
Security Review Report
NM-0432 Lagoon Protocol



NETHERMIND
SECURITY

(Jan 30, 2025)

Contents

| | | |
|----------|--|-----------|
| 1 | Executive Summary | 2 |
| 2 | Audited Files | 3 |
| 3 | Summary of Issues | 3 |
| 4 | System Overview | 4 |
| 4.1 | Actors | 4 |
| 4.2 | Vault States | 4 |
| 4.3 | Deposit and Redeem operations | 4 |
| 4.4 | Fees | 5 |
| 5 | Risk Rating Methodology | 6 |
| 6 | Issues | 7 |
| 6.1 | [Info] <code>maxWithdraw(...)</code> function returns wrong value when the vault is paused | 7 |
| 7 | Documentation Evaluation | 8 |
| 8 | Test Suite Evaluation | 9 |
| 8.1 | Compilation Output | 9 |
| 8.2 | Tests Output | 10 |
| 9 | About Nethermind | 14 |

1 Executive Summary

This document presents the security review performed by [Nethermind Security](#) for [Lagoon Protocol](#) smart contracts. Lagoon Protocol is a decentralized asset management platform that enables asset managers to create Lagoon Vaults. These Vaults provide efficient, non-custodial, and risk-managed asset management solutions.

Built on a foundation of smart contract standards, Lagoon Protocol leverages the power of Gnosis Safe, Zodiac Roles Modifier, and other key components to create highly customizable and secure vaults for managing digital assets.

The audit focuses on the changes added through the [Pull Request 180](#).

The audit was performed using (a) manual analysis of the codebase, (b) automated analysis tools, and (c) creation of test cases. **Along this document, we report** one point of attention, classified as Informational. The issues are summarized in Fig. 1.

This document is organized as follows. Section 2 presents the files in the scope. Section 3 summarizes the issues. Section 4 presents the system overview. Section 5 discusses the risk rating methodology. Section 6 details the issues. Section 7 discusses the documentation provided by the client for this audit. Section 8 presents the compilation, tests, and automated tests. Section 9 concludes the document.

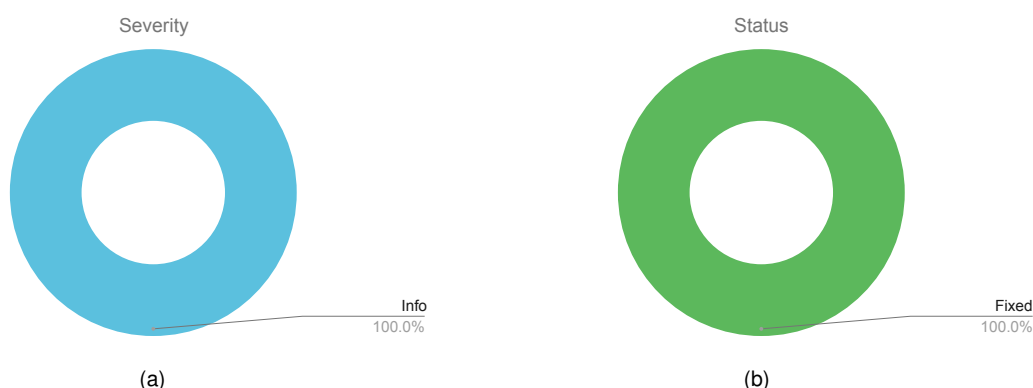


Fig. 1: Distribution of issues: Critical (0), High (0), Medium (0), Low (0), Undetermined (0), Informational (1), Best Practices (0).
Distribution of status: Fixed (1), Acknowledged (0), Mitigated (0), Unresolved (0)

Summary of the Audit

| | |
|---------------------------------|--|
| Audit Type | Security Review |
| Initial Report | January 29, 2025 |
| Final Report | January 30, 2025 |
| Repository | lagoon-v0 |
| Commit | 8303fc5c3f789369967b4fafdc00e4058ecb21ac |
| Final Commit | 3d0034136a5be28459b1884095e9658d1e95bd6a |
| Documentation | Docs |
| Documentation Assessment | High |
| Test Suite Assessment | High |

2 Audited Files

| | Contract | LoC | Comments | Ratio | Blank | Total |
|---|--|------------|------------|--------------|------------|-------------|
| 1 | src/vault/FeeManager.sol | 150 | 67 | 44.7% | 43 | 260 |
| 2 | src/vault/ERC7540.sol | 418 | 169 | 40.4% | 130 | 717 |
| 3 | src/vault/Vault.sol | 237 | 119 | 50.2% | 50 | 406 |
| | Total | 805 | 355 | 44.1% | 223 | 1383 |

* The review was focused on the changes introduced by the [Pull Request 180](#).

3 Summary of Issues

| | Finding | Severity | Update |
|---|--|----------|--------|
| 1 | maxWithdraw(...) function returns wrong value when the vault is paused | Info | Fixed |

4 System Overview

Lagoon Protocol is a decentralized asset management platform that enables asset managers to create *Lagoon Vaults*. These Vaults provide efficient, non-custodial, and risk-managed asset management solutions.

Built on a foundation of smart contract standards, Lagoon Protocol leverages the power of Gnosis Safe, Zodiac Roles Modifier, and other key components to create highly customizable and secure vaults for managing digital assets.

