!

!""#""$#%&' ( )'*(++#,'-%.'/0%1'*(%1#%&,-&0(%"' 0%!"#$#%#&' %#"()# '

!"#$%&'&(#)*$+,(#'&'"#$%'&$%'#'.(/'!'()%*' +!)#$!'01'$,(-($%(' +2)&',,'3$%4',(*$ 5').(6$.(/(0% +!)#)*$%4'/'7'$ 12#3*!4(*%) +8,'*$!'0(&'&$ 536()(#!78$!(9#!9'#(:&$ %".('!,3*-%:*%

! !"#$%&'()*(+",&-(.#/01#02(31/40,5/&/(6"%"'5/"(70%"1&"1(80%/(9":;$52(<=>??(80%/2(70%"1&"12(6"%"'5/"
" !"#$%&'()*(@1*),:"&/#5("1A(9):;$&/1B2(31/40,5/&/(.$%&"1(C"/1"%(DE/A/12(F05$&(9":;$52(G0,01BB"1$2(6"%"'5/" (

!"#$%&'$((H$0(&)(0#)1):/#(B,)I&-("1A(/1#,0"50A(-$:"1("#&/4/&/052(%",B0(":)$1&5( )*(:0&"%(;)%%$&"1&5(-"40(E001(A/5#-",B0A(/1&)(&-0("J$"&/#(014/,)1:01&K("#$#%#&'%#"()#(*-/#-(/5("(*/%&0,(*00A0,(#)#L%0(5;0#/052(#"1("#&("5("1(/1A/#"&),(&)(04"%$"&0(&-0(;,0501#0( )*(:0&"%(0%0:01&5K(@&(/5("(;,):/101&(#)#L%0(5;0#/05("1A("1(/:;),&"1&(;,)&0/1(5)$,#0(/1(.)$&-0"5&(D5/"K(G-$52(&-/5(5&$A'("/:5(&)(04"%$"&0(&-0(A/5&,/E$&/)15(%#:0&"%5(/1(#)::0,#/"%/50A(!"#$#%#&'%#"()#(5":;%0A(*,):(80%/(I0&(:",L0&2("1A(&)("55055(&-0(5"*0&'()*(#)15$:;&/)1($5/1B(G",B0&(M"N",A(O$)&/01&5(PGMOQK(G-0(#)1#01&,"&/)15()*(9$2("1A(C1(/1(&-)50(5":;%05(I0,0(A0&0,:/10A($5/1B(&-0("#/A(A/B05&/)1(:0&-)A2(I-/#-("5(E001(40,/*/0A(I/&-(5&"1A",A(,0*0,01#0(:"&0,/"%(K"50A()1(&-0(*/1A/1B52(:0&"%(#)1#01&,"&/)15(/1(!"#$#%#&'%#"()#(*)%%)I0A(&-0(),A0,()*R(C1(S(9$K(G-0(A/**0,01#05(/1(:0&"%("##$:$%"&/)1( )E50,40A(/1(!"#$#%#&'%#"()#(0,0(;,)E"E%'(A$0(&)(&-0(A/**0,01#05(/1(&-0/,(014/,)1:01&"%(#)1A/&/)15K(T05$%&5(*,):(;,0%/:/1","(,/5L("55055:01&5(5$BB05&(&-"&(&-0(,/5L5(;)50A(E'(:0&"%5(4/"(#)15$:;&/)1(!"#$#%#&'%#"()#(*),(9$("1A(C1(I0,0(I/&-/1(&-0(&)%0,"E%0(,0B/)1K(G-0(M"N",A(O$)&/01&(PMOQ( )*2(9$("1A(C1(I"5(U(<2(/1A/#"&/1B(1)(;)&01&/"%(-$:"1(-0"%&-(,/5LK((M)I040,2(/&(/5("A4/5"E%0(&)(%/:/&(&-0(/1&"L0()*(!"#$#%#&'%#"()#(&)(,0A$#0(&-0(,/5L()*(;)&01&/"%(-0"%&-(0**0#&5K

