Workbook: **R50_distribution.xls**
Worksheet: **calculations**

Equation Listing

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Distribution Module

Column	Name	Formula	Description
X	pairs required per branch cable	=IF(AND(P2=0,V2>0),(lines_adj/V2)/VLOOKUP('cluster input data'!$R2,density_inputs,2),0)	Pairs required per branch cable with cable sizing factor
Y	branch cable cross section	=IF(P2=0,INDEX(cable_range,MATCH($X2-Z2*max_cable,cable_range,-1),1),0)	assigned branch cable cross section; if maximum-sized cables are present, this value covers remaining lines not served by maximum cable
Z	number of maximum branch cables	=TRUNC(X2/max_cable)	calculates number of "overflow" branch cables required by cluster
AA	backbone cross section	=IF(P2=0,INDEX(cable_range,MATCH((1/(S2)*V2*0.5*(Y2+Z2*max_cable))-$AB2*max_cable,cable_range,-1),1),0)	assigned backbone cable size; computed from branch cable size and number of branch cables to ensure preservation of binder-group integrity
AB	number of max backbone cables	=TRUNC(1/(S2)*V2*0.5*(Y2+Z2*max_cable)/max_cable)	computes number of backbone "overflow" cables required
AC	Backbone Taper Factor	=IF(V2/(S2*U2)<=2,1,0.5)	factor accounting for tapering of backbone cable when more than two branch cables connect to each backbone cable
AD	effective subscriber road cable distance	=IF(OR(P2=0,Q2<2),0,5280*MAX(SQRT('cluster input data'!O2*aspect),SQRT('cluster input data'!O2/aspect))+MAX(0,5280*MIN(SQRT('cluster input data'!O2*aspect),SQRT('cluster input data'!O2/aspect))-2*VLOOKUP(density,density_inputs,9)))*IF(diff_sfc>1,dstnc_mult,1)	computes length of cable required to serve outlier locations; length computed as the major dimension of the outlier area plus the minor dimension less two drop lengths, adjusted for difficult surface routing if elected by user
AE	required subscriber road cable pairs	=IF(P2=1,(lines_adj)/MAX(1,BQ2)/VLOOKUP('cluster input data'!R2,density_inputs,2),0)	cable pairs, including sizing factor, required to serve subscribers centered on outlier position
AF	subscriber road cable cross section, per cable	=IF(P2=1,INDEX(cable_range,MATCH(AE2-AG2*max_cable,cable_range,-1),1),0)	assigned road cable cross section in addition to any necessary maximum-sized cables
AG	number of max road cables	=IF(P2=1,TRUNC(AE2/max_cable),0)	computes number of maximum-sized road cables
AH	unadjusted road subscriber cable investment	=IF(AND(P2=1,BH2=0),AD2*AG2*max_cable_inv+AD2*VLOOKUP(calculations!AF2,cable_inv,2,FALSE),0)	total road cable investment for outlier without adjustments for aerial, buried, or underground use
AI	effective road T1 cable distance	=IF(P2=1,'cluster input data'!N2*(SIN(PI()/180*'cluster input data'!M2)+COS(PI()/180*'cluster input data'!M2)),0)*IF(diff_sfc>1,dstnc_mult,1)	T1 road cable distance assuming rectangular routing between end points, with difficult surface routing adjustment if elected by user
AJ	required road T1 cable pairs, per cable	=IF(OR(P2=0,AK2=0,BH2=1),0,2*total_T1s/AK2/VLOOKUP('cluster input data'!R2,density_inputs,2))	required cable pairs, including two pairs per T1 on cable and cable sizing factor
AK	number of road T1 cables	=IF(OR(P2=0,BH2=1),0,CEILING(total_T1s/max_T1s_cable,1))	number of T1 cables required; controlled by maximum allowable T1 pairs in cable assigned T1 cable cross section
AL	road T1 cable cross section	=IF(P2=1,INDEX(cable_range,MATCH(AJ2,cable_range,-1),1),0)	assigned T1 cable cross section

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AM	unadjusted road T1 cable investment	=IF(AND(P2=1,BH2=0),AI2*AK2*VLOOKUP(AL2,cable_inv,2,FALSE),0)	total T1 cable investment for this outlier, unadjusted for aerial, buried, or underground structure
AN	total unadjusted cable investment	=IF(BH2=1,0,((IF(P2=0,VLOOKUP(Y2,cable_inv,2,FALSE)*W2*V2+AC2*2*S2*U2*T2*VLOOKUP(calculations!AA2,cable_inv,2,FALSE),0)+AH2+AM2+(AC2*2*S2*U2*T2*AB2+Z2*W2*V2)*max_cable_inv)))	total cable investment for cluster or outlier, including branch, backbone (for clusters) and T1 road, and customer road cables (for outliers); connecting cable investment, if any, is computed by feeder module
AO	underground cable inv	=($AN2)*CF2	computes underground fraction of total cable investment using input underground structure fraction
AP	buried cable inv	=($AN2)*CD2*inputs!$C$19	computes buried cable investment, including additional cable investment for filled cable, using computed buried structure fraction
AQ	aerial cable investment	=($AN2)*CE2+BM2	total aerial cable investment computed with calculated aerial structure fraction
AR	total structure distance	=IF(BH2=1,0,IF(P2=1,AI2+IF(CI3<=CI2,0.5*AD2,0)+IF(Q2<2,0,0.5*(5280*MAX(SQRT('cluster input data'!O2*aspect),SQRT('cluster input data'!O2/aspect))+MAX(0,5280*MIN(SQRT('cluster input data'!O2*aspect),SQRT('cluster input data'!O2/aspect))-2*VLOOKUP(density,density_inputs,9)))),2*S2*U2*T2+V2*W2))	computes total structure distance for cluster; for outliers, includes total distance for T1 cables plus one-half the sum of the major outlier dimension and the minor outlier dimension less two drop lengths; for terminal outliers, total also includes one-half the suuscriber road cable distance
AS	pole investment	=IF(OR(BH2=1,'cluster input data'!R2>=inputs!$B$12),0,((1+CEILING(AR2*CE2/VLOOKUP('cluster input data'!R2,density_inputs,8),1))*(pole_inv+pole_labor*((1-wtg_pole_set)+wtg_pole_set*labor_adj)*(rock_mult+diff_sfc-1))))	computes total pole investment, including pole setting, with adjustments for local surface and rock conditions and labor rates
AT	buried placement	=IF($BH2=1,0,AR2*CD2*VLOOKUP('cluster input data'!$R2,density_inputs,7)*(rock_mult+diff_sfc-1)*((1-wtg_excav)+wtg_excav*labor_adj))	computes total buried placement investment, with adjustments for local surface and rock conditions and labor rates
AU	conduit investment	=IF($BH2=1,0,IF(P2=0,(2*S2*U2*$T2*(1+sp_tubes+$AB2)+$V2*$W2*(1+sp_tubes+$Z2)),(AI2+IF(CI3<=CI2,0.5*AD2,0))*(1+sp_tubes+AG2))*CF2*conduit_inv)	computes total conduit investment, including spare tubes
AV	conduit placement	=IF($BH2=1,0,AR2*CF2*VLOOKUP('cluster input data'!$R2,density_inputs,6)*(rock_mult+diff_sfc-1)*((1-wtg_excav)+wtg_excav*labor_adj))	computes total underground placement investment, with adjustments for local surface and rock conditions and labor rates
AW	vertical connecting cable length, ft	=IF($P2=1,0,2*U2*(S2-1)*(T2+depth))	optical connecting cable (feeder) used in subdivided backbone cables to connect subfeeder to RTs; investment computed in feeder module