Lagoon Protocol enables the creation of decentralized Vaults (Lagoon Vaults) that support various roles, including Asset Managers, NAV Committees, Vault Creators, and Fund Depositors. These Vaults are governed by smart contracts that allow for a wide range of DeFi strategies, from asset management to yield farming, all while maintaining a high level of security and control. The protocol's design prioritizes flexibility, enabling asset managers to configure their Vaults with specific DeFi protocol whitelists, separation of power, fee structures, and more. It follows the **ERC-7540** standard for **Asynchronous ERC-4626 Tokenized Vaults**.

4.1 Actors

- **AssetManager:** The asset manager is the actor in charge of using the funds in the Vault to generate more value. The AssetManager will interact with the Vault through a Gnosis Safe wallet that will restrict the type of operations the manager can do. Only the manager can execute settlement operations.
- **NAV Committees:** The NAV Committee will submit new valuation proposals to the Vault. This actor is in charge of calculating the current value of all the assets held by the Vault and submitting it for future settlement.
- **Owner:** The owner of the Vault can change multiple parameters from the configuration of the vault, including the fee rates and receivers. The owner can also change the current NAV Committee address or start the Vault closing procedure.
- **Users:** The User actor refers to regular users using the Vault. These users will deposit assets in exchange for shares that can be redeemed later. Redeeming shares will give the user a certain amount of assets relative to the valuation of the vault at the moment of the redeeming action.

4.2 Vault States

A Vault can be in three main states: **Open**, **Closing**, and **Closed**. Depending on the current state of the Vault, it will behave differently for certain actions.

- **Open:** After a Vault is initialized, it will be automatically in the **Open** state. In this state, the Vault is open to deposits and withdrawals. New valuations can be proposed and settled. An **Open** Vault can only transition to the **Closing** state.
- **Closing:** Only the **Owner** actor can change the Vault to the **Closing** state. The *requestRedeem* operations are no longer possible in this state. It is possible for the NAV Committee to propose new valuations, but settlement operations cannot be executed. To execute another settlement, a call to the *close(...)* function must be made; this call will transition the Vault to the **Closed** state.
- **Closed:** At this state, the Vault is closed; settlements are locked, and withdrawals are guaranteed at a fixed price per share. No new valuations can be proposed, and settlements cannot be executed anymore. The Vault cannot transition to a different state.

It is important to note that **requestDeposit** operations are always available, even when executing any new settlements is impossible. If a user requests a deposit and no new settlement can be executed, the user can cancel the request and recover the funds.

4.3 Deposit and Redeem operations

Deposit and Redemption are the most important operations from the Vault. These are the actions executed by users to deposit assets and redeem shares. These operations are executed asynchronously. Users first need to create a request and wait until a settlement is executed, which will complete their request. After a request is completed, a user can finish the deposit or redeem operation. A request can only be completed if it was placed before the final evaluation for the current settlement period. This means that if the settlement occurs after the request has been placed but without any evaluations between these two events, this settlement will not complete the request. The user will have to wait until the next evaluation and settlement.

Compared to synchronous vaults, in asynchronous vaults, the users do not know the price per share that will be executed for their operation at the moment of the request. When they start a request, the involved assets are sent to the pending silo contract until the operation is settled. After the operation is settled, depending on the type of operation, the funds will be sent to the asset manager or the vault. Users can claim their assets or shares based on the price per share related to their settlement.

4.4 Fees

The Vault will charge two types of fees: management and performance fees.

The management fees are calculated based on the assets under management (AUM) and are charged over time and collected during vault settlement. The formula used here calculates management fees by multiplying the assets by the management rate (a percentage expressed in basis points or BPS) and prorating it by the time elapsed (relative to one year).

$$managementFee = \left(\frac{asset * rate}{BPS} \right) * \frac{time_{elapsed}}{1year}$$

The performance fees are charged on profits and are calculated only when the value of the assets exceeds a high water mark (the highest historical value per one share). This is done to ensure that fees are charged only on actual profits and not on recovered losses.

$$performanceFee = \frac{((pricePerShare - highWaterMark) * totalSupply) * rate}{BPS}$$

5 Risk Rating Methodology

The risk rating methodology used by [Nethermind Security](#) follows the principles established by the [OWASP Foundation](#). The severity of each finding is determined by two factors: **Likelihood** and **Impact**.

Likelihood measures how likely the finding is to be uncovered and exploited by an attacker. This factor will be one of the following values:

- a) **High**: The issue is trivial to exploit and has no specific conditions that need to be met;
- b) **Medium**: The issue is moderately complex and may have some conditions that need to be met;
- c) **Low**: The issue is very complex and requires very specific conditions to be met.

When defining the likelihood of a finding, other factors are also considered. These can include but are not limited to motive, opportunity, exploit accessibility, ease of discovery, and ease of exploit.

Impact is a measure of the damage that may be caused if an attacker exploits the finding. This factor will be one of the following values:

- a) **High**: The issue can cause significant damage, such as loss of funds or the protocol entering an unrecoverable state;
- b) **Medium**: The issue can cause moderate damage, such as impacts that only affect a small group of users or only a particular part of the protocol;
- c) **Low**: The issue can cause little to no damage, such as bugs that are easily recoverable or cause unexpected interactions that cause minor inconveniences.

