Alliance Block Liquidity Staker

Security Assessment

November 3rd, 2020

For :
Alliance Block

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Overview

Project Summary

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Alliance Block Liquidity Staker</th>
</tr>
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<tbody>
<tr>
<td>Description</td>
<td>Implementation of liquidity staking and rewards economics based on a specific time duration of staking.</td>
</tr>
<tr>
<td>Platform</td>
<td>Ethereum; Solidity</td>
</tr>
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<td>Codebase</td>
<td>[GitHub Repository]</td>
</tr>
<tr>
<td>Commits</td>
<td>Pre-audit: 65290342a3515df5857f9d066495c759a7a50333 Post-audit: f1b518ea678499a3be4a29e291355389ab572fb4</td>
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Audit Summary

<table>
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<tr>
<th>Delivery Date</th>
<th>Nov. 03, 2020</th>
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<tbody>
<tr>
<td>Method of Audit</td>
<td>Static Analysis, Manual Review</td>
</tr>
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<td>Consultants Engaged</td>
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<td>Timeline</td>
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Vulnerability Summary

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<th>Total Issues</th>
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<tr>
<td>Total Critical</td>
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<tr>
<td>Total Minor</td>
<td>3</td>
</tr>
<tr>
<td>Total Informational</td>
<td>35</td>
</tr>
</tbody>
</table>
Executive Summary

The codebase comprise of contracts implementing Staking Rewards contract and its Factory contract. The Factory contract keeps track of stakingToken and its correspondingly deployed Rewards contract. Users are able to deposit stakingToken and receive rewards in the form of Reward Tokens.

The contracts make use of OpenZeppelin contracts to implement ERC20 token, pausable, whitelisting and ownable functionalities.

All of the contracts in repository were reviewed and majority of the findings are informational for enhancing the optimization and code legibility of the contracts and two critical findings were identified related to correctness of the code.
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<thead>
<tr>
<th>ID</th>
<th>Title</th>
<th>Type</th>
<th>Severity</th>
<th>Resolved</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDR-01</td>
<td>Confusing Entity Name</td>
<td>Coding Style</td>
<td>Informational</td>
<td>✓</td>
</tr>
<tr>
<td>RDR-02</td>
<td>Unlocked Compiler Version</td>
<td>Language Specific</td>
<td>Informational</td>
<td>✓</td>
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<tr>
<td>SRS-01</td>
<td>Incorrect <code>import</code></td>
<td>Inconsistency</td>
<td>Informational</td>
<td>✓</td>
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<tr>
<td>SRS-02</td>
<td>Redundant <code>struct</code> Property</td>
<td>Gas Optimization</td>
<td>Informational</td>
<td>✓</td>
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<td>SRS-03</td>
<td>Unnecessary Constructor Parameter</td>
<td>Gas Optimization</td>
<td>Informational</td>
<td>✓</td>
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<td>Confusing Variable Name</td>
<td>Language Specific</td>
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<td>SRS-06</td>
<td>Use of Literal Value</td>
<td>Undocumented Literal</td>
<td>Major</td>
<td>✓</td>
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<tr>
<td>SRS-07</td>
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<td>Inefficient Greater-Than Comparison w/ Zero</td>
<td>Optimization</td>
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<td>SRS-09</td>
<td>Inefficient <code>storage</code> Read</td>
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<td>Incorrect Function Implementation</td>
<td>Code Legibility</td>
<td>Critical</td>
<td>✓</td>
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<td>Comment</td>
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<td>✓</td>
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<td>Redundant require statement</td>
<td>Code Legibility</td>
<td>Minor</td>
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<td>✔️</td>
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<td>Returned Value of Function is not Checked</td>
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<td>Minor</td>
<td>✔️</td>
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<td>SRS-21</td>
<td>Usage of both {now} and {block.timestamp}</td>
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<tr>
<td>SRS-22</td>
<td>Incorrect Manipulation of State Variable</td>
<td>Code Legibility</td>
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<tr>
<td>SRS-23</td>
<td>Unlocked Compiler Version</td>
<td>Language Specific</td>
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<tr>
<td>SRS-24</td>
<td>Incorrect Order of Functions</td>
<td>Language Specific</td>
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<td>SRS-25</td>
<td>Visibility can be changed from {public} to {external}</td>
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<tr>
<td>SRF-01</td>
<td>Inefficient storage Layout</td>
<td>Optimization</td>
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<td>SRF-02</td>
<td>Usage of {uint} alias instead of {uint256}</td>
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<tr>
<td>SRF-03</td>
<td>Unnecessary explicit usage of modifier {Ownable}</td>
<td>Optimization</td>
<td>Informational</td>
<td>✔️</td>
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<td>Resolved</td>
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<td>----------------------------------------------------------------------</td>
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<td>----------</td>
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<tr>
<td>SRF-04</td>
<td>Visibility can be changed from <code>public</code> to <code>external</code></td>
<td>Optimization</td>
<td>Informational</td>
<td>✓</td>
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<td>SRF-05</td>
<td>Inefficient Greater-Than Comparison w/ Zero</td>
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<td>✓</td>
</tr>
<tr>
<td>SRF-06</td>
<td>Ineffectual Predicate in <code>require</code> Statement</td>
<td>Code Legibility</td>
<td>Informational</td>
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<tr>
<td>SRF-07</td>
<td>Spelling Error</td>
<td>Comment</td>
<td>Informational</td>
<td>✓</td>
</tr>
<tr>
<td>SRF-08</td>
<td>Reward Tokens and Amounts can be moved to StakingRewards Contract</td>
<td>Code Legibility</td>
<td>Informational</td>
<td>✓</td>
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<tr>
<td>SRF-09</td>
<td>Explicit Passing of <code>msg.sender</code> can be Omitted</td>
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<td>SRF-10</td>
<td>Incorrect Order of Functions</td>
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<td>SRF-11</td>
<td>Unlocked Compiler Version</td>
<td>Language Specific</td>
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<td>✓</td>
</tr>
<tr>
<td>SRF-12</td>
<td>Returned Value of Function is not Checked</td>
<td>Code Legibility</td>
<td>Minor</td>
<td>✓</td>
</tr>
<tr>
<td>SRF-13</td>
<td>Visibility can be changed from public to external</td>
<td>Optimization</td>
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<tr>
<td>TEC-01</td>
<td>Usage of <code>uint</code> alias instead of <code>uint256</code></td>
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<td>Informational</td>
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</table>
**RDR-01: Confusing Entity Name**