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AX	horizontal connecting cable length, ft	=IF(P2=1,0,2*(U2-1)*(W2+front_lot))	connecting cable horizontal optical connecting cable used to connect subfeeder to RTs when branch cables are subdivided; investment computed in feeder module
AY	vertical structure distance, ft	=IF(P2=1,0,2*U2*(S2-1)*(depth))	structure required to support vertical connecting cable; may be shared with backbone structure in certain cases
AZ	horizontal structure distance, ft	=IF(P2=1,0,IF(EVEN(V2)/4<>TRUNC(EVEN(V2)/4),2*(U2-1)*front_lot,AX2))	structure required to support horizontal connecting cable; may be shared with branch structure in certain cases
BA	total required SAI capacity, per SAI	=(3.5*'cluster input data'!AC2+2*('cluster input data'!X2+SA_loops+'cluster input data'!AA2))/(S2*U2)	computes SAI capacity as the sum of the feeder and distribution connections
BB	max SAIs	=IF(BH2=1,0,TRUNC(SAI_cap/max_SAI))	computes number of maximum-sized SAIs required for cluster
BC	SAI size	=IF(OR(P2=1,BH2=1),0,INDEX(SAI_range,MATCH(SAI_cap-BB2*max_SAI,SAI_range,-1),1))	assigns SAI size for determination of investment
BD	SAI investment	=IF(OR(P2=1,BH2=1),0,BB2*max_SAI_inv+VLOOKUP(BC2,SAI_inv,3,FALSE))*S2*U2	computes total SAI investment
BE	max SAIs, high-rise	=IF(BH2=1,TRUNC((SAI_cap)/max_SAI),0)	computes number of maximum-sized indoor SAIs required
BF	SAI size, high-rise	=IF(BH2=1,INDEX(SAI_range,MATCH(SAI_cap-BE2*max_SAI,SAI_range,-1),1),0)	assigns indoor SAI size for determination of investment
BG	SAI investment, high-rise	=IF(BH2=1,BE2*max_SAI_inv+VLOOKUP(BF2,SAI_inv,2,FALSE),0)*S2*U2	computes total indoor SAI investment
BH	high-rise indicator	=IF(AND(P2=0,clustr_area<0.03,'cluster input data'!R2>30000),1,0)	ates whether high-rise calculations are to be invoked; requires line density > 30,000 lines/sq mi and cluster area < 0.03 sq mi
BI	high-rise factor	=IF(BH2=0,0,('cluster input data'!AC2*1500+'cluster input data'!AO2*200)/((1-inputs!$F$30)*'cluster input data'!O2*5280^2))	estimates number of "floors" using assumed floor areas per household and employees
BJ	number of riser pairs required per cable	=(2*'cluster input data'!AC2+'cluster input data'!AA2+SA_loops+'cluster input data'!X2)/2	computes required cable pairs, including cable sizing factor; two equally-sized cables assumed
BK	number of maximum riser cables	=TRUNC(BJ2/max_riser)*2	computes number of maximum-sized riser cables
BL	riser cable cross section	=INDEX(riser_range,MATCH(BJ2-$BK2/2*max_riser,riser_range,-1),1)	assigns riser cable size
BM	riser cable investment	=IF(BH2=1,(BK2*max_riser_inv+2*VLOOKUP(BL2,riser_inv,2,FALSE))*15*CEILING(MIN(BI2,50),1),0)	computes total riser cable investment; limits building to fifty stories
BN	total T1s required per route	=IF(P2=1,CN2,0)	repeats count of T1s traversing or terminating at current outlier

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BO	total repeaters required per cable	=IF(P2=1,CEILING(AI2/(1000*T1_rptr_spcng/(CE2*T1_atten_aerial+(1-CE2)*T1_atten_buried)),1)*BN2,0)	computes repeaters required for T1s in outlier segment by considering aerial and ug/buried structure fractions, number of T1, distance, and allowable cable loss between repeaters
BP	total installed repeater investment per cable	=BO2*repeater_inv	computes total investment in T1 repeaters per cable; multiplied by number of T1 cables in output sheet (AF2)
BQ	road RT indicator/copper distance multiplier	=IF(AND(P2=1,CR2=0),MAX(1,CEILING(AI2/max_cu_dstnc,1)),0)	computes factor to add RTs in outlier distribution if total outlier customer distance exceeds maximum copper distance
BR	total road RTs	=IF(AND(P2=1,BQ2>0),BQ2*CEILING(lines_adj/BQ2/RT_fill/24,1),0)	calculates number of small RTs to serve subscribers assigned to outliers
BS	total installed terminal investment per cable	=IF(AND(P2=1,BR2>0),BR2*(road_RT_inv+road_COT_per_RT_inv)+CU_inv_road*calculations!R2/RT_fill,0)	computes total RT investment, including common equipment and channel units, for outlier
BT	average loop length in cluster	=IF(P2=0,0.5*(T2+W2+AW2/U2+AX2)+E2,0)	estimates average loop length within cluster, including common feeder distance for all cluster lines; includes effects of connecting cable when present
BU	distribution route distance in cluster	=IF(P2=0,2*S2*U2*T2+V2*W2+CQ2,0)	calculates total route, or structure, distance for cluster
BV	maximum loop length in cluster	=IF(P2=0,E2+T2+W2+0.5*(AW2/U2+AX2),0)	calculates maximum loop length within cluster
BW	equivalent SA loops	=sa_lines*(DS0_frac*DS0_pair+DS1_frac*DS1_pair+DS3_frac*DS3_pair)	computes equivalent special access loops for users with access to precise input data concerning types and numbers of multiplexed special access lines in cluster
BX	adjusted total lines	=lines-sa_lines+SA_loops	adjusts input line total for re-computed special access loop total for users having access to precise special access facility data for cluster
BY	number of DLC LD terminals	=IF(OR(P2=1,(R2+CS2)/(S2*U2)>=inputs!$C$105),0,S2*U2*CEILING((R2+CS2)/(S2*U2)/(inputs!$D$96*inputs!$D$97*(1+inputs!$D$110)),1))	computes number of low-density remote terminals required for cluster; includes effects of branch and backbone subdivision, if required
BZ	LD terminal investment	=IF(OR(P2=1,(R2+CS2)/(S2*U2)>=inputs!$C$105),0,inputs!$D$95+inputs!$D$107+inputs!$D$98*BY2+IF((R2+CS2)/(S2*U2)/inputs!$D$97>inputs!$D$96,CEILING(((R2+CS2)/(S2*U2)/inputs!$D$97-inputs!$D$96)/inputs!$D$96,1)*inputs!$D$109,0)+(CEILING((output!$L2+output!$M2+CS2)/(S2*U2)/inputs!$D$97/inputs!$D$100,1)*inputs!$D$99+CEILING(output!$O2/(S2*U2)/inputs!$D$97/inputs!$D$102,1)*inputs!$D$101))	computes total investment in low-density remote terminals, including site, common equipment, and channel units

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CA	number of GR303 RTs	=IF(OR(P2=1,(R2+CS2)/(S2*U2)<inputs!$C$105),0,S2*U2*CEILING((R2+CS2)/(S2*U2)/(inputs!$C$96*inputs!$C$97*(1+inputs!$C$110)),1))	calculates number of GR-303 remote terminals to serve cluster; this calculation and that in BZ are mutually exclusive
CB	GR303 RT investment	=IF(OR(P2=1,(R2+CS2)/(S2*U2)<inputs!$C$105),0,inputs!$C$95+inputs!$C$107+inputs!$C$98*CA2+IF((R2+CS2)/(S2*U2)/inputs!$C$97>inputs!$C$96,CEILING(((R2+CS2)/(S2*U2)/inputs!$C$97-inputs!$C$96)/inputs!$C$96,1)*inputs!$C$109,0)+(CEILING((output!$L2+output!$M2+CS2)/(S2*U2)/inputs!$C$97/inputs!$C$100,1)*inputs!$C$99+CEILING(output!$O2/(S2*U2)/inputs!$C$97/inputs!$C$102,1)*inputs!$C$101))	calculates total investment in GR303 remote terminal, including site, common equipment, and channel units, as well as CO multiplexing equipment
CC	fiber strands required	=BY2*inputs!$D$106+CA2*inputs!$C$106	calculates number of fiber strands required to serve cluster according to computed RT totals and user-set number of strands per RT
CD	effective buried fraction distribution	=VLOOKUP('cluster input data'!R2,density_inputs,5)+DC2	computes effective buried structure fraction according to local surface and rock conditions
CE	effective aerial fraction distribution	=MAX(0,1-CD2-CF2)	computes effective aerial structure fraction according to local surface and rock conditions
CF	effective u/g fraction distribution	=VLOOKUP('cluster input data'!R2,density_inputs,3)	repeats input underground structure fraction set by user
CG	cluster serial number	=RIGHT(LEFT(B2,SEARCH(".",B2)-1),SEARCH(".",B2)-2)	extracts basic cluster serial number from cluster or outlier ID in cluster input data
CH	outlier number	=RIGHT(B2,LEN(B2)-SEARCH(".",B2))	Extracts outlier extension from cluster ID
CI	outlier order	=IF(P2=1,LEN(CH2)/3,0)	Computes outlier level from outlier number
CJ	outlier root ID	=IF(ISBLANK(CH2),0,LEFT(CH2,3))	extracts number of outlier on which current outlier chain homes
CK	cluster -- attached outlier indicator	=IF(AND(P2=0,P3=1),1,0)	indicates for clusters whether any outliers are attached; used in specifying whether fiber feeder is required
CL	cumulative lines in chain	=IF(ISBLANK(CH2),0,IF(AND(CJ3=CJ2,CG3=CG2),CL3+CU2,CU2))	accumulates line count within outlier chain
CM	number of T1s req'd -- terminal outlier	=IF(P2=0,0,IF(CI3>CI2,0,CEILING(CU2/RT_fill/24,1)))	calculates number of T1s required to serve last outlier in chain
CN	number of T1s reqd -- "through" clusters	=IF(CI3<=CI2,CM2,CEILING((CL2-IF(AND(CI2=1,AI2<max_cu_dstnc),CU2,0))/RT_fill/24,1))	computes total of number of T1s required to serve current and subsequent outliers in chain
CO	total T1s in chain	=IF(CI2=1,CN2,0)	
CP	cumulative T1s in cluster	=IF(CG3=CG2,CP3+CO2,CO2)	accumulates number of T1s required to serve all outliers in cluster
CQ	cumulative outlier road distance in cluster	=IF(CG3=CG2,CQ3+AI2,AI2)	accumulates outlier road distance for cluster

