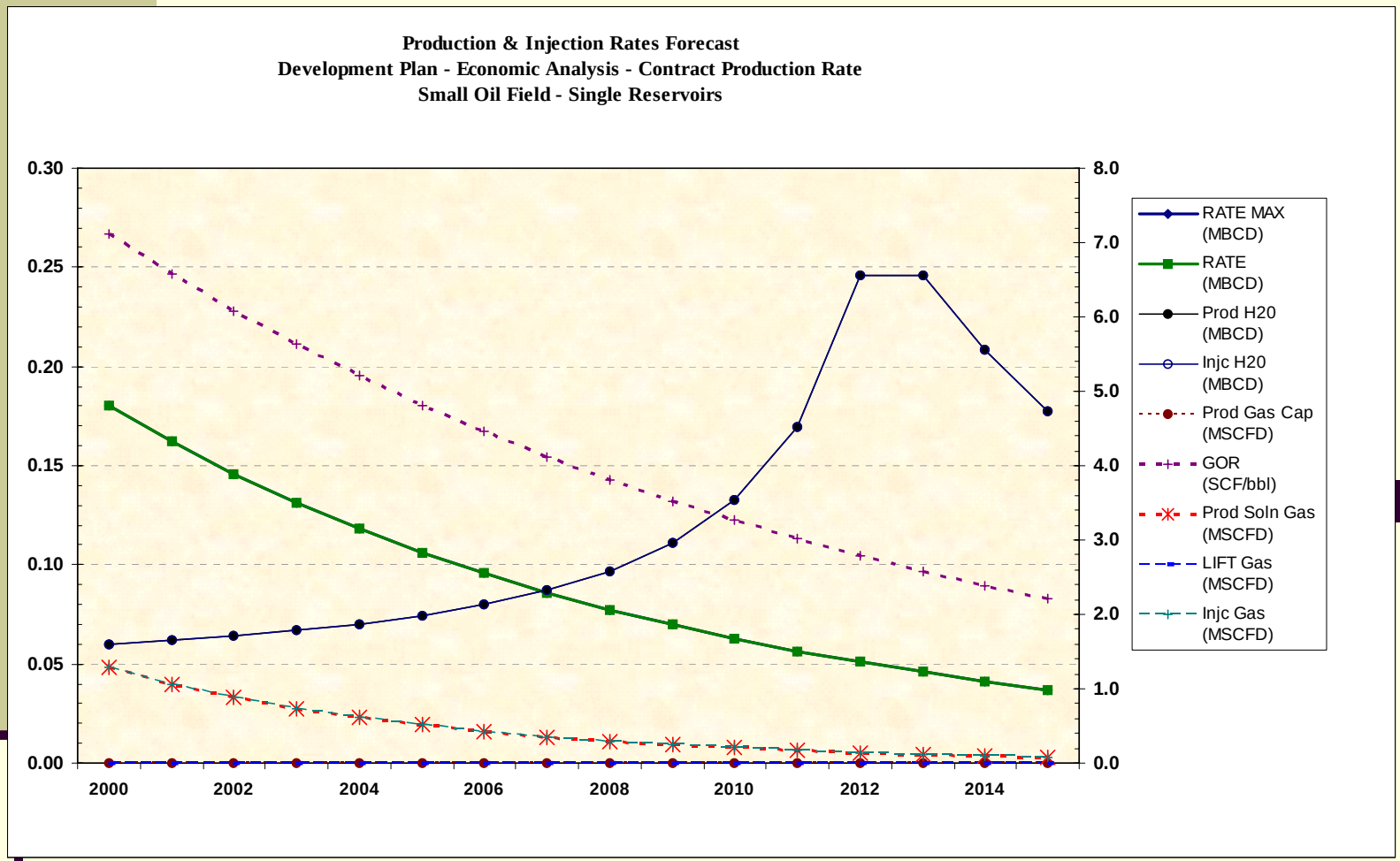
Petroleum Economics

- Harold Irby

Petroleum Economics - Outline

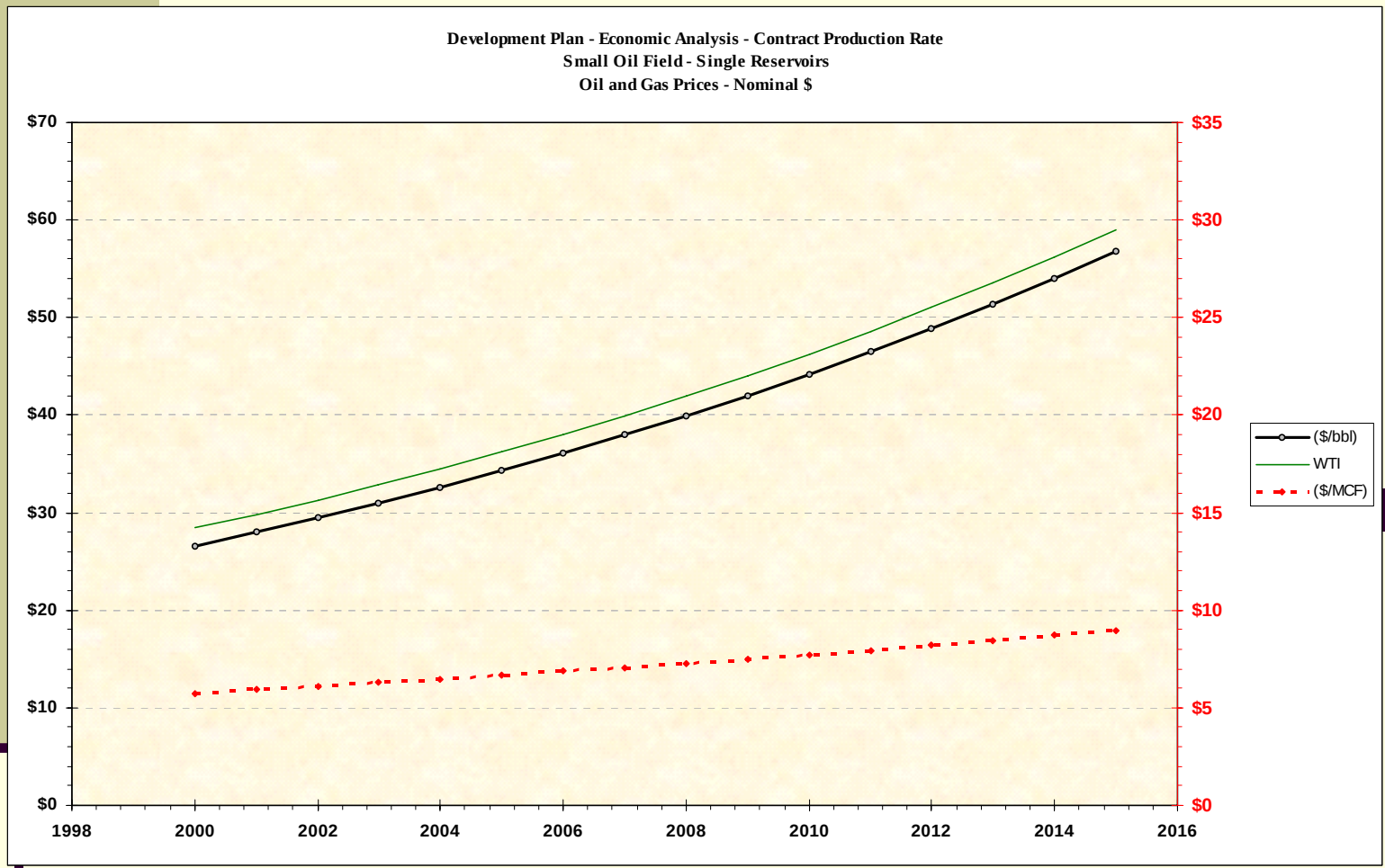
- Petroleum Economics
  - Small Field Single Well
  - Basic Economic Measures
- Cost Data Base
- Project Ranking
- Work Over Economics
- Incremental Work Over Economics
- Probabilistic Economics
  - Field Development Case
  - Probabilistic Measures

Petroleum Economics



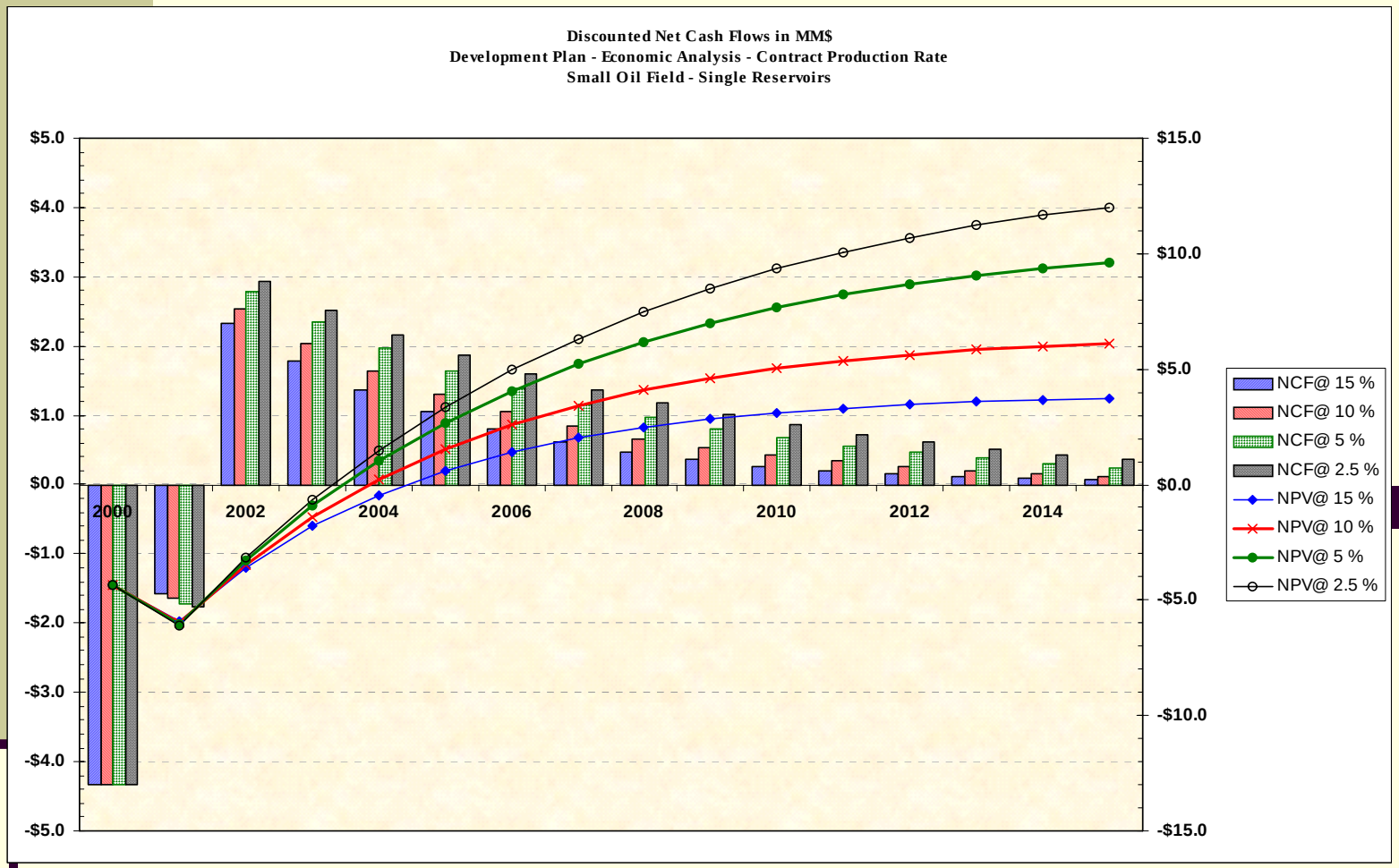
Typical / Example Production Profile

Petroleum Economics



Typical / Example Oil & Gas Price Forecast

Petroleum Economics



Cash Flow & NPV @ x% Profiles

Petroleum Economics

Development Plan - Economic Analysis - Contract Production Rate							
Annual Nominal Discount Rate, ANDR (%) : **10.00** (%)		Undiscounted CF @ 0%			Discounted CF @		
Annual General Background Inflation Rate, f (% **2.50** (%)		Base-Year	Nominal	Real 2000 $			
Annual Real Discount Rate, ARDR (%) : **7.32**		2000 $	(Then Crnt $)	Dsc @ 2.5 %	5.0 %	10.0 %	15.0 %
2000-2016Project Life: 16 (Years), n **16** (including year 2000 as Year-0 or Base-Year)		16	16	16			
Cum Present Value Factor (Inverse of Capital Recovery Factor)					10.84	7.82	5.95
VALUE ANALYSIS							
Net Present Value, NPV (MM$)		8.648	15.012	12.010	9.621	**6.119**	3.735
Annualized Net Present Value, ANPV (MM$)		0.540	0.938	0.751	0.888	0.782	0.627
Profitability Index, PI ($ Returned / $ Invested) = 1 + NPV / PVC							
- Based on Initial Capital only		1.62	2.07	1.86	1.70	1.45	1.28
- Based on Total Capital		1.62	2.07	1.86	1.70	1.45	1.28
Investment Efficiency, IE ($ NPV / $ Investment) = NPV / Net Investment							
- Based on Initial Capital only		0.62	1.08	0.86	0.70	0.45	0.28
- Based on Total Capital		0.62	1.08	0.86	0.70	0.45	0.28
Internal Rate of Return (%)	*- Nominal*		**29.2**			**29.2**	
	- Real { = [(Nominal IRR + 1) / (1 + f) - 1] x 100 }	**22.1**		**26.1**		**26.1**	
Growth Rate of Return (%)	*- Real*		**3.3%**			**3.3%**	
DCF Rate of Return (%)		22.1	29.2	26.1	23.1	17.5	12.4
Cumulative Oil Production (MMSTB)	*- Undiscounted*	0.535	0.535	0.535	0.535	0.535	0.535
	- Discounted	0.535	0.535	0.472	0.421	0.347	0.296
Average Unit NPV Profit (AUP) ($/bbl)	Using Undiscounted Production	16.15	28.04	22.43	17.97	11.43	6.98
EXPENDITURE ANALYSIS							
Present Value Cost, PVC (MM$) :							
1) Capital Expenditures Only	*- Initial (3-Yr Development Only)*	13.960	14.014	13.885	13.762	13.532	13.532
	- Total (16 -Yr Production Period)	13.960	14.014	13.885	13.762	13.532	13.322
2) Operating Expenditures Only		6.822	7.386	6.087	5.096	3.729	2.867
3) Total Capital & Operating Expenditures		20.782	21.400	19.972	18.858	17.261	16.189
Annualized Present Value Cost, APVC (MM$)	*- OPEX Only*	0.426	0.462	0.380	0.470	0.477	0.482
	- Total Costs	1.299	1.338	1.248	1.740	2.206	2.719
Average Cost of Oil Prod (ACOP) ($/bbl)	*- OPEX Only*	12.74	13.79	11.37	9.52	6.96	5.35
	- Total Costs	38.81	39.97	37.30	35.22	32.24	30.24
Break Even Cost/Price of Oil Production, MCOP/MPOP ($/bbl)							
(Equivalent to Annualized Unit Cost, AUC Using Discounted Prod)	*- OPEX Only*	12.74	13.79	12.91	12.11	10.75	9.68
	- Total Costs	38.81	39.97	42.35	44.80	49.77	54.64
PAY OUT & CAPITAL RISK							
Pay-out Time after Production Start-up (Years)		3.71 Yrs	**2.98 Yrs**	4.6 Yrs	3.62 Yrs	4.6 Yrs	5.93 Yrs
1 Capital / (Captial + NPV)	*- Total (16 -Yr Production Period)*	0.617	0.483	0.536	0.589	**0.689**	0.781