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
</tr>
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<tbody>
<tr>
<td>Coding Style</td>
<td>Informational</td>
<td>[RewardsDistributionRecipient.sol L5](RewardsDistributionRecipient.sol L5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[RewardsDistributionRecipient.sol L9](RewardsDistributionRecipient.sol L9)</td>
</tr>
</tbody>
</table>

**Description:**

The state variable `rewardsDistribution` on L7 refers to the factory contract that deploys and distribute rewards to instances of `StakingRewards` contracts. The name of the variable is confusing as it seems to refer to an operation rather than an entity. Similarly, the same variable name is utilized in the modifier `onlyRewardsDistribution` on L9. The confusing names for state variable and modifier decreases the quality of code.

**Recommendation:**

We advise that the state variable's and modifier's names on the aforementioned lines be rectified to correctly represent its content of address of `StakingRewardsFactory`. The names can be changed to f.e. `rewardsDistributor` and `onlyRewardsDistributor` or `factory` and `onlyFactory`.

```solidity
address public rewardsDistributor;

modifier onlyRewardsDistributor() {
    require(msg.sender == rewardsDistribution, "Caller is not RewardsDistribution contract");
    _;
}
```

**Alleviation:**

Alleviations were applied as advised.
**RDR-02: Unlocked Compiler Version**

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Language Specific</td>
<td>Informational</td>
<td>RewardsDistributionRecipient.sol L1-L3</td>
</tr>
</tbody>
</table>

**Description:**

The contract has unlocked compiler version. An unlocked compiler version in the source code of the contract permits the user to compile it at or above a particular version. This, in turn, leads to differences in the generated bytecode between compilations due to differing compiler version numbers. This can lead to an ambiguity when debugging as compiler specific bugs may occur in the codebase that would be hard to identify over a span of multiple compiler versions rather than a specific one.

**Recommendation:**

We advise that the compiler version is instead locked at the lowest version possible that the contract can be compiled at. For example, for version `v0.5.16` the contract should contain the following line:

```solidity
pragma solidity 0.5.16;
```

**Alleviation:**

Alleviations were applied as advised.
<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
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<tbody>
<tr>
<td>Coding Style</td>
<td>Informational</td>
<td>StakingRewards.sol L6</td>
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</table>

**Description:**

The import of `ERC20Detailed.sol` on the aforementioned line provides access to `IERC20` interface inside the context of contract. A more appropriate way would have to import the `IERC20.sol` directly.

```solidity
import "openzeppelin-solidity-2.3.0/contracts/token/ERC20/ERC20Detailed.sol";
```

**Recommendation:**

We advise that the unused import on the aforementioned line be removed to increase the legibility of the code and instead replaced with the following import.

```solidity
import "openzeppelin-solidity-2.3.0/contracts/token/ERC20/IERC20.sol";
```

**Alleviation:**

Alleviations were partly applied. An interface for `IERC20` by the name of `IERC20Detailed` was introduced and used in the contract. We further recommend that `IERC20Detailed` be named to `IERC20`, so that only `IERC20` is used instead of both `IERC20Detailed` and `IERC20`.

```solidity
import "openzeppelin-solidity-2.3.0/contracts/token/ERC20/IERC20.sol";
```
### Description:

The property `tokenInstance` of struct `RewardInfo` can be removed because the same property is available as `key` of the mapping `rewardsTokensMap` in form of type `address`. As the mentioned mapping is the only data structure utilizing `RewardInfo` struct, so wherever the property `tokenInstance` is needed, it can be replaced by the `key` value casted to `IERC20`. This will save gas cost associated with additional `storage` slot utilization for writing and reading.