! " #$%&'()*%+'$

5;/(*&! %9! /6;! ;9<%$89);9/! =(9! =8);! :$8)! (! <($%;/>! 8:! &83$=;&+! %9=*3#%9?! 28/6! 9(/3$(*! ?;8*8?%=! &83$=;&! (9#! 63)(9! &83$=;&A! 1&! (! $;&3*/! 8:! ;=898)%=! ?$8B/6! (9#! 63)(9! (=/%<%/%;&+! *($?;! ()839/&! 8:!);/(*&! 6(<;! 2;;9! #%&=6($?;#! %9/8! /6;! (C3(/%=! ;9<%$89);9/! DEF 5;/(*&! ($;! ()89?! /6;! G8**3/(9/&! /6(/! 3&! 2;! (##$;&&;#! #3;! /8! /6;%$! *89?! G;$&%&/;9=;! G8/;9/%(*A! H8**8B%9?! /6;%$! %9/$8#3=/%89! %9/8! /6;! (C3(/%=! ;9<%$89);9/+!);/(*&!)(>! 2%8(==3)3*(/;#! 2>! (C3(/%=! &G;=%;&! (9#! 2%8)(?9%:%;#! (*89?! /6;! :88#! =6(%9?! %9! %9(;*;<(/;#! *;<;*&! %9! G$;#(/8$&! (9#! /6;! 63)(9! 28#>A! I&&;9/%(*!);/(*&+! &3=6! (&! J3! (9#! ,9+! $;C3%$;#! %9! #;:%=%;9/! ()839/&+! =(9! 6(<;! (#<;$&;! 2%8*8?%=(*! =89&;C3;9=;&! (/! 6%?6

[#] !9),,05;)1A/1B("$&-),V(5-"-/,$%W$:LK0A$K!(

!

© The Authors, published by EDP Sciences. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).

!

=89=;9/$(/%89&!K/6;$&+!&3=6!(&!J#+!($;!/8L%=!(9#!6($):3*!;<;9!(/!*8B!=89=;9/$(/%89&+!B6%=
=(9!=(3&;!/8L%=%/>!;::;=/&!!DMF

! 5;/(*&! %9! &3$:(=;! B(/;$+! &3&G;9#;#! B(&/;+! (9#! &;#%);9/+! (9#! %9/;$&/%/%(*! B(/;$+! :8$
;L()G*;+!($;!=89&/(9/*>!%9!=89/(=/!B%/6!=8D-N!&A!.6;!=8=-*&;$!#'7"='$%&!$;=8?9%&;#!(&!
(!*8B@G$%=;#!&83$=;!8:!G$8/;%9!%9!/$8G%=(*!($;(&+!G($/%=3@Q*>%9!/6;!"9#89!(9#!
;=898)%=!%)G8$/(9=;!%9!5(*(>&%(A!"9!5(*(>&%(9!:%&6%9?!<%**(8;&<#?/6;$8)!
2;(=6!2;#&!%&!(!G8G3*($!(=/%<%/>!#3;!/8!;#%2*;!&G;=%;&A!P%9=;!/6;>!($;!&;&&%*;+!:%*/;$!8$
:;;#;$&!B%/6!(!6%?6!:%*/;$%9?!$(/;+!$;&/$%=/;#!%9!/6;%$!=(G(=%/>!/8!2%8/$(9&:8$)!/8L%9&+
(!6%?6!/8*;$(9=;!/8!&;<;$(*!:8$)&!8:!G8**3/%8&!D@Q*!+!'B;$;!8:/;9!3/%*%&;#!%9!G$;<%83&!
&/3#>!(&!2%8)89%/8$%9?!8$?(9%&)A!DR+

! .6;$;:8$;+! %/! %&! 8:! ?$;(/! =89=;$9! /8! -98B! /6;! G8&&%2%*%/>! 8:! /6;&;! =89/()%9(9/&! /8
(==3)3*(/%9?!%9!/6;!<#'7"='!/8!;9&3$;!/6;!%9/(-;!&/(>&!B%/6%9!(==;G/(2*;!*%)%/&A!
8:!/6;%$!/;9#;9=>!/8!#;G8&%/!);/(*&!%9&%#;!/6;%$!/%&&3;&+!:%*/;$!:;;#;$!&<#'7"='!&3=6!(&!
6(<;!*89?!2;;9!3&;#!(&!2%8)89%/8$%9?!8$?(9%&)&!/8!#;/;=/!);/(*!G8**3/%89&+!(!&/3#>!
89!8;$<#'7"='!B(&!=89#3=/;#!%9!8$#;$!/8!(&&;&&!$%&-!/8!63)(9!=89&3)G/%89A

