physicochemical parameters mentioned below. **<u>Monitoring of Drilling Cuttings</u>** • The drilling cuttings in the land farming area will be evaluated by taking two samples from the site. One sample will be taken after the drilling operations begin and the other at the end. • The samples taken in a composite way and at different heights in the heaps will be taken to the laboratory for type TCLP analysis (leaching potential) to assess the heavy metals of health interest, nitrites and nitrates in the leachate. • The results from potential leaching are not the same as the results from metal content through chemical breakdown with acids but are simulations of the leaching process of the material to determine its potential. **<u>Results Analysis</u>** • To analyze the physicochemical and bacteriological results it is advisable to draw diagrams or charts, showing clearly the variation of parameters over time at different sampling points to help with its interpretation. • It is important to take into account the conditions of the sampling site, permissible ranges according to current legislation.		

Parameters to Assess

- **Physicochemical Parameters:** pH, temperature, alkalinity, total solids, dissolved solids, suspended solids, color, chloride, conductivity, sulfate, turbidity, dissolved oxygen, acidity, nitrites, nitrates, iron, phosphates, total hardness, phenols, DBO_5, DQO, grease and oil.
- **Bacteriological Parameters:** Total coliforms and fecal (E. Coli)
- **For the solids type TCLP:** The results of the TCLP simulations should be compared with the human consumption limits for heavy metals since eventually their leached is mixed with ground water that can be collected from nearby cisterns. You can also compare the results against the metal content limit to consider waste as hazardous according to Colombian environmental laws.

Recommendations for sampling and analysis

- Use clean and sterilized containers.
- Carefully label the corresponding container each collected sample. The lids should also be labeled since they can be changed.
- For the analysis of grease and oil content in water, the sample must be collected very precisely in glass bottles, because if plastic bottles are used the sample may adhere to the side of the bottle or be absorbed.
- For the bacteriological sample it is recommended for the container where the sample is collected to be sterilized and clean. It is important to avoid eventual external pollution. It is important to record the time, temperature and the aspect of the water at the time when that sample is collected.

TECHNOLOGY USED

Physicochemical Sampling

For this type of sampling the containers used are transparent glass and plastic usually of 500 to 1000 ml, with appropriate plastic lids. The minimum recommended volume is 500 ml for a routine analysis. The water sample must be representative of the fluid system in order to obtain satisfactory results and conclusions.

For the preservation of the samples for physicochemical analysis, the recommendations by the Standards Methods for the Examination of Water and Waste Water, last edition, should be followed.

Sampling, Preservation and Conservation of Samples

Parameter	Container	Minimum Quantity of Sample [ml]	Preservation	Maximum Storage*
Alkalinity	Plastic, Glass	200	Refrigerate	24h/14d
Chlorides	Glass	240	Analyze immediately	-
Conductivity	Plastic, Glass	500	Refrigerate	28d/28d
Carbon dioxide	Plastic, Glass	100	Analyze immediately	-
DBO	Plastic, Glass	1000	Refrigerate	6h/48 h
DQO	Plastic, Glass	100	Analyze as soon as possible or add H_2SO_4 to pH<2	7 d /28 d
Hardness	Plastic, Glass	100	Add HNO_3 to pH<2	6m/6m
Phenols	Plastic, Glass	500	Refrigerate, add H_2SO_4 to pH<2	24h/28h
Greases and Oils	Glass	400	Add H_2SO_4 a pH<2	28 d /28 d
Metals	Plastic (A), Glass (A)	-	For dissolved metals filter immediately. Add HNO_3 to pH<2	6m/6m
Dissolved Oxygen	Glass bottles	300	Analyze immediately	-

	pH	Plastic, Glass	-	Analyze immediately	2h/2h
	Solids	Plastic, Glass	-	Refrigerate	7d /7-14d
	Sulphates	Plastic, Glass	-	Refrigerate	28 d /28 d
	Sulfides	Plastic, Glass	100	Refrigerate. Add 4 drops of zinc acetate to 2N/100 ml.	28 d /28 d
	Temperature	Plastic, Glass	-	Analyze immediately	-
	Turbidity	Plastic, Glass	-	Analyze the same day	24h/24h
	Fecal Coliforms	Plastic	500	Analyze the same day. Refrigerate.	-
	Total Coliforms	Plastic	500	Analyze the same day. Refrigerate.	-
	* Recommended / Regulated H= hours, d= days, m= months V (A)= rinse with HNO3 (1:1), P (A)= rinse with HNO3 (1:1) Source: Standards Methods for the Examination of water and wastewater.				
PLACE OF EXECUTION	Affluent of the Industrial WASTE WATER treatment system of the wells.				
RESPONSIBLE FOR EXECUTION	Well Chief and the contractor under the supervision of the Environmental Coordinator from **UT-IJP**.				
EXPECTED RESULTS	Full compliance with the permit for industrial wastewater disposal. No effect on natural resource for industrial wastewater disposal during the drilling stage.				
REMARKS	It is important to process the Environmental Compliance Reports (EVR) from the Ministry				

6.4.2.4 Guidelines on Waste Management

OBJECTIVE	Provide information on the measures to carry out an effective control of pollution that may be generated by the well location improvements.		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restoration / Abandonment**	
ENVIRONMENTAL IMPACT	• Emissions of particle to the atmosphere caused by the machinery and equipment. • High noise level produced by machinery and equipment in the work area. • Disposal of polluting materials (construction material, solid and liquid waste, or fuel and lubricants) in water bodies or soil by workers • High visual impact for dumping solid and liquid waste in zones close to the work area. • Soil pollution due to accidental spill of fuel and lubricants from machinery. • Pollution of groundwater supplies by spills described in the preceding item.		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE TAKEN	• Conduct periodic inspections of smoke emissions from machinery. The emissions that are too high need to be immediately corrected. Also, the operation of machinery with hydraulic oil or fuel leaks will not be allowed since they affect the soil. • Conduct periodic checkups of the machinery in the work area, for leakages of fuel and / or lubricants. • Select the area for fuel and oil storage away from water streams. This fuel storage area should have geo-membrane flooring or a cement floor and have a grease trap. It is recommended that this area have a ceiling, posted No Smoking signs, and be lined with security tape. • The machinery leaking polluting fluids will not be allowed to function and will not return to work until the leakage is repaired. • Do not wash work machinery and equipment in water bodies located in the vicinity of the work area. • Change of lubricants or fuel must be carried out in remote areas of vegetation or water bodies and placing 55 gallon metallic barrels to receive the lubricant that is been changed or to contain accidental spilling of fuel. Also, the soil must be protected with polyethylene to prevent pollution. • Provide training to workers about the importance of pollution control in the		

	work area, including issues such as causes, consequences and control methods. • Inform workers in due course on the rules established in the work area to avoid the impacts caused by pollution at the site of the work. • The disposal of surplus construction materials or organic residues by workers in places like water bodies, work place surrounding areas, springs, or other places than authorized areas will not be allowed. • The containers to store solid waste produced by workers will be strategically placed in the work area. The facilities needed for the management of domestic waste water will be provided.
TECHNOLOGY USED	• Waste collection systems in plastic containers. • Knowledge and experience of the Environmental Inspector to detect pollutant factors. • Septic tanks and / or portable toilets for domestic waste management.
PLACE OF EXECUTION	Access roads, location and flow line.
RESPONSIBLE FOR THE EXECUTION	Well Chief under the supervision of the Environmental Coordinator from **UT-IJP**.
EXPECTED RESULTS	Adequate waste management and minimization of visual impact generated.
REMARKS	None

6.4.3 GENERAL GUIDELINES ON HEALTH AND OCCUPATIONAL SAFETY

A complete Manual of Occupational Health and Safety for UT can be found in Annex 4.

6.4.3.1 Sign Posting Guideline (Access Road, Location, Flow Line)

OBJECTIVE	Establish adequate signs and the basic industrial safety measures to carry out, in an efficient and safe manner, the execution of the works.		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restoration / Abandonment**	
ENVIRONMENTAL IMPACT	• High accident rate in the high-risk activities at the field. • Occurrence of environmental incidents due to the lack of knowledge of the work procedures and of the work area.		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE TAKEN	• The following signs will be made and placed according to the type of work, area, and accident risk: • Warning signs: This type of sign warns workers regarding possible danger in the work area, and must be placed closest to the place where an accident may occur. • Informational signs: The informational signs are located in pertinent places to guide the personnel in the work area, showing direction to work areas. • Hold periodic talks with workers at every level of the works, involving basic industrial safety aspects. • Prepare and implement a monitoring and control program of industrial safety elements, confirming its effectiveness. • Install signs as to the access to the well for the vehicles that transport material and equipment for the drilling operations (name of the well and approximate distance). • Install CAUTION SCHOOL ZONE signs and post speed limit signs at appropriate areas around the school.		
TECHNOLOGY USED	• Skilled labor.		
PLACE OF EXECUTION	Access road, location and flow line.		
RESPONSIBLE FOR THE EXECUTION	The Well Chief, under the supervision of the Environmental Coordinator of the **UT- IJP**.		

EXPECTED RESULTS	Zero operational accidents with environmental or occupational health impact on the road and the location during construction works.
REMARKS	None.

6.4.3.2 Guideline of Handling and Storage of Chemical Products

OBJECTIVE	Stipulate the actions for handling, storage and disposal of chemical residues generated during the Drilling of Wells of the Palagua – Caipal Field.		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restoration / Abandonment**	
ENVIRONMENTAL IMPACT	Pollution of water bodies and soils by chemical products and fuel spills.		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE TAKEN	• Execution of proper warehouses for storing chemicals and empty packaging and containers. • Post appropriate signs. • Classify the chemicals to be stored according to flammability and/or reaction to other products, to determine the adequate storage areas within the warehouse. • Adequate labeling of the containers of the chemical products to minimize risks. • Forbid the reuse of the packaging of special products in all activities. It is recommended that the packaging be returned to / reused directly by the supplier and / or manufacturer. • Implement the "Material Safety Data Sheet – MSDS" (commonly known as Safety Sheet) for each product and have them available for information of the worker.		

TECHNOLOGY USED	**Specifications and Location of the Warehouse or Chemical Products Containers** • Building of a chemical products storage warehouse preferably covered with sheets of zinc or plastic to prevent rain runoff from chemicals to the soil or nearby water bodies and on a concrete surface surrounded by a perimeter channel that allows collecting rain water and possible spills; otherwise install containers to do so. • The warehouse or chemical products and fuel storage containers will have to be built or installed in a place distant from the dormitories and of the drinking water and food storage areas. • For the storage of Packaging a provisional storage place will have to be used until the contractors remove them; the area will have to be covered to prevent rain runoff from dragging chemicals to the soil or nearby water bodies. **Chemicals Control on Locations** • Complete list of all the chemicals stored at the locations. • Inventory of the products taken in and stored during the operation. • Safety Sheets – MSDS of each of the products, that will include a separate part that contains the instructions on how to store, collect and clean in case of spilling on water or on the floor, and their environmental implications. **Chemicals Handling** • The staff responsible for the safety of these products should receive the training and protective clothing and equipment needed to prevent workers' health from exposure and handling of toxic and flammable substances.
PLACE OF EXECUTION	Location area of the wells.
RESPONSIBLE FOR THE EXECUTION	The Drilling Company and the contractors, under the supervision of the Environmental Coordinator of the **UT- IJP.**
EXPECTED RESULTS	Zero pollution of soil or water from chemical spills. Zero accidents or incidents reported from improper handling of chemicals.
REMARKS	Before the beginning of the operation, the staff must be familiar with the handling of the waste produced by the operation.

6.4.4 GENERAL GUIDELINES FOR HEALTH AND SAFETY OF THE COMMUNITY

6.4.4.1 Guideline of Control and Monitoring to the Social Management Program

OBJECTIVE	• Develop the different actions required for the adequate execution of the Social Management Plan in the area of influence of the project. • To exercise continuous control in the Social Management Program projects, in the different actions of UT-IJP.		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restoration / Abandonment**	
ENVIRONMENTAL IMPACT	• Commitment at a management level of the project and the technical leader to comply with social management associated to the EMP. • Provision the economic resources for the execution of social management. • Enablement of positive impacts.		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**

ACTIONS TO BE TAKEN	The actions to be taken should be directed towards: • Initial review of the Social Management Plan and ensure the awareness and commitment of the projects' management to social management. • Take part in meetings and workshops, in the observation and analysis of written documents, and take minutes. • Timely meet the needs of the community which must be managed using the company's legal support and with full knowledge of the project's management. • Monitor and control of the activities from the Social Management Program, periodically. This includes monitoring and control over: • Meetings and workshops • Community involvement • Number of Participants to the Meetings and Workshops. • Evaluations of the meetings and workshops with the participants. • General Dynamic of the Meetings. • Execution in the time specified.

6.4.4.2 Guideline of Dump Areas, Land Removal and Fillings Management at the Locations

OBJECTIVE	Establish the applicable environmental management measures to execute the land removal in the preparation of the well location.		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restoration / Abandonment**	
ENVIRONMENTAL IMPACT	• Hydric or wind superficial erosion. • Contribution of sediment to adjacent water bodies. • Noise, gas or particle emissions. • Changes in landscape. • Creation of obstacles to natural drainage near or included in the dump area site.		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE TAKEN	• The locations are in acceptable condition to install drilling infrastructure. Additional to this the fractions of materials such as rubble and certain building materials waste, which require change or renewal, will be used in the geo-morphological recovery of an external area affected by natural erosion and not induced by the existing operation. • According to preliminary calculations of the movement of earth and the requirements of the project, no surplus material will be generated, therefore the will be no need to use dump areas. • Adapt protection works, such as bag-concrete or wood barriers, that are resistant and with high bearing capacity, to protect the slope located behind the wells.		
TECHNOLOGY USED	Heavy machinery: bulldozers, backhoes, front loader, motor grader, metal roller vibrocompactor.		
PLACE OF EXECUTION	Location of the development well Palagua – Caipal Field.		
RESPONSIBLE FOR THE EXECUTION	Environmental Coordinator of the **UT- IJP**.		

6.4.4.3 Guideline of Drainage Management of Access Roads and Locations

OBJECTIVE	Design and implement a program for the proper management of drainage in access roads and locations to the wells, through the building of drainage works.		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restoration / Abandonment**	
ENVIRONMENTAL IMPACT	• Changes in the drainage pattern of the site. • Contribution of sediment to nearby streams.		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE TAKEN	• Protect the soils with polyethylene or a similar material when making mortars or concrete during the building of drainage works. • Construct the drainage works that are needed for the disposal of rainwater in the access roads: • Build the necessary drainage works at the location for the disposal of rain and industrial water, as described below: - A perimeter ditch will be built in the area of each location to dispose of rain water, in a trapezoidal shape of 0.80 m. width, 25 cm. depth, 0.40 m. base and 7.5 cm. thick in concrete with f'c = 2,000 psi. - Channels to collect oily water will be built. These channels will deliver water to a skimmer, and later carry this water to the treatment tanks. - As a part of the treatment for the drilling water, a trap for oily water will be built at the location.		
TECHNOLOGY USED	Small equipment: concrete mixers, vibrators, building formwork.		
PLACE OF EXECUTION	Access roads and location.		
RESPONSIBLE FOR THE EXECUTION	Environmental Coordinator of the **UT- IJP**.		

EXPECTED RESULTS	Adequate handling of rain water at the locations. Adequate handling of polluted rain water at the locations.

6.4.5 GENERAL GUIDELINES FOR CONSTRUCTION AND DECOMMISSIONING

6.4.5.1 Environmental Alternatives Guideline (Abandonment Stage)

OBJECTIVE	Identify and present the alternatives that will exist after completion of the operation stage.		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restoration / Abandonment**	
ENVIRONMENTAL IMPACT	Pollution of the water, air and soil resource at the location and in general, in the area of the project.		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE TAKEN	Execute or implement environmental alternatives identified at the completion of the drilling phase and production tests of the wells.		
TECHNOLOGY USED	**<u>Positive Production Tests</u>**. - If the well is productive, the access roads will be kept. - The areas of the well locations are part of the current production areas of the development wells and will be left in the same conditions as before. - The flow lines will be installed to connect the well to the production flow lines of the Field. **<u>Negative Production Tests (Dry Well).</u>** The same measures presented above will be implemented except for the installation of flow lines.		
PLACE OF EXECUTION	Access roads, flow lines and location of the wells.		
RESPONSIBLE FOR THE EXECUTION	The Superintendent of the Palagua – Caipal Field and the Environmental Coordinator of the **UT- IJP.**		

EXPECTED RESULTS	Dismantling and total cleanup of the area of the location, without causing pollution or negative effects. Recovering of the intervened area and permanent harmonization with the environment surrounding it.

6.4.5.2 Liquid Waste Management Guideline (Abandonment Stage)

OBJECTIVE	• Dismantling and cleaning the location to leave it environmentally and technically ready for its subsequent recovery. • Removing the components installed for the management of domestic liquid waste generated in the execution of the typical activities of the company. • Removing the structures built in order to prevent alterations to the terrain.		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restoration / Abandonment**	
ENVIRONMENTAL IMPACT	Affectation of the soil as a result of an inadequate disposition of waste from the dismantling of the location. Change in the natural landscape and its landforms.		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE TAKEN	Removal of structures and facilities set up during the building and assembly process. Treatment of all sanitary facilities that were built. Adequate disposition of the waste generated during the drilling and production tests, as well as the waste generated in the dismantling of the facilities and the demolition of structures.		
TECHNOLOGY USED	**<u>Removal of the drill structures and facilities</u>** The dismantling will begin with the disassembling and removal of drilling equipment and piping, auxiliary equipment such as mud pumps, warehouses, and office camps. The disassembling should not leave waste at the location, metal scrap and accumulated waste will be collected disposed of properly. **<u>Closing and Final Management of Sanitary Facilities</u>** Grounded structure, cement and concrete such as grease traps, sediment traps, ditches and canals must be dismantled and /or demolish. Organic waste accumulated in them should be transferred to be mixed with the closure material, since it can be useful for re-vegetation processes.		
PLACE OF EXECUTION	Location		

RESPONSIBLE FOR THE EXECUTION	The Field Superintendent and the contractors, under the supervision of the Environmental Coordinator of the **UT- IJP.**
EXPECTED RESULTS	Dismantling and total cleanup of the area of the location, without causing pollution or negative effect to achieve recovery.

6.5 GUIDELINES FOR THE EVALUATION AND MANAGEMENT RISK FOR OIL AND GAS DEVELOPMENT

The following table contains a summary of the guidelines of the Environmental, Health and Safety Program. A table with each one of these guidelines can be found below.

