State of Connecticut
Connecticut Siting Council

Life-Cycle Cost Studies for Overhead and Underground Electric Transmission Lines

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ACRES

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Executive Summary

Executive Summary

Introduction

The Connecticut Siting Council has been charged to investigate the comparative life-cycle costs of overhead and underground electric transmission lines (Connecticut General Statutes Section 16-50r).

The purpose of the investigation is to address all relevant life-cycle costs of 115 kV transmission lines, including reliability, constraints on access and construction, potential effects on the environment and compatibility with existing electric supply systems. Life-cycle costs include all capital and operating costs that occur over the expected operational life of such transmission lines.

Life-Cycle

A summary of the first costs[1] and life-cycle costs[2] for all alternatives are shown on Table 1.1. The components of first costs and life-cycle costs for typical overhead and underground lines are shown in Figures 1.1 and 1.2 respectively.

The summary shows

- The typical single-circuit underground line life-cycle cost is three to four times that of an overhead single-circuit line. Life-cycle costs are very dependent on the first cost of construction. For underground lines the first cost is five to six times that of an equivalent overhead circuit. Hence underground life-cycle costs are higher.

- Double circuit underground lines may cost five times as much as overhead double circuit lines.

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[1]First costs are defined as construction costs, including all labor, materials, engineering, administration, and permitting spent at the time of construction of the transmission line.

[2]Life cycle costs are defined as the total fixed costs, operation and maintenance costs, and cost of losses over the life of a transmission line during a 35 year period.

Table 1.1

First Project Cost and Life-Cycle Project Costs for all Alternative Overhead and Underground Configurations

Costs are for a 5 mile project and include terminal equipment	First Costs		Life Cycle Costs	
	*Scenario A $1000	*Scenario B $1000	*Scenario A $1000	*Scenario B $1000
Overhead				
Single Circuit (I-string insulator except as noted)				
H-frame	1,917	2,040	4,924	5,803
H-frame with compact spacing	1,969	2,092	4,997	5,876
Wood pole with delta arrangement	2,007	2,137	5,055	5,944
Steel pole	2,501	2,660	5,734	6,663
Steel pole with compact spacing	2,518	2,679	5,758	6,690
Steel pole with delta arrangement	2,441	2,595	5,649	6,572
Steel pole with compact spacing delta arrangement	2,429	2,561	5,632	6,524
Double Circuit (I-string insulator except as noted)				
H-frame	3,334	3,574	6,969	8,013
H-frame with alternative phasing	3,334	3,574	6,969	8,013
H-frame with compact spacing and alternative phasing	3,450	3,690	7,133	8,176
Steel pole	3,246	3,536	6,832	7,946
Steel pole with alternative spacing	3,246	3,536	6,832	7,946
Steel pole with compact spacing	3,308	3,578	6,920	8,006
Steel pole with compact spacing and alternative phasing using V-string insulators	3,308	3,578	6,920	8,006
Steel pole with compact spacing and alternative phasing using stand-off insulators	3,519	3,770	7,217	8,276
Underground				
Single Circuit				
High pressure gas-filled	12,924	12,924	19,014	19,014
High pressure fluid-filled	12,926	12,926	19,016	19,016
High pressure fluid-filled with closed loop cirulation	13,605	13,605	19,972	19,972
Self contained fluid-filled	14,839	14,839	21,622	21,622
Solid dielectric with horizontal arrangement	12,603	12,603	18,475	18,475
Solid dielectric with delta arrangement	12,422	12,422	18,220	18,220
Solid dielectric with L-shaped arrangement	12,422	12,422	18,220	18,220
Double Circuit				
High pressure gas-filled	24,197	24,197	35,013	35,013
High pressure fluid-filled	23,684	23,684	34,291	34,291
High pressure fluid-filled with closed loop circulation	26,477	26,477	38,223	38,223
Self contained fluid-filled	27,313	27,313	39,306	39,306
Solid dielectric with horizontal arrangement	24,348	24,348	35,022	35,022
Solid dielectric with horizontal arrangement and alternative phasing	24,348	24,348	35,022	35,022
Solid dielectric with vertical arrangement	24,348	24,348	35,022	35,022
Solid dielectric with vertical with alternative phasing	24,348	24,348	35,022	35,022
Solid dielectric with delta arrangement	23,717	23,717	34,134	34,134

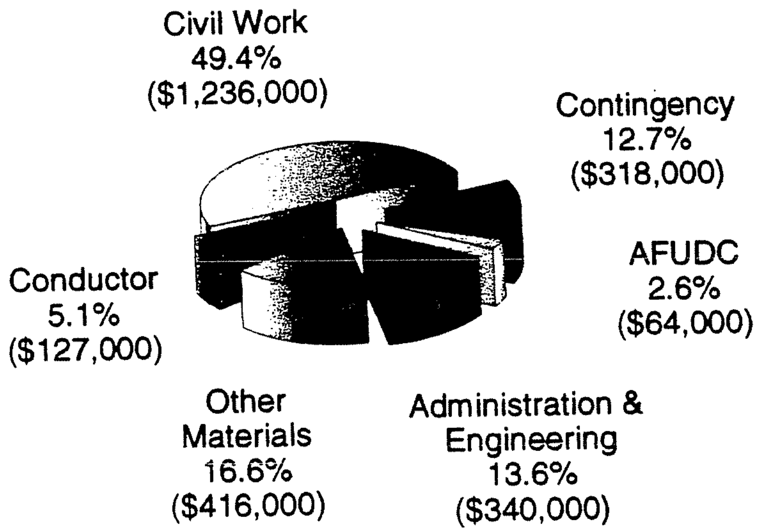
***See Table 1.2 for definitions of scenarios.**

Table 1.2

Connecticut Transmission Line Load Level Scenarios and Ratings

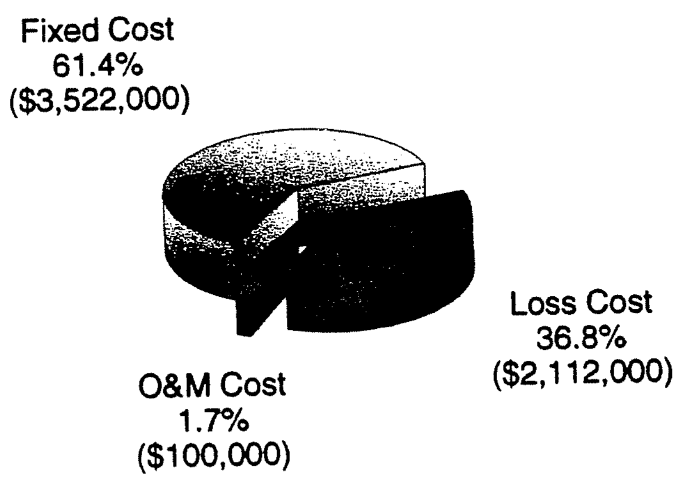
		Scenario A (115 kV)	Scenario B (115 kV)
Summer	Expected Average Load Level	350 amps	500 amps
	Normal Rating	1000 amps	1250 amps
	Long Term Emergency Rating	1250 amps	1500 amps
	Short Term Emergency Rating	1500 amps	2000 amps
Winter	Expected Average Load Level	350 amps	500 amps
	Normal Rating	1250 amps	1500 amps
	Long Term Emergency Rating	1500 amps	2000 amps
	Short Term Emergency Rating	1750 amps	2500 amps

Overhead First Costs Of Construction (Typical)



Total First Cost: $2,501,000

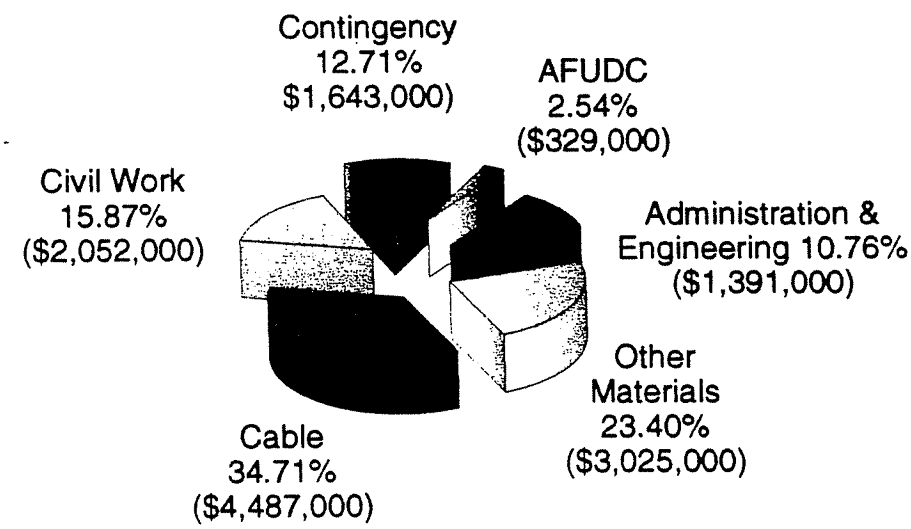
Overhead Life Cycle Costs (Typical)



Total Life Cycle Cost: $5,734,000

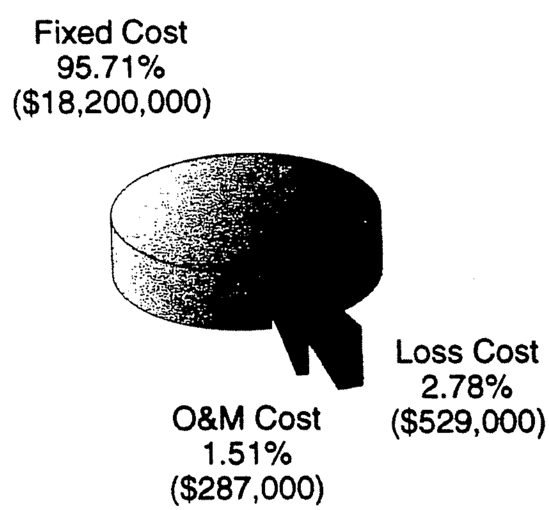
Figure 1.1

Underground First Costs Of Construction (Typical)



Total First Cost: $12,926,000

Underground Life Cycle Costs (Typical)



Total Life Cycle Cost: $19,016,000

Figure 1.2

Underground Alternatives

- High pressure fluid-filled circuits have the highest life-cycle cost.
- All other technologies are very close in life cycle costs.

Overhead Alternatives

- H-frame lines tend to have the lowest life-cycle costs but cost differences between alternatives are generally small.

Magnetic Fields

Magnetic field values are very dependent on the current in the circuit. Long-term average currents result in fields well below the values that briefly exist when high emergency currents flow.

Magnetic fields decrease rapidly with distance. Under conditions of expected average current, the fields at 50 ft from the center line of the right-of-way are as low as one-third of the maximum value.

Magnetic fields surrounding underground circuits decrease more rapidly away from the center line than for comparable overhead circuits.

The lowest overall fields, irrespective of overhead or underground, are produced by the underground pipe type fluid-filled or gas-filled cables.

Underground Circuits

- Pipe type cables (high pressure gas-filled, high pressure fluid-filled, and high pressure fluid-filled with closed loop circulation) have the lowest magnetic fields of all the alternatives. This is true for both single circuit and double circuit.
- The highest magnetic fields resulted from alternatives with non-canceling horizontal arrangements (both solid dielectric and self contained cable types). Peak values in these alternatives were comparable to the highest overhead values. This held true for both single and double circuits.

- Alternative phasing arrangements were effective in reducing magnetic fields and produced peak fields as low as one-half that of the non-canceling alternatives at the center line.

Overhead Circuits

- For single circuit overhead lines, the lowest magnetic fields are produced by the alternative using a compact conductor spacing in a delta arrangement. Highest values are produced by the H-frame in a horizontal arrangement. In the delta arrangement there is a greater degree of magnetic field cancellation.

- In the double circuit alternatives, the lowest fields also result from the delta arrangement

- With compact spacing and alternative phasing arrangements the highest magnetic fields result from a horizontal configuration.

- Using an alternative phasing arrangement sometimes produces an additive effect and in other alternatives a canceling effect. As seen at the center line of the right-of-way, for the double circuit H-frame alternative, changing the phase configuration produced an additive effect and for the double steel pole alternative, a canceling effect.

Electric Fields

Electric fields are a function of voltage and conductor configuration. Changing the conductor size and current does not affect the electric field in any appreciable manner.

Electric fields from underground circuits are zero at ground level since they are completely dissipated in the soil surrounding the cable.

Electric fields decrease with increasing distance from the source.

Life Expectancy

The life expectancy for all alternatives has been taken as 35 years, and all life-cycle costs are based on this value. While the physical life of a transmission line may exceed 35 years, due to changing load patterns, it cannot be assumed that the line will be electrically viable after 35 years. It is also important to recognize that increasing the life expectancy beyond 35 years has little impact on the life-cycle cost.

Environmental Impact

Environmental factors are important considerations in the siting, construction and operation of any transmission line whether placed underground or overhead.

Conventional environmental impacts such as environmental field surveys, permitting, facility construction as well as operations and maintenance such as vegetation control, are relatively well known. An allowance has been made in the life-cycle costs to accommodate conventional environmental requirements.

External costs, which are indirect costs to society, include visual quality, changes of habitat or changes in biodiversity due to the creation of a maintained corridor. The level of impact that individuals attribute to such environmental externalities is highly subjective and very project-specific. Such external costs typically can not be assigned a monetary value, either in the market place or by regulation. Literature research conducted as part of the life cycle cost assessment failed to identify any available models that could be used to quantify environmental externalities for transmission lines on a generic basis.

Although environmental externalities thus could not be quantified as part of the life cycle cost analysis, types of potential externalities have been discussed qualitatively throughout the environmental analysis in this report. This discussion is intended to provide a basis for the qualitative consideration of externalities as part of transmission line planning and decision-making, on a project-by-project basis

However, both conventional and externality costs should be considered in the planning, decision-making, or comparison of either type of transmission line. Such environmental evaluations must necessarily be performed on a project-specific basis, because environmental resource considerations will vary significantly as a function of project location.

The use of standard methods for evaluating environmental resources issues could be applied to facilitate either quantitative or qualitative comparisons among project alternatives.

In the environmental investigation, no available data provided a direct, comparative evaluation of the environmental effects of overhead versus underground transmission lines on a project specific basis.

Significant issues are:

- Single overhead lines typically require a 100 foot right-of-way, double overhead lines normally require 150 feet, and underground lines 25 feet.

- While there may be a general perception that underground lines result in fewer overall environmental impacts, this is not the case in the construction phase, or for subsequent repairs to the line.

- Overhead lines are an important factor in scenic quality.

Reliability

Well built properly maintained transmission systems are very reliable, whether placed overhead or underground. However, these two systems are not equal in all circumstances for the following reasons:

- Overhead lines are more susceptible to interruptions from external forces such as inclement weather, but problems are easier to find, and repair.

- Underground lines are less susceptible to inclement weather, but problems take longer to find and repair.

Compatibility with the Existing Electric System

Overhead and underground systems are not electrically equivalent due to differences in current carrying capabilities, load sharing, charging currents, fault currents, system restoration and losses. Overhead transmission lines therefore cannot be replaced with underground transmission lines on a simple one for one basis.

Applicability of Study Results

First Costs The first costs obtained from the study are very close to the actual costs reported for 115 kV line projects in Connecticut, particularly when comparing the relative costs of alternative configurations.

Land Costs Land costs have not been included in the cost models. While this may not be of concern for the foreseeable future when all new construction will be on existing rights-of-way, it will affect the cost model markedly should future land acquisitions be necessary.

Electric and Magnetic Fields The electric field calculations are suitable for comparison purposes only. Many factors affect magnetic or electric fields. For example with an overhead line, distances between the conductors vary along the length of the line depending on whether the conductor is near a dead end, angle or tangent structure, and conductor loading.

Loading Equivalency Overhead and underground transmission lines included in this study cannot always carry equal loads of electricity. While the overhead lines can carry the loads specified, the underground lines cannot meet the values under some emergency circumstances. Increasing the conductor size to meet all loads would result in special custom-made cables with larger sizes unavailable in some cable types. The sizes chosen represent practical maximum sizes at this time and are similar in size to the largest now used in Connecticut. Where underground ratings are inadequate it may be necessary to either install duplicate facilities or to make compensatory additions elsewhere in the transmission system.

High Voltage Transmission Line Concepts

2 High Voltage Transmission Line Concepts

A Glossary of Terms used throughout the report is included in Appendix D. The following outlines some of the terms of particular importance to understanding transmission line design and selection.

Electricity is defined in terms of electric charge. The potential energy stored in electric charge is measured as volts (V). The movement of electric charges is measured in amperes (A) (often referred to as "amps", symbol I).

Alternating current, (AC) predominantly used in the United States, has a current which rises and reverses at regular intervals, with both positive and negative values. Rising and reversing 60 times per second, AC has a frequency of 60 Hertz (Hz).

All 60 Hz transmission lines are three-phase lines. Each phase is carried by an independent wire. The difference between the three phases is that the rising and falling is time shifted between them. The time shifting is equally spaced and the phases are displaced from each other by exactly 1/3 of an electrical cycle.

Magnetic fields are produced whenever electric current flows. Any wire carrying current will have an associated magnetic field, measured in milligauss (mG).

Electric fields are present whenever there is an electric charge. Measurement of electric fields is in kilovolts per meter (kV/m).

Transmission lines have electrical properties of resistance, inductance and capacitance.

Resistance (R) can be understood as a dissipator of energy. Current flowing through a resistance will create heat. Measurement of resistance is in ohms (**Ω**) measurement of the loss to heat is in watt hours (Wh).

Inductance (L) is the property that determines the voltage induced in a circuit for a changing current. It also determines the magnetic energy stored. Measurement is in henrys (H).

Capacitance (C) is the property that determines the charge per unit voltage and the electric energy stored. Measurement is in farads (F).

The Circular mil is used to define conductor and cable cross - sectional areas and is equal to the area of a circle 1 mil in diameter. One mil is equal to one thousandth of an inch. Sizes are stated in thousands of circular mils (Kcmil or MCM).

Transmission lines are the highest voltage part of the power system used to transmit electrical power from generating plants to the customers. Typical voltage levels are 69 kV, 115 kV and 345 kV. For the purposes of this study 115 kV has been selected.

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Part B

Transmission Line Configurations

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Underground Lines - Diagrams and Tables

Introduction

Part B details all the alternative configurations of 115 kV transmission considered in this study. These configurations are expected to cover the range of designs that might be used in Connecticut over the next 5-10 years. Each alternative has the following:

- ***Outline Diagram*** showing the physical arrangement of the configuration.

- ***Cost Estimates*** showing the first cost and the life cycle costs and, in the case of underground, the loading performance. Cost estimates are given for a base case to which "adders" should be added for various factors which increase costs.

- ***Magnetic Field Profile*** showing the value of the magnetic field to a distance of 200 feet either side of the transmission line center line for the specified loadings.

- ***Electric Field Profile*** showing the value of the electric field to the distance of 200 feet either side of the transmission line center line for the specified conductor sizes.

- ***Life-Cycle Analysis*** showing the annual present value of the first cost, operations and maintenance, and cost of losses. Details on the capital recovery factor (FC) are included in Appendix B.

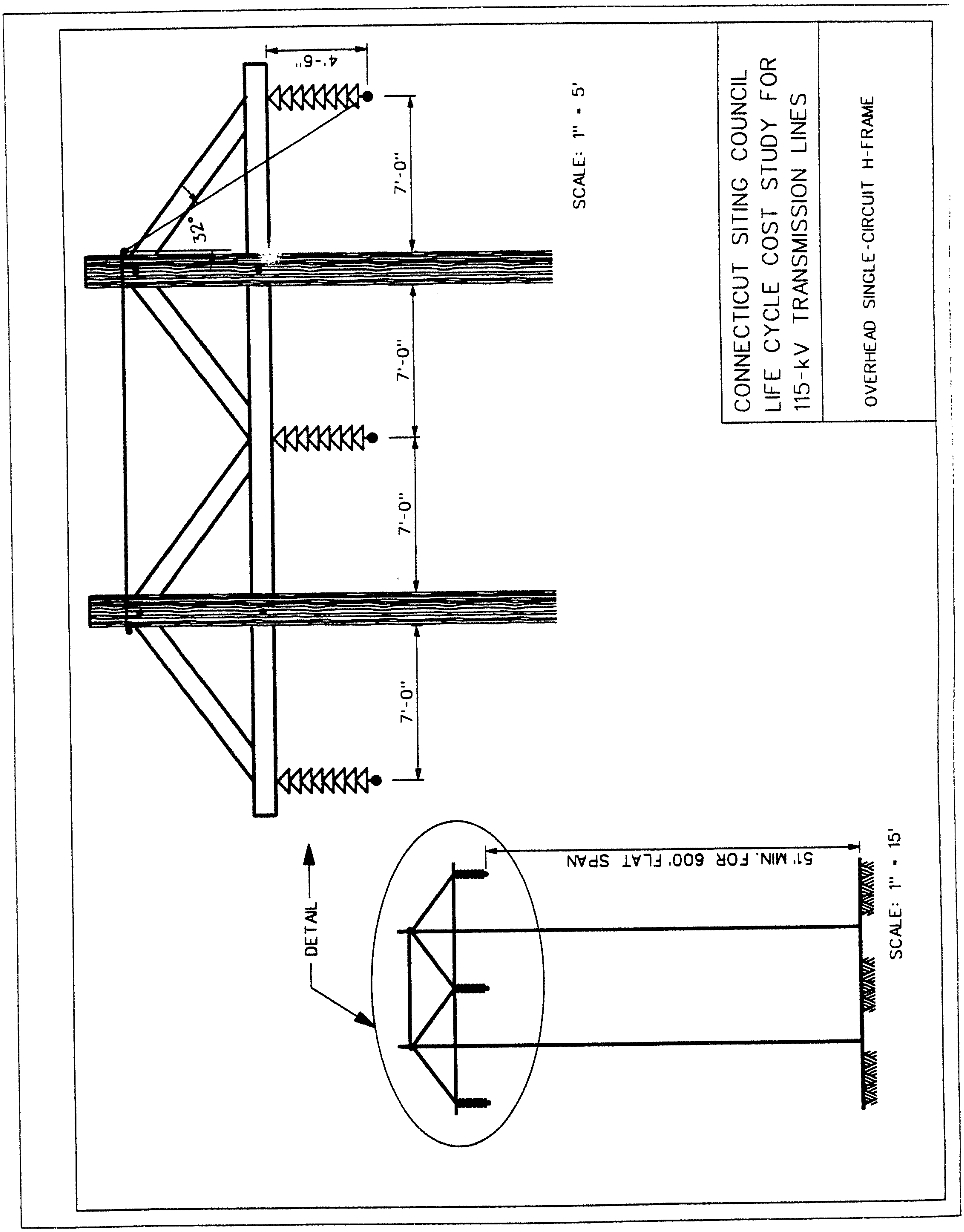
- ***Construction Cost Estimate***.

For overhead lines, life cycle costs are shown for two scenarios:

A - 350A average current, 795 Kcmil conductor
B - 500A average current, 1272 Kcmil conductor

For underground lines, life cycle costs are shown only for Scenario A - 350A average current. This is because emergency rating criteria result in the same cable size being necessary for both scenarios, as detailed in Part C - Section 3.4. Since the first cost of an underground cable is therefore the same for both scenarios, the only difference in life-cycle costs relates to losses. Since the differences in losses between the two scenarios is very small there is no significant difference in life-cycle costs between the two scenarios.

Overhead Lines


4'-6"
32°
7'-0"
7'-0"
7'-0"
7'-0"
SCALE: 1" - 5'
DETAIL
51' MIN. FOR 600' FLAT SPAN
SCALE: 1" - 15'
CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES
OVERHEAD SINGLE-CIRCUIT H-FRAME

Construction Cost Estimates
Overhead Single-circuit H-Frame

Base costs

Per Mile Base		
Scenario A 795 kcmil	$351,590	(a)
Scenario B 1272 kcmil	$376,243	(a)
Per Project Base		
Terminal equipment (Scenario A)	$40,953	(b)
Terminal equipment (Scenario B)	$40,953	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder		
Urban location	$207,000	(d)
Per Project Adder		
Winter construction	$6,000	(e)

Base Case - Scenario A

First cost	5 miles, rural, summer work	$1,917,000	5x(a) +(b)+(c)
Life cycle cost		$4,924,000	

Base Case - Scenario B

First cost	5 miles, rural, summer work	$2,040,000	5x(a) +(b)+(c)
Life cycle cost		$5,803,000	

Notes:
1) Base case is for a single circuit line installed in a rural environment.

Life Cycle Cost Analysis
Overhead Single-circuit H-Frame (5 Miles, Scenario A: 795 kcmil)

			FC rate		Fixed cost
Construction	1,917,000	x	0.146	=	279,882
Land	0				0
Total					279,882

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	279,882	10,042	57,646	347,570	0.91	315,973	315,973
2	279,882	6,980	65,598	352,460	0.83	291,289	607,262
3	279,882	7,260	73,900	361,041	0.75	271,256	878,518
4	279,882	7,550	75,684	363,116	0.68	248,013	1,126,531
5	279,882	7,852	86,906	374,641	0.62	232,622	1,359,153
6	279,882	8,166	96,221	384,270	0.56	216,910	1,576,064
7	279,882	8,493	105,935	394,310	0.51	202,343	1,778,407
8	279,882	8,833	135,982	424,696	0.47	198,124	1,976,531
9	279,882	9,186	149,601	438,669	0.42	186,038	2,162,569
10	279,882	9,553	163,798	453,234	0.39	174,741	2,337,310
11	279,882	9,935	184,015	473,832	0.35	166,075	2,503,386
12	279,882	10,333	266,324	556,539	0.32	177,331	2,680,716
13	279,882	10,746	281,283	571,911	0.29	165,662	2,846,378
14	279,882	11,176	296,808	587,866	0.26	154,804	3,001,182
15	279,882	12,776	320,766	613,424	0.24	146,849	3,148,031
16	279,882	13,287	355,672	648,841	0.22	141,207	3,289,237
17	279,882	13,819	381,871	675,572	0.20	133,658	3,422,896
18	279,882	14,372	397,497	691,751	0.18	124,417	3,547,313
19	279,882	14,946	428,847	723,676	0.16	118,327	3,665,640
20	279,882	21,547	458,120	759,549	0.15	112,902	3,778,542
21	279,882	22,409	482,944	785,234	0.14	106,109	3,884,651
22	279,882	23,305	517,971	821,158	0.12	100,876	3,985,527
23	279,882	24,237	548,520	852,639	0.11	95,221	4,080,749
24	279,882	25,207	586,273	891,361	0.10	90,496	4,171,245
25	279,882	26,215	619,353	925,450	0.09	85,415	4,256,660
26	279,882	27,264	663,890	971,035	0.08	81,475	4,338,135
27	279,882	28,354	710,216	1,018,452	0.08	77,685	4,415,820
28	279,882	29,488	762,459	1,071,829	0.07	74,324	4,490,144
29	279,882	30,668	801,688	1,112,237	0.06	70,115	4,560,259
30	279,882	31,894	869,076	1,180,853	0.06	67,673	4,627,932
31	279,882	33,170	927,758	1,240,810	0.05	64,645	4,692,577
32	279,882	34,497	988,767	1,303,146	0.05	61,720	4,754,297
33	279,882	35,877	1,056,762	1,372,521	0.04	59,096	4,813,393
34	279,882	37,312	1,127,464	1,444,658	0.04	56,548	4,869,941
35	279,882	38,804	1,200,964	1,519,650	0.04	54,075	4,924,016

Life Cycle PV Cost **4,924,000**

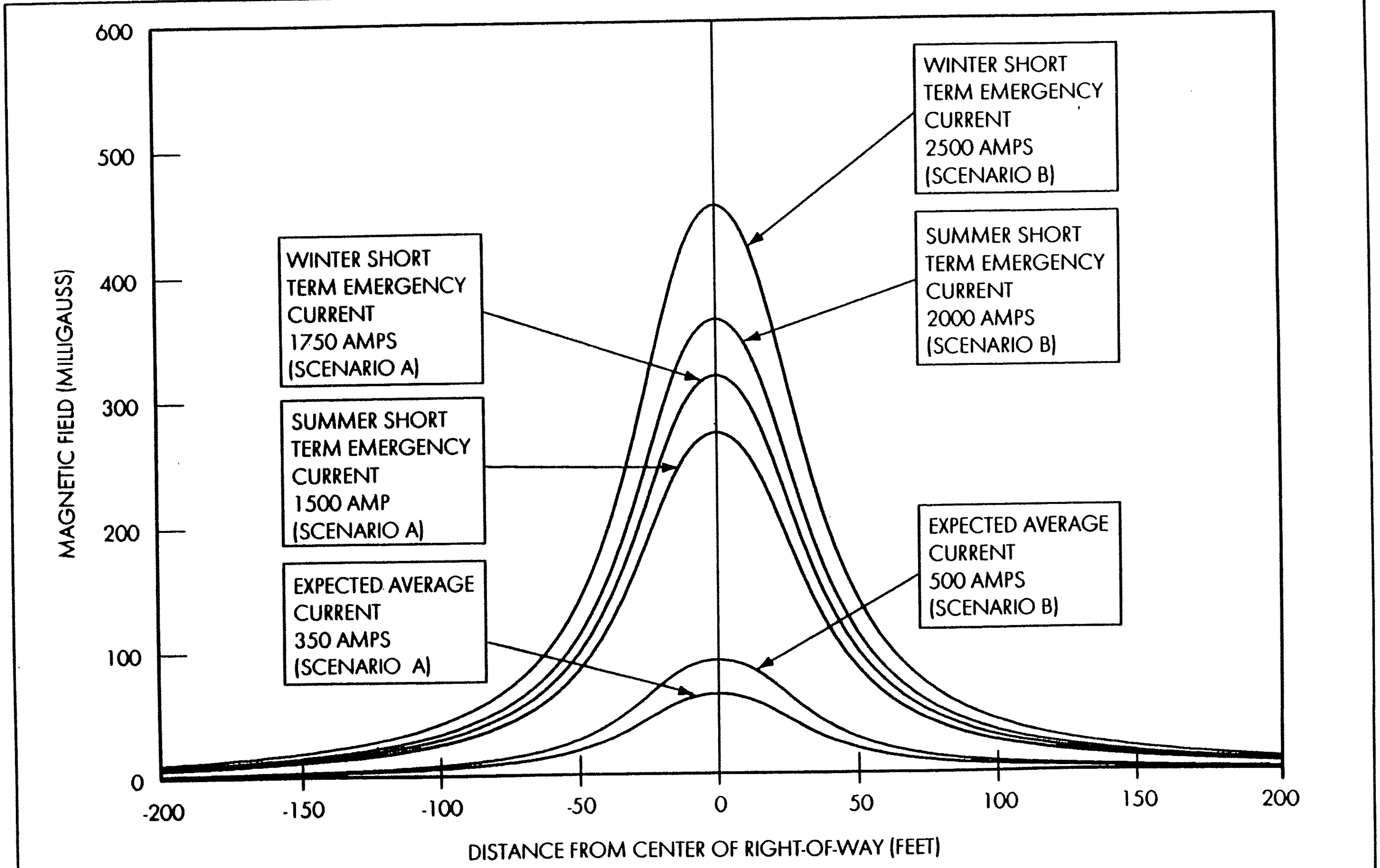
Life Cycle Cost Analysis
Overhead Single-circuit H-Frame (5 Miles, Scenario B: 1272 kcmil)

			FC rate		Fixed cost
Construction	2,040,000	x	0.146	=	297,840
Land	0				0
Total					297,840

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

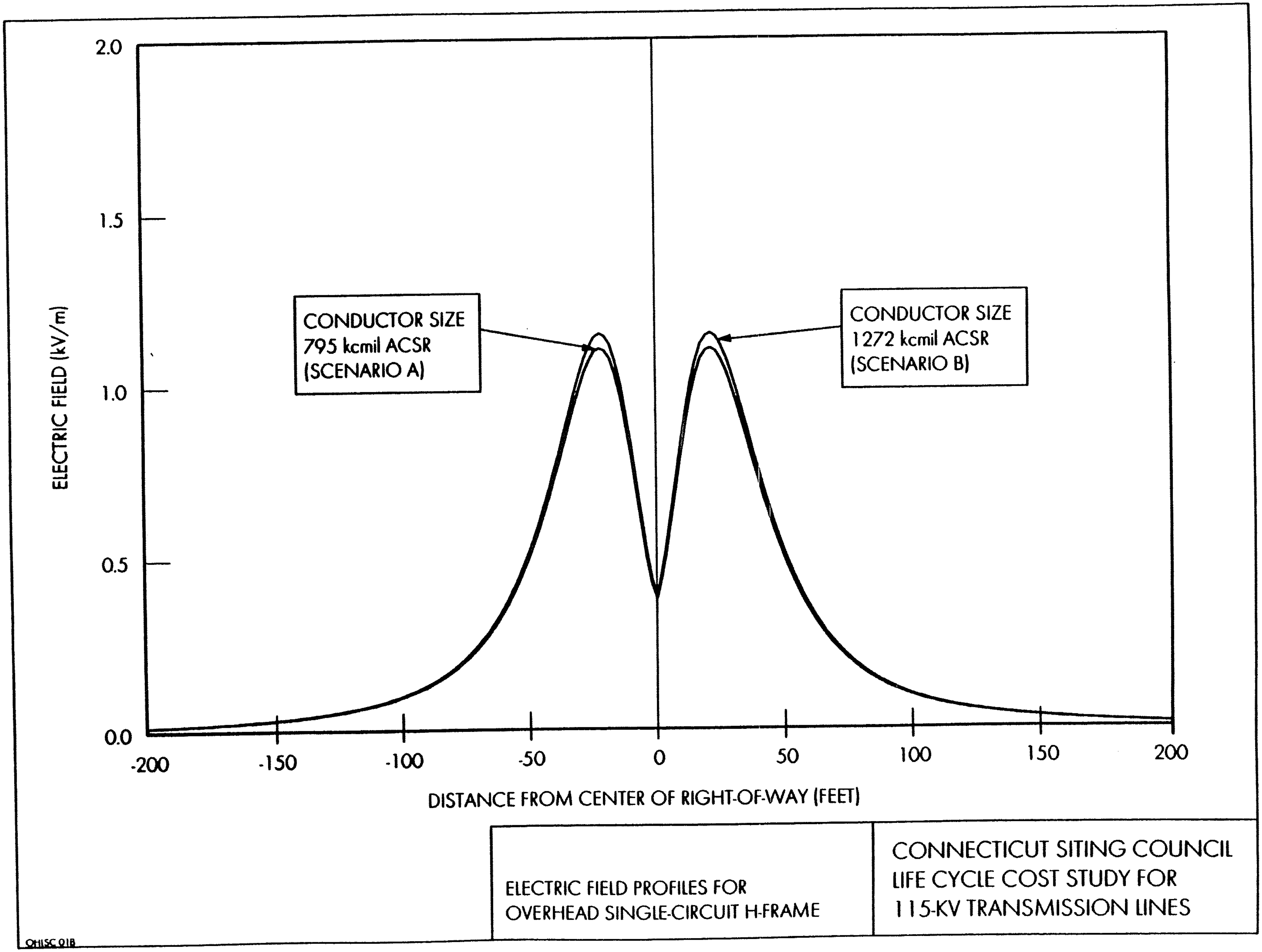
Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	297,840	10,042	76,902	384,784	0.91	349,803	349,803
2	297,840	6,980	87,509	392,330	0.83	324,239	674,043
3	297,840	7,260	98,584	403,684	0.75	303,294	977,336
4	297,840	7,550	100,964	406,355	0.68	277,546	1,254,882
5	297,840	7,852	115,936	421,628	0.62	261,798	1,516,680
6	297,840	8,166	128,362	434,368	0.56	245,190	1,761,869
7	297,840	8,493	141,321	447,654	0.51	229,717	1,991,586
8	297,840	8,833	181,403	488,076	0.47	227,691	2,219,277
9	297,840	9,186	199,572	506,597	0.42	214,847	2,434,124
10	297,840	9,553	218,512	525,905	0.39	202,759	2,636,883
11	297,840	9,935	245,481	553,256	0.35	193,913	2,830,796
12	297,840	10,333	355,284	663,457	0.32	211,398	3,042,194
13	297,840	10,746	375,239	683,825	0.29	198,080	3,240,274
14	297,840	11,176	395,950	704,966	0.26	185,640	3,425,913
15	297,840	12,776	427,911	738,527	0.24	176,797	3,602,711
16	297,840	13,287	474,476	785,604	0.22	170,970	3,773,681
17	297,840	13,819	509,427	821,086	0.20	162,448	3,936,128
18	297,840	14,372	530,272	842,484	0.18	151,528	4,087,657
19	297,840	14,946	572,095	884,881	0.16	144,685	4,232,342
20	297,840	21,547	611,146	930,532	0.15	138,318	4,370,659
21	297,840	22,409	644,260	964,509	0.14	130,335	4,500,994
22	297,840	23,305	690,988	1,012,133	0.12	124,336	4,625,331
23	297,840	24,237	731,741	1,053,818	0.11	117,689	4,743,019
24	297,840	25,207	782,104	1,105,151	0.10	112,201	4,855,220
25	297,840	26,215	826,234	1,150,289	0.09	106,167	4,961,387
26	297,840	27,264	885,648	1,210,751	0.08	101,589	5,062,976
27	297,840	28,354	947,449	1,273,643	0.08	97,151	5,160,126
28	297,840	29,488	1,017,141	1,344,470	0.07	93,230	5,253,356
29	297,840	30,668	1,069,474	1,397,982	0.06	88,128	5,341,484
30	297,840	31,894	1,159,372	1,489,107	0.06	85,339	5,426,823
31	297,840	33,170	1,237,655	1,568,666	0.05	81,725	5,508,548
32	297,840	34,497	1,319,043	1,651,380	0.05	78,213	5,586,762
33	297,840	35,877	1,409,750	1,743,467	0.04	75,068	5,661,830
34	297,840	37,312	1,504,068	1,839,220	0.04	71,992	5,733,821
35	297,840	38,804	1,602,119	1,938,764	0.04	68,989	5,802,811

Life Cycle PV Cost **5,803,000**



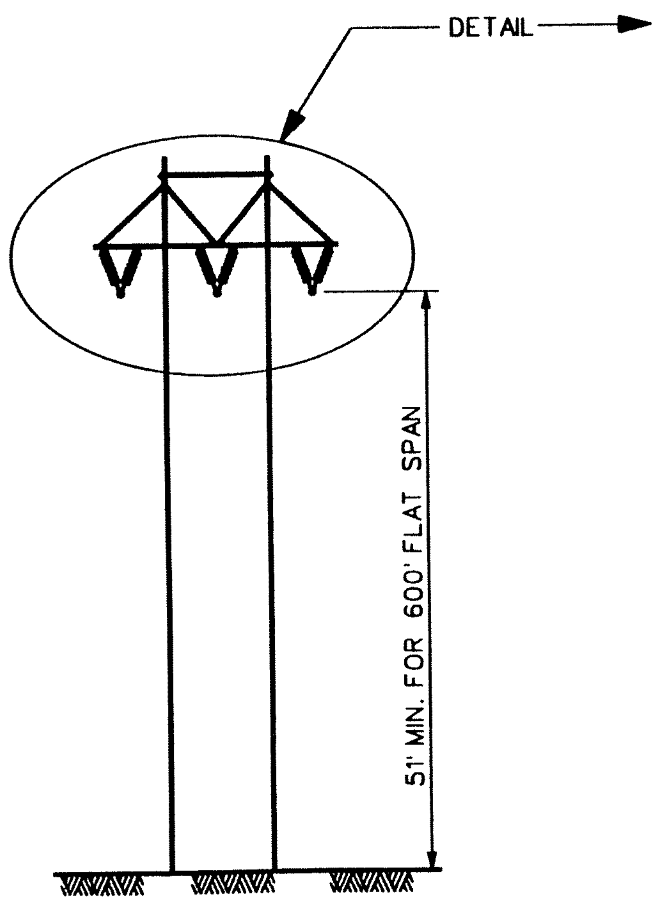
MAGNETIC FIELD PROFILES FOR OVERHEAD SINGLE-CIRCUIT H-FRAME

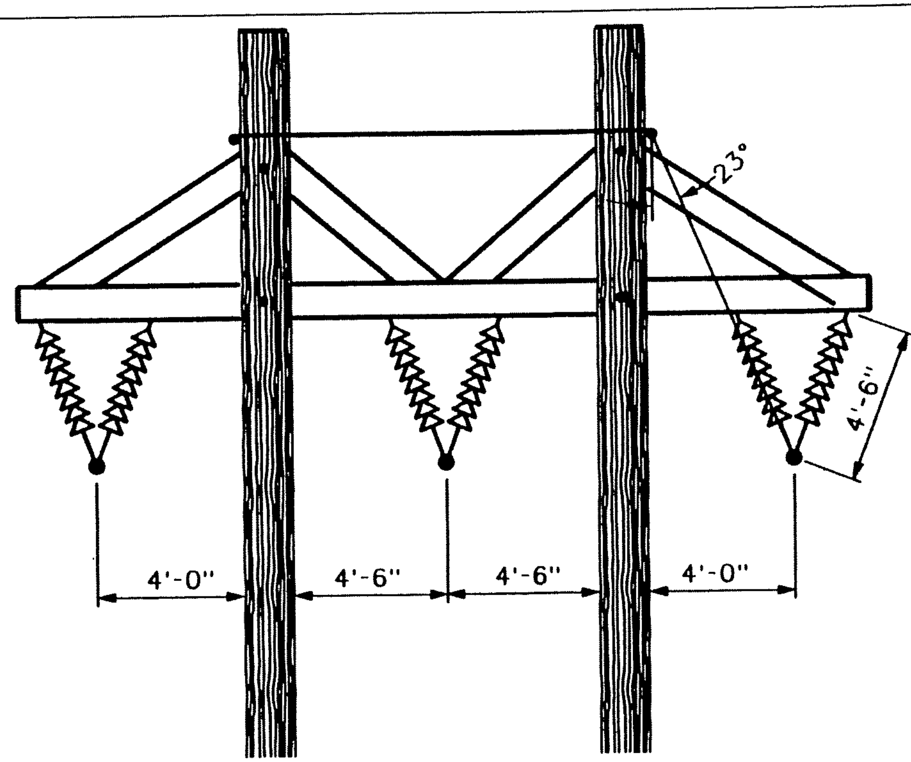
CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES



ELECTRIC FIELD PROFILES FOR
OVERHEAD SINGLE-CIRCUIT H-FRAME

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES





CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

OVERHEAD SINGLE-CIRCUIT H-FRAME
WITH COMPACT SPACING

Construction Cost Estimates
Overhead Single-circuit H-Frame with compact spacing

<u>Base costs</u>

Per Mile Base		
Scenario A 795 kcmil	$362,022	(a)
Scenario B 1272 kcmil	$386,675	(a)
Per Project Base		
Terminal equipment (Scenario A)	$40,953	(b)
Terminal equipment (Scenario B)	$40,953	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

<u>Adders</u>

Per Mile Adder		
Urban location	$207,000	(d)
Per Project Adder		
Winter construction	$6,000	(e)

<u>Base Case - Scenario A</u>

First cost	5 miles, rural, summer work	$1,969,000	5x(a) +(b)+(c)
Life cycle cost		$4,997,000	

<u>Base Case - Scenario B</u>

First cost	5 miles, rural, summer work	$2,092,000	5x(a) +(b)+(c)
Life cycle cost		$5,876,000	

<u>Notes:</u>

1) Base case is for a single circuit line installed in a rural environment.

Life Cycle Cost Analysis
Overhead Single-circuit H-Frame with Compact Spacing (5 Miles, Scenario A: 795 kcmil)

			FC rate		Fixed cost
Construction	1,969,000	x	0.146	=	287,474
Land	0				0
Total					287,474

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	287,474	10,042	57,646	355,162	0.91	322,875	322,875
2	287,474	6,980	65,598	360,052	0.83	297,564	620,438
3	287,474	7,260	73,900	368,633	0.75	276,960	897,398
4	287,474	7,550	75,684	370,708	0.68	253,199	1,150,597
5	287,474	7,852	86,906	382,233	0.62	237,336	1,387,933
6	287,474	8,166	96,221	391,862	0.56	221,196	1,609,129
7	287,474	8,493	105,935	401,902	0.51	206,239	1,815,368
8	287,474	8,833	135,982	432,288	0.47	201,666	2,017,034
9	287,474	9,186	149,601	446,261	0.42	189,258	2,206,292
10	287,474	9,553	163,798	460,826	0.39	177,668	2,383,960
11	287,474	9,935	184,015	481,424	0.35	168,736	2,552,696
12	287,474	10,333	266,324	564,131	0.32	179,750	2,732,446
13	287,474	10,746	281,283	579,503	0.29	167,861	2,900,307
14	287,474	11,176	296,808	595,458	0.26	156,803	3,057,110
15	287,474	12,776	320,766	621,016	0.24	148,666	3,205,776
16	287,474	13,287	355,672	656,433	0.22	142,859	3,348,635
17	287,474	13,819	381,871	683,164	0.20	135,160	3,483,796
18	287,474	14,372	397,497	699,343	0.18	125,783	3,609,578
19	287,474	14,946	428,847	731,268	0.16	119,568	3,729,147
20	287,474	21,547	458,120	767,141	0.15	114,031	3,843,177
21	287,474	22,409	482,944	792,826	0.14	107,135	3,950,312
22	287,474	23,305	517,971	828,750	0.12	101,809	4,052,121
23	287,474	24,237	548,520	860,231	0.11	96,069	4,148,190
24	287,474	25,207	586,273	898,953	0.10	91,267	4,239,457
25	287,474	26,215	619,353	933,042	0.09	86,116	4,325,573
26	287,474	27,264	663,890	978,627	0.08	82,112	4,407,685
27	287,474	28,354	710,216	1,026,044	0.08	78,264	4,485,949
28	287,474	29,488	762,459	1,079,421	0.07	74,851	4,560,800
29	287,474	30,668	801,688	1,119,829	0.06	70,593	4,631,393
30	287,474	31,894	869,076	1,188,445	0.06	68,108	4,699,501
31	287,474	33,170	927,758	1,248,402	0.05	65,040	4,764,541
32	287,474	34,497	988,767	1,310,738	0.05	62,080	4,826,621
33	287,474	35,877	1,056,762	1,380,113	0.04	59,423	4,886,044
34	287,474	37,312	1,127,464	1,452,250	0.04	56,845	4,942,889
35	287,474	38,804	1,200,964	1,527,242	0.04	54,346	4,997,235

Life Cycle PV Cost **4,997,000**

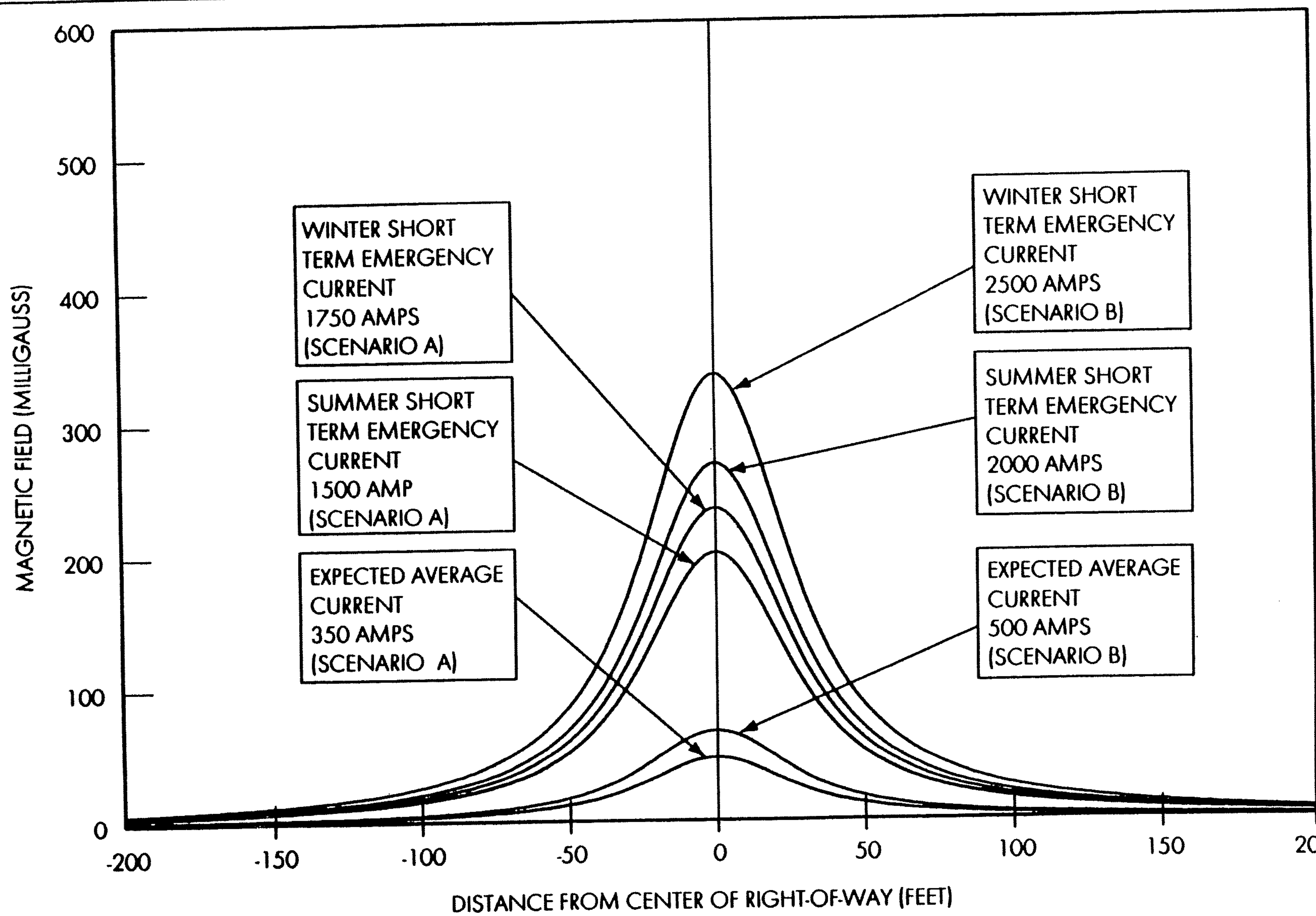
Life Cycle Cost Analysis
Overhead Single-circuit H-Frame with Compact Spacing (5 Miles, Scenario B: 1272 kcmil)

			FC rate		Fixed cost
Construction	2,092,000	x	0.146	=	305,432
Land	0				0
Total					305,432

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

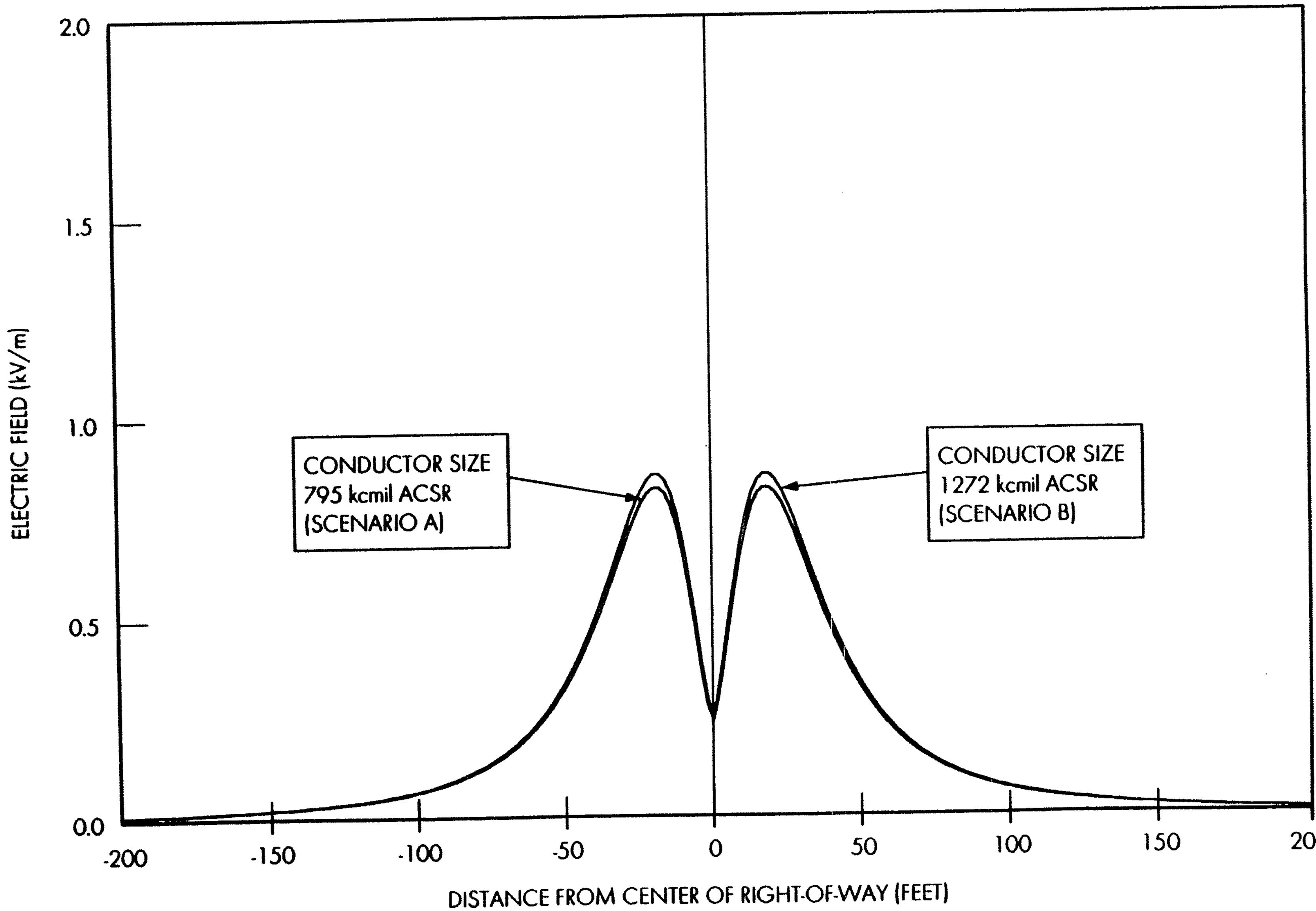
Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	305,432	10,042	76,902	392,376	0.91	356,705	356,705
2	305,432	6,980	87,509	399,922	0.83	330,514	687,219
3	305,432	7,260	98,584	411,276	0.75	308,998	996,217
4	305,432	7,550	100,964	413,947	0.68	282,731	1,278,948
5	305,432	7,852	115,936	429,220	0.62	266,512	1,545,459
6	305,432	8,166	128,362	441,960	0.56	249,475	1,794,934
7	305,432	8,493	141,321	455,246	0.51	233,613	2,028,547
8	305,432	8,833	181,403	495,668	0.47	231,233	2,259,780
9	305,432	9,186	199,572	514,189	0.42	218,067	2,477,846
10	305,432	9,553	218,512	533,497	0.39	205,686	2,683,533
11	305,432	9,935	245,481	560,848	0.35	196,574	2,880,106
12	305,432	10,333	355,284	671,049	0.32	213,817	3,093,923
13	305,432	10,746	375,239	691,417	0.29	200,279	3,294,202
14	305,432	11,176	395,950	712,558	0.26	187,639	3,481,841
15	305,432	12,776	427,911	746,119	0.24	178,615	3,660,456
16	305,432	13,287	474,476	793,196	0.22	172,623	3,833,079
17	305,432	13,819	509,427	828,678	0.20	163,950	3,997,028
18	305,432	14,372	530,272	850,076	0.18	152,894	4,149,922
19	305,432	14,946	572,095	892,473	0.16	145,926	4,295,848
20	305,432	21,547	611,146	938,124	0.15	139,446	4,435,294
21	305,432	22,409	644,260	972,101	0.14	131,361	4,566,655
22	305,432	23,305	690,988	1,019,725	0.12	125,269	4,691,924
23	305,432	24,237	731,741	1,061,410	0.11	118,536	4,810,460
24	305,432	25,207	782,104	1,112,743	0.10	112,972	4,923,432
25	305,432	26,215	826,234	1,157,881	0.09	106,868	5,030,300
26	305,432	27,264	885,648	1,218,343	0.08	102,226	5,132,526
27	305,432	28,354	947,449	1,281,235	0.08	97,730	5,230,255
28	305,432	29,488	1,017,141	1,352,062	0.07	93,756	5,324,012
29	305,432	30,668	1,069,474	1,405,574	0.06	88,607	5,412,618
30	305,432	31,894	1,159,372	1,496,699	0.06	85,774	5,498,392
31	305,432	33,170	1,237,655	1,576,258	0.05	82,121	5,580,513
32	305,432	34,497	1,319,043	1,658,972	0.05	78,573	5,659,086
33	305,432	35,877	1,409,750	1,751,059	0.04	75,395	5,734,481
34	305,432	37,312	1,504,068	1,846,812	0.04	72,289	5,806,770
35	305,432	38,804	1,602,119	1,946,356	0.04	69,259	5,876,029

Life Cycle PV Cost **5,876,000**



MAGNETIC FIELD PROFILES FOR OVERHEAD SINGLE-CIRCUIT H-FRAME WITH COMPACT SPACING

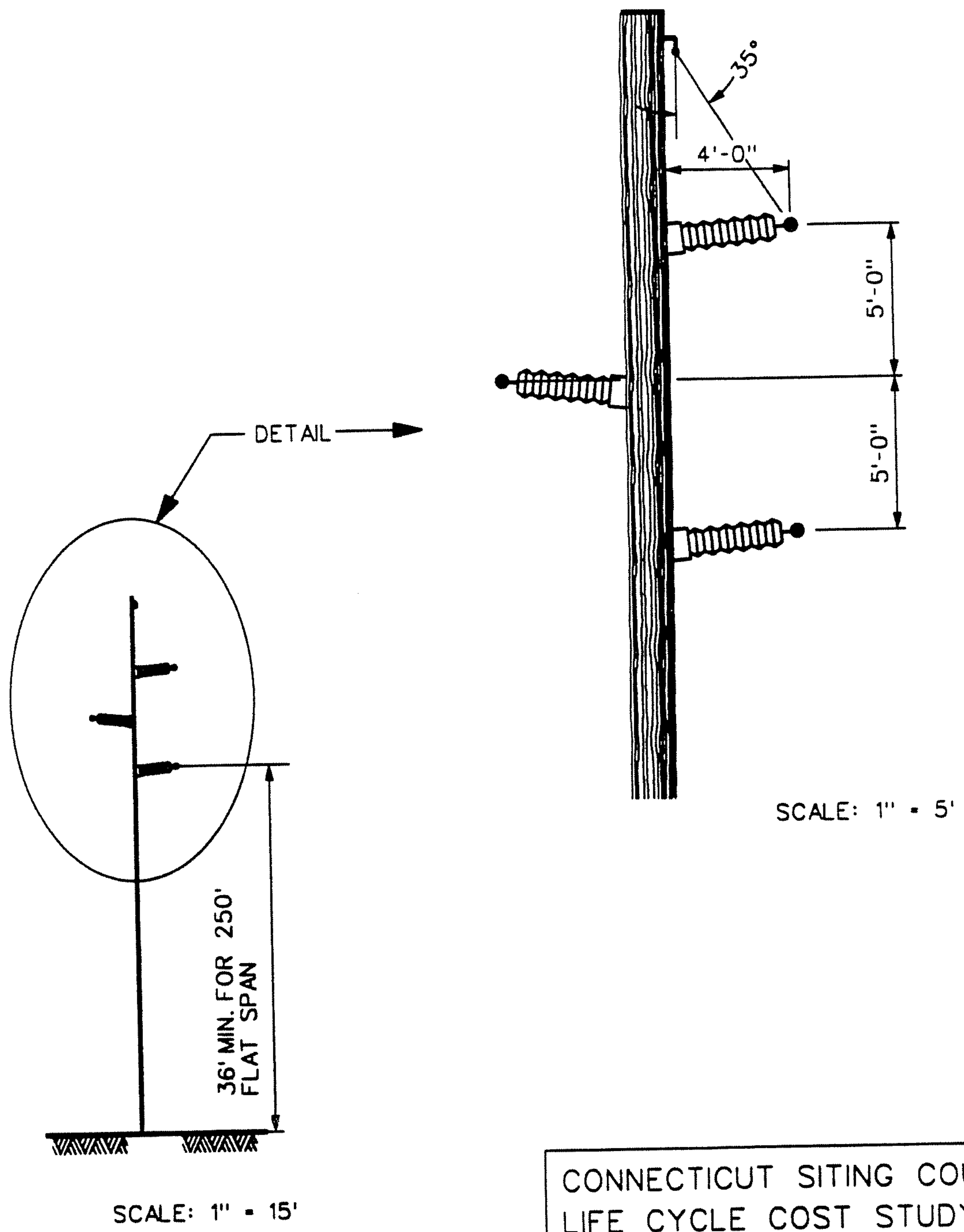
CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES



ELECTRIC FIELD PROFILES FOR OVERHEAD SINGLE-CIRCUIT H-FRAME WITH COMPACT SPACING

CONNECTICUT SITING COUNCIL LIFE CYCLE COST STUDY FOR 115-KV TRANSMISSION LINES

OHLSC 02B



CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

OVERHEAD SINGLE-CIRCUIT WOOD POLE
WITH COMPACT DELTA ARRANGEMENT

Construction Cost Estimates
Overhead Single-circuit Wood Pole with Compact Delta Arrangement

<u>Base costs</u>		
Per Mile Base		
Scenario A 795 kcmil	$372,659	(a)
Scenario B 1272 kcmil	$398,716	(a)
Per Project Base		
Terminal equipment (Scenario A)	$25,700	(b)
Terminal equipment (Scenario B)	$25,700	(b)
Regulatory Cost & Permit Fees	$118,000	(c)
<u>Adders</u>		
Per Mile Adder		
Urban location	$207,000	(d)
Per Project Adder		
Winter construction	$6,000	(e)

<u>Base Case - Scenario A</u>

First cost	5 miles, rural, summer work	$2,007,000	5x(a) +(b)+(c)
Life cycle cost		$5,055,000	

<u>Base Case - Scenario B</u>

First cost	5 miles, rural, summer work	$2,137,000	5x(a) +(b)+(c)
Life cycle cost		$5,944,000	

<u>Notes:</u>

1) Base case is for a single circuit line installed in a rural environment.

Life Cycle Cost Analysis
Overhead Single-circuit Wood Pole with Compact Delta Arrangement (5 Miles, Scenario A: 795 kcmil)

			FC rate		Fixed cost
Construction	2,007,000	x	0.146	=	293,022
Land	0				0
Total					293,022

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	293,022	14,585	57,646	365,253	0.91	332,048	332,048
2	293,022	6,934	65,598	365,553	0.83	302,110	634,159
3	293,022	7,211	73,900	374,133	0.75	281,091	915,250
4	293,022	7,499	75,684	376,205	0.68	256,953	1,172,203
5	293,022	7,799	86,906	387,728	0.62	240,749	1,412,952
6	293,022	8,111	96,221	397,355	0.56	224,296	1,637,248
7	293,022	8,436	105,935	407,393	0.51	209,057	1,846,305
8	293,022	8,773	135,982	437,777	0.47	204,226	2,050,532
9	293,022	9,124	149,601	451,747	0.42	191,585	2,242,116
10	293,022	9,489	163,798	466,310	0.39	179,783	2,421,899
11	293,022	9,869	184,015	486,906	0.35	170,657	2,592,556
12	293,022	10,264	266,324	569,610	0.32	181,495	2,774,052
13	293,022	10,674	281,283	584,979	0.29	169,448	2,943,499
14	293,022	11,101	296,808	600,931	0.26	158,244	3,101,743
15	293,022	12,917	320,766	626,704	0.24	150,028	3,251,771
16	293,022	13,433	355,672	662,127	0.22	144,098	3,395,869
17	293,022	13,971	381,871	688,864	0.20	136,288	3,532,157
18	293,022	14,529	397,497	705,049	0.18	126,809	3,658,967
19	293,022	15,111	428,847	736,980	0.16	120,502	3,779,469
20	293,022	21,724	458,120	772,866	0.15	114,882	3,894,350
21	293,022	22,593	482,944	798,558	0.14	107,910	4,002,260
22	293,022	23,496	517,971	834,489	0.12	102,514	4,104,774
23	293,022	24,436	548,520	865,978	0.11	96,711	4,201,484
24	293,022	25,414	586,273	904,708	0.10	91,851	4,293,335
25	293,022	26,430	619,353	938,805	0.09	86,648	4,379,983
26	293,022	27,487	663,890	984,399	0.08	82,596	4,462,580
27	293,022	28,587	710,216	1,031,825	0.08	78,705	4,541,285
28	293,022	29,730	762,459	1,085,211	0.07	75,252	4,616,537
29	293,022	30,920	801,688	1,125,629	0.06	70,959	4,687,496
30	293,022	32,156	869,076	1,194,255	0.06	68,441	4,755,937
31	293,022	33,443	927,758	1,254,223	0.05	65,343	4,821,281
32	293,022	34,780	988,767	1,316,569	0.05	62,356	4,883,637
33	293,022	36,172	1,056,762	1,385,955	0.04	59,675	4,943,311
34	293,022	37,618	1,127,464	1,458,104	0.04	57,074	5,000,385
35	293,022	39,123	1,200,964	1,533,109	0.04	54,554	5,054,940

Life Cycle PV Cost **5,055,000**

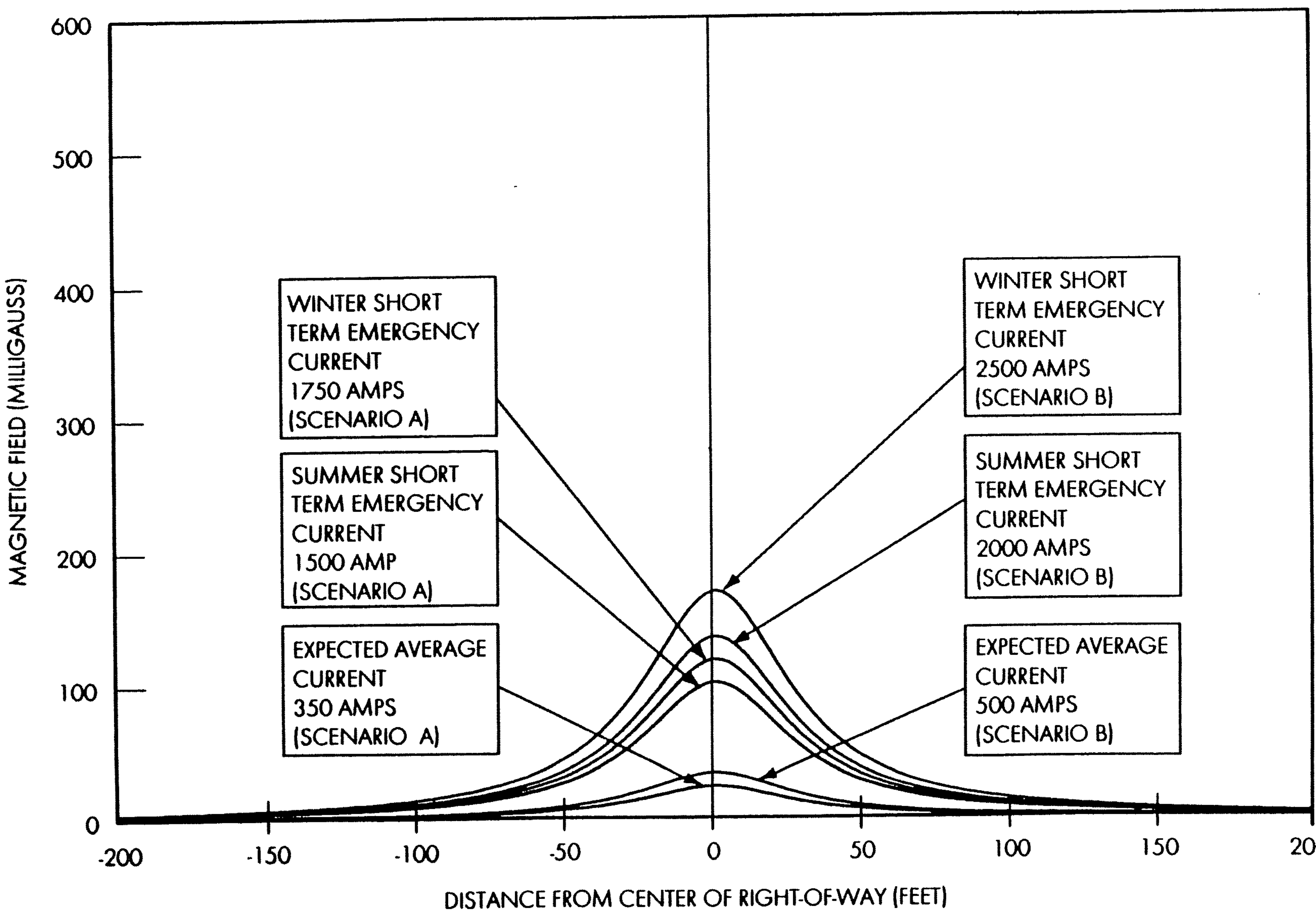
Life Cycle Cost Analysis
Overhead Single-circuit Wood Pole with Compact Delta Arrangement (5 Miles, Scenario B: 1272 kcmil)

			FC rate		Fixed cost
Construction	2,137,000	x	0.146	=	312,002
Land	0				0
Total					312,002

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	312,002	14,585	76,902	403,489	0.91	366,808	366,808
2	312,002	6,934	87,509	406,445	0.83	335,905	702,713
3	312,002	7,211	98,584	417,797	0.75	313,897	1,016,610
4	312,002	7,499	100,964	420,466	0.68	287,184	1,303,794
5	312,002	7,799	115,936	435,737	0.62	270,558	1,574,352
6	312,002	8,111	128,362	448,475	0.56	253,153	1,827,505
7	312,002	8,436	141,321	461,759	0.51	236,955	2,064,460
8	312,002	8,773	181,403	502,179	0.47	234,270	2,298,730
9	312,002	9,124	199,572	520,698	0.42	220,827	2,519,557
10	312,002	9,489	218,512	540,003	0.39	208,194	2,727,751
11	312,002	9,869	245,481	567,352	0.35	198,853	2,926,605
12	312,002	10,264	355,284	677,550	0.32	215,888	3,142,493
13	312,002	10,674	375,239	697,915	0.29	202,161	3,344,654
14	312,002	11,101	395,950	719,053	0.26	189,349	3,534,003
15	312,002	12,917	427,911	752,829	0.24	180,221	3,714,225
16	312,002	13,433	474,476	799,912	0.22	174,084	3,888,309
17	312,002	13,971	509,427	835,400	0.20	165,279	4,053,588
18	312,002	14,529	530,272	856,804	0.18	154,104	4,207,692
19	312,002	15,111	572,095	899,207	0.16	147,028	4,354,719
20	312,002	21,724	611,146	944,871	0.15	140,449	4,495,168
21	312,002	22,593	644,260	978,855	0.14	132,273	4,627,442
22	312,002	23,496	690,988	1,026,486	0.12	126,100	4,753,541
23	312,002	24,436	731,741	1,068,180	0.11	119,292	4,872,834
24	312,002	25,414	782,104	1,119,520	0.10	113,660	4,986,493
25	312,002	26,430	826,234	1,164,666	0.09	107,494	5,093,988
26	312,002	27,487	885,648	1,225,137	0.08	102,796	5,196,783
27	312,002	28,587	947,449	1,288,037	0.08	98,249	5,295,032
28	312,002	29,730	1,017,141	1,358,874	0.07	94,229	5,389,261
29	312,002	30,920	1,069,474	1,412,396	0.06	89,037	5,478,297
30	312,002	32,156	1,159,372	1,503,531	0.06	86,165	5,564,462
31	312,002	33,443	1,237,655	1,583,100	0.05	82,477	5,646,940
32	312,002	34,780	1,319,043	1,665,825	0.05	78,898	5,725,837
33	312,002	36,172	1,409,750	1,757,924	0.04	75,690	5,801,528
34	312,002	37,618	1,504,068	1,853,689	0.04	72,558	5,874,086
35	312,002	39,123	1,602,119	1,953,244	0.04	69,504	5,943,590

Life Cycle PV Cost **5,944,000**



MAGNETIC FIELD PROFILES FOR OVERHEAD SINGLE-CIRCUIT WOOD POLE WITH DELTA ARRANGEMENT

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES

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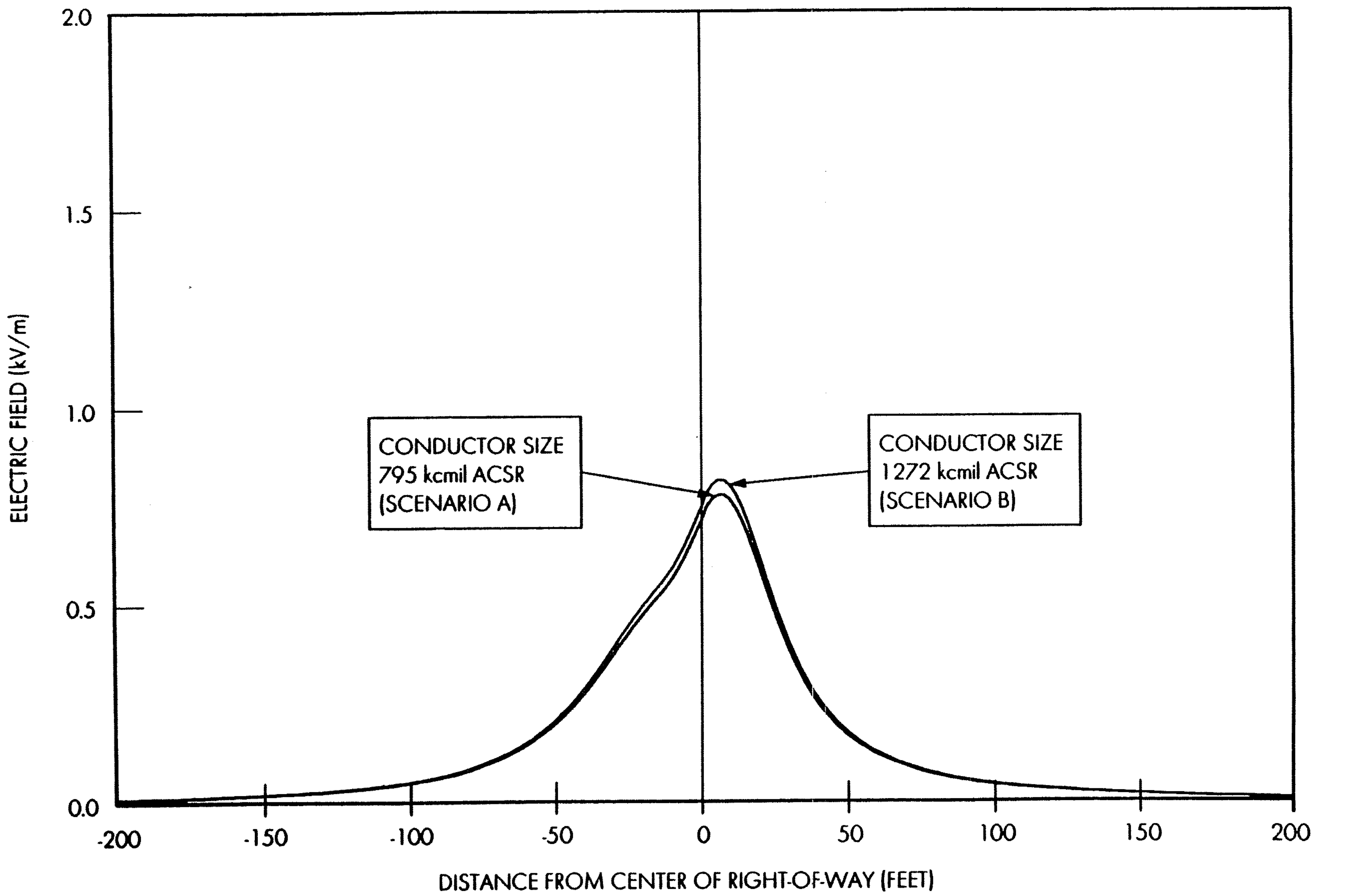

ELECTRIC FIELD PROFILES FOR OVERHEAD SINGLE-CIRCUIT WOOD POLE WITH DELTA ARRANGEMENT

CONNECTICUT SITING COUNCIL LIFE CYCLE COST STUDY FOR 115-KV TRANSMISSION LINES

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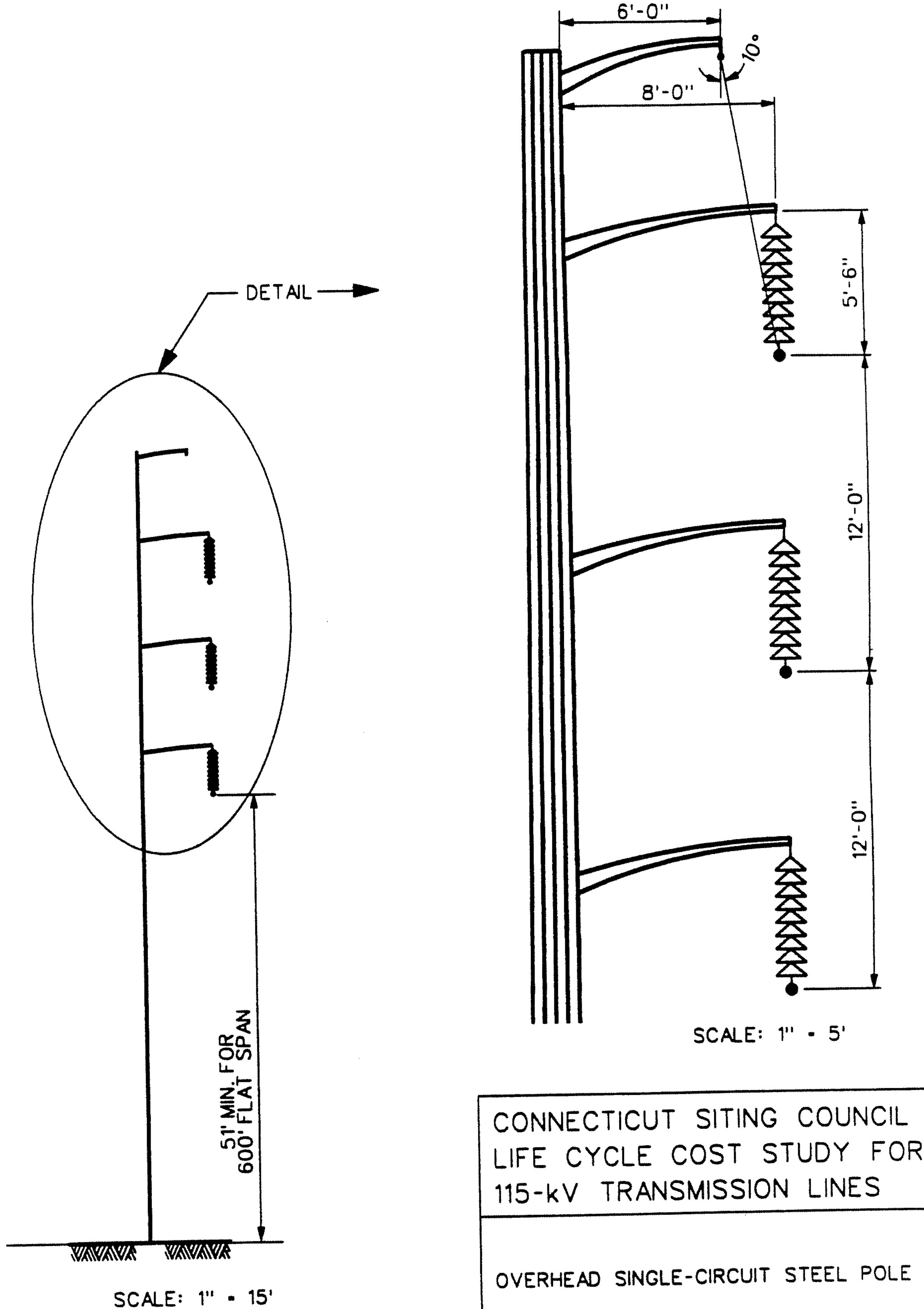


CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

OVERHEAD SINGLE-CIRCUIT STEEL POLE

Construction Cost Estimates
Overhead Single-circuit Steel Pole

Base costs

Per Mile Base		
Scenario A 795 kcmil	$464,962	(a)
Scenario B 1272 kcmil	$496,314	(a)
Per Project Base		
Terminal equipment (Scenario A)	$57,933	(b)
Terminal equipment (Scenario B)	$60,540	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder		
Urban location	$207,000	(d)
Per Project Adder		
Winter construction	$6,000	(e)

Base Case - Scenario A

First cost	5 miles, rural, summer work	$2,501,000	5x(a) +(b)+(c)
Life cycle cost		$5,734,000	

Base Case - Scenario B

First cost	5 miles, rural, summer work	$2,660,000	5x(a) +(b)+(c)
Life cycle cost		$6,663,000	

Notes:
1) Base case is for a single circuit line installed in a rural environment.

Life Cycle Cost Analysis
Overhead Single-circuit Steel Pole (5 Miles, Scenario A: 795 kcmil)

			FC rate		Fixed cost
Construction	2,501,000	x	0.146	=	365,146
Land	0				0
Total					365,146

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	365,146	14,638	57,646	437,430	0.91	397,664	397,664
2	365,146	6,566	65,598	437,309	0.83	361,413	759,076
3	365,146	6,828	73,900	445,874	0.75	334,992	1,094,068
4	365,146	7,101	75,684	447,931	0.68	305,943	1,400,011
5	365,146	7,385	86,906	459,438	0.62	285,275	1,685,286
6	365,146	7,681	96,221	469,048	0.56	264,765	1,950,051
7	365,146	7,988	105,935	479,069	0.51	245,838	2,195,889
8	365,146	8,307	135,982	509,435	0.47	237,655	2,433,545
9	365,146	8,640	149,601	523,387	0.42	221,967	2,655,512
10	365,146	8,985	163,798	537,930	0.39	207,395	2,862,907
11	365,146	9,345	184,015	558,506	0.35	195,753	3,058,660
12	365,146	9,719	266,324	641,189	0.32	204,303	3,262,962
13	365,146	10,107	281,283	656,536	0.29	190,175	3,453,137
14	365,146	10,512	296,808	672,466	0.26	177,081	3,630,218
15	365,146	10,932	320,766	696,844	0.24	166,819	3,797,037
16	365,146	11,369	355,672	732,187	0.22	159,345	3,956,383
17	365,146	11,824	381,871	758,842	0.20	150,133	4,106,515
18	365,146	12,297	397,497	774,940	0.18	139,380	4,245,895
19	365,146	12,789	428,847	806,782	0.16	131,915	4,377,811
20	365,146	13,301	458,120	836,567	0.15	124,350	4,502,161
21	365,146	13,833	482,944	861,922	0.14	116,472	4,618,633
22	365,146	14,386	517,971	897,503	0.12	110,255	4,728,888
23	365,146	14,961	548,520	928,627	0.11	103,707	4,832,595
24	365,146	15,560	586,273	966,978	0.10	98,173	4,930,768
25	365,146	16,182	619,353	1,000,681	0.09	92,359	5,023,127
26	365,146	16,829	663,890	1,045,865	0.08	87,754	5,110,881
27	365,146	17,503	710,216	1,092,865	0.08	83,361	5,194,242
28	365,146	18,203	762,459	1,145,807	0.07	79,454	5,273,696
29	365,146	18,931	801,688	1,185,765	0.06	74,750	5,348,446
30	365,146	25,302	869,076	1,259,524	0.06	72,181	5,420,627
31	365,146	26,314	927,758	1,319,218	0.05	68,730	5,489,357
32	365,146	27,366	988,767	1,381,279	0.05	65,421	5,554,778
33	365,146	28,461	1,056,762	1,450,369	0.04	62,448	5,617,226
34	365,146	29,599	1,127,464	1,522,209	0.04	59,583	5,676,809
35	365,146	30,783	1,200,964	1,596,893	0.04	56,824	5,733,633

Life Cycle PV Cost **5,734,000**

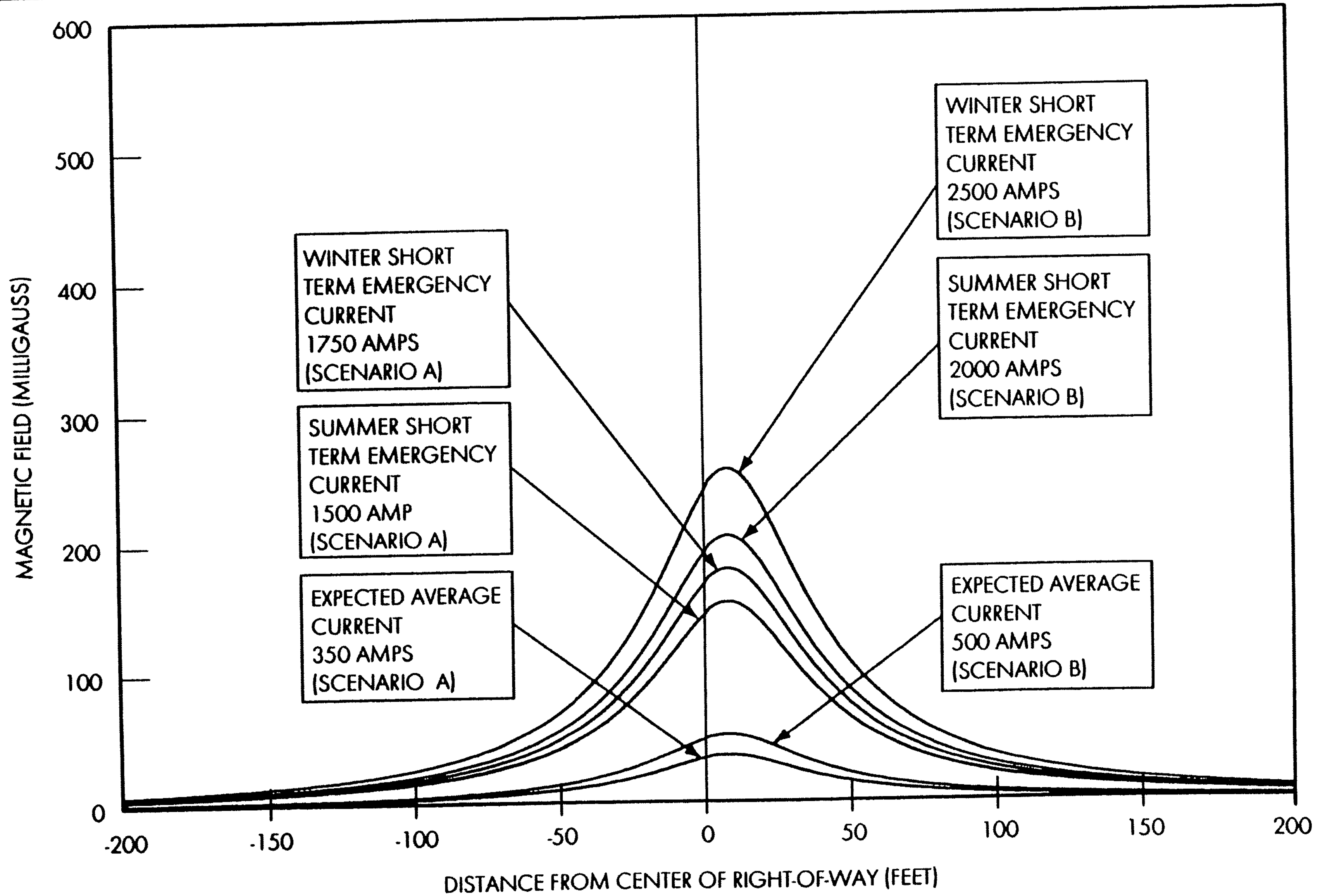
Life Cycle Cost Analysis
Overhead Single-circuit Steel Pole (5 Miles, Scenario B: 1272 kcmil)

			FC rate		Fixed cost
Construction	2,660,000	x	0.146	=	388,360
Land	0				0
Total					388,360

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	388,360	14,638	76,902	479,900	0.91	436,272	436,272
2	388,360	6,566	87,509	482,435	0.83	398,706	834,979
3	388,360	6,828	98,584	493,772	0.75	370,978	1,205,957
4	388,360	7,101	100,964	496,426	0.68	339,065	1,545,023
5	388,360	7,385	115,936	511,681	0.62	317,714	1,862,736
6	388,360	7,681	128,362	524,403	0.56	296,012	2,158,748
7	388,360	7,988	141,321	537,669	0.51	275,909	2,434,657
8	388,360	8,307	181,403	578,071	0.47	269,674	2,704,331
9	388,360	8,640	199,572	596,571	0.42	253,004	2,957,336
10	388,360	8,985	218,512	615,857	0.39	237,439	3,194,775
11	388,360	9,345	245,481	643,186	0.35	225,433	3,420,208
12	388,360	9,719	355,284	753,363	0.32	240,045	3,660,252
13	388,360	10,107	375,239	773,706	0.29	224,115	3,884,368
14	388,360	10,512	395,950	794,822	0.26	209,301	4,093,669
15	388,360	10,932	427,911	827,203	0.24	198,026	4,291,695
16	388,360	11,369	474,476	874,206	0.22	190,253	4,481,948
17	388,360	11,824	509,427	909,611	0.20	179,962	4,661,909
18	388,360	12,297	530,272	930,930	0.18	167,436	4,829,345
19	388,360	12,789	572,095	973,244	0.16	159,133	4,988,478
20	388,360	13,301	611,146	1,012,806	0.15	150,547	5,139,025
21	388,360	13,833	644,260	1,046,453	0.14	141,408	5,280,433
22	388,360	14,386	690,988	1,093,733	0.12	134,361	5,414,794
23	388,360	14,961	731,741	1,135,063	0.11	126,762	5,541,556
24	388,360	15,560	782,104	1,186,024	0.10	120,412	5,661,967
25	388,360	16,182	826,234	1,230,776	0.09	113,596	5,775,563
26	388,360	16,829	885,648	1,290,837	0.08	108,308	5,883,871
27	388,360	17,503	947,449	1,353,311	0.08	103,227	5,987,099
28	388,360	18,203	1,017,141	1,423,704	0.07	98,724	6,085,823
29	388,360	18,931	1,069,474	1,476,765	0.06	93,094	6,178,918
30	388,360	25,302	1,159,372	1,573,034	0.06	90,148	6,269,066
31	388,360	26,314	1,237,655	1,652,329	0.05	86,084	6,355,150
32	388,360	27,366	1,319,043	1,734,769	0.05	82,163	6,437,313
33	388,360	28,461	1,409,750	1,826,571	0.04	78,646	6,515,959
34	388,360	29,599	1,504,068	1,922,028	0.04	75,233	6,591,192
35	388,360	30,783	1,602,119	2,021,263	0.04	71,925	6,663,117

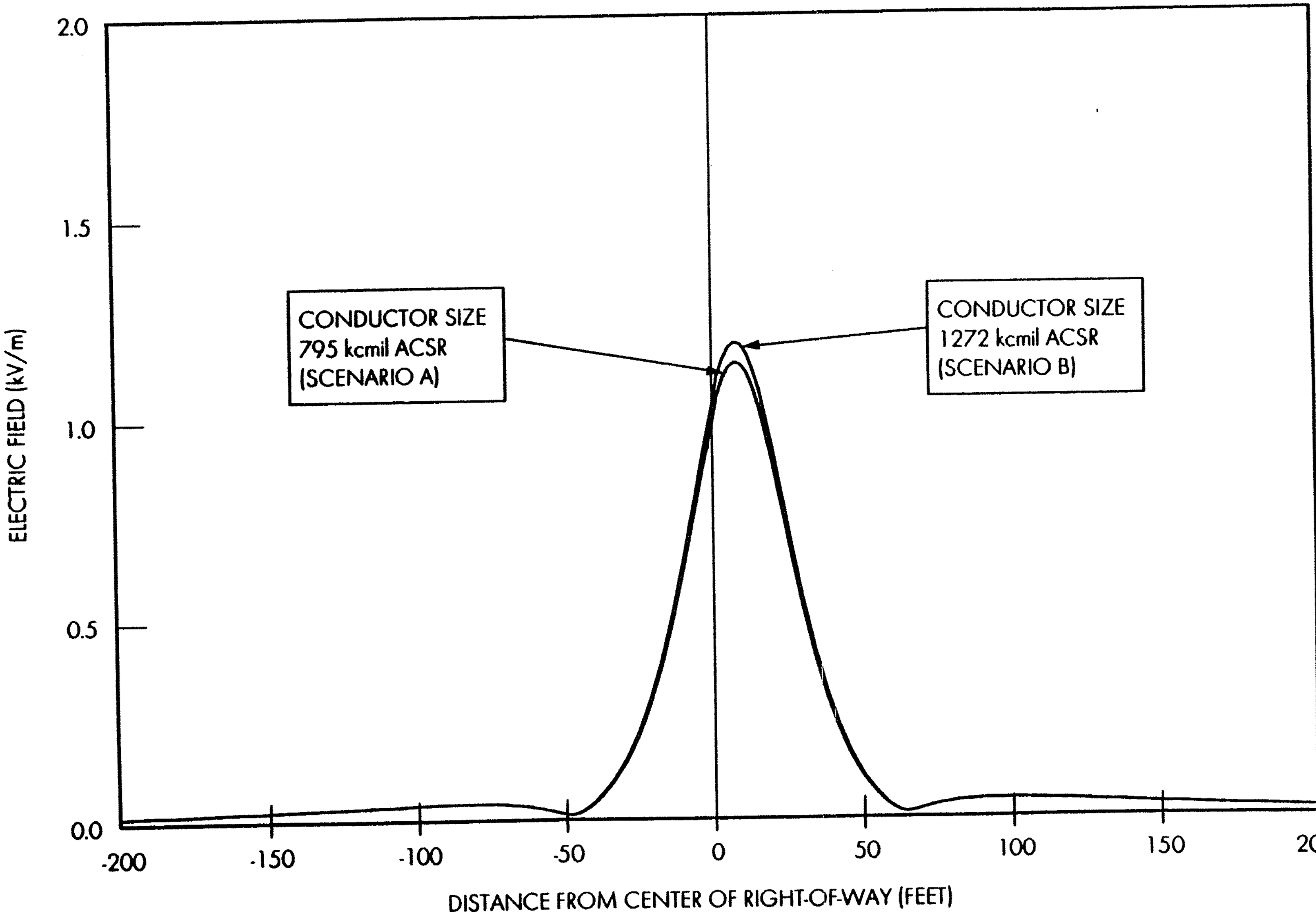
Life Cycle PV Cost **6,663,000**



MAGNETIC FIELD PROFILES FOR OVERHEAD SINGLE-CIRCUIT STEEL POLE

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES

OHLSC 04



ELECTRIC FIELD PROFILES FOR
OVERHEAD SINGLE-CIRCUIT
STEEL POLE

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES

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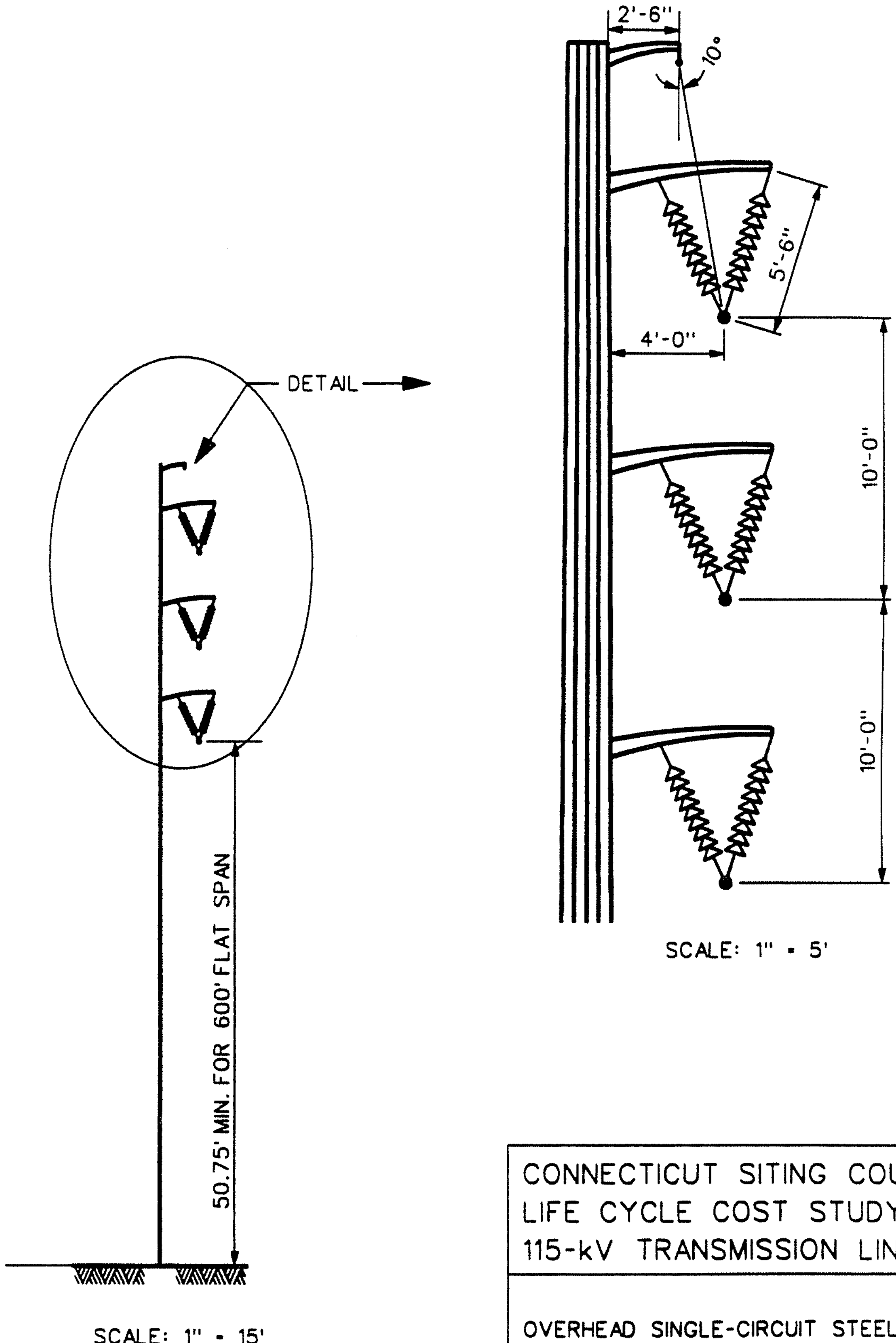


CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

OVERHEAD SINGLE-CIRCUIT STEEL POLE
WITH COMPACT SPACING

Construction Cost Estimates
Overhead Single-circuit Steel Pole with Compact Spacing

Base costs

Per Mile Base		
Scenario A 795 kcmil	$468,904	(a)
Scenario B 1272 kcmil	$500,492	(a)
Per Project Base		
Terminal equipment (Scenario A)	$54,989	(b)
Terminal equipment (Scenario B)	$58,254	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder		
Urban location	$207,000	(d)
Per Project Adder		
Winter construction	$6,000	(e)

Base Case - Scenario A

First cost	5 miles, rural, summer work	$2,518,000	5x(a) +(b)+(c)
Life cycle cost		$5,758,000	

Base Case - Scenario B

First cost	5 miles, rural, summer work	$2,679,000	5x(a) +(b)+(c)
Life cycle cost		$6,690,000	

Notes:
1) Base case is for a single circuit line installed in a rural environment.

