COMPUTING COMPONENTS SUPPLY CHAIN

Memory Insights – November 2022

Important Disclosures in the Appendix

Adjusting C4Q22 DRAM ASPs to decline ~18-22%+ Q/Q, as supplier/s increasingly pursuing pull-in deals while buyers remain focused on DOI digestion, see limited improvement until mid-CY23; NAND/SSD ASP erosion accelerating QTD

Key Takeaways

1. Adjusting CY22 DRAM bit demand lower (again) to ~5-7% Y/Y growth, order/pull adjustments reflect ongoing inventory correction across most/all end markets, a dynamic that's likely continue into C1Q23 – hindering actual end demand/consumption visibility
2. CY22 DRAM bit production growth of +17-19% Y/Y unchanged as supplier/s unable to adjust near-term production output, supply/demand imbalance widening and leading to significant supplier inventory build; reducing CY22 bit shipments to +1-3% Y/Y
3. CY23 DRAM bit production growth forecasts unchanged at +8-12% Y/Y, as adjustments to-date (capex/WFE) unlikely to materially impact supply growth until late-CY23/CY24; yet supplier/s likely to continue to closely evaluate/adjust capex (and supply) plans accordingly given uncertain CY23 demand backdrop and likely record levels of inventory build/carryover into next year
4. CY23 DRAM bit demand forecasts remain fluid, yet maintaining low-10% Y/Y growth; adjusting server bit demand growth forecasts lower to +15% Y/Y (assuming some C2H22 pull-in cannibalization), PC bit demand down ~5% Y/Y, mobile bit demand +10-15% Y/Y
5. Adjusting C4Q22 32GB/64GB RDIMM ASPs lower to down ~20-22%+ Q/Q to <$90/$170, as select supplier/s continue to push for additional pull-ins via ASP flexibility, expect M/M ASP concessions to continue/accelerate thru YE22 w/ C1Q23 ASP pull-in offers
6. Forecasting C4Q22 8GB PC DRAM ASPs to decline ~18-20%+ Q/Q to ~$18.5 +/- $0.50, select PC OEM orders cited as stabilizing and/or improving while other OEMs remain focused on inventory digestion/cutting orders – supplier/s still pursuing YE22 pull-ins
7. Adjusting C4Q22 mobile DRAM ASP forecasts lower to down high teens % Q/Q, as supplier attempts to defend ~$0.30/Gb in late-Sept/Oct'22 appeared to reverse as limited order volumes/OEM inventory management drove ASPs to/below ~$0.28-0.29/Gb
8. Maintaining view DRAM ASPs remain deflationary into C1H23, albeit at slower ~10% (and <5%) Q/Q pace, increased focus on supplier/s margins/cash costs likely to influence the longevity of downturn yet record levels of inventory carryover into CY23 (and limited near-term supply/utilization) actions likely to weigh on demand/ASP recovery timeline – DDR5 mix issues need monitored
9. CY22 NAND bit production growth of high-20% Y/Y unchanged, CY22 NAND bit demand forecasts continue to moderate to low-10% or less, while supplier/s NAND bit shipments tracking up mid-single-digits % Y/Y – supplier/s DOI increasing to 14-16+ weeks
10. Maintaining CY23 NAND bit production forecast of mid-10% Y/Y growth, assuming supplier/s will eventually be forced to take additional (more severe) supply actions as NAND ASPs decline to/below cash costs; WD's CY23 NAND supply growth forecast of low/mid-20% Y/Y appeared to surprise peers, yet we expect additional adjustments as likely as margins/ASP further erode
11. Adjusting CY23 NAND bit demand growth forecasts to +15-20% Y/Y, vs. prior forecasts of mid-teens % Y/Y growth as PC OEMs now forecasting a step-up in demand elasticity as ASPs have sharply eroded throughout C2H22; thus, we're now forecasting cSSD bit demand to increase ~10%+ Y/Y, eSSD bit demand +15-20% Y/Y (unchanged), and mobile bit demand of mid/high teens % Y/Y
12. eMCP ASP forecasts unchanged at down ~15-20% Q/Q in C4Q22, forecasting C1Q23 ASPs to decline ~6-10% Q/Q expecting supplier/s to pursue pull-ins via ASP flexible through YE22; mobile OEM demand unlikely to recover until C2Q23 at the earliest
13. CY22 smartphone unit shipment forecasts unchanged at down ~7-11% Y/Y to ~1.2-1.25B units, forecasting CY23 units flat/up low single-digits % Y/Y – yet supplier/s hope for China recovery mixed as most China branded OEMs forecasting units flat Y/Y
14. Adjusting C4Q22 cSSD 512GB/1TB ASPs lower to down >20% Q/Q; select supplier/s have and will likely continue to leverage ASP flexibility (C1Q23 ASP pull-ins) in bid to boost shipments/pulls before YE22 – forecasting C1Q23 cSSD ASPs down ~8-12%+ Q/Q
15. C4Q22 eSSD ASPs forecasts unchanged at down mid/high teens % Q/Q as OEM order cuts of 10-20%+ led supplier/s to turn more ASP flexible; DC SSD ASP forecasts unchanged at down ~20-25%+ Q/Q – forecasting C1Q23 DC/eSSD ASPs down ~8-10%+ Q/Q

Conclusion

Our latest research is unchanged in that the DRAM market dynamics remain challenged as the supply/demand imbalance has and/or will lead to record levels of DRAM supplier/s on-hand inventories by YE22. In general, the combination of a sharp deterioration in end demand across most/all end markets via an industry wide inventory correction and industry overproduction has led to a significant build of supplier/s inventories along with a collapse in DRAM ASPs throughout C2H22. Overall, DRAM suppliers are likely to exit CY22 near/at record levels of DRAM DOI as production growth of +17-19% Y/Y will significantly exceed DRAM supplier/s bit shipment growth of +1-3% Y/Y. In the near-term, we're adjusting our latest C4Q22 DRAM ASP forecasts lower to down ~18-22%+ Q/Q, reflecting a step-up in ASP flexibility over the past few months as supplier/s continue to pursue order pull-ins given the decline in overall

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orders/demand. While the near-term decline in DRAM ASPs are noteworthy, the supply chain has largely shifted their focus/attention towards CY23 DRAM bit supply/demand, as it remains increasingly clear that the current (and CY23) demand backdrop is unlikely to organically balance the current oversupply environment. At the moment, Micron and Hynix have announced a sharp ~30%/50% reduction in FY23/CY23 capex, and a 50% Y/Y reduction in WFE capex (Micron), yet the near/medium-term impact of these adjustments are likely to be minimal while supplier/s remain mum to-date regarding reducing wafer utilization. Alternatively, Samsung still non-committal to-date in adjusting their production plans, while offering minimal insight into their CY23 capex plans. For CY23, we're maintaining our DRAM bit production growth forecast of +8-12% Y/Y yet current forecasts are likely to remain fluid as DRAM supplier/s continue to evaluate/cross-check CY23 DRAM demand forecasts with key customers – particularly during CY23 LTA/MOU discussions. Furthermore, due to the sharp decline in DRAM ASPs, which has accelerated over the past few months, there is a growing focus across the supply chain regarding the longevity of continued DRAM ASP declines into C1H23/CY23, with a greater focus regarding individual supplier/s DRAM cash costs/margins. We will continue to monitor/adjust our latest CY23 DRAM demand (and ASP) forecasts accordingly yet given the decline in DRAM orders/ASPs we're maintaining the view that additional/more severe actions are needed.

Our research is unchanged in that near-term NAND/SSD fundamentals remain extremely challenged as supplier/s continue to highlight the sheer lack of demand as leading to a significant build of internal inventories, with multiple supplier/s now expected to exit CY22 with >15 weeks of NAND DOI. In general, our research suggests CY22 industry NAND bit shipments are now trending to mid-single-digits % Y/Y growth (bit demand low-10% Y/Y growth), while CY22 NAND bit production is still trending in the upper-20% Y/Y range. Thus, while select supplier/s have pursued multi-quarter/pull-in deals, our research suggests the results of these offers were mixed as most buyers continue to highlight limited desire to build additional inventories, a trend that is likely to continue through YE22 and into C1Q23. Alternatively, our research suggests that despite a sharp decline in LTA/order volumes over the past few months, ASP erosion has sharply accelerated as supplier/s acknowledge that "in order to maintain" even limited shipments they had to accept the level of ASP concessions buyers were seeking. Thus, for C4Q22, our research suggest blended NAND/SSD ASPs are likely to decline by at least mid/high teens % Q/Q yet depending on the individual supplier/buyer we're seeing ASPs decline by as much as 20-25% Q/Q. Overall, our latest research is unchanged in that the sheer level of NAND oversupply has limited suppliers' ability to limit the pace of ASP erosion, particularly as the degree of supply adjustments to-date have been limited beyond capex/WFE cuts which are unlikely to materialize until C2H23/C1H24. However, due to the level of ASP erosion that we're currently seeing (with likely additional cuts before YE22), we're expecting most/all suppliers to approach negative operating margins by YE22 – which we believe will eventually 1) force additional supplier/s to take more severe actions regarding their CY23 NAND supply growth plans and/or 2) limit their ability to match the level of ASP erosion led by leading cost suppliers. We will continue to monitor/adjust our latest forecasts accordingly, yet we're maintaining the view that more severe adjustments are needed/inevitable as the sheer amount of NAND oversupply and uncertain CY23 demand outlook is likely to limit any near-term organic stabilization/recovery in NAND fundamentals.

TOP 3 DRAM HIGHLIGHTS

1. Near/medium-term outlook remains challenged as DRAM orders/pulls across most end markets remain muted into C4Q22, suppliers continue to pursue pull-in deals to limit shortfall in C4Q22/YE22 sales targets; ASP erosion accelerated in Oct'22
2. Server market remains area of focus as supplier/s pursue pull-in deals yet opportunities limited given most buyers focus on DOI digestion, buyers willing/able to pull-in benefited from sharp erosion in Oct'22; adjusting C4Q22 RDIMM ASPs down ~20-22% Q/Q
3. PC OEM orders into Oct'22/C4Q22 mixed with select OEMs orders stabilizing/improving slightly Q/Q while other OEMs continue to sharply dial back orders/pulls Q/Q given DOI focus; adjusting C4Q22 8GB PC DRAM ASPs lower to down ~18-20%+ Q/Q to <$19

Sever DRAM orders remain weak QTD as most enterprise OEM/hyperscalers adjusting order/pull volumes given continued push to digest DOI, yet step-up in supplier/s pull-in deals driving increased ASP erosion QTD. Our latest research suggests the near/medium-term RDIMM (and overall DRAM) demand environment has continued to moderate as most buyers continue to cite their desire to digest DOI through YE22, a dynamic that has led supplier/s to increasingly seek out upside/pull-in deals in an attempt to offset the shortfall in LTA/pull volumes. However, our research suggests most buyers remain resistant in pulling-in additional volumes at the moment due to 1) ongoing focus/directive to digest elevated DOI, in a bid to improve cash flow through YE22, and 2) general belief amongst most/all buyers that the current oversupply environment will persist throughout at least C1H23, maintaining a favorable pricing environment for the foreseeable future. In general, while pockets of IC/component supply challenges are still being cited by select OEM/hyperscalers, weaker demand/new orders and reduced backlogs into C2H22 (and likely C1H23) are being cited by multiple enterprise OEMs (and select hyperscalers) as factoring into their decision to reduce RDIMM orders/pulls. Overall, our research is unchanged in that most/all buyers overpurchased throughout C1H22 due to a variety of industry/individual directives – yet given the

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reduction in overall server builds/orders (enterprise OEMs) and greater focus to reduce DOI/improve cash flows (enterprise OEMs/hyperscalers) there has been a sharp reversal in orders/pulls relative to initial LTAs. While U.S. hyperscale demand/capex plans YTD (and CY23) still appear relatively healthy, most hyperscalers have adjusted their RDIMM orders/pulls lower into C2H22, yet still appear willing to entertain pull-in/deals depending on the individual supplier/s degree of ASP flexibility. Alternatively, select 3rd party hub partners of enterprise OEMs (and hyperscalers) have been increasingly resistant to buying/holding additional inventory since Jul/Aug'22, with select OEMs/hyperscalers now being directed to digest/consume inventory through YE22 – yet another headwind to new orders/pulls. We will continue to monitor/adjust our current supply/demand (and ASP) forecasts yet we're adjusting our latest C4Q22 (and C1Q23) RDIMM ASP forecasts lower (again) given the apparent step-up in ASP flexibility select supplier/s have promoted over the past few months, which we attribute to their attempt to drive additional bit shipments/revenue before YE22.