, " -.%/&+.01".$("-/%2'(1 "

. 6;!8;$<#'7"=' !V9WNXY!B(&!G3$=6(&;#!%9!'3*>!/8!P;G/;)2;$!MXMM!:$8)!';*%!B(/!($-;/A!
&()G*;&!B;$;!G(=-;#!%9!*8@;9&%/>!G8*>;/6>*;9;!&()G*;%9?!2(?&+!$;:$%?;$(/;#!%9!(9!%=;!28L+!
(9#!/$(9&G8$/;#!/8!/6;!*(28$(/8$>!/6;!&();!#(>!T;:8$;!#%&&;=/%89+!/6;!&G;=%);9&!B;$;!G*(=;#!
%9!(!MX!ZJ!:$;;0;$!(9#!/6;%$!*;9?/6!(9#!B;%?6/!B;$;!);(&3$;#A!.%&&3;!8:!<#'7"='$/6(/!6(#!
2;;9!$;)8<;#!:$8)!/6;%$!&6;**&!B;$;!=*;(9;#!(9#!&;<;$(*!/%);&!B%/6!#;%89%0;#!B(/;$!2;:8$;!#$%;#!
%9!/6;!8<;9!(/!EEX!ZJ!/8!(=6%;<;!=89&/(9/!B;%?6/A!$%;#!/%&&3;!B(&!G3*<;$%&;#!B%/6!(!
G;&/*;!(9#!)8$/($!/8!%)G$8<;!&()G*;!68)8?;9;%/>+!(9#!/6;9!-;G/!%9!(!#;&%==(/8$

2.1 Laboratory procedure!

1**!=6;)%=(*&!3&;#!B;$;!8:!(9(*>/%=(*!C3(*%/>+!B6;$;!=89=;9/$(/;#!9%/$%=!(=%#![V47K
VB\BYY!&8*3/%89!B;$;!8:!P3G$(C3(*%/>A!J;$/%:%;#!];:;$;9=;!5(/;$%(*&!!1@TQMM!
V/$(=;!;*;);9/&!%9!:%&6!)3&=*;Y!:$8)!"9&/%/3/;!:8$!];:;$;9=;!5(/;$%(*&!(9#!5;(&3$;);9/&!
V"]55+!T;*?%3)Y!B(&!3&;#!/8!(&&;&&!/6;!(==3$(=>!8:!);(&3$;);9/!);/68#&!:8$!);/(*&!%9!8;$
<#'7"=' A!1GG$8L%)(/;*>!EAX!?!8:!#$%;#!&()G*;&!B;$;!#%&$;=/>!B;%?6;#!%9/8!(!RX!)*!2;(-;$!
(9#!#%?;&/;#!8$!/6;!:%$&/!683$!89!(!68/!G*(/;!(/!QX!ZJ!B%/6!EXX!)*!8:!=89=;9/$(/;#!47K A!.6;!
/;)G;$(/3$;!B(&!/6;9!%9=$;(&;#!/8!EQX!ZJ!(9#!-;G/!/6;$;!:8$!(98/6;$!N!683$&A!.&8!
G$8=;&&!B(&!=8)G*;/;#!B6;9!(**!/%&&3;!&()G*;&!B;$;!=8)G*;/;*>!#%&&8*<;#!(9#!(!=*;(%A
(**8B!/6;!&()G*;!/8!=88*!/8!$88)!/;)G;$(/3$;!2;:8$;!2;%9?!(##;#!/8!(!MRX!)*<8*3);/$%=!
:*(&-!8:!#832*;@#%&/%**;#!B(/;$A!=*;($!&()G*;!B(&!:%*/;$;#!<%(!(!XAQR!)!O.HI!);)2$(9;A!
^%*3/;#!&()G*;!&8*3/%89&!B;$;!/6;9!-;G/!%9!=;9/$%:3?;!/32;&!(/!/;)G;$(/3$;!&!2;*8B!_ZJ+!(9#!
=89=;9/$(/%89&!B;$;!#;/;$)%9;#!3&%9?!(9!%9#3=/%<;*>!=83G*;#!G*(&)(!)(&&!&G;=/$8);/;$