Life Cycle Cost Analysis
Overhead Single-circuit Steel Pole with Compact Spacing (5 Miles, Scenario A: 795 kcmil)

			FC rate		Fixed cost
Construction	2,518,000	x	0.146	=	367,628
Land	0				0
Total					367,628

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	367,628	14,638	57,646	439,912	0.91	399,920	399,920
2	367,628	6,566	65,598	439,791	0.83	363,464	763,384
3	367,628	6,828	73,900	448,356	0.75	336,856	1,100,240
4	367,628	7,101	75,684	450,413	0.68	307,638	1,407,879
5	367,628	7,385	86,906	461,920	0.62	286,816	1,694,694
6	367,628	7,681	96,221	471,530	0.56	266,166	1,960,861
7	367,628	7,988	105,935	481,551	0.51	247,112	2,207,973
8	367,628	8,307	135,982	511,917	0.47	238,813	2,446,786
9	367,628	8,640	149,601	525,869	0.42	223,020	2,669,805
10	367,628	8,985	163,798	540,412	0.39	208,352	2,878,158
11	367,628	9,345	184,015	560,988	0.35	196,623	3,074,780
12	367,628	9,719	266,324	643,671	0.32	205,093	3,279,874
13	367,628	10,107	281,283	659,018	0.29	190,894	3,470,768
14	367,628	10,512	296,808	674,948	0.26	177,735	3,648,503
15	367,628	10,932	320,766	699,326	0.24	167,413	3,815,916
16	367,628	11,369	355,672	734,669	0.22	159,885	3,975,801
17	367,628	11,824	381,871	761,324	0.20	150,624	4,126,425
18	367,628	12,297	397,497	777,422	0.18	139,826	4,266,251
19	367,628	12,789	428,847	809,264	0.16	132,321	4,398,572
20	367,628	13,301	458,120	839,049	0.15	124,719	4,523,292
21	367,628	13,833	482,944	864,404	0.14	116,807	4,640,099
22	367,628	14,386	517,971	899,985	0.12	110,559	4,750,659
23	367,628	14,961	548,520	931,109	0.11	103,985	4,854,643
24	367,628	15,560	586,273	969,460	0.10	98,425	4,953,068
25	367,628	16,182	619,353	1,003,163	0.09	92,588	5,045,656
26	367,628	16,829	663,890	1,048,347	0.08	87,962	5,133,618
27	367,628	17,503	710,216	1,095,347	0.08	83,551	5,217,169
28	367,628	18,203	762,459	1,148,289	0.07	79,626	5,296,795
29	367,628	18,931	801,688	1,188,247	0.06	74,906	5,371,701
30	367,628	25,302	869,076	1,262,006	0.06	72,324	5,444,025
31	367,628	26,314	927,758	1,321,700	0.05	68,859	5,512,884
32	367,628	27,366	988,767	1,383,761	0.05	65,538	5,578,422
33	367,628	28,461	1,056,762	1,452,851	0.04	62,555	5,640,977
34	367,628	29,599	1,127,464	1,524,691	0.04	59,680	5,700,657
35	367,628	30,783	1,200,964	1,599,375	0.04	56,912	5,757,570

Life Cycle PV Cost **5,758,000**

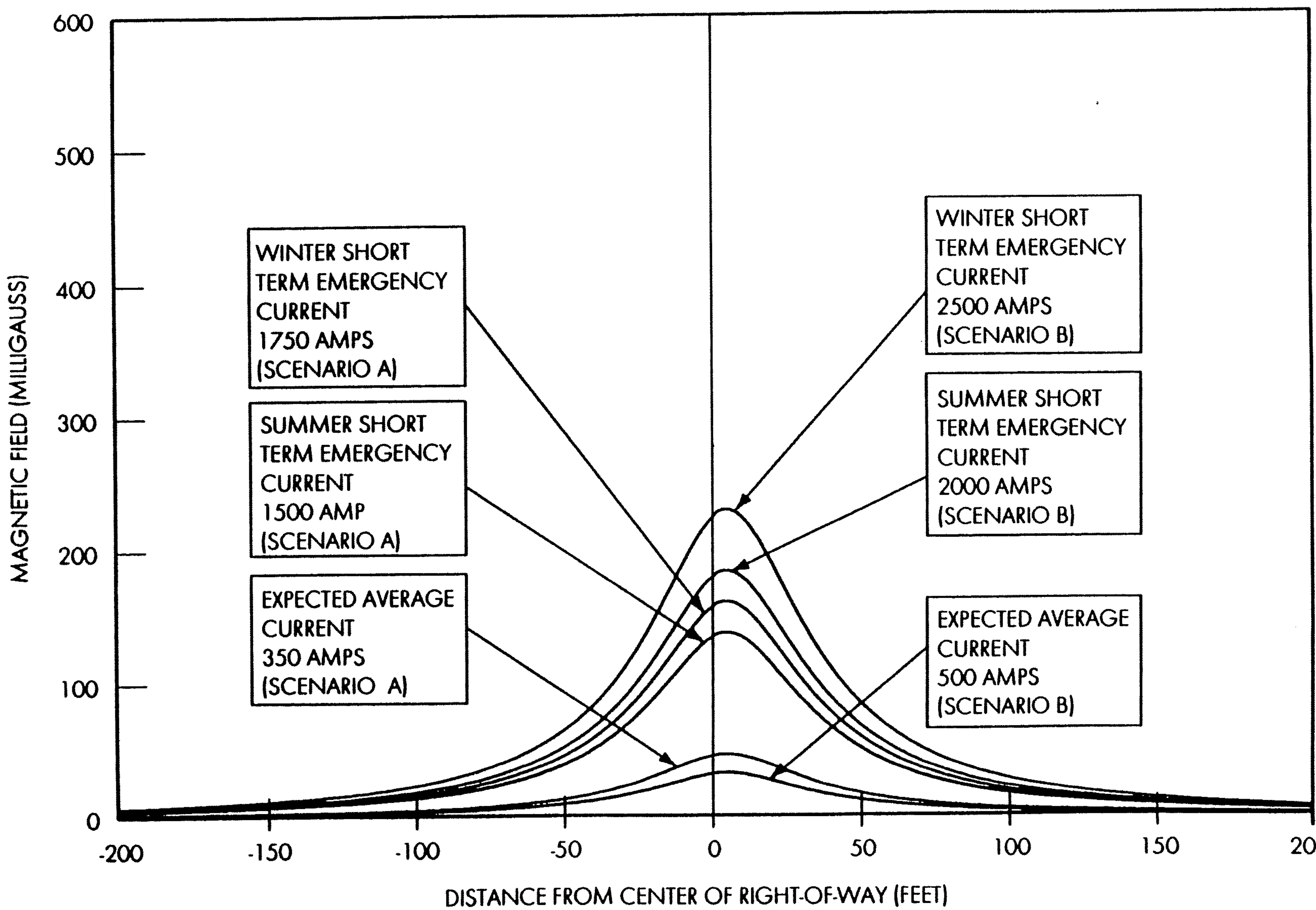
Life Cycle Cost Analysis
Overhead Single-circuit Steel Pole with Compact Spacing (5 Miles, Scenario B: 1272 kcmil)

			FC rate		Fixed cost
Construction	2,679,000	x	0.146	=	391,134
Land	0				0
Total					391,134

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	391,134	14,638	76,902	482,674	0.91	438,794	438,794
2	391,134	6,566	87,509	485,209	0.83	400,999	839,793
3	391,134	6,828	98,584	496,546	0.75	373,063	1,212,856
4	391,134	7,101	100,964	499,200	0.68	340,960	1,553,816
5	391,134	7,385	115,936	514,455	0.62	319,436	1,873,252
6	391,134	7,681	128,362	527,177	0.56	297,578	2,170,829
7	391,134	7,988	141,321	540,443	0.51	277,333	2,448,162
8	391,134	8,307	181,403	580,845	0.47	270,968	2,719,130
9	391,134	8,640	199,572	599,345	0.42	254,181	2,973,311
10	391,134	8,985	218,512	618,631	0.39	238,509	3,211,820
11	391,134	9,345	245,481	645,960	0.35	226,405	3,438,225
12	391,134	9,719	355,284	756,137	0.32	240,928	3,679,154
13	391,134	10,107	375,239	776,480	0.29	224,919	3,904,072
14	391,134	10,512	395,950	797,596	0.26	210,032	4,114,104
15	391,134	10,932	427,911	829,977	0.24	198,690	4,312,794
16	391,134	11,369	474,476	876,980	0.22	190,856	4,503,650
17	391,134	11,824	509,427	912,385	0.20	180,511	4,684,161
18	391,134	12,297	530,272	933,704	0.18	167,935	4,852,096
19	391,134	12,789	572,095	976,018	0.16	159,587	5,011,683
20	391,134	13,301	611,146	1,015,580	0.15	150,960	5,162,642
21	391,134	13,833	644,260	1,049,227	0.14	141,783	5,304,425
22	391,134	14,386	690,988	1,096,507	0.12	134,702	5,439,126
23	391,134	14,961	731,741	1,137,837	0.11	127,071	5,566,198
24	391,134	15,560	782,104	1,188,798	0.10	120,693	5,686,891
25	391,134	16,182	826,234	1,233,550	0.09	113,852	5,800,743
26	391,134	16,829	885,648	1,293,611	0.08	108,541	5,909,284
27	391,134	17,503	947,449	1,356,085	0.08	103,439	6,012,723
28	391,134	18,203	1,017,141	1,426,478	0.07	98,917	6,111,640
29	391,134	18,931	1,069,474	1,479,539	0.06	93,269	6,204,909
30	391,134	25,302	1,159,372	1,575,808	0.06	90,307	6,295,216
31	391,134	26,314	1,237,655	1,655,103	0.05	86,229	6,381,445
32	391,134	27,366	1,319,043	1,737,543	0.05	82,294	6,463,739
33	391,134	28,461	1,409,750	1,829,345	0.04	78,766	6,542,505
34	391,134	29,599	1,504,068	1,924,802	0.04	75,342	6,617,846
35	391,134	30,783	1,602,119	2,024,037	0.04	72,024	6,689,870

Life Cycle PV Cost **6,690,000**



MAGNETIC FIELD PROFILES FOR OVERHEAD SINGLE-CIRCUIT STEEL POLE WITH COMPACT SPACING

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES

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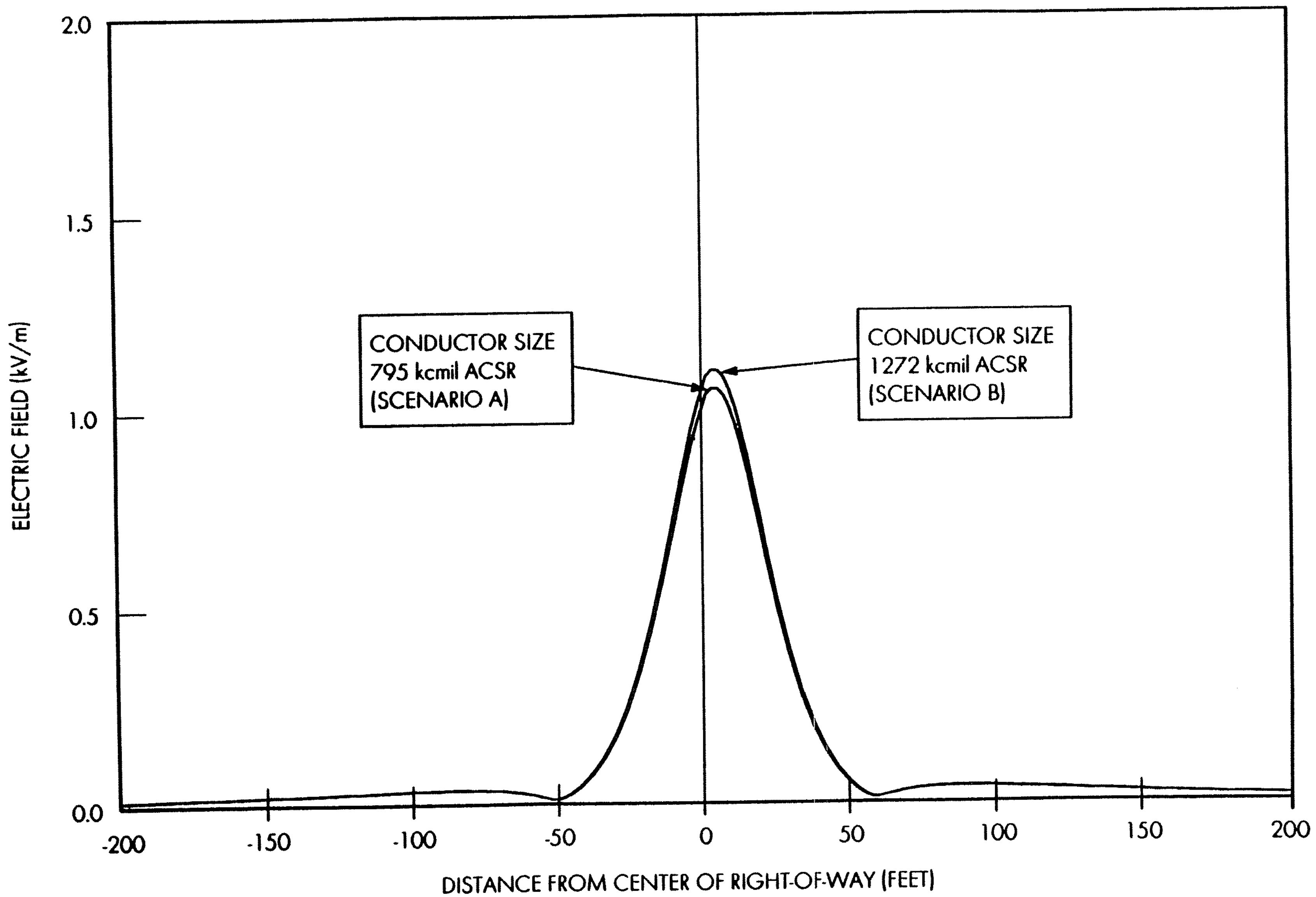

ELECTRIC FIELD PROFILES FOR OVERHEAD SINGLE-CIRCUIT STEEL POLE WITH COMPACT SPACING

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES

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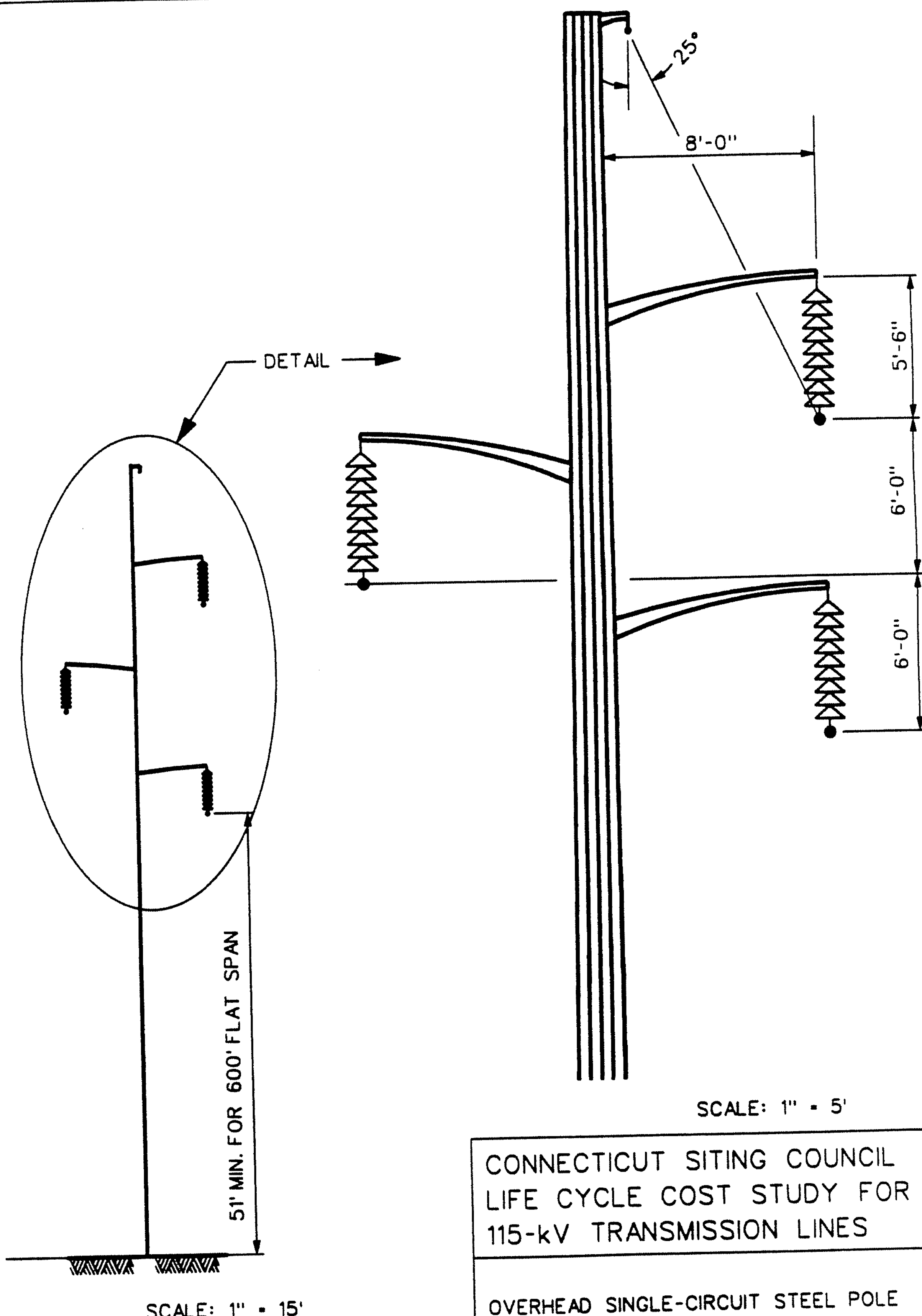


CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

OVERHEAD SINGLE-CIRCUIT STEEL POLE
WITH DELTA ARRANGEMENT

Construction Cost Estimates
Overhead Single-circuit Steel Pole with Delta Arrangement

<u>Base costs</u>		
Per Mile Base		
Scenario A 795 kcmil	$453,589	(a)
Scenario B 1272 kcmil	$484,017	(a)
Per Project Base		
Terminal equipment (Scenario A)	$54,989	(b)
Terminal equipment (Scenario B)	$57,275	(b)
Regulatory Cost & Permit Fees	$118,000	(c)
<u>Adders</u>		
Per Mile Adder		
Urban location	$207,000	(d)
Per Project Adder		
Winter construction	$6,000	(e)

<u>Base Case - Scenario A</u>

First cost	5 miles, rural, summer work	$2,441,000	5x(a) +(b)+(c)
Life cycle cost		$5,649,000	

<u>Base Case - Scenario B</u>

First cost	5 miles, rural, summer work	$2,595,000	5x(a) +(b)+(c)
Life cycle cost		$6,572,000	

<u>Notes:</u>

1) Base case is for a single circuit line installed in a rural environment.

Life Cycle Cost Analysis
Overhead Single-circuit Steel Pole with Delta Arrangement (5 Miles, Scenario A: 795 kcmil)

			FC rate		Fixed cost
Construction	2,441,000	x	0.146	=	356,386
Land	0				0
Total					356,386

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	356,386	14,638	57,646	428,670	0.91	389,700	389,700
2	356,386	6,566	65,598	428,549	0.83	354,173	743,873
3	356,386	6,828	73,900	437,114	0.75	328,410	1,072,283
4	356,386	7,101	75,684	439,171	0.68	299,960	1,372,243
5	356,386	7,385	86,906	450,678	0.62	279,835	1,652,078
6	356,386	7,681	96,221	460,288	0.56	259,821	1,911,899
7	356,386	7,988	105,935	470,309	0.51	241,343	2,153,242
8	356,386	8,307	135,982	500,675	0.47	233,569	2,386,811
9	356,386	8,640	149,601	514,627	0.42	218,252	2,605,063
10	356,386	8,985	163,798	529,170	0.39	204,018	2,809,080
11	356,386	9,345	184,015	549,746	0.35	192,682	3,001,763
12	356,386	9,719	266,324	632,429	0.32	201,511	3,203,274
13	356,386	10,107	281,283	647,776	0.29	187,638	3,390,912
14	356,386	10,512	296,808	663,706	0.26	174,774	3,565,686
15	356,386	10,932	320,766	688,084	0.24	164,722	3,730,408
16	356,386	11,369	355,672	723,427	0.22	157,439	3,887,847
17	356,386	11,824	381,871	750,082	0.20	148,400	4,036,247
18	356,386	12,297	397,497	766,180	0.18	137,804	4,174,051
19	356,386	12,789	428,847	798,022	0.16	130,483	4,304,534
20	356,386	13,301	458,120	827,807	0.15	123,048	4,427,582
21	356,386	13,833	482,944	853,162	0.14	115,288	4,542,870
22	356,386	14,386	517,971	888,743	0.12	109,178	4,652,049
23	356,386	14,961	548,520	919,867	0.11	102,729	4,754,778
24	356,386	15,560	586,273	958,218	0.10	97,284	4,852,062
25	356,386	16,182	619,353	991,921	0.09	91,550	4,943,612
26	356,386	16,829	663,890	1,037,105	0.08	87,019	5,030,631
27	356,386	17,503	710,216	1,084,105	0.08	82,693	5,113,324
28	356,386	18,203	762,459	1,137,047	0.07	78,847	5,192,170
29	356,386	18,931	801,688	1,177,005	0.06	74,198	5,266,368
30	356,386	25,302	869,076	1,250,764	0.06	71,679	5,338,048
31	356,386	26,314	927,758	1,310,458	0.05	68,273	5,406,321
32	356,386	27,366	988,767	1,372,519	0.05	65,006	5,471,327
33	356,386	28,461	1,056,762	1,441,609	0.04	62,071	5,533,398
34	356,386	29,599	1,127,464	1,513,449	0.04	59,240	5,592,638
35	356,386	30,783	1,200,964	1,588,133	0.04	56,512	5,649,150

Life Cycle PV Cost **5,649,000**

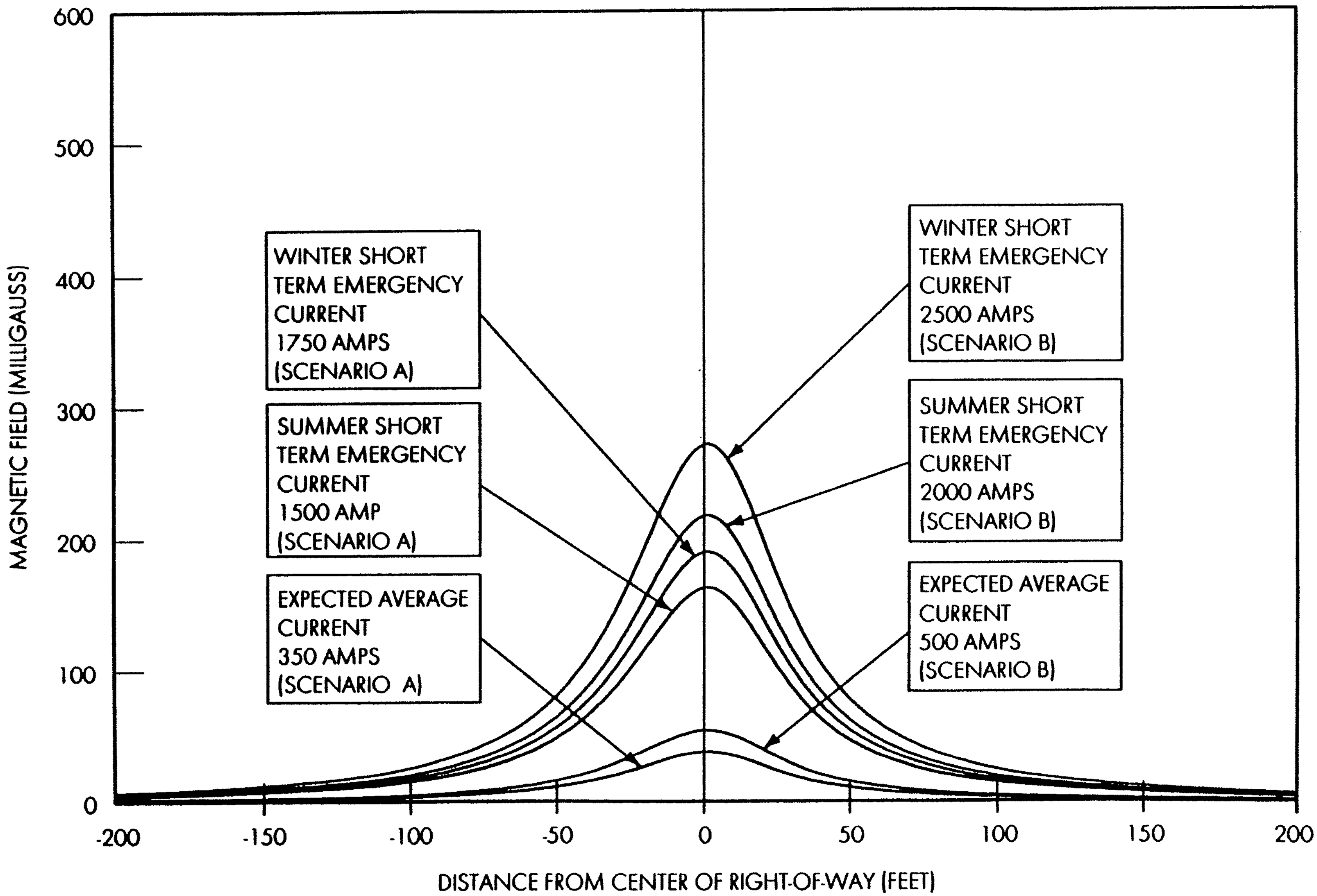
Life Cycle Cost Analysis
Overhead Single-circuit Steel Pole with Delta Arrangement (5 Miles, Scenario B: 1272 kcmil)

			FC rate		Fixed cost
Construction	2,595,000	x	0.146	=	378,870
Land	0				0
Total					378,870

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	378,870	14,638	76,902	470,410	0.91	427,645	427,645
2	378,870	6,566	87,509	472,945	0.83	390,863	818,508
3	378,870	6,828	98,584	484,282	0.75	363,849	1,182,357
4	378,870	7,101	100,964	486,936	0.68	332,584	1,514,941
5	378,870	7,385	115,936	502,191	0.62	311,821	1,826,762
6	378,870	7,681	128,362	514,913	0.56	290,655	2,117,417
7	378,870	7,988	141,321	528,179	0.51	271,039	2,388,456
8	378,870	8,307	181,403	568,581	0.47	265,247	2,653,703
9	378,870	8,640	199,572	587,081	0.42	248,980	2,902,683
10	378,870	8,985	218,512	606,367	0.39	233,781	3,136,463
11	378,870	9,345	245,481	633,696	0.35	222,106	3,358,570
12	378,870	9,719	355,284	743,873	0.32	237,021	3,595,591
13	378,870	10,107	375,239	764,216	0.29	221,366	3,816,957
14	378,870	10,512	395,950	785,332	0.26	206,802	4,023,759
15	378,870	10,932	427,911	817,713	0.24	195,754	4,219,513
16	378,870	11,369	474,476	864,716	0.22	188,187	4,407,701
17	378,870	11,824	509,427	900,121	0.20	178,084	4,585,785
18	378,870	12,297	530,272	921,440	0.18	165,729	4,751,514
19	378,870	12,789	572,095	963,754	0.16	157,581	4,909,095
20	378,870	13,301	611,146	1,003,316	0.15	149,137	5,058,232
21	378,870	13,833	644,260	1,036,963	0.14	140,125	5,198,357
22	378,870	14,386	690,988	1,084,243	0.12	133,195	5,331,552
23	378,870	14,961	731,741	1,125,573	0.11	125,702	5,457,254
24	378,870	15,560	782,104	1,176,534	0.10	119,448	5,576,702
25	378,870	16,182	826,234	1,221,286	0.09	112,720	5,689,422
26	378,870	16,829	885,648	1,281,347	0.08	107,512	5,796,934
27	378,870	17,503	947,449	1,343,821	0.08	102,504	5,899,438
28	378,870	18,203	1,017,141	1,414,214	0.07	98,066	5,997,504
29	378,870	18,931	1,069,474	1,467,275	0.06	92,496	6,090,000
30	378,870	25,302	1,159,372	1,563,544	0.06	89,604	6,179,605
31	378,870	26,314	1,237,655	1,642,839	0.05	85,590	6,265,194
32	378,870	27,366	1,319,043	1,725,279	0.05	81,713	6,346,908
33	378,870	28,461	1,409,750	1,817,081	0.04	78,238	6,425,145
34	378,870	29,599	1,504,068	1,912,538	0.04	74,862	6,500,007
35	378,870	30,783	1,602,119	2,011,773	0.04	71,587	6,571,594

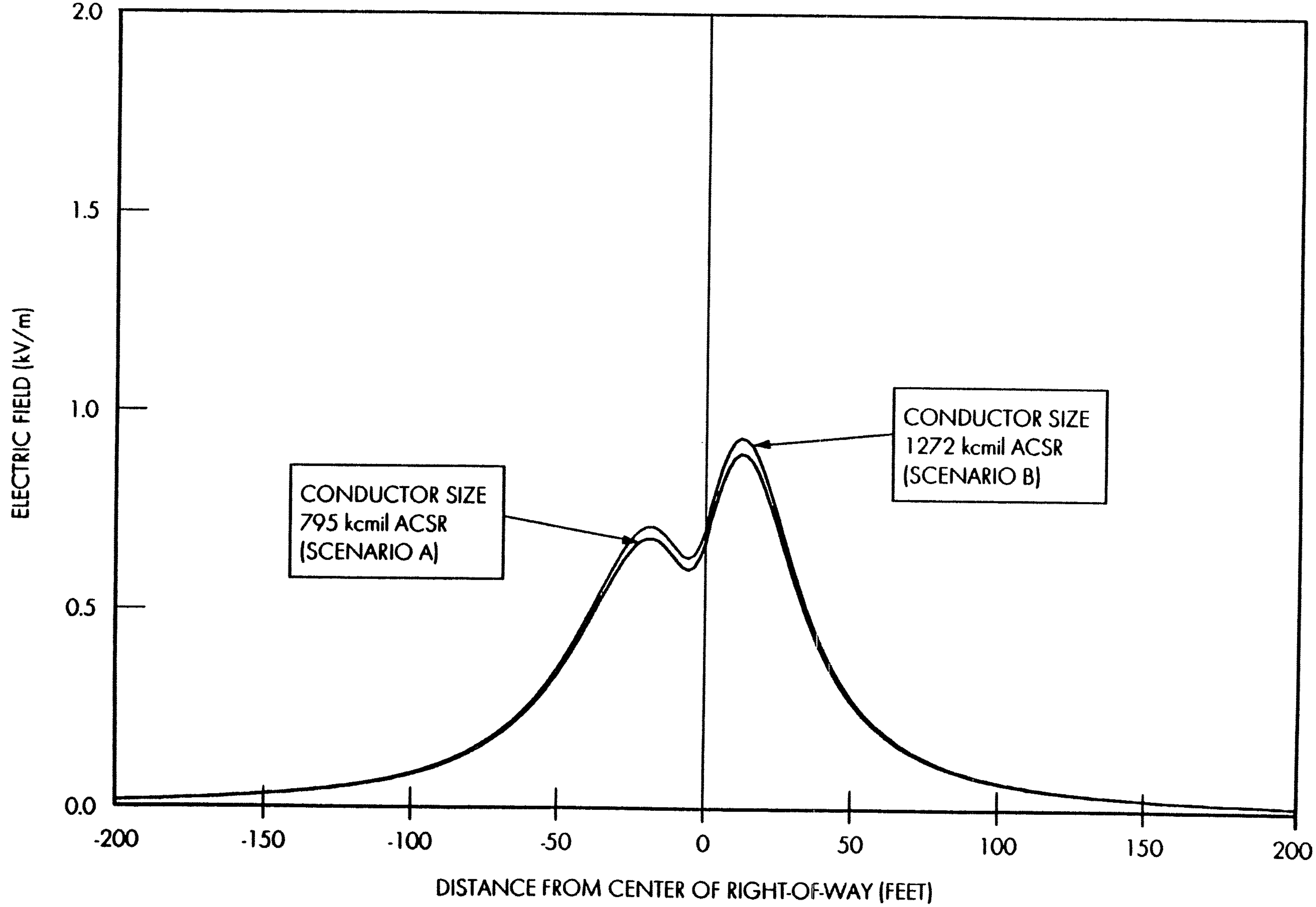
Life Cycle PV Cost **6,572,000**



MAGNETIC FIELD PROFILES FOR OVERHEAD SINGLE-CIRCUIT STEEL POLE WITH DELTA ARRANGEMENT

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES

OHLSC 06



ELECTRIC FIELD PROFILES FOR
OVERHEAD SINGLE-CIRCUIT STEEL POLE
WITH DELTA ARRAMGEMENT

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES

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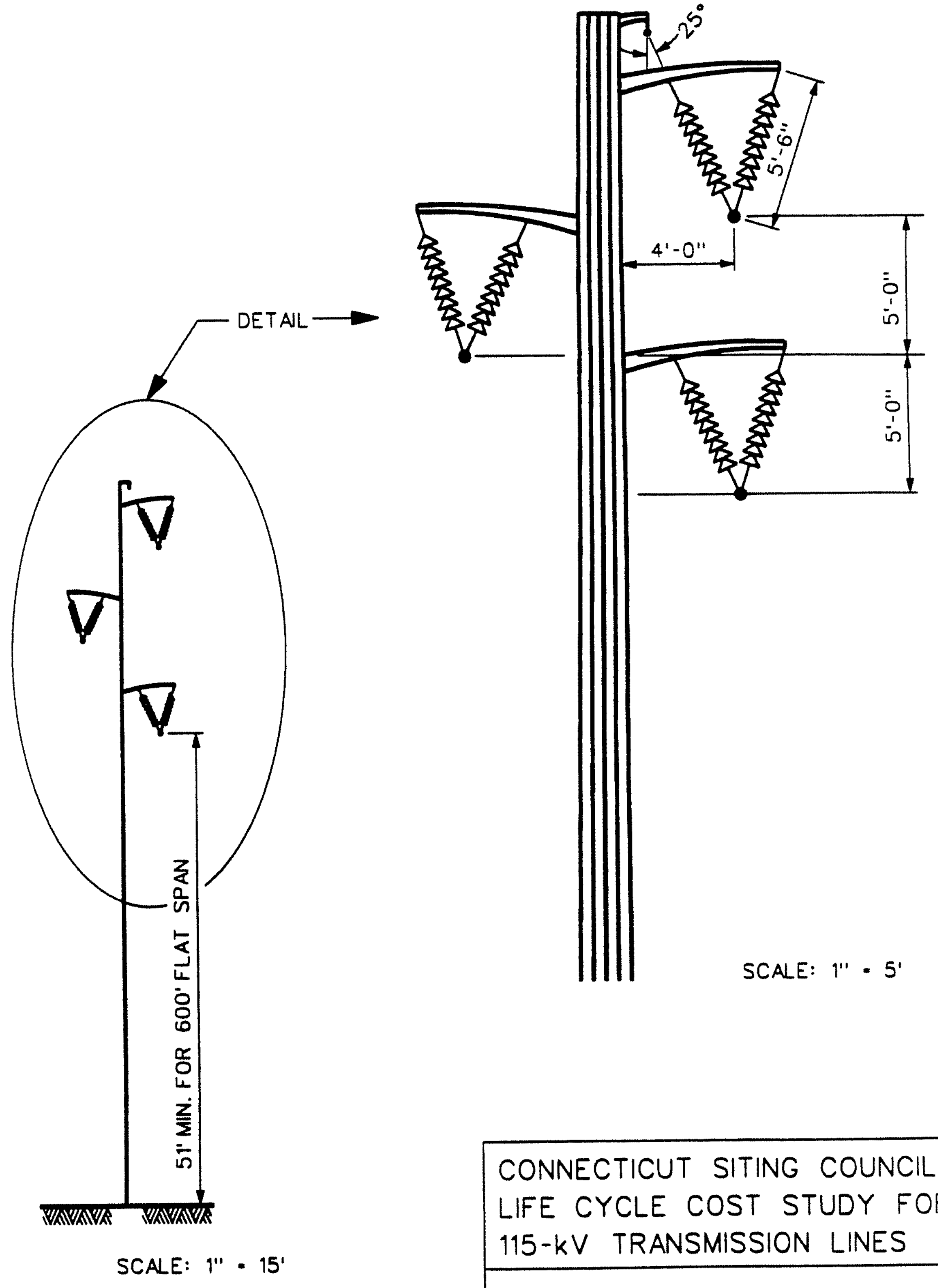


CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

OVERHEAD SINGLE-CIRCUIT STEEL POLE
WITH COMPACT SPACING
AND DELTA ARRANGEMENT

Construction Cost Estimates
Overhead Single-circuit Steel Pole with Compact Spacing and Delta Arrangement

Base costs

Per Mile Base		
Scenario A 795 kcmil	$452,828	(a)
Scenario B 1272 kcmil	$478,874	(a)
Per Project Base		
Terminal equipment (Scenario A)	$46,989	(b)
Terminal equipment (Scenario B)	$48,459	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder		
Urban location	$207,000	(d)
Per Project Adder		
Winter construction	$6,000	(e)

Base Case - Scenario A

First cost	5 miles, rural, summer work	$2,429,000	5x(a) +(b)+(c)
Life cycle cost		$5,632,000	

Base Case - Scenario B

First cost	5 miles, rural, summer work	$2,561,000	5x(a) +(b)+(c)
Life cycle cost		$6,524,000	

Notes:

1) Base case is for a single circuit line installed in a rural environment.

Life Cycle Cost Analysis
Overhead Single-circuit Steel Pole with Compact Spacing and Delta Arrangement
(5 Miles, Scenario A: 795 kcmil)

			FC rate		Fixed cost
Construction	2,429,000	x	0.146	=	354,634
Land	0				0
Total					354,634

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	354,634	14,638	57,646	426,918	0.91	388,107	388,107
2	354,634	6,566	65,598	426,797	0.83	352,725	740,832
3	354,634	6,828	73,900	435,362	0.75	327,094	1,067,926
4	354,634	7,101	75,684	437,419	0.68	298,763	1,366,689
5	354,634	7,385	86,906	448,926	0.62	278,748	1,645,437
6	354,634	7,681	96,221	458,536	0.56	258,832	1,904,269
7	354,634	7,988	105,935	468,557	0.51	240,444	2,144,713
8	354,634	8,307	135,982	498,923	0.47	232,751	2,377,464
9	354,634	8,640	149,601	512,875	0.42	217,509	2,594,973
10	354,634	8,985	163,798	527,418	0.39	203,342	2,798,315
11	354,634	9,345	184,015	547,994	0.35	192,068	2,990,383
12	354,634	9,719	266,324	630,677	0.32	200,953	3,191,337
13	354,634	10,107	281,283	646,024	0.29	187,130	3,378,467
14	354,634	10,512	296,808	661,954	0.26	174,313	3,552,780
15	354,634	10,932	320,766	686,332	0.24	164,302	3,717,082
16	354,634	11,369	355,672	721,675	0.22	157,058	3,874,140
17	354,634	11,824	381,871	748,330	0.20	148,053	4,022,193
18	354,634	12,297	397,497	764,428	0.18	137,489	4,159,682
19	354,634	12,789	428,847	796,270	0.16	130,197	4,289,879
20	354,634	13,301	458,120	826,055	0.15	122,788	4,412,666
21	354,634	13,833	482,944	851,410	0.14	115,052	4,527,718
22	354,634	14,386	517,971	886,991	0.12	108,963	4,636,681
23	354,634	14,961	548,520	918,115	0.11	102,533	4,739,215
24	354,634	15,560	586,273	956,466	0.10	97,106	4,836,320
25	354,634	16,182	619,353	990,169	0.09	91,389	4,927,709
26	354,634	16,829	663,890	1,035,353	0.08	86,872	5,014,581
27	354,634	17,503	710,216	1,082,353	0.08	82,559	5,097,140
28	354,634	18,203	762,459	1,135,295	0.07	78,725	5,175,865
29	354,634	18,931	801,688	1,175,253	0.06	74,087	5,249,953
30	354,634	25,302	869,076	1,249,012	0.06	71,579	5,321,532
31	354,634	26,314	927,758	1,308,706	0.05	68,182	5,389,714
32	354,634	27,366	988,767	1,370,767	0.05	64,923	5,454,636
33	354,634	28,461	1,056,762	1,439,857	0.04	61,996	5,516,632
34	354,634	29,599	1,127,464	1,511,697	0.04	59,172	5,575,804
35	354,634	30,783	1,200,964	1,586,381	0.04	56,450	5,632,254

Life Cycle PV Cost **5,632,000**

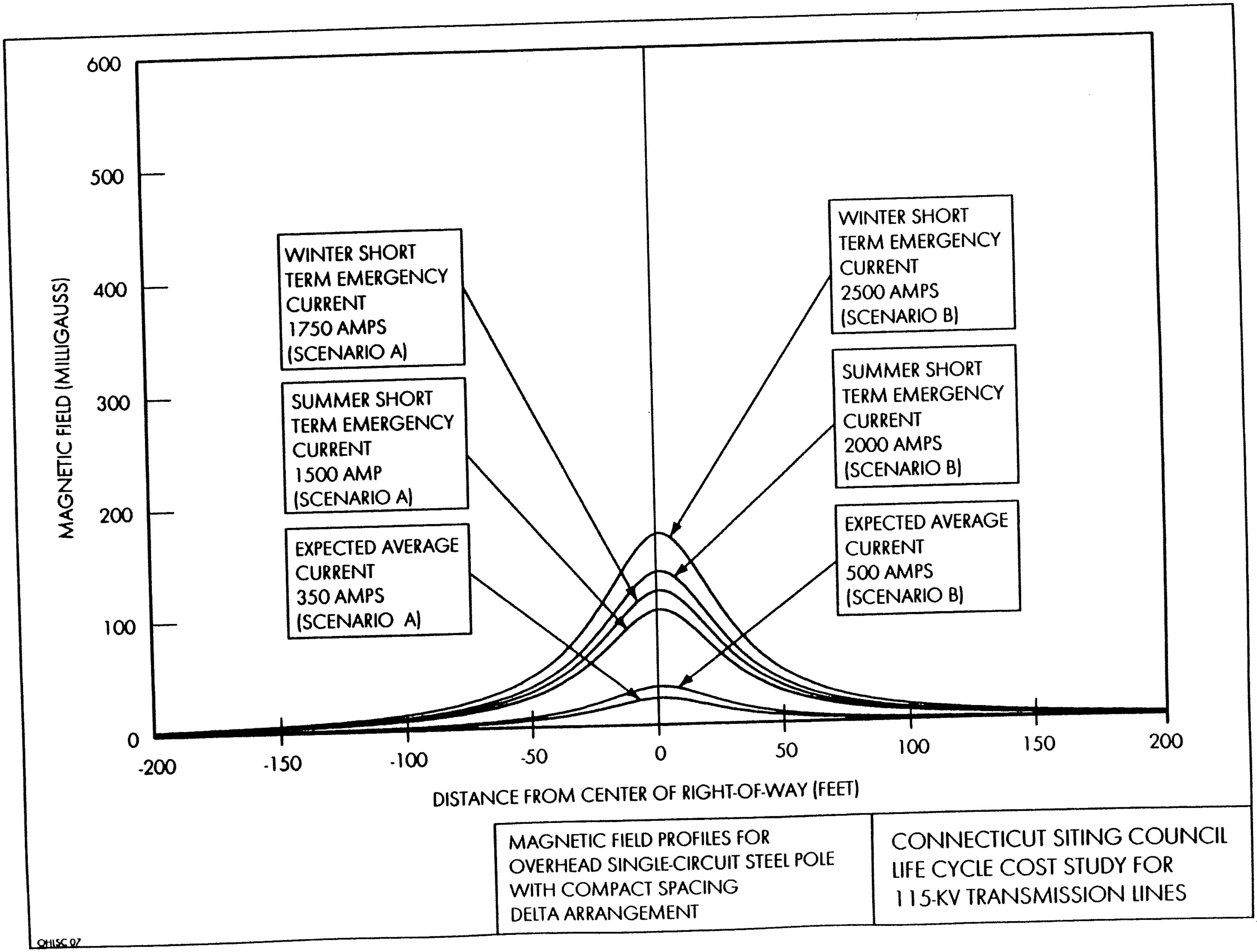
Life Cycle Cost Analysis
Overhead Single-circuit Steel Pole with Compact Spacing and Delta Arrangement
(5 Miles, Scenario B: 1272 kcmil)

			FC rate		Fixed cost
Construction	2,561,000	x	0.146	=	373,906
Land	0				0
Total					373,906

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

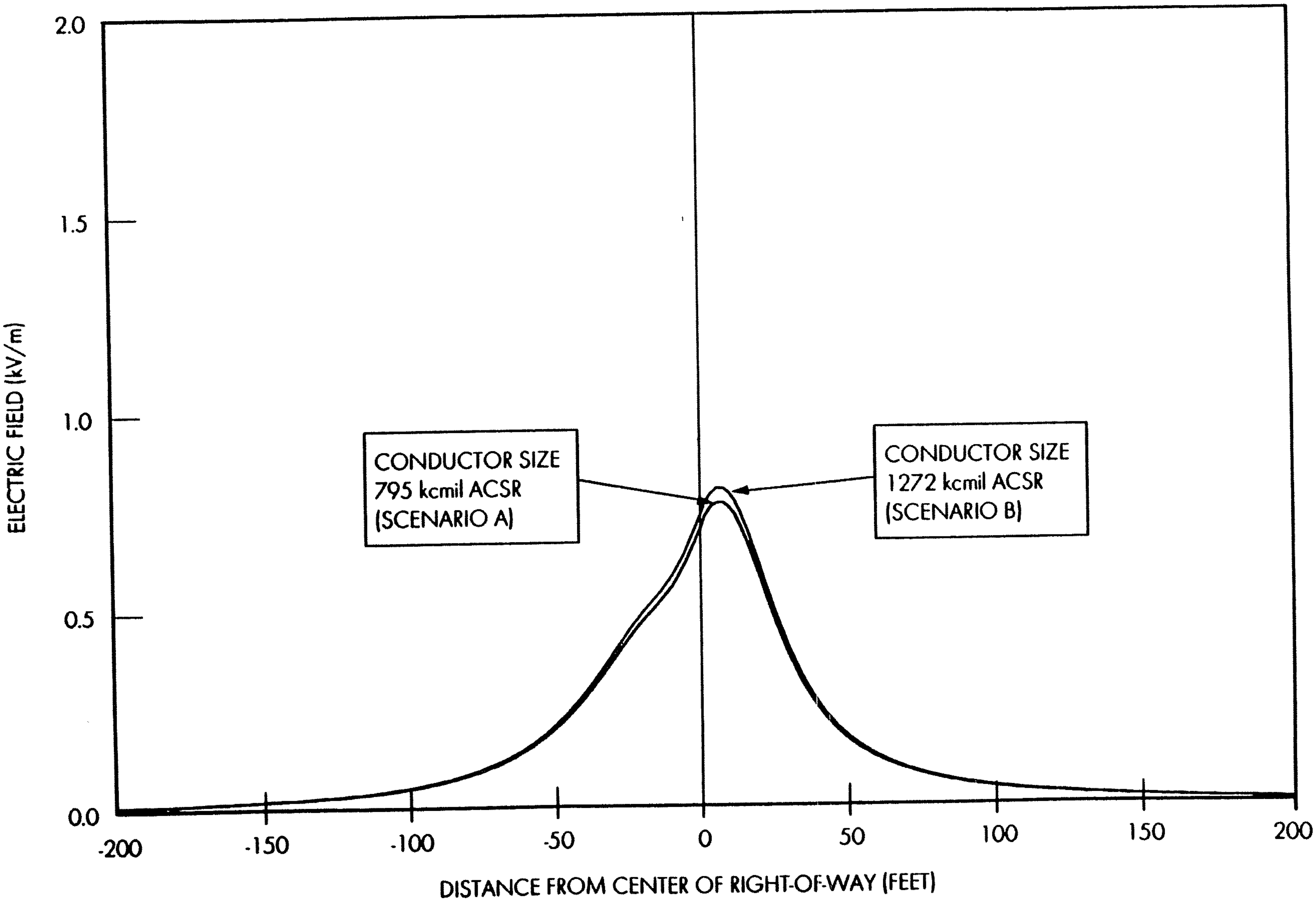
Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	373,906	14,638	76,902	465,446	0.91	423,132	423,132
2	373,906	6,566	87,509	467,981	0.83	386,761	809,893
3	373,906	6,828	98,584	479,318	0.75	360,119	1,170,012
4	373,906	7,101	100,964	481,972	0.68	329,193	1,499,205
5	373,906	7,385	115,936	497,227	0.62	308,739	1,807,944
6	373,906	7,681	128,362	509,949	0.56	287,853	2,095,797
7	373,906	7,988	141,321	523,215	0.51	268,492	2,364,289
8	373,906	8,307	181,403	563,617	0.47	262,931	2,627,220
9	373,906	8,640	199,572	582,117	0.42	246,875	2,874,095
10	373,906	8,985	218,512	601,403	0.39	231,867	3,105,962
11	373,906	9,345	245,481	628,732	0.35	220,367	3,326,328
12	373,906	9,719	355,284	738,909	0.32	235,439	3,561,767
13	373,906	10,107	375,239	759,252	0.29	219,928	3,781,696
14	373,906	10,512	395,950	780,368	0.26	205,495	3,987,191
15	373,906	10,932	427,911	812,749	0.24	194,566	4,181,757
16	373,906	11,369	474,476	859,752	0.22	187,107	4,368,864
17	373,906	11,824	509,427	895,157	0.20	177,102	4,545,966
18	373,906	12,297	530,272	916,476	0.18	164,836	4,710,802
19	373,906	12,789	572,095	958,790	0.16	156,770	4,867,572
20	373,906	13,301	611,146	998,352	0.15	148,399	5,015,970
21	373,906	13,833	644,260	1,031,999	0.14	139,455	5,155,425
22	373,906	14,386	690,988	1,079,279	0.12	132,585	5,288,010
23	373,906	14,961	731,741	1,120,609	0.11	125,148	5,413,158
24	373,906	15,560	782,104	1,171,570	0.10	118,944	5,532,102
25	373,906	16,182	826,234	1,216,322	0.09	112,262	5,644,364
26	373,906	16,829	885,648	1,276,383	0.08	107,096	5,751,459
27	373,906	17,503	947,449	1,338,857	0.08	102,125	5,853,584
28	373,906	18,203	1,017,141	1,409,250	0.07	97,722	5,951,306
29	373,906	18,931	1,069,474	1,462,311	0.06	92,183	6,043,489
30	373,906	25,302	1,159,372	1,558,580	0.06	89,320	6,132,809
31	373,906	26,314	1,237,655	1,637,875	0.05	85,331	6,218,140
32	373,906	27,366	1,319,043	1,720,315	0.05	81,478	6,299,619
33	373,906	28,461	1,409,750	1,812,117	0.04	78,024	6,377,643
34	373,906	29,599	1,504,068	1,907,574	0.04	74,667	6,452,310
35	373,906	30,783	1,602,119	2,006,809	0.04	71,410	6,523,720

Life Cycle PV Cost **6,524,000**



MAGNETIC FIELD PROFILES FOR OVERHEAD SINGLE-CIRCUIT STEEL POLE WITH COMPACT SPACING DELTA ARRANGEMENT

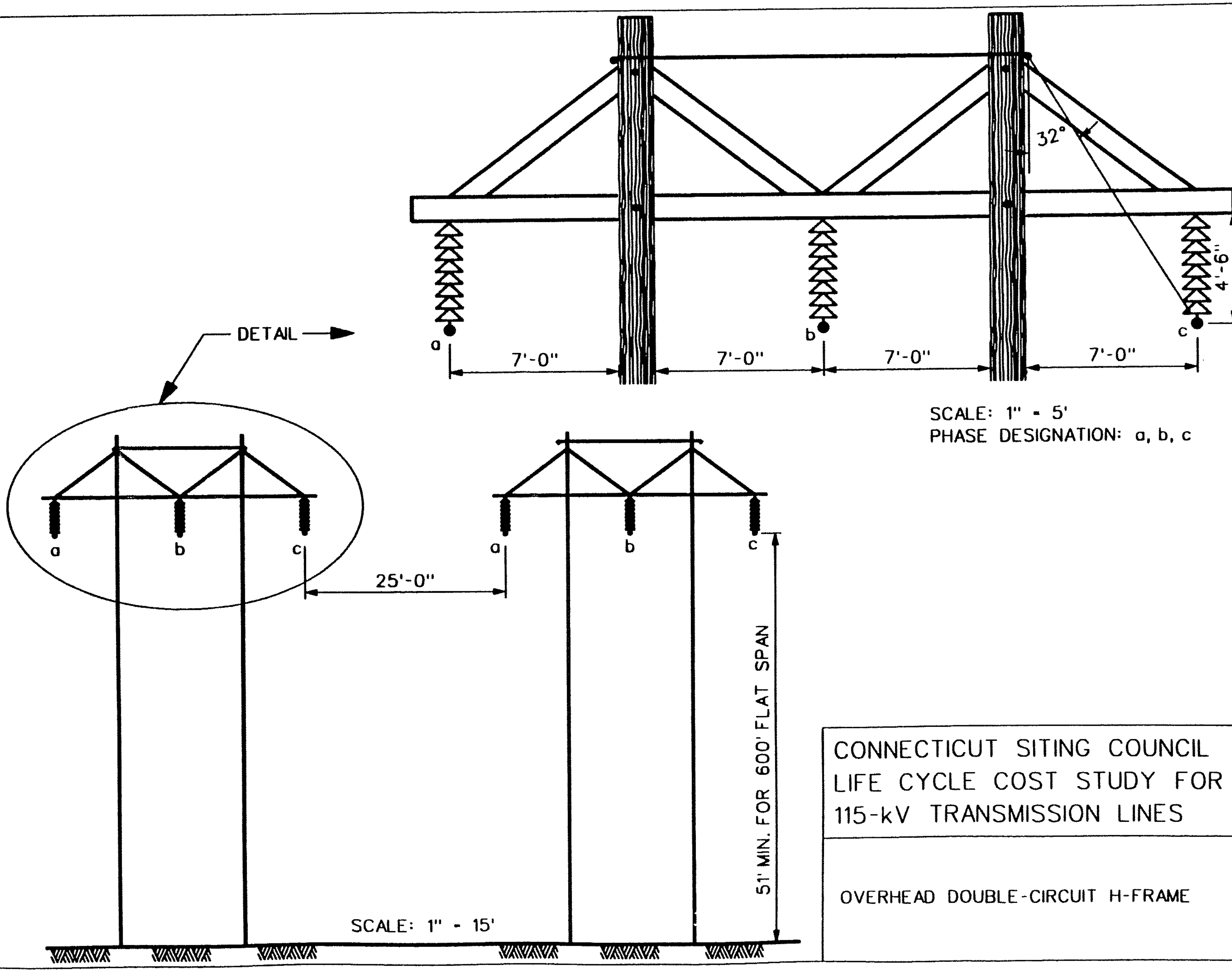
CONNECTICUT SITING COUNCIL LIFE CYCLE COST STUDY FOR 115-KV TRANSMISSION LINES



ELECTRIC FIELD PROFILES FOR OVERHEAD SINGLE-CIRCUIT STEEL POLE WITH COMPACT SPACING DELTA ARRANGEMENT

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES

OHLSC 97B



CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

OVERHEAD DOUBLE-CIRCUIT H-FRAME

Construction Cost Estimates
Overhead Double-circuit H-Frame

Base costs

Per Mile Base		
Scenario A 795 kcmil	$627,657	(a)
Scenario B 1272 kcmil	$675,762	(a)
Per Project Base		
Terminal equipment (Scenario A)	$77,240	(b)
Terminal equipment (Scenario B)	$77,240	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder		
Urban location	$207,000	(d)
Per Project Adder		
Winter construction	$6,000	(e)

Base Case - Scenario A

First cost	5 miles, rural, summer work	$3,334,000	5x(a) +(b)+(c)
Life cycle cost		$6,969,000	

Base Case - Scenario B

First cost	5 miles, rural, summer work	$3,574,000	5x(a) +(b)+(c)
Life cycle cost		$8,013,000	

Notes:
1) Base case is for a double-circuit line installed in a rural environment.

Life Cycle Cost Analysis
Overhead Double-circuit H-Frame (5 Miles, Scenario A: 795 kcmil)

			FC rate		Fixed cost
Construction	3,334,000	x	0.146	=	486,764
Land	0				0
Total					486,764

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	486,764	16,320	57,646	560,730	0.91	509,755	509,755
2	486,764	10,046	65,598	562,408	0.83	464,800	974,555
3	486,764	10,448	73,900	571,112	0.75	429,085	1,403,640
4	486,764	10,866	75,684	573,314	0.68	391,581	1,795,221
5	486,764	11,301	86,906	584,971	0.62	363,221	2,158,442
6	486,764	11,753	96,221	594,738	0.56	335,714	2,494,156
7	486,764	12,223	105,935	604,922	0.51	310,421	2,804,577
8	486,764	12,712	135,982	635,457	0.47	296,446	3,101,023
9	486,764	13,220	149,601	649,585	0.42	275,487	3,376,510
10	486,764	13,749	163,798	664,311	0.39	256,121	3,632,631
11	486,764	14,299	184,015	685,078	0.35	240,116	3,872,747
12	486,764	14,871	266,324	767,959	0.32	244,696	4,117,442
13	486,764	15,466	281,283	783,513	0.29	226,956	4,344,398
14	486,764	16,085	296,808	799,657	0.26	210,575	4,554,972
15	486,764	19,035	320,766	826,564	0.24	197,873	4,752,845
16	486,764	19,796	355,672	862,232	0.22	187,647	4,940,492
17	486,764	20,588	381,871	889,223	0.20	175,928	5,116,420
18	486,764	21,411	397,497	905,673	0.18	162,893	5,279,313
19	486,764	22,268	428,847	937,879	0.16	153,351	5,432,664
20	486,764	30,004	458,120	974,888	0.15	144,911	5,577,575
21	486,764	31,204	482,944	1,000,911	0.14	135,254	5,712,829
22	486,764	32,452	517,971	1,037,187	0.12	127,414	5,840,243
23	486,764	33,750	548,520	1,069,034	0.11	119,388	5,959,631
24	486,764	35,100	586,273	1,108,137	0.10	112,504	6,072,135
25	486,764	36,504	619,353	1,142,621	0.09	105,459	6,177,594
26	486,764	37,964	663,890	1,188,618	0.08	99,732	6,277,326
27	486,764	39,483	710,216	1,236,463	0.08	94,315	6,371,640
28	486,764	41,062	762,459	1,290,285	0.07	89,473	6,461,113
29	486,764	42,705	801,688	1,331,156	0.06	83,915	6,545,028
30	486,764	44,413	869,076	1,400,253	0.06	80,246	6,625,275
31	486,764	46,189	927,758	1,460,711	0.05	76,101	6,701,376
32	486,764	48,037	988,767	1,523,568	0.05	72,160	6,773,536
33	486,764	49,958	1,056,762	1,593,484	0.04	68,610	6,842,146
34	486,764	51,957	1,127,464	1,666,184	0.04	65,219	6,907,365
35	486,764	54,035	1,200,964	1,741,762	0.04	61,979	6,969,344

Life Cycle PV Cost **6,969,000**

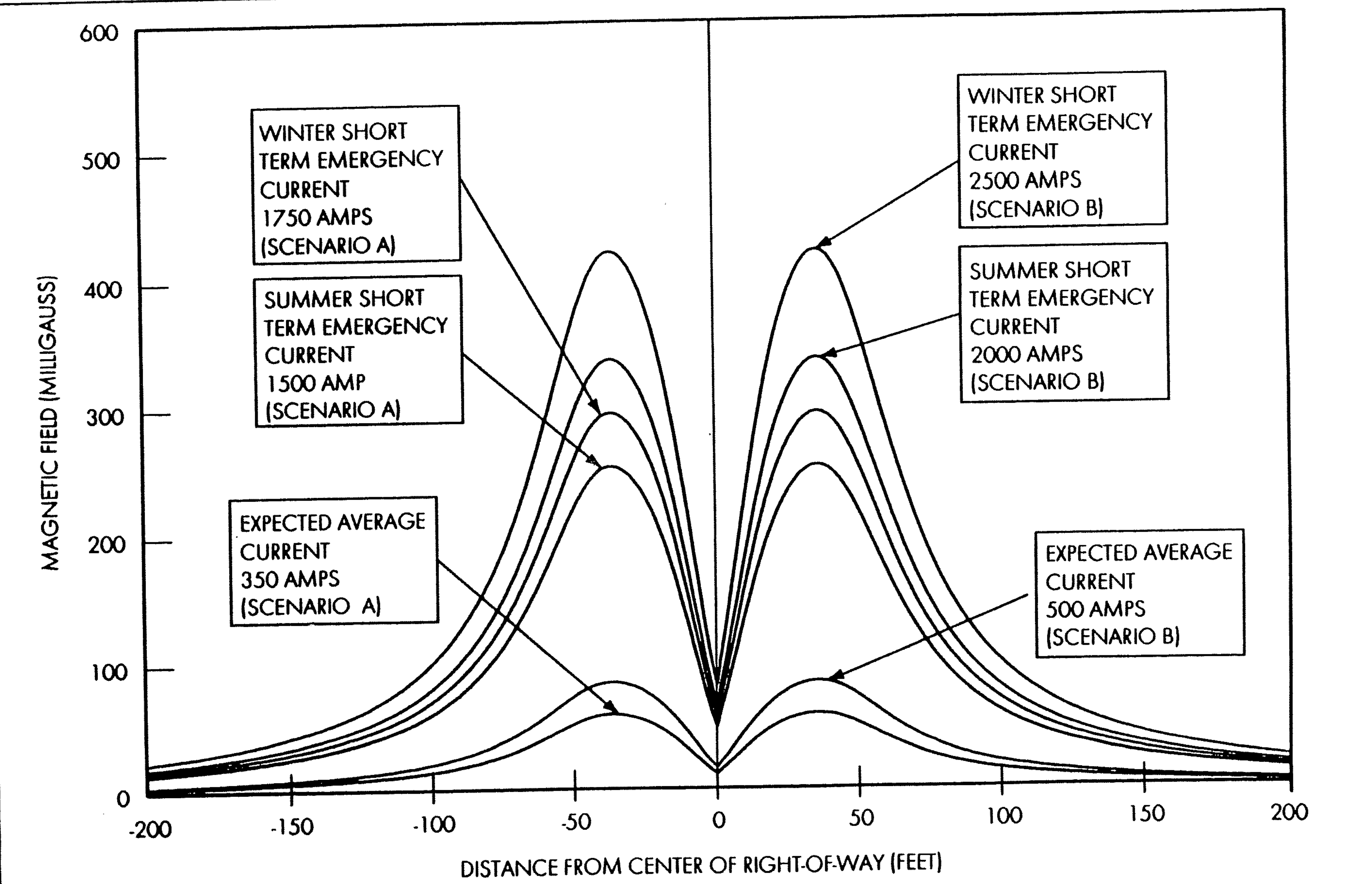
Life Cycle Cost Analysis
Overhead Double-circuit H-Frame (5 Miles, Scenario B: 1272 kcmil)

			FC rate		Fixed cost
Construction	3,574,000	x	0.146	=	521,804
Land	0				0
Total					521,804

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

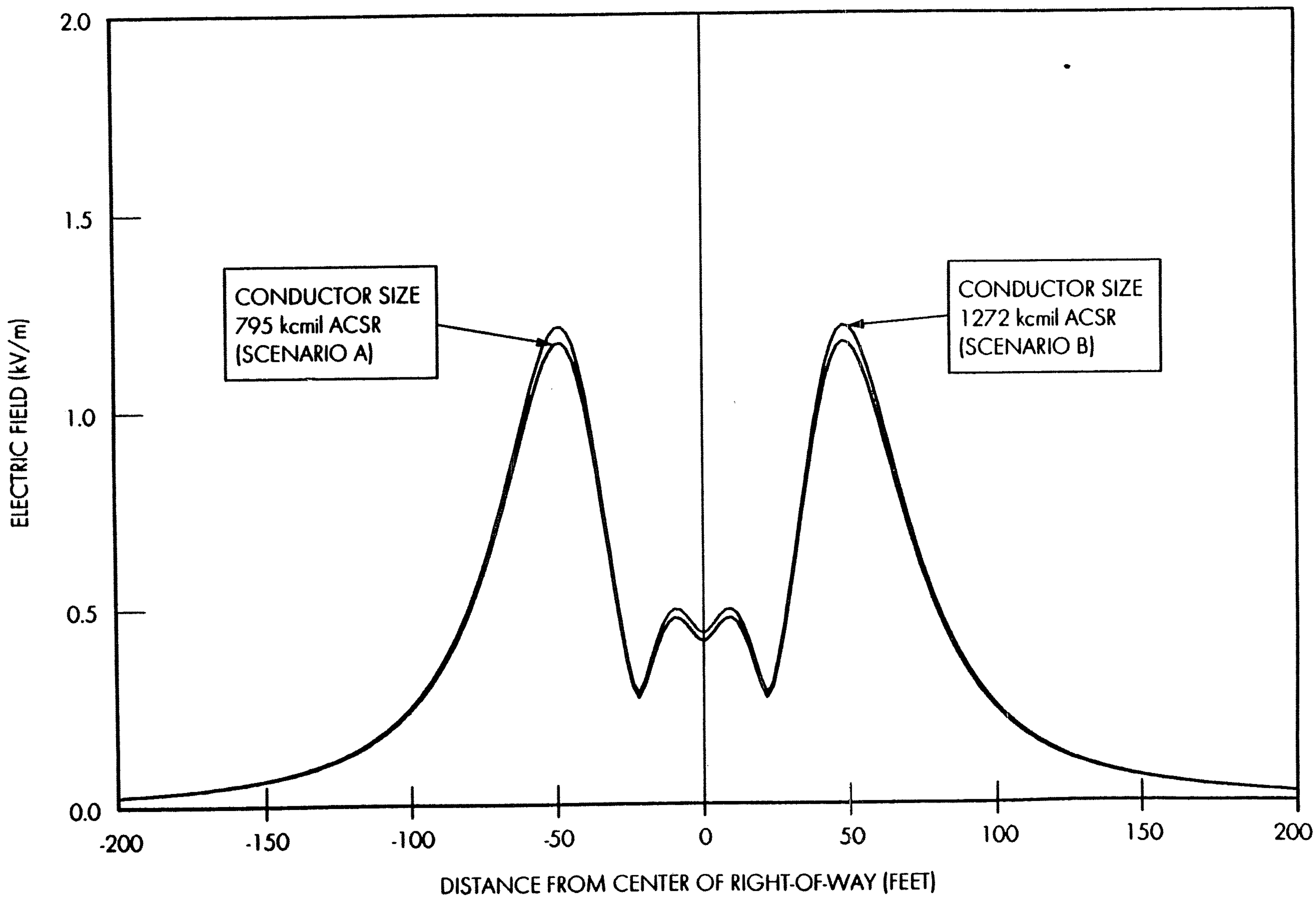
Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	521,804	16,320	76,902	615,026	0.91	559,114	559,114
2	521,804	10,046	87,509	619,360	0.83	511,867	1,070,982
3	521,804	10,448	98,584	630,836	0.75	473,957	1,544,938
4	521,804	10,866	100,964	633,635	0.68	432,781	1,977,719
5	521,804	11,301	115,936	649,041	0.62	403,003	2,380,722
6	521,804	11,753	128,362	661,919	0.56	373,636	2,754,358
7	521,804	12,223	141,321	675,348	0.51	346,560	3,100,919
8	521,804	12,712	181,403	715,919	0.47	333,982	3,434,900
9	521,804	13,220	199,572	734,596	0.42	311,540	3,746,441
10	521,804	13,749	218,512	754,065	0.39	290,725	4,037,165
11	521,804	14,299	245,481	781,584	0.35	273,940	4,311,106
12	521,804	14,871	355,284	891,959	0.32	284,206	4,595,311
13	521,804	15,466	375,239	912,509	0.29	264,321	4,859,633
14	521,804	16,085	395,950	933,839	0.26	245,909	5,105,542
15	521,804	19,035	427,911	968,749	0.24	231,911	5,337,452
16	521,804	19,796	474,476	1,016,076	0.22	221,128	5,558,580
17	521,804	20,588	509,427	1,051,819	0.20	208,097	5,766,677
18	521,804	21,411	530,272	1,073,488	0.18	193,076	5,959,753
19	521,804	22,268	572,095	1,116,166	0.16	182,502	6,142,255
20	521,804	30,004	611,146	1,162,953	0.15	172,866	6,315,121
21	521,804	31,204	644,260	1,197,268	0.14	161,788	6,476,909
22	521,804	32,452	690,988	1,245,244	0.12	152,973	6,629,882
23	521,804	33,750	731,741	1,287,295	0.11	143,763	6,773,644
24	521,804	35,100	782,104	1,339,008	0.10	135,944	6,909,588
25	521,804	36,504	826,234	1,384,542	0.09	127,788	7,037,376
26	521,804	37,964	885,648	1,445,416	0.08	121,278	7,158,654
27	521,804	39,483	947,449	1,508,735	0.08	115,083	7,273,737
28	521,804	41,062	1,017,141	1,580,007	0.07	109,563	7,383,300
29	521,804	42,705	1,069,474	1,633,982	0.06	103,005	7,486,305
30	521,804	44,413	1,159,372	1,725,589	0.06	98,891	7,585,196
31	521,804	46,189	1,237,655	1,805,649	0.05	94,072	7,679,268
32	521,804	48,037	1,319,043	1,888,884	0.05	89,462	7,768,730
33	521,804	49,958	1,409,750	1,981,512	0.04	85,318	7,854,048
34	521,804	51,957	1,504,068	2,077,829	0.04	81,331	7,935,379
35	521,804	54,035	1,602,119	2,177,958	0.04	77,501	8,012,880

Life Cycle PV Cost **8,013,000**



MAGNETIC FIELD PROFILES FOR OVERHEAD DOUBLE-CIRCUIT H-FRAME

CONNECTICUT SITING COUNCIL LIFE CYCLE COST STUDY FOR 115-KV TRANSMISSION LINES



ELECTRIC FIELD PROFILES FOR OVERHEAD DOUBLE-CIRCUIT H-FRAME

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES

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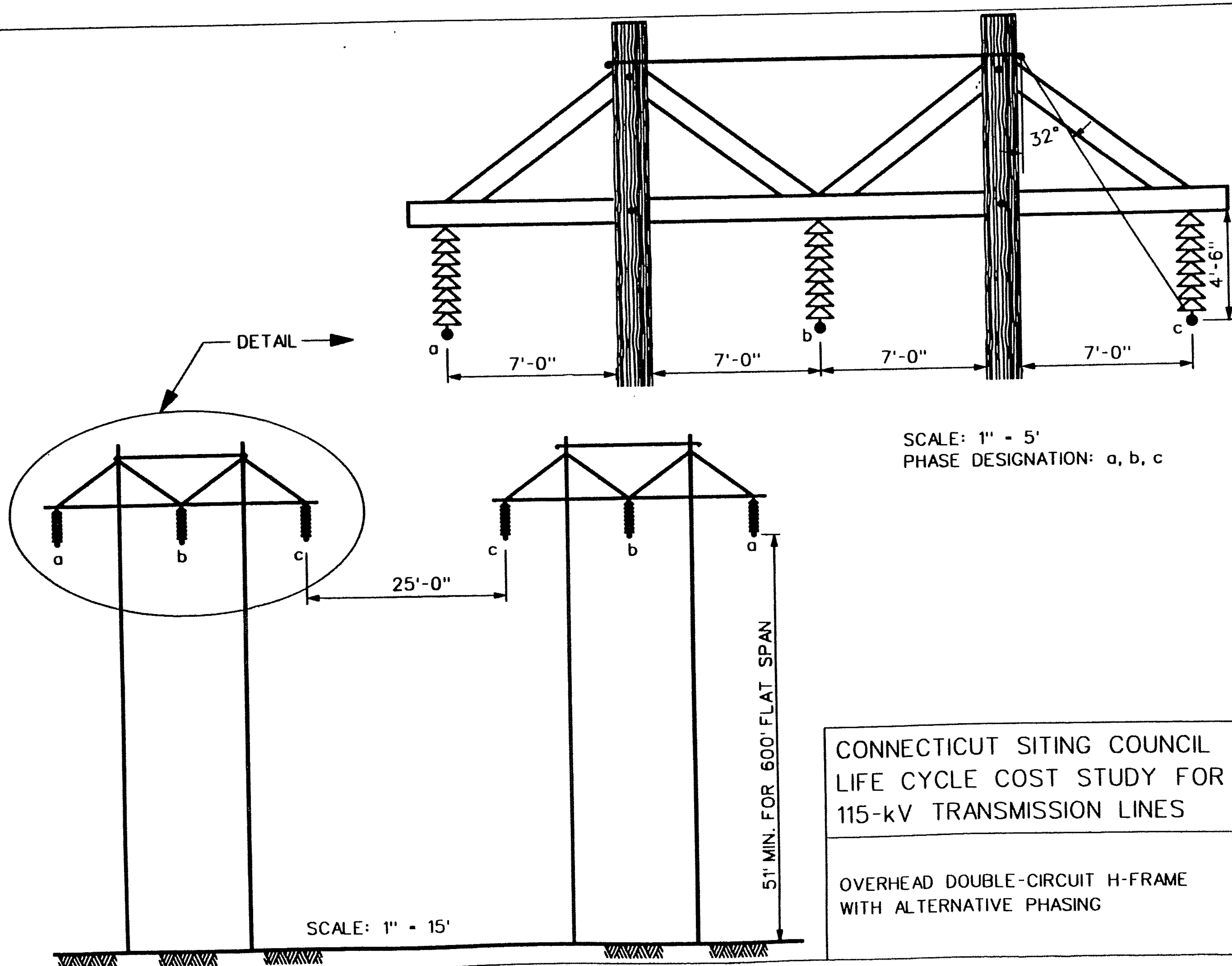


SCALE: 1" - 5'
PHASE DESIGNATION: a, b, c

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

OVERHEAD DOUBLE-CIRCUIT H-FRAME
WITH ALTERNATIVE PHASING

Construction Cost Estimates
Overhead Double-circuit H-Frame with Alternative Phasing

Base costs

Per Mile Base		
Scenario A 795 kcmil	$627,657	(a)
Scenario B 1272 kcmil	$675,762	(a)
Per Project Base		
Terminal equipment (Scenario A)	$77,240	(b)
Terminal equipment (Scenario B)	$77,240	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder		
Urban location	$207,000	(d)
Per Project Adder		
Winter construction	$6,000	(e)

Base Case - Scenario A

First cost	5 miles, rural, summer work	$3,334,000	5x(a) +(b)+(c)
Life cycle cost		$6,969,000	

Base Case - Scenario B

First cost	5 miles, rural, summer work	$3,574,000	5x(a) +(b)+(c)
Life cycle cost		$8,013,000	

Notes:

1) Base case is for a double-circuit line installed in a rural environment.

Life Cycle Cost Analysis
Overhead Double-circuit H-Frame with Alternative Phasing (5 Miles, Scenario A: 795 kcmil)

			FC rate		Fixed cost
Construction	3,334,000	x	0 146	=	486,764
Land	0				0
Total					486,764

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1 2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	486,764	16,320	57,646	560,730	0.91	509,755	509,755
2	486,764	10,046	65,598	562,408	0.83	464,800	974,555
3	486,764	10,448	73,900	571,112	0.75	429,085	1,403,640
4	486,764	10,866	75,684	573,314	0.68	391,581	1,795,221
5	486,764	11,301	86,906	584,971	0.62	363,221	2,158,442
6	486,764	11,753	96,221	594,738	0.56	335,714	2,494,156
7	486,764	12,223	105,935	604,922	0.51	310,421	2,804,577
8	486,764	12,712	135,982	635,457	0.47	296,446	3,101,023
9	486,764	13,220	149,601	649,585	0.42	275,487	3,376,510
10	486,764	13,749	163,798	664,311	0.39	256,121	3,632,631
11	486,764	14,299	184,015	685,078	0.35	240,116	3,872,747
12	486,764	14,871	266,324	767,959	0.32	244,696	4,117,442
13	486,764	15,466	281,283	783,513	0.29	226,956	4,344,398
14	486,764	16,085	296,808	799,657	0.26	210,575	4,554,972
15	486,764	19,035	320,766	826,564	0.24	197,873	4,752,845
16	486,764	19,796	355,672	862,232	0.22	187,647	4,940,492
17	486,764	20,588	381,871	889,223	0.20	175,928	5,116,420
18	486,764	21,411	397,497	905,673	0.18	162,893	5,279,313
19	486,764	22,268	428,847	937,879	0.16	153,351	5,432,664
20	486,764	30,004	458,120	974,888	0.15	144,911	5,577,575
21	486,764	31,204	482,944	1,000,911	0.14	135,254	5,712,829
22	486,764	32,452	517,971	1,037,187	0.12	127,414	5,840,243
23	486,764	33,750	548,520	1,069,034	0.11	119,388	5,959,631
24	486,764	35,100	586,273	1,108,137	0.10	112,504	6,072,135
25	486,764	36,504	619,353	1,142,621	0.09	105,459	6,177,594
26	486,764	37,964	663,890	1,188,618	0.08	99,732	6,277,326
27	486,764	39,483	710,216	1,236,463	0.08	94,315	6,371,640
28	486,764	41,062	762,459	1,290,285	0.07	89,473	6,461,113
29	486,764	42,705	801,688	1,331,156	0.06	83,915	6,545,028
30	486,764	44,413	869,076	1,400,253	0.06	80,246	6,625,275
31	486,764	46,189	927,758	1,460,711	0.05	76,101	6,701,376
32	486,764	48,037	988,767	1,523,568	0.05	72,160	6,773,536
33	486,764	49,958	1,056,762	1,593,484	0.04	68,610	6,842,146
34	486,764	51,957	1,127,464	1,666,184	0.04	65,219	6,907,365
35	486,764	54,035	1,200,964	1,741,762	0.04	61,979	6,969,344

Life Cycle PV Cost **6,969,000**

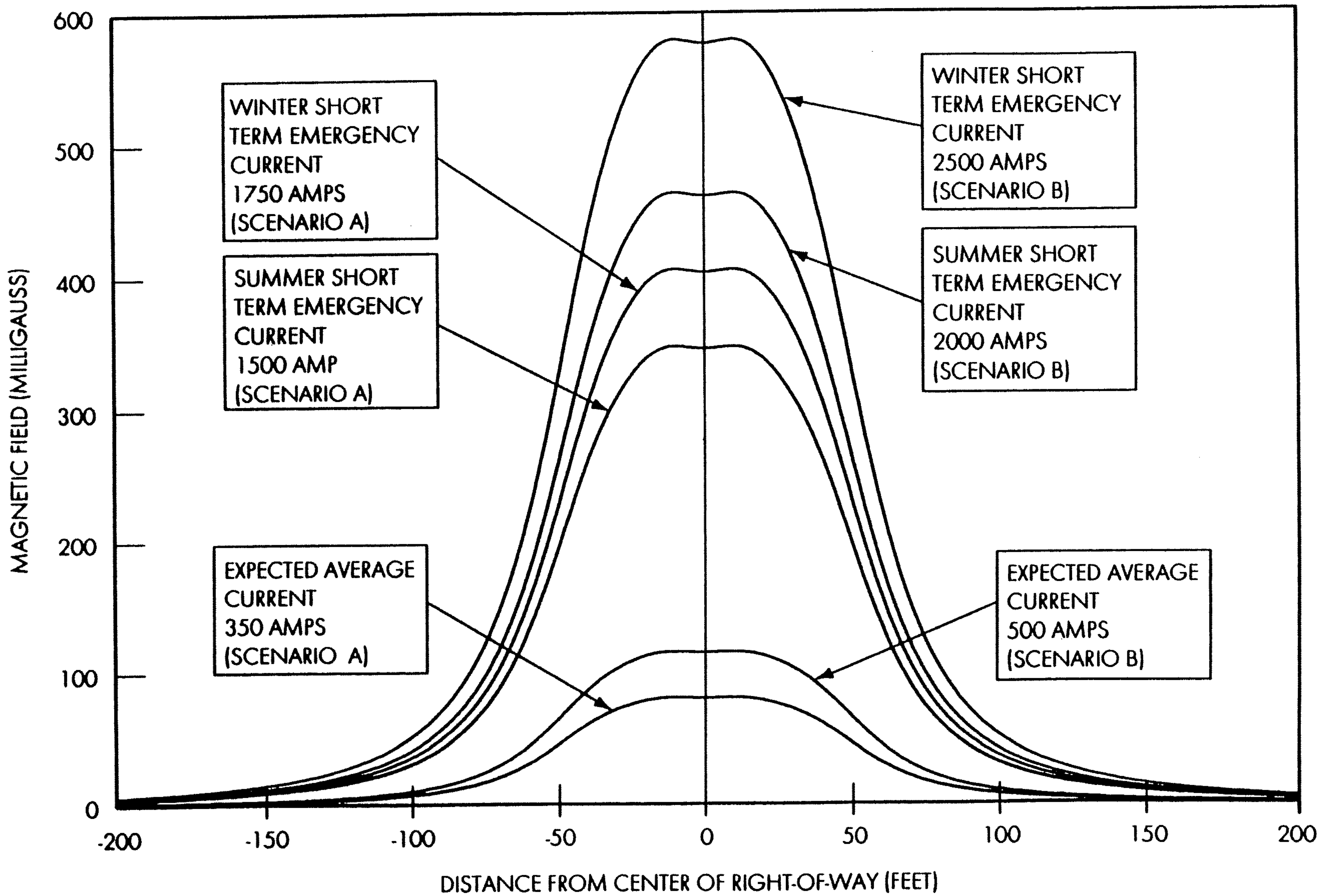
Life Cycle Cost Analysis
Overhead Double-circuit H-Frame with Alternative Phasing (5 Miles, Scenario B: 1272 kcmil)

			FC rate		Fixed cost
Construction	3,574,000	x	0.146	=	521,804
Land	0				0
Total					521,804

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

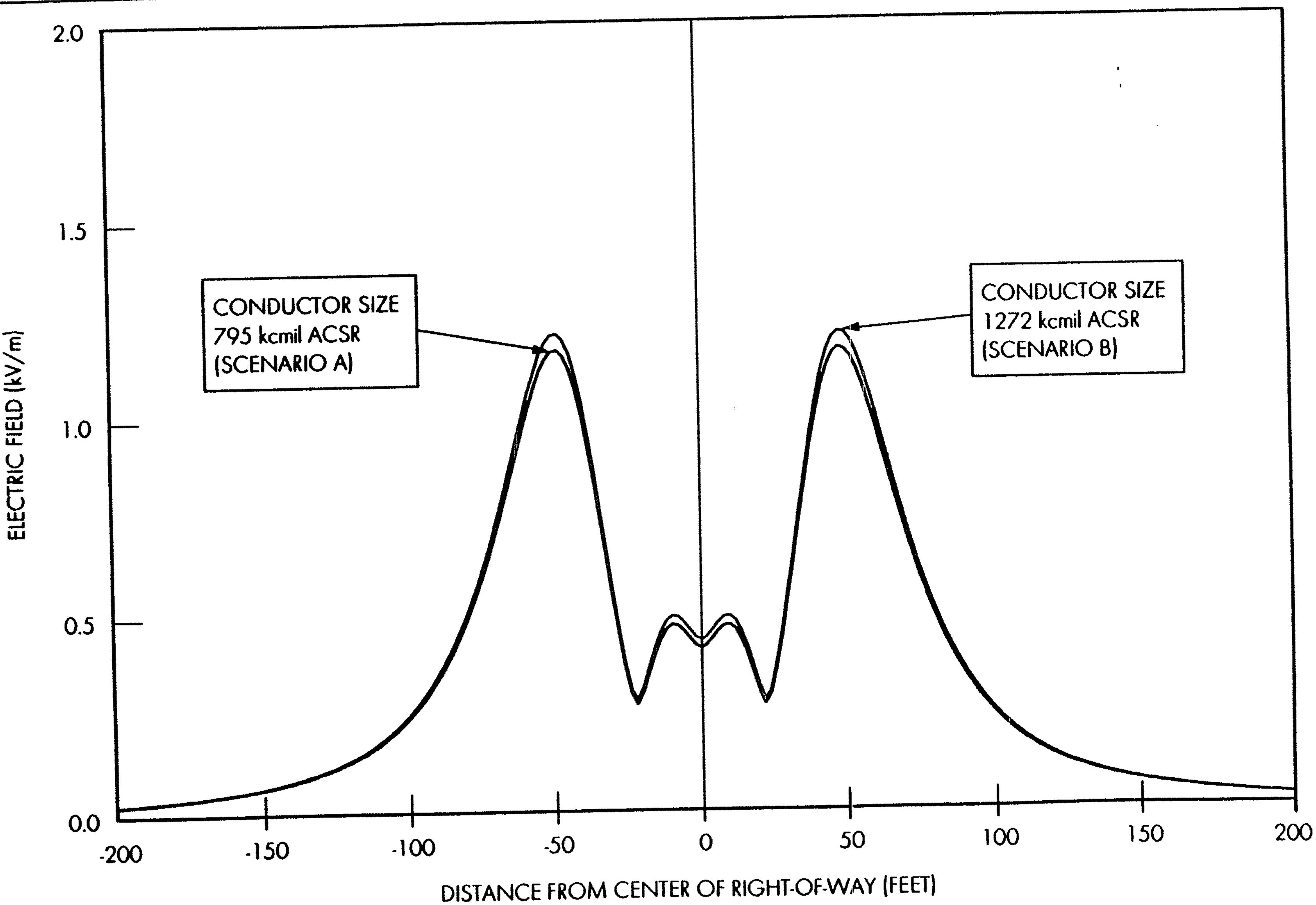
Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	521,804	16,320	76,902	615,026	0.91	559,114	559,114
2	521,804	10,046	87,509	619,360	0.83	511,867	1,070,982
3	521,804	10,448	98,584	630,836	0.75	473,957	1,544,938
4	521,804	10,866	100,964	633,635	0.68	432,781	1,977,719
5	521,804	11,301	115,936	649,041	0.62	403,003	2,380,722
6	521,804	11,753	128,362	661,919	0.56	373,636	2,754,358
7	521,804	12,223	141,321	675,348	0.51	346,560	3,100,919
8	521,804	12,712	181,403	715,919	0.47	333,982	3,434,900
9	521,804	13,220	199,572	734,596	0.42	311,540	3,746,441
10	521,804	13,749	218,512	754,065	0.39	290,725	4,037,165
11	521,804	14,299	245,481	781,584	0.35	273,940	4,311,106
12	521,804	14,871	355,284	891,959	0.32	284,206	4,595,311
13	521,804	15,466	375,239	912,509	0.29	264,321	4,859,633
14	521,804	16,085	395,950	933,839	0.26	245,909	5,105,542
15	521,804	19,035	427,911	968,749	0.24	231,911	5,337,452
16	521,804	19,796	474,476	1,016,076	0.22	221,128	5,558,580
17	521,804	20,588	509,427	1,051,819	0.20	208,097	5,766,677
18	521,804	21,411	530,272	1,073,488	0.18	193,076	5,959,753
19	521,804	22,268	572,095	1,116,166	0.16	182,502	6,142,255
20	521,804	30,004	611,146	1,162,953	0.15	172,866	6,315,121
21	521,804	31,204	644,260	1,197,268	0.14	161,788	6,476,909
22	521,804	32,452	690,988	1,245,244	0.12	152,973	6,629,882
23	521,804	33,750	731,741	1,287,295	0.11	143,763	6,773,644
24	521,804	35,100	782,104	1,339,008	0.10	135,944	6,909,588
25	521,804	36,504	826,234	1,384,542	0.09	127,788	7,037,376
26	521,804	37,964	885,648	1,445,416	0.08	121,278	7,158,654
27	521,804	39,483	947,449	1,508,735	0.08	115,083	7,273,737
28	521,804	41,062	1,017,141	1,580,007	0.07	109,563	7,383,300
29	521,804	42,705	1,069,474	1,633,982	0.06	103,005	7,486,305
30	521,804	44,413	1,159,372	1,725,589	0.06	98,891	7,585,196
31	521,804	46,189	1,237,655	1,805,649	0.05	94,072	7,679,268
32	521,804	48,037	1,319,043	1,888,884	0.05	89,462	7,768,730
33	521,804	49,958	1,409,750	1,981,512	0.04	85,318	7,854,048
34	521,804	51,957	1,504,068	2,077,829	0.04	81,331	7,935,379
35	521,804	54,035	1,602,119	2,177,958	0.04	77,501	8,012,880

Life Cycle PV Cost **8,013,000**



MAGNETIC FIELD PROFILES FOR OVERHEAD DOUBLE-CIRCUIT H-FRAME WITH ALTERNATIVE PHASING

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES



ELECTRIC FIELD PROFILES FOR OVERHEAD DOUBLE-CIRCUIT H-FRAME WITH ALTERNATIVE PHASING	CONNECTICUT SITING COUNCIL LIFE CYCLE COST STUDY FOR 115-KV TRANSMISSION LINES

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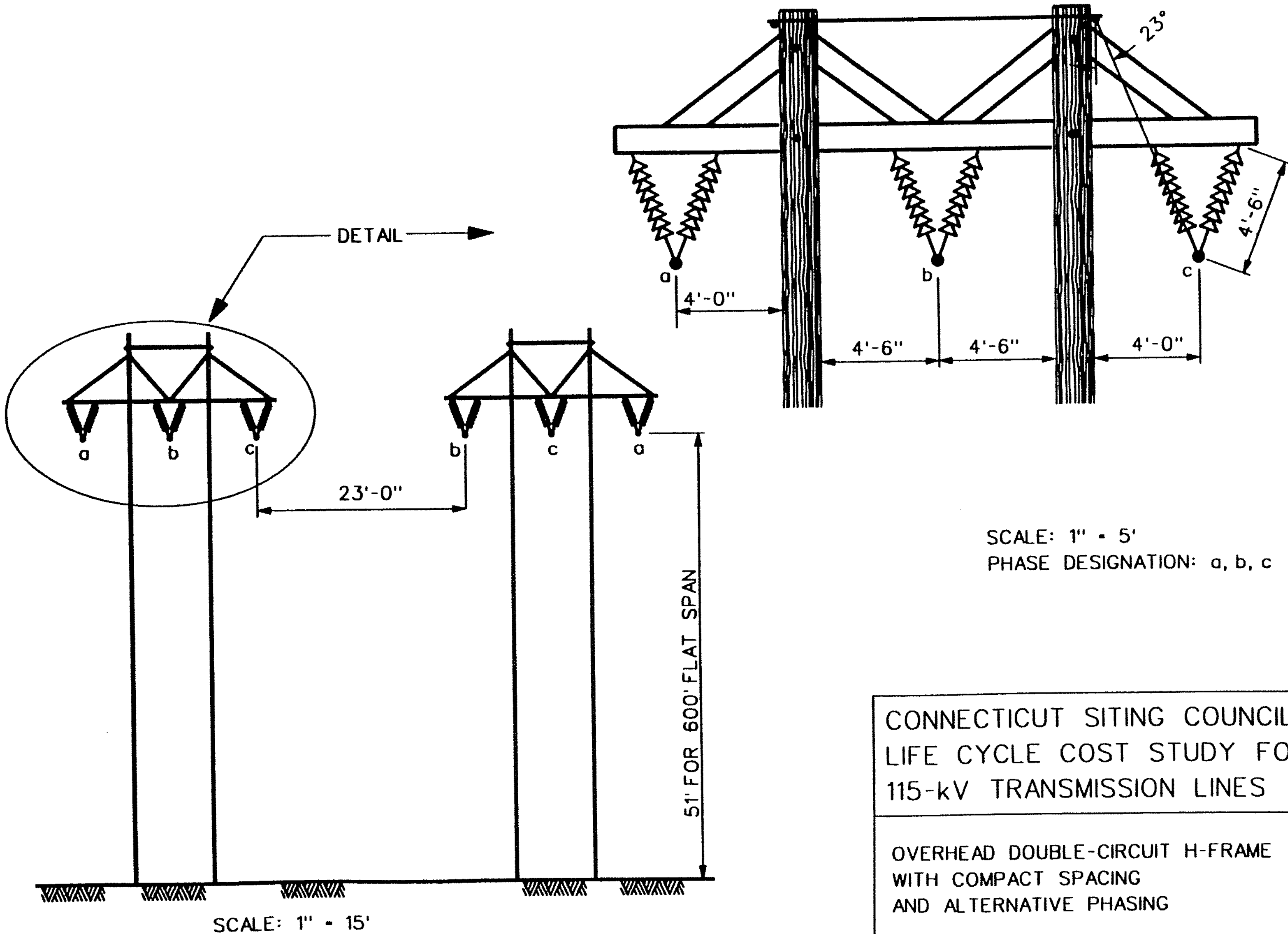


CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

OVERHEAD DOUBLE-CIRCUIT H-FRAME
WITH COMPACT SPACING
AND ALTERNATIVE PHASING

Construction Cost Estimates
Overhead Double-circuit H-Frame with Compact Spacing and Alternative Phasing

Base costs

Per Mile Base		
Scenario A 795 kcmil	$650,932	(a)
Scenario B 1272 kcmil	$699,037	(a)
Per Project Base		
Terminal equipment (Scenario A)	$77,240	(b)
Terminal equipment (Scenario B)	$77,240	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder		
Urban location	$207,000	(d)
Per Project Adder		
Winter construction	$6,000	(e)

Base Case - Scenario A

First cost	5 miles, rural, summer work	$3,450,000	5x(a) +(b)+(c)
Life cycle cost		$7,133,000	

Base Case - Scenario B

First cost	5 miles, rural, summer work	$3,690,000	5x(a) +(b)+(c)
Life cycle cost		$8,176,000	

Notes:
1) Base case is for a double-circuit installed in a rural environment.