When defining the impact of a finding, other factors are also considered. These can include but are not limited to Data/state integrity, loss of availability, financial loss, and reputation damage. After defining the likelihood and impact of an issue, the severity can be determined according to the table below.

| | | Severity Risk | | |
|--------|--------------|---------------------|--------------|--------------|
| Impact | High | Medium | High | Critical |
| | Medium | Low | Medium | High |
| | Low | Info/Best Practices | Low | Medium |
| | Undetermined | Undetermined | Undetermined | Undetermined |
| | | Low | Medium | High |
| | | Likelihood | | |

To address issues that do not fit a High/Medium/Low severity, [Nethermind Security](#) also uses three more finding severities: **Informational**, **Best Practices**, and **Undetermined**.

- a) **Informational** findings do not pose any risk to the application, but they carry some information that the audit team intends to pass to the client formally;
- b) **Best Practice** findings are used when some piece of code does not conform with smart contract development best practices;
- c) **Undetermined** findings are used when we cannot predict the impact or likelihood of the issue.

6 Issues

6.1 [Info] `maxWithdraw(...)` function returns wrong value when the vault is paused

File(s): [src/vault/Vault.sol](#)

Description: When the Vault is paused `withdraw(...)` operations are not possible. The `maxWithdraw(...)` function does not take into account when the Vault is paused for its returned value.

Recommendation(s): Return zero from the `maxWithdraw(...)` function when the Vault is paused.

Status: Fixed.

Update from the client: Fixed in commit [aa3f87](#).

7 Documentation Evaluation

Software documentation refers to the written or visual information that describes the functionality, architecture, design, and implementation of software. It provides a comprehensive overview of the software system and helps users, developers, and stakeholders understand how the software works, how to use it, and how to maintain it. Software documentation can take different forms, such as user manuals, system manuals, technical specifications, requirements documents, design documents, and code comments. Software documentation is critical in software development, enabling effective communication between developers, testers, users, and other stakeholders. It helps to ensure that everyone involved in the development process has a shared understanding of the software system and its functionality. Moreover, software documentation can improve software maintenance by providing a clear and complete understanding of the software system, making it easier for developers to maintain, modify, and update the software over time. Smart contracts can use various types of software documentation. Some of the most common types include:

- Technical whitepaper: A technical whitepaper is a comprehensive document describing the smart contract's design and technical details. It includes information about the purpose of the contract, its architecture, its components, and how they interact with each other;
- User manual: A user manual is a document that provides information about how to use the smart contract. It includes step-by-step instructions on how to perform various tasks and explains the different features and functionalities of the contract;
- Code documentation: Code documentation is a document that provides details about the code of the smart contract. It includes information about the functions, variables, and classes used in the code, as well as explanations of how they work;
- API documentation: API documentation is a document that provides information about the API (Application Programming Interface) of the smart contract. It includes details about the methods, parameters, and responses that can be used to interact with the contract;
- Testing documentation: Testing documentation is a document that provides information about how the smart contract was tested. It includes details about the test cases that were used, the results of the tests, and any issues that were identified during testing;
- Audit documentation: Audit documentation includes reports, notes, and other materials related to the security audit of the smart contract. This type of documentation is critical in ensuring that the smart contract is secure and free from vulnerabilities.

These types of documentation are essential for smart contract development and maintenance. They help ensure that the contract is properly designed, implemented, and tested, and they provide a reference for developers who need to modify or maintain the contract in the future.

Remarks about the Lagoon Protocol documentation

The documentation for the Lagoon Protocol was provided through their [official docs](#). This documentation provided a high-level overview of the protocol and details of its implementation. Moreover, the Lagoon Protocol team addressed all questions and concerns raised by the Nethermind Security team, providing valuable insights and a comprehensive understanding of the project's technical aspects.


```
Warning (2072): Unused local variable.
--> test/FeeManager.t.sol:310:9:
|
|      uint256 balance2Before = assetBalance(user2.addr);
|      ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
|
Warning (2072): Unused local variable.
--> test/FeeManager.t.sol:320:9:
|
|      uint256 user2Shares = vault.balanceOf(user2.addr);
|      ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
|
Warning (2072): Unused local variable.
--> test/FeeManager.t.sol:518:9:
|
|      uint256 user1AssetBefore = assetBalance(user1.addr);
|      ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
|
```