2.2 Calculation and analyses!

1**!&/(/%&/%=(*!(*=3*(/%89&!B;$;!=($$%;#!83/!3&%9?!/6;!&8:/B($;!G(=-(?;&+!5%=$8&8:/`!IL=;
MXMX!(9#!P1P`'5O`!<;$&%89!1A! (9(*>&%&!8:!<($%(9=;!V17Kb1Y!B(&!;)G*8>;#!/8!
(9(*>&;!/6;!&%?9%:%=(9/!#%::;$;9=;!2;/B;;9!/6;!&/3#%;#!!";9/$!"9!/6%&!&/3#>+!/6;!
);/68#8*8?>!:8$!;&/%)(/%9?!/($?;/!6(0($#&!G$8<%#;#!(9!%9#%=(/%89!8:!63)(9!6;(*/6!$%&-!&
$;*(/;#!/8!G8**3/(9/!;LG8&3$;A!1&!(!$;&3*/+!/6;!C3(/%89!3&;#!/8!;&/%)(/;!/6;!6(0($#!C38/%;9/!%&
(&!:8**8B&!DaF

! "#$!%! $\frac{EDI}{RfD}$! ! ! ! ! ! ! #!$!

!

!

! .6;!/($?;/!6(0($#!C38/%;9/!V.4dY!%&8()!G=*%=(/;#!+($%(2*;!/6(/!%&!:$;C3;9/*>!3&;#!/8!
;<(*3(/; !/6;!G8&&%2%*%/>!@(!9=*%98?;9%=!$$%*&/-&!/8!*89?@$)!;LG8&3$;!/8!6;(<>!
);/(*&! :$8)! #%;/($>! &83$=;&! &3=6! (&! B(/;$! (9#! (C3(/%=! *%:;A! H3$/6;$)8$;+! .4d!);$;*>!
#%&G*(>&!(!$%&-!*;<;*!(&&8=%(/;#!B%/6!G8**3/(9/!;LG8&3$;!23/!#8;&!98/!(&&;&&!/6;!#(9?;$&A!
$(/%8!%&!*;&&!/6(9!E+!/6;!;LG8&;#!G8G3*(/%89!%?;$!(9#!%/!%&!&(:;A!48B;<;$+!/6;$;!%&!(!
=6(9=;!/6(/!/6;!%9<;&/%?(/;#!);/(*!B%**!6(<;!9;?(/%<;!6;(*/6!%)G(=/&!B6;9!/6;!$(/%8!%&!*($?;$!
/6(9!E!DaFA!.6;!6(0($#!(9(*>&%&!B(&!3/%*%&;#!(&!/6;!%9%/%(*!&/(?;!%9!(!G$8=;#3$;!/8!#;/;$
/6;!$%&-!(&&8=%(/;#!B%/6!8;$<#'7"=' !%9?;&/%89A

3" 4/1)0%1".$("5+1*)11+'$ "

.8!;9&3$;!/6;!(==3$(=>!8:!/6;!(=%#!#%?;&/%89!G$8=;&&+!=;$/%:%;#!$;:;$;9=;!)(/;$%(*!VI]5` @
TTQMMY!B(&!3&;#A!.(2*;!E!&68B&!/6(/!/6;!*;);9/(*!=89=;9/$(/%89&!#;/;$)%9;#!%9!/6;!=;$/%:%;#!
$;:;$;9=;!)(/;$%(*&!B;$;!%9!(!?88#!(?$;;);9/A
!