PROGRAM	Number in the document	ENVIRONMENTAL, HEALTH AND SAFETY MANAGEMENT GUIDELINES		
COMPREHENSIVE PROGRAM OF EVALUATION AND MANAGEMENT OF RISKS AND SPECIFIC POTENTIAL IMPACTS OF THE PROJECT	6.5.1		Assessment and management of risk and potential impacts of emissions into the air	
	6.5.2		Wastewater discharge management – Effluents	
	6.5.3	6.5.3.1	Solid waste management	Solid and liquid waste management
		6.5.3.2	Liquid waste management	
	6.5.4		Assessment and management of risk and potential impacts from noise generation	
	6.5.5	6.5.5.1	Conformation and stabilization of slopes at the locations	Terrestrial impact management
		6.5.5.2	Environmental revegetation and recovery of the surrounding area	
	6.5.6	6.5.6.1	Environmental management of production testing	Spills
		6.5.6.2	Waste management and pollution control	
	6.5.7		Assessment And Management Risk For Blow Out (Well Control Policy)	
	6.5.8		Measures for energy saving and efficient use	
	6.5.9		Water conservation measures	
	6.5.10		Water quality	

6.5.1 ASSESSMENT AND MANAGEMENT OF RISK AND POTENTIAL IMPACTS OF EMISSIONS INTO THE AIR

OBJECTIVE	• Comply with the regulations of air quality. • Identify and minimize atmospheric pollution from emissions. • Perform monitoring activities to determine volumes of total suspended pollutant particles (TSP), particulate matter, Sulfur Oxides (SOx), Nitrogen Oxides (NOx), Carbon Dioxide (CO2) and Ozone (O3).		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restoration / Abandonment**	
ENVIRONMENTAL IMPACT	• Air quality deterioration from emissions of CO, CO_2, NOx, particulate matter as a result from machinery operation and vehicle traffic. • Disturbances to the fauna, flora and human settlements located near the wells' facilities.		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE TAKEN	• Keep records of the state and maintenance of vehicles and equipment used during the development of the project. • Verify the compliance with regulations of the vehicles used regarding air quality.		
TECHNOLOGY USED	**If required, it** is essential to take into account the relevant provisions in Article 33 of Decree 02 of 1982, the air quality verification should be evaluated using the following methods:		

Pollutant	Method of Analysis
Particles in suspension	Gravimetric by high volume sampler
Sulfur Dioxide	Colorimetric using pararosaniline
Carbon Monoxide	Analyzer, non-dispersive infrared
Photochemical oxidants (O_3)	Gas-phase chemiluminescence
Nitrogen oxides	Jacobs and Hochheiser
NPA	Slow response sound level meter

PLACE OF IMPLEMENTATION	Wells location and surrounding areas.
RESPONSIBLE FOR THE IMPLEMENTATION	Well Chief and the contractor company under the supervision of the Environmental Coordinator of the **UT-IJP**.
EXPECTED RESULTS	• No effect of emissions caused on the activity to the fauna and the people of the areas surrounding the wells. • Identification and reduction of the polluting sources of the air by emission of pollutants. • Monitoring records of air quality in terms of TSP, SOx, NOx, CO and HC. • Permanent use of elements of personal protection by workers of the company.

6.5.2 WASTEWATER DISCHARGE MANAGEMENT – EFFLUENTS

OBJECTIVE	Prevent or mitigate pollution of soil, surface water bodies and aquifers, by the improper disposal of waste water – effluents. Implement environmental management measures to manage liquid waste generated by activities of the company.		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restoration / Abandonment**	
ENVIRONMENTAL IMPACT	Change in the physical, chemical and microbiological properties of the soil, water bodies, streams and aquifers produced by handling and pouring of untreated liquid waste.		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE TAKEN	**Wash Water** • The location will have a drainage system to collect rain water, wash water, oil and chemical leaks from the equipment used in the operations. These waters will pass through an oil trap before taking it to the industrial waste water treatment system of the well. • To minimize the production of wash water from machinery and equipment, the equipment and machinery should be washed as seldom as possible and when they are washed, use as little water as possible. The vehicles should not be washed at the well location. **Domestic Waters** • Sewage water will be collected by separate sanitary networks, built in PVC of 3" or 4". • The treatment of domestic waste water will be done using compact portable plants of activated sludge. Some sewage water will be treated in grease traps. • The effluent of the activated sludge treatment plant and the grease tramp will be taken to the industrial waste water treatment system of the well, where once it complies with what is established in Decree 1594 of 1984 will be uploaded to a tank truck to be transported to the Palagua – Caipal Battery, where it will be treated with produced water from the field and then injected into deep reservoir.		

	Industrial Water • The industrial water that will be treated is mainly from mud dewatering or due to changes in the mud program. • Water will be sent to the storage tank at the well, where a conventional physicochemical treatment will be done (TECHNOLOGY USED). Once the water complies with what is established in Decree 1594 of 1984 will be uploaded to a tank truck for its mixing and treatment with waters from the field and then injected into deep reservoir. • Another alternative is to sprinkle the water on the roads, once it complies with the requirements established in Decree 1594 of 1984 for its use. **Oily Liquid Waste** • Oily waste generated in the well is burnt lubricants from oil changes of engines, therefore it is suggested that the contractors do not perform maintenance to engines at the well site.
TECHNOLOGY USED	**Sewage Water – Activated Sludge Plant** Activated portable treatment plants are the most commonly used for sewage water treatment, that consist of contact between waste water and bacteria that feed on organic waste in the presence of oxygen. The residual water that enters the system is mixed with activated sludge by recirculation. The mixture is aerated to allow different oxidation reactions to occur, that remove many organic components from the residual water. The characteristics of the design of the activated sludge treatment plant are: - Hydraulic retention time: 18 – 24 hours - Operation mode: full mixture - Type of Aeration: compressed air or mechanical aeration - Feeding / microorganisms ratio: 0.05 - 0.15 d-1 (d – 1 = days) - Solids retention time: 20 – 40 days - Concentration of suspended solids mixing liquor SSML: 3000 – 5000 mg/L **Industrial Water** The treatment of industrial waste water will be done in a tank and will consist of a physiochemical process, although a bacteriological process will also be carried out when the results from the monitoring samples show it is needed. The physicochemical treatment will include a pH adjustment, adding coagulants, flocculants and polymers when the latter are necessary, given that their use should be minimal and must be approved by the staff HSE of the UT- IJP. All the water must be disinfected before being transported to the water plant.

PLACE OF IMPLEMENTATION	Location where the wells are drilled.
RESPONSIBLE FOR THE IMPLEMENTATION	The Drilling company under the supervision of the Environmental Coordinator of the **UT- IJP.**
EXPECTED RESULTS	Comprehensive management and handling of liquid waste generated by the drilling of wells.

6.5.3 SOLID AND LIQUID WASTE MANAGEMENT

6.5.3.1 Solid Waste Management

OBJECTIVE	Prevent and/or mitigate potential impact caused by improper management, storage and final disposal of solid waste that will affect soil, superficial water bodies and aquifers.		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restoration / Abandonment**	
ENVIRONMENTAL IMPACT	Change in the physical and chemical properties of the soil and water bodies by improper disposal of solid waste.		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE TAKEN	<u>**Domestic Solid Waste**</u> • **Separation at the Source** Organic and recyclable waste has to be separated in order to facilitate its handling and disposal. To do so, there must be 55 gallon barrels at the location, strategically placed, appropriately colored and labeled as follows: ♦ <u>Black Color - organic waste:</u> food waste, fruit peels, etc. ♦ <u>Green or White Color - recyclable waste:</u> print paper, newspapers, magazines, cardboard, aluminum, disposable polystyrene, glass in all its presentations, ferrous metals, wood, etc. Some wastes that are neither technically or economically recyclable nor biodegradable must be collected in this container, to separate them in the treatment phase. ♦ <u>Red Color - special waste:</u> paper waste from sanitary facilities. The location must be kept clean. • **Collection** The waste bags, place in containers at the location, must be collected regularly. • **Storage** The bags will be stored in a collection center, in which they will be arranged and organized on pallets, according to their classification. The collection center must have a retaining wall, roof and three walls for the		

protection of the waste from the weather, and good ventilation.

- **Treatment and Final Disposal**

  - Organic waste will be stored and disposed of in the landfill in Puerto Boyacá.
  - The food waste will be given to people in the region, to feed animals (pig breeding).
  - Recyclables will be handled through the community action board of the rural area of Palagua for marketing.
  - Special waste will be disposed of by incineration in accordance with the Management Plan implemented by the contractor.

Industrial Waste

- **Drill Cuttings**
  - The most important industrial waste by quantity and quality, that is generated in a drilling well is composed of two fractions: the cuttings separated from the mud in the solid waste control equipment (product from the excavation of soil by action of the drilling bit); and the solids resulting from dewatering or dehydration of mud (removed from the line due to aging, loss of rheological properties or changes in the mud program).
  - The drill cuttings will be stored in a tank at the location, which will be transferred to the land-farming area for final disposal. I

- **Other Industrial Waste**

  - *Soil pollution from hydrocarbons*

The polluted soils generated in the wells are minimal; they will be transported and put in the oily waste storage yard at Palagua Field, next to the Water Injection Plant. An economical and technical viable volume will be held in storage, until it is put through a Bioremediation process in the land farming area.

  - *Cans, packaging, plastics and other*

Diesel fuel containers, packaging of chemicals for the preparation of drilling mud, plastic drums, gallons, pails, etc., generated by emptying chemicals, drilling pipe thread protectors, junk hoses, waste PVC pipe, etc.

  - All the products containing chemicals must be evacuated by the supplier of the service and cannot be sold or given away for any activity.
  - All containers of the chemicals for mud preparation or water treatment will be collected by the contractor (supplier).
  - The chemicals storage containers should be collected by the contractor

	(supplier). - The pipe thread protectors will be reused by the pipe supplying companies. - *Filters* Oil, air and engine fuel used filters are usually of fabric or cardboard with galvanized steel frame. This kind of waste, if possible, should not be generated, provided that the contractor performs equipment maintenance to the engines before arriving at the location. - *Wood, paper, cardboard* Wood is generated from the packaging of equipment and spare parts used in drilling. Paper and cardboard are generated from the bags and sacks used in packaging of mud chemicals, cements, completion fluids and water treatment. The material will be collected and stacked in the well location area and then removed by the contractors. - *Metal Scrap* Produced in the manufacture of homemade tools, components, parts, etc., changing parts and repair shop activities. The non-reusable material will be sent to the storage yard for industrial solid waste of the field, adjacent to Palagua – Caipal Battery. - *Polluted Textiles* Waste such as burlap, gloves, overalls, rags and other textiles, which cannot be recycled, will be taken to the industrial waste storage yard at the field, adjacent to Palagua –Caipal Battery.
TECHNOLOGY USED	**Solidification and Stabilization of Solid Waste from Drilling** This is a treatment and disposal process for solid waste from drilling consisting of reducing humidity and stabilizing waste through the use of materials such as quicklime (purity > 65% of CaO), which generates an exothermic reaction that guarantees dehydration and compacting of the waste. Solidification and stabilization is recommended for cuttings resulting from water based mud systems. The water based cuttings, once solidified and stabilized, can be mixed with cementitious material for later use. The same procedure is utilized for treating the sand produce from the clean out services.

PLACE OF IMPLEMENTATION	The location where the development wells are drilled.

RESPONSIBLE FOR THE IMPLEMENTATION	The Drilling Company and the contractors, under the supervision of the Environmental Coordinator of the **UT- IJP.**
EXPECTED RESULTS	• Comprehensive solid waste management for waste generated during well drilling. • Adequate handling of solid waste in collection, temporary storage and final disposal.
REMARKS	The Contractors of the project are responsible for the comprehensive waste management of the waste produced during the development of the activities.

6.5.3.2 Liquid Waste Management

OBJECTIVE	• Formulate the liquid waste management measures to prevent or minimize the alteration of the drainage of the area of influence of the project. • The waste generated in the management and operative quarters is treated and disposed of according to the current environmental legislation and in an environmentally safe manner.		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restoration / Abandonment**	
ENVIRONMENTAL IMPACT	• Pollution of soil and water bodies. • Possible change in the physical, chemical and biological properties of the surface and ground water and the soil.		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE TAKEN	During operation, special care will be taken for the liquid waste management at the management quarters and the area surrounding the location of the wells. Drainage should be through ditches, sewers, culverts, dock and/or sumps, in order to minimize contact of soil and natural water with pollutants. The workers should be familiar with the measures so that the liquid waste will not be disposed of in surface water bodies.		
TECHNOLOGY USED	At the location, it is expected that liquid wastes be separated into independent collection systems for industrial liquid waste. The rain water management system consists of ditches, sewers, culverts, docks and/or slumps which are separated from greasy and oily water before being taken to the grease trap.		
PLACE OF IMPLEMENTATION	Perimeter areas of the location.		
RESPONSIBLE FOR THE IMPLEMENTATION	Environmental Coordinator of the **UT- IJP** and the Well Supervisor as representative of the drilling company.		
EXPECTED RESULTS	Disposing of liquid waste and runoff water without pollution.		

6.5.4 ASSESSMENT AND MANAGEMENT OF RISK AND POTENTIAL IMPACTS FROM NOISE GENERATION

OBJECTIVE	• Comply with the regulations for noise generation and keep sound levels within the established standards of the current environmental legislation. • Identify and minimize the noise pollution sources. • Implement control measures to mitigate noise levels produced by machinery operation at the development wells.		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restoration / Abandonment**	
ENVIRONMENTAL IMPACT	• Deterioration of the air quality by noise generation, resulting from functioning machinery and vehicular traffic. • Affectation of fauna and human settlements located close to the wells facilities.		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE TAKEN	• Keep records of the state and maintenance of vehicles and equipment during the development of the project. • Verify compliance of vehicles with the regulations regarding noise emissions.		
TECHNOLOGY USED	**If required,** the technology for environmental noise measuring will be taken into account included in the resolution 627 of 2006 by the Ministry, Housing and Land Development (MHTD):		

NPS	Method of Analysis	Sampling Frequency
75 dB	TEFC	Daytime maximum value (7:01 to 21:00)
70 dB	TEFC	Nighttime maximum value (21:01 to 7:00)

PLACE OF IMPLEMENTATION	Wells locations and surrounding areas.
RESPONSIBLE FOR THE IMPLEMENTATION	Well Chief and the contractor under the supervision of the Environmental Coordinator of the **UT-IJP**.

EXPECTED RESULTS	No effects on the fauna, the inhabitants of the surrounding areas of the well and workers due to high sound levels caused by the activity. Identification and reduction of noise pollution.

6.5.5 TERRESTRIAL IMPACT MANAGEMENT AND TRACE OF THE PROJECT

6.5.5.1 Conformation and Stabilization of slopes at the locations

OBJECTIVE	Establish the appropriate measures to manage fill slopes of the wells locations, related with the stability during and after the execution of works.		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restoration / Abandonment**	
ENVIRONMENTAL IMPACT	• Changes in the drainage system of the place. • Negative visual changes. • Removal of the vegetation cover of the affected area. • Instability of slopes caused by filling and excavation activities.		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE TAKEN	• There are no slopes near to the access roads and the locations where their height is over 4 m., therefore there is no need to build coronation ditches. • Revegetalize the fill slopes at the locations. • The angle of inclination of the fill slopes cannot exceed a maximum of 1V: 1H.		
TECHNOLOGY USED	Heavy machinery: Bulldozer, backhoe and motor grader.		
PLACE OF IMPLEMENTATION	Access road and location.		
RESPONSIBLE FOR THE IMPLEMENTATION	Environmental Coordinator of **UT- IJP**.		
EXPECTED RESULTS	Stability of the executed works, adequate management of the environment and minimization of the visual impact generated by the works.		

6.5.5.2 Environmental Revegetation and Recovery of the Surrounding Area

OBJECTIVE	• Mitigate the landscape impact caused during location preparation. • Restore the vegetation cover lost during the adaptation of the locations. • Contribute to landscape improvement and the conservation of the species of ecological importance in the area. • Protect the existing fill slope at the location with vegetation cover in order to prevent landslides or destabilization of the fill slope.		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restoration / Abandonment**	
ENVIRONMENTAL IMPACT	• Loss of the vegetation cover during construction. • Destabilization of slopes.		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE TAKEN	**<u>Species Selection</u>** • The arboreal species selected should be, as much as possible, of rapid growth during the early years, with easily dispersed seeds for rapid growth of foliage. • The graminea to be used should be adapted to the region, easily obtainable and of good performance. It is recommended to use braciaria grass as introduced species, with good adaptability. • The recommended planting depth depends on the species (between 50 cm and 1.5 m). **<u>Planting Location</u>** • The species should be planted around the locations and on the sides of the road leading to the wells. The arboreal species will be planted at a spacing of approximately 10 to 15 meters.		
TECHNOLOGY USED	**<u>Sowing Time</u>** It is recommended that the planting be done during rainy periods. In that way, it will take advantage of the whole wet season in order to have a good adaptation. Planting can be done at other times if IJP UT does the watering when necessary, at least every third day during the dry or low precipitation season.		

	Type of Spacing To take maximum advantage of the area to be reforested and to create favorable conditions for optimal growth and natural pruning, it is recommended to place trees with regular and dense spacing, when required by the terrain. **Sowing of Grass** • The grass will be planted by seed scattering at a rate of 20 kg/ha prior soil preparation. Since the seed in very light it should be sown with a mixture of soil to give it a very light coverage. • Planting of braciaria runners is used to recover graminae coverage areas. The sections should be planted with a triangle or staggered system. The runner chosen must present at least a 15 cm section which should include at least one leaf, node or bud. • The soil fertilization must be the same as that used for the planting of native species. As in the case of braciaria grass, it develops very well in poor soils and is not demanding in nutrients.
PLACE OF IMPLEMENTATION	Well location.
RESPONSIBLE FOR THE IMPLEMENTATION	Field Superintendent and the contractor of the works under the supervision of the Environmental Coordinator of the **UT-IJP**.
EXPECTED RESULTS	Total recovery of the intervened area and/or harmonization of the landscape. Stabilization of all slopes.
REMARKS	Due to the fact that the construction of the Palagua well location does not imply removal of arboreal species, the application of this fact sheet is not mandatory, but for landscape beautification reasons.

6.5.6 SPILLS

6.5.6.1 Environmental Management of Production Testing

OBJECTIVE	• Present management measures for well production testing at the location to minimize the environmental risks that may be generated. • Provide safety guidelines for the transportation of produced fluids.		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restoration / Abandonment**	
ENVIRONMENTAL IMPACT	Alteration of physical, chemical and biological properties of water and soil.		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE TAKEN	• Adopt adequate storage and transportation measures for fluids produced during the testing. • Follow the management procedures for polluted waste generated during production testing.		
TECHNOLOGY USED	• The crude and formation water will be separated and stored at the location in tanks, to be then transported in tank trucks to the Palagua Battery. • If there is gas production during the testing, it will be burnt in a flare that allows full combustion in order to avoid emission of particles, following the regulations with respect to height and placement of the flare and according to the specifications in the Decrees 02/82 and 948/95. • The procedures for solid and liquid waste designed for the drilling stage will be followed. • Storage will be done in hermetic tanks and provided with flood levees. • In the event of a leak in the production line, the procedures for solid and liquid waste management designed for the drilling stage will be followed. • The tank trucks for transportation of formation fluids should be securely airtight, and should follow the safety regulations to avoid spilling		
PLACE OF IMPLEMENTATION	Location of the wells to be drilled.		

