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The Replacement Cost Integration Program

User's Guide

David B. Reister

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Fossil
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ORNL/TM-11124

Engineering Physics and Mathematics Division

THE REPLACEMENT COST INTEGRATION PROGRAM

USER'S GUIDE

David B. Reister

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ABSTRACT

The Oak Ridge National Laboratory and subcontractor ICF-Lewin Energy have developed a set of computer models to forecast the replacement cost of domestic crude oil. The REPCO model forecasts the replacement cost in the lower 48 states. The Arctic Economics Model forecasts the replacement cost in Alaska. The two models of the replacement cost system forecast domestic oil supply curves (schedules of the amount of oil available at various costs). The Replacement Cost Integration Program (RCIP) integrates the output from the two models to forecast the annual discoveries and production of domestic crude oil.

RCIP is a user-friendly menu-driven program that is designed to run on an IBM-PC. RCIP allows the user to conveniently edit the input parameters, to calculate the results, and to display the output. In addition, the user can easily store a scenario on a disk and retrieve a scenario from the disk. The built-in output editor allows the user to choose an aggregation scheme for the regional results and retrieve a scenario for comparison. The output can be directed to a file or to the screen.

This user's guide for RCIP contains detailed directions for installing and operating RCIP. The guide discusses all of the parameters on the input screens of the model. The format and units of the output files of the model are reviewed in Appendix B.

1. INTRODUCTION

The U.S. Department of Energy's Fossil Energy (DOE-FE) program manages a program of long-term, high-risk R&D to develop advanced energy technologies that produce or consume fossil energy. The management of the program continually faces the question: when will an advanced technology be competitive with any alternative technologies? The standard method for comparing a set of alternative technologies is to perform a discounted cash flow analysis. There are many types of discounted cash analyses; one of the standard methods is to calculate a life-cycle cost for each alternative technology. The life-cycle cost is the constant or levelized cost that will recover all of the costs necessary to produce the product over the life cycle of the project. The technology with the lowest life-cycle cost will tend to capture the largest share of the market. DOE-FE supports research to produce liquid and gaseous fuels. The conventional technology to produce these fuels is to drill wells to extract liquid or gaseous fuels. Because the advanced technologies must compete with the conventional technology, the life-cycle cost of conventional oil and natural gas is of interest to the management of the program.

Conventional oil and gas are finite resources. As the resources are consumed, the life-cycle cost of the next barrel, the replacement cost, will tend to increase. As the replacement cost increases and R&D lowers the cost of advanced energy technologies, eventually the advanced technologies will penetrate the market.

The program has sponsored research by the Oak Ridge National Laboratory and subcontractor ICF-Lewin Energy to develop a set of computer models to forecast the replacement cost of domestic crude oil and natural gas and to forecast the contribution to the U.S. oil supply from domestic crude oil and Enhanced Oil Recovery (EOR). The Replacement Cost (REPCO) model forecasts the replacement cost of domestic crude oil for 6 onshore regions and 14 offshore regions. The Arctic Economics Model (AEM) forecasts the replacement cost for 15 regions in Alaska. The Replacement Cost Integration Program (RCIP) uses the output from REPCO and AEM to forecast the discovery and production of crude oil in 31 regions (16 regions in the lower 48 states and 15 regions in Alaska).

To completely account for domestic oil production, RCIP allows the user to insert values for oil production from enhanced oil recovery, heavy oil, tar sands, and other. The user can define "other"; possible definitions include: natural gas liquids, shale oil, or coal liquids.

The life cycle of an oil field has several stages. In the onshore section of REPCO, the stages are exploration, development, and production. In the first year, preexploration activities are conducted. In the second year, a lease agreement is signed with the landowner. In the third year, exploratory drilling discovers the field. In the fourth year, production from the successful exploratory well begins and the drilling of development wells begins. The development stage can last 3 to 9 years, depending on the size of the field. The production stage lasts 15 years for small fields and 20 years for large fields. In the offshore section of REPCO, the development stage includes the construction of the drilling platform.

In REPCO and the AEM, engineering process models forecast the capital costs, operating costs, and the production level for oil and gas for each year for each field class in each region. In REPCO and the AEM, the subroutine ANETPV calculates the replacement cost of domestic oil for each field class in each region (the replacement cost is the constant or levelized cost that will recover all of the costs necessary to produce crude oil over the life cycle of the oil field). The inputs to ANETPV are the outputs of the process models (time series of capital costs, operating costs, and production) and parameters (the discount rate, the royalty rate, the tax rate, the overhead rate, and the transportation cost).

In the sensitivity analysis of REPCO, the parameter with the largest sensitivity coefficient was the discount rate. In the previous versions of RCIP, the replacement cost was an input that depended on the parameters required by ANETPV. Each change in a key parameter required a new run of REPCO and the AEM. In the current version of RCIP, the ANETPV calculation is performed in RCIP. Thus, the inputs to RCIP are the outputs of the process models and the parameters. The input data editor allows the user to easily change the values of key parameters.