Table 1. (D1"%'5/5()*(#0,&/*/0A(,0*0,01#0(:"&(0,/"%

(	90,&/*/0A(X(:B(LB%(	!)$1A(X(:B(LB%(	T0#)40,'(X(Y(
9$(	<K>=(	<KZ[(	=\(
C1(	<>K?(	<]K?(	<<ZK^(

! ! !!!!!!!!V7$>$?$@
!
! "9!8$#;$!/8!(##$;&&!/6;!G8/;9/%(*!<($%(2%*%/>!(&&8=%(/;#!B%/6!&%0;!<($%(/%89!%9!/6;
&/3#>+!(9!;::8$/!B(&!)(#;!/8!&()G*;!8;$<#'7"='$8:!=8)G($(2*;!&%0;+!(9#!/6;!%$!)8$G68);/$%=!
#(/(!($;!&68B9!%9!.(2*;!M+!(9#!%&!%&!(*&8!);(9/!/8!)%9%)%0;!/6;!G8&&%2*;!;:::;=/!8:!&%0;!(9#!(?;!
<($%(/%89!89!);/(*!(==3)3*(/%89A!48B;<;$+!(!G$;<%83&!&/3#>!2>!]%(9%!DEXF!&/(/;#!/6(/!&)(*
&6;**&!6(<;!(!6%?6;$!/;9#;9=>!/8!(==3)3*(/;!6;(<>!);/(*&A!.6;!23%*#3G!8:!6;(<>!);/(*&!B%**!
=89/%93(&! /6;! (?;! 8:! =8=-*;&! %9=$;(&;&A! .63&+! /6;! *($?;! &%0;! 8;$<#'7"='! /;9#&! /8!
(==3)3*(/;!6%?6;$!=89=;9/$(/%89&!8:!);/(*&!DEXFA
!
! .6;!);(9! =89=;9/$(/%89&! 8:! 6;(<>!);/(*&! %9! /6;! &/3#%;#! /%&&3;$&!8;$<#'7"='! ($;!
&3))($%&;#! %9! .(2*;! M+! ;LG$;&&;#! %9!)?\-?! 89! (! #$>! B;%?6/! 2(&%&A! e;9;$(**>+! /6;! $;&3*/&
#;)89&/$(/;#!/6(/!/6;!&/3#%;#!8;$<#'7"='!=89/(%9;#!6%?6;$!=89=;9/$(/%89&!8:!,9A!I&&;9/%(*!
);/(*&!&3=6!(&!,9!($;!9;;#;#!%9!)($%9;!8$?(9%&)&!f!);/(28*%&)A!1&!(9!%)G8$/(9/!=8)G89;9/!
8:!93);$83&!;90>);&+!0%9=!%&!-;G/!(/!(!$;(&89(2*>!6%?6!*;<;*!%9!/6;!28#%;&!8:!)(9>!&G;=%;&-
%9=*3#%9?!=8=-*;&A!^#%$/8!$;9/!G(//;$9&!8:!&/8$(?;+!:;;#%9?!6(2%/&+!%9/;$9(*!$;?3*(/%89+
(9#!;9<%$89);9/(*!:(=/8$&!8;$<#'7"='!&68B&!&%?9%:%=(9/!#%::;$;9=;&!VG!g!XAXXRY!%9!);/(
(==3)3*(/%89!$(/;&!D!SFA
!
!
!
!

!

!

Table 2. (F/):0&,/#(;",":0&0,5("1A(:0&"%#()1#01&,"&/)15()"*#$#%#&'%#"()&

F/):0&,/#(;",":0&0,5 (		(
e01B&-(P#:Q `0/B-&(PBQ	ZK>d(f(?K(<\ <K=Z(f(?K(Z]	(
60&"%#()1#01&,"&/)1 P:BXLBQ		_0,:/55/E%0(%/:/&(E'(!Dg(P<d][Q(P:BXL(BQ
9$(	>K?](f(<K(?	[? (
C1(	d\K][(f(?K^(	[? (