Server DRAM Contract Price Forecasts - DDR4 32GB/64GB RDIMMs

DDR4 32GB	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22
Price	$141	$139	$137	$136	$136	$133	$122	$114	$99	$91	$88	$85
Qtr Avg.			***$139***			***$135***			***$112***			***$88***
M/M	*-2%*	*-2%*	*-1%*	*0%*	*0%*	*-2%*	*-8%*	*-6%*	*-13%*	*-9%*	*-3%*	*-4%*
Q/Q			***-6.3%***			***-2.7%***			***-17.2%***			***-21.6%***
Y/Y	*17%*	*12%*	*3%*	*-7%*	*-9%*	*-12%*	*-24%*	*-28%*	*-37%*	*-40%*	*-41%*	*-41%*

DDR4 64GB	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22
Price	$277	$274	$274	$272	$270	$260	$236	$222	$192	$175	$169	$161
Qtr Avg.			***$275***			***$267***			***$217***			***$169***
M/M	*-1%*	*-1%*	*0%*	*-1%*	*-1%*	*-3%*	*-9%*	*-6%*	*-14%*	*-9%*	*-3%*	*-5%*
Q/Q			***-5.2%***			***-3.0%***			***-18.9%***			***-22.2%***
Y/Y	*21%*	*16%*	*8%*	*-3%*	*-5%*	*-10%*	*-24%*	*-29%*	*-39%*	*-41%*	*-42%*	*-42%*

Source: Edgewater Research Estimates

Highlighted above are our latest CY22 DDR4 32GB/64GB RDIMM price forecasts. Our latest research suggests the pricing environment throughout late-C3Q22/into C4Q22 has become increasingly blurred as the sheer reduction in orders/pulls (and LTA decommitments) has led to a sharp uptick in "one-off" pull-in offers. In general, our research suggests that over the past few months, select supplier/s have been cited as seeking out buyers willing/able to take additional volumes with more favorable pull-in ASPs, payment terms, etc. However, despite the sharp uptick in supplier/s ASP flexibility, supplier/s ability to boost bit shipments via a step-up in ASP flexibility remained limited as most buyers remain focused on digesting DOI and/or are maintaining the view that there will be even more favorable offers later in the quarter and/or into C1Q23. Furthermore, select supplier/s pursuit of multi-quarter volume commitments last quarter was met with limited relative success, as while select U.S. (and China) hyperscalers appeared to agree to these offers most/all of these buyers have chosen to delay pulling volumes until late-C4Q22. Overall, we're maintaining the view that these initial agreements in Jul/Aug'22 were the accelerator for the stepdown in ASPs over the past few months, especially as most supplier/s have increasingly focused on boosting bit shipments via increased ASP flexibility. In general, our research suggests that while the initial multi-quarter volume commitments were $15-20+ below average Aug'22 ASPs, the decline in ASPs since late Aug'22 until now has made these agreements appear less favorable. Thus, it appears most buyers have been increasingly resistant in multi-quarter/pull-in offers, given their focus on DOI digestion, a dynamic that has/will weigh on supplier/s bit shipments. As a result, RDIMM orders/pulls QTD remain well below supplier/s targets, and thus the degree of ASP flexibility has accelerated over the past two months as supplier/s increasingly leverage a "pulling-in" of C1Q23 (or C2Q23) volumes (and pricing) as an incentive to boost pulls. Thus, our research suggests 32GB/64GB RDIMM ASPs have yet again taken a step down M/M throughout Oct'22 with ASPs trending as low as <$90 for the 32GB, and as wide as <$160 to $180+ for the 64GB depending on individual/buyers. For C4Q22, while baseline vs. pull-ins of ASP/volumes continue to blur average ASPs, we're adjusting our average 32GB/64GB RDIMM ASP forecasts lower to down ~20-22% Q/Q, or to <$90/$170 – yet we expect ASPs to decline M/M via pull-ins and likely exit the year ~$5-10+ below our quarterly average.

Our research suggests C4Q22 ODM L6 motherboard build/shipment forecasts are unchanged M/M at +1-3% Q/Q (flat/down low single-digits % Y/Y, led by continued Q/Q growth in U.S. hyperscale orders while enterprise OEM and China OEM/hyperscale orders are forecasted to decline Q/Q. While CY23 visibility remains limited given uncertainty regarding the global economy/IT budgets, we're forecasting units to increase ~3-5% Y/Y – yet we acknowledge that current forecasts remain fluid across the supply chain. Overall, the sustainability of U.S. hyperscale capex/infrastructure deployments is viewed as critical in driving CY23 server unit growth, as the

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decline in enterprise OEM backlogs throughout C2H22 and an increasingly cautious global macro environment are likely to remain headwinds to on-prem IT spending throughout at least C1H23. While most U.S. hyperscalers continue to talk optimistically regarding current (and CY23) capex plans/strong investments within infrastructure, a growing number of hyperscalers (recently highlighted by AMD) have cited a push to increase efficiencies/utilization of their infrastructure into CY23. Furthermore, our research remains guarded regarding the timeline/degree of China OEM/hyperscale recovery into CY23, as while most across the supply chain view the current slowdown as "unsustainable" our research suggests there are limited signals of any notable recovery in investment plans until at least late-C2Q23 – with domestic gov't initiatives expected to have an oversized influence on the timeline/pace of China CSP/IDC demand recovery. Highlighted below are our latest CY23 DDR4 32GB/64GB RDIMM ASP forecasts. While our latest CY23 forecasts are likely to remain volatile given current market dynamics – the degree of ASP erosion over the past few months has led buyers to increasingly question the longevity of continued declines into CY23, due to the deterioration in supplier margins. However, while near-term supplier/s cost/margin pressures are likely to intensify, the degree of carryover inventory into CY23 remains a troublesome issue in being able to balance the market throughout at least C1H23, barring more forceful CY23 bit production/wafer utilization adjustments. However, our research suggests buyers are wary regarding potential DDR5-related mix issues and the possible impact DDR5 could have on overall DRAM supply sufficiency into C2H23 as another dynamic that needs monitoring in the coming months.

Server DRAM Contract Price Forecasts - DDR4 32GB/64GB RDIMMs

DDR4 32GB	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23
Price	$82	$81	$78	$78	$78	$78	$78	$78	$81	$83	$86	$88
Qtr Avg.			***$80***			***$78***			***$79***			***$86***
M/M	*-3%*	*-2%*	*-3%*	*0%*	*0%*	*0%*	*0%*	*1%*	*3%*	*3%*	*3%*	*3%*
Q/Q			***-8.6%***			***-3.0%***			***1.5%***			***8.5%***
Y/Y	*-42%*	*-42%*	*-43%*	*-43%*	*-43%*	*-41%*	*-36%*	*-32%*	*-19%*	*-8%*	*-3%*	*4%*

DDR4 64GB	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23
Price	$156	$153	$148	$148	$148	$148	$148	$149	$154	$158	$163	$168
Qtr Avg.			***$153***			***$148***			***$150***			***$163***
M/M	*-3%*	*-2%*	*-3%*	*0%*	*0%*	*0%*	*0%*	*1%*	*3%*	*3%*	*3%*	*3%*
Q/Q			***-9.6%***			***-3.0%***			***1.5%***			***8.5%***
Y/Y	*-44%*	*-44%*	*-46%*	*-46%*	*-45%*	*-43%*	*-37%*	*-33%*	*-20%*	*-10%*	*-4%*	*4%*

Source: Edgewater Research Estimates

PC OEM DRAM orders mixed into Nov'22 as select OEM order/pulls now aligning with consumption while other OEMs continue to cut orders intra-quarter; supplier/s remain active in pushing select OEMs to "pull-in" additional 3+ months of volumes. Our research suggests PC OEM DRAM orders are mixed QTD, as while select OEMs appear to have lowered their DRAM DOI to desired levels and thus have resumed orders to consumption levels into C4Q22, other OEMs have continued to adjusted/reduce their order volumes throughout Oct/Nov'22. Overall, current order dynamics remain fluid as while select OEMs have cited their ability to normalize their DRAM DOI and thus have resumed order volumes QTD, other OEMs have been cited as further reducing their DRAM orders QTD given their focus to further digest internal (and/or 3rd party) DRAM DOI through at least YE22. Furthermore, select supplier/s appeared to incentivize select OEMs to pull-in C4Q22 volumes (at C4Q22 ASP levels) into Sept'22 in a bid to boost overall C3Q22 shipments yet at the expense of current quarter order/pulls. As a result, the pricing environment has proven to be even more flexible than anticipated particularly as select supplier/s were cited as being quite active in attempting to boost shipments over the past two months/before the end of Oct'22. Overall, our research suggests the current environment remains increasingly challenged for supplier/s despite pockets of order improvements, as C4Q22 PC build/shipments (excluding Apple) are still forecasted to remain flat/down Q/Q, a 4th straight quarter of sequential declines. For C4Q22, our latest research suggests PC ODM/notebook builds are currently projected to decline by ~15%+ Q/Q, as MacBook (Quanta) builds are projected to decline by >25% Q/Q following the initial ramp in builds last quarter. Overall, our research suggests most/all Windows-based PC OEMs are forecasting notebook builds to decline by as much as ~10-20% Q/Q in C4Q22, depending on the individual OEM – while most/all are also projecting PC shipments to remain flat to down low/mid-single-digits % Q/Q. Thus, for CY22, we're forecasting PC unit shipments to decline to ~290-295M units, or down ~18-20% Y/Y. For CY23, we're forecasting PC units to decline another ~5-10% Y/Y to ~265-270M units yet current forecasts across the supply chain continue to range as wide as flat/up low single-digits % Y/Y to down >10% Y/Y.

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PC DRAM Contract Price Forecasts - DDR4 8GB/16GB DIMMs

DDR4 8GB	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22
Price	$29.05	$28.88	$28.80	$28.55	$28.14	$27.22	$24.97	$23.64	$21.05	$19.22	$18.81	$18.22
Qtr Avg.			***$28.91***			***$27.97***			***$ 23.22***			***$18.75***
M/M	*-3%*	*-1%*	*0%*	*-1%*	*-1%*	*-3%*	*-8%*	*-5%*	*-11%*	*-9%*	*-2%*	*-3%*
Q/Q			***-5.6%***			***-3.3%***			***-17.0%***			***-19.3%***
Y/Y	*13%*	*11%*	*5%*	*-12%*	*-14%*	*-17%*	*-28%*	*-31%*	*-37%*	*-39%*	*-39%*	*-39%*

DDR4 16GB	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22
Price	$ 56.47	$ 56.14	$ 55.98	$ 55.51	$ 54.72	$ 52.93	$ 48.55	$ 45.97	$ 40.94	$ 37.32	$ 36.51	$ 35.37
Qtr Avg.			***$ 56.20***			***$ 54.38***			***$ 45.15***			***$ 36.40***
M/M	*-3%*	*-1%*	*0%*	*-1%*	*-1%*	*-3%*	*-8%*	*-5%*	*-11%*	*-9%*	*-2%*	*-3%*
Q/Q			***-5.6%***			***-3.2%***			***-17.0%***			***-19.4%***
Y/Y	*12%*	*10%*	*4%*	*-12%*	*-15%*	*-18%*	*-28%*	*-32%*	*-37%*	*-39%*	*-39%*	*-39%*

Source: Edgewater Research Estimates

PC DRAM Contract Price Forecasts - DDR5 8GB/16GB DIMMs

DDR5 8GB	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22
Price	$40.09	$39.85	$39.74	$38.54	$37.70	$36.47	$33.20	$30.73	$27.15	$24.60	$23.88	$22.78
Qtr Avg.			***$39.89***			***$37.57***			***$ 30.36***			***$23.75***
M/M	*-*	*-1%*	*0%*	*-3%*	*-2%*	*-3%*	*-9%*	*-7%*	*-12%*	*-9%*	*-3%*	*-5%*
Q/Q	*-*	*-*	*-*	*-*	*-*	***-5.8%***			***-19.2%***			***-21.8%***
Y/Y	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*