RESPONSIBLE FOR THE IMPLEMENTATION	Production supervisor, under the supervision of the Environmental Coordinator of the **UT- IJP.**
EXPECTED RESULTS	• Zero spills of produced fluids. • Adequate disposal of produced water. • Adequate disposal of solid waste (domestic and industrial) during the operation.

6.5.6.2 Waste Management and Pollution Control

OBJECTIVE	Develop procedures for effective control of pollution that may arise by access roads and the location preparation work.		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restoration / Abandonment**	
ENVIRONMENTAL IMPACT	• Emissions of particles to the atmosphere caused by the machinery and equipment used. • High noise levels produced by machinery and equipment at the work area. • Disposal of polluting materials (Building material, solid and liquid waste, or fuel and lubricants) in water bodies or soil by workers. • High visual impact for dumping solid and liquid waste in zones close to the work area. • Soil contamination due to an accidental spill of fuel and lubricants from machinery. • Contamination of ground water supplies by spills described in the preceding item.		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE TAKEN	• Conduct periodic checkups of the machinery in the work area, to prevent spills caused by leakages of fuel and/or lubricants onto the ground or into water bodies,. • Select an area where fuel and oil can be stored without the possibility of affecting water streams. This fuel storage area should have geomembrane flooring or a cement floor and have a grease trap. It is recommended that this area have a ceiling with No Smoking signs posted. • Change of lubricants or supplying fuel must be carried out in remote areas away from vegetation or water bodies. Lubricant that is been changed will be placed in 55-gallon metallic barrels. Likewise, the soil must be protected with polyethylene to prevent contamination. • Inform workers of the rules established in the work area to avoid the impacts caused by pollution at the site of the works. • The disposal of surplus materials or organic residues by workers in places like water bodies, work place surrounding areas and springs will not be allowed. • The containers to store solid waste produced by workers will be strategically		

	placed in the work area.
TECHNOLOGY USED	• Waste collection systems in plastic containers. • Knowledge and experience of the Environmental Inspector to detect pollutant factors. • Septic tanks and / or portable toilets for domestic waste management.
PLACE OF IMPLEMENTATION	Well location and flow line.
RESPONSIBLE FOR THE IMPLEMENTATION	The Well Supervisor, under the supervision of the Environmental Coordinator of the **UT- IJP**.
EXPECTED RESULTS	Adequate waste management and minimization of visual impact generated by the work.

(See Figure 53, Areas in the Palagua field Susceptible to Spills, on the next page).

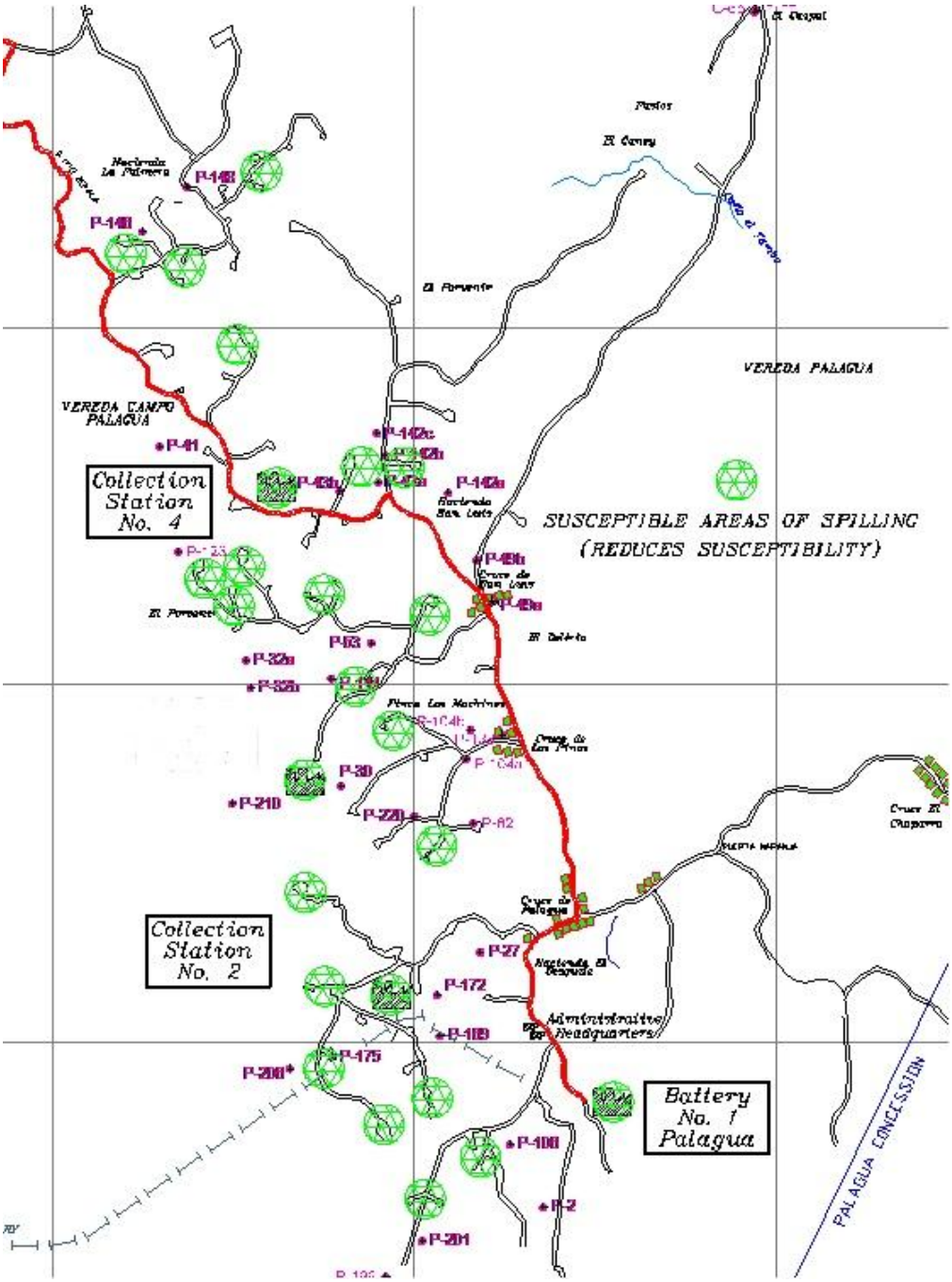


Figure 53 Areas in the Palagua field Susceptible to Spills

6.5.7 ASSESMENT AND MANAGEMENT RISK FOR BLOW OUT (WELL CONTROL POLICY)

OBJECTIVE	UTIJP's well control policy is to have pressure barriers that prevent uncontrolled flows of oil, gas or water either to the surface during drilling and workover activities. All field operations are conducted in such a way that operations do not expose to unreasonable well control risks		
EXECUTION	1. Planning	2. Preparation and Installation	
	3. Drilling	4. Area Restoration / Abandonment	
ENVIRONMENTAL IMPACT	• Workforce health and life • Spillage in the area		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	Prevention	Mitigation	Correction
	Compensation	Control	Protection

TECHNICAL CONSIDERATIONS

- The risk of well flowing to the surface during the drilling operations arises when the reservoir is over pressured. The over pressures reservoir is defined as the reservoir, where the downhole reservoir pressure is more than the NORMAL hydrostatic gradient of 0.44 psi/ft. for example, the reservoirs in the Palagua-Caipal field are 5000 ft deep. The normal hydrostatic pressure at this depth is 5000 * 0.44 psi/ft= 2200 psi.

- In the Palagua –Caipal fields, which are on production from 1957, the reservoirs are depleted, which means the reservoir pressure is less than the normal hydrostatic pressure of 2200 psi at 500 ft depth. Due to depletion of pressure, the wells in Palagua field cannot flow oil to the surface, without the help of a pump. Hence, <u>it is not possible to have a blow out of a well in this pressure depleted Palagua- Caipal oil field</u>.

- The operator, UT-IJP, measures reservoir pressures by shutting the wells for few days and then measure reservoir pressure. This is also called as a pressure build-up test. The low reservoir pressure (below the hydrostatic pressure) is confirmed by build-up pressure tests shown in the table below.

Date	Well	Datum (feet)	Formation Pressure (psi)	Hydrostatic pressure (psi)	REMARKS
7-21-2004	P-179	4,569	1,829	2,025	Reservoir depleted
7-6-2006	P-185	5,064	1,444	2,243	Reservoir depleted
5-12-2007	P-204	4,432	1,660	1,965	Reservoir depleted

ACTIONS TO BE TAKEN

- **Primary control (Adequate drilling mud weight)**

Primary well control is maintained by controlling formation pressures with the hydrostatic pressure of the drilling fluid. The hydrostatic pressure of a mud column is a function of the mud density and the true vertical depth of the well.

Although the Palagua and Caipal reservoirs are pressure depleted, they are drilled using a drilling fluid (mud) that is able to provide sufficient hydrostatic pressures to equal or exceed the reservoir pressures. Therefore, the hydrostatic pressure of the drilling fluid is an essential feature in maintaining control of a well and preventing blowouts. Insufficient pressure in the hole while drilling control can cause kicks, hole heaving, and blowouts. For this reason, Palagua and Caipal wells are drilled with a drilling fluid having a hydrostatic pressure of 0.478 psi/ft (i.e., mud weight of 9.2 pounds per gallon or density of 68.86 lbs per cubic ft).

- **Secondary control**

When primary control of the well has been lost due to insufficient mud hydrostatic pressure, it becomes necessary to seal or close the well to prevent an uncontrolled flow, or blowout, of formation fluids. This secondary seal or close the well is provided by installing a Blowout Preventer (BOP). It consists of drill pipe blowout preventers designed to stop the flow through the drill pipe and annular (BAG) preventers designed to stop the flow from the annulus.

To activate the BOP there are two methods. The primary method of closing both ram and annular preventers is by hydraulically operated accumulators. The accumulator has to be capable to supply sufficient pressure fluid to close all preventer units in the BOP stack. The accumulator itself is equipped with a pressure regulating system that allows adjusting the closing pressure on the preventers.

In case the hydraulic system fails, the second method is manual, where ram preventers have a screw-type locking device that can be used manually to close them. On onshore locations such as Palagua field, the access to manual control method is easily available.

The drilling rig must be evaluated to determine if its BOP equipment meets the minimum specifications. The Palagua field has never experienced a problem with the BOP while drilling.

BOP STACK INSTALLED

RAM TYPE PREVENTER

BAG TYPE PREVENTER

- **Tertiary control**

In an emergency and extreme case, and where secondary control is not reliable due to equipment failure or hole conditions, tertiary procedures can be employed.

Tertiary procedures are the 'last resource' and to be considered only in an

	emergency situation. In most cases it is expected to lose the well or part of the hole. Two common types of tertiary control techniques are cement and barite plugs.
TECHNOLOGY USED	**Primary control** Common forms of the hydrostatic pressure equation are as follows: Hydrostatic pressure (psi) = 0.052 x Mud Weight (ppg) x Depth (ft) The mud hydrostatic pressure for Palagua and Caipal wells corresponding to a depth of 5,000 ft is: Hydrostatic pressure = 0.052 x 9.2 ppg x 5000' = 2392 psi, which exceeds the reservoir pressure of 1829 psi recorded in the well P-179. Thus, a bottomhole pressure of 2392 psi will prevent oil flow into the wellbore during drilling. This is because reservoir pressure of 1829 psi is less than the bottomhole pressure of 2392 psi. **Secondary control** For secondary control, the following are the minimum or equivalent specifications for the drilling rig:

BOP Well Control Equipment	
Nominal 11" – BOP Stack	
BAG TYPE PREVENTER	CAMERON Type D
Size	11"
Working Pressure	5000 psi
Top connection type	Flange
Top Connection size	11 x 5000 psi x R-54
Bottom Connection Type	Flange
Bottom Connection Size	11 x 5000 psi x R-54
RAM TYPE PREVENTER	CAMERON QRC
Size	11 "
Working Pressure	5000 psi
Top Connection type	Flange
Top Connection Size	11" x 5000 psi x R-54
Bottom Connection Type	Flange
Bottom Connection Size	11" x 5000 psi

Pipe ram size available	4 ½ “, 3 ½ “, 2 7/8 “, 7”, 9 5/8”
Blind Ram	1 set
Nominal 11” Drill Spools “T”	CAMERON, type “T”
Top Connection type	Flange
Top Connection size WP	11” x 5000 psi x R-54
Bottom Connection Type	Flange
Bottom Connection Size WP	11” x 5000 psi x R-54
ED x Height	44”
Outlets	No. 2 Side gate valves and check valve
Outlets size WP	4” x 5000 psi
Choke valve	FLOCON
Hydraulic Operated	Type HCR
Number	No. 1
Size & Working pressure	4 1/16” x 5000 psi
Check Valve	FLOCON
Type	ONE WAY DROP
Number	No. 1
Size	2 1/16”
Working Pressure	5000 psi
ADAPTER / SPOOLS	No. 1
BOP Control System & Associated Equipment	
BOP control system	KOONEY
	Type 80
Surface accumulator unit	Model MOD-160-80G
Installation site	
Soluble oil reservoir capacity	280 Gal.
Accumulator Skid consisting of	HUDSON MACH WKS
Number of bottles No. 2 Guide float	
Accumulator	
Total Bottles capacity	80 Gal. E/A
Bottles working pressure	3000 psi
Control Panel	GENERAL ELECTRIC CR-206-D704 MABA
Triplex Pumps	KOOMEY
	Model UET20B
Each pump delivers	8.7 GPM
Max. Working pressure	3000 psi

With Electrical motor	U.S. MOTOR
	Model R7509-00-046M, Type L, 25 hp.
	230/460V. 60 Hz, 3ph, 50.6/25.3A, 1765 rpm
	GENERAL ELECTRIC
Control Panel	CR-206-d704, 460v, 60hZ
Air Pumps	Model U7A26
Each pump delivers	9.6 gpm
Max. Working pressure	3000 psi
Drilling control panels	Model KOOMEY A 7GR8
Remote control panel	Model KOOMEY A 7GR8
Installation site	RIG FLOOR
	AG MODEL 5120
Air Compressor	Size 6” x ¾” x 4”
Accumulator	Model WP200H2412
Electrical motor	Make-U.S. MOTOR
	Type L, 230/460 V. 60 Hz, 50/25 A
	1755 RPM, 3 PH 25 HP
Choke Manifold	
Size	2” x9 Valves
Working Pressure	5000 psi
Number of adjustable choke	2
Make	FLOCON
Maximum Aperture	64/64”
Kill & Choke lines From drilling Spools to choke man	1
Inside diameter/Working pressure	2” X 5000 PSI
Chicksan Joints	
Quantity	6
Size	2”
Working Pressure	5000 psi
Length of Each Joint	8 Ft

Tertiary control

- *Barite plugs*

A barite plug is a slurry mixture of barite in fresh water or diesel oil that is placed in the hole via the work string. The idea is that the solids settle out rapidly to form an impermeable plug. This plug is impermeable and is known to shut off the well

	flow. - *Cement plugs* Cement plugs may be used to isolate downhole flows. Cementing is also considered a 'last' option and should only be used if there is no other choice. Note that cementing will most likely result in the loss of the well and total abandonment. It may also cause the tools and work string to be cemented in place.
PLACE OF IMPLEMENTATION	This fact sheet will be applied inside the location where the development wells are drilled, and outside the location, at the main office at bidding time.
RESPONSIBLE FOR THE IMPLEMENTATION	The Drilling Company and the contractors, under the supervision of the Environmental Coordinator of the UT- IJP.
EXPECTED RESULTS	Adequate well control during the drilling campaign.
REMARKS	In Palagua field, the reservoirs are depleted and their pressure is below the normal hydrostatic pressure. Hence, oil from the reservoir cannot flow to the surface on its own, without installing a pump. However, as an extra precaution, a high density drilling fluid shall be used which provides significantly high pressures in the hole as compared to the reservoir pressure, preventing any possibility of the well blow out during drilling.

6.5.8 MEASURES FOR ENERGY SAVING AND EFFICIENT USE

OBJECTIVE	• Present options and effective measures or programs for energy conservation. • Save energy in different areas and stages of the Project with the participation of the company's employees. • Obtain benefits from energy conservation by continuous administrative and operational improvements.		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restoration / Abandonment**	
ENVIRONMENTAL IMPACT	Improvement in Energy efficiency.		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE TAKEN	• Adopt habits of energy efficiency without changing the Company's typical activities. • Be proactive in activities intended to reduce energy consumption. • Reduce the Company's energy consumption.		

TECHNOLOGY USED	**Change of consumption habits for immediate benefit, through actions such as:** • Turn off lights and disconnect equipment while not in use in the office. • Minimize the use of electric light during daylight hours. • Reduce lighting in corridors during daylight hours. • Control of air conditioning (closing doors when entering and exiting) • Use of energy efficient lights. • Avoid dampness in walls of the facilities. • Avoid leaks through doors and windows. • Divide the lighting circuits and take advantage of natural light. • Control leaks and air conditioning with exhaust fans in restrooms. • Paint walls of facilities with light colors. • Clean and maintain lighting and air conditioning systems. **Save non- renewable fuels, such as oil, through actions such as:** • Avoid use of automobile for a short distance. • Drive the vehicle correctly (avoid abrupt starts and brakes) • Optimize routes to cut down on distance. • Tune the motor and inflate tires correctly. • Reduce the use of public transportation outside of rush hours. • Keep internal roads in good conditions. **Staff Training :** • Train staff in saving energy and being efficient. • Encourage workers to adopt new energy-saving habits.
PLACE OF IMPLEMENTATION	Local facilities- Administrative and operative areas. Location of the wells to be drilled.
RESPONSIBLE FOR THE IMPLEMENTATION	Production Supervisor**,** with the Supervision of the Environmental Coordinator of **UT- IJP.**
EXPECTED RESULTS	• Reduction of energy use, to be undertaken by the members of the organization, by improving their habits. • Reduce energy use expenses. • Higher efficiency in the use of natural resources.

6.5.9 WATER CONSERVATION MEASURES

OBJECTIVE	• Present water conservation options in a comprehensive program to protect natural resources that are directly and indirectly in the Palagua – Caipal Field. • Inform and train Company employees and residents of the Palagua – Caipal field about the importance of conserving water and suggest measures to improve efficiency in water use.		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restoration / Abandonment**	
ENVIRONMENTAL IMPACT	Change in the physical, chemical and biological properties of water Reduction in consumption of the water in the Palagua – Caipal field area.		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE TAKEN	• Identify and repair leaks in the Company's distribution services. • Identify the areas of the Company that consume the most water and plan measures in addition to the distribution system, if it becomes necessary. • Adopt water saving measures and habits. • Make good use of water for human consumption (do not waste) • Avoid polluting bodies of water in the Palagua – Caipal field area. • Avoid oil or toxic substance spills that may filter into bodies of water on the surface or underground. In the event of a spill, actions noted in section 6.5.6 (Spills) should be taken. • Use rain water for irrigation and cleaning activities. • Forbid the disposal of dangerous waste in landfills. • Monitoring aquifers and treated water before their injection in to the deep Wells.		
PLACE OF APPLICATION	Local facilities- Administrative and operative areas. Location of the wells to drill.		
RESPONSIBLE FOR EXECUTION	Production Supervisor**,** with the Supervision of the Environmental Coordinator of **UT- IJP.**		
EXPECTED RESULTS	• Reduction in the water use and conservation of the underground and surface water quality and volumes. • Reduce expenses in water consumption. • More efficient use of natural resources.		

