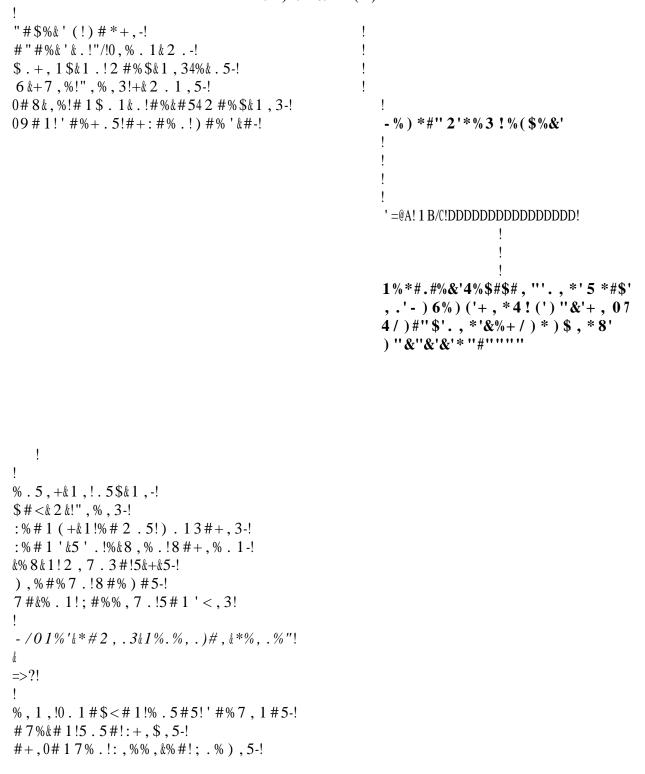
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 IFA!'OML@?LPILB>!BH!IFA! 2 L= J L!: LAG?!. HHLPA!BH!& J J LQM=ILB>!=>?! 'O@IB J @!, >HBMPA J A>I!ei&', jg/!#GG!

 "AILILB>AM@!=MA!=I!L J J L>A>I!ML@Y!BH!PB>IM=PIL>Q!PBMB>=KLMO@!?L@A=@A!T_RS!ei'. 8&74RSjg!=@!=!MA4

 @OGI!BH!IFALM!L>=ELGLIN!IB!HBGGB] ! 'A>IAM!HBM!7L@A=@A! 'B>IMBG!ei '7 'jg!QOL?AGL>A@!=>?!@I=IA!=>?!GBP=G!

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 MAGA=@A! "AILILB>AM@-!=>?!BIFAM@!L>!IFA!PG=@@!IFAN!MAXMA@A>I-!@B!IF=I!IFAN!P=>!@FAGIAM!L>!XG=PA-!HBGGB] !

 '7 '!OOL?AGL>A@-!=>?!MA?OPA!IFALM!GLYAGLFBB?!BH!L>HAPILB>!=>?!LGG>A@@/!

 $T/ : A?AM=G!^O?QA@!=PMB@@!IFA!PBO>IMN!F=KA!BM?AMA?!IFA!OMQA>I!MAGA=@A!BH!>B>PLILkA>@-! A XG=L>L>Q!IFA!XMA@@L>Q!FA=GIF!ML@Y@!PMA=IA?!EN!?AI=L>L>Q!QMBOX@!BH!XABXGA!=I!IFL@!IL J A/^R!!$

Z/ .>!#XMLG!W-!T_T_-!9/5/!7L@IMLPI! 'BOMI!OO?QA! 6 LGGL=J!)/!*BO>Q!BM?AMA?!&', !IB!MA4 GA=@A!?AI=L>A?!L>?LKL?O=G@!EAP=O@A!BH!IFA!'. 8&74RS!IFMA=IC!i\$FA!@LIO=ILB>!L@!OMQA>I!=>?!O>XMAPA4

^R& '66D&6EFE-!G9CH&HI?=J?&K6<&LE&4?;;-!T_T_!6+!RUTSW[[!eSIF&'LM/!2=M/!TU-!T_T_g!!\$?;78:& \$ I:9M&LE&59>e-!'=@A!1B/!T_4PK4_mTa4\$0<45<(!e'/7/!'=G/!#XM/!T-!T_T_g-!,':!1B/!RU!!"9N>6<& "9B;&FI6M&LE&59>e-!T_4PK4_mT[4\$0<4

?A>IA?-!=>?!/!/!/!=!MA?OPILB>!L>!IFA!>O J EAM!BH!XABXGA!] FB!=MA!FAG?!L>!PO@IB?N!L@!>APA@@=MN/j! 2 A J 4 BM=>?O J !=>?! . M?AM!=I!TW-! ' ?L8: 9&LE& '9IM?-! ' =@A! 1 B/!RCT_4PK4R_mR[4 6) * !e7/! 2 =@@/! #XM/!W-! T T g!e7, !mUg!ePBXN!=I! #XX\/!&-!, \F/! #-!R4TSg/!

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U/ \$FA!@XMA=?!BH!'. 8&74RS!L>!&', !?AIA>ILB>!L>!: 6BML?=!F=@!EAA>! J =MYA?!EN!@APMAPN! =>?!PBKAM4OX/!!

a/ #@!A=MGN!=@! 2 =MPF!T[-!T_T_-!GBP=G!=IIBM>AN@!MAXBMIA?!IB!IFALM!KBGO>I=MN!E=M!=@@BPL4 =ILB>!IF=I!IFALM!iPGLA>I@!F=KA!L>?LP=IA?!IFAMA!=MA!@LPY!L>?LKL?O=G@!L>!?AIA>ILB>!GBP=GGN-!bO=M=>IL>A?! L>?LKL?O=G@-!=>?!?AI=L>AA@!] A=ML>Q!XMBIAPILKA!QA=M/j!e#XX\!&-!, \F/!O-!=I!Z_4ZT-!Z_!OR/g/!!#HIAM!=! E=M!=@@BPL=ILB>!GL=L@B>! J A J EAM!=@YA?!&', !LH!IFAMA!] AMA!?AI=L>A?!L>?LKL?O=G@!] FB!F=?!IA@IA?!XB@L4 ILKA-!@FA!MAXBMIA?!E=PY!IB! J A J EAM@FLX!IF=I!iIFAMA!F=@!EAA>! 1 . ! ' . 1 : &% 2 # \$& . 1 !EN!& ', !BH!?A4 I=L>AA@!=I!; \$ ' !BM! (MB J A!] FB!F=KA!IA@IA?!XB@LILKA!HBM! ' . 8 &7 4RSp!=>?!MAHAMMA?! J A J EAM@!IB! & ', `@!] AE@LIA!] FAMA!LI!MAXBMI@!PB>HLM J A?!XB@LILKA!P=@A@/!e)*B*/g!eA J XF=@L@!L>!BMLQL>=Gg/!

m/ .>! 2 B>?=N-!#XMLG!m-!T_T_-!IFA! 2 L= J L!<AM=G?!MAXBMIA?!IF=I!I] B!BHHLPAM@!] BMYL>Q! =I! (MB J A!5AMKLPA! "MBPA@@L>Q! ' A>IAM!L>! 2 L= J L!F=?!IA@IA?!XB@LILKA!HBM! ' . 8 & 7 4RS-!=>?! J =>N!BIF4 AM@!] AMA!=] =LIL>Q!MA@OGI@!HMB J !IFALM!IA@I@/!e#XX\!&-!, \F/! ' -!=I!ZZ4ZW/g!

[/ .>!IF=I!@= J A!?=N-!&', !IBG?!IFA!<AM=G?!IF=I!:9!?AI=L>A?!L>?LKL?O=G@!L>!:GBML?=!F=?!IA@IA?!XB@LILKA/!e#XX\!&-!, \F/!7-!=I!ZS4Um-!U 4URg!ei:BM!] AAY@ q =>?!=@!MAPA>IGN!=@! 2 B>?=N q

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PA>IAM!IA@IA?!XB@LILKA!HBM!'. 8&74RS-!LI`@!=G@B!>BI!PB J XGAIAGN!=PPOM=IA!=@!IA@IL>Q!L@!>BI!PB>?OPIA?! B>!@LIA!=>?!?AI=L>AA@!=MA!@A>I!IB!=>!BHH4@LIA!FB@XLI=G!IB!EA!IA@IA?/j!!e#XX\!&-!, \F/!7-!=I!UR/g!

S/ & `, !>B] !=? J LI@!IF=I!IFAMA!=MA!GA=@I!I] B!?AI=L>A?!L>?LKL?O=G@!L>! 2 L= J L!] FB!F=KA!IA@IA?!XB@LILKA!HBM! `. 8 & 7 4RS-!B>A!POMMA>IGN!=I! (MB J A-!=>?!=!@APB>?!=I!=!GBP=G!FB@XLI=G!L>! 2 L4 = J L/T!

R_/ & ', !MAHO@A@!IB!?L@PGB@A!] FAIFAM!IFLM?4X=MIN!PB>IM=PIBM@!IA@I!XB@LILKA!HBM! '. 8&74 RS-!XMBKL?L>Q!IFA J !=!iGBBXFBGAj!IB!MAXBMIL>Q!IFA!=PIO=G!>O J EAM!BH! '. 8&74RS!P=@A@!= J B>Q!LI@! A J XGBNAA@!L>!?AIA>ILB>!PA>IAM@/!\$FLM?4X=MIN!PB>IM=PIBM@!PB J XML@A!=! J =^BMLIN!BH!A J XGBNAA@!L>!?A4 IA>ILB>!PA>IAM@/!!e#XX\!&-!, \F/!7-!=I!Za4Zm/g!

 $\label{eq:result} RR/ \quad ' . \ 8 \& 7 \ 4 RS \ !IFMA=IA>0 \ !AKAMN! \] \ B \ J => \ !=> \ ?! \ J => \ ?! \ J => \ ?! \ A = IA \ ?! = I! \ (\ MB \ J \ A \ !SAMKLPA! \ "MB4 \ PA00 \ L>Q! \ ' \ A>IAM \ !e \ (\ MB \ J \ A \ j \ g-! \) \ G= \ ?A0! \ ' \ BO>IN! \ 7 \ AIA>ILB>! \ ' \ A>IAM \ !e \) \ G= \ ?A0 \ j \ g-! => \ ?! \ ;MB \] = M \ ?! \ SM=>0 \ LA \ ILB>= \ G! \ ' \ A>IAM \ !e \ ; \ S \ ' \ j \ g/! \ \# \ !PF=MI \ !BH! \ IFA \ !MAXBMIA \ ?! \ ' \ . \ 8 \& \ 7 \ 4 RS \ !P=0 \ A0 \ !BH! \ XABXGA \ !L>!\& \ ' \ , \ !?AIA>ILB>! \ ?A4 \ ILB>= \ G! \ ' \ A>IAM \ !e \ ; \ S \ ' \ j \ g/! \ \# \ !PF=MI \ !BH! \ IFA \ !MAXBMIA \ ?! \ . \ 8 \& \ 7 \ 4 RS \ !P=0 \ A0 \ !BH! \ XABXGA \ !L>!\& \ ' \ , \ !?AIA>ILB>! \ ?A4 \ XLPI0 \ !=> \ !=G=M \ J \ L>Q \ !0 \ IAAX \ !POMKA/!e \ \# \ XX \ !\&-! \ , \ \ /F/! \ , \ -!=I!U \ [\ g1! < 66 \ \& \ ?> < 9! \ 7 \ APG=M=ILB>!BH! \ 7 \ M'!OB0AXF! \ !SFL>-! \ 2 \ 7 \ -! \ 2 \ SP \ ?=IA?! \ \# \ XMLG!RZ-!T \ T \ \ !e \ i \ SFL>! \ 7 \ APG/j \ g!ooZS4URe \ , \ \ F/!Tg/!$

RT/ #GIFBOQF! (MB J A-!) G=?A@-!=>?!; \$ '!=MA!MO>!EN!XMLK=IA!XML@B>!QMBOX@-!L>?AXA>?A>I! PB>IM=PIBM@-!=>?!=!PBO>IN-!IFA@A!QMBOX@!F=KA!:9!=OIFBMLIN!IB!MAGA=@A!=!XAM@B>/!.>GN!IFA!HA?AM=G! QBKAM> J A>I!%A@XB>?A>I@!P=>!XMBKL?A!IFA!MA J A?N!MAbOA@IA?!EN!IFL@!=PILB>/!

 $\label{eq:RZ} RZ/ , = PF!BH!IFA!IFMAA!?AIA>ILB>!PA>IAM@!ALIFAM!F=@!PB>HLM J A?!P=@A@!BH!IFA!KLMO@!BM!F=@! QMBOX@!BH!L>?LKL?O=G@!FAM?A?!IBQAIFAM!L>!iPBFBMI!bO=M=>IL>Aj!EAP=O@A!IFAN!F=KA!EAA>!A \XB@A?/! %=IFAM!IF=>! J LILQ=IA!IFA!ML@Y!BH!IM=>@ J L@@LB>-!IFA@A!PBFBMI!bO=M=>IL>A@!?M=@ILP=GGN!L>PMA=@A!IFA!$

^T'#+%'2:;<=>?@'A>'+, 1#&7BCD'EF=GH':I<=H@<') IJK'BLD'MLMLD'NOPN'400D'=!''#\$''%\$&'''(0' FIIX@Cff]]]/LPA/QBKfPBMB>=KLMO@<u>K</u>'

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> $T_{/} = 9 > ?AM!IFA@A!PLMPOJ@I = PA@-!' . 8 & 7 4RS!] LGC!i@XMA = ?!GLYA!] LG?HLMA-j! = PPBM?L > Q!IB! = !$ HBM J AM!FLQF4GAKAG!&', !BHHLPL=G/!!e#XX\!&-!, \F/!) -!=I! [U4WR-![a4[m!omg!e?APG=M=ILB>!BH!OBF>!5=>?4] AQ-!: BM J AM!#PIL>Q!7LMAPIBM!BH!&', g/Z!!\$FA! 6 BMG?! < A=GIF! . MQ=>Lk=ILB>-!MAPBQ>LkL>Q!IFA!IFMA=I!

@IO?N!L>PGO?A?!X=@@A>QAM@!HMB J !IFA! 7 L= J B>?! "ML>PA@@/!\$FA@A!@IO?LA@!HBO>?!IF=I!L>! ' . 8 & 7 !L>4 HAPIA?!XAM@B>@-!aSv -!ZRv !=>?!RW v 1!MA@XAPILKAGN-!] AMA!=@N J XIB J =ILP!BM! J LG?GN!@N J XIB J =ILP/j! '66&5FL>!7 APG/-!oTU!e, \F/!Tg/!!!

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 $TT/ 7 AI=L>AA!MAXBMI@!HMB J != GG!IFMAA!H=PLGLILA@!?BPO J A>I!IF=I!@BPL=G!?L@I=>PL>Q!L@!L J XB@4 @LEGA-!XABXGA!A \FLELIL>Q!HGO4GLYA!@N J XIB J @!=MA!FBO@A?!L>!IFA!QA>AM=G!XBXOG=ILB>-!=>?! J =L>I=L>L>Q! XAM@B>=G!FNQLA>A!L@!PB>@IM=L>A?!EN!IFA!PMB] ?A?!H=PLGLILA@!=>?!G=PY!BH!PGA=>L>Q!@OXXGLA@/!#I!; $ ' ! =>?!) G=?A@-! J A>!=>?!] B J A>! J O@I!M=ILB>!@B=X!] AAYGN q$

 Ta/
 !\$FMBOQFBOI!IFA!] BMG?-!IFA! ' . 8 & 7 4RS!X=>?A J LP!L@!L>HAPIL>Q!=>?!YLGGL>Q!] B J A>-!

 J A>-!=>?!PFLG?MA>/!\$FA!9>LIA?!5I=IA@!F=@!>B] !@OMX=@@A?!IFA!MA@I!BH!IFA!] BMG?!L>!EBIF!IFA!>O J EAM!

 BH!PB>HLM J A?!P=@A@!=>?!IFA!FLQFA@I!>O J EAM!BH!?A=IF@/! . KAM!TT-!___!# J AMLP=>@!F=KA!?LA?/^m!! , \4

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TW/ 9 > HBMIO >= IAGN -!&', !L@!XMAKA > IL > Q!XABXGA != I! (MBJA -!) G = ?A@ -! => ?!; \$'!HMBJ!PBJ4 XGNL > Q!] LIF!@FAGIAML > Q!L > !XG = PA!XMBIBPBG@ !=> ?! '7'!QOL?AGL > A@/!7 A@XLIA!] = M > L > Q@!HMBJ!JA?LP = G! = > ?!XOEGLP!FA = GIF!XMBHA@@LB > = G@!IF = I!MAGA = @L > Q!?AI = L > A?!LJJLQM => I@!L@!IFA!B > GN!KL = EGA!BXILB > !IB! PBJXGN!] LIF!@BPL = G!?L@I = > PL > Q - !L > ?LKL?O = G!DO = M = > IL > A - ! = > ?!BIFAM! '7'!MABOLMAJA > I@! = > ?!GBP = G! = > ?! @I = IA!BM?AM@ - !IFA! = QA > PN!F = @!QA > AM = GGN!MAHO@A?!IB!MAGA = @A!L > ! = > N!JA = > L > QHOG!] = N - !L > !IFA! = E@A > PA!BH!

ZR/ "AILILB>AM!) 4) *#+#, '4K'9%*, ''#0, !L@!=!PLILkA>!BH!) O=IA J =G=!] FB!L@!?AI=L>A?!

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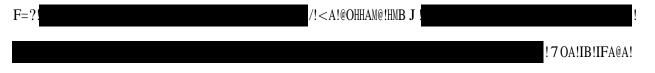
FL@!O>LI!=MA!KAMN!@LPY/!&H!MAGA=@A?-!FA!F=@!I]B!XG=PA@!IB!@I=N!L>!+=YA! 6 BMIF-!]LIF!FL@!X=MI>AM!=>?!PFLG?MA>!=>?!]LIF!FL@!EMBIFAM-!]FAMA!FA!P=>!XM=PILPA!@BPL=G!?L@I=>PL>Q!=>?!@AGH4bO=M=>IL>A/!



=EBOI!PB>IM=PIL>Q! ' . 8&74RS-!] FLPF!] BOG?!EA!H=I=6!?OA!IB!FAM!XBBM!FA=GIF/!\$FA!PAGG@!=>?!XB?@! =MA!@B!@ J =GG!\$=FL J L!P=>>BI!XM=PILPA!@BPL=G!?L@I=>PL>Q-!=>?! J =>N!BH!IFA!XABXGA!L>!FAM!XB?!=MA!@LPY/! &H!MAGA=@A?!HMB J !?AIA>ILB>-!@FA!] BOG?!GLKA!] LIF!FAM!X=MI>AM!L>!<L=GA=F-!: GBML?=!] FAMA!@FA!] BOG?! EA!=EGA!IB!@AGH4bO=M=>IL>A!=>?!XM=PILPA!@BPL=G!?L@I=>PL>Q/!

!5FA!L@!] BMMLA?!

U_/ "AILILB>AM!.*) "**R**/#'''*) **0**, "'**2**, "**S**) / %**S**!L@!=!>=ILB>=G!BH!IFA!7BJL>LP=>! %AXOEGLP!]FB!F=@!EAA>!?AI=L>A?!=I!)G=?A@!'BO>IN!7AIA>ILB>!'A>IAM!@L>PA!:AEMO=MN!TU-!T_T_/!<A!



 $A \ L@IL>Q!FA=GIF!L@@OA@-!L>!X=MILPOG=M!IFB@A!MAG=IA?!IB \ PAGE IA?!IB \ PAGE IA?!IA \ PAGE IA \ PAGE$

!] LGG! J =YA!FL J ! J BMA!KOG>AM=EGA!IB!@AKAMA!LGG>A@@!BM!?A=IF!LH!FA!PB>IM=PI@! ' . 8 & 7 4
RS/! < A!L@!] BMMLA?!EAP=O@A! J B@I!BH!IFA!IL J A!LI!L@!L J XB@@LEGA!HBM!FL J !IB!@BPL=G!?L@I=>PA/!&H!MAGA=@A?-!
FA!] LIF!FL@!=O>I!L>! 1 A] !OAM@AN-!] FAMA!@FA!F=@!=!@AX=M=IA!MBB J !HBM!FL J !IB!@AGH4L@BG=IA/!

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UT/ "AILILB>AM!.*) "+#(+,'*#1%*,'1) /%*, "!L@!=!G=] HOG!XAM J =>A>I!MA@L?A>I!BH! IFA!9>LIA?!5I=IA@!] FB!L@!?AI=L>A?!EN!&', !=I!) G=?A@! 'BO>IN!7AIA>ILB>! 'A>IAM/!<A!F=@!EAA>!L>! &', !PO@IB?N!@L>PA!O=>O=MN!Tm-!T T /!<A!@OHHAM@!HMB J !

!<A!L@!XMA@PMLEA?!

!FL@! J A?LP=6!PB>?LILB>@/!#@!=!PB>@AbOA>PA!BH!FL@!FA=GIF!PB>?LILB>@-!FA!L@!=I! FLQF!ML@Y!HBM!@AKAMA!LGG>A@@!BM!?A=IF!LH!FA!PB>IM=PI@! ' . 8 & 7 4RS/!\$FAMA!=MA!Sm!?AI=L>AA@!L>!FL@!XB?-! =>?!=GG!Sm! J A>!F=KA!IB!@F=MA!B>A!IBLGAI/!&H!MAGA=@A?-!FA!] LGG!GLKA!] LIF!FL@!] LHA!L>! 1 =XGA@-! : GBML?=!] FAMA!FA!] LGG!HBGGB] !=GG!MAPB J J A>?=ILB>@!HMB J !IFA! ' 7 '/!

UZ/ "AILILB>AM! **2% / 6% * '(, ''\$) 8'. ! ''% S**!&@!=!PLILkA>!BH!) O=IA J =G=!] FB!L@!?A4 I=L>A?!EN!& ', !=I!; MB] =M?!\$M=>@LILB>=G! 'A>IAM/!<A!F=@!EAA>!L>!& ', !PO@IB?N!@L>PA!=XXMB\L J =IAGN! . PIBEAM!TW-!T_RS/!<A!@OHHAM@!HMB J !

!\$FAMA!F=KA!EAA>!QMBOX@!BH! J A>!IM=>@HAMMA?!L>IB!; \$ '-!=>?!FA!L@!O>@OMA!LH!IFAN!F=KA!EAA>!
IA@IA?!HBM! ' . 8 & 7 4RS/!<A!L@!PB>PAM>A?!EAP=O@A!FA!F=@!EAA>!
IA@IA?!HBM! ' . 8 & 7 4RS!BM!F=?!FL@!IA J XAM=IOMA!I=YA>/!&H!FA!L@!MAGA=@A?-!FA!] LGG!GLKA!] LIF!FL@!] LHA!BM!
FL@!@XB>@BM!L>!+AFLQF!#PMA@-!:GBML?=/!

UU/ "AILILB>AM!**9**!)"'+)*/,(')/.)*,'**2**)*+#)!L@!=!PLILKA>!BH! 2 A\LPB!=>?!=@N4 GO J !@AAYAM!] FB!L@!?AI=L>A?!EN!&',!=I! (MB J A!5AMKLPA!"MBPA@@L>Q! 'A>IAM/!<A!F=@!EAA>!L>!&', !PO@4 IB?N!@L>PA!B>!BM!=MBO>?! 2 =MPF!m-!T_T_/!<A!@OHHAM@!HMB J []] FLPF!XOI@!FL J !=I!FLQF!ML@Y!HBM! @AKAMA!LGG>A@@!BM!?A=IF!LH!FA!PB>IM=PI@!'. 8&74RS/!<A!L@!] BMMLA?!EAP=O@A! J =>N! J A>!L>!FL@!PAGG! F=KA!HAKAM@!=>?!PBOQF@/! 6 FA>!IFAN!=MA!L>!IFALM!O>LI-!LI!L@!L J XB@@LEGA!IB! J =L>I=L>!@BPL=G!?L@I=>PA/! &H!MAGA=@A?-!FA!] BOG?!EA!=EGA!IB!@I=N!] LIF!FL@!] LHA!L>!: GBML?=!] FAMA!FA!] BOG?!EA!=EGA!IB!XM=PILPA! @BPL=G!?L@I=>PL>Q/!