DDR5 16GB	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22
Price	$76.80	$76.35	$76.13	$73.83	$72.22	$69.86	$63.60	$58.85	$51.99	$47.02	$45.64	$43.51
Qtr Avg.			***$ 76.43***			***$ 71.97***			***$ 58.15***			***$ 45.39***
M/M	*-*	*-1%*	*0%*	*-3%*	*-2%*	*-3%*	*-9%*	*-7%*	*-12%*	*-10%*	*-3%*	*-5%*
Q/Q	*-*	*-*	*-*	*-*	*-*	***-5.8%***			***-19.2%***			***-21.9%***
Y/Y	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*

Source: Edgewater Research Estimates

Highlighted above are our latest CY22 DDR4 (and DDR5) PC DRAM price forecasts. We're adjusting our C4Q22 DDR4 8GB PC DRAM ASP forecasts lower to down ~18-20%+ Q/Q to $18.50 +/- $0.50, in an attempt to reflect the current range of ASPs while factoring in the likelihood of additional ASP concessions later in the quarter. In general, current PC DRAM ASPs are fluid given various pull-in offers that are being proposed by select supplier/s over the past few months. Overall, our research suggests that while Oct'22 PC DRAM ASPs appeared to trend in the $19 +/- range, volume orders were limited and/or only reflected current demand/consumption; whereas select supplier/s have been cited as approaching PC OEMs with offers to pull-in additional volumes (next month/quarter/s) at pricing levels that reflect where ASPs are likely to be trending at time of actual consumption. Thus, given these various dynamics, current ASPs remain fluid as while the current rate of PC DRAM ASPs (for consumption purposes) appear to be trending in the $19 +/- range, our research suggests PC OEMs have notified supplier/s that any additional volumes/pulls beyond current month consumption levels will require additional ASP concessions. Thus, our research suggests the range of PC OEM DRAM ASPs in Oct'22 ranged as wide as ~$18.5 to ~$19.5+, depending on the individual OEM/supplier and anticipated timeline of actual consumption. Furthermore, our research suggests that PC DRAM ASP trends throughout Nov/Dec'22 are likely to mirror trends seen in Aug/Sept'22, in which individual supplier/s are likely to promote additional bit shipments via a pulling-in of C1Q23 ASPs and/or price protection. Thus, we're adjusting our latest monthly (and C4Q22) PC DRAM ASPs lower to reflect 1) increased pull-in incentives select supplier/s are likely to pursue through YE22, and 2) mixed volume pulls/commitments most/all PC OEMs are likely to accept given most OEMs desire to digest and/or maintain leaner DRAM DOI along with the widely held view amongst OEMs that ASPs are likely to remain deflationary throughout at least C1H23. We will continue to monitor/adjust our latest forecasts accordingly as our research suggests the current rate of ASP erosion has accelerated over the past few months as supplier/s increasingly leverage a pulling-in of C1Q23 (and/or even C2Q23) pricing as an incentive to try and encourage OEMs to pull-in additional volumes. Our latest PC DRAM DDR5 ASP premium forecasts are unchanged M/M and still projected to decline to the mid/upper-20% range this quarter, yet our research suggests select supplier/s have already (and will likely continue) to offer greater premium concessions in return for firmer volume commitments.

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On-Board PC/LP4x DRAM Component Price Forecasts

	1Q21	2Q21	3Q21	4Q21	1Q22	2Q22	3Q22	4Q22e	1Q23e	2Q23e	3Q23e	4Q23e
PC DRAM DDR4 8Gb (mono)	$3.50	$4.29	$4.42	$3.98	$3.76	$3.68	$2.98	$2.40	$2.20	$2.14	$2.18	$2.38
Q/Q	*6.6%*	*22.5%*	*3.0%*	*-10.0%*	*-5.4%*	*-2.3%*	*-18.9%*	*-19.4%*	*-8.4%*	*-2.7%*	*1.9%*	*9.0%*
PC DRAM DDR4 16Gb (DDP)	$7.71	$9.27	$9.37	$8.36	$7.90	$7.72	$6.26	$5.05	$4.62	$4.50	$4.59	$5.00
Q/Q	*6.6%*	*20.3%*	*1.1%*	*-10.8%*	*-5.4%*	*-2.3%*	*-18.9%*	*-19.4%*	*-8.4%*	*-2.7%*	*1.9%*	*9.0%*
PC DRAM DDR4 16Gb (mono)	$6.80	$8.41	$8.84	$7.96	$7.45	$7.28	$5.85	$4.71	$4.29	$4.18	$4.24	$4.62
Q/Q	*8.9%*	*23.7%*	*5.1%*	*-10.0%*	*-6.4%*	*-2.3%*	*-19.7%*	*-19.4%*	*-8.9%*	*-2.7%*	*1.4%*	*9.0%*
PC DRAM DDD4 32Gb (DDP)	$14.41	$17.84	$18.57	$16.55	$15.35	$14.99	$12.04	$9.66	$8.76	$8.44	$8.56	$9.33
Q/Q	*7.9%*	*23.7%*	*4.1%*	*-10.8%*	*-7.3%*	*-2.3%*	*-19.7%*	*-19.8%*	*-9.3%*	*-3.6%*	*1.4%*	*9.0%*
PC DRAM DDR5 16Gb (mono)					$10.12	$9.54	$7.69	$6.01	$5.35	$5.04	$5.04	$5.28
Q/Q					-	*-5.7%*	*-19.4%*	*-21.9%*	*-10.9%*	*-5.8%*	*0.0%*	*4.6%*
PC DRAM DDR5 32Gb (DDP)					$21.26	$19.85	$15.84	$12.38	$10.92	$10.19	$10.19	$10.66
Q/Q					-	*-6.6%*	*-20.2%*	*-21.9%*	*-11.8%*	*-6.7%*	*0.0%*	*4.6%*
	1Q21	2Q21	3Q21	4Q21	1Q22	2Q22	3Q22	4Q22e	1Q23e	2Q23e	3Q23e	4Q23e
PC LP4/LP4x 8Gb (mono)	$4.25	$4.45	$4.50	$4.20	$4.00	$3.90	$3.25	$2.60	$2.40	$2.30	$2.35	$2.55
Q/Q	*1.2%*	*4.7%*	*1.1%*	*-6.7%*	*-4.8%*	*-2.5%*	*-16.7%*	*-20.0%*	*-7.7%*	*-4.2%*	*2.2%*	*8.5%*
PC LP4/LP4x 16Gb (DDP)	$8.46	$8.86	$8.96	$8.36	$7.96	$7.76	$6.47	$5.17	$4.78	$4.58	$4.68	$5.07
Q/Q	*2.2%*	*4.7%*	*1.1%*	*-6.7%*	*-4.8%*	*-2.5%*	*-16.7%*	*-20.0%*	*-7.7%*	*-4.2%*	*2.2%*	*8.5%*
PC LP4/LP4x 32Gb (QDP)	$16.92	$17.71	$17.87	$16.67	$15.88	$15.44	$12.87	$10.30	$9.50	$9.11	$9.31	$10.10
Q/Q	*2.2%*	*4.7%*	*0.9%*	*-6.7%*	*-4.8%*	*-2.7%*	*-16.7%*	*-20.0%*	*-7.7%*	*-4.2%*	*2.2%*	*8.5%*
PC LP5 8Gb (mono)				$4.62	$4.36	$4.17	$3.33	$2.60	$2.40	$2.29	$2.33	$2.50
Q/Q				-	*-5.6%*	*-4.3%*	*-20.2%*	*-22.0%*	*-7.7%*	*-4.6%*	*1.7%*	*7.4%*
PC LP5 16Gb (mono/DDP)				$9.19	$8.68	$8.30	$6.63	$5.17	$4.78	$4.55	$4.63	$4.97
Q/Q				-	*-5.6%*	*-4.3%*	*-20.2%*	*-22.0%*	*-7.7%*	*-4.6%*	*1.7%*	*7.4%*
PC LP5 32Gb (DDP)				$18.39	$17.35	$16.61	$13.23	$10.32	$9.53	$9.09	$9.24	$9.92
Q/Q				-	*-5.6%*	*-4.3%*	*-20.4%*	*-22.0%*	*-7.7%*	*-4.6%*	*1.7%*	*7.4%*

Source: Edgewater Research Estimates

Highlighted above are our latest on-board PC/LP4x component price forecasts. For C4Q22, we're adjusting our latest DDR4 PC on-board DRAM ASP forecasts lower to ~$2.3-2.5/GB, or down ~19-20% Q/Q. In general, the overall trajectory of on-board (and PC DRAM DIMM) ASPs likely to remain fluid given the intra-quarter ASP adjustments to-date, a dynamic that is likely to continue through YE22, as supplier/s are increasingly leveraging ASP concessions in a bid to boost shipments. Thus, our research suggests select supplier/s have and/will likely continue to leverage a "pulling-in" of next month/quarter ASPs throughout Nov/Dec'22 in an attempt to incentivize additional volume pull-ins before year-end. In general, our research suggests the current baseline of on-board ASPs actually consumed this month/quarter are likely tracking towards the mid/upper-end of latest forecast/s, yet we're adjusting our latest average quarterly ASP forecasts lower to reflect the anticipated pulling-in of next month/quarter ASPs though YE22. Our latest DDR5 16Gb (and 32Gb DDP) on-board ASP forecasts for C4Q22 are slightly outpacing our latest adjustment to DDR4 16GB (and 32Gb DDP) ASP forecasts as our research suggests the DDR5 on-board component premium has narrowed vs. DDR4 on-board component (similar to DDR4/DDR5 DIMM premiums). For PC LP4x, we're adjusting our blended C4Q22 ASP forecasts lower to ~$2.5-2.7/GB, or down ~20% Q/Q, as supplier/s remain active/more ASP flexible across PC LP4x (and LP5) in an attempt to offset the sharp deterioration in mobile LP4x/LP5 demand, especially as PC LP4x/LP5 ASPs command a premium vs. mobile LP4x/LP5 ASPs. Furthermore, the PC LP5 premium vs. LP4x has narrowed into C2H22, with multiple OEMs highlighting their ability to achieve ASP parity – with most/all OEMs expected to achieve PC LP4x/LP5 ASP parity this quarter. Highlighted below are our latest CY23 DDR4 (and DDR5) PC DRAM ASP forecasts, which will likely remain volatile given current dynamics in which weaker orders and inventory digestion (and thus supplier/s push to boost bit shipments) continues to supersede any immediate concerns regarding supplier/s commentary on CY23 supply/capex cuts. Overall, we're forecasting PC (and overall) DRAM ASP erosion to continue throughout C1H23 (albeit at a sharply slower rate vs. C2H22) – yet we will continue to monitor for signals of additional adjustments to CY23 supply growth/inventory digestion and thus an overall shift in buyer (and market) sentiment/inventory positioning to gain more confidence regarding our latest forecast.