6.5.10 WATER QUALITY

OBJECTIVE	• Continue the waste water injection program performed in the plant. • Monitor injection water quality near its treatment site. • Guarantee injection water quality by improving quality from the starting conditions to the sewage plant for its injection		
EXECUTION	**1. Planning**	**2. Preparation and Installation**	
	3. Drilling	**4. Area Restoration/Abandonment**	
ENVIRONMENTAL IMPACT	• Pollution of soil and water bodies. • Change in the physical, chemical and biological properties of soil, surface and under-ground water.		
TYPE OF ENVIRONMENTAL MANAGEMENT MEASURE	**Prevention**	**Mitigation**	**Correction**
	Compensation	**Control**	**Protection**
ACTIONS TO BE TAKEN	• During the drilling operation of wells, the sewage will be treated for its injection. • The waste water quality will be monitored at the entrance and exit of the treatment plant analyzing the physical-chemical parameters: O/W, Suspended Solids, Turbidity, and Dissolved Oxygen. • Ensure that none of the waste water is disposed in water bodies, nor in areas of the Palagua field. Any treated sewage is re-injected.		
TECHNOLOGIES USED	The Palagua – Caipal field has a water treatment plant. Once treated, water is re-injected in the reservoir.		
PLACE OF APPLICATION	Location – Water treatment plant.		
RESPONSIBLE FOR EXECUTION	Environmental Coordinator of **UT- IJP** and the Well Supervisor as representative of the drilling company.		
EXPECTED RESULTS	Improvement of water quality. Water Conservation		

6.6 EMERGENCY AND CONTINGENCY PLAN - GENERAL

6.6.1 INTRODUCTION

Preparing for emergency response is important given the legal, economic and environmental implications that can be caused by emergencies. For this reason, being prepared for emergencies is a priority since they may occur at any given time, resulting in devastating consequences.

This guide establishes the mechanisms and response actions to attend in a timely, efficient and effective manner any partial or total disruption of activities of the 32-well expansion project for development well drilling in the Palagua field**.** The safety of workers or visitors, the operational stability of the different areas or work sites, and members of the community working in the surrounding area is ensured through the Emergency and Contingency Plan. It also seeks to reduce the environmental impact caused to the affected area.

The activities developed within the 32-well expansion project for development well drilling in the Palagua field are diverse and vary in time. The *Emergency Plan* aims to cover most of the possible events, but there are several activities that require adjustments or adaptation to external procedures, thus leaving open the possibility of adopting temporary measures and plans which are developed according to the particular circumstances.

6.6.2 APPLICABLE DEFINITIONS

Contingency: An event that has the possibility of occurrence or non-occurrence.

Emergency: An event that has been calculated to occur.

Possibility: Something that can be done, exists or occurs. It is analyzed from a qualitative point of view, for example: Low, Medium or High.

Probability: Eminent occurrence of the event, without specifying the time. The valuation system is taken from the quantification of the level of possibility.

Incipient Emergency: An event that can be controlled by a group of people with basic training and available equipment in the area.

Internal Emergency: An event that occurs in or around the project area that requiring specialized staff.

General Emergency: An event that occurs within the institution and also threatens neighboring institutions.

Vulnerability: Weakness due to an event that can cause impairment.

Risk: Degree of impairment resulting from an event.

Emergency Committee: An administrative group which is responsible for organizing and operating the Emergency Plan.

Emergency Brigade: Task Force trained to attend or respond to emergencies.

Provision for Emergency Care: Clothing that provides protection to the task force faced with an emergency.

Emergency Care Equipment: Equipment designed to be operated by the brigade in accordance to the risk factor.

6.6.3 LEGAL FRAMEWORK

The Colombian legal basis on which the Emergency and Contingency Plan (ECP) was built remains the same as presented in the 2010 ESIA and will be reproduced here:

- **Law 9. of 1979:** National Health Code, Articles 80, 84, 96 and 114.
- **Resolution 1016 of 1989:** By which the organization, operation and method of Occupational Health Programs developed by employers in the country is regulated.
- **Decree 1295 of 1994:** By which the organization and administration of the General System of Occupational Hazards is determined.
- **Decree 033 of 1998:** National Earthquake Resistance Code.
- **Substantive Labor Code:** Article 205

The list above provides the legal basis for the ECP. Table 90 provides a more comprehensive list of all laws, decrees and resolutions that must be adhered to with regard to the ECP, to date.

Table 90 COMPREHENSIVE LIST OF LAWS GOVERNING THE ECP

ENVIRONMENTAL REGULATION	DESCRIPTION	ENTITY
Political Constitution of Colombia 1991	Articles 8 - 78, 79, 80, 83, 88, 90, 95, 330, 332, and 360	**Congress of the Republic**
Decree 2811 of 1974	Dictated by the National Code of Renewable Natural Resources and the Protection of the Environment. Article 8-31	**President of the Republic of Colombia**
Decree 1547 of 1984	Creation of National Catastrophe Fund	**President of the Republic of Colombia**
Law 46 of 1988	Establishes the National System for Prevention and Attention to Emergencies (SNPAD)	**Congress of the Republic**
Decree 919 of 1989	Organizes the national system for the prevention and attention to emergencies	**Ministry of Government**
Resolution 1016 of 1989	Regulates organization, performance, and form of occupational health programs that employers may develop in the country	**Labor and Social Security Ministries**
Presidential Directive 33 of 1990	Responsibilities of entities in the public sector in the development and operation of a national system for the prevention and attention to disasters	**Presidency of the Republic**
Decree 283 of 1990	Regulates the storage, management, transport, and distribution of combustible liquids derived from petroleum and the transport by tank cars of crude petroleum	**Mining and Energy Ministry**
Presidential Directive 05 on December 28, 1991	Establishes the responsibilities of the state entities in the development of a national strategy against violence	**Presidency of the Republic**
Decree 1295 of 1994	Establishes the organization and administration of the professional risk system	**Finance and Public Credit Ministry**
Decree 1281 of 1994	Regulates high-risk operations	**Finance and Public Credit Ministry**
Decree 93 of 1998	Adoption of the national plan for prevention and attention to disasters	**Congress of the Republic**
Decree 321 of 1999	Adopts the national emergency plan against spills of hydrocarbons, their derivatives, and harmful substances in marine waters, floodwaters, and lacustrine waters	**Ministry of the Interior and Justice**
Decree 2015 of 2001	Regulates the shipping of licenses, urbanization, and construction subsequent to the declaration of public disaster situations	**Ministry of the Interior**
Decree 1609 of 2002	Regulates and manages the ground transport of dangerous merchandise by highway	**Housing, Environment, and Territorial Development Ministry**
Decree 4741 of 2005	Partially regulates the prevention and management of dangerous residue or waste generated in the course of integrated management	**Housing, Environment, and Territorial Development Ministry**
Decree 4550 of 2009	Regulates the adjustment, repair, and/or construction of structures subsequent to the declaration of a disaster situation or a public catastrophe	**Ministry of the Interior and Justice**
Decree 1454 of 2009	Details functions of the director of risk management for prevention and attention to disasters in his post as Expense Operator for the National Catastrophe Fund	**Ministry of the Interior and Justice**
Decree 023 of 2010	Through which a departmental or district disaster situation is declared	**Ministry of the Interior**

6.64 SCOPE

To develop an Emergency and Contingency Plan for employees, visitors and other persons involved in the expansion project for the 32-well expansion project for development well drilling in the Palagua field through a document that states and applies knowledge to act efficiently and promptly in case of emergency.

This plan is applicable for the different stages of the project to prevent, control, and recover from an emergency event.

6.6.5 OBJECTIVES

6.6.5.1 MAIN OBJECTIVE

To identify potential threats or risks that may arise from natural or anthropogenic causes, to take measures for prevention and control, through the formation of emergency brigades and by developing procedures for emergency care.

6.6.5.2 SPECIFIC OBJECTIVES

- Establish and generate skills, conditions and procedures that allow users (workers, visitors and other persons involved in the project) to prevent and to protect themselves in case of disaster or collective threats that may jeopardize the project, through quick, coordinated and reliable actions, and to have and organizational structure that provides adequate health care to all injured persons, if any.

- Plan evacuation drills.

- Identify and implement a planning process of prevention, forecasting, mitigation, preparedness, response and recovery in case of disaster.

- Have an adequate organizational structure in case of emergency.

- Determine threats, conduct vulnerability analysis and define levels of risk.

- Establish a standard evacuation procedure for all project users (operators, contractors, visitors).

- Establish an operational system " IN SITU " for the attention of potential injuries during all types of emergencies.

- Promote among workers or employees an environment of trust, and to motivate their participation in the emergency prevention measures and activities.

6.6.6 RESPONSIBLE PERSONNEL FOR THE IMPLEMENTATION OF THE PROCEDURES

The UT-IJP, will monitor and supervise the overall development and implementation of the Emergency and Contingency Plan for all activities during the operation of the 32-well expansion project for development well drilling in the Palagua field. It will also provide the necessary infrastructure and resources for the proper implementation of this plan.

Finally all the people working on the Project are responsible for developing and implementing the activities described to control and to prevent emergencies.

6.6.7 NATURAL, TECHNOLOGICAL AND ANTHROPOGENIC RISK ASSESSMENT

6.6.7.1 EVALUATION OF THE VARIOUS THREATS

- ***Threat Identification.***

The following table presents a summary of the existing potential threats.

Table 91 EXISTING POTENTIAL THREATS

POTENTIAL THREATS	POSSIBLE SCENARIOS	FACTORS THAT PROMOTE RISK
ANTHROPIC Civil disorder type Bombing Assault, robbery, theft Kidnapping or an attempt	Work Fronts, Camp Areas	Project Location Social, economic characteristics of the sector Existence of infrastructure and urban settlements that increase the likelihood Of an accident or the severity of its consequences. Main street area, Project Security, Social situation in the area.
NATURAL Earthquake Weather Floods	Work Fronts, Camp Areas	Location of medium - high seismic zone. History of occurrence of climate-related events (blizzards, hail, storms). Infrastructure, characteristics that increase the likelihood of an event or the severity of its consequences.
TECHNOLOGICAL Electrical Fire, Fire Fuels Exhaust Gas Explosion	Work Fronts, Camp Areas	Human error. Misuse of equipment and tools. Poor use of materials and supplies. Improper storage of combustibles. Inadequate signs. Inadequate maintenance of machinery and tools.

Source: Work Group

- ***Probability of occurrence of the threat***

To organize the basic information for the design of the Emergency and Contingency Plan and to set priorities, emergencies were classified according to their severity, as seen in the table below.

Table 92 PROBABILITY OF OCCURRENCE OF THE EMERGENCY

CATEGORY	PROBABILITY
LOW	Event that has never happened, but there is information that does not preclude its occurrence, it is unlikely to happen. It is characterized by the color green.
MEDIUM	Event has already occurred at the site or in similar conditions and may even occur in these conditions. It is represented by yellow.
HIGH	Instrumented event or with information which makes it evident and detectable. It has happened in previous projects, and is represented by the color red.

Source: Field Work

- ***Assessment of vulnerability conditions.***

The assessment of vulnerability is established by qualitatively measuring the impact of threats on people and its economic implications. The methodology and results on each assessment is presented below.

- **Vulnerability of Individuals**

The potential impact of each emergency is analyzed. The categories in which the severity of the threats is quantified, are described in the following table.

Table 93 VULNERABILITY OF THE PEOPLE RELATED THREAT/RISK

CATEGORIES	VULNERABILITY	COLOR
LOW	The event can produce mild injuries in people without disabilities.	GREEN
MEDIUM	The event can produce injuries resulting in temporary incapacity for up to 180 days, which can be extended another 180 days	YELLOW
HIGH	The event can result in serious injury, permanent disability, death, and high economic losses.	RED

Source: Law 1295 of 1994

- **Vulnerability and Threat Analysis**

Vulnerability analysis is a process which determines the level of exposure and susceptibility to the loss of an element or group of elements to a specific threat. These features can be seen in the following tables.

Table 94 ANTHROPOGENIC THREATS

THREAT	LIKELIHOOD	VULNERABILITY	COMMENTS AND RECOMMENDATIONS
CIVIL DISORDER	LOW	LOW	The location of the Project and the current social situation do not create crowd movements that are difficult to control.
BOMBING	LOW	HIGH	The social situation of our country makes this a potential risk for all.
ASSAULT, THEFT, or HOLD UP	LOW	HIGH	The remote location of the project may provoke these types of actions at different levels of complexity. People must be alert.
KIDNAPPING OR ATTEMPTED KIDNAPPING	LOW	HIGH	While the risk of kidnapping is possible, it is unlikely to happen in this type of project and work front. However, each officer must ensure his or her own work safety, especially when travelling to and from the workplace.

Table 95 NATURAL HAZARDS

THREAT	LIKELIHOOD	VULNERABILITY	COMMENTS AND RECOMMENDATIONS
EARTHQUAKE	MEDIUM	HIGH	The location of the Project makes this a medium probability risk. The physical and constructive nature of the project estimates considerable consequences in case of an earthquake. It is recommended that the areas of refuge for people in case of an earthquake should be located in the projects and all the staff should be informed of them. Bulky or heavy items should be safely stored and secured to prevent falling; fuels should be safeguarded.
FLOOD	MEDIUM	LOW	The project location has a tendency to flood. Isolated events may occur in some areas of the project due to heavy rain. The drilling locations are mostly on hill top areas and hence the chance of flooding is very low.
STORM, HAIL AND STRONG WIND	LOW	MEDIUM	Under particular weather conditions, such as strong winds, storms and even hail, the project may be affected. However, the nature of the infrastructure used during the project makes potential damage a small possibility. It is recommended to periodically review temporary camps, signs, ceilings, lighting and other items that my fall during high winds.

Source: RPS -- Work Group

Table 96 ORIGIN OF TECHNOLOGICAL THREATS

THREAT	LIKELIHOOD	VULNERABILITY	COMMENTS AND RECOMMENDATIONS
ELECTRIC AND FUEL FIRE	MEDIUM	MEDIUM	There are several fuel sources in the project. Different types of materials such as combustible materials (solids, liquids, electrical), as well as the presence of heat sources such as sparks, stoves or welding equipment, among others, are stored on site. Electrical installations should be periodically checked in order to keep them in good physical condition and performance. Adequate storage facilities of liquid fuels exist. All personnel must be trained in fire prevention and control, and these issues should be reviewed periodically. Fire control drills are recommended as part of the planned activities of the Industrial Safety and Occupational Health program.
EXPLOSION	LOW	HIGH	Propane gas cylinders, oxygen and acetylene used in machinery, welding and cutting processes are stored in the project area in workshops or storage. Considering their location on site, there is a low probability of an incedent as long as the appropriate security standards are implemented.
GAS LEAK	MEDIUM	MEDIUM	Along the field, there is a gas transmission network, which may constitute a petential emergency threat. All staff should be informed of the network location in order to prevent it from being accidentially damaged. Activities near this area should be avoided as much as possible. It is important to note that daily gas production from the field is small.

Source: RPS -- Work Group

Risk assessment

The risk matrix allows for a global view on the impact of a threat in different areas of the project.

Table 97 EMERGENCY HAZARDS GENERATORS

ANTHROPOLOGIC RISKS

THREAT	LIKELIHOOD	VULNERABILITY	RISK
CIVIL DISORDER	LOW	LOW	LOW
BOMBING		HIGH	MEDIUM
ASSAULT, THEFT, or HOLD UP			
KIDNAPING OR ATTEMPTED KIDNAPPING			

NATURAL HAZARDS

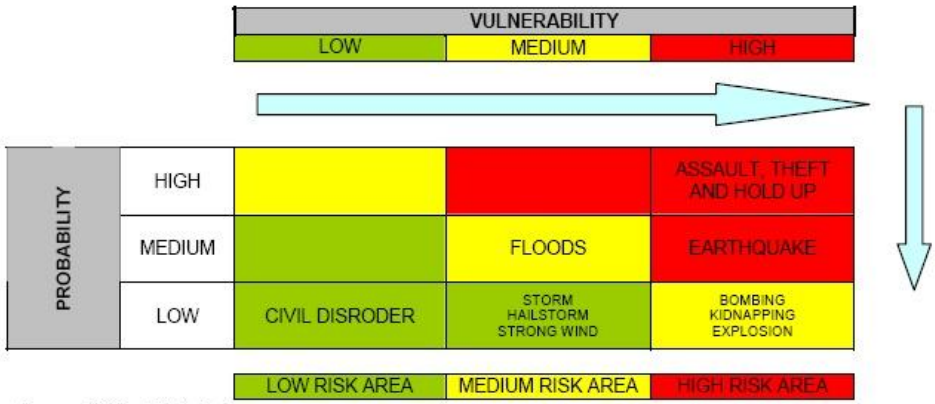
THREAT	LIKELIHOOD	VULNERABILITY	RISK
EARTHQUAKE	MEDIUM	HIGH	HIGH
FLOOD		LOW	MEDIUM
STORM, HAIL AND STRONG WIND	LOW	MEDIUM	LOW

TECHNOLOGICAL THREATS

THREAT	LIKELIHOOD	VULNERABILITY	RISK
ELECTRIC AND FUEL FIRE	MEDIUM	MEDIUM	MEDIUM
EXPLOSION	LOW	HIGH	
GAS LEAK	MEDIUM	MEDIUM	

Source: RPS -- Work Group

The following figure summarizes the risks that generate emergencies and their assessment according to the risk area:



Source: RPS -- Work Group

Figure 54 Summary of Risks that Generate Emergencies

In conclusion it is possible to state that there are high risks associated with the multiplicity of factors in the area. In the anthropic aspect, assault robbery or holdup are worth noting, in the technological aspect, stands the risk of fire of different types, in the natural aspect, the highest vulnerability regards to the occurrence of an earthquake, which can trigger all types of emergencies. In the medium-risk area, there are floods and explosions, explosions due to project activities, kidnapping or kidnapping attempts and, finally disorders related to civil crowds and those related to weather conditions.