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$$\begin{split} &XAM@B>=G!XMBIAPILKA!AbOLX J A>I!BM!@=>LI=MN!@OXXGLA@!L>!IFA!H=PLGLIN/!&H!MAGA=@A?-!FA!] BOG?!EA!=EGA!IB!\\ &@I=N!] LIF!FL@!QLMGHMLA>?!L>! 2 L= J L-!: GBML?=!] FAMA!FA!] BOG?!EA!=EGA!IB!@AGH4L@BG=IA!=>?!@AGH4bO=M=>4\\ &IL>A/!! \end{split}$$

aR/ "AILILB>AM! **0 !** -) **0 0**) **&**') /) **0** '**R** -) '' !L@!=!PLILkA>!BH! "=YL@I=>!] FB!L@!?AI=L>A?! =I! (MB J A!5AMKLPA! "MBPA@@L>Q! ' A>IAM/!<A!F=@!EAA>!L>!& ' , !PO@IB?N!@L>PA!7 APA J EAM!R_-!T_RS/!<A! @OHHAM@!HMB J !

/!#@!=!PB>@AbOA>PA!BH!FL@!

 $\label{eq:solution} FA=GIF!PB>?LILB>@-!FA!L@!=I!FLQF!ML@Y!HBM!@AKAMA!LGG>A@@!BM!?A=IF!LH!FA!PB>IM=PI@! ' . 8 & 7 4RS/! < A!L@!$ $] BMMLA?!EAP=O@A!IFAMA!=MA!=XXMB \L J =IAGN!Ua!BIFAM!?AI=L>A?!L>?LKL?O=G@!FBO@A?!] LIF!FL J -!=>?!LI!$ $L J XB@@LEGA!HBM!IFA J !IB!MA J =L>!@L \!HAAI!=X=MI/!&H!MAGA=@A?-!FA!] BOG?!QB!E=PY!FB J A!=>?!GLKA!] LIF!$ FL@!] LHA!=>?!PFLG?MA>!L>!\$= J =M=P-! : GBML?=/!!!!

aT/ "AILILB>AM!9, (%'+ -) 1%S!L@!=!PLILkA>!BH!?OM=@!]FB!L@!?AI=L>A?!=I! (MB J A! 5AMKLPA!"MBPA@@L>Q!'A>IAM/!<A!F=@!EAA>!L>!&', !PO@IB?N!@L>PA!OOGN!RS-!T_RS/!<A!@OHHAM@!HMB J !

/! < A!F = @! = !FL@IBMN!BH!EAL>Q!FB@XLI=GLkA?!HBM! ??OA!IB!FL@!XBBM! ?OA!IB!FL@!XBBM! ?A=GIF/! # @!=!PB>@AbOA>PA!BH!FL@! ??A=GIF/! # @!=!PB>@AbOA>PA!BH!FL@! ??A=GIF/! # @!=!PB>@AbOA>PA!BH!FL@! ??A=GIF/! # @!=!PB>@AbOA>PA!BH!FL@! ??A=GIF/! # @!=I!FLQF!ML@Y!HBM!@AKAMA!LGGA ?A@@!BM!?A=IF!LH!FA!PB>IM=PI@! ' . 8 & 7 4RS/!0B@A!L@!L>!=!O>LI!] LIF!UR! J A>-!=>?!IFAN!=MA!>BI!=EGA!IB! @BPL=GGN!?L@I=>PA!?OA!IB!IFA!PGB@A!bO=MIAM@!L>!] FLPF!IFAN!=MA!YAXI/!&H!MAGA=@A?!FA!] BOG?!EA!=EGA!IB! GLKA!] LIF!FL@!@XBO@A!=>?!PFLG?MA>!L>! 7 =KLA-! : GBML?=!] FAMA!FA!] BOG?!EA!=EGA!IB!XM=PILPA!@BPL=G!?L@4 I=>PL>Q!=>?!@AGH4bO=M=>IL>A/!!

aZ/ "AILILB>AM!&) #*, "'6) **%&, '() "+ - %S!L@!=!PLILkA>!BH! 'OE=!] FB!L@!?A4 I=L>A?!=I!) G=?A@! 'BO>IN!7AIA>ILB>! 'A>IAM!=>?!AGLQLEGA!HBM!=?^O@I J A>I!O>?AM!IFA! 'OE=>!#?^O@I4 J A>I!#PI/!<A!F=@!EAA>!L>!&', !PO@IB?N!@L>PA!: AEMO=MN!RZ-!T_T_/!7=MLB>!@OHHAM@!HMB J



L@!] BMMLA?!=EBOI!H=I=G!'. 8&74RS!A\XB@OMA!L>!?AIA>ILB>!] FAMA!BIFAM!?AI=L>A?!L>?LKL?O=G@!=MA!@LPY! =>?!@BPL=G!?L@I=>PL>O!L@!L J XB@@LEGA/!

 $!\$FAMA!=MA!BKAM!S_!JA>!L>!IFA!GLKL>Q!O>LI-!=>?!LI!L@!LJXB@@LEGA!IB!J=L>I=L>!$ $@L \ !HAAI!BH!?L@I=>PA!=] =N!HMBJ !BIFAM!?AI=L>A?!L>?LKL?O=G@/!&H!MAGA=@A?-!FA!] LGG!GLKA!] LIF!FL@!X=MI>AM!$ =>?!PFLG?!L>! . MG=>?B-!: GBML?=!] FAMA!FA!] BOG?!EA!=EGA!IB!XM=PILPA!@=HA!@BPL=G!?L@I=>PL>Q!=>?!@AGH4 bO=M=>IL>A/!

aU/ "AILILB>AM! **0**) **8 R% / '1**) **/ %***) **'***) **0 #*%S'**L@!=!PLILkA>!BH! 'OE=!] FB!L@!?AI=L>A?! =I!; MB] =M?!\$M=>@LILB>=G! 'A>IAM/!<A!F=@!EAA>!L>!& ', !PO@IB?N!@L>PA! 7 APA J EAM!T_RS/!<A!@OHHAM@!

HMB J	!HBM!FL@!PB>	>?LILB>/	!

<A!L@!] BMMLA ?!=EBOI!PB>IM=PIL>Q! ' . 8 & 7 4RS !EAP=O@A!BIFAM! ?AI=L>A ?!L> ?LKL ?O=G@!XMAX=MA!IFA!HBB ?! =>?!PGA=>!IFA!H=PLGLIN-!=>?!IFAN! ?B!>BI!] A=M! J =@Y@-!=>?!@B J AIL J A@!QGBKA@-!] FLGA!PGA=>L>Q/! < A!L@! PB>PAM>A ?!IF=I!FL@!FA=GIF!PB>?LILB>@-!PBOXGA ?!] LIF!IFA!H=PI!IF=I!FA!P=>>BI!@BPL=G! ?L@I=>PA!] FLGA! ?AI=L>A ?-!XOI@!FL J !=I!=!FLQFAM!ML@Y!BH!PB>IM=PIL>Q! ' . 8 & 7 4RS/!&H!FA!L@!MAGA=@A ?!HMB J !?AIA>ILB>-!FA!] LGG!GLKA!] LIF!FL@!PBO@L>!L>!''=@PB-! 6 =@FL>QIB>/!

aa/ "AILILB>AM! /) S) * , ' , +) ") '2 ! S 0) " 'L@!=!PLILkA>!BH! 2 A\LPB!] FB!L@!?AI=L>A?! =I! (MB J A!5AMKLPA! "MBPA@@L>Q! ' A>IAM/! <A!F=@!EAA>!L>!& ' , !PO@IB?N!@L>PA! 2 =MPF!T_-!T_T_/! <A!@OH4 HAM@!HMB J **PLOTE**!] FLPF!L@!A\=PAME=IA?!IB!IFA!XBL>I!BH!EAL>Q!O>=EGA!IB!@XA=Y!] FA>!@LPY/! <A!] =@!L>!=!PBFBMI!bO=M=>IL>A!] LIF!m_! J A>!O>ILG!MAPA>IGN-!EOI!AKA>!L>!IFA!PBFBMI!FA!] =@!>BI!=EGA!IB! J =L>I=L>!=!@=HA!@BPL=G!?L@I=>PA!HMB J !IFA!MA@I!BH!IFA! J A>/! <A!L@!PB>PAM>A?!=EBOI!PB>IM=PIL>Q!

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'. 8 & 7 4RS!=I! (MB J A-!X=MILPOG=MGN!L>!KLA] !BH!FL@!PFMB>LP!LGG>A@@/!&H!MAGA=@A?-!FA!] BOG?!EA!=EGA!IB! GLKA!] LIF!FL@!EMBIFAM!L>!+=MQB-!: GBML?=!] FAMA!FA!PBOG?!@AGH4bO=M=>IL>A/!!

am/ "AILILB>AM!") # 0 ') * *) **R**'L@!=!PLILkA>!BH!\$O>L@L=!] FB!L@!?AI=L>A?!=I! (MB J A!5AM4 KLPA! "MBPA@@L>Q! ' A>IAM/!<A!F=@!EAA>!L>!& ', !PO@IB?N!@L>PA!OOGN!T-!T_RS/!<A!@OHHAM@!HMB J [______] !<A!L@!KAMN!PB>PAM>A?!EAP=O@A!

FA!] =@!IBG?!IFMAA!BHHLPAM@!IA@IA?!XB@LILKA-!=>?!FA!IFL>Y@!B>A!BH!IFB@A!BHHLPAM@!F=@!@ILGG!EAA>!] BMY4 L>Q!L>!IFA!H=PLGLIN/!#G@B-!@I=HH!=MA!>BI!O@L>Q!IFA!=XXMBXML=IA!XAM@B>=G!XMBIAPILKA!AbOLX J A>I!=>?!=MA! @ILGG!?BL>Q!IFMAA!@F=YA!?B]>@!BH!IFALM!EO>Y@!=!?=N-!IBOPFL>Q!=GG!BH!IFA! J A>d@!XAM@B>=G!EAGB>QL>Q@/! &H!MAGA=@A?-!FA!P=>!@I=N!] LIF!FL@!=?BXILKA!PLILKA>!X=MA>I@!L>!8LMQL>L=!] FAMA!FA!] LGG!F=KA!FL@!B]>! MBB J !IB!L@BG=IA!=>?!@BPL=G!?L@I=>PA/!!

 $a[/ "AILILB>AM!) 2) "\%'5) * () 0\%'L@!=!PLILkA>!BH!5BJ=GL=!]FB!L@!?AI=L>A?!=I! (MBJA! 5AMKLPA!"MBPA@@L>Q!'A>IAM/!<A!F=@!EAA>!L>!&', !PO@IB?N!@L>PA!#OQO@I!R-!T_R[/!<A!@OHHAM@!HMBJ!$

=>?!]=@!=!PFMB>LP!@JBYAM!EAHBMA!XG=PA?!L>!&', !PO@IB?N/!

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/!<A!L@!IAMMLHLA?!IF=I!FA!] LGG!PB>IM=PI! ' . 8 & 7 4RS!EAP=O@A!IFA!?A4 I=L>A?!L>?LKL?O=G@!] LIFL>!IFA! O@A?!IB!EA!FBO@A?!L>!IFA!O>LI!L@!>B] !L@BG=IA?!=I!=!FB@XLI=G/!<A!L@!] LIFL>!@L\!HAAI!BH!=>BIFAM!XAM@B>! =I!=GG!IL J A@!] LIFL>!IFA! /!&H!MAGA=@A?!HMB J !?AIA>ILB>-!FA!] LGG!MAIOM>!IB!GLKA!] LIF!FL@!] LHA!L>! <OIPFL>@B>-! 2 L>>A@BI=/!

aW/ "AILILB>AM! -) (() "'0 , -) 0 %&'.) *) - 'L@!=!PLILkA>!BH!5B J =GL=!] FB!L@!?A4 I=L>A?!=I! (MB J A!5AMKLPA! "MBPA@@L>Q! ' A>IAM/!<A!F=@!EAA>!L>!& ' , !PO@IB?N!@L>PA! . PIBEAM!Rm-!T_R [/! <A!@OHHAM@!HMB J !

 $! < A!L@!FBO@A?!L>!IFA! J A>!L>!FL@!O>LI!=MA!A \ FLELIL>Q!HGO!$

GLYA!@N J XIB J @-!=>?!FA!L@!] BMMLA?!EAP=O@A!FA!] =@!IBG?!IF=I!IFAN!M=>!BOI!BH!F=>?!@=>LILKAM!=>?! IFAMA!L@!>B! J BMA!@B=X/! ' B J J L@@=MN!L@!>B] !PGB@A?/!<A!L@!=G@B!PB>PAM>A?!EAP=O@A! J =>N!QO=M?@! B>GN!] A=M!XAM@B>=G!XMBIAPILKA!AbOLX J A>I!] FA>!IFAN!=MA!EAL>Q!] =IPFA?!EN!@OXAMKL@BM@-!BIFAM] L@A! IFAN!?B!>BI!O@A!IFA!AbOLX J A>I!EAP=O@A!IFAN!@=N!?B!>BI!GLYA!O@L>Q!LI/!

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!&H!MAGA=@A?-!

FA!] LGG!GLKA!] LIF!FL@!] LHA!=>?!PFLG?MA>!L>! 2 L>>A@BI=!] FAMA!FA!] LGG!HBGGB] !IFA! 2 L>>A@BI=!@I=N!=I! FB J A!BM?AM!=>?!@I=N!L>!L@BG=ILB>/!!

 aS/
 "AILILB>AM!*!6%''',*/)"&,'/,*%('*)0,('!@!=!U_4NA=M!BG?!PLILKA>!BH!

 ?OM=@!]FB!L@!?AI=L>A?!=I!(MBJA!5AMKLPA!"MBPA@@L>Q!'A>IAM/!<A!F=@!EAA>!L>!&', !PO@IB?N!

 @L>PA!2=MPF!S-!T_T_/!<A!@OHHAM@!HMBJ!</td>
 -!=>?!@L>PA!FL@!ILJA!L>!

 (MBJA!FL@!
 !>APA@@LI=IL>Q!L>PMA=@A?!JA?LP=ILB>/!<A!F=@!</td>

 =6@B!EAA>!F=KL>Q!?LHHLPOGIN!EMA=IFL>Q/!<A!L@!L>!=!bO=M=>IL>A!PBFBMI!O>LI!=>?!L@!O>=EGA!IB!@=HAGN!

 ?L@I=>PA!FLJ@AGH!HMBJ!IFA!JA>/!7OA!IB!=!G=PY!BH!@FB]AM@-!IFA!JA>!=MA!>BI!=EGA!IB!

 @FB]AM!MAQOG=MGN/!
 !

!5B J A!

J A>!=MA>`I!=GGB] A?!IB!O@A!IFA!XFB>A!IB!PB>I=PI!IFALM!=IIBM>AN@!EAP=O@A!IFAN!F=KA!MAXBMIA?!IFA! QO=M?@!PB>?OPI/!&H!MAGA=@A?-!FA!] BOG?!GLKA!] LIF!FL@!H= J LGN!L>! 1 A] ! . MGA=>@-!+BOL@L=>=!] FAMA!FA! PBOG?!I=YA!P=MA!BH!FL J @AGH!=>?!@AX=M=IA!FL J @AGH!HMB J !BIFAM@/!

!\$FA! (MBJA!@I=HH!=>?!>OM@A@!=MA!IAGGL>Q!FLJ!IF=I!IFAMA!=MA!XABXGA!L>!f(2FFAMA!L&L=01272.

T_!

!; AP=O@A!BH!FL@!O>?AMGNL>Q! J A?LP=G!PB>?L4

ILB>-!FA!L@!=I!ML@Y!HBM!H=I=G!PB J XGLP=ILB>@!LH!FA!] AMA!IB!PB>IM=PI! ' . 8 & 7 4RS/! < A!L@!PB>PAM>A?!EA4 P=O@A!FA!L@!O>=EGA!IB!@BPL=G!?L@I=>PA-!A@XAPL=GGN!?OML>Q! J A=G@!] FAMA!AKAMNB>A!L@!B>GN!=EBOI!IFMAA! HAAI!=X=MI/!&H!MAGA=@A?-!FA!] LGG!MAIOM>!FB J A!=>?!GLKA!] LIF!FL@!] LHA!=>?!HBGGB] ! ' 7 ' !MAPB J J A>?=4 ILB>@/!

mU/ %A@XB>?A>I! **0** #+ -) %/' **5** K' **0** %) &%!L@!IFA!: LAG?! . HHLPA!7LMAPIBM!HBM!IFA!&', ! 2 L4 = J L!: LAG?! . HHLPA/!!\$FA!&', ! 2 L= J L!: LAG?! . HHLPA!F=@!PB J XGAIA!PB>IMBG!BKAM!IFA!=? J L@@LB>!=>?!MA4 GA=@A!BH!>B>PLILkA>@!?AI=L>A?!=I! (MB J A-!; \$ '-!=>?!) G=?A@/!!%A@XB>?A>I! 2 A=?A!L@!IFA!L J J A?L=IA! =>?!GAQ=G!PO@IB?L=>!BH! "AILILB>AM@/!!<A!L@!@OA?!L>!FL@!BHHLPL=G!P=X=PLIN/!!

ma/ %A@XB>?A>I! **5** #/ / #) **0** '**4**K'**6**) * * !L@!IFA!9>LIA?!5I=IA@! # IIBM>AN!) A>AM=G/!!&>!IFL@! P=X=PLIN-!FA!F=@!@OXAMKL@BMN!=OIFBMLIN!BKAM!=GG!BXAM=ILB>!BH!IFA!, \APOILKA! . HHLPA!BH!& J J LQM=ILB>! %AKLA] !e , . &%g!] FLPF!L>PGO?A@!=GG!IFA!L J J LQM=ILB>!PBOMI@!=>?!IFA! ; B=M?!BH!& J J LQM=ILB>! # XXA=G@! e ; & # g/!!W!9/5/ ' /!uRR_ZeQg1!W! ' : %!uR_Z/_/!!<A!L@!=G@B!PF=MQA?!] LIF!IFA!=? J L>L@IM=ILB>!=>?!IFA! A>HBMPA J A>I!BH!IFA!L J J LQM=ILB>!G=] @!O>?AM!W!9/5/ ' /!uRR_Ze=g/!!%A@XB>?A>I! ; =MM!L@!=!GAQ=G!PO@IB4 ?L=>!BH! " AILILB>AM@/!!<A!L@!@OA?!L>!FL@!BHHLPL=G!P=X=PLIN/!!

<u>4*,4,(%&'+/)(('</u>

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mm/ "AILILB>AM@!HLGA!IFL@!=PILB>!B>!EAF=GH!BH!=!FLQFGN!KOG>AM=EGA!XOI=ILKA!PG=@@C!=GG!L>?L4
KL?O=G@!L>!PLKLG!L J J LQM=ILB>!?AIA>ILB>-!=@!BH!IFA!?=IA!BH!IFA!HLGL>Q!BH!IFL@!=PILB>-!=I!IFMAA!:GBML?=!
?AIA>ILB>!PA>IAM@-! (MB J A!5AMKLPA! "MBPA@@L>Q! ' A>IAM-!; MB] =M?!\$M=>@LILB>=G! ' A>IAM-!=>?!) G=?A@!
' BO>IN! 7 AIA>ILB>! ' A>IAM/!, =PF!L>?LKL?O=G!L@!=I!L J J L>A>I!ML@Y!BH!PB>IM=PIL>Q! ' . 8&74RS!EAP=O@A!

TT!

BH!IFA!GLHA4IFMA=IA>L>Q!PB>?LILB>@!O>?AM!] FLPF!IFAN!=MA!PB>HL>A? q PB>?LILB>@!IF=I!KLBG=IA! '7 '!

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QOL?AGL>A@!=>?!5I=IA!=>?!'BO>IN!BM?AM@!=@!IFAN!XAMI=L>!IB!'. 8&74RS/!

m[/ 1 = J A?! "AILILB>AN@!EML>Q!IFL@!=PILB>!=@!MAXMA@A>I=ILKA@!BH!IFA!HBGGB]L>Q!XNBXB@A?!

PG = @@C!

GG!PLKLG!L J J LQM=ILB>!?AI=L>A?!L>?LKL?O=G@!] FB!=MA!FAG?-!BM!] FB!] LGG!EA! FAG?-!EN!%A@XB>?A>I@!=I!IFA! (MB J A!5AMKLPA! "MBPA@@L>Q! ' A>IAM!ei (MB J Ajg-!IFA! ; MB] =M?!\$M=>@LILB>=G! ' A>IAM!ei ; \$ ' jg-!=>?!=I!) G=?A@! ' BO>IN!7AIA>ILB>! :=PLGLIN! ei) G=?A@jg!=@!BH!IFA!LL J A!BH!IFA!HLGL>Q!BH!IFL@!=PILB>!] FB!=MAC!

 $(: T7?F=GG') C!?AI=L>A?!L>?LKL?O=G@!] LIF!=!@I=EGA!GBP=ILB>!=>?fBM!XG=PA!BH!MA@L4 ?A>PN!L>!] FLPF!IFAN!P=>!@AGH4bO=M=>IL>A!=>?!XM=PILPA!@BPL=G!?L@I=>PL>Q!=>?!FN4 QLA>A!XOM@O=>I!IB!IFA! ' 7 ' !QOL?AGL>A@!=>?!, \AP/! . M?AM! 1 B/!T_4SR!OXB>!MAGA=@A/!$

(:T7?F=GG'6C!=GG!BIFAM!?AI=L>A?!L>?LKL?O=G@!]LIFBOI!=PPA@@!IB!=!@I=EGA!GBP=ILB>! =>?fBM!XG=PA!BH!MA@L?A>PN!L>!]FLPF!IFAN!P=>!@AGH4bO=M=>IL>A!=>?!XM=PILPA!@BPL=G! ?L@I=>PL>Q!=>?!FNQLA>A!XOM@O=>I!IB!'7'!500050.2(H)#7000502.2(F!IJei)0.2R-0.2(!=)0.2([T/) G=?A@!?AI=L>@!=>!=KAM=QA!BH!U_[!LJJLQM=>I!?AI=L>A?!L>?LKL?O=G@!=I!=!ILJA/!e#XX\! &-!, \F/!(-!=I!Rma/g!

KLBG=ILB>!BH!IFA!/!/!/!G=] @!/!/!/BH!IFA!9>LIA?!5I=IA@/j!'66&O6:<>6P&LE& \$ I: &C&A?>&*9I;7-!URR!9/5/! ZUa-!ZaR!eRS [Zgl!TW!9/5/'/!u!TTURePgeZg/!

!

 $WR/ : A?AM=G!?L@IMLPI!PBOMI@!F=KA!^OML@?LPILB>!IB!FA=M!F=EA=@!PG=LJ@!EN!>B>PLILkA>@!PF=G4$ $GA>QL>Q!IFA!G=] HOG>A@@!BM!PB>@ILIOILB>=GLIN!BH!IFALM!?AIA>ILB>!EN!7 < 5/! '66D&6EFED&Q?BLPB?<&LE&1?=L8<-!aZZ!9/5/!m[W-!mW[!eT_Rg1!J6::8:F<&LE&''9B;8F16M-!RZW!5/! 'I/!WZ_!eT_RWg/!$

WT/ : A?AM=G!?L@IMLPI!PBOMI@!F=KA!^OML@?LPILB>!IB!FA=M!F=EA=@!PG=L J @!EN!>B>PLILkA>@!@AAY4 L>Q!IB!XMBIAPI!IFALM!?OA!XMBPA@@!MLQFI@/! '66&)N; ?H8K&LE&OC9<7?-!1B/!R[4 ' 84TUa[U-!T_RW!6+! aWTaT_-!=I!nU!e5/7/!:G=/!O=>/!Tm-!T_RWg/!

WZ/ !"OM@O=>I!IB!LI@!^OML@?LPILB>-!IFL@! ' BOMI! J

! !

!

5OXX/!Z?!RRmW-!RRW[!e1/7/!'=G/!T_R[g!eHL>?L>Q!IFA!GBP=G!.%%!BHHLPL=G!@OE^API!IB!^OML@?LPILB>!L>! IFA!1BMIFAM>!7L@IMLPI!BH!'=GLHBM>L=!EAP=O@A!@FA!]=@!E=@A?!L>!5=>!:M=>PL@PBg/!

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<u>%U-)!(\$#,''',.')&0#''#(\$*)\$#1%'*%0%&#%('</u>

WW/ \$FAMA!L@!>B!@I=IOIBMN!MAbOLMA J A>I!BH!A\F=O@ILB>!BH!=? J L>L@IM=ILKA!MA J A?LA@!] FAMA! =!>B>PLILkA>!PF=GGA>QA@!IFA!PB>?LILB>@!BH!?AIA>ILB>/! '66&O?878?:& "6@IF66&*7;ED&):CE&LE&, 6><9:-!W[T! :/T?!Raaa-!RamR!eRRIF! 'LM/!RSWSg/!!