+",-./ &

48B;<;$+! =89=;9/$(/%89&! 8:! ,9! ;L=;;#;#! /6;!)(L%)3)! G;$)%&&%2*;! *%)%/! &;/! 2>! H1K! VEa_NYA! .6%&! =83*#! 2;! (9! (*($)%9?! :%9#%9?+! (9#! %/! %&! (#<%&(2*;! /8! *%)%9&;$! =89&3)G/%89! <#'7"=(!%9!8$#;$!/8!*;&&;9!/6;!*%-;*%688#!8:!(#<;$&;!6;(*/6!;::;=/&A!e;9;$(*@;#!%9#%7;!$ 2%<(*<;!&3=6!(&$!<#'7"='!($;!&68B9!/8!(==3)3*(/;!/6;!6%?6;&/!*;<;*&!8:!,9!:$8)!(C3(/%=! ;9<%$89);9/&A! .6;!$;&3*/&! :839#! %9! /6%&! &/3#>! ($;! =8)G(/%2*;! B%/6! /6;! :%9#%9?&! $;G8$/;#! '3$3!(9#!';$(B%!]%<;$&+!O;9(9?+!#3;!/8!%9#3&/$%(*!;::*3;9/!DEEFA

1&!&68B9!%9!.(2*;!N+!/6;!.4d!<(*3;&!($;!)3=6!*8B;$!/6(9!89;+!&68B%9?!/6(/!/6;!);/(*&! &/3#%;#!%9!<#'7"='!&8:/!/%&&3;!G8&;!98!6;(*/6!$%&-&!/8!=89&3)$;&A!! M(B;$!+!%/!%&!82&;$<;#! /6(/!.4d!8:!J#!(9#!,9!($;!9;($!/8!89;A! T(&;#!89!/6;!.4d!<(*3;&+!%/!%9#%=(/;&!/6(/!=89&3)%9?! 8;$<#'7"='!/6$83?683/!(!*%:;/%);!%&!*%-;*>!/8!6(<;!(9!(#<;$&;!;::;=/!89!5(*(>&!%(9&A

!

Table 3. (G-0(&",B0&(-"N",A(J$)&/01&("1A(05&/:"&0A(A"/%'(/1&"L0(*),(:0&"%((/1B05&/)1

(	GMO(P:BXL(BQ	+H@(P:BXL(BQ	_G`@(:BXLB(a<(Z
9$(	?K[]((	<K=(c(<%(?	Z\^ (
C1(	?K]?(	ZKZ(c(<%(?	\d? (

!

! .6;!^(%*>!);/(*!%9/(-;!VI^"Y!B(&!=(*=3*(/;#!2(&;#!89!/6;!(<;$(?;!);/(*!=89=;9/$(/%89&! %9!8;$<#'7"='! &8:/! /%&&3;&! (9#! /6;! #(%*>! =89&3)G/%89! $(/;&A! J3$$;9/!);/(*! %9/(-;&! B;$;! =8)G($;#! B%/6! /6;! $;&G;=/%<;! $;=8));9#;#! #(%*>! #%;/($>! (**8B(9=;! $;=8));9#;#! 2>! 'IJH1!(&!&68B9!%9!.(2*;!NA! G;!:%9#%9?&!%9#%=(/;!/6(/!8;$<#'7"='!%9/(-;!%&!*;&&!&3&=;G/%2*;! /8!;9<%$89);9/(*!=89/()%9(/%89!%9!?;9;$(*+!(&!/6;!I^"!B;$;!:839#!/8!2;!*8B;$!/6(9!/6;!O.h"! $;::;$;9=;!<(*3;&A!63&+!/6;!$;&3*/&!$;<;(*;#!/6(/!/6;!&/3#%;#!&G;=%;&!=89&3)G/%89!)%?6/!98/! 6(<;!(9>!(#<;$&;!;::;=/!89!63)(9!6;(*/6A!T8/6!/6;!()839/!8:!);/(*!G$;&;9/!%9!:88#!(9#!68B!)3=6!8:!%/!%&!;(/;9!(=6!#(>!(::;=/!/6;!#(%*>!%9/(-;!8:!);/(*&A!1##%/%89(**>+!(!G;$&89i&!28#> B;%?6/!)%?6/! (::;=/! 68B! B;**! /6;>! /8*;$(/;! G8**3/%89A! DEMFA! .6;! =3$$;9/! &/3#>i&! I^"! =(*=3*(/%89! &8*;*>! =89&%#;$&!8;$<#'7"='-! B6%=6! =89/$%23/;&! j3&/! (! &)(**! G8$/%89! 8:! =89/()%9(/%89!%9/(-;!/6$83?6!#(%*>!:88#!=89&3)G/%89A!1&!(!$;&3*/+!);/(*!=89=;9/$(/%89&!%9! 8/6;$! (&G;=/&! 8:! /6;! (C3(/%=! ;9<%$89);9/+! &3=6! (&! B(/;$! 8$! &;#%);9/! &()G*;&+!)3&/! 2;! =89&%#;$;#A!48B;<;$+!2(&;#!89!/6;!($;&;&);9/!8:!8;$<#'7"='-!#(%*>!=89&3)G/%89!)(>! 98/!?;9;$(/;!(9>!(#<;$&;!6;(*/6!;::;=/&A

!