### Recommendation:

We recommend to remove `tokenInstance` property of the struct `RewardInfo` and instead the `key` of mapping `rewardsTokensMap` be used by casting it to `IERC20` to save gas cost associated with `storage` operations.

### Alleviation:

Alleviations were applied as advised.
**SRS-03: Unnecessary Constructor Parameter**

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Optimization</td>
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<td>StakingRewards.sol L83</td>
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<td></td>
<td></td>
<td>StakingRewards.sol L94</td>
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</table>

**Description:**

The `StakingRewards` contract is always deployed by the contract `StakingRewardsFactory`. The `constructor` of `StakingRewards` has parameter `_rewardsDistribution` on L83 which is always equal to the address of `StakingRewardsFactory`. The parameter on L83 can be removed and the state variable `rewardsDistribution` can initialized with `msg.sender`. This will result in savings in gas cost associated with additional `constructor` parameter.

**Recommendation:**

We recommend to remove the `constructor` parameter on L83 and initialize `rewardsDistribution` with `msg.sender`.

```solidity
constructor(
    address _rewardsDistribution,
    address[] memory _rewardsTokens,
    address _stakingToken,
    uint256 _rewardsDuration
) public {...}

rewardsDistribution = msg.sender;
```

**Alleviation:**

Alleviations were applied as advised.
SRS-04: Confusing Variable Name

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
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</thead>
<tbody>
<tr>
<td>Language Specific</td>
<td>Informational</td>
<td>StakingRewards.sol L26</td>
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</table>

**Description:**

The name of state variable `_totalSupply` can be confusing and misleading as it is generally associated with total supply of tokens of a kind but here it represents the total amount of `stakeToken` deposited by users in the contract.

**Recommendation:**

We recommend that the name of state variable `_totalSupply` be changed to something more close to what it has inside it f.e. `totalStakesAmount`.

**Alleviation:**

Alleviations were applied as advised.
SRS-05: Inefficient storage Read

<table>
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<tr>
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<th>Severity</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimization</td>
<td>Informational</td>
<td>StakingRewards.sol L118 - L133</td>
</tr>
</tbody>
</table>

**Description:**

The function `rewardPerToken` accesses `storage` pointer to struct `RewardInfo` several times in its body using mapping `rewardsTokensMap`. It is inefficient to compute `storage` pointer multiple times.

**Recommendation:**

We recommend to store the struct pointer in a local `storage` variable instead of performing mapping lookup multiple times to reduce gas costs.

```solidity
function rewardPerToken(address rewardToken) public view returns (uint256) {
    RewardInfo storage ri = rewardsTokensMap[rewardToken];
    if (_totalSupply == 0) {
        return ri.latestRewardPerTokenSaved;
    }

    uint256 timeSinceLastSave = lastTimeRewardApplicable(rewardToken).sub(
        ri.lastUpdateTime
    );

    uint256 rewardPerTokenSinceLastSave = timeSinceLastSave
        .mul(ri.rewardRate)
        .mul(1e18)
        .div(_totalSupply);

    return ri.latestRewardPerTokenSaved.add(rewardPerTokenSinceLastSave);
}
```

**Alleviation:**

Alleviations were applied as advised.
SRS-06: Use of Literal Value

<table>
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<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
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<tbody>
<tr>
<td>Undocumented Literal</td>
<td>Major</td>
<td>StakingRewards.sol L129</td>
</tr>
<tr>
<td></td>
<td></td>
<td>StakingRewards.sol L146</td>
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</table>

**Description:**

The aforementioned lines make use of literal `1e18` to represent `stakingToken` decimals multiplier. There will be incorrect calculations if any `stakingToken` contract has different decimals number than `18`.

**Recommendation:**

We recommend that `decimals` function is called on the `stakingContract` to get decimals and compute decimals multiplier using it.

```solidity
uint256 rewardPerTokenSinceLastSave = timeSinceLastSave
  .mul(rewardsTokensMap[rewardToken].rewardRate)
  .mul(10 ** IERC20(stakingToken).decimals())
  .div(_totalSupply);

uint256 newReward = _balances[account]
  .mul(userRewardPerTokenSinceRecorded)
  .div(10 ** IERC20(stakingToken).decimals());
```

If it is certain that all of the staking tokens will have exactly `18` decimals then a constant can be introduced in the contract and be used instead of the literal value.

```solidity
uint256 constant private DECIMALS_MULTIPLIER = 1e18;

uint256 rewardPerTokenSinceLastSave = timeSinceLastSave
  .mul(rewardsTokensMap[rewardToken].rewardRate)
  .mul(DECIMALS_MULTIPLIER)
  .div(_totalSupply);

uint256 newReward = _balances[account]
  .mul(userRewardPerTokenSinceRecorded)
  .div(DECIMALS_MULTIPLIER);
```

**Alleviation:**

Alleviations were applied as advised.
SRS-07: Inefficient \texttt{storage} Read

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Optimization</td>
<td>Informational</td>
<td>StakingRewards.sol L139 - L149</td>
</tr>
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**Description:**

The function \texttt{earned} access \texttt{storage} pointer to struct \texttt{RewardInfo} twice in its body using mapping \texttt{rewardsTokensMap}. It is inefficient to compute \texttt{storage} pointer multiple times.

