GMX · SECURITY REVIEW

GMX
Morpho Liquidation Module.

A security review of Morpho Liquidation Module.

CLIENT	PROJECT	AUDITORS	AUDIT WINDOW	FINAL REPORT
GMX	Morpho Liquidation Module	Felipe Gomez, Michael Lett, Ferran Celades	November 13 – November 19, 2026	November 26, 2026

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§ 00

Contents.

13 pages: overview, confidence ranking, scope, 3 findings, disclaimer, and about Guardian.

§ 01 **Overview** P. 03

§ 02 **Confidence Ranking** P. 04

§ 03 **Scope & Classifications** P. 05

Files in Scope P. 06

§ 04 **Findings** P. 07

Main Review · 3 findings P. 08

§ 05 **Disclaimer** P. 12

§ 06 **About Guardian** P. 13

§ 01

Overview.

Guardian reviewed Morpho Liquidation Module across 2 review rounds. The final report includes 3 Informational findings.

AUDIT FIRM
Guardian

CLIENT
GMX

PROJECT
Morpho Liquidation Module

PREPARED BY
Felipe Gomez, Michael Lett, Ferran Celades

AUDIT WINDOW
November 13 – November 19, 2026

FINAL REPORT
November 26, 2026

REPOSITORY
https://github.com/gmx-io/gmx-ops-contracts

METHODOLOGY
Smart contract · Manual · Main Review · Remediation Review

MAIN REVIEW COMMIT
0c0c28e0c49b

REMEDIATION REVIEW COMMIT
f3c37625bda8

1.1 Confidence Ranking

5 / 5

Very High Confidence

Guardian assigns a Confidence Ranking of 5 out of 5, combining finding severity, remediation outcome, and the reviewer's assessment of latent risk. The full scale is on the next page.

1	2	3	4	5
VERY LOW CONFIDENCE	LOW CONFIDENCE	MODERATE CONFIDENCE	HIGH CONFIDENCE	VERY HIGH CONFIDENCE

1.2 Findings at a Glance

SEVERITY	TOTAL	PENDING	ACK	PARTIAL	RESOLVED
Critical	**0**	0	0	0	0
High	**0**	0	0	0	0
Medium	**0**	0	0	0	0
Low	**0**	0	0	0	0
Informational	**3**	0	1	0	2
All severities	**3**	**0**	**1**	**0**	**2**

§ 02

Confidence Ranking.

Guardian assigns a project-level confidence score using the scale below. The ranking combines finding severity, remediation outcome, and the reviewer's assessment of latent risk.

CONFIDENCE RANKING	DEFINITION AND RECOMMENDATION	RISK PROFILE
5 Very High Confidence ASSIGNED	Codebase is mature, clean, and secure. No High or Critical vulnerabilities were found. Follows modern best practices with high test coverage and thoughtful design. Recommendation: code is highly secure at time of audit.	0 High/Critical findings and few Low/Medium severity findings.
4 High Confidence	Code is clean, well-structured, and adheres to best practices. Design patterns are sound and test coverage is strong. Recommendation: suitable for deployment after remediations; consider periodic review with changes.	0-1 High/Critical findings per engagement week and little to no Medium severity findings.
3 Moderate Confidence	Code is functional but shows gaps in defensive programming or test coverage. Recommendation: remediate the findings and re-review the changes before deployment.	Some High/Critical findings, with various Medium severity findings.
2 Low Confidence	Recurring issues suggest systemic gaps rather than isolated mistakes. Recommendation: remediate, then commission a follow-up review at a frozen commit.	Over 6 High and Critical findings across the engagement.
1 Very Low Confidence	The volume and severity of findings indicate the codebase is not ready for production. Recommendation: substantial rework, then a full re-review.	Over 12 High and Critical findings across the engagement.

§ 03

Scope & Classifications.

Guardian reviewed Morpho Liquidation Module in `https://github.com/gmx-io/gmx-ops-contracts`. The scope includes 261 source lines across 1 file.

3.1 Severity Matrix

	IMP · HIGH	IMP · MED	IMP · LOW
LIK · HIGH	Critical	High	Medium
LIK · MED	High	Medium	Low
LIK · LOW	Medium	Low	Low

IMPACT · HIGH	Significant loss of assets, harm to a group of users, or core protocol functionality is disrupted.
IMPACT · MEDIUM	Small amount of funds can be lost, or ancillary functionality is affected. Users may experience reduced or delayed receipt.
IMPACT · LOW	Unexpected behavior in some functionality that is notable but does not meet the criteria for higher severity.
LIKELIHOOD · HIGH	Possible with reasonable assumptions that mimic on-chain conditions; cost is low compared to amount gained.
LIKELIHOOD · MEDIUM	Possible only in uncommon cases or requires a large amount of capital relative to disruption caused.
LIKELIHOOD · LOW	Unlikely to ever occur in production.