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PC DRAM Contract Price Forecasts - DDR4 8GB/16GB DIMMs

DDR4 8GB	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23
Price	$17.55	$17.22	$16.64	$16.64	$16.56	$16.56	$16.56	$16.72	$17.22	$17.72	$18.21	$18.80
Qtr Avg.			***$17.14***			***$16.58***			***$ 16.83***			***$18.24***
M/M	*-4%*	*-2%*	*-3%*	*0%*	*0%*	*0%*	*0%*	*1%*	*3%*	*3%*	*3%*	*3%*
Q/Q			***-8.6%***			***-3.2%***			***1.5%***			***8.4%***
Y/Y	*-40%*	*-40%*	*-42%*	*-42%*	*-41%*	*-39%*	*-34%*	*-29%*	*-18%*	*-8%*	*-3%*	*3%*

DDR4 16GB	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23
Price	$ 33.99	$ 33.36	$ 32.22	$ 32.22	$ 32.07	$ 32.07	$ 31.99	$ 32.31	$ 33.27	$ 34.15	$ 35.11	$ 36.24
Qtr Avg.			***$ 33.19***			***$ 32.12***			***$ 32.52***			***$ 35.17***
M/M	*-4%*	*-2%*	*-3%*	*0%*	*0%*	*0%*	*0%*	*1%*	*3%*	*3%*	*3%*	*3%*
Q/Q			***-8.8%***			***-3.2%***			***1.3%***			***8.1%***
Y/Y	*-40%*	*-41%*	*-42%*	*-42%*	*-41%*	*-39%*	*-34%*	*-30%*	*-19%*	*-8%*	*-4%*	*2%*

Source: Edgewater Research Estimates

PC DRAM Contract Price Forecasts - DDR5 8GB/16GB DIMMs

DDR5 8GB	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23
Price	$21.76	$21.18	$20.46	$20.13	$19.87	$19.70	$19.70	$19.73	$20.14	$20.55	$20.76	$21.05
Qtr Avg.			***$21.13***			***$19.90***			***$ 19.86***			***$20.79***
M/M	*-4%*	*-3%*	*-3%*	*-2%*	*-1%*	*-1%*	*0%*	*0%*	*2%*	*2%*	*1%*	*1%*
Q/Q			***-11.0%***			***-5.8%***			***-0.2%***			***4.7%***
Y/Y	*-46%*	*-47%*	*-49%*	*-48%*	*-47%*	*-46%*	*-41%*	*-36%*	*-26%*	*-16%*	*-13%*	*-8%*

DDR5 16GB	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23
Price	$41.47	$40.36	$38.99	$38.34	$37.84	$37.52	$37.43	$37.48	$38.26	$38.94	$39.32	$39.86
Qtr Avg.			***$ 40.27***			***$ 37.90***			***$ 37.72***			***$ 39.37***
M/M	*-5%*	*-3%*	*-3%*	*-2%*	*-1%*	*-1%*	*0%*	*0%*	*2%*	*2%*	*1%*	*1%*
Q/Q			***-11.3%***			***-5.9%***			***-0.5%***			***4.4%***
Y/Y	*-46%*	*-47%*	*-49%*	*-48%*	*-48%*	*-46%*	*-41%*	*-36%*	*-26%*	*-17%*	*-14%*	*-8%*

Source: Edgewater Research Estimates

Mobile DRAM order trends unchanged, as most OEMs continue to focus on inventory digestion/management as end demand/sell-thru remains challenged globally; supplier/s remain "hopeful" unit (and DRAM orders) recover into C2Q23/C2H23. In general, our research is relatively unchanged in that mobile DRAM (and embedded) orders remain muted/sub-seasonal as most OEMs continue to highlight their desire to minimize finished smartphone (and component) inventories through YE22 given the current macro environment. Overall, our research suggests smartphone OEMs continue to cite their desire to digest and/or maintain lean inventories through YE22 given 1) the continued downtick in overall unit shipments/demand throughout C2H22, 2) ongoing pessimism regarding any near-term recovery in unit demand given continued global macro/consumer spending pressures, and 3) view that mobile DRAM (and embedded) ASPs will remain deflationary throughout C1H23, thus limiting their willingness/desire to maintain/build on-hand inventories. Our research is unchanged in that weak China consumer demand remains a main area of focus across the supply chain (given the longevity of the current downturn), yet our research suggests most/all end geographies remain under pressure due to persistent macro/inflationary concerns. Our latest research suggests China smartphone demand/sell-thru throughout Oct'22 has sharply downticked across all OEMs, including Apple, with units declining >17% on a Y/Y basis throughout 2H Oct'22, suggesting unit shipments are still trending down by at least ~13-15% Y/Y to <280M units. Thus, while segments of the supply chain were cautiously optimistic regarding a potential recovery in demand following China's Party Congress meeting in mid-Oct'22, our latest research suggests demand/sell-thru has actually further waned, with Apple shipments appearing to have actually declined at a sharper Y/Y basis vs. domestic China brand OEMs. For CY22, our smartphone unit shipment forecasts are unchanged at down ~7-11% Y/Y, or to ~1.2-1.25B units (vs. initial forecasts of ~1.35B+ units entering the year) – while 5G shipment forecasts have been adjusted lower (again) by major suppliers including MediaTek, Qualcomm, and Qorvo to ~600M units (vs. initial forecasts of ~700M units entering the year). For CY23, while visibility remains limited given ongoing global macro uncertainties, we're forecasting units to remain flat/up low single-digits % Y/Y – yet we continue to see growing signals that mobile OEMs (and AP suppliers Qualcomm/MediaTek) are shifting more of their focus to lower/mid-range 5G models likely assuming the global consumer will remain pressured into CY23.

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Mobile DRAM LP4x/LP5 Price Forecasts

	1Q21	2Q21	3Q21	4Q21	1Q22	2Q22	3Q22	4Q22e	1Q23e	2Q23e	3Q23e	4Q23e
32Gb (4GB) - LP4x	$12.61	$13.75	$15.40	$14.17	$13.46	$12.92	$11.11	$9.11	$8.38	$8.13	$8.38	$8.88
Q/Q	*2.0%*	*9.0%*	*12.0%*	*-8.0%*	*-5.0%*	*-4.0%*	*-14.0%*	*-18.0%*	*-8.0%*	*-3.0%*	*3.0%*	*6.0%*
48Gb (6GB) - LP4x	$18.35	$20.00	$22.40	$20.61	$19.58	$18.79	$16.16	$13.25	$12.19	$11.83	$12.18	$12.91
Q/Q	*2.0%*	*9.0%*	*12.0%*	*-8.0%*	*-5.0%*	*-4.0%*	*-14.0%*	*-18.0%*	*-8.0%*	*-3.0%*	*3.0%*	*6.0%*
48Gb (6GB) - LP5	$19.50	$21.25	$23.46	$21.58	$20.50	$19.59	$16.77	$13.75	$12.59	$12.09	$12.27	$12.88
Q/Q	*1.0%*	*9.0%*	*10.4%*	*-8.0%*	*-5.0%*	*-4.5%*	*-14.4%*	*-18.0%*	*-8.4%*	*-3.9%*	*1.5%*	*5.0%*
64Gb (8GB) - LP5	$25.92	$28.25	$31.19	$28.69	$27.26	$26.04	$22.29	$18.28	$16.73	$16.08	$16.32	$17.12
Q/Q	*1.0%*	*9.0%*	*10.4%*	*-8.0%*	*-5.0%*	*-4.5%*	*-14.4%*	*-18.0%*	*-8.4%*	*-3.9%*	*1.5%*	*5.0%*
96Gb (12GB) - LP5	$36.70	$40.00	$44.16	$40.63	$38.60	$36.88	$31.56	$25.88	$23.70	$22.76	$23.10	$24.25
Q/Q	*1.0%*	*9.0%*	*10.4%*	*-8.0%*	*-5.0%*	*-4.5%*	*-14.4%*	*-18.0%*	*-8.4%*	*-3.9%*	*1.5%*	*5.0%*
128Gb (16GB) - LP5	$47.71	$52.00	$57.41	$52.82	$50.17	$47.94	$41.03	$33.64	$30.80	$29.59	$30.03	$31.52
Q/Q	*1.0%*	*9.0%*	*10.4%*	*-8.0%*	*-5.0%*	*-4.5%*	*-14.4%*	*-18.0%*	*-8.4%*	*-3.9%*	*1.5%*	*5.0%*

Source: Edgewater Research Estimates

Highlighted above are our latest discrete mobile LP4x/LP5 DRAM price forecasts. We're adjusting our C4Q22 (and C1Q23) discrete LP4x/LP5 ASP forecasts lower to reflect an increasingly ASP flexible environment. In general, our research had previously highlighted that LP4x ASPs had already dropped below the $0.30/Gb threshold for select China OEMs in Sept'22, which was leveraged by OEMs as a baseline target into C4Q22. Thus, while we had previously assumed that supplier/s would resist lowering ASPs <$0.30/Gb entering Oct'22, the degree of mobile DRAM ASP flexibility accelerated last month aligning with trends seen within PC/server DRAM. Thus, we're adjusting our latest C4Q22 mobile LP4x/LP5 ASPs lower to down high teens % Q/Q, while maintaining the view that ASPs are likely to drift lower intra-quarter as mobile OEM pulls remain relatively muted, which is likely to spur supplier/s to pursue additional ASP concessions later in the quarter in an attempt to boost shipments before YE22. Overall, while pockets of mobile LP4x DRAM ASPs appeared to decline to/below $0.30/Gb by late Sept'22, our research suggests muted orders led to an acceleration in ASP concessions by select suppliers/s throughout Oct'22, with ASPs as low as ~$0.27-0.28/Gb. Our research is unchanged in that most OEMs remain wary of pulling-in large volumes, beyond what can be near-term consumed, leading to increased speculation that supplier/s could offer additional ASP concessions later in the quarter. Thus, we're maintaining the view that mobile (and overall) DRAM ASPs are likely to decline throughout C1H23. We're forecasting mobile DRAM ASPs to decline mid/high single-digits % Q/Q in C1Q23 (and low/mid-single-digits % Q/Q in C2Q23) – assuming mobile DRAM ASPs trough at ~$0.24-0.26/Gb by mid-CY23. For LP5, while select supplier/s had been cited as being more ASP flexible with LP5-based solutions throughout C1H22, yet due to the sharp decline in mobile DRAM orders over the past few months and global decline in premium-based handsets (excluding Apple) it appears LP5 demand has waned. Thus, our research suggests the LP5 premium remains fluid with select mobile OEMs (able to commit to large volumes) likely able to achieve low single-digit % premiums while other OEMs, whose demand remains soft, are seeing premiums as high as 5%+ in C4Q22.

DRAM Component Price/Gb Forecasts - Estimates by Production Segment *(1Gb eq.)*

	1Q21	2Q21	3Q21	4Q21	1Q22	2Q22	3Q22	4Q22e	1Q23e	2Q23e	3Q23e	4Q23e
PC DDR4	$0.38	$0.48	$0.50	$0.44	$0.42	$0.40	$0.33	$0.26	$0.23	$0.22	$0.23	$0.25
Server DDR4*	$0.41	$0.49	$0.53	$0.49	$0.46	$0.44	$0.36	$0.28	$0.25	$0.24	$0.25	$0.27
PC DDR5 *(16Gb)*	-	-	-	-	$0.56	$0.52	$0.41	$0.31	$0.27	$0.25	$0.25	$0.26
Server DDR5 *(16Gb)*	-	-	-	-	$0.60	$0.58	$0.46	$0.34	$0.29	$0.27	$0.26	$0.27
Mobile LP4x	$0.39	$0.42	$0.47	$0.43	$0.41	$0.39	$0.34	$0.28	$0.26	$0.25	$0.26	$0.27
Mobile LP5	$0.41	$0.45	$0.49	$0.45	$0.43	$0.41	$0.35	$0.29	$0.27	$0.25	$0.26	$0.27
Graphics GDDR5	$0.69	$0.85	$0.92	$0.89	$0.87	$0.85	$0.74	$0.65	-	-	-	-
Graphics GDDR6	$0.66	$0.82	$0.87	$0.83	$0.79	$0.78	$0.68	$0.60	$0.57	$0.56	$0.58	$0.61
Graphics GDDR6 *(16Gb)*	$0.62	$0.76	$0.80	$0.76	$0.72	$0.70	$0.60	$0.51	$0.46	$0.44	$0.45	$0.47

*Source: ERC Estimates; based on 8Gb chip price estimates unless otherwise noted. *Server DDR4 DRAM Price/Gb forecast are based on 16Gb chip price starting C1Q23*

Highlighted above are our latest DRAM component price/Gb by DRAM market segment. Our component price/Gb forecasts are our attempt to compare our PC/server DIMM/RDIMM ASP forecasts, excluding PCB costs, with our mobile/graphics (and PC on-board) component ASP estimates. Our DRAM on-board component ASP forecasts reflect PC OEM ASPs, which typically have a different price formula depending on individual supplier/capacity/node. Our latest C4Q22 PC DDR4 DIMM component price forecasts were revised to ~$0.26/Gb, aligning within the incremental downtick in our latest PC DIMM ASP forecast. Furthermore, we're adjusting our latest C1Q23/C2Q23 PC DDR4 DIMM component price forecasts to ~$0.22-0.23/Gb. Alternatively, our latest PC DDR4 on-board 8Gb/16Gb

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component price forecasts are now trending to ~$0.29-0.30/Gb in C4Q22 and projected to ~$0.26-0.27/Gb throughout C1H23. Our latest PC DDR5 DIMM ASP component price forecasts were also revised lower to ~$0.31/Gb this quarter, declining to ~$0.25-0.26/Gb throughout C1H23 – reflecting our latest view regarding the relative DDR5 premium vs. DDR4 DIMM (and on-board components). Due to the deterioration in DRAM demand (and ASP) fundaments, there is now a greater focus on supplier/s cash costs (operating margins excluding depreciation), which admittedly remains fluid given individual supplier costs/margins. However, based on our latest forecasts, we estimate supplier/s cash costs for DDR4 8Gb-based PC/RDIMM solutions are likely in the ~$0.20-0.22/Gb range and ~$0.18-0.20/Gb range for DDR4 16Gb-based PC/RDIMM solutions. Overall, we're revising our latest C4Q22 (and C1H23) PC DRAM ASP forecasts lower given ongoing near-term supply/demand pressures – as the gap between CY22 DRAM production and demand/shipments continue to weigh on ASPs. Our latest C4Q22 DDR4 RDIMM component price forecasts were revised lower to ~$0.28/Gb, and currently forecasted to trough at ~$0.24-0.25/Gb throughout C1H23. We will continue to monitor/adjust our latest CY23 DRAM ASP forecasts accordingly, yet we're maintaining the view that DRAM ASPs are likely to remain deflationary throughout C1H23 given the current demand/supply gap – while awaiting greater clarity on supplier/s CY23 supply plans, inventory digestion progress, and overall end demand trends before making any additional adjustments to our latest forecast.