WS/ , F=0@ILB>!BH!=? J L>L@IM=ILKA!MA J A?LA@!L@!=G@B!>BI!MAbOLMA?!] FAMA!LI!] BOG?!EA!HO4 ILGA-!] FAMA!=? J L>L@IM=ILKA!MA J A?LA@!=MA!L>=?AbO=IA-!=>?!] FAMA!LMMAX=M=EGA!F=M J !] BOG?!MA@OGI! $HMB J !MAbOLML>Q!A F=0@ILB>/! '66\&, 86;6:N6;F\&LE\&O6?;7\&*7;E\&9@\&' VE\&S>?ED\&+EOE-!WZa!: /!5OXX/!RU_U-!$ $RU_[!e 2/7/!:G=/!RSSZg/!$

 $S_{\text{AMA!L}0!>B!A F=0@ILB>!MAbOLMA J A>I!] FAMA!=!XAILILB>AM!=@@AMI@!PB>@ILIOILB>=6!$ $PG=L J @!IF=I!IFA!=QA>PN!P=>>BI!=??MA@@/! '66\& .6@oALE\& ''6:9-!S [T!:/!5OXX/!m_W-!mRm!e5/7/!:G=/!RSS [g! eC878: F&O?878?:&''6@IF66&*7;E-!W [T!:/T?!=I!Ram_g1!<66&?><9&*;?P79:&LE&*?>>?H?:-!RT_!:/Z?!RTR [-! RTTT!eRRIF! 'LM/!RSS [g!ei , F=O@ILB>!J=N!EA!A PO@A?!] FA>!IFA!B>GN!PB>IA@IA?!L@@OA!L@!PB>@ILIO4
<math display="block">ILB>=G-!PBGG=IAM=G!IB!IFA!PB>@L?AM=ILB>!BH!sIFAt!PG=L J !sEAHBMA!IFA!=QA>PNt-!=>?!LI@!MA@BGOILB>!IFAMA4
HBMA!H=GG@!BOI@L?A!IFA!=QA>PN`@!=OIFBMLIN/jg!! 5?;<?K6&LE&2E'E&O779;:6P&-6:E-![Sm!:A?/!#XX \/!SSZ-!
<math display="block">R_m!eRRIF! 'LM/!T_T_g!ei ; AP=O@A!IFA! ; &# !?BA@!>BI!F=KA!IFA!XB] AM!IB!?APL?A!PB>@ILIOILB>=6!
PG=L J @$

TW!

$\& x 1 ! 7 \text{ AP} / !aTS-!aZT!e ; \& \# !RSSTg!e>BIL>Q!IF=I!iLI!L@!@AIIGA?j!IF=I!IFA!LJJLQM=ILB>!^O?QA!=>?!IFA! ; \& \# ! P=>>BI!?APL?A!PB>@ILIOILB>=6!bOA@ILB>@g$

Sa/ & > HAPIA?!L>?LKL?O=G@!P=>!H=PA!XMBGB>QA?!IMA=IJA>I!=>?!MAPBKAMN!XAMLB?@-!MABOLML>Q! FLQFGN!=IIA>ILKA!FB@XLI=G!P=MA!=>?!KA>ILG=IBM@!IF=I!=MA!L>!L>PMA=@L>QGN!@FBMI!@OXXGN/!\$FB@A!]FB!?B! >BI!?LA!P=>!H=PA!@AMLBO@!?=J=QA!IB!IFA!GO>Q@-!FA=MI-!GLKAM-!BM!BIFAM!BMQ=>@/RR!

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 Sm/
 'BJXGLP=ILB>@!HNBJ!'. 8&74RS!P=>!J=>LHA@I!=I!=>!=G=MJL>Q!X=PA/!"=ILA>I@!P=>!QB!

 HMBJ!EAL>Q!JA?LP=GGN!@I=EGA!]LIF!>B!>AA?!HBM!@OXXGAJA>I=G!B\NQA>!IB!MAbOLML>Q!L>IOE=ILB>!=>?!

 KA>ILG=IBM4=@@L@IA?!EMA=IFL>Q!]LIFL>!TU!FBOM@/!5IO?LA@!A@ILJ=IA!IF=I!IFA!=KAM=QA!GA>QIF!BH!ILJA!

 HMBJ!B>@AI!BH!@NJXIBJ@!IB!FB@XLI=GLk=ILB>!BM!IFA!?AKAGBXJA>I!BH!@AKAMA!@NJXIBJ@!L@!B>GN![4S!?=N@/!

 $\label{eq:sphere:sphe$

 SW/
 5L>PA!IFA!HLM@I!P=@A!] =@!MAXBMIA?!L>!7 APA J EAM!T_RS-!IFA!IM=>@ J L@@LB>!BH! ' . 8&74

 RS!F=@!EAA>!QMB] L>Q!A\XB>A>IL=66N/!! 6 BMG?] L?A-!IFA!>O J EAM!BH!MAXBMIA?!P=@A@!PGL J EA?!HMB J !R!IB!

 R_____!L>!m [!?=N@1!HMB J !R_____!IB!T____!L>!B>GN!RR!?=N@1!=>?!HMB J !T_____!IB!Z____!L>!

 ^O@I!U!?=N@/^{RZ!}!

 $[\]label{eq:RR} \begin{array}{l} & \mathbb{R}^{R}! + \mathbb{L}@=! \ 2 = \mathbb{M} = \mathbb{Q} = \mathbb{Y} \mathbb{L}@: 1 \ 2 \ / 7 \ / ! \ 2 \ / ' \ / < / ! \)^{L} \mathcal{L}@k} \\ & * \ \# \ (\) \ I = \mathbb{Z}[\mathbb{E}\& \ 5 \ H ? 7\& (H9I) > B\&)\& GTAGC7_\& 0 \\ & \mathbb{B} \\ & \mathbb{E}\& \mathbb{B} \\ & \mathbb{E}\& \mathbb{E}\&$

 $SS/ .>! 2 = MPF!RR - !T_-!IFA! 6 BMG?! < A = GIF! . MQ = >Lk = ILB > !ei 6 < . jg!?APG = MA?!IFA!BOI4$ EMA = Y! = !QGBE = G!X = >?A J LP - RU! = >?! ' . 8 & 7 4RS!F = @!>B] !IBOPFA?! > A = MGN!AKAMN!PBO>IMN!B>!IFA!XG = >AI/^{Ra}!!

 $\label{eq:result} R_/ \qquad \$FA! \ 6 < . \ !F=@!A \setminus FBMIA ? !EBIF!L \ J \ J \ LQM=ILB > !=> ? !PML \ J \ L>= G!^O@ILPA! ?APL@LB > ! \ J = YAM@!IB! O@A! \ i > B > 4PO@IB ?L=G! \ J \ A=@OMA@j \ !IB!XMBIAPI!L>P=MPAM=IA ?! \ J \ A>-! \] \ B \ J \ A>-!=> ? !PFLG ?MA>!=> ?!IB!@IA \ J \ !IFA! A@P=G=IL>Q!IM=>@ \ J \ L@@LB>!M=IA/!e \ \# \ XX \ !\&-! \ , \ \ F/!<-!=I!STg!!!$

 $R_R / \# @!BH! \# XMLG!RT-!T_T_!IFA!>O J EAM!BH!PB>HLM J A?!P=@A@!] BMG?] L?A!F=@!@OMX=@@A?!$ $B>A!=>?!=!F=GH! J LGGLB>-!L>PGO?L>Q!BKAM!am_-__!XABXGA!L>!IFA! 9>LIA?!5I=IA@/!! . KAM!RRU-__!XABXGA!$ $F=KA!?LA?!=@!=!MA@OGI!BH! ' . 8 & 7 4RS!] BMG?] L?A-!L>PGO?L>Q!=I!GA=@I!TT- !L>!IFA! 9>LIA?!5I=IA@'^{Rm}!!$

 $\label{eq:result} R_T/ \qquad 1 = ILB > = GGN - !XMB^APILB > @!EN!IFA! '7 '!L > ?LP = IA!IF = I!BKAM!T_!JLGGLB > !XABXGA!L > !IFA! 'APILB > @!EN!IFA! 'APILB > @!EN!APILB > @!EN!IFA! 'APILB > @!EN!APILB > @!EN!IFA! 'APILB > @!EN!APILB > @!EN!APILB > @!EN!APILB > @!EN!IFA! 'APILB > @!EN!APILB > @!EN!APILB > @!EN!IFA! 'APILB > @!EN!APILB > @!EN!APILB > @!EN!IFA! 'APILB > @!EN!IFA! 'APILB > @!EN!APILB > @!EN!APILB > @!EN!IFA! 'APILB > @!EN!APILB > @!EN!IFA! 'APILB > @!EN!IFA! 'APILB > @!EN!IFA! 'APILB > @!EN!IFA! 'APILB > @!EN!APILB > @!EN!IFA! '$

FIIX@Cff]]]/P>EP/PB J fT_T_f_ZfTZfPBMB>=KLMO@4X=>?A J LP4L@4=PPAGAM=IL>Q4=@4P=@A@4APGLX@A4 Za____4]FB4@=N@/FI J G/!

 $\label{eq:solution} \begin{array}{l} \mbox{Ra}!*9;9:?L\&;I < \&B\& < 6? < 6\& b \] Z[\& c * \# (\) \ I = Z[d\& '87I?7\&9:\& ''6A9;7\& a\& c -! \ 6 \ BMG?! < A = GIF! \ . \ MQ = >L& = ILB>! \\ \mbox{e } \# XM/!T-!T_T_g-!FIIX@Cff \] \] \ / \] \ FB/L>If?BP@f?AH=OGI4@BOMPAfPBMB>=KLMO@Af@LIO=ILB>4MA4 \\ \ XBMI@fT_T_U_T4@LIMAX4[Z4PBKL?4RS/X?Hz@HKM@> \ { a=ATaEP[DUFIIX@Cff \] \] \ / \] \ FB/L>If?BP@f?AH=OGI4 \\ \ @BOMPAfPBMB>=KLMO@Af@LIO=ILB>4MAXBMI@fT_T_ZZ_4@LIMAX4[_4PBKL?4RS/X?Hz@HKM@> \ [A_HAZHWDT/! \\ \end{array}$

 $\label{eq:memory_loss} \begin{array}{c} \mbox{Rm}! \ 6 \ \mbox{BMG?B J AIAMC! 'BMB} = \mbox{KLMO@-!FIIX@Cff]]] /] BMG?B J AIAM@/L> \mbox{HBfPBMB} = \mbox{KLMO@f | PBO>IMLA@!eG=@I! = } \\ = \mbox{PPA@@A?! \# XM/!RT-!T_T_g/! } \end{array}$

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?MBXGAI@!BM!IBOPFA@!=!PB>I= J L>=IA?!@OMH=PA?!=>?!IFA>!IBOPFA@!IFALM! J BOIF-!>B@A-!BM!ANA@/

! !

XMBXFNG=PILP! J A?LP=ILB>@!IF=I!] LGG!

A\IA>?L>Q!IB!m_! J LGGLB>!XABXGA!L>! ' FL>=/^{ZU}!! : BGGB] L>Q!IFA!GBPY?B] >-! 6 OF=>!@=] !=!@O@I=L>A?!?A4 PMA=@A!L>!IM=>@ J L@@LB>!BH! ' . 8 & 7 4RS-!=>?!I] B! J B>IF@!G=IAM-!IFA!?=LGN!>O J EAM!BH!MAXBMIA?!P=@A@! ?MBXXA?!IB!kAMB/!

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 $\label{eq:response} RRR/ $FMBOQFBOI!IFA!] BMG?-!BIFAM!PBO>IMLA@!F=KA!=6@B!L J XGA J A>IA?!?M=@ILP!@BPL=6!?L@4 \\ I=>PL>Q! J A=@OMA@!L>!=>!AHHBMI!IB!PB>IMBG!IFA! ' . 8 & 7 4RS!X=>?A J LP!=>?!XMBIAPI!XABXGA`@!FA=GIF!=>?! \\ GLKA@/!!: M=>PA-!HBM!A = J XGA-!L J XB@A?!=!@IMLPI!>=ILB>] L?A!GBPY?B] >-!XMBFLELIL>Q!Q=IFAML>Q@!BH!=>N! \\ @LkA!=>?!BM?AML>Q!=GG!MA@L?A>I@!IB!0I=N!=I!FB J A/Za!! . KAM=GG-!PBO>IMLA@!A>PB J X=@@L>Q!=>!A@IL J =IA?! \\ B>A!IFLM?!BH!IFA!] BMG?`@!XBXOG=ILB>!F=KA!A>=PIA?!@L J LG=M!MA@IMLPILB>@/Zm!!#PMB@@!IFA! 9>LIA?!5I=IA@-! \\ PLILA@!=>?!@I=IA@!=MA!L J XB@L>Q!L>PMA=@L>QGN!@IML>QA>I! J A=@OMA@!IB!AHHAPIO=IA!@BPL=G!?L@I=>PL>Q/!!#@! \\ BH!#XMLG![-!T_T_-!=I!GA=@I!UT!@I=IA@-!IFMAA!PBO>ILA@-!=>?!>L>A!PLILA@!F=?!BM?AMA?!IFALM!MA@L?A>I@!IB! \\ i @FAGIAM!L>!XG=PAj !BM!@I=N!=I!FB J A/ZI!!! \\ \end{tabular}$

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^{Zm}!#>?MA=!5=GPA?B!x!)L>=!'FAMAGO@-!*9;9:?L8;I<&.;?L6>&"6<7;8C789:<D&OC;9<<&7H6&->9N6-!\$FA! 1 A] !*BMY!\$L J A@!e#XM/!R-!T_T_g!FIIX@Cff]]]/>NIL J A@/PB J f=MILPGAfPBMB>=KLMO@4IM=KAG4MA4 @IMLPILB>@/FI J G/!

^{ZU}!# J N!) O>L=-!**H*8: ?^<*k*1; ?C9:8?:*k*/9CRB9V:*k*)<*k* - 6778: *Fk**;6B87*k*09;*k*'>9V8: *Fk**9;9: ?L8; *I*<*Ek* 59*I*>B*k*)7*k*59; *Rk*0: *PVH*6;6*k*%><6_-!\$L J A! 2 =Q=*k*L>A!e 2 =*M*/!RZ-!T_T_g-! FIIX@CffIL J A/PB J fa [SmUTafPFL>=4PBMB>=KLMO@46BPY?B] >f/!

$$[\]label{eq:alpha} \begin{split} &\mathbb{Z}^{a}: \mathsf{MN}=>! \ \mathsf{LAI@PF-!} f \ 5 \ 6\&??\&??\&V?;^Y\&S;?:C6^{\&A}; 6^{\&B6}:?\&gI<?\&?::9I:C6B\&?\&Z`=B?P\&>9CRB9V:D\&\\ &N?::\&:F\&IX\&C\&F??H6;\&:F<\&?:B\&V?>R<\&9I?B99;<-!:;O@L>A@@!\&>@L?AM!e \ 2=M/!Rm-!T_T_g-!\\ &\mathsf{FIIX@Cff} \] \] \ \mathsf{EO@L}>A@@L>@L?AM/PB \ \mathsf{J} \ \mathsf{fPBMB}>=KLMO@4HM=>PA4XMA@L?A>I4 \ \mathsf{J}=PMB>4=>>BO>PA@4Ra4?=N4GBPY4\\ &?B \]>4T_T_4Z/! \end{split}$$

^Z[!5=M=F! 2 AMKB@F-!AI!=G/-! 5 H8CH& '7?76<&?: B& *8786<&O?L6&. 9>B& ''6<8B6:7<&79& '7?P&?7&O9K6D! 1 A] ! * BMY!\$L J A@!eG=@I!OX?=IA?!#XM/![-!T_T_g-!FIIX@Cff]]]/>NIL J A@/PB J fL>IAM=PILKAFT_T_fO@fPBMB>=4 KLMO@4@I=N4=I4FB J A4BM?AM/FI J G

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;;K #>'J@GIA>G@'HA'HX@'+, 1#&7BC'I=><@W;?D'=FF'F@[@FG'AY'VA[@J>W@>H'X=[@'<;7 J@?H@<'I@AIF@'HA'GX@FH@J';>'IF=?@D'=><'IJ=?H;?@'GA?;=F'<;GH=>?;>V'=><'[;V;F=>H' X\V;@>@K'

 $\label{eq:RRT} RRT/ .>! 2 = MPF!R-!T_T_!) BKAM>BM! 7 A5 =>IL@!L@@OA?! , \APOILKA! . M?AM!T_4aR!?LMAPIL>Q!IFA! : 6BML?=! 7 AX=MI J A>I!BH!<A=6IF!IB!L@@OA!=! "OE6LP!<A=6IF! , J AMQA>PN/!!$

 $\label{eq:RRZ} RRZ/ .> !IFA !@= J A !? = N-!IFA !5I = IA !5 OMQAB> !) A>AM=6 !=>? !5I = IA !< A=GIF !. HHLPA !? APG=MA?!IF=I != "OEGLP !< A=GIF !, J AMQA>PN !A \L@I@ !L> !IFA !5I = IA !BH !: GBML?= != @ != !MA@OGI !BH !'. 8 & 7 4 RS /!$

 $\label{eq:RRU} RRU/ .>! 2 = MPF!S : T_T_! BKAM>BM! 7 A5 => IL@!?APG=MA?! = !@I=IA!BH!A J AMQA>PN!HBM!IFA!A>4 \\ ILMA!@I=IA!BH! : GBML?= -!?A@PMLEL>Q!IFA!@XMA=?!BH! ' . 8 & 7 4RS! = @!i=!ML@Y!IB!IFA!A>ILMA!@I=IA!BH! : GBML?=/j!! . AP/! . M?AM! 1 B/!T 4aT/^{ZW}!$

$$\begin{split} & \text{RRa}/ \qquad .> !\ 2 = \texttt{MPF!RZ-!T_T_-!"MA@L?A>I!7B>=6?!0/!\$MOJX!?APG=\texttt{MA?!=!>=ILB>=6!AJAMQA>PN-! \\ & =>?!B>!\ 2 = \texttt{MPF!Rm-!T_T_-!IFA!"MA@L?A>I!=>?!IFA!'7'!L@@OA?!QOL?=>PA!ILIGA?!iRa!7=N@!IB!5GB]!IFA! \\ & 5XMA=?-j!=?KL@L>Q!L>?LKL?O=G@!IB!=KBL?!@BPL=G!Q=IFAML>Q@!L>!QMBOX@!BH!JBMA!IF=>!R_!XABXGA!=>?! \\ & =?KL@L>Q!BG?AM!XAM@B>@!=>?!XAM@B>@!]LIF!@AMLBO@!O>?AMGNL>Q!FA=GIF!PB>?LILB>@!IB!@I=N!FBJA!=>?! \\ & =]=N!HMBJ!BIFAM@/! \end{split}$$

 $\label{eq:RRM} RRm/ .>! 2 = MPF!RS-!T_T_! 2 = NBM!) L J A>Ak!L@@OA?! 2 L= J L47 = ?A!, J AMQA>PN! . M?AM!_[4 T_-!=?BXIL>Q! '7 '!QOL?AGL>A@!A>PBOM=QL>Q!@BPL=6!?L@I=>PL>Q!=>?! J =L>I=L>L>Q!=!m4HBBI!@AX=M=ILB>! EAI] AA>!MA@L?A>I@!IB!@GB] !IFA!@XMA=?!BH!L>HAPILB>!=>?!IF=I!AKA>I@!] LIF! J BMA!IF=>!IA>!=IIA>?AA@! ALIFAM!EA!P=>PAGGA?!BM!FAG?!KLMIO=GGN/^{ZS}!$

^{ZW}!!*OL*?8>?*N*>6*k*?7C!FIIX@Cff]]]/HGQBK/PBJf]X4PB>IA>IfOXGB=?@fT_T_f_Zf,.4T_4aT/X?H/!

 $[\]label{eq:stability} \begin{array}{l} \mathbb{ZS}! \# \mbox{K=LG=EGA}! = \mbox{IC!FIIX@Cff} \mbox{I} \mbox{J} \mbox{L} = \mbox{L} \mbox{L} = \m$

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 $RR[/ .>! 2 = MPF!T_-!T_T_-!) BKAM>BM! 7 A5 =>IL@!L@@OA?!, APOILKA! .M?AM!T_4[_!IB!iF=MJB4 >LkAj!; MB] = M?!=>?!"=GJ!; A=PF!'BO>IN!] LIF! 2 L= JL47=?A-!BM?AML>Q!IFA!PGB@OMA!BH!=GG!MA@I=OM=>I@-! E=M@-!=>N!BIFAM!=GPBFBGfHBB?!@AMKLPA!EO@L>A@@!A@I=EGL@FJA>I!] LIF!@A=IL>Q!HBM!JBMA!IF=>!R_!XABXGA-! L>!=??LILB>!IB!=GG!JBKLA!IFA=IAM@-!PB>PAMI!F=GG@-!=O?LIBMLOJ@-!XG=NFBO@A@-!EB]GL>Q!=GGAN@-!QNJ>=4 @LOJ@-!HLI>A@@!PA>IAM@!=>?!EA=PFA@/^U-!$

 $\label{eq:RRW} RRW/ .>! 2 = MPF!TZ-!T_T_! BKAM>BM! 7 A5 =>IL@!L@@OA?!, APOILKA! M?AM!T_4W_-!MAbOLML>Q! = GG!L>?LKL?O=G@! BB!HGN!L>IB!: GBML?=!HMB J !@I=IA@! LIF!@OE@I=>IL=G!PB J J O>LIN!@XMA=?!IB!@AGH4L@BG=IA! L>!: GBML?=!HBM!RU!?=N@!BM!IFA!?OM=ILB>!BH!IFALM!IMLX-! FLPFAKAM!L@!@FBMIAM/!$

 $\label{eq:RRS} RRS/ .> ! 2 = \mbox{MPF!TU-!T_T_!} BKAM>BM! 7 A5 => IL@!L@@OA?!, \APOILKA! . M?AM!T_4WZ-!?LMAPIL>Q! IFA!5I=IA!50MQAB>!) A>AM=6!=>?!5I=IA!<A=GIF! . HHLPAM!IB!L@@OA!=!XOEGLP!FA=GIF!=?KL@BMN!OMQL>Q!IFA! XOEGLP!IB!=KBL?!=GG!@BPL=6!BM!MAPMA=ILB>=6!Q=IFAML>Q@!BH!R_!XABXGA!BH! J BMA/!, \AP/! . M?AM! 1 B/!T_4 WZ/UR! \\$

 $\label{eq:result} RT_/ \qquad .> != ! 2 = MPF!T[-!T_T_!) BKAM>BM! 7 A5 => IL@!L@@OA?!, APOILKA! . M?AM!T_4Wm-!MAbOLM4 \\ L>Q!= 66!L>?LKL?O= 6@!IF=I!?MLKA!L>IB!: 6BML?= !HMB J !@I=IA@!] LIF!@OE@I=> IL=6!PB J J O>LIN!@XMA=?!IB!@A6H4 \\ L@B6=IA!L>!: 6BML?= !HBM!HBOMIAA>!?= N@!BM!IFA!?OM=ILB>!BH!IFALM!IMLX-!] FLPFAKAM!L@!@FBMIAM/! \\ \label{eq:result}$

RTR/ .>! 2 = MPF!Z_-!T_T_!) BKAM>BM! 7 A5=>IL@!L@@OA?!, \APOILKA!. M?AM! 1 B/!T_4WS-!BM?AM4 L>Q! 2 L= J L47=?A! ' BO>IN-!; MB] = M?! ' BO>IN-!''=G J !; A=PF! ' BO>IN!=>?! 2 B>MBA! ' BO>IN!IB!MA@IMLPI!

ZW!

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 $\label{eq:RTa} RTa/ .> ! \# XMLG!U-!T_T_! 2 L= J L! 7 = ?A! 2 = NBM! '= MGB@!) L J A>Ak!L@@OA?!, J AMQA>PN! . M?AM! RS4T_-!BM?AML>Q!IF=I!= GG!XAM@B>!BOI@L?A!IFALM!FB J A@!= MA!A>PBOM=QA?!IB!] A=M!= !PGBIF!H=PL=G!PBKAML>Q! PB>@L@IA>I!] LIF!POMMA>I! '7 '!QOL?AGL>A@/!, J AM/! . M?AM/! 1 B/!RS4T_/^{Ua}!$

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 $\label{eq:RTm} RTm/ \ .>! \# XML6!W-!T_T_-! \ 2 = NBM! \) \ L \ J \ A>Ak!A \ IA>?A?!IFA!@I=IA!BH!A \ J \ AMQA>PN!HBM! \ 2 \ L= \ J \ L4 \ 7 = ?A! \ ' \ BO>IN/! \ , \ \ AP/! \ . \ M?AM! \ , \ \ \ \ IA>?L>Q! \ 7 \ APG=M=ILB>!BH!+BP=G! \ 5I=IA!BH! \ , \ \ \ J \ \ AMQA>PN/^{Um}!$

6K) FF'@] I@JHG'=VJ@@'HX=H'+ , 1#&7BC'^;FF'F;Z@F\'J=[=V@'_=;FGD'

!