**Recommendation:**

We recommend to store the struct pointer in a local \texttt{storage} variable instead of performing mapping lookup multiple times to reduce gas costs.

```solidity
function earned(address account, address rewardToken) public view returns (uint256) {
    RewardInfo storage ri = rewardsTokensMap[rewardToken];
    uint256 userRewardPerTokenSinceRecorded = rewardPerToken(rewardToken).sub(
        ri.userRewardPerTokenRecorded[account]
    );
    
    uint256 newReward = _balances[account].mul(userRewardPerTokenSinceRecorded).div(1e18);
    
    return ri.rewards[account].add(newReward);
}
```

**Alleviation:**

Alleviations were applied as advised.
SRS-08: Inefficient Greater-Than Comparison w/ Zero

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<tr>
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<td>StakingRewards.sol L167</td>
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</tr>
</tbody>
</table>

**Description:**

The linked greater-than comparisons with zero compare variables that are restrained to the non-negative integer range, meaning that the comparator can be changed to an inequality one which is more gas efficient.

**Recommendation:**

We advise that the above paradigm is applied to the linked greater-than statements.

**Alleviation:**

Alleviations were applied as advised.
SRS-09: Inefficient 

Type | Severity | Location
--- | --- | ---
Optimization | Informational | StakingRewards.sol L167
 |  | StakingRewards.sol L169

**Description:**

The function `earned` access `storage` pointer to struct `RewardInfo` twice in its body using mapping `rewardsTokensMap`. It is inefficient to compute struct `storage` pointer multiple times.

**Recommendation:**

We recommend to store the struct pointer in a local `storage` variable instead of performing mapping lookup multiple times to reduce gas costs.

```solidity
def function `getPeriodsToExtend(address rewardToken, uint256 rewardAmount)`
    public
    view
    returns (uint256 periodsToExtend)
{
    require(rewardAmount > 0, "Rewards should be greater than zero");
    RewardInfo storage ri = rewardsTokensMap[rewardToken];
    require(ri.rewardRate > 0, "Staking is not yet started");

    uint256 periodToExtend = rewardAmount.div(ri.rewardRate);
    return periodToExtend;
}
```

**Alleviation:**

Alleviations were applied as advised.
SRS-10: Explicitly Returning a Local Variable

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimization</td>
<td>Informational</td>
<td>StakingRewards.sol L164</td>
</tr>
<tr>
<td></td>
<td></td>
<td>StakingRewards.sol L169</td>
</tr>
<tr>
<td></td>
<td></td>
<td>StakingRewards.sol L170</td>
</tr>
</tbody>
</table>

**Description:**

The function `getPeriodsToExtend` declares and explicitly returns a `uint256` `periodToExtend` local variable, which increases the overall cost of gas:

```
uint256 periodToExtend = rewardAmount.div(rewardsTokensMap[rewardToken].rewardRate);
return periodToExtend;
```

Additionally, a local variable `periodsToExtend` declared in the function signature as part of return value is never used within the function.

**Recommendation:**

We advise to consider refactoring to remove the local variable declaration and explicit return statement in order to reduce the overall cost of gas and replace unused named return local variable `periodsToExtend` with `periodToExtend` that was being explicitly returned.

```
function getPeriodsToExtend(address rewardToken, uint256 rewardAmount)
    public
    view
    returns (uint256 periodToExtend)
{...}
    periodToExtend = rewardAmount.div(rewardsTokensMap[rewardToken].rewardRate);
```

**Alleviation:**

Alleviations were applied as advised.
### SRS-11: Incorrect Function Implementation

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code Legibility</td>
<td>Critical</td>
<td>StakingRewards.sol L192 - L205</td>
</tr>
</tbody>
</table>

#### Description:

The function `hasPeriodFinished` is supposed to return `true` if all of the reward tokens have their `periodFinish` reached and return `false` if a single reward token does not have its `periodFinish` reached. The function has incorrect implementation such that on line 199, the predicate inside the `if` statement evaluates to `true` if a single reward token has its `periodFinish` reached and the function returns `false`, which is wrong.

```solidity
if (block.timestamp >= rewardsTokensMap[rewardsTokensArr[i]].periodFinish) {
    return false;
}
```

#### Recommendation:

We recommend to change the predicate of `if` statement such that it returns `false` when any of the reward tokens has not reached its `periodFinish`.

```solidity
if (block.timestamp < rewardsTokensMap[rewardsTokensArr[i]].periodFinish) {
    return false;
}
```