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CR	first-order outlier lines not on T1	=IF(AND(CI2=1,AI2+0.5*AD2<max_cu_dstnc),CU2,0)	calculates number of lines in first-order outliers (those connected directly to clusters) that lie within maximum copper distance
CS	cumulative first-order outlier lines not on T1	=IF(CG3=CG2,CS3+CR2,CR2)	accumulates non-T1-served first-order outlier lines for cluster
CT	terminal outlier indicator	=IF(AND(P2=1,CI3<=CI2),1,0)	indicates whether outlier is last in chain
CU	outlier lines	=IF(P2=1,R2,0)	repeats total line count for outlier
CV	distribution buried investment/foot, cable + placement, with sharing	=VLOOKUP(IF(P2=0,$Y2,AF2),cable_inv,2,FALSE)*inputs!$C$19+VLOOKUP(density,density_inputs,7)*VLOOKUP(density,density_inputs,19)	calculates buried cable and placement investment per foot, with effect of structure sharing
CW	distribution aerial investment/foot, cable	=VLOOKUP(IF(P2=0,$Y2,AF2),cable_inv,2,FALSE)	calculates aerial cable investment per foot
CX	distribution aerial investment/foot, pole, with sharing	=(inputs!$C$16+inputs!$C$17*inputs!$C$25)/VLOOKUP(density,density_inputs,8)*VLOOKUP(density,density_inputs,18)	calculates aerial structure investment per foot, with effects of structure sharing
CY	std buried LC cost/ft, with sharing	=CV2*(LCFactors!$D$3+LCFactors!$C$3)	calculates life cycle cost per foot of buried cable and structure without effects of local rock and surface conditions
CZ	std aerial LC cost/ft, with sharing	=CW2*(LCFactors!$D$5+LCFactors!$C$5)+CX2*(LCFactors!$D$9+LCFactors!$C$9)	calculates life cycle cost per foot of aerial cable and structure without effects of local rock and surface conditions
DA	local buried LC cost/ft, w/sharing	=(VLOOKUP(IF(P2=0,$Y2,AF2),cable_inv,2,FALSE)*inputs!$C$19*+(I2+J2-1)*VLOOKUP(density,density_inputs,7)*VLOOKUP(density,density_inputs,19))*(LCFactors!$D$3+LCFactors!$C$3)	calculates life cycle cost of buried cable and structure, with effects of local rock and surface conditions
DB	local aerial LC cost/ft, w/sharing	=CW2*(LCFactors!$D$5+LCFactors!$C$5)+(inputs!$C$16+(I2+J2-1)*inputs!$C$17*inputs!$C$25)/VLOOKUP(density,density_inputs,8)*VLOOKUP(density,density_inputs,18)*(LCFactors!$D$9+LCFactors!$C$9)	calculates life cycle cost of aerial cable and structure, with effects of local rock and surface conditions
DC	buried adjustment	=(0.5-1/(1+(CY2/CZ2)/((DA2/DB2)^inputs!$G$82)))*VLOOKUP(density,density_inputs,21)	calculates adjustment to buried fraction using standard and local costs in logistic function
DD	wire center	='cluster input data'!A2	repeats wire center location ID from cluster input data
DE	quadrant	='cluster input data'!F2	repeats quadrant number from cluster input data
DF	sign	=VLOOKUP('cluster input data'!G2,inputs!$X$5:$Y$8,2)	determines sign of cluster angular coordinate
DG	angle	=DF2*'cluster input data'!H2	attaches sign to cluster angular coordinate
DH	maincluster angle x radius	=IF(P2=0,DG2*'cluster input data'!I2,0)	calculates distance weighting for angular coordinate of cluster

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DI	cumulative product	=IF(AND(DD3=DD2,DE3=DE2),DI3+DH2,DH2)	accumulates weighted angle for feeder route (quadrant)
DJ	main cluster cumulative radius	=IF(AND(DD3=DD2,DE3=DE2),DJ3+IF(P2=0,'cluster input data'!I2,0),IF(P2=0,'cluster input data'!I2,0))	accumulates distance for clusters along feeder route
DK	wtd avg feeder offset angle (no limit)	=IF(OR(DD1<>DD2,DE1<>DE2),DI2/DJ2,0)	calculates feeder steering angle offset to be applied to angular coodinate for each cluster when feeder steering enabled
DL	repeated offset	=IF(fdr_steer_enable,IF(AND(DD1=DD2,DE1=DE2),DL1,DK2),0)	repeats offset angle for each cluster in feeder route (quadrant)
DM	resultant	=ABS(DG2-DL2)	applies offset to angle when feeder steering enable
DN	RT est. annual cost, w/per-line EO adjustments	=IF(P2=0,(BZ2+CB2-BX2*(inputs!$G$101+inputs!$G$102))*(LCFactors!$C$10+LCFactors!$D$10),0)	estimates annual life-cycle cost for remote terminals, including end-office adjustments for DLC per-line investment and MDF savings
DO	copper cable est. annual cost	=IF(P2=0,lines_adj*E2*inputs!$G$100/VLOOKUP(density,inputs!$F$89:$G$97,2)*(CE2*(LCFactors!$C$5+LCFactors!$D$5)+CD2*(LCFactors!$C$3+LCFactors!$D$3)+CF2*(LCFactors!$C$7+LCFactors!$D$7)),0)	estimates annual life-cycle cost for copper feeder cable to serve cluster
DP	fiber cable est. annual cost	=IF(P2=0,E2*CC2*inputs!$G$99*(CD2*(LCFactors!$C$4+LCFactors!$D$4)+CE2*(LCFactors!$C$6+LCFactors!$D$6)+CF2*(LCFactors!$C$8+LCFactors!$D$8)),0)	estimates annual life-cycle cost for fiber feeder cable to serve cluster
DQ	cumulative cable and structure investment	=IF(CG3=CG2,DQ3+AO2+AP2+AQ2+AS2+AT2+AU2+AV2,AO2+AP2+AQ2+AS2+AT2+AU2+AV2)	accumulates cable and structure investment for cluster and outliers to determine total per-line investment for cluster/outlier system
DR	cumulative DLC and T1 investment	=IF(CG3=CG2,DR3+BZ2+CB2+BP2+BS2,BZ2+CB2+BP2+BS2)	accumulates T1 investment for outliers to determine total per-line investment for cluster/outlier system
DS	cumulative SAI investment	=IF(CG3=CG2,DS3+BD2+BG2,BD2+BG2)	accumulates SAI investment for cluster and outliers to determine total per-line investment for cluster/outlier system
DT	terminal investment	=IF(calculations!BH2=0,lines_adj*VLOOKUP(density,density_inputs,16),0)	calculates terminal investment for cluster or outlier
DU	cumulative terminal investment	=IF(CG3=CG2,DU3+DT2,DT2)	accumulates terminal investment for cluster and outliers to determine total per-line investment for cluster/outlier system

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DV	drop investment	=IF(calculations!BH2=1,0,VLOOKUP(density,density_inputs,17)*('cluster input data'!AB2+'cluster input data'!AD2+'cluster input data'!AE2+'cluster input data'!AF2+'cluster input data'!AG2+'cluster input data'!AL2+'cluster input data'!AM2)+VLOOKUP(density,density_inputs,15)*('cluster input data'!X2-'cluster input data'!AB2+'cluster input data'!AA2+SA_loops+IF('cluster input data'!AC2=0,0,('cluster input data'!AH2+'cluster input data'!AI2+'cluster input data'!AJ2+'cluster input data'!AK2)/'cluster input data'!AC2*'cluster input data'!Y2)))	computes drop investment for cluster or outlier
DW	cumulative drop investment	=IF(CG3=CG2,DW3+DV2,DV2)	accumulates drop investment for cluster/outlier system
DX	NID investment	=IF(calculations!BH2=0,hh_tot*inputs!$C$30+'cluster input data'!Y2*inputs!$C$32+('cluster input data'!X2+SA_loops)*(inputs!$C$35/inputs!$C$38+inputs!$C$36)+(inputs!$C$35+inputs!$C$36)*'cluster input data'!AA2,NID_indoor*lines_adj)	computes NID investment for cluster or outlier
DY	cumulative NID investment	=IF(CG3=CG2,DY3+DX2,DX2)	accumulates NID investment for cluster/outlier system
DZ	cumulative lines	=IF(CG3+CG2,DZ3+lines_adj,lines_adj)	accumulates total line count for cluster/outlier system
EA	total distribution investment per line	=IF(AND(P2=0,DZ2>0),(DQ2+DR2+DS2+DU2+DW2+DY2)/DZ2,0)	computes total per-line investment for distribution plant and equipment
EB	wireless cap indicator	=IF(AND(wireless_cap_enable,P2=0,clustr_tot_lines<=brdcast_lines_max),IF(EA2>IF(clustr_tot_lines<=brdcast_thresh,wireless_cap,brdcast_common_inv*CEILING(clustr_tot_lines/brdcast_lines_max,1)/clustr_tot_lines+brdcast_var_inv),1,0),0)	when wireless cap enabled, compares total per-line distribution investment to estimated wireless technology investment and indicates when wireless estimate is less than wireline
EC	repeated wireless cap indicator	=IF(CG1=CG2,EC1,EB2)	repeats wireless cap indicator for all outliers in cluster/outlier system
ED	maximum outlier dimension, ft	=IF(P2=1,5280*MAX(SQRT('cluster input data'!O2*aspect),SQRT('cluster input data'!O2/aspect)),0)	computes maximum outlier dimension in feet using input outlier area and aspect ratio
EE	outlier subscriber road cable adjustment to average loop length wtd by lines	=IF(P2=1,IF(CU2<=1,0,IF(CU2<=2,0.5*ED2,IF(CU2<=3,5*ED2/12,1.5*ED2)))*CU2,0)	computes average distance from outlier center to subscribers served by subscriber road cable, wtd by lines in outlier
EF	cumulative weighted outlier adjustment	=IF(CG3=CG2,EF3+EE2,EE2)	accumulates weighted outlier adjust across all outliers in cluster
EG	weighted average outlier subscriber road cable adjustment	=IF(OR(P2=1,'cluster input data'!AR2=0),0,EF2/'cluster input data'!AR2)	computes wtd average adjustment for cluster