Life Cycle Cost Analysis
Overhead Double-circuit H-Frame with Compact Spacing and Alternative Phasing
(5 Miles, Scenario A: 795 kcmil)

			FC rate		Fixed cost
Construction	3,450,000	x	0.146	=	503,700
Land	0				0
Total					503,700

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	503,700	16,320	57,646	577,666	0.91	525,151	525,151
2	503,700	10,046	65,598	579,344	0.83	478,797	1,003,948
3	503,700	10,448	73,900	588,048	0.75	441,809	1,445,757
4	503,700	10,866	75,684	590,250	0.68	403,149	1,848,906
5	503,700	11,301	86,906	601,907	0.62	373,737	2,222,643
6	503,700	11,753	96,221	611,674	0.56	345,274	2,567,917
7	503,700	12,223	105,935	621,858	0.51	319,112	2,887,029
8	503,700	12,712	135,982	652,393	0.47	304,346	3,191,375
9	503,700	13,220	149,601	666,521	0.42	282,670	3,474,045
10	503,700	13,749	163,798	681,247	0.39	262,650	3,736,695
11	503,700	14,299	184,015	702,014	0.35	246,052	3,982,747
12	503,700	14,871	266,324	784,895	0.32	250,092	4,232,839
13	503,700	15,466	281,283	800,449	0.29	231,861	4,464,700
14	503,700	16,085	296,808	816,593	0.26	215,034	4,679,735
15	503,700	19,035	320,766	843,500	0.24	201,927	4,881,662
16	503,700	19,796	355,672	879,168	0.22	191,333	5,072,995
17	503,700	20,588	381,871	906,159	0.20	179,279	5,252,273
18	503,700	21,411	397,497	922,609	0.18	165,939	5,418,213
19	503,700	22,268	428,847	954,815	0.16	156,120	5,574,332
20	503,700	30,004	458,120	991,824	0.15	147,428	5,721,761
21	503,700	31,204	482,944	1,017,847	0.14	137,542	5,859,303
22	503,700	32,452	517,971	1,054,123	0.12	129,495	5,988,798
23	503,700	33,750	548,520	1,085,970	0.11	121,279	6,110,077
24	503,700	35,100	586,273	1,125,073	0.10	114,224	6,224,301
25	503,700	36,504	619,353	1,159,557	0.09	107,022	6,331,323
26	503,700	37,964	663,890	1,205,554	0.08	101,153	6,432,476
27	503,700	39,483	710,216	1,253,399	0.08	95,606	6,528,082
28	503,700	41,062	762,459	1,307,221	0.07	90,647	6,618,729
29	503,700	42,705	801,688	1,348,092	0.06	84,983	6,703,712
30	503,700	44,413	869,076	1,417,189	0.06	81,217	6,784,929
31	503,700	46,189	927,758	1,477,647	0.05	76,983	6,861,913
32	503,700	48,037	988,767	1,540,504	0.05	72,962	6,934,875
33	503,700	49,958	1,056,762	1,610,420	0.04	69,339	7,004,214
34	503,700	51,957	1,127,464	1,683,120	0.04	65,882	7,070,096
35	503,700	54,035	1,200,964	1,758,698	0.04	62,582	7,132,677

Life Cycle PV Cost **7,133,000**

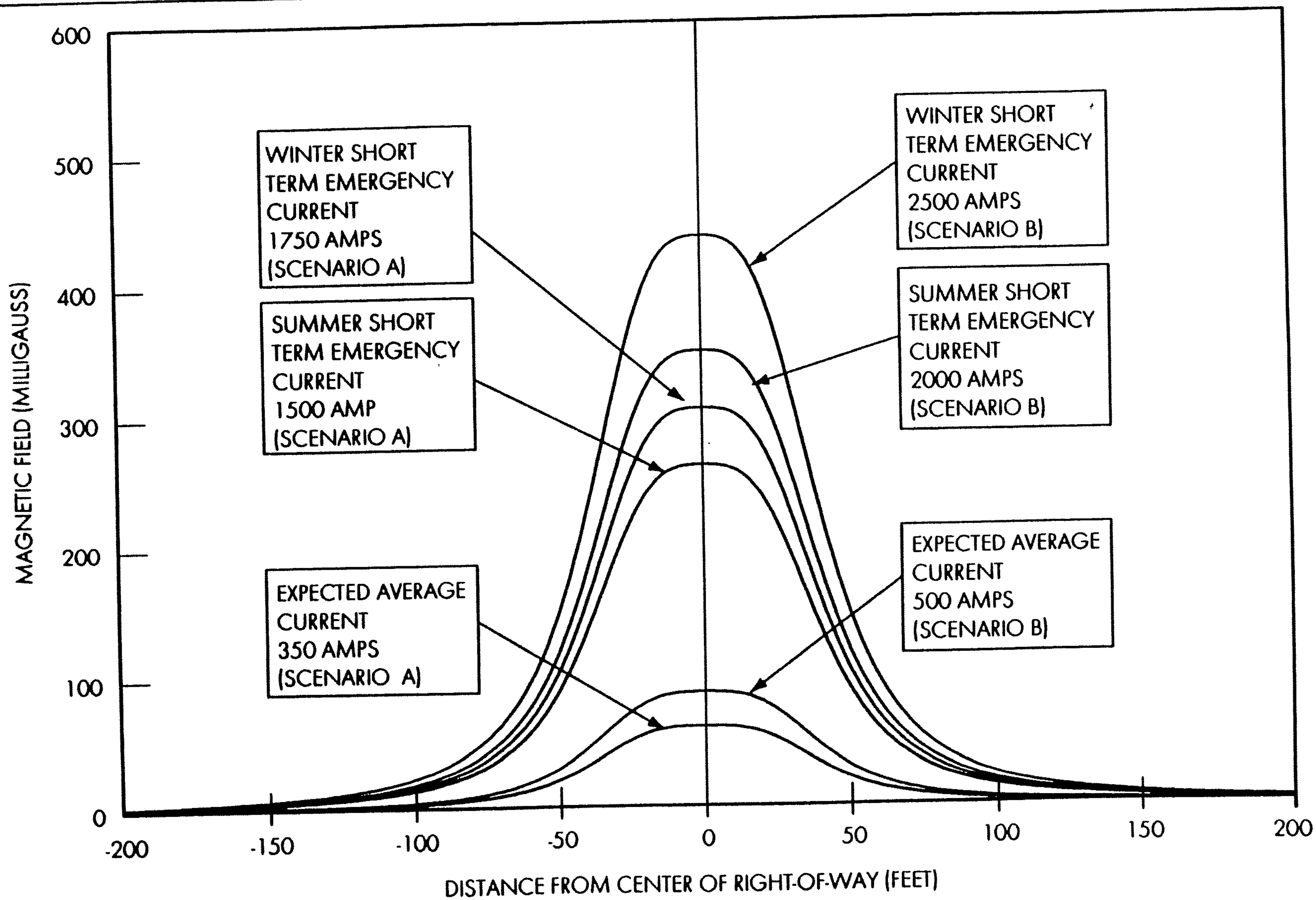
Life Cycle Cost Analysis
Overhead Double-circuit H-Frame with Compact Spacing and Alternative Phasing
(5 Miles, Scenario B: 1272 kcmil)

			FC rate		Fixed cost
Construction	3,690,000	x	0.146	=	538,740
Land	0				0
Total					538,740

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	538,740	16,320	76,902	631,962	0.91	574,511	574,511
2	538,740	10,046	87,509	636,296	0.83	525,864	1,100,375
3	538,740	10,448	98,584	647,772	0.75	486,681	1,587,056
4	538,740	10,866	100,964	650,571	0.68	444,348	2,031,404
5	538,740	11,301	115,936	665,977	0.62	413,519	2,444,923
6	538,740	11,753	128,362	678,855	0.56	383,196	2,828,119
7	538,740	12,223	141,321	692,284	0.51	355,251	3,183,370
8	538,740	12,712	181,403	732,855	0.47	341,882	3,525,252
9	538,740	13,220	199,572	751,532	0.42	318,723	3,843,975
10	538,740	13,749	218,512	771,001	0.39	297,254	4,141,230
11	538,740	14,299	245,481	798,520	0.35	279,876	4,421,106
12	538,740	14,871	355,284	908,895	0.32	289,602	4,710,708
13	538,740	15,466	375,239	929,445	0.29	269,227	4,979,935
14	538,740	16,085	395,950	950,775	0.26	250,369	5,230,304
15	538,740	19,035	427,911	985,685	0.24	235,965	5,466,269
16	538,740	19,796	474,476	1,033,012	0.22	224,814	5,691,083
17	538,740	20,588	509,427	1,068,755	0.20	211,447	5,902,530
18	538,740	21,411	530,272	1,090,424	0.18	196,122	6,098,652
19	538,740	22,268	572,095	1,133,102	0.16	185,271	6,283,924
20	538,740	30,004	611,146	1,179,889	0.15	175,383	6,459,307
21	538,740	31,204	644,260	1,214,204	0.14	164,076	6,623,383
22	538,740	32,452	690,988	1,262,180	0.12	155,054	6,778,436
23	538,740	33,750	731,741	1,304,231	0.11	145,654	6,924,091
24	538,740	35,100	782,104	1,355,944	0.10	137,663	7,061,754
25	538,740	36,504	826,234	1,401,478	0.09	129,351	7,191,105
26	538,740	37,964	885,648	1,462,352	0.08	122,699	7,313,804
27	538,740	39,483	947,449	1,525,671	0.08	116,375	7,430,178
28	538,740	41,062	1,017,141	1,596,943	0.07	110,737	7,540,916
29	538,740	42,705	1,069,474	1,650,918	0.06	104,073	7,644,989
30	538,740	44,413	1,159,372	1,742,525	0.06	99,862	7,744,850
31	538,740	46,189	1,237,655	1,822,585	0.05	94,954	7,839,805
32	538,740	48,037	1,319,043	1,905,820	0.05	90,264	7,930,069
33	538,740	49,958	1,409,750	1,998,448	0.04	86,047	8,016,116
34	538,740	51,957	1,504,068	2,094,765	0.04	81,994	8,098,110
35	538,740	54,035	1,602,119	2,194,894	0.04	78,103	8,176,213

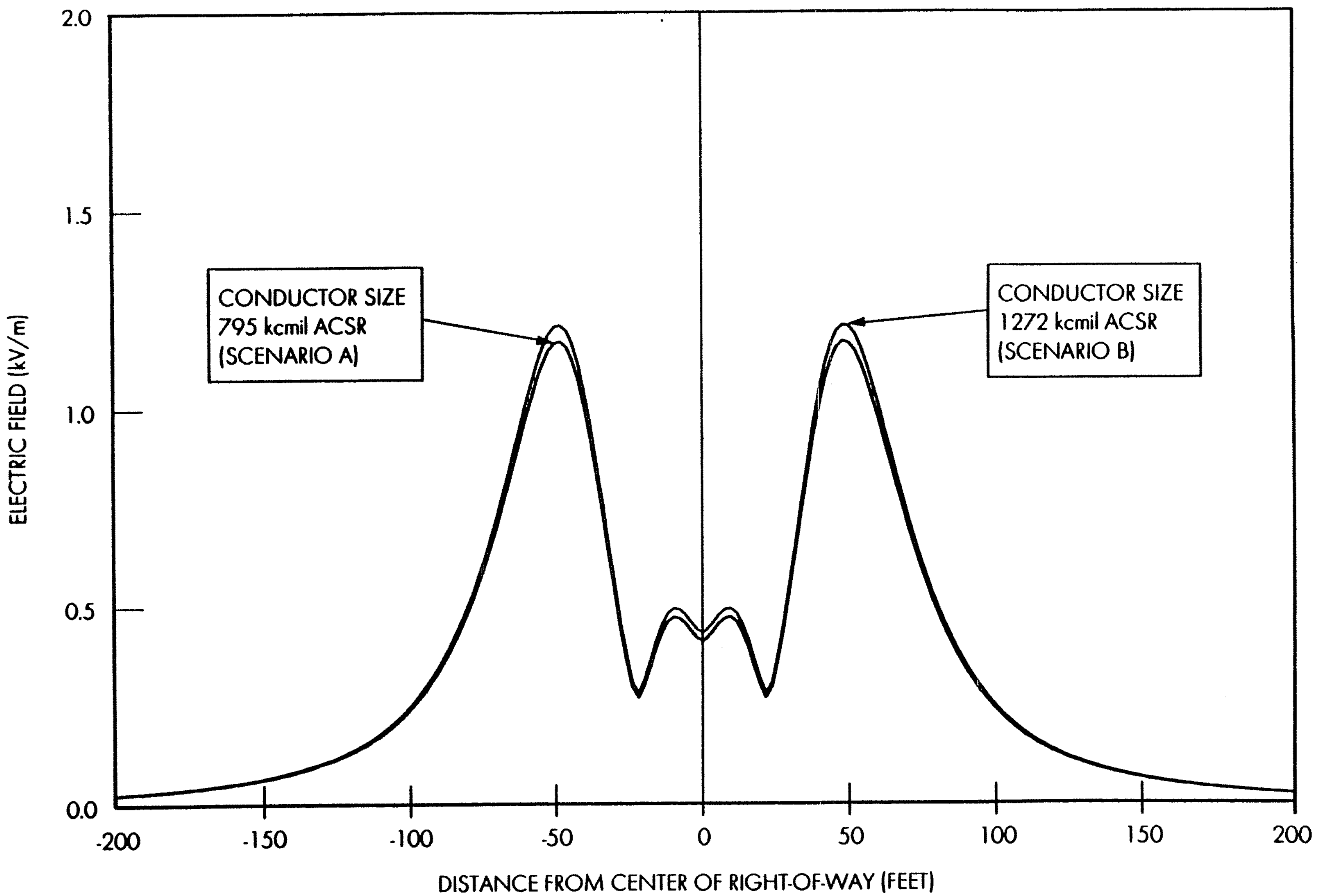
Life Cycle PV Cost **8,176,000**



MAGNETIC FIELD PROFILES FOR OVERHEAD DOUBLE-CIRCUIT H-FRAME WITH COMPACT SPACING AND ALTERNATIVE PHASING

CONNECTICUT SITING COUNCIL LIFE CYCLE COST STUDY FOR 115-KV TRANSMISSION LINES

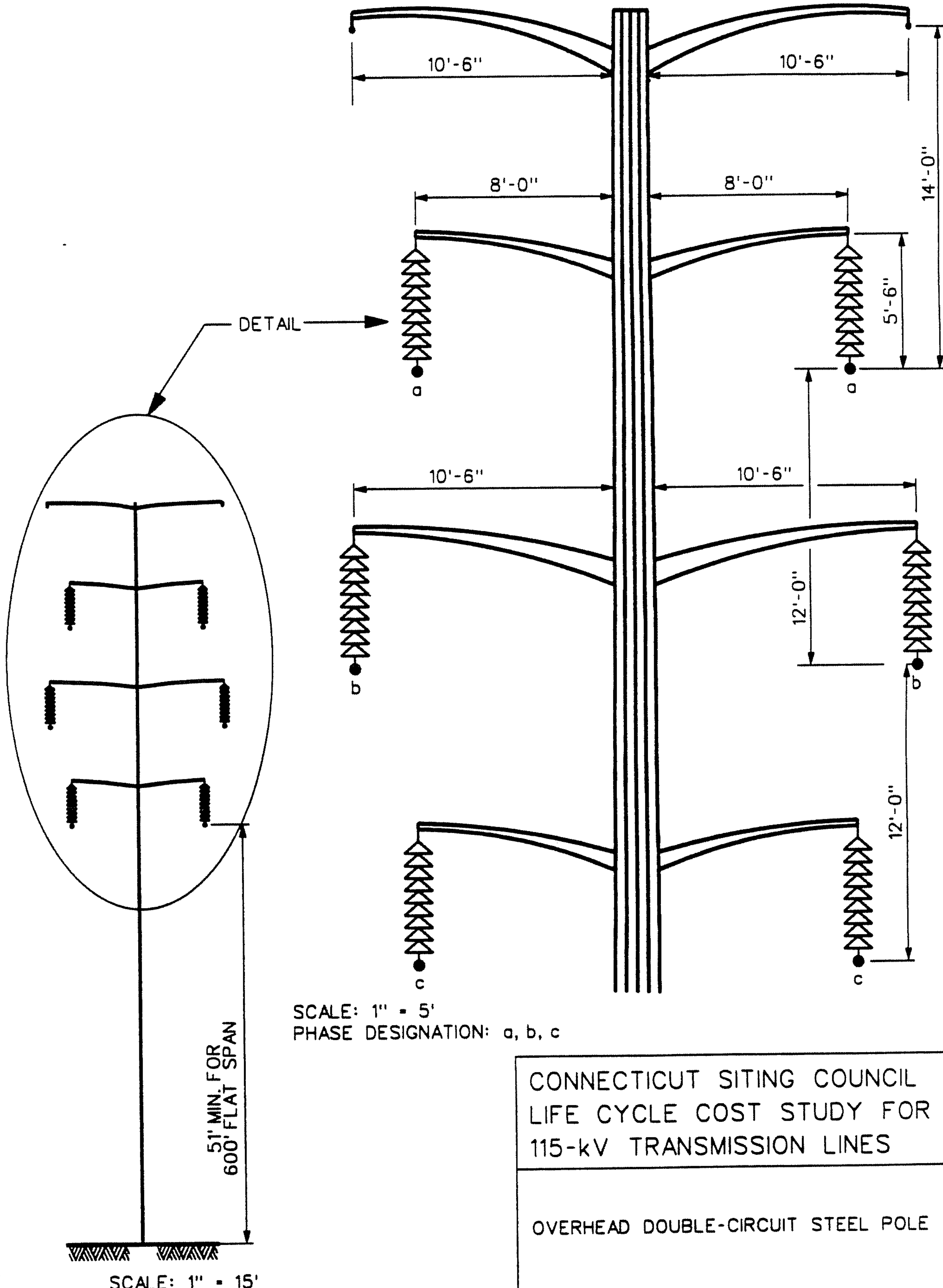
OHIDC19



ELECTRIC FIELD PROFILES FOR OVERHEAD DOUBLE-CIRCUIT H-FRAME WITH COMPACT SPACING AND ALTERNATIVE PHASING

CONNECTICUT SITING COUNCIL LIFE CYCLE COST STUDY FOR 115-KV TRANSMISSION LINES

OHIDC108



CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

OVERHEAD DOUBLE-CIRCUIT STEEL POLE

Construction Cost Estimates
Overhead Double-circuit Steel Pole

Base costs

Per Mile Base		
Scenario A 795 kcmil	$610,588	(a)
Scenario B 1272 kcmil	$668,332	(a)
Per Project Base		
Terminal equipment (Scenario A)	$75,499	(b)
Terminal equipment (Scenario B)	$76,642	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder		
Urban location	$207,000	(d)
Per Project Adder		
Winter construction	$6,000	(e)

Base Case - Scenario A

First cost	5 miles, rural, summer work	$3,246,000	5x(a) +(b)+(c)
Life cycle cost		$6,832,000	

Base Case - Scenario B

First cost	5 miles, rural, summer work	$3,536,000	5x(a) +(b)+(c)
Life cycle cost		$7,946,000	

Notes:

1) Base case is for a double-circuit line installed in a rural environment.

Life Cycle Cost Analysis
Overhead Double-circuit Steel Pole (5 Miles, Scenario A: 795 kcmil)

			FC rate		Fixed cost
Construction	3,246,000	x	0.146	=	473,916
Land	0				0
Total					473,916

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	473,916	25,911	57,646	557,473	0.91	506,794	506,794
2	473,916	9,631	65,598	549,145	0.83	453,839	960,633
3	473,916	10,017	73,900	557,832	0.75	419,108	1,379,740
4	473,916	10,417	75,684	560,017	0.68	382,499	1,762,240
5	473,916	10,834	86,906	571,657	0.62	354,954	2,117,194
6	473,916	11,267	96,221	581,405	0.56	328,188	2,445,381
7	473,916	11,718	105,935	591,570	0.51	303,569	2,748,950
8	473,916	12,187	135,982	622,084	0.47	290,207	3,039,157
9	473,916	12,674	149,601	636,191	0.42	269,807	3,308,964
10	473,916	13,181	163,798	650,896	0.39	250,948	3,559,913
11	473,916	13,709	184,015	671,639	0.35	235,405	3,795,318
12	473,916	14,257	266,324	754,497	0.32	240,406	4,035,724
13	473,916	14,827	281,283	770,026	0.29	223,049	4,258,773
14	473,916	15,420	296,808	786,144	0.26	207,016	4,465,790
15	473,916	16,037	320,766	810,719	0.24	194,080	4,659,869
16	473,916	16,679	355,672	846,266	0.22	184,172	4,844,041
17	473,916	17,346	381,871	873,133	0.20	172,745	5,016,786
18	473,916	18,040	397,497	889,453	0.18	159,976	5,176,762
19	473,916	18,761	428,847	921,525	0.16	150,677	5,327,439
20	473,916	19,512	458,120	951,548	0.15	141,442	5,468,880
21	473,916	20,292	482,944	977,152	0.14	132,043	5,600,923
22	473,916	21,104	517,971	1,012,990	0.12	124,442	5,725,365
23	473,916	21,948	548,520	1,044,384	0.11	116,635	5,842,000
24	473,916	22,826	586,273	1,083,014	0.10	109,954	5,951,954
25	473,916	23,739	619,353	1,117,008	0.09	103,095	6,055,049
26	473,916	24,688	663,890	1,162,494	0.08	97,540	6,152,589
27	473,916	25,676	710,216	1,209,808	0.08	92,281	6,244,870
28	473,916	26,703	762,459	1,263,078	0.07	87,586	6,332,456
29	473,916	27,771	801,688	1,303,375	0.06	82,164	6,414,620
30	473,916	34,495	869,076	1,377,488	0.06	78,942	6,493,562
31	473,916	35,875	927,758	1,437,549	0.05	74,894	6,568,456
32	473,916	37,310	988,767	1,499,993	0.05	71,043	6,639,500
33	473,916	38,803	1,056,762	1,569,480	0.04	67,577	6,707,076
34	473,916	40,355	1,127,464	1,641,734	0.04	64,262	6,771,338
35	473,916	41,969	1,200,964	1,716,849	0.04	61,093	6,832,430
				Life Cycle PV Cost			**6,832,000**

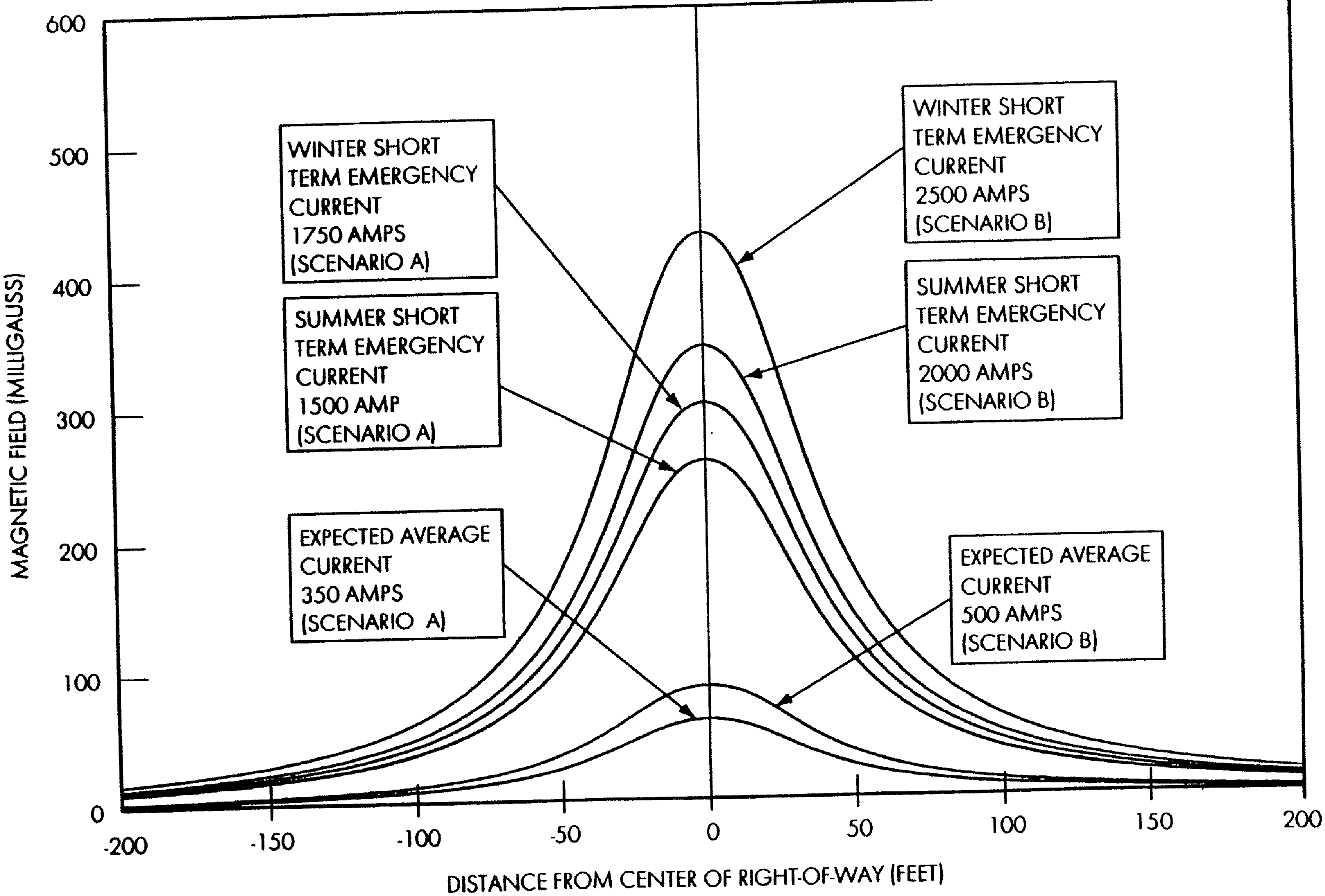
Life Cycle Cost Analysis
Overhead Double-circuit Steel Pole (5 Miles, Scenario B: 1272 kcmil)

			FC rate		Fixed cost
Construction	3,536,000	x	0.146	=	516,256
Land	0				0
Total					516,256

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	516,256	25,911	76,902	619,069	0.91	562,790	562,790
2	516,256	9,631	87,509	613,397	0.83	506,939	1,069,729
3	516,256	10,017	98,584	624,857	0.75	469,464	1,539,193
4	516,256	10,417	100,964	627,638	0.68	428,685	1,967,878
5	516,256	10,834	115,936	643,026	0.62	399,268	2,367,147
6	516,256	11,267	128,362	655,885	0.56	370,230	2,737,377
7	516,256	11,718	141,321	669,295	0.51	343,454	3,080,831
8	516,256	12,187	181,403	709,846	0.47	331,148	3,411,979
9	516,256	12,674	199,572	728,502	0.42	308,956	3,720,935
10	516,256	13,181	218,512	747,949	0.39	288,367	4,009,302
11	516,256	13,709	245,481	775,445	0.35	271,789	4,281,091
12	516,256	14,257	355,284	885,797	0.32	282,242	4,563,333
13	516,256	14,827	375,239	906,322	0.29	262,529	4,825,862
14	516,256	15,420	395,950	927,627	0.26	244,273	5,070,135
15	516,256	16,037	427,911	960,204	0.24	229,865	5,300,001
16	516,256	16,679	474,476	1,007,411	0.22	219,242	5,519,243
17	516,256	17,346	509,427	1,043,029	0.20	206,358	5,725,600
18	516,256	18,040	530,272	1,064,568	0.18	191,472	5,917,072
19	516,256	18,761	572,095	1,107,112	0.16	181,022	6,098,094
20	516,256	19,512	611,146	1,146,913	0.15	170,481	6,268,575
21	516,256	20,292	644,260	1,180,808	0.14	159,563	6,428,138
22	516,256	21,104	690,988	1,228,347	0.12	150,898	6,579,036
23	516,256	21,948	731,741	1,269,945	0.11	141,825	6,720,861
24	516,256	22,826	782,104	1,321,186	0.10	134,134	6,854,995
25	516,256	23,739	826,234	1,366,229	0.09	126,097	6,981,093
26	516,256	24,688	885,648	1,426,592	0.08	119,699	7,100,792
27	516,256	25,676	947,449	1,489,380	0.08	113,606	7,214,398
28	516,256	26,703	1,017,141	1,560,100	0.07	108,183	7,322,581
29	516,256	27,771	1,069,474	1,613,501	0.06	101,714	7,424,295
30	516,256	34,495	1,159,372	1,710,124	0.06	98,005	7,522,299
31	516,256	35,875	1,237,655	1,789,787	0.05	93,246	7,615,545
32	516,256	37,310	1,319,043	1,872,609	0.05	88,691	7,704,236
33	516,256	38,803	1,409,750	1,964,809	0.04	84,598	7,788,835
34	516,256	40,355	1,504,068	2,060,679	0.04	80,660	7,869,495
35	516,256	41,969	1,602,119	2,160,344	0.04	76,874	7,946,369

Life Cycle PV Cost **7,946,000**



MAGNETIC FIELD PROFILES FOR OVERHEAD DOUBLE-CIRCUIT STEEL POLE

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES

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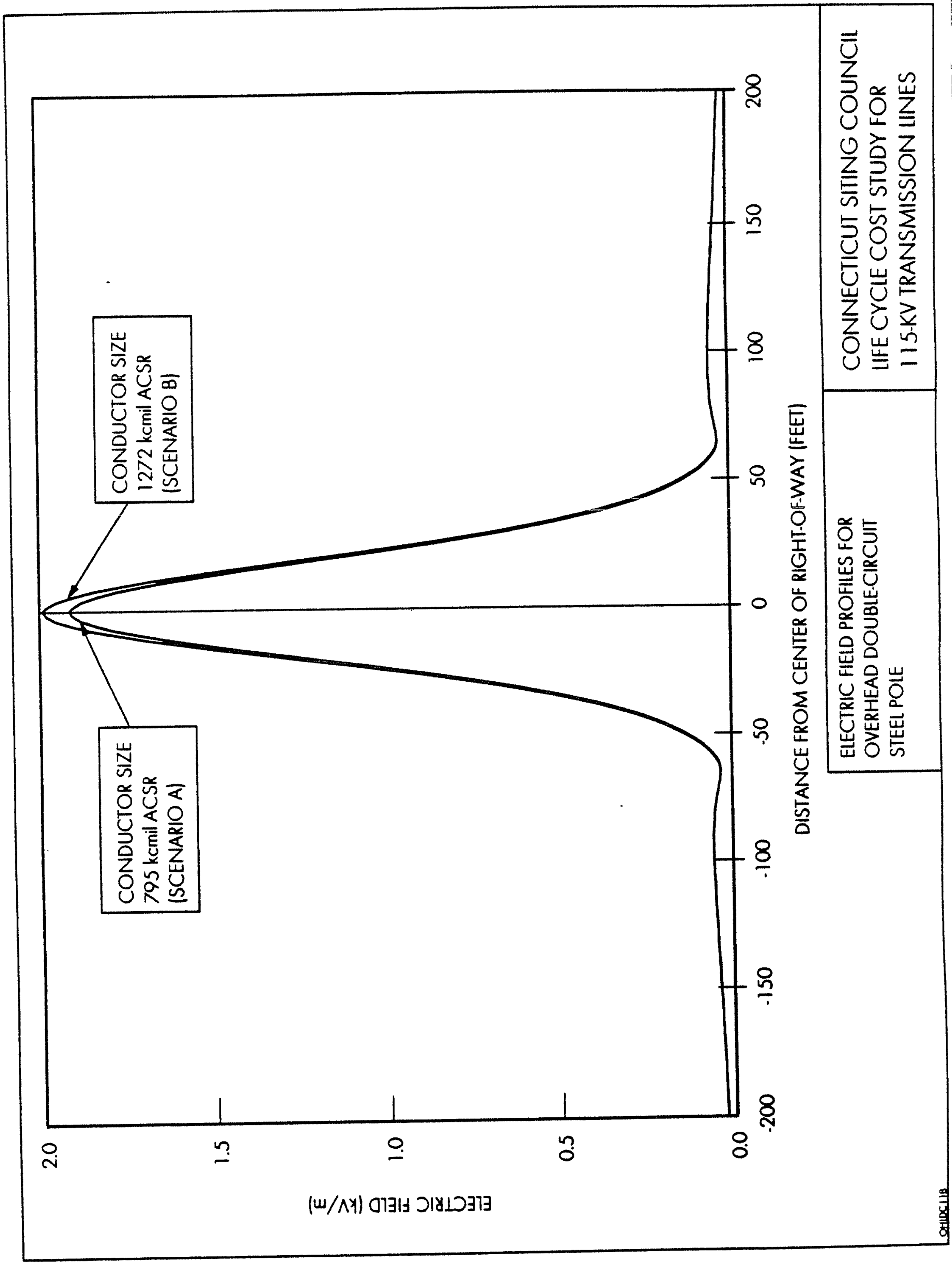
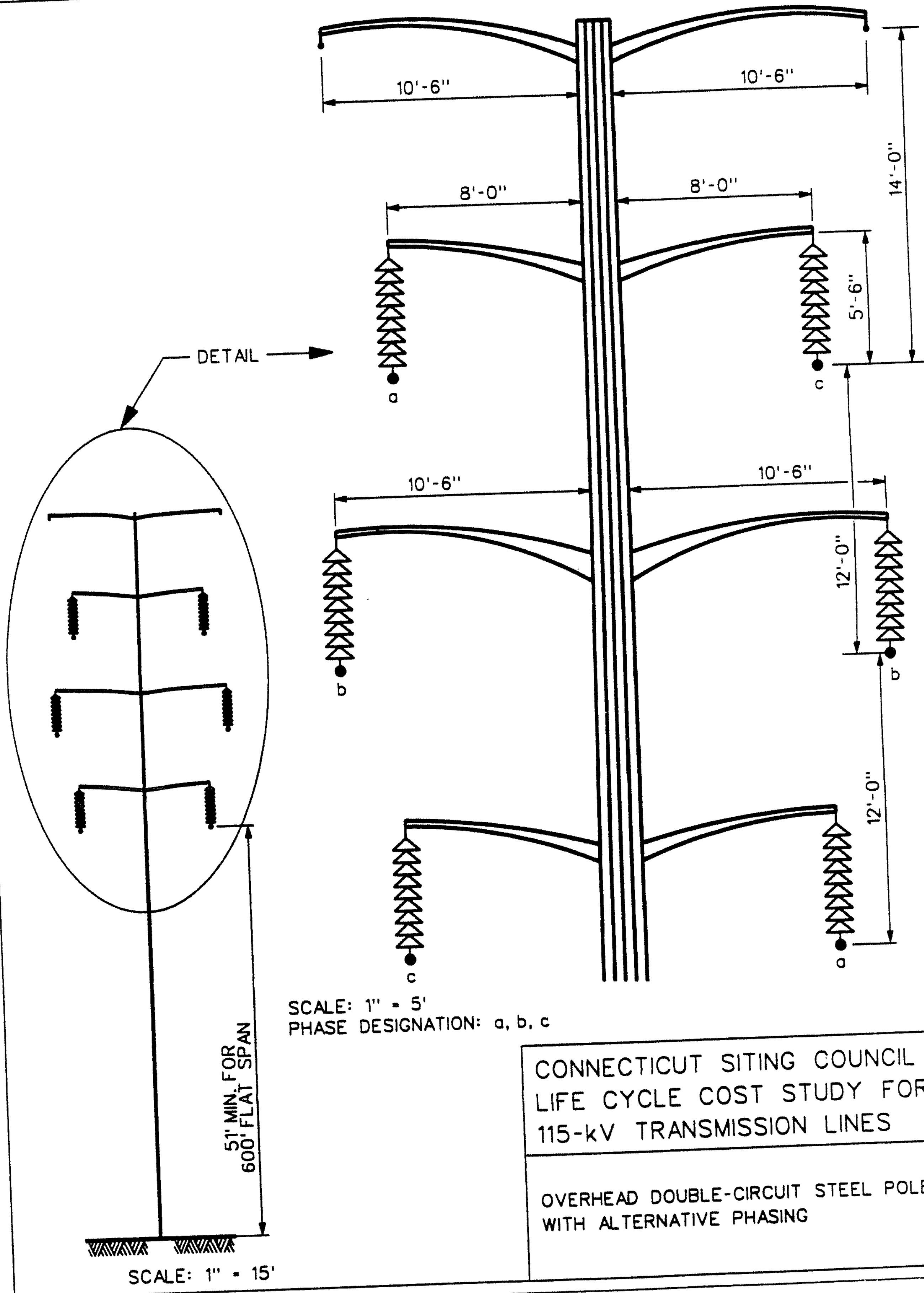

CONDUCTOR SIZE
1272 kcmil ACSR
(SCENARIO B)
CONDUCTOR SIZE
795 kcmil ACSR
(SCENARIO A)
ELECTRIC FIELD (kV/m)
2.0
1.5
1.0
0.5
0.0
-200
-150
-100
-50
0
50
100
150
200
DISTANCE FROM CENTER OF RIGHT-OF-WAY (FEET)
ELECTRIC FIELD PROFILES FOR
OVERHEAD DOUBLE-CIRCUIT
STEEL POLE
CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES



CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

OVERHEAD DOUBLE-CIRCUIT STEEL POLE
WITH ALTERNATIVE PHASING

Construction Cost Estimates
Overhead Double-circuit Steel Pole with Alternative Phasing

Base costs

Per Mile Base		
Scenario A 795 kcmil	$610,588	(a)
Scenario B 1272 kcmil	$668,332	(a)
Per Project Base		
Terminal equipment (Scenario A)	$75,499	(b)
Terminal equipment (Scenario B)	$76,642	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder		
Urban location	$207,000	(d)
Per Project Adder		
Winter construction	$6,000	(e)

Base Case - Scenario A

First cost	5 miles, rural, summer work	$3,246,000	5x(a) +(b)+(c)
Life cycle cost		$6,832,000	

Base Case - Scenario B

First cost	5 miles, rural, summer work	$3,536,000	5x(a) +(b)+(c)
Life cycle cost		$7,946,000	

Notes:

1) Base case is for a double-circuit line installed in a rural environment.

Life Cycle Cost Analysis
Overhead Double-circuit Steel Pole with Alternative Phasing (Scenario A: 795 kcmil)

			FC rate		Fixed cost
Construction	3,246,000	x	0.146	=	473,916
Land	0				0
Total					473,916

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	473,916	25,911	57,646	557,473	0.91	506,794	506,794
2	473,916	9,631	65,598	549,145	0.83	453,839	960,633
3	473,916	10,017	73,900	557,832	0.75	419,108	1,379,740
4	473,916	10,417	75,684	560,017	0.68	382,499	1,762,240
5	473,916	10,834	86,906	571,657	0.62	354,954	2,117,194
6	473,916	11,267	96,221	581,405	0.56	328,188	2,445,381
7	473,916	11,718	105,935	591,570	0.51	303,569	2,748,950
8	473,916	12,187	135,982	622,084	0.47	290,207	3,039,157
9	473,916	12,674	149,601	636,191	0.42	269,807	3,308,964
10	473,916	13,181	163,798	650,896	0.39	250,948	3,559,913
11	473,916	13,709	184,015	671,639	0.35	235,405	3,795,318
12	473,916	14,257	266,324	754,497	0.32	240,406	4,035,724
13	473,916	14,827	281,283	770,026	0.29	223,049	4,258,773
14	473,916	15,420	296,808	786,144	0.26	207,016	4,465,790
15	473,916	16,037	320,766	810,719	0.24	194,080	4,659,869
16	473,916	16,679	355,672	846,266	0.22	184,172	4,844,041
17	473,916	17,346	381,871	873,133	0.20	172,745	5,016,786
18	473,916	18,040	397,497	889,453	0.18	159,976	5,176,762
19	473,916	18,761	428,847	921,525	0.16	150,677	5,327,439
20	473,916	19,512	458,120	951,548	0.15	141,442	5,468,880
21	473,916	20,292	482,944	977,152	0.14	132,043	5,600,923
22	473,916	21,104	517,971	1,012,990	0.12	124,442	5,725,365
23	473,916	21,948	548,520	1,044,384	0.11	116,635	5,842,000
24	473,916	22,826	586,273	1,083,014	0.10	109,954	5,951,954
25	473,916	23,739	619,353	1,117,008	0.09	103,095	6,055,049
26	473,916	24,688	663,890	1,162,494	0.08	97,540	6,152,589
27	473,916	25,676	710,216	1,209,808	0.08	92,281	6,244,870
28	473,916	26,703	762,459	1,263,078	0.07	87,586	6,332,456
29	473,916	27,771	801,688	1,303,375	0.06	82,164	6,414,620
30	473,916	34,495	869,076	1,377,488	0.06	78,942	6,493,562
31	473,916	35,875	927,758	1,437,549	0.05	74,894	6,568,456
32	473,916	37,310	988,767	1,499,993	0.05	71,043	6,639,500
33	473,916	38,803	1,056,762	1,569,480	0.04	67,577	6,707,076
34	473,916	40,355	1,127,464	1,641,734	0.04	64,262	6,771,338
35	473,916	41,969	1,200,964	1,716,849	0.04	61,093	6,832,430

Life Cycle PV Cost **6,832,000**

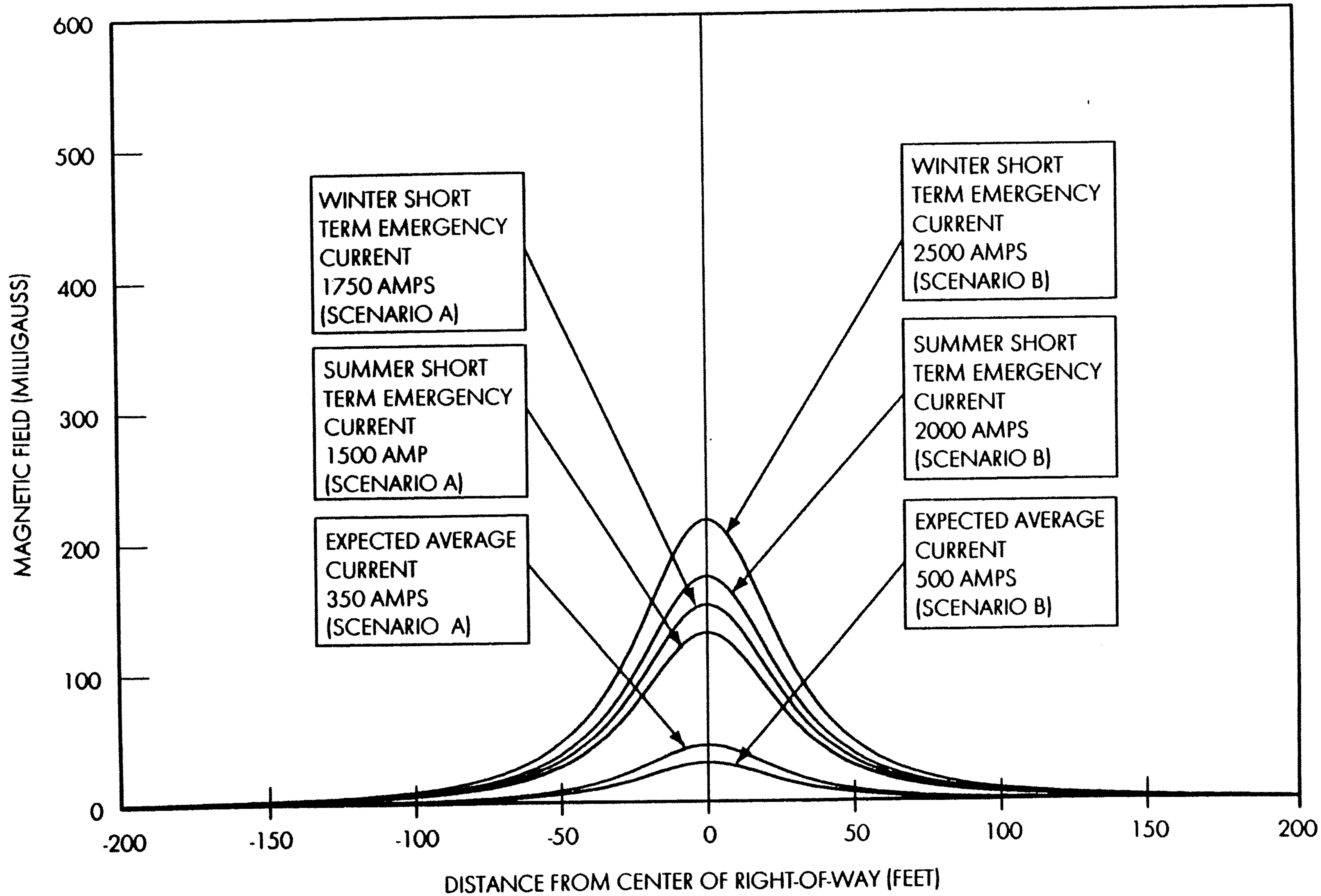
Life Cycle Cost Analysis
Overhead Double-circuit Steel Pole with Alternative Phasing (Scenario B: 1272 kcmil)

			FC rate		Fixed cost
Construction	3,536,000	x	0.146	=	516,256
Land	0				0
Total					516,256

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

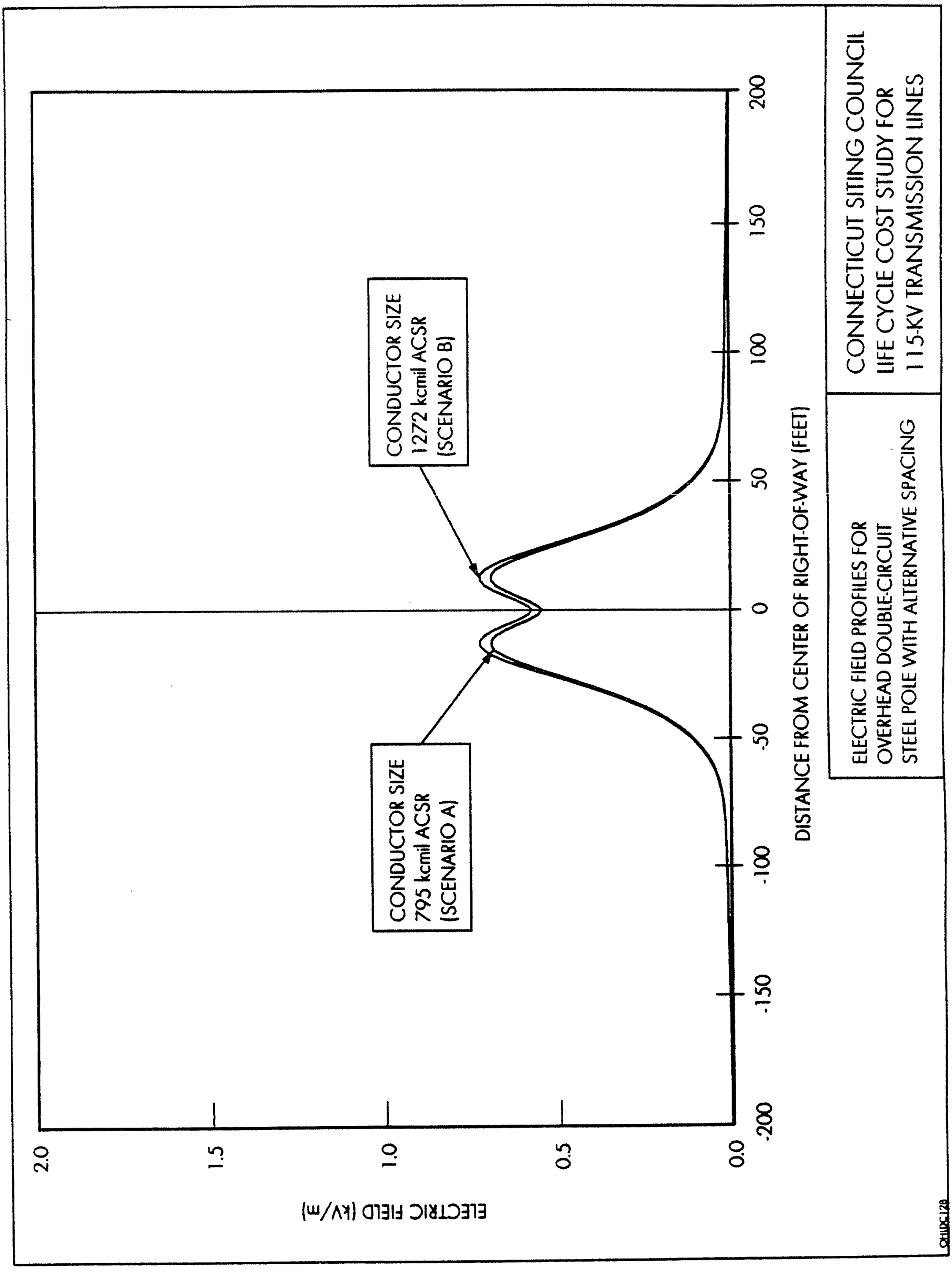
Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	516,256	25,911	76,902	619,069	0.91	562,790	562,790
2	516,256	9,631	87,509	613,397	0.83	506,939	1,069,729
3	516,256	10,017	98,584	624,857	0.75	469,464	1,539,193
4	516,256	10,417	100,964	627,638	0.68	428,685	1,967,878
5	516,256	10,834	115,936	643,026	0.62	399,268	2,367,147
6	516,256	11,267	128,362	655,885	0.56	370,230	2,737,377
7	516,256	11,718	141,321	669,295	0.51	343,454	3,080,831
8	516,256	12,187	181,403	709,846	0.47	331,148	3,411,979
9	516,256	12,674	199,572	728,502	0.42	308,956	3,720,935
10	516,256	13,181	218,512	747,949	0.39	288,367	4,009,302
11	516,256	13,709	245,481	775,445	0.35	271,789	4,281,091
12	516,256	14,257	355,284	885,797	0.32	282,242	4,563,333
13	516,256	14,827	375,239	906,322	0.29	262,529	4,825,862
14	516,256	15,420	395,950	927,627	0.26	244,273	5,070,135
15	516,256	16,037	427,911	960,204	0.24	229,865	5,300,001
16	516,256	16,679	474,476	1,007,411	0.22	219,242	5,519,243
17	516,256	17,346	509,427	1,043,029	0.20	206,358	5,725,600
18	516,256	18,040	530,272	1,064,568	0.18	191,472	5,917,072
19	516,256	18,761	572,095	1,107,112	0.16	181,022	6,098,094
20	516,256	19,512	611,146	1,146,913	0.15	170,481	6,268,575
21	516,256	20,292	644,260	1,180,808	0.14	159,563	6,428,138
22	516,256	21,104	690,988	1,228,347	0.12	150,898	6,579,036
23	516,256	21,948	731,741	1,269,945	0.11	141,825	6,720,861
24	516,256	22,826	782,104	1,321,186	0.10	134,134	6,854,995
25	516,256	23,739	826,234	1,366,229	0.09	126,097	6,981,093
26	516,256	24,688	885,648	1,426,592	0.08	119,699	7,100,792
27	516,256	25,676	947,449	1,489,380	0.08	113,606	7,214,398
28	516,256	26,703	1,017,141	1,560,100	0.07	108,183	7,322,581
29	516,256	27,771	1,069,474	1,613,501	0.06	101,714	7,424,295
30	516,256	34,495	1,159,372	1,710,124	0.06	98,005	7,522,299
31	516,256	35,875	1,237,655	1,789,787	0.05	93,246	7,615,545
32	516,256	37,310	1,319,043	1,872,609	0.05	88,691	7,704,236
33	516,256	38,803	1,409,750	1,964,809	0.04	84,598	7,788,835
34	516,256	40,355	1,504,068	2,060,679	0.04	80,660	7,869,495
35	516,256	41,969	1,602,119	2,160,344	0.04	76,874	7,946,369

Life Cycle PV Cost **7,946,000**

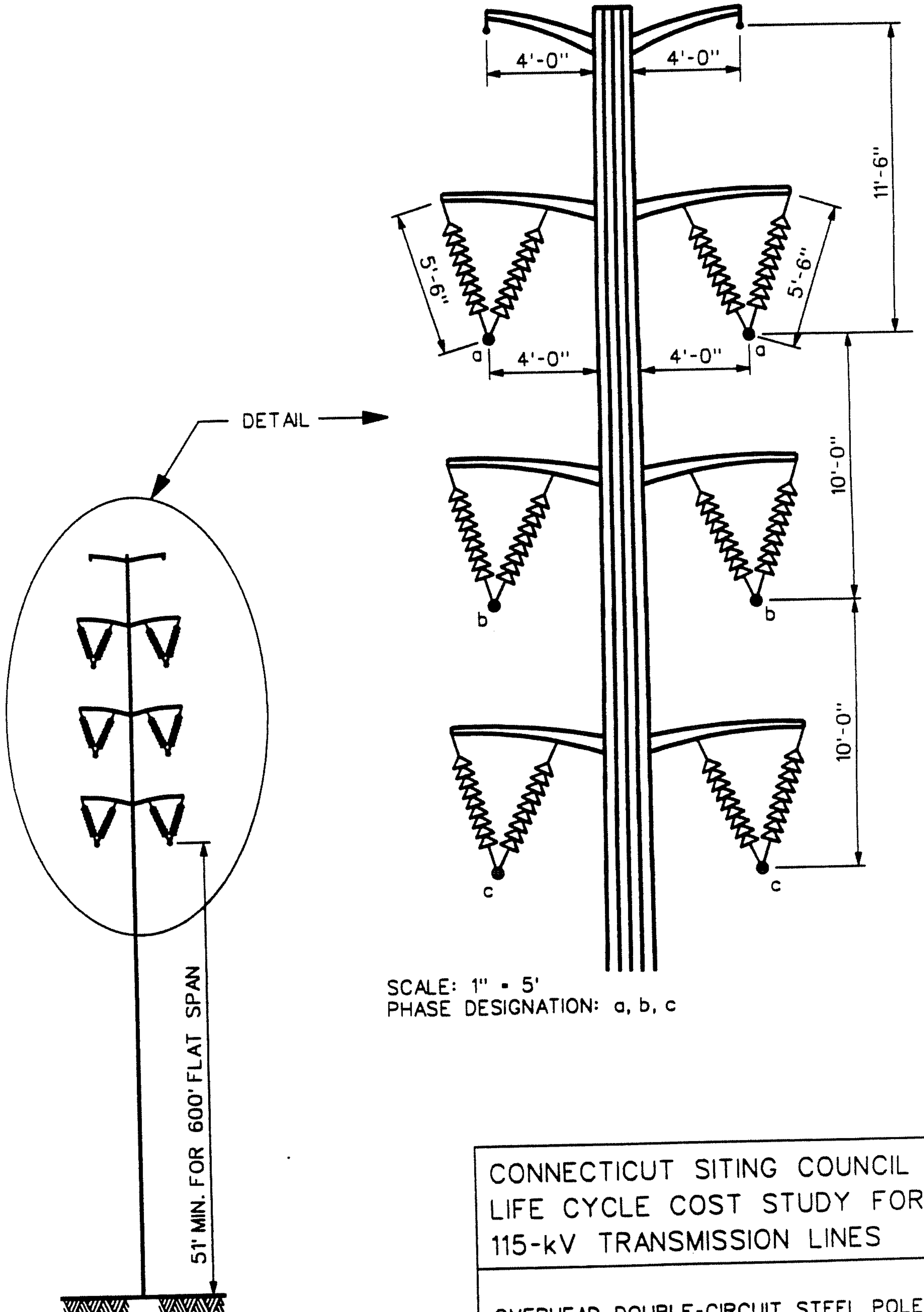


MAGNETIC FIELD PROFILES FOR OVERHEAD DOUBLE-CIRCUIT STEEL POLE WITH ALTERNATIVE SPACING

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES



ELECTRIC FIELD (kV/m)
2.0
1.5
1.0
0.5
0.0
-200
-150
-100
-50
0
50
100
150
200
DISTANCE FROM CENTER OF RIGHT-OF-WAY (FEET)
CONDUCTOR SIZE
795 kcmil ACSR
(SCENARIO A)
CONDUCTOR SIZE
1272 kcmil ACSR
(SCENARIO B)
ELECTRIC FIELD PROFILES FOR
OVERHEAD DOUBLE-CIRCUIT
STEEL POLE WITH ALTERNATIVE SPACING
CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES



CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

OVERHEAD DOUBLE-CIRCUIT STEEL POLE
WITH COMPACT SPACING

Construction Cost Estimates
Overhead Double-circuit Steel Pole with Compact Spacing

Base costs

Per Mile Base		
Scenario A 795 kcmil	$623,518	(a)
Scenario B 1272 kcmil	$677,323	(a)
Per Project Base		
Terminal equipment (Scenario A)	$72,234	(b)
Terminal equipment (Scenario B)	$73,768	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder		
Urban location	$207,000	(d)
Per Project Adder		
Winter construction	$6,000	(e)

Base Case - Scenario A

First cost	5 miles, rural, summer work	$3,308,000	5x(a) +(b)+(c)
Life cycle cost		$6,920,000	

Base Case - Scenario B

First cost	5 miles, rural, summer work	$3,578,000	5x(a) +(b)+(c)
Life cycle cost		$8,006,000	

Notes:

1) Base case is for a double-circuit line installed in a rural environment.

Life Cycle Cost Analysis
Overhead Double-circuit Steel Pole with Compact Spacing (5 Miles, Scenario A: 795 kcmil)

			FC rate		Fixed cost
Construction	3,308,000	x	0.146	=	482,968
Land	0				0
Total					482,968

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	482,968	25,911	57,646	566,525	0.91	515,023	515,023
2	482,968	9,631	65,598	558,197	0.83	461,320	976,343
3	482,968	10,017	73,900	566,884	0.75	425,909	1,402,251
4	482,968	10,417	75,684	569,069	0.68	388,682	1,790,933
5	482,968	10,834	86,906	580,709	0.62	360,574	2,151,508
6	482,968	11,267	96,221	590,457	0.56	333,297	2,484,805
7	482,968	11,718	105,935	600,622	0.51	308,214	2,793,019
8	482,968	12,187	135,982	631,136	0.47	294,430	3,087,449
9	482,968	12,674	149,601	645,243	0.42	273,646	3,361,095
10	482,968	13,181	163,798	659,948	0.39	254,438	3,615,533
11	482,968	13,709	184,015	680,691	0.35	238,578	3,854,111
12	482,968	14,257	266,324	763,549	0.32	243,290	4,097,402
13	482,968	14,827	281,283	779,078	0.29	225,671	4,323,073
14	482,968	15,420	296,808	795,196	0.26	209,400	4,532,473
15	482,968	16,037	320,766	819,771	0.24	196,247	4,728,719
16	482,968	16,679	355,672	855,318	0.22	186,142	4,914,862
17	482,968	17,346	381,871	882,185	0.20	174,536	5,089,397
18	482,968	18,040	397,497	898,505	0.18	161,604	5,251,001
19	482,968	18,761	428,847	930,577	0.16	152,157	5,403,158
20	482,968	19,512	458,120	960,600	0.15	142,787	5,545,945
21	482,968	20,292	482,944	986,204	0.14	133,266	5,679,211
22	482,968	21,104	517,971	1,022,042	0.12	125,554	5,804,765
23	482,968	21,948	548,520	1,053,436	0.11	117,646	5,922,411
24	482,968	22,826	586,273	1,092,066	0.10	110,873	6,033,284
25	482,968	23,739	619,353	1,126,060	0.09	103,931	6,137,214
26	482,968	24,688	663,890	1,171,546	0.08	98,299	6,235,513
27	482,968	25,676	710,216	1,218,860	0.08	92,972	6,328,485
28	482,968	26,703	762,459	1,272,130	0.07	88,214	6,416,699
29	482,968	27,771	801,688	1,312,427	0.06	82,735	6,499,434
30	482,968	34,495	869,076	1,386,540	0.06	79,461	6,578,894
31	482,968	35,875	927,758	1,446,601	0.05	75,366	6,654,260
32	482,968	37,310	988,767	1,509,045	0.05	71,472	6,725,732
33	482,968	38,803	1,056,762	1,578,532	0.04	67,966	6,793,699
34	482,968	40,355	1,127,464	1,650,786	0.04	64,616	6,858,315
35	482,968	41,969	1,200,964	1,725,901	0.04	61,415	6,919,729

Life Cycle PV Cost **6,920,000**

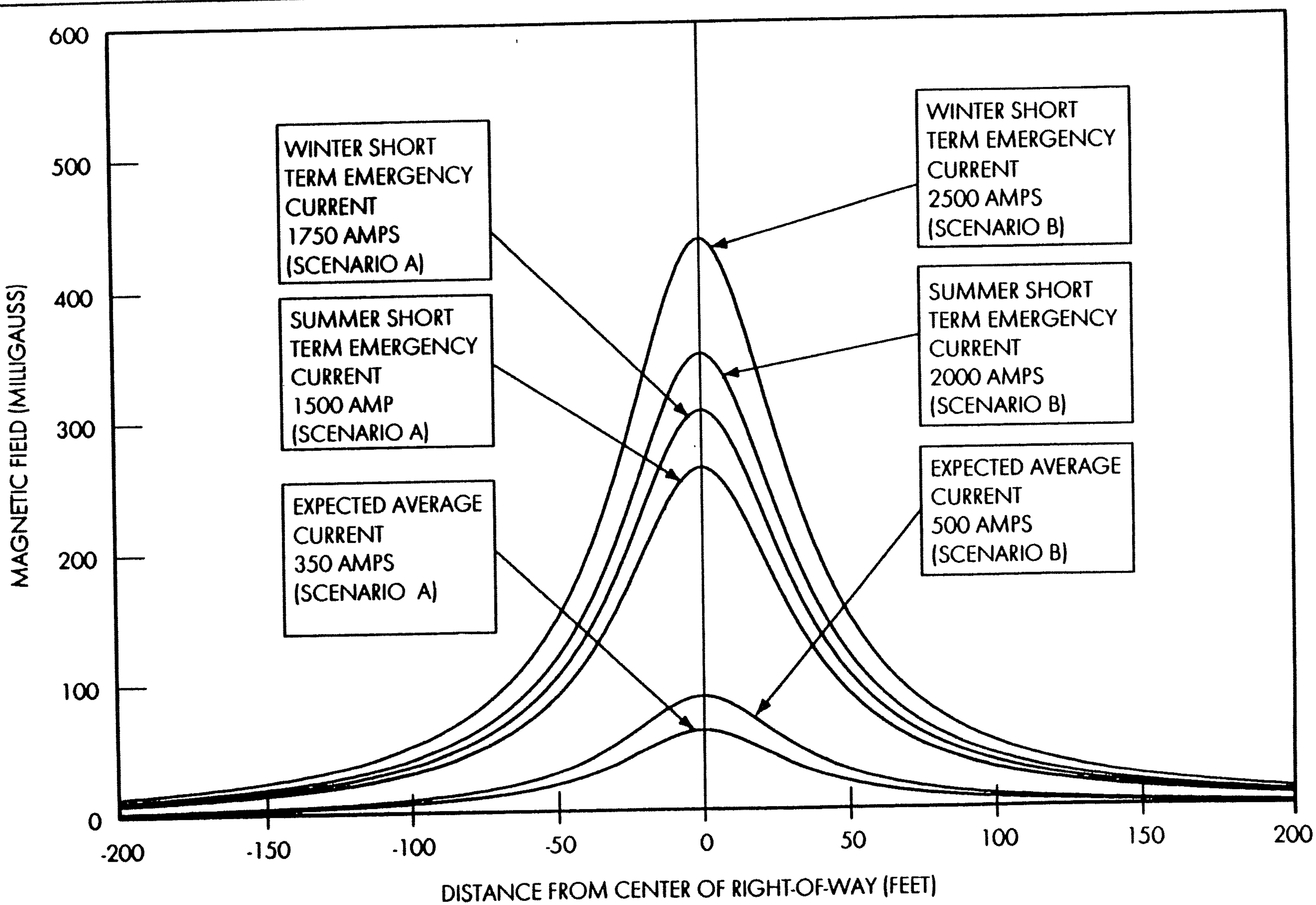
Life Cycle Cost Analysis
Overhead Double-circuit Steel Pole with Compact Spacing (5 Miles, Scenario B: 1272 kcmil)

			FC rate		Fixed cost
Construction	3,578,000	x	0.146	=	522,388
Land	0				0
Total					522,388

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	522,388	25,911	76,902	625,201	0.91	568,364	568,364
2	522,388	9,631	87,509	619,529	0.83	512,007	1,080,371
3	522,388	10,017	98,584	630,989	0.75	474,071	1,554,443
4	522,388	10,417	100,964	633,770	0.68	432,873	1,987,316
5	522,388	10,834	115,936	649,158	0.62	403,076	2,390,392
6	522,388	11,267	128,362	662,017	0.56	373,692	2,764,083
7	522,388	11,718	141,321	675,427	0.51	346,601	3,110,684
8	522,388	12,187	181,403	715,978	0.47	334,009	3,444,693
9	522,388	12,674	199,572	734,634	0.42	311,556	3,756,250
10	522,388	13,181	218,512	754,081	0.39	290,731	4,046,981
11	522,388	13,709	245,481	781,577	0.35	273,938	4,320,919
12	522,388	14,257	355,284	891,929	0.32	284,196	4,605,115
13	522,388	14,827	375,239	912,454	0.29	264,305	4,869,420
14	522,388	15,420	395,950	933,759	0.26	245,888	5,115,308
15	522,388	16,037	427,911	966,336	0.24	231,333	5,346,641
16	522,388	16,679	474,476	1,013,543	0.22	220,576	5,567,218
17	522,388	17,346	509,427	1,049,161	0.20	207,571	5,774,788
18	522,388	18,040	530,272	1,070,700	0.18	192,575	5,967,363
19	522,388	18,761	572,095	1,113,244	0.16	182,024	6,149,387
20	522,388	19,512	611,146	1,153,045	0.15	171,393	6,320,780
21	522,388	20,292	644,260	1,186,940	0.14	160,392	6,481,172
22	522,388	21,104	690,988	1,234,479	0.12	151,651	6,632,823
23	522,388	21,948	731,741	1,276,077	0.11	142,510	6,775,333
24	522,388	22,826	782,104	1,327,318	0.10	134,757	6,910,090
25	522,388	23,739	826,234	1,372,361	0.09	126,663	7,036,753
26	522,388	24,688	885,648	1,432,724	0.08	120,213	7,156,966
27	522,388	25,676	947,449	1,495,512	0.08	114,074	7,271,041
28	522,388	26,703	1,017,141	1,566,232	0.07	108,608	7,379,648
29	522,388	27,771	1,069,474	1,619,633	0.06	102,101	7,481,749
30	522,388	34,495	1,159,372	1,716,256	0.06	98,356	7,580,105
31	522,388	35,875	1,237,655	1,795,919	0.05	93,565	7,673,670
32	522,388	37,310	1,319,043	1,878,741	0.05	88,982	7,762,652
33	522,388	38,803	1,409,750	1,970,941	0.04	84,862	7,847,514
34	522,388	40,355	1,504,068	2,066,811	0.04	80,900	7,928,415
35	522,388	41,969	1,602,119	2,166,476	0.04	77,092	8,005,507

Life Cycle PV Cost **8,006,000**



MAGNETIC FIELD PROFILES FOR OVERHEAD DOUBLE-CIRCUIT STEEL POLE WITH COMPACT SPACING

CONNECTICUT SITING COUNCIL LIFE CYCLE COST STUDY FOR 115-KV TRANSMISSION LINES

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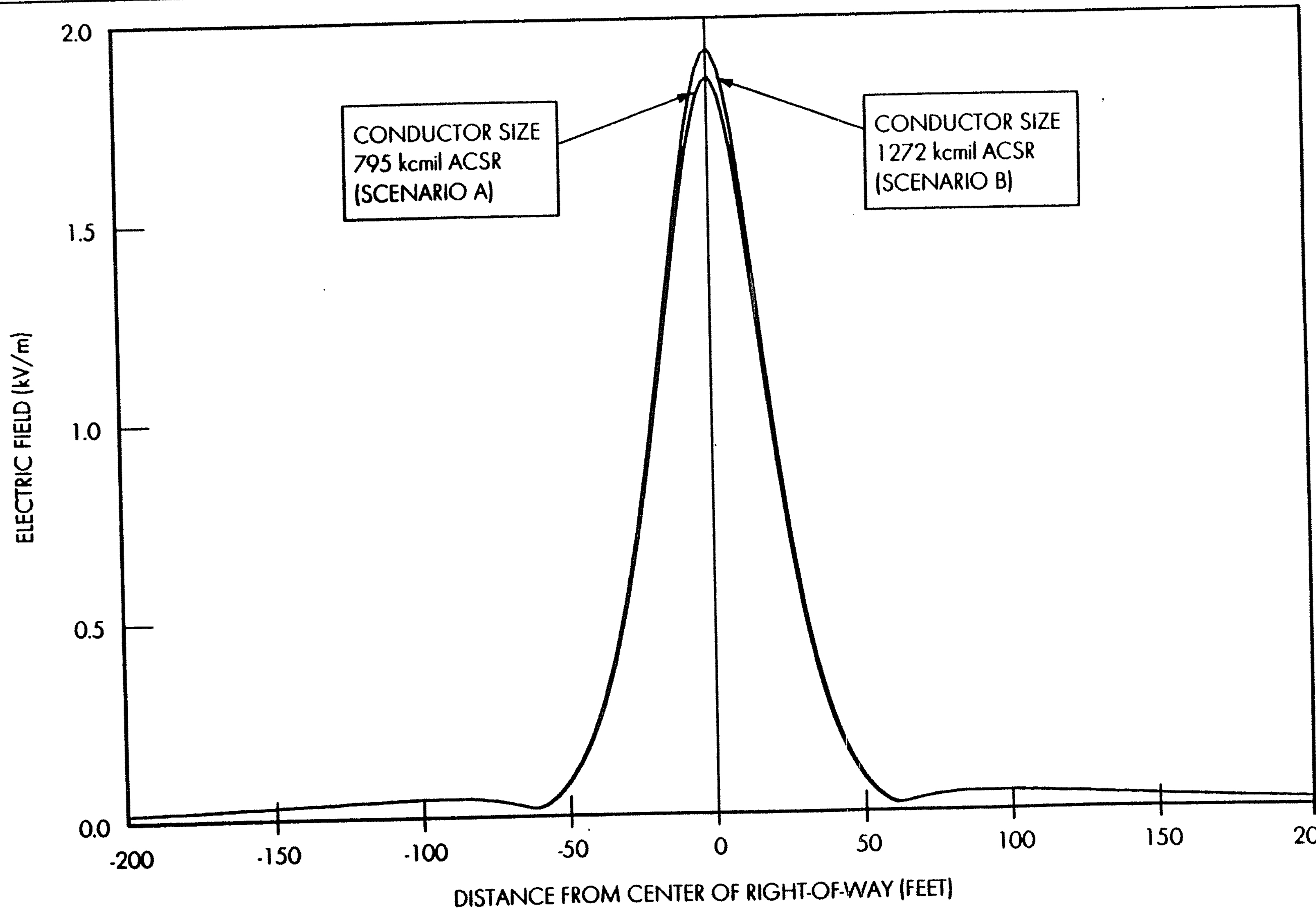
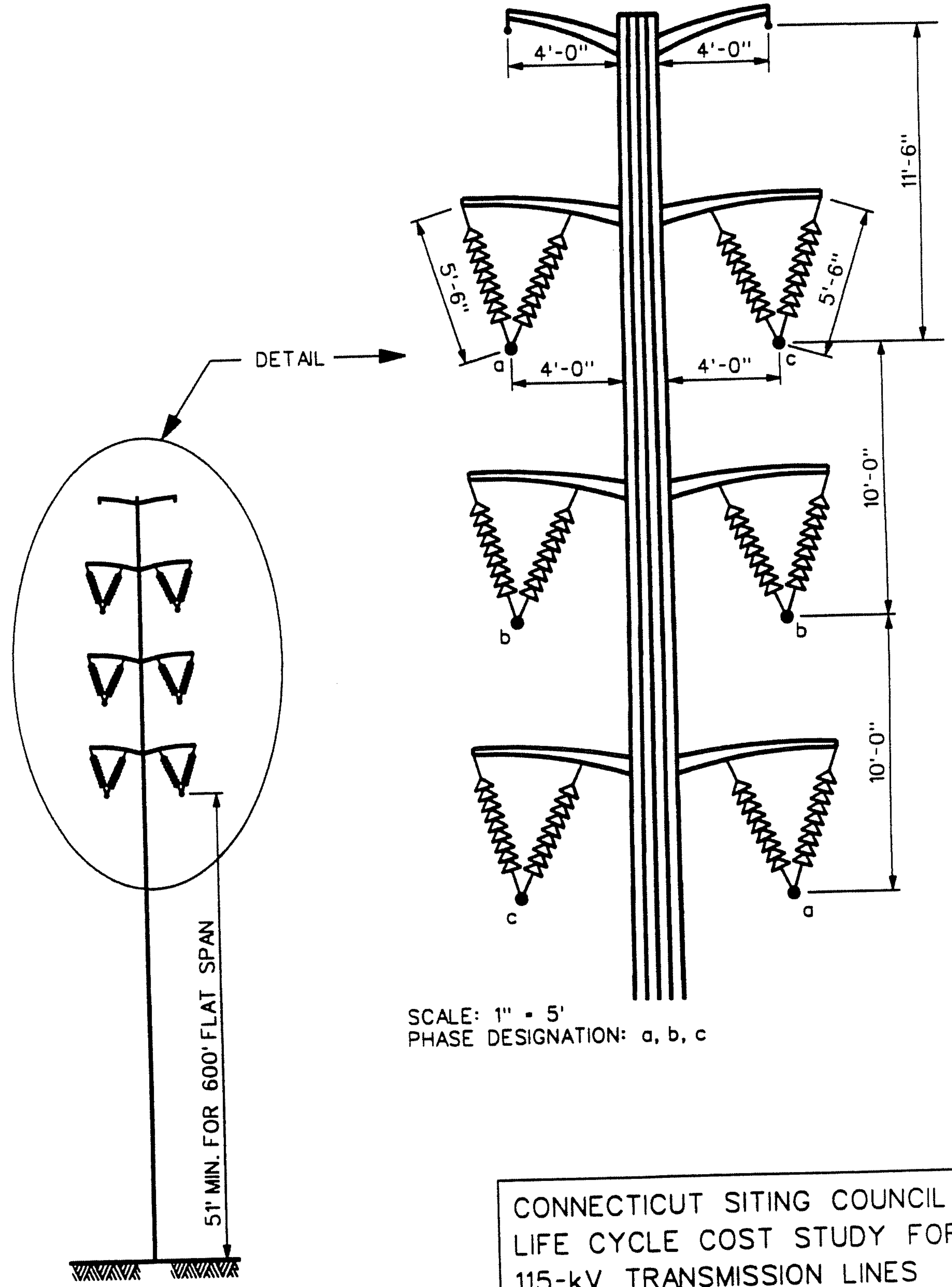


ELECTRIC FIELD PROFILES FOR OVERHEAD DOUBLE-CIRCUIT STEEL POLE WITH COMPACT SPACING

CONNECTICUT SITING COUNCIL LIFE CYCLE COST STUDY FOR 115-KV TRANSMISSION LINES



CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

OVERHEAD DOUBLE-CIRCUIT STEEL POLE WITH COMPACT SPACING AND ALTERNATIVE PHASING USING V-STRING INULATORS

Construction Cost Estimates
Overhead Double-circuit Steel Pole with Compact Spacing and Alternative Phasing using V-String Insulators

Base costs

Per Mile Base		
Scenario A 795 kcmil	$623,518	(a)
Scenario B 1272 kcmil	$677,323	(a)
Per Project Base		
Terminal equipment (Scenario A)	$72,234	(b)
Terminal equipment (Scenario B)	$73,768	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder		
Urban location	$207,000	(d)
Per Project Adder		
Winter construction	$6,000	(e)

Base Case - Scenario A

First cost	5 miles, rural, summer work	$3,308,000	5x(a) +(b)+(c)
Life cycle cost		$6,920,000	

Base Case - Scenario B

First cost	5 miles, rural, summer work	$3,578,000	5x(a) +(b)+(c)
Life cycle cost		$8,006,000	

Notes:
1) Base case is for a double-circuit line installed in a rural environment.

Life Cycle Cost Analysis
Overhead Double-circuit Steel Pole with Compact Spacing and Alternative Phasing using V-String Insulators (Scenario A: 795 kcmil)

			FC rate		Fixed cost
Construction	3,308,000	x	0.146	=	482,968
Land	0				0
Total					482,968

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	482,968	25,911	57,646	566,525	0.91	515,023	515,023
2	482,968	9,631	65,598	558,197	0.83	461,320	976,343
3	482,968	10,017	73,900	566,884	0.75	425,909	1,402,251
4	482,968	10,417	75,684	569,069	0.68	388,682	1,790,933
5	482,968	10,834	86,906	580,709	0.62	360,574	2,151,508
6	482,968	11,267	96,221	590,457	0.56	333,297	2,484,805
7	482,968	11,718	105,935	600,622	0.51	308,214	2,793,019
8	482,968	12,187	135,982	631,136	0.47	294,430	3,087,449
9	482,968	12,674	149,601	645,243	0.42	273,646	3,361,095
10	482,968	13,181	163,798	659,948	0.39	254,438	3,615,533
11	482,968	13,709	184,015	680,691	0.35	238,578	3,854,111
12	482,968	14,257	266,324	763,549	0.32	243,290	4,097,402
13	482,968	14,827	281,283	779,078	0.29	225,671	4,323,073
14	482,968	15,420	296,808	795,196	0.26	209,400	4,532,473
15	482,968	16,037	320,766	819,771	0.24	196,247	4,728,719
16	482,968	16,679	355,672	855,318	0.22	186,142	4,914,862
17	482,968	17,346	381,871	882,185	0.20	174,536	5,089,397
18	482,968	18,040	397,497	898,505	0.18	161,604	5,251,001
19	482,968	18,761	428,847	930,577	0.16	152,157	5,403,158
20	482,968	19,512	458,120	960,600	0.15	142,787	5,545,945
21	482,968	20,292	482,944	986,204	0.14	133,266	5,679,211
22	482,968	21,104	517,971	1,022,042	0.12	125,554	5,804,765
23	482,968	21,948	548,520	1,053,436	0.11	117,646	5,922,411
24	482,968	22,826	586,273	1,092,066	0.10	110,873	6,033,284
25	482,968	23,739	619,353	1,126,060	0.09	103,931	6,137,214
26	482,968	24,688	663,890	1,171,546	0.08	98,299	6,235,513
27	482,968	25,676	710,216	1,218,860	0.08	92,972	6,328,485
28	482,968	26,703	762,459	1,272,130	0.07	88,214	6,416,699
29	482,968	27,771	801,688	1,312,427	0.06	82,735	6,499,434
30	482,968	34,495	869,076	1,386,540	0.06	79,461	6,578,894
31	482,968	35,875	927,758	1,446,601	0.05	75,366	6,654,260
32	482,968	37,310	988,767	1,509,045	0.05	71,472	6,725,732
33	482,968	38,803	1,056,762	1,578,532	0.04	67,966	6,793,699
34	482,968	40,355	1,127,464	1,650,786	0.04	64,616	6,858,315
35	482,968	41,969	1,200,964	1,725,901	0.04	61,415	6,919,729

Life Cycle PV Cost **6,920,000**

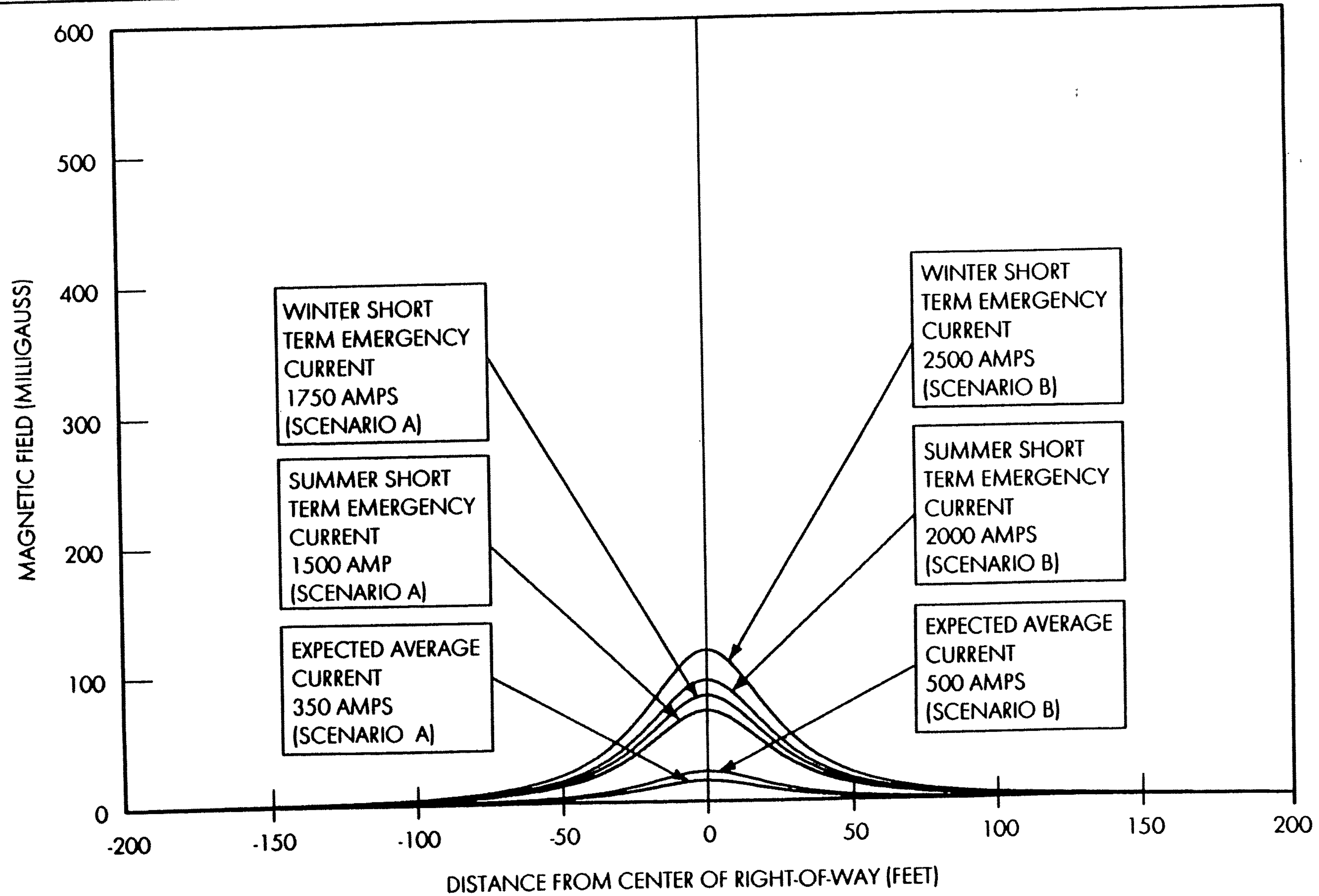
Life Cycle Cost Analysis
Overhead Double-circuit Steel Pole with Compact Spacing and Alternative Phasing using V-String Insulators (Scenario B: 1272 kcmil)

			FC rate		Fixed cost
Construction	3,578,000	x	0.146	=	522,388
Land	0				0
Total					522,388

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

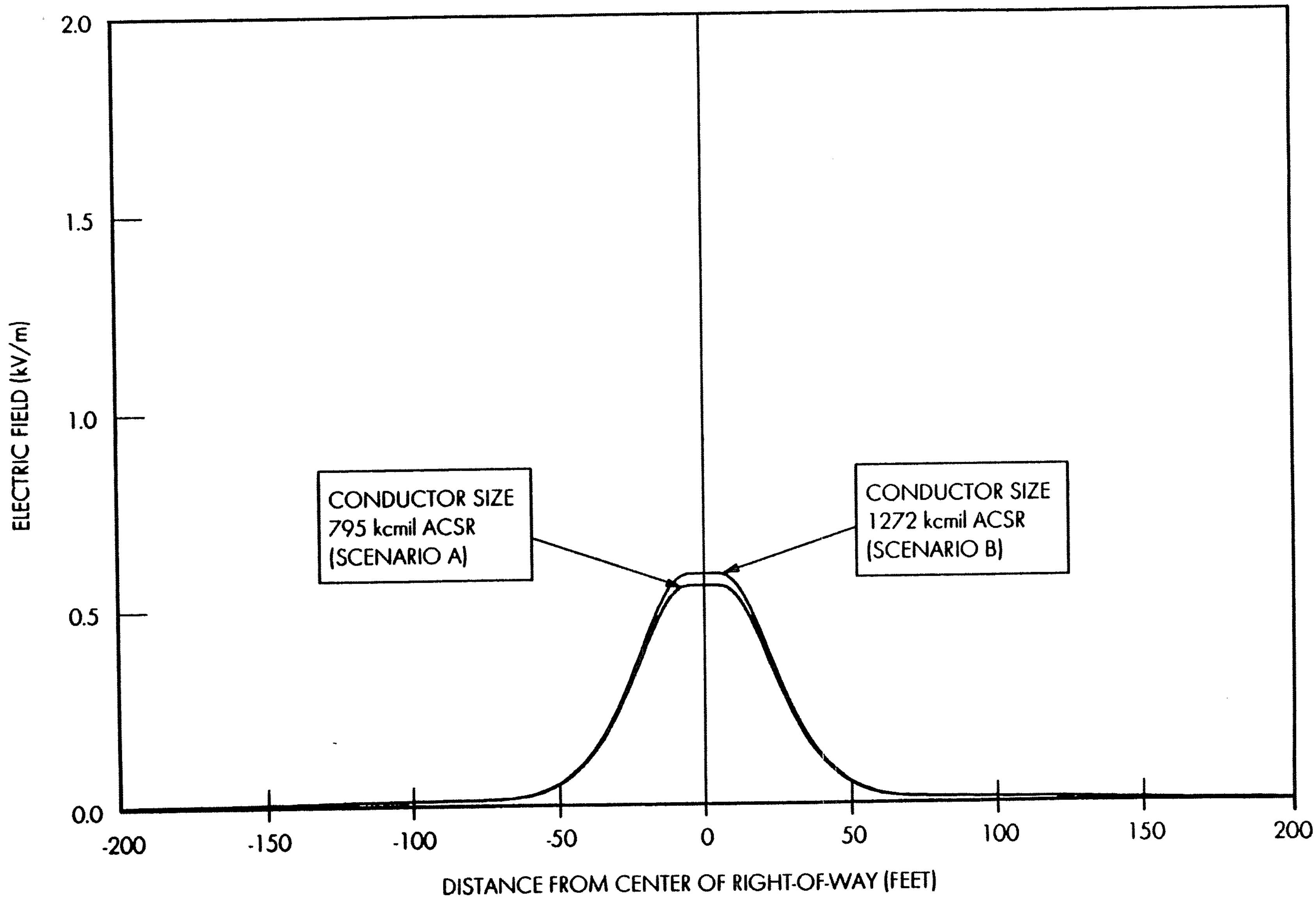
Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	522,388	25,911	76,902	625,201	0.91	568,364	568,364
2	522,388	9,631	87,509	619,529	0.83	512,007	1,080,371
3	522,388	10,017	98,584	630,989	0.75	474,071	1,554,443
4	522,388	10,417	100,964	633,770	0.68	432,873	1,987,316
5	522,388	10,834	115,936	649,158	0.62	403,076	2,390,392
6	522,388	11,267	128,362	662,017	0.56	373,692	2,764,083
7	522,388	11,718	141,321	675,427	0.51	346,601	3,110,684
8	522,388	12,187	181,403	715,978	0.47	334,009	3,444,693
9	522,388	12,674	199,572	734,634	0.42	311,556	3,756,250
10	522,388	13,181	218,512	754,081	0.39	290,731	4,046,981
11	522,388	13,709	245,481	781,577	0.35	273,938	4,320,919
12	522,388	14,257	355,284	891,929	0.32	284,196	4,605,115
13	522,388	14,827	375,239	912,454	0.29	264,305	4,869,420
14	522,388	15,420	395,950	933,759	0.26	245,888	5,115,308
15	522,388	16,037	427,911	966,336	0.24	231,333	5,346,641
16	522,388	16,679	474,476	1,013,543	0.22	220,576	5,567,218
17	522,388	17,346	509,427	1,049,161	0.20	207,571	5,774,788
18	522,388	18,040	530,272	1,070,700	0.18	192,575	5,967,363
19	522,388	18,761	572,095	1,113,244	0.16	182,024	6,149,387
20	522,388	19,512	611,146	1,153,045	0.15	171,393	6,320,780
21	522,388	20,292	644,260	1,186,940	0.14	160,392	6,481,172
22	522,388	21,104	690,988	1,234,479	0.12	151,651	6,632,823
23	522,388	21,948	731,741	1,276,077	0.11	142,510	6,775,333
24	522,388	22,826	782,104	1,327,318	0.10	134,757	6,910,090
25	522,388	23,739	826,234	1,372,361	0.09	126,663	7,036,753
26	522,388	24,688	885,648	1,432,724	0.08	120,213	7,156,966
27	522,388	25,676	947,449	1,495,512	0.08	114,074	7,271,041
28	522,388	26,703	1,017,141	1,566,232	0.07	108,608	7,379,648
29	522,388	27,771	1,069,474	1,619,633	0.06	102,101	7,481,749
30	522,388	34,495	1,159,372	1,716,256	0.06	98,356	7,580,105
31	522,388	35,875	1,237,655	1,795,919	0.05	93,565	7,673,670
32	522,388	37,310	1,319,043	1,878,741	0.05	88,982	7,762,652
33	522,388	38,803	1,409,750	1,970,941	0.04	84,862	7,847,514
34	522,388	40,355	1,504,068	2,066,811	0.04	80,900	7,928,415
35	522,388	41,969	1,602,119	2,166,476	0.04	77,092	8,005,507

Life Cycle PV Cost **8,006,000**



MAGNETIC FIELD PROFILES FOR OVERHEAD DOUBLE-CIRCUIT STEEL POLE WITH COMPACT SPACING AND ALTERNATE PHASING USING V-STRING INSULATORS

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES



ELECTRIC FIELD PROFILES FOR OVERHEAD DOUBLE-CIRCUIT STEEL POLE WITH COMPACT SPACING AND ALTERNATE PHASING USING V-STRING INSULATORS

CONNECTICUT SITING COUNCIL LIFE CYCLE COST STUDY FOR 115-KV TRANSMISSION LINES

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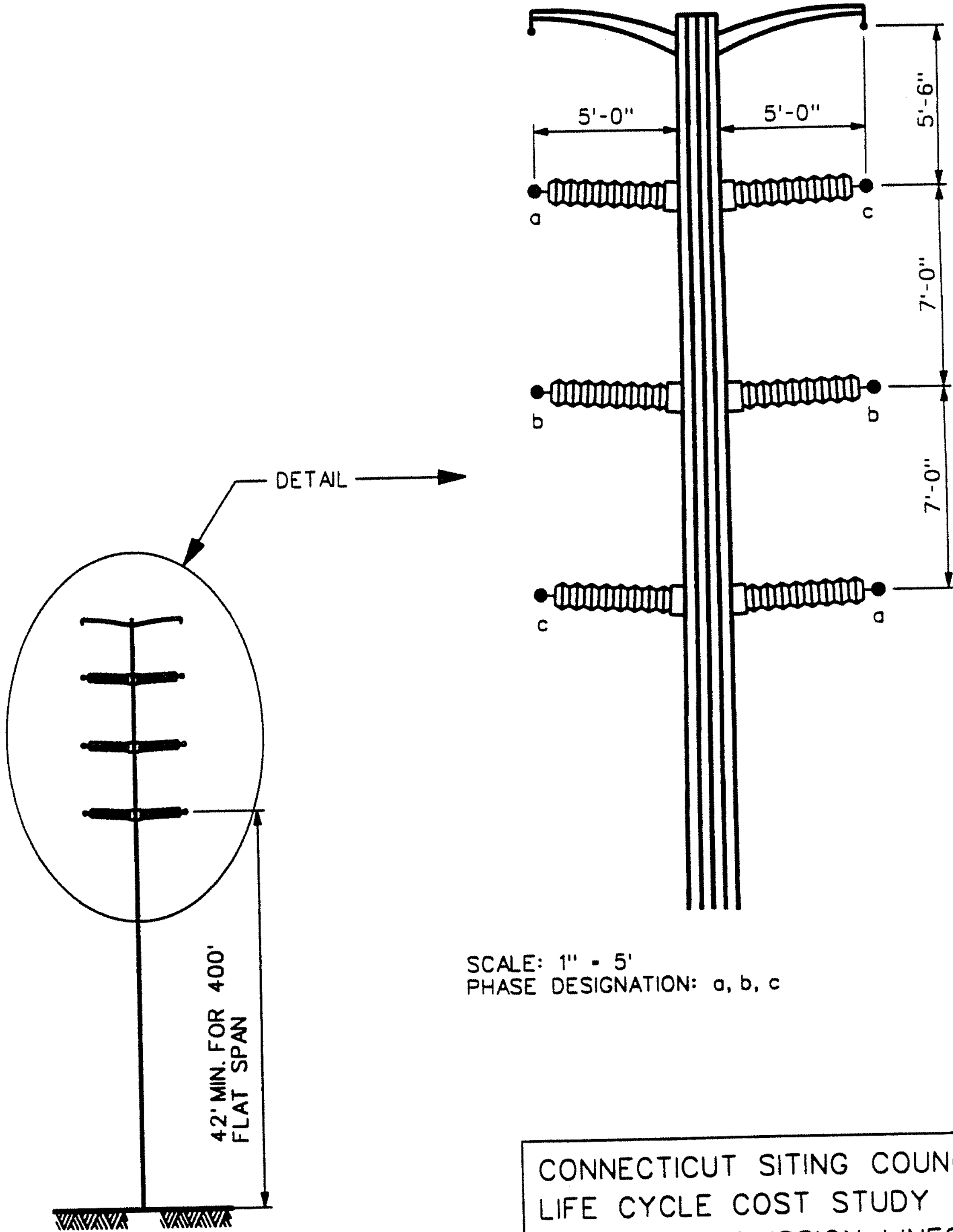


SCALE: 1" = 5'
PHASE DESIGNATION: a, b, c

SCALE: 1" = 15'

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

OVERHEAD DOUBLE-CIRCUIT STEEL POLE WITH COMPACT SPACING AND ALTERNATIVE PHASING USING STANDOFF INSULATORS

Construction Cost Estimates
Overhead Double-circuit Steel Pole with Compact Spacing and Alternative Phasing using Standoff Insulators

Base costs

Per Mile Base		
Scenario A 795 kcmil	$669,114	(a)
Scenario B 1272 kcmil	$718,959	(a)
Per Project Base		
Terminal equipment (Scenario A)	$55,908	(b)
Terminal equipment (Scenario B)	$57,051	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder		
Urban location	$207,000	(d)
Per Project Adder		
Winter construction	$6,000	(e)

Base Case - Scenario A

First cost	5 miles, rural, summer work	$3,519,000	5x(a) +(b)+(c)
Life cycle cost		$7,217,000	

Base Case - Scenario B

First cost	5 miles, rural, summer work	$3,770,000	5x(a) +(b)+(c)
Life cycle cost		$8,276,000	

Notes:

1) Base case is for a double-circuit line installed in a rural environment.