The net present value calculation can be performed for either a constant price track or a variable price track. Given expected domestic oil prices, ANETPV can calculate the discounted present value of the profits from the development of an oil field that commenced in a certain

year. For the historical period (1960 to 1987), expected domestic oil prices were not the same as actual domestic oil prices. If oil companies had known about the increases in oil price in 1974 and 1979, they would have increased the level of drilling in the period from 1968 to 1974. In 1981, the domestic oil price reached $41 per barrel, and the industry expected that the price would soon reach $100 per barrel. However, in 1987, the price was $18 per barrel and the industry expected a slow increase in price. The expected prices in 1981 encouraged a much higher level of drilling than the expected prices in 1987. The input data editor allows the user to easily change the values of both the future oil price and the expected oil price.

After ANETPV calculates the expected profits from the development of each oil field in each year, the current version of RCIP estimates the total level of drilling and oil discoveries by region and field size in each year. Having forecast the regional oil discoveries, RCIP uses two production profiles (one for large fields and a second for small fields) to estimate future oil production. A price elasticity parameter allows the oil production to respond immediately to price changes.

RCIP is a user-friendly menu-driven program that is designed to run on an IBM-PC. The next section describes how to install RCIP. The third section describes the operation of RCIP. Appendix A describes the input and output screens of the RCIP data editor. Appendix B provides an introduction to the output files. Appendix C provides a brief discussion of a method for producing printed graphs from the RCIP output files.

2. INSTALLATION

RCIP is designed to run on an IBM PC-XT with 640K of RAM, a hard disk, an 8087 coprocessor, and a color graphics card. Since the (TURBO) Pascal source code is included, the user can tailor the model to other hardware configurations. The RCIP program and input data sets comprise 29 files that occupy three diskettes. To install the model, create a directory ("make directory") (MD\RCIP) and copy the 29 files to the directory. To run the model, type "RCIP." RCIP will read the input data sets and write the output data sets.

The RCIP program comprises the following 10 files:

1.	RCIP.COM	2.	MENU.CHN
3.	EDITOR.CHN	4.	CALC.CHN
5.	STORE.CHN	6.	RETRIEVE.CHN
7.	OUTPUT.CHN	8.	RCIPON.CHN
9.	RCIPOFF.CHN	10.	RCIPALAS.CHN

RCIP calls the main menu (MENU). MENU can call EDITOR, CALC, OUTPUT, STORE, or RETRIEVE. EDITOR calls either MENU or OUTPUT. CALC can call the onshore model (RCIPON), the offshore model (RCIPOFF), or the Alaskan model (RCIPALAS).

The same editor is used to change the parameters for both input and output. In the input phase, the user can change parameter values on eight screens. The parameter values on the eight input screens define a scenario. In the output phase, the user can change parameter values on three screens. The parameter values on the three output screens define the aggregation patterns for the model output.

The eleven data sets that define the eight input screens and the three output screens are as follows:

1.	PARAM.TTT	2.	WOP.TTT
3.	RSRCUS.TTT	4.	RSRCAL.TTT
5.	LEASEUS.TTT	6.	LEASEAL.TTT
7.	EOR.TTT	8.	IFIDRSV.UUU
9.	AGGREGNM.UUU	10.	AGGREGUS.UUU
11.	AGGREGAL.UUU		

The file name extension for the eight input data sets is "TTT," while the extension for the three output data sets is "UUU." The eleven input and output screens will be discussed in Appendix A.

In addition to the eleven data sets that can be changed by the RCIP editor, RCIP contains the following eight data sets:

1.	ONPARAM.DAT	2.	OFFPARAM.DAT
3.	AEMPARAM.DAT	4.	ALMMS.DAT
5.	NPCDIST.DAT	6.	ONSHORE.INP
7.	OFFANET.BBB	8.	DSKDALK.BBB

Although most users of RCIP will not need to change the values in these data sets, the eight data sets are text files that can be edited by any text editor.

3. OPERATION

When installation has been completed, the model starts when you type "RCIP." Once RCIP has been activated, it displays the main menu. The main menu has seven options:

1. **R**etrieve scenario from disk to memory
2. **E**dit parameters in memory
3. **C**alculate results
4. **S**tore scenario from memory to disk
5. Go to **O**utput menu
6. **D**efine the Output Aggregation Regions
7. **EX**it from RCIP

To select an option, press the appropriate highlighted key (the choices are R, E, C, S, O, D, and X).

When you choose the edit option, you will have the opportunity to change parameter values on eight screens. The editor has two modes: editor and command. In the editor mode, you can use the arrow keys to move to any cell on the screen, and you can change the data in the cell. To enter the command mode, you type "/." In the command mode, you have three options: return to the editor mode by typing "/," proceed to the next screen by typing "P," or save the revisions by typing "S." If you proceed to the next screen, your revisions will not be saved.