Workbook: **R50_distribution.xls**
Worksheet: **output**

Equation Listing

Hatfield Model, v5.0
Distribution Module

Column	Name	Formula	Description
A	company	='cluster input data'!B2	reports operating company name
B	operating company indicator	='cluster input data'!C2	reports operating company type indicator from 'cluster input data'
C	wire center	='cluster input data'!A2	reports 8-character location identifier (specifies wire center)
D	CBG number	=IF(calculations!P2=0,'cluster input data'!D2,0)	reports principal CBG identifier for cluster
E	quadrant	=IF(calculations!P2=0,'cluster input data'!F2,0)	reports which wire center quadrant the cluster falls in
F	main feeder distance, ft	=calculations!C2	reports main feeder distance, modified by difficult terrain or route/air multiplier as required
G	subfeeder cable distance, ft	=calculations!D2	reports subfeeder cable distance, modified by difficult terrain distance multiplier if required
H	total distribution route distance in cluster, ft	=calculations!BU2	reports total structure distance for distribution plnnt
I	total lines	=lines_adj	reports total line count, including adjusted special access lines, public lines, business and residential lines
J	density -- lines/sq mi	=IF(calculations!P2=0,'cluster input data'!R2,0)	reports density expressed as total lines per sq mi of cluster or outlier area
K	area, sq mi	='cluster input data'!O2	reports cluster or outlier area in sq mi
L	business lines	='cluster input data'!X2	reports total business lines, including single- and multi-line service
M	residential lines	='cluster input data'!Y2	reports total residential lines, including first and multiple lines
N	individual SA lines -- VG/DS-0 equiv	=SA_loops	reports special access total voice grade/DS0 equivalents
O	public lines	='cluster input data'!AA2	reports total public lines
P	households	='cluster input data'!AC2	reports total households in cluster or outlier
Q	single-line business lines	='cluster input data'!AB2	reports total single-line business lines; total included in business line count
R	distribution cable inv, underground	=IF(wireless_cap_ind=0,calculations!AO2,0)	reports total investment in underground distribution cable
S	distribution cable inv, buried	=IF(wireless_cap_ind=0,calculations!AP2,0)	reports total investment in buried distribution cable
T	distribution cable inv, aerial	=IF(wireless_cap_ind=0,calculations!AQ2,0)	reports total investment in aerial distribution cable
U	distribution conduit inv	=IF(wireless_cap_ind=0,calculations!AU2,0)	reports total investment in distribution conduit materials

Workbook: **R50_distribution.xls**
Worksheet: **output**

Equation Listing

Hatfield Model, v5.0
Distribution Module

Column	Name	Formula	Description
V	distribution conduit placement inv	=IF(wireless_cap_ind=0,calculations!AV2,0)	reports total investment in distribution conduit placement
W	distribution poles inv	=IF(wireless_cap_ind=0,calculations!AS2,0)	reports total investment in distribution poles and pole setting
X	distribution buried placement inv	=IF(wireless_cap_ind=0,calculations!AT2,0)	reports total investment in distribution buried cable placement
Y	rock plcmt mult	=IF(calculations!P2=0,rock_mult,0)	reports rock placement multiplier to be used by feeder module in modifying placement investment as may be required by shallow bedrock conditions
Z	difficult surface mult	=IF(calculations!P2=0,diff_sfc,0)	reports difficult surface placement multiplier to be used by feeder module in modifying placement investment as may be required by difficult surface conditions
AA	water table depth, ft	=IF(calculations!P2=0,'cluster input data'!V2,0)	reports water table depth for use by feeder module in modifying manhole investment in presence of high water table
AB	effective distribution fill	=IF(AND(wireless_cap_ind=0,calculations!P2=0),(0.5*calculations!R2/(calculations!S2*calculations!U2)/(calculations!AA2+calculations!AB2*max_cable)),0)	reports achieved distribution cable fill factor as computed at distribution side of SAI
AC	number of high-density RTs	=IF(wireless_cap_ind=0,IF(calculations!F2=1,calculations!CA2,0),0)	reports total high-density remote terminals required in cluster; includes effects of branch or backbone subdivision, if required
AD	high-density RT investment	=IF(wireless_cap_ind=0,IF(calculations!F2=1,calculations!CB2,0),IF(calculations!P2=0,IF(clustr_tot_lines<=brdcast_thresh,clustr_tot_lines*wireless_cap,brdcast_common_inv*CEILING(clustr_tot_lines/brdcast_lines_max,1)+brdcast_var_inv*clustr_tot_lines),0))	reports total investment in high-density DLC remote terminals for cluster; computes representative wireless investment totals if wireless "cap" calculations are enabled and local distribution investment exceeds either point-to-point or broadcast "cap"
AE	number of low-density DLC RTs	=IF(wireless_cap_ind=0,IF(calculations!F2=1,calculations!BY2,0),0)	reports total low-density remote terminals required in cluster; includes effects of branch or backbone subdivision, if required
AF	low-density DLC and T1 road terminal and repeater investment	=IF(wireless_cap_ind=0,IF(calculations!F2=1,calculations!BZ2,0)+calculations!BP2*calculations!AK2+calculations!BS2,0)	reports investment in low-density DLC remote terminals and in T1 equipment for outliers
AG	fiber strands required	=IF(wireless_cap_ind=0,IF(calculations!F2=1,calculations!CC2,0),IF(calculations!P2=0,4,0))	reports total fiber strands needed by RTs in cluster; if wireless cap exceeded, reports four fibers for radio equipment

Workbook: **R50_distribution.xls**
Worksheet: **output**

Equation Listing

Hatfield Model, v5.0
Distribution Module

Column	Name	Formula	Description
AH	SAI investment	=IF(wireless_cap_ind=0,calculations!BD2+calculations!BG2,0)	reports total SAI investment for cluster, including indoor SAI totals when high-rise calculations are invoked
AI	terminal investment	=IF(wireless_cap_ind=0,calculations!DT2,0)	reports total investment in terminals (interface between drops and distribution cable)
AJ	drop investment	=IF(wireless_cap_ind=0,calculations!DV2,0)	reports total investment in installed subscriber drops
AK	NID investment	=IF(wireless_cap_ind=0,calculations!DX2,0)	reports total investment in network interface devices
AL	number of DLC lines	=IF(AG2=0,0,calculations!DZ2)	reports total number of lines served by DLC in cluster and outliers
AM	vertical connecting cable length, ft	=IF(wireless_cap_ind=0,calculations!AW2,0)	reports vertical (optical fiber) connecting cable to feeder module for sizing and investment computation when backbone cable is subdivided
AN	horizontal connecting cable length, ft	=IF(wireless_cap_ind=0,calculations!AX2,0)	reports horizontal (optical fiber) connecting cable to feeder module for sizing and investment computation when branch cables are subdivided
AO	vertical connecting structure distance, ft	=IF(wireless_cap_ind=0,calculations!AY2,0)	reports structure distance for vertical connecting cable, when present
AP	horizontal connecting structure distance, ft	=IF(wireless_cap_ind=0,calculations!AZ2,0)	reports structure distance for horizontal connecting cable, when present
AQ	average loop length, ft	=IF(wireless_cap_ind=0,calculations!BT2,0)	reports average loop length within cluster
AR	maximum loop length, ft	=IF(wireless_cap_ind=0,calculations!BV2,0)	reports maximum loop length in cluster
AS	cluster ID	='cluster input data'!E2	repeats cluster ID from cluster input sheet
AT	cluster serial number	=calculations!CG2	reports basic cluster serial number without outlier extensions for use by interface in totalling cluster investments
AU	wireless cap indicator	=IF(calculations!P2=0,wireless_cap_ind,0)	reports whether wireless cap is reached for cluster; saved in workfile
AV	lines affected by wireless cap	=IF(AND(AU2=1,calculations!P2=0),calculations!DZ2,0)	If wireless cap applies, records total lines in cluster and outliers; save in workfile
AW	cable+structure+DLC inv less wireless estimate	=IF(AND(AU2=1,calculations!P2=0),calculations!EA2-output!AD2,0)	calculates investment saved by employment of wireless assumptions
AX	calc buried fraction -- main cluster	=IF(AND($AU2=0,calculations!$P2=0),calculations!CD2,0)	reports calculated buried fraction
AY	calc aerial fraction -- main cluster	=IF(AND($AU2=0,calculations!$P2=0),calculations!CE2,0)	reports calculated aerial structure fraction