Life Cycle Cost Analysis

Overhead Double-circuit Steel Pole with Compact Spacing and Alternative Phasing using Standoff Insulators (5 Miles, Scenario A: 795 kcmil)

			FC rate		Fixed cost
Construction	3,519,000	x	0.146	=	513,774
Land	0				0
Total					513,774

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	513,774	25,911	57,646	597,331	0.91	543,028	543,028
2	513,774	9,631	65,598	589,003	0.83	486,779	1,029,808
3	513,774	10,017	73,900	597,690	0.75	449,054	1,478,861
4	513,774	10,417	75,684	599,875	0.68	409,723	1,888,584
5	513,774	10,834	86,906	611,515	0.62	379,702	2,268,287
6	513,774	11,267	96,221	621,263	0.56	350,687	2,618,973
7	513,774	11,718	105,935	631,428	0.51	324,022	2,942,995
8	513,774	12,187	135,982	661,942	0.47	308,801	3,251,796
9	513,774	12,674	149,601	676,049	0.42	286,711	3,538,507
10	513,774	13,181	163,798	690,754	0.39	266,315	3,804,823
11	513,774	13,709	184,015	711,497	0.35	249,375	4,054,198
12	513,774	14,257	266,324	794,355	0.32	253,106	4,307,304
13	513,774	14,827	281,283	809,884	0.29	234,594	4,541,899
14	513,774	15,420	296,808	826,002	0.26	217,512	4,759,411
15	513,774	16,037	320,766	850,577	0.24	203,621	4,963,032
16	513,774	16,679	355,672	886,124	0.22	192,847	5,155,879
17	513,774	17,346	381,871	912,991	0.20	180,630	5,336,509
18	513,774	18,040	397,497	929,311	0.18	167,145	5,503,654
19	513,774	18,761	428,847	961,383	0.16	157,194	5,660,848
20	513,774	19,512	458,120	991,406	0.15	147,366	5,808,214
21	513,774	20,292	482,944	1,017,010	0.14	137,429	5,945,643
22	513,774	21,104	517,971	1,052,848	0.12	129,338	6,074,981
23	513,774	21,948	548,520	1,084,242	0.11	121,086	6,196,067
24	513,774	22,826	586,273	1,122,872	0.10	114,000	6,310,068
25	513,774	23,739	619,353	1,156,866	0.09	106,774	6,416,842
26	513,774	24,688	663,890	1,202,352	0.08	100,884	6,517,726
27	513,774	25,676	710,216	1,249,666	0.08	95,322	6,613,047
28	513,774	26,703	762,459	1,302,936	0.07	90,350	6,703,397
29	513,774	27,771	801,688	1,343,233	0.06	84,677	6,788,074
30	513,774	34,495	869,076	1,417,346	0.06	81,226	6,869,300
31	513,774	35,875	927,758	1,477,407	0.05	76,971	6,946,271
32	513,774	37,310	988,767	1,539,851	0.05	72,931	7,019,202
33	513,774	38,803	1,056,762	1,609,338	0.04	69,293	7,088,495
34	513,774	40,355	1,127,464	1,681,592	0.04	65,822	7,154,316
35	513,774	41,969	1,200,964	1,756,707	0.04	62,511	7,216,827

Life Cycle PV Cost **7,217,000**

Life Cycle Cost Analysis

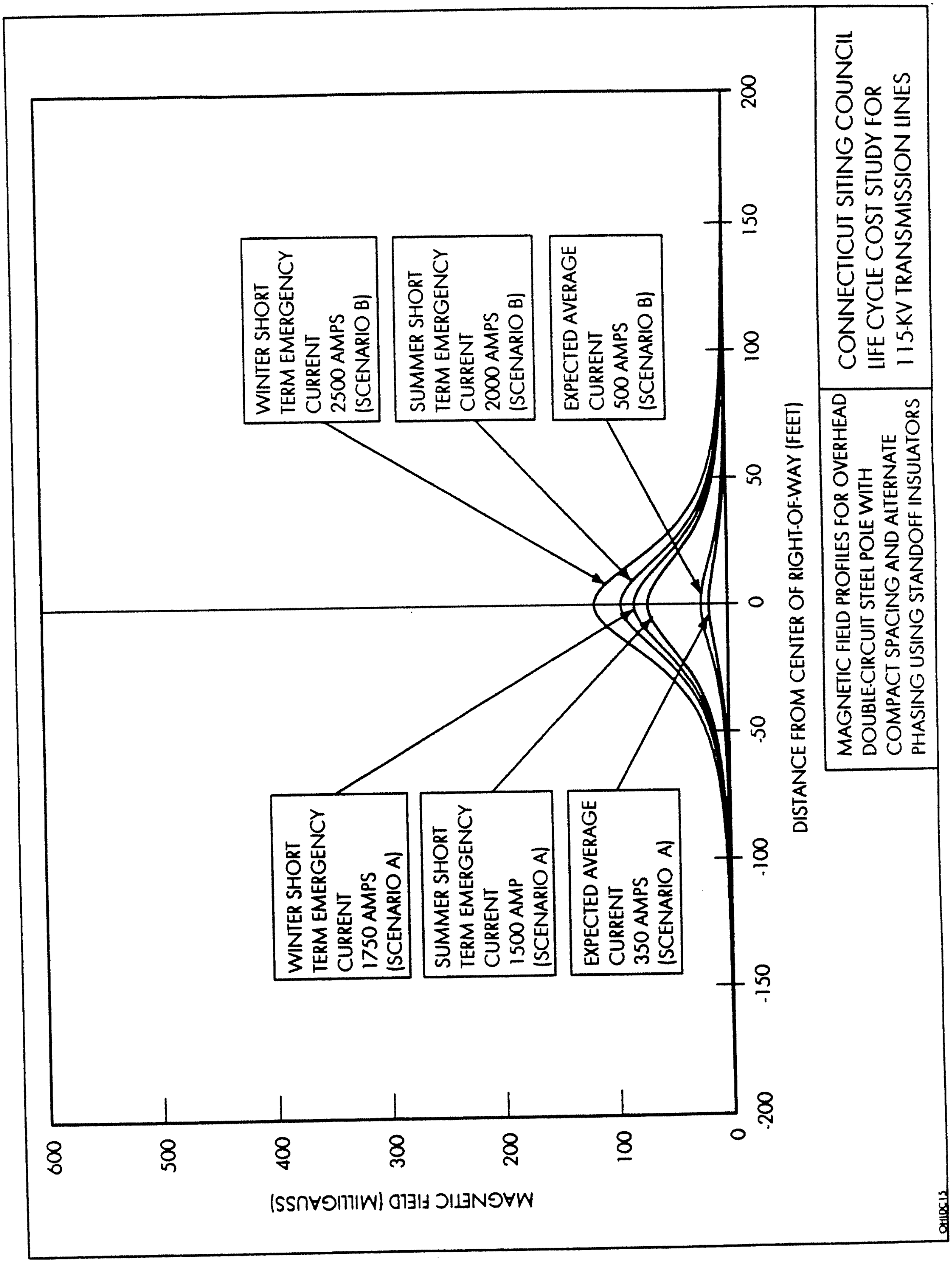
Overhead Double-circuit Steel Pole with Compact Spacing and Alternative Phasing using Standoff Insulators (5 Miles, Scenario B: 1272 kcmil)

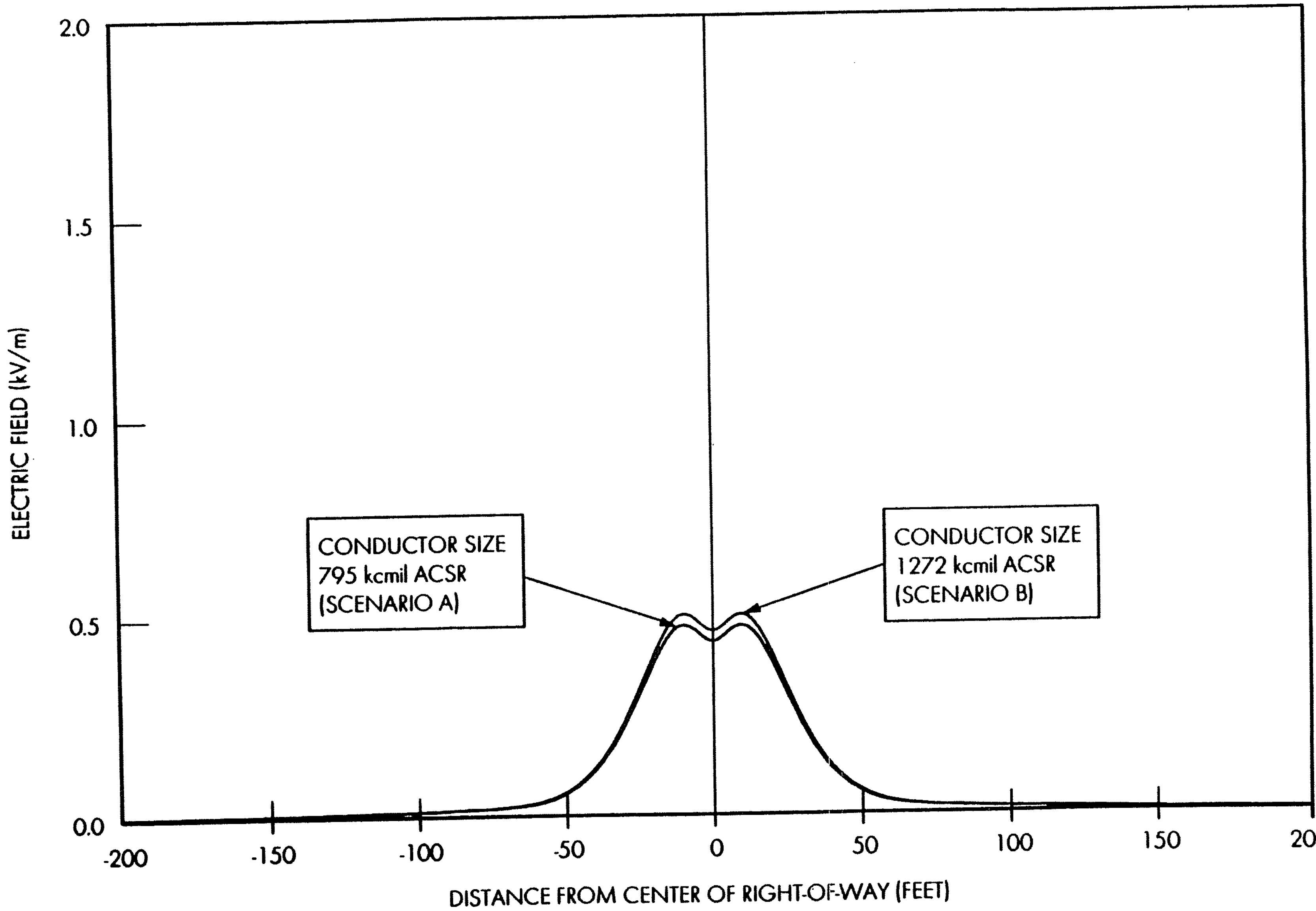
			FC rate		Fixed cost
Construction	3,770,000	x	0.146	=	550,420
Land	0				0
Total					550,420

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	550,420	25,911	76,902	653,233	0.91	593,848	593,848
2	550,420	9,631	87,509	647,561	0.83	535,174	1,129,022
3	550,420	10,017	98,584	659,021	0.75	495,132	1,624,154
4	550,420	10,417	100,964	661,802	0.68	452,020	2,076,174
5	550,420	10,834	115,936	677,190	0.62	420,482	2,496,655
6	550,420	11,267	128,362	690,049	0.56	389,515	2,886,170
7	550,420	11,718	141,321	703,459	0.51	360,986	3,247,156
8	550,420	12,187	181,403	744,010	0.47	347,086	3,594,242
9	550,420	12,674	199,572	762,666	0.42	323,445	3,917,687
10	550,420	13,181	218,512	782,113	0.39	301,538	4,219,225
11	550,420	13,709	245,481	809,609	0.35	283,763	4,502,988
12	550,420	14,257	355,284	919,961	0.32	293,128	4,796,116
13	550,420	14,827	375,239	940,486	0.29	272,425	5,068,541
14	550,420	15,420	395,950	961,791	0.26	253,270	5,321,811
15	550,420	16,037	427,911	994,368	0.24	238,044	5,559,855
16	550,420	16,679	474,476	1,041,575	0.22	226,677	5,786,532
17	550,420	17,346	509,427	1,077,193	0.20	213,117	5,999,649
18	550,420	18,040	530,272	1,098,732	0.18	197,617	6,197,265
19	550,420	18,761	572,095	1,141,276	0.16	186,608	6,383,873
20	550,420	19,512	611,146	1,181,077	0.15	175,560	6,559,433
21	550,420	20,292	644,260	1,214,972	0.14	164,180	6,723,612
22	550,420	21,104	690,988	1,262,511	0.12	155,094	6,878,707
23	550,420	21,948	731,741	1,304,109	0.11	145,641	7,024,347
24	550,420	22,826	782,104	1,355,350	0.10	137,603	7,161,950
25	550,420	23,739	826,234	1,400,393	0.09	129,251	7,291,201
26	550,420	24,688	885,648	1,460,756	0.08	122,565	7,413,766
27	550,420	25,676	947,449	1,523,544	0.08	116,212	7,529,979
28	550,420	26,703	1,017,141	1,594,264	0.07	110,552	7,640,530
29	550,420	27,771	1,069,474	1,647,665	0.06	103,868	7,744,398
30	550,420	34,495	1,159,372	1,744,288	0.06	99,963	7,844,361
31	550,420	35,875	1,237,655	1,823,951	0.05	95,025	7,939,386
32	550,420	37,310	1,319,043	1,906,773	0.05	90,309	8,029,695
33	550,420	38,803	1,409,750	1,998,973	0.04	86,069	8,115,765
34	550,420	40,355	1,504,068	2,094,843	0.04	81,997	8,197,762
35	550,420	41,969	1,602,119	2,194,508	0.04	78,090	8,275,852

Life Cycle PV Cost **8,276,000**


MAGNETIC FIELD (MILLIGAUSS)
600
500
400
300
200
100
0
-200
-150
-100
-50
0
50
100
150
200
DISTANCE FROM CENTER OF RIGHT-OF-WAY (FEET)
WINTER SHORT TERM EMERGENCY CURRENT 2500 AMPS (SCENARIO B)
SUMMER SHORT TERM EMERGENCY CURRENT 2000 AMPS (SCENARIO B)
EXPECTED AVERAGE CURRENT 500 AMPS (SCENARIO B)
WINTER SHORT TERM EMERGENCY CURRENT 1750 AMPS (SCENARIO A)
SUMMER SHORT TERM EMERGENCY CURRENT 1500 AMP (SCENARIO A)
EXPECTED AVERAGE CURRENT 350 AMPS (SCENARIO A)
MAGNETIC FIELD PROFILES FOR OVERHEAD DOUBLE-CIRCUIT STEEL POLE WITH COMPACT SPACING AND ALTERNATE PHASING USING STANDOFF INSULATORS
CONNECTICUT SITING COUNCIL LIFE CYCLE COST STUDY FOR 115-KV TRANSMISSION LINES
OHIDC15

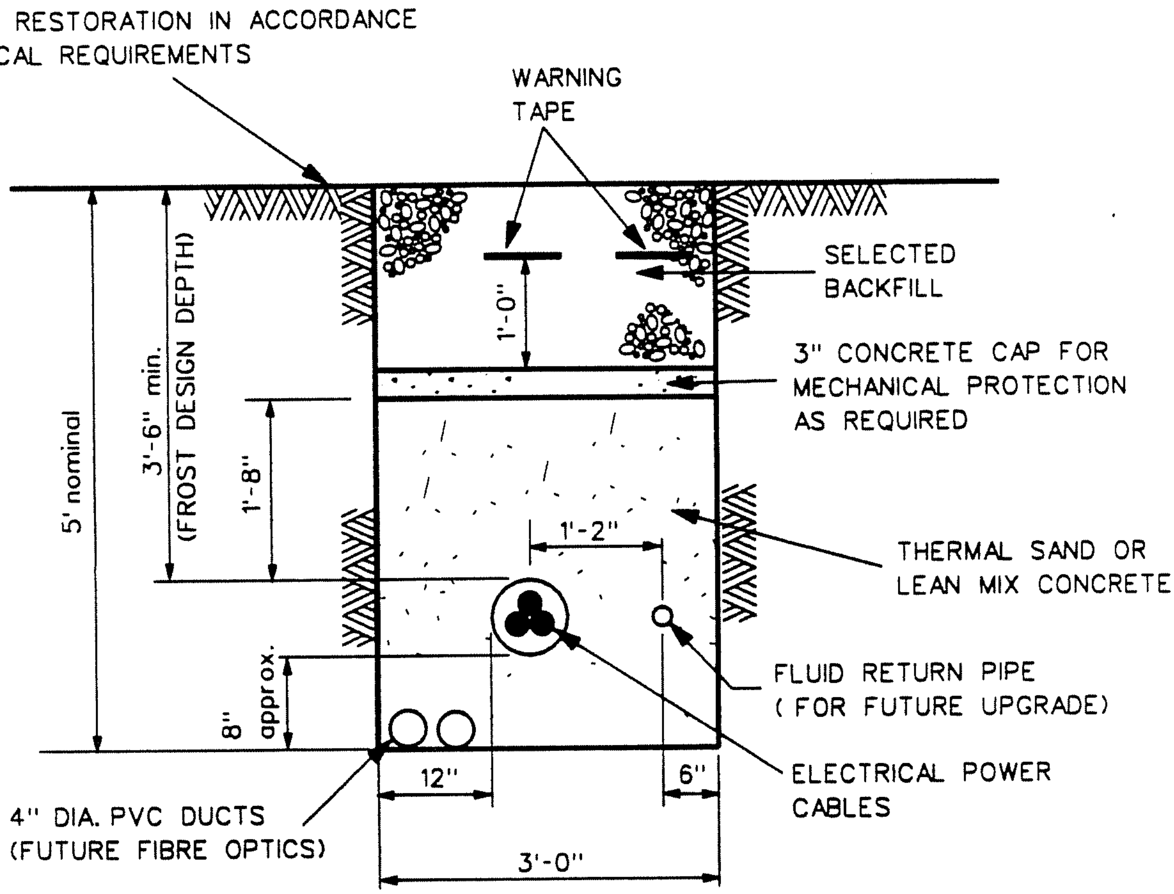


ELECTRIC FIELD PROFILES FOR OVERHEAD DOUBLE-CIRCUIT STEEL POLE WITH COMPACT SPACING AND ALTERNATE PHASING USING STANDOFF INSULATORS

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES

OHLDC15B

Underground Lines



SCALE : 1" = 1.5'

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

UNDERGROUND SINGLE-CIRCUIT
HIGH PRESSURE GAS-FILLED

Construction Cost Estimates
Underground Single Circuit High Pressure Gas-Filled

Base costs

Per Mile Base

Urban roadway location	$2,505,418	(a)

Per Project Base

Terminal equipment	$278,440	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder

Rural location	($412,000)	(d)

Per Project Adder

Winter construction	$75,000	(e)

Base Case

First cost	5 miles, urban, summer work	**$12,924,000**	5*(a)+(b)+(c)
Life cycle cost		**$19,014,000**	

Notes:

1) Base case is for a single circuit installed in an urban environment, open cut trench, concrete encased, no access roads, no vegetation clearing, with allowance for after hours work.

2) Cable performance

	Scenario A			Scenario B		
	Normal Rating	Long term emergency	Short term emergency	Normal Rating	Long term emergency	Short term emergency
Summer	1000	1250	1390	1223	1351	1390
Winter	1250	1395	1432	1272	1395	1438

3) Electrical parameters

Conductor Size	2500	kcmil
Resistance	0.03146	ohm/mile
Capacitance	531	microfarad/mile
Charging current	13.3	A/mile

Life Cycle Cost Analysis
Underground Single Circuit High Pressure Gas-Filled

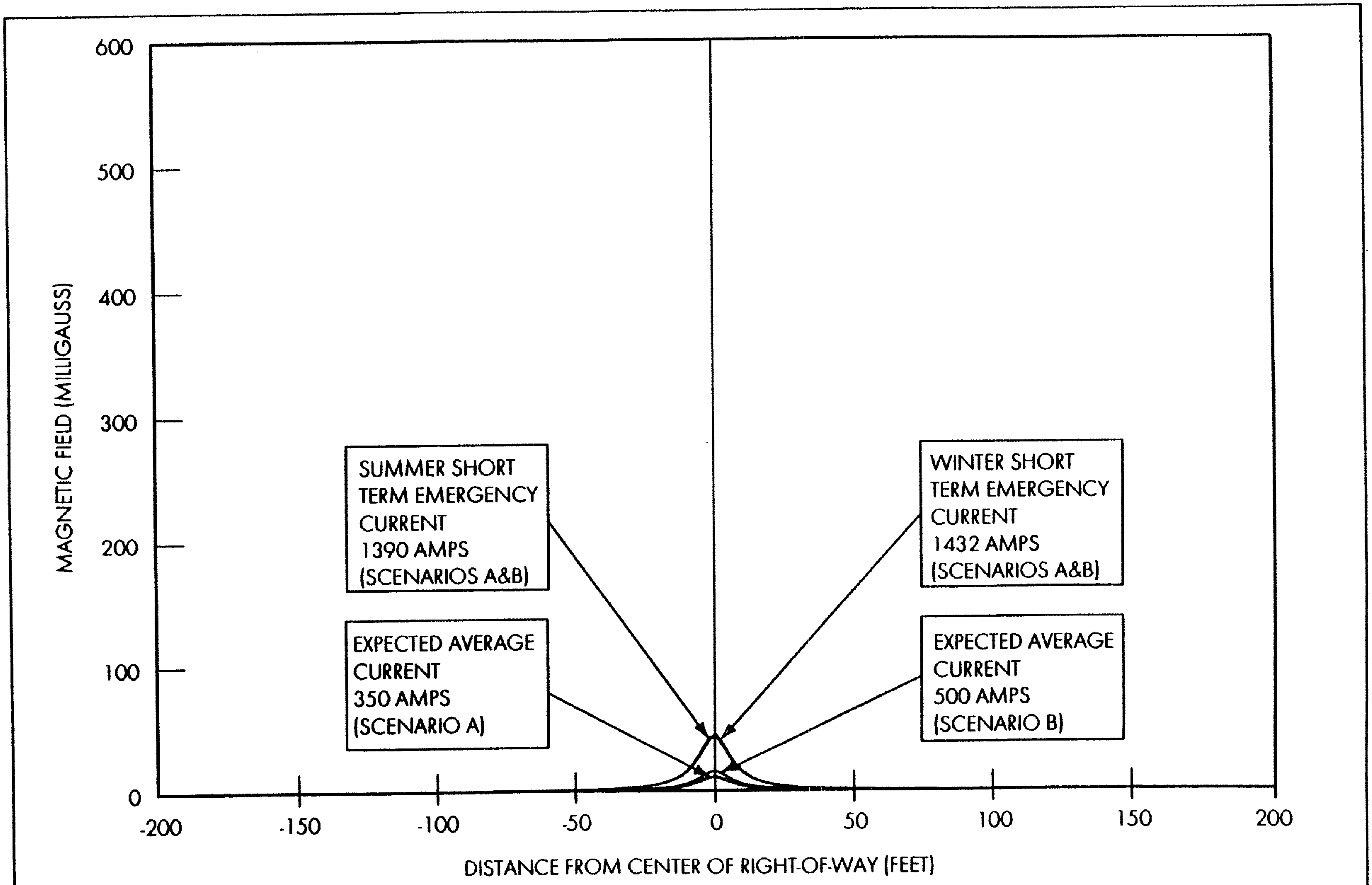
5 Miles, Scenario A - Summer loading

			FC rate		Fixed cost
Construction	12924000	x	0.146	=	1886904
Land	0				0
Total					1,886,904

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

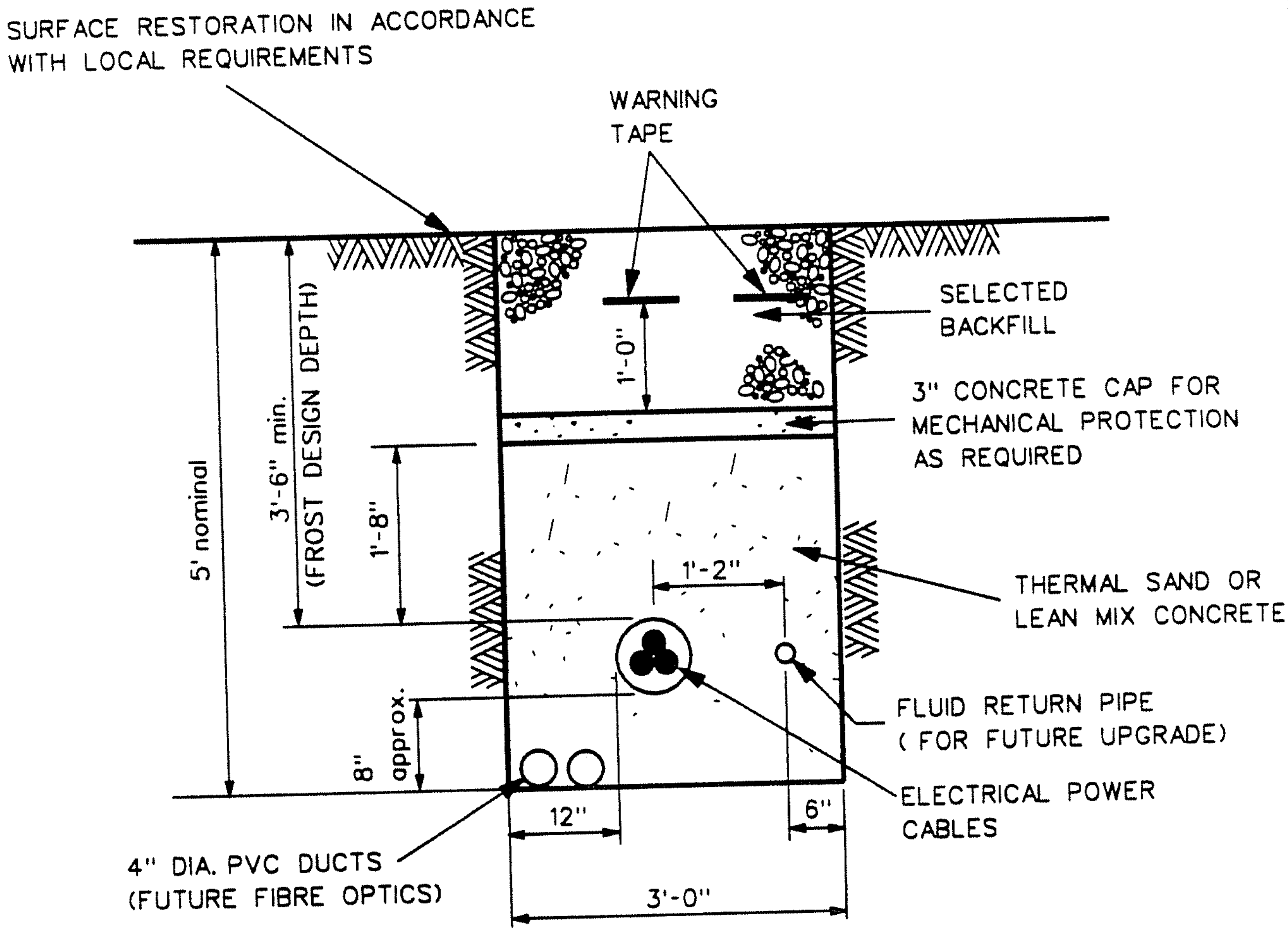
Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	1,886,904	20,039	14,432	1,921,375	0.91	1,746,705	1,746,705
2	1,886,904	20,841	16,423	1,924,168	0.83	1,590,221	3,336,926
3	1,886,904	21,674	18,502	1,927,080	0.75	1,447,843	4,784,769
4	1,886,904	22,541	18,948	1,928,393	0.68	1,317,119	6,101,888
5	1,886,904	23,443	21,758	1,932,105	0.62	1,199,685	7,301,573
6	1,886,904	24,381	24,090	1,935,374	0.56	1,092,468	8,394,042
7	1,886,904	25,356	26,522	1,938,782	0.51	994,902	9,388,943
8	1,886,904	26,370	34,044	1,947,318	0.47	908,438	10,297,381
9	1,886,904	27,425	37,454	1,951,783	0.42	827,746	11,125,128
10	1,886,904	28,522	41,009	1,956,434	0.39	754,290	11,879,418
11	1,886,904	29,663	46,070	1,962,637	0.35	687,892	12,567,310
12	1,886,904	30,849	66,677	1,984,430	0.32	632,301	13,199,611
13	1,886,904	32,083	70,422	1,989,409	0.29	576,261	13,775,872
14	1,886,904	33,366	74,309	1,994,579	0.26	525,235	14,301,107
15	1,886,904	34,701	80,307	2,001,912	0.24	479,242	14,780,348
16	1,886,904	36,089	89,046	2,012,039	0.22	437,878	15,218,227
17	1,886,904	37,533	95,605	2,020,042	0.20	399,655	15,617,881
18	1,886,904	39,034	99,517	2,025,455	0.18	364,296	15,982,177
19	1,886,904	40,595	107,366	2,034,866	0.16	332,717	16,314,894
20	1,886,904	42,219	114,695	2,043,818	0.15	303,801	16,618,695
21	1,886,904	43,908	120,910	2,051,722	0.14	277,250	16,895,945
22	1,886,904	45,664	129,679	2,062,247	0.12	253,339	17,149,284
23	1,886,904	47,491	137,327	2,071,722	0.11	231,366	17,380,650
24	1,886,904	49,390	146,779	2,083,074	0.10	211,485	17,592,135
25	1,886,904	51,366	155,061	2,093,331	0.09	193,206	17,785,341
26	1,886,904	53,421	166,211	2,106,536	0.08	176,750	17,962,091
27	1,886,904	55,558	177,810	2,120,271	0.08	161,729	18,123,820
28	1,886,904	57,780	190,889	2,135,573	0.07	148,088	18,271,908
29	1,886,904	60,091	200,710	2,147,706	0.06	135,390	18,407,298
30	1,886,904	62,495	217,582	2,166,981	0.06	124,187	18,531,485
31	1,886,904	64,994	232,273	2,184,172	0.05	113,792	18,645,277
32	1,886,904	67,594	247,548	2,202,046	0.05	104,294	18,749,572
33	1,886,904	70,298	264,571	2,221,773	0.04	95,662	18,845,234
34	1,886,904	73,110	282,272	2,242,286	0.04	87,769	18,933,003
35	1,886,904	76,034	300,673	2,263,611	0.04	80,549	19,013,551

Life Cycle PV Cost **19,014,000**



MAGNETIC FIELD PROFILES FOR UNDERGROUND SINGLE-CIRCUIT HIGH PRESSURE GAS-FILLED

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES



SCALE : 1" = 1.5'

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

UNDERGROUND SINGLE-CIRCUIT
HIGH PRESSURE FLUID-FILLED

Construction Cost Estimates
Underground Single Circuit High Pressure Fluid-Filled

Base costs

Per Mile Base

Urban roadway location	$2,402,163	(a)

Per Project Base

Terminal equipment	$797,419	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder

Rural location	($412,000)	(d)

Per Project Adder

Winter construction	$75,000	(e)

Base Case

First cost	5 miles, urban, summer work	**$12,926,000**	5*(a)+(b)+(c)
Life cycle cost		**$19,016,000**	

Notes:

1) Base case is for a single circuit installed in an urban environment, open cut trench, concrete encased, no access roads, no vegetation clearing, with allowance for after hours work.

2) Cable performance

	Scenario A		
	Normal Rating	Long term emergency	Short term emergency
Summer	1000	1250	1416
Winter	1250	1419	1458

Scenario B		
Normal Rating	Long term emergency	Short term emergency
1240	1375	1416
1289	1419	1458

3) Electrical parameters

Conductor Size	2500	kcmil
Resistance	0.03146	ohm/mile
Capacitance	547	microfarad/mile
Charging current	13.7	A/mile

Life Cycle Cost Analysis
Underground Single Circuit High Pressure Fluid-Filled

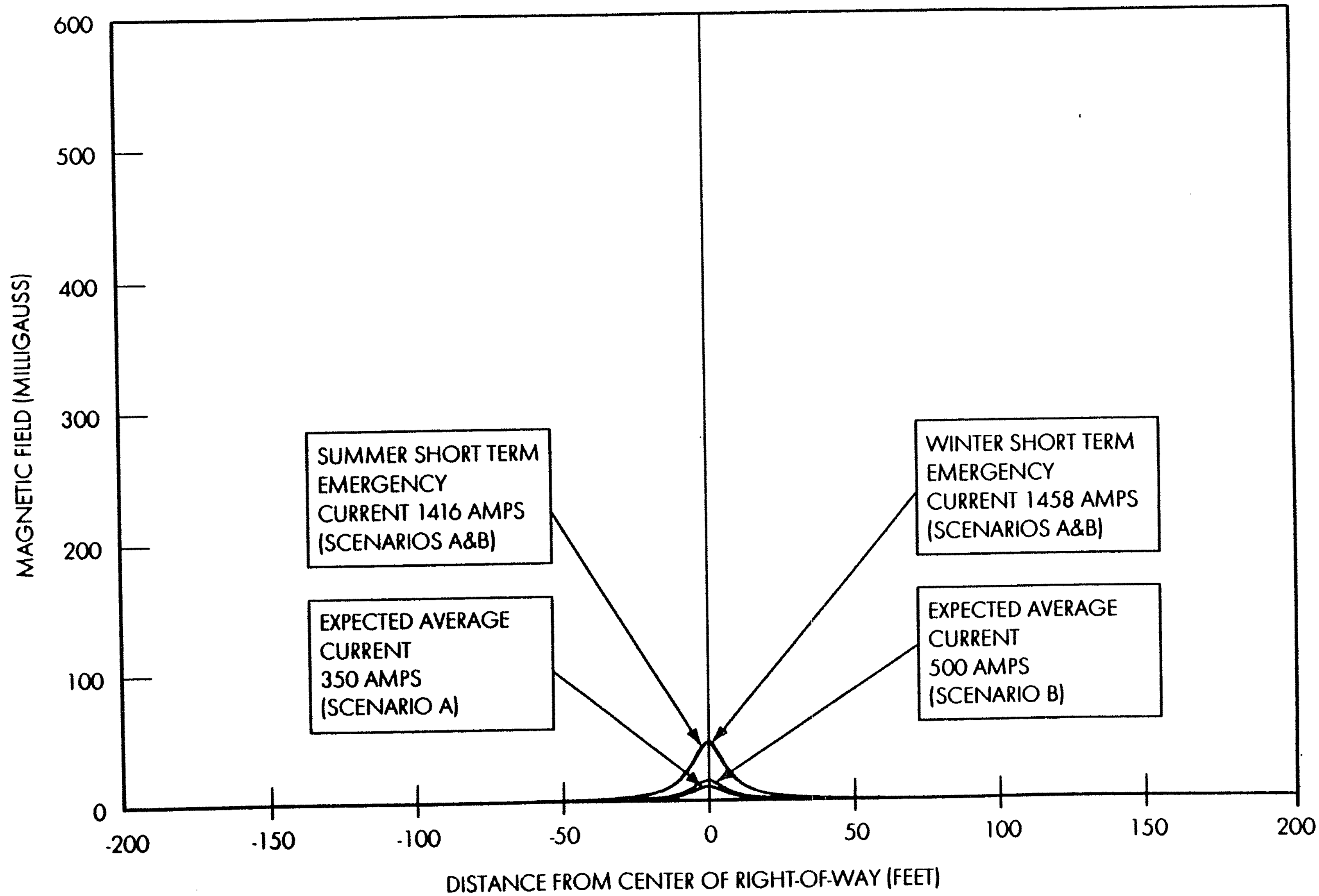
5 Miles, Scenario A - Summer loading

			FC rate		Fixed cost
Construction	12,926,000	x	0.146	=	1,887,196
Land	0				0
Total					1,887,196

PV discount	10%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	1,887,196	20,039	14,432	1,921,667	0.91	1,746,970	1,746,970
2	1,887,196	20,841	16,423	1,924,460	0.83	1,590,462	3,337,433
3	1,887,196	21,674	18,502	1,927,372	0.75	1,448,063	4,785,496
4	1,887,196	22,541	18,948	1,928,685	0.68	1,317,318	6,102,814
5	1,887,196	23,443	21,758	1,932,397	0.62	1,199,866	7,302,680
6	1,887,196	24,381	24,090	1,935,666	0.56	1,092,633	8,395,313
7	1,887,196	25,356	26,522	1,939,074	0.51	995,051	9,390,365
8	1,887,196	26,370	34,044	1,947,610	0.47	908,575	10,298,939
9	1,887,196	27,425	37,454	1,952,075	0.42	827,870	11,126,810
10	1,887,196	28,522	41,009	1,956,726	0.39	754,403	11,881,212
11	1,887,196	29,663	46,070	1,962,929	0.35	687,994	12,569,207
12	1,887,196	30,849	66,677	1,984,722	0.32	632,394	13,201,600
13	1,887,196	32,083	70,422	1,989,701	0.29	576,346	13,777,946
14	1,887,196	33,366	74,309	1,994,871	0.26	525,312	14,303,258
15	1,887,196	34,701	80,307	2,002,204	0.24	479,312	14,782,569
16	1,887,196	36,089	89,046	2,012,331	0.22	437,942	15,220,511
17	1,887,196	37,533	95,605	2,020,334	0.20	399,712	15,620,224
18	1,887,196	39,034	99,517	2,025,747	0.18	364,348	15,984,572
19	1,887,196	40,595	107,366	2,035,158	0.16	332,765	16,317,337
20	1,887,196	42,219	114,695	2,044,110	0.15	303,844	16,621,181
21	1,887,196	43,908	120,910	2,052,014	0.14	277,290	16,898,470
22	1,887,196	45,664	129,679	2,062,539	0.12	253,375	17,151,845
23	1,887,196	47,491	137,327	2,072,014	0.11	231,399	17,383,244
24	1,887,196	49,390	146,779	2,083,366	0.10	211,515	17,594,759
25	1,887,196	51,366	155,061	2,093,623	0.09	193,233	17,787,992
26	1,887,196	53,421	166,211	2,106,828	0.08	176,774	17,964,766
27	1,887,196	55,558	177,810	2,120,563	0.08	161,752	18,126,518
28	1,887,196	57,780	190,889	2,135,865	0.07	148,108	18,274,626
29	1,887,196	60,091	200,710	2,147,998	0.06	135,408	18,410,034
30	1,887,196	62,495	217,582	2,167,273	0.06	124,203	18,534,238
31	1,887,196	64,994	232,273	2,184,464	0.05	113,808	18,648,045
32	1,887,196	67,594	247,548	2,202,338	0.05	104,308	18,752,353
33	1,887,196	70,298	264,571	2,222,065	0.04	95,675	18,848,028
34	1,887,196	73,110	282,272	2,242,578	0.04	87,780	18,935,808
35	1,887,196	76,034	300,673	2,263,903	0.04	80,559	19,016,367

Life Cycle PV Cost **19,016,000**



MAGNETIC FIELD PROFILES FOR UNDERGROUND SINGLE-CIRCUIT HIGH PRESSURE FLUID-FILLED

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES

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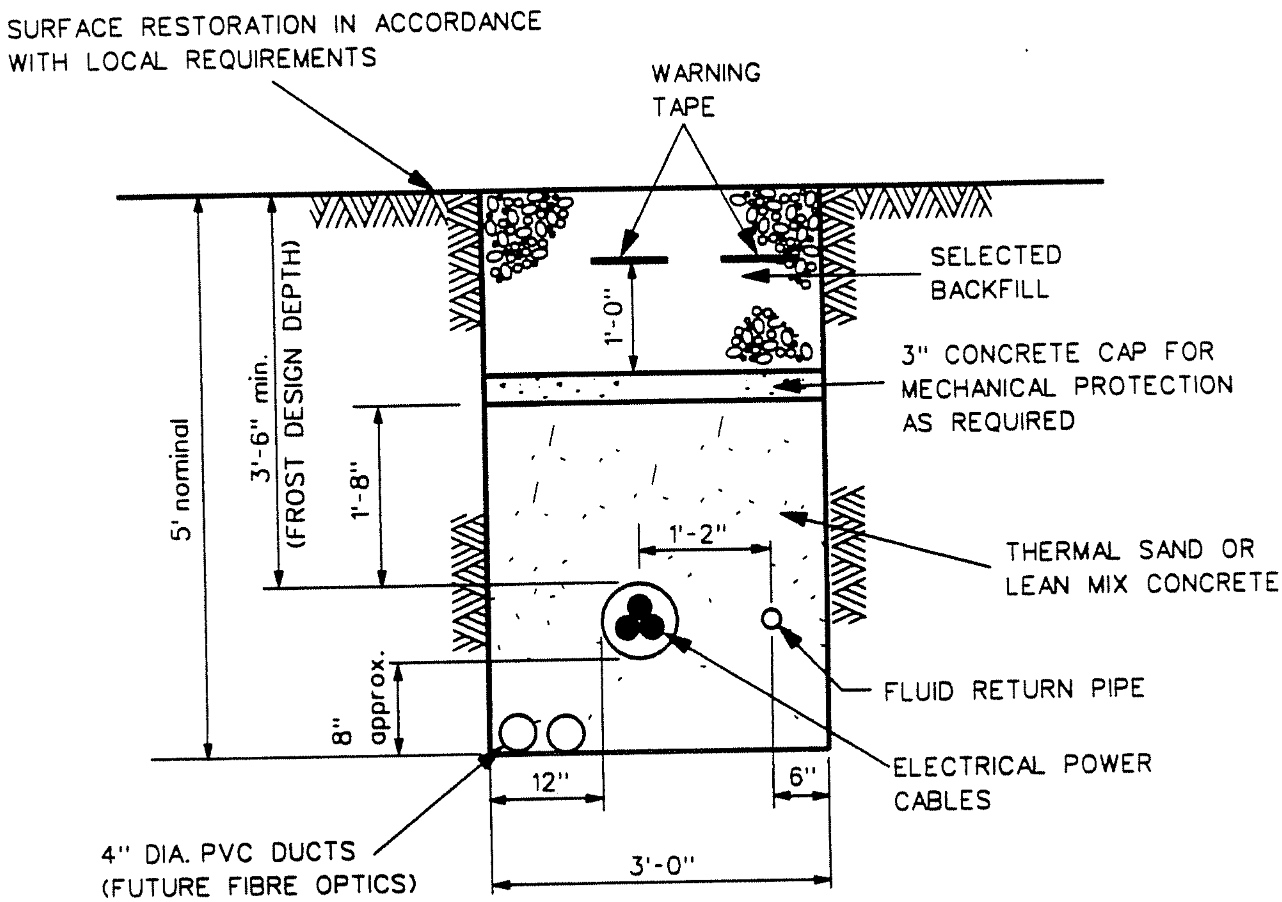


SCALE : 1" = 1.5'

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

UNDERGROUND SINGLE-CIRCUIT
HIGH PRESSURE FLUID-FILLED
WITH CLOSED LOOP CIRCULATION

Construction Cost Estimates
Underground Single Circuit High Pressure Fluid-Filled with Closed Loop Circulation

Base costs

Per Mile Base

Urban roadway location	$2,537,973	(a)

Per Project Base

Terminal equipment	$797,419	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder

Rural location	($412,000)	(d)

Per Project Adder

Winter construction	$75,000	(e)

Base Case

First cost	5 miles, urban, summer work	**$13,605,000**	5*(a)+(b)+(c)
Life cycle cost		**$19,972,000**	

Notes:

1) Base case is for a single circuit installed in an urban environment, open cut trench, concrete encased, no access roads, no vegetation clearing, with allowance for after hours work.

2) Cable performance

	Scenario A			Scenario B		
	Normal Rating	Long term emergency	Short term emergency	Normal Rating	Long term emergency	Short term emergency
Summer	1000	1250	1416	1240	1375	1416
Winter	1250	1419	1458	1289	1419	1458

3) Electrical parameters

Conductor Size	2500	kcmil
Resistance	0.03146	ohm/mile
Capacitance	547	microfarad/mile
Charging current	13.7	A/mile

Life Cycle Cost Analysis
Underground Single Circuit High Pressure Fluid-Filled with Closed Loop Circulation

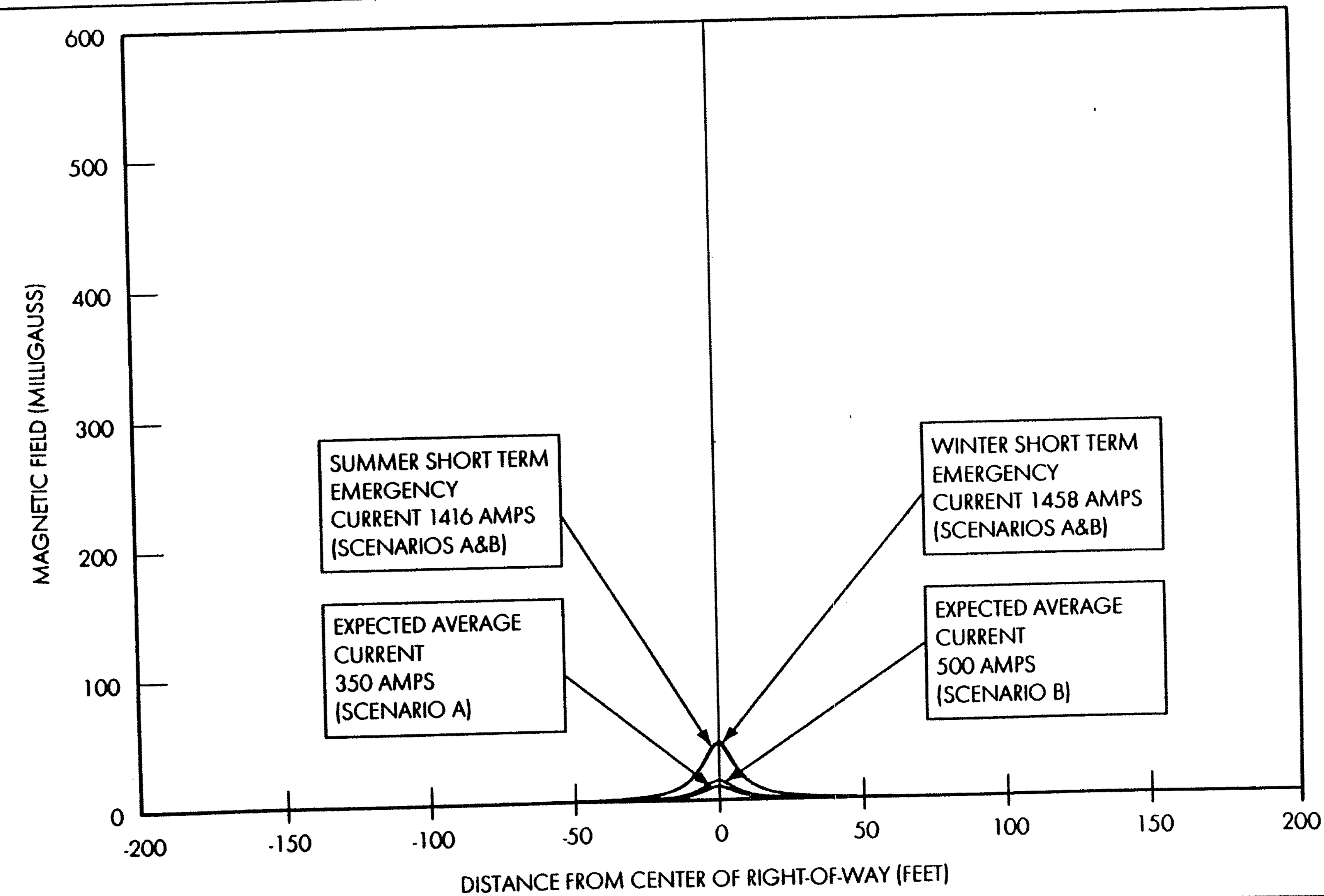
5 Miles, Scenario A - Summer loading

			FC rate		Fixed cost
Construction	13605000	x	0.146	=	1986330
Land	0				0
Total					1986330

PV discount	10.00%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	1,986,330	20,039	14,432	2,020,801	0.91	1,837,092	1,837,092
2	1,986,330	20,841	16,423	2,023,594	0.83	1,672,391	3,509,483
3	1,986,330	21,674	18,502	2,026,506	0.75	1,522,544	5,032,027
4	1,986,330	22,541	18,948	2,027,819	0.68	1,385,028	6,417,055
5	1,986,330	23,443	21,758	2,031,531	0.62	1,261,421	7,678,476
6	1,986,330	24,381	24,090	2,034,800	0.56	1,148,592	8,827,068
7	1,986,330	25,356	26,522	2,038,208	0.51	1,045,923	9,872,991
8	1,986,330	26,370	34,044	2,046,744	0.47	954,821	10,827,812
9	1,986,330	27,425	37,454	2,051,209	0.42	869,913	11,697,725
10	1,986,330	28,522	41,009	2,055,860	0.39	792,623	12,490,348
11	1,986,330	29,663	46,070	2,062,063	0.35	722,740	13,213,088
12	1,986,330	30,849	66,677	2,083,856	0.32	663,981	13,877,069
13	1,986,330	32,083	70,422	2,088,835	0.29	605,061	14,482,130
14	1,986,330	33,366	74,309	2,094,005	0.26	551,417	15,033,547
15	1,986,330	34,701	80,307	2,101,338	0.24	503,044	15,536,591
16	1,986,330	36,089	89,046	2,111,465	0.22	459,516	15,996,107
17	1,986,330	37,533	95,605	2,119,468	0.20	419,325	16,415,432
18	1,986,330	39,034	99,517	2,124,881	0.18	382,179	16,797,611
19	1,986,330	40,595	107,366	2,134,292	0.16	348,974	17,146,585
20	1,986,330	42,219	114,695	2,143,244	0.15	318,580	17,465,164
21	1,986,330	43,908	120,910	2,151,148	0.14	290,686	17,755,850
22	1,986,330	45,664	129,679	2,161,673	0.12	265,553	18,021,403
23	1,986,330	47,491	137,327	2,171,148	0.11	242,470	18,263,873
24	1,986,330	49,390	146,779	2,182,500	0.10	221,580	18,485,452
25	1,986,330	51,366	155,061	2,192,757	0.09	202,383	18,687,835
26	1,986,330	53,421	166,211	2,205,962	0.08	185,092	18,872,927
27	1,986,330	55,558	177,810	2,219,697	0.08	169,313	19,042,241
28	1,986,330	57,780	190,889	2,234,999	0.07	154,982	19,197,223
29	1,986,330	60,091	200,710	2,247,132	0.06	141,658	19,338,881
30	1,986,330	62,495	217,582	2,266,407	0.06	129,884	19,468,765
31	1,986,330	64,994	232,273	2,283,598	0.05	118,972	19,587,738
32	1,986,330	67,594	247,548	2,301,472	0.05	109,003	19,696,741
33	1,986,330	70,298	264,571	2,321,199	0.04	99,943	19,796,684
34	1,986,330	73,110	282,272	2,341,712	0.04	91,660	19,888,345
35	1,986,330	76,034	300,673	2,363,037	0.04	84,087	19,972,431

Life Cycle PV Cost **19,972,000**



MAGNETIC FIELD PROFILES FOR UNDERGROUND SINGLE-CIRCUIT HIGH PRESSURE FLUID-FILLED WITH CLOSED LOOP CIRCULATION

CONNECTICUT SITING COUNCIL LIFE CYCLE COST STUDY FOR 115-KV TRANSMISSION LINES

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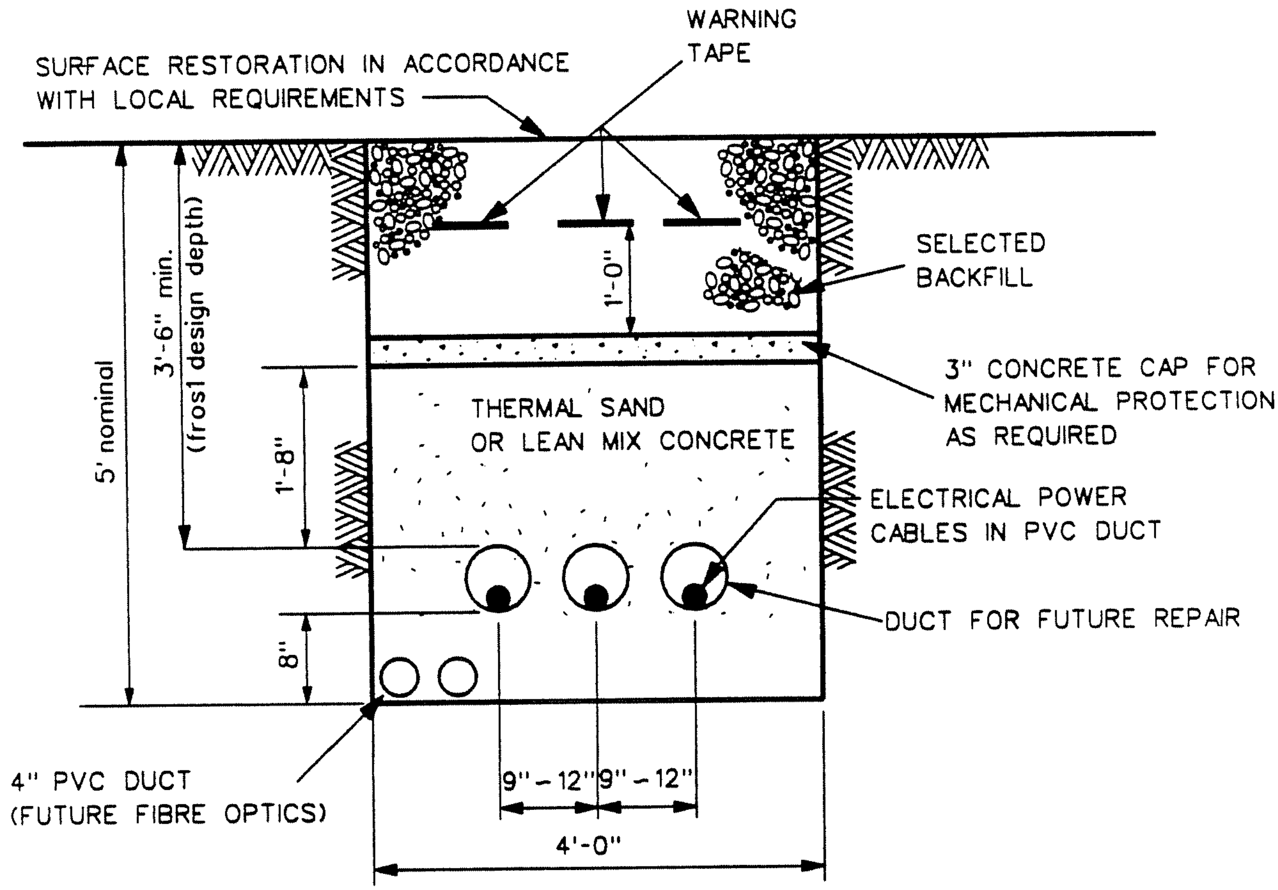


SCALE : 1" = 1.5'

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

UNDERGROUND SINGLE-CIRCUIT
SELF-CONTAINED FLUID-FILLED

Construction Cost Estimates
Underground Single Circuit Self Contained Fluid Filled

Base costs

Per Mile Base

Urban roadway location	$2,901,612	(a)

Per Project Base

Terminal equipment	$213,217	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder

Rural location	($503,000)	(d)

Per Project Adder

Winter construction	$75,000	(e)

Base Case

First cost	5 miles, urban, summer work	**$14,839,000**	5*(a)+(b)+(c)
Life cycle cost		**$21,622,000**	

Notes:

1) Base case is for a single circuit installed in an urban environment, open cut trench, concrete encased, no access roads, no vegetation clearing, with allowance for after hours work.

2) Cable performance

	Scenario A		
	Normal Rating	Long term emergency	Short term emergency
Summer	1000	1250	1500
Winter	1250	1500	1741

Scenario B		
Normal Rating	Long term emergency	Short term emergency
1250	1500	1691
1500	1694	1741

3) Electrical parameters

Conductor Size	2750	kcmil
Resistance	0.0271	ohm/mile
Capacitance	1015	microfarad/mile
Charging current	25.4	A/mile

Life Cycle Cost Analysis
Underground Single Circuit Self Contained Fluid Filled

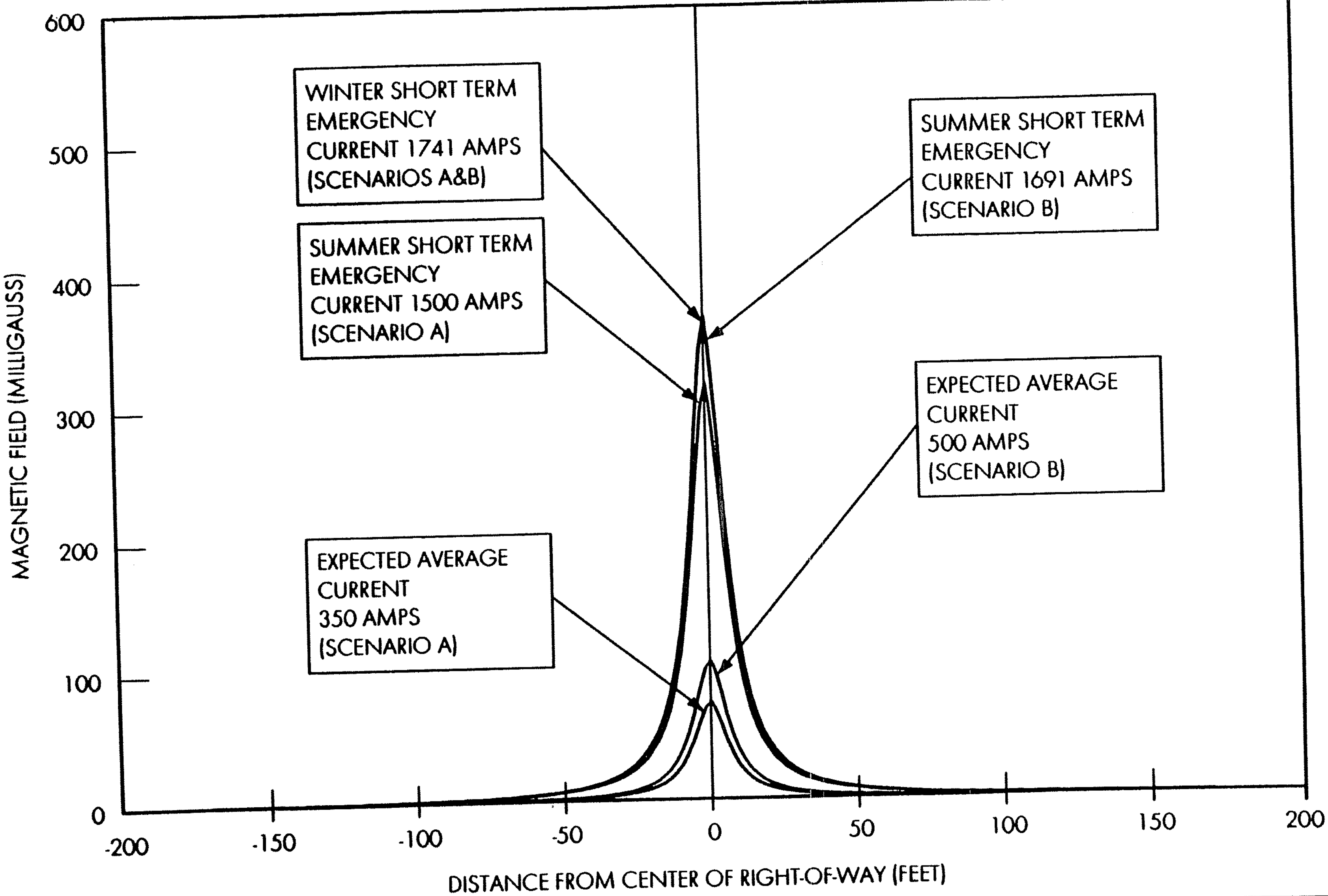
5 Miles, Scenario A - Summer loading

			FC rate		Fixed cost
Construction	14839000	x	0.146	=	2166494
Land	0				0
Total					2,166,494

PV discount	10%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	2,166,494	19,036	12,432	2,197,962	0.91	1,998,147	1,998,147
2	2,166,494	19,797	14,147	2,200,438	0.83	1,818,544	3,816,692
3	2,166,494	20,589	15,937	2,203,021	0.75	1,655,162	5,471,854
4	2,166,494	21,413	16,322	2,204,229	0.68	1,505,518	6,977,372
5	2,166,494	22,269	18,743	2,207,506	0.62	1,370,688	8,348,059
6	2,166,494	23,160	20,751	2,210,406	0.56	1,247,716	9,595,776
7	2,166,494	24,087	22,846	2,213,427	0.51	1,135,838	10,731,614
8	2,166,494	25,050	29,326	2,220,870	0.47	1,036,052	11,767,666
9	2,166,494	26,052	32,263	2,224,809	0.42	943,536	12,711,202
10	2,166,494	27,094	35,325	2,228,913	0.39	859,343	13,570,545
11	2,166,494	28,178	39,685	2,234,357	0.35	783,129	14,353,673
12	2,166,494	29,305	57,436	2,253,235	0.32	717,950	15,071,624
13	2,166,494	30,477	60,662	2,257,633	0.29	653,956	15,725,580
14	2,166,494	31,696	64,010	2,262,201	0.26	595,708	16,321,288
15	2,166,494	32,964	69,177	2,268,635	0.24	543,093	16,864,381
16	2,166,494	34,283	76,705	2,277,482	0.22	495,646	17,360,028
17	2,166,494	35,654	82,356	2,284,504	0.20	451,977	17,812,004
18	2,166,494	37,080	85,725	2,289,300	0.18	411,751	18,223,755
19	2,166,494	38,563	92,486	2,297,544	0.16	375,667	18,599,422
20	2,166,494	40,106	98,800	2,305,400	0.15	342,683	18,942,105
21	2,166,494	41,710	104,153	2,312,357	0.14	312,470	19,254,575
22	2,166,494	43,379	111,707	2,321,580	0.12	285,197	19,539,772
23	2,166,494	45,114	118,295	2,329,903	0.11	260,199	19,799,971
24	2,166,494	46,918	126,437	2,339,850	0.10	237,555	20,037,526
25	2,166,494	48,795	133,571	2,348,860	0.09	216,790	20,254,316
26	2,166,494	50,747	143,176	2,360,417	0.08	198,052	20,452,368
27	2,166,494	52,777	153,167	2,372,438	0.08	180,964	20,633,332
28	2,166,494	54,888	164,434	2,385,816	0.07	165,440	20,798,773
29	2,166,494	57,083	172,894	2,396,472	0.06	151,072	20,949,845
30	2,166,494	59,367	187,428	2,413,288	0.06	138,302	21,088,147
31	2,166,494	61,741	200,083	2,428,318	0.05	126,512	21,214,659
32	2,166,494	64,211	213,240	2,443,945	0.05	115,751	21,330,410
33	2,166,494	66,779	227,904	2,461,178	0.04	105,970	21,436,380
34	2,166,494	69,451	243,152	2,479,097	0.04	97,038	21,533,419
35	2,166,494	72,229	259,003	2,497,726	0.04	88,879	21,622,298

Life Cycle PV Cost **21,622,000**



MAGNETIC FIELD PROFILES FOR UNDERGROUND SINGLE-CIRCUIT SELF CONTAINED FLUID-FILLED

CONNECTICUT SITING COUNCIL LIFE CYCLE COST STUDY FOR 115-KV TRANSMISSION LINES

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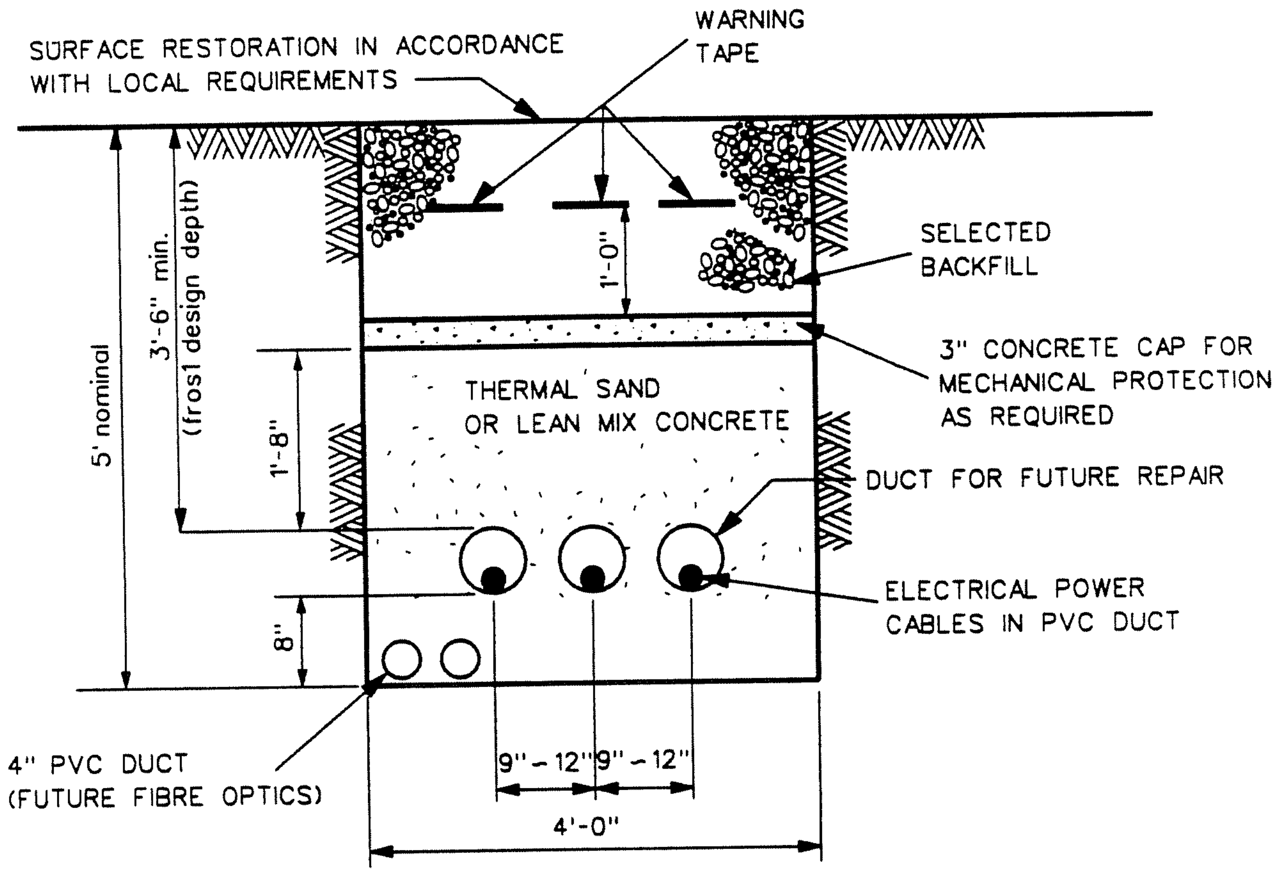


SCALE : 1" = 1.5'

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

UNDERGROUND SINGLE-CIRCUIT
SOLID DIELECTRIC WITH
HORIZONTAL ARRANGEMENT

Construction Cost Estimates
Underground Single Circuit Solid Dielectric with Horizontal Arrangement

Base costs

Per Mile Base

Urban roadway location	$2,468,836	(a)

Per Project Base

Terminal equipment	$140,680	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder

Rural location	($503,000)	(d)

Per Project Adder

Winter construction	$75,000	(e)

Base Case

First cost	5 miles, urban, summer work	**$12,603,000**	5*(a)+(b)+(c)
Life cycle cost		**$18,475,000**	

Notes:

1) Base case is for a single circuit installed in an urban environment, open cut trench, concrete encased, no access roads, no vegetation clearing, with allowance for after hours work.

2) Cable performance

	Scenario A		
	Normal Rating	Long term emergency	Short term emergency
Summer	1000	1250	1500
Winter	1250	1500	1750

Scenario B		
Normal Rating	Long term emergency	Short term emergency
1250	1500	1719
1500	1726	1767

3) Electrical parameters

Conductor Size	2500	kcmil
Resistance	0.03146	ohms/mile
Capacitance	370	microfarad/mile
Charging current	9.3	A/mile

Life Cycle Cost Analysis
Underground Single Circuit Solid Dielectric with Horizontal Arrangement

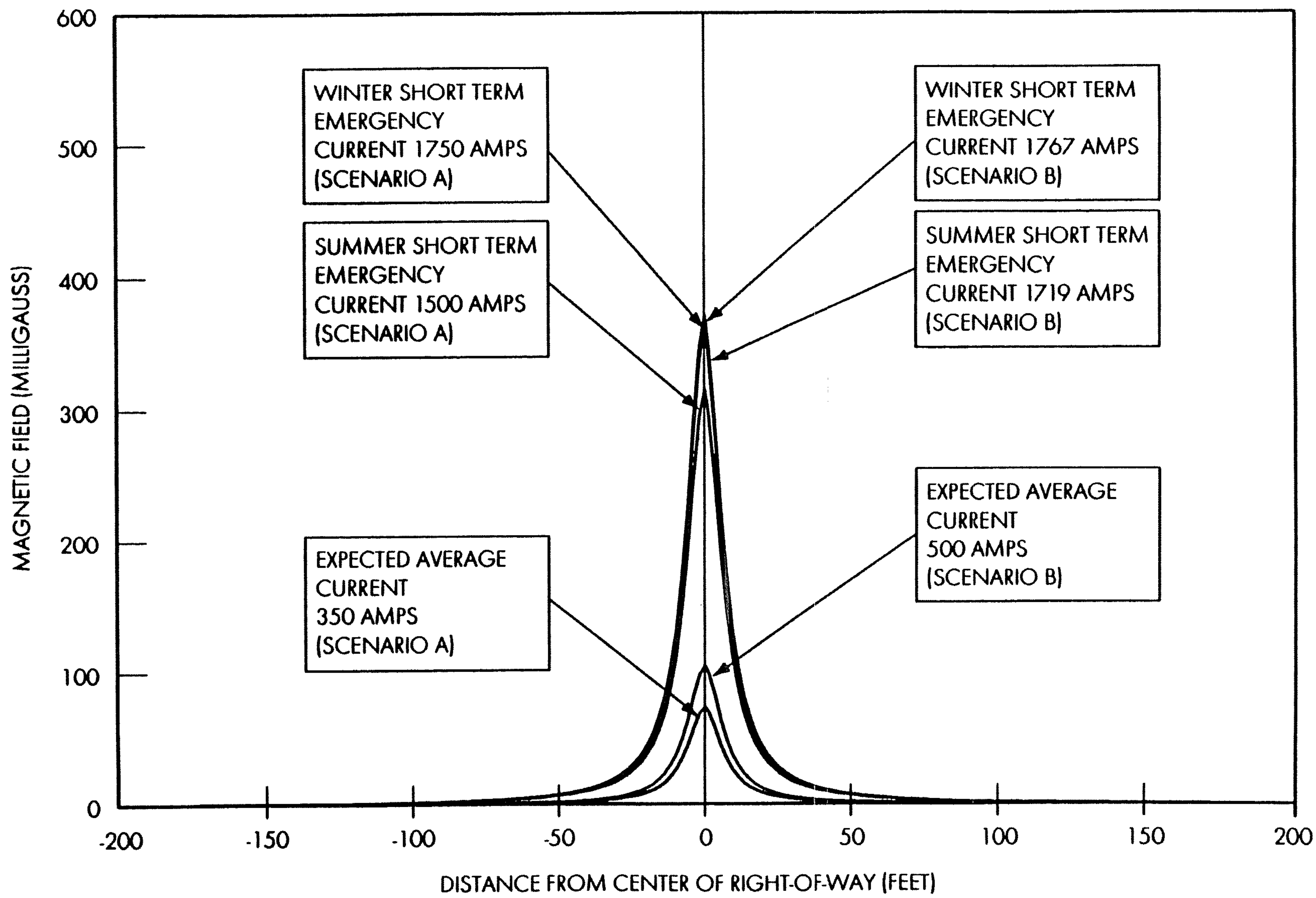
5 Miles, Scenario A - Summer loading

			FC rate		Fixed cost
Construction	12603000	x	0.146	=	1840038
Land	0				0
Total					1,840,038

PV discount	10%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	1,840,038	13,978	14,432	1,868,448	0.91	1,698,589	1,698,589
2	1,840,038	14,537	16,423	1,870,998	0.83	1,546,279	3,244,869
3	1,840,038	15,119	18,502	1,873,658	0.75	1,407,707	4,652,576
4	1,840,038	15,723	18,948	1,874,710	0.68	1,280,452	5,933,028
5	1,840,038	16,352	21,758	1,878,148	0.62	1,166,182	7,099,210
6	1,840,038	17,006	24,090	1,881,134	0.56	1,061,851	8,161,061
7	1,840,038	17,687	26,522	1,884,247	0.51	966,916	9,127,978
8	1,840,038	18,394	34,044	1,892,476	0.47	882,854	10,010,832
9	1,840,038	19,130	37,454	1,896,622	0.42	804,353	10,815,185
10	1,840,038	19,895	41,009	1,900,942	0.39	732,895	11,548,080
11	1,840,038	20,691	46,070	1,906,799	0.35	668,321	12,216,401
12	1,840,038	21,518	66,677	1,928,233	0.32	614,395	12,830,796
13	1,840,038	22,379	70,422	1,932,839	0.29	559,875	13,390,671
14	1,840,038	23,274	74,309	1,937,621	0.26	510,236	13,900,907
15	1,840,038	24,205	80,307	1,944,550	0.24	465,510	14,366,417
16	1,840,038	25,174	89,046	1,954,258	0.22	425,303	14,791,720
17	1,840,038	26,181	95,605	1,961,824	0.20	388,136	15,179,857
18	1,840,038	27,228	99,517	1,966,783	0.18	353,743	15,533,600
19	1,840,038	28,317	107,366	1,975,721	0.16	323,046	15,856,646
20	1,840,038	29,450	114,695	1,984,183	0.15	294,936	16,151,582
21	1,840,038	30,628	120,910	1,991,575	0.14	269,123	16,420,705
22	1,840,038	31,853	129,679	2,001,570	0.12	245,885	16,666,590
23	1,840,038	33,127	137,327	2,010,492	0.11	224,528	16,891,118
24	1,840,038	34,452	146,779	2,021,269	0.10	205,211	17,096,328
25	1,840,038	35,830	155,061	2,030,929	0.09	187,447	17,283,775
26	1,840,038	37,263	166,211	2,043,512	0.08	171,462	17,455,237
27	1,840,038	38,754	177,810	2,056,601	0.08	156,873	17,612,109
28	1,840,038	40,304	190,889	2,071,231	0.07	143,626	17,755,735
29	1,840,038	41,916	200,710	2,082,664	0.06	131,290	17,887,025
30	1,840,038	43,593	217,582	2,101,212	0.06	120,417	18,007,443
31	1,840,038	45,336	232,273	2,117,648	0.05	110,327	18,117,770
32	1,840,038	47,150	247,548	2,134,735	0.05	101,106	18,218,876
33	1,840,038	49,036	264,571	2,153,644	0.04	92,729	18,311,605
34	1,840,038	50,997	282,272	2,173,307	0.04	85,069	18,396,673
35	1,840,038	53,037	300,673	2,193,748	0.04	78,063	18,474,736

Life Cycle PV Cost **18,475,000**



MAGNETIC FIELD PROFILES FOR UNDERGROUND SINGLE-CIRCUIT SOLID DIELECTRIC WITH HORIZONTAL ARRANGEMENT

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES

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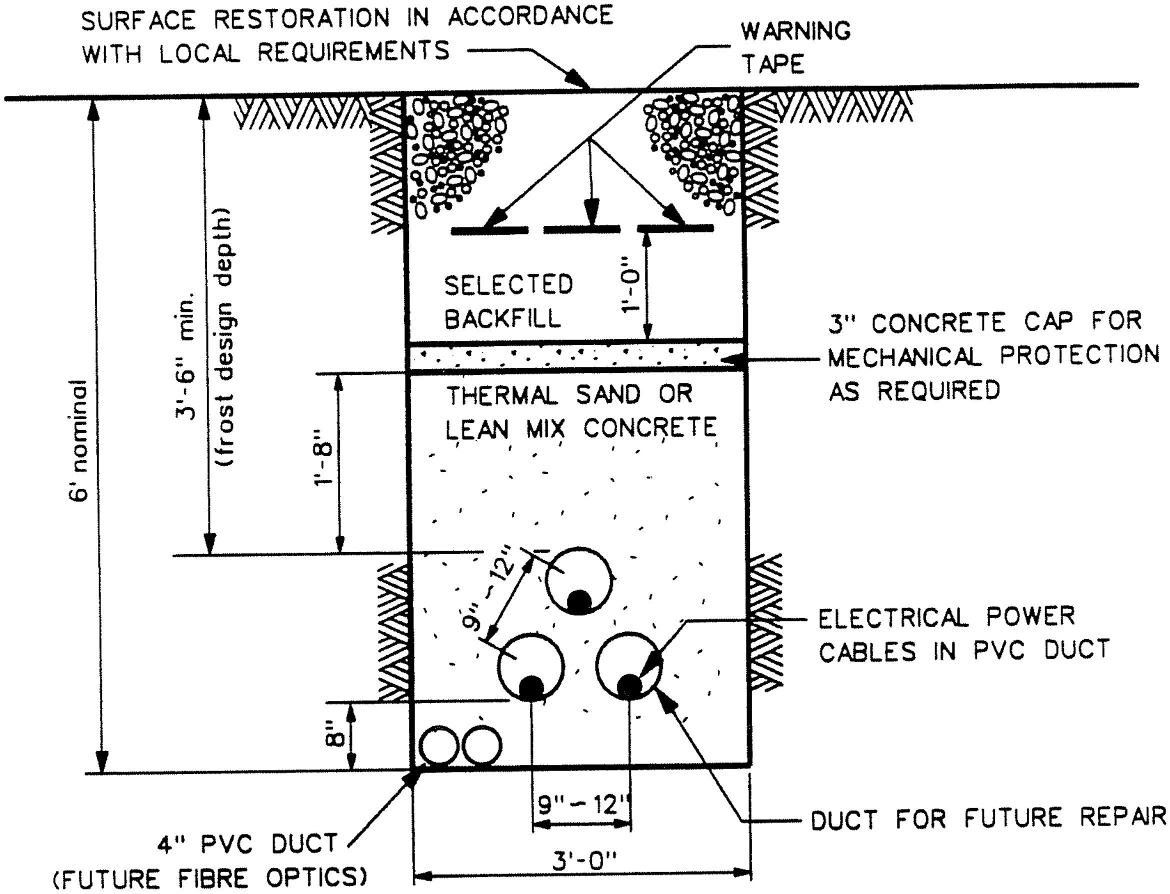


SCALE : 1" = 1.5'

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

UNDERGROUND SINGLE-CIRCUIT
SOLID DIELECTRIC WITH
DELTA ARRANGEMENT

Construction Cost Estimates
Underground Single Circuit Solid Dielectric with Delta Arrangement

Base costs

Per Mile Base

Urban roadway location	$2,432,600	(a)

Per Project Base

Terminal equipment	$140,680	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder

Rural location	($452,000)	(d)

Per Project Adder

Winter construction	$75,000	(e)

Base Case

First cost	5 miles, urban, summer work	**$12,422,000**	5*(a)+(b)+(c)
Life cycle cost		**$18,220,000**	

Notes:

1) Base case is for a single circuit installed in an urban environment, open cut trench, concrete encased, no access roads, no vegetation clearing, with allowance for after hours work.