#### Alleviation:

Alleviations were applied as advised.
SRS-12: Comment Discrepency

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comment</td>
<td>Informational</td>
<td>StakingRewards.sol L190</td>
</tr>
</tbody>
</table>

**Description:**

The comment on the aforementioned says that the function `hasPeriodFinished` returns `true` when at least one of the reward tokens does not have its `periodFinish` reached. This is incorrect as it would/should return `false` when one of the reward tokens does not have its `periodFinished` reached.

```solidity
// * Returns true if atleast one reward token has not yet finished
```

**Recommendation:**

We recommend to rectify the comment on the aforementioned line such that the function following returns `false` when one of the reward token does not have its `periodFinish` reached.

```solidity
// * Returns false if atleast one reward token has not yet finished
```

**Alleviation:**

Alleviations were applied as advised.
SRS-13: Incorrect Grammar

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grammar</td>
<td>Informational</td>
<td>StakingRewards.sol L198</td>
</tr>
</tbody>
</table>

**Description:**

The comment on the aforementioned line has incorrect grammar.

```solidity
// on first token which period has not been expired return false
```

**Recommendation:**

We advise to rectify the grammar of the comment.

```solidity
// on first token for which the period has not expired, returns false.
```

**Alleviation:**

Alleviations were applied as advised.
**SRS-14: Inefficient Read from storage**

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
<td>Optimization</td>
<td>Informational</td>
<td>StakingRewards.sol L246</td>
</tr>
</tbody>
</table>

**Description:**

The `for` loop on the aforementioned line reads a `storage` slot `rewardsTokensArr` in its predicate. As this comparison part of the `for` loop is executed repeatedly and hence the same `storage` slot is read multiple times rendering the implementation inefficient.

```solidity
for (uint i = 0; i < rewardsTokensArr.length; i++) {...}
```

**Recommendation:**

We recommend to store length of `rewardsTokenArr` read `storage` to be stored in a local variable and that be used in the predicate of `for` loop, so the gas cost from repeated `storage` read could be saved.

```solidity
uint256 tokenArrLength = rewardsTokensArr.length;
for (uint i = 0; i < tokenArrLength; i++) {...}
```

**Alleviation:**

Alleviations were applied as advised.
SRS-15: Inefficient [storage] Read

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimization</td>
<td>Informational</td>
<td>StakingRewards.sol L</td>
</tr>
</tbody>
</table>

Description:

The function `getReward` access [storage] pointer to struct `RewardInfo` several times in its body using mapping `rewardsTokensMap`. It is inefficient to compute struct [storage] pointer multiple times. Additionally, it accesses [storage] twice to read address of reward token at `rewardsTokensArr[i]`.

Recommendation:

We recommend to store the struct pointer in a local [storage] variable instead of performing mapping lookup multiple times to reduce gas costs. And also the address read for reward token from `rewardsTokensArr[i]` can be stored in a local variable of type [address].

```solidity
function getReward()
    public
    nonReentrant
    updateReward(msg.sender)
{
    for (uint i = 0; i < rewardsTokensArr.length; i++) {
        address token = rewardsTokensArr[i];
        RewardInfo storage ri = rewardsTokensMap[token];
        uint256 reward = ri.rewards[msg.sender];
        if {reward > 0} {
            ri.rewards[msg.sender] = 0;
            ri.tokenInstance.safeTransfer(msg.sender, reward);
            emit RewardPaid(msg.sender, token, reward);
        }
    }
}
```

Alleviation:

Alleviations were applied as advised.
SRS-16: Spelling Error

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
<td>Comment</td>
<td>Informational</td>
<td>StakingRewards.sol L265</td>
</tr>
</tbody>
</table>

**Description:**

The comment on the aforementioned line has incorrect spelling for the word `staking`.

```solidity
/** @dev Makes the needed calculations and starts the starking/rewarding.
---
```

**Recommendation:**

We recommend to rectify the incorrect spelling.

```solidity
/** @dev Makes the needed calculations and starts the staking/rewarding.
---
```

**Alleviation:**

Alleviations were applied as advised.
<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
<td>Code Legibility</td>
<td>Minor</td>
<td>StakingRewards.sol L274 - L277</td>
</tr>
</tbody>
</table>

**Description:**

The function `start` is called from `StakingRewardsFactory` contract's function `startStaking`. The `require` statement on the aforementioned line is redundant as the same check is performed in `startStaking` function of `StakingRewardsFactory` on L141.

**Recommendation:**

We recommend to remove the `require` check on the aforementioned line as it is redundant.

**Alleviation:**

Alleviations were applied as advised.
SRS-18: Unnecessary Function Parameter

Type: Optimization  Severity: Informational  Location: StakingRewards.sol L269

Description:
The function `start` on the aforementioned line has parameter `_rewardsTokens` which can be omitted and instead `rewardsTokensArr` can be read from `storage` of the contract which will have exactly the same data. There might not be any significant benefit with respect to gas cost but it should make the code legible.

Recommendation:
We recommend to remove the said parameter from the function signature and instead it read from the from `storage` using `rewardsTokensArr`.