Workbook: **R50_distribution.xls**
Worksheet: **output**

Equation Listing

Hatfield Model, v5.0
Distribution Module

Column	Name	Formula	Description
AZ	calc u/g fraction -- main cluster	=IF(AND($AU2=0,calculations!$P2=0),calculations!CF2,0)	reports underground structure fraction

Workbook: **R50_feeder.xls**
Worksheet: **distribution input**

Equation Listing

Hatfield Model, v5.0
Feeder Module

Column	Name	Formula	Description
A	Company	The data for this sheet is taken from output sheet of the distribution module.	
B	operating company indicator		
C	wire center		
D	CBG geocode		
E	quadrant		
F	main feeder distance		
G	subfeeder		
H	distribution distance		
I	total lines		
J	density, lines/sq mi		
K	area, sq mi		
L	business lines		
M	residential lines		
N	SA lines		
O	public lines		
P	households		
Q	single-line business lines		
R	distribution cable, underground		
S	distribution cable, buried		
T	distribution cable, aerial		
U	distribution conduit		
V	distribution conduit placement		
W	distribution poles		
X	distribution buried plcmt		
Y	rock plcmt mult		
Z	difficult surface mult		
AA	water table depth, ft		
AB	effective distribution cable fill		
AC	number of TR-303 RTs		
AD	TR-303 investment		
AE	number of low-density DLC RTs		

Workbook: **R50_feeder.xls**
Worksheet: **distribution input**

Equation Listing

Hatfield Model, v5.0
Feeder Module

Column	Name	Formula	Description
AF	low-density DLC investment		
AG	fiber strands required		
AH	SAI inv		
AI	terminal inv		
AJ	drop inv		
AK	NID inv		
AL	number of DLC lines		
AM	vertical connecting cable length, ft		
AN	horizontal connecting cable length, ft		
AO	vertical structure distance, ft		
AP	horizontal structure distance, ft		
AQ	average loop length, ft		
AR	maximum loop length, ft		
AS	cluster ID		
AT	cluster serial number		
AU	wireless cap indicator		
AV	lines affected by wireless cap		
AW	cable+structure+DLC inv less wireless estimate		
AX	calc buried fraction -- main cluster		
AY	calc aerial fraction -- main cluster		
AZ	calc u/g fraction -- main cluster		

Workbook: **R50_feeder.xls**
Worksheet: **cable investment**

Equation Listing

Hatfield Model, v5.0
Feeder Module

Column	Name	Formula	Description
A	wire center	='distribution input'!C2	Wire center serving this cluster
B	Quadrant	='distribution input'!E2	Quadrant where this cluster is located.
C	main feeder distance, ft	='distribution input'!F2	Main feeder distance from the wire center to the subfeeder splice for this cluster
D	subfeeder distance	='distribution input'!G2	Subfeeder distance from the main feeder splice to the center of this cluster
E	basic lines	='distribution input'!I2	Total lines in cluster
F	line density per sq mi	='distribution input'!J2	Repeats line density in lines/sq mi for cluster
G	strands required	='distribution input'!AG2	Number of fiber strands required to serve the DLC remote terminal(s)
H	copper subfeeder size	=IF(OR(subfeeder_dist=0,basic_segment_type="DLC"),"N/A",AJ2)	repeats assigned copper subfeeder cable cross section, if equipped
I	current segment inv	=IF(AG2=0,0,X2*(AH2*max_copper_inv+VLOOKUP(AG2,copper_inv,2,FALSE)*((1-wtg_copper_const)+wtg_copper_const*labor_adj)))	Investment in copper feeder cable required for feeder segment serving cluster
J	max copper cable inv (subfeeder)	=IF(basic_segment_type<>"Cable",0,max_copper_inv*(subfeeder_dist*AK2)*((1-wtg_copper_const)+wtg_copper_const*labor_adj))	calculates investment in maximum (overflow) copper subfeeder cables, if present
K	fiber subfeeder size	=IF(AND(subfeeder_dist<>0,basic_segment_type="DLC"),MAX(min_fiber_subfdr, INDEX(fiber_range,MATCH('distribution input'!$AG2/VLOOKUP(line_density,density_inputs,3),fiber_range,-1),1)),"N/A")	assigns cable size for fiber subfeeder cable
L	fiber subfeeder investment	=IF(K2="N/A",0,(subfeeder_dist+'distribution input'!AN2+'distribution input'!AM2)*VLOOKUP(K2,fiber_inv,2,FALSE))	calculates fiber subfeeder cable investment
M	fiber main segment investment	=IF(AC2=0,0,X2*VLOOKUP(AL2,fiber_inv,2,FALSE)+AM2*max_fiber_inv*X2)	calculates investment in fiber cable for feeder segment serving cluster, including investment in any overflow cables
N	fiber subfeeder segment investment	=IF(basic_segment_type="DLC",L2,0)	Repeats investment in fiber subfeeder cable
O	segment number	=IF(this_wire_cntr=0,0,IF(AND(this_wire_cntr=next_wire_cntr,this_quadrant=next_quadrant),O3+1,1))	Numbers clusters along feeder route beginning at 1 for cluster nearest wire center
P	segment investment per line	=IF(AD2=0,0,I2/AD2)	Divides segment investment for copper cable by number of lines in current cluster and sum of lines in all clusters served by copper more distant from the wire center
Q	cumulative investment per line	=IF(OR(O1=1,ISTEXT(Q1)),P2,P2+Q1)	Accumulates investment per line in copper cable from wire center end of feeder route
R	assigned copper cable investment	=IF(basic_segment_type="Cable",basic_lines*Q2,0)	assigns copper cable investment to cluster by multiplying segment investment per line by number of lines in cluster

Workbook: **R50_feeder.xls**
Worksheet: **cable investment**

Equation Listing

Hatfield Model, v5.0
Feeder Module

Column	Name	Formula	Description
S	segment investment per strand	=IF(AC2=0,0,M2/AC2)	calculates investment per strand of fiber cable for segment serving this cluster
T	cumulative investment per strand	=IF(OR(O1=1,ISTEXT(T1)),S2,S2+T1)	Accumulates investment per strand along feeder route, beginning at wire center end of route
U	assigned fiber investment	=G2*T2	Assigns share of fiber cable investment to cluster
V	max distance	=IF(OR(W3=1,ISBLANK(W3)),C2,V3)	Computes and repeats maximum distance along feeder route
W	cluster sequence number	=IF(OR(this_quadrant<>B1,this_wire_cntr<>A1),1,W1+1)	Numbers cluster appearance along feeder route, beginning at wire center
X	segment distance	=IF(AND(this_wire_cntr=A1,this_quadrant=B1),C2-C1,C2)	Computes length of main feeder segment connecting previous cluster to current cluster
Y	basic segment type	=IF(this_wire_cntr="","",IF(G2=0,"Cable","DLC"))	Indicates whether segment is served by fiber feeder ("DLC") or copper feeder ("Cable")
Z	secondary segment type	=IF(this_quadrant=0,"",IF(OR(W3=1,AND(this_wire_cntr=next_wire_cntr,this_quadrant=next_quadrant,basic_segment_type=Y3,ISBLANK(Z3))),"",IF(basic_segment_type<>Y3,Y3,Z3)))	Indicates whether clusters farther along feeder route from current cluster use feeder cable type different from that used by current cluster
AA	cumulative required copper pairs	=IF(basic_segment_type="Cable",IF(OR(W3=1,AND(W3<>1,basic_segment_type<>Y3,next_quadrant<>this_quadrant,Z2<>"Cable"),ISBLANK(AA3)),basic_lines/VLOOKUP(line_density,density_inputs,2),basic_lines/VLOOKUP(line_density,density_inputs,2)+AA3),IF(W3=1,0,AA3))	Accumulates required copper cable pair count, including cable sizing factor, from far end of cable toward wire center
AB	cumulative lines served by fiber	=IF(basic_segment_type="DLC",IF(OR(W3=1,AND(W3<>1,basic_segment_type<>Y3,Z2<>"DLC"),ISBLANK(AB3)),basic_lines,basic_lines+AB3),IF(Z2="DLC",AB3,0))	accumulates lines served by fiber from remote end of feeder route
AC	total number of fiber strands	=IF(AB2=0,0,IF(W3=1,G2,IF(AB2=AB3,AC3,G2+AC3)))	accumulates number of fiber strands required from remote end of feeder route
AD	cumulative copper lines	=IF(basic_segment_type="Cable",IF(OR(W3=1,AND(W3<>1,basic_segment_type<>Y3,next_quadrant<>this_quadrant,Z2<>"Cable"),ISBLANK(AA3)),basic_lines,basic_lines+AD3),IF(W3=1,0,AD3))	accumulates lines served by copper from remote end of feeder route
AE	cumulative fiber lines	=IF(basic_segment_type="DLC",IF(OR(W3=1,AND(W3<>1,basic_segment_type<>Y3,next_quadrant<>this_quadrant,Z2<>"DLC"),ISBLANK(AA3)),basic_lines,basic_lines+AE3),IF(W3=1,0,AE3))	Computes cumulative fiber line count from far end of feeder route for use in feeder conduit calculation
AF	calc copper feeder fill	=IF(OR(AG2=0,basic_segment_type="DLC"),0,AD2/(AG2+AH2*max_copper))	calculates achieved copper feeder fill factor for segment serving cluster
AG	equipped feeder cable	=IF(AA2<>0,INDEX(copper_range,MATCH(AA2-(max_copper*AH2),copper_range,-1),1),0)	determines feeder cable size in segment serving cluster
AH	number of maximum-sized main feeder cables	=TRUNC(IF(AA2>max_copper,AA2/max_copper,0))	computes number of "overflow," or maximum-sized, main feeder cables required, if any