Typical / Example Economic Measures

Cost Data Base

Cost Data Base

BASIS COST DATA - DRILL & WORK OVER ETC.							BASIS COST DATA - DRILL & WORK OVER ETC.
LOCATION	TYPE	UNIT	VALUE	COMMENT	Mnemonic	Mnemonic	REMARK
On-Land	DRSR	(M$/Day)	100.0	Base-Yr 2007	DR	SR	On-Land DRSR Drilling Spend Rate
On-Land	WOSR	(M$/Day)	75.0	Base-Yr 2007	WO	SR	On-Land WOSR Work Over (W/O) Spend Rate
On-Land	WODC	# Days	10	#	WO	DC	On-Land WODC Work Over (W/O) Days - Conventional
On-Land	WODH	# Days	10	#	WO	DH	On-Land WODH Work Over (W/O) Days - Horizontal
On-Land	WSWT	(M$/Job)	7.5	n.b. M$	WS	WT	On-Land WSWT Well Service Well Test
On-Land	MOLN	(MM$/Job)	0.300	n.b. MM$	MO	LN	On-Land MOLN Mobilize Land
On-Land	DMLN	(MM$/Job)	0.300	n.b. MM$	DM	LN	On-Land DMLN De-Mobilize Land
On-Land	FLCP	(MM$)	0.111	Base-Yr 2007	FL	CP	On-Land FLCP Flowline (F/L) Cost P-Type (OP, GP & EV)
On-Land	FLCW	(MM$)	1.111	Base-Yr 2007	FL	CW	On-Land FLCW Flowline (F/L) Cost W-Type (WI, GI, WD & WS
Offshore	DRSR	(M$/Day)	400.0	Base-Yr 2007	DR	SR	Offshore DRSR Drilling Spend Rate
Offshore	WOSR	(M$/Day)	300.0	Base-Yr 2007	WO	SR	Offshore WOSR Work Over (W/O) Spend Rate
Offshore	WODC	# Days	15	#	WO	DC	Offshore WODC Work Over (W/O) Days - Conventional
Offshore	WODH	# Days	15	#	WO	DH	Offshore WODH Work Over (W/O) Days - Horizontal
Offshore	WSWT	(M$/Job)	75.0	n.b. M$	WS	WT	Offshore WSWT Well Service Well Test
Offshore	MOOF	(MM$/Job)	0.750	n.b. MM$	MO	OF	Offshore MOOF Mobilize Off-shore
Offshore	DMOF	(MM$/Job)	0.750	n.b. MM$	DM	OF	Offshore DMOF De-Mobilize Off-shore
Offshore	FLCP	(MM$)	0	Base-Yr 2007	FL	CP	Offshore FLCP Flowline (F/L) Cost P-Type (OP, GP & EV)
Offshore	FLCW	(MM$)	0	Base-Yr 2007	FL	CW	Offshore FLCW Flowline (F/L) Cost W-Type (WI, GI, WD & WS
On-Land	ESEJ	(MM$/Well)	0.175	Base-Yr 2007	ES	EJ	On-Land ESEJ=> ESP Installed ESP W/O Cost/Well
On-Land	PNSJ	% of Total Wells	100.0	%	PN	SJ	On-Land PNSJ=> % Number Well Srvc Jobs/Yr
On-Land	PNTJ	% of Total Wells	0.0	%	PN	TJ	On-Land PNTJ=> % Number Well Test Jobs/Yr
On-Land	PNWJ	% of Total Wells	0.0	%	PN	WJ	On-Land PNWJ=> % Number W/O Jobs/Yr
Offshore	ESEJ	(MM$/Well)	0.375	Base-Yr 2007	ES	EJ	Offshore ESEJ=> ESP Installed ESP W/O Cost/Well
Offshore	PNSJ	% of Total Wells	100.0	%	PN	SJ	Offshore PNSJ=> % Number Well Srvc Jobs/Yr
Offshore	PNTJ	% of Total Wells	0.0	%	PN	TJ	Offshore PNTJ=> % Number Well Test Jobs/Yr
Offshore	PNWJ	% of Total Wells	0.0	%	PN	WJ	Offshore PNWJ=> % Number W/O Jobs/Yr
1	2	4	3	5	6	7	8

Typical / Example Cost Data Base – Table 1/3

Cost Data Base

BASIS COST DATA - DRILLING							BASIS COST DATA - DRILLING
LOCATION	TYPE	UNIT	VALUE	Mnemonic	Mnemonic	Mnemonic	REMARK
On-Land	OPC	# Drill Days	60	O	P	C	On-Land OPC OIL Producer Conventional
On-Land	GPC	# Drill Days	62	G	P	C	On-Land GPC GAS Producer Conventional
On-Land	GIC	# Drill Days	50	G	I	C	On-Land GIC GAS Injector Conventional
On-Land	WIC	# Drill Days	50	W	I	C	On-Land WIC WATER Injector Conventional
On-Land	WDC	# Drill Days	50	W	D	C	On-Land WDC WATER Disposal Conventional
On-Land	WSC	# Drill Days	50	W	S	C	On-Land WSC WATER Supply Conventional
On-Land	EVC	# Drill Days	60	E	V	C	On-Land EVC Evaluation (EV-Well) Conventional
On-Land	OPH	# Drill Days	75	O	P	H	On-Land OPH OIL Producer Horizontal
On-Land	GPH	# Drill Days	75	G	P	H	On-Land GPH GAS Producer Horizontal
On-Land	GIH	# Drill Days	62	G	I	H	On-Land GIH GAS Injector Horizontal
On-Land	WIH	# Drill Days	58	W	I	H	On-Land WIH WATER Injector Horizontal
On-Land	WDH	# Drill Days	50	W	D	H	On-Land WDH WATER Disposal Horizontal
On-Land	WSH	# Drill Days	50	W	S	H	On-Land WSH WATER Supply Horizontal
On-Land	EVH	# Drill Days	55	E	V	H	On-Land EVH Evaluation (EV-Well) Horizontal
Offshore	OPC	# Drill Days	40	O	P	C	Offshore OPC OIL Producer Conventional
Offshore	GPC	# Drill Days	40	G	P	C	Offshore GPC GAS Producer Conventional
Offshore	GIC	# Drill Days	40	G	I	C	Offshore GIC GAS Injector Conventional
Offshore	WIC	# Drill Days	40	W	I	C	Offshore WIC WATER Injector Conventional
Offshore	WDC	# Drill Days	0	W	D	C	Offshore WDC WATER Disposal Conventional
Offshore	WSC	# Drill Days	0	W	S	C	Offshore WSC WATER Supply Conventional
Offshore	EVC	# Drill Days	50	E	V	C	Offshore EVC Evaluation (EV-Well) Conventional
Offshore	OPH	# Drill Days	60	O	P	H	Offshore OPH OIL Producer Horizontal
Offshore	GPH	# Drill Days	60	G	P	H	Offshore GPH GAS Producer Horizontal
Offshore	GIH	# Drill Days	60	G	I	H	Offshore GIH GAS Injector Horizontal
Offshore	WIH	# Drill Days	55	W	I	H	Offshore WIH WATER Injector Horizontal
Offshore	WDH	# Drill Days	0	W	D	H	Offshore WDH WATER Disposal Horizontal
Offshore	WSH	# Drill Days	0	W	S	H	Offshore WSH WATER Supply Horizontal
Offshore	EVH	# Drill Days	58	E	V	H	Offshore EVH Evaluation (EV-Well) Horizontal
1	2	3	4	5	6	7	8

Typical / Example Cost Data Base – Table 2/3

Cost Data Base

BASIS COST DATA - PLATFORM & FLOW LINE							BASIS COST DATA - PLATFORM & FLOW LINE
LOCATION	TYPE	UNIT	VALUE	COMMENT		Mnemonic	REMARK
Offshore	24WPF	MM$	105.000	Base-Yr 2007		24WPF	24-Well Platform
Offshore	12WPF	MM$	54.000	Base-Yr 2007		12WPF	12-Well Platform
Offshore	8-WPF	MM$	34.000	Base-Yr 2007		8-WPF	8-Well Platform
Offshore	6-WPF	MM$	27.000	Base-Yr 2007		6-WPF	6-Well Platform
Offshore	4-WPF	MM$	20.000	Base-Yr 2007		4-WPF	4-Well Platform
Offshore	TRIPD	MM$	4.444	Base-Yr 2007		TRIPD	Tripod Platform
Offshore	MLS	MM$	0.999	Base-Yr 2007		MLS	Multilateral Slot
Offshore	FSCND	MM$	0.333	Base-Yr 2007		FSCND	Free Standing Conductor
Offshore	TIEPF	MM$	62.000	Base-Yr 2007		TIEPF	Tie-In P/F
1	2	3	4	5	6	7	8

BASIS COST DATA - FACILITY			OPEX	OPEX			BASIS COST DATA - FACILITY
LOCATION	TYPE	Fixed %	Fixed	Variable	Variable %	Mnemonic	REMARK
Up-Stream	GOSP	0.50%	0.000	0.000	0.40%	GOSP	Gas Oil Separation Plant
Up-Stream	GGCF	0.50%	0.000	0.000	0.40%	GGCF	Gas Gathering & Crude Handling Facilities
Up-Stream	WCHF	0.50%	0.000	0.000	0.40%	WCHF	Wet Crude Handling Facilities
Up-Stream	WIP	0.50%	0.000	0.000	0.40%	WIP	Water Injection Plant
Up-Stream	ALFT	0.50%	0.000	0.000	0.40%	ALFT	Artificial Lift Facility
Up-Stream	GICP	0.50%	0.000	0.000	0.40%	GICP	Gas Injection & Crude Processing
Up-Stream	UPS1	0.40%	0.000	0.000	0.30%	UPS1	Other Up-Stream -1
Up-Stream	UPS2	0.40%	0.000	0.000	0.30%	UPS2	Other Up-Stream -2
DownSteam	PPLN	0.40%	0.000	0.000	0.30%	PPLN	Pipelines
DownSteam	DNS1	0.40%	0.000	0.000	0.30%	DNS1	Other DownStream -1
DownSteam	DNS2	0.40%	0.000	0.000	0.30%	DNS2	Other DownStream -2
Mob Fclty	MOB	0.20%	0.000	0.000	0.10%	MOB	Mobilization CAPEX
DeMob Fclty	DMOB	0.20%	0.000	0.000	0.10%	DMOB	De-Mobilization CAPEX
Support Fclty	SPRT	0.20%	0.004	0.002	0.10%	SPRT	General Support Faculties
		% of Initial Cost	2007 Base Yr. MM$	$/bbl or $/MCF	% of Initial Cost		
1	2	3	4	5	6	7	8

Typical / Example Cost Data Base – Table 3/3

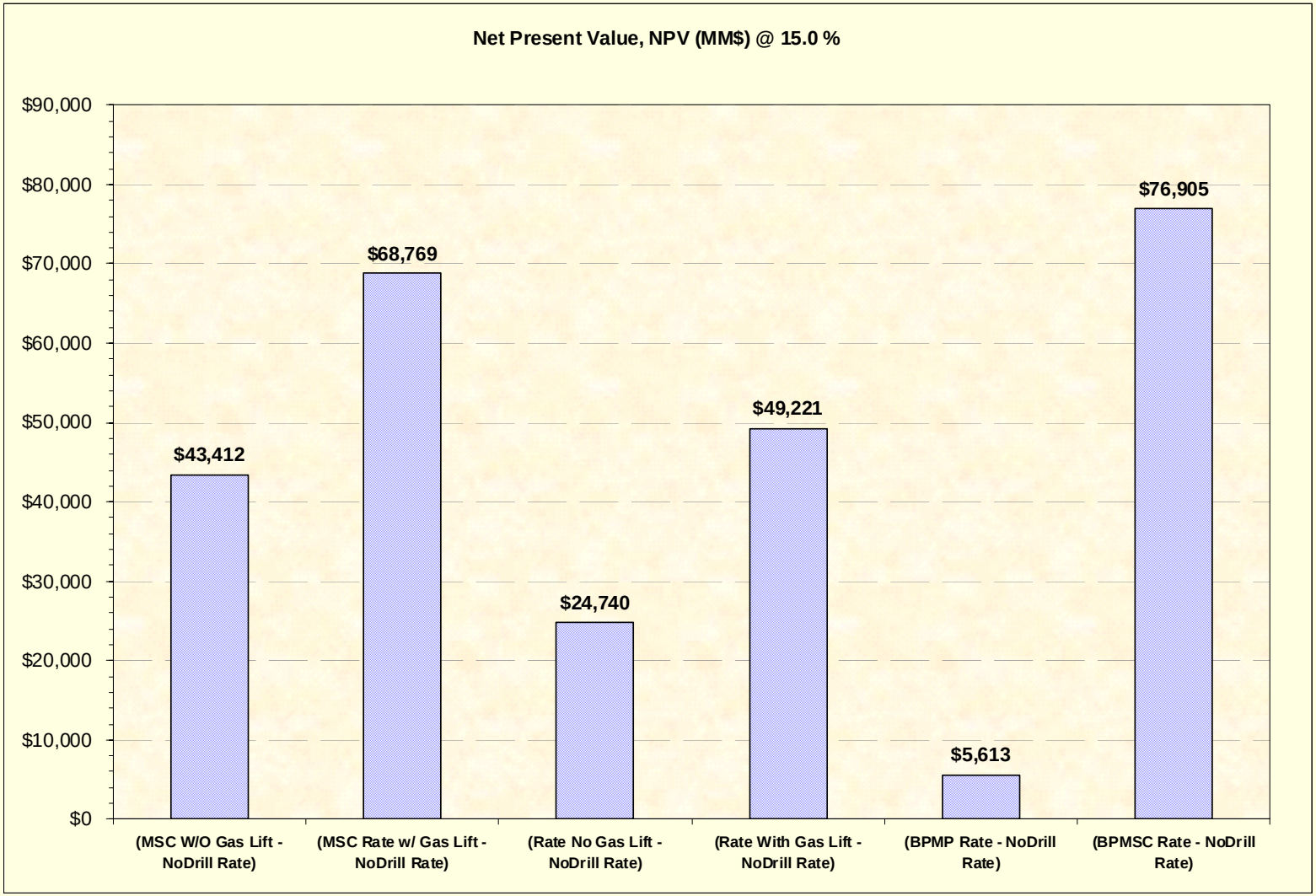
Cost Data Base

Mnemonic	Remark
O	OIL
G	GAS
W	WATER
E	Evaluation
P	Producer
I	Injector
D	Disposal
S	Supply
V	(EV-Well)
C	Conventional
H	Horizontal
DR	Drilling
SR	Spend Rate
WO	Work Over (W/O)
WJ	W/O Jobs/Yr
DC	Days - Conventional
DH	Days - Horizontal
WS	Well Service
SJ	Well Srvc Jobs/Yr
WT	Well Test
TJ	Well Test Jobs/Yr
FL	Flowline (F/L)
CP	Cost P-Type (OP, GP & EV)
CW	Cost W-Type (WI, GI, WD & WS)
ES	ESP Installed
EJ	ESP W/O Cost/Well
PN	% Number
PF	Platform (P/F)
MO	Mobilize
DM	De-Mobilize
LN	Land
OF	Off-shore
GOSP	Gas Oil Separation Plant
GGCF	Gas Gathering & Crude Handling Facilities
WCHF	Wet Crude Handling Facilities
WIP	Water Injection Plant
ALFT	Artificial Lift Facility
GICP	Gas Injection & Crude Processing
UPS1	Other Up-Stream -1
UPS2	Other Up-Stream -2
PPLN	Pipelines
DNS1	Other DownStream -1
DNS2	Other DownStream -2
SPRT	General Support Faculties
FSCND	Free Standing Conductor
24WPF	24-Well Platform
12WPF	12-Well Platform
8-WPF	8-Well Platform
6-WPF	6-Well Platform
4-WPF	4-Well Platform
TRIPD	Tripod Platform
MLS	Multilateral Slot
TIEPF	Tie-In P/F
PFUFD	P/F-Type Used For Field Development
MORG	Mobilize Rig
DMRG	De-Mobilize Rig
MOB	Mobilization CAPEX
DMOB	De-Mobilization CAPEX