2) Cable performance

	Scenario A		
	Normal Rating	Long term emergency	Short term emergency
Summer	1000	1250	1500
Winter	1250	1500	1750

Scenario B		
Normal Rating	Long term emergency	Short term emergency
1250	1500	1710
1500	1717	1758

3) Electrical parameters

Conductor Size	2500 kcmil
Resistance	0.03146 ohms/mile
Capacitance	370 microfarad/mile
Charging current	9.3 A/mile

Life Cycle Cost Analysis
Underground Single Circuit Solid Dielectric with Delta Arrangement

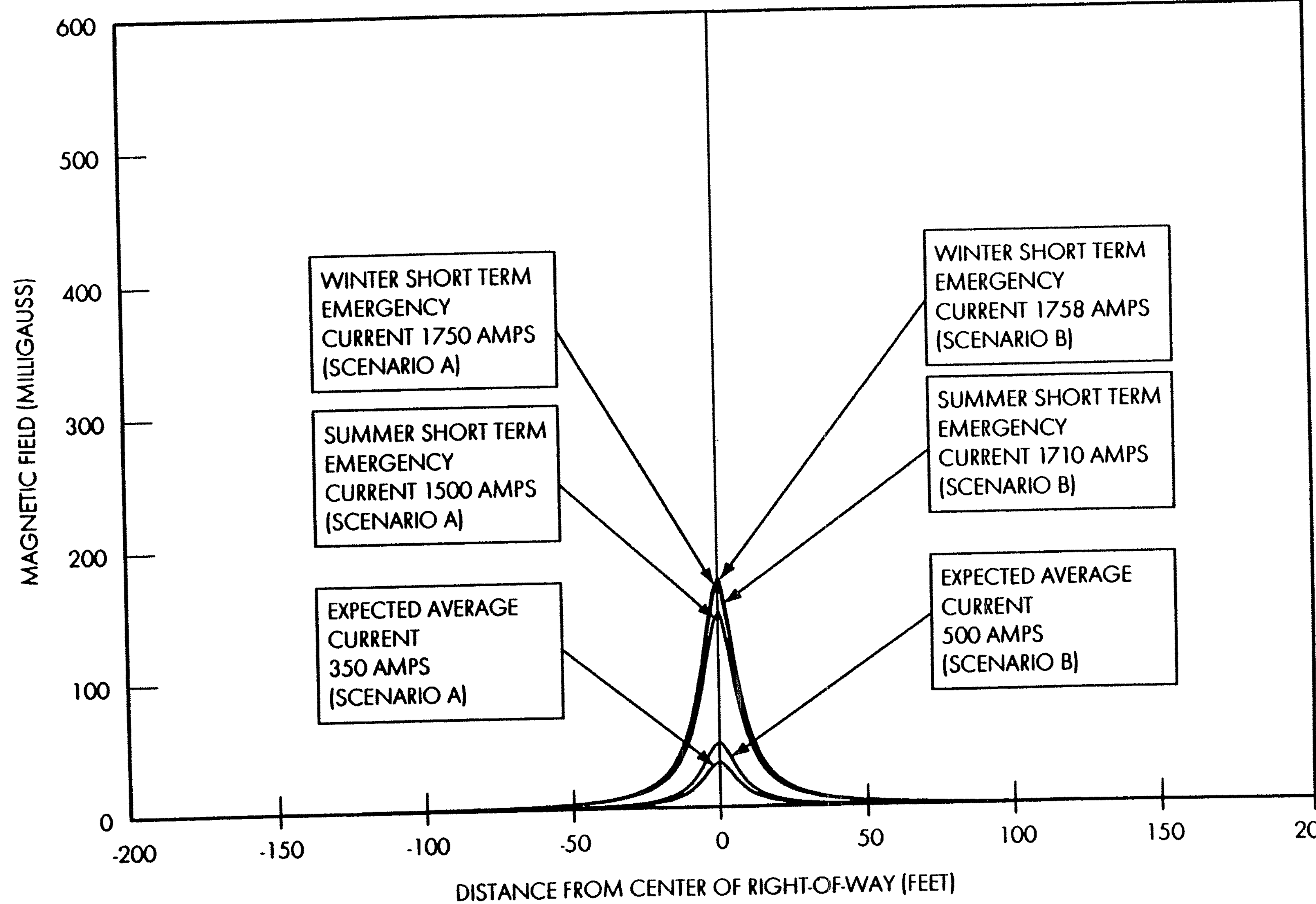
5 Miles, Scenario A - Summer loading

			FC rate		Fixed cost
Construction	12422000	x	0.146	=	1813612
Land	0				0
Total					1,813,612

PV discount	10%
O&M escalation	4%
Load growth (annual)	1.2%

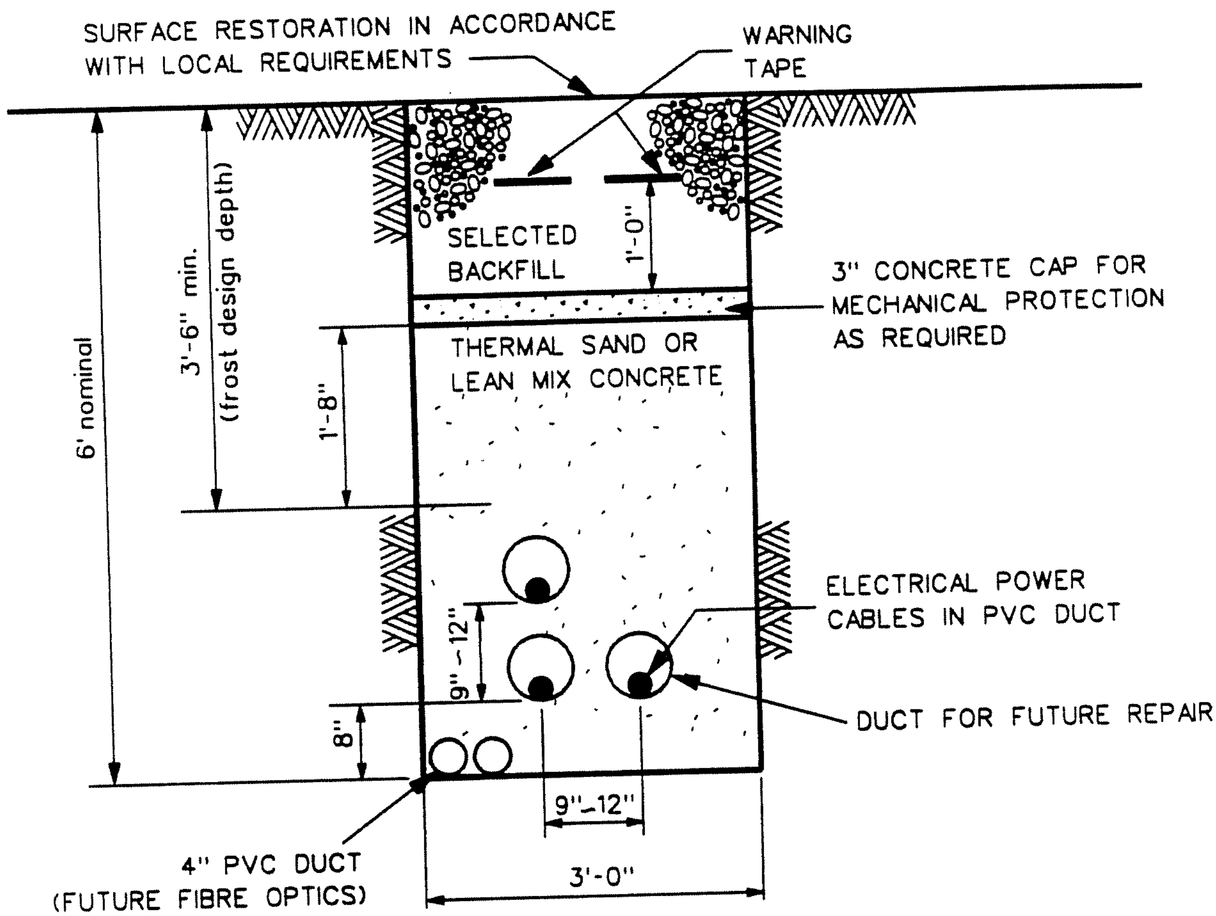
Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	1,813,612	13,978	14,432	1,842,022	0.91	1,674,566	1,674,566
2	1,813,612	14,537	16,423	1,844,572	0.83	1,524,440	3,199,006
3	1,813,612	15,119	18,502	1,847,232	0.75	1,387,853	4,586,858
4	1,813,612	15,723	18,948	1,848,284	0.68	1,262,403	5,849,261
5	1,813,612	16,352	21,758	1,851,722	0.62	1,149,774	6,999,035
6	1,813,612	17,006	24,090	1,854,708	0.56	1,046,935	8,045,969
7	1,813,612	17,687	26,522	1,857,821	0.51	953,356	8,999,325
8	1,813,612	18,394	34,044	1,866,050	0.47	870,526	9,869,851
9	1,813,612	19,130	37,454	1,870,196	0.42	793,146	10,662,997
10	1,813,612	19,895	41,009	1,874,516	0.39	722,707	11,385,704
11	1,813,612	20,691	46,070	1,880,373	0.35	659,059	12,044,763
12	1,813,612	21,518	66,677	1,901,807	0.32	605,974	12,650,737
13	1,813,612	22,379	70,422	1,906,413	0.29	552,220	13,202,957
14	1,813,612	23,274	74,309	1,911,195	0.26	503,277	13,706,235
15	1,813,612	24,205	80,307	1,918,124	0.24	459,184	14,165,419
16	1,813,612	25,174	89,046	1,927,832	0.22	419,552	14,584,971
17	1,813,612	26,181	95,605	1,935,398	0.20	382,908	14,967,879
18	1,813,612	27,228	99,517	1,940,357	0.18	348,990	15,316,869
19	1,813,612	28,317	107,366	1,949,295	0.16	318,725	15,635,595
20	1,813,612	29,450	114,695	1,957,757	0.15	291,008	15,926,603
21	1,813,612	30,628	120,910	1,965,149	0.14	265,552	16,192,154
22	1,813,612	31,853	129,679	1,975,144	0.12	242,638	16,434,793
23	1,813,612	33,127	137,327	1,984,066	0.11	221,577	16,656,370
24	1,813,612	34,452	146,779	1,994,843	0.10	202,528	16,858,897
25	1,813,612	35,830	155,061	2,004,503	0.09	185,008	17,043,905
26	1,813,612	37,263	166,211	2,017,086	0.08	169,245	17,213,149
27	1,813,612	38,754	177,810	2,030,175	0.08	154,857	17,368,007
28	1,813,612	40,304	190,889	2,044,805	0.07	141,794	17,509,800
29	1,813,612	41,916	200,710	2,056,238	0.06	129,624	17,639,424
30	1,813,612	43,593	217,582	2,074,786	0.06	118,903	17,758,327
31	1,813,612	45,336	232,273	2,091,222	0.05	108,950	17,867,277
32	1,813,612	47,150	247,548	2,108,309	0.05	99,855	17,967,132
33	1,813,612	49,036	264,571	2,127,218	0.04	91,591	18,058,723
34	1,813,612	50,997	282,272	2,146,881	0.04	84,034	18,142,757
35	1,813,612	53,037	300,673	2,167,322	0.04	77,122	18,219,879

Life Cycle PV Cost **18,220,000**



MAGNETIC FIELD PROFILES FOR UNDERGROUND SINGLE-CIRCUIT SOLID DIELECTRIC WITH DELTA ARRANGEMENT

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES



SCALE : 1" = 1.5'

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

UNDERGROUND SINGLE-CIRCUIT
SOLID DIELECTRIC WITH
L - SHAPED ARRANGEMENT

Construction Cost Estimates
Underground Single Circuit Solid Dielectric with L-Shaped Arrangement

Base costs

Per Mile Base

Urban roadway location	$2,432,597	(a)

Per Project Base

Terminal equipment	$140,680	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder

Rural location	($452,000)	(d)

Per Project Adder

Winter construction	$75,000	(e)

Base Case

First cost	5 miles, urban, summer work	**$12,422,000**	5*(a)+(b)+(c
Life cycle cost		**$18,220,000**	

Notes:

1) Base case is for a single circuit installed in an urban environment, open cut trench, concrete encased, no access roads, no vegetation clearing, with allowance for after hours work.

2) Cable performance

	Scenario A		
	Normal Rating	Long term emergency	Short term emergency
Summer	1000	1250	1500
Winter	1250	1500	1750

Scenario B		
Normal Rating	Long term emergency	Short term emergency
1250	1500	1755
1500	1762	1803

3) Electrical parameters

Conductor Size	2500	kcmil
Resistance	0.03146	ohms/mile
Capacitance	370	microfarad/mile
Charging current	9.3	A/mile

Life Cycle Cost Analysis
Underground Single Circuit Solid Dielectric with L-Shaped Arrangement

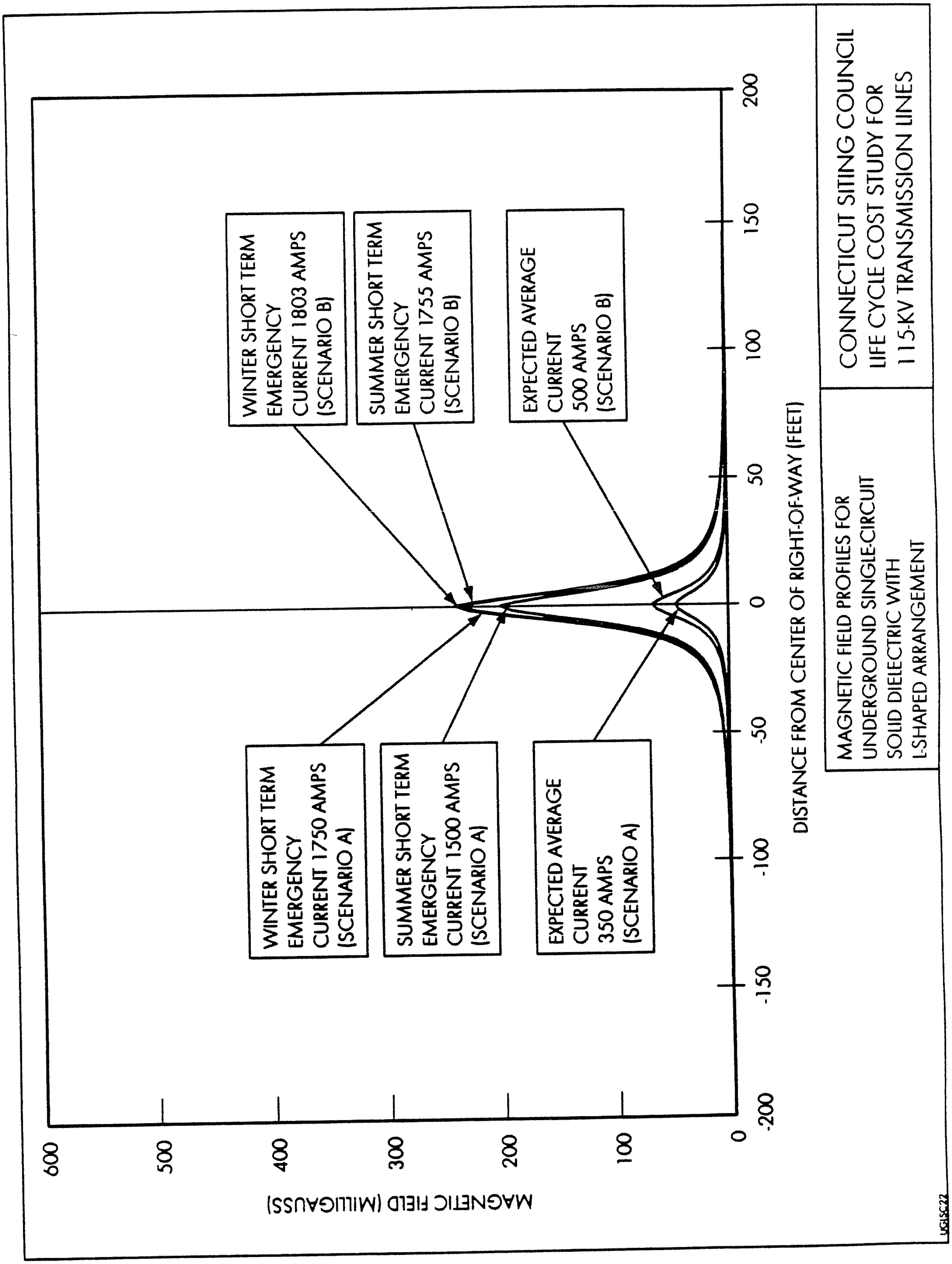
5 Miles, Scenario A - Summer loading

			FC rate		Fixed cost
Construction	12422000	x	0.146	=	1813612
Land	0				0
Total					1,813,612

PV discount	10%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	1,813,612	13,978	14,432	1,842,022	0.91	1,674,566	1,674,566
2	1,813,612	14,537	16,423	1,844,572	0.83	1,524,440	3,199,006
3	1,813,612	15,119	18,502	1,847,232	0.75	1,387,853	4,586,858
4	1,813,612	15,723	18,948	1,848,284	0.68	1,262,403	5,849,261
5	1,813,612	16,352	21,758	1,851,722	0.62	1,149,774	6,999,035
6	1,813,612	17,006	24,090	1,854,708	0.56	1,046,935	8,045,969
7	1,813,612	17,687	26,522	1,857,821	0.51	953,356	8,999,325
8	1,813,612	18,394	34,044	1,866,050	0.47	870,526	9,869,851
9	1,813,612	19,130	37,454	1,870,196	0.42	793,146	10,662,997
10	1,813,612	19,895	41,009	1,874,516	0.39	722,707	11,385,704
11	1,813,612	20,691	46,070	1,880,373	0.35	659,059	12,044,763
12	1,813,612	21,518	66,677	1,901,807	0.32	605,974	12,650,737
13	1,813,612	22,379	70,422	1,906,413	0.29	552,220	13,202,957
14	1,813,612	23,274	74,309	1,911,195	0.26	503,277	13,706,235
15	1,813,612	24,205	80,307	1,918,124	0.24	459,184	14,165,419
16	1,813,612	25,174	89,046	1,927,832	0.22	419,552	14,584,971
17	1,813,612	26,181	95,605	1,935,398	0.20	382,908	14,967,879
18	1,813,612	27,228	99,517	1,940,357	0.18	348,990	15,316,869
19	1,813,612	28,317	107,366	1,949,295	0.16	318,725	15,635,595
20	1,813,612	29,450	114,695	1,957,757	0.15	291,008	15,926,603
21	1,813,612	30,628	120,910	1,965,149	0.14	265,552	16,192,154
22	1,813,612	31,853	129,679	1,975,144	0.12	242,638	16,434,793
23	1,813,612	33,127	137,327	1,984,066	0.11	221,577	16,656,370
24	1,813,612	34,452	146,779	1,994,843	0.10	202,528	16,858,897
25	1,813,612	35,830	155,061	2,004,503	0.09	185,008	17,043,905
26	1,813,612	37,263	166,211	2,017,086	0.08	169,245	17,213,149
27	1,813,612	38,754	177,810	2,030,175	0.08	154,857	17,368,007
28	1,813,612	40,304	190,889	2,044,805	0.07	141,794	17,509,800
29	1,813,612	41,916	200,710	2,056,238	0.06	129,624	17,639,424
30	1,813,612	43,593	217,582	2,074,786	0.06	118,903	17,758,327
31	1,813,612	45,336	232,273	2,091,222	0.05	108,950	17,867,277
32	1,813,612	47,150	247,548	2,108,309	0.05	99,855	17,967,132
33	1,813,612	49,036	264,571	2,127,218	0.04	91,591	18,058,723
34	1,813,612	50,997	282,272	2,146,881	0.04	84,034	18,142,757
35	1,813,612	53,037	300,673	2,167,322	0.04	77,122	18,219,879

Life Cycle PV Cost **18,220,000**


WINTER SHORT TERM EMERGENCY CURRENT 1803 AMPS (SCENARIO B)
SUMMER SHORT TERM EMERGENCY CURRENT 1755 AMPS (SCENARIO B)
EXPECTED AVERAGE CURRENT 500 AMPS (SCENARIO B)
WINTER SHORT TERM EMERGENCY CURRENT 1750 AMPS (SCENARIO A)
SUMMER SHORT TERM EMERGENCY CURRENT 1500 AMPS (SCENARIO A)
EXPECTED AVERAGE CURRENT 350 AMPS (SCENARIO A)
MAGNETIC FIELD (MILLIGAUSS)
0
100
200
300
400
500
600
-200
-150
-100
-50
0
50
100
150
200
DISTANCE FROM CENTER OF RIGHT-OF-WAY (FEET)
MAGNETIC FIELD PROFILES FOR UNDERGROUND SINGLE-CIRCUIT SOLID DIELECTRIC WITH L-SHAPED ARRANGEMENT
CONNECTICUT SITING COUNCIL LIFE CYCLE COST STUDY FOR 115-KV TRANSMISSION LINES
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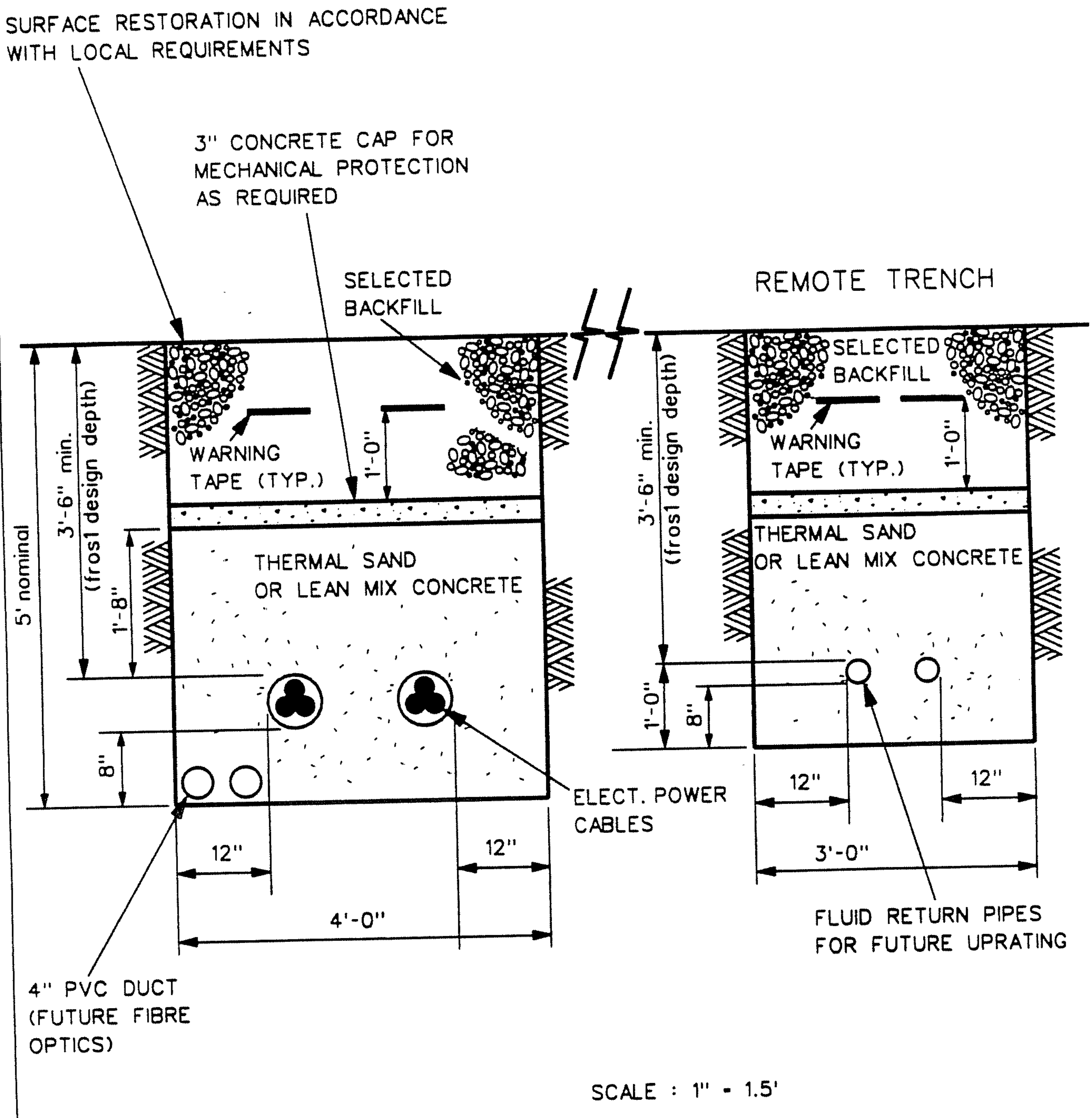


CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

UNDERGROUND DOUBLE-CIRCUIT
HIGH PRESSURE GAS-FILLED

Construction Cost Estimates
Underground Double Circuit High Pressure Gas-Filled

Base costs

Per Mile Base

Urban roadway location	$4,704,517	(a)

Per Project Base

Terminal equipment	$556,881	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder

Rural location	($659,000)	(d)

Per Project Adder

Winter construction	$75,000	(e)

Base Case

First cost	5 miles, urban, summer work	**$24,197,000**	5*(a)+(b)+(c)
Life cycle cost		**$35,013,000**	

Notes:

1) Base case is for a double circuit installed in an urban environment, open cut trench, concrete encased, no access roads, no vegetation clearing, with allowance for after hours work.

2) Cable performance

	Scenario A Normal Rating	Scenario A Long term emergency	Scenario A Short term emergency	Scenario B Normal Rating	Scenario B Long term emergency	Scenario B Short term emergency
Summer	1000	1166	1200	1052	1166	1200
Winter	1096	1205	1238	1096	1205	1238

3) Electrical parameters

Conductor Size	2500	kcmil
Resistance	0.03146	ohms/mile
Capacitance	531	microfarad/mile
Charging current	13.3	A/mile

Life Cycle Cost Analysis
Underground Double Circuit High Pressure Gas-Filled

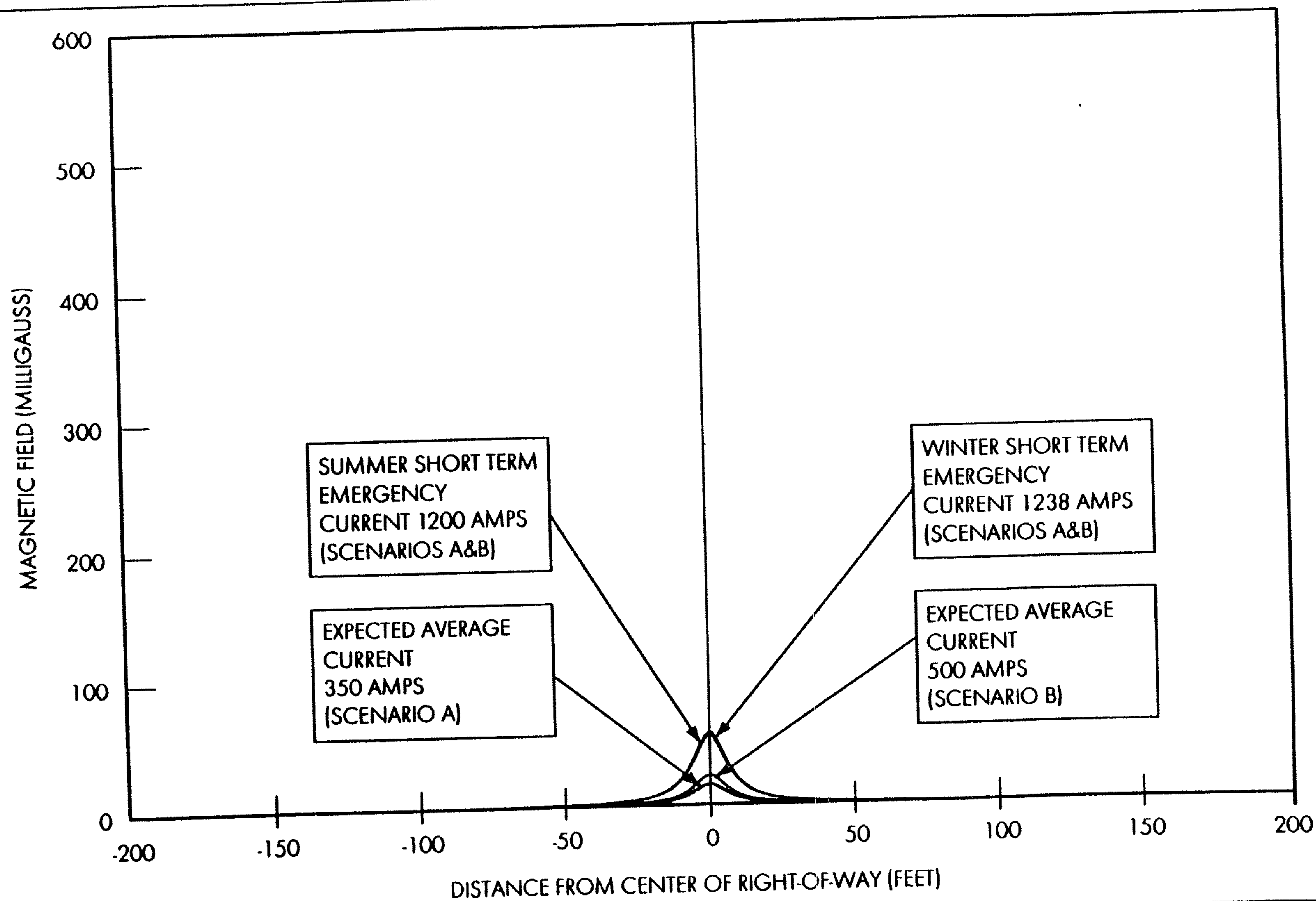
5 Miles, Scenario A - Summer loading

			FC rate		Fixed cost
Construction	24197000	x	0.146	=	3532762
Land	0				0
Total					3,532,762

PV discount	10%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	3,532,762	28,870	14,432	3,576,064	0.91	3,250,968	3,250,968
2	3,532,762	30,025	16,423	3,579,210	0.83	2,958,025	6,208,992
3	3,532,762	31,226	18,502	3,582,489	0.75	2,691,577	8,900,569
4	3,532,762	32,475	18,948	3,584,185	0.68	2,448,047	11,348,616
5	3,532,762	33,774	21,758	3,588,294	0.62	2,228,048	13,576,664
6	3,532,762	35,125	24,090	3,591,977	0.56	2,027,577	15,604,241
7	3,532,762	36,530	26,522	3,595,814	0.51	1,845,221	17,449,462
8	3,532,762	37,991	34,044	3,604,797	0.47	1,681,665	19,131,127
9	3,532,762	39,511	37,454	3,609,727	0.42	1,530,876	20,662,003
10	3,532,762	41,091	41,009	3,614,862	0.39	1,393,686	22,055,689
11	3,532,762	42,735	46,070	3,621,567	0.35	1,269,337	23,325,026
12	3,532,762	44,444	66,677	3,643,883	0.32	1,161,053	24,486,079
13	3,532,762	46,222	70,422	3,649,406	0.29	1,057,103	25,543,182
14	3,532,762	48,071	74,309	3,655,142	0.26	962,513	26,505,695
15	3,532,762	49,993	80,307	3,663,062	0.24	876,908	27,382,603
16	3,532,762	51,993	89,046	3,673,801	0.22	799,526	28,182,129
17	3,532,762	54,073	95,605	3,682,440	0.20	728,551	28,910,681
18	3,532,762	56,236	99,517	3,688,515	0.18	663,412	29,574,093
19	3,532,762	58,485	107,366	3,698,614	0.16	604,753	30,178,845
20	3,532,762	60,825	114,695	3,708,282	0.15	551,212	30,730,058
21	3,532,762	63,258	120,910	3,716,929	0.14	502,271	31,232,329
22	3,532,762	65,788	129,679	3,728,229	0.12	457,998	31,690,327
23	3,532,762	68,420	137,327	3,738,509	0.11	417,510	32,107,836
24	3,532,762	71,156	146,779	3,750,698	0.10	380,792	32,488,628
25	3,532,762	74,003	155,061	3,761,826	0.09	347,201	32,835,830
26	3,532,762	76,963	166,211	3,775,936	0.08	316,822	33,152,651
27	3,532,762	80,041	177,810	3,790,613	0.08	289,139	33,441,790
28	3,532,762	83,243	190,889	3,806,894	0.07	263,983	33,705,773
29	3,532,762	86,573	200,710	3,820,045	0.06	240,813	33,946,587
30	3,532,762	90,035	217,582	3,840,379	0.06	220,087	34,166,673
31	3,532,762	93,637	232,273	3,858,672	0.05	201,032	34,367,705
32	3,532,762	97,382	247,548	3,877,692	0.05	183,657	34,551,362
33	3,532,762	101,278	264,571	3,898,610	0.04	167,862	34,719,223
34	3,532,762	105,329	282,272	3,920,363	0.04	153,453	34,872,676
35	3,532,762	109,542	300,673	3,942,977	0.04	140,307	35,012,984

Life Cycle PV Cost **35,013,000**



MAGNETIC FIELD PROFILES FOR UNDERGROUND DOUBLE-CIRCUIT HIGH PRESSURE GAS-FILLED

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES

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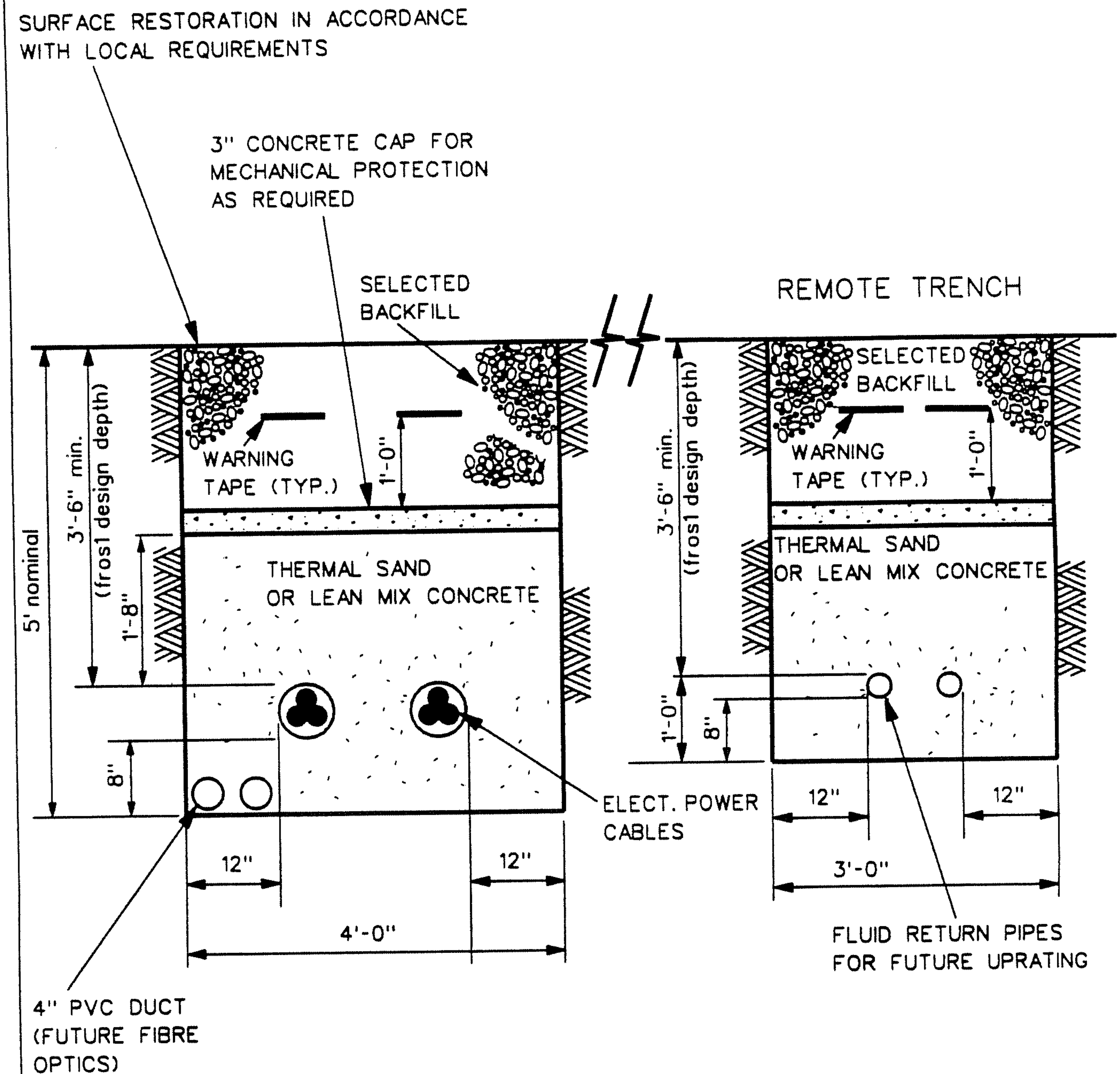


SCALE : 1" = 1.5'

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

UNDERGROUND DOUBLE-CIRCUIT
HIGH PRESSURE FLUID-FILLED

Construction Cost Estimates
Underground Double Circuit High Pressure Fluid-Filled

Base costs

Per Mile Base

Urban roadway location	$4,498,008	(a)

Per Project Base

Terminal equipment	$1,075,860	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder

Rural location	($659,000)	(d)

Per Project Adder

Winter construction	$75,000	(e)

Base Case

First cost	5 miles, urban, summer work	**$23,684,000**	5*(a)+(b)+(c)
Life cycle cost		**$34,291,000**	

Notes:

1) Base case is for a double circuit installed in an urban environment, open cut trench, concrete encased, no access roads, no vegetation clearing, with allowance for after hours work.

2) Cable performance

	Scenario A		
	Normal Rating	Long term emergency	Short term emergency
Summer	1000	1184	1219
Winter	1109	1223	1257

Scenario B		
Normal Rating	Long term emergency	Short term emergency
1052	1166	1219
1109	1223	1257

3) Electrical parameters

Conductor Size	2500	kcmil
Resistance	0.03146	ohms/mile
Capacitance	547	microfarad/mile
Charging current	13.7	A/mile

Life Cycle Cost Analysis
Underground Double Circuit High Pressure Fluid-Filled

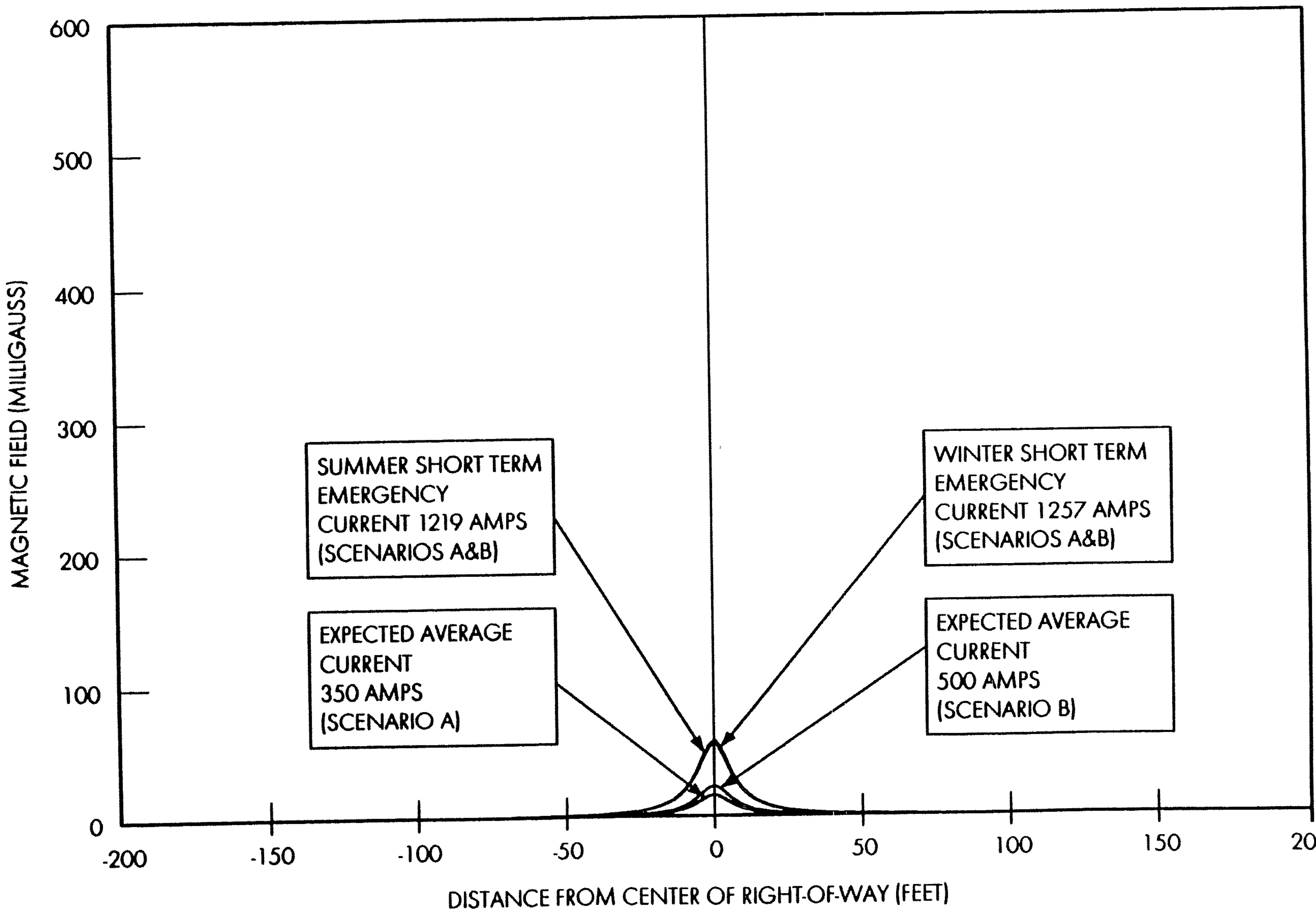
5 Miles, Scenario A - Summer loading

			FC rate		Fixed cost
Construction	23684000	x	0.146	=	3457864
Land	0				0
Total					3457864

PV discount	10%
O&M escalation	4%
Load growth (annual)	1.2%

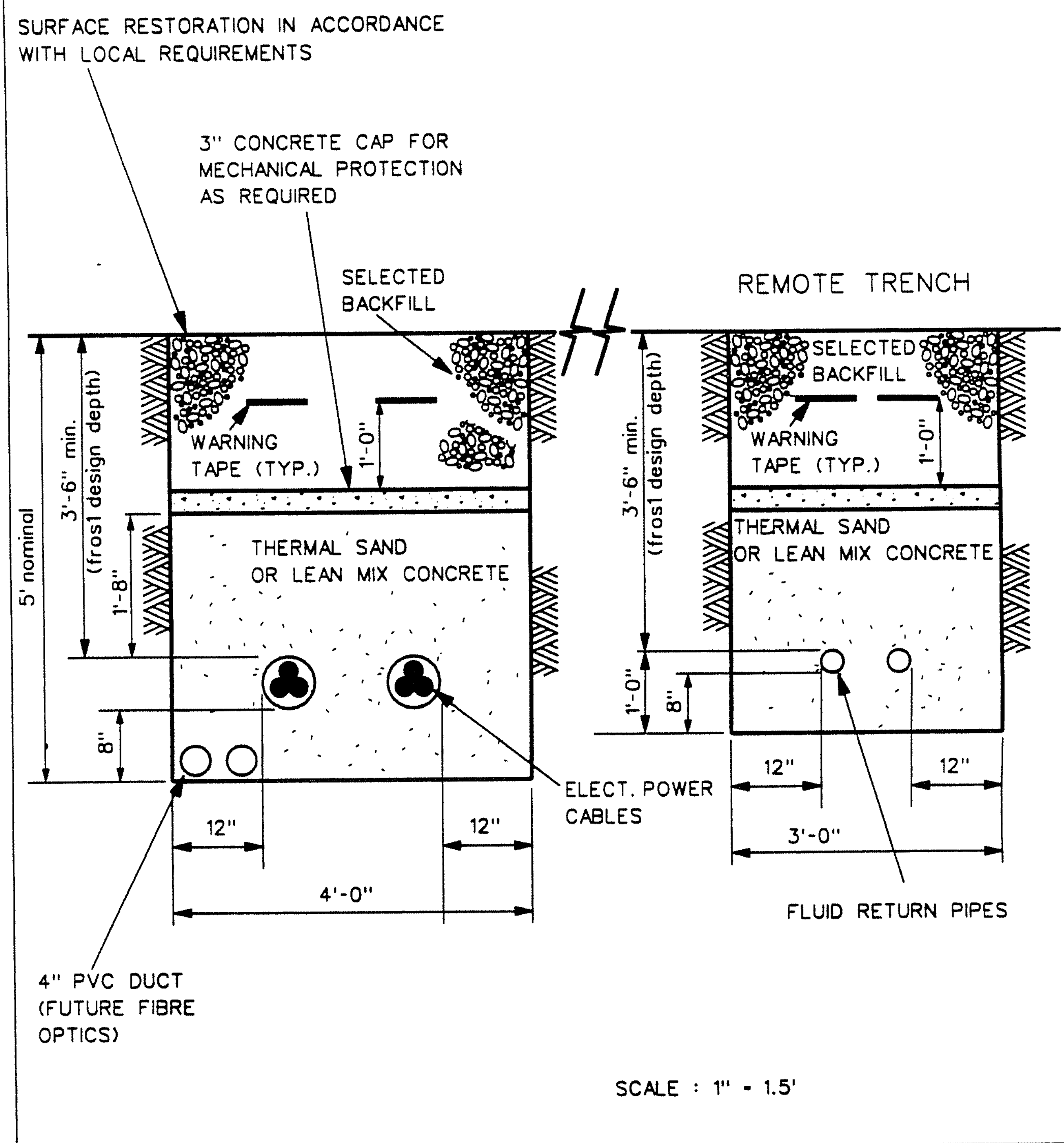
Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	3,457,864	28,870	14,432	3,501,166	0.91	3,182,878	3,182,878
2	3,457,864	30,025	16,423	3,504,312	0.83	2,896,125	6,079,004
3	3,457,864	31,226	18,502	3,507,591	0.75	2,635,305	8,714,309
4	3,457,864	32,475	18,948	3,509,287	0.68	2,396,890	11,111,199
5	3,457,864	33,774	21,758	3,513,396	0.62	2,181,542	13,292,742
6	3,457,864	35,125	24,090	3,517,079	0.56	1,985,299	15,278,041
7	3,457,864	36,530	26,522	3,520,916	0.51	1,806,786	17,084,828
8	3,457,864	37,991	34,044	3,529,899	0.47	1,646,724	18,731,552
9	3,457,864	39,511	37,454	3,534,829	0.42	1,499,112	20,230,664
10	3,457,864	41,091	41,009	3,539,964	0.39	1,364,809	21,595,473
11	3,457,864	42,735	46,070	3,546,669	0.35	1,243,086	22,838,559
12	3,457,864	44,444	66,677	3,568,985	0.32	1,137,189	23,975,747
13	3,457,864	46,222	70,422	3,574,508	0.29	1,035,408	25,011,155
14	3,457,864	48,071	74,309	3,580,244	0.26	942,790	25,953,945
15	3,457,864	49,993	80,307	3,588,164	0.24	858,978	26,812,923
16	3,457,864	51,993	89,046	3,598,903	0.22	783,226	27,596,149
17	3,457,864	54,073	95,605	3,607,542	0.20	713,733	28,309,882
18	3,457,864	56,236	99,517	3,613,617	0.18	649,941	28,959,823
19	3,457,864	58,485	107,366	3,623,716	0.16	592,506	29,552,330
20	3,457,864	60,825	114,695	3,633,384	0.15	540,079	30,092,409
21	3,457,864	63,258	120,910	3,642,031	0.14	492,150	30,584,559
22	3,457,864	65,788	129,679	3,653,331	0.12	448,797	31,033,356
23	3,457,864	68,420	137,327	3,663,611	0.11	409,145	31,442,501
24	3,457,864	71,156	146,779	3,675,800	0.10	373,188	31,815,689
25	3,457,864	74,003	155,061	3,686,928	0.09	340,289	32,155,977
26	3,457,864	76,963	166,211	3,701,038	0.08	310,537	32,466,515
27	3,457,864	80,041	177,810	3,715,715	0.08	283,426	32,749,941
28	3,457,864	83,243	190,889	3,731,996	0.07	258,789	33,008,730
29	3,457,864	86,573	200,710	3,745,147	0.06	236,092	33,244,822
30	3,457,864	90,035	217,582	3,765,481	0.06	215,794	33,460,616
31	3,457,864	93,637	232,273	3,783,774	0.05	197,130	33,657,746
32	3,457,864	97,382	247,548	3,802,794	0.05	180,110	33,837,855
33	3,457,864	101,278	264,571	3,823,712	0.04	164,637	34,002,492
34	3,457,864	105,329	282,272	3,845,465	0.04	150,521	34,153,013
35	3,457,864	109,542	300,673	3,868,079	0.04	137,642	34,290,655

Life Cycle PV Cost **34,291,000**



MAGNETIC FIELD PROFILES FOR UNDERGROUND DOUBLE-CIRCUIT HIGH PRESSURE FLUID-FILLED

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES



CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

UNDERGROUND DOUBLE-CIRCUIT
HIGH PRESSURE FLUID-FILLED
WITH CLOSED LOOP CIRCULATION

Construction Cost Estimates
Underground Double Circuit High Pressure Fluid-Filled with Closed Loop Circulation

Base costs

Per Mile Base

Urban roadway location	$5,056,615	(a)

Per Project Base

Terminal equipment	$1,075,860	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder

Rural location	($891,000)	(d)

Per Project Adder

Winter construction	$75,000	(e)

Base Case

First cost	5 miles, urban, summer work	**$26,477,000**	5*(a)+(b)+(c)
Life cycle cost		**$38,223,000**	

Notes:

1) Base case is for a double circuit installed in an urban environment, open cut trench, concrete encased, no access roads, no vegetation clearing, with allowance for after hours work.

2) Cable performance

	Scenario A		
	Normal Rating	Long term emergency	Short term emergency
Summer	1000	1184	1219
Winter	1109	1223	1257

Scenario B		
Normal Rating	Long term emergency	Short term emergency
1065	1184	1219
1109	1223	1257

3) Electrical parameters

Conductor Size	2500 kcmil
Resistance	0.03146 ohms/mile
Capacitance	547 microfarad/mile
Charging current	13.7 A/mile

Life Cycle Cost Analysis
Underground Double Circuit High Pressure Fluid-Filled with Closed Loop Circulation

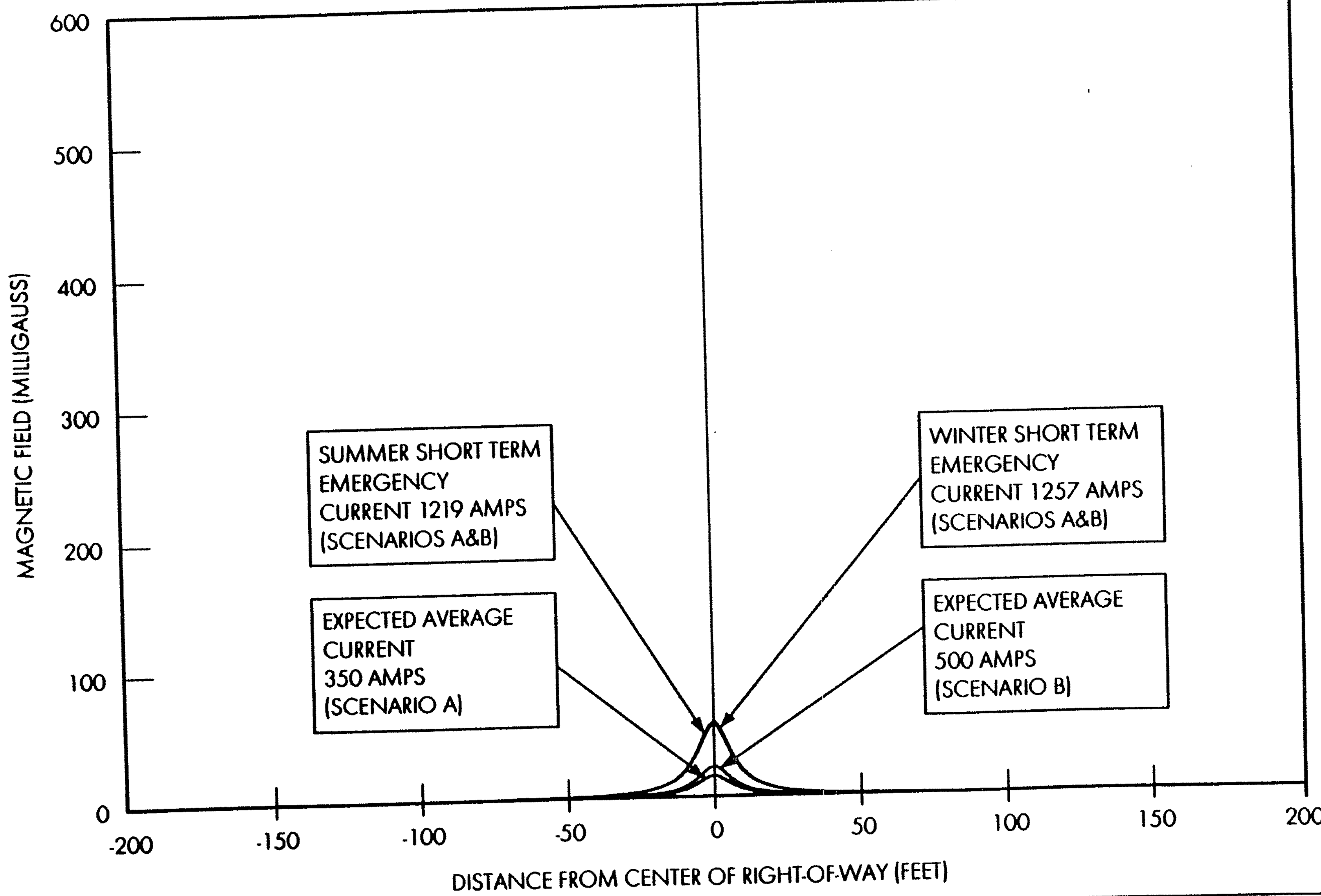
5 Miles, Scenario A - Summer loading

			FC rate		Fixed cost
Construction	26,477,000	x	0.146	=	3865642
Land	0				0
Total					3865642

PV discount	10%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	3,865,642	28,870	14,432	3,908,944	0.91	3,553,586	3,553,586
2	3,865,642	30,025	16,423	3,912,090	0.83	3,233,132	6,786,718
3	3,865,642	31,226	18,502	3,915,369	0.75	2,941,675	9,728,393
4	3,865,642	32,475	18,948	3,917,065	0.68	2,675,408	12,403,801
5	3,865,642	33,774	21,758	3,921,174	0.62	2,434,740	14,838,541
6	3,865,642	35,125	24,090	3,924,857	0.56	2,215,479	17,054,021
7	3,865,642	36,530	26,522	3,928,694	0.51	2,016,041	19,070,062
8	3,865,642	37,991	34,044	3,937,677	0.47	1,836,956	20,907,017
9	3,865,642	39,511	37,454	3,942,607	0.42	1,672,050	22,579,067
10	3,865,642	41,091	41,009	3,947,742	0.39	1,522,025	24,101,092
11	3,865,642	42,735	46,070	3,954,447	0.35	1,386,009	25,487,102
12	3,865,642	44,444	66,677	3,976,763	0.32	1,267,119	26,754,221
13	3,865,642	46,222	70,422	3,982,286	0.29	1,153,526	27,907,747
14	3,865,642	48,071	74,309	3,988,022	0.26	1,050,171	28,957,918
15	3,865,642	49,993	80,307	3,995,942	0.24	956,597	29,914,515
16	3,865,642	51,993	89,046	4,006,681	0.22	871,971	30,786,486
17	3,865,642	54,073	95,605	4,015,320	0.20	794,410	31,580,895
18	3,865,642	56,236	99,517	4,021,395	0.18	723,283	32,304,179
19	3,865,642	58,485	107,366	4,031,494	0.16	659,181	32,963,360
20	3,865,642	60,825	114,695	4,041,162	0.15	600,693	33,564,053
21	3,865,642	63,258	120,910	4,049,809	0.14	547,253	34,111,306
22	3,865,642	65,788	129,679	4,061,109	0.12	498,891	34,610,197
23	3,865,642	68,420	137,327	4,071,389	0.11	454,685	35,064,882
24	3,865,642	71,156	146,779	4,083,578	0.10	414,588	35,479,470
25	3,865,642	74,003	155,061	4,094,706	0.09	377,925	35,857,395
26	3,865,642	76,963	166,211	4,108,816	0.08	344,752	36,202,147
27	3,865,642	80,041	177,810	4,123,493	0.08	314,530	36,516,677
28	3,865,642	83,243	190,889	4,139,774	0.07	287,066	36,803,743
29	3,865,642	86,573	200,710	4,152,925	0.06	261,798	37,065,541
30	3,865,642	90,035	217,582	4,173,259	0.06	239,163	37,304,704
31	3,865,642	93,637	232,273	4,191,552	0.05	218,374	37,523,079
32	3,865,642	97,382	247,548	4,210,572	0.05	199,423	37,722,502
33	3,865,642	101,278	264,571	4,231,490	0.04	182,194	37,904,696
34	3,865,642	105,329	282,272	4,253,243	0.04	166,483	38,071,179
35	3,865,642	109,542	300,673	4,275,857	0.04	152,153	38,223,331

Life Cycle PV Cost **38,223,000**



MAGNETIC FIELD PROFILES FOR UNDERGROUND DOUBLE-CIRCUIT HIGH PRESSURE FLUID-FILLED WITH CLOSED LOOP CIRCULATION

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES

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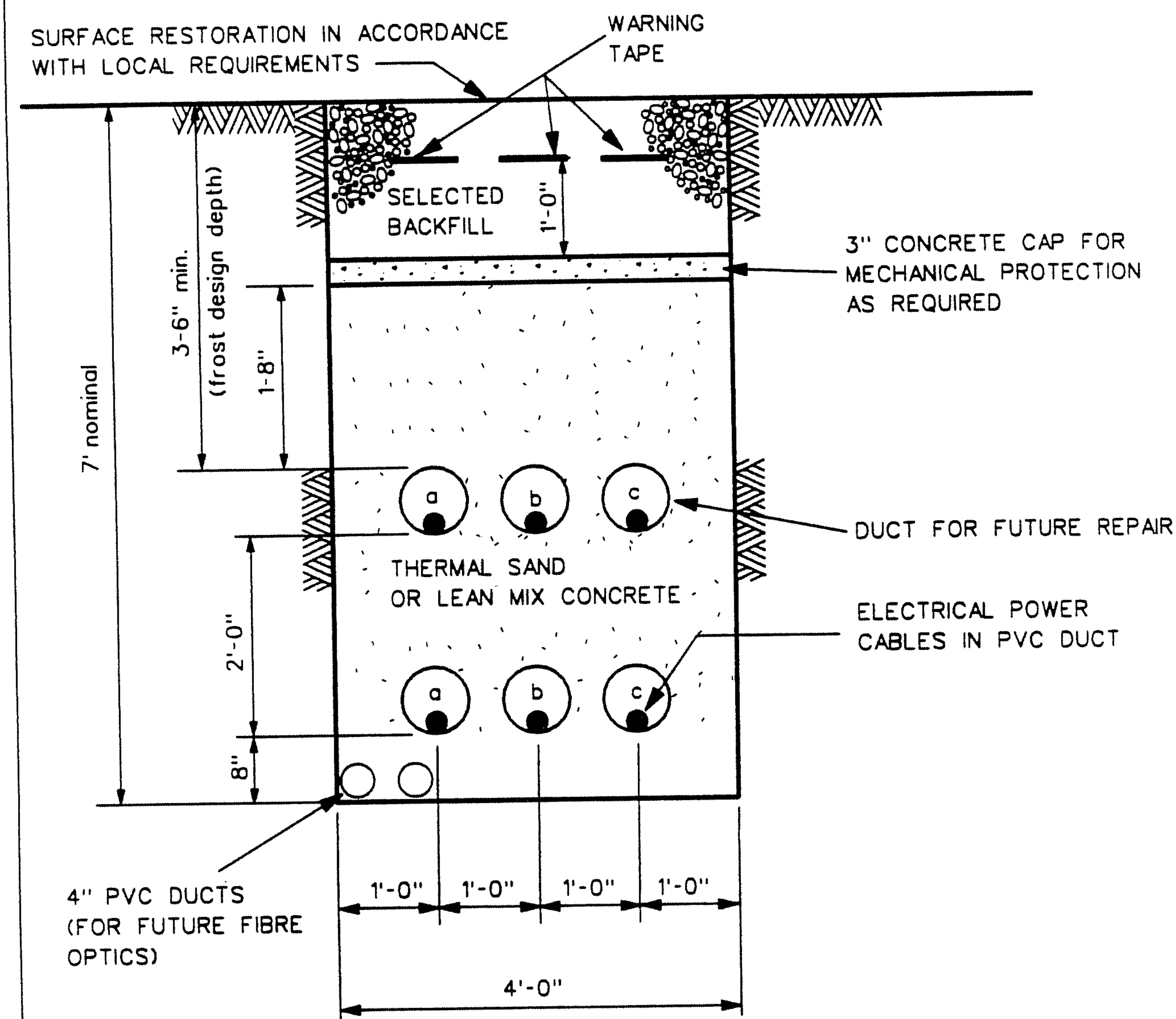


SCALE : 1" = 1.5'

PHASE DESIGNATION: a, b, c

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

UNDERGROUND DOUBLE-CIRCUIT
SELF-CONTAINED FLUID-FILLED

Construction Cost Estimates
Underground Double Circuit Self Contained Fluid Filled

Base costs

Per Mile Base

Urban roadway location	$5,327,106	(a)

Per Project Base

Terminal equipment	$559,024	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder

Rural location	($882,000)	(d)

Per Project Adder

Winter construction	$75,000	(e)

Base Case

First cost	5 miles, urban, summer work	**$27,313,000**	5*(a)+(b)+(c)
Life cycle cost		**$39,306,000**	

Notes:

1) Base case is for a double circuit installed in an urban environment, open cut trench, concrete encased, no access roads, no vegetation clearing, with allowance for after hours work.

2) Cable performance

	Scenario A		
	Normal Rating	Long term emergency	Short term emergency
Summer	1000	1250	1426
Winter	1250	1430	1470

Scenario B		
Normal Rating	Long term emergency	Short term emergency
1245	1384	1426
1297	1430	1470

3) Electrical parameters

Conductor Size	2500	kcmil
Resistance	0.0271	ohms/mile
Capacitance	1015	microfarad/mile
Charging current	25.4	A/mile

Life Cycle Cost Analysis
Underground Double Circuit Self Contained Fluid-Filled

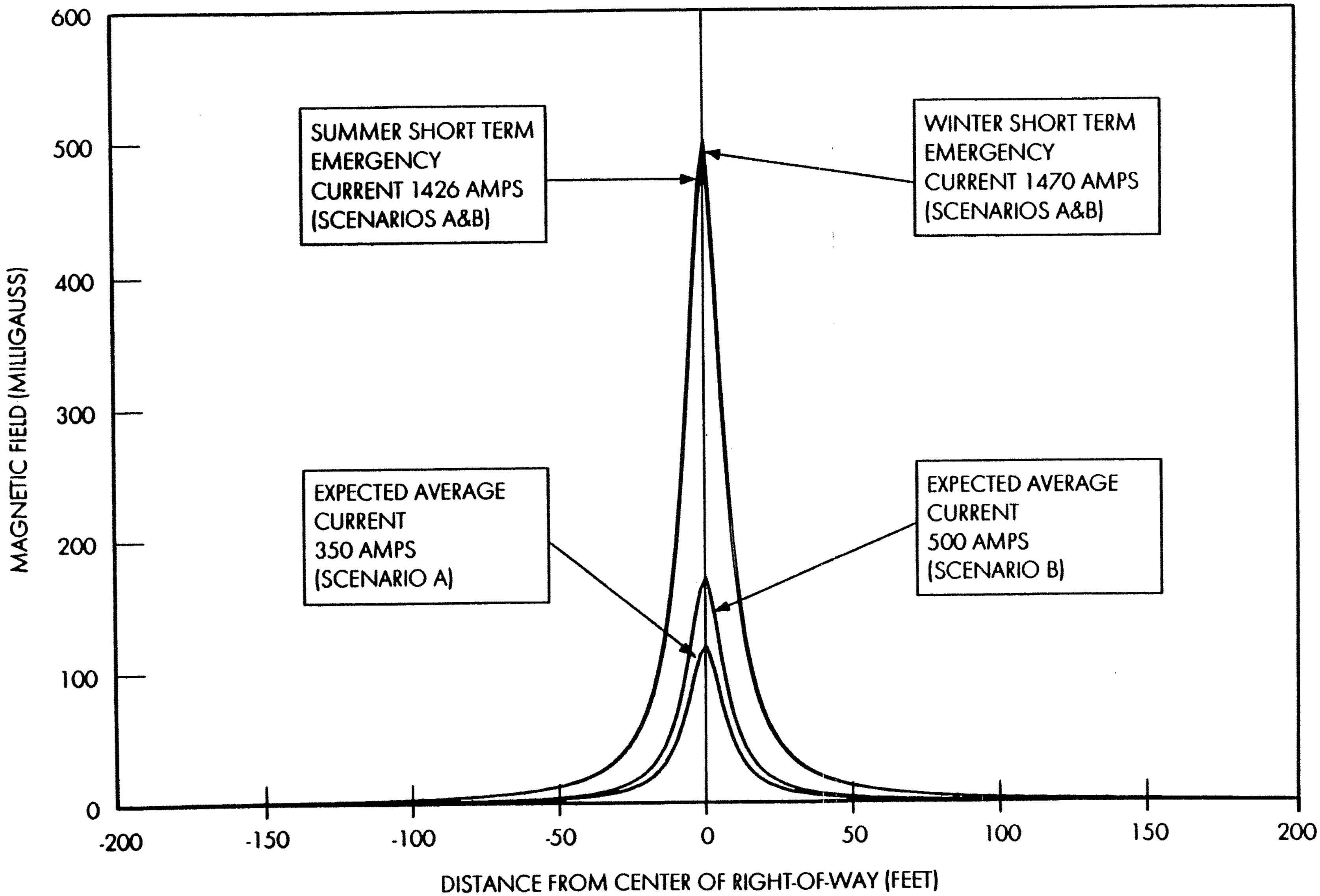
5 Miles, Scenario A - Summer loading

			FC rate		Fixed cost
Construction	27,313,000	x	0.146	=	3987698
Land	0				0
Total					3987698

PV discount	10%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	3,987,698	27,365	12,432	4,027,495	0.91	3,661,359	3,661,359
2	3,987,698	28,460	14,147	4,030,305	0.83	3,330,830	6,992,189
3	3,987,698	29,598	15,937	4,033,233	0.75	3,030,228	10,022,417
4	3,987,698	30,782	16,322	4,034,802	0.68	2,755,824	12,778,242
5	3,987,698	32,013	18,743	4,038,454	0.62	2,507,562	15,285,804
6	3,987,698	33,294	20,751	4,041,743	0.56	2,281,459	17,567,262
7	3,987,698	34,625	22,846	4,045,170	0.51	2,075,812	19,643,074
8	3,987,698	36,010	29,326	4,053,035	0.47	1,890,771	21,533,844
9	3,987,698	37,451	32,263	4,057,412	0.42	1,720,739	23,254,583
10	3,987,698	38,949	35,325	4,061,972	0.39	1,566,066	24,820,649
11	3,987,698	40,507	39,685	4,067,890	0.35	1,425,771	26,246,420
12	3,987,698	42,127	57,436	4,087,261	0.32	1,302,327	27,548,747
13	3,987,698	43,812	60,662	4,092,172	0.29	1,185,357	28,734,104
14	3,987,698	45,565	64,010	4,097,273	0.26	1,078,940	29,813,044
15	3,987,698	47,387	69,177	4,104,263	0.24	982,528	30,795,572
16	3,987,698	49,283	76,705	4,113,686	0.22	895,258	31,690,830
17	3,987,698	51,254	82,356	4,121,308	0.20	815,379	32,506,209
18	3,987,698	53,304	85,725	4,126,728	0.18	742,228	33,248,437
19	3,987,698	55,436	92,486	4,135,621	0.16	676,207	33,924,644
20	3,987,698	57,654	98,800	4,144,152	0.15	616,002	34,540,646
21	3,987,698	59,960	104,153	4,151,811	0.14	561,037	35,101,682
22	3,987,698	62,358	111,707	4,161,764	0.12	511,256	35,612,938
23	3,987,698	64,853	118,295	4,170,846	0.11	465,792	36,078,731
24	3,987,698	67,447	126,437	4,181,582	0.10	424,538	36,503,268
25	3,987,698	70,145	133,571	4,191,414	0.09	386,851	36,890,119
26	3,987,698	72,951	143,176	4,203,825	0.08	352,724	37,242,843
27	3,987,698	75,869	153,167	4,216,734	0.08	321,643	37,564,486
28	3,987,698	78,903	164,434	4,231,035	0.07	293,394	37,857,880
29	3,987,698	82,060	172,894	4,242,652	0.06	267,454	38,125,334
30	3,987,698	85,342	187,428	4,260,467	0.06	244,161	38,369,495
31	3,987,698	88,756	200,083	4,276,537	0.05	222,802	38,592,297
32	3,987,698	92,306	213,240	4,293,244	0.05	203,339	38,795,636
33	3,987,698	95,998	227,904	4,311,600	0.04	185,644	38,981,279
34	3,987,698	99,838	243,152	4,330,688	0.04	169,514	39,150,793
35	3,987,698	103,831	259,003	4,350,533	0.04	154,810	39,305,603

Life Cycle PV Cost **39,306,000**



MAGNETIC FIELD PROFILES FOR UNDERGROUND DOUBLE-CIRCUIT SELF CONTAINED FLUID-FILLED

CONNECTICUT SITING COUNCIL LIFE CYCLE COST STUDY FOR 115-KV TRANSMISSION LINES

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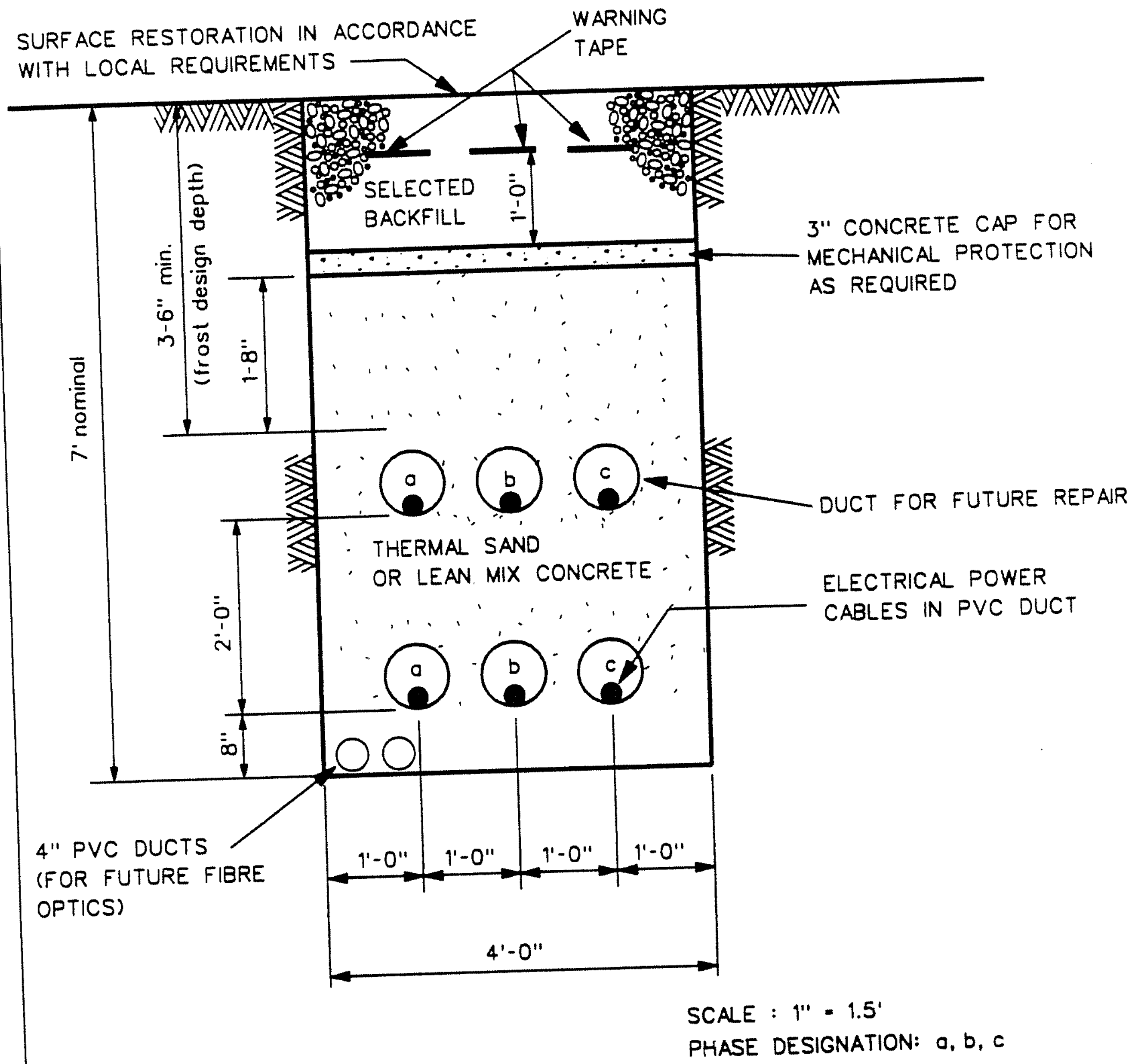


CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

UNDERGROUND DOUBLE-CIRCUIT
SOLID DIELECTRIC WITH
HORIZONTAL ARRANGEMENT

Construction Cost Estimates
Underground Double Circuit Solid Dielectric with Horizontal Arrangement

Base costs

Per Mile Base

Urban roadway location	$4,789,656	(a)

Per Project Base

Terminal equipment	$281,360	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder

Rural location	($882,000)	(d)

Per Project Adder

Winter construction	$75,000	(e)

Base Case

First cost	5 miles, urban, summer work	**$24,348,000**	5*(a)+(b)+(c)
Life cycle cost		**$35,022,000**	

Notes:

1) Base case is for a double circuit installed in an urban environment, open cut trench, concrete encased, no access roads, no vegetation clearing, with allowance for after hours work.

2) Cable performance

	Scenario A		
	Normal Rating	Long term emergency	Short term emergency
Summer	1000	1250	1500
Winter	1250	1500	1605

Scenario B		
Normal Rating	Long term emergency	Short term emergency
1250	1500	1561
1487	1567	1605

3) Electrical parameters

Conductor Size	2750	kcmil
Resistance	0.0271	ohms/mile
Capacitance	370	microfarad/mile
Charging current	9.3	A/mile

Life Cycle Cost Analysis
Underground Double Circuit Solid Dielectric with Horizontal Arrangement

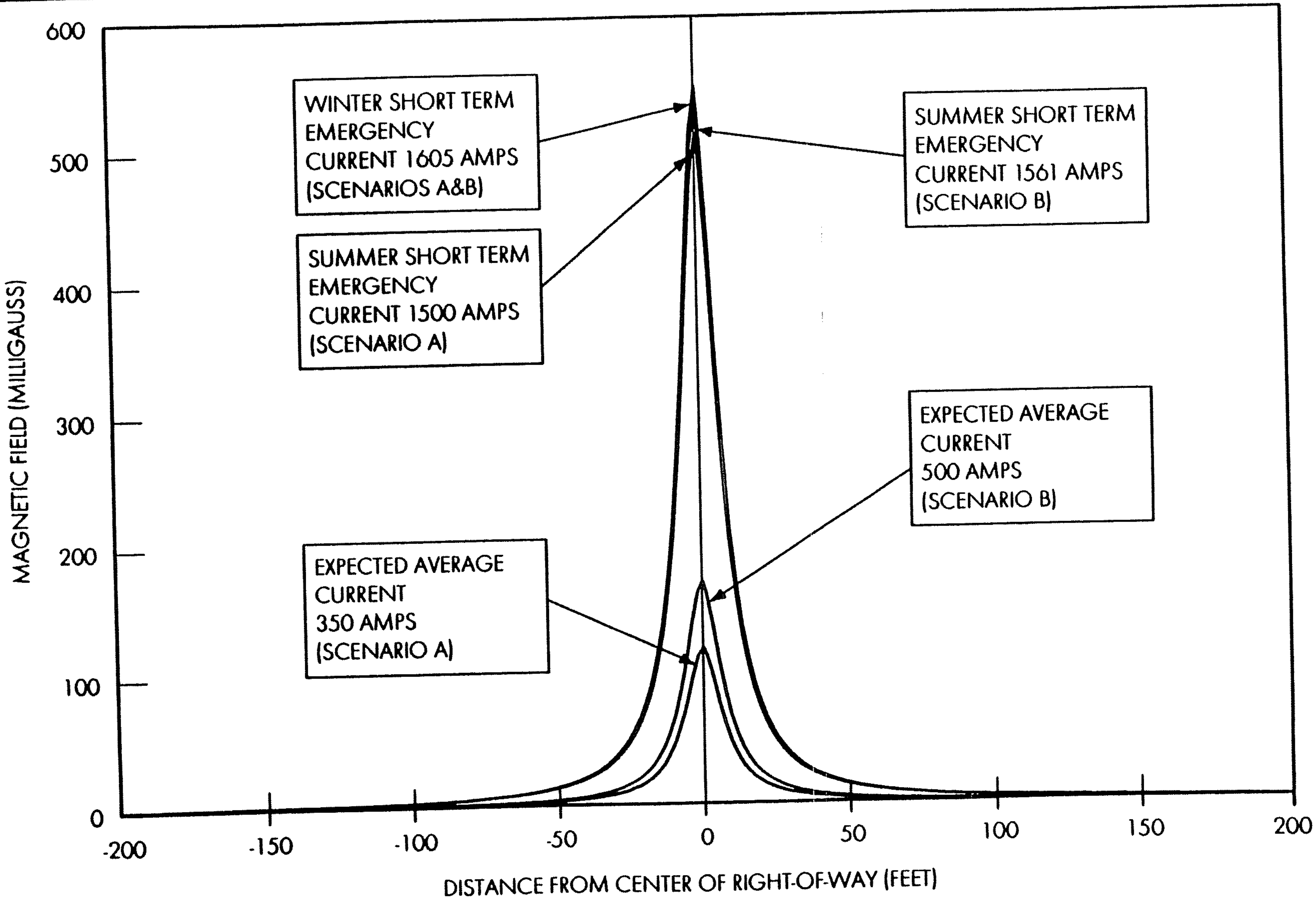
5 Miles, Scenario A - Summer loading

			FC rate		Fixed cost
Construction	24348000	x	0.146	=	3554808
Land	0				0
Total					3,554,808

PV discount	10%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	3,554,808	19,778	12,432	3,587,018	0.91	3,260,926	3,260,926
2	3,554,808	20,569	14,147	3,589,524	0.83	2,966,549	6,227,474
3	3,554,808	21,392	15,937	3,592,137	0.75	2,698,826	8,926,300
4	3,554,808	22,248	16,322	3,593,378	0.68	2,454,325	11,380,626
5	3,554,808	23,137	18,743	3,596,688	0.62	2,233,260	13,613,886
6	3,554,808	24,063	20,751	3,599,622	0.56	2,031,893	15,645,779
7	3,554,808	25,025	22,846	3,602,680	0.51	1,848,744	17,494,523
8	3,554,808	26,026	29,326	3,610,161	0.47	1,684,167	19,178,690
9	3,554,808	27,068	32,263	3,614,139	0.42	1,532,748	20,711,438
10	3,554,808	28,150	35,325	3,618,283	0.39	1,395,005	22,106,443
11	3,554,808	29,276	39,685	3,623,769	0.35	1,270,109	23,376,552
12	3,554,808	30,447	57,436	3,642,692	0.32	1,160,674	24,537,225
13	3,554,808	31,665	60,662	3,647,135	0.29	1,056,445	25,593,671
14	3,554,808	32,932	64,010	3,651,750	0.26	961,620	26,555,291
15	3,554,808	34,249	69,177	3,658,234	0.24	875,752	27,431,043
16	3,554,808	35,619	76,705	3,667,132	0.22	798,075	28,229,118
17	3,554,808	37,044	82,356	3,674,207	0.20	726,922	28,956,040
18	3,554,808	38,526	85,725	3,679,059	0.18	661,711	29,617,751
19	3,554,808	40,067	92,486	3,687,361	0.16	602,913	30,220,664
20	3,554,808	41,669	98,800	3,695,277	0.15	549,279	30,769,943
21	3,554,808	43,336	104,153	3,702,297	0.14	500,294	31,270,237
22	3,554,808	45,069	111,707	3,711,585	0.12	455,953	31,726,190
23	3,554,808	46,872	118,295	3,719,976	0.11	415,440	32,141,630
24	3,554,808	48,747	126,437	3,729,992	0.10	378,690	32,520,320
25	3,554,808	50,697	133,571	3,739,076	0.09	345,102	32,865,422
26	3,554,808	52,725	143,176	3,750,709	0.08	314,705	33,180,127
27	3,554,808	54,834	153,167	3,762,809	0.08	287,018	33,467,145
28	3,554,808	57,027	164,434	3,776,269	0.07	261,859	33,729,004
29	3,554,808	59,308	172,894	3,787,011	0.06	238,731	33,967,735
30	3,554,808	61,681	187,428	3,803,916	0.06	217,997	34,185,732
31	3,554,808	64,148	200,083	3,819,039	0.05	198,967	34,384,699
32	3,554,808	66,714	213,240	3,834,762	0.05	181,624	34,566,323
33	3,554,808	69,382	227,904	3,852,095	0.04	165,859	34,732,181
34	3,554,808	72,158	243,152	3,870,118	0.04	151,486	34,883,668
35	3,554,808	75,044	259,003	3,888,855	0.04	138,381	35,022,049

Life Cycle PV Cost **35,022,000**



MAGNETIC FIELD PROFILES FOR
UNDERGROUND DOUBLE-CIRCUIT
SOLID DIELECTRIC WITH
HORIZONTAL ARRANGEMENT

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES

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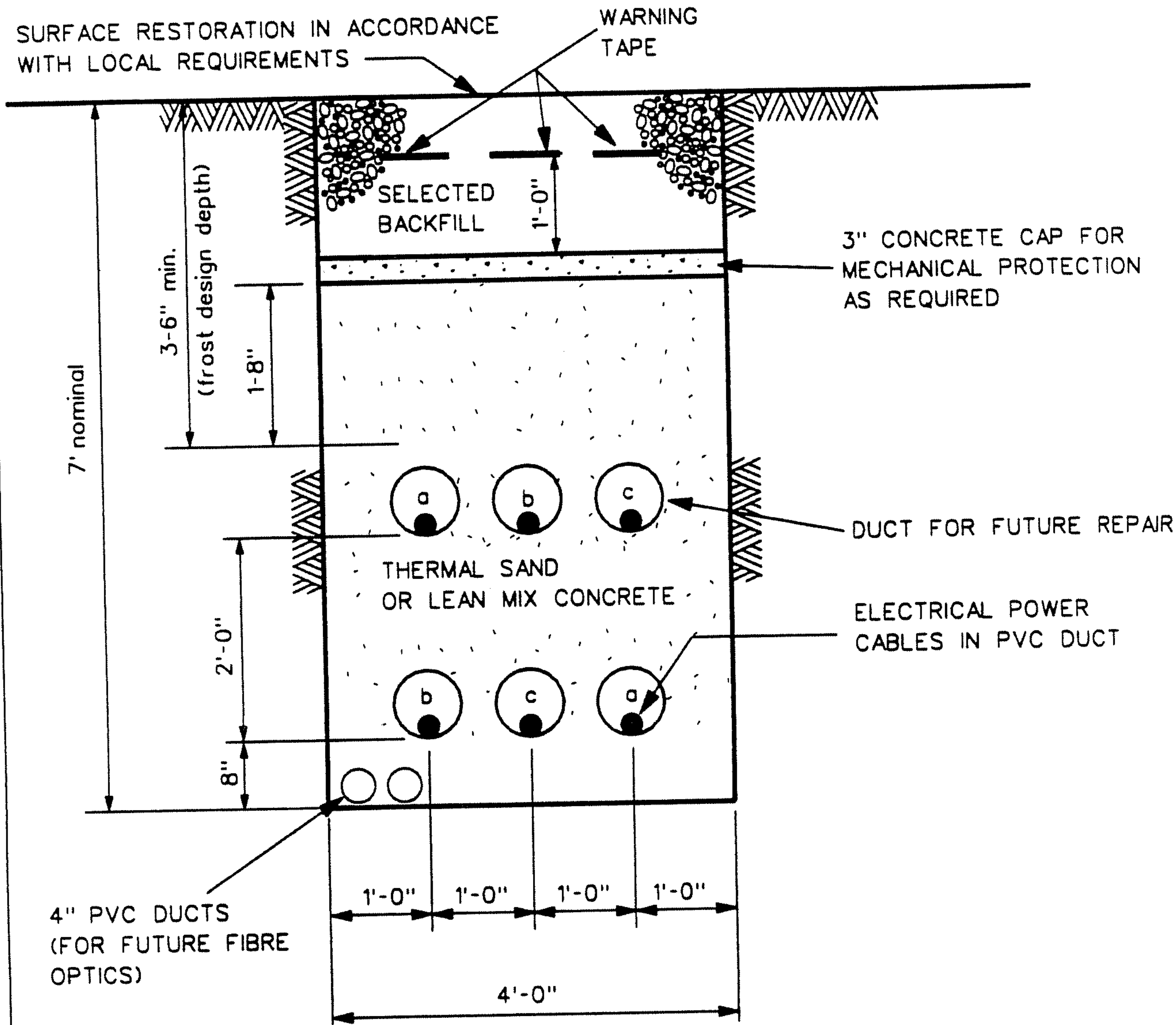


SCALE : 1" = 1.5'

PHASE DESIGNATION: a, b, c

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

UNDERGROUND DOUBLE-CIRCUIT
SOLID DIELECTRIC WITH
HORIZONTAL ARRANGEMENT
AND ALTERNATIVE PHASING

Construction Cost Estimates

Underground Double Circuit Solid Dielectric with Horizontal Arrangement and Alternative Phasing

Base costs

Per Mile Base

Urban roadway location	$4,789,656	(a)

Per Project Base

Terminal equipment	$281,360	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder

Rural location	($882,000)	(d)

Per Project Adder

Winter construction	$75,000	(e)

Base Case

First cost	5 miles, urban, summer work	**$24,348,000**	5*(a)+(b)+(c)
Life cycle cost		**$35,022,000**	

Notes:

1) Base case is for a double circuit installed in an urban environment, open cut trench, concrete encased, no access roads, no vegetation clearing, with allowance for after hours work.

2) Cable performance

	Scenario A		
	Normal Rating	Long term emergency	Short term emergency
Summer	1000	1250	1500
Winter	1250	1500	1605

Scenario B		
Normal Rating	Long term emergency	Short term emergency
1250	1500	1561
1487	1567	1605

3) Electrical parameters

Conductor Size	2750	kcmil
Resistance	0.0271	ohms/mile
Capacitance	370	microfarad/mile
Charging current	9.3	A/mile

Life Cycle Cost Analysis

Underground Double Circuit Solid Dielectric with Horizontal Arrangement and Alternative Phasing

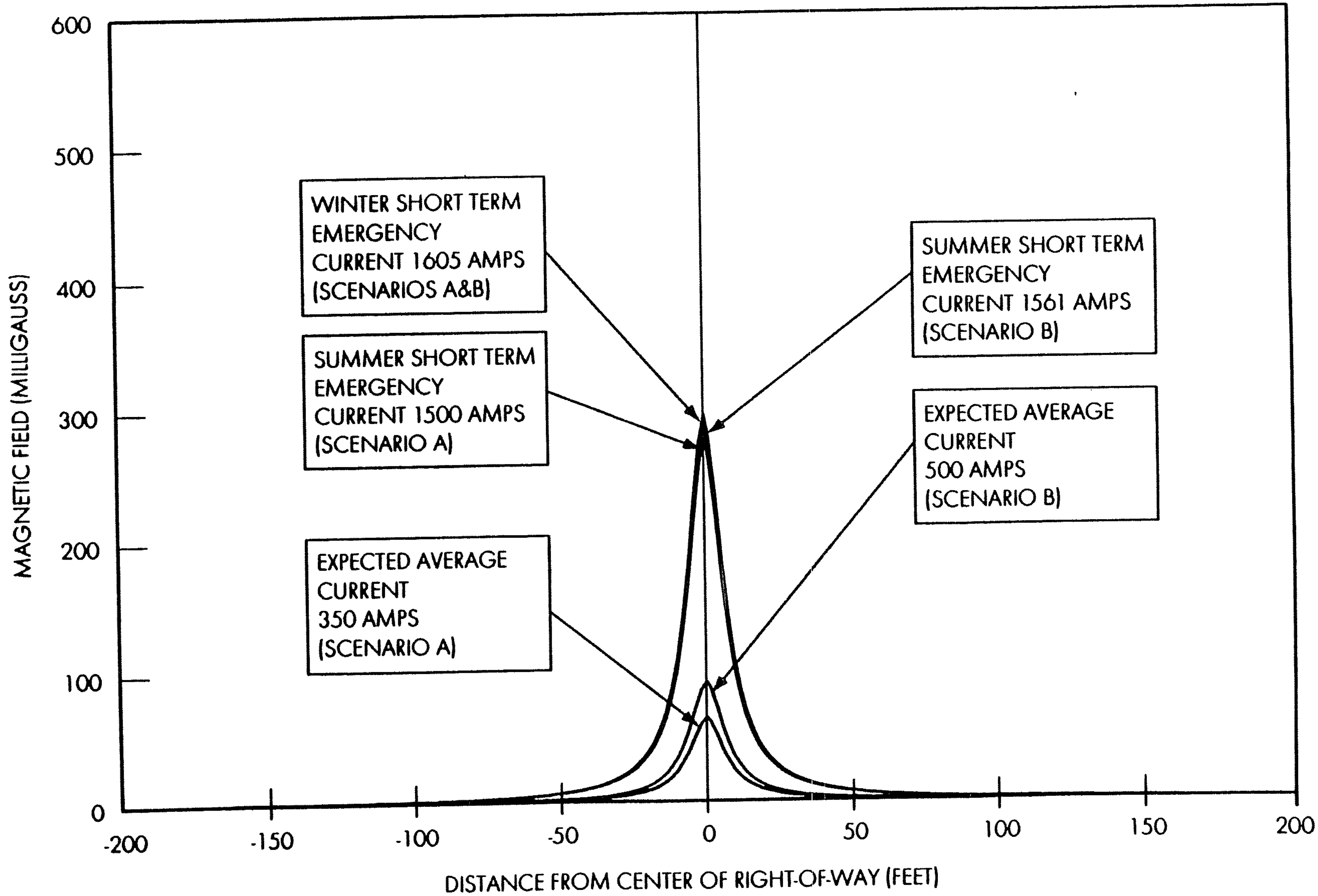
5 Miles, Scenario A - Summer loading

			FC rate		Fixed cost
Construction	24348000	x	0.146	=	3554808
Land	0				0
Total					3,554,808

PV discount	10%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	3,554,808	19,778	12,432	3,587,018	0.91	3,260,926	3,260,926
2	3,554,808	20,569	14,147	3,589,524	0.83	2,966,549	6,227,474
3	3,554,808	21,392	15,937	3,592,137	0.75	2,698,826	8,926,300
4	3,554,808	22,248	16,322	3,593,378	0.68	2,454,325	11,380,626
5	3,554,808	23,137	18,743	3,596,688	0.62	2,233,260	13,613,886
6	3,554,808	24,063	20,751	3,599,622	0.56	2,031,893	15,645,779
7	3,554,808	25,025	22,846	3,602,680	0.51	1,848,744	17,494,523
8	3,554,808	26,026	29,326	3,610,161	0.47	1,684,167	19,178,690
9	3,554,808	27,068	32,263	3,614,139	0.42	1,532,748	20,711,438
10	3,554,808	28,150	35,325	3,618,283	0.39	1,395,005	22,106,443
11	3,554,808	29,276	39,685	3,623,769	0.35	1,270,109	23,376,552
12	3,554,808	30,447	57,436	3,642,692	0.32	1,160,674	24,537,225
13	3,554,808	31,665	60,662	3,647,135	0.29	1,056,445	25,593,671
14	3,554,808	32,932	64,010	3,651,750	0.26	961,620	26,555,291
15	3,554,808	34,249	69,177	3,658,234	0.24	875,752	27,431,043
16	3,554,808	35,619	76,705	3,667,132	0.22	798,075	28,229,118
17	3,554,808	37,044	82,356	3,674,207	0.20	726,922	28,956,040
18	3,554,808	38,526	85,725	3,679,059	0.18	661,711	29,617,751
19	3,554,808	40,067	92,486	3,687,361	0.16	602,913	30,220,664
20	3,554,808	41,669	98,800	3,695,277	0.15	549,279	30,769,943
21	3,554,808	43,336	104,153	3,702,297	0.14	500,294	31,270,237
22	3,554,808	45,069	111,707	3,711,585	0.12	455,953	31,726,190
23	3,554,808	46,872	118,295	3,719,976	0.11	415,440	32,141,630
24	3,554,808	48,747	126,437	3,729,992	0.10	378,690	32,520,320
25	3,554,808	50,697	133,571	3,739,076	0.09	345,102	32,865,422
26	3,554,808	52,725	143,176	3,750,709	0.08	314,705	33,180,127
27	3,554,808	54,834	153,167	3,762,809	0.08	287,018	33,467,145
28	3,554,808	57,027	164,434	3,776,269	0.07	261,859	33,729,004
29	3,554,808	59,308	172,894	3,787,011	0.06	238,731	33,967,735
30	3,554,808	61,681	187,428	3,803,916	0.06	217,997	34,185,732
31	3,554,808	64,148	200,083	3,819,039	0.05	198,967	34,384,699
32	3,554,808	66,714	213,240	3,834,762	0.05	181,624	34,566,323
33	3,554,808	69,382	227,904	3,852,095	0.04	165,859	34,732,181
34	3,554,808	72,158	243,152	3,870,118	0.04	151,486	34,883,668
35	3,554,808	75,044	259,003	3,888,855	0.04	138,381	35,022,049

Life Cycle PV Cost **35,022,000**



MAGNETIC FIELD PROFILES FOR UNDERGROUND DOUBLE-CIRCUIT SOLID DIELECTRIC WITH HORIZONTAL ARRANGEMENT AND ALTERNATE PHASING

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-KV TRANSMISSION LINES

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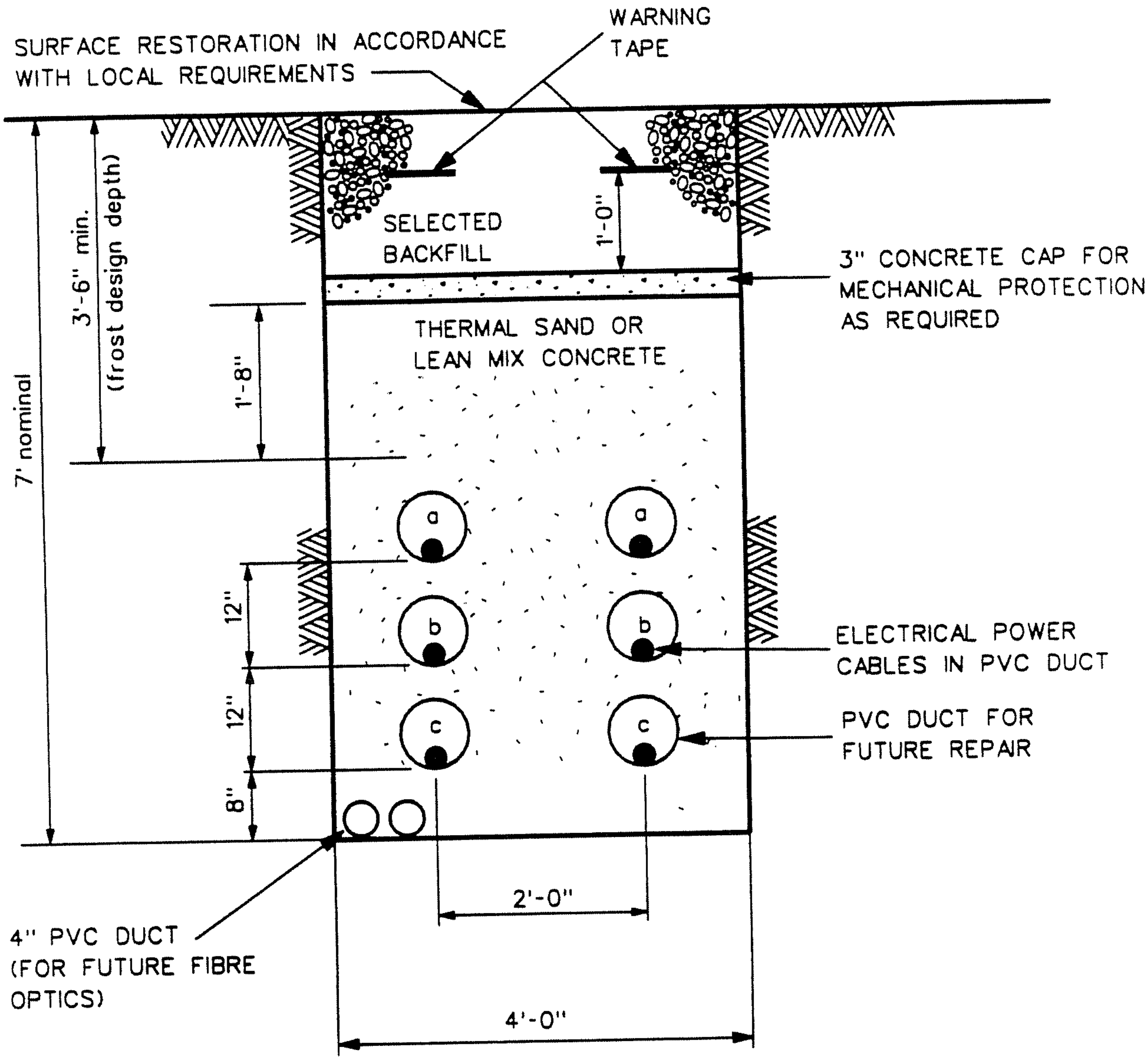


SCALE : 1" = 1.5'
PHASE DESIGNATION: a, b, c

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

UNDERGROUND DOUBLE-CIRCUIT
SOLID DIELECTRIC WITH
VERTICAL ARRANGEMENT

Construction Cost Estimates
Underground Double Circuit Solid Dielectric with Vertical Arrangement

Base costs

Per Mile Base

Urban roadway location	$4,789,656	(a)

Per Project Base

Terminal equipment	$281,360	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder

Rural location	($882,000)	(d)

Per Project Adder

Winter construction	$75,000	(e)

Base Case

First cost	5 miles, urban, summer work	**$24,348,000**	5*(a)+(b)+(c)
Life cycle cost		**$35,022,000**	

Notes:

1) Base case is for a double circuit installed in an urban environment, open cut trench, concrete encased, no access roads, no vegetation clearing, with allowance for after hours work.