Our latest graphics card research suggests demand challenges are unchanged, yet it appears Nvidia (and supply chain partners) have been successful in managing channel inventories lower while lingering higher-end RTX 3000 series inventories were mostly written-off before the RTX 4090/4080 market launch. AIB/channel partners have noted selling-out of limited RTX 4090/4080 stock because of strong gaming/enthusiast demand, which has caused higher-end RTX 3000 series pricing to stabilize due to a lack of alternatives. Our research suggests Nvidia likely undersold RTX 4000 series demand to protect higher-end RTX 3000 series demand as Nvidia plans to unwind on-hand inventories of high-end GPU stock into mid-CY23 via new graphics card models and increased sales of RTX 3080 10GB. Furthermore, we expect AIB partners to launch additional graphics cards including RTX 3060 8GB, 3060Ti with added GDDR6X, and a specialized 3070Ti, which are expected to help clear high-end GPU stock (and graphics DRAM). Going forward, our research suggests Nvidia intends to be more disciplined on RTX 4000 series production given the current macro headwinds (and existing stock of RTX 3000 series) yet AIB partners are expecting additional cards including RTX 4070/4060 to become available in Jan'23. For AMD, our research suggests less enthusiasm on the upcoming Radeon 7000 series launch due to lackluster performance expectations and elevated channel inventory. Similarly, our research remains muted on Intel's new Arc series graphics cards – citing few AIB partners. Our research suggests Gaming Console builds likely peaked last quarter and likely to decline into CY23 Y/Y as AMD recently noted expectations for their Gaming revenues (which includes Gaming Console and GPUs) to remain flat Y/Y. Overall, we're maintaining our latest GDDR6 8Gb ASP forecasts of down 10-15% Q/Q in C4Q22 to slightly below $5, while projecting declines into CY23 to be less severe vs. GDDR6 16Gb given the increased relative volume of GDDR6 16Gb in next-gen GPU products from Nvidia, AMD, and Intel. Furthermore, we're forecasting GDDR6 16Gb ASPs to decline ~15% Q/Q to $8-9, yet we continue to see a wide deviation in ASP trends as PC OEMs are just starting to shift their orders/mix to GDDR6 16Gb (from 8Gb) in C4Q22/CY23, while Gaming and GPU OEMs have been early volume adopters of this solution.

CY22 DRAM bit demand tracking to +5-7% Y/Y growth, yet decline in orders/inventory digestion across most end markets continue to cloud visibility, expect supplier/s to push late-year shipments; CY23 DRAM bit demand forecasted to low-10% Y/Y. Our latest research is unchanged in that CY22 DRAM bit demand growth forecasts continue to downtick given continued negative adjustments to orders/pulls over the past few months. As highlighted previously, adjustments to CY22 DRAM bit demand growth forecasts were initially concentrated around the PC/mobile/consumer market segments; however, entering into C3Q22 enterprise OEM (and U.S. hyperscalers) began to adjust/lower their RDIMM LTA/order forecasts. Thus, as noted by most supplier/s, visibility regarding actual CY22 DRAM end demand remains mixed as most/all end markets have aggressively shifted to digest their DRAM on-hand inventories over the past few quarters, a trend that is expected to persist throughout at least YE22. Our latest research suggests DRAM supplier/s bit shipments have sharply decelerated into C2H22 – yet it appears the pace of shipment declines are actually exceeding actual end demand/consumption as most market segments have/will continue to digest inventory in the near-term. By end market, our CY22 PC unit shipment forecasts are unchanged at ~290-295M units, or down ~18-20% Y/Y, while our latest CY23 PC unit shipment forecasts are also unchanged at ~265-270M units, or down ~5-10% Y/Y. Our latest CY22 smartphone shipment forecasts are also unchanged, with unit shipments forecasted to decline ~7-11% Y/Y to ~1.2-1.25B units. For CY23, while acknowledging limited visibility given ongoing global macro uncertainties, we're forecasting smartphone units to remain flat/up low single-digits % Y/Y. Thus, based on our latest analysis of PC/smartphone unit shipment (and DRAM order/TAM forecasts), we estimate PC/mobile DRAM bit demand growth is trending down ~2-3% Y/Y, as reduced orders/inventory digestion continues to weigh on overall bit shipments. We're forecasting CY22 server DRAM bit demand to low-20% Y/Y growth assuming continued adjustments/reductions in orders by enterprise OEMs (and select U.S. hyperscalers) over the past few months has dampened the pace of growth. Furthermore, select U.S. hyperscalers continue

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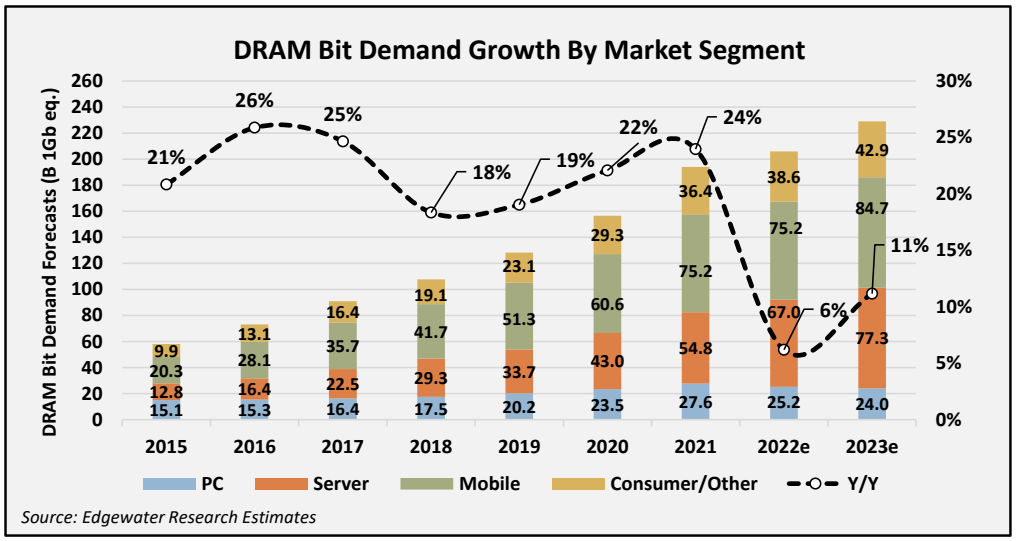
to suggest that at least a portion of their CY23 demand is likely being cannibalized as supplier/s continue to pursue pull-ins to-date (and likely through YE22) – a dynamic that is expected to weigh on orders throughout at least C1H23.



Source: Edgewater Research Estimates

For CY22, we're adjusting our latest DRAM bit demand growth forecast lower again to +5-7% Y/Y, yet near-term visibility remains challenged given the conflicting trends in which most buyers remain focused on digesting on-hand inventories via order reductions despite supplier/s attempts to boost shipments order pull-ins via an acceleration in ASP flexibility. By end market, we're adjusting our latest CY22 server DRAM bit demand growth to low-20% Y/Y, a further downtick in growth forecasts in an effort to reflect ongoing order/pull adjustments/cuts across multiple enterprise OEM/hyperscale buyers. We continue to attribute these order adjustments to 1) push to digest elevated on-hand RDIMM inventories through YE22, 2) increased near-term (and CY23) demand uncertainties, and 3) buyers desire to pursue/seek out greater ASP concessions – given the widening supply sufficiency gap as DRAM bit production has far outpaced DRAM bit demand. For mobile, we're adjusting our latest CY22 mobile DRAM bit demand growth forecast to flattish % Y/Y, as the decline in unit shipments (and OEM inventory digestion) offset the modest increase in content per box growth. For PC, we're forecasting CY22 PC DRAM bit demand to decline ~8-10% Y/Y, as the sharp decline in unit shipments more than offset the relatively positive mix shift in unit builds/shipments. For CY23, we're maintaining our previously adjusted DRAM bit demand growth forecasts, reflecting continued uncertainty regarding the macro/economic backdrop and uncertainty regarding how individual supplier/s are likely to react/plan their CY23 production/supply plans – as the sharp decline in demand/shipments has contributed to record channel inventories and a sharp deterioration in DRAM supplier/s ASP/margins. While select supplier/s continue to cite a relatively optimistic outlook regarding CY23 DRAM bit demand rebounding to mid-teens % Y/Y (or higher), led by continued server DRAM demand growth and a recovery in mobile, our research remains more mixed/guarded on the pace of recovery into next year. Overall, we're maintaining our CY23 industry DRAM demand growth forecast of low-10% Y/Y, yet we're adjusting our latest server DRAM demand growth forecasts lower to +15% Y/Y (due to the dynamics highlighted above), while slightly revising our latest mobile DRAM bit demand growth forecasts higher to +10-15% Y/Y, and PC DRAM bit demand to decline ~3-5% Y/Y.

Adjusting CY22 DRAM supplier/s bit shipment growth sharply lower to +1-3% Y/Y, as sharp inventory correction and pushed-out/cancelled orders weigh heavily on C2H22 shipments; increased ASP flexibility having limited impact on orders to-date. Based on our latest research, we're adjusting our latest CY22 DRAM supplier bit shipment forecast sharply lower to +1-3% Y/Y vs. CY22 DRAM bit production growth of +17-19% Y/Y as supplier/s have limited near-term levers to pull to adjust current production output beyond reducing wafer utilization rates – a dynamic that supplier/s remain uninterested in at the moment. As highlighted previously, Micron's announcement regarding their decision to "selectively reduce utilization in DRAM approximately in the mid-single-digit % range" is mixed as it appears the supplier has reduced utilization of 1xnm nodes, while also planning on using any equipment (and freed up space) to deploy new technology transitions (1β). Overall, Micron (and Hynix/Samsung) are expected to experience a significant build of on-hand DRAM inventories throughout at least YE22 (and likely into C1Q23) as CY22 DRAM production output growth remains on pace to more than double the pace of DRAM bit shipment growth. As a result, CY23 DRAM supplier/s capex/production growth plans are likely to remain fluid given the degree of "carryover inventory" internally and/or at end customers entering next year, and when combined with a relatively muted demand recovery – we're maintaining the view that supplier/s will need to make additional