Workbook: **R50_feeder.xls**
Worksheet: **cable investment**

Equation Listing

Hatfield Model, v5.0
Feeder Module

Column	Name	Formula	Description
AI	sub cable pairs	=IF(basic_segment_type="Cable",basic_lines/VLOOKUP(line_density,density_inputs,2),0)	determines number of copper pairs required in subfeeder cable to serve cluster; includes effect of cable sizing factor
AJ	sub cable size	=IF(AI2<>0,INDEX(copper_range,MATCH(AI2-(max_copper*AK2),copper_range,-1),1),0)	Assigns subfeeder cable size
AK	max sub cables	=TRUNC(IF(AI2>max_copper,AI2/max_copper,0))	Calculates number of overflow subfeeder copper cables, if any
AL	fiber cable size	=IF(AC2=0,0,INDEX(fiber_range,MATCH(AC2/VLOOKUP(line_density,density_inputs,3)-max_fiber*TRUNC(AC2/(max_fiber*VLOOKUP(line_density,density_inputs,3))),fiber_range,-1),1))	assigns fiber cable cross section for segment serving cluster.
AM	max fiber cables	=IF(AC2/VLOOKUP(line_density,density_inputs,3)>max_fiber,TRUNC(AC2/(max_fiber*VLOOKUP(line_density,density_inputs,3))),0)	calculates number of overflow fiber cables main feeder segment serving this cluster, if required
AN	fiber segment cumulative distance	=IF(AND(basic_segment_type<>"DLC",Z2<>"DLC"),0,IF(AND(this_wire_cntr=A1,this_quadrant=B1),X2+AN1,X2))	accumulates fiber segment distance beginning at wire center end of feeder route
AO	fiber segment total distance from end	=IF(OR(basic_segment_type="DLC",Z2="DLC"),IF(OR(W3=1,AND(Y3<>"DLC",Z3<>"DLC")),AN2,AO3),0)	Calculates distance from cluster to end of fiber route
AP	copper feeder conduit inv	=IF(OR(basic_segment_type="Cable",Z2="Cable"),(X2*(1+AH2+spare_tubes_sect))*BU2*conduit_mat_inv_ft,0)	Computes investment in conduit for copper feeder cable for segment, including spare tubes and tubes for overflow cables, if any
AQ	copper feeder manholes	=IF(OR(basic_segment_type="Cable",Z2="Cable"),X2*BU2/VLOOKUP(line_density,density_inputs,7)*(VLOOKUP(line_density,density_inputs,17)+IF('distribution input'!AA2<=water_thresh,(min_water_factor+(max_water_factor-min_water_factor)/water_thresh*(water_thresh-'distribution input'!AA2))*VLOOKUP(line_density,inputs!$B$16:$G$24,6),0)),0)	Computes investment in manholes for copper feeder cable; includes extra investment for dewatering, which varies linearly with water table depth
AR	copper feeder u/g trenching	=IF(basic_segment_type="Cable",X2*BU2*VLOOKUP(line_density,density_inputs,9)*((1-wtg_excav)+wtg_excav*labor_adj)*('distribution input'!Y2+'distribution input'!Z2-1),0)	Computes investment in underground placement for segment
AS	copper feeder buried placement	=IF(basic_segment_type="Cable",X2*BS2*VLOOKUP(line_density,density_inputs,8)*((1-wtg_excav)+wtg_excav*labor_adj)*('distribution input'!Y2+'distribution input'!Z2-1),0)	Calculates investment in buried feeder placement for segment
AT	copper feeder pole inv	=IF(basic_segment_type="Cable",(1+CEILING(X2*BT2/VLOOKUP(line_density,density_inputs,19),1))*(pole_materials+pole_labor*((1-wtg_pole_set)+wtg_pole_set*labor_adj))*('distribution input'!Y2+'distribution input'!Z2-1),0)	Computes investment in feeder poles for copper cable; poles carry both copper and optical fiber cable when required
AU	fiber feeder conduit inv	=IF(AND(basic_segment_type="Cable",Z2<>"DLC"),0,IF(AO2=0,0,1/AO2*V2*X2*BX2*((1+spare_tubes_sect)*(conduit_mat_inv_ft)+AM2*inner_duct_inv_ft)))	Computes investment in conduit for underground fiber feeder cable, including any required inner duct for overflow cable

Workbook: **R50_feeder.xls**
Worksheet: **cable investment**

Equation Listing

Hatfield Model, v5.0
Feeder Module

Column	Name	Formula	Description
AV	fiber fdr pullboxes	=IF(basic_segment_type<>"Cable",IF(AQ2<>0,0,X2*BX2/VLOOKUP(line_density,density_inputs,13)*VLOOKUP(line_density,density_inputs,18)),0)	Calculates investment for pullboxes for fiber feeder cable in segment
AW	fiber feeder u/g trenching	=IF(basic_segment_type<>"Cable",X2*BX2*VLOOKUP(line_density,density_inputs,15)*((1-wtg_excav)+wtg_excav*labor_adj)*('distribution input'!Y2+'distribution input'!Z2-1),0)	Computes investment in placement for underground fiber cable for segment
AX	fiber feeder buried placement	=IF(basic_segment_type<>"Cable",X2*BV2*VLOOKUP(line_density,density_inputs,14)*((1-wtg_excav)+wtg_excav*labor_adj)*('distribution input'!Y2+'distribution input'!Z2-1),0)	Calculates investment in buried placement for fiber feeder cable for this segment
AY	fiber feeder poles	=IF(basic_segment_type<>"Cable",(1+CEILING((X2)*BW2/VLOOKUP(line_density,density_inputs,19),1))*(pole_materials+pole_labor*((1-wtg_pole_set)+wtg_pole_set*labor_adj))*('distribution input'!Y2+'distribution input'!Z2-1),0)	Computes investment in feeder poles for fiber cable for this segment
AZ	cumulative number of lines	=IF(O2=1,basic_lines,basic_lines+AZ3)	Accumulates total lines from remote end of feeder route.
BA	copper feeder conduit segment inv per line	=IF(AD2=0,0,AP2/AD2)	Computes copper conduit investment for the current segment per line
BB	cumulative conduit inv per line	=IF(OR(O1=1,ISTEXT(BB1)),BA2,BA2+BB1)	accumulates per-line conduit investment from beginning of feeder route
BC	assigned copper feeder conduit inv	=IF(basic_segment_type="Cable",basic_lines*BB2+subfeeder_dist*(1+AK2+spare_tubes_sect)*BU2*conduit_mat_inv_ft,0)	Computes cluster's share of copper conduit investment plus conduit required for copper subfeeder. Note that connecting cable and structure distances do not affect this calculation because they are only used with fiber feeder
BD	total feeder manhole sgmt inv per line	=IF(AZ2=0,0,(AQ2+AV2)/AZ2)	computes manhole and pullbox investment per cumulative line
BE	cumulative inv per line	=IF(OR(O1=1,ISTEXT(BE1)),BD2,BD2+BE1)	accumulates per-line investment in manholes and pullboxes from beginning of route
BF	assigned total feeder manhole inv	=IF(basic_segment_type="Cable",subfeeder_dist*BU2/VLOOKUP(line_density,density_inputs,7)*VLOOKUP(line_density,density_inputs,17),(subfeeder_dist+'distribution input'!AO2+'distribution input'!AP2)*BX2/VLOOKUP(line_density,density_inputs,13)*VLOOKUP(line_density,density_inputs,18))+basic_lines*BE2	assigns manhole and pullbox investment to current cluster according to total lines in cluster; includes investment required for subfeeder (with connecting cables, if present)
BG	total feeder u/g placement segment inv per line	=IF(AZ2=0,0,(AR2+AW2)/AZ2)	calculates total underground (conduit) placement investment per line
BH	cumulative u/g placement investment per line	=IF(OR(O1=1,ISTEXT(BH1)),BG2,BG2+BH1)	accumulates feeder (conduit) underground placement investment per line