6.6.7.2 MONITORING AND EVALUATION

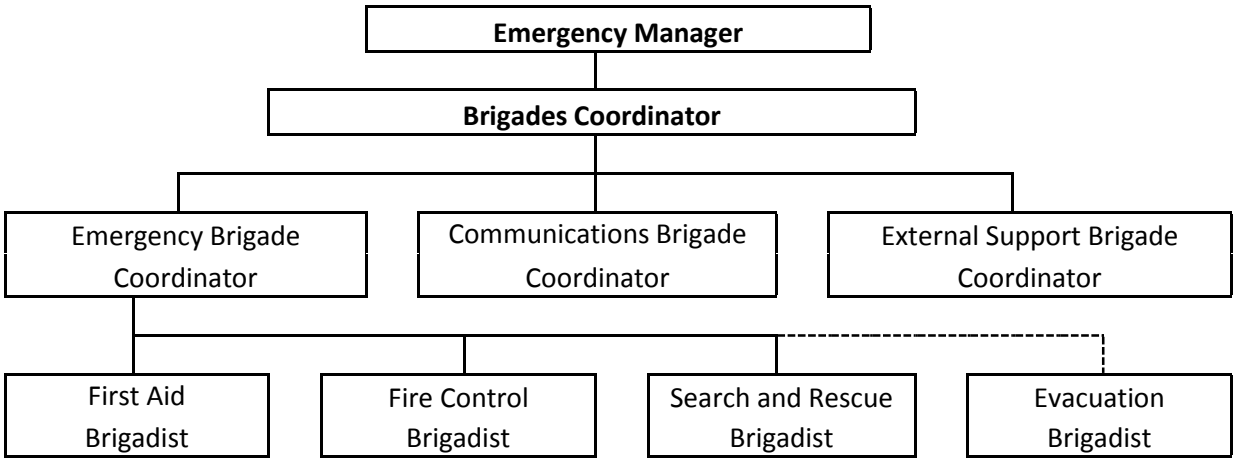
Emergency program drills should be scheduled to assess the preparedness of those who visit the project and its labor force. Staff or emergency response brigades must verify the availability of equipment used for emergency support.

6.6.8 REACTION GROUP ORGANIZATION AND OPERATING PROCEDURES

The immediate and safe response to emergencies depends on efficient care to minimize workers' injuries, damages or losses to equipment, machinery and infrastructure. It also serves as a guide for employees for the procedures to follow in an emergency.

6.6.8.1 ORGANIZATIONAL STRUCTURE OF THE RESPONSE TEAM

During the drilling project activities, a variable number of personnel will be working. However, the steps to be undertaken during an emergency response will be distributed among the most permanent staff. There would always be a person responsible for these activities. Nevertheless, a basic structure as follows should be taken into account:



* People who make up these groups should be designated and trained promptly

Figure 55 Organizational Structure of the Response Team

- ***General Procedure***

Once the emergency response personnel or brigade is designated, training workshops will be specific to each of the brigades. These people will be identified and are in turn responsible for disseminating and monitoring the emergency plan and actively participating in case of an emergency. The Emergency Plan should be made available to all staff working in the project, as well as identity of people in the emergency response team:

- ***Control Actions***

1. The person who discovers the emergency should report what happened to coworkers who are in the area, or to the Brigade formed at this point or the nearest camp. If the person is trained, he or she should attempt to control it, if it is not so, he or she should evacuate.

2. Upon hearing the alarm signal, depending on the type of emergency that has occurred, all staff should apply the established and known procedures. The following are the steps that should be considered:

   - The Brigade staff of the area where the emergency comes up should report to the camp and inform the type of event and the site where it is happening. Then, he or she should proceed to control the emergency and evacuate his or her staff if necessary.
   - The person who receives the communication in the camp, proceeds to report the event to the Coordinator of Brigades and immediately, if necessary, requests backup from the corresponding

external emergency response team (Fire, Red Cross, Police, etc.) Priority is given to keeping telephone lines and roads clear.

- The Brigades Coordinator being informed of the case, makes sure that the emergency response personnel is aware of the emergency. He performs the appropriate analysis of the situation and if necessary goes to the site to support the emergency.
- The general emergency groups begin the process of preparation for exit on each of their areas and await confirmation of the evacuation command, in order to move the staff.
- Other personnel suspend their activities, initiate the process of preparing for exit and wait for the brigade´s command to start the evacuation.
- Upon confirmation of the evacuation, personnel go along the established route towards the agreed meeting point and remains in place until further notice.
- Once at the check point each brigade or guide counts the people which he is in charge of for the evacuation and informs the General Evacuation Coordinator.
- When the emergency is controlled and it is deemed safe to return to the facilities and work areas, the Emergency Coordinator advises or reports to the staff at the check point.

o ***Final Check Point***

In each work area, there should be a suitable site located to reunite the staff, considering the number of evacuees and checking that everyone has been able to get out. This is managed by the emergency coordinator so that in case that there is someone missing, it can be reported in order to start the search procedure.

o ***Notifying Rescue Agencies***

Depending on the extent of the emergency and in case support is needed; rescue or first aid agencies close to the area will be notified. This may mean that lives will be saved or serious damage to the facility will be prevented.

For this notification the following steps should be taken into account:

1. Use the emergency telephone list that should remain in a visible place, or be carried by field personnel.

2. Provide clear and specific information as follows:

    - Name of the company.
    - Name and job position of who makes the call.
    - Description of the situation at hand and special requirements if any
    - Exact address of the company or the site where the emergency occurs (giving directions to make access to the location easier.)

- Phone number of where to call to confirm the veracity of the claim made
- Any other information requested by the rescue agency.

  - ***Evacuation of Wounded or Injured People***

In case that there are injuries during an emergency, the injured person must be taken to the meeting point and, if necessary, the Emergency Coordinator will request the necessary assistance for transportation to a nearby medical center to receive the required assistance.

  - ***Communication Systems***

The work area should keep available communication equipment (Avantel, PTT radio, cellular) in order to have timely communication both internally and externally. This will be verified. It is necessary to have the list of numbers and references of people, who have such equipment, e.g.:

- Radio # 5, Juan Perez, Brigade Force 3.
- Mobile 357-800-800, Mr. Pedro Rodriguez, Camp # 2.

The Emergency Manager will inform the directors of the project regarding the evolution of the event and will make the necessary requests to attend the emergency.

  - **Measures to protect property.**

The activities of the 32-well expansion project for development well drilling in the Palagua field**,** requires an established procedures for rapid protection of physical documents, securities, money, information, or any other valuable element. Such procedures must be fully known by those in charge of the mentioned elements.

The procedure for this staff is the following:

1. Define specifically which documents should be protected in the event of an evacuation.

2. Establish the place where they will be safely stored and protected. It should be noted that they might be locked and this place should preferably be fireproof.

3. When the alarm sounds and the process of preparing for exit begins. The person in charge should proceed to place the documents in the pre-defined location to protect them, or be carried by the person responsible.

  - ***Determining when danger has passed***

The Emergency Coordinator together with rescue agencies, shall determine when the situation has been controlled and will evaluate if it is safe for staff to enter the facility again, or if they must remain outside.

- ***Reestablishment of activities***

If there is no risk in re-entering the facility, the Emergency Coordinator advises the staff through the communication system or directly, giving the necessary recommendations for each case.

6.7 CONTINGENCY PLAN IN CASE OF FIRE OUTBREAK

Fire is a phenomenon that occurs when one or more combustible or flammable materials are consumed in an uncontrolled way by fire, causing losses in lives and property. The initial stage of a fire is called fire outbreak. It is at this stage where individuals with basic knowledge of this risk can intervene and prevent the fire.

6.7.1 CAUSE

It is crucial to learn that there are four classes of fires. Fires can be set off by different factors: chemical, physical, mechanical or electrical. They can occur because of facilities or equipment, or ungrounded electrical connections (wiring), accumulation, storage and improper handling of combustible materials, and tank or fuel spillage. For each of these kinds of fires, different substances are used to extinguish them. The equipment containing these substances are called extinguishers.

6.7.2 PREVENTATIVE MEASURES

The purpose of the Fire Prevention and Control Plan is to eliminate the causes of fire, prevent loss of life and property by fire, and to comply with the applicable provisions of NFPA (including Code 30 for flammable and Combustible Liquids) and API Standard 2610. It provides employees with information and guidelines that will assist them in recognizing, reporting, and controlling fire hazards. The Fire Prevention and Control Plan is written for a facility with more than 10 employees. The Fire Prevention and Control Plan will:

- Identify materials that are potential fire hazards and their proper handling and storage procedures;
- Distinguish potential ignition sources and the proper control procedures of those materials;
- Describe fire protection equipment and/or systems used to control fire hazards;

- Identify persons responsible for maintaining the equipment and systems installed to prevent or control ignition of fires;
- Identify persons responsible for the control and accumulation of flammable or combustible material;
- Describe good housekeeping procedures necessary to insure the control of accumulated flammable and combustible waste material and residues to avoid a fire emergency;
- Provide training to employees about fire hazards.

6.7.3 GENERAL PRECAUTIONS

- Make sure that the doors, hallways, stairs, and other exit routes are kept free of obstructions;
- Dispose of combustible waste in covered, airtight, metal containers;
- Use only nonflammable cleaning products;
- Store chemically reactive substances away from each other;
- Perform "hot work" such as welding, working with an open flame and/or other ignition sources in controlled and well-ventilated areas;
- Where flammable vapor-air mixtures cannot be eliminated, sources of ignitions shall be controlled;
- Maintain all the equipment in good working order. Inspect all electrical wirings and electrical appliances regularly and avoid accumulation of dust and grease on motors and machine tools;
- Ensure that all the heating units are safeguarded;
- Look out for gas leaks, and report all gas leaks immediately. The authorized person shall ensure that all gas leaks are repaired immediately upon notification;
- Repair and clean up flammable liquid leaks immediately;
- Keep work areas free of dust, lint, sawdust, scraps, and similar material;
- Do not rely on extension cords if wiring improvements are needed, and ensure that the circuits are not loaded with multiple pieces of equipment;
- Ensure that required hot work permits are obtained;
- Turn off electrical equipment when not in use.

6.7.4 RESPONSIBILITY

Fire safety is everyone's responsibility. All employees (managers, on-site administrators, supervisors and general employees) should know how to prevent and respond to fires, and are responsible for adhering to company policy regarding fire emergencies.

Management determines the UT-IJP's fire prevention and protection policies. Management will provide adequate controls to provide a safe workplace, and will provide adequate resources and training to its employees to encourage fire prevention and the safest possible response in the event of a fire emergency.

An On-site Administrator shall manage the Fire Prevention and Control Plan for UT-IJP, and maintain all records pertaining to the plan. This administrator will also have the following duties:

- Develop and administer the UT/JTI's fire prevention training program;
- Ensure that fire control equipment and systems are properly maintained;
- Control fuel source hazards;
- Conduct fire risk surveys and make recommendations;

Supervisors are responsible for ensuring that employees receive appropriate fire safety training, and for notifying the responsible person(s) when changes in operation increase the risk of a fire. Supervisors are also responsible for enforcing UT-IJP's fire prevention and protection policies.

All employees shall:

- Complete all required training before working without supervision;
- Conduct operations safely to limit the risk of fire;
- Report potential fire hazards to their supervisors; and
- Follow fire emergency procedures.

The person(s) responsible for the facility will ensure that all the equipment is maintained according to manufacturer's specifications. UT-IJP will also comply with requirements of the National Fire Protection Association (NFPA) codes for specific equipment. Only the properly trained individuals will perform all the maintenance work.

The following equipment is subject to regular inspection, maintenance, and testing procedures:

- Equipment installed to detect fuel leaks, to control heating, and to control the system pressurization;
- Different fire extinguishing systems such as portable fire extinguishers, automatic sprinkler systems, and fixed fire extinguishing systems;
- Smoke, Heat and Flame detection systems;
- Fire alarms; and
- Emergency backup systems and the equipment they support.

Photo 119

Photo 120

Photo 121

Photo 122

Photo 120 and Photo 121 Weekly testing of the firefighting system in Palagua field
Photo 122 and Photo 123 Emergency team (Brigade) training at UT-IJP, Palagua field

6.7.5 POTENTIAL HAZARDS

6.7.5.1 STORAGE TANKS

This section applies to the commonly recognized management techniques and fire control methods used to prevent the loss from fire or explosion in the tank storage facilities. To prevent fire hazards due to leaks or spillage from storage tanks, the following precautionary steps need to be taken:

- Tank storage facilities shall have fire prevention and control for life and safety, for minimizing property loss, and for reducing fire exposure to adjoining facility resulting from fire and explosion;
- Tanks shall be of steel or other approved noncombustible material, considering all the limitation and exceptions;
- The materials of construction for tanks shall be compatible with the liquid to be stored;

- Unlined concrete tanks can be used only for liquid with having gravity 40° API or higher;
- The type of lining and its thickness shall depend on the type of material to be stored in the tank;
- The thickness of the tank and its lining should also be considered for resistance to vehicular impact;
- Pressure vessels or tanks shall not be operated above their design pressure, the normal operating pressure shall not exceed the design pressure of the tank or vessel;
- Support for the tanks shall be designed and constructed in accordance with recognized engineering standards;
- Pressure vessels or tanks shall be adequately vented to prevent the development of pressure or vacuum that exceeds the design pressure of the tank or vessel while filling, emptying or due to the change in atmospheric temperature;
- The normal vents in the tanks shall be sized in accordance with either API Standard 2000, or another accepted standard. In no case shall it be less than 32 mm nominal inside diameter;
- If the tank or vessel has more than one fill or withdrawal connection and simultaneous filling or withdrawal can be made, the vent size shall be based on the maximum anticipated simultaneous flow;
- For all kind of pressure vessels or tanks, the vents and vent drains shall be arranged to discharge in a manner that prevents localized overheating of or flame impingement on any part of the tank, if vapors from any tank are ignited;
- Every aboveground storage tank shall have emergency relief venting in the form of construction or a device or devices that will relieve excessive internal pressure caused by exposure fire;
- Metal used to fabricate the tank shall be thick enough to compensate for internal corrosion expected during the design life of the tank;
- If the internal corrosion is anticipated beyond that provided for in the design formulas or standards used, additional metal thickness or suitable protective coating or lining shall be provided to compensate for the corrosion loss expected during the design life of the tank;
- To overcome the loss due to external corrosion of the tank, the type of material selected shall be based upon the corrosion history of the area and the judgment of a qualified engineer;
- The walls and the floor of the vaults shall be constructed of reinforced concrete at least 150 mm thick;
- The top of an vault that contains a tank used to store Class I and II liquid, shall be constructed of a noncombustible material and shall be designed to be weaker than the walls of the vault;
- Sufficient clearance between the tank and the walls of the vault shall be provided to allow for visual inspection and maintenance of the tank;
- Adjacent vaults shall be permitted to share a common wall;
- The vaults shall be provided with an approved means to admit a fire suppression agents;
- The vaults enclosure have no openings except those necessary for access to, inspection of, and filling, emptying and venting of the tank;
- Vent pipes that are provided for normal venting shall terminate outside the vault and at least 3.6 m above the ground level, while emergency vents shall be vapor tight and shall be permitted to discharge inside the vault;

- An approved means of overfill protection system will be installed to every tank;
- The vaults shall be provided with an approved vapor and liquid detection system and equipped with on-site audible and visual warning devices with battery back-up; Each tank shall be inspected and maintained to ensure compliance with the requirements in the NPFA Code 30, and maintained liquid tight.

6.7.5.2 CONTAINERS AND PORTABLE STORAGE TANKS

This section applies to the storage of liquids in drums or other containers that do not exceed 450 L, in overpack drums used for temporary containment, in portable tanks, and in intermediate bulk containers that do not exceed 3000L. To prevent fire hazards due to any leaks or spillage from any containers and portable storage tanks the following precautionary steps needs to be taken:

- The containers and the portable storage tanks can be made of metals, plastic, fiber and rigid nonmetallic material;
- The material used to make these containers should be authorized by the U.S. Department of Transportation Hazardous Materials Regulations, 49 CFR or by Part 6 of the UN Recommendations on Transport of Dangerous Goods;
- Proper steps must be taken to ensure that all the containers and the portable storage tanks are securely closed and placed in their proper locations;
- Each portable tank or intermediate bulk container shall be provided with one or more devices installed in top with sufficient emergency vending capacity to limit internal pressure under fire exposure conditions to a gauge pressure of 70 kPa or 30 percent of the bursting pressure of the portable tank, whichever is greater;
- The maximum allowable size of a container or metal portable tank shall be decided according to the guidelines provided in NFPA Code 30;
- Leaking or damaged containers up to 230 L capacity shall be permitted to be stored temporarily, provided they are enclosed in a overpack containers;
- The cabinets were the containers and portable storage tanks are kept shall be marked in conspicuous lettering: “FLAMMABLE – KEEP FIRE AWAY”;
- Wood at least 25mm nominal thickness shall be permitted to be used for shelving, racks, dunnage, scuffboards, floor relays, and similar installations;
- Solid pile and palletized storage in liquid warehouses shall be arranged so that piles are separated from each other by at least 1.2 m. Aisle shall be provided and arranged so that no container or portable tank is more than 6 m from an aisle. Main aisle shall be a minimum of 2.4 m wide;
- The height up to which these containers can be stored in the room, and the allowable quantity shall we decided on basis of the guidelines given in the NFPA Code 30;
- Containers of liquid in their original shipping packages shall be permitted to be stored either palletized or solid piled. Unpackaged containers shall be permitted to be stored on shelves or directly on the floor of the locker;

- No flammable or combustible materials shall be permitted in the vicinity of the containers or the portable storage tanks;
- An automatic sprinkler and foam-water fire protection systems shall be installed in the area designated for the containers and portable storage tanks;
- Power-operated industrial trucks must be used to move the containers and care must be taken that the containers and the portable storage tanks are properly closed at the time of shifting to avoid any spillage of the liquid, and to protect against any accidents.

6.7.5.3 PIPING SYSTEMS

This section shall apply to piping systems consisting of pipe, tubing, flanges, bolting, gaskets, valves, fittings, flexible connectors, strainers, and devices used for the purpose of mixing, separating, distributing, or secondary containment of liquids. To prevent fire hazards due to any leaks from any pipes the following precautionary steps needs to be taken:

- The design, fabrication, assembly, test, and inspection of piping systems shall be suitable for expected working pressures and structural stresses. They should comply with applicable sections of ASME B31, Code for Pressure Piping;
- Piping systems shall be maintained liquid-tight, and the piping that has a leak and may result in hazard shall be emptied of liquid or repaired;
- Valves at storage tanks and their connections to the tank shall be steel or ductile iron;
- Valves at the storage tanks shall be permitted to be other than steel or ductile iron where the chemical characteristics of the liquid stored inside are not compatible with steel or if the valves are installed internally to the tank;
- Cast irons, brass, copper, aluminum, malleable iron, and similar materials shall also be used, provided they are compatible with the type of liquid being handled;
- Piping systems shall be substantially supported and protected against physical damage and excessive stresses arising from settlement, vibrations, expansion, or contraction. The installation of nonmetallic piping shall be in accordance with manufacturer's instructions;
- Piping that passes through or pierces a dike wall or the wall of a structure shall be designed to prevent excessive stresses and leakage due to settlement
- Piping systems that are subject to corrosion shall be suitable protected;
- Underground piping shall be installed on a bedding of at least 150 mm of well-compacted backfill material, in areas subjected to vehicle traffic, the pipe trench shall be of sufficient depth to permit a cover of at least 450 mm;
- Two or more levels of pipes within the same trench shall be separated vertically by a minimum 150 mm of well-compacted backfill;
- If loading and unloading is done through a common pipe system, a check valve shall not be required, however, an isolation valve shall be provided. This valve shall be located so that it is readily accessible or shall be remotely operated;

- Piping systems shall be grounded properly.