When you choose the calculate option, you will have the opportunity to choose a number and a name for the scenario, and you will proceed to the calculation menu. RCIP can calculate crude oil discoveries and production for three regions: lower 48 states-onshore, lower 48 states-offshore, and Alaska. On the calculation menu, you decide whether or not to perform the calculations for each of the three regions. The initial choices are "No" for all three regions. Options are chosen by pressing the highlighted keys (N, F, A, or R). If you press the key for a region, the "No" will change to a "Yes." When you have completed your selection, press "R," and the calculations will be performed for the selected regions.

After the calculation is completed, you should select the store option. The only choice on the store option is the name for the output file.

If you want to compare two scenarios, you can use the retrieve option to retrieve the second scenario. RCIP has storage locations for two scenarios: primary and secondary. When you perform a calculation, the results are placed in the primary scenario. On the scenario retrieval menu, you have three choices: retrieve a primary scenario, retrieve a secondary scenario, or quit. When RCIP starts, the initial values for the two storage locations are set to 0.0. You can change the values in the primary scenario by performing calculations or by retrieving scenarios. For example, you could retrieve a primary scenario for all three regions and then perform the calculation for Alaska. The resulting primary scenario would have new values for Alaska and old values for the lower 48 states.

When you choose the define option, you have the opportunity to change parameter values on three screens. The first screen allows you to select names for up to 10 aggregate regions. The second screen allows you to define the members of the aggregate regions for the lower 48 states. The third screen allows you to define the aggregate regions for Alaska, EOR, and other. After you have defined the regions, or if you select the output option, RCIP calculates the aggregated results and offers three options for each aggregate region: display a graph, save a summary of the results, and save detailed results.

In addition to any output files produced by saving scenarios, RCIP produces the following nine output files:

1.	RCIPSUM.OUT	2.	RCIPSUM.ON
3.	RCIPSUM.OFF	4.	RCIPSUM.AL
5.	RCIPDET.OUT	6.	RCIPDATA.OUT
7.	REPCOST.ON	8.	REPCOST.OFF
9.	REPCOST.AL		

RCIPSUM.OUT is the summary output from the output editor. RCIPSUM.ON, RCIPSUM.OFF, and RCIPSUM.AL are the summary output from the regional calculations. RCIPDET.OUT is the detailed output from the output editor. RCIPDATA.OUT is a summary of the input data for the scenario. REPCOST.ON, REPCOST.OFF, and REPCOST.AL display the replacement cost of domestic crude

oil for each of the three regions. The format and units of the output data sets will be discussed in Appendix B.

Appendix A.
INPUT AND OUTPUT SCREENS

This Appendix discusses the format and units for the eleven input and output screens. The first input screen is displayed in Table A.1. The four parameters are dimensionless.

Table A.1. First input screen.

Key Parameters (%)	
Discount Rate	10
Federal Tax Rate	28
Income Tax Credit Rate	0
Supply Elasticity	10

The second input screen, displayed in Table A.2, allows the user to change the values of three time series: price, growth, and drilling. Price is the domestic oil price. Growth is the expected growth rate for the domestic oil price. Drilling is an index of the cost of drilling oil wells. The key factor that controls the level of domestic drilling is the discounted present value of expected profits from the initiation of an oil development project. The expected profits depend on the expected price for oil over the lifetime of the project. The expected oil price is determined by the current value (Price) and by the growth rate (Growth). The drilling price index is used exclusively by the model for the lower 48 onshore region.

The 15 values in Table A.2 are interpolated to produce the 40 values required by the model. A zero value will be replaced by an interpolated value. The values in 2020 should not be zero. The values for the years may be changed.

Table A.2. Second input screen.

In this data set a zero value will be replaced by an interpolated value. The values in 2020 should not be zero. 1985 Dollars.

Year	Price	Growth	Drilling
1981	40.61	1.02	1.32
1982	34.72	0.00	1.28
1983	30.90	0.00	1.00
1984	29.46	0.00	0.00
1985	26.66	1.01	1.00
1986	14.44	1.02	0.60
1987	16.65	0.00	0.60
1988	14.00	1.02	0.60
1989	0.00	0.00	0.00
1990	20.00	0.00	0.00
1995	0.00	0.00	0.00
2000	30.00	0.00	0.00
2005	0.00	0.00	0.00
2010	0.00	0.00	0.00
2020	50.00	1.01	0.60

The third input screen, displayed in Table A.3, allows the user to set the resource base for the lower 48 region. The units are billions of barrels. The resource base is the undiscovered recoverable oil as of January 1, 1987. The low, mean, and high values are from U.S. Geological Survey Open-File Report 88-373.

The fourth input screen, displayed in Table A.4, allows the user to set the resource base for Alaska. The resource base is the undiscovered recoverable oil as of January 1, 1987. The low, mean, and high values are from U.S. Geological Survey Open-File Report 88-373.

Table A.3. Third input screen.

Undiscovered recoverable crude oil for the lower 48 states as of January 1, 1987. (Values given in billion barrels.)