!

!

!

6" 7'$*0)1+'$ "

1!&/3#>!89!/6;!J3!(9#!,9!=89=;9/$(/%89&;%9!#'7"='!6(&!2;;9!39#;$/(-;9A!T(&;#!89!.4d! <(*3;&+!/6;!:%9#%9?&!%9#%=(/;!/6(/!);/(*&!(&&;&&;#!89!/6;!;#%2;8;!G#/7=!G8&;!98! 6;(*/6!$%&-&A!48B;<;$+!2;=(3&;!/6;!.4d!<(*3;&!8:!,9!8;$!<#'7"='!($;!(GG$8(=6%9?!89;+! ;L/$(!=89&%#;$(/%89!&683*#!2;!?%<;9!/8!%/&!=89&3;/;%89!(9#!%#!/6;!G8&&%2%*%/>!8:! (#<;$&;!6;(*/6!=89&;C3;9=;&+!%#!%&(2/;8!*%)%/!%9/(-;!8;$<#'7"=';!

!

G-0("$&-),5(B,"&0*$%%'(&-"1L(*/1"1#/"%(5$;;),&(*),(&-/5(I),L(*,):(&-0(31/40,5/&/(6"%"'5/"(70%"1&"1(5-),&(&0,:(B,"1&(P3679g6(Z?ZZV(TX9g6XD?]??X?<=\>DX??\XZ?Z[X?<<[dQ("1A(&0#-1/#"%("55/5&"1#0(A$,/1B(%"E),"&),'(I),L(*,):(&-0(!"#$%&'()*(+",&-(.#/01231/40,5/&/(6"%"'5/"(70%"1&"1(

4/8/&/$*/1 "

EA PA!kA!h(9?+!IA!]A!I3+!mA!IA!P39+!'A!kA!k%3+!4ABTC4$,B:'*$D"**):("7$(7$E"'=:'*$ '#B'=$".$%"):&$F&(7'G$8$#BC5(B1%9;!O8**3/%89!T3*!7(192),!U@R!VMXMENY

MA TAKA!T8/B;AB'C4$,B:'*$E"7EB7:#':("7=$(7$.(CB$.(=&$=DBE(B=$.#",$:&B$H)*.$".$H)(7B'$ '73$:&B(#$&),'7$&B'*:&$(,D*(E':("7!;?%89(*!P/3#%;&!%9!5($%9;!P=4(;9X=HUSN! VMXMEY

NA JA!nA!m(G+!mA!4(//(+!HA!TA!I#B($#+!PAFeA!D!(9=!'7$".$&B'C4$,B:'*$E"7EB7:#':("7=$ IF3-$F)-$JB-$!($'73$97@$(7$:&B$=&B**=$'73$3(..B#B7:$=".:$:(==)B=$".$87'3'#'$<#'7' E"**BE:B3$.#",$KB#',-$L)'*$K)#)$'73$L)'*$L)#')-$MB7(7=)*'#$2'*'4=A!O;$/(9%-(! '83$9(*!8:!.$8G%=(*!1?$%=3*/3$(*!P31(2),!MXM@IER!VMXX_Y

QA PA!1A!5%$&(#;?6%+!5A!OA!,(-($%(+!JA!nA!m(G+!HCA!e:87&'A$:&B$D":B7:("*$ O("'EE),)*':("7$'O(*(:4$".$:&B$O*""3$E"EP*B$I87'3'#'$<#$Q;@$."#$'==B==,B7:$".$ B7C(#"7,B7:'*$,':#(EB=$".$,)3.*':+!P=%;9=;!8:!/6;!.8/(*!I9<%$89);9/454-455+!R_@ RaU!VMXENY