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Equation Listing

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Feeder Module

Column	Name	Formula	Description
BI	assigned total feeder u/g placement inv	=IF(basic_segment_type="Cable",subfeeder_dist*BU2*VLOOKUP(line_density,density_inputs,9)*((1-wtg_excav)+wtg_excav*labor_adj),(subfeeder_dist+'distribution input'!AO2+'distribution input'!AP2)*BX2*VLOOKUP(line_density,density_inputs,15)*((1-wtg_excav)+wtg_excav*labor_adj))*('distribution input'!Y2+'distribution input'!Z2-1)+basic_lines*BH2	Assigns cluster share of main feeder underground placement investment according to lines in cluster; adds subfeeder placement
BJ	total feeder buried placement segment inv per line	=IF(AZ2=0,0,(AS2+AX2)/AZ2)	calculates buried placement investment for current segment expressed per line
BK	cumulative buried placement investment per line	=IF(OR(O1=1,ISTEXT(BK1)),BJ2,BJ2+BK1)	accumulates buried placement investment per line from beginning of feeder route
BL	assigned total feeder buried placement inv	=IF(basic_segment_type="Cable",subfeeder_dist*BS2*VLOOKUP(line_density,density_inputs,8)*((1-wtg_excav)+wtg_excav*labor_adj),(subfeeder_dist+'distribution input'!AO2+'distribution input'!AP2)*BV2*VLOOKUP(line_density,density_inputs,14)*((1-wtg_excav)+wtg_excav*labor_adj))*('distribution input'!Y2+'distribution input'!Z2-1)+basic_lines*BK2	computes cluster's share of total buried placement investment according to lines in cluster; includes subfeeder buried placement and connecting cables for fiber subfeeder, when present
BM	feeder pole segment inv per line	=IF(AZ2=0,0,(AT2+AY2)/AZ2)	calculates feeder pole investment for current segment per line
BN	cumulative inv per line	=IF(OR(O1=1,ISTEXT(BN1)),BM2,BM2+BN1)	Accumulates feeder pole investment per line from beginning of feeder route
BO	assigned feeder pole inv	=basic_lines*BN2+IF(basic_segment_type="Cable",(1+CEILING(subfeeder_dist*BT2/VLOOKUP(line_density,density_inputs,19),1))*(pole_materials+pole_labor*((1-wtg_pole_set)+wtg_pole_set*labor_adj)*('distribution input'!Y2+'distribution input'!Z2-1)),0)+IF(basic_segment_type<>"Cable",(1+CEILING((subfeeder_dist+'distribution input'!AO2+'distribution input'!AP2)*BW2/VLOOKUP(line_density,density_inputs,19),1))*(pole_materials+pole_labor*((1-wtg_pole_set)+wtg_pole_set*labor_adj))*('distribution input'!Y2+'distribution input'!Z2-1),0)	assigns feeder pole investment to cluster according to total lines in cluster; includes subfeeder poles
BP	fiber feeder conduit segment inv per line	=IF(AE2=0,0,AU2/AE2)	Computes per-line investment in conduit containing fiber feeder cable per line
BQ	cumulative inv per line	=IF(OR(O1=1,ISTEXT(BQ1)),BP2,BP2+BQ1)	accumulates fiber conduit investment per line from beginning of feeder route
BR	assigned fiber feeder conduit inv	=IF(basic_segment_type="DLC",basic_lines*BQ2,0)+IF(basic_segment_type="Cable",0,IF(AO2=0,"",(subfeeder_dist+'distribution input'!AO2+'distribution input'!AP2)*BU2*(conduit_mat_inv_ft*(1+spare_tubes_sect))))	Assigns fiber conduit investment to cluster according to total lines in cluster; includes subfeeder conduit

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Equation Listing

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Feeder Module

Column	Name	Formula	Description
BS	effective copper buried fraction	=VLOOKUP(line_density,density_inputs,5)+CF2	Computes effective buried structure fraction according to local conditions and user-set input values
BT	effective copper aerial fraction	=MAX(0,1-BS2-BU2)	computes effective aerial structure fraction for copper cable from buried and underground fractions
BU	effective copper u/g fraction	=VLOOKUP(line_density,density_inputs,6)	Repeats user-selected copper cable underground fraction for cluster density range
BV	effective fiber buried fraction	=VLOOKUP(line_density,density_inputs,11)+CN2	Computes effective buried fiber cable structure fraction according to local conditions and user-set input values
BW	effective fiber aerial fraction	=MAX(0,1-BV2-BX2)	computes effective aerial structure fraction for fiber cable from buried and underground fractions
BX	effective fiber u/g fraction	=VLOOKUP(line_density,density_inputs,12)	Repeats user-selected fiber cable underground fraction for cluster density range
BY	copper buried investment/foot, cable + placement, with sharing	=IF(Y2="Cable",((AH2*max_copper_inv+VLOOKUP(AG2,copper_inv,2,FALSE))*inputs!$C$57+VLOOKUP(line_density,density_inputs,28))*((1-wtg_copper_const)+wtg_copper_const*labor_adj),0)	Computes total copper buried investment per foot, including placement and structure sharing
BZ	copper aerial investment/foot, cable	=IF(Y2="Cable",(AH2*max_copper_inv+VLOOKUP(AG2,copper_inv,2,FALSE)*((1-wtg_copper_const)+wtg_copper_const*labor_adj)),0)	Calculates aerial copper cable investment per foot
CA	copper aerial investment/foot, pole, with sharing	=IF(Y2="Cable",(pole_materials+pole_labor*((1-wtg_pole_set)+wtg_pole_set*labor_adj))/VLOOKUP(line_density,density_inputs,19)*VLOOKUP(line_density,density_inputs,20),0)	Calculates pole investment per foot for copper cables, including effects of pole sharing
CB	std copper buried LC cost/ft, with sharing	=BY2*(LCFactors!$C$3+LCFactors!$D$3)	Computes life cycle cost/ft of buried cable, including capital carrying costs, maintenance costs, and effects of structure sharing; result represents "standard" cost unaffected by local conditions
CC	std copper aerial LC cost/ft, with sharing	=BZ2*(LCFactors!$C$5+LCFactors!$D$5)+CA2*(LCFactors!$C$9+LCFactors!$D$9)	Computes life cycle cost/ft of aerial cable, including capital carrying costs, maintenance costs, and effects of structure sharing; result represents "standard" cost unaffected by local conditions
CD	local copper buried LC cost/ft, w/sharing	=IF(Y2="Cable",((AH2*max_copper_inv+VLOOKUP(AG2,copper_inv,2,FALSE))*inputs!$C$57+('distribution input'!Y2+'distribution input'!Z2-1)*VLOOKUP(line_density,density_inputs,28))*((1-wtg_copper_const)+wtg_copper_const*labor_adj),0)*(LCFactors!$C$3+LCFactors!$D$3)	Computes life cycle cost/ft of buried cable, including capital carrying costs, maintenance costs, and effects of structure sharing and local rock and difficult surface conditions; result represents local cost adjusted to local conditions