Region	Low	Mean	High	Choice
West Coast	1.18	3.49	7.57	3.49
Rocky Mountains	2.76	6.02	11.36	6.02
MidContinent	1.09	1.89	2.95	1.89
West Texas	1.41	2.56	4.18	2.56
Gulf Coast	2.25	4.24	7.12	4.24
Appalachia	1.13	2.02	3.32	2.02
West South Shelf	0.12	0.52	1.08	0.52
West North Shelf	0.20	0.70	1.27	0.70
West South Slope	0.13	0.67	1.55	0.67
West North Slope	0.58	1.63	2.85	1.63
Gulf Shelf	3.05	5.66	9.01	5.66
Gulf Slope	2.14	3.91	6.11	3.91
East North Shelf	0.01	0.16	0.42	0.16
East North Slope	0.04	0.42	1.12	0.42
East South Shelf	0.00	0.04	0.23	0.04
East South Slope	0.00	0.32	1.49	0.32

Table A.4. Fourth input screen.

Undiscovered recoverable crude oil for Alaska as of January 1, 1987. (Values given in billion barrels.)

Region	Low	Mean	High	Choice
Beaufort Shelf	0.49	1.27	3.74	1.27
Chukchi and Hope Shelf	0.00	2.24	7.23	2.24
Bristol Basin Shelf	0.00	0.03	0.02	0.03
Navarin Basin Shelf	0.00	0.07	0.12	0.07
Norton Basin	0.00	0.01	0.05	0.01
Other Bering Sea Shelf	0.00	0.03	0.05	0.03
South Offshore Shelf	0.00	0.20	1.87	0.20
South Offshore Slope	0.00	0.00	0.00	0.00
Beaufort Slope	0.00	0.00	0.00	0.00
Chukchi and Hope Slope	0.00	0.00	0.00	0.00
Other Bering Sea Slope	0.00	0.00	0.00	0.00
Gulf of Alaska-Onshore	0.12	0.59	1.71	0.59
ANWR	1.04	4.77	12.54	4.77
NPRA	0.78	3.59	9.43	3.59
North Slope (Other)	0.92	4.23	11.12	4.23

The fifth input screen, displayed in Table A.5, allows the user to set the lease schedule and land-set-aside scenario for the lower 48 region. The parameters are the fraction of the undiscovered oil that is available before the date. For example, 98% of the undiscovered oil was available in the onshore West Coast region before 2000.

Table A.5. Fifth input screen.

Lease schedule and land-set-aside scenario for lower 48. The parameters are the percent of resource available before the date.

Region	2000	2020
West Coast	98	100
Rocky Mountains	96	100
MidContinent	100	100
West Texas	100	100
Gulf Coast	100	100
Appalachia	100	100
West South Shelf	80	100
West North Shelf	80	100
West South Slope	80	100
West North Slope	80	100
Gulf Shelf	80	100
Gulf Slope	80	100
East North Shelf	40	100
East North Slope	40	100
East South Shelf	40	100
East South Slope	40	100

The sixth input screen, displayed in Table A.6, allows the user to set the lease schedule and land-set-aside scenario for Alaska. The parameters are the fraction of the undiscovered oil, expressed in percent, that is available before the date.

Table A.6. Sixth input screen.

Lease schedule and land-set-aside scenario for Alaska. The parameters are the percent of resource available before the date.

Region	2000	2020
Beaufort Shelf	80	100
Chukchi and Hope Shelf	80	100
Bristol Basin Shelf	80	100
Navarin Basin Shelf	80	100
Norton Basin	80	100
Other Bering Sea Shelf	80	100
South Offshore Shelf	80	100
South Offshore Slope	80	100
Beaufort Slope	80	100
Chukchi and Hope Slope	80	100
Other Bering Sea Slope	80	100
Gulf of Alaska-Onshore	100	100
ANWR	40	100
NPRA	40	100
North Slope (Other)	100	100

The seventh input screen, displayed in Table A.7, allows the user to set the regional values for inferred and indicated reserves of crude oil as of January 1, 1987. The values are from U.S. Geological Survey Open-File Report 88-373.

Table A.7. Seventh input screen.

Inferred and Indicated Reserves of Crude Oil as of January 1, 1987. (Values given in billion barrels.)

Region	USGS	Choice
Onshore - West Coast	1.141	1.141
Onshore - Rocky Mountains	1.780	1.780
Onshore - Mid Continent	1.383	1.383
Onshore - West Texas	3.836	3.836
Onshore - Gulf Coast	4.826	4.826
Onshore - Appalachia	0.768	0.768
Onshore - Alaska	6.379	6.379
Offshore - West Coast	0.243	0.243
Offshore - Gulf Coast	1.372	1.372

The eighth input screen, displayed in Table A.8, allows the user to set the level of production of EOR, heavy oil, tar sands, and other. The 7 values in Table A.8 are interpolated to produce the 34 values required by the model.

Table A.8. Eighth input screen.

In this data set, a zero value will be replaced by an interpolated value. The values in 2020 should not be zero. The units are 1000 barrels per day.