6.7.5.4 ELECTRICAL EQUIPMENT AND INSTALLATIONS

Electrical system failures and the misuse of electrical equipment are leading causes of workplace fires. Fires can result from loose ground connections, wiring with frayed insulation, or overloaded fuses, circuits, motors, or outlets. To prevent fire hazards related to electrical equipment and its installation, the following precautionary steps need to be taken:

- Any electrical equipment provided shall not constitute a source of ignition for the flammable vapor that might be present under normal operation or during a spill;
- All electrical equipment and wiring shall be of a type specified by and installed in accordance with NFPA 70, National Electrical Code (NEC);
- All the wiring in hazardous locations will be regularly inspected where the risk of fire is especially high;
- The guidelines given in the NFPA Code 30 manual shall be used to delineate and classify areas for the purpose of installation of electrical equipment under normal conditions;
- All the electrical equipment shall be regularly inspected to check the condition of wires, if any of the wires are found to be worn out, they have to be replaced immediately;
- The fuses used shall be installed in accordance with NFPA 70, National Electrical Code (NEC);
- An extension cord shall not be used as a substitute for wiring improvements;
- All the electrical equipment shall be properly inspected to ensure that they are double insulated or are properly grounded;
- High level of safety shall be observed while performing maintenance.

6.7.5.5 OPERATIONS

This section shall apply to operations involving the use or handling of liquids either as a principal or incidental activity. To prevent fire hazards related to various operations the following precautionary steps needs to be taken:

- All the equipment used directly or indirectly in the operations shall comply with the NFPA Code 30;
- Operators of heat transfer systems shall be trained in the hazards of system misoperation and leakage and shall be trained to recognize upset conditions that can lead to dangerous situations;
- Safety interlocks shall be inspected, calibrated, and tested annually in accordance with appropriate standards to determine that they are in proper operating conditions;
- During all operations special care shall be taken to minimize the generation of static electricity, all the means provided to reduce static electricity shall meet the requirements stated in NFPA Code 30;

- When pumps are used for liquid transfer, means shall be provided to deactivate liquid transfer in the event of a fire due to liquid leak or spill;
- A loading or unloading facilities shall be provided with drainage systems or other means to contain spills;
- A loading or unloading facility shall be provided with a canopy or roof that does not limit firefighting access or control;
- During all the loading and/or unloading of liquid to the tank vehicles, the vehicle engine shall be shut down;
- Liquids shall be loaded into the tank vehicles whose material of construction is compatible with the chemical characteristics of the liquid;
- The liquid being loaded into the tank vehicle shall be the same liquid hauled on the previous load unless the vehicle has been cleaned;
- Tanks and equipment shall have independent venting for overpressure or vacuum conditions that occur from malfunction of the vapor recovery or vapor processing system;
- Metals or conductive objects, such as gauge tapes, sample containers, and thermometers, shall not be lowered or suspended in a tank vehicle when the vehicle is being filled or immediately after cessation of pumping to permit the relaxation of charge.

6.7.5.6 CUTTING, WELDING AND/OR OPEN FLARE WORK

This section shall apply to operations involving the use of open flames in case of welding and operations involving cutting, which may produce a spark or intense heat. To prevent fire hazards due to the ignition of flammable vapors by sources like open flames, cutting, welding, frictional heat or sparks the following precautionary steps needs to be taken:

- Before the start of any of the above-mentioned work the required hot work permits shall be obtained;
- Cutting and welding shall be done by authorized personnel in designated cutting and welding areas whenever possible;
- Welding, cutting and similar spark producing operations shall not be permitted in any areas containing flammable liquids, except when a written permit authorization such work is issued. This permit shall be issued by a person in authority following his/her inspection in the area to assure that proper precautions have been taken;
- All the equipment used for these operations shall be properly grounded;
- Adequate ventilation shall be provided in the area were such operations are taking place;
- All the equipment used for these operations shall comply with the regulations stated by NFPA;
- The personnel performing these operations shall always wear eye protection and protective clothing at the time of the operation;
- These operations shall be prohibited on metal walls, ceilings, or roofs built of combustible sandwich-type panel construction or having combustible covering;

- Confined spaces such as tanks shall be tested to ensure that the atmosphere is not over ten percent of the lower flammable limit before these operations are performed in or on the tank;
- Small tanks, piping, or containers that cannot be entered shall be cleaned, purged, and tested before these operations are performed;
- Smoking shall be permitted only in designated and properly identified areas.

6.7.5.7 FLAMMABLE AND COMBUSTIBLE MATERIALS

Certain types of liquids can ignite at relatively low temperatures or pose a risk of catastrophic explosion if ignited. Such liquids obviously require special care and handling.

Any liquids that have a closed-cup flash point below 100°F are known as Flammable liquids. They are classified a Class I liquids. Any liquids that have a closed-cup flash point at or above 100°F are known as Combustible liquids. They are classified a Class II or Class III liquids.

- Class I liquids: Any liquid that has a closed-cup flash point below 100F and a Reid vapor pressure not exceeding 40 psia at 100°F, as determined by ASTM D 323, Standard Method of Test for vapor pressure of Petroleum Products. This types of liquids are further classified as:
    - Class IA – liquids that have flash points below 73°F and boiling points below 100°F;
    - Class IB – liquids that have flash points below 73°F and boiling points at or above 100°F;
    - Class IC – liquids that have flash points at or above 73°F but below 100°F.
- Class II liquids: Any liquid that has a closed-cup flash point at or above 100°F and below 140°F.
- Class III liquids: Any liquid that has a closed-cup flash point above 140°F. They are further classified as follows:
    - Class IIIA – liquids that have flash point at or above 140°F, but below 200°F;
    - Class IIIB – liquids that have flash point at or above 200°F.

To prevent fire hazards due to flammable and combustible liquids the following precautionary steps needs to be taken:

- Only approved pumps, taking suction from the top, to dispense liquids from tanks, drums, barrels, or similar containers (or use approved self-closing valves or faucets).
- Combustible and flammable liquids shall not be dispensed into containers unless the nozzle and container are electrically interconnected by contact or by a bonding wire. Either the tank or container must be grounded;

- Flammable and combustible liquid shall not be used as a cleaning agent inside a building;
- Flammable and combustible liquids shall not be used, handled, or stored near exits, stairs, or any other areas normally used as exits;
- All the personnel in the facility should know the location of and how to use the nearest portable fire extinguisher rated for flammable and combustible liquids;
- Water should not be used to extinguish fires caused by flammable and combustible liquids. Water can cause the burning liquid to spread, making the fire worse. To extinguish a fire caused by flammable and combustible liquids, exclude the air around the burning liquid. The following fire-extinguishing agents are approved for these kinds of liquids: carbon dioxide, multi-purpose dry chemical (ABC), halon 1301, and halon 1211.

6.7.5.8 OFFICE FIRES

Fire hazards may be due to other reasons than the one discussed above. In an industrial facility, fires can take place in the office building. Fires in offices have become more likely because of the increased use of electrical equipment, such as computers and fax machines. To prevent fire hazards in offices the following precautionary steps needs to be taken:

- Precautions shall be taken to avoid overloading circuits with office equipment such as computers, radios, faxes, etc.;
- It shall be ensured that all the nonessential electrical equipment is turned off at the end of each workday;
- It shall be ensured that all the storage areas are kept clear of rubbish;
- It shall be ensured that extension cords are not placed under carpets;
- It shall be ensured that the trash and paper set aside for recycling is not allowed to accumulate.

6.7.6 ALTERNATE METHODS OF FIRE CONTROL

Although fire prevention equipment is installed in the facility, the following techniques can also be used to control fire:

6.7.6.1 CONTROLLED BURN

With a fire involving flammable and combustible liquids, rapid extinguishment may not be possible or prudent. Where heat impingement on other vessels or facilities may be controlled and there is no danger to the public, it may be acceptable and sometimes safer to allow the fire to burn itself out, under controlled conditions. This practice usually involves controlling the flow or otherwise limiting the amount

of material involved in fire. The decision to select this method of fire control shall be made with the advice of qualified fire control personnel.

6.7.6.2 MANUAL CONTROL AND EXTINGUISHMENT

This method involves the use of portable fire extinguishers on fires in their incipient and initial stages. Large fires usually require the application of water for control and cooling application of foam and fire extinguishers. Larger fires, like those involving tanks, extinguishment requires special techniques, material, equipment and trained personnel. Manual attacks on fire shall be supervised and conducted only by trained and qualified personnel.

6.7.7 PALAGUA AND CAIPAL FIRE FIGHTING SYSTEM

In the Palagua field, the risk of a possible fire is in Stations 1, 2, and 4 where crude oil storage tanks are installed. (Please note that Station 3 is closed). We have installed firefighting equipment in these three stations. The description of the firefighting system is given below.

Specific firefighting systems have been installed in each one of the stations in the Palagua field. In addition, a fire truck was added to the system. This unit is able to fight fire with water and foam. The tables below list the current firefighting equipment in the field. (The words Battery and Station are used interchangeably).

Table 98 STATION NO. 1

No.	DESCRIPTION	CHARACTERISTICS
1	Main Pump with electrical motor	750 gpm @ 150 PSI
2	Pump 2 with diesel motor (Cummins)	750 gpm @ 150 PSI
3	Emergency pump (Jockey) with diesel motor	750 gpm @ 150 PSI
4	Main ring in tubing	6" size
5	Water hydrants	6ea of 250 gpm/ea
6	Water-foam hydrants	4ea of 150 gpm/ea
7	Refrigeration rings (4ea).	1ea/tk of 250 gpm
8	Water storage tank	5000 bls
9	Foam storage tank	700 bbls

Table 99 STATION NO. 2

No.	DESCRIPTION	CHARACTERISTICS
1	Main Pump with electrical motor	750 gpm @ 125 PSI
2	Emergency pump with diesel motor	750 gpm @ 125 PSI
3	Ring main in pipe	6" size
4	Water hydrants	3ea of 250 gpm/ea
5	Foam water monitors	5ea of 150 gpm/ea
6	Cooling ring.	250 gpm at tank 3000-22
7	Water storage tank	5000 bls capacity

Table 100 STATION NO. 4

No.	DESCRIPTION	CHARACTERISTICS
1	Main Pump with electrical motor	750 gpm @ 125 PSI
2	Emergency pump with diesel motor	750 gpm @ 125 PSI
3	Main ring in tubing	6" size
4	Water hydrants	2ea of 250 gpm/ea
5	Water-foam hydrant monitors	5ea of 150 gpm/ea
6	Water storage tank	2000 bls

The following photos show the foam and water truck and the training exercises on the use of the truck.

Photo 123

Photo 124

Photo 125

Photo 126

Photo 124 and Photo 125 Foam and water firefighting truck for the Palagua field
Photo 126 and Photo 127 Training on the firefighting truck

In Station No. 1, the fire prevention system has an electric engine and a diesel engine, each one with a pump; the two engines can work with the water system, foam system or as two parallel systems.

There are two manifolds at the outlet of the each pump, which are connected to the four tanks in Station No. 1, where cooling rings have been installed. These rings are triggered manually from the manifold exit. The system also has monitoring pressure devices on all four sides of the tanks, which can be maneuvered with different kinds of jets and aim the stream to where the cooling is required.

The foam system also has a Jockey pump that maintains the pressure, which is utilized for the generation of foam. Foam is equally directed from the manifold toward each one of the tanks. A chamber of injection has been installed permitting the entrance of the foam to the inside of the tanks resulting in fire extinction by isolation of oxygen. Within the area of the tanks and the station, a foam monitor has been installed which allows aiming foam directly (or by means of a hose) for protection of equipment in case of fire.

In the area of the pumping system of the oil pipeline, a system of sprinklers of foam and water has been installed for the protection of the equipment installed.

6.7.7.1 FOAM SYSTEM

A foam system was installed In Station (Battery) No. 1. This system consist of a generator device which generates fixed-foam (foam supply tank is under pressure) with a pipe supplying water. The foam is discharged directly on the fire using the foam cameras on the hydrocarbon storage tanks or using water hoses to attack fire on the ground.

The supply is obtained by the use of an orifice plate for water and an orifice plate for concentrate of foam, both discharging at reduced pressure to the Discharge Header.

The foam is a homogeneous mixture of water and protein foam concentrate (These foam concentrates consist of additives and inhibitory products of a hydrolysis of protein stabilization) in a proportion of 3% of foam concentrate and 97% water.

The foam extinguishes fire by reducing the concentration of oxygen around the fire and reducing convection and the radiation and movement of inflammable vapor.

Foam is an effective firefighting tool for extinguishing fire due to ordinary fuels, inflammable liquids and combustible liquids.

The foam system is not recommended for use in fires caused by chemical such as cellulose nitrate, that generates enough oxygen or any other oxidizing agent to maintain the combustion, electrical equipment not contained in isolation equipment, reactive metals with water such as sodium, potassium, etc., and unsafe materials that react with water, such as pentoxide of phosphorus and tri-ethyl aluminum, inflammable liquefied gas.

The discharge of large quantities of foam blocks the vision, causes difficulty to listen, creates shortness of breathing and causes space disorientation. It is dangerous to enter a facility which is on fire and has low visibility.

6.7.7.2 FOAM STORAGE TANK

The foam storage tank is made out of a corrosion resistant material and is rated for 250 psig maximum working pressure as per ASME, Section VIII, Division 1 Code. The tank has a vent, inspection port, and a drainage valve at its lowest point. In order to maintain an ample reserve supply of foam, 55-gallon drums with liquid foam concentrate have been placed nearby the storage tank. These drums are stored at a temperature between 35°F (2 °C) and 100°F (38 °C).

Characteristics of the Foam Storage Tank

Brand:	National Foam
Header:	PPH 50
Tank Diameter:	4 ft – 6 in.
Tank length:	4 ft – 8 in.
Tank Capacity:	700 Gallons
P min	165 psi
Foam Concentrate:	Proteinico National Foam Aero-foam XD3 Angus Fire FP70

6.7.7.3 WATER DISTRIBUTION AND FOAM SOLUTION NETWORKS

The pipe utilized for the construction network of water cooling and foam solution is Casing N80 of 7 " of nominal diameter, with a working pressure no less than 175 psi.

The pipes used for distribution from the header (discharge manifold) are buried with proper protection and at safe levels of depth.

The feed flow lines that connect to the foam cameras and the flow line that supplies water to the sprinkler rings around the tank are fasten in such a way that insures their immobility during the operation.

6.7.7.4 SYSTEM OF SPRINKLER RINGS FOR WATER COOLING TANKS

It is an integrated system by a subterranean flow line with the shape of a semi-ring around the tanks to be cooled. The system is designed hydraulically following the norms of anti-fire protection. The system operates with open sprinklers that are joined to a flow line system and connected to a water supply through a valve that opens manually. When this valve opens, the water flows through the flow lines and discharges from the sprinklers around the ring and cools the exposed area.

6.7.7.5 SPRINKLER SYSTEM AT THE VASCONIA PIPELINE

There is a sprinkler system at the Vasconia pipeline. In the sprinkler system, the flow line is connected to the feed (discharge manifold) of the foam solution, using a manual valve. When this valve is opened, the foam solution is discharged. Also the system could be used to discharge water alone (without mixing it with any solution, for a certain period of time).

6.7.7.6 ANTI-FIRE MONITORING WATER OUTLETS

These are devices or headers connected to the main water pipes to supply water to the anti-fire hoses or any other appliance of anti-fire protection. The water outlets have specifically designed nozzle devices to give a powerful current for the protection of the tank, process vessels and any other risky area, at a discharge rate of 200 - 250 gpm. The nozzle sizes vary from 1½ to 2 inches. Additionally, the water outlets have (at the exit) a 2 ½ " screwed valve with a female connection for the counter-fire hose connection.

6.7.7.7 ANTI-FIRE CABINETS

These are steel cabinets housing hose assemblies with reduction nozzles of 2 ½, 1 ½ inches. The cabinet is installed near the Cummins engine of the anti-fire system of Battery No. 1.

6.7.7.8 ANTI-FIRE HOSES

The hoses connected to the water supply or foam solution are lined and coated. The size and length of hose are selected according to hydraulics of the system. The diameter of the hoses available are 1 ½, 2 ½ inches, with an approximate length of 100 feet. The hoses are stored in the anti-fire cabinet, located strategically for immediate use and protection against the weather (changes in temperature to avoid hose damage).

6.7.7.9 WATER TANK STORAGE

In the north side of the anti-fire system, in a most elevated level, a water tank is constructed with a capacity of 5,000 bbl supply for the anti-fire system. For the filling and maintenance of water in the tank, a flow line is installed that pumps water from Palagua Well–1.

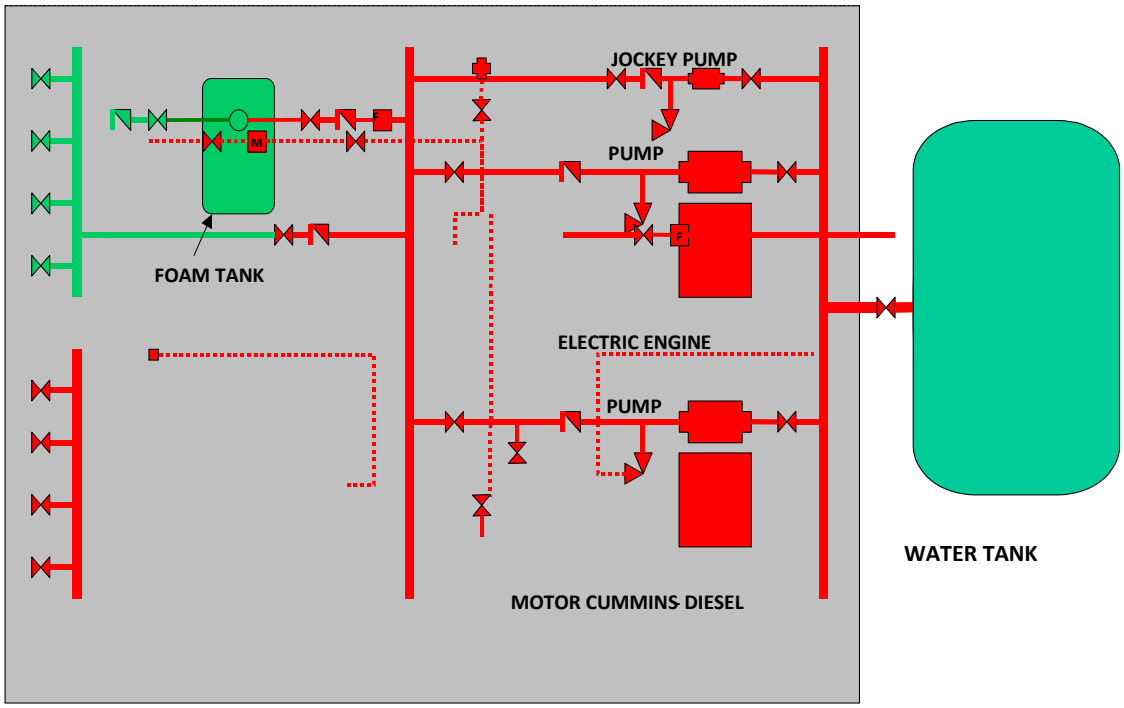
There is enough storage water to supply water to the automatic sprinklers for more than two hours. The water storage tank capacity is about 5,000 bbls (about 800 cubic meters) which would be needed in a worst case scenario. The worst case scenario is defined as four fixed tanks storing Class I liquids to be protected by foam cannons, as shown in the following table.