8.2 Tests Output

```
forge test
[] Compiling...
No files changed, compilation skipped

Ran 6 tests for test/unitTests/FeeRegistry.t.sol:TestFeeRegistry
[PASS] test_cancelCustomRate() (gas: 43630)
[PASS] test_customRate() (gas: 57475)
[PASS] test_init() (gas: 12715)
[PASS] test_protocolRate() (gas: 29645)
[PASS] test_updateProtocolFeeReceiver() (gas: 20770)
[PASS] test_updateProtocolFeeReceiver_revertIfNotOwner() (gas: 10726)
Suite result: ok. 6 passed; 0 failed; 0 skipped; finished in 2.55s (5.91ms CPU time)

Ran 2 tests for test/Silo.t.sol:TestSilo
[PASS] test_constructorGivesInfiniteApprovalToMsgSender() (gas: 133979)
[PASS] test_vaultHasInfiniteApprovalOnPendingSilo() (gas: 25730)
Suite result: ok. 2 passed; 0 failed; 0 skipped; finished in 2.08s (738.87ms CPU time)

Ran 4 tests for test/Operator.t.sol:TestOperator
[PASS] test_addOperator() (gas: 44133)
[PASS] test_addOperatorwhenOpIsAlreadyOp() (gas: 48289)
[PASS] test_rmVOperator() (gas: 34455)
[PASS] test_rmVOperatorWhenAddressIsNotOperator() (gas: 24252)
Suite result: ok. 4 passed; 0 failed; 0 skipped; finished in 6.01s (3.02ms CPU time)

Ran 5 tests for test/CancelRequest.t.sol:TestCancelRequest
[PASS] test_cancelRequestDeposit() (gas: 136608)
[PASS] test_cancelRequestDeposit_revertsWhenNewTotalAssetsHasBeenUpdated() (gas: 200012)
[PASS] test_cancelRequestDeposit_when0PendingRequest() (gas: 17864)
[PASS] test_cancelRequestDeposit_whenNoRequestWereMade() (gas: 17867)
[PASS] test_cancelRequestDeposit_whenRequestIsClaimable() (gas: 17859)
Suite result: ok. 5 passed; 0 failed; 0 skipped; finished in 6.02s (5.12ms CPU time)

Ran 4 tests for test/Deposit.t.sol:TestDeposit
[PASS] test_deposit() (gas: 639615)
[PASS] test_deposit_revertIfNotOperator() (gas: 15684)
[PASS] test_deposit_revertIfRequestIdNotClaimable() (gas: 151431)
[PASS] test_deposit_shouldRevertIfInvalidReceiver() (gas: 615877)
Suite result: ok. 4 passed; 0 failed; 0 skipped; finished in 6.02s (1.25s CPU time)

Ran 14 tests for test/Pause.t.sol:TestPause
[PASS] test_cancelRequestDeposit_whenPaused_shouldFail() (gas: 157868)
[PASS] test_claimSharesAndRequestRedeem_whenPaused_shouldFail() (gas: 15508)
[PASS] test_deposit_whenPaused_shouldFail() (gas: 53918)
[PASS] test_mint_whenPaused_shouldFail() (gas: 54124)
[PASS] test_pauseShouldPause() (gas: 10674)
[PASS] test_requestDeposit_whenPaused_shouldFail() (gas: 21187)
[PASS] test_requestRedeem_whenPaused_shouldFail() (gas: 23279)
```

```
[PASS] test_setOperator_whenPaused_shouldFail() (gas: 13470)
[PASS] test_settleDeposit_whenPaused_shouldFail() (gas: 86600)
[PASS] test_settleRedeem_whenPaused_shouldFail() (gas: 86622)
[PASS] test_unpauseShouldUnpause() (gas: 14606)
[PASS] test_updateNewTotalAssets_whenPaused_shouldFail() (gas: 19463)
[PASS] test_withdraw_whenPausedAndVaultClosed_shouldFail() (gas: 594966)
[PASS] test_withdraw_whenPaused_shouldFail() (gas: 428308)
Suite result: ok. 14 passed; 0 failed; 0 skipped; finished in 6.02s (11.04ms CPU time)

Ran 5 tests for test/Mint.t.sol:TestMint
[PASS] test_mint() (gas: 687754)
[PASS] test_mintAsOperator() (gas: 709928)
[PASS] test_mint_revertIfNotOperator() (gas: 15748)
[PASS] test_mint_revertIfRequestIdNotClaimable() (gas: 151384)
[PASS] test_mint_shouldRevertIfInvalidReceiver() (gas: 637230)
Suite result: ok. 5 passed; 0 failed; 0 skipped; finished in 6.02s (1.25s CPU time)

Ran 10 tests for test/Roles.t.sol:TestMint
[PASS] test_feeReceiver() (gas: 12890)
[PASS] test_feeRegistry() (gas: 12826)
[PASS] test_protocolFeeReceiver() (gas: 18170)
[PASS] test_safe() (gas: 12803)
[PASS] test_updateFeeReceiver() (gas: 19926)
[PASS] test_updateNewTotalAssetsManager() (gas: 19858)
[PASS] test_updateNewTotalAssetsManager_notOwner() (gas: 11070)
[PASS] test_updateWhitelistManager() (gas: 19796)
[PASS] test_valuationManager() (gas: 12824)
[PASS] test_whitelistManager() (gas: 12754)
Suite result: ok. 10 passed; 0 failed; 0 skipped; finished in 7.05ms (1.01ms CPU time)

Ran 9 tests for test/RequestRedeem.t.sol:TestRequestRedeem
[PASS] test_requestRedeem() (gas: 110249)
[PASS] test_requestRedeemTwoTimes() (gas: 123430)
[PASS] test_requestRedeem_OnlyOneRequestAllowed() (gas: 185445)
[PASS] test_requestRedeem_ShouldBeAbleToRequestRedeemAfterNAVUpdateAndClaimTheCorrectAmountOfAssets() (gas: 761890)
[PASS] test_requestRedeem_asAnOperator() (gas: 148972)
[PASS] test_requestRedeem_asAnOperatorNotAllowed() (gas: 30756)
[PASS] test_requestRedeem_notEnoughBalance() (gas: 74604)
[PASS] test_requestRedeem_updateClaimableDepositRequestAndPendingDepositRequest() (gas: 1046742)