Year	EOR	Heavy Oil	Tar Sands	Other
1987	500	0	0	0
1990	900	0	0	0
1995	1100	0	0	0
2000	1200	0	0	0
2005	1100	0	0	0
2010	950	0	0	0
2020	700	0	0	0

The first output screen, displayed in Table A.9, allows the user to define the names for up to 10 aggregate regions.

Table A.9. First output screen.

On the next two screens, you can group the detailed output. On this screen, you can define the names of the aggregate regions.

Region Name	Region
Lower 48 - Onshore	1
Lower 48 - Offshore	2
Alaska - Onshore	3
Alaska - Offshore	4
Alaska	5
EOR and Other	6
Region 7	7
Region 8	8
Region 9	9
Region 10	10

The second output screen, displayed in Table A.10, allows the user to define the aggregate regions for the lower 48 states. To assign a detailed region to an aggregate region, enter the number of the aggregate region (defined in Table A.9) next to the name of the detailed region.

The third output screen, displayed in Table A.11, allows the user to define the aggregate regions for Alaska and for EOR.

Table A.10. Second output screen.

On this screen, you define the aggregate regions for the Lower 48.

Detailed Region	Aggregate Region
West Coast	1
Rocky Mountains	1
Midcontinent	1
West Texas	1
Gulf Coast	1
Appalachia	1
West South Shelf	2
West North Shelf	2
West South Slope	2
West North Slope	2
Gulf Shelf	2
Gulf Slope	2
East North Shelf	2
East North Slope	2
East South Shelf	2
East South Slope	2

Table A.11. Third output screen.

On this screen, you define the aggregate regions for Alaska and EOR.

Detailed Region	Aggregate Region
Beaufort Shelf	5
Chukchi and Hope Shelf	5
Bristol Basin Shelf	5
Navarin Basin Shelf	5
Norton Basin	5
Other Bering Sea Shelf	5
South Offshore Shelf	5
South Offshore Slope	5
Beaufort Slope	5
Chukchi and Hope Slope	5
Other Bering Sea Slope	5
Gulf of Alaska-Onshore	5
ANWR	5
NPRA	5
North Slope (Other)	5
EOR	6
Heavy Oil	6
Tar Sands	6
Other	6

Appendix B
OUTPUT DATA SETS

RCIP produces the following nine output files:

1. RCIPSUM.OUT
2. RCIPSUM.ON
3. RCIPSUM.OFF
4. RCIPSUM.AL
5. RCIPDET.OUT
6. RCIPDATA.OUT
7. REPCOST.ON
8. REPCOST.OFF
9. REPCOST.AL

This appendix will discuss all of the variables that are displayed in the output files.

RCIPSUM.OUT

The first section of RCIPSUM.OUT displays the names of the detailed regions that are contained in the aggregate regions. For example, the lower 48 - onshore region has six sections:

Definition of the Aggregate Regions.

Lower 48 - Onshore	
1	West Coast
2	Rocky Mountains
3	MidContinent
4	West Texas
5	Gulf Coast
6	Appalachia

For each of the aggregate regions and for the national total, RCIPSUM.OUT displays a summary of production and discoveries for five-year periods. The units are millions of barrels in five years. The following is a sample summary:

Region = National Total

From	To	Production		Discoveries	
1986	1990	12145	12145	5931	5931
1991	1995	14744	14246	13725	6397
1996	2000	14521	12102	17105	2500
2001	2005	15218	9034	11792	956
2006	2010	15087	5026	4321	355
2011	2015	12589	2693	1299	131
2016	2020	9010	1818	607	48
	Total	93314	57064	54780	16317

Because two scenarios have been loaded, the summary has two columns for production and two columns for discoveries. Because the name of the summary file is fixed, you must rename the summary file to save it.

RCIPDET.OUT

For each of the aggregate regions and for the national total, RCIPDET.OUT displays annual production and discoveries. The units are millions of barrels per year. The following is a sample of the detailed output:

Region = National Total

Year	Production		Discoveries	
1987	3045.5	3045.5	1806.0	1806.0
1988	3039.3	3039.3	1048.7	1048.7
1989	3032.8	3032.8	1327.9	1327.9
1990	3027.1	3027.1	1748.0	1748.0
1991	2993.8	2979.8	2104.8	1676.0
1992	2966.5	2921.0	2480.1	1488.1
1993	2945.6	2850.9	2863.0	1281.5
1994	2925.6	2784.6	3002.8	1093.1
1995	2912.6	2709.2	3274.8	858.1
1996	2901.8	2622.0	3508.3	700.3
1997	2902.5	2525.3	3684.5	583.9
1998	2889.3	2422.0	3441.1	484.7
1999	2893.7	2314.7	3451.0	400.9
2000	2933.4	2218.0	3020.5	330.7

Because two scenarios have been loaded, the detailed file has two columns for production and two columns for discoveries. Because the name of the detailed file is fixed, you must rename the detailed file to save it.

RCIPSUM.ON

Each of the three modules of RCIP (onshore, offshore, and Alaska) produces a summary output. RCIPSUM.ON is the summary output for the onshore module. The first section of the summary output follows (terms are defined in the test).