Alleviation:
Alleviations were applied as advised.
<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
<td>Comment</td>
<td>Informational</td>
<td>StakingRewards.sol L302</td>
</tr>
</tbody>
</table>

**Description:**

The comment on the aforementioned line has incorrect spelling for the word `distributed`.

**Recommendation:**

We advise to rectify the spellings.

**Alleviation:**

Alleviations were applied as advised.
SRS-20: Returned Value of Function is not Checked

<table>
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<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
<td>Code Legibility</td>
<td>Informational</td>
<td>StakingRewards.sol L311</td>
</tr>
</tbody>
</table>

**Description:**

The `transferFrom` call on the aforementioned does not have its returned value checked which can lead to inaccuracies if the call returns `false`, and it will be treated as successful in the context of current execution.

```solidity
IERC20(rewardToken).transferFrom(msg.sender, address(this), rewardAmount);
```

**Recommendation:**

We recommend to use `safeTransferFrom` function from the library `SafeERC20`, which is already imported in the contract.

```solidity
IERC20(rewardToken).safeTransferFrom(msg.sender, address(this), rewardAmount);
```

**Alleviation:**

Alleviations were applied as advised.
SRS-21: Usage of both `now` and `block.timestamp`

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code Legibility</td>
<td>Informational</td>
<td>StakingRewards.sol L315</td>
</tr>
</tbody>
</table>

**Description:**

The aforementioned line uses global variable `now` to read epoch time. All the other such instances in the contract use `block.timestamp` to read epoch time.

```solidity
emit RewardExtended(rewardToken, rewardAmount, now, periodToExtend);
```

**Recommendation:**

We recommend to use `block.timestamp` instead of `now` on the aforementioned line make the code legible and consistent.

```solidity
emit RewardExtended(rewardToken, rewardAmount, block.timestamp, periodToExtend);
```

**Alleviation:**

Alleviations were applied as advised.
SRS-22: Incorrect Manipulation of State Variable

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
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<tbody>
<tr>
<td>Code Legibility</td>
<td>Critical</td>
<td>StakingRewards.sol L155</td>
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<td></td>
<td>StakingRewards.sol L313</td>
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</tbody>
</table>

### Description:

The function `addRewards` rewards extends reward duration for a specific reward token by increasing it `periodFinish` property. However, on L313, the state variable `rewardsDuration` is also increased by a certain amount which results in the function `getRewardForDuration` returning correct amount on L155, only for the reward token for which `addRewards` was executed and for the rest it will return incorrect amounts.

```solidity
return rewardsTokensMap[rewardToken].rewardRate.mul(rewardsDuration);
```

### Recommendation:

We recommend to add `rewardsDuration` as property of the struct `RewardInfo` and it be increased for only the reward token for which the `addRewards` is executed.

```solidity
struct RewardInfo {
    uint256 rewardDuration;
}

rewardsTokensMap[rewardToken].rewardDuration = rewardsTokensMap[rewardToken].rewardDuration.add(periodToExtend);
```

The function `getRewardForDuration` will be rectified to read `rewardDuration` specific to the reward token from its struct.

```solidity
function getRewardForDuration(address rewardToken) external view returns (uint256) {
    RewardInfo storage ri = rewardsTokensMap[rewardToken];
    return ri.rewardRate.mul(ri.rewardsDuration);  
}
```

### Alleviation:

Alleviations were applied as advised.
**SRS-23: Unlocked Compiler Version**

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
<td>Language Specific</td>
<td>Informational</td>
<td>StakingRewards.sol L2</td>
</tr>
</tbody>
</table>

**Description:**

The contract has unlocked compiler version. An unlocked compiler version in the source code of the contract permits the user to compile it at or above a particular version. This, in turn, leads to differences in the generated bytecode between compilations due to differing compiler version numbers. This can lead to an ambiguity when debugging as compiler specific bugs may occur in the codebase that would be hard to identify over a span of multiple compiler versions rather than a specific one.

**Recommendation:**

We advise that the compiler version is instead locked at the lowest version possible that the contract can be compiled at. For example, for version `0.5.16`, the contract should contain the following line:

```
pragma solidity 0.5.16;
```

**Alleviation:**

Alleviations were applied as advised.
SRS-24: Incorrect Order of Functions

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Language Specific</td>
<td>Informational</td>
<td>StakingRewards.sol</td>
</tr>
</tbody>
</table>

**Description:**

The structure of the codebase does not conform to the official Solidity style guide of v0.5.16.

**Recommendation:**

Functions should be grouped according to their visibility and ordered:

```solidity
constructor
\* fallback function (if exists)
\* external
\* public
\* internal
\* private
```

Within a grouping, place the `view` and `pure` functions last.

**Alleviation:**

Alleviations were partly applied.
SRS-25: Visibility can be changed from `public` to `external`.