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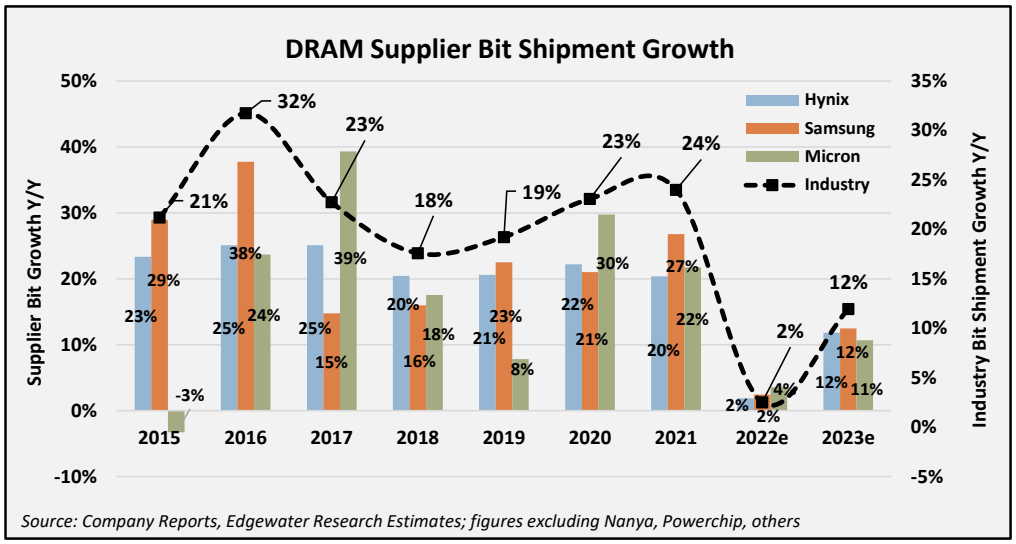
adjustments to their current CY23 DRAM production growth plans, especially as DRAM ASPs inch closer to supplier/s cash costs over the next 1-2 quarters. At the moment, Samsung's CY23 DRAM bit production growth is being forecasted to +8-10% Y/Y, yet prior WFE availability concerns being cited for the decline in bit production growth Y/Y now appears in flux given the adjustments/cuts made by peer suppliers over the past few months. Micron guided their FY23 (Aug'23) WFE spend to decline 50% Y/Y, reflecting a slower ramp of their 1β node, yet the degree/impact from their announced WSPM/utilization reduction remains less clear. Hynix guided their CY23 capex spend to decline >50% Y/Y, while also reducing production of lower-margin products, reducing DRAM wafer production in CY23, and slowing tech migration plans. Despite these announcements, our research suggests Micron's (and Hynix) CY23 DRAM bit production is still trending to low-10% Y/Y, with additional levers available to further slow production growth likely to be more C2H23-weigthed (beyond utilization cuts). Overall, all three DRAM supplier/s continue to allude to the possibility of making additional adjustments to CY23 DRAM bit production/capex plans, yet the degree of on-hand inventory built by the various suppliers (and buyers) throughout C2H22 will need to be monitored closely in order to determine the longevity of the current downturn.



Source: Company Reports, Edgewater Research Estimates; figures excluding Nanya, Powerchip, others

Highlighted in the chart above are our latest DRAM supplier bit shipment growth forecasts, through CY23. Micron guided CY22 industry DRAM bit demand growth to be in the low/mid-single-digit % Y/Y range, yet we believe this forecast reflects Micron (and industry) bit shipments vs. actual end demand – which is being blurred (as highlighted above) by the sharp inventory digestion most/all end markets are going through. Micron guided F1Q23 (Nov'22) DRAM bit shipments to decline ~20% Q/Q, which would peg Micron's CY22 DRAM bit shipment growth in the low single-digit % Y/Y range. Micron's F4Q22 (Aug'22) inventory increased ~18% Q/Q and ~49% Y/Y to $6.66B, while their average DOI increased 30 days Q/Q to 139 days (exiting the quarter at ~151 DOI) – and is now expected to go "well above 150 days" in the current quarter with inventories likely to remain elevated/above their ~150 day target throughout all of FY23 (Aug'23). Hynix recently guided CY22 industry DRAM bit demand growth to be in the low/mid-single-digit % Y/Y, which we believe reflects the decline in orders/pulls throughout C2H22, aligning with our prior adjustment for Hynix's CY22 DRAM bit shipments to decline to <5% Y/Y as their prior demand (and shipment) forecasts appeared too optimistic. Furthermore, Hynix's C3Q22 inventory increased to KRW 14.7T, or +24% Q/Q and +122% Y/Y; Hynix's DOI increased to ~188 days, up from ~144 days Q/Q – while implying that they are likely to further build DOI through C1Q23. Hynix guided CY23 industry DRAM bit demand growth to low teens % Y/Y. Samsung initially guided their C3Q22 DRAM bit shipments to remain flat Q/Q yet reported that their bit shipments declined high teens % Q/Q, as attempts to boost shipments via multi-quarter/pull-ins appeared to be more than offset by weaker overall DRAM orders in the quarter. Samsung guided industry C4Q22 bit shipments up high single-digits % Q/Q (and that they would exceed that level), while guiding CY22 industry (and their) bit shipments up low/mid-single-digits % Y/Y – implying Samsung's C4Q22 DRAM bit shipments need to increase ~20-25% Q/Q, a forecast that appears optimistic/and likely lead to an even greater pace of ASP erosion through YE22. Overall, our research suggests all three DRAM suppliers are likely to experience a significant build of on-hand DRAM inventories through YE22 (and likely into C1Q23) – which we believe is likely to weigh on their ability to balance the market (ASP erosion) in the near-term barring more severe near-term adjustments to current CY23 bit production growth plans.

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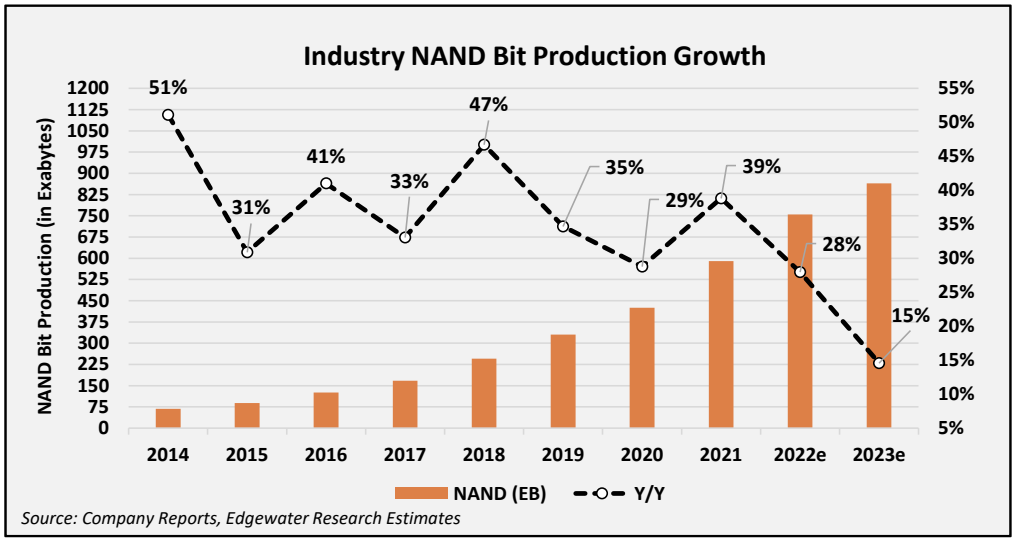
TOP 3 NAND FLASH HIGHLIGHTS

1. Current NAND/SSD fundamentals unchanged w/ supply significantly outpacing demand into C4Q22, leading to sharp ASP erosion and increase in supplier/s DOI – additional measures needed into CY23 despite pockets of supplier/s supply/capex adjustments
2. DC/eSSD orders unchanged QTD, most enterprise OEMs (and hyperscalers) still cited as adjusting/cutting orders, blended ASPs still trending down ~15-20%+ Q/Q; CY23 DC/eSSD demand forecasts mixed, CSPs forecasted to see sharp slowdown in Y/Y demand
3. PC OEM cSSD orders mixed into C4Q22, w/ pockets of demand increases following sharp cuts/inventory digestion last quarter by most PC OEMs – ASP erosion accelerating to 20%+ Q/Q as supplier/s pursue volume pull-ins yet OEMs appetite to buy limited

NAND/SSD outlook remains challenged as sharp contraction in orders throughout C2H22 expected to reduce CY22 industry NAND bit shipments to <10% Y/Y, leading to substantial increase in supplier/s NAND DOI entering CY23. Our research has seen little signals of any recovery in NAND/SSD orders QTD as buyers across most end markets remain focused on inventory digestion/management. At the moment, it appears most buyers continue to cite multiple factors as contributing to their desire to digest and/or maintain leaner inventories including 1) global macro/inflationary concerns and its impact on consumer/business sentiment, 2) increased focus on financials/improve cash flows/positioning, and 3) general view across most/all buyers that the current NAND/SSD oversupply environment will likely continue into at least C1H23. By end market, our research is unchanged in that while PC/mobile/consumer buyers had been the first market segment to begin reducing orders throughout C1H22, enterprise OEM and global hyperscalers also began to reduce their orders/pulls last quarter, a trend that has continued into the current quarter. Thus, our research suggests the NAND/SSD pricing environment remains dynamic as select supplier/s continue to push buyers to pull-in additional volumes – yet despite the sharp decline in ASPs, most buyers remain focused on limiting/digesting on-hand inventories through YE22. Furthermore, our research suggests most buyers see little/no urgency in pulling-in additional volumes to-date given the belief that the sharp decline in orders over the past few months has led to likely record levels of channel/supplier/s DOI. Thus, our research suggests most buyers continue to believe "time is on their side", in the sense that the longer they delay orders/pulls the more favorable ASPs will ultimately be later in the quarter and/or into C1Q23. Overall, we're maintaining the view that average cSSD, mobile NAND, and DC/eSSD ASPs are likely to decline by at least mid/high teens % Q/Q yet OEMs willing/able to pull-in additional volumes are seeing pockets of ASP concessions of 20-25%+ Q/Q. We will continue to monitor our latest NAND demand/supply (and ASP) forecasts closely yet given the severity of the supply/demand gap and limited near-term clarity regarding individual supplier/s production (and wafer utilization adjustment) plans into CY23 – we're maintaining the view that NAND ASPs (and overall NAND supply sufficiency) is likely to remain a challenge for suppliers/s throughout at least C1H23. Thus, our research is unchanged in that greater/more severe supply adjustments including NAND wafer utilization cuts (beyond Kioxia) are needed in order to balance supply/demand by C2H23.



Source: Company Reports, Edgewater Research Estimates

Highlighted above are our latest NAND Flash bit production growth forecasts, through CY23. Our research is unchanged in that CY22 industry NAND bit production growth still appears to be trending in the high-20% Y/Y range, driven by a combination of strong Y/Y capex spending trends over the past few years alongside node tech migrations, and increased WSPM loading by select NAND supplier/s earlier in the year immediately following the WD/Kioxia fab contamination. Alternatively, while Kioxia announced their decision to reduce production at their Yokkaichi and Kitakami fabs by ~30% in early Oct'22 – the impact from this adjustment is likely to have

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limited/no impact on CY22 bit production but is being factored into our CY23 NAND bit production growth forecast. Beyond Kioxia, Micron (and Hynix) have announced their intention to selectively reduce NAND utilization, primarily for lower margin profits (i.e. lagging edge node production), while Micron noted that they will use the equipment/space that is freed up to deploy new technology transition – blurring visibility regarding the actual impact on supply output. Furthermore, WD and Samsung have provided mixed feedback regarding their CY23 supply plans, with neither supplier sponsoring the idea of reducing wafer utilization while providing mixed commentary regarding their decisions to delay/push-out the development/ramp of their BiCS6/V7 while weighing the possibility of pulling-in their BiCS8(Plus)/V8 investment/ramp timeline. Overall, given the sharp decline in demand across most/all end markets throughout C2H22, our research suggests CY22 NAND bit demand growth is now tracking <15% Y/Y (while supplier/s bit shipments are now tracking well below <10% Y/Y) yet the range in forecasts deviate widely across the supply chain as supplier/s continue to cite difficultly in being able to gauge actual end demand given the degree of inventory digestion most buyers are currently pursuing. Thus, given limited/no near-term actions to adjust NAND bit production growth, our research suggests multiple supplier/s are now likely to exit the year holding >15 weeks of NAND DOI. Alternatively, our research is unchanged in suggesting that select DC/hyperscale NAND/SSD inventory positions remain elevated – a dynamic these buyers could leverage well into CY23. We will continue to monitor our latest forecasts accordingly yet given the deterioration in supplier/s NAND operating margins we continue to believe that there is a need for additional/more severe adjustments to CY23 supply plans beyond current measures of reduced capex.