Files in Scope.

FILE	NSLOC	TOTAL
MAIN REVIEW		
src/morpho/MorphoLiquidationModule.sol	261	344
REMEDIATION REVIEW		
src/morpho/MorphoLiquidationModule.sol	0	349

§ 04

Findings.

Grouped by round. Visible IDs reset by severity within each round, so a finding is named the same way in the report as it was in the channel it was written in. Status is where each finding ended up; its own page says how.

ID	TITLE	CATEGORY	SEVERITY	STATUS	PAGE
MAIN REVIEW					
I-01	Bad-debt repay fails for large positions	Documentation	INFORMATIONAL	RESOLVED	p. 8
I-02	Bad-debt repay needs undocumented slack	Documentation	INFORMATIONAL	RESOLVED	p. 10
I-03	Bad-debt repay has no minimum GLV seized	Suggestion	INFORMATIONAL	ACKNOWLEDGED	p. 11

INFORMATIONAL **I-01** RESOLVED

Bad-debt repay fails for large positions

CATEGORY	Documentation
LOCATION	`MorphoLiquidationModule.sol:277`
REVIEW	Main Review

DESCRIPTION

`repayBadDebtAndLiquidate` lets the operator use Safe funds to pay part of an underwater borrower's bad debt, so lenders lose less. In one call, the Safe repays some of the borrower's USDG debt, then liquidates the position by seizing all of its GLV (`MorphoLiquidationModule.sol:277`). Seizing all the GLV is what makes Morpho write off the remaining bad debt.

To seize all the GLV, the Safe must also repay USDG debt worth the GLV's value minus the liquidation bonus. That repayment is checked against `maxLiquidationRepayAssets` , a USDG cap (`MorphoLiquidationModule.sol:367`). So when the cap is below what a full seizure costs, the call always reverts, even if the bad debt payment is small. For example, today's largest borrower has 310.5k USDG of debt; with a cap of, say, 50k USDG, it can never be helped in one call.

The NatSpec of `repayBadDebtAndLiquidate` does not mention this limit; only `liquidate` documents the cap (`MorphoLiquidationModule.sol:243`). An operator or bot built from the docs will hit this revert on the large positions, where bad debt matters most, and must first fall back to several partial `liquidate` calls. While those run, the position stays open. If an external liquidator seizes all its GLV in the meantime, Morpho writes the whole bad debt off to lenders.

RECOMMENDATION

Consider documenting in the NatSpec of `repayBadDebtAndLiquidate` that the full seizure counts against `maxLiquidationRepayAssets` , so large positions must first be reduced with partial `liquidate` calls, ideally batched in one transaction.

RESOLUTION

Status: Resolved.

I-01 Bad-debt repay fails for large positions CONTINUED

GMX Team: Fixed in the NatSpec of repayBadDebtAndLiquidate. Batching the partial liquidations with the call is left to the operator, since the module has no batching function of its own.

`https://github.com/gmx-io/gmx-ops-contracts/commit/310405b2eca3c2a95bd3fe2de0405b55ae31d5a2`

INFORMATIONAL I-02

RESOLVED

Bad-debt repay needs undocumented slack

CATEGORY	Documentation
LOCATION	`MorphoLiquidationModule.sol:271`
REVIEW	Main Review

DESCRIPTION

`repayBadDebtAndLiquidate` takes `repayShares`, a fixed number of borrow shares the operator computes off-chain. It repays them with Safe USDG, then seizes all of the borrower's GLV. As the NatSpec notes, the full seizure reverts on a borrow shares underflow if the repay leaves the position no longer underwater. So the repay must stay below the position's bad debt.

Both that bad debt and the USDG cost are only set at execution. Morpho accrues interest and converts the shares to USDG, rounding up, inside the call (`MorphoLiquidationModule.sol:271`), so the payment can exceed the operator's estimate. An upward GLV oracle update in between lowers the bad debt. In a 7-day sample this market's oracle moved up to 0.1% per hour: about 290 USDG on a position whose full seizure repays 290k USDG. If the operator aimed at the full bad debt, the call reverts.