[PASS] test_requestRedeem_withClaimableBalance() (gas: 465727)
Suite result: ok. 9 passed; 0 failed; 0 skipped; finished in 6.03s (13.86ms CPU time)

Ran 11 tests for test/ClaimSharesAndRequestRedeem.t.sol:TestDeposit
[PASS] test_claimSharesAndRedeem_IfRequestIdNotClaimableShouldIgnore() (gas: 278724)
[PASS] test_claimSharesAndRequestRedeem() (gas: 107460)
[PASS] test_claimSharesAndRequestRedeemTwoTimes() (gas: 115996)
[PASS] test_claimSharesAndRequestRedeemWithZeroInInput() (gas: 539963)
[PASS] test_claimSharesAndRequestRedeem_OnlyOneRequestAllowed() (gas: 189446)
[PASS] test_claimSharesAndRequestRedeem_allPossibleShares() (gas: 571288)
[PASS] test_claimSharesAndRequestRedeem_almostAllPossibleShares() (gas: 571324)
[PASS] test_claimSharesAndRequestRedeem_moreThanAllPossibleShares() (gas: 550368)
[PASS] test_claimSharesAndRequestRedeem_notEnoughBalance() (gas: 76758)
[PASS] test_claimSharesAndRequestRedeem_withClaimableBalance() (gas: 459995)
[PASS] test_requestRedeem_updateClaimableDepositRequestAndPendingDepositRequest() (gas: 1037499)
Suite result: ok. 11 passed; 0 failed; 0 skipped; finished in 6.03s (20.53ms CPU time)

Ran 3 tests for test/Withdraw.t.sol:TestWithdraw
[PASS] test_withdraw() (gas: 974764)
[PASS] test_withdraw_revertIfNotOperator() (gas: 20163)
[PASS] test_withdraw_revertIfRequestIdNotClaimable() (gas: 712378)
Suite result: ok. 3 passed; 0 failed; 0 skipped; finished in 15.20ms (7.19ms CPU time)

Ran 15 tests for test/Misc.t.sol:TestMisc
[PASS] test_contractSize() (gas: 4923971)
[PASS] test_decimals() (gas: 26888)
[PASS] test_depositId() (gas: 634745)
[PASS] test_epochSettleId() (gas: 979876)
[PASS] test_getRoleStorage() (gas: 32616)
[PASS] test_lastDepositRequestId() (gas: 1007799)
[PASS] test_lastRedeemRequestId() (gas: 1599253)
[PASS] test_pendingSilo() (gas: 26156)
[PASS] test_previewDeposit() (gas: 8554)
[PASS] test_previewMint() (gas: 8512)
[PASS] test_previewRedeem() (gas: 8436)
```

```
[PASS] test_previewWithdraw() (gas: 8646)
[PASS] test_redeemId() (gas: 910176)
[PASS] test_share() (gas: 8772)
[PASS] test_supportsInterface() (gas: 18596)
Suite result: ok. 15 passed; 0 failed; 0 skipped; finished in 6.04s (1.28s CPU time)

Ran 1 test for test/Referral.t.sol:TestReferral
[PASS] test_referral() (gas: 153921)
Suite result: ok. 1 passed; 0 failed; 0 skipped; finished in 4.52ms (541.92µs CPU time)

Ran 4 tests for test/Redeem.t.sol:TestRedeem
[PASS] test_redeem() (gas: 953671)
[PASS] test_redeem_revertIfRequestIdNotClaimable() (gas: 703750)
[PASS] test_redeem_whenNotOperatorShouldRevert() (gas: 914012)
[PASS] test_redeem_whenOperator() (gas: 983509)
Suite result: ok. 4 passed; 0 failed; 0 skipped; finished in 12.62ms (12.23ms CPU time)

Ran 9 tests for test/FeeManager.t.sol:TestFeeManager
[PASS] test_CloseTakesCorrectAmountOfFees() (gas: 1480439)
[PASS] test_FeesAreTakenAfterFreeride() (gas: 2608942)
[PASS] test_NoFeesAreTakenDuringFreeRide() (gas: 2201258)
[PASS] test_SettleRedeemTakesCorrectAmountOfFees() (gas: 1680739)
[PASS] test_defaultHighWaterMark_equalsPricePerShares() (gas: 20183)
[PASS] test_feeReceiverAndDaoHaveNoVaultSharesAtVaultCreation() (gas: 25706)
[PASS] test_takeFees_cantBeCalledMultipleTimes() (gas: 197550)
[PASS] test_updateRates_revertIfManagementRateAboveMaxRates() (gas: 23479)
[PASS] test_updateRates_revertIfPerformanceRateAboveMaxRates() (gas: 23537)
Suite result: ok. 9 passed; 0 failed; 0 skipped; finished in 6.47s (2.59s CPU time)

Ran 2 tests for test/InitiateClosing.t.sol:TestInitiateClosing
[PASS] test_RequestRedeemAfterNewTTAUpdateMustNotBeLockedBecauseOfClosing() (gas: 485079)
[PASS] test_closeWithoutNewTotalAssetsUpdated() (gas: 156569)
Suite result: ok. 2 passed; 0 failed; 0 skipped; finished in 6.59s (2.87ms CPU time)

Ran 18 tests for test/Close.t.sol:TestInitiateClosing
[PASS] test_CloseCantBeCalledAfterVaultIsClosed() (gas: 252476)
[PASS] test_cantCallInitiateClosingTwice() (gas: 15842)
[PASS] test_cantCloseAVaultWithoutFullUnwind() (gas: 276254)
[PASS] test_cantUpdateNewTotalAssetsWhenClosed() (gas: 256090)
[PASS] test_claimSharesAndRequestRedeem_whenNotOpen_shouldFail() (gas: 282431)
[PASS] test_close_onPendingDeposit() (gas: 270404)
[PASS] test_close_onPendingRedeem() (gas: 265437)
[PASS] test_close_revertsIfPendingRequestCantBeFullfilled() (gas: 333353)
[PASS] test_closingVaultMarkTheVaultAsClosed() (gas: 251411)
[PASS] test_inClosedStateCanWithdrawAndRedeemIfOperatorOrEnoughAllowance() (gas: 418380)