By supplier, Micron revised their CY22 NAND bit demand growth forecast to "slightly greater than 10% Y/Y" yet given their push to expand 176L adoption our research suggests Micron's CY22 supply growth is still trending in line with overall industry supply growth. Samsung guided their/industry CY22 bit growth (shipments) to be up mid-single-digits % Y/Y yet remained mum regarding their utilization/capex plans entering CY23. Our research suggests Samsung is likely to maintain strong investments/capex as the supplier pushes to ramp V8/23xL – a dynamic that will weigh on the need to reduce supply growth into CY23 yet will allow the supplier to become more cost competitive. Hynix announced a sharp reduction in their CY23 capex by >50% Y/Y, which includes a plan to reduce NAND wafer production and slow their tech migration next year. However, Hynix (and Micron) guided CY23 industry NAND bit demand to increase mid/high-20% Y/Y, a forecast that appears optimistic based on our latest research. Alternatively, while Kioxia was the first supplier to announce a cut to their NAND wafer utilization rates, WD noted that while they will pushout their BiCS6 (162L) transition, the supplier hasn't taken any major underutilization actions in their NAND fabs – while forecasting their CY23 NAND bit supply (production) growth to ~20-25% Y/Y. Overall, for CY23, we're forecasting NAND production growth to mid-10% Y/Y to reflect already announced capex/wafer utilization cuts (Kioxia), while maintaining the view that additional adjustments are needed/likely as supply growth will need to be further dialed back given the supply imbalance and negative operating margins most/all supplier/s will suffer from entering into next year. While CY23 NAND demand visibility remains limited, forecasts sourced across multiple PC and DC/eSSD OEMs (hyperscalers) suggest demand is likely to remain challenged (relative to supplier/s forecasts), yet we're starting to see pockets of demand elasticity kick-in given the sharp deterioration in ASPs. Our latest research suggests PC cSSD bit demand is now projected to increase ~10%+ Y/Y while DC/eSSD bit demand is still projected to +15-20% Y/Y. Thus, while Micron (and Hynix) recently guided CY23 NAND bit demand to mid-20%+ Y/Y, our research suggests CY23 NAND bit demand growth is likely trending to ~15-20% Y/Y.

Mobile/eMCP order trends unchanged QTD as OEMs remain focused on maintaining lean inventory levels through YE22; supplier/s cited as increasingly pushing OEMs (and agents/partners) to pull-in more given wide gap between orders/LTAs. Our research is unchanged in that eMCP/uMCP (and discrete eMMC/UFS) OEM orders/pulls remain muted as OEMs focus on maintaining leaner inventories through YE22, and likely into C1Q23 due to typical seasonality. In general, while supplier/s are still being cited as being increasingly active in encouraging OEMs to pull-in more volumes over the past few months, most OEMs remain resistant given their desire to maintain lean inventories through YE22. However, our research suggests select supplier/s have been cited as being more active in pushing OEMs and/or agents/partners to pull-in additional volumes over the past month given the shortfall in orders/pulls vs. initial LTAs – a dynamic that is likely to lead to a significant build of channel DOI through YE22. As highlighted in the mobile DRAM section of this update, our latest research suggests China smartphone demand/sell-thru in Oct'22 decelerated with shipments declining ~18% Y/Y in the month and optimism regarding any material recovery in demand during the 11/11 Shopping Holiday remains muted. Thus, our latest CY22 industry smartphone unit shipment forecasts are unchanged at down ~7-11% Y/Y, or ~1.2-1.25B units. For CY23, we're forecasting units to remain flat/up low single-digits % Y/Y (yet some forecasts are projecting units increase mid-single-digits % Y/Y). However, our research suggests most OEMs acknowledge near-term visibility remains challenged and given persistent macro/inflationary pressures (and global recessionary concerns) current forecasts for modest low single-digit % Y/Y growth may prove optimistic. Furthermore, our research suggests China branded OEMs Oppo, Vivo, and Xioami have suggested that they are currently forecasting their CY23 smartphone units to be flat "best case", with Samsung, Apple, and Honor likely key to growing overall CY23 smartphone units Y/Y. Overall, we're maintaining our latest C4Q22 average eMCP ASPs lower to down ~15-20% Q/Q, while adjusting

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our latest C1Q23 eMCP ASP forecasts marginally lower to down ~6-10% Q/Q. In general, our research suggests select supplier/s have continued to push OEMs (and agents) to pull additional volumes which will likely lead to greater intra-quarter ASP erosion.

Mobile eMCP Pricing Forecasts

	1Q21	2Q21	3Q21	4Q21	1Q22	2Q22	3Q22	4Q22e	1Q23e	2Q23e	3Q23e	4Q23e
16+16 (eMMC + LP3/4x)	$11.70	$ 12.81	$ 13.84	$ 13.14	$ 12.75	$ 12.62	$ 11.11	$ 9.44	$ 8.88	$ 8.61	$ 8.87	$ 9.31
Q/Q	*2.2%*	*9.5%*	*8.0%*	*-5.0%*	*-3.0%*	*-1.0%*	*-12.0%*	*-15.0%*	*-6.0%*	*-3.0%*	*3.0%*	*5.0%*
32+16 (eMMC + LP3/4x)	$12.35	$ 13.52	$ 14.47	$ 13.75	$ 13.33	$ 13.07	$ 11.50	$ 9.77	$ 9.19	$ 8.91	$ 9.18	$ 9.64
Q/Q	*2.1%*	*9.5%*	*7.0%*	*-5.0%*	*-3.0%*	*-2.0%*	*-12.0%*	*-15.0%*	*-6.0%*	*-3.0%*	*3.0%*	*5.0%*
32+24 (eMMC + LP3/4x)	$16.00	$ 17.36	$ 18.58	$ 17.27	$ 16.58	$ 16.25	$ 13.98	$ 11.46	$ 10.54	$ 10.12	$ 10.32	$ 10.84
Q/Q	*4.9%*	*8.5%*	*7.0%*	*-7.0%*	*-4.0%*	*-2.0%*	*-14.0%*	*-18.0%*	*-8.0%*	*-4.0%*	*2.0%*	*5.0%*
64+32 (eMMC + LP4x)	$22.75	$ 24.68	$ 26.41	$ 24.56	$ 23.33	$ 22.63	$ 19.24	$ 15.78	$ 14.51	$ 13.93	$ 14.21	$ 14.92
Q/Q	*4.6%*	*8.5%*	*7.0%*	*-7.0%*	*-5.0%*	*-3.0%*	*-15.0%*	*-18.0%*	*-8.0%*	*-4.0%*	*2.0%*	*5.0%*
128+32 (eMMC + LP4x)	$27.50	$ 29.70	$ 31.78	$ 29.24	$ 27.77	$ 26.94	$ 22.63	$ 18.10	$ 16.29	$ 15.48	$ 15.63	$ 16.42
Q/Q	*3.8%*	*8.0%*	*7.0%*	*-8.0%*	*-5.0%*	*-3.0%*	*-16.0%*	*-20.0%*	*-10.0%*	*-5.0%*	*1.0%*	*5.0%*
128+48 (eMMC + LP4x)	$35.00	$ 37.80	$ 40.45	$ 37.21	$ 35.35	$ 34.29	$ 28.12	$ 22.49	$ 20.24	$ 19.23	$ 19.42	$ 20.40
Q/Q	*3.7%*	*8.0%*	*7.0%*	*-8.0%*	*-5.0%*	*-3.0%*	*-18.0%*	*-20.0%*	*-10.0%*	*-5.0%*	*1.0%*	*5.0%*

Source: Edgewater Research Estimates

PC OEM cSSD orders mixed w/ select OEMs cited as resuming orders albeit off lower C3Q22 baseline, while other OEM orders remain muted/decreasing Q/Q; adjusting C4Q22 cSSD ASPs lower to down 20%+ Q/Q, volume dependent. Our latest research suggests cSSD order volumes remain mixed as while select OEM order volumes are projecting modest growth Q/Q (albeit off low C3Q22 baselines), other OEMs have continued to cut/reduce orders/pulls QTD given their desire to digest and/or maintain leaner cSSD DOI through YE22. In general, our research suggests that most/all PC OEMs continue to highlight a desire for maintaining and/or depleting their cSSD DOI through YE22 due to a variety of factors including 1) continued/negative adjustments to PC build/shipment forecasts, a trend expected to continue into C4Q22), 2) increased focus to improve cash flows via inventory digestion of all unconstrained components, including cSSDs, and 3) belief that continued inventory/revenue pressures will lead to further ASP erosion into C1Q23/C1H23. Additionally, our research suggests that even with the modest uptick in cSSD unit/bit order volumes into C4Q22 by select PC OEMs, the same OEMs are highlighting the fact that their overall order volumes are still tracking as low as half of their C1Q22/C2Q22 order volumes. Thus, for CY22, our research suggests PC OEM cSSD (EB) demand growth is tracking relatively flat Y/Y, well short of initial target/forecasts at the start of the year which had targeted ~25-30% Y/Y (EB) demand growth. While this significant shortfall in cSSD (EB) demand, along with the deterioration in mobile/consumer and DC/eSSD demand, has led to a sharp collapse in NAND/SSD ASPs – our latest research suggests there are now growing pockets of demand elasticity that are starting to become visible. For CY23, our latest research suggests PC OEM cSSD (EB) demand forecasts have improved over the past month with select OEMs now projecting 10-15%+ Y/Y growth in content per box – given the decline in 512GB/1TB cSSD ASPs, a trend that is expected to continue into C1H23. We will continue to monitor/adjust our latest cSSD demand (and ASP) forecasts accordingly yet based on our latest research while PC OEM order/pull volumes remain challenged into C4Q22, the decline in cSSD ASPs to-date (and likely into C1H23) now appears to be leading select PC OEMs to increase content per box/cSSD and thus overall (EB) demand growth forecasts into CY23.

Client Solid State Drive (SSD) Average Price Forecasts

Client SSDs	3Q22	4Q22e	Q/Q	ASP/GB	1Q23e	Q/Q	ASP/GB	2Q23e	Q/Q	ASP/GB	3Q23e	Q/Q	ASP/GB	4Q23e	Q/Q	ASP/GB
256GB vPCIe (TLC) *Gen3*	$31.0	$27.0	-12.9%	$0.11	$24.8	-8.3%	$0.10	$24.8	0.0%	$0.10	---	---	---	---	---	---
512GB vPCIe (TLC) *Gen3*	$49.3	$39.0	-20.8%	$0.08	$35.0	-10.3%	$0.07	$34.5	-1.4%	$0.07	---	---	---	---	---	---
1TB vPCIe (TLC) *Gen3*	$83.0	$65.0	-21.7%	$0.06	$57.5	-11.5%	$0.06	$56.5	-1.7%	$0.06	---	---	---	---	---	---
256GB vPCIe (TLC) *Gen4*	$32.1	$27.3	-15.0%	$0.11	$24.8	-9.2%	$0.10	$24.5	-1.0%	$0.10	$24.5	0.0%	$0.10	$25.8	5.1%	$0.10
512GB vPCIe (TLC) *Gen4*	$50.5	$38.8	-23.1%	$0.08	$34.7	-10.7%	$0.07	$34.0	-1.9%	$0.07	$34.0	0.0%	$0.07	$35.5	4.4%	$0.07
1TB vPCIe (TLC) *Gen4*	$84.2	$64.4	-23.6%	$0.06	$56.6	-12.0%	$0.06	$55.5	-2.0%	$0.05	$55.5	0.0%	$0.05	$57.5	3.6%	$0.06
512GB vPCIe (QLC) *Gen4*	$48.0	$37.0	-22.9%	$0.07	$33.0	-10.8%	$0.06	$32.3	-2.3%	$0.06	$32.3	0.0%	$0.06	$33.8	4.7%	$0.07
1TB vPCIe (QLC) *Gen4*	$82.5	$63.5	-23.0%	$0.06	$55.5	-12.6%	$0.05	$54.0	-2.7%	$0.05	$54.0	0.0%	$0.05	$56.5	4.6%	$0.06
256GB pPCIe (TLC) *Gen3*	$36.3	$31.5	-13.1%	$0.12	---	---	---	---	---	---	---	---	---	---	---	---
512GB pPCIe (TLC) *Gen3*	$56.8	$44.5	-21.6%	$0.09	---	---	---	---	---	---	---	---	---	---	---	---
1TB pPCIe (TLC) *Gen3*	$96.0	$75.0	-21.9%	$0.07	---	---	---	---	---	---	---	---	---	---	---	---
256GB pPCIe (TLC) *Gen4*	$37.0	$31.5	-14.8%	$0.12	$28.8	-8.7%	$0.11	$28.5	-0.9%	$0.11	$28.5	0.0%	$0.11	$29.8	4.4%	$0.12
512GB pPCIe (TLC) *Gen4*	$57.6	$44.3	-23.1%	$0.09	$39.5	-10.8%	$0.08	$38.5	-2.5%	$0.08	$38.5	0.0%	$0.08	$40.0	3.9%	$0.08
1TB pPCIe (TLC) *Gen4*	$97.4	$74.3	-23.8%	$0.07	$65.0	-12.5%	$0.06	$63.3	-2.7%	$0.06	$63.3	0.0%	$0.06	$65.3	3.2%	$0.06