Typical / Example Cost Data Base – Mnemonics

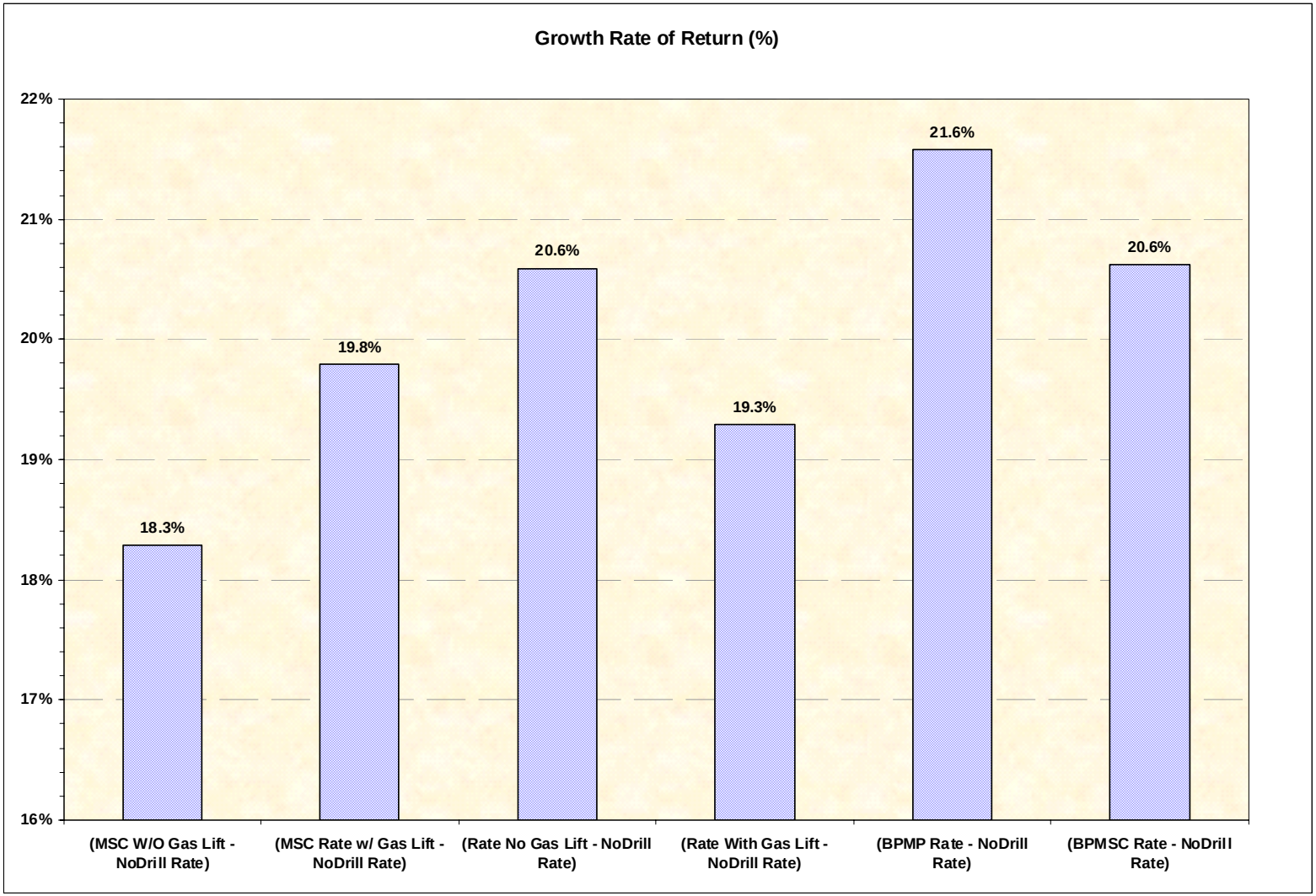
Project Ranking

Project Ranking



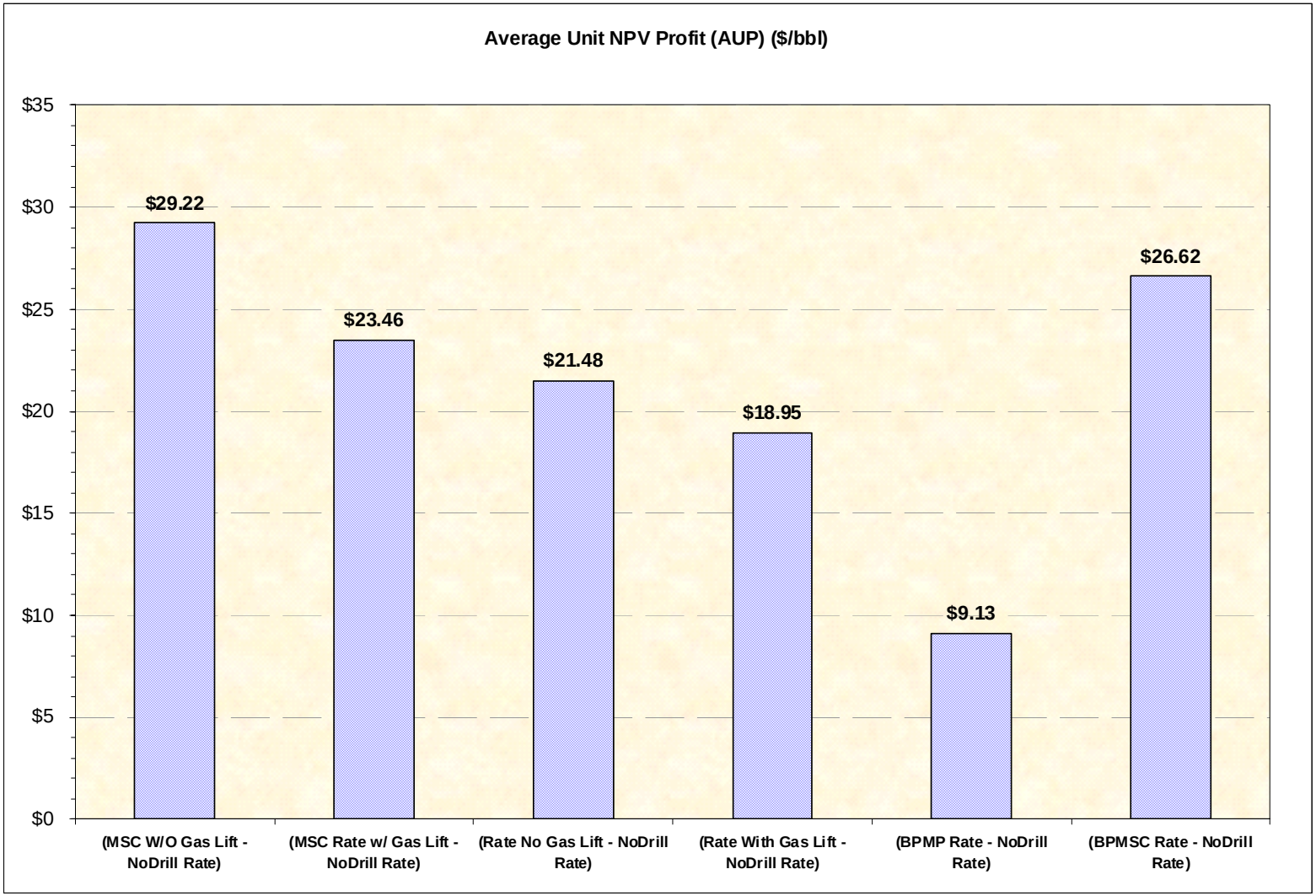
Typical / Example Project Ranking - NPV

Project Ranking



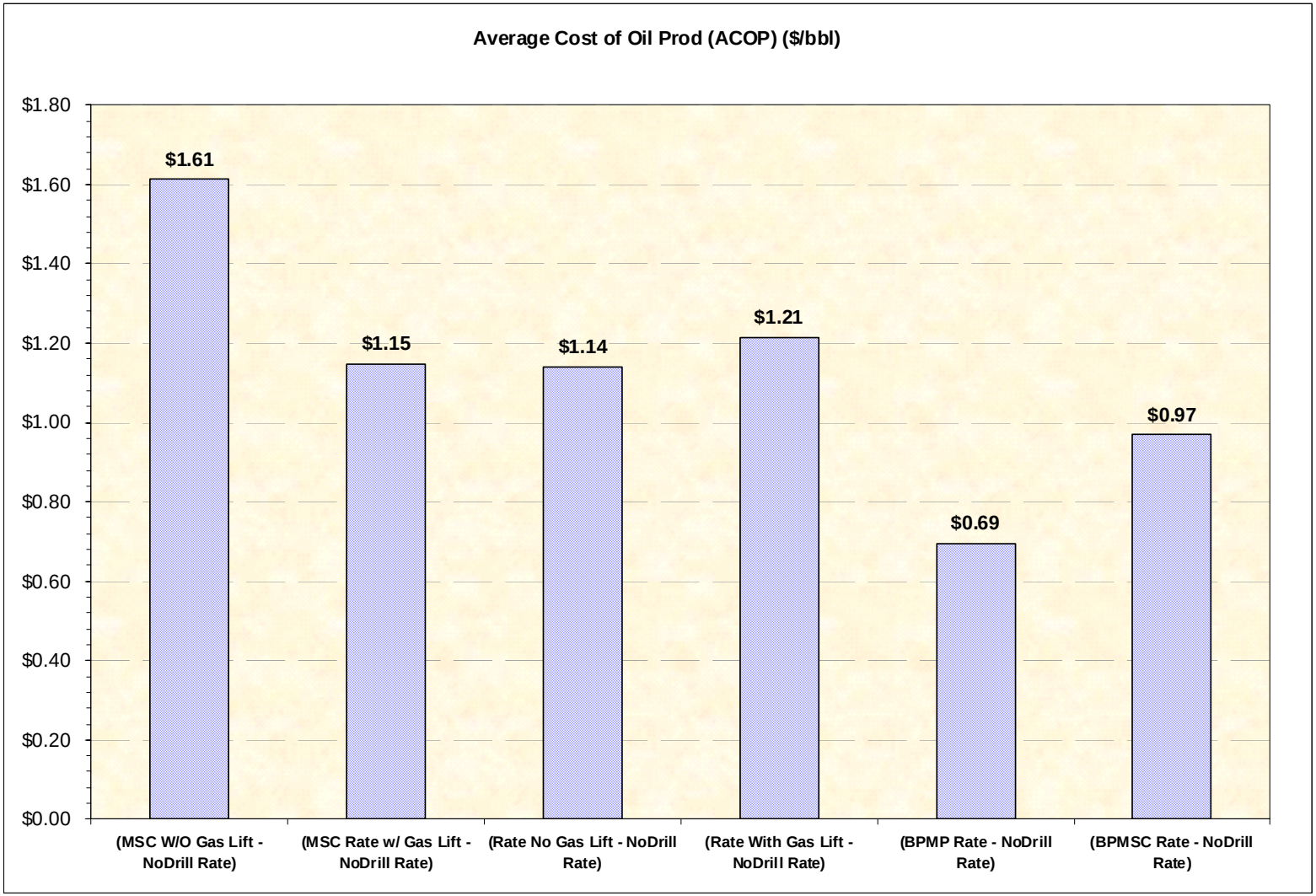
Typical / Example Project Ranking - GRR

Project Ranking



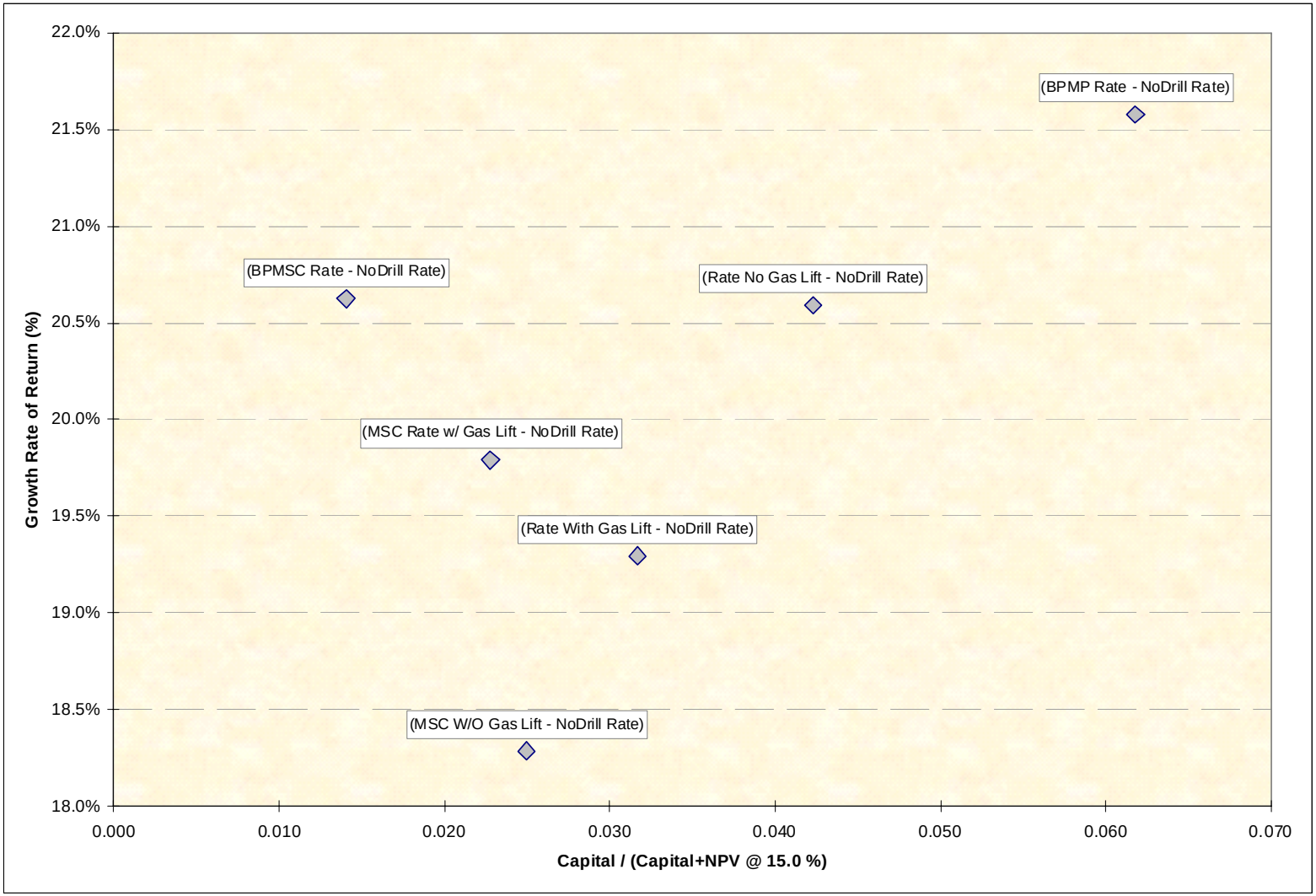
Typical / Example Project Ranking – Unit NPV