Table 101 WATER TANK CAPACITY

Item	Duration (Class I liquid) (minutes)	Flow (L/min)	Total Water Requirement (m3)
Cooling to expose floating roof tanks	120	2000	240
Cooling to expose fixed roof tanks	120	3200	384
Cooling to tank on fire	55/330	4000	220/120
Rim-seal foam system	20	900	18
Top pourer/Base injection foam to fixed roof	55/30	2000	110/60
Foam cannons to fixed roof	65/50	3100	202/155

$$V = 384 + 220 + 202 = 806\ m^3 \text{ (approximately 5,000 bbls)}$$

The following figure is a schematic drawing of the anti-fire system.



SOURCE: ACT. RDP 2005

Figure 56 Anti-fire system distribution in Palagua field

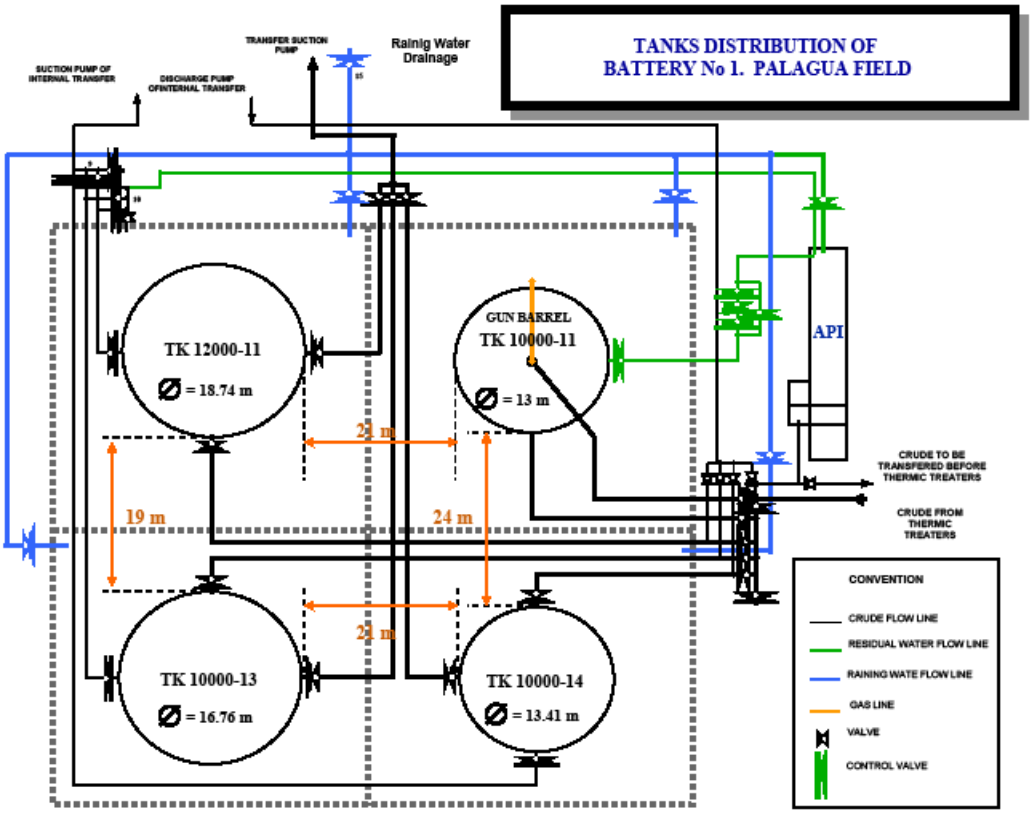


Figure 57 Distribution of gun barrel tanks at Palagua field

Following is a photo gallery of the firefighting equipment and training exercises in Palagua field.

Training and usage of the foam

Training operation of the anti-fire system

On-ground foam discharge near equipment

Foam tank-outlet manifolds

Engine and anti-fire diesel Cummins engine

Water storage tank for the anti-fire system

Activation of the cooling rings K-12000-11

Activation of the sprinklers around the tanks

Activation of the cooling ring K-10000-11

Firefighting system installed at Station 4

Testing the system at Station 4

Testing the system at Station 4

Firefighting system training at Station 2

Firefighting system training at Station 2

Table 102 ACTIONS IN CASE OF FIRE THREAT

STEP	WHAT TO DO?	HOW TO DO IT?
1	1.Notify or imform the occurrence of event	Whoever finds the event, immediately warns the camp, or Emergency Coordinator in the area. If you are in a closed site, go outside, leaving the door closed without lock, go to an open area and wait for instructions from emergency personnel. Turn off electrical equipment near to the event
2	2. Remove people to a secure site	Start immediate evacuation, with the support of the brigade. Remove people at least at a distance of 10 m
3	3. If the threat is not controlled, get help from the Firefighters	The brigade attempted to fight the fire with the extinguishers available. If the outbreak of fire is not controlled, immediately notify the firefighters
4	4. Ensure that all staff are in the meeting place	The emergency coordinator, calls the emergency and contingency brigade, who support and direct the evacuation process.
5	5. After inspecting the fire investigation to proceed	The brigades are working with the fire department guide them on the event and the additional risks that can be met. After inspecting and controlling the event, theinvestigation phase of the accident will begin.

Source: RPS - Working Group

6.7.8 AFTER THE CONTINGENCY

1. Maintain contact with workers from the area where the event took place.
2. Help those who need care.
3. Assess the situation for safe return to the site.
4. If the electricity supply was interrupted, do not try to restore it until it is verified that it will not cause any further damage.
5. Keep track of and follow up on the recovery of injured, if any.

6.7.9 REVIEWING AND RECORD KEEPING

The Fire Prevention and Control Plan shall be reviewed regularly and updated as equipment and operating conditions change. The plan shall be reviewed at least once every year. Updating and the filling of the plan shall be in accordance with the local requirement. As the plan includes assistance from outside source such as local fire department, the plan has to be reviewed with them in case of any changes in the plan. All the personnel shall be made familiar with all the changes made in the plan.

6.7.9.1 FIRE RISK SURVEY

Type of Fire Hazard	Location	Emergency Actions	Required changes

Completed by:_____ Date:_____

6.7.9.2 GENERAL FIRE PREVENTION CHECKLIST

Use this checklist to ensure fire prevention measures comply with the general fire prevention requirements found in NFPA standards.

□ Yes □ No	Is the local fire department acquainted with your facility, its location, and specific hazards?
□ Yes □ No	If you have a fire alarm system, is it tested at least annually?
□ Yes □ No	If you have interior stand pipes and valves, are they inspected regularly?
□ Yes □ No	If you have outside private fire hydrants, are they on a routine preventive maintenance schedule and flushed at least once a year?
□ Yes □ No	Are fire doors and shutters in good operating condition?
□ Yes □ No	Are fire doors and shutters unobstructed and protected against obstructions, including their counterweights?
□ Yes □ No	Are automatic sprinkler system water control valves, air pressure, and water pressure checked weekly or periodically?
□ Yes □ No	Has responsibility for the maintenance of automatic sprinkler systems been assigned to an employee or contractor?
□ Yes □ No	Are sprinkler heads protected by metal guards?
□ Yes □ No	Is proper clearance maintained below sprinkler heads?
□ Yes □ No	Are portable fire extinguishers provided in adequate number and type?*
□ Yes □ No	Are fire extinguishers mounted in readily accessible locations?*
□ Yes □ No	Are fire extinguishers recharged regularly with the recharge date noted on an inspection tag?*
□ Yes □ No	Are employees periodically instructed in the use of extinguishers and fire protection procedures?*

*(NOTE: Use of fire extinguishers is based on company policy regarding employee firefighting in your Emergency Action Plan and local fire code.)

Completed by:_____ Date:_____

6.7.9.3 EXITS CHECKLIST

Use this checklist to evaluate UT/JTI comply with NFPA standard on emergency exit routes.

□ Yes □ No	Is each exit marked with an exit sign and illuminated by a reliable light source?
□ Yes □ No	Are the directions to exits, when not immediately apparent, marked with visible signs?
□ Yes □ No	Are doors, passageways, or stairways that are neither exits nor access to exits, and which could be mistaken for exits, marked "NOT AN EXIT" or other appropriate marking?
□ Yes □ No	Are exit signs provided with the word "EXIT" in letters at least five inches high and with lettering at least one inch wide?
□ Yes □ No	Are exit doors side-hinged?
□ Yes □ No	Are all exits kept free of obstructions?
□ Yes □ No	Are there at least two exit routes provided from elevated platforms, pits, or rooms where the absence of a second exit would increase the risk of injury from hot, poisonous, corrosive, suffocating, flammable, or explosive substances?
□ Yes □ No	Is the number of exits from each floor of a building and from the building itself appropriate for the building occupancy? (NOTE: Do not count revolving, sliding, or overhead doors when evaluating whether there are sufficient exits.)
□ Yes □ No	Are exit stairways that are required to be separated from other parts of a building enclosed by at least one-hour fire-resistant walls (or at least two-hour fire-resistant walls in buildings over four stories high)?
□ Yes □ No	Are the slopes of ramps used as part of emergency building exits limited to one foot vertical and 12 feet horizontal?
□ Yes □ No	Are glass doors or storm doors fully tempered, and do they meet the safety requirements for human impact?
□ Yes □ No	Can exit doors be opened from the direction of exit travel without the use of a key or any special knowledge or effort?
□ Yes □ No	Are doors on cold storage rooms provided with an inside release mechanism that will release the latch and open the door even if it's padlocked or otherwise locked on the outside?
□ Yes □ No	Where exit doors open directly onto any street, alley, or other area where vehicles may be operated, are adequate barriers and warnings provided to prevent employees from stepping into the path of traffic?
□ Yes □ No	Are doors that swing in both directions and are located between rooms where there is frequent traffic equipped with glass viewing panels?

Completed by:_____ Date:_____

6.7.9.4 FLAMMABLE AND COMBUSTIBLE MATERIALS CHECKLIST

Use this checklist to evaluate UT/JTI comply with NFPA's standards on flammable and combustible materials:

□Yes □No	Are combustible scrap, debris, and waste materials such as oily rags stored in covered metal receptacles and removed from the worksite promptly?
□Yes □No	Are approved containers and tanks used for the storage and handling of flammable and combustible liquids?
□Yes □No	Are all connections on drums and combustible liquid piping vapor and liquid tight?
□Yes □No	Are all flammable liquids kept in closed containers when not in use?
□Yes □No	Are metal drums of flammable liquids electrically grounded during dispensing?
□Yes □No	Do storage rooms for flammable and combustible liquids have appropriate ventilation systems?
□Yes □No	Are NO SMOKING signs posted on liquefied petroleum gas tanks?
□Yes □No	Are all solvent wastes and flammable liquids kept in fire-resistant covered containers until they are removed from the worksite?
□Yes □No	Is vacuuming used whenever possible rather than blowing or sweeping combustible dust?
□Yes □No	Are fuel gas cylinders and oxygen cylinders separated by distances or fire-resistant barriers while in storage?
□Yes □No	Are fire extinguishers appropriate for the materials in the areas where they are mounted?*
□Yes □No	Are appropriate fire extinguishers mounted within 75 feet of outside areas containing flammable liquids and within 10 feet of any inside storage area for such materials?*
□Yes □No	Are extinguishers free from obstruction or blockage?*
□Yes □No	Are all extinguishers serviced, maintained, and tagged at least once a year?*
□Yes □No	Are all extinguishers fully charged and in their designated places?*
□Yes □No	Where sprinkler systems are permanently installed, are the nozzle heads directed or arranged so that water will not be sprayed into operating electrical switchboards and equipment?
□Yes □No	Are NO SMOKING signs posted in areas where flammable or combustible materials are used or stored?
□Yes □No	Are safety cans utilized for dispensing flammable or combustible liquids at the point of use?
□Yes □No	Are all spills of flammable or combustible liquids cleaned up promptly?
□Yes □No	Are storage tanks adequately vented to prevent the development of an excessive vacuum or pressure that could result from filling, emptying, or temperature changes?

*(NOTE: Use of fire extinguishers is based on company policy regarding employee firefighting in your Emergency Action Plan and local fire code.)

Completed by:_____ Date:_____

6.8 OTHER CONTINGENCIES IN THE FIELD

6.8.1 CONTINGENCY PLAN IN CASE OF BOMBING WITH EXPLOSIVES IN THE AREA

6.8.1.1 CAUSES

The country's current social situation creates this risk.

6.8.1.2 PREVENTIVE MEASURES

- Observe and report any suspicious activity to authorities
- Do not touch or move any suspicious material
- Restrict access to the general public
- Evacuate calmly and without creating panic

6.8.1.3 PROCEDURE

Table 103 PROCEDURE IN CASE OF ATTACK WITH EXPLOSIVES IN THE SECTOR

STEP	WHAT TO DO?	HOW TO DO IT?
1	The staff lies dow n on the floor	Move towards the outside of buildings, whenever possible. In open areas lie on the ground and seek shelter.
2	Notice to physical security institutions	The Emergency Coordinator communicates with the hotline
3	Identify other possible artifacts and inform the competent authorities	The Emergency Coordinator gives notice to the emergencies and contingencies brigade. The brigade identifies foreign elements, such as packages, vehicles, bicycles, motorcycles, packages, boxes or cans that are suspecious, but not approach or handle them.
4	Provide first aid for injured	The emergency and contingency brigade evaluate the staff members who havs suffered injury. Ask for support from ambulances and refer injured workers to the nearest health centers . They fill in an accident at work report for ARP. When private individualsare injured the data of the referral sitemust be written down.
5	The brigade prepares a census: injured personnel, and damages to equipment, property, and enviorement.	The emergency and contingency brigade prepared census: injured personnel, equipment and property involved, affected parties, property damage in the environment. The Emergency Management Coordinator reports this in turn to the Building Manager.
6	Ensure that the area is controlled and safe	The administration through the person he delegated decrees the emergency has beencontrolled, and people return to their normal work activities. The an accident investigation must be carried out.

Source: RPS - Working Group

6.8.1.4 AFTER THE CONTINGENCY

a. Assist if needed.
b. Maintain contact with police authorities
c. Evaluate the area before returning to the site
d. If the electricity supply was interrupted, not try to restore it; without verifying first that it will not cause other damage.
e. If anyone was injured, do follow up as to their location and the treatment provided

6.8.2 CONTINGENCY PLAN IN CASE OF EARTHQUAKES

6.8.2.1 CAUSES

Studies conducted by different institutions at the national level have defined an average level of seismicity for the project area.

6.8.2.2 PREVENTIVE MEASURES

- Identify the safest places on site where daily activities are carried out.
- In enclosed areas, identify resistant structural columns or sturdy resistant tables.
- In open areas, locate places away from where building or construction debris or stacking materials, walls, poles and wires of high and medium voltage or fallen buildings may be.
- Memorize, identify, and locate evacuation routes and MEETING POINTS.
- Do not place heavy or breakable objects on unsecured shelves or file cabinets
- Check that there are no electrical wires obstructing the exit routes.
- Do not place heavy objects and glass on the top shelves or racks, separate chemicals, fuels, and glassware.
- Check that water pipes and other facilities are in good condition: natural gas, electricity and telephone.
- Maintain high traffic places such as stairs, hallways and exits clear of obstructive objects.
- Maintain good condition of storage areas of chemicals and fuels.

6.8.2.3 PROCEDURE

Table 104 ECP-1 PROCEDURE IN CASE OF EARTHQUAKE

STEP	WHAT TO DO?	HOW TO DO IT?
1	Remain calm and seek shelter at a secure site	All staff should avoid running when evacuating. Seek refuge near strong structural elements or under strong elements: tables or desks.
2	Evacuate the entire staff to the Meeting Point.	Through coordination of brigade, evacuate the camps and work fronts calmly. Meet at the Meeting Point
3	Evaluate the w ork area to asses the present physical conditions.	The emergengy and contingency brigadists will search for: structural damages,broken or damaged water pipes, gas pipe leaks, damage in electrical installations, lack of stability in debris piles or stored materials.Verify for any earthquake victims.
4	Transfer of injured people to health care centers	If there are victims, provide first aid, contact the emergency pre-defined lines, assist in rescue, and evacuation to hospitals. If the victims are workers, carry out work accident report for the ARP.
5	Assess damage to infrastructure	If gas leaks: implement contingency plan for a gas leak. If structural damage: Do not allow entry of personnel to the affected area. In case of a broken water pipe: close valves where possible to channel water flow, using pumps to drain. In case of damage to electrical installations: interrupt the service and restore it to sites affected if possible. If there is piled debris with stacking instability: remove height.
6	After analyzing the state of the physical structures return to the area.	Brigades reported the situation to the Emergency Coordinator. He a in turn relays information to the Building Manager. Based on risk assessment, staff is either authorized or not to enter the facility. If anyone was injured conduct the accident investigation.

Source: RPS - Working Group

6.8.2.4 AFTER THE CONTINGENCY

- Do not enter the affected area until you understand and meet the security conditions, and receive reports from the area of communications, the Emergency Coordinator.
- Keep track of and follow up on the recovery of injured, if any.
- Report if there are any damaged or broken gas, water, or sewer pipes, or electrical wiring and a risk of electrocution.
- Wait for instructions to return to the work area

6.8.3 CONTINGENCY PLAN IN CASE OF EXPLOSION

6.8.3.1 CAUSE

The nature and quantity of materials stored, allows establishing a low probability of explosion, as long as they are stored under security regulations.

6.8.3.2 PREVENTIVE MEASURES

a. Do not store flammable products. In an absolutely necessary case, store in closed containers, in a well-ventilated place.

b. Avoid connecting more than one appliance in each electrical outlet. Do not overload power lines.

c. No smoking in restricted areas

d. Report the presence of gas or fuel leaks or spills of flammable liquids

e. Identify emergency exits and nearest phones to call external support groups.

f. Adapt specific sites for fuel storage and supply.