[PASS] test_inClosingStateCanNotWithdrawOrRedeemIfNotOperatorAndEvenWithEnoughAllowance() (gas: 63968)
[PASS] test_inClosingStateCanWithdrawAndRedeemIfOperator() (gas: 105391)
[PASS] test_newSettleDepositAreForbiddenButClaimsAreAvailable() (gas: 318049)
[PASS] test_redeemAssetWithoutClaimableRedeem() (gas: 334709)
[PASS] test_redeemSharesWithClaimableRedeem() (gas: 590822)
[PASS] test_redeemSharesWithClaimableRedeemWithProfits() (gas: 653220)
[PASS] test_requestRedemptionAreImpossible() (gas: 284626)
[PASS] test_withdrawAssetWithoutClaimableRedeem() (gas: 810083)
Suite result: ok. 18 passed; 0 failed; 0 skipped; finished in 6.80s (443.72ms CPU time)

Ran 16 tests for test/RequestDeposit.t.sol:TestRequestDeposit
[PASS] test_only_one_request_allowed_per_settle_id() (gas: 241277)
[PASS] test_requestDeposit() (gas: 159586)
[PASS] test_requestDepositTwoTimes() (gas: 196348)
[PASS] test_requestDeposit_ShouldBeAbleToDepositAgainWhenIndeterminationIsRaidedAtSettlement() (gas: 669897)
[PASS] test_requestDeposit_ShouldBeAbleToRequestDepositAfterNAVUpdateAndClaimTheCorrectAmountOfShares() (gas: 879180)
[PASS] test_requestDeposit_asAnOperator() (gas: 201991)
[PASS] test_requestDeposit_asAnOperatorButOwnerNotEnoughApprove() (gas: 155508)
[PASS] test_requestDeposit_asAnOperatorNotAllowed() (gas: 33766)
[PASS] test_requestDeposit_notEnoughBalance() (gas: 75967)
[PASS] test_requestDeposit_revertIfNotOperator() (gas: 15812)
[PASS] test_requestDeposit_shouldBeCancelableAfterSettlementWhenRequestIsMadeDuringTheCurrentEpoch() (gas: 696021)
[PASS] test_requestDeposit_updateClaimableDepositRequest() (gas: 1248504)
[PASS] test_requestDeposit_withClaimableBalance() (gas: 722052)
[PASS] test_requestDeposit_withClaimableBalance_with_eth() (gas: 3219)
[PASS] test_requestDeposit_with_eth() (gas: 6981385)
[PASS] test_requestDeposit_with_eth_and_wrong_userBalance() (gas: 6337)
Suite result: ok. 16 passed; 0 failed; 0 skipped; finished in 1.49s (1.79s CPU time)
```

```
Ran 13 tests for test/Whitelist.t.sol:TestWhitelist
[PASS] test_addToWhitelist_revert() (gas: 7049642)
[PASS] test_noWhitelist() (gas: 6858987)
[PASS] test_requestDeposit_ShouldFailWhenControllerNotWhitelisted() (gas: 7059689)
[PASS] test_requestDeposit_ShouldNotFailWhenControllerNotWhitelistedandOperatorAndOwnerAre() (gas: 7142771)
[PASS] test_requestDeposit_WhenOwnerWhitelistedAndOperator() (gas: 7166302)
[PASS] test_requestRedeemWithoutBeingWhitelisted() (gas: 7789393)
[PASS] test_revokeFromWhitelist_revert() (gas: 7049698)
[PASS] test_transfer_ShouldWorkWhenReceiverWhitelisted() (gas: 7634238)
[PASS] test_transfer_WhenReceiverNotWhitelistedAfterDeactivateOfWhitelisting() (gas: 7591812)
[PASS] test_unwhitelist() (gas: 7084316)
[PASS] test_unwhitelistList() (gas: 7083140)
[PASS] test_whitelist() (gas: 7076325)
[PASS] test_whitelistList() (gas: 7104707)
Suite result: ok. 13 passed; 0 failed; 0 skipped; finished in 2.89s (1.41s CPU time)

Ran 5 tests for test/RatesUpdate.t.sol:testRateUpdates
[PASS] test_ratesShouldMatchValuesAtInit() (gas: 6786039)
[PASS] test_ratesShouldRevertAtInitWhenTooHigh() (gas: 6765333)
[PASS] test_updateRatesOverMaxPerformanceRateShouldRevert() (gas: 6784245)
[PASS] test_updateRatesShouldBeApplied24HoursAfter() (gas: 6820115)
[PASS] test_updateRatesShouldBeApplied24HoursAfter_VerifyThroughASettle() (gas: 7777638)
Suite result: ok. 5 passed; 0 failed; 0 skipped; finished in 1.91s (446.96ms CPU time)

Ran 13 tests for test/Settle.t.sol:TestSettle
[PASS] test_close_revertIfNotTotalAssetsManager() (gas: 12004)
[PASS] test_close_revertIfWrongNewTotalAssets() (gas: 104683)
[PASS] test_settleDepositAfterUpdate() (gas: 344647)
[PASS] test_settleDepositThenRedeemAfterUpdate() (gas: 161321)
[PASS] test_settleDeposit_revertIfNotTotalAssetsManager() (gas: 12123)
[PASS] test_settleDeposit_revertIfWrongNewTotalAssets() (gas: 73920)
[PASS] test_settleRedeemAfterUpdate() (gas: 308847)
[PASS] test_settleRedeem_revertIfNotTotalAssetsManager() (gas: 12115)
[PASS] test_settleRedeem_revertIfWrongNewTotalAssets() (gas: 73965)
[PASS] test_settle_deposit_without_totalAssets_update_reverts() (gas: 7408331)
[PASS] test_settle_redeem_totalAssets_update_reverts() (gas: 7570821)
[PASS] test_simple_settle() (gas: 652504)
[PASS] test_updateNewTotalAssets_revertIfNotTotalAssetsManager() (gas: 12056)
Suite result: ok. 13 passed; 0 failed; 0 skipped; finished in 1.91s (3.50s CPU time)

Ran 21 test suites in 9.65s (80.94s CPU time): 169 tests passed, 0 failed, 0 skipped (169 total tests)
```