Project Ranking



Typical / Example Project Ranking – Unit Cost

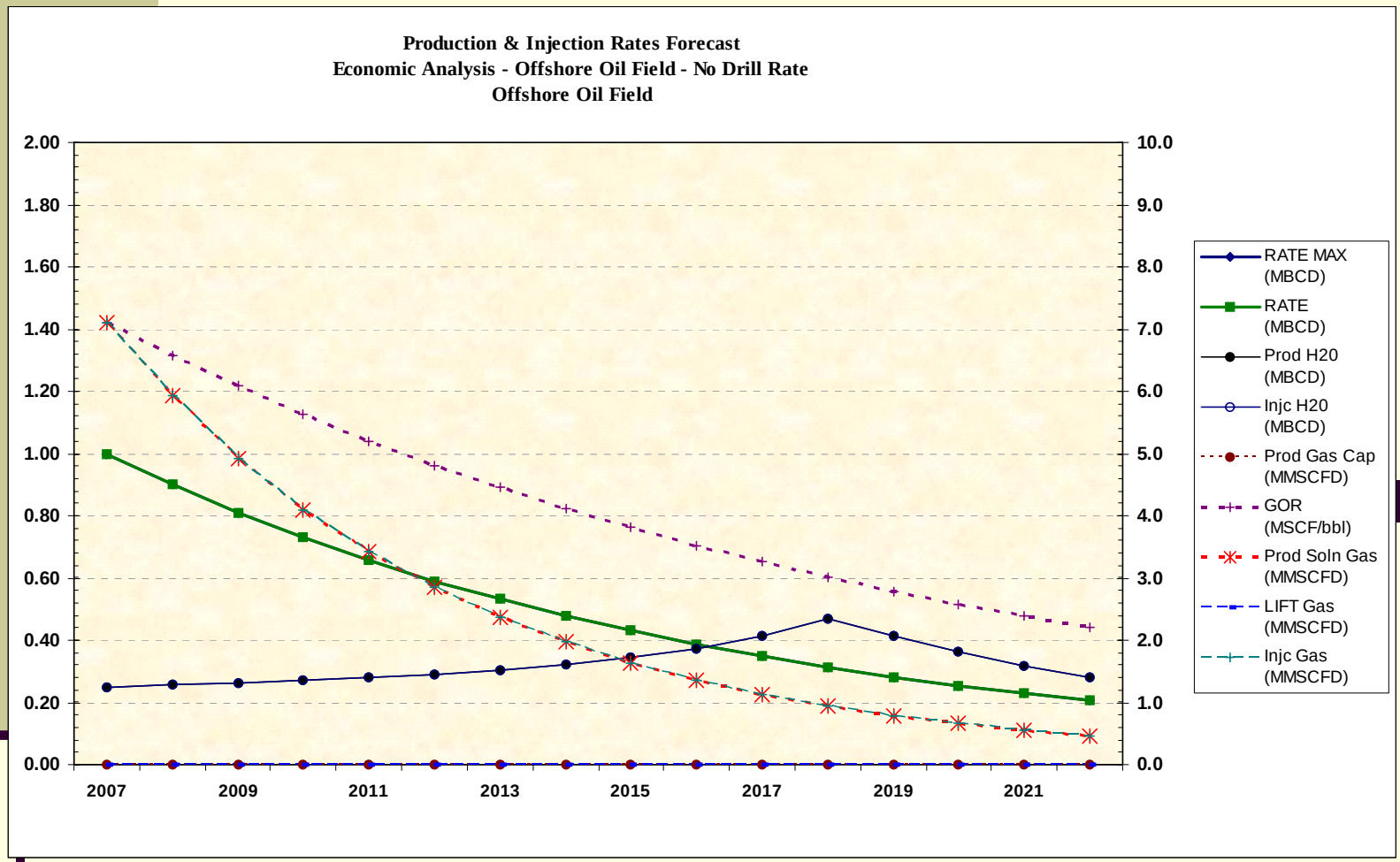
Project Ranking



Typical / Example Project Ranking – Capital Risk vs GRR

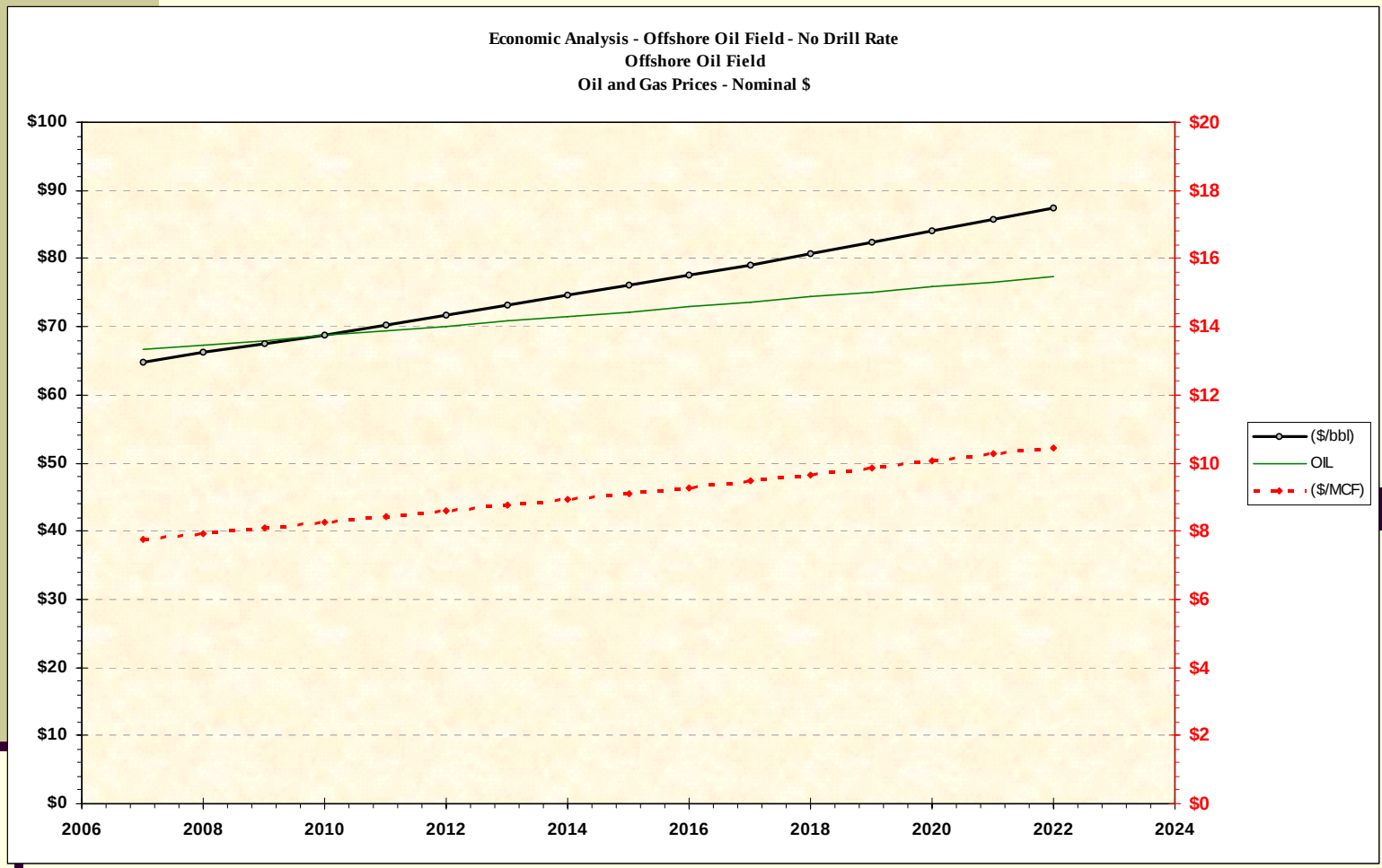
Work Over Economics

Work Over Economics



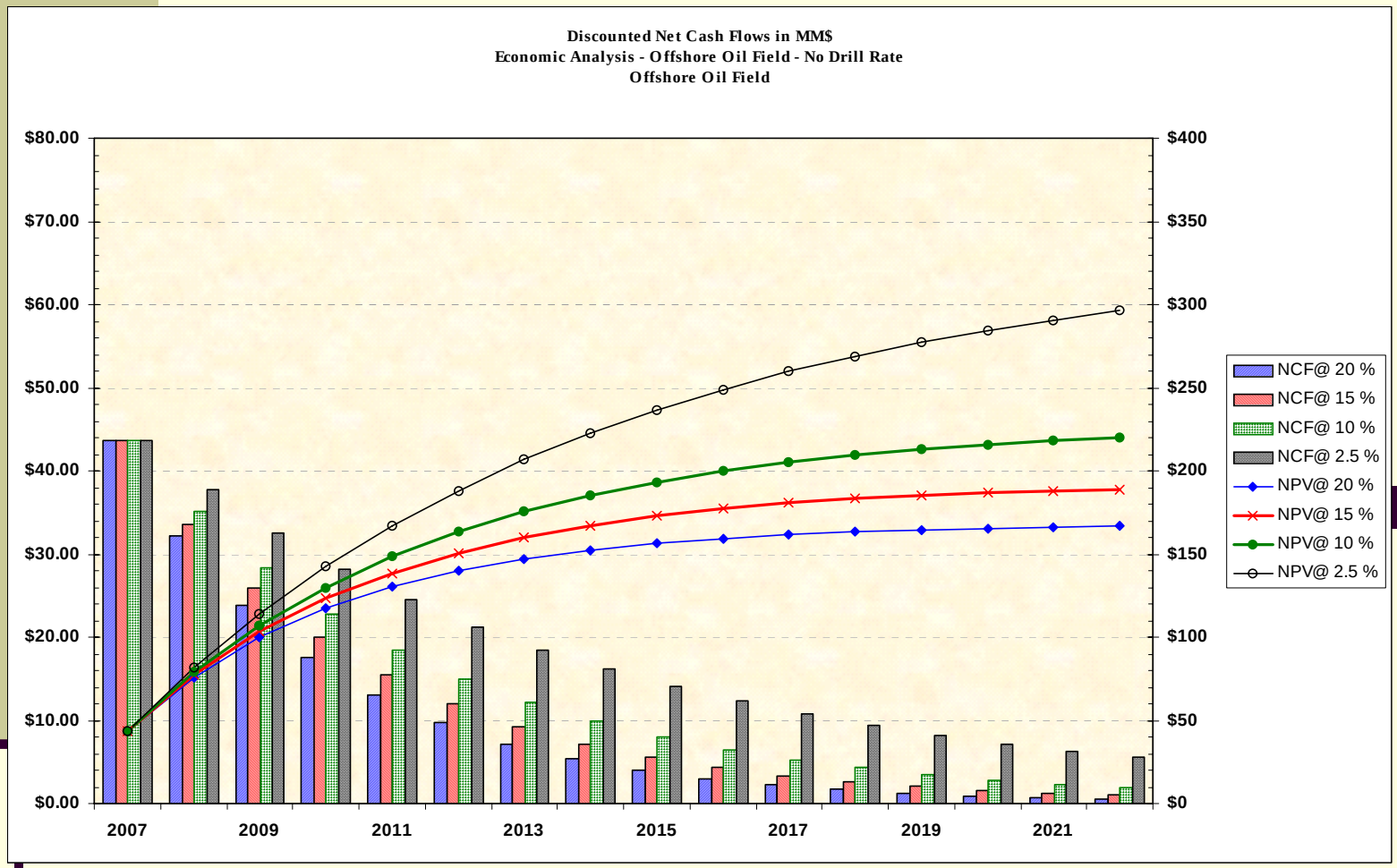
Well Typical / Example Current & Forecast Production Profile – No Drill

Work Over Economics



Current / Example Oil & Gas Price Forecast

Work Over Economics



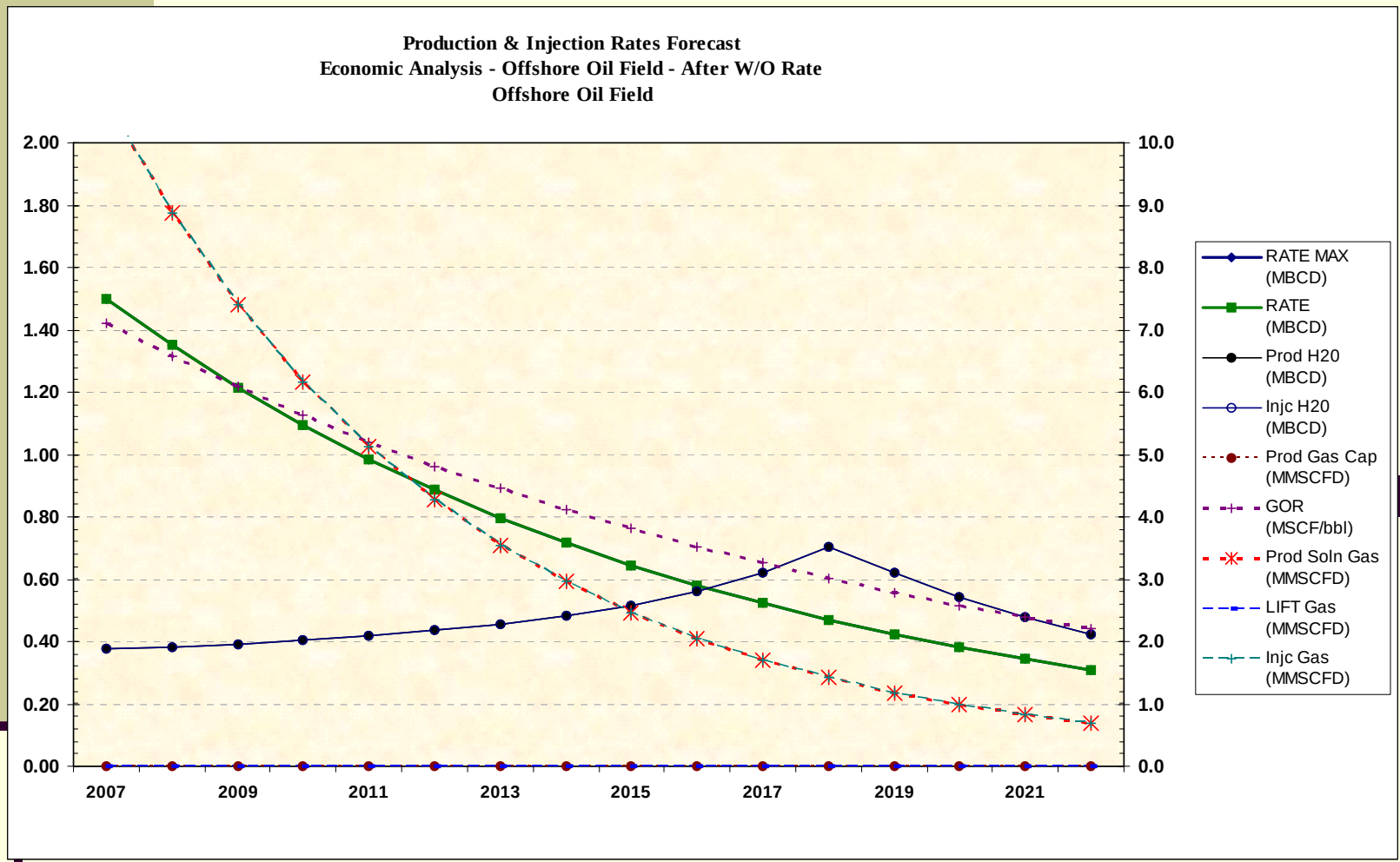
Well Cash Flow & NPV @ x% Profiles – No Drill

Work Over Economics

Economic Analysis - Offshore Oil Field - No Drill Rate							
Annual Nominal Discount Rate, ANDR (%) : **15.00** (%)		Undiscounted CF @ 0%			Discounted CF @		
Annual General Background Inflation Rate, f (% **2.50** (%)		Base-Year	Nominal	Real 2007 $			
Annual Real Discount Rate, ARDR (%) : **12.20**		2007 $	(Then Crnt $)	Dsc @ 2.5 %	10.0 %	15.0 %	20.0 %
2007-2023Project Life: 16 (Years), n **16** (including year 2007 as Year-0 or Base-Year)		16	16	16			
Cum Present Value Factor (Inverse of Capital Recovery Factor)					7.82	5.95	4.73
VALUE ANALYSIS							
Net Present Value, NPV (MM$)		303.095	335.045	296.270	220.083	**189.013**	166.740
Annualized Net Present Value, ANPV (MM$)		18.943	20.940	18.517	28.130	31.744	35.255
Profitability Index, PI ($ Returned / $ Invested) = 1 + NPV / PVC							
- *Based on Initial Capital only*		1,263.90	1,356.10	1,244.54	1,027.25	942.12	831.22
- *Based on Total Capital*		169.39	159.29	172.12	213.22	241.53	269.68
Investment Efficiency, IE ($ NPV / $ Investment) = NPV / Net Investment							
- *Based on Initial Capital only*		1,272.19	1,406.30	1,243.54	1,026.25	941.12	883.62
- *Based on Total Capital*		168.39	186.14	164.59	212.22	240.53	268.68
Internal Rate of Return (%) - *Nominal*			**n/a**			**n/a**	
- *Real* { = [(Nominal IRR + 1) / (1 + f) - 1] x 100 }		**n/a**		**n/a**		**n/a**	
Growth Rate of Return (%) - *Real*			**27.4%**			**27.4%**	
DCF Rate of Return (%)		n/a	n/a	n/a	n/a	n/a	n/a
Cumulative Oil Production (MMSTB) - *Undiscounted*		2.974	2.974	2.974	2.974	2.974	2.974
- *Discounted*		2.974	2.974	2.619	1.927	1.646	1.445
Average Unit NPV Profit (AUP) ($/bbl) Using Undiscounted Production		101.93	112.67	99.63	74.01	63.56	56.07
EXPENDITURE ANALYSIS							
Present Value Cost, PVC (MM$) :							
1) Capital Expenditures Only - *Initial (3-Yr Development Only)*		0.240	0.247	0.238	0.214	0.201	0.201
- *Total (16 -Yr Production Period)*		1.800	2.117	1.731	1.037	0.786	0.621
2) Operating Expenditures Only		1.968	2.123	1.764	1.115	0.878	0.721
3) Total Capital & Operating Expenditures		3.768	4.240	3.496	2.152	1.664	1.342
Annualized Present Value Cost, APVC (MM$) - *OPEX Only*		0.123	0.133	0.110	0.142	0.147	0.152
- *Total Costs*		0.235	0.265	0.218	0.275	0.279	0.284
Average Cost of Oil Prod (ACOP) ($/bbl) - *OPEX Only*		0.66	0.71	0.59	0.37	0.30	0.24
- *Total Costs*		1.27	1.43	1.18	0.72	0.56	0.45
Break Even Cost/Price of Oil Production, MCOP/MPOP ($/bbl)							
(Equivalent to Annualized Unit Cost, AUC Using Discounted Prod) - *OPEX Only*		0.66	0.71	0.67	0.58	0.53	0.50
- *Total Costs*		1.27	1.43	1.33	1.12	1.01	0.93
PAY OUT & CAPITAL RISK							
Pay-out Time after Production Start-up (Years)		0 Yrs	**0 Yrs**	0 Yrs	0 Yrs	0 Yrs	0 Yrs
2 CAPEX+OPEX / (CAPEX+OPEX + NPV) - *Total (16 -Yr Production Period)*		0.012	0.012	0.012	0.010	**0.009**	0.008