6.8.3.3 PROCEDURE

Table 105 WHAT TO DO IN CASE OF EXPLOSION

STEP	WHAT TO DO?	HOW TO DO IT?
1	Report the occurrence of event	Whoeverdiscovers the event immediately notifies the Emergency Coordinator or the nearest person in charge.
2	Isolate the area w here the event happened	Once the Emergency Coordinatorhas been informed, he will communicated by radio with the Response GroupBrigade, and they will isolate the area.
3	Inventory of injured people sent to hospitals	Having secured the area,if there was a threat of fire, the Response Group puts out the outbreak . If there is fire, they will ask the Fire Department for help. An inventory of the injured people is conducted . If thecasualties are sent to hospital a reportof the accident must be made .
4	Report and Resume Normal Activities	Report the end of theincident to the Emergency Coordinatorto whom it was who initially reported: who in turn, reports to the Building Department and based on risk analysis, the decision to resume normal activities or not is taken. If someone was injured, an accident investigation must be conducted.

Source: Consortium IASCOL-CGS

6.8.3.4 AFTER THE CONTINGENCY

- Maintain contact with workers in the area where the incident happened.
- Help all those in need.
- Depending on the danger of the situation, do not to return to the site
- If the electricity supply was interrupted, not try to restore it until it is verified that it will not cause any further damage.
- Keep track of and follow up on the recovery of injured, if any.

6.9 EMERGENCY PLAN

The emergency plan provides preventive measures and training activities for workers. It describes the activities necessary to control emergency situations.

The purpose is to give all workers a basic knowledge of emergency preparedness, so that they can react appropriately and contribute to preserving their own personal safety as well as that of the public. This plan is based on educational activities and training drills for any emergency situations. The following strategy was developed to achieve the aforementioned plan.

6.9.1 INSTITUTIONALIZATION OF THE EMERGENCY PLAN

Once the document has been revised and approved, the Management Department should issue a communication indicating:

i. That from this day on the Emergency Plan has been adopted.
ii. That the Emergency Plan is known and can be applied by company employees rather than contractors and/or subcontractors.

6.9.2 DISCLOSURE OF THE EMERGENCY PLAN

Aimed at workers and visitors emphasizing the actions to follow in case of:

i. Discover emergency events (fire, gas leak, explosion, bomb attack, earthquake, etc.).
ii. Activation of emergency alarms in case of accident or sudden illness of a worker.

The surrounding community must also be involved and integrated to participate in prevention activities and emergency care as part of an ongoing educational process developed within the training and outreach activities.

6.9.3 EDUCATION AND TRAINING OF RESPONSE TEAM

The brigaders and workers will be trained regularly to update their knowledge on management and control of emergencies and contingencies that apply to different groups. This programming will be published periodically in the activities schedule. The training will be based on the following topics:

i. ***First Aid:*** Attitude of the volunteer helper, evaluation of the injured, rescue technique, cardio pulmonary resuscitation, altered consciousness, shock, soft tissue injuries, wounds, bleeding, osteo-muscular trauma, immobilization, bandaging, and first aid techniques.

ii. **Prevention, control and firefighting:** chemistry and physics of fires; different kinds of fires and fuels, fire extinguishing systems, and the use of fire extinguishers

iii. **Evacuation and rescue:** effective communication, evacuation, relocation of people, salvage of material belongings and evacuation process, basic transportation of injured personnel, coordination of evacuation process, and, basic rules for evacuation of personnel.

iv. **Management of hazardous substances:** Layout and knowledge of safety data sheets with hazardous substances management and contingency measures in case of spillage.

v. **Practice Drills** of possible emergencies in the respective area.

6.9.4 PLAN OF EMERGENCY CONTROL ACTIONS

To operate the emergency control actions, it is necessary to establish actions chronologically distributed before, during and after the emergency. This is necessary because the emergency response requires an organization that allows the use of all available resources efficiently, minimizing personal injury, damage to equipment, and loss of property.

6.9.5 OPERATING PROCEDURE OF THE EMERGENCY BRIGADES

Emergencies present during the execution of the project will be classified according to severity, and this will be the starting point for defining the emergencies that will be handled by the Emergency Coordinator.

Table 106 SEQUENCE OF ACTION IN CASE OF EMERGENCY

STAGE	RESPONSIBLE	TAKE ACTIONS	OTHER ACTIONS
1	Who discovers an event: * Workers * Visitors * Security Guards * Others (community)	Notify nearest person to assure that it is reported immediately to one of the following: * Emergency Coordinator * Response Group Brigade	* Prioritize the safety of persons * Control the situation if it is possible to do so in a safe manner *Protect equipment and installations from further damage of the event ONLY IF possible and safe.
2	Staff who is informed * Emergency Coordinator * Response Group Brigade * Director of Emergency (Camp)	* Assess the situation. Determine need for evacuation of areas. * Coordinate control of the event actions with the Brigades . * Communicate with Central Office or Unified Command Post. * Request help from any relief corps present in the area	* Make follow-up of the event and the chances of successful control. * Feedback information to the Communications Director (or Project Manager)
3	Emergency Coordinator Response Group Brigades	* Support the intervention of relief corps * Provide first aid to those affected as required. * Evacuate personnel threatened by the event. * Coordinate the transfer of injured who require attencion to the health care centers, using vehicles.	* Feedback your information to Communications Director (or Manager) or Project Manager
4	Emergency Coordinator Response Group Brigades	Coordinate actions for the restitution of normality after the emergency. * Reset communications. * Take stock inventory of the event. * Retrieve informacióm. * Retrieve information for the Communications Director . * Restore the basic services: energy, water, gas, etc. * Request staff, substitutes, if required.	Responsibilities of the Communications Director * Submit official version of the events. * Communicate with different stakeholders.

Source: RPS - Work Group

6.9.6 EMERGENCY EQUIPMENT

The main elements that should form the emergency response team in the field camp and at the work front are presented in the following table.

Table 107 MINIMUM EQUIPMENT FOR EMERGENCY CARE AT CAMP SITES AND WORK FRONTS

MINIMUM EQUIPMENT	QUANTITY IN OFFICE AND/OR FIELD	QUANTITY AT WORK FRONT
First Aid Kits	One at the First Aid Area	One per vehicle for non-exclusive use in Emergencies.
Stretchers	One at the First Aid Area	One per Work Area
Directory of work posts and external support agencies	One Published on the Bulletin board	One for each non-exclusive use vehicle for emergencies
First Aid Area	One Located at the Main Office	Not applicable
Fire Extinguishers	According to Risk Analysis at the Camp Site or Office	One per vehicle and / or machine (PQS-multipurpose min. 10 lbs.)
Surveillance Personnel	According to the project's needs	According to the project's needs
Radio or mobile cellphone	One at each Office or Camp Site	One per activity coordinator

Table 108 MINIMUM EQUIPMENT FOR EMERGENCIES AT OFFICES AND/OR CAMP SITES

MINIMUM EQUIPMENT	AT CAMPSITE AND/OR OFFICE	AT WORK FRONT
First Aid Kits	One (1)	Clean and sterile gauze, cloth tape, tongue depressors, latex gloves, elastic bandage, povidone, (iodine solution), saline solution, thermometer, antiseptic alcohol, antiseptic soap, (disinfectant), bandages. Elements for restraining arm and leg injuries.
Gurneys	One (1)	One (1) portable stretcher.

Source: RPS – Work Group

6.9.7 SUPPORT AGENCIES

List of centers and relief agencies that provide support in emergency care: clinical and hospital centers, and government entities, rescue and help corps.

Table 109 EMERGENCY TELEPONE FIXED LINES, MOBILE AND AVANTEL

NAME	NUMBER	COVERAGE
Disaster Warning	111	National
Police	112 ; *118 Tigo	National
Time	117	National
Fire	119 ; *115-120 Tigo	National
District Attorney	122	National
Single National Emergency Number	123 *128 Tigo	National
Health Emergency Services (Ambulance)	125	National
Highway Patrol	126 - #767 (*SOS)	National
Transit	127	National
Red Cross	132	National
Ambulance	137	National
Civil Defense	144	National
Emergency Assistance Military Forces	146	National
Army	152	National
DAS	153	National
CAI	156	National
Dijin	157	National
Gaula Anti-Kidnapping	147, 165	National
Narcotics	167	National

SOURCE: RPS –Work Group

6.9.8 EVACUATION PLAN

6.9.8.1 OBJECTIVE

Protect the life and physical integrity of workers and visitors who are in the offices, camps or working areas at the front at the time of an emergency, moving them to safety with the lowest risk possible

6.9.8.2 RESPONSIBILITIES – EXECUTIVE LEVEL

Work Management: their responsibility is to maintain this evacuation plan in permanent operational conditions.

6.9.8.3 LEVEL COORDINATOR AND EMERGENCY RESPONSE TEAMS

For workers in the Emergency Response Group (evacuation and rescue, first aid, prevention of fire outbreaks) present in the project and at work fronts: their responsibility is to implement the necessary actions for carrying out the evacuation procedures in order to insure the safety of the people threatened by the emergency.

Initially, there will be an alarm system consisting of whistles which will be kept by the Emergency Coordinator, brigaders and security personnel; later, there will be a siren warning system.

6.9.8.4 COMMUNICATION EQUIPMENT

The communications system consists of:

i. Mobile phones, Avantel (walkie-talkie/mobile combination) and Radios will be kept at the camp's management office.

ii. PTT radios and mobile cell phones will be available at the work fronts, as well as temporary camps, and other security points.

6.9.8.5 EVACUATION ROUTES

Table 91 provides a comprehensive list of evacuation routes that is area specific to the field.

Table 110 EVACUATION ROUTES

ROUTE	DESCRIPTION
Battery 1	In case of an emergency, personnel should follow the route indicated in the evacuation plan installed at the entrance to Battery 1. In this Battery we will act if the emergency is in the tank area or internal areas of the battery. Those who find themselves here should direct themselves to the meeting point, found outside the Battery in the parking zone, in front of the office of the plant supervisor.
Station 2	In case of an emergency, personnel should follow the route indicated on the evacuation plan installed at the entrance to Station 2. In this Station, we will act if the emergency is present in any internal area, looking to evacuate personnel from the affected area in case of emergency present in the tanks, separators, or thermal treaters. Those who find themselves in this situation should direct themselves to the meeting point at the outskirts of the battery in an empty field, as specified in the evacuation plan.
Station 4	In case of an emergency, personnel should follow the route indicated on the evacuation plan installed at the entrance to Station 4. In this Station, we will act if the emergency is present in any internal area, looking to evacuate personnel from the affected area in case of emergency especially if present in the tanks, separators, or thermal treaters. Those who find themselves in this situation should direct themselves to the meeting point at the outskirts of the battery in an empty field, as specified in the evacuation plan.
PIA Station 3	In case of an emergency, personnel should follow the route indicated on the evacuation plan installed at the entrance to the station. In this Station, we will act if the emergency is present in any internal area, looking to evacuate personnel from the affected area in case of emergency especially if present in the tanks, separators, or thermal treaters. Those who find themselves in this situation should direct themselves to the meeting point located on the outskirts of the station, on the right side of the entrance.
Operations Zone Palagua Field	In case of an emergency, personnel should follow the areas indicated on the evacuation plan installed at the entrance to the Operations Zone. In this area, we will act if the emergency is present in the offices or warehouses of electric or mechanical maintenance. Those who find themselves in this situation should direct themselves to the meeting point located across from the store, in the parking lot on the left side.
Wells	In case of an emergency, personnel should follow the areas indicated on the evacuation plan installed at the entrance to the Operations Zone. For each one of the wells we will take the closest meeting point according to the crude conduction line that feeds into the well from the closest location.

6.9.9 ROLES AND RESPONSIBILITIES OF THE BRIGADERS

6.9.9.1 EMERGENCY COORDINATOR

Functions:

- The emergency coordinator's main task is to establish, implement and evaluate the Emergency Plan, in coordination with different groups. Manage the resources allocated, following the rules and procedures established by the project.

- He/She oversees the organization and the conditions necessary to ensure the success of the evacuation. He must also ensure compliance with the emergency plan ensuring the administrative technical and logistical resources for its implementation, maintenance and commissioning.

- In an emergency, the Coordinator will assume the communications' control and management and is therefore responsible for making decisions such as: partial or total evacuation and shut-down activities.

Responsibilities:

- Give support and back up to the organizational structure of the emergency plan taking leadership of it.
- Participate in the selection process of members of different groups of the Brigade.
- Develop, revise and implement the operational procedures and regulations policy for the conditions of company-specific hazards in their stages of prevention, care and recovery.
- Establish lines of authority and allocation of responsibilities to ensure compliance with plans and the bylaws of the Emergency Brigade.
- Coordinate beforehand with agencies working in emergencies, and in advance establishes procedures to follow if necessary.
- Encourage each member of the Brigade, to cooperate, participate and comply with the provisions of the Emergency Plan and the bylaws of the organization as well as training programs and training.
- Evaluate periodically the activities scheduled by the Brigade

- Run a national emergency drill at least once a year.
- Seek advice on a permanent basis and provides training to members of the Brigade, in management and disaster prevention.
- Make the Emergency Plan known to all members of the staff.
- Keep the group coordinators always informed on changes or security policies adopted by him or by the general management.
- Receive the alarm or communication and activates the Emergency Plan. If the alarm is communicated by a person, inquire with the leader of the respective area as to the type and characteristics of the emergency
- Establish permanent communication with all area leaders or their alternates, providing the necessary support to control the emergency.
- Make decisions and takes extraordinary control actions not contemplated for an effective control of the emergency

Assess and communicate the needs of:

- Evacuation
    - Intervention group or domestic support (Brigade)
    - Intervention teams or external support (Fire, Red Cross, Civil Defense, among others.)
    - Return to normal
- Maintain the number of brigaders in accordance with the requirements of coverage for the company besides ensuring that they cover all their work hours as well.

- Receive reports of safety inspections carried out by the control groups and fire prevention, evacuation, rescue, first aid, to give the corresponding processed correction of anomalies.

- Coordinate with the agencies in emergency care, the procedures to be followed in each case.

6.9.9.2 FIRE CONTROL GROUP

Functions:

The group is directly responsible for monitoring fire protection equipment, to ensure adequate operation at the time of an emergency, and to coordinate the necessary resources for the proper functioning of each team.

Group Leader:

- Plans and maintains the organization of the group.

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- Has his staff registered and develops action plans.
- Provides whatever is needed for preparing and training his group.
- Checks that all the equipment is maintained, cared for, and used properly.

Brigaders:

BEFORE THE EMERGENCY

- Obtain basic knowledge of fire and fire control methods.
- Conduct trainings and practices that enable them to acquire the necessary skills to perform.
- Participate in defining the elements needed to perform their work safely.
- Perform preventive maintenance of equipment.
- Carry out inspections of workplaces, report abnormal conditions and suggest methods of control.
- Train other staff members in aspects of fire prevention and control.
- Know the different fire hazards that are present in their area of responsibility and monitor their control.

DURING THE EMERGENCY

- Respond promptly to any emergency situation that is present on the premises of the company, using equipment available to take care of them.
- Act in coordination with other response teams and follow the instructions given by the group leader and coordinator of the brigade.
- Support the evacuation of the facility and possible rescue of trapped.

AFTER THE EMERGENCY

- Perform debris removal, collect and clean the equipment used in emergency care.
- Assess the procedures performed and, if necessary, suggest any amendments.
- Prepare report on what happened, possible causes, actions, and recommendations for correction.
- Carry out the preparation of the equipment needed to respond to another emergency in the shortest time possible.

RESPONSIBILITIES

- Conduct regular inspections of existing firefighting equipment in their area of responsibility.
- Check the operation of the alarm transmission mechanisms within the company and to support areas from local authorities.
- Oversee the operation of pumps and valves of the hydraulic firefighting system (if any).
- Make the control of public services in the area of the fire.
- Fire extinguishing or control.
- Conduct research as to the causes of fires.
- Permanent training.
- Prepare and train the staff in use of fire extinguishers.

6.9.9.3 FIRST AID GROUP

Functions:

The group must ensure the maintenance of first aid equipment and identify the needs of acquiring new equipment to enable the proper care of the wounded, through the brigade coordinator.

Group Leader:

- Plans and directs the operation of the First Aid group.
- Makes list of officials for each of the areas of the project and submits permanent disabilities or illnesses and constantly updated.
- Provides whatever is necessary for preparing and training the group.
- Checks that equipment is maintained and used properly

Brigaders:

BEFORE THE EMERGENCY

- Participate in training and simulations that will enable them to master the knowledge and skills to administer first aid.
- Define the elements and equipment necessary to perform their work.
- Regularly check the provision of first aid kits and the state of the support elements available for the project and keep them in condition to be used at any time.
- They make sure to implement a rapid and appropriate transportation system and verify its operation.
- Perform the location and classification of health facilities in the area of interest according to their distance and level of care

DURING THE EMERGENCY

- Collaborate in the evacuation of staff from any area where they might be

- Move the equipment needed to provide first aid care for injuries.
- Provide first aid.
- Under the supervision of attending physician coordinate and monitor the movement of the injured to health facilities.
- Complete the report of the care given to each one of the victims or injured

AFTER THE EMERGENCY

- Assess the quality and timeliness in providing first aid.
- Make recommendations for the adjustment of procedures or attention plans.
- Inspect, clean and replenish the elements and equipment used for the care of the injured leaving them in proper conditions to be used again.
- Present report to the coordinator of the brigade activities done, caseload, severity, and place shipments for reference and information necessary for the replenishment

6.9.9.4 SUPPORT AND CONTROL GROUP

Functions:

- To cordon off the affected area or areas in an emergency.
- Restrict the entry and control the exit of people to the project in coordination with the Brigade Coordinator and / or Emergency Coordinator.
- Prevent acts of theft and/or vandalism with the security groups.
- Immediately notify External Support Groups (Fire, Red Cross, Civil Defense, Police, among others), according to indications given by the Brigade Coordinator and / or team Emergency Coordinator. In case of not having effective communication with the above, the Safety Coordinator should call relief units upon his sole discretion.
- Support the Brigade, during and after the emergency.
- Provide support and guidance to external emergency services upon arrival and enter the company premises.

MEMBERS OF THE EMERGENCY BRIGADE

BRIGADE COORDINATOR (TO BE ELECTED)
NAME: _____
TELEPHONE: _____

FIRE CONTROL GROUP (TO BE ELECTED

NAME _____ NAME _____
PHONE _____ PHONE _____

NAME _____ _____
PHONE _____ PHONE _____

FIRST AID GROUP (TO BE ELECTED)
NAME _____ NAME _____
PHONE _____ PHONE _____

NAME _____ NAME _____
PHONE _____ PHONE _____

EVACUATION GROUP (TO BE ELECTED)
NAME _____ NAME _____
PHONE _____ PHONE _____

NAME _____ NAME _____
PHONE _____ PHONE _____

GROUP SUPPORT AND CONTROL (TO BE ELECTED)

NAME _____ NAME _____
PHONE _____ PHONE _____

NAME _____ NAME _____
PHONE _____ PHONE _____

ANNEX 1

MAP OF 32-WELL EXPANSION PROJECT FOR 2012

ANNEX 2 – Field Maps

ANNEX 3

Letter OFI10-6514-GCP-0201 from the Colombian Ministry of the Interior and Justice

ANNEX 4

MANUAL FOR OCCUPATIONAL HEALTH AND SAFETY