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Column	Name	Formula	Description
CE	local copper aerial LC cost/ft, w/sharing	=IF(Y2="Cable",BZ2*(LCFactors!$C$5+LCFactors!$D$5)+(pole_materials+('distribution input'!Y2+'distribution input'!Z2-1)*pole_labor*((1-wtg_pole_set)+wtg_pole_set*labor_adj))/VLOOKUP(line_density,density_inputs,19)*VLOOKUP(line_density,density_inputs,20)*(LCFactors!$C$9+LCFactors!$D$9),0)	Computes life cycle cost/ft of aerial cable, including capital carrying costs, maintenance costs, and effects of structure sharing and local rock and difficult surface conditions; result represents "local" cost adjusted for local conditions
CF	copper buried adjustment	=IF(Y2="Cable",(0.5-1/(1+(CB2/CC2)/((CD2/CE2)^inputs!$G$82)))*VLOOKUP(line_density,density_inputs,23),0)	Calculates adjustment to input buried structure fraction for local density range using user-specified buried "swing" factor and standard and local cost inputs to logistic function
CG	fiber buried investment/foot, cable + placement, with sharing	=IF(Y2="DLC",VLOOKUP(AL2,fiber_inv,2,FALSE)+inputs!$C$58+AM2*(max_fiber_inv+inputs!$C$58)+VLOOKUP(line_density,density_inputs,29),0)	Computes total fiber buried investment per foot, including placement and structure sharing
CH	fiber aerial investment/foot, cable	=IF(Y2="DLC",VLOOKUP(AL2,fiber_inv,2,FALSE)+AM2*(max_fiber_inv),0)	Calculates aerial fiber cable investment per foot
CI	fiber aerial investment/foot, pole, with sharing	=IF(Y2="DLC",(pole_materials+pole_labor*((1-wtg_pole_set)+wtg_pole_set*labor_adj))/VLOOKUP(line_density,density_inputs,19)*VLOOKUP(line_density,density_inputs,24),0)	Calculates pole investment per foot for fiber cables, including effects of pole sharing
CJ	std fiber buried LC cost/ft, with sharing	=CG2*(LCFactors!$C$4+LCFactors!$D$4)	Computes life cycle cost/ft of buried cable, including capital carrying costs, maintenance costs, and effects of structure sharing; result represents "standard" cost unaffected by local conditions
CK	std fiber aerial LC cost/ft, with sharing	=CH2*(LCFactors!$C$6+LCFactors!$D$6)+CI2*(LCFactors!$C$9+LCFactors!$D$9)	Computes life cycle cost/ft of aerial cable, including capital carrying costs, maintenance costs, and effects of structure sharing; result represents "standard" cost unaffected by local conditions
CL	local fiber buried LC cost/ft, w/sharing	=IF(Y2="DLC",VLOOKUP(AL2,fiber_inv,2,FALSE)+inputs!$C$58+AM2*(max_fiber_inv+inputs!$C$58)+('distribution input'!Y2+'distribution input'!Z2-1)*VLOOKUP(line_density,density_inputs,29),0)*(LCFactors!$C$4+LCFactors!$D$4)	Computes life cycle cost/ft of buried cable, including capital carrying costs, maintenance costs, and effects of structure sharing and local rock and difficult surface conditions; result represents local cost adjusted to local conditions
CM	local fiber aerial LC cost/ft, w/sharing	=IF(Y2="DLC",CH2*(LCFactors!$C$6+LCFactors!$D$6)+(pole_materials+('distribution input'!Y2+'distribution input'!Z2-1)*pole_labor*((1-wtg_pole_set)+wtg_pole_set*labor_adj))/VLOOKUP(line_density,density_inputs,19)*VLOOKUP(line_density,density_inputs,24)*(LCFactors!$C$9+LCFactors!$D$9),0)	Computes life cycle cost/ft of aerial cable, including capital carrying costs, maintenance costs, and effects of structure sharing and local rock and difficult surface conditions; result represents "local" cost adjusted for local conditions

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Equation Listing

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Column	Name	Formula	Description
CN	fiber buried adjustment	=IF(Y2="DLC",(0.5-1/(1+(CJ2/CK2)/((CL2/CM2)^inputs!$G$82)))*VLOOKUP(line_density,density_inputs,27),0)	Calculates adjustment to input fiber buried structure fraction for local density range using user-specified buried "swing" factor and standard and local cost inputs to logistic function

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Column	Name	Formula	Description
A	wire center	='distribution input'!C2	repeats wire center location ID from distribution input sheet
B	operating company	='distribution input'!A2	repeats company name from distribution input sheet
C	cluster	='distribution input'!D2	repeats cluster ID from distribution input sheet
D	operating company indicator	='distribution input'!B2	repeats operating company type indicator from distribution input sheet
E	total lines	='distribution input'!I2	repeats total lines from distribution input sheet
F	business lines	='distribution input'!L2	repeats business lines from distribution input sheet
G	res lines	='distribution input'!M2	repeats residential line total from distribution input sheet
H	SA lines	='distribution input'!N2	repeats special access line total from distribution input sheet
I	public lines	='distribution input'!O2	repeats public line total from distribution input sheet
J	households	='distribution input'!P2	repeats household total from distribution input sheet
K	single-line business lines	='distribution input'!Q2	repeats single-line business line total from distribution input sheet
L	area, sq mi	='distribution input'!K2	repeats area from distribution input sheet
M	density lines/sq mi	='distribution input'!J2	repeats line density from distribution input sheet
N	density range	=VLOOKUP(M2,density_inputs,16)	repeats density range from distribution input sheet
O	cpr fdr cbl inv, u/g	=('cable inv'!$R2+'cable inv'!J2)*'cable inv'!BU2+IF('cable inv'!H2="N/A",0,'cable inv'!D2*VLOOKUP('cable inv'!H2,copper_inv,2,FALSE)*'cable inv'!BU2)	computes overall feeder copper cable investment for underground placement, including effect of regional labor multiplier
P	cpr fdr cbl inv, buried	=('cable inv'!$R2+'cable inv'!J2)*'cable inv'!BS2*inputs!$C$57+IF('cable inv'!H2="N/A",0,'cable inv'!D2*VLOOKUP('cable inv'!H2,copper_inv,2,FALSE)*'cable inv'!BS2)*inputs!$C$57	computes overall feeder copper cable investment for buried placement, including effect of regional labor multiplier
Q	cpr fdr cbl inv, aerial	=('cable inv'!$R2+'cable inv'!J2)*'cable inv'!BT2+IF('cable inv'!H2="N/A",0,'cable inv'!D2*VLOOKUP('cable inv'!H2,copper_inv,2,FALSE)*'cable inv'!BT2)	computes overall feeder copper cable investment for aerial placement, including effect of regional labor multiplier
R	fiber fdr cbl inv, u/g	=('cable inv'!$U2+'cable inv'!N2)*'cable inv'!BX2	computes overall feeder fiber cable investment for underground placement
S	fiber fdr cbl inv, buried	=('cable inv'!$U2+'cable inv'!N2+IF('cable inv'!Y2<>"Cable",('cable inv'!D2+'cable inv'!X2+'distribution input'!AM2+'distribution input'!AN2)*inputs!$C$58,0))*'cable inv'!BV2	computes overall feeder fiber cable investment for buried placement,
T	fiber fdr cbl inv aerial	=('cable inv'!$U2+'cable inv'!N2)*'cable inv'!BW2	computes overall feeder fiber cable investment for aerial placement

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Column	Name	Formula	Description
U	fdr conduit inv	='cable inv'!BC2+'cable inv'!BR2	calculates total conduit investment as sum of copper and fiber investments
V	feeder manhole inv	='cable inv'!BF2	repeats feeder manhole investment (includes pullboxes for fiber)
W	feeder u/g copper plcmt inv	=IF('cable inv'!$Y2="Cable','cable inv'!$BI2,0)	repeats underground copper placement investment
X	feeder u/g fiber plcmt inv	=IF('cable inv'!$Y2="DLC','cable inv'!$BI2,0)	repeats feeder underground fiber placement investment
Y	feeder buried copper plcmt inv	=IF('cable inv'!$Y2="Cable','cable inv'!$BL2,0)	repeats feeder buried copper placement investment
Z	feeder buried fiber plcmt inv	=IF('cable inv'!$Y2="DLC','cable inv'!$BL2,0)	repeats feeder buried fiber placement investment
AA	feeder pole inv	='cable inv'!BO2	repeats feeder pole investment
AB	dist cable inv, underground	='distribution input'!R2	repeats distribution underground cable investment
AC	dist cable inv, buried	='distribution input'!S2	repeats buried distribution cable investment
AD	dist cable inv, aerial	='distribution input'!T2	repeats distribution aerial cable investment
AE	distribution conduit inv	='distribution input'!U2	repeats distribution conduit investment
AF	distribution conduit plcmt inv	='distribution input'!V2	repeats distribution underground conduit placement investment
AG	dist buried plcmt inv	='distribution input'!X2	repeats distribution buried placement investment
AH	dist pole inv	='distribution input'!W2	repeats distribution pole investment
AI	calc cpr fdr fill	='cable inv'!AF2	repeats calculated copper feeder achieved fill at cluster
AJ	calc dist fill	='distribution input'!AB2	repeats calculated distribution achieved fill
AK	calc "mainframe" fill	=IF(AND('cable inv'!W2=1,'cable inv'!Y2="Cable"),output!AI2,0)	selects achieved copper feeder fill at first cluster along copper feeder cable route; equivalent to fill at mainframe
AL	DLC inv w/site	='distribution input'!AD2+'distribution input'!AF2	repeats DLC investment
AM	SAI inv	='distribution input'!AH2	repeats SAI investment
AN	terminal inv	='distribution input'!AI2	repeats terminal investment
AO	drop inv	='distribution input'!AJ2	repeats drop investment
AP	NID inv	='distribution input'!AK2	repeats NID investment
AQ	feeder distance	='cable inv'!X2+'cable inv'!D2	calculates incremental distance from previous cluster plus subfeeder distance
AR	total dist distance	='distribution input'!H2	repeats total distribution structure distance
AS	DLC lines	=IF('cable inv'!Y2="DLC','cable inv'!E2,0)	repeats number of lines served by DLC

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Column	Name	Formula	Description