2) Cable performance

	Scenario A		
	Normal Rating	Long term emergency	Short term emergency
Summer	1000	1250	1500
Winter	1250	1500	1569

Scenario B		
Normal Rating	Long term emergency	Short term emergency
1250	1487	1526
1454	1532	1569

3) Electrical parameters

Conductor Size	2750	kcmil
Resistance	0.0271	ohms/mile
Capacitance	370	microfarad/mile
Charging current	9.3	A/mile

Life Cycle Cost Analysis
Underground Double Circuit Solid Dielectric with Vertical Arrangement

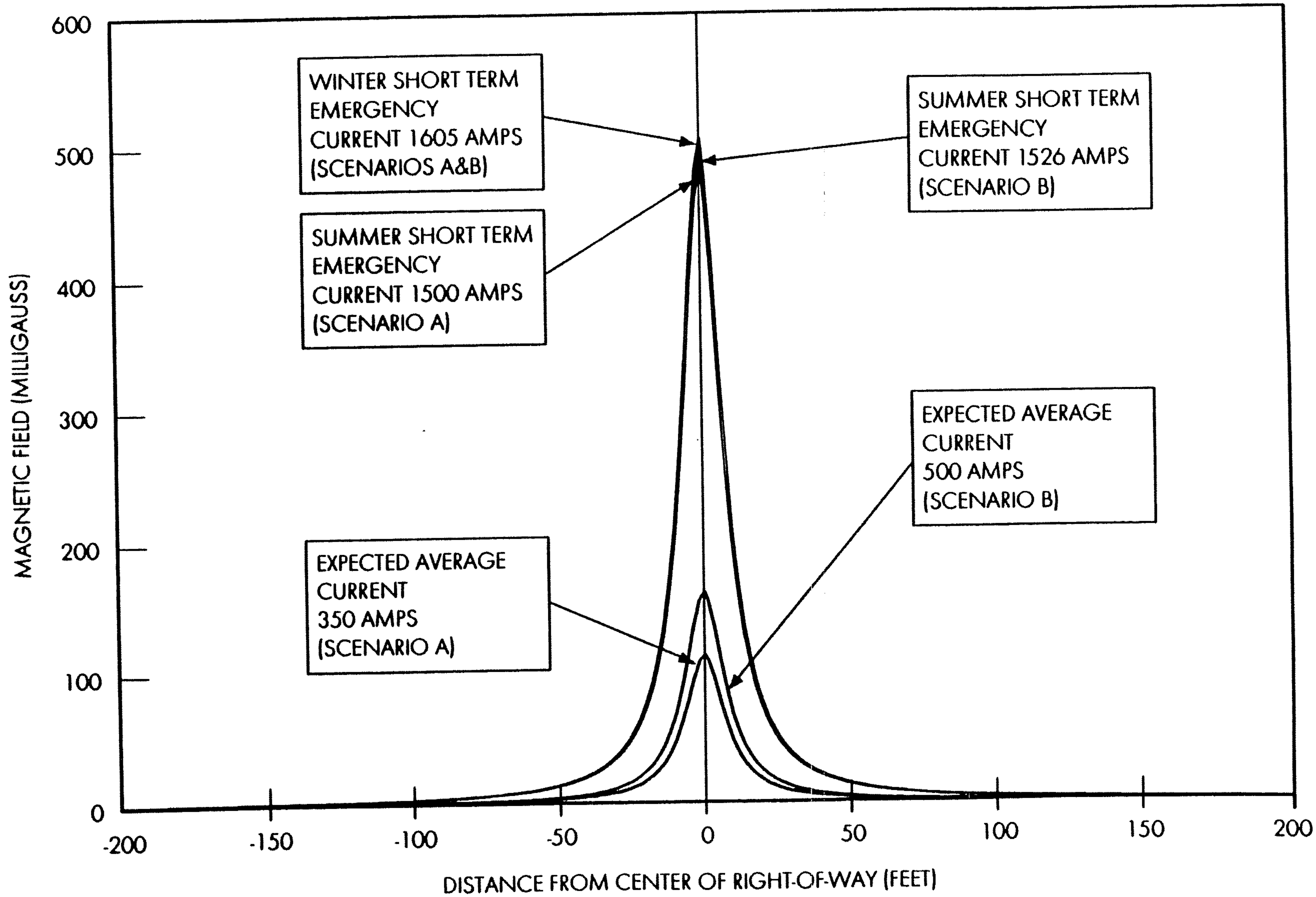
5 Miles, Scenario A - Summer loading

			FC rate		Fixed cost
Construction	24348000	x	0.146	=	3554808
Land	0				0
Total					3,554,808

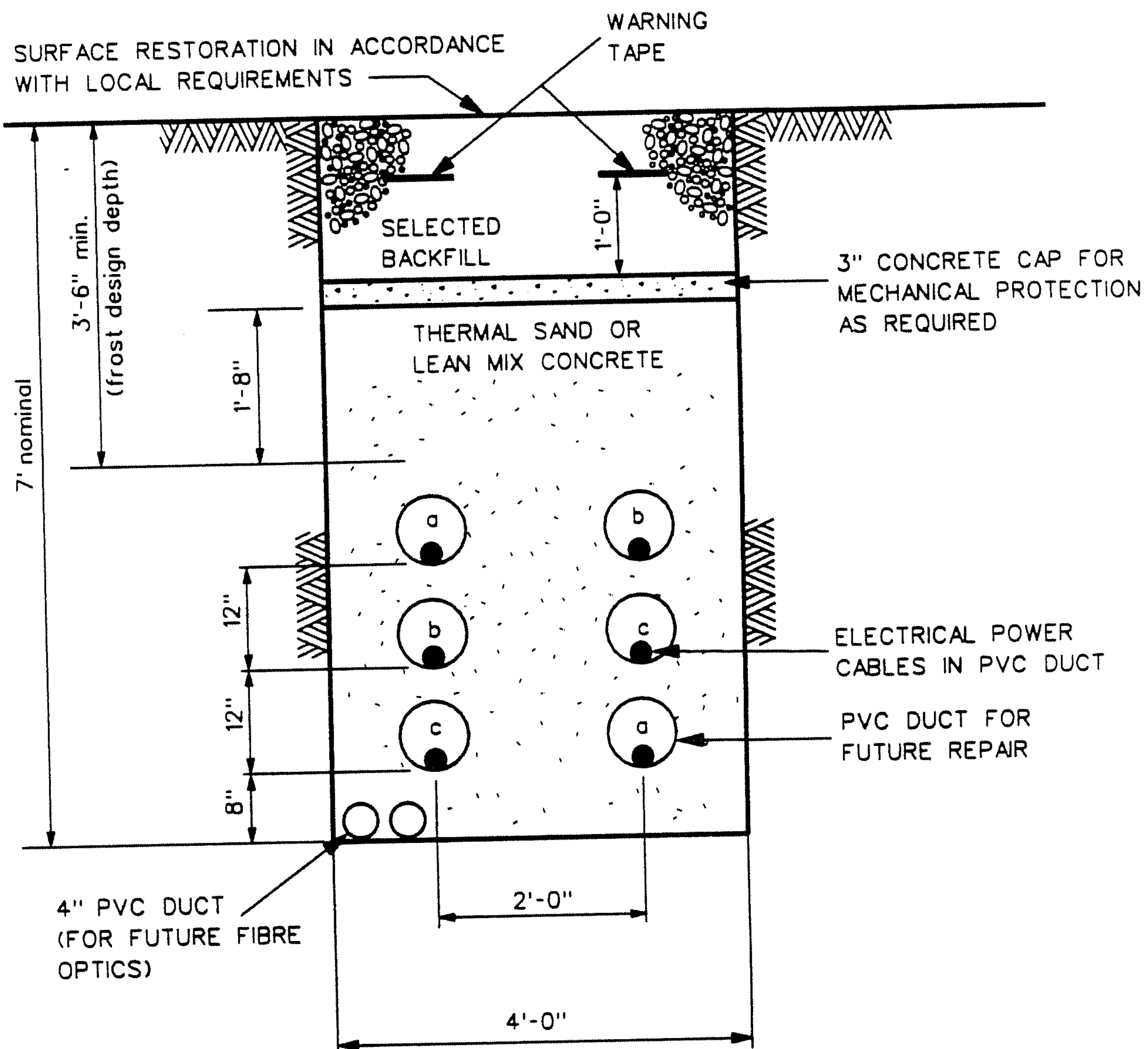
PV discount	10%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	3,554,808	19,778	12,432	3,587,018	0.91	3,260,926	3,260,926
2	3,554,808	20,569	14,147	3,589,524	0.83	2,966,549	6,227,474
3	3,554,808	21,392	15,937	3,592,137	0.75	2,698,826	8,926,300
4	3,554,808	22,248	16,322	3,593,378	0.68	2,454,325	11,380,626
5	3,554,808	23,137	18,743	3,596,688	0.62	2,233,260	13,613,886
6	3,554,808	24,063	20,751	3,599,622	0.56	2,031,893	15,645,779
7	3,554,808	25,025	22,846	3,602,680	0.51	1,848,744	17,494,523
8	3,554,808	26,026	29,326	3,610,161	0.47	1,684,167	19,178,690
9	3,554,808	27,068	32,263	3,614,139	0.42	1,532,748	20,711,438
10	3,554,808	28,150	35,325	3,618,283	0.39	1,395,005	22,106,443
11	3,554,808	29,276	39,685	3,623,769	0.35	1,270,109	23,376,552
12	3,554,808	30,447	57,436	3,642,692	0.32	1,160,674	24,537,225
13	3,554,808	31,665	60,662	3,647,135	0.29	1,056,445	25,593,671
14	3,554,808	32,932	64,010	3,651,750	0.26	961,620	26,555,291
15	3,554,808	34,249	69,177	3,658,234	0.24	875,752	27,431,043
16	3,554,808	35,619	76,705	3,667,132	0.22	798,075	28,229,118
17	3,554,808	37,044	82,356	3,674,207	0.20	726,922	28,956,040
18	3,554,808	38,526	85,725	3,679,059	0.18	661,711	29,617,751
19	3,554,808	40,067	92,486	3,687,361	0.16	602,913	30,220,664
20	3,554,808	41,669	98,800	3,695,277	0.15	549,279	30,769,943
21	3,554,808	43,336	104,153	3,702,297	0.14	500,294	31,270,237
22	3,554,808	45,069	111,707	3,711,585	0.12	455,953	31,726,190
23	3,554,808	46,872	118,295	3,719,976	0.11	415,440	32,141,630
24	3,554,808	48,747	126,437	3,729,992	0.10	378,690	32,520,320
25	3,554,808	50,697	133,571	3,739,076	0.09	345,102	32,865,422
26	3,554,808	52,725	143,176	3,750,709	0.08	314,705	33,180,127
27	3,554,808	54,834	153,167	3,762,809	0.08	287,018	33,467,145
28	3,554,808	57,027	164,434	3,776,269	0.07	261,859	33,729,004
29	3,554,808	59,308	172,894	3,787,011	0.06	238,731	33,967,735
30	3,554,808	61,681	187,428	3,803,916	0.06	217,997	34,185,732
31	3,554,808	64,148	200,083	3,819,039	0.05	198,967	34,384,699
32	3,554,808	66,714	213,240	3,834,762	0.05	181,624	34,566,323
33	3,554,808	69,382	227,904	3,852,095	0.04	165,859	34,732,181
34	3,554,808	72,158	243,152	3,870,118	0.04	151,486	34,883,668
35	3,554,808	75,044	259,003	3,888,855	0.04	138,381	35,022,049

Life Cycle PV Cost **35,022,000**



MAGNETIC FIELD PROFILES FOR UNDERGROUND DOUBLE-CIRCUIT SOLID DIELECTRIC WITH VERTICAL ARRANGEMENT	CONNECTICUT SITING COUNCIL LIFE CYCLE COST STUDY FOR 115-KV TRANSMISSION LINES



SCALE : 1" = 1.5'

PHASE DESIGNATION: a, b, c

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

UNDERGROUND DOUBLE-CIRCUIT
SOLID DIELECTRIC WITH
VERTICAL ARRANGEMENT
AND ALTERNATIVE PHASING

Construction Cost Estimates

Underground Double Circuit Solid Dielectric with Vertical Arrangement and Alternative Phasing

Base costs

Per Mile Base

Urban roadway location	$4,789,656	(a)

Per Project Base

Terminal equipment	$281,360	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder

Rural location	($882,000)	(d)

Per Project Adder

Winter construction	$75,000	(e)

Base Case

First cost	5 miles, urban, summer work	**$24,348,000**	5*(a)+(b)+(c)
Life cycle cost		**$35,022,000**	

Notes:

1) Base case is for a double circuit installed in an urban environment, open cut trench, concrete encased, no access roads, no vegetation clearing, with allowance for after hours work.

2) Cable performance

	Scenario A		
	Normal Rating	Long term emergency	Short term emergency
Summer	1000	1250	1500
Winter	1250	1500	1569

Scenario B		
Normal Rating	Long term emergency	Short term emergency
1250	1487	1526
1454	1532	1569

3) Electrical parameters

Conductor Size	2750	kcmil
Resistance	0.0271	ohms/mile
Capacitance	370	microfarad/mile
Charging current	9.3	A/mile

Life Cycle Cost Analysis

Underground Double Circuit Solid Dielectric with Vertical Arrangement and Alternative Phasing

5 Miles, Scenario A - Summer loading

			FC rate		Fixed cost
Construction	24348000	x	0.146	=	3554808
Land	0				0
Total					3,554,808

PV discount	10%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	3,554,808	19,778	12,432	3,587,018	0.91	3,260,926	3,260,926
2	3,554,808	20,569	14,147	3,589,524	0.83	2,966,549	6,227,474
3	3,554,808	21,392	15,937	3,592,137	0.75	2,698,826	8,926,300
4	3,554,808	22,248	16,322	3,593,378	0.68	2,454,325	11,380,626
5	3,554,808	23,137	18,743	3,596,688	0.62	2,233,260	13,613,886
6	3,554,808	24,063	20,751	3,599,622	0.56	2,031,893	15,645,779
7	3,554,808	25,025	22,846	3,602,680	0.51	1,848,744	17,494,523
8	3,554,808	26,026	29,326	3,610,161	0.47	1,684,167	19,178,690
9	3,554,808	27,068	32,263	3,614,139	0.42	1,532,748	20,711,438
10	3,554,808	28,150	35,325	3,618,283	0.39	1,395,005	22,106,443
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18	3,554,808	38,526	85,725	3,679,059	0.18	661,711	29,617,751
19	3,554,808	40,067	92,486	3,687,361	0.16	602,913	30,220,664
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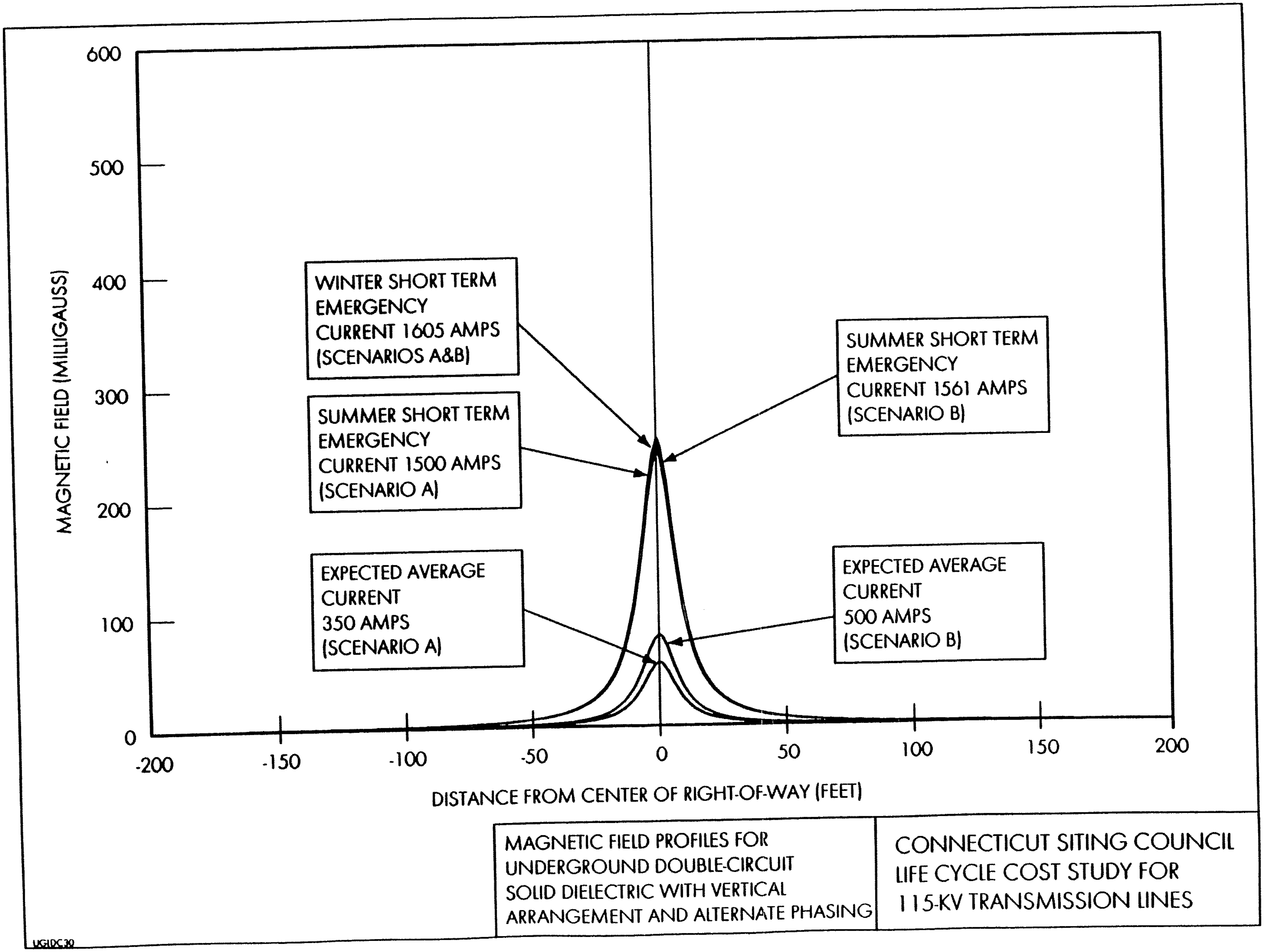
21	3,554,808	43,336	104,153	3,702,297	0.14	500,294	31,270,237
22	3,554,808	45,069	111,707	3,711,585	0.12	455,953	31,726,190
23	3,554,808	46,872	118,295	3,719,976	0.11	415,440	32,141,630
24	3,554,808	48,747	126,437	3,729,992	0.10	378,690	32,520,320
25	3,554,808	50,697	133,571	3,739,076	0.09	345,102	32,865,422
26	3,554,808	52,725	143,176	3,750,709	0.08	314,705	33,180,127
27	3,554,808	54,834	153,167	3,762,809	0.08	287,018	33,467,145
28	3,554,808	57,027	164,434	3,776,269	0.07	261,859	33,729,004
29	3,554,808	59,308	172,894	3,787,011	0.06	238,731	33,967,735
30	3,554,808	61,681	187,428	3,803,916	0.06	217,997	34,185,732
31	3,554,808	64,148	200,083	3,819,039	0.05	198,967	34,384,699
32	3,554,808	66,714	213,240	3,834,762	0.05	181,624	34,566,323
33	3,554,808	69,382	227,904	3,852,095	0.04	165,859	34,732,181
34	3,554,808	72,158	243,152	3,870,118	0.04	151,486	34,883,668
35	3,554,808	75,044	259,003	3,888,855	0.04	138,381	35,022,049

Life Cycle PV Cost **35,022,000**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600
500
400
300
200
100
0
-200
-150
-100
-50
0
50
100
150
200
DISTANCE FROM CENTER OF RIGHT-OF-WAY (FEET)
WINTER SHORT TERM EMERGENCY CURRENT 1605 AMPS (SCENARIOS A&B)
SUMMER SHORT TERM EMERGENCY CURRENT 1500 AMPS (SCENARIO A)
EXPECTED AVERAGE CURRENT 350 AMPS (SCENARIO A)
SUMMER SHORT TERM EMERGENCY CURRENT 1561 AMPS (SCENARIO B)
EXPECTED AVERAGE CURRENT 500 AMPS (SCENARIO B)
MAGNETIC FIELD PROFILES FOR UNDERGROUND DOUBLE-CIRCUIT SOLID DIELECTRIC WITH VERTICAL ARRANGEMENT AND ALTERNATE PHASING
CONNECTICUT SITING COUNCIL LIFE CYCLE COST STUDY FOR 115-KV TRANSMISSION LINES
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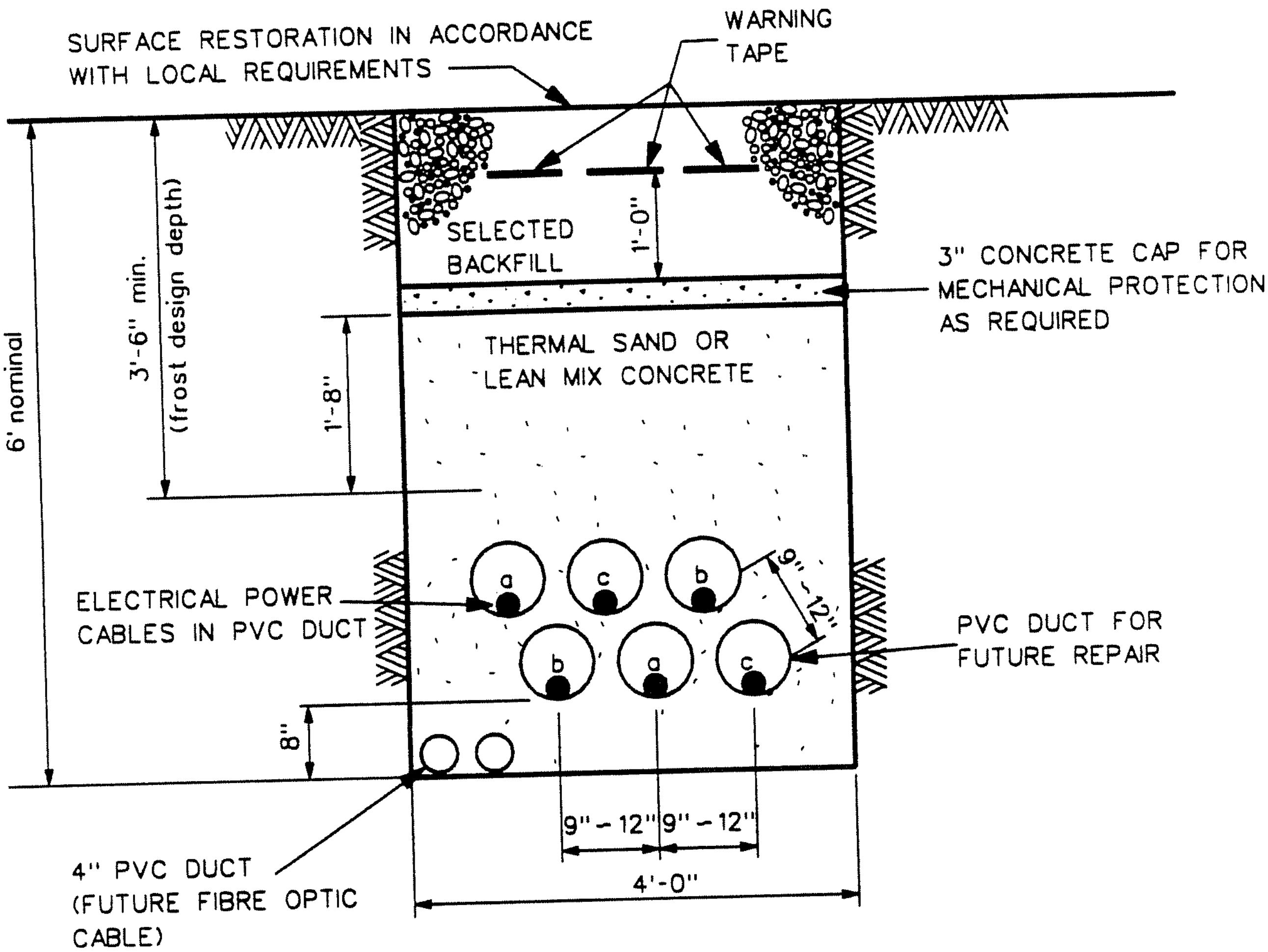


SCALE : 1" = 1.5'
PHASE DESIGNATION: a, b, c

CONNECTICUT SITING COUNCIL
LIFE CYCLE COST STUDY FOR
115-kV TRANSMISSION LINES

UNDERGROUND DOUBLE-CIRCUIT
SOLID DIELECTRIC WITH
DELTA ARRANGEMENT

Construction Cost Estimate
Underground Double Circuit Solid Dielectric with Delta Arrangement

Base costs

Per Mile Base

Urban roadway location	$4,663,487	(a)

Per Project Base

Terminal equipment	$281,360	(b)
Regulatory Cost & Permit Fees	$118,000	(c)

Adders

Per Mile Adder

Rural location	($782,000)	(d)

Per Project Adder

Winter construction	$75,000	(e)

Base Case

First cost	5 miles, urban, summer work	**$23,717,000**	5*(a)+(b)+(c)
Life cycle cost		**$34,134,000**	

Notes:

1) Base case is for a double circuit installed in an urban environment, open cut trench, concrete encased, no access roads, no vegetation clearing, with allowance for after hours work.

2) Cable performance

	Scenario A		
	Normal Rating	Long term emergency	Short term emergency
Summer	1000	1250	1500
Winter	1250	1500	1585

Scenario B		
Normal Rating	Long term emergency	Short term emergency
1250	1500	1541
1468	1548	1585

3) Electrical parameters

Conductor Size	2750	kcmil
Resistance	0.0271	ohms/mile
Capacitance	402	microfarad/mile
Charging current	10.1	A/mile

Life Cycle Cost Analysis
Underground Double Circuit Solid Dielectric with Delta Arrangement

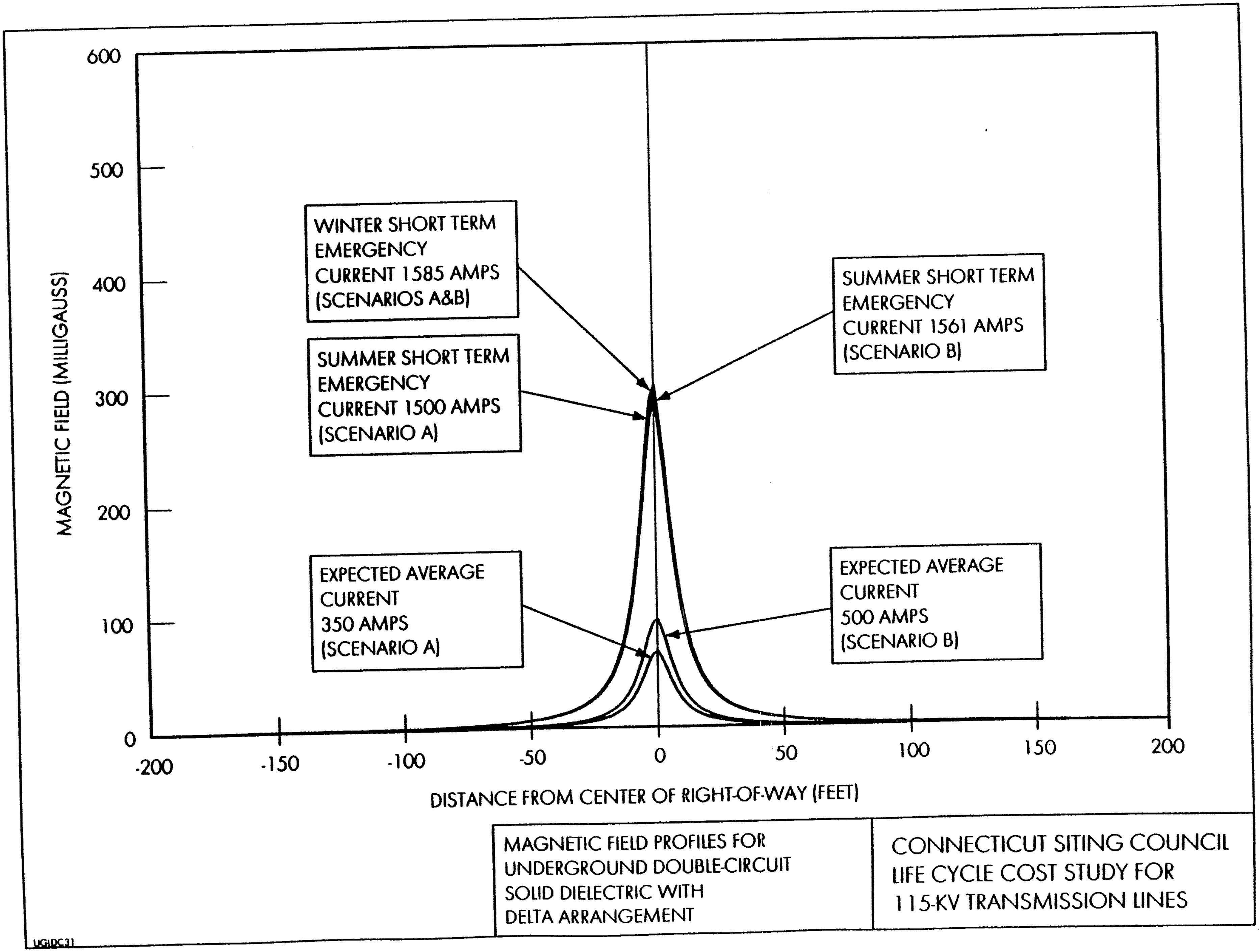
5 Miles, Scenario A - Summer loading

			FC rate		Fixed cost
Construction	23717000	x	0.146	=	3462682
Land	0				0
Total					3,462,682

PV discount	10%
O&M escalation	4%
Load growth (annual)	1.2%

Year	Fixed Costs	O&M Costs	Loss Costs	Total Costs	PV Factor	PV Cost	Cum. PV
1	3,462,682	19,778	12,432	3,494,892	0.91	3,177,175	3,177,175
2	3,462,682	20,569	14,147	3,497,398	0.83	2,890,412	6,067,586
3	3,462,682	21,392	15,937	3,500,011	0.75	2,629,610	8,697,197
4	3,462,682	22,248	16,322	3,501,252	0.68	2,391,402	11,088,599
5	3,462,682	23,137	18,743	3,504,562	0.62	2,176,057	13,264,656
6	3,462,682	24,063	20,751	3,507,496	0.56	1,979,890	15,244,546
7	3,462,682	25,025	22,846	3,510,554	0.51	1,801,469	17,046,015
8	3,462,682	26,026	29,326	3,518,035	0.47	1,641,189	18,687,205
9	3,462,682	27,068	32,263	3,522,013	0.42	1,493,677	20,180,882
10	3,462,682	28,150	35,325	3,526,157	0.39	1,359,486	21,540,368
11	3,462,682	29,276	39,685	3,531,643	0.35	1,237,819	22,778,188
12	3,462,682	30,447	57,436	3,550,566	0.32	1,131,320	23,909,507
13	3,462,682	31,665	60,662	3,555,009	0.29	1,029,760	24,939,267
14	3,462,682	32,932	64,010	3,559,624	0.26	937,360	25,876,627
15	3,462,682	34,249	69,177	3,566,108	0.24	853,698	26,730,325
16	3,462,682	35,619	76,705	3,575,006	0.22	778,026	27,508,351
17	3,462,682	37,044	82,356	3,582,081	0.20	708,696	28,217,046
18	3,462,682	38,526	85,725	3,586,933	0.18	645,141	28,862,188
19	3,462,682	40,067	92,486	3,595,235	0.16	587,850	29,450,037
20	3,462,682	41,669	98,800	3,603,151	0.15	535,585	29,985,623
21	3,462,682	43,336	104,153	3,610,171	0.14	487,844	30,473,467
22	3,462,682	45,069	111,707	3,619,459	0.12	444,636	30,918,103
23	3,462,682	46,872	118,295	3,627,850	0.11	405,152	31,323,255
24	3,462,682	48,747	126,437	3,637,866	0.10	369,337	31,692,591
25	3,462,682	50,697	133,571	3,646,950	0.09	336,599	32,029,190
26	3,462,682	52,725	143,176	3,658,583	0.08	306,975	32,336,165
27	3,462,682	54,834	153,167	3,670,683	0.08	279,991	32,616,157
28	3,462,682	57,027	164,434	3,684,143	0.07	255,471	32,871,627
29	3,462,682	59,308	172,894	3,694,885	0.06	232,923	33,104,551
30	3,462,682	61,681	187,428	3,711,790	0.06	212,717	33,317,268
31	3,462,682	64,148	200,083	3,726,913	0.05	194,167	33,511,435
32	3,462,682	66,714	213,240	3,742,636	0.05	177,260	33,688,696
33	3,462,682	69,382	227,904	3,759,969	0.04	161,892	33,850,588
34	3,462,682	72,158	243,152	3,777,992	0.04	147,880	33,998,468
35	3,462,682	75,044	259,003	3,796,729	0.04	135,103	34,133,571

Life Cycle PV Cost **34,134,000**


600
500
400
300
200
100
0
MAGNETIC FIELD (MILLIGAUSS)
-200
-150
-100
-50
0
50
100
150
200
DISTANCE FROM CENTER OF RIGHT-OF-WAY (FEET)
WINTER SHORT TERM EMERGENCY CURRENT 1585 AMPS (SCENARIOS A&B)
SUMMER SHORT TERM EMERGENCY CURRENT 1500 AMPS (SCENARIO A)
EXPECTED AVERAGE CURRENT 350 AMPS (SCENARIO A)
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EXPECTED AVERAGE CURRENT 500 AMPS (SCENARIO B)
MAGNETIC FIELD PROFILES FOR UNDERGROUND DOUBLE-CIRCUIT SOLID DIELECTRIC WITH DELTA ARRANGEMENT
CONNECTICUT SITING COUNCIL LIFE CYCLE COST STUDY FOR 115-KV TRANSMISSION LINES
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Part C

Factors in Selecting a Transmission Line Design

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List of Tables - Part C

1 Overhead Transmission Line Technology

1.1 General Description

Most transmission lines are constructed overhead.

High voltage overhead transmission use conductors to carry electricity. Conductors are made of aluminum strands or a mixture of aluminum and steel strands and are isolated electrically by the surrounding air. Conductors are held in place by insulators and supported by structures.

This study considered only the use of wood pole or steel pole structures. Structures are erected along the right-of-way at chosen locations prior to stringing of the conductor. On most lines, the majority of structures are "tangent" structures that carry the conductor on either a straight line or a very shallow angle (5° - 10°). Sharper bends require "angle" structures which are typically more costly. At each end of a line and periodically along its length "dead-end" structures are used. Unlike tangent and most angle structures, dead-end structures are designed to withstand the unbalanced load carried in the event that all the conductors on one side go slack. Dead-end structures are more expensive than tangent and most angle structures. Special structures are often required for river crossings and other major crossings.

Conductor is made in dedicated facilities and brought to site on large reels. Conductor is strung from structure to structure. At the end of each length of conductor a splice is made, joining the two sections together. At the ends of the transmission lines, the conductors are terminated at terminal structures.

1.2 Physical Design Factors

All electric supply lines are designed in accordance with the National Electrical Safety Code (NESC). The NESC defines the requirements for clearances, grounding, grades of construction, mechanical loading, overload capacity factors and insulation for transmission lines.

Physical design factors taken into account:

Loading

The NESC defines Connecticut as a "heavy loading" district, requiring lines be designed to withstand ½" of ice radially coated on the conductors, combined with a wind speed of 40 mph at a temperature of 0°F. Using overload capacity factors, overhead lines and foundations are designed to withstand the loads. These heavy loading conditions impose design constraints on Connecticut utitlities which can be different than other parts of the United States, and this may affect costs.

For this study, all direct buried poles are considered as buried to a depth of 10 % of the length of the pole plus 2 ft.

Conductor Selection

Conductor is selected based on a number of different factors, including:

- purchase price
- losses - to minimize cost of electrical losses
- strength - must be strong enough to withstand the heavy loading
- standardization - storing many different sizes and types along with the associated range of fastening hardware and tooling is expensive
- environment - ability to withstand corrosive atmospheres like salt spray
- span lengths - long spans may need higher strength conductors.

For the purposes of this study conductor has been selected as 795 kcmil Aluminum Conductor with a Steel Reinforced core (ACSR) and 1,272 kcmil ACSR.

Span Length

Span length is the distance from structure to structure. A significant part of any overhead transmission line cost is the number of structures required. The more structures, the higher the cost. It is preferable to have spans as long as possible to reduce costs, but there are limits to the maximum length of span.

Span lengths are limited by the strength of the conductor, the strength of the structures, the swing of the conductors, the profile of the terrain, the sag of the conductor under load and the available width of right-of-way.

Clearances

Overhead transmission lines have to be designed to have sufficient electrical clearances between conductors and between the lowest conductor and the ground.

The NESC defines clearances for various circumstances, including vertical clearances to open ground, roads, railways and water surfaces. Vertical clearances are specified under the largest final sag of the conductor. Specified clearances also include distances to other conductors, communication wires, equipment mounted on supporting structures, swimming pools, buildings and various other installations.

Conductor Spacing

Another physical design factor that has an impact on the line configuration is the conductor spacing. The NESC defines clearances for conductors carried on the same supporting structure. Wind causes conductors and suspension-type insulators to swing. Clearances have to be maintained however, and the structures have to be designed for maximum swing. Simply put, for longer spans, conductors have to be moved farther apart possibly requiring a wider right of way. Longer davits or cross-arms can be used, but these increase the strength requirements and hence the cost of the structures.

Grounding

The NESC provides methods of electrical grounding to safeguard employees and the public from the hazard of electric potential. Grounding consists of connecting metallic parts, shield wires, and surge arresters to a grounding electrode. Grounding electrodes are typically eight foot steel rods driven into the ground at the base of structures, penetrating below the frost line.

Shield Wires

Shield wires are located at the top of the transmission line and consist of one or two additional wires. Shield wires shield the transmission line conductors from lightning strikes and consequent damage to equipment. Shield wires are connected to the ground rods allowing surges from lightning strikes to be conducted to the ground.

Shield wires are smaller than phase conductors. For this study Alumoweld shield wires have been chosen in accordance with the practice of Connecticut utilities. Alumoweld is a stranded wire with each strand consisting of a steel core over which an aluminum covering has been extruded.

Insulators

Insulators are a critical component of any overhead line since they support a conductor physically and electrically, separate it from other conductors and from "ground". Selected insulators must have the appropriate mechanical strength and electrical characteristics, including:

(a) mechanical strength. Insulators have to support the weight of conductors plus ice and wind forces, including the effect of any difference in pole elevation; and

(b) electrical. Insulators are designed to withstand overvoltages even under conditions of contamination. Factors such as dry arcing distance, leakage distance, and impulse flashover voltages are taken into account.

The study assumed the use of polymer (silicone coated) insulators.

Hilly Terrain

Overhead transmission lines must be specifically designed for hilly terrain, because hilly terrain causes a number of basics to change.

- ***Weight of Span*** An overhead span crossing a wide valley would put more weight on the supporting structures. Special structures may have to be designed to support the weight under all conditions. Wider structures may also be required, to move the phases farther apart from each other.

- ***Angle Structures*** Lines in hilly terrain may require more angle structures as the line is routed around obstacles.

- ***Uplift*** Structures may experience uplift due to the tension in the conductors causing the structure to be under an uplifting force. An example would be a structure in a valley with the natural catenary of the conductor above the structure.

- ***Construction Access*** Hilly terrain may make clearing, construction and transporation of crews and equipment much more difficult.

Hilly terrain may not require any more structures than flat terrain in total numbers. However, it will likely require more special structures such as dead ends, long span tangents and more angle structures than a comparable line on flat terrain. The costs of construction will also rise due to difficult access for crews and materials. Hilly terrain is more expensive, depending on the specific terrain.

2 Underground Line Technology

2.1 General Description

High voltage underground transmission makes use of underground cables to carry the electricity. Cables consist of a central core (called a conductor) of copper wires surrounded by electrical insulation.

Cable companies manufacture the cable in dedicated facilities and transport it to site on large cable reels. The cable is ready for installation directly from the reel and either goes straight into a pre-dug trench or is pulled into a steel pipe or plastic duct already in the trench.

There is a limit to the amount of cable that can be placed on a reel however. Cables have to be joined with splices. Splices, made in manholes, are expensive and time consuming.

At the end of the cable is a termination. Cable terminations are made in "potheads" and have surge protectors to protect the cable from voltage surges.

2.2 Physical Design Factors

Placing transmission lines underground is technically feasible at 115 kV. Underground transmission lines can be very reliable with proper selection of the specific technology, use of proper construction methods and attention to necessary operation and maintenance procedures.

Insulation

The significant difference between various types of cables is the insulation. In this study the alternatives considered are:

(1) Fluid-filled systems (high pressure pipe type, and low-pressure self-contained cable)

(2) Compressed gas insulated cable

(3) Solid dielectric insulated cable

(1) Fluid-Filled Cable Systems

(a) High-pressure fluid filled pipe-type cable system (HPFF)

In this system a coated steel pipe containing three paper-insulated cables is installed within a sand bed at the bottom of a trench. Coated pipes in nominal 40-foot lengths are welded together to make a continuous pipe. Joints are then X-rayed to verify the integrity of the weldment, and the welded area is then encased in a coating material. The trench is backfilled, usually with a graded sand selected for its good thermal conductivity or with lean mix (low strength) concrete, over which is placed selected backfill. A limiting factor in designing underground systems is heat dissipation. Heat conductivity close to the cable is a critical factor requiring the use of special backfill. Finally, the street or ground surface is appropriately restored.

Manholes, within which splices are made between cable lengths, are located to accommodate the limitations of cable shipping lengths and to limit the tensile forces imposed on the cable during installation by pulling friction, particularly around pipe bends. Generally, manholes are spaced 1/4 mile to 1/2 mile apart.

Three paper-insulated cables are pulled together into each pipe. These cables are spliced within the manholes, and pipe sleeves are installed over the splices.

Before a completed pipe-cable installation can operate, a vacuum is pulled on the sealed system to evacuate moist air, and an insulating synthetic fluid (non-toxic) resembling mineral oil in consistency is installed and pressurized to about 200 lbs. per square inch (psi). Pumping plants and reservoirs at one or more transition terminals maintain pressure on the system within acceptable limits.

The reliability of HPFF cable systems has been excellent, and fluid leaks have been rare. HPFF is a popular choice among U.S. utilities.

(b) Self-contained Fluid-filled Cable Systems (SCFF)

In the low pressure fluid-filled (LPFF) system, the paper-insulated single-phase cables have a hollow core into which fluid is placed and maintained under pressure. The LPFF system maintains this pressure at about 25 psi by simple tanks which are partially filled with fluid and charged with dry nitrogen to compensate for changes in fluid volume caused by changes in cable temperature.

Self-contained fluid-filled cable systems may be direct buried in a thermal sand backfill with a concrete protective cap in off-road areas or pulled into a concrete-encased duct system in established roadways. Splices in urban areas are usually made in manholes similar to those for HPFF. In rural areas splices could be either direct buried or enclosed in manholes.

LPFF cable systems are typically used for short runs, up to several thousand feet.

(2) High Pressure Gas-Filled Cables (HPGF)

High Pressure gas-filled systems are similar to HPFF systems except that dry nitrogen gas is used instead of an insulating fluid. Only a few gas-insulated cable systems have been installed in the U.S. and some have since been converted to fluid systems to increase their electrical capacity.

(3) Solid Dielectric Insulated Cable Systems

Solid dielectric cables use an extruded dielectric material typically cross linked polyethylene (XLPE) for insulation. Individual cables may be direct buried in a thermal sand backfill with a concrete protective cap or pulled into a concrete encased duct system.

U.S. experience with early versions of XLPE was relatively poor. While easy to work with and easy to splice, the cable was relatively unreliable due to premature failure of the insulation. Early XPLE suffered from a phenomenon known as "treeing" of the insulation. XLPE compounds now use a "tree-retardant" and are referred to as TRXLPE. Coupled with improvements in cleanliness, water blocking compounds and super-clean cable shields, TRXLPE has resulted in a vastly superior product in comparison to the early XLPE. Solid dielectric cables can also be made of ethylene propylene rubber (EPR). EPR has a lower share of the market in comparison to TRXLPE, as it has a significantly higher cost. The advantage of EPR is it's resistance to treeing. Manufacturers of TRXLPE and EPR offer extended life warranties.

XLPE at 115 kV is becoming more popular with U.S. utilities.

Choosing between the different cable types depends on a number of factors, including:

- ***Purchase Price*** XLPE is less expensive than paper type fluid- and gas-filled
- ***Maintenance Costs*** XLPE requires no maintenance costs, whereas pumping stations and reservoirs require some maintenance
- ***Reliability*** paper type fluid and gas-filled cables have been proven over the years and are considered reliable, whereas early XLPE had reliability problems. XLPE manufacturers now claim to have overcome these concerns.
- ***Standardization*** if a utility has standardized on the use of fluid-filled cable systems, there is a significant incentive to stay with fluid-filled due to cost savings in staff training, equipment, trouble shooting and parts
- ***Skilled Trades*** terminating and splicing procedures are critical to reliability. These skills develop with experience. XLPE is considered the easiest to splice and terminate, although work must be of a high standard to reduce the risk of premature failure.

All three of these cable systems require transition facilities to connect underground cables to an overhead transmission line or a substation bus. Such transitions include cable potheads (porcelain bushings which house the insulation transition from the cable system to open air), lightning arresters, usually a circuit disconnecting switch, and a pumping plant and reservoir system for fluid or gas systems. These facilities within fenced-in yards are necessary for both long or short sections of underground line.

Conductor Size

In choosing conductor size, the amount of current flowing in the conductor is critical. To have a long life, cable must not be overheated since this degrades the integrity of the insulation. The amount of heat in a cable is proportional to the square of the current and the resistance of the cable. The resistance of the cable is proportional to the cross-sectional area of the conductor.

Larger cables use more copper and cost more. Therefore, the designer selects a cable size that will carry the current, but not overheat. For this study overheating during normal use is defined as a conductor temperature of 85°C for paper type cables and 90°C for solid dielectric cables such as cross linked polyethylene.

Soil surrounding the cable will help carry away the heat depending on the temperature and type of the soil. In winter the soil is colder and carries away more heat than in summer. Cables in the study have been selected using 15°C soil temperature for winter and 20°C for summer. The soil type is specified by its thermal resistivity, 90°C cm/W for this study. Another source of heat that acts as a derating factor on a cable is other cables in the same trench. Due to the heating effect of other cables, each cable in the trench containing several cables must be limited to a lower current carrying capacity than when operating alone.

Cables in the study are sized and rated in accordance with Association of Edison Illuminating Companies (AEIC) standards.

2.3 Construction Considerations

Right of Way Access

Trucks carrying large, heavy reels of cable must have level or only gently sloping routes of access to points where the cable is to be installed. Cable reels are up to 15 feet in diameter, and weigh many tons. Road slopes must be prepared to be no steeper than most state highways so that an over-the-road truck can safely traverse grade changes. A firm accessway must be established to meet these requirements along the entire route where cable is to be direct buried, and to each manhole when pipe or conduit systems are to be installed.

Additionally, an accessway must be prepared along the entire length of any buried system, with grade limits that will allow travel of equipment used for excavation, backfill and material delivery. Construction of such an accessway can be a substantial part of the cost of an underground system, and could present significant visual and environmental concerns along a steep off-road right-of-way. Also, gaps in the construction road along an underground route would not be possible at environmentally sensitive areas such as steep slopes, wetlands and water courses. A passway may need to be prepared along the entire route. For these reasons most underground transmission lines are located under roadways, even if that makes the route longer and impacts traffic during construction.

Hilly Terrain

Long steep slopes present an additional challenge to cable design and installation. Any cable within an enclosure, conduit or steel pipe, will in time tend to slide downhill. This can cause excessive mechanical stress in the insulation due to stretching at the top of the slope, and bending, as a result of accumulation of cable at the bottom of the slope. To keep these effects within allowable limits, armored cables are specified for such locations. The armor can be secured to the enclosure at intervals, thus breaking a long slope into several short sections to keep insulation mechanical stresses within safe limits.

Other Underground Facilities

Ground penetrating radar (GPR) systems can be used to locate metallic and non-metallic facilities underground such as water, gas or communications circuits. The accurate location of such buried utilities is imperative in the construction of any underground facilities such as transmission lines. Using a high resolution GPR, the underground utilities can be quickly located and their location and depth marked on the pavement.

The effectiveness of GPR is limited by soil type and depth of penetration. Up to a depth of 3-1/2 feet GPR works well, but is less effective after this depth. In sand, GPR works well, but in clay, GPR is more limited and requires an experienced operator.

3 Equivalence of Underground and Overhead Transmission Lines

3.1 Electrical Characteristics

Inductance and Capacitance

The electrical characteristics of underground cables are quite different from those of overhead lines. Because the conductors of underground cables are much closer together than those of overhead lines, the inductances of underground cables are much smaller than for overhead lines. Since the inductance of a transmission line is, along with its resistance, a "series" element of the electrical circuit, it acts to impede the flow of current and contributes to the voltage drop along the line.

The close spacing of conductors results in a much greater capacitance for underground cables than for overhead lines. Since capacitance is a "shunt" element of the electrical circuit, it draws a charging current which is diverted from the end-to-end flow of current.

The difference in ratios between inductance and capacitance in overhead and underground lines is a major influence on their relative performance in a power system.

Resistance

Relative to small conductors, large ones cost more but have lower resistance, lower losses and dissipate less heat. In practical terms, a balance is struck in selecting conductor sizes and due to the different heat dissipation processes involved, underground lines typically have lower resistances than overhead lines in comparable service.

3.2 Surge Impedance Loading and Reactive Power

Surge impedance loading (SIL) is the ratio of inductance to capacitance (L/C) in a line and is a useful tool for characterizing the behavior of an individual line in a transmission system. When power flow is greater than the SIL the series inductance dominates the behavior of the line and it absorbs reactive power. When power flow is below SIL the shunt capacitance dominates line behavior and it produces reactance power.

For 115-kV transmission lines the SIL is about 45 MW for overhead lines and 260 MW for underground lines. In typical utility operations, overhead lines might operate either below or above their SIL while underground lines always operate well below. In a mixed overhead/underground system it may be necessary to install reactors to ensure proper balancing of reactive power flows resulting from the wide differences in SILs encountered.

3.3 Current Carrying Capacity

The ultimate current carrying capacity limit of a transmission line is determined by its maximum thermal rating. At its thermal limit heat resulting from current flow through the resistance of the conductor has raised the conductor temperature to the maximum possible without causing permanent damage. For an overhead line the thermal limit is dictated by the annealing properties of the conductor and is the point that the conductor takes on a permanent stretch so that ground clearance is reduced. For an underground cable the maximum temperature is dictated by the withstand capability of the electrical insulating material.

However, the operating limit of a line is also dependent on the overall operation of the power system. System stability and voltage regulation constraints may result in operating limits which are well below thermal limits. This is typically the case for longer overhead lines. Short overhead lines and underground lines typically are constrained by their thermal limits.

Since the thermal limit involves the buildup of heat, it is apparent that brief overloads above the normal thermal limit can be accommodated providing they are removed before excessive temperatures are reached. This gives rise to both short-term and long-term emergency ratings which are well above the normal rating of a line. Due to differences in the mechanisms for heat dissipation, the relationship between normal and emergency ratings in underground lines is different to that for overhead lines.

3.4 Ampacity Rating

It is difficult to design an underground cable which is exactly equivalent to an overhead line. In this study, all of the 31 overhead line and underground cable configurations are designed to meet to the maximum extent, those current carrying levels used by Connecticut utilities as shown in Table 3.1.

For overhead line configurations, these design requirements can be satisfied. However, current carrying capacities for underground cables are much more complex.

Table 3.1

Connecticut Transmission Line Load Level Scenarios and Ratings

		Scenario A (115 kV)	Scenario B (115 kV)
Summer	Expected Average Load Level	350 amps	500 amps
	Normal Rating	1000 amps	1250 amps
	Long Term Emergency Rating	1250 amps	1500 amps
	Short Term Emergency Rating	1500 amps	2000 amps
Winter	Expected Average Load Level	350 amps	500 amps
	Normal Rating	1250 amps	1500 amps
	Long Term Emergency Rating	1500 amps	2000 amps
	Short Term Emergency Rating	1750 amps	2500 amps

Basically, there are two factors which dictate the maximum current carrying capacities of the underground cable configurations used. These are:

- For all configurations involving pipe-type cables (HPFF and HPGF), the eight inch steel pipe limits the maximum conductor size to 2500 kcmil.

- For self-contained cables (LPFF and XLPE), the cable conductor size is limited to 2750 kcmil by the eight inch duct.

Table 3.2 summarizes the actual current carrying capacities for all the underground cable configurations. The above constraints lead to the same size of conductor being used for both Scenario A (350A average) and Scenario B (500A average). The shaded area indicates where the attainable rating is lower than the value preferred. To meet the required capacity, self-contained cables of 3500 to 4000 kcmil would have to be used. That implies use of ten inch or larger ducts, and, subsequently wider trenches. Such large sizes are not generally available with the possible exception of oil-filled cables.

Table 3.2

Loading Summary for Underground Cables

SUMMER	Scenario A - Summer				Scenario B - Summer			
	Expected Average 350A	Normal Rating 1000A	Long term emergency 1250A	Short term emergency 1500A	Expected Average 500A	Normal Rating 1250A	Long term emergency 1500A	Short term emergency 2000A
Single Circuit								
high pressure gas-filled 2500 kcmil	350	1000	1250	1390	500	1223	1351	1390
high pressure fluid-filled 2500 kcmil	350	1000	1250	1416	500	1240	1375	1416
high pressure fluid-filled w/ closed loop 2500 kcmil	350	1000	1250	1416	500	1240	1375	1416
self-contained fluid-filled 2750 kcmil	350	1000	1250	1500	500	1250	1500	1691
solid dielectric - horizontal 2500 kcmil	350	1000	1250	1500	500	1250	1500	1719
solid dielectric - delta 2500 kcmil	350	1000	1250	1500	500	1250	1500	1710
solid dielectric - L-shaped 2500 kcmil	350	1000	1250	1500	500	1250	1500	1755
Double Circuit								
high pressure gas-filled 2500 kcmil	350	1000	1166	1200	500	1052	1166	1200
high pressure fluid-filled 2500 kcmil	350	1000	1184	1219	500	1065	1184	1219
high pressure fluid-filled w/ closed loop 2500 kcmil	350	1000	1184	1219	500	1065	1184	1219
self-contained fluid-filled 2750 kcmil	350	1000	1250	1426	500	1245	1384	1426
solid dielectric - horizontal 2750 kcmil	350	1000	1250	1500	500	1250	1500	1561
solid dielectric - horizontal with alternative phasing 2750 kcmil	350	1000	1250	1500	500	1250	1500	1581
solid dielectric - vertical 2750 kcmil	350	1000	1250	1500	500	1250	1487	1526
solid dielectric - vertical with alternative phasing 2750 kcmil	350	1000	1250	1500	500	1250	1487	1526
solid dielectric - delta 2750 kcmil	350	1000	1250	1500	500	1250	1500	1541

Shaded areas indicate levels below preferred ratings (Section 3.3)

Table 3.2 (cont.)

Loading Summary for Underground Cables

WINTER	Scenario A - Winter				Scenario B - Winter			
	Expected Average 350A	Normal Rating 1250A	Long term emergency 1500A	Short term emergency 1750A	Expected Average 500A	Normal Rating 1500A	Long term emergency 2000A	Short term emergency 2500A
Single Circuit								
high pressure gas-filled 2500 kcmil	350	1250	1395	1432	500	1272	1395	1432
high pressure fluid-filled 2500 kcmil	350	1250	1419	1458	500	1289	1419	1458
high pressure fluid-filled w/ closed loop 2500 kcmil	350	1250	1419	1458	500	1289	1419	1458
self-contained fluid-filled 2750 kcmil	350	1250	1500	1741	500	1500	1694	1741
solid dielectric - horizontal 2500 kcmil	350	1250	1500	1750	500	1500	1726	1767
solid dielectric - delta 2500 kcmil	350	1250	1500	1750	500	1500	1717	1758
solid dielectric - L-shaped 2500 kcmil	350	1250	1500	1750	500	1500	1762	1803
Double Circuit								
high pressure gas-filled 2500 kcmil	350	1096	1205	1238	500	1096	1205	1238
high pressure fluid-filled 2500 kcmil	350	1109	1223	1257	500	1109	1223	1257
high pressure fluid-filled w/ closed loop 2500 kcmil	350	1109	1223	1257	500	1109	1223	1257
self-contained fluid-filled 2750 kcmil	350	1250	1430	1470	500	1297	1430	1470
solid dielectric - horizontal 2750 kcmil	350	1250	1500	1605	500	1487	1567	1605
solid dielectric - horizontal with alternative phasing 2750 kcmil	350	1250	1500	1605	500	1487	1567	1605
solid dielectric - vertical 2750 kcmil	350	1250	1500	1569	500	1454	1532	1569
solid dielectric - vertical with alternative phasing 2750 kcmil	350	1250	1500	1569	500	1454	1532	1569
solid dielectric - delta 2750 kcmil	350	1250	1500	1585	500	1468	1548	1585

When the preferred rating cannot be achieved with practically available cable sizes, a second circuit may be added. Alternatively, the utility may accept the limitation, probably by revising their overall system plan and making compensatory additions elsewhere.

3.5 Operation Considerations of Underground Cables

The difference in electric characteristics of overhead lines and underground cables has to be considered from a system operation point of view when integrating underground cables into a power system. Some of the most important effects of underground cables on system operation are:

Load Sharing

If an underground cable forms a parallel path with other transmission lines in a power system, the cable is most likely going to carry more than its share of load because of its relatively low series impedance. Therefore, the design and operation of the system must allow satisfactory operation without overloading the cable.

Charging Current

An underground cable presents a large capacitance between conductors and ground which results in a charging current which affects the operation of the overall system.

Firstly, the capacitive charging current is a significant source of reactive power which must be absorbed by inductive loads or generators. If the system connected to the cable has a low reactance, shunt reactors may be installed to accommodate the charging current.

Secondly, the charging current is generated over the length of an underground cable, increasing linearly along the cable. The passage of the charging current through the series inductance of a connected system component (an overhead line or transformer) may cause a voltage rise at the connected point, which might be harmful to the components.

Thirdly, the high value of charging current at the end of an underground cable can limit real power transfer since it results in losses and temperature rise which reduce the margin remaining to the thermal limit.

Fault Currents

In power systems, fault currents depend on fault location and system characteristics. For a given system configuration, since an underground cable has low series-impedance (typically half that of an overhead line), the fault current will be higher if a fault occurs on the cable, compared with an overhead line. The increased prospective fault level can result in the need to install circuit breakers and other power system equipment with higher ratings than would otherwise be necessary. Alternatively, it may be practical to install a series reactor near the underground cable termination to reduce the fault level.

System Restoration

For underground cables, system restoration following a whole or partial blackout presents special problems. Restoration requires the system to be put back together piece by piece, while ensuring that the voltages and loadings of all equipment remain within ratings.

An overhead line can be re-energized from a relatively weak source without causing excessive voltages. However, an underground cable must be energized from a source with sufficient reactive power absorption capability to handle the charging current, which limits options in restoring a dead system.

Energization of an underground cable without sufficient shunt compensation, or before the system is able to absorb the reactive current from the cable without causing excessive overvoltages, can result in a collapse of the system thus far assembled or even cause cable damage.

3.6 Losses

Losses on a transmission line can be divided into two categories: voltage-dependent losses and current-dependent losses. Voltage-dependent losses are present whenever a line is energized, and current-dependent losses vary with (real and reactive) power flows. Voltage-dependent losses are also called dielectric losses because they occur in the insulation of a line.

An underground cable usually has a larger conductor size for a given current carrying capacity than an overhead line. As a result, the total losses of an underground cable are less than that of an overhead line.

Voltage-dependent losses often are neglected for overhead lines. However, because of its solid insulation, an underground cable usually has a higher proportion of dielectric loss in its total losses. When transmission voltage is high, voltage-dependent losses should be considered in loss calculations. At 115 kV, voltage-dependent losses are usually less than 10% of the current-dependent losses for underground cables. Only the current-dependent losses were considered in loss calculations for this study.

3.7 Reliability

The reliability of a transmission system is a function of both duration (how often does the transmission line fail) and frequency (how long is the power off because of the failure).

Table 3.3 compares the reliability of overhead and underground transmission lines.

Table 3.3

Relative Reliability of Overhead and Underground Transmission Lines

	Overhead	Underground
	Frequency of Failure	
Failure Type		
Insulation	lower	higher
Splice	lower	higher
Termination	lower	higher
Dig-in	lower	higher
Tree contact	higher	nil
Vehicle accident	higher	nil
Storm - high wind	higher	nil
Storm - lightning	higher	lower
Bird contact	higher	nil
	Duration of Failure	
Action		
Locate fault	faster	slower
Repair fault	faster	slower
Temporary fix (if reqd)	faster	slower

Relative reliability depends on a number of issues including:

- Sound design
- Good construction practices
- Quality of materials, particularly cable
- Quality of splices and terminations
- Good maintenance practices - tree trimming, insulator washing
- Quality of outage records and failure analysis
- Experience and training of line crews

Underground cable at 115 kV is considered very reliable, with a very low frequency of failure. Typical failures may include splice failure due to the ingress of water, insulation failure due to imperfect manufacture, or dig-ins. None of the failure mechanisms are considered common occurrences and the frequency of failure is therefore low. Duration however, is a concern, since once a failure has occurred in an underground system, it can be very difficult to find and once found can take a long time to repair. The only alternative is to take the cable out of service until it is repaired. Service to customers on systems with full back up capability can be restored immediately whereas customers without back up capability must wait for an extended period of time while repairs are made. Special equipment and specially trained crews are often required to locate difficult faults. Once located the failed portions of cable have to be dug up, cut out and new sections spliced in.

Typically, overhead failures are easier to find and easier to repair. Most failures are self-clearing in that they are caused by momentary tree contacts or lightning strikes. For this type of fault, the arc is extinguished by deenergizing the line briefly, following which it can be reenergized. This entire "trip and reclose" sequence is automated and results in an outage lasting less than a second. Persistent faults of this nature, particularly in the absence of lighting storms, would be located by patrolling the line. Other types of failures on overhead lines are generally easier to locate than for underground lines. Once located, overhead line repairs are also generally less time consuming. Overhead lines are therefore characterized by a larger number of faults of shorter duration compared to underground lines.

Transmission systems are designed so that supply is not interrupted to customers in the event of the failure of a single line. Two simultaneous failures will likely result in service interruptions so the risk of supply interruptions is particularly high throughout the entire repair time of a faulted line. Underground lines can result in a higher exposure to the risk of service interruptions due to their longer repair time.

Due to the inherent differences between overhead and underground lines their reliability varies depending on the circumstances. Quality overhead and underground systems can both be very reliable.

3.8 Rights-of-Way

Right-of-way acquisition costs have been specifically excluded from the study since all 115-kV line construction in Connecticut over the next five years is expected to use existing rights-of-way. However, in comparing overhead and underground lines in general, rights-of-way should not be ignored. Underground lines have an advantage over overhead lines in some locations. For example, undergrounding may be used to overcome physical and/or economic constraints which preclude overhead lines, such as long crossings of water bodies. In densely developed urban areas, use of overhead support structures may be impossible or economically prohibitive. Underground lines require considerably less right of way width and in many cases may be the only answer.

4 Cost Estimates

4.1 Cost Types

A number of different cost types have been included in this study (detailed figures are included in the Appendix).

- ***Civil Works*** Included are the costs of clearing, access roads, excavation, concrete, and backfilling. In urban areas, allowance has been made for the use of police for traffic control and for the use of some overtime should the roadways not be available during normal working hours.

- ***Overhead and Underground Materials*** All line materials have been included in this section. Also included are an allowance for testing and commissioning as well as a material storage and handling overhead charge.

- ***Administration and Engineering and Permit Fees*** These costs include all engineering, administration, site supervision and project management costs, as well as regulatory and permit fees and associated costs.

- ***Allowance for Funds Used During Construction (AFUDC)*** AFUDC has been included at the rate of 1/2% per month applied to the total value of the project. It is assumed that the funding is only required for 6 months.

- ***Contingency*** A contingency has been allowed for at 15% of the total value of the project.

- ***Operations and Maintenance (O&M)*** Included in the O&M costs are all the costs associated with the on-going use of the line. These include inspection, maintenance and occasional repairs.

- ***Losses*** All transmission lines have losses in that a small portion of the energy flowing through the conductors leaves a line as heat. The cost of losses depends on the resistance of the conductors, current levels and dollar value of power and energy. The assumptions and calculation methods used in this study are detailed in Appendix B.

4.2 Factors that Affect Cost Estimates

As can be seen from the detailed estimate sheets, costs have been included for all reasonable material, construction, engineering, administration and permitting costs. By combining these costs with the maintenance costs and the cost of losses, the life-cycle costs are obtained.

While the costs are reasonable, and can be used effectively in making comparisons, in a real life construction of a new transmission line, prices may vary. Consider the example of cable. Prices for cable used in the estimates are based on prices supplied by cable manufacturers. As such they represent the best information available at this time. But they may vary due to several factors including:

- ***Market Forces*** Buying in a period of high demand will likely result in high prices

- ***Quantities*** Buying one mile of cable will likely result in higher unit prices than buying five miles of cable. There are fixed set up costs for manufacturing and construction that have to be paid irrespective of quantity ordered.

- ***Raw Materials*** All raw material prices vary. Copper and aluminum have been particularly volatile recently. Variations in prices can be expected on all raw materials, such as oil, steel, paper, XLPE, concrete, sand and silicon.

- ***Local Requirements*** Are very hard to quantify, but they may have a very significant impact on costs. Work may have to be carried out at night, or local authorities may require surface paving over a complete lane instead of just the width of the trench, or boring under the road may be required instead of an open cut trench. All of these considerations are expected to increase costs.

- ***Environmental Mitigation*** The crossing of wetlands, streams, rivers, lakes, the locations of historic sites and recreational use of adjacent land, may all influence the requirements of the transmission line.

- ***Hilly Terrain*** Affects the cost of both overhead and underground transmission lines. Overhead lines are affected because they may require shorter spans and hence more towers; underground lines because they may require more pumping stations or simply be more difficult to construct.

- ***Existing Lines*** Influence the cost estimate as it may be necessary to dismantle the existing line prior to constructing the new line, or existing lines might remain and the construction contractor has to follow restrictive procedures in working around energized lines.

- ***Right-of-Way Costs*** Have not been included since the study assumes use of existing rights-of-way. However the impact of such costs may be significant on new green field sites.

- ***Winter Work*** Frost rates in the winter are higher and will influence costs.

The significant factors in the life-cycle costs are the ***first cost of construction***, the ***fixed charge rate*** (capital recovery factor) and the ***discount rate***. Costs of losses and maintenance costs are relatively small and the life-cycle cost is not sensitive to them. Varying the first cost of construction and the fixed charge rate produces a proportionate change in the present value life-cycle cost. If, for example, cable costs increase by 20% and this increases the first cost by 10%, an increase of essentially 10% will be experienced in the life-cycle cost. Conversely, the life-cycle cost is inversely affected by the discount rate.

4.3 Operation and Maintenance Costs

Operation and maintenance (O&M) activities of overhead transmission lines and underground cables may include inspection, including instrument reading and testing; and maintenance, which usually includes some repair activities.

The degree of inspection is quite discretionary and varies widely among North American utilities. For example, some utilities require each transmission structure to be climbed and inspected annually while others carry this out only as required. The frequency of foot and aerial patrols is another activity that can differ in frequency between companies and even over the years within one utility, as system components reveal their reliability.

Maintenance of overhead lines is restricted largely to the occasional repair of weakened or failed components. The frequency of repairs depends on the environmental conditions and human activity around the line, as well as on the performance of individual line components. Naturally, there is considerable variability in these influences, even within any one utility, such as damage to insulators from lightning, gun-shot or salt spray. This study has attempted to use repair frequencies for average Connecticut conditions.

Transmission Lines

In this study, the line maintenance practices of Connecticut Light & Power and United Illuminating have been used, wherever feasible, to estimate the O&M costs.

Northeast Utilities has in place a set of procedures for transmission line inspection and maintenance, which are used by Connecticut Light & Power. The line maintenance cycles specified therein were used as a basis for estimating the O&M costs for each line configuration. A maintenance model was developed using estimates of the person-hours required for each maintenance activity using, as a basis, the actual maintenance costs for Connecticut Light & Power for 1994 and the budget figures for 1995, the most recent years available.

The model can thus highlight the relative O&M costs for different line configurations. The costs are similar to the overall US transmission line maintenance costs of $885/mile determined from overall FERC data.

The O&M costs were estimated on the following basis:

- The right-of-way clearing and danger tree removal costs are based on those of Connecticut Light & Power for the years 1994 and 1995. This work is done on a 5-year cycle by outside contractors and the cost of its administration and supervision by utility staff has been included.

- A commissioning inspection of each structure of the line is included for the first year of operation.

- Wood pole testing and treating is normally started after about 15 years into the life of the line. It has been included in the line maintenance costs at a rate of 10% of poles per year from year 15 to the end of the line's 35 year economic life.

- Wood pole replacement was assumed to be required for a small number of poles each year (1%), starting in the 25th year, until the end of the line's economic life.

- For steel poles, it was assumed that repainting would be required on selected poles (10%) each year, starting in the 30th year.

- Most areas in Connecticut do not suffer from severe atmospheric corrosion due to sea spray or industrial pollution, so that line hardware, conductors, insulation and structure life are not adversely affected. Also, suspension insulator life is not abnormally impaired by gun-shot damage or high lightning activity.

- Since severe climatic events such as tornados, hurricanes and ice storms are relatively rare in Connecticut, no allowance has been made for the cost of restoration in such events.

- It is likely that a line will be uprated, for instance by reconducting or tower raising, during its physical life, but not necessarily within its economic life of 35 years. No allowance has therefore been made for this possibility since this is a capital rather than a maintenance expense and very project specific.

Underground Cables

Underground transmission systems in the State of Connecticut are relatively small compared with those in larger states. In addition, use of solid dielectric cables is still growing and the operating experience still evolving. Consequently, it was necessary to consult with utilities having more extensive underground cable systems, and utilities having experience with solid dielectric cables in order to develop O&M costs. Consolidated Edison (470 miles of high voltage cable) and Ontario Hydro (140 miles of high voltage cable) were consulted, as was Southern California Edison, which has the largest 69 kV solid dielectric cable system in the US (160 miles).

A model annual maintenance schedule, including the person-hours required for different activities, was constructed from the experience of these utilities. The conditions under which cables operate in Connecticut is generally quite different from New York City, Ontario or California, which was taken into consideration.

Experience with solid dielectric cables is not sufficiently mature to determine a meaningful failure rate due to cable deficiencies. Consequently, no costs have been included for cable and accessory repair that might be required for this or any of the other cable types.

Comments

The main cost differences between configurations arise due to the structure types and, as a result of the associated average span length, the number of structures in the line. Although the person-hours required to carry out a certain maintenance activity can be influenced by the configuration, other uncertainties (work practices, types of equipment used, inspection frequencies, staffing levels, terrain, etc) make it unreasonable to take this into account.

The O&M cost of each configuration includes the hourly cost of vehicles and equipment required to carry out the repairs allowed for in the model, such as trucks, aerial devices and digger derrick trucks. For overhead lines, equipment should be available from a pool for the utility as a whole, so it is reasonable to allow only for hourly equipment costs.

For underground cables, it is less likely that all types of equipment needed would be available within the utility. Given the relatively short lengths of underground used, utility-based equipment would see very light use and would result in very heavy charges per mile of line. To avoid such extreme costs, it was assumed that the equipment for cable maintenance would be available at an hourly rate from an outside source.

For configurations using compact construction, the phase-to-ground and phase-to-phase distances are probably smaller than the safe working distances permitted by the Occupational Safety and Health Administration (OSHA) and the National Electrical Safety Code (NESC), depending on the switching overvoltage levels of the power system. As a result, live line work (such as replacing insulators) and even climbing of the structure at the conductor level (for inspection or painting), would not be possible. Although Connecticut utilities presently perform little live line maintenance, the utilities will need such capability in the future. Depending upon power system conditions, line outages can be difficult to schedule and the cost of the alternative supply could add significantly to the cost of the procedure. Compact configurations therefore incur premium maintenance costs.

5 Life Cycle Costing

5.1 Concept of Present Value Costing

Money has a time value because of the existence of interest. The concept of compounding money due to an interest payment is well known. If an investment is made the principal will compound each year as interest is paid again and again on the principal plus the interest earned. The result is that the future value of an investment is worth more than its present value. The opposite of compounding is discounting which results in money received in the future being worth less than today.

One widely accepted approach of comparing options over their entire life-cycles is to bring all costs to a single point in time - the present. This can be done by applying present value (PV) factors to all costs incurred in the future and then adding them to actual present costs to provide an overall PV cost. The PV's can then be compared for the different project alternatives.

To calculate the PV for a transmission line:

(1) Account for all Costs

- ***First Cost*** includes construction costs including all labor, materials, engineering, administration, permitting etc. These costs are spent at the time of construction of the transmission line.

- ***Operation & Maintenance Costs*** include ongoing costs incurred over the life of the transmission line. O&M costs also increase with time, and an escalation rate of four percent was used in the study.

- ***Losses*** Electrical losses occur 24 hours a day, every day. As stated before, electrical losses are primarily dependent on the square of the current flowing through the conductor. The cost of losses will also increase with time and the cost data used in the study is detailed in Appendix B.

(2) Calculate the Annual Cost of the Alternative for Each Year of Life

- ***First Cost*** To calculate the contribution to the transmission line costs for each year of life of the project, a levelized annual capital recovery factor is used. The levelized factor is multiplied by the first cost and this produces a number that is considered the annual cost contribution due to construction. Further details on the capital recovery factor are included in Appendix B.

- ***O&M Costs*** are added to the levelized annual cost on an annual basis. To allow for escalation, the O&M costs are increased by four percent annually.

- ***Losses*** Costs are also added to the first cost on an annual basis. The losses increase annually due to load growth. An annual load growth rate of 1.2% was used in the study which resulted in losses increasing at the square of this. The cost of these losses is then further increased by price escalation.

(3) Calculate the Life Cycle Cost

- Add up the annual figures for first cost, O&M cost and losses in each year.
- Multiply the total annual cost by the PV factor for that year to determine its PV.
- Add up all annual PV values to arrive at the total life cycle cost.

5.2 Life Expectancy

It is generally accepted that transmission lines have finite lives, as noted below.

• Wood pole	40 years
• Steel pole	60 years
• Underground cable	35 - 40 years

The actual life achieved by the line may vary considerably however, depending on a number of factors:

- design practices

- construction practices

- quality of materials

- quality of workmanship

- maintenance practices
- policy of incremental improvement, for example by analyzing failures by and implementing improvements
- well trained and motivated crews
- operational practices
- load growth
- change in the nature or location of the load.

Our study of Connecticut utilities indicates that many lines are replaced or significantly altered before they reach the end of their physical life. This results from the changing nature of electrical loads which vary as customers needs change and as industries establish themselves, close or relocate.

Fortunately, the uncertainty associated with the expected life of a line in the range of 35 - 60 years has a relatively minor effect on its life cycle cost. This is due to the fact that the PV factors become very small in later years.

As can be seen from the life cycle tables, the PV decreases to 0.1 in 24 years which means that 90% of the PV occurs in the first 22 years. At 35 years, the PV factor is 0.04, so that working with lives greater than 35 years has very little effect on the final result. It is for these reasons the life cycle calculation is based on 35 years for all alternatives.

6 Environmental Factors

6.1 Introduction

Environmental factors are major considerations in the siting, construction, and operation of any type of transmission line whether placed underground or overhead. In the development of a typical transmission line project, the importance of environmental features is reflected in siting and design considerations; in the detailed environmental reviews that regulatory agencies perform as part of permitting processes; and in both construction and operation/maintenance procedures that are developed and implemented to minimize environmental impacts.

Objectives

The purpose of this chapter is to identify the principal environmental factors that influence transmission line siting, construction, and operation in Connecticut, and to describe methods for evaluating and comparing such factors, either quantitatively or qualitatively, for underground and overhead transmission lines. In particular, this chapter:

- Describes the typical right-of-way configurations in Connecticut for both overhead and underground transmission lines and the primary environmental characteristics with respect to each.

- Identifies the types of environmental factors that merit consideration when evaluating any type of transmission line in Connecticut.

- Discusses the regulatory permits and approvals required for transmission line development in Connecticut, identifying the differences (if any) between permitting for overhead and underground construction.

- Describes the environmental factors relevant to different stages in the life cycle of transmission lines (i.e., siting, construction, operation and maintenance).

- Summarizes methods for integrating environmental externalities into the project planning, design, and decision-making process.

Consistent with the projects presently included in the future plans of utilities in Connecticut, these analyses inherently assume that any facility replacement, upgrade, or expansion in the near-term future will be accomplished by using or expanding existing transmission line rights-of-way, rather than by developing facilities on new "greenfields" rights-of-way.

Environmental Life Cycle Cost Components

This analysis assumes that inherent in the life-cycle costs of either an overhead or an underground transmission line are the conventional (direct and indirect) environmental expenditures associated with each project, as well as external costs, or costs to society, as a result of the project. Conventional environmental costs, which may be tracked and quantified include expenditures for:

- ***Project Planning and Design*** including field surveys to identify environmental resources of concern (e.g., wetlands delineations, stream surveys, endangered/threatened species investigations) and to finalize the alignment of overhead structures or underground facilities so as to minimize environmental impact.

- ***Permitting*** including the development of certificate and/or permit applications, environmental reports and maps; permit/certificate application filing fees; support of the permit/certificate applications at agency hearings; and preparation of management plans and other studies as may be required as a condition of certification and/or permit approval.

- ***Facility Construction*** including the implementation of environmental protection measures and mitigation plans, and environmental monitoring (if required).

- ***Facility Operation/Maintenance*** including right-of-way vegetation control and maintenance activities involving environmental stabilization.

Most of these costs are in fact not tracked specifically by utilities, although generalized estimates of the total cost of environmental permitting and compliance are available.

Social costs, also referred to as "externalities", are environmental costs that may result from a project, but are subjective and not easily quantifiable in terms of dollar amounts (i.e., "monetized"). Because a dollar value cannot be easily assigned either in the market place or by regulation, externalities often may not be taken into full account in project decision making. Such externalities may include the effect of a transmission structure on visual resource quality; nuisance effects attributable to noise from overhead transmission lines; or a change in habitat or biodiversity due to the creation of a maintained corridor.

6.2 Data Sources

The analysis of environmental factors relevant to transmission line planning was based on various agency/utility consultations; the review of various published reports, articles, and other documents; and a field reconnaissance of representative existing 115 kV transmission line rights-of-way maintained by United Illuminating (UI) and Northeast Utilities Service Company (NU) in Connecticut. In addition, data were compiled based on:

- A review of CSC files concerning transmission line certification over the past 15 years;
- A review of the files of the New York State Department of Public Service regarding the annual costs of utility right-of-way maintenance;
- Consultations with representatives of the Connecticut utilities who maintain 115 kV transmission lines in the state; with representatives of various government permitting and regulatory agencies throughout the United States with experience in utility siting; and with personnel involved in performing environmental analyses for linear corridor projects in Connecticut; and
- Evaluations of the existing literature regarding both overhead and underground transmission line siting and environmental externalities associated with transmission line development.

It should be noted that the results of these analyses did not uncover any available data that provides a direct, comparative evaluation of the environmental effects of overhead versus underground transmission lines on a project-specific basis. For example, although the CSC (and agencies in some other states) require consideration of undergrounding of transmission lines in utilities' project-specific permit applications for overhead transmission lines, undergrounding has typically been evaluated only on a gross cost scale, without detailed comparative evaluations of the environmental impacts of undergrounding versus an overhead line along the same right-of-way.

Moreover, few transmission lines have been undergrounded in Connecticut (or elsewhere) and those that have been are typically short segments within road rights-of-way or beneath an environmental feature of concern (e.g., a river crossing). Finally, environmental costs in general are subjective and difficult to quantify, and thus often must be evaluated on a qualitative basis.

Consequently, this analysis draws upon the information that is available to provide an environmental comparison of overhead and underground transmission lines, and provides recommendations for tracking and evaluating environmental costs for future transmission line projects of both types.

6.3 Configuration of Typical 115 kV Rights-of-Way

The transmission line configurations of interest are detailed in Part B of this report. To determine the settings in which these lines might be constructed a reconnaissance was conducted of representative existing 115 kV transmission facilities in New Haven, Hartford, and Fairfield counties. In addition, UI and NU were consulted regarding standard easement widths. This review demonstrated that the right-of-way characteristics of both utilities' existing overhead and underground transmission lines are similar.

Overhead Transmission Lines

In Connecticut, the typical right-of-way width for a single 115 kV transmission line is 100 feet. In some areas of urban congestion, the maintenance of a 100-foot-wide right-of-way is not possible, although it is generally desired by the utilities.

A wider right-of-way is typically required for multiple transmission lines; generally, an additional 50 feet is needed for each additional 115 kV line. However, the width of the right-of-way required depends on the structure type and line configuration. For example, a 100-foot-wide right-of-way could support two 115 kV circuits if vertically configured structures are used.

Overhead rights-of-way are maintained in low-growing vegetation. NU maintains vegetation on a five-to-six year cycle for each transmission line. Selective vegetation maintenance techniques are used, including hand cutting, mowing, and herbicide application (both foliar and basal). Semi-annual inspections also are conducted of the rights-of-way, at which time any danger trees are identified and removed.

Underground Transmission Lines

The majority of the existing underground transmission lines in Connecticut are within or adjacent to highway rights-of-way, either below pavement or within road shoulders.

As a result, a separate right-of-way for these underground transmission lines is not required and no vegetation maintenance is needed. NU has one underground transmission line that is along an abandoned railroad. Vegetation maintenance on this recently installed line has not yet been required, but in the future will consist of the control of woody species with large root systems.

Underground transmission lines require a permanent 15- to 25- foot-wide right-of-way for a single circuit. If more than one circuit is to be located within the same right-of-way, additional easement width is required to maintain the horizontal spacing between the lines.

6.4 Environmental Considerations in Transmission Line Planning, Decision-Making, and Evaluation

Connecticut has a diverse environment, with environmental characteristics that vary significantly depending on location within the state. Population density, which also varies substantially, has a major influence on the environmental, social and cultural features of importance in a given area of the state.

Because of the state's diverse environmental conditions, the environmental criteria important to the siting, construction, and operation of transmission lines will vary, depending on the location in which the facilities must be placed; the type of transmission facilities to be developed; and the environmental conditions in the specific area. Such factors also will influence the environmental costs associated with the development and operation of a transmission line. For example, the siting of a transmission line in the densely developed urban areas of New Haven or Bridgeport, where work space for construction and impacts on traffic congestion may be prime concerns, will require a focus on different types of environmental factors than would the development of the same type of line in a rural area of Litchfield County, where environmental resources such as wetlands, steep slopes, buried archaeological sites, and wildlife may be a comparatively greater focus.

Although the environmental considerations will vary between projects, the set of environmental resource factors that should be assessed in transmission line planning, decision-making, and evaluation can be identified, along with the potential impact issues that are generally associated with each resource. The environmental resource issues that should be considered for transmission line planning and decision-making include the following major categories:

- Water resources (surface water [wetlands, streams, rivers] and groundwater).
- Biological resources.
- Land use and recreation.
- Topography, geology, and soils.
- Visual resources.
- Cultural resources (prehistoric and historic archaeological sites, standing historic structures).
- Air quality and noise.
- Socioeconomics (population density, economic costs/benefits, traffic).
- Agricultural resources.
- Marine/coastal zone resources.
- Health and safety (discussed separately in Section 7 of this report).

These resource factors are pertinent to both overhead and underground transmission lines, although the applicability of the different environmental resources will depend on the particular characteristics of a project's location, type, and design. Table 6.1 summarizes the environmental features and potential impacts associated with each of these resource categories.

For the analysis of environmental resource categories and for the discussion of other environmental factors involved in project life cycle costing, the following assumptions have been made to take into account the environmental issues that will require consideration for different types of projects in different environmental situations.

Table 6.1

Environmental Factors for Transmission Line Siting and Operation

Environmental Resource	Potential Impact Issues for Transmission Lines*
Water Resources	
• Wetlands • Streams • Groundwater • Lakes and ponds	• Erosion and sedimentation into waterbodies • Loss of stream and wetland habitat and function • Alterations in localized groundwater flow due to blasting (e.g., individual wells) • Adverse effects on water quality as a result of herbicide use • Adverse effects of access roads and/or facilities placed in or across water resources
Biological Resources	
• Wildlife • Vegetation • Fisheries • Rare, Threatened, or Endangered (RTE) Species	• Disturbance to or loss of habitat • Modifications to vegetative diversity • Effects on birds (collisions, electrocution, disruption of nesting by vegetation clearing) • Effects of herbicides • Effects on RTE habitat or individuals • Effects of stream bank and water quality modifications, as well as loss of riparian vegetation on fisheries
Land Use and Recreation	
• Parks and public use areas • Land uses on and adjacent to right-of-way • Third party uses of right-of-way	• Restrictions on use options for land • Multiple use of right-of-way • Impacts of unauthorized use (e.g., ATV use leading to erosion/-sedimentation)
Topography, Geology, and Soils	
• Bedrock outcrops or shallow depth to bedrock • Steep slopes • Highly erodible, floodplain, or hydric soils	• Conditions affect engineering design of transmission facilities (e.g., structure footing, spans, practicality of undergrounding) • Modifications to topography (and effect of topography on feasibility of transmission line installation) • Amount of blasting required • Soil erosion and/or instability • Soil compaction
Visual Resources	
• Proximity to structures on National Register of Historic Places • Proximity to visually sensitive areas (e.g., recreational or scenic areas, residential areas) • Proximity to public roads or other public use areas that offer a large population views of the facility	• Intrusive effects of towers and/or maintained right-of-way and other aboveground facilities • Degree of visual contrast to viewers
Cultural Resources	
• Archaeological resources (prehistoric and historic) • Historic (standing structures)	• Direct effects on buried cultural resource sites • Indirect effects on standing historic structures as a result of views of transmission facilities

Environmental Resource	Potential Impact Issues for Transmission Lines*
Air Quality and Noise	
	• Fugitive dust during construction • Noise during construction and from transmission wires during operation (audible corona discharge (crackling), under certain weather conditions is unlikely to occur with 115-kV or lower voltage facilities)
Socioeconomics	
• Traffic • Employment/income • Property values	• Traffic congestion during construction • Impacts (real, perceived) on property values and taxes • Increases in employment and income during construction
Agricultural Resources	
• Crop and hay land • Pasture land • Special uses (e g., orchards, tree farms)	• Decrease in agricultural land/agricultural land production from placement of structures in agricultural areas • Impacts to productivity caused by soil mixing, compaction (as a result of equipment access through agricultural areas, trenching) • Impacts to livestock
Marine/Coastal Zone Resources**	
• Coastal zone land use management objectives • Marine/anadromous fisheries • Shellfish resources • Coastal recreational uses	• Direct effects associated with transmission line construction (e g., trenching) • Indirect effects associated with sedimentation • Conformance of transmission line development to specified plans for coastal development

* Potential impacts listed are generic, and may be associated with overhead and/or underground transmission line construction and/or operation/maintenance.

** Only applicable to projects in state-designated coastal zone

1. Type of Location

(a) ***Urban*** An urban project is defined as one that is located in densely developed, and highly populated areas, such as the cities of Bridgeport and New Haven. It is assumed that urban projects consist of a transmission line right-of-way that will be entirely within city streets or other highly disturbed areas (e.g., railroad rights-of-way, parking lots). Although environmental features may be located adjacent to such urban project areas, it is assumed that none are within the project area.

(b) ***Rural*** A rural project is defined as any project outside of urbanized areas in Connecticut. The typical rural project is assumed to consist of an existing transmission line corridor that may traverse a variety of vegetation community types and land uses, and that may be characterized by crossings of wetlands and streams; varied terrain, including rugged and/or steep slopes; and/or agricultural areas. It is assumed that residential development is generally of low to moderate density.

2. Type of Project

(a) ***Overhead*** A typical overhead transmission line project is assumed to consist of a reconstruction, upgrade, or expansion that will be performed within the confines of an existing transmission line corridor. It is assumed that vegetation may not have been maintained on all of the existing corridor, and that additional clearing may be required. It is also assumed that equipment access will be required along the right-of-way for both construction and operation/maintenance activities.

(b) ***Underground*** A typical underground transmission line project is assumed to consist of the installation of a buried pipe or duct bank within an existing transmission line right-of-way. It is assumed that all areas within the defined construction work area will be disturbed as a result of trenching, equipment movements, etc., and that both temporary and permanent access for equipment will be required along the right-of-way. It should be noted however that underground rights do not always exist in the rights-of-way of overhead lines in which case underground lines must be installed in roadways or new rights-of-way.

These definitions are used throughout the following analyses, and serve to establish a base case for the environmental cost evaluation.

6.5 Project Planning and Design

The first phase in the development of a transmission line project -- either overhead or underground -- is conceptual project design, including the performance of site and environmental evaluations to investigate alternatives and to refine a preferred alignment. The extent to which special environmental investigations or field surveys are required will be a function of the characteristics of the project area. Consequently, the costs associated with these activities will vary substantially from project-to-project, regardless of whether the proposed transmission line is overhead or underground.

As part of this phase, the following types of environmental activities may be performed:

- Agency consultations to compile background environmental data.

- Environmental field studies, as required.

- Coordination of environmental field investigations with engineering design and right-of-way considerations to identify measures to mitigate environmental impacts in the project planning phase such as, in the case of overhead transmission lines, locating structures out of wetland areas where possible, or in the case of underground lines, narrowing the construction work area to minimize impacts to wetlands that cannot otherwise be avoided.

- Reports documenting the results of field surveys.

The environmental field studies that may be required, depending on the project location (urban or rural), the type (overhead or underground), and the environmental characteristics of the project area, are summarized in Table 6.2. It is emphasized that Table 6.2 should be viewed as a guideline, with the understanding that the types of environmental field studies that may be required for an actual project are a direct function of the specific environmental resources in the project area.

Although specific survey costs are difficult to assign on a generic basis, the comparative costs for environmental planning surveys for overhead and underground transmission lines can be identified. Table 6.3 provides a general comparison of potential environmental survey costs, indicating whether the environmental survey typically would be more or less costly for an overhead versus an underground transmission line.