9 About Nethermind

Nethermind is a Blockchain Research and Software Engineering company. Our work touches every part of the web3 ecosystem - from layer 1 and layer 2 engineering, cryptography research, and security to application-layer protocol development. We offer strategic support to our institutional and enterprise partners across the blockchain, digital assets, and DeFi sectors, guiding them through all stages of the research and development process, from initial concepts to successful implementation.

We offer security audits of projects built on EVM-compatible chains and Starknet. We are active builders of the Starknet ecosystem, delivering a node implementation, a block explorer, a Solidity-to-Cairo transpiler, and formal verification tooling. Nethermind also provides strategic support to our institutional and enterprise partners in blockchain, digital assets, and decentralized finance (DeFi). In the next paragraphs, we introduce the company in more detail.

Blockchain Security: At Nethermind, we believe security is vital to the health and longevity of the entire Web3 ecosystem. We provide security services related to Smart Contract Audits, Formal Verification, and Real-Time Monitoring. Our Security Team comprises blockchain security experts in each field, often collaborating to produce comprehensive and robust security solutions. The team has a strong academic background, can apply state-of-the-art techniques, and is experienced in analyzing cutting-edge Solidity and Cairo smart contracts, such as ArgentX and StarkGate (the bridge connecting Ethereum and StarkNet). Most team members hold a Ph.D. degree and actively participate in the research community, accounting for 240+ articles published and 1,450+ citations in Google Scholar. The security team adopts customer-oriented and interactive processes where clients are involved in all stages of the work.

Blockchain Core Development: Our core engineering team, consisting of over 20 developers, maintains, improves, and upgrades our flagship product - the Nethermind Ethereum Execution Client. The client has been successfully operating for several years, supporting both the Ethereum Mainnet and its testnets, and now accounts for nearly a quarter of all synced Mainnet nodes. Our unwavering commitment to Ethereum's growth and stability extends to sidechains and layer 2 solutions. Notably, we were the sole execution layer client to facilitate Gnosis Chain's Merge, transitioning from Aura to Proof of Stake (PoS), and we are actively developing a full-node client to bolster Starknet's decentralization efforts. Our core team equips partners with tools for seamless node set-up, using generated docker-compose scripts tailored to their chosen execution client and preferred configurations for various network types.