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
<td>Optimization</td>
<td>Informational</td>
<td>StakingRewards.sol L45</td>
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<td>StakingRewards.sol L53</td>
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<td>StakingRewards.sol L61</td>
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<tr>
<td></td>
<td></td>
<td>StakingRewards.sol L192</td>
</tr>
</tbody>
</table>

**Description:**

The function on the aforementioned lines can have their visibilities changed from `public` to `external` as they are never called from within the contract.

**Recommendation:**

We recommend to change the visibilities of functions on the aforementioned lines from `public` to `external`.

**Alleviation:**

Alleviations were applied except for `L192` which is on `L311` in the post-audit commit.
<p><strong>Description:</strong></p>

The mappings on the aforementioned lines have same key type of <code>stakingToken</code> and can be condensed with their value types declared in a <code>struct</code>. This will greatly reduce the mappings lookup gas cost in the function where the read operations are performed on two or more mappings.

<p><strong>Recommendation:</strong></p>

We recommend to introduce a <code>struct</code> type which will have all the values types of the mappings as its keys.

```solidity
struct StakingInfo {
    address stakingReward;
    address[] rewardsTokens;
    uint256[] rewardsAmount;
}

mapping(address => StakingInfo) public stakingInfoMap;
```

<p><strong>Alleviation:</strong></p>

The concerned code was removed as an alleviation for another exhibit, so this exhibit is longer applicable.
SRF-02: Usage of `uint` alias instead of `uint256`

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
<td>Language Specific</td>
<td>Informational</td>
<td>StakingRewardsFactory.sol</td>
</tr>
</tbody>
</table>

**Description:**

The contract is using `uint` to declare 256-bit unsigned integers. Although, `uint` is an alias for `uint256` and both represent the same underlying integer allocation. It is advisable that for clean coding practices the complete form `uint256` should be used instead of the alias `uint`.

**Recommendation:**

We advise to use `uint256` instead of alias `uint` in all of the occurrences in the contract.

**Alleviation:**

Alleviations were applied as advised.
SRF-03: Unnecessary explicit usage of modifier

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
<td>Optimization</td>
<td>Informational</td>
<td>StakingRewardsFactory.sol L42</td>
</tr>
</tbody>
</table>

**Description:**

The explicit usage of `Ownable()` to call constructor of the `Ownable` contract is unnecessary as the constructor does not expect arguments and is called implicitly nevertheless.

```solidity
constructor(
    uint _stakingRewardsGenesis
) Ownable() public {...}
```

**Recommendation:**

We recommend to remove the explicit usage of modifier `Ownable` as it is implicitly called.

```solidity
constructor(
    uint _stakingRewardsGenesis
) public {...}
```

**Alleviation:**

Alleviations were applied as advised.
Description:

The function `deploy` on the aforementioned line can be declared `external` as it is never called internally from within the contract. This function when declared `external` would be cheaper to execute as its arguments of `_rewardsTokens` and `_rewardsAmounts` would reside in `calldata` which is cheaper to use than `memory`.

Recommendation:

We recommend to change visibility of the aforementioned function to `external` and accordingly change the data location of its `memory` parameters to `calldata`.

```solidity
function deploy(
    address          _stakingToken,
    address[] calldata _rewardsTokens,
    uint[]    calldata _rewardsAmounts,
    uint        _rewardsDuration
) public onlyOwner {...}
```

Alleviation:

Alleviations were applied as advised.
SRF-05: Inefficient Greater-Than Comparison w/ Zero

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
<td>Optimization</td>
<td>Informational</td>
<td>StakingRewardsFactory.sol L63</td>
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<td>StakingRewardsFactory.sol L64</td>
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<td>StakingRewardsFactory.sol L69</td>
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<td>StakingRewardsFactory.sol L92</td>
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<td>StakingRewardsFactory.sol L101</td>
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<td>StakingRewardsFactory.sol L112</td>
</tr>
</tbody>
</table>

**Description:**

The linked greater-than comparisons with zero compare variables that are restrained to the non-negative integer range, meaning that the comparator can be changed to an inequality one which is more gas efficient.

**Recommendation:**

We advise that the above paradigm is applied to the linked greater-than statements.

**Alleviation:**

Alleviations were applied as advised.
SRF-06: Ineffectual Predicate in `require` Statement

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
<td>Code Legibility</td>
<td>Informational</td>
<td>StakingRewardsFactory.sol L64 - L65</td>
</tr>
</tbody>
</table>

**Description:**

Any of the comparison in `require` statement on L64 can be removed because the L65 does the equality comparison between both which makes one of the comparisons redundant in the `require` statement on L64.

```solidity
require(_rewardsTokens.length > 0 && _rewardsAmounts.length > 0);
```

**Recommendation:**

We recommend that any one of the comparison be removed to save gas associated with execution of redundant code.

```solidity
require(_rewardsTokens.length > 0);
```

**Alleviation:**

Alleviations were applied as advised.
SRF-07: Spelling Error

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comment</td>
<td>Informational</td>
<td>StakingRewardsFactory.sol L130</td>
</tr>
</tbody>
</table>

**Description:**

The comment on the aforementioned line incorrectly refers to function `startStakings()` as `startsStakings()`.