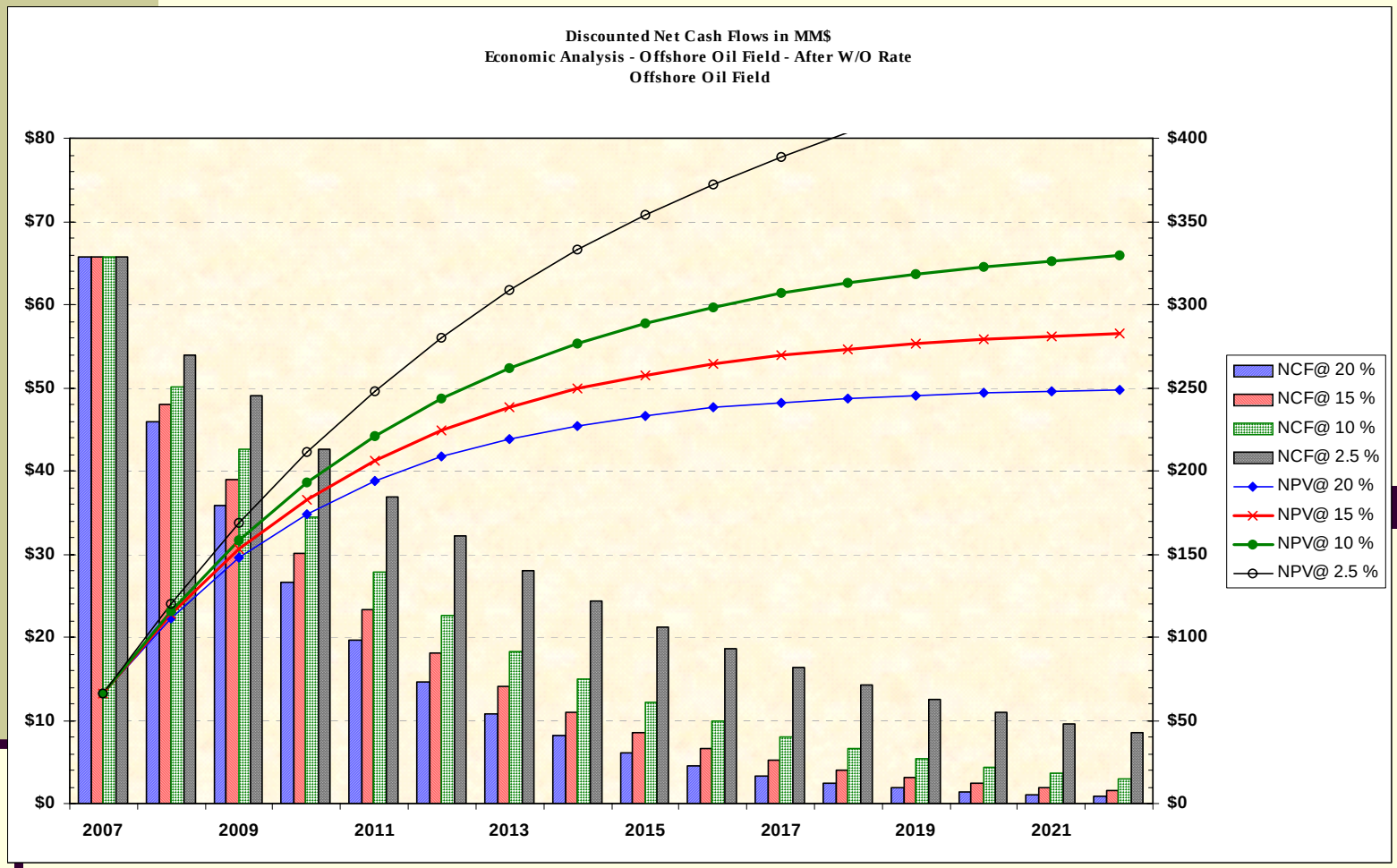
Typical / Example Economic Measures – No Drill

Work Over Economics



Well Typical / Example Current & Forecast Production Profile – W/O

Work Over Economics



Well Cash Flow & NPV @ x% Profiles – W/O

Work Over Economics

Economic Analysis - Offshore Oil Field - After W/O Rate							
Annual Nominal Discount Rate, ANDR (%) : **15.00** (%)		Undiscounted CF @ 0%			Discounted CF @		
Annual General Background Inflation Rate, f (% **2.50** (%)		Base-Year 2007 $	Nominal (Then Crnt $)	Real 2007 $ Dsc @ 2.5 %	10.0 %	15.0 %	20.0 %
Annual Real Discount Rate, ARDR (%) : **12.20**							
2007-2023Project Life: 16 (Years), n **16** (including year 2007 as Year-0 or Base-Year)		16	16	16			
Cum Present Value Factor (Inverse of Capital Recovery Factor)					7.82	5.95	4.73
VALUE ANALYSIS							
Net Present Value, NPV (MM$)		455.071	503.304	444.578	329.345	**282.440**	248.860
Annualized Net Present Value, ANPV (MM$)		28.442	31.457	27.786	42.096	47.435	52.618
Profitability Index, PI ($ Returned / $ Invested) = 1 + NPV / PVC							
- *Based on Initial Capital only*		1,751.27	1,880.04	1,723.50	1,418.61	1,299.13	1,144.80
- *Based on Total Capital*		234.37	220.49	238.03	294.15	332.78	371.15
Investment Efficiency, IE ($ NPV / $ Investment) = NPV / Net Investment							
- *Based on Initial Capital only*		1,763.15	1,950.03	1,722.50	1,417.61	1,298.13	1,217.37
- *Based on Total Capital*		233.37	258.10	227.99	293.15	331.78	370.15
Internal Rate of Return (%) - *Nominal*			**n/a**			**n/a**	
- *Real* { = [(Nominal IRR + 1) / (1 + f) - 1] x 100 }		**n/a**		**n/a**		**n/a**	
Growth Rate of Return (%) - *Real*			**28.2%**			**28.2%**	
DCF Rate of Return (%)		n/a	n/a	n/a	n/a	n/a	n/a
Cumulative Oil Production (MMSTB) - *Undiscounted*		4.460	4.460	4.460	4.460	4.460	4.460
- *Discounted*		4.460	4.460	3.929	2.890	2.469	2.168
Average Unit NPV Profit (AUP) ($/bbl) Using Undiscounted Production		102.02	112.84	99.67	73.84	63.32	55.79
EXPENDITURE ANALYSIS							
Present Value Cost, PVC (MM$) :							
1) Capital Expenditures Only - *Initial (3-Yr Development Only)*		0.260	0.268	0.258	0.232	0.218	0.218
- *Total (16 -Yr Production Period)*		1.950	2.293	1.876	1.123	0.851	0.672
2) Operating Expenditures Only		3.274	3.330	3.195	2.883	2.724	2.589
3) Total Capital & Operating Expenditures		5.224	5.624	5.070	4.006	3.575	3.261
Annualized Present Value Cost, APVC (MM$) - *OPEX Only*		0.205	0.208	0.200	0.368	0.458	0.547
- *Total Costs*		0.326	0.351	0.317	0.512	0.600	0.690
Average Cost of Oil Prod (ACOP) ($/bbl) - *OPEX Only*		0.73	0.75	0.72	0.65	0.61	0.58
- *Total Costs*		1.17	1.26	1.14	0.90	0.80	0.73
Break Even Cost/Price of Oil Production, MCOP/MPOP ($/bbl)							
(Equivalent to Annualized Unit Cost, AUC Using Discounted Prod) - *OPEX Only*		0.73	0.75	0.81	1.00	1.10	1.19
- *Total Costs*		1.17	1.26	1.29	1.39	1.45	1.50
PAY OUT & CAPITAL RISK							
Pay-out Time after Production Start-up (Years)		0 Yrs	**0 Yrs**	0 Yrs	0 Yrs	0 Yrs	0 Yrs
2 CAPEX+OPEX / (CAPEX+OPEX + NPV) - *Total (16 -Yr Production Period)*		0.011	0.011	0.011	0.012	**0.013**	0.013

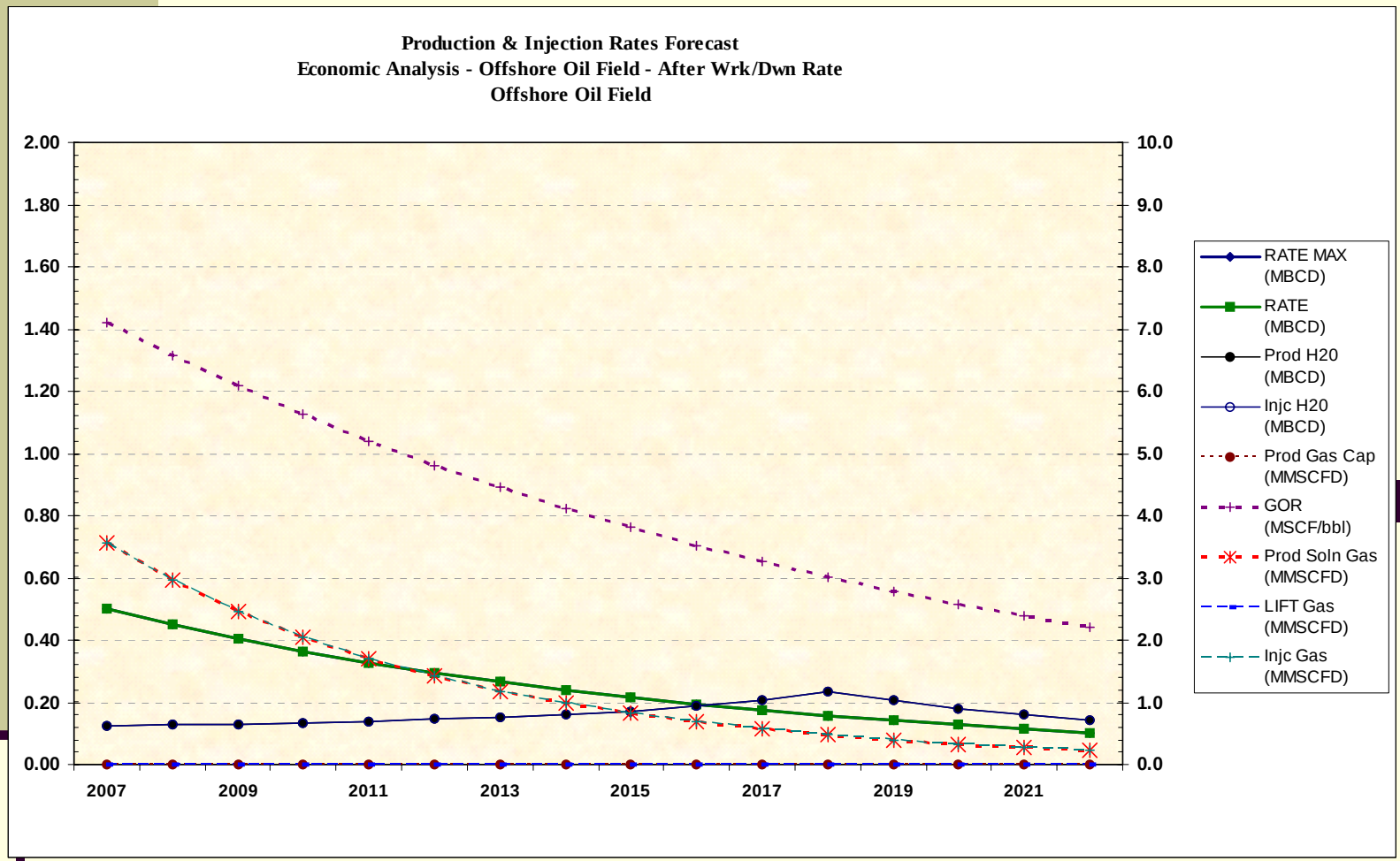
Typical / Example Economic Measures – W/O

Incremental Work Over Economics

Incremental Economic Analysis - (After W/O Rate - No Drill Rate)		(After W/O Rate - No Drill Rate)			(After W/O Rate - No Drill Rate)		
Annual Nominal Discount Rate, ANDR (%) : **15.00** (%)		Undiscounted CF @ 0%			Discounted CF @		
Annual General Background Inflation Rate, f (% **2.50** (%)		Base-Year 2007 $	Nominal (Then Crnt $)	Real 2007 $ Dsc @ 2.5 %	10.0 %	15.0 %	20.0 %
Annual Real Discount Rate, ARDR (%) : **12.20**							
2007-2023Project Life: 16 (Years), n **16** (including year 2007 as Year-0 or Base-Year)		16	16	16			
Cum Present Value Factor (Inverse of Capital Recovery Factor)					7.82	5.95	4.73
VALUE ANALYSIS							
Net Present Value, NPV (MM$)		152.0	168.3	148.3	109.3	**93.4**	82.1
Annualized Net Present Value, ANPV (MM$)		9.5	10.5	9.3	14.0	15.7	17.4
Profitability Index, PI ($ Returned / $ Invested) = 1 + NPV / PVC							
- Based on Initial Capital only		7,599.8	8,167.3	7,471.0	6,114.9	5,583.2	4,907.7
- Based on Total Capital		1,014.2	954.9	1,028.9	1,265.3	1,427.7	1,588.9
Investment Efficiency, IE ($ NPV / $ Investment) = NPV / Net Investment							
- Based on Initial Capital only		7,654.7	8,474.9	7,470.0	6,113.9	5,582.2	5,222.3
- Based on Total Capital		1,013.2	1,121.7	988.7	1,264.3	1,426.7	1,587.9
Internal Rate of Return (%)	*- Nominal*		**n/a**			**n/a**	
	- Real { = [(Nominal IRR + 1) / (1 + f) - 1] x 100 }	**n/a**		**n/a**		**n/a**	
Growth Rate of Return (%)	*- Real*		**30.1%**			**30.1%**	
DCF Rate of Return (%)		n/a	n/a	n/a	n/a	n/a	n/a
Cumulative Oil Production (MMSTB)	*- Undiscounted*	1.487	1.487	1.487	1.487	1.487	1.487
	- Discounted	1.487	1.487	1.310	0.963	0.823	0.723
Average Unit NPV Profit (AUP) ($/bbl)	Using Undiscounted Production	102.21	113.17	99.75	73.49	62.84	55.23
EXPENDITURE ANALYSIS							
Present Value Cost, PVC (MM$) :							
1) Capital Expenditures Only	*- Initial (3-Yr Development Only)*	0.0200	0.0206	0.0199	0.0179	0.0167	0.0167
	- Total (16 -Yr Production Period)	0.1500	0.1764	0.1443	0.0864	0.0655	0.0517
2) Operating Expenditures Only		1.3061	1.2073	1.4304	1.7683	1.8464	1.8681
3) Total Capital & Operating Expenditures		1.4561	1.3837	1.5747	1.8548	1.9119	1.9198
Annualized Present Value Cost, APVC (MM$)	*- OPEX Only*	0.082	0.075	0.089	0.226	0.310	0.395
	- Total Costs	0.091	0.086	0.098	0.237	0.321	0.406
Average Cost of Oil Prod (ACOP) ($/bbl)	*- OPEX Only*	0.88	0.81	0.96	1.19	1.24	1.26
	- Total Costs	0.98	0.93	1.06	1.25	1.29	1.29
Break Even Cost/Price of Oil Production, MCOP/MPOP ($/bbl)							
(Equivalent to Annualized Unit Cost, AUC Using Discounted Prod)	*- OPEX Only*	0.88	0.81	1.09	1.84	2.24	2.58
	- Total Costs	0.98	0.93	1.20	1.93	2.32	2.66
PAY OUT & CAPITAL RISK							
Pay-out Time after Production Start-up (Years)		0 Yrs	**0 Yrs**	0 Yrs	0 Yrs	0 Yrs	0 Yrs
2 CAPEX+OPEX / (CAPEX+OPEX + NPV)	*- Total (16 -Yr Production Period)*	0.009	0.008	0.011	0.017	**0.020**	0.023

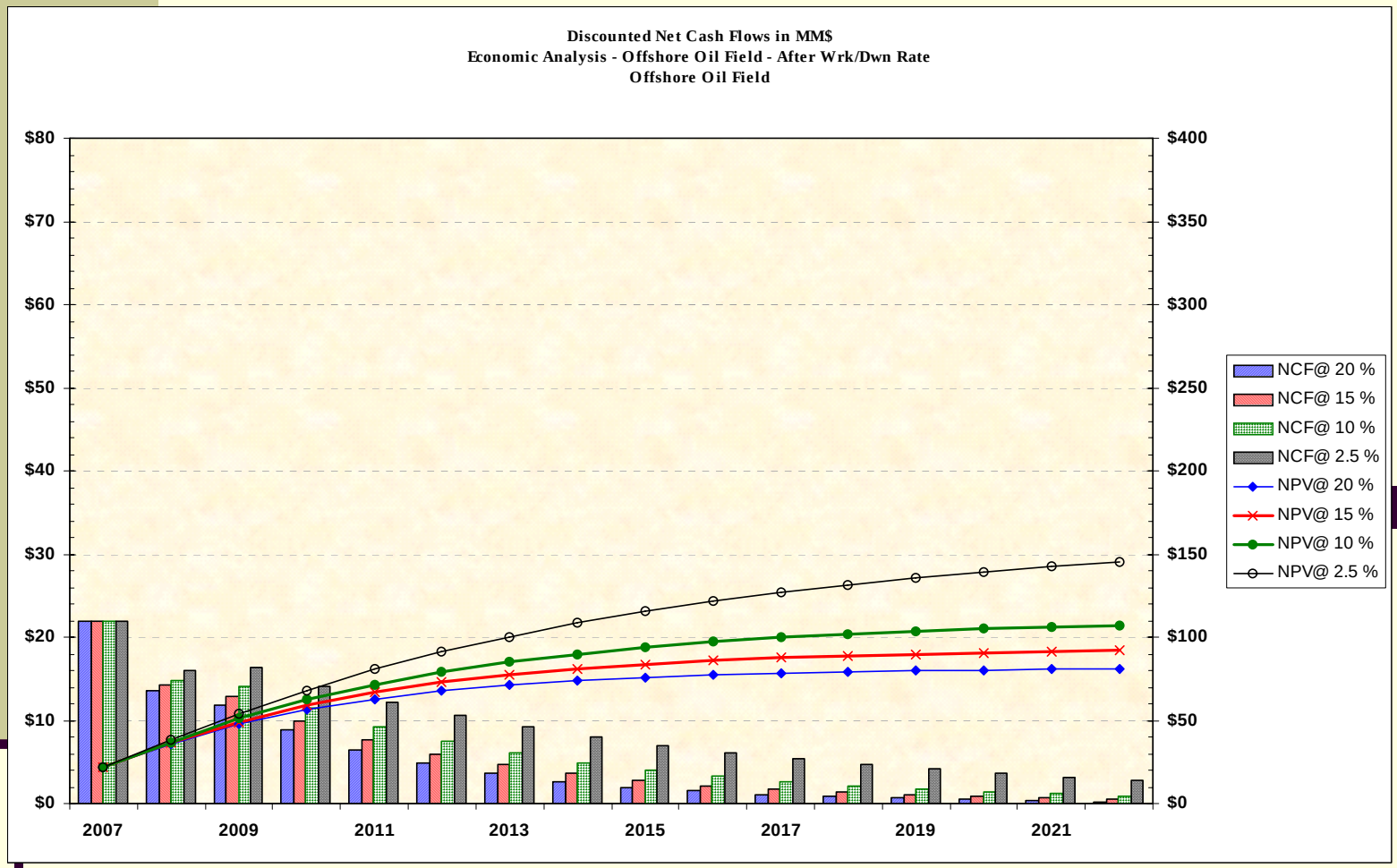
Well Typical / Example Economic Measures: No Drill - W/O