 $oU_{!e}, F/!Tg/!'66& ?><9D&)MAAM! 7 APG/!oZ_!e, F/!Zg!ei FAMA!L@!>B! = N!HBM!L J J LQM=ILB>!?AIA>ILB>!H=4 PLGLILA@!IB!PB J XGN! LIF! '7 '!QOL?AGL>A@!B>!@BPL=G!?L@I=>PL>Q!=>?!bO=M=>IL>L>Q!O>GA@@!%A@XB>?A>I@!MAGA=@A!?AI=L>A?! J A>!=>?!]B J A>!B>!=!G=MQA!@P=GA/jg/!$

!

RTS/ \$FA!PB>PGO@L

bOA>PA@!IF=I!=!' . 8&74RS!BOIEMA=

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RZm/

BH! ' . 8 & 7 4RS!] LGG!P=O@A/!

 $IFA!X = @I!PBOXGA!NA = M@^{am}!L > !=??LILB > !IB!BOIEMA = Y@!L > !BIFAM!XML@B > @!=>?!^{=LG@/a[!!}$

!

 $MAPBQ>LkA?!IFA!IFMA=I!XB@A?!EN!' . 8&74RS!=>?!MAGA=@A?!?AI=L>A?!L>?LKL?O=G@/!&M=>-^{aW}!, IFLBXL=-^{aS}!$

=>?! A \ = $@^{m}-!$ => ?!F=KA!=GG!EAQO>!IB!MAGA=@A!XABXGA!IB! J LILQ=IA!IFA!F=M J !IF=I!IFA!L J XA>?L>Q!@XMA=?!

 $1 = ILB > = GGN! = ?!L > IAM > = ILB > = GGN - !QBKAM > J A > I@! = ?!^{=LG!} = ?!AUL@B > !@I = HH!F = KA! = GMA = ?N!$

 $MA?OPILB>!L>!=MMA@I@!=>?!EBBYL>Q@!BH!m_v/^{mT}!$

L>Q! 2 L= J L47=?A! ' BNMAPILB>@!IB!L J XGA J A>I!FA=GIF!@=HAIN!XMBIBPBG@!L>!IFA! 2 AIMB! 6 A@I!7 AIA>ILB>!

'A>IAM/!!. M?AM-!'V?8:&LE&JI:89;-!T_4PK4TRUa[4(26!e5/7/!:G=/!#XM/![-!T_T_g!ePBXN!=I!#XX\!&-!

, \F/! 2 -!=I!TUT4U[g/!

!

!

RZS/ \$FA!: A?AM=G!; OMA=O!BH! "ML@B>@!F=@!L>@INOPIA?!XML@B>!?LMAPIBM@!IB!XMLBMLILkA!MAGA=@4

L>Q!HA?AM=G!L>J=IA@!IB!FBJA!PB>HL>AJA>I-!I=YL>Q!L>IB!PB>@L?AM=ILB>!H=PIBM@!L>PGO?L>Q!isItFA!=QA!

 $=>?!KOG>AM=ELGLIN!BH!IFA!L>J=IA!IB!' . 8&74RS-!L>!=PPBM?=>PA!]LIF!IFA!s'7't!QOL?AGL>A@/j^{mZ}!$

+K \$X@'+@>H@J'YAJ'&;G@=G@'+A>HJAF'=><'HX@'<@H@>H;A>'GH=><=J<G';>YAJW'#+%`G'<:H;@G'HA' I@AIF@'=H'RJAW@D'2F=<@GD'=><'6\$+K'''

RU_/ (MB J A!=>?!; \$ '!=MA!@OE^API!IB!&', `@!"AMHBM J =>PA4; =@A?!1=ILB>=G!7AIA>ILB>!

 $5I = ?= M?@!T_RR!ei''; 175jg/!e#XX\/!&-!, \F/!(-!=I!RaT-!Ramg/!!)$

RUR/ 5APILB>!U/Ze&&geR_g!MAbOLMA@!IF=I!i 'A>IAM@!HBM!7L@A=@A! 'B>IMBG!=>?!"MAKA>ILB>!

e ' 7 ' g!QOL?AGL>A@!HBM!IFA!XMAKA>ILB>!=>?!PB>IMBG!BH!L>HAPILBO@!=>?!PB J J O>LP=EGA!?L@A=@A@!@F=GG!

EA!HBGGB] A?/j!& ', !"; 1 7 5!e#XX\!&-!, \F/! 1 -!=I!TUW4S [-!TaZg/^{mU}!

^{mZ}! . HHLPA!BH!IFA!#IIBM>AN!) A>AM=G-! 6 =@FL>QIB>-!7 '-! 2 A J BM=>?O J !HBM! 7 LMAPIBM!BH!; OMA=O! "ML@B>@-!+;89;878M?789:&9@&O9K6&*9:@8:6K6:7&O<&OAA;9A;8?76&8:&"6<A9:<6&79&*#()1=Z[&+?:= B6K8C&2 =M/!Tm-!T_T_g-!&FIIX@Cff]]]/XBGLILPB/PB J fHfzL?{_____R[R4RWTm4?U=R4=?[[4 H?=m[RUT____/!

^{mU}!:OGG!PBXN!=K=LG=EGA!=IC!FIIX@Cff]]]/LPA/QBKf?BPGLEf?AIA>ILB>4@I=>?4 =M?@fT_RRfXE>?@T_RRMT_Rm/X?H/!

$$\begin{split} RUZ/ & 9 > ?AM!@APILB > !R/Re\&g!BH!IFA! 1 \ 7 \ 5 - !PBKAMA?!iH=PLGLIsLA@t!] \ LGG!BXAM=IA!L>!=PPBM?=>PA! \\] \ LIF!=GG!=XXGLP=EGA!MAQOG=ILB>@!=>?!PB?A@-!@OPF!=@!IFB@A!BH!/!/!IFA! ' A>IAM@!HBM! \ 7 \ L@A=@A! ' B>IMBG! \\ =>?!''MAKA>ILB>!e ' 7 ' g/j!\& ' , ! 1 \ 7 \ 5 \ !e \ # XX \ !\&-! , \ F/! \ . \ . \ !=I!Z_Ug/mm! \end{split}$$

 $\begin{aligned} & \text{RUU} \quad \text{SFA!} \quad 7 \quad !\text{F=}@!L@@OA?!=>!\&>IAML J !) OL?=>PA!B>! 2 =>=QA J A>I!BH! \quad BMB>=KLMO@! 7 L@4 \\ & A=@A!T_RS!e \quad . & \& 7 4RSg!L>! \quad BMMAPILB>=G!=>?! 7 AIA>ILB>! :=PLGLILA@/!e # XX \/!&-! , \F/!: -!=I!UW4 [Zg/!$FL@! \\ & QOL?=>PA!@IMA@@A@!IFA!KLI=G!L J XBMI=>PA!BH!A>@OML>Q!@BPL=G!?L@I=>PL>Q-!XMBXAM!FNQLA>A-!=PPA@@!IB! \\ & IA@IL>Q-!&: B&L&BI ?>!L@BG=ILB>!BH!XABXGA!] FB!F=KA!IFA!KLMO@-!=>?!bO=M=>IL>A!BH!XABXGA!A \XB@A?!IB! \\ & IFA!KLMO@/!$FA!QOL?=>PA!@XAPLHLP=GGN!@I=IA@!IF=I!LI!L@!L>IA>?A?!HBM!& ' , -!=@!=!G=] !A>HBMPA J A>I! \\ &=QA>PN!] LIF!PO@IB?L=G!=OIFBMLIN!BH!?AI=L>A?!XBXOG=ILB>@/! \end{aligned}$

 RUm/
 #>!L>?LKL?O=6!L@!PB>@L?AMA?!=!PGB@A!PB>I=PI!LH!IFAN!F=KA!EAA>!] LIFL>!=XXMB \L4

 J =IAGN!m!HAAI!BH!=!
 . 8 & 7 4RS!P=@A!HBM!=!XMBGB>QA?!XAMLB?!BH!IL J A-!BM!F=KA!F=?!?LMAPI!PB>I=PI!] LIF!

1

ma!50XAM@A@@LB>!>BIA?!=IC!]] /LPA/QBKf?AIA>ILB>4@I=>?=M?@fT____/!

^{mm}!:OGG!PBXN!=K=LG=EGA!=IC!]]/LPA/QBKf?BPGLEf?AIA>ILB>4@I=>?=M?@fT_RSf>?@T_RS/X?H/!

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RaR%! '7 & EMA(&)70 .' 2) QL?2 # ARAB@I=ZIA@00HE=H)?AIA; ALB: 2!RA>DAM@!2FBDQ?!XD45XAE&X9A!A) AB@A & HE5000501195.67X21 PGB@A!PB>I=PI!]LIF!PB>HLM J A?!BM!@N J XIB J =ILP! '. 8&74RS!P=@A@!L>!8:B8L8B1?>-!>BI!QMBOX-!bO=M=>4 IL>AC!i:=PLGLILA@!@FBOG?!J=YA!6L6; P&A9<<8N>6&6@9; 7!IB!bO=M=>IL>A!PGB@A!PB>I=PI@!BH! '. 8&74RS! P=@A@!L>?LKL?O=CGN/j!e#XX\/!&-!, \F/!:-!=I!mmg!eA J XF=@L@!=??A?g/! 'BFBMI!bO=M=>IL>A!iL490.2(I)0.2(!mmg)]TJ

 $\label{eq:result} Raa/ <B] AKAM-!IFA!>AA?!IB! i sMtA@IMLPI!bO=M=>IL>A?!L>?LKL?O=G@!HMB J !GA=KL>Q!IFA!H=PLGLIN! eL>PGO?L>Q!IM=>@HAM@!IB!BIFAM!H=PLGLILA@gj !L@!@OE^API!IB!=>!A \PAXILB>!HBM!?AI=L>A?!L>?LKL?O=G@! i MA4 GA=@A?!HMB J !PO@IB?N/j !e #XX \/!&-!, \F/!:-!=I!mWg!$

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&K +A>H;>:@<'<@H@>H;A>';>'HX@':>;a:@'?;J?:WGH=>?@G'AY'HX@'?:JJ@>H'I=><@W;?'IAG@G'=' <;J@'=><';WW;>@>H'HXJ@=H'HA'4@H;H;A>@JG'=><'AHX@JG'=H'RJAW@D'2F=<@GD'=><'6\$+K'

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 $\label{eq:rescaled} RmT/ \& `, `@!Y>B] L>Q!=>?!=HHLM J =ILKA!PB>?OPI!L>!H=LGL>Q!IB!=??MA@@!IFA!PGA=M!HBMA@AA=ELG4 \\ LIN!BH!@AKAMA!BOIEMA=Y@!=I! (MB J A-! ; $ `-!=>?!) G=?A@-!=>?!IB!I=YA!IFA!=PILB>!BH!MAGA=@L>Q!'' AILILB>4 \\ AM@-!?A J B>@IM=IA@!=!?L@MAQ=M?!HBM!IFA!MLQFI@-!] AGG4EAL>Q-!=>?!IFA!FO J =>LIN!BH!?AI=L>A?!L J J L4 \\ QM=>I@/!$FA!PB>IL>OA?!?AIA>ILB>!BH!'' AILILB>AM@!=>?!BIFAM!?AI=L>A?!L>?LKL?O=G@!=I! (MB J A-!) G=?A@-! \\ =>?! ; $ `!L@!MAPYGA@@/!$

 RmZ/
 7 A@XLIA!IFA!QGBE=G!X=>?A J LP!=>?!@FAGIAM4L>4XG=PA!BM?AM@!=PMB@@!IFA!PBO>IMN!=>?!

 Y>B] L>Q!IFA!ML@Y@-!& ', !=HHLM J =ILKAGN!PB>IL>OA@!IB!EML>Q!: 6V!XABXGA!L>IB!?AIA>ILB>!PA>IAM@!=>?!IB!

 IM=>@HAM!XMAKLBO@GN!?AI=L>A?!XABXGA!EAI] AA>!H=PLGLILA@/m[!& ', !PB>IL>OA@!IB!L@@OA!?AI=L>AM!MAbOA@I@!

 IB!PBO>ILA@!L>@IMOPIL>Q!^=LG!BHHLPL=G@!IB!FBG?!XABXGA!HBM!IFA J !X=@I!IFA!XBL>I!BH!PML J L>=G!PO@IB?N!

 PB J L>Q!IB!=>!A>?/!& ', !IFA>!IM=>@XBMI@!IFA@A! J A>!=>?!] B J A>!HMB J !IFA!GBP=G!^=LG!IB!L J J LQM=ILB>!

 ?AIA>ILB>!=I! (MB J A-!) G=?A@-!=>?! ; \$ '/!!!

 $\label{eq:result} RmU/ \qquad 6 \ LIF!MA@XAPI!IB!XABXGA!GLYA!"AILILB>AM@!] FB!=MA!=GMA=?N!L>!PO@IB?N-!&', !L@!KLBG=I4 \\ L>Q!IFA!'7'!QOL?AGL>A@!=>?!?AIA>ILB>!@I=>?=M?@!L>! J \ OGILXGA!] =N@/!!$

 Rma/
 %=IFAN!IF=>!O@A!8: B8L8BI ?>!bO=M=>IL>L>Q!BH!XABXGA!] FB!F=KA!EAA>!A\XB@A?!IB!

 '. 8 & 7 4RS-!& ', !MBOIL>AGN!O@A@!A>! J =@@A! i PBFBMI!bO=M=>IL>L>Q/j !!& ', !PB J J A>?@!LI@AGH!HBM!F=KL>Q!

 XG=PA?!G=MQA!QMBOX@!BH!XABXGA!] FB!F=KA!EAA>!A\XB@A?!IB! '. 8 & 7 4RS!IBQAIFAM!L>!IFA!@= J A!GLKL>Q!

 @X=PA-!?A@XLIA!IFA! ' 7 '`@!@I=IA J A>I@!IF=I!IFL@! J A=@OMA!V8>>&??6!IFA!@XMA=?!BH!IFA!KLMO@!

!

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$$\begin{split} & O@A?!9:>P\&?<\&?&?&?<7\&;6<9;7&\&&',-!FB] AKAM-!L@!O@L>Q!PBFBMIL>Q!=@!IFA!XG=>>A? q =>?!XML J = MN q MA4 \\ & @XB>@A!IB!=!Y>B] >! ' . 8&74RS!A \ XB@OMA-!>BI!=!XM=PILPA!BH!G=@I!MA@BMI/!e # XX \ /!&-!, \ F/!&_!=I!RTZ! oR_g/! \end{split}$$

!

 $\label{eq:ms/2} RmS/2 BMABKAM-!PBFBMIA?!QMBOX@!=MA!PB>HL>A?!L>!@X=PA@!IF=I!XMAKA>I!IFA J !HMB J !XM=PILP4 \\ L>Q!@BPL=G!?L@I=>PL>Q/! ' BFBMIA?!QMBOX@!=MA!>BI!XMBKL?A?!] LIF! J =@Y@!IB!XMAKA>I!IFA!IM=>@ J L@@LB>! \\ BH! ' . 8 & 7 4RS-!=@!MAbOLMA?!EN!IFA! ' 7 ' !XMBIBPBG@/!e#XX\/!&-!, \F/!:-!=I!m[g/! \\ \end{tabular}$

 $\label{eq:result} R[_/ \&', !F=@!>B!XG=>@!IB!XG=PA!@O@XAPIA?!' . 8\&74RS!P=@A@!L>!L>?LKL?O=G!JA?LP=G!L@BG=4 \\ ILB>!L>!] FLPF! i sAt=PF!L@BG=IA?!L>?LKL?O=G!@FBOG?!EA!=@@LQ>A?!IFALM!B]>!FBO@L>Q!@X=PA!=>?!E=IF4 \\ \mbox{MBB J - j != @!IFA! ' 7 ' !L>@IMOPI@/!e#XX\/!&-!, \F/!: -!=I!mTg! 2 BMABKAM-!XABXGA!] FB!A\FLELI!HGO4GLYA! \\ \mbox{@N J XIB J @!=MA!>BI!=G] =N@!MA J BKA?!HMB J !IFA!QA>AM=G!XBXOG=ILB>!EOI!L>@IA=?!=MA!@GAAXL>Q!=>?!A=I4 \\ \mbox{L>Q!] LIFL>!HAAI!BH!BIFAM@/! \\ \label{eq:result}$

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P=GG@!I] LPA!=!?=N-!=@!IFA!?AIA>ILB>!@I=>?=M?@!MAbOLMA-!LI!I=YA@!I] B!IB!ALQFI!?=N@!IB!IML=QA!=!@LPY! P=GG/!e#XX\!&-!, \F/!(-!Ra_/g! 6 FA>! J A?LP=G!L@@OA@!=MA!=??MA@@A?-!L>?LKL?O=G@!MAXBMI!>BI!EAL>Q! XMBXAMGN!IMA=IA?!BM!>BI!IMA=IA?!=I!=GG/!e#XX\!&-!, \F/!(-!Ra_/g!"MBKL>Q!LEOXMBHA>!L@!PB J J B>GN!O@A?! =@!=!EG=>YAI!@BGOILB>!IB!=>N!=>?!=GG! J A?LP=G!L@@OA@/!e#XX\!&-!, \F/!(-!Ra_/g!

RWT/ !; AP=O@A! (MB J A!H=LG@!IB! J AAI!?AI=L>A?!L>?LKL?O=G`@! J A?LP=G!>AA?@!O>?AM!>BM J =G! PLMPO J @I=>PA@-!IFA! J A?LP=G!@I=HH!=MA!LGG4XMAX=MA?!IB!XMBKL?A!=?AbO=IA! J A?LP=G!IMA=I J A>I!= J L?@I! IFA! '. 8&74RS!X=>?A J LP/!

 RWZ/
 (MB J A!F=@!=!G=MQA!XBXOG=ILB>!=>?!L@!BHIA>!BKAMPMB] ?A?/!e #XX\!&-!, \F/!:-!=I!RUS4

 a_g!eBKAMPMB] ?L>Q!=I! (MB J Ag/!&', !P=>!ILQFIGN!?AI=L>!OX!IB!R-___!L>?LKL?O=G@!L>!IFA!H=PLGLIN/!

 e # XX\!&-!, \F/! (-!TZ_!eA>?>BIA!RRWg/g! 6 FA>!IFA!XBXOG=ILB>!MA=PFA@!IF=I!>O J EAM-!LI!EAPB J A@!?=>4

 QAMBO@GN!BKAMPMB] ?A?!] LIF!R__!BM! J BMA!XABXGA!L>!=!XB?!] LIF!ma!EA?@/!\$B!FBO@A!IFA@A!>O J EAM@-!

 (MB J A!@OXXGLA@!@I=PY=EGA!EA?@!XG=PA?!EAI] AA>!EO>YEA?@-!L>!HMB>I!BH!IFA!@FB] AM@!=>?!E=IFMBB J @-!

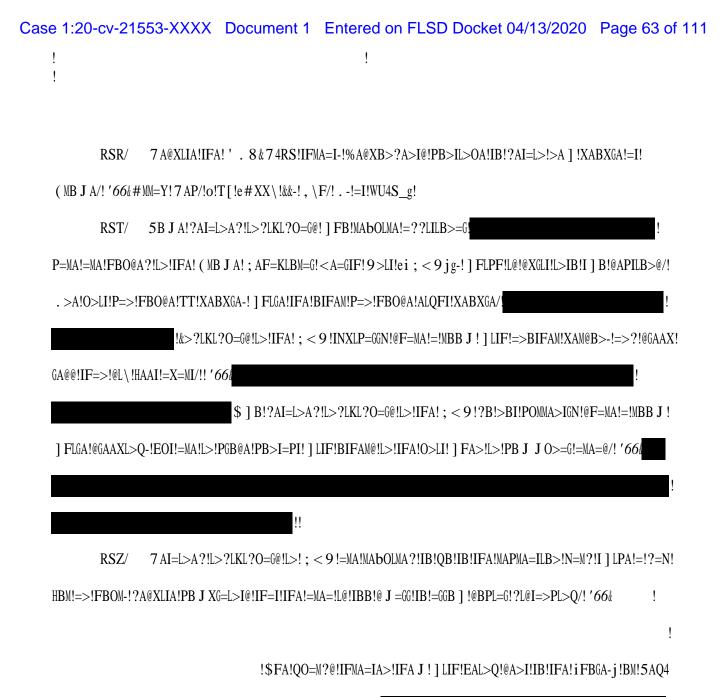
 >A\I!IB!IFA!XFB>A@-!=>?!L>!IFA!PB J J B>!IAGAKL@LB>!=MA=/!e #XX\!&-!, \F/! (-!RUS/g! # I!GA=@I!B>A!XB?-!

] LIF!RT_!?AI=L>AA@-!L@!POMMA>IGN!L>!@OPF!=!PMB] ?A?!@I=IA/!

RWU/ . KAMPMB] ?L>Q!=I! (MB J A!F=@!GA?!IB! J =>N!@=>LI=ILB>!=>?!FA=GIF!L@@OA@/!e#XX\!&-! , \F/! (-!Ra_/g!&I!EAPB J A@!L J XB@@LEGA!IB!=KBL?!FO J =>!PB>I=PI!=>?!IFA!O>LI!L@!F=M?AM!IB!YAAX!PGA=>/! e#XX\!&-!, \F/! (-!Ra_g!

am!

RWa/ !



MAQ=IA?!<BO@L>Q!9>LI-!O>GA@@!IFAN!QB!IB!MAPMA=ILB>/! 5B J A!?AI=L>A?!L>?LKL?O=G@!HAAG!IFAN!>AA?!IB!QB!L>IB!?L@PLXGL>=MN!FBO@L>Q!BM!MA J =L>!L@BG=IA?!L>! IFALM!MBB J @!IB!XMAKA>I!IFA!ML@Y!BH!L>HAPILB>-!EOI!=MA!PB>PAM>A?!IFALM! J A>I=G!FA=GIF!PB>?LILB>@-!L>4 PGO?L>Q!XB@I4IM=O J =ILP!@IMA@@!?L@BM?AM!=>?! J =^BM!?AXMA@@LKA!?L@BM?AM-!] LGG!] BM@A>/!

RSU/ 2 A=G@!L>!IFA!; < 9 !=MA!@AMKA?!L>!IFA!?=NMBB J !IB!=GG!?AI=L>A?!L>?LKL?O=G@!=I!IFA! @= J A!IL J A-!EOI!IFAMA!=MA!B>GN!I] B!I=EGA@!=>?!HA] !PF=LM@-!=>?!@B J A!F=KA!IB!@LI!B>!IFA!HGBBM!IB!A=I/!

!\$FA!I=EGA@!=>?!I]B!XFB>A@!L>!IFA!?=NMBBJ!IF=I!=66!

?AI=L>A?!L>?LKL?O=G@!L>!; < 9 !O@A!=MA!>BI!EAL>Q!PGA=>A?/

!

!\$FAN!B>GN!F=KA!IBLGAI!X=XAM!=K=LG=EGA!IB!PGA=>!IFA!I=EGA@!L>!IFA!PB J J B>!=MA=-!=>?!B>A! J =>!

MAXBMI@!O@L>Q!IBLGAI!X=XAM!IB!PGA=>!FL@!MBB J /! '66&

! (MB J A!@I=HH!EML>Q!HBB?!L>!=!P=MI!IB!IFA!O>LI!HBM!=GG!

!\$FA!QO=M?@!G=OQF!=I!IFA@A!MAbOA@I@/!

$$\begin{split} & \text{RSa}/ \quad 7 \text{AI=L} > A ? ! L > ? L K L ? O = G @ != MA ! M A b O A @ I L > Q ! H = PA ! J = @ Y @ - ! E O I ! @ I = H H ! F = K A ! > B I ! X M B K L ? A ? ! I F A J ! \\ & = > ? ! F = K A ! @ = L ? ! I F A N != MA !> B I !> A P A @ @ = M N ! H B M ! ? A I = L > A A @ ! B M != MA ! B > G N ! H B M ! B H H L P A M @ /! '66 & 6 = M @ = > A ! 7 A P /! O ! T a ! \\ & e \# X X \setminus ! \& \& -! , \setminus F /! y -! = I ! S W 4 R_a g I !< = @ = > ! 7 A P /! O ! R S 4 T_! e \# X X \setminus ! \& \& -! , \setminus F /! \% -! = I ! R_m 4 R T g I ! \# M M = Y ! 7 A P /! O ! R a -! \\ & T R ! e \# X X \setminus ! \& \& -! , \setminus F /! . -! = I ! W U 4 S_g I ! : = M = F ! 7 A P /! O ! R R ! e \# X X \setminus ! \& \& -! , \setminus F /! " -! = I ! S R 4 S [g /! ! \end{split}$$

 RSm/
 5B=X!F=@!>BI!EAA>!MA=?LGN!=K=LG=EGA-!=>?!@B J A!L>?LKL?O=G@!F=KA!>BI!EAA>!=EGA!IB!