**Recommendation:**

We advise correct the reference to function by providing its correct name.

**Alleviation:**

Alleviations were applied as advised.
SRF-08: Reward Tokens and Amounts can be moved to StakingRewards Contract

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code Legibility</td>
<td>Informational</td>
<td>StakingRewardsFactory.sol L21 - L25</td>
</tr>
</tbody>
</table>

**Description:**

The StakingRewardsFactory contract in addition to acting as factory for StakingRewards contract also stores reward tokens and amounts corresponding to staking tokens. To observe separation of concern and increase legibility and quality of the codebase, the reward amounts can be moved StakingRewards contract as reward tokens are already stored in the contract.

**Recommendation:**

We recommend to move the reward amounts to the corresponding StakingRewards contract by passing the values through constructor and any utilization of reward amount can be accessed through querying the relevant StakingRewards contract.

**Alleviation:**

Alleviations were applied as advised.
SRF-09: Explicit Passing of `msg.sender` can be Omitted

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
<td>Optimization</td>
<td>Informational</td>
<td>StakingRewardsFactory.sol L72</td>
</tr>
</tbody>
</table>

**Description:**

The aforementioned line explicitly pass `msg.sender` as argument to the constructor of `StakingRewards` contract. Taking into the exhibit `SRS-03`, the parameter can be removed.

**Recommendation:**

We recommend to remove the unnecessary constructor argument of `msg.sender` on the aforementioned line as part of exhibit `SRS-03`.

**Alleviation:**

Alleviations were applied as advised.
**SRF-10: Incorrect Order of Functions**

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Language Specific</td>
<td>Informational</td>
<td>StakingRewardsFactory.sol</td>
</tr>
</tbody>
</table>

**Description:**

The structure of the codebase does not conform to the official Solidity style guide of [v0.5.16](#).

**Recommendation:**

Functions should be grouped according to their visibility and ordered:

```solidity
constructor
fallback function (if exists)
external
public
internal
private
```

Within a grouping, place the `view` and `pure` functions last.

**Alleviation:**

Alleviations were partly applied.
SRF-11: Unlocked Compiler Version

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
<td>Language Specific</td>
<td>Informational</td>
<td>StakingRewardsFactory.sol L2</td>
</tr>
</tbody>
</table>

**Description:**

The contract has unlocked compiler version. An unlocked compiler version in the source code of the contract permits the user to compile it at or above a particular version. This, in turn, leads to differences in the generated bytecode between compilations due to differing compiler version numbers. This can lead to an ambiguity when debugging as compiler specific bugs may occur in the codebase that would be hard to identify over a span of multiple compiler versions rather than a specific one.

**Recommendation:**

We advise that the compiler version is instead locked at the lowest version possible that the contract can be compiled at. For example, for version `0.5.16` the contract should contain the following line:

```
pragma solidity 0.5.16;
```

**Alleviation:**

Alleviations were applied as advised.
**SRF-12: Returned Value of Function is not Checked**

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
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</thead>
<tbody>
<tr>
<td>Code Legibility</td>
<td>Informational</td>
<td>StakingRewardsFactory.sol L103</td>
</tr>
</tbody>
</table>

**Description:**

The `approve` call on the aforementioned does not have its returned value checked which can lead to inaccuracies if the call returns `false` and it will be treated as successful in the context of current execution.

```
; tkn.approve(sr, extendRewardAmount);
```

**Recommendation:**

We recommend to use the `safeApprove` function from the library `SafeERC20`.

```
; tkn.safeApprove(sr, extendRewardAmount);
```

**Alleviation:**

Alleviations were applied as advised.
SRF-13: Visibility can be changed from public to external

<table>
<thead>
<tr>
<th>Type</th>
<th>Severity</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Optimization</td>
<td>Informational</td>
<td>StakingRewardsFactory.sol L27</td>
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<tr>
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<td></td>
<td>StakingRewardsFactory.sol L84</td>
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<td></td>
<td></td>
<td>StakingRewardsFactory.sol L111</td>
</tr>
</tbody>
</table>

**Description:**
The function on the aforementioned lines can have their visibilities changed from public to external as they are never called from within the contract.

**Recommendation:**
We recommend to change the visibilities of functions on the aforementioned lines from public to external.

**Alleviation:**
Alleviations were applied as advised.
**TEC-01: Usage of `uint` alias instead of `uint256`**

<table>
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<tr>
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<th>Severity</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Language Specific</td>
<td>Informational</td>
<td>TestERC20.sol L8</td>
</tr>
</tbody>
</table>

**Description:**

The contract is using `uint` to declare 256-bit unsigned integers. Although, `uint` is an alias for `uint256` and both represent the same underlying integer allocation. It is advisable that for clean coding practices the complete form `uint256` should be used instead of the alias `uint`.

**Recommendation:**

We advise to use `uint256` instead of alias `uint` in all of the occurrences in the contract.

**Alleviation:**

Alleviations were applied as advised.