	Qstart	Qclass	FR	Avdep	Region
1	22471	436.25	40.60	5.778	West Coast
2	12065	752.50	21.46	9.319	Rocky Mountains
3	18470	236.25	15.70	5.189	MidContinent
4	35569	320.00	20.40	6.085	West Texas
5	45256	530.00	29.05	7.761	Gulf Coast
6	8958	252.50	21.52	2.822	Appalachia

Qstart is the amount of oil that had been discovered before January 1, 1987 (the sum of cumulative production and proved reserves). The units are millions of barrels. Qstart is an input and is part of the data set ONPARAM.DAT. The values are from the U.S. Geological Survey Open-File Report 88-373.

For the onshore module, the undiscovered oil is subdivided into eight resource intervals. Qclass is the amount of resource in each interval and is equal to one-eighth of of the resource specified on the third input screen. The units for Qclass are millions of barrels. For the West Coast region, 436 million barrels is one eighth of 3490 million barrels.

FR is the successful exploratory finding rate (measured in barrels per foot). The value for the West Coast region (40.60) is discussed on page A-1 of the methodology report (Note: Qclass and FR are no longer part of the finding rate calculation). Avdep is the average depth of a well (measured in thousands of feet). The value for the West Coast region (5.778) is derived on page A-13 of the methodology report.

The second section of the onshore summary report follows (terms are defined in the text).

	Wult	NDH	DDHR	INX	Region
1	234.57	4.579	0.139	2	West Coast
2	200.00	2.528	0.282	2	Rocky Mountains
3	81.46	2.263	0.366	2	MidContinent
4	124.13	2.284	0.180	2	West Texas
5	225.46	1.960	0.401	2	Gulf Coast
6	60.75	2.299	0.169	1	Appalachia

Wult is the average value for the amount of oil that will be ultimately recovered from a well (measured in thousands of barrels). Wult is the product of FR and Avdep. NDH is the number of dry exploratory holes per successful exploratory well. The value for the West Coast region (4.579) is derived on page A-26 of the methodology report.

DDHR, the developmental dry hole rate is determined by contrasting the number of dry developmental holes with the successful developmental wells. INX is a parameter equal to 1 if Avdep is less than 5.0, equal to 2 if Avdep is between 5.0 and 10.0, and equal to 3 if Avdep is greater than 10.0.

All of the values in the first two sections of the onshore summary report are simple transformations of the input data from ONPARAM.DAT and from the third input screen (RSRCUS.TTT).

The third section of the onshore summary report displays the results of the onshore module (terms are defined in the text).

1 West Coast

Year	Prod	Disc E	Disc D	Cum Disc	Undis Oil	Inf Resv
1986				22471.00	3420.20	1141.00
1990	1596.39	11.68	653.29	23135.96	3331.67	564.57
1995	1664.73	18.39	660.65	23815.01	3192.21	24.98
2000	1221.36	17.68	119.78	23952.47	3058.17	21.56
2005	927.84	13.19	93.76	24059.41	3027.98	14.60
2010	367.74	8.32	60.63	24128.36	2964.89	8.75
2015	91.26	4.71	35.01	24168.09	2929.15	4.76
2020	56.64	2.46	18.56	24189.11	2910.47	2.42
Total	5925.97	76.44	1641.67			

Each entry for oil production (Prod) (measured in millions of barrels) is given for a five-year period (except that the first period is four years). The additions to proved reserves from exploratory (Disc E) and developmental (Disc D) drilling for a five-year period are measured in millions of barrels.

The cumulative amount of oil that has been discovered (Cum Disc) is measured in millions of barrels. The initial value for Cum Disc is Qstart. The Hubbert Field Growth Factor (k) is the ratio of the amount of oil ultimately recovered from an oil field to the initial estimate of proved reserves from exploratory drilling. The value of k = 7.58. Each barrel of oil added to proved reserves by exploratory drilling will ultimately result in the production of k barrels of oil. Each year the value of Cum Disc is increased by the product of k and the exploratory additions to proved reserves.

The amount of oil that is available to be discovered (Undis Oil) is measured in millions of barrels. The third input screen and the fifth input screen control the amount of undiscovered resource and the rate at which the undiscovered resource is added to Undis Oil. Oil is made unavailable by being discovered (additions to Cum Disc are reductions in Undis Oil).

The amount of oil that has been discovered, the sum of inferred plus indicated reserves (Inf Resv), and is available for development (measured in millions of barrels). Let e(t) be the amount of oil that was added to proved reserves as the result of exploratory drilling in year t and let d(t) be the amount of oil that was added to proved reserves as the result of developmental drilling in year t. The total amount of oil discovered by exploratory drilling was k*e(t). Of the total, e(t) was reported, and the remainder (k-1)*e(t) was not reported but is added to Inf Resv for later development. Each year, the developmental additions to proved reserves [d(t)] are removed from Inf Resv.