 @FB] AM!O>GA@@!IFAN!F=?!HO>?@!IB!XOMPF=@A!@B=X!HMB J !PB J J L@@=MN/! 6 =M@=>A! 7 AP/!o!R [!e #XX \!&&-!

 , \F/! y -!=I!SW4R_agI!<=@=>! 7 AP/!o!RR-!RZ!e #XX \!&&-!
 , \F/!%-!=I!R_m4RTgI! #MM=Y! 7 AP/!o!W-!TZ!e #XX \!&&-!

 , \F/! y -!=I!SW4R_agI!<=@=>! 7 AP/!o!RR-!RZ!e #XX \!&&-!
 , \F/!%-!=I!R_m4RTgI! #MM=Y! 7 AP/!o!W-!TZ!e #XX \!&&-!

 &&-!
 , \F/! . -!=I!WU4S_gI!:=M=F! 7 AP/!o!T_!e #XX \!&&-!
 , \F/!"-!=I!SR4S [g/!
 , KA>!] FA>!XOMPF=@A?-!?A4

 I=L>A?!L>?LKL?O=G@!=MA!>BI!EAL>Q!QLKA>!IFA@A!LIA J @!HBM!@AKAM=G!?=N@!=>?!=MA!MO>>L>Q!BOI!BH!A@@A>4
 IL=G@!GLYA!@B=X!=>?!@F= J XBB/! 6 =M@=>A! 7 AP/!o!RW!e #XX \!&&-!
 , \F/! y -!=I!SW4R_agI!<=@=>! 7 AP/!o!RR!

 e #XX \!&&-!
 , \F/!%-!=I!R_m4RTgI!:=M=F! 7 AP/!o!T_!e #XX \!&&-!
 , \F/!" -!=I!SR4S [g/!<=>?!@=>LILkAM!=XXA=M@!

 IB!EA!B>GN!=K=LG=EGA!IB!>OM@A@-!
 J FB!@B J AIL J A@!@XM=N!@=>LILkAM!B>!?AI=L>A?!L>?!LSR4S [g/!<=>?!@
 >?!@=>2!@

] FA>!IFAN!=MA!MAPALKL>Q! J A?LP=ILB>/! '668

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$$\begin{split} & \text{RSW} \qquad \$ \text{FA!>O J EAM!BH!XABXGA!L>!=GG!BH!IFA!QA>AM=G!XBXOG=ILB>!O>LI@!L@!FLQF-!=>?!>A] !?A4 \\ & \text{I=L>A?!L>?LKL?O=G@!F=KA!PB>IL>OA?!IB!PB J A!L>!BKAM!IFA!X=@I!HA] !] AAY@/! '66&7 = M] N>!7 AP/!o!me^g! \\ & e\#XX \!&\&-!, \F/!, -!=I!Z_4ZUg1!\$BGA>IL>B!7 AP/!o!m-!RR!e#XX \!&&-!, \F/!5-!=I!RRZ4R [g1!\$AXAI=IA4 2 = M4 \\ & \text{IL>Ak!7 AP/!=I!o!Ra!e#XX \!&&-!, \F/!$-!=I!RRW4TZg1&) = NGA!7 AP/!=I!o!RR!e#XX \!&&-!, \F/!; -!=I!R_4RU!g1! \\ & \#ML=@4 2 = MIL>Ak!7 AP/!=I!o!R_!e#XX \!&&-!, \F/! ' -!=I!Ra4TRg1! (F=>!7 AP/!=I!o!WeYg!e#XX \!&&-!, \F/!+-!=I! \\ & mW4 [Ug/! "AILILB>AM!#X=MLPLB!F=@!@AA>!=EBOI!Ra!>A] !?AI=L>A?!L>?LKL?O=G@!L>!FL@!O>LI!L>!IFA!G=@I!I] B! \\ &] AAY@/! '66&#X=MLPLB!7 AP/!o![!e#XX \!&&-!, \F/!:-!=I!Za4ZSg/!! \\ \end{split}$$

 $RSS/ #@!MAPA>IGN!=@!#XMLG!U-!T_T_!>A] !?AI=L>A?!L>?LKL?O=G@!F=KA!EAA>!IM=>@HAMMA?!IB!$ (MB J A!=>?!] AMA!>BI!EAL>Q!IA@IA?!IB!?AIAM J L>A!] FAIFAM!IFAN!F=KA! ' . 8 & 7 4RS/! '66&0=GGBF! 7 AP/!o! RZ!e#XX | &&-!, F/!7-!=I!TT4TSgl! "BMIOB>?B!7 AP/!=I!o!RZ!e#XX | &&-!, F/!#-!R4Sg/!!

 $T_/ #I!GA=@I!I] B!BH!IFA!?AI=L>A?!L>?LKL?O=G@!MAPA>IGN!IM=>@HAMMA?!IB! (MB J A!F=?!HAKAM@-!B>A!BH!] FB J !] =@!KL@LEGN!@F=YL>Q!L>!IFA!?L>L>Q!MBB J /!; BIF!] AMA!AK$

T_U/

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T_[/ 6 FA>!?AI=L>A?!L>?LKL?O=G@!INN!IB! J =YA!IFALM!B] >! J =@Y@-!IFAN!=MA!IBG?!IFAN!=MA!>BI! =GGB] A?!IB!PBKAM!IFALM!H=PA@/! '66&#X=MLPLB!7 AP/!o![!e#XX\!&&-!, \F/!:-!=I!Za4ZSgl!, @PBE=M!7 AP/!o!W! $e # XX \setminus !\&\&-!, \ F/! < -!=I!U[4aRg/!!]$

T W/ \$FAMA!L@!>B!F=>?!@=>LILkAM!=K=LG=EGA!L>!IFA!PB J J B>!=MA=/! '66!" BMIOB>?B!7 AP/!=I!o! $T_e#XX | \&\&-!, F/!#-!R4Sgl!#GH=MB! = MPL=!7 AP/!=I!0!RR!e#XX | \&\&-!, F/!(-!=I!mR4m[gl!$AXAI=IA4 2 = M4 + MPL=!7 AP/!=I!0!RR!e#XX | &\&-!, F/!(-!=I!mR4m[gl!$AXAI=IA4 2 = M4 + MPL=!7 AP/!=I!0!RR!e#XX | &\& -!, F/!(-!=I!mR4m[gl!$AXAI=IA4 2 = M4 + MPL=!7 AP/!=I!0!RR!e#XX | &\& -!, F/!(-!=I!mR4m[gl!$AXAI=IA4 2 = M4 + MPL=!7 AP/!=I!0!RR!e#XX | &\& -!, F/!(-!=I!mR4m[gl!$AXAI=IA4 2 = M4 + MPL=!7 AP/!=I!0!RR!e#XX | &\& -!, F/!(-!=I!mR4m[gl!$AXAI=IA4 2 = M4 + MPL=!7 AP/!=I!0!RR!e#XX | & AXAI=IA4 2 = M4 + MPL=!7 AP/!=I!0!RR!e#XX | & AXAI=IA4 2 = M4 + MPL=!7 AP/!=I!0!RR!e#XX | & AXAI=IA4 2 = M4 + MPL=!7 AP/!=I!0!RR!e#XX | & AXAI=IA4 2 = M4 + MPL=!7 AP/!=I!0!RR!e#XX | & AXAI=IA4 2 = M4 + MPL=!7 AP/!=I!0!RR!e#XX | & AXAI=IA4 2 = M4 + MPL=!7 AP/!=I!0!RR!e#XX | & AXAI=IA4 2 = M4 + MPL=!7 AP/!=I!0!RR!e#XX | & AXAI=IA4 2 = M4 + MPL=!7 AP/!=I!0!RR!e#XX | & AXAI=IA4 2 = M4 + MPL=!7 AP/!=I!0!RR!e#XX | & AXAI=IA4 2 = M4 + MPL=!7 AP/!=I!0!RR!e#XX | & AXAI=IA4 2 = M4 + MPL=!7 AP/!=I!0!R!e#XX | & AXAI=IA4 + MPL=!7 AP/!=I!0!R!e#XX | & AXAI=!7 AP/!=I!0!R!e#XX | & AXAI=!7$ IL>Ak!7AP/!=I!o!W!e#XX\!&&-!, \F/!\$-!=I!RRW4TZg1!7=M]N>!7AP/!o!ae?g!e#XX\!&&-!, \F/!, -!=I!Z_4ZUg1! 'F=KAk!7AP/!=I!o!Rm!e#XX\!&&-!,\F/!)-!=I!U 4Umg/!7AI=L>A?!L>?LKL?O=G@!F=KA!MAXBMIA?!@AAL>O!IFA! QO=M?@!]LIF!F=>?!@=>LILkAM!EOI!?AI=L>A?!L>?LKL?O=G@!=MA!>BI!=GGB]A?!IB!O@A!LI/&'66!"BMIOB>?B!7AP/! =I!o!T !e#XX\!&&-!, \F/!#-!R4Sgl! 'F=KAk!7AP/!=I!o!Rm!e#XX\!&&-!, \F/!)-!=I!U 4Umg/!!

T S/ \$FAMA!L@!F=>?!@=>LILkAM!L>!IFA!>OM@A`@!=MA=!] FAMA!?AI=L>A?! J A>!MAPALKA! J A?LP=4 ILB>/! '668 !<B] AKAM-!?AI=L>A?!L>?LKL?O=G@!=MA!

B>GN!=GGB] A?!B>A!@bOLMI!] FA>!MAPALKL>Q! J A?LP=ILB>/! '66!

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TR_/ 9>ILG!MAPA>IGN-! (MB J A!@I=HH!] AMA!>BI!] A=ML>Q! J =@Y@!BM!OGBKA@/! '66! "BMIOB>?B! $7 \text{ AP}/!=I!\text{o}!\text{Ta}!e\#XX \setminus \&\&-!, \\ F/!\#-!\text{R4Sg}\&\#E?\text{OG}!0=66BF!7 \text{ AP}/!\text{o}!\text{Ta}!e\#XX \setminus \&\&-!, \\ F/!7-!=I!\text{TT4TS}!g!!"\text{AMAk}!$ +L J B>A@! 7 AP/!=I!o!RR!e#XX\!&&-!, \F/! 2 -!=I! [a4 [Wg1! ' F=KAk! 7 AP/!=I!o!TR!e#XX\!&&-!, \F/!) -!=I!U_4 Umg/!5B J A!BHHLPAM@!@ILGG!H=LG!IB!] A=M!QGBKA@!BM! J =@Y@/! '66! 6 =M@=>A!7 AP/!o!TR-!TS!e#XX\!&&-!, \F/! $v_{!=1!SW4R} = 0 = 1 \text{ AP}/0!TZ_{!TU!e#XX} = 0 = 1 \text{ AP}/0!TZ_{!TU!e} = 0 = 1$ RT4RU!e#XX\!&&-!,\F/!"-!=I!SR4S[gl!"BMIOB>?B!7AP/!=I!o!Tm!e#XX\!&&-!,\F/!#-!R4Sgl!'F=KAk!7AP/!=I! o!TT!e#XX\!&&-!,\F/!)-!=I!U_4Umg/!)O=M?@!=MA!@AA>!IBOPFL>Q!IFALM!H=PA@!=>?!IFA>!IFL>Q@!L>!IFA! XB?@-!@OPF!=@!XABXGA-!HBB?!IM=N@!=>?!BIFAM!LIA J @!L>!IFA!GLKL>O!=MA=-!=>?!IFAN!=MA!>BI!BE@AMKA?! $] = @FL>0!IFALM!F=>?@!BHIA>/!'66& #E?OG!0=GGBF!7AP!o!Tm4TW!e#XX\!&&-!, \F/!7-!=I!TT4TSg1!#GH=MB!$

) =MPL=! 7 AP/!=I!oo!R_4RR-!RU!e#XX\!&&-!, \F/! (-!=I!mR4m[gl!\$AXAI=IA4 2 =MIL>Ak!7 AP/!=I!oo!RZ4RU! e#XX\!&&-!, \F/!\$-!=I!RRW4TZgl!7=M] N>!7 AP/!o!meFg4eLg!e#XX\!&&-!, \F/!, -!=I!Z_4ZUgl&"BMIOB>?B!7 AP/! =I!o!T[!

 $TRU/ #@!BH! # XMLG! [-!T_T_-!?AI=L>A?!L>?LKL?O=G@!F=KA!F=?!IFALM! $ 8 @-!XFB>A@-!=>?!I=EGAI@!$ $PB>HL@P=IA?/! '66! "BMIOB>?B!7 AP/!=I!o!RS!e # XX \ !&&-!, \ F/! #-!R4Sg/! 1 B!O>LI!] LIFL>! (MB J A!L@!=GGB] A?!$ $IB!] =IPF! $ 8/k '66! "BMIOB>?B!7 AP/!=I!o!RS!e # XX \ !&&-!, \ F/! #-!R4Sg!! # GH=MB!) =MPL=!7 AP/!=I!o![!e # XX \ !&&-!, \ F/! (-!=I!mR4m[gl! '66k7=M] N>!7 AP/!o!W!e # XX \ !&&-!, \ F/!, -!=I!Z_4ZUg/!$

TRa/ #!MAPA>I!A J AMQA>PN!IF=I!] =@!=>>BO>PA?!BKAM!IFA!@XA=YAM@!=I! (MB J A!] =@!?OA!IB! ' . 8 & 7 4RS/! '66&#E?OG!0=GGBF! 7 AP/!0!TS!e#XX\!&&-!, \F/! 7 -!=I!TT4TSg/!

TRm/ .>!#XMLG![-!@B J A!?AI=L>A?!L>?LKL?O=G@!M=L@A?!PB>PAM>@!=EBOI!PB>?LILB>@!=>?!HA=M@! BH! ' . 8 & 7 4RS!=>?!QO=M?@!EAQ=>!EA=IL>Q!IFA J /!: GBMA@!%= J B@!7 AP/!o!T_!e#XX\!&&-!, \F/!9-!=I!RTU4 Z_g/!.>A!XAM@B>!]=@!YLPYA?!L>!IFA!MLE@!=GIFBOQF!FA!]=@!>BI!= J B>Q!IFB@A! J =YL>Q!PB J XG=L>I@/! :GBMA@!%= J B@!7 AP/!o!T_!e#XX\!&&-!, \F/!9-!=I!RTU4Z_g/!\$FA!QO=M?@!=MA!>BI!=GGB] L>Q!?AI=L>A?!XAB4 XGA!IB!PB>I=PI!IFALM!=IIBM>AN@-!] FLPF!IF=I! J =>!EAGLAKA@!L@!MAI=GL=ILB>!L>!MA@XB>@A!IB!IFA@A!PB J 4 XG=L>I@/!:GBMA@!%= J B@!7 AP/!o!TR!e#XX\!&&-!, \F/!9-!=I!RTU4Z_g/!

 TR [/ 5L>PA!IFA!'. 8 & 7 4RS !BOIEMA=Y!=I! (MB J A-!IFAMA!F=@!EAA>!=!?APMA=@A!L>! J A?LP=G!

 @I=HH/!'66d
 !\$FAMA!F=@!EAA>!>B!L>PMA=@A!L>!

 @PMAA>L>Q@/&'66d
 !7 AI=L>A?!L>?LKL?O=G@!] FB!MAbOA@I!

 AK=GO=ILB>!=>?!IB!@AA!=!?BPIBM!F=KA!F=?!IFALM!MAbOA@I@!?A>LA?/&'66d
 !

TRW/ 6 FA>!@B J AB>A!L@!@LPY!] LIF!PBG?!@N J XIB J @-!IFAN! J O@I!] =LI!HLKA!IB!ALQFI!?=N@!EA4 HBMA!IFAN!P=>!@AA!=!?BPIBM/! '66 ! ! 6 FA>!BIFAM! ?AI=L>A?!L>?LKL?O=G@!=MA!I=YA>!BOI!BH!IFA!XB?@!HBM!PBOQFL>Q!BM!L@@OA@!]LIF!EMA=IFL>Q-!IFA!BIFAM!?A4 I=L>A?!L>?LKL?O=G@!=MA!>BI!IBG?!]FAIFAM!IFAN!F=KA!EAA>!A\XB@A?!IB!'. 8&74RS/!'66& !

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TRS/ # !?AI=L>A?! J =>!] = @!@LPY!] LIF!=!PBOQF!=>?!MAbOA@IA?!IB!@AA!=!?BPIBM-!EOI!] = @!IBG?!IF=I!FA!] = @!>BI!=!XMLBMLIN/! '66& !<A!] = @!>BI!L@BG=IA?!HMB J !IFA!MA@I!BH!IFA!XB?/!)B' 6 6 & !

 $IB!IFA!PMB] ?A?!H=PLGLIN!L>! 2 L= J L!F=?!IFA!@FAMLHH!`@!BHHLPA!O>A=@N!BKAM!IFA!XB@@LELGLIN!IF=I!IFA! PBMB>=KLMO@!PBOG?!A=@LGN!EA!IM=>@ J LIIA?/j!e#XX\!&-!, \F/!y-!ZZm4UR/g!$

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 $TTU/ .>!# XMLG!W-!T_T_-!IFA!# @@L@I=>I!: LAG?! . HHLPAM!+L=>=!0/! '=@I=>B!@I=IA?!L>!=!?APG=M=4$ ILB>!IB!IFL@!PBOMI!IF=I! (MB J A!F=?!Z!P=@A@!BH!G=EBM=IBMN!PB>HLM J A?!XB@LILKA@!HBM! '. 8&74RS! $= J B>Q@I!@I=HH!=>?!=!?AI=L>A?!L>?LKL?O=G-!=>?!IF=I!=I!GA=@I!TZW!?AI=L>A?!L>?LKL?O=G@!] AMA!A \ XB@A?!$ $IB!=!PB>HLM J A?!P=@A!BH! '. 8&74RS/!!e#XX \ !&-!, \ F/!&-!=I!RTZ4TTU!o!RT/g!$FA@A!TZW!L>?LKL?O=G@!] FB!$ $F=KA!EAA>!A \ XB@A?!IB!=!XAM@B>!PB>HLM J A?!IB!F=KA! '. 8&74RS!=MA!EAL>Q!XG=PA?!L>!iPBFBMI@!] LIF!$ $MA@IMLPIA?! J BKA J A>I/j!e#XX \ !&-!, \ F/!&-!=I!RTZ!o!R_/g!$

TTm/

> : 6BML?=-!L>PGO?L>Q!; MB] =M?!\$M=>@LILB>=6! 'A>IAM!=>?!) G=?A@! 'BO>IN!7AIA>ILB>! 'A>IAM-!P=>!EA! =KBL?A?/j!!e#XX\!&-!, \F/!%-!=I!ZUT4UZ/g!\$FA@A!JAJEAM@!BH! 'B>QMA@@!A\XMA@@A?!IF=I!IFAN!]AMA! i?AAXGN!?L@IOMEA?!EN!& ', `@!PB>IL>OA?!=PILKLIN!IB!IM=>@HAM!=>?!?AI=L>!G=MQA!QMBOX@!BH!LJJLQM=>I@! L>!IFA!JL?@I!BH!=!QGBE=G!X=>?AJLP-!A@XAPL=GGN!=I!=!H=PLGLIN!]FAMA!?AI=L>AA@!=>?!AJXGBNAA@!F=KA! IA@IA?!XB@LILKA/j!e#XX\!&-!, \F/!%-!=I!ZUTg!!

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TTW/ \$FA@A!HBOM! J A J EAM@!BH! 'B>QMA@@!=G@B!@I=IA?!IF=I!isLt!!L@!O>?L@XOIA?!IF=I!^=LG@-!XML@4 B>@-!=>?!?AIA>ILB>!PA>IAM@!=MA!FLQFGN!KOG>AM=EGA!IB! '. 8&74RSp!?OA!IB!IFA!H=PI!IF=I!isAtHHAPILKA! @BPL=G!?L@I=>PL>Q!L@!=G J B@I!L J XB@@LEGA!=>?!>APA@@=NN!?L@L>HAPI=>I!L@!M=MAGN!=K=LG=EGA!IB!?AI=L>AA@-j! =>?!A@XAPL=GGN!@B!QLKA>!IF=I!IFA!@LIO=ILB>!L>!i (MB J A!L@!X=MILPOG=MGN!=G=M J L>Q!L>!IFL@!MA@XAPIj !L>! GLQFI!BH!MAXBMIA?!iBKAMPMB] ?A?!PB>?LILB>@!AKA>!XMLBM!IB!IFA!L J X=PI!BH! '. 8&74RS/j!e#XX\!&-!, \F/! %-!=I!ZUT/g!!\$FAN!=G@B!=??A?!IF=I!iLI!=XXA=M@!IF=I! (MB J A!L@!>BI!=I!=GG!XMAX=MA?!IB! J LILQ=IA!A \XB4 @OMA!IB! '. 8&74RS-!BM!IB!=?AbO=IAGN!MA@XB>?!@FBOG?!=>!BOIEMA=Y!=I!IFA!H=PLGLIN!BPPOM/!\$FA@A!L@4 @OA@!=MA!B>GN!PB J XBO>?A?!EN!IFA!H=PI!IF=I! '. 8&74RS!F=@!>B] !MA=PFA?! (MB J A/j!e#XX\!&-!, \F/! %-!=I!ZUT4UZg!

TTS/ !5I=HH!=I! (MB J A!=MMLKA!=>?!GA=KA!B>!=!@FLHI!E=@L@-!=>?!IFAMA!L@!GL J LIA?!=ELGLIN!IB!=?4AbO=IAGN!@PMAA>!L>PB J L>Q!@I=HH!HBM!>A] -!=@N J XIB J =ILP!L>HAPILB>/!5I=HH!QA>AM=GGN!GLKA!L>!IFA!PB J 4 J O>LILA@!>A=M!IFA@A!H=PLGLILA@ q =MA=@!] FAMA!IFAMA!=MA!PB>HLM J A?!P=@A@!BH! ' . 8&74RS/!!!

 $TZ_{/} ! FA!BOIEMA=Y!=I! (MB J A!F=@!=HHAPIA?!IFA!L J J LQM=ILB>!PBOMI!FBO@A?!=I!IFA!H=PLGLIN! =>?!MO>!EN!IFA!, \APOILKA!. HHLPA!HBM!& J J LQM=ILB>!%AKLA] !ei, . &%jg/! (MB J A!& J J LQM=ILB>! 'BOMI!L@! =PPA@@A?!IFMBOQF!IFA!@= J A!GBEEN!=@!IFA!?AIA>ILB>!PA>IAM/!OO?QA@-!PBOMI!@I=HH-!=>?!EBIF!QBKAM>4 J A>I!=>?!?AHA>@A!=IIBM>AN@!F=KA!A \XMA@@A?!PB>PAM>!=EBOI!IFALM!@=HAIN!=>?!FA=GIF/!!$

mS!

TZR/ . >! 2 = MPF!TT-!T_T_!IFA! 1 = ILB>= G! # @@BPL=ILB>!BH!& J J LQM=ILB>!OO?QA@!ei 1 # &0 jg-!

IFA!&', !''MBHA@@LB>=G@!9>LB>!ei&', !9>LB>jg-!=>?!IFA!#JAMLP=>!&JJLQM=ILB>!+=]NAM@!#@@BPL=4

ILB>!ei #&+ # jg-!] MBIA!=!^BL>I!@I=IA J A>I!?A J =>?L>Q!IF=I!, . & !PGB@A!=GG!BH!IFA!L J J LQM=ILB>!PBOMI@!

>=ILB>] L?A-!=>?!@I=IL>Q-!= J B>Q!BIFAM!IFL>Q@-!IF=IC!!