Work Over Economics



Well Typical / Example Current & Forecast Production Profile – W/Down

Work Over Economics



Well Cash Flow & NPV @ x% Profiles – W/Down

Work Over Economics

Economic Analysis - Offshore Oil Field - After Wrk/Dwn Rate							
Annual Nominal Discount Rate, ANDR (%) :	**15.00** (%)	Undiscounted CF @ 0%			Discounted CF @		
Annual General Background Inflation Rate, f (%	**2.50** (%)	Base-Year	Nominal	Real 2007 $			
Annual Real Discount Rate, ARDR (%) :	**12.20**	2007 $	(Then Crnt $)	Dsc @ 2.5 %	10.0 %	15.0 %	20.0 %
2007-2023Project Life: 16 (Years), n	**16** (including year 2007 as Year-0 or Base-Year)	16	16	16			
Cum Present Value Factor (Inverse of Capital Recovery Factor)					7.82	5.95	4.73
VALUE ANALYSIS							
Net Present Value, NPV (MM$)		148.522	164.387	145.114	107.291	**91.900**	80.887
Annualized Net Present Value, ANPV (MM$)		9.283	10.274	9.070	13.714	15.434	17.102
Profitability Index, PI ($ Returned / $ Invested) = 1 + NPV / PVC							
- *Based on Initial Capital only*		676.10	726.31	665.46	546.78	500.18	440.36
- *Based on Total Capital*		91.01	85.72	92.44	113.86	128.58	143.19
Investment Efficiency, IE ($ NPV / $ Investment) = NPV / Net Investment							
- *Based on Initial Capital only*		680.07	752.71	664.46	545.78	499.18	467.62
- *Based on Total Capital*		90.01	99.63	87.95	112.86	127.58	142.19
Internal Rate of Return (%)	- *Nominal*		**n/a**			**n/a**	
	- *Real* { = [(Nominal IRR + 1) / (1 + f) - 1] x 100 }	**n/a**		**n/a**		**n/a**	
Growth Rate of Return (%)	- *Real*		**21.7%**			**21.7%**	
DCF Rate of Return (%)		n/a	n/a	n/a	n/a	n/a	n/a
Cumulative Oil Production (MMSTB)	- *Undiscounted*	1.487	1.487	1.487	1.487	1.487	1.487
	- *Discounted*	1.487	1.487	1.310	0.963	0.823	0.723
Average Unit NPV Profit (AUP) ($/bbl)	Using Undiscounted Production	99.89	110.56	97.60	72.16	61.81	54.40
EXPENDITURE ANALYSIS							
Present Value Cost, PVC (MM$) :							
1) Capital Expenditures Only	- *Initial (3-Yr Development Only)*	0.220	0.227	0.218	0.197	0.184	0.184
	- *Total (16 -Yr Production Period)*	1.650	1.940	1.587	0.951	0.720	0.569
2) Operating Expenditures Only		3.259	3.315	3.182	2.875	2.718	2.585
3) Total Capital & Operating Expenditures		4.909	5.255	4.769	3.826	3.439	3.153
Annualized Present Value Cost, APVC (MM$)	- *OPEX Only*	0.204	0.207	0.199	0.368	0.457	0.546
	- *Total Costs*	0.307	0.328	0.298	0.489	0.578	0.667
Average Cost of Oil Prod (ACOP) ($/bbl)	- *OPEX Only*	2.19	2.23	2.14	1.93	1.83	1.74
	- *Total Costs*	3.30	3.53	3.21	2.57	2.31	2.12
Break Even Cost/Price of Oil Production, MCOP/MPOP ($/bbl)							
(Equivalent to Annualized Unit Cost, AUC Using Discounted Prod)	- *OPEX Only*	2.19	2.23	2.43	2.99	3.30	3.58
	- *Total Costs*	3.30	3.53	3.64	3.97	4.18	4.36
PAY OUT & CAPITAL RISK							
Pay-out Time after Production Start-up (Years)		0 Yrs	**0 Yrs**	0 Yrs	0 Yrs	0 Yrs	0 Yrs
2 CAPEX+OPEX / (CAPEX+OPEX + NPV)	- *Total (16 -Yr Production Period)*	0.032	0.031	0.032	0.034	**0.036**	0.038

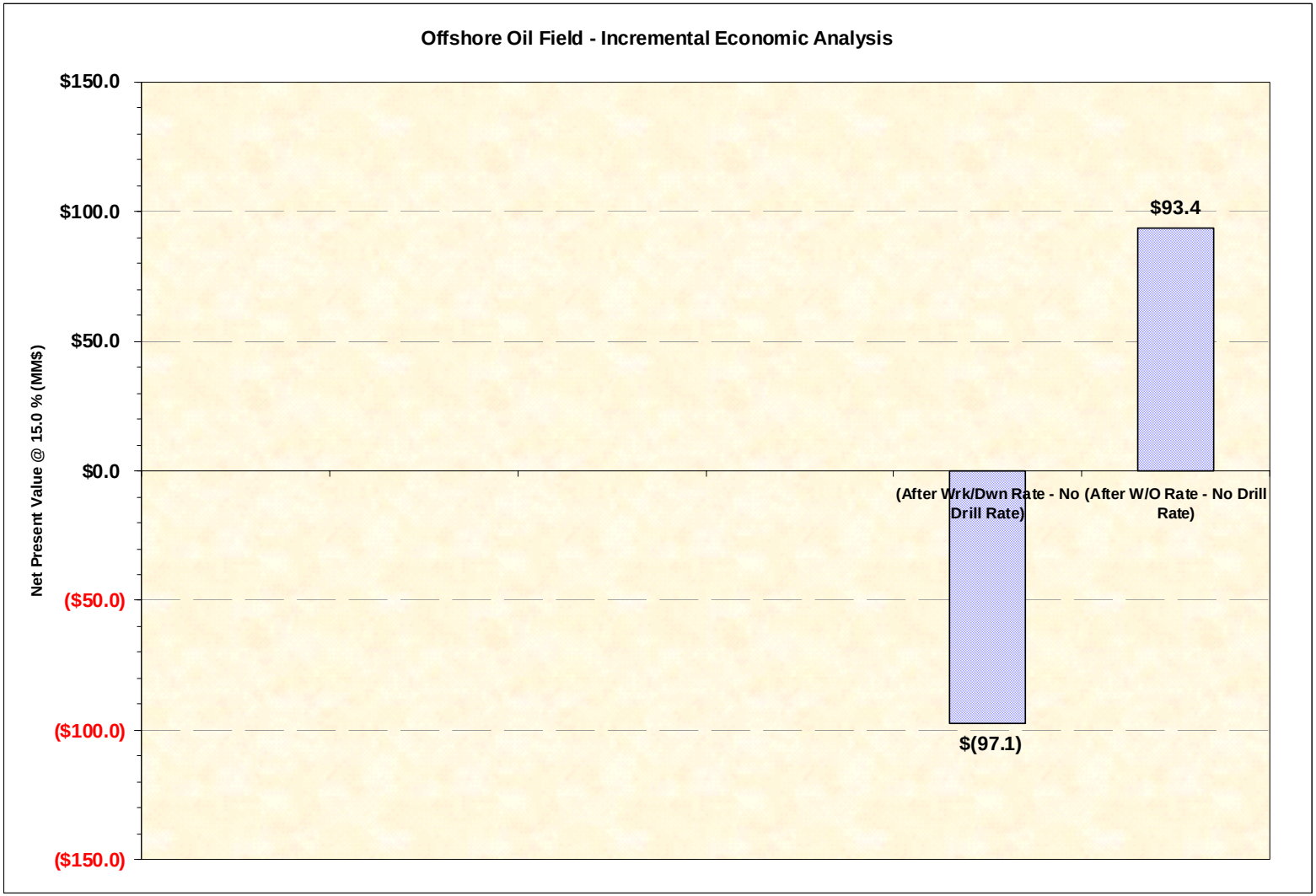
Well Typical / Example Economic Measures – W/Down

Incremental Work Over Economics

Incremental Economic Analysis - (After Wrk/Dwn Rate - No Drill Rate)		(After Wrk/Dwn Rate - No Drill Rate)			(After Wrk/Dwn Rate - No Drill Rate)		
Annual Nominal Discount Rate, ANDR (%) : **15.00** (%)		Undiscounted CF @ 0%			Discounted CF @		
Annual General Background Inflation Rate, f (% **2.50** (%)		Base-Year	Nominal	Real 2007 $			
Annual Real Discount Rate, ARDR (%) : **12.20**		2007 $	(Then Crnt $)	Dsc @ 2.5 %	10.0 %	15.0 %	20.0 %
2007-2023Project Life: 16 (Years), n **16** (including year 2007 as Year-0 or Base-Year)		16	16	16			
Cum Present Value Factor (Inverse of Capital Recovery Factor)					7.82	5.95	4.73
VALUE ANALYSIS							
Net Present Value, NPV (MM$)		-154.6	-170.7	-151.2	-112.8	**-97.1**	-85.9
Annualized Net Present Value, ANPV (MM$)		-9.7	-10.7	-9.4	-14.4	-16.3	-18.2
Profitability Index, PI ($ Returned / $ Invested) = 1 + NPV / PVC							
- Based on Initial Capital only		7,729.7	8,283.8	7,614.4	6,312.4	5,803.5	5,130.7
- Based on Total Capital		1,031.5	968.5	1,048.7	1,306.1	1,484.0	1,661.1
Investment Efficiency, IE ($ NPV / $ Investment) = NPV / Net Investment							
- Based on Initial Capital only		7,785.5	8,595.7	7,613.4	6,311.4	5,802.5	5,459.6
- Based on Total Capital		1,030.5	1,137.7	1,007.7	1,305.1	1,483.0	1,660.1
Internal Rate of Return (%)	*- Nominal*		**n/a**			**n/a**	
	- Real { = [(Nominal IRR + 1) / (1 + f) - 1] x 100 }	**n/a**		**n/a**		**n/a**	
Growth Rate of Return (%)	*- Real*		**-32.1%**			**-32.1%**	
DCF Rate of Return (%)		n/a	n/a	n/a	n/a	n/a	n/a
Cumulative Oil Production (MMSTB)	*- Undiscounted*	-1.487	-1.487	-1.487	-1.487	-1.487	-1.487
	- Discounted	-1.487	-1.487	-1.310	-0.963	-0.823	-0.723
Average Unit NPV Profit (AUP) ($/bbl)	Using Undiscounted Production	-103.96	-114.78	-101.66	-75.86	-65.32	-57.74
EXPENDITURE ANALYSIS							
Present Value Cost, PVC (MM$) :							
1) Capital Expenditures Only	*- Initial (3-Yr Development Only)*	-0.0200	-0.0206	-0.0199	-0.0179	-0.0167	-0.0167
	- Total (16 -Yr Production Period)	-0.1500	-0.1764	-0.1443	-0.0864	-0.0655	-0.0517
2) Operating Expenditures Only		1.2920	1.1920	1.4178	1.7607	1.8406	1.8635
3) Total Capital & Operating Expenditures		1.1420	1.0156	1.2735	1.6743	1.7751	1.8118
Annualized Present Value Cost, APVC (MM$)	*- OPEX Only*	0.081	0.074	0.089	0.225	0.309	0.394
	- Total Costs	0.071	0.063	0.080	0.214	0.298	0.383
Average Cost of Oil Prod (ACOP) ($/bbl)	*- OPEX Only*	-0.87	-0.80	-0.95	-1.18	-1.24	-1.25
	- Total Costs	-0.77	-0.68	-0.86	-1.13	-1.19	-1.22
Break Even Cost/Price of Oil Production, MCOP/MPOP ($/bbl)							
(Equivalent to Annualized Unit Cost, AUC Using Discounted Prod)	*- OPEX Only*	-0.87	-0.80	-1.08	-1.83	-2.24	-2.58
	- Total Costs	-0.77	-0.68	-0.97	-1.74	-2.16	-2.51
PAY OUT & CAPITAL RISK							
Pay-out Time after Production Start-up (Years)		0 Yrs	**0 Yrs**	0 Yrs	0 Yrs	0 Yrs	0 Yrs
2 CAPEX+OPEX / (CAPEX+OPEX + NPV)	*- Total (16 -Yr Production Period)*	-0.007	-0.006	-0.008	-0.015	**-0.019**	-0.022

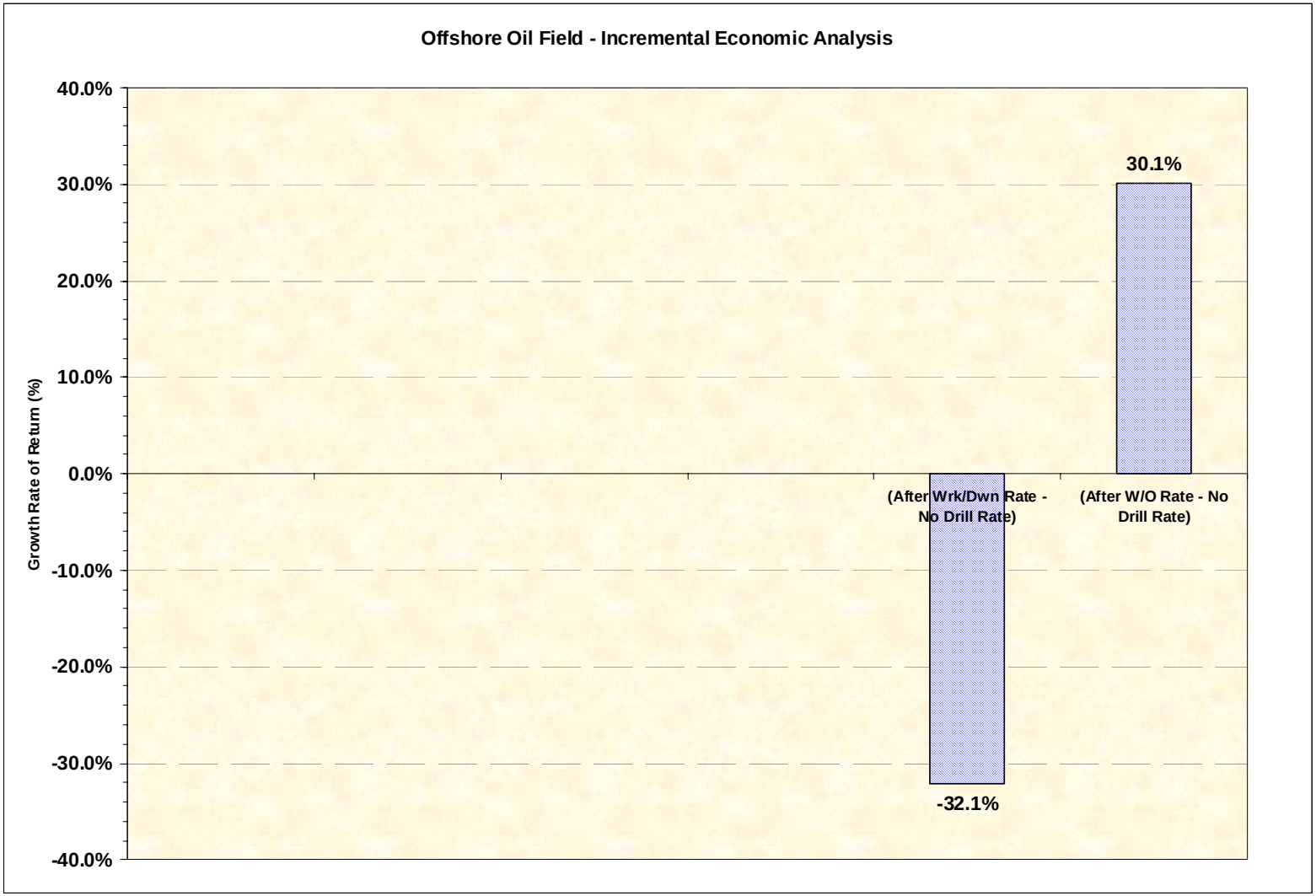
Well Typical / Example Economic Measures: No Drill – W/Down