RCIPSUM.OFF AND RCIPSUM.AL

The summary output for the offshore module (RCIPSUM.OFF) and for the Alaskan module (RCIPSUM.AL) are similar and will be discussed together. An example of the summary output is displayed below.

Produce is production for a five year period. Discover is the additions to proved reserves for a five-year period. Profit is the average value of the discounted present value of the profits in the last year of the period (the weights for the average are the field-class distribution of the undiscovered oil). Available is the total amount of oil that is available to be discovered. The units for production, discoveries, and available oil are millions of barrels. Available oil is increased by the lease schedule and land-set-aside scenario (input screens five and six) and decreased by being discovered. Ann Disc are the annual additions to proved reserves, while Pot Disc are the potential additions to proved reserves. If the Available oil is small, the annual additions can be less than the potential additions.

9 Gulf of Mexico - Shelf

Year	Produce	Discover	Profit	Available	Ann Disc	Pot Disc
1990	946.29	688.41	0.72	4096.06	256.47	256.47
1995	1210.43	1733.22	0.99	2488.18	381.80	381.80
2000	1388.64	1919.25	0.97	560.55	373.43	373.43
2005	1675.69	1319.12	0.76	18.30	18.30	273.91
2010	1800.10	0.00	0.56	0.00	0.00	175.35
2015	1387.32	0.00	0.41	0.00	0.00	99.73
2020	746.38	0.00	0.28	0.00	0.00	51.93
Total	9154.84	5660.00				

RCIPDATA.OUT

The store option on the main menu archives the output of the model. RCIPDATA.OUT is designed to store the input data that were used to create a scenario. Because the model always uses the same name for the data summary, RCIPDATA.OUT must be renamed to be archived.

The first section of RCIPDATA.OUT displays the key parameters from the first input screen. The second section of RCIPDATA.OUT summarizes the resource base and lease schedule scenario defined on input screens three to six. The EOR values defined on input screen eight appear directly in the output and are not archived in RCIPDATA.OUT.

The third section of RCIPDATA.OUT is a summary of the second input screen (terms are defined in the text).

Year	Price	Growth	Pdrill	Popcol
1981	40.61	1.02	1.32	1.31
1985	26.66	1.01	1.00	0.86
1990	20.00	1.02	0.60	0.65
1995	25.00	1.02	0.60	0.81
2000	30.00	1.02	0.60	0.97
2005	35.00	1.01	0.60	1.13
2010	40.00	1.01	0.60	1.29
2015	45.00	1.01	0.60	1.46
2020	50.00	1.01	0.60	1.62

The values for Price, Growth, and for the drilling cost index (Pdrill) are displayed every 5 years after interpolation. The cost index for the fuel and power used to drill the wells (Popcol) is calculated by dividing the domestic oil price by the value in 1983. For example, (40.61)/(30.90) = 1.31. Pdrill and Popcol are used in the onshore module but are not used in the offshore or Alaskan modules.

REPCOST.ON

In addition to oil discoveries and production, RCIP calculates the replacement cost (REPCO) for oil. The output data set REPCOST.ON displays the replacement cost calculated by the onshore module. The following is an example of REPCOST.ON (terms are defined in the text).

Year = 1990

Region	fc	Explor	Devel	Prod	Tang	Intang	Opcol	Opco23
1	1	10.94	10.37	426.33	1.11	1.14	0.25	0.87
2	1	11.35	11.14	427.07	1.21	1.56	0.26	0.77
3	1	10.96	10.79	198.88	1.18	1.04	0.32	1.09
4	1	11.85	11.12	234.86	1.29	1.26	0.28	0.94
5	1	11.43	11.89	338.85	1.27	1.48	0.33	0.95
6	1	11.22	10.63	119.62	1.16	0.84	0.34	1.35

REPCOST.ON summarizes the replacement cost in 1987 and at ten year intervals from 1990 to 2020. The column labeled fc is the resource interval and is always equal to 1. The onshore module treats exploratory drilling and developmental drilling as separate activities. The column labeled Explor is the replacement cost of exploratory oil (measured in dollars per barrel), whereas the column labeled Devel is the replacement cost of developmental oil (measured in dollars per barrel). Prod is the average yield of a well (measured in thousands of barrels). Tang is capitalized (tangible) investment per barrel and Intang is the expensed (intangible) investment expense per barrel. Opcol is the fuel and power cost per barrel and Opco23 is the operating cost for water, labor, and materials. The units for Tang, Intang, Opcol, and Opco23 are dollars per barrel.

REPCOST.OFF and REPCOST.AL

The output data sets REPCOST.OFF and REPCOST.AL display the replacement cost calculated by the offshore and Alaskan modules. An example of REPCOST.OFF follows (terms are defined in the text).