DevOps and Infrastructure Management: Our infrastructure team ensures our partners' systems operate securely, reliably, and efficiently. We provide infrastructure design, deployment, monitoring, maintenance, and troubleshooting support, allowing you to focus on your core business operations. Boasting extensive expertise in Blockchain as a Service, private blockchain implementations, and node management, our infrastructure and DevOps engineers are proficient with major cloud solution providers and can host applications in-house or on clients' premises. Our global in-house SRE teams offer 24/7 monitoring and alerts for both infrastructure and application levels. We manage over 5,000 public and private validators and maintain nodes on major public blockchains such as Polygon, Gnosis, Solana, Cosmos, Near, Avalanche, Polkadot, Aptos, and StarkWare L2. Sedge is an open-source tool developed by our infrastructure experts, designed to simplify the complex process of setting up a proof-of-stake (PoS) network or chain validator. Sedge generates docker-compose scripts for the entire validator set-up based on the chosen client, making the process easier and quicker while following best practices to avoid downtime and being slashed.

Cryptography Research: At Nethermind, our Cryptography Research team is dedicated to continuous internal research while fostering close collaboration with external partners. The team has expertise across a wide range of domains, including cryptography protocols, consensus design, decentralized identity, verifiable credentials, Sybil resistance, oracles, and credentials, distributed validator technology (DVT), and Zero-knowledge proofs. This diverse skill set, combined with strong collaboration between our engineering teams, enables us to deliver cutting-edge solutions to our partners and clients.

Smart Contract Development & DeFi Research: Our smart contract development and DeFi research team comprises 40+ world-class engineers who collaborate closely with partners to identify needs and work on value-adding projects. The team specializes in Solidity and Cairo development, architecture design, and DeFi solutions, including DEXs, AMMs, structured products, derivatives, and money market protocols, as well as ERC20, 721, and 1155 token design. Our research and data analytics focuses on three key areas: technical due diligence, market research, and DeFi research. Utilizing a data-driven approach, we offer in-depth insights and outlooks on various industry themes.

Our suite of L2 tooling: Warp is Starknet's approach to EVM compatibility. It allows developers to take their Solidity smart contracts and transpile them to Cairo, Starknet's smart contract language. In the short time since its inception, the project has accomplished many achievements, including successfully transpiling Uniswap v3 onto Starknet using Warp.

- **Voyager** is a user-friendly Starknet block explorer that offers comprehensive insights into the Starknet network. With its intuitive interface and powerful features, Voyager allows users to easily search for and examine transactions, addresses, and contract details. As an essential tool for navigating the Starknet ecosystem, Voyager is the go-to solution for users seeking in-depth information and analysis;
- **Horus** is an open-source formal verification tool for StarkNet smart contracts. It simplifies the process of formally verifying Starknet smart contracts, allowing developers to express various assertions about the behavior of their code using a simple assertion language;
- **Juno** is a full-node client implementation for Starknet, drawing on the expertise gained from developing the Nethermind Client. Written in Golang and open-sourced from the outset, Juno verifies the validity of the data received from Starknet by comparing it to proofs retrieved from Ethereum, thus maintaining the integrity and security of the entire ecosystem.

Learn more about us at nethermind.io.

General Advisory to Clients

As auditors, we recommend that any changes or updates made to the audited codebase undergo a re-audit or security review to address potential vulnerabilities or risks introduced by the modifications. By conducting a re-audit or security review of the modified codebase, you can significantly enhance the overall security of your system and reduce the likelihood of exploitation. However, we do not possess the authority or right to impose obligations or restrictions on our clients regarding codebase updates, modifications, or subsequent audits. Accordingly, the decision to seek a re-audit or security review lies solely with you.

Disclaimer

This report is based on the scope of materials and documentation provided by you to [Nethermind](#) in order that [Nethermind](#) could conduct the security review outlined in **1. Executive Summary** and **2. Audited Files**. The results set out in this report may not be complete nor inclusive of all vulnerabilities. [Nethermind](#) has provided the review and this report on an as-is, where-is, and as-available basis. You agree that your access and/or use, including but not limited to any associated services, products, protocols, platforms, content, and materials, will be at your sole risk. Blockchain technology remains under development and is subject to unknown risks and flaws. The review does not extend to the compiler layer, or any other areas beyond the programming language, or other programming aspects that could present security risks. This report does not indicate the endorsement of any particular project or team, nor guarantee its security. No third party should rely on this report in any way, including for the purpose of making any decisions to buy or sell a product, service or any other asset. To the fullest extent permitted by law, [Nethermind](#) disclaims any liability in connection with this report, its content, and any related services and products and your use thereof, including, without limitation, the implied warranties of merchantability, fitness for a particular purpose, and non-infringement. [Nethermind](#) does not warrant, endorse, guarantee, or assume responsibility for any product or service advertised or offered by a third party through the product, any open source or third-party software, code, libraries, materials, or information linked to, called by, referenced by or accessible through the report, its content, and the related services and products, any hyperlinked websites, any websites or mobile applications appearing on any advertising, and [Nethermind](#) will not be a party to or in any way be responsible for monitoring any transaction between you and any third-party providers of products or services. As with the purchase or use of a product or service through any medium or in any environment, you should use your best judgment and exercise caution where appropriate. FOR AVOIDANCE OF DOUBT, THE REPORT, ITS CONTENT, ACCESS, AND/OR USAGE THEREOF, INCLUDING ANY ASSOCIATED SERVICES OR MATERIALS, SHALL NOT BE CONSIDERED OR RELIED UPON AS ANY FORM OF FINANCIAL, INVESTMENT, TAX, LEGAL, REGULATORY, OR OTHER ADVICE.