 $\begin{aligned} & \mbox{$FA!7.0}^{@}\POMMA>I!MA@XB>@A!IB!IFA!'. 8&74RS!X=>?AJLP!=>?!L0!@XMA=?!L0!?L0PB>>APIA?! \\ & \mbox{$HMBJ!IFA!>AA?@!=>?!=?KLPA!BH!PBJJO>LIN!GA=?AM@!=>?!@PLA>ILHLP!A\XAMI@/!!$FA!&JJLQM=ILB>! \\ & \mbox{$'BOMI@!=MA!A@XAPL=GGN!KOG>AM=EGA!IB!IFA!@XMA=?!BH!IFA!'BMB>=KLMO@/!!, KAMN!GL>Y!L>!IFA!PF=L>! \\ & \mbox{$'IF=I!EML>Q0!L>?LKL?O=G0!IB!IFA!PBOMI-!HMBJ!IFA!O@A!BH!XOEGLP!IM=>@XBMI=ILB>-!IB!@APOMLIN!GL>A@-! \\ & \mbox{$'PMB]?A?!AGAK=IBM0-!F=GG]=N@-!IFA!PM=JXA?!POELPGA!@X=PA0!BH!PBOMI!@I=HH-!L>=?AbO=IA!]=LI4 \\ & \mbox{$L>Q!MBBJ!H=PLGLILA@!L>!IFA!PBOMIFBO@A@-!=>?!@P=>I!@=>L1LkL>Q!MA@BOMPA0!=I!IFA!PBOMI@-!=GG! \\ & \mbox{$XG=PA!GLKA0!=I!ML@Y/!!&>?LKL?O=G0!]FB!L>!J=>N!L>@I=>PA0!F=KA!]=LIA?!NA=M0!HBM!=!FA=ML>Q! \\ & \mbox{$J=N!=G@B!HAAG!XMA@@OMA?!IB!=XXA=M!h!AKA>!LH!IFAN!HAAG!@LPY-!HBM!HA=M!BH!EAL>Q!BM?AMA?!?A4 \\ & \mbox{$XBMIA?/!!} \end{aligned}$

 $e # XX \setminus !\&-!, \ F/!5-!=I!ZUa4U[-!ZUmg!]$

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TZT/ .>! 2 = MPF!Tm-!T_T_-!IFA!1 #&0-!IFA!&', !9>LB>-!#&+#-!=>?!=! J OGILIO?A!BH!BIFAM!BM4

Q = Lk = ILB > 0!] MBIA!=!GAIIAM!?LMAPIGN!IB!#IIBM>AN!) A>AM=G!; =NM!?A J =>?L>Q!IFA!PGB@OMA!BH!=GG!L J J L4

QM=ILB>!PBOMI@!>=ILB>]L?A-!=>?!@I=IL>Q!IF=I!i?AI=L>A?!PBOMI@!JO@I!=G@B!EA!PGB@A?!IB!L>4XAM@B>!

FA=ML>Q@!L>!BM?AM!IB! J L>L J LKA!IFA!@XMA=?!BH!IFA!KLMO@-!@6B] !IFA!M=IA!BH!>A] !L>HAPILB>@-!=>?!IB!

=KBL?!BKAN] FAG J L>Q!GBP=G!MA@BOMPA@/j !!e#XX\!&-!, \F/!\$-!=I!ZUW4aRg!!

TZZ/ .>! 2 = MPF!Z_-!T_T_-!IFA! 1 #&0!L@@OA?!=>!=??LILB>=G!@I=IA J A>I/!!\$FA!@I=IA J A>I!EA4

 $QL \ge 0!EN!bOBIL \ge Q! = !iPOMMA \ge I!LJJLQM = ILB \ge !^O?QA! |FB!L0! = !9/5/!JLGLI = MN!KAIAM = > i!0! = IL \ge QC!$

 $\& : ?B > dI : @ = N : IFL @ : CLQFIGN - !EOI!, & & & : F = @ : ?A J B > @ IM = IA ? : IF = I : IFAN! > AA ? : IB : EA ! QOIIA ? ! = > ? : MAEOLGI! \\ HMB J : IFA : = @FA@ / : ! & & & & : A$

 $e#XX \!\&-!, \F/!9-!=I!ZaT4am-!ZaTg!$

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TZS/ 2 =>N!?AI=L>A?!L>?LKL?O=G@!F=KA!A XAMLA>PA?!@LQ>LHLP=>I!IOM>BKAM!BH!PAGG J =IA@-! $F=KL>Q!OX!IB!@L \!BM!@AKA>!>A] !PAGG J =IA@!@L>PA!IFALM!?AIA>ILB>!L>!) G=?A@/& '66!7=LMB>! ; =MMA?B!$ $5=>PFAk!7 AP/!o!m!e#XX \!&&-!, \F/!8-!=I!RZR4ZWgI!) AM=M?B!8=MQ=@!7 AP/!o!m!e#XX \!&&-!, \F/!*-!=I!$ $RaR4amgl!\$=FL J L!"AMAk!o!S!e#XX \!&&-!, \F/!6-!=I!RZS4UUgI! : M=>YGL>!%= J B>!) B>k=GAk!o!m!e#XX \!&&-!, \F/!V-!=I!RUa4a_g/!$

TU_/ \$FAMA!=MA!=XXMB\LJ=IAGN!Sa!?AI=L>A?!L>?LKL?O=G@!L>!=!XB?!=I!=!ILJA/!'66!7=LMB>! ;=MMA?B!5=>PFAk!7AP/!0!R[!e#XX\!&&-!, \F/!8-!=I!RZR4ZWgI!:M=>PL@PB!%LKAMB!8=GAMB>!7AP/!0![! e#XX\!&&-!, \F/!3-!=I!Ra[4mTg/!\$FA!XB?@!=MA!@B!PMB]?A?-!IF=I!@BPL=G!?L@I=>PL>Q!=I!=!@=HA!@L\!HAAI! ?L@I=>PA!L@!LJXB@@LEGA-!A@XAPL=GGN!]LIF!IFA!PB>@I=>I!L>HGO\!BH!?AI=L>A?!L>?LKL?O=G@/!'66!7=LMB>! ;=MMA?B!5=>PFAk!7AP/!0!RT!e#XX\!&&-!, \F/!8-!=I!RZR4ZWgI!)AM=M?B!8=MQ=@!7AP/!0!m-!W!e#XX\!&&-! , \F/!*-!=I!RaR4amg1!&MKL>!2A>?Bk=!5LGL@!7AP/!0!m!e#XX\!&&-!, \F/!##-!=I!RmZ4m[g1!:M=>PL@PB! %LKAMB!8=GAMB>!7AP/!0![!e#XX\!&&-!, \F/!3-!=I!Ra[4mTg1!\$=FLJL!"AMAk!0!RZ!e#XX\!&&-!, \F/!6-!=I! RZS4UUg1!:M=>YGL>!%=JB>!)B>k=GAk!0!RR!e#XX\!&&-!, \F/!V-!=I!RUa4a_g/!

TUR/ # (G!?AI=L>A?!L>?LKL?O=G@!L>!=!XB?!=G@B!@F=MA!PB J J O>=G!E=IFMBB J @!=>?!@FB] AM@-! $] FLPF!?B!>BI!F=KA!@L \ !HAAI!BH!?L@I=>PA!EAI] AA>!IFA J -! J =YL>Q!LI!L J XB@@LEGA!IB! J =L>I=L>!=!@=HA!@B4$ PL=G!?L@I=>PA!AKA>!] FLGA!O@L>Q!IFA!MA@IMBB J !BM!E=IFL>Q/! '66!7 =LMB>! ; =MMA?B!5=>PFAk!7 AP/!o!RZ! $e # XX \setminus !\&\&-!, \ F/! 8 -!=I!RZR4ZWg1!) AM=M?B! 8 = MQ=@!7 AP/!o!m!e # XX \setminus !\&\&-!, \ F/! * -!=I!RaR4amg1! : M=>YGL>!$ $\%= J B>!) B>k=GAk!o!m!e # XX \setminus !\&\&-!, \ F/!V-!=I!RUa4a_g/!$

TUT/ 9 > GLYA!; \$`!BM! (MBJA-!IFAMA!L@!>B!P=HAIAML=/!7AI=L>A?!L>?LKL?O=G@!A=I!L>!IFA!PBJ4 $JO>=G!@A=IL>Q!=MA=!L>!IFALM!XB?-!Y>B]>!=@!i@=IAGGLIA!HAA?L>Q/j!e#XX\!&-!, \F/!(-!=I!RmT/g!$FA!I=4$ EGA@!O@A?!HBM!A=IL>Q!=>?!?=LGN!GLKL>Q!O@O=GGN!@A=I!HBOM!XABXGA-!EOI!?OA!IB!BKAMPMB]?L>Q-!IFAN!=MA! $>B] !@A=IL>Q!HLKA!IB!@L \!XABXGA!=I!=!ILJA/!'66!) AM=M?B!8=MQ=@!7AP/!o![!e#XX \!&&-!, \F/!*-!=I!RaR4$

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amg/!#@!=!MA@OGI-!IFAMA!L@!B>GN!=EBOI!U_!IB!a_!PA>IL J AIAM@!BH!@AX=M=ILB>!EAI] AA>!?AI=L>A?!L>?LKL?O4
=G@!] FA>!IFAN!=MA!A=IL>Q!=I!IFA!I=EGA@/! '66!: M=>PL@PB!%LKAMB!8=GAMB>!7 AP/!o![!e#XX\!&&-!, \F/!3-!=I!
Ra[4mTg/!

 TUZ/
 1 A] !?AI=L>A?!L>?LKL?O=G@!=MMLKA!=I!) G=?A@!AKAMN!?=N-!@B J A!=GMA=?N!A \FLELIL>Q!HGO!

 GLYA!@N J XIB J @!GLYA!PBOQFL>Q/! '66]
 g/!\$FAMA!

 L@!>B!L>?LP=ILB>!IF=I!>A] !?AI=L>A?!L>?LKL?O=G@!=MA!IA@IA?!HBM! ' . 8&74RS!BM!MBOIL>AGN!bO=M=>IL>A?!

 EAHBMA!EAL>Q!XG=PA?!L>!IFA!XB?!] LIF!IFA!MA@I!BH!IFA!?AI=L>A?!L>?LKL?O=G@/&)B!e#XX \!&&-! , \F/! ; ; -!=I!

 RmW4 [Tg1! 7 =LMB>! ; =MMA?B!5=>PFAk! 7 AP/!o!S!e#XX \!&&-! , \F/! 8 -!=I!RZR4ZWg1! : M=>PL@PB!%LKAMB! 8 =GA4

 MB>! 7 AP/!o!RR!e#XX \!&&-! , \F/!3 -!=I!Ra [4mTg1!\$=FL J L! "AMAk! 7 AP/!o!R_!e#XX \!&&-! , \F/! 6 -!=I!RZS4

 UUg/!

 $TUU/ \&>!=6G!@L \setminus !XB ?@!L>?LKL ?O=G@!@F=MA! J =>N!PB J J B>!@X=PA@!=>?!IBOPF!IFA!@= J A!@OM4 H=PA@/! # GG!@L \setminus !O>LI@!=>?!IFA!@AQMAQ=ILB>!O>LI!@F=MA!=!PB J J B>!G=] !GLEM=MN/!&>!A=PF!XB ?-!IFAMA!=MA! B>GN!HBOM!XFB>A@!=K=LG=EGA!XAM!XB ?!IF=I!AKAMNB>A! J O@I!@F=MA-!=>?!XABXGA! J O@I!=G@B!@F=MA!I=EGAI@/! 5L J LG=MGN-!=GG!?AI=L>A?!L>?LKL ?O=G@!L>!IFA!@AQMAQ=ILB>!O>LI!@F=MA!IFA!@= J A!I] B!XFB>A@/!$

 $\label{eq:two-stars} TUm/ \quad B>IM=PIBM@!=>?!?AI=L>A?!L>?LKL?O=G@!F=KA!PB>IL>OBO@GN!MAXBMIA?!O>@=>LI=MN!XFN@L4 \\ P=G!PB>?LILB>@-!G=PY!BH! J A?LP=G!P=MA-!=>?!XFN@LP=G! J L@IMA=I J A>I/!e # XX \ !&-!, \F/! (-!=I!RmT/g!) G=?A@! \\ F=@!H=LGA?!IB!@OE@I=>ILKAGN!MA J A?N!IFA@A!XBBM!PB>?LILB>@/!! \\ \label{eq:two-stars}$

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 $TU[/ 9>@=>LI=MN!E=IFMBB J @!=MA!=!XAM@L@IA>I!XMBEGA J /!$FA!^=LG!HBMEL?@!IFA!O@A!BH!EGA=PF!$ $HBM!PGA=>L>Q!IFA!E=IFMBB J @/!e # XX \ !\&-!, \ F/! (-!=I!RmT/g!5F=J XBB!L@!INXLP=GGN!O@A?!=@!=!@OE@ILIOIA!$ $HBM!@B=X/!e # XX \ !\&-!, \ F/! (-!=I!RmT/g!$FAMA!L@! J BG?!L>!IFA!E=IFMBB J @/!e # XX \ !\&-!, \ F/! (-!=I!RmT/g!!$ $e # XX \ !\&-!, \ F/! 6 -!=I!Zm [4mWg!e 7 < 5! . HHLPA!BH!\&>@XAPIBM!) A>/!% AXBMI! . \&) 4RW4ZT-!>BIL>Q!G=PY!BH!$ PGA=>GL>A@@-!GL J LIA?!FNQLA>LP!@OXXGLA@-!=>?!XBIA>IL=GGN!O>@=HA!HBB?!F=>?GL>Qg/!

TUW/ \$FAMA!F=KA!EAA>!MAXBMI@!BH!L>A?LEGA!HBB?!XMBKL?A?!IB!?AI=L>A?!L>?LKL?O=G@/!e#XX\! &-!, \F/!(-!=I!RmZ/g!\$FA!i?ML>YL>Q!]=IAM!F=@!=!NAGGB]L@F!FOA!=>?!=>!B??!I=@IA/j!!e#XX\-!, \F/!(-!=I! RmZg/!

TUS/ \$FA!@XMA=?!BH!PBOQF-!HGO-!=>?!BIFAM!MA@XLM=IBMN!PB>?LILB>@!L>!IFA!?BM J @!F=KA!EAA>! =IIMLEOIA?!IB!IFA!O>@=>LI=MN!PB>?LILB>@/!!e#XX\!&-!, \F/!(-!=I!RmT/g!, KA>!EAHBMA!IFA!'. 8&74RS! X=>?A J LP-!) G=?A@!H=LGA?!IB!XMBKL?A!=?AbO=IA! J A?LP=G!P=MA!IB!?AI=L>A?!] B J A>!=>?! J A>/!e#XX\!&-! , \F/!, -!=I!aW4m_1!W_4WR/g^{[T}!!

 $Ta_{/} = GGN! = 2M = GGN! = M = SGN! = M = SGN! = M = SGN! = SG$

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! ! $\label{eq:RU!e} RU!e \# XX \setminus !\&\&-!, \ \ F/! * -! = I!RaR4amg1!: M => PL@PB!\%LKAMB! \\ &= GAMB>! \ 7 \ AP/!o!R_!e \# XX \setminus !\&\&-!, \ \ F/! \\ &= I!Ra[4mTg/!!]$

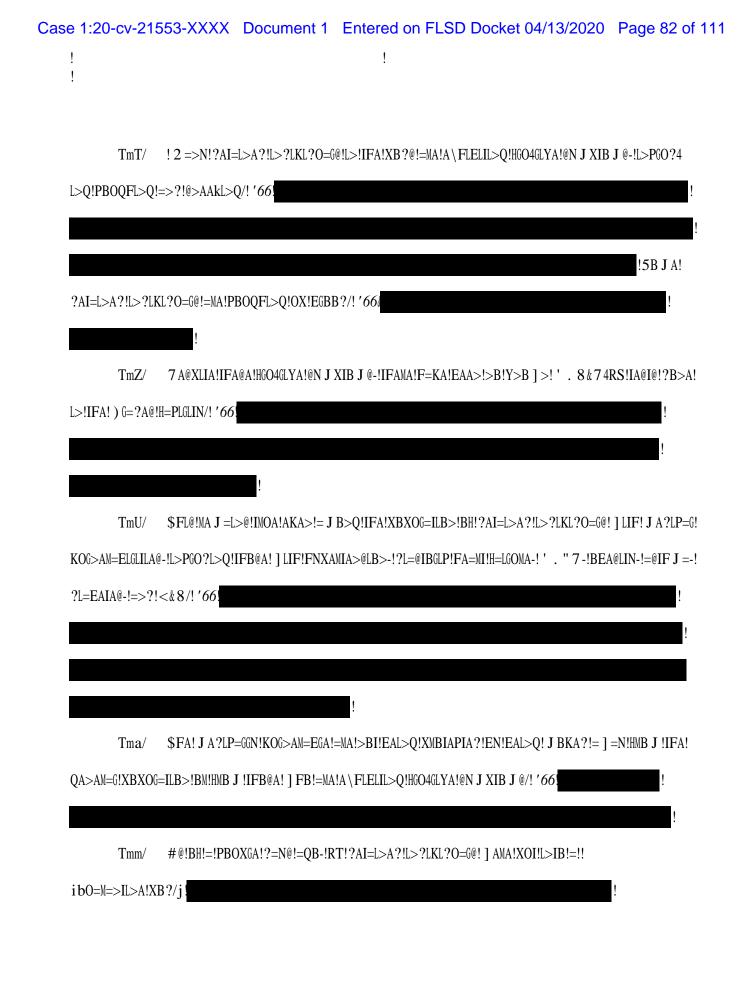
!

 TaS/
 #GIFBOQF!IFA!@I=HH!=MA!>BI!O@L>Q!IFA!XMBXAM!XMBIAPILKA!QA=M-!IFAN!@ILGG!A>IAM!IFA!GLK4

 L>Q!O>LI@-!IBOPF!IFA!?AI=L>A?!L>?LKL?O=G@-!IFALM!XAM@B>=G!EAGB>QL>Q@-!=>?!IFA!HBB?!IM=N@/! '66!

 7=LMB>!;=MMA?B!5=>PFAk!7AP/!o!Ta-!ZU!e#XX\!&&-!,\F/!8-!=I!RZR4ZWgI!)AM=M?B!8=MQ=@!7AP/!o!Ra!

 e#XX\!&&-!,\F/!*-!=I!RaR4



Tm [/ 7 AI=L>A?!L>?LKL?O=G@!=MA!>BI!=EGA!IB!@AA!IFA! J A?LP=G!@I=HH!L>!=!IL J AGN! J =>>AM-!=>?!] FA>!IFAN!=MA!=EGA!IB!@AA!IFA! J A?LP=G!@I=HH-!IFALM!IA J XAM=IOMA!L@!>BI!EAL>Q!I=YA>/! '66! !

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TmW/ .>A!?AI=L>A?!L>?LKL?O=G!]=@!=?KL@A?!EN!=!>OM@A!IF=I!FA!F=?!IFA!HGO-!EOI!=>BIFAM! >OM@A!L>HBM J A?!FL J !IF=I!FA!?L?!>BI/! '66! !

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$6 JA^{J}=J<' J=>G;H;A>=F'+@>H@J'$

TmS/ ; \$ '!L@!=>!LJ J LQM=ILB>!?AIA>ILB>!PA>IAM!L>!"B J X=>B!; A=PF-!:GBML?=!HBM!i>B>4 PML J L>=G!=>?!GB] !@APOMLINj!?AI=L>A?!L>?LKL?O=G@!BXAM=IA?!EN!=!XMLK=IA!PB>IM=PIBM-!IFA!HBM4XMBHLI! $XML@B>!PBMXBM=ILB>!$FA!), . !) MBOX-!&>P/!ei), . jg/!e#XX\!&-!, \F/!(!=I!RaZ/g!), . !F=@!LI@!FA=?4$

 $T[U/ #I!; $'-!L>?LKL?O=G@!] LIF!PFMB>LP! J A?LP=G!PB>?LILB>@!MAXBMIA?!IMA J A>?BO@!?LHHL4 POGILA@!MAPALKL>Q!>APA@@=MN!=PPB J J B?=ILB>@!HBM!IFALM!FA=GIF!XMBEGA J @-!@OPF!=@!?LAI=MN!=PPB J J B4 ?=ILB>@/!e#XX\!&-!, \F/! (!=I!RUZ/g! . >A!L>?LKL?O=G!MA J A J EAMA?!=! J =>!] LIF!?L=EAIA@!GB@L>Q!=!HL>QAM! =@!=!MA@OGI!BH!IFA!L>=?AbO=IA! J A?LP=G!P=MA!=I!; $ '/!e#XX\!&-!, \F/! (!=I!RUZ/g!$

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 $T[a/ 7 OML>Q!IFA!@O J J AM!BH!T_RS-!IFAMA!] = @!=! J O J X@!BOIEMA=Y!=I!; $ '!L>!] FLPF!?A4$ I=L>A?!L>?LKL?O=G@!] AMA!bO=M=>IL>A?/

 $T[W/ 7 AI=L>A?! J A>!=I!; $'!=MA!@GAAXL>Q!L>!PA660?] LIF!HLKA!IB!@L\!L>?LKL?O=60!L>!EO>Y4$ EA?@-!] FLPF!=MA!>BI!@L\!HAAI!=X=MI/! '66&8=GAM=!%= J LMAK! 7 AP/!=I!o!m!e#XX\!&&-!, \F/!)) -!=I!RSW4 $T_Zgl!5B@=!: GAIA@! 7 AP/!=I!o!a!e#XX\!&&-!, \F/!<<-!=I!T_U4_Wgl!5B>I=N!: O>Ak! 7 AP/!=I!o!S!e#XX\!&&-!, \F/!:::-!=I!RSR4S[gl!%B@=@!'=M?A>=@! 7 AP/!=I!o!m!e#XX\!&&-!, \F/!, , -!=I!RWm4S_gl!; AI=>PBOMI! 7 AP/!
=I!o!a!e#XX\!&&-!, \F/! 7 7 -!=I!RW4Wagl!: AMMALM=!; BMQA@! 7 AP/!=I!o!m!e#XX\!&&-!, \F/!&&-!T_S4RUg/!$FL@!
@GAAXL>Q!=MM=>QA J A>I! J =YA@!LI!L J XB@@LEGA!IB!MA J =L>!@L\!HAAI!=X=MI!=>?!XM=PILPA!@BPL=6!?L@I=>PL>Q/!
'66&5B@=!: GAIA@! 7 AP/!=I!o!a!e#XX\!&&-!, \F/!</T_S4RUg/!$LEL=>B!5B=MA@! 7 AP/!=I!o![!e#XX\!&&-!, \F/!..., \F/!...., \F/!..., \F/!...., \F/!...., \F/!...., \F/!...., \F/!...., \F/!...., \F/!...., \F/$

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 $T[S/ \ \ FA!?AI=L>A?!L>?LKL?O=6@!=MA!PGB@A!IB!A=PF!IBQAIFAM!] FA>!IFAN!A=I!EAP=O@A!IFA!$ PF=LM@!=MA!=II=PFA?!IB!IFA!HGBBM-!IFAN!F=KA!IB!@LI!=PMB@@!HMB J !A=PF!BIFAM!B>!IFA!I=EGA-!=>?!IFAMA!L@! $>BI!A>BOQF!MBB J !IB!MA J =L>!@L \!HAAI!=X=MI/\& '66! 8 = GAM=!\% = J LMAk! 7 AP/!=I!o!m!e # XX \!&\&-!, \F/!)) -!=I!$ $RSW4T_Zg1!5B@=!: GAIA@! 7 AP/!=I!o!RZ!e # XX \!&\&-!, \F/! < <-!=I!T_U4_Wg1!: AMMALM=!; BMQA@! 7 AP/!=I!o![! e # XX \!&\&-!, \F/!&<-!=I!O!m!e # XX \!&\&-!, \F/!, , -!=I!RWm4S_g1!\%B?=@!$ $"A?MB! 7 AP/!=I!o!RZ!e # XX \!&\&-!, \F/!OO-!=I!TRa4RSg/! 7 AI=L>A?!L>?LKL?O=6@!] =LI!L>!GL>A!KAMN!PGB@A!IB!$ $A=PF!BIFAM!] FLGA!] =LIL>Q!IB!A>IAM!IFA!?L>L>Q!F=66/! '66! 8 =GAM=!\% = J LMAk! 7 AP/!=I!o!m!e # XX \!&\&-!, \F/!$ $)) -!=I!RSW4T_Zg1!; AI=>PBOMI! 7 AP/!=I!o!a!e # XX \!&\&-!, \F/! 7 7 -!=I!RW4Wag/!$

 $TW_/ 5BJA!?AI=L>A?!L>?LKL?O=G@!=MA!A XAMLA>PL>Q!HGO!GLYA!@NJXIBJ@-!L>PGO?L>Q!PBOQF4 L>Q-!PB>QA@ILB>!=>?!?LHHLPOGIN!EMA=IFL>Q/!'66& !$

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TWR/ 7 A@XLIA!F=KL>Q!@N J XIB J @-!?AI=L>A?!L>?LKL?O=G@!F=KA!?LHHLPOGIN!EAL>Q!=EGA!IB!@AA!IFA! J A?LP=G!@I=HH!L>!=!IL J AGN! J =>>AM/! '66d

/!.>A!?AI=L>AA!]LIF!=>!O>EA=M=EGA!PBOQF!@OE JLIIA?!=!]MLIIA>!MABOA@I-!]A>I!I]LPA!IB!IFA!JA?4 LP=G!BHHLPA-!=>?!IFA>!PB J XG=L>A?!IB!=!OO=M?-!EAHBMA!FA!]=@!=GGB]A?!IB!@AA!=!?BPIBM/!'66@

/!