So the operator must leave slack below its estimate, and Morpho writes that slack off to lenders. The function cannot reliably clear a position's full bad debt in one call.

RECOMMENDATION

Consider documenting in the NatSpec of `repayBadDebtAndLiquidate` that `repayShares` should leave slack below the estimated bad debt, to absorb interest accrual and oracle updates before execution.

RESOLUTION

Status: Resolved.

GMX Team: Fixed in the NatSpec of repayBadDebtAndLiquidate.

`https://github.com/gmx-io/gmx-ops-contracts/commit/50c0e314b42cad906531c47f27d13f925dfdbc54`

INFORMATIONAL I-03 ACKNOWLEDGED

Bad-debt repay has no minimum GLV seized

CATEGORY	Suggestion
LOCATION	`MorphoLiquidationModule.sol:266`
REVIEW	Main Review

DESCRIPTION

`repayBadDebtAndLiquidate` repays part of an underwater position's bad debt with Safe USDG, then seizes all of its GLV. The full seizure also earns the Safe the liquidation bonus, which on large positions is bigger than the bad debt payment. The function re-reads the collateral at execution and only rejects zero (`MorphoLiquidationModule.sol:266`). There is no minimum amount of GLV to seize.

If another liquidator seizes all but a few wei of GLV before the operator's transaction, the call still succeeds: the Safe makes the full bad debt payment and gets almost no GLV. On an Arbitrum fork with the largest borrower, a third party seized all but 1 wei, and the Safe then paid 19,429 USDG for 1 wei of GLV. Without the third party, the same call would have earned the Safe about 36.8k USDG of liquidation bonus, more than covering the payment.

Lenders lose the same amount in both cases. But if the operator only means to pay bad debt as part of a full liquidation, it cannot enforce that, and nothing documents that the payment may come with no GLV.

RECOMMENDATION

Consider adding a `minSeized` argument to `repayBadDebtAndLiquidate` and reverting when the GLV seized is below it.

RESOLUTION

Status: Acknowledged.

GMX Team: This is by design. The repay is meant to lower the bad debt lenders take, which it does however little GLV the Safe gets, and maxBadDebtRepayAssets bounds the repay in each call.

§ 05

Disclaimer.

This report is not, nor should be considered, an "endorsement" or "disapproval" of any particular project or team. This report is not, nor should be considered, an indication of the economics or value of any "product" or "asset" created by any team or project that contracts Guardian to perform a security assessment. This report does not provide any warranty or guarantee regarding the absolute bug-free nature of the technology analyzed, nor do they provide any indication of the technologies proprietors, business, business model or legal compliance.

This report should not be used in any way to make decisions around investment or involvement with any particular project. This report in no way provides investment advice, nor should be leveraged as investment advice of any sort. This report represents an extensive assessing process intending to help our customers increase the quality of their code while reducing the high level of risk presented by cryptographic tokens and blockchain technology.

Blockchain technology and cryptographic assets present a high level of ongoing risk. Guardian's position is that each company and individual are responsible for their own due diligence and continuous security. Guardian's goal is to help reduce the attack vectors and the high level of variance associated with utilizing new and consistently changing technologies, and in no way claims any guarantee of security or functionality of the technology we agree to analyze.

The assessment services provided by Guardian is subject to dependencies and under continuing development. You agree that your access and/or use, including but not limited to any services, reports, and materials, will be at your sole risk on an as-is, where-is, and as-available basis.

Cryptographic tokens are emergent technologies and carry with them high levels of technical risk and uncertainty. The assessment reports could include false positives, false negatives, and other unpredictable results. The services may access, and depend upon, multiple layers of third-parties.

Notice that smart contracts deployed on the blockchain are not resistant from internal/external exploit. Notice that active smart contract owner privileges constitute an elevated impact to any smart contract's safety and security. Therefore, Guardian does not guarantee the explicit security of the audited smart contract, regardless of the verdict.

§ 06

About Guardian.

Guardian is a smart contract security firm. Every engagement is worked by two independent teams competing on the same scope, each with its own tooling and methods, so no single reviewer's blind spot survives.

$45B+
DIGITAL ASSETS UNDER REVIEW

200+
ENGAGEMENTS COMPLETED

500+
CRITICAL & HIGH FINDINGS REPORTED

Reach us at audits@guardianaudits.com, or read more at **guardian.security**.

This report and its findings are also published at guardian.security/portfolio/gmx/morpho-liquidation-module-2026-11-26.