9 Gulf of Mexico - Shelf

Class	Repco	Prod	Tang	Intang	Opcol	Opco23
20	6.72	2000.00	0.68	0.74	0.14	1.49
19	7.79	1120.00	0.81	0.89	0.16	1.61
18	9.09	560.00	1.08	1.20	0.21	1.87
17	12.20	280.00	1.51	1.66	0.29	2.27
16	15.97	146.00	2.20	2.12	0.35	2.61
15	21.04	72.00	2.92	3.01	0.53	3.45
14	27.31	36.00	3.81	4.16	0.76	4.51
13	34.30	18.20	4.79	5.62	1.00	5.66
12	39.60	9.20	5.32	7.24	1.04	6.30
11	56.47	4.60	7.41	10.57	1.81	9.56
10	73.09	2.40	10.12	14.88	3.10	14.56
9	115.65	1.20	15.57	23.55	5.79	24.82
8	188.35	0.60	24.73	38.02	10.99	43.75
7	339.87	0.30	43.95	67.60	21.50	82.02

In REPCOST.OFF and REPCOST.AL, Class is the field class and Repco is the replacement cost. As the field class decreases from 20 to 7, the replacement cost increases from $6.72 to $340/bbl. Prod, Tang, Intang, Opcol, and Opco23 have the same definitions and units as for REPCOST.ON.

Appendix C
PRINTED GRAPHICAL OUTPUT

This appendix describes how the user can use Version 2.00 of Microsoft CHART to produce printed graphs of RCIP results. As an example, we will describe how we produced the graphs in the Results section of the Model Overview volume of this report.

To create a graph, we use the External Text sequence to import a text file into CHART. The first step is to produce the text file. The graphs in the Results section display oil discoveries and production for a high-price case and for a low-price case. We created the high scenario and used the **Store** option to save the results as HIGHCASE.HHH. Next, we created the low scenario and saved the results as LOWCASE.LLL. We used the **Retrieve** option to load both scenarios into RCIP. We used the **Output** option to compare the two sets of results. We renamed the detailed output (RCIPDET.OUT) with the name HIGHLOW.DAT. The first few lines of HIGHLOW.DAT follow.

R C I P - V E R S I O N 3.10

Date: 9/18/1988 Time: 12:42

Region = National Total

Year	Production		Discoveries	
1987	3045.5	3045.5	1806.0	1806.0
1988	3039.3	3039.3	1048.7	1048.7
1989	3032.8	3032.8	1327.9	1327.9
1990	3027.1	3027.1	1748.0	1748.0
1991	2993.8	2979.8	2104.8	1676.0
1992	2966.5	2921.0	2480.1	1488.1
1993	2945.6	2850.9	2863.0	1281.5
1994	2925.6	2784.6	3002.8	1093.1
1995	2912.6	2709.2	3274.8	858.1
1996	2901.8	2622.0	3508.3	700.3
1997	2902.5	2525.3	3684.5	583.9
1998	2889.3	2422.0	3441.1	484.7
1999	2893.7	2314.7	3451.0	400.9
2000	2933.4	2218.0	3020.5	330.7

The format for HIGHLOW.DAT is a title block followed by five columns of data. RCIP produces a title block that is six lines long and includes two blank lines (lines that consist of a carriage return and a line feed). However, CHART does not seem to count blank lines in the title block. Before importing the file, we have used a text editor to eliminate the blank lines. An alternative is to skip the blank lines, when determining the rows to import to CHART. As displayed in RCIP-Version 3.10, the title block occupies rows 1 to 4 and the data occupy rows 5 to 18. The first column of data is 20 spaces wide and the next four columns are 10 spaces wide.

The syntax to import the text file into CHART is **EX**ternal, **T**ext, and **C**olumnar (the user types **X**, **T**, and **C**). CHART responds with a screen with nine questions. To move between questions, use the tab key. To cycle the options, use the space bar. When all of the questions are answered, enter the carriage return.

To import HIGHLOW.DAT, the correct answers to the nine questions are the following:

1.	Filename:	HIGHLOW.DAT
2.	Linked:	No
3.	Selected Rows:	5:18
4.	Selected Columns:	2:5
5.	Column Width:	20, 10
6.	Orient Series By:	Column
7.	Series Names From:	(Leave Blank)
8.	Categories From:	1
9.	Series Type:	Number

If the data file is in another directory, the user can add the appropriate path to the filename. If the graph and the data set are linked, any changes in the data set will automatically appear on the graph. We have adopted the strategy of using unlinked graphs. Each data set is imported into CHART and saved as a separate graph file. If the user wishes to display a series of similar graphs, the format (without the data) of a previous graph can be loaded into CHART using the Transfer option. HIGHLOW.DAT has one set of values for the x-axis (Year) and four sets of values for the y-axis (Production and Discoveries). CHART calls the x-axis "Categories." The response to question eight tells CHART that the values for the x-axis are in the first column.

To complete the EXternal Text sequence, the user must name the data series. The series name appears in the legend on the graph. Our graphs are identified by "High" and "Low." Thus, the series names will be "High" and "Low." To name the data series, the user selects Name on the List Screen and answers the following questions:

1.	Series Name:	High
2.	Category Name:	Year
3.	Value Name:	Production

We selected the first 10 years of data from HIGHLOW.DAT. To display all 34 years, we should select rows 5 to 38. To import the second data series, we would select rows 41 to 74.

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