Source: Edgewater Research Estimates

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Highlighted above are our latest client SSD price forecasts, through YE23. As highlighted previously, cSSD ASPs remain fluid as while C4Q22 "baseline" ASP declines appeared to trend lower by ~15-20% Q/Q we're seeing continued signals of select supplier/s attempting to boost shipment volumes via additional ASP flexibility QTD, a trend that is likely to persist through YE22. In general, our research suggests most PC OEMs cited being approached by select supplier/s throughout last quarter with offers to pull-in and/or to simply maintain initial order volumes in return for additional ~10-20% ASP concessions vs. their initial C3Q22 baseline. Thus, entering C4Q22, cSSD ASP erosion proved to be more severe than initially anticipated as select supplier/s appeared increasingly motivated to pull-in volume shipments before the end of last quarter at "pulled-in" C4Q22 ASP levels – setting a new baseline for ASP expectations entering the quarter. However, over the past month, our research suggests ASP flexibility has continued/intensified which has further blurred ASP trends given that most OEMs appeared wary of locking-in large volume orders yet remain willing to entertain pull-in offers that carried additional ASP concessions to-date. By capacity, our research is unchanged in that lower capacity 128GB/256GB ASP erosion is more subdued at down ~10-15% Q/Q, as supplier/s continue to push/incentivize OEMs to increase higher density cSSD solutions. For 512GB/1TB, our research suggests average ASPs are now trending lower by ~20%+ Q/Q, yet we continue to see a wide deviation in ASPs depending on individual supplier/OEM and volume commitments. For the 512GB, our research suggests ASPs are currently trending as wide as low/mid-$30 to as high as $40, whereas the 1TB solutions are also trending as wide as low/mid-$60 to >$65. Entering C1Q23, we're adjusting our latest cSSD ASP forecasts lower to down high single/low double-digits % Q/Q, assuming a repeat of trends seen throughout Sept'22 – in which select supplier/s offer even greater ASP concessions in an attempt to boost shipments before YE22 – setting a baseline for ASP expectations during C1Q23 RFQs. We will continue to monitor/adjust our cSSD ASP forecasts closely yet based on our latest research we're further adjusting our latest C4Q22 (and C1Q23) ASP forecasts lower to reflect ongoing signals of increased supplier/s ASP flexibility. However, we remain cognizant that as multiple market segments approach/decline below NAND supplier/s cash costs that more dramatic supply actions are need/likely, yet at the moment most supplier/s still appear unwilling to make the needed adjustments to bring the market into balance before C2H23 at the earliest.

Datacenter/eSSD orders unchanged, enterprise OEMs and hyperscalers still appear focused on inventory digestion while select hyperscalers cited as facing challenges in being able to pull-in additional volumes due to space limitations. In general, our research remains unchanged in that DC/eSSD order volumes/pulls have moderated over the past few months as enterprise OEM and select hyperscalers have been increasingly vocal regarding the need to digest elevated DC/eSSD DOI. As highlighted previously, our research suggests multiple enterprise OEMs first appeared to adjust their orders last quarter, with the same OEMs being cited as further adjusting/reducing their C4Q22 eSSD order volumes lower by 10-20%+ vs. initial forecasts. Overall, most enterprise OEMs continue to cite elevated eSSD inventories as leading to their decision to adjust order volumes lower throughout C2H22 – which we primarily attribute to 1) overordering/buffering due to supply chain concerns throughout C1H22, and 2) weaker end demand/consumption as IT/on-prem spending has waned due to global macro challenges. Alternatively, our research remains mixed regarding U.S. hyperscale demand/outlook as while select hyperscalers have been cited as notifying supplier/s of their inability to achieve prior LTA/volumes – supplier/s have noted receiving mixed messages from hyperscalers in their willingness to discuss additional upside/pull-in volumes. Thus, while select supplier/s have cited a reduction in hyperscale NAND/SSD pull-volumes, other supplier/s have cited their belief that the same hyperscalers have been open/willing to determine volume pull-its albeit with additional ASP concessions. These conflicting views across various suppliers have created additional visibility challenges, yet at the moment our research suggests most supplier/s remain wary regarding their own internal (and hyperscaler) inventory positions entering into CY23. Furthermore, most supplier/s appear to acknowledge that continued attempts to boost shipments via pull-ins before YE22, will likely weigh on hyperscalers C1H23/CY23 demand. For CY22, we're forecasting DC/eSSD EB bit demand growth to low/mid-20% Y/Y, with relatively mixed views on U.S. hyperscale demand (and/or potential of late-year pull-ins) driving the wider forecast range. For CY23, we're forecasting DC/SSD bit demand growth of ~15-20% Y/Y, yet it appears pockets of the supply chain are hopeful that sharp ASP erosion this year will drive an uptick in demand elasticity into next year. We will continue to monitor/adjust our latest DC/eSSD demand (and ASP) forecasts accordingly, yet we're adjusting our latest C1Q23 ASP forecasts lower to down high single/low double digits % Q/Q – which will likely force supplier/s to take more dramatic actions on CY23 production plans given the collapse in ASPs over the past few quarters.

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Datacenter NVMe & Enterprise SATA & DP NVMe/SAS SSD - ASP/GB *(Raw NAND)* Price Forecasts

	1Q21	2Q21	3Q21	4Q21	1Q22	2Q22	3Q22	4Q22e	1Q23e	2Q23e	3Q23e	4Q23e
SATA (High/Mid Cap/Volume)	$0.103	$0.113	$0.133	$0.138	$0.133	$0.145	$0.133	$0.108	$0.098	$0.095	$0.095	$0.099
Q/Q	*-6.8%*	*9.8%*	*17.8%*	*3.8%*	*-3.6%*	*9.4%*	*-8.0%*	*-19.0%*	*-9.0%*	*-3.0%*	*0.0%*	*4.0%*
SATA (Mid/Low Cap/Volume)	$0.123	$0.130	$0.148	$0.153	$0.150	$0.168	$0.152	$0.125	$0.115	$0.110	$0.110	$0.115
Q/Q	-5.8%	6.1%	13.5%	3.4%	-1.6%	11.7%	-9.0%	-18.0%	-8.0%	-4.0%	0.0%	4.0%
SP NVMe PCIe (High Cap/Volume)	$0.080	$0.088	$0.103	$0.100	$0.095	$0.103	$0.087	$0.065	$0.060	$0.059	$0.059	$0.062
	-8.6%	*9.4%*	*17.1%*	*-2.4%*	*-5.0%*	*7.9%*	*-15.0%*	*-25.0%*	*-8.0%*	*-2.0%*	*0.0%*	*5.0%*
SP NVMe PCIe (Mid Cap/Volume)	$0.103	$0.113	$0.133	$0.130	$0.125	$0.135	$0.119	$0.096	$0.088	$0.085	$0.085	$0.088
Q/Q	*-6.8%*	*9.8%*	*17.8%*	*-1.9%*	*-3.8%*	*8.0%*	*-12.0%*	*-19.0%*	*-9.0%*	*-3.0%*	*0.0%*	*4.0%*
SP NVMe PCIe (Low Cap/Volume)	$0.125	$0.133	$0.150	$0.150	$0.145	$0.160	$0.141	$0.115	$0.105	$0.102	$0.102	$0.106
Q/Q	-5.7%	6.0%	13.2%	0.0%	-3.3%	10.3%	-12.0%	-18.0%	-9.0%	-3.0%	0.0%	4.0%
DP NVMe/SAS (High Cap/Volume)	$0.128	$0.135	$0.150	$0.153	$0.148	$0.160	$0.146	$0.119	$0.109	$0.105	$0.105	$0.110
	-5.6%	*5.9%*	*11.1%*	*1.7%*	*-3.3%*	*8.5%*	*-9.0%*	*-18.0%*	*-9.0%*	*-3.0%*	*0.0%*	*4.0%*
DP NVMe/SAS (Mid Cap/Volume)	$0.138	$0.143	$0.158	$0.160	$0.155	$0.170	$0.153	$0.127	$0.114	$0.110	$0.110	$0.113
Q/Q	*-5.2%*	*3.6%*	*10.5%*	*1.6%*	*-3.1%*	*9.7%*	*-10.0%*	*-17.0%*	*-10.0%*	*-4.0%*	*0.0%*	*3.0%*
DP NVMe/SAS (Low Cap/Volume)	$0.173	$0.175	$0.190	$0.190	$0.188	$0.208	$0.187	$0.155	$0.140	$0.134	$0.134	$0.138
Q/Q	-4.2%	1.4%	8.6%	0.0%	-1.3%	10.7%	-10.0%	-17.0%	-10.0%	-4.0%	0.0%	3.0%

Source: Edgewater Research Estimates

Highlighted above are our latest datacenter/enterprise SSD price forecasts, through YE23. Based on our latest research, we're maintaining our previously adjusted blended C4Q22 DC/eSSD ASP forecasts of down mid/high teens % Q/Q, while maintaining the view that there were likely pockets of erosion (depending on the individual supplier/buyer) that pushed declines to >20% Q/Q. Furthermore, our research suggests multiple hyperscalers (and enterprise OEMs) have delayed/limited C4Q22 RFQs and/or reduced order volumes due to the various market dynamics highlighted above – which has led select supplier/s to seek out special offers and/or C1Q23/C1H23 volume pull-ins which has continued to weigh on overall/blended ASPs QTD. For eSSDs, we're forecasting blended C4Q22 ASPs to decline mid/high teens % Q/Q, as signals of OEMs adjusting/cutting prior LTA/order volumes last quarter (and into C4Q22) has led supplier/s to further capitulate on ASPs in a bid to maintain/gain share given the decline in overall TAM. For DC-grade SP NVMe SSDs, our research suggests the pace of ASP erosion has accelerated as supplier/s appear to have little/no leverage beyond ASP concessions to drive additional bit shipments – whereas buyers continue to provide mixed messages to supplier/s regarding their ability to pull-in additional volumes citing reduced demand/elevated DOI. However, our research suggests despite these mixed messages, it appears these buyers are still willing and/or able to accept additional pull-in volumes albeit at additional ASP concessions. Thus, for DC-grade SP NVMe SSDs, we're now forecasting ASPs to decline by as much as 20-25%+ Q/Q, particularly as select U.S. hyperscalers are still pushing for/or below $0.06/GB for higher capacity 8TB+ solutions. For C1Q23/CY23, we're maintaining the view that ASPs are likely to decline, as we're now forecasting blended DC/eSSD ASPs to decline another high single/low double-digit % Q/Q – as supply/capex adjustments to-date don't appear severe enough to materially impact the current downturn. However, we're maintaining the view that NAND/SSD ASP (and margin) pressures are likely to continue/intensify which will eventually force even greater adjustments to supply growth – yet given the sheer amount of inventory spillover into CY23, we continue to see limited signals that would lead to a material correction/stabilization in ASPs until at least mid-CY23 at the earliest.

APPENDIX

We, Sean Muir, John Spohn, and Kevin Rottinghaus hereby certify that the views expressed in this research report accurately reflect our personal views about any or all of the subject securities referred to in this research report. We certify that no part of our compensation was, is or will be directly or indirectly related to the specific recommendations or views expressed in this research report. The analyst(s) responsible for the preparation of this report have no ownership stake in this company. Edgewater Research Company provides no investment banking services on this or any company.

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