Incremental Work Over Economics



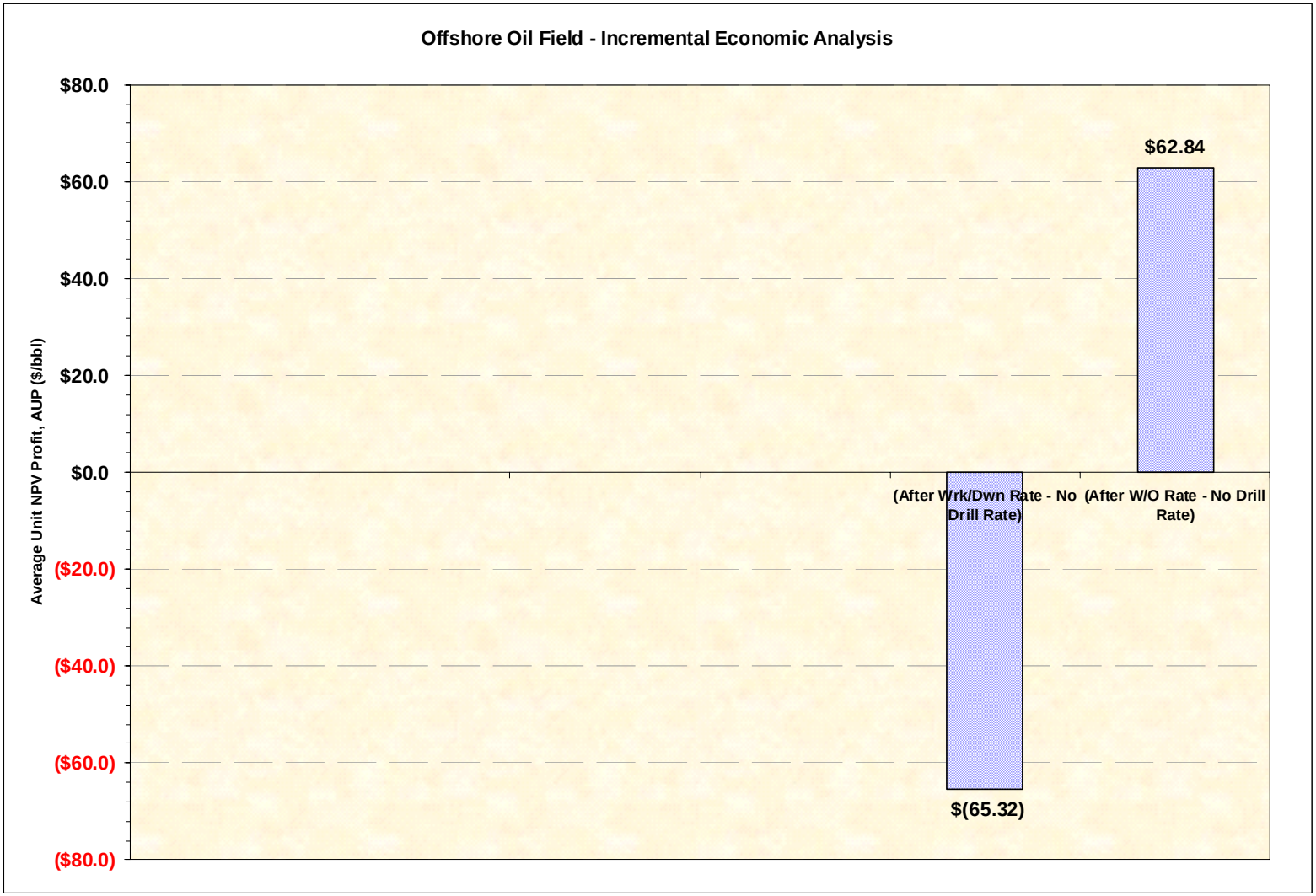
Typical / Example Project Ranking - NPV

Incremental Work Over Economics



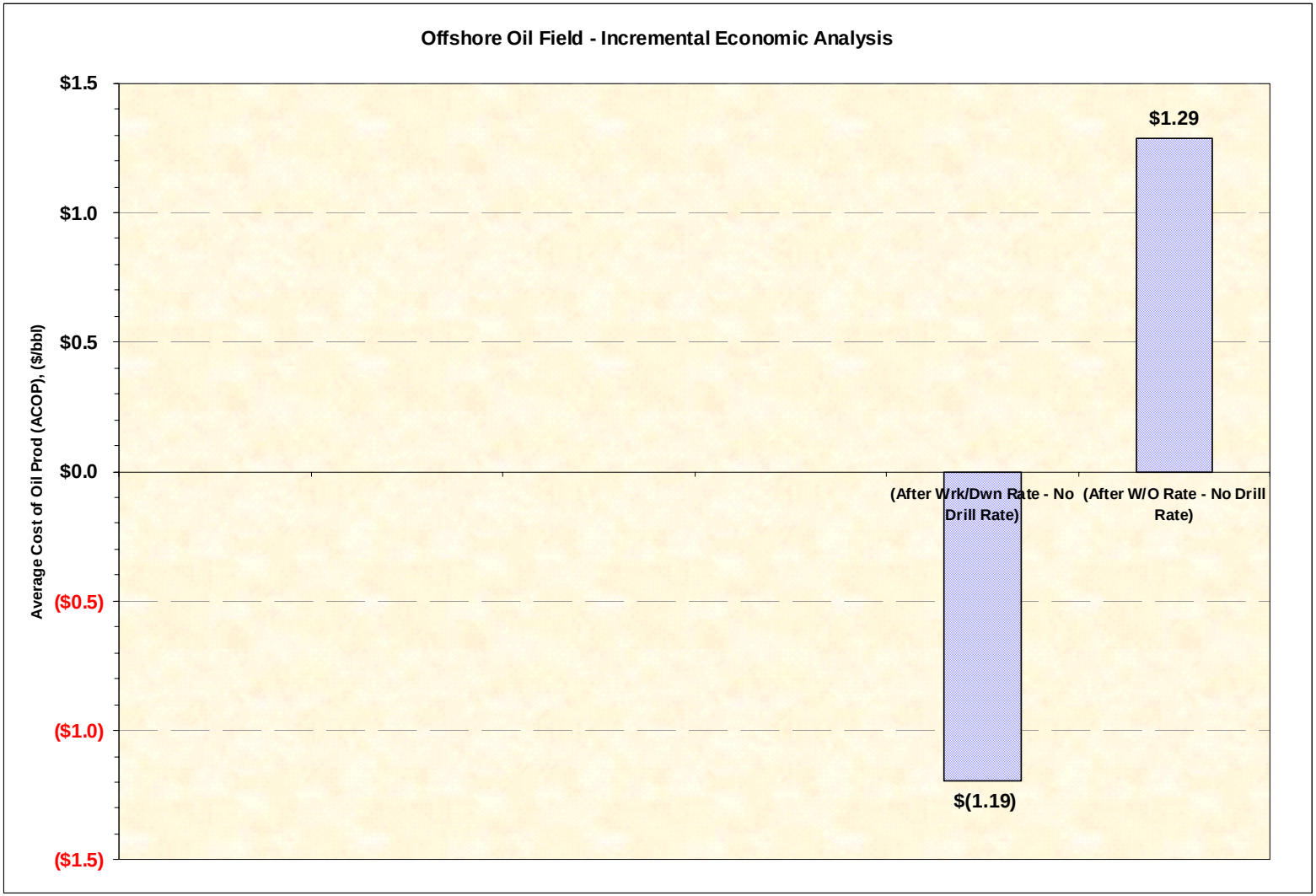
Typical / Example Project Ranking - GRR

Incremental Work Over Economics



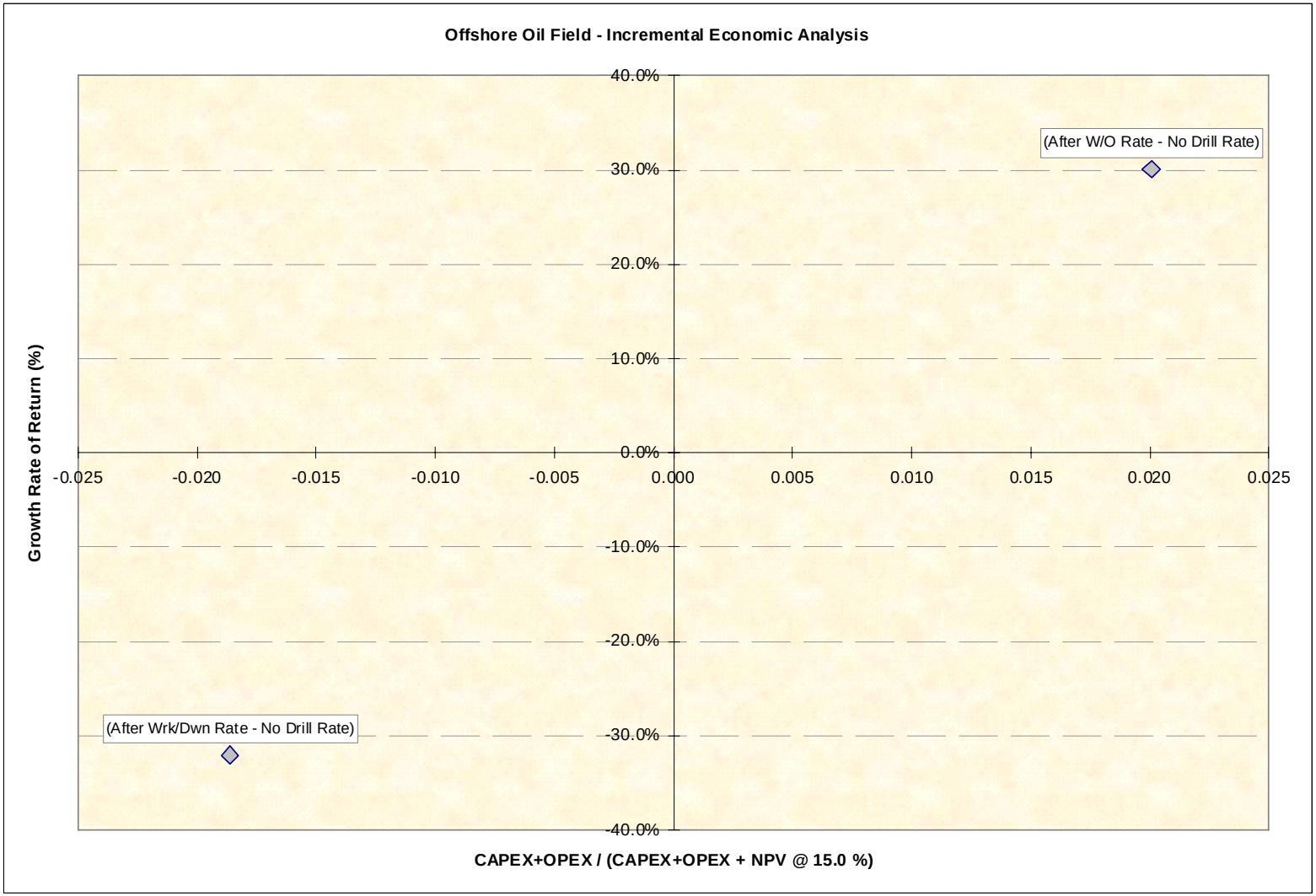
Typical / Example Project Ranking – Unit NPV