Table 6.2

Summary of Typical Environmental Surveys for Project Planning, by Type of Project and Location

Type of Environmental Survey	Project Location		Project Type	
	Rural Area[1]	Urban Area[2]	Overhead	Underground
Wetland Survey (Delineation and flagging of wetlands, using state and federal delineation criteria)	Yes	No	Yes (for access roads, tower footings)	Yes (along entire route to be disturbed)
Stream Survey (Identify bank/bottom type and characteristics, width and depth, etc)	Yes	No	Yes (to identify methods for equipment crossings)	Yes (to identify methods for trenching across stream)
Vegetation Surveys (e g., to determine clearing requirements and techniques)	Yes	No	Yes	Yes
Cultural Resource Surveys (archaeological and standing historic structures)	Yes	No (depends on project area)	Yes (for tower footings. access roads)	Yes (all areas of soil disturbance or equipment use)
Rare, Threatened, and Endangered Species Surveys (To determine presence of habitat or species in project area Only if habitats or records indicate species may be present)	Yes	No	Yes	Yes
Visual Resource Surveys (to identify whether facilities are within viewsheds of visually sensitive areas or historic structures)	Maybe	No	Maybe	Maybe (depends on location of aboveground facilities)
Agricultural Resource Surveys (To evaluate crop type, soil type, presence of drain tile, etc)	Yes	No	Yes (to identify access, time construction to avoid impacts to farm operations)	Yes (to identify drain tile that will be cut, plan construction to minimize impacts)

[1]Rural area is any project outside of urbanized areas in Connecticut, including an existing transmission line corridor crossing wetlands, streams, varied terrain, steep slopes, and/or agricultural areas.

[2]Urban area is any project in a densely developed and highly populated area, entirely within city streets, or highly disturbed areas such as railroad ROWs, parking lots.

Table 6.3

Comparative Cost Ranking for Performance of Typical Environmental Planning Surveys

Type of Environmental Study	Overhead Transmission Line	Underground Transmission Line
Wetlands Survey [1]	0	0
Stream Survey [2]	0	+ 1
Vegetation Survey [3]	+ 1	0
Cultural Resource Survey [4]	0	+ 1
Visual Survey [5]	+ 1	0
RTE Survey [6]	0	0
Agricultural Survey [7]	0	+ 1
Engineering Survey [8]	0	0

Notes:

Rating of 0 is the base case A (+ 1) indicates a higher comparative cost than the base case, but makes no quantification of how much higher the survey cost may be

All comparisons assume the installation of either an overhead or an underground transmission line along the same alignment, in a rural project location (For an urban project location, few environmental surveys would be required)

1 Wetland survey costs for either type of transmission line along the same right-of-way will be the same. This is because all wetlands in the project area must be delineated, regardless of whether they will be spanned by transmission conductors or affected directly by trenching

2 Stream survey costs will tend to be higher for underground transmission lines because additional information may have to be compiled to evaluate the direct impacts to streams as a result of trenching

3 Vegetation survey costs will typically be higher for overhead lines, along which clearing techniques vary, depending on the type of species. Along underground lines, because all vegetation will have to be maintained, the performance of a detailed vegetation survey is not warranted

4 Cultural resource costs for underground lines will be higher than for overhead lines because of the greater amount of soil disturbance and thus a larger area that must be surveyed.

5 The need for visual surveys, or viewshed analyses, to determine the effect of the transmission facilities on visual resources will depend on the proximity of the project to features such as scenic/public use areas, important vantage points, residential areas, and/or standing historic structures A visual survey is considerably more likely to be required to evaluate an overhead transmission line (including a reconstruction project) than for an underground line, particularly if the underground line is to be located within an already maintained right-of-way

6 Surveys of rare, threatened and endangered (RTE) species if required, will be similar for either type of transmission line

7 Agricultural surveys will cost comparatively more for underground lines than for overhead lines because of the additional information that must be compiled to evaluate the impacts of and to design mitigation for trenching across agricultural areas

8 Engineering survey costs can be expected to be similar for either type of transmission line, as detailed elevations and profiles are required in either case

6.6 Environmental Certification and Permitting

Various permits and approvals are required for the construction of a typical transmission line in Connecticut. The general types of approvals, and corresponding application fees, that are or may be required are similar for both overhead and underground transmission lines. These are included in Table 6.4.

Permit and Certificate Application Costs

The preparation and support of environmental permit applications can be both costly and time consuming. The cost of permitting varies widely as a function of the project, and in particular the types of permits required, the potential for and magnitude of environmental impacts, the degree of public controversy, and the overall time required to obtain all necessary permit approvals.

Environmental permitting may result in expenditures on all or some of the items detailed in Table 6.5 in addition to those incurred during the environmental planning/design phase:

Table 6.4

Primary Environmental Permit/Certificate Approvals and Application Fees for Typical Transmission Line (Overhead or Underground)

Agency	Type of Approval Required	Permit Application Fees
	State	
Connecticut Siting Council	Certificate of Environmental Compatibility and Public Need	Based on % of construction cost (see note 1)
Connecticut Department of Environmental Protection	401 Water Quality Certification Storm Water Pollution Prevention Approval for temporary disturbance of more than 5 acres of land Coastal Zone Consistency Certification or Structures and Dredging Permit for coastal zone or tidally influenced areas (from DEP, Office of Long Island Sound Programs)	0 $250 $350 basic application fee 875 ft^2 - 5500 ft^2, 0 40/ft^2 additional fee. Over 5500 ft^2, 05 ft^2 additional fee.
Connecticut Historical Commission	Review of archaeological and historic resources; approval by finding of no adverse effect	0
Department of Public Utility Control	Method and Manner of Construction approval Approval to Energize	0 -
	Federal	
U.S. Army Corps of Engineers, New England Division	404 permit for dredge and fill activities or *nationwide permit approval (*for most utilities) Section 10 permit for work in navigable waterway	$100 for individual permit, payable upon permit acceptance; 0 for nationwide
Federal Aviation Administration	Notification of presence of overhead lines only	

Note 1: Fee for a Declaratory Judgment is $500. CSC certificate application fees are based on a percentage of the construction cost for a project, as follows:

Estimated construction cost:	Fee:
• Up to $5,000,000	0.05% or $1,000, whichever is greater
• Above $5,000,000	0.1% or $25,000, whichever is less.

Table 6.5

Permitting Costs

	Labor Costs	Material Costs	Other
1	Time required to attend pre-application conferences with agencies and (for CSC filings) pre-application public hearings in towns, if required	n/a	Travel costs, public notice costs for pre-application hearings, if required
2	Time required to prepare permit application forms and supporting environmental reports, detailed maps and drawings. Typically requires input of personnel with specialties in environmental science, engineering/drafting, and right-of-way	Production of multiple copies of application documents, and distribution to appropriate parties	Filing fees
3	Testimony at CSC public hearings, if required, and legal support	Production of responses to data requests and provision to parties (if required)	Travel costs, mailing
4	Time required to consult with other permitting agencies (e.g., state, federal) outside of CSC process	Production of responses to data requests	n/a
5	Time required for public relations/-community affairs support, as required (e.g., for public notices, attendance at hearings)	n/a	n/a

Most of these types of permitting costs have not been specifically tracked, since such an accounting is not required by the regulatory agencies and has not traditionally been performed by the utilities. UI estimates that its per project permitting costs are in the range of $100,000 to $150,000, and notes that this includes the costs for the preparation of an environmental impact statement (or equivalent) and other technical reports, permit fees, legal fees relating to environmental permitting, costs of public notices, and miscellaneous expenses (e.g., travel, administrative). UI cautions, however, that this cost range is based on a limited number of projects and also notes that the environmental permitting costs will vary.

NU's environmental permitting is performed as part of project engineering, and has not been accounted for separately. NU estimates that engineering is approximately 5% of a large project's total cost, and that for projects requiring a CSC certificate, approximately half of the engineering cost is for regulatory work.

Agency Application Fees and Review Costs

The CSC is the lead agency with respect to transmission line approval in Connecticut. The time and costs for CSC approval vary, depending on whether the project must be reviewed pursuant to the CSC's certificate process, or whether the CSC can issue a Declaratory Ruling. A Declaratory Ruling, the application fee for which is $500, applies when the Council is petitioned for a determination that a project will not result in any substantial adverse environmental effects, and thus no certificate application is required.

The costs associated with the review of a CSC certificate application may differ from the initial certificate application fee, depending on the significance of environmental and other issues surrounding a project. If the CSC incurs actual costs not covered by the initial project application fee, the additional costs are assessed to the project sponsor. Such costs may be to cover additional CSC reviews, hearings, field inspections, project monitoring, etc. Any underexpenditures from the original application fee are refunded to the project applicant.

Table 6.6 summarizes the CSC's costs for the filing and review of representative overhead and underground transmission line dockets from 1985 to the present, as well as the time required to approve each application (i.e., from date of application submittal to date of certificate issuance). As Table 6.6 illustrates, the per mile transmission line costs for the CSC's application review appear to vary widely, ranging for overhead lines from $806/mile to $44,000/mile and for underground lines from $1,000/mile to $11,936/mile.

However, discounting the highest per mile costs for the review of each type of transmission line, then the average cost per mile is quite comparable -- $1,874/mile for overhead transmission lines and $1,872/mile for underground transmission lines.

Table 6.6

Summary of Connecticut Siting Council Costs and Time Frames for 115 kV Transmission Line Certification

CSC Docket No. and Project Type	Project Name/Year	Project Sponsor	Project Length (miles)	Cost			Time Required for Certification
				CSC Application Fee	CSC Additional Costs	Total	
OVERHEAD							
48	Bridgeport CRRA Plant-Ash Creek Pequonnock (new line)/1985	UI	0.45	$20,000	-	$20,000	4.5 months
57	Trumbull Junction to Old Town Substation, Bridgeport/1985-1986	CL & P	3.1	$2,500	-	$2,500	5.5 months
97	Farmington Substation to North Bloomfield Substation/ 1988-1989	CL & P	11.7	$6,000	$13,968.07	$19,968.07	7.5 months
105	Stevenson to Newtown-Plumtrees Line/1988-1989	CL & P	12.5	$8,700	$12,249.23	$20,949.23	9 months
141	Pequuonnock Substation, Bridgeport to Ely Avenue Junction, Norwalk/1991	CL & P and UI	15.3	$23,100	$27,529.37	$50,629.37	15 months
UNDERGROUND							
82	Capitol Avenue to S. Whitney Avenue, Hartford/1987 (new)	CL & P	1	$1,000	-	$1,000	2 months
85	Dexter Cogeneration to Windsor Locks/1988-1989 (new)	CL & P	0.3	$1,000	-	$1,000	4.5 months
98	Sterling Tire Plant to Plainfield Line/1988-1989 (new)	CL & P	7.6	$1,750	$10,540.42	$12,290.42	10.5 months
115	New Haven Substation to Water Street Substation/1989-1990 (new)	UI	3.2	$25,000	$13,194.48	$38,194.48	8 months

6.7 Environmental Factors During Construction

The construction of a transmission line -- either overhead or underground -- will result in various environmental impacts, which will differ in magnitude, duration, and extent, based on the type and location of the project. Both conventional costs and external environmental costs (impacts) will be incurred during project construction.

- ***Conventional Costs*** (monetary expenditures) will be incurred to comply with environmental specifications and permit/certificate requirements (e.g., cost of silt fence or hay bales for use as temporary erosion controls, cost of agency inspections of environmental aspects of construction work, cost for restoration and right-of-way revegetation).

- ***External Costs*** (non-dollar costs) will occur in the form of disturbance to the right-of-way, visual impacts, impacts to biota, nuisance impacts to the public (such as traffic congestion, noise, localized dust emissions) sedimentation into watercourses, etc.

Although the internal (conventional) costs of environmental compliance during construction can be quantified, for the same reasons as described in Section 6.6, utilities have not historically recorded such data. Typically, the conventional costs for environmental compliance are only a small percentage of the total cost of a project. Such conventional costs may include expenditures for items such as:

- Materials and supplies for use in the field during construction, such as erosion controls (silt fence, hay/straw bales, erosion control fabric or blankets), wetland crossing mats, mulch, fertilizer, seed, etc.

- Labor, both to implement the environmental protection measures in the field and to track regulatory compliance on an administrative basis.

- Agency compliance inspections (if not otherwise accounted for in permit filing fees).

For a particular project, conventional environmental costs are directly dependent on the project location (rural versus urban), type of construction, and environmental resources on or in the vicinity of the right-of-way. Such costs are one-time capital expenditures associated with a particular project. Table 6.7 provides a general comparison of the typical construction requirements for overhead versus underground transmission lines in

Table 6.7

Summary of Typical Transmission Line Construction Requirements

Construction Requirements	Type of Transmission Line: Urban Area		Type of Transmission Line: Rural Area	
	Overhead	Underground	Overhead	Underground
Right-of-Way Width	100 feet	Within city streets: 15 feet estimated	100 feet	50 feet (25 feet for construction and 25 feet permanent)
Staging Areas (for equipment, material storage, construction headquarters, etc.) (Preference is to use company-owned property)	Varies	Varies	Varies	Varies
Vegetation Clearing	If necessary, entire right-of-way (may involve selective cutting or trimming)	Not necessary if within city streets or road shoulders	Entire right-of-way. May use different cutting/clearing techniques, or only clear those areas required for access roads, pole sites, etc.	Entire right-of-way must be cleared
Grading	Probably not	No	Probably not, except in selected areas along access roads	May involve extensive grading and possibly grade blasting depending on topography
Blasting and Excavating	Blasting if necessary, only to excavate hole for pole. Excavation limited to pole holes.	Blasting not expected; excavation to create trench for pipe cable approximately 2'-3' wide and 5' deep (may be deeper in streets to avoid other utilities)	Blasting if necessary, only to excavate hole for pole. Excavation limited to pole holes	Extensive excavation and potentially blasting to create trench for underground cable or pipe. Trench typically is 2'-3' wide and 5' deep.
Wire Stringing and Pulling Sites (within right-of-way)	Yes	N/A	Yes	N/A
Access Roads (temporary)	Not generally. Use streets or access along railroad corridor	No	Yes	Yes (adjacent to trench area)
Stream/Wetland Crossings	No	No	Yes (access roads only)	Yes (trenching through and access)

Construction Requirements	Type of Transmission Line: Urban Area		Type of Transmission Line: Rural Area	
	Overhead	Underground	Overhead	Underground
Right-of-Way Restoration	Yes (as necessary)	Yes (repaving, etc.)	Yes (selective regrading, if necessary, revegetate, stabilize permanent access roads)	Yes (regrade entire disturbed right-of-way to approximate pre-construction conditions, stabilize right-of-way, and revegetate)
Permanent Access Road	No (use other existing access along streets, etc.)	No	Yes	No (maintain right-of-way so as to allow access along it)
Temporary Erosion Controls (e.g., silt fence, hay bales, jute, mulch)	Maybe	No	Yes (around areas of disturbed soils where vegetation is cleared)	Yes (all disturbed areas)
Estimated Time Frame for Construction	1 mile/month (NU)	1 mile/month (NU) 2-3 months (UI)* *single circuit	1 mile/month (NU) Variable (UI)	1 mile/month (NU)

rural versus urban areas, and offers an overall indication of the factors that are likely to influence relative environmental costs for each type of project.

In contrast to conventional environmental costs, impacts to environmental resources and to the public (i.e., project externalities) as a result of transmission line construction are not quantifiable in terms of dollar value. This is because many of these impacts are based on public perceptions, which vary individually (e.g., the "value" the public places on a view of a hillside with a visible right-of-way, the "cost" society associates with a temporary loss in wildlife habitat or a temporary decrease in water quality in a wetland crossed by construction equipment). As a result, impacts to environmental resources can only be identified and described qualitatively.

While monetary values can not be assigned to environmental resource costs, these impacts can be compared for different types of projects, qualitatively. Table 6.8 lists the common environmental impacts that can be expected from overhead and underground transmission line projects. The table assigns relative weights to the impacts to each type of environmental resource from the different types of transmission line construction, in rural versus urban areas.

In general, the installation of underground transmission lines in rural areas causes or has the potential to cause greater environmental resource impacts than the installation of overhead transmission lines. This is chiefly because substantially more land is temporarily disturbed in order to dig a trench than is disturbed to install individual structures for overhead lines.

Further, the installation of underground transmission lines in urban areas has been shown to be time-consuming and to require extensive coordination with other involved authorities and utilities (e.g., Department of Transportation, railroads) in order to limit nuisance impacts to the commuting public and commercial traffic. These factors, which are measures to mitigate environmental nuisance effects (e.g., traffic delays), should be considerations in decision-making.

Thus, while there may be a general perception that underground electric transmission lines result in fewer overall environmental impacts (perhaps based on a public viewpoint of "out of sight, lesser impact"), this is not the case for the construction phase.

Table 6.8

Comparison of Environmental Impacts and Mitigation for Overhead and Underground Transmission Lines*

Environmental Resource	Environmental Impacts/Mitigation: Urban Area		Environmental Impacts/Mitigation: Rural Area	
	Overhead	Underground	Overhead	Underground
WATER RESOURCES • Wetlands • Streams • Groundwater • Lakes and ponds	0/+1 *Impact:* None if within developed areas. Minor potential for erosion or sedimentation if certain structures are in or adjacent to water bodies. *Mitigation:* Temporary erosion controls. Revegetate disturbed sites.	0 *Impact:* None if within streets	+5 *Impact:* Localized to construction areas (e.g., structure sites and along access roads, not entire width of right-of-way if most existing vegetative cover is not removed), but same types of impacts as for rural UG. *Mitigation:* Avoid water resources by spanning wherever possible. Otherwise, same as for rural UG, but localized to limited areas of disturbance	+10 *Impact:* Along entire right-of-way, erosion and sedimentation into waterbodies; loss of stream and/or wetland habitat and function as a result of vegetation clearing or creation of access roads across waterbodies, impacts to groundwater wells due to blasting *Mitigation:* Installation of erosion controls to minimize sedimentation; prompt restoration and re-establishment of vegetative cover on disturbed sites. Can not avoid.
BIOLOGICAL RESOURCES • Wildlife • Vegetation • Fisheries • RTE Species	0 *Impact:* None if within urban area with no wildlife value	0 *Impact:* None	+5 *Impact:* At construction sites, disturbance to or loss of habitat, change in vegetative diversity, direct effects on less mobile forms of wildlife *Mitigation:* Time construction to avoid critical periods in lifecycles of wildlife (e.g., bird nesting, fish spawning). Revegetate disturbed areas with species beneficial to wildlife, if possible.	+10 *Impact:* Along entire right-of-way, disturbance to or loss of habitat; modifications to vegetative diversity stream bank and water quality modifications; effects of loss of riparian vegetation on fisheries *Mitigation:* Same as OH
LAND USE AND RECREATION • Parks/public use areas • Land uses • Third party uses of right-of-way	+1 *Impact:* Temporary disruption at construction sites (e.g., parking areas, other corridors) *Mitigation:* Restore previous land use, if possible	+1 *Impact:* N/A (except street disturbance)	+5 *Impact:* Temporary disruption to land use at construction sites. Unauthorized use of right-of-way can lead to erosion. *Mitigation:* Restore right-of-way to allow certain uses (agricultural, etc.). Barriers to deter unauthorized access.	+5 *Impact:* Restrictions on use options for land; temporary disruption of land use along entire right-of-way; impacts of unauthorized use (e.g., ATV use) *Mitigation:* Same as for OH

* Refer to key to comparative impact ranking codes at end of table

Table 6.8 (cont'd)

Comparison of Environmental Impacts and Mitigation for Overhead and Underground Transmission Lines*

Environmental Resource	Environmental Impacts/Mitigation: Urban Area		Environmental Impacts/Mitigation: Rural Area	
	Overhead	**Underground**	**Overhead**	**Underground**
TOPOGRAPHY, GEOLOGY, AND SOILS • Bedrock outcrops or shallow depth to bedrock • Steep slopes • Highly erodible, floodplain, or hydric soils	+1 *Impact:* Generally minor potential for adverse effects to soils, or significant areas of slopes or rock. *Mitigation:* Erosion controls	0 *Impact:* None.	+5 *Impact:* Potential for grading leading to erosion along access roads on steep slopes; blasting at selected pole locations. *Mitigation:* Avoid steep slopes and erodible soils by spanning. Adhere to blasting codes and requirements, use erosion controls to minimize potential for erosion.	+10 *Impact:* Can not be avoided; steep slopes may require extensive grading/blasting, increasing potential for erosion. Potential for permanent alteration to grade. Increased potential for blasting-related damages, caused by fly rock and detonation noise. Increased potential for soil compaction along entire right-of-way. *Mitigation:* Install soil erosion devices, control fly rock, decompact soils as appropriate.
VISUAL RESOURCES • National Register of Historic Places sites; visually sensitive areas • Proximity to public roads or other public use areas that offer a large population views of the facility	+5 *Impact:* View of structures against skyline *Mitigation:* Tower color to limit contrast	0 *Impact:* N/A; Temporary visual impact from construction disturbance.	+10 *Impact:* View of areas disturbed during construction; intrusive effects of towers and/or right-of-way; impact depends on degree of visual contrast to viewers. *Mitigation:* Tower placement to limit views, tower color to limit contrast, vegetative screening at road crossings and similar vantage points	+5 *Impact:* View of areas disturbed during construction and of maintained right-of-way thereafter (contrast between type of vegetation on and off right-of-way). *Mitigation:* Vegetation screening at road crossings. Longer right-of-way maintenance cycle to allow greater periods of vegetative regrowth on right-of-way, if possible.
CULTURAL RESOURCES • Archaeological • Historic	+1 *Impact:* Indirect effects on views/context from structures. Direct effects due to limited pole excavations unlikely in already disturbed areas. *Mitigation:* Pole color to limit contrast.	+1 *Impact:* Possible direct effects to buried resources during trench excavation. *Mitigation:* Consult with CHC, take appropriate action.	+5 *Impact:* Potential for greater direct effects on buried cultural resources along previously undisturbed access roads and at new pole sites. Indirect effects on standing historic structures as a result of views of transmission facilities *Mitigation:* Same as for UG, urban.	+10 *Impact:* Greatest potential for direct adverse impacts to cultural resources because of large areas of soil disturbance (i.e., potential impact area encompasses entire right-of-way). Views of right-of-way can cause indirect effects to context of standing historic structures. *Mitigation:* Same as for UG, urban. Will be more costly if more cultural resource sites must be mitigated.

* Refer to key to comparative impact ranking codes at end of table

Table 6.8 (cont'd)

Comparison of Environmental Impacts and Mitigation for Overhead and Underground Transmission Lines*

Environmental Resource	Environmental Impacts/Mitigation: Urban Area		Environmental Impacts/Mitigation: Rural Area	
	Overhead	Underground	Overhead	Underground
AIR QUALITY AND NOISE	+1 *Impact:* Fugitive dust, construction noise. *Mitigation:* Schedule noise hours to minimize nuisance effects; apply dust suppressants if necessary	+5 *Impact:* Same types of impacts as OH, but greater level due to extent of excavation required. *Mitigation:* Same as for OH	+1 *Impact:* Same as for urban OH. *Mitigation:* Same as for urban OH.	+1 *Impact:* Same as for urban OH. *Mitigation:* Same as for urban OH.
SOCIOECONOMICS • Traffic • Employment/income • Property values	+1 *Impact:* Traffic congestion during construction near structure sites only (otherwise roads spanned); impacts on property values and taxes; beneficial increases in employment and income. *Mitigation:* Time construction to avoid peak traffic periods. Screen/design facilities to limit views and reduce perceived effects on property values (as related to views of facilities).	+5 *Impact:* Same types as OH, except traffic disruptions more significant and longer-term due to extensive excavation work in streets. *Mitigation:* Same as for OH, except UG facilities not visible within streets and therefore no adverse effect on property values.	+1 *Impact:* Same as for urban project, except traffic congestion impacts less severe in rural areas. *Mitigation:* Same as for OH, urban.	+5 *Impact:* Same as for OH rural, except traffic congestion impacts more severe due to trenching across or beneath roads (rather than spanning) *Mitigation:* Same as for OH. UG rural right-of-way will be visible and therefore likely to have same perceived effects on property values as OH, rural.
AGRICULTURAL RESOURCES • Crop and hay land • Pasture land • Special uses	0 *Impact:* N/A	0 *Impact:* N/A	+1 *Impact:* Decrease in agricultural land/agricultural land production from placement of structures in agricultural areas; impacts to productivity caused by soil mixing or compaction; impacts to livestock. (ingestion of construction debris, disturbance caused by construction noise) *Mitigation:* Avoid placing structures in agricultural areas if possible. Time construction activities to avoid disturbance to livestock. Remove construction debris from agricultural areas. Restore crop and hay land productivity by decompaction, importing topsoil, fertilizing, etc.	+5 *Impact:* Same as for OH, rural except that UG construction will result in greater direct impacts to soil profile from trenching and use of entire right-of-way for equipment access. May involve cutting of underground tile drains, etc. *Mitigation:* Same as for OH, rural, except may involve extensive effort to restore soil productivity if soils are severely mixed or compacted, as well as to restore subsurface soil drainage patterns in certain types of soils.

* Refer to key to comparative impact ranking codes at end of table

Table 6.8 (cont'd)

Comparison of Environmental Impacts and Mitigation for Overhead and Underground Transmission Lines*

Environmental Resource	Environmental Impacts/Mitigation: Urban Area		Environmental Impacts/Mitigation: Rural Area	
	Overhead	Underground	Overhead	Underground
MARINE/COASTAL ZONE RESOURCES* • Coastal zone land use management objectives • Marine/anadromous fisheries • Shellfish resources • Recreational uses (* Only applicable to projects in state-designated coastal zone or within tidally influenced areas)	+1 *Impact:* N/A except in urban areas within coastal zone, where installation of OH line may adversely affect visual environment, inconsistent with coastal zone management goals. *Mitigation:* Screening, pole placement/color to limit visual impacts.	0 *Impact:* N/A	+5 *Impact:* Same as for OH, urban, except right-of-way as well as towers could be visible to the public in the coastal zone area. OH lines would generally span coastal waterbodies, avoiding direct impacts. Also limited potential for sedimentation into coastal waters at specific construction work areas (e.g., pole sites, access roads). *Mitigation:* Apply erosion controls to limit potential for sedimentation. Mitigation for visual effects more difficult, use similar techniques as for OH, urban.	+5 *Impact:* Trenching across streams or waterbodies within coastal zone can not be avoided, and results in associated effects of sedimentation on marine water quality and species. Impacts of views of cleared right-of-way on coastal recreation, etc. *Mitigation:* Avoid trenching in coastal waters in critical periods for fisheries. Apply visual screening to limit views of right-of-way to users of coastal zone.

Note: *Impacts* identified are generic and comparative. Additional, or different, types of impacts to be identified on a site-specific basis.

Impact Key Code: A relative impact ranking was assigned to indicate the comparative relationship between the potential impacts to an environmental resource from different types of transmission line construction and project locations. Impact: ranking is without consideration of mitigation. The key is:

0 = No impact
+1 = Minor impact
+5 = Moderate impact
+10 = Significant impact

6.8 Environmental Factors During Operation

As is the case for construction, the operation of transmission lines results in conventional environmental costs that can be (but have not traditionally been) quantified, as well as environmental effects that can only be assessed qualitatively. The primary environmental factors involved in transmission line operation include:

- ***Conventional Costs*** (labor and equipment) that are incurred to perform standard right-of-way vegetation maintenance and stabilization (e.g., vegetation control, repair of eroded areas), as well as labor (management or administrative) required to monitor or document compliance with and long-term environmental permit conditions (if any).

- ***Externalities*** associated with the maintenance of a maintained right-of-way, such as the effects on biological resources, as well as any perceived effects on visual resources and property values as a result of views of the rights-of-way and associated poles and other structures .

Table 6.9 summarizes the types of environmental effects that may be associated with different transmission project scenarios.

Conventional Costs

Of the conventional costs listed in Table 6.9, data are only available regarding the general costs of vegetation control on overhead transmission line rights-of-way. UI does not distinguish between the costs of right-of-way vegetation maintenance and other types of tree trimming, whereas NU estimates an average annual cost of approximately $663/circuit mile of 115 kV overhead line.

In New York State, the Department of Public Service requires that utilities annually submit data on herbicide use and costs for vegetation control on transmission line rights-of-way. Although these data provide overall annual costs and do not distinguish between types of transmission line right-of-way (voltage, width), the information illustrates the costs in general associated with different vegetation treatment methods (refer to Table 6.10).

Externality Costs

Externality costs associated with the different transmission line scenarios, as generally identified in Table 6.9, will vary substantially depending on the environmental conditions along and in the vicinity of a particular right-of-way, as well as on public perceptions and attitudes concerning the views of maintained rights-of-way, structures, and other

Table 6.9

Summary of Environmental Effects: Transmission Line Operation

Project Area	Overhead	Underground
RURAL	<u>Conventional Costs</u> • Right-of-way vegetation control (including herbicide use) • Other environmental maintenance • Regulatory compliance monitoring <u>Externalities</u> • View of right-of-way and structures • Perceptions about property values • Noise (nuisance) from corona discharge (crackling) in certain weather conditions (not normally a factor at 115-kV) • Effects on biological resources from vegetation control/habitat modification, bird collisions and wildlife electrocutions	<u>Conventional Costs</u> • Right-of-way vegetation control (in-cluding herbicide use) • Other environmental maintenance • Regulatory compliance monitoring <u>Externalities</u> • View of maintained right-of-way (contrast with adjacent vegetation) and any aboveground structures • Perceptions about property values • Effects on biological resources from vegetation control/habitat modification • Potential for spill or leak to the environment
URBAN	<u>Conventional Costs</u> None if right-of-way is in developed area <u>Externalities</u> • View of structures and wires • Perceptions about property values • Noise (nuisance) from corona discharge (crackling) • Bird collisions and wildlife electrocutions	<u>Conventional Costs</u> None <u>Externalities</u> • View of any aboveground structures • Potential for spill or leak to the environment

Table 6.10

Summary of Herbicide Cost for Transmission Right-of-Way Vegetation Maintenance (average 1990-1994)*

Treatment Acreage/ Methods	Company					
	Con Ed[1]	CHG & E[2]	O & R[3]	NYSEG[4]	Niagara Mohawk	RG & E[5]
Acres Treated	312	1,306	950	4.877	6,349	201
Treatment Costs ($)/Acre						
Foliar	$260	$339	$150	$240	$339	$432
Basal	$72	$275	$203	$346	$389	$146
Cut & Stump Treat		$640	$796	$349	$432	$400
Cut & No treat			$984	$331	$371	$247
Trim/Mile		$3,115		$1,509	$764	$3,268/acre
Brush Hog				$471	$352	

*Utilities do not necessarily perform all types of maintenance each year. Figures represent averages for years for which data were available.

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[1]Consolidated Edison

[2]Central Hudson Gas and Electric

[3]Orange and Rockland Utilities

[4]New York State Electric and Gas

[5]Rochester Gas and Electric

aboveground facilities. The primary potential adverse effects of transmission lines that have been the subject of research studies to date are:

- Aesthetic impairment (from overhead lines in particular, but also from rights-of-way in general);
- Noise (overhead lines operating at voltages above 115 kV only);
- Interference with radio reception (localized effects, overhead lines only); and
- Reduction in property values.

No particular studies were identified regarding the environmental effects of the operation/maintenance of an underground transmission line. For example, no research was found regarding the potential environmental effects of a leak or rupture of a fluid-filled underground transmission line. In addition, although wildlife may be affected by overhead transmission lines (e.g., through exposure to herbicides or to EMF, bird collisions, electrocutions), such potential effects are difficult to quantify or qualify and thus are not discussed further.

The following briefly summarizes the results of research on the other potential external costs of transmission lines.

Visual Resources In general, research studies have identified visual blight as a public concern with respect to overhead transmission lines, and have identified overhead transmission lines as an important contributor to the ranking of scenic quality. However, no studies have been identified that quantify the willingness of the public to pay to avoid these aesthetic impacts (RCG/Hagler, Bailey, Inc. 1993). On a project-by-project basis, the value attached to visual resources could be equated to the additional costs that the public (and regulatory agencies) are willing to have the utility (i.e., ratepayers) incur to avoid or minimize visual impacts (e.g., by rerouting, by undergrounding (if applicable), or by adopting a "no action" alternative).

Noise and Radio Reception Both of these externalities associated with overhead transmission line operation are localized in the immediate vicinity of the transmission corridor. Research concerning these externalities has not revealed a willingness to pay to avoid these nuisance factors. The noise and certain types of radio interference result from "corona discharge" which is not significant at 115-kV and is normally a factor in the design of facilities operating above about 230 kV.

Property Value Studies Considerable research has been performed to try to quantify adverse impacts on residential property values associated with proximity to overhead transmission lines, and to utility corridors in general. Although there is a perception that proximity to transmission lines could adversely affect property values, the results of studies performed to date have not supported this hypothesis by identifying lower sale prices for homes near transmission lines compared to similar homes elsewhere. One study did show, however, that homes near transmission lines did require a longer time to sell, which would equate to an impact in terms of the homeowner's asset liquidity (RCG/Hagler Bailey, Inc. 1993).

Summary of Environmental Factors During Operations

In sum, the environmental externality costs associated with the operation of a transmission line are generally perceived as less for an underground facility, in either rural or urban areas. Underground transmission avoids some of the environmental issues associated with overhead transmission lines (e.g., views of structures, potential for impacts to wildlife). However, externalities related to views of a maintained right-of-way and some aboveground structures remain issues for underground transmission lines (in rural areas), as will the issue of effects on property values.

6.9 Environmental Externalities and Integration into Project Planning and Decision-Making for Transmission Lines

As part of the evaluation of environmental life cycle costs for overhead versus underground transmission lines, available documents regarding methods for quantifying and incorporating environmental externalities into life cycle cost assessments were reviewed. The purpose of this review was to determine the availability of an externality model that could be applied to incorporate environmental externalities into the transmission line siting and review process in Connecticut.

The results of the review of published documents regarding externalities, as well as consultations with representatives of various agencies, organizations, and the utility sector, did not identify any existing models for incorporating externalities associated with transmission lines into utility or agency decision-making processes. For the most part, the externality models currently in use for energy planning are narrowly focused on methods for quantifying externalities associated with air emissions from electricity generation. Other types of externalities, such as those associated with resource extraction or energy transportation, typically are not discussed or are identified only on a qualitative basis. In the overall accounting of environmental externalities from power systems, the environmental costs of transmission are considered to be relatively insignificant (Edison Electric Institute 1994).

A recent environmental externalities study commissioned by the Empire State Electric Energy Research Corporation did generally describe the impacts of electricity transmission, but in the context of new transmission lines that would be necessary to connect new electric generating plants to the power grid. In particular, the study discussed externalities associated with overhead transmission lines, such as damages to land use and terrestrial resources (e.g., aesthetic impairment, noise, radio signal interference, loss of open space/biodiversity/habitat), as well as possible adverse effects to human health and to the health of wildlife near transmission lines. However, this analysis was a qualitative review and did not present a model for identifying or ranking transmission line externalities. The study did suggest that the damages associated with loss of open space, terrestrial impacts, and aesthetics could be quantified, on an order-of-magnitude basis, using property value studies (RCG/Hagler Bailey, Inc. 1993).

Another New York State study noted that while the idea of internalizing externalities into overall energy planning and decision-making has conceptual appeal, the actual operational task is made difficult by the almost infinite number of potential externalities (not only environmental, but also those relating to health, safety, and social welfare). The study further noted that externality valuation is a function of society's willingness and ability to pay for perceived benefits or changes in social welfare, which also are very difficult to measure (New York State Department of Public Service et al. 1994).

It would appear that externalities can be easily measured only on a project-specific basis, in situations where an actual value can be attributed to a specific outcome. For example, in order to preserve a forested buffer area between their homes and transmission line, a group of central Connecticut homeowners whose property abutted a transmission corridor within which a new line was to be built paid the utility's cost to relocate the line near their properties to the opposite side of the transmission right-of-way. In this instance, a specific value (the cost of the relocation) can be assigned to the value that the homeowners placed on aesthetics.

Other studies and reports (e.g., Buchanan July 1990) similarly have noted that it is difficult, if not impossible, to attempt to quantify some environmental externalities, which are in reality environmental risks. Examples are the risk of damage to a National Register of Historic Places site or to a designated rare, threatened or endangered (RTE) species, to which the allocation of dollar values may be impractical or inappropriate.

Studies (Buchanan July 1990) indicate that, in some cases, environmental costs may be integrated into decision-making by evaluating them in terms of society's willingness to pay, based on:

- Cost to control the impact (e.g., costs to adhere to special timing restrictions and crossing techniques to minimize impacts to a sensitive fisheries resource; transmission pole realignment to limit impacts to visual resources);

- Cost to mitigate the impact after the fact (e.g., restoration costs); or

- Damage costs associated with environmental risks (e.g., clean-up costs for a spill of fluid from an underground fluid-filled cable).

However, because of the limited historical environmental cost data available for transmission lines, there is little, if any basis upon which to derive standard estimates for environmental control, damage, or mitigation costs. On the other hand, such costs could be estimated on a project-specific basis to place a value on specific environmental resources of concern.

Finally, some attempts have been made to use matrices and weighted values to compare the external environmental impacts of different types of energy projects. For example, as described by Putta (July 1990), New York State developed techniques for setting price equivalents for some environmental impacts as part of that state's utility bidding program for power generation.

Part of the New York method involved the use of an Environmental Scoring Form, which lists and weights environmental attributes (e.g., "visual aesthetics" is assigned a weight of 1), along with point scores for different levels of impacts that a project will have on an attribute (e.g., a highly visible project is assigned 0 points, whereas one that is not visible from public roads is assigned the highest point ranking of 5). Impacts to environmental attributes are scored by multiplying points with weighting. A high number indicates a low impact level. An example is shown in Table 6.11 (Putta; July 1990).

Although the New York Environmental Scoring Form was designed for use by utilities in evaluating generation projects, it could theoretically be adapted by Connecticut utilities for use in decision-making for transmission line projects. However, the use of any matrix weighting scheme necessarily involves value judgments and qualitative comparisons that will always be subject to controversy. Overall, until (and if) relevant models are developed, environmental externalities for transmission lines are best evaluated qualitatively, and on a project-specific basis.

Table 6.11

Example of Environmental Scoring Form

Environmental Attribute	Weight (W)	Points (P)						Score (W x P)
		0	1	2	3	4	5	
Water Effects								
Water Quality Class	1	AA or better	A	**B**	C	NC	No water resources	1 x 2 = 2
Wetlands	2	Singnif. wetland, or more than 10 acres affected	between 5 and 10 acres affected	between 1 and 5 acres of wetland affected	less than 1 acres	**no perm. impacts**	No wetlands	2 x 4 = 8
Visual Effects	2	Highly visible to scenic resource site		**Within existing devel-oped area**		Not visible from public roads	Not visible to public	2 x 2 = 4
etc								

7 Associated Effects

7.1 Electric and Magnetic Fields

The Nature of EMF

Electric and magnetic fields (EMF) are invisible lines of force surrounding any wire or device that uses electricity. These fields are part of a broad electromagnetic spectrum. At the top of the spectrum are high frequency and very short wavelength fields associated with ionizing radiation such as X-rays. EMF associated with power transmission lines is at the bottom of the spectrum and has the same frequency as the electricity which creates them. In North America, this frequency is 60 Hertz (Hz), and is referred to as being in the extremely low frequency part of the electromagnetic spectrum.

At 60 Hz, EMF can be considered as two separated fields: an electric field and a magnetic field. An electric field is the product of voltage, which is comparable to the pressure of water in a pipe. It is measured in kilovolts per meter (kV/m). On the other hand, a magnetic field is the product of electric current, which can be best compared to the quantity of water flow in a pipe. It is usually measured in milligauss (mG).

EMF strengths around a transmission line vary in different locations. Of the most interest are EMF strengths at the ground level. The Institute of Electrical and Electronic Engineers (IEEE) has developed and published guidelines and standards for EMF measurement procedures. For transmission lines, the standards state that the EMF at ground level is to be measured at one meter (3.28 feet) above the ground.

Basics of EMF

The basics of EMF associated with power transmission lines can be summarized as follows:

- The strength of an electric field increases with the level of voltage, while the strength of a magnetic field increases with the amount of current.

- The field strengths are greatest in the immediate vicinity of a transmission line. They drop off rapidly with distance from the line.

- Electric fields can exist in any medium that does not conduct electricity (e.g. air) but not in media that do conduct electricity (e.g. soil).

- Magnetic fields can exist in any medium that is not magnetically permeable (e.g. air, soil) but not in media that are magnetically permeable (e.g. iron).

- Two electric fields or two magnetic fields can add together or cancel each other depending upon whether they are in the same or opposite directions.

- Because there is a degree of cancelation between the fields produced by each phase of a three-phase transmission line, the physical configuration of the conductors and their relative spacing affects the net EMF. The smaller the spacing, the weaker the fields.

- Due to the extremely low frequency involved, transmission lines do not "radiate" energy comparable to radio and television antennas.

- The biological effects from extremely low frequency fields are difficult to detect and define. At the present time, many studies on the subject of health risk and EMF have been conducted worldwide. To date, the scientific evidence is inconclusive, and a direct link between adverse health and EMF associated with electric power frequency (60 Hertz in North America) cannot be confirmed or denied.

Overhead Lines versus Underground Cables

EMF created by overhead lines and underground cables exhibit different features. Since soil is a relatively good electric conductor, there are no electric fields at ground level from underground cables. In the case of overhead lines, electric fields at ground level can be significantly reduced by trees, buildings, and other physical objects.

Usually underground cables are buried just a few feet below the ground, while overhead transmission lines are at least 30 feet above the ground. As a result, at ground level in the center of a right-of-way the magnetic fields from underground cables often exceed those from overhead lines.

On the other hand, beyond the edge of a right-of-way, the magnetic fields from underground cables are much weaker than those from overhead lines. This is because underground cables have a much more compact conductor spacing than do overhead lines.

Conductor height varies between two overhead transmission line structures. The minimum clearance or the greatest sag is usually at the midpoint of the span. As a result, the magnetic field at ground level is highest at the midpoint. Underground cables are usually buried at a reasonably uniform depth with the result that the magnetic fields do not vary much along the route.

EMF Management Options

In general, there are three approaches that can be used to reduce the EMF associated with transmission lines. These three approaches are

- reduce the current (magnetic field) or voltage (electric field) of the line
- increase the distance between ground level and the conductors
- arrange the geometric configuration of the conductors in such a way that the EMF produced by each tends to cancel.

Because the current and voltage level of a line are dictated by the load being served by the transmission system they cannot be considered as an option for controlling EMF levels. Increasing the distance between conductors and ground level requires taller structures for overhead lines and deeper trenches for underground lines, both of which will increase costs and other impacts of the line. EMF management options therefore revolve around selecting the most favorable geometric configuration of conductors.

One approach is to adopt a "compact design" where the separation between phase conductors is reduced. This results in the field cancellation effects between conductors being more pronounced as measured at ground level. In the case of overhead lines, compact spacing entails the use of shorter spans, more structures and more complex maintenance procedures, all of which tend to increase costs. Underground lines are inherently compact but in designs using single-core cables where some further degree of compaction may be feasible either the cost or performance of the line must be compromised due to the greater difficulty of dissipating heat.

A second approach to EMF management is to arrange the conductors in a delta or triangular configuration. Since the delta configuration approximates mutual symmetry between phase conductors more closely than do vertical or horizontal configurations, it results in a greater degree of EMF cancellation between phases.

For double-circuit lines six phase conductors are involved and a greater range of configuration options is possible. Options that minimize the EMF at the edge of the right-of-way do not necessarily give the minimum level at the center of the right-of-way but are usually chosen since field levels at the edge of the right-of-way are typically more important.

For underground cables, enclosing the cable in a metallic pipe will attenuate the magnetic field due to the counter-current that is induced in the pipe. Since this counter-current is related to the net unbalance between the phase currents it is much smaller than the phase currents under most operating conditions. However, since it is a source of loss on the line and therefore detracts significantly from the line performance, design measures are taken to reduce the magnitude of the counter-current and prevent it from flowing from end-to-end on the cable.

EMF Calculation

The EMF plots in Part B of this report are for the fields at ground level (one meter or 3.28 feet above the ground). A minimum clearance of 30 feet is used for all the overhead line configurations, while an average depth of four feet is assumed for underground cables. For each overhead line configuration, a total of six magnetic field profiles were calculated corresponding to six different current levels as detailed in Table 7.1. In the case of underground cables, less than six calculations are required because often the summer short term emergency currents for Scenario A and B, as well as the winter long term emergency currents, are equal (see Table 3.2 Loading Summary for Underground Cables in Section 3).

Table 7.1

Conditions for EMF Profile Calculation

	Scenario A	Scenario B
Expected Average Current	350 A	500 A
Summer Short Term Emergency Current	1500 A	2000 A
Winter Long Term Emergency Current	1750 A	2500 A

For the electric fields associated with overhead lines, only two profiles are needed to be calculated corresponding to the two different conductor sizes Scenario A and B. It is noted that the effects of conductor size on electric fields are very limited. With a large conductor size, the maximum increase in the fields is less than 5% and is usually at a location close to the center of the right-of-way. At the edge of the right-of-way, the effect of conductor size can normally be neglected. For underground cables, there is no need to calculate the electric fields because they are blocked by the ground.

EMF profiles were calculated, using the FIELDS program developed by Southern California Edison (SCE). This program has been validated against the program developed by Bonneville Power Administration as well as a program developed by Acres International.

A few assumptions, which are common in computing EMF profiles, are also used in this study. These assumptions are

- The transmission line is located on bare and flat terrain.
- Other nearby power lines are ignored.
- Changes in resistivity of the earth along the right-of-way are neglected.
- The effect of the metallic pipe of a pipe-type underground cable on magnetic fields is not considered.

7.2 Overhead Line Safety

While overhead transmission lines present a greater hazard to the public and utility workers than underground cables, the rate of injury is small. Over the past ten years, only two accidents involving 115 kV overhead lines (one resulting in human fatality) have been reported to the State of Connecticut Department of Utility Control (DPUC). Logically, it would be inappropriate to assess the risk of fatality based on this single incident. Proper risk analysis necessitates the collection and evaluation of many years of data in a larger population of circuits which reveal a similar level of exposure to the public as in Connecticut.

Non-fatal injuries from accidents due to overhead lines are more common, but often poorly reported. However, a portion of these incidents involve utility personnel, reports of which are available.

Line Contact Fatalities

In Canada, fatal accidents involving the public and utility systems are reported annually by the Canadian Electrical Association (CEA) in its "Accident Statistics". Unfortunately, an extensive search among US experts and publications revealed that there is no similar single source of this information in the US. In this search, the following avenues were investigated:

- Utility associations such as the Edison Electric Institute (EEI), the American Public Power Association (APPA) and the National Rural Electric Cooperative Association (NRECA) were assessed to be possible sources of overhead line contact accident data. Contact was made with each association, but none collect this information.

- The US Department of Energy's Energy Information Administration and the Utility Data Institute, both of which collect and report utility data, also do not collect accident data.

- Injury data from the Occupational Safety & Health Administration (OSHA) is quite complete and relatively accessible, but includes only work accidents and only those involving persons falling under OSHA jurisdiction, which are reported to be only about half of work-related electrocutions. Another major disadvantage of these data is that it is not possible to determine an incident rate, that is incidents per mile of transmission line.

- States with large populations are likely to have overhead line contact accident rates high enough to provide useful statistics, but the population density should be similar to that of Connecticut (approximately 640/square mile) to be representative. New York (population 18 million, 370/sq.mile) and Pennsylvania (population 12 million, 260/sq.mile) are the two most appropriate states. Overhead line contacts are reported to state regulatory bodies, similar to the DPUC, in each state. The Department of Public Service of New York State has approximately ten reports each year of fatal accidents involving transmission and distribution systems, but no statistics are prepared. The information is kept on file and copies are not furnished to others. The Pennsylvania Public Utility Commission similarly only keeps the fatal contact reports, which number less than ten per year, without further analysis or dissemination.

- Two major utilities in each of these states, the New York Power Authority and PECO Energy (Pennsylvania), were contacted, as well as the Pennsylvania

Electric Association, to determine if there was any state-wide effort to collect line contact accident data in each case, but to no avail.

- In its annual publication "Accident Facts", the National Safety Council publishes data on causes of death from accidents, compiled from death certificates gathered by the National Center for Health Statistics (NCHS). Included are accidental deaths due to "electric current", classified in accordance with the International Classification of Diseases (ICD) under five sources of electric current. Briefly, these are: domestic, power generation and distribution, industrial, other and unspecified. Most powerline contacts should fall under the second category, but the other and unspecified causes are generally quite extensive and will include many powerline related deaths, such as those resulting from electrical burns.

In the absence of accident data directly related to 115 kV lines, the overall rate of accidental death due to "electric current", published by the National Safety Council, can be used as a basis for estimating a fatal injury risk. The number of fatalities due to electric current has been steadily declining from 1,200 twenty years ago, to a projected 575 in 1995. A study of work-related fatalities in the US (Suruda July 1988) as well as a study of all electrical accidents in Canada (Hotte et al August 1990) report that sixty per cent of electrocutions are due to contact with powerlines. This implies that approximately 345 electrical fatalities are caused by powerlines each year.

To estimate the risk related to 115 kV lines, one can assume that the frequency of contact is the same for all overhead lines, which probably overestimates those for 115 kV and above. The EEI 1992 Statistical Yearbook reports a total of 468,877 circuit miles of lines operating at between 41 and 800 kV in the US. The Newton-Evans Research Co. estimated a US total of 4,092,000 line miles of overhead distribution in 1993. A total of 345 line contact fatalities involving 4,561,000 miles of overhead line then implies an overall rate of 0.084 fatalities per 1,000 miles of line per year. For one mile of line, this translates to one potential fatality in about 12,000 years. For the 1,300 miles of transmission line in Connecticut, it translates to one fatality in about 9 years, which is consistent with the single fatality reported by the DPUC over the past 10 years.

It must be realized, however, that the figure of 0.084/1,000 miles/year is calculated for the whole of the US, which has an overall population density of about 71 per square mile, compared with Connecticut with 640 per square mile, or nine times greater. Since greater population density also implies an increased density of overhead lines, the exposure and resulting risk of contact could conceivably be more than nine times greater than for the US as a whole. However, this cannot be validated with any data at this time.

Suruda (July 1988) reports an average of 158 OSHA-reported fatalities due to contact with powerlines. If it is assumed that OSHA reports only fifty per cent of this type of accident in the US, covering a total of 4,561,000 miles of overhead line, the fatality rate would be 0.07/1,000 miles/year, which is similar to the figure of 0.084 calculated above.

The relative validity of the estimated rate of 0.084/1,000 miles/year for lines in the actual 115 kV range can be assessed against the annual "Accident Statistics" data of the Canadian Electrical Association (CEA). Twenty-seven years of records for 115 to 160 kV lines reveal a total of 51 fatalities, a figure which includes 26 utility staff. Non-utility incidents included: climbing of structures (9), contact by high vehicles (4) such as cranes, sailboat masts and dump trucks, and trees felled into the line (4). Utility staff accidents included: falls from a structure (8), struck by a falling object (6), impact by a helicopter or aircraft carrying an employee (6), and electrical contact (2); at least 4 fatalities occurred during construction.

On the basis of the number of circuit miles of 115 to 161 kV line in all of Canada, this represents an overall rate of 0.06 fatalities/1,000 miles/year, of which 0.032/1,000 miles/year are electrical. Compared with the figure 0.084 electrical fatalities/1,000 miles/year estimated above for both transmission and distribution lines of all voltages in the US, this suggests that 115 kV lines have a lower risk of contact than distribution lines.

Using the Canadian figure of 0.06/1,000 miles/year, the 1,300 miles of 115 kV circuits in Connecticut could be expected to result in one fatality in a 13 year period, compared with the one incident reported in the 1985 to 1994 period. Again, Connecticut's greater population density, as compared to populated areas in Canada, could result in a higher incidence of line contact fatalities.

Taking the more conservative estimate of 0.084/1,000 miles/year, calculated for the whole of the US transmission and distribution system, the probability of a fatality on a one mile stretch of 115 kV transmission line is 8.4×10^{-5}/year. Consequently, there is an estimated 0.3% chance of a fatality during the 35-year life of a mile of line. This figure applies to a single-circuit line and should be doubled for two circuits, although it is debatable whether a two-circuit line poses the same risk as two single circuit lines.

Non-Fatal Line-Related Injuries

Many accidents involving transmission lines are non-fatal. For instance, cases have been reported where a person has survived a fall from a tower, and it is reported that 40% of people who have directly contacted 115 kV lines have survived (Hotte et al August 1990). Statistics on non-fatal accidents are very difficult to obtain, except for those involving utility personnel, and they form the majority.

CL&P employee injury reports for the years 1991 to 1994 form a good basis for estimating an injury rate. During this period, 76 transmission line related work injuries were reported during maintenance or construction. Of these, 42% were falls, trips, sprains etc, and 38% were insect bites or stings (71% of these involved ticks with the consequent concern for Lyme disease). No electrical contact injuries were reported. Many of the accidents, such as trips and insect bites occurred on rights-of-way and were not necessarily directly related to line work; similar accidents could happen along an underground cable route. Only 50% of the injuries were directly associated with line work.

For 1,625 miles of CL&P 69 to 345 kV lines, and taking just 50% of the injuries, this translates to an overall rate of 0.0058 injuries/circuit mile/year. For each mile of line, this implies a 4% chance of a utility worker being injured during the 35 year economic life of a single-circuit line and 8% in the case of a double-circuit line.

Most of the injuries were relatively minor, only four (5%) being severe enough to require medical treatment. Therefore, the rate of 0.0058 injuries/circuit mile/year is a pessimistic view of the potential injury risk of a 115 kV overhead line.

Transmission Line Related Accidents

Accidents involving transmission lines can also result in only property damage, without bodily harm. CL&P reports four contact incidents involving 115 kV lines during the past 10 years, which is a rate of 0.24/1,000 circuit miles/year. For each mile of line this would translate to a risk of 0.24 x 10^{-3}/circuit mile/year, or a 0.8% chance of a line contact incident without injuries, in a single-circuit line's 35-year life (1.6% for double circuit). Naturally, this only represents incidents that were sufficiently significant for a damage claim, and there could be many more that were not reported.

Associated with these incidents is possible cost of property damage and, in some cases, a line outage. But because the probability of a severe impact is small, the expected cost is also relatively small. For example, helicopter and aircraft impacts represent a category of accident where property damage would be high. Among the 27 years of CEA data were five helicopter and two plane crashes associated with transmission lines, translating to a rate of 0.00278/1,000 miles/year. For each mile of line, this implies a cost of approximately $100 per $1,000,000 of aircraft cost over the 35-year line life.

Unlike distribution lines, most 115 kV lines in Connecticut are generally not located along roadways, so there are few vehicle-structure impacts, with their concomitant loss of life and property damage. The reduced possibility of access, relative to distribution lines, also ensures fewer contacts by cranes and other elevating equipment that are frequently involved in distribution line contacts.

7.3 Underground Cable Safety

The frequency of injuries associated with underground cables is much smaller than those due to overhead transmission lines. In Connecticut, the DPUC has no record of any such event in the past ten years. Suruda (July 1988) reports only four underground high voltage cable fatalities among 475 work-related powerline contact fatalities. Since the total length of transmission and distribution cable in the US is about 1/6th of the total miles of underground and overhead line, the risk of fatalities per mile for underground lines may represent about 5% of that for overhead lines.

If the risk of fatality for 115 kV overhead lines is 8.4×10^{-5}/circuit mile/year, this leads to a risk of 115 kV underground cable contact fatality of 1×10^{-6}/year. That is, there is an estimated 0.01% chance of a fatality during the 35-year life of the line.

For another perspective on the number of possible underground cable-caused fatalities, one can consider the number of accidental dig-ins reported to the DPUC. The current aggregate length of buried utility plant (electrical, telephone, gas, cable television, water) in Connecticut is 27,420 miles, and this figure is increasing by about 1,000 miles per year. The number of dig-in incidents has averaged about 600, or 0.024/mile/year, over the past five years and is decreasing, largely due to regulations that were reinforced in 1987. "Call-before-you-dig" requirements are now also much more stringent. This frequency lies within the wide range of the high voltage cable dig-in rates being experienced by Consolidated Edison in New York, and Ontario Hydro, which are approximately 0.2/mile/year and 0.0015/mile/year respectively.

On the basis of an overall Connecticut rate of 0.024/mile/year, the potential number of dig-ins per mile of 115 kV cable would be about 0.8 during its 35-year life.

The number of injuries associated with cable dig-ins is low and little US data is available. Reports by the Province of Alberta in Canada, where reporting of all dig-in incidents is mandatory, showed two injuries in 461 incidents, or 0.43 per cent. On this basis, the probability of an injury caused by dig-in would be 1 x 10^{-4}/circuit mile/year, or a 0.36% chance per mile of cable of an injury during the 35-year life of the cable.

7.4 Overhead versus Underground Safety Comparison

Table 7.2 summarizes the statistical risk data developed in the preceding sections. All figures are for one circuit-mile of line over a 35-year period.

Table 7.2

Risk Comparison of Overhead versus Underground Lines

Risk	**Estimated Probability (during 35 year life)**	
	Overhead	**Underground**
Fatality	0.3%[1]	0.01%[2]
Injury	4%[3]	0.36%[4]
Contact with Lines	>0.8%[5]	0.8 dig-ins[6]

Notes:

All figures are estimates based on data and assumptions drawn from various sources (see text):

1 Based on data for the US as a whole, OSHA incident ratios and estimates of US transmission and distribution line miles

2 Based on (1) and OSHA underground/overhead fatality ratio and estimates of US transmission and distribution underground cable miles.

3 From 4-years of CL&P employee injury reports, injuries from insect stings to those requiring subsequent medical treatment.

4 Based on (6) and injury/dig-in ratio from Province of Alberta data.

5 From 10 years of CL&P damage claim information.

6 Based on DPUC dig-in data for all underground utilities in Connecticut.

Part D

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Appendix A

Detailed Construction Cost Estimates

Construction Cost Estimate

Overhead Single-circuit H-Frame (Scenario A: 795 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
<u>Civil Work</u>							
R-O-W clearing	6.06	acre	$3,500	$5,000.00	$21,215	$30,307	$51,522
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7,200
Structure erection: Wooden H-frames	9.8	ea	$7,200		$70,560	$0	$70,560
Structure grounding	9.8	ea	$300		$2,940	$0	$2,940
Guying	4	ea	$900		$3,600	$0	$3,600
Stringing	8.8	span	$3,630		$31,944	$0	$31,944
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$133,859*	*$33,907*	*$167,766*
<u>Overhead Line</u>							
Conductor:							
- 795 kcmil ACSR (DRAKE)	16650	ft	$0	$1.33	$0	$22,149	$22,149
Shield wire	11100	ft	$0	$0.30	$0	$3,330	$3,330
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434.60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519.40	$0	$0	$0
- 4.5 feet long suspension insulator	32.4	ea	$0	$233.20	$0	$7,556	$7,556
- 5.5 feet long suspension insulator	0	ea	$0	$265.00	$0	$0	$0
Shield wire support arm	49	lb	$0	$1.06	$0	$52	$52
Structure supply:							
- Wooden H-frames: Tangent	7.8	ea	$0	$4,897.20	$0	$38,198	$38,198
- Wooden H-Frame: Angle	1	ea	$0	$5,386.92	$0	$5,387	$5,387
- Wooden H-Frame: Dead End	1	ea	$0	$5,720.82	$0	$5,721	$5,721
Material handling & storage	15%	lot			$0	$12,359	$12,359
Sub-total					*$0*	*$94,752*	*$94,752*
Administration	2%	lot					$5,250
Engineering & supervision	11.5%	lot					$30,190
AFUDC	3%	lot					$8,939
Contingency	15%	lot					$44,694
Total Line Cost (per Mile)							**$351,590**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Terminal structures:	2	ea	$3,710	$5,720.82	$7,420	$11,442	$18,862
Testing & commissioning	1	lot	$10,000		$10,000	$0	$10,000
Material handling & storage	15%	lot			$0	$1,716	$1,716
Sub-total					*$17,420*	*$13,158*	*$30,578*
Administration	2%	lot					$612
Engineering & supervision	11.5%	lot					$3,516
AFUDC	3%	lot					$1,041
Contingency	15%	lot					$5,206
Total Terminal Cost							**$40,953**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate

Overhead Single-circuit H-Frame (Scenario B: 1272 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total Cost Total
Civil Work							
R-O-W clearing	6.06	acre	$3,500	$5,000.00	$21,215	$30,307	$51,522
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7,200
Structure erection: Wooden H-frames	9.8	ea	$7,200		$70,560	$0	$70,560
Structure grounding	9.8	ea	$300		$2,940	$0	$2,940
Guying	4	ea	$900		$3,600	$0	$3,600
Stringing	8.8	span	$4,140		$36,432	$0	$36,432
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$138,347*	*$33,907*	*$172,254*
Overhead Line							
Conductor:							
- 1272 kcmil ACSR (PHEASANT)	16650	ft	$0	$2.05	$0	$34,098	$34,098
Shield wire	11100	ft	$0	$0.30	$0	$3,330	$3,330
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434.60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519.40	$0	$0	$0
- 4.5 feet long suspension insulator	32.4	ea	$0	$233.20	$0	$7,556	$7,556
- 5.5 feet long suspension insulator	0	ea	$0	$265.00	$0	$0	$0
Shield wire support arm	49	lb	$0	$1.06	$0	$52	$52
Structure supply:							
- Wooden H-frames: Tangent	7.8	ea	$0	$4,897.20	$0	$38,198	$38,198
- Wooden H-Frame: Angle	1	ea	$0	$5,542.74	$0	$5,543	$5,543
- Wooden H-Frame: Dead End	1	ea	$0	$5,720.82	$0	$5,721	$5,721
Material handling & storage	15%	lot			$0	$14,175	$14,175
Sub-total					*$0*	*$108,672*	*$108,672*
Administration	2%	lot					$5,619
Engineering & supervision	11.5%	lot					$32,306
AFUDC	3%	lot					$9,566
Contingency	15%	lot					$47,828
Total Line Cost (per Mile)							**$376,243**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total Cost Total
Terminal structures:	2	ea	$3,710	$5,720.82	$7,420	$11,442	$18,862
Testing & commissioning	1	lot	$10,000		$10,000	$0	$10,000
Material handling & storage	15%	lot			$0	$1,716	$1,716
Sub-total					*$17,420*	*$13,158*	*$30,578*
Administration	2%	lot					$612
Engineering & supervision	11.5%	lot					$3,516
AFUDC	3%	lot					$1,041
Contingency	15%	lot					$5,206
Total Terminal Cost							**$40,953**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate

Overhead Single-circuit H-Frame with compact spacing (Scenario A: 795 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip	Total Cost Labor	Total Cost Material	Total Cost Total
Civil Work							
R-O-W clearing	6 06	acre	$3,500	$5,000.00	$21,215	$30.307	$51 522
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7 200
Structure erection: Wooden H-frames	9.8	ea	$7,200		$70,560	$0	$70,560
Structure grounding	9.8	ea	$300		$2,940	$0	$2,940
Guying	3	ea	$900		$2,700	$0	$2,700
Stringing	8.8	span	$3,630		$31.944	$0	$31.944
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$132,959*	*$33,907*	*$166 866*
Overhead Line							
Conductor:							
- 795 kcmil ACSR (DRAKE)	16650	ft	$0	$1 33	$0	$22,149	$22.149
Shield wire	11100	ft	$0	$0.30	$0	$3,330	$3.330
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434 60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519 40	$0	$0	$0
- 4 5 feet long suspension insulator	64 8	ea	$0	$233.20	$0	$15,111	$15,111
- 5 5 feet long suspension insulator	0	ea	$0	$265.00	$0	$0	$0
Shield wire support arm	49	lb	$0	$1 06	$0	$52	$52
Structure supply:							
- Wooden H-frames: Tangent	7.8	ea	$0	$4,897.20	$0	$38,198	$38,198
- Wooden H-Frame: Angle	1	ea	$0	$5,386.92	$0	$5,387	$5,387
- Wooden H-Frame: Dead End	1	ea	$0	$5,720.82	$0	$5,721	$5,721
Material handling & storage	15%	lot			$0	$13,492	$13,492
Sub-total					*$0*	*$103,441*	*$103,441*
Administration	2%	lot					$5 406
Engineering & supervision	11 5%	lot					$31,085
AFUDC	3%	lot					$9.204
Contingency	15%	lot					$46,020
Total Line Cost (per Mile)							**$362,022**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip	Total Cost Labor	Total Cost Material	Total Cost Total
Terminal structures:	2	ea	$3,710	$5,720.82	$7,420	$11,442	$18,862
Testing & commissioning	1	lot	$10,000		$10,000	$0	$10,000
Material handling & storage	15%	lot			$0	$1,716	$1,716
Sub-total					*$17,420*	*$13,158*	*$30,578*
Administration	2%	lot					$612
Engineering & supervision	11 5%	lot					$3,516
AFUDC	3%	lot					$1,041
Contingency	15%	lot					$5,206
Total Terminal Cost							**$40,953**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate

Overhead Single-circuit H-Frame with compact spacing (Scenario B: 1272 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Civil Work							
R-O-W clearing	6.06	acre	$3,500	$5,000.00	$21,215	$30,307	$51,522
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7,200
Structure erection: Wooden H-frames	9.8	ea	$7,200		$70,560	$0	$70,560
Structure grounding	9.8	ea	$300		$2,940	$0	$2,940
Guying	3	ea	$900		$2,700	$0	$2,700
Stringing	8.8	span	$4,140		$36,432	$0	$36,432
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$137,447*	*$33,907*	*$171,354*
Overhead Line							
Conductor:							
- 1272 kcmil ACSR (PHEASANT)	16650	ft	$0	$2.05	$0	$34,098	$34,098
Shield wire	11100	ft	$0	$0.30	$0	$3,330	$3,330
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434.60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519.40	$0	$0	$0
- 4.5 feet long suspension insulator	64.8	ea	$0	$233.20	$0	$15,111	$15,111
- 5.5 feet long suspension insulator	0	ea	$0	$265.00	$0	$0	$0
Shield wire support arm	49	lb	$0	$1.06	$0	$52	$52
Structure supply:							
- Wooden H-frames: Tangent	7.8	ea	$0	$4,897.20	$0	$38,198	$38,198
- Wooden H-Frame: Angle	1	ea	$0	$5,542.74	$0	$5,543	$5,543
- Wooden H-Frame: Dead End	1	ea	$0	$5,720.82	$0	$5,721	$5,721
Material handling & storage	15%	lot			$0	$15,308	$15,308
Sub-total					*$0*	*$117,361*	*$117,361*
Administration	2%	lot					$5,774
Engineering & supervision	11.5%	lot					$33,202
AFUDC	3%	lot					$9,831
Contingency	15%	lot					$49,154
Total Line Cost (per Mile)							**$386,675**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Terminal structures:	2	ea	$3,710	$5,720.82	$7,420	$11,442	$18,862
Testing & commissioning	1	lot	$10,000		$10,000	$0	$10,000
Material handling & storage	15%	lot			$0	$1,716	$1,716
Sub-total					*$17,420*	*$13,158*	*$30,578*
Administration	2%	lot					$612
Engineering & supervision	11.5%	lot					$3,516
AFUDC	3%	lot					$1,041
Contingency	15%	lot					$5,206
Total Terminal Cost							**$40,953**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate

Overhead Single-circuit wood pole with compact delta arrangement (Scenario A: 795 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Civil Work							
R-O-W clearing	6.06	acre	$3,500	$5,000.00	$21,215	$30,307	$51.522
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7.200
Structure erection: Wooden H-frames	22.12	ea	$4,000		$88,480	$0	$88,480
Structure grounding	22.12	ea	$200		$4,424	$0	$4.424
Guying	5	ea	$500		$2,500	$0	$2.500
Stringing	21.12	span	$1,560		$32,947	$0	$32,947
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$153,166*	*$33,907*	*$187 073*
Overhead Line							
Conductor:							
- 795 kcmil ACSR (DRAKE)	16650	ft	$0	$1.33	$0	$22,149	$22,149
Shield wire	5550	ft	$0	$0.30	$0	$1,665	$1,665
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	63.36	ea	$0	$434.60	$0	$27,536	$27,536
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519.40	$0	$0	$0
- 4.5 feet long suspension insulator	9	ea	$0	$233.20	$0	$2,099	$2.099
- 5.5 feet long suspension insulator	0	ea	$0	$159.00	$0	$0	$0
Shield wire support arm	110.6	lb	$0	$1.06	$0	$117	$117
Structure supply:							
- Wooden H-frames: Tangent	20.12	ea	$0	$1,070.60	$0	$21,540	$21,540
- Wooden H-Frame: Angle	1	ea	$0	$2,024.60	$0	$2,025	$2,025
- Wooden H-Frame: Dead End	1	ea	$0	$2,151.80	$0	$2,152	$2,152
Material handling & storage	15%	lot			$0	$11,893	$11,893
Sub-total					*$0*	*$91,176*	*$91,176*
Administration	2%	lot					$5,565
Engineering & supervision	11.5%	lot					$31,999
AFUDC	3%	lot					$9,474
Contingency	15%	lot					$47,372
Total Line Cost (per Mile)							**$372,659**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Terminal structures:	2	ea	$2,120	$2,151.80	$4,240	$4,304	$8,544
Testing & commissioning	1	lot	$10,000		$10,000	$0	$10,000
Material handling & storage	15%	lot			$0	$646	$646
Sub-total					*$14,240*	*$4,949*	*$19,189*
Administration	2%	lot					$384
Engineering & supervision	11.5%	lot					$2,207
AFUDC	3%	lot					$653
Contingency	15%	lot					$3,267
Total Terminal Cost							**$25,700**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate

Overhead Single-circuit wood pole with compact delta arrangement (Scenario A: 1272 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Civil Work							
R-O-W clearing	6.06	acre	$3,500	$5,000.00	$21,215	$30,307	$51,522
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7,200
Structure erection: Wooden H-frames	22.12	ea	$4,000		$88,480	$0	$88,480
Structure grounding	22.12	ea	$200		$4,424	$0	$4,424
Guying	6	ea	$500		$3,000	$0	$3,000
Stringing	21.12	span	$1,800		$38,016	$0	$38,016
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$158,735*	*$33,907*	*$192,642*
Overhead Line							
Conductor:							
- 1272 kcmil ACSR (PHEASANT)	16650	ft	$0	$2.05	$0	$34,098	$34,098
Shield wire	5550	ft	$0	$0.30	$0	$1,665	$1,665
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	63.36	ea	$0	$434.60	$0	$27,536	$27,536
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519.40	$0	$0	$0
- 4.5 feet long suspension insulator	9	ea	$0	$233.20	$0	$2,099	$2,099
- 5.5 feet long suspension insulator	0	ea	$0	$159.00	$0	$0	$0
Shield wire support arm	110.6	lb	$0	$1.06	$0	$117	$117
Structure supply:							
- Wooden H-frames: Tangent	20.12	ea	$0	$1,070.60	$0	$21,540	$21,540
- Wooden H-Frame: Angle	1	ea	$0	$2,151.80	$0	$2,152	$2,152
- Wooden H-Frame: Dead End	1	ea	$0	$2,151.80	$0	$2,152	$2,152
Material handling & storage	15%	lot			$0	$13,704	$13,704
Sub-total					*$0*	*$105,063*	*$105,063*
Administration	2%	lot					$5,954
Engineering & supervision	11.5%	lot					$34,236
AFUDC	3%	lot					$10,137
Contingency	15%	lot					$50,684
Total Line Cost (per Mile)							**$398,716**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Terminal structures:	2	ea	$2,120	$2,151.80	$4,240	$4,304	$8,544
Testing & commissioning	1	lot	$10,000		$10,000	$0	$10,000
Material handling & storage	15%	lot			$0	$646	$646
Sub-total					*$14,240*	*$4,949*	*$19,189*
Administration	2%	lot					$384
Engineering & supervision	11.5%	lot					$2,207
AFUDC	3%	lot					$653
Contingency	15%	lot					$3,267
Total Terminal Cost							**$25,700**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate

Overhead Single-circuit steel pole (Scenario A: 795 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total Cost Total
Civil Work							
R-O-W clearing	6.06	acre	$3,500	$5,000.00	$21,215	$30,307	$51,522
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7,200
Structure erection: Steel poles	9.8	ea	$2,000	$4,000.00	$19,600	$39,200	$58,800
Pad & Pier foundations	2	ea	$15,000	$35,000.00	$30,000	$70,000	$100,000
Structure grounding	9.8	ea	$200		$1,960	$0	$1,960
Guying	0	ea	$500		$0	$0	$0
Stringing	8.8	span	$3,150		$27,720	$0	$27,720
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$104,095*	*$143,107*	*$247,202*
Overhead Line							
Conductor:							
- 795 kcmil ACSR (DRAKE)	16650	ft	$0	$1.33	$0	$22,149	$22,149
Shield wire	5550	ft	$0	$0.30	$0	$1,665	$1,665
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434.60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519.40	$0	$0	$0
- 4.5 feet long suspension insulator	0	ea	$0	$233.20	$0	$0	$0
- 5.5 feet long suspension insulator	35.4	ea	$0	$265.00	$0	$9,381	$9,381
Shield wire support arm	490	lb	$0	$1.06	$0	$519	$519
Structure supply:							
-Steel poles: Tangent	31200	lb	$0	$1.06	$0	$33,072	$33,072
-Steel pole: Angle	7000	lb	$0	$1.06	$0	$7,420	$7,420
- Steel pole: Dead End	12000	lb	$0	$1.06	$0	$12,720	$12,720
Material handling & storage	15%	lot			$0	$13,039	$13,039
Sub-total					*$0*	*$99,966*	*$99,966*
Administration	2%	lot					$6,943
Engineering & supervision	11.5%	lot					$39,924
AFUDC	3%	lot					$11,821
Contingency	15%	lot					$59,105
Total Line Cost (per Mile)							$464,962

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total Cost Total
Terminal structures:	24000	lb	$4,000	$1.06	$4,000	$25,440	$29,440
Testing & commissioning	1	lot	$10,000		$10,000	$0	$10,000
Material handling & storage	15%	lot			$0	$3,816	$3,816
Sub-total					*$14,000*	*$29,256*	*$43,256*
Administration	2%	lot					$865
Engineering & supervision	11.5%	lot					$4,974
AFUDC	3%	lot					$1,473
Contingency	15%	lot					$7,364
Total Terminal Cost							$57,933

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			$118,000

Construction Cost Estimate
Overhead Single-circuit steel pole (Scenario B: 1272 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Civil Work							
R-O-W clearing	6.06	acre	$3,500	$5,000.00	$21,215	$30,307	$51,522
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7,200
Structure erection: Steel poles	9.8	ea	$2,000	$4,000.00	$19,600	$39,200	$58,800
Pad & Pier foundations	2	ea	$15,000	$35,000.00	$30,000	$70,000	$100,000
Structure grounding	9.8	ea	$200		$1,960	$0	$1,960
Guying	0	ea	$500		$0	$0	$0
Stringing	8.8	span	$3,660		$32,208	$0	$32,208
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$108,583*	*$143,107*	*$251,690*
Overhead Line							
Conductor:							
- 1272 kcmil ACSR (PHEASANT)	16650	ft	$0	$2.05	$0	$34,098	$34,098
Shield wire	5550	ft	$0	$0.30	$0	$1,665	$1,665
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434.60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519.40	$0	$0	$0
- 4.5 feet long suspension insulator	0	ea	$0	$233.20	$0	$0	$0
- 5.5 feet long suspension insulator	35.4	ea	$0	$265.00	$0	$9,381	$9,381
Shield wire support arm	490	lb	$0	$1.06	$0	$519	$519
Structure supply:							
- Steel poles: Tangent	33150	lb	$0	$1.06	$0	$35,139	$35,139
- Steel pole: Angle	8600	lb	$0	$1.06	$0	$9,116	$9,116
- Steel pole: Dead End	12700	lb	$0	$1.06	$0	$13,462	$13,462
Material handling & storage	15%	lot			$0	$15,507	$15,507
Sub-total					*$0*	*$118,887*	*$118,887*
Administration	2%	lot					$7,412
Engineering & supervision	11.5%	lot					$42,616
AFUDC	3%	lot					$12,618
Contingency	15%	lot					$63,091
Total Line Cost (per Mile)							**$496,314**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Terminal structures:	25400	lb	$4,240	$1.06	$4,240	$26,924	$31,164
Testing & commissioning	1	lot	$10,000		$10,000	$0	$10,000
Material handling & storage	15%	lot			$0	$4,039	$4,039
Sub-total					*$14,240*	*$30,963*	*$45,203*
Administration	2%	lot					$904
Engineering & supervision	11.5%	lot					$5,198
AFUDC	3%	lot					$1,539
Contingency	15%	lot					$7,696
Total Terminal Cost							**$60,540**

Regulatory & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate

Overhead single-circuit steel pole with compact spacing (Scenario A: 795 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Civil Work							
R-O-W clearing	6 06	acre	$3,500	$5,000.00	$21,215	$30,307	$51.522
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7.200
Structure erection: Steel poles	9 8	ea	$2,000	$4,000.00	$19,600	$39,200	$58,800
Pad & Pier foundations	2	ea	$15,000	$35,000.00	$30,000	$70,000	$100.000
Structure grounding	9 8	ea	$200		$1,960	$0	$1,960
Guying	0	ea	$500		$0	$0	$0
Stringing	8 8	span	$3,150		$27,720	$0	$27,720
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$104,095*	*$143,107*	*$247,202*
Overhead Line							
Conductor:							
- 795 kcmil ACSR (DRAKE)	16650	ft	$0	$1 33	$0	$22,149	$22.149
Shield wire	5550	ft	$0	$0 30	$0	$1,665	$1 665
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434.60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519.40	$0	$0	$0
- 4.5 feet long suspension insulator	0	ea	$0	$233 20	$0	$0	$0
- 5.5 feet long suspension insulator	61 8	ea	$0	$265.00	$0	$16,377	$16.377
Shield wire support arm	245	lb	$0	$1.06	$0	$260	$260
Structure supply:							
-Steel poles: Tangent	28860	lb	$0	$1.06	$0	$30,592	$30.592
-Steel pole: Angle	6400	lb	$0	$1 06	$0	$6,784	$6,784
- Steel pole: Dead End	11000	lb	$0	$1 06	$0	$11,660	$11,660
Material handling & storage	15%	lot			$0	$13,423	$13.423
Sub-total					*$0*	*$102,910*	*$102,910*
Administration	2%	lot					$7.002
Engineering & supervision	11 5%	lot					$40 263
AFUDC	3%	lot					$11,921
Contingency	15%	lot					$59,606
Total Line Cost (per Mile)							**$468,904**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Terminal structures:	22000	lb	$4,240	$1 06	$4,240	$23,320	$27,560
Testing & commissioning	1	lot	$10,000		$10,000	$0	$10,000
Material handling & storage	15%	lot			$0	$3,498	$3,498
Sub-total					*$14,240*	*$26,818*	*$41,058*
Administration	2%	lot					$821
Engineering & supervision	11 5%	lot					$4,722
AFUDC	3%	lot					$1,398
Contingency	15%	lot					$6,990
Total Terminal Cost							**$54,989**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate

Overhead single-circuit steel pole with compact spacing (Scenario B: 1272 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip	Total Cost Labor	Total Cost Material	Total Cost Total
Civil Work							
R-O-W clearing	6.06	acre	$3,500	$5,000.00	$21,215	$30,307	$51,522
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7,200
Structure erection: Steel poles	9.8	ea	$2,000	$4,000.00	$19,600	$39,200	$58,800
Pad & Pier foundations	2	ea	$15,000	$35,000.00	$30,000	$70,000	$100,000
Structure grounding	9.8	ea	$200		$1,960	$0	$1,960
Guying	0	ea	$500		$0	$0	$0
Stringing	8.8	span	$3,660		$32,208	$0	$32,208
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$108,583*	*$143,107*	*$251,690*
Overhead Line							
Conductor:							
- 1272 kcmil ACSR (PHEASANT)	16650	ft	$0	$2.05	$0	$34,098	$34,098
Shield wire	5550	ft	$0	$0.30	$0	$1,665	$1,665
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434.60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519.40	$0	$0	$0
- 4.5 feet long suspension insulator	0	ea	$0	$233.20	$0	$0	$0
- 5.5 feet long suspension insulator	61.8	ea	$0	$265.00	$0	$16,377	$16,377
Shield wire support arm	245	lb	$0	$1.06	$0	$260	$260
Structure supply:							
- Steel poles: Tangent	30654	lb	$0	$1.06	$0	$32,493	$32,493
- Steel pole: Angle	8000	lb	$0	$1.06	$0	$8,480	$8,480
- Steel pole: Dead End	12000	lb	$0	$1.06	$0	$12,720	$12,720
Material handling & storage	15%	lot			$0	$15,914	$15,914
Sub-total					*$0*	*$122,007*	*$122,007*
Administration	2%	lot					$7,474
Engineering & supervision	11.5%	lot					$42,975
AFUDC	3%	lot					$12,724
Contingency	15%	lot					$63,622
Total Line Cost (per Mile)							**$500,492**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip	Total Cost Labor	Total Cost Material	Total Cost Total
Terminal structures:	24000	lb	$4,240	$1.06	$4,240	$25,440	$29,680
Testing & commissioning	1	lot	$10,000		$10,000	$0	$10,000
Material handling & storage	15%	lot			$0	$3,816	$3,816
Sub-total					*$14,240*	*$29,256*	*$43,496*
Administration	2%	lot					$870
Engineering & supervision	11.5%	lot					$5,002
AFUDC	3%	lot					$1,481
Contingency	15%	lot					$7,405
Total Terminal Cost							**$58,254**

Regulatory & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate

Overhead Single-circuit Steel Pole with Delta Arrangement (Scenario A: 795 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Civil Work							
R-O-W clearing	6.06	acre	$3,500	$5,000.00	$21,215	$30,307	$51,522
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7,200
Structure erection: Steel poles	9.8	ea	$2,000	$4,000.00	$19,600	$39,200	$58,800
Pad & Pier foundations	2	ea	$15,000	$35,000.00	$30,000	$70,000	$100,000
Structure grounding	9.8	ea	$200		$1,960	$0	$1,960
Guying	0	ea	$500		$0	$0	$0
Stringing	8.8	span	$3,150		$27,720	$0	$27,720
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$104,095*	*$143,107*	*$247,202*
Overhead Line							
Conductor:							
- 795 kcmil ACSR (DRAKE)	16650	ft	$0	$1.33	$0	$22,149	$22,149
Shield wire	5550	ft	$0	$0.30	$0	$1,665	$1,665
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434.60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519.40	$0	$0	$0
- 4.5 feet long suspension insulator	0	ea	$0	$233.20	$0	$0	$0
- 5.5 feet long suspension insulator	34.4	ea	$0	$265.00	$0	$9,116	$9,116
Shield wire support arm	98	lb	$0	$1.06	$0	$104	$104
Structure supply:							
-Steel poles: Tangent	26676	lb	$0	$1.06	$0	$28,277	$28,277
-Steel pole: Angle	6200	lb	$0	$1.06	$0	$6,572	$6,572
- Steel pole: Dead End	11000	lb	$0	$1.06	$0	$11,660	$11,660
Material handling & storage	15%	lot			$0	$11,931	$11,931
Sub-total					*$0*	*$91,474*	*$91,474*
Administration	2%	lot					$6,774
Engineering & supervision	11.5%	lot					$38,948
AFUDC	3%	lot					$11,532
Contingency	15%	lot					$57,660
Total Line Cost (per Mile)							**$453,589**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Terminal structures:	22000	lb	$4,240	$1.06	$4,240	$23,320	$27,560
Testing & commissioning	1	lot	$10,000		$10,000	$0	$10,000
Material handling & storage	15%	lot			$0	$3,498	$3,498
Sub-total					*$14,240*	*$26,818*	*$41,058*
Administration	2%	lot					$821
Engineering & supervision	11.5%	lot					$4,722
AFUDC	3%	lot					$1,398
Contingency	15%	lot					$6,990
Total Terminal Cost							**$54,989**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate

Overhead Single-circuit Steel Pole with Delta Arrangement (Scenario B: 1272 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Civil Work							
R-O-W clearing	6.06	acre	$3,500	$5,000.00	$21,215	$30,307	$51,522
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7,200
Structure erection: Steel poles	9.8	ea	$2,000	$4,000.00	$19,600	$39,200	$58,800
Pad & Pier foundations	2	ea	$15,000	$35,000.00	$30,000	$70,000	$100,000
Structure grounding	9.8	ea	$200		$1,960	$0	$1,960
Guying	0	ea	$500		$0	$0	$0
Stringing	8.8	span	$3,660		$32,208	$0	$32,208
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$108,583*	*$143,107*	*$251,690*
Overhead Line							
Conductor:							
- 1272 kcmil ACSR (PHEASANT)	16650	ft	$0	$2.05	$0	$34,098	$34,098
Shield wire	5550	ft	$0	$0.30	$0	$1,665	$1,665
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434.60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519.40	$0	$0	$0
- 4.5 feet long suspension insulator	0	ea	$0	$233.20	$0	$0	$0
- 5.5 feet long suspension insulator	34.4	ea	$0	$265.00	$0	$9,116	$9,116
Shield wire support arm	98	lb	$0	$1.06	$0	$104	$104
Structure supply:							
- Steel poles: Tangent	28860	lb	$0	$1.06	$0	$30,592	$30,592
- Steel pole: Angle	7000	lb	$0	$1.06	$0	$7,420	$7,420
- Steel pole: Dead End	11700	lb	$0	$1.06	$0	$12,402	$12,402
Material handling & storage	15%	lot			$0	$14,309	$14,309
Sub-total					*$0*	*$109,706*	*$109,706*
Administration	2%	lot					$7,228
Engineering & supervision	11.5%	lot					$41,560
AFUDC	3%	lot					$12,306
Contingency	15%	lot					$61,528
Total Line Cost (per Mile)							**$484,017**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Terminal structures:	23400	lb	$4,240	$1.06	$4,240	$24,804	$29,044
Testing & commissioning	1	lot	$10,000		$10,000	$0	$10,000
Material handling & storage	15%	lot			$0	$3,721	$3,721
Sub-total					*$14,240*	*$28,525*	*$42,765*
Administration	2%	lot					$855
Engineering & supervision	11.5%	lot					$4,918
AFUDC	3%	lot					$1,456
Contingency	15%	lot					$7,281
Total Terminal Cost							**$57,275**

Regulatory & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate

Overhead single-circuit Steel Pole with Compact Spacing & Delta Arrangement (Senario A: 795 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Civil Work							
R-O-W clearing	6.06	acre	$3,500	$5,000.00	$21,215	$30,307	$51,522
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7,200
Structure erection: Steel poles	9.8	ea	$2,000	$4,000.00	$19,600	$39,200	$58,800
Pad & Pier foundations	2	ea	$15,000	$35,000.00	$30,000	$70,000	$100,000
Structure grounding	9.8	ea	$200		$1,960	$0	$1,960
Guying	0	ea	$500		$0	$0	$0
Stringing	8.8	span	$3,150		$27,720	$0	$27,720
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$104,095*	*$143,107*	*$247,202*
Overhead Line							
Conductor:							
- 795 kcmil ACSR (DRAKE)	16650	ft	$0	$1.33	$0	$22,149	$22,149
Shield wire	5550	ft	$0	$0.30	$0	$1,665	$1,665
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434.60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519.40	$0	$0	$0
- 4.5 feet long suspension insulator	0	ea	$0	$233.20	$0	$0	$0
- 5.5 feet long suspension insulator	60.8	ea	$0	$265.00	$0	$16,112	$16,112
Shield wire support arm	98	lb	$0	$1.06	$0	$104	$104
Structure supply:							
-Steel poles: Tangent	23010	lb	$0	$1.06	$0	$24,391	$24,391
-Steel pole: Angle	5250	lb	$0	$1.06	$0	$5,565	$5,565
- Steel pole: Dead End	8550	lb	$0	$1.06	$0	$9,063	$9,063
Material handling & storage	15%	lot			$0	$11,857	$11,857
Sub-total					*$0*	*$90,906*	*$90,906*
Administration	2%	lot					$6,762
Engineering & supervision	11.5%	lot					$38,882
AFUDC	3%	lot					$11,513
Contingency	15%	lot					$57,563
Total Line Cost (per Mile)							$452,828
Terminal Cost - Per Project							
Terminal structures:	17100	lb	$4,240	$1.06	$4,240	$18,126	$22,366
Testing & commissioning	1	lot	$10,000		$10,000	$0	$10,000
Material handling & storage	15%	lot			$0	$2,719	$2,719
Sub-total					*$14,240*	*$20,845*	*$35,085*
Administration	2%	lot					$702
Engineering & supervision	11.5%	lot					$4,035
AFUDC	3%	lot					$1,195
Contingency	15%	lot					$5,973
Total Terminal Cost							$46,989
Regulatory Cost & Permit Fees - Per Project							
Regulatory cost & permit fees		lot					$100,000
AFUDC	3%	lot					$3,000
Contingency	15%	lot					$15,000
Total Fees							$118,000

Construction Cost Estimate

Overhead single-circuit Steel Pole with Compact Spacing & Delta Arrangement (Senario A: 1272 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total Cost Total
Civil Work							
R-O-W clearing	6.06	acre	$3,500	$5,000.00	$21,215	$30,307	$51,522
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7.200
Structure erection: Steel poles	9.8	ea	$2,000	$4,000.00	$19,600	$39,200	$58,800
Pad & Pier foundations	2	ea	$15,000	$35,000.00	$30,000	$70,000	$100.000
Structure grounding	9.8	ea	$200		$1,960	$0	$1,960
Guying	0	ea	$500		$0	$0	$0
Stringing	8.8	span	$3,660		$32,208	$0	$32,208
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$108,583*	*$143,107*	*$251,690*
Overhead Line							
Conductor:							
- 1272 kcmil ACSR (PHEASANT)	16650	ft	$0	$2.05	$0	$34.098	$34.098
Shield wire	5550	ft	$0	$0.30	$0	$1,665	$1.665
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434.60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519.40	$0	$0	$0
- 4.5 feet long suspension insulator	0	ea	$0	$233.20	$0	$0	$0
- 5.5 feet long suspension insulator	60.8	ea	$0	$265.00	$0	$16,112	$16,112
Shield wire support arm	98	lb	$0	$1.06	$0	$104	$104
Structure supply:							
- Steel poles: Tangent	23010	lb	$0	$1.06	$0	$24,391	$24,391
- Steel pole: Angle	5800	lb	$0	$1.06	$0	$6,148	$6,148
- Steel pole: Dead End	9000	lb	$0	$1.06	$0	$9,540	$9,540
Material handling & storage	15%	lot			$0	$13,809	$13,809
Sub-total					*$0*	*$105,866*	*$105,866*
Administration	2%	lot					$7.151
Engineering & supervision	11.5%	lot					$41,119
AFUDC	3%	lot					$12,175
Contingency	15%	lot					$60,874
Total Line Cost (per Mile)							**$478,874**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total Cost Total
Terminal structures:	18000	lb	$4,240	$1.06	$4,240	$19,080	$23,320
Testing & commissioning	1	lot	$10,000		$10,000	$0	$10,000
Material handling & storage	15%	lot			$0	$2,862	$2,862
Sub-total					*$14,240*	*$21,942*	*$36,182*
Administration	2%	lot					$724
Engineering & supervision	11.5%	lot					$4,161
AFUDC	3%	lot					$1,232
Contingency	15%	lot					$6,160
Total Terminal Cost							**$48,459**

Regulatory & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate

Overhead double-circuit H-Frames (Scenario A: 795 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Civil Work							
R-O-W clearing	9.09	acre	$3,500	$5,000.00	$31,822	$45,460	$77,282
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7,200
Structure erection: Wooden H-frames	19.6	ea	$6,480		$127,008	$0	$127,008
Structure grounding	19.6	ea	$270		$5,292	$0	$5,292
Guying	6	ea	$810		$4,860	$0	$4,860
Stringing	17.6	span	$3,267		$57,499	$0	$57,499
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$230,081*	*$49,060*	*$279,142*
Overhead Line							
Conductor:							
- 795 kcmil ACSR (DRAKE)	33300	ft	$0	$1.33	$0	$44,299	$44,299
Shield wire	22200	ft	$0	$0.30	$0	$6,660	$6,660
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434.60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519.40	$0	$0	$0
- 4.5 feet long suspension insulator	64.8	ea	$0	$233.20	$0	$15,111	$15,111
- 5.5 feet long suspension insulator	0	ea	$0	$265.00	$0	$0	$0
Shield wire support arm	98	lb	$0	$1.06	$0	$104	$104
Structure supply:							
- Wooden H-frames: Tangent	15.6	ea	$0	$4,897.20	$0	$76,396	$76,396
- Wooden H-Frame: Angle	2	ea	$0	$5,386.92	$0	$10,774	$10,774
- Wooden H-Frame: Dead End	2	ea	$0	$5,720.82	$0	$11,442	$11,442
Material handling & storage	15%	lot			$0	$24,718	$24,718
Sub-total					*$0*	*$189,504*	*$189,504*
Administration	2%	lot					$9,373
Engineering & supervision	11.5%	lot					$53,894
AFUDC	3%	lot					$15,957
Contingency	15%	lot					$79,787
Total Line Cost (per Mile)							**$627,657**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Terminal structures:	4	ea	$3,339	$5,720.82	$13,356	$22,883	$36,239
Testing & commissioning	1	lot	$18,000		$18,000	$0	$18,000
Material handling & storage	15%	lot			$0	$3,432	$3,432
Sub-total					*$31,356*	*$26,316*	$57,672
Administration	2%	lot					$1,153
Engineering & supervision	11.5%	lot					$6,632
AFUDC	3%	lot					$1,964
Contingency	15%	lot					$9,819
Total Terminal Cost							**$77,240**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate

Overhead double-circuit H-Frames (Scenario B: 1272 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total Cost Total
<u>Civil Work</u>							
R-O-W clearing	9.09	acre	$3,500	$5,000.00	$31,822	$45,460	$77,282
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7,200
Structure erection: Wooden H-frames	19.6	ea	$6,480		$127,008	$0	$127,008
Structure grounding	19.6	ea	$270		$5,292	$0	$5,292
Guying	6	ea	$810		$4,860	$0	$4,860
Stringing	17.6	span	$3,726		$65,578	$0	$65,578
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$238,160*	*$49,060*	*$287,220*
<u>Overhead Line</u>							
Conductor:							
- 1272 kcmil ACSR (PHEASANT)	33300	ft	$0	$2.05	$0	$68,196	$68,196
Shield wire	22200	ft	$0	$0.30	$0	$6,660	$6,660
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434.60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519.40	$0	$0	$0
- 4.5 feet long suspension insulator	64.8	ea	$0	$233.20	$0	$15,111	$15,111
- 5.5 feet long suspension insulator	0	ea	$0	$265.00	$0	$0	$0
Shield wire support arm	98	lb	$0	$1.06	$0	$104	$104
Structure supply:							
- Wooden H-frames: Tangent	15.6	ea	$0	$4,897.20	$0	$76,396	$76,396
- Wooden H-Frame: Angle	2	ea	$0	$5,542.74	$0	$11,085	$11,085
- Wooden H-Frame: Dead End	2	ea	$0	$5,720.82	$0	$11,442	$11,442
Material handling & storage	15%	lot			$0	$28,349	$28,349
Sub-total					*$0*	*$217,344*	*$217,344*
Administration	2%	lot					$10,091
Engineering & supervision	11.5%	lot					$58,025
AFUDC	3%	lot					$17,180
Contingency	15%	lot					$85,902
Total Line Cost (per Mile)							**$675,762**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total Cost Total
Terminal structures:	4	ea	$3,339	$5,720.82	$13,356	$22,883	$36,239
Testing & commissioning	1	lot	$18,000		$18,000	$0	$18,000
Material handling & storage	15%	lot			$0	$3,432	$3,432
Sub-total					*$31,356*	*$26,316*	*$57,672*
Administration	2%	lot					$1,153
Engineering & supervision	11.5%	lot					$6,632
AFUDC	3%	lot					$1,964
Contingency	15%	lot					$9,819
Total Terminal Cost							**$77,240**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate
Overhead double-circuit H-Frames with Alternative Phasing (Scenario A: 795 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Civil Work							
R-O-W clearing	9 09	acre	$3,500	$5,000.00	$31,822	$45,460	$77,282
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7,200
Structure erection: Wooden H-frames	19.6	ea	$6,480		$127,008	$0	$127,008
Structure grounding	19.6	ea	$270		$5,292	$0	$5,292
Guying	6	ea	$810		$4,860	$0	$4 860
Stringing	17 6	span	$3,267		$57,499	$0	$57 499
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$230,081*	*$49,060*	*$279.142*
Overhead Line							
Conductor:							
- 795 kcmil ACSR (DRAKE)	33300	ft	$0	$1 33	$0	$44,299	$44.299
Shield wire	22200	ft	$0	$0 30	$0	$6,660	$6,660
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434 60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519 40	$0	$0	$0
- 4 5 feet long suspension insulator	64 8	ea	$0	$233 20	$0	$15,111	$15,111
- 5.5 feet long suspension insulator	0	ea	$0	$265.00	$0	$0	$0
Shield wire support arm	98	lb	$0	$1.06	$0	$104	$104
Structure supply:							
- Wooden H-frames: Tangent	15.6	ea	$0	$4,897.20	$0	$76,396	$76,396
- Wooden H-Frame: Angle	2	ea	$0	$5,386.92	$0	$10,774	$10,774
- Wooden H-Frame: Dead End	2	ea	$0	$5,720.82	$0	$11,442	$11,442
Material handling & storage	15%	lot			$0	$24,718	$24,718
Sub-total					*$0*	*$189,504*	*$189,504*
Administration	2%	lot					$9,373
Engineering & supervision	11 5%	lot					$53,894
AFUDC	3%	lot					$15,957
Contingency	15%	lot					$79,787
Total Line Cost (per Mile)							**$627,657**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Terminal structures:	4	ea	$3,339	$5,720.82	$13,356	$22,883	$36,239
Testing & commissioning	1	lot	$18,000		$18,000	$0	$18,000
Material handling & storage	15%	lot			$0	$3,432	$3,432
Sub-total					*$31,356*	*$26,316*	*$57,672*
Administration	2%	lot					$1,153
Engineering & supervision	11 5%	lot					$6,632
AFUDC	3%	lot					$1,964
Contingency	15%	lot					$9,819
Total Terminal Cost							**$77,240**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate

Overhead double-circuit H-Frames with Alternative Phasing (Scenario B: 1272 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Civil Work							
R-O-W clearing	9.09	acre	$3,500	$5,000.00	$31,822	$45,460	$77,282
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7,200
Structure erection: Wooden H-frames	19.6	ea	$6,480		$127,008	$0	$127,008
Structure grounding	19.6	ea	$270		$5,292	$0	$5,292
Guying	6	ea	$810		$4,860	$0	$4,860
Stringing	17.6	span	$3,726		$65,578	$0	$65,578
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$238,160*	*$49,060*	*$287,220*
Overhead Line							
Conductor:							
- 1272 kcmil ACSR (PHEASANT)	33300	ft	$0	$2.05	$0	$68,196	$68,196
Shield wire	22200	ft	$0	$0.30	$0	$6,660	$6,660
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434.60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519.40	$0	$0	$0
- 4.5 feet long suspension insulator	64.8	ea	$0	$233.20	$0	$15,111	$15,111
- 5.5 feet long suspension insulator	0	ea	$0	$265.00	$0	$0	$0
Shield wire support arm	98	lb	$0	$1.06	$0	$104	$104
Structure supply:							
- Wooden H-frames: Tangent	15.6	ea	$0	$4,897.20	$0	$76,396	$76,396
- Wooden H-Frame: Angle	2	ea	$0	$5,542.74	$0	$11,085	$11,085
- Wooden H-Frame: Dead End	2	ea	$0	$5,720.82	$0	$11,442	$11,442
Material handling & storage	15%	lot			$0	$28,349	$28,349
Sub-total					*$0*	*$217,344*	*$217,344*
Administration	2%	lot					$10,091
Engineering & supervision	11.5%	lot					$58,025
AFUDC	3%	lot					$17,180
Contingency	15%	lot					$85,902
Total Line Cost (per Mile)							**$675,762**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Terminal structures:	4	ea	$3,339	$5,720.82	$13,356	$22,883	$36,239
Testing & commissioning	1	lot	$18,000		$18,000	$0	$18,000
Material handling & storage	15%	lot			$0	$3,432	$3,432
Sub-total					*$31,356*	*$26,316*	*$57,672*
Administration	2%	lot					$1,153
Engineering & supervision	11.5%	lot					$6,632
AFUDC	3%	lot					$1,964
Contingency	15%	lot					$9,819
Total Terminal Cost							**$77,240**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate

Overhead double-circuit H-Frame with compact spacing and Alternative Phasing (Scenario A: 795 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Civil Work							
R-O-W clearing	9.09	acre	$3,500	$5,000.00	$31,822	$45,460	$77,282
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7,200
Structure erection: Wooden H-frames	19.6	ea	$6,480		$127,008	$0	$127,008
Structure grounding	19.6	ea	$270		$5,292	$0	$5,292
Guying	6	ea	$810		$4,860	$0	$4,860
Stringing	17.6	span	$3,267		$57,499	$0	$57,499
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$230,081*	*$49,060*	*$279,142*
Overhead Line							
Conductor:							
- 795 kcmil ACSR (DRAKE)	33300	ft	$0	$1.33	$0	$44,299	$44,299
Shield wire	22200	ft	$0	$0.30	$0	$6,660	$6,660
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434.60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519.40	$0	$0	$0
- 4.5 feet long suspension insulator	129.6	ea	$0	$233.20	$0	$30,223	$30,223
- 5.5 feet long suspension insulator	0	ea	$0	$265.00	$0	$0	$0
Shield wire support arm	98	lb	$0	$1.06	$0	$104	$104
Structure supply:							
- Wooden H-frames: Tangent	15.6	ea	$0	$4,897.20	$0	$76,396	$76,396
- Wooden H-Frame: Angle	2	ea	$0	$5,386.92	$0	$10,774	$10,774
- Wooden H-Frame: Dead End	2	ea	$0	$5,720.82	$0	$11,442	$11,442
Material handling & storage	15%	lot			$0	$26,985	$26,985
Sub-total					*$0*	*$206,882*	*$206,882*
Administration	2%	lot					$9,720
Engineering & supervision	11.5%	lot					$55,893
AFUDC	3%	lot					$16,549
Contingency	15%	lot					$82,746
Total Line Cost (per Mile)							**$650,932**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Terminal structures:	4	ea	$3,339	$5,720.82	$13,356	$22,883	$36,239
Testing & commissioning	1	lot	$18,000		$18,000	$0	$18,000
Material handling & storage	15%	lot			$0	$3,432	$3,432
Sub-total					*$31,356*	*$26,316*	*$57,672*
Administration	2%	lot					$1,153
Engineering & supervision	11.5%	lot					$6,632
AFUDC	3%	lot					$1,964
Contingency	15%	lot					$9,819
Total Terminal Cost							**$77,240**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate

Overhead double-circuit H-Frame with compact spacing and Alternative Phasing (Scenario B: 1272 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total Cost Total
Civil Work							
R-O-W clearing	9.09	acre	$3,500	$5,000.00	$31,822	$45,460	$77,282
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7,200
Structure erection: Wooden H-frames	19.6	ea	$6,480		$127,008	$0	$127,008
Structure grounding	19.6	ea	$270		$5,292	$0	$5,292
Guying	6	ea	$810		$4,860	$0	$4,860
Stringing	17.6	span	$3,726		$65,578	$0	$65,578
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$238,160*	*$49,060*	*$287,220*
Overhead Line							
Conductor:							
- 1272 kcmil ACSR (PHEASANT)	33300	ft	$0	$2.05	$0	$68,196	$68,196
Shield wire	22200	ft	$0	$0.30	$0	$6,660	$6,660
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434.60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519.40	$0	$0	$0
- 4.5 feet long suspension insulator	129.6	ea	$0	$233.20	$0	$30,223	$30,223
- 5.5 feet long suspension insulator	0	ea	$0	$265.00	$0	$0	$0
Shield wire support arm	98	lb	$0	$1.06	$0	$104	$104
Structure supply:							
- Wooden H-frames: Tangent	15.6	ea	$0	$4,897.20	$0	$76,396	$76,396
- Wooden H-Frame: Angle	2	ea	$0	$5,542.74	$0	$11,085	$11,085
- Wooden H-Frame: Dead End	2	ea	$0	$5,720.82	$0	$11,442	$11,442
Material handling & storage	15%	lot			$0	$30,616	$30,616
Sub-total					*$0*	*$234,722*	*$234,722*
Administration	2%	lot					$10,439
Engineering & supervision	11.5%	lot					$60,023
AFUDC	3%	lot					$17,772
Contingency	15%	lot					$88,861
Total Line Cost (per Mile)							**$699,037**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total Cost Total
Terminal structures:	4	ea	$3,339	$5,720.82	$13,356	$22,883	$36,239
Testing & commissioning	1	lot	$18,000		$18,000	$0	$18,000
Material handling & storage	15%	lot			$0	$3,432	$3,432
Sub-total					*$31,356*	*$26,316*	*$57,672*
Administration	2%	lot					$1,153
Engineering & supervision	11.5%	lot					$6,632
AFUDC	3%	lot					$1,964
Contingency	15%	lot					$9,819
Total Terminal Cost							**$77,240**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate

Overhead double-circuit steel pole (Scenario A: 795 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total Cost Total
Civil Work							
R-O-W clearing	6 06	acre	$3,500	$5,000.00	$21,215	$30,307	$51 522
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7 200
Structure erection: Steel poles	9 8	ea	$2,000	$4.000 00	$19,600	$39,200	$58.800
Pad & Pier foundations	2		$20,500	$44,500.00	$41,000	$89,000	$130,000
Structure grounding	9.8	ea	$200		$1,960	$0	$1 960
Guying	8.8	span	$5,670		$49,896	$0	$49.896
Stringing	8.8	span	$5,670				
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$137,271*	*$162,107*	*$299 378*
Overhead Line							
Conductor:							
- 795 kcmil ACSR (DRAKE)	33300	ft	$0	$1 33	$0	$44,299	$44.299
Shield wire	11100	ft	$0	$0.30	$0	$3,330	$3,330
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434.60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519 40	$0	$0	$0
- 4 5 feet long suspension insulator	0	ea	$0	$233.20	$0	$0	$0
- 5.5 feet long suspension insulator	61 8	ea	$0	$265.00	$0	$16 377	$16,377
Shield wire support arm	1960	lb	$0	$1 06	$0	$2,078	$2,078
Structure supply:							
- Wooden H-frames: Tangent	40560	lb	$0	$1.06	$0	$42,994	$42,994
- Wooden H-Frame: Angle	11500	lb	$0	$1 06	$0	$12,190	$12,190
- Wooden H-Frame: Dead End	14000	lb	$0	$1 06	$0	$14,840	$14.840
Material handling & storage	15%	lot			$0	$20,416	$20,416
Sub-total					*$0*	*$156,523*	*$156,523*
Administration	2%	lot					$9,118
Engineering & supervision	11 5%	lot					$52.429
AFUDC	3%	lot					$15.523
Contingency	15%	lot					$77,617
Total Line Cost (per Mile)							**$610,588**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total Cost Total
Terminal structures:	28000	lb	$4,240	$1 06	$4,240	$29,680	$33,920
Testing & commissioning	1	lot	$18,000		$18,000	$0	$18,000
Material handling & storage	15%	lot			$0	$4,452	$4,452
Sub-total					*$22,240*	*$34,132*	*$56,372*
Administration	2%	lot					$1.127
Engineering & supervision	11.5%	lot					$6,483
AFUDC	3%	lot					$1,919
Contingency	15%	lot					$9,597
Total Terminal Cost							**$75,499**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate
Overhead double-circuit steel pole (Scenario B: 1272 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Civil Work							
R-O-W clearing	6 06	acre	$3,500	$5,000.00	$21,215	$30,307	$51 522
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7 200
Structure erection: Wooden H-frames	9 8	ea	$2,000	$4,000.00	$19,600	$39,200	$58,800
Structure grounding	2	ea	$20,500	$44,500.00	$41,000	$89,000	$130,000
Guying	9 8	ea	$200		$1,960	$0	$1,960
Stringing	0	ea	$500		$0	$0	$0
	8.8	span	$6,588		$57,974	$0	$57,974
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$145,349*	*$162,107*	*$307.456*
Overhead Line							
Conductor:							
- 1272 kcmil ACSR (PHEASANT)	33300	ft	$0	$2 05	$0	$68,196	$68,196
Shield wire	11100	ft	$0	$0 30	$0	$3,330	$3,330
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434 60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519 40	$0	$0	$0
- 4 5 feet long suspension insulator	0	ea	$0	$233.20	$0	$0	$0
- 5.5 feet long suspension insulator	61.8	ea	$0	$265 00	$0	$16,377	$16,377
Shield wire support arm	1960	lb	$0	$1 06	$0	$2,078	$2,078
Structure supply:							
- Wooden H-frames: Tangent	45708	lb	$0	$1.06	$0	$48,450	$48,450
- Wooden H-Frame: Angle	12200	lb	$0	$1.06	$0	$12,932	$12,932
- Wooden H-Frame: Dead End	14350	lb	$0	$1 06	$0	$15,211	$15,211
Material handling & storage	15%	lot			$0	$24,986	$24,986
Sub-total					*$0*	*$191,560*	*$191,560*
Administration	2%	lot					$9,980
Engineering & supervision	11 5%	lot					$57,387
AFUDC	3%	lot					$16 991
Contingency	15%	lot					$84.957
Total Line Cost (per Mile)							$668,332

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Terminal structures:	28700	lb	$4,240	$1.06	$4,240	$30,422	$34,662
Testing & commissioning	1	lot	$18,000		$18,000	$0	$18,000
Material handling & storage	15%	lot			$0	$4,563	$4,563
Sub-total					*$22,240*	*$34,985*	$57,225
Administration	2%	lot					$1,145
Engineering & supervision	11 5%	lot					$6,581
AFUDC	3%	lot					$1,949
Contingency	15%	lot					$9,743
Total Terminal Cost							$76,642

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			$118,000

Construction Cost Estimate

Overhead Double-circuit Steel Pole with Alternative Phasing (Scenario A: 795 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Civil Work							
R-O-W clearing	6.06	acre	$3,500	$5,000 00	$21,215	$30,307	$51,522
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7.200
Structure erection: Steel poles	9 8	ea	$2,000	$4,000 00	$19,600	$39,200	$58,800
Pad & Pier foundations	2		$20,500	$44,500 00	$41 000	$89,000	$130,000
Structure grounding	9.8	ea	$200		$1,960	$0	$1.960
Guying	8.8	span	$5,670		$49,896	$0	$49,896
Stringing	8.8	span	$5,670				
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$137.271*	*$162.107*	*$299.378*
Overhead Line							
Conductor:							
- 795 kcmil ACSR (DRAKE)	33300	ft	$0	$1 33	$0	$44,299	$44,299
Shield wire	11100	ft	$0	$0.30	$0	$3,330	$3,330
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434.60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519 40	$0	$0	$0
- 4.5 feet long suspension insulator	0	ea	$0	$233.20	$0	$0	$0
- 5.5 feet long suspension insulator	61.8	ea	$0	$265.00	$0	$16,377	$16,377
Shield wire support arm	1960	lb	$0	$1 06	$0	$2,078	$2,078
Structure supply:							
- Wooden H-frames: Tangent	40560	lb	$0	$1 06	$0	$42,994	$42,994
- Wooden H-Frame: Angle	11500	lb	$0	$1.06	$0	$12,190	$12,190
- Wooden H-Frame: Dead End	14000	lb	$0	$1.06	$0	$14,840	$14,840
Material handling & storage	15%	lot			$0	$20,416	$20,416
Sub-total					*$0*	*$156,523*	*$156,523*
Administration	2%	lot					$9,118
Engineering & supervision	11 5%	lot					$52,429
AFUDC	3%	lot					$15,523
Contingency	15%	lot					$77,617
Total Line Cost (per Mile)							**$610,588**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Terminal structures:	28000	lb	$4,240	$1 06	$4,240	$29,680	$33,920
Testing & commissioning	1	lot	$18,000		$18,000	$0	$18,000
Material handling & storage	15%	lot			$0	$4,452	$4,452
Sub-total					*$22,240*	*$34,132*	*$56,372*
Administration	2%	lot					$1,127
Engineering & supervision	11.5%	lot					$6,483
AFUDC	3%	lot					$1,919
Contingency	15%	lot					$9,597
Total Terminal Cost							**$75,499**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate

Overhead Double-circuit Steel Pole with Alternative Phasing (Scenario B: 1272 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total Cost Total
Civil Work							
R-O-W clearing	6.06	acre	$3,500	$5,000.00	$21,215	$30,307	$51 522
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7,200
Structure erection: Wooden H-frames	9.8	ea	$2,000	$4,000.00	$19,600	$39,200	$58.800
Structure grounding	2	ea	$20,500	$44,500.00	$41,000	$89,000	$130,000
Guying	9.8	ea	$200		$1,960	$0	$1,960
Stringing	0	ea	$500		$0	$0	$0
	8.8	span	$6,588		$57,974	$0	$57,974
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$145,349*	*$162,107*	*$307,456*
Overhead Line							
Conductor:							
- 1272 kcmil ACSR (PHEASANT)	33300	ft	$0	$2.05	$0	$68,196	$68,196
Shield wire	11100	ft	$0	$0.30	$0	$3,330	$3.330
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434.60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519.40	$0	$0	$0
- 4.5 feet long suspension insulator	0	ea	$0	$233.20	$0	$0	$0
- 5.5 feet long suspension insulator	61.8	ea	$0	$265.00	$0	$16,377	$16.377
Shield wire support arm	1960	lb	$0	$1.06	$0	$2,078	$2,078
Structure supply:							
- Wooden H-frames: Tangent	45708	lb	$0	$1.06	$0	$48,450	$48,450
- Wooden H-Frame: Angle	12200	lb	$0	$1.06	$0	$12,932	$12,932
- Wooden H-Frame: Dead End	14350	lb	$0	$1.06	$0	$15,211	$15.211
Material handling & storage	15%	lot			$0	$24,986	$24,986
Sub-total					*$0*	*$191,560*	*$191,560*
Administration	2%	lot					$9,980
Engineering & supervision	11.5%	lot					$57,387
AFUDC	3%	lot					$16,991
Contingency	15%	lot					$84,957
Total Line Cost (per Mile)							**$668,332**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total Cost Total
Terminal structures:	28700	lb	$4,240	$1.06	$4,240	$30,422	$34,662
Testing & commissioning	1	lot	$18,000		$18,000	$0	$18,000
Material handling & storage	15%	lot			$0	$4,563	$4,563
Sub-total					*$22,240*	*$34,985*	*$57,225*
Administration	2%	lot					$1,145
Engineering & supervision	11.5%	lot					$6,581
AFUDC	3%	lot					$1,949
Contingency	15%	lot					$9,743
Total Terminal Cost							**$76,642**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate

Overhead double-circuit steel pole with compact spacing (Scenario A: 795 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Civil Work							
R-O-W clearing	6.06	acre	$3,500	$5,000.00	$21,215	$30,307	$51,522
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7.200
Structure erection: Steel poles	9.8	ea	$2,000	$4,000.00	$19,600	$39,200	$58.800
Pad & Pier foundations	2		$20,500	$44,500.00	$41,000	$89,000	$130.000
Structure grounding	9.8	ea	$200		$1,960	$0	$1.960
Guying	8.8	span	$5,670		$49,896	$0	$49,896
Stringing	8.8	span	$5,670				
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$137,271*	*$162,107*	*$299.378*
Overhead Line							
Conductor:							
- 795 kcmil ACSR (DRAKE)	33300	ft	$0	$1.33	$0	$44,299	$44,299
Shield wire	11100	ft	$0	$0.30	$0	$3,330	$3,330
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434.60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519.40	$0	$0	$0
- 4.5 feet long suspension insulator	0	ea	$0	$233.20	$0	$0	$0
- 5.5 feet long suspension insulator	120.6	ea	$0	$265.00	$0	$31,959	$31,959
Shield wire support arm	980	lb	$0	$1.06	$0	$1,039	$1,039
Structure supply:							
- Wooden H-frames: Tangent	36660	lb	$0	$1.06	$0	$38,860	$38,860
- Wooden H-Frame: Angle	10600	lb	$0	$1.06	$0	$11,236	$11,236
- Wooden H-Frame: Dead End	13000	lb	$0	$1.06	$0	$13,780	$13,780
Material handling & storage	15%	lot			$0	$21,675	$21,675
Sub-total					*$0*	*$166,178*	*$166.178*
Administration	2%	lot					$9,311
Engineering & supervision	11.5%	lot					$53,539
AFUDC	3%	lot					$15,852
Contingency	15%	lot					$79,261
Total Line Cost (per Mile)							**$623,518**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Terminal structures:	26000	lb	$4,240	$1.06	$4,240	$27,560	$31,800
Testing & commissioning	1	lot	$18,000		$18,000	$0	$18,000
Material handling & storage	15%	lot			$0	$4,134	$4,134
Sub-total					*$22,240*	*$31,694*	*$53,934*
Administration	2%	lot					$1,079
Engineering & supervision	11.5%	lot					$6,202
AFUDC	3%	lot					$1,836
Contingency	15%	lot					$9,182
Total Terminal Cost							**$72,234**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fess		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate

Overhead double-circuit steel pole with compact spacing (Scenario B: 1272 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Civil Work							
R-O-W clearing	6.06	acre	$3,500	$5,000.00	$21,215	$30,307	$51,522
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7,200
Structure erection: Wooden H-frames	9.8	ea	$2,000	$4,000.00	$19,600	$39,200	$58,800
	2	ea	$20,500	$44,500.00	$41,000	$89,000	$130,000
Structure grounding	9.8	ea	$200		$1,960	$0	$1,960
Guying	0	ea	$500		$0	$0	$0
Stringing	8.8	span	$6,588		$57,974	$0	$57,974
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$145,349*	*$162,107*	*$307,456*
Overhead Line							
Conductor:							
- 1272 kcmil ACSR (PHEASANT)	33300	ft	$0	$2.05	$0	$68,196	$68,196
Shield wire	11100	ft	$0	$0.30	$0	$3,330	$3,330
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434.60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519.40	$0	$0	$0
- 4.5 feet long suspension insulator	0	ea	$0	$233.20	$0	$0	$0
- 5.5 feet long suspension insulator	114.6	ea	$0	$265.00	$0	$30,369	$30,369
Shield wire support arm	980	lb	$0	$1.06	$0	$1,039	$1,039
Structure supply:							
- Wooden H-frames: Tangent	40755	lb	$0	$1.06	$0	$43,200	$43,200
- Wooden H-Frame: Angle	11320	lb	$0	$1.06	$0	$11,999	$11,999
- Wooden H-Frame: Dead End	13470	lb	$0	$1.06	$0	$14,278	$14,278
Material handling & storage	15%	lot			$0	$25,862	$25,862
Sub-total					*$0*	*$198,273*	*$198,273*
Administration	2%	lot					$10,115
Engineering & supervision	11.5%	lot					$58,159
AFUDC	3%	lot					$17,220
Contingency	15%	lot					$86,100
Total Line Cost (per Mile)							**$677,323**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Terminal structures:	26940	lb	$4,240	$1.06	$4,240	$28,556	$32,796
Testing & commissioning	1	lot	$18,000		$18,000	$0	$18,000
Material handling & storage	15%	lot			$0	$4,283	$4,283
Sub-total					*$22,240*	*$32,840*	*$55,080*
Administration	2%	lot					$1,102
Engineering & supervision	11.5%	lot					$6,334
AFUDC	3%	lot					$1,875
Contingency	15%	lot					$9,377
Total Terminal Cost							**$73,768**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate

Overhead double-circuit steel pole with compact spacing and Alternative Phasing using V-String Insulators (Scenario A: 795 kcmil)

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total Cost Total
Line Cost - Per Mile							
Civil Work							
R-O-W clearing	6.06	acre	$3,500	$5,000.00	$21,215	$30,307	$51,522
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7,200
Structure erection: Steel poles	9.8	ea	$2,000	$4,000.00	$19,600	$39,200	$58,800
Pad & Pier foundations	2		$20,500	$44,500.00	$41,000	$89,000	$130,000
Structure grounding	9.8	ea	$200		$1,960	$0	$1,960
Guying	8.8	span	$5,670		$49,896	$0	$49,896
Stringing	8.8	span	$5,670				
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$137,271*	*$162,107*	*$299,378*
Overhead Line							
Conductor:							
- 795 kcmil ACSR (DRAKE)	33300	ft	$0	$1.33	$0	$44,299	$44,299
Shield wire	11100	ft	$0	$0.30	$0	$3,330	$3,330
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434.60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519.40	$0	$0	$0
- 4.5 feet long suspension insulator	0	ea	$0	$233.20	$0	$0	$0
- 5.5 feet long suspension insulator	120.6	ea	$0	$265.00	$0	$31,959	$31,959
Shield wire support arm	980	lb	$0	$1.06	$0	$1,039	$1,039
Structure supply:							
- Wooden H-frames: Tangent	36660	lb	$0	$1.06	$0	$38,860	$38,860
- Wooden H-Frame: Angle	10600	lb	$0	$1.06	$0	$11,236	$11,236
- Wooden H-Frame: Dead End	13000	lb	$0	$1.06	$0	$13,780	$13,780
Material handling & storage	15%	lot			$0	$21,675	$21,675
Sub-total					*$0*	*$166,178*	*$166,178*
Administration	2%	lot					$9,311
Engineering & supervision	11.5%	lot					$53,539
AFUDC	3%	lot					$15,852
Contingency	15%	lot					$79,261
Total Line Cost (per Mile)							**$623,518**
Terminal Cost - Per Project							
Terminal structures:	26000	lb	$4,240	$1.06	$4,240	$27,560	$31,800
Testing & commissioning	1	lot	$18,000		$18,000	$0	$18,000
Material handling & storage	15%	lot			$0	$4,134	$4,134
Sub-total					*$22,240*	*$31,694*	*$53,934*
Administration	2%	lot					$1,079
Engineering & supervision	11.5%	lot					$6,202
AFUDC	3%	lot					$1,836
Contingency	15%	lot					$9,182
Total Terminal Cost							**$72,234**
Regulatory Cost & Permit Fees - Per Project							
Regulatory cost & permit fees		lot					$100,000
AFUDC	3%	lot					$3,000
Contingency	15%	lot					$15,000
Total Fees							**$118,000**

Construction Cost Estimate

Overhead double-circuit steel pole with compact spacing and Alternative Phasing using V-String Insulators (Scenario B: 1272 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
<u>Civil Work</u>							
R-O-W clearing	6.06	acre	$3,500	$5,000.00	$21,215	$30,307	$51,522
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7,200
Structure erection: Wooden H-frames	9.8	ea	$2,000	$4,000.00	$19,600	$39,200	$58,800
Structure grounding	2	ea	$20,500	$44,500.00	$41,000	$89,000	$130,000
Guying	9.8	ea	$200		$1,960	$0	$1,960
Stringing	0	ea	$500		$0	$0	$0
	8.8	span	$6,588		$57,974	$0	$57,974
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$145,349*	*$162,107*	*$307,456*
<u>Overhead Line</u>							
Conductor:							
- 1272 kcmil ACSR (PHEASANT)	33300	ft	$0	$2.05	$0	$68,196	$68,196
Shield wire	11100	ft	$0	$0.30	$0	$3,330	$3,330
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434.60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	0	ea	$0	$519.40	$0	$0	$0
- 4.5 feet long suspension insulator	0	ea	$0	$233.20	$0	$0	$0
- 5.5 feet long suspension insulator	114.6	ea	$0	$265.00	$0	$30,369	$30,369
Shield wire support arm	980	lb	$0	$1.06	$0	$1,039	$1,039
Structure supply:							
- Wooden H-frames: Tangent	40755	lb	$0	$1.06	$0	$43,200	$43,200
- Wooden H-Frame: Angle	11320	lb	$0	$1.06	$0	$11,999	$11,999
- Wooden H-Frame: Dead End	13470	lb	$0	$1.06	$0	$14,278	$14,278
Material handling & storage	15%	lot			$0	$25,862	$25,862
Sub-total					*$0*	*$198,273*	*$198,273*
Administration	2%	lot					$10,115
Engineering & supervision	11.5%	lot					$58,159
AFUDC	3%	lot					$17,220
Contingency	15%	lot					$86,100
Total Line Cost (per Mile)							**$677,323**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Terminal structures:	26940	lb	$4,240	$1.06	$4,240	$28,556	$32,796
Testing & commissioning	1	lot	$18,000		$18,000	$0	$18,000
Material handling & storage	15%	lot			$0	$4,283	$4,283
Sub-total					*$22,240*	*$32,840*	*$55,080*
Administration	2%	lot					$1,102
Engineering & supervision	11.5%	lot					$6,334
AFUDC	3%	lot					$1,875
Contingency	15%	lot					$9,377
Total Terminal Cost							**$73,768**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate

Overhead double-circuit steel pole with compact spacing and Alternative Phasing using Standoff Insulators (Scenario A: 795 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Civil Work							
R-O-W clearing	6.06	acre	$3,500	$5,000.00	$21,215	$30,307	$51.522
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7,200
Structure erection: Steel poles	14.2	ea	$2,000	$4,000.00	$28,400	$56,800	$85.200
Pad & Pier foundations	2	ea	$20,500	$44,500.00	$41,000	$89,000	$130.000
Structure grounding	14.2	ea	$200		$2,840	$0	$2.840
Guying	0	ea	$500		$0	$0	$0
Stringing	13.2	span	$4,140		$54,648	$0	$54,648
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$151,703*	*$179,707*	*$331.410*
Overhead Line							
Conductor:							
- 795 kcmil ACSR (DRAKE)	33300	ft	$0	$1.33	$0	$44,299	$44,299
Shield wire	11100	ft	$0	$0.30	$0	$3,330	$3,330
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434.60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	82.2	ea	$0	$519.40	$0	$42,695	$42,695
- 4.5 feet long suspension insulator	0	ea	$0	$233.20	$0	$0	$0
- 5.5 feet long suspension insulator	15	ea	$0	$265.00	$0	$3,975	$3,975
Shield wire support arm	2840	lb	$0	$1.06	$0	$3,010	$3,010
Structure supply:							
- Wooden H-frames: Tangent	31598	lb	$0	$1.06	$0	$33,494	$33.494
- Wooden H-Frame: Angle	6575	lb	$0	$1.06	$0	$6,970	$6,970
- Wooden H-Frame: Dead End	8000	lb	$0	$1.06	$0	$8,480	$8,480
Material handling & storage	15%	lot			$0	$21,938	$21,938
Sub-total					*$0*	*$168,190*	*$168.190*
Administration	2%	lot					$9.992
Engineering & supervision	11.5%	lot					$57,454
AFUDC	3%	lot					$17,011
Contingency	15%	lot					$85,057
Total Line Cost (per Mile)							**$669,114**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip.	Total Cost Labor	Total Cost Material	Total
Terminal structures:	16000	lb	$4,240	$1.06	$4,240	$16,960	$21,200
Testing & commissioning	1	lot	$18,000		$18,000	$0	$18,000
Material handling & storage	15%	lot			$0	$2,544	$2,544
Sub-total					*$22,240*	*$19,504*	*$41.744*
Administration	2%	lot					$835
Engineering & supervision	11.5%	lot					$4,801
AFUDC	3%	lot					$1,421
Contingency	15%	lot					$7,107
Total Terminal Cost							**$55,908**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate

Overhead double-circuit steel pole with compact spacing and Alternative Phasing using Standoff Insulators (Scenario B: 1272 kcmil)

Line Cost - Per Mile

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip	Total Cost Labor	Total Cost Material	Total
Civil Work							
R-O-W clearing	6.06	acre	$3,500	$5,000.00	$21,215	$30,307	$51,522
Access road	1800	sy	$2	$2.00	$3,600	$3,600	$7 200
Structure erection: Wooden H-frames	14.2	ea	$2,000	$4,000.00	$28,400	$56,800	$85 200
Structure grounding	2	ea	$20,500	$44,500 00	$41,000	$89,000	$130,000
Guying	14.2	ea	$200		$2,840	$0	$2,840
Stringing	0	ea	$500		$0	$0	$0
	13.2	span	$4,806		$63,439	$0	$63,439
Police	0	lot	$0	$0.00	$0	$0	$0
Overtime	0%	lot			$0	$0	$0
Sub-total					*$160,494*	*$179,707*	*$340 201*
Overhead Line							
Conductor:							
- 1272 kcmil ACSR (PHEASANT)	33300	ft	$0	$2.05	$0	$68,196	$68 196
Shield wire	11100	ft	$0	$0.30	$0	$3,330	$3,330
Insulators & hardwares:							
- 4 feet long horizontal Line post Insulator	0	ea	$0	$434.60	$0	$0	$0
- 5 feet long horizontal Line post Insulator	82.2	ea	$0	$519.40	$0	$42,695	$42,695
- 4.5 feet long suspension insulator	0	ea	$0	$233.20	$0	$0	$0
- 5.5 feet long suspension insulator	15	ea	$0	$265.00	$0	$3,975	$3,975
Shield wire support arm	2840	lb	$0	$1.06	$0	$3,010	$3,010
Structure supply:							
- Wooden H-frames: Tangent	31598	lb	$0	$1.06	$0	$33,494	$33,494
- Wooden H-Frame: Angle	7000	lb	$0	$1.06	$0	$7,420	$7,420
- Wooden H-Frame: Dead End	8350	lb	$0	$1.06	$0	$8,851	$8,851
Material handling & storage	15%	lot			$0	$25,646	$25,646
Sub-total					*$0*	*$196,616*	*$196,616*
Administration	2%	lot					$10 736
Engineering & supervision	11.5%	lot					$61,734
AFUDC	3%	lot					$18,279
Contingency	15%	lot					$91,393
Total Line Cost (per Mile)							**$718,959**

Terminal Cost - Per Project

	Quantity	Unit	Unit Cost Labor	Unit Cost Mat'l & Equip	Total Cost Labor	Total Cost Material	Total
Terminal structures:	16700	lb	$4,240	$1.06	$4,240	$17,702	$21,942
Testing & commissioning	1	lot	$18,000		$18,000	$0	$18,000
Material handling & storage	15%	lot			$0	$2,655	$2,655
Sub-total					*$22,240*	*$20,357*	*$42,597*
Administration	2%	lot					$852
Engineering & supervision	11.5%	lot					$4,899
AFUDC	3%	lot					$1,450
Contingency	15%	lot					$7,252
Total Terminal Cost							**$57,051**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	$100,000
AFUDC	3%	lot	$3,000
Contingency	15%	lot	$15,000
Total Fees			**$118,000**

Construction Cost Estimate
Underground Single Circuit High Pressure Gas-Filled

Cable Cost - Per Mile

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total
Civil Work							
Normal excavation	2,933	cy	20	0	58,660	0	58,660
Rock excavation	0	cy	100	0	0	0	0
Lean mix concrete	1,760	cy	0	74	0	130,240	130,240
Spoil disposal	1,760	cy	7	2	12,320	3,578	15,898
Backfill & tampering	1,173	cy	0.5	2	622	2,346	2,968
Paving - temp & permanent	1,760	sy	15	36	26,400	63,360	89,760
Manholes 15x6x7H	3	ea	3000	7000	9,000	21,000	30,000
Major crossings	1	ea	10000	20000	10,000	20,000	30,000
Road crossings	1	ea	7700	1000	7,700	1,000	8,700
Police	1	lot	16000	0	16,000	0	16,000
					140,702	241,524	382,226
Overtime factor	20%	lot			28,140		28,140
Sub-total					168,843	241,524	410,366
Underground cable							
Cable 2500 kcmil Cu 115 kV	16315	lf	0	52.61	0	858,307	858,307
Pipe coated 8"	5438	lf	15	20	81,576	108,768	190,344
Gas (Nitrogen)	1	lot	0	10000	0	10,000	10,000
Fluid return pipes (future)	0	lf	4.0	12.0	0	0	0
Fiber optic PVC duct 2x4"	5438	lf	2.8	4.2	15,344	23,017	38,361
Cable pulls	3	ea	15000	0	45,000	0	45,000
Cable splices	3	ea	35000	4000	105,000	12,000	117,000
Pressurizing reservoirs	3	ea	5000	10000	15,000	30,000	45,000
					261,920	1,042,091	1,304,012
Material handling & storage	15%						156,314
Sub-total					261,920	1,042,091	1,460,326
Administration	2%	lot					37,414
Engineering & surveying	12%	lot					215,130
AFUDC	3%						63,697
Contingency	15%						318,485
Sub-total							634,726
Total Cable Cost (per Mile)							**$2,505,418**

Terminal Cost - Per Project

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total
Cable terminations	6	ea	3000	12000	18,000	72,000	90,000
Terminating structures & trifur.	2	ea	20000	11000	40,000	22,000	62,000
Cathodic protection	1	lot	8000	12000	8,000	12,000	20,000
Testing & commissioning	1	lot	20000	0	20,000	0	20,000
					86,000	106,000	192,000
Material handling & storage	15%					15,900	15,900
Sub-total					86,000	121,900	207,900
Administration	2%	lot					4,158
Engineering & surveying	12%	lot					23,909
AFUDC	3%						7,079
Contingency	15%						35,395
Sub-total							70,540
Total Terminal Cost							**$278,440**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	100,000
AFUDC	3%		3,000
Contingency	15%		15,000
Total Fees			**$118,000**

Construction Cost Estimate
Underground Single Circuit High Pressure Fluid-Filled

Cable Cost - Per Mile

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total cost Total
Civil Work							
Normal excavation	2,933	cy	20	0	58,660	0	58.660
Rock excavation	0	cy	100	0	0	0	0
Lean mix concrete	1,760	cy	0	74	0	130.240	130,240
Spoil disposal	1,760	cy	7	2	12,320	3,578	15.898
Backfill & tampering	1,173	cy	0.5	2	622	2,346	2.968
Paving - temp & permanent	1,760	sy	15	36	26,400	63,360	89.760
Manholes 15x6x7H	3	ea	3000	7000	9,000	21,000	30,000
Major crossings	1	ea	10000	20000	10,000	20,000	30,000
Road crossings	1	ea	7700	1000	7,700	1,000	8,700
Police	1	lot	16000	0	16,000	0	16,000
					140,702	241.524	382.226
Overtime factor	20%	lot			28,140		28,140
Sub-total					168,843	241,524	410.366
Underground cable							
Cable 2500 kcmil Cu 115 kV	16315	lf	0	47.83	0	780,310	780,310
Pipe coated 8"	5438	lf	15	20	81,576	108,768	190,344
Oil	16000	gall	0	4	0	64,000	64,000
Fluid return pipes (future)	0	lf	4	12	0	0	0
Fiber optic PVC duct 4"	5438	lf	2.8	4.2	15,344	23,017	38,361
Cable pulls	3	ea	15000	0	45,000	0	45,000
Cable splices	3	ea	35000	4000	105,000	12,000	117,000
					246,920	988,095	1,235,015
Material handling & storage	15%						148,214
Sub-total					246,920	988,095	1,383,230
Administration	2%	lot					35,872
Engineering & surveying	12%	lot					206.264
AFUDC	3%						61.072
Contingency	15%						305.360
Sub-total							608.567
Total Cable Cost (per Mile)							**$2,402,163**

Terminal Cost - Per Project

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total cost Total
Cable terminations	6	ea	3000	12000	18,000	72,000	90,000
Terminating structures & trifur.	2	ea	20000	11000	40,000	22,000	62,000
Cathodic protection	1	lot	8000	12000	8,000	12,000	20,000
Pressurizing plant	1	ea	100000	250000	100,000	250,000	350,000
Testing & commissioning	1	lot	20000	0	20,000	0	20,000
					186,000	356,000	542,000
Material handling & storage	15%					53,400	53,400
Sub-total					186,000	409,400	595,400
Administration	2%	lot					11,908
Engineering & surveying	12%	lot					68,471
AFUDC	3%						20,273
Contingency	15%						101,367
Sub-total							202,019
Total Terminal Cost							**$797,419**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	100,000
AFUDC	3%		3,000
Contingency	15%		15,000
Total Fees			**$118,000**

Construction Cost Estimate
Underground Single Circuit High Pressure Fluid-Filled with Closed Loop Circulation

Cable Cost - Per Mile

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total cost Total
Civil Work							
Normal excavation	2,933	cy	20	0	58,660	0	58,660
Rock excavation	0	cy	100	0	0	0	0
Lean mix concrete	1,760	cy	0	74	0	130,240	130,240
Spoil disposal	1,760	cy	7	2	12,320	3,578	15,898
Backfill & tampering	1,173	cy	0.5	2	622	2,346	2,968
Paving - temp & permanent	1,760	sy	15	36	26,400	63,360	89,760
Manholes 15x6x7H	3	ea	3000	7000	9,000	21,000	30,000
Major crossings	1	ea	10000	20000	10,000	20,000	30,000
Road crossings	1	ea	7700	1000	7,700	1,000	8,700
Police	1	lot	16000	0	16,000	0	16,000
					140,702	241,524	382,226
Overtime factor	20%	lot			28,140		28,140
Sub-total - Civil Work					168,843	241,524	410,366
Underground cable							
Cable 2500 kcmil Cu 115 kV	16315	lf	0	47.83	0	780,310	780,310
Pipe coated 8"	5438	lf	15	20	81,576	108,768	190,344
Oil	17000	gall	0	4	0	68,000	68,000
Fluid return pipes 4"	5438	lf	4	12	21,754	65,261	87,014
Fiber optic PVC duct 2x4"	5438	lf	2.8	4.2	15,344	23,017	38,361
Cable pulls	3	ea	15000	0	45,000	0	45,000
Cable splices	3	ea	35000	4000	105,000	12,000	117,000
					268,674	1,057,356	1,326,030
Material handling & storage	15%						158,603
Sub-total					268,674	1,057,356	1,484,633
Administration	2%	lot					37,900
Engineering & surveying	12%	lot					217,925
AFUDC	3%						64,525
Contingency	15%						322,624
Sub-total							642,973
Total Cable Cost (per Mile)							**$2,537,973**

Terminal Cost - Per Project

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total cost Total
Cable terminations	6	ea	3000	12000	18,000	72,000	90,000
Termination structures & trifur.	2	ea	20000	11000	40,000	22,000	62,000
Cathodic protection	1	lot	8000	12000	8,000	12,000	20,000
Pressurizing plant	1	ea	100000	250000	100,000	250,000	350,000
Testing & commissioning	1	lot	20000	0	20,000	0	20,000
					186,000	356,000	542,000
Material handling & storage	15%					53,400	53,400
Sub-total					186,000	409,400	595,400
Administration	2%	lot					11,908
Engineering & surveying	12%	lot					68,471
AFUDC	3%						20,273
Contingency	15%						101,367
Sub-total							202,019
Total Terminal Cost							**$797,419**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	100,000
AFUDC	3%		3,000
Contingency	15%		15,000
Total Fees			**$118,000**

Construction Cost Estimate
Underground Single Circuit Self Contained Fluid Filled

Cable Cost - Per Mile

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total cost Total
Civil Work							
Normal excavation	3,911	cy	20	0	78,222	0	78,222
Rock excavation	0	cy	100	0	0	0	0
Lean mix concrete	2,347	cy	0	74	0	173,653	173,653
Spoil disposal	2,347	cy	7	2	16,427	4,770	21,197
Backfill & tampering	1,564	cy	0 5	2	830	3,129	3,959
Paving - temp & permanent	2,347	sy	15	36	35,200	84,480	119.680
Manholes 15x6x7H	5	ea	3000	7000	15,000	35,000	50,000
Major crossings	1	ea	10000	20000	10,000	20,000	30,000
Road crossings	1	ea	7700	1000	7,700	1,000	8,700
Police	1	lot	16000	0	16,000	0	16,000
					179,379	322,033	501,411
Overtime factor	20%	lot			35,876		35,876
Sub-total - Civil Work					215,255	322,033	537,287
Underground cable							
Cable 2750 kcmil Cu 115 kV	16315	lf	0	59 78	0	975,388	975,388
Cable duct 3 - 8"	16315	lf	5 6	8 4	91,365	137,048	228,413
Fluid	0	lot	0	0	0	0	0
Fluid return pipes (future)	0	lf	4.0	12.0	0	0	0
Fiber optic PVC duct 2x4"	5438	lf	2.8	4 2	15,343	23,015	38,358
Cable pulls	15	ea	5000	0	75,000	0	75,000
Cable splices + transposition	15	ea	5000	1000	75,000	15,000	90,000
Pressurizing reservoirs	3	ea	5000	10000	15,000	30,000	45,000
					271,708	1,180,451	1,452,159
Material handling & storage	15%						177,068
Sub-total					271,708	1,180,451	1,629,227
Administration	2%	lot					43,330
Engineering & surveying	12%	lot					249,149
AFUDC	3%						73,770
Contingency	15%						368,849
Sub-total							735,098
Total Cable Cost (per Mile)							**$2,901,612**

Terminal Cost - Per Project

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total cost Total
Cable terminations	6	ea	3000	12000	18,000	72,000	90,000
Terminating structures	2	ea	10000	8000	20,000	16,000	36,000
Cathodic protection		lot	8000	12000	0	0	0
Testing & commissioning	1	lot	20000	0	20,000	0	20,000
					58,000	88,000	146,000
Material handling & storage	15%					13,200	13,200
Sub-total					58,000	101,200	159,200
Administration	2%	lot					3,184
Engineering & surveying	12%	lot					18,308
AFUDC	3%						5,421
Contingency	15%						27,104
Sub-total							54,017
Total Terminal Cost							**$213,217**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	100,000
AFUDC	3%		3,000
Contingency	15%		15,000
Total Fees			**$118,000**

Construction Cost Estimate
Underground Single Circuit Solid Dielectric with Horizontal Arrangement

Cable Cost - Per Mile

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total cost Total
<u>Civil Work</u>							
Normal excavation	3,911	cy	20	0	78,222	0	78,222
Rock excavation	0	cy	100	0	0	0	0
Lean mix concrete	2,347	cy	0	74	0	173,653	173,653
Spoil disposal	2,347	cy	7	2	16,427	4,770	21,197
Backfill & tampering	1,564	cy	0.5	2	830	3,129	3,959
Paving - temp & permanent	2,347	sy	15	36	35,200	84,480	119,680
Manholes 15x6x7H	5	ea	3000	7000	15,000	35,000	50,000
Major crossings	1	ea	10000	20000	10,000	20,000	30,000
Road crossings	1	ea	7700	1000	7,700	1,000	8,700
Police	1	lot	16000	0	16,000	0	16,000
					179,379	322,033	501,411
Overtime factor	20%	lot			35,876		35,876
Sub-total - Civil Work					215,255	322,033	537,287
<u>Underground cable</u>							
Cable 2500 kcmil Cu 115 kV	16315	lf	0	38.90	0	634,694	634,694
Cable duct 3x8"	16315	lf	5.6	8.4	91,365	137,048	228,413
Fiber optic PVC duct 2x4"	5438	lf	2.8	4.2	15,343	23,015	38,358
Cable pulls	15	ea	5000	0	75,000	0	75,000
Cable splices + transpositions	15	ea	5000	7850	75,000	117,750	192,750
					256,708	912,507	1,169,215
Material handling & storage	15%						136,876
Sub-total					256,708	912,507	1,306,091
Administration	2%	lot					36,868
Engineering & surveying	12%	lot					211,988
AFUDC	3%						62,767
Contingency	15%						313,835
Sub-total							625,458
Total Cable Cost (per Mile)							**$2,468,836**

Terminal Cost - Per Project

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Labor	Material	Total
Cable terminations	6	ea	3000	5600	18,000	33,600	51,600
Terminating structures	2	ea	10000	8000	20,000	16,000	36,000
Testing & commissioning	1	lot	10000	0	10,000	0	10,000
					48,000	49,600	97,600
Material handling & storage	15%					7,440	7,440
Sub-total					48,000	57,040	105,040
Administration	2%	lot					2,101
Engineering & surveying	12%	lot					12,080
AFUDC	3%						3,577
Contingency	15%						17,883
Sub-total							35,640
Total Terminal Cost							**$140,680**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	100,000
AFUDC	3%		3,000
Contingency	15%		15,000
Total Fees			**$118,000**

Construction Cost Estimate
Underground Single Circuit Solid Dielectric with Delta Arrangement

Cable Cost - Per Mile

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total cost Total
Civil Work							
Normal excavation	3,520	cy	20	0	70,400	0	70,400
Rock excavation	59	cy	100	0	5,900	0	5,900
Lean mix concrete	2,444	cy	0	74	0	180,856	180,856
Spoil disposal	2,444	cy	7	2	17,108	4,968	22,076
Backfill & tampering	1,076	cy	0.5	2	571	2,152	2,723
Paving - temp & permanent	1,760	sy	15	36	26,400	63,360	89,760
Manholes 15x6x7H	5	ea	3000	7000	15,000	35,000	50,000
Major crossings	1	ea	10000	20000	10,000	20,000	30,000
Road crossings	1	ea	7700	1000	7,700	1,000	8,700
Police	1	lot	16000	0	16,000	0	16,000
					169,079	307,336	476,415
Overtime factor	20%	lot			33,816		33,816
Sub-total - Civil Work					202,895	307,336	510,231
Underground cable							
Cable 2500 kcmil Cu 115 kV	16315	lf	0	38.90	0	634,694	634,694
Cable duct 3x8"	16315	lf	5.6	8.4	91,365	137,048	228,413
Fiber optic PVC duct 2x4"	5438	lf	2.8	4.2	15,343	23,015	38,358
Cable pulls	15	ea	5000	0	75,000	0	75,000
Cable splices + transpositions	15	ea	5000	7850	75,000	117,750	192,750
					256,708	912,507	1,169,215
Material handling & storage	15%						136,876
Sub-total					256,708	912,507	1,306,091
Administration	2%	lot					36,326
Engineering & surveying	12%	lot					208,877
AFUDC	3%						61,846
Contingency	15%						309,229
Sub-total							616,278
Total Cable Cost (per Mile)							**$2,432,600**

Terminal Cost - Per Project

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Labor	Material	Total
Cable terminations	6	ea	3000	5600	18,000	33,600	51,600
Terminating structures	2	ea	10000	8000	20,000	16,000	36,000
Testing & commissioning	1	lot	10000	0	10,000	0	10,000
					48,000	49,600	97,600
Material handling & storage	15%					7,440	7,440
Sub-total					48,000	57,040	105,040
Administration	2%	lot					2,101
Engineering & surveying	12%	lot					12,080
AFUDC	3%						3,577
Contingency	15%						17,883
Sub-total							35,640
Total Terminal Cost							**$140,680**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	100,000
AFUDC	3%		3,000
Contingency	15%		15,000
Total Fees			**$118,000**

Construction Cost Estimate
Underground Single Circuit Solid Dielectric with L-Shaped Arrangement

Cable Cost - Per Mile

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total cost Total
Civil Work							
Normal excavation	3,520	cy	20	0	70,400	0	70,400
Rock excavation	59	cy	100	0	5,867	0	5,867
Lean mix concrete	2,444	cy	0	74	0	180,890	180,890
Spoil disposal	2,444	cy	7	2	17,111	4,969	22,080
Backfill & tampering	1,076	cy	0.5	2	571	2,151	2,722
Paving - temp & permanent	1,760	sy	15	36	26,400	63,360	89,760
Manholes 15x6x7H	5	ea	3000	7000	15,000	35,000	50,000
Major crossings	1	ea	10000	20000	10,000	20,000	30,000
Road crossings	1	ea	7700	1000	7,700	1,000	8,700
Police	1	lot	16000	0	16,000	0	16,000
					169,049	307,371	476,419
Overtime factor	20%	lot			33,810		33,810
Sub-total - Civil Work					202,858	307,371	510,229
Underground cable							
Cable 2500 kcmil Cu 115 kV	16315	lf	0	38.90	0	634,694	634,694
Cable duct 3x8"	16315	lf	5.6	8.4	91,365	137,048	228,413
Fiber optic PVC duct 2x4"	5438	lf	2.8	4.2	15,343	23,015	38,358
Cable pulls	15	ea	5000	0	75,000	0	75,000
Cable splices + transpositions	15	ea	5000	7850	75,000	117,750	192,750
					256,708	912,507	1,169,215
Material handling & storage	15%						136,876
Sub-total					256,708	912,507	1,306,091
Administration	2%	lot					36,326
Engineering & surveying	12%	lot					208,877
AFUDC	3%						61,846
Contingency	15%						309,228
Sub-total							616,277
Total Cable Cost (per Mile)							**$2,432,597**

Terminal Cost - Per Project

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total cost Total
Cable terminations	6	ea	3000	5600	18,000	33,600	51,600
Terminating structures	2	ea	10000	8000	20,000	16,000	36,000
Testing & commissioning	1	lot	10000	0	10,000	0	10,000
					48,000	49,600	97,600
Material handling & storage	15%					7,440	7,440
Sub-total					48,000	57,040	105,040
Administration	2%	lot					2,101
Engineering & surveying	12%	lot					12,080
AFUDC	3%						3,577
Contingency	15%						17,883
Sub-total							35,640
Total Terminal Cost							**$140,680**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	100,000
AFUDC	3%		3,000
Contingency	15%		15,000
Total Fees			**$118,000**

Construction Cost Estimate
Underground Double Circuit High Pressure Gas-Filled

Cable Cost - Per Mile

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total cost Total
Civil Work							
Normal excavation	3,911	cy	20	0	78,222	0	78,222
Rock excavation	0	cy	100	0	0	0	0
Lean mix concrete	2,347	cy	0	74	0	173,653	173,653
Spoil disposal	2,347	cy	7	2	16,427	4,770	21.197
Backfill & tampering	1,564	cy	0.5	2	830	3,129	3,959
Paving - temp & permanent	3,520	sy	15	36	52,800	126,720	179,520
Manholes 15x6x7H	3	ea	3000	7000	9,000	21,000	30,000
Major crossings	1	ea	10000	20000	10,000	20,000	30,000
Road crossings	1	ea	7700	1000	7,700	1,000	8,700
Police	1	lot	16000	0	16,000	0	16,000
					190,979	350,273	541.251
Overtime factor	20%	lot			38,196		38,196
Sub-total - Civil Work					229,175	350,273	579,447
Underground cable							
Cable 2500 kcmil Cu 115 kV	32630	lf	0	52.61	0	1,716,614	1,716,614
Pipe coated 8"	10877	lf	20	20	217,536	217,536	435.072
Gas (nitrogen)	2	lot		10000	0	20,000	20,000
Fluid return pipes (future)	0	lf	4.0	12.0	0	0	0
Fiber optic PVC duct 2x4"	5438	lf	2.8	4.2	15,344	23,017	38,361
Cable pulls	6	ea	15000	0.0	90,000	0	90,000
Cable splices	6	ea	35000	4000	210,000	24,000	234,000
Pressurizing plant	6	ea	5000	10000	30,000	60,000	90,000
					562,880	2,061,166	2,624,047
Material handling & storage	15%						309,175
Sub-total					562,880	2,061,166	2,933,222
Administration	2%	lot					70.253
Engineering & surveying	12%	lot					403,957
AFUDC	3%						119,606
Contingency	15%						598,032
Sub-total							1,191,849
Total Cable Cost (per Mile)							**$4,704,517**

Terminal Cost - Per Project

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total cost Total
Cable terminations	12	ea	3000	12000	36,000	144,000	180,000
Terminating structures & trifur.	4	ea	20000	11000	80,000	44,000	124,000
Cathodic protection	2	lot	8000	12000	16,000	24,000	40,000
Testing & commissioning	2	lot	20000	0	40,000	0	40,000
					172,000	212,000	384,000
Material handling & storage	15%					31,800	31,800
Sub-total					172,000	243,800	415,800
Administration	2%	lot					8,316
Engineering & surveying	12%	lot					47,817
AFUDC	3%						14,158
Contingency	15%						70,790
Sub-total							141,081
Total Terminal Cost							**$556,881**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	100,000
AFUDC	3%		3,000
Contingency	15%		15,000
Total Fees			**$118,000**

Construction Cost Estimate
Underground Double Circuit High Pressure Fluid-Filled

Cable Cost - Per Mile

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total cost Total
Civil Work							
Normal excavation	3,911	cy	20	0	78,222	0	78,222
Rock excavation	0	cy	100	0	0	0	0
Lean mix concrete	2,347	cy	0	74	0	173,653	173,653
Spoil disposal	2,347	cy	7	2	16,427	4,770	21,197
Backfill & tampering	1,564	cy	0.5	2	830	3,129	3,959
Paving - temp & permanent	3,520	sy	15	36	52,800	126,720	179,520
Manholes 15x6x7H	3	ea	3000	7000	9,000	21,000	30,000
Major crossings	1	ea	10000	20000	10,000	20,000	30,000
Road crossings	1	ea	7700	1000	7,700	1,000	8,700
Police	1	lot	16000	0	16,000	0	16,000
					190,979	350,273	541,251
Overtime factor	20%	lot			38,196		38,196
Sub-total - Civil Work					229,175	350,273	579,447
Underground cable							
Cable 2500 kcmil Cu 115 kV	32630	crt lf	0	47.83	0	1,560,621	1,560,621
Pipe coated 8"	10877	lf	20	20	217,536	217,536	435,072
Oil	32000	gall	0	4	0	128,000	128,000
Fluid return pipes (future)	0	lf	4	12	0	0	0
Fiber optic PVC duct 4"	5438	lf	2.8	4.2	15,344	23,017	38,361
Cable pulls	6	ea	15000	0	90,000	0	90,000
Cable splices	6	ea	35000	4000	210,000	24,000	234,000
					532,880	1,953,173	2,486,054
Material handling & storage	15%						292,976
Sub-total					532,880	1,953,173	2,779,030
Administration	2%	lot					67,170
Engineering & surveying	12%	lot					386,225
AFUDC	3%						114,356
Contingency	15%						571,781
Sub-total							1,139,531
Total Cable Cost (per Mile)							**$4,498,008**
Terminal Cost - Per Project							
Cable terminations	12	ea	3000	12000	36,000	144,000	180,000
Terminating structures & trifur.	4	ea	20000	11000	80,000	44,000	124,000
Cathodic protection	2	lot	8000	12000	16,000	24,000	40,000
Pressurizing plant	1	ea	100000	250000	100,000	250,000	350,000
Testing & commissioning	2	lot	20000	0	40,000	0	40,000
					272,000	462,000	734,000
Material handling & storage	15%					69,300	69,300
Sub-total					272,000	531,300	803,300
Administration	2%	lot					16,066
Engineering & surveying	12%	lot					92,380
AFUDC	3%						27,352
Contingency	15%						136,762
Sub-total							272,560
Total Terminal Cost							**$1,075,860**
Regulatory Cost & Permit Fees - Per Project							
Regulatory cost & permit fees		lot					100,000
AFUDC	3%						3,000
Contingency	15%						15,000
Total Fees							**$118,000**

Construction Cost Estimate
Underground Double Circuit High Pressure Fluid-Filled with Closed Loop Circulation

Cable Cost - Per Mile

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total cost Total
Civil Work							
Normal excavation	6,551	cy	20	0	131,022	0	131,022
Rock excavation	0	cy	100	0	0	0	0
Lean mix concrete	4,107	cy	0	74	0	303,893	303,893
Spoil disposal	4,107	cy	7	2	28,747	8,348	37,095
Backfill & tampering	2,444	cy	0.5	2	1,297	4,889	6,186
Paving - temp & permanent	3,520	sy	15	36	52,800	126,720	179,520
Manholes 15x6x7H	3	ea	3000	7000	9,000	21,000	30,000
Major crossings	1	ea	10000	20000	10,000	20,000	30,000
Road crossings	1	ea	7700	1000	7,700	1,000	8,700
Police	1	lot	16000	0	16,000	0	16,000
					256,566	485,850	742,416
Overtime factor	20%	lot			51,313		51,313
Sub-total - Civil Work					307,879	485,850	793,729
Underground cable							
Cable 2500 kcmil Cu 115 kV	32630	crt lf	0	47.83	0	1,560,621	1,560,621
Pipe coated 8"	10877	lf	20	20	217,536	217,536	435,072
Oil	34000	gall	0	4	0	136,000	136,000
Fluid return pipes 4"	10877	lf	4	12	43,507	130,522	174,029
Fiber optic PVC duct 4"	5438	lf	2.8	4.2	15,344	23,017	38,361
Cable pulls	6	ea	15000	0	90,000	0	90,000
Cable splices	6	ea	35000	4000	210,000	24,000	234,000
					576,388	2,091,695	2,668,083
Material handling & storage	15%						313,754
Sub-total					576,388	2,091,695	2,981,837
Administration	2%	lot					75,511
Engineering & surveying	12%	lot					434,190
AFUDC	3%						128,558
Contingency	15%						642,790
Sub-total							1,281,050
Total Cable Cost (per Mile)							**$5,056,615**

Terminal Cost - Per Project

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total cost Total
Cable terminations	12	ea	3000	12000	36,000	144,000	180,000
Terminating structures & trifur.	4	ea	20000	11000	80,000	44,000	124,000
Cathodic protection	2	lot	8000	12000	16,000	24,000	40,000
Pressurizing plant	1	ea	100000	250000	100,000	250,000	350,000
Testing & commissioning	2	lot	20000	0	40,000	0	40,000
					272,000	462,000	734,000
Material handling & storage	15%					69,300	69,300
Sub-total					272,000	531,300	803,300
Administration	2%	lot					16,066
Engineering & surveying	12%	lot					92,380
AFUDC	3%						27,352
Contingency	15%						136,762
Sub-total							272,560
Total Terminal Cost							**$1,075,860**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	100,000
AFUDC	3%		3,000
Contingency	15%		15,000
Total Fees			**$118,000**

Construction Cost Estimate
Underground Double Circuit Self Contained Fluid-Filled

Cable Cost - Per Mile

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total
Civil Work							
Normal excavation	5,476	cy	20	0	109,511	0	109 511
Rock excavation	156	cy	100	0	15,644	0	15,644
Lean mix concrete	4,002	cy	0	74	0	296,177	296 177
Spoil disposal	4,002	cy	7	2	28,017	8,136	36.153
Backfill & tampering	1,473	cy	0.5	2	782	2,946	3,728
Paving - temp & permanent	4,693	sy	15	36	70,400	168,960	239,360
Manholes 15x6x7H	5	ea	3000	7000	15,000	35,000	50,000
Major crossings	1	ea	10000	20000	10,000	20,000	30,000
Road crossings	1	ea	7700	1000	7,700	1,000	8,700
Police	1	lot	16000	0	16,000	0	16,000
					273,054	532,220	805,274
Overtime factor	20%	lot			54,611		54,611
Sub-total - Civil Work					327,665	532,220	859 884
Underground cable							
Cable 2750 kcmil Cu 115 kV	32630	lf	0	59.78	0	1,950.776	1,950,776
Cable duct 3 - 8"	32630	lf	5.6	8.4	182,730	274,095	456,826
Fluid	0	lot	0	0	0	0	0
Fluid return pipes (future)	0	lf	4.0	12.0	0	0	0
Fiber optic PVC duct 2x4"	5438	lf	2.8	4 2	15,344	23,017	38,361
Cable pulls	30	ea	5000	0	150,000	0	150,000
Cable splices +transposition	30	ea	5000	1000	150,000	30,000	180,000
					498,075	2,277,888	2,775,963
Material handling & storage	15%						341,683
Sub-total					498,075	2,277,888	3,117,646
Administration	2%	lot					79,551
Engineering & surveying	12%	lot					457,416
AFUDC	3%						135,435
Contingency	15%						677,174
Sub-total							1,349,576
Total Cable Cost (per Mile)							**$5,327,106**

Terminal Cost - Per Project

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total
Cable terminations	12	ea	3000	12000	36,000	144,000	180,000
Terminating structures	4	ea	10000	8000	40,000	32,000	72,000
Cathodic protection		lot	8000	12000	0	0	0
Pressurizing plant	6	ea	5000	10000	30,000	60,000	90,000
Testing & commissioning	2	lot	20000	0	40,000	0	40,000
					146,000	236,000	382,000
Material handling & storage	15%					35,400	35,400
Sub-total					146,000	271,400	417,400
Administration	2%	lot					8,348
Engineering & surveying	12%	lot					48,001
AFUDC	3%						14,212
Contingency	15%						71,062
Sub-total							141,624
Total Terminal Cost							**$559,024**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	100,000
AFUDC	3%		3,000
Contingency	15%		15,000
Total Fees			**$118,000**

Construction Cost Estimate
Underground Double Circuit Solid Dielectric with Horizontal Arrangement

Cable Cost - Per Mile

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total
Civil Work							
Normal excavation	5,476	cy	20	0	109,511	0	109.511
Rock excavation	156	cy	100	0	15,644	0	15.644
Lean mix concrete	4,002	cy	0	74	0	296,177	296,177
Spoil disposal	4,002	cy	7	2	28,017	8,136	36,153
Backfill & tampering	1,473	cy	0.5	2	782	2,946	3,728
Paving - temp & permanent	4,693	sy	15	36	70,400	168,960	239,360
Manholes 15x6x7H	5	ea	3000	7000	15,000	35,000	50,000
Major crossings	1	ea	10000	20000	10,000	20,000	30.000
Road crossings	1	ea	7700	1000	7,700	1,000	8.700
Police	1	lot	16000	0	16,000	0	16,000
					273,054	532,220	805.274
Overtime factor	20%	lot			54,611		54,611
Sub-total - Civil Work					327,665	532,220	859,884
Underground cable							
Cable 2750 kcmil Cu 115 kV	32630	lf	0	42.79	0	1,396,327	1,396,327
Cable duct 3x8"	32630	lf	5.6	8.4	182,730	274,095	456,826
Fiber optic PVC duct 2x4"	5438	lf	2.8	4.2	15,344	23,017	38,361
Cable pulls	30	ea	5000	0	150,000	0	150,000
Cable splices + transpositions	30	ea	5000	7850	150,000	235,500	385,500
					498,075	1,928,939	2,427,013
Material handling & storage	15%						289,341
Sub-total					498,075	1,928,939	2,716,354
Administration	2%	lot					71,525
Engineering & surveying	12%	lot					411,267
AFUDC	3%						121,771
Contingency	15%						608,855
Sub-total							1,213,418
Total Cable Cost (per Mile)							**$4,789,656**

Terminal Cost - Per Project

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Labor	Material	Total
Cable terminations	12	ea	3000	5600	36,000	67,200	103,200
Terminating structures	4	ea	10000	8000	40,000	32,000	72,000
Testing & commissioning	2	lot	10000	0	20,000	0	20,000
					96,000	99,200	195,200
Material handling & storage	15%					14,880	14,880
Sub-total					96,000	114,080	210,080
Administration	2%	lot					4,202
Engineering & surveying	12%	lot					24,159
AFUDC	3%						7,153
Contingency	15%						35,766
Sub-total							71,280
Total Terminal Cost							**$281,360**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	100,000
AFUDC	3%		3,000
Contingency	15%		15,000
Total Fees			**$118,000**

Construction Cost Estimate

Underground Double Circuit Solid Dielectric with Horizontal Arrangement and Alternative Phasing

Cable Cost - Per Mile

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total
Civil Work							
Normal excavation	5,476	cy	20	0	109,511	0	109,511
Rock excavation	156	cy	100	0	15,644	0	15,644
Lean mix concrete	4,002	cy	0	74	0	296,177	296,177
Spoil disposal	4,002	cy	7	2	28,017	8,136	36,153
Backfill & tampering	1,473	cy	0.5	2	782	2,946	3,728
Paving - temp & permanent	4,693	sy	15	36	70,400	168,960	239,360
Manholes 15x6x7H	5	ea	3000	7000	15,000	35,000	50,000
Major crossings	1	ea	10000	20000	10,000	20,000	30,000
Road crossings	1	ea	7700	1000	7,700	1,000	8,700
Police	1	lot	16000	0	16,000	0	16,000
					273,054	532,220	805,274
Overtime factor	20%	lot			54,611		54,611
Sub-total - Civil Work					327,665	532,220	859,884
Underground cable							
Cable 2750 kcmil Cu 115 kV	32630	lf	0	42.79	0	1,396,327	1,396,327
Cable duct 3x8"	32630	lf	5.6	8.4	182,730	274,095	456,826
Fiber optic PVC duct 2x4"	5438	lf	2.8	4.2	15,344	23,017	38,361
Cable pulls	30	ea	5000	0	150,000	0	150,000
Cable splices + transpositions	30	ea	5000	7850	150,000	235,500	385,500
					498,075	1,928,939	2,427,013
Material handling & storage	15%						289,341
Sub-total					498,075	1,928,939	2,716,354
Administration	2%	lot					71,525
Engineering & surveying	12%	lot					411,267
AFUDC	3%						121,771
Contingency	15%						608,855
Sub-total							1,213,418
Total Cable Cost (per Mile)							**$4,789,656**

Terminal Cost - Per Project

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total
Cable terminations	12	ea	3000	5600	36,000	67,200	103,200
Terminating structures	4	ea	10000	8000	40,000	32,000	72,000
Testing & commissioning	2	lot	10000	0	20,000	0	20,000
					96,000	99,200	195,200
Material handling & storage	15%					14,880	14,880
Sub-total					96,000	114,080	210,080
Administration	2%	lot					4,202
Engineering & surveying	12%	lot					24,159
AFUDC	3%						7,153
Contingency	15%						35,766
Sub-total							71,280
Total Terminal Cost							**$281,360**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	100,000
AFUDC	3%		3,000
Contingency	15%		15,000
Total Fees			**$118,000**

Construction Cost Estimate
Underground Double Circuit Solid Dielectric with Vertical Arrangement

Cable Cost - Per Mile

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total
<u>Civil Work</u>							
Normal excavation	5,476	cy	20	0	109,511	0	109.511
Rock excavation	156	cy	100	0	15,644	0	15,644
Lean mix concrete	4,002	cy	0	74	0	296,177	296.177
Spoil disposal	4,002	cy	7	2	28,017	8,136	36.153
Backfill & tampering	1,473	cy	0.5	2	782	2,946	3,728
Paving - temp & permanent	4,693	sy	15	36	70,400	168,960	239,360
Manholes 15x6x7H	5	ea	3000	7000	15,000	35,000	50,000
Major crossings	1	ea	10000	20000	10,000	20,000	30,000
Road crossings	1	ea	7700	1000	7,700	1,000	8,700
Police	1	lot	16000	0	16,000	0	16.000
					273,054	532,220	805.274
Overtime factor	20%	lot			54,611		54.611
Sub-total - Civil Work					327,665	532,220	859.884
<u>Underground cable</u>							
Cable 2750 kcmil Cu 115 kV	32630	lf	0	42.79	0	1,396,327	1,396.327
Cable duct 3x8"	32630	lf	5.6	8.4	182,730	274,095	456,826
Fiber optic PVC duct 2x4"	5438	lf	2.8	4.2	15,344	23,017	38.361
Cable pulls	30	ea	5000	0	150,000	0	150,000
Cable splices + transpositions	30	ea	5000	7850	150,000	235,500	385,500
					498,075	1,928,939	2,427,013
Material handling & storage	15%						289,341
Sub-total					498,075	1,928,939	2,716,354
Administration	2%	lot					71.525
Engineering & surveying	12%	lot					411,267
AFUDC	3%						121,771
Contingency	15%						608,855
Sub-total							1,213.418
Total Cable Cost (per Mile)							**$4,789,656**

Terminal Cost - Per Project

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total
Cable terminations	12	ea	3000	5600	36,000	67,200	103,200
Terminating structures	4	ea	10000	8000	40,000	32,000	72,000
Testing & commissioning	2	lot	10000	0	20,000	0	20,000
					96,000	99,200	195,200
Material handling & storage	15%					14,880	14,880
Sub-total					96,000	114,080	210,080
Administration	2%	lot					4,202
Engineering & surveying	12%	lot					24,159
AFUDC	3%						7,153
Contingency	15%						35,766
Sub-total							71,280
Total Terminal Cost							**$281,360**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	100,000
AFUDC	3%		3,000
Contingency	15%		15,000
Total Fees			**$118,000**

Construction Cost Estimate

Underground Double Circuit Solid Dielectric with Vertical Arrangement and Alternative Phasing

Cable Cost - Per Mile

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total
Civil Work							
Normal excavation	5,476	cy	20	0	109,511	0	109,511
Rock excavation	156	cy	100	0	15,644	0	15,644
Lean mix concrete	4,002	cy	0	74	0	296,177	296,177
Spoil disposal	4,002	cy	7	2	28,017	8,136	36,153
Backfill & tampering	1,473	cy	0.5	2	782	2,946	3,728
Paving - temp & permanent	4,693	sy	15	36	70,400	168,960	239,360
Manholes 15x6x7H	5	ea	3000	7000	15,000	35,000	50,000
Major crossings	1	ea	10000	20000	10,000	20,000	30,000
Road crossings	1	ea	7700	1000	7,700	1,000	8,700
Police	1	lot	16000	0	16,000	0	16,000
					273,054	532,220	805,274
Overtime factor	20%	lot			54,611		54,611
Sub-total - Civil Work					327,665	532,220	859,884
Underground cable							
Cable 2750 kcmil Cu 115 kV	32630	lf	0	42.79	0	1,396,327	1,396,327
Cable duct 3x8"	32630	lf	5.6	8.4	182,730	274,095	456,826
Fiber optic PVC duct 2x4"	5438	lf	2.8	4.2	15,344	23,017	38,361
Cable pulls	30	ea	5000	0	150,000	0	150,000
Cable splices + transpositions	30	ea	5000	7850	150,000	235,500	385,500
					498,075	1,928,939	2,427,013
Material handling & storage	15%						289,341
Sub-total					498,075	1,928,939	2,716,354
Administration	2%	lot					71,525
Engineering & surveying	12%	lot					411,267
AFUDC	3%						121,771
Contingency	15%						608,855
Sub-total							1,213,418
Total Cable Cost (per Mile)							**$4,789,656**

Terminal Cost - Per Project

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total
Cable terminations	12	ea	3000	5600	36,000	67,200	103,200
Terminating structures	4	ea	10000	8000	40,000	32,000	72,000
Testing & commissioning	2	lot	10000	0	20,000	0	20,000
					96,000	99,200	195,200
Material handling & storage	15%					14,880	14,880
Sub-total					96,000	114,080	210,080
Administration	2%	lot					4,202
Engineering & surveying	12%	lot					24,159
AFUDC	3%						7,153
Contingency	15%						35,766
Sub-total							71,280
Total Terminal Cost							**$281,360**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	100,000
AFUDC	3%		3,000
Contingency	15%		15,000
Total Fees			**$118,000**

Construction Cost Estimate
Underground Double Circuit Solid Dielectric with Delta Arrangement

Cable Cost - Per Mile

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Total cost Labor	Total cost Material	Total cost Total
Civil Work							
Normal excavation	4,693	cy	20	0	93,867	0	93,867
Rock excavation	78	cy	100	0	7,822	0	7,822
Lean mix concrete	3,220	cy	0	74	0	238,293	238,293
Spoil disposal	3,220	cy	7	2	22,541	6,546	29,087
Backfill & tampering	1,473	cy	0.5	2	782	2,946	3,728
Paving - temp & permanent	4,693	sy	15	36	70,400	168,960	239,360
Manholes 15x6x7H	5	ea	3000	7000	15,000	35,000	50,000
Major crossings	1	ea	10000	20000	10,000	20,000	30,000
Road crossings	1	ea	7700	1000	7,700	1,000	8,700
Police	1	lot	16000	0	16,000	0	16,000
					244,112	472,745	716,857
Overtime factor	20%	lot			48,822		48,822
Sub-total - Civil Work					292,934	472,745	765,679
Underground cable							
Cable 2750 kcmil Cu 115 kV	32630	lf	0	42.79	0	1,396,327	1,396,327
Cable duct 3x8"	32630	lf	5.6	8.4	182,730	274,095	456,826
Fiber optic PVC duct 2x4"	5438	lf	2.8	4.2	15,344	23,017	38,361
Cable pulls	30	ea	5000	0	150,000	0	150,000
Cable splices + transpositions	30	ea	5000	7850	150,000	235,500	385,500
					498,075	1,928,939	2,427,013
Material handling & storage	15%						289,341
Sub-total					498,075	1,928,939	2,716,354
Administration	2%	lot					69,641
Engineering & surveying	12%	lot					400,434
AFUDC	3%						118,563
Contingency	15%						592,816
Sub-total							1,181,454
Total Cable Cost (per Mile)							**$4,663,487**

Terminal Cost - Per Project

	Quantity	Unit	Unit cost Labor	Unit cost Mat'l & Equip	Labor	Material	Total
Cable terminations	12	ea	3000	5600	36,000	67,200	103,200
Terminating structures	4	ea	10000	8000	40,000	32,000	72,000
Testing & commissioning	2	lot	10000	0	20,000	0	20,000
					96,000	99,200	195,200
Material handling & storage	15%					14,880	14,880
Sub-total					96,000	114,080	210,080
Administration	2%	lot					4,202
Engineering & surveying	12%	lot					24,159
AFUDC	3%						7,153
Contingency	15%						35,766
Sub-total							71,280
Total Terminal Cost							**$281,360**

Regulatory Cost & Permit Fees - Per Project

	Quantity	Unit	Total
Regulatory cost & permit fees		lot	100,000
AFUDC	3%		3,000
Contingency	15%		15,000
Total Fees			**$118,000**

Appendix B

Cost Calculations

Appendix B
Cost Calculations

B.1 Cost of Losses

Transmission line losses occur due to the flow of current through the conductors and the presence of voltage across the insulation. At 115 kV, voltage-dependent losses are typically less than 10% of current-dependent losses and are therefore ignored in this study.

Current dependent losses for each year are given by

$$LC=\frac{3RI^2 8760}{1000\ L_D^2}\left(L_o\ E_c\ +C_c\right)$$

where

LC	=	cost of losses ($/mile/year)
R	=	conductor resistance (ohms/phase/mile)
I	=	annual average current (amps)
L_D	=	annual load factor
L_o	=	annual loss factor
E_c	=	annual average cost of energy ($/kWh)
C_c	=	annual average cost of capacity ($/kWh)

The following data was used for this study:

L_D = 0.60
L_o = 0.38

The costs of energy and capacity for each year are shown in Table B.1.

The current values used were

350A = (Scenario A)
500A = (Scenario B)

in Year 1 and were escalated by 1.2% each year to account for load growth

Table B.1

Annual Costs for Evaluating Transmission Losses

Year	Cents/kWh		Year	Cents/kWh	
	Energy	Capacity		Energy	Capacity
1996	2.7	0.0	2014	8.6	1.7
1997	3.0	0.0	2015	8.9	1.8
1998	3.3	0.0	2016	9.3	1.8
1999	3.3	0.0	2017	9.7	1.9
2000	3.7	0.0	2018	10.2	1.9
2001	4.0	0.0	2019	10.6	2.0
2002	4.3	0.0	2020	11.1	2.0
2003	4.6	0.3	2021	11.6	2.1
2004	5.0	0.3	2022	12.1	2.2
2005	5.4	0.3	2023	12.7	2.3
2006	6.0	0.3	2024	13.2	2.3
2007	6.7	1.1	2025	13.8	2.5
2008	7.0	1.1	2026	14.4	2.6
2009	7.3	1.1	2027	15.0	2.7
2010	7.6	1.2	2028	15.7	2.8
2011	7.7	1.5	2029	16.4	2.9
2012	8.0	1.6	2030	17.1	3.0
2013	8.2	1.6			

B.2 Capital Recovery Factor

The Capital Recovery Factor (FC) or Fixed Charge Rate is a factor by which the first cost of a transmission line is multiplied to spread the cost over the life time of the line. This process results in splitting the first cost in a series of equal or levelized annual amounts. In addition to first cost depreciation, FC includes allowances for various taxes and return costs to lenders and investors who financed the first cost.

An FC of 0.146 (14.6%) was used in this study consistent with the practice of Connecticut utilities. This value is based on a depreciation period of 35 years and zero salvage value.

B.3 Operation and Maintenance

Costs associated with overhead transmission lines and underground cables are treated in separate cost models. They are built up as outlined in the following.

B3.1 Transmission Lines

The Operation and Maintenance (O&M) costs are essentially those of: a commissioning inspection after construction, periodic inspection, routine maintenance and repair as required. The total cost for the 5-mile line is naturally a function of the type of structure (steel or wood; 1 or 2 circuits; single pole or H-frame) and the number of structures in the line.

Commissioning

In year one, climbing inspection of every structure of the line at 2 person.hours for wood pole structures and 5 person.hours for steel poles.

Periodic Inspection

- Foot patrol: one/year at 1 mph by one person plus cost on one pickup truck
- Helicopter patrol: 2/year at 40 minutes for 5 miles, at $450/hour including pilot, plus cost of observer
- Climbing inspection: 1% per year, at 4 person.hours per tower (not woodpole) with 4 person crew plus costs of pickup truck and line truck
- Infrared inspection: 33% per year; 40 minutes for 5 miles line, at $450/hour, including pilot, plus cost of observer
- Right-of-way clearing: contracted out annually at $44/acre, taking a 100 foot width for a single circuit and 150 feet for a double circuit right-of-way
- Pole test and treat (wood); starting in year 15, 10% of poles per year, at 2 person.hours per pole
- Pole replacement (wood); starting in year 20, 1% of poles per year, plus wood pole cost (dependent on length)
- Pole painting (steel): starting in year 30, 5% of steel poles per year at $900 per pole

Maintenance as Required

The following are estimated frequencies for a 5-mile line.

- Woodpecker damage (wood): once per year, 2 hours with crew of 2, plus cost of pickup truck
- Loose guys (wood): once in 2 years, 2 hours with crew of 2, plus cost of pickup truck
- Structure grounding (wood): once in 2 years, 1 hour with crew of 2, plus cost of pickup truck
- Insulator replacement: twice a year, 2.5 hours with crew of 3, plus cost of pickup truck, line truck and material ($210/string)
- Hardware replacement: once in 3 years, 2.5 hours with crew of 3, plus cost of pickup truck, linetruck and material ($25)
- Damper replacement: once a year, 2 hours with crew of 3, plus cost of pickup truck, line truck and material ($50/damper)
- Conductor or shieldwire damage: once in 10 years, 4 hours with crew of 4, plus cost of pickup truck, line truck, aerial device and material ($130 each)
- Minor modification: once in 5 years, 8 hours with crew of 4, plus cost of pickup truck, line truck, and a crane for one third of cases; no material cost included

Hourly Costs

Personnel:	$37.00	($23 salary plus 60% fringe benefits and employment overhead)
Pickup truck:	$3.75	
Line truck:	$29.25	
Aerial device:	$29.25	
Crane:	$41.00	
Helicopter and pilot:	$450.00	

Administration

An additional 2% head office overhead is applied to the O&M costs.

B3.2 Underground Cables

The annual underground cable O&M costs include the following activities.

Cable Location

Cable location comprises activities such as stake-out, communication with outside parties and updating of plans and records. One hundred twenty five person hours per year, for 5 miles of all cable types, plus cost of pickup truck; applies to either single or double circuit

Planned Maintenance and Inspection

The following person.hours per year, for 5 miles of cable:

- high pressure gas/fluid filled - 100
- self-contained fluid-filled - 80
- solid dielectric - 50
- plus costs of pickup truck, trailer and manhole cleaner
- multiplied by 1.5 for 2 circuit; 50% of total costs attributable to the cable terminals.

Unscheduled Maintenance and Repair

The following person hours per year, for 5 miles of cable:

- high pressure gas/fluid filled - 100
- self-contained fluid-filled - 100
- solid dielectric - 50
- plus cost of pickup truck, cable trucks, backhoe, manhole cleaner, splicer, utility truck, and walk-in van
- multiplied by 1.5 for 2 circuit; 70% of total costs attributable to the cable terminals.

Administration

Seventy-five person hours per year, for 5 miles of all cable types; multiplied by 2 for 2 circuit: 70% of the cost attributable to the cable terminals.

An additional 2% is applied to the total cost for head office overhead.

Hourly Costs

Personnel	$37.00	($23 salary plus 60% fringe benefits and employment overhead)
Pickup truck	$3.75	
Cable trucks	$29.30	
Backhoe	$26.00	
Trailer	$14.50	
Manhole cleaner	$33.60	
Splicer	$8.13	
Utility truck	$8.13	
Van, walk-in	$8.13	

Appendix C

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Appendix C

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Appendix D

Glossary of Terms

Appendix D - Glossary

Capacitance	See "Electrical Characteristics"
Clearance to ground	The conductors of an overhead line will span between the towers and the clearance to ground is the distance to ground from the lowest point where the conductor sags.
Conductor	The stranded metal wire that carries the electrical current on power transmission lines. On overhead lines, the conductor consists of an inner core of galvanized steel strands, to provide strength, surrounded by aluminum alloy strands which provide good electrical conductivity. On underground lines, the conductor is usually made of stranded copper and is surrounded by an electrical insulating jacket.
Conductor Phasing and Configuration	The power is transmitted in three phase conductors (Red, White and Blue Phases) which are energized, and the phasing refers to the relative sequence of these three conductors. The conductor configuration refers to the way the three conductors are physically situated relative to each other e.g. L-Shaped, Delta in an underground cable duct.
Conductor Size	The Circular mil is used to state the conductor size representing the cross sectional area. One circular mil is equal to the area of a circle 1 mil (one thousandth of an inch) in diameter. Cable cross sections are typically several hundred mils in diameter
Current Flows:	The current flow is the movement of electric charges and is measured in Amperes (A), Symbol I
Alternating Currents	Means that the current rises and reverses 60 times per second for the standard 60 Hz (Hertz) transmission lines in North America
Charging Currents	The current required to charge the capacitance of a line
Load Currents	Normal, Average or Emergency (Short or Long Term Levels) Currents are the expected requirements of a transmission line to carry currents.
Fault Currents	The fault current that flows in the line for a fraction of a second, when a short-circuit occurs.
Ampacity Current Rating	The rated current carrying capability of a transmission line based upon its thermal characteristics, ambient conditions and the time duration that any overload is expected to last.

Dielectric Insulation	In the case of underground lines, the conductors are separated from the surrounding earth by a dielectric electrical insulation and a cable sheath. Fluids (oils), compressed gas or solid dielectrics such as cross-linked polythene (XLPE) are used as the insulating medium.
Electric Fields	An electric field is produced, in the immediate vicinity of a transmission line, by the voltage and is measured in kilovolts/meter (kV/m).
Electrical Characteristics	The Resistance, Inductance and Capacitance are the main electrical characteristics of a transmission line.
Resistance	Resistance R (measured in ohms (Ω)) is the property of a conductor that causes the dissipation of energy in the line. The resistance decreases as the cross-section of the conductor gets larger.
Inductance	Inductance L is the property that determines the magnetic energy stored in the line and is measured in henrys (H). The inductance of a transmission line reduces as the spacing between adjacent conductors is reduced and therefore underground transmission line cables have a relatively low inductance.
Capacitance	Capacitance C is the property that determines the electric energy stored in a transmission line and is measured in farads (F). The capacitance increases as the spacing between the conductors is reduced and therefore underground transmission line cables have a relatively high capacitance.
Externalities	Externalities or societal costs are real or perceived environmental costs that may result from a project, but that are subjective and difficult to quantify in dollar terms. Examples are aesthetic impairment of views, adverse effects of noise and radio reception, property values, plant or wildlife habitat.
Fault	An unwanted electrical short circuit condition on an electrical power system. Faults on overhead transmission lines can result from cranes or other foreign objects touching the conductors as well as from lightning strikes. Faults on underground transmission lines can result from such things as dig-ins, washouts, soil shifting or subsidence.
First Costs	The total costs incurred to construct the transmission line and to place it into service for the first time
Fixed Charge Rate	The Fixed Charge Rate (FC) or the Capital Recovery Factor is a factor by which the first cost of a transmission line is multiplied to spread the cost evenly over the life time of the line.
Ground Level EMF	EMF strengths measured at 1 meter (3.28 feet) above ground level

Grounding	Grounding consists of connecting metallic parts of the line (which are not energized) to the ground via metal rods or wires buried in the ground.
Inductance	See "Electrical Characteristics".
Insulators	Transmission line conductors which are energized at high voltage must be physically and electrically separated from each other and from the ground. The conductors in an overhead line are suspended from a tower by insulators made from ceramic, polymers or glass.
Life-Cycle Cost	The total costs of the transmission line over its life, which is a total of the fixed costs (first costs and financing costs) and the variable costs of operation, maintenance and the cost of the losses incurred by power flow on that line. These operating costs are converted to their Present Value over the life of the transmission line. The total of these costs and the fixed costs give the total life-cycle cost.
Losses	Energy consumed in the resistance of the line measured in kilowatt-hours or kWh.
Magnetic Fields	A magnetic field is produced whenever currents flow in a wire and is usually measured in milligauss (mG)
Mechanical Loading	The ice loading (one half inch of ice radially coated on the conductors with a coincident wind speed of 40 mph) is taken as the design mechanical load for transmission lines in Connecticut.
Power Flow	Power Flow in a transmission line has two components; Real Power (measured in Megawatts-MW) and Reactive Power (measured in MegaVAR-MVar). In simple terms, the Power Flow is the product of the Voltage (V) and the Current(I). One MW is equal to 1000 kW.
Present Value Costs	The Present Value of a series of payments or income is calculated as the sum of the cash flows in each future year multiplied by a PV factor. The PV cost represents the time value of money.
Reliability	The Reliability of a transmission line is measured by the frequency and duration of failures which remove the line from service
Resistance	See "Electrical Characteristics"
Shield Wires	Located at the top of an overhead transmission line, one or two additional wires, called shield wires, act to divert lightning strikes to the ground.

Voltage	The potential energy stored in electric charge is measured in volts (V). This is analogous to pressure in a water supply system.
Voltage Levels	Voltage used in parts of the transmission system for example 69,000, 115,000 and 345,000 volts. This study covers only 115,000 volt (or 115-kV) transmission lines.

Abbreviations

AFUDC	Allowance for Funds used during construction
APPA	American Public Power Association
CEA	Canadian Electricity Association
CL&P	Connecticut Light & Power
CSC	Connecticut Siting Council
DPUC	State of Connecticut Department of Utility Control
EEI	Edison Electric Institute
EMF	Electric and Magnetic Fields are invisible lines of force surrounding any wire or device using electricity at 60 Hz.
FC	Fixed Charge Rate or Capital Recovery Factor
IEEE	The Institute of Electrical and Electronic Engineers
NCHS	National Center for Health Statistics
NESC	National Electric Safety Codes which define the requirements for clearances, grounding, grades of construction, mechanical loading, overload capacity factors and insulation.
NRECA	National Rural Electric Cooperative Association
NU	Northeast Utilities Service Company
OSHA	Occupational Safety and Health Administration
RTE	Rare, Threatened or Endangered Species
SCE	Southern California Edison
SIL	Surge Impedance Loading is the nominal power loading capacity of a transmission line, when considering the voltage profile of the power system
UI	United Illuminating