TWZ/ #!MAPA>IGN!IM=>@HAMMA?!?AI=L>A?!XAM@B>!MAXBMIA?!F=KL>Q!A>IAMA?!; \$ '!]LIF!=!E=?! PBG?!=>?!PBOQF-!EOI!]=@!>AKAM!IA@IA?!HBM!'. 8&74RS!BM!L@BG=IA?!HMBJ!IFA!QA>AM=G!XBXOG=ILB>/!'66!

TWU/ 7 AI=L>A?!L>?LKL?O=G@!F=KA!IMBOEGA!=PPA@@L>Q! J A?LP=G!=IIA>ILB>-!L>PGO?L>Q!HBM!@AML4 BO@!PFMB>LP!PB>?LILB>@!@OPF!=@!=@IF J =/! '66! !!

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g/! 2 A?LP=G!@I=HH!F=KA!EAPB J A!@B!BKAM] FAG J A?!] LIF! IFA!>O J EAM!BH!@LPY! J A>!?AI=L>A?!L>!IFA!H=PLGLIN!IF=I!B>A!?BPIBM!Q=KA!=>!L>?LKL?O=G!FL@!A>ILMA!EBI4 IGA!BH!EGBB?!XMA@@OMA! J A?LPL>A!IB!I=YA!B>!FL@!B] >-!@L>PA!@FA!>B!GB>QAM!F=?!IL J A!IB!?L@XA>@A!FL@! XLGG!MAQOG=MGN/! '66

 $TWa/ #I!GA=@I!U_!JA>!F=KA!EAA>!EMBOQFI!L>IB!; $'!L>!IFA!X=@I!HA]!]AAY@/!'66!; BMQA@! 7 AP/!=I!o!RU!e#XX\!&&-!, \F/!&&-!T_S4RUg/!1A]!?AI=L>A?!XABXGA!F=KA!EAA>!XG=PA?!LJJA?L=IAGN!L>IB!$ $@F=MA?!MBBJ@!]LIFBOI!EAL>Q!L@BG=IA?!HLM@I/!'66!; BMQA@!7AP/!=I!oRU!e#XX\!&&-!, \F/!&&-!T_S4RUg1!$ $%B@=@!'=M?A>=@!7AP/!=I!oRT!e#XX\!&&-!, \F/!, , -!=I!RWm4S_g/!. >A!QMBOX!BH!>A]!=MMLK=G@!P=JA!$

=EBOI!B>A!] AAY!=QB!HMB J ! (MB J A-!] FLPF!=GMA=?N!F=?!PB>HLM J A?! ' . 8 & 7 4RS!P=@A@-!=>?!IFAN!] AMA! XG=PA?!] LIF!IFA!QA>AM=G!XBXOG=ILB>!BH! ; \$ '/! '66! ; AI=>PBOMI! 7 AP/!=I!oRZ!e # XX\!&&-! , \F/! 7 7 -!=I!RW4 Wag/!&>?LKL?O=G@!?AI=L>A?!=I! ; \$ ' !] AMA!IBG?!IFA!L>HAPIA?!XAM@B>!=I! (MB J A!] =@!@A>I!FB J A/! '66& %B?=@! "A?MB! 7 AP/!=I!o! [!e # XX\!&&-! , \F/!00-!=I!TRa4RSg/!

TWm/ \$FAMA!=MA!>B!XMAP=OILB>@!I=YA>!IB!XMBIAPI!IFB@A!]FB!=MA!JA?LP=GGN!KOG>AM=EGA!IB! '. 8&74RS/!'66

TW[/ 7AI=L>A?!L>?LKL?O=6@!XMAX=MA!IFA!HBB?!=>?!PGA=>!=I!; \$'/!.>A!?AI=L>A?!XAM@B>! $]FB!XMAKLBO@GN!XMAX=MA?!IFA!HBB?!=I!; $' !MAXBMIA?!F=KL>Q!HGO!GLYA!@N J XIB J @/! '664
['!7AI=L>A?!L>?LKL?O=6@!]FB!]BW?!L>!IFA!YLIPFA>!?B!>BI!
[=6]=N@!]A=M!J=@Y@!]FA>!XMAX=ML>Q!IFA!HBB?!=>?!=MA!>BI!I=OQFI!'. 8&74RS!FNQLA>A!JA=@OMA@/!)B& =I!o!S!e#XX\!&&-!, \F/!''-!=I!R[Z4[SgI!%B?=@!"A?MB!7AP/!=I!o!RU!e#XX\!&&-!, \F/!00-!=I!TRa4RSg/!!
TWW/ 7AI=L>A?!L>?LKL?O=6@!F=KA!>BI!BE@AMKA?!QMA=IAM!AHHBMI@!IB!PGA=>!L>!MA@XB>@A!IB!
'. 8&74RS/!%B?=@!"A?MB!7AP/!=I!o!Ra!e#XX\!&&-!, \F/!00-!=I!TRa4RSg/! 2B@I!?AI=L>A?!L>?LKL?O=6@!
=MA!>BI!XMBKL?A?!]LIF!J=@Y@!BM!QGBKA@!]FA>!IFAN!PGA=>!PBJJB>!=MA=@/!'66&8=GAM=!%=JLMAK!7AP/!
=I!o!W!e#XX\!&&-!, \F/!))-!=I!RSW4T_ZgI!5B@=!:GAIA@!7AP/!=I!o![!e#XX\!&&-!, \F/!<<-!=I!T_U4_Wg/!
6FA>!=@YA?!IBIPGA=>!IFALM!PAGG@:IB>GN!B>A!X=LM!BH!QGBKA@!L@!XMBKL?A?/!'66&5B>=N!:O>AK!7AP/!=I!o!
R_!e#XX\!&&-!, \F/!::-!=I!RSR4S[g/!6FA>!J=@Y@!=>?!QGBKA@!!MA!=K=LG=EGA-IIFAN!=MA!B>GN!HBM!PGA=>4
L>Q-!BIFAM]L@A!IFAMA!L@!>B]=PPA@@!IB!QGBKA@!=>?!J=@Y@!'66&;AI=>PBOMI!7AP/!=I!o!m!e#XX\!&&-!, \F/!$

77-!=I!RW4Wag/!!

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TWS/ ; \$ '!@I=HH!>BI!O@L>Q!XMBIAPILKA!QA=M!A>IAM!GLKL>Q!H=PLGLILA@!=>?!O@A!IFALM!E=MA!F=>?@!IB!IBOPF!?AI=L>A?!L>?LKL?O=G@!=>?!IFALM!XAM@B>=G!EAGB>QL>Q@/!'66!; LEL=>B!5B=MA@!7AP/!=I!o!Ra!

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, \F/! ' '-!=I!R [Z4[Sgl!; AI=>PBOMI!7 AP/!=I!o!a!e#XX\!&&-!, \F/!77-!=I!RW4Wagl!: AMMALM=!; BMQA@!7 AP/! =I!o!S!e#XX\!&&-!, \F/!&&-!T_S4RUgl!5B@=!: GAIA@!7 AP/!=I!o!m!e#XX\!&&-!, \F/!<<-!=I!T_U4_Wg/!\$FAN! F=KA!>BI!EAA>!QLKA>!F=>?!@=>LILkAM/! '66!%B?=@!''A?MB!7 AP/!=I!o!W!e#XX\!&&-!, \F/!00-!=I!TRa4RSg/!!

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 $TST/ 7 AI=L>A?!L>?LKL?O=6@!F=KA!>BI!EAA>!QLKA>!=>N!HBM J = 6!A?OP=ILB>!=EBOI!FNQLA>A! J A=@OMA@!IB!XMAKA>I!IFA!@XMA=?!BH! ' . 8 & 7 4RS/! ' 66! ; LEL=>B!5B=MA@! 7 AP/!=I!o!RS!e # XX \!&&-! , \F/! ' ' -!=I!R[Z4[Sgl!; AI=>PBOMI! 7 AP/!=I!o!W!e # XX \!&&-! , \F/! 7 7 -!=I!RW4Wagl!: AMMALM=! ; BMQA@! 7 AP/!=I!o! Rm!e # XX \!&&-! , \F/!&&-!T_S4RUg-! 8 = 6AM=!%= J LMAk! 7 AP/!=I!o!RT!e # XX \!&&-! , \F/!)) -!=I!RSW4T_Zgl! % B@=@! ' =M?A>=@! 7 AP/!=I!o!W!e # XX \!&&-! , \F/! , , -!=I!RWm4S_gl!5B@=!: 6AIA@! 7 AP/!=I!o!W!e # XX \!&&-! , \F/! < <-!=I!T_U4_Wgl!5B>=N!: O>Ak! 7 AP/!=I!o!R [!e # XX \!&&-! , \F/!:: :-!=I!RSR4S [gl!%B?=@! '' A?MB! 7 AP/!=I!o! R [!e # XX \!&&-! , \F/!: :-!=I!RSR4S [gl!%B?=@! '' A?MB! 7 AP/!=I!o! R [!e # XX \!&&-! , \F/!: :-!=I!RSR4S [gl!%B?=@! '' A?MB! 7 AP/!=I!o! R [!e # XX \!&&-! , \F/!: :-!=I!RSR4S [gl!%B?=@! '' A?MB! 7 AP/!=I!o! R [!e # XX \!&&-! , \F/!: :-!=I!RSR4S [gl!%B?=@! '' A?MB! 7 AP/!=I!o! R [!e # XX \!&&-! , \F/!: :-!=I!RSR4S [gl!%B?=@! '' A?MB! 7 AP/!=I!o! R [!e # XX \!&&-! , \F/!: :-!=I!RSR4S [gl!%B?=@! '' A?MB! 7 AP/!=I!o! R [!e # XX \!&&-! , \F/!: :-!=I!RSR4S [gl!%B?=@! '' A?MB! 7 AP/!=I!o! R [!e # XX \!&&-! , \F/!: :-!=I!RSR4S [gl!%B?=@! '' A?MB! 7 AP/!=I!o! R [!e # XX \!&&-! , \F/!: :-!=I!RSR4S [gl!%B?=@! '' A?MB! 7 AP/!=I!o! R [!e # XX \!&&-! , \F/!: :-!=I!RSR4S [gl!%B?=@! '' A?MB! 7 AP/!=I!o! R [!e # XX \!&&-! , \F/!: :-!=I!RSR4S [gl!%B?=@! '' A?MB! 7 AP/!=I!o! R [!e # XX \!&&-! , \F/!: :-!=I!RSR4S [gl!%B?=@! '' A?MB! 7 AP/!=I!o! R [!e # XX \!&&-! , \F/!: :-!=I!RSR4S [gl!%B?=@! '' A?MB! 7 AP/!=I!o! R [!e # XX \!&&-! , \F/!: :-!=I!RSR4S [!e # XX \!&&-! , \F/!]) -!=I!RSW4T_Zgl!%B@=@! '' = A?A==!? AP/!=I!O!RT!e # XX \!&&-! , \F/!)) -!=I!RSW4T_Zgl!%B@=@! ''= M?A>=@! 7 AP/!=I!O!W!e # XX \!&&-! , \F/! , , -!=I!RWm4S_g/!!$

 $TSZ/ 7 AI=L>A?!L>?LKL?O=G@!F=KA!>B!=PPA@@!IB! J = @Y@!BM!QGBKA@-!AKA>!HMB J !IFA!PB J J L@4 @=MN/! ; BMQA@! 7 AP/!=I!o!RT!e#XX\!&&-!, \F/!&&-!T_S4RUg1! ; AI=>PBOMI! 7 AP/!=I!oR_!e#XX\!&&-!, \F/! 7 7 -! =I!RW4Wag/!$

TSU/ ; \$ '!@I=HH!MBI=IA!L>!=>?!BOI!BH!; \$ '!B>!=!MAQOG=M!E=@L@/!5I=HH!QA>AM=GGN!GLKA!L>!IFA!PB J J O>LILA@!>A=M!; \$ ' q =MA=@!] FAMA!IFAMA! J =>N!PB>HLM J A?!P=@A@!BH! ' . 8 & 7 4RS/!!

TSa/ ; \$ ' !F=@!=!FL@IBMN!BH!BOIEMA=Y@!BH!PB>I=QLBO!e#0500589.5789.9143 c mBT!

Wm!

> $TSm/ .>! 2 = MPF!R[-!T_T_!?AI=L>A?!XAM@B>@!=I!; $ '!] AMA!@OE^APIA?!IB!=!a4FBOM!] = IAM!$ @IBXX=QA-!?OML>Q!] FLPF!IFAN!F=?!>B!=PPA@@!IB!]=IAM!IB!]=@F!IFALM!F=>?@-!E=IFA-!BM!O@A!IFA!IBLGAI/^{[S}! #+%`G') FH@J>=H;[@G'HA'&@H@>H;A>'4JAVJ=W'

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TS [/ : BM!BKAM!Ra!NA=M@!!7 < 5f&', !F=@!@BOQFI!=>?!BEI=L>A?!PB>QMA@@LB>=G!HO>?L>Q!HBM! LI@!#GIAM>=ILKA@!IB!7AIA>ILB>!ei#\$7jg!XMBQM=J-!]FLPF!O@A@!@OXAMKL@A?!MAGA=@A-!P=@A!J=>=QA4 JA>I-!=>?!JB>LIBML>Q!BH!L>?LKL?O=G@!L>@IA=?!BH!?AIA>ILB>/^W-!&', !F=@!MAXA=IA?GN!IBG?!'B>QMA@@!IF=I! IFA!#\$7!XMBQM=J!L>PMA=@A@!&', `@!BXAM=ILB>=G!AHHAPILKA>A@@!=>?!L>?LKL?O=G!PBJXGL=>PA!]LIF!MA4 GA=@A!PB>?LILB>@/!!

[S!FIIX@Cff]]]/]GN>/BMQfXB@IfPBMB>=KLMO@4GLKA4OX?=IA@4I]B4EMB]=M?4AGAPILB>4XBGG4]BMYAM@4IA@I4XB@ILKA4PBKL?4RS|@IMA=Jf_!

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 $TSW/ \qquad \text{FA!} \ 7 < 5!: \ * T_TR! \ ' B>QMA@@LB>=G!; O?QAI!OO@ILHLP=ILB>!HBM!\&', !@I=IA@!IF=I!LI!PB@I@! \\ RTa/_m!XAM!?=N!IB!^=LG!=>!=?OGI!L J J LQM=ILB>!L>!\&', !PO@IB?N/!$FA!=KAM=QA!PB@I!XAM! # $ 7 !X=MILPL4 \\ X=>I!L@! \} U/UZ!XAM!?=N/!$FA! 7 < 5!: \ * T_TR!HO>?L>Q!MABOA@I!@AAY@!IB!@OXXBMI!RT_-___!?=LGN!X=MILPL4 \\ X=>I@!L>!# $ 7 /^WR!$

 $TSS/ # !T_RU!) # . !%AXBMI!HBO>?!IF=I!Sav!BH!IFB@A!B>!HOG64@AMKLPA!#$7!eIFB@A!IF=I!L>4$ $PGO?A!P=@A! J =>=QA J A>Ig!=XXA=M!HBM!IFALM!HL>=G!FA=ML>Q@/WT! # PPBM?L>Q!IB!T_R[!PB>IM=PI!?=I=-!@O4$ XAMKL@LB>!PBOXGA?!] LIF!@B J A!P=@A! J =>=QA J A>I!MA@OGI@!L>!=! J BMA!IF=>!SS v !=XXA=M=>PA!M=IA!HBM!=GG! L J J LQM=ILB>!PBOMI!FA=ML>Q@-!=>?!=! J BMA!IF=>!SR v !=XXA=M=>PA!M=IA!HBM!HL>=G!FA=ML>Q@/WZ!

 $\label{eq:started_st$

 $^{\rm WT}!$) # . 4Ra4Tm-!#GIAM>=ILKA@!IB!7AIA>ILB>-!=I!Z_!e1BK/!T_RUg-!=K=LG=EGA!=I! FIIX@Cff]]]/Q=B/QBKf=@@AI@fm[_fmmmSRR/X?H/!

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 $\label{eq:wz} \end{tabular} \end{tabular}$

<u>/%2)/'.*)0%5,*R</u>'

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 $Z_R/ = \$FA! 7 \text{ OA}! \text{"MBPA@@!'} = 0@A!XMBKL?A@!IF=I!>B!XAM@B>!@F=GG! i EA!?AXMLKA?!BH!GLHA-!GLE4$ AMIN-!BM!XMBXAMIN-!] LIFBOI!?OA!XMBPA@@!BH!G=] / j ! 9/5/! ' B>@I/!= J A>?/! 8 /!&I@!XMBIAPILB>@!A \IA>?!IB! AKAMN!XAM@B>!] LIFL>!IFA!>=ILB>`@!EBM?AM@!MAQ=M?GA@@!BH!L J J LQM=ILB>!@I=IO@/! *\$?7H6V<&LE& 1 8?M*-!UTm! 9/5/!m [-![[-!eRS [mg!ei , KA>!B>A!] FB@A!XMA@A>PA!L>!IFL@!PBO>IMN!L@!O>G=] HOG-!L>KBGO>I=MN-!BM!IM=>4 @LIBMN!L@!A>ILIGA?!IB!IF=I!PB>@ILIOILB>=G!XMBIAPILB>/jg/!

) K &:@'4JA?@GG'*;VXH'HA'*@=GA>=TF\'(=Y@'''A>74:>;H;[@'+;[;F'&@H@>H;A>'

 $Z_T/ ! 6 FA>!IFA!QBKAM> J A>I!I=YA@!=!XAM@B>!L>IB!PO@IB?N!=>?!?AI=L>@!FL J !=Q=L>@I!IFA!$ XAM@B>`@!] LGG-!IFA! ' B>@ILIOILB>!L J XB@A@!OXB>!IFA!QBKAM> J A>I!=!?OIN!IB!=@@O J A!MA@XB>@LELGLIN!HBM! $IF=I!?AI=L>AA`@!@=HAIN!=>?!QA>AM=G!] AGGEAL>Q/! '66&O6>>8: F&LE& $C ! 8: :6P-!a_S!9/5/!Ta-!ZT!eRSSZg/!$ 9>?AM!IFA!, LQFIF! # J A>? J A>I-!IFA!) BKAM> J A>I! J O@I!XMBKL?A!PML J L>=G!?AI=L>AA@!] LIF!E=@LP!FO4 J =>!>AA?@-!L>PGO?L>Q!MA=@B>=EGA!@=HAIN/!!)BE&!

$$\label{eq:started} \begin{split} & Z_Z/ \qquad \$FA!QBKAM>JA>I!KLBG=IA@!IFA!, LQFIF! \# JA>? JA>I!LH!LI!PB>HL>A@!=!PML JL>=G!?AI=L>AA! \\ & L>!O>@=HA!PB>?LILB>@/!)BE!=I!ZZ/!! \end{split}$$

 $Z_U/ = 6 \text{ FA} > !IFA !QBKAM > J \text{ A} > I! ?AI = L > @! = !XAM@B > !HBM!IFA !KLBG = ILB > !BH! = > !L J J LQM = ILB > !G =] -!$ IFA !XAM@B > !L@! = !PLKLG! ?AI = L > AA - !AKA > !LH!FA !F = @! = !XMLBM!PML J L > = G!PB > KLPILB > /! '66&Q?BLPB ? < &LE& 1 ?L8 < -! $aZZ! 9/5/!m[W-!mS_!eT_Rg/!$

 $Z_a/ # @!PLKLG!?AI=L>AA@-!"AILILB>AM@!=MA!A>ILIGA?!IB! J BMA!PB>@L?AM=IA!IMA=I J A>I!IF=>!$ $PML J L>=G!?AI=L>AA@-!] FB@A!PB>?LILB>@!BH!PB>HL>A J A>I!=MA!?A@LQ>A?!IB!XO>L@F/!5AA! $?;<H&LE&S>?E& 16A^7&9& *9;;E-!ZZ_!:/!#XX`\!R[S-!RWT!eRRIF!'LM/!T_Sg!ebOBIL>Q!$

WS!

!

Z_m/ \$FA!: LHIF! # J A>? J A>I! 7 OA! "MBPA@@! 'G=O@A!XMBFLELI@!XO>L@F J A>I!BH!XABXGA!L>!PLKLG! PO@IB?N/!46>>&LE& 5 9>@8<H-!UUR!9/5/!aT_-!aZa!>/Rm!eRS[Sgl! \$?F>I7?&LE& ' ?KA>6<-!Z[a!:/Z?!RTmS-! RT[Z!eRRIF! 'LM/!T__Ugl!O?KK&LE& 1 6R?>N& *7PE-![[U!:/T?!Ram[-!Ra[T!eRRIF! 'LM/!RSWag!ePLIL>Q!):= F; ?H?K&LE! 5 ;8FH7-!UZ_!9/5/!maR-!m[R!>/!U_!eRS[[gg/!

 $Z_{[/} $B!A@I=EGL@F!IF=I!=!X=MILPOG=M!PB>?LILB>!BM!MA@IMLPILB>!BH!?AIA>ILB>!PB>@ILIOIA@!L J 4$ XAM J L@@LEGA!XO>L@F J A>I-!=!XAILILB>AM! J O@I!@FB] !ALIFAM!eRg!=>!A \ XMA@@A?!L>IA>I!B!XO>L@FI!BM!eTg! $G=PY!BH!=!MA=@B>=EGA!MAG=ILB>@FLX!IB!=!GAQLIL J =IA!QBKAM> J A>I=G!XOMXB@A-!HMB J !] FLPF!=>!L>IA>I!IB!
XO>L@F! J =N!EA!L>HAMMA?/! '66& 5 9>&&<H-!UUR!9/5/!=I!aZW/!#E@A>I!=>!A \ XGLPLI!L>IA>ILB>!IB!XO>L@FI!BM!eTg!
PBOMI! J O@I!=XXGN!=!I] B4X=MI!IA@IC! i : LM@I-!=!PBOMI! J O@I!=@Y!] FAIFAM!=>N!rGAQLIL J =IA!QB=G`!] =@!
@AMKA?!EN!IFA!XML@B>!PB>?LILB>@/!5APB>?-!LI! J O@I!=@Y!] FAIFAM!IFA!PB>?LILB>@!=MA!rMA=@B>=EGN!MA4
G=IA?`!IB!IF=I!QB=6/j!$ *J?C9NP&LE&4* $?>BV8: & *7PE-!WZa! : /Z?!RZZW-!RZUa!eRRIF! ' LM/!T_Rmg/! i s&tH!PB>?L4
ILB>@!=MA!@B!A \ IMA J A!IF=I!GA@@!F=M@F!=GIAM>=ILKA@!=MA!A=@LGN!=K=LG=EGA-!IFB@A!PB>?LILB>@!PB>@ILIOIA!
rXO>L@F J A>I^`j!. 6>@?8; & & bN6; F-!WmW! : /5OXX/!RZSm-!RURT!e5/7/!) =/!RSSUg!ePLIL>Q! 5 9>&&<H-!UUR!
9/5/!=I!aZW4ZS!>/T g/!$

 $Z_W/ \quad is \ 6 \ tFA>!IFA!5I=IA!I=YA@!=!XAM@B>!L>IB!LI@!PO@IB?N!=>?!FBG?@!FL J !IFAMA!=Q=L>@I!FL@!$ $] \ LGG-!IFA! 'B>@ILIOILB>!L J XB@A@!OXB>!LI!=!PBMMA@XB>?L>Q!?OIN!IB!=@@O J A!@B J A!MA@XB>@LELGLIN!HBM!FL@!$ $@=HAIN!=>?!QA>AM=G!] \ AGG4EAL>Q/j! \ 1 \ 6 \ 'H?: \ 6P\ LE\& \ 5 \ 8:: \ 6N?F9\& \ 7PE\& \ 1 \ 6A^{7E\&}90\& \ '9CE\& \ '6; \ L</-!UWS! 9/5/!RWS-!$ $RSS4T_!eRSWSg/!$FA!QBKAM> J A>I! J O@I!XMBKL?A!?AI=L>A?!L>?LKL?O=G@!] \ LIF!E=@LP!>APA@@LILA@-!@OPF!$ =@!=?AbO=IA! J A?LP=G!P=MA-!HBB?-!PGBIFL>Q-!=>?!@FAGIAMI!IFA!H=LGOMA!IB!XMBKL?A!IFA@A!>APA@@LILA@!KLB4 $G=IA@!?OA!XMBPA@@/!O?KK-![[U!: /T?!=I!Ra [Z1! \ 99R\&6T\&; 6>E\&\%<7?76\&90\&. \ 6<<86; \ LE\& \ 'H6; \ 800\&90\& \ $9: ; 96\& \ *7P/-!U_T!: /Z?!R_ST-!RRRa!eRRIF! 'LM/!T_ag/!$

S_!