Incremental Work Over Economics



Typical / Example Project Ranking – Unit Cost

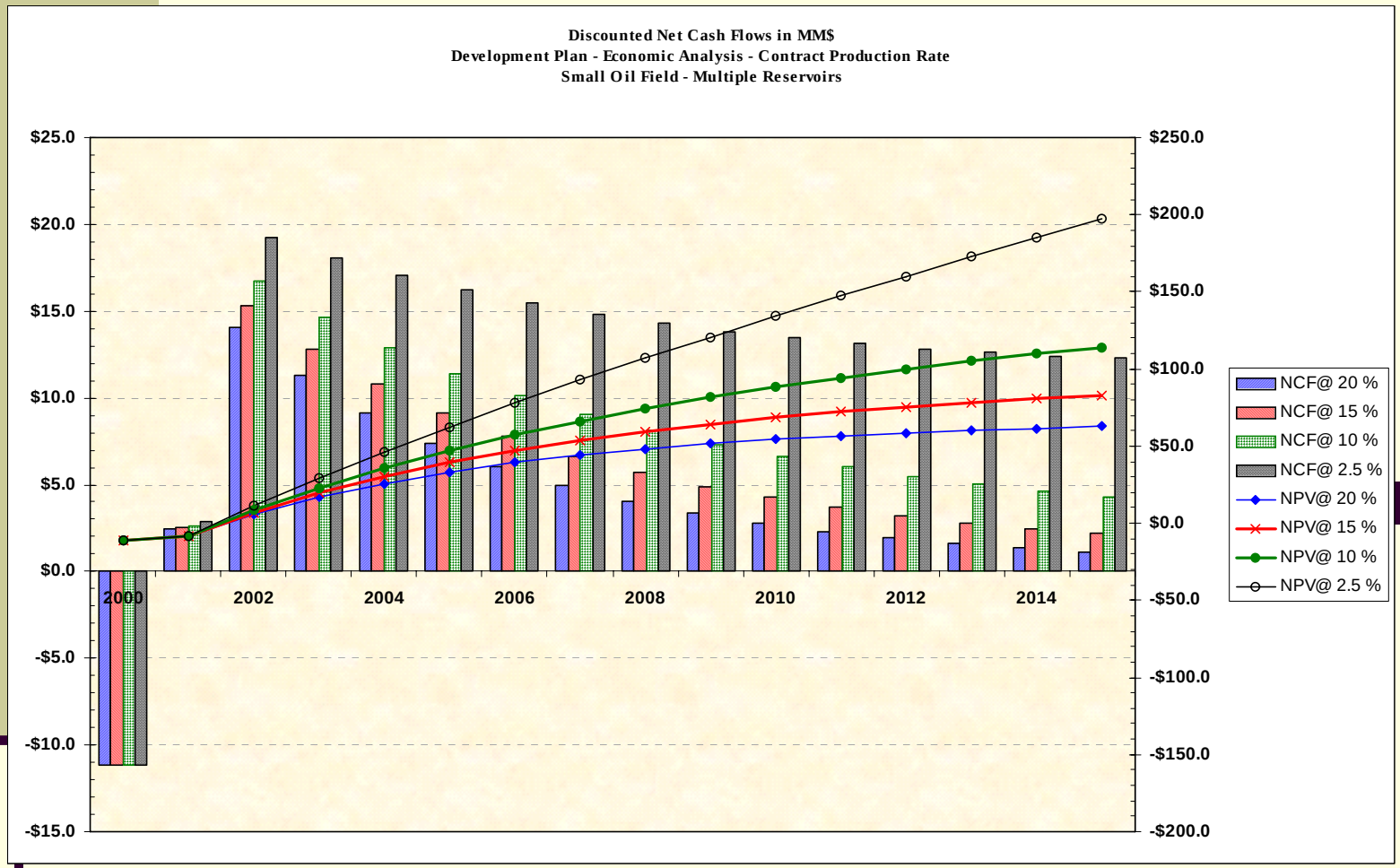
Incremental Work Over Economics



Well Typical / Example Project Ranking – Capital Risk vs GRR

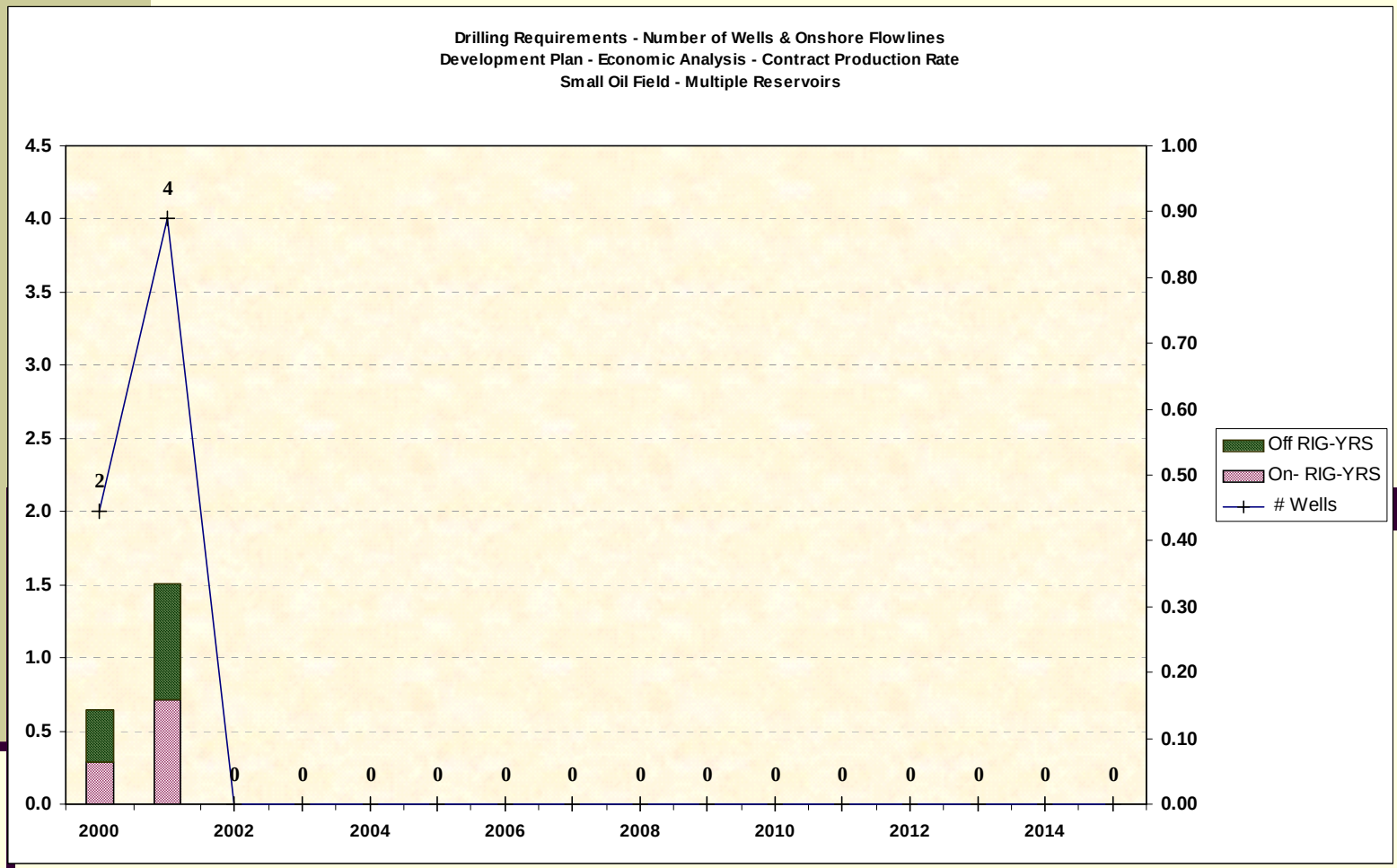
Probabilistic Economics

Field Development Cash Flow



Cash Flow & NPV @ x% Profiles

Development Wells / Rig Years



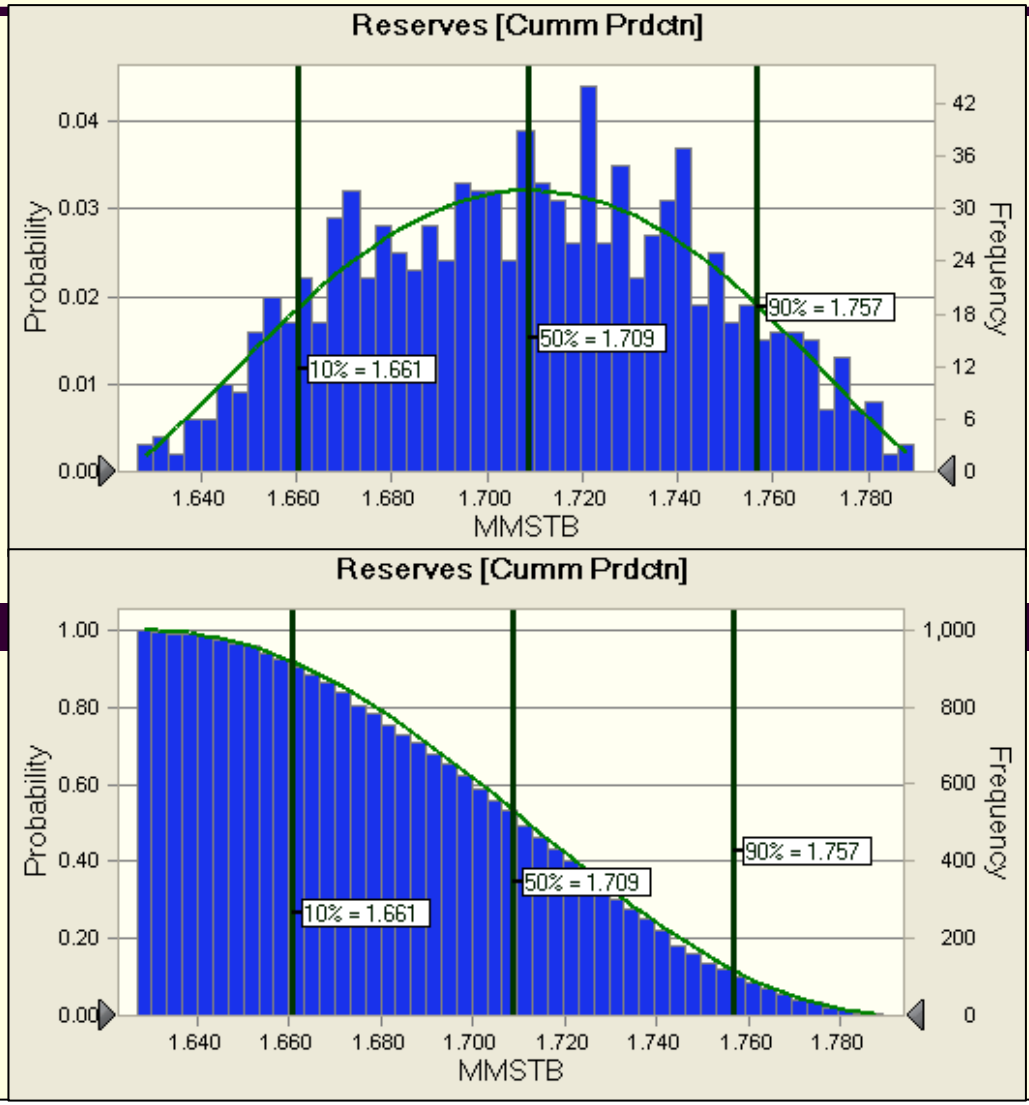
Wells & Rig-Years

Field Development Economics

Development Plan - Economic Analysis - Contract Production Rate								
Annual Nominal Discount Rate, ANDR (%) :	**15.00** (%)	Undiscounted CF @ 0%			Discounted CF @		
Annual General Background Inflation Rate, f (%	**2.50** (%)	Base-Year	Nominal	Real 2000 $			
Annual Real Discount Rate, ARDR (%) :	**12.20**	2000 $	(Then Crnt $)	Dsc @ 2.5 %	10.0 %	15.0 %	20.0 %
2000-2016Project Life: 16 (Years), n	**16** (including year 2000 as Year-0 or Base-Year)	16	16	16			
Cum Present Value Factor (Inverse of Capital Recovery Factor)					7.82	5.95	4.73
VALUE ANALYSIS							
Net Present Value, NPV (MM$)		203.380	243.372	197.503	113.859	**83.077**	62.596
Annualized Net Present Value, ANPV (MM$)		12.711	15.211	12.344	14.553	13.953	13.235
Profitability Index, PI ($ Returned / $ Invested) = 1 + NPV / PVC							
- *Based on Initial Capital only*		5.64	6.55	5.54	3.67	2.97	2.49
- *Based on Total Capital*		5.64	6.55	5.54	3.67	2.97	2.50
Investment Efficiency, IE ($ NPV / $ Investment) = NPV / Net Investment							
- *Based on Initial Capital only*		4.67	5.59	4.54	2.67	1.97	1.50
- *Based on Total Capital*		4.64	5.56	4.51	2.67	1.97	1.50
Internal Rate of Return (%) - *Nominal*			**100.8**			**100.8**	
- *Real* { = [(Nominal IRR + 1) / (1 + f) - 1] x 100 }		**95.8**		**95.9**		**95.9**	
Growth Rate of Return (v/v) - *Real*	(%)		**8.6%**			**8.6%**	
DCF Rate of Return (%)		95.8	100.8	95.9	82.6	74.6	67.3
Cumulative Oil Production (MMSTB) - *Undiscounted*		1.707	1.707	1.707	1.707	1.707	1.707
- *Discounted*		1.707	1.707	1.482	1.053	0.885	0.767
Average Unit NPV Profit (AUP) ($/bbl) Using Undiscounted Production		119.12	142.55	115.68	66.69	48.66	36.66
EXPENDITURE ANALYSIS							
Present Value Cost, PVC (MM$) :							
1) Capital Expenditures Only - *Initial (3-Yr Development Only)*		43.810	43.864	43.535	42.636	42.103	42.103
- *Total (16 -Yr Production Period)*		43.810	43.864	43.535	42.636	42.103	41.613
2) Operating Expenditures Only		36.018	38.300	33.033	23.390	19.802	17.381
3) Total Capital & Operating Expenditures		79.828	82.164	76.568	66.026	61.904	58.994
Annualized Present Value Cost, APVC (MM$) - *OPEX Only*		2.251	2.394	2.065	2.990	3.326	3.675
- *Total Costs*		4.989	5.135	4.786	8.439	10.397	12.474
Average Cost of Oil Prod (ACOP) ($/bbl) - *OPEX Only*		21.10	22.43	19.35	13.70	11.60	10.18
- *Total Costs*		46.76	48.13	44.85	38.67	36.26	34.55
Break Even Cost/Price of Oil Production, MCOP/MPOP ($/bbl)							
(Equivalent to Annualized Unit Cost, AUC Using Discounted Prod) - *OPEX Only*		21.10	22.43	22.29	22.21	22.38	22.66
- *Total Costs*		46.76	48.13	51.66	62.70	69.98	76.91
PAY OUT & CAPITAL RISK							
Pay-out Time after Production Start-up (Years)		0.99 Yrs	**1.23 Yrs**	0 Yrs	0.09 Yrs	0 Yrs	0 Yrs
1 Capital / (Captial + NPV) - *Total (16 -Yr Production Period)*		0.177	0.153	0.181	0.272	**0.336**	0.399

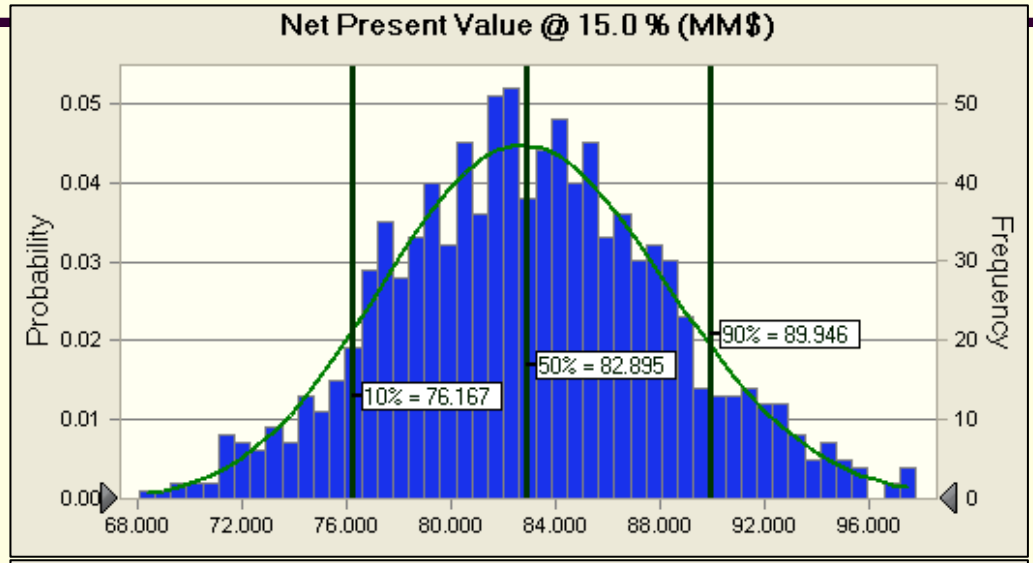
Typical / Example Economic Measures

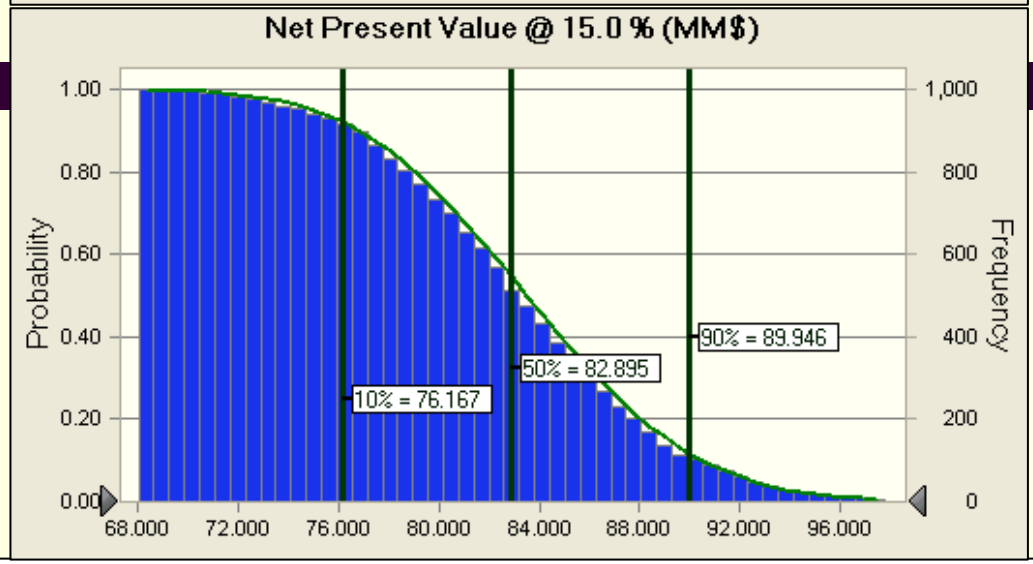
Probabilistic Reserves Estimates



Example Distributions – Normal & Reverse Cumulative

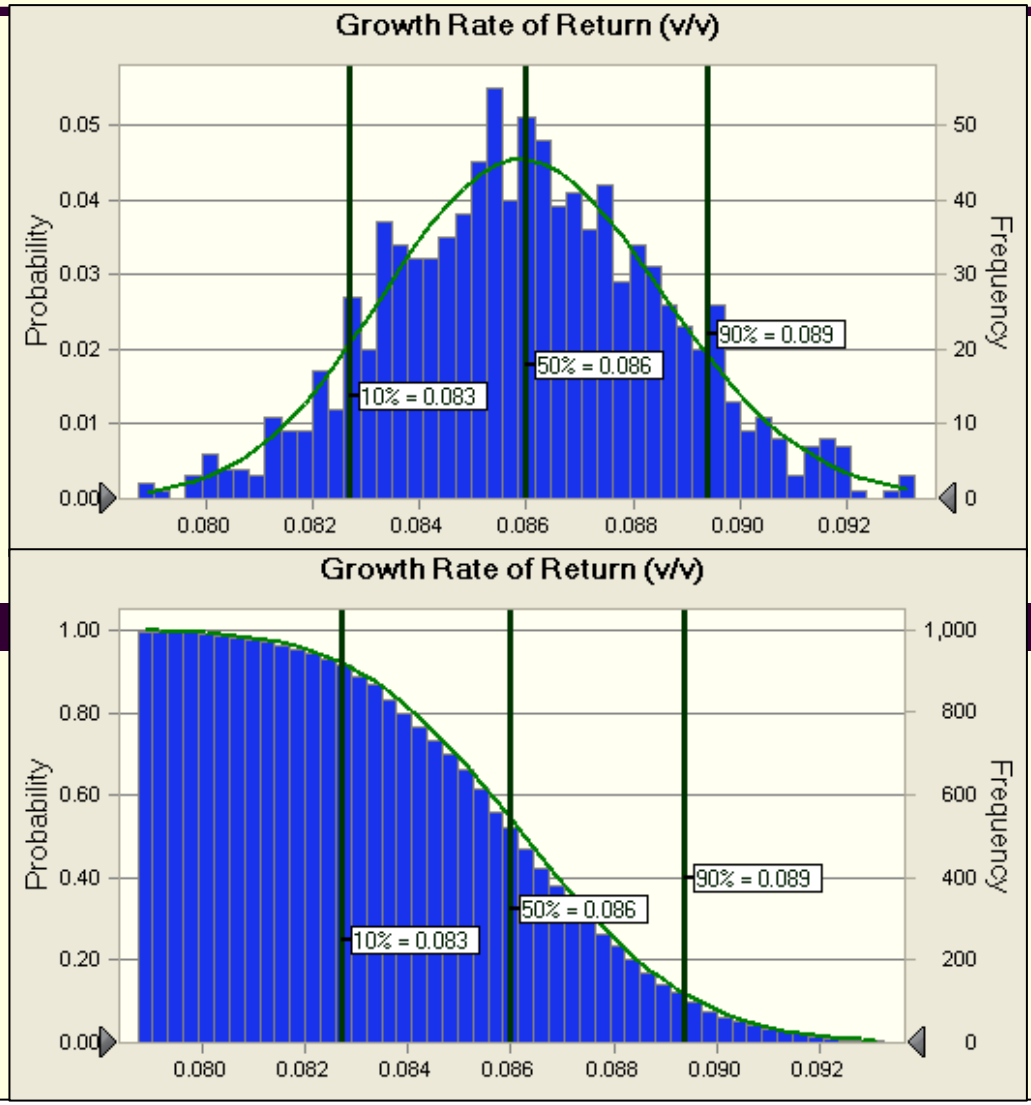
Probabilistic Net Present Value





Example Distributions – Normal & Reverse Cumulative

Probabilistic Growth Rate of Return



Example Distributions – Normal & Reverse Cumulative