RA JA!4A!kA!]%9=89+!IA'AOA!P(*()(9=(+!'A!]A!JA!n%9/0+!KA!bA!k%0=@98!9(A!!J$30 7;%$(!+8==B==,B7:$".$,B#E)#4$'73$*B'3$E"7:',(7':("7$)=(7<$:&B$O(C'*CB$87'3'#'$:)OB#E)*"='$I8#E(3'B@$(7$'7$B=:)'#4$".$:&B$F"*",O('7$MBE(9!O8**3/%89!T3**;/%9+! 187+!EEQREa!VMXMNY

SA eA!HA!T%$=6+!mA!P6(*;)+!nA!k;B/(&+!JA!4A!2B;&$E"7EB7:#':("7=$(7$%437B4$F"EP*B$ I87'3'#'$:#'DB/('@$:(==)B$'73$',O(B7:$=B3(,B7:$(7$'$R'3(&B3$B=:)'#4$I%437B4$ B=:)'#4-$8)=:#'*('@!5($%9;!!O8**3/%89!T3**;%9+!1449@MaQX_!VMXEaY

UA nA!PA!P(jB(9+!nA!PA!n3)($+!PA!O($()(&%<()+!PA!PA!J8)G/89+!'A!OA!M*B(B7#&$9 =:':)=$(7$=B3(,B7:$'73$8,B#(E'7$"4=:B#$E"**BE:B3$.#",$%'C'77'&$,'#=&SB=:)'#(7B$ BE"=4=:B,$'$D#B*(,(7'#4$'==B==,B7:$=6%<;&!8:!I9<%$89);9/(*!J89/()%9(/%89!(9#! .8L%=8*8?>!54(2)+!MQ6MR!VMXXUY

_A 7A!PA!pA!"#$%&+!7A!'3$>+!7A!1A!586#!.(*%2+!7A!PA!12#3*!4(*%)+!7A!m((-32+!7A!^A!5($% 8==B==,B7:$".$,B:'*$E"7EB7:#':("7=$(7$M"*4,B="3'$BTD'7='$.#",$%)7<'($HB:(7<-$ 5),D':-$LB*'7:'7$'73$'=="E(':B3$&B'*:&A"KO!J89:A!P;$%;&c!I($/6!I9<%$89A596+!%A! VMXMXY

aA PA!h(6;;#+!]A!7A!5(*%-+!PA!'(6(AB!*:&$#(=P$.#",$8=$E"7:',(7':B3$.(=&$E"7=),D:("7$ O4$D"D)*':("7$*(C(7<$'#")73$U(CB#$F&B7'O-$M9<%$89);9/(*!.8L%=8*8?>!(9#! O6($)(=8*8?>!36+!RU@R_U!VMXENY

EXA IA!]%(9%5$&B-,'**$<#BB7$=&B**=$'=$VC'E)),$E*B'7B#W$."#$(73)=:#('*$'#B'$*(6)(3$1'=:B :&':$B7:B#$:&B$1':B#=$".$K'P'#:'$X'4$I(7$X'&'='$Y73!7B/3$(;14+MQ@QX!VMXXaY

!

EEA HA!5A!122(&!1*-($-6%+!7A!"&)(%*+!1A!5(/!8(&;B!==,B7:$".$'#=B7(E$'73$&B'C4$,B:'*$
E"7:B7:=$(7$E"EP*B=!I87'3'#'$<#'7"='@$)=(7<$,)*:(C'#(':B$=:':(=:(E'*$:BAE'&3($)B!=
8:!4(0($#83&!5(/;$%(*&A0,!U_MO_a!VMXX_Y

EMA IJH1!MXXX!I<(*3(/%89!8:!=;$/(%9!:88#!(##%/%<;&!(9#!=89/()%9$/&A(T:&$#BD"#:$
".$:&B$0"(7:$J8ZS[AZ$BTDB#:$E",,(::BB$'73$'33(/(4B=:$=69%=(*!];G8$/!P;$%;&+!
78A!_aS!h8$*#!4;(*/6!K$?(9%0(/%89ce;9;<(