 $Z_S/ #I!=! J L>L J O J -!IFA!: LHIF! # J A>? J A>I! 7 OA! "MBPA@@! 'G=O@A!XMBFLELI@!%A@XB>?A>I@`! ?AGLEAM=IA!L>?LHHAMA>PA!IB!=!@OE@I=>IL=G!ML@Y!BH!@AMLBO@!F=M J !IF=I!] BOG?!ML@A!IB!IFA!GAKAG!BH!=>! , LQFIF! # J A>? J A>I!KLBG=ILB>!L>!IFA!XB@I4PB>KLPILB>!PML J L>=G!PB>IA\I/! "6L6; 6&LE& ?<<E& - 6: E& O9<AE-!UmZ! 9/5/!TZS-!TUU!eRSWZg!eis$tFA!?OA!XMBPA@@!MLQFI@!BH!=!s?AI=L>AAt!=MA!=I!GA=@I!=@!QMA=I!=@! IFA!, LQFIF! # J A>? J A>I!XMBIAPILB>@!=K=LG=EGA!IB!=!PB>KLPIA?!XML@B>AW/jgl!@66&?><9&O?>6&LE& . ?>>?A999<?&*7PE-!a_!:/!Z?!Ra[S-!RaWT!>/U!eRRIF! 'LW/!RSSag/!$

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 $ZR_{/} $B!?A J B>@IM=IA!IF=I!%A@XB>?A>I@!=MA!=PIL>Q!] LIF!?AGLEAM=IA!L>?LHHAMA>PA-!"AILILB>4$ AM@! J O@I!@FB] !A XB@OMA!IB!=!@OE@I=>IL=G!ML@Y!BH!@AMLBO@!F=M J !BH!] FLPF!%A@XB>?A>I@!=MA!=] =MA!=>?! F=KA!?L@MAQ=M?A?/!S?; K6; &LE&4; 6::?:-!aRR!9/5/!WTa-!WZU-!WZ[4ZW!eRSSUg]! \$?;NI;P&LE&5?;B6:-! $SZm!:/Z?!RTT[-!RTZZ!eRRIF!'LM/!T_RSg]!$

IM=QLP!AKA>Ij!EAHBMA!@AAYL>Q!MAGLAH!HMB J !=!PB>?LILB>!BH!PB>HL>A J A>I!IF=I!O>PB>@ILIOILB>=GGN!A>4 $?=>QAM@!IFA J /! '66!O6>>8: F-&a_S! 9/5/!=I!ZZ!eFBG?L>Q!XML@B>AM^@!, LQFI! # J A>? J A>I!PG=L J !PBOG?!EA!$ E=@A?!OXB>!XB@@LEGA!HOIOMA!F=M J !IB!FA=GIF-!=@!] AGG!=@!XMA@A>I!F=M J g/!!!

ZRZ/ i 1 BM!?BA@!LI! J = IIAM!IF = I!@B J A!L > J = IA@! J = N! > BI!EA! = HHAPIA?!EN!IFA!PB > ?LILB > != >?! IF = I!IFA!F = M J !L@!IFO@-!L > != !@A > @A - !B > GN!XBIA > IL = G!F = M J /!\$FA! 'BOMI!F = @!HBO > ?! = >! , LQFIF! # J A > ? J A > I! KLBG = ILB > !rAKA > !IFBOQF!LI!] = @! > BI! = GGAQA?!IF = I!IFA!GLYAGN!F = M J !] BOG?!BPPOM!L J J A ?L = IAGN! = > ?!AKA > ! $IFBOQF!IFA!XB@@LEGA!L > HAPILB > ! J LQFI! > BI! = HHAPI! = GG!BH!IFB@A!A \ XB@A?/^ j! . 877 > 6 & LE& J6@@6; <9 : & *7P/!$ $*9KK^{-} : -!R_! : /Z?!RaZa - !RaUZ!eRRIF! 'LM/!RSSUg!ebOBIL > Q!O6 >> 8 : F - !a_S! 9 / 5 /! = I!ZZg/!!$

6K'''\$X@')**''+,#'&A?HJ;>@''

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ZRa/ = 6 FLGA!KLBG=ILB>@!BH!iL>IAM>=G!=QA>PN!XMBPA?OMA@j!?B!>BI!=G] = N@!MAbOLMA!=!MA J A?N-! $OCC?; B8`@!MOGA!=XXGLA@!] LIF!HOGG!HBMPA!] FA>!iIFA!MLQFI@!BM!L>IAMA@I@!BH!IFA!BE^APIL>Q!X=MINj!=MA!i=H4$ HAPIA?/j! \$ 9:87>?&LE&), 'MSTm!: /T?!RmT-!Rm[!eT?/! 'LM/!RSSRg!ePLIL>Q!P=@A@g!ei # PP=M?L!?BPIML>A!L@! XMA J L@A?!B>!HO>?= J A>I=G!>BILB>@!BH!H=LM!XG=N!O>?AMGNL>Q!IFA!PB>PAXI!BH!?OA!XMBPA@@jgl!<66&?<9& $5 \& < 9: \&LE\& * 9KK^{,\&9@\&} '9CE\& '6CE-!Z[W!: /Z?!aUR-!aUa4Um!emIF! 'LM/!T_Ug!e>BIL>Q!IF=I!=>!OCC?;B8!KLB4$ G=ILB>! J = N!EA!=!?OA!XMBPA@@!KLBG=ILB>-!=>?!IFA!QBKAM> J A>I`@!=PILB>! J = N!EA!@AI!=@L?A!XOM@O=>I!IB! IFA! # "#gl!'?K66: ?Dk): CE&LE& 2E'E&O8;&S9;C6-!RU[!: /Z?!RRUW-!RRaZ!eSIF! 'LM/!RSSWg!ei #>!=QA>PN`@! H=LGOMA!IB!HB6GB] !LI@!B] > !MAQOG=ILB>@!/!/!/! J = N!MA@OGI!L>!=!KLB6=ILB>!BH!=>!L>?LKL?O=G`@!PB>@ILIOILB>=G!

!

+K' (H=H@'+J@=H@<'&=>V@J'

 $ZRm/ \qquad \text{FA!7 OA!" MBPA@@! ' G=O@A!iL J XB@A@!=!?OIN!B>!@I=IA!=PIBM@!IB!XMBIAPI!BM!P=MA!HBM!PLIL4}\\ kA>@!L>!] FA>!IFA!@I=IA!=HHLM J =ILKAGN!XG=PA@!=!X=MILPOG=M!L>?LKL?O=G!L>!=!XB@LILB>!BH!?=>QAM!IFA!L>?L4\\ kL?O=G!] BOG?!>BI!BIFAM] L@A!F=KA!H=PA?/j! - ;6F9; P&LE& *87P&9@& "9F6; <D&O;R-!S[U!:/T?!R_m-!R_R_! eWIF! ' LM/!RSSTg!eA>!E=>Pg/!$

ZR[/ \$FA!QBKAM> J A>I!KLBG=IA@!=>!L>?LKL?O=G`@!MLQFI!IB!?OA!XMBPA@@!]FA>!LI!eRg!i=HHLM J = 4 ILKAGN!XG=PAs@t!sIFAt!L>?LKL?O=G!L>!?=>QAM-j!eTg!EN!i=PIL>Q!]LIF!r?AGLEAM=IA!L>?LHHAMA>PA!IB!s=t! $Y>B]>!BM!BEKLBO@!?=>QAM^j!!6::6BP&LE&*87P&9@&''8BF6@86>B-!UZS!:/Z?!R_aa-!R_mT!eSIF!'LM'!T_mg!$ ebOBIL>Q! \$ I:F6; &LE&*87P&9@&->?<F9V

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ZRW/ i # !?OIN!BH!XMBIAPILB>!=ML@A@!] FAMA!IFA!@I=IA!F=@!=!PO@IB?L=G!MAG=ILB>@FLX!] LIF!IFA! L>?LKL?O=G-!=ML@L>Q!HMB J !@OPF!PLMPO J @I=>PA@!=@!L>P=MPAM=ILB>!L>!XML@B>!BM!L>KBGO>I=MN!PB J J LI4 J A>I!L>!=! J A>I=G!L>@ILIOILB>/j ! *1 ?L&<&LE& * ?;76;-*!aaa!: /Z?!S [S-!SWT!>/T!eRRIF! ' LM/!T__Sg/!\$FA!B>GN! MAG=ILB>@FLX@!IF=I!=OIB J =ILP=GGN!QLKA!ML@A!IB!=!QBKAM> J A>I=G!?OIN!IB!XMBIAPI!L>?LKL?O=G@!HMB J !F=M J ! O>?AM!IFA!@OE@I=>ILKA!?OA!XMBPA@@!PG=O@A!=MA!PO@IB?L=G!MAG=ILB>@FLX@!IFMBOQF!] FLPF!IFA!QBKAM>4 J A>I!?AXMLKA@!L>?LKL?O=G@!BH!IFALM!GLEAMIN!=>?!IFO@!BH!IFALM!=ELGLIN!IB!I=YA!P=MA!BH!IFA J @AGKA@/!! '66& 5 H876&LE&/6K ?CR<-'RWZ!: /Z?!RTaZ-!RTa[!eRRIF! ' LM/!RSSSg/!

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 $ZRS/ \qquad \$FA!QBKAN>JA>I!=PI@!] LIF!?AGLEAM=IA!L>?LHHAMA>PA!IB!=!Y>B] >!BM!BEKLBO@!?=>QAM! \\] FA>!LI!MAPBQ>LkA@!=>!O>MA=@B>=EGA!ML@Y!=>?!=PIO=GGN!Y>B] L>QGN!A \XB@A@!IFA!XAILILB>AM/! #>!O>4 \\MA=@B>=EGA!ML@Y!L>PGO?A@!HOIOMA!F=MJ !P=O@A?!EN!PB>?LILB>@!BH!PB>HL>AJA>I/! '66&O6>>8: F&LE& $C!8:=:6P-!a_S!9/5/!Ta-!ZZ!eRSSZg/!$

<u>+)!(%(',.')+\$#,'''</u>

+, ! ''\$', ''%'7') - -). /0'&, +\$*#''%'E.#.\$-') 0%''&0%''\$b)4)0'c

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 $ZTS/ \qquad \%A@XB>?A>I@!F=KA!>BI!L J XGA J A>IA?!=?AbO=IA!@BPL=G!?L@I=>PL>Q!XM=PILPA@/!*9K=A?;6&'7'!) OL?=>PA!=I!RR!e#XX\!&-!, \F/!:-!=I!aWgI!V87H&7 APG=M=ILB>@!BH!&>?LKL?O=G@!7 AI=L>A?!=I!=GG!IFMAA!H=PLGLILA@C! (MB J A!e 6 = M@=>A!7 AP/-!<=@=>!7 AP/-!:=M=F!7 AP/-!#MM=Y!7 AP/gI!) G=?A@!e$

L>!PGB@A!@GAAXL>Q-!A=IL>Q-!=>?!GLKL>Q!bO=MIAM@!=I! (MB J A-!) G=?A@-!=>?!; \$'/!!:OMIFAM-!EAP=O@A!%A4 @XB>?A>I@!P=>!=>?!@FBOG?!MAGA=@A!"AILILB>AM@!=>?!IFB@A!@L J LG=MGN!@LIO=IA?-!iPBFBMI!bO=M=>IL>Aj!L@! >BI!IFA!B>GN!i=K=LG=EGA!BXILB>/j!!!

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ZZT/ 'BFBMIL>Q!L@!>BI!IFA!@= J A!=@!bO=M=>IL>A!BM! J A?LP=G!L@BG=ILB>!=>?!IFA! '7 '! J =YA@! LI!PGA=M!IF=I!PBFBMIL>Q!L@!IB!EA!O@A?!B>GN!=@!=!G=@I!MA@BMI!L>!IFB@A! i PBMMAPILB>=G!H=PLGLILA@!=>?!?AIA>4 ILB>!PA>IAM@!?B!>BI!F=KA!A>BOQF!L>?LKL?O=G!PAGG@j !HBM!bO=M=>IL>A!BM! J A?LP=G!L@BG=ILB>/!&>IAML J !) OL?=>PA-!=I!Z-!Ra!e#XX\-!, \F/!:-!=I!a_-!mTg/!\$FA! '7 '!=>?!BIFAM! J A?LP=G!A\XAMI!BXL>LB>@!PB>4 HLM J !IF=I!PBFBMIL>Q!L>?LKL?O=G@!] FB!F=KA!>BI!EAA>!PB>HLM J A?!IB!EA!L>HAPIA?!] LIF! '. 8&74RS! i XOI@!AKAMNB>A!=I!KAMN!FLQF!ML@Y!BH!PB>IM=PIL>Q!=>?!@XMA=?L>Q! '. 8&74RS/j!5FL>!7APG/-!o!ZZ! e, \F/!Tg/!!!

 $ZZZ/ .>! 2 = MPF!ZR-!T_T_!IFA! "MA@L?A>I!OX?=IA?!IFA!QOL?=>PA-!MA>= J L>Q!LI!iZ_!7=N@!IB!$ 56B] !IFA!5XMA=?-j!=>?!=6B>Q!] LIF!IFA! 6 FLIA!<BO@A! ' BMB>=KLMO@!\$=@Y! : BMPA!OMQA?!# J AMLP=>@!IB!
PB>IL>OA!IB!=?FAMA!IB!IFA! ' 7 ' !QOL?AGL>A@!=>?!A\X=>?!PB J J O>LIN! J LILQ=ILB>!AHHBMI@/j! .>!#XMLG!R-!

 $PB J XGN!] LIF! ' 7 ' !QOL?AGL>A@!B>!@BPL=G!?L@I=>PL>Q!=>?!bO=M=>IL>L>Q!O>GA@@!%A@XB>?A>I@!MAGA=@A! ?AI=L>A?! J A>!=>?!] B J A>!B>!=!G=MQA!@P=GA/j!!)BE&=I!oo!ZS4U_/!!7M/!5FL>!PB>PGO?A?!IF=I!LI!L@!i J N! XMBHA@@LB>=G!BXL>LB>!IF=I!H=LGOMA!IB!MAGA=@A!?OML>Q!IFA! ' . 8&74RS!X=>?A J LP!L@!=!KLBG=ILB>!BH!IFA!$

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XG=PA!" AILILB>AM@!=I!QMA=IAM!ML@Y!BH!PB>IM=PIL>Q!" . 8 & 7 4RS!EN!L J XGA J A>IA?!XM=PILPA@!IF=I!IM=>@HAM!XABXGA!L>IB!=>?!BOI!BH!H=PLGLILA@-!=>?!A J XGBN@!PBFBMI!bO=M=>IL>L>Q!=XXMB=PF!h!IF=I!?M=@ILP=GGN!L>4PMA=@A@!IFA!?=>QAM!BH!IFA!KLMO@!@XMA=?L>Q/!%A@XB>?A>I@!F=KA!=PIA?!] LIF!?AGLEAM=IA!L>?LHHAMA>PA!IB!IFA!PGA=M!AGAK=IA?!GAKAG@!BH!IFMA=I!P=O@A?!IB!" AILILB>AM@/!!

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ZaT/ !%A@XB>?A>I@!F=KA!=HHLM J =ILKAGN!XG=PA?!"AILILB>AM@!L>!?=>QAM!EN!HBMPL>Q!IFA J !L>IB! $=!XB@LILB>! J BMA!?=>QAMBO@!IF=>!LI!HBO>?!IFA J -!A \XB@L>Q!IFA J !IB!AGAK=IA?!?=>QAMBO@!EN!H=LGL>Q!IB!$ HBGGB] L>Q! ' 7 ' !QOL?AGL>A@!L>PGO?L>Q!EN!IM=>@HAMML>Q!XABXGA!= J B>Q!H=PLGLILA@!=>?!L J XMBXAMGN!O@4 L>Q!PBFBMI!bO=M=>IL>A@!L>!=! J =>>AM!IF=I!XG=PA@!"AILILB>AM@!L>!=! J BMA!?=>QAMBO@!@LIO=ILB>!IF=I!LI! HBO>?!IFA J /!%A@XB>?A>I@! J =?A!IFA!=HHLM J =ILKA!?APL@LB>!IB!>BI!MAGA=@A!"AILILB>AM@!BM!O@A! # \$ 7 @-! =>?!L>@IA=?!L J XGA J A>IA?!PBFBMI!bO=M=>IL>A@!L>!=! J =>>AM!IF=I!?M=@ILP=GGN!L>PMA=@A!IFA!XB@@LELGLIN! BH!IM=>@ J L@@LB>-!L>HAPILB>-!=>?!H=PLGLIN4] L?A!BOIEMA=Y!EN!QMBOXL>Q!IBQAIFAM!XABXGA!] FB!F=KA!=G4 $MA=?N!EAA>!A \XB@A?!IB!IFA!KLMO@/! '66&5FL>! 7 APG/!OU_!e , \F/!Tg!!) MAAM! 7 APG/-!ooZU4Za!e , \F/!Zg/!!!!$

 $ZaZ/ \qquad \%A@XB>?A>I@!PB>IL>OA!IB!?AI=L>!"AILILB>AM@!]LIFBOI!I=YL>Q!>APA@@=MN!XMAP=OILB>@!$ $IB!MA?OPA!IFA!ML@Y!BH! ' . 8&74RS!IM=>@JL@@LB>/!%A@XB>?A>I@!F=KA!IFO@!A\XB@A?!"AILILB>AM@!IB!=!$ QMA=IAM!ML@Y!BH!PB>IM=PIL>Q! ' . 8&74RS!IF=>!IFAN!]BOG?!F=KA!BIFAM]L@A!H=PA?/!

 $R_T!$

H=PA!LH!IFAN!] AMA!>BI!L>!?AIA>ILB>!=>?!] AMA!=EGA!IB!I=YA!>APA@@=MN!XMAP=OILB>@!IB!XMBIAPI!IFA J 4 @AGKA@/!

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Za[/ %A@XB>?A>I@!L J XGA J A>IA?!=!PBFBMI!bO=M=>IL>A!=XXMB=PF!IF=I!?BA@!>BI!PB J XGN!] LIF! ' 7 ' !QOL?AGL>A@!=>?!?M=@ILP=GGN!L>PMA=@A@!IFA!ML@Y!BH! ' . 8&7

<u>4*)8%*'.,*'*%/#%.'</u>

6 <, %, : . %, ! "AILILB>AM@!MAbOA@I!IF=I!IFA! ' BOMI!QM=>I!IFA!HBGGB] L>Q!MAGLAHC!!

=/ #@@O J A!^OML@?LPILB>!BKAM!IFL@! J =IIAM1!

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E/ , >^BL>!%A@XB>?A>I@!HMB J !IM=>@HAMML>Q! "AILILB>AM@-!=>?!IFA!PG=@@!IFAN!MAXMA@A>I-! HMB J ! (MB J A-!) G=?A@-!BM! ; \$ ' -!O>ILG!IFA! ' BOMI!F=@!?APL?A?!IFL@!=PILB>1!!

 $P/ \qquad \& @@OA!=! \ 6 \ MLI!BH! <= EA=@! \ ' \ BMXO@!B>!IFA!QMBO>?!IF=I!% A@XB>?A>I@`!PB>IL>OA?!?AIA>4 \\ ILB>!BH! " AILILB>AM@-!=>?!IFA!PG=@@!IFAN!MAXMA@A>I-!KLBG=IA@!IFA! 7 OA! " MBPA@@! \ G=O@A!=>?!BM?AM!IFA! \\ L J J A ?L=IA!MAGA=@A!BH! " AILILB>AM@!=>?!IFA!PG=@@!IFAN!MAXMA@A>I-!] LIF!=XXMBXML=IA!XMAP=OILB>=MN! \\ XOEGLP!FA=GIF! J A=@OMA@1! \\ \end{cases}$

?/ &@@OA!L>^O>PILKA!MAGLAH!BM?AML>Q!%A@XB>?A>I@!IB!L J J A?L=IAGN!MAGA=@A! "AILILB>AM@! =>?!=GG!@L J LG=MGN!@LIO=IA?!?AI=L>AA@!L>! (MB J A!5AMKLPA! "MBPA@@L>Q! ' A>IAM-!) G=?A@! ' BO>IN! 7 AIA>4 ILB>! ' A>IAM-!=>?! ; MB] =M?!\$M=>@LILB>=G! ' A>IAM!] LIF!=XXMBXML=IA!XMAP=OILB>=MN!XOEGLP!FA=GIF! J A=@OMA@-!B>!IFA!QMBO>?@!IF=I!PB>IL>OA?!?AIA>ILB>!KLBG=IA@!IFA!PB>@ILIOILB>=G! 7 OA! "MBPA@@!MLQFI@! BH! "AILILB>AM@!=>?!IFA!PG=@@!IFAN!MAXMA@A>II!!

A/ &@@OA!=!?APG=M=ILB>!IF=I!%A@XB>?A>I@`!PB>IL>OA?!?AIA>ILB>!BH!"AILILB>AM@!=>?!=66! PG=@@! J A J EAM@!PMA=IA@!=>!O>?OA!L>PMA=@A?!ML@Y!BH!@AKAMA!L66>A@@!BM!?A=IF-!=>?!IFO@!KLB6=IA@!IFA! 7 OA!"MBPA@@! ' G=O@A1!!

Q/ #] =M?! "AILILB>AM@!IFALM!PB@I@!=>?!MA=@B>=EGA!=IIBM>AN@`!HAA@!L>!IFL@!=PILB>!O>?AM! IFA!, bO=6! # PPA@@!IB!OO@ILPA! # PI!ei, #0 # jg-!=@!= J A>?A?-!a!9/5/ '/!u!a_U!=>?!TW!9/5/ '/!u!TURT-!

R_U!

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=>?!B>!=>N!BIFAM!E=@L@!^O@ILHLA?!O>?AM!G=]1!=>?!!			

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) M=>I!=>N!BIFAM!=>?!HOMIFAM!MAGLAH!IF=I!IFL@! ' BOMI! J =N!?AA J !HLI!=>?!XMBXAM/!
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7 = IA?C!! # XMLG!RZ-!T_T_! ! !
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                                      %A@XAPIHOGGN!@OE J LIIA?-!
                                      ; NC!<u>f@f!%AEAPP=!5F=MXGA@@</u>!!!!!!!
                                      %,;,''#!5<#%"+,55!
                                      :GBML?=!;=M!1B/!_RZR_TU!
                                      \% . 2 * !+, \% 1, \% !
                                      :GBML?=!;=M!1B/!RRm[RZ!
                                      (#$#%&1#!2/!) . 2 , 3-!+=]!5IO?A>I!
                                       2, \%, 7\& <!<. :: 2 \# 1-!+= ] !5I0?A>I!
                                       2 #%&#!#/!++ . % , 15-!+=]!5IO?A>I!
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                                       .+\&8\&\#!)/!"\#\%\&5,-!+=]!5IO?A>I!
                                       2 #%&#!#/!"&5,++&-!+=]!5IO?A>I!
                                      91\&8, \%5\&\$*! : : ! 2 &# 2 &! 5 ' < . . +! . : ! + # 6 !
                                      & 2 2 & ) % # $& . 1! ' + & 1 & '!
                                      RZRR! 2 LGGAM! 7 MLKA! 5 OLIA-!, 4T [Z!
                                       'BM=G!) =EGA@-!: GBML?=!ZZRUm!!
                                      $AGC!eZ_ag!TWU4Za[m!
                                      :=\C!eZ_ag!TWU4m_ST!
                                      M@F=MXGA@@ \sim G= ] / J L= J L/A?O!
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> 2 #% (!# 1 7%, 6!"% # 7 #! :G=/!;=M!1B/!SRSS[! #1\$<.1*!%&'<#%7!7.2&1)9,3! :G=/!;=M!1B/!R_TTZU! "% # 7 #!9%&3#%-!"++'! ZRSR!'BM=6!6=N-!50LIA!a_!

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<u>4%\$#\$#, ''%*74/)#''\$#..(`'1%*#.#+)\$#, '''</u>

$\&!= \mathbf{J} ! @OE \mathbf{J} LIIL > Q!IFL@!KAMLHLP = ILB > !B > !EAF = GH!BH!IFA! "AILILB > AM4 "G=L > ILHH@!EAP = O@A!\&! = \mathbf{J